Monitoring of environmental indicators in Wilderness National Park

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Abbreviations and Acronyms

$CaCO_3$	-	Calcium carbonate
CapeNature	-	Western Cape Nature Conservation Board
Cl^-	-	Chloride
CO_2	-	Carbon dioxide
CO_3^{2-}	-	Carbonate
DO	-	dissolved oxygen
DWAF	-	Department of Water Affairs and Forestry
F^-	-	Flouride
$g\ kg^{-1}$	-	grams per kilogram (= ‰ or parts per thousand)
GIS	-	geographic information system
GPS	-	global positioning system
H^+	-	Hydrogen
H_2CO_3	-	Carbonic acid
H_2O	-	Water
ha	-	hectares
HCO_3^-	-	Hydrogen carbonate
HWS	-	high water springs
$indiv\ m^{-2}$	-	individuals per square meter
IUCN	-	International Union for Conservation of Nature and Natural Resources
K^+	-	Potasium
LWS	-	low water springs
m amsl	-	meters above mean sea level
$mg\ l^{-1}$	-	milligrams per litre (= parts per million)
Mg^{2+}	-	Magnesium
Na^+	-	Sodium
NH_4^+	-	Ammonium
NO_2^+	-	Nitrite
NO_3^-	-	Nitrate
NP	-	National Park
NTU	-	nephelometric turbidity units
PO_4^{3-}	-	Phosphate
RDB	-	red data book
SAM	-	strategic adaptive management
SANParks	-	South African National Parks
SASS	-	South African Scoring System
Si	-	Silicon
SO_4^{2-}	-	Sulphate
TDS	-	total dissolved solids / total dissolved salts
TPC	-	Threshold of potential concern
TSS	-	total suspended solids

1. Introduction

Increasing recognition that heterogeneity is a major driver of the richness and productivity of ecological systems (Picker *et al.* 2003) and hence wider acceptance of the necessity to manage for spatial and temporal heterogeneity requires adoption of a goal orientated adaptive management approach within conservation practice (Pomeroy *et al.* 2004). There are many models of adaptive management, though all have basically similar steps from setting of a desired future state within a vision statement, through objective and goal setting, to planning and implementation of management actions accompanied by monitoring of indicators to audit goal achievement and enable informed evaluation of the management process. Adaptive management as being implemented within SANParks to embrace the concept of ecosystem heterogeneity has been titled Strategic Adaptive Management (SAM) (Rogers & Bestbier 1997) which differs from earlier models as greater emphasis is placed on forward planning and proactive decision making (Biggs & Rogers 2003). The backbone for SAM is the planning and setting up of an effective monitoring programme (Rogers & Bestbier 1997) in order to test the hypothesis of no change from a set point or set of limits. The necessity for definition of operational goals which define limits of change in relation to conservation objectives prior to sampling and analysis has been emphasized in several publications on monitoring methodology (Spellerberg 1991; Hellawell 1992; Finlayson 1994). Such operational goals need to enable clear and unambiguous assessment of the significance of change in biotic diversity, indicated by the non-achievement of a specified state or set of criteria (Goldsmith 1991; Finlayson 1996). The concept of pre-defined limits or thresholds has long been applied in some aspects of monitoring; with for example water quality standards, though definition of scientifically rigorous limits of changes for management of broader ecosystem heterogeneity have proved more problematic. Early attempts as applied by SANParks to aquatic systems were called Limits of Acceptable Change after terminology used by Finlayson (1994) and others, though the concept has subsequently been redefined as Thresholds of Potential Concern, or TPCs (Rogers & Bestbier 1997). TPCs are in essence hypotheses of upper and lower levels of acceptable ecosystem change (Rogers 2003) and as such are always open to debate and refinement.

Deciding on what should and can be monitored is influenced by the desirability of measuring indicators as surrogates for ecosystem structure and function at multiple levels of organization over a range of spatial and temporal scales. Numerous processes are operative within the estuarine systems at multiple levels (Fig 1) and although it is desirable that indicators be drawn from a variety of levels, practical limitations such as finite financial and human recourses limits the number of indicators that can be selected.

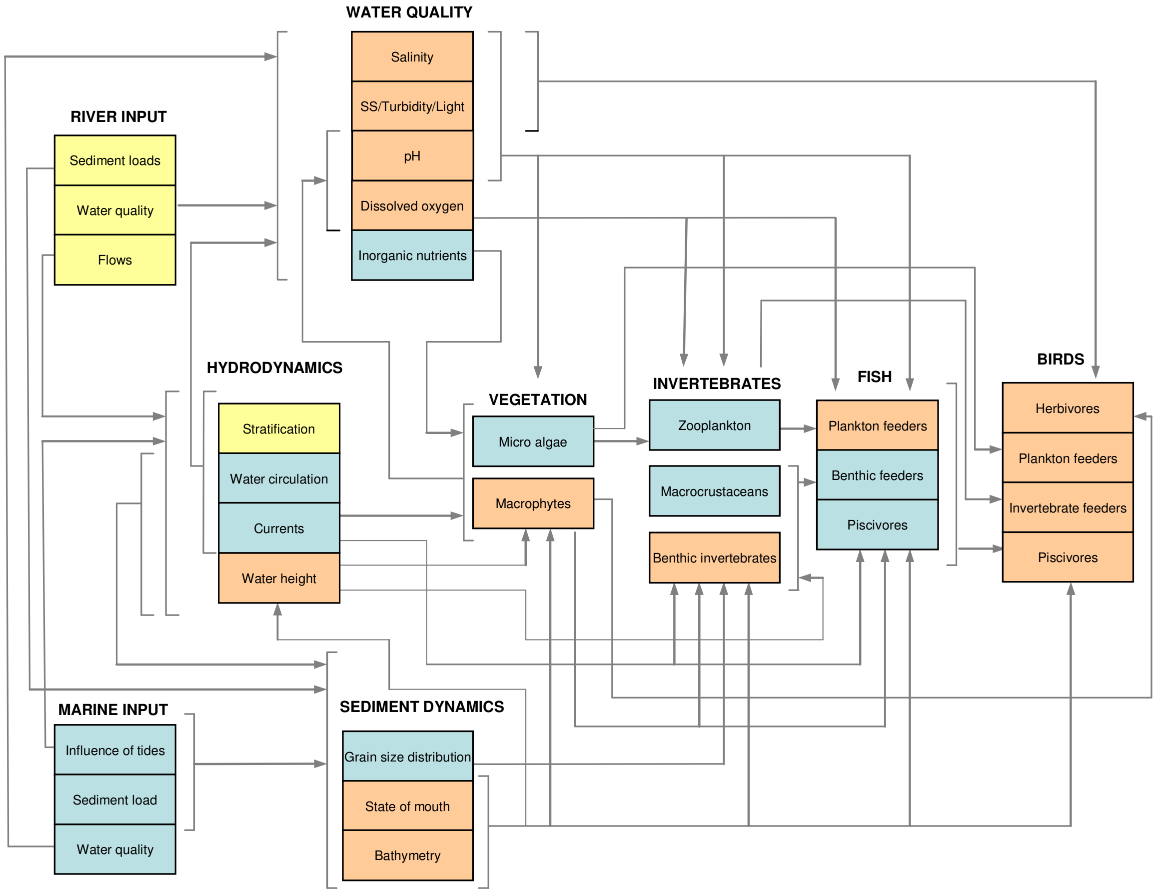

Figure 1: Conceptual model of anticipated major natural processes and interactions relevant to estuarine systems in Wilderness NP (modified from Taljaard *et al*. 2003). Brown boxes are indicators included partially or wholly in the Wilderness NP estuary monitoring program; yellow boxes are indicators forming component of the surveillance program by SANParks and other agencies; blue boxes are indicators that are not regularly measured or not measured at all in the estuarine component of the Wilderness NP monitoring program.

The suite of indicators both in the monitoring and supporting surveillance programs have been selected to, wherever possible, be complimentary, with individual indicators embodying as many as possible of the attributes described by Noss (1990) and Margolius & Salafsky (1998) cited in Pomeroy *et al.* (2004) as indicative of a good indicator, namely:

Measurable: Able to be recorded and analysed in quantitative or qualitative terms.
Precise: Widely applicable. Defined the same way by all people.
Consistent: Provides continual assessment over a wide range of stress. Not changing over time so that it always measures the same thing.
Sensitive: Sensitive enough to provide early warning of change. Changing proportionally in response to actual changes in the attribute or item being measured.
Simple: Easy and cost effective to measure. Simple indicators are generally preferred to complex ones. Independent of sample size.

Relevant: Relevant to ecologically significant phenomena and specific management goals. Discrimination between natural fluxes and anthropogenic stress.

The Wilderness NP monitoring program addresses patterns and process at a variety of different levels, from sediment dynamics, to water chemistry, botanical changes, fishes and waterbirds which relate to different park objectives as outlined in the Park Management Plan (Table 1).

Table 1 Conservation objectives for the Wilderness NP as given in the park management plan, with indicators used in the monitoring programme to test the achievement of objectives. The numbering of indicators is as given in the main body of the text.

Objective	Sub-objective	Indicator
Representative ecosystems: To incorporate a spectrum of viable aquatic and terrestrial ecosystems characteristic of the Wilderness area, and to re-introduce missing elements where possible.	**Consolidation and expansion of land areas:** Consolidation of protected areas focusing on under representative ecosystems, functional linkages and processes.	Nil
	Reintroduction of biota: Reestablishment where possible, of locally extinct or depleted biodiversity components and populations in accordance with IUCN principles and guidelines.	Nil
Functional ecosystems: To ensure the long term persistence of biodiversity patterns and processes, enabling natural variation in structure, function and composition over space and time.	**Estuary Management**: Manipulate appropriate biophysical aspects of estuarine environment to achieve social and ecosystem conservation objectives.	Sandbar height. (No. 4.3) Recruitment of marine biota (No. 3.1)
	Fire management: Apply appropriate fire regime in fynbos areas (frequency, season, intensity, size).	Fire regime (No. 3.2)
	Threatened biota: Maintain viable populations of threatened species in order to meet SANParks obligations in terms of international agreements and conventions.	Waterbirds (No. 2.4) Knysna seahorse (No. 2.3)
Rehabilitation: Rehabilitate degraded areas, including the re-establishment of natural biodiversity patterns, and	**Wetlands:** Re-establishment of physical, chemical and biological processes in degraded wetland areas.	Physical hazards (No. 4.2) Emergent aquatic plants. (No. 2.2)

the restoration of key processes which support the long term persistence of biodiversity.	**Alien plants and other alien biota:** Control and where possible eliminate alien biota to facilitate re-establishment of natural biodiversity pattern and process in invaded areas.	Aquatic alien & extralimital biota (No. 2.5)
Reconciling biodiversity with other park objectives: To ensure that non-biodiversity management aspects of SANParks operations (revenue generation including tourism, resource use, developments, management activities, etc.) are informed and constrained by biodiversity conservation objectives, and that the impacts of these activities on biodiversity are minimised.	**Internal developments:** Minimise the impacts associated with the development of tourism and park management infrastructure, and ensure that such developments do not compromise biodiversity objectives.	Nil
	Internal activities: Minimise the impacts associated with tourism and park management activities, and ensure that such activities do not compromise biodiversity objectives.	Nil
	Extractive resource use: Minimise the impacts of extractive resource use, and ensure that such activities are aligned with corporate guidelines; are within management capacity constraints, and do not compromise biodiversity objectives.	Estuarine bait organisms (No. 4.4)
Reconciling biodiversity with external threats: To reduce external threats and pressures, and limit impacts of surrounding land & resource use on biodiversity conservation within the park.	**External developments:** Minimise the impacts associated with inappropriate developments outside the park	Nil
	External activities: Negotiate to ensure that external resource and land use do not detrimentally affect ecological processes within the park.	Nil
	Hydrological and water chemistry changes: Participate in activities for the maintenance of river flow regimes and water chemistry within limits for the maintenance of ecosystem processes in aquatic ecosystems within the park.	Waterbody aesthetics (No. 4.1) Estuary water quality (pH, dissolved oxygen, salinity, turbidity) (No. 2.1)
	Illegal harvesting of resources: Prevent the illegal collection, removal and destruction of physical and biological resources.	Nil

Indicators used within the monitoring programme can be divided into three broad groupings, namely those addressing (i) physical, chemical or biological patterns; (ii) physical, chemical or biological processes; and (iii) resource utilization and societal effects. Description of components of the monitoring programs including proposed TPCs are given under these headings below.

2. Indicators in the Wilderness NP monitoring programme addressing physical, chemical and biological patterns.

2.1 ESTUARY WATER QUALITY

2.1.1 Rationale

Water quality variables potentially affecting estuarine ecosystems, or in some cases affected by estuarine organisms, may be chemical (e.g. pH, dissolved oxygen, salinity) or physical (e.g. turbidity). pH is largely determined by the concentration of hydrogen ions (H^+) in solution. pH of estuarine waters vary depending on the extent of inflow of waters from the sea (usually 7.8-8.3) and rivers (4.0-7.0) as well as internal processes where the absorption of HCO_3^- during photosynthesis and production during respiration or decomposition influences the availability of hydrogen ions in the pathway $CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow HCO_3^- + H^+ \leftrightarrow 2H^+ + CO_3^{2-}$ In dense growths of aquatic plants, for example, pH may rise to 9.6 during the day, but at night may fall to 6.8 (Day 1981). pH may thus provide an approximate measure of biological activity.

The solubility of oxygen in estuary waters is a function of its partial pressure and the temperature and salinity of the water. Photosynthesis supplements the oxygen absorbed from the atmosphere, whereas respiration and decomposition of organic matter removes oxygen from the water column. Horizontal variations in dissolved oxygen depend largely on the distribution of aquatic plants, with higher oxygen values being associated with the presence of aquatic plants (Howard-Williams & Allanson 1979). Deoxygenation has been recorded in localised areas in the Swartvlei Estuary towards the end of the closed phase (Howard-Williams & Allanson 1979). These areas are at the sides of the channel where mats of floating algae start to rot, and in deeper portions of the estuary. Decomposition of organic matter in the bottom sediments of Swartvlei Lake rapidly uses up the oxygen and increases the concentration of carbon dioxide (Howard-Williams & Allanson 1979) making the bottom half of Swartvlei Lake naturally a very toxic environment for animal life.

Salinity relates to the mass of dissolved inorganic solids, which in seawater is typically 35g kg^{-1}. Eleven major constituents comprise over 99.6% of the dissolved solids, of which Na^+ and Cl^-, and to a lesser extent SO_4^{2-} and Mg^{2+} dominate. Salinity may vary longitudinally, vertically and temporally within an estuary, and is controlled largely by water exchange at the seaward end, evaporation from the estuary, and freshwater inflow. Although strong horizontal salinity gradients are sometimes present in Swartvlei Lake and the estuaries, particularly during phases when the estuary mouths are open, more uniform oligohaline (0.5-4.9g kg^{-1}) or mesohaline (5.0-17.9g kg^{-1}) conditions usually prevail in the shallower lakes as well as estuaries during prolonged closed phases. Freshwater depravation, altered breaching patterns, and changes to water movement between waterbodies are amongst the man-made changes to the lake systems that could result in altered salinity.

The penetration of light in the photosynthetic range is important in the productivity of photosynthetic organisms (phytoplankton & plants) and influences the depth to which attached plants can grow. The subsurface attenuation of light is due to absorption by water molecules and organic substances and to scattering and reflection by suspended particles including plankton and silt or clay. Changes in turbidity may be due to a variety of factors including the particulate content in influent water, both from rivers and the sea, and the extent of turbulence caused by wave action, river inflow or wind. Most of the Wilderness lakes are naturally clear water systems (<10 NTU), though at times turbidity may increase substantially, particularly due to the import of silt and clays during river floods. Although the juveniles of several estuarine associated fishes are attracted to turbid waters, excessively high turbidities have been shown to negatively effect egg survival, hatching success, feeding efficiency, growth rate and population size

2.1.2 Threshold of potential concern

A threshold of potential concern is reached if one or more of the following conditions apply:

pH

Mean pH of surface waters in saline waterbodies of the Wilderness lakes (measured between 08h00 and 13h00 at 30 cm depth) exceeds the ranges:

- 4.0-8.5 in Karatara Lake.
- 7.0-9.0 in Swartvlei Lake.
- 7.0-9.5 in Swartvlei Estuary, Touw Estuary and Eilandvlei.
- 7.5-9.5 in Rondevlei and Langvlei.

Dissolved oxygen

Mean dissolved oxygen (mg l^{-1}) of surface waters of a saline waterbody in the Wilderness lakes, measured between 08h00 and 13h00 at 30cm depth; and where 5 or more widely interspaced measurements are taken per waterbody, is either:

- Less than 4.0 mg l^{-1} at 50% or more of sample points.
- Greater than 10.0 mg l^{-1} at 50% or more of sample points.
- Between 4.0 and 5.0 mg l^{-1} at 75% or more of sample points.
- Between 9.0 and 10.0 mg l^{-1} at 75% or more of sample points.

Salinity

Mean salinity (g kg^{-1}) in surface water of saline waterbodies of the Wilderness lakes, measured at 30cm depth exceed, for a period longer than ninety (90) days, the ranges:

- 0.5-11.0 g kg^{-1} in Karatara Lake.
- 0.5-35.0 g kg^{-1} in Swartvlei Estuary and Touw Estuary.
- 3.0-12.0 g kg^{-1} in Eilandvlei.
- 4.0-13.0 g kg^{-1} in Langvlei.
- 4.0-16.0 g kg^{-1} in Swartvlei Lake.
- 8.0-16.0 g kg^{-1} in Rondevlei.

Turbidity

Mean turbidity in surface water of waterbodies of the Wilderness lakes (measured at 30 cm depth) during non-flood periods is greater than:

- 7 NTU in Swartvlei Estuary or Touw Estuary.
- 10 NTU in Swartvlei Lake, Langvlei or Rondevlei.

- 12 NTU in Eilandvlei.
- 20 NTU in Karatara Lake.

Mean turbidity in surface water of waterbodies of the Wilderness lakes (measured at 30 cm depth) during flood and post-flood (defined as no greater than three calendar months after significantly higher than average fluvial inflow event) are greater that:
- 20 NTU in Langvlei or Rondevlei.
- 25 NTU in Touw Estuary.
- 40 NTU in Eilandvlei, Swartvlei Estuary, Swartvlei Lake or Karatara Lake.

Limits based primarily on rounded values of high percentiles of recorded variability during the 1990s and early 2000s.

2.1.3 Sampling methods

Procedure - Water pH, salinity and dissolved oxygen concentration will be measured in the field at 30cm depth using appropriate portable electronic pH, salinity and DO meters. A water sample will be collected at 30cm depth at all sample sites and used within 48 hours of collection to determine turbidity with an appropriate laboratory turbidimeter.

Spatial scale - Five localities in each of Rondevlei, Langvlei and Eilandvlei, 6 in Swartvlei Lake, 1 in Karatara Lake, and 8 in each of Swartvlei Estuary and Touw Estuary depending on site accessibility.

Temporal scale - Quarterly (January, April, July, October).

2.1.4 Reporting frequency

Annual.

2.1.5 Project commencement

Commenced 1992 - ongoing.

2.1.6 Responsibilities

Data collection - Scientific Services.
Data interpretation - Scientific Services.
Data maintenance - Scientific Services.
Reporting - Scientific Services.

2.2 EMERGENT AQUATIC PLANTS

2.2.1 Rationale

The lakes are fringed by a narrow margin of emergent aquatic plants with *Phragmites australis*, *Typha capensis*, S*choenoplectus scirpoideus* and *Juncus kraussii* being abundant (Russell 2003). Mapping of the distribution of emergent aquatic plants in the 1970s (Weisser & Howard-Williams 1982) and 1990s (Russell 2003) indicated localised increases in *P. australis, T. capensis,* Scrub or trees, and Grass or Fields, and decreases in *J. kraussii, S. scirpoideus* and Low scrub or fynbos in the Touw System. Probable causes of change include the natural tendency of plants to colonise new areas, as well as anthropogenic manipulation of physical, chemical and biological processes, including the cessation of disturbance by large herbivores, water-level stabilisation, changes in soil salinity and the accumulation of plant litter within wetland areas (Russell 2003).

2.2.2 Threshold of potential concern

A threshold of potential concern is reached if a plant species category which, within a waterbody, or collectively amongst waterbodies, occupy or has dominated in 5% or more of the wetland area studied undergoes a 50% or greater change in area of dominance compared to 1978 surveys, and/or 20% or greater change compared to 1997 surveys, where such change indicates increasing dominance by dry-land elements (scrub, trees, fynbos, grass) or *P. australis*.

Extent of change determined by collective judgement.

2.2.3 Sampling methods

Procedure - Mapping of vegetation units from 1:5000 colour photographs. Ground truthing to take place within 3 months of photography. Comparisons of data to be undertaken using GIS software. The use of satellite imagery, and computed aided image analysis and interpretation as means of streamlining data acquisition and analysis phases needs to be investigated.

Spatial scale - Complete coverage of all wetland areas.

Temporal scale - Once every 10 years.

2.2.4 Reporting frequency

Proposed once every 10 years.

2.2.5 Project commencement

Evaluations were last undertaken in 1997. Repeat evaluation will only be possible with either (a) availability of additional funding of approximately R120 000 (estimated in 2007) to undertake low level aerial photographs during targeted assessment year, or (b) suitability of alternative evaluation methods using satellite imagery, assessment of which will be undertaken during 2008 and 2009.

2.2.6 Responsibilities:

Data collection - Scientific Services.

Data interpretation - Scientific Services.

Data maintenance - Scientific Services.

Reporting - Scientific Services.

2.3 KNYSNA SEAHORSE

2.3.1 Rationale

The Knysna seahorse (*Hippocampus capensis*) was the first seahorse to be listed on the IUCN red data list (Hilton-Taylor 2000). This conservation status derives from its small area of occupancy and its low abundance. It is the worlds only seahorse known to exclusively inhabit estuaries and permanent populations have been recorded from only three estuaries in South Africa (Swartvlei, Knysna and Keurbooms). As such it has the smallest distribution range of any seahorse. The three populations have a common origin, likely the Knysna Estuary, though can be considered as distinct management units (Teske *et al*. 2003). Little scientific information is available on population size, population structure and habitat requirements (Skelton 1987). Most studies have been undertaken on captive specimens (Grange & Cretchley 1995; Fourie 1997; Lockyear *et al*. 1997) with *in situ* ecological research being extremely limited, basically restricted to work undertaken by Bell *et al*. (2003) in the Knysna Estuary and Lockyear *et al.* (2006). Pollution events or other disturbances affecting the submerged aquatic plants in Swartvlei Estuary will have a direct impact on the seahorse population (Skelton 1987).

2.3.2 Threshold of potential concern

Seahorse density in Swartvlei Estuary is below 0.01 indiv m^{-2} for two or more consecutive surveys.

Limit determined as one third of estimated previous (Lockyear *et al.* 2006) density assessment for Swartvlei Estuary.

2.3.3 Sampling methods

Procedure - Sampling will be undertaken using an anchovy seine 5m x 1.5m x 2mm. A minimum of four adjacent effective seine net pulls each of about 10m long will be undertaken at each sample locality during each survey.

Spatial scale - Sampling will be undertaken at five different localities along the length of Swartvlei estuary in areas where submerged aquatic plants, particularly *Zostera capensis* and/or *Ruppia cirrhosa*, occur.

Temporal scale - Surveys undertaken twice annually, preferably once when the estuary mouth is open and once when it is closed.

2.3.4 Reporting frequency

Annual.

2.3.5 Project commencement

Project will be started in 2008.

2.3.6 Responsibilities

Data collection - Scientific Services will schedule surveys, with field work being undertaken by a team comprising both Scientific Services and Park Management.

Data interpretation - Scientific Services.

Data maintenance - Scientific Services.

Reporting - Scientific Services.

2.4 WATERBIRDS

2.4.1 Rationale

The Wilderness lakes support a diverse waterbird community with 84 species having been recorded in the Wilderness NP and surrounding areas (Boshoff 1991). Rondevlei and

Langvlei frequently support the most diverse and abundant waterbird communities (Boshoff & Piper 1992), with surveys on Langvlei indicating that at times waterbird abundance can exceed 7000 individuals comprising 65 species (Boshoff & Palmer 1981). This abundance of waterbirds, and in particular Anatidae (ducks and geese) which on Langvlei alone at times exceeds 2000 individuals of nine species, represents the largest concentration of species and individuals along the southern and eastern Cape coasts (Underhill *et al*. 1980). Portions of the Touw System (Rondevlei, Langvlei, Eilandvlei, Serpentine) were designated in terms of the Convention on Wetlands (Ramsar Convention) as a Wetland of International Importance in 1991, based on the regular occurrence of >1% of the world population of some waterbird species.

2.4.2 Threshold of potential concern

A threshold of potential concern is reached if the total abundance of a species for the Wilderness Lakes, for four or more counts undertaken over two consecutive years, is consistently below (names as in List of the Birds of the Afrotropics):

- 1 African marsh-harrier.
- 2 African fish eagle.
- 4 purple swamphen.
- 8 grey heron.
- 12 kelp gull.
- 12 little egret.
- 15 African darter.
- 15 blacksmith plover.
- 25 black-winged stilt.
- 30 white-breasted cormorant.
- 40 moorhen.
- 50 great crested grebe.
- 50 southern pochard.
- 55 Egyptian goose.
- 120 long-tailed cormorant.
- 250 little grebe.
- 300 yellow-billed duck.
- 300 Cape shoveler.
- 3200 red-knobbed coot.

Limits determined as rounded values of one third of mean density as assessed in the 1990s and early 2000s.

A threshold of potential concern is reached if one or more of the following conditions apply pertaining to the abundance of selected waterbird species throughout the Wilderness Lakes:

- Great crested grebe - less than 100 individuals for a survey, as well as less than 100 individuals in 40% or more of all surveys undertaken for the previous five consecutive years.

- Cape shoveler - less than 350 individuals for a survey, as well as less than 350 individuals in 40% or more of all surveys undertaken for the previous five consecutive years.
- Yellow-billed duck - less than 1000 individuals for a survey, as well as less than 1000 individuals in 25% or more of all surveys undertaken for the previous five consecutive years.
- Little grebe - less than 1000 individuals for a survey, as well as less than 1000 individuals in 350% or more of surveys undertaken in winter for the previous five consecutive years.
- Red-knobbed coot - less than 10000 individuals for a survey, as well as less than 10000 individuals in 15% or more of all surveys undertaken for the previous five consecutive years.

Limits determined as approximately half of the percentage of surveys undertaken from 1993 to 2007 where abundance exceeded 1% of estimated world population as given in Wetlands International (2002).

2.4.3 Sampling methods

Procedure - Waterbird abundance to be determined in Touw Estuary, Eilandvlei, Langvlei, Rondevlei, Swartvlei Lake and Swartvlei Estuary. Counts to be conducted by up to four observers using field glasses, from a boat following a standardized route.

Spatial scale - The route must enable observation of not less than 95% of open water areas, and not less than 90% of marginal areas with emergent macrophytes.

Temporal scale - Biannually surveys during January-February (Summer) and July-August (Winter)

2.4.4 Reporting frequency

Annual.

2.4.5 Project commencement

Commenced 1992 - ongoing.

2.4.6 Responsibilities

Data collection - Scientific Services.
Data interpretation - Scientific Services.
Data maintenance - Scientific Services.
Reporting - Scientific Services.

2.5 AQUATIC ALIEN AND EXTRALIMITAL BIOTA

2.5.1 Rationale

Known established alien and translocated aquatic biota in Wilderness NP consists of two floating aquatic plants and four fishes. High densities of alien aquatic plants can significantly effect aquatic ecosystems and threaten biodiversity (Henderson & Cilliers 2002) principally through water quality changes, shading, and overcrowding. Invasive fishes may have several harmful effects including habitat alterations such as removal of vegetation and degradation of water quality; introduction of parasites and diseases; trophic alterations such as competition for food and predation; hybridization; and spatial alterations such as overcrowding (Bruton & Merron 1985). The possibility of introduction and/or establishment of new species is high, with concerns particularly for the establishment in lake systems of *Arundo donax* Giant reed, *Cyprinus carpio* Common carp and *Clarias gariepinus* Sharptooth catfish.

2.5.2 Threshold of potential concern

A threshold of potential concern is reached if one or more of the following conditions apply:

- Establishment of a self perpetuating population of any alien or extralimital vertebrate, with the exception of established species (as occurring in 2007) for which no practical means of elimination exist, which consist of :
  Oreochromis mossambica (Mozambique tilapia) - lakes and rivers.
  Gambusia affinis (Mosquito fish) – lakes and rivers.
  Micropterus dolomieu (Smallmouth bass) - rivers.
  Micropterus salmoides (Largemouth bass) - rivers.

- Occurrence of an individual or individuals of an alien or extralimital vertebrate capable of interbreeding with indigenous biota.

- Occurrence of individuals or establishment of stands of any alien or extralimital submerged, emergent or free floating aquatic plant, with the exception of established species (as occurring in 2007) for which no practical means of elimination exist, which consist of:
  Azolla filiculoides (red water fern) – lakes and rivers.
  Salvinia molesta (Kariba weed) – rivers entering Swartvlei Lake.

- Stands of either *Azolla filiculoides* (red water fern) or *Salvinia molesta* (Kariba weed) occur in any waterbody in a density where the total surface area occupied exceeds, by estimation, $100m^2$**.**

Species compliments based on recorded occurrences, with area occupied by floating macrophytes determined by collective judgement.

2.5.3 Sampling methods

Procedure - Observations by conservation personnel during routine patrols, and follow-up of situations or instances reported by other SANParks personnel or public. Assessment will be made of the distribution and extent of floating aquatic plants during biannual waterbird surveys.

Spatial scale - Coverage of all wetland areas.

Temporal scale - *Ad hoc* observations. Minimum of monthly patrol of all channels and waterways.

2.5.4 Reporting frequency

Annual.

2.5.5 Project commencement

Project will be started in 2008.

2.5.6 Responsibilities:

Data collection - Park Management with assistance (e.g. species identifications) by Scientific Services. Observations of floating aquatic plants during biannual waterbird counts by Scientific Services.

Data interpretation - Park Management.

Data maintenance - Park Management.

Reporting - Park Management.

3. Indicators in the Wilderness NP monitoring programme addressing physical, chemical and biological processes.

3.1 RECRUITMENT OF MARINE BIOTA

3.1.1 Rationale

Several biota occurring in the estuarine environments have an obligate marine phase in their life cycle. For most fully aquatic species movement between the estuarine and marine environments can only be achieved during periods when the estuary mouth is open (Whitfield 1989a, 1989b), or in the case of some larval fishes, when there is substantial over-wash of the sandbar (Whitfield 1992). The absence of an open mouth phase during various life-cycle stages could, in the short term, result in reduced or failed recruitment and hence underrepresented or lost age cohorts, and in the long term, loss of species.

3.1.2 Threshold of potential concern

A threshold of potential concern is reached if either the Touw Estuary or Swartvlei Estuary fails to remain open continuously for at least one complete lunar cycle (approximately 28 days) during the period 1 September to 31 March for two consecutive years.

Duration determined by collective judgement based on understanding of recruitment and breeding strategies of euryhaline marine and obligate catadromous fishes (cf. categories IIa, IIb, IIc and Va in Whitfield (1998)) and timing based on optimal recruitment period for the majority of abundant estuarine fishes cf. Whitfield (1998).

3.1.3 Sampling methods

Procedure - Observation of whether estuary mouths are open or closed (either with or without overtopping). Recording of breaching times and water level using a dumpy level and staff at breaching.

Spatial scale - Swartvlei Estuary mouth and Touw Estuary mouth.

Temporal scale - Daily observations of mouth state. Water level measurements at time of breaching.

3.1.4 Reporting frequency

Annual.

3.1.5 Project commencement

Commenced mid 1980s - ongoing.

3.1.6 Responsibilities:

Data collection - Park Management.

Data interpretation - Park Management to provide data to Scientific Services who will undertake analysis and interpretation.

Data maintenance - databases to be maintained by Scientific Services.

Reporting - Scientific Services.

3.2 FIRE REGIME

3.2.1 Rationale

The Goukamma Fynbos/Thicket Mosaic found within Wilderness NP is dependent on fire to maintain the co-existence of dune fynbos and dune thicket in a mosaic pattern (Cowling 1984; Euston-Brown 2005; Helme 2005), to stimulate recruitment of many fynbos species, and thus to retain maximum species richness (Bond *et al.* 1990; De Villiers *et al.* 2005). The frequency, intensity, season and extent of fires are critical determinants of plant species composition, vegetation structure and successional patterns (Kruger & Bigalke 1984; Van Wilgen *et al.* 1992). Fire regimes according to which fynbos should be managed are largely dictated by the slow-maturing obligatory reseeding component of the vegetation (e.g. *Agathosma*, *Muraltia*, *Felicia*, and *Metalasia*) (Pierce & Cowling 1991). Species with small, short-lived seed banks and plant longevity of less than 30 years would be vulnerable to local extinction under long (*ca.* 50-year) fire intervals (Kruger 1984). On the other hand, short fire intervals or fires in the wrong season could result in the depletion of seed banks if fires occur before seed set or plant maturity (Pierce 1987). The natural fire season is late summer to early autumn and has weather associated with higher intensity fires. For these reasons, hot fires at 12-40 year intervals in late summer/early autumn are deemed suitable for dune fynbos vegetation (Midgley 1989; Bond *et al.* 1990). A patchy landscape, with a variety of habitat structure- and age-classes, is considered ideal as it will contribute to overall diversity and species richness (Bond *et al.* 1995; De Villiers *et al.* 2005). The small size of Wilderness NP, however, imposes a limit on the degree of patchiness that can be achieved. Knysna Afromontane Forest and solid dune thicket are largely fire-free under natural conditions (Midgley *et al.* 1997; Clark & De Villiers 2005) and should be protected from wild fires of unnatural cause.

3.2.2 Threshold of potential concern

A threshold of potential concern is reached if one or more of the following conditions apply:

- More than 33% of the total area of dune fynbos/thicket burnt in any one year.

- Veld age class distribution deviates substantially from ⅓ young (<10yrs), ⅓ mature (10-30yrs), ⅓ old (>30yrs).
- Interval between fires is less than the time taken by slowest-maturing species to set seed.
- Any area having burnt twice in succession outside of the ecological fire season (December-April).
- Control fires being either excessively hot or very cool.
- Indicator species (e.g. slow-maturing reseeding species) and/or plant Species of Special Concern failing to recruit after fire.

TPCs are largely based on recruitment requirements (as referenced under Rationale above) of slow-maturing reseeding species to prevent their loss from the system. TPCs are in line with the thresholds used by other fynbos-managing authorities in the area (i.e. CapeNature).

3.2.3 Sampling methods

Procedure - Post-fire mapping of extent of accidental/control fires with GPS and subsequently captured in GIS database. Monitoring of fire intensity by measuring evaporation from water-filled cans during control fires. Monitoring of post-fire recruitment of Indicator plant species & Species of Special Concern by means of field surveys.

Spatial scale - Coverage of areas burned.

Temporal scale - Intermittent dependant on fire frequency.

3.2.4 Reporting frequency

Intermittent dependant on fire incidences.

3.2.5 Project commencement

Project will be started in 2008.

3.2.6 Responsibilities

Data collection

- Provision of historical records of fires - Park Management.
- Capture of historical records on GIS - Scientific Services.
- Notifying Scientific Services of the occurrence of fires - Park Management.
- Mapping of fires – Scientific Services.
- Monitoring of fire intensity – Park Management to assist with field work; further measurements and analysis by Scientific Services.
- Monitoring of post-fire plant recruitment – Scientific Services.

Data interpretation

- Implementation of control burns as per agreed fire regime – Scientific Services to advise and make recommendations and Park Management to implement.
- Analysis of fire regime in relation to TPCs – Scientific Services.

Data maintenance - Scientific Services.

Reporting - Scientific Services.

4. Indicators in the Wilderness NP monitoring programme addressing resource utilization and societal effects.

4.1 WATERBODY AESTHETICS

4.1.1 Rationale

Most of the waterbodies within Wilderness NP are used for recreational purposes which, with the exception of Rondevlei and Langvlei, include both intermediate contact (boating) and full-contact (swimming) recreation. Aesthetic and hygienic water qualities for such use may be substantially reduced by various types of matter entering the lake systems from land-based sources such as adjacent residential or agricultural areas.

4.1.2 Threshold of potential concern

A threshold of potential concern is reached if one or more of the following conditions apply:

- Waters contain floating particulate matter or residues from land-based sources in amounts sufficient to be unsightly or objectionable.
- Waters contain materials from land-based sources which may settle to form putrescent or objectionable deposits.
- Waters contain materials from land-based sources which produce colour, odours, turbidity or taints to such a degree as to be unsightly or objectionable.

Type and nature of variable determined by collective judgement.

4.1.3 Sample methods

Procedure - Observations by conservation personnel during routine patrols, and follow-up of situations or instances reported by other SANParks personnel or public.
Spatial scale - Coverage of all wetland areas.
Temporal scale - *Ad hoc* observations.

4.1.4 Reporting frequency

Annual.

4.1.5 Project commencement

Project will be started in 2008.

4.1.6 Responsibilities

Data collection - Park Management.
Data interpretation - Park Management.
Data maintenance - Park Management.
Reporting - Park Management.

4.2 PHYSICAL HAZARDS & OBSTRUCTIONS

4.2.1 Rationale

The Wilderness NP is located in an urban setting, with the lakes also being downstream of areas of intensive agricultural practice. Consequently sediments or objects (for example logs or other plant debris) may enter the waterbodies by unnatural means, for example by being washed down the rivers into the lakes or being deposited into channels from roads that transverse the lakes. Such objects or accumulations may cause a physical hazard to water users and/or an obstruction to water and/or animal movement within and between lakes. It may be either ecologically or socially desirable to remove such objects or accumulations.

4.2.2 Threshold of potential concern

A threshold of potential concern is reached if one or more of the following conditions apply:

- Waters contain submerged objects and other sub-surface hazards which have arisen from other than natural origins and which would be a danger or cause nuisance or interfere with any designated use.
- Blockage of a channel between waterbodies through the deposition of sediments, road debris, or the growth of submerged or emergent aquatic plants, such that water movement between waterbodies is inhibited, or the movement of fishes between waterbodies is likely to be hindered.

Type and nature of variable determined predominantly by collective judgement, with the effect on fish recruitment based on known past distribution of species within the lakes cf. Hall *et al*. (1987) and Russell (1996).

4.2.3 Sampling methods

Procedure - Observation of the accumulation of plant and other debris, and growth of sand bars during routine patrol of all channels and waterways within the park. Follow-up of situations or instances reported by other SANParks personnel or public. Specific sandbanks of concern may be surveyed using a dumpy level and staff.

Spatial scale - Coverage of all wetland areas.

Temporal scale - *Ad hoc* observations. Minimum of monthly patrol of all channels and waterways. In addition all channels and waterways must be inspected within one week of any flood event. Surveying of sandbanks at least once per year.

4.2.4 Reporting frequency

Annual.

4.2.5 Project commencement

Project will be started in 2008.

4.2.6 Responsibilities

Data collection

- Park Management to undertake routine patrols and observations.
- Monitoring of the dimensions of specific problematic sandbanks, such as that occurring at the junction of the Serpentine channel and Touw Estuary, undertaken by Scientific Services.

Data interpretation

- Data from routine observations - Park Management.
- Analysis of sediment profiles by Scientific Services.

Data maintenance

- Data from routine observations - Park Management.
- Profiles of problematic sandbanks - Scientific Services.

Reporting - Park Management with dimensions of targeted sandbanks provided by Scientific Services.

4.3 SANDBAR HEIGHT

4.3.1 Rationale

The Touw and Swartvlei estuaries are artificially breached by SANParks to reduce the probability of flooding of adjacent residential properties. Elevated sandbar heights at the estuary mouths could potentially exacerbate flooding during high rainfall/runoff events if the estuary water level, prior to breaching being possible, exceed the level where breaching would normally be undertaken. Placing an upper limit on the height of the sandbars at the estuary mouths could potentially reduce the frequency and extent of flooding in adjacent areas during high rainfall events.

4.3.2 Threshold of potential concern

A threshold of potential concern is reached if one or more of the following conditions apply:

- Minimum sandbar height at the Touw Estuary mouth exceeds 2.4m amsl during any period when the estuary mouth is closed.
- Minimum sandbar height at the Swartvlei Estuary mouth exceeds 3.0m amsl during any period when the estuary mouth is closed.

Heights based on established practice according to hydraulic and ecological assessments and collective judgement.

4.3.3 Sampling methods

Procedure - Measurement of sandbar height at estuary mouths relative to know height reference sites using a dumpy level and staff.

Spatial scale - Touw and Swartvlei estuary mouths.

Temporal scale - Measurements taken a minimum of once per week. Measurements are only undertaken during periods when the estuary mouth is closed.

4.3.4 Reporting frequency

Annual.

4.3.5 Project commencement

Measurement of sandbar at Touw Estuary mouth commenced mid 1980s and will be ongoing; regular measurement at Swartvlei Estuary mouth will be started in 2008.

4.3.6 Responsibilities

Data collection - Park Management.

Data interpretation - Park Management.
Data maintenance - Park Management.
Reporting - Park Management.

4.4 ESTUARINE BAIT ORGANISMS

4.4.1 Rationale

To comply with the legislation of the National Environmental Management: Protected Areas Act (Act 57 of 2003), SANParks needs to monitor the use of natural resources in its parks. Fishing and bait collecting within Wilderness NP occurs primarily in the Swartvlei estuary, and to a much lesser extent at Touw Estuary and Eilandvlei. These water-bodies are important estuarine systems. Swartvlei was calculated (based on rating scores for size, habitat importance, zonal type rarity and biodiversity importance) to be the seventh most important estuarine system in South Africa, and the Wilderness system (Touw Estuary, Eilandvlei, Langvlei and Rondevlei) 24^{th} in significance (Turpie *et al.* 2002).

The quantity of bait removed from Swartvlei estuary is estimated to be approximately one-tenth of that harvested from Knysna estuary (Turpie & Clark 2007), where approximately 85 % of mud prawns (*Upogebia africana*) are harvested by 'non-leisure' fishers (Hodgson *et al.* 2000b). Bait collecting in Knysna estuary and Langebaan Lagoon during the early to mid 1990s did not appear to result in a noticeable over-exploitation of the standing biomass of prawns (Wynberg & Branch 1991, 1994; Cretchley 1997). However, there are additional factors that need to be considered. Wynberg and Branch (1994) showed that the disturbance associated with bait digging at Langebaan Lagoon caused a decrease in numbers, biomass and species richness, and that took more than 18 months for this component of the benthos to recover.

4.4.2 Threshold of potential concern

- Threshold of potential concern would be the occurrence of salinities of less than 17g kg^{-1} along more than half the length of the estuary, and for more than three months between April and September during two consecutive years.
- More than 60 % of the intertidal sand prawn (*Callianassa kraussi*) areas of Swartvlei Estuary are being heavily exploited.
- More than a 50% differences in prawns densities (determined by insitu counts) between two paired heavily exploited and lightly (or un) exploited areas in the lower reaches of Swartvlei Estuary.
- More than 25 % differences in the total macrofaunal densities (determined sieving out samples) by between heavily exploited and lightly (or un) exploited areas in Swartvlei Estuary.

Salinity tolerance values based on work by Forbes (1977) with acceptable levels of exploitation determined by collective judgement.

4.4.3 Sampling methods

Procedure - Sand prawns and mud prawns have characteristic burrow openings (Zoutendyk & Bickerton 1988), and in comparative sampling Wynberg & Branch (1991) determined a ratio of 1:1 burrow openings / animal for sand prawns and 2:1 for mud prawns. Burrow counts have been used to estimate population densities of one or both of these prawn species in the intertidal areas of Langebaan Lagoon (Wynberg & Branch 1991; P. Nel unpubl. data) and subtidal areas of Knysna estuary (Hodgson *et al.* 2000). This method will be used in Swartvlei estuary.

To assess the general distribution and density of prawns, transects will be done across the estuary in the lower, middle and upper reaches. In the intertidal zone a transect line will be laid from LWS to HWS and the number of prawn opening will be counted in duplicate 0.25m² counted at every 5m intervals up the shore. In the subtidal region counts will be done every 10m. From this data and visual assessments the proportion of the total sand-prawn population/habitat, which is currently heavily exploited, will be determined. Three heavily exploited and three lightly exploited sites will be selected. At each of these site a transect line will be laid from LWS to HWS and the number of prawn opening in triplicate 0.25m² counted at between 2 and 5m intervals, depending on the gradient of the sand bank. At the LWS site triplicate 0.25m² samples will be dug to a depth of 10 cm sieved through a 1-2mm mesh sieve. The macrofauna collected will be counted and weighed. The density and biomass of fauna at heavily exploited sites will be compared with that of lightly exploited sites.

Spatial scale - Swartvlei Estuary.
Temporal scale - One initial survey thereafter annual measurement.

4.4.4 **Reporting frequency**
Annual.

4.4.5 **Project commencement**
Project will be started in 2008.

4.4.6 **Responsibilities**:
Data collection
- Numbers and location of bait diggers – Park Management.
- Prawn burrow counts – Scientific Services.
- Total macrofaunal densities – Scientific Services.

Data interpretation
- Numbers and location of bait diggers – Park Management.
- Burrow counts and faunal densities - Scientific Services.

Data maintenance - Scientific Services.
Reporting
- Numbers and location of bait diggers – Park Management.
- Burrow counts and faunal densities - Scientific Services.

5. Data collection and reporting

Of the 11 subcomponents of a monitoring programme described above, not all require systematic, regular data collection, and furthermore no all could be undertaken with existing SANParks resources and capacity. Indicators that it is proposed that be regularly evaluated and reported on, based on data collected during formal monitoring using existing SANParks capacity are:

- Estuarine physical & chemical properties.
- Knysna seahorse population size in Swartvlei Estuary.
- Waterbird community assessments.
- Recruitment of marine biota.
- Sandbar height.
- Estuarine bait organisms.

The emergent aquatic plant indicator can only be reported on if there is additional investment in staff capacity and/or resources. Indicators that it is proposed be regularly evaluated and reported on, based on *ad hoc* data collection using existing SANParks capacity, are:

- Aquatic alien and extralimital biota
- Fire management
- Waterbody aesthetics
- Physical hazards & obstructions

6. Surveillance programme

Interpretation of the cause and significance of changes recorded within the monitoring programme can be greatly facilitated by the availability of supplementary data. For this purpose a complementary surveillance programme will also be also undertaken which entails the regular collection of data for a variety of parameters but for which no TPCs will be developed. Surveillance and supporting data collection that will be undertaken with existing SANParks capacity are:

- Meteorology - daily (08h00) measurements (dry bulb temp, wet bulb temp, max temp, min temp, rainfall @ 1.2m, rainfall @ 0.2m, A-pan evaporation, S-pan evaporation, cloud cover, visibility, wind direction) at Rondevlei 3rd order meteorology station.
- Submerged aquatic plants (*Zostera capensis*, *Potamogeton/Ruppia*, *Ceratophyllum demersum*, *Chara* spp, *Najas marina*, epiphytic and epipsammic algae) and detritus biomass - annual assessment (May-June) in all lakes and estuaries.
- Sediment movement - sediment profiles (Swartvlei Estuary = 10; Touw Estuary = 15) measured in the lower portions of estuaries, usually annually though the frequency may alter depending on the interval between estuary breaching.
- Water quality (temp, pH, salinity, conductivity, TSS, TDS, turbidity, secchi depth) - quarterly measurements (January, April, July, October) in lower portions of six rivers (Touw, Duiwe, Langvlei Spruit, Wolwe, Karatara, Höekraal) entering the Touw and Swartvlei systems.

Surveillance that is undertaken by external agencies but where the available data could be used to support the Wilderness NP monitoring programme includes:

- Water level in lakes and estuaries - continuous measurements (typically approximately 6 minute intervals) in Touw Estuary, Eilandvlei, Langvlei, Rondevlei and Swartvlei Lake by the Department of Water Affairs and Forestry (DWAF). Approximate 3 month lag between data measurement and availability.
- Water quality in rivers - usually monthly measurement of electrical conductivity, total dissolved solids, pH, and concentrations of Mg^{2+}, Na^{+}, Cl^{-}, K^{+}, F^{-}, Si, HCO_3^{-}, SO_4^{2-},

$CaCO_3$, NH_4^+, NO_3^-+NO_2^+ and PO_4^{3-} in the mid to upper reaches of four rivers entering the Wilderness lakes by DWAF. Approximate 6 month lag between data measurement and availability.
- Flow volumes in the Duiwe, Höekraal and Karatara rivers by DWAF.
- River health assessments in Touw, Duiwe, Diep/Wolwe, Klein Wolwe, Höekraal and Karatara rivers by team lead by CapeNature with logistical and field assistance by DWAF and SANParks.

7. Future monitoring requirements

The Wilderness NP has one of the most comprehensive environmental monitoring and surveillance programs of any national park in South Africa, which represents a significant investment of resources in such a relatively small land area, particularly when it is considered that the 2 595 ha Wilderness NP, the smallest of 21 national parks, comprises less than 0.07% of the approximate 3 750 000 ha South African national park estate. The future trend may well not be to significantly expand the monitoring programme, but rather wherever possible to reduce it in a way that does not result in reduced understanding of environmental change or predictive capability. There is a growing school of thought that the diversity and complexity of ecological systems can be traced to a small number of highly influential processes (biotic and abiotic) with few species running these processes (Holling 2001). Identification and emphasis of such processes or species as indicators within a monitoring program should form component of a regular evaluation and review process. It is also probable, however, that future environmental and/or legislative changes may necessitate incorporation of indicators not currently included within the monitoring and surveillance programme. At present it is foreseen that, subject to the availability of resources and increased SANParks capacity, the environmental monitoring/surveillance program could benefit by inclusion of assessments of:
- Estuarine fish resource utilization in the Touw and Swartvlei systems.
- RDB freshwater fishes, particularly the forest lineage of *Pseudobarbus afer* (Swartz *et al.* 2007).
- RDB plant populations, particularly *Disa procera* and *Disa hallackii* (Kraaij 2007).
- Freshwater aquatic invertebrates (SASS Ver.5), particularly in catchments with intensive resource utilization.
- Terrestrial alien and extralimital biota.

Mechanisms to evaluate the achievement of unmonitored conservation sub-objectives (consolidation and expansion of land areas; reintroduction of locally extinct biota; impact of internal and external developments and activities; illegal harvesting) will also need to be developed by Park Management.

Finding the appropriate balance between inclusiveness, efficiency and economy will be ongoing.

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Appendix 1 - Species mentioned in text

Plants

Agathosma spp.	-	buchu
Arundo donax	-	giant reed
Azolla filiculoides	-	red water fern
Ceratophyllum demersum	-	water hornwarth
Chara spp.	-	stoneworts
Disa hallackii	-	orchid / "moederkappie"
Disa procera	-	orchid / "moederkappie"
Felicia spp.	-	daisy / "bloublommetjie"
Juncus kraussii	-	sharp dune slack rush
Metalasia spp.	-	"blombos"
Muraltia spp.	-	purple gorse
Najas marina	-	prickly waternymph
Phragmites australis	-	common reed
Potamogeton pectinatus	-	fennel-leaved pondweed
Ruppia cirrhosa	-	spiral tassleweed
Salvinia molesta	-	Kariba weed
Schoenoplectus scirpoideus	-	clubrush
Typha capensis	-	bulrush
Zostera capensis	-	eelgrass

Invertebrates

Callianassa kraussi	-	sandprawn
Upogebia africana	-	mudprawn

Fishes

Clarias gariepinus	-	sharptooth catfish
Cyprinus carpio	-	common carp
Gambusia affinis	-	mosquito fish
Hippocampus capensis	-	Knysna seahorse
Micropterus dolomieu	-	smallmouth bass
Micropterus salmoides	-	largemouth bass
Oreochromis mossambica	-	Mozambique tilapia
Pseudobarbus afer	-	Eastern cape redfin

Birds

Alopochen aegyptiacus	-	Egyptian goose

Anas smithii	-	Cape shoveler
Anas undulata	-	yellow-billed duck
Anhinga melanogaster	-	African darter
Ardea cinerea	-	grey heron
Circus ranivorus	-	African marsh-harrier
Egretta garzetta	-	little egret
Fulica cristata	-	red-knobbed coot
Gallinula chloropus	-	moorhen
Haliaeetus vocifer	-	fish eagle
Himantopus himantopus	-	black-winged stilt
Hoplopterus armatus	-	blacksmith plover
Larus dominicanus	-	kelp gull
Netta erythrophthalma	-	southern pochard
Phalacrocorax africanus	-	long-tailed cormorant
Phalacrocorax carbo	-	white-breasted cormorant
Podiceps cristatus	-	great crested grebe
Porphyrio porphyrio	-	purple swamphen
Tachybaptus ruficollis	-	little grebe