COASTAL AND MARINE BIODIVERSITY PLAN FOR KWAZULU-NATAL, SOUTH AFRICA

Spatial Priorities for the Conservation of Coastal and Marine Biodiversity

SeaPLAN Technical Report

2012

SCIENTIFIC SERVICES
EZEMVELO KZN WILDLIFE
steering conservation through science

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1 Acronyms and definitions

1.1 Acronyms

EEZ	Exclusive Economic Zone
Ezemvelo	Ezemvelo KZN Wildlife
EIA	Environmental Impact Assessment
GIS	Geographical Information System
ICMA	National Environmental Management: Integrated Coastal Management Act No. 24 of 2008
IDP	Integrated Development Plan
KZN	KwaZulu-Natal
MLRA	Marine Living Resources Act No.18 of 1998
MPA	Marine Protected Area
ORI	Oceanographic Research Institute
SST	Sea surface temperature
3D	Three Dimensional
NBSAP	National Biodiversity Strategy and Action Plan
NEMA	National Environmental Management Act No. 107 of 1998
NEEMPAA	National Environmental Management: Protected Areas Act No. 57 of 2003
NSBA	National Spatial Biodiversity Assessment
NRF	National Research Foundation
ACEP	African Coelacanth Ecosystem Programme
WWF	WorldWide Fund for Nature (check in internet how to spell WorldWide)
WSSD	World Summit for Sustainable Development
CBD	Convention on Biological Biodiversity

1.2 Definitions

Biodiversity - "Biological diversity" or "biodiversity" is a measure of the variety of organisms present in different ecosystems. This can refer to genetic variation, ecosystem variation, or species variation (number of species) within an area, biome, or planet.

Biodiversity features – these include the spatial delineation (mapping) of species' distributions and habitats, and ecological processes, for example, macro-ecological corridors, oceanographic fronts and eddies.

Biodiversity Assessment – is a measure of the amount (and thus proportion) of each biodiversity feature within protected areas. This measure allows one to calculate if biodiversity targets (see below) for each feature are met within existing protected areas, and if not, what the shortfall is. Shortfalls require additional protection (and options for the areas for additional protection are identified by the conservation plan).

Biodiversity Plan (defined here as a systematic conservation plan or SCP) - a systematic and transparent method, using software tools, to identify options for additional areas for protection. These additional areas are required to ensure that all biodiversity targets are met within protected areas. We used biodiversity and socio-economic data in our analyses (i.e. we tried to meet all biodiversity targets while avoiding conflicts with areas important to other stakeholders).

Irreplaceability map - produced using C-Plan or Marxan software, this map gives a value to each planning unit (PU, see below) depending on the contribution it makes to achieving feature targets.

Cost Layer – a map of the spatial extent, and sometimes also intensity, of the different pressures on marine biodiversity.

C-Plan – systematic conservation planning software (Pressey *et al*. 2005**)**

Marxan – systematic conservation planning software (Ball and Possingham, 2000**)**

Critical Biodiversity Area - Irreplaceable (CBA irreplaceable) for the purposes of this report are areas based on the **C-Plan or Marxan** Irreplaceability analyses, and have an irreplaceability value between 0.8 - 1.0 in C-Plan and between 80-100% in Marxan. These planning units represent areas of significantly high biodiversity value and in some cases are the only localities for which the conservation targets for one or more of the biodiversity features can be achieved i.e. there are few, or no, alternative sites available.

Critical Biodiversity Area - Optimal (CBA optimal) areas are areas identified by the Marxan analyses and represents the best option, out of a potentially larger selection of options, of a selection of planning units that meet biodiversity targets. The CBA optimal areas are the same as the "Best" solution output from Marxan, minus the **CBA irreplaceable** areas described above.

Decision Support Layers – GIS maps used in C-Plan (and Marxan) to allow the user to manually choose between different options (solution outputs) from the software.

Planning Domain - this refers to the entire area under consideration within a planning strategy. In the KwaZulu-Natal Province, the planning domain of the marine biodiversity plan extends to the Exclusive Economic Zone (EEZ).

Planning Units - once biodiversity patterns and processes have been spatially delineated, the study area is subdivided into a set of relevant planning units. Each planning unit contains information on the amounts (areas) of biodiversity features contained within its extent. Presence data and/or other species-specific data can also be attributed to planning units, as can a calculation of its cost (the cost value previously described).

Pressures – this refers to the stresses that human activities induce on the environment and these area mapped according to the areas in which these stresses occur.

Target (biodiversity) - A systematic conservation plan relies on the definition of biodiversity targets (quantitative expressions of a region's conservation goals), which define how much of each biodiversity feature (e.g. habitat types, species), and biodiversity processes, should be included within protected area boundaries (existing and proposed).

Target (protected area) - the protected area target is an area based target and is the amount of area needed to be conserved within a protected area. These targets are time based and dependant on laws and legislation such as the International agreements by the *Convention on Biological Biodiversity* which sets a ten percent target of marine systems to be conserved by 2020. The areas, in which these protected area targets should be met, should be determined by a systematic conservation plan and the related biodiversity targets of the features for the area, thereby focusing conservation efforts in the most efficient areas to meet a number of biodiversity needs.

Selection frequency - Selection frequency is produced from the summed solution output of the MARXAN analysis – this output is equal to the number of times a planning unit was chosen during the MARXAN analysis.

2 Acknowledgements

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- Council for Marine Geoscience (CMG)
- Council for Scientific and Industrial Research (CSIR)
- University of Cape Town (UCT)
- South African Institute of Aquatic Biodiversity (SAIAB)
- University of Reunion Island
- Stakeholders, including representatives from NGOs, fisheries associations, government departments, etc.

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Summary

This report provides a summary of the updated products of the KwaZulu-Natal (KZN) Coastal and Marine Biodiversity Plan previously referred to as the SeaPLAN project, and aims to 1) provide a systematic framework for assessment of the status of biodiversity protection in the province of KZN, and 2) enable planning for marine biodiversity protection by identifying spatial priorities for ongoing and future marine conservation efforts.

South Africa's environmental legislation (various acts, conventions and guidelines) provide the legal framework within which the Plan was developed. Legislation states that biodiversity conservation planning must be undertaken to facilitate the integration of human and ecosystem requirements in a sustainable manner. The marine plan is a critical component of the planning process required to bring about this integration. Relevant outcomes of the Plan are: 1) to provide guidance to inter alia the provincial and national coastal management programmes required in terms of Integrated Coastal Management Act; and 2) contribute to the KZN Provincial Biodiversity Plan (which has terrestrial, estuarine and fresh water components). This integrated Provincial Plan in turn supports legal requirements for protected area expansion, the identification of critical biodiversity areas, the development of bioregional plans, and guidance for development.

The Coastal and Marine Biodiversity Plan includes both the coastal (shoreline and nearshore) and offshore environments of the KZN Province (vegetation line on the shore, to Exclusive Economic Zone offshore). It maps the location and extent of existing marine protected areas (MPAs), as well as that of biodiversity features (habitats and species) and oceanographic processes, and human activities. To date, it is the most complete and detailed exercise of this nature in South Arica's marine environment. Using systematic conservation planning (SCP) principles, and SCP software (C-Plan and Marxan), it assesses the current state of protection of biodiversity, and identifies key areas that require increased protection within existing protected areas as well as areas outside of these protected areas that are important for future conservation management actions.

An inclusive stakeholder engagement process was undertaken in development of this Plan. The project was led by the Scientific Services division of Ezemvelo KZN Wildlife in collaboration with a large number of scientists and students, consultants, institutions, government authorities, NGOs (Non-Governmental Organisations), marine stakeholders, and the general public. The process began in the late 1990s, with systematic field collection and collation of data required, and this project pioneered all further marine conservation planning approaches and projects in South Africa. One of the advantages and aims of this Plan is that it is an adaptive plan, which is developed and owned and updated and implemented by Ezemvelo, and contributed by the conservation agency officially to national planning processes for marine conservation priorities. These are considered key elements of success for planning initiatives to move from plans to implementation.

The value of an adaptive (constantly evolving) marine biodiversity plan for the KZN Province is the following:
1. It provides a scientific framework and transparent process to inform protected area expansion;
2. It guides decisions concerned with types of management interventions (e.g. protected areas versus temporally closed fishing areas);
3. It forms a starting point to build upon in an adaptive management process (the authority responsible for planning in the region is the developer, custodian and implementer of the plan)
4. It helps to identify data gaps in the marine environment, for example, more (and new) species data are required along the shoreline and the offshore environment, and a more accurate and complete rocky reef map is required.
5. It furthers our understanding of marine ecosystems and the human activities that depend on these ecosystems.

The final spatial product of the Plan is a map of Focus Areas, which are made up of Critical Biodiversity Areas (CBAs) that are either "irreplaceable" (there are no other options in space), or "optimal" (there may be other options in space but these are the best options given a number of requirements). These Focus Areas are the ones that the SCP software identifies when asked to meet biodiversity targets that are set by the user. Each biodiversity feature mapped and used in this Plan, had a particular target (e.g. percentage area of its extent, or number of locations of occurrence of a species), and the software searches for places in the study area that can meet these targets in the least amount of space. This is termed efficiency, and refers to the need to trade off conservation areas with areas

important for other type of uses (e.g. fishing, mining, coastal development). The software also tries to meet biodiversity targets in areas that are not very important to other user groups, and this is termed cost-avoidance.

The Focus Areas of the Plan are currently being used to guide South Africa's National Protected Area Expansion Strategy. Although the KZN plan is underpinned by a systematic process, its results cannot be used in isolation from other plans. At a National level there is a need to increase the protection in the Natal Bioregion as well as in the offshore areas. The KZN CBAs map will thus be used, together with expert knowledge, focused surveys or extra information available within each focus areas, to help determine exact boundaries and zonation of any new proposed MPA. The CBA map will also be used to assess a number of proposed MPAs that have been put forward by stakeholders within the Province, to determine if these areas are suitable to take forward, and then to determine suitable boundaries and zonation for these areas. Any new proposed MPA is required to follow a number of legal steps and a stakeholder consultative process is required by law before MPAs can be approved at a National level.

The KZN Marine Biodiversity Plan is scheduled to be updated every five years with any new information that becomes available. Future analyses hope to have sufficient information to produce separate benthic and pelagic biodiversity plans which would help to streamline conservation efforts and allow for more specific protection and management for particular habitats, species and processes, with the use of a suite of management tools such as MPAs, temporally closed areas, harvesting quotas, fishing gear restrictions, bycatch management, improved industry standards for particular activities, etc.

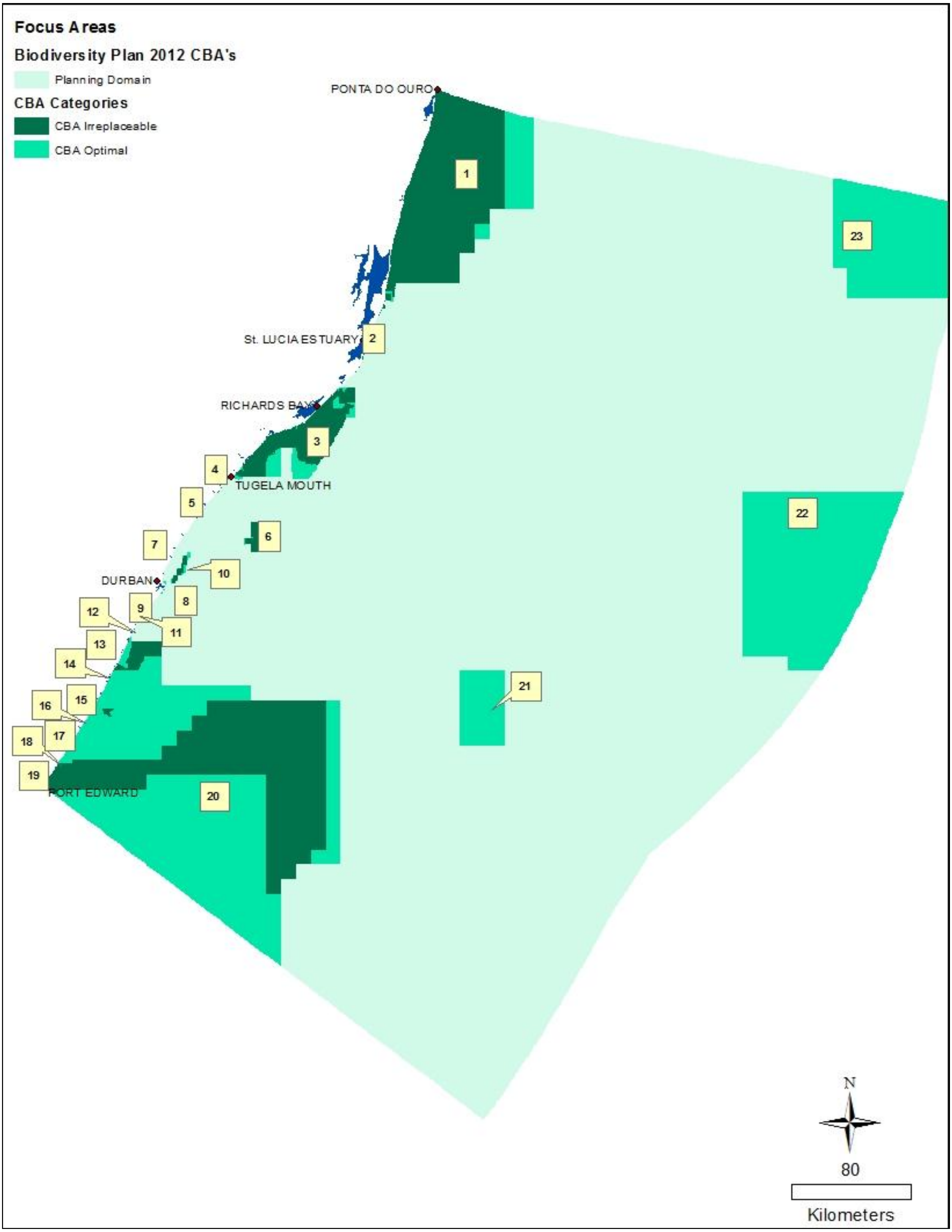


Figure 1: The map of critical biodiversity areas developed from the KZN biodiversity plan.

3 Background

3.1 Importance and benefits of coastal and marine biodiversity

The oceans cover over 70 percent of the Earth's surface and dominate the living space on earth. They account for 98 percent of the potentially habitable volume, the majority of which is represented by deep ocean water (Monterey Bay Research Institute Report, 2008). Ecosystem services provided by the marine environment are one of the greatest contributors to human wellbeing (Costanza et al.,1997) and provide us with provisioning services such as oxygen, food, water and sustainable energy; regulating services such as climate control and coastal protection against extreme weather events; and cultural services such as recreational, transport, aesthetic and spiritual benefits.

In terms of provisioning services, almost 30% of South Africas population lives within 60 kilometres of coast (CLA Report, 2010) and the coastal resources contribute towards US$5.7 billion toward the South African economy (Turpie and Wilson, 2011). Seafood acts as an important source of protein for many communities living within the coastal region, as well as attracting recreational users to the coastal environment. Fisheries within South Africa were valued at approximately R7 billion in 2010 and produce between 600 000 – 800 000 tons of food per year (DAFF Annual Report, 2011/12). The Indian Ocean off of the coast of KZN is less productive in terms of commercial fishing than the Atlantic Ocean waters situated on the West coast of SA, but has a large diversity of marine organisms such as squid, linefish and a wide range of intertidal resources which provide important sources of food and livelihoods for coastal communities. Within KZN, subsistence and recreational fishers are responsible for the harvesting of intertidal species such as mussels, oysters, crabs and crayfish, while many species of fish are also caught along the coastline by recreational shore anglers and spear fishers. Commercial fishers operate offshore and prawn trawling occurs along the continental shelf within the KZN Bight (between Durban and Richards Bay).

Marine ecosystem regulate climate by producing oxygen, and regulating the amount of CO2 in the atmosphere by providing an exchange surface for atmospheric carbon through a number of biological and physical processes. Marine ecosystems thus form an essential part of the global carbon cycle (http://www.research.noaa.gov/climate/t_carboncycle.html). The coastal environment also protects us from natural disasters such as floods, storms, and disease (Worm et al, 2006).

Cultural services add to the socio-economic benefits of the marine environment and include non-consumptive activities such a snorkelling, scuba diving, whale watching and create tourism opportunities (Hilchey, 2003). Coastal tourism is the fastest growing sector of the global tourism industry while scuba diving and other nature-based tourism activities contribute significantly to the global and national economy.

3.2 Protected Area Targets

Marine and coastal ecosystems currently face many anthropogenic pressures. Unsustainable extractive resource use, together with pollution, invasive species, habitat degradation and climate change, are some of the pressures affecting marine systems (Leslie, 2005). The need to protect representative as well as adequate examples of Biodiversity **features** (Banks et al., 2005) has thus been recognised worldwide as an essential task (WSSD, 2002), and International agreements such as the Convention on Biological Biodiversity (CBD) have been developed to promote increased protection of both marine and terrestrial ecosystems. In 2007, the CBD Conference of the Parties (COP) agreed to a target of 10% of country's oceanic regions to be protected within marine protected areas (MPAs) by 2012. In South Africa the National Marine Protected Expansion Strategy (NPAES) has been developed in order to address these targets at a National level and aims to expand the protected area network in the most cost effective way for ecological sustainability and climate change adaptation (NPAES, 2009). The NPAES targets for marine protected area expansion are set per marine bioregion: inshore and offshore bioregions have targets of 25% and 20% respectively, to be achieved over a twenty year period.

Protected area targets are thus expressed as the percentage of a country's total terrestrial or marine estate that needs to be protected (within protected areas) within a specified amount of time, and in South Africa these target are defined in National policy. Current levels of marine protection in South Africa, particularly in the offshore environment, fall short of targets for many bioregions. It is thus necessary to identify additional areas for protection, but these areas cannot be randomly placed in the environment but rather need to be placed in areas that conflict as little as possible with other stakeholder activities, while still being representative of the full suite of biodiversity features in any given bioregion. Fortunately, a number of software packages exist that offer this functionality and can be used to identify additional areas for protection.

3.3 Biodiversity targets

Biodiversity targets are expressed as the percentage of each biodiversity feature that requires protection within a protected area. Different features often have different targets (e.g. highly threatened, rare habitats or species often have higher targets than less threatened, widely distributed habitats or species). A biodiversity target is theoretically defined as the minimum percentage of a feature that is required to ensure its adequate ecosystem functioning and persistence into the future. Biodiversity targets are used in conservation plans to assess how well the current protected area estate is doing (with respect to meeting biodiversity targets), and to plan where additional protected areas need to be placed, or where other forms of protection need to be undertaken (e.g. seasonal closures).
Very little research has been done in marine systems to determine ecologically sensible targets for protection. International policy statements issued by the World Summit on Sustainable Development (United Nations 2002) and the World Parks Congress (IUCN 2004) set a target for governments to protect 20–30% of all marine habitats under their jurisdiction (i.e. within their EEZ) by 2012. This value is based on the results of fishery model studies which indicate that the risk of a fishery collapsing increases dramatically if spawner biomass (the mass of adult fish above the age of sexual maturity) falls below 25% of its unexploited biomass. It has been suggested however, that marine protected area targets should be extended to 30% where there is poor fishery management in exploited areas (Plan Development Team 1990). Consequently, targets of 20 to 30% were used for most of our biodiversity planning analyses.

3.4 Historical context of MPAs and marine conservation in KZN

The establishment of MPAs in KZN (as in the rest of the world) has fallen well behind the proclamation of terrestrial protected areas (Robinson 1977). Nevertheless, the rapid increase in KZN's coastal population and the mounting demands made on the marine environment led to the realisation of the need to establish a system of MPAs along the coast during the late 1960s (Grindley 1975). The first progress made in this regard was the establishment of the St Lucia Marine Reserve (Cape Vidal to White Sands just north of Sodwana) on the KZN north coast and the small Trafalgar Marine Reserve (Marina Beach to Palm Beach) on the KZN south coast in 1979 (Figure 2: Marine Protected Areas of KwaZulu-NatalFigure 2). The St Lucia Marine Reserve covers an area of approximately 441 km^2 and stretches 3 nm offshore, while the Trafalgar Marine Reserve is the smallest MPA offshore of KZN covering an area of 8.1 km^2 and stretching approximately 4.5 km along the coast and 1 nm offshore. This was followed by the proclamation of the Maputaland Marine Reserve, adjacent to the St Lucia Marine Reserve in 1986 resulting in the entire coastline from Cape Vidal to the RSA/Mozambique border falling into one contiguous MPA (~145 km stretching three nautical miles out to sea and covering an area of approximately 825 km^2). At the time this formed the largest MPA in South Africa and it was subsequently incorporated into the iSimangaliso Wetland Park, South Africa's first World Heritage Site in 2000. The only other MPA that has subsequently been established along the KZN coast was the Aliwal Shoal MPA proclaimed in June 2004 stretching from the Umkomass River to the Mzimayi River just south of Rocky Bay and extending seven kilometres out to sea and covering approximately 125 km^2. All four of the above mentioned MPAs have been proclaimed under Section 43 of the Marine Living Resources Act (Act 18 of 1998) and the two MPAs within the iSimangaliso Wetland Park have also been proclaimed under the World Heritage Convention Act (Act 49 of 1999). It is important to note that the Pondoland MPA (currently South Africa's largest continental MPA in terms of surface area ~900 km^2) was also proclaimed in June 2004 just south of the KZN/Eastern Cape border stretching from the Mzamba River to the Umzimvubu River at Port St Johns. Also of relevance is the recent proclamation of the Ponto do Ouro Partial Marine Reserve in Mozambique extending northwards from the RSA/Mozambique border to Inhaca Island.

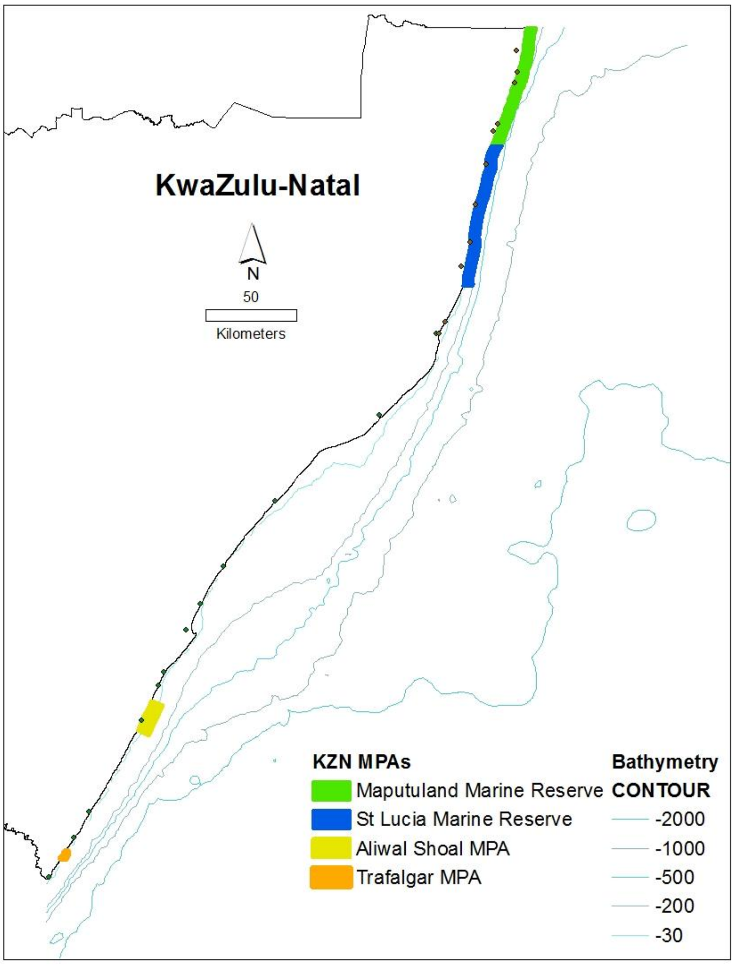


Figure 2: Marine Protected Areas of KwaZulu-Natal

3.5 Zonation

Marine protected areas are divided into different use zones which define the types of activities that may occur within them. Different zones thus provide different levels of protection to the biodiversity features within them and these levels of protection should be considered when proclaiming new MPAs. South Africa currently has 23.2% of its coastline within MPAs, however, only 9% is zoned as no-take (no extraction of resources permitted). MPAs can often be high nodes of exploitation (e.g. more shore angling inside than outside the MPA) owing to the marine resources found within them, and thus no-take areas are essential to provide adequate protection to the species and habitats within them. Other types of zones are often used to manage user conflict. There is currently no national standard for MPA zonation, but Ezemvelo has proposed a zonation scheme based on the categories A, B and C described below (Figure 3). Zone activities are described in Appendix 1.

Category A: MPA A-Zone, otherwise known as a Sanctuary Area or no-take zone. No extractive activities are allowed in these zones.

Category B: MPA B-Zone or Restricted Area. Limited extraction of resources is allowed.

Category C: MPA C-Zone or Controlled Use Area where controlled extractive activities such as fishing and intertidal harvesting may take place.

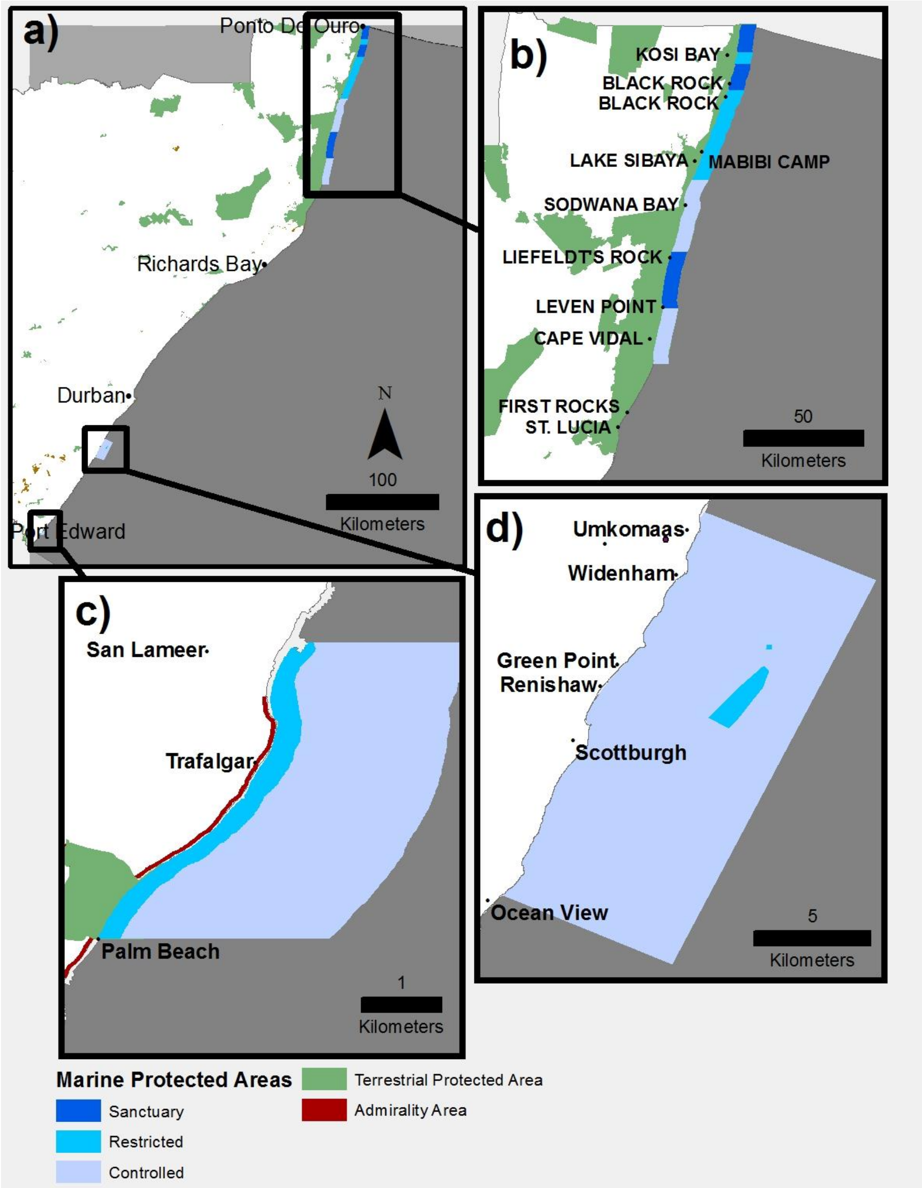


Figure 3: The current MPA network, MPA categories and other types of protection in KZN: iSimangaliso Marine Protected Area (b), Trafalgar (c) and Aliwal Shoal Marine Reserve (d). The EEZ is shaded in grey. Note the different scales.

3.6 Policy and Legislation

The loss of biodiversity is a worldwide issue in both the marine and terrestrial environments and the effect of this decline on the quality of human life requires urgent attention (WPC, 2003). South Africa is committed to the protection of marine biodiversity, ecological integrity and the sustainable use of resources. These commitments have been ratified under several international conventions and agreements and are embedded in South Africa's national legislation and policy. Brief details of this legislative framework are provided below.

International

International agreements such as the *Convention on Biological Biodiversity* (CBD) have been developed in order to focus conservation efforts in the protection of both marine and terrestrial habitats. As a signatory of the CBD South Africa is committed to develop and implement a strategy for the conservation, sustainable use and equitable sharing of the benefits of biodiversity. In 2010 an updated Strategic Plan for Biodiversity with associated targets for 2011-2020 (Aichi Biodiversity Targets) was adopted by the COP (Decision x/2 CBD). For the marine environment the following targets are of particular relevance: (i) By 2020 all fish and invertebrate stocks and aquatic plants are managed and harvested in a sustainable manner based on an ecosystem approach. (ii) By 2015 pressure on coral reefs and other vulnerable marine ecosystems are minimised and the integrity and functioning of these ecosystems are protected. (iii) By 2020 ten percent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved via protected areas and other applicable mechanisms and integrated into the wider seascapes (Aichi biodiversity Targets number 6, 10 and 11, Decision x/2 CBD).

The *Convention on Migratory Species (Bonn Convention)* was developed for the conservation of animals that migrate across National borders and commits South Africa to maintain the habitats utilised by migratory species, and to preserve the biological process of these habitats. South Africa is the range limit for many of the migratory species including the Palaeoarctic waders (birds) and Antarctic species such as the humpback and southern right whales and other birds such as the Arctic tern (http://www.unep-wcmc.org/cms).

The *Nairobi Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Western African Region* and associated protocols: (i) Protocol for the Protection of the Marine and Coastal Environment of the Western Indian Ocean from Land-Based Sources and Activities and (ii) Protocol Concerning Protected Areas and Wild Fauna and Flora in the Eastern African Region, commits South Africa to coordination of efforts to protect, manage and sustainably develop the East African coastal and marine environment. South Africa must also endeavour to protect and preserve rare or fragile ecosystems as well as rare, depleted, threatened or endangered species and their habitats.

The Johannesburg Plan of Implementation, which was an outcome of the 2002 World Summit for Sustainable Development (WSSD), includes a number of targets for the management of oceans, including the implementation of the ecosystem approach in managing fisheries and the establishment of representative marine protected area networks by 2012.

The fifth World Parks Congress (2003) built on the international commitment made by the WSSD Plan of Implementation in terms of marine and coastal issues. The Durban Action Plan (*Durban Action Plan,* IUCN, 2005) highlighted concern over the lack of protection for marine systems being because less than 1% of the ocean is protected, and set out that by 2012 representative networks of marine and coastal protected areas, based on an ecosystem or landscape-scale protected area planning approach, must be in place.

Domestic

The *Constitution of South Africa Act No. 108 of 1996* sets out South African citizen's environmental rights and requires the prevention of pollution, promotion of conservation and environmental sustainable development.

> *Section 24 "Everyone has the right-*
> *(a) to an environment that is not harmful to their health or well-being; and*
> *(b) to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that-*
> *(i) prevent pollution and ecological degradation*
> *(ii) promote conservation; and*
> *(iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development."*

The Constitution further sets out in Schedule 4 that the environment and nature conservation is a concurrent competency between the National and Provincial government. In KwaZulu-Natal, Ezemvelo is the mandated provincial authority to conserve biodiversity in the province under the KZN Nature Conservation Management Act, Act 9 of 1997.

The *National Environmental Management Act No. 107 of 1998* (NEMA) provides the overarching legislative framework for environmental governance in South Africa. The principles set out in this Act inform many other pieces of legislation and development of policy. NEMA's Chapter 2 principles apply to all organs of state that may significantly affect the environment and requires that the principles are used by these organs of state as a guideline when undertaking their functions. The four principles outlined below could be said to be of particular relevance when considering the management and protection of coastal and estuarine systems and biodiversity in general:

- Sensitive, vulnerable, highly dynamic or stressed ecosystems, such as coastal shores, estuaries, wetlands, and similar systems require specific attention in management and planning procedures, especially where they are subject to significant human resource usage and development pressure.
- A risk-averse and cautious approach must be applied, which takes into account the limits of current knowledge about the consequences of decisions and actions.
- Global and international responsibilities relating to the environment must be discharged in the national interest.
- The environment is held in public trust for the people, the beneficial use of environmental resources must serve the public interest and the environment must be protected as the people's common heritage.

The *National Environmental Management Biodiversity Act No. 10 of 2004* (NEMBA) sets out the requirements for the management of biodiversity in South Africa. NEMBA, amongst others, requires that provinces develop conservation management plans in line with national guidelines, as well as bioregional plans that must set out the biodiversity components in each region together with the effective management of this biodiversity.

The National Environmental Management Protected Areas Act No. 57 of 2003 (NEMPAA) provides for the declaration and protection of ecologically viable areas that are representative of South Africa's natural biodiversity. Marine protected areas can be declared in terms of NEMPAA, but have in general in the past been declared in terms of the Marine Living Resources Act No. 18 of 1998.

The *National Environmental Management: Integrated Coastal Management Act No. 24 of 2008* (ICMA) aims to establish a system of integrated coastal and estuarine management to promote the conservation of the coastal environment and maintain the coastal landscapes and seascapes, as well as to ensure sustainable development and use of natural resources. Features of ICMA include the declaration of special management areas in order to facilitate: objectives of coastal management programmes; management of coastal resources; sustainable livelihoods; and the conservation, protection or enhancement of coastal ecosystems and biodiversity (Section 23 of ICMA). Development of national, provincial and municipal coastal management programmes that ensures an integrated and coordinated approach by all organs of state in all spheres of government, as well as by non-govermental organisations, the private sector and local communities (Section 44 to 49 of ICMA).

The *Marine Living Resources Act No. 18 of 1998* (MLRA) provides for the conservation of the marine ecosystem and the long-term sustainable utilisation of marine living resources. Such provisions include fisheries management areas which can be "any area of the South African waters" (Section 15 MLRA) and marine protected areas. Marine Protected areas may be declared (Section 43 of MLRA) for the protection of fauna and flora and the physical features on which they depend and to diminish any conflict that may arise from competing uses in the area. No person may remove or destroy any fauna (including fish) and flora, alter or destroy the natural environment nor carry on any activity which may adversely impact on the ecosystems within these Marine Protected Areas.

The Local Government: Municipal Systems Act No.32 of 2000 requires that each municipality compiles Integrated Development Plans (IDPs) which set out the planning framework for the municipality. Each municipality must ensure that its IDPs are aligned with other local, provincial and national plans. Section 51 of the National Environmental Management Integrated Coastal Management Act, 2008 also requires that these IDPs are aligned with the applicable coastal management programmes.

Section 51 of the National Environmental Management Act provides for "An environmental implementation or environmental management plan in terms of Chapter 3, an integrated development plan in terms of the Local Government: Municipal Systems Act, 2000, and a provincial or municipal land development plan must:

(a) be aligned with the national coastal management programme and any applicable provincial coastal management programme;
(b) contain those provisions of the national coastal management programme and any applicable provincial coastal management programme that specifically applies to it; and
(c) give effect to the national coastal management programme and any applicable provincial coastal management programme"

The *Environmental Impact Assessment Regulations, 2010* promulgated in terms of the NEMA, sets out what activities require environmental authorisation and how the environmental application process and assessment is to be undertaken. The activities are identified in three lists, namely Listing Notice 1 (GG No R544, LN1) and Listing Notice 2 (GG No R545, LN2) which identified activities requiring authorisation in South Africa as a whole, and Listing Notice 3 (GG No R546, LN3) which identifies activities requiring Environmental Authorisation within designated province specific sensitive areas.

Policy / Guidelines

The Department of Environmental Affairs, in terms of the obligations arising from the CBD, the Constitution of South Africa and NEMBA, undertook a National Biodiversity Assessment (NBA) in 2004 (Driver et al., 2004) and a related National Biodiversity Strategy and Action Plan in 2005 (NBSAP) which fed into the National Biodiversity Framework. The NBA was updated in 2011 (Driver et al., 2011) and the priority actions for conserving South Africa's biodiversity were listed as follows:

- Reduce loss and degradation of natural areas in priority areas
- Protect critical ecosystems
- Restore and enhance ecological infrastructure

In 2004, the marine component of the NBA (Lombard et al., 2004) reported that although 23% of the country's coastline (in terms of distance) falls within designated marine protected areas, only 9% of this is within fully protected no-take zones and the offshore area is severely lacking in any type of protection. Five years later the marine component of the 2011 NBA (Sink et al., 2011) showed that only 9% of the coastal and inshore habitats and 4% of the offshore habitat types are well protected, while 47% of the coastal and marine habitat types are threatened and 40% of them are not represented in South Africa's MPA network at all. Fishing remains the greatest pressure on our marine biodiversity with coastal development being the greatest pressure on coastal biodiversity.

Some priority actions identified for the coastal and marine environment were (Sink et al, 2011):

- Minimise impacts on priority ecosystems
- Expand and strengthen the Marine Protected Area Network
- Support the recovery of overexploited resources and threatened species
- Prevent further introduction and spread of invasive species
- Support good environmental practice and effective regulation of the emerging mariculture sector
- Strengthen climate change resilience
- Ensure sufficient freshwater flow to the coastal and marine environment
- Strengthen institutional arrangements to facilitate integrated ecosystem-based management
- Invest in the knowledge base to support biodiversity assessment and management

The priority actions described above aimed to support the NBA which identified key strategic objectives to achieve its primary goal, namely to conserve and manage terrestrial and aquatic biodiversity to ensure sustainable and equitable benefits to the people of South Africa, now, and in the future.

Strategic objective 5	**Required Outcomes**
A network of conservation areas conserves a representative sample of biodiversity and maintains key ecological processes across the landscape and	Biodiversity priority areas identified in the NSBA are refined in provincial, regional and local systematic biodiversity plans
	The protected area network is secured,

seascape	expanded and managed to ensure that a representative sample of biodiversity and key ecological processes are conserved
	Biodiversity is effectively managed in key ecological corridors and high priority fragments of natural habitat across the landscape and seascape
	Management plans for species of special concern ensure their long-term survival
	Research and monitoring programmes support the establishment and effective management of the network of conservation areas

In line with the NBSA, the National Department of Environment and SANBI have compiled a National Protected Area Expansion Strategy for South Africa, which aims to achieve cost effective protected area expansion for ecological sustainability and climate change adaptation (DEAT & SANBI Draft National Protected Area Expansion Strategy for South Africa: Priorities for Expanding the Protected Area Network for Ecological Sustainability and Climate Change Adaptation, August 2008). The document indicates that South Africa is working towards a protected area target of 20% for its marine protected areas, and that currently the marine bioregions, particular offshore ecosystems, are inadequately protected. The document further identifies that a greater percentage of Protected Areas, including current areas, need to be No-take zones to allow for the recovery of overexploited fish stocks.

The SANBI Offshore Marine Protected Areas (MPA) Project which aims to facilitate the development of a representative network of offshore spatial management measures, including MPAs (Sink and Attwood, 2008) has identified ten focus areas for offshore protection (Sink et al. 2011).

The 2010 KZN State of biodiversity report focused on the waters offshore of KZN and noted that the Delagoa Bioregion within KZN has 100% of its protected area targets met, while only 6% of the Natal bioregion falls within a marine protected area and 0.28% of the offshore area falls within a MPA. It was also noted that within the Natal Bioregion the only fully protected or sanctuary zone occurs within the Pondoland MPA and neither of the two MPAs in the Natal bioregion contain a sanctuary area.

Context of the Biodiversity Plan

The various acts, conventions and guidelines briefly discussed above all set out the imperative that biodiversity conservation planning must be undertaken to facilitate the integration of human and ecosystem requirements in a sustainable manner. The coastal and marine biodiversity plan is a critical component of the planning process required to bring about this integration.

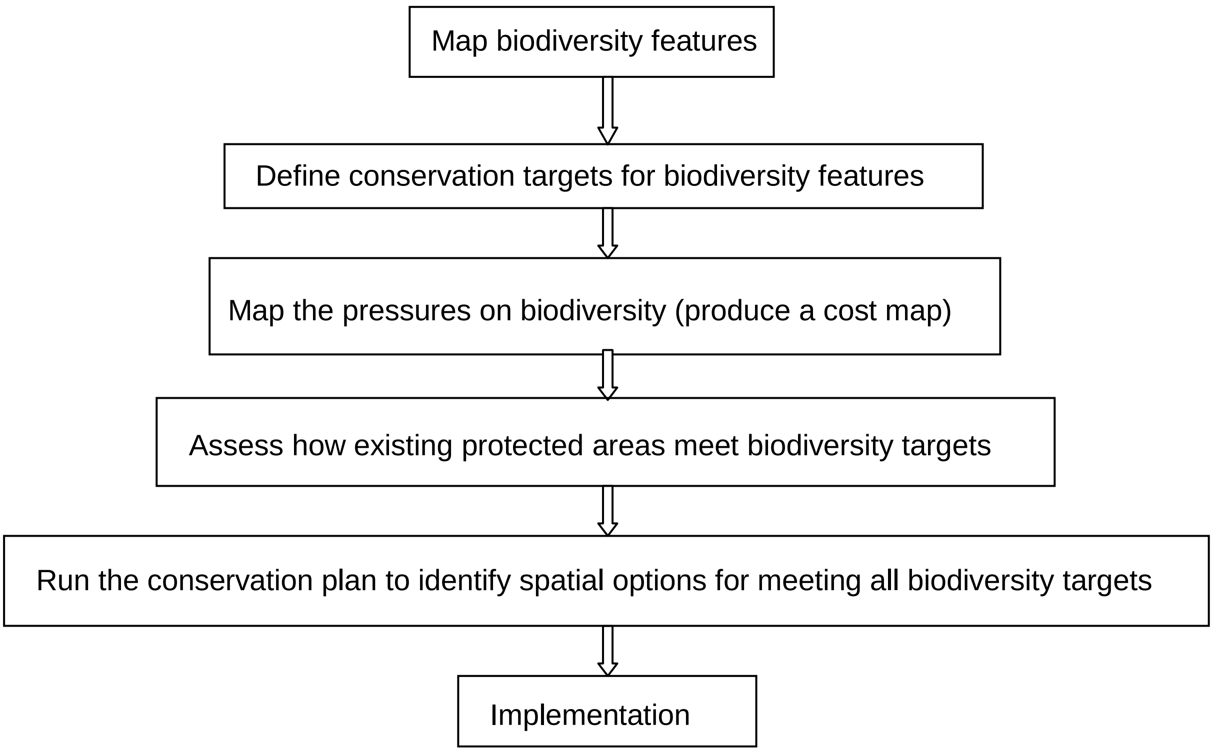
It is envisaged that the outcomes of the coastal and marine biodiversity plan would:

- Provide guidance to *inter alia* the provincial and national coastal management programmes required in terms of ICMA.
- Be one of the features contributing to the KZN Provincial Biodiversity Plan, thereby facilitating:
  - The identification of priority areas to support MPA expansion
  - The identification of critical biodiversity areas to support environmental management in terms of the NEMA-EIA regulations
  - To contribute towards the developing of district bioregional plans required in terms of NEMBA,
  - A plan that can guide the various government departments which have authority over activities that could impact on the coastal environment.

3.7 Systematic Conservation Planning Principles

During the past two decades, the field of systematic conservation planning (Pressey et al. 1993, Margules & Pressey 2000) has developed rapidly. Systematic planning is based on the need to conserve a representative sample of a region's biodiversity and to ensure its persistence through the exclusion of threatening processes and the inclusion of ecological and evolutionary processes that maintain and generate biodiversity (Balmford et al. 1998, Cowling et al. 2003). The systematic conservation planning process aims to identify the most efficient or near-optimal spatial solution to meet biodiversity targets, while trying where possible to avoid highly utilised areas.

Systematic conservation plans are based on the development of a spatial framework using the following steps to guide the planning process.



The initial task involves the generation of spatial data drawing from field data, expert interviews and literature. This is followed by data collation, verification, and standardisation for all spatial datasets for the planning domain. The second step involves target definition. Targets are quantitative expressions of a region's conservation goals which define how much of each biodiversity pattern (e.g. habitat types or species), and which biodiversity processes (e.g. spawning areas), should be included within the protected area boundaries and/or should be considered for other types of protection.

Mapping pressures on biodiversity requires the development of a list of human activities, both marine and land-based, that threaten the persistence of biodiversity within the planning area. Once these activities are identified, available data are sourced to produce maps depicting the extent of the activities and where possible, their intensity. These data are then collated to produce a final cost map depicting the current pressures on the marine environment and high use areas to be avoided when identifying spatial options for additional protection.

Once biodiversity patterns and processes have been spatially delineated and the pressure mapping complete, the study area is subdivided into planning units (typically grid squares or hexagons). Each planning unit contains information on the amount (area) of biodiversity features contained in it, data on protected areas (if present), as well as data on the pressures operating there (from the final cost map).The contribution of each planning unit to the quantitative targets is then calculated, thus providing a simple assessment of the current protection state of a planning region's biodiversity features and the outstanding targets still required to be met.

Once the assessment is complete the conservation planning software can be run in order to identify an efficient (with respect to total area required) and practical (with respect to avoiding high cost areas) spatial arrangement of planning units to meet all the targets. Various software systems are available to perform these calculations, for example C-Plan and MARXAN (Pressey 1999, Ball & Possingham 2000, Possingham et al. 2000). These software programs identify irreplaceable areas (areas that must be inside MPAs if conservation targets are to be met), and they also identify alternative networks of complementary MPAs that efficiently achieve all conservation targets (Sarkar and Margules, 2002). The Irreplaceability value in C-Plan is similar in principle to the selection frequency value in Marxan, and these values are calculated for each planning unit. A high value indicates that the planning unit is very important for target achievement and may even be irreplaceable (i.e. no other options exist for the conservation of a particular feature that occurs in that planning unit). A low value indicates that a particular planning unit may not be required for protection because there are many other planning units that contain the same features so any one of them would do (this indicates that there are options or choices among planning units to meet the targets of the features that occur there). The use of these programs thus allows for the identification of spatial options to meet biodiversity targets while avoiding high cost areas. The next step is to choose final areas for protected area expansion from among the options presented.

The final and probably most difficult step in the process is implementation, i.e. delineation, declaration and management of marine protected areas (or other forms of protection, such as seasonal closures, fishing gear restrictions or fish length and mass limits).

4 Introduction

4.1 Purpose and Objectives of the Plan

The KZN Marine Biodiversity Plan (referred to as SeaPLAN) was developed to 1) provide a spatial framework for assessment of the status of biodiversity protection in the province of KwaZulu-Natal (KZN), and 2) enable planning for marine biodiversity protection by identifying additional spatial priorities for marine protection.

The planning domain covered both the coastal (shoreline and nearshore) and offshore areas of the province of KZN. Data included maps of the location and extent of biodiversity features (species, habitats and processes), as well as data on human use. Estuaries within the bioregion are the subject of a separate Estuary Plan being undertaken by Ezemvelo. The results of this plan were integrated with the present study. Quantitative targets were defined for the desired protection of biodiversity features, and the human use data (commercial, subsistence and recreational) were used to develop a cost layer to inform the future placement of MPAs. Systematic conservation planning software (C-Plan and Marxan) were used to assess the current state of protection of biodiversity targets, and to delineate options for future protection to meet all targets. The Coastal and Marine Biodiversity Plan thus also provides a product for the conservation sector to use in integration of biodiversity conservation priorities with multi-sectorial provincial planning frameworks.

4.2 Planning Processes and Participants

Conservation planning requires the combination of scientific knowledge with an understanding of the stakeholders involved in the planning process (Knight et al., 2006). The participation of stakeholders is vital for the development and implementation of conservation plans (Castella et al., 2005; Brown, 2003), and thus the planning process must address the behaviour of the social groups involved in the development of the plan. This strategy aimed to improve the connectivity between conservation, research and stakeholders. Nevertheless, the value of the participatory conservation planning process always depends on the willingness of the participants to engage in it.

Since 2000, a large number of scientists and stakeholders were involved in SeaPLAN. The project consisted of team of core members referred to as the planning team and a number of other key participants and stakeholders who aided in the planning process by contributing data, time and effort.

Planning team

The project was led by the current Head of Scientific Services at Ezemvelo (Dr J.M. Harris), in collaboration with the co-ordinator of Biodiversity Planning (Dr P. Goodman), assisted by the Marine GIS Analyst (T. Livingstone). The team also involved two marine conservation planners (Prof. A.T. Lombard and Dr E. Lagabrielle), a MSc student (P. Haupt) who was involved in fish distribution mapping, and a number of colleagues who worked on developing the human use data (B. Naidoo, A. Brahmin, J. Govender, and Dr K. Sink) and the shoreline component (Dr . J.M. Harris, M. Tomalin, Dr K. Sink, and T. Livingstone). Ezemvelo MPA managers were also involved in developing the project, and contributing towards data collection.

Key contributors
Scientists from the following institutions were consulted to develop the plan: University of KZN (UKZN), Nelson Mandela Metropolitan University (NMMU), Oceanographic Research Institute (ORI), The University of Cape Town (UCT), KwaZulu-Natal Sharks Board, Marine Geoscience Unit at UKZN, Marine Geosolutions, Department of Environmental Affairs (DEA), Council for Scientific and Industrial Research (CSIR), South African Institute for Aquatic Biodiversity (SAIAB), and the African Coelacanth Ecosystems Programme (ACEP).

Stakeholders

Stakeholders involved included representatives from the fishing sector (line-fishers, spearfishers, etc), scuba divers, urban planners, conservation NGOs, MPA proposers, etc. National and Provincial authorities also participated in the project and were regularly informed of its development (see list below)

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Involvement of stakeholders and scientists

a) Biodiversity data collection

Participants provided data on the marine environment for the species and habitat mapping. An example is the rocky reef layer, which involved data provided by a number of scientists and stakeholders such as scuba divers, spear fishermen and commercial fishermen. This was one of the initial collaboration processes and allowed the participants involved to understand more about conservation planning and the processes involved. One-on-one interaction with specialist scientists also occurred to gather specific information such as bathymetric and coral reef data.

b) Human activities data collection

Some key observers or stakeholders involved in marine uses and management provided data on human activities interacting with the marine environment - more information can be found in section 6 on Pressures on coastal and marine biodiversity features: Cost .

c) Participatory planning process

Participants (scientists and stakeholders) were involved via individual interviews, field trips, emails and workshops. Workshops with relevant parties were held to discuss the reef data, fish data and human use data. A number of workshops were held to inform stakeholders and participants of the preliminary results from the conservation plan, as well as updates once the data had been refined and finalised. During each of these meeting the SeaPLAN project objectives were presented together with the data used to develop the plan.

Table 2: Table of stakeholder workshops

11 and 12 August 2009	**Stakeholder workshop to present SeaPLAN assessment results and preliminary results of conservation plan (100 participants)**
20 May 2010	**Stakeholder workshop to present SeaPLAN assessment and plan and to discuss proposed MPAs put forward by stakeholders (50 participants)**
21 July 2011	**Stakeholder workshop to discuss changes in the conservation plan and developments in the proposed MPAs put forward (52 participants)**
27 November 2012	**Stakeholder workshop to discuss developments in conservation plan and taking forward of proposed MPAs (40 participants)**

5 Biodiversity Planning Methods

5.1 Biodiversity Mapping

This section describes the data layers used in the biodiversity plan. All data are curated by the Scientifi Services Biodiversity Spatial Planning and Information Department (BSPI) at Ezemvelo, and are stored in Geographic Information Systems (GIS) format (ArcView 3.2, ESRI 1998).

5.2 General Layers

5.2.1.1 Planning Domain

The spatial extent of the planning domain) extends from the coastal vegetation line to the 200 nautical mile boundary of the Exclusive Economic Zone (EEZ) offshore of the KZN Province. The EEZ is defined as “an area, not exceeding 200 nautical miles from the baselines from which the breadth of the territorial sea is measured, subject to a specific legal regime established in the United Nations Convention on the Law of the Sea under which the coastal state has certain rights and jurisdiction” (IHO Dictionary, S-32, 5th Edition).

Landward boundary

The marine and terrestrial biodiversity plans developed for the Province share a common boundary on the shoreline, allowing the two planning initiatives to inform one another seamlessly (Figure 4). The landward boundary of the planning domain was defined as the edge of the permanent vegetation along the dune cordon at the base of the scrub dune. This terrestrial vegetation line was digitised using the best available aerial imagery at the time (Figure 5).

Figure 4: The marine and terrestrial biodiversity conservation plans for KZN Province use a common boundary in order to fit seamlessly together.

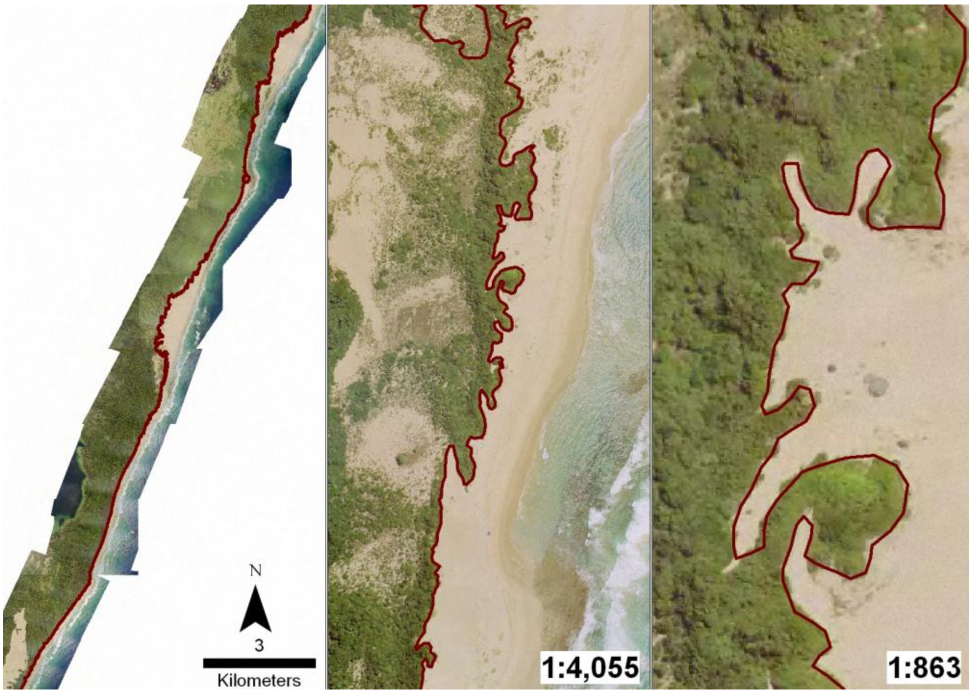


Figure 5: The landward boundary of the planning domain. Map scales are shown at bottom right.

Seaward Limit
The seaward limit of the planning domain boundary is the EEZ which lies 200 nautical miles offshore. This boundary line was obtained from the Maritime Boundaries Geodatabase (VLIZ, 2009).

Northern and Southern boundary
The northern boundary is defined by the Mozambique / RSA marine boundary supplied by the Navy hydrographer. The southern boundary of the planning domain were defined by a line drawn at 90 degrees to the low water line and extended 200 nautical miles offshore to the seaward limit (Figure 6)

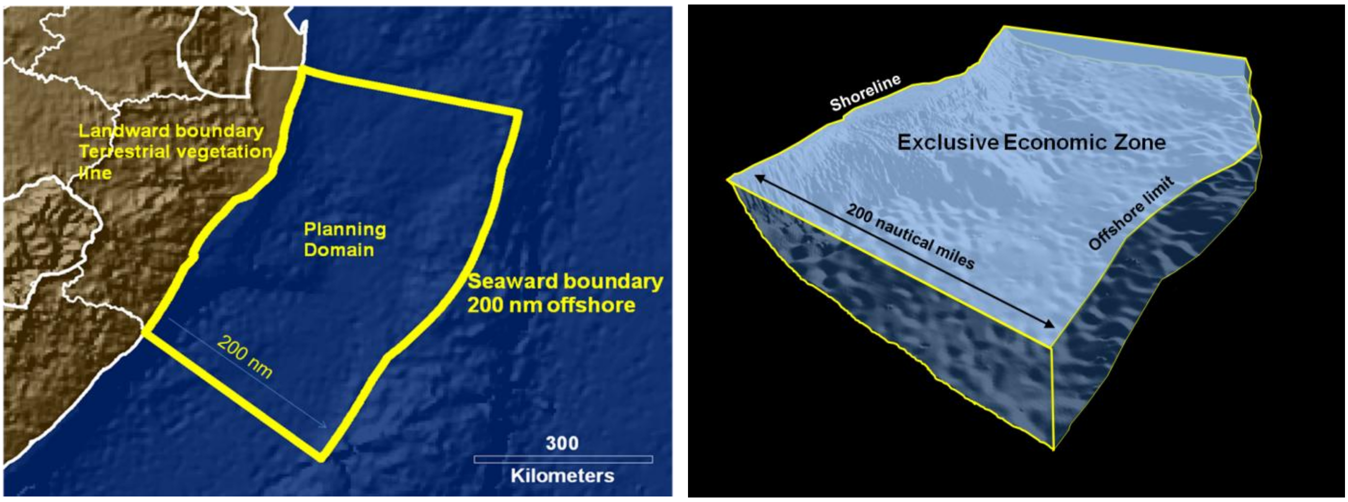


Figure 6: The Planning Domain depicted in yellow. The Planning Domain stretches from the Mozambique/KZN border in the north to the Port Edward/KZN border in the south and stretches offshore to 200 nm.

Based on these data, the total length of the KZN coastline is approximately 640 km, and the total surface area of sea that falls within the planning domain is 233 747 km^2.

5.2.1.2 Protected Areas

Digital data for the existing MPAs were obtained from the Government Gazette (Marine Living Resources Act). Each MPA was plotted in the (GIS) using the coordinates from the Gazette. The MPAs were divided into zonation categories as described in section 3.5.

The boundaries of proposed MPAs were mapped with the groups of proposers using Google Maps and GPS points.

Terrestrial protected area boundaries were provided by Ezemvelo. Admiralty Reserve and State Land boundaries were obtained from the Kwazulu-Natal Provincial Planning & Development Commission.

5.2.2 Coastal Layers

5.2.2.1 Estuaries

Estuaries were mapped as point features along the coastline with the following attributes: ID, name, average annual flow, open/close and irreplaceability. Estuary codes match the estuary's ID used for the estuary plan.

Irreplaceability values were extracted from the KZN Estuaries Systematic Conservation Plan that was based on the province's 76 recognised estuaries and, using C-Plan software, attempted to identify areas of high biodiversity importance. This was achieved by using the estuary classification, as well as specific rare and endangered plant and fish species (the latter expressed as presence/absence data only) occurring in estuaries. Unless otherwise specified, all biodiversity features where assigned a target of 20%, with the condition that a minimum number of three of each feature had to be represented. An irreplaceability map was then generated, providing a surface of areas of options for meeting biodiversity targets. Each estuary received an irreplaceability value ranging from 0 to 1, with '0' indicating an estuary that did not contribute to the specified targets of the systematic conservation plan and '1' indicating irreplaceability (i.e. the estuary represented features that were not present in any other estuary, or it was required in order to meet overall targets, meaning that there were no other options for target achievement). A 'summed irreplaceability' map was also produced, within which the sum of the irreplaceability values for all of the biodiversity features within each estuary was generated. This value was incorporated into the SeaPLAN analysis (Figure 7). (Figure 7).

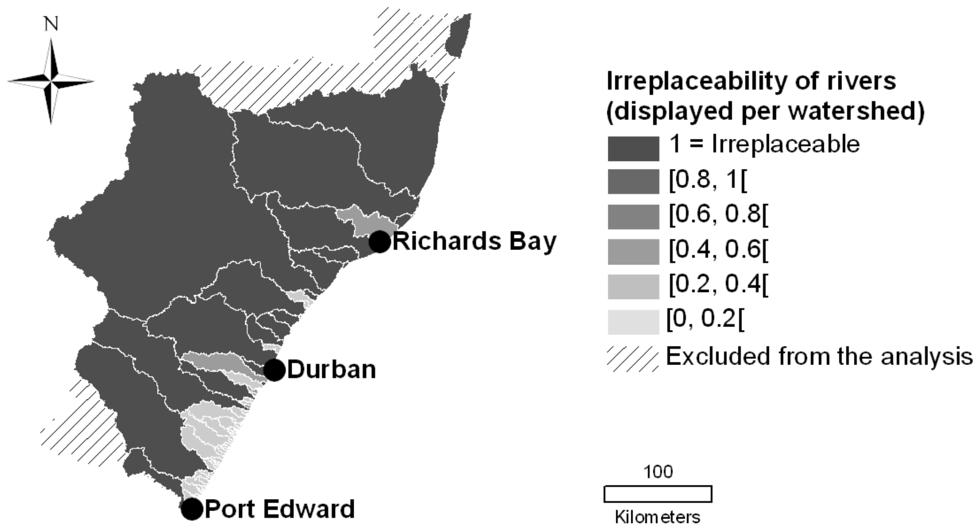


Figure 7: Map of major river watersheds in KZN. Irreplaceability values were calculated for estuaries in the framework of the KZN Estuaries Spatial Conservation Plan using C-Plan

The area of influence of each estuary was mapped as a circular area (Figure 8), the radius of which is proportional to the average annual flow of the river. The radius for all rivers was calibrated based on the area of influence of the Tugela River (highest annual flow in KZN) with a radius of 10 km. This distance was set according to discussions with experts and based on a short literature survey (Meyer et al., 2002, Cooper, 1993, Flemming, 1981). For instance, Cooper (2002) wrote that “such a link between beach ridge growth and periods of river floods indicates that the extent of coastal influence of fluvial sediment derived from the Tugela extends for more than 20 km alongshore.” Following the precautionary principle, the minimum area of influence of a single river was set to 500 m.

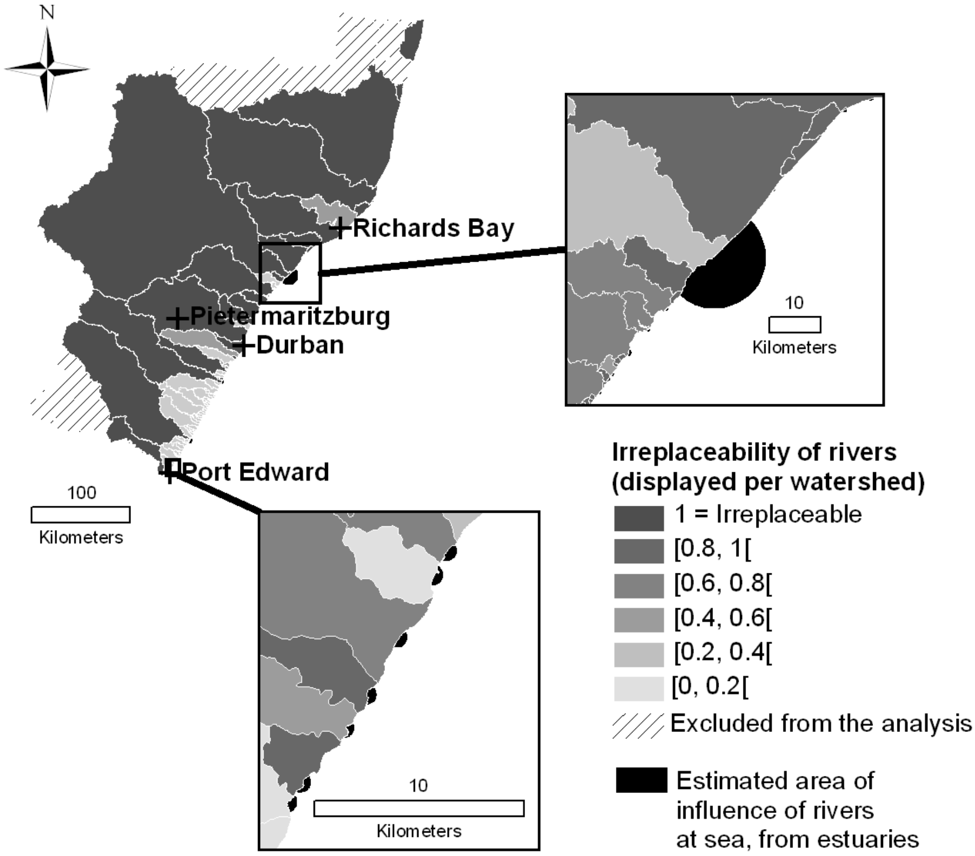


Figure 8: Marine area of influence estimated for each estuary

5.2.3 Marine Layers

5.2.3.1 Bathymetry

Bathymetry data were obtained from Paul Young at the UKZN Marine Geosciences. Young (2009) compiled an extensive dataset for KZN producing a bathymetric grid and contour lines.

A total of 32 datasets was acquired to develop this map using a range of techniques and instruments used between 1911 and 2006. Twenty nine of these were near-shore datasets with data densities varying from 6 to 57 406 points per km^2 ,15 were acquired from the Council for GeoScience, 9 from the South African Navy and 5 from the African Coelacanth Ecosystem Programme (ACEP). Two of the remaining 3 deep-water datasets were grids acquired digitally for this work, while the third was a digitised contour dataset. The 2003 General Bathymetric Chart of the Oceans (GEBCO) grid is based on digitised point and contour data with a point every 1 852 m (British Oceanographic Data Centre, 2003; GEBCO Task Group, 2003), while the 1997 Smith and Sandwell grid is based on predicted satellite altimetry data with a point every 3 704 m (Smith and Sandwell, 1997). The third deep-water dataset was digitised from a northern Natal Valley bathymetric contour map developed in 1978 and has data densities varying from 0.02 to 1 points per km^2 (Dingle et al., 1987). Data were processed by Marine Geosciences by interpolating a point surface to 500 m resolution. A 100 m resolution surface was then interpolated from this data set, and clipped to the EEZ extent (i.e. from the KZN high-water mark, out to 200 nautical miles, bound to the provincial waters).Edge effects were removed by using the original dataset to interpolate a 1 km surface, which was then rescaled to 100 m, and only its edges used to replace faulty edge values of the bathymetry map (Figure 9).

The final bathymetry map was supplied at a 100 m resolution and this was resampled to fit the planning unit grid.

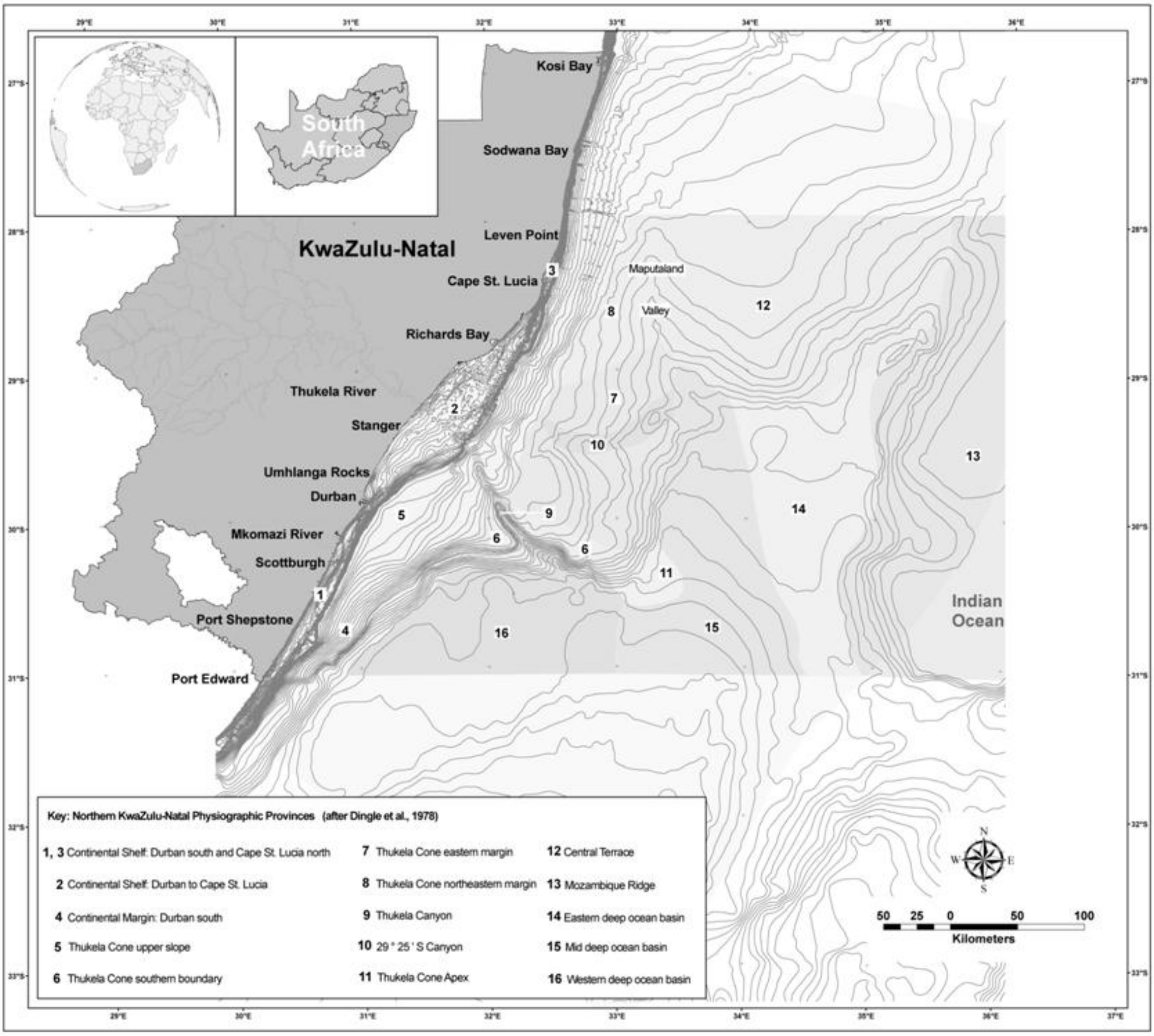


Figure 9: The Integrated marine GIS bathymetric contour dataset for KwaZulu-Natal after Young (2009). The northern Natal physiographic provinces after Dingle et al. (1987) are also shown. Regional scale artefacts from conjoined arc-like contours can be seen and artefacts from the presence of noisy satellite altimetry data south of 31° S

A slope layer (Figure 11) was generated from the bathymetric data (Figure 10) using the 'Slope' tool in Idrisi (IDRISI Andes, Version 15). This surface analysis uses the bathymetric digital elevation layer to produce a slope layer by examining the heights of locations compared to the heights of neighbouring locations (Eastman 2003).

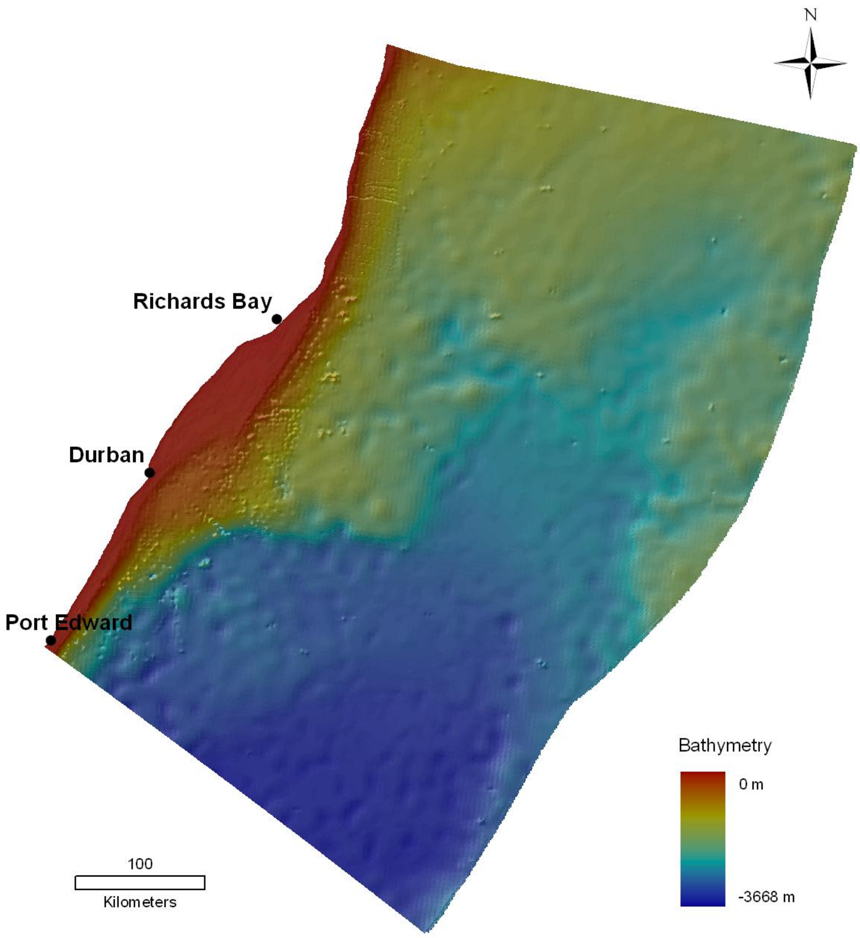


Figure 10: Bathymetric Data for KZN out to the EEZ boundary

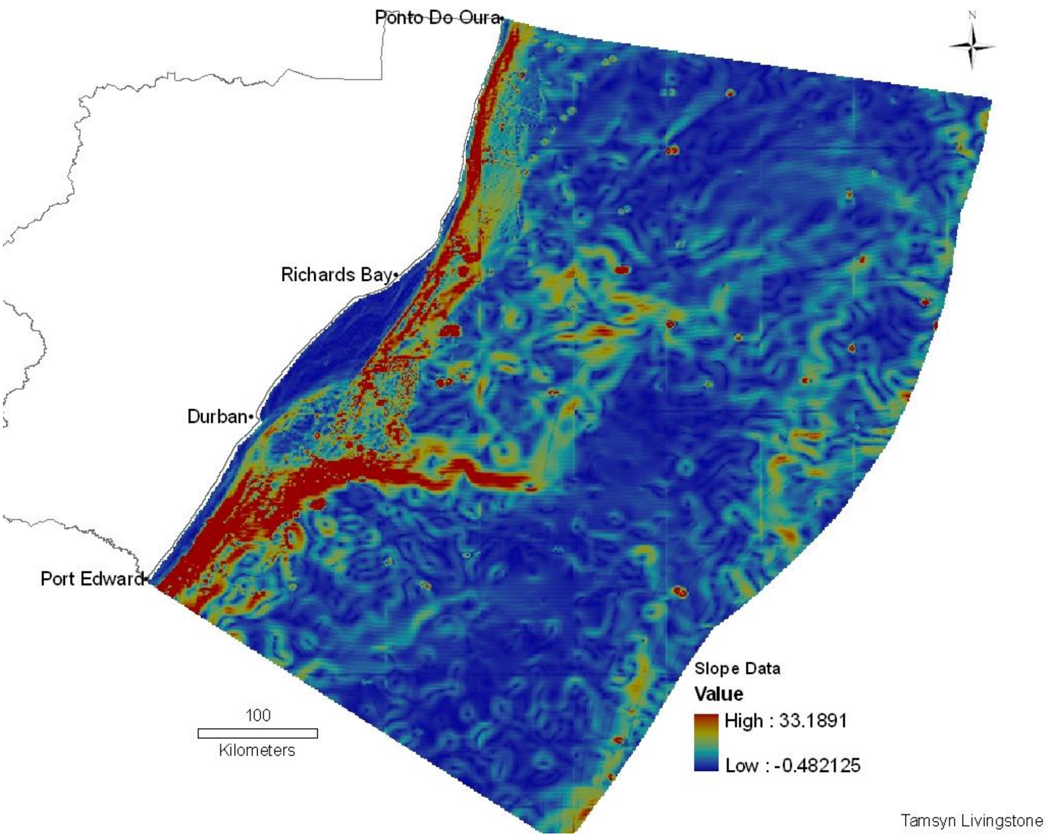


Figure 11: Slope Layer generated from bathymetric data. Red areas highlight steep slopes on the seabed.

5.2.3.2 Rocky reefs

Rocky reefs presence, density and size along the KZN coastline were mapped using a number of sources from 0-200 m depth. Data were obtained by conducting interviews with recreational and commercial line-anglers and spearfishers. These data were incorporated with data obtained from the SA Navy, ORI, Marine Geoscience, Ezemvelo management staff, students and scientists. Data were also digitised from the literature. A shallow reef habitat survey was conducted during which positions of reefs were recorded and incorporated into the database

and a coastal flight also provided GPS positions of shallow and visible reefs.

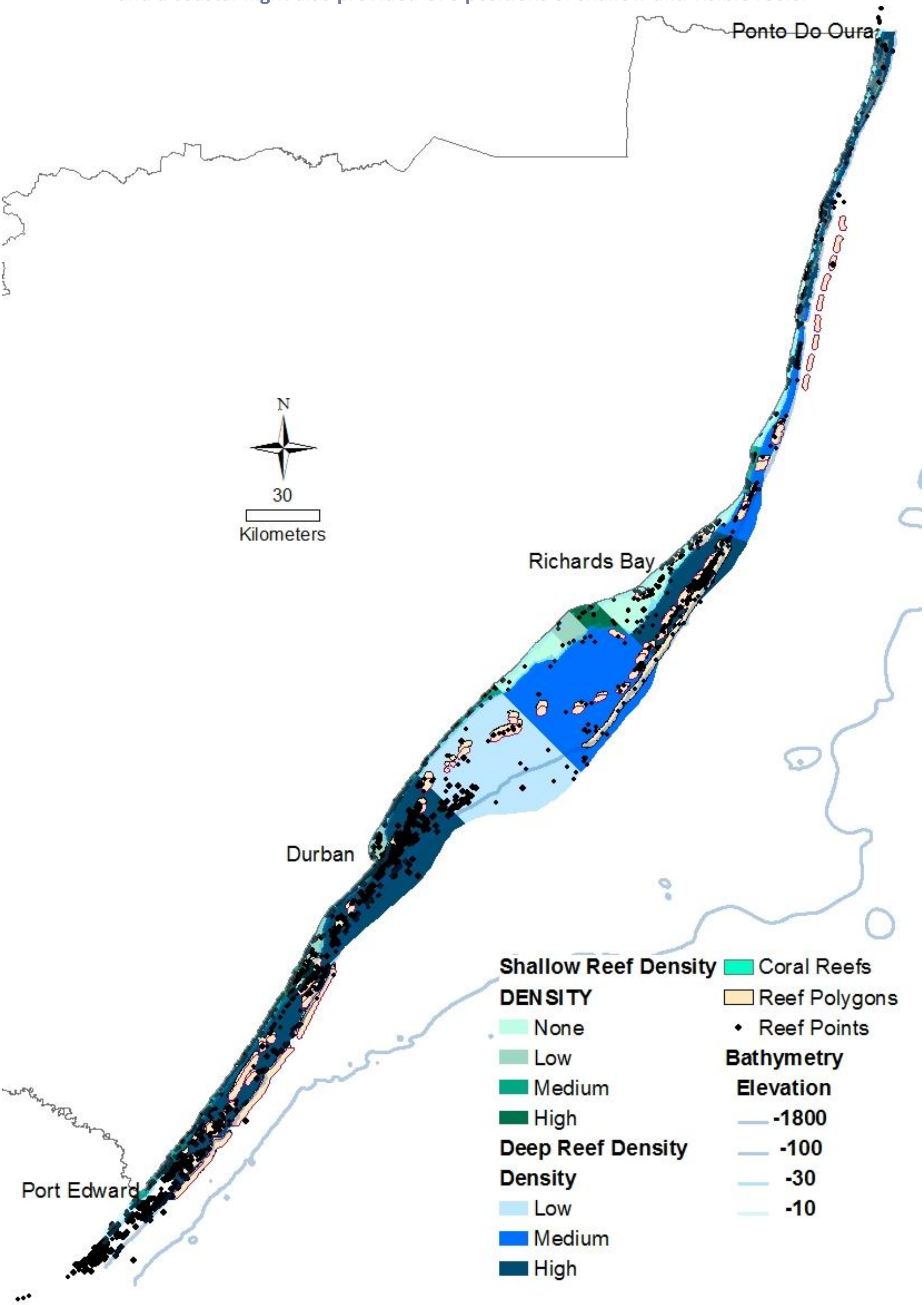


Figure 12 shows these original datasets and Table 3 lists the sources.

Data were captured in Access and Excel databases and were verified and mapped spatially in geographical coordinates (WGS 84 spheroid), decimal degrees. Reef data points at depths deeper than -200 m were deleted as the accuracy of these points was uncertain.

These data provided the best-available map of known rocky reefs (Figure 13) along the KZN coastline (although it must be considered incomplete in areas where the presence of reefs has not been reported). The reef data were used to populate a 1 km reef grid indicating the presence and absence of reef data. The offshore biozone map was overlaid over the final rocky reef grid and the reefs grouped according to the different biozones within which they occurred.

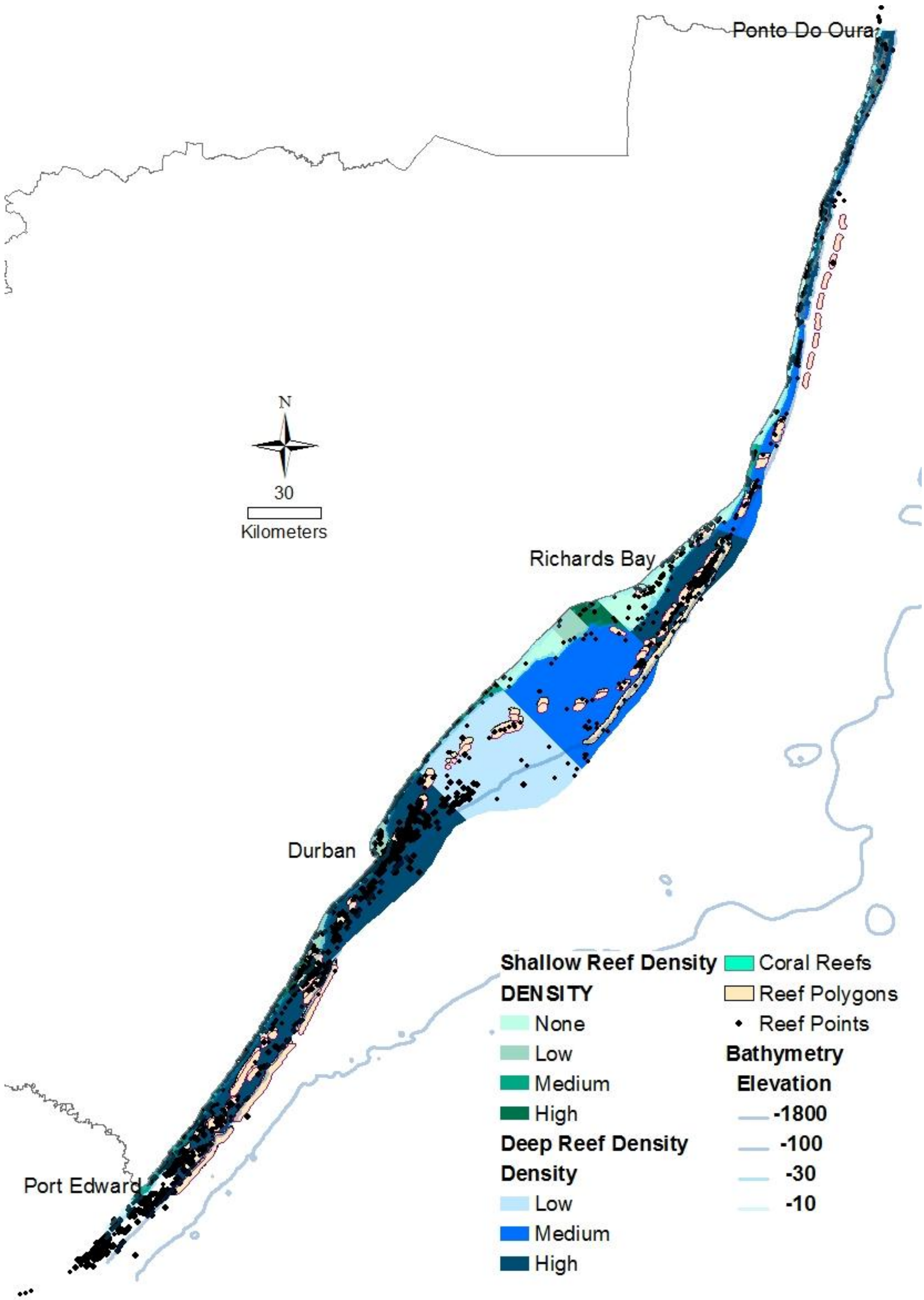


Figure 12: Original reef datasets collected for the SeaPLAN project

Table 3: Reef data sources and descriptions

Data Set	Source	Description
Ezemvelo Data	Dive surveys	GPS points taken during Ezemvelo dive surveys
	Ezemvelo managers	GPS points collected from Ezemvelo managers
	Ezemvelo skippers	GPS points collected from Ezemvelo skippers
ORI	Bruce Mann and Mike Schleyer	Series of data points obtained from Bruce Mann and Mike Schleyer including Pondoland reef points, points from Mann 2002 study and other studies
Spearfishers	Spearfishers willing to give data (3 participants)	Co-ordinates obtained from spearfishers of popular sites
Pete Fielding	Pete fielding	GPS points taken during field surveys
Cheney and Mann	Jack Cheney, Bruce Mann and Ezemvelo managers	GPS points taken during interviews between users and Ezemvelo managers
Anton Koornhof	Anton Koornhof book: "The dive sites of South Africa"	GPS points taken from book
Navy	SA Navy	GPS points obtained from SA Navy
Reef Density	Stakeholders	Reef density indicating an estimated number of reefs within a gridcell
Coastal Flight data	Sean Porter	GPS positions of reefs taken during coastal flights
Shallow Reefs	Sean Porter	GPS positions of shallow reefs from coastal survey by Sean Porter
Commercial	Mitty Chelin Arie Frater and Mike Coke	GPS points from commercial skipper given to us by Bruce Mann Co-ordinates of reefs collected by Cloverly Lawrence
Pat Garret	Pat Garret	Polygons indicating reef areas
Marine Geoscience	Pete Ramsay	GIS Shape files of certain reefs from bathymetric surveys
Oyster Points	Paul de Bruyn	Shallow reef points taken during oyster surveys
Hutchings	Hutchings et al. (2002)	Polygons digitised from manuscript
Kerry Sink	Kerry Sink	GPS points of two known reefs

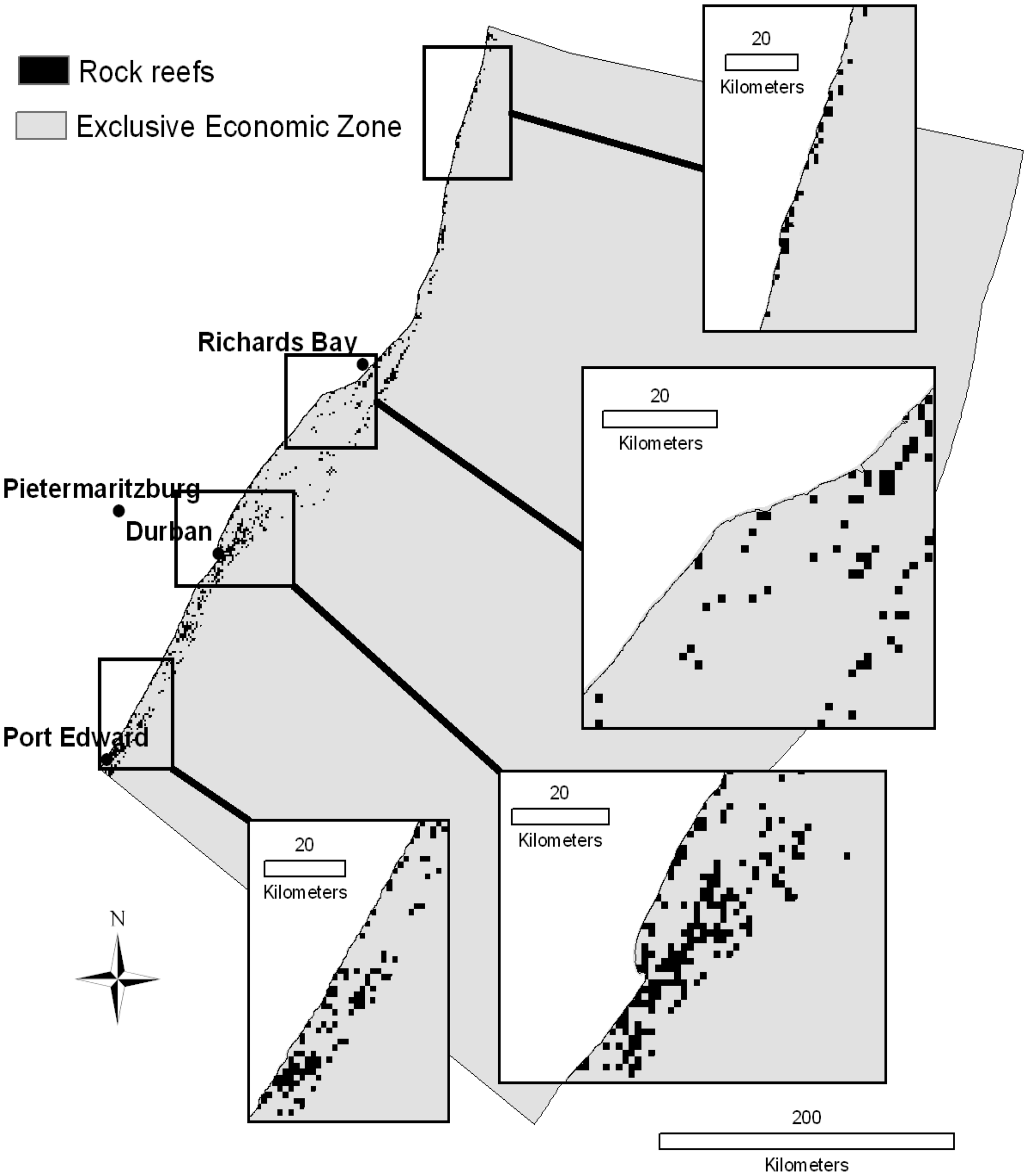


Figure 13: Spatial distribution of rocky reefs in KwaZulu-Natal. Reefs were mapped between 0 and -200 m depth only.

5.2.3.3 Coral reefs

Spatial data for coral reefs were provided by ORI (Schleyer and Celliers, 2005). These data were produced for the project entitled "The Development of an Expert Marine Geographical Information System to Provide an Environmental and Economic Decision Support System for Coastal Tourism and Leisure Developments within the Lubombo Spatial Development Initiative". The different coral communities also referred to as clusters and the three Coral Complexes are distinguished as The North Complex, Central Complex and Southern Complex, as indicated in Figure 14.

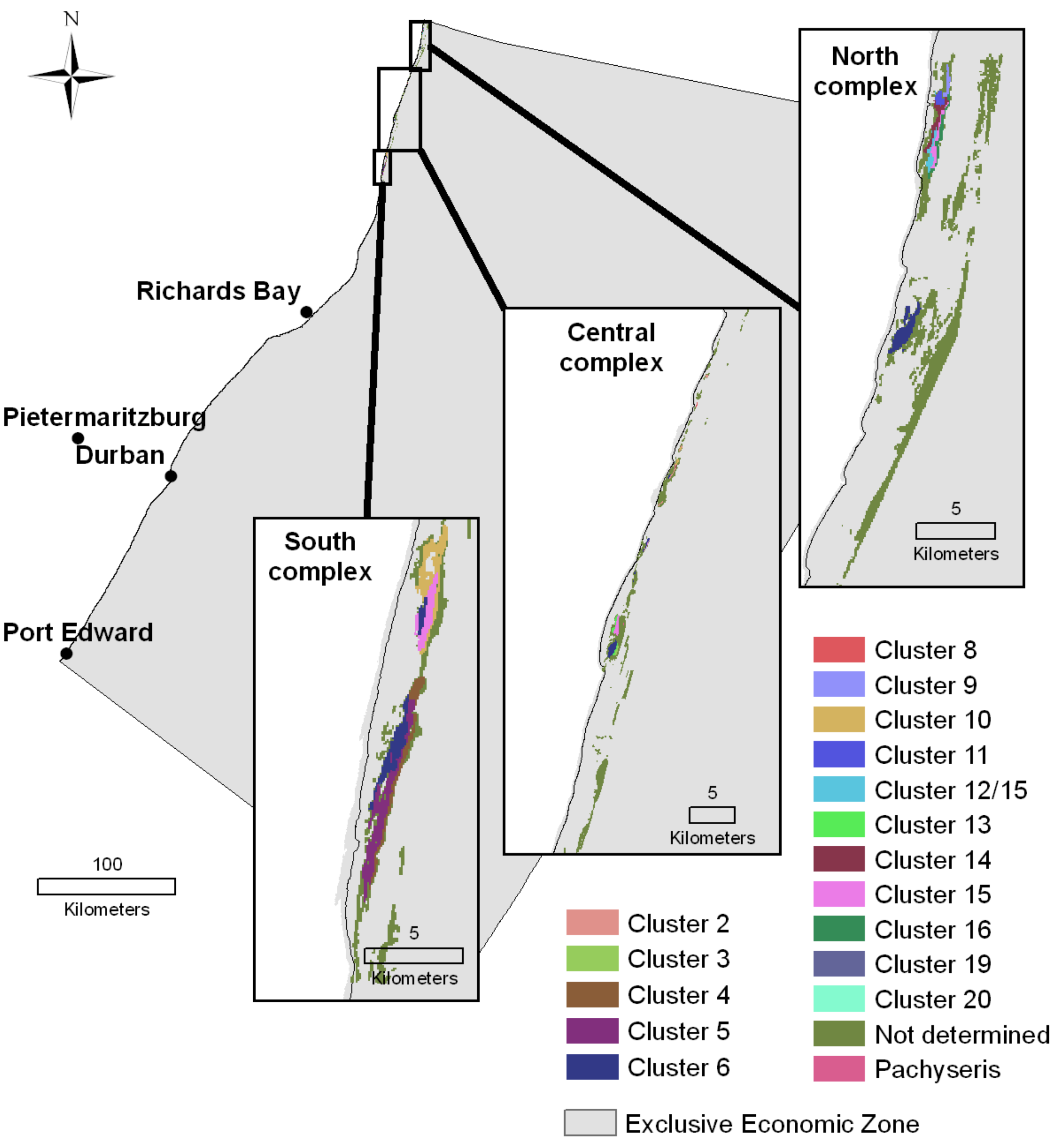


Figure 14: Spatial distribution of coral reef clusters in KwaZulu-Natal. Data provided by Schleyer and Celliers (2005).

5.2.3.4 Canyons

A multi-beam bathymetric survey of the northern KZN continental shelf was undertaken by Marine GeoSolutions (Pty) Ltd in conjunction with the National Research Foundation. This survey was used to identify known submarine canyons between Leven Point and Island Rock and to provide bathymetric maps and three-dimensional models of these canyons (Miller and Ramsay 2002). The bathymetric data of these canyons was provided to Ezemvelo.

Marine Geoscience at the University of KZN provided the detailed bathymetric maps of canyons found elsewhere along the KZN continental shelf break. The canyons were mapped between the 50 and 300 m depth contours using the bathymetric layer as a guide (Figure 15).

Additional canyons were mapped by E. Lagabrielle for the SeaPLAN Project, based on interpretation of the isobaths. This was not used in the biodiversity plan (as per expert recommendation from Andrew Green and Kerry Sink).

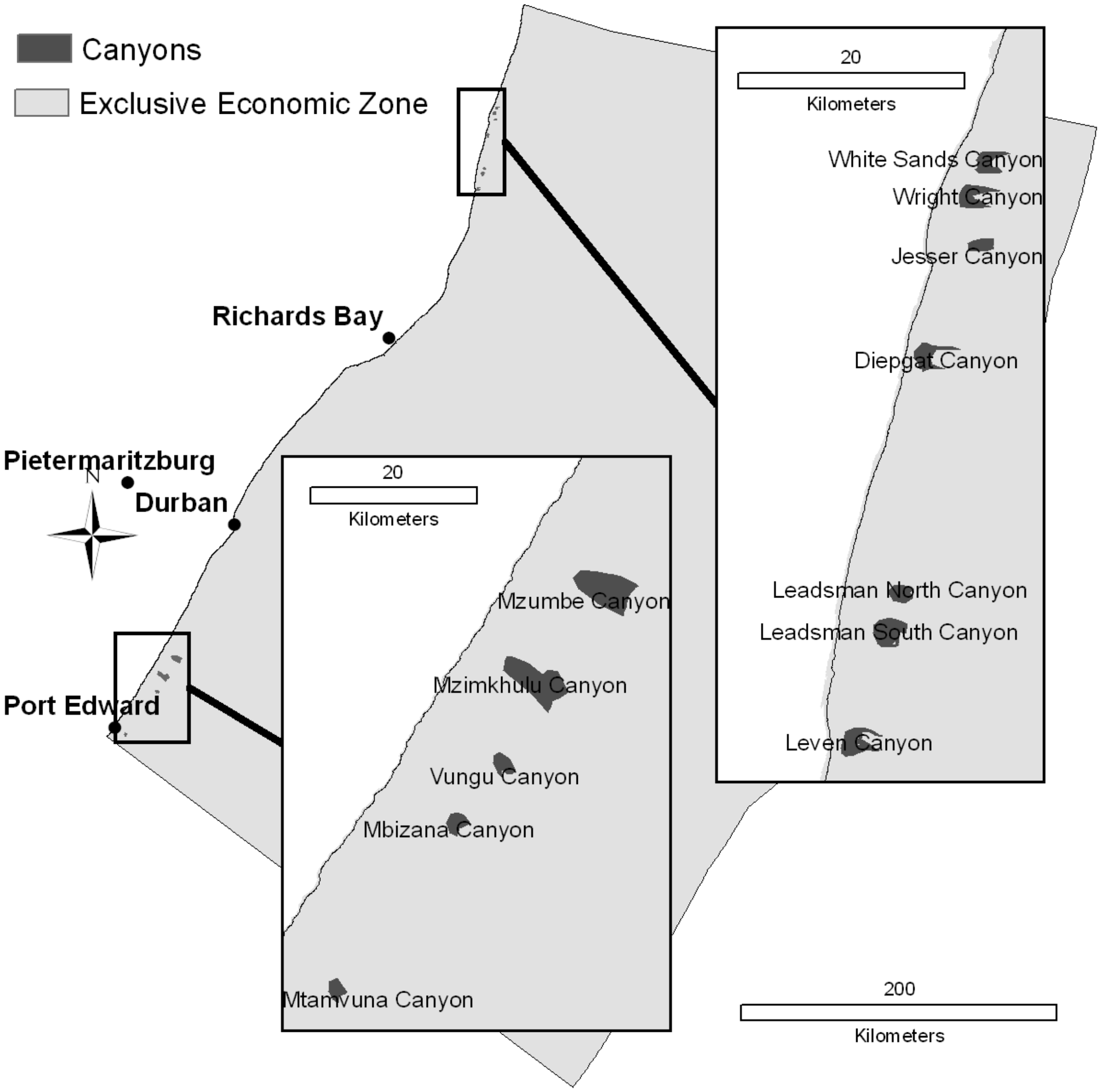


Figure 15: Spatial distribution of submarine canyons in KwaZulu-Natal. Northern canyons were mapped by Miller and Ramsay (2002) and southern canyons by Marine Geosolutions.

5.2.4 Coastal Habitat Map

5.2.4.1 Shoreline habitats

Shoreline habitats and features such as landmarks, estuary mouths etc. of the 640 km coastline were mapped in the field by Ezemvelo scientific and management staff. GPS coordinates were recorded to allow verification of the field-mapped data. For each 25 m section of shoreline, data were recorded for eight parallel shoreline zones (Figure 16). This includes two zones to landward that are entirely terrestrial, i.e. the forest dune and scrub dune (which were not included in this analysis). Adjacent to the scrub dune is the fore dune, followed by the top shore (backbeach), both of which are influenced by and have an influence on the adjacent marine environment. Below the backbeach are the intertidal zones (highshore, midshore and lowshore). The surf-zone (infratidal) lies to seaward of the intertidal

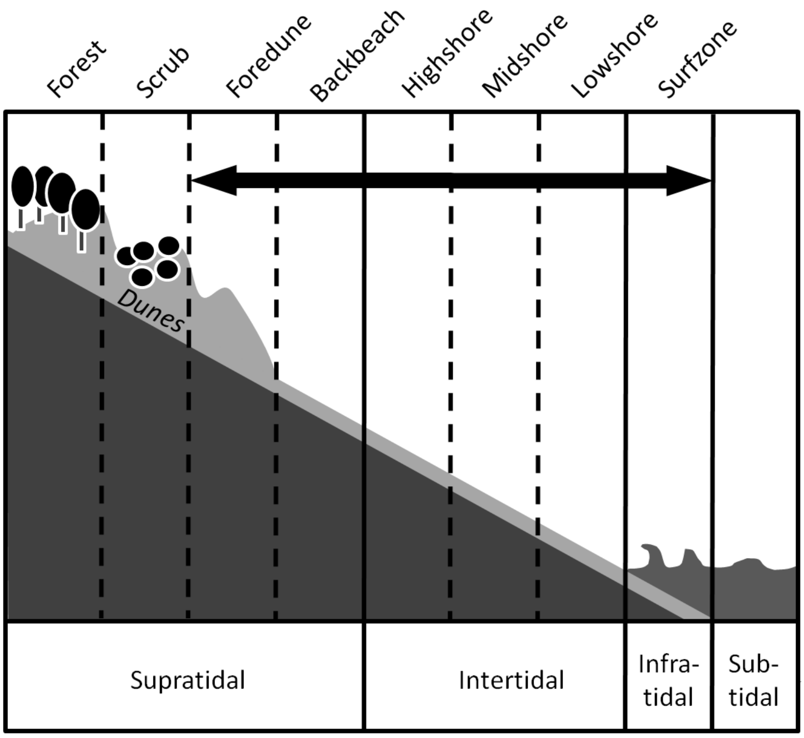
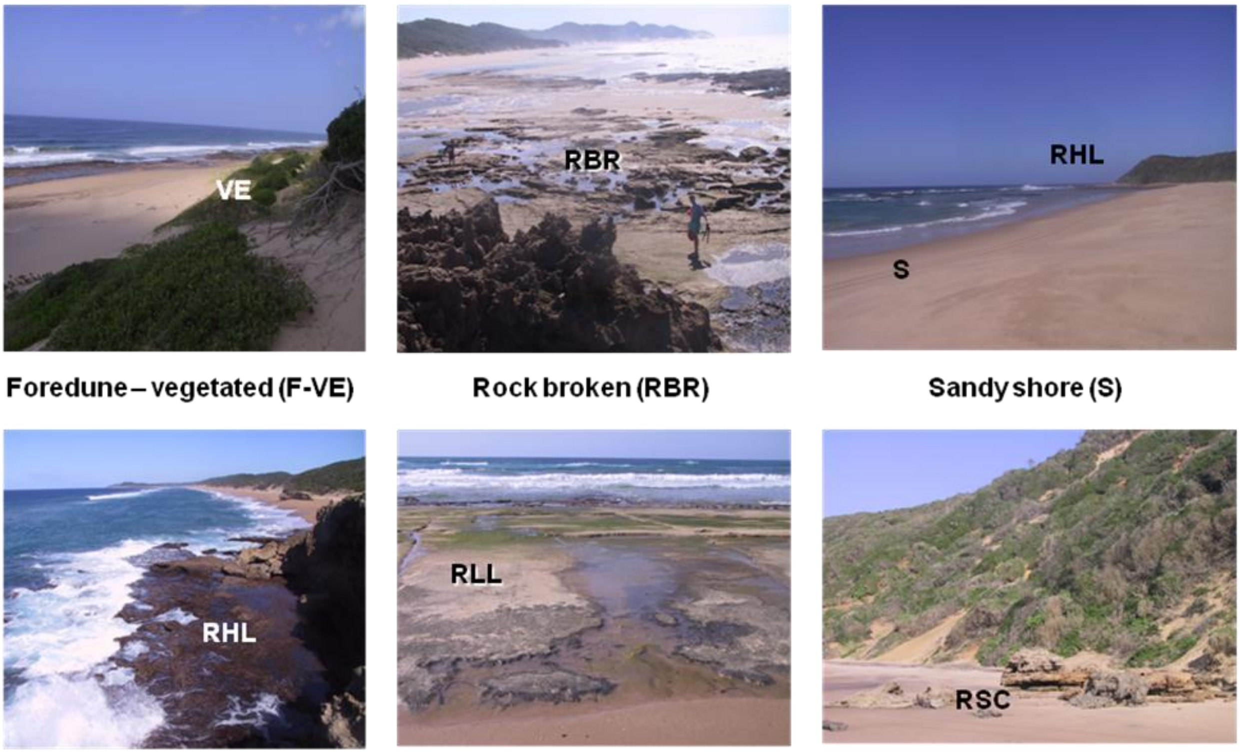


Figure 16: The shoreline zones starting from the forest dune up at the top of the shore and running down to the surf-zone in the infratidal zone. The black arrow indicates the zones mapped for the SeaPLAN project.

The shoreline consists of two substrata (sand and rock) and in some cases is transformed by man-made structures (e.g. tidal pools and harbour walls). Various stages of erosion of the beach-rock (e.g. by undermining, pothole abrasion, and sand abrasion) (Miller and Mason, 1994), result in diverse topographical features and rocky shores of different size, shape and structure such that they provide very disparate habitats for biological communities. The presence of those different types of substrata was recorded for each zone in each 25 m strip of shore. The position and extent of features such as estuary mouths, access points, major landmarks (e.g. lighthouses, beacons) and infrastructures (roads, paths, developments) were also included. The intertidal has been classified in terms of structure, erosional state and nature of habitat provided for biological colonisation into the following intertidal shore types (Figure 17).



Foredune – vegetated (F-VE) | Rock broken (RBR) | Sandy shore (S)

Rock high ledge (RHL) | Rock low ledge (RLL) | Rock scattered-mix (RSC)

Figure 17: Shoreline images indicating some of the shoreline habitat classifications

High ledges (RHL) are beach-rock platforms that are raised more than 20 cm out of surrounding sand. They are typically flat, but have high within-shore topographical complexity (potholes, crevices). They are fairly stable habitats (i.e. not ephemeral) and support rich biological communities.

Low ledges (RLL) are beach-rock platforms that are deeply embedded in the beach sand with less than 20 cm of rock raised above the sand surface. These are sand scoured and frequently covered by sand and provide a harsh environment to the relatively depauperate biota that inhabit them.

Broken high ledges (RBR) are high ledges in advanced stages of erosion – these provide a complex infratidal habitat with many large crevices and gulleys.

Boulder (RBO) shores

Scattered rocks / mixed shores (RSC) (rock and sand) are identified since they provide a specific type of habitat for some species. These differ from broken ledge shores, in that at least 50% of the shore is sand.

Sand shores (S) are areas in which sand occurs in all six zones and these are described in more detail later.

In addition, the two zones that border the intertidal are:

Foredunes (FD) – vegetated foredunes and bare dunes (supratidal)

Surf-zone (SZ) – i.e. to approximately 2 m behind the backline of waves (infratidal)

The shoreline information was originally entered into Excel spread sheets. Subsequently an Access database was designed and the data imported and verified. This database allows for the data to be easily exported in a number of formats (e.g. ‘presence/absence’, abundance) for each of the eight zones at 25 m intervals, or integrated for every 100 m segment of the shoreline, after which the data can be imported into GIS and attached to the relevant polygons (Figure 18).

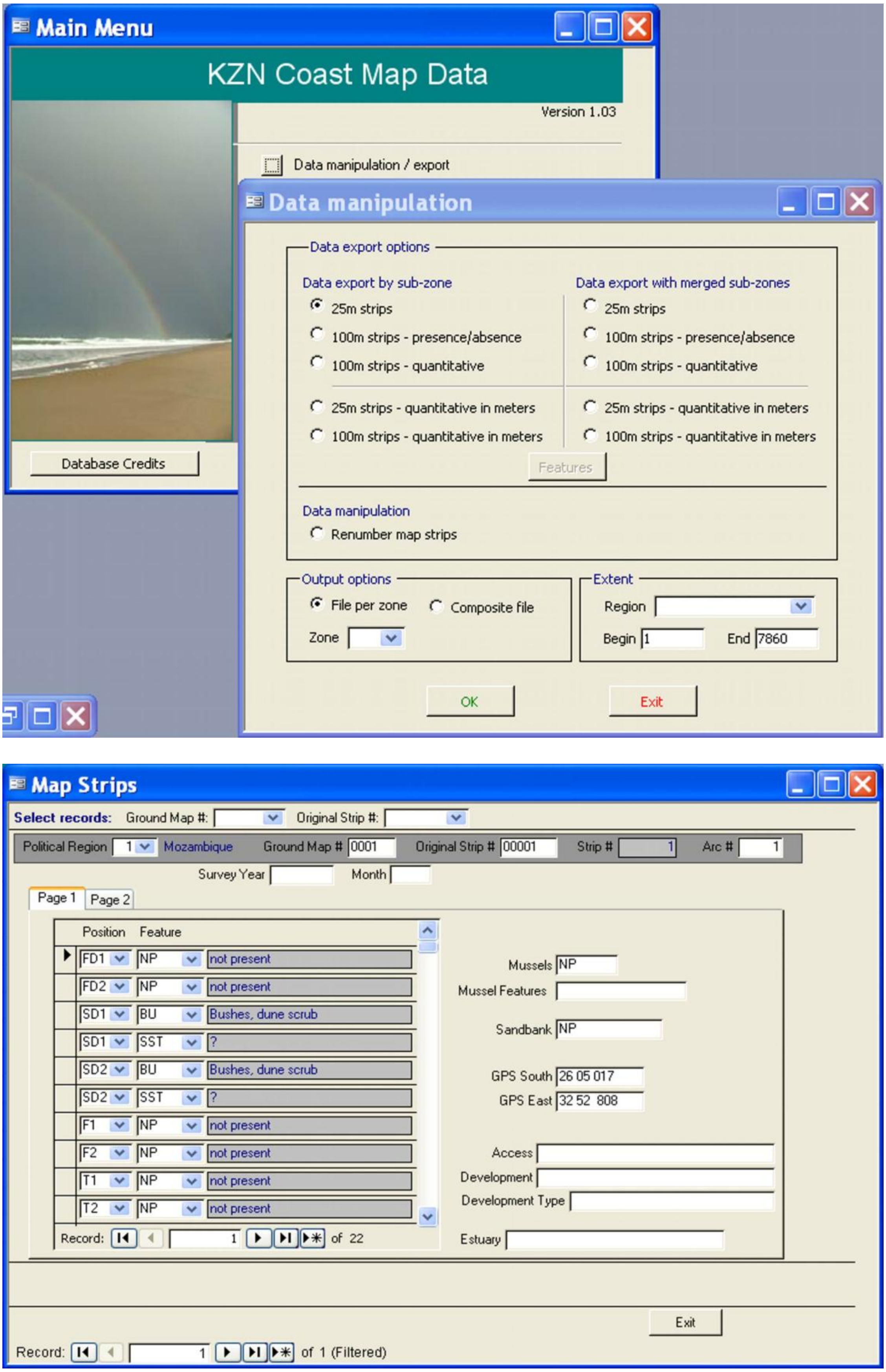


Figure 18: Images of the shoreline habitat database export user-interface and an example of the data within one of the shoreline strips. All shoreline data are stored within the shoreline database which has been cleaned and verified and can be easily exported into .dbf format.

The original shoreline database contained a larger number of shoreline habitats and multiple habitat types per 25 m section. In order to reduce the complexity of the database, some ecologically similar habitats were combined into biozone level II codes and only one dominant habitat type per polygon was retained. A new database for biozone level II type codes was created and the final codes used within the database are listed in Appendix 3: Final shoreline codes used within the biozone level II database.

A total of 27 different shoreline habitats were identified and are listed in Table 4. Further information on the types of developments and other vegetation types identified is in Appendix 3: Final shoreline codes used within the biozone level II database.

Table 4: Shoreline habitats identified along the KZN coast and associated codes

Shoreline Habitat Codes	Description of Shoreline Habitats
DH-BA-A	Bare dune hummocks including narrow foredune
DH-VE-A	Vegetated foredune including extensive dune hummocks
R-	Rock not specified
R-A	Rocks mega <5m
R-ALGAE	*Caulerpa* (intertidal)
RBO-A	Rock boulders
RBO-ARTF	Rock boulders Artificial
RBR-A	High broken rock
RE-A	Rocks emergent
REEF	Reef
R-G-A	Rough irregular rocks
R-H	Rocks High
RLBR-TA	Rock Broken Ledge
RLBR-TB	Rock Low Ledge Broken
RL-M	Mega Rock High Ledge
RL-TA	High ledge
RL-TB	Low ledge
RPEB-A	Gravel
R-POOLS	Rock Pools
R-Pt-A	Point
R-Rdg	Rock ridge
RS-A	Rocks submerged
RSC-A	Scattered rocks
R-SM	Smooth flat sheets
RSO-A	Solid rocks
R-VS.	Very sanded
S-A	Sand

5.2.4.2 Sandy Shore Analysis

The shoreline sampling coded all unconsolidated sediments as sand, which was considered too simplistic since there is a difference in the physical characteristics and biodiversity of beaches and mixed shores as well as among beaches of different morphodynamic types. Field sampling was conducted to obtain data to classify the beaches in KZN and to map the extent of each category of beach. The entire coastline from Kosi mouth to Port Edward was covered either on foot or by vehicle and various beach parameters were coded within an hour before and after spring low tide. The factors coded were: wave height; wave period and average grain size (to determine beach morphodynamic state); intertidal beach width and height; and back-beach width and height (at 5 different points) to characterise the intertidal slope. A total of 315 transects was measured.

At least three major beach types were identified during the sandy shore sampling:

Reflective beaches – characterised by coarse sand and steep beach faces (Figure 19). These are colloquially known as “sugar-sand” beaches (although are not restricted to these). Reflective beaches tend to be low in diversity. Wave action?

Intermediate beaches – have intermediate beach slopes with medium particle sizes. They are often formed under exposed conditions. Most beaches are of the intermediate type (actually four specific phases/types of intermediate beaches exist but are not discriminated here because they change phase over time).

Dissipative beaches – have wide surf zones, flat beach faces and fine sand. These are the widest beaches and are very popular for recreation. However, they have the highest infaunal diversity, which is susceptible to trampling, driving or any other kind of disturbance.

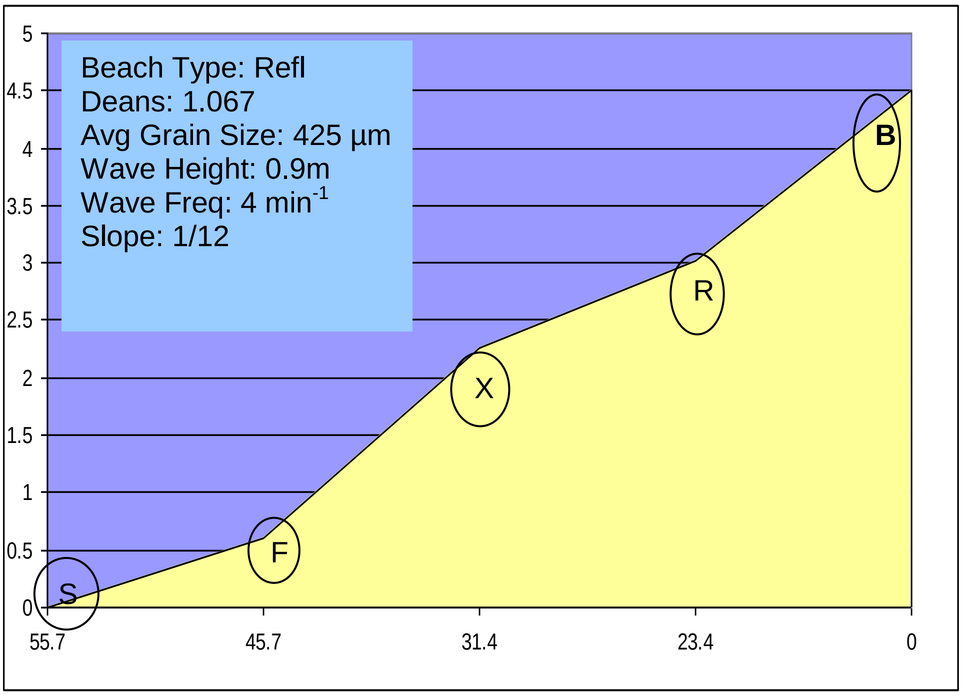


Figure 19: Example of an intertidal transect from the low shore (s=swash) to the dune base (=B) indicating the physical factors that were measured for each intertidal transect (S=swash; F=effluent line; X=mid-shore; R=drift line & B= Dune base)

Data from beach surveys were captured by spatial mapping in Arcview GIS software. This process involved the use of digital aerial imagery and orthophotos along the entire length of the coastline and the creation of a series of points generated along the drift line at the beginning and end of each sandy beach. The points were then populated with the beach classification data obtained during the sampling trips. In some areas where sandy beaches were broken up by estuaries or rocky shores, sampling did not occur at each of these in-between beaches, and thus data were unavailable. In these cases the classification was generated using the digital aerial imagery and orthophotos. The series of beach classification points were then used to populate the low water line indicating the extent of each beach type along the coast as well as the spatial demarcation of the both the sandy and rocky shores for the entire KZN coast.

5.2.4.3 Final Coastal Habitat Layer

In order to produce a series of polygons down the length of the coastline representing the 25 m mapped areas, a total of 23864 planning units were needed. This initial exercise involved digitising “shorelines” used to divide the coastline into the six zones. These shorelines were digitized from the best available aerial imagery of the coastline at the time. The waveline otherwise referred to as the low water line is meant to demarcate the lowest tide line at spring low tides. This low water line as well as the high water line was digitised using aerial imagery. Sources included aerial imagery of the iSimangaliso Wetland Park, eThekweni municipality, Ugu municipality, Umhlatuze municipality and Surveyor General 1:10 000 orthophoto series for areas in which no aerial imagery was available. The shorelines in between these lines (ie the foredune, highshore and lowshore line) were generated using an automated process in arcview. Shorelines were delineated in the original projection of Cape Datum LO33 and converted to WGS 84 (Figure 20). The -5 m contour line was generated from the 1:10 000 orthophotos and this was used together with the bathymetric contours from the Navy to deduce the -2 m depth contour.

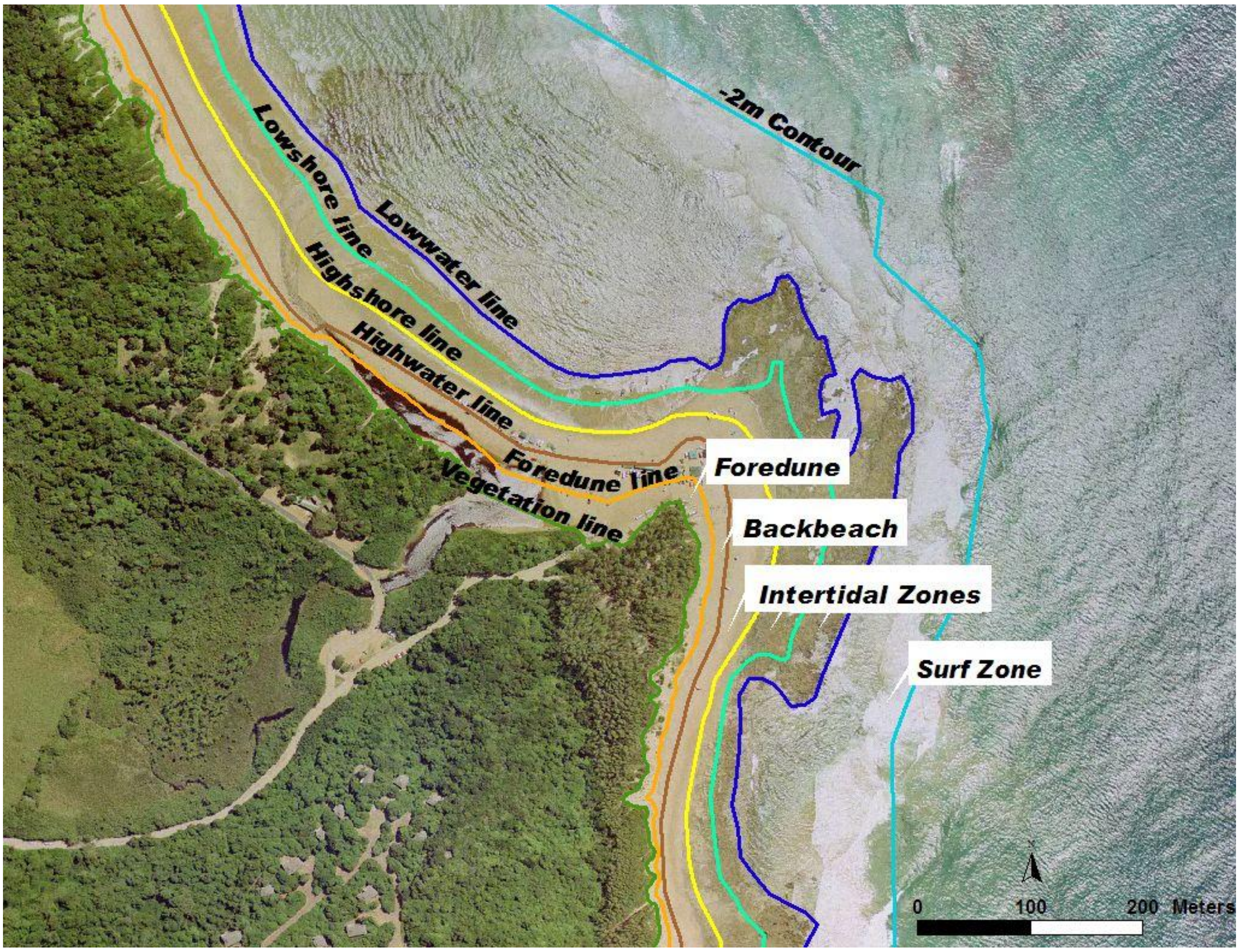


Figure 20: Image indicating the digitised shorelines and associated shore zones. Lines are overlaid on ortho-corrected aerial photographs.

The shoreline closest to the actual pathway walked during the mapping exercise was demarcated as the low shore line. Once these lines were digitised the low shore line was punctuated by 23864 points at approximately 25 m intervals down the coast. Thiessen polygons were created in Arcview using these points and these provided a series of polygons perpendicularly intersecting the shore line down the entire length of the coastline. These polygons were then intersected with the other shore lines to create a series of polygons to which the corresponding shoreline data from the Access database could be attached. Editing of the Thiessen polygons particularly around rocky points and some other sections of coastline was essential in order to produce a consecutive series of polygons down the length of the coastline and across the shore zones (Figure 21).

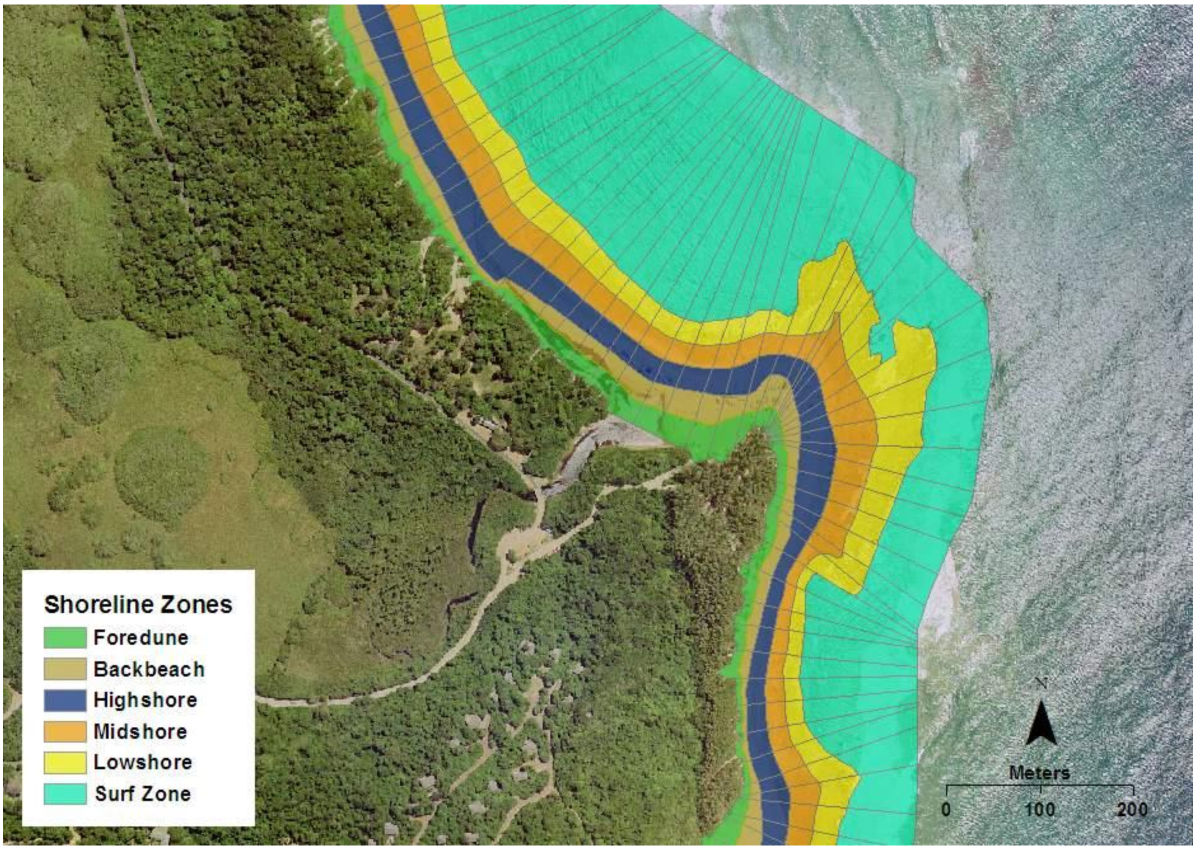


Figure 21: Image depicting the shoreline polygons. Habitat and transformation information can be queried for each polygon within the GIS database.

Shoreline data from the final version of the shoreline database were exported and attached to the shoreline polygons. Multiple codes still existed in some of the fields and so a further cleaning and checking exercise was performed in ArcMap. The final polygon layer can thus be queried for the presence of different shoreline features (habitats, access points) in each of the six zones for each 25 m segment. Sandy shore data were also added to the shoreline polygon layer and used to define sandy shore sub-type within the shoreline polygons. Checks were performed along the entire length of the coastline (using aerial photos and known points such as lighthouses) to ensure that each GIS block corresponded to the correct habitat data in the Access database and sandy shore layer. The final shoreline layer thus resulted in a series of polygons containing habitat, transformation and sandy shore data.

5.2.5 Offshore habitat Map

A number of spatial surrogates were used to delineate a map of proposed biodiversity patterns and a classification of ocean biozones for the KZN province. The methods form part of post graduate studies by Tamsyn Livingstone. Data used for the analysis consisted of pathfinder AVHRR sea surface temperature data (SST), SeaWiFFs chlorophyll-a data and K490 AquaModis (turbidity) data. The initial analyses involved defining the most appropriate variables to create a biologically meaningful classification. Pelagic variables were thus limited SST max, SST mean, SST coefficient of variation (CV), Chlorophyl-a (Chl-a) mean, Chl-a CV, Turbidity mean, Turbidity CV (Figure 22 and Figure 23), bathymetry and slope.

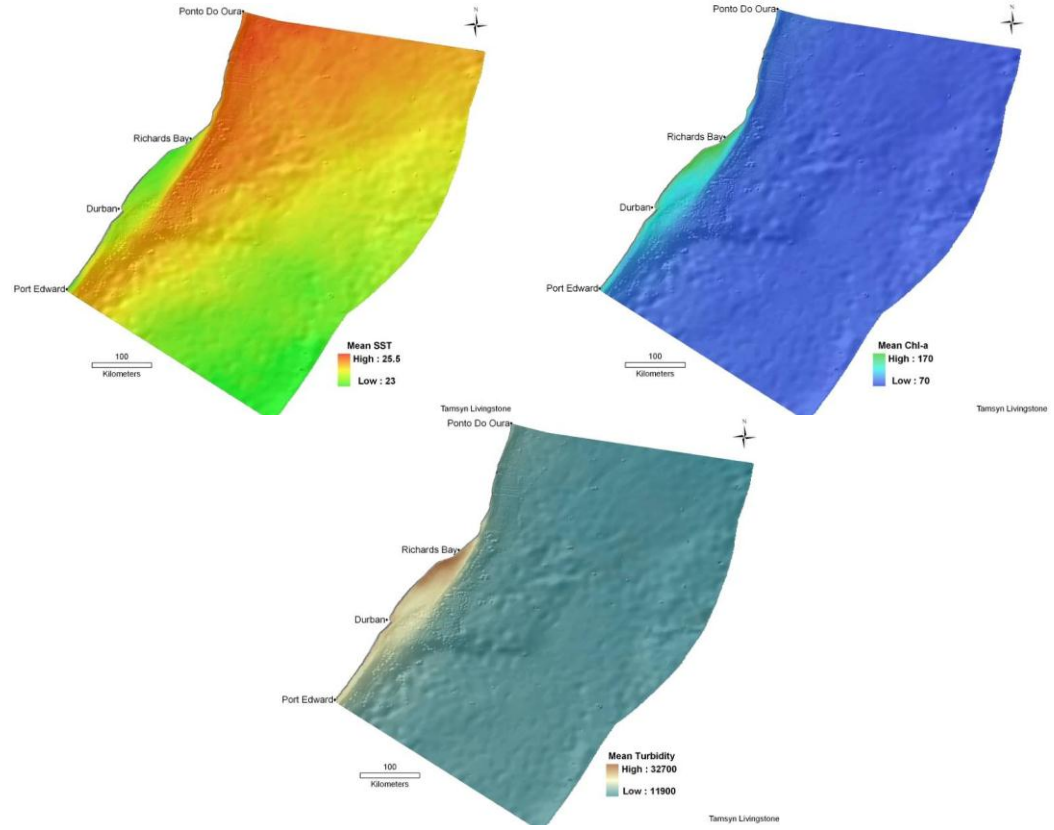


Figure 22: Mean SST, Chl-a and K490 Turbidity Data

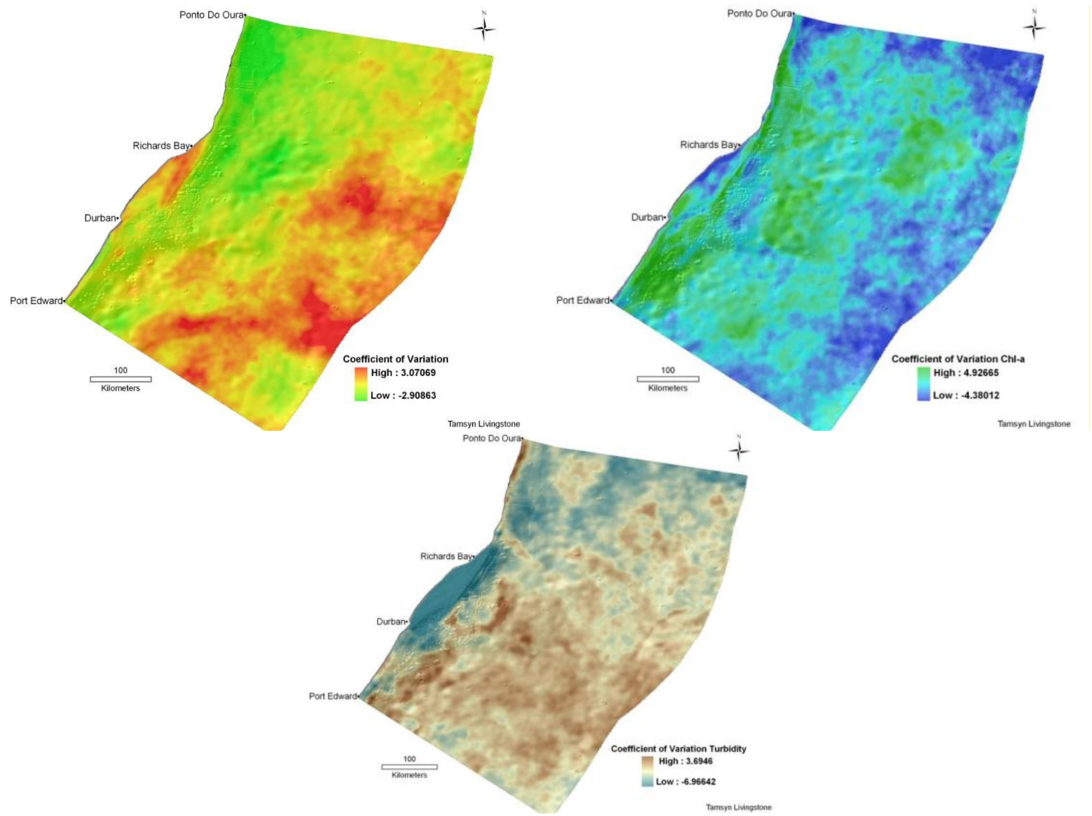


Figure 23: Coefficient of Variation Data for SST, Chl-a and K490 Turbidity data

A K-mean cluster analyses was performed in the statistical program R on the above-mentioned variables. The sum of squares was used to determine a suitable number of clusters to create the bioregional map. The initial results indicate that three main clusters are present with distinctly defining features and these are referred to Bioregions. Further K-mean analyses were then performed within each of the Bioregional clusters in order to allow the subtle changes of temperature and productivity within each of these clusters to emerge. To this purpose, additional data for the inshore Biozones were used for the continental shelf classification: bottom sediments (mud, silt, clay, sand and gravel, Birch (1996)); and seabed oxygen and temperature (Fiona Duncan, UCT, pers comm.). This allowed refinement of the inshore clusters into biozones. The final cluster analyses resulted in twelve Biozones (Figure 24). Two of the inshore Biozones, the Delagoa and Natal biozone, were added inshore of the classification extending the classification to the low water line. The cluster centre and relevance of each parameter to cluster formation is listed in Table 5.

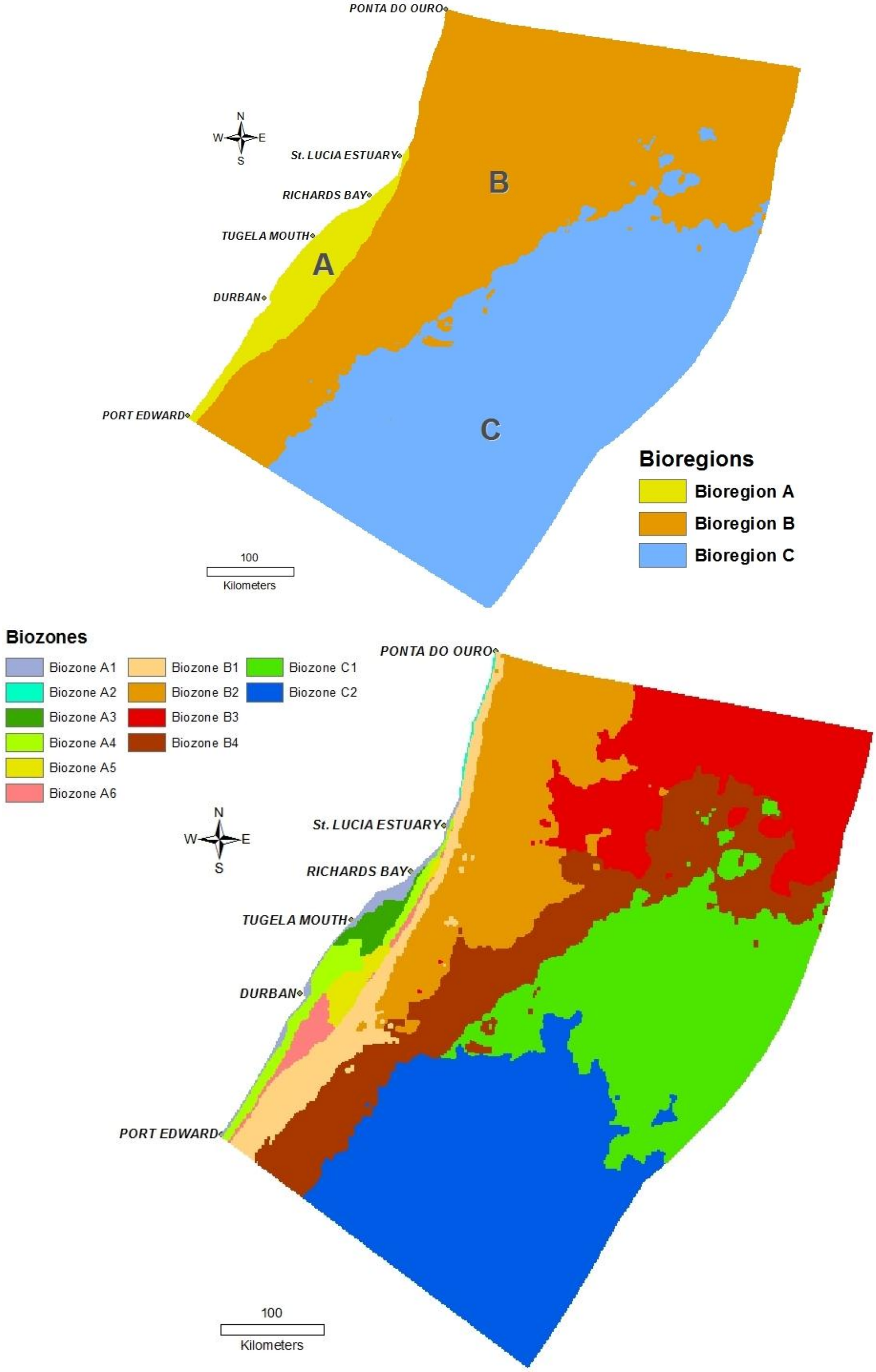


Figure 24: Spatial distribution of biozones: Biozones are spatially nested in three Bioregions.

Table 5: Classification parameters and cluster centres for Bioregions and Biozones. Biozone 3, 4, 5 and 6 integrated parameters on bottom properties including sediment texture, phosphate, organic C, seabed oxygen and temperature. Biozone A1 and A2 are not reflected in the table because they were delineated based on bathymetry (0 - 30m) and limits between the Delagoa and Natal bioregions. CV is the coefficient of variation, Max is maximum.

	Bioregions			Biozones									
Biozones	A	B	C	A3	A4	A5	A6	A7	B1	B2	B3	C1	C2
Max Sea Surface Temperature	4	6	3	2	3	6	6	5	5	6	3	4	5
Mean Sea Surface Temperature	3	6	3	2	4	6	6	5	8	5	3	6	3
CV Sea Surface Temperature	5	3	6	7	4	4	3	4	4	6	5	5	5
Mean chlorophyll-*a*	12	4	4	7	4	3	3	9	5	3	4	3	6
CV chlorophyll-*a*	6	5	4	2	6	5	6	7	5	3	5	4	5
Mean turbidity	12	4	4	7	4	3	3	9	5	3	4	3	6
CV turbidity	-1	4	5	2	5	5	3	5	4	3	6	4	5
Depth	9	3	3	6	6	3	2	7	6	5	3	7	3
Slope	4	5	4	4	4	5	7	8	4	2	4	5	4
Mud, Silt, Clay				4	3	7	3						
Sand, Gravel				4	6	3	5						
Phosphate				3	5	6	4						
Organic carbon				6	3	6	4						
Seabed Oxygen				4	5	3	5						
Seabed Temperature				7	5	3	2						

5.2.6 Species Layers

5.2.6.1 Fish Species (including Sharks)

The following methods of species selection and spatial mapping were developed by Philip Haupt (Haupt, 2010).

The KZN marine environment includes an estimated 1640 marine fish species (Junor,1992). In order to reduce this to a practical number to map, criteria were developed to select particular species for range mapping. Three principals were used to identify these species and more specifically those at risk of falling through a broad habitat net (i.e. species that occur at a finer scale than that at which surrogate habitats and processes are mapped and represented in a biodiversity plan). The principles, were developed in consultation with Dr K. Sink, Dr P. Goodman, AT Lombard, B.Q. Mann, Dr. J. Harris, Dr T. Rebelo and Dr P. Desmet, and include the following: (i) limited conservation options, (ii) threatened species, and (iii) species that are inherently vulnerable. Seven characteristics (which pertain to one or more of the principles) were used to identify species for inclusion (See Figure 25).This provided a list of 280 species, but species for which fewer than 10 specimens have ever been recorded and/or species for which taxonomic uncertainty exists were removed from this list, leaving a total of 250 species. This final list was further reduced to a manageable list of 81 species using methods described in Haupt (2010), (Figure 25).

Prioritising fish species for conservation in SeaPLAN

Species with limited conservation options

Threatened species

Inherently vulnerable species

Seven criteria						
*Endemic species	*Species of conservation concern	Species with life history vulnerability	Highly resident species	Estuarine-dependent species	Rare species	Species dependent on specialised habitats
Qualifying Conditions						
Limited to particular region.	Threatened on IUCN, CITES, TOPs, NSBA, Overexploited, Published concern lists	Reproduction traits, Behavioural traits (e.g. high catchability)	Move < 15 km mean; < 1000 km max	Dependent for spawning and juvenile nurseries	Localised or widespread uncommon species	Habitats that occur at finer scales than the mapped broad habitats

List One

Species that meet the qualifying conditions of at least one of the seven criteria. This list contained 280 species.

List Two

Species with fewer than 10 records in KwaZulu-Natal and/or with taxonomic ambiguity were removed. List two contained 250 species, but was still too many species for the resources of this study.

List Three

Species that satisfy the qualifying conditions of at least two criteria, of which one is either endemic or species of conservation concern. List Three contained 81 species, which were then included in the conservation plan.

Figure 25: Diagram illustrating the process followed to select fish species for SeaPLAN. Reproduced from Haupt et al. (2010).

In order to model the 81 species' distribution ranges, spatio-temporal dynamics were considered. For example, species assemblages in KZN are not static and vary with seasonal changes (van der Elst 1988). The full suite of species associated with the province is comprised of resident and seasonal visitors. There is thus a near continuous influx of species from different neighbouring bioregions (Table 6). Local species for the purpose of this analysis are defined as those that are found offshore of KZN.

Table 6. Species occupancy in KwaZulu-Natal (adapted from van der Elst (1988)).

Group	Occupancy	Temporal association
	Resident fish that spawn locally and have local nurseries	All year
	Pelagic summer migrants that spawn in the tropics and have distant nurseries	Summer
	Winter migrants that are mostly endemic to Southern African waters, spawn locally and have Cape nurseries	Winter

The influx of species to KZN waters is often associated with the completion of species life cycles: the adult feeding stage, the reproductive stage and forming of new individuals (eggs or live born etc.), and the juvenile stages. Many species need to migrate to specific locations to complete these life cycles. For example, estuaries form important nursery areas for a few marine fish species (e.g. spotted grunter *Pomadasys commersonnii*). Some species have predictable aggregative spawning behaviour, in which large groups will come together and spawn simultaneously (e.g. seventy-four *Polysteganus undulosus*).

IDRISI v16.5 and maxent software was used to model fish species distribution ranges. Fish species Distribution Areas (FDA) were captured in GIS format by applying Boolean rules (suitable/non-suitable) to the following layers: depth, range, and distance to coast and habitat type (rocky/sandy/estuary). All these layers were then combined (multiplication operator) to model the FDA. In addition, maxent software was used to model the spatial nad temporal probability of occurrence of species that had appropriate data.

The division of FDAs into three Species Life Cycles occurred for 23 species based on available information. Cycle Envelops, hereafter named SLICES, which are spatial components associated with the species life cycles are listed below:

1. Adults reproductive areas, including spawning/mating/pupping/gestating (elasmobranchs)
2. Juveniles feeding/growing areas
3. Adults feeding/persisting areas

The individual distribution ranges of the respective phases of the life cycle were modelled in KZN waters (see Figure 26 for an example).

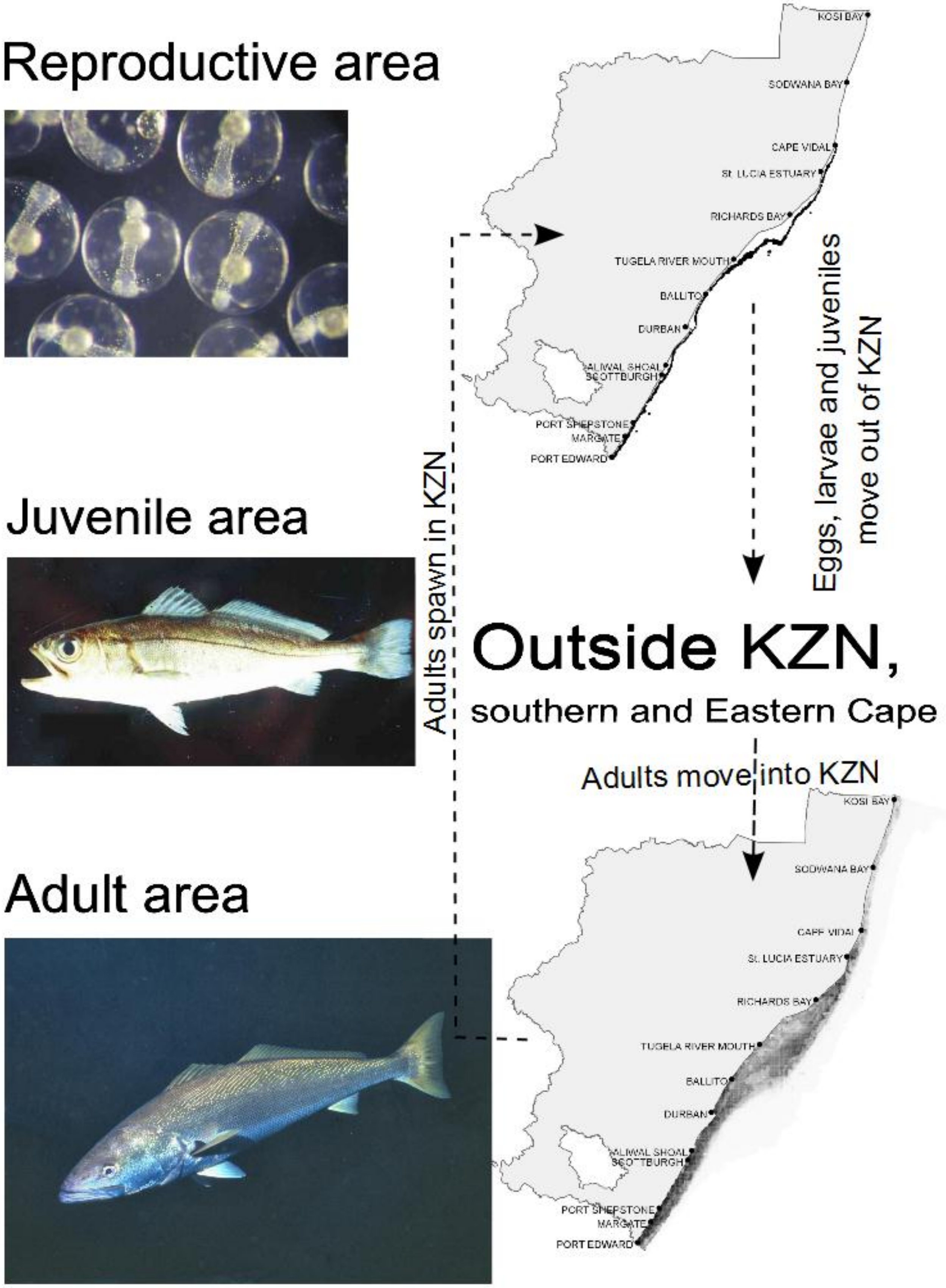


Figure 26. The areas occupied during three life cycle phases of a fish species were identified, and the species distributions in KZN were modelled. In this example the spawning area and distribution of adult geelbek, *Atractoscion aequidens*, is shown; the juvenile life phase occurs outside of KZN. The pictures were provided by Dennis King, and Dr. Allan Connell (egg from www.fisheggsandlarvae.com).

The distribution models were evaluated by experts identified during multiple independent workshops: the first workshop, 4 December 2008, was attended by Allan Connell, Mike Fraser, Neville Ayliffe, Dennis King, Jeremy Williams, Sean Fennesey, Malcolm Smale, and members of the SeaPLAN technical team. The maps were evaluated in a power point presentation including name, picture (photos supplied by Dennis King), distribution information and a map of the modelled distribution. Experts then drew on knowledge and experience to help to refine maps and provide more detailed information on core ranges and areas of special interest. The input from the experts was hugely valuable to fill in the knowledge gaps unavailable from the published literature. During the workshops, experts increasingly displayed confidence in the distribution models and the conservation planning exercise. The distribution models were updated with the new information obtained in the workshops. The amended distribution models were then evaluated by Bruce Mann (ORI). Several of the shark distribution models were evaluated by Sheldon Dudley, Geremy Cliff and Sabine Wintner from KZN Sharks Board, who provided further useful information, especially in terms of species selection and new species on the IUCN Red List. Further information was supplied through email correspondence with several of the experts, in particular Bruce Mann and Sean Fennessy (ORI), the aforementioned members from KZN Sharks board, and Allan Connell, throughout the duration of the project, which led to continuous updating of several of the species distribution models.

Migration pathways of some species were also mapped in Arcview, using geostrophic current arrows as a guideline and assuming that species follow the shortest path. These pathways stretched from inside the planning domain to outside its boundaries, an example being the sardine run. There is however very little data regarding species migration and thus for this project this analysis was not considered, but should be noted as a possible idea for the next rerun of the plan.

Updated species distribution models that used point locality data in combination with environmental parameters have subsequently been developed by P. Haupt and have been made available to Ezemvelo KZN Wildlife for sequential releases of the SCP.

5.2.6.2 Turtles

The two species included were the loggerhead turtle, *Caretta caretta,* and the leatherback, *Dermochelys coriacea*. In terms of the IUCN Red List, these two species were categorised as e*ndangered and critically endangered*, respectively. Both these species have suffered population declines with key pressures including coastal development, climate change and incidental capture by fisheries such as trawl and longlines. The shark control program in KZN also captures turtles (Nel 2006). Both these species use the northern beaches of KZN as nesting areas which is an extremely vulnerable phase of their life cycles and thus the protection of these areas is essential.

The turtle monitoring program was started in 1965 by Dr George Hughes and is one of KZN's longest on-going monitoring projects. Females start laying their eggs from the middle of October and hatchlings begin to emerge from January to late March. Turtle monitoring data are collected annually between Kosi Bay and Sodwana. Locations of nesting females and hatchlings are recorded using turtle beacons established at approximately 500 m intervals by turtle monitors during the turtle season from November to March. The hard copy data is then sent to Ezemvelo and recorded and verified in the turtle monitoring database.

Owing to the wide ranging and complex nature of these species' movement patterns (Nel 2006) it was not attempted to model their marine distributions. Both species are known to use the same areas as nesting sites (Nel 2006, Bachoo and Olbers, 2009) and therefore modelled nesting sites for both species were based on data from the Ezemvelo turtle monitoring programme. The final layer (Figure 27) indicating their distribution range was approximated by the sandy shores habitat data in the shoreline layer, up to the coastal dune, and stretching from Richards Bay in the south to the Mozambique border in the north of KZN (Nel 2006). Although more nesting sites are recorded in the northern parts of their nesting range compared to their southerly limit near Richards Bay, we did not take these differences into account for the distribution models. This decision was based on lower data collection efforts outside of existing protected areas, in particular south of Cape Vidal, thus naturally biasing data towards the northern section of KZN and not accurately reflecting patterns south of the protected area, even though this is the end of their distribution range (Bachoo and Olbers 2009).

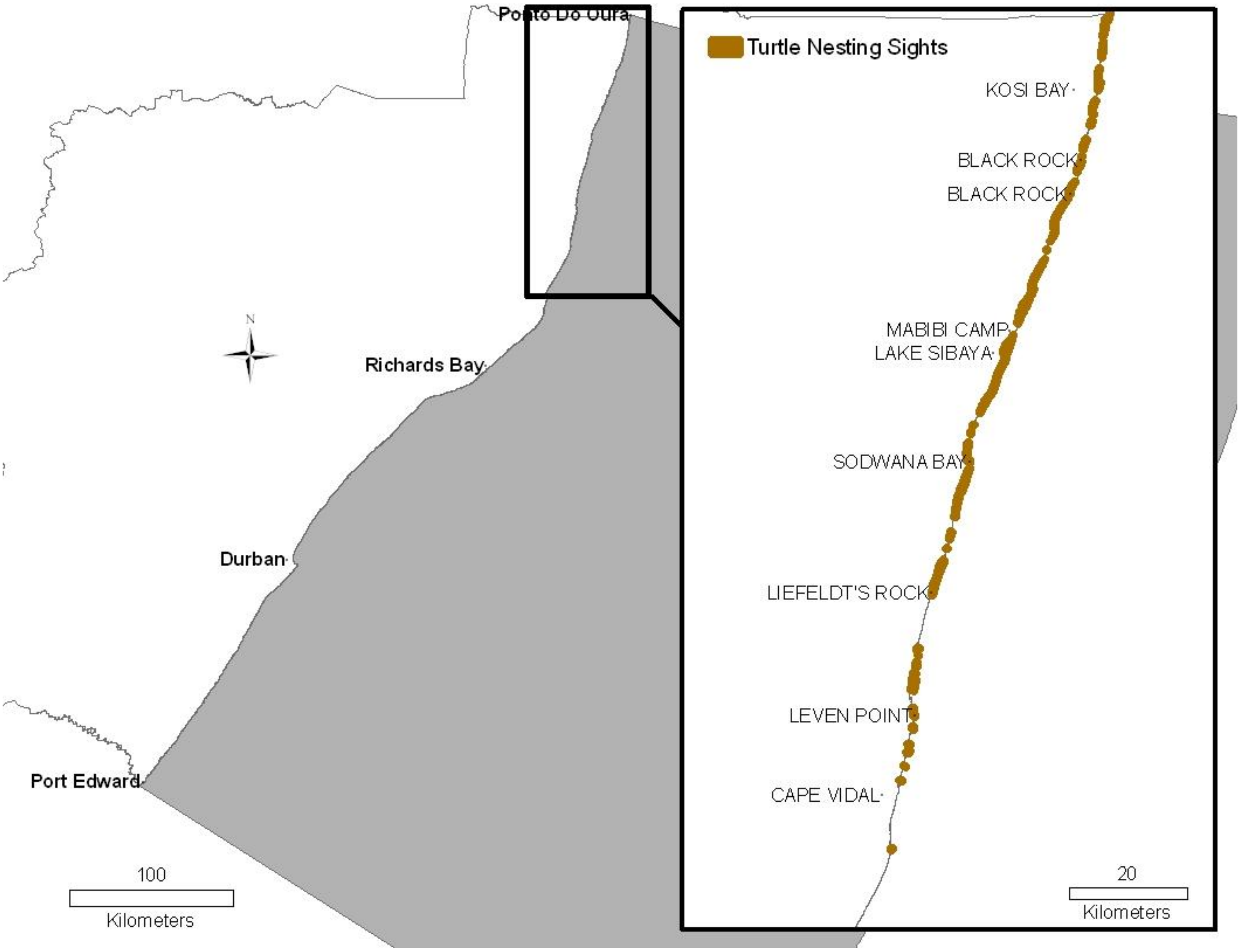


Figure 27: Known turtle nesting sites along the KwaZulu-Natal coast north of St Lucia mouth.

5.2.6.3 Cetaceans

Cetaceans included in SeaPLAN were based on the size of their distribution range, duration of their presence in KZN waters, and the vulnerability of the population in the province. The same methods used to model fish distributions were used to model suitable inshore habitat for four cetacean species: the Bottle nose dolphin '*Tursiops*', the humpback dolphin '*Sousa*', the sperm whale '*Physeter macrocephalus'* and the humpback whale '*Megaptera novaeangliae'*. Although several of the cetaceans like humpback whales and humpback-dolphins have been observed in open ocean waters, only their most critical inshore habitats were modelled for this project. Sperm whales are the only species that are confined to the offshore and the area from the 1000 m depth contour out to the offshore boundary of the EEZ was mapped as their habitat. Humpback whales have nearshore migration routes between their Antarctic feeding grounds and tropical calving grounds. This route was captured in a GIS layer, using the description of Findlay (1989) who describes the route as predominantly between 1 – 3.5 km offshore. Dr's Peter Best and Ken Findlay were contacted to gain their insight into species selection, information on important reference works and distributions of the species. Further information was obtained through email correspondence with Ken Findlay whose PhD thesis (1989) formed the primary source of information on species distributions.

5.2.7 Process Layers

Mesoscale oceanographic features such as mesoscale eddies, areas of upwelling and sea surface temperature (SST) and chlorophyll-*a* (chl-*a*) fronts have an important impact on the exchange of biophysical material and energy in the ocean and are often associated with higher primary productivity. In the Mozambique Channel, it was demonstrated that top predators, such as seabirds and tuna, tend to concentrate in areas with slightly enhanced productivity such as a zone of strong eddies (Weimerskirch et al. 2004).

To detect mesoscale oceanographic features such as eddies or fronts, remote sensing technology has the advantage of covering large areas, over long periods and on a real-time basis. Various techniques have been developed to detect mesoscale features using remote sensing data, classically using sea-surface temperature, chlorophyll concentration and altimetry data. Techniques for the extraction of oceanographic features range from photo-interpretation, to more complex automatic extraction techniques such as object-oriented extraction methods (Hai et al. 2008). In this study, we used a front detection algorithm on sea-surface temperature and chlorophyll-a concentration data to map SST and chl-*a* fronts, and altimetry data to map eddies over a time series.

5.2.7.1 Mesoscale Fronts

Sea Surface Temperature fronts and Chlorophyll-*a* fronts were derived from 8 days (2002-2007) MODIS data at 4 km resolution. Data were downloaded from the NASA oceancolor website (ftp://oceans.gsfc.nasa.gov). Fronts were extracted using the Cayula-and Cornillon algorithm (Cayula and Cornillon. 1992) on non-physical values images (8 bits format). This algorithm is implemented in the Arctool Box MGET (Roberts *et al.* 2010) downloaded from http://mgel.env.duke.edu/tools. Zones with a frequency of front occurrence > 50 % over the time series were integrated into SeaPLAN (Figure 28a,b).

5.2.7.2 Mesoscale Eddies

Cyclonic eddies are associated with negative sea level anomalies (SLA) whereas anticyclonic eddies exhibit positive SLA values. A threshold of + or - 10 cm on altimetry data was retained in order to extract cyclonic and anticyclonic eddies within the EEZ of the KZN Province (H. Grantham, pers. comm.)

These thresholds were applied over HYCOM Monthly 2001-07 Mean Sea Level Anomalies data (computed with respect to a 2001-07 mean) available at 10 km resolution. HYCOM is a spatially nested oceanographic current model, used to calculate the frequency of eddies (both cyclonic and anticyclonic) over the entire time series. Data were provided by B. Backeberg from the Department of Oceanography at the University of Cape Town. Zones with a frequency > 50% were extracted from the data and targeted in the biodiversity plan (Figure 28).

A similar analysis was applied to another dataset of AVISO 8 days 2001-07 Delayed Time Mean Sea Level Anomalies data (computed with respect to a 2001-07 mean). Spatial resolution of AVISO products is 30 km. This layer wasn't used in the plan but is provided in the database. Results are supported by those obtained using the HYCOM model.

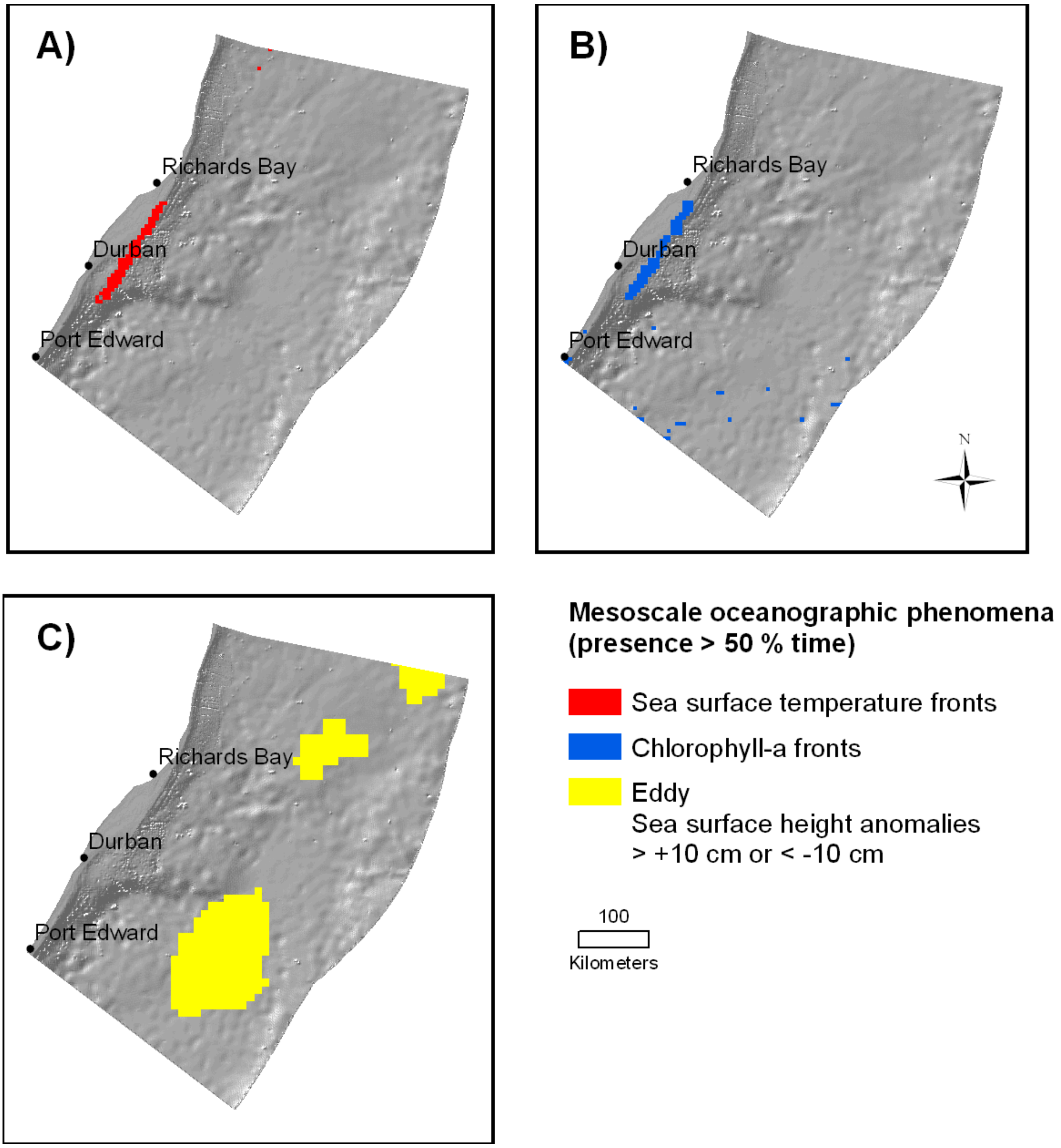


Figure 28: Average position of sea surface temperature fronts, chlorophyll-a fronts and eddies (cyclonic and anticyclonic), in the Kwazulu-Natal province EEZ. Only locations with more than 50% of occurrence are displayed.

5.2.8 Pressures on coastal and marine biodiversity features: Cost layers

5.2.8.1 Rationale and identification

Pressures are defined as human activities, both marine and land-based, that threaten the persistence of biodiversity within the EEZ of the KZN province. Once these activities were identified, available data were sourced to produce a set of spatial maps depicting the extent of the activities and where possible, their intensity. These data were then collated to produce a final “cost layer” depicting the current pressures on the marine environment and high- use areas to be avoided when identifying priority areas for protection.

The identification of these activities and uses of the marine environment were determined in a number of workshops with managers, scientists and marine resource users (Appendix 4: Human-activities Workshop .

These initial workshops developed a list of all currently known pressures occurring within KZN waters (Table 7).

Table 7: Initial list of activities that threaten the marine environment

No.	Activity
1	Commercial linefishing
2	Commercial pelagic longlining
3	Commercial inshore crustacean trawling
4	Commercial offshore crustacean trawling
5	Commercial deepwater rocklobster trap fishing
6	Commercial rock oyster harvesting
7	Small scale seine-net fishery for sardines
8	Small scale experimental fishery for redeye
9	Small scale seine-net fishery (Durban)
10	Subsistence linefishing
11	Subsistence rocky-shore intertidal benthic invertebrate harvesting
12	Subsistence- sandy-beach invertebrate harvesting
13	Recreational linefishing (shore fishing)
14	Recreational linefishing (skiboat gamefishing)
15	Recreational linefishing (skiboat bottomfishing)
16	Recreational paddle-ski (gamefishing)
17	Recreational paddle-ski (bottomfishing)
18	Recreational spearfishing (gamefish)
19	Recreational spearfishing (bottomfish)
20	Recreational charter boat linefishing
21	Recreational east coast rock lobster harvesting
22	Recreational mussel harvesting
23	Recreational oyster harvesting
24	Recreational octopus harvesting
25	Recreational bait fishing (cast-netting)
26	Recreational bait harvesting - rocky shore invertebrates (mussels, limpets, redbait, rock crabs etc.)
27	Recreational bait harvesting - sandy beach invertebrates (mole crabs, ghost crabs etc.)
28	Shark Control Programme
29	Aquarium collecting - commercial
30	Aquarium collecting - recreational
31	Ornamental shell collecting
32	Mariculture – prawn farming (Amatikulu)
33	Alien invasive species
34	Sand winning
35	Fossil fuel mining
36	Titanium mining
37	Shipping general
38	Shipping casualties
39	Effluent pipelines - industrial waste
40	Outfalls - sewerage and stormwater
41	Poor catchment management
42	Poor estuary management
43	Boat launch sites - without hard structures

44	Off road vehicles - beach driving
45	Concession driving areas
46	Land-based marine ecotourism - e.g. turtles
47	Boat-based ecotourism - e.g. whales, dolphins
48	Diver based 1 e.g. scuba diving
49	Diver based 1 e.g. deep diving
50	Diver based 2 e.g. shark diving
51	Coastal infrastructure
52	Boat launch sites – with hard structures
53	Harbours
54	Climate change impacts

5.2.8.2 Costs weighting

In order to rate the potential impact of the different pressure layers on the marine environment a set of weighting factors was produced. The criteria to produce the weighting factors were developed through an expert workshop (including K. Sink, T. Samaai and G. Cliff). These ratings are shown below in Table 8 and are based on six additional criteria with values from 1 to 3, or 1 to 5.

Table 8: Criterion and scoring used to weight pressures on the marine environment off KZN

Criterion	Scoring Range (low - high)	Example of score and pressure
Impact on species	1-5	1- Seine netting for sardines 5- Prawn trawling
Impact in terms of biomass	1-5	1- Subsistence fishing, 5- Commercial longlining
Habitat destruction	1-5	1- Scuba diving 5- Demersal crustacean trawl fishing
Trophic impacts	1-3	1- Octopus fishing 3- Commercial longlining
Risk (large impact but seldom occurs)	1-3	1- Recreational skiboat fishing. 3- Oil spills (shipping lane)
Habitat degradation	1-3	0- Spearfishing 1- Sandy beaches bait collection 3- Sewage pipelines
Economic Incentive	1-3	1- Recreational linefishing 3- Commercial linefishing

5.2.8.3 GIS mapping methods

Once the initial pressures list was finalised, a further assessment was undertaken to determine whether spatial data on location and intensity of the listed activities could be obtained. Following this assessment, the spatial envelops of 39 pressures on the marine environment were mapped as presence/absence layers (Table 9). Continuous intensity layers (from low to high intensity) were generated for a subset of 16 pressures. Various modelling techniques including spatial interpolation, fuzzy logic and kernel analysis were used to generate these layers and the exact techniques are described in subsequent sections.

Table 9: The final pressure list and associated weighting factors. The table includes all the layers for which spatial maps are available.

N°	Description	Intensity layer	WEIGHT
1	Area of influence of shark-nets along KZN coast	No	18
2	Small-scale seine netters (Durban)	No	7
4	Potential distribution of alien species	No	19
5	Recreational skiboat linefishing (bottom fishing)	Yes	12
6	Commercial linefishing	No	16
7	Subsistence linefishing	No	7
8	Subsistence intertidal invertebrate extraction	No	6
9	Recreational paddle-ski linefishing –(bottom fishing)	Yes	6
10	Small-scale commercial seine netting of sardines	No	5
11	Recreational skiboat linefishing (game fishing)	Yes	5
12	Recreational spearfishing (bottom fish)	Yes	8
13	Recreational spearfishing (game fish)	Yes	6
14	Recreational charter boat fishing	No	15
15	Recreational East Coast rock lobster collection	No	5
16	Recreational mussel collection	No	6
17	Recreational oyster collection	No	8
18	Commercial oyster harvesting	No	19
19	Jet-skis	Yes	5
20	Recreational octopus collection	No	5
21	Recreational bait fishery (rocky shores) collection	No	6
22	Recreational bait fishery (sandy beach) collection	No	5
23	Permitted beach driving	No	8
24	Recreational aquarium collection	No	7
25	Recreational paddle-ski linefishing (gamefish)	Yes	6
26	Harbours	No	19
27	Scuba diving	Yes	5
28	Permitted beach driving for turtle tourism	No	8
29	Coelacanth deep diving areas	Yes	5
30	Recreational spearfishing	No	5
31	Area of influence of industrial pipelines	Yes	18
32	Area of influence of urban areas	Yes	19
33	Shipping lanes	Yes	16
34	Crustacean trawling	Yes	21.5
35	Pelagic longlining	Yes	20
36	Shore angling	Yes	10
37	Unpermitted subsistence intertidal harvesting	No	15
38	Residential sewage pipelines	No	9.5
39	Shoreline frequentation (accessibility to people)	Yes	5

The spatial envelopes of all 39 activities were defined by experts and were based on the following parameters: distance from the coast, depth, range and legal restrictions (for instance, prohibited activities such as fishing in certain zones of an MPA. All grid layers had a spatial resolution of 20 m to be compatible with the smallest planning units used for the assessment analyses.

Exact details of binary pressures maps can be found in Appendix 5 and some images are displayed in Figure 29.

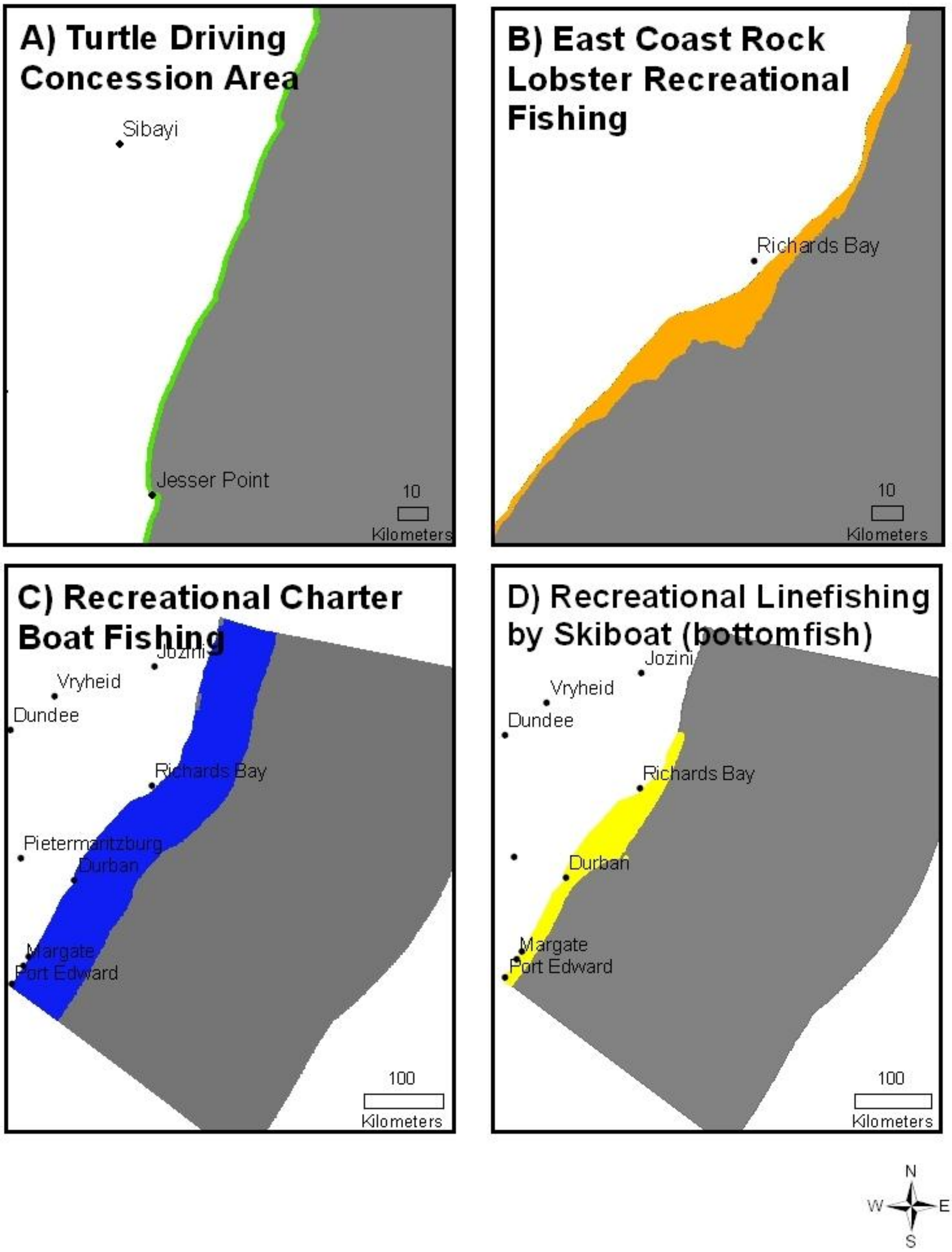


Figure 29: Some examples of the binary pressure layers. A) Turtle driving concessions areas; B) East Coast Rock Lobster recreational fishing areas; C) Recreational charter boat fishing areas; D) Recreational line fishing by ski boats for bottom fish. These pressures layers are presence/absence layers and were developed using known occurrence and existing legislation. Layers thus indicate areas where these activities can take place and not necessarily the actual distributions.

5.2.8.4 Pressure intensity mapping methods

5.2.8.4.1 Small vessel boating activities

The technique described below was used to model pressures 5, 9, 11, 12, 13, 19, 25, 27 and 29 (Table 9).

The intensity of small vessel (< 10 m) boating activities was derived from an initial map of launch sites, to which data on launch site statistics were attached. This data was obtained from ORI (i.e. the Boat Launch Site Monitoring System) and consisted of records on the number and type of boats (i.e. ski-boats, inflatable boats, paddle-skis and jet-skis) launched over a one year period (2006) from the participating launch sites along the KZN coastline. These launch sites were further grouped into 40 sites. A 100 m grid was derived for each boat type (n = 4), with each launch site being represented by a single cell grid. The grid cell value was equal to the number of boats launched over a year period. The grids were log(X+1) transformed in order to standardise the values. This layer is referred to as [Layer 1]. Note that for diving related activities, it was considered that 70% of divers dived from inflatable boats and 30% from ski boats.

Secondly, the potential spatial distribution of boat fleets, per boat type, from each launch site was modelled using the set of fuzzy rules described in Figure 30. This set of rules was developed with experts: B. Mann (ORI), J. Harris (Ezemvelo) and N. Scott-Williams (Subtech Diving). It was implemented in ArcGis 9.2 using the toolbox "Spatial Data Modeller" (Sawatzky et al., 2008).

Technical/logistical constraints limit the geographic distribution of the boat fleet and a number of assumptions were made based on existing knowledge. For example, skiboats are limited by engine, fuel, time and safety constraints and thus the assumption is that they do not travel more than 50 km from their launch site. Based on this set of rules, a probable distribution of boats, per boat type, from each launch site, was derived. Other more complicated parameters, such as preferences for fishing spots were not integrated into the analysis. The final fuzzy layer contains values ranging from 0 to 1 and it is referred to as [Layer 2].

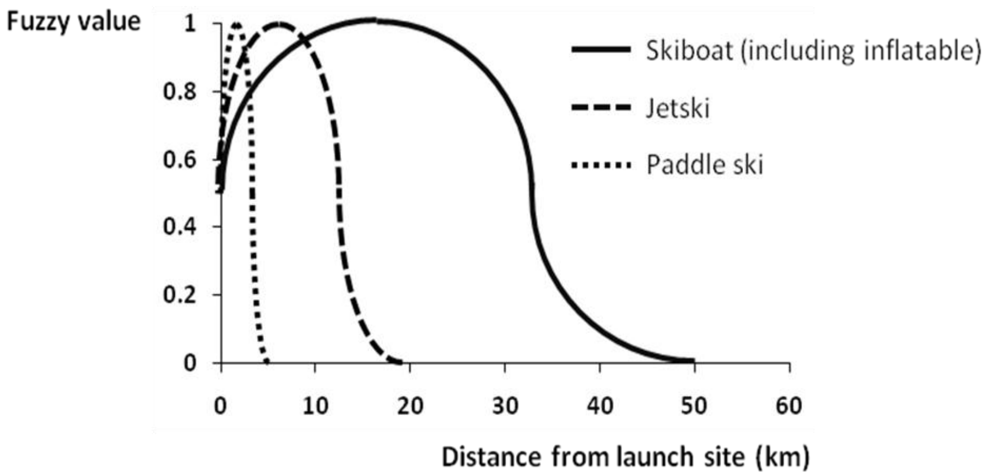


Figure 30: Fuzzy function showing likely location of boats, per boat type, depending on distance from launch sites.

A kernel analysis (sum operator, circular shape) was performed over [Layer 1] to assess the number of boats that could potentially reach each cell in the EEZ. The radius of this focal analysis was set for each boat type (n=4), according to their maximum operational distance. Thus if a cell can be reached from harbour H1 with 20 launches per year and from harbour H2 with 30 launches per year, then this cell received the value 20 + 30 = 50. The layer resulting from the focal analysis was transformed to a fuzzy layer with values ranging from 0 to 1, hereafter referred to as [Layer 3].

Finally, [Layer 2] and [Layer 3] were combined using a fuzzy sum operator. The resulting layer is the density of boats, per boat type in the ocean. It is assumed that boat density acts as a surrogate for fishing pressure.

5.2.8.4.2 *Influence of industrial pipelines*

Five industrial pipelines were identified along the KZN coastline using GPS coordinates obtained from experts or the industry itself. The discharge of each pipeline was determined and mapped as a grid layer (100 m resolution) with one cell for each pipeline. The value of the cell was equal to the discharge. This layer is referred to as [Layer 1]. Expert advice provided by T. Samaai (DEA) established the maximum distance of contamination of a pipeline to be 5 km, with a minimum distance of 2 km, and using this advice, the maximum area of influence for each pipeline was determined (Table 10). In a fourth step a kernel analysis (sum operator, circular shape) was applied to [Layer 1]. The radius of the kernel was the maximum area of influence of the pipeline. This layer was transformed to fuzzy values ranging from 0 to 1, hereafter referred to as [Layer 2]. Distances to the pipelines were calculated as a grid layer. This layer was transformed to fuzzy values with a linearly decreasing function with a value of 1 at the pipeline down to 0 outside the area of influence. This layer is referred to as [Layer 3]. Finally [Layer 2] and [Layer 3] were combined using a fuzzy sum operator. The resulting layer is the modelled intensity of the impact of industrial pipelines.

Table 10: Data and data sources for Industrial pipelines.

Name	Source	Length (km)	Discharge (m^3/hr)	Radius (km)
End Cap - AECI	Caroline Dickens - AECI	6.5	45	2
Huntsman Tioxide - I	Irene - SA Tioxide	1.7	30	2
Central Works Outfall	Tim McClurg-CSIR	3.2	60	2
Southern Works Outfall	Tim McClurg-CSIR	4.2	50	2
SAPPI SAICCOR	Derek Airey - SAPPI	6.5	45	4
Richards Bay	SAN chart 1993.47	4.95	30	3

5.2.8.4.3 *Influence of urban areas*

The urban layer was extracted from the KZN landcover data. Distances to core urban areas were extracted and mapped as a grid layer. This grid layer was further transformed into a fuzzy layer using a linearly decreasing function. This function was set as follows: at 0 km the fuzzy value is 1 (membership to highly impacted zones) and further than 5 km the fuzzy value is 0 (no impact).

5.2.8.4.4 *Shipping lanes*

The data set on shipping lanes is extracted from the study by Halpern et al. (2008). Data were collected over 12 months from the beginning of October 2004 (collected as part of the World Meteorological Organization Voluntary Observing Ships Scheme; http://www.vos.noaa.gov/vos_scheme.shtml). Mobile ship data was connected and used to create ship tracks, under the assumption that ships travel in straight lines. The 799,853 line segments were then buffered to be 1 km wide thus accounting for the width of shipping lanes, and all buffered line segments were summed to account for overlapping ship tracks. The summed ship tracks were converted to raster data. This produced 1 km^2 raster cells with values ranging from 0 to 1158, the maximum number of ship tracks recorded in a single 1 km^2 cell. Because the VOS program is voluntary, it should be noted that the estimates on the impact of shipping are biased (in an unknown way) to locations and types of ships engaged in the program.

5.2.8.4.5 *Crustacean trawl and pelagic longlining*

Data on crustacean trawling and pelagic longlining were provided by SANBI (K. Sink). The data were provided as a net of 16 x16 km square grid cells. The intensity of these activities on the marine ecosystem were mapped using the total number of crustacean trawling hours and the catch per unit effort (CPUE) for pelagic longlining. The data were then interpolated to fit a 100 m resolution grid using a kriging technique (with surrounding 20 points).

5.2.8.4.6 Shore angling

Data on shore angling were provided by B. Mann (ORI) who conducted an aerial survey of the KwaZulu-Natal coast to determine total shore angling effort (Mann et al. 2008). Between March 2007 and February 2008 a total of 36 flights was conducted, half along the north coast (Virginia to Kosi Bay) and half along the south (Virginia to Port St Johns). The method was to fly at a low level (400-500 ft) along the coastline at a speed of 70-90 knots, counting all observed shore anglers using a manual tally counter. The data were provided in an Access database and were integrated into a GIS format by Ezemvelo with the help of B. Mann. The number of anglers per km of coast was determined for each section of the coast identified in the study by a unique ID. This layer was further transformed to a fuzzy layer using a linear function, with final values ranging from 0 to 1.

5.2.8.4.7 Shoreline frequentation (accessibility to people)

A number of different types of shoreline access areas were noted during the coastal mapping exercise and are recorded in the coastal biozone layer (e.g. parking lots and piers, toll roads, public access paths, viewing platforms, promenades, stairways etc.). These access areas were grouped into five access types which were used as surrogates for the shoreline frequentation. They are weighted from 1 (low frequentation) to 5 (high frequentation). Ezemvelo experts determined the maximum walking distance from these points to be approximately 1 km with the majority of people found within a 200 m radius of the access point. This rule was applied using a fuzzy logic approach based on distance to access points. A frequentation layer was produced for each access category and the final five layers were weight summed. The resulting layer was linearly transformed into a fuzzy layer with values ranging from 1 (highly frequented) to 0 (not frequented).

5.2.8.5 Synthesis map - final cost layer

The 39 pressure layers were weight summed to produce the final cost layer (Figure 31). The image indicates higher pressures or uses closer to the shoreline increasing southwards from Richards Bay to Durban and down to Port Edward and decreasing as you move offshore. This is logical as this is the most socio-economically important area of the KZN coast. Red spots of high pressure are also noted offshore and are a result of pelagic longlining. The 3D representation of the data clearly shows high pressure spots around launching sites.

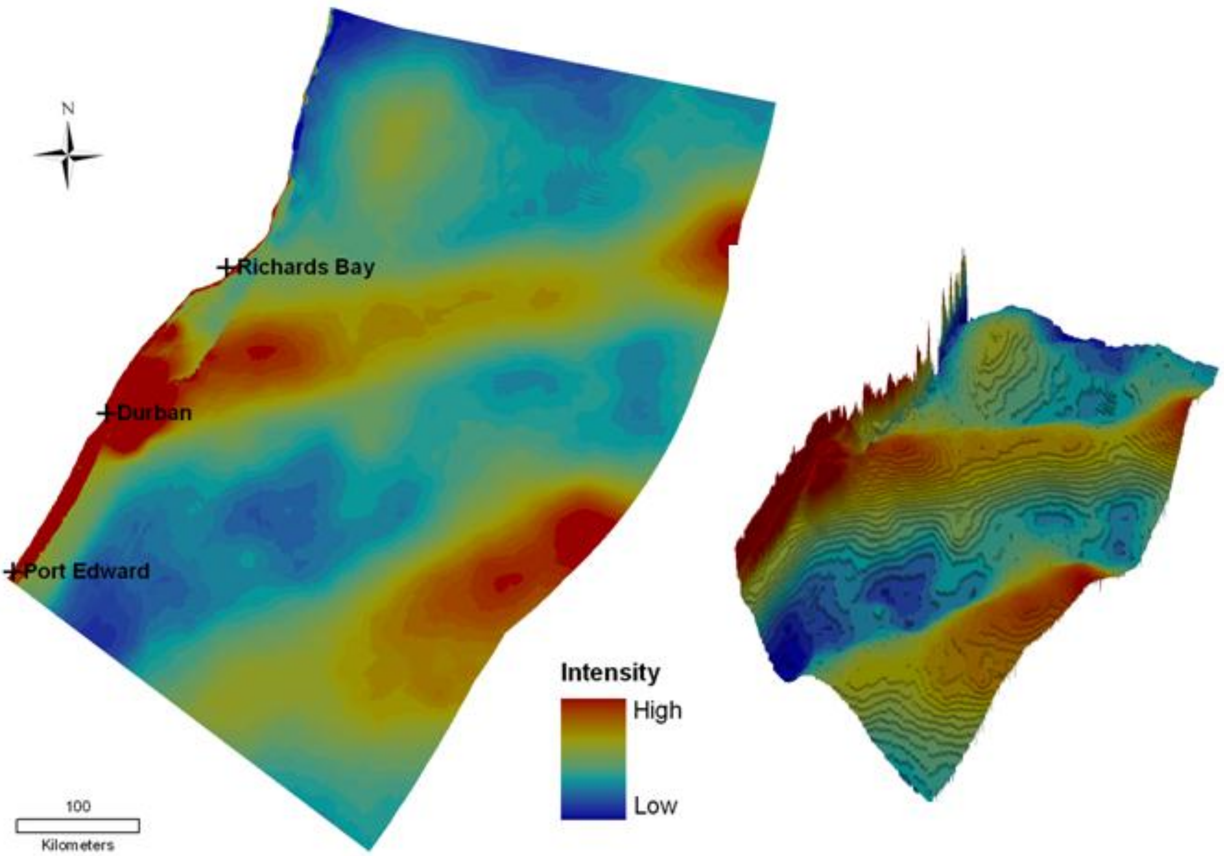


Figure 31: 2D and 3D representation of pressures on biodiversity in the EEZ offshore of the KwaZulu-Natal Province.

Pressure values within the C zones of MPAs were often higher than pressures outside MPAs (Figure 32). For this reason, C zones were considered to not contribute to meeting biodiversity targets and were thus ignored during SCP analyses

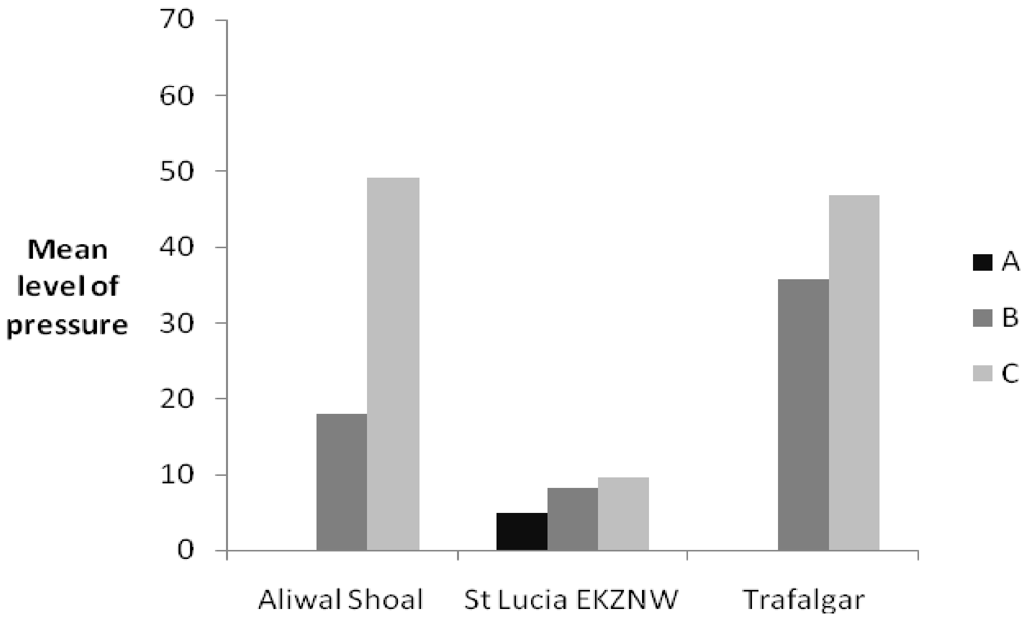


Figure 32: Mean of pressure values inside current marine protected area zones in KZN. Pressure values range from 0 to 100.

5.2.9 Planning units layer

Once biodiversity patterns and processes had been spatially delineated, the study area was subdivided into planning units (PUs). Each PU contains information on the amount (area) of biodiversity features contained in it, as well as a pressure (cost) value. The contribution of each PU to the quantitative targets was then calculated (i.e. the biodiversity assessment), and an efficient (smallest total area) and practical complementary spatial arrangement of PUs was then identified to meet all the targets (i.e. the biodiversity plan).

For this study, three overlapping PU layers were developed and made up of square cells of 0.2 km, 1 km and 10 km resolution (Figure 33). This multi-resolution approach aimed to reflect the multi-scalar nature of ecological systems. For instance, oceanographic eddies operate at a very broad scale whereas estuaries may have a more localised influence. To account for the scalar gap between the different features the PUs size needs to be compatible with the scale of biodiversity patterns and processes. For instance 10 x 10 km PUs are acceptable to develop a biodiversity plan for offshore MPAs but a finer spatial resolution layer is required for planning of coastal MPAs. A fine resolution PU layer was not technically manageable over the entire EEZ and thus for this biodiversity plan the development of three PU layers of different resolution was an sensible solution. It required some methodological development but has the advantage of fitting the resolution of the available data, fine-scale on the shoreline (field survey) but very broad scale offshore (satellite imagery), into one plan. The spatial extent of each PU layer is restricted by depth zones. All PU layers have been developed to partially overlap, thus “informing” each other. For example, in the biodiversity plan, the identification of priority areas identified at the 10 km resolution is influenced by the priority areas identified at 1 km resolution.

The three overlapping and nested PU layers had the following specifications (Figure 33):

- 10 km resolution from the 2 m depth to the offshore boundaries of the EEZ
- 1 km resolution from 2 m to 200 m depth,
- 200 m resolution from 2 m to 30 m depth. This layer also contained shoreline PUs delineated by the limits of the shoreline biozones beginning at the terrestrial/coastal boundary (vegetation line), with alongshore sections every 100 m.

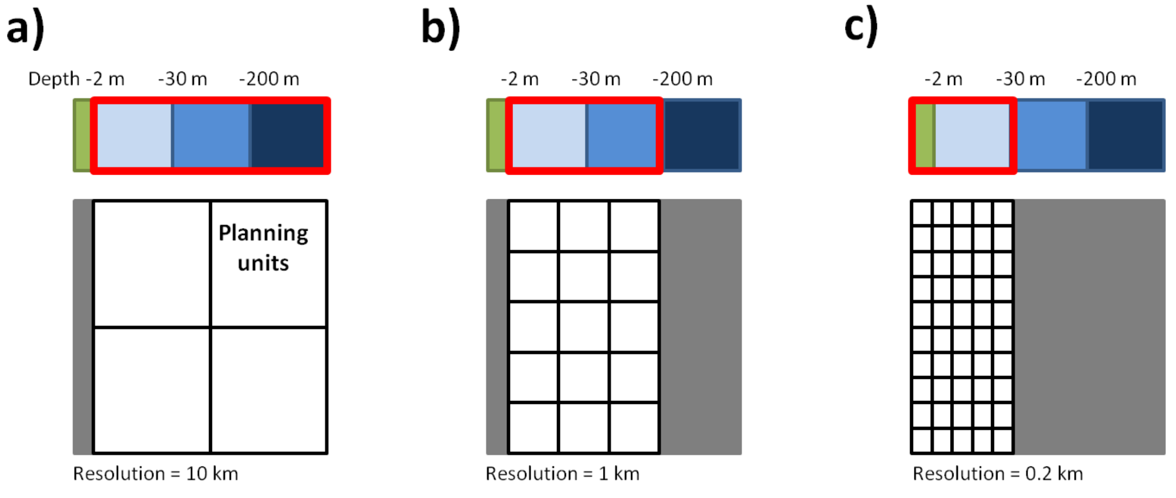


Figure 33: The three PU layers: a) 10 km resolution, b) 1 km and c) 0.2 km. Grey zones indicate areas not included in the layer. Note that all layers overlap partially to allow the “inheritance” of spatial information from one layer to another.

Each of the layers was then intersected with the boundaries of the extant network of protected areas. This network included: MPAs (zones A, B and C), terrestrial protected areas, admiralty zones and state land. Depth contours were extracted from the bathymetry layer described previously. PUs smaller than 5000 m^2

were dissolved into adjacent polygons. This resulted in a single multi-resolution PU layer containing 64189 Pus (Figure 34).

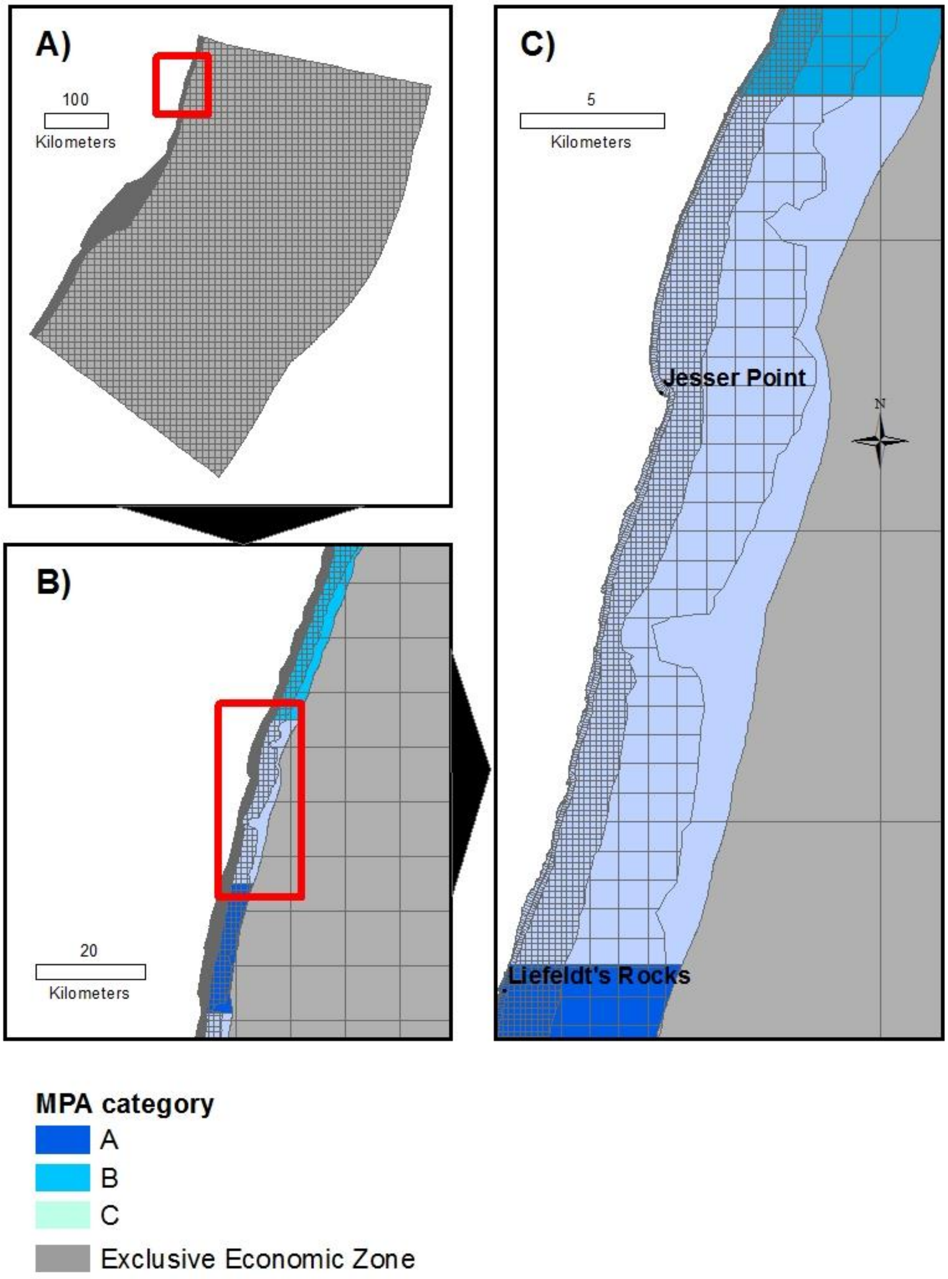


Figure 34: Extract of the mixed-resolution PU layer used for the conservation assessment.

5.2.9.1 Feature coding

Once all the data has been collected, verified and converted into spatial layers, these layers are used to populate the PUs layer. In order to easily identify each feature within the PU layer a unique feature code is applied to each data layer. Each biodiversity feature layer was attributed a unique ID in Excel. This ID is made up of 7 digits. The first digit represents the type of feature: 1 for Habitats, 2 for Species or 3 for Processes. The subsequent digits reflect sub-categories of the broad feature categories shown in Table 11.

Table 11: Example of feature ID coding

ID	Digit 1	Digit 2	Digit 3	Digit 4	Digit 5
1260056	1- Habitat	2- Coastal Biozones - Surfzone	6 - Zone 6	0 - All regions	060 - Solid Continuous Rocks

5.3 Biodiversity Target

A list of biodiversity targets for each of the mapped features is required in order to assess the current status of biodiversity protection and to determine how much of each feature requires additional protection. Biodiversity targets in SeaPLAN refer to the current distribution of biodiversity features. In a first step, a baseline target of 20 % of their distribution area was applied to all features as stated in the National Biodiversity Strategy and Action Plan (Department of Environmental Affairs 2005). This 20 % baseline target was adjusted for some features (ranging from an additional 0 to 80 %) based on a feature's rarity, endemism, specialisation, localised distribution, and intrinsic vulnerability as advised by experts. In a second step, the proportion of the target to be protected in A zone versus B zone MPAs was also defined. This is because A zones provide greater protection for certain features than B zones, and biodiversity features differ in the type of protection they require. Consequently, each feature had two targets: the first was for A zone MPA protection and the second was for B zone MPA protection. As a default, biodiversity targets for features were divided into equal A and B zone targets unless otherwise specified by experts (Figure 35). Appendix 7 lists all biodiversity feature targets.

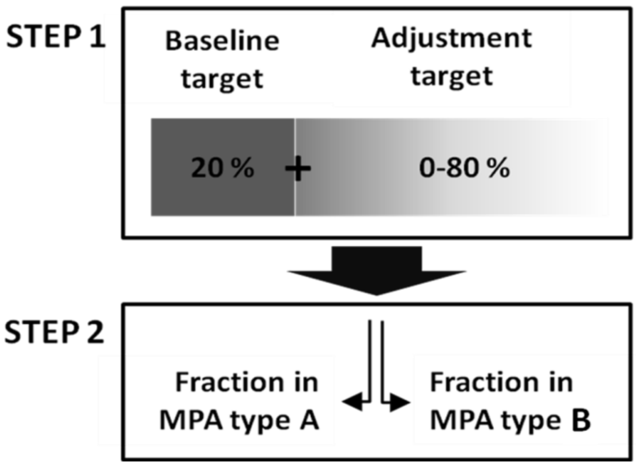


Figure 35: The two steps for determining biodiversity targets in SeaPLAN

5.3.1 Habitats targets

Targets for habitats were set to 20% for offshore biozones, rock reefs and shoreline biozones and divided between the A and B zoned MPAs. Targets for coral reefs were defined with an ORI scientist (M. Schleyer); they range from 80% to 100% due to the uniqueness, low resilience, high vulnerability and pressure exposure of coral reefs in the KZN region. Targets for canyons were set as follows: one canyon with 100% type A protection and one canyon with 100% type B protection in each bioregion (Natal and Delagoa). The canyons were pre-selected by their proximity to existing protected areas - this was due to the limitation of the program which would have chosen percentages of each canyon otherwise. Targets for estuaries were set to 20% within a B zone for 13 estuaries. Due to the small number of estuaries occurring in the Delagoa bioregion all those in this bioregion were targeted. Targeted estuaries in the Natal bioregion were selected on the basis of their irreplaceability score in the Estuaries Systematic Conservation Plan.

5.3.2 Species targets

Baseline targets for fish and cetacean species were set to 20%. The adjustment target for those species varied according to the following criteria:

	Criteria	Additional fraction (Min-Max)
1	Endemicity	0-10%
2	Rarity	0-10%
3	Specialisation	0-10%
4	Localised distribution	0-10%
5	Intrinsic vulnerability	0-10%

1 - Endemicity: Endemic species are those confined to a particular area at different scalar levels: province of KZN, Natal bioregion or an assemblage of bioregions and Southern Africa. The adjustment target for endemicity varies from 0 to 10% as follows:

	Criteria	Additional fraction
1a	KZN provincial endemic/Strict endemic	10%
1b	East Coast endemic - (Natal, Delagoa & Agulhas bioregions)	5%
1c	Southern African endemic – (Namibia to Delagoa bioregion)	2%
1d	Not endemic	0

2 - Rarity: Naturally rare species are those that are never common wherever they are found, even if they can be found over the entire KZN EEZ. A target increase is needed to increase the probability of representing these widespread species in the biodiversity plan.
3 - Specialisation: Species documented or reported to be confined to specific habitats, and these specific habitats are not captured within the habitat types e.g. Staghorn coral beds within coral reefs. A higher target is required to increase the probability of capturing these species and their specialised habitats in the biodiversity plan.
4 - Localised distribution: Species with localised distribution are KZN endemic species that are recorded in fewer than three sites (site area < 100 km2). A higher target is required because fewer spatial options exist for their conservation. This criterion mostly applies to identified spawning sites.
5 - Intrinsic vulnerability: These species are particularly vulnerable to biological and anthropogenic impacts because of one or more of their life history traits.
- High age at maturity/Slow growth and longevity
- Small litter size (elasmobranchs)/Low fecundity

Species with vulnerable life histories require higher targets to compensate for their intrinsic vulnerability. A standard increase of 10% was applied to all species of any of the listed characteristics.

5.3.3 Process targets

Targets for processes were set to 10% of their distribution area: zones with frequent fronts or gyres. These features indicate areas of importance for pelagic ecosystems and since they are most commonly associated with species aggregation areas this 10% is set to fall within an MPA type A zone.

5.4 Biodiversity Assessment

Once biodiversity patterns and processes have been spatially delineated and the pressure mapping complete, the study area is subdivided into planning units and the existing MPA network is overlaid to calculate the representation of each feature in each type of MPA. This provides PU an assessment of the current level of protection of each biodiversity target and quantifies unmet targets for each feature.

5.4.1 Target achievement

Microsoft Excel was used to perform this assessment and the area of each feature within each zonation category within an MPA was calculated, and thus the percentage of each feature currently being conserved was calculated. The detailed results of the biodiversity protection assessment indicated that currently only 8% of offshore habitats, 44% of coastal habitats, 52% of species and 0% of processes meet their current targets (Figure 36) within an MPA A (Sanctuary) and MPA B (Restricted) zone. MPA C (Controlled) zones did not contribute to target achievements (as previously explained).

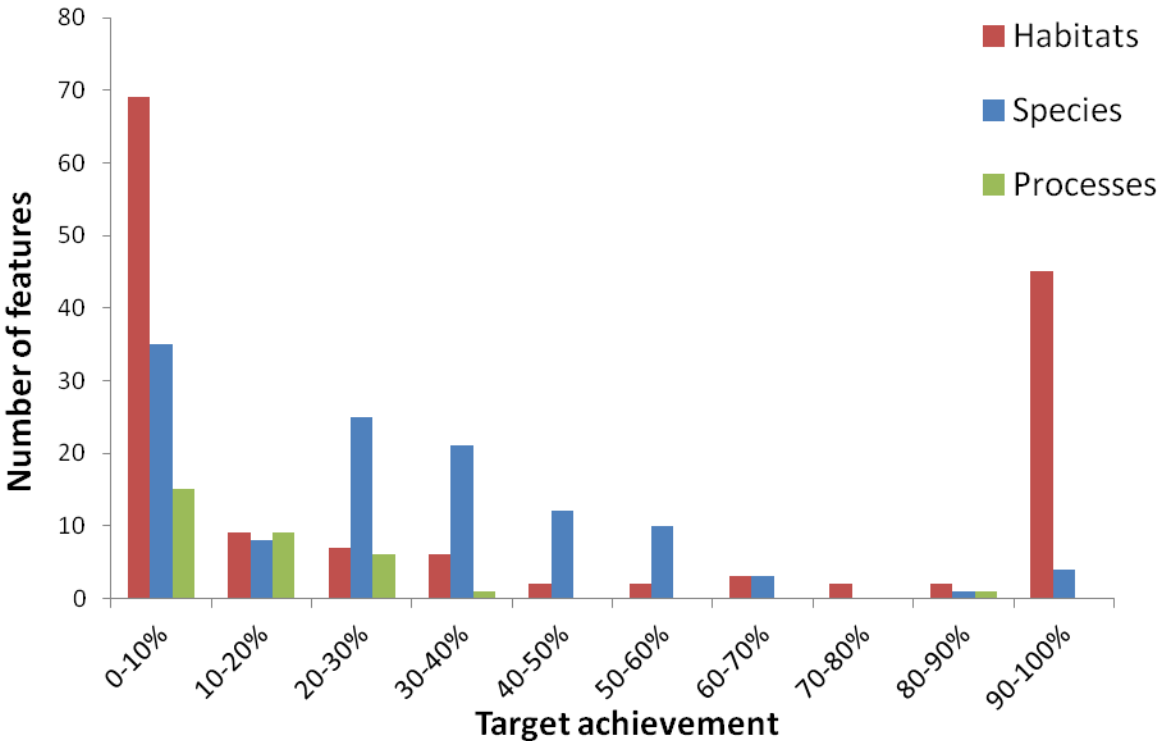


Figure 36: Overall target achievement for habitats, species and processes within the current MPA network within KZN, taking in to account MPA A and B zones only.

For easier interpretation habitats, species and processes were arranged into groups and the target achievement per groups are represented in Figure 37 Figure 39.

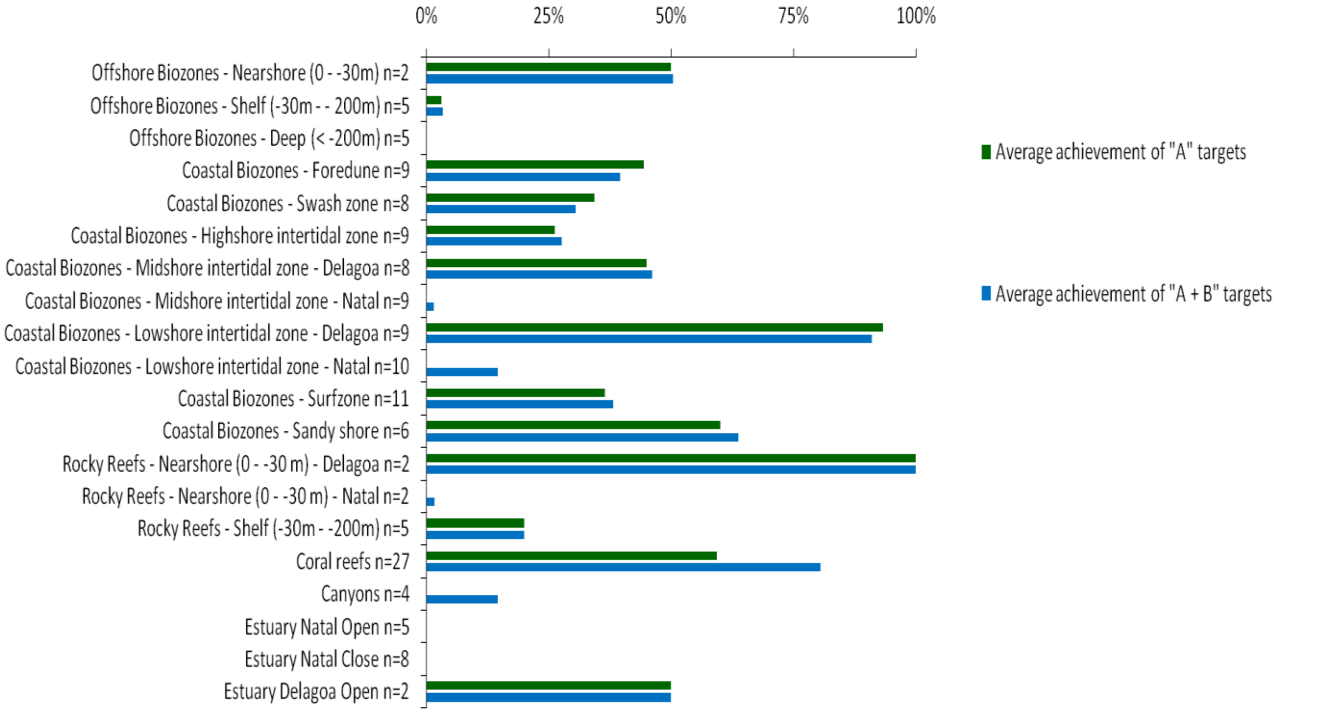


Figure 37: Mean percentage of target achieved for habitat groups

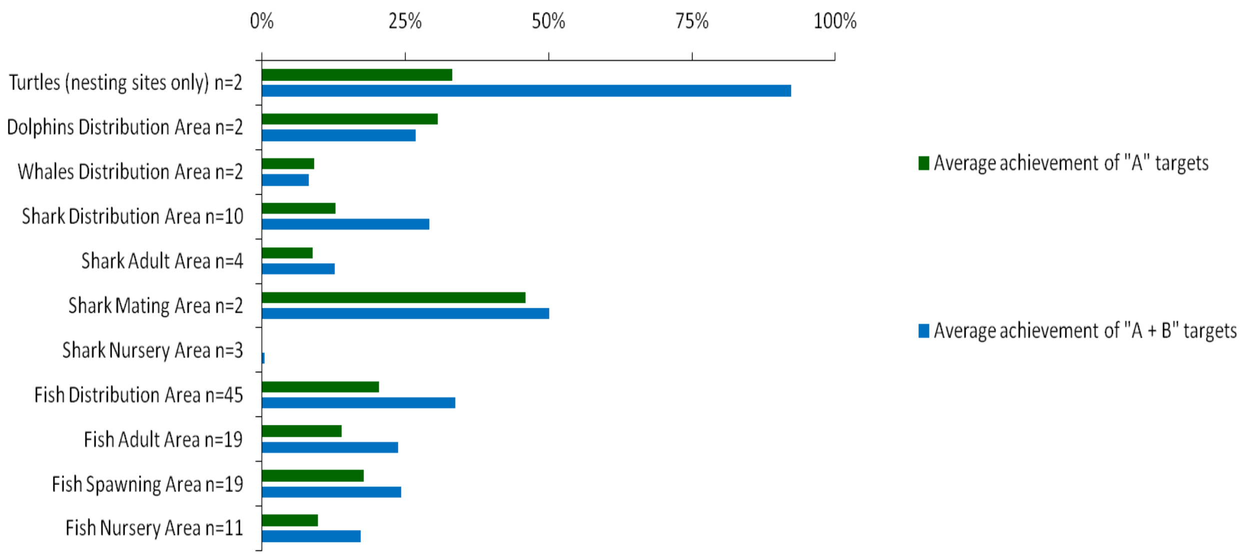


Figure 38: Mean percentage of target achieved for species groups

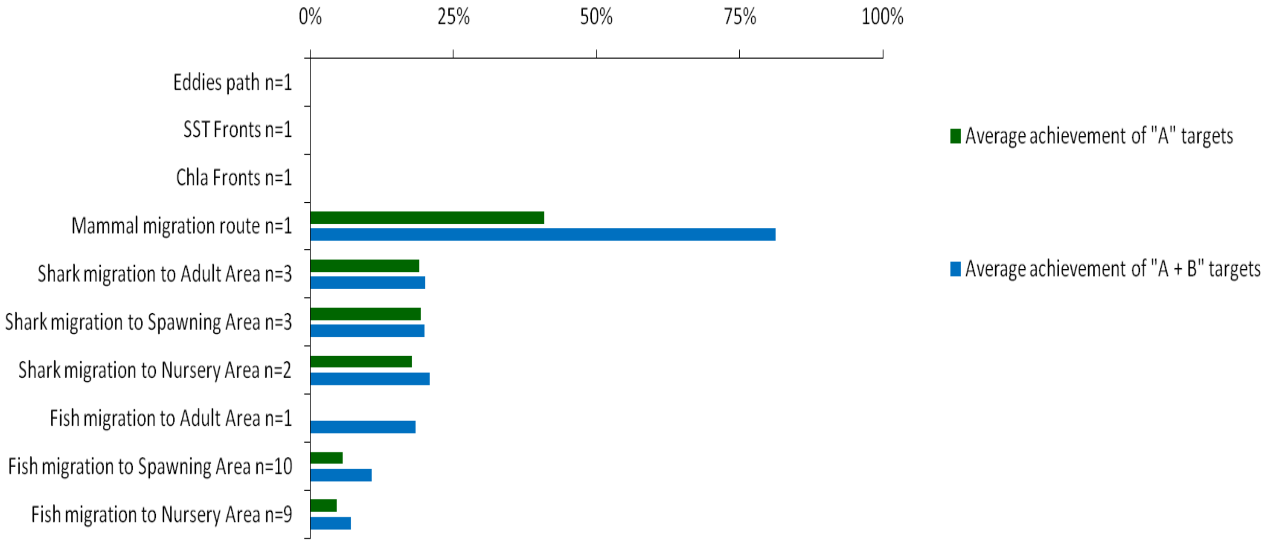


Figure 39: Mean percentage of target achieved for processes and species groups

The target achievement of each biodiversity feature currently within the existing Sanctuary Zones (A) zones and Restricted (B) zones is listed in Appendix 8: Contribution of MPA A zones to the target achievement for each feature and 9.

The target achievement of each biodiversity features within each zonation category including MPA C zones is listed in Appendix 10: Target achievement per biodiversity features within each zonation category indicating the contribution of these controlled zones towards target achievement. Controlled zones which are currently exhibiting higher pressures inside the MPA than outside could possibly achieve greater protection and target achievement by changing to a different zonation category thereby affording greater protection to the features within this zone.

5.5 Biodiversity Plan

The conservation planning software C-Plan (Pressey et al., 2008) and MARXAN (Ball and Possingham, 2000), and its interface CLUZ (Smith, 2004) in Arcview 3.2 (ESRI, Redlands, California) were used to develop the biodiversity plan. C-Plan allows the user to identify totally irreplaceable areas while MARXAN allows the users to identify a network of complementary MPAs that efficiently achieve all biodiversity targets while avoiding high use (cost) areas (Sarkar and Margules, 2002). Both software types try to minimise the total area (number of PUs) required to meet all biodiversity targets (and this is referred to as efficiency). Marxan calculates a “best” solution, which is the suite of PUs that meets all the defined objectives of the user most closely (this is achieved by minimising a mathematical vale called the objective function within the software analytical run).

C-Plan is a decision support tool and uses a GIS to produce a map indicating options for meeting biodiversity targets. The software calculates the irreplaceability value of each PU. This value reflects the importance of a PU in achieving biodiversity targets and does not take into account any cost or pressures associated with the area. MARXAN software is designed with the use of stochastic optimization routines (simulated annealing, Kirkpatrick et al., 1983). Following an iterative selection process, the algorithm attempts to identify a near-optimal reserve system called *solution*, by minimising its total cost (Possingham et al., 2000). The results produce a selection frequency analysis indicating the number of times a PU is chosen and thus how necessary a PU is to achieve the target for a conservation feature (Possingham, et al., 2000). PUs frequently selected within solutions are considered the most irreplaceable (MARXAN sensu) and thus have the greatest contribution toward meeting targets. MARXAN is able to take into account cost values and avoidance of these areas, as well as being able to clump the output so as to produce a set of results which are more practical for implementation and management

The costs and the number of runs in Marxan were calibrated heuristically. The total cost is calculated as follows:

First, the “fine” to be paid if a biodiversity target is not achieved: we assigned a prohibitive value of 10 million per biodiversity feature to this parameter (thus ensuring that each solution met targets for all features).

Second, the cost of each PU: to calculate this parameter, we used the summed cost layer, which was scaled for impact as described in the Costs weighting section. Recent observations have indicated that all pressures should be weighted equally and this should be noted for future runs of the biodiversity plan.

Third, the Boundary Length Modifier (BLM) which is the cost associated with the management of reserve boundaries per kilometre (Table 12). Increasing this cost promotes the compactness of the reserve network identified.

Table 12: Boundary Length Modifier (BLM) selected to run MARXAN.

PUs resolution (km)	10	1	0.2
Boundary Length Modifier (BLM)	1000	100	100

The biodiversity plan aimed to conserve three sets of biodiversity features (sets 1, 2 and 3) respectively using 0.2 km, 1 km and 10 km resolution PUs. Biodiversity features were attributed to one of the three spatial resolution PU layers (see Figure 40 and Appendix 7)). For instance Offshore Biozones were integrated in the 10 km resolution PU layer whereas Shoreline Biozones were integrated in the 0.2 km resolution PU layer.

Table 13: The allocation of features to PUs layers of different resolutions

Features name	PU layer resolution (km)		
	10	1	0.2
Habitats			
Offshore Biozones	x		
Coastal biozones			x
Rock reefs		x	
Coral reefs		x	
Submarine canyons		x	
Estuaries			x
Estuaries : Mzimkhulu and Thukela		x	
Species			
Fish (including sharks)		x	
Turtles			x
Cetaceans		x	
Processes			
Eddies	x		
Sea Surface Temperature fronts	x		
Chlorophyll-a fronts	x		
Fish migration pathways		x	
Cetacean migration pathways		x	

To link biodiversity plans across scales, focus areas identified on the 0.2 km resolution PU layer forced the identification of focus areas at the 1 km resolution. This was achieved by selecting all 1 km PUs connected to the best solution identified at 0.2 km resolution. Similarly, we forced the selection of 10 km resolution PUs containing more than 50 % of the best solution identified at 1 km resolution. Finally, focus areas identified within single resolution layers were merged into one composite layer containing the overall best solution and highest selection frequency value calculated among single-resolution layers.

At each stage, the plan was run for “A” targets and then for “B” targets using the best network selected to achieve “A” targets set as ‘conserved’ so as to ensure its contribution. The plan was run with and without the existing protected areas network (Figure 40).

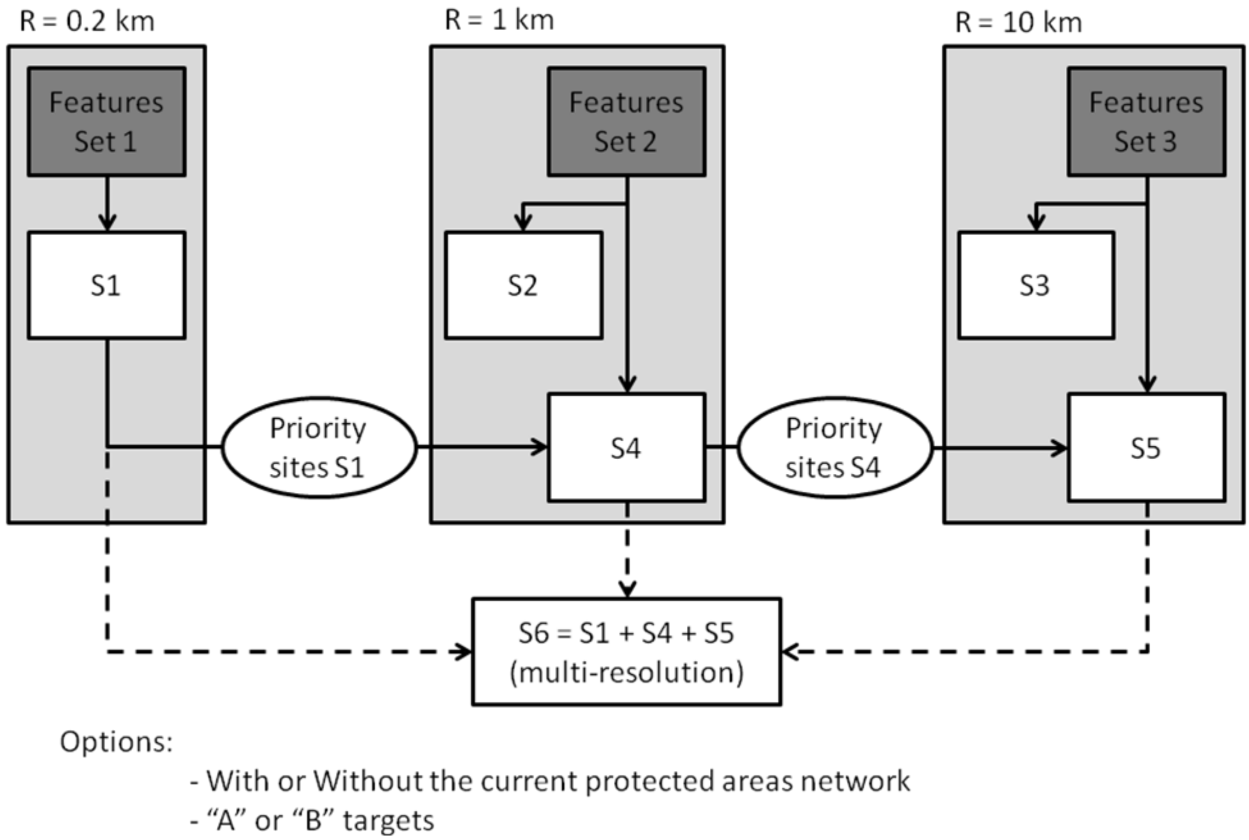


Figure 40: Scheme of the multi-resolution conservation planning method. S stands for "Stage of the multi-resolution biodiversity plan" and R stands for "PUs resolution". The biodiversity plan aims to conserve three sets of biodiversity features (Feature sets 1, 2 and 3) respectively using 0.2 km, 1 km and 10 km resolution PUs. In a first step, the three biodiversity plans (S1, S2 and S3) are developed independently and latter used for measuring trade-offs. In a second step, priority areas identified in S1 (0.2 km resolution) are used to force the identification of priority areas in S4 (1 km resolution). Priority areas identified in S4 (1 km resolution) are then used to force the identification of priority areas in S5 (10 km resolution). Finally, priority areas identified within single resolution layers S1, S4 and S5 are merged into one multi-resolution layer (S6).

The images below indicate the different phases of development in the C-PLAN and MARXAN analysis.

The conservation software C-Plan was used to create an initial map of irreplaceability identifying totally irreplaceable areas to be included in the MARXAN analyses (Figure 41). PUs with irreplaceability = 1 have biodiversity features in them which cannot be conserved anywhere else. These totally irreplaceable cells identified in the C-PLAN analyses were compulsory areas that needed to be conserved in the MARXAN runs thus forcing their selection and ensuring their protection when identifying focus areas for conservation.

5.5.1 Development Stages

5.5.1.1 C-Plan Analysis

C-Plan was run on the final PU layer and the results are displayed in the Irreplaceability map (Figure 41). These results indicate the relative biodiversity importance of all PUs relative to one another based solely on each PU's biodiversity feature content and the target requirement for each of these features. The integrated resolutions help to identify the position of totally irreplaceable PUs without taking into account cost factors and clumping values. The totally irreplaceable cells (Irreplaceability = 1) identified within this analysis are referred to as **Critical Biodiversity Areas: Irreplaceable** areas and are thus areas which are critical and must be included in the MPA network. These areas were compulsory starting points in the Marxan analysis.

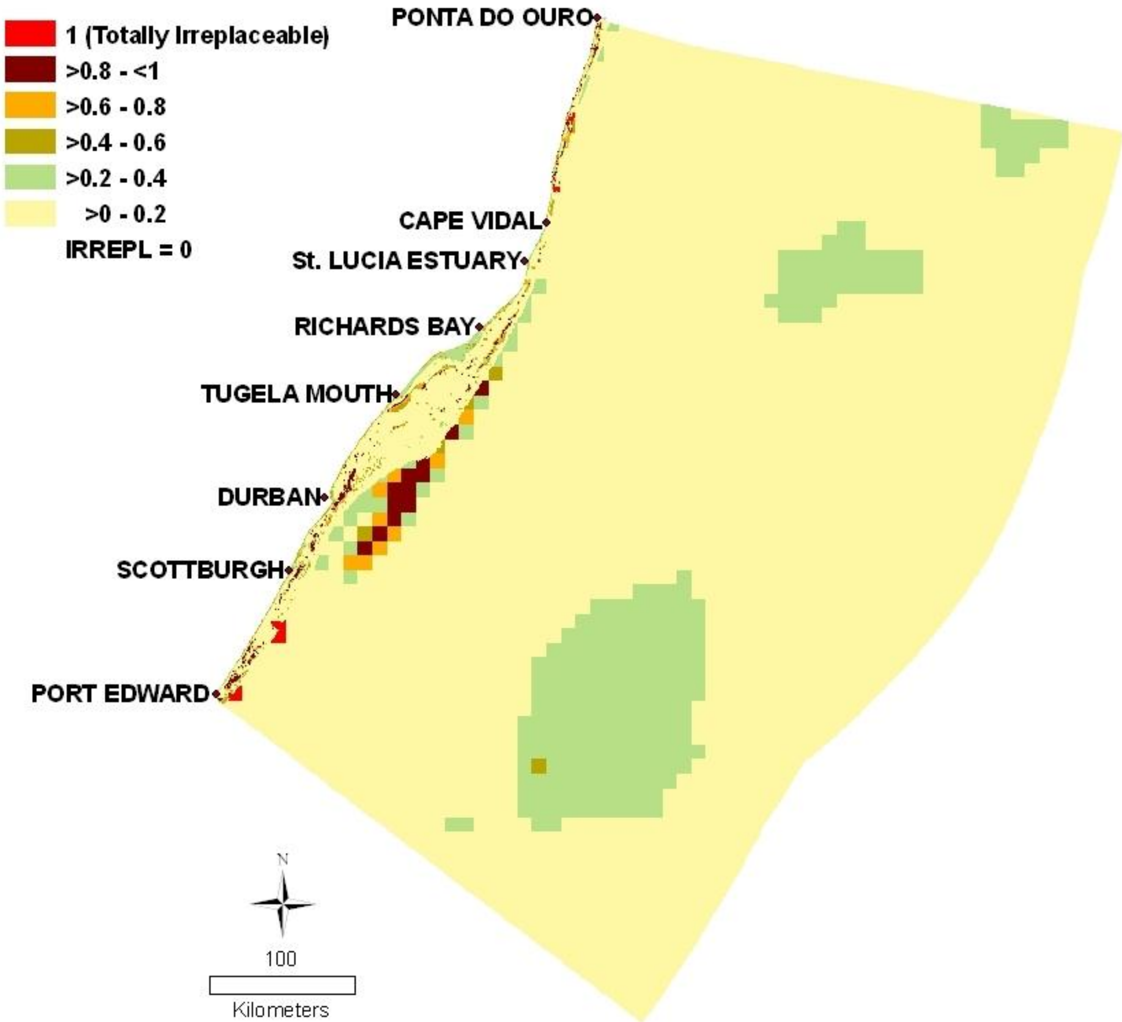


Figure 41: C-Plan analysis showing irreplaceability values of PUs. Red cells indicate totally irreplaceable PUs which meets biodiversity targets that cannot be met elsewhere.

5.5.1.2 Marxan Analyses

The initial MARXAN analyses were run at the different resolutions without the focus areas from previous resolutions being compulsory for selection. These results allow for users to see options for meeting biodiversity targets at that level of resolution. However, in order to produce the most efficient solution (least total area), the results from these analyses are not always practical and inheriting compulsory areas from previous runs into consecutive runs allows for increased efficiency. The end solution would therefore be similar to one if the plan was run over the whole planning area at once taking into consideration all biodiversity targets. Once the analysis at the 0.2 km scale is completed and the focus areas identified from the “Best” selected runs have been assessed and accepted, these focus areas are then deemed compulsory as ‘already conserved’ areas in the 1 km resolution. The same applies when moving from the 1 km analysis to the 10 km analysis.

The results below indicate the selection frequency analysis as well as the “Best” selected areas from the final run taking into account the compulsory areas from previous runs. The Marxan analysis also inherits compulsory areas (totally irreplaceable areas) from the C-Plan analysis as well as taking into account the cost surface and trying to avoid high cost areas where options for meeting targets exist.

5.5.1.2.1 0.2 km Analysis Results

The first run was at the 0.2 km resolution (Figure 42). Because the software aims to meet all targets in the most efficient manner, this results in areas being chosen which contain sections of coastline with many different coastal habitat types. Certain shoreline habitat types (rock high ledges and solid rocks) need to be greater than 100 m in order to be ecologically viable but because of the clumping value of the analysis the results did not always satisfy this requirement. The “Best” selected areas were thus manipulated in some areas to include viable areas of these habitat types and thus certain areas along the coastline were manually deselected and others selected until targets were met.

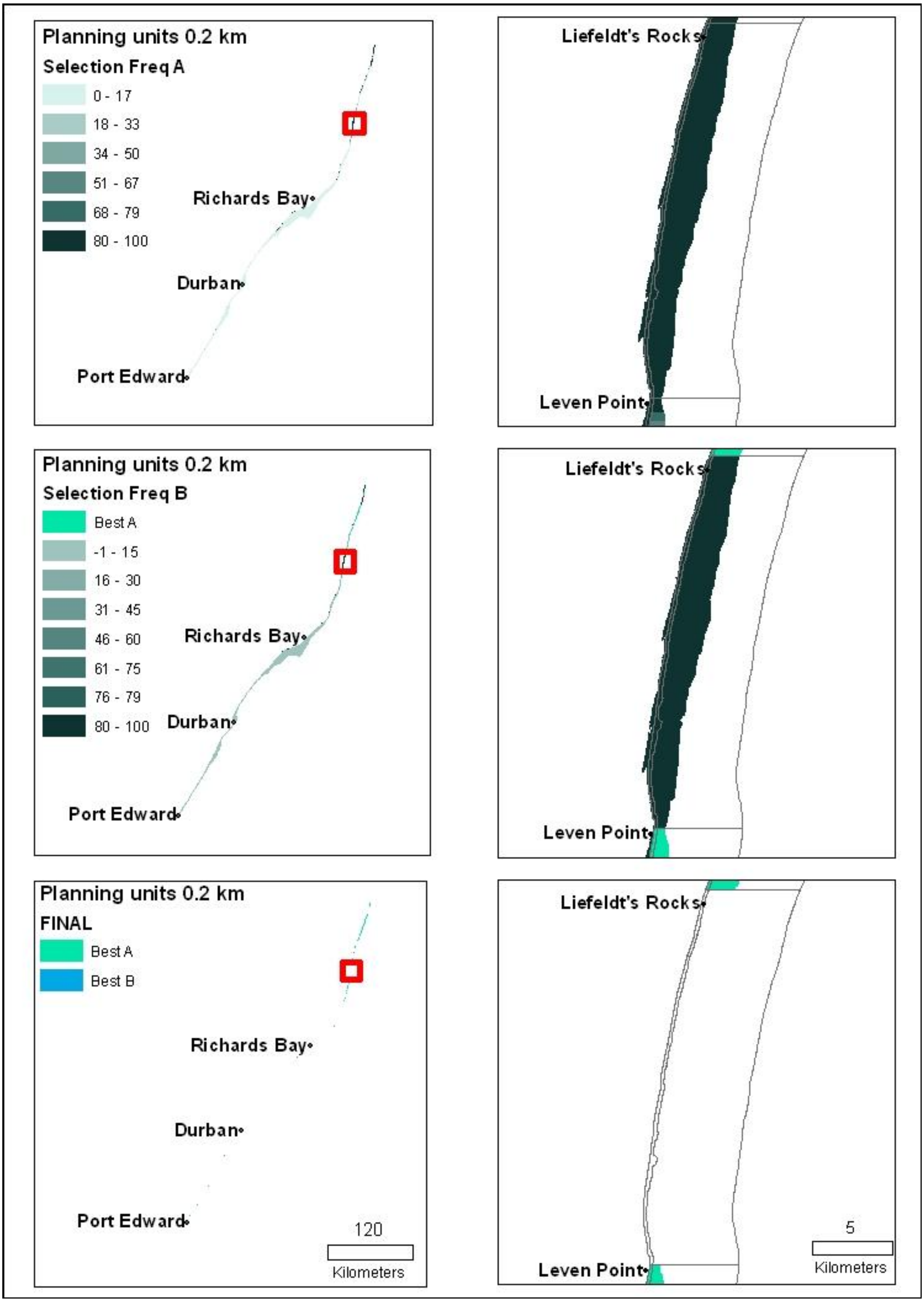


Figure 42: Results of the 0.2 km Marxan analysis taking into account existing MPAs as well as irreplaceable areas from the C-Plan analysis.

5.5.1.2.2 1 km Analysis Results

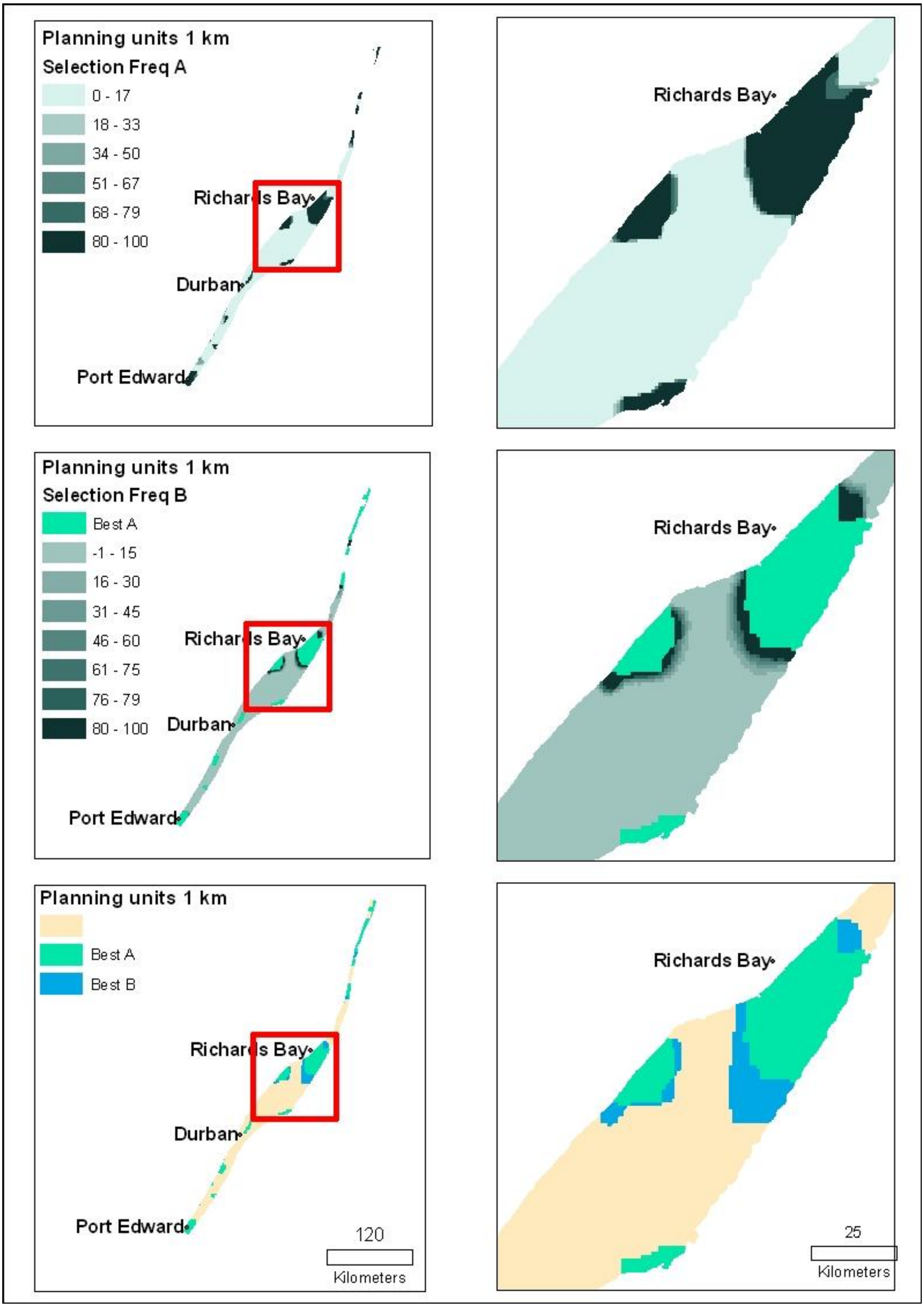


Figure 43: Results of the 1 km Marxan analysis taking into account existing MPAs as well as totally irreplaceable areas from the C-Plan analysis.

5.5.1.2.3 10 km Analysis Results

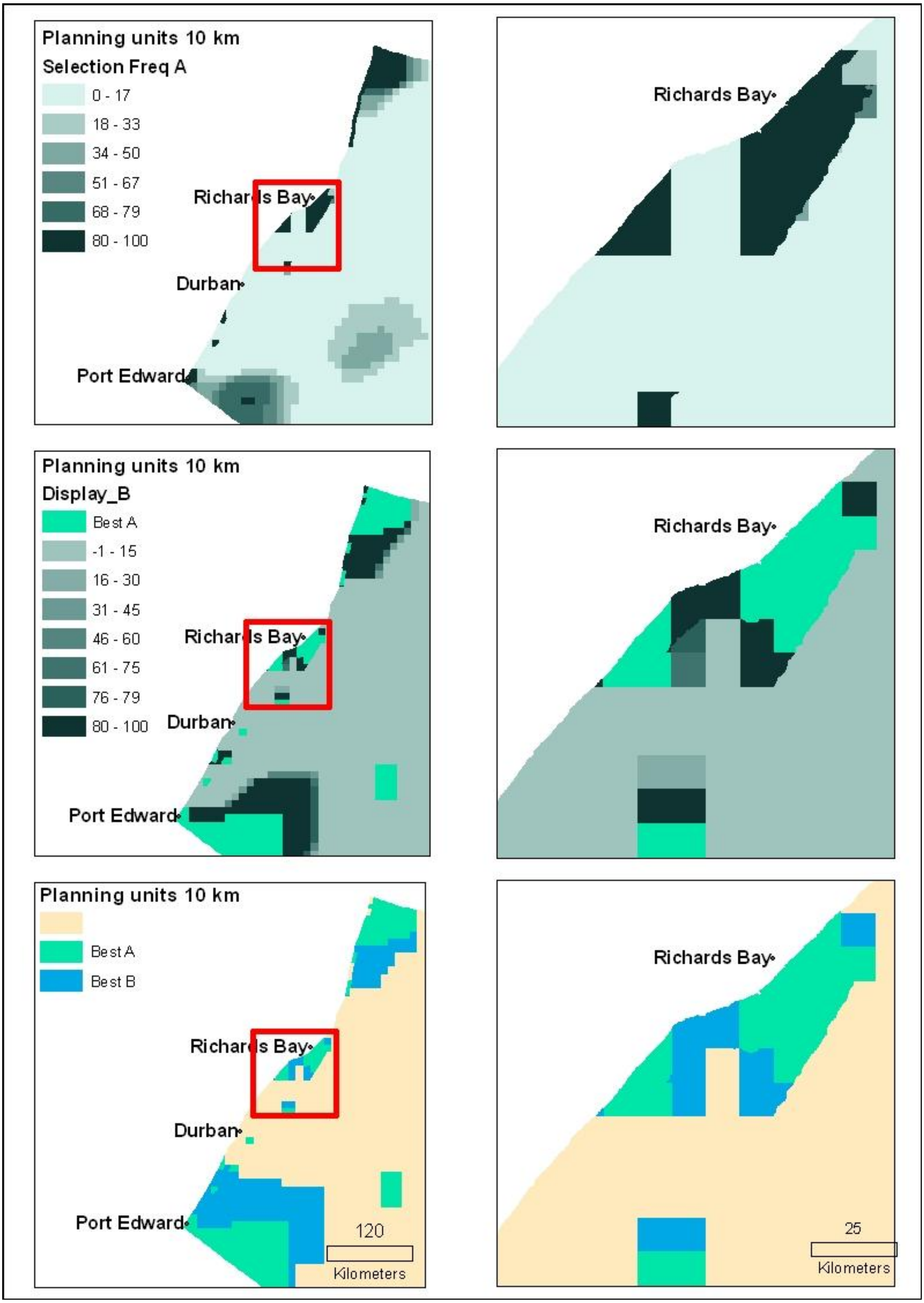


Figure 44: Results of the 10 km Marxan analysis taking into account existing MPAs as well as totally irreplaceable areas from the C-Plan analysis.

5.5.1.3 The Final Combination Maps

Figure 45 - Figure 49 below show selection frequencies and “best” solutions, respectively. The best selected areas from the first run for “A” targets are deemed compulsory as ‘already conserved’ areas in the run for “B” targets and the resulting map indicates the best selected areas for meeting A and B targets.

The results of the analyses over the different resolution are combined into a single map for easy viewing. Figure 45 and Figure 46 represent the final combined maps reflecting the selection frequency results and ‘best’ solution outputs for ‘A’ targets and then ‘B’ targets and Figure 47 indicates only the best selected sites.

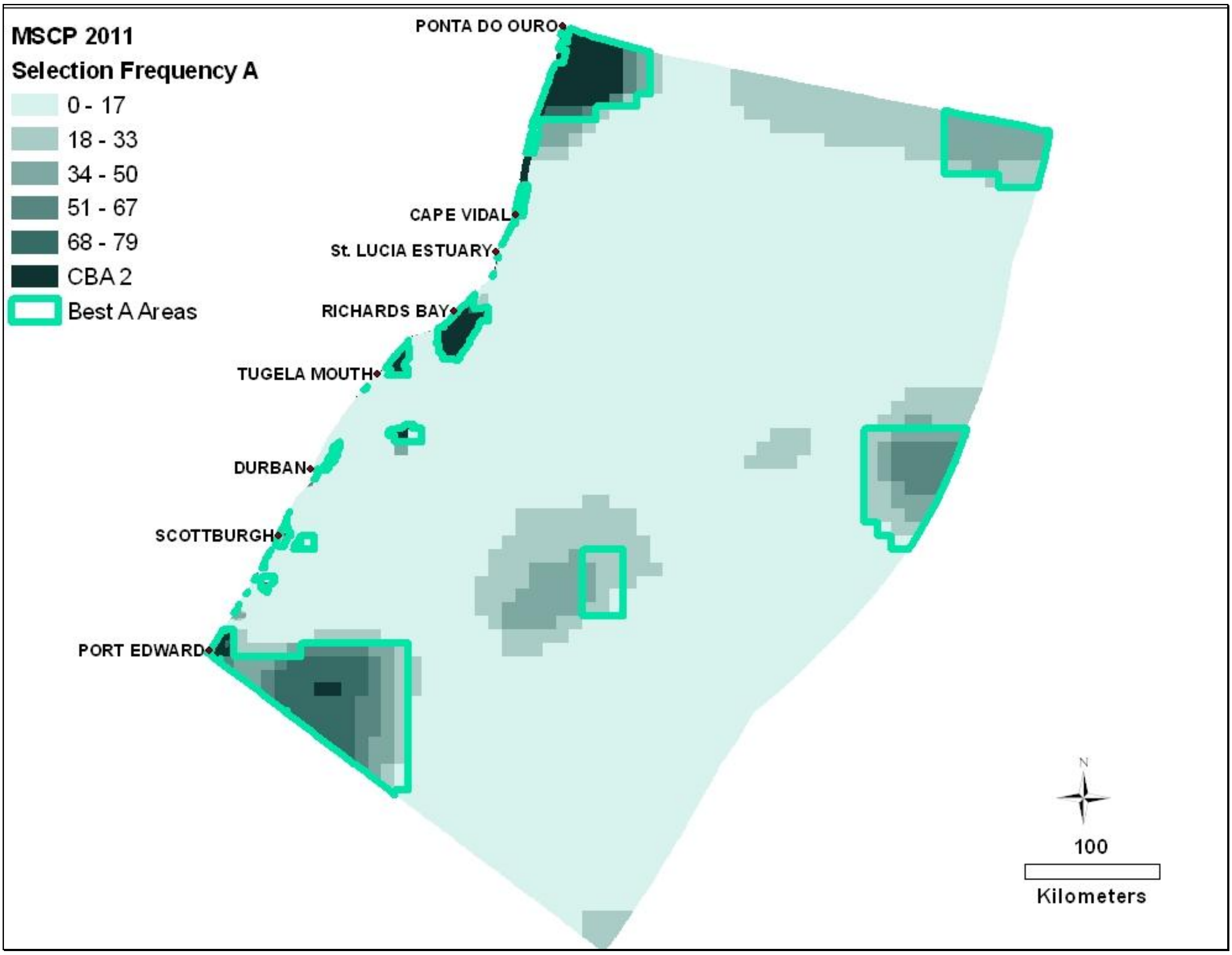


Figure 45: Composite layer showing the selection frequency as well as the best solution outputs calculated at 0.2 km, 1 km and 10 km resolution to achieve biodiversity ‘A’ targets for all features and processes.

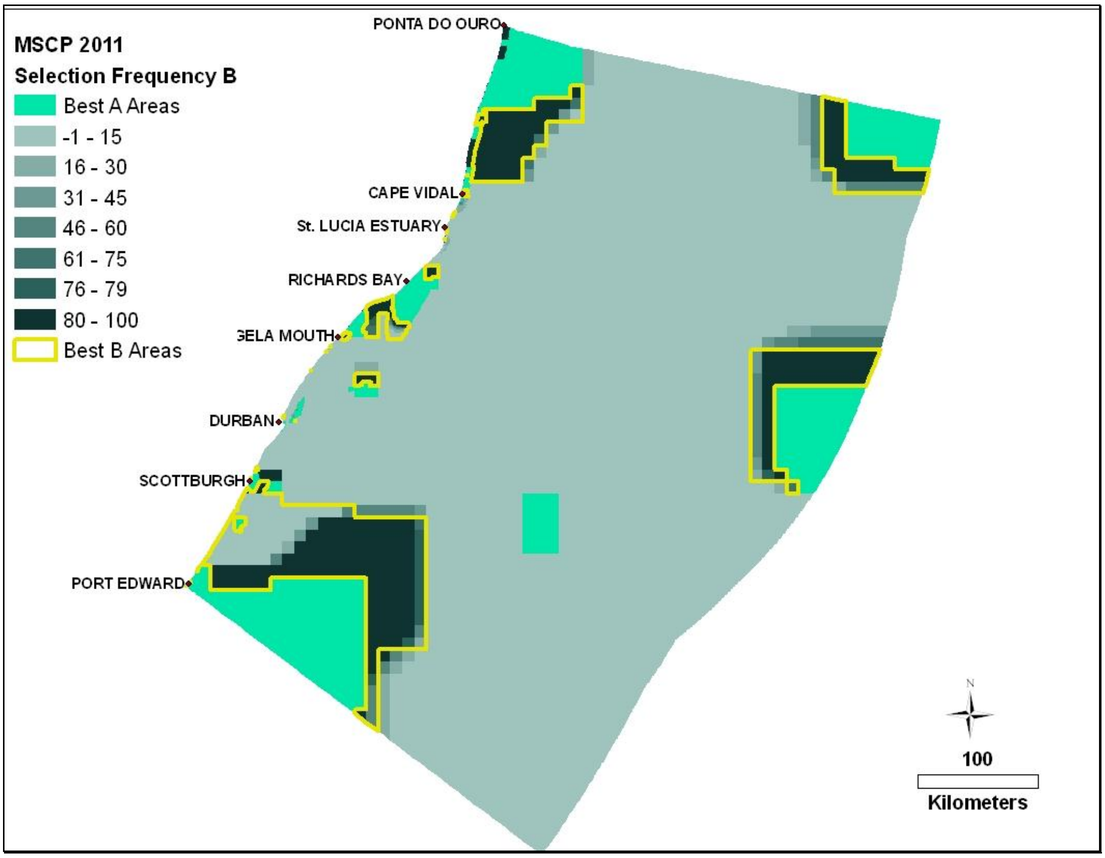


Figure 46: Composite layer showing the selection frequency and best solution outputs calculated at 0.2 km, 1 km and 10 km resolution to achieve biodiversity 'B' targets for all features and processes.

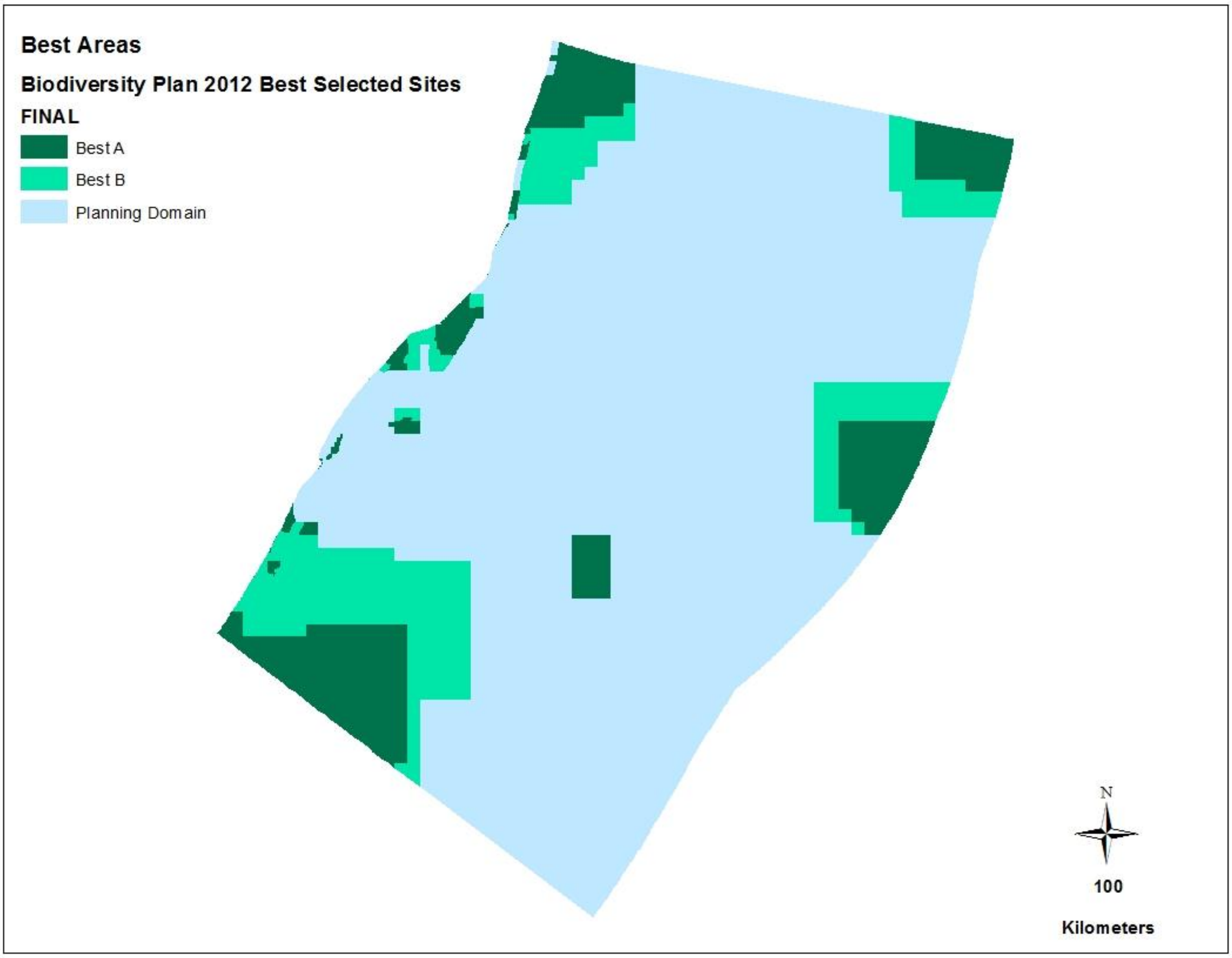


Figure 47: Composite layer showing the best solution outputs calculated at 0.2 km, 1 km and 10 km resolution to achieve biodiversity targets for all features and processes.

5.5.2 Critical Biodiversity Areas

The integrated KZN Provincial Biodiversity Plan provides a spatial representation of land, coastal and marine areas required to promote the persistence of biodiversity within the Province and consists of the coastal and marine biodiversity plan, estuarine biodiversity plan, freshwater biodiversity plan and terrestrial biodiversity plan. The Provincial Plan has been produced as a tool for: (i) guiding protected area expansion priority areas and identification of stewardship sites and; (ii) informing all other economic sectors' strategic spatial planning processes with the intention of ensuring more sustainable development in KZN.

The Provincial Plan delineates critical biodiversity areas (CBA's) and ecological support areas (ESA's), but the marine plan produces only CBAs. The mapping of CBAs is undertaken firstly at a provincial scale, mapping then shifts to a district scale, and the Biodiversity Sector Plan (BSP) utilises the Provincial Plan information clipped to a district scale and refined by input of local knowledge; this then develops district-specific CBAs and ESAs. The BSP will in future be used as a framework for the development of the final Bioregional Plan and other spatial planning tools as represented below in Figure X.

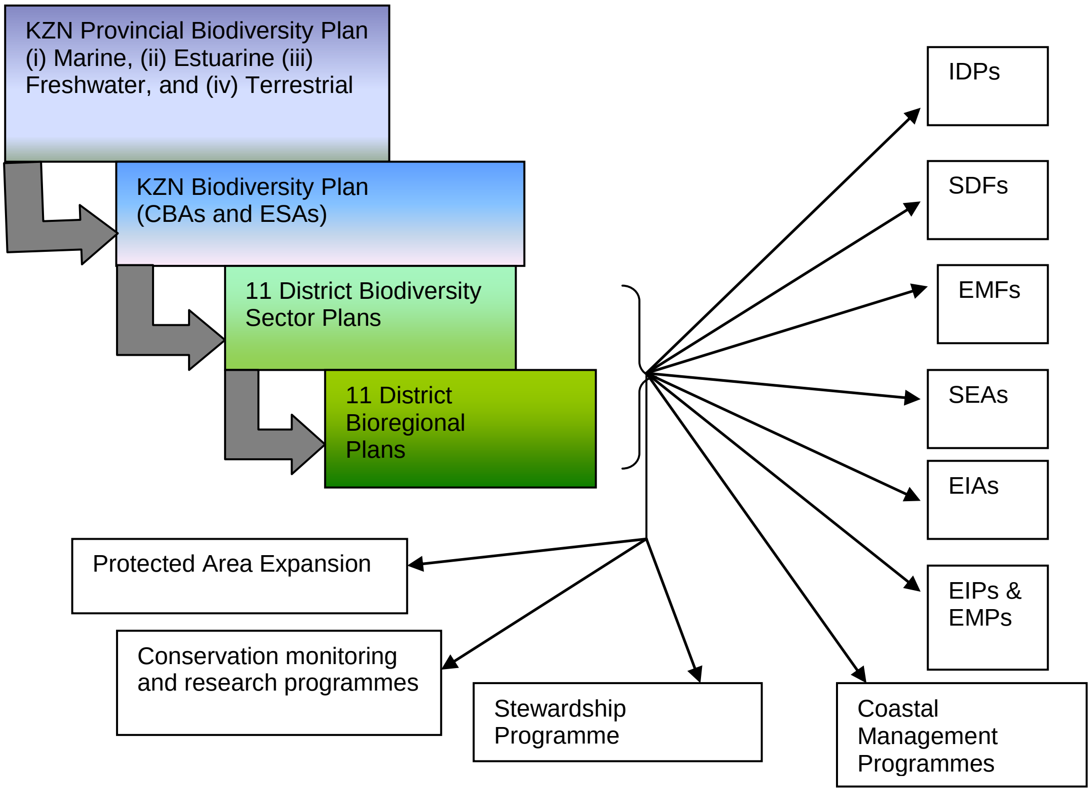


Figure 48: Flow diagram indicating the integration of the KZN Provincial Biodiversity Plan with the other spatial tools used within the Province.

Bioregional Plans (BRPs) are one of a range of tools provided for in the Biodiversity Act (NEMBA) that can be used to facilitate biodiversity conservation in priority areas outside existing protected areas. The SANBI guideline for developing bioregional plans (DEAT, 2009) sets out the purpose of a bioregional plan as: One of the intentions of the KZN Provincial Plan is that this plan will form the basis for the proposed 11 District Bioregional Plans that are to be developed for KZN. This is in line and is required in terms of the SANBI guideline which states that bioregional plans must be based on a systematic biodiversity plan using the best available science, and that the underlying systematic biodiversity plan on which the bioregional plan is based must take into account the continuity of ecosystems and ecological processes across administrative boundaries. The development of the KZN Provincial Plan, which takes into account neighbouring ecosystems and delineates CBAs and ESAs, thus complies with this requirement and supports the development of bioregional plans in the KZN Province.

The critical biodiversity map for the marine environment is made from a combination of the C-Plan and Marxan Analysis results as reflected in section 5.5.1 above. The results from these analyses are used to extract the following categories which are then combined to produce a final map of critical biodiversity areas for the KZN Marine environment. The categories are as follows:

5.5.2.1 Critical Biodiversity Area: Irreplaceable

The CBA Irreplaceable Areas are identified as having an Irreplaceability value of 1 within a C-Plan analysis and these PUs represent the only localities for which the biodiversity targets for one or more of the biodiversity features contained within can be achieved i.e. there are no alternative sites available.

The CBA High Irreplaceable Areas represent areas of significantly high biodiversity value. In C-Plan analyses, these areas are identifiable as having an Irreplaceability value of >= 0.8 and <1.0 whilst the MARXAN equivalent is reflected in PUs displaying a selection frequency value of between 80 – 100%. In practical terms, this means that there are alternate sites within which the targets can be met for the

biodiversity features contained within, but there aren't many. This site was chosen because it represents the most efficient area for choice in the systematic planning process, meeting both the biodiversity target for the features concerned as well as a number of other guiding criteria as defined by the **Decision Support Layers** or
Cost Layer . Whilst the targets could be met elsewhere, the revised reserve design (derived through either the C-Plan MINSET or MARXAN analysis) would more often than not require more area in order to meet its conservation objectives. The scarcity of the Biodiversity features contained within is, however, still the primary driver for this PUs selection in the biodiversity analyses.

5.5.2.2 Critical Biodiversity Area: Optimal

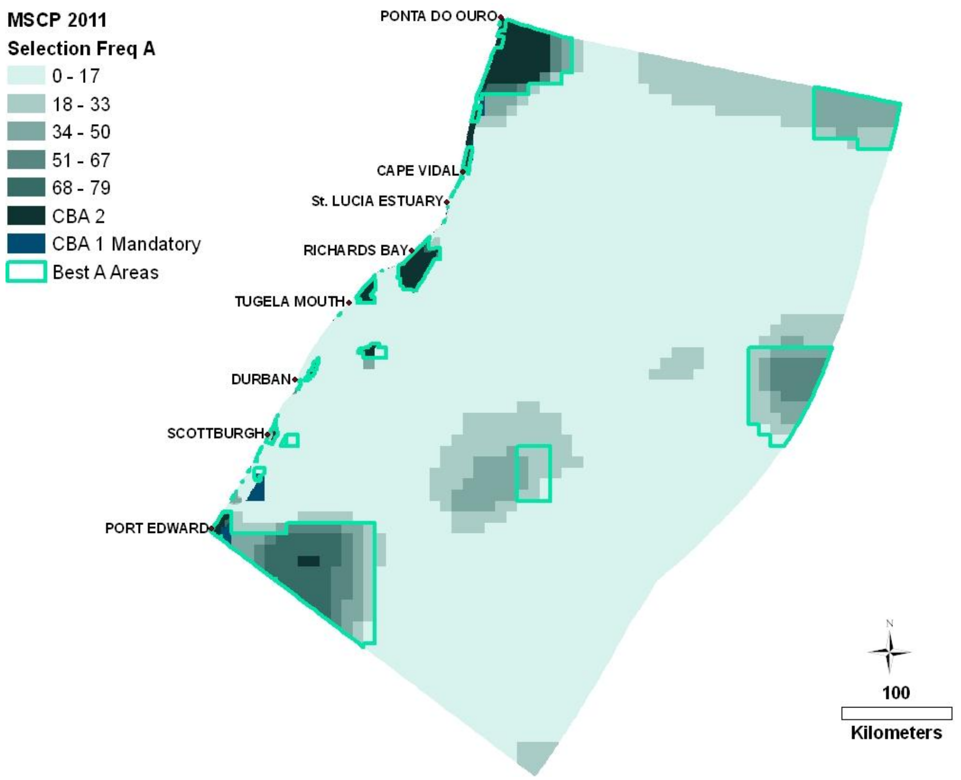
The CBA Optimal Areas are areas which represent the best localities out of a potentially larger selection of available PUs that are optimally located to meet both the biodiversity target but also the criteria defined by the
Cost Layer .

Within MARXAN these areas are reflected as the “Best” solution output less the **CBA Irreplaceable Areas** (the “Best” solution output is essentially the most efficient solution and thus the most optimal solution to meet all biodiversity targets while avoiding high cost areas as much as possible).

Even though these areas may display a lower Irreplaceability value or selection frequency score than the previous categories, it must be noted that these areas, together with the above two categories, collectively reflect the minimal reserve design required to meet the **Biodiversity Plan** (defined here as a systematic conservation plan or SCP) targets and as such, they are also regarded as CBA areas.

Figure 49Figure 50: Composite map of critical biodiversity areas (CBAs) for the KZN marine planning domain. indicates the CBA areas as well as the best area to meet A and B targets and thus the overlap between them can be easily viewed.

5.5.2.3 Selection Frequency Results



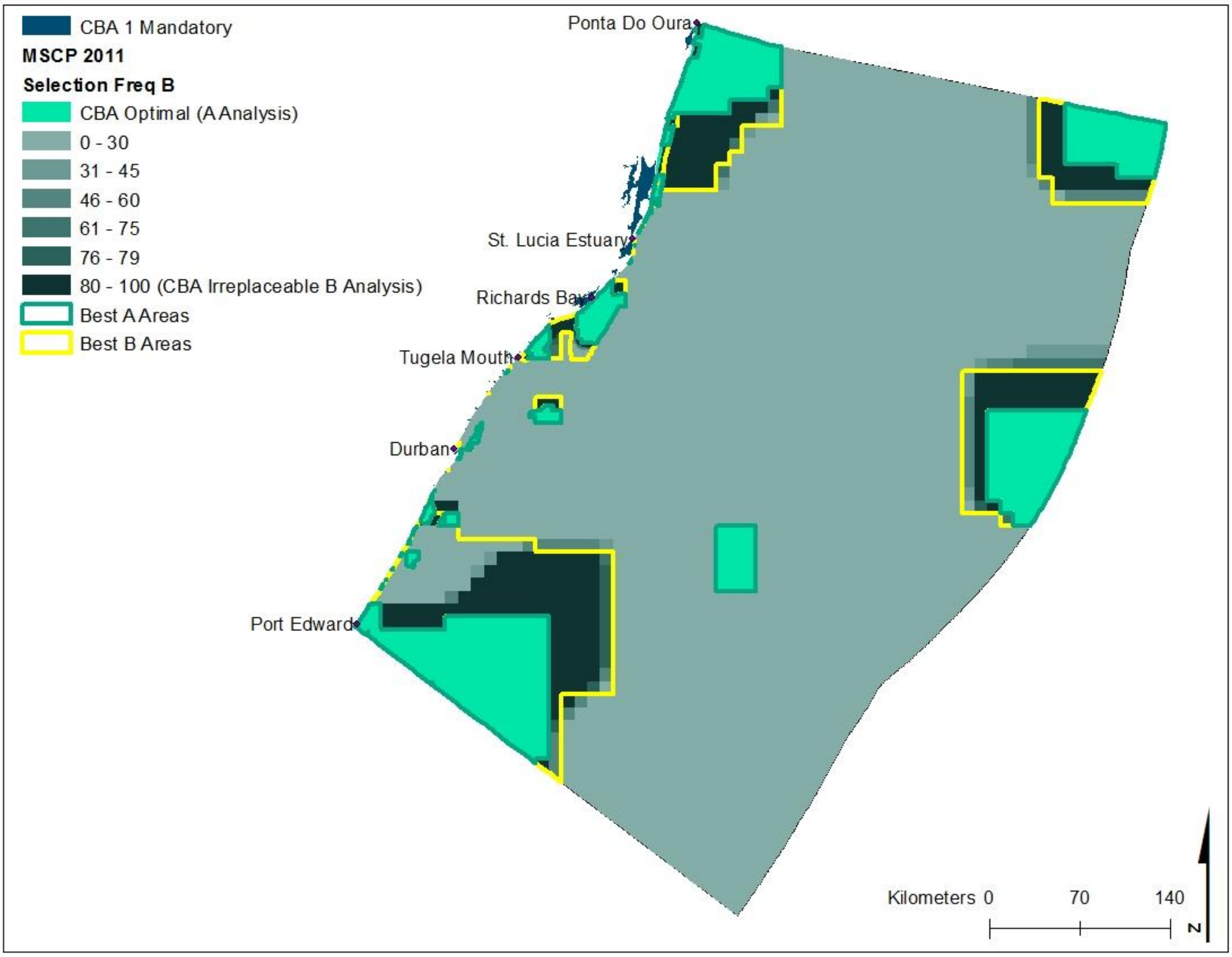


Figure 49: Composite map of selection frequency results as well as the Best solution output also reflecting the CBA categories.

The final CBA map which takes in to account only the CBA categories as defined above is shown in Figure 51. The areas furthest offshore are driven by the large scale eddy areas (these areas were initially selected as CBA 1 and CBA 2 areas, but were all changed to CBA 2 areas given increased uncertainty inherent in modelled data and the difficulty to implement and manage these areas.

5.5.2.4 Final Critical Biodiversity Areas Map

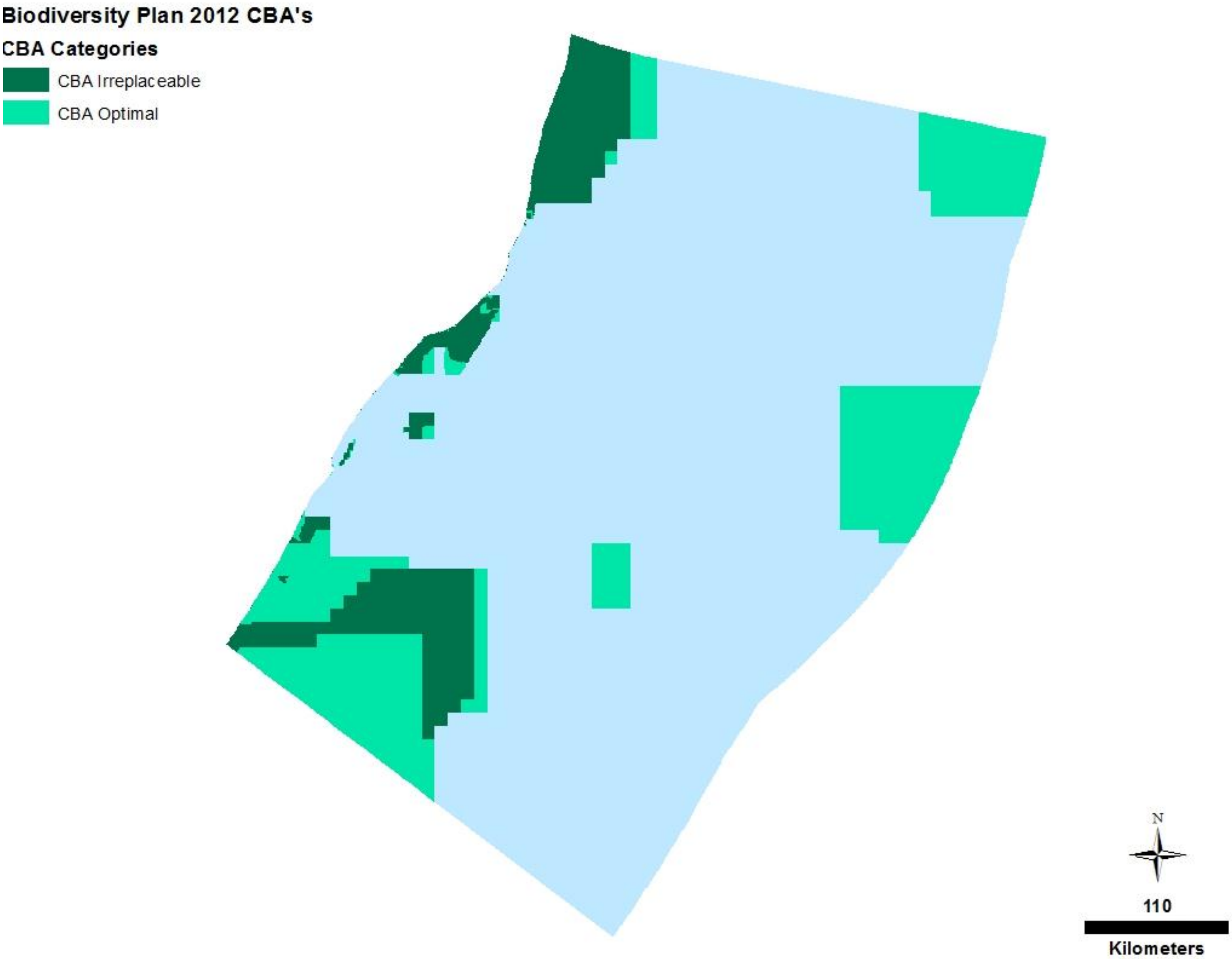


Figure 50: Composite map of critical biodiversity areas (CBAs) for the KZN marine planning domain.

5.6 Marine Protected Area Expansion Priorities

Focus areas are important for conservation attention and represent the amalgamation of the three CBAs identified by the Marine Biodiversity Plan. Focus areas (Figure 51) are thus the demarcation of areas where biodiversity targets can most practically and efficiently be met and/or where critical biodiversity is in need of additional protection. The biodiversity plan identified 23 focal areas (Figure 51). Table 13 describes each area briefly, together with its key drivers.

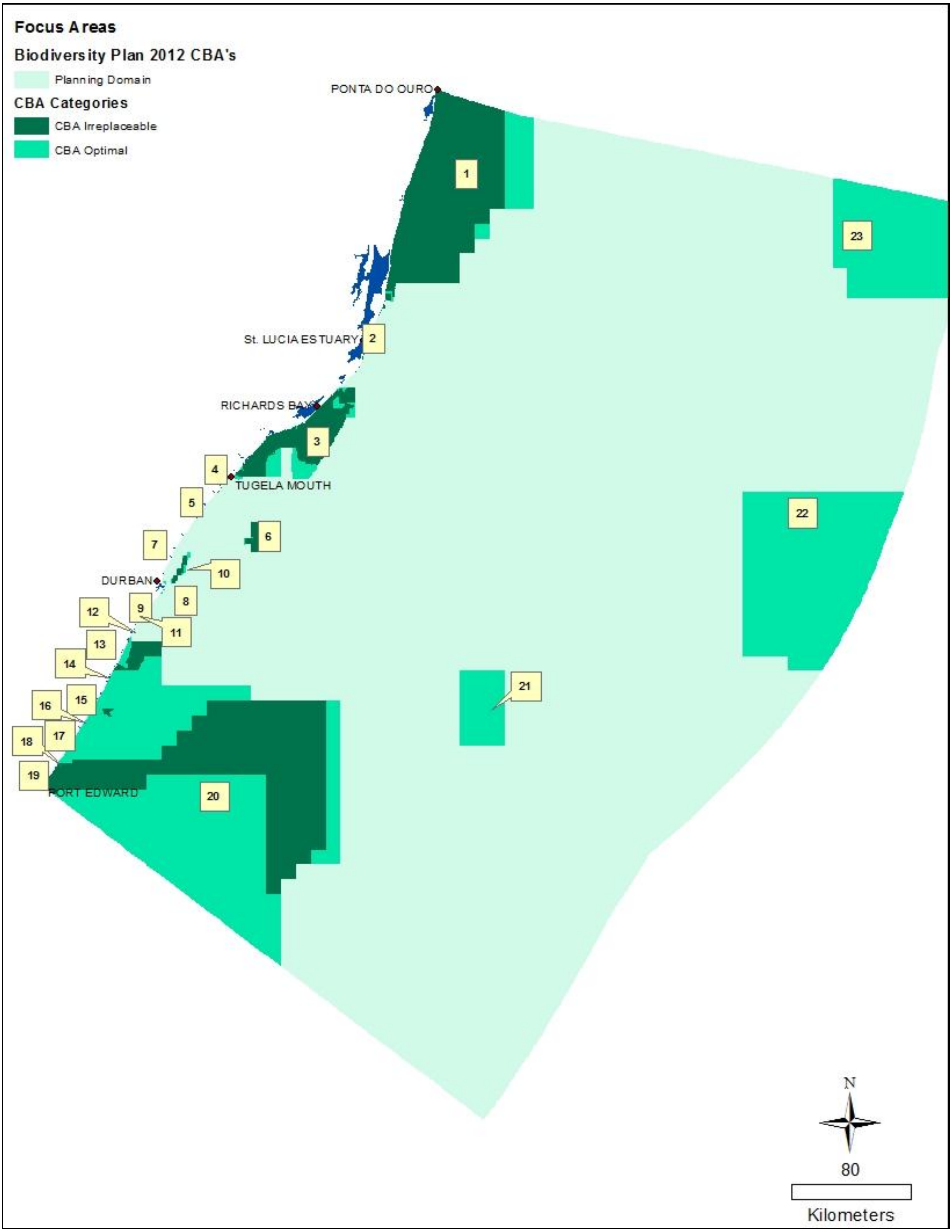


Figure 51: The final CBA Map with numbered focus areas

More information on the focus areas and the protected area expansion strategy can be obtained from the Focus Areas report (Ezemvelo unpublished report 2012).

Table 13: Table indicating the key drivers determining the selection of each focus area.

Focus Area	Area	Key Drivers
1	iSimangaliso Wetland Park extension	Offshore extension of iSimangaliso Offshore habitats, processes and fish species
2	Cape St Lucia area	Southern extension of iSimangaliso Shoreline habitats, high rock ledges, broken rocks and rock boulders; fish species
3	Tugela Banks Area	Shoreline habitats: estuaries, vegetated dune hummocks, intermediate sandy shores; Offshore soft Sediment habitat and reefs, fish, sharks and mammals.
4	Zinkwazi Estuary and shoreline area	Shoreline habitats: dissipative sandy shore, rock ledges and scattered rocks.
5	Mhlali Estuary and shoreline	Mhlali Estuary and mixed shore
6	KZN central Bight	Offshore area near continental shelf edge of the KZN Bight consisting of offshore habitats; Chl-*a* and SST fronts; fish species
7	Beachwood Mangroves	Shoreline habitats: vegetated dune hummocks, rock boulders and the Mgeni estuary
8	Durban	Subtidal fish species
9	Bluff Area	Shoreline habitats: Vegetated Dune hummocks, broken ledges: subtidal fish species, rocky reefs
10	KZN Bight south	Subtidal fish species
11	iSipingo	iSipingo estuary and shoreline habitats: mixed shores plus intermediate sandy shore
12	Karridene	Shoreline area south of Karridene between the Msimbazi and Mgababa Rivers mixed shores plus intermediate sandy shore
13	Aliwal Shoal	Shoreline habitats: mixed shores, rock ledges, dissipative and intermediate sandy shores; offshore habitats: rocky reefs; number of fish species
14	Umdoni	Shoreline area between Umdoni Park and Bazley beach Shoreline habitats: high rock ledges, solid rocks and boulder shores
15-19	Hibiscus Coast	Shoreline habitats: high rock ledges, solid rocks and boulder shores and a number of estuaries
20	Offshore areas	Offshore habitat: biozones, offshore processes: SST and Chl-a fronts; fish, shark and mammal species
21-22	Offshore areas	Offshore habitat: biozones, SST fronts and Eddys;

6 Way forward

The value of an adaptive (constantly evolving) marine biodiversity plan for the KZN Province is the following:
1. it provides a scientific framework and transparent process to inform protected area expansion;
2. it guides decisions concerned with types of management interventions (e.g. protected areas versus temporally closed fishing areas);
3. It forms a starting point to build upon in an adaptive management process (the authority responsible for planning in the region is the developer, custodian and implementer of the plan)

4. it helps to identify data gaps in the marine environment, for example, more (and new) species data are required along the shoreline and the offshore environment, and a more accurate and complete rocky reef map is required.
5. it furthers our understanding of marine ecosystems and the human activities that depend on these ecosystems.

The focus areas of the KZN Biodiversity Plan are currently being aligned with the National focus areas by collaboration with Ezemvelo and SANBI scientists to guide the National Protected Area Expansion Strategy (Department of Environmental Affairs and Tourism 2008). Although the KZN plan is underpinned by a systematic process, its results cannot be used in isolation from other plans. At a National level there is a need to increase the protection in the Natal Bioregion as well as in the offshore areas. The KZN CBAs map will thus be used, together with expert knowledge, focused surveys or extra information available within each focus area, to help determine exact boundaries and zonation of any new proposed MPA. The CBA map will also be used to assess a number of proposed MPAs that have been put forward by stakeholders within the KZN Province, to determine if these areas are suitable to take forward, and then to determine suitable boundaries and zonation for these areas. Any new proposed MPA is required to follow a number of legal steps and a stakeholder consultative process is required by law before MPAs can be approved at a National level.

The KZN Marine Biodiversity Plan is scheduled to be updated every five years with any new information that becomes available. Future analyses hope to have sufficient information to produce separate benthic and pelagic biodiversity plans which would help to streamline conservation efforts and allow for more specific protection and management for particular habitats, species and processes, with the use of a suite of management tools such as MPAs, temporally closed areas, harvesting quotas, fishing gear restrictions, bycatch management, improved industry standards for particular activities, etc.

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8 Appendices

Appendix 1: MARINE ZONATION

ZONATION CATEGORIES FOR MARINE PROTECTED AREAS IN KWAZULU-NATAL

Currently (20XX - put year) the marine protected areas within KZN have three types of zonation within which certain activities can occur and for which different levels of biodiversity protection are afforded.

A / Sanctuary Zone: This zone aims to maintain biodiversity and ecological processes and to provide visitors with natural/spiritual/educational experiences in the marine environment. There is no extractive resource use except limited traditional subsistence harvesting in specified areas.

B / Restricted Zone: This zone aims to conserve biodiversity and ecological processes and to provide visitors with a very exclusive high quality nature-based outdoor experience in a marine environment. Certain activities such as catch and release fishing or harvesting of pelagic gamefish are permitted.

C/ Controlled Zone: This zone aims to restore and maintain the natural environment and ecological processes by providing an affordable, comfortable, informative, safe, enjoyable and sustainable outdoor recreational experience in a relatively unspoilt marine environment. This zone allows for controlled extractive resource use of specified species.

The zonation scheme and related activities for KwaZulu-Natal MPAs are detailed below.

A: Sanctuary (Marine)

UNMODIFIED NATURAL ENVIRONMENT. Similar to an IUCN Terrestrial Wilderness area – Primitive Zone and designated Sanctuary to enable the protection of specific attributes of value.	
Inherent Attributes/ Characteristics	Similar to those of a Wilderness area but the area under consideration does not qualify for true wilderness status due to: i Some visual evidence (limited in extent yet discernable to even the general public) of human activities in the recent past (for example, ship wrecks). ii It being too small in size to maintain ecological processes without some ongoing management intervention. iii It not being large enough to be physically, visually and/or audibly buffered from adjacent areas of extant human activities to provide a true high quality wilderness experience. The primary purpose of a Sanctuary Zone is the protection of a particular species, community, habitat type or ecosystem, and for scientific benchmarking purposes.
Focal Purpose of Zone	i Maintain a scientific benchmark area of biodiversity and ecosystem processes. ii Provide visitors with nature/spiritual/education experiences in a marine environment.
Permissible Uses & Activities	No activities should conflict with principles of Wilderness. *Inshore:* i Research and monitoring with a scientific permit and special motivation (typically only research and monitoring for benchmarking, for demonstrating value of sanctuaries and where it has been ascertained that the work cannot be done elsewhere, e.g. only place a species occurs). ii Guided educational tours on foot (turtle walks, wilderness trails). iii Walking on beaches and swimming. iv Surfing and surf skiing but with paddling out only from demarcated areas / sandy shores (jumping off and paddling from intertidal rocks not permitted) v Essential management activities (compliance and monitoring and emergencies only, not drive through) *Offshore:* i Research and monitoring with a scientific permit and special motivation (see above for inshore). ii Minimum required law enforcement patrol and reaction. iii Sea-kayaking and kite & wind-surfing but with paddling out only from demarcated areas / sandy shores (jumping off and paddling from intertidal rocks not permitted) iv Guided Educational tours (non-motorised, non-mechanised) v Public boating: Vessels have the right of passage, through a designated Sanctuary area but must have all fishing gear stowed and may not be in possession of any fish or parts thereof, and may not stop for any reason, other than a declared emergency (e.g. sinking).
Non-Permissible Uses & Activities	The following activities are not permissible: *Inshore:* i Harvesting of intertidal or shallow subtidal organisms ii Vehicles on beaches (except for essential management activity and research/monitoring under special permit)) iii Fossiking and shell collecting. iv Launching of boats v Walking on intertidal rocks (including jumping off of intertidal rocks by surfers) vi Riding of motor bikes vii Horse-riding viii Snorkelling ix Use of jetskis x Rock and surf angling xi Any other activity not specifically listed as permissible Offshore: i Scuba diving (except for monitoring and research under special permit), snorkelling, kite & wind-surfing. ii Educational tours using motorised vessels. iii Parasailing from boat or use of jetskis. iv All forms of extractive use, including reef & pelagic fishing, spearfishing, collection of biota, marine products (shells) and rocks/sand, etc. v Self-launch or concession boat launching. vi Private or concession boating, except through-passage carrying no fish. vii Harassing of marine mammals and whale sharks. viii Dredging or extraction of sand, rock, gravel or other minerals. ix Any other activity not specifically listed as permissible.
Use Intensity/ **Frequency**	Law enforcement, management, research, monitoring and visitor use strictly limited to: i Very low intensity. ii Very low frequency, the emphasis being on transient use only. iii Small group sizes.

	Also, very strict regulation and control over entry. Note, guided walkers and kayaker groups should be managed such as not to overlap
Development Nodes	No Development Nodes
Development Restrictions	i. All types and forms of development prohibited, in both the marine environment and the adjacent inland terrestrial environment ii. Access roads/ramps, parking, view sites and picnic areas in the dune cordon alongside this zone are prohibited.

B1: Restricted (Marine)

PARTLY MODIFIED NATURAL ENVIRONMENT. Equivalent to an IUCN Terrestrial Restricted Zone.	
Inherent Attributes/ Characteristics	A marine area that may have some (but limited in extent and impact) adjacent extant human settlement, developed infrastructure (e.g. buoys) and/or limited consumptive activities (e.g. catch and release fishing, subsistence fishing) and some visual evidence (limited in extent and impact but relatively more than that acceptable for sanctuary zones) of their occurrence in the recent past. Nevertheless, regardless of whether extant or residual, the human induced modifications to the environment must either pose no significant threats (to ecological processes, biodiversity and landscape quality) or it is feasible to dispose of or remove them and/or mitigate their negative impacts over time. Accordingly, to qualify as a low use zone, the area must have the potential for restoration to a state that the general public regards, for the most part, as a near-pristine landscape.
Focal Purpose of Zone	i Conservation of biodiversity and ecological processes. ii Provide visitors with an exclusive high quality nature-based outdoor experience in a marine environment.
Permissible Uses & Activities	Inshore: i Educational tours (non extractive). ii Research and monitoring with scientific permit. iii Walking on beaches and rocks. iv Fossiking (i.e. non-extractive). v Swimming and snorkelling in rock pools and shallow subtidal areas. vi Surfing, surf-skiing, kite and wind surfing. vii Scientific research and management beach-driving. Offshore: i Concession Scuba diving (code of conduct applies, i.e. no use of gloves). ii Snorkelling, iii Sea-kayaking. iv Offshore Boating (DOT/SAMSA registered). v Concession-based boat launching at designated launch sites. vi Research and monitoring for registered projects with scientific permit. vii Educational tours (non-extractive e.g. whale watching). viii Management motorised boating
Non-Permissible Uses & Activities	Inshore - the following activities are not permitted except under special permit: iii Vehicles on the beach except under recreational and educational use permits for concession operators, and authorised management and research vehicles. iv Recreational rock and surf angling. v Use of jetskis. vi Special events (e.g. weddings). vii Any other activity not specifically listed as permissible. Offshore: viii Recreational fishing and spearfishing including bottom fishing (whether catch and release or not). ix Para-sailing from boat x Use of jetskis. xi Self-launch boat launch sites. xii Harassing of marine mammals and whale sharks. xiii Dredging or extraction of sand, rock, gravel or other minerals. xiv Any other activity not specifically listed as permissible.
Use Intensity/ **Frequency**	xv Regulated and controlled use of low intensity and moderate frequency. Limited and mainly permit-regulated activities.
Development Nodes	xvi Only Low Intensity Tourism Day Visitor Nodes and Park Management Nodes permitted.
Development Restrictions	xvii Permanent development of any type or form prohibited on beach and in intertidal/subtidal and foredune areas. Development from base-of-dune to dune-crest and inland must conform to the restrictions laid down for the Terrestrial Restricted Zone.

B2: Restricted (Marine)

PARTLY MODIFIED NATURAL ENVIRONMENT. Equivalent to an IUCN Terrestrial Restricted Zone.	
Inherent Attributes/ Characteristics	A marine area that may have some (but limited in extent and impact) adjacent extant human settlement, developed infrastructure (e.g. buoys) and/or limited consumptive activities (e.g. catch and release fishing, subsistence fishing) and some visual evidence (limited in extent and impact but relatively more than that acceptable for limited use zones) of their occurrence in the recent past. Nevertheless, regardless of whether extant or residual, the human induced modifications to the environment must either pose no significant threats (to ecological processes, biodiversity and landscape quality) or it is feasible to dispose of or remove them and/or mitigate their negative impacts over time. Accordingly, to qualify as a low use zone, the area must have the potential for restoration to a state that the general public regards, for the most part, as a near-pristine landscape.
Focal Purpose of Zone	xviii Conservation of biodiversity and ecological processes. xix Provide visitors with an exclusive high quality nature-based outdoor experience in a marine environment.
Permissible Uses & Activities	Inshore: I. Educational tours (non extractive). II. Research and monitoring with scientific permit. III. Walking on beaches and rocks. IV. Recreational rock and surf angling (catch and release only). V. Fossiking (i.e. non-extractive). VI. Swimming and snorkelling in rock pools and shallow subtidal areas VII. Surfing, surf-skiing, kite and wind surfing. VIII. Scientific research and management beach-driving.

	Offshore: I. Recreational scuba diving and snorkelling (code of conduct applies, i.e. no use of gloves). II. Sea-kayaking. III. Offshore Boating (DOT/SAMSA registered) IV. Concession-based boat launching at designated launch sites. V. Recreational fishing (catch and release only). VI. Research and monitoring for registered projects with scientific permit. VII. Educational tours (non-extractive). VIII. Management motorised boating
Non-Permissible Uses & Activities	Inshore - the following activities are not permitted except under special permit: I. Vehicles on the beach except under recreational and educational use permits for concession operators, and authorised management and research vehicles. II. Special events III. Extractive fishing IV. Any other activity not specifically listed as permissible Offshore: i Bottom fishing (whether catch and release or not). ii Para-sailing from boat iii Use of jetskis. iv Self-launch boat launch sites. v Extractive recreational fishing and spearfishing. vi Dredging or extraction sand, rock, gravel or other minerals vii Any other activity not specifically listed as permissible viii Harassing of marine mammals and whale sharks
Use Intensity/ **Frequency**	Regulated and controlled use of low intensity and moderate frequency. Limited and mainly permit regulated activities.
Development Nodes	Only Low Intensity Tourism Day Visitor Nodes and Park Management Nodes permitted.
Development Restrictions	Permanent development of any type or form prohibited on beach and in intertidal/subtidal and foredune areas. Development from base-of-dune to dune-crest and inland must conform to the restrictions laid down for the Terrestrial Restricted Zone.

C: Controlled (Marine)

MODIFIED NATURAL ENVIRONMENT. Noticeably less pristine than a Restricted Zone, but offering a measure of greater protection to species and ecosystems and enhanced care for the environment than in areas outside protected areas.	
Inherent Attributes/ Characteristics	A marine area where the seascape, ecosystems and habitats, and ecological processes may have been noticeably transformed by past or present developments (piers, buoys) or human activities (fishing, estuary mouth manipulation) within the area or in the terrestrial area immediately adjacent to it, but with significant interventions over time it could be restored to: i A natural setting that appears to the general public as largely unmodified. ii A system where the ecological processes function naturally. iii A situation where, as a combination of achieving the above, the area could be regarded as partly modified and hence could be upgraded to a Restricted Zone. iv Proactive and reactive management interventions may be required indefinitely for the maintenance of the above.
Focal Purpose of Zone	The restoration and maintenance of natural landscapes and ecological processes. Provide an affordable, comfortable, informative, safe, enjoyable and sustainable outdoor recreational experience in a relatively unspoilt marine environment.
Permissible Uses & Activities	Inshore: i Recreational rock & surf angling (according to a fish list, all other species to be returned). ii Recreational spearfishing (according to fish list). iii Recreational invertebrate harvesting. iv Horse-riding. v Walking on beaches & rocks or fossiking. vi Swimming, snorkelling, surfing & surf-skiing. vii Educational tours. viii Research and monitoring activities with scientific permit. ix Management activities. x Beach-driving by scientific and management vehicles. xi Special events. Offshore i Recreational Scuba diving (code of conduct applies, i.e. no use of gloves). ii Snorkelling. iii Boating (DOT registered). iv Use of fishing jetskis. v Recreational fishing (according to fish list, all other species to be returned). vi Recreational spearfishing (according to fish list). vii Research and monitoring for registered projects with scientific permit. viii Educational tours (non-extractive, e.g. whale watching, dive trails). ix Sea-kayaking, kite & wind-surfing, or parasailing from boat. x Special events. xi Management activities.
Non-Permissible Uses & Activities	Inshore i Keeping fish not on the fish list. ii Any other activity not specifically listed as permissible. Offshore i Bottom fishing. ii Chumming or feeding of fish (including sharks) except under special permit. iii Keeping fish not on fish list. x Dredging or extraction of sand, rock, gravel or other minerals. iv Harassing of marine mammals and whale sharks.
Use Intensity/ Frequency	Use of moderate intensity and fairly high frequency, with entry/access restricted to and controlled at entrance gates or other demarcated points of entry.
Development Nodes	Only Tourism Day Visitor Nodes and Park Management Nodes permitted. Medium and high intensity tourism overnight nodes.
Development restrictions	Only very low key, unobtrusive and low impact development permitted from base of dune to low water mark. No development of any type or form permitted from low water mark to outer seaward limit of Marine Reserve. Development from base-of-dune to dune-crest and inland must conform to restrictions laid down for the adjacent Development Node or Terrestrial Zone which, in many instances, will be a Terrestrial Controlled Zone.

Summary of permissible marine activities per zone

	SANCTUARY ZONE A	RESTRICTED ZONE B1	RESTRICTED ZONE B2	CONTROLLED ZONE C
PERMISSIBLE ACTIVITIES	**Inshore** ❖ Research and monitoring for **registered research projects with a scientific permit**, requiring special motivation (typically only research and monitoring for benchmarking, for demonstrating value of sanctuaries and where it has been ascertained that the work cannot be done elsewhere, e.g. only place a species occurs). ❖ Guided educational tours on foot (turtle walks, wilderness trails). ❖ Walking on beaches and swimming. ❖ Surfing and sea-kayaking **but with paddling out only from sandy shores (jumping off and paddling from intertidal rocks not permitted**) ❖ Essential management activities (compliance and monitoring and emergencies only, not drive through)	**Inshore** ❖ Educational tours ❖ Research and monitoring for registered projects with scientific permit. ❖ Walking on beaches and rocks. Fossiking (i.e. non-extractive). ❖ Swimming and snorkelling. ❖ Surfing, surf-skiing, kite and wind surfing. ❖ Scientific research and management beach-driving.	**Inshore** ❖ Educational tours ❖ Research and monitoring **for registered projects** with scientific permit. ❖ Walking on beaches and rocks. ❖ Recreational rock and surf angling (catch and release only) ❖ Fossiking ❖ Swimming and snorkelling. ❖ Surfing, surf-skiing, kite and wind surfing. ❖ Scientific research and management beach-driving.	**Inshore** ❖ Recreational rock and surf angling (according to a fish list, all other species to be returned). ❖ Recreational spear fishing (according to a fish list with some local areas where fishing is prohibited). ❖ Recreational invertebrate harvesting. ❖ Horse-riding. ❖ Walking on beaches and rocks or fossiking. ❖ Swimming and snorkelling. ❖ Surfing, sea-kayaking, surf-skiing, kite and wind surfing. ❖ Educational tours (e.g. turtle). ❖ Research and monitoring **for registered projects** with scientific permit. ❖ Management activities. ❖ Beach-driving by scientific and management vehicles.
	SANCTUARY ZONE A	**RESTRICTED ZONE B1**	**RESTRICTED ZONE B2**	**CONTROLLED ZONE C**
PERMISSIBLE ACTIVITIES	**Offshore** ❖ Research and monitoring with a scientific permit and special motivation (see above for inshore). ❖ Minimum required law enforcement patrol and reaction. ❖ Guided sea-kayaking. ❖ Guided educational tours (non-motorised, non-mechanised ❖ Public boating: vessels at sea within the 3 nautical mile limit offshore have the right of passage, may not be in possession of any fish or parts thereof, and may not stop for any reason, other than a declared emergency (e.g. sinking).	**Offshore** ❖ Concession Scuba diving . ❖ Snorkelling. ❖ Sea-kayaking. ❖ Offshore boating (DOT/SAMSA registered) ❖ Concession-based boat launching at designated launch sites. ❖ Research and monitoring **for registered projects** with scientific permit. ❖ Educational tours (non-extractive). ❖ Management motorised boating.	**Offshore** ❖ Recreational scuba diving. ❖ Snorkelling, ❖ Sea-kayaking. ❖ Offshore boating (DOT/SAMSA registered). ❖ Concession-based boat launching at designated launch sites. ❖ Recreational fishing (catch and release only). ❖ Research and monitoring **for registered projects** with scientific permit. ❖ Educational tours (non-extractive). ❖ Management motorised boating.	**Offshore** ❖ Recreational scuba diving. ❖ Snorkelling. ❖ Boating (DOT registered). ❖ Recreational fishing according to fish list (with some local areas where fishing prohibited). ❖ Recreational spear fishing (with some local areas where fishing prohibited). ❖ **Use of fishing jetskis.** ❖ Research and monitoring **for registered projects** with scientific permit. ❖ Educational tours (non-extractive, e.g. whale watching, dive trails). ❖ Sea-kayaking, kite & wind-surfing, or parasailing from boat. ❖ **Concession-based and self-boat launching at designated launch sites.** ❖ Special events. ❖ Management activities.

Summary of non-permissible marine activities per zone

	SANCTUARY ZONE A	RESTRICTED ZONE B1	RESTRICTED ZONE B2	CONTROLLED ZONE C
NON-PERMISSIBLE ACTIVITIES	**Inshore** ❖ Harvesting of intertidal or shallow subtidal organisms. ❖ Vehicles on beaches (except for essential management activity and research/monitoring under special permit). ❖ Fossiking and shell collecting. ❖ Launching of boats. ❖ Walking on intertidal rocks **(including jumping off of intertidal rocks by surfers).** ❖ Riding of bikes. ❖ Horse-riding. ❖ Snorkelling. ❖ Rock and surf angling. ❖ Use of jetskis. ❖ Any other activity not specifically listed as permissible.	**Inshore** ❖ Vehicles on the beach except under recreational and educational use permits for concession operators, and authorised management and research vehicles. ❖ Extractive recreational fishing. ❖ Use of Jetskis. ❖ Special events. ❖ Any other activity not specifically listed as permissible.	**Inshore** ❖ Vehicles on the beach except under recreational and educational use permits for concession operators, and authorised management and research vehicles. ❖ Extractive recreational fishing. ❖ Use of Jetskis. ❖ Special events. ❖ Any other activity not specifically listed as permissible.	**Inshore** ❖ Keeping of fish not on “fish list”. ❖ Any other activity not listed as permissible.

	SANCTUARY ZONE A	RESTRICTED ZONE B1	RESTRICTED ZONE B2	CONTROLLED ZONE C
NON-PERMISSIBLE ACTIVITIES	**Offshore** ❖ Scuba diving (except for monitoring and research under special permit), snorkelling, kite & wind-surfing. ❖ Educational tours using motorised vessels. ❖ Parasailing from boat. ❖ Jetskis. ❖ All forms of extractive use, including reef & pelagic fishing; spearfishing, collection of biota, marine products (shells) and rocks/sand, etc. ❖ Self-launch or concession boat launching. ❖ Private or concession boating, except through-passage carrying no fish. ❖ Harassing of marine mammals and whale sharks. ❖ Dredging or extraction of sand, rock, gravel or minerals. ❖ Any other activity not specifically listed as permissible.	**Offshore** ❖ Bottom fishing (whether catch and release or not). ❖ Recreational fishing (whether catch and release or not). ❖ Para-sailing from boat. ❖ Use of jetskis. ❖ Self-launch boat launch sites. ❖ Extractive recreational fishing and spearfishing. ❖ Chumming or feeding of fish including sharks. ❖ Harassing of marine mammals and whale sharks. ❖ Dredging or extraction of sand, rock, gravel or minerals. ❖ Any other activity not specifically listed as permissible.	**Offshore** ❖ Bottom fishing (whether catch and release or not). ❖ Para-sailing from boat. ❖ Use of jetskis. ❖ Self-launch boat launch sites. ❖ Extractive recreational fishing and spearfishing. ❖ Chumming or feeding of fish including sharks. ❖ Harassing of marine mammals and whale sharks. ❖ Dredging or extraction of sand, rock, gravel or minerals. ❖ Any other activity not specifically listed as permissible.	**Offshore** ❖ Bottom fishing. ❖ Chumming or feeding of fish (including sharks). ❖ Keeping fish not on fish list. ❖ Harassing of marine mammals and whale sharks. ❖ Dredging or extraction of sand, rock, gravel or minerals. ❖ Any other activity not specifically listed as permissible.

Appendix 2: Coastal and Marine Biodiversity Plan datasets and sources

Dataset	Data source	Used in the plan
Broad scale (1 km to 10 km accuracy)		
Habitats		
Offshore habitats	Offshore habitat classification produced by T. Livingstone (Ezemvelo), based on the following datasets: Sea Surface Temperature, Chlorophyll-a, Turbidity, Bathymetry (depth, slope), Sediments, Phosphate, Organic carbon, Bottom oxygen and temperature.	Yes
Sea Surface Temperature [Mean], [maximum], [coefficient of variation]	NOAA/AVHRR Sea surface temperature (SST) data, 1 km resolution, Jan 2001 to Dec 2004. Data processed and provided by the Oceanography Department at the University of Cape Town (Christo Whittle). Best cloud free image per month for a total of 46 images. Time series analysis processed by T. Livingstone.	Yes (subsidiary layer for offshore habitats)
Chlorophyll-a [Mean], [coefficient of variation]	SeaWiffs chlorophyll (Chl-a) data, 1 km resolution, Jan 2001 to Dec 2004. Data processed and provided by the Oceanography Department at the University of Cape Town (Christo Whittle). Best cloud free image per month for a total of 51 images. Time series analysis processed by T. Livingstone.	Yes (subsidiary layer for offshore habitats)
Turbidity [Mean], [coefficient of variation]	AquaModis diffuse-attenuation coefficient for PAR (m-1), 4 km resolution resampled to 1 km, Jul 2001 to Dec 2004. Data downloaded from the NASA oceancolor website (http://oceancolor.gsfc.nasa.gov/cgi/level3.pl). Monthly composite data for a total of 30 images. Time series analysis processed by T. Livingstone.	Yes (subsidiary layer for offshore habitats)
Processes		
Average position of Sea Surface Temperature and Chlorophyll fronts	Sea Surface Temperature fronts and Chlorophyll-*a* fronts frequency were derived from 8 days (2002-2007) MODIS data, 4 km resolution. Data downloaded from the NASA oceancolor website (ftp://oceans.gsfc.nasa.gov) or provided by A.G. Smith. Fronts were extracted using the Cayula-and Cornillon algorithm (Cayula and Cornillon. 1992). This algorithm is implemented in the Arctool Box GMET (Roberts *et al.* in review) downloaded from http://mgel.env.duke.edu/tools. Zones with a frequency > 50 % were extracted. Data processed by E. Lagabrielle.	Yes
Average position of eddies (satellite altimetry)	Anticyclonic and cyclonic eddy features were extracted by applying a +-10 cm threshold over AVISO 8 days from (??) 2001-07 Delayed Time Mean Sea Level Anomalies data (computed with respect to a 2001-07 mean), 30 km resolution. The frequency of eddies (both cyclonic and anticyclonic) was then calculated over the entire time series. Zones with a frequency > 50 % were extracted. Data processed by E. Lagabrielle.	No
Average position of eddies (HYCOM oceanographic current model)	Anticyclonic and cyclonic eddies features were extracted by applying a +-10 cm threshold over HYCOM Monthly 2001-07 Mean Sea Level Anomalies data (computed with respect to a 2001-07 mean), 10 km resolution. The frequency of eddies (both cyclonic and anticyclonic) was then calculated over the entire time series. Zones with a frequency > 50 % were extracted. Data provided by the Department of Oceanography at the University of Cape Town, contact: B. Backeberg. Data processed by E. Lagabrielle.	Yes
Geostropic currents (HYCOM oceanographic	HYCOM currents (U and V components) extracted from monthly 2001-07 Mean Sea Level data, 10 km resolution. Data provided	No

current model) [Mean], [Eigen vectors/Principal Component Analysis]	by the Department of Oceanography at the University of Cape Town, contact: B. Backenberg. Time series analysis processed by E. Lagabrielle.	
Medium scale (100 m to 1 km accuracy)		
Habitats		
Bathymetry [Depth], [slope]	Paul Young from UKZN Marine Geoscience produced a comprehensive bathymetric grid and contour lines compiled from a number of sources.	Yes
Sediments	Birch manuscript (1996) was captured electronically by T. Livingstone. Data were imported into ArcGis and maps representing inshore sediment distributions over the continental shelf were produced. Maps represented a gradient between the data points rather than rigid boundaries as previously represented on the available hand drawn imagery. Sand, gravel, mud and clay sediment maps were produced.	Yes (subsidiary layer for offshore habitats)
Phosphate	Birch manuscript (1996) was captured electronically by T. Livingstone. Data were imported into ArcGis and a map representing phosphate distribution over the continental shelf was produced.	Yes (subsidiary layer for offshore habitats)
Organic carbon	Birch manuscript (1996) was captured electronically by T. Livingstone. Data were imported into ArcGis and a map representing organic carbon distribution over the continental shelf was produced.	Yes (subsidiary layer for offshore habitats)
Seabed oxygen and temperature	Department of Oceanography at the University of Cape Town, contact: F. Duncan. Hydrographic data obtained from the South African Data Centre for Oceanography (SADCO), Marine and Coastal Management (MCM) and Bayworld Centre for Research and Education (BCRE) were used and seabed oxygen and temperature were extracted. Data points obtained from Fiona Duncan were mapped in ArGIS by T.Livingstone and interpolated for KZN.	Yes
Estuaries	Ezemvelo KZN Wildlife (Estuaries Spatial Conservation Plan), contact: B. Escott. Estuaries points located by E. Lagabrielle.	Yes
Rock reefs	Ezemvelo KZN Wildlife. Data obtained from interviews with recreational, commercial and spear-fishers. Data were incorporated with datasets obtained from the SA Navy, ORI, Marine Geoscience and Ezemvelo KZN Wildlife. Data were also digitised from the literature. Additional GPS positions of coastal visible reefs were collected during ground and aerial surveys. Data processed by T. Wolf to produce a 1 km presence / absence grid of reef areas.	Yes
Coral reefs	ORI, database from the project entitled ‘The Development of an Expert Marine Geographical Information System to Provide an Environmental and Economic Decision Support System for Coastal Tourism and Leisure Developments within the Lubombo Spatial Development Initiative’, contact: M. Schleyer	Yes
Deep-sea canyons	Marine GeoSolutions, P. Ramsey.	Yes
Species (life cycles envelops, including migration pathways)		
Fish (including sharks)	Ezemvelo KZN wildlife and ORI. Selection criteria and mapping method developed by P. Haupt, K. Sink, P. Goodman, B.Q. Mann, J. Harris, T. Robelo, P. Desmet and E. Lagabrielle. Species life cycles envelops and migration pathways modelled by P. Haupt.	Yes
Cetaceans	IUCN	Yes

Invertebrates: Amphipods	NMFS-COPEPOD global plankton database downloaded from http://www.st.nfms.noaa.gov/plankton.	No
Invertebrates: Oysters	ORI, Database from the project entitled '**Stock status of edible oysters in KwaZulul-Natal'**, contact; M. Shleyer.	No
Pressures on biodiversity	Multiple sources (Table 9)	Yes
Fine scale (< 100 m accuracy)		
Habitats		
Coastal habitats	Ezemvelo KZN wildlife surveys. Data processed by T. Livingstone.	Yes
Species		
Turtles (nesting sites)	Ezemvelo KZN wildlife. Nesting sites (sandy beaches) mapped with S. Bachoo and J. Olbers using the map of fine scale coastal habitats. Data processed by T. Livingstone and E. Lagabrielle.	Yes
Management boundaries		
EEZ (200 nm)	Maritime Boundaries Geodatabase (VLIZ, 2009 shoreline redelineated using the map of fine scale coastal habitats).	Yes
Protected areas	Ezemvelo KZN wildlife. MPA geographic coordinates were extracted from the Government Gazette (Marine Living Resources Act) and mapped by T. Livingstone and E. Lagabrielle. Terrestrial protected area boundaries were provided by Ezemvelo KZN Wildlife. Admiralty Reserve and State Land boundaries were obtained from the Kwazulu-Natal Provincial Planning & Development Commission.	Yes
Proposed marine protected areas	Ezemvelo KZN wildlife, delineated with proposers by T. Livingstone.	Yes

Appendix 3: Final shoreline codes used within the biozone level II database

FeatureTypeCode	FeatureDescription	FeatureCategory
?-A	Mappers uncertain, not specified	Other
AP	Path - not specified	Access
AP-II	Access path parallel	Access
AP-O	Path - public	Access
AP-P	Path - private	Access
AP-S	Path - subsistence	Access
AR	road	Access
AR-II	Access road parallel	Other
AR-II-HY	Highway	Access
AR-T	Tarr access road	Access
CF-BAY	Bay	Other
CF-BOG	Bog	Dune-Scrub dune
CF-CH	Channel (usually subtidal)	Other
CF-CLIFF	Cliff / Erosion	Dune-Fore dune
CF-DL	Drainage line	Dune-Forest dune
CF-ER	Erosion	Dune-Forest dune
CF-EST-A	Estuary / River mouth	Other
CF-FW	Fresh water Pools / Spring water	Other
CF-GULLEY	Gulley	Other
CF-HLL	Hill	Dune-Forest dune
CF-MCLIFF	Mega cliff	Other
CF-SBLW	Sandblow	Dune-Scrub dune
CF-SLIDE	Slide / Eroded dune	Dune-Fore dune
CF-SLN	Dune slump (current,serious)	Dune-Fore dune
CF-SLO	Dune slump (old, not serious)	Dune-Fore dune
CF-STREAM	Stream	Other
CF-WFALL	Waterfall	Other
CF-WL	Wetland	Other
CF-XER	Large erosion area	Dune-Forest dune
DE-?	Unspecified development	Development
DE-AG	Agriculture	Dune-Forest dune
DE-AG-CANE	Alien - sugar cane	Dune-Forest dune
DE-AIRPT	Airport	Development
DE-ARMY	Army base camp	Development
DE-B	Development building	Development
DE-BAYCO	Bay industries	Development
DE-BENCH	Development bench	Dune-Scrub dune
DE-BRAAI	Braai and /or picnic area	Development
DE-BRIDGE	Bridge	Development
DE-BRKWT	Breakwater / Dolosses	Dune-Forest dune
DE-CBD	Town / CBD area	Development
DE-CLUB	Club (usually ski boat)	Development
DE-CMP	Campsites	Development
DE-COT	Cottages	Development
DE-CP	Concrete pillar	Development
DE-DEPOT	Depot	Development
DE-DOLPH	Seaworld dolphinarium	Development

DE-DUC	Harbour / Bay	Development
DE-EMB	Embankment	Development
DE-ESPL	Esplanade	Development
DE-FACT	Factory shop	Development
DE-FARM	Animal farm	Development
DE-FENCE	Fences	Development
DE-FIRE	Fire place for subsistence	Dune-Fore dune
DE-FL	Flats	Development
DE-GA	Garden	Development
DE-GABION	Gabions	Development
DE-GOLFC	Golf club	Development
DE-GR	Grass / Lawn	Development
DE-H	House	Development
DE-HAR	Harbour	Development
DE-HOSP	Hospital	Development
DE-HOT	Hotels	Development
DE-HUT	Lifesaver huts	Development
DE-LANDING	Landing strip	Development
DE-MINE-RBM	Richards Bay Minerals	Other
DE-NCP	NCP Yeast Building	Development
DE-NUN	Convent	Development
DE-ORI	Oceanographic Research Institute	Development
DE-P	Parking	Development
DE-PIER	Pier	Development
DE-PIPE	Pipes	Development
DE-PL	Power line	Other
DE-PLAT	Viewing platform	Development
DE-PO	Poles	Development
DE-PR	Prominade	Development
DE-RAIL	Railway line	Development
DE-RTR	Restaurant / Tea room	Development
DE-RUBBLE	Rubble	Rocks
DE-RW	Retaining wall	Development
DE-SEW	Sewage pump	Other
DE-SF	Soccer field	Development
DE-SHOP	Shops	Development
DE-SI		Development
DE-ST	Stairway	Development
DE-STASIE	Station	Development
DE-SW	Swimming pools	Development
DE-TANK	Water tank	Development
DE-TH	Tribal house	Development
DE-TOI	Toilets	Development
DE-TOURIST	Tourist Information Offices	Development
DE-TOWER	Vodacom / Radio tower	Development
DE-TP	Tidal pool	Development
DE-VG	Village green	Development
DE-WALL	Concrete wall	Development
DE-WW	Water World / Supertube	Development
DH-BA-A	Bare dune hummocks including narrow foredune	Dune-Fore dune
DH-VE-A	Vegetated foredune including extensive foredune	Dune-Fore dune

HF-LTHS	Lighthouse	Dune-Forest dune
HF-WRECK	Wreck	Other
NP	not present	Other
R-	Rock not specified	Rocks
R-A	rocks mega <5m	Rocks
R-ALGAE	*Caulerpa* (intertidal)	Other
RBO-A	Rock boulders	Rocks
RBO-ARTF	Rock boulders artificial	Rocks
RBR-A	High broken rock	Rocks
RE-A	Rocks emergent	Rocks
REEF	Reef	Other
R-G-A	Rough irregular rocks	Rocks
R-H	Rocks high	Rocks
RLBR-TA	Rock broken ledge	Rocks
RLBR-TB	Rock low ledge broken	Rocks
RL-M	Mega rock high ledge	Rocks
RL-TA	High ledge	Rocks
RL-TB	Low ledge	Rocks
RPEB-A	Gravel	Sand
R-POOLS	Rock pools	Other
R-Pt-A	Point	Rocks
R-Rdg	Rock ridge	Rocks
RS-A	Rocks submerged	Rocks
RSC-A	Scattered rocks	Rocks
R-SM	Smooth flat sheets	Rocks
RSO-A	Solid rocks	Rocks
R-VS.	Very sanded	Sand
S-A	Sand	Sand
VEG-AL	Aliens	Dune-Forest dune
VEG-AL-CCRI	*Cassuarina* clearing	Dune-Forest dune
VEG-AL-CRI	*Cassuarina*	Dune-Forest dune
VEG-AL-CROM	Alien *Crommalina*	Dune-Forest dune
VEG-AL-DRAC	Alien Drac sp	Dune-Forest dune
VEG-AL-PPC	Alien - prickly pear cluster	Dune-Forest dune
VEG-AL-PRI	Alien - *Passuarina rigidar*	Dune-Forest dune
VEG-IN-ALOE	*Aloe* in dune forest	Dune-Forest dune
VEG-IN-BRAC	*Brachylaena discolour*	Dune-Forest dune
VEG-IN-BU	Bushes, dune scrub	Dune-Scrub dune
VEG-IN-CAR	Bush clump - *Carissa bispinosa*	Dune-Scrub dune
VEG-IN-CARPO	*Carpobrotes* sp.	Dune-Fore dune
VEG-IN-EUPH	*Euphorbia*	Dune-Forest dune
VEG-IN-FOREST	Indigenous, coastal forest	Dune-Forest dune
VEG-IN-FOREST-K	Forest dune small	Dune-Fore dune
VEG-IN-FOREST-L	Forest dune large	Dune-Fore dune
VEG-IN-GR	Grass	Dune-Scrub dune
VEG-IN-HIB	*Hibiscus tilicea*	Dune-Forest dune
VEG-IN-ICASS	Indigenous *Cassuarina*	Dune-Scrub dune
VEG-IN-KN	Red hot poker (*Kniphofia*)	Dune-Scrub dune
VEG-IN-MANG	Mangroves	Dune-Forest dune
VEG-IN-MW	Milkwood vegetation	Dune-Forest dune
VEG-IN-NCEMA	Ncema grass (*kraussi*)	Other
VEG-IN-NIX	Phoenix	Dune-Forest dune
VEG-IN-PASS	*Passurina rigida*	Dune-Forest dune

VEG-IN-REED	Reed grass	Dune-Forest dune
VEG-IN-SED	Sedge grass	Dune-Scrub dune
VEG-IN-SVF	Coastal silverleaf	Dune-Forest dune
WATER	Water	Other

Appendix 4: Human-activities Workshop .

The following participants attended the first human activities workshop at which pressures on marine biodiversity were listed and discussed.

Participants:

Brent Newman (CSIR)
Tim Maclurg (CSIR)
Tandi Breetzke (DAEA)
Nandi Dube (DWAFF)
Bee Kasserpersaud (Ezemvelo)
Rob Broker (Ezemvelo)
Jean Harris (Ezemvelo)
Tamsyn Livingstone (Ezemvelo)
Kerry Sink (SANBI)
Mike Schleyer (ORI)
Pierre Pradervand (ORI)
Rory Lynsky (SA Sugar Association)
Sheldon Dudley (Sharks Board)
Geremy Cliff (Sharks Board)
Fathima Ahmed (PhD student at UKZN)
Muzi Mdamba (Uthugulu District – Empangeni)
Di Dold (WESSA)
Judy Bell (WESSA)

Appendix 5: Methodology for binary layers

Twenty-two binary layers were created. The metadata for each layer is described below.

1_ kzn_shrknets_1109_w31: Area of Influence of Sharknets along the KZN Coastline
NSB collected data from the field using a GPS. Points were plotted using ArcView 3 and edits were performed. Points deleted were Scottburgh, Karridene, Umgababa and Umdloti due to inaccurate GPS points provided by NSB. Sheldon Dudley provided further details through e-mail which was used to create the final file. GPS points were collected by the operations team of the NSB. The locations were captured over 3 months in 2005. Every time the nets were replaced a GPS may not have been used to locate the original point thus the NSB team estimated the area where the nets were to be set. They are generally within 500m from the original points.
According to expert knowledge (Sheldon Dudley) the area of influence alongshore of the shark nets is estimated to be 5km. To represent this spatially, the points provided by NSB (Greg Thompson) were buffered by 5km. In certain areas the buffered areas overlapped. According to expert knowledge (Sheldon Dudley) the area of influence offshore of the shark nets is between the shoreline and the -30m contour. To represent this spatially, the kzn_wave_line_w31.shp was used to represent the shoreline and kzn_30m_depare_line_w31.shp, (which is an extract from the navy bathymetry data) represented the furthest offshore extent. These two files were used to create a polygon to indicate the area offshore. The buffered points were overlaid with the offshore polygon to identify the exact areas of influence.

2_kzn_dbnseinenet_1209_w31: Area utilised by small-scale seine netters in Durban
Karl Bentley was the expert used to assist with the creation of this layer. Using his expert advice the area utilised by the seine netters was demarcated on a 1:50 000 topographical map which was then digitised using ArcView 3.2. The area of utilization commenced from Vetches Pier (using the kzn_waveline_w31) and up to 500m north along the beach and approximately 300m offshore.

4_ kzn_aliendistr_1209_w31: Potential Distribution of Alien Species
Polygons were clipped from the EEZ dataset illustrating the potential distribution of alien Species

5_kzn_rec_lsb_bf_1209_w31: Areas along the KZN coastline where recreational skiboat linefishing for bottomfish occurs.
This layer was created using the regulations as stipulated in the MLRA and expert knowledge. Areas applicable to this fishery are any waters along the KZN coastline except for areas stipulated in the MLRA. According to expert knowledge this fishery will only occur at depths between -2m and -200m. The kzn_wave_line_w31 was buffered at 40nm (74 km) using the Xtools function in ArcView 3.2. A cut of depth of -200m was used (kzn_200m_depare_line_w31). This contour line was extracted from the bathymetry data (kzn_depare_line_w31). According to expert knowledge this activity does not take place in areas less than -2m and therefore the (kzn_2m_contour_line_w31) was used to exclude these areas. According to the MLRA recreational skiboat linefishing (bottomfish) is permitted all along the KZN coastline except in the MPA (with exception of Aliwal Shoal MPA. Here the activity is excluded only from the Crown and produce area) which was obtained from the kzn_mpas (archived by Heidi Snyman at QEP) dataset created by Mandy Lombard. MPAs were reedited by Tamsyn Livingstone. The resulting dataset was polygons indicating areas were this activity is allowed and most likely to occur.

6_kzn_comm_l_1209_w31: Areas along the KZN coastline where commercial linefishing occur
Using MLRA regulations, expert knowledge from Rob Broker and other experts from the workshop this layer was generated. Areas applicable to this fishery are any waters along the KZN coastline 40 nm from the shore, except for areas stipulated in the MLRA. According to expert knowledge, this activity should only occur -2m and deeper. The -2m contour (kzn_2m_contour_line_w31) line was used and buffered at 40nm (74 km) using the buffering tool in XTools in ArcView 3.2. According to the MLRA, commercial linefishing is permitted all along the KZN coastline except in the MPAs which was obtained from the kzn_mpas (archived by Heidi Snyman at QEP) dataset created by Mandy Lombard. MPAs were re-edited by Tamsyn Livingstone. The resulting dataset was polygons indicating areas were this activity is allowed and most likely to occur.

7_kzn_sub_linefish_1209_w31: Areas along the KZN coastline where subsistence linefishing occur
Dataset was created using field data collected by Mariana Tomalin and Vuyi Radebe. An excel table was obtained from Mariana and Vuyi, which contained GPS points of areas demarcated for subsistence linefishing. The file was cleaned and points were corrected and converted to polylines using the kzn_highwater_mark_w31 as a guideline for the coastline and with expert knowledge it was determined that the furthest a subsistence fisher could cast from the low water mark is 100m offshore from the waveline (kzn_wave_line_w31). Using these criteria polygons were created from the polylines.

8_kzn_sub_intertidal_sandyshore_1209_w31: Areas along the KZN coastline where subsistence intertidal extraction occur
Dataset was created using field data collected by Mariana Tomalin and Vuyi Radebe. An excel table was obtained from Mariana and Vuyi, which contained GPS points of areas demarcated for subsistence intertidal extraction. The file was cleaned and points where corrected. The points were converted to polylines (using kzn_highwater_mark_w31 and kzn_wave_line_w31 as a guideline for the intertidal area). Using these criteria polygons were created from the polylines.

9_kzn_rec_lfpc_bf_1209_w31: Areas in KZN were recreational linefishing can take place from paddlecraft– bottomfish
This layer was created by Bimall Kasseepursad using information collected from EZEMVELO managers in September 2006 and edits were performed based on comments made at workshop. Using the buffering tool in XTools ArcView 3.2, the waveline (kzn_wave_line_w31) was buffered at 1nm (1850m). This fishery does not take place in waters less than -2m and therefore the kzn_2m_contour_line_w31 dataset was used to exclude areas less than -2m. According to the MLRA this fishery cannot occur in SLMR, MMRs, and Trafalgar MR and these areas were removed by overlaying the MPA polygons from the kzn_mpas (archived by Heidi Snyman at QEP) dataset created by Mandy Lombard. Note that in the Aliwal MPA only the Crown and Restricted Use areas have been excluded because recreational fishing is allowed in the C zone. MPAs were re-edited by Tamsyn Livingstone.

10_kzn_sc_seinenet_sardine_1209_w31: Small Scale Commercial Seine Netting of Sardines
Bimall Kasseepursad created this layer using information collected from the EZEMVELO managers and Mike Anderson Reed in September 2006. The waveline boundary kzn_waveline_w31 was selected. Using the buffering tool in Xtools in ArcView 3.2, the kzn_waveline_w31.shp was buffered 300m. Using the MPAs boundaries from the kzn_mpas_wlo31, Trafalgar MPA was removed leaving two polygons which represent the areas along the KZN coastline were small scale commercial seine netting of sardines can occur.

11_kzn_rec_lsb_gf_1209_w31: Areas along the KZN coastline where recreational skiboat linefishing (gamefish) occur
Dataset was created using the regulations as stipulated in the MLRA and expert knowledge. Areas applicable to this fishery are any waters along the KZN coastline 40 nm from the shore, except for areas stipulated as prohibited in the MLRA. The KZN boundary (the EEZ coastline boundary was used i.e. kzn_eez_line_w31) was buffered at 40nm (74 km) using ED tools in ArcView 3.2. According to the MLRA, recreational skiboat linefishing (gamefish) is permitted all along the KZN coastline except in the sanctuary areas of the SLMR, MMR and the Crown and Produce area of the Aliwal MPA which were obtained from the kzn_mpas (archived by Heidi Snyman at QEP) dataset created by Mandy Lombard. MPAs were re-edited by Tamsyn Livingstone. The resulting dataset was polygons indicating areas were this activity is allowed and most likely to occur.

12_kzn_rec_boat based spearfishing_bottomfish_1209_w31: Areas along the KZN coastline where recreational spearfishing–bottomfishing occurs
Dataset was created using the regulations as stipulated in the MLRA and expert knowledge. According to experts this activity takes place by boat from the backline (2m) to up to 30m depth line. According to the legislation spearfishing is allowed all along the KZN Coast except in the sanctuary areas of the MMMR and SLMR. The 2 meter contour line (kzn_2m_contour_line_w31) was created. The -30m contour line was extracted from the kzn_depare_line_w31 bathymetry file to create kzn_30m_depare_line_w31. These two files were used to create a polygon which indicated the areas along the coastline where this activity occurs. The exclusion areas were removed by overlaying the sanctuary area polygons from the kzn_mpas

(archived by Heidi Snyman at QEP) dataset created by Mandy Lombard. MPAs were re-edited by Tamsyn Livingstone.

13_kzn_rec_boat based spearfishing_gamefish_1209_w31: Areas along the KZN coastline where recreational boat based spearfishing- gamefishing occurs

Dataset was created using the regulations as stipulated in the MLRA and expert knowledge. According to experts this activity takes place by boat from the backline (2 meter line) to up to 30m depth line. According to the legislation spearfishing is allowed all along the KZN Coast except in the sanctuary areas of the MMMR and SLMR. The 2 meter contour line (kzn_2m_contour_line_w31) was created. The -30m contour was extracted from the kzn_depare_line_w31 bathymetry file to create kzn_30m_depare_line_w31. These two files were used to create a polygon which indicated the areas along the coastline where this activity occurs. The exclusion areas were removed by overlaying the sanctuary area polygons from the kzn_mpas (archived by Heidi Snyman at QEP) dataset created by Mandy Lombard. MPAs were re-edited by Tamsyn Livingstone.

14_kzn_rec_charter_1209_w31: Areas along the KZN coastline where recreational charter boat fishing occurs

Dataset was created using the regulations as stipulated in the MLRA and expert knowledge provided by Dr Kerry Sink and EZEMVELO officers. According to the legislation recreational charter boat fishing is allowed all along the KZN Coast except in the sanctuary areas of the MMR and SLMR. The furthest the boats can travel is 40nm offshore (74km). The high water mark i.e. kzn_highwater_mark_w31 was used as the base data, which was buffered at 40nm using the buffering tool in XTools in ArcView 3. According to expert knowledge the activity does not take place in areas less than -2m and therefore the kzn_2m_contour_line_w31 was used to exclude these areas. This activity is prohibited in the MMR & SLMR sanctuary areas. These areas were excluded by overlaying the sanctuary area polygons from the kzn_mpas (archived by Heidi Snyman at QEP) dataset created by Mandy Lombard. MPAs were re-edited by Tamsyn Livingstone.

15_kzn_rec_ecrocklob_1209_w31: Recreational East Coast Rock Lobster Collection

Dataset was created using the regulations as stipulated in the MLRA, expert knowledge and base datasets from various sources. According to expert knowledge (06 November 2006 workshop) collection of east coast rock lobsters takes place up to -30m contour. Furthermore it was decided that the furthest an individual could swim is 1km offshore. According to legislation the collection is allowed all along KZN coast except in the MPAs and Durban Bay. The -30m contour was extracted from the kzn_depare_line_w31 bathymetry file to create kzn_30m_depare_line_w31. Using the kzn_wave_line_w31 and the kzn_30m_depare_line_w31 a polygon was created which indicated the areas along the coastline where this activity could possibly occur. kzn_wave_line_w31 was buffered by 1km to demarcate the swimming distance limitation. This file was merged with the file indicating the areas were this resource occurs and the areas outside the 1km zone were removed. The exclusion areas were removed by overlaying the MPA polygons from the kzn_mpas (archived by Heidi Snyman at QEP) dataset created by Mandy Lombard and the Durban Bay polygon created by Bimall Kasseepursad. MPAs were re-edited by Tamsyn Livingstone.

16_kzn_rec_mussel_1209_w31: Recreational Mussel Collection

Dataset was created using the regulations as stipulated in the MLRA and expert knowledge and base datasets from various sources. According to expert knowledge (06 November 2006 workshop) collection of mussels takes place in the intertidal rocky areas. According to legislation the collection is allowed all along KZN coast except in the MPAs, Durban Bay and subsistence use areas. The kzn_wave_line_w31 and the kzn_highwater_mark_w31 were used to create a polygon which indicated the intertidal areas along the coastline where this activity occurs. The exclusion areas were removed by overlaying the MPA polygons from the kzn_mpas (archived by Heidi Snyman at QEP) dataset created by Mandy Lombard and the Durban Bay polygon created by Bimall Kasseepursad and the kzn_sub_intertidal_wlo31 created by Bimall Kasseepursad. MPAs were re-edited by Tamsyn Livingstone.

17_kzn_rec_oyster_1209_w31: Recreational Oyster Collection

Dataset was created using the regulations as stipulated in the MLRA and expert knowledge and base datasets from various sources. According to expert knowledge (06 November 2006 workshop) collection of oysters takes place in the shallow subtidal rocky areas. According to legislation the collection is allowed all along KZN coast except in the MPAs. The waveline (kzn_wave_line_w31) and the -2m contour line (kzn_2m_contour_line_w31) were used to create a polygon which indicated the shallow subtidal (surfzone pers. comm. Jean Harris) areas along the coastline where this activity occurs. The exclusion areas were removed by overlaying the MPA polygons from the kzn_mpas (archived by Heidi Snyman at QEP) dataset created by Mandy Lombard. MPAs were re-edited by Tamsyn Livingstone.

18_kzn_comm_oyster_1209_w31: Commercial Oyster Harvesting
Dataset was created using the regulations as stipulated in the MLRA and expert knowledge provided by Dr Kerry Sink & Rob Broker. According to expert knowledge commercial harvesting of oysters takes place in the low shore of the intertidal rocky areas to a depth of -15m. According to legislation this activity is allowed all along KZN coast except in the MPAs. The waveline (kzn_wave_line_w31) and the 15 meter depth line (kzn_15m_depare_line_w31) were used to create a polygon which indicated the intertidal areas along the coastline where this activity occurs. The exclusion areas were removed by overlaying the MPA polygons from the kzn_mpas (archived by Heidi Snyman at QEP) dataset created by Mandy Lombard. Please note this shapefile does not distinguish between rocky shore, reef or sandy shore. MPAs were re-edited by Tamsyn Livingstone.

19_kzn_jetskis_1209_w31: Jet skis along KZN coastline
According to experts this activity takes place from the kzn_wave_line_31, extending to a maximum of 20km offshore. This shapefile illustrates areas were this activity is permitted, where it occurs as well as its intensity. The maximum distance that a jetski will travel is 20km. Using the function with distance, i.e. Fuzzy Logic, jetskis monotically decreases at 20km with an inflection point at 10km. For paddleskis the maximum distance that a paddle ski will travel is 5km while the inflection point is 3km. MPAs were re-edited by Tamsyn Livingstone

20_kzn_rec_octopus_1209_w31: Recreational Octopus Collection
Dataset was created using the regulations as stipulated in the MLRA and expert knowledge and base datasets from various sources. According to expert knowledge (06 November 2006 workshop) octopus occurs in the intertidal and shallow subtidal rocky areas. According to legislation the collection is allowed all along KZN coast except in the MPAs and Durban Bay. The waveline (kzn_wave_line_w31) and the high-water mark (kzn_highwater_mark_w31) were used to create a polygon, which indicated the intertidal areas. The kzn waveline (kzn_waveline_w31) and the 2m contour line (kzn_2m_contourline_w31) were used to create a polygon, which indicated the shallow subtidal (surfzone pers. comm. Jean Harris). The intertidal and subtidal areas were combined to indicate areas along the coastline where this activity occurs; hence the polygon extends from the kzn_highwater_mark_w31 to the kzn_2m_contour_line_w31. The exclusion areas were removed by overlaying the MPA polygons from the kzn_mpas (archived by Heidi Snyman at QEP) dataset created by Mandy Lombard and the Durban Bay polygon created by Bimall Kasseepursad. MPAs were re-edited by Tamsyn Livingstone.

21_kzn_bait_rockyshores_1209_w31: Recreational Bait fishery (rocky shores) Collection
Dataset was created using the regulations as stipulated in the MLRA and expert knowledge and base datasets from various sources. According to expert knowledge (Kerry Sink - SANBI, Jean Harris - EZEMVELO) the rocky shore bait fishery collection occurs in the intertidal and shallow subtidal rocky areas. According to legislation the collection is allowed all along KZN coast except in the MPAs and Durban Bay. The kzn waveline (kzn_waveline_w31) and the high water mark (kzn_higwater_mark_w31) were used to create a polygon which indicated the intertidal areas. The kzn waveline (kzn_waveline_w31) and the -2m contour line (kzn_2m_contour_line_w31) were used to create a polygon which indicated the shallow subtidal (surfzone pers. comm. Jean Harris). The intertidal and subtidal areas were combined to indicate areas along the coastline where this activity occurs. The exclusion areas were removed by overlaying the MPA polygons from the kzn_mpas (archived by Heidi Snyman at QEP) dataset created by Mandy Lombard and the Durban Bay polygon created by Bimall Kasseepursad. MPAs were re-edited by Tamsyn Livingstone.

22_kzn_bait_sandybeach_1209_w31: Recreational Bait fishery (sandy beach) Collection
Dataset was created using the regulations as stipulated in the MLRA and expert knowledge and base datasets from various sources. According to expert knowledge (Kerry Sink - SANBI, Jean Harris -

EZEMVELO) this activity takes place in the intertidal sandy beach areas. According to legislation the collection is allowed all along KZN coast except in the MPAs and Durban Bay. The kzn waveline (kzn_waveline_w31) and the high water mark (kzn_higwater_mark_w31) were used to create a polygon, which indicated the intertidal areas along the coastline where this activity occurs. The exclusion areas were removed by overlaying the MPA polygons from the kzn_mpas (archived by Heidi Snyman at QEP) dataset created by Mandy Lombard and the Durban Bay polygon created by Bimall Kasseepursad. MPAs were re-edited by Tamsyn Livingstone.

23_kzn_beachdriving_1209_w31: Areas where beach driving is permitted
According to Richard Penn Sawyers - EZEMVELO beach driving is allowed from Jesser Point to 4km north. The location of Jesser point was captured of a 1: 50 000. The point was overlaid on the high water line (kzn_highwater_mark_w31) and using the divide line evenly tool in ArcView, the high-water line was divided into 4km segments (??). The relevant segment was extracted and this describes the area where beach driving is allowed.

24_kzn_aquatrade_1209_w31: Recreational Aquarium Collection
Dataset was created using the regulations as stipulated in the MLRA and expert knowledge and base datasets from various sources. According to MLRA this collection is allowed all along the KZN coastline except in the MPAs. According to expert knowledge (06 November 2006 workshop) the maximum a person can free dive is 30m. The polygon was created by combining the high-water mark shapefile (kzn_highwater_mark_w31) and the -30m contour line extracted from the bathymetry data (kzn_30m_depare_line_w31). The exclusion areas were removed by overlaying the MPA polygons from the kzn_mpas (archived by Heidi Snyman at QEP) dataset created by Mandy Lombard. MPAs were re-edited by Tamsyn Livingstone.

25_kzn_rec_lfpc_p_1209_w31: Areas in KZN were recreational linefishing from paddlecraft (pelagic) can take place
Created by Bimall Kasseepursad using info collected from EZEMVELO managers in September 2006 and edits were based on comments made at workshop. Edited by Erwann Lagabrielle. Using the buffering tool in XTools ArcView 3.2, the waveline (kzn_wave_line_w31) was buffered at 1nm (1850m). This fishery does not take place in waters less than -2m and therefore the (kzn_2m_contour_line_w31) was used to exclude areas less than -2m. According to the MLRA this fishery can occur in MPAs, but not in the MMR & SLMR sanctuaries. These areas were removed by overlaying the MPA polygons from the kzn_mpas (archived by Heidi Snyman at QEP) dataset created by Mandy Lombard. Note that in the Aliwal MPA only the Crown and Restricted Use areas have been excluded. MPAs were re-edited by Tamsyn Livingstone.

26_kzn_hab_1209_w31: KZN Harbours
Polygons were clipped from the EEZ dataset created by Dr A.T. (Mandy) Lombard.

27_kzn_scubadiving_1209_w31: Scuba Diving in KZN
A criterion for this activity was provided by Dr Kerry Sink. According to expert knowledge scuba diving is allowed along the KZN Coastline except in the sanctuaries and occurs primarily in depths between -5m and -30m. The 5 meter contour line (kzn_5m_contour_line_w31) and -30 meter depth line (kzn_30m_depare_line_w31 were merged to create a polygon showing areas where scuba diving takes place at these depths. The sanctuaries were extracted from the kzn_mpas_wlo31 dataset (archived by Heidi Snyman at QEP) created by Mandy Lombard. Note that in the Aliwal MPA only the Crown and Restricted Used areas have been included as areas where scuba diving in sanctuaries is allowed. MPAs were re-edited by Tamsyn Livingstone.

28_kzn_turtledriving_concpl_1209_w31: Areas along the KZN Coastline Designated for Beach Driving for Turtle Tourism
Dataset created from Draft National Operational Management Plan for the Conservation of Sea Turtles in SA. According to Draft National Operational Management Plan for the Conservation of Sea Turtles in SA Turtle Drive Concessions are allowed along areas between Rocktail Bay and Nine Mile, Nine Mile to Adlims Bay and then from Cape Vidal to Leven Point. These points were captured of 1:50 000 using onscreen digitising in ArcView 3.2. These points were verified using the excel spreadsheet tie in point file created by Tamsyn Livingstone. Beach driving should only occur between the high-water mark and waveline. The

kzn_highwater_mark_w31 and kzn_wave_line_w31 were the datasets used to designate this area. These files were merged and converted from polyline to polygons.

29_kzn_coeldiving_1209_w31: Coelacanth Diving Areas along KZN Coastline
According to expert knowledge and the Coelacanth Management Plan, coelacanth diving is allowed along the KZN Coastline except in the Coelacanth Sanctuary (which is the Wright Canyon area) and MPA sanctuaries. The north south extent of Coelacanth Sanctuary was obtained from the Coelacanth Management Plan. According to expert knowledge the depth zone for coelacanth diving is between -60m and -140m. The kzn_60m_140m_contour_line_w31 was generated by Tamsyn Livingstone from the 1km raster grid file kznbathywdd created by Geoscience. According to expert knowledge and the Coelacanth Management Plan, coelacanth diving is allowed along the KZN Coastline except in the Coelacanth Sanctuary (which is the Wright Canyon area) and MPA sanctuaries. The north south extent of Coelacanth Sanctuary was obtained from the Coelacanth Management Plan. According to expert knowledge the depth zone for coelacanth diving is between -60m and -140m. -60m and -140m contours were generated by Tamsyn Livingstone from the 1km raster grid file kznbathywdd created by Geoscience. These two lines were used to create a polygon along the kzn coastline. The exclusion areas were removed by intersecting this polygon with the Coelacanth Sanctuary polygon (created by Bimall Kasseepursad) and the sanctuaries extracted from kzn_mpas (archived by Heidi Snyman at QEP) dataset created by Mandy Lombard. MPAs were re-edited by Tamsyn Livingstone

30_kzn_rec_shorespearfishing_1209_w31: Areas along the KZN coastline where recreational spearfishing occur
Dataset was created using the regulations as stipulated in the MLRA and expert knowledge of Mr. Bruce Mann. According to experts this activity takes place from the backline (kzn_2m_contour_line_w31) to 30m depth line (kzn_30m_depare_line_w31) and up to 1km offshore. According to the legislation spearfishing is allowed all along the KZN Coast except in the sanctuary areas of the MMR and SLMR. The 2 meter contour line (kzn_2m_contour_line_w31) was created. From the kzn_2m_contour_line_w31 a 1km buffer was created which indicated the area along the coastline where this activity occurs. The exclusion areas were removed by overlaying the sanctuary area polygons from the kzn_mpas (archived by Heidi Snyman at QEP) dataset created by Mandy Lombard. MPAs were re-edited by Tamsyn Livingstone.

31_kzn_industrial_pipelines_1209_w31: Industrial Pipelines along the KZN coastline
5 industrial pipelines were identified along the KZN coastline. Using expertise advice provide by Toufiek Samaai (tsamaai@deat.gov.za) it was established that the maximum distance of contamination is 5km, minimum distance is 2km. The distance to each point within the envelope was calculated. Distance to intensity (2, 3 and 5) was assigned. Fuzzy function was applied, decreased distance based on the 5km value.

32_kzn_urbanisation_1209_w31:Urban areas along the KZN coastline
Urban areas were filtered (expand10/shrink10 generalised urban areas) and vectorised. Distances were calculated, ranging from 1km to 5km and areas were buffered. http://wims.unice.fr/wims/wims.cgi 5000 = a*1 + b, 1000 = 0*a + b. Areas were regrouped according to classes and intensities (0 – 0.2 – 0.4 – 0.6 – 0.8 – 1)
.

33_kzn_shipping_1209_w31: Shipping activities along the KZN coastline
Downloaded for South Africa 18 May (??) 2005 to 18 May (??) 2009 from http://www.aoml.noaa.gov/phod/trinanes/BBXX/

34_kzn_crustacean_trawl_1209: Crustacean trawling along the KZN coastline
Log (1 + X) + scaled 0 to 1 (justification for log is that otherwise big values scales down low values)
=TRUNC(((X2-(MIN($X$2:$X$607)))/((MAX($X$2:$X$607))-(MIN($X$2:$X$607)))),2)

35_kzn_large_longline cpue_1209: Longlining along the KZN coastline
Log (1 + X) + scaled 0 to 1 (justification for log is that otherwise big values scales down low values)
=TRUNC(((X2-(MIN($X$2:$X$607)))/((MAX($X$2:$X$607))-(MIN($X$2:$X$607)))),2)

36_ kzn_shoreanglers_1209_w31: Shore anglers along the KZN coastline

Using the CoastMap and various other data sources the geographical co-ordinates of each locality was extracted. A polygon was created from the low water mark to 100m out. The polygon was cut from locality to locality for example from RSA Border to Beacon 13, then from Beacon 13 to Boteler Point, etc. Each locality was given the northern density {(average anglers divided by distance = anglers per km (equals density)}.

37_kzn_sub_int_unpermitted_1209_w31: Areas along KZN Coast where unpermitted subsistence intertidal harvesting occurs

Data extracted from Coastmap database by Tamsyn Livingstone. According to expert knowledge this fishery occurs on the rocky shores between Mabibi and Kosi Bay. The intertidal areas, which contain rocky shores, were extracted from the Coastmap database; this will be later edited when the entire coastmap has been georectified. Note that the info relating to this fishery was extracted from the coastmap data. It needs to be georectified accordingly.

38_ kzn_stormwater_runoffs_1209_w31: Pipelines (excluding industrial pipelines) along KZN Coast

The kzn_stormwater_outfalls were extracted from the Coastmap database. An additional field was added to the attribute table. All pipelines were assigned the value 1 and non-pipelines were assigned the value 0. Using select by attribute the pipelines with the value of 1 were extracted, creating the kzn_stormwater_runoffs layer.

Appendix 6: Methodology for continuous (intensity) layers

Sixteen binary layers were created. The metadata for each layer is described below.

5_kzn_rec_lsb_bf_1209_w31: Areas along the KZN coastline where recreational skiboat linefishing for bottomfish occurs.

Areas applicable to this fishery are any waters along the KZN coastline except for areas stipulated in the MLRA. Launch site statistics were obtained from ORI. This dataset consisted of records of the number and type of boats (boat, inflatable boat, paddle ski and jetski) launched over a year from the launch sites along the KZN coastline. Launch sites were mapped and grouped into 40 different types. A 100 m grid was derived for each boat type (n = 4), with each launch site being represented by a single cell grid. The value of the cell was the number of boats launched over a year period. The grids were log (X+1) transformed in order to flatten high values. The potential spatial distribution of boat fleets, per boat type, from each of the launch sites was then modelled using a set of fuzzy rules. This set of rules was developed with experts: B. Mann (ORI), J. Harris (EZEMVELO) and N. Scott-Williams (Subtech Diving). It was implemented in ArcGis 9.2 using the toolbox "Spatial Data Modeller" (Sawatzky et al., 2008).

The distribution of boat fleets in the geographic space is limited by technical constraints. It is assumed that skiboats don't go further than 50 km from their launch site due to engine, fuel, time and security constraints. Based on this set of rules, a probable distribution of boats, per boat type, from each launch site, was derived over the KZN EEZ. A kernel analysis (sum operator, circular shape) was performed over the above layer to assess the number of boats that could potentially reach each cell in the EEZ. The radius of this focal analysis was set for each boat type (n=4), according to their maximum operational distance. The resulting layer as transformed to a fuzzy layer with values ranging from 0 to 1. The above layers were combined using a fuzzy sum operator. The resulting layer is the density of boats, per boat type in the ocean. We assumed that boat density acts as a surrogate for fishing pressure

9_kzn_rec_lfpc_bf_1209_w31: Areas in KZN were recreational linefishing can take place from paddlecraft– bottomfish

Areas applicable to this fishery are any waters along the KZN coastline except for areas stipulated in the MLRA. Launch site statistics were obtained from ORI. This dataset consisted of records of the number and type of boats (boat, inflatable boat, paddle ski and jetski) launched over a year from the launch sites along the KZN coastline. Launch sites were mapped and grouped into 40 different types. A 100 m grid was derived for each boat type (n = 4), with each launch site being represented by a single cell grid. The value of the cell was the number of boats launched over a year period. The grids were log (X+1) transformed in order to flatten high values. The potential spatial distribution of boat fleets, per boat type, from each of the launch sites was then modelled using a set of fuzzy rules. This set of rules was developed with experts: B. Mann (ORI), J. Harris (EZEMVELO) and N. Scott (Subtech Diving). It was implemented in ArcGis 9.2 using the toolbox "Spatial Data Modeller" (Sawatzky et al., 2008).

The distribution of boat fleets in the geographic space is limited by technical constraints. It is assumed that paddle skis do not go further than 5 km from their launch site due to time and physical paddling ability. Based on this set of rules, a probable distribution of boats, per boat type, from each launch site, was derived over the KZN EEZ. A kernel analysis (sum operator, circular shape) was performed over the above layer to assess the number of boats that could potentially reach each cell in the EEZ. The radius of this focal analysis was set for each boat type (n=4), according to their maximum operational distance. The resulting layer as transformed to a fuzzy layer with values ranging from 0 to 1. The above layers were combined using a fuzzy sum operator. The resulting layer is the density of boats, per boat type in the ocean. We assumed that boat density acts as a surrogate for fishing pressure.

11_kzn_rec_lsb_gf_1209_w31: Areas along the KZN coastline where recreational skiboat linefishing (gamefish) occur

Areas applicable to this fishery are any waters along the KZN coastline except for areas stipulated in the MLRA. Launch site statistics were obtained from ORI. This dataset consisted of records of the number and type of boats (boat, inflatable boat, paddle ski and jetski) launched over a year from the launch sites along the KZN coastline. Launch sites were mapped and grouped into 40 different types. A 100 m grid was derived for each boat type (n = 4), with each launch site being represented by a single cell grid. The value of the cell was the number of boats launched over a year period. The grids were log (X+1) transformed in order to flatten high values. The potential spatial distribution of boat fleets, per boat type, from each of the launch sites was then modelled using a set of fuzzy rules. This set of rules was developed with experts: B. Mann (ORI), J. Harris (EZEMVELO) and N. Scott (Subtech Diving). It was implemented in ArcGis 9.2 using the toolbox "Spatial Data Modeller" (Sawatzky et al., 2008).

The distribution of boat fleets in the geographic space is limited by technical constraints. It is assumed that skiboats do not go further than 50 km from their launch site due engine, fuel, time and security constraints. Based on this set of rules, a probable distribution of boats, per boat type, from each launch site, was derived over the KZN EEZ. A kernel analysis (sum operator, circular shape) was performed over the above layer to assess the number of boats that could potentially reach each cell in the EEZ. The radius of this focal analysis was set for each boat type (n=4), according to their maximum operational distance. The resulting layer as transformed to a fuzzy layer with values ranging from 0 to 1. The above layers were combined using a fuzzy sum operator. The resulting layer is the density of boats, per boat type in the ocean. We assumed that boat density acts as a surrogate for fishing pressure

12_kzn_rec_boat based spearfishing_bottomfish_1209_w31: Areas along the KZN coastline where recreational spearfishing–bottomfishing occurs

Areas applicable to this fishery are any waters along the KZN coastline except for areas stipulated in the MLRA. Launch site statistics were obtained from ORI. This dataset consisted of records of the number and type of boats (boat, inflatable boat, paddle ski and jetski) launched over a year from the launch sites along the KZN coastline. Launch sites were mapped and grouped into 40 different types. A 100 m grid was derived for each boat type (n = 4), with each launch site being represented by a single cell grid. The value of the cell was the number of boats launched over a year period. The grids were log (X+1) transformed in order to flatten high values. The potential spatial distribution of boat fleets, per boat type, from each of the launch sites was then modelled using a set of fuzzy rules. This set of rules was developed with experts: B. Mann (ORI), J. Harris (EZEMVELO) and N. Scott (Subtech Diving). It was implemented in ArcGis 9.2 using the toolbox “Spatial Data Modeller” (Sawatzky et al., 2008).

The distribution of boat fleets in the geographic space is limited by technical constraints. It is assumed that paddle skis do not go further than 5 km from their launch site due to time and physical paddling ability, and according to the experts this activity does not occur deeper than 30 m and thus a depth cut off was also assigned. Based on this set of rules, a probable distribution of boats, per boat type, from each launch site, was derived over the KZN EEZ. A kernel analysis (sum operator, circular shape) was performed over the above layer to assess the number of boats that could potentially reach each cell in the EEZ. The radius of this focal analysis was set for each boat type (n=4), according to their maximum operational distance. The resulting layer as transformed to a fuzzy layer with values ranging from 0 to 1. The above layers were combined using a fuzzy sum operator. The resulting layer is the density of boats, per boat type in the ocean. We assumed that boat density acts as a surrogate for fishing pressure

13_kzn_rec_boat based spearfishing_gamefish_1209_w31: Areas along the KZN coastline where recreational boat based spearfishing- gamefishing occurs

Areas applicable to this fishery are any waters along the KZN coastline except for areas stipulated in the MLRA. Launch site statistics were obtained from ORI. This dataset consisted of records of the number and type of boats (boat, inflatable boat, paddle ski and jetski) launched over a year from the launch sites along the KZN coastline. Launch sites were mapped and grouped into 40 different types. A 100 m grid was derived for each boat type (n = 4), with each launch site being represented by a single cell grid. The value of the cell was the number of boats launched over a year period. The grids were log (X+1) transformed in order to flatten high values. The potential spatial distribution of boat fleets, per boat type, from each of the launch sites was then modelled using a set of fuzzy rules. This set of rules was developed with experts: B. Mann (ORI), J. Harris (EZEMVELO) and N. Scott (Subtech Diving). It was implemented in ArcGis 9.2 using the toolbox “Spatial Data Modeller” (Sawatzky et al., 2008).

The distribution of boat fleets in the geographic space is limited by technical constraints. It is assumed that paddle skis do not go further than 5 km from their launch site due to time and physical paddling ability, and according to the experts this activity does not occur deeper than 30 m and thus a depth cut off was also assigned. Based on this set of rules, a probable distribution of boats, per boat type, from each launch site, was derived over the KZN EEZ. A kernel analysis (sum operator, circular shape) was performed over the above layer to assess the number of boats that could potentially reach each cell in the EEZ. The radius of this focal analysis was set for each boat type (n=4), according to their maximum operational distance. The resulting layer as transformed to a fuzzy layer with values ranging from 0 to 1. The above layers were combined using a fuzzy sum operator. The resulting layer is the density of boats, per boat type in the ocean. We assumed that boat density acts as a surrogate for fishing pressure

19_kzn_jetskis_1209_w31: Jet skis along KZN coastline

Areas applicable to this fishery are any waters along the KZN coastline except for areas stipulated in the MLRA. Launch site statistics were obtained from ORI. This dataset consisted of records of the number and type of boats (boat, inflatable boat, paddle ski and jetski) launched over a year from the launch sites along the KZN coastline. Launch sites were mapped and grouped into 40 different types. A 100 m grid was derived for each boat type (n = 4), with each launch site being represented by a single cell grid. The value of the cell was the number of boats launched over a year period. The grids were log (X+1) transformed in order to flatten high values. The potential spatial distribution of boat fleets, per boat type, from each of the launch sites was then modelled using a set of fuzzy rules. This set of rules was developed with experts: B. Mann (ORI), J. Harris (EZEMVELO) and N. Scott (Subtech Diving). It was implemented in ArcGis 9.2 using the toolbox “Spatial Data Modeller” (Sawatzky et al., 2008).

The distribution of boat fleets in the geographic space is limited by technical constraints. It is assumed that jet skis don’t go further than 20 km from their launch site due to engine, fuel, time and security constraints. Based on this set of rules, a probable distribution of boats, per boat type, from each launch site, was derived over the KZN EEZ. A kernel analysis (sum operator, circular shape) was performed over the above layer to assess the number of boats that could potentially reach each cell in the EEZ. The radius of this focal analysis was set for each boat type (n=4), according to their maximum operational distance. The resulting layer as transformed to a fuzzy layer with values ranging from 0 to 1. The above layers were combined using a fuzzy sum operator. The resulting layer is the density of boats, per boat type in the ocean. We assumed that boat density acts as a surrogate for fishing pressure

25_kzn_rec_lfpc_p_1209_w31: Areas in KZN were recreational linefishing from paddlecraft (pelagic) can take place

Areas applicable to this fishery are any waters along the KZN coastline except for areas stipulated in the MLRA. Launch site statistics were obtained from ORI. This dataset consisted of records of the number and type of boats (boat, inflatable boat, paddle ski and jetski) launched over a year from the launch sites along the KZN coastline. Launch sites were mapped and grouped into 40 different types. A 100 m grid was derived for each boat type (n = 4), with each launch site being represented by a single cell grid. The value of the cell was the number of boats launched over a year period. The grids were log (X+1) transformed in order to flatten high values. The potential spatial distribution of boat fleets, per boat type, from each of the launch sites was then modelled using a set of fuzzy rules. This set of rules was developed with experts: B. Mann (ORI), J. Harris (EZEMVELO) and N. Scott (Subtech Diving). It was implemented in ArcGis 9.2 using the toolbox “Spatial Data Modeller” (Sawatzky et al., 2008).

The distribution of boat fleets in the geographic space is limited by technical constraints. It is assumed that paddle skis do not go further than 5 km from their launch site due to time and physical paddling ability. The dataset was also clipped to 1 nm offshore according to expert knowledge. Based on this set of rules, a probable distribution of boats, per boat type, from each launch site, was derived over the KZN EEZ. A kernel analysis (sum operator, circular shape) was performed over the above layer to assess the number of boats that could potentially reach each cell in the EEZ. The radius of this focal analysis was set for each boat type (n=4), according to their maximum operational distance. The resulting layer as transformed to a fuzzy layer with values ranging from 0 to 1. The above layers were combined using a fuzzy sum operator. The resulting layer is the density of boats, per boat type in the ocean. We assumed that boat density acts as a surrogate for fishing pressure.

27_kzn_scubadiving_1209_w31: Scuba Diving in KZN

A criterion for this activity was provided by Dr Kerry Sink. According to expert knowledge scuba diving is allowed along the KZN Coastline except in the sanctuaries and occurs primarily in depths between -5m and -30m.The distribution of boat fleets in the geographic space is limited by technical constraints. It is assumed that ski boats do not go further than 50 km from their launch site due to engine, fuel, time and security constraints. Based on this set of rules, a probable distribution of boats, per boat type, from each launch site, was derived over the KZN EEZ and the dataset clipped to -30 m depth. A kernel analysis (sum operator, circular shape) was performed over the above layer to assess the number of boats that could potentially reach each cell in the EEZ. The radius of this focal analysis was set for each boat type (n=4), according to their maximum operational distance. The resulting layer as transformed to a fuzzy layer with values ranging from 0 to 1. The above layers were combined using a fuzzy sum operator. The resulting layer is the density of boats, per boat type in the ocean. We assumed that boat density acts as a surrogate for fishing pressure.

29_kzn_coeldiving_1209_w31: Coelacanth Diving Areas along KZN Coastline

According to expert knowledge and the Coelacanth Management Plan, coelacanth diving is allowed along the KZN Coastline except in the Coelacanth Sanctuary (which is the Wright Canyon area) and MPA sanctuaries. The north south extent of Coelacanth Sanctuary was obtained from the Coelacanth Management Plan. According to expert knowledge the depth zone for coelacanth diving is between -60m and -140m. The distribution of boat fleets in the geographic space is limited by technical constraints. It is assumed that ski boats do not go further than 50 km from their launch site due to engine, fuel, time and security constraints. Based on this set of rules, a probable distribution of boats, per boat type, from each launch site, was derived over the KZN EEZ. A kernel analysis (sum operator, circular shape) was performed over the above layer to assess the number of boats that could potentially reach each cell in the EEZ. The radius of this focal analysis was set for each boat type (n=4), according to their maximum operational distance. The resulting layer as transformed to a fuzzy layer with values ranging from 0 to 1. The above layers were combined using a fuzzy sum operator. The resulting layer is the density of boats, per boat type in the ocean. We assumed that boat density acts as a surrogate for fishing pressure.

31_kzn_industrial_pipelines_1209_w31: Industrial Pipelines along the KZN coastline

Five industrial pipelines were identified along the KZN coastline. Using expertise advice provided by T. Samaai (DEAT) it was established that the maximum distance of contamination of those pipelines is 5km, minimum distance is 2km. First we obtained the GPS coordinates of industrial pipelines along the KZN coastline from experts or industrials.

Second, we determined the discharge of each pipelines and we mapped it as a grid layer (100 m resolution) with one cell for each pipeline. The value of the cell was the discharge. The maximum area of influence of those pipelines was determined with T. Samaai and a kernel analysis (sum operator, circular shape) was applied. The radius of the kernel was the maximum area of influence of the pipeline. This layer was transformed into a new layer with fuzzy values ranging from 0 to 1 [Layer 2]. A separate layer was created by calculating the distances to pipelines as a grid layer. This layer was transformed to fuzzy values with a linearly decreasing function with a value of 1 at the pipeline down to 0 outside the area of influence [Layer 3]. Finally [Layer 2] and [Layer 3] were combined using a fuzzy sum operator. The resulting layer is the modelled intensity of the impact of industrial pipelines.

32_kzn_urbanisation_1209_w31:Urban areas along the KZN coastline

Distances to urban areas were mapped as a grid layer. This grid layer was further transformed into a fuzzy layer using a linearly decreasing function. This function was set as follows: at 0 km the fuzzy value is 1 (membership to highly impacted zones) and further than 5 km the fuzzy value is 0 (no impact).

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33_kzn_shipping_1209_w31: Shipping activities along the KZN coastline

The dataset on shipping lanes is extracted from the study by Halpern et al. (2008). 12 months of data beginning October 2004 (collected as part of the World Meteorological Organization Voluntary Observing Ships Scheme; http://www.vos.noaa.gov/vos_scheme.shtml) was collected. All the mobile ship data was connected to create ship tracks, under the assumption that ships travel in straight lines. The line 799,853 segment was then buffered to 1 km width to account for the width of shipping lanes, all the buffered line segments were summed to account for overlapping ship tracks, and the summed ship tracks were converted to a raster dataset. This produced 1 km2 raster cells with values ranging from 0 to 1,158, the maximum number of ship tracks recorded in a single 1 km2 cell. Because the VOS program is voluntary, those estimates of the impact of shipping are biased (in an unknown way) to locations and types of ships engaged in the program.

34_kzn_crustacean_trawl_1209: Crustacean trawling along the KZN coastline

Data provided by the OMPA project (SANBI) and originally sourced from Department of Environmental Affairs and Tourism: Marine and Coastal Management. Data consisted of Catch and Effort data for the Inshore and Offshore Crustacean Trawl Fishery. The dataset commences in January 2001 and ends in December 2005. The data were provided using the commercial trawl grid i.e. 20 x 20 nautical miles (16x16 km square cells). To map the impact of the activity on the marine ecosystem, the total number of trawling hours for crustacean trawling was used. As the data resolution was broad, we interpolated the data to 100 m resolution using a kriging technique (with surrounding 20 points).

35_kzn_large_longline cpue_1209: Longlining along the KZN coastline

Data provided by the OMPA project (SANBI) and originally sourced from Department of Environmental Affairs and Tourism: Marine and Coastal Management. The data were provided using the commercial grid of 20 x 20 nautical miles (i.e. 16x16 km square cells). To map the impact of the activity on the marine ecosystem, the Catch per Unit Effort (CPUE) for large longlining was used. As the data resolution was broad, we interpolated the data to 100 m resolution using a kriging technique (with surrounding 20 points).

36_ kzn_shoreanglers_1209_w31: Shore anglers along the KZN coastline

Data on shore angling were provided by B. Mann (ORI) who conducted an aerial survey of the KwaZulu-Natal coast to determine *the total* shore angling effort on the KZN shoreline. Between March 2007 and February 2008 a total of 36 flights were conducted, half along the north coast (Virginia to Kosi Bay) and half along the south (Virginia to Port St-Johns). The modus operandi was to fly at low level (400-500 ft) along the coastline at a speed of 70-90 knots and all anglers observed were counted using a manual tally counter. The database in Access format was integrated in a GIS format by Ezemvelo KZN Wildlife team with help of B. Mann. The number of anglers per km of coast was determined for each section of the coast identified in the study by a unique ID. This layer was further transformed to a fuzzy layer using a linear function, with final values ranging from 0 to 1.

Appendix 7: List of biodiversity features and targets

Feature Code	Feature Name	Target A	Target B	Resolution (km)
Habitats				
	Offshore Biozones			
1100001	Offshore Biozone 1 - Natal (0-30 m)	**10%**	**10%**	10
1100002	Offshore Biozone 2 - Delagoa (0-30 m)	**10%**	**10%**	10
1100003	Offshore Biozone 3 - Turbid Tugela	**10%**	**10%**	10
1100004	Offshore Biozone 4 - Sandy shelf	**10%**	**10%**	10
1100005	Offshore Biozone 5 - Muddy shelf	**10%**	**10%**	10
1100006	Offshore Biozone 6 - Sloping shelf	**10%**	**10%**	10
1100007	Offshore Biozone 7 - Steep slope	**10%**	**10%**	10
1100008	Offshore Biozone 8 - Agulhas current	**10%**	**10%**	10
1100009	Offshore Biozone 9 - Agulhas eddy	**10%**	**10%**	10
1100010	Offshore Biozone 10 - Deep Agulhas	**10%**	**10%**	10
1100011	Offshore Biozone 11 - Deep offshore	**10%**	**10%**	10
1100012	Offshore Biozone 12 - Deep Eddy transition	**10%**	**10%**	10
	Coastal Biozones			
1200008	Estuary	**0%**	**0%**	200
1200036	Bare Dune Hummock	**0%**	**20%**	200
1200039	Vegetated Dune Hummock	**0%**	**20%**	200
1200063	Dune scrub bushes	**0%**	**0%**	200
1200064	Indigenous coastal forest	**0%**	**0%**	200
1200065	Grass	**0%**	**0%**	200
1210049	Rock boulders in foredune	**0%**	**10%**	200
1210050	Artificial rock boulders in foredune	**0%**	**0%**	200
1210051	Broken rocks in foredune	**0%**	**10%**	200
1210053	High rock ledge in foredune	**0%**	**10%**	200
1210056	Rock Broken Ledge High in foredune	**0%**	**10%**	200
1210059	Scattered rocks in foredune	**0%**	**10%**	200
1210060	Solid Continuous Rocks in foredune	**0%**	**10%**	200
1220047	Smooth rocks in topshore	**0%**	**0%**	200
1220049	Rock boulders in topshore	**0%**	**20%**	200
1220050	Artificial rock boulders in topshore	**0%**	**0%**	200
1220051	Broken rocks in topshore	**0%**	**20%**	200
1220053	High rock ledge in topshore	**0%**	**20%**	200
1220054	Low rock ledge in topshore	**0%**	**20%**	200
1220056	Rock Broken Ledge High in topshore	**0%**	**20%**	200
1220057	Rock Broken Ledge Low in topshore	**0%**	**20%**	200
1220059	Scattered rocks in topshore	**0%**	**20%**	200
1220060	Solid Continuous Rocks	**0%**	**20%**	200
1230049	Rock boulders in highshore	**0%**	**20%**	200
1230050	Artificial rock boulders in highshore	**0%**	**0%**	200
1230051	Broken rocks in highshore	**10%**	**10%**	200
1230053	High rock ledge in highshore	**10%**	**10%**	200
1230054	Low rock ledge in highshore	**0%**	**20%**	200
1230055	Mixture of High and Low rock ledge in highshore	**0%**	**20%**	200

1230056	Rock Broken Ledge High in highshore	**10%**	**10%**	200
1230057	Rock Broken Ledge Low in highshore	**0%**	**20%**	200
1230059	Scattered rocks in highshore	**0%**	**20%**	200
1230060	Solid Continuous Rocks	**10%**	**10%**	200
1241049	Delagoa - Rock boulders in midshore	**20%**	**0%**	200
1241051	Delagoa - Broken rocks in midshore	**0%**	**20%**	200
1241053	Delagoa - High rock ledge in midshore	**20%**	**0%**	200
1241054	Delagoa - Low rock ledge in midshore	**0%**	**20%**	200
1241055	Delagoa - Mixture of High and Low rock ledge in midshore	**0%**	**20%**	200
1241056	Delagoa - Rock Broken Ledge High in midshore	**20%**	**0%**	200
1241057	Delagoa - Rock Broken Ledge Low in midshore	**0%**	**20%**	200
1241059	Delagoa - Scattered rocks in midshore	**0%**	**20%**	200
1242049	Natal - Solid Continuous Rocks in midshore	**20%**	**0%**	200
1242050	Natal - Artificial rock boulders in midshore	**0%**	**0%**	200
1242051	Natal - Broken rocks in midshore	**0%**	**20%**	200
1242053	Natal - High rock ledge in midshore	**20%**	**0%**	200
1242054	Natal - Low rock ledge in midshore	**0%**	**20%**	200
1242055	Natal - Mixture of High and Low rock ledge in midshore	**0%**	**20%**	200
1242056	Natal - Rock Broken Ledge High in midshore	**20%**	**0%**	200
1242057	Natal - Rock Broken Ledge Low in midshore	**0%**	**20%**	200
1242059	Natal - Scattered rocks in midshore	**0%**	**20%**	200
1242060	Natal - Solid Continuous Rocks in midshore	**20%**	**0%**	200
1251049	Delagoa - Rock boulders in lowshore	**20%**	**0%**	200
1251051	Delagoa - Broken rocks in lowshore	**0%**	**20%**	200
1251053	Delagoa - High rock ledge in lowshore	**20%**	**0%**	200
1251054	Delagoa - Low rock ledge in lowshore	**0%**	**20%**	200
1251055	Delagoa - Mixture of High and Low rock ledge in lowshore	**0%**	**20%**	200
1251056	Delagoa - Rock Broken Ledge High in lowshore	**20%**	**0%**	200
1251057	Delagoa - Rock Broken Ledge Low in lowshore	**0%**	**20%**	200
1251059	Delagoa - Scattered rocks in lowshore	**0%**	**20%**	200
1251067	Delagoa - Mixture of Broken low and High ledge in lowshore	**20%**	**20%**	200
1252049	Natal - Rock boulders in lowshore	**20%**	**0%**	200
1252051	Natal - Broken rocks in lowshore	**0%**	**20%**	200
1252053	Natal - High rock ledge in lowshore	**20%**	**0%**	200
1252054	Natal - Low rock ledge in lowshore	**0%**	**20%**	200
1252055	Natal - Mixture of High and Low rock ledge in lowshore	**0%**	**20%**	200
1252056	Natal - Rock Broken Ledge High in lowshore	**20%**	**0%**	200
1252057	Natal - Rock Broken Ledge Low in lowshore	**0%**	**20%**	200
1252059	Natal - Scattered rocks in lowshore	**0%**	**20%**	200
1252060	Natal - Solid Continuous Rocks in lowshore	**20%**	**0%**	200
1252067	Natal - Mixture of Broken low and High ledge in lowshore	**0%**	**20%**	200
1260041	Mixture of Emergent and Submerged rocks in surfzone	**0%**	**20%**	200
1260042	Rough rocks in surfzone	**0%**	**0%**	200
1260044	High rocks in surfzone	**0%**	**0%**	200
1260047	Smooth rocks in surfzone	**0%**	**0%**	200
1260049	Rock boulders in surfzone	**0%**	**0%**	200
1260051	Broken rocks in surfzone	**0%**	**20%**	200

1260052	Emergent rocks in surfzone	**0%**	**10%**	200
1260053	High rock ledge in surfzone	**10%**	**10%**	200
1260054	Low rock ledge in surfzone	**0%**	**20%**	200
1260055	Mixture of High and Low rock ledge in surfzone	**0%**	**20%**	200
1260056	Rock Broken Ledge High in surfzone	**10%**	**10%**	200
1260057	Rock Broken Ledge Low in surfzone	**0%**	**20%**	200
1260058	Submerged rocks in surfzone	**0%**	**10%**	200
1260059	Scattered rocks in surfzone	**0%**	**20%**	200
1260060	Solid Continuous Rocks in surfzone	**10%**	**10%**	200
	Sandy Shore			
1300101	Intermediate sandy shore	**0%**	**20%**	200
1300102	Intermediate sandy shore within 500m of an estuary	**0%**	**20%**	200
1300103	Reflective sandy shore	**0%**	**20%**	200
1300104	Dissipative sandy shore	**0%**	**20%**	200
1300105	Reflective sandy shore within 500m of an estuary	**0%**	**20%**	200
1300106	Dissipative sandy shore within 500m of an estuary	**0%**	**20%**	200
	Rock Reefs			
1410001	Rock reefs in Offshore biozone 1 (Delagoa) 0-10 m	**0%**	**20%**	1
1410002	Rock reefs in Offshore biozone 2 (Natal) 0-10 m	**0%**	**20%**	1
1420001	Rock reefs in Offshore biozone 1 (Delagoa) 10-30 m	**0%**	**20%**	1
1420002	Rock reefs in Offshore biozone 2 (Natal) 10-30 m	**0%**	**20%**	1
1430001	Rock reefs in Offshore biozone 3 30-200 m	**0%**	**20%**	1
1430002	Rock reefs in Offshore biozone 4 30-200 m	**0%**	**20%**	1
1430003	Rock reefs in Offshore biozone 5 30-200 m	**0%**	**20%**	1
1430004	Rock reefs in Offshore biozone 6 30-200 m	**0%**	**20%**	1
1430005	Rock reefs in Offshore biozone 7 30-200 m	**0%**	**20%**	1
	Coral Reefs			
1510005	Cluster 6 North Complex	**40%**	**40%**	1
1510007	Cluster 9 North Complex	**40%**	**40%**	1
1510009	Cluster 11 North Complex	**80%**	**20%**	1
1510010	Cluster 12 and 15 North Complex	**80%**	**20%**	1
1510012	Cluster 14 North Complex	**40%**	**40%**	1
1510013	Cluster 15 North Complex	**50%**	**30%**	1
1510014	Cluster 16 North Complex	**50%**	**30%**	1
1510017	Deep cluster 6 North Complex	**40%**	**40%**	1
1510018	Not determined North Complex	**40%**	**40%**	1
1520001	Cluster 2 Central Complex	**80%**	**20%**	1
1520002	Cluster 3 Central Complex	**40%**	**40%**	1
1520005	Cluster 6 Central Complex	**40%**	**40%**	1
1520006	Cluster 8 Central Complex	**40%**	**40%**	1
1520008	Cluster 10 Central Complex	**40%**	**40%**	1
1520011	Cluster 13 Central Complex	**50%**	**30%**	1
1520012	Cluster 14 Central Complex	**40%**	**40%**	1
1520013	Cluster 15 Central Complex	**50%**	**30%**	1
1520016	Cluster 20 Central Complex	**100%**	**0%**	1
1520018	Not determined Central Complex	**40%**	**40%**	1
1520019	Pachyseris Central Complex	**80%**	**20%**	1
1530003	Cluster 4 South Complex	**40%**	**40%**	1

1530004	Cluster 5 South Complex	**40%**	**40%**	1
1530005	Cluster 6 South Complex	**40%**	**40%**	1
1530008	Cluster 10 South Complex	**40%**	**40%**	1
1530013	Cluster 15 South Complex	**50%**	**30%**	1
1530015	Cluster 19 South Complex	**100%**	**0%**	1
1530018	Not determined South Complex	**40%**	**40%**	1
	Canyons			
1711043	Canyon Delagoa ID 43	**0%**	**100%**	1
1711044	Canyon Delagoa ID 44	**0%**	**0%**	1
1711045	Canyon Delagoa ID 45	**0%**	**0%**	1
1711046	Canyon Delagoa ID 46	**0%**	**0%**	1
1711047	Canyon Delagoa ID 47	**0%**	**0%**	1
1711048	Canyon Delagoa ID 48	**100%**	**0%**	1
1711049	Canyon Delagoa D 49	**0%**	**0%**	1
1712002	Canyon Natal ID 2	**100%**	**0%**	1
1712003	Canyon Natal ID 3	**0%**	**0%**	1
1712004	Canyon Natal ID 4	**0%**	**0%**	1
1712005	Canyon Natal ID 5	**0%**	**0%**	1
1712006	Canyon Natal ID 6	**0%**	**100%**	1
1721001	Sub-marine shelf feature Delagoa ID 1	**0%**	**0%**	1
1721039	Sub-marine shelf feature Delagoa ID 39	**0%**	**0%**	1
1721040	Sub-marine shelf feature Delagoa ID 40	**0%**	**0%**	1
1721041	Sub-marine shelf feature Delagoa ID 41	**0%**	**0%**	1
1721042	Sub-marine shelf feature Delagoa ID 42	**0%**	**0%**	1
1721050	Sub-marine shelf feature Delagoa ID 50	**0%**	**0%**	1
1721051	Sub-marine shelf feature Delagoa ID 51	**0%**	**0%**	1
1722007	Sub-marine shelf feature Natal ID 7	**0%**	**0%**	1
1722008	Sub-marine shelf feature Natal ID 8	**0%**	**0%**	1
1722009	Sub-marine shelf feature Natal ID 9	**0%**	**0%**	1
1722010	Sub-marine shelf feature Natal ID 10	**0%**	**0%**	1
1722011	Sub-marine shelf feature Natal ID 11	**0%**	**0%**	1
1722012	Sub-marine shelf feature Natal ID 12	**0%**	**0%**	1
1722013	Sub-marine shelf feature Natal ID 13	**0%**	**0%**	1
1722014	Sub-marine shelf feature Natal ID 14	**0%**	**0%**	1
1722015	Sub-marine shelf feature Natal ID 15	**0%**	**0%**	1
1722016	Sub-marine shelf feature Natal ID 16	**0%**	**0%**	1
1722017	Sub-marine shelf feature Natal ID 17	**0%**	**0%**	1
1722018	Sub-marine shelf feature Natal ID 18	**0%**	**0%**	1
1722019	Sub-marine shelf feature Natal ID 19	**0%**	**0%**	1
1722020	Sub-marine shelf feature Natal ID 20	**0%**	**0%**	1
1722021	Sub-marine shelf feature Natal ID 21	**0%**	**0%**	1
1722022	Sub-marine shelf feature Natal ID 22	**0%**	**0%**	1
1722023	Sub-marine shelf feature Natal ID 23	**0%**	**0%**	1
1722024	Sub-marine shelf feature Natal ID 24	**0%**	**0%**	1
1722025	Sub-marine shelf feature Natal ID 25	**0%**	**0%**	1
1722026	Sub-marine shelf feature Natal ID 26	**0%**	**0%**	1
1722027	Sub-marine shelf feature Natal ID 27	**0%**	**0%**	1
1722028	Sub-marine shelf feature Natal ID 28	**0%**	**0%**	1

1722029	Sub-marine shelf feature Natal ID 29	**0%**	**0%**	1
1722030	Sub-marine shelf feature Natal ID 30	**0%**	**0%**	1
1722031	Sub-marine shelf feature Natal ID 31	**0%**	**0%**	1
1722032	Sub-marine shelf feature Natal ID 32	**0%**	**0%**	1
1722033	Sub-marine shelf feature Natal ID 33	**0%**	**0%**	1
1722034	Sub-marine shelf feature Natal ID 34	**0%**	**0%**	1
1722035	Sub-marine shelf feature Natal ID 35	**0%**	**0%**	1
1722036	Sub-marine shelf feature Natal ID 36	**0%**	**0%**	1
1722037	Sub-marine shelf feature Natal ID 37	**0%**	**0%**	1
1722038	Sub-marine shelf feature Natal ID 38	**0%**	**0%**	1
	Estuaries			
1911002	Estuary - St Lucia	**0%**	**20%**	200
1911003	Estuary - Nundwane (Richards Bay)	**0%**	**0%**	200
1911004	Estuary - Mhlatuze	**0%**	**0%**	200
1911005	Estuary - Mlalazi	**0%**	**20%**	200
1911006	Estuary - Mvoti	**0%**	**0%**	200
1911007	Estuary - Tongati	**0%**	**0%**	200
1911008	Estuary - Mngeni	**0%**	**20%**	200
1911009	Estuary - Durban Bay	**0%**	**0%**	200
1911010	Estuary - Mlazi (Umlaas canal)	**0%**	**0%**	200
1911011	Estuary - Mkomazi	**0%**	**20%**	200
1911012	Estuary - Mzimkhulu	**0%**	**20%**	1
1912001	Estuary - Kosi	**0%**	**20%**	200
1912076	Estuary - Mgobozeleni	**0%**	**20%**	200
1921013	Estuary - Mbango	**0%**	**0%**	200
1921014	Estuary - Mtentweni	**0%**	**0%**	200
1921015	Estuary - Mhlangamkulu	**0%**	**0%**	200
1921016	Estuary - Domba	**0%**	**0%**	200
1921017	Estuary - Koshwana	**0%**	**0%**	200
1921018	Estuary - Ntshambili	**0%**	**0%**	200
1921019	Estuary - Mzumbe	**0%**	**0%**	200
1921020	Estuary - Mhlabatashane (Mzimayi2	**0%**	**0%**	200
1921021	Estuary - Mhlungwa	**0%**	**0%**	200
1921023	Estuary - Mfazazana	**0%**	**0%**	200
1921025	Estuary - Mnamfu	**0%**	**0%**	200
1921026	Estuary - Mtwalume	**0%**	**0%**	200
1921027	Estuary - Mvuzi	**0%**	**0%**	200
1921028	Estuary - Fafa	**0%**	**0%**	200
1921029	Estuary - Mdesingane	**0%**	**0%**	200
1921030	Estuary - Sezela	**0%**	**0%**	200
1921031	Estuary - Mkumbane	**0%**	**0%**	200
1921032	Estuary - Mzinto	**0%**	**0%**	200
1921033	Estuary - Mzimayi	**0%**	**0%**	200
1921034	Estuary - Nkamba	**0%**	**0%**	200
1921035	Estuary - Mpambanyoni	**0%**	**0%**	200
1921036	Estuary - Mahlongwa	**0%**	**20%**	200
1921037	Estuary - Mahlongwana	**0%**	**0%**	200
1921038	Estuary - Ngane	**0%**	**0%**	200

1921039	Estuary - Mgababa	**0%**	**0%**	200
1921040	Estuary - Msimbazi	**0%**	**0%**	200
1921041	Estuary - Lovu	**0%**	**0%**	200
1921042	Estuary - Little Manzimtoti	**0%**	**0%**	200
1921043	Estuary - Manzimtoti	**0%**	**0%**	200
1921044	Estuary - Mbokodweni	**0%**	**0%**	200
1921045	Estuary - Sipingo	**0%**	**20%**	200
1921046	Estuary - Ohlanga	**0%**	**0%**	200
1921047	Estuary - Mdloti	**0%**	**0%**	200
1921048	Estuary - Mhlali	**0%**	**20%**	200
1921049	Estuary - Shark Bay Estuary	**0%**	**0%**	200
1921050	Estuary - Seteni	**0%**	**0%**	200
1921051	Estuary - Mdlotane	**0%**	**0%**	200
1921052	Estuary - Nonoti	**0%**	**0%**	200
1921053	Estuary - Zinkwazi	**0%**	**20%**	200
1921054	Estuary - Mngwenya	**0%**	**0%**	200
1921055	Estuary - Siyaya	**0%**	**0%**	200
1921056	Estuary - Thukela	**0%**	**20%**	1
1921057	Estuary - Boboyi	**0%**	**0%**	200
1921058	Estuary - Zotsha	**0%**	**20%**	200
1921059	Estuary - Mhlanga	**0%**	**0%**	200
1921060	Estuary - Vungu	**0%**	**20%**	200
1921061	Estuary - Kongweni	**0%**	**0%**	200
1921062	Estuary - Vuzana	**0%**	**0%**	200
1921063	Estuary - Bilanhlolo	**0%**	**0%**	200
1921064	Estuary - Mvutshini	**0%**	**0%**	200
1921065	Estuary - Mbizana	**0%**	**0%**	200
1921066	Estuary - Kaba	**0%**	**0%**	200
1921067	Estuary - Umhlangankulu (south)	**0%**	**0%**	200
1921068	Estuary - Mpenjati	**0%**	**20%**	200
1921069	Estuary - Kandandlovu	**0%**	**0%**	200
1921070	Estuary - Tongazi	**0%**	**0%**	200
1921071	Estuary - Kuboboyi	**0%**	**0%**	200
1921072	Estuary - Sandlundlu	**0%**	**20%**	200
1921073	Estuary - Mtamvuna	**0%**	**20%**	200
1921074	Estuary - Zolwane	**0%**	**0%**	200
1921075	Estuary - Nhlabane	**0%**	**0%**	200
	Species			
M = Mammal, S = Shark, F = Fish				
DA = Distribution Area				
SPA = Spawning area, NA = Nursery Area, AA = Adult area				
2230001	Logger heads Nesting Site	**20%**	**80%**	1
2230002	Leather backs Nesting Site	**20%**	**80%**	1
2245001	Bottle nose Dolphin MDA	**15%**	**15%**	1
2245002	Hump back Dolphin MDA	**20%**	**20%**	1
2246001	Sperm whales MDA	**15%**	**15%**	1
2246002	Hump back whales MDA	**15%**	**15%**	1
2251008	*Rhinocodon typus* SDA	**0%**	**30%**	1

2251017	*Scylliogaleus quecketti* SDA	**45%**	**0%**	1
2251022	*Sphyrna mokarran* SDA	**0%**	**30%**	1
2251024	*Carcharodon carcharias* SDA	**0%**	**30%**	1
2251029	*Pristis microdon* SDA	**20%**	**0%**	1
2251030	*Pristis zijsron* SDA	**20%**	**0%**	1
2251034	*Dipturus campbelli* SDA	**35%**	**0%**	1
2251039	*Rhina ancylostoma* SDA	**40%**	**0%**	1
2251051	*Urogymnus asperrimus* SDA	**30%**	**0%**	1
2251053	*Latimeria chalumnae* FDA	**42%**	**0%**	1
2251071	*Hyporhamphus capensis* FDA	**0%**	**25%**	1
2251079	*Hippocampus whitei* FDA	**30%**	**0%**	1
2251100	*Epinephelus albomarginatus* FDA	**35%**	**0%**	1
2251101	*Epinephelus marginatus* FDA	**30%**	**0%**	1
2251103	*Anthias connelli* FDA	**40%**	**0%**	1
2251107	*Epinephelus andersoni* FDA	**35%**	**0%**	1
2251108	*Epinephelus lanceolatus* FDA	**30%**	**0%**	1
2251111	*Epinephelus tukula* FDA	**20%**	**0%**	1
2251122	*Dinoperca petersi* FDA	**30%**	**0%**	1
2251123	*Lutjanus sanguineus* FDA	**40%**	**0%**	1
2251128	*Chrysoblephus anglicus* FDA	**25%**	**0%**	1
2251129	*Chrysoblephus cristiceps* FDA	**35%**	**0%**	1
2251132	*Chrysobelphus lophus* FDA	**25%**	**0%**	1
2251135	*Diplodus cervinus hottentotus* FDA	**25%**	**0%**	1
2251136	*Diplodus sargus capensis* FDA	**35%**	**0%**	1
2251139	*Pachymetopon grande* FDA	**35%**	**0%**	1
2251142	*Polyamblyodon germanum* FDA	**25%**	**0%**	1
2251143	*Polysteganus coeruleopunctatus* FDA	**25%**	**0%**	1
2251144	*Polysteganus praeorbitalis* FDA	**25%**	**0%**	1
2251146	*Porcostoma dentata* FDA	**25%**	**0%**	1
2251151	*Rhabdosargus thorpei* FDA	**25%**	**0%**	1
2251155	*Dichistius capensis* FDA	**32%**	**0%**	1
2251157	*Neoscorpis lithophilus* FDA	**25%**	**0%**	1
2251163	*Gerres methueni* FDA	**25%**	**0%**	1
2251169	*Umbrina robinsoni* FDA	**20%**	**0%**	1
2251171	*Apolemichthys kingi* FDA	**30%**	**0%**	1
2251175	*Chaetodon marleyi* FDA	**25%**	**0%**	1
2251176	*Oplegnathus conwayi* FDA	**25%**	**0%**	1
2251178	*Oplegnathus robinsoni* FDA	**20%**	**0%**	1
2251188	*Chirodactylus jessicalenorum* FDA	**25%**	**0%**	1
2251191	*Anchichoerops natalensis* FDA	**35%**	**0%**	1
2251207	*Liza tricuspidens* FDA	**25%**	**0%**	1
2251226	*Pavoclinus mentalis* FDA	**0%**	**35%**	1
2251229	*Caffrogobius caffer* FDA	**25%**	**0%**	1
2251231	*Caffrogobius natalensis* FDA	**35%**	**0%**	1
2251257	*Redigobius dewaalii* FDA	**25%**	**0%**	1
2251259	*Taeniodes esquivel* FDA	**25%**	**0%**	1
2251260	*Taeniodes jacksoni* FDA	**40%**	**0%**	1
2251292	*Torquigener marleyi* FDA	**40%**	**0%**	1

2251298	*Myxus capensis* FDA	**30%**	**0%**	1
2251306	*Lutjanus argentimaculatus* FDA	**30%**	**0%**	1
2251307	*Lutjanus rivulatus* FDA	**30%**	**0%**	1
2251308	*Pomadasys furcatum* FDA	**20%**	**0%**	1
2251310	*Anacanthobatis marmoratus* SDA	**40%**	**0%**	1
2251312	*Dichistius multifasciatus* FDA	**35%**	**0%**	1
2252027	*Carcharias taurus* SSPA	**20%**	**0%**	1
2252040	*Rhinobatos annulatus* SSPA	**22%**	**0%**	1
2252060	*Sardinops sagax* FSPA	**0%**	**20%**	1
2252116	*Pomatomus saltatrix* FSPA	**0%**	**20%**	1
2252117	*Pomadasys commersonnii* FSPA	**20%**	**0%**	1
2252120	*Pomadasys olivaceum* FSPA	**20%**	**0%**	1
2252124	*Acanthopagrus vagus* FSPA	**25%**	**0%**	1
2252133	*Chrysoblephus puniceus* FSPA	**25%**	**0%**	1
2252134	*Cymatoceps nasutus* FSPA	**25%**	**0%**	1
2252138	*Pachymetopon aeneum* FSPA	**25%**	**0%**	1
2252141	*Petrus rupestris* FSPA	**25%**	**0%**	1
2252145	*Polysteganus undulosus* FSPA	**25%**	**0%**	1
2252149	*Rhabdosargus holubi* FSPA	**25%**	**0%**	1
2252150	*Rhabdosargus sarba* FSPA	**20%**	**0%**	1
2252152	*Sarpa salpa* FSPA	**20%**	**0%**	1
2252165	*Argyrosomus japonicus* FSPA	**20%**	**0%**	1
2252166	*Argyrosomus thorpei* FSPA	**22%**	**0%**	1
2252167	*Atractoscion aequidens* FSPA	**11%**	**11%**	1
2252182	*Lichia amia* FSPA	**0%**	**20%**	1
2252299	*Otolithes ruber* FSPA	**30%**	**0%**	1
2252313	*Scomber japonicus* FSPA	**0%**	**20%**	1
2253010	*Carcharhinus leucas* SNA	**20%**	**20%**	1
2253040	*Rhinobatos annulatus* SNA	**22%**	**0%**	1
2253117	*Pomadasys commersonnii* FNA	**20%**	**0%**	1
2253120	*Pomadasys olivaceum* FNA	**20%**	**0%**	1
2253124	*Acanthopagrus vagus* FNA	**25%**	**0%**	1
2253125	*Argyrops spinifer* FNA	**30%**	**0%**	1
2253133	*Chrysoblephus puniceus* FNA	**25%**	**0%**	1
2253134	*Cymatoceps nasutus* FNA	**35%**	**0%**	1
2253138	*Pachymetopon aeneum* FNA	**25%**	**0%**	1
2253150	*Rhabdosargus sarba* FNA	**20%**	**0%**	1
2253152	*Sarpa salpa* FNA	**20%**	**0%**	1
2253166	*Argyrosomus thorpei* FNA	**22%**	**0%**	1
2253299	*Otolithes ruber* FNA	**30%**	**0%**	1
2253311	*Carcharhinus obscurus* SNA	**10%**	**10%**	1
2254010	*Carcharhinus leucas* SAA	**15%**	**15%**	1
2254027	*Carcharias taurus* SAA	**20%**	**0%**	1
2254040	*Rhinobatos annulatus* SAA	**22%**	**0%**	1
2254116	*Pomatomus saltatrix* FAA	**0%**	**20%**	1
2254117	*Pomadasys commersonnii* FAA	**20%**	**0%**	1
2254120	*Pomadasys olivaceum* FAA	**20%**	**0%**	1
2254124	*Acanthopagrus vagus* FAA	**25%**	**0%**	1

2254125	*Argyrops spinifer* FAA	**20%**	**0%**	1
2254133	*Chrysoblephus puniceus* FAA	**25%**	**0%**	1
2254134	*Cymatoceps nasutus* FAA	**35%**	**0%**	1
2254138	*Pachymetopon aeneum* FAA	**35%**	**0%**	1
2254141	*Petrus rupestris* FAA	**25%**	**0%**	1
2254145	*Polysteganus undulosus* FAA	**35%**	**0%**	1
2254150	*Rhabdosargus sarba* FAA	**20%**	**0%**	1
2254152	*Sarpa salpa* FAA	**20%**	**0%**	1
2254165	*Argyrosomus japonicus* FAA	**30%**	**0%**	1
2254166	*Argyrosomus thorpei* FAA	**32%**	**0%**	1
2254167	*Atractoscion aequidens* FAA	**16%**	**16%**	1
2254182	*Lichia amia* FAA	**0%**	**20%**	1
2254272	*Scomberomorus commerson* FAA	**0%**	**20%**	1
2254299	*Otolithes ruber* FAA	**30%**	**0%**	1
2254311	*Carcharhinus obscurus* SAA	**15%**	**15%**	1
2254313	*Scomber japonicus* FAA	**0%**	**20%**	1
Processes				
M = Mammal, S = Shark, F = Fish				
P = Pathway for migration				
SPA = Spawning area, NA = Nursery Area, AA = Adult area, _= Not specified				
3100001	Eddies path HYCOM	**10%**	**0%**	10
3300001	SST front Cornillon (4 km Resolution)	**10%**	**0%**	10
3500001	CHL-*a* front Cornillon (4 km Resolution)	**10%**	**0%**	10
3446002	Hump back whales MP_	**20%**	**0%**	1
3452010	*Carcharhinus leucas* SPSPA	**10%**	**10%**	1
3452027	*Carcharias taurus* SPSPA	**20%**	**0%**	1
3452060	*Sardinops sagax* FPSPA	**0%**	**20%**	1
3452116	*Pomatomus saltatrix* FPSPA	**0%**	**20%**	1
3452141	*Petrus rupestris* FPSPA	**20%**	**0%**	1
3452145	*Polysteganus undulosus* FPSPA	**20%**	**0%**	1
3452149	*Rhabdosargus holubi* FPSPA	**20%**	**0%**	1
3452165	*Argyrosomus japonicus* FPSPA	**20%**	**0%**	1
3452167	*Atractoscion aequidens* FPSPA	**10%**	**10%**	1
3452182	*Lichia amia* FPSPA	**0%**	**20%**	1
3452272	*Scomberomorus commerson* FPSPA	**0%**	**20%**	1
3452311	*Carcharhinus obscurus* SPSPA	**10%**	**10%**	1
3452313	*Scomber japonicus* FPSPA	**0%**	**20%**	1
3453010	*Carcharhinus leucas* SPNA	**10%**	**10%**	1
3453027	*Carcharias taurus* SPNA	**20%**	**0%**	1
3453060	*Sardinops sagax* FPNA	**0%**	**20%**	1
3453116	*Pomatomus saltatrix* FPNA	**0%**	**20%**	1
3453141	*Petrus rupestris* FPNA	**20%**	**0%**	1
3453145	*Polysteganus undulosus* FPNA	**20%**	**0%**	1
3453149	*Rhabdosargus holubi* FPNA	**20%**	**0%**	1
3453165	*Argyrosomus japonicus* FPNA	**20%**	**0%**	1
3453167	*Atractoscion aequidens* FPNA	**10%**	**10%**	1
3453182	*Lichia amia* FPNA	**0%**	**20%**	1
3453313	*Scomber japonicus* FPNA	**0%**	**20%**	1

3454010	*Carcharhinus leucas* SPAA	**10%**	**10%**	1
3454027	*Carcharias taurus* SPAA	**20%**	**0%**	1
3454272	*Scomberomorus commerson* FPAA	**0%**	**20%**	1
3454311	*Carcharhinus obscurus* SPAA	**10%**	**10%**	1

Appendix 8: Contribution of MPA A zones to the target achievement for each feature

See attached PDF

Appendix 9: Contribution of MPA B zones to the target achievement for each feature

See attached PDF

Appendix 10: Target achievement per biodiversity features within each zonation category

See attached PDF