

**GEOMORPHOLOGY, ICHTHYOFAUNA,
WATER QUALITY AND AESTHETICS OF
SOUTH AFRICAN ESTUARIES**

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PREPARED FOR: Department of Environmental Affairs & Tourism
Private Bag X447
PRETORIA
0001
SOUTH AFRICA

PREPARED BY: Division of Water, Environment and Forestry Technology
ENVIRONMENTEK
CSIR
P O Box 17001
CONGELLA
4013
SOUTH AFRICA

PROJECT TEAM: T. D. Harrison, J. A. G. Cooper* & A. E. L. Ramm**

*Coastal Studies Research Group
University of Ulster
COLERAINE
BT52 1SA
NORTHERN IRELAND

**Ecology & Environment Inc.
8438 Lyons Rd
Sherman
NEW YORK
14787
UNITED STATES

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EXECUTIVE SUMMARY

The South African 3 000 km coastline has approximately 370 outlets to the sea ranging from small coastal streams to large permanently open tidal estuaries. The current state of scientific information on the vast majority of these systems, however, is virtually nil. As part of a national program to assess the state of South Africa's estuarine environment, basic surveys were conducted on these systems during the period 1992 to 1999. This included ichthyofauna (fish), water quality, and geomorphological and aesthetic observations. Some 67% of South Africa's 'estuaries' have been surveyed to date. This baseline data has been analysed and synthesised to render it understandable to the non-specialist but at a sufficiently high level to inform potential end users of the state of South Africa's estuaries.

A conceptual classification of the geomorphic variability among South Africa's estuaries has been produced. Several systems particularly on the west coast were not considered estuaries either due to their small size, their ephemeral nature, or because they were essentially isolated. Six basic estuary types were identified. These were divided into normally open and normally closed systems. Two types of normally closed estuaries were recognised. These were systems where the water level was typically perched above sea level and those where the water level was approximately at sea level. In this report, however, the normally closed estuaries were sub-divided into small, medium, and large systems based on surface area. The normally open systems were divided into barred and non-barred estuaries. Two types of permanently open barred estuaries were recognised: river-dominated and tide-dominated systems. In this report the two types of normally open barred estuaries were not identified but were sub-divided into small and medium to large systems based on their mean annual runoff.

Based on the ichthyofaunal data and the geomorphological classification, the three biogeographic regions that characterise the coastline were identified and delineated. These were the cool-temperate region from the Gariiep (Orange River) estuary to Cape Agulhas, the warm-temperate region from Cape Agulhas to and including the Mdumbi estuary, and the subtropical region from the Mdumbi to Kosi Bay.

Aspects of the fish community structure of each geomorphic estuary type were investigated and each estuary type appeared to contain fairly distinctive fish assemblages although some overlap did exist. The fish community structure (species richness, composition and relative abundance) of each estuary type within each biogeographic region was described and this was used as a reference against which each estuary could be assessed.

In terms of their species richness, composition and relative abundance, two systems (8%) in the cool-temperate region had low ratings. Ten estuaries (42%) were rated as moderate and the remaining 12 systems (50%) had a good overall rating. Of a total of 119 estuaries analysed in the warm-temperate region, nine (8%) had a relatively poor overall rating, 35 (29%) were rated moderate and the remaining 75 (63%) had a good overall rating. In the subtropical region, three estuaries (5%) were rated poor, 23 (36%) had a moderate overall rating and the remaining 37 (59%) had a good rating.

The results of the water quality surveys were summarised into an estuarine water quality index (eWQI) to provide a 'snapshot' of the average water quality of South Africa's estuaries. Six indicators of estuarine water quality were chosen and these were divided into three categories: suitability for aquatic life (dissolved oxygen, oxygen absorbed, unionized ammonia), suitability for human contact (faecal coliforms), and trophic status (nitrate nitrogen, ortho-phosphate). The effect of including/removing chlorophyll-*a* in the water quality index was also tested. The results indicated that the exclusion of chlorophyll had no significant effect on the relative index ranking for the estuaries tested. The sensitivity of the index to various aggregation formulas was also tested. Alternative formulations did not significantly alter the relative ranking of the estuaries tested. Using the eWQI values, five water quality classes were identified. Approximately 74% of all the systems sampled were classified in a "Fair" or better condition. The remaining 26% were classed as "Poor" or "Very Poor". Systems on the south and south-east coasts had the best overall water quality with a preponderance of estuaries classed as "Good" or "Very Good". Estuaries on the Transkei and KwaZulu-Natal had a relatively high proportion of systems in "Poor" condition.

Aesthetic observations on each estuary were divided into 14 weighted categories: floodplain landuse, shoreline status, estuary surrounds, bridges, dams and weirs, mouth stabilisation, litter and rubble, human use, algal growth, turbidity, odour, air pollution, noise, and invasive and exotic vegetation. The aesthetic state of each estuary was assessed according to the type and degree of impairment to each category. Overall, 251 systems were assessed and 18 (7%) had relatively poor aesthetic ratings, 88 (35%) were regarded as moderate while the remaining 145 (58%) were rated relatively good aesthetically.

The results of this study provide a useful summary of the status of South Africa's estuaries, however, there exists a need to make all of the basic data, as well as various forms of summarised data, available to interested parties from scientists to managers and even the general public. Furthermore, much of the baseline data collected during these surveys has not been fully analysed. The assessment of the fish fauna was only based on a few components of the fish community. Other aspects of community structure such as biomass composition, life-history styles and trophic structure should be investigated. In terms of water quality, a physical water quality impairment category, involving such indicators as temperature, salinity, pH, and turbidity should be explored. Also water quality rating curves for different estuary types should be investigated.

There are also some obvious significant gaps in the database. A number of estuaries, particularly in the Transkei, have not been sampled and these gaps need to be filled. The geomorphological classification is based only on available data and additional information is required to improve its resolution for example data on mouth condition and tidal prisms. Long-term data sets are also required to establish the range of the natural variation between and within estuaries on a seasonal basis. This would provide a better understanding of how estuaries of various types function, a critical requirement for effectively managing coastal issues such as artificial breaching, estuarine water requirements, eutrophication of estuaries, and biological functioning. There is also a lack of a cohesive plan for temporal monitoring of key systems. Investigations into other estuarine components (e.g. hydrology, sediment

biogeochemistry, vegetation, zooplankton, zoobenthos, birds, habitat assessment, catchment land-use) should also be undertaken to ensure a more complete appraisal of the ecological integrity of the nation's estuarine resource.

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1.

INTRODUCTION

The South African coast is well endowed with estuaries and in many areas they form an important element of the coastal zone ecologically, economically and culturally. Estuaries are, however, more than simply discrete elements of the coastal zone. They form an interface between the terrestrial drainage system and the sea and are thus susceptible to changes far inland in the coastal hinterland. In addition, estuaries can be viewed as the landward extension of the marine ecosystem, and are thus also influenced by conditions at sea.

The transitional position of estuaries means that they are subject to a diverse range of factors that influence their function, importance, and state. The value or status of an estuary or group of estuaries can be assessed from many different perspectives (e.g. ecological, socio-economic, cultural). An indication of an estuary's condition might be regarded as not only indicative of the estuary itself but to a certain extent of the health of its hinterland and the adjacent marine environment.

To determine the health of an estuary, a wide variety of approaches could be taken, depending on one's perspective, scale of interest, or area of responsibility. Such an assessment usually requires some baseline or reference against which to measure the current state and to monitor improvement or degradation. However, little or no scientific information exists on many South African estuaries and hence the potential for holistic estuarine management was much curtailed.

The objectives of this study were (i) to conduct multidisciplinary basic surveys of South Africa's estuaries using a consistent protocol for sampling and analysis and (ii) to compile these data in such a form that the status of estuaries could be ascertained at regional and individual levels. This report and the data acquired in its compilation represents the most comprehensive assessment and collection of baseline data on South African estuaries yet undertaken. The data can be accessed at a variety of levels from precise data on each individual system to condensed and simplified data on groups of estuaries or estuaries within a particular region. An approach to the

assessment of South Africa's estuaries and the presentation of that information in a useful format for managers with a variety of interests and areas of responsibility is outlined in this report.

The final representation of data in the form of indexed strip map information is intended as a guide to the status of the estuary at the time that it was sampled. The structure of the index means that the estuary is being compared with others that are similar to it and thus its status may be regarded as an absolute measure. It is cautioned, however, that simplification of data may mask details that exists in the data pertaining to an individual system. While this is a necessary sacrifice in order to gain a regional or national perspective on estuary status, the regional data should be interpreted only in an indicative way. For example, a low water quality score in one of the water quality categories might be regarded as indicative of a potential problem and might require further investigation to determine its persistence.

This research is based on seven years of intensive field sampling during which some 250 estuaries were visited between the Orange (Gariep) and Kosi Bay. At each estuary a suite of geomorphological, ichthyological, water chemistry and aesthetic measurements were made in a consistent manner. These data are recorded on a CSIR database. In addition, preliminary reports on the status of each individual system were compiled on a regional basis at the conclusion of each year's fieldwork. These reports (Cooper *et al.*, 1993, Harrison *et al.*, 1994, 1995, 1996, 1997, 1998) each deal with about 50 estuaries that were sampled each year and contain further information on individual systems as well as a preliminary index assessment of the status of each system. Because the reports were based on purely practical constraints of resource availability that determined a 50 estuary per year sampling strategy, they did not explicitly take account of the biogeographic variability of the coast. In addition, each year effectively extended the available database and yielded findings that influenced the interpretations in the previous reports. This summary report which condenses the findings of previous reports, and attempts to take a national perspective on estuarine status and variability, takes account of biogeographic constraints and utilises the full dataset available in an attempt to address the status of South African estuaries.

This report is divided into several sections dealing with specific, linked elements of the estuarine environment. Firstly, the geomorphology is addressed which provides the physical basis for variability between estuaries, secondly, the fish communities collected in estuaries is discussed and interpreted, thirdly, the water quality parameters measured in the field are described and interpreted and fourthly, the aesthetic parameters as assessed in the field are detailed. In the final analysis these data are amalgamated to produce a composite index that provides an indication of the health of each estuary relative to others of the same type.

In this report a geomorphological classification of each of the estuaries sampled is presented. This enabled the recognition of several types of estuaries which then permits individual systems to be properly compared with physically similar estuaries. This is a necessary prerequisite such that estuaries of vastly different characteristics are not compared with each other. The specific types of estuary identified are then considered from a fish community perspective. A set of fish expectation criteria was drawn up for each type of estuary, against which actual fish communities could be compared and assessed. The water quality parameters measured in each estuary are transformed from their original units to comparable scales and grouped to reflect suitability for various uses (human contact, aquatic life and trophic status). An aesthetic assessment was undertaken based upon a combination of factors related to the estuary floodplain, its surrounds and the water surface of the estuary and assesses the deviation from natural conditions.

In this report, a level of depiction of estuarine status has been selected that enables the four parameters to be assessed and some of these to be sub-divided. The geomorphological type of an estuary is identified so that its condition relative to others may be assessed. The fish community data is reduced to a three-factor index of health as reflected in the fish fauna, the water quality is expressed as a three-factor index of water suitability and the aesthetic data is presented as a single value figure of deviation from natural conditions. The objective in doing this is to render baseline data understandable to the non-specialist and to depict it at a sufficiently high level to inform potential managers and users of the status of estuaries on the South African coast.

Each of these parameters can be assessed at higher and lower levels than those presented here, but the choice of depiction at this level is seen as a compromise between detail and perspective such that large strips of coast can be assessed at a suitable level of detail without losing the regional perspective. This report is designed as an aid to coastal zone management; by reference to it, the relative status of estuaries can be assessed on the basis of data collected during these surveys. Identification of potential problems is aided by the presentation of the information at an interpreted level rather than as raw data. This does hold a number of advantages and also several disadvantages and in terms of the latter, several points should be stressed. These are outlined below.

The geomorphological classification presented is based on available data, which is in many cases, insufficient to classify an estuary to the highest level of resolution, thus some variation may exist among the groups identified. Additional information is required to enhance this classification and enable finer levels of subdivision.

The fish community structure is based on a comprehensive sampling programme at each site. It is, however, recognised that these one-off sampling exercises may yield anomalous results under certain circumstances (recent floods, breaches, etc). This is an unavoidable constraint, imposed by sampling many systems in a short period.

The water quality data were collected at an instant in time and may therefore not be representative of long-term conditions, or of episodic events in estuaries. Again, this is an unavoidable effect of large spatial scale sampling.

In each instance, the information presented provides a baseline against which to monitor change and to assess future trends. In every instance, more detailed information is held by the authors in a raw data form.

The report should be regarded as an indicative guide to the status of estuaries around the South African coast and it is hoped it will identify actual and potential environmental problems and assist in planning future monitoring and research needs.