The recreational fishery in the Kosi estuarine lake system, South Africa

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The Kosi estuarine system, located in northern KwaZulu-Natal, is becoming an increasingly popular angling venue. Recreational catch card data from the National Marine Linefish System for the years 1986 to 1999 were analysed to determine total catch, catch composition, catch per unit effort (CPUE), seasonality of catches and annual trends in catch composition. A total of 17 families, comprising 34 species, was reported in catches of recreational anglers. *Pomadasys* spp., predominantly *Pomadasys commersonnii,* was the most prominent taxon caught in terms of both numbers and mass. Seasonal trends in catch rates were observed, with more fish caught in the summer and autumn months. The catch rate fluctuated annually. Fluctuations in CPUE were closely correlated to the number of cards collected, which reflects bias in the data. Despite annual fluctuations in CPUE, regression analysis revealed a slight increase in overall CPUE with time. However, CPUE for *Acanthopagrus berda* and *Lutjanus argentimaculatus* decreased steadily since 1986. The decline of these two estuarine-dependent species may indicate that the total fishing levels are not sustainable.

Key words: angling, catch composition, catch per unit effort.

INTRODUCTION

The Kosi estuarine system (Fig. 1), which consists of four connected lakes, is located on the east coast of South Africa, and extends from 26°50′S to 27°11′S and 32°38′E to 32°53′E (Begg 1978). The system is approximately 10 km long and runs parallel to the Indian Ocean, behind coastal dunes. The four lakes drain through a permanently open estuary, which opens to the sea 2 km south of the Mozambique/South African border. The southernmost lake, Amanzimnyama is completely fresh, but the other three lakes are influenced by the sea, and thus support euryhaline fauna (Blaber 1978). The Kosi system is unique in KwaZulu-Natal, in that it is a large clear-water system. The two small rivers which enter the system rise in leached acidic sands and, as a consequence, carry little silt (Mountain 1990).

The clear water of the system, together with the proximity of the lakes to tropical waters, result in a diverse fish fauna (Blaber 1980). A total of 163 marine species has been recorded in the system. The local Tonga inhabitants have fished in the Kosi system for centuries, using traps and traditional spears. Recreational anglers began utilizing the system towards the end of the 1940s, fishing from small boats in the three northern lakes (Makhawulani, Mpungwini and Nhlange). Since 1950, there has been a camping facility, which is used primarily by recreational anglers, on the northwestern shore of Lake Nhlange (Kyle 1986). Local children also fish by rod and line, but from the banks of the system. Species caught by the children are generally small species which are not targeted by recreational anglers. The most commonly caught species are the pouter (*Gerres acinaces*) and *Terapon jarbua,* a species that is viewed as a pest by recreational anglers (Kyle 1992). There is also a limited amount of recreational shore angling that takes place at the mouth of the system from the north bank. The small reef just inside the mouth and the beach south of the mouth fall into sanctuary areas closed to fishing.

The diverse fish fauna supports a traditional trap fishery, a recreational fishery, and a recent gill net fishery. The fish traps (kraals) are built in the estuary and Lake Makhawulani, which have greater tidal flow (Kyle & Robertson 1997). Gill netting is only permitted at the margins of Lake Nhlange and away from any channel entrances (Kyle 1999). Both the Kosi trap fishery and the gill net fishery have been studied (Kyle 1981, 1986, 1999), but little research has been done on the recreational fishery in the Kosi estuarine system. This paper provides an analysis of recreational angling in the Kosi estuarine system, based on

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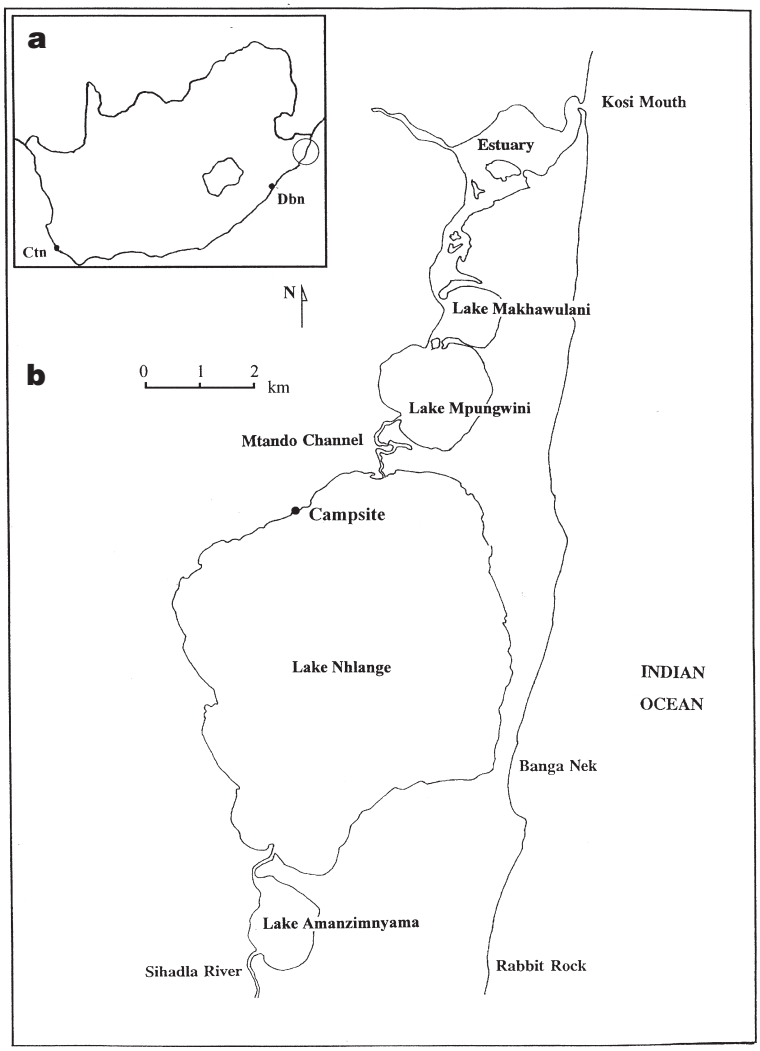

Fig. 1. **a**, Location of the greater St Lucia Wetland Park in KwaZulu-Natal, South Africa; **b**, map of the Kosi estuarine lake system.

catch card data from anglers based at the Nhlange campsite. The Kosi estuarine system forms part of the Kosi Bay Nature Reserve, which was proclaimed in 1987, and has recently been incorporated into the Greater St Lucia Wetland Park (GSLWP). The KwaZulu-Natal Nature Conservation Service (KZNNCS) is the management authority responsible for the protection and management of the GSLWP, which was declared a World Heritage Site in 1999.

METHODS

Since 1986, recreational anglers at Kosi Bay have been requested to complete catch cards after each fishing outing. The catch cards, which are available at the fish cleaning site, are completed voluntarily by anglers, and collected from the site by KZNNCS staff. Where possible, KZNNCS staff also visit the campsite to encourage and assist fishermen in filling out catch cards. There is no cross-check on the accuracy of reporting. The angling details recorded are number of anglers per boat, date, time spent fishing and catch (number and estimated mass per individual fish). Each catch card represents a complete angling outing. The completed catch cards are sent to the Oceanographic Research Institute (ORI) in Durban, for entry onto the National Marine Linefish System

Table 1. Angling effort from the Kosi system between 1986 and 1999.

Year	Number of outings recorded	Number of anglers per outing (mean = 3.07 ± 0.25 S.D.)	Number of hours per outing (mean = 5.3 ± 0.53 S.D.)	Total number of monitored hours
1986	510	3.7	5.4	2343
1987	991	3.1	4.9	4517
1988	1601	3.1	4.9	7674
1989	1181	3.0	5.1	5970
1990	1060	3.1	5.1	5370
1991	1312	3.0	5.0	6235
1992	1003	3.1	5.6	5265
1993	1973	2.9	5.2	10054
1994	2379	2.9	5.1	11619
1995	2288	2.9	5.2	11464
1996	1698	3.1	5.2	8223
1997	825	3.2	5.5	3916
1998	653	3.3	6.2	3611
1999	892	2.6	5.8	4824

(NMLS) database and subsequent analysis.

Recreational catch card data from 1986 to 1999 were analysed to determine total catch, catch composition, catch per unit effort (CPUE), seasonality of catches and annual trends in the numbers and mass of important angling species. Owing to the inability of fishermen to accurately identify all fish to species level, certain species were grouped at genus level.

There are numerous biases in the voluntary NMLS data, which can affect analyses. These biases include prestige bias, digit bias, unintentional misreporting, deliberate misreporting, apathy and non-response bias (Pollock *et al.* 1994). Prestige bias refers to the tendency of some anglers to overestimate the number and size of fish caught, while digit bias occurs when anglers round up or round down the mass or number of fish caught. Misreporting may be unintentional, as anglers are often unable to distinguish between different fish species, or intentional out of fear of prosecution. Apathy in completing cards is also problematic. In addition, effort by and efficiency of KZNNCS staff in collecting catch cards varied with time. Some anglers were confused and entered shore fishing data on estuarine catch cards.

RESULTS

Angling effort

The number of reported angling outings increased from 510, at the inception of the project, to a peak of 2379 in 1994, declining thereafter to 892 in 1999 (Table 1). The number of anglers per outing varied little throughout the study period, with a mean of 3.07 anglers per outing (S.D. = 0.25). The mean number of hours fished per outing was also fairly stable throughout the study period, ranging from 4.9 to 6.2 hours, with a mean of 5.3 hours per outing (S.D. = 0.53).

The total number of monitored hours fished in a year (Table 1) followed the same trends as the number of angling outings reported and was highest between 1993 and 1996, and lowest at the beginning and end of the study period. Care should be taken in interpreting these results as they often reflect the amount of effort put into collecting catch cards, rather than an actual increase or decrease in angling effort.

CPUE was generally higher during the summer and autumn months (November to May) and lowest during winter and spring (June to October) (Fig. 2).

Catch composition

Based on the information provided by anglers, a total of 17 families and 34 species was recorded in the catches from 1986 to 1999 (Table 2). Species believed to have been caught by shore anglers were excluded from the analysis (Appendix 1). Teleosts accounted for 33 of the species, while elasmobranchs were only represented by one species. Fig. 3a,b depicts the catch composition for the 14-year study period by numbers and mass, respectively. *Pomadasys* (almost exclusively

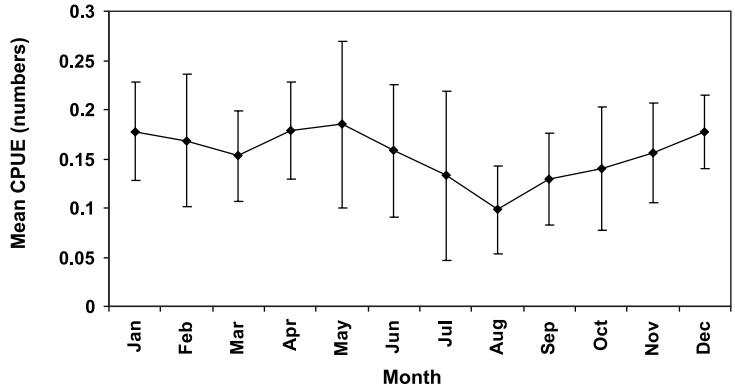

Fig. 2. Mean monthly CPUE (fish/angler/h) for all angling species reported on catch cards in the Kosi system between 1986 and 1999; error bars are the standard error of mean.

P. commersonnii), was the most prominent genus caught in terms of both numbers and mass, at 54 % and 57 %, respectively. *Rhabdosargus* spp. (predominantly *R. sarba*) and *Caranx* spp. (predominantly *C. ignobilis* and *C. sexfasciatus*) made up a fair percentage of the catch, contributing 16 % and 7 %, respectively, of the catch by numbers, and 7 % and 11 % of the catch by mass. The other angling species made up a fairly low percentage of the catch, with *Acanthopagrus berda* contributing 6 % of the catch by numbers but only 2 % by mass. *Lutjanus argentimaculatus* contributed only 4 % of the catch by numbers but 7 % of the catch by mass. The remaining species only amounted to 13 % of the catch by numbers and 16 % by mass.

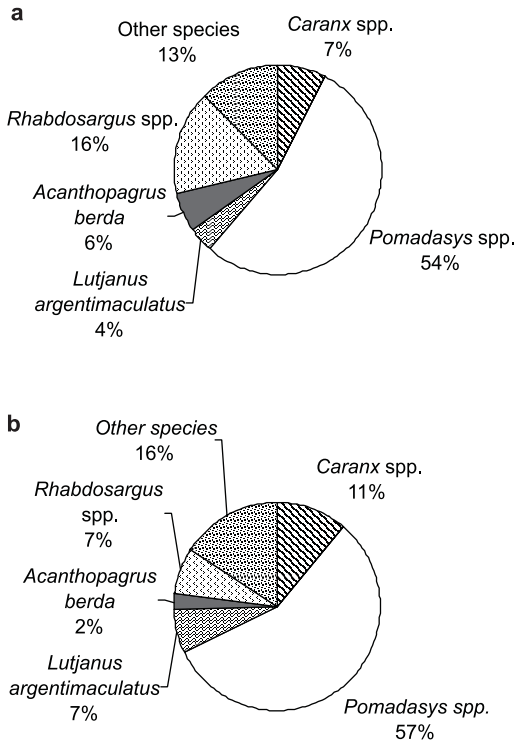

Fig. 3. Catch composition of recreational angling species caught in the Kosi system between 1986 and 1999 by (**a**) number and (**b**) mass.

Annual trends in catch composition by numbers and mass are depicted in Fig. 4a and Fig. 4b, respectively. The contribution that *Pomadasys* spp. makes to total catch by numbers and mass has been fairly stable throughout the study period. By contrast, *Rhabdosargus* spp. showed the greatest fluctuations, with contribution by numbers to the total catch ranging from 5.7 % to 25.7 %, and contribution by mass ranging from 1.9 % to 11.7 %. The contribution of *Caranx* spp. by numbers ranged from 4 % to 14 %. The percentage contribution of *A. berda* by mass to the total catch remained fairly constant from 1987 to 1995 but then declined sharply from a high of 4.1 % in 1994 to a low of 0.6 % in 1999, while the contribution by numbers declined from 1996. The contribution of *L. argentimaculatus* by numbers to the total catch ranged from 2 % to 6.3 %.

Catch per unit effort (CPUE)

CPUE was at its lowest in 1995 at 0.13 fish/angler/h and 0.19 kg/angler/h, and highest at the beginning and end of the study period (Fig. 5). The mean CPUE, for the study period, was 0.16 fish/angler/h (S.D. = 0.031) and 0.25 kg/angler/h (S.D. = 0.062). Regression analysis of CPUE revealed a slight decrease in terms of CPUE by numbers but a slight increase in CPUE by mass.

CPUE appeared to be correlated with the number of outings reported. Regression analysis

Table 2. Species reported in estuarine catches of recreational anglers in the Kosi system from 1986 to 1999. (This species list is subject to bias, including unintentional and intentional misreporting by anglers and should not be viewed as a species checklist for the system.)

Family	Scientific name	Common name	Numbers caught (*n*)
Belonidae	*Ablennes hians*	Garfish	86
Carangidae	*Caranx ignobilis*	Giant kingfish	3 860
	Caranx papuensis	Brassy kingfish	
	Caranx sem	Blacktip kingfish	
	Caranx sexfasciatus	Bigeye kingfish	
	Scomberoides spp.	Queenfish	332
Chanidae	*Chanos chanos*	Milkfish	381
Cichlidae	*Oreochromis mossambicus*	Mozambique tilapia	265
Clariidae	*Clarius gariepinus*	Barbel	410
Dasyatidae	*Himantura uarnak*	Honeycomb stingray	39
Elopidae	*Elops machnata*	Springer	828
Haemulidae	*Plectorhinchus* spp.	Rubberlip	2
	Pomadasys commersonnii	Spotted grunter	23 606
	Pomadasys kaakan	Javelin grunter	
	Pomadasys multimaculatum	Cock grunter	
Lutjanidae	*Lutjanus argentimaculatus*	River snapper	1 708
	Lutjanus russelli	Russell's snapper	5
Monodactylidae	*Monodactylus argenteus*	Natal moony	5
	Monodactylus falciformis	Cape moony	
Mugilidae	*Mugilid* spp.	Mullet spp.	1
Muraenesocidae	*Muraenesox bagio*	Pike conger	21
Platycephalidae	*Platycephalus indicus*	Bartail flathead	28
Sciaenidae	*Argyrosomus japonicus*	Dusky kob	64
	Johnius dorsalis	Mini-kob	1
	Otolithes ruber	Snapper kob	12
	Epinephelus lanceolatus	Brindle bass	1
	Epinephelus spp.	Rockcod	54
Sparidae	*Acanthopagrus berda*	River bream	2 595
	Lithognathus mormyrus	Sand steenbras	3
	Rhabdosargus holubi	Cape stumpnose	7 045
	Rhabdosargus sarba	Natal stumpnose	
Sphyraenidae	*Sphyraena barracuda*	Great barracuda	1 217
	Sphyraena jello	Pickhandle barracuda	
Teraponidae	*Terapon jarbua*	Thornfish	15

of the number of outings reported against CPUE (numbers and mass), depicted in Fig. 6a,b, indicated r^2 values of 0.43 and 0.71, respectively. Further, there is a strong positive correlation (r^2 = 0.85) between the number of angler outings reported and the percentage of zero catches reflected on cards (Fig. 7). This indicates that the higher the number of outings reported, the greater the percentage of zero catches reflected on cards.

Trends in CPUE for the most important angling species are depicted in Fig. 8a–e. The catch rate of *Pomadasys* spp. by recreational anglers, depicted in Fig. 8b, fluctuated considerably during the study period, but showed no consistent trend. Similarly, CPUE for *Rhabdosargus* spp. and *Caranx* spp. (Fig. 8 c,a) fluctuated widely from year to year but showed no consistent trends. By contrast CPUE for *L. argentimaculatus* and particularly *A. berda* decreased from 1986 (Fig. 8d,e).

Annual changes in mean mass

Figure 9 depicts the annual mean mass of the five most important taxa in the catches. The mean mass of *Caranx* spp. caught remained relatively stable until 1993, after which it increased sharply. The mean mass of *Pomadasys* spp. caught remained fairly stable throughout the study period, ranging from 1.6 to 2.0 kg. The mean mass of *Rhabdosargus* spp. caught also remained fairly stable, with a range of 0.6–1.3 kg. The mean mass of *A. berda*

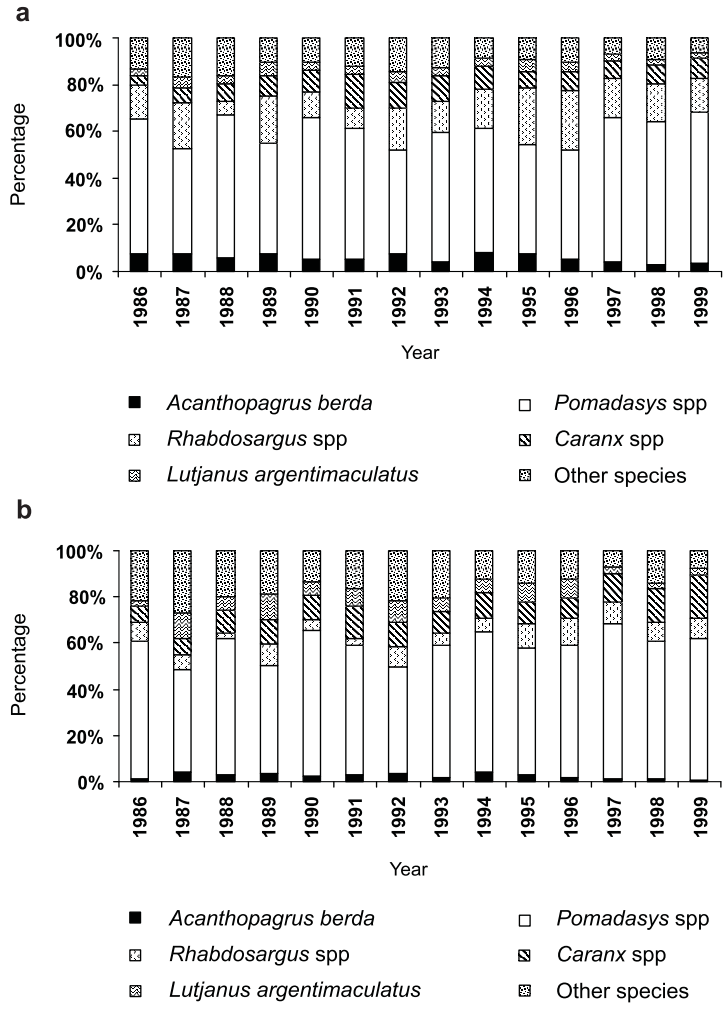

Fig. 4. Annual catch composition in terms of (**a**) numbers and (**b**) mass between 1986 and 1999.

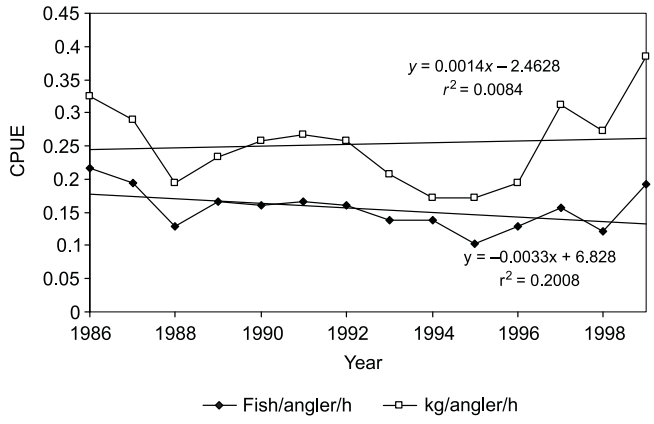

Fig. 5. Annual CPUE for all angling species reported on catch cards in the Kosi system between 1986 and 1999.

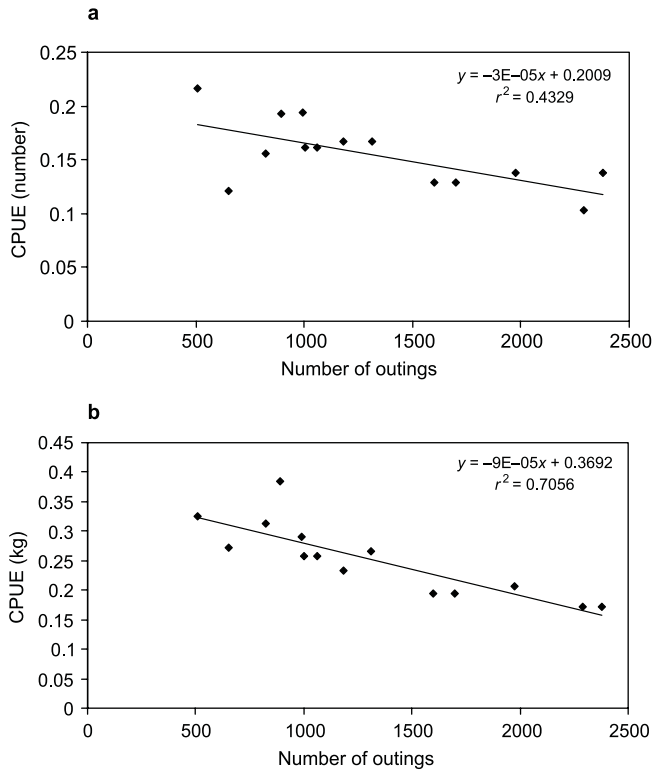

Fig. 6. Regression of the number of outings reported against (**a**) fish/angler/h and (**b**) kg/angler/h.

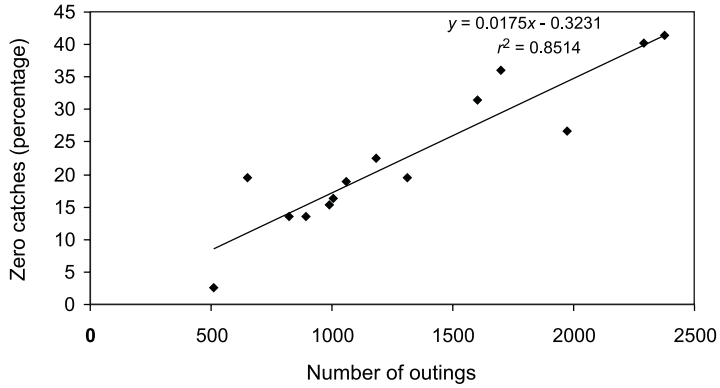

Fig. 7. Regression of the number of outings reported against percentage zero catches.

reported in catches was also stable with a range of 0.6–0.9 kg. The mean mass of *L. argentimaculatus* showed the greatest degree of fluctuation, with mean mass ranging from 2.2 to 3.3 kg.

DISCUSSION

The Kosi estuarine system has been accessible to recreational anglers since the 1940s. Recreational angling takes place principally from small boats and is restricted to Lakes Makhawulani, Mpungwini and Nhlange (Kyle & Robertson 1997). The maximum number of boat outings reported from Kosi was 2379 in 1994, considerably fewer than that found during a similar study in St Lucia, where Mann (1994) estimated the number of boat outings in 1992 as 11 640 and in 1993 as 9135. Gaustella (1994) was unable to estimate the number of boat outings in Durban harbour, although

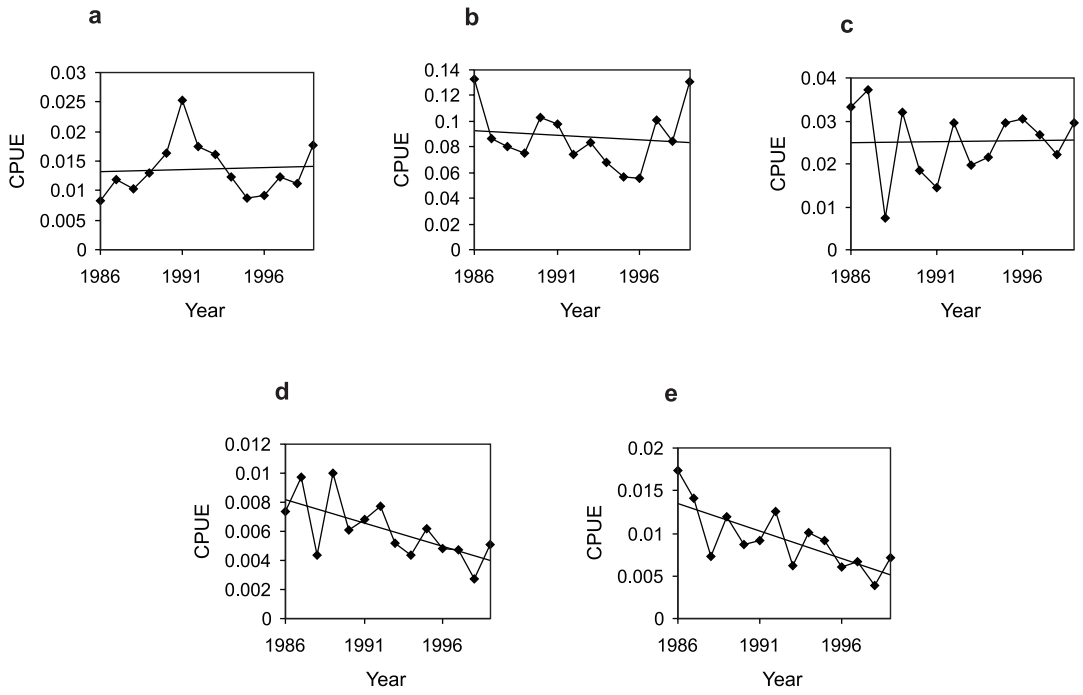

Fig. 8. Annual CPUE trends in fish/angler/h of (**a**) *Caranx* spp., (**b**) *Pomadasys* spp., (**c**) *Rhabdosargus* spp., (**d**) *L. argentimaculatus* and (**e**) *A. berda* from the Kosi system between 1986 and 1999. Linear regressions were fitted to the CPUE data using Microsoft Excel.

Environmental Services (1991) estimated that 16 000 outings were conducted in 1987. As Kosi is at the northeastern extreme of the South African coastline and not as easily accessible to anglers as St Lucia and Durban Harbour, fewer angler outings per year are to be expected. However, as not all anglers complete catch cards at Kosi, this is an underestimate of the total number of boat outings. Based on spot checks conducted by KZNNCS at Kosi Bay campsite between 1988 and 1996, the percentage of angler outings recorded on catch cards was estimated to be approximately 70 % (R. Kyle, unpubl. data). Using this estimate and the number of catch cards recorded, the total number

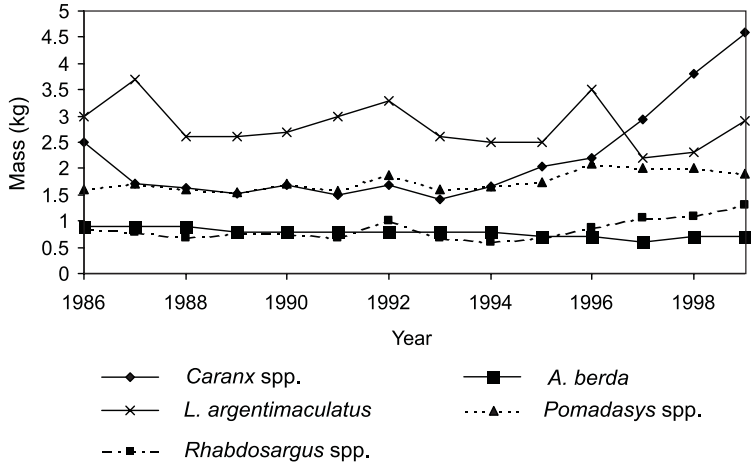

Fig. 9. Annual trends in the mean mass of important angling species from the Kosi system between 1986 and 1999.

of boat outings at Kosi Bay is estimated to be an average of 2300 (±738 S.D.) outings per annum between 1988 and 1996. However, the reduction in recorded outings between 1994 and 1999 (Table 1) is a reflection of reduced effort in collection of catch cards by the KZNNCS rather than a reduction in the actual number of boat outings.

According to Blaber and Cyrus (1981) a total of 163 marine species has been recorded in the Kosi estuarine system, and of these Whitfield (1998) reported that fewer than 30 species are abundant in the lakes as most species occur close to the estuary mouth. Similar trends were observed in the St Lucia system, where species abundance is highest in the estuary (Whitfield 1998). Latitude affects both the diversity and abundance of fish species found in estuaries, and though Kosi supports over 150 species of fish, Swartvlei, a clear-water estuarine system in the Western Cape, has fewer than 50 species of fish (Whitfield 1998). Similar trends have been observed in Australia, where temperate estuaries such as the Swan, Peel-Harvey and Blackwood estuaries support fewer than 60 species of fish (Potter *et al.* 1990).

Despite the possibility of misidentification, recreational anglers reported a total of 17 families, comprising 34 species in their catches from the Kosi estuarine system over the 14-year study period. By contrast, a total of 15 and 17 species were recorded in anglers' catches in the temperate Sundays and Swartkops estuaries, respectively (Daniel 1994). The water in the Kosi estuarine system is clear compared to estuaries such as St Lucia, and consequently, clear-water species such as *Caranx* spp., *Sphyraena* spp. and *Lutjanus argentimaculatus* are present in larger numbers and frequently reported in catches. These are piscivores which are visual hunters. Predators such as the dusky kob (*Argyrosomus japonicus*), which features prominently in catches in St Lucia (Mann 1994), are far less abundant in recreational catches in the Kosi estuarine system, probably because these predators favour more turbid water (van der Elst 1977).

The most frequently caught species in the Kosi system were *Pomadasys commersonnii, Rhabdosargus sarba, Caranx* spp. (predominantly *C. sexfasciatus* and *C. ignobilis*), *A. berda* and *L. argentimaculatus.* In both Durban Harbour and St Lucia, *P. commersonnii* made up a large percentage of catches (Gaustella 1994; Mann 1994), and in all three systems they contribute more than 20 % of the total catch. In the less species diverse Sundays and Swartkops estuaries in the Eastern Cape, *P. commersonnii* and the dusky kob (*A. japonicus*) comprised significant proportions of the recreational catch, and together these two species accounted for about 90 % of anglers catches (Baird *et al.* 1996).

During most of the study period seasonal trends in catch rates were observed, with CPUE (fish/angler/h) at its highest in the summer and autumn months. Seasonality in catches in the Kosi system may be closely related to the breeding cycles and thus estuarine abundance of the fish. High gill net catches are often associated with pre-spawning emigrations from the lakes and post-spawning immigration (Kyle 1999), and similar seasonal trends have also been observed in the Kosi trap fishery, with peak catches recorded during the summer months (R. Kyle, unpubl. data). Wallace (1975) found that most estuarine fish species in KwaZulu-Natal start spawning during late winter and early spring. Certain piscivorous species, such as larger carangids and sphyraenids enter estuaries in early summer and exit in late summer, while post-spawning adult *R. sarba* and *P. commersonnii,* which spawn in the marine environment from late winter to early summer, revisit estuaries thereafter to feed (Wallace 1975). The 'grunter run' or migration of post-spawning *P. commersonnii* into Lake St Lucia during spring (Wallace 1975) is known to attract thousands of anglers annually (Day *et al.* 1981). Some species, such as *L. argentimaculatus,* remain in the system throughout the year, but feed more actively during the summer months, thus contributing to higher catches during these months.

Salinity is also an important factor affecting the abundance of some fish species within estuaries (Whitfield 1998). For example, catches of *R. sarba* in the Kosi trap fishery decreased in the 1980s, when salinity declined, and then increased sharply in the early 1990s as salinity increased (R. Kyle, unpubl. data). Throughout this study the percentage contribution (by numbers and mass) of most species fluctuated, possibly in response to variable environmental conditions.

The analysis of CPUE between 1986 and 1999 revealed distinct annual fluctuations in both the numbers and the mass of fish caught per angler hour. Fluctuations in CPUE were found to be closely correlated to the number of cards collected. When the number of outings reported was low (1990–1992 and 1997–1999), CPUE was higher than when the number of outings reported was high (1993–1996). This is believed to reflect a bias in

the data, as during periods when the number of cards collected was high (i.e. KZNNCS staff actively issued and collected cards), more unsuccessful (zero catch) fishing trips were recorded, contributing to a more realistic CPUE. However, when fewer cards were submitted (i.e. less collecting effort by KZNNCS staff), it was generally only the successful angling outings that were reported by avid anglers, leading to a biased increase in CPUE.

As CPUE can be used as a measure of fish abundance, the overall stable trend of CPUE suggests that there is little change in the overall fish abundance, and that recreational catches appear to be sustainable. According to Kyle & Robertson (1997), CPUE in the trap fishery at Kosi has also fluctuated widely, with no consistent trend. Similarly, there has been no clear trend in CPUE in the Kosi gill net fishery since it was implemented in 1992 (Kyle 1999).

Trends in CPUE (by numbers) for the different species showed that overall CPUE recorded for *Pomadasys* spp., *Rhabdosargus* spp. and *Caranx* spp. remained relatively constant, despite fluctuating from year to year. However, CPUE for *A. berda* and *L. argentimaculatus* have decreased since 1986. This may reflect a decrease in abundance of both species in the Kosi system. *A. berda* is an estuarine-dependent species, and the Kosi population is fairly isolated from populations in other estuaries, as adults appear to be virtually confined to the estuary (Garratt 1993). In addition to being estuarine-dependent, *A. berda* is a partial protandrous hermaphrodite (some males change sex to females), which potentially makes it more vulnerable to overfishing as larger fish are primarily females (Garratt 1993). A decline in CPUE for *A. berda* in St Lucia, attributed to estuarine degradation, has also been reported (van der Elst 1977; Mann 1994). *L. argentimaculatus* is also an estuarine-dependent species, with juveniles occurring in Transkei and KwaZulu-Natal estuaries. A decline in CPUE of this species was noted between 1981 and 1984 in Kosi trap catches (Kyle 1986). Reductions in catches may be partly due to an increase in fishing pressure, but also to estuarine degradation, which in other KwaZulu-Natal estuaries has probably had a serious effect on populations of this species (Mann & Fennessy 2000).

The mean mass of important taxa in catches, with the exception of *Caranx* spp., fluctuated slightly throughout the study period, but overall remained relatively stable. The mean mass of *Caranx* spp. reported in catches increased sharply after 1993. The sharp increase in the mean mass of *Caranx* spp. may be attributed to an increase in the number of giant kingfish which entered the Kosi system, possibly related to rising salinity (R. Kyle, pers. obs.). Most kingfish are caught either on live bait or artificial lures and improved catches of this species may also be because of more effective targeting by anglers. The mass recorded by anglers must be viewed with caution as anglers estimate mass, and measurements are thus subject to prestige and digit bias.

A recent analysis of the Kosi gill-net fishery (Kyle 1999) revealed that 16 families, comprising 23 species, are caught by gill-netters. Although Carangidae, Haemulidae, Sparidae and Lutjanidae, which are of importance to recreational anglers, are caught in the gill nets they are not the target species. Gerreidae, mostly *G.methueni,* Cichlidae and Mugilidae, which are not targeted in the recreational fishery, are the most important species caught in terms of numbers and mass. Likewise, most of the trap-caught species are not target species for recreational anglers. In an analysis of the Kosi trap fishery between 1985 and 1995, (R. Kyle, unpubl. data) it was found that Mugilidae, *G. methueni* and other species not important to the recreational fishery comprised 52 % of the catch by numbers and 47 % of the catch by mass. However, species such as *P. commersonnii* and *R. sarba* comprise an important component of both fisheries.

As accessibility improves, the Kosi estuarine system is becoming an increasingly popular angling destination. Percentage occupancy at the campsite has shown an annual 14 % increase since 1990 (KZNNCS visitor statistics). The northeastern corner of Maputaland has been earmarked as a trans-national tourism axis and as a result a new road is being built which will greatly increase the accessibility of the area. This should result in an increase in tourism to the area, particularly as the Kosi estuarine system is already considered a prime angling venue. Increased tourism will place additional pressure on the fish resources of the Kosi estuarine system, which are already under increasing pressure from artisanal/subsistence fishers. The number of fish traps and gill nets in the system has increased substantially in recent years, as fishers recognize the commercial value of their catches (R. Kyle, unpubl. data). Trap catches increased from about 40 000 fish in 1981 to a high of 93 000 fish in 1993. Gill nets have been used in the

Kosi system illegally since the 1950s, but in 1992, partially in an effort to control this, gill netting was legalized by the establishment of an experimental fishery. The number of permits issued was increased from five in 1992 to 45 at present, but catches by illegal gill-netters in the system persist and are substantial (Kyle 1997, 1999). The KZNNCS, the conservation authority responsible for the Kosi lakes area, is concerned about the overall levels of fishing occurring within the reserve.

In order to ensure the future sustainability of Kosi's fish resources a number of suggestions are proposed. First, the sanctuary at Kosi mouth must be protected from any type of harvesting as a number of fish species aggregate and spawn in this area. Second, the number of public access sites to the lake and boat launching facilities should be restricted. Third, the number of fish traps should be restricted and these should be evenly distributed and not concentrated towards the mouth region. Fourth, the channels between lakes must be kept open and no netting or fish traps should be allowed to extend into the channels (a channel of at least 30m width must be maintained). Finally, gill-netting should be restricted to Lake Nhlange only and the current level of effort should be capped.

Although there are numerous biases associated with catch cards, and the data must be viewed with caution some important trends are still evident. The most important is probably that the total CPUE in the recreational fishery showed no consistent trend during the study period. Only individual CPUE of *A. berda* and *L. argentimaculatus* declined. As these two species are estuarine-dependent, they may be indicating that the combined current level of harvesting by all sectors of the Kosi fishery is too high to be sustainable. In this regard a stock assessment of *A. berda* is currently being undertaken in the Kosi and other large north-coast estuarine systems to look at the overall status of this species (N. James, unpubl. data).

In order to undertake more effective analyses of recreational fishing data the catch-card system needs to be improved. The completion of catch cards should be compulsory. After each fishing expedition KZNNCS staff should question fishermen and fill out catch cards for them. This would help to reduce the biases in the data and prevent shore fishing data from being included on estuarine catch cards. For this to become a reality more effort and financial support need to be allocated to the collection of recreational fishing data.

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Appendix 1. Species suspected to have been caught by shore anglers while fishing in the surf zone (outside the Kosi system). These catches were unfortunately filled in on estuarine catch cards.

Family	Scientific name	Common name	Numbers caught (*n*)
Albulidae	*Albula vulpes*	Bonefish	15
Carangidae	*Lichia amia*	Garrick	2
	Trachinotus africanus	African pompano	19
	Trachinotus botla	Largespot pompano	85
Carcharhinidae	*Carcharhinus limbatus*	Blackfin shark	7
	Rhizoprionodon acutus	Milk shark	5
Chirocentridae	*Chirocentrus dorab*	Wolfherring	15
Dasyatidae	*Dasyastis kuhlii*	Blue stingray	1
	Gymnura natalensis	Diamond ray	1
	Himantura gerrardi	Brown stingray	1
Drepanidae	*Drepane longimanus*	Concertina fish	3
Ephippidae	*Tripterodon orbis*	Spadefish	1
Lethrinidae	*Lethrinus* sp.	Emperor	1
Plotosidae	*Plotosus nkunga*	Eel-barbel	1
Pomatomidae	*Pomatomus saltatrix*	Elf	22
Sciaenidae	*Umbrina canariensis*	Baardman	1
Scombridae	*Scomberomorus commerson*	King mackerel	3
Scorpididae	*Neoscorpis lithophilus*	Stonebream	7
Serranidae	*Epinephelus andersoni*	Catface rockcod	4
Sparidae	*Diplodus cervinus*	Zebra	1
	Diplodus sargus	Blacktail	23
	Sarpa salpa	Strepie	45
Trichiuridae	*Trichiurus lepturus*	Cutlassfish	8