A MULTI-SECTORAL RESOURCE PLANNING PLATFORM FOR SOUTH AFRICA'S ESTUARIES

L van Niekerk, S Taljaard, C-L Ramjukadh, JB Adams, SJ Lamberth, S Weerts, C Petersen, M Audouin and A Maherry

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A multi-sectoral Resource Planning Platform for South Africa's estuaries

Report to the

WATER RESEARCH COMMISSION

Compiled by

L van Niekerk, S Taljaard, C-L Ramjukadh, JB Adams, SJ Lamberth, S Weerts, C Petersen, M Audouin and A Maherry

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Estuary Spatial Planning Platform weblink available at:
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EXECUTIVE SUMMARY

RATIONALE

With the burgeoning demand for coastal and estuarine space and resources, and the increased commitment to biodiversity conservation, serious multi-user conflicts have emerged within these environments. In South Africa estuarine resource management still has a strong single sector focus (e.g. fisheries, conservation, water and waste, marine aquaculture). As a result the use of natural resources (i.e. water, land and estuarine biodiversity) are planned and managed by different authorities through sector-specific statutory systems. However, single sector management approaches, e.g. focusing just on fisheries, conservation, or water and waste management, are most likely to be successful when these are embedded in broader, multi-sector strategic resource planning processes. This is because resource use within one sector may impact on those of another. Also improved coordination of sector-based resource management plans will enhance optimal use of limited natural resources, and address potential conflicts.

The spatial planning process has proven to be a practical, rational tool to facilitate multi-sector resource planning (as has been applied for decades in terrestrial land-use planning). This process requires the physical demarcation of multiple uses in environmental spaces, and in doing so provides a platform to acknowledge potential conflicts and, to negotiate biophysical, social and economic objectives across sectors.

In light of the above, the focus of this study was to address multi-sector strategic resources planning in South African estuaries. Specifically the aim was to:

- **Develop a science-based strategic, spatial planning platform** to inform multi-sector strategic resource planning for South Africa's estuaries, including the following key tasks:
    - Collating existing data and information (already residing within various sectors and the scientific literature) and standardizing the formats (e.g. using geo-referenced spatial formats) suitable for multi-sector strategic resource planning processes.
    - Designing a spatial planning platform (using spatially explicit software and/or spreadsheets) to enable intuitive (visual) interpretation and analysis of data and information to inform strategic resource planning.
- **Demonstrate the application** and value of this platform in multi-sector estuarine resource.
- **Propose an appropriate governing system** (management framework and institutional arrangements) for multi-sector strategic resource utilisation planning of South Africa's estuaries considering international best practice, as well as national legislation, protocols, programmes and guidelines linked that may be relevant.

Important to note is that in the context of this study "strategic" is used as opposed to "individual". Where "individual" resource planning deals with negotiation of the allocation or utilisation within an individual estuary, "strategic" resource planning refers to the negotiation of broader resource allocation or utilisation across a selection of estuaries, for example a selection of estuaries within a municipal area, or a Water Management Area (WMA), a province, and even at a national scale.

ESTUARINE SPATIAL PLANNING PLATFORM

The estuary spatial planning platform was developed using a geodatabase and spatial software that is ArcGIS Geodatabase and ArcGIS Pro because one of its key features is that it can be shared online and is thus available and accessible to large audiences.

Estuary Spatial Planning Platform weblink available at:
https://csir.maps.arcgis.com/apps/MapSeries/index.html?appid=a58ab2075a954549b9b1f8b5e063380e

Because the focus is on strategic resources planning, it was important to include relevant, general information that is typically required for estuarine resource planning. Thus two general information modules were included, namely one on important administrative information and another that presents general biophysical information on all South Africa's estuaries, both spatially referenced. Because estuarine resources management in South Africa remains largely sector-based, with each sector having a "different set of lenses" of how they view or approach resource management in their domain, the platform allows users to access spatial information through key "sector modules". This provides for sector managers to enter the platform though a familiar space, but then guided into a multi-sector space, for example by understanding potential conflicts with other sectors. The key sector modules (and the lead authorities), in addition to the two general information modules are as follows:

Administrative Information	• Boundaries of Provincial, District and Local municipalities, Water Management Areas & Protected areas	National to Local
Estuary Information	• Estuary features, Estuary Habitat, Estuary Health, Ecological Importance and Key Pressures	National to Local
Conservation	• Protected estuaries, National Estuary Biodiversity Plan, Ecological Importance, Estuary Health & Potential Conflicts with other uses	DEA / Provincial authorities
Fisheries	• Fishing catch, Fish Health, Estuary Nursery Function, No-take zones, Fishing Pressure, Bait collection & Potential Conflicts with other uses	DAFF
Pollution	• Waste Water discharge, Water Quality Health, Catchment Water Quality, Resilience to WW discharges & Potential Conflicts with other uses	DEA / DWS
Flow modification	• Flow modification, Hydrology Health, Resilience to Flow modification & Potential Conflicts with other uses	DWS
Recreational use	• Blue Flag Beaches, Water Quality Health, Waste Water discharge & Potential Conflicts with other uses	DEA/District & Local Municipalities
Marine Aquaculture	• Aquaculture facilities, Water Quality health, Suitability for In-stream Aquaculture & Potential Conflicts with other uses	DAFF / DEA
Coastal Land-use	• Coastal Development in EFZ, Habitat Health, Artificial Breaching & Potential Conflicts with other uses	DEA/Provincial authorities/ Municipalities

Spatially referenced information contained in each of the modules aims to answer the following key questions such as:

- How is the estuary resource being used from this sector perspective?
- What is the state (health) of the "resource" being managed by this sector?
- Importance of the resource (ecosystem services);
- Are the individual estuaries suitable for this form of resource utilisation? AND/OR Are the individual estuaries in their natural state resilient to this form of resource utilisation?
- Is there potential conflict between users?

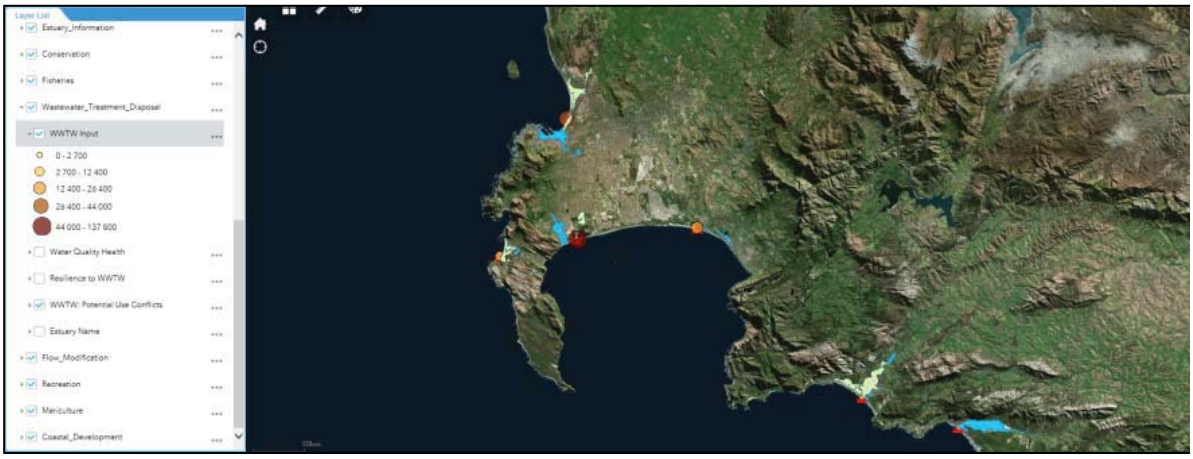
Once sector managers become more familiar with the platform, the systems allow them to interrogate information across sectors, through the "Multi-sector Module" where the information of all the different sectors have been combined. This multi-sector module, for example, can be used to intersect information layers of different sectors to identify conflict or potential conflict, as may be required in strategic resource planning processes such as regional estuarine management planning, water resource classification, protected areas expansion planning and fisheries allocations.

In summary, the information contained in the spatial planning platform can be used in various modes to inform strategic estuarine resource planning, including:

- Spatial visualisation of the data and information;
- Identifying potential conflicts and gleaning the potential sources of the conflict; and
- Rudimentary analysis of spatial information and data.

The overlay of different data sets in a sector and/or across sectors, provides the user with an oversight of important sector-relevant information and potential conflicts.

KEY QUESTION:	***Where and how much Waste-Water is being discharged in Priority estuaries targeted for formal protection?***	
Module/sector:	*Pollution*	*Conservation*
Layer:	*Wastewater discharge*	*National Estuaries Biodiversity Plan*



For example, a large number of estuaries identified as part of the core set of estuaries in need of protection to achieve South Africa's biodiversity targets are subject to wastewater discharges that reduce or negate their ability to contribute to national biodiversity targets.

KEY QUESTION:	***Where is there conflict in between communities that potentially qualify for small-scale fisheries exceptions, nursery function and the natural resilience of individual estuaries to fishing?***		
MODULE/SECTOR:	*Fishing*	*Fishing*	*Fishing*
LAYER:	*Small-scale fisheries exceptions*	*Nursery function*	*Resilience to fishing*

This example shows that whilst most communities along the east coast of South Africa potentially qualify for small-scale fisheries exemptions, most of the estuaries along this coastline have very little natural resilience to fishing pressure (i.e. small estuaries that close off to the sea) and will be effectively "mined". This is especially the case where estuaries have been identified as important fish nursery systems that support marine fisheries.

KEY QUESTION:	Where is there conflict between existing Marine Aquaculture facilities and Estuary Water Quality health?	
MODULE/SECTOR:	Marine Aquaculture	Marine Aquaculture
LAYER:	Aquaculture	Estuary Water Quality

Very few estuaries in South Africa are suitable for instream aquaculture as they lack sufficient depth (>5 m) to support the required infrastructure (i.e. rafts and cages). In addition, the poor water quality currently observed in a number of systems further reduces their viability for aquaculture.

PROPOSED GOVERNING SYSTEM FOR STRATEGIC ESTUARINE RESOURCE PLANNING

Critical to successful multi-sector, strategic estuarine resource planning is the formalisation of an appropriate framework, as well as the establishment of the institutional structures through which to develop and implement such resource planning. Currently, strategic estuarine resource planning is not explicitly integrated into the National Estuarine Management Protocol and remains a shortcoming of the Protocol that must be addressed in future amendments. An institutional model that can be considered for stronger coordination and cooperation in strategic estuarine resource planning at the national scale is the National Estuaries Management Task Group, an advisory body to Working Group 8 (see Figure below).

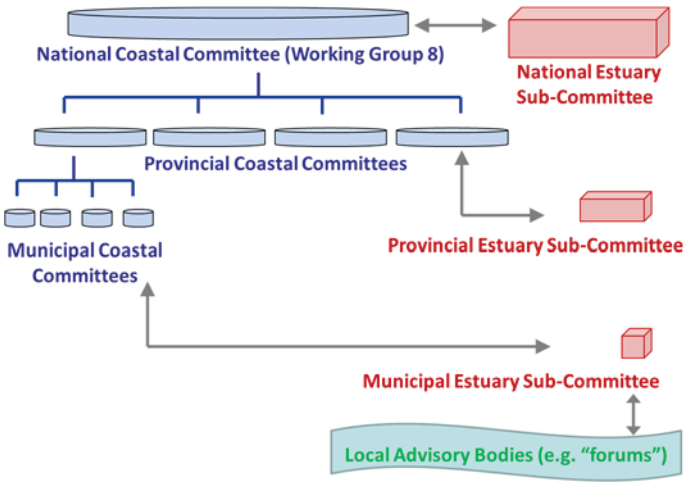


Figure: Institutional structures for estuarine management planning in South Africa, also proposed for strategic estuarine resource planning

As a result of the current vacuum left in strategic estuarine resource planning under the National Environmental Management: Integrated Coastal Management Act (No. 24 of 2008) and the National Estuary Management Protocol, other legal instruments such as the National Water Resources Classification Process under the National Water Act morphed into an ad hoc framework for strategic estuarine resource planning, focusing at the Water Management Area scale. Current structures can support strategic estuarine resource management with minor adjustments to their scope and functions. It is therefore recommended that the Department of Water and Sanitation Classification decision-making process where it relates to estuaries be more explicitly incorporated into the functions of Working Group 8 (at present Classification activities are just reported but no formal approvals are required).

RELEVANCE TO THE BLUE ECONOMY

Strategic spatial planning is one of the important tools that can be used in negotiating the balance between ecological protection, social priorities and economic development as required in terms of the Blue Economy agenda (also referred to as the Green Economy applied in the Blue World). Blue Economy concept could be embedded within the rationale for strategic estuarine resource planning, e.g. identifying estuaries that can support ecotourism and ensuring their future health. In particular, spatial planning has the potential to increase the transparency with which decisions are made that affect the country's transition to a blue-green economy. Within this context, the spatial planning platform developed within this study can be viewed as a first step towards consolidating available information and transposing this into a spatial format, in support of effective strategic estuarine resource planning in South Africa towards unlocking a blue-green economy. However, to effectively enable a transition to the blue-green economy in South Africa's estuaries a set of related principles should be developed and incorporated into future amendments of the National Estuary Management Protocol. Such principles could then be translated into more specific criteria to guide the design and assessment of both strategic and individual estuarine resource planning and management in the future.

RECOMMENDATIONS GOING FORWARD

In order to maintain and grow the value and relevance of the spatial planning platform, the following is recommended:

- That a roadshow is run to familiarize the coastal provinces with the layout of the Spatial Planning Platform and how to use it. This will avoid unnecessary misunderstandings in the implementation of the platform and assist with sourcing data.
- Regular updates of the data and information using the 5- to 7-year cycle in which the National Biodiversity Assessment (NBA) is updated. In this regard SANBI has been approached to consider such updates as a formal component of future NBAs, as well as hosting spatial data on their BGIS site for wide distribution.
- Establishment of a small steering committee (comprising key research organisations and national/provincial government) to assist with critical, ongoing data and information updates between major NBA updates.
- Linking the platform to the Ocean and Coastal Information Management System (OCIMS), a Department of Environmental Affairs coastal data initiative.
- Extending the type of data and information contained in the Platform, for example:

- Expanding the Administrative Information module to include detail on the 1:100-year flood lines and Coastal Management/Set back lines as data becomes available.
- Expanding the Conservation module to include endangered species data (plants, invertebrates, fish, birds, mammals & reptiles) per estuary.
- Expanding the Fisheries module to address bait collection in a more quantitative manner than just presence/absence of bait collection and indicate the stock status of key species being caught in each estuary.
- Expanding the Recreation module to also address boating activities including type of boating activities and seasonal/holiday hives of activity.
- Expanding the Pollution module to also address plastic pollution (e.g. micro-plastics), desalination and Harmful Algae Blooms (HABs) in South Africa's estuaries.
- Future updates of the Platform should add modules on: the mining sector, potential vulnerability of estuaries to climate change, soil erosion/sediment loads entering estuaries, estuary rehabilitation/restoration, ecological infrastructure and natural resource utilization linked to socio-economic livelihoods (currently embedded in Fisheries and Land-use Modules), the occurrence and impact of invasive alien species.
- Future updates of the Platform should investigate how to hyperlink the "Whitfield Bibliography" to the individual estuaries. This may require some advanced coding.

- In order to address the needs of a broad range of resource users that are not GIS literate (i.e. required for a tool that is easy to use) we excluded the use of specialised software that would require a high degree of technical knowledge from this phase of the development of the Platform. However, collating, organising and doing basic analysis on estuarine resource use is only the first step in the complex process of estuarine resource spatial planning. It is therefore recommended that a next generation version of the Estuary Spatial Planning Platform be developed and hosted on a more sophisticated information technology platform that would allow for seamless integration between Java/HTML coding, geodatabases, spreadsheets and web-enabled GIS displays. Dynamic links should be developed that allows for interactive interrogation of resource condition and pressures to provide resource managers with insights on how resource management in one sector impacts on resource availability in other sectors.

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SPECIALIST	AFFILIATION	AREA OF RESPONSIBILITY
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LIST OF SYMBOLS AND ABBREVIATIONS

CD	Chief Directorate
CMA	Catchment Management Agency
CPUE	Catch-per-unit-effort
CSIR	Council for Scientific and Industrial Research
DEA	Department of Environmental Affairs
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EFZ	Estuary Functional Zone
EHI	Estuarine Health Index
EIS	Estuarine Importance Score
EMP	Estuarine Management Plan
EWR	Ecological Water Requirement
H	High
IDP	Integrated Development Plan
L	Low
M	Medium
MAR	Mean Annual Runoff
MCM	Million Cubic Metres
MCM/a	Million Cubic Metres per annum
MLRA	Marine Living Resources Act (No. 18 of 1998)
MPA	Marine Protected Area
MSL	Mean Sea Level
NBA	National Biodiversity Assessment
NEMA	National Environmental Management Act (No. 107 of 1998)
NMU	Nelson Mandela University
NWA	National Water Act (No. 36 of 1998)
NWRS	National Water Resources Strategies
PES	Present Ecological Status
Protocol (the)	National Estuarine Management Protocol
RDM	Resource Directed Measures
REC	Recommended Ecological Category
RQO	Resource Quality Objectives
SA	South Africa
VH	Very high
VL	Very low
WMA	Water Management Area

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1. INTRODUCTION

1.1 Background

With the burgeoning demand for coastal and estuarine space and resources, and the increased commitment to biodiversity conservation, serious multi-user conflicts have emerged within these environments (Crowder et al. 2006).

In South Africa estuarine resource management still has a **strong single sector focus** (e.g. fisheries, conservation, water and waste, marine aquaculture, etc.). As a result the conservation and use of these natural resources (i.e. water, land and estuarine biodiversity) are planned and managed by different authorities through sector-specific statutory systems. The South Africa's National Biodiversity Assessment 2011 (Van Niekerk and Turpie 2013) demonstrated the marked (negative) environmental consequences on our estuarine systems as a result of uncoordinated sector-based planning. At present the various sectors allocate estuarine resource uses without negotiating present and future uses amongst themselves first. However, single sector management approaches, e.g. focusing just on fisheries, conservation, or water and waste management, are most likely to be successful when these are embedded in broader, **multi-sector strategic resource planning processes**. This is because resource use within one sector may impact on those of another. Also improved coordination of sector-based resource management plans will enhance optimal use of limited natural resources, and address potential conflicts.

There are two different views emerging on the **meaning of sustainability** and how it is implemented in multi-sector resource protection and use planning processes (Qiu and Jones 2013). These represent the different values and collective choices that humans have for a preferred future. "Soft" sustainability is based on the view that depletion in natural capital (e.g. through overexploitation of living resources, decline in biodiversity) can be compensated for through economic growth and related improvement in technology. The economic pillar of sustainability is seen as the foundation for the well-being of society. "Hard" sustainability is based on the view that natural capital cannot be substituted by man-made capital, and that increases in man-made capital should not be based on over-consumption of natural capital and should not undermine the natural systems and process that are vital to the existence of humans. The environmental pillar is therefore seen as the foundation for the well-being of society. From a "soft" sustainability perspective ecosystem conservation is considered as one type of "sectorial" use in relation to other uses. This approach is more likely to be adopted in countries with existing large coastal and maritime industries with related increasing competition for space/resource use among different sectors (Qiu and Jones 2013). By contrast, planning processes based on "hard" sustainability holds ecosystem limits and ecosystem conservation through the declaration of formally protected areas (including Marine Protected Areas) as central to the ecosystem-based approach. This approach in generally followed in less developed countries with still intact ecosystems in place, and therefore, has a focus on the conservation of ecosystem health and protection of wild stock (Qiu and Jones 2013). It can be argued that the DWS approach of ensuring water resource allocation "some for all, for ever" captures this philosophy well in a country where there is a high level of social dependency on natural resources to reduce the impact of past social injustices and poverty.

The **spatial planning process** has proven to be a practical, rational tool to facilitate multi-sector resource planning. The concept of spatial planning is one of the common approaches to multi-use control in terrestrial environments (Courtney & Wiggen 2003), but major interest in marine and coastal resource planning processes only commenced in the mid-2000s (Halpern et al. 2012; Ehler and Douvere 2009; Katsanevakis et al. 2011). Historically, spatial planning in these environments was mostly applied in a sector-based manner, for example for navigation, disposal areas, military security zones, concession zones for mineral extraction, Marine Aquaculture sites and conservation areas (Douvere 2008). While a more multi-sector based approach has been part of conservation planning in marine and coastal environments for some time (Day 2002; Douvere and Ehler 2009), they are only now starting to be

applied in a truly multi-sector mode. Since then it has evolved to a more inclusive, multi-use approach, in which a balance is sought between social priorities, economic development and biodiversity protection, commonly referred to as marine spatial planning (MSP) (Douvere and Ehler 2009; UNESCO 2012). This process allows for the physical demarcation of multiple uses in environmental spaces, and in doing so provide a platform to acknowledge potential conflicts and, to negotiate biophysical, social and economic objectives across sectors. The literature emphasizes two important aspects of strategic spatial planning of natural resources, namely embedding it in a *broader integrated environmental management framework* and coordinating thereof through a *centralized cross-sectoral governing institution*. Thus, spatial planning within a demarcated environment is by no means an end in itself, but rather it must fit within the broader integrated environmental management framework (USESCO 2012; Taljaard 2011). Also, Ehler and Douvere (2009) propose that a centralised cross-sectoral organisation should be specifically designed for the purposes of coordinating multi-use spatial planning. However, their experience across several countries showed that it still remains most effective to leave *implementation* components within the integrated management framework to the existing management authorities responsible for single sector concerns or activities. In other words, multi-use spatial planning does not replace 'single-sector' planning, but rather ensures that *"…the sum of all decisions is orientated toward integrated ecosystem-based management of the demarcated spaces"* (Ehler and Douvere (2009).

Strategic estuarine resource planning in South Africa remains wholly sector-based. A paradigm shift is required as this situation is not sustainable. Unless science-based tools and governing processes are developed and implemented to facilitate multi-sector strategic estuarine resource planning, South Africa's valuable (and limited) estuarine resources will soon degrade to a point where they will lose their ability to provide essential ecosystem services to society (e. g. storm protection, food provision, aesthetic and biodiversity value (Rollason et al. 2012)) and contribute to coastal resilience. In this light the aim of this study is to explore **common, science-based spatial planning platforms**, as well as **appropriate governing systems**, to inform **multi-sector, strategic estuarine resource planning focusing on South Africa.**

Important to note is that in the context of this study **"strategic"** is used as opposed to **"individual".** "Individual" resource planning deals with negotiation of the allocation or utilisation within a **specific estuary** (as defined by its estuary functional zone [EFZ]). In the estuarine management planning terminology of South Africa this is referred to as "zoning" (DEA 2015). On the other hand, "strategic" resource planning refers to the negotiation of **resource allocation or utilisation across a selection of estuaries**. For example, this can be a selection of estuaries within a municipal area or a Water Management Area (WMA). It can refer to negotiation of broad resource allocation and utilisation within a province, or even at a national scale. Strategic estuarine resource planning views the estuary as the smallest unit, rather than focusing on allocation (or zoning) within its EFZ (as is the purpose of "individual" estuarine resource planning). Individual estuarine resource planning is addressed through the National Estuarine Management Protocol that sets out to effectively plan and manage the country's estuaries in a more holistic, multi-sectoral manner.

1.2 Purpose of Project

Multi-sector strategic estuarine resource planning in South Africa is lacking and in order to provide support for establishing such as resource planning approach, the aim of this research project was to:

- Develop a common **scientific-based spatial planning platform** to inform multi-sector strategic resource utilisation planning for SA's estuaries, including the following key tasks:
    - Collating existing data and information (already residing within various sectors and the scientific literature) and standardizing the formats (e.g. using geo-referenced spatial formats) suitable for multi-sector strategic resource planning processes.

- Designing a spatial planning platform (using spatially explicit software and/or spreadsheets) to enable intuitive (visual) interpretation and analysis of data and information to inform strategic resource planning.

- **Demonstrate the application** and value of this platform in multi-sector estuarine resource.
- **Propose an appropriate governing system** (management framework and institutional arrangements) for multi-sector strategic resource utilisation planning of SA's estuaries considering international best practice, as well as national legislation, protocols, programmes and guidelines linked that may be relevant.

The target audience for this product is national government departments tasked with estuarine resource management, provincial authorities, local and district municipalities and estuarine researches.

1.3 Structure of this Report

The structure of this report is as follows:

- **CHAPTER 1: INTRODUCTION** details the project background and objectives.
- **CHAPTER 2: ESTUARINE RESOURCE PLANNING IN SOUTH AFRICA** summarise the *status quo* of sector-based resource management and the lack of strategic (across) estuary resource planning. It also touched on current efforts being made to facilitate multi-sector estuarine resource planning on the individual estuary scale.
- **CHAPTER3: OVERVIEW OF RELEVANT INTERNATIONAL SPATIAL PLANNING PLATFORMS** provides a brief summary of some international attempts at achieving strategic spatial planning.
- **CHAPTER 4: DEVELOPING THE ESTUARY SPATIAL PLANNING PLATFORM** provides the motivation for the software used, the primary sources of spatial data and information incorporated into the platform and highlights some of the visualisation techniques followed in the development of the platform.
- **CHAPTER 5: DESIGN OF THE ESTUARINE SPATIAL PLANNING PLATFORM** provides the motivation for the modular approach and includes more detail on module selection and layout design.
- **CHAPTER 6: APPLICATION OF THE SPATIAL PLANNING PLATFORM** provides examples of how the platform should be used.
- **CHAPTER 7: PROPOSED GOVERNING SYSTEM FOR STRATEGIC ESTUARINE RESOURCE PLANNING** recommends away forward for achieving strategic estuarine resource planning in South Africa.
- **CHAPTER 8: ESTUARY RESOURCE PLANNING AND THE BLUE ECONOMY** provides an overview of the Blue Economy and lists the key principals underpinning the Green and Blue Economies. The chapter concludes with recommendations around embedding the Blue-Green Economy in Estuarine Resource Planning.
- **CHAPTER 9: CONCLUSIONS AND RECOMMENDATIONS** provides an overview of the way forward

2. ESTUARINE RESOURCE PLANNING IN SOUTH AFRICA

2.1 *Status Quo:* Sector-based Resource Planning

A major constraint in estuarine resource planning in South Africa is not just the sectorial fragmentation, but also the overlap in certain legislation and related mandates as is demonstrated in Table 2.1. The majority of environmental legislation is aimed at providing guidance for the management and control of specific resources from a single sector perspective). As a result various sectors (e.g. fisheries, biodiversity, water and waste, marine aquaculture, mining, etc.) tend to allocate estuarine resource use without negotiating present and future uses amongst themselves first.

Table 2.1 Important key sector-based resource planning legislation relevant to estuaries

SECTOR	KEY LEGISLATION/PLAN	LEAD AUTHORITY
Conservation/Biodiversity protection	National Environmental Management: Biodiversity Act (No. 10 of 2004)	Department of Environmental Affairs (DEA) South African National biodiversity Institute (SANBI) South African National Parks (SANParks) Provincial Conservation agencies
	Protected Areas Act (Act No. 57 of 2003) (Protected Areas Act)	
	Marine Living Resources Act (Act No. 18 of 1998)	Department of Agriculture, Forestry and Fisheries (DAFF)
	Protected Areas Act	DEA/SANParks/Provincial Conservation agencies
	National Environmental Management: Integrated Coastal Management Act (Act No. 24 of 2008)	DEA
	Environmental Conservation Act (No. 73 of 1989) (areas specifically gazetted in the Garden Route and south coast of KZN).	DEA
Flow modification	National Water Act (Act No. 36 of 1998)	Department of Water and Sanitation (DWS)
Fishing	Marine Living Resources Act (Act No. 18 of 1998) (MLRA)	DAFF
Wastewater Management	National Environmental Management: Integrated Coastal Management Act (Act No. 24 of 2008) National Water Act (Act No. 36 of 1998)	DEA/DWS
Marine Aquaculture	Marine Living Resources Act (Act No. 18 of 1998) (MLRA)	DAFF
Coastal Land-use and Development	National Environmental Management: Integrated Coastal Management Act (Act No. 24 of 2008) as specified in National Estuarine Management Protocol	Municipalities/Provincial Environmental Departments/DEA/SANParks
	Municipal Systems Act (Act No. 32 of 2000),	
	Spatial Planning and Land Use Management Act (Act. No. 16 of 2013) (SPLUMA)	
	Provincial Planning and Development Acts	
	National Ports Act(Act No. 12 of 2005)	National Port Authority
Recreation	National Health Act (Act No. 61 of 2003)	Municipalities
Mining	Mineral and Petroleum Resources Development Act (Act No. 28 of 2002)	Department of Mineral Resources (DMR)

An overview of the most important national scale estuarine resource planning mandates is discussed here.

2.1.1 Conservation Planning (DEA/SANBI: Biodiversity/Protected Areas Acts)

The objective of the **National Environmental Management: Biodiversity Act (No. 10 of 2004)** is to provide for the conservation of biological diversity, the protection of species and ecosystems, the regulation of the sustainable use of biological resources and the assurance of a fair and equitable sharing of the benefits arising from the use of genetic resources. The Act also provides for cooperative governance in biodiversity management and conservation and the establishment of the South African National Biodiversity Institute (SANBI). The Act confirms the state as the custodian of South Africa's biological diversity, committed to respecting, protecting, promoting and fulfilling the constitutional rights of its citizens. The lead agent is the DEA. The Act recognises that South Africa is party to the Convention on Biological Diversity, the Convention on International Trade in Endangered Species of Flora and Fauna (CITES), the Convention on Wetlands of International Importance especially Waterfowl Habitat (the Ramsar Convention) and the Convention on Migratory Species. It requires the identification of landscapes and their natural processes, of ecosystems and ecological processes and of species important for the conservation of biological conservation. It also requires the establishment of monitoring procedures to determine the status and trends of such features. The Act provides for a national classification process for protected areas and for the proclamation and deproclamation of protected areas. The Act also calls for the management and control of alien, exotic and invasive species.

The **National Environmental Management: Protected Areas Act (No. 57 of 2003)** provides, within the framework of NEMA, for the declaration and management of a national system of protected areas in South Africa as part of a strategy to manage and conserve its biodiversity and provide for a representative network of protected areas on state land, private land and communal land. In addition, the Act promotes the sustainable utilisation of protected areas for the benefit of people and participation of local communities in the management of protected areas. The Act also gives effect to international agreements on protected areas that are binding on South Africa and provides for cooperative governance in the declaration and management of protected areas. The lead agent is DEA. The Act applies to terrestrial and marine areas.

In South Africa, the promulgation and spatial demarcation of marine protected areas is also governed under the Marine Living Resources Act (Act 18 of 1998, amended 2000) (MLRA). Marine protected areas (MPAs) –in terms of the MLRA (Section 43) – remained designated to the Minister (Environment). Specifically MPAs, in terms of the MLRA is declared for the protection of fauna and flora or a particular species of fauna or flora and the physical features on which they depend, to facilitate fishery management by protecting spawning stock, allowing stock recovery, enhancing stock abundance in adjacent areas, and providing pristine communities for research, or to diminish any conflict that may arise from competing uses in that area.

South Africa's National Biodiversity Assessment provided an assessment of the current state of health and protection of all ecosystems in South Africa, including estuaries, and fills gaps in the biodiversity planning efforts such as the development of the **National Estuarine Biodiversity Plan**. The main objective of this plan was to prioritise estuaries for Estuarine Protected Area (EPA) status. Biodiversity planning is an evolving field that has allowed a move from *ad hoc* protection to systematic planning that takes pattern, process and biodiversity persistence into account. More recently, attention has been focused on incorporating socio-economic realities into biodiversity planning, particularly in terms of minimising the management and opportunity costs of protection. While the 2011 plan does not explicitly take social and economic costs and benefits into consideration, estuary health was incorporated as a cost, in that more degraded estuaries were assigned exponentially increasing costs. Highly impacted estuaries probably also have relatively high costs of conservation – both in terms of rehabilitation costs as well as forgone opportunity costs. Estuaries where the opportunity costs of protection are likely to be high are also likely to be heavily utilised systems that are in a poorer state of health.

Estuary Biodiversity Targets were defined in terms of achieving representation of ecosystem types, habitats and species, as well as meeting population targets that ensure their viability. The overall target was to protect a minimum of 20% of total estuarine area. Population targets were calculated as a proportion of the total abundance for estuary-dependent fish and bird species as follows:

- 50% of the population of threatened species (based on Red Lists) and overexploited/collapsed species;
- 40% of the population of exploited species; and
- 30% of the population of all other species.

2.1.2 Water Sector (DWS: Water Act)

In estuaries, water quantity and quality related issues are dealt with mainly under the **National Water Act (NWA) (No. 36 of 1998)**. The Act's purpose is to ensure that South Africa's water resources are protected, used, developed, conserved, managed and controlled with due cognisance of factors such as basic human needs, the protection of aquatic and associated ecosystems and their biodiversity, the facilitation of social and economic development, the promotion of the efficient, sustainable and beneficial use of water, the reduction and prevention of pollution, the meeting of international obligations, the redress of past discriminations and the management of floods and droughts. The Act has a wide definition of water use and covers abstraction, consumption and discharge but focuses primarily on the use of water resources. The Act prescribes a two-tier approach to the development of water resource management strategies, namely the **National Water Resources Strategies (NWRS)** and the **Catchment Management Strategies (CMS)**. The CMS allows for public participation by providing for the establishment of water management institutions. The NWRS provides for the integration of water resources management and cooperative governance. Both the NWRS and CMS incorporate concepts such as **ecological water requirements (the ecological "Reserve")**, social and economic requirements (a **Reserve for basic human needs**), requirements for integrated resource management and the **class of a water body being managed** (i.e. an integrated measure of quantity). The Act provides detailed guidelines and protocols to derive **Resource Quality Objectives** (RQO) for the protection of aquatic ecosystems (i.e. guidelines for water quality, water quantity, habitat integrity and the biotic integrity for rivers, wetlands, estuaries and groundwater). The Act is currently by far the most important statute relating to the control of water recourses in South Africa and therefore has a major impact on the effective management of estuaries.

The **Water Resource Classification Process** give effect to **the Resource Directed Measures Strategy**, in that determination of the management class in this way will allow a Reserve determination, as opposed to a Preliminary Reserve Determination. The main difference is that the Classification process involves a catchment-scale study, whereas the Preliminary Reserve Methods are designed for reach-level assessments.

The Classification Process results in the setting of the Management Class (which describes degree of use and reflects desired condition of water resources), the Reserve and the Resource Quality Objectives (RQOs) by the Minister or delegated authority for every significant water resource (watercourse, surface water, estuary, or aquifer) in the country. This in turn, will set the constraints in the determination the allocatable portion of a water resource for use. The Classification Process thus have considerable economic, social and ecological implications. The Classes define the extent of water resource use for each integrated unit of analysis (a group of one or more river reaches/estuaries/other water resources within a larger catchment or water management area), on a rating of I to III (Table 2.2), and is linked to the management categories (A to D) that are defined at a reach or resource level. In other words, the allowable level of use is determined by the desired condition of each of the water resources in the integrated unit of analysis.

Table 2.2 Guidelines for determining the an estuary class (modified from Dollar et al. 2006)

MANAGEMENT CLASS	PERCENTAGE ECOLOGICAL CATEGORY REPRESENTATION OF WATER RESOURCE UNITS IN AN IUA				
	≥A/B	≥B	≥C	≥D	<D
Class I Minimally used: The configuration of water resources within a catchment results in an overall water resource condition that is minimally altered from its pre-development condition.	≥40	≥60	≥80	≥99	-
Class II Moderately used: The configuration of water resources within a catchment results in an overall water resource condition that is moderately altered from its pre-development condition	-	≥40	≥70	≥95	-
Class III Heavily used: The configuration of water resources within a catchment results in an overall water resource condition that is significantly altered from its pre-development condition.	-	-	≥30	≥80	-
		-	-	100	-

In conclusion, traditionally the management of estuaries has had a very strong water sector focus (DWA 2008). This in turn has led to the development of decision-making platform (e.g. Water Resource Classification and Ecological Flow Requirement processes) that allows for limited interactions with other sectors that also benefit from, and as a result impact significantly on, estuary health.

2.1.3 Fisheries Sector (DAFF: MLR Act)

The management and control of exploited living resources in estuaries fall primarily under the **Marine Living Resources Act (MLRA) (No. 18 of 1998)**. The lead agent in the management and control of living resources in estuaries is DAFF. The primary purpose of the MLRA is to protect marine living resources (including those of estuaries) through establishing sustainable limits for the exploitation of resources; declaring fisheries management areas for the management of species; approving plans for their conservation, management and development; prohibit and control destructive fishing methods and the declaration of Marine Protected Areas (MPAs) (a function currently delegated to DEA). The MLRA overrides all other conflicting legislation relating to marine living resources. This resulted in some provincial and local legislation providing for the effective protection of living resources being superseded before proper protection measures were put in place under the new Act. This situation resulted in some estuaries becoming vulnerable to overexploitation of, for example, bait species such as prawns.

2.1.4 Wastewater Discharges/Management (DEA: ICM Act Municipal Systems Water Act/DWS: National Water Act)

Chapter 8 of the **ICM Act (No. 24 of 2008)** deals with Marine and Coastal Pollution Control and specifically addresses 'Discharge of effluent into coastal waters'. Wastewater discharge is list as a scheduled activity under the NEMA (No. 107 of 1998) EIA Regulations (contained in Government Notices R544, R545 & R546, Government Gazette 33306, 18 June 2010) promulgated under Chapter 5 of NEMA

In the case of point source pollution source (e.g. WWTW effluents), actions to meet water quality objectives (i.e. Resource Quality Objectives) can be addressed through discharge licenses or permits (e.g. issued under the National Water Act [rivers] or the ICM Act [estuaries]). These licenses or permits set quantitative limits for effluent volume and composition, e.g. *Escherichia coli,* faecal coliform. Meeting such limits may mean meeting instream objectives, for example specified as risk levels used by SA's National Microbial Monitoring Programme (NMMP). In the same way reducing inorganic nutrient (e.g. nitrogen and phosphate) levels in effluent discharges may mean meeting the instream RQO set downstream driven by aquatic ecosystem requirements.

2.1.5 Marine Aquaculture (DAFF: MLRA Act)

Marine aquaculture and harvesting of marine living resources are governed under the MLRA by the Department responsible for fisheries. The collection of marine vegetation (e.g. kelp) also requires a permit in terms of the MLRA.

Under the MLRA, each marine aquaculture enterprise has to apply for a right to engage in marine aquaculture. Each application is assessed for viability, economic, social and environmental aspects by the Marine Aquaculture Working Group. Further to this, applicants need to apply for permits to collect brood stock, import and export animals, engage in marine aquaculture activities (production, hatchery), transport animals, seed and harvest abalone for ranching. Farms are visited at least annually to assess adherence to permit conditions and rights. Disease surveillance of each of the marine farms is undertaken by qualified veterinarian service provider appointed by the DAFF. In terms of the permit conditions, production facilities are required to comply with the requirements of the relevant food safety programmes such as the South African Molluscan Shellfish Monitoring and Control Programme.

2.2 Efforts to Faciliate Multi-sector Estuarine Resource Planning

The majority of estuarine resource planning initiatives in South Africa do not take cognisance of the regional interaction between estuaries. Reasons accounting for this state of affairs include:

- **Narrow focus of Classification and Ecological Water Requirement studies (i.e. individual estuaries or on catchment-scales not bioregional scales):** Studies to define the freshwater "Reserve" for estuaries (conducted as part of the RDM procedures under the National Water Act No. 36 (NWA) (South Africa 1998c)) do not recognise explicitly the connectivity between estuaries in a region (DWAF 2004). At most, this aspect might be addressed as a part of determining the "Functional importance" of an estuary. The "Functional importance", an aspect of the overall ecological importance of the estuary, together with its current health status, is used to determine the "Recommended Ecological Category" or "Desired State" of an estuary. An estuary's importance status will influence the choice of management class and hence the freshwater allocation under the NWA. The Ecological Water Requirement methods for estuaries do not have any explicit guidelines for dealing with the connectivity between estuaries in a region or assessing accumulative regional impacts. The spatial connectivity between systems are not accounted for.
- **Lack of acknowledgement of interaction with marine environment interaction:** The NWA (South Africa 1998c) does not recognise the marine environment as a receiving environment for freshwater flows and there is no recognition of the freshwater requirements of the marine environment and the link between the land and sea. Reducing freshwater flows to the marine environment impacts on the marine habitat directly (Gillanders & Kingsford 2002; Strydom, Whitfield & Wooldridge 2003; Van Ballegooyen et al. 2006), which in turn impacts on the health of estuarine-dependent and associated species that utilise the surf zone and nearshore marine environment. This reduction in the health of marine habitats contributes to the general decline in estuarine health status associated with freshwater modifications.
- **Narrowness in Terms of Reference, only addressing specific issues:** In general, most estuarine assessments and studies suffer from very narrow terms of reference. Research (especially field-data collection) is costly and clients require only explicit questions answered, e.g. the impact of a golf-estate development on an estuary or a dam development on a specific estuary. Holistic aspects, such as regional-scale interactions, are seen as being of secondary importance and are therefore not funded.
- **Lack of cumulative assessment accounting:** No cumulative assessment is done on the impact of multiple activities on the same system or in a region. In most studies, it is implicitly assumed that all other

anthropogenic variables (e.g. mouth management, local developments and recreational fishing pressures) will remain stable and that only the issues under investigation (e.g. flow modification) will change.

Government's response to facilitate integrated (multi-sector) planning and management of estuarine resources in South Africa came through the National Environmental Management: Integrated Coastal Management Act (Act 24 of 2008), specifically Chapter 4. In May 2013, the National Estuarine Management Protocol (called the Protocol) (as required under the ICM Act) was published. In order to effectively plan and manage the unique environmental, economic and social aspects of the country's estuaries in a more holistic, multi-sectoral manner the Protocol set the following national objectives of estuarine management, namely:

- To **conserve, manage and enhance sustainable economic and social use** without compromising the ecological integrity and functioning of estuarine ecosystems,
- To maintain and/or restore the ecological integrity of South African estuaries by ensuring that the **ecological interactions between adjacent estuaries, between estuaries** and their catchments, and between estuaries and other ecosystem, are maintained,
- To **manage estuaries co-operatively** through all spheres of government and to engage the private sector/entities and civil society in estuarine management,
- To **protect a representative sample of estuaries** (such protection could range from partial protections to full protection) in order to achieve overall estuarine biodiversity targets as determined by the NBA 2011 and the subsequent updates,
- To promote awareness, education and training that relate to the **importance, value and management** of South African estuaries,
- To minimize the potential **detrimental impacts of predicted climate change** through a precautionary approach to development in and around estuaries and with regard to the utilization of estuarine habitat and resources.

The holistic, multi-sectoral approach is further supported in a list of "key management standards" in the Protocol. Some of these standards explicitly acknowledge integration across sectors such as "*… an estuary must be maintained in its ecological category as determined in the 2011 NBA* (Biodiversity Act) *and subsequent updates in order to meet biodiversity targets…*" and *"...the classification and setting of the Reserve and Resource Quality Objectives of an estuary* (National Water Act) *must take into account current ecological health status, recommended extent of protection and recommended ecological category in order to meet the biodiversity targets as set in the 2011 NBA and the subsequent updates*".

While the Protocol provides detailed requirements in terms of individual estuarine resource planning and management, it is largely silent of strategic estuarine resource planning. The latter remains largely sector-based under different pieces of legislation as explained earlier.

3. OVERVIEW OF KEY INTERNATIONAL SPATIAL PLANNING PLATFORMS

3.1 Pacific North Coast Integrated Management Area (PNCIMA)

The increase in ocean use and a decline in ocean health in the PNCIMA marine environment made managers and decision makers re-examine how they use ocean space and resources and how to manage their activities. The existing management systems deal with each industry, activity and conservation initiative largely independently as though they don't affect one another. As the health and wealth of the coastal communities and ocean economies declines, it become more and more apparent that this approach was not adequately taking care of the "whole". These challenges, as well as important opportunities, drove the need for an integrated management plan in PNCIMA. The proactive planning process developed as part of the PNCIMA initiative aimed to (http://www.pncima.org/):

- Forecast and address future developments and needs;
- Establish goals and strategies to adapt to change;
- Coordinate new and existing processes;
- Reduce cumulative impacts;
- Provide greater certainty and stability in planning for new investments; and
- Reduce conflicts between uses and user groups.

The PNCIMA objective is to engage all interested and affected parties in the collaborative development and implementation of an integrated management plan to ensure a healthy, safe and prosperous ocean area. The plan is high level and strategic, and provides direction on and commitment to integrated, ecosystem-based and adaptive management of marine activities and resources in the planning area. It is distinct from the detailed operational direction for management that will be provided in a work plan for its implementation. The plan focuses on the overall management of PNCIMA by considering ocean uses and the environment. This enables marine planning, management and decision-making to occur at appropriate spatial scales from regional to site-specific. It also promotes the consideration of the interactions among human activities, and between human activities and the ecosystem.

The plan presents an ecosystem-based management (EBM) framework that provides context and direction for management. It also contains a set of long-term, overarching goals for ecological integrity, human well-being, collaboration, integrated governance, and improved understanding of the area. These goals are supported by more specific objectives that express desired outcomes and conditions for PNCIMA. The goals and objectives provide the basis for defining management strategies and measuring progress on plan implementation. Above all, the ecosystem-based management framework seeks to ensure that relationships between ecosystem and human use objectives are recognized and reflected in future management decisions. Together, PNCIMA's EBM framework, information base and decision support tools contribute to the foundation for integrated oceans management in the area, and will support and enable integrated management within other planning, regulatory, decision-making and stewardship processes.

The development of the PNCIMA plan are been supported by a collaborative governance framework between federal, provincial, and First Nations governments. This proactive approach to governance was designed to support key principles of integrated management, including the recognition of existing authorities and jurisdictions of key parties as well as the need for enhanced communications and coordination between levels of

government. Maintaining an ongoing, adaptive governance arrangement will support successful implementation of the PNCIMA plan.

The PNCIMA plan has also been informed by extensive input and advice from marine stakeholders, scientists, and the general public. The PNCIMA Integrated Oceans Advisory Committee (IOAC), a multi-sector advisory body, was a central component of the planning process and was essential in facilitating ongoing engagement with stakeholders as the process evolved. The IOAC consisted of participants from industry, regional districts, recreational groups, environmental non-governmental organizations, and other interested parties.

The plan also provides an information base and a number of management tools that can be used by other parties to facilitate the application of EBM at a variety of scales in PNCMA.

- The PNCIMA plan identifies five priorities for near-term implementation, to address PNCIMA goals: governance arrangements for implementation
- Marine protected area network planning (will open in a new window/tab)
- Monitoring and adaptive management
- Integrated economic opportunities
- Tools to support plan implementation

Plan implementation is the shared responsibility of all signatories to the planning process. Implementation is expected to result in greater certainty and stability in oceans management in the region; better integration and coordination of new and existing management and planning processes; sustainable management of resources; and contributions to a national network of marine protected areas (Table 3.1).

Table 3.1 Atlas of the Pacific North Coast Integrated Management Area design

OBJECTIVE OF PROJECT	MODULES/DATA LAYERS
The Atlas of the Pacific North Coast Integrated Management Area (PNCIMA) is a reference document comprised of a large selection of maps and accompanying text relevant to the PNCIMA planning process The PNCIMA initiative's aim is to engage all interested and affected parties in the collaborative development and implementation of an integrated management plan to ensure a healthy, safe and prosperous ocean area.	**Communities** First Nation Communities; Regional Districts and Communities; Ports, Marinas and Small Craft Harbours; Population Figures
	Physical Oceanography Bathymetry; Undersea and Geographic Features; Sea Surface Currents
	Hydrology Watershed Boundaries and Major Drainages; Salmon Stream Escapement Observations
	Ecological Estuaries; Marine Protected Areas; Ecologically and Biologically Significant Areas; Distribution of Eelgrass and Kelp; Sponge and Coral Areas; Sea Otter and Pinniped Areas; Grey, Sperm and Humpback Whale Areas; Blue, Sei and Fin Whale Areas; Killer Whale Areas and Critical Habitat; Leatherback Turtle Areas; Important Bird Areas Herring and Eulachon Areas; Tanner Crab Areas; Manila Clam and Razor Clam Areas
	Commercial Fisheries Pacific Fishery Management Areas; Groundfish; Halibut; Sablefish; Salmon; Fishery Stock Assessment Areas; Sea Cucumber; Red and Green Sea Urchin; Geoduck; Crab; Shrimp; Prawn Fishery Effort
	Recreation And Tourism Fishing Lodges
	Aquaculture Finfish Aquaculture and Shellfish Aquaculture Tenures

OBJECTIVE OF PROJECT	MODULES/DATA LAYERS
	Energy Renewable Ocean Energy Potential: Tidal, Wave, Wind; Renewable Energy Sites: Tenures and Applications; Sedimentary Basins; Oil and Gas Exploratory Wells and Tenures
	Forestry Log Handling and Storage Tenures
	Mining Mining Sites
	Point Source Pollution Disposal at Sea Sites
	Marine Transportation Areas of Refuge for Vessels in Distress; Passenger Ferry Routes; All Vessel Traffic Density; Oil Tanker Vessel Traffic Density; Fishing Industry Vessel Traffic Density; Cruise Ship Traffic Density

3.2 SeaSketch

SeaSketch (http://www.seasketch.org) is a Marine Spatial Planning application that aims to provide ocean planners, stakeholders and the public with tools that are normally limited to GIS professionals, enabling participatory marine spatial planning processes that are closely tied to the relevant science and information. The software is designed to be easy to use, e.g. users can generate and evaluate a number of alternative scenarios from a range of perspectives in a map interface. SeaSketch also provides analytical feedback. Reports can be generated for metrics such as protected habitats, potential social or economic costs and benefits. The software can even include the results of advanced analyses such as Marxan and Cumulative Impacts.

SeaSketch is open source software, but users are expected to pay for customized interfaces to meet specific project's goals. The fee includes determining what level of technical support, training and custom development is needed. SeaSketch can be used to engage stakeholders face-to-face and online. Users can share their sketches, discuss their ideas, share views of maps, and post file uploads to discussion forums. Process facilitators organize discussion forums to encourage cross-interest discussion and collaboration, or limit some discussions to specific groups of users (Table 3.2).

Table 3.2 Application of the SeaSketch Platform

OBJECTIVE OF PROJECT	MODULES/DATA LAYERS
MaPP Marine Plan Portal – Marine Planning Partnership for the North Pacific Coast (British Columbia)	
MaPP is a sophisticated tool that allows users to look at sub-regional marine spatial plan zones and get information related to the planning process. The Portal can be used to: view the MaPP sub-regional marine spatial plan zones and get information on recommended uses and activities in each zone; view publicly available spatial data layers – ecological, social, cultural, economic and administrative; overlap spatial data layers with the MaPP sub-regional marine spatial plan zones to learn about the different values found in each zone; read descriptions of marine data and follow links to the data sources; and print high quality maps or save maps as images.	**Administrative areas** Boundaries; Conservation areas
	Information on the marine environment Ecosystem classification; Oceanography; Bathymetry Hydrology; Algae & plants; Fish; Birds; Reptiles; and Mammals
	Uses and activities Fisheries; Forestry; Aquaculture; Infrastructure; pollution; renewable energy; Mining, Oil and Gas; Public Recreation; Shipping & Transport
	Mapp Analyses Marxan High Priority Conservation Areas

Sea Change – Tai Timu Tai Pari (New Zeeland)	
A collaborative marine spatial planning process aimed at developing a plan to reverse the declining health of the Hauraki Gulf Marine Park and secure a productive and sustainable future. To ensure that the plan reflected the many interests and aspirations in the area a stakeholder working group consisting representatives of māori, environmental groups, the dairy and aquaculture industry, commercial and recreational fishing, and local communities, was tasked with developing the plan. The project was used to: make over a 100 layers of data publicly available; used it for crowd sourcing of information and as an engagement tool; used it in and outside meetings during the development stages of the project.	**Administrative Boundaries** Regional Council Boundaries; Territorial Boundaries; Conservation areas; Place names
	Existing Management Area based fish restrictions; Management Areas; Marine Protected Areas; Public Conservation Land; Ramsar Sites
	Marine environment Biodiversity; Goods & Services; Physical properties; contaminants
	Uses and Activities Aquaculture; Existing Consented Activities; Fishing; Heritage; Recreation & Tourism; Shipping and Navigation
	Land-use & Catchment Catchment Boundaries; Land-use Classification; Rivers; Threatened Environment Classification (Landcare)
	Engagement Activities Love Our Coast
Lesser Sunda Ecoregion SeaSketch project	
To create an opportunity for users to view spatial information to support marine planning activities in the ecoregion. Users of this project can: View available spatial information; read descriptions of the marine data and follow links for more information; print or save high quality maps, and use advanced functions including sketching and analytics, as they become available.	**Marine Spatial pattern** Sea lanes; Conservation areas; general Use Areas; National Strategic Areas; Other (land-use & settlement areas, Forest)
	Administrative Areas District Boundaries; Buffer Areas; Sea Administration
	Marine Environment Habitats (reefs, estuaries, mangroves, seagrass); Species (Birds, Fish, Reptiles); Deep sea features (atolls, canyons, seamounts)
	Environmental Threats Fishing; Mining; Farming; Mangrove cutting; Pollution/Waste Disposal; Sand mining
	Coastal Disaster Risk Flood prone areas; Volcanoes; Tsunami prone; Landslide Vulnerable; Earthquake history
	Ecosystem Services Carbon; Fisheries; Natural Coastal protection; Climate; Recreation and Tourism

3.3 Marine Scotland

Marine Scotland Information is a web portal that provides access to descriptions and information about the Scottish marine environment while providing links to datasets and map resources that are made available by Marine Scotland and Partners (https://marinescotland.atkinsgeospatial.com/nmpi/#). On the portal, content is grouped into 3 types, and users can use the tabs to explore the content (Table 3.2):

- Information: Text and background, organised into themes that are aligned with the Scottish Government vision for managing their marine environment.
- Maps: Spatial data presented as interactive or downloadable map sources.
- Data: Datasets, statistics, downloadable documents, and links to other websites.

Marine Scotland's on-line, interactive mapping system makes spatial data available to marine stakeholders in an easily accessible form to assist with the implementation of marine planning. The creation of the Scottish National Marine Plan involved a wide range of supporting documents and information. The purpose of the portal is to provide one web area where users can find all of the documents mentioned in the Plan, as well as supporting information. This web portal brings together datasets and maps from government data sources to provide context and information on these resources (Table 3.3).

Table 3.3 Marine Scotland Maps NMPI Platform design

OBJECTIVE OF PROJECT	MODULES/DATA LAYERS
This interactive mapping tool assists in the development and implementation of Scotland's National Marine Plan by Marine Scotland. Additional data are regularly added to the system over time.	**Overall Assessment** Scotland's Marine Atlas (Clean and Safe Seas; Healthy and Biologically diverse habitats/species; Productive Seas Assessment)
	Physical Characteristics Waves and Sea level; Ocean Climate; Seabed Geology, predicted Seabed habitats; Coastal Physiographic features; Annual cycles of physical, chemical and Biological Parameters; Countries of Europe
	Clean and Safe Hazardous Substance; Biological Effects; Oil spill Contingency, Casualties and Search & Rescue; Microbiological Contamination; Biotoxin Monitoring; Eutrophication; Low impact land Claim (dissolved oxygen); Ait Quality Management Areas
	Healthy and Biologically Diverse Protected Areas, Intertidal Rock/Sediments; Subtidal Rock; Inshore and Shelf Subtidal Sediments; Deep Sea Habitats; Sand Dunes and Salt Marshes; Plankton; Commercial Fish and Shellfish Stocks; Large Scale Features of functional significance; Demersal Fish Community; Sharks and Rays; Seals; cetaceans; Seabirds; Water Birds; Scottish marine Animal Standings; Non-native species
	Productive Economic Analysis; Aquaculture; Seaweed; Fishing; Leisure and Recreation; Historic Environment and Cultural heritage; Coastal Protection and Flood Defence; Carbon Capture and Storage; Oil, Gas, Pipelines and Storage; Water Abstraction; Maritime Transport; Waste Disposal Dredge Spoil/Wastewater; Defence; Telecommunications; Marine Management
	Climate Change Carbon Budgets and potential Blue Carbon; Climate projections; Intertidal climate change indicators
	Administrative Human Population, Limits and boundaries; Marine Scotland Seabed data; Fishing grounds

3.4 Common elements/themes in international Spatial Planning Platforms

The following elements or themes were common to most of the Spatial Planning platforms reviewed as part of this study

- Administrative boundaries were seen as critical to the process.
- As much as possible Biophysical information regarding the environment was collated, sorted and grouped to inform decision-makers and planners on critical processes and resources.
- Conservation requirements or targets were explicitly displayed
- Existing uses such as Fishing, Recreational use, Disposal of waste/pollution, Aquaculture were either grouped or displayed with sub categories.
- Ecosystem services such as Nursery and spawning grounds, Harvesting of mangroves and Coastal protection were included in most platforms to show the benefits society derive from the natural environment.
- Many of the planning platforms include information on Climate Change.
- More complex analysis tools, e.g. Marxan, was run offline and then reduced to layers that can be used for scenario planning
- Language was kept simple and relative self-explanatory to enable non-GIS to interface with ease.

4. APPROACH AND METHOD FOR DEVELOPMENT OF SPATIAL PLANNING PLATFORM

4.1 Selection of Software

The Spatial Planning Platform should allow for the access and view of multiple users/decision makers with spatial skills ranging from advanced to no skills. The platform needs to be compatible across multiple software platforms (e.g. Google Earth, QGIS) and support the visualization of the outputs. The platform also needed to ensure data fidelity (deal with both historical and present data sets) and allow for continuous updates. The following range of software options were evaluated (Table 4.1):

- **Geographic Information System (GIS) (ArcGIS Pro):** ArcGIS software (Environmental System Research Institute [ESRI] Pty Ltd) is spatial explicit software developed for working with maps and geographic information. It is used for: creating and using maps; compiling geographic data; analysing mapped information; sharing and discovering geographic information; using maps and geographic information in a range of applications; and managing geographic information in a database. The system provides an infrastructure for making maps and geographic information available throughout an organization, across a community, and openly on the Web through its Web Map Application (WMA). ArcGIS provides a smart, intuitive online framework for looking at and interacting with maps. It is a configurable web application that allows you to easily build your own custom mapping application in just a few minutes, with no programming required. The open source software Quantum GIS (QGIS) and its associated web application, Leaf, provide similar capabilities.

- **Conservation planning software (Marxan):** The software is designed to support systematic protected areas design on conservation planning. With the use of stochastic optimisation routines (Simulated Annealing) the software generates spatial explicit best selection of areas that achieve particular biodiversity representation goals with reasonable optimality. The simulated annealing algorithm attempts to minimise the total cost of the reserve system, while achieving a set of conservation goals (typically that a certain percentage of each geographical/biological feature is represented by the reserve system).

- **Google Earth:** Google Earth is a virtual globe, map and geographical information program. It maps the Earth by the superimposition of images obtained from satellite imagery, aerial photography and GIS onto a 3D globe. The product is available for use on personal computers and as a browser plugin and for mobile viewers. Google also added the imagery from the Earth database to their web-based mapping software, Google Maps. Google Earth displays satellite images of varying resolution of the Earth's surface, the degree of resolution available is based somewhat on the points of interest and popularity, but most land is covered in at least 15 meters of resolution. Google Earth allows users to search for places by name, enter coordinates, or simply use the mouse to browse to a location. Some people use the applications to add their own data, making them available through various sources, such as the Bulletin Board Systems (BBS) or blogs mentioned in the link section below. Google Earth is able to show various kinds of images overlaid on the surface of the earth and is also a Web Map Service client.

- **Spreadsheets (Microsoft Excel):** Excel is a spreadsheet developed by Microsoft for Windows, Mac OS X, Android and iOS. A spreadsheet is an interactive computer application for organization, analysis and storage of data in tabular form. Spreadsheets are developed as computerized simulations of paper accounting worksheets. The program operates on data entered in cells of a table. Each cell may contain either numeric or text data, or the results of formulas that automatically calculate and display a value based on the contents of other cells. Excel features calculation, graphing tools, pivot tables, and a macro

programming language called Visual Basic for Applications. It has been a very widely applied spreadsheet for these platforms, especially since version 5 in 1993, and it has replaced Lotus 1-2-3 as the industry standard for spreadsheets. While not spatially explicit in the same way that GIS tools are it can be configured to show x-y location information (point data).

Table 4.1 Evaluation of software tools that can be used in spatial resource allocation processes

CRITERIA	ARCGIS WMA	QGIS WMA	GOOGLE EARTH	MARXAN	EXCEL
Ease of use	✓	✓	✓	✗	✓
Spatial visualization capabilities	✓	✓	✓	✓	✗
Share data easily	✓	✓	✓	✗	✓
Do not require an informed user (once configured)	✓	✓	✓	✗	✗
Not proprietary software (once configured)	✓	✓	✓	✓	✗
Easily share data across platforms	✓	✓	✓	✗	✗
Control access/sharing rights	✓	✓	✗	✗	✗
Simple data analyses	✓	✓	✗	✓	✓
Data fidelity (e.g. errors resulting from different data sources/projection systems)	✓	✗	✗	✗	✗

Overall GIS software allows for the most effective storage and relationships within fields or between feature classes in geodatabases. Although QGIS also enables subtypes through a PostSQL server, it is less easy to implement compared to the ArcGIS subtypes. Both ArcGIS and QGIS enables topological clean capturing of polygon data through the autocomplete polygon tool, however QGIS has shown some instability in topological clean shapefiles when working across large regions. For this purpose the team selected ArcGIS above the open source software, for the consolidation of various data sets into a central geodatabase, and data capturing of the estuarine and coastal ecosystems.

The Estuary Spatial Planning Platform was therefore developed using a geodatabase and spatial software, e.g. ArcGIS Geodatabase and ArcGIS Pro.

4.1.1 ArcGIS geodatabase

An ArcGIS file geodatabase (.gdb) is a way to store GIS information containing multiple feature data sets or rasters, storing up to 256 TB in a local database. It enables the storing of a relational database with a set of geographic datasets or an existing database structure, such as MS Access or SQL. Shapefiles in a geodatabase are referred to as feature classes. Feature classes are managed in feature data sets (FDS), which allows one to set a preferred projection and holds this fidelity over all feature classes added to the geodatabase. Subtypes and domains can also be used in a feature data class to ensure consistency between classes and avoid typing errors by data capturers. This is ideal when gathering GIS data from many different sources which might use different projection forcing your feature classes to use the appropriate projection. Geodatabase works with numerous GIS data sources and holds them as either a series of tables with feature classes, raster datasets and attributes. Spatial relationships of core features, rasters and attributes can be made within geodatabases. Topology rules can be assessed and apply within a FDS for individual feature classes (horizontal topology) or between feature classes (vertical topology). The geodatabase allows for the capture of metadata documentation (e.g. authors, date captures, summary, data sources) and ensures that it is embedded in the description of data layers.

File storage in geodatabases is more efficient and often takes up less disk space compared to shape files. The collection of data will therefore be stored in an ArcGIS file geodatabase and not individual shapefiles. The geodatabase can easily be opened in QGIS software for viewing at a desktop level.

4.1.2 ArcGIS Pro – Enabling viewing access to resource planners

ArcGIS Pro is an online addition to the ArcGIS suite of desktop applications which allows you to render and process spatial data easier and faster. It allows you to create and work with multiple displays and layouts, and publish finished web maps directly to ArcGIS Online or a portal for ArcGIS or Uniform Resource Locator (URL), connecting you to users within and across your organisation and globally.

It has multiple feature providing smooth map displaying, visualisation and analysis. It has a built-in connection to the ArcGIS platform allowing you immediate access to a vast database of relevant online maps and data sources, such as freely available South Africa satellite imagery. This ability makes collaboration with others easier through sharing your final work via maps, 3D scenes, web services and focused apps.

ArcGIS Pro is not replacing ArcMap, on the contrary, it works well with ArcMap, allowing you to do heavy applications through the desktop software and share and connect your work with people anywhere in the world.

ArcGIS Pro allows you to work through projects which houses all your resources such as maps, layouts, layers, tables, tasks, tools and connects to servers, databases, folders and styles. You can visualize your data as maps or scenes. You can create and store as many maps as you need in the same project. Editing allows you to create, update and maintain geospatial information that are stored and organized in layers. You can create new features in a layer and assess their attributes to define characteristics, and update existing features to reflect their current condition based on newly acquired data or information.

Spatial analysis and the management of GIS data can be done through a suite of tools provided via geoprocessing application. Your geoprocessing and spatial analysis history of your project can be viewed so that you can easily run tools previously run in the project with the same or modified settings. Geoprocessing history is a key feature for sharing geoprocessing tools, as you can share any tool that has been run successfully.

One of the key features of ArcGIS Pro is being able to share your work online, i.e. Web Feature Services (WFS). You can either share your entire project, or map layers and other components of your work. You can share your project as web maps, which can be reused in ArcGIS Pro as well as other ArcGIS applications, and can be viewed in browsers or mobile devices.

A Web Map Applications (WMA) is an interactive display of geographic information. Maps contain a basemap, a set of data layers (which include interactive pop-up windows with information about the data, a scale and navigations tools. These maps can be opened and viewed in web browsers, mobile devices and desktop map viewers. They are shared through links, websites and used to create map-based web apps. When the map is shared the author decides what to include in and with the map. For example, a map shared to the general public can include options to change basemaps, view a legend, view details about the map, share, print, measure, and find locations on the map. ArcGIS users can sign in and may access additional options such as, adding layers, performing analysis and getting directions. Maps embedded in websites and shared through apps often contain a focused set of tools for a specific purpose. You can create a web app map through the Web AppBuilder for ArcGIS which offers various functionality to configure and display the web map. ArcGIS readily allows you to convert shape files to KMZ or KML files which are input data layers for Google Earth users.

An overall advantage of sharing and accessing data online is that it is less costly and time consuming than via disks. An online data source ensures that data is readily available, enables version control more effectively. This also allow for easy update of existing data which would allow the planning platform to stay relevant.

4.2 Primary sources of spatial data and information included in the Platform

4.2.1 Existing point or polygon spatial data

Relevant available estuary spatial information was collated from a range of sources. Spatial data was either in point form (X-Y location) or in polygon form. Examples of existing point data sets include estuary names and location of Blue Flag Beaches. Examples of existing polygon data are the boundaries of the Municipalities, Provinces and Water Management Areas; and Priority Estuaries identified in the National Estuary Biodiversity Plan.

Where possible data was sourced form government departments mandated to plan and manage estuary resources, e.g. DEA Coastal viewer, SANBI BGIS, DWS website.

4.2.2 Existing Estuary Data and Assessment were spatially enabled

Very little estuary specific data were available in a spatial format. To overcome this limitation non-spatial data and estuary assessment were spatially enabled by linking data/information to either the estuary point data sets or the polygons of the Estuary Functional Zone. Examples of such data sets include the Present Ecological State (Estuary condition) as expressed in terms of the DWS A-F scale (A: Natural, F: Extremely degraded); and Estuarine Importance derived from a national estuary rating (Turpie and Clark 2007; Turpie et al. 2002) indicating High importance to Low/Average importance.

4.2.3 New data generated as part of this study

Some data sets were generated as part of this study. For example, “Conflict layers” were generated for each sector to highlight estuaries in which potential conflict exist between uses. A conflict rating scale (“High”, “Medium”,” Low”) with criteria were develop to guide users in prioritising systems that require interventions or trade-offs. Other examples include the development of a spatial layer to indicate estuaries “suitable” for Marine Aquaculture or “Resilient” to fishing effort based on their physical features.

4.3 Visualisation Techniques

4.3.1 Colour schemes

Colour schemes (also called colour palettes or colour ramps) were used to depict information consistently across the Spatial Planning Platform. The “robot” colours were used where possible to intuitively communicate a positive or negative outcome, e.g. “green” was used to indicate a “Low” pressure, while “red” was used to indicate a “High” pressure (Figure 4.11).

Similarly a colour scheme was developed to indicate estuaries in a good condition through shades of “blue”, in contrast with those in a poor condition indicated by shades of “brown” or “red”. Where a use was depicted as an amount/volume shades of the same colour with increasing intensity were used to indicate levels of use.

Figure 4.1 Using greens and reds/browns to intuitively communicate a positive or negative outcome, e.g. "green" was used to indicate a "Low" pressure, while "red" was used to indicate a "High" pressure

4.3.2 Symbology

A range of symbols and icons was used to distinguish between different types of uses. For example, the pressure rating layer was represented by "circles" while the conflict layers were depicted as "triangles" to distinguish between different types of data sets (Figure 4.22). Where possible a symbol was only used once in a sector to allow for the overlaying of data sets.

To allow for the display of data at a range of scales, layers that related to resource health (e.g. overall estuary health, fish health) were shaded according to their condition rating (A-F) and depicted as a coloured circle or a shaded EFZ polygon. When interrogating the platform at the national level a shaded "circle" is more visible than the EFZ polygon, while at the municipal scale it may be very relevant to see the size and shape of individual systems in relation to their neighbours.

Figure 4.2 A range of symbols and icons was used to distinguish between different types of uses, e.g. the conflict layers were depicted as "triangles" to distinguish between different types of data sets

4.3.3 Scaling symbols by size

Where a use (e.g. flow modification, fishing effort, wastewater discharge) was depicted as an amount/volume "circles" increasing in size were used to show increasing intensity in used, i.e. a small discharge volume would be associated with a small "circle" in contrast with a high discharge volume symbolised by a large "circle" (Figure 4.33).

Figure 4.3 "Circles" increasing in size were used to show increasing intensity in use

4.3.4 Scaling layers

Estuaries are relative small features in the landscape. For example, on the national and provincial scale the EFZ of most medium to small systems "disappear" from view. Therefore most data sets were converted to point data (x-y data) that is visible at all scales of assessment. However, critical to the understanding of the data/information, as is the case for Estuary Health, both a point (x-y data sets) and a polygon layer were produced. These "dual" layers were then set to interchangeably "appear" depending on the scale at which the features are being viewed at, i.e. Estuary Health polygons are only visible at the municipal scale.

4.4 Consultation process followed in the development of the Platform

During the design of the Estuary Spatial Planning Platform extensive consultation was held with a range of stakeholders to assist with the design, layout and future usefulness of the platform.

Formal and informal discussions were held at the **Western Cape Estuaries Task Team** (Chaired by the Western Cape Government and CapeNature) meetings on the layout, future use and important information requirements envisaged for the Spatial Planning Platform. Requirements identified during these meetings include the need for detailed information on estuarine pressures, estuary health, and fish health. Estuary conservation is a key concern and the project team was asked to collate as much information as possible on this aspect.

A presentation was made at the **Biodiversity Planning Forum (2016)** to generate awareness of the Platform and have discussions around linking the outcomes of this project to the National Biodiversity Assessment. Representatives from national (e.g. DEA) and provincial government (e.g. KZN Wildlife) made recommendations

on data visualization and data availability. The project team was warned of data overload and the need to structure the layout in such a manner that information is layered.

National Estuary Management Task Group of Mintech Working Group 8 (for the Implementation of the National Estuarine Management protocol) were consulted for additional input as they represent the target audience, i.e. all key national, provincial and local authorities involved in estuarine resource planning and management serve on the Task Group. Key issues raised at the meeting was that the platform had to be user friendly as a large number of the estuary resource managers were not GIS literate. However, DEA stressed at the onset that all spatial data generated as part of this project must meet the relevant standards, e.g. correct projection systems. Discussions were also had around how to link the Spatial Planning Platform to the Estuary Management Planning processes; the DWS Ecological Water Requirement and Classification processes; and the National Estuaries Biodiversity Plan and the need to include relevant information in the Platform.

WRC Steering Committee provided guidance on the overall requirements such as keeping the software products user friendly and non-technical to ensure ease of use. They also identified the need for non-proprietor software to view the interface. The steering committee assisted in highlighting sectors that needed to be included in the Platform such as flow modification, pollution, fisheries, marine aquaculture, and coastal development. The Steering Committee also highlighted the need for additional research on catchment water quality, conflict between users, the inherent resilience of estuaries to certain pressures, and micro-estuaries.

DAFF and **Cape Nature** were consulted on aspects of fisheries management that lends itself for inclusion in the Platform. It was highlighted that the estimated catch data needs to be included and documented how it was updated as the original data set is more than 10 years old. The importance of the nursery layer was stressed.

A **Pilot testing workshop** was held with **representatives of the Western Cape Government**. The Western Cape was targeted as the region had active Water Resource Classification project in progress, was systematically rolling out Estuary Management Plans to all estuaries in the province, and the national governments department tasked with estuarine resource management reside in Cape Town. During the workshop additional recommendations were made regarding refinements to the Platform. Detailed feedback was given on the appropriateness of sector groupings, data visualisation and the information embedded in the Platform. Data gaps such as the inclusion of public land and erf numbers were recommended, making the platform more useful for Estuarine Managers. More information was requested on key data sources (especially estuary health state). It was also stressed that an information section needs to be added that provides more detail on aspects such as the “Conflict layers”. The need for additional sector modules on “Mining” and “Climate change” was raised at the workshop, but due to resource constraints not further addressed as part of this study.

5. DESIGN OF ESTUARINE SPATIAL PLANNING PLATFORM

5.1 Why a Modular approach?

In South Africa estuary resources and activities are managed in sectors, with each sector having a "different set of lenses" of how they view or approach resource management in their domain. For example, the sectors may have sector-specific terminology (e.g. fish stock vs fish biomass) or be only interested in one component of a complex result (e.g. fish health vs overall estuary health).

Therefore, for the Platform to be useful to resource managers, it was important to present users with information in a manner that would be relevant to their sector and targeted at their needs. This gave rise to the need for the Platform to have "Sector Modules" that would layer information in appropriate batches and prevent information overload.

See Estuary Spatial Planning Platform weblink for dynamic interface: https://csir.maps.arcgis.com/apps/MapSeries/index.html?appid=a58ab2075a954549b9b1f8b5e063380e

5.2 Module Selection and Layout Design

5.2.1 General information

Two general information modules were developed to assist with an overview of:

- Administrative Information; and
- Estuary Information.

Estuaries are governed by a range of authorities across three spheres of government, e.g. provincial authority; district and local municipality. This information is presented as "**Administrative Information"** to assist resource managers with identifying shared responsibilities. Critical to any decision relating to estuaries are their key features, current ecological condition (also called Present Ecological State), ecological importance, and an indication of the key pressure influencing the condition of a specific system. This information was captured in an **"Estuary Information"** module.

5.2.2 Sector modules

From a review of key legislation, international approaches; interactions with resource managers; and data availability the following sectors were targeted for the development of modules (Figure 5.1):

- Conservation:
- Fisheries;
- Wastewater management;
- Flow modification;

- Recreational use;
- Marine Aquaculture; and
- Coastal development.

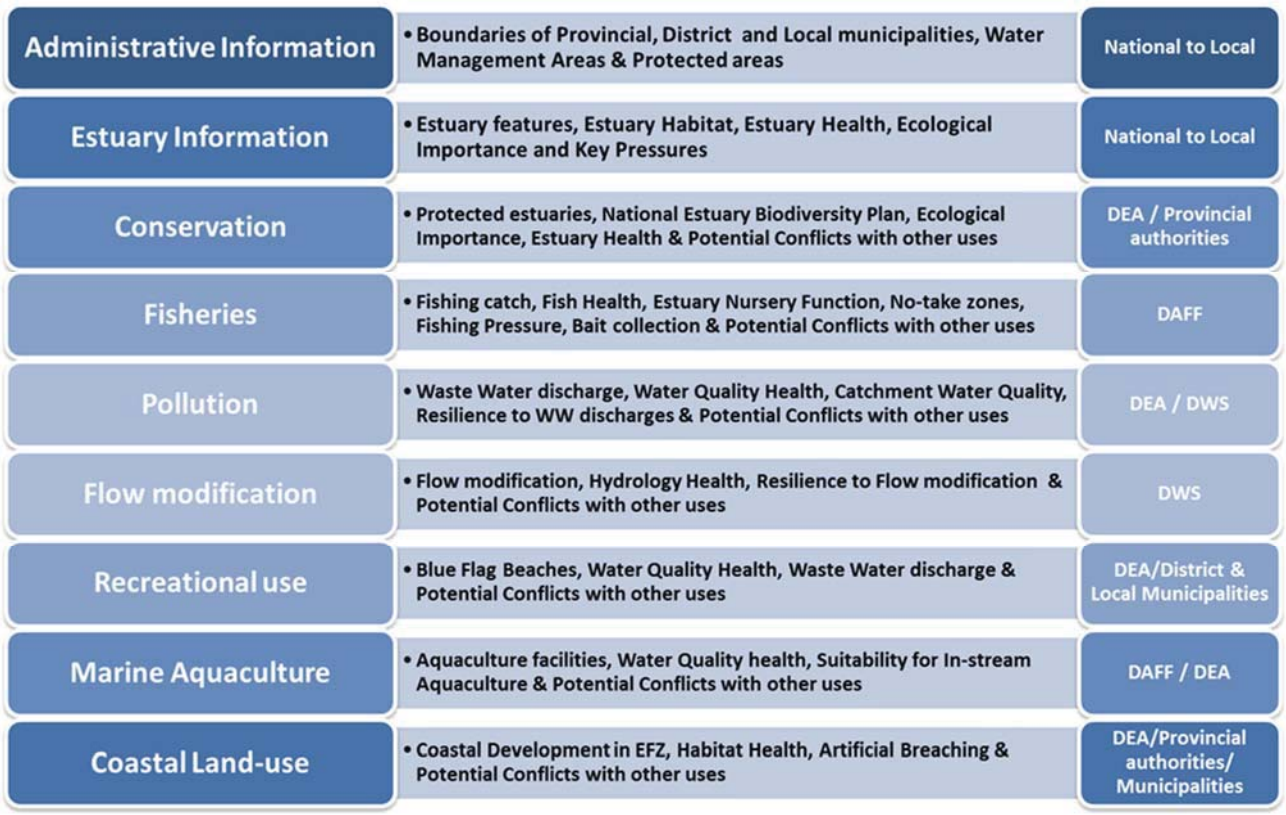


Figure 5.1 The Estuarine Spatial Planning Platform modules, target audience and examples of information layers incorporated in each module

Information on various sectors provides insight on resource allocation, resource condition, the degree of pressure on the resource, as well as potential conflict among the various competing sectors using a particular estuary. The sector modules aim to answer the following key question were possible:

- *How is the resource being used from this sector perspective?*
- *What is the state (health) of the "resource" being managed by this sector?*
- *Importance of the resource (ecosystem services);*
- *Are the individual estuaries suitable for this form of resource utilisation? AND/OR Are the individual estuaries in its natural state resilient to this form of resource utilisation?*
- *Is their potential conflict between users?*

Detailed information was collated per system on the overall sector use where possible. Examples of resource use include: Wastewater discharge volumes, flow reduction/elevation, estimates of the tonnes of fish exploited from each estuary. Where no information was available the presence or absence of an activity was used as a proxy.

Health of the resource was derived from the Estuary Health Index as applied in DWS Ecological Water Requirement or Classification studies. The Present Ecological State (Estuary condition) is expressed in terms of the A-F scale (A: Natural, F: Extremely degraded). It must be emphasised that the A to F scale represents a continuum, and that the

boundaries between categories are conceptual points along the continuum. There may therefore be cases where there is uncertainty as to which category a particular estuary belongs, potentially having components that have membership in two categories. To reflect this, straddling categories (±3 from the category scoring range) were therefore introduced, denoted by A/B, B/C, C/D, and so on in the overall Estuary Health Categories. Data were collated from the latest DWS Classification studies, DWS Ecological Water Requirement studies; and Desktop Estuary Health Assessments, with higher confidence studies taking precedent over lower confidence historical studies.

Where information was available the importance of the resource was incorporated into the sector modules. As part of this project additional effort were made to refine/develop Ecosystem Service Importance rating layers for Estuary Nursery layer and Estuary Habitat.

Where possible the suitability and/or natural state resilience to a specific form of resource utilisation were highlighted. These ratings were derived for the individual systems physical features, e.g. size, flows, degree of connectivity to the sea.

Potential conflict with other sectors was identified and rated “High”, “Medium” or “Low”. The conflict layers were derived from the sensitivity of the resource to use and the degree to which this is already a pressure on the system. A “High” or “Medium” rating indicates potentially conflicting uses that should be addressed by managed interventions. The rating does not imply that no management actions are currently being implemented, but it does emphasis the need for multi-sector co-ordination of resource utilisation.

The detailed spatial data and information captured in each module is described in Appendix A and B.

5.3 Multi-sector Module

However, multi-sector use requires that resource managers be able to interrogate data sets and information across sectors. To accommodate this need the modules were combined into the **"Multi-sector Module".** The Tool, for example, can be used to intersect information layers of different sectors to identify conflict or potential conflict, as may be required in strategic resource planning in Estuary Management Planning, Water Resource Classification, Protected Areas Expansion Planning and Fisheries allocations.

To avert information overload, the data sets of each sector module were grouped, which allows users to only interrogate overlapping sectors data sets of interest, without the overwhelming “clutter” the other sector information presents.

6. APPLICATION OF THE SPATIAL PLANNING PLATFORM

The Estuarine Spatial Planning Platform can be applied in a number of ways including:

- Spatial visualisation of the data and information;
- Identifying potential conflicts and gleaming the potential sources of the conflict;
- Conduct rudimentary analyse of spatial information and data.

6.1 Spatial Visualisation of Data and Information

Foremost, the Platform was developed to enable the display of estuary sector relevant information spatially (Figures 6.1 and 6.3). This, in turn, allows the user to intuitively grasp aspects such as the distance to the next estuary/along the coast; or the size of the estuary/ies being evaluated.

The Platform also allows users to interrogate individual datasets relevant to a sector, without the need to migrate across different types of media, e.g. GIS displays, reports, web sites. Where relevant, more detail is displayed as attribute field linked to the data set.

KEY QUESTION:	***How much does the boundaries of a Province and a Water Managed Area overlap?*** ***How many/which estuaries fall within a Water Management Area/province/municipal boundary?***	
MODULE/SECTOR:	*Administrative*	*Administrative*
LAYER:	*Water Management Area*	*Artificial breaching*

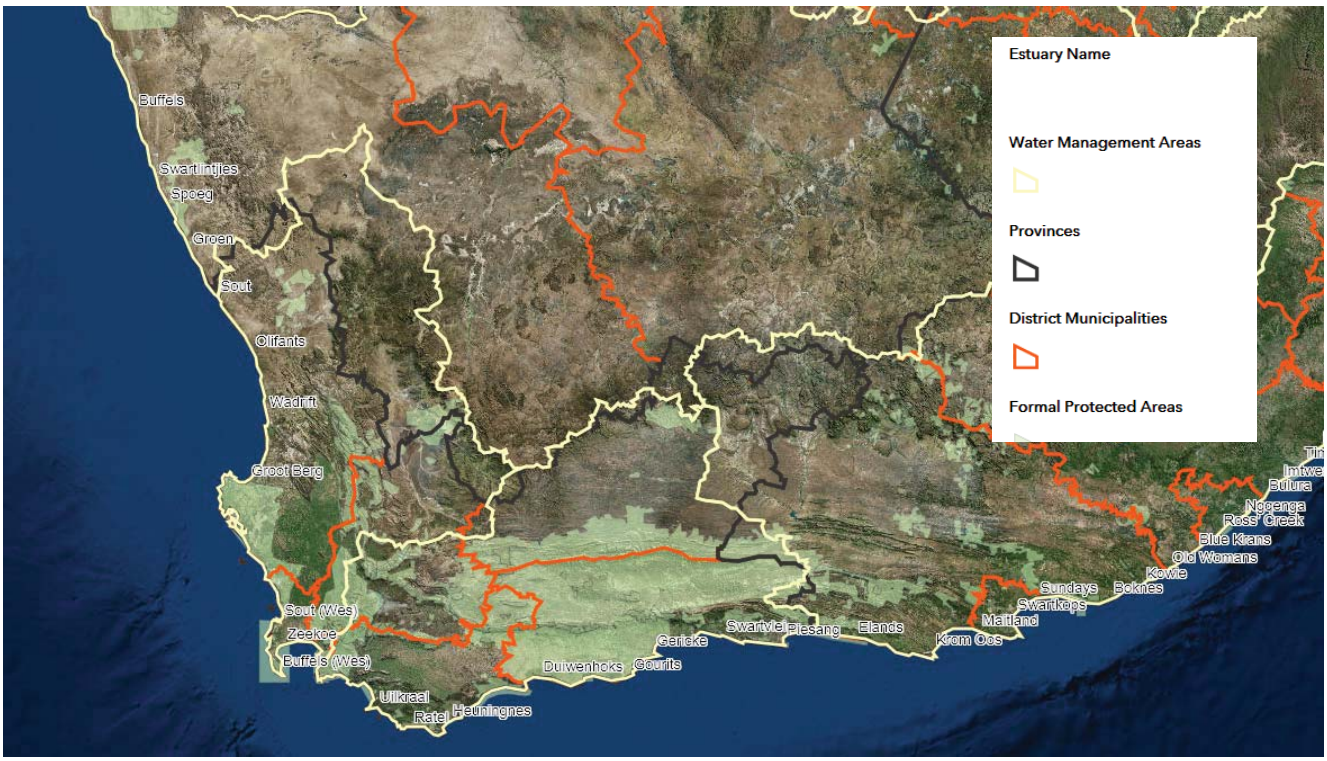


Figure 6.1 Example of managed boundaries showing the provincial and municipal boundaries and overlap with protected areas

KEY QUESTION:	Where and how much wastewater is being discharged in South Africa's estuaries and what is the Estuary Water Quality Health of those estuaries?	
MODULE:	Pollution	Pollution
LAYER:	Wastewater discharge	Estuary Water Quality Health

Figure 6.2 Displaying simultaneously Wastewater Treatment Works discharge volumes and Estuary Water Quality Health

KEY QUESTION:	What type of land-use is occurring in and around estuaries that are being breached artificially?	
MODULE/SECTOR:	Coastal land-use	Coastal land-use
LAYER:	Extent of Coastal land-use	Artificial breaching

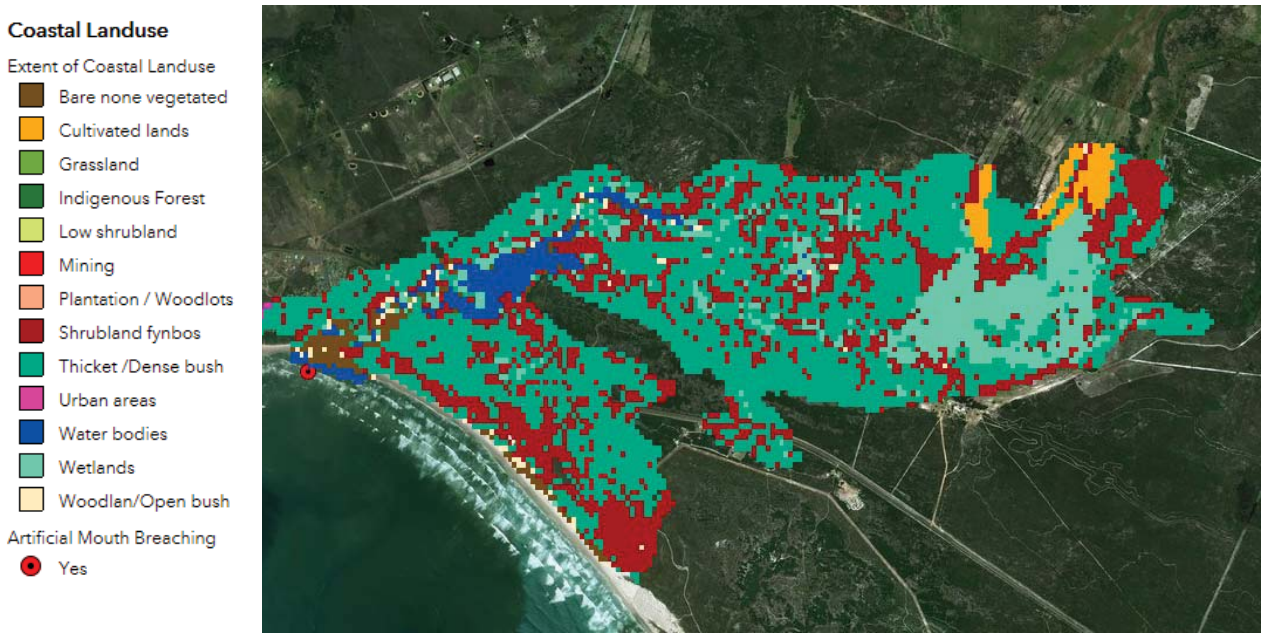


Figure 6.3 Example of Coastal land-use in relation to artificial breaching

6.2 Conflict Identification

In its simplest application, potential conflicts can be identified through the display of more than one layer at a time. The overlay of different data sets in a sector provides the user with an oversight of important sector relevant information and potential conflicts (See Figure 6.4 to 6.6).

KEY QUESTION:	***Where is there conflict between existing Marine Aquaculture and Estuary Water quality health?***	
MODULE/SECTOR:	*Marine Aquaculture*	*Marine Aquaculture*
LAYER:	*Aquaculture*	*Estuary Water Quality*

Figure 6.4 Conflict between existing Marine Aquaculture and Estuary Water Quality Health

KEY QUESTION:	***Where is there conflict between Recreation at Blue Flag Beaches and Estuary Water Quality Health?***	
MODULE/SECTOR:	*Recreation*	*Recreation*
LAYER:	*Blue Flag Beaches*	*Estuary Water Quality*

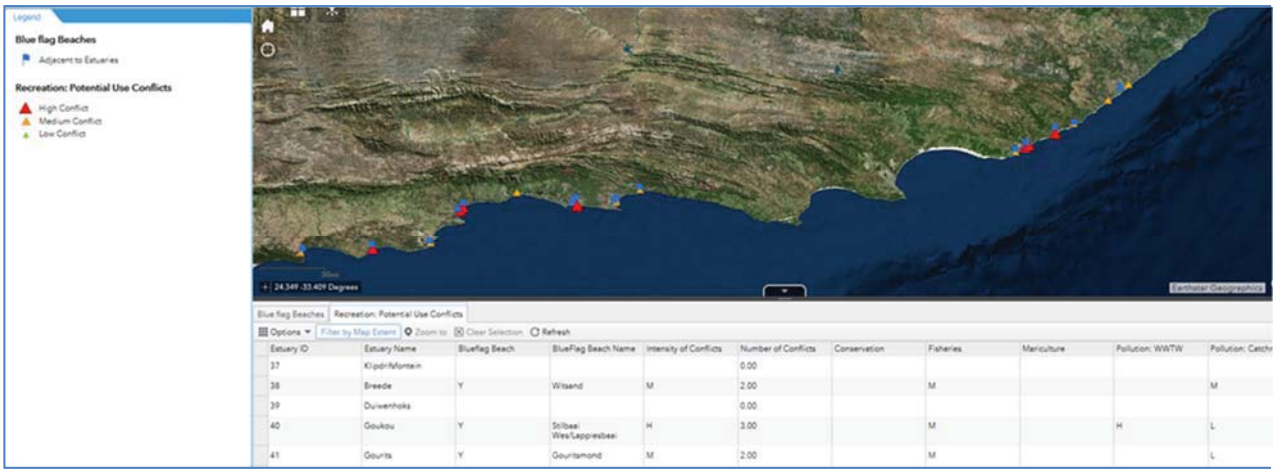
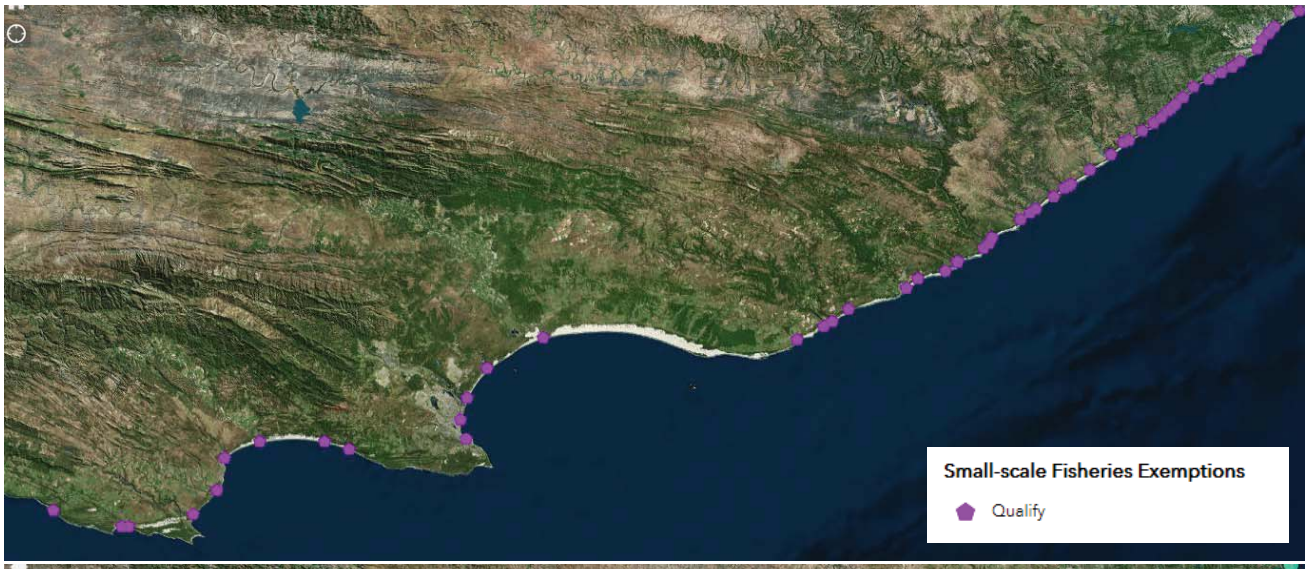


Figure 6.5 Conflict between Recreation at Blue Flag Beaches and Estuary Water Quality Health

KEY QUESTION:	Where is there conflict in between the small-scale fisheries exceptions, nursery function and the natural resilience of individual estuaries to fishing?		
MODULE/SECTOR:	Fishing	Fishing	Fishing
LAYER:	Small-scale fisheries exceptions	Nursery function	Resilience to fishing



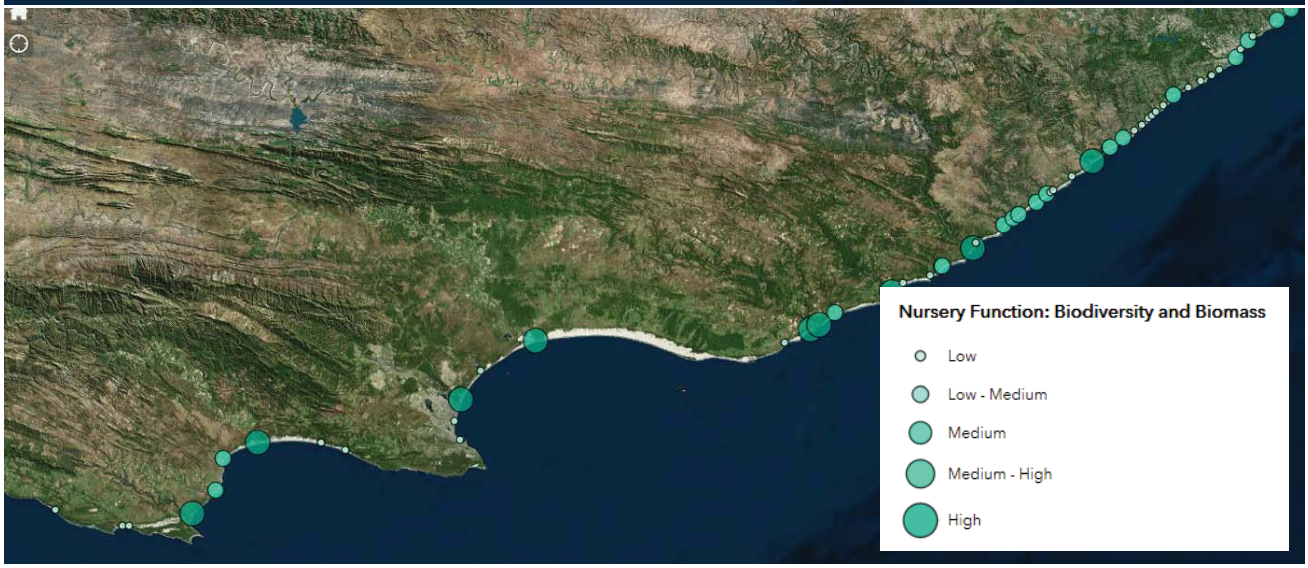


Figure 6.6 Example of conflict in between the small-scale fisheries exceptions, nursery function and the natural resilience of individual estuaries to fishing

In addition, ”Conflict” layers were developed that provide a more integrative view on potential conflicts between resource users from a sector perspective, e.g. the potential conflict between “Fishing” and “Flow modification” or “Pollution”. Each “Conflict” layer has an attribute table that provides more detail on the source of the potential conflicts.

Potential conflict with other sectors was identified and rated (high/medium/low). A “High” or “Medium” rating indicates potentially conflicting uses that should be addressed by managed interventions such as: development of an integrative sector resource plan; Zonation; and the development of Estuary Management Plans (Table 6.1).

Table 6.1 Examples of management interventions to mitigate conflicts

SECTOR	EXAMPLES OF MANAGED INTERVENTIONS
Conservation	Zonation; controlled access; and the development of Protected Areas; and Development of Estuary Management Plans
Fisheries	No-take zonation; controlled access; gear restrictions; closed periods/ban on night fishing; Development of Estuary Management Plans
Wastewater management	Signage indicating human health risk; regular monitoring of the water quality; reduction of waste input through reuse/recycling of wastewater; Development of Estuary Management Plans.
Flow modification	DWS Classification/Ecological Water Requirement studies; Development of Estuary Management Plans. It is important to note that a reduction in freshwater input would require a concomitant reduction in fishing and pollution pressure to ensure future suitability of the resource.
Recreational use	Signage indicating human health risk; regular monitoring of water quality; zonation of activities such as boating and fishing; Development of Estuary Management Plans
Marine Aquaculture	Reduction in waste input; Development of Estuary Management Plans
Coastal Land-use and development	Determining flood lines; development of setback lines; zonation of activities; reduction in waste input; Development of Estuary Management Plans

6.3 Spatial Analyses

The **Multi-sector Module** (i.e. the module where all the sector layers are combined) can be used to intersect information layers of different sectors to identify conflicts or potential conflicts between sectors, as may be required in strategic resource planning in Estuary Management Planning, Water Resource Classification, Protected Areas Expansion Planning and Fisheries allocations.

Answers to some key questions can be derived by selecting the relevant sector modules (e.g. conservation, fishing, pollution and marine aquaculture) and activating the uses/pressures/conflicts of concern. Examples of some of the key questions that can be answered through the Multi-sector Module are listed below in Figures 6.7 and 6.8.

KEY QUESTION:	*Where and how much Waste-Water is being discharged in Priority estuaries targeted for formal protection?*	
Module/sector:	*Pollution*	*Conservation*
Layer:	*Wastewater discharge*	*National Estuaries Biodiversity Plan*

Figure 6.7 Multi-sector Module: Potential conflict between conservation areas and wastewater discharges

KEY QUESTION:	*Where are potential conflicts between the National Estuaries Biodiversity Plan and other users that need to be resolved?*	
Module:	*Conservation*	*Conservation*
Layer:	*National Estuaries Biodiversity Plan*	*Conservation: Potential use conflict layer*

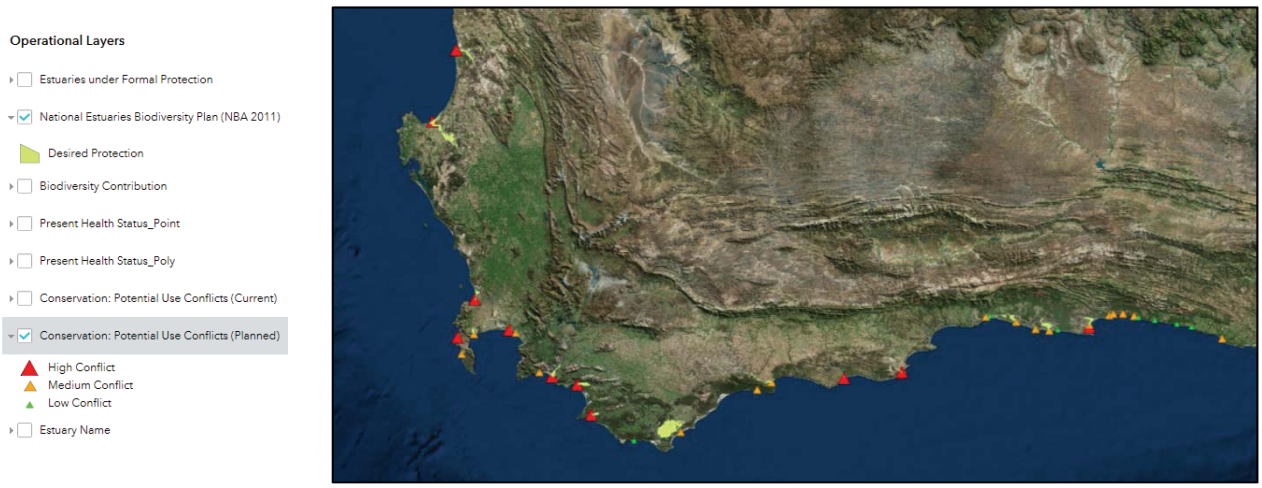


Figure 6.8 Multi-sector Module: Priority estuaries targeted for Conservation and potential conflicts with other users that needs to be considered in the planning process

All spatial information collated or generated as part of this study will also be made available for detailed in-depth analysis by sophisticated GIS users. Users are referred to Appendix A for a list of data sources and acknowledgements.

7. PROPOSED GOVERNING SYSTEM FOR STRATEGIC ESTUARINE RESOURCE PLANNING

Strategic estuarine resource planning and management should be undertaken within a framework that emphasises the principles of sustainable development, biodiversity conservation, the precautionary principle, integrated management, self-regulation and sensitivity to local circumstances. Particular emphasis should be placed on the need for the various actors, agencies and levels of government to work together and seek consensus aimed at the continued sustainability of South Africa's estuaries. Successful strategic estuarine resource planning and management requires the political will, cooperation among government departments at all levels, and a national approach that is supported by a sound understanding of the various physical, chemical and ecological interactions at a national, regional and local scale. If this cannot be achieved, the prospects for either long-term resource protection or sustained delivery of estuarine ecosystem services are poor.

Critical to achieving the above, is the formalisation of a governing system for strategic estuarine resource planning, including an appropriate framework, as well as the establishment of the institutional structures through which to develop and implement such resource planning. Currently, strategic estuarine resource planning is not explicitly addressed in the National Estuarine Management Protocol and remains a shortcoming of the Protocol that must be integrated in future amendments. However, current structures can support strategic estuarine resource management with minor adjustments to their scope and functions.

Intergovernmental Relations Framework Act (No. 13 of 2005) provides for the Ministerial political (MINMEC) and technical (MINTEC) structures to ensure policy and strategy coherence between the three spheres of government. MINMEC: Environment is a standing intergovernmental body consisting of the Minister of Environmental Affairs, Members of the provincial Executive Councils responsible for environmental management functions and South African Local Government Association (SALGA). MINTEC: Environment is a standing intergovernmental body that provides technical input into the MINMEC. The MINTEC consists of the Director-General of the DEA, the heads of the provincial departments responsible for environmental management functions, and SALGA. **Working Group 8 coordinates Oceans and Coastal Management have replaced the role of the National Coastal Committee.** Working Group 8 is chaired by the Chief-Director: Integrated Coastal Management of Oceans and Coast Branch of DEA. The Group is attended by all spheres of government and representatives from provincial lead agents for ICM. Working Group 8 feeds into the MINTECH and ultimately to MINMEC.

Chapter 5 of the ICM Act provides further direction on institutional arrangements that could also contribute to cooperative strategic estuarine resource governance in South Africa. According to the ICM Act, the embodiment of cooperative governance is vested in **coastal committees** that are established at **national, provincial and municipal levels (Figure 7.1)**.

The National Estuarine Management Protocol adopts these same institutional arrangements for estuarine resource planning and management, but at the moment the Protocol only addresses the roles and responsibilities of these committees in terms of individual estuarine management planning (i.e. within a specific estuary), but not for strategic estuarine resource planning (i.e. across a selection of estuaries).

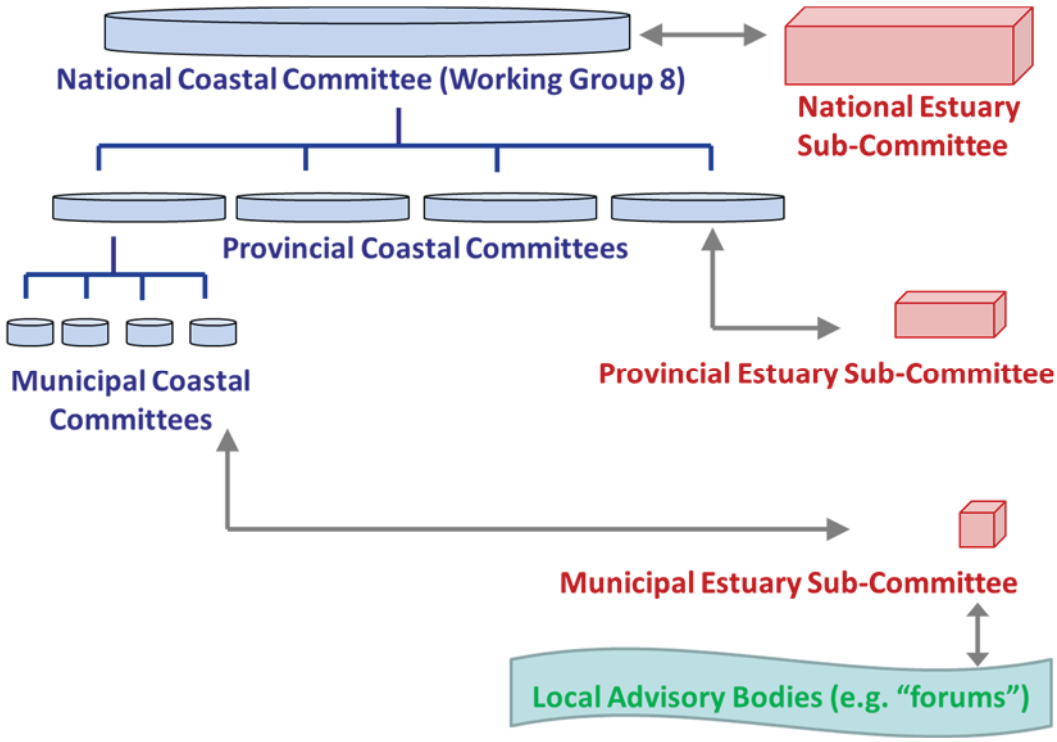


Figure 7.1 Institutional structures for estuarine management planning in South Africa, also proposed for strategic estuarine resource planning

An institutional model that can be considered for stronger coordination and cooperation in strategic estuarine resource planning at national scale is the **National Estuaries Management Task Group (an advisory body to Working Group 8).** This Task Group provides government authorities (and other key role players) with a platform to coordinate resource planning across all sectors and to optimise the use of limited estuarine resources. Similarly **estuarine sub-committees** under the **Provincial Coastal Committees** and **Municipal Coastal Committees** can facilitate stronger coordination and cooperation in strategic estuarine resource planning across estuaries in a province or in a municipal area. The **Estuarine Spatial Planning Platform** developed as part of this study, can be used to inform strategic estuarine resource planning in all of the above situations.

As a result of the vacuum left in strategic estuarine resource planning under the ICM Act and the Protocol, other legal instruments such as the **National Water Resources Classification Process** (Dollar et al. 2006) under the **National Water Act** morphed into an ad hoc framework for strategic estuarine resource planning, focusing at the Water Management Area scale. The Classification process gives effect to the **Resource Directed Measures Strategy**, in that determination of the management class in this way will allow a Reserve determination, as opposed to a Preliminary Reserve Determination.

The Classification process ultimately intends to set the Management Class (desired condition of the resources), the Reserve and the Resource Quality Objectives (RQOs) for each estuary in the country. The Classification Process thus has considerable economic, social and ecological implications. The process involves all aspects of integrated water resource management, and needs to consider factors such as Existing Lawful Use (ELU), coastal discharges, conservation requirements, and poverty alleviation. During the Classification process a larger stakeholder committee is established comprising key government departments and interest groups to guide the Classification process.

As freshwater is a key aspect in the provision of estuarine ecosystem resources and services; directly, or indirectly, all aspects of strategic estuarine resource planning are represented here as resource allocation is done across a Water Management Area with the aim of meeting multiple objectives. Unfortunately, the other key departments (e.g. DEA, DAFF, SANBI) and central role players (e.g. metros and municipalities) are viewed as just stakeholders

and not partners in this complex process, not allowing for the high level consultation and deliberations required to ensure that multi-objective targets (e.g. Conservation or recovery of fish stocks) are met and optimum solutions are found.
For example, estuaries can play a critical role in determining water allocation in a catchment. In order for an estuary to have a minimum D-class (e.g. still contribute to estuarine/marine fisheries), some river reaches in the upstream catchment potentially have to be maintained in a higher class than required. If the estuary is to be in a higher class, this can have even greater implications in limiting the potential for water use in the entire catchment. Some very sensitive estuaries may require as much as 90% of the natural runoff to remain functional, and the concern is that this would not be seen as viable if only viewed from a single sector perspective as done for the Classification system.

A solution could be to more tightly bind the DWS Classification decision-making process to that of Working Group 8. With strong oversight and more high level involvement from all relevant departments, multi-sector objectives and targets can be more explicitly incorporated into resource allocation processes across a Water Management Area or even bioregion.

The Estuarine Spatial Planning Platform can assist in making some of the more implicit aspects of resource planning explicit, for example clearly showing conflicts and need for trade-offs, where required. It can also assist resource managers to visualise the complex interactions between estuaries in a manner that reports, tables and spreadsheets cannot at present.

8. ESTUARY RESOURCE PLANNING AND THE BLUE ECONOMY

8.1 Overview of the Blue Economy

Internationally the term **Blue Economy** has more than one meaning. The World Wildlife Foundation (WWF, n.d.) defines a sustainable blue economy as a marine-based economy that:

- "Provides social and economic benefits for current and future generations, by contributing to food security, poverty eradication, livelihoods, income, employment, health, safety, equity, and political stability.
- Restores, protects and maintains the diversity, productivity, resilience, core functions, and intrinsic value of marine ecosystems – the natural capital upon which its prosperity depends.
- Is based on clean technologies, renewable energy, and circular material flows to secure economic and social stability over time, while keeping within the limits of one planet."

In summary, United Nations Environment Programme (UNEP) refers to a sustainable Blue Economy as a ***"Green Economy in a Blue World"*** (UNEP 2012). Initially, the concept of the 'Green Economy' was largely promoted through UNEP's Green Economy Initiative (GEI) which, together with other organizations, ensured that it was placed on the Rio +20 Agenda. However maritime nations, especially the small island states, argued that the 'Green Economy' was too focused on land-based processes, and did not adequately address their fundamental dependence on the sea (WWF 2015). So they introduced a parallel concept of Blue Economy. In essence, a **Blue Economy** is a **Green Economy** applied to coastal- and ocean-based economies.

A green economy was initially defined as *"…one that results in improved well-being and social equity, while significantly reducing environmental risks and ecological scarcities*" (UN Environment, n.d.). Later, greater emphasis was placed on inclusivity and equity issues and the definition evolved to (UN Environment, n.d.):

"An Inclusive Green Economy is an alternative to today's dominant economic model, which generates widespread environmental and health risks, encourages wasteful consumption and production, drives ecological and resource scarcities and results in inequality. It is an opportunity to advance both sustainability and social equity as functions of a stable and prosperous financial system within the contours of a finite and fragile planet. It is a pathway towards achieving the 2030 Agenda for Sustainable Development, eradicating poverty while safeguarding the ecological thresholds, which underpin human health, well-being and development".

The green economy concept (and its application to our oceans) in also embedded in South Africa's National Development Plan 2030 (NDP) and one of the key policy documents to guide South Africa's transition to a green economy is the Green Economy Accord (Department of Economic Development 2011).

Of specific relevance to the Blue Economy in this country is Operation Phakisa. This initiative was launched in 2014 by national government to address the development challenges prioritized in the NDP, one being the growth of our oceans economy. Within this theme, six potential growth areas were identified, namely (Bowman Gilfillan Africa Group 2015):

- Marine transport and manufacturing
- Offshore oil and gas exploration
- Aquaculture
- Marine protection services and ocean governance

- Small harbour development
- Coastal and marine tourism.

8.2 Key Principles underpinning the Green and Blue Economy

In light of the above discussion, the principles of a green economy are relevant to understanding what the concept might mean in the coastal and ocean environment ('the blue world'). Such principles also assist in the application of the green economy concept in governance processes. A single, internationally agreed upon set of principles does not exist; however, numerous sets have been developed by various international organisations, as the concept has evolved. A useful review of eight lists of green economy principles (and in some cases, characteristics) was undertaken by Allen (2012); who then distilled a list of 11 common principles as shown in the box below.

GREEN ECONOMY PRINCIPLES (adapted from Allen 2012)

A Green Economy:

1. **Is a means for achieving sustainable development**
2. **Should create decent work and green jobs (e.g. jobs that address the challenges of environmental protection, economic development and social inclusion (International Labour Organisation, n.d.)**
3. **Is resource and energy efficient**
4. **Respects planetary boundaries or ecological limits or scarcity**
5. **Uses integrated decision-making (i.e. decisions that include social, ecological and economic aspects)**
6. **Measures progress beyond Gross Domestic Product (GDP) using appropriate indicators/metrics**
7. **Is equitable, fair and just – between and within countries and between generations**
8. **Protects biodiversity and ecosystems**
9. **Delivers poverty reduction, well-being, livelihoods, social protection and access to essential services**
10. **Improves governance and the rule of law. It is inclusive; democratic; participatory; accountable transparent and stable**
11. **Internalises externalities (e.g. the costs of the effects of pollution are borne by the polluter and not by local communities, for instance).**

In the light of the strong alignment between the Green Economy and Blue Economy concepts, these principles can be viewed as useful in guiding planning, policy and management relating to coast and ocean economies.

8.3 Embedding Blue Economy in Estuarine Resource Planning

The spatial footprint of estuaries (the EFZ), is situated across the land-ocean interface. As such, estuarine resource planning straddles the coast/ocean economy and the land-based economy. The integration of the "Blue" and the "Green" economic agendas is therefore particularly relevant within environments such as estuaries (WWF 2015). Blue Economy concept could be embedded within the rationale for strategic estuarine resource planning, e.g. identifying estuaries that can support ecotourism and ensuring their future health.

Spatial planning is one of the important tools that can be used in negotiating the balance between ecological protection, social priorities and economic development; as required in terms of blue-green agenda (WWF 2015). In particular, spatial planning has the potential to increase the transparency with which decisions are made that affect the country's transition to a blue-green economy (WWF 2015). Within this context, the Spatial Planning Platform developed within this study, is a first step in consolidating available information and transposing this into a spatial format, in support of effective strategic estuarine resource planning in South Africa.

Considering some of the key economic sectors (or use) relevant, or potentially relevant, to South Africa estuaries. Table 8.1 below translates some of the key principles (listed above) into typical practical considerations in support of a sustainable Blue/Green economy.

Table 8.1 Example considerations: Transition to a Blue-Green Economy in South African estuaries

SECTOR/THEME	EXAMPLE CONSIDERATIONS
Coastal land-use	Minimising the potential risk from flooding to the health and livelihoods of local communities, resulting from inappropriate development (e.g. development within the set-back lines).
	Avoiding the negative impact of inappropriate development on the ecological habitats that support the resources (e.g. fish) provided by the estuary; thereby threatening local livelihoods and economic activities dependent on the estuary.
Pollution	The extent to which land use activities within the catchment generate waste; and the ways in which this may be minimised and/or re-used.
	Avoiding the disposal of waste into high-retention estuarine environments to prevent any negative effects on the health of local communities and tourists.
Flow allocations (water demand and supply)	In the process of setting flow allocations, balancing the goals of: maintaining ecological integrity (both within the estuary and in flow-dependent marine environments); meeting basic human needs; and promoting economic development.
Estuarine fisheries	Ensuring that estuaries can sustainably support recreational, subsistence and commercial fisheries – and associated jobs – in the long-term.
	Ensuring that estuaries can sustainably support commercial marine fisheries, considering that a large number of exploited fish stocks are estuarine-associated and at collapsed or over-exploited levels.
Tourism (including recreation)	Providing equitable access to opportunities for tourism development related to the estuarine environment (e.g. for small-medium-micro enterprises (SMMEs) based on eco-tourism, such as small Bed and Breakfast facilities)
	Developing the tourist sector around estuaries in a way which maximized the creation of green jobs (e.g. guided boat trips for bird watching)
Marine aquaculture	Minimising the potential risk to wild fisheries that can be created by introducing inappropriate cultured stocks.
	Ensure that particular estuarine environments are suitable for the selected marine aquaculture activity (e.g. most South African estuaries are less than 5 m deep and therefore cannot support structures such as grow-out cages or oyster racks).

The table above provides examples of issues that should be addressed when enabling a transition to the blue-green economy in South Africa's estuaries. However, to effectively contribute towards this transition, a set of blue-green principles could be developed and incorporated into future amendments of the Protocol) (published under the ICM Act) that guides the planning and management of estuaries in South Africa. Such principles could then be translated into more specific criteria to guide the design and assessment of both strategic and individual estuarine resource plans.

9. CONCLUSIONS AND RECOMMENDATIONS

9.1 Keeping the spatial data and information relevant moving forward

To ensure regular updates of the data and information captured in the Platform it is critical to link it to the 5 to 7 year cycle in which the National Biodiversity Assessment (NBA) is updated. More than 90% of the information collated/generated as part of this project is associated with the NBA: Estuaries Component. SANBI has therefore been approached with the concept of linking future updates formally to the NBA and has in principal agreed that it is possible, but further discussion will be need to formalise the process, e.g. future contractual arrangements/Key Performance Areas for the NBA component leads. Linking the update of the information/data to the NBA also has the advantage that spatial layers can be hosted on the SANBI BGIS site for wide distribution.

Ocean and Coastal Information System (OCIMS) (a DEA Coastal data initiative) in turn can then refer to the SANBI host site, which is targeted for the automatic integration of coastal data versus having to update a range of separate layers (e.g. information from DWS and DAFF) that is not in the correct format.

Ideally the Platform would also need annual updates on some more operational aspects. It is recommended that a small steering committee be established (comprising key research organisations and national/provincial government) to assist with this updating process. The advantage of this approach is that it would facilitate buy-in and provide oversight to the process. Open Source platforms such as Google Documents allow for restricted access in a user friendly manner.

9.2 Hosting of Estuary Spatial Planning Platform Interface

Estuary Spatial Planning Platform is hosted on the ESRI online server, which provides a global open platform for GIS users around the world. The WRC owns the IP (e.g. data organisation, platform layout, visualisation techniques) generated during the development of the Estuary Spatial Planning Platform and as such it is therefore freely available for future refinements or upgrades.

9.3 Hosting of primary data sets

The CSIR is at present one of the few state- or parastatal organisations that have a Geoportal server and online ESRI licence that allows it to link and update data sets. In the short-term the CSIR will maintain and update the data sets.

9.4 Additional information that should be incoporated in future updates of the platform

The following data sets were identified as potentially useful to estuarine resource managers that should be included once the information becomes available:

- Future modules that need to be developed include:
    - Soil erosion/sediment loads entering estuaries and the nearshore marine environment;
    - Current and future mining (sand, diamonds, heavy minerals) in estuaries.

- The potential vulnerability of South African estuaries to Climate Change (Van Niekerk et al. in prep.).
- A Rehabilitation/restoration module should be developed to assist government with the planning restoration efforts in estuaries;
- Ecological infrastructure and natural resource utilization inked to socio-economic livelihoods (currently embedded in Fisheries and Land-use Modules);
- The occurrence and impact of invasive alien species.

- Information should be added on boating activities. Where no information is available, estuary open water area can be used as a proxy of high boat activity. If possible, add an attribute that shows if boating at a specific estuary is all year round or a seasonal/holiday hot spot.
- At present the bait collection layer only indicates presence/absence of bait collection and not the level of pressure on the resource. More quantitative information needs to be added to the bait collection layer. DAFF is responsible for the collation and update of such data.
- A layer should be developed that shows the stock status of key species being caught in each estuary to assist with on-the-ground fisheries management.
- Endangered species data (fish and birds) should be added per estuary to enable future conservation planning and estuary management.
- The Administrative Information Module should be expanded to include detail on the 1:100-year flood lines and Coastal Management/Set back lines as data becomes available.
- Future updates of the Pollution Module should include information on plastic pollution (e.g. micro-plastics), desalination and Harmful Algal blooms (HABs) in South Africa's estuaries.
- Future updates of the Platform should investigate how to hyperlink the Whitfield Bibliography to the individual estuaries. This may require some advanced coding.

9.5 Scenario Planning with Marine Spatial Planning Software

Meeting the needs of a broad range of resource users that is not GIS literate (i.e. required a tool that is easy to use) excluded the use of specialised software that would require a high degree of technical knowledge from this phase of the development of the Platform.

However, collating, organising and doing basic analysis on estuarine resource use is only the first step in the complex process of estuarine resource spatial planning. With the data now in the correct spatial format and users synthesis to the complex interactions between users and the needs for trade-offs, is would be a worthwhile planning exercise to run some dynamic scenario analyses with conservation/spatial planning software such as Marxan/Marxan with zones or SeaSketch. Outputs of these analyses can then be pulled into the Platform to report on the results.

Scenario testing in its most dynamic form would require an interactive play between estuary resource condition and an escalation/elevation of pressures through trade-offs. It is therefore recommended that a next generation version of the Estuary Spatial Planning Platform be developed and hosted on a more sophisticated information technology platform that would allow for seamless integration between Java/HTML coding, geodatabases, spreadsheets and web-enabled GIS displays. Dynamic links should be developed that allows for interactive

interrogation of resource condition and pressures to provide resource managers with insights on how resource management in one sector impacts on resource availability in other sectors.

9.6 Proposed governing system for strategic estuarine resource planning

Critical to achieving Strategic Estuarine Resource Planning is the formalisation of an appropriate framework, as well as the establishment of the institutional structures through which to develop and implement such resource planning. Currently, **strategic** estuarine resource planning is not explicitly addressed in the National Estuarine Management Protocol and remains a shortcoming of the Protocol that must be addressed in future amendments.

An institutional model that can be considered for stronger coordination and cooperation in strategic estuarine resource planning at national scale is the **National Estuaries Management Task Group (an advisory body to Working Group 8).** This Task Group provides government authorities (and other key role players) with a platform to coordinate resource planning across all sectors and to optimise the use of limited estuarine resources. Similarly **estuarine sub-committees** under the **Provincial Coastal Committees** and **Municipal Coastal Committees** can facilitate stronger coordination and cooperation in strategic estuarine resource planning across estuaries in a province or in a municipal area.

As a result of the vacuum left in strategic estuarine resource planning under the ICM Act and the Protocol, other legal instruments such as the **National Water Resources Classification Process** under the **National Water Act** morphed into an ad hoc framework for strategic estuarine resource planning, focusing at the Water Management Area scale.

It is therefore recommended that the DWS Classification decision-making process where it relates to estuaries be more explicitly incorporated into the functions of Working Group 8 (at present Classification activities are just reported but no formal approvals required). With strong oversight and more high level involvement from all relevant departments, multi-sector objectives and targets can be more explicitly incorporated into resource allocation processes across a Water Management Area or even bioregion.

9.7 Blue-Green Economy

To enable a transition to the blue-green economy in South Africa's estuaries, a set of blue-green principles should be developed and incorporated into future amendments of the National Estuarine Management Protocol (Protocol) (published under the ICM Act) that guides the planning and management of estuaries in South Africa. Such principles could then be translated into more specific criteria to guide the design and assessment of both strategic and individual estuarine resource plans in the future.

9.8 Knowledge dissemination

Conduct a roadshow to familiarize the other coastal provinces with the layout of the Estuarine Spatial Planning Platform and how to use it. This will avoid unnecessary misunderstandings in the implementation of the platform and assist with sourcing data.

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11. APPENDICES

APPENDIX A: DATA SOURCES AND OWNERSHIP

Key data sets and ownership are listed in Table A.1.

Table A.1 Key data sources and authorship/ownership

MODULE	LAYER	DATA SOURCE	SPATIAL DATA SET GENERATED BY:
MANAGED AUTHORITIES	Provincial boundaries (polygon)	National Geo-spatial Information (NGI), a component of Department of Rural Development and Land Reform (DRDLR) provides an integrated survey system and provision of extensive mapping coverage of the country. NGI is also known as South Africa's national mapping organisation.	DRDLR
	District municipal boundaries (polygon)	http://www.demarcation.org.za/index.php/municipal-boundaries	Demarcation Board
	Local municipal boundaries (polygon)	http://www.demarcation.org.za/index.php/municipal-boundaries	Demarcation Board
	DWS Water Management Areas (polygon)	The amended Water Management Areas (WMA's) of the Republic of South Africa from the Directorate Institutional Oversight, Department Water and Sanitation (DWS).	DWS
	Formal Protected Areas (National & Provincial) (national polygon)	The SAPAD is a GIS inventory of all protected and conservation areas in South Africa. Access Protected and Conservations Areas (PACA) data, Protected Areas Register and Feedback Application here.	DEA
	EFZ: Estuary authorities	Intersected EFZ polygon layer with management authorities and assign as attribute fields	CSIR
	EFZ: Estuaries under formal protection	DEA Formal Protected Areas layer “clipped” with EFZ polygon layer.	CSIR
ESTUARY INFORMATION	Catchment Land cover	DEA National Land Cover 2014	DEA
	Catchment information	Developed as part of this study. Catchment information is presented the Natural and Present Mean Annual Runoff (MAR); and Seasonality of rainfall (highest flow month).	CSIR
	Estuarine features	Developed as part of this study.	CSIR
	Estuary Habitat	National Estuaries Botanical Database. The Nelson Mandela University is the custodian of the National Estuaries Botanical Database which is based on mapped data and historical observations. The dataset is regularly updated with the results of research projects and Ecological Water Requirement studies.	NMMU /CSIR
	Estuary Health	The Present Ecological State (Estuary condition) is expressed in terms of the DWS A-F scale. Data were collated from the latest DWS Classification studies, DWS Ecological Water Requirement studies; and Desktop Estuary Health Assessments, with higher confidence studies taking precedence over lower confidence historical studies.	CSIR
	Ecological Importance rating	Ecological importance is derived from a national estuary rating (Turpie and Clark 2007; Turpie et al. 2002) indicating High importance to Low/Average importance. The rating takes size, the rarity of the estuary type within its biographical zone, habitat, and biodiversity importance of the estuary into account. Biodiversity importance, in turn, is based on the assessment of the importance of the estuary for plants, invertebrates, fish and birds, using rarity indices. These importance scores ideally refer to the system in its natural condition.	CSIR
	Rating of Pressures	Refined from 2011 National Biodiversity Assessment Pressure rating (Van Niekerk and Turpie 2012) updated from the latest DWS Classification studies, DWS Ecological	CSIR

MODULE	LAYER	DATA SOURCE	SPATIAL DATA SET GENERATED BY:
		Water Requirement studies; and Desktop Estuary Health Assessments	
CONSERVATION	Estuaries under Formal protected areas (FPA)	DEA Formal Protected Areas were "clipped" with the EFZ polygon layer	CSIR
	National estuaries biodiversity plan (NBA 2011)	**Priority estuaries** as identified in the National Estuary Biodiversity Plan 2011 in the National Biodiversity Assessment 2011 (Turpie et al. 2012; Van Niekerk and Turpie 2012). The plan developed a biodiversity plan for the estuaries of South Africa by prioritising and establishing which of them should be assigned partial or full Estuarine Protected Area status.	CSIR
	Biodiversity (ecological) importance	Ecological importance is derived from a national estuary rating (Turpie and Clark 2007; Turpie et al. 2002) indicating High importance to Low/Average importance. The rating takes size, the rarity of the estuary type within its biographical zone, habitat, and biodiversity importance of the estuary into account. Biodiversity importance, in turn, is based on the assessment of the importance of the estuary for plants, invertebrates, fish and birds, using rarity indices. These importance scores ideally refer to the system in its natural condition.	CSIR
	Present Ecological Status	The Present Ecological State (Estuary condition) is expressed in terms of the Department of Water and Sanitation A-F scale. Data were collated from the latest DWS Classification studies, DWS Ecological Water Requirement studies; and Desktop Estuary Health Assessments, with higher confidence studies taking precedence over lower confidence historical studies.	CSIR
	Social dependency	Derived from DAFF's identification of communities that qualify for small-scale fisheries exemptions	CSIR
	Potential conflict between users	Potential conflict with other sectors was identified and rated "High", "Medium" or "Low" depending on existing use and the compatibility of uses (See Appendix C for more detail).	CSIR
FISHING	Fishing effort	Fishing catch (in tons) per estuary was adjusted from Van Niekerk and Turpie (2012) and Lamberth and Turpie (2003) with available recent data where available. Potential conflict with other sectors was identified and rated "High", "Medium" or "Low". A "High" or "Medium" rating indicate potentially conflicting uses that should be addressed by managed interventions such as: zonation; controlled access; gear restrictions; closed periods/ban on night fishing; and the development of Estuary Management Plans.	
	Fish health	Fish Health was determined by the Estuary Health Index. Data were collated from the latest DWS Classification studies, DWS Ecological Water Requirement studies; and Desktop Estuary Health Assessments, with higher confidence studies taking precedence over lower confidence historical studies.	CSIR
	Resilience to fishing pressure	Estuary resilience to fishing pressure was derived from the size of the estuary and degree of connectivity to the sea, with large permanently open systems being more resilient in comparison with small nearly permanently closed systems that have no resilience to exploitation of fish resources (shooting fish in a barrel situation).	DAFF/CSIR
	Contribution to estuarine/nearshore fisheries	Refined from National Biodiversity Assessment 2011. Estuarine fish-nursery contribution to estuarine and	DAFF/CSIR

MODULE	LAYER	DATA SOURCE	SPATIAL DATA SET GENERATED BY:
		nearshore marine fisheries were categorised as "High", "Medium", "Low" based on the size of the estuaries and recruitment, diversity and abundance of exploited species in individual estuaries.	
	No take zones	Estuaries with restrictions on fishing activities (fully or partially formally declared no-take areas in government gazette) (Van Niekerk and Turpie 2012)	CSIR
	Extent of over-exploitation	Degree of exploitation of fish resources was derived from the fish health score, but also took into consideration fishing effort (e.g. number of fishers, gear used, e.g. gillnets versus fishing rods); catch composition and size, age distribution of fish in sample data sets. "Very high" is associated with gillnetting or fish traps. "High" mostly indicates high recreational or subsistence exploitation. Similarly, "Medium" indicates a medium level of recreational or subsistence exploitation whilst "Low" indicates little fishing pressure on the system, but considering that fish populations in all estuaries all reflect the impact of beach and nearshore fishing, locally and countrywide.	DAFF/CSIR
	Bait Collection	Presence/absence of bait collection in a system. Where data was available, fields indicate the type of bait being targeted, e.g. mudprawns, sandprawns, pencil bait. Local communities with high levels of social dependency on estuarine resources are indicated (as identified by DAFF for small-scale commercial allocations) (Van Niekerk and Turpie 2012).	CSIR
	Potential conflict between users	Potential conflict between fishing sectors was identified and rated "High", "Medium" or "Low" depending on existing use and the compatibility of users (See Appendix C for more detail).	CSIR
	Small-scale fisheries exemptions	Derived from DAFF's identification of communities that qualify for small-scale fisheries exemptions	CSIR
POLLUTION	WWTW input	Data were collated from the latest DWS Classification studies, DWS Ecological Water Requirement studies; and Desktop Estuary Health Assessments, with higher confidence studies taking precedent over lower confidence historical studies.	CSIR
	Water quality health	Fish Health as determined by the Estuary Health Index. Data were collated from the latest DWS Classification studies, DWS Ecological Water Requirement studies; and Desktop Estuary Health Assessments, with higher confidence studies taking precedence over lower confidence historical studies.	CSIR
	Resilience to WWTW input	CSIR research. See Appendix F for more detail.	CSIR
	Potential conflict between users	Potential conflict with other sectors was identified and rated "High", "Medium" or "Low" depending on existing use and the compatibility of users (See Appendix C for more detail).	CSIR
MARINE AQUACULTURE	Existing marine aquaculture	Data collated as part of this study in consultation with DAFF and DEA.	CSIR
	Water quality health	The Water Quality Health as determined by the Estuary Health Index. Data were collated from the latest DWS Classification studies, DWS Ecological Water Requirement studies; and Desktop Estuary Health Assessments, with higher confidence studies taking precedence over lower confidence historical studies.	CSIR
	Resilience to in-stream aquaculture	Derived from physical features (Appendix H)	CSIR

MODULE	LAYER	DATA SOURCE	SPATIAL DATA SET GENERATED BY:
	Suitability for in-stream aquaculture	Derived from physical features (Appendix H)	CSIR
	Potential conflict between users	Potential conflict with other sectors was identified and rated "High", "Medium" or "Low" depending on existing use and the compatibility of users (See Appendix C for more detail).	CSIR
RECREATION	Blue Flag Beaches	Data sourced from DEA and global Blue flag site: http://www.blueflag.global/ http://blueflag.org.za/index.php/25-welcome-to-blue-flag	DEA/ CSIR
	Water quality health	The Water Quality Health as determined by the Estuary Health Index. Data were collated from the latest DWS Classification studies, DWS Ecological Water Requirement studies; and Desktop Estuary Health Assessments, with higher confidence studies taking precedence over lower confidence historical studies.	CSIR
	Potential conflict between users	Potential conflict with other sectors was identified and rated "High", "Medium" or "Low" depending on existing use and the compatibility of users (See Appendix C for more detail).	CSIR
FLOW MODIFICATION	Flow modification	Data were collated from the latest DWS Classification studies, DWS Ecological Water Requirement studies; and Desktop Estuary Health Assessments, with higher confidence studies taking precedent over lower confidence historical studies.	CSIR
	Hydrology health	The hydrological Health as determined by the Estuary Health Index. Data were collated from the latest DWS Classification studies, DWS Ecological Water Requirement studies; and Desktop Estuary Health Assessments, with higher confidence studies taking precedent over lower confidence historical studies.	CSIR
	Resilience to flow modification	Derived from physical features (Appendix F)	CSIR
	Potential conflict between users	Potential conflict with other sectors was identified and rated "High", "Medium" or "Low" depending on existing use and the compatibility of users (See Appendix C for more detail).	CSIR
COASTAL LAND-USE	Extent of Coastal development	South African Landcover layer "cut" by EFZ polygon layer	CSIR
	Habitat health	The Habitat Health as determined by the Estuary Health Index. Data were collated from the latest DWS Classification studies, DWS Ecological Water Requirement studies; and Desktop Estuary Health Assessments, with higher confidence studies taking precedent over lower confidence historical studies.	CSIR
	Artificial mouth breaching	Adjusted from NBA 2011 (Van Niekerk and Turpie 2012)	CSIR
	Potential conflict between users	Potential conflict with other sectors was identified and rated "High", "Medium" or "Low" depending on existing use and the compatibility of users (See Appendix C for more detail).	CSIR

APPENDIX B: DETAIL ON KEY DATA AND INFORMATION

B.1 Administrative information

Estuaries are governed by a range of authorities across three spheres of government. The information in the platform is depicted as the various spheres/sectors of government's management boundaries and Administrative information linked to a specific estuary.

Management boundaries relevant to estuaries include:

- Provincial authority;
- District municipality;
- Local municipality;
- Water Management Area;
- Conservation Authorities;
- Cadastral boundaries (Erf numbers); and
- Public land fringing on estuaries.

Administrative information relevant to individual estuaries include:

- Estuary Functional Zone (EFZ) layer with attribute fields that provide information on key authorities responsible for managing estuarine related resource; and
- The part of the individual estuaries under formal protection.

Figure B.1 Example of managed boundaries showing the provincial and municipal boundaries and overlap with protected areas

B.2 Estuary Information

Critical to any decision relating to estuaries are their key features, current ecological condition (also called Present Ecological State), ecological importance, and an indication of the key pressures influencing the condition of a specific system. This information is captured as follows:

- **Estuary features** list information on the overall size, length and open-water area of individual estuaries.
- **Estuary Habitat** as defined by the National Estuaries Botanical Database. The Nelson Mandela University is the custodian of the National Estuaries Botanical Database which is based on mapped data and historical observations. The dataset is regularly updated with the results of research projects and Ecological Water Requirement studies.
- **Catchment information** is presented as **Catchment Features** (indicating the Natural and Present Mean Annual Runoff (MAR); and Seasonality of highest flow) and the **Catchment Landcover** (2014).
- The **Present Ecological State** (Estuary condition) is expressed in terms of the Department of Water and Sanitation A-F scale (A: Natural, F: Extremely degraded). It must be emphasised that the A to F scale represents a continuum, and that the boundaries between categories are conceptual points along the continuum. There may therefore be cases where there is uncertainty as to which category a particular estuary belongs, potentially having components that have membership in two categories. To reflect this, straddling categories (±3 from the category scoring range) were therefore introduced, denoted by A/B, B/C, C/D, and so on. Data were collated from the latest DWS Classification studies, DWS Ecological Water Requirement studies; and Desktop Estuary Health Assessments, with higher confidence studies taking precedence over lower confidence historical studies.
- **Ecological importance** is derived from a national estuary rating (Turpie and Clark 2007; Turpie et al. 2002) indicating High importance to Low/Average importance. The rating takes size, the rarity of the estuary type within its biographical zone, habitat, and biodiversity importance of the estuary into account. Biodiversity importance, in turn, is based on the assessment of the importance of the estuary for plants, invertebrates, fish and birds, using rarity indices. These importance scores ideally refer to the system in its natural condition. The Ecological Importance rating group overall scores of 0-60 as “Important”, 60.1-80 as “Very important”; and 80.1-100 as “Extremely important”. The category “Important” was allocated to a number of small systems that was not included in the 2002 and 2007 assessments.
- The **Degree of Development Pressure** is indicated by a Low/Medium/High/Very High rating for Flow modification; Water quality; Development in the functional zone; and Fishing. The degree of pressure on individual estuaries were derived from the estuary health condition, with low condition score associated with relative high pressure ratings and good condition scores associated with relative low pressure ratings. The pressure ratings are dependent on both the intensity of the activities causing the pressure and the ability of individual systems to assimilate such pressure, e.g. a large estuary can assimilate more wastewater that a small system. Fishing pressure was derived from the fish health score, but also takes into consideration fishing effort (e.g. number of fishers, gillnets versus fishing rods); catch composition and size, age distribution of fish in sample data sets.

Figure B.2 Example of estuary information

B.3 Conservation

Information relevant to **the Conservation management of estuarine resources** was listed as follows:

- Estuaries under **Formal Protection** (in national or provincial parks)
- **Priority estuaries** as identified in the National Estuary Biodiversity Plan 2011 in the National Biodiversity Assessment 2011 (Turpie et al. 2012; Van Niekerk and Turpie, 2012). The plan developed a biodiversity plan for the estuaries of South Africa by prioritising and establishing which of them should be assigned partial or full Estuarine Protected Area status. The plan indicates that, on a national scale 133 estuaries (61 require full protection and 72 require partial protection) including those already protected, would be required to meet biodiversity targets.
- **Ecological importance** is derived from a national estuary rating (Turpie and Clark 2007; Turpie et al. 2002) indicating "High importance" to "Low/Average importance". The rating takes size, the rarity of the estuary type within its biographical zone, habitat, biodiversity importance of the estuary into account.
- Communities with a high level of **social dependency** on estuarine resources (as determined by DAFF for resource allocation process).
- **Potential conflict with other sectors** was identified and rated "High", "Medium" or "Low". A "High" or "Medium" rating indicates potentially conflicting uses that should be addressed by managed interventions such as: zonation; controlled access; and the development of Protected Areas and Estuary Management Plan.

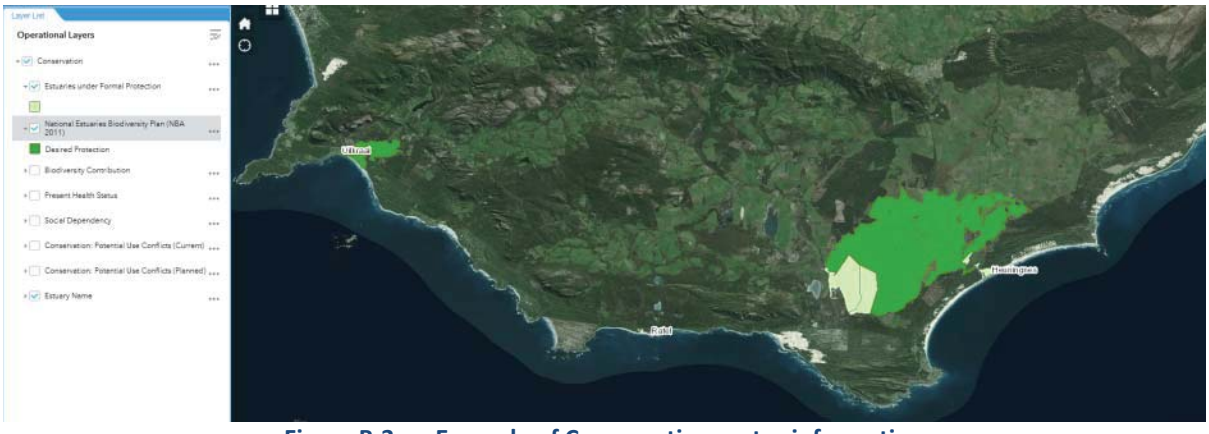

Figure B.3 Example of Conservation sector information

B.4 Fisheries

Information relevant to the **Fisheries sector** was grouped as follows:

- **Fish catch** (in tons) per estuary was adjusted from Van Niekerk and Turpie (2012) and Lamberth and Turpie (2003) with available recent data where available.
- **Fish health** (condition) per estuary as defined by the Estuary Health Index.
- **Estuary resilience** to fishing pressure (High, medium, Low) was derived from the size of the estuary and degree of connectivity to the sea, with large permanently-open systems being resilient in comparison with small predominantly closed systems that have no resilience to exploitation of fish resources.
- **Estuarine fish-nursery contributions to estuarine and nearshore marine fisheries** were categorised as "High", "Medium", "Low" based on the size of the estuaries and recruitment, diversity and abundance of exploited species in individual estuaries.
- Estuaries with **restrictions on fishing activities** (fully or partially formally declared no-take areas in government gazette).
- **Degree of exploitation** of fish resources was derived from the fish health score, but also takes into consideration fishing effort (e.g. number of fishers, gillnets versus fishing rods); catch composition and size, age distributions of fish in sample data sets. "Very high" is associated with gillnetting or fish traps. "High" generally indicate high recreational or subsistence exploitation. Similarly, "Medium" indicates an intermediate level of recreational or subsistence exploitation whilst "Low" indicates little fishing pressure on the system, but considering that all populations of estuary-dependent fish also reflect the impact of shore and nearshore fishing countrywide.
- Occurrence/absence of **bait collection** in a system. Where data were available attribute fields indicate the type of bait being targeted, e.g. mudprawns, sandprawns, pencil bait.
- Local communities with high levels of **social dependency** on estuarine resources (as identified by DAFF for small-scale commercial allocations).
- **Potential conflict with other sectors** was identified and rated "High", "Medium" or "Low". A "High" or "Medium" rating indicate potentially conflicting uses that should be addressed by managed interventions such as: zonation; controlled access; gear restrictions; closed periods (closed seasons, night-time and pre-breaching fishing prohibitions, and the development of Estuary Management Plans.
- 

Figure B.4 Example of Fisheries sector information

B.5 Pollution

Information relevant to the **Disposal of Wastewater** was grouped as follows:

- **Effluent discharge volumes** per estuary (sourced from Green drop reports).
- **Estuary Water Quality Health** (condition rated A to F) per estuary as defined by Estuary Health Index.
- **Estuary resilience** to pollution pressure was derived from key physical parameters such as estuary size, degree of connectivity to the sea, flushing rate (relationship between volume and river inflow), perched/constricted mouth.
- **Degree of pressure on the overall water quality (High, Medium, Low)** of an estuary was derived from the water quality condition score as it integrates the resilience to pollution pressure and the actual pollution input on the system.
- **Catchment water quality** (rated A to F) was derived from the type of land use in the catchment based on available landcover information.
- **Potential conflict** with other sectors was identified and rated "High", "Medium" or "Low". A "High" or "Medium" rating indicate potentially conflicting uses that should be addressed by managed interventions such as: Signage indicating health risk; regular monitoring of the water quality; reduction of waste input trough reuse/recycling of wastewater; and the development of Estuary Management Plans.

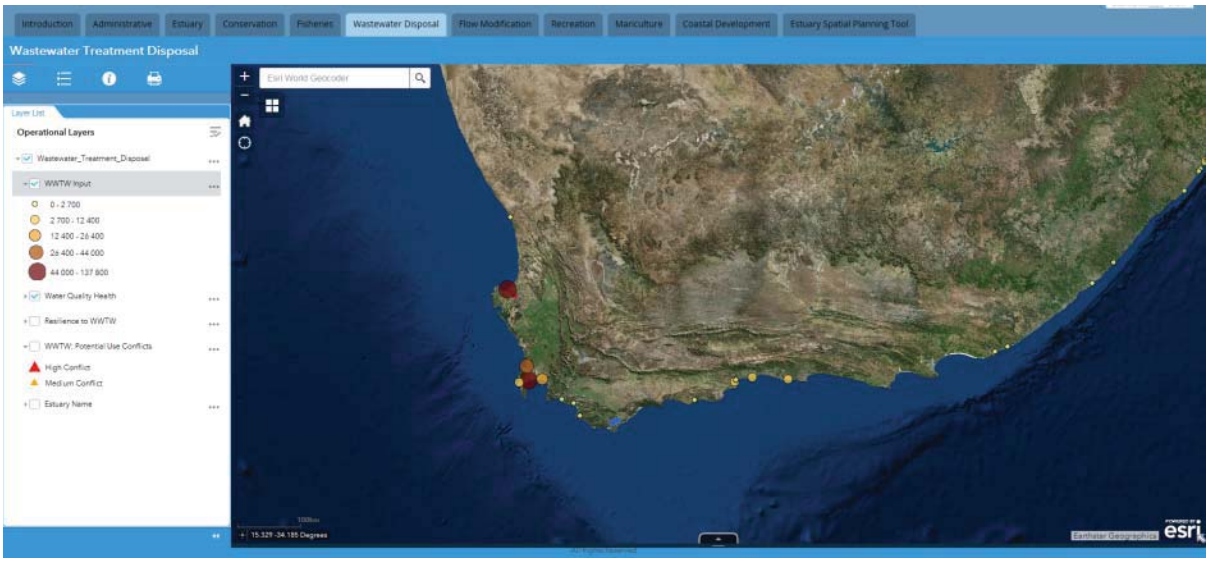

Figure B.5 Example of Pollution sector information

B.6 Flow modification

Information relevant to the **Flow Allocation** was listed as follows:

- **Flow modification** presented as volume of water removed or added. Information was collated from the latest DWS Classification studies, DWS Ecological Water Requirement studies; and Desktop Estuary Health Assessments, with higher confidence studies taking precedence over lower confidence historical studies.
- **Hydrological Health** (condition) per estuary as defined by Estuary Health Index.
- **Resilience to flow modification** was derived from the size of the catchment, with estuaries fed by larger catchments more resilient to modification in runoff than those fed by smaller catchment.
- **Potential conflict** with other sectors was identified and rated "High", "Medium" or "Low". A "High" or "Medium" rating indicates potentially conflicting uses that should be addressed by managed interventions such as: DWS Classification/Ecological Water Requirement studies; and the development of Estuary Management Plans. It is important to note that a reduction in freshwater input would require a concomitant reduction in fishing and pollution pressure to ensure future suitability of the resource.

Figure B.5 Example of Flow Modification sector information

B.7 Recreational use

Information relevant to the **recreational use of estuaries** were grouped as follows:

- The location of **Blue Flag Beaches (as provided by DEA)** to show areas of high recreational use.
- **Water Quality Health** (ecological condition) per estuary as defined by Estuary Health Index.
- **Potential conflict** with other sectors was identified and rated "High", "Medium" or "Low". A "High" or "Medium" rating indicate potentially conflicting uses that should be addressed by managed interventions such as: Signage indicating health risk; regular monitoring of the water quality; zonation of activities such as boating and fishing; and the development of Estuary Management Plans.

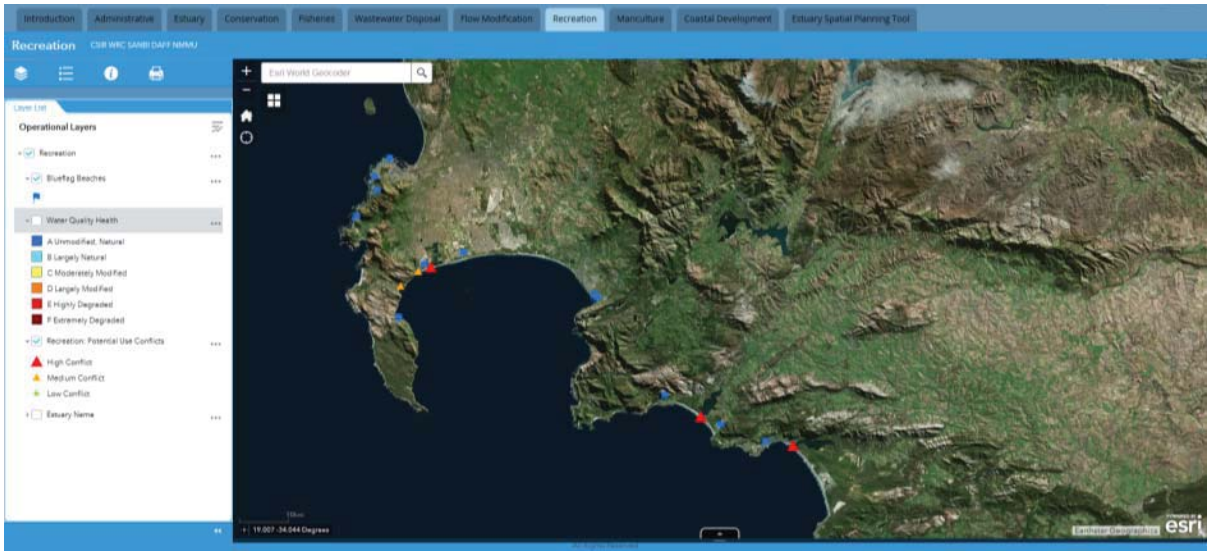

Figure B.7 Example of wastewater management information showing potential conflict between Blue flag beaches and other uses

B.8 Marine aquaculture

Information relevant to the **Marine Aquaculture Sector** was grouped as follows:

- The **existing Aquaculture** ventures in estuaries.
- **Water Quality Health** (condition in A to F categories) per estuary as defined by Estuary Health Index as an indicator of estuaries where water quality may not be of a sufficient standard to support Marine Aquaculture ventures.
- Estuary **Resilience to Aquaculture discharges**
- **Suitability for In-stream Marine Aquaculture** based on key characteristics required to support future ventures: Estuary mouth 100% open, estuary openwater area more than 200 ha; Estuary depth greater 5 m to accommodate rafts; Not an important nursery for fish.
- **Potential conflict** with other sectors was identified and rated “High”, “Medium” or “Low”. A “High” or “Medium” rating indicate potentially conflicting uses that should be addressed by managed interventions such as: zonation of activities such as boating and fishing; reduction in waste input; and the development of Estuary Management Plans.

Figure B.8 Example of Marine Aquaculture sector related information

B.9 Coastal Land-use and development

Information relevant to the **Management of Estuary Development sector** was grouped as follows:

- **Extent of Coastal development** (based on available Landcover (2014 or updates thereof) within the Estuary functional zone).
- **Habitat Health** (condition) per estuary as defined by Estuary Health Index.
- **Artificial Breaching/mouth manipulation** at relevant estuaries (as recoded by the NBA Estuary Monitoring and Management Registry (Van Niekerk et al. 2017)).
- High level of **social dependency** on estuarine resources (focussing on harvesting of mangroves).
- **Potential conflict** with other sectors was identified and rated “High”, “Medium” or “Low”. A “High” or “Medium” rating indicate potentially conflicting uses that should be addressed by managed interventions such as: determining flood lines; development of setback lines; zonation of activities; reduction in waste input; and the development of Estuary Management Plans.

Figure B.9 Example of Coastal development sector spatial information on landcover and artificial breaching

APPENDIX C: QUANTIFICATION OF USER CONFLICT

Authors: Lara van Niekerk and Susan Taljaard

To enable multi-sector resource planning, potential user conflict between the following sectors were identified using a set of predefined criteria:

- Conservation (Table C.1);
- Fisheries (Table C.2);
- Wastewater management (Table C.3);
- Flow modification (Table C.4);
- Recreational use (Table C.5);
- Marine Aquaculture (Table C.6); and
- Coastal development (Table C.7).

Potential conflict with among sectors was cross tabulated and rated "High", "Medium" or "Low" depending on the intensity of the conflicts. A "High" or "Medium" rating indicates potentially conflicting uses that should be addressed by managed interventions and the development of Estuary Management Plans.

Table C.1 Criteria for quantification of potential conflict between Current or Planned Estuarine Protected Areas and other estuarine resource users

OTHER RESOURCE USE	INTENSITY OF CONFLICT SCORE
Fisheries (present levels of effort)	Use fishing pressure rating: 3= High and Very high 2= Medium 1= Low
WWTW	3= If present
Marine Aquaculture	3= If present
Recreation	Little to no conflict
Flow Modification	Use Flow modification pressure rating: 3= High and Very high 2= Medium 1= Low
Coastal Development and Land-use	Use Habitat modification pressure rating: 3= High and Very high 2= Medium 1= Low
Pollution from catchment land-use	Use WQ Index River rating (Appendix G): 13= High and Very high (score of 5 or more) 2= Medium (score 3 or 4) 1= Low (score 2 or less)

Table C.2 Criteria for quantification of potential conflict between fishing and other estuarine resource users

OTHER RESOURCE USE	INTENSITY OF CONFLICT SCORE
Conservation	Use fishing pressure rating: 3= High and very high 2= Medium 1= Low
WWTW	3= If present
Marine Aquaculture	2 = If present
Recreation	2 = If present
Flow Modification	Use flow modification pressure rating: 3= High and Very high 2= Medium 1= Low
Coastal Development and Land-use	Use Habitat modification pressure rating: 1= Medium, High and Very high
Pollution from catchment land-use	Use WQ Index River rating (Appendix G): 13= High and Very high (score 5 or more) 2= Medium (score 3 or 4) 1= Low (score 2 or less)

Table C.3 Criteria for quantification of potential conflict between flow modification and other estuarine resource users

OTHER RESOURCE USE	INTENSITY OF CONFLICT SCORE
Conservation	Use Flow modification pressure rating: 3= High and Very high 2= Medium 1= Low
WWTW	Use Flow modification pressure rating: 3= High and Very high 2= Medium 1= Low
Fisheries	Use Flow modification pressure rating: 3= High and Very high 2= Medium 1= Low
Marine Aquaculture	Use Flow modification pressure rating: 3= High and Very high 2= Medium 1= Low
Coastal Development and Land-use	Use Flow modification pressure rating: 3= High and Very high 2= Medium 1= Low
Recreation	Little to no conflict
Pollution from catchment land-use	Little to no conflict

Table C.4 Criteria for quantification of potential conflict between Pollution from the catchment and other estuarine resource users

OTHER RESOURCE USE	INTENSITY OF CONFLICT SCORE
Conservation	Use WQ Index River rating (Appendix G): 3= High and Very high (score of 5 or more) 2= Medium (score 3 or 4) 1= Low (score 2 or less)
Fisheries	Use WQ Index River rating (Appendix G): 3= High and Very high (score of 5 or more) 2= Medium (score 3 or 4) 1= Low (score 2 or less)
Marine Aquaculture	Use WQ Index River rating (Appendix G): 3= High and Very high (score of 5 or more) 2= Medium (score 3 or 4) 1= Low (score 2 or less)
Recreation	3= If present
Coastal Development	2= If WWTW present
Flow Modification	Use Flow modification pressure rating: 3= High and Very high 2= Medium 1= Low
Conservation	Use WQ Index River rating (Appendix G): 3= High and Very high (score of 5 or more) 2= Medium (score 3 or 4) 1= Low (score 2 or less)

Table C.5 Criteria for quantification of potential conflict between wastewater discharges and other estuarine resource users

OTHER RESOURCE USE	INTENSITY OF CONFLICT SCORE
Conservation	3= If present
Fisheries	3= If present
Marine Aquaculture	3= If present
Recreation	3= If present
Coastal Development	2= If WWTW present
Flow Modification	Use Flow modification pressure rating: 3= High and Very high 2= Medium 1= Low
Pollution from catchment land-use	Use WQ Index River rating (Appendix G): 13= High and Very high (score of 5 or more) 2= Medium (score 3 or 4) 1= Low (score 2 or less)

Table C.6 Criteria for quantification of potential conflict between Recreation and other estuarine resource users

OTHER RESOURCE USE	INTENSITY OF CONFLICT SCORE
Conservation	Little to no conflict
Fisheries	2= If present
Marine Aquaculture	2= If present
WWTW	3= If present
Flow Modification	Little to no conflict
Pollution from catchment land-use	Use WQ Index River rating (Appendix G): 3= High and Very high (score of 5 or more) 2= Medium (score 3 or 4) 1= Low (score 2 or less)

Table C.7 Criteria for quantification of potential conflict between Marine Aquaculture and estuarine resource other users

OTHER RESOURCE USE	INTENSITY OF CONFLICT SCORE
Conservation	3= If present
Fisheries	2= If present
WWTW	3= If present
Recreation	2= If present
Flow Modification	Use Flow modification pressure rating: 3= High and Very high 2= Medium 1= Low
Pollution from catchment land-use	Use WQ index River rating (Appendix G): 3= High and Very high (score of 5 or more) 2= Medium (score 3 or 4) 1= Low (score 2 or less)

Table C.8 Criteria for quantification of potential conflict between Coastal Development and Land-use and other estuarine resource users

OTHER RESOURCE USE	INTENSITY OF CONFLICT SCORE
Conservation	Use Habitat modification pressure rating: 3= High and Very high 2= Medium 1= Low
Fisheries	Use Habitat modification pressure rating: 1= Medium, High and Very high
WWTW	2= If WWTW present
Recreation	Little to no conflict
Flow Modification	Use Flow modification pressure rating: 3= High and Very high 2= Medium 1= Low
Marine Aquaculture	Little to no conflict
Pollution from catchment land-use	Little to no conflict

APPENDIX D: QUANTIFICATION OF NURSERY FUNCTION

Authors: Stephen Lamberth, Steven Weerts, Lara van Niekerk

Refinements of what was done for the NBA 2011 (Van Niekerk et al. 2012). Estuarine fish-nursery contributions to estuarine and nearshore marine fisheries were categorised as “High”, “Medium”, “Low” based on the size of the estuaries and recruitment, diversity and abundance of exploited species in individual estuaries.

Lamberth and Turpie (2003) estimate that about 50% of the 160 species of fish that occur in South Africa estuaries are utilised in fisheries (subsistence, recreational and commercial). At least 60% of these species are considered entirely or partially dependent on estuaries, and are thus likely to be affected by changes in runoff.

The total landed catch of fish taken directly from estuaries (2 500 t per annum) is considerably lower than the total estimated catch of inshore marine fisheries (28 000 t per annum). However, depending on bioregion and fishery sector, up to 83 % of the catch by inshore fisheries may comprise estuary-associated species. These authors estimate that the total value of estuary fisheries and the contribution of estuary fish to the inshore marine fisheries, is about R1.2 billion per annum in 2011 Rands.

The life-history characteristics of most of South Africa’s coastal fish species are fairly well known allowing them to be categorised into the various levels of estuary-association developed by Whitfield (1994). Less well known is the degree of intra-specific variation in estuary-dependence between the different biogeographical regions or whether suitable nursery or spawning areas are limited due to the narrow or critical habitat requirements of some species.

For some species, the level of estuary-association appears to vary across biogeographical regions. This may have been selected for at the population level and/or a result of the behavioural and physiological plasticity of the species concerned. Knysna sandgoby *Psammogobius knysnaensis* range from having mostly estuary-resident populations on the subtropical and warm Temperate east coast to equivalent estuary and surf-zone populations on the cool Temperate west coast. On the east and south coast, dusky kob *Argyrosomus japonicus* are obligate estuary-dependent species whereas silver kob *Argyrosomus inodorus* are not and never enter estuaries there. On the cool west coast where the warm-Temperate *A. japonicus* do not occur, *A. inodorus* utilize the Orange and other estuaries, probably for feeding or as a warm-water refuge. The Angolan dusky kob *A. coronus* occurs in the sea on the cool-Temperate west coast, until the warm-Temperate Cunene, where it is dominant in estuaries and *A. inodorus* no longer occur (Lamberth et al. 2008).

Although there are close to 300 estuaries along South Africa’s coast, the specific habitat requirements of some fish at certain stages of their life may make the choice of juvenile nursery habitat or spawning ground extremely limited. Small juvenile dusky kob *A. japonicus* less than 1-year old prefer the fine sediments of highly turbid estuaries being adapted to find refuge in a “viscous” environment from which other predatory fish are physiologically excluded. This type of habitat comprises less than 5 % of the total estuarine area in South Africa. Of the 20 largest catchments in the country, only four, the Mbashe, Great Kei, Mzimvubu and Mtata have estuaries with the suitable sediment and turbidity characteristics as do an undetermined number of smaller systems such as the Kwelera and Nahoon. For adolescents, the habitat requirements appear to be broader with at least 50% of large and medium size estuaries being suitable nursery environments.

White steenbras *Lithognathus lithognathus* occur from the Orange River to the warm-Temperate/subtropical transition zone on the east coast. There is an annual spawning migration to this bioregion transition zone, spawning occurring late July to September on the fluvial fans off selected estuary mouths. These fluvial fans appear to be limited with the Mbashe as the only confirmed spawning area and the Mtata, Mzimvubu and Great Kei as the only other systems having similar catchment and sediment characteristics. If *L. Lithognathus* are restricted to spawning on these few fluvial fans, the entire South African spawning habitat may be less than 50 hectares. Historically, there may have also been a west coast spawning population with the Orange having a suitable fluvial fan. Intensive beach-seine and gillnet fishing over the last 100 years may have seen this population become extinct or indiscernible.

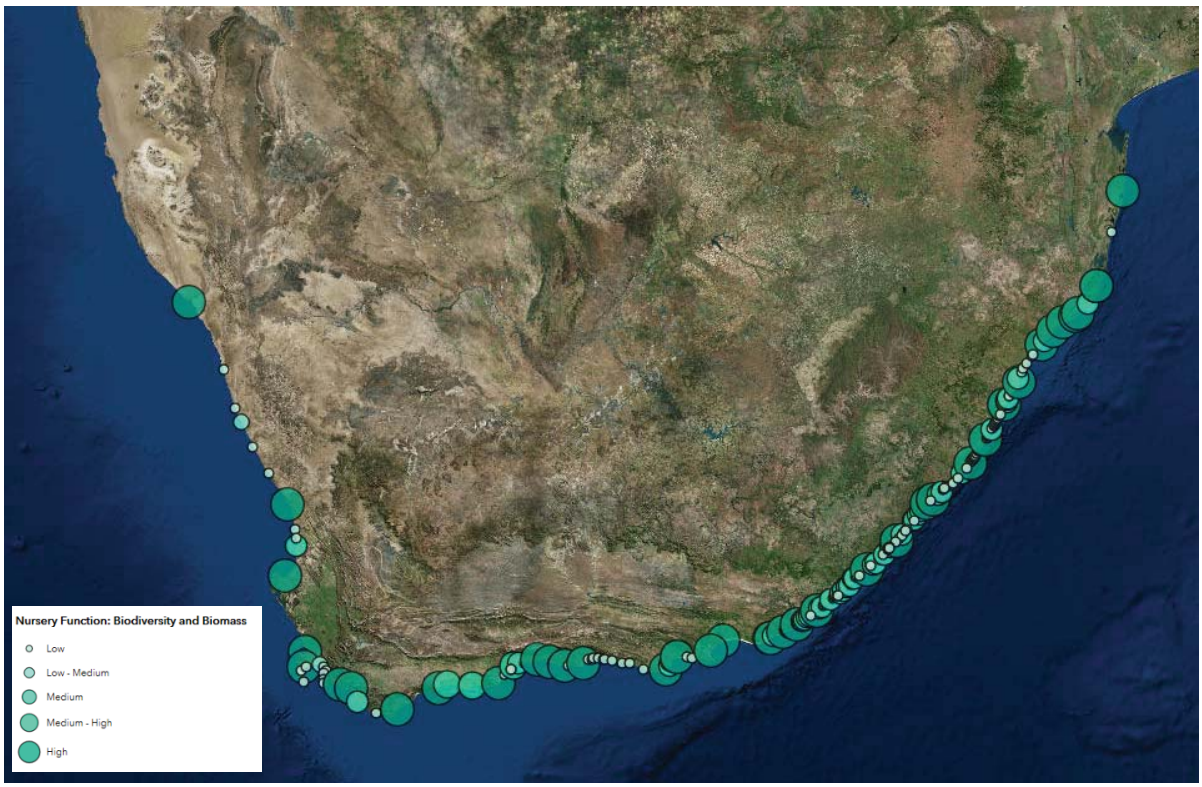

Figure D.1 Important fish nurseries for biodiversity and fisheries

In South Africa no studies have examined habitat requirements for neonatal, juvenile and adult Zambezi sharks. It is likely, however, that physico-chemical factors – as well as the physical characteristics of an estuary (e.g. depth, prey availability) – determine the suitability of a system for reproductive purposes. Based on these characteristics, several other estuaries have been identified as possible pupping and nursery grounds, including the Umzimvubu and Breede River systems. A rapid assessment of the physico-chemical and physical characteristics of South Africa's rivers – and therefore suitability for Zambezi sharks – indicates several of the major river systems may be suitable habitat. These include (from West to East) the: Breede, Gouritz, Gamtoos, Sundays, Great Fish, Great Kei, Umtata, Umzimvubu, Mngazana, Thukela and Lake St Lucia systems. Although several of these systems may not be used for reproductive purposes, many are likely to be visited during the 11-month gestation period and so they should be considered critical habitat for ensuring the health of Zambezi shark populations in South Africa. Table D.1 Summary of South Africa's very important nursery estuaries provides a summary of South Africa's important nursery areas. All estuaries larger than a 100 ha in total habitat were included in the list. In addition some smaller estuaries with known endemic fish or invertebrate species, e.g. East Kleinmonde that is the prime nursery for the Estuarine Pipefish *Syngnathus watermeyeri*, were also incorporated. Confirmed importance is indicated by an X, while an X? indicates unconfirmed status (but likely) as estuary and catchment characteristics indicate suitable habitat.

Table D.1 Summary of South Africa's very important nursery estuaries (adapted from Van Niekerk and Turpie 2012)

ESTUARY	NURSERY: OVERALL BIODIVERSITY	ESTUARINE CONTRIBUTION TO MARINE FISHERIES	ESTUARINE CONTRIBUTION TO ESTUARINE FISHERY	Nursery: Fisheries Estuary Associated/Dependant (2a, 2b, 2c)	Nursery: Fisheries Marine (Marine)	Nursery: Fisheries freshwater (4)	Nursery: Fisheries Eels	Nursery: Mullet	Nursery: Leervis	Nursery: Grunter	Specialised Habitat: cob species (Silver, Dusky, West Coast)	Specialised Habitat: White steenbras	Zambezi sharks
Orange	**H**	**H**	**H**	H	L	H		H			H	H	
Buffels	**L**												
Swartlintjies	**L**												
Spoeg	**L-M**												
Groen	**L**												
Sout	**L**												
Olifants	**H**	**H**	**H**	H	M	M		H			H	H	
Jakkalsvlei	**L**												
Wadrift	**L**												
Verlorenvlei	**M**	**H**	**H**	H		M		H				M	
Groot Berg	**H**	**H**	**H**	H	M	M		H			H	H	
Rietvlei/Diep	**H**	**H**	**H**	H	L	M		H			L	H	
Sout (Wes)	**L**												
Houtbaai	**L**												
Wildevoëlvlei	**L**	**L**	**L**	L				L					
Bokramspruit	**L**												
Schuster	**L**												
Krom	**L**												
Buffels Wes	**L**												
Elsies	**L**												
Silvermine	**L**												
Sand	**H**	**H**	**H**	H	L	M	L	H			M	H	
Zeekoei	**L**												
Eerste	**M**						H						
Lourens	**L**						M						
Sir Lowry's Pass	**L**						L						
Steenbras	**L**		**L**		L		M						
Rooiels	**L**			L			M						
Buffels (Oos)	**L**												
Palmiet	**L**			L			H						
Bot/Kleinmond	**H**	**H**	**H**	H		M	M	H			H	H	
Onrus	**L**												
Klein	**H**	**H**	**H**	H		M	M	H			H	H	
Uilkraals	**M**	**M**	**M**	M			M	M			L	M	

ESTUARY	NURSERY: OVERALL BIODIVERSITY	ESTUARINE CONTRIBUTION TO MARINE FISHERIES	ESTUARINE CONTRIBUTION TO ESTUARINE FISHERY	Nursery: Fisheries Estuary Associated/Dependant (2a, 2b, 2c)	Nursery: Fisheries Marine (Marine)	Nursery: Fisheries freshwater (4)	Nursery: Fisheries Eels	Nursery: Mullet	Nursery: Leervis	Nursery: Grunter	Specialised Habitat: cob species (Silver, Dusky, West Coast)	Specialised Habitat: White steenbras	Zambezi sharks
Ratel	**L**												
Heuningnes	**H**	**H**	**H**	H	M	M	M	H		H	H	H	
Klipdrifsfontein	**L**												
Breë	**H**	**H**	**H**	H	M	M	H	H		H	H	H	H
Duiwenhoks	**M-H**	**H**	**H**	H	M	L	H	H		H	H	H	
Goukou	**M-H**	**H**	**H**	H	M	L	H	H		H	H	H	L
Gourits	**H**	**H**	**H**	H	M	L	H	H		H	H	H	H
Blinde	**L**												
Gericke	**L**												
Tweekuilen	**L**												
Hartenbos	**M**	**H**	**M**	M	L		L	M		M	M	H	
Klein Brak	**M-H**	**H**	**H**	H	L	L	M	H		H	H	H	
Groot Brak	**M**	**H**	**M**	M	L		L	M		M	M	H	
Maalgate	**L**						M						
Gwaing	**L**						M						
Kaaimans	**L**						H						
Wilderness	**H**	**H**	**H**	H	L	M	H	H		M	M	H	
Swartvlei	**H**	**H**	**H**	H	L	M	H	H		H	M	H	
Goukamma	**M**	**H**	**H**	H	L	L	H	M		M	M	H	
Knysna	**H**	**H**	**H**	H	H	L	M	H		H	H	H	L
Noetsie	**L**												
Piesang	**M**												
Keurbooms	**H**	**H**	**H**	H	M	L	H	H		H	M	H	
Matjies	**L**						M						
Sout (Oos)	**L**						M						
Groot (Wes)	**L**						M						
Bloukrans	**L**						M						
Lottering	**L**						M						
Elandsbos	**L**						M						
Storms	**L**						M						
Elands	**L**						M						
Groot (Oos)	**L**						M						
Tsitsikamma	**L**						M						
Klipdrif	**L**						M						
Slang	**L**						M						
Krom Oos (Kromme)	**H**	**H**	**H**	H	M	L	L	H		H	H	H	
Seekoei	**M**	**H**	**H**	H	L	L	L	H		M	M	M	
Kabeljous	**M**	**H**	**H**	H	L	L	L	H		M	M	M	

ESTUARY	NURSERY: OVERALL BIODIVERSITY	ESTUARINE CONTRIBUTION TO MARINE FISHERIES	ESTUARINE CONTRIBUTION TO ESTUARINE FISHERY	Nursery: Fisheries Estuary Associated/Dependant (2a, 2b, 2c)	Nursery: Fisheries Marine (Marine)	Nursery: Fisheries freshwater (4)	Nursery: Fisheries Eels	Nursery: Mullet	Nursery: Leervis	Nursery: Grunter	Specialised Habitat: cob species (Silver, Dusky, West Coast)	Specialised Habitat: White steenbras	Zambezi sharks
Gamtoos	H	H	H	H	L	M	M	H		H	H	H	L
Van Stadens	L												
Maitland	L												
Baakens	L												
Papenkuils	L												
Swartkops	H	H	H	H	L	L	M	H		H	H	H	
Coega (Ngcura)	L												
Sundays	H	H	H	H	L	M	M	H		H	H	H	L
Boknes	L												
Bushmans	H	H	H	H	L	M	M	H		H	H	H	
Kariega	H			H	L	M	M	H		H	H	H	L
Kasuka	M	M	M	M			M	M		M	M	M	
Kowie	H	H	H	H	L	M	M	H		H	H	H	
Rufane	L												
Riet	L												
Kleinemond Wes	M	M	M	M			M	M		M	M	M	
Kleinemond Oos	M	M	M	M			M	M		M	M	M	
Klein Palmiet	L												
Great Fish	H	H	H	H		M	H	H		H	H	H	L
Old Womans	L												
Mpekweni	M	M	M	M			L	M		M	M	M	
Mtati	M	M	M	M			L	M		M	M	M	
Mgwalana	M	M	M	M			L	M		M	M	M	
Bira	M	M	M	M			L	M		M	M	M	
Gqutywa	M			M			L	M		M	M	M	
Ngculura	L												
Blue Krans	L												
Mtana	L												
Keiskamma	H	H	H	H		M	H	H		H	H	H	L
Ngqinisa	L												
Kiwane	M	M	M	M			L	M		M	M	M	
Tyolomnqa	M	M	M	M		L	M	M		M	M	M	
Shelbertsstroom	L												
Lilyvale	L												
Ross' Creek	L												
Ncera	L												
Mlele	L												
Mcantsi	L												

ESTUARY	NURSERY: OVERALL BIODIVERSITY	ESTUARINE CONTRIBUTION TO MARINE FISHERIES	ESTUARINE CONTRIBUTION TO ESTUARINE FISHERY	Nursery: Fisheries Estuary Associated/Dependant (2a, 2b, 2c)	Nursery: Fisheries Marine (Marine)	Nursery: Fisheries freshwater (4)	Nursery: Fisheries Eels	Nursery: Mullet	Nursery: Leervis	Nursery: Grunter	Specialised Habitat: cob species (Silver, Dusky, West Coast)	Specialised Habitat: White steenbras	Zambezi sharks
Gxulu	**M**	**M**	**M**	M			L	M		M	M	M	
Goda	**L**												
Hlozi	**L**												
Hickman's	**L**												
Mvubukazi	**L**												
Ngqenga	**L**												
Buffalo	**M**	**H**	**M**	M		L	M	M		M	H	M	
Blind	**L**												
Hlaze	**L**												
Nahoon	**M**	**H**	**M**	M		L	M	M		M	H	M	
Qinira	**L**												
Gqunube	**M**	**H**	**M**	M		L	M	M		M	H	M	
Kwelera	**M**	**H**	**M**	M		L	M	M		M	H	M	
Bulura	**L**												
Cunge	**L**												
Cintsa	**L**												
Cefane	**M**	**M**	**M**	M			L	M		M	M	M	
Kwenxura	**M**	**M**	**M**	M			L	M		M	M	M	
Nyara	**L**												
Mtwendwe	**L**												
Haga-haga	**L**												
Mtendwe	**L**												
Quko	**M**	**M**	**M**	M			L	M		M	M	M	
Morgan	**M**	**H**	**M**	M		L	M	M		M	H	M	
Cwili	**L**												
Great Kei	**H**	**H**	**H**	H		M	H	H		H	H	H	M
Gxara	**L**												
Ngogwane	**L**												
Qolora	**L**												
Ncizele	**L**												
Timba	**L**												
Kobonqaba	**M**	**M**	**M**	M			L	M		M	M	M	
Nxaxo/Ngqusi	**M**	**M**	**M**	M			L	M		M	M	M	
Cebe	**L**												
Gqunqe	**L**												
Zalu	**L**												
Ngqwara	**L**												
Sihlontlweni/Gcin	**L**												

ESTUARY	NURSERY: OVERALL BIODIVERSITY	ESTUARINE CONTRIBUTION TO MARINE FISHERIES	ESTUARINE CONTRIBUTION TO ESTUARINE FISHERY	Nursery: Fisheries Estuary Associated/Dependant (2a, 2b, 2c)	Nursery: Fisheries Marine (Marine)	Nursery: Fisheries freshwater (4)	Nursery: Fisheries Eels	Nursery: Mullet	Nursery: Leervis	Nursery: Grunter	Specialised Habitat: cob species (Silver, Dusky, West Coast)	Specialised Habitat: White steenbras	Zambezi sharks
Nebelele	L												
Qora	M	M	M	M			L	M		M	M	M	
Jujura	L												
Ngadla	L												
Shixini	L												
Beechamwood	L												
Kwazlelitsha/Kwazweda	L												
Kwa-Goqo	L												
Ku-Nocekedwa	L												
Nqabara/Nqabarana	M	M	M	M			L	M		M	M	M	
Ngoma/Kobule	L												
Mendu	L												
Mendwana	L												
Mbashe	H	H	H	H		M	H	H		H	H	H	M
Ku-Mpenzu	L												
Mbhanyana	L												
Kwa-Suka	L												
Ntlonyane	L												
Nkanya	L												
Sundwana	L												
Xora	M	M	M	M			L	M		M	M		
Bulungula	L												
Ku-Amanzimuzama	L												
Nqakanqa	L												
Unnamed2	L												
Mncwasa	L												
Mpako	L												
Nenga	L												
Mapuzi	L												
Mtata	M	M	M	M			L	M		M	M		M
Tshani	L												
Mdumbi	M	M	M	M			L	M		M	M		M
Lwandilana	L												
Lwandile	L												
Mtakatye	M	M	M	M			M	M		M	M		L
Hluleka/Majusini	L												
Mnenu	M	M	M	M			L	M		M	M		L
Mtonga	L												

ESTUARY	NURSERY: OVERALL BIODIVERSITY	ESTUARINE CONTRIBUTION TO MARINE FISHERIES	ESTUARINE CONTRIBUTION TO ESTUARINE FISHERY	Nursery: Fisheries Estuary Associated/Dependant (2a, 2b, 2c)	Nursery: Fisheries Marine (Marine)	Nursery: Fisheries freshwater (4)	Nursery: Fisheries Eels	Nursery: Mullet	Nursery: Leervis	Nursery: Grunter	Specialised Habitat: cob species (Silver, Dusky, West Coast)	Specialised Habitat: White steenbras	Zambezi sharks
Mpande	L												
Sinangwana	L												
Mngazana	H	H	H	H	L		M	M		H	H	L	L
Mngazi	M	M	M	M			M	M		M	M		
Gxwaleni	L												
Bulolo	L												
Mtumbane	L												
Mzimvubu	H	H	H	H		M	H	H		H	H		H
Ntlupeni	L												
Nkodusweni	L												
Mntafufu	M	M	M	M			M	M		M	M		
Mzintlava	M	M	M	M			M	M		M	M		
Mzimpunzi	L												
Kwa-Nyambalala	L												
Mbotyi	L												
Mkozi	L												
Myekane	L												
Lupatana	L												
Mkweni	L												
Sitatsha	L												
Msikaba	L												
Butsha	L												
Mgwegwe	L												
Mgwetyana	L												
Mtentu	M	M	M	M			M	M		M	M		
Sikombe	L												
Kwanyana	L												
Mtolane	L												
Mnyameni	L												
Mpahlanyana	L												
Mpahlane	L												
Mzamba	M	M	M	M			M	M		M	M		
Mtentwana	L												
Mtamvuna	H	H	H	H			H	H		H	H		
Zolwane	L												
Sandlundlu	L												
Ku-Boboyi	L												
Tongazi	L												

ESTUARY	NURSERY: OVERALL BIODIVERSITY	ESTUARINE CONTRIBUTION TO MARINE FISHERIES	ESTUARINE CONTRIBUTION TO ESTUARINE FISHERY	Nursery: Fisheries Estuary Associated/Dependant (2a, 2b, 2c)	Nursery: Fisheries Marine (Marine)	Nursery: Fisheries freshwater (4)	Nursery: Fisheries Eels	Nursery: Mullet	Nursery: Leervis	Nursery: Grunter	Specialised Habitat: cob species (Silver, Dusky, West Coast)	Specialised Habitat: White steenbras	Zambezi sharks
Kandandhlovu	**L**												
Mpenjati	**L**			L		L	L	L		L			
Umhlangankulu	**L**												
Kaba	**L**												
Mbizana	**L**	**L**	**L**	L		L	L	L		L			
Mvutshini	**L**												
Bilanhlolo	**L**												
Uvuzana	**L**												
Kongweni	**L**												
Vungu	**L**												
Mhlangeni	**L**												
Zotsha	**L**												
Boboyi	**L**												
Mbango	**L**												
Mzimkulu	**H**	**H**	**H**	H			H	H		H	H		
Mtentweni	**L**												
Mhlangamkulu	**L**												
Damba	**L**												
Koshwana	**L**												
Intshambili	**L**												
Mzumbe	**L**												
Mhlabatshane	**M**			M		L		L		L	L		
Mhlungwa	**L**												
Mfazazana	**L**												
Kwa-Makosi	**L**												
Mnamfu	**L**												
Mtwalume	**L**												
Mvuzi	**L**												
Fafa	**L**												
Mdesingane	**L**												
Sezela	**L**												
Mkumbane	**L**												
Mzinto	**L**												
Nkomba	**L**												
Mzimayi	**L**												
Mpambanyoni	**L**												
Mahlongwa	**L**												
Mahlongwane	**L**												

ESTUARY	NURSERY: OVERALL BIODIVERSITY	ESTUARINE CONTRIBUTION TO MARINE FISHERIES	ESTUARINE CONTRIBUTION TO ESTUARINE FISHERY	Nursery: Fisheries Estuary Associated/Dependant (2a, 2b, 2c)	Nursery: Fisheries Marine (Marine)	Nursery: Fisheries freshwater (4)	Nursery: Fisheries Eels	Nursery: Mullet	Nursery: Leervis	Nursery: Grunter	Specialised Habitat: cob species (Silver, Dusky, West Coast)	Specialised Habitat: White steenbras	Zambezi sharks
Mkomazi	**H**	**H**	**H**	H			H	H		H	H		L
Ngane	**L**												
Umgababa	**M**			L		L	L	M		M	L		
Msimbazi	**M**			L		L	L	M		M	L		
Lovu	**M**			M		L	M	M		M	M		
Little Manzimtoti	**L**												
Manzimtoti	**L**												
Mbokodweni	**L**												
Sipingo	**L**												
Durban Bay	**H**	**H**	**H**	H	H			H		H	H		M
Mgeni	**M**	**M**	**M**	M			H	M		M	M		L
Mhlanga	**L**												
Mdloti	**L**												
Tongati	**L**												
Mhlali	**L**												
Bob's Stream	**L**												
Seteni	**L**												
Mvoti	**L**												
Mdlotane	**L**												
Nonoti	**L**												
Zinkwasi	**H**	**M**	**M**	M		L	L	M		L	L		
Tugela/Thukela	**M**	**H**	**H**	H		L	H	M		M	H		L
Matigulu/Nyoni	**H**	**M**	**H**	H		L	L	M		M	L		
Siyaya	**L**					L							
Mlalazi	**H**	**M**	**H**	H	L	L	M	M		M	M		
Mhlathuze	**H**	**H**	**H**	H	M		H	H		H	H		H
Richards Bay	**H**	**H**	**H**	H	H		H	H		H	H		
Nhlabane (Present)	**M**			M		L	L	L					
Mfolozi	**H**	**H**	**H**	H		M	H	H		H	H		H
St Lucia	**H**	**H**	**H**	H		H	H	H		H	H		H
Mgobezeleni	**L**		**L**			L	L						
Kosi	**H**	**H**	**H**	H			H	H		H			

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APPENDIX E: QUANTIFICATION OF ESTUARINE HABITAT RELATED ECOSYSTEM SERVICES

Authors: Sinegugu Mbense and Janine Adams, Nelson Mandela University

Estuarine habitat potential to supply ecosystem services was determined by assigning a value or score to each estuary based on the capacity to deliver that particular service. The scores/values were assigned differently for each service. The ecosystem services quantified include (Table E.1):

- Plant utilization including harvesting of mangroves, reeds and sedges, grazing, browsing by domestic animals
- Nutrient cycling
- Waste remediation
- Flood attenuation and coastal protection
- Carbon sequestration in mangroves, salt marsh and seagrass habitats
- Macrophyte habitat contribution to Nursery function
- Habitat for invertebrates

Table E.1 Quantification of Estuarine habitat related ecosystem services

Mangrove harvesting Data source/origin: Hoppe-Speer, S. 2013. Response of mangroves in South Africa to anthropogenic and natural impacts. PhD thesis, Department of Botany, Nelson Mandela Metropolitan University. 174 pp.	
0	No harvesting
1	Low to medium harvesting
2	Medium harvesting
3	High harvesting
4	Very High (Extensive) harvesting
Resources utilization/grazing – this was determined from the pressures sheet of the botanical database and includes reeds, sedge harvesting as well as grazing Data source/origin: Adams, J.B., Veldkornet, D., Tabot, P. 2016. Distribution of macrophyte species and habitats in South African estuaries. South African Journal of Botany 107: 5-11.	
0	No plant utilization
1	Low plant utilization
2	Medium plant utilization
3	High plant utilization
4	Very high plant utilization
Nutrient cycling Data source/origin: Determined according to estuarine type and retention time	
0	N/A
1	Low nutrient cycling for river mouths
2	Moderate nutrient cycling for permanently open estuaries
3	High nutrient cycling for TOCEs
4	Very high nutrient cycling for estuarine lakes
Waste remediation Data source/origin: Estuaries with large seagrass areas act as filters for pollutants and waste material (Beaumont et al. 2007).	
0	N/A
1	Low seagrass area < 10 ha – low level waste remediation
2	Medium seagrass area (10-100 ha) – moderate waste remediation
3	High seagrass area > 100 ha – high waste remediation
4	Very high seagrass area (> 1000 ha) – very high waste remediation

Coastal protection/Flood attenuation Data source/origin: Determined according to salt marsh and mangrove area	
0	No salt marsh and/or mangrove area
1	Low salt marsh and/or mangrove area (< 50 ha)
2	Moderate salt marsh and/or mangrove area (50-100 ha)
3	High salt marsh, flood plain area and/or mangrove area (> 100 ha)
4	Very high salt marsh, flood plain and mangroves area (> 100 for salt marsh and mangroves)
Carbon sequestration Data source/origin: Ranks were determined according to Tier 1 assessment (Howard et al. 2014) for mangroves, salt marsh and seagrasses where the habitat area was multiplied by the carbon estimate for each habitat type (mangroves, salt marsh and seagrasses). Carbon stored was expressed in Megagrams carbon (MgC).	
0	No blue carbon stored
1	Small amounts of blue carbon (1-500 MgC)
2	Moderate/medium amounts (500-1000 MgC)
3	High amounts (1000-10 000 MgC)
4	Very high large amounts of blue carbon (> 10 000 MgC)
Macrophyte habitat contribution to nursery areas Data source/origin: Ranked based on macrophyte area	
0	No contribution (no salt marsh/seagrasses and mangroves)
1	Low contribution (low salt marsh/seagrass/mangrove area)
2	Moderate contribution (medium salt marsh/seagrass/mangrove area)
3	High contribution (high salt marsh/seagrass/mangrove area)
4	Very high contribution (Very high salt marsh/seagrass/mangrove area)
Habitats for invertebrates (e.g. mudprawn, crabs) Data source/origin: Ranked based on mudbank area	
0	Low salt marsh (1-50 ha) and low mudbank area(<10 ha)/Low mangrove (1-50 ha) and mudbank area (<10 ha)
1	Low salt marsh (1-50 ha) and moderate (10-50 ha) to high mudbank (>50 ha)/low mangrove (1-50 ha) and moderate (10-50) to high mudbank (> 50 ha)
2	Moderate salt marsh (50-90 ha) and moderate mudbank (10-50 ha)/Moderate mangrove (50-90 ha) and moderate (10-50 ha) mudbank
3	High salt marsh (> 90 ha) and moderate (10-50 ha) to high (> 50 ha) mudbank area/high mangrove (> 90) and moderate (10-50 ha) to high mudbank area (> 50 ha)
4	Very high salt marsh, mudbank and mangrove area

Sources

- Beaumont, N.J., Austen, M.C., Atkins, J.P., Burdon, D., Degraer, S., Dentinho, T.P., & Marboe, A.H. (2007). Identification, definition and quantification of goods and services provided by marine biodiversity: implications for the ecosystem approach. Marine Pollution Bulletin, 54(3), 253-265.
- Carbon sequestration data source: Howard, J., Hoyt, S., Isensee, K., Pidgeon, E., Telszewski, M. 2014. Coastal Blue Carbon: Methods for assessing carbon stocks and emissions factors in mangroves, tidal salt marshes, and seagrass meadows. Conservation International, Intergovernmental Oceanographic Commission of UNESCO, International Union for Conservation of Nature. Arlington, Virginia, USA.

APPENDIX F: QUANTIFICATION OF RESILIENCE TO FISHING

Authors: Stephen Lamberth (DAFF), Steven Weerts (CSIR), Lara van Niekerk (CSIR)

Estuary resilience to fishing pressure was derived from the size of the estuary and the degree of connectivity to the sea.

In their natural state, large permanently open estuaries are more resilient to fishing in comparison with small nearly permanently closed systems (fish in a barrel syndrome). Large systems (> 300 ha in open water) support a higher biomass of fish and generally have a diversity of habitats were fish can shelter from predators and fishers. Small systems (<100 ha in open water area) contain less biomass and are generally associated with less habitat diversity.

Permanently open estuaries can replenish fish by means of recruitment and migration through the mouth, while in contrast, closed systems contain easily depleted resources that can only be replenished if connectivity with the sea is re-established both spatially and temporally. The more disconnected the system is from the sea the less its resilience to fishing.

To reflect the above a High/Medium/Low rating was developed based on the matrix presented in Table F.1.

Table F.1 Quantification of estuary Resilience to fishing effort

Open water area	Mouth State (% Open)				
	100	99-75	75-50	50-25	25-0
>300	H	M	L	L	L
300-100	M	M	L	L	L
100-50	L	L	L	L	L
<50	L	L	L	L	L

APPENDIX G: QUANTIFICATION OF RELATIVE WASTEWATER ASSIMILATIVE CAPACITY (NATURAL RESILIENCE) (CSIR unpublished data)

Authors: Susan Taljaard and Lara van Niekerk, CSIR

In the context of this rating system, natural resilience refers to the relative ability of an estuary (i.e. compared with other estuaries) to assimilate biodegradable wastewater (e.g. domestic sewage with high organic and nutrient content) before triggering, for example eutrophication. While this is not a simple calculation, a key physical factor that determines resilience, is the volume of water in an estuary. This is based on the argument that, from a pure physical perspective, a larger "bucket" of water can assimilate a larger nutrient load, compared with a smaller "bucket", before some sort of threshold concentration would be reached. However, even a large "bucket" of water will reach a threshold under continuous nutrient loading unless there is some sort of "re-setting" or flushing mechanism. In the case of estuaries fluvial flushing (as influenced by river inflow volume proportional to estuary size and depth) and tidal flushing (as influenced by the state of mouth and whether a system is perched or not) are important "re-setting" mechanisms. Our approach therefore argues that a second key factors influencing natural resilience, in addition to volume, is the extent of fluvial and/or tidal flushing.

NOTE: Ratings refer to natural resilience, but existing wastewater loading may have "used" this resilience. Thus it is always critical to view this in the context of the present WQ condition.

Following the argument put forward in the approach relative resilience in estuaries are primarily determined by volume, and then modified by the extent of fluvial and/or tidal flushing.

To accurately determine the volume of an estuary requires detail bathymetric surveys, Also, at any time an estuaries volume is determined by factors such as the state of the mouth, tidal state and volume of river inflow. However, for the purposes of this strategic level assessment, it was assumed that the volume could be calculated roughly from the average area and average depth estimated for a particular system, i.e.:

Volume = Areas x depth

Based on the simple assumption that large volumes represent higher resilience, the following volume ranges were considered appropriate to rate resilience from 1 (low) to 5 (high) in Table G.1.

Table G.1 Criteria for the Relative Resilience Capacity Rating

RELATIVE RESILIENCE CAPACITY RATING	Volume (m^3)
5 (High)	$> 10^7$
4 (High/medium)	10^7-$5x10^6$
3 (medium)	$5x10^6$-10^6
2 (Medium/low)	10^6-10^5
1 (Low)	$< 10^5$

In order to quantify the influence of fluvial flushing as a modifier of resilience, mean annual runoff (MAR), volume and average depth of an estuary were used as proxies. First the MAR divided by the volume provided a rough estimate of the extent of fluvial flushing, i.e.:

MAR/Volume = Amount of times the volume of a system can be replaced in a year

It was further argued that the efficiency by which systems of comparable volume and MAR would be flushed is influenced by average water depth, i.e. shallower systems will typically be better flushed compared with deeper systems as a result of processes such as stratification. Based on this argument the proxies for fluvial flushing were allocated ratings in Table G.2.

Table G.2 Criteria for Fluvial flushing

RELATIVE RESILIENCE RATING	MAR/Volume	Depth (m)
5 (High)	>300	< 1
4 (High/medium)	100-300	2-1
3 (medium)	30-100	3-2
2 (Medium/low)	1-30	5-3
1 (Low)	<1	> 5

A second modifier of volume as a measure of resilience is tidal flushing. Here the average state of the mouth (expressed as the % mouth open), as well as the degree to which an estuary mouth was perched (i.e. indicator of the efficiency of the extent of tidal flushing in temporarily open/close estuaries) and length (i.e. indicator of efficiency of extent tidal flushing in permanently open estuaries) was used as proxies. These proxies were allocated relative resilience capacity ratings in Table G.3:

Table G.3 Criteria for adjusting the Relative Resilience Rating based on estuary length, perched or constricted inlet, and degree of connectivity to the sea

RELATIVE RESILLIENCE RATING	LENGTH (M) (PERMANENTLY OPEN)	PERCHED/CONSTRICTED (TEMPORARILY OPEN/CLOSED)	% MOUTH OPEN (TEMPORARILY OPEN/CLOSED)
5 (High)	<1000	Non-perched	
4 (High/medium)	1000-5000		**>75**
3 (medium)	5000-10000	Semi-perched	**75-50**
2 (Medium/low)	10000-30000		**50-25**
1 (Low)	>30000	Perched//constricted	**<25**

The index comprises a number of incremental steps to estimate relative resilience. Look-up tables to combine the various factors were derived from own experience, as well as incremental refinements using case studies:

1. Derive an overall fluvial flushing modifier using the following look-up table:

FLUVIAL FLUSHING MODIFIER					
Depth (m)	MAR/Vol				
	< 1 [1]	1-30 [2]	30-100 [3]	100-300 [4]	>300 [5]
>5 [1]	**1**	**1**	**2**	**3**	**5**
5-3 [2]	**1**	**1**	**2**	**3**	**5**
3-2 [3]	**1**	**2**	**3**	**4**	**5**
2-1 [4]	**1**	**2**	**3**	**4**	**4**
<1 [5]	**1**	**2**	**3**	**4**	**4**

2. Derive an overall tidal flushing modifier using the following look-up table:

Length (m)	TIDAL FLUSHING MODIFIER (permanently open)
<1000 [5]	5
1000-5000 [4]	5
5000-10000 [3]	4
10000-30000 [2]	3
>30000 [1]	2

TIDAL FLUSHING MODIFIER (temporarily open/close)					
% open	0 [5]		0.5 [3]		1 [1]
>75 [1]	5		3		1
75-50 [2]	4		2		1
50-25 [3]	3		1		1
25-0 [4]	1		1		1

3. A Combined flushing modifier is calculated as follows:

   Average (Fluvial Flushing modifier, Tidal flushing modifier), except in systems with % mouth open <25%, then assume modifier as 1

4. An average of the above modifiers (flushing and tidal) were then combined with the primary driver (i.e. volume) to obtain the Relative Resilience of an estuary as follows:

RELATIVE RESILIENCE					
Combined Flushing Modifier	Volume (m^3)				
	$< 10^5$ [1]	10^6-10^5 [2]	$5x10^6$-10^6 [3]	10^7-$5x10^6$ [4]	$> 10^7$ [5]
1	1	1	1	1	1
2	1	1	2	2	3
3	1	2	3	3	4
4	2	3	4	4	5
5	3	4	4	5	5

The modifier represents the extent of "re-setting", where a rating of 5 indicate low residence time as a result of good flushing (i.e. "frequent re-setting") and a rating of 1 reflect long residence time of water as a result of weak flushing (i.e. infrequent "re-setting"). Therefore, a system with a large volume, and high average flushing modifier score, are considered to have a higher resilience compared with a system of similar volume with lower average flushing, that is:

Volume (rating 5) with Flushing modifier (Rating 5) = Relative Resilience (Rating 5)
Volume (rating 5) with Flushing modifier (Rating 1) = Relative Resilience (Rating 1)

Similarly a system of small volume and low average flushing modifier score will have low resilience compared with a similar volume system that has higher average flushing, that is:

Volume (rating 1) with Flushing modifier (Rating 5) = Relative Resilience (Rating 3)
Volume (rating 1) with Flushing modifier (Rating 1) = Relative Resilience (Rating 1)

APPENDIX H: QUANTIFICATION OF SUITABILITY FOR USE 0F INSTREAM MARINE AQUACULTURE

Authors: Stephen Lamberth (DAFF) and Lara van Niekerk (CSIR)

Global experiences have demonstrated how marine aquaculture practices have impacted on wildlife (mammals, birds and reptiles), caused habitat destruction or alteration, resulted in organic and nutrient pollution and impoverishment of biodiversity (Cowley et al. 1998) (Table H.1).

Table H.1 Potential impact of marine aquaculture on South African Estuaries (Source: Cowley et al. 1998)

KEY CONCERN	POTENTIAL IMPACT
Habitat destruction	• habitat loss of resident and/or endemic aquatic fauna; • habitat loss or alteration of terrestrial wildlife; • impoverishment of biodiversity; • destruction of nurseries and feeding guilds for estuarine biota; • reduction of natural fisheries production; • alteration of production patterns from detritus-based to plankton-based food pathways (i.e. estuarine food-chain alterations); • alteration of shoreline configuration and coastal erosion patterns; • increased sediment load of coastal waters; • interference with estuarine freshwater inputs (salinization); • release of oxidizable particles from the soil into the water column; and • many secondary effects (e.g. fish kills) from the dissolution of strong acidic or basic materials • particularly in areas with high acid sulphate soils.
Impact on wildlife (e.g. mammals and birds)	• physical damage caused by protective or preventative devices; • accidental entrapment in anti-predator nets and fencing; • disturbance by the farming activities and scaring devises; • deliberate killing and live trapping by farmers; and • disruption of natural habitats and ecosystems by the establishment and operation of farms.
Degradation of Water quality	**Nutrient/enrichment** • depletion of oxygen levels in the water column; • sediment accumulation, including anoxic sediments; • production of toxic gases (e.g. hydrogen sulphide); • alteration or modification of nutrient cycles; • increased nitrogen and phosphorous levels in the surrounding water column; • alterations to the natural composition of macro- and micro-nutrients; • changes in the composition and abundance of phytoplankton populations, including • the production of toxic algal blooms; • changes in the abundance and diversity of bacterial populations which increase the • risk of disease outbreaks; and • loss of both cultured and natural organisms. **Toxins** • antibiotics could be transferred to wild fish and shellfish in the vicinity of cage/pen farms using medicated feeds; • the continued use of antibiotics and/or their persistence in the sediments could lead to the proliferation of antibiotic-resistant pathogens which may complicate disease treatments; and • the presence of antibiotics in the bottom sediments may affect natural bacterial decomposition processes and hence influence the ecological structure of benthic microbial communities.

KEY CONCERN	POTENTIAL IMPACT
Introduction of exotic species	• escapement into the wild; • establishment of viable reproducing populations; • competition with indigenous species for food and space; • displacement or extinction of indigenous species (impoverishment of biodiversity); • habitat alteration or destruction; • introduction of associated organisms; and • transmission of diseases.

The suitability of individual estuaries for the use of marine aquaculture was derived from their physical features (Cowley et al. 1998). Four criteria were identified as critical for the support of Marine Aquaculture ventures in South Africa, namely (Table H.2):

- Mouth state;
- Large open water areas;
- Average depth; and
- Important nursery function.

Additional criteria that should be considered in the development of future Aquaculture facilitates include:

- The suitability of the system from a water quality perspective. Deteriorating/poor water quality in a number of estuaries can result in the development of anoxia/hypoxia during the low flow/closed periods.
- Aquaculture products can pose potential human health hazards. For example, organisms cultured in waters with high *Escherichia coli* counts are not suitable for human consumption. Other health risks include the transmission of water-borne diseases (e.g. typhoid, hepatitis and cholera) and the contamination of cultured stock by toxins (Cowley et al. 1998).
- Many alien cultured species are known vectors and/or intermediate hosts of pathogens and parasites, e.g. Chinese mitten crab is host to the sometimes fatal human lung fluke the latter which already has transferred to the indigenous freshwater crab (*Potamonautes*) populations in KZN.
- Marine Aquaculture represents a severe risk to biodiversity conservation (Table H.1) and therefore should not be considered in systems targeted for conservation (Cowley et al. 1998).

Overall very few South African estuaries key out as suitable for Marine Aquaculture.

Table H.2 Quantification of the Suitability of individual estuaries for Instream Marine Aquaculture

CRITERIA THAT WOULD MAKE AN ESTUARY SUITABLE FOR MARINE AQUACULTURE		MOTIVATION
1	Is the mouth of the estuary 100% open?	Marine Aquaculture ventures produce waste and require good circulation to optimise production and transport waste away from the aquaculture facility. If the mouth of an estuary closes waste accumulates and oxygen levels decline.
2	Is the open water area of the estuary greater than 200 ha?	Marine Aquaculture facilities require space for the deployment of structures such as rafts and cages. Facilities need to be away from high levels of recreational activities and not be easy to reach from land to reduce the risk of damage to structures and theft of produce. In turn, aquaculture structures represent a navigational risk to boating activities.
3	Is the average depth greater than 5 m?	Industry has set a minimum requirements of 5 m depth for instream marine aquaculture. This is to allow for the deployment of rafts and gauges (2-4 m) below the surface at low tide. In addition to the structural depth requirements, an additional 1 to 2 m clearance is also required to ensure that the cultured organisms are not suspended in their own waste that accumulates below rafts/gauges and deplete water of oxygen. Very few South African estuaries have an average depth of 5 m in their lower and middle reaches.
4	It is not an important nursery for fisheries production?	Marine Aquaculture represents a severe risk to the nursery function of estuaries (Table H.1), examples include: • Genetic contamination through interbreeding with wild stock; • Parasites and Pathogens (e.g. Epizootic Ulcerative Syndrome, human lung flukes); • Introduction of invasive alien species Aquaculture should therefore not be considered in important nursery systems.
CRITICAL DATA SETS THAT SHOULD BE VIEWED IN CONJUNCTION WITH EXISTING/PLANNED AQUACULTURE VENTURES.		
1	Is the current estuary water quality of a sufficiently good quality that it can support the culturing of food?	• Water Quality Health as determined by the Estuary health Index as a proxy for the development of anoxia/hypoxia during the low flow/closed periods. • Wastewater Discharges into estuaries.
2	Marine Aquaculture and conservation are not mutually compatible in estuaries	Marine Aquaculture represents a severe risk to biodiversity protection (Table H.1) and therefore should not be considered in systems targeted for conservation. Two layers that should be viewed in conjunction with the Aquaculture layers are: • Estuaries under Formal Protection. • Priority estuaries as identified in the National Estuary Biodiversity Plan 2011 in the National Biodiversity Assessment 2011

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