A SURVEY OF FISHERY RESOURCE UTALIZATION ON FOUR EASTERN CAPE ESTUARIES (GREAT FISH, WEST KLEINEMONDE, EAST KLEINEMONDE AND KOWIE).

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INTRODUCTION

The principal objectives of modern day fisheries management are to conserve aquatic biodiversity, obtain sustainable yields and achieve equitable distribution of the benefits derived from the fishery. The general lack of information to achieve these objectives has arguably created the vacuum in which estuarine fisheries are currently being managed in South Africa. Good information on the biology of the targeted species, the way they utilise estuarine environments and interact with other organisms is only partially understood for some species in a select few estuaries. Furthermore, information on the demographic and socio-economic characteristics of the people who exploit estuarine fishery resources and their motivation for doing so are also scant (see Wood 2001 for a review on estuarine fishery surveys in South Africa). Consequently, there is a need for more dedicated research to provide baseline data for the development of appropriate management schemes to ensure sustainability of South African estuarine fishery resources.

In the context of the Eastern Cape Estuaries Management Programme (sustainable use sub-programme) it was necessary to collect detailed information from selected estuaries to obtain a better understanding of the fishery dynamics of “typical” Eastern Cape estuaries. A series of one-year roving creel fishery surveys were conducted on two large permanently open estuaries (Great Fish and Kowie) and two small temporarily open/closed estuaries (East and West Kleinemonde; Figure 5.1). The aim of the surveys was to (i) describe the demographics of the various fishery sectors, (ii) estimate the total catch and effort in the linefishery, (iii) assess the catch composition and seasonality of fish catches, (iv) calculate catch per unit effort (cpue) for individual species and the entire fishery, and (v) determine the species composition and total yields in the bait fishery. This document reports on the findings of these surveys.

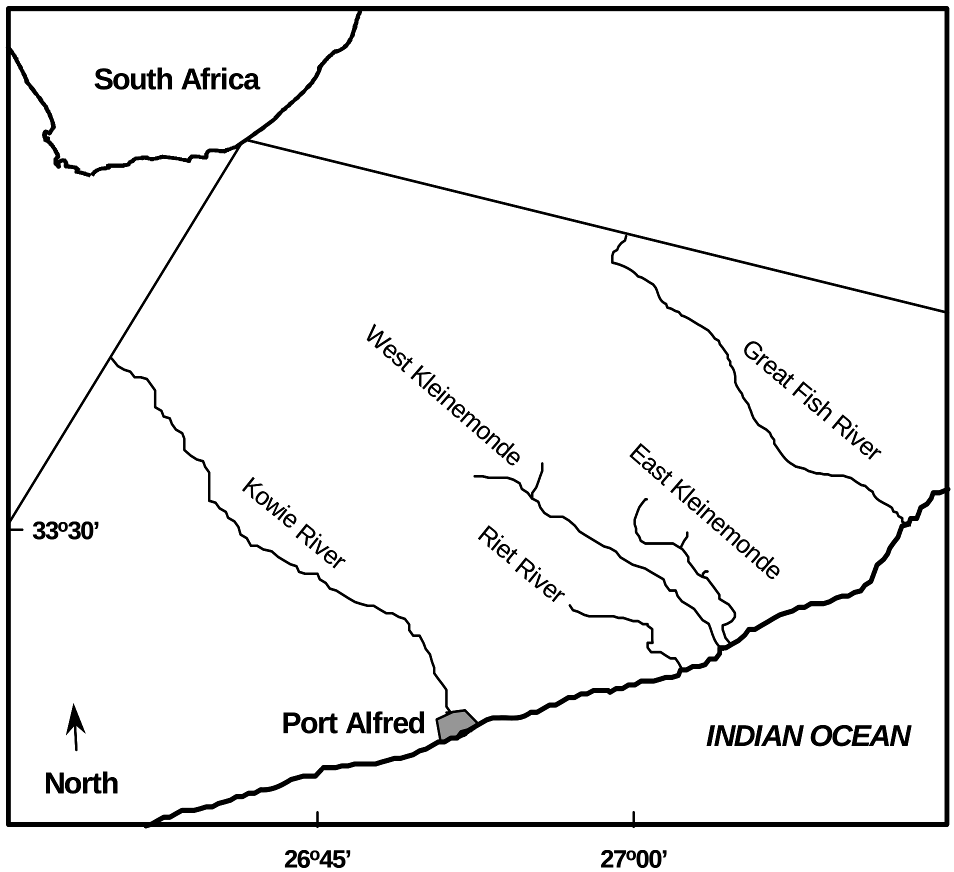

Figure 5.1 Map of South Africa showing the location of the estuaries surveyed during this study.

5.1 The Great Fish Estuary

5.1.1 Study site

The 650 km long Fish River drains a catchment of more than 30 000 km^2 and enters the Indian Ocean at 33˚28'S and 27˚10'E, approximately half way between Port Elizabeth and East London. The mean annual run-off of the Great Fish catchment area has been estimated at about 500 million m^3 per year (O'Keeffe 1989). This water is not only derived from the catchment area of the river, but also via the Orange-Fish water transfer scheme. This inter-basin scheme also accounts for continuous nutrient inputs and hence elevated phytoplankton production. The estuary water is very turbid with a high load of fluvially dominated sediments (Grange *et al*. 2000).

The estuary with a permanent link to the sea is situated in a sparsely populated rural area. The main channel in the mouth region is approximately 30 m wide and is often restricted by the presence of extensive sand banks. Following a flood event, the main channel can be up to 200 m wide. The length of the estuary is approximately 15 km, with a surface area of about 120 hectares. The estuary is mostly shallow, ranging between 1 m and 2 m, except for some areas in the lower and upper reaches that have depths of up to 3 and 6 m respectively (Cowley and Daniel 2001). Water temperatures (0.5 m below the surface) in the lower and upper reaches of the estuary range from 13 – 21^{o}C and 11 – 26^{o}C respectively (Allanson and Read 1987; Whitfield 1994). Seasonal changes in the mouth region are less pronounced and appear to be controlled by ambient sea conditions. The salinity profile of the estuary clearly reflects high levels of fresh water input as oligohaline conditions often extend into the lower reaches of the estuary. Furthermore, a strong vertical salinity gradient of up to 20‰ often exists in the lower and middle reaches.

There are very few intertidal or submerged macrophytes present in the Great Fish estuary. The eastern bank consists mainly of coastal bushveld, while most of the western bank is encompassed in either the Kap River Reserve or the Great Fish Wetland Reserve. There is a large salt marsh on the west bank, which also falls within the Wetland Reserve. Anecdotal records suggest that wetlands habitat on the west bank above the road bridge has changed significantly over the past century. The reeds and sedges in this area have replaced typical salt marsh vegetation (Cowley and Daniel 2001).

5.1.2 Fishery survey methods

The survey represented an on-site direct-contact roving creel survey conducted on foot. Surveys were conducted on three days per month between March 2001 and February 2002. Due to time and other logistical constraints, the dates for each survey were not randomly selected, but instead predetermined at the beginning of each month. The survey days comprised two weekdays and one weekend day or public holiday per month. All surveys were only conducted during daylight hours (sunrise to sunset).

For anglers who had been fishing since the previous day (i.e. overnight), the first interview recorded by the survey clerk included any fish caught by the angler from 18h00 the previous day up to the time of interception on the survey day. 18h00 was also the time recorded for start of angling effort for fishers who had been fishing since the previous day. The standardisation of the time that fishing was initiated was necessary due to the difficulty in obtaining an accurate estimate of effort by the temporarily resident subsistence fishers on this estuary.

All people engaged in resource use practices (linefishing and bait collecting) were interviewed, except for those boat anglers that the survey clerk was not able to reach during the survey period. The exact location of each angler was recorded on a map to assess the distribution of effort along the estuary. On the occasions when an individual angler was intercepted on a subsequent trip on the same day, the interview sheet was amended to include the corrected data on effort and catch. Information gathered from the interviews included: (i) user demographics (name, age, gender, race, and home town); (ii) resource use sector (subsistence shore, recreational shore or recreational boat); where a subsistence user was defined as a poor person who personally harvested marine resources as a source of food or to sell them to meet the basic needs of food security, and the kinds of resources they harvested generated only sufficient returns to meet the basic needs of food security (Branch *et al*. 2002); (iii) catch species and size composition; to avoid misidentification of species and size aggregations all retained fish were inspected, identified and measured (to the nearest cm TL), while information on the released catch was attained from the angler. Length of fish released, eaten, or sold were assumed to be accurate to 5 cm; (iv) duration of fishing trip, which included time the fishing trip began, time of interview and expected ending time; (v) number of rods/lines and (vi) bait used.

Typically angler survey data is analysed to provide daily catch estimates. However, due to the low number of interviews obtained on certain days, data were analysed to calculate mean monthly estimates. The averaging procedure followed the "mean of the ratios" method (after Pollock *et al*. 1994).

Catch: The total catch for each month included both retained and released fish. Upon confronting a party of anglers, effort was made to separate catch by individual anglers in order to avoid "party bias". For anglers who had been fishing consistently since the previous day, total catch represented that landed from 18h00 the previous day until the last interview of the survey day.

Effort: The unit of angling effort chosen was angler-hours. An estimate of total daily effort was obtained by multiplying the average turnover time (time started to expected ending time) of all interviewed anglers by the total number of anglers counted on that day. The time started was taken as 18h00 for fishers who started earlier on the previous day (see above). The total effort recorded on each survey day represented a good estimate of absolute effort due to the presence of the survey clerk from dawn to dusk. The average value from the three survey days was multiplied by the number of days in that month to obtain a total monthly effort estimate. Since subsistence anglers could rarely provide an estimated time that fishing would cease due to almost continuous effort while residing on the banks of the estuary, the total effort was taken as the actual observed (recorded) effort expended each survey day.

Cpue: Cpue was calculated by dividing the total number/weight of fish recorded on each survey day by the total effort (angler hours) recorded on that day. The values obtained for each of the three sampling days were then averaged again and multiplied by the number of days in the month to obtain a monthly cpue estimate expressed as fish.angler-hour^{-1}, or grams.angler-hour^{-1}. The measured (or estimated) lengths of all fish caught were converted to mass using Mann (2000). Cpue was also calculated for selected species under the assumption that effort was directed equally at all species. The overall cpue (per species) for the entire survey period was calculated as the mean of the cpue values for each month of the survey.

5.1.3 Results

Angler demographics

A total of 235 subsistence anglers, 145 recreational shore anglers and 19 recreational boat anglers were interviewed. The majority of anglers intercepted were blacks (55%), followed by whites (28%), and coloureds (17%). Subsistence fishers dominated (59%), with shore angling being more popular than boat angling amongst the recreational anglers (36% and 5% respectively). Participation in the fishery was largely male dominated, with only one female being recorded of the 399 fishers intercepted. Of all fishers encountered, 33% were aged between 31 and 40 and 22% between 19 and 30 (Figure 5.1.1).

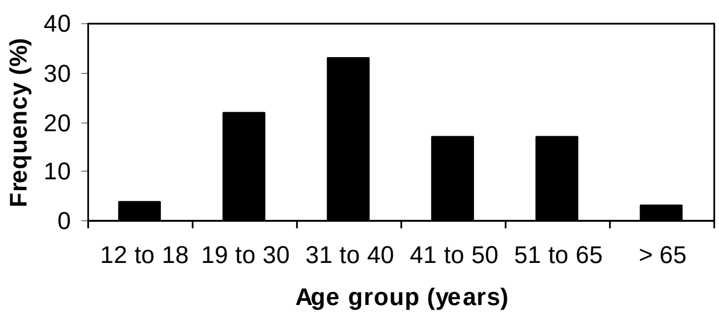

Figure 5.1.1 Age group frequency distribution of anglers interviewed on the Great Fish estuary between March 2001 and February 2002.

The majority of the users (48%) resided in towns less than 50 km away (Port Alfred, Bathurst and Peddie), while 33% lived between 51-100 km away (Grahamstown and East London) and 19% resided more than 100km from the Great Fish estuary. The turnover of individual fishers was high, as 91% of individual fishers were encountered on only one of the 35 survey days and 5% encountered on four to eight of the survey days. Only 4% of all fishers were interviewed for nine or more of the survey days.

Catch composition

A total of seven species were recorded, but a large portion of the catch (97%) compromised only three species (Table 5.1.1). Spotted grunter *Pomadasys commersonnii* (54%) was most commonly caught, followed by dusky kob *Argyrosomus japonicus* (23%) and white seabarbel *Galeichthys feliceps* (20%). In terms of mass, the overall catch was dominated by *P. commersonnii* (52%), followed by *A. japonicus* (26%), and *G. feliceps* (16%). Subsistence fishers accounted for most of the catch (Table 5.1.2).

P. commersonnii was present in the catches during all months of the year except June, and was the dominant component by number and mass during most months. Although *A. japonicus* was recorded throughout the year, it only dominated catches (by number and mass) during May. Although less important in terms of mass, *G. feliceps* consistently constituted a noticeable proportion of the catches by number throughout the year. This species was numerically dominant in June, July and August, and also dominant by mass in June and July (Figures 5.1.2 and 5.1.3).

Table 5.1.1 Catch composition of all fish (retained and released) recording from the Great Fish estuary during the survey period.

Species	Common name	Number caught	Percentage composition	Total mass (kg)	Percentage composition
Pomadasys commersonnii	Spotted grunter	394	54.1	331.9	52.1
Argyrosomus japonicus	Dusky kob	167	22.9	168.0	26.4
Galeichthys feliceps	White seabarbel	145	19.9	100.2	15.7
Lithognathus lithognathus	White steenbras	14	1.9	23.2	3.7
Rhabdosargus holubi	Cape stumpnose	4	0.6	0.5	< 0.1
Cyprinus carpo	Common carp	2	0.3	7.1	1.1
Amblyrhynchotes honckenii	Evileye blaashop	1	0.1	0.2	< 0.1
Acanthopagrus berda	Estuarine bream	1	0.1	0.4	< 0.1
Total		**728**		**636.9**	

Table 5.1.2 The contribution of fish landed catch by subsistence fishers on the Great Fish estuary between March 2001 and February 2002 (values given as % of total landed catch).

Species	Number	Mass (kg)
Pomadasys commersonnii	74	70
Argyrosomus japonicus	66	45
Galeichthys feliceps	88	88

Size composition

The dominant size classes for *P. commersonnii* and *A. japonicus* were 300mm-399mm (79%) and 400mm-499mm (68%) respectively. A large portion of the recorded catch was below the legal size limit (40% of *P. commersonnii*, 49% of *A. japonicus*, 86% of Lithognathus *lithognathus* and 100% of *Rhabdosargus holubi*; Table 5.1.3).

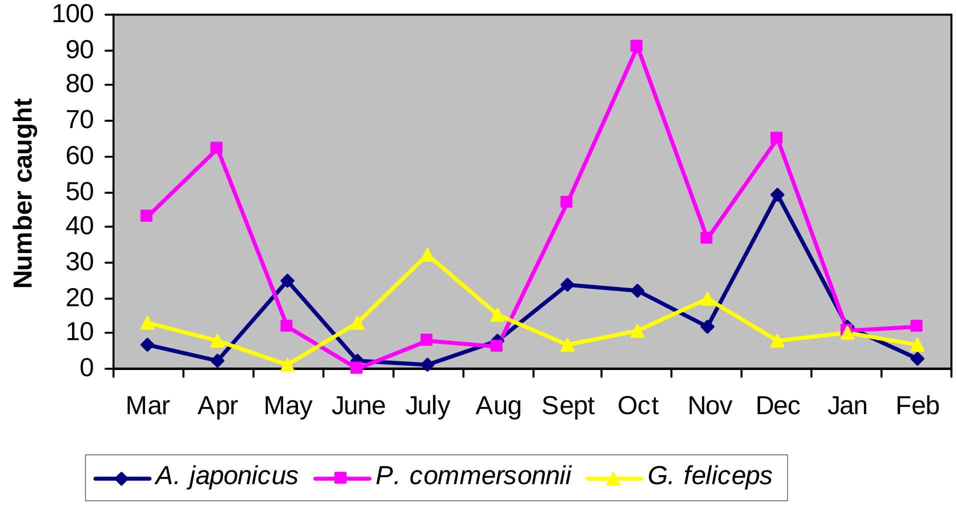

Figure 5.1.2 Monthly catches of *P. commersonnii*, *A. japonicus* and *G. feliceps* by number in the Great Fish estuary between March 2001 and February 2002.

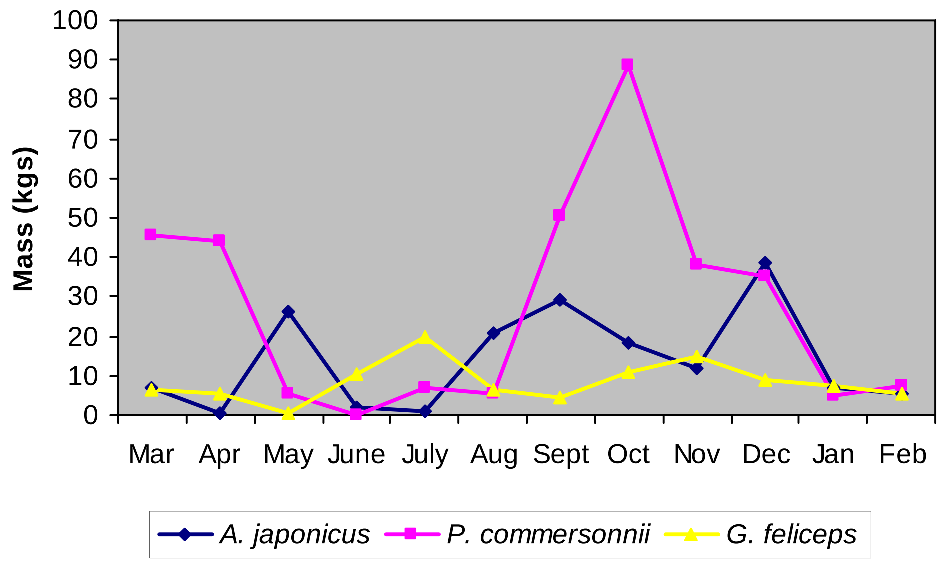

Figure 5.1.3 Monthly catches for *P. commersonnii*, *A. japonicus* and *G. feliceps* by mass in the Great Fish estuary between March 2001 and February 2002.

Table 5.1.3 Percentage of important species caught in each size class. Shaded blocks represent the portions below the legal size limit.

Size range (mm TL)	*Pomadasys commersonnii*	*Argyrosomus japonicus*	*Lithognathus lithognathus*	*Rhabdosargus holubi*
<200		1%		100%
200-299	5%	12%		
300-399	35%	36%	21%	
400-499	44%	32%	50%	
500-599	12%	7%	14%	
600-699	3%	8%	14%	
>700	1%	5%		

Angler bag frequencies

The maximum daily catch recorded by an individual fisher was 13 and 10 for *P. commersonnii* and *A. japonicus* respectively. However, a catch rate of only one fish angler^{-1} day^{-1} (excluding days with no catches) was most frequently observed; 32% for *P. commersonnii* and 54% for *A. japonicus*. Furthermore, 20% and 6% of anglers achieved or exceeded their bag limit of five *P. commersonnii* and *A. japonicus* respectively per day (Figures 5.1.4).

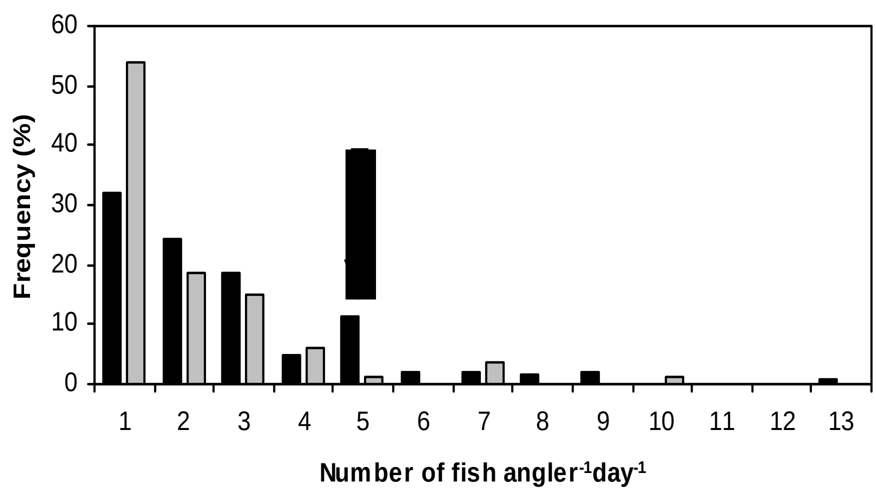

Figure 5.1.4 Angler bag frequencies for *P. commersonnii* (solid bars) and *A. japonicus* (grey shaded bars) caught on the Great Fish estuary. Arrow indicates the legal bag limit.

Distribution of fishing effort

Fishing effort was concentrated in the lower reaches of the estuary. A total of 47% of all fish landed were taken from the eastern bank within a distance of 800 meters above the bridge. The remainder of the fish were landed from the eastern bank 700 meters further upstream from this point (17%), and on the eastern and western banks below the bridge towards to the estuary mouth (12% and 8% respectively).

Catch trends

The estimated total annual catch for the estuary was estimated at 6.53 tons per annum, of which *P. commersonnii* and *A. japonicus* contributed 3.4 tons and 1.76 tons, respectively (Table 5.1.4). Figure 5.1.5 displays the projected monthly catch totals for dominant fishery species. There was a strong correlation (0.87) between the total number of rods/lines used and the number of fish caught (Figure 5.1.6).

Table 5.1.4 Projected monthly and annual catches for all species caught on the Great Fish estuary.

Species	Projected catch	
	kg month^{-1}	kg year^{-1}
Pomadasys commersonnii	283.68	3404.2
Argyrosomus japonicus	145.89	1750.69
Galeichthys feliceps	88.04	1056.42
Lithognathus lithognathus	19.8	237.56
Cyprinus carpo	6	71.95
Rhabdosargus holubi	0.39	4.63
Acanthopagrus berda	0.31	3.71
Total	**544.1**	**6529.16**

Trends in fishing effort

The mean turnover time (time spent fishing per day by an individual angler) for all fishing sectors was estimated at 12h 30min. Projected turnover time peaked in August with a high of 20h 40min, and with a low in January of 08h 35min. Considering the individual fishing sectors, subsistence fishers on average spent 16 hours a day fishing, and exhibited a peak towards spring and early summer (August-November; Figure 5.1.7). Although recreational boat anglers were only recorded between September and December, they spent on average, more time fishing during this period, than the recreational shore anglers (11h25 and 9h15 hours respectively). However, recreational shore anglers observed the highest monthly peak in mean turnover time (22h 10min) in August.

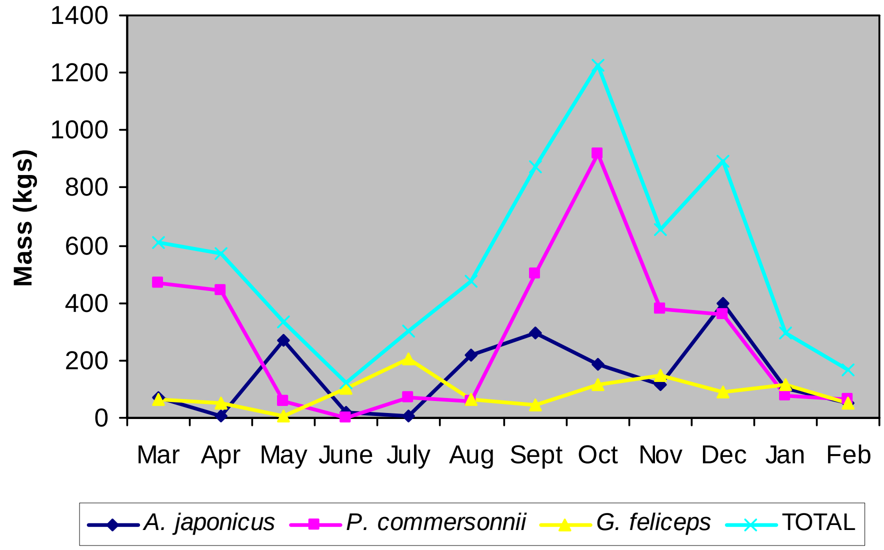

Figure 5.1.5 Estimated monthly catches (in kilograms) for the dominant fishery species on the Great Fish estuary between March 2001 and February 2002.

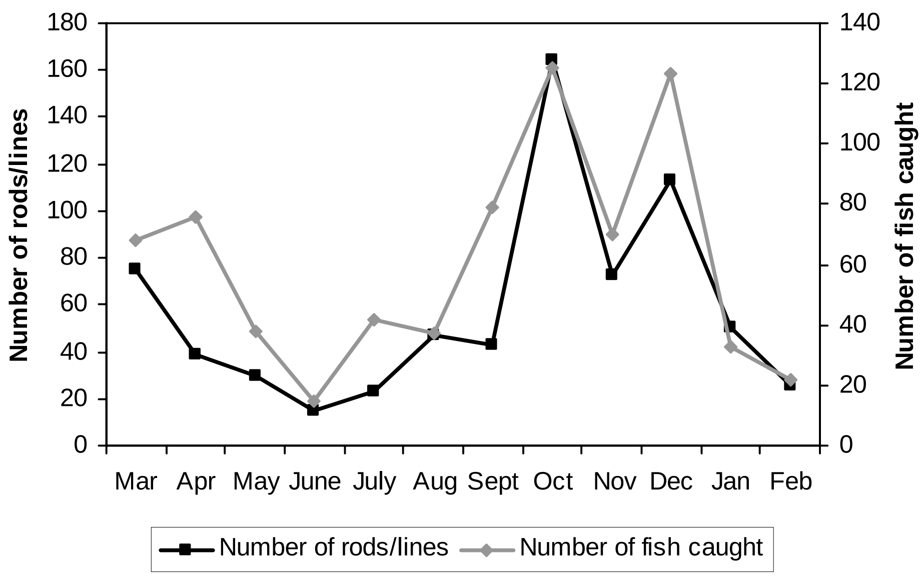

Figure 5.1.6 The correlation (0.87) between the number of fish caught and the number of rods/lines in use between March 2001 and February 2002.

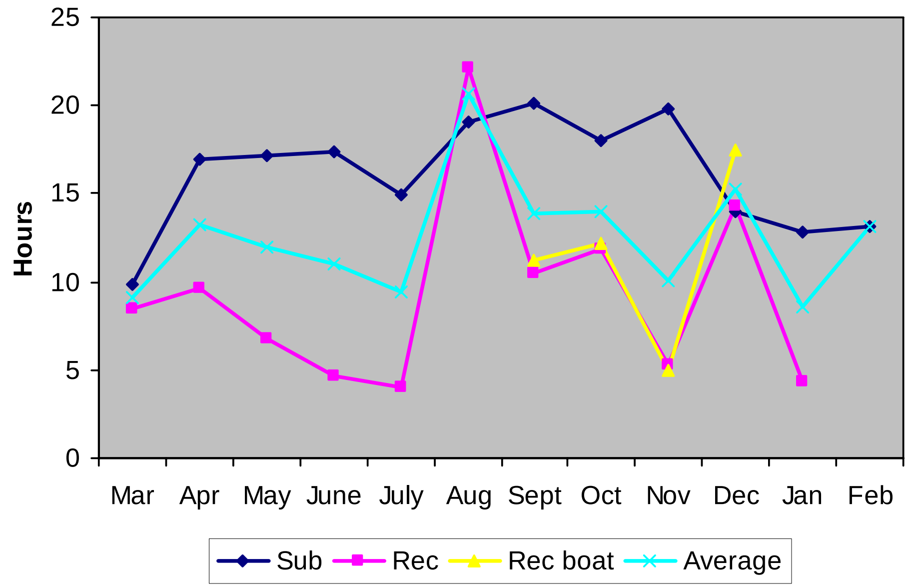

Figure 5.1.7 Projected monthly variation in turnover time for the different fishing sectors on the Great Fish estuary between March 2001 and February 2002.

Total annual fishing effort on the Great Fish estuary was estimated at 62319 angler-hours (SD = 3563), with a peak in October (11504 angler-hours). Subsistence fishers accounted for most of the effort (60%), followed by recreational shore anglers (35%), with recreational boat anglers only contributing 5%. The monthly trends in fishing effort by the different fishery sectors in given in Figure 5.1.8. Subsistence fishing effort peaked in October (7307 angler-hours), with a low in June (1322 angling-hours), while recreational angler effort peaked in August (6138 angler-hours), with a low in July (137 angler-hours). A comparison of total daily effort between week and weekend days for all fishery sectors revealed a higher mean effort over weekend days (205h 10min versus 155h 45min). However, subsistence fishers expended more effort over week than weekend days (120h versus 88h 40 min per day).

Trends in cpue

The mean annual cpue (by number) was 0.123 fish angler-hour^{-1} (SD = 0.045). Monthly cpue values peaked during early autumn (March) and again in spring (September-November), while the lowest cpue values were recorded in May and August. In terms of mass, the mean annual cpue was 88.1 grams angler-hour^{-1} (SD = 47), and exhibited a peak in early autumn (March), and once again in spring to mid summer (September-December; Figure 5.1.9).

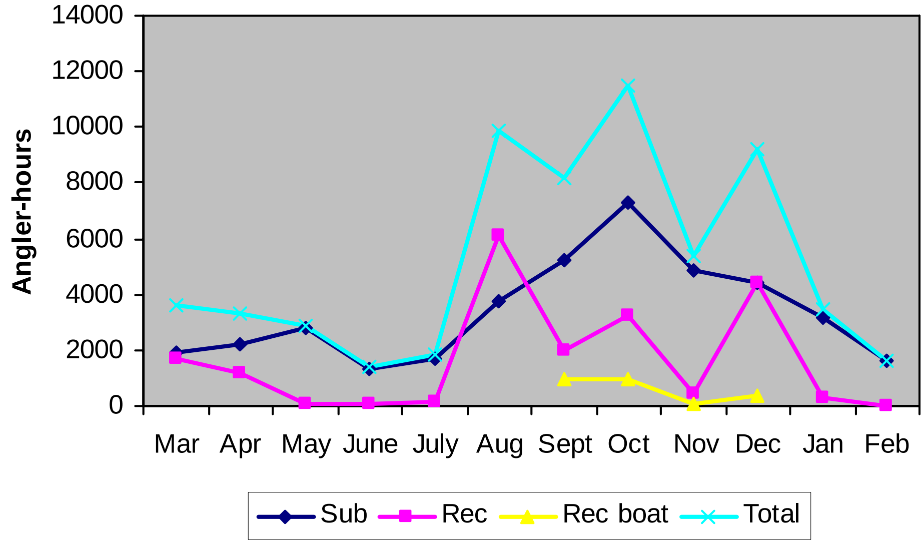

Figure 5.1.8 Estimated monthly effort for the different fishery sectors on the Great Fish estuary between March 2001 and February 2002.

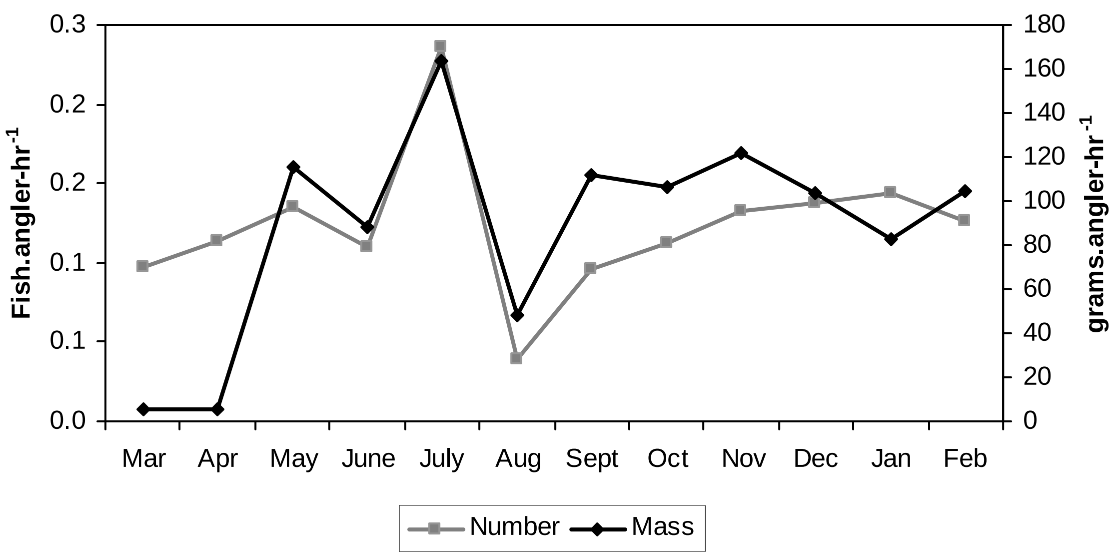

Figure 5.1.9 Mean monthly cpue by number and mass for all fishery sectors on the Great Fish estuary between March 2001 and Feb 2002.

Subsistence shore fishers attained higher cpue values than recreational shore throughout the study period, except in May and November. However, recreational boat anglers generally attained the highest cpue values

(Figure 5.1.10). The mean cpue for *P. commersonnii* and *A. japonicus* over the survey period was calculated at 0.07 and 0.03 fish angler-hour^{-1}.

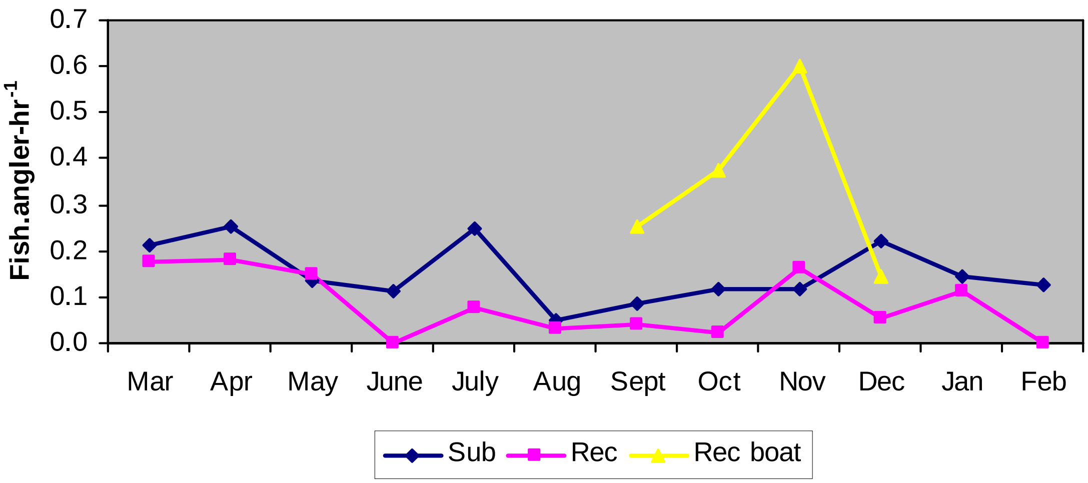

Figure 5.1.10 Cpue by number for the different fishery sectors in the Great Fish estuary between March 2001 and February 2002.

In terms of mass, recreational boat fishers attained the highest cpue values, with the exception of May when recreational shore fishers had the highest value (Figure 5.1.11).

Bait utilisation

The majority of interviewees (64%) only collected bait organisms from the estuary, while some fishers (23%) only used bought bait. Mud prawn *Upogebia africana*, sand prawn *Callianasa krausii* and mullet (Mugilidae species) were the dominant bait organisms collected from the estuary. A list of all bait organisms used on the estuary is given in Table 5.1.5. The most popular bait species used by both subsistence anglers and recreational shore anglers was *U. africana*. Amongst the recreational boat anglers and recreational shore anglers, chokka squid *Loligo vulgaris reynaudii* and pilchid *Sardinops sagax* were also popular bait organisms.

A total of 13 107 mud prawns were harvested on the 35 survey days, with an estimated annual harvest of 137 000 individuals. Subsistence fishers accounted for 84% of the total number of mud prawns collected.

Only 2011 *C. krausii* and 72 Mugilidae were collected on the survey days, with an estimated annual harvest of 21 000 and 750 respectively.

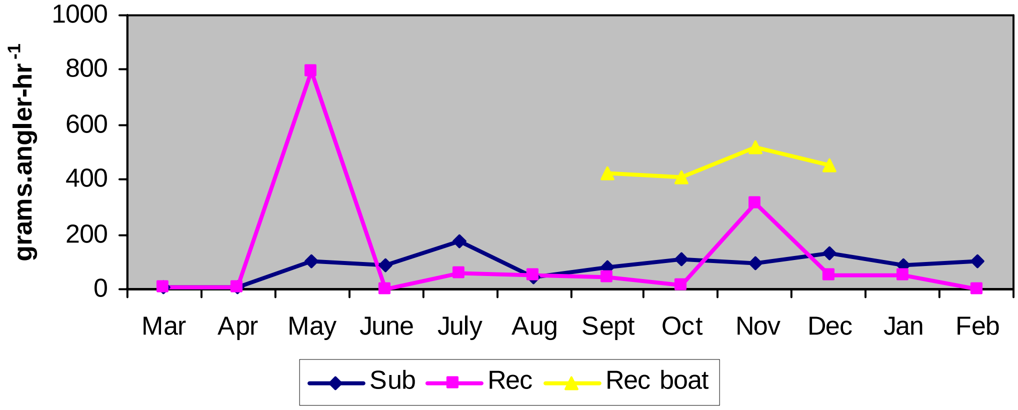

Figure 5.1.11 Cpue by mass for the different fishery sectors in the Great Fish estuary between March 2001 and February 2002.

Table 5.1.5 Different bait organisms used with annual harvest estimates for those organisms collected from the Great Fish estuary between March 2001 and February 2002.

Species name	Common name	Annual harvest
Upogebia africana	Mudprawn	131070
Callianasa krausii	Sandprawn	20110
Mugilidae spp.	Mullet species	720
Sardinops sagax	Pilchard	-
Loligo vulagaris reynaudii	Chokka squid	-
Polybrachiorhynchus dayi	White tapeworm	-
Pyura stolonifera	Redbait	-
Octopus vulgaris	Octopus	-
Penaeus indicus	Swimming prawn	-
Pseudoneires vulgaris	Mussel worm	-
Solen capensis	Pencil bait	-
Various species	Pinkprawn	-
Gunnarea capensis	Cape reef worm	-
Various products	Artificial lures	-

5.2 East Kleinemonde Estuary

5.2.1 Study site

The neighbouring East and West Kleinemonde estuaries are situated in the small coastal town of Seafield (Kleinemonde), approximately 15 km north east of Port Alfred (see Figure 5.1). The region has witnessed a rapid increase in residential development in recent years, placing increased pressure on the estuaries. Due to the small size and predominantly closed nature of both estuaries are sensitive to high consumptive and non-consumptive recreational use.

The East Kleinemonde estuary is classified as a medium sized, temporarily open/closed estuary. This system has a surface area of approximately 17.5 hectares, excluding the shallow salt marsh area, which is only inundated during periods of high water levels. It is navigable for approximately 3 km and the widest portion (in the lower reaches) is about 120 m. The estuary is mostly shallow, with the main channel depth ranging between 1 and 2 m in the navigable portion of the system. After a mouth opening event the estuary is very shallow with a maximum channel depth of approximately 1 m. During periods of extended mouth closure the estuary water level often exceeds that of mean sea level due to extensive sandbar development on the seaward side of the mouth. Average monthly water temperatures in the East Kleinemonde estuary range from 15°C (June) to 27°C (January). Mean monthly salinities in the East Kleinemonde estuary range from 0 to 25‰ depending on the amount of rainfall and condition of the estuary mouth. Mouth opening events occur during or shortly after periods of high rainfall (usually following sustained rainfall exceeding 100 mm; Cowley, 1998).

5.2.2 Fishery survey methods

A total of 36 on-foot roving creel surveys were undertaken between August 2001 and July 2002. Surveys were conducted on three days per month, two on weekdays and the remaining one on either a weekend day or a public holiday. In total 24 week days and 12 weekend or public holidays were sampled.

5.2.3 Results

Angler Demographics

A total of 101 resource uses were interviewed on the East Kleinemonde estuary of which 63% were fishermen and 37% only used the estuary to collect bait to fish elsewhere. Of the anglers 6% used boats, while the remainder fished from shore. Fishery participants were predominantly white (94%) males (92%). Other ethnic groups included blacks and coloureds (6%). All anglers were classed as being recreational users. The average age of all interviewees was 38±16 years, while the youngest and oldest individuals were

11 and 72 years old, respectively. The age distribution of resource users on the East Kleinemonde estuary is shown in Figure 5.2.1.

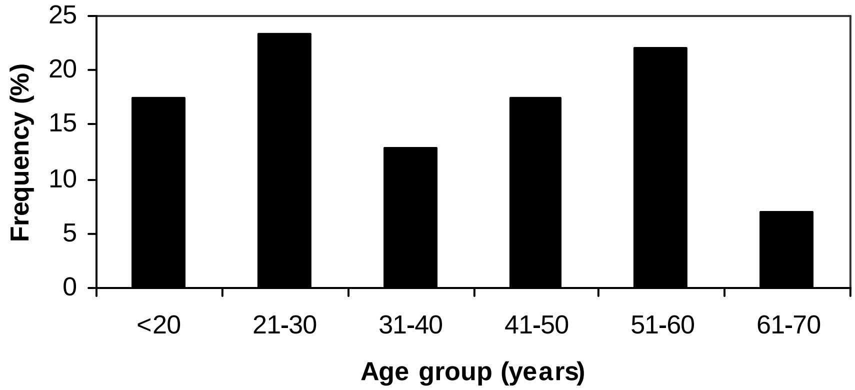

Figure 5.2.1 Age distribution of fishers interviewed on the East Kleinemonde estuary between August 2001 and July 2002.

The majority (55%) of the anglers encountered resided more than 100km away from the estuary. This, however, was due to the influx of holidaymakers during the Christmas and Easter periods when families travel to the coast from inland. Local fishermen, residing less than 15km away comprised 33% of all interviewees. The East Kleinemonde estuary was characterised by a high turnover of anglers as 88% of individuals were encountered only once during the 36 survey days. 9.6% of individuals were interviewed twice and only one individual was recorded on three occasions and another individual on five occasions.

Catch composition

Only four species of fish were recorded in the catches from the East Kleinemonde estuary. *P. commersonnii* and *R. holubi* comprised the majority of the catch (42% each) with *Lithognathus lithognathus* and *Mugil cephalis* only comprising a small portion of the catch (Table 5.2.1).

Bag frequencies

No anglers managed to achieve the daily bag limit of five fish for any of the major estuarine fishery species. Most angler outings were unsuccessful (79%), while only 13% caught one fish. In addition, 2% caught two or four fish and 4% caught three fish per outing.

Table 5.2.1 Species composition and sizes of fish caught in the East Kleinemonde estuary between August 2001 and July 2002.

Species	Common Name	Number caught	Percentage composition	Mean length (mm TL)	Min size (mm TL)	Max Size (mm TL)
Pomadasys commersonnii	Spotted grunter	10	42%	436	320	550
Rhabdosargus holubi	Cape stumpnose	10	42%	109	100	150
Lithognathus lithognathus	White steenbras	1	4%	330	-	-
Mugil cephalis	Mullet	3	12%	350	340	360

Distribution of effort

Most fishing (excluding those only collecting bait) took place in the lower reaches of the estuary (below the road bridge), primarily (59%) on the western bank. Only 8% of the fishers were encountered above the road bridge.

Catch trends

The total number of fish caught during the survey period was very low and therefore catch trends could not be calculated for individual species. The total catch of all species was used to estimate the monthly and annual catches in the East Kleinemonde estuary. The number of fish caught per month was highly variable (Figure 5.2.2) and the total annual catch was estimated at only 225 fish.

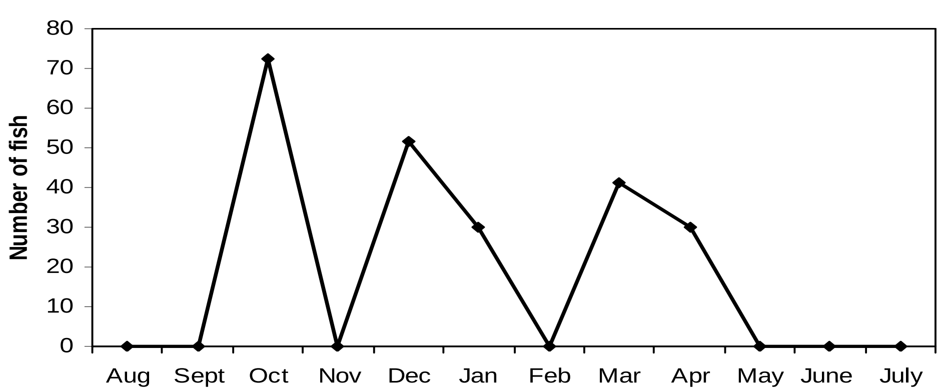

Figure 5.2.2 Estimated monthly catches (numbers) for all species in the East Kleinemonde estuary between August 2001 and July 2002.

Trends in fishing effort

The mean turnover time for all fishers interviewed on the East Kleinemonde estuary was calculated at 2h 40min. There was however great variability over the survey period, ranging from 1hr 20 min to 4hr 30 min (Figure 5.2.3).

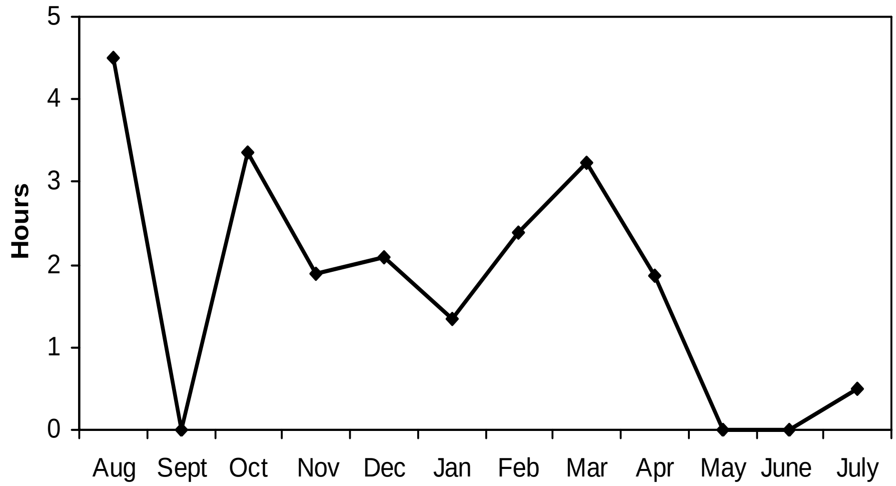

Figure 5.2.3 The mean monthly turnover time of fishers on the East Kleinemonde estuary between August 2001 and July 2002.

The total daily effort on the East Kleinemonde estuary was considerably higher on weekend days (8h 48min) than on weekdays (2h 15min). Total monthly effort on the estuary was highly variable ranging from 0 to 468 angler-hours (Figure 5.2.4). The calculated annual fishing effort on the East Kleinemonde estuary was estimated to be 1498 anger-hours.

Bait utilisation

Seven types of baits were used for fishing in the estuary. The most popular bait organism was *C. kraussii*, collected from the estuary (76% Frequency of occurrence). Other common baits used included pilchards (*Sardinops sagax* ; 9% FO), chokka squid (*Loligo vulagaris reynaudii* ; 7% FO), and live mullet, artificial lures and pink prawn (each with 2% FO). The annual harvest of sand prawns from the East Kleinemonde estuary was estimated at 25621 individuals.

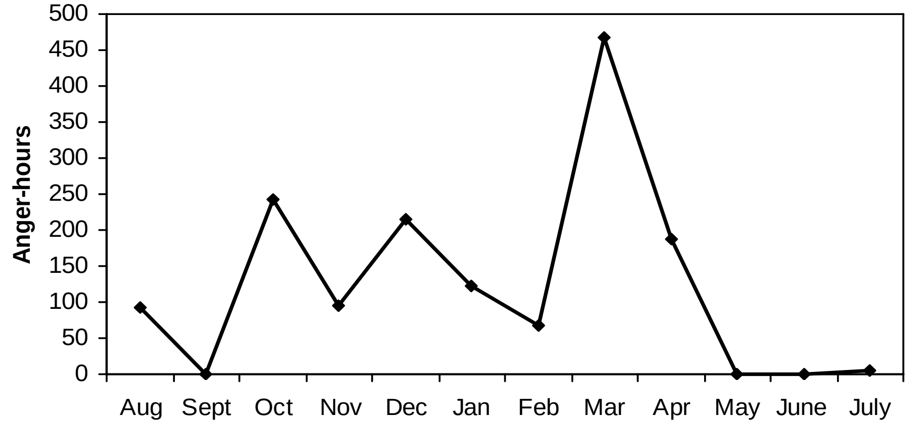

Figure 5.2.4 Calculated total monthly effort on the East Kleinemonde estuary between August 2001 and July 2002.

5.3 WEST KLEINEMONDE ESTUARY

5.3.1 Study site

The West Kleinemonde is classified as a large temporarily open/closed system. The estuary is navigable for approximately 6 km and encompasses a surface area of approximately 80 hectares. It is a relatively wide and shallow system, between 30 m and 200 m in width and 2 m and 3 m in depth. This estuary is predominantly closed (often for periods exceeding one year) and breaches following periods of high rainfall. Under normal (closed) conditions, the estuary has a longitudinal salinity gradient, with the upper reaches being between 5‰ and 10‰ and the lower reaches having salinities of 25 - 30‰. A high seasonal variability in temperatures is evident with summer temperatures being between 22°C and 29°C and winter temperatures falling to 15°C or even 12°C.

5.3.2 Fishery survey methods

Fishery surveys on the West Kleinemonde estuary were conducted on the same days as those on the East Kleinemonde estuary. All methods were the same in both estuaries.

5.3.3 Results

Fisher demographics

A total 123 resource users (fishers and bait collectors) were interviewed over the survey period. Of these 78% used the estuary for fishing and bait collection while 28% used the estuary exclusively for collecting bait organisms to fish elsewhere. Only 7% of the interviewees fished from boats, while the remaining 93% were shore anglers. The motivation for fishing was almost exclusively for recreational purposes (97%), with only 3% being subsistence fishers. Fishery participants were predominantly white (97%) males (88%), while coloured men (3%) and white females (12%) were in the minority. People of all ages participated in resource use practices (min = 6 ; max = 72 ; mean = 31±16 years. The age distribution of all interviewees is shown in Figure 5.3.1.

The distances travelled by anglers using the West Kleinemonde revealed a distinct seasonal trend. The majority of fishers travelling great distances were encountered over the school holiday periods, while local residents (people travelling <15km) were encountered more frequently on weekends out of peak seasons.

There was a high turnover of individual fishers with 67% being encountered only once during the 36 sampling days. A total of 29% of interviewees were encountered twice and only 4% were encountered on more than two occasions during the year.

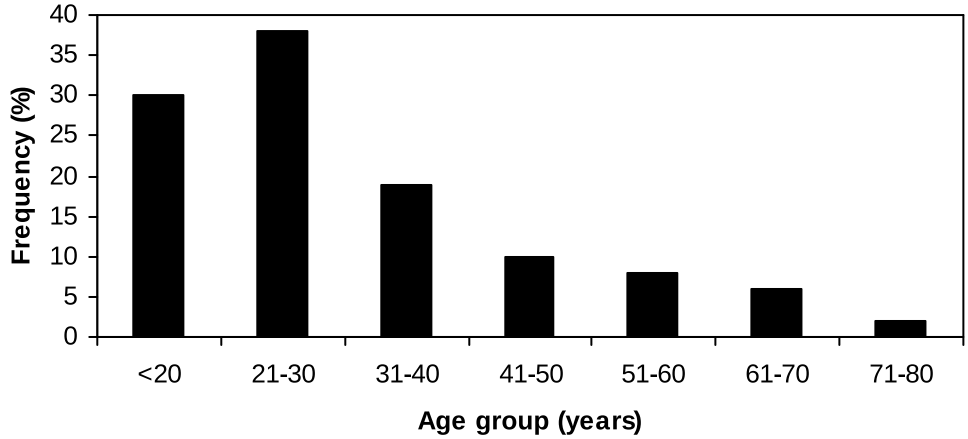

Figure 5.3.1 Age distribution of fishers interviewed on the West Kleinemonde estuary between August 2001 and July 2002.

Catch composition

A total of six fish species were recorded during the survey period, with *A. japonicus* (45%) and *L.amia* (26%) comprising the majority of the catch (Table 5.3.1). Recreational fishermen accounted for all the catch.

Table 5.3.1 The catch composition and sizes of fish recorded from the West Kleinemonde estuary between August 2001 and July 2002.

Species	Common name	Number caught	Percentage composition	Mean length (mm TL)	Min size (mm TL)	Max size (mm TL)
Argyrosomus japonicus	Dusky kob	19	45.2	440±134	200	760
Lichia amia	Leervis	11	26.2	330±39	300	400
Rhabdosargus holubi	Cape stumpnose	8	19.0	120±64	80	280
Pomadasys commersonnii	Spotted Grunter	2	4.8	335±77	280	390
Monodactylus falciformis	Cape Moonfish	1	2.4	100	-	-
Galeichthys feliceps	White seabarbel	1	2.4	300	-	-

Bag Frequencies

Of all the fishers encountered during the survey period only one individual managed to attain the daily bag limit of five fish (*A. japonicus*). Most fishers (80%) caught no fish, while only 9% caught one or two fish, and only 2% caught three or more. Anglers were responsive to legal size limits as many fish were released after capture (*A. japonicus* = 54%; *P. commersonnii* = 50%; *L. amia* =100% and *R. holubi* = 100%).

Distribution of effort

A large majority (75%) of resource users were encountered in the lower reaches of the West Kleinemonde estuary, in the region below the road bridge. Of those fishing in the estuary, slightly more (57%) were located on west bank of the estuary.

Catch trends

Due to the low number of fish caught during the sampling period, no clear trends emerged from the data. However, it appeared that better catches were made in the warmer months between October and May (Figure 5.3.2). The total annual catch was calculated to be 421 fish, primarily consisting of *A. japonicus* (45%), *L. amia* (26%) and *R. holubi* (20%).

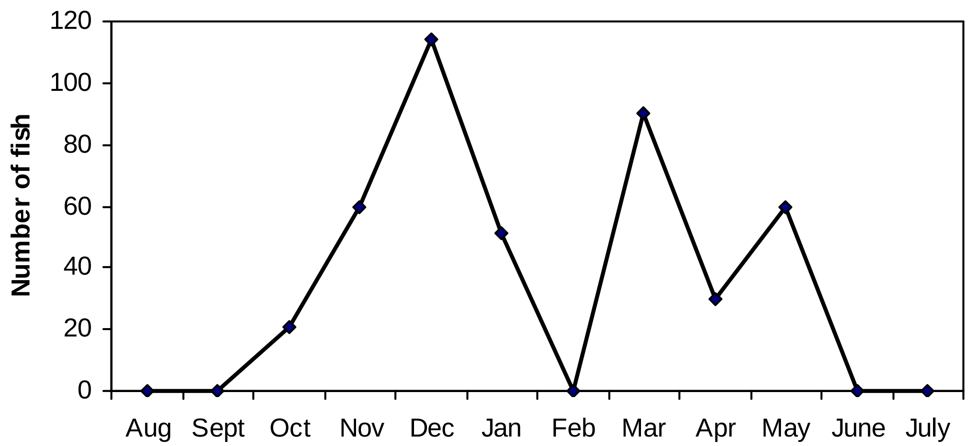

Figure 5.3.2 Estimated monthly catches from the West Kleinemonde estuary between August 2001 and July 2002.

Trends in fishing effort

The mean turnover time (time spent fishing by an individual angler) for all fishers interviewed during the survey period was 2h 54min. Turnover time was highest during the months of March, April and May (Figure 5.3.3). The estimated total monthly effort ranged between 0 and 1402 angler-hours (Figure 5.3.4), with a mean effort of below 200 angler-hours per month. The projected annual effort on the West Kleinemonde estuary was calculated to be 2 372 angler-hours.

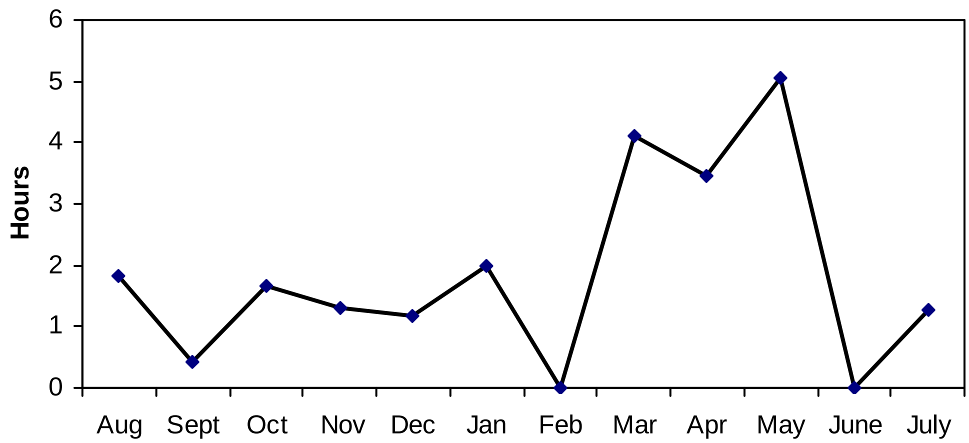

Figure 5.3.3 The mean monthly turnover time of recreational fishers on the West Kleinemonde estuary between August 2001 and July 2002.

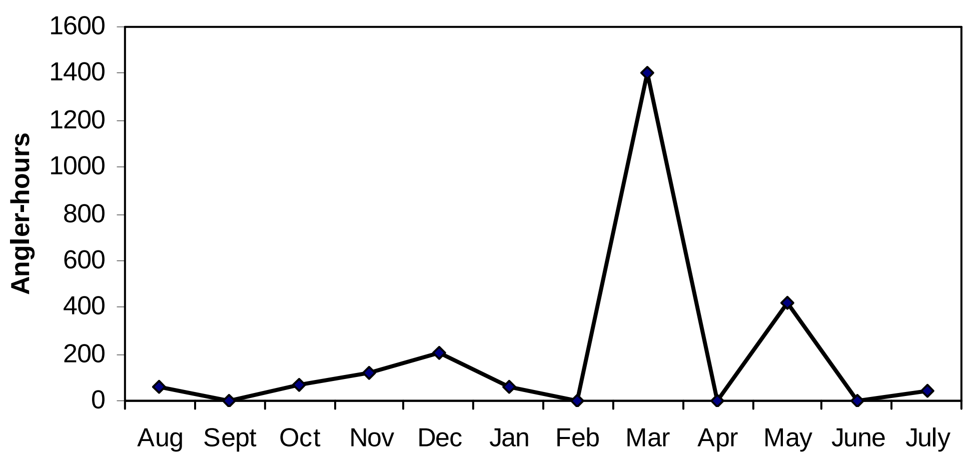

Figure 5.3.4 Calculated total monthly effort on the West Kleinemonde estuary between August 2001 and July 2002.

Bait utilisation

Seven types of baits were used for fishing in the estuary. Most interviewees (74%) used bait collected from the estuary, which consisted of mainly sand prawn (*Callianassa kraussii* ; 58%) and mullet (Mugilidae species). A further 16% of the fishers used fresh bait purchased from retail outlets, consisting of pilchard (*Sardinops sagax* ; 10%), chokka squid (*Loligo vulgaris reynaudii* ; 5%), pink prawn (<1%) and mudprawn (*Upogebia africana* ; <1%). The remaining 10% of fishers used artificial lures. The West Kleinemonde estuary had an estimated annual harvest of 21680 sand prawns, of which approximately half (52%) were collected for use elsewhere, primarily in the sea.

5.4 The Kowie Estuary

5.4.1 Study site

From its source in the hills near Grahamstown, the Kowie River flows until it enters the Indian Ocean at Port Alfred at 33° 36′ S; 26° 54′ (see Figure 5.1). The river is 70km long and its catchment covers 769km^2. Average rainfall in the catchment is 638mm per year, most of it falling in spring and autumn (Day 1981). Water temperatures show a seasonal range of 11 – 27^o C in the upper reaches of the estuary, and 14 to 22^o C in the mouth region, sometimes dropping below 14^o C when there is upwelling of cold water along the coast (Bok 1983). The river's annual flow is erratic due to frequent droughts and floods in the catchment. Estimates of mean annual run off for the Kowie river range from 17x10^6 to 50x10^{6}m^3 (Heydorn and Grindley 1982). The river flows mainly through privately owned farmland and indigenous scrub forest of the Thicket Biome. The underlying rocks consist mostly of shale and sandstone, and are responsible for the river's low silt load (mean secchi disc transparency 71 - 103mm), its high pH (mean 8.2), and its high alkalinity (139 – 185ppm $CaCO_3$). Bok (1983) reported that the average salinity of the water is approximately 30 ‰, but may range between 40 ‰ during drought, and 0 ‰ in the mouth region during prolonged river floods. Heydorn and Grindley (1982) reported that although there are a number of bridges and dams in the upper reaches of the river, it is only the weir just above the "Ebb and Flow" which restricts fish movement up river. The Kowie estuary with a surface area of approximately 120 hectares is tidal for at least 21 km from the mouth (Heydorn and Grindley 1982). *Ruppia sp.* and *Phragmites australis* are the most common aquatic macrophytes on the estuary, although near the Bay of Biscay and along Bell's Reach *Zostera capensis* is the dominant species. Remnants of reed swamps can be found at the lower East Bank lagoon, and to the east of the "Wreck". The salt marshes to the north of the Bay of Biscay consist of *Sarcocornia perennis* near the water edge, and *Sporobolus virginicus*, Sarcocornia *decumbens* and *Juncus kraussii* (Cowley and Daniel 2001).

5.4.2 Fishery survey methods

Similar methods to those used for the other estuaries in this chapter were adopted except that on the Kowie estuary the roving creel surveys were conducted from a boat. Each boat trip took place from the entrance to the Royal Alfred Marina up to The Reef approximately 15 km upstream.

5.4.3 Results

Fisher demographics

A total of 156 boat trips (271 survey hours) were carried out on 35 days between July 2000 and June 2001 on the Kowie estuary. During this period 1619 fishers were intercepted, of which 958 were interviewed.

The linefishery was dominated by the recreational sector (87%) consisting of white (75%) males (90%). Blacks, coloureds and Asians constituted 19%, 6% and 0.2% of the interviewees respectively. The turnover of individual anglers was high as 73% of interviewees were encountered only once during the survey period.

The majority of the subsistence fishers on the Kowie estuary were aged between 12 and 18 years (42%), while the age distribution of recreational fishers was more evenly distributed (Table 5.4.1). Overall the mean individual age was 34±17 (min = 3 ; max = 77).

Table 5.4.1 The distribution of age groups among anglers interviewed on the Kowie estuary between July 2000 and June 2001.

	Age groups (years)						
Category	**<12**	**12-18**	**19-30**	**31-40**	**41-50**	**51-65**	**>65**
Sub	19	57	20	24	9	5	0
Rec. shore	41	54	96	89	83	67	13
Rec. boat	13	46	61	61	61	97	42
Total	**73**	**157**	**177**	**174**	**153**	**169**	**55**

Catch composition

A total of 20 species representing 15 families were identified in the catches of the interviewed fishers. The three dominant species by number were *Rhabdosargus holubi*, *Pomadasys commersonnii* and *Argyrosomus japon*icus, which collectively contributed 85% of the total catch by number (Table 5.4.2). By mass, the dominant catch species was *P. commersonnii* (40.5%), followed by *R. holubi* (14.5%), *and A. japon*icus (14.3%). The linefishery also included an important invertebrate species, namely the estuarine mud crab (*Scylla serrata*), with an estimated annual harvest of 1882 individuals.

Size composition

The dominant size classes for *P. commersonnii* (32%) and *A. japonicus* (48.5%) were 300 – 399 mm TL and < 200 mm TL (79.7%) for *R. holubi*. The mean individual lengths for *P. commersonnii*, *A. japonicus* and *R. holubi* were 326.4 mm (0.653 kg), 154.8 mm (0.064 kg) and 366.6 mm TL (0.601kg), respectively. Most of the recorded catch for the dominant species was below the minimum legal size (80.3% of *P. commersonnii*, 74.2% of *A. japonicus* and 79.7% of *Rhabdosargus holubi* ; Table 5.4.3).

Table 5.4.2 Catalogue composition of all fish recorded from the Kowie estuary during the survey period, with proportions (%) of fish retained.

Species	Common name	Total catch (n)	Percentage composition	Percentage retained
Rhabdosargus holubi	Cape Stumpnose	622	62.3	67
Pomadasys commersonnii	Spotted Grunter	172	17.2	40
Argyrosomus japonicus	Dusky Kob	66	6.6	41
Galeichthys feliceps	White Seabarbel	27	2.7	59
Diplodus cervinus hottentotus	Zebra	20	2.0	65
Mugilidae spp.	Mullet species	20	2.0	65
Lithognathus lithognathus	White Steenbras	15	1.5	60
Pomadasys olivaceum	Olive Grunter	13	1.3	77
Platycephalus indicus	Bartail Flathead	9	0.9	33
Pomatomus saltatrix	Shad	6	0.6	100
Epinephelus andersoni	Catface Rockcod	6	0.6	33
Lichia amia	Leervis	4	0.4	50
Sarpa salpa	Strepie	4	0.4	0
Torpedo sinuspersici	Marbled electric ray	4	0.4	0
Diplodus sargus capensis	Blacktail	3	0.3	33
Elops machnata	Springer	3	0.3	0
Amblyrhynchotes honckenii	Evileye Blaasop	2	0.2	50
Gobiidae sp.	Goby species	1	0.1	0
Pseudorhombus arsius	Flounder	1	0.1	0
Raja miraletus	Twineye skate	1	0.1	0

Table 5.4.3 Percentage size class contributions for the important species recorded on the Kowie estuary from July 2000 to June 2001. Shaded areas represent portions below the minimum legal size limit.

Size range (mm TL)	*Pomadasys commersonnii*	*Argyrosomus japonicus*	*Rhabdosargus holubi*
< 200	4.7	1.5	79.7
200 - 299	32.0	24.2	19.9
300 - 399	43.6	48.5	0.4
400 - 499	15.6	15.2	-
500 - 599	2.9	7.6	-
600 - 699	1.2	-	-
700 - 799	-	1.5	-
> 800	-	1.5	-

Catch trends

The annual yield of fish from the Kowie estuary was estimated to be 16 240 individuals (1.013 tons), of which 38% were caught by recreational boat-based fishers. The subsistence and shore-based recreational sectors accounted for 31.3% and 30.9% of the total catch, respectively.

Trends in fishing effort

Total annual fishing effort on the Kowie estuary was estimated at 30 952 angler-hours. The boat-based recreational sector accounted for 45% of the total effort, while the shore-based recreational sector and the subsistence sector accounted for 39% and 16% respectively.

Monthly variation in total fishing effort for each of the fishery sectors over the survey period is shown in Figure 5.4.1. Total fishing effort peaked in summer, with December alone contributing over 25% of the overall annual fishing effort. There was a drop in fishing effort during mid-winter, especially during June/July.

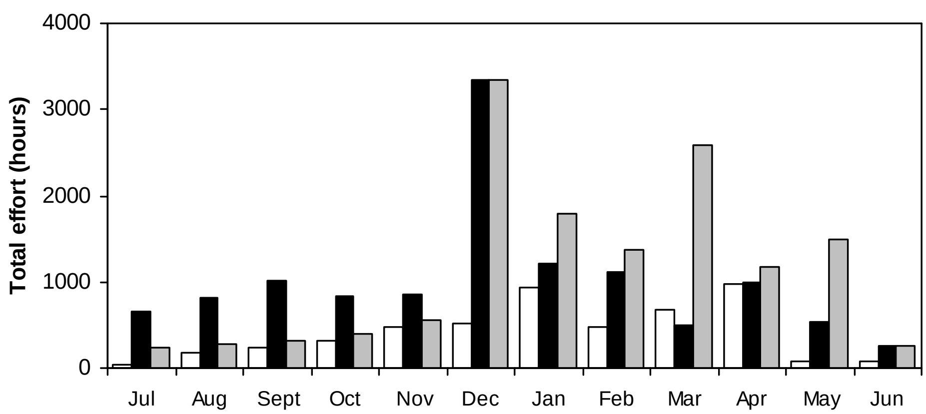

Figure 5.4.1 Monthly variation in fishing effort for the different fishery sectors on the Kowie estuary between July 2000 and June 2001 (Solid bars = Recreational shore; Grey shaded bars = Recreational boat and Open bars = Subsistence).

Despite the changes in total monthly effort, the mean turnover time for all fishery sectors revealed no distinct seasonal trends and ranged from 2h 40 min to 4h 20min (mean = 3h 10min) over the survey period (Figure 5.4.2).

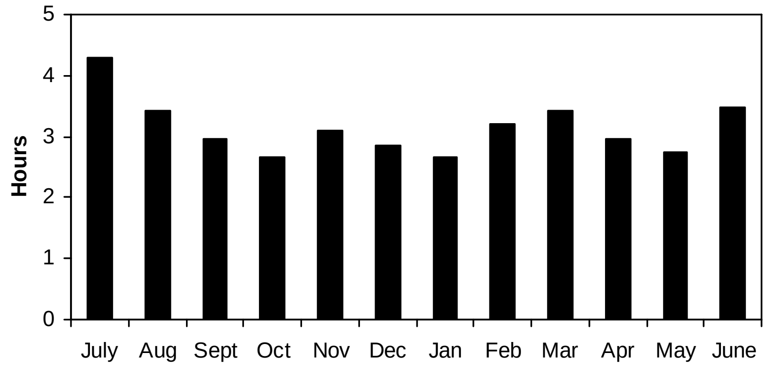

Figure 5.4.2 Mean turnover time between July 2000 and June 2001 on the Kowie estuary.

Trends in cpue

The overall catch rate for the Kowie estuary fishery was estimated at 0.57 fish angler-hour^{-1} (0.2 kg angler-hour^{-1}). Subsistence fishers had the highest overall catch rate by number (1.13 fish angler-hour^{-1}), while estimates for the shore-based and boat-based recreational fishers were almost equal (0.52 and 0.51 fish angler-hour^{-1}, respectively).

Figure 5.4.3 compares the temporal variation in overall catch rate by number and mass on the estuary during the survey period. Catch rate by number fluctuated throughout the study period, the lowest occurring in December (0.26 fish angler-hour^{-1}), and the highest in June (1 fish angler-hour^{-1}). Seasonal trends in catch rate by mass were more pronounced, with higher catch rates during summer, especially in December, and lower values in winter (May to July).

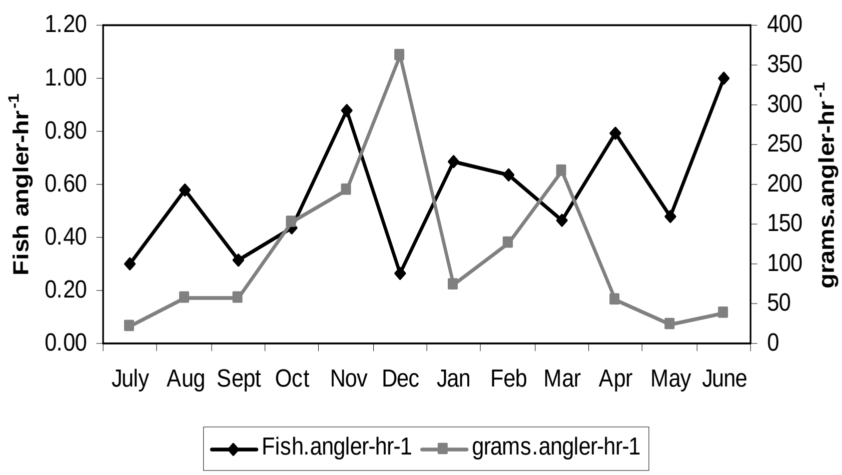

Figure 5.4.3 Temporal variation in the cpue number and mass for all fishery sectors on the Kowie estuary between July 2000 and June 2001.

The monthly variation in *cpue* for the different fishery sectors is given in Figure 5.4.4. The catch rate of the subsistence fishers was highest in June (2.25 fish angler-hour^{-1}), in March for the shore-based recreational sector (1.05 fish angler-hour^{-1}), and November for the boat-based sector (1.15 fish angler-hour^{-1}). The lowest catch rate in the subsistence and shore-based recreational sectors were in September (0.22 fish angler-hour^{-1} and 0.27 fish angler-hour^{-1} respectively), and in December for the boat-based recreational sector (0.24 fish angler-hour^{-1}). Monthly catch rates in the subsistence fishery exceeded those in the recreational sectors in all the months except September/October and March.

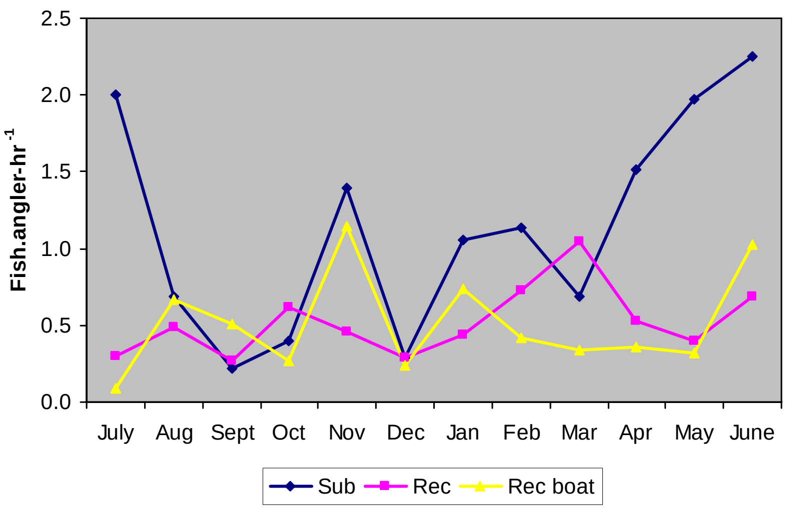

Figure 5.4.4 A comparison of monthly *cpue* (by number) between different fishery sectors on the Kowie estuary between July 2000 and June 2001.

Table 5.4.4 compares the overall catch rate (by number and mass) of the four major catch species on the estuary. In terms of fish numbers, the species with the highest overall catch rate on the estuary was *R. holubi*. However, in terms of fish mass, *P. commersonnii* had the highest overall catch rate on the estuary.

Table 5.4.4 A comparison of overall *cpue* (fish angler-hour^{-1} and grams angler-hour^{-1}) for the four major catch species on the Kowie estuary between July 2000 and June 2001.

Species	fish angler-hour^{-1}	grams angler-hour^{-1}
Rhabdosargus holubi	0.313	21
Pomadasys commersonnii	0.089	59
Argyrosomus japon icus	0.034	21
Lithognathus lithognathus	0.008	10

Species-specific cpue values (by number) attained by the different fishery sectors are given in Table 5.4.5. In all the three fishery sectors, the catch rate of *R. holubi* was the highest, although that of the subsistence sector (0.753 fish angler-hour^{-1}) was four times that in the boat-based recreational sector (0.169 fish angler-hour^{-1}), and almost twice that in the shore-based recreational sector (0.311 fish angler-hour^{-1}). The highest catch rate of *P. commersonnii*, and *A. japonicus* occurred in the boat-based recreational fishery (0.133 and 0.068 fish angler-hour^{-1} respectively). The catch rate of *L. lithognathus* was very low in all the fishery sectors (average 0.008 fish angler-hour^{-1}).

Table 5.4.5 Cpue (fish angler-hour^{-1}) values for different species across the different fishery sectors on the Kowie estuary.

Species	Shore-based Subsistence	Shore-based Recreational	Boat-based Recreational
Rhabdosargus holubi	0.753	0.311	0.169
Pomadasys commersonnii	0.068	0.041	0.133
*Argyrosomus japon*icus	0.025	0.007	0.068
Lithognathus lithognathus	0.006	0.009	0.008

The Bait Fishery

Demographics of bait collectors: During the survey period, a total of 277 bait collectors were counted on the estuary, of which 161 were interviewed. Most of the bait fishery participants (78%) belonged to the subsistence sector, which included individuals who collected bait to sell and/or to catch fish. The majority of the bait collectors on the estuary were male (98%), and black (80%). Whites and coloureds formed 16% and 4% of the interviewed bait collectors, respectively. All of the subsistence bait collectors were Port Alfred residents, while only 57% of the recreational bait collectors were local to the area.

Similar to the linefishery, there was a high turnover of individual bait collectors. Of the 35 recreational users interviewed only one was recorded collecting bait on two of the survey days. Among the subsistence collectors, 60 individuals were intercepted once, 15 twice, three on three occasions, two on four survey days, two on six occasions and one on seven survey days.

The age distribution of both subsistence and recreational bait collectors was unimodal and dominated by youths in both sectors (Figure 5.4.5).

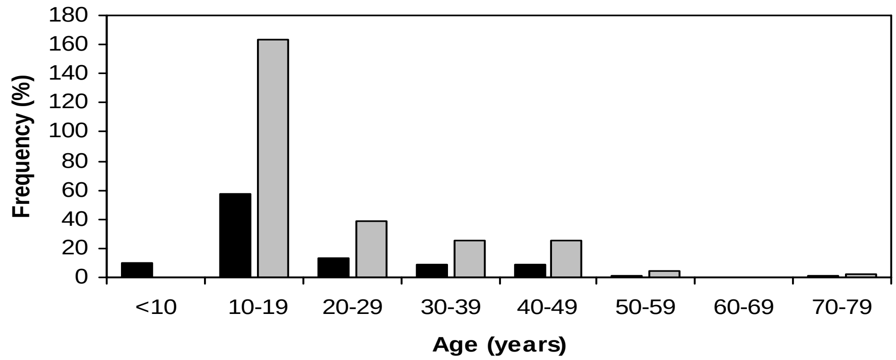

Figure 5.4.5 Age frequency distribution of recreational (solid bars) and subsistence bait collectors (grey shaded bars) from the Kowie estuary between July 2000 and June 2001.

Seasonality: Figure 5.4.6 shows the monthly variation in the number of subsistence and recreational bait collectors recorded on the estuary during the survey period. Although dominant in all months of the years, the number of subsistence bait collectors peaked in December and April.

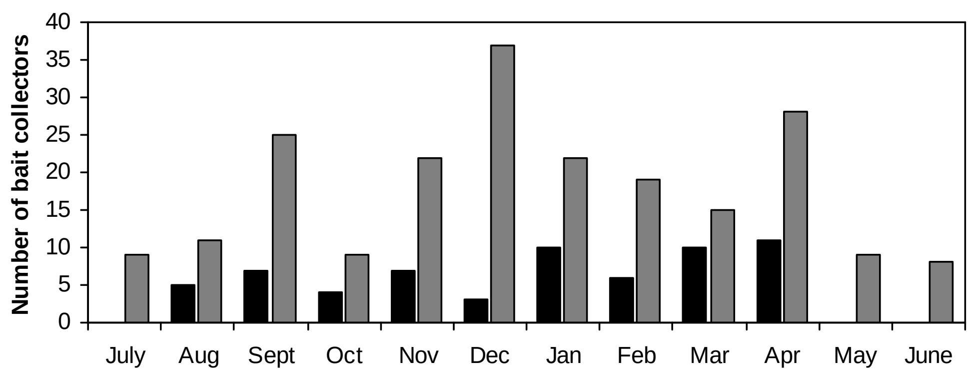

Figure 5.4.6 Monthly variation in the number of subsistence and recreational bait collectors recorded on the Kowie estuary between June 2000 and July 2001.

Catch composition: Fishers on the Kowie estuary used a total of 20 different bait types during the survey period. Five invertebrates and five fish species (and fish roe of various species) were collected from the estuary (Table 5.4.6).

The estimated annual harvest of mudprawns from the Kowie estuary was 260 648 individuals. Most were collected during December and April (34.5%), coinciding the major school holiday periods. Subsistence collectors accounted the bulk of the yield (64%) (Figure 5.4.7).

Bag frequencies: The mean number of mudprawns per person for interviewees who claimed to have finished harvesting was calculated at 99 (max = 462; min = 10), exactly twice the legal bag limit of 50 per person per day. Almost half (49%) of interviewees claimed that they sold their mudprawns. Based on this conservative estimate mudprawn harvesting generated approximately R27000-00 over the one-year survey period.

Table 5.4.6 List of bait organisms used on the Kowie estuary between July 2000 and June 2001 with estimated annual yields for the dominant species collected from the estuary.

	Species name	Common name	Annual harvest
Collected form estuary	*Upogebia africana*	Mudprawn	260 650
	Callianasa krausii	Sandprawn	2 315
	Mugilidae spp.	Mullet species	3 100
	Salpa salpa	Strepie	94
	Rhabdosargus holubi	Cape stumpnose	320
	Pomadasys olivaceum	Olive grunter	-
	Sepia vermiculata	Cuttlefish	-
	Penaeus indicus	Swimming prawn	-
	Various species	Fish roe	-
	Polybrachiorhynchus dayi	White tapeworm	-
	Pyura stolonifera	Redbait	-
Collected elsewhere	*Gunnarea capensis*	Cape reef worm	-
	Pseudoneires vulgaris	Mussel worm	-
	Striostrea margaritacea	Oyster	-
	Octopus vulgaris	Octopus	-
Purchased	*Sardinops sagax*	Pilchard	-
	Scomber japonicus	Mackerel	-
	Loligo vulagaris reynaudii	Chokka squid	-
	Various species	Pinkprawn	-
	Various products	Artificial lures	-

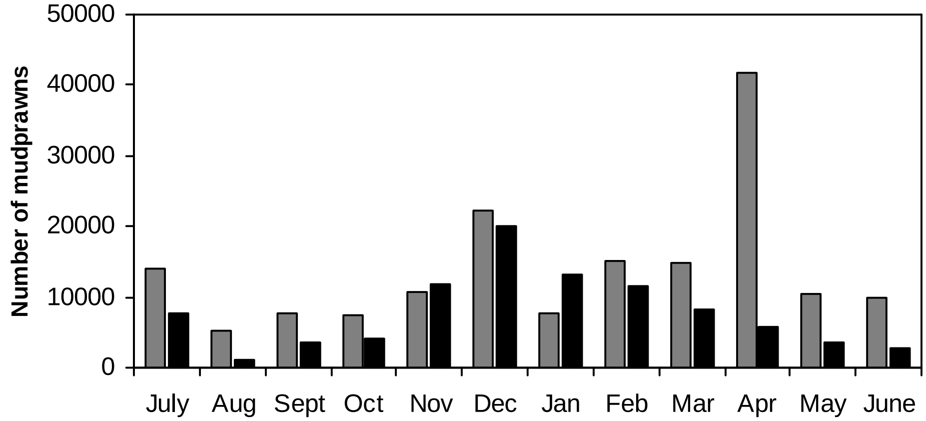

Figure 5.4.7 Estimated total monthly harvest of mudprawns by recreational (solid bars) and subsistence (grey shaded bars) collectors in the Kowie estuary between July 2000 and June 2001.

5.5 Discussion

The physical conditions and mouth status of estuarine ecosystems are known to influence the diversity and abundance of fauna, including fishery resources (Whitfield 1998). Permanently open systems allow for annual (continuous) recruitment of fishery species, while the seasonal timing and duration of open mouth phases in temporarily open/closed estuaries influences the recruitment dynamics of such species. The demand for fishery resources however, appears to be governed by the nature and availability of local infrastructure and its associated socio-economic characteristics. Table 5.5.1 summarises the major physical, social (demographics) and fishery characteristics of the four study estuaries. The estuaries associated with a coastal town (urban) and/or coastal resort settlement (peri-urban), namely Kowie, and East and West Kleinemonde respectively, serviced predominantly recreational-based line- and bait fisheries. The fishery on the rural Great Fish estuary, on the other hand, was subsistence-dominated. Furthermore, available infrastructure also influences the type of fishery participation. For example, the highest participation of boat-based recreational fishers was observed on the Kowie estuary and probably related to the availability of jetties, slipways and boat mooring (small boat harbour) facilities.

The seasonal nature of fishing effort and hence resource exploitation in the coastal town settlements is a reflection of an influx of tourists over the main holiday periods (Christmas = December and Easter = March/April). For example, 25% of the annual fishing effort on the Kowie estuary was recorded in December. The sustained (year-round) effort on the Great Fish estuary, on the contrary, revealed a greater dependence on fishery resources by the subsistence sector. The high retention rate of landed catches (95%

of spotted grunter and 93% of dusky kob) and high turnover time (duration of an outing) by anglers provided further evidence of the economic dependence of fishery resources on this estuary.

The characteristics of the bait fisheries also reflected on the socio-economic status of the local population demographics. Port Alfred, situated on the Kowie estuary, has a high population density and unemployment rate. Consequently, the harvesting and selling of bait organisms (mudprawns), pursued mostly by poor young blacks, provides a means of earning extra money during the tourist/holiday seasons. Unfortunately, the high ratio of mudprawns harvested (260000) to fish caught (16240) suggests that there is considerable wastage of this resource. Further research is required to examine the sustainability of this fishery practice. The absence of high-density poor settlements in the Kleinemonde region mitigated the presence of a subsistence sector in the linefishery. Although bait harvesting (sandprawns) was high in both Kleinemonde estuaries, the demand not only satisfied the estuarine linefishery, but also that of recreational beach anglers.

Table 5.5.1 A summary of the major physical, social (demographics) and fishery characteristics of the Great Fish, East Kleinemonde, West Kleinemonde and Kowie estuaries.

	Great Fish	East Kleinemonde	West Kleinemonde	Kowie
Mouth condition	Open	Mostly closed	Mostly closed	Open
Estuary size (ha)	120	18	50	120
Location	Rural	Peri-urban	Peri-urban	Urban
Dominant fishery sector	Subsistence	Recreational	Recreational	Recreational
Seasonality of effort	No (but summer dominant)	Yes (holiday seasons)	Yes (holiday seasons)	Yes (holiday seasons)
Annual effort (hrs)	62300	1500	2400	31000
Turnover time (outing duration)	12h 30min	2h 40min	2h 54min	3h10
Prawns harvested (N)	137000 (mudprawns)	26500 (sandprawns)	22000 (sandprawns)	260000 (sandprawns)
Annual fish catch (N)	7380	225	421	16240
Individual fisher turnover (%)	91	88	67	73
Most important species	Spotted grunter, dusky kob & seacatfish	Spotted grunter, Cape stumpnose & white steenbras	Dusky kob, leervis & Cape stumpnose	Cape stumpnose, spotted grunter& dusky kob
Cpue (fish angler.hr^{-1})	0.123	0.15	0.15	0.57

It is well known that estuaries serve as important nursery areas for many fish and other invertebrate species (e.g. swimming prawns). Therefore, the capture of juvenile (under-sized) fishes is to be expected in estuarine fisheries, but the very high retention rate of undersized fish (lack of compliance) recorded in this study is a major management concern. It is possible that the high turnover of individual anglers (i.e. high percentage of anglers only interviewed once) does not provide for a sense of ownership and hence improved management by way of self-governance of the estuary and its resources.

The diversity of fishery species varied considerably between the study estuaries, however certain species (viz. spotted grunter, dusky kob and Cape stumpnose) were prominent in the catches from all four systems. These species are also important in other estuaries in South Africa (Kosi Bay – James *et al.* 2001; St Lucia – Mann 1994; Durban Bay – Gaustella 1994; Gamtoos, Sundays – Pradervand & Baird 2002), while species such as dusky kob and white steenbras (both heavily over-exploited species) are also well represented in the catches of beach shore-anglers (Brouwer *et al.* 1997).

The Great Fish estuary with enhanced freshwater inputs is known to be very productive, yet it yielded the lowest overall cpue value (0.123 fish. angler-hr^{-1}). The freshwater deprived Kowie estuary, on the other hand, had the highest cpue value (0.57 fish. angler-hr^{-1}). These catch trends were influenced by the differences in catch composition, size composition and fishing effort. The dominant catch species on the Kowie was Cape stumpnose, which are very abundant as juveniles in estuaries with large submerged macrophyte beds. They seldom return to estuaries once emigrated back to sea following their juvenile nursery phase. Therefore, the abundance of these small-sized fish elevated the cpue value in the Kowie estuary. The Great Fish estuary lacks submerged macrophytes (= absence of Cape stumpnose) but has large intertidal mudbanks, which provided suitable habitat for juvenile and seasonally immigrating adult spotted grunter; a species that is considerably larger than Cape stumpnose. Furthermore, the Great Fish estuary yielded a far greater annual harvest than the Kowie estuary (5.44 tons versus 1.01 tons), providing better evidence of its productivity. A further reason for the deflated cpue value from the Great Fish estuary can be ascribed the dynamics of the dominant fishery sector (i.e. subsistence). These fishers were found to camp on the banks of the estuary for several days and as a result gave rise to an elevated daily turnover time (mean effort = 12h 30min per person per day) and annual effort estimate (62300 hrs).

5.6 Conclusion

The findings of this study have highlighted the dynamic nature of estuarine fishery resource utilisation. Despite their close proximity, the results revealed distinct differences in catch composition, size composition, fisher demographics, fisher behaviour, catch rates, effort trends and annual yields for the four neighbouring estuaries. Consequently, improved management of estuarine fishery resource utilisation hinges on the adoption of a holistic approach. Management schemes must be developed for individual estuaries and need to consider the following issues: the physical and biological characteristics of the ecosystem itself, the dynamics and availability of various resources, the sustainability of targeted species, the economic benefits derived from each type of exploitation, the socio-economic demographics of the region, the needs and responsibilities (actions) of resource users, the resolution of conflict between different user groups, the formulation of knowledge-based local regulations as well as the implications of nation and international policies, and the implementation of monitoring programmes.

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