

**CAPE ACTION PLAN FOR THE
ENVIRONMENT**

**FINAL REPORT OF THE
ESTUARINE COMPONENT**

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EXECUTIVE SUMMARY

In order to assess the biodiversity of estuaries within the Cape Floral Kingdom, data were collated on the distribution of various species of aquatic plants, invertebrates, fish and birds. In this initial phase, all South Africa's estuaries were included to determine the comparative importance of the CFK estuaries, which were then rated in terms of their conservation value. In addition, threats to these estuaries were identified and ranked.

KEY FINDINGS

- Data on the distribution and abundance of most groups of organisms, and in particular invertebrates, are limited.
- Some process data are wholly inadequate, e.g. data on the movements, reproduction and recruitment of fishes, particularly those which are endemic to southern Africa and which are exploited by commercial and/or recreational fisheries.
- Estuarine biodiversity was found to be relatively low on the west coast, increasing towards the south and east coasts. Consequently, estuaries within the CFK region have a moderate level of biodiversity when viewed in a national context. Endemism is relatively high, and estuaries within the CFK region house almost 70% of South Africa's endemic estuarine fishes.
- In determining the conservation importance of the CFK estuaries, they were assessed in terms of their ability to conserve:
 - particular groups of organisms
 - ecological processes that maintain the integrity of estuarine ecosystems
 - exploited and exploitable resources for the benefit of humans
 - all of the above combined.

Of the 58 estuaries studied within the CFK region, 23 were highlighted as being important in at least one of these proposed scenarios, with 65% of these being important in more than one of the proposed scenarios.

MAJOR THREATS

- Numerous threats which currently operate on estuaries in the C.A.P.E. region were identified. The majority of these affect the physical environment and the dynamics of the estuarine systems, and in so doing are liable to affect the biotic composition of the estuaries. These threats include alteration or interference with the dynamics of the estuary mouth, development surrounding and encroaching on the estuary, pollution (in terms of litter, sewage and other chemical pollution), water abstraction from catchment areas, and siltation.. Direct threats to the biota of estuaries include the exploitation of organisms (especially fish and bait organisms) and disturbance to the biota (especially birds).
- Threats may come from within the estuary itself, but are also imposed on the estuary through the terrestrial, freshwater and marine environments surrounding the estuary. In addition, these threats are not only generated within the surrounds of the estuary, but also in their catchment areas.

STRATEGY IMPLICATIONS

- Effective estuarine conservation requires improved knowledge on the distribution of species, as well as processes that affect them.
- All estuaries are unique and deserve some form of conservation, whether in the form of direct protection, such as reserves, or management actions such as pollution control and periodic flood releases to flush siltation.
- The 23 estuaries highlighted in this report are those which are most likely to conserve current estuarine biodiversity within the C.A.P.E. region, and should thus receive the most immediate attention.
- The dynamics of estuaries are highly dependent on upstream catchment processes. It is therefore necessary to conserve not only the estuary, but also its entire catchment.

BIODIVERSITY IN C.A.P.E. ESTUARINE SYSTEMS

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1 INTRODUCTION

1.1 THE DYNAMICS OF ESTUARINE SYSTEMS

Estuaries are formed where freshwater from rivers meets the saltwater of the sea. The water in estuaries is very seldom static - it is almost always flowing. Freshwater flows in from rivers, while the water is alternately pushed in or sucked out of the mouth of the estuary by the tide. As a consequence, estuaries are highly dynamic systems.

Estuaries are also highly productive systems. Unlike other marine systems, phytoplankton do not form the basis of the food web. The major reason for this is that planktonic organisms experience great difficulty in maintaining their position in an estuary against the flow gradient. Instead, the food base in estuaries is provided by aquatic macrophytes and benthic diatoms. This is enhanced by a highly efficient decomposer cycle.

Very little of the water in an estuary is a mixture of fresh-and saltwater. Due to the higher density of seawater, this component usually lies near the substratum, forming what is known as a salt wedge, which is alternately pushed up or sucked down the estuary by the tide. Freshwater, flowing in from upstream, is less dense and thus tends to flow over the top of the salt wedge.

Tidal changes in estuaries have the result of changing the salinity as the salt wedge oscillates, thus subjecting some organisms to alternately high and low salinities. These oscillations may also result in changes in temperature. Possibly the most profound tidal change in estuaries is the exposure of often large areas of sand- or mudflat during low tide. Organisms need to be adapted to cope with increased temperatures and the threat of desiccation at low tide, as well as total submersion during high tide. These tidal fluctuations are, however, regular and predictable, and organisms living in estuaries are well adapted to cope with them.

It is the inflow from rivers that presents the greatest challenge to estuarine organisms. A massive influx of freshwater during a flood may lower the salinity drastically throughout the estuary, and may last for long periods. Although estuarine organisms are generally able to tolerate a wide range of salinities, the suddenness with which this can happen, the extent to which the salinity may decrease, and the length of time over which this may persist, can often exceed their capabilities to deal with it, and mass mortalities may result. Because of the unpredictability of these events, few organisms are able to adapt to such extremes. Reduced water inflow may be just as disastrous for estuarine organisms. If freshwater inflow is reduced, salinity may increase to such a level that the physiological capabilities of estuarine organisms to deal with high salinity is exceeded, again resulting in mass mortalities. This example has served to illustrate that estuaries exist in a delicate balance maintained primarily by freshwater inflow.

Some estuaries are characterised by having mouths which are permanently open, others by mouths which are permanently closed, and still others in which the mouth opens on a regular basis, but is closed for some or most of the time. The opening or closure of an estuary mouth depends on the interaction between wave action on the seaward side and the inflow of water from the river. The open or closed state of an estuary has a large bearing on the number and types of species which are present in the estuary. In addition, the timing of mouth opening, especially relative to the timing of recruitment by marine organisms such as fish, may determine the species complement in the estuary.

1.2 SCOPE AND METHODOLOGY

The C.A.P.E. region includes all estuaries from the Olifants River Mouth on the west coast to the Van Stadens River Mouth just west of Port Elizabeth. For the purposes of this section of the report, however, all the estuaries along the South African coast have been considered, in an attempt to place those within the C.A.P.E. region into a national context.

For the purposes of the C.A.P.E. project, estuaries are loosely defined as brackish-water coastal systems. This includes water bodies which are not strictly estuaries, but which do contain assemblages typical of estuaries. Some overlap with the Freshwater Resources component is inevitable but not, however, disadvantageous.

Estuaries generally function independently of one another. Each also usually suffers from a unique combination of management or conservation problems due to differences in geographical location, upstream processes, flow requirements, alteration (both within the estuary and upstream), surrounding development and human commercial or recreational use. Estuaries are thus treated as individual units of the purposes of this report, although some broad generalisations can be made.

Existing data have been and are currently being amalgamated into databases which detail the species richness of the biota within each estuary. Where reliable data exist, measures of abundance will also be used. Organismal groups were chosen for inclusion primarily on the basis of the availability and quality of existing data. Groups chosen were aquatic macrophytes, macro-invertebrates, fishes and birds. Planktonic organisms have not been included as they have not been studied in sufficient detail in the majority of South African estuaries.

This report deals specifically with the composition of the biota of South African estuaries, and serves primarily to describe the diversity present within these. Later stages of this project will incorporate factors such as areal extent of each estuary, and the current state and conservation status, development, commercial or recreational use, and rehabilitation potential of each system in order to devise a practical method for priority ranking of estuaries for conservation purposes.

2 DISTRIBUTION AND BIOGEOGRAPHY OF SOUTH AFRICAN ESTUARIES

Estuaries are not evenly distributed around the South African coast, primarily as a result of the strong rainfall gradient that exists, with the western areas being dry and

more easterly areas far wetter. As a consequence, the west coast of South Africa has only 20 estuaries (9% of the total for the country), while the south and east coasts have 85 and 124 respectively (37% and 54%). Just over one quarter of the estuaries within South Africa fall within the Cape Floristic Region (27%; $n=61$), making this an important region in terms of estuaries.

3 BIODIVERSITY IN SOUTH AFRICAN ESTUARIES

3.1 AQUATIC MACROPHYTES

Species richness of aquatic macrophytes was investigated in 151 South African estuaries. Species richness appeared to peak on the south coast, tailing off in estuaries situated towards the west and east (Figure 1). Of the five most species rich estuaries, only one falls within the C.A.P.E. region (Figure 2). The other four were the Swartkops, Riet, Bira and Keiskamma estuaries. The most species rich estuary within the C.A.P.E. region is Elandsbos, followed by the Klein at Hermanus, the Knysna lagoon and the Piesang and Keurbooms estuaries.

Only one species of aquatic macrophyte was recorded in 51 estuaries around the South African coast (Figure 2). Of these, ten fall within the C.A.P.E. region. These are: Steenbras, Breede, Maalgate, Gwaing, Goukamma, Noetsie, Storms, Groot (east), Klipdrift and Kromme estuaries.

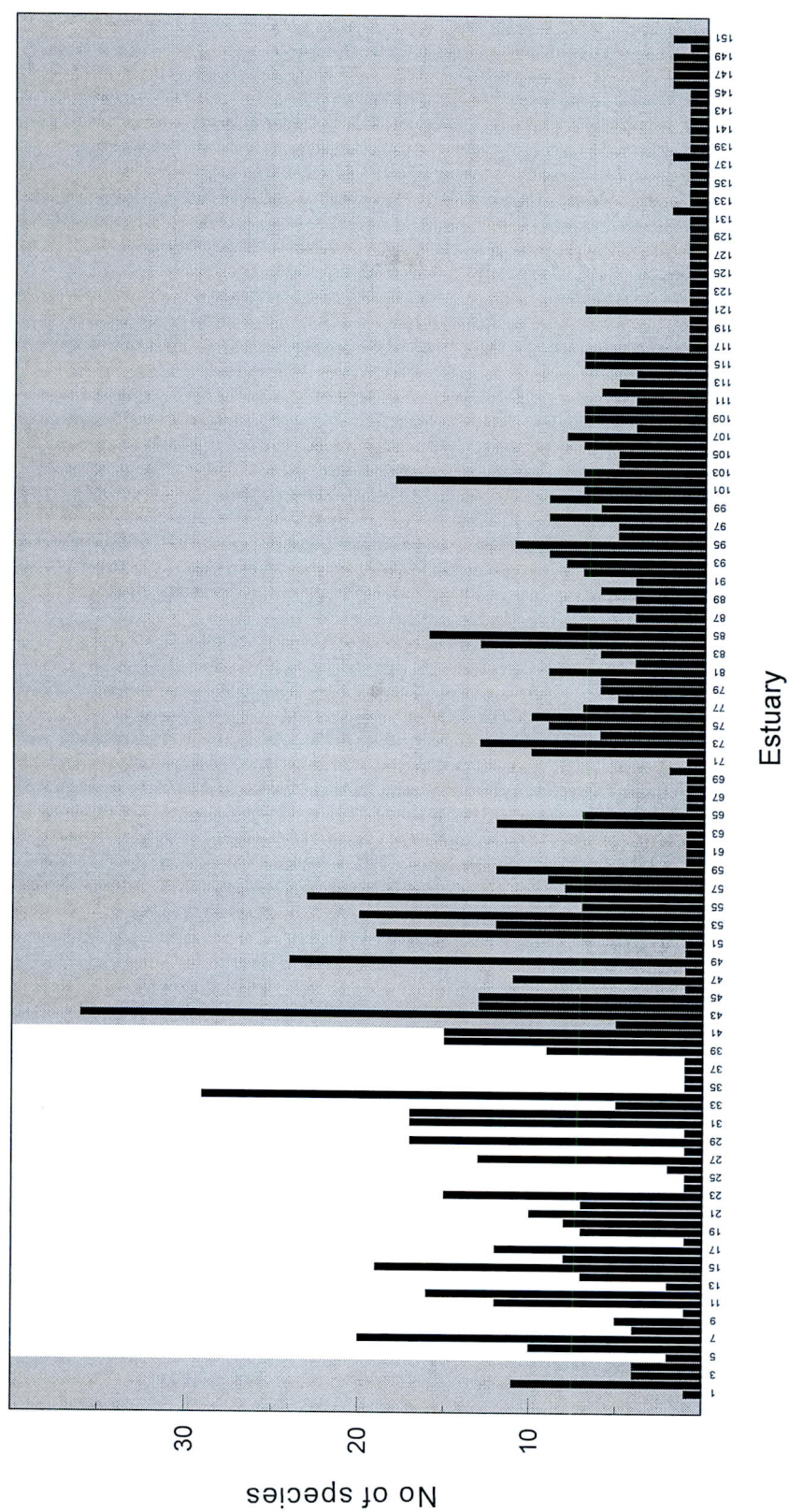


Figure 1. The number of macrophyte species recorded from 151 estuaries ordered from west to east around the South African coast. The shaded area represents that which is outside of the Cape Floristic Region. The numerical codes for estuaries can be found in Table 1.

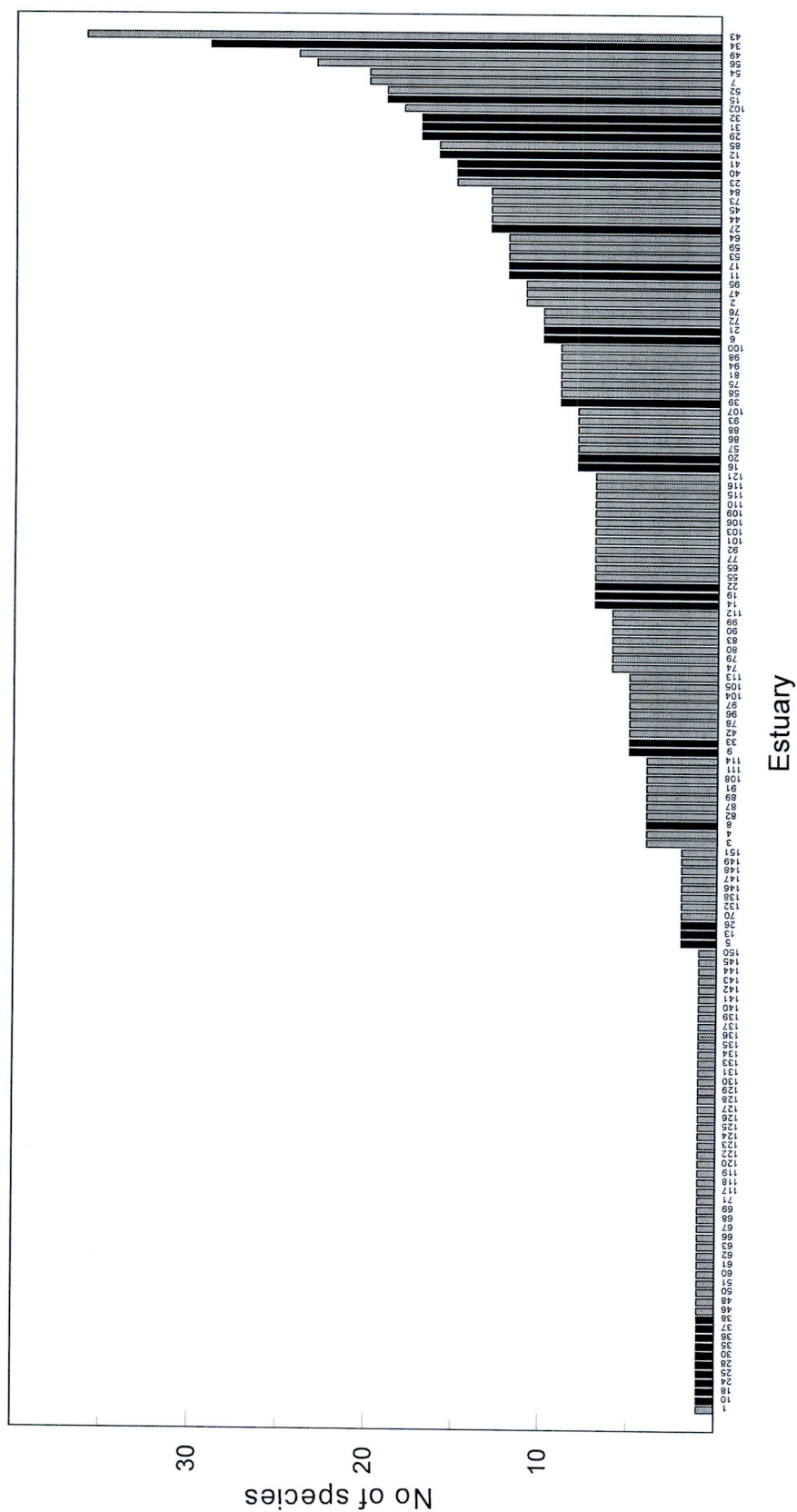


Figure 2. The number of macrophyte species recorded from 151 estuaries on the South African coast. Estuaries are ordered in increasing species richness. Solid bars represent estuaries which occur within the Cape Floristic Region, while shaded bars represent estuaries outside of the Cape Floristic Region. The numerical codes for estuaries can be found in Table 1.

Table 1. Numerical codes and estuary names for macrophyte data.

NUMBER	SYSTEM	NUMBER	SYSTEM	NUMBER	SYSTEM
1	Orange River	52	Great Fish	102	Mgazana
2	Buffels (west)	53	Mpekweni	103	Mngazi
3	Swartlintjies	54	Bira	104	Mzimvubu
4	Groen	55	Gqutywa	105	Nkodusueni
5	Olifants	56	Keiskamma	106	Mntafutu
6	Verlorenvlei	57	Nqinisa	107	Mbotyi
7	Wildevolevlei	58	Kiwane	108	Mkweni
8	Silvermine	59	Tyolomnqa	109	Msikaba
9	Zeekeo	60	Gxulu	110	Mtentu
10	Steenbras	61	Goda	111	Sikambe
11	Rooi-els	62	Hickmans	112	Mnyameni
12	Buffels (Pringle Bay)	63	Buffalo	113	Mpahlanyana
13	Palmiet	64	Nahoon	114	Mpahlane
14	Kleinmond	65	Gqunube	115	Mzamba
15	Klein (Hermanus)	66	Kwelera	116	Mtamvuna
16	Uilkraals	67	Bulwa	117	Sandhlundhlu
17	Heuningnes	68	Cintsa	118	Ku-Bobyi
18	Brede	69	Kwenxura	119	Mpenjati
19	Duiwenhoks	70	Nyana	120	Mbizana
20	Kafferkuils	71	Haga-haga	121	Bilanholo
21	Gouritz	72	Kuko	122	Kongweni
22	Blinde	73	Great Kei	123	Vungu
23	Hartenbos	74	Gwara	124	Mzimkulu
24	Maalgate	75	Qolora	125	Mtentweni
25	Gwaing	76	Kobonqaba	126	Mhlangamkulu
26	Kaaimans	77	Ngqwana	127	Mhlungwa
27	Swartvlei	78	Sihlantweni	128	Mtwalune
28	Goukamma	79	Qora	129	Zafa
29	Knysna	80	Jujura	130	Mzinto
30	Noetsie	81	Nqabara	131	Mpambanyoni
31	Piesang	82	Ngoma	132	Mahlongwa
32	Keurbooms	83	Mendu	133	Mkomazi
33	Bloukrans	84	Mbashe	134	Umgababa
34	Elandsbos	85	Mbanyana	135	Msibazi
35	Storms	86	Ntlanyane	136	Lovu
36	Groot	87	Nkanya	137	Manzimtoti
37	Klipdrift	88	Xora	138	Durban Bay
38	Kromme	89	Bulungula	139	Mgeni
39	Seekoei	90	Mnewasa	140	Mhlanga
40	Kabeljous	91	Mpako	141	Mvoti
41	Gamtoos	92	Nenga	142	Mdlotani
42	Van Stadens	93	Mapuze	143	Nonoti
43	Swartkops	94	Mtata	144	Zinkwasi
44	Coega	95	Mdumbi	145	Matigulu
45	Sundays	96	Lwandilana	146	Siyai
46	Boesmans	97	Lwandile	147	Mlalazi
47	Kariega	98	Mtakatje	148	Richards Bay
48	Kowie	99	Mnenu	149	Mklozi
49	Riet	100	Mtonga	150	St Lucia
50	Kleinmonde (west)	101	Sinangwana	151	Kosi Bay
51	Kleinmonde (east)				

3.2 INVERTEBRATES

Species richness of invertebrates in estuaries was accumulated for 29 estuaries spanning the South African coast. Although there is some noise in the data, it is evident that there is a trend of increasing species richness from west to east along the coast (Figure 3). This trend mirrors that for coastal invertebrates. The data do, however, show a high degree of variability. This variability may be caused by one or numerous factors, including differences in the size of the estuary, the intensity of sampling that has been undertaken in that estuary, the current condition of the estuary and the open or closed status of the mouth.

Figure 4 plots species richness in the 29 estuaries, but in this case the estuaries are ordered along the x-axis from least to most diverse. It is interesting to note that all three of the estuaries with the highest species richness fall outside of the Cape Floristic Region. Only one of the top five estuaries (in terms of species richness) falls within the Cape Floristic Region. This is the Breede River. Of the five estuaries which have the lowest species richness, two occur within the Cape Floristic Region. These are Wildevoelelei on the west coast of the Cape Peninsula, and the Gamtoos near Port Elizabeth. The three other estuaries with the lowest species richness are the Swartlinterjies and the Spoeg on the west coast and St Lucia on the northern KwaZulu-Natal coast. It is unlikely that this figure for St Lucia is accurate - in fact the database includes only 3 species present in this system. This result is likely to be an artefact of a paucity of data for this region.

Multivariate analysis based on the presence or absence of invertebrates in South African estuaries indicates some preliminary trends in biogeographic distribution (Figure 5). Again, various factors may be contributing to the quality and variability of these data. Nevertheless, three groupings may be established. Group A contains mostly estuaries situated on the west coast of South Africa, while Groups B and C are comprised predominantly of estuaries on the south coast. Groups B and C can be distinguished on the basis of their species richness. Estuaries in Group B display a moderate species richness (mean = 24.6; range = 14-37), while those in Group C have a far greater species richness (mean = 111.2; range = 57-188).

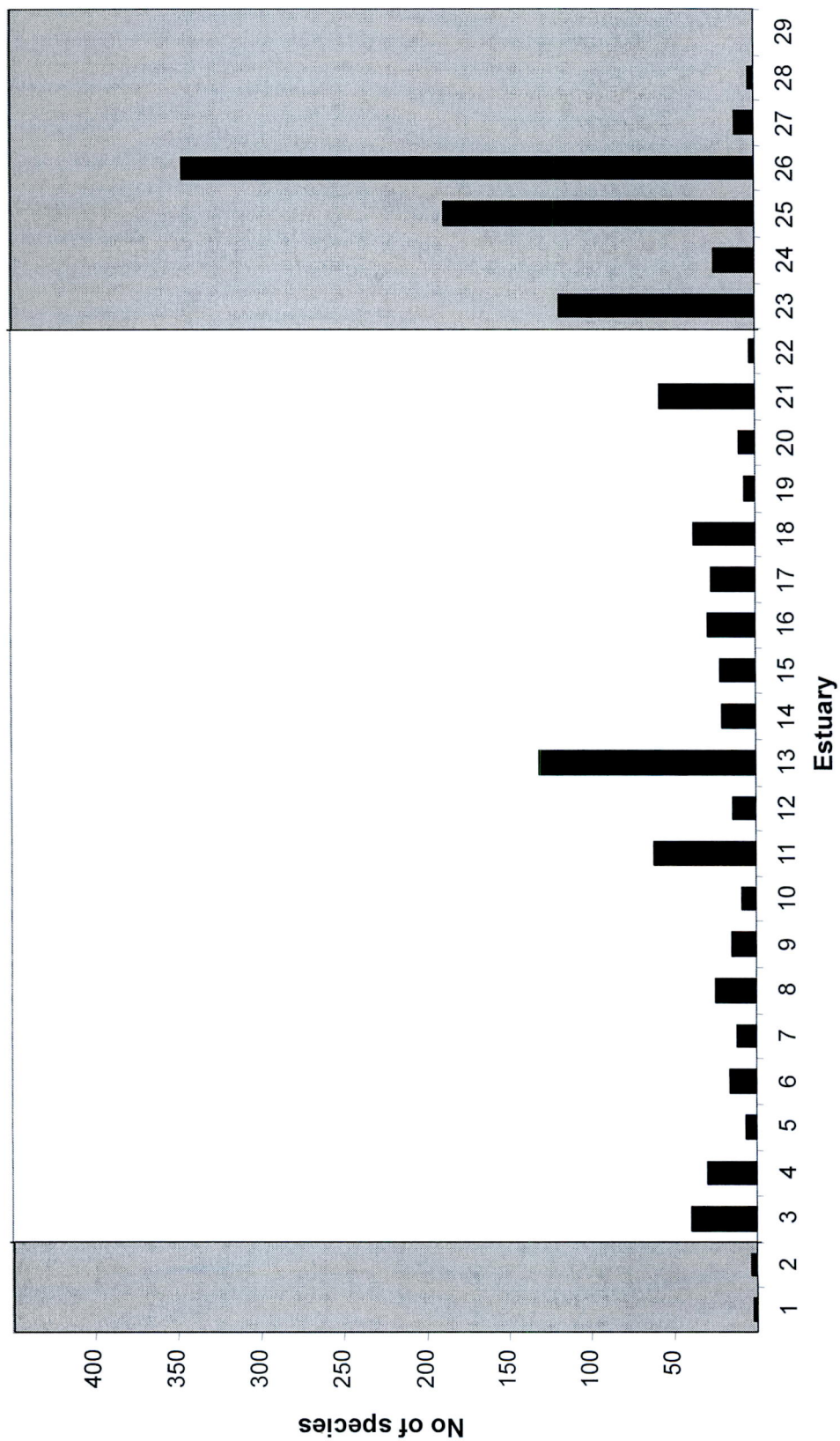


Figure 3. The number of invertebrate species recorded from 29 estuaries ordered from west to east around the South African coast. The shaded area represents that which is outside of the Cape Floristic Region. The numerical codes for estuaries can be found in Table 2.

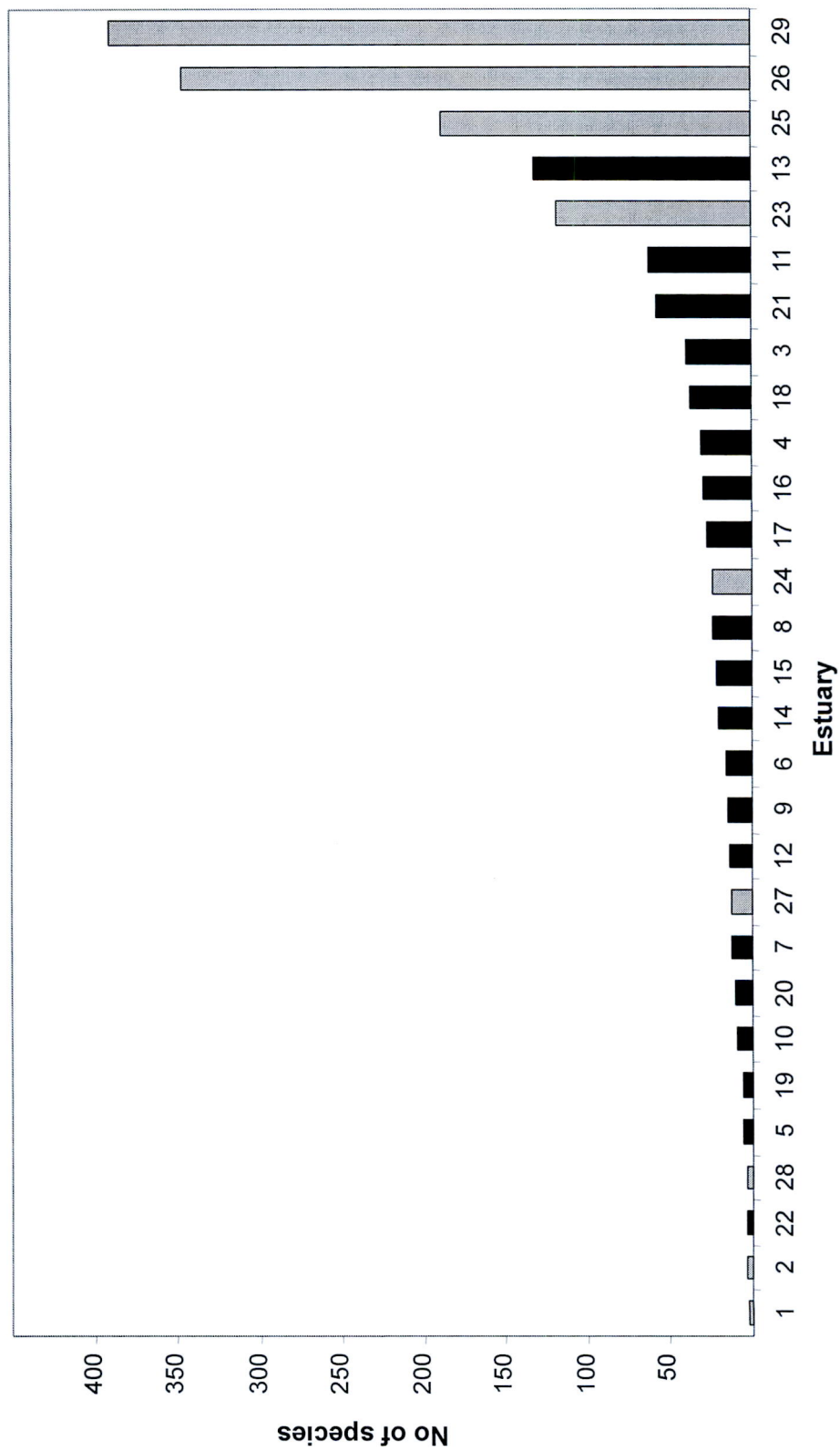


Figure 4. The number of invertebrate species recorded from 29 estuaries on the South African coast. Estuaries are ordered in increasing species richness. Solid bars represent estuaries which occur within the Cape Floristic Region, while shaded bars represent estuaries outside of the Cape Floristic Region. The numerical codes for estuaries can be found in Table 2.

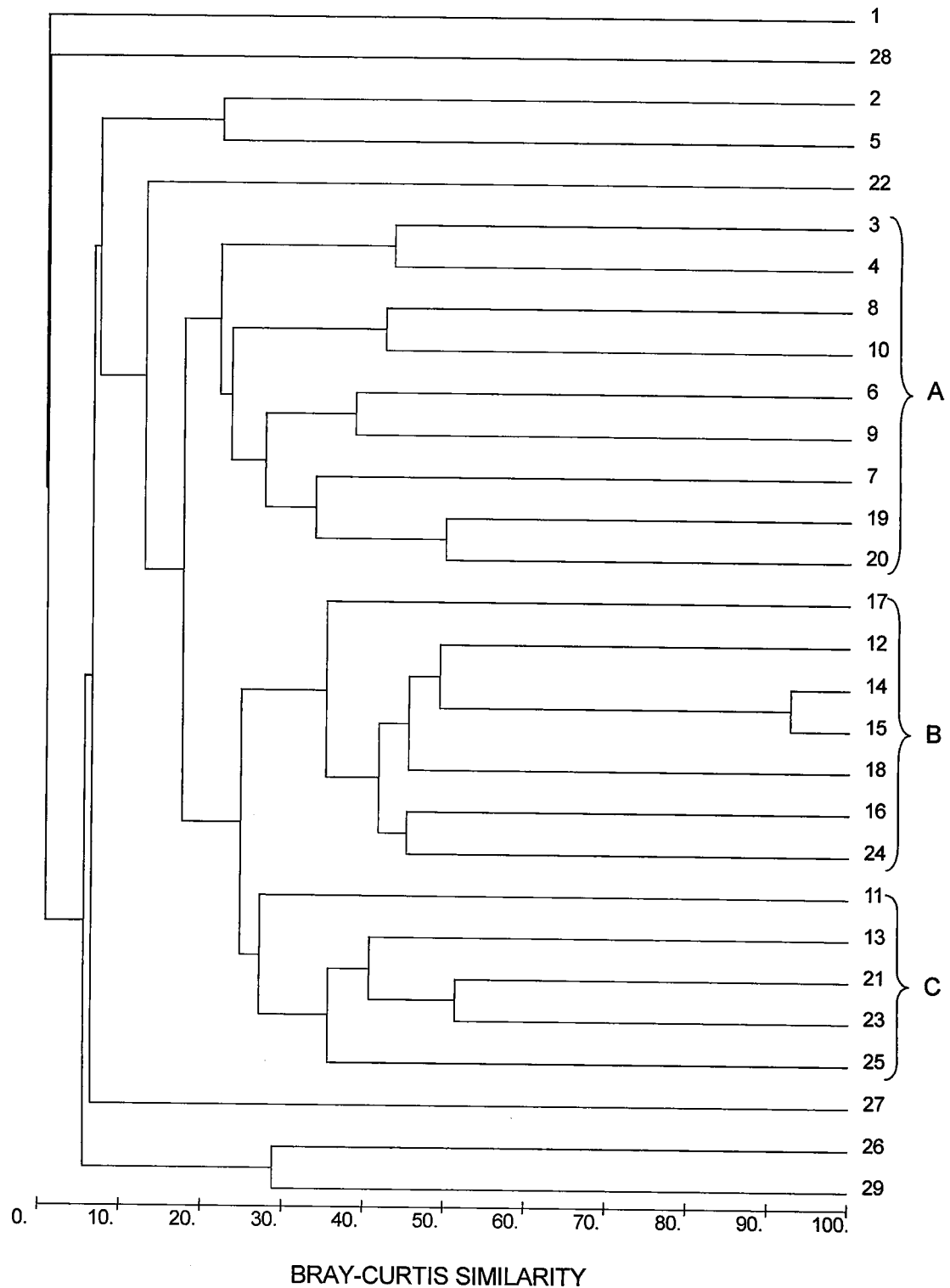


Figure 5. Dendrogram of similarities between estuaries based on the presence or absence of invertebrate species. Numerical codes for estuaries can be found in Table 2.

Table 2. Numerical codes and estuary names for estuarine invertebrate data.

NUMBER	SYSTEM
1	Swartlintjies
2	Spoeg
3	Olifants
4	Milnerton Lagoon
5	Wildevoevllei / Noordhoek
6	Sand
7	Rooiels
8	Palmiet
9	Bot
10	Onrus
11	Klein (Hermanus lagoon)
12	Heuningnes
13	Bree
14	Duiwenhoks
15	Kafferkuils
16	Groot Brak
17	Knysna
18	Keurbooms
19	Sout
20	Groot (Wes)
21	Kromme
22	Gamtoos
23	Swartkops
24	Nahoon
25	Mngazana
26	Durban Bay
27	Mhlanga
28	St Lucia
29	Morrumbene

3.3 FISHES

Using a subset of estuarine fishes, and their distributions as recorded in Day, Blaber & Wallace (1981), indicates that there are three major distributional groups of intertidal fish - those that occur only on the South African east coast, those whose distributions span both the south and east coasts, and those whose distribution ranges include the west and south coasts (Figure 6). Interestingly, unlike coastal invertebrates, no estuarine fish species occurs exclusively on the west coast. The areas in which species reach the ends of their distributional limits are Cape Point and Bashee River.

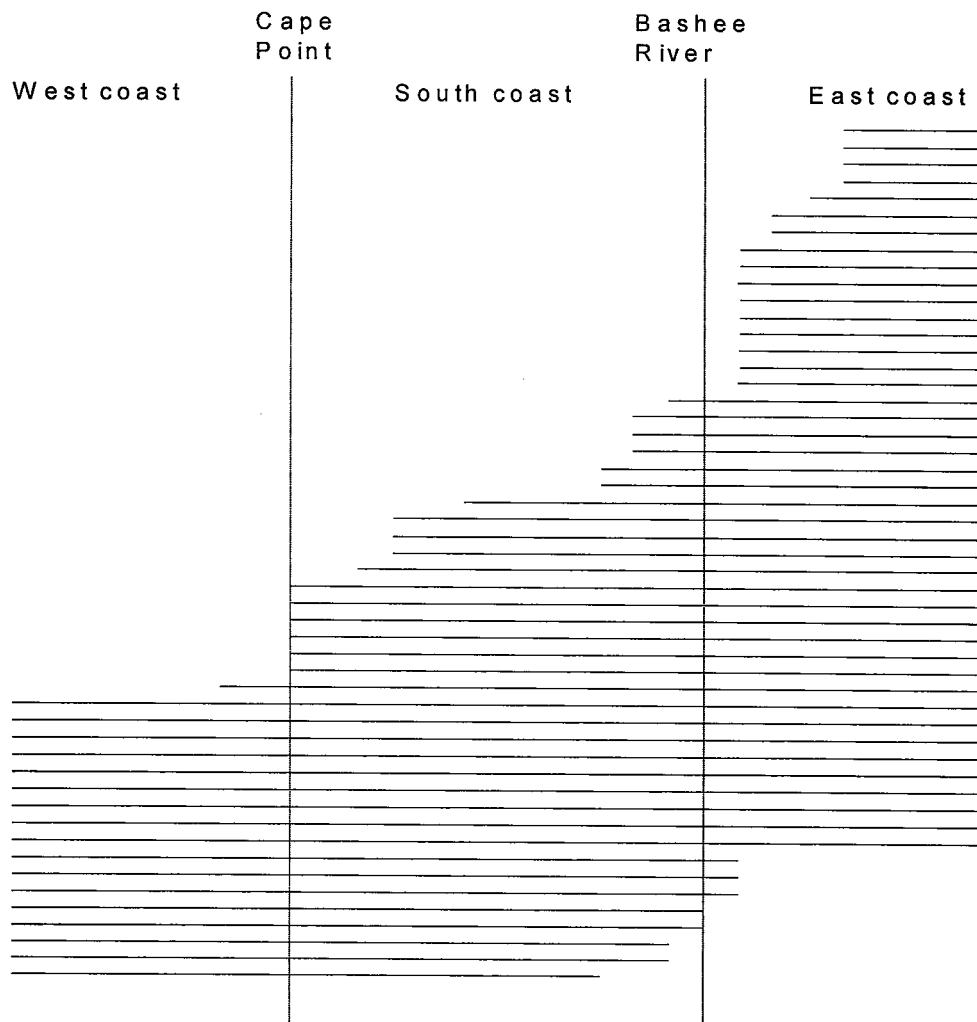


Figure 6. The distribution ranges of 57 species of estuarine fishes. Data were sourced from Day, Blaber & Wallace (1981).

The numbers of fish species occurring in the different marine biogeographic provinces of the country indicates an increase in species richness from west to east around the coast (Figure 7). Of the subset of 57 estuarine fish species, 18 occur on the west coast, 35 on the south coast, and 52 are found on the east coast.

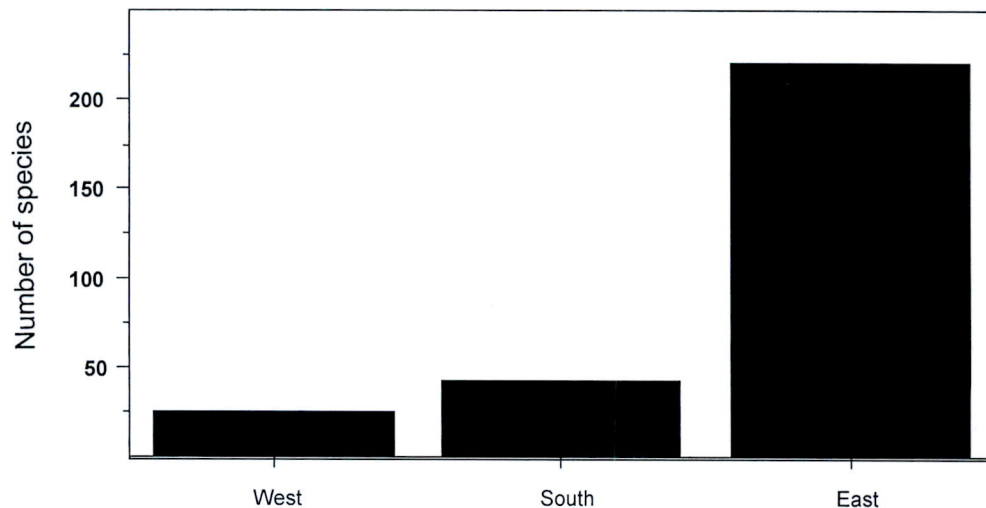


Figure 7. The number of fish species occurring in each of the three regions around the South African coast. Data were sourced from Smith & Heemstra (1986).

Although the number of species increases from west to east around the coast, the proportion of these that is made up by endemic species is greatest in the west and decreases towards the east (Figure 8). Investigating the endemic species more closely reveals that none of the endemic species occur exclusively in either the Cool Temperate West Coast or the Subtropical East Coast biogeographic provinces (Figure 9). Instead, the centre of distribution of the endemic estuarine fishes lies within the Warm Temperate South Coast Province. Indeed, the major proportion of endemic fishes are found within estuaries along the west and south coasts (Figure 9), mostly within the Cape Floristic Region.

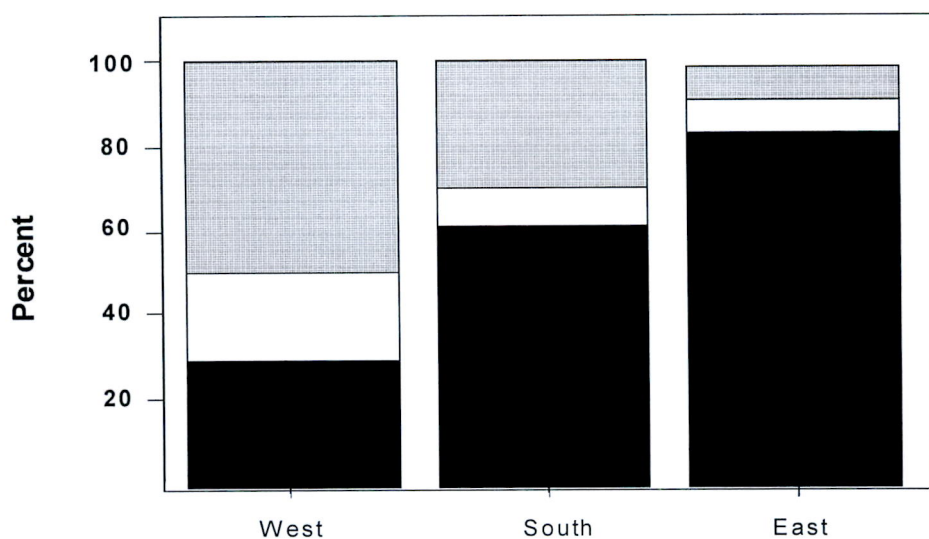


Figure 8. The percentage of the estuarine fish fauna in the three regions of the coast which are made up by tropical (solid shading), cosmopolitan (open) and southern African endemic species (stippled). Data were sourced from Smith & Heemstra (1986).

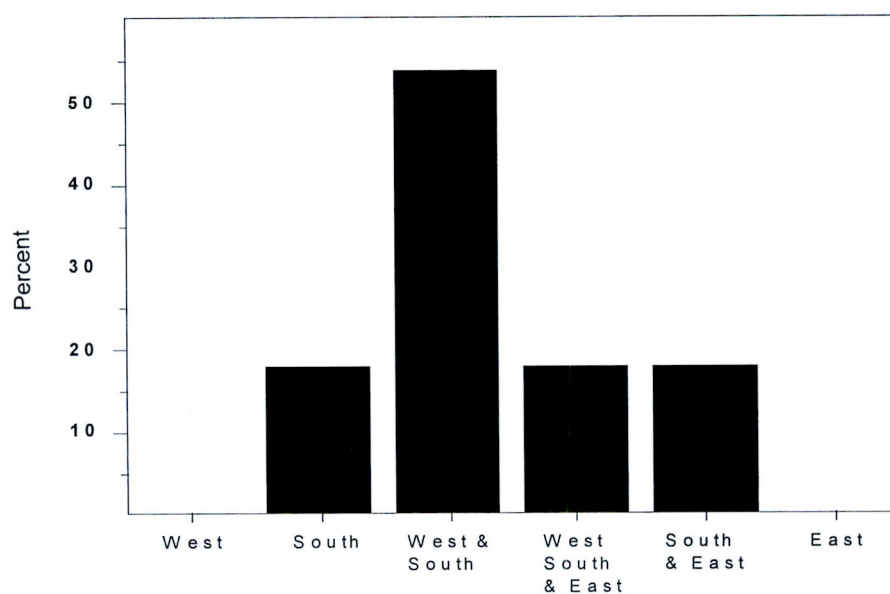


Figure 9. The percentage of the total endemic estuarine fishes which occur exclusively in each sector of the South African coast. Data were sourced from Smith & Heemstra (1986).

Examining endemism in the estuarine fish fauna of the whole of South Africa indicates that the greater proportion of the fauna consists of non-endemic fishes (84%), of which introduced fishes make up 2%. Endemic fishes constitute 16% of the South African estuarine fish fauna. These figures change dramatically, however, when the C.A.P.E. region is investigated in isolation. Here endemic fishes contribute 38% to the total fish fauna, while non-endemic fishes contribute 62%. Estuaries within the C.A.P.E. region are home to almost 70 percent ($n=49$ species) of the 71 species of endemic fishes sampled within South African estuaries.

The predominance of endemic fishes on the south coast may be attributed to two factors. Firstly, the way the term "endemism" is defined biases the result so that species near the edges of the defined boundaries are less likely to occur only within the demarcated area. Secondly, this result may be due to an increase in the representation of species with Indo-West Pacific distributions ("tropical" species) in the warmer waters of the east coast. The west coast has the greatest proportion of cosmopolitan fish species, probably since these are hardy species, and are thus likely to occur over large geographic ranges.

The estuarine locality data for fishes are far more complete than those for invertebrates. For fishes, data were available from 71 estuaries around the South African coast, more than double the number for invertebrates. However, great variability still exists in the data, for the similar reasons mentioned in section 4.2 above.

The numbers of fish species shows a gradual increase from west to east around the South African coast (Figure 10). Ranking the estuaries in order of species richness indicates that the six estuaries with the most diverse fish fauna all fall outside the Cape Floristic Region (Figure 11). The four estuaries within the Cape Floristic Region which have the greatest species richness are the Breede, Swartvlei, Knysna and Kromme estuaries. Of these, the Knysna estuary has the greatest fish species richness with 86 species having been recorded here. Mean species richness of fishes in estuaries in the Cape Floristic Region is roughly half (22.8 species) that for estuaries outside of the Cape Floristic Region (46.3 species), and is less than that for the South African coast as a whole (34.2 species).

Multivariate analysis of presence or absence of fish species in individual estuaries resulted in some highly jumbled clusterings of estuaries (Figure 12). As with the invertebrate data, the confusion is likely to be due to estuaries of different size, conditions, and to different levels of sampling intensity in different estuaries.

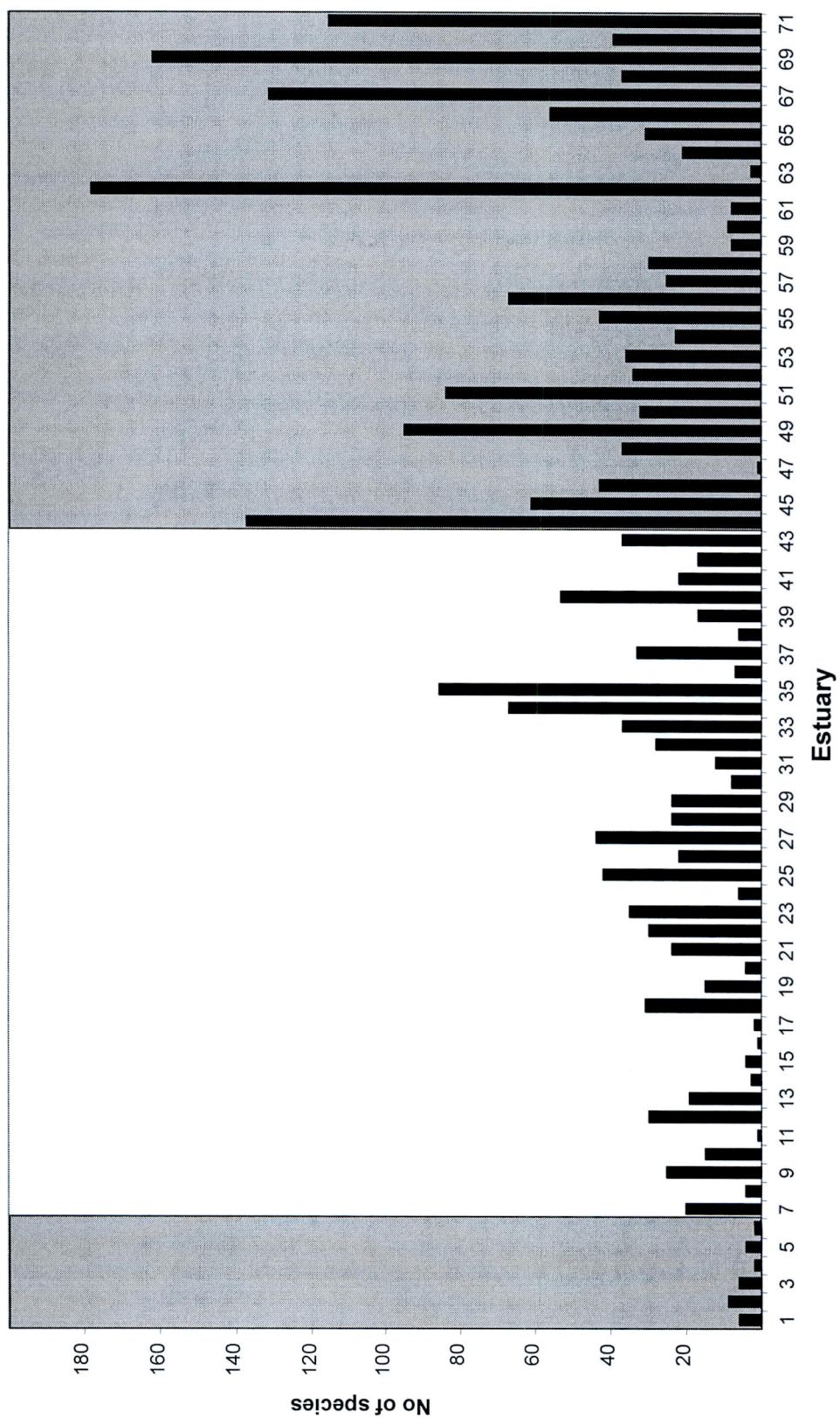


Figure 10. The number of fish species recorded from 71 estuaries ordered from west to east around the South African coast. The shaded area represents that which is outside of the Cape Floristic Region. The numerical codes for estuaries can be found in Table 3.

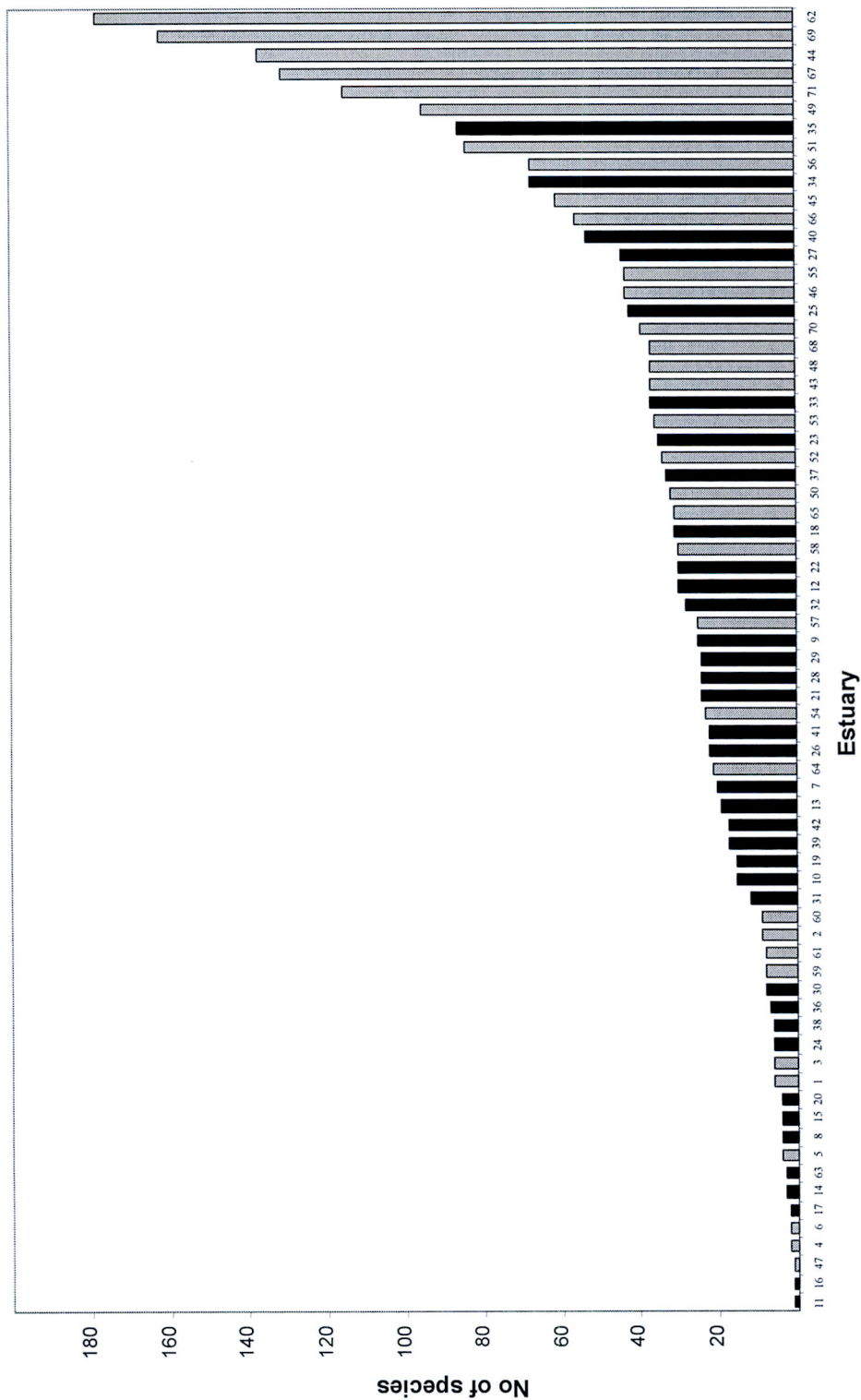


Figure 11. The number of fish species recorded from 71 estuaries along the South African coast. Estuaries are ordered in increasing species richness. Solid bars represent estuaries which occur within the Cape Floristic Region, while shaded bars represent estuaries outside of the Cape Floristic Region. The numerical codes for estuaries can be found in Table 3.

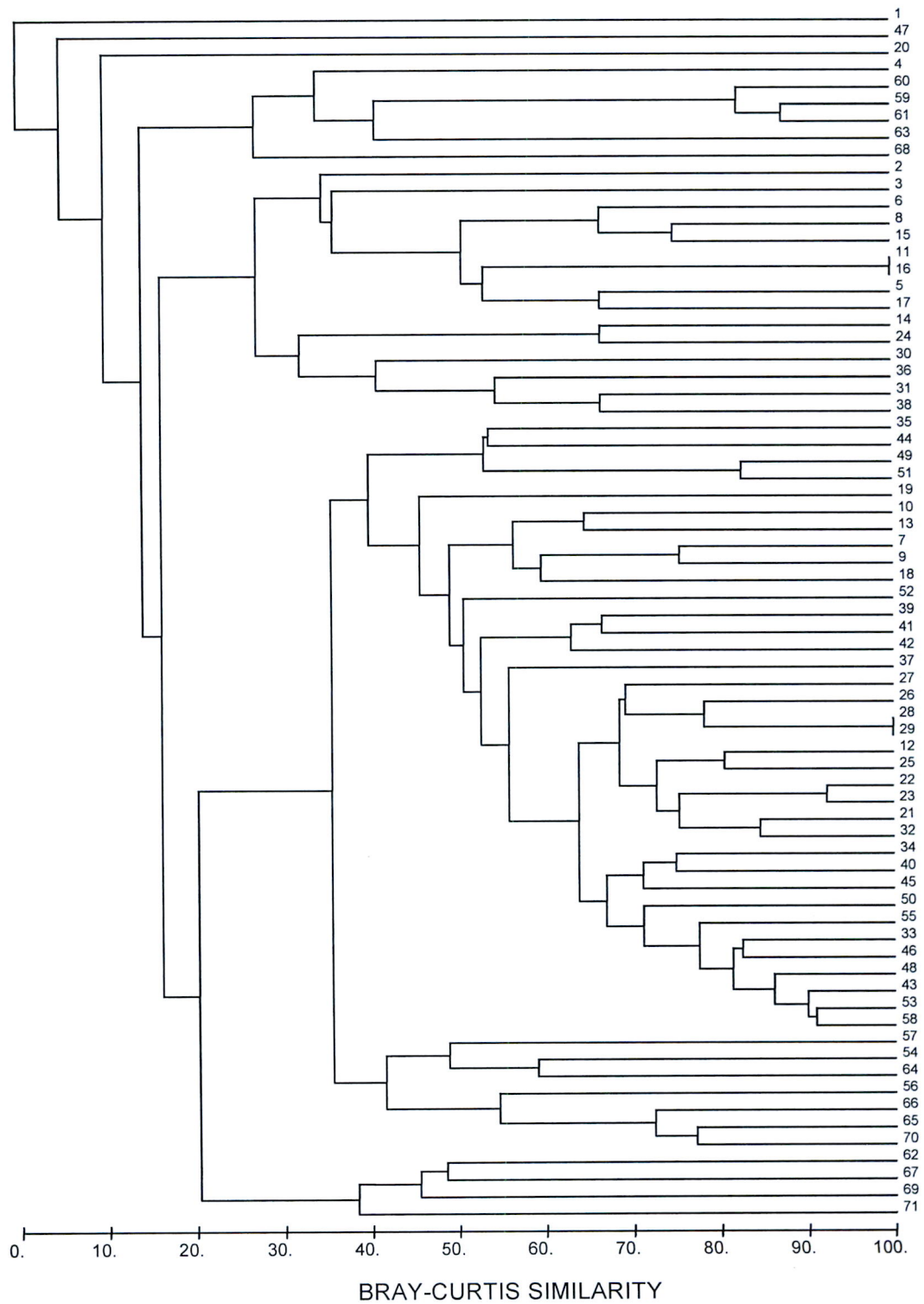


Figure 12. Dendrogram of similarities between estuaries based on the presence or absence of fish species. Numerical codes for estuaries can be found in Table 3.

Table 3. Numerical codes and estuary names for estuarine fish data.

NUMBER	SYSTEM	NUMBER	SYSTEM
1	Kunene	37	Keurbooms
2	Orange	38	Sout
3	Holgat	39	Groot (Wes)
4	Spoeg	40	Kromme
5	Groen	41	Seekoei
6	Sout	42	Kabeljous
7	Olifants	43	Gamtoos
8	Verlore	44	Swartkops
9	Berg	45	Sundays
10	Langebaan Lagoon	46	Bushmans
11	Modder	47	Kasuka
12	Milnerton Lagoon	48	Keiskamma River
13	Diep	49	Nahoon
14	HoutBay	50	Qinira
15	Wildevoel	51	Gqunube
16	Schuster	52	Quko
17	Booiskraal	53	Kei
18	Sand	54	Kobole
19	Eerste	55	Mbashe
20	Rooiels	56	Mngazana
21	Palmiet	57	Mtata
22	Kleinmond	58	Mzimvubu
23	Bot	59	Msikaba
24	Onrus	60	Mtentu
25	Hermanus lagoon	61	Impenjati
26	Heuningnes	62	Durban Bay
27	Breëde	63	Umgeni
28	Duiwenhoks	64	Mhlanga
29	Kafferkuils	65	Malazi
30	Gourits	66	Richards Bay
31	Hartenbos	67	St. Lucia
32	Groot Brak	68	Sodwana
33	Wilderness	69	Kosi
34	Swartvlei	70	Inhaca Island
35	Knysna	71	Morrumbene Estuary
36	Piesang		

3.4 BIRDS

Data for bird distributions were examined for a total of 115 estuaries around the South African coast (Table 4). Species richness varied widely between estuaries (Figure 13), with no apparent trend in increasing species richness towards the east, as was indicated for invertebrates and fishes.

Of the three estuaries with the greatest richness of bird species, two (Verlorenvlei and the Berg River Estuary) fall within the C.A.P.E. region (Figure 14). The highest species richness of birds was recorded at St. Lucia on the northern KwaZulu-Natal coast. An absence of bird species was recorded at 11 estuaries, only one of which is within the C.A.P.E. region. This is the Buffels River Estuary at Pringle Bay, a small, blackwater estuary.

It is evident from both Figures 13 and 14 that the species richness of birds is generally greater in estuaries within the C.A.P.E. region than in those outside this area. The average species richness of birds in estuaries in the C.A.P.E.

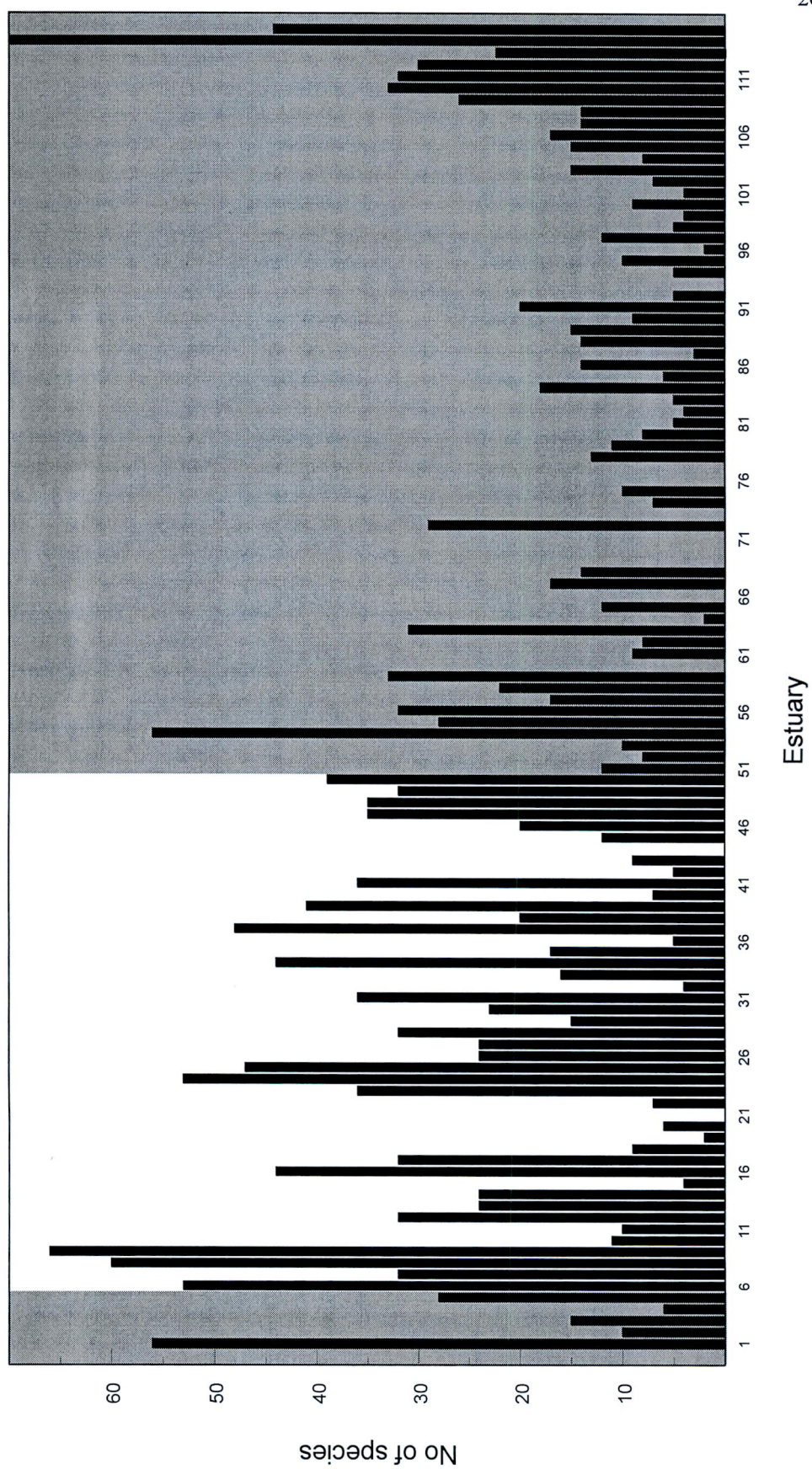


Figure 13. The maximum number of bird species recorded from 115 estuaries ordered from west to east around the South African coast. The shaded area represents that which is outside of the Cape Floristic Region. The numerical codes for estuaries can be found in Table 4.

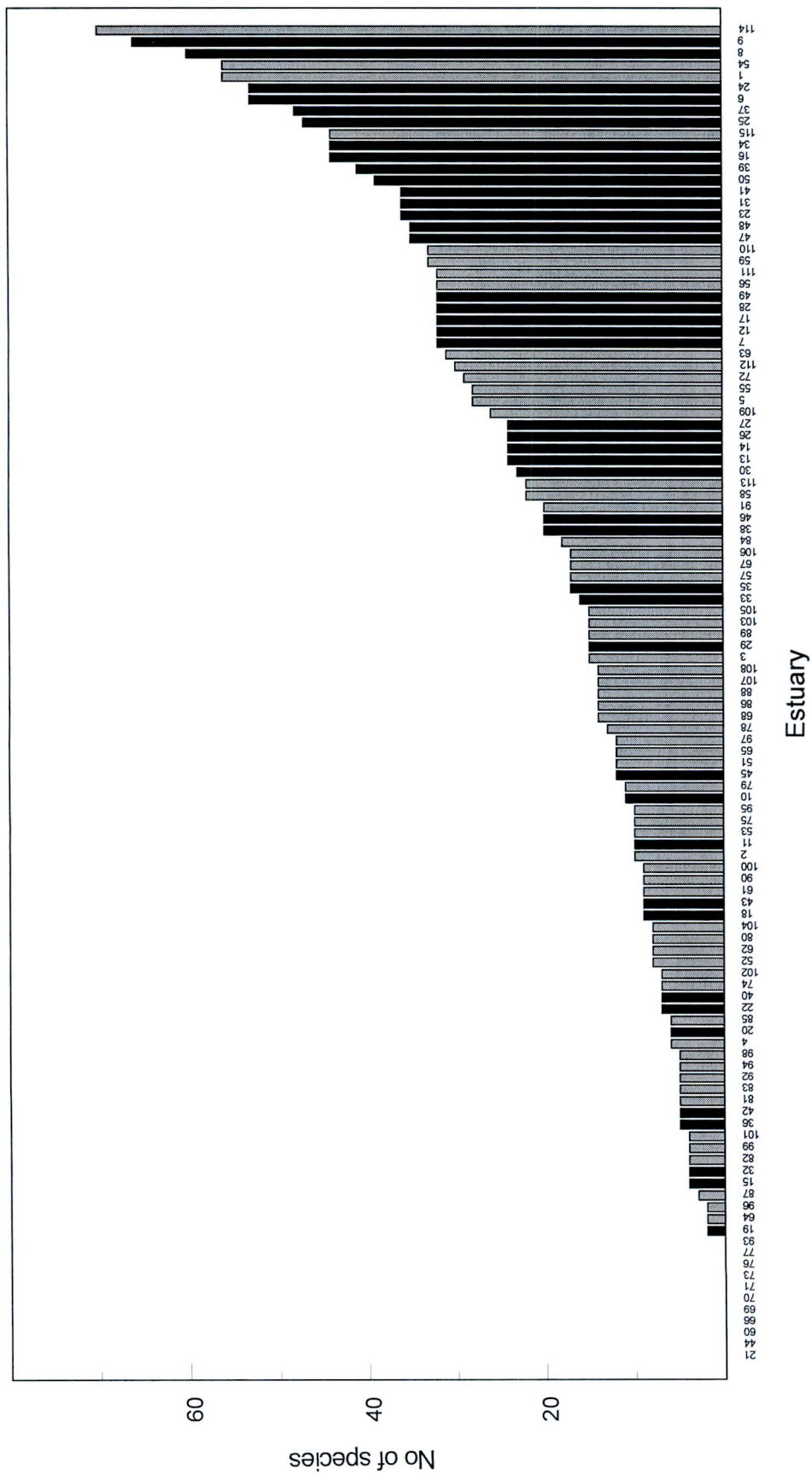


Figure 14. The maximum number of bird species recorded from 115 estuaries on the South African coast. Estuaries are ordered in increasing species richness. Solid bars represent estuaries which occur within the Cape Floristic Region, while shaded bars represent estuaries outside of the Cape Floristic Region. The numerical codes for estuaries can be found in Table 4.

Table 4. Numerical codes and estuary names for bird data.

NUMBER	SYSTEM	NUMBER	SYSTEM	NUMBER	SYSTEM
1	Orange River	41	Keurbooms	81	Cove Rock
2	Swartlintjies	42	Sout	82	Hickman's
3	Spoeg	43	Groot	83	Buffalo
4	Bitter	44	Storms	84	Nahoon
5	Groen	45	Tsitsikamma	85	Quinera Lagoon
6	Olifants	46	Klipdrift	86	Gqunube
7	Wadrif	47	Kromme	87	Kwelera
8	Verlorenvlei	48	Seekoei	88	Bulura
9	Berg	49	Kabeljous	89	Cintsa
10	Modder	50	Gamtoos	90	Cefane
11	Sout	51	Van Stadens	91	Kwenxura
12	Diep/Milnerton	52	Maitland	92	Nyara
13	Black	53	Papkuilsrivier	93	Quko
14	Wildevleivlei	54	Swartkops	94	Morgan Bay
15	Silvermine	55	Sundays	95	Kei
16	Sandvlei	56	Boknesrivier	96	Qolora
17	Zeekeo	57	Boesmansrivier	97	Nxaxo
18	Eerste	58	Kariegarivier	98	Cebe
19	Lourens	59	Kowie	99	Ngqwana
20	Rooi-els	60	Rietrivier	100	Bashee
21	Buffels	61	Kleinmonde west	101	Bulungula
22	Palmiet	62	Kleinmonde east	102	Mtamvuna
23	Kleinmond	63	Great Fish	103	Mpanjeti
24	Bot	64	Old Women's	104	Kongweni
25	Klein (Hermanus)	65	Mpekweni	105	Mtentweni
26	Uilkraals	66	Mtati	106	Mhlungwa
27	Heuningnes	67	Mgwalana	107	Ifafa
28	Brede	68	Bira	108	Mzimayi
29	Duiwenhoks	69	Gqutywa	109	Umgababa
30	Kafferkuils	70	Ngculura	110	Mdloti
31	Gouritz	71	Ntana	111	Mdlotane
32	Blinde	72	Keiskamma	112	Nthlabane
33	Hartenbos	73	Nqinisa	113	Lake Sibayi
34	Klein Brak	74	Tyolomnqa	114	Lake St Lucia
35	Groot Brak	75	Ncera	115	Kosi Bay
36	Touws	76	Mlele		
37	Swartvlei	77	Mcantsi		
38	Goukamma	78	Gxulu		
39	Knysna	79	Goda		
40	Piesang	80	Hlozi Lagoon		

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6 EXPERTS CONSULTED

Aquatic macrophytes

Data for aquatic macrophytes were supplied by Brian Colloty of the Botany Department at the University of Port Elizabeth. This data was collected under the auspices of the Department of Water Affairs and Forestry.

Birds

Data for birds were supplied by Prof. Les Underhill of the Avian Demography Unit at the University of Cape Town.

AN ASSESSMENT OF THE THREATS TO ESTUARINE SYSTEMS OF THE C.A.P.E. REGION AND A PRELIMINARY METHOD OF PRIORITISING ESTUARIES FOR CONSERVATION OF BIODIVERSITY

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1 BACKGROUND TO THREATS TO THE PHYSICAL ENVIRONMENT

The threats to the physical functioning and biodiversity of estuaries are numerous and varied, and operate on a range of different spatial scales. Threats may come from within the estuarine system itself, but are also imposed on the estuary through the terrestrial, freshwater and marine environments. In addition, these threats are not only generated within the surrounds of the estuary, but also in their catchment areas. Several of the threats which face estuaries are interlinked or interdependent, and these links will be highlighted in the relevant sections below, and summarised in Section 4.1.

1.1 ALTERATION OF MOUTH DYNAMICS

The mouth of an estuary is its link with the sea, and is the corridor through which marine organisms may enter or leave the estuary. The mouth is maintained by a balance between deposition and erosion of the sandbar at the back of the beach. Estuaries may fall into three categories depending on the opened or closed state of the mouth. Some estuaries are permanently open to the sea, while in others the sandbar is never breached, and the estuary is permanently closed. A third group of estuaries is characterised by periodic (usually seasonal) opening or closing of the mouth. Estuaries within the C.A.P.E. region fall into all three of these categories, with the majority (59%) having mouths which are open for at least some of the time. In these estuaries, the mouth is usually opened when winter floods wash away the sandbar which has been deposited by wave action.

The timing of mouth opening or closure can have profound effects on the biota. These include physiological effects which come about through increased or decreased salinities, temperatures and oxygen concentrations, and, in extreme cases, can result in mortality of organisms inhabiting the estuary. Most of these effects, however, are part of the natural seasonal cycle of mouth opening or closure. Timing of opening or closure can also have very important consequences for organisms such as fishes which use estuaries only during vulnerable stages of their life cycles. Many species of fishes (and particularly some of the endemic fishes) use estuaries as nursery areas. Adults spawn in the sea towards the east coast of South Africa. The larvae travel westwards and enter estuaries where they are relatively safe from predators, and where there is abundant food. Spawning usually occurs in autumn or early winter (check???) so that the estuary mouths have usually been opened by winter rains by the time the larvae reach them, thus allowing the larvae to enter the estuaries freely. Disruption of the timing of opening of the estuary mouths can thus result in failure of recruitment to certain fish stocks.

There are three major ways in which the dynamics of estuary mouths can be altered. They can be artificially breached, permanently moved, or hardened. Artificial breaching of estuary mouths is usually used as a means of preventing flooding of surrounding developments. In these cases, the developments are usually inappropriately built below the natural flood line. Artificial breaching may also be undertaken to dispel foul odours that may result from decomposition of estuarine

organisms which have died as a result of natural variations in temperature, salinity or oxygen concentration.

Relocation of estuary mouths is usually undertaken in order to accommodate developments. This can result in the mouth being altered from permanently closed to permanently open, and vice versa, due to the counterplay of erosional and depositional forces operating in that specific area of the estuary.

Hardening of estuary mouths is usually associated with the development of harbour facilities, and has the effect of keeping the mouth permanently open. In some cases, however, weirs have been built across the estuary mouth, and the opening and closure of the mouth is completely artificially controlled. The decision whether to open or close the mouth is an arbitrary one as far as the estuarine biota are concerned, and the ecological functioning of these estuaries is severely disrupted, if not destroyed.

Links with other threats:

Water abstraction
Siltation
Type of surrounding development
Encroachment of surrounding development
Sewage pollution

1.2 SURROUNDING DEVELOPMENT

1.2.1 Type of development

The type of land use or development surrounding an estuary can have major effects on the dynamics of the estuarine system, as well as interfering with the aesthetic qualities of the estuary. Rural or eco-tourism developments are likely to have the least effect on the estuary, while heavy industry situated near the estuary may cause pollution, siltation, or disturbance to estuarine organisms, particularly birds. Industrial development, such as that associated with harbours, may result in alteration of the state of the estuary mouth. Some development types necessitate the dredging of estuarine sediments. This may have several effects, including the destruction of shallow fish feeding banks, destruction of seagrass beds which stabilise the sediment and act as a refuge for estuarine organisms, and the resuspension of heavy metals which may have accumulated in the sediments.

Links with other threats:

Alteration of mouth dynamics
Siltation
Encroachment of surrounding development
Garbage pollution
Sewage pollution
Chemical pollution

1.2.2 Encroachment onto estuary

Saltmarshes and reedbeds surrounding estuaries have important physical and ecological functions. Detritus from saltmarshes, which are bathed by the tidal action

in the estuary, may form a large proportion of the food base in estuaries. They are also important in filtering nutrients from the water, and converting these to usable energy for estuarine animals. Destruction of the saltmarsh surrounding the estuary can therefore have far-reaching effects on the ecological functioning of the estuary.

Reedbeds may perform a similar function to that of saltmarshes, with one important addition - they also act as sediment traps. Reedbeds slow down water movement so that sediment suspended in the water is deposited in the reeds, rather than elsewhere in the estuary. Destruction of the reedbeds may lead to siltation in other parts of the estuary where it is ecologically undesirable and may interfere with the dynamics of the estuary mouth.

The ideal situation is one in which there is no encroachment of developments onto the estuary banks, while the widespread destruction of the reedbed and/or saltmarsh habitat may result in severe degradation of the estuary.

Links with other threats:

Alteration of mouth dynamics
Type of surrounding development

1.2.3 Pace of development

The pace at which development is progressing in the area surrounding an estuary has bearing on its potential as a conservation area. There is little point in earmarking estuaries for conservation in the future if the system will have become degraded by then.

1.3 POLLUTION

1.3.1 Garbage

Garbage pollution does not have severe direct threats on biodiversity in estuaries, but it certainly interferes with the aesthetic quality of the estuary. The problem is usually easily rectified if the source of the garbage comes from within the vicinity of the estuary. The problem is harder to solve, however, if the source of the garbage is located in areas upstream of the estuary.

Links with other threats:

Type of development

1.3.2 Sewage

The biota of estuaries are generally hardy, and can tolerate a wide range of physical and chemical conditions. However, extremes can usually only be tolerated for short periods of time. If conditions remain unfavourable for long periods of time, loss of biodiversity occurs. Sewage pollution is invariably a chronic problem and, where this is severe, can thus lead to exclusion of organisms from certain estuaries. In small quantities, sewage can be beneficial to estuaries. The increase in nutrients acts as a fertiliser, increasing the productivity of the estuary. In large, quantities, however, it can be detrimental to the estuarine biota as the increased nutrient load leads to vast

blooms of unicellular algae which, when they die, decompose. This large-scale decomposition leads to a reduction in oxygen in the water which may result in mass mortality of estuarine plants and animals.

The addition of sewage effluent to estuaries may also change the mouth dynamics and the seasonal character of the estuary. A constant inflow of effluent may result in the mouth of the estuary remaining open throughout the year, rather than closing on a seasonal cycle.

Links with other threats:

Alteration of mouth dynamics

Type of development

1.3.3 Chemical

The term "chemical pollution" includes a large variety of pollutants. Although some of these may cause chronic problems in estuaries, the large majority of chemical pollution occurs through accident. Accidental chemical pollution cannot usually be predicted, and the range of contaminants that could be included here is potentially huge. This report will thus deal with the most common forms of chemical pollution.

Organic pesticides and fertilisers used for agriculture in catchment areas and areas directly surrounding the estuary usually have the effect of increasing the nutrient status of the estuarine water. In small quantities this may act as a fertiliser, increasing productivity within the estuary. In large quantities, however, it can operate in a similar manner to sewage pollution, leading to eutrophication and eventual loss of biodiversity.

Heavy metals may accumulate in estuarine sediments, either from a source located near the estuary, or via the river system feeding the estuary. These heavy metals are concentrated by estuarine organisms, particularly the filter-feeding animals, and are passed up the food chain. These can have devastating effects which, in the case of long-lived species such as migratory birds, can operate on extremely long time scales, and only manifest themselves a long distance from the source.

Oil pollution is not common in estuaries where there is no harbour development. Oil spilled at sea can, however, find its way into estuaries if the mouth is in an open state at the time. The effects of oil spills are very difficult to predict, as they vary widely depending on the type and amount of oil spilled, and prevailing weather conditions. Two major points are worth mentioning, however. Firstly, many estuarine organisms are able to survive isolated oil spill incidents, but repeated spillages can lead to a loss of biodiversity in the estuary. Secondly, surfactants used to disperse the oil can have a more devastating effect on the estuarine biota than the oil itself.

Links with other threats:

Type of development

1.4 WATER ABSTRACTION

The removal of water from upstream areas can cause serious perturbations to the natural dynamics of estuarine systems. Water abstraction results in a decrease of flushing and hence an accumulation of sediment in the estuary, which can result in estuaries silting up entirely. In estuaries in which the mouth is closed for most of the time, a reduction in freshwater inflow can lead to severe increases in salinity and loss of biodiversity.

Links with other threats:

Alteration of mouth dynamics

Siltation

1.5 SILTATION

Part of the natural cycle of estuaries includes the accumulation of silt brought downstream to the estuary by the rivers that feed it. The accumulated silt is cleared from the estuary during floods. The process of siltation is exacerbated by a number of factors, including bad farming practices that lead to soil erosion in the catchment, destruction of the reedbeds and saltmarshes which stabilise the banks of the estuary, alteration of the mouth dynamics, and a reduction in flood water flow.

Links with other threats:

Alteration of mouth dynamics

Water abstraction

Type of surrounding development

2 BACKGROUND TO DIRECT THREATS TO THE BIOTA

2.1 DISTURBANCE TO ESTUARINE ORGANISMS

Estuarine organisms may be affected directly by disturbance caused by human activities. Of all organisms within estuaries, birds are the most likely to be affected in this manner. People using the shore may disturb feeding or roosting birds, while water-based activities may affect more open-water species. Noise created by boating activities may also cause a general disturbance to the avifauna of estuaries. Where disturbance levels are high, some species of birds, at least, may abandon the area completely.

2.2 EXPLOITATION OF ESTUARINE ORGANISMS

Exploitation of estuarine organisms has the obvious effect of removing individuals from the local population. If this is extreme, it may lead to local extinction of certain species. Fish are heavily targetted in estuaries, both by angling and netting. While many are caught for consumption purposes, several species, such as the Knysna Seahorse, are collected for the aquarium trade. All these activities are currently regulated, but an unknown amount of poaching and other illegal activities continues. Invertebrates are exploited mostly for bait. Species affected include primarily prawns, bivalves and polychaete worms.

3 THE CURRENT STATE OF ESTUARIES OF THE C.A.P.E. REGION

In order to evaluate the current state of C.A.P.E. estuaries, the input of 20 South African marine scientists and managers with local knowledge of certain estuaries was solicited. These specialists were each sent a number of evaluation sheets to complete which would give an indication of the physical state of each estuary. An example of the sheet is included overleaf. These evaluation sheets were designed in such a way as to minimise subjectivity and enhance objectivity, and so that they were quick and relatively simple for those with local knowledge to complete. Twelve of the 20 people responded to the evaluation sheets, and their responses covered 52 of the 58 C.A.P.E. estuaries. The information gathered from these is summarised in the following pages.

C.A.P.E. ESTUARY EVALUATION SHEET

Name of estuary:.....Your name:.....

Please put a cross in the box which corresponds closest to your estimate of the state of each parameter. Do not leave any lines out, and don't forget the reverse side of the page.

A: Condition rating	4	3	2	1	0
State of mouth	Mouth operates on a completely natural cycle		Mouth periodically artificially breached		Mouth altered and/or artificially controlled
Type of surrounding development	None	Rural (farmland, smallholdings, eco-tourism development)	Dispersed residential (holiday cottages)	Intense residential (urban environment, high-intensity tourist development)	Industrial
Encroachment of surrounding development	None (eg. reserve)	Slight (Development well set back from banks)	Moderate (Development occasionally encroaches onto banks, bank at least 90% untransformed)	High (Development often encroaches on banks, destruction of reedbeds and/or saltmarsh, bank 25-90% untransformed)	Very high (Widespread destruction of reedbeds and/or saltmarsh, development may extend into intertidal area, bank <25% untransformed)
Garbage or litter	None	Slight	Moderate	Heavy	Extreme
Sewage or sewage effluent inflow	None	Slight	Moderate	Heavy	Extreme
Chemical pollution	None	Slight	Moderate	Heavy	Extreme
Water abstraction	None	Slight	Moderate	Heavy	Extreme
Siltation	None	Slight	Moderate	Heavy	Extreme
Human disturbance	None	Slight or infrequent	Moderate	Heavy or frequent	Extreme
Fish stocks	Pristine	Healthy	Moderate	Degraded	Destroyed
Bait organisms	Pristine	Healthy	Moderate	Degraded	Destroyed

3.1.1.1 Office use only - do not fill in

SUBTOTAL					
				TOTAL A	

Your overall evaluation of state of estuary	Pristine	Slightly perturbed, rehabilitation unnecessary	Moderately perturbed, some rehabilitation necessary	Heavily perturbed, rehabilitation difficult	Completely transformed, no chance of successful rehabilitation
The future of the estuary (20 year projection)	Remain the same	Slow development with little degradation	Moderate development and some degradation	Rapid development and degradation	Very rapid degradation, or already destroyed

Continued overleaf...

Fill in only the block "Importance as nursery for fish" – we will insert quantitative data available for shaded portions

B: Biological value	4	3	2	1	0
Importance as nursery for fish	Critically important (for some species at least)	Important	Moderate	Slight	Insignificant
Importance as bird habitat	Critically important (for some species at least)	Important	Moderate	Slight	Insignificant
Species richness					
No. southern African endemics (fish & birds)					
Size					

3.1.1.1.2 Office use only – do not fill in

SUBTOTAL					
				TOTAL B	

3.1.1.1.3 Office use only – do not fill in

TOTAL A	TOTAL B	A*B

Any other comments about this estuary, or the evaluation form

.....

.....

.....

.....

.....

.....

.....

.....

.....

THANK YOU FOR YOUR HELP

OLIFANTS RIVER ESTUARY

State of mouth

Mouth operates on a completely natural cycle

Type of surrounding development

Rural, extensive diamond mining on the northern bank.

Encroachment of surrounding development

Slight, mining may encroach on banks.

Garbage or litter

Slight

Sewage or sewage effluent inflow

Slight. This is derived from the surrounding developments at Ebenhaeser and Papendorp, but is not of serious concern.

Chemical pollution

Slight. Fertilizers and pesticides enter the system from the intensively farmed lower Olifants valley.

Water abstraction

Moderate

Siltation

Moderate

Human disturbance

Slight or infrequent

Fish stocks

Degraded. Excessive and uncontrolled gill-netting currently taking place.

Bait organisms

Healthy

SCORES

31-34, Average = 32 (n=4)

OVERALL EVALUATION OF STATE OF ESTUARY

Slightly perturbed, rehabilitation unnecessary

The future of the estuary (20 year projection)

Moderate development and some degradation

WADRIF ESTUARY

State of mouth

Mouth altered and/or artificially controlled. A railway causeway has effectively isolated Wadrif from the sea. It no longer functions as an estuary.

Type of surrounding development

Rural

Encroachment of surrounding development

Slight

Garbage or litter

None

Sewage or sewage effluent inflow

None

Chemical pollution

Slight

Water abstraction

Slight

Siltation

Slight

Human disturbance

Slight or infrequent

Fish stocks

Destroyed

Bait organisms

Destroyed

SCORES

Score: 26 (n=1)

OVERALL EVALUATION OF STATE OF ESTUARY

Heavily perturbed, rehabilitation difficult

The future of the estuary (20 year projection)

Slow development with little degradation

VERLORENVLEI**State of mouth**

Mouth periodically artificially
breached

Type of surrounding development

Rural

**Encroachment of surrounding
development**

Slight

Garbage or litter

Slight

Sewage or sewage effluent inflow

Slight

Chemical pollution

Slight

Water abstraction

Heavy

Siltation

Moderate

Human disturbance

Moderate

Fish stocks

Healthy

Bait organisms

Healthy

SCORES

Scores: 31-34, Average = 33 (n=2)

OVERALL EVALUATION OF STATE OF ESTUARY

Moderately perturbed, some rehabilitation necessary

The future of the estuary (20 year projection)

Moderate development and some degradation

BERG RIVER ESTUARY

State of mouth

Mouth altered and/or artificially controlled

Type of surrounding development

Intense residential

Encroachment of surrounding development

High. Proposed new marina on south bank could exacerbate the problem.

Garbage or litter

Moderate

Sewage or sewage effluent inflow

Slight

Chemical pollution

Moderate. The river is quite heavily contaminated by agrochemicals and industrial wastes. The fish processing plant of Marine Products is situated on the estuary and discharges 13 200m³.day⁻¹ of effluent during the fishing season. A recent survey could detect no effect of this or other organic enrichment on the benthic fauna.

Water abstraction

Heavy at present. Effects of Saldanha Bay industrial water demand unknown.

Siltation

Moderate

Human disturbance

Moderate

Fish stocks

Healthy

Bait organisms

Moderate

Other comments

The estuary and the floodplain are vitally important in a regional context for birds.

This is one of the few important estuaries for fish on the west coast of South Africa.

SCORES

Scores: 16-23, Average = 20 (n=4)

OVERALL EVALUATION OF STATE OF ESTUARY

Moderately perturbed, some rehabilitation necessary

The future of the estuary (20 year projection)

Rapid development and degradation

MODDER

State of mouth

Mouth operates on a completely natural cycle.

Type of surrounding development

Rural

Encroachment of surrounding development

Slight

Garbage or litter

Slight

Sewage or sewage effluent inflow

None

Chemical pollution

Slight

Water abstraction

Moderate

Siltation

Slight

Human disturbance

Slight or infrequent

Fish stocks

Pristine

Bait organisms

Pristine

SCORES

Scores: 37-38, Average = 38 (n=2)

OVERALL EVALUATION OF STATE OF ESTUARY

Slightly perturbed, rehabilitation unnecessary

The future of the estuary (20 year projection)

Slow development with little degradation

DIEP RIVER/ MILNERTON ESTUARY

State of mouth

Mouth operates on a completely natural cycle

Type of surrounding development

Intense residential

Encroachment of surrounding development

High

Garbage or litter

Moderate

Sewage or sewage effluent inflow

Moderate. Sewage treatment works upstream result in organic enrichment. Run-off from stormwater drains may add to this.

Chemical pollution

Moderate. Some pollution from industrial effluents.

Water abstraction

Moderate

Siltation

Moderate

Human disturbance

Heavy or frequent

Fish stocks

Degraded

Bait organisms

Degraded

Other comments

One of the few important estuaries for fish on the west coast of South Africa despite high levels of development.

SCORES

Scores: 18-22, Average = 19 (n=3)

OVERALL EVALUATION OF STATE OF ESTUARY

Heavily perturbed, rehabilitation difficult

The future of the estuary (20 year projection)

Rapid development and degradation

BLACK RIVER

State of mouth

Mouth altered and/or artificially controlled

Type of surrounding development

Industrial

Encroachment of surrounding development

Very high

Garbage or litter

Extreme. This is especially bad after heavy rains.

Sewage or sewage effluent inflow

Extreme

Chemical pollution

Extreme

Water abstraction

Moderate

Siltation

Moderate

Human disturbance

Heavy or frequent

Fish stocks

Destroyed

Bait organisms

Destroyed

Other comments

This system is largely regulated by the input of processed sewage.

SCORES

Scores: 7-10, Average = 8 (n=3)

OVERALL EVALUATION OF STATE OF ESTUARY

Completely transformed, no chance of successful rehabilitation

The future of the estuary (20 year projection)

Very rapid degradation, or already destroyed

DISA RIVER**State of mouth**

Mouth periodically artificially breached. This is done in summer to release stagnant water from the lower reaches.

Type of surrounding development

Intense residential

Encroachment of surrounding development

High

Garbage or litter

Moderate

Sewage or sewage effluent inflow

Moderate. Mostly seepage from domestic septic tanks.

Chemical pollution

Slight

Water abstraction

Slight

Siltation

Slight

Human disturbance

Heavy or frequent

Fish stocks

Destroyed

Bait organisms

Degraded

SCORES

Score: 19 (n=1)

OVERALL EVALUATION OF STATE OF ESTUARY

Heavily perturbed, rehabilitation difficult

The future of the estuary (20 year projection)

Rapid development and degradation

WILDEVOËLVLEI

State of mouth

Mouth periodically artificially breached

Type of surrounding development

Intense residential

Encroachment of surrounding development

Moderate

Garbage or litter

Moderate

Sewage or sewage effluent inflow

Extreme. 2 000m³ of treated sewage effluent is discharged into this system daily.

Chemical pollution

Heavy

Water abstraction

None

Siltation

Moderate

Human disturbance

Heavy or frequent

Fish stocks

Degraded

Bait organisms

Degraded

Other comments

In the past, Wildevoëlvlei was an ephemeral system, drying up in summer. The input of treated sewage effluent has resulted in the vlei becoming perennial. This, together with the high organic loading, has resulted in toxic algal blooms during the summer months when conditions favour these algae. The vlei has become a health hazard.

SCORES

Scores: 17-18, Average = 18 (n=2)

OVERALL EVALUATION OF STATE OF ESTUARY

Heavily perturbed, rehabilitation difficult

The future of the estuary (20 year projection)

Rapid development and degradation

SCHUSTER'S RIVER

State of mouth Mouth operates on a completely natural cycle	Chemical pollution None
Type of surrounding development None	Water abstraction None
Encroachment of surrounding development None	Siltation None
Garbage or litter None	Human disturbance None
Sewage or sewage effluent inflow None	Fish stocks Pristine
	Bait organisms Pristine

SCORES

Score: 44 (n=1)

OVERALL EVALUATION OF STATE OF ESTUARY

Pristine

The future of the estuary (20 year projection)

Remain the same

SILVERMINE RIVER**State of mouth**

Mouth operates on a completely natural cycle

Type of surrounding development

Intense residential

Encroachment of surrounding development

Moderate

Garbage or litter

Moderate

Sewage or sewage effluent inflow

Moderate

Chemical pollution

Slight

Water abstraction

Slight

Siltation

Slight

Human disturbance

Moderate

Fish stocks

Degraded

Bait organisms

Degraded

SCORES

Score: 23 (n=1)

OVERALL EVALUATION OF STATE OF ESTUARY

Moderately perturbed, some rehabilitation necessary

The future of the estuary (20 year projection)

Rapid development and degradation

SANDVLEI

State of mouth

Mouth altered and/or artificially controlled

Type of surrounding development

Intense residential

Encroachment of surrounding development

Very high

Garbage or litter

Moderate

Sewage or sewage effluent inflow

Moderate. Overflows from sewage pumping stations have presented problems in the past.

Chemical pollution

Moderate

Water abstraction

Slight

Siltation

Moderate

Human disturbance

Heavy or frequent

Fish stocks

Degraded

Bait organisms

Degraded

Other comments

This system is completely modified. The weir at the mouth prevents the movement of marine organisms into and out of the estuary. The system is under increasing pressure from the intensive urbanisation of its catchment.

SCORES

Scores: 15-20, Average = 18 (n=3)

OVERALL EVALUATION OF STATE OF ESTUARY

Heavily perturbed, rehabilitation difficult

The future of the estuary (20 year projection)

Rapid development and degradation

ZEEKEOVLEI**State of mouth**

Mouth altered and/or artificially controlled

Type of surrounding development

Intense residential

Encroachment of surrounding development

Very high

Garbage or litter

Heavy

Sewage or sewage effluent inflow

Extreme. Seepage and effluent from oxidation ponds at the Cape Flats Sewage Works, together with seepage from septic tanks, results in high organic and nutrient loads.

Chemical pollution

Moderate

Water abstraction

Slight

Siltation

Slight

Human disturbance

Extreme

Fish stocks

Destroyed

Bait organisms

Destroyed

SCORES

Score: 12 (n=1)

OVERALL EVALUATION OF STATE OF ESTUARY

Completely transformed, no chance of successful rehabilitation

The future of the estuary (20 year projection)

Very rapid degradation, or already destroyed

EERSTE RIVER

State of mouth

Mouth operates on a completely natural cycle

Type of surrounding development

Dispersed residential

Encroachment of surrounding development

Moderate

Garbage or litter

Moderate

Sewage or sewage effluent inflow

Moderate. This estuary receives 20 000m³ of treated sewage effluent daily from the Macassar Sewage Works, as well as from sewage works upstream.

Chemical pollution

Moderate. This results from winery and distillery operations and from minor industries. Studies show the presence of oils, fats, soaps and excess nutrients in the water entering the estuary. On some occasions pollution had killed virtually all the fish in the estuary.

Water abstraction

Moderate

Siltation

Moderate

Human disturbance

Slight or infrequent

Fish stocks

Moderate

Bait organisms

Moderate

SCORES

Score: 25 (n=1)

OVERALL EVALUATION OF STATE OF ESTUARY

Moderately perturbed, some rehabilitation necessary

The future of the estuary (20 year projection)

Rapid development and degradation

STEENBRAS RIVER

State of mouth

Mouth operates on a completely natural cycle

Type of surrounding development

Dispersed residential

Encroachment of surrounding development

Slight

Garbage or litter

Slight

Sewage or sewage effluent inflow

None

Chemical pollution

Slight. This takes the form of filter backwash from Steenbras Dam.

Water abstraction

Extreme. Most of the water from this river is captured in the Steenbras Dam, which supplies water to the greater Cape Town metropolitan area.

Siltation

Slight

Human disturbance

Moderate

Fish stocks

Moderate

Bait organisms

Moderate

SCORES

Score: 29 (n=1)

OVERALL EVALUATION OF STATE OF ESTUARY

Slightly perturbed, rehabilitation unnecessary

The future of the estuary (20 year projection)

Moderate development and some degradation

ROOI-ELS

State of mouth

Mouth operates on a completely natural cycle

Type of surrounding development

Dispersed residential

Encroachment of surrounding development

Moderate

Garbage or litter

Slight

Sewage or sewage effluent inflow

Slight

Chemical pollution

None

Water abstraction

Slight

Siltation

Slight

Human disturbance

Moderate

Fish stocks

Moderate

Bait organisms

Moderate

SCORES

Score: 29 (n=1)

OVERALL EVALUATION OF STATE OF ESTUARY

Moderately perturbed, some rehabilitation necessary

The future of the estuary (20 year projection)

Rapid development and degradation

PALMIET

State of mouth

Mouth operates on a completely natural cycle

Type of surrounding development

Rural

Encroachment of surrounding development

Slight

Garbage or litter

Slight

Sewage or sewage effluent inflow

None

Chemical pollution

None

Water abstraction

Heavy

Siltation

None

Human disturbance

Moderate

Fish stocks

Healthy

Bait organisms

Healthy

Other comments

Proposed dams in the catchment pose a great threat to this system.

SCORES

Scores: 31-36, Average = 34 (n=4)

OVERALL EVALUATION OF STATE OF ESTUARY

Slightly perturbed, rehabilitation unnecessary

The future of the estuary (20 year projection)

Moderate development and some degradation

KLEINMOND

State of mouth

Mouth periodically artificially
breached

Type of surrounding development

Dispersed residential

**Encroachment of surrounding
development**

Moderate

Garbage or litter

Slight

Sewage or sewage effluent inflow

Slight

Chemical pollution

None

Water abstraction

Slight

Siltation

Moderate

Human disturbance

Heavy or frequent

Fish stocks

Healthy

Bait organisms

Healthy

SCORES

Scores: 29-32, Average = 31 (n=2)

OVERALL EVALUATION OF STATE OF ESTUARY

Moderately perturbed, some rehabilitation necessary

The future of the estuary (20 year projection)

Moderate development and some degradation

BOT RIVER ESTUARY**State of mouth**

Mouth periodically artificially
breached

Type of surrounding development

Dispersed residential

**Encroachment of surrounding
development**

Moderate

Garbage or litter

Slight

Sewage or sewage effluent inflow

Slight

Chemical pollution

Slight

Water abstraction

Slight

Siltation

Moderate

Human disturbance

Moderate

Fish stocks

Moderate

Bait organisms

Moderate

SCORES

Scores: 22-31, Average = 28 (n=4)

OVERALL EVALUATION OF STATE OF ESTUARY

Moderately perturbed, some rehabilitation necessary

The future of the estuary (20 year projection)

Rapid development and degradation

ONRUS RIVER**State of mouth**

Mouth operates on a completely natural cycle

Type of surrounding development

Dispersed residential

Encroachment of surrounding development

Moderate

Garbage or litter

Slight

Sewage or sewage effluent inflow

Slight

Chemical pollution

Slight

Water abstraction

Heavy

Siltation

Extreme

Human disturbance

Moderate

Fish stocks

Degraded

Bait organisms

Degraded

SCORES

Score: 21 (n=1)

OVERALL EVALUATION OF STATE OF ESTUARY

Heavily perturbed, rehabilitation difficult

The future of the estuary (20 year projection)

Remain the same

KLEIN (HERMANUS)

State of mouth

Mouth periodically artificially
breached

Siltation

Slight

Type of surrounding development

Dispersed residential

Human disturbance

Moderate

**Encroachment of surrounding
development**

Moderate

Fish stocks

Moderate

Garbage or litter

Slight

Bait organisms

Moderate

Sewage or sewage effluent inflow

Slight

Other comments

The artificial breaching of the mouth is done to protect properties which have been developed below the natural flood line. This has had the effect of accumulating marine sediments in the mouth region. Freshwater inflow has been reduced by alien plant infestations in the catchment.

Chemical pollution

Slight

Water abstraction

Slight

SCORES

Scores: 27-29, Average = 28 (n=3)

OVERALL EVALUATION OF STATE OF ESTUARY

Moderately perturbed, some rehabilitation necessary

The future of the estuary (20 year projection)

Moderate development and some degradation

UILKRAALS**State of mouth**

Mouth operates on a completely natural cycle

Type of surrounding development

Dispersed residential

Encroachment of surrounding development

Slight

Garbage or litter

Slight

Sewage or sewage effluent inflow

Slight

Chemical pollution

Slight

Water abstraction

Slight

Siltation

Slight

Human disturbance

Slight or infrequent

Fish stocks

Healthy

Bait organisms

Healthy

SCORES

Score: 32 (n=1)

OVERALL EVALUATION OF STATE OF ESTUARY

Slightly perturbed, rehabilitation unnecessary

The future of the estuary (20 year projection)

Moderate development and some degradation

HEUNINGNES

State of mouth

Mouth periodically artificially breached. This is done to prevent flooding of surrounding farmland.

Type of surrounding development

Rural

Encroachment of surrounding development

None

Garbage or litter

None

Sewage or sewage effluent inflow

None

Chemical pollution

None

Water abstraction

Slight

Siltation

Slight

Human disturbance

Slight or infrequent

Fish stocks

Healthy

Bait organisms

Pristine

Other comments

Damara Terns, which are endemic to southern Africa, feed in the estuary and breed in nearby dunefields. This is the only breeding colony of Damara Terns outside of Namibia.

SCORES

Scores: 35-41, Average = 37 (n=4)

OVERALL EVALUATION OF STATE OF ESTUARY

Slightly perturbed, rehabilitation unnecessary

The future of the estuary (20 year projection)

Remain the same

BREDE

State of mouth

Mouth operates on a completely natural cycle

Type of surrounding development

Dispersed residential

Encroachment of surrounding development

Moderate

Garbage or litter

Slight

Sewage or sewage effluent inflow

Slight

Chemical pollution

Slight

Water abstraction

Moderate

Siltation

Moderate

Human disturbance

Moderate

Fish stocks

Healthy

Bait organisms

Healthy

SCORES

Scores: 28-31, Average = 29 (n=4)

OVERALL EVALUATION OF STATE OF ESTUARY

Moderately perturbed, some rehabilitation necessary

The future of the estuary (20 year projection)

Rapid development and degradation

DUIWENHOKS

State of mouth

Mouth operates on a completely natural cycle

Chemical pollution

None

Type of surrounding development

Rural

Water abstraction

Moderate

Encroachment of surrounding development

Slight

Siltation

Slight

Garbage or litter

None

Human disturbance

Slight or infrequent

Sewage or sewage effluent inflow

None

Fish stocks

Moderate

Bait organisms

Moderate

SCORES

Score: 34 (n=1)

OVERALL EVALUATION OF STATE OF ESTUARY

Slightly perturbed, rehabilitation unnecessary

The future of the estuary (20 year projection)

Slow development with little degradation

KAFFERKUILS

State of mouth

Mouth operates on a completely natural cycle

Chemical pollution

Slight

Type of surrounding development

Intense residential

Water abstraction

Moderate

Encroachment of surrounding development

High

Siltation

Slight

Garbage or litter

Slight

Human disturbance

Moderate

Sewage or sewage effluent inflow

Slight. Takes the form of seepage from septic tanks.

Fish stocks

Healthy

Bait organisms

Healthy

SCORES

Score: 28 (n=1)

OVERALL EVALUATION OF STATE OF ESTUARY

Slightly perturbed, rehabilitation unnecessary

The future of the estuary (20 year projection)

Rapid development and degradation

GOURITZ**State of mouth**

Mouth operates on a completely natural cycle

Type of surrounding development

Dispersed residential

Encroachment of surrounding development

Moderate

Garbage or litter

Slight

Sewage or sewage effluent inflow

None

Chemical pollution

None

Water abstraction

Moderate

Siltation

Moderate

Human disturbance

Moderate

Fish stocks

Moderate

Bait organisms

Moderate

SCORES

Scores: 30-38, Average = 34 (n=2)

OVERALL EVALUATION OF STATE OF ESTUARY

Slightly perturbed, rehabilitation unnecessary

The future of the estuary (20 year projection)

Moderate development and some degradation

HARTENBOS

State of mouth

Mouth periodically artificially
breached

Type of surrounding development

Dispersed residential

**Encroachment of surrounding
development**

High

Garbage or litter

Moderate

Sewage or sewage effluent inflow

Extreme. The Mossel Bay Sewage
Works discharges 3 000m³ of sewage
effluent into the estuary daily.
Seepage from septic tanks noted.

Chemical pollution

None

Water abstraction

None

Siltation

Slight

Human disturbance

Moderate

Fish stocks

Degraded

Bait organisms

Destroyed

SCORES

Score: 21 (n=1)

OVERALL EVALUATION OF STATE OF ESTUARY

Heavily perturbed, rehabilitation difficult

The future of the estuary (20 year projection)

Very rapid degradation, or already destroyed

KLEIN BRAK**State of mouth**

Mouth operates on a completely natural cycle

Type of surrounding development

Intense residential

Encroachment of surrounding development

High

Garbage or litter

Heavy

Sewage or sewage effluent inflow

Moderate

Chemical pollution

None

Water abstraction

Moderate

Siltation

Moderate

Human disturbance

Heavy or frequent

Fish stocks

Moderate

Bait organisms

Moderate

Other comments

One of the few estuaries in the area that still fulfils the requirements as a nursery area for fish.

SCORES

Score: 22 (n=1)

OVERALL EVALUATION OF STATE OF ESTUARY

Heavily perturbed, rehabilitation difficult

The future of the estuary (20 year projection)

Moderate development and some degradation

GROOT BRAK

State of mouth

Mouth periodically artificially breached

Type of surrounding development

Intense residential, with some industrial development

Encroachment of surrounding development

High

Garbage or litter

Moderate

Sewage or sewage effluent inflow

Moderate

Chemical pollution

Moderate. Relatively high metal concentrations, especially of chromium, reported in the sediments may reflect past industrial pollution. Sources now removed. The Venpet/Venoil disaster resulted in serious oil pollution in 1977, but the fauna has long since recovered.

Water abstraction

Heavy

Siltation

Moderate

Human disturbance

Heavy or frequent

Fish stocks

Degraded

Bait organisms

Degraded

Other comments

This estuary is the only one in South Africa that is fully managed and monitored. Approximately one million cubic metres of water per annum is allocated for release for environmental purposes.

SCORES

Scores: 11-22, Average = 16 (n=3)

OVERALL EVALUATION OF STATE OF ESTUARY

Heavily perturbed, rehabilitation difficult

The future of the estuary (20 year projection)

Rapid development and degradation

KAAIMANS**State of mouth**

Mouth operates on a completely natural cycle

Chemical pollution

None

Type of surrounding development

Rural. Much of one bank transformed by the N2 freeway.

Water abstraction

Moderate

Encroachment of surrounding development

High

Siltation

Moderate

Human disturbance

Moderate

Garbage or litter

Slight

Fish stocks

Moderate

Sewage or sewage effluent inflow

Slight

Bait organisms

Moderate

SCORES

Scores: 25-31, Average = 28 (n=3)

OVERALL EVALUATION OF STATE OF ESTUARY

Moderately perturbed, some rehabilitation necessary

The future of the estuary (20 year projection)

Moderate development and some degradation

TOUW RIVER

State of mouth

Mouth periodically artificially
breached

Type of surrounding development

Dispersed residential

**Encroachment of surrounding
development**

High

Garbage or litter

Slight

Sewage or sewage effluent inflow

Slight

Chemical pollution

Slight

Water abstraction

Moderate

Siltation

Moderate

Human disturbance

Moderate

Fish stocks

Moderate

Bait organisms

Moderate

SCORES

Scores: 22-28, Average = 25 (n=2)

OVERALL EVALUATION OF STATE OF ESTUARY

Moderately perturbed, some rehabilitation necessary

The future of the estuary (20 year projection)

Slow development with little degradation

SWARTVLEI**State of mouth**

Mouth periodically artificially
breached

Type of surrounding development

Intense residential

**Encroachment of surrounding
development**

High

Garbage or litter

Moderate

Sewage or sewage effluent inflow

Slight

Chemical pollution

Slight

Water abstraction

Moderate

Siltation

Moderate

Human disturbance

Heavy or frequent

Fish stocks

Moderate

Bait organisms

Moderate

SCORES

Scores: 20-29, Average = 23 (n=3)

OVERALL EVALUATION OF STATE OF ESTUARY

Moderately perturbed, some rehabilitation necessary

The future of the estuary (20 year projection)

Rapid development and degradation

GOUKAMMA**State of mouth**

Mouth periodically artificially
breached

Type of surrounding development

Rural

**Encroachment of surrounding
development**

Moderate

Garbage or litter

Slight

Sewage or sewage effluent inflow

Slight

Chemical pollution

Slight

Water abstraction

Slight

Siltation

Slight

Human disturbance

Slight or infrequent

Fish stocks

Healthy

Bait organisms

Healthy

SCORES

Score: 31 (n=1)

OVERALL EVALUATION OF STATE OF ESTUARY

Slightly perturbed, rehabilitation unnecessary

The future of the estuary (20 year projection)

Slow development with little degradation

KNYSNA

State of mouth

Mouth operates on a completely natural cycle

Type of surrounding development

Intense residential

Encroachment of surrounding development

Very high

Garbage or litter

Moderate

Sewage or sewage effluent inflow

Moderate. The sewage treatment works discharges 2 000m³ of effluent into the estuary daily.

Chemical pollution

Moderate. Some pollution from pesticides and fertilizers. Heavy metal pollution has generally been low, but transitory anomalies do occur.

Water abstraction

Moderate

Siltation

Moderate

Human disturbance

Heavy or frequent

Fish stocks

Moderate

Bait organisms

Healthy

SCORES

Scores: 20-27, Average = 23 (n=3)

OVERALL EVALUATION OF STATE OF ESTUARY

Moderately perturbed, some rehabilitation necessary

The future of the estuary (20 year projection)

Rapid development and degradation

NOETSIE**State of mouth**

Mouth operates on a completely
natural cycle

Type of surrounding development

Dispersed residential

**Encroachment of surrounding
development**

Slight

Garbage or litter

Slight

Sewage or sewage effluent inflow

Slight

Chemical pollution

Slight

Water abstraction

None

Siltation

None

Human disturbance

Slight or infrequent

Fish stocks

Healthy

Bait organisms

Healthy

SCORES

Score: 35 (n=1)

OVERALL EVALUATION OF STATE OF ESTUARY

Moderately perturbed, some rehabilitation necessary

The future of the estuary (20 year projection)

Slow development with little degradation

PIESANG

State of mouth

Mouth periodically artificially breached

Type of surrounding development

Intense residential

Encroachment of surrounding development

High

Garbage or litter

Moderate. Holiday makers tend to use the river and estuary for general waste disposal.

Sewage or sewage effluent inflow

Moderate. Accidental discharge of sewage has been reported.

Chemical pollution

Moderate

Water abstraction

Moderate

Siltation

Moderate

Human disturbance

Moderate

Fish stocks

Moderate

Bait organisms

Moderate

SCORES

Score: 20 (n=1)

OVERALL EVALUATION OF STATE OF ESTUARY

Moderately perturbed, some rehabilitation necessary

The future of the estuary (20 year projection)

Rapid development and degradation

KEURBOOMS

State of mouth

Mouth operates on a completely natural cycle

Type of surrounding development

Dispersed residential

Encroachment of surrounding development

Moderate

Garbage or litter

Slight

Sewage or sewage effluent inflow

Slight. Plettenberg Bay Sewage Treatment Works discharges into the estuary and there is often a high level of faecal coliforms due to human habitation upstream without proper sanitary facilities.

Chemical pollution

Slight. Relatively high cadmium values have been recorded, but these are probably of geochemical origin.

Water abstraction

Moderate

Siltation

Slight

Human disturbance

Moderate

Fish stocks

Healthy

Bait organisms

Healthy

SCORES

Scores: 26-32, Average = 29 (n=4)

OVERALL EVALUATION OF STATE OF ESTUARY

Moderately perturbed, some rehabilitation necessary

The future of the estuary (20 year projection)

Rapid development and degradation

SOUT (EAST)**State of mouth**

Mouth operates on a completely
natural cycle

Chemical pollution

None

Type of surrounding development

None

Water abstraction

Slight

**Encroachment of surrounding
development**

None

Siltation

None

Garbage or litter

Slight

Human disturbance

None

Sewage or sewage effluent inflow

None

Fish stocks

Healthy

Bait organisms

Healthy

SCORES

Score: 40 (n=1)

OVERALL EVALUATION OF STATE OF ESTUARY

Pristine

The future of the estuary (20 year projection)

Remain the same

GROOT (WEST)**State of mouth**

Mouth periodically artificially
breached

Type of surrounding development

Dispersed residential

**Encroachment of surrounding
development**

Slight

Garbage or litter

Slight

Sewage or sewage effluent inflow

Slight

Chemical pollution

Slight

Water abstraction

Moderate

Siltation

Slight

Human disturbance

Slight or infrequent

Fish stocks

Healthy

Bait organisms

Moderate

SCORES

Score: 29 (n=1)

OVERALL EVALUATION OF STATE OF ESTUARY

Slightly perturbed, rehabilitation unnecessary

The future of the estuary (20 year projection)

Slow development with little degradation

BLOUKRANS**State of mouth**

Mouth operates on a completely
natural cycle

Chemical pollution

None

Type of surrounding development

None

Water abstraction

Slight

**Encroachment of surrounding
development**

None

Siltation

None

Garbage or litter

None

Human disturbance

None

Sewage or sewage effluent inflow

None

Fish stocks

Pristine

Bait organisms

Pristine

SCORES

Score: 43 (n=1)

OVERALL EVALUATION OF STATE OF ESTUARY

Pristine

The future of the estuary (20 year projection)

Remain the same

ELANDSBOS**State of mouth**

Mouth operates on a completely
natural cycle

Chemical pollution

None

Type of surrounding development

None

Water abstraction

None

**Encroachment of surrounding
development**

None

Siltation

None

Garbage or litter

None

Human disturbance

None

Sewage or sewage effluent inflow

None

Fish stocks

Pristine

Bait organisms

Pristine

SCORES

Score: 44 (n=1)

OVERALL EVALUATION OF STATE OF ESTUARY

Pristine

The future of the estuary (20 year projection)

Remain the same

STORMS**State of mouth**

Mouth operates on a completely natural cycle

Type of surrounding development

None

Encroachment of surrounding development

None

Garbage or litter

None

Sewage or sewage effluent inflow

Slight

Chemical pollution

Slight. Primarily from a large service station situated approximately 9 kilometres upstream of the mouth.

Water abstraction

Moderate

Siltation

None

Human disturbance

Slight or infrequent

Fish stocks

Healthy

Bait organisms

Healthy

SCORES

Score: 37 (n=1)

OVERALL EVALUATION OF STATE OF ESTUARY

Pristine

The future of the estuary (20 year projection)

Remain the same

ELANDS

State of mouth

Mouth operates on a completely natural cycle

Type of surrounding development

None

Encroachment of surrounding development

None

Garbage or litter

None

Sewage or sewage effluent inflow

None

Chemical pollution

None

Water abstraction

Slight. Could increase dramatically in the near future if a scheme to supply Port Elizabeth with water from the Elands River is approved.

Siltation

None

Human disturbance

None

Fish stocks

Pristine

Bait organisms

Pristine

SCORES

Score: 43 (n=1)

OVERALL EVALUATION OF STATE OF ESTUARY

Pristine

The future of the estuary (20 year projection)

Remain the same

GROOT (EAST)**State of mouth**

Mouth operates on a completely
natural cycle

Chemical pollution

None

Type of surrounding development

Rural

Water abstraction

Moderate

**Encroachment of surrounding
development**

Slight

Siltation

Slight

Garbage or litter

Slight

Human disturbance

Slight or infrequent

Sewage or sewage effluent inflow

None

Fish stocks

Moderate

Bait organisms

Moderate

SCORES

Scores: 33-37, Average = 35 (n=2)

OVERALL EVALUATION OF STATE OF ESTUARY

Slightly perturbed, no rehabilitation necessary

The future of the estuary (20 year projection)

Slow development with little degradation

TSITSIKAMMA**State of mouth**

Mouth operates on a completely
natural cycle

Type of surrounding development

Rural

**Encroachment of surrounding
development**

Slight

Garbage or litter

None

Sewage or sewage effluent inflow

Slight

Chemical pollution

Slight

Water abstraction

Moderate

Siltation

Slight

Human disturbance

Slight or infrequent

Fish stocks

Healthy

Bait organisms

Healthy

SCORES

Scores: 31-39, Average = 34 (n=3)

OVERALL EVALUATION OF STATE OF ESTUARY

Slightly perturbed, rehabilitation unnecessary

The future of the estuary (20 year projection)

Moderate development and some degradation

KROMME

State of mouth

Mouth operates on a completely natural cycle

Type of surrounding development

Dispersed residential

Encroachment of surrounding development

Moderate

Garbage or litter

Moderate

Sewage or sewage effluent inflow

Slight. Some septic tank seepage present.

Chemical pollution

Slight. Elevated heavy metal concentrations have been reported, the source of which is unknown. Not considered serious.

Water abstraction

Extreme

Siltation

Moderate

Human disturbance

Heavy or frequent

Fish stocks

Moderate

Bait organisms

Moderate

SCORES

Scores: 19-27, Average = 24 (n=4)

OVERALL EVALUATION OF STATE OF ESTUARY

Heavily perturbed, rehabilitation difficult

The future of the estuary (20 year projection)

Rapid development and degradation

SEEKOEI

State of mouth

Mouth altered and/or artificially
controlled

Chemical pollution

Slight

Type of surrounding development

Intense residential

Water abstraction

Extreme

**Encroachment of surrounding
development**

High

Siltation

Extreme

Garbage or litter

Moderate

Human disturbance

Extreme

Sewage or sewage effluent inflow

Moderate

Fish stocks

Degraded

Bait organisms

Degraded

SCORES

Scores: 12-15, Average = 14 (n=3)

OVERALL EVALUATION OF STATE OF ESTUARY

Completely transformed, no chance of successful rehabilitation

The future of the estuary (20 year projection)

Very rapid degradation, or already destroyed

KABELJOUS**State of mouth**

Mouth periodically artificially
breached

Type of surrounding development

Dispersed residential

**Encroachment of surrounding
development**

Moderate

Garbage or litter

Slight

Sewage or sewage effluent inflow

Slight

Chemical pollution

Slight

Water abstraction

Moderate

Siltation

Moderate

Human disturbance

Moderate

Fish stocks

Moderate

Bait organisms

Moderate

SCORES

Scores: 21-27, Average = 25 (n=3)

OVERALL EVALUATION OF STATE OF ESTUARY

Moderately perturbed, some rehabilitation necessary

The future of the estuary (20 year projection)

Rapid development and degradation

GAMTOOS

State of mouth

Mouth operates on a completely natural cycle

Type of surrounding development

Rural

Encroachment of surrounding development

Moderate

Garbage or litter

Slight

Sewage or sewage effluent inflow

Slight

Chemical pollution

Slight. Mostly from agrochemicals; not severe.

Water abstraction

Moderate

Siltation

Moderate

Human disturbance

Moderate

Fish stocks

Healthy

Bait organisms

Healthy

SCORES

Scores: 29-32, Average = 31 (n=4)

OVERALL EVALUATION OF STATE OF ESTUARY

Moderately perturbed, some rehabilitation necessary

The future of the estuary (20 year projection)

Moderate development and some degradation

VAN STADENS**State of mouth**

Mouth altered and/or artificially
controlled

Type of surrounding development

Dispersed residential

**Encroachment of surrounding
development**

High

Garbage or litter

Heavy

Sewage or sewage effluent inflow

Slight

Chemical pollution

Slight

Water abstraction

Moderate

Siltation

Heavy

Human disturbance

Heavy or frequent

Fish stocks

Degraded

Bait organisms

Degraded

SCORES

Scores: 16-23, Average = 20 (n=2)

OVERALL EVALUATION OF STATE OF ESTUARY

Heavily perturbed, rehabilitation difficult

The future of the estuary (20 year projection)

Rapid development and degradation

4 ASSESSMENT OF THREATS TO C.A.P.E. ESTUARIES

4.1 THREATS TO THE PHYSICAL ENVIRONMENT

A number of threats to the physical functioning of C.A.P.E. estuaries were identified. The responses of 12 specialists to these are summarised in Table 1 and will be discussed in the sections below.

Table 1. The percentage of C.A.P.E. estuaries falling within the various physical condition categories. Totals may not add up to 100 due to rounding.

State of mouth	Mouth operates on a completely natural cycle 58		Mouth periodically artificially breached 29		Mouth altered and/or artificially controlled 13
Type of surrounding development	None 12	Rural 23	Dispersed residential 35	Intense residential 29	Industrial 2
Encroachment of surrounding development	None 13	Slight 23	Moderate 29	High 27	Very high 8
Garbage or litter	None 17	Slight 46	Moderate 29	Heavy 6	Extreme 2
Sewage or sewage effluent inflow	None 25	Slight 46	Moderate 21	Heavy 0	Extreme 8
Chemical pollution	None 29	Slight 50	Moderate 17	Heavy 2	Extreme 2
Water abstraction	None 10	Slight 29	Moderate 46	Heavy 10	Extreme 6
Siltation	None 15	Slight 35	Moderate 44	Heavy 2	Extreme 4
The future of the estuary (20 year projection)	Remain the same 16	Slow development with little degradation 16	Moderate development and some degradation 24	Rapid development and degradation 37	Very rapid degradation, or already destroyed 8

4.1.1 Alteration of mouth dynamics

In more than half (58%) of estuaries in the C.A.P.E. region, the mouth still operates on a completely natural cycle (Table 1). In almost one third (29%) the mouth is periodically artificially breached. The remaining 13% (n=7) of C.A.P.E. estuaries have mouths which have been altered and/or are artificially controlled. These estuaries are: Wadrif, Berg River, Black River, Sandvlei, Zeekoevlei, Seekoei and Van Stadens.

4.1.2 Surrounding development

Almost one third (31%) of C.A.P.E. estuaries are surrounded by intense residential or industrial developments (Table 1). A further third (35%) are surrounded by dispersed residential developments, such as holiday cottages, while the land surrounding the last third is either undeveloped or is rural in nature.

Similarly, approximately one third (35%) of the estuaries in the C.A.P.E. region suffer from high or very high encroachment by surrounding developments, while in another third (29%) encroachment is moderate, and in the last third (36%) there is little or no encroachment onto the estuary by surrounding developments.

The 20-year projections, which give an indication of the pace of development around estuaries, indicated that 16% of estuaries would not be likely to receive additional developments within the next 20 years. In a further 16% it was indicated that development was likely to be slow, and little degradation would result. Thus approximately one third (32%) of C.A.P.E. estuaries do not appear to be under threat from increased development within the next 20 years. At the other extreme, 8% of C.A.P.E. estuaries were placed in the category "very rapid degradation, or already destroyed". All of these were placed in this category because they are already destroyed, rather than because of increased development. The remaining 61% of estuaries were perceived to be under some threat from future development, either moderate (24%) or rapid (37%), and would suffer some degradation within the next 20 years.

4.1.3 Pollution

For the purposes of this study, "pollution" was divided into three components, namely garbage or litter, sewage or sewage effluent, and chemical. Almost two thirds (63%) of the estuaries within the C.A.P.E. region have no, or very low levels, of garbage or litter (Table 1). A further 29% have moderate levels of garbage, while only 8% were identified as having a problem in this regard ("heavy" & "extreme").

One quarter of C.A.P.E. estuaries do not suffer from sewage pollution. However, 46% and 21% suffer from "slight" and "moderate" levels of sewage pollution. Together these make up two thirds (67%) of all estuaries within the region. No estuaries were identified as having "heavy" levels of sewage, but almost 10% (n=4) suffer from extreme sewage pollution. These were the Black River, Wildevoëlvlei, Zeekoevlei and Hartenbos. It should be noted that the first three of these lie in or near Cape Town, the largest urban area in the C.A.P.E. region.

Chemical pollution, which includes a wide range of substances, does not appear to be a widespread problem in C.A.P.E. estuaries. 29% of estuaries have no chemical pollution, while this is considered "slight" in 50% and "moderate" in 17%. Chemical pollution is only considered severe ("heavy" & "extreme") in 4% of estuaries.

An analysis of the general pollution levels (including all types of pollution) in C.A.P.E. estuaries is presented in Table 2. Almost two thirds (63%) of estuaries were considered to be in a "pristine" state, or to have acceptable pollution levels. However, approximately one third (37%) appear to have pollution problems. Of these, 22% are considered mildly polluted, while 15% are considered heavily polluted.

Table 2. Categorisation of estuaries on the C.A.P.E. region on the basis of their pollution levels. This categorisation includes all types of pollution. Estuaries in each column are ordered from west to east around the coast.

"Pristine" or acceptable		Mildly polluted	Heavily polluted
Wadrif	Kaaimans	Olifants	Verlorenvlei
Schuster's	Touws River	Berg River	Sout (West)
Silvermine	Swartvlei	Modder	Black
Steenbras	Goukamma	Diep	Wildevogelvlei
Rooi-els	Noetsie	Disa	Sandvlei
Buffels	Sout (East)	Hartenbos	Zeekeovlei
Palmiet	Groot (West)	Klein Brak	Eerste
Kleinmond	Bloukrans	Groot Brak	Lourens
Bot River	Elandsbos	Knysna	
Onrus	Storms	Piesang	
Klein	Elands	Keurbooms	
Uilkraals	Groot (East)	Seekoei	
Heuningnes	Tsitsikamma		
Breede	Kromme		
Duiwenhoks	Kabeljous		
Kafferkuils	Gamtoos		
Gouritz	Van Stadens		

4.1.4 Water abstraction

Ninety percent of all estuaries within the C.A.P.E. region suffer from water abstraction in upstream areas (Table 1). Only 10% of estuaries are unaffected by water abstraction, and these are mostly very small estuaries. In 16% of estuaries, water abstraction was rated as "heavy" or "extreme", while this was rated as "moderate" in almost 50% of estuaries.

4.1.5 Siltation

Siltation affects 85% of C.A.P.E. estuaries (Table 1). Within these, siltation is slight in 35%, moderate in 44%, heavy in 2%, and extreme in 4%. Thus half (50%) of the estuaries within the C.A.P.E. region suffer from relatively high levels of siltation.

4.2 DIRECT THREATS TO THE BIOTA

Direct threats to the estuarine biota take the form of disturbance and exploitation. Table 3 summarises the biological state of C.A.P.E. estuaries. In approximately one third (35%) of estuaries, there is little or no disturbance by humans. In approximately another third (37%) disturbance caused by human activities was regarded as moderate, while the remaining third (31%) are subjected to heavy or extreme levels of disturbance by humans.

Fish and bait stocks are both considered to be in a pristine or healthy state in 41% of C.A.P.E. estuaries. Stocks of these organisms are considered moderate in almost one third (fish=31%, bait organisms=33%) of estuaries. In almost 30% of estuaries, however, stocks of these organisms were rated as being either degraded or destroyed (fish=29%, bait organisms=27%). These estuaries suffer from a number of problems, with alteration and/or artificial control of the estuary mouth, extreme sewage pollution and very high levels of encroachment by surrounding developments being the most important of these.

Table 3. Percentages of C.A.P.E. estuaries which are affected by differing levels of disturbance and the state of stocks of fish and bait organisms. Totals may not add up to 100 due to rounding.

Human disturbance	None 10	Slight or infrequent 25	Moderate 37	Heavy or frequent 25	Extreme 4
Fish stocks	Pristine 10	Healthy 31	Moderate 31	Degraded 21	Destroyed 8
Bait organisms	Pristine 12	Healthy 29	Moderate 33	Degraded 19	Destroyed 8

4.3 SUMMATION OF THREATS TO C.A.P.E. ESTUARIES

Numerous threats currently operate on estuaries of the C.A.P.E. region. The majority of these affect the physical environment and the dynamics of the estuarine system, and in so doing are liable to affect the biotic composition of the estuaries. Direct threats to the biota include exploitation of organisms and disturbance to estuarine biota, particularly birds.

Several factors threaten the physical environment and dynamics of the estuarine systems of the C.A.P.E. region. Background information relating to these is given in Section 1. Probably the most important factor in maintaining the estuarine dynamics is to maintain the balance between erosional and depositional forces which regulate the natural opening and closing regime of the estuary mouth. This is not as simple as it sounds, however, since almost all the other threats to C.A.P.E. estuaries have some influence on the mouth dynamics, and several of the threats are interlinked. These linkages were highlighted in Section 1, and are summarised in Figure 1. Of all the threats, the type of development surrounding an estuary is the most important of these, as it has bearing on a large number of other threats.

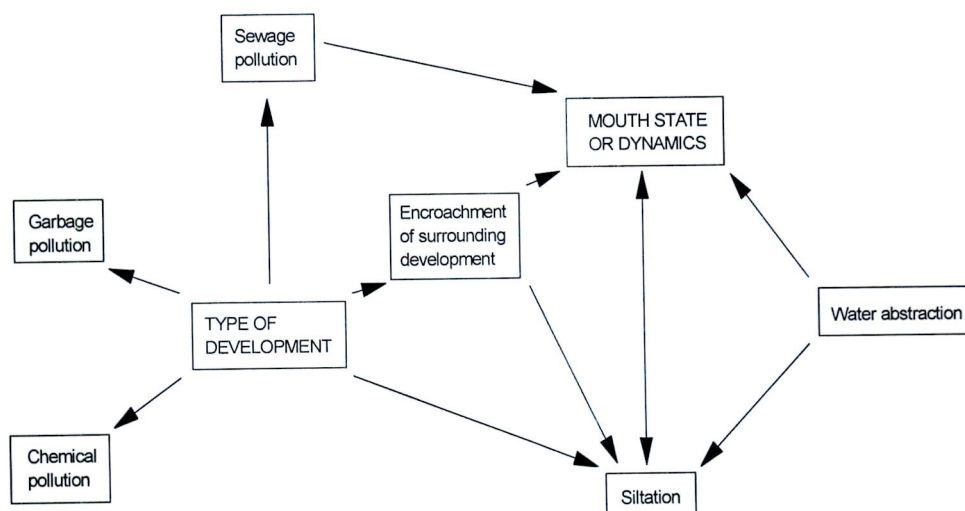


Figure 1. Summary of the linkages between threats operating on the physical functioning of C.A.P.E. estuaries.

4.4 FACING THE THREATS TO THE ESTUARIES OF THE C.A.P.E. REGION

As indicated previously, the threats operating on estuaries within the C.A.P.E. region may be broken down into two types - those that threaten the physical environment of the estuary, and those that pose a direct threat to the biota. Because of this difference, any effort towards conservation of these estuarine systems needs to consider two approaches. The first of these is conservation of the habitat, which includes management of the physical environment. Since all estuaries are unique, this would require the development of individual management plans and conservation targets for each estuary. These will need to address both water quality and quantity, and reaching targets may involve the creation of new, and better enforcement of existing, legislation. It is important to note that since many of the threats originate in the catchment, rather than at the estuary itself, management of the catchment which feeds that estuary will be of paramount importance. To some extent, at least, this is dealt with in the Freshwater Component of the C.A.P.E. project.

The second approach is conservation of the biota, including conservation not only of biodiversity, but also of stocks for exploitative use. Conservation of biodiversity may require only relatively low-level conservation actions. However, ensuring stocks of organisms for exploitative use may require more stringent measures, which may include areas of low disturbance and zero exploitation. The conservation of coastal fishes, for example cannot be entirely successful without the aid of Marine Protected Areas (dealt with in the Marine Component of the C.A.P.E. project). A number of these fishes (including some which are endemic to the southern African region) use estuaries at least during a portion of their life cycle. If conservation efforts targeted at these species are to be successful, then protection from exploitation whilst they are in the estuarine environment is vital in order to complement their protected status on the open coast.

The "scores" that were generated through the evaluation sheets can be used to "rank" estuaries in terms of their physical state (Table 4). The five "best" estuaries were Schuster's, Elandbos, Bloukrans, Elands and Sout (East), all being assigned a minimum ranking of 40 out of a possible 44. At the opposite end of the spectrum, eight estuaries were given a ranking of less than 20. These were the Diep, Disa, Wildevoeëlvlei, Sandvlei, Groot Brak, Seekoei, Zeekoevlei and the Black River. Six of these estuaries lie in or near Cape Town.

Table 4. "Ranking" of estuaries from "best" to "worst" in terms of their physical state. The highest ranking possible is 44, and the lowest zero. Where more than one evaluation sheet was returned, "rankings" are averages.

Rank	Estuary	Rank	Estuary	Rank	Estuary
44	Schuster's	31	Kleinmond	23	Silvermine
	Elandsbos		Goukamma		Swartvlei
43	Bloukrans		Gamtoos		Knysna
	Elands	26	Steenbras	22	Klein Brak
40	Sout (East)		Rooi-els	21	Onrus
38	Modder		Breede		Hartenbos
37	Heuningnes		Keurbooms	20	Berg River
	Storms		Groot (West)		Piesang
35	Noetsie	28	Bot River		Van Stadens
	Groot (East)		Klein	19	Diep
34	Palmiet		Kafferkuils		Disa River
	Duiwenhoks		Kaaimans	18	Wildevoëlvlei
	Gouritz	26	Wadrif		Sandvlei
	Tsitsikamma	25	Eerste	16	Groot Brak
33	Verlorenvlei		Touw	14	Seekoei
32	Olifants		Kabeljous	12	Zeekoevlei
	Uilkraals	24	Kromme	8	Black River

5 PRELIMINARY ASSESSMENT OF AMENABILITY OF C.A.P.E. ESTUARIES TO CONSERVATION

In terms of physical condition, estuaries which scored relatively high rankings would appear to be the most amenable to conservation. However, there was little concordance between the "rank" assigned to each estuary and the overall evaluation of the state of the estuary (Table 5). The only generalisations that could possibly be made are as follows:

- estuaries with a ranking of 40 or above are in a pristine state
- estuaries with a ranking of 16-20 are heavily perturbed
- estuaries with a ranking of 15 or less are completely transformed.

Table 5. The "rank" and overall assessment of C.A.P.E. estuaries.

Rank	Overall assessment	Rank	Overall assessment
44	Pristine	28	Slightly perturbed
44	Pristine	28	Moderately perturbed
43	Pristine	28	Moderately perturbed
43	Pristine	28	Moderately perturbed
40	Pristine	26	Heavily perturbed
38	Slightly perturbed	25	Moderately perturbed
37	Pristine	25	Moderately perturbed
37	Slightly perturbed	25	Moderately perturbed
35	Slightly perturbed	24	Heavily perturbed
35	Moderately perturbed	23	Moderately perturbed
34	Slightly perturbed	23	Moderately perturbed
34	Slightly perturbed	23	Moderately perturbed
34	Slightly perturbed	22	Heavily perturbed
34	Slightly perturbed	21	Heavily perturbed
33	Moderately perturbed	21	Heavily perturbed
32	Slightly perturbed	20	Moderately perturbed
32	Slightly perturbed	20	Moderately perturbed
31	Slightly perturbed	20	Heavily perturbed
31	Moderately perturbed	19	Heavily perturbed
31	Moderately perturbed	19	Heavily perturbed
29	Slightly perturbed	18	Heavily perturbed
29	Slightly perturbed	18	Heavily perturbed
29	Moderately perturbed	16	Heavily perturbed
29	Moderately perturbed	14	Completely transformed
29	Moderately perturbed	12	Completely transformed
		8	Completely transformed

Categorising estuaries in terms of their overall evaluation (Table 6) gives a further indication of the physical state of the estuary and hence its amenability to conservation. Here the same five estuaries which scored more than 40 were rated as pristine, with the addition of a sixth estuary (Storms River). The three estuaries which received less than 15 in the rankings were all classed as completely transformed, with no chance of successful rehabilitation possible. The five estuaries which were assigned rankings of between 16 and 20 were all deemed to be heavily perturbed, and rehabilitation difficult.

Table 6. Categorisation of estuaries in terms of overall evaluation.

Pristine	Slightly perturbed	Moderately perturbed	Heavily perturbed	Completely transformed
Schuster's	Olifants	Verlorenvlei	Wadrif	Black River
Sout (East)	Modder	Berg River	Diep	Zeekoevlei
Bloukrans	Steenbras	Silvermine	Disa	Seekoei
Elandsbos	Palmiet	Eerste	Wildevoëlvlei	
Storms	Uilkraals	Rooi-els	Sandvlei	
Elands	Heuningnes	Kleinmond	Onrus	
	Duiwenhoks	Bot River	Hartenbos	
	Kafferkuils	Klein	Klein Brak	
	Gouritz	Brede	Groot Brak	
	Goukamma	Kaaimans	Kromme	
	Groot (West)	Touws River	Van Stadens	
	Groot (East)	Swartvlei		
	Tsitsikamma	Knysna		
		Noetsie		
		Piesang		
		Keurbooms		
		Kabeljous		
		Gamtoos		

6 PRELIMINARY ANALYSIS OF BIOTIC DATA

Preliminary analysis of the biotic data in order to evaluate the conservation importance of C.A.P.E. estuaries have been done using the data for fishes. Estuaries were classified in terms of their importance as a nursery area for juvenile fishes (Table 7). Approximately one third (34%) of estuaries were termed important or critically important in terms of their nursery function, while a further 22% were classified as of moderate importance as fish nursery areas. A relatively large proportion (44%) were deemed insignificant or only of slight importance in terms of their nursery function.

Table 7. The relative importance of C.A.P.E. estuaries as nursery areas for fishes.

Critically important	Important	Moderate	Slight	Insignificant
Olifants	Diep	Rooi-els	Verlorenvlei	Wadrif
Berg River	Eerste	Palmiet	Wildevogelvlei	Modder
Sandvlei	Kleinmond	Uilkraals	Steenbras	Black
Bot River	Klein	Duiwenhoks	Onrus	Disa
Heuningnes	Touws	Kafferkuils	Groot Brak	Schuster's
Breede	Kromme	Gouritz	Groot (West)	Silvermine
Klein Brak	Gamtoos	Kaaimans	Bloukrans	Zeekeovlei
Swartvlei		Goukamma	Elandsbos	Hartenbos
Knysna		Piesang	Storms	Sout (East)
Keurbooms		Groot (East)	Seekoei	Elands
		Tsitsikamma	Kabeljous	
			Van Stadens	
20% (n=10)	14% (n=7)	22% (n=11)	24% (n=12)	20% (n=10)

The species richness data collected during the first phase of this project was subjected to stepwise selection analysis to reveal the minimum number of estuary which could theoretically conserve all the fish species which occur in estuaries in the C.A.P.E. region. It should be noted that these analyses should not be used for conservation planning, as they are based purely on the numbers of species present. The outcomes (estuaries) do not necessarily include viable population sizes, nor sufficient buffering to withstand the effects of natural or anthropogenic changes or catastrophes.

Using data only for fishes of marine or estuarine origin (i.e. not fishes of freshwater origin) which are endemic to southern Africa resulted in the selection of eight estuaries which would conserve all of the 42 endemic marine fishes which occur in C.A.P.E. estuaries. These were:

Knysna	34 species
Bot River or Klein	2 species
Olifants	1 species
Berg River	1 species
Diep/Milnerton	1 species
Breede	1 species
Swartvlei	1 species
Keurbooms	1 species

The same analysis was performed on fishes of marine and estuarine origin which are endemic to southern Africa, and which are either wholly dependent on estuaries or depend more on estuaries than other coastal habitats (estuarine dependence categories I, IIa & IIb *sensu* Whitfield 1998). This revealed only two estuaries which were necessary to conserve the 17 fish species which fell into this classification. These were:

Knysna or Swartvlei	16 species
Bot River or Klein	1 species

It would thus appear that, in terms of conservation of the endemic fishes, and particularly those that depend on estuaries for the completion of their life cycles, that Knysna and the Bot River or Klein (at Hermanus) are of utmost importance.

7 SYNTHESIS

This report has dealt at some length with the current threats to C.A.P.E. estuaries and the current physical state of those estuaries. Some attempt should be made to overlay the physical state of the estuary with its biological importance. Superimposing the physical state on the importance of the nursery function of estuaries in the C.A.P.E. region yields some interesting results (Table 8).

It is evident that, of the 17 estuaries which are important or critically important in terms of their nursery function for fishes, four (Sandvlei, Klein Brak, Diep & Kromme) are either heavily perturbed or completely transformed, while 11 are considered to be in a moderately perturbed state. Only two (Olifants & Heuningnes) are considered to be in a pristine or slightly perturbed state. It is interesting to note here that only one of these (Olifants) was selected as necessary for conserving the diversity of endemic marine fishes, and only one species of fish was involved. The most important estuaries in terms of conservation of fish diversity (Knysna, Swartvlei, Bot River & Klein), which are also important in terms of their nursery function, are considered to be moderately perturbed, and some rehabilitation of these estuaries is deemed necessary.

Table 8. The relative importance of C.A.P.E. estuaries as nursery areas for fishes.

* indicates those estuaries which are classed as being heavily perturbed or completely transformed. ° indicates those estuaries which are considered to be in a pristine state or are only slightly perturbed. Those estuaries without a prefix are considered to be moderately perturbed.

Critically important	Important	Moderate	Slight	Insignificant
°Olifants	*Diep	Rooi-els	Verlorenvlei	*Wadrif
Berg River	Eerste	°Palmiet	*Wildevogelvlei	°Modder
*Sandvlei	Kleinmond	°Uilkraals	°Steenbras	*Black
Bot River	Klein	°Duiwenhoks	*Onrus	*Disa
°Heuningnes	Touws	°Kafferkuils	*Groot Brak	°Schuster's
Brede	*Kromme	°Gouritz	°Groot (West)	Silvermine
*Klein Brak	Gamtoos	Kaaimans	°Bloukrans	*Zeekeovlei
Swartvlei		°Goukamma	°Elandsbos	*Hartenbos
Knysna		Piesang	°Storms	°Sout (East)
Keurbooms		°Groot (East)	*Seekoei	°Elands
		°Tsitsikamma	Kabeljous	
			*Van Stadens	

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PRIORITISING C.A.P.E. ESTUARIES FOR CONSERVATION

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1 BACKGROUND

Estuaries are complex, dynamic systems which offer a wide range of ecological services. These services may be of benefit to entire ecosystems (such as the physical and biological filtering of water passing through the system), to the biota inhabiting estuaries (such as providing nursery areas for juvenile fishes), or to humans (such as the maintenance of exploitable stocks). The C.A.P.E. region houses just under 60 estuaries, each of which differs in its physical and biological characteristics. Many attempts have been made in the past to classify estuaries, the result of which has been a global awareness that every estuary is unique, and that broad generalisations concerning estuaries cannot be easily made or applied. This observation leads to the general statements below:

- Within the C.A.P.E. region (and elsewhere) **all estuaries** are **important** and should be afforded **some form of conservation**.
- Given this situation, the idealist view is to conserve all estuaries. However, this is not practical, and **some** estuaries are undoubtedly **more important** than others in terms of the services they provide to biota and humans, and should thus receive some **direct form of protection**.

These two arguments suggest that a two-tiered approach, based on protection and conservation would be the most parsimonious way of ensuring the maintenance of ecological functioning and the continued support of biological diversity within estuarine systems.

1.1 CONSERVATION

Conservation may take a number of forms and/or involve a number of actions which are directed towards the maintenance of a system in its current condition, or to enhance the current condition if it has already been perturbed. Such actions usually involve regulations which govern the use of certain species, resources, or areas. Some such conservation actions are currently in place to protect the biota of estuaries (for example the regulations specified by the Chief Directorate of Marine and Coastal Management of the Department of Environment Affairs and Tourism). However, there are almost none, with the exception of the recent Water Act which are aimed at conserving the physical processes which ultimately sustain biological processes. In the past, conservation measures have largely included restrictions on the quantities of the most heavily exploited organisms that were allowed to be harvested. The strong dependence of the functioning of estuarine systems on freshwater inflow from rivers has long been ignored because of the difficulty of conserving whole catchments, and because of the growing demand for freshwater resources in a country that is relatively poor in water.

1.2 PROTECTION

Protection is a special form of conservation which legally protects the ecological processes or biological attributes of a system, and usually involves the establishment of reserve areas. Such areas need not be off-limits in terms of utilisation by humans, but may allow controlled levels of both consumptive and non-consumptive use.

2 ACCESS: ASSESSMENT CRITERIA FOR CONSERVATION OF ESTUARINE SYSTEMS

This two-tiered approach (conservation and protection) requires that some method be established which allows the prioritisation of estuaries in terms of their importance or usefulness to the conservation of biological diversity. To this end, a workshop of estuarine specialists was convened on 10 September 1999, which attempted to devise a methodology which allows comparative assessment of the conservation importance of individual estuarine systems.

The brief of the C.A.P.E. project is to conserve biodiversity within the Cape Floristic Region, its associated rivers, estuaries and coastline. Since this goal is rather broad, it became necessary to set more specific conservation objectives which could be used to prioritise estuaries within the C.A.P.E. region in terms of their conservation importance. The aim of this workshop was twofold:

- 1) to generate a number of objectives which would fulfil the overall goal of "conserving biodiversity", and
- 2) to identify criteria which would allow an assessment of how well individual estuaries meet those objectives.

It was decided by those present at the workshop that a system similar to the COMPARE system designed for open coasts (Hockey & Branch 1997) should be devised for use in estuaries. Such a system could then be applied to prioritising estuaries within the C.A.P.E. region in terms of their conservation importance.

During the workshop, the ACCESS system was devised. (ACCESS = Assessment Criteria for Conservation of Estuarine Systems). This system is based on a number of objectives, which are detailed below. Eight criteria are used to assess to what extent an individual estuary fulfils each of the 6 objectives.

2.1 OBJECTIVES OF ESTUARINE CONSERVATION

The objectives of conserving estuarine habitats can be divided into two categories - protection of the physical and biotic environment, and continuation of benefits to humans.

2.1.1 *Protection of the physical and biotic environment of estuaries*

Four objectives were defined within this broad group.

1. Representativeness

To ensure protection of estuaries which are representative of the biogeographic region in which they occur, and of various estuarine types.

For the purposes of the C.A.P.E. project, only two biogeographic provinces are relevant, namely the Cool Temperate West Coast or Namaqua Province and the Warm Temperate South Coast or Agulhas Province (after Emanuel *et al.* 1992).

Estuarine types are those proposed by Whitfield (1992). These include temporarily closed estuaries, permanently open estuaries, river mouths, estuarine lakes, and estuarine bays.

2. Habitat diversity

To ensure protection of estuaries containing a diversity of habitats (and thus diversity of species).

3. Rare/endemic species

To ensure protection of rare, endemic or range-restricted species within estuaries.

4. Ecological functioning

To ensure protection of estuaries in which ecological processes are relatively unperturbed and unthreatened.

2.1.2 Benefits to humans

Estuaries provide a wide range of benefits to humans. These were condensed into two categories.

5. Consumptive use

To ensure the protection of species, stocks or processes which sustain or enhance the consumptive use of estuarine organisms by humans.

6. Non-consumptive use

To ensure the protection of processes which maintain the estuarine condition for non-consumptive recreational usage of estuaries by humans.

2.2 CRITERIA USED TO MEASURE PERFORMANCE OF INDIVIDUAL ESTUARIES

Eight criteria were developed to evaluate the extent to which individual estuaries fulfil the objectives outlined above.

1. Degree of representation

Estuaries in different biogeographic provinces support different suites of species, as do estuaries of different types. This question asks whether the estuary is a good representative of either the biogeographic province in which it occurs, or the type of estuary it represents.

2. Level of habitat diversity

Different species have different habitat requirements. Protection of a low number of habitat types will thus only protect relatively low numbers of species. This question asks what range of habitats are supported in the system. Habitats here include saltmarshes, floodplains, emergent vegetation of different types, areas which experience different flow patterns and thus have different sediment characteristics, etc.

3. Habitats or species of special interest?

Particular habitats or species may hold special interest for a number of reasons. They may be rare, endemic to either the estuary or the southern African region, have particular significance to humans, be particularly good examples of a habitat type, etc. This question asks to what degree the estuary contains such habitats or species.

4. Vulnerable stages supported?

The life histories of most organisms (plants and animals) have stages which are vulnerable to threats imposed on them by human activities. Examples include migratory birds which feed in estuaries (either in summer, or as overwintering juveniles, or as a stop-over point on migration), fishes on spawning migrations, and juvenile fish which use estuaries as nursery areas. In order to ensure the long term survival of these species, it is essential that those vulnerable stages receive adequate protection. The question asks what range of vulnerable stages the estuary supports, and how important the estuary is in fulfilling these functions in the life histories of the species concerned.

5. Condition suitable?

The physico-chemical condition of the estuary ultimately affects the biology of that estuary. This question asks if the physico-chemical condition of the estuary is suitable for the maintenance of that particular attribute or activity.

6. Range of ecological services?

The term "ecological services" is used broadly here. In the context of objectives which aim to protect the physical and biotic nature of estuaries, "ecological services" includes attributes which maintain the ecological functioning of the system. This includes such "services" as providing feeding, breeding or nursery grounds, etc. to estuarine biota. In the context of benefits to humans, "ecological services" refers to the services that the system does or can provide to humans (eg. provides fish or bait resources, provides wide scope for recreational use, etc.).

7. Importance to fish or fisheries?

Here the word "fish" is used in the broadest sense, and includes any aquatic plant, invertebrate or vertebrate species. The question asks how important the area is as a habitat for "fish" (protection objectives), and for fisheries (human benefit objectives).

8. Size adequate/viable populations?

Although certain estuaries may appear to be important in terms of both their biota and the benefits they offer to humans, their size, or the populations of organisms they support, may be insufficient to maintain these attributes over time. This question thus asks whether the size of the estuary, or the populations of organisms within them, are large enough to sustain various objectives over time.

2.3 USE AND INTERPRETATION OF THE ACCESS SHEET

Mis-use or mis-interpretation of the objectives and the criteria could lead to erroneous evaluations. It is thus imperative that the sheets be used properly. The criteria should be viewed as questions, with the objectives as the end goal of those questions. For example, using the criterion *Is the condition suitable?* to achieve the objective *Consumptive use*, one would be asking the question "What is the condition of this estuary in terms of its suitability for the maintenance of consumptive use?". The answer can then be ranked according to how well the criterion achieves that objective. The ranking system is as follows:

0	1	2	3	4
Non/no value	Poor	Moderate	Good	Very good/excellent

2.4 THE ACCESS SYSTEM

Estuary name:.....

CRITERIA	OBJECTIVES	PROTECTION				HUMAN BENEFITS		TOTALS FOR CRITERIA	PERCENTAGES	POSSIBLE MAXIMA
		1. Representativeness	2. Habitat diversity	3. Rare/endemic species	4. Ecological functioning	5. Consumptive use	6. Non-consumptive use			
1. Degree of representation?										4
2. Level of habitat diversity?										4
3. Habitats or species of special interest?										8
4. Vulnerable stages supported?										8
5. Condition suitable?										12
6. Range of ecological services?										8
7. Importance to fish or fisheries?										8
8. Size adequate/viable populations?										16
TOTALS FOR OBJECTIVES										
PERCENTAGES										
POSSIBLE MAXIMA		8	12	8	12	20	8			

TOTAL SCORES			
PERCENTAGE SCORES			
POSSIBLE MAXIMUM SCORES	40	28	68

SCALE

- 0 None/no value
- 1 Poor
- 2 Moderate
- 3 Good
- 4 Very good/excellent

2.5 TESTING THE APPLICATION OF THE ACCESS SYSTEM

During the workshop, the ACCESS system was applied to six estuaries within the C.A.P.E. region. These were chosen to represent a wide range of estuaries, and included the Black River, Sandvlei, Palmiet, Berg, Breede and Knysna. The completed ACCESS sheet for each estuary appears below.

The relative scores awarded to the six estuaries using the ACCESS system were in line with what would have been expected. The Black River, which is a highly perturbed and degraded system, received a total of only 3%, suggesting that it is not an important estuary. In terms of protection of biodiversity, it received zero, while its contribution to benefits to humans was minimal, at 7%. At the opposite extreme, Knysna achieved a total score of 97%. The contribution of this estuary to protection of biodiversity was rated as 100%, while the benefits it offers to humans scored 93%.

Table 1. The percentage scores achieved using the ACCESS system for six C.A.P.E. estuaries.

Estuary	Protection	Human benefits	Total
Black	0	7	3
Sandvlei	43	43	43
Palmiet	45	57	50
Berg	95	64	82
Breede	88	93	90
Knysna	100	93	97

Estuary name: **Black River**

CRITERIA	OBJECTIVES	PROTECTION				HUMAN BENEFITS		TOTALS FOR CRITERIA	PERCENTAGES	POSSIBLE MAXIMA
		1. Representativeness	2. Habitat diversity	3. Rare/endemic species	4. Ecological functioning	5. Consumptive use	6. Non-consumptive use			
1. Degree of representation?		0						0	0	4
2. Level of habitat diversity?			0					0	0	4
3. Habitats or species of special interest?				0		0		0	0	8
4. Vulnerable stages supported?					0	0		0	0	8
5. Condition suitable?			0			0	1	1	8	12
6. Range of ecological services?					0		1	1	13	8
7. Importance to fish or fisheries?					0	0		0	0	8
8. Size adequate/viable populations?		0	0	0		0		0	0	16
TOTALS FOR OBJECTIVES		0	0	0	0	0	2	2		
PERCENTAGES		0	0	0	0	0	25			
POSSIBLE MAXIMA		8	12	8	12	20	8			

TOTAL SCORES	0	2	2
PERCENTAGE SCORES	0	7	3
POSSIBLE MAXIMUM SCORES	40	28	68

SCALE

- 0 None/no value
- 1 Poor
- 2 Moderate
- 3 Good
- 4 Very good/excellent

Estuary name: **Sandvlei**

CRITERIA	OBJECTIVES	PROTECTION				HUMAN BENEFITS		TOTALS FOR CRITERIA	PERCENTAGES	POSSIBLE MAXIMA
		1. Representativeness	2. Habitat diversity	3. Rare/endemic species	4. Ecological functioning	5. Consumptive use	6. Non-consumptive use			
1. Degree of representation?	1							1	25	4
2. Level of habitat diversity?		2						2	50	4
3. Habitats or species of special interest?				1		1		2	25	8
4. Vulnerable stages supported?					2	2		4	50	8
5. Condition suitable?		1				1	3	5	42	12
6. Range of ecological services?					2		3	5	63	8
7. Importance to fish or fisheries?					2	1		3	38	8
8. Size adequate/viable populations?		2	3	1		1		7	44	16
TOTALS FOR OBJECTIVES		3	6	2	6	6	6	29		
PERCENTAGES		38	50	25	50	30	75			
POSSIBLE MAXIMA		8	12	8	12	20	8			

TOTAL SCORES	17	12	29
PERCENTAGE SCORES	43	43	43
POSSIBLE MAXIMUM SCORES	40	28	68

SCALE

- 0 None/no value
- 1 Poor
- 2 Moderate
- 3 Good
- 4 Very good/excellent

Estuary name: **Palmiet**

CRITERIA	PROTECTION				HUMAN BENEFITS		TOTALS FOR CRITERIA	PERCENTAGES	POSSIBLE MAXIMA
	1. Representativeness	2. Habitat diversity	3. Rare/endemic species	4. Ecological functioning	5. Consumptive use	6. Non-consumptive use			
1. Degree of representation?	3						3	75	4
2. Level of habitat diversity?		1					1	25	4
3. Habitats or species of special interest?			1		1		2	25	8
4. Vulnerable stages supported?				2	2		4	50	8
5. Condition suitable?		3			4	4	11	92	12
6. Range of ecological services?				2		2	4	50	8
7. Importance to fish or fisheries?				2	1		3	38	8
8. Size adequate/viable populations?	1	2	1		2		6	38	16
TOTALS FOR OBJECTIVES	4	6	2	6	10	6	34		
PERCENTAGES	50	50	25	50	50	75			
POSSIBLE MAXIMA	8	12	8	12	20	8			

TOTAL SCORES	18	16	34
PERCENTAGE SCORES	45	57	50
POSSIBLE MAXIMUM SCORES	40	28	68

SCALE

- 0 None/no value
- 1 Poor
- 2 Moderate
- 3 Good
- 4 Very good/excellent

Estuary name: **Berg**

CRITERIA	OBJECTIVES	PROTECTION				HUMAN BENEFITS		TOTALS FOR CRITERIA	PERCENTAGES	POSSIBLE MAXIMA
		1. Representativeness	2. Habitat diversity	3. Rare/endemic species	4. Ecological functioning	5. Consumptive use	6. Non-consumptive use			
1. Degree of representation?		3						3	75	4
2. Level of habitat diversity?			4					4	100	4
3. Habitats or species of special interest?				4		1		5	63	8
4. Vulnerable stages supported?					4	1		5	63	8
5. Condition suitable?			3			4	3	10	83	12
6. Range of ecological services?					4		3	7	88	8
7. Importance to fish or fisheries?					4	2		6	75	8
8. Size adequate/viable populations?		4	4	4		4		16	100	16
TOTALS FOR OBJECTIVES		7	11	8	12	12	6	56		
PERCENTAGES		88	92	100	100	60	75			
POSSIBLE MAXIMA		8	12	8	12	20	8			

TOTAL SCORES	38	18	56
PERCENTAGE SCORES	95	64	82
POSSIBLE MAXIMUM SCORES	40	28	68

SCALE

- 0 None/no value
- 1 Poor
- 2 Moderate
- 3 Good
- 4 Very good/excellent

Estuary name: **Breede**

CRITERIA	OBJECTIVES	PROTECTION				HUMAN BENEFITS		TOTALS FOR CRITERIA	PERCENTAGES	POSSIBLE MAXIMA
		1. Representativeness	2. Habitat diversity	3. Rare/endemic species	4. Ecological functioning	5. Consumptive use	6. Non-consumptive use			
1. Degree of representation?	4							4	100	4
2. Level of habitat diversity?		2						2	50	4
3. Habitats or species of special interest?			2			3		5	63	8
4. Vulnerable stages supported?					4	4		8	100	8
5. Condition suitable?		3				3	4	10	83	12
6. Range of ecological services?					4		4	8	100	8
7. Importance to fish or fisheries?					4	4		8	100	8
8. Size adequate/viable populations?	4	4	4			4		16	100	16
TOTALS FOR OBJECTIVES		8	9	6	12	18	8	61		
PERCENTAGES		100	75	75	100	90	100			
POSSIBLE MAXIMA		8	12	8	12	20	8			

TOTAL SCORES	35	26	61
PERCENTAGE SCORES	88	93	90
POSSIBLE MAXIMUM SCORES	40	28	68

SCALE

- 0 None/no value
- 1 Poor
- 2 Moderate
- 3 Good
- 4 Very good/excellent

Estuary name: **Knysna**

CRITERIA	OBJECTIVES	PROTECTION				HUMAN BENEFITS		TOTALS FOR CRITERIA	PERCENTAGES	POSSIBLE MAXIMA
		1. Representativeness	2. Habitat diversity	3. Rare/endemic species	4. Ecological functioning	5. Consumptive use	6. Non-consumptive use			
1. Degree of representation?	4							4	100	4
2. Level of habitat diversity?		4						4	100	4
3. Habitats or species of special interest?				4		3		7	88	8
4. Vulnerable stages supported?					4	4		8	100	8
5. Condition suitable?		4				4	4	12	100	12
6. Range of ecological services?					4		4	8	100	8
7. Importance to fish or fisheries?					4	4		8	100	8
8. Size adequate/viable populations?	4	4	4			3		15	94	16
TOTALS FOR OBJECTIVES		8	12	8	12	18	8	66		
PERCENTAGES		100	100	100	100	90	100			
POSSIBLE MAXIMA		8	12	8	12	20	8			

TOTAL SCORES	40	26	66
PERCENTAGE SCORES	100	93	97
POSSIBLE MAXIMUM SCORES	40	28	68

SCALE

- 0 None/no value
- 1 Poor
- 2 Moderate
- 3 Good
- 4 Very good/excellent

It became evident during the workshop that many estuaries, although they may be in a pristine state, would not achieve a high score in terms of the protection objectives simply because they are too small to maintain large-scale ecological processes. The list of estuaries to which the ACCESS system was applied thus included only 27 of the 58 C.A.P.E. estuaries (Table 2). Estuaries were selected for this list primarily on the basis of their size. In addition, it was felt that any estuary which performed a substantial nursery function for juvenile fishes warranted being on the list. Thus estuaries which were rated as "Important" or "Critically important" in terms of their nursery function (as identified in the second interim report of the estuarine sub-component of the C.A.P.E. project) were also included in the list, regardless of their size.

Table 2. List of C.A.P.E. estuaries to be assessed using the ACCESS system. Italics indicate that no ACCESS sheets were completed for these estuaries.

Olifants	Verlorenvlei	Berg
Diep/Milnerton	Wildevogelvlei	Sandvlei
Eerste	Palmiet	Kleinmond
Bot	Klein (Hermanus)	Heuningnes
Brede	Gouritz	<i>Hartenbos</i>
<i>Klein Brak</i>	<i>Groot Brak</i>	Touws
Swartvlei	Knysna	Piesang
Keurbooms	Kromme	Seekoei
Gamtoos	Swartkops	Duiwenhoks

The specialists present at the workshop were asked to complete a number of ACCESS sheets and return them. It was decided that these people should complete the sheets since they were already familiar with the ACCESS system. ACCESS sheets for 24 of the 27 estuaries were completed, and the following analyses are based on these responses. The three estuaries for which ACCESS sheets have not yet been received are listed in italics in Table 2. They are the Klein Brak, Groot Brak and Hartenbos estuaries.

3 METHODS FOR PRIORITISING C.A.P.E. ESTUARIES FOR CONSERVATION

Conserving the biological diversity of estuarine systems may be approached from one of three viewpoints - purely biological, purely in terms of human use of estuarine resources, or a combination of the two. In each case, one or a number of conservation scenarios were determined and evaluated using one or a combination of techniques. These are outlined below.

3.1 THE BIOLOGICAL VIEWPOINT

The goal of conserving biological diversity can be viewed from a purely biological viewpoint. In this case, there are two possible approaches - to conserve the greatest number of species possible, and to conserve the physical and biological processes which maintain that species richness. In this approach, estuaries which house the greatest numbers of species, or which provide the greatest habitat diversity and range of ecological functions, would be given high priority, while those that house fewer species or provide low habitat diversity and few ecological functions would receive a lower priority.

3.1.1 *Species scenarios*

In these scenarios, biodiversity was used in its most literal sense, i.e. numbers of species present in each estuary. An iterative selection technique was applied to arrange the estuaries in order of greatest to least number of species. This was done by first selecting the estuary with the greatest number of species, then selecting the estuary with the greatest number of remaining species, etc. until all species which occur within the C.A.P.E. region were accounted for. This resulted in a hierarchical list of estuaries based on the number of species they contained. In some cases, more than one estuary could be chosen at a certain level in the hierarchy. In these instances, the relative scores derived from the ACCESS assessments were used to indicate which estuary should be given priority at that level. Due to constraints within the datasets (see report 1), this type of scenario could not be evaluated for all species groups combined, and was thus repeated separately for three groups - aquatic macrophytes, fish and birds.

The quality of the fish data allowed four separate scenarios to be proposed:

- 1) all fish species found in estuaries in the C.A.P.E. region
- 2) only endemic fishes of marine origin
- 3) all fish species found in estuaries in the C.A.P.E. region which fall into estuarine dependence categories I, IIa and IIb (see below)
- 4) only endemic fishes of marine origin which fall into estuarine dependence categories I, IIa, and IIb (see below).

For the purposes of these scenarios, categories I, IIa and IIb were used as they represent fishes for which estuaries are critical to their long-term reproductive success, and hence their continued existence. Loss of estuarine habitats would be likely to lead directly to the extinction of these fish species.

Table 3. The five categories of estuarine dependence in southern African fishes (after Whitfield 1998).

Category	Description
I	Estuarine species which breed in southern African estuaries
Ia	Resident species which have not been recorded spawning in marine or freshwater environments
Ib	Resident species which also have marine or freshwater breeding populations
II	Euryhaline marine species which usually breed at sea with the juveniles showing varying degrees of dependence on southern African estuaries
IIa	Juveniles dependent on estuaries as nursery areas
IIb	Juveniles occur mainly in estuaries, but are also found at sea
IIc	Juveniles occur in estuaries, but are usually more abundant at sea
III	Marine species which occur in small numbers but are not dependent on these systems
IV	Freshwater species, whose penetration into estuaries is determined primarily by salinity tolerance
V	Catadromous species which use estuaries as transit routes between the marine and freshwater environments but may also occupy estuaries in certain regions
Va	Obligate catadromous species which require a freshwater phase in their development
Vb	Facultative catadromous species which do not require a freshwater phase in their development

The data for birds were extracted from Turpie (1995). In keeping with the data for other groups, only the ranking based on species richness was used for the bird data, and only the top ten estuaries within the C.A.P.E. region were considered.

These scenarios should be treated with some caution, as the data on which the analyses are based have limited predictive power. Because the data concern only numbers of species, and the result is only the minimum set of estuaries which would fulfil the criterion of housing all species within the C.A.P.E. region, these analyses do not necessarily include, and cannot guarantee, that viable populations of all species will be supported by that set of estuaries. Neither do these scenarios necessarily, or guarantee to, include ecological buffering against catastrophic events which may render an entire estuary unsuitable for its present species complement.

3.1.2 Process scenarios

The structure of the biotic assemblages of estuaries (or any other habitat type) are in effect a result of the physical and biological processes which operate there, and the continued existence of most species in a particular system depends directly on the continuation of those processes. Conserving these processes can thus be used as a surrogate for species diversity.

Four scenarios were thus generated using the relative scores derived from the ACCESS assessments to prioritise the estuaries in terms of their performance under the four protection objectives, both individually and combined:

1. Representativeness and habitat diversity scenario
2. Rare/endemic species scenario
3. Ecological functioning scenario
4. Overall protection scenario

3.2 HUMAN UTILISATION SCENARIOS

The conservation of biological diversity in estuaries can be approached from an entirely different perspective. The greatest threats to estuarine biodiversity are undoubtedly the numerous ways in which estuaries and their biota are used by humans. Approaching biodiversity conservation by examining the cause of the problem rather than the symptom is an alternative approach. For example, if overexploitation of fish stocks threatens biodiversity, then maintenance of those fish stocks is desirable, not only from a purist point of view, but it is also desirable to maintain those stocks for the direct benefit of humans. Conservation which is directed at maintaining the benefits of those stocks to humans will thus have the effect of relieving the threat to biodiversity. Estuaries comprising these scenarios were thus prioritised using the relative ACCESS scores of the human benefits objectives (objectives 5 & 6) for individual estuaries.

3.3 COMBINED BIOTIC AND HUMAN USE SCENARIO

The biological attributes of estuaries, and the benefits which humans derive from them, may be used in conjunction to prioritise the conservation importance of those estuaries. In this scenario, the total scores (including both the protection and human benefits objectives) were used to prioritise the estuaries for conservation.

4 SPECIES SCENARIOS

4.1 AQUATIC MACROPHYTES

The species scenario using aquatic macrophytes resulted in the following estuaries being ranked as the top ten (Table 4). These 10 estuaries together support 71 species of aquatic macrophytes, which account for 73% of the total number (n=97) of aquatic macrophyte species found in estuaries in the C.A.P.E. region.

Table 4. The top ten estuaries in terms of the numbers of aquatic macrophyte species which they support.

Estuary	Number of species	Cumulative number of species
Berg	25	25
Buffels (East)	14	39
Wildevogelvlei	9	48
Diep/Milnerton	6	54
Piesang	5	59
Hartenbos	4	63
Keurbooms	2	65
Heuningnes	2	67
Klein (Hermanus)	2	69
Gamtoos	2	71

4.2 FISHES

Four different scenarios were compiled using the data for fishes in the C.A.P.E. region. These were:

- 1) all fish species in the C.A.P.E. region
- 2) endemic fishes of marine origin
- 3) all fish species which fall into estuarine dependence categories I, IIa and IIb
- 4) endemic fishes of marine origin which fall into dependence categories I, IIa and IIb.

4.2.1 All fish species in the C.A.P.E. region

Under this scenario, 125 fish species are supported from a total species pool of 131 species. Thus 95% of the fish species occurring in C.A.P.E. estuaries are supported by this scenario. Biogeographic representation is poor, however, with only estuary (Olifants) from the Cold Temperate West Coast Province being included in the minimum set.

Table 5. The top ten estuaries of the C.A.P.E. region in terms of the total number of fish species which they support.

Estuary	Number of species	Cumulative number of species
Knysna	81	81
Swartvlei	12	93
Keurbooms	7	100
Kromme	7	107
Breede	5	112
Olifants	4	116
Sandvlei	4	120
Bot	2	122
Gamtoos	2	124
Klein (Hermanus)	1	125

4.2.2 *Endemic fishes of marine origin*

Using only fishes of marine origin which are endemic to southern Africa resulted in a minimum set of nine estuaries which support the total complement of 43 fish species. This minimum set of nine estuaries contains two which fall into the Cold Temperate West Coast Biogeographic Province, and seven which are in the Warm Temperate South Coast Province. There is thus a reasonable spread of estuaries around the C.A.P.E. coast, and both major biogeographic provinces are represented.

Table 6. The nine estuaries which support the total complement of endemic fishes of marine origin which occur in C.A.P.E. estuaries.

Estuary	Number of species	Cumulative number of species
Knysna	34	34
Olifants	2	36
Keurbooms	1	37
Breede	1	38
Swartvlei	1	39
Bot	1	40
Klein (Hermanus)	1	40
Berg	1	42
Diep/Milnerton	1	43

4.2.3 All estuarine dependent fish species

Five estuaries make up the minimum set which supports all 34 estuarine dependent fish species in the C.A.P.E. region. These estuaries are all situated in the Warm Temperate South Coast Province, and there is thus little biogeographic representation.

Table 7. The minimum set of five estuaries which support the total complement of 34 estuarine dependent fish species in the C.A.P.E. region.

Estuary	Number of species	Cumulative number of species
Knysna	30	30
Bot	1	31
Klein (Hermanus)	1	32
Gamtoos	1	33
Seekoei	1	34

4.2.4 Endemic fishes of marine origin which are estuarine dependent

Only two estuaries are necessary as a minimum set to support the endemic fishes of marine origin which are dependent on estuaries. Both Knysna and Swartvlei contain 16 of the 17 species, while both the Bot and the Klein (Hermanus) contain one further species. This species (*Clinus spatulatus*) is endemic to these two systems.

Table 8. The minimum set of two estuaries which support the total complement of 17 species of fishes which are endemic to southern Africa, of marine origin, and which fall into estuarine dependence categories I, IIa and IIb. The two choices represent a straight "either/or" decision.

Estuary	Number of species	Cumulative number of species
Knysna/Swartvlei	16	16
Bot/Klein (Hermanus)	1	17

4.3 BIRDS

The ten C.A.P.E. estuaries with the greatest richness of bird species are given in Table 9. This list includes three estuaries (Berg, Verlorenvlei and Olifants) which fall within the Cold Temperate West Coast Biogeographical Province, while the remainder are situated within the Warm Temperate South Coast Province.

Table 9. The ten C.A.P.E. estuaries with the greatest number of bird species. Data from Turpie (1995).

Estuary	Number of species
Berg	63
Verlorenvlei	54
Olifants	51
Bot	43
Klein (Hermanus)	43
Swartvlei	41
Sandvlei	40
Klein Brak	40
Knysna	34
Gamtoos	34

Over the entire South African coast, Turpie (1995) indicated that a minimum set of ten estuaries were necessary to conserve all 88 estuarine-associated bird species. Of these, six estuaries fall within the C.A.P.E. region (Table 10). This list includes reasonable biogeographical representation, with two estuaries (Berg and Verlorenvlei) from the Cold Temperate West Coast Province, and four from the Warm Temperate South Coast Province.

Table 10. The minimum set of C.A.P.E. estuaries which are required to support all southern African estuarine-associated birds. Data were derived from Turpie (1995).

Estuary	Number of species	Cumulative number of species
Berg	34	49
Touw (whole system)	15	15
Verlorenvlei	14	63
Klein (Hermanus)	5	68
Swartkops	5	73
Sandvlei	3	76

A note of caution should be raised here concerning the use of bird diversity data for conservation planning. Unfortunately, birds are not particularly discerning in their use of aquatic resources, and often congregate in areas of extremely poor water quality, and hence areas which are unsuitable for the conservation of other biodiversity (sewage works, for example). Thus data relating to bird diversity are not necessarily a true reflection of the total diversity of an area, and in fact may often be the opposite. Where bird data are used on their

own, then, caution should be exercised in the interpretation of these data, and it is advisable that certain species which are intolerant of conditions of poor water quality be flagged and used as indicators. In this study, however, birds have been included only as part of the diversity, and their representation can thus be analysed in the context of the total diversity of the system.

5 PROCESS SCENARIOS

The process scenarios were generated using the scores awarded to estuaries with the ACCESS system. These data are summarised in Table 11.

Table 11. The relative rankings achieved by 24 C.A.P.E. estuaries in terms of their protection functions. The relative percentage scored by each estuary under that particular category is given.

Representativeness & habitat diversity	Rare/endemic species	Ecological functioning	Overall protection
100 Knysna	100 Knysna	100 Knysna	100 Knysna
100 Keurbooms	100 Keurbooms	100 Keurbooms	100 Keurbooms
100 Swartvlei	100 Swartvlei	100 Swartvlei	95 Swartvlei
100 Duiwenhoks	100 Berg	100 Berg	95 Berg
95 Olifants	88 Olifants	100 Duiwenhoks	95 Duiwenhoks
90 Heuningnes	88 Heuningnes	100 Breede	93 Olifants
90 Klein	88 Klein	92 Olifants	90 Bot
90 Swartkops	88 Gamtoos	92 Gamtoos	88 Gamtoos
90 Berg	88 Bot	83 Heuningnes	88 Heuningnes
85 Breede	88 Swartkops	83 Swartvlei	88 Breede
85 Touw	88 Touw	83 Touw	85 Touw
85 Bot	75 Duiwenhoks	75 Klein	85 Klein
85 Gamtoos	75 Breede	75 Swartkops	85 Swartkops
80 Gouritz	63 Gouritz	67 Gouritz	73 Gouritz
80 Diep	63 Diep	58 Diep	70 Diep
60 Kleinmond	63 Verlorenvlei	58 Kleinmond	55 Kleinmond
50 Kromme	63 Kromme	50 Kromme	53 Kromme
50 Palmiet	50 Seekoei	50 Palmiet	48 Verlorenvlei
50 Verlorenvlei	38 Kleinmond	50 Sandvlei	45 Palmiet
45 Sandvlei	25 Sandvlei	33 Verlorenvlei	43 Sandvlei
40 Seekoei	25 Palmiet	33 Seekoei	40 Seekoei
40 Eerste	25 Eerste	33 Eerste	35 Eerste
35 Piesang	25 Piesang	25 Piesang	30 Piesang
10 Wildvoëlsvlei	0 Wildvoëlsvlei	25 Wildvoëlsvlei	13 Wildvoëlsvlei

5.1 REPRESENTATIVENESS AND HABITAT DIVERSITY

The five top estuaries in terms of representativeness and habitat diversity all achieved at least 95% for this criterion. These were Knysna, Keurbooms, Swartvlei, Duiwenhoks and Olifants. The Heuningnes, Klein (Hermanus), Swartkops, Berg and Breede systems were all ranked in the top ten. This list of top ten estuaries includes two (Olifants and Berg) which fall within the Cold Temperate West Coast Province. There is thus reasonable biogeographic representation in this list.

5.2 RARE/ENDEMIC SPECIES

In terms of rare and/or endemic species, Knysna, Keurbooms, Swartvlei, Berg and Olifants ranked in the top five estuaries, all achieving 100% for this criterion. Also in the top ten were the Heuningnes, Klein (Hermanus), Gamtoos, Bot and Swartkops estuaries. As with the previous scenario, there is reasonable biogeographic representation, with the Berg and Olifants systems representing the Cold Temperate West Coast Province.

5.3 ECOLOGICAL FUNCTIONING

In terms of ecological functioning, six estuaries achieved 100%. These were Knysna, Keurbooms, Bot, Berg, Duiwenhoks and Breede. The Olifants, Gamtoos, Heuningnes and Swartvlei estuaries were ranked within the top ten. Again, the two west coast estuaries (Berg and Olifants) ranked in the top ten, assuring biogeographic representation within the list.

5.4 OVERALL PROTECTION SCENARIO

When all four protection objectives are considered together, the Knysna and Keurbooms estuaries rank at the top of the list, with 100%. Included in the top five are the Swartvlei, Berg and Duiwenhoks estuaries. Within the top five, only one of the estuaries falls within the Cold Temperate West Coast Province, and four within the Warm Temperate South Coast Province. The Olifants, Bot, Gamtoos, Heuningnes and Breede systems were also ranked in the top ten estuaries.

6 HUMAN UTILISATION SCENARIOS

In terms of the human utilisation of estuaries, Knysna, Breede, Olifants and Heuningnes ranked at the top of the list for consumptive use, while seven estuaries (Knysna, Breede, Duiwenhoks, Klein, Swartkops, Bot and Gouritz) all achieved 100% for non-consumptive use (Table 12). In terms of the overall benefits to humans, the Knysna and Breede estuaries were ranked the highest, achieving 93% overall. Seven other estuaries achieved more than 80% for their overall benefits to humans. These were the Duiwenhoks, Klein, Swartkops, Heuningnes, Olifants, Bot and Keurbooms systems. Of the top ten estuaries overall, only one (Olifants) falls within the Cold Temperate West Coast Province, and biogeographic representation is thus poor.

Table 12. The rankings achieved by 24 C.A.P.E. estuaries in terms of their benefits to humans.

Consumptive use		Non-consumptive use		Overall benefits	
90	Knysna	100	Knysna	93	Knysna
90	Breede	100	Breede	93	Breede
90	Olifants	100	Duiwenhoks	89	Duiwenhoks
90	Heuningnes	100	Klein	89	Klein
85	Duiwenhoks	100	Swartkops	89	Swartkops
85	Gamtoos	100	Bot	89	Heuningnes
85	Klein	100	Gouritz	86	Olifants
85	Swartkops	88	Heuningnes	82	Bot
80	Keurbooms	88	Keurbooms	82	Keurbooms
75	Swartvlei	88	Swartvlei	79	Swartvlei
75	Bot	88	Diep	79	Gamtoos
70	Touw	75	Olifants	68	Berg
60	Berg	75	Berg	64	Berg
50	Gouritz	75	Kromme	64	Gouritz
50	Diep	75	Sandvlei	61	Diep
50	Palmiet	75	Palmiet	57	Palmiet
50	Kromme	63	Gamtoos	57	Kromme
45	Kleinmond	63	Touw	43	Sandvlei
30	Sandvlei	50	Seekoei	39	Kleinmond
30	Verlorenvlei	50	Verlorenvlei	36	Verlorenvlei
30	Seekoei	38	Piesang	39	Seekoei
25	Piesang	38	Eerste	29	Piesang
15	Eerste	25	Kleinmond	21	Eerste
0	Wildvoëlsvlei	25	Wildvoëlsvlei	10	Wildvoëlsvlei

7 COMBINED BIOTIC AND HUMAN USE SCENARIO

The combined biotic and human use scenario was devised by using the overall scores achieved by estuaries through the ACCESS system (Table 13). Knysna was ranked first under both the protection and the human benefits objectives, and achieved the top rank overall. The Keurbooms, Duiwenhoks, Breede and Olifants systems all ranked in the top five estuaries, achieving a score of at least 90% overall. The Heuningnes, Swartvlei, Klein (Hermanus), Swartkops and Bot estuaries were all ranked in the top ten. Biogeographic representation is poor in this list, with only one estuary (Olifants) from the Cold Temperate West Coast Province being included. However, two further estuaries (Gamtoos and Berg) both achieved an overall score of more than 80%, and should probably be included in this list for the sake of biogeographic representation.

Table 13. The rankings achieved by 24 C.A.P.E. estuaries in terms of their protection function, the benefits they offer to humans, and their overall scores as determined by the ACCESS system.

Protection		Benefits to humans		Overall	
100	Knysna	93	Knysna	97	Knysna
100	Keurbooms	93	Brede	93	Keurbooms
95	Duiwenhoks	89	Duiwenhoks	93	Duiwenhoks
95	Berg	89	Klein	90	Brede
95	Swartvlei	89	Swartkops	90	Olifants
93	Olifants	89	Heuningnes	88	Heuningnes
90	Bot	86	Olifants	88	Swartvlei
88	Brede	82	Bot	87	Klein
88	Heuningnes	82	Keurbooms	87	Swartkops
88	Gamtoos	79	Swartvlei	87	Bot
85	Klein	79	Gamtoos	84	Gamtoos
85	Touw	68	Touw	82	Berg
85	Swartkops	64	Berg	78	Touw
73	Gouritz	64	Gouritz	69	Gouritz
70	Diep	61	Diep	66	Diep
55	Kleinmond	57	Kromme	54	Kromme
53	Kromme	57	Palmiet	50	Palmiet
48	Verlorenvlei	43	Sandvlei	49	Kleinmond
45	Palmiet	39	Kleinmond	43	Sandvlei
43	Sandvlei	36	Verlorenvlei	43	Verlorenvlei
40	Seekoei	36	Seekoei	37	Seekoei
53	Eerste	29	Piesang	29	Piesang
30	Piesang	21	Eerste	29	Eerste
13	Wildvoëlsvlei	7	Wildvoëlsvlei	10	Wildvoëlsvlei

8 SUMMATION

Many current conservation targets are based on conserving or protecting a certain percentage of different habitat types. Since estuaries are all unique and each contain a number of different habitat types, the combinations of which may differ widely between different estuaries, this approach would be simultaneously too simplistic and too complex to apply to estuaries. Working towards protection of 20% of different habitat types in estuaries would necessitate the protection of 20% of saltmarsh and floodplain vegetation, reedbeds of different species, submerged vegetation of different species, intertidal mudflats, estuarine channels, permanently closed or open and periodically closed estuaries, estuaries with different flow regimes, etc. In order to achieve this, it is likely that all the estuaries within the C.A.P.E. region would need to be afforded some protection.

It is important to note here that it is impractical to conserve only a portion of an estuary. Most estuarine processes are driven by the nature of the physical environment, operating on relatively large spatial scales. Thus an attempt to protect saltmarsh vegetation, for example, by controlling trampling of the delicate vegetation is unlikely to succeed if nutrient input (usually via sewage and sewage effluent) exceeds the ability of the plants to act as a "sink" for these nutrients. It is thus imperative that the functioning of the entire estuarine system be kept intact.

Protection may vary from relatively low-level conservation actions (such as restrictions on the level of sewage or other pollutants allowed to enter the system) to more drastic conservation actions, including the establishment of undisturbed (in the widest sense) systems (analogous to Marine Protected Areas, but including a far greater geographical area than that which the estuary itself covers, to include the catchment). Since it would not be practical to apply the latter types of conservation actions to all estuaries, it stands to reason that those which have the greatest value (in terms of both ecological functions and benefits to humans) should receive the greatest conservation efforts. The following analysis has thus attempted to rank estuaries in terms of a holistic value. In order to achieve this, a number of scenarios have been put forward, and each has resulted in a list of estuaries which should receive some sort of protection in order to conserve certain attributes of the biology and ecology of estuaries of the C.A.P.E. region as a whole. Twenty-four estuaries were highlighted as being important in at least one of these scenarios (Table 14). Of these 24 estuaries, the Klein (Hermanus) estuary was rated as being important in all five of the scenarios. The Knysna, Bot, Gamtoos, Keurbooms, Olifants and Berg systems were each rated as important in four of the five scenarios, while the Swartvlei, Breede, Heuningnes and Swartkops estuaries were important in three of the five scenarios.

It is evident that these systems are important in the maintenance of biodiversity and ecological processes in the estuarine systems of the C.A.P.E. region, as well as being of benefit to humans. Any system designed at conservation of the biodiversity within the estuaries of the C.A.P.E. region should thus at least pay particular attention to these 11 estuaries, and afford them some measure of legal protection. This list not only fulfils the requirements of "conserving biodiversity", but also assures biogeographic representation, since it includes two large systems which fall within the Cold Temperate West Coast Province (the Berg and Olifants systems).

Table 14. The number of scenarios in which 23 estuaries either comprised the minimum set for support of a particular species group, or ranked in the top ten in any given scenario. The five scenarios used for this analysis included the species scenario for aquatic macrophytes (1), all the fish species scenarios combined (2), all the bird species scenarios combined (3), the overall process scenario (4), and the overall human utilisation scenario (5). For the overall process and human utilisation scenarios, only those systems which scored more than 80% have been included. An "x" denotes that that system was important in fulfilling that scenario. Please note that the absence of an "x" does not necessarily mean that the system is unimportant for that function.

Estuary	Number of scenarios	1	2	3	4	5
Klein (Hermanus)	5	x	x	x	x	x
Keurbooms	4	x	x		x	x
Gamtoos	4	x	x	x	x	
Berg	4	x	x	x	x	
Knysna	4		x	x	x	x
Bot	4		x	x	x	x
Olifants	4		x	x	x	x
Heuningnes	3	x			x	x
Swartvlei	3		x	x	x	
Breede	3		x		x	x
Swartkops	3			x	x	x
Diep/Milnerton	2	x	x			
Sandvlei	2		x	x		
Touw	2			x	x	
Duiwenhoks	2				x	x
Wildevogelvlei	1	x				
Piesang	1	x				
Hartenbos	1	x				
Buffels (East)	1	x				
Kromme	1		x			
Seekoei	1		x			
Verlorenvlei	1			x		
Klein Brak	1			x		

This gives some indication of the conservation priority of estuaries within the C.A.P.E. region. However, it gives no indication of kinds of conservation and/or management options would be appropriate for each estuary. In order to gain a better understanding, therefore, it is necessary to investigate each estuary individually and in more detail.

8.1 KLEIN (HERMANUS)

This was the only estuary which was important in fulfilling the objectives of all five of the scenarios. Thus the Klein should receive a relatively high level of protection. This estuary has a fairly small catchment, and thus affording it total protection would be a possibility.

However, the physical state of this estuary scored only 28 out of a possible 44 (64%), and its overall evaluation was rated as moderately perturbed and in need of some rehabilitation (see page 65). The major problem associated with this estuary was the periodic artificial breaching of the mouth to protect properties which have been developed below the natural flood line. This practice has had the effect of reducing scouring during periods of floods, and thus sediments have accumulated, and reedbanks have invaded a large portion of the water surface, thereby reducing the water volume of the system, as well as the habitable area for organisms such as invertebrates and fish. Although water abstraction was rated as "slight" in this estuary, flow has also been reduced by alien plant infestations in the catchment.

The 20-year projection for the future of this estuary was that it would receive a moderate level of development and further degradation would occur.

Perceived needs: This estuary should receive full protection. Some rehabilitation is necessary if it is to continue to fulfil its ecological functions successfully.

8.2 KEURBOOMS

The Keurbooms Estuary was important in fulfilling the objectives of four of the five scenarios. The only scenario in which it was not rated among the most important was in terms of bird diversity. The current physical state of the estuary was rated as moderately perturbed, with some rehabilitation necessary, and scored 29 out of a possible 44 (66%) for its physical state. The major problems associated with this estuary were moderate water abstraction and moderate levels of disturbance caused by humans. Sewage and chemical pollution were rated as slight.

The future of the estuary on a 20-year projection was that there would be rapid development and degradation of the system.

Perceived needs: This estuary should receive complete protection, and steps should be taken to ensure that the condition of this estuary does not deteriorate further.

8.3 GAMTOOS

The Gamtoos was important in fulfilling the objectives of four of the five scenarios. The only scenario in which it was not rated as important was in terms of benefits to humans. The physical state of this estuary scored 31 out of a possible 44 (70%), and the overall evaluation being that it was moderately perturbed and would require some rehabilitation. The major problems associated with this estuary were that, although the surrounding developments are of a rural nature, they have encroached to a moderate degree on the estuary itself. Water abstraction and siltation were also ranked as moderate, as was disturbance caused by humans.

The 20-year projection for this estuary was that it would see moderate development and some further degradation.

Perceived needs: The rural setting of this estuary would make it ideal for complete protection. Although fish and bait stocks are considered to be in a healthy state, the problems of water abstraction and siltation would need to be arrested at least, and improved at best.

8.4 BERG

The estuary of the Berg River was important in fulfilling the objectives of four of the five scenarios. The only scenario in which it was not rated as one of the most important was in terms of human benefits. In terms of its physical state, the Berg scored only 20 out of a possible 44 (45%). The problems faced by this estuary are numerous. Probably the greatest problem is that of water abstraction in the catchment, which is regarded as "heavy". In addition, intense residential (and some industrial) development surrounds the estuary and has encroached to a large degree on the estuary. In addition, chemical pollution is considered to be moderate in this estuary. Overall, the evaluation of the physical state of the Berg estuary was that it is moderately perturbed, and in need of some rehabilitation.

The 20-year projection of the future of the estuary is that it would see rapid development and degradation.

Perceived needs: Due to the existing state of the Berg River Estuary, complete protection of the kind offered by National Parks would seem impractical. However, the importance of this estuary in terms of both the biota it supports and its geographical position makes it imperative that some conservation action is directed towards at least maintaining the current state of the estuary. Although this estuary has been proposed as a Ramsar site, this proposal has been turned down by the national (South African) Ramsar committee, not because of the state of its physical or biotic environment, but because there is currently no management plan or legal protected status for this estuary. Neither of these criteria are imposed by the international Ramsar committee.

8.5 KNYSNA

The Knysna Estuary was important in fulfilling the objectives of four of the five scenarios. The only scenario in which it was rated as relatively unimportant was that of macrophyte diversity. In terms of its physical state, Knysna scored 23 out of a possible 44 (52%), and the overall evaluation of the state of the estuary was that it is moderately perturbed, and some rehabilitation is necessary. The major problems associated with this estuary were related to water abstraction and siltation, and the high level of residential development which has encroached to a large degree on the estuary, and resulted in a high level of disturbance and pollution of various forms. The large degree of encroachment of surrounding developments onto the estuary is likely to be one of the key factors which has resulted in Knysna not appearing to be important in terms of the diversity of aquatic macrophytes, as the marginal vegetation has been largely destroyed.

The 20-year projection of the future of the estuary was that it would see rapid development and further degradation.

Perceived needs: The high level of residential development around the Knysna estuary would make it impractical to try to conserve this estuary as a complete protection area. In addition, the large size of the catchment imposes an even greater number of problems for the conservation of this system. However, this estuary is extremely valuable to the biota, as it not only houses a number of endemic species (including the Knysna Seahorse), but is also

large enough to sustain viable populations of these and other organisms (including some commercially and recreationally important species). Efforts therefore need to be focused on at the very least maintaining the present state of this estuary.

8.6 BOT

The Bot River Estuary was important in fulfilling the objectives of four of the five scenarios. The only scenario for which it appeared not to be important was macrophyte diversity. The overall evaluation of the physical state of this estuary was that it was moderately perturbed, and required some rehabilitation. In terms of physical state, the Bot scored 28 out of a possible 44 (64%). The major problem faced by this estuary was alteration of the dynamics of the mouth by artificial breaching, which is usually done to prevent flooding of properties built below the natural flood level. As a result, the mouth is opened before sufficient water has built up to flush accumulated sediments from the system, and sedimentation is thus an associated problem. Fish stocks and bait organisms are in a moderate state, both jeopardised by a number of factors, including over-exploitation and alteration of the mouth dynamics.

The 20-year projection for the future of the estuary was that it would be subject to rapid development and degradation.

Perceived needs: Some conservation action is necessary to at least maintain the estuary in its current state and retard further degradation of the physical and biotic environment. In particular, the problems of artificial breaching of the mouth and associated siltation need to be addressed.

8.7 OLIFANTS

The Olifants Estuary was important in fulfilling the objectives of four of the five scenarios. The only scenario for which it appeared not to be important was for macrophyte diversity. This current physical state of this estuary scored 32 out of possible 44 (73%) and the overall evaluation was that it was slightly perturbed, and rehabilitation would not be necessary. Although at present encroachment of surrounding developments was considered slight, there was some concern that mining activities may encroach onto the banks of the estuary. Water abstraction and associated siltation were considered to be moderate. Fish stocks were considered to be degraded, primarily due to uncontrolled gill-netting operations.

The 20-year projection for the future of this estuary was that it would receive moderate development and some further degradation.

Perceived needs: As one of the few (and large) estuaries on the west coast, the Olifants Estuary deserves some form of protection so that the predicted development is halted, or at least conducted in a sensitive manner. The rural nature of the estuary surrounds would make it practical to afford this estuary a relatively high level of protection. Although rehabilitation was considered unnecessary, better management of the gill-net fishery in this area would help to improve the status of the fish stocks.

8.8 HEUNINGNES

The Heuningnes Estuary was important in fulfilling the objectives of three of the five scenarios. Thus it was important in terms of macrophyte diversity, overall protection and human benefits. The physical state of this estuary scored 37 out of a possible 44 (84%), and the overall evaluation was that this estuary was slightly perturbed and no rehabilitation would be necessary. The 20-year projection for the future of this estuary was that it would remain in its current state.

Perceived needs: The Heuningnes Estuary falls within a protected area, and no further conservation actions are deemed necessary at present.

8.9 SWARTVLEI

Swartvlei was important in fulfilling the objectives of three of the five scenarios. It was important for fish and bird diversity, as well as its overall protection function. It was not one of the most important estuaries, however, for either macrophyte diversity or for the benefits it offers to humans. The current physical state of this estuary was rated as moderately perturbed with some rehabilitation necessary, and scored 23 out of a possible 44 (52%). The major problems associated with this estuary were moderate water abstraction and siltation, alteration of the mouth dynamics, encroachment of surrounding developments onto the estuary, and moderate over-exploitation of fish and bait resources.

The 20-year projection for the future of this estuary was that it would receive rapid development and degradation.

Perceived needs: The existing intense residential developments surrounding Swartvlei make it impractical to afford this estuary complete protection. However, conservation actions should be geared towards arresting further development, or at least ensuring that these are environmentally sensitive. The problems of alteration of the mouth dynamics, water abstraction and associated siltation need attention. Some conservation efforts should also be made to ensure that exploitation of fish and bait organisms does not escalate.

8.10 BREEDE

The estuary of the Breede River was important in fulfilling the objectives of three of the five scenarios. It was rated as important for fish diversity, its overall protection function, and the benefits it offers to humans. In terms of its current physical state, the Breede scored 29 out of a possible 44 (66%), and the overall evaluation of this estuary was that it was moderately perturbed, and some rehabilitation would be necessary. The major problems associated with this estuary were moderate water abstraction in the catchment and subsequent siltation, and a moderate level of encroachment of surrounding developments onto the banks of the estuary.

The 20-year projection for the future of the estuary was that it would receive rapid development and degradation.

Perceived needs: The Breede River Estuary should receive some form of protection, although this need not necessarily be complete protection. In particular, steps should be

taken to curtail further development, or ensure that these are done in an environmentally sensitive manner.

8.11 SWARTKOPS

The Swartkops Estuary was important in fulfilling the objectives of three of the five scenarios. The reason that it appeared not to be important for macrophyte or fish diversity is that it was not included in the initial analyses, and was only incorporated during the later stages of the project. It is thus likely that, had this estuary been included earlier, it may been important in fulfilling the objectives of more than three scenarios. This project did not gather information regarding the current physical state of the Swartkops, and thus no further interpretation can be made regarding this estuary.

8.12 DIEP/MILNERTON

This estuary was important in fulfilling the objectives of two of the five scenarios (macrophyte and fish diversity). The physical state of this estuary scored 19 out of a possible 44 (43%), and the overall evaluation was that it was heavily perturbed and rehabilitation would be difficult. This estuary faces problems associated with intense urban development and associated pollution, moderate water abstraction and siltation, and degraded fish and bait resources.

The 20-year projection for the future of the Diep was that it would experience further rapid development and degradation.

Perceived needs: Since the Diep is one of the few estuaries on the west coast which is important in maintaining fish populations, some form of protection and conservation effort are necessary in order to maintain, and perhaps even enhance, this function. The urban setting of this estuary makes this difficult. This estuary is linked to the Rietvlei wetland complex, and should thus be managed in conjunction with the rest of the Rietvlei complex.

8.13 SANDVLEI

Sandvlei was important in fulfilling the objectives of two of the scenarios, namely fish and bird diversity. The current physical state of the estuary scored only 18 out of a possible 44 (41%), and the overall evaluation was that it is heavily perturbed and rehabilitation would be difficult. The two major problems associated with this estuary are the intense urban developments which surround not only the estuary but its catchment as well, and the artificial control of the estuary mouth. The urban setting of this estuary has lead to numerous associated problems, including those of pollution, water abstraction and siltation, and degradation of the biota. In the past, this estuary was an important habitat for juvenile fish in False Bay. However, the weir at the mouth, which is used exclusively to control water levels, obstructs the movement of fishes into and out of the estuary, and it no longer contributes to the maintenance of fish populations.

The 20-year projection for the future of the estuary is that it will see rapid further development and degradation.

Perceived needs: The urban setting of Sandvlei has resulted in severe degradation of this estuary. Probably the most important conservation action that could be applied to this estuary would be to restore the natural functioning of the mouth. Combined with Marine Protected Areas on the open coast, this would go a long way to ensuring maintenance not only of fish diversity, but also of fish stocks.

8.14 TOUW

This estuary was important in fulfilling the objectives of two of the five scenarios. These were bird diversity and the overall protection scenarios. In terms of its current physical state, the Touw Estuary scored 25 out of a possible 44 (57%), and the overall evaluation was that it is moderately perturbed and in need of some rehabilitation. Major problems were the artificial breaching of the mouth, the high level of encroachment of surrounding developments onto the estuary, and moderate water abstraction and siltation.

The 20-year projection for the future of this estuary was that there would be slow development and little degradation.

Perceived needs: Although the Touw Estuary currently receives some protection, this could be increased. In particular, the discharge of sewage effluent, which is currently slight, but is likely to increase as the surrounding area becomes increasingly developed, needs to be addressed, as does the artificial breaching of the mouth.

8.15 DUIWENHOKS

The Duiwenhoks estuary was important in fulfilling the objectives of two of the five scenarios. These were the overall protection and human benefits scenarios. In terms of its current physical state, this estuary scored 34 out of a possible 44 (77%), and the overall evaluation was that it is slightly perturbed, but no rehabilitation is necessary. The major problem associated with this estuary is water abstraction. The 20-year projection for the future of this estuary was that it would experience slow development with little degradation.

Perceived needs: The rural setting and relatively unperturbed physical state of this estuary make it ideal for complete protection.

8.16 ESTUARIES IMPORTANT IN ONLY ONE SCENARIO

Eight estuaries appeared to be important in fulfilling the objectives of only one scenario. Of these, four were important for macrophyte diversity (Wildevogelvlei, Piesang, Hartenbos and Buffels(East)), two for fish diversity (Kromme and Seekoei), and two for bird diversity (Verlorenvlei and Klein Brak). It is important to note that three of these estuaries (Hartenbos, Buffels(East) and Klein Brak) were not included in the analysis of the protection and human benefits scenarios, and could thus also have been important in one of these scenarios.

It is imperative to note here that the fact that these estuaries were only important in one scenario does not mean that they have little conservation value. The number of scenarios for

which an estuary is important is merely an indication of the versatility of that system, and not its relative importance within any one scenario. The importance of these estuaries in fulfilling the objectives of one of the scenarios may therefore be critical. Below follows a list of these estuaries, with notes on their relative importance within one scenario.

8.16.1 Buffels (East)

This estuary was rated second in terms of the macrophyte diversity it supports, containing 20% of the total 71 species of macrophytes.

8.16.2 Wildevoëlsvlei

This was the third most important estuary for macrophyte diversity, housing 13% of the total 71 species of aquatic macrophytes.

8.16.3 Piesang

The Piesang was ranked fifth in terms of the diversity of macrophytes it supports (7% of the total number of species).

8.16.4 Hartenbos

This was rated sixth in terms of macrophyte diversity, containing 6% of the total number of macrophyte species.

8.16.5 Kromme

The Kromme Estuary was ranked fourth in terms of the total number of fish species which it supports.

8.16.6 Seekoei

The Seekoei was rated fifth in terms of the diversity of estuarine dependent fish species it supports (3% of the total), and was one of the five selected in the minimum set which supports the total complement of estuarine dependent fish species in the C.A.P.E. region.

8.16.7 Verlorenvlei

Verlorenvlei was the second most important estuary in terms of the number of bird species which it supports (20% of the total number of species), and was selected third in the minimum set of six estuaries which are necessary to support the total number of estuarine-associated birds in the C.A.P.E. region.

8.16.8 Klein Brak

This estuary was ranked eighth in terms of the total number of bird species that it supports.

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10 PARTIES PRESENT AT THE WORKSHOP

Kim Prochazka	Zoology Department, University of Cape Town (Workshop convenor)
Charles Griffiths	Zoology Department, University of Cape Town (Workshop convenor)
George Branch	Zoology Department, University of Cape Town
Jane Turpie	Zoology Department, University of Cape Town
Pat Morant	Ematek, CSIR, Stellenbosch
Guy Bate	Botany Department, University of Port Elizabeth
Alan Whitfield	JLB Smith Institute of Ichthyology, Rhodes University

11 COMMENTS FROM THE PUBLIC PARTICIPATION PROCESS

The questionnaire "Summary of Interim Research Findings, March 2000" reached a total of 1012 people, of which only 111 returned the completed questionnaire. Of these, 29 people responded to statement 1.3 "Estuarine biodiversity is most affected by indirect impacts. Direct threats to the biota of estuaries include exploitation (especially in the case of fish and bait organisms) and disturbance (particularly to birds)". The majority (79%) of the responses were a result of a misunderstanding caused by ambiguous wording in the above statement. The words "most affected by indirect impacts" gave an incorrect impression of what is presented in the original report, which does not divide the threats into "direct" and "indirect" threats, but rather into "threats to the **physical environment**" and direct threats to the **biota**".

Two comments (7%) dealt with issues of awareness and lack of resources:

- "Lack of resources to protect and the commitment by politicians"
- "Lack of public/developers/authorities awareness"

These do, indeed, pose great problems to the conservation not only of estuarine, but also global, biodiversity. Their solution, however, lies not within the narrow confines of a specialist study on estuarine biodiversity, but within society as a whole. It is hoped that the C.A.P.E. project in its entirety will contribute at least in some measure to increasing an awareness of and commitment to conservation, as well as generating funding interest in conservation in the region.

Three comments (10%) dealt with specific conservation actions that could take place. These included:

- “When it gets down to the strategies phase; it has got to be no-go bait areas for example as in Knysna. It works 100%.”
- “Restrict access, particularly 4x4 vehicles.”
- “Decanalisation of eg. Black River mouth might help.”

These are all valid comments, of which it is hoped that implementing agencies will take note.

The last comment stated “And global climate change”. Global climate change may certainly have a profound influence on the estuaries and their associated biodiversity within the C.A.P.E. region. This problem is generated and operates on such a large scale, however, that it was deemed to be impractical for the C.A.P.E. project to attempt to deal with it in a meaningful way, and was thus not included in the report.