C.A.P.E. ESTUARIES PROGRAMME

Sustainable Fishing in Estuaries

G.7

C.A.P.E. Estuarine Management Guideline

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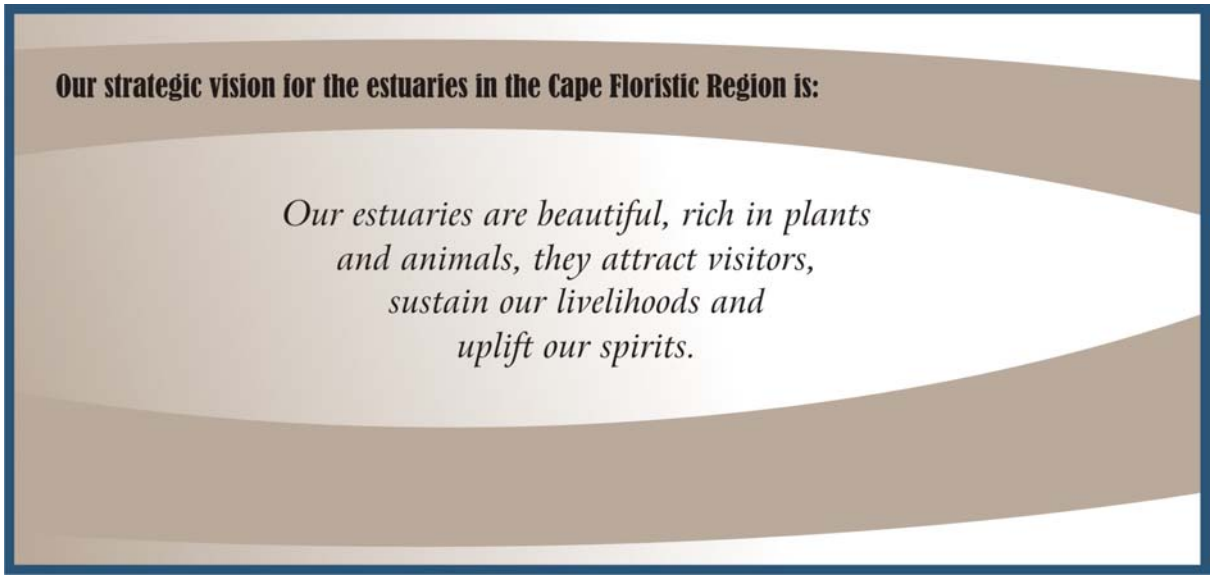
September 2007



C.A.P.E. Estuaries Guideline 7: Sustainable fishing in estuaries

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Sustainable Fishing

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1. The line and other nearshore fisheries

The Marine Living Resources Act (Act No. 18 of 1998) holds that the marine living resources are the heritage of all South Africans but that national government is responsible for their management. Management recommendations are submitted by the Branch, Marine and Coastal Management (MCM), to the Minister of Environmental Affairs and Tourism for approval and promulgation.

Estuarine and estuarine dependent fisheries in South Africa may be commercial, recreational or subsistence in nature and include shore and boat-based linefishing, gillnetting, beach-seining, finfish mariculture and the traditional spear and trap fisheries. Due to the overlaps in operational area and species caught these fisheries cannot be managed separately and are therefore, in the broader sense, usually considered under the linefishery. Owing to its multi-species, multi-user nature, and also the large area of operation, there are three key role players involved with the management of the linefishery. The Linefish Working Group (LWG) of MCM, consisting of 8 scientists from MCM and other institutions, is tasked with the formulation and scientific evaluation of management recommendations. If needed, fisheries managers are also invited to give their input.

Recommendations on legislation or management are usually submitted to the South African Marine Linefish Management Association (SAMLMA), comprising NGO scientists and representatives from all commercial and recreational fishing sectors, for further evaluation and input. At this stage user groups decide on the most acceptable combination of regulations designed to attain management targets. On the other hand, recommendations generated by SAMLMA (initially tabled by scientists or fishing sectors) are channelled (via the Deputy Director General of MCM) to the Linefish Management Advisory Group (LMAG, fishery & management representatives) and LWG prior to ministerial submission.

Until recently, draft management regulations usually passed through the Consultative Advisory Forum (CAF), comprised of 18 fishery representatives and scientists and which was established to provide advice to the minister. The CAF could autonomously address issues concerning the management of marine living resources, but scientific input was usually requested from MCM. A more recent development has been the establishment of the Fishing Industry Task Team (FITT) which comprises only industry membership and may replace the CAF. It is also possible for user groups to independently submit recommendations to the minister, but these are generally evaluated by the LWG, LMAG and, if necessary, SAMLMA. The current linefish management system is therefore flexible and involves input from a wide variety of sources; as a result it includes aspects of both "consultative" and "cooperative" co-management.

The South African marine linefishery lands approximately 200 species of which 31 contribute significant proportions of the overall catch. User groups may be broadly divided into recreational, commercial and subsistence components each of which contains small sub-components that may be regarded as artisanal or traditional in nature (Griffiths & Lamberth 2002).

The recreational sector comprises 412 000 shore anglers, 72 000 estuarine anglers, 12 000 boat anglers, 7 000 spearfishers and 5 000-odd castnetters. Prior to the allocation of long-term fishing rights, the commercial linefishery comprised 18 600 participants, many part-time and spread out amongst the traditional line, hake handline and tuna pole fisheries.

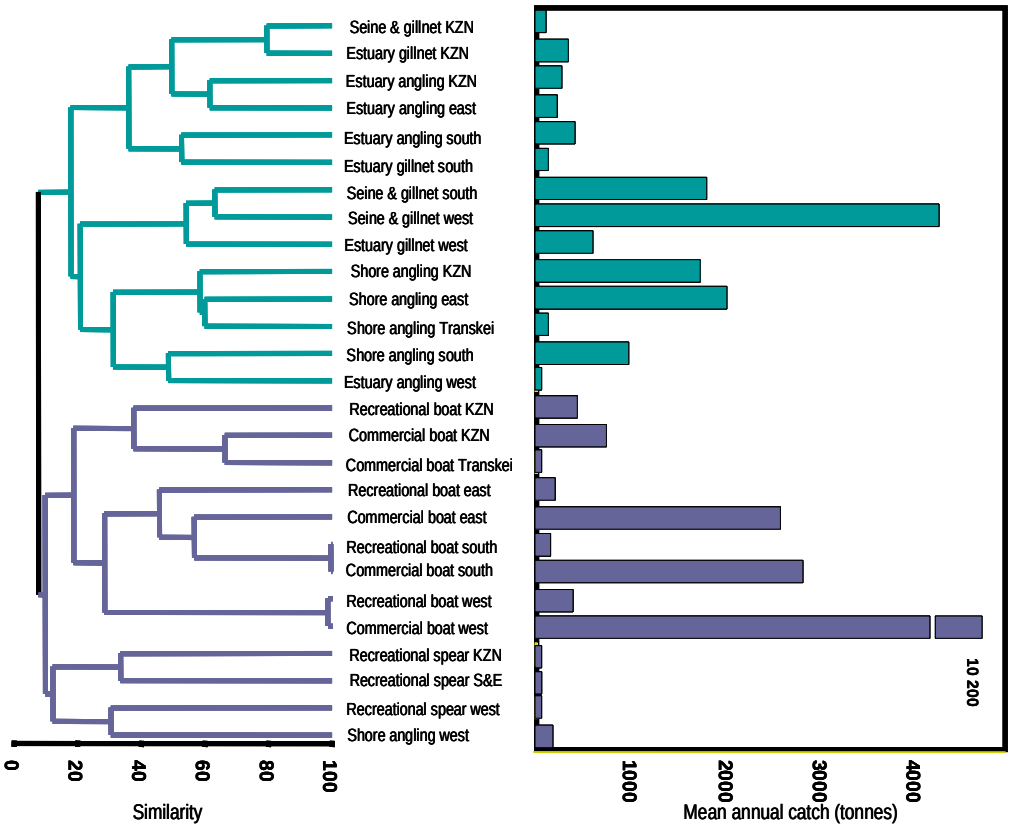

Figure 1. *Cluster analysis of the catch contribution of the inshore and estuarine fisheries by region and fishing sector using the Bray-Curtis measure of similarity, and the total catch estimated for each sector (bars). After Griffiths & Lamberth 2002.*

Also targeting linefish are 2-3 000 legal and illegal beach-seine and gillnet fishers mostly on the west coast. Subsistence fishing is mostly limited to estuarine and shore-based activities from Port Elizabeth eastwards. However, approximately 25 000 recreational anglers fall with the lower two quintiles of South African earners and may be regarded as at least partially dependent on this activity as a source of protein.

The linefishery, including the estuarine component, is estimated to provide employment for in excess of 130 000 people, and to contribute about R 2.7 billion to the South African GDP. Although the commercial component is responsible for 79% of the estimated total catch, the recreational component provides 81% of the employment and generates 82% of the revenue. Species targeted by the linefishery display diverse life-history strategies including estuarine dependence, longevity (>20 years), sex change and aggregating behaviour. The species composition and mass of landed catches form two distinct fishery groupings before differentiating according to biogeographical region (Fig. 1). Estuarine and shore angling as well as beach-seine and gillnet fishing are largely responsible for over-fishing estuarine-dependent and surf-zone species whereas boat-based recreational and commercial fishing have been the major factor in the demise of bottom dwelling offshore species.

Fishery monitoring, historical data and recent stock assessments indicated that, for a variety of reasons ranging from non-compliance to politics, many linefish are severely over-exploited and that many of the regulations introduced in the last two decades are failing

to limit catch (Griffiths *et al*. 1999). As a result, recent management measures have been effort limitation in the commercial linefishery and the development of a Linefish Management Protocol (LMP) in which management plans are required for each species (Griffiths *et al*. 1999). Key features of the LMP include:

- The type of data required to assess individual stocks;
- The quantitative approach to be used;
- spawner biomass per recruit or catch-per-unit-effort (*cpue)* models being the most frequent;
- Appropriate biological reference points; including changes in cpue and catch composition;
- Long-term goals for each stock;
- Management action that will be taken to achieve these goals; and
- User group involvement in the development of regulations (and combinations thereof) to achieve the biological reference points.

Application of the LMP (to those species for which sufficient data are available) has resulted in extensive revision of size and bag limits for recreational fishers (Table 1). Bag limit reductions of more than 80% are required to achieve target levels of fishing mortality for many species. Because of the large number of species targeted by the linefishery, it is not possible to assign the same management priority to each one (Lamberth & Joubert 1998). An additional complication is the multi-sectorial nature of the fishery where each sector has its own suite of important species and different management actions may be required for the same species. Therefore a Multiple Criteria Decision Analysis (MCDA) technique is used to determine the frequency with which stocks are reviewed (Griffiths & Lamberth 2002, Lamberth & Joubert 1998).

Table 1. *Summary of stock status and the species-specific management regulations emanating from the application of the Linefish Management Protocol to species for which sufficient scientific information existed. Daily Bag limits were generally determined for recreational anglers (based on bag frequency analysis), but those with an asterix apply to commercial fishers as well. After Griffiths & Lamberth 2002.*

Species	*Stock Status*	*Assessment Method*	*Daily Bag*	*Minimum Size (cm)*
Silver kob	*Collapsed*	*SB/R(6%), CPUE (4-9%)*	*5 5*	*40 50*
Dusky kob	*Collapsed*	*SB/R (2%)*	*5 *1*	*40 60*
Squaretail kob	*Collapsed*	*CPUE (5%)*	*5 5*	*35 40*
Geelbek	*Collapsed*	*SB/R(5%), CPUE(3%)*	*10 2*	*60 60*
Yellowbelly rockcod	*Collapsed*	*SB/R(24%)*	*5 1*	*40 60*
Catface rockcod	*Collapsed*	*SB/R(19%)*	*5 5*	*40 50*
Dageraad	*Collapsed*	*SB/R(3%), CPUE (6%)*	*5 *1*	*30 40*
Seventy-four	*Collapsed*	*SB/R(<5%), CPUE(10%)*	*0 0*	*Moratorium*
Slinger	*Collapsed*	*SB/R(15%), CPUE(14%)*	*5 5*	*25 25*
Red Steenbras	*Collapsed*	*CPUE(0.2%)*	*2 *1*	*40 60*
White Steenbras	*Collapsed*	*SB/R(6%)*	*5 *1*	*60 60*
Red Stumpnose	*Collapsed*	*CPUE(1-5%)*	*5 1*	*30 30*
Roman	*Collapsed*	*CPUE(5-17%)*	*5 2*	*30 30*
Scotsman	*Collapsed*	*CPUE(35%)*	*5 1*	*30 40*
Englishman	*Collapsed*	*Sex ratio 1:40*	*5 1*	*None 40*
Poenskop	*Collapsed*	*CPUE(20%)*	*2 *1*	*50 50*
Musselcracker	*Collapsed*	*CPUE(20%)*	*5 *1*	*60 60*
Strepie	*Underexploited*	*SB/R(60%)*	*None 10*	*Stat. Quo*
Panga	*Underexploited*	*APM(67%)*	*10 10*	*None*
Snoek		*CPUE (58%)*		
Galjoen	*Collapsed*	*SB/R(17%), CPUE(20)*	*5 *2*	*35 35*
Elf/shad	*Over exploited*	*SB/R(34%)*	*5 4*	*30 30*
Yellowtail	*Opt. Exploited*	*VPA(40%), CPUE(60%)*	*10 10*	*None*
King Mackerel	*Over Exploited*	*SB/R(33%)*	*10 10*	*None*
Queen Mackerel	*Opt. Exploited*	*SB/R(50%)*	*10 10*	*None*
Longfin Tuna	*Opt. Exploited*	*APM(20%)*	*10 5*	*None*
Hake	*Opt. Exploited*	*SB/R+APM*	*5 5*	*None*

SB/R = spawner biomass per recruit APM = age structured production model,VPA= Virtual Population Analysis, *CPUE* = Catch per unit effort (a status indicator). Numbers in parentheses in the "Assessment Method" column indicate current spawner biomass per recruit ratios, spawner biomass (VPA or APM) and catch per unit of effort as a percentage of pristine or historical levels. Ranges are given where calculations were made for separates stocks or regions. Data sources: Griffiths (2000), Mann (2000) and Web.

2. Estuarine associated fish and descriptions of their respective life history strategies

Different species have different degrees of association with estuaries, and estuarine fish have been classified into five broad categories of association, which may be further subdivided into 9 types (Whitfield 1994, Table 2). Category Ia and IIa species are entirely dependent on estuaries, as are category V species. Category IIb species are largely dependent on estuaries, while numbers of category IIc species are augmented by estuaries. Category III and IV species are found in estuaries, but are not dependent on them. About 160 species occur in South African estuaries, of which about 80 species are utilised in fisheries. Of the 80 utilized species, 3, 47, 21, 3 and 6 species fall into categories I to V, respectively (Table 3). Of particular importance are the category I and II species, for which management of estuaries plays a crucial role in fisheries. Catches of estuarine-associated fish species differ from west to east around the coast, following biogeographical changes from the cool temperate region on the west coast through to the subtropical region north of the Mbashe River in the Transkei. The cool temperate region is relatively species poor but productive, and the fisheries include only about 19 estuarine-associated species (Table 3). Numbers of estuarine species in catches almost double immediately east of Cape Point, and increase towards the east, with up to 71 species in KwaZulu-Natal (Table 3). Some 28 estuarine-associated species are caught only or predominantly in KwaZulu-Natal. Within regions, species composition of catches within estuaries also differs between estuaries of different types and sizes, with greater species richness associated with larger and permanently open estuaries.

Table 2. *The five major categories of fishes which utilize South African estuaries (After Whitfield 1994)*

Categories	*Description of categories*
I	*Estuarine species which breed in southern African estuaries. Further divided into:* ***Ia***. *Resident species which have not been recorded spawning in the marine or freshwater environment* ***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. Further divided into:* ***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 estuaries in small numbers but are not dependent on these systems*
IV	*Euryhaline freshwater species, whose penetration into estuaries is determined by salinity tolerance. Includes some species which may breed in both freshwater and estuarine systems.*
V	*Catadromous species which use estuaries as transit routes between the marine and freshwater environments. Further divided into:* ***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*

Table 3. *Estuarine-associated species caught in South African fisheries, given in order of estuarine dependence category (Table 2), and giving distribution of catches around the coast. Distribution is divided into West coast (Orange River to Cape Point), South Coast (Cape Point to Port Elizabeth), East Coast (Swartkops to Kei River), Transkei and Kwazulu Natal (Port Edward to Kosi Bay). The three biogeographical provinces are separated by Cape Point and roughly at the Bashee River in the Transkei (Emanuel et al. 1992, Turpie et al. 1999, Maree et al. 2000a,b).*
After Lamberth & Turpie 2003.

Species	Common name	Dependence category	Distribution				
			Cool	Warm Temperate			Subtropical
			West	South	East	Transkei	KZN
Ambassis productus	*Longspine glassy*	*Ia*					X
Ambassis gymnocephalus	*Bald glassy*	*Ib*		X	X	X	X
Ambassis natalensis	*Slender glassy*	*Ib*					X
Rhabdosargus holubi	*Cape stumpnose*	*IIa*	X	X	X	X	X
Argyrosomus japonicus	*Dusky kob*	*IIa*		X	X	X	X
Mugil cephalus	*Flathead/springer mullet*	*IIa*	X	X	X	X	X
Elops machnata	*Ladyfish/tenpounder*	*IIa*		X	X	X	X
Lichia amia	*Leervis/garrick*	*IIa*	X	X	X	X	X
Acanthropagrus berda	*Perch/riverbream*	*IIa*				X	X
Pomadasys commersonni	*Spotted grunter*	*IIa*		X	X	X	X
Lithognathus lithognathus	*White steenbras*	*IIa*	X	X	X	X	X
Monodactylus falciformis	*Cape/Oval moony*	*IIa*			X	X	X
Liza macrolepis	*Largescale mullet*	*IIa*					X
Valamugil cunnesius	*Longarm mullet*	*IIa*				X	X
Valamugil robustus	*Robust mullet*	*IIa*				X	X
Terapon jarbua	*Thornfish*	*IIa*			X	X	X
Galeichthyes feliceps	*Barbel*	*IIb*	X	X	X	X	X
Sphyraena barracuda	*Barracuda*	*IIb*					X
Caranx sexfasciatus	*Bigeye kingfish*	*IIb*					X
Caranx ignobilis	*Giant kingfish*	*IIb*				X	X
Rhabdosargus sarba	*Natal stumpnose*	*IIb*				X	X
Scomberoides lysan	*Doublespotted queenfish*	*IIb*					X
Liza tricuspidens	*Striped mullet*	*IIb*		X	X	X	X
Thryssa vitrirostris	*Orangemouth glassnose*	*IIb*					X
Gerres acinaces	*Smallscale pursemouth*	*IIb*					X
Gerres methueni/rappi	*Evenfin pursemouth*	*IIb*					X
Leiognathus equula	*Slimy*	*IIb*					X
Monodactylus argenteus	*Natal/Round moony*	*IIb*				X	X
Liza alata	*Diamond mullet*	*IIb*				X	X
Liza dumerilii	*Groovy mullet*	*IIb*		X	X	X	X
Liza luciae	*St Lucia mullet*	*IIb*					X
Platycephalus indicus	*Bartailed flathead*	*IIc*			X	X	X
Diplodus sargus	*Dassie/blacktail*	*IIc*		X	X	X	X
Pomatomus saltatrix	*Elf*	*IIc*	X	X	X	X	X
Liza richardsonii	*Harder*	*IIc*	X	X	X		
Pomadasys hasta/kakaan	*Javelin grunter*	*IIc*					X
Johnius dussumieri	*Mini kob*	*IIc*			X	X	X
Sphyraena jello	*Pickhandle barracuda*	*IIc*					X
Lutjanus argentimactulus	*River snapper*	*IIc*				X	X

Table 3 continued…

Species	Common name	Dependence category	Distribution				
			Cool	Warm Temperate			Subtropical
			West	South	East	Transkei	KZN
Sillago sihama	*Silver sillagio*	*IIc*					X
Sarpa salpa	*Strepie*	*IIc*		X	X	X	X
Rhabdosargus globiceps	*White stumpnose*	*IIc*	X	X	X		
Carcharhinus leucas	*Zambezi shark*	*IIc*					X
Strongylura leiura	*Yellowfin needlefish*	*IIc*					X
Caranx melampygus	*Bluefin kingfish*	*IIc*					X
Caranx papuensis	*Brassy kingfish*	*IIc*					X
Chanos chanos	*Milkfish*	*IIc*					X
Lutjanus fulviflamma	*Dory snapper*	*IIc*					X
Valamugil buchanani	*Bluetail mullet*	*IIc*					X
Valamugil seheli	*Bluespot mullet*	*IIc*					X
Dasyatis chrysonota	*Blue stingray*	*III*	X	X	X		
Himantura uamak	*Honeycomb stingray*	*III*					X
Gymnura natalensis	*Butterfly/diamond ray*	*III*		X	X	X	X
Myliobatus aquila	*Eagleray*	*III*	X	X	X		
Mustelus mustelus	*Smooth houndshark*	*III*	X	X	X	X	X
Rhinobatos annulatus	*Lesser guitarfish/sandshark*	*III*	X	X	X	X	
Epinephelus andersoni	*Catface rockcod*	*III*				X	X
Epinephelus malabaricus	*Malabar rockcod*	*III*					X
Pomadasys multimaculatum	*Cock grunter*	*III*					X
Pomadasys olivaceum	*Piggy*	*III*	X				
Chelidonichthyes capensis	*Gurnard*	*III*	X	X	X		
Trachurus trachurus	*Maasbanker*	*III*	X	X	X		
Lithognathus mormyrus	*Sand steenbras*	*III*	X	X	X		
Otolithes ruber	*Snapper kob*	*III*					X
Trachinotus africanus	*Southern pompano*	*III*			X	X	X
Spondyliosoma emarginatum	*Steentjie*	*III*	X	X	X	X	X
Sparodon durbanensis	*White musselcracker*	*III*		X	X	X	X
Diplodus cervinus	*Zebra/wildeperd*	*III*		X	X	X	X
Kuhlia mugil	*Barred flagtail*	*III*			X	X	X
Muraenesox bagio	*Pike conger*	*III*			X	X	X
Thrysoidea macrura	*Slender giant moray*	*III*					X
Oreochromis mossambicus	*Mozambique tilapia*	*IV*	X	X	X	X	X
Clarius gariepinus	*Sharptooth catfish*	*IV*	X	X	X	X	X
Glossogobius giuris	*Tank goby*	*IV*					X
Anguilla bengalensis	*African mottled eel*	*Va*		X	X	X	X
Anguilla bicolor	*Shortfin eel*	*Va*		X	X	X	X
Anguilla marmorata	*Giant mottled eel*	*Va*		X	X	X	X
Anguilla mossambica	*Longfin eel*	*Va*		X	X	X	X
Megalops cyprinoides	*Oxeye tarpon*	*Vb*					X
Myxus capensis	*Freshwater mullet*	*Vb*		X	X	X	X
TOTAL	***80***		***19***	***34***	***41***	***43***	***71***

3. The role of estuaries in South African fisheries

3.1 Estuarine fisheries

3.1.1 Linefishing

Linefishing, from the shore or from boats (canoes to skiboats), and using handlines or rods, is popular in estuaries throughout South Africa. This is primarily a recreational angling pursuit (requiring a permit). A small number of subsistence fishers are active, mainly from Port Elizabeth to KwaZulu-Natal, and subsistence permits are in the process of being introduced. No commercial linefishing is permitted in estuaries.

Angling is limited on the west coast due to lack of suitable angling fish, but assuming angler densities similar to adjacent shorelines, there may be up to 0.12 anglers per km of estuary at any one time, or a maximum of 4400 angler-days per year on west coast estuaries. This represents the effort of approximately 147 fishers (Lamberth 2000a). All the effort is currently recreational, although about 14% of these anglers admit to selling part of their catch (Lamberth 1996). This said, the closure of the Berg Estuary gillnet fishery has seen an increase in the average size of fish caught as well as a two-orders-of-magnitude increase in recreational angler effort (Hutchings *et al*. 2007).

On the south coast, from Cape Point to Port Elizabeth, based on angler densities on adjacent shorelines and angler and boat counts on the Breede, Klein, Bot, Heuningnes and Swartkops estuaries, there are an estimated 133 000 angler-days per year expended by 7 400 anglers in estuaries along this stretch of coastline. These effort estimates are probably extremely conservative, as about 1 200 boat permits are issued each year, mostly for the Breede River. In addition, confusion over estuarine regulations and commercial linefish permits has led to commercial linefishers fishing illegally in estuaries to an unknown extent. In all, there are close to 8 000 recreational anglers fishing in the estuaries of the Cape Floral Region. The total number of anglers using estuaries in South Africa is estimated to be in the region of 67 000 (Lamberth & Turpie, 2003).

3.1.2 Castnetting

Castnetting is mainly used by recreational and subsistence anglers to catch bait fish such as mullet, is practised throughout South Africa, and requires a permit. The gear used is restricted to a weighted monofilament or braided nylon net of 1.5-4m diameter, with a mesh size of 15-20mm. On the east coast larger nets are used for catching linefish species, but amendments to the regulations are intended to curtail this practice. The regulations will restrict castnets to 2m diameter, with mesh sizes of 13-20mm.

On the west coast, castnets are used regularly by about 95 recreational shore anglers, almost exclusively targeting harders, with a total effort of about 2 837 angler-days per year. This accounts for approximately 1.2% of angler effort (Lamberth 2000a,b). On the south coast, approximately 300 shore-anglers use castnets regularly, with a total effort of approximately 8 972 angler-days per year (Lamberth 1996). The total number of castnetters using estuaries in South Africa is estimated to be about 5 700 (Lamberth & Turpie, 2003).

3.1.3 Gillnetting

Gillnetting is a passive form of fishing using monofilament or woven nylon nets, deployed either from a boat or walking out from the shore, in the hope that a shoal of fish will swim into them and become entangled. These nets may either drift, be staked or be anchored, but in terms of legislation they may not be left unattended except in KwaZulu-Natal where they are set overnight and retrieved in the morning. In addition to legal netting, substantial illegal gillnetting occurs in estuaries throughout South Africa. Overall, catch rates dictate that the fishery changes from a largely commercial venture on the west coast to more subsistence and opportunistic in nature as one moves eastwards.

On the west coast, gillnetting takes place in the Olifants, Berg and Rietvlei/Diep estuaries. There are 45 gillnet permit holders in the Olifants estuary, and an additional 20-30 people operating without permits. Annual effort is about 15 300 net days/year (Lamberth 2000a). On the Berg River estuary, until recently there were 120 gillnet permit holders, plus about 100 illegal operators, and annual effort was approximately 13 230 net days of legal effort plus at least 4000 net days of illegal effort (Hutchings & Lamberth 1999). Effort has declined substantially with the closure of the legal fishery. The Rietvlei-Diep system is fished by about 10 or 12 illegal netters (Lamberth 2000a).

Along the south coast, at least 3 teams of illegal netters operate in the Bot/Kleinmond and Klein estuaries (2-6 people per team), and according to Cape Nature Conservation, up to 5 nets have been found in either estuary at any one time. There are also up to 10 illegal nets used in the Breede and Duiwenhoks estuaries, mostly by landowners and holiday home owners, but sometimes also by west-coast gillnetters targeting spotted grunter and flathead mullet. Based on compliance successes, similar effort probably takes place in the Goukou, Gouritz, Klein Brak, and Groot Brak estuaries.

Overall, there are approximately 600 gillnetters operating in estuaries in the C.A.P.E. region or 50% of the roughly 1 200 gillnetters throughout South Africa (Table 3).

3.1.4 Seine netting

Seine netting is an active form of fishing in which woven nylon nets are either rowed or walked out to encircle a shoal of fish. The net is then hauled to shore by a crew of 6 to 30 persons, depending on the size of the net and the length of the haul (Lamberth *et al.* 1997). With the exception of Richard's Bay harbour, there are currently no seine net permits issued for estuaries in South Africa (Beckley *et al.* 2000). Nevertheless, a small amount of seine netting occurs illegally in estuaries throughout South Africa, In the C.A.P.E region Illegal seine netting occurs in the Heuningnes and Breede estuaries. The total number of seine netters using South African estuaries probably does not exceed 150.

3.1.5 Traditional fisheries

Traditional fishing methods, which are common in tropical countries to the north, are mostly, if not exclusively, confined to the Kosi system in South Africa. In the C.A.P.E. region, the remnants of historical stone fish traps or "vywers"are found throughout much of the south coast with a few either adjacent to, or in, estuaries such as the Breede and Goukou. None of the estuarine traps are maintained (Kemp 2006).

3.2 Influence of estuary characteristics on catch

Estuary size alone explains over 80% of the variation in catch in the warm temperate region and over 90% of variation in catch in the cool temperate and subtropical regions (Lamberth & Turpie 2003, Fig. 2). The steeper slope in the cool temperate region reflects greater productivity in that region as compared with the other two, which have similar slopes. In turn, the slope of the regression between estuary area and catch is steeper for permanently open than temporarily open/closed estuaries indicating higher productivity in the open systems (Fig 3). Also of significance, is that temporarily closed estuaries are generally smaller than 150 ha, whereas permanently open estuaries include large estuaries of up to 500 ha.

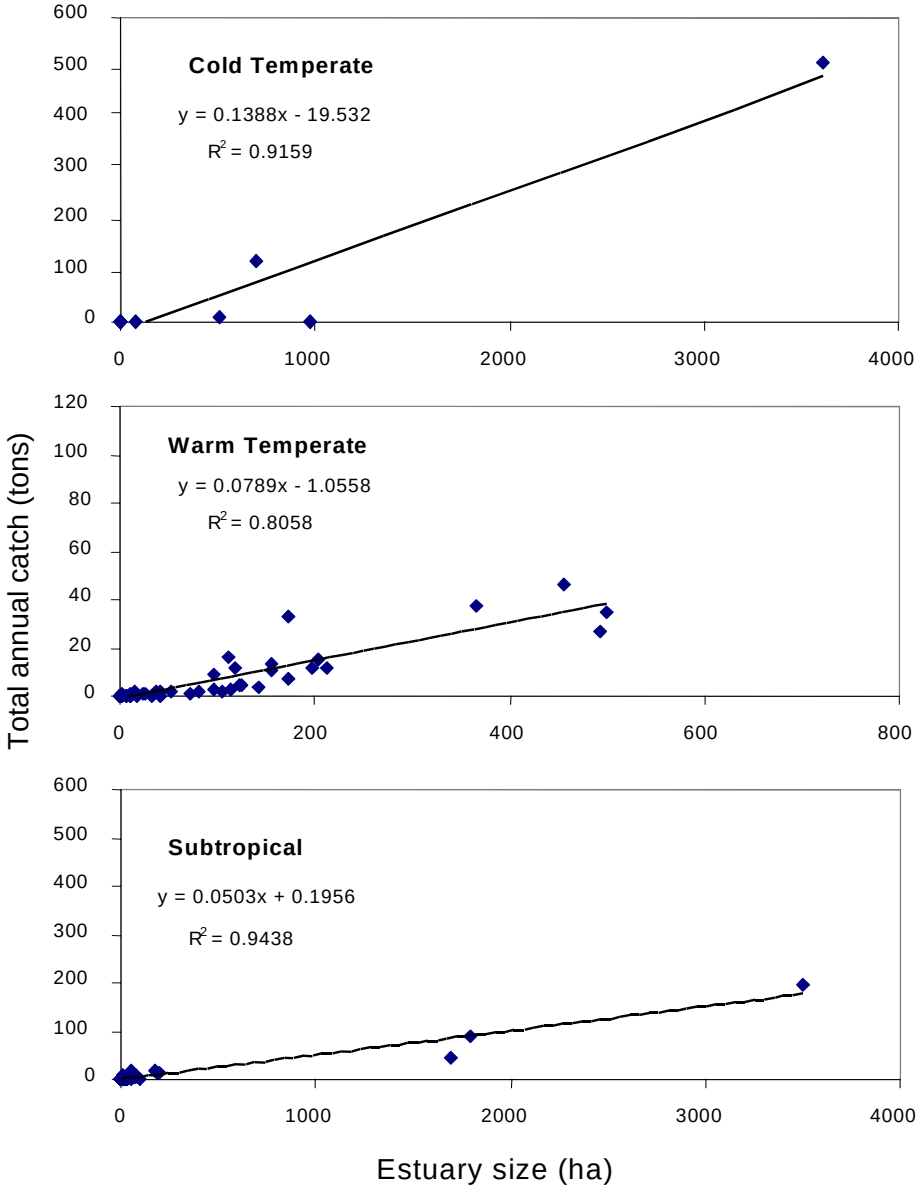

Figure 2. *Relationships between estuary size and catch in each of the three biogeographical regions of the South African coast.*

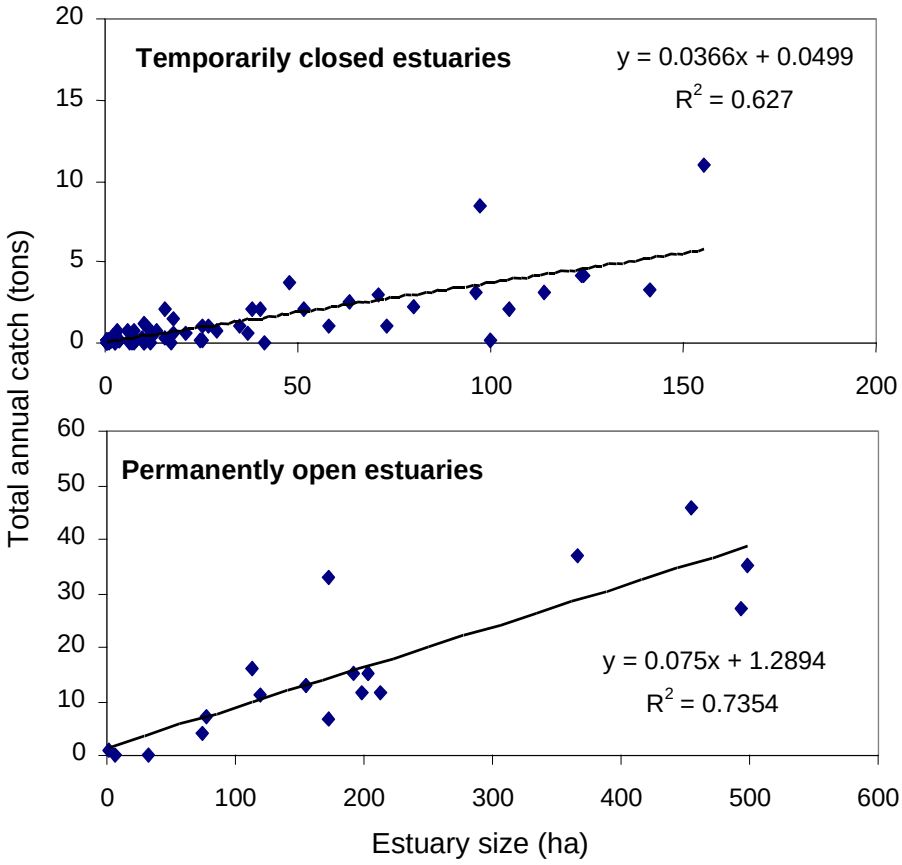

Figure 3. *Difference in the relationship between estuary size and catch for permanently open and temporarily closed estuaries in the warm temperate and subtropical regions.*

Using general linear models (GLMs) and known catch estimates for 129 estuaries, total estuarine catch for the 255 estuaries countrywide was estimated to be 2482 tons (Lamberth & Turpie 2003). Sixty-two percent of this catch was from estuaries in the C.A.P.E region. Anglers (including castnet activities) and gillnetters account for 93% of the total catch, with total catches being roughly equal for the two groups of fishers. Seine-net and traditional fisheries account for the remainder (Table 4).

Table 4. *Estimated total catches (tons) per fishery for all estuaries in each of five coastal regions in South Africa. After Lamberth & Turpie 2003.*

	Estuaries	*Ha*	*Angling*	*Castnet*	*Gill-net*	*Seine-net*	*Traps*	*Spear*	*Total*	*kg/ha*
West	*9*	*5 884.0*	*14.0*	*2.2*	*625.0*	-	-	-	***641.2***	*109.0*
South	*52*	*12 865.9*	*409.6*	*31.1*	*151.6*	*12.0*	-	-	***604.3***	*47.0*
East	*54*	*3 763.9*	*223.5*	*19.9*	*51.5*	-	-	-	***294.8***	*78.3*
Transkei	*67*	*2 611.8*	*141.1*	*12.5*	*32.5*	-	-	-	***186.1***	*71.2*
KZN	*73*	*46 810.6*	*245.4*	*52.4*	*296.5*	*72*	*73*	*16*	***755.3***	*16.1**
TOTAL	***155***	***71 936.2***	***1033.6***	***118.1***	***1157.0***	***84.0***	***73.0***	***16.0***	***2481.7***	***34.5***

** excluding St Lucia, the average yield for KwaZulu-Natal is 58.1kg/ha*

West coast estuaries have the highest yields per ha (Table 4), reflecting the generally high fishery productivity of this region. The high overall catch emanates from a small number of large estuaries, mainly the Berg and Olifants estuaries. In KwaZulu-Natal, most of the catch is from the Kosi and St. Lucia estuaries. On the south coast, Knysna is estimated by the model to have a catch of over 250 tons, but this is likely to be an overestimate (Appendix 1).

3.3 Estuarine catch composition

Catches within estuaries in South Africa are dominated by harders, most of which are caught on the west coast (Table 5). Spotted grunter and dusky kob are the next most important species caught in estuaries, being the main catch on the south coast and the rest of the country (Table 5). These three species make up 69% of the total biomass of fish caught in estuaries. On the west coast, harders make up 86% of catches, and elf make up most of the remaining catch (10%). On the south coast, spotted grunter makes up 45% of catches, harder 18% and white steenbras 10%, and dusky kob makes up 6% of catch weight. On the east coast, catches are dominated by dusky cob (48%) and spotted grunter (31%). Catch composition in Transkei is unknown. In KwaZulu-Natal, catches are dominated by dusky kob (35%), flathead mullet (11%) and spotted grunter (11%), and evenfin pursemouth, Mozambique tilapia, groovy mullet, largescale mullet make up >5% of catch weight.

4. Management recommendation towards implementing the guidelines

Estuaries contribute a significant value to the economy in terms of both estuarine fisheries and their contribution to inshore marine fisheries, with the latter contribution slightly exceeding the value realised within estuaries. Although commercial catches are substantial both within estuaries and in the marine environment, it is recreational fishing activities that contribute most value to the economy, with 22 times as many participants (500 000 versus <23 000) and realising a value more than 100 times greater per kg of fish caught. Subsistence fisheries are very localised, and involve very small numbers of fishers and low values, but important in the context of their livelihoods.

However, an assessment of the status of estuarine fish stocks suggests that the **currently high value of estuarine fish production is probably not sustainable**. Dwindling fish stocks will affect catches per unit effort and overall catches, and the value realised from these fisheries may well drop substantially if current trends are maintained. This would have much greater impact on commercial fisheries, upon which many people rely for their livelihoods, particularly in marine fisheries, than on recreational fisheries, which are less sensitive to catch returns. It is clear that sound management practices will need to be put in place in order to sustain these values in future, as well as to ensure the conservation of estuarine biodiversity.

Management strategies chosen for estuarine species may differ depending on socio-economic goals, e.g. whether to secure livelihoods of small-scale commercial fishers, or whether to increase overall contribution to the economy. No doubt, an equitable balance of these goals is required. Nevertheless, any management strategy ultimately has to concentrate on maintaining maximal productivity of resources if benefits are to be sustained in the long term.

Linefish and netfish management is currently undergoing complete revision in order to address these challenges. A **linefish management protocol** has been developed (Griffiths *et al.* 1999) which requires species-specific management plans. Under the Marine Living

Table 5. *Catch composition by weight and percentage, excluding Transkei catches and traditional fisheries in KwaZulu-Natal.*

Species	*Common name*	*Cat.*	*West Tons*	*South Tons*	*East Tons*	*KZN Tons*	*TOTAL Tons*	*%*
Liza richardsonii	*Harder*	*IIc*	*539.79*	*110.89*	*17.91*	*-*	*668.59*	*31.52*
Pomadasys commersonni	*Spotted grunter*	*IIa*	*-*	*270.62*	*73.51*	*71.88*	*416.01*	*19.61*
Argyrosomus japonicus	*Dusky kob*	*IIa*	*-*	*36.35*	*113.31*	*227.51*	*377.17*	*17.78*
Mugil cephalus	*Flathead mullet*	*IIa*	*10.64*	*13.56*	*2.16*	*72.14*	*98.50*	*4.64*
Pomatomus saltatrix	*Elf*	*IIc*	*62.58*	*0.87*	*1.63*	*1.47*	*66.55*	*3.14*
Lithognathus lithognathus	*White steenbras*	*IIa*	*0.22*	*60.22*	*4.47*	*-*	*64.92*	*3.06*
Gerres methueni/rappi	*Evenfin pursemouth*	*IIb*	*-*	*-*	*-*	*50.52*	*50.52*	*2.38*
Liza dumerilii	*Groovy mullet*	*IIb*	*-*	*13.02*	*0.50*	*35.07*	*48.59*	*2.29*
Oreochromis mossambicus	*Mozambique tilapia*	*IV*	*0.20*	*-*	*-*	*44.11*	*44.31*	*2.09*
Liza macrolepis	*Largescale mullet*	*IIa*	*-*	*-*	*-*	*35.20*	*35.20*	*1.66*
Clarius gariepinus	*Sharptooth catfish*	*IV*	*-*	*-*	*-*	*28.34*	*28.34*	*1.34*
Liza tricuspidens	*Striped mullet*	*IIb*	*-*	*26.34*	*1.46*	*-*	*27.80*	*1.31*
Lichia amia	*Leervis/garrick*	*IIa*	*0.79*	*21.13*	*4.09*	*-*	*26.00*	*1.23*
Rhinobatos annulatus	*Lesser guitarfish*	*III*	*0.20*	*22.94*	*-*	*-*	*23.13*	*1.09*

Species	Common name	Cat.	West Tons	South Tons	East Tons	KZN Tons	TOTAL Tons	%
Acanthropagrus berda	*Perch/riverbream*	*IIa*	*0.63*	*-*	*0.67*	*19.33*	*20.63*	*0.97*
Elops machnata	*Ladyfish/tenpounder*	*IIa*	*-*	*-*	*7.38*	*9.36*	*16.73*	*0.79*
Rhabdosargus holubi	*Cape stumpnose*	*IIa*	*-*	*14.26*	*1.63*	*-*	*15.89*	*0.75*
Leiognathus equula	*Slimy*	*IIb*	*-*	*-*	*-*	*14.25*	*14.25*	*0.67*
Rhabdosargus sarba	*Natal stumpnose*	*IIb*	*-*	*-*	*-*	*14.17*	*14.17*	*0.67*
Trachurus trachurus	*Maasbunker*	*III*	*12.14*	*-*	*-*	*-*	*12.14*	*0.57*
Pomadasys hasta/kakaan	*Javelin grunter*	*IIc*	*-*	*-*	*-*	*10.06*	*10.06*	*0.47*
Galeichthyes feliceps	*Barbel*	*IIb*	*1.55*	*1.62*	*3.58*	*-*	*6.75*	*0.32*
Diplodus sargus	*Dassie/blacktail*	*IIc*	*-*	*3.18*	*0.27*	*-*	*3.45*	*0.16*
Lutjanus argentimactulus	*River snapper*	*IIc*	*-*	*-*	*-*	*3.38*	*3.38*	*0.16*
Myxus capensis	*Freshwater mullet*	*Vb*	*-*	*0.46*	*-*	*2.39*	*2.85*	*0.13*
Rhabdosargus globiceps	*White stumpnose*	*IIc*	*0.13*	*2.60*	*0.11*	*-*	*2.84*	*0.13*
Sparodon durbanensis	*White musselcracker*	*III*	*-*	*2.60*	*0.16*	*-*	*2.76*	*0.13*
Johnius dussumieri	*Mini kob*	*IIc*	*-*	*-*	*-*	*2.70*	*2.70*	*0.13*
Chelidonichthyes capensis	*Gurnard*	*III*	*0.28*	*-*	*2.01*	*-*	*2.29*	*0.11*
Carcharhinus leucas	*Zambezi shark*	*IIc*	*-*	*-*	*-*	*2.17*	*2.17*	*0.10*
Platycephalus indicus	*Bartailed flathead*	*IIc*	*-*	*-*	*-*	*2.17*	*2.17*	*0.10*
Muraenesox bagio	*Pike conger*	*III*	*-*	*-*	*-*	*1.36*	*1.36*	*0.06*
Chanos chanos	*Milkfish*	*IIc*	*-*	*-*	*-*	*1.09*	*1.09*	*0.05*
Monodactylus falciformis	*Cape/Oval moony*	*IIa*	*0.06*	*0.61*	*0.07*	*-*	*0.73*	*0.03*
Caranx ignobilis	*Giant kingfish*	*IIb*	*-*	*-*	*-*	*0.70*	*0.70*	*0.03*
Caranx sexfasciatus	*Bigeye kingfish*	*IIb*	*-*	*-*	*-*	*0.70*	*0.70*	*0.03*
Caranx melampygus	*Bluefin kingfish*	*IIc*	*-*	*-*	*-*	*0.70*	*0.70*	*0.03*
Caranx papuensis	*Brassy kingfish*	*IIc*	*-*	*-*	*-*	*0.70*	*0.70*	*0.03*
Diplodus cervinus	*Zebra/wildeperd*	*III*	*-*	*0.56*	*0.07*	*-*	*0.62*	*0.03*
Liza alata	*Diamond mullet*	*IIb*	*-*	*-*	*-*	*0.58*	*0.58*	*0.03*
Scomberoides lysan	*Doublespotted queenfish*	*IIb*	*-*	*0.41*	*-*	*-*	*0.41*	*0.02*
Lithognathus mormyrus	*Sand steenbras*	*III*	*-*	*0.41*	*-*	*-*	*0.41*	*0.02*
Thryssa vitrirostris	*Orangemouth glassnose*	*IIb*	*-*	*-*	*-*	*0.41*	*0.41*	*0.02*
Gerres acinaces	*Smallscale pursemouth*	*IIb*	*-*	*-*	*-*	*0.28*	*0.28*	*0.01*
Megalops cyprinoides	*Oxeye tarpon*	*Vb*	*-*	*-*	*-*	*0.27*	*0.27*	*0.01*
Dasyatis chrysonota	*Blue stingray*	*III*	*0.26*	*-*	*-*	*-*	*0.26*	*0.01*
Sarpa salpa	*Strepie*	*IIc*	*-*	*0.15*	*0.07*	*-*	*0.21*	*0.01*
Mustelus mustelus	*Smooth houndshark*	*III*	*0.10*	*-*	*0.11*	*-*	*0.21*	*0.01*
Monodactylus argenteus	*Natal/Round moony*	*IIb*	*-*	*-*	*-*	*0.15*	*0.15*	*0.01*
Pomadasys multimaculatum	*Cock grunter*	*III*	*-*	*-*	*-*	*0.08*	*0.08*	*-*
Myliobatus aquila	*Eagleray*	*III*	*0.07*	*-*	*-*	*-*	*0.07*	*-*
Sphyraena barracuda	*Barracuda*	*IIb*	*-*	*-*	*-*	*0.05*	*0.05*	*-*
Sphyraena jello	*Pickhandle barracuda*	*IIc*	*-*	*-*	*-*	*0.05*	*0.05*	*-*
Terapon jarbua	*Thornfish*	*IIa*	*-*	*-*	*-*	*0.02*	*0.02*	*-*
Glossogobius giuris	*Tank goby*	*IV*	*-*	*-*	*-*	*0.02*	*0.02*	*-*
Anguilla bengalensis	*African mottled eel*	*Va*	*-*	*-*	*-*	*0.02*	*0.02*	*-*
Anguilla bicolour	*Shortfin eel*	*Va*	*-*	*-*	*-*	*0.02*	*0.02*	*-*
Anguilla marmorata	*Giant mottled eel*	*Va*	*-*	*-*	*-*	*0.02*	*0.02*	*-*
Anguilla mossambica	*Longfin eel*	*Va*	*-*	*-*	*-*	*0.02*	*0.02*	*-*
Spondyliosoma emarginatum	*Steentjie*	*III*	*0.01*	*-*	*-*	*-*	*0.01*	*-*
Lutjanus fulviflamma	*Dory snapper*	*IIc*	*-*	*-*	*-*	*0.01*	*0.01*	*-*
Ambassis productus	*Longspine glassy*	*Ia*	*-*	*-*	*-*	*0.01*	*0.01*	*-*
Ambassis gymnocephalus	*Bald glassy*	*Ib*	*-*	*-*	*-*	*0.01*	*0.01*	*-*
Ambassis natalensis	*Slender glassy*	*Ib*	*-*	*-*	*-*	*0.01*	*0.01*	*-*
		Total catch (tons)	***629.64***	***602.79***	***235.15***	***653.49***	***2121.07***	

Resources Act, estuaries fall within the marine environment, and these management plans include estuarine populations. Apart from the reduction of overall commercial effort, including in estuaries, there has been a substantial revision of bag and size limits for recreational, subsistence and commercial fisheries (Appendix 2). With compliance, the effort directed at many of these species is likely to decrease.

Reduced catches in estuaries are needed to secure estuarine contributions to marine inshore fisheries. If current regulations were complied with, this would be achieved, providing the estuarine environments (e.g. freshwater inflows) were also sufficiently protected. In the recreational fishery, a large proportion of landed catches comprise undersized fish, ranging from 90% on the west coast to 50% and 60% on the south and east coasts, respectively (Lamberth 1996, 2000a, Cowley 2000). In other words, catches would be much lower if there was compliance. A reduction in angler pressure would almost certainly serve to increase present abundance of certain species. For example, along the east coast of the Eastern Cape and in KwaZulu-Natal, elf has increased in numbers following increased protection (van der Elst & De Freitas 1987, Garrett & van der Elst 1990). Technically, catches could be reduced without reducing the value of the fishery, as most recreational anglers would still go fishing if they were more strictly policed. It also makes good economic sense to remove all commercial fisheries from estuaries, thereby halving the catch, but only reducing economic contribution by 1%. Commercial fishing in estuaries is predominantly gillnetting, which is unselective, usually with a high by-catch of undersized and immature linefish and other species. These species are already overexploited and this fishing pressure occurs during a particularly vulnerable stage of their life while they are in estuaries. It has already been stressed that these fisheries are seldom viable in the short term and almost never in the long term. By removing commercial fisheries, much greater recruitment will be facilitated into the sea.

Furthermore, **subsistence and commercial effort should be excluded from temporarily closed systems**, whether large or small, as these stocks are easily overexploited (Pease 1999). The protection of small and closed systems should not be done at the expense of the larger, permanently open systems, however. Protection should be levelled at all estuarine types at a rational scale, as they all support different and valuable fish communities.

Ideally, **different fisheries should target different species within the same estuaries**. Multi-user fisheries are seldom sustainable. However this is difficult to control, especially those sectors assigned less lucrative species. This is thus a further argument against including commercial fisheries in estuaries. Estuarine exploitation in South Africa should be limited to subsistence and recreational use. However the South African experience is that designated subsistence fishers soon realise the value of their non-target species, and it is hard to prevent them from shifting to these species. This often leads to chaos and user conflict, as has happened in Kosi and St. Lucia. Subsistence fisheries should be confined to traditional fisheries, and preferably assigned to homogenous communities. In other areas, the *'knee jerk"* allocation of subsistence rights should rather be addressed by finding alternative livelihoods for the fishers involved.

In general, the **protection of estuarine fish resources will also depend on the sound management of activities which affect estuarine environments**. Apart from the direct effect on fish stocks, recreational angling involves boat traffic and bait digging, leading to disturbance, trampling and depletion of prey for fish. More importantly, perturbations that occur in the marine environment or catchment may negatively impact on fish populations in estuaries (Whitfield & Marais 1999). In particular, if freshwater requirements of estuaries are not adequately met, the resultant chemical and biophysical changes in the estuarine headwaters and in mouth condition can severely hamper fish recruitment. Indeed,

freshwater inputs probably have the most important impact on species distribution, composition and abundance in estuaries. For these reasons it is strongly advocated that a philosophy of ecosystem preservation be used in management policy (Whitfield & Marais 1999) in addition to individual species conservation efforts. Such policies will lead to more rational decisions in terms of all developments which affect estuarine ecology, including development of marinas (which tend to favour ichthyoplankton but not large fish - Cloete 1993).

Thus, in summary, **the most sensible overall policy would be to conserve estuarine stocks as nursery and source areas for marine fisheries**. This is the most efficient option in terms of maximising resource productivity, economic benefits and biodiversity conservation. Resource productivity in both estuaries and the inshore marine environment can be enhanced by concentrating conservation efforts on estuarine stocks. Stock status can only be improved by reduction of catches. In order to minimise the cost of this, it should be targeted at fisheries which are either low value per unit catch (e.g. estuarine commercial net fisheries), or fisheries whose value is not strongly affected by catch rates (i.e. the recreational fishery, which is much smaller in estuaries than on the open coast). Conserving estuary stocks requires the sound holistic management of estuaries, a spin-off being the improved conservation of all estuarine biodiversity.

5. Estuary specific guidelines

Wood *et al*. 2004 list guidelines for the sustainable use of Eastern Cape estuaries under four broad categories; resource, ecosystem, socio-economic and institutional. Although these guidelines may be regarded as generic, in most cases they would be adapted or adjusted to suite the requirements of a particular estuary. In turn, although activities such as bait collection, power-boating and wastewater treatment are not strictly fishing, they all have an indirect influence on its' sustainability and are thus included here. The categories and associated guidelines are then discussed in terms of sustainable fishing.

5.1 Resource

- Control access to bait collecting areas.
- Rotate bait collection areas to be on an annual basis to allow for recovery.
- Restrict collection of mud prawn, sand prawn, bloodworm, pencil bait and tapeworm only during daylight hours and using only legal implements.
- Restrict fishing to daylight hours
- Control ornamental fish collection.
- Disallow capture of fish (irrespective of methods) during mouth breaching events in temporarily open/closed systems.
- Disallow capture of linefish species (e.g. grunter) with cast nets, seine nets, gill nets and traps.
- Disallow the harvesting of larval and juvenile fish for growing out by the mariculture industry
- Disallow the 'reintroduction" of hatchery reared fish into estuaries When reintroduction cannot be avoided, restrict the introduction or growing out of hatchery reared fish into a specific estuary to fish derived from broodstock from that system. Reduce the number of fishing competitions.
- Develop key indicators and implement effective monitoring programmes dedicated to individual species.Undertake directed research aimed at stock status and sustainable yields.
- Reduce bag limits on all threatened estuarine angling species.

5.2 Ecosystem

- Minimise impacts on associated sensitive habitats found adjacent to bait collection and fishing areas (e.g. salt marshes), by the construction of walkways. Restrict number of boats and access according to carrying capacity of the estuary.
- Establish sanctuary areas where threatened invertebrate and floral species occur.
- Adopt holistic approach to estuarine management (i.e. incorporate issues related to the catchment and adjacent terrestrial and marine environments).
- Identify potential Estuarine Protected Areas (EPA)1 for the conservation of over-exploited linefish species (e.g. dusky kob and white steenbras). These areas must include the mouth regions and adjacent marine environment.
- Ensure that artificial breaching of estuary mouths (how and when) is done in accordance with guidelines and regulations in the Sea Shore Act No 21 of 1935 and

[1] Currently no specific provision for EPAs in the MLRA and they would need to be proclaimed under the new Protected Areas Bill when it comes into effect.

the National Water Act No 36 of 1998 (NWA).

- Protect sensitive and riparian habitats with reference to the use of vehicles, boat mooring sites and agricultural activities.
- Assess and monitor accumulative impacts using tools such as Ecosystem Based Methods and Strategic Environmental Assessments.

5.3 Socio-economic

- Apply zonation, through consultation with all Interested and Affected Parties (IAPs), of estuaries for recreational and subsistence fishing activities and non-consumptive activities to reduce user conflict.
- Prohibit power boating or impose engine size restrictions.
- Restrict recreational activities such as skiing and power-boating to certain times of the day to avoid user group conflict.
- Promote estuarine awareness and instil a feeling of social responsibility towards estuaries through advertising & marketing and education of managers, user groups and the general public.
- Promote co-operative management through community involvement.
- Use of funds raised from estuary activities, to be used for estuary management in the same region.
- Identify and mitigate against impacts resulting from industrial and mining activities, and urban development.
- Promote alternatives to consumptive exploitation. For example, catch and release fisheries and eco-tourism or alternative livelihood options such as mariculture ventures and job creation for subsistence users.
- Reduce fishing effort by controlled access or increased access costs.
- Prioritise and increase funding for research and enforcement.
- Address the cause (e.g. poverty) and not the symptom (over-exploitation) in EMPs.

5.4 Institutional

- Identify and quantify (monitor) consumptive resources, their value, and the present levels of exploitation in all systems.
- Enforce, through compliance monitoring, existing legislation under the MLRA, e.g. permits, catch restrictions, use of cast nets etc. Penalties need to be severe and convictions need to be secured.
- Prevent illegal syndicates from using local communities to poach estuarine resources, in particular linefish, swimming prawns and mud crabs.
- Eliminate illegal activities (e.g. gill netting, crab trapping and netting of swimming prawns). Promote communication and co-operation between local, provincial and national authorities.
- Generate database/s on historic and current biophysical and socio-economic characteristics to facilitate monitoring programme/s.
- Control pollution and waste emissions including sewage, detergents, agricultural runoff, urban runoff, industrial waste, solid waste and fossil fuels.
- Control erosion and runoff associated with infrastructure development (roads, residential and industrial).
- Enforce existing legislation under the NWA, e.g. water abstraction and catchment management.

- Control harvesting of mangroves, reeds and riparian vegetation.
- Enforce legislation pertaining to activities that impact on estuary ecosystems and their functioning (e.g. National Environmental Management Act No 107 of 1998 (NEMA), Environmental Conservation Act No 73 of 1989, Agricultural Resources Act No 43 of 1983, etc.).
- Empower and encourage local authorities (managers) to enforce National legislation (e.g. MLRA) as well as municipal by-laws.
- Return custodianship of estuaries (from MCM) to local authorities and forums to manage within a national framework.
- Incorporate findings and recommendations arising from research programmes into management plans.
- Police user groups equally and consistently between and within the different groups. Establish a lead agent Non Governmental Organisation (NGO) to market estuaries and sell their value to government and the general public.
- Address estuaries specifically in all forms of legislation (e.g. Coastal Bill, NWA and MLRA), and do not include under an all-encompassing banner such as 'coastal zone'.
- Improve capacity through employment of competent staff and the concentration of effort in priority areas or estuaries.

6. Guidelines in perspective

Bait collection is dealt with under the associated C.A.P.E. Estuaries Guidelines 3. However, spatial and temporal restrictions on bait collection will undoubtedly have an impact on fishing effort and targeting. Disturbance and removal of bait organisms will impact on prey availability which in turn will influence fish foraging behaviour and ultimately catchability. A reduction in prey availability may reduce the number of fish that can be supported by a system.

In most cases, fish within any estuary are part of regional or national stocks. Consequently, legislation surrounding bag limits, minimum sizes, closed seasons, gear restrictions and the capture of ornamental fish are dealt with on a national basis. Similarly, resource directed research, such as stock assessment, is usually regional or national in nature.

Table 6. *Catch composition, day and night proportions of total catch and catch-per-unit-effort (fish per angler-day) in the Breede Estuary.*

		% Catch			Fish per angler-day	
		All	Night	Day	Night	Day
Argyrosomus japonicus	Dusky kob	54.11	47	53	0.510	0.278
Pomadasys commersonii	Spotted grunter	18.70	35	65	0.131	0.128
Rhabdosargus holubi	Cape stump	3.71	36	64	0.035	0.028
Pomatomus saltatrix	Elf	3.32	28	72	0.018	0.027
Mugilidae spp	Mullet spp.	0.40	33	67	0.002	0.003
Lichia amia	Leervis	3.58	19	81	0.013	0.038
Galeichthys feliceps	Barbel	4.24	16	84	0.014	0.032
Lithognathus lithognathus	White steenbras	1.99	7	93	0.005	0.019
Monodactylus falciformis	Cape moony	0.40	33	67	0.002	0.002
Diplodus sargus	Dassie / blacktail	1.33	10	90	0.005	0.016
Elops machnata	Springer / tenpounder	0.13	0	100		0.002
Sarpa salpa	Strepie	0.13	0	100		0.001
Trachurus trachurus	Maasbanker	0.27	0	100		0.001
Pomadasys olivaceum	Piggy	0.13	0	100		0.001
Diplodus cervinus	Wildeperd	0.13	0	100		0.002
Elasmobranch spp.	Shark spp.	0.13	0	100		0.001
Rajiformes spp.	Skates & Rays	0.13	0	100		0.001
Total			36	64	0.734	0.636

This said, there may occasionally be merit in conducting **stock assessments in individual estuaries** especially those which are temporally open/closed systems and/or those in which recruitment is limited and in which there are high levels of fishing effort. Although most legislation is national, the trick lies in delegating enforcement and monitoring to competent local authorities.

With the exception of zonation, **estuarine specific fishing legislation** is likely to remain rare. When they do occur, estuarine specific regulations (e.g. bag limits) will be implemented due to fish being extremely vulnerable in a particular system. Consequently, these type of regulations will tend to be more severe than those applied nationally. By example, the Breede Estuary is regarded as one of the most important estuarine nursery and foraging

areas for juvenile and adult dusky kob (*Argyrosomus japonicus*). Ongoing catch monitoring by the Breede River Conservancy (a good example of co-operative management) raised concerns regarding the number of large adults caught, even though national legislation provided for a bag limit of one per angler per day. The conservancy, supported by local ratepayers and angling clubs, suggested that night fishing be banned in the Breede Estuary. Catch monitoring data showed that this would halve the total catch of dusky kob without impacting much on the overall catch of other species targeted as most of these were caught during the day (Table 6). In turn, there was little difference between the night and daytime catches of large dusky kob (Fig 4).

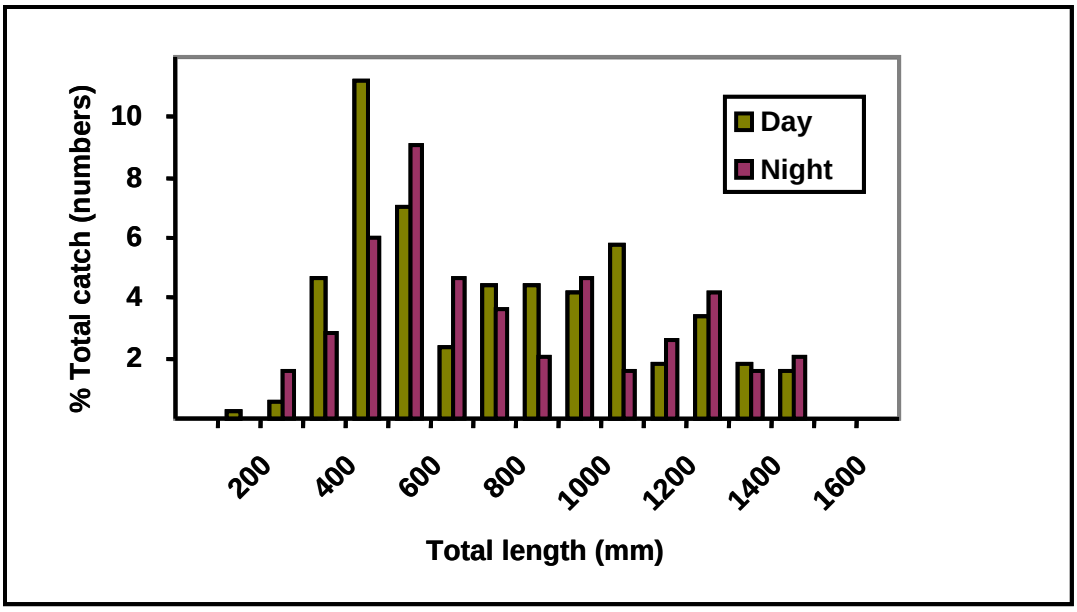

Figure 4. *Size frequency distributions of day and night kob (Argyrosomus japonicus) catches in the Breede Estuary.*

The difference lay in the fact that more small fish were caught in the daytime. Consequently, catch-per-unit-effort, if measured in fish per angler-day, of large fish, did not really differ between day and night. In fact, daytime angler-days were only 5 hrs compared to 15 hrs for night-time which suggests that cpue in the daytime was actually higher and that a ban on night-time fishing would have little impact on individual angler cpue. The ban on night-time fishing on the Breede is currently draft legislation. Should it prove successful, it will likely be extended to other estuaries. The prohibition and phasing out of estuarine gillnet fisheries has merit in that catch rates are orders of magnitude higher than the linefisheries and mortalities of non-target species are high. High bycatch, perpetual economic loss as well as recruitment and growth overfishing led to the closure of the Berg Estuary gillnet fishery in 2004. Since then, there has been an increase in fish diversity and mean size of fish caught, restoration of estuarine nursery function for exploited fish species and the establishment of a viable recreational fishery in the system (Fig 5, Hutchings *et al.* 2007). Overall, due to improved catches by the commercial gillnet fishery in the adjacent sea and due to the increase in local recreational angling tourism, there has been a nett economic benefit/gain to the local economy as opposed to the loss previously incurred by the net-fishery.

Mariculture, especially that of finfish, poses one of the greatest threats to estuarine fish production and diversity in South Africa. Ranching or the reintroduction of hatchery-reared fish into estuaries should be avoided at all costs as the global experience has been loss of genetic diversity, behavioural changes and disease amongst wild stocks. When the 'reintroduction' of hatchery-reared fish to a particular estuary cannot be avoided, the fish should be restricted to those derived from broodstock from that system. In turn, there should be a national prohibition on the capture of juvenile fish (estuarine & marine) for growing out by the mariculture industry. Assessments of estuarine fish assemblages throughout the country indicate that without any exception, stocks and populations of exploited and unexploited fish species are all prone to collapse from this practice, which in reality is a capture fishery.

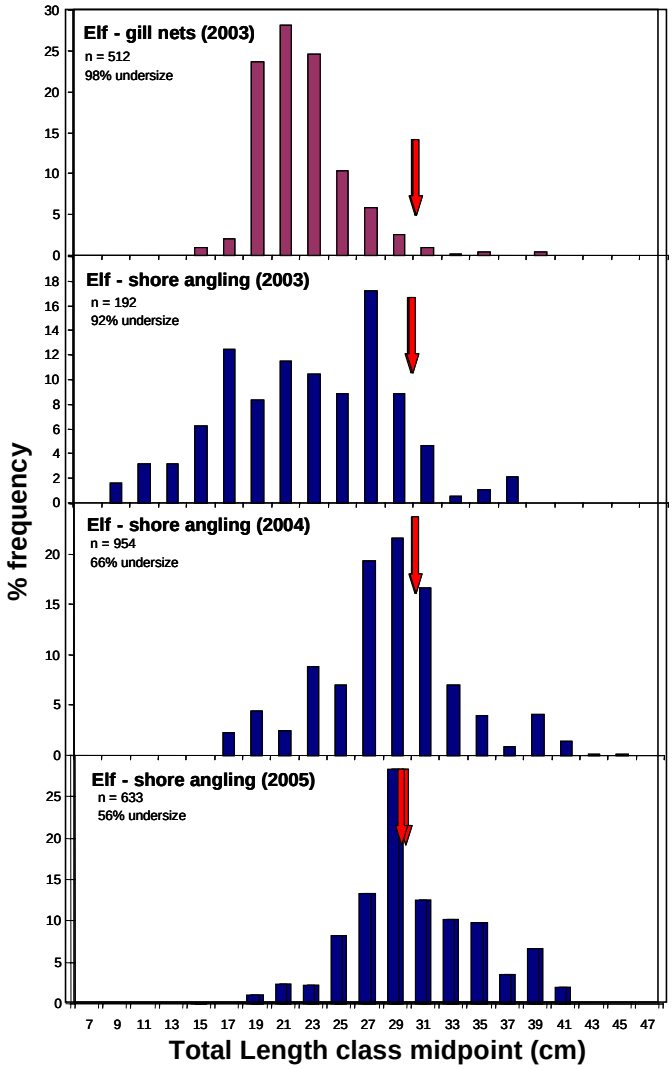

Figure 5. *Size frequency distribution of elf (Pomatomus saltatrix) in the Berg River Estuary before (2003) and after (2004 & 2005) closure of the gillnet fishery. After Hutchings et al. 2007.*

All **commercial fishers**, including those in estuaries, are required to provide monthly catch returns to management. The Olifants River Estuary harder fishery is a good example of where catch monitoring is proving a useful indicator of seasonal and other interactions in the system. Also interesting, is that an area with arguably one of the lower literacy levels in

the country, has fishers providing the most accurate catch returns in the gillnet fishery. Another example as to the value of monitoring is the recording of anglers catches by the rangers of the Breede River Conservancy. Catch monitoring by rangers employed exclusively on the estuary and adjacent coastline has provided valuable catch and effort data including that supporting a ban on nighttime fishing. Also important, is that this is an NGO that has been delegated the responsibility of carrying out government functions. Fishing and bait collection have an impact beyond the removal of the target species. Trampling of saltmarsh and mudflats during bait collection or bank erosion due to the wakes of powered fishing boats all have an impact on the estuarine ecosystem and ultimately fish habitat. Outboard fuel may be toxic to fish and invertebrates whereas noise pollution may be enough to drive fish from an estuary. For example, angler catches in the Breede Estuary peak during the summer months. During the year-end holiday period, initial high summer catches and *cpue* decline with the influx of recreational anglers. However, the decline in overall catch and *cpue* is higher than can be attributed to more anglers sharing the same amount of fish, which suggests that disturbance from boat traffic, and other sources also play a role. Consequently, aside from limiting catch, restrictions on boat traffic and sanctuary areas are also necessary in limiting disturbance.

Estuarine Protected Areas (EPAs) are a relatively new concept in South Africa. Most existing protected estuaries have arisen by default due to falling within nature reserves (e.g. Klipdrift), national parks (e.g. Lottering) and mining exclusion zones (e.g. Orange). Similarly, proposed EPAs such as the Goukou Estuary, are currently only possible due to being included as integral parts of MPAs on the adjacent coastline. Estuary sanctuary areas may be zoned to protect particularly sensitive fish habitat and populations. EPAs are dealt with in detail by Turpie & Clark (2007).

Estuary mouth manipulation should, as far as possible, allow mouth dynamics to follow natural patterns. In turn, artificial breaching of estuary mouths should be timed to maximise the recruitment window for the larvae and juveniles of exploited and unexploited fish species. Given the frequent large and vulnerable aggregations of fish prior to mouth breaching events, fishing of any nature should be prohibited until management judges the fish to have dispersed.

Estuaries may be zoned to protect resources as well as to **limit conflict between resource users.** However, although most realise the common sense of separating angling and water-skiing or limiting fishing effort, zonation (e.g. development) should not be allowed to unfairly restrict public access to estuaries and the adjacent shoreline. This said, co-operative management and the establishment of estuarine conservancies are invaluable in demarcating use zones and the monitoring and control of fishing. Co-operative management may also play a role in promoting alternatives to consumptive use such as eco-tourism and job creation for commercial and subsistence fishers or catch and release for recreational anglers.

A substantial proportion of the total landed catch in South African estuaries is through **illegal fishing activities**. Illicit catch may comprise more than 90% of the landed mass in some estuaries. Compliance monitoring, enforcement of existing legislation and appropriate penalties would go a long way in reducing these catches. In turn, improved communication and co-operation between local, provincial and national authorities would help these bodies pool resources and direct them to where they are needed most. This includes the devolution of compliance and monitoring responsibilities to local authorities and conservancies.

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Appendix 1. Estimated total catches by fishery (legal and illicit) for each estuary in the C.A.P.E. area. Totals in italics estimated using general linear models. Berg River Estuary catch estimates are those prior to the closure of the gillnet fishery in 2004. After Lamberth and Turpie 2003.

Biog	Coast		Size		Estimated annual catch (tons)						
Reg	Section	Estuary	(ha)	Type	Angling	Castnet	Gillnet	Seine	Traps	Spear	Total
C	West	Olifants	701.7	Perm open	1.0	0.1	120.0	<0.1	<0.1	<0.1	121.1
C	West	Berg (Groot)	3615.0	Perm open	10.0	1.0	500.0	<0.1	<0.1	<0.1	511.0
C	West	Rietvlei/Diep	515.0	Temp closed	2.0	1.0	5.0	<0.1	<0.1	<0.1	8.0
C	West	Houtbaai		River mouth	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
C	West	Wildevoëlvlei	75.8	Temp closed	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
C	West	Bokramspruit		Temp closed	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
C	West	Schuster		Temp closed	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
C	West	Krom		Temp closed	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
W	South	Silvermine	6.5	Temp closed	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
W	South	Sand	155.5	Temp closed	10.0	1.0	<0.1	<0.1	<0.1	<0.1	11.0
W	South	Eerste	10.2	Temp closed	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
W	South	Lourens	7.1	Temp closed	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
W	South	Sir Lowry's Pass	3.0	Temp closed	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
W	South	Steenbras	1.9	Perm open	<0.1	1.0	<0.1	<0.1	<0.1	<0.1	1.0
W	South	Rooiels	10.8	Temp closed	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	0.1
W	South	Buffels (Oos)	17.3	Temp closed	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
W	South	Palmiet	33.0	Perm open	0.1	0.1	<0.1	<0.1	<0.1	<0.1	0.2
W	South	Bot/Kleinmond	1698.4	Lake	5.0	1.0	10.0	<0.1	<0.1	<0.1	16.0
W	South	Onrus	41.1	Temp closed	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
W	South	Klein	2958.9	Lake	10.0	1.0	5.0	<0.1	<0.1	<0.1	16.0
W	South	Uilskraals	104.7	Temp closed	1.0	0.1	1.0	<0.1	<0.1	<0.1	2.1
W	South	Ratel	10.0	Temp closed	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
W	South	Heuningnes	172.5	Perm open	5.6	0.1	<0.1	1.0	<0.1	<0.1	6.7
W	South	Klipdrifsfontein		Temp closed	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
W	South	Breë	455.3	Perm open	40.0	1.0	3.0	2.0	<0.1	<0.1	46.0
W	South	Duiwenhoks	203.1	Perm open	5.0	0.1	1<0.1	<0.1	<0.1	<0.1	15.1
W	South	Goukou	154.8	Perm open	10.0	1.0	2.0	<0.1	<0.1	<0.1	13.0
W	South	Gourits	112.6	Perm open	1.0	1.0	5.0	<0.1	<0.1	<0.1	16.0
W	South	Blinde		Temp closed	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
W	South	Hartenbos	40.6	Temp closed	2.0	0.1	<0.1	<0.1	<0.1	<0.1	2.1
W	South	Klein Brak	96.0	Temp closed	2.0	0.1	1.0	<0.1	<0.1	<0.1	3.1
W	South	Groot Brak	113.9	Temp closed	2.0	0.1	1.0	<0.1	<0.1	<0.1	3.1
W	South	Maalgate	13.5	Temp closed							1.8
W	South	Gwaing		Temp closed							
W	South	Kaaimans	8.0	Perm open							4.0
W	South	Wilderness		Lake							
W	South	Swartvlei	1076.6	Lake							73.9
W	South	Goukamma	270.0	Temp closed							19.2
W	South	Knysna	3594.0	Bay							244.6
W	South	Noetsie	8.0	Temp closed							1.4
W	South	Piesang	92.2	Temp closed							7.2
W	South	Keurbooms	295.2	Perm open							23.4
W	South	Matjies/Bitou		Temp closed							<0.1
W	South	Sout (Oos)	52.2	Perm open							<0.1

Biog Reg	Coast Section	Estuary	Size (ha)	Type	Estimated annual catch (tons)						Total
					Angling	Castnet	Gillnet	Seine	Traps	Spear	
W	South	Groot (Wes)	39.3	Temp closed							<0.1
W	South	Bloukrans		River mouth							<0.1
W	South	Lottering	17.0	River mouth							<0.1
W	South	Elandsbos	6.0	River mouth							<0.1
W	South	Storms		River mouth							
W	South	Elands		River mouth							
W	South	Groot (Oos)		River mouth							
W	South	Tsitsikamma		Temp closed							
W	South	Klipdrif		Temp closed							
W	South	Slang		Temp closed							
W	South	Kromme	240.3	Perm open							19.7
W	South	Seekoei	132.2	Temp closed							9.9
W	South	Kabeljous	117.9	Temp closed							8.9
W	South	Gamtoos	467.0	Perm open							35.1
W	South	Van Stadens	28.0	Temp closed							2.8
W	South	Maitland	0.2	Temp closed							0.9
W	East	Swartkops	499.0	Perm open	30.0	3.0	2.0	<0.1	<0.1	<0.1	35.0