NINA Project Report 28

Preliminary report:

Trends in fishery resource utilisation on the Great Fish Estuary

Interim report: October 2003 – March 2004

W.M. Potts, P.D. Cowley, B. Corroyer, and T.F. Næsje

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Abstract

Potts, W.M., Cowley, P.D., Corroyer, B. & Næsje, T.F. 2004. Preliminary report: Trends in fishery resource utilisation on the Great Fish Estuary. - NINA Project Report 28. 26pp.

The Great Fish Estuary, located in the Eastern Cape Province is becoming an increasingly popular fishing venue. A resource utilisation study that consisted of a series of roving creel surveys was conducted in the estuary between March 2001 and February 2002 and in this interim report compared to the first six months of an ongoing year-long study, conducted between October 2003 and March 2004. During interviews with resource users, demographic information as well as catch, effort, bait, duration of fishing trip and number of rods/lines was obtained. Subsistence fishers (59%) dominated during the first study period, while recreational fishers (54%) dominated during the second study period. There was a considerable increase in the number of recreational boat fishers from the first (5%) to the second study (22%). These differences were partly attributed to the increased sampling on weekend days during the second study and also due to the improved infrastructure at the Fish River Diner Caravan Park. Although the catch composition was similar during both study periods, there overall catch per unit effort was lower during the second (0.16 fish/angler-hour) than during the first (0.22 fish/angler-hour) study period. The distribution of fishing effort was more widespread during the second study period than in the first. Despite its six month duration, the total fishing effort during the second study period was higher (69 888 hrs) and the total catch was only one third lower (9182 fish) than in the first study period (60 436 hrs, 12 752 fish, respectively). While the study showed a variety of short-term fluctuations, long term monitoring studies are recommended to examine trends in this and other estuarine fisheries in South Africa.

Preface

The aims of the project are to investigate the movement behaviour, migrations and habitat use of important estuarine fishery species (spotted grunter and dusky kob) and local exploitation from fisheries to contribute to the development of a sustainable utilisation strategy.

Background

The utilisation of estuarine fish resources plays a major role in the local economy and food supply in many poorly developed areas. In South Africa, fish species that spend parts of their life in estuaries, such as the spotted grunter (*Pomadasys commersonnii*) and dusky kob (*Argyrosomus japonicus*), are exploited for both food (subsistence and small scale fisheries) and recreation. Such estuarine species may also form an important component of commercial coastal fisheries. Due to the poor status of many of the estuarine associated fish stocks, the sustainability of these fisheries is in question. It is therefore urgent to develop sound management practices based on adequate knowledge of the population biology, habitat use, and migratory behaviour of the targeted species.

Project purpose

The purpose of this project is to investigate the movement behaviour of two of South Africa's most important estuarine fishery species, the spotted grunter and dusky kob, the exploitation of these species in estuaries and its implications for management. The movements and activity patterns of the spotted grunter and dusky kob are recorded by making use of acoustic telemetry methods, while the fisheries data are collected using structured visual surveys and on-sight direct contact roving creel (interview) surveys. Results from the project will contribute significantly to ensure sustainable utilization of these heavily targeted species.

Specific objectives

- Describe the movement behaviour of spotted grunter and dusky kob within the Great Fish River estuary and to describe behavioural responses to anomalous natural events and anthropogenic influences
- Describe habitat utilization of spotted grunter and dusky kob within the estuary,
- Establish the periodicity and duration of the fishes' movements between the estuary and the sea,
- Describe spatial and temporal trends in catch and effort by the different fishery sectors.

Ultimate objectives

- Collate fishery statistics, fishing areas and angler catch data with the observed daily and seasonal movement trends of the fish species in order to assess the species susceptibility to local depletion
- Explore the effectiveness and consequences of different management measures such as bag limits, minimum legal sizes, estuarine protected areas, and effort restriction as appropriate conservation strategies for the fish species
- Assist in developing a sustainable exploitation strategy for the different fishery sectors (subsistence, recreational, commercial) and develop recommendations to assist with the overall management of spotted grunter and dusky kob stocks

Methods

Telemetry enables us to track the behaviour of individual fish by means of acoustic transmitters attached to the fish. The fish can be continuously tracked for reasonable periods of time, up to a year or longer depending on the setup of the transmitters. Each tag transmits coded signals on a fixed frequency, allowing for simultaneous tracking of several individual fish. The transmitted coded signals may be retrieved by either stationary receivers positioned in the estuary, or by a hand held receiver. In this study spotted grunter and dusky are tagged with surgically implanted transmitters in the Great Fish River estuary. Their movements and habitat utilization are monitored during both summer and winter. The stationary receivers monitor the fish continuously for as long as they are in the estuary, while the hand held hydrophone is used to monitor the individuals more intensively on shorter time scales.

Aspects of the recreational and subsistence fisheries in the estuary are studied both while manually tracking the fish from a boat and by on-site direct-contact roving creel surveys (interview surveys) conducted on foot on the shore. Observations of number of lines in the water, the number of fisherfolk, classification of anglers (recreational or subsistence), whether they are fishing from land or boat, and their position are done while manually tracking the fish. While information on demographics, resource use sector, area use, catch, and effort are obtained through the interviews of fishers.

Funding and project partners
The following institutions collaborate in the project: South African Institute for Aquatic Biodiversity (SAIAB), Norwegian Institute for Nature Research (NINA), Rhodes University, and University of Zululand. It is the intent of the collaborating institutions that the project and relationships established should form the basis for long-term collaborative links between South African and Norwegian scientists and institutions.

The project is funded by the South Africa / Norway Programme on Research Cooperation (National Research Foundation of South Africa, and the Research Council of Norway), South African Institute for Aquatic Biodiversity (SAIAB), and Norwegian Institute for Nature Research (NINA). We would like to thank these institutions for their financial support to the project.

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1 Introduction

The Great Fish Estuary is a large (approximately 100 ha) permanently open, freshwater dominated system situated in the rural Eastern Cape. The estuary is characterised by low diversity, but high abundance of fishes (Whitfield *et al.* 1994). The low diversity has been attributed to a narrow habitat range and high turbidity, while the high abundance is partly attributed to high inorganic and nutrient inputs (Whitfield *et al.* 1994).

The estuary is a popular fishing venue and is host to recreational boat and shore fishers as well as a subsistence fishing community. The subsistence fishery began as recently as 1983, when four fishers, two from Port Alfred and two from Peddie began temporarily residing on the banks of the river (John Dokwe, subsistence fisher, pers. comm.). Since then, this fishery sector has grown considerably and is evident from the number of individuals selling fish on the road bridge crossing the estuary. The recreational fishery is traditionally supported by people from the closest urban centres such as East London, Grahamstown and Port Alfred. Over the last five years, there has been a substantial increase in recreational fishing effort in the Great Fish Estuary (Hendrik Swart, Fish River Caravan Park, pers. comm.). With increasing human pressure, it is important to obtain baseline information on the resources and their exploitation levels in the estuary.

Although biological research has been conducted on the Great Fish Estuary (e.g. Whitfield *et al.* 1994, Ter Morshuizen et al. 1996, Webb 2002), except for a brief linefishery assessment by Pradevand and Baird (2002) fisheries research in the estuary has been largely ignored.

This report documents the findings of a resource utilisation study conducted on the Great Fish Estuary between March 2001 and February 2002 and compares them with the findings of the first six months (October 2003 - March 2004) of a second year-long resource utilisation survey.

The aim of the report is to compare the demographics, catch composition, effort, catch per unit effort (*cpue*), estimated catch and bait organism utilisation of the various user groups between the two study periods.

2 Materials and methods

2.1 Study site

The 650 km long Great Fish Estuary enters the Indian Ocean approximately half way between Port Elizabeth and East London at 33° 29' 28"S, 27° 13' 06" E, and has a road bridge crossing the estuary approximately 1 000 m from the mouth (Vorwerk *et al.* 2001, **Figure 1** and **2**). This river system has a catchment area of approximately 30300 km^2 and a mean annual runoff of 525 X 10^6 m^3/yr (Vorwerk *et al.* 2001). The Great Fish River once formed the boundary between the Eastern Cape Province and the former Ciskei homeland.

Most of the catchment area is used for low impact agricultural activities such as cattle, sheep, goats and game farming, while some of the low-lying floodplain areas along the banks of the river and the estuary have been cultivated (mostly maize). In addition, some arable lands in the high lying coastal region are cultivated with pineapple crops.

The permanently open estuary mouth is maintained by enhanced freshwater inputs from an inter-basin transfer system located on the Orange River (Vorwerk *et al.* 2001). This inter-basin scheme also accounts for continuous nutrient inputs and, hence, elevated phytoplankton production in the Great Fish Estuary. The main channel in the mouth region of the estuary is usually approximately 30 m wide and is restricted by the presence of extensive sand banks. Following flood events, however, the main channel can be up to 200 m wide. The estuary is mostly shallow, ranging between 1 m and 2 m (mean 1.4 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).

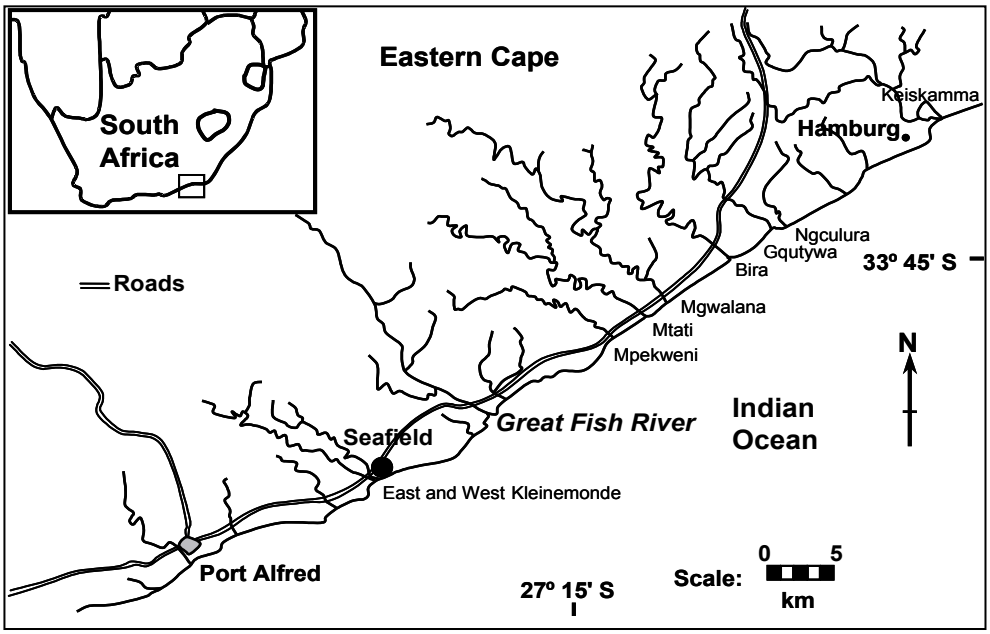


Figure 1
Map of the coastal region between Port Alfred and Hamburg (Eastern Cape), showing the location of the Great Fish Estuary and other estuaries.

2.2 User access

Access to the estuary and its fishery resource is gained via four possible routes. A gravel road, off the R 72 (coastal road) approximately 30km east of Port Alfred (see **Figure 2**) provides access to the western shore of the estuary between the mouth and just above the R72 road bridge. This areas forms part of the Great Fish Wetlands Reserve is controlled by the Ndlambe Municipality and provides a functional slipway and ablution facilities for day visitors and overnight campers. A small residential settlement (also within the Wetlands Reserve) consisting of "holiday shack" homes is located close to the western bank in the region of the estuary mouth (**Figure 2**). This settlement is under the management of the Ndlambe Municipality and homeowners have land lease agreements (Cowley and Daniel 2001).

Approximately 50m above (north of) the road bridge, the western shoreline becomes part of the Kapriver Reserve (**Figure 2**). There is no access to the western shore except to a small open access area (where fishing is allowed) approximately 3km upriver from the mouth (**Figure 2**).

The eastern shore is accessible both below and above the road bridge (**Figure 2**). Access to the eastern shore of the river between the mouth and the road bridge is controlled by the Fish River Diner and Caravan Park (**Figure 2**). This property and its facilities were owned by the Eastern Cape Government but was privately managed through a long-term lease agreement until the beginning of 2004, when it was purchased by a private enterprise. Since 2000 (the first study), the camping, caravanning and ablution facilities have been upgraded significantly and the entrance and campsite fees have also risen. There is a functional slipway in the caravan park. Access to the eastern shore (above the road bridge) is free and can be obtained by foot from the R72 or via an old vehicle track over privately owned land (see **Figure 2**).

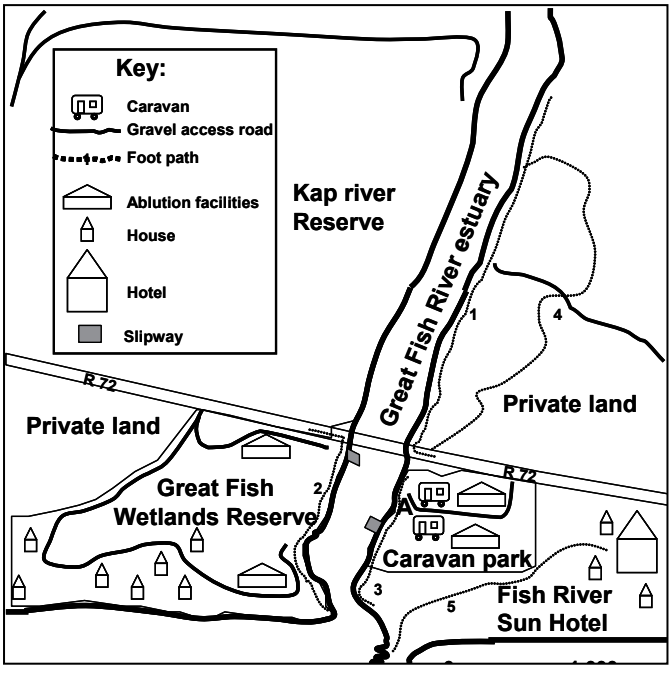


Figure 2
Detailed map showing the main access routes to, and land-use around, the lower regions of the Great Fish Estuary. 1- 5 = footpaths.

2.3 Survey methods

Period one:
The first study was initiated as part of a comparative assessment of the resource utilisation on four Eastern Cape Estuaries. A summary of the findings are presented in Cowley *et al.* 2004, however, the detailed results are presented here and compared with those from period two.

Surveys were conducted on two weekdays and one weekend day (or public holiday) each 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. This sampling strategy allowed us to estimate total annual fishing effort and compare the difference in effort between weekdays, public holidays and weekend days. All surveys were conducted during daylight hours (sunrise to sunset).

Period two:
Surveys were conducted on two weekdays (Tuesday – Thursday), two Fridays and two Saturdays each month. Survey days were selected to include the neap and spring tidal cycles each month. To obtain an estimate of total annual fishing effort (for comparison with the survey in period one), it was essential to obtain an estimate of fishing effort on each day of the week in each month. Since surveys were not conducted on Sundays or Mondays, effort was estimated using point counts from a fixed position at 8h00 and 17h00 on the Sunday and Monday after each Saturday survey.

Survey procedure
Three groups of fisher's viz. subsistence, recreational shore and recreational boat were recognised before the first study. Subsistence fishing occurred mostly above the road ridge on the eastern bank and very few subsistence fishers were observed in the Great Fish Wetlands Reserve and the caravan park (**Figure 2**). Recreational shore fishers were found almost exclusively below the bridge on both the east and west banks (**Figure 2**). Three roving creel survey routes were selected for both survey periods. Route 1 (Foot path 1, **Figure 2**) was used to interview shore fishers (mostly subsistence) above the bridge on the east bank. Route 2 and 3 (Foot path 2 and 3, **Figure 2**), extended from the road bridge to the mouth on the west and east bank, respectively and were used to interview all shore fishers (mostly recreational) below the bridge.

Period one:
On arrival at sunrise, the survey clerk began a continuous roving creel survey along routes 1, 2 or 3. To ensure that the maximum amount of information was obtained, the choice of route on each occasion was made by determining where fishers were most likely to depart first. The roving creel surveys along routes 1, 2 or 3 continued throughout the day until sunset to ensure complete coverage of the estuary.

Period two:
The continuous roving creel nature of the first study period resulted in the survey clerk not intercepting a high proportion of boat fishers. The recreational boat fishermen were found all over the river but their access was restricted to two slipways below the road bridge (**Figure 2**). To obtain the maximum amount of information from the subsistence, recreational shore and recreational boat fishers, we designed a complimented survey for the second study period that included a point count, direct-contact roving creel and access point survey.

On arrival (08h00) at the estuary, the survey clerk took a point count and recorded the location of all shore and boat fishers between the road bridge and estuary mouth and all boat fishers above the bridge from a fixed position A in the caravan park (**Figure 2**). This point count was repeated at hourly intervals (except for 9:00 and 16:00, when the roving creel surveys were undertaken) until a final point count at 18:00.

Three roving creel survey routes were selected. Route 1 (Foot path 1, **Figure 2**) was used to interview shore fishers (mostly subsistence) above the bridge on the east bank. Route 2 and 3 (Foot path 2 and 3, **Figure 2**), extended from the road bridge to the mouth on the west and east bank, respectively and were used to interview all shore fishers (mostly recreational) below the bridge. Each route was walked once in the morning after the first point count. To ensure that fishers who had fished the previous night were interviewed, the order of route selection was based on where fishers were most likely to depart first. Roving creel surveys along all three routes were repeated in the afternoon (starting at 15h30) to record daytime catch and effort. Since the roving creel surveys intercepted anglers during their fishing trips, the information collected was "incomplete trip" data. Information from the hourly point counts were used to determine the

end time of shore fishers trips. From this, the duration of the complete trip of all shore fishers could be calculated.

An access point and point count survey was used to monitor the recreational boat fishers. The movement of the boat fishers was recorded hourly throughout the day from fixed position A (**Figure 2**) or from the roving creel routes and these individuals were interviewed at the slipway access point sites (**Figure 2**) when they departed. This provided us with "complete trip" data from the recreational boat fishery. Not all boat fishers completed their trips during the survey period and these fishers were therefore not interviewed.

Interviews

The same interview process was used in both study periods. During the roving creel surveys, 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 (Appendix 1) to assess the distribution of effort along the estuary. On the occasions that an individual angler was intercepted later on the same day, the interview sheet was amended to include the corrected data on effort and catch. When a party of anglers was encountered, an effort was made to separate catch by individual anglers in order to avoid "party bias".

A copy of the questionnaire is appended (Appendix 2). Information gathered from the interviews included: (i) user demographics (name, age, gender, race, and home town); (ii) resource use sector (subsistence[1] shore, recreational shore or recreational boat); (iii) catch species and size composition (to avoid misidentification of species and prevent size bias, all retained fish were inspected, identified and measured to the nearest mm fork length (FL) and total length (TL). Information on the released, eaten or sold catch was also obtained from the angler and was 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.

For anglers who had been fishing consistently since the previous day, total catch was everything landed between 18h00 the previous day until their last interview of the survey day. To calculate fishing effort, the start of the fishing trip for a person who had fished since the previous day was recorded as 18h00. This was necessary due to the difficulty in obtaining an accurate estimate of effort by subsistence fishers. Since many fishers had difficulty in predicting when they would end their fishing trip in period one, the point survey information collected in period two was used to verify their estimated departure time.

2.4 Data analysis

Distance from home – Data from the "hometown question" were used to calculate the distance that fishers travel to the estuary from their homes. Distance travelled was separated into categories; < 15km, 15-50km, 50-100km and over 100km and compared between user groups and the two studies using a chi square analysis.

Fishing Effort – Since subsistence anglers could rarely provide an estimated time that fishing would cease (due to almost continuous effort while temporarily residing on the banks of the estuary), the actual observed effort was considered to be the total effort for subsistence anglers. For comparative purposes, the unit of angling effort chosen was angler-hours. In study period one, 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. In study period two, total effort was calculated by summing the individual angler turnover time (time started to time departed) and when the anglers were not interviewed, the point survey data. Fishers that arrived or departed before or after each hourly point survey were assumed to have arrived or departed on the half hour.

We calculated and compared the difference in fishing effort between weekdays and weekends (or public holidays) in survey period one and two by counting the number of fishers present from the various sec-

1) 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)

tors. Differences in the number of fishers between weekend and weekdays and between survey period one and two were tested using a t-test.

To calculate annual effort in survey period one, we first calculated monthly weekday effort. This was estimated by calculating the average effort on the two weekday surveys each month and multiplying this value by the number of weekdays in that month. The effort on the weekend or public holiday survey was multiplied by the number of those days in that month. Total monthly effort was calculated as the sum of the weekday and weekend effort estimates and annual effort was calculated as the sum of the monthly effort estimates from all months.

The results from the point surveys in survey period two suggested that fishing effort on Fridays and Sundays could be assumed to be equal, while fishing effort on Mondays could be assumed to be equal to Tuesdays, Wednesdays and Thursdays. Fishing effort on Saturdays was higher than all other days of the week. Monthly weekday effort was therefore estimated by calculating the average effort on the two weekday surveys and multiplying this value by the number of Mondays, Tuesdays, Wednesdays and Thursdays in that month. The average fishing effort on the two Friday surveys was multiplied by the number of Fridays in that month and weekday effort was calculated as the sum of the Monday to Thursday and Friday effort estimates. Weekend effort was calculated as the sum of the estimated Saturday and Sunday effort. The average effort on the two Saturday surveys was multiplied by the number of Saturdays in that month. To estimate effort on Sundays, the average effort on the Friday surveys (since effort on Sundays and Fridays were assumed to be equal) was multiplied by the number of Sundays in that month.

Cpue

In survey period one, the total number and mass[2] of retained and released fish captured on each survey day was divided by the total fishing effort on that day to estimate the *cpue*, which was expressed as fish/angler-hour, or grams/angler-hour. The mean *cpue* was calculated as the average cpue for all the surveys.

In period two, the number and mass[2] of retained and released fish captured by each fisher was divided by the duration of his/her fishing trip at their last interview. Individual *cpue* was expressed as fish/angler-hour, or grams/angler-hour. The mean *cpue* was then calculated as the average individual *cpue* estimates for all surveys.

Estimated catch

The estimated total annual catch for study period one and the estimated catch for the six month second study period was calculated by multiplying the mean *cpue* by the total fishing effort.

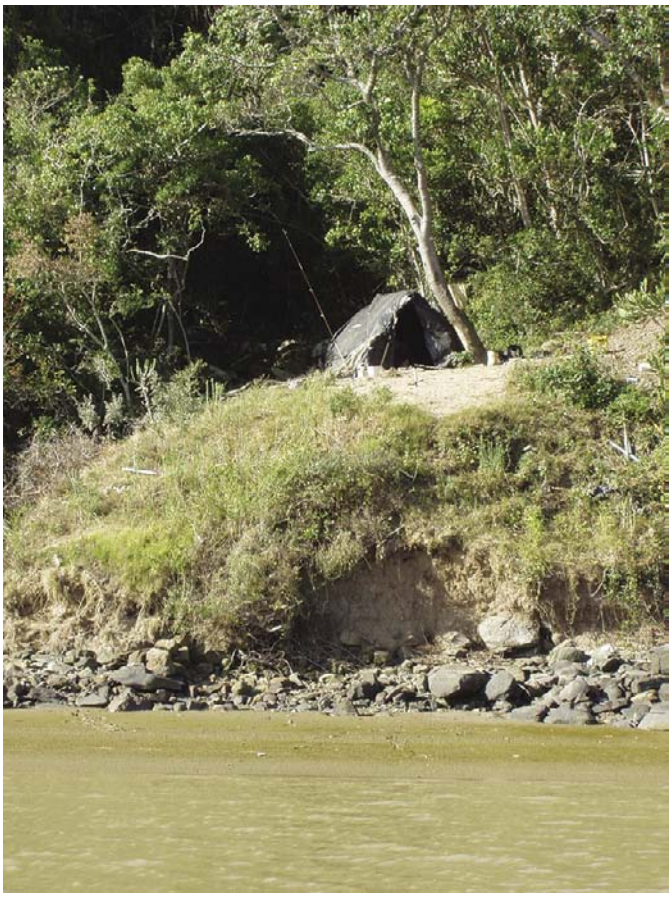
2) The measured (or estimated) lengths of all fish caught were converted to mass using the length to weight ratio (Mann, 2000 and Potts, unpublished data).

Mouth of the Great Fish Estuary with saline water pressing in. The picture was taken from the camp site on the eastern side.

Field survey personnel during the 2003-2004 survey.

The camping site in the east bank of Great Fish Estuary.

Recreational fisher with dusky kob.



Temporary home of subsistence fishers at the banks of Great Fish Estuary.

Subsistence fisherman with a nice catch of spotted grunter.

Not all areas in the lower part of Great Fish Estuary is open for non paying fishers.

Recreational boat-fishing in the lower part of the Great Fish Estuary.

Subsistence fisherman with newly caught dusky kob outside his temporary home at the banks of Great Fish Estuary.

Subsistence fishermen with dusky kob (right) and spotted grunter (left).

3 Results

3.1 Angler demographics

In the first study period, 35 survey days were conducted between March 2001 and February 2002. In the second study, 36 survey days were conducted between October 2003 and March 2004.

A total of 717 and 1 157 interviews were conducted in the first and second study periods, respectively. In the first study period the majority of fishers (n = 399) interviewed were subsistence fishers (59%), followed by recreational shore (36%) and recreational boat fishers (5%) (**Figure 3**). In contrast, of the 462 fishers interviewed in the second study period, 54.1% were recreational shore fishers, 23.4% were subsistence fishers and 22.5% were recreational boat fishers (**Figure 3**).

Of the fishers interviewed in the first study period, 55% were black, 29% were white and 18% were coloured. In the second study period, similarly the fishers interviewed were white (58%), followed by black (26%), coloured (12%) and indian (5%). Participation in the fishery was male dominated during both surveys. However, the number of females interviewed increased from one recreational fisher in the first study (0.3%) to one female subsistence fisher (0.2%) and 38 female recreational fishers (8.7%) in the second study.

During both study periods, the most common age group of the recreational fishers was 30 – 39 years (**Figure 4a**). This trend was also evident among subsistence fishers in the first study period (**Figure 4b**). However, in the second study period there was a marked increase in the proportion of young fishers (10- 20 years). Similarly, amongst the recreational fishers, the proportion of young fishers (0 – 20 years) increased in the second study period (**Figure 4a**).

Although the majority of recreational users resided between 50 and 100km from the estuary in both study periods (**Figure 5**), a significantly greater proportion of recreational fishers travelled over 100km in the second study (**Figure 5**) (χ^2 = 14.1). Very few of the recreational fishers interviewed lived within 15km of the estuary in both studies (**Figure 5**).

All subsistence fishers in both study periods travelled less than 50km from their permanent homes to the estuary. In the first study, 50% of subsistence fishers resided in Peddie and 35% resided in Port Alfred. In the second study, 80% of subsistence fishers resided in Peddie and 20% in Port Alfred.

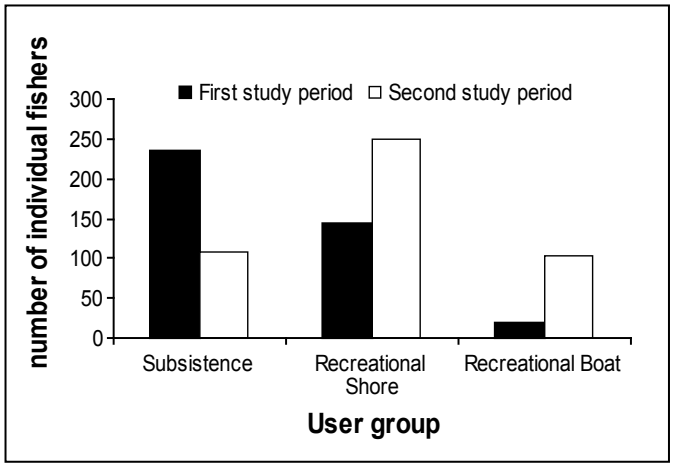


Figure 3
A comparison of the fishery user groups in the Great Fish Estuary between March 2001-February 2002 (first study period) and September 2003 - March 2004 (second study period).

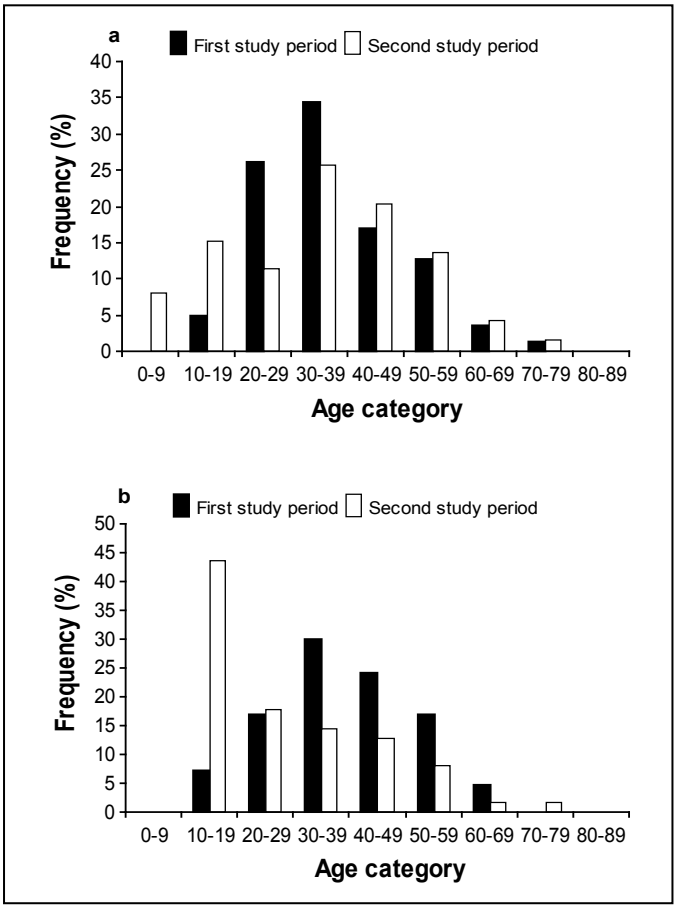


Figure 4
Age group frequency distribution of recreational (a) and subsistence (b) fishers interviewed on the Great Fish Estuary between March 2001and February 2002 (first study period) and October 2003 and March 2004 (second study period).

Only 5 recreational and 12 subsistence fishers that were interviewed in the first study period were re-interviewed in the second study period. Within each study period, the turnover of individual fishers was relatively high with 77% and 72% of individual fishers encountered on only one of the survey days in the first and second study periods, respectively (**Figure 6**). Fewer fishers (17% and 23%) were encountered on between two and five of the survey days and in the first and second study periods, respectively (**Figure 6**). Just over 5% of the fishers were encountered more than 10 times during both study periods (**Figure 6**).

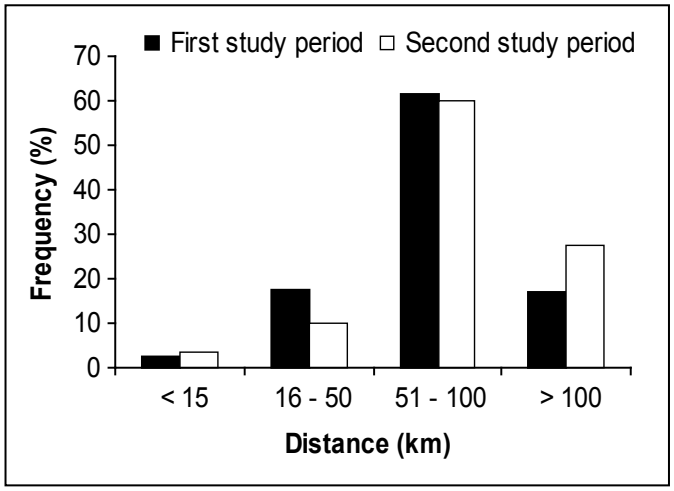


Figure 5
A comparison of the distance that recreational fishers travelled from their home town to the Great Fish Estuary between March 2001 and February 2002 (first study period) and October 2003 and March 2004 (second study period).

3.2 Catch composition

The species composition comprised seven species during the first study period and ten species during the second study period. The catch composition was very similar in both studies. Spotted grunter (*Pomadasys commersonnii*) dominated the catches in terms of number and mass in both studies, followed by dusky kob (*Argyrosomus japonicus*) and white seabarbel (*Galeichthys feliceps*) (**Table 1**).

Of the fish captured, 95% of the spotted grunter, 90% of the dusky kob and 88% of the white seabarbel were retained by fishermen during the first study period (**Figure 7**), while 85% of the spotted grunter, 53% of the dusky kob and 41% of the white seabarbel were retained (**Figure 7**) during the second study period.

Subsistence fishers landed the most spotted grunter, dusky kob and white seabarbel during the first study period (**Table 2**). Similarly, during the second study, subsistence fishers captured the most grunter and white seabarbel, but recreational boat fishers captured the most dusky kob (**Table 3**). In terms of mass, subsistence fishers captured the most spotted grunter, dusky kob and white seabarbel in both studies (**Tables 2 and 3**).

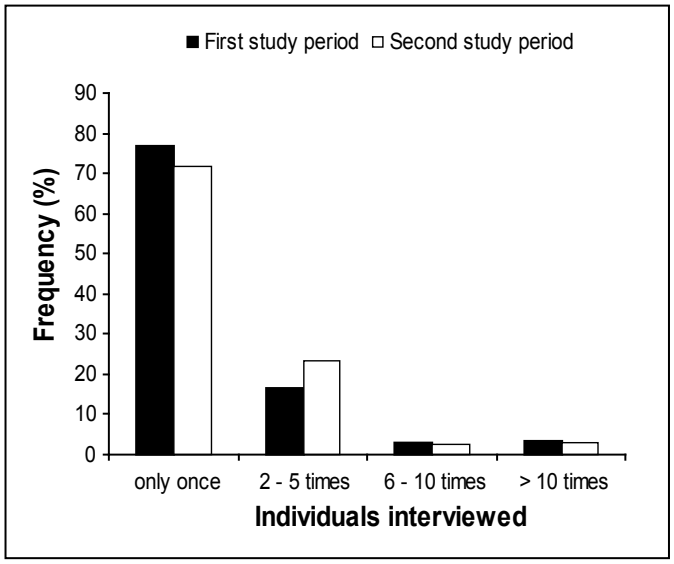


Figure 6
Number of times that individual fishers were interviewed at the Great Fish Estuary between March 2001 and February 2002 (first study period) and October 2003 and March 2004 (second study period).

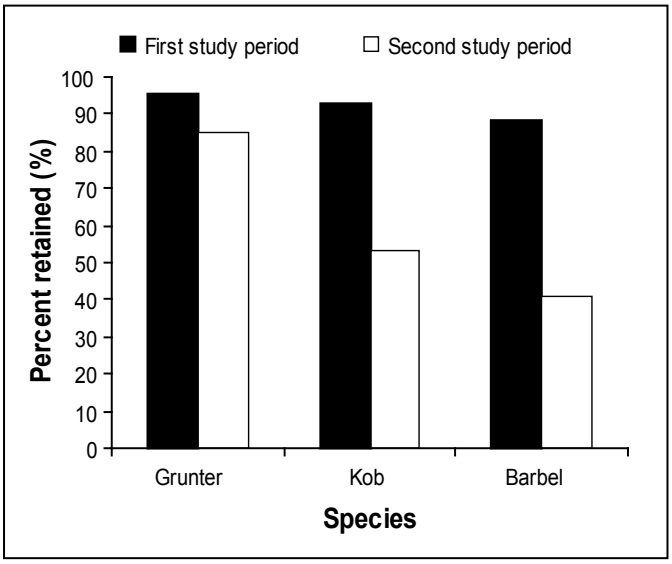


Figure 7
Percent retained fish for the dominant fishery species on the Great Fish Estuary between March 2001 and February 2002 (first study period) and October 2003 and March 2004 (second study period).

Table 1. *Angler catch composition (retained and released) for the Great Fish Estuary between the first (March 2001 - February 2002) and second (October 2003 - March 2004) study periods (ranked in order of abundance).*

Species	Common name	No. 1st	No. 2nd	No. % 1st	No. % 2nd	mass (kg) 1st	mass (kg) 2nd	mass % 1st	mass % 2nd
Pomadasys commersonnii	Spotted grunter	394	1105	54,1	54,4	331,9	1092	52,1	60,5
Argyrosomus japonicus	Dusky kob	167	550	22,9	27,1	168,0	455	26,4	25,2
Galeichthys feliceps	White seabarbel	145	309	19,9	15,2	100,2	190	15,7	10,5
Lithognathus lithognathus	White steenbras	14	39	1,9	1,9	23,2	42	3,7	2,3
Rhabdosargus holubi	Cape stumpnose	4	4	0,6	0,2	0,7	0,7	0,1	<0,1
Clarias gariepinus	Sharptotth catfish	0	19	0	0,9	0	17,9	0	1,0
Cyprinus carpio	Common carp	2	0	0,3	0	7,1	0	1,1	0
Acanthopagrus berda	River bream	1	1	0,1	<0,1	0,37	0,7	0,1	<0,1
Rhinobatos annulatus	Lesser sandshark	0	4	0	0,2	0	4,1	0	0,2
Diplodus sargus capensis	Blacktail	0	1	0	<0,1	0	0,8	0	<0,1
Mugil cephalus	Flathead mullet	0	1	0	<0,1	0	0,1	0	<0,1
Amblyrhynchotes honkennii	Evileye blaasop	1	0	0,1	0	?	0	?	0
Total		**728**	**2032**			**667**	**1803**		

Table 2. *Contribution of the total landed catch by the different fisher groups between March 2001 and February 2002 (values given as % of total landed catch).*

	Subsistence		Recreational boat		Recreational shore	
	No (%)	Mass (%)	No (%)	Mass (%)	No (%)	Mass (%)
Spotted grunter	74	70	11	16	15	15
Dusky kob	66	45	9	6	25	38
White seabarbel	88	88	3	5	9	7

Table 3. *Contribution of the total landed catch by the different fisher groups between October 2003 and March 2004 (values given as % of total landed catch).*

	Subsistence		Recreational boat		Recreational shore	
	No (%)	Mass (%)	No (%)	Mass (%)	No (%)	Mass (%)
Spotted grunter	67	74	17	10	17	15
Dusky kob	32	49	56	43	36	8
White seabarbel	44	44	40	40	16	16

Table 4. *Length frequency distribution (%) of retained catch for the dominant fishery species captured in the Great Fish Estuary between two study periods (March 2001- February 2002 and October 2003 – March 2004). Shaded numbers represent the portions below the legal size limit.*

Size range (mm TL)	Spotted grunter		Dusky kob		White steenbras	
	1st study	2nd study	1st study	2nd study	1st study	2nd study
<200	***<1***	***<1***		***5***		
200-299	***9***	***4***	***16***	***36***		***25***
300-399	***46***	***36***	***39***	***33***	***43***	***10***
400-499	29	42	28	19	***29***	***40***
500-599	11	16	7	5	***14***	***20***
600-699	3	4	6	3	14	5
700-799	1	<1	3	<1		

3.3 Size composition

During both study periods, the landed catch of all important linefish species were dominated by small individuals. During the first study 56% of the retained spotted grunter, 55% of the retained dusky kob and 86% of the retained white steenbras were below the legal size limit (**Table 4**). During the second study period, 41% of of the retained spotted grunter, 74% of the retained dusky kob and 95% of the retained white steenbras were illegal (**Table 4**).

3.4 Angler bag frequencies

The angler bag frequencies (number of fish caught per person per day) for the two study periods are given in **Figure 8 and 9**. The maximum daily catch of spotted grunter by an individual angler was 13 and 14 fish in the first and second study period, respectively. The maximum daily catch of dusky kob by an individual angler was 10 and 25 in the first and second study period, respectively. Of the 717 fishermen interviewed in the first study, most failed to capture a spotted grunter (69.6%) (**Figure 8**) and dusky kob (85.4%) (**Figure 9**) on a single day outing. Similarly, in the second study, of the 1157 fishermen interviewed, most did not catch a spotted grunter (70.3%) (**Figure 8**) and dusky kob (82.4%) (**Figure 9**) during a daily outing. Of the fishers that did capture spotted grunter or dusky kob, a catch rate of only one fish angler^{-1} day^{-1} was most frequently observed in both studies (**Figure 8 and 9**). The bag limit for spotted grunter was exceeded on 1.8% of fisher outings in the first study and by 1.6% during the second study. The bag limit for dusky kob was exceeded on 0.6% and 0.9% of fisher outings in the first and second study periods, respectively.

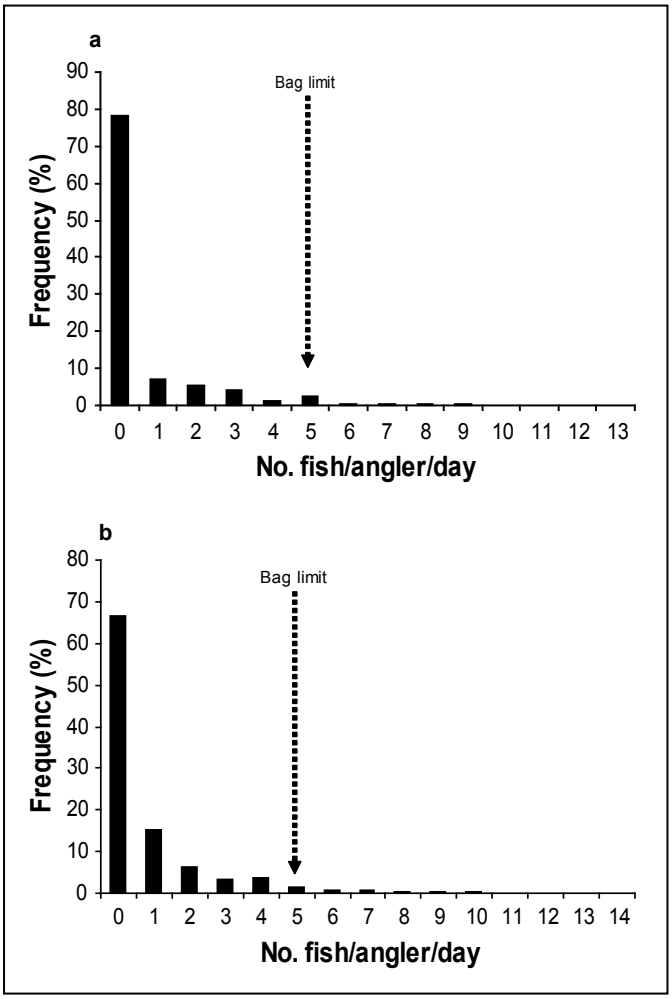


Figure 8
Angler bag frequency for spotted grunter on the Great Fish Estuary. a = March 2001 – February 2002, b = October 2003 – March 2004.

Table 5. *Mean number of fishers (± SD) per survey day on weekend days (first period 23; second period 24) and weekdays (first period 11; second period 12) recorded on the Great Fish Estuary over the two study periods.*

	Weekends				Weekdays			
	Boat fishers	**Recreational shore**	**Subsistence shore**	**Total shore**	**Boat fishers**	**Recreational shore**	**Subsistence shore**	**Total shore**
Study period one	0,5 ±1,0	8,2 ±7,9	5,9 ±3,4	14,1 ±8,9	0,3 ±0,7	2,7 ±3,3	8,0 ±4,1	10,7 ±6,3
Study period two	8,7 ±8,0	19,4 ±18,3	11,2 ±18,3	30,5 ±20,4	6,4 ±6,4	33 ±5,2	17,1 ±5,2	24,3 ±12,3

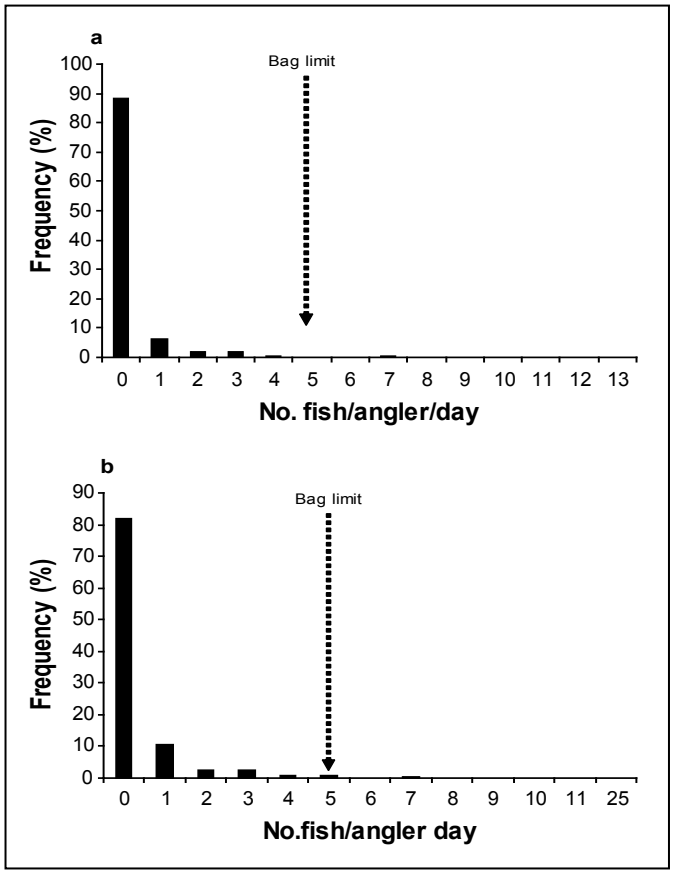


Figure 9
Angler bag frequency for dusky kob on the Great Fish Estuary. a = March 2001 – February 2002, b = October 2003 – March 2004.

3.5 Weekday and weekend effort

There was no significantly difference in the number of boat fishers between weekdays and weekend days ($p = 0.17$) when the data was pooled for both studies. However, the number of recreational shore fishers was significantly higher ($p < 0.01$) and the number of subsistence fishers was significantly lower on weekend days ($p = 0.03$). When comparing the results between the two study periods, the number of boat, recreational shore and subsistence fishers present on weekdays was significantly higher in the second study ($p < 0.01$). In addition, there was a significantly higher number of boat ($p < 0.01$) and subsistence ($p = 0.02$) fishers on weekend days in the second study period (**Table 5**). Although the number of recreational shore fishers on weekend days in the second study period was more than double the first study period (**Table 5**), the difference was not significant ($p = 0.08$).

3.6 Distribution of fishing effort

During the first study period, 10% of the shore fishing effort occurred between the mouth and 1 km upriver on the western side of the estuary. Over 35% occurred below the bridge on the eastern side and the rest occurred above the bridge on the eastern side of the estuary (**Figure 10a**). During the second study period, approximately one third of fishing effort occurred on the western side of the estuary from the mouth to just over 1km upriver. Two thirds of the fishing effort was observed on the eastern side of the estuary. Fourteen percent of the effort occurred between the mouth and bridge (Caravan Park) on the eastern side and the rest above the bridge (**Figure 10b**). A small amount of fishing effort was observed approximately 4km upriver in an open access area in the Kap River Reserve.

3.7 Distribution of catches

During the first study less than 5% of the fish were captured on the western side of the estuary (**Figure 11a**). Most fish (≈ 55%) were captured between 1.5 and 3.0 km upriver on the eastern side (**Figure 11a**). During the second study, just fewer than 20% of the fish were captured from the western side of the river (**Figure 11b**). Of the remaining 80%, approximately half were captured between 1.0 – 1.5 km and 3.0 – 3.5 km upriver from the mouth (**Figure 11b**).

Figure 10
Distribution of total fishing effort (%) in the Great Fish Estuary between a) March 2001 and February 2002 and b) October 2003 and March 2004 (dotted line indicate 500m intervals).

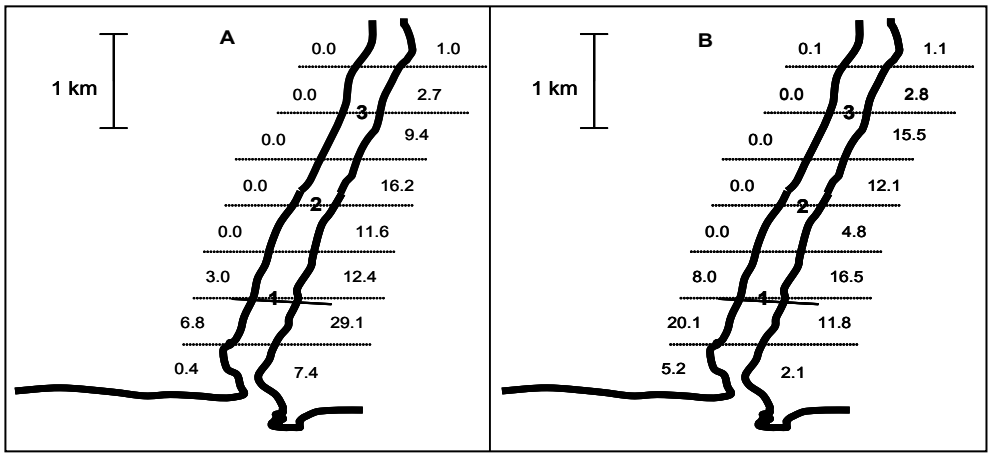
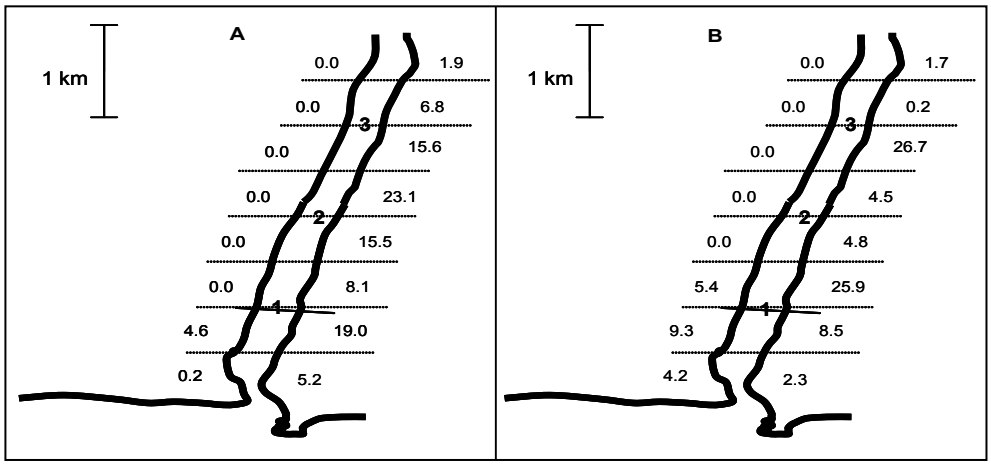


Figure 11
Distribution of fisher catches in the Great Fish Estuary between a) March 2001 and February 2002 and b) October 2003 and March 2004 (dotted lines indicate 500 m intervals).



3.8 Trends in fishery effort

The mean turnover time (time spent fishing per day by an individual angler) for all fishing sectors was estimated at 12h30min and 14h05min during the first and second study periods, respectively. Subsistence fishers spent an average of 16 and 20 hours fishing each day during the first and second study period, respectively. Mean turnover time for recreational boat fishers was 11 and 8 hours during the first and second study periods, respectively. Recreational shore fishers had a mean turnover time of 9 hours during both study periods.

The total effort estimate was higher during the second study period despite only being a six month study (**Table 6**). Subsistence fishers accounted for most of the effort during both studies, followed by recreational shore and recreational boat fishers (**Table 6**).

3.9 Catch per unit effort (*cpue*)

The mean cpue (by number) was 0.22 ± 0.71 and 0.16 ± 0.43 fish/angler-hour during the first and second study periods, respectively (**Table 7**). There was a reduction in the *cpue* of subsistence and recreational shore fishers from the first to the second study and an increase in *cpue* of recreational boat fishers from the first to the second study (**Table 7**). Recreational boat fishers attained the highest cpue of all user groups during both studies.

3.10 The bait fishery

The majority of interviewees (64% - 1st study and 63% - 2nd study) only collected bait organisms from the estuary. During the first and second study, 23% and 16% of the fishers only used bait purchased from a retail outlet, while only 6% and 19.1% of fishers bought bait and collected bait during the first and second study period, respectively.

A variety of bait organisms were used by fishers in both studies (**Table 9**). Seventy-five and 72.8 % of fishers used mud prawn (*Upogebia africana*) in the first and second study period, respectively. Pilchard (*Sardinops sagax*) was the second most popular bait, followed by sand prawn (*Callianasa krausii*) (**Table 10**).

Table 6. *A comparison of the estimated total fishing effort on the Great Fish Estuary between the two study periods (March 2001- February 2002 and October 2003 – March 2004)*

	1st study period		2nd study period	
	Effort (hrs)	%	Effort (hrs)	%
Recreational boat	2371	3,9	6452	18,9
Recreational shore	19005	31,4	13066	9,4
Subsistence	38210	63,2	49496	71,7
Total	60436		69988	

Table 7. *Catch per unit effort (fish/angler-hour) for the different user groups on the Great Fish Estuary between March 2000 - February 2001 (Study period one) and October 2003 – March 2004 (Study period two).*

	1st study	2nd study
Subsistence	0,22 ± 0,79	0,09 ± 0,13
Recreational boat	0,31 ± 0,28	0,49 ± 0,90
Recreational shore	0,19 ± 0,58	0,12 ± 0,32

Table 8. *A comparison of the estimated fish catch (in numbers) in the Great Fish Estuary between March 2000 and February 2001 (study period one) and October 2003 and March 2004 (study period two).*

	1st study		2nd study	
	total catch	%	Total catch	%
Recreational boat	8406	65,5	4452	48,5
Recreational shore	735	5,8	3162	17,1
Subsistence	3611	28,3	1568	34,4
Total	12752		9182	

Table 9. *Percent of fishers using different bait organisms in the Great Fish Estuary between March 2000 and February 2001 (study period one) and October 2003 and March 2004 (study period two).*

Species name	Common name	Fishers using bait organism (%) 1st study	Fishers using bait organism (%) 2nd study
Upogebia africana	Mudprawn	75	72,8
Callianassa krausii	Sandprawn	12,9	16,4
Mugilidae spp.	Mullet	1,9	3,4
Sardinops sagax	Pilchars	21	20,5
Loligo vulagaris reynauldii	Chokka squid	3,0	9,0
Arenicola loveni	Bloodworm	0,2	3,0
Solen capensis	Pencil bait	0,2	1,2
Polybrachiorhynchus dayi	Tapeworm	0,0	0,6
Octopus vulgaris	Octopus	0,5	1,2
Gunnarea capensis	Rockworm	3,7	1,1
Various species	Pinkprawn	1,2	0,7
	Artificial lures	1,4	0,7

4 Discussion

The Great Fish Estuary is situated in a rural area of the Eastern Cape Province in South Africa. Consequently, the dominance of subsistence fishers is likely, as witnessed during the first study period. However the results of Pradevand and Baird (2002) between January 1996 and April 1997 and the second study revealed more recreational fishers in the fishery. These differences may be explained by examining the sampling protocol of each study. Sixty percent of the surveys by Pradevand and Baird (2002) were conducted on weekend days. Similarly, two-thirds of the surveys in the second study period were conducted on Fridays or Saturdays. In contrast, only one third of the surveys in the first study period were conducted on weekend days. These differences in the sampling protocol may have influenced the results, particularly since the number of recreational fishers was significantly higher on weekend days and the number of subsistence fishers was significantly higher on weekdays in both study periods.

The proportion of recreational boat fishers was considerably different between the first (5.0%) and second study period (22.5%). However, Pradevand and Baird (2002) noted that 41.0% of the fishers fished from boats. As with the racial composition of fishers, it appears that the proportion of boat fishers recorded was related to the sampling protocol. In addition, the inclusion of the point access surveys in the second study period ensured that a higher proportion of boat fishers were interviewed. These results have some implications for the design of future estuarine fishery surveys. To adequately assess an estuarine fishery and the dynamics of the fisher sector participants, we suggest that the ratio of weekday and weekend day surveys is proportionate to the same day type in a calendar year. This approach was adopted during the first study period (March 2000 - February 2001). In addition, the study survey procedure conducted in each estuary must be carefully designed to ensure maximum coverage for all user groups. Since each estuarine fishery is likely to be different in nature, a pilot study that considers the behaviour of the various user groups is suggested before the survey procedure is designed.

There were a far greater proportion of younger fishers from both the subsistence and recreational groups in the second study period. The increase in the young recreational fishers could be attributed to the enhanced popularity of the caravan park as a family destination. In a socio-economic study of the lifestyles of subsistence fishers, Branch *et al.* (2002) found that most subsistence fishers were between 22 and 40 years of age. While the results from the first survey period appear to be agreement with those of Branch *et al.* (2002), the sharp increase in young subsistence fishers could be attributed to fishers being recent school leavers without employment.

Spotted grunter, dusky kob and white seacatfish were the dominant species in both survey periods as well as in Pradevand and Baird's (2002) study. This result is expected as Ter Morsthuizen *et al.* (1996) using gillnets found that these were the most dominant species in the Great Fish Estuary. In addition, the spotted grunter is one of the most dominant estuarine fishery species throughout its distributional range. This fish was most frequently captured in the six of the eight Eastern Cape estuaries surveyed by Pradevand and Baird (2002). In Kwazulu-Natal this fish was the most frequently captured species in the Kosi Lake estuarine line fishery (James *et al.* 2001) and second most dominant species in the fishers catches in St Lucia estuary (Mann et al. 2002).

A high percentage of all fish landed were below the legal size limit in both studies. This is expected since estuaries are known to function as nursery areas for the juveniles of at least 81 fish species (Day 1981, Wallace *et al.* 1984, Whitfield 1998). A disturbing trend observed in both studies was the high percentage of undersize fish that were retained by the fishers. With the exception of spotted grunter in the second study, more that half of all undersize fish landed were retained. Although minimum size limits, in theory, have the potential to substantially reduce fishing mortality, it appears that the reluctance of fishers to return undersize fish prevents this fishery-control option from offering an effective means of reducing fishing mortality.

Bag limits are another fishery-control option used to reduce fishing mortality. However, several studies have shown that this is an ineffective method of reducing total catch for most species (Bennett *et al.* 1994, Attwood and Bennett 1995, Cowley *et al.* 2002). This study has provided further evidence of the inadequacy of this fishery-control option since the current legislated bag limit for spotted grunter and dusky

kob was reached by less than 2 % and 1% of the fishers, respectively.

On closer inspection of the results from the second study, it appears that a reduction in the bag limit from 5 to 4 would only result in a 5% reduction in the retained catch for both species (**Figure 12**). A reduction in the bag limit from 5 to 3 would result in a reduction in the retained catch of about 15% for spotted grunter and about 10% for the dusky kob (**Figure 12**). The new proposed bag limit for the dusky kob is 1 fish per angler per day, while the bag limit for spotted grunter will remain at 5 fish per angler per day. In the Great Fish Estuary, the reduction of the bag limit for dusky kob will result in a substantial 42.3% reduction in the retained catch of this species. However, as with the size limit regulations, this fishery-control option will only function effectively if the regulations are observed. Since very few fisheries law enforcement officers were observed during the both survey periods, it is unlikely that compliance with the new bag and size limits will be observed.

There was a large increase in fishing effort and a difference in fisher distribution between the two study periods. Despite the fact that the second study period was only six months long, the total effort estimate for all user groups was higher than the first study period. In addition, the recreational boat and subsistence fishing effort was considerably higher in the second study period. The biggest change in the distribution of fishers was the marked increase (10% to 33%) in the proportion of fishers on the west side in the Great Fish River Wetlands Reserve. The increase in the cost of admission to the caravan park may have played a role in this change. Although the number of fishers in the caravan park was similar, the proportion of fishers was reduced from 29% in the first to 12% in the second study. It is assumed that the fishers in the Great Fish River Wetlands Reserve were not prepared to pay the caravan park admission fees. Another change in the distribution of effort is the presence of fishers in the Kap River Reserve, where road access is now permitted to some individuals. While the effort in the Kap River Reserve in the second study was limited, it is expected to increase. The increased effort in the Great Fish River Wetlands Reserve was mirrored by an increase in catches in this area in the second study. In addition, the high effort occurring on the eastern bank in both studies resulted in substantially higher catches in this area. This begs the question whether area management (eg. protected areas or restricted access) could be an effective fishery (effort) control measure in the Great Fish and other estuaries and is an area worthy of further research attention.

Figure 12
The percentage retained fish reduction for daily bag limit restrictions of five fish or less, based on bag frequencies collected in the second study period in the Great Fish Estuary.

The *cpue* of fishers in the Great Fish Estuary during the first (0.22) and second (0.16) study periods were similar to the overall *cpue* for the St Lucia estuarine system (0.19) (Mann *et al.* 2002) and the Kosi estuarine lake system (0.16) (James et al. 2001) between 1986 and 1999. The substantial reduction in the cpue from the first to the second study period appears to be a characteristic of estuarine systems where large annual differences in *cpue* are common (Mann *et al.* 2002, James *et al.* 2001).

Although the second study was half the duration of the first study period, the overall catch was only one-third less than recorded in the first study period. It is therefore likely that the annual catch for the second study period will exceed that of the first study period. The estimated annual catch (in numbers) in the first study period was approximately 20% lower than that for the nearby Kowie Estuary over the same period. Subsistence fishers captured the majority of fishes during both study periods. However, the effect of the increase in recreational boat fishing in the second study was evident, as this group accounted for more than 4 times the number captured during the first study period.

Aspects of the bait fishery were very similar between the two study periods. The high proportion of fishers using mud prawn and sand prawn in this estuary suggests that there may be opportunities to establish a small scale bait fishery for these species. Despite the lack of truly quantitative assessments, these species are considered fairly resilient to several high levels of exploitation (Britz *et al.* 2001). The development of a subsistence bait fishery may have some potential in the Great Fish Estuary. Such a fishery could offer the current subsistence fishers a better livelihood and also alleviate some of the pressure on the fish resource.

The results of this study have highlighted changes in the Great Fish Estuarine fishery over the last few years. These include changes in the fisher demographics, effort, effort distribution, cpue and total catch. However, due to the short-term nature of both study periods, few conclusions can be drawn with regards to trends in the fishery. Due to the dynamic nature of estuaries, estuarine fisheries are likely to show large short-term variability and therefore, long term monitoring studies such as those conducted by James *et al.* (2001) and Mann *et al.* (2002) are the only conclusive method for examining trends in the dynamics of estuarine fisheries.

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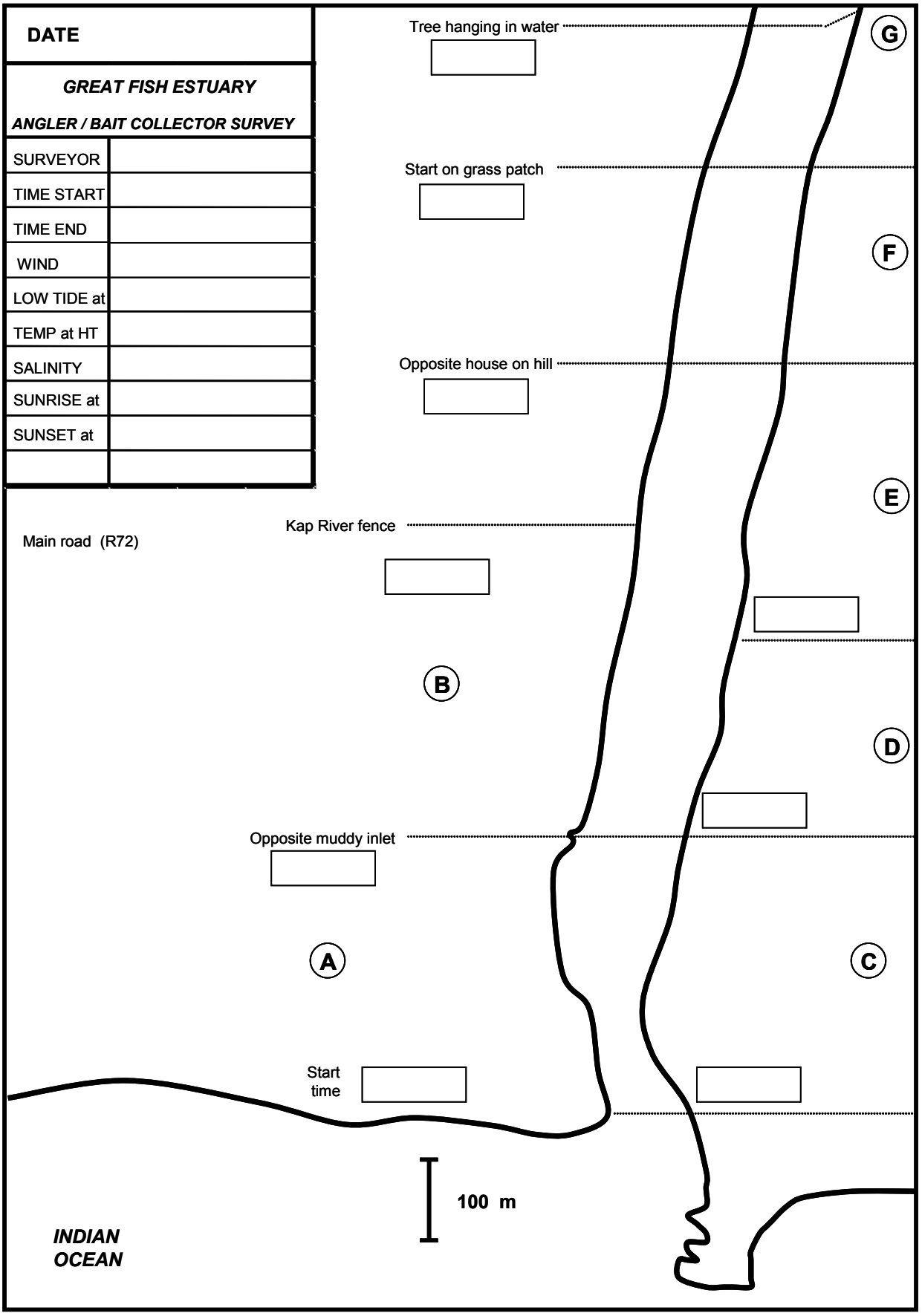
Appendix 1.


DATE
GREAT FISH ESTUARY
ANGLER / BAIT COLLECTOR SURVEY
SURVEYOR
TIME START
TIME END
WIND
LOW TIDE at
TEMP at HT
SALINITY
SUNRISE at
SUNSET at
Tree hanging in water
Start on grass patch
Opposite house on hill
Kap River fence
Main road (R72)
Opposite muddy inlet
Start time
G
F
E
B
D
A
C
100 m
INDIAN OCEAN

Appendix 2.

DATE			ESTUARY		
Name, sex and age:				Method used	Number got
Home town:			mud prawns		
Subs / recr:	Zone (see map):		sand prawns		
Rods / lines (n):					
Time Start:	Time now:		Expected time end:		
Fish species	Fork (mm)	Total (mm)	Bait used	Time caught	Kept / Rtn

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