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Trends in fishery resource utilisation on the Great Fish Estuary

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Great Fish Estuary Programme:

Behaviour and management of important estuarine fishery species

A project within the South Africa / Norway Programme on Research Cooperation

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

Aspects of the recreational and subsistence fisheries in the estuary were 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 fishers, classification of anglers (recreational or subsistence), whether they were fishing from land or boat, and their position were done while manually tracking the fish. Information on demographics, resource use sector, area use, catch, and effort were obtained through rowing creel surveys.

Funding and project partners

The following institutions collaborate on the project: the South African Institute for Aquatic Biodiversity (SAIAB), the 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 projects were funded by the South Africa / Norway Programme on Research Cooperation (National Research Foundation of South Africa, and the Research Council of Norway), the South African Institute for Aquatic Biodiversity (SAIAB), the Norwegian Institute for Nature Research (NINA), and East Cape Estuaries Management Programme (Marine and Coastal Management). We would like to thank these institutions for their financial support.

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Abstract

Potts, W.M., Cowley, P.D., Corroyer, B. & Næsje, T.F. 2005. Trends in fishery resource utilisation on the Great Fish Estuary. - NINA Report 50. 34pp.

The Great Fish Estuary, located in the Eastern Cape Province, is becoming an increasingly popular fishing venue. A resource utilisation study consisting of a series of roving creel interview surveys was conducted in the estuary between March 2001 and February 2002 and between October 2003 and September 2004. During interviews with resource users, demographic information as well as catch, effort, bait, duration of the fishing trip and number of rods/lines were obtained. Recreational shore fishers dominated during both study periods (54 %, both periods), followed by subsistence fishers (40 % - 1st study period, 23 % - 2nd study period) and recreational boat fishers (5 % - 1st study period, 23 % - 2nd study period). The increase in recreational boat fishers between the two study periods, was most probably attributed to the increased sampling on weekend days during the second study period and to the improved infrastructure at the Fish River Diner Caravan Park. Spotted grunter (*Pomadasys commersonnii*) and dusky kob (*Argyrosomus japonicus*) dominated the catches during both study periods. The overall catch per unit effort was lower during the second (0.19 fish/angler-hour) than during the first (0.22 fish/angler-hour) study period, while the distribution of fishing effort was more widespread during the second study period than in the first. The total fishing effort during the second study period was twice as high (122 044 hrs), while the total catch was only one third higher (18 978 fish) than in the first study period (60 436 hrs and 12 752 fish, respectively). Results from the two study periods were used to make recommendations for the design of future estuarine fishery surveys. While the study showed a variety of short-term fluctuations, long term monitoring studies are recommended to examine trends in the Great Fish Estuary fisheries and other estuarine fisheries in South Africa.

Contents

1 Introdution

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, which 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), and the ongoing study of movement behaviour, migrations and habitat use of spotted grunter (*Pomadasys commersonnii*) and dusky kob (*Argyrosomus japonicus*) (this programme), fisheries research in the estuary has been largely ignored except for a brief linefishery assessment by Pradevand and Baird (2002).

This report documents the findings and compares two, year long, resource utilisation studies conducted on the Great Fish Estuary, the first, between March 2001 and February 2002 and the second between October 2003 and September 2004. The aims of this report are to describe the demographics, catch composition, effort, catch per unit effort (*cpue*), estimated catch and bait organism utilisation of the various user groups in the two study periods, and study possible differences between the two 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, and 27° 13' 06" E. A road bridge crosses the estuary approximately 1 km from the mouth (Vorwerk *et al.* 2001, **Figure 1**). The 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. In the mouth region of the estuary the main channel is usually approximately 30 m wide and 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).

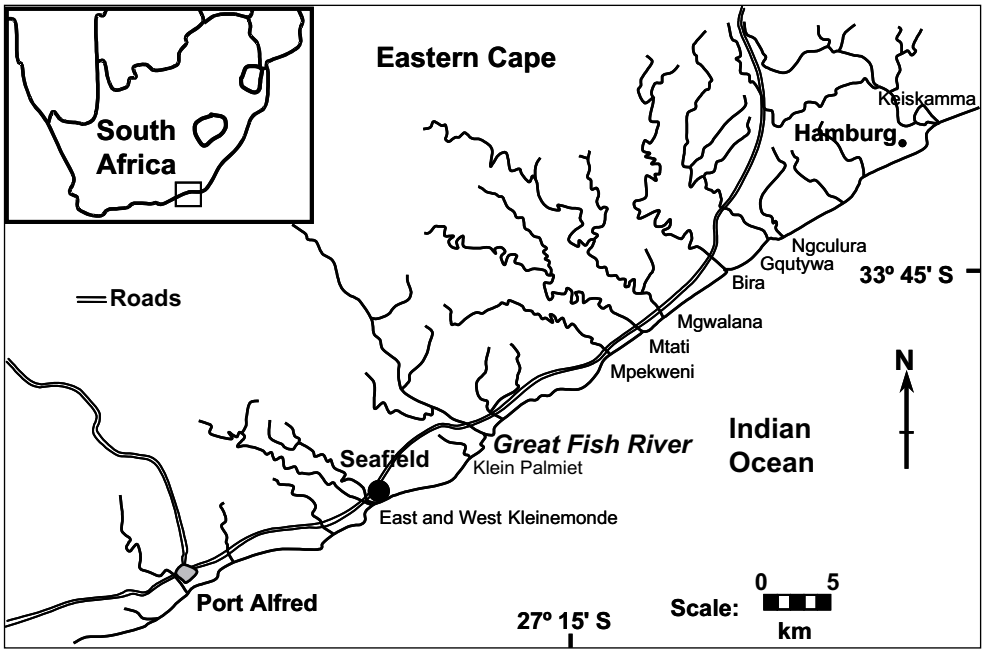

***Figure 1**. Map of the coastal region between Port Alfred and Hamburg (Eastern Cape), showing the location of the Great Fish Estuary and neighbouring estuaries.*

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 30 km east of Port Alfred (see **Figure 2**), provides access to the western shore of the estuary, between the mouth and just above the R 72 road bridge. This area, that 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 50 m 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 3 km 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 were 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 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 R 72 or via an old vehicle track over privately owned land (see **Figure 2**).

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 in this report and compared with those from the second study period.

In the fist study period 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 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).

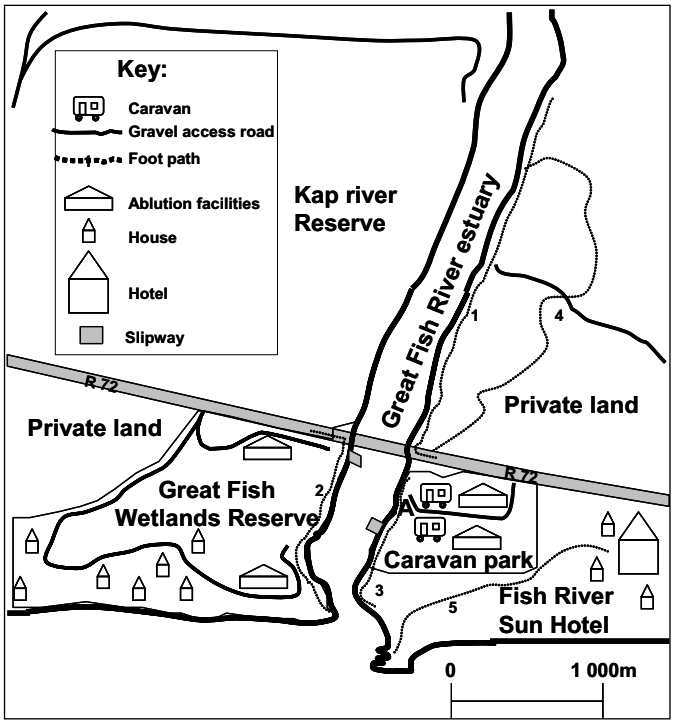

***Figure 2**. Detailed map showing the main access routes and land-use around the lower regions of the Great Fish Estuary. 1 - 5 indicate footpaths.*

Period two

In the second study period 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 comparable 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 and adjusted using point counts from a fixed position at 08h00 and 17h00 on the Sunday and Monday after each Saturday survey.

2.4 Survey procedure

Three groups of fishers 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 when they departed. 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. All boat fishers above the bridge were recorded 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 as most fishers continued fishing after the interview. 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. These individuals were interviewed at the slipway access point sites when they departed (**Figure 2**). This provided us with "complete trip" data from the recreational boat fishery. Not all boat fishers completed their trips during the survey period and hence, were 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. 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, 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/or 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 type used and the number of bait organisms of each type removed from the estuary.

For anglers who had been fishing consistently since the previous day, total catch was fish 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.

2.5 Data analysis

Distance from home:

The location of the fishers permanent home was used to calculate the distance that they travelled to the estuary. Distance travelled was separated into categories: < 15 km, 15-50 km, 50-100 km and over 100 km, and compared between user groups and the two studies using a chi square analysis.

Effort:

A number of different terms, referring to fishing effort are used in this report:

Fishing effort: The amount of fishing time spent by an individual, group or sector of fishers in a day, month or year (expressed in angler-hours).

Observed effort: The amount of fishing time recorded by the survey clerk for an individual fisher on a survey day.

[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)*

Turnover time: The duration of a daily fishing trip by a fisher (expressed in hours and minutes).

Total daily effort: The calculated number of angler-hours for each survey day.

Total monthly effort: The calculated number of angler-hours for each month.

Total annual effort: The calculated number of angler-hours for the year.

For comparative purposes, the unit of fishing effort chosen was angler-hours. In 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 was used. 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 sectors. Differences in the number of fishers between weekend and weekdays and between survey period one and two were tested using a factorial ANOVA.

To calculate annual effort in survey period one, we first calculated monthly weekday effort as:

$$E_{mw} = \left[\frac{\sum^{n} E_{wkd}}{n} \times M_{wkd} \right] + \left[\frac{\sum^{n} E_{wke}}{n} \times M_{wke} \right] \qquad (1)$$

where E_{wkd} is the number of angler hours recorded during the weekday surveys in that month, M_{wkd} is the number of weekdays in the month, E_{wke} is the number of angler hours recorded during the weekend or public holiday survey in that month and M_{wke} is the number of weekend and public holiday days in the month.

Results from the point surveys in survey period two were used to determine the differences in effort between Sundays and Mondays when compared with the survey days. The point surveys indicated that the mean number of fishers on Sundays was similar to Fridays and the mean number of fishers on Mondays was 60% less than on Tuesdays, Wednesdays and Thursdays. Consequently, effort on Sundays was assumed to be equal to Fridays and Monday effort was assumed to be 60% lower than the effort on the weekdays. Monthly weekday effort (E_{mw}) was therefore calculated as:

$$E_{mw} = \left[\frac{\sum^{n} E_{twt}}{n} \times 0.4 \times M_{mon} \right] + \left[\frac{\sum^{n} E_{twt}}{n} \times M_{twt} \right] + \left[\frac{\sum^{n} E_{fri}}{n} \times M_{fri} \right] \qquad (2)$$

where E_{twt} is the number of angler hours recorded during the Tuesday, Wednesday or Thursday surveys, M_{mon} is the number of Mondays in the month, M_{twt} is the number of Tuesdays, Wednesdays and Thursdays in the month, E_{fri} is the number of angler hours recorded during the Friday surveys and M_{fri} is the number of Fridays in the month.

Monthly weekend effort (E_{mwk}) was calculated as:

$$E_{mwk} = \left[\frac{\sum^{n} E_{sat}}{n} \times M_{sat} \right] + \left[\frac{\sum^{n} E_{fri}}{n} \times M_{sun} \right] \qquad (3)$$

where E_{sat} is the number of angler hours recorded during the Saturday surveys, M_{sat} is the number of Saturdays in the month, E_{fri} is the number of angler hours recorded during the Friday surveys and M_{sun} is the number of Sundays in the month.

Monthly effort (E_m) for both study periods was calculated as:

$$E_m = E_{mw} + E_{mwk} \qquad (4)$$

Total annual effort was calculated as the sum of the monthly effort estimates.

Catch per unit effort (*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 total catch

The estimated total monthly catch for both study periods was calculated by multiplying the mean monthly *cpue* by the total calculated fishing effort for that month. The estimated total catch was obtained by summation of the monthly catches for each study period.

Law enforcement

The number and affiliation of law enforcement officials was recorded during the second study period. In addition, their interaction with the various user groups was monitored. When fishers were subsequently intercepted, details of their interaction with law enforcement officials were requested.

Optimising the data collection protocol

Since fishery surveys require relatively large amounts of manpower and field time, it is preferable to optimise the efficiency of the data collection process. An experimental design that ensures unbiased data collection and maximises the information collected, while also reducing the manpower and time spent in the field is most preferable. The more intensive second study provided an opportunity to test the potential consequences of reducing the field time by half, while maintaining the same, randomly stratified sampling protocol. Therefore, from the raw data in the second study, we randomly discarded data from one of the two weekdays, in addition to Fridays and Saturdays and estimated total effort and *cpue* using the methods described above. The results were compared to those from the complete data set using ANOVA.

[2] *The measured (or estimated) lengths of all fish caught were converted to mass using the length : 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 fisher 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

A total of 717 and 1 911 interviews were conducted in the first and second study periods, respectively. In both study periods, most of the fishers interviewed were recreational shore fishers (54 % in both study periods), followed by subsistence (40 % - first period, 23 % - second period) and recreational boat fishers (5 % - first period, 23 % - second period) (**Figure 3 and 6**).

Of the 375 fishers interviewed in the first study period, 45 % were black, 37 % were white and 17 % were coloured. In the second study period, the majority of the 912 fishers interviewed were white (65 %), followed by black (20 %), coloured (11 %) and indian (4 %). 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 (0.1 %) and 74 female recreational fishers (8.1 %) 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 - 19 years). Similarly, amongst the recreational fishers, the proportion of young fishers (0 – 19 years) increased in the second study period (**Figure 4a**).

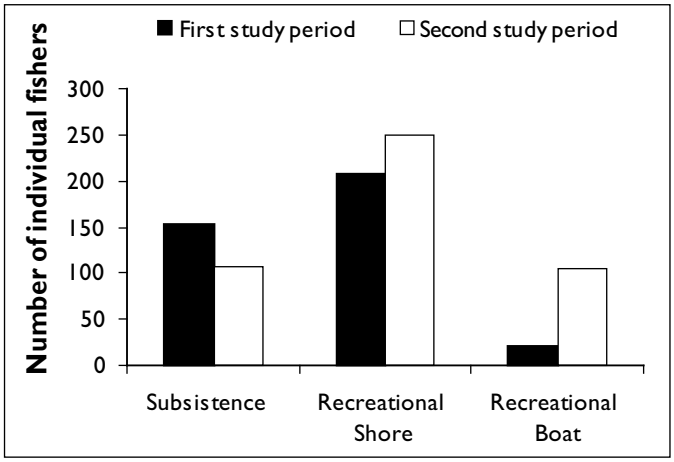

***Figure 3**. Comparison of the fishery user groups (no of fishers) in the Great Fish Estuary between March 2001 - February 2002 (first study period) and October 2003 - September 2004 (second study period).*

Although the majority of recreational users resided between 50 and 100 km from the estuary in both study periods (**Figure 5**), a significantly greater proportion of recreational fishers travelled over 100 km in the second study (**Figure 5**) ($\chi^2 = 14.1$; $p < 0.05$). In both studies very few of the recreational fishers interviewed lived within 15 km of the estuary (**Figure 5**).

In both study periods all subsistence fishers travelled less than 50 km from their permanent homes to the estuary. In the first study, 50 % of subsistence fishers resided in Peddie, 35 % in Port Alfred and the remainder within 50 km from the estuary. In the second study, 70 % of subsistence fishers resided in Peddie, 27 % in Port Alfred and the remaining 3% within 50 km from the estuary.

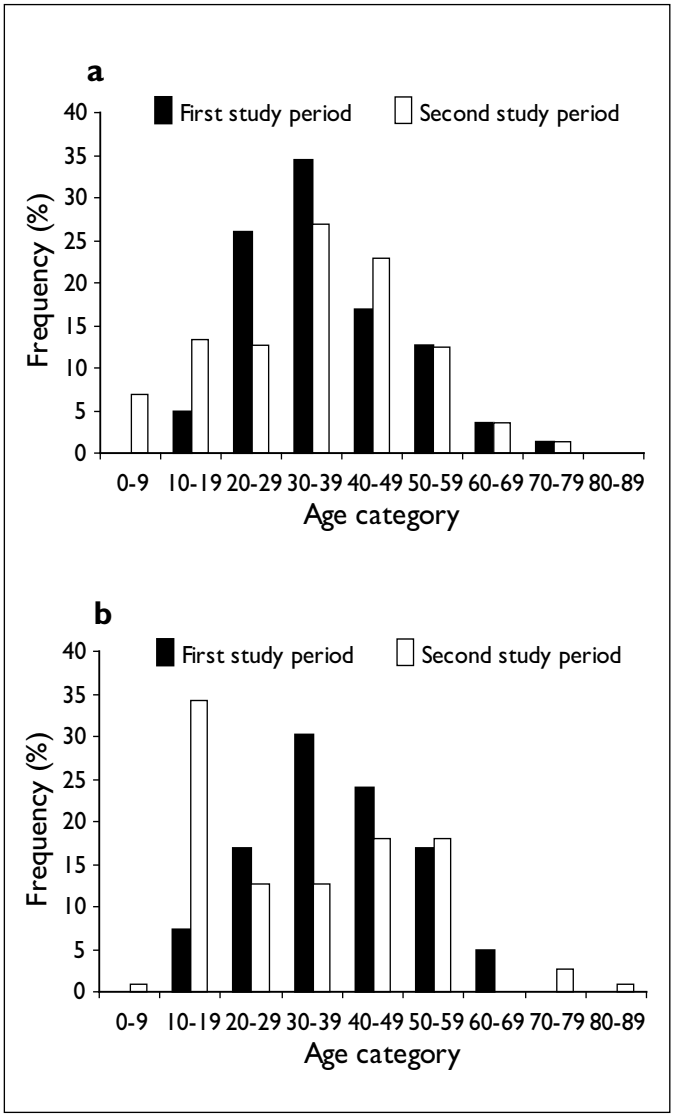

***Figure 4**. Age group frequency distribution of (a) recreational, and (b) subsistence fishers, interviewed on the Great Fish Estuary between March 2001 and February 2002 (first study period) and October 2003 and September 2004 (second study period)*

Seventeen recreational and 16 subsistence fishers that were interviewed during the first study were re-interviewed during the second study. Within each study period, the turnover of individual fishers was relatively high with 77 % and 72 % of individual fishers were interviewed on only one occasion in the first and second study periods, respectively (**Figure 6**). Seventeen and 24 % were interviewed between two and five times during the first and second study periods, respectively (**Figure 6**), while less than 5 % of the fishers were interviewed more than 10 times during both study periods (**Figure 6**).

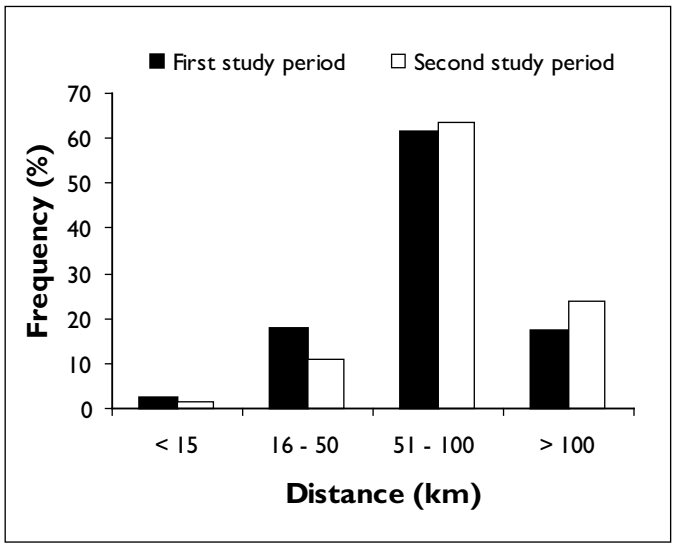

***Figure 5**. Comparison of the distance travelled by recreational fishers from their home to the Great Fish Estuary between March 2001 and February 2002 (first study period) and October 2003 and September 2004 (second study period).*

3.2 Catch composition

The species composition in the fishers catches comprised seven species during the first study and twelve species during the second study. The relative catch composition was, however, 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, while 86 % of the spotted grunter, 56 % of the dusky kob and 50 % of the white seabarbel were retained during the second study (**Figure 7**).

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 the first study period (**Tables 2**). During the second study period, subsistence fishers captured the most spotted grunter and white seabarbel in weight, while recreational shore fishers captured the most dusky kob (**Table 3**).

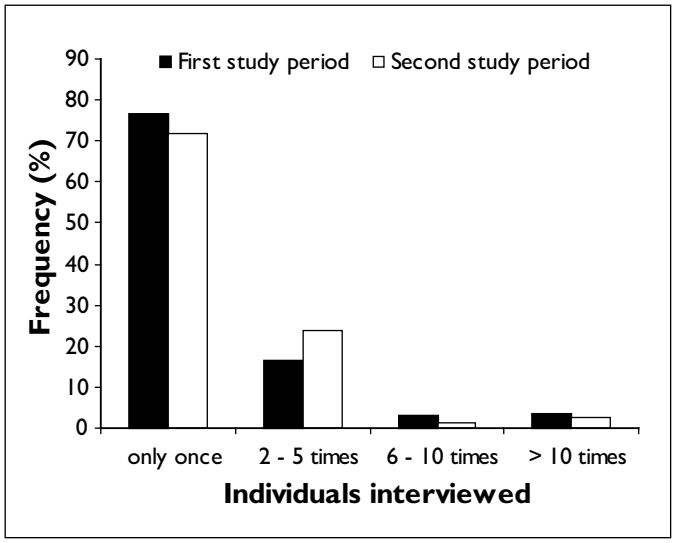

***Figure 6**. Number of times that individual fishers were interviewed at the Great Fish Estuary between March 2001 and February 2002 (first study period) and October 2003 and September 2004 (second study period).*

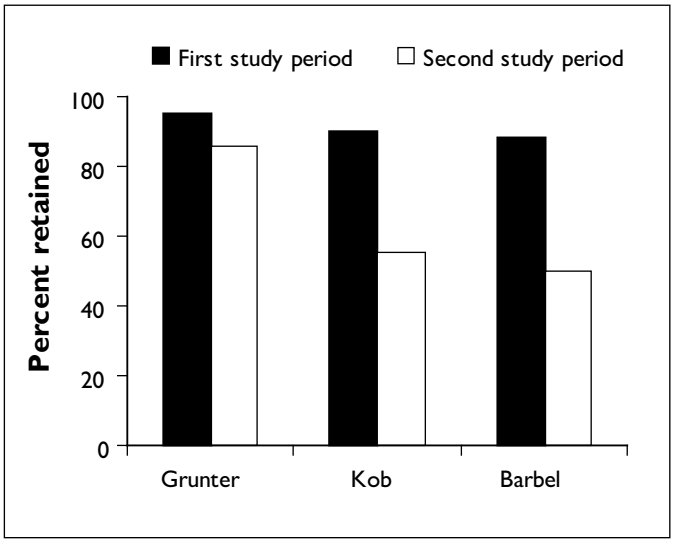

***Figure 7**. Percent retained fish for the dominant fishery species on the Great Fish Estuary between March 2001 and February 2002 (first study period) and October 2003 and September 2004 (second study period).*

Table 1. *Angler catch composition (both retained and released fish) in numbers (No.), numbers in percent (No. %), mass (Mass kg), and mass in percent (Mass %) for the Great Fish Estuary between the first (March 2001 - February 2002) and second (October 2003 - September 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	1829	54.1	53.8	331.9	1936	52.1	58.5
Argyrosomus japonicus	Dusky kob	167	638	22.9	18.8	168.0	645.3	26.4	19.5
Galeichthys feliceps	White seabarbel	145	777	19.9	22.9	100.2	558.0	15.6	16.9
Lithognathus lithognathus	White steenbras	14	78	1.9	2.3	23.9	128.62.6	03.6	3.9
Rhabdosargus holubi	Cape stumpnose	4	28	0.6	0.8	0.7	21.9	0.1	<0.1
Clarias gariepinus	Sharptooth catfish	0	23	0	0.7	0	0	0	0.7
Cyprinus carpio	Common carp	2	0	0.3	0.0	7.1	2.6	1.1	0
Acanthopagrus berda	River bream	1	4	0.1	0.1	0.37	9.4	0.1	<0.1
Rhinobatos annulatus	Lesser sandshark	0	9	0	0.3	0	4.1	0	0.3
Diplodus sargus capensis	Blacktail	0	6	0	0.2	0	0.3	0	0.1
Mugil cephalus	Flathead mullet	0	2	0	0.1	0	?	0	<0.1
Amblyrhynchotes honkennii	Evileye blaasop	1	3	0.1	0.1	?	3.0	?	?
Sparadon durbanensis	Musselcracker		1		<0.1			0	0.1
TOTAL		728	3398			637	3178		

Table 2. *Contribution in numbers and weight 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 in numbers and weight of the total landed catch by the different fisher groups between October 2003 and September 2004 (values given as % of total landed catch).*

	Subsistence		Recreational boat		Recreational shore	
	No (%)	Mass (%)	No (%)	Mass (%)	No (%)	Mass (%)
Spotted grunter	59	65	22	19	19	16
Dusky kob	32	33	51	24	17	42
White seabarbel	45	45	35	30	20	25

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 – September 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		<1		
200-299	9	2	16	4		21
300-399	46	26	39	29	43	6
400-499	29	41	28	35	29	21
500-599	11	22	7	22	14	26
600-699	3	8	6	6	14	23
700-799	1	<1	3	4		4

3.3 Size composition

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 the corresponding values were, 29 % of the spotted grunter, 55 % of the dusky kob and 73 % of the white steenbras were undersize (**Table 4**).

Monthly catches of major species

In the first study period, spotted grunter was present in catches during all months of the year except June, and this species was the dominant component by number and mass during most months (**Figure 8**). Although dusky kob was recorded in angler catches for all months, it only dominated catches during May (both number and mass) (**Figure 8**). White seabarbel consistently constituted a noticeable proportion of the catches by number throughout the year, constituting the majority of the catch by number in June, July and August, and by mass in June and July (**Figure 8**).

In terms of mass, spotted grunter dominated the catches in the second study except in November, December and August when dusky kob was dominant (**Figure 9**). Spotted grunter also numerically dominated the catches in all months except for November and December when dusky kob was dominant and in August where white seabarbel the dominant catch. As in the first study, white seabarbel was consistently captured in relatively large numbers throughout the year (**Figure 9**). The catches of spotted grunter during both survey periods peaked in the warmer months (September – April), while the only major peak in dusky kob catches was in December (**Figure 9**).

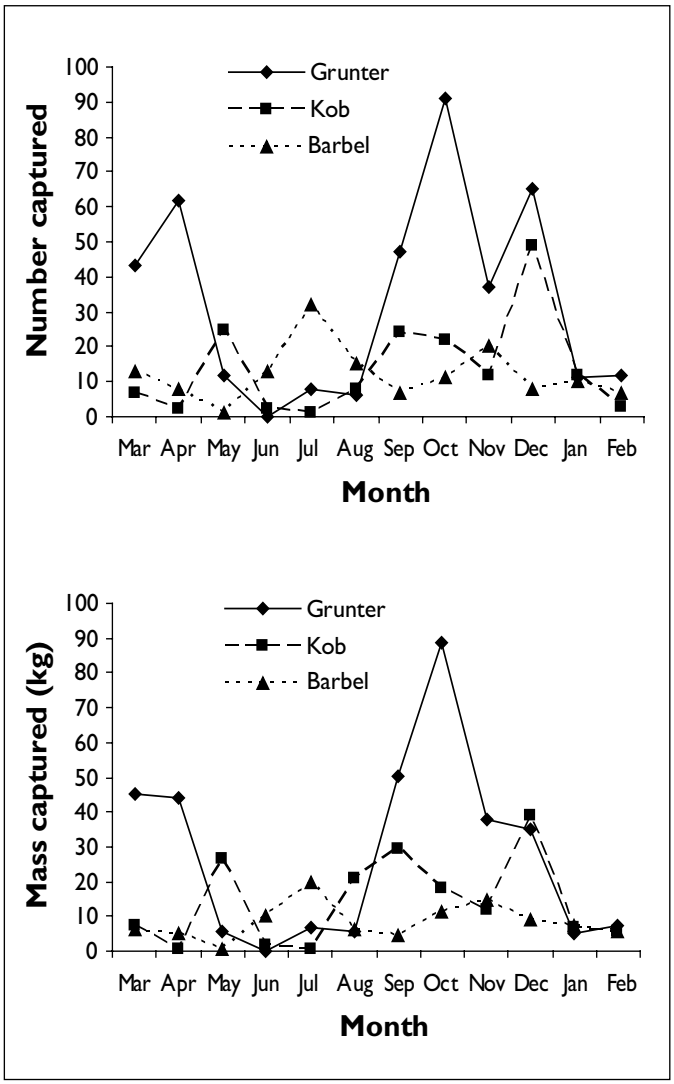

Figure 8*. Monthly catches (a = numbers, b = mass) of spotted grunter, dusky kob and white seabarbel by fishers in the Great Fish Estuary between March 2001 and February 2002.*

3.4 Angler bag frequencies

The maximum daily catch of spotted grunter by an individual angler was 13 and 25 fish in the first and second study periods, respectively (**Figure 10 and 11**). The maximum daily catch of dusky kob by an individual angler was 10 and 25 in the first and second study, respectively. Of the 717 fishermen interviewed in the first study, most failed to capture a spotted grunter (78 %) (**Figure 10**) and dusky kob (89 %) (**Figure 11**) on a single day outing. Similarly, during the second study, of the 1911 fishermen interviewed, most did not catch a spotted grunter (65 %) (**Figure 10**) and dusky kob (86 %) (**Figure 11**). Of the fishers that did catch a fish, a catch rate of only one fish angler^{-1} day^{-1} was most frequently observed in both studies (**Figure 10 and 11**). The bag limit for spotted grunter was exceeded on 1.8 % of fisher outings in the first study and by 3.2 % during the second study. The bag limit for dusky kob was exceeded on 0.6 % of fisher outings during both study periods.

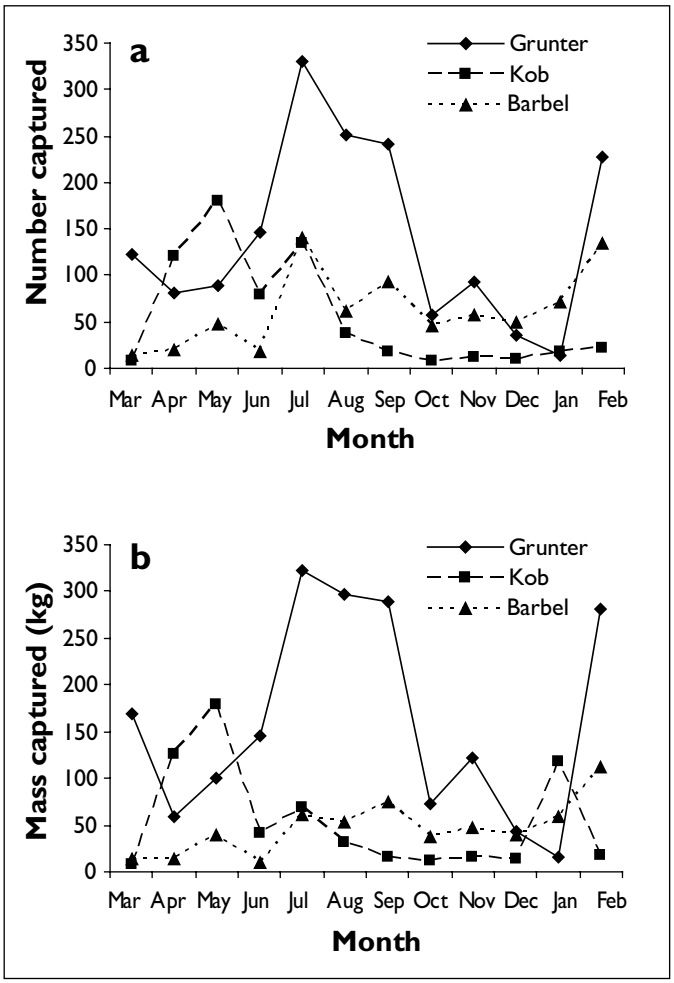

***Figure 9**. Monthly catches (a = numbers, b = mass) of spotted grunter, dusky kob and white seabarbel by fishers in the Great Fish Estuary between October 2003 and September 2004.*

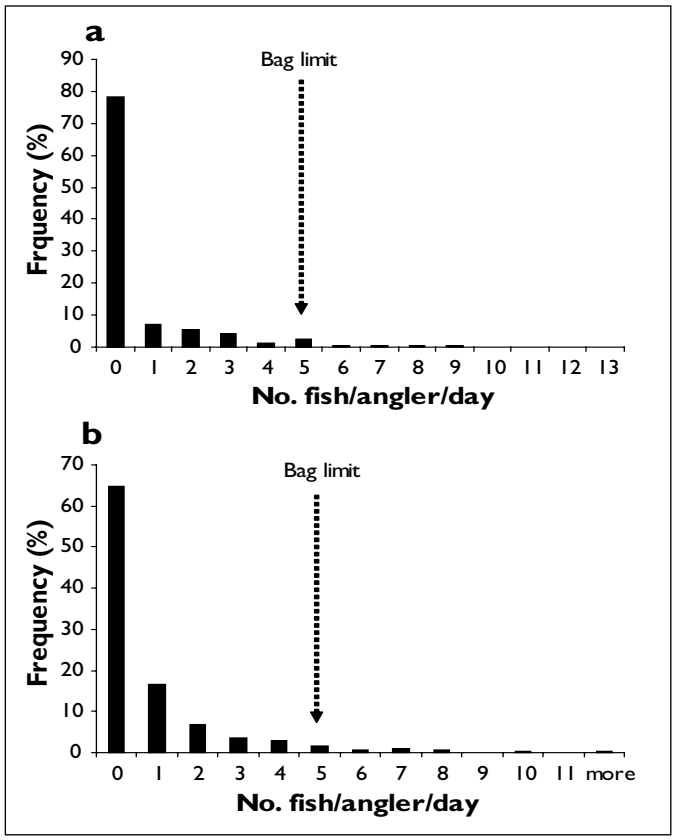

***Figure 10**. Angler bag frequency for spotted grunter on the Great Fish Estuary. a = March 2001 – February 2002, b = October 2003 – September 2004. The bag limits is indicated by the arrows.*

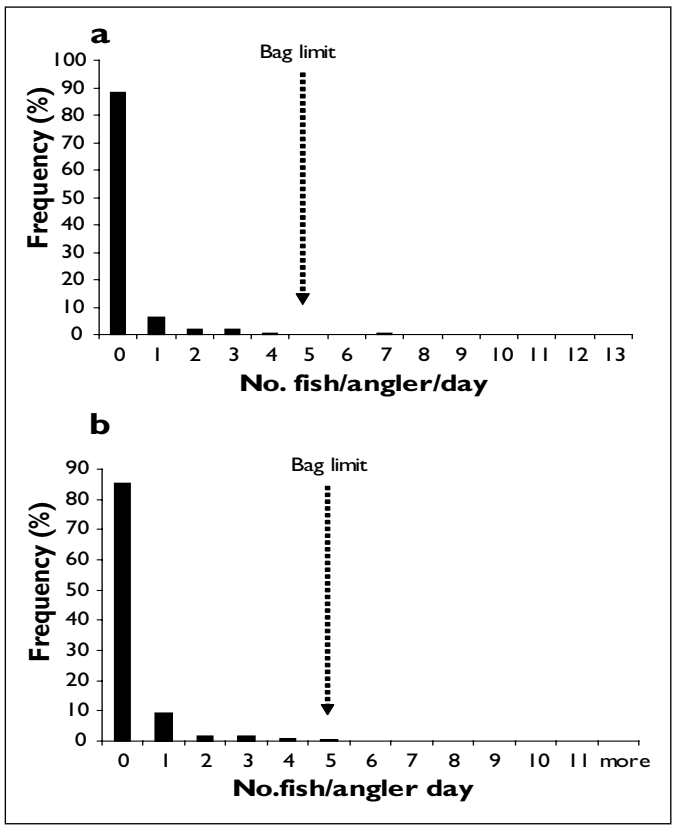

***Figure 11**. Angler bag frequency for dusky kob on the Great Fish Estuary. a = March 2001 – February 2002, b = October 2003 – September 2004. The bag limits is indicated by the arrows.*

3.5 Weekday and weekend effort

There was a significant increase in the mean number of recreational boat ($p < 0.01$), recreational shore ($p < 0.01$) and subsistence fishers ($p = 0.01$) between the first and second study periods (**Figure 12, Table 5**). When combining the data from both studies, there was a significantly higher number of recreational boat ($p = 0.02$) and recreational shore fishers ($p < 0.01$) and a significantly lower number of subsistence fishers ($p = 0.02$) on weekend days compared with weekdays.

There was no significant difference in the number of boat fishers between weekdays and weekend days in the first study ($p = 0.99$) (**Figure 12**). However, in the second study, there was a significantly higher number of boat fishers on weekend days ($p < 0.01$) (**Figure 12**). As with the boat fishers, there was no significant difference in the number of subsistence ($p = 0.83$) and recreational shore fishers ($p = 0.30$) between weekdays and weekend days in the first study (**Figure 12, Table 5**). However, there was a significantly greater number of recreational shore and a significantly lower numbers of subsistence fishers on weekend days in the second study (**Figure 12, Table 5**).

3.6 Distribution of fishing effort

Shore fishers contributed 96 % of the 8078 angler hours recorded during the first study period. Just over 5 % 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 13a**). During the second study period, shore fishers contributed 90 % of the 23107 angler hours recorded. Approximately one quarter of shore fishing effort occurred on the western side of the estuary from the mouth to just over 1 km upriver. Three quarters of

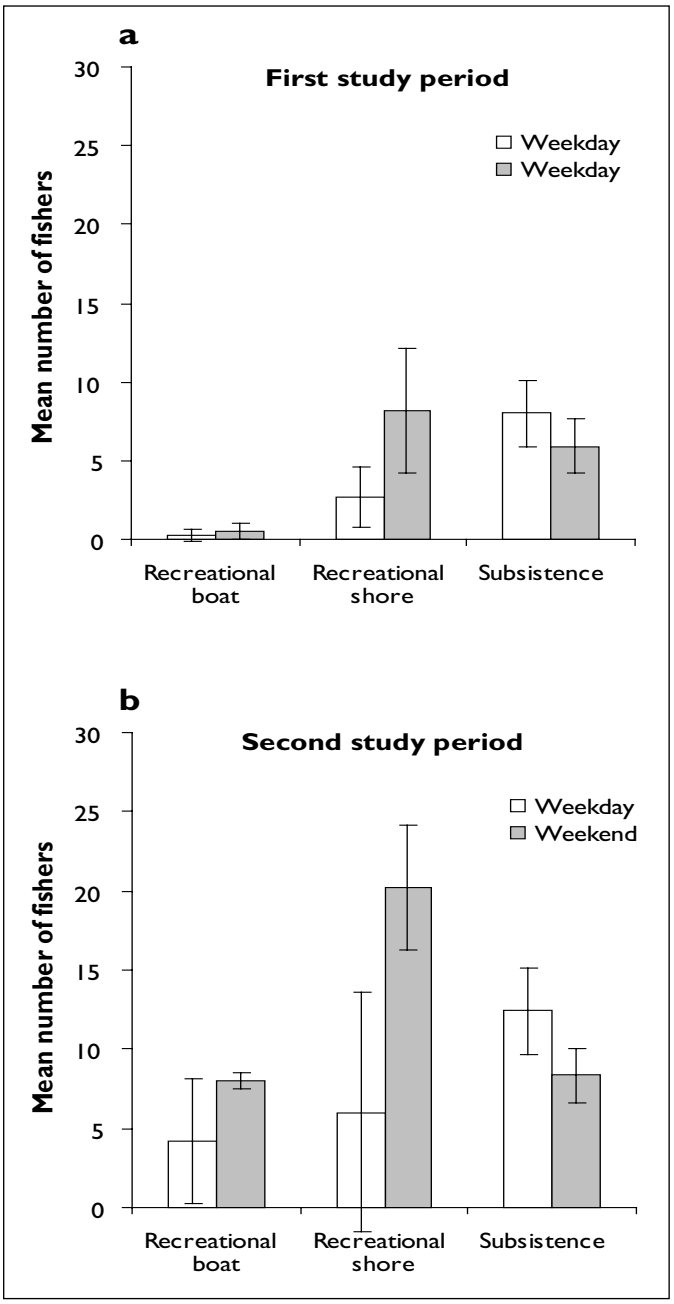

Figure 12. *Mean number of fishers (± SD) per survey day on weekend days (first period 23 days; second period 48 days) and weekdays (first period 11 days; second period 24 days) recorded on the Great Fish Estuary over the two study periods. a = March 2001 – February 2002; b = October 2003 – September 2004.*

Table 5. *Mean number of fishers (± SD) per survey day on weekend days (first period 23; second period 48) and weekdays (first period 11; second period 24) 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	05.9 ± 3.4	14.1 ± 8.9	0.3 ± 0.7	02.7 ± 3.3	8.0 ± 4.1	10.7 ± 6.3
Study period two	8.0 ± 7.8	20.2 ± 15.0	08.3 ± 5.5	28.5 ± 17.4	4.2 ± 5.3	6.0 ± 4.9	12.4 ± 8.5	18.4 ± 11.1

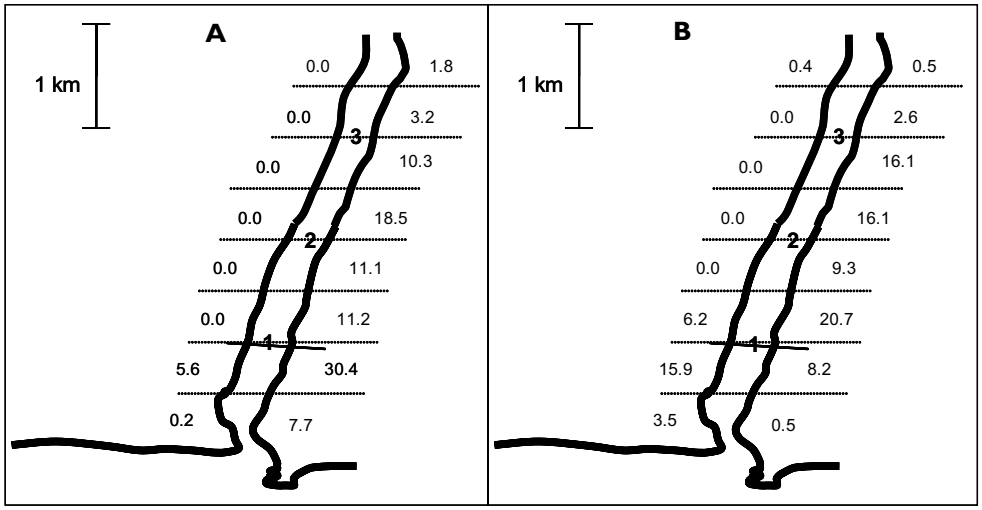

***Figure 13**. Distribution of shore fishing effort (%) in the Great Fish Estuary between a) March 2001 and February 2002 and b) October 2003 and September 2004. Dotted lines indicate 500 m intervals.*

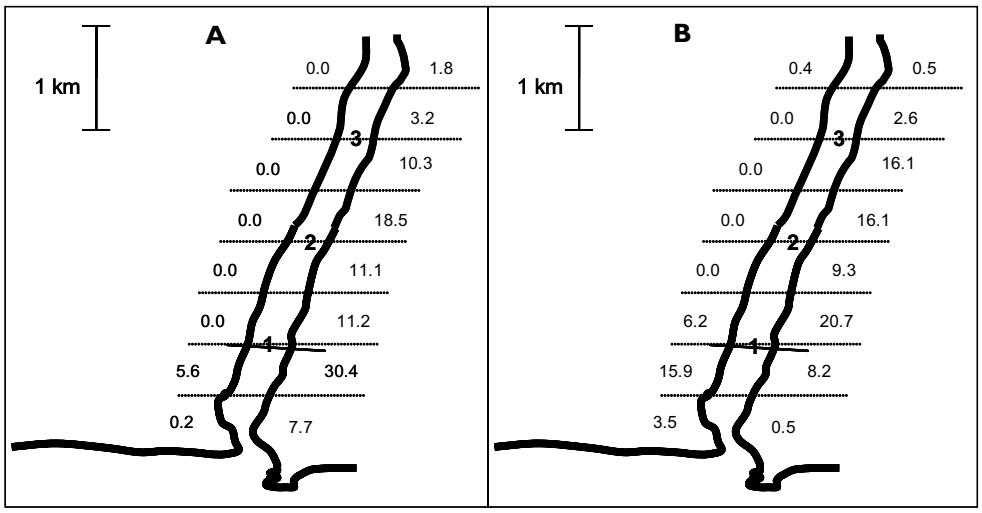

***Figure 14**. Distribution of boat fishing effort (%) in the Great Fish Estuary between a) March 2001 and February 2002 and b) October 2003 and September 2004. Dotted lines indicate 500 m intervals.*

the fishing effort was observed on the eastern side of the estuary. Ten percent of the effort occurred between the mouth and bridge (Caravan Park) on the eastern side, and the rest above the bridge (**Figure 13b**). A small amount of fishing effort was observed approximately 4 km upriver in an open access area in the Kap River Reserve.

In the first study, most of the boat fishing effort occurred between the mouth and just above the bridge (79 %), while a small amount of effort upriver (21 %) (**Figure 14**). In the second study, boat fishing occurred between the mouth and 8 km upriver. About 40 % of the fishing occurred between the bridge and the mouth. Approximately 35 % of boat fishing effort occurred between the bridge and 4 km upriver, while 25 % occurred between 4 and 8 km upriver (**Figure 14**).

3.7 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 13h05min during the first and second study periods, respectively. Subsistence fishers spent an average of 13h40min and 20h20min hours fishing each day during the first and second study period, respectively. Mean turnover time for recreational boat fishers was 13h05min and 7h20min hours during the first and second study periods, while recreational shore fishers had a mean turnover time of 12h30min and 13h05min during first and second study.

Overall, there was a 218 % increase in monthly effort between the two study periods (**Table 6**). The efforts in August, September and October were most similar between the two studies (**Table 6**). Generally, effort was highest in the warmer months (September to April), dropping noticeably during winter (May to August) (**Table 6**).

Table 6. *Comparison of the monthly fishing effort in the Great Fish Estuary between the first (March 2001 – February 2002) and second (October 2003 – September 2004) study periods.*

Month	First study (effort)	Second study (effort)	Difference	Increase (%)
March	3085.8	15196.1	12110.3	392.5
April	3350.5	8940.1	5589.6	166.8
May	2478.2	6276.6	3798.4	153.3
June	1359.3	6342.4	4983.1	366.6
July	1710.7	4967.7	3257.0	190.4
August	7406.5	5132.0	-2274.5	-30.7
September	7945.3	9362.4	1417.1	17.8
October	9893.4	10260.9	367.5	3.7
November	5288.8	14270.7	8981.9	169.8
December	7133.9	17137.1	10003.2	140.2
January	2151.7	12353.3	10201.6	474.1
February	1745.9	11805.8	10059.9	576.2
Total	53550.0	122043.9	68494.9	218.4

Table 7. *Comparison of the estimated total fishing effort of the different groups of fishers on the Great Fish Estuary between the two study periods (March 2001- February 2002 and October 2003 – September 2004).*

	1st study period Effort (hrs)	%	2nd study period Effort (hrs)	%
Recreational boat	2274	4.2	12045	9.8
Recreational shore	13065	24.4	32217	25.6
Subsistence	38210	71.4	78782	64.5
Total	53550		122 044	

Subsistence fishers accounted for most of the effort during both studies, followed by recreational shore and recreational boat fishers (**Table 7**).

3.8 Catch per unit effort (*cpue*)

During the first study, the *cpue* of shore fishers was highest just below the bridge on the western shore (**Figure 15a**). On the eastern shore the *cpue* was highest near the mouth, just above the bridge and between 3.0 – 4.0 km upriver (**Figure 15a**). During the second study, the *cpue* of shore fishers was highest just below the bridge on the eastern shore and 3.5 km upriver on the western shore (**Figure 15b**). The *cpue* in the remainder of the estuary was consistent at 0.1 fish/angler-hour (**Figure 15b**).

During the first study period, the *cpue* of recreational boat fishers was highest just above the road bridge, followed by the mouth region and the area between 3.0 and 3.5 km upriver (**Figure 16a**). During the second study period, the recreational boat fishers *cpue* was highest in the mouth region followed by the area between 2.0 and 3.0 km upriver (**Figure 16b**).

There was no significant difference in mean *cpue* (by number) between the first (0.22 ± 0.71 fish/angler-hour) and second study period (0.19 ± 0.60 fish/angler-hour) ($p = 0.14$). Similarly, there was no significant difference in the *cpue* of any user group between the first and second study (**Table 8**). However, the *cpue* of subsistence fishers during the second study was less than half of the first study. The *cpue* of recreational shore fishers and of recreational boat fishers were similar in the two study periods (both: $p > 0.05$). Recreational boat fishers attained the highest *cpue* of all user groups during both studies.

3.9 Estimated total catch

The estimated total annual catch was 12752 and 18978 fishes during the two study periods, respectively (Table 9). Subsistence fishers captured a similar number of fish in both study periods (approximately 8000 fish), which constituted 66 % and 43 % of the total catch, respectively (**Table 9**). In both recreational shore and land fisheries there were increases in the total catch in

numbers between the two study periods. Recreational shore fishers captured 28 % of the fish during the first study period, followed by recreational boat fishers (6 %) (**Table 9**). During the second study, recreational shore and boat fishers contributed a similar proportion to the total catch (≈28 %) (**Table 9**).

3.10 The bait fishery

The majority of interviewees (64 % - 1st study, and 63 % - 2nd study) did not purchase any bait at retail outlets, but collected bait organisms from the estuary. Only 23 % and 16 % of the fishers only used bait purchased from a retail outlet, while only 6 % and 19 %

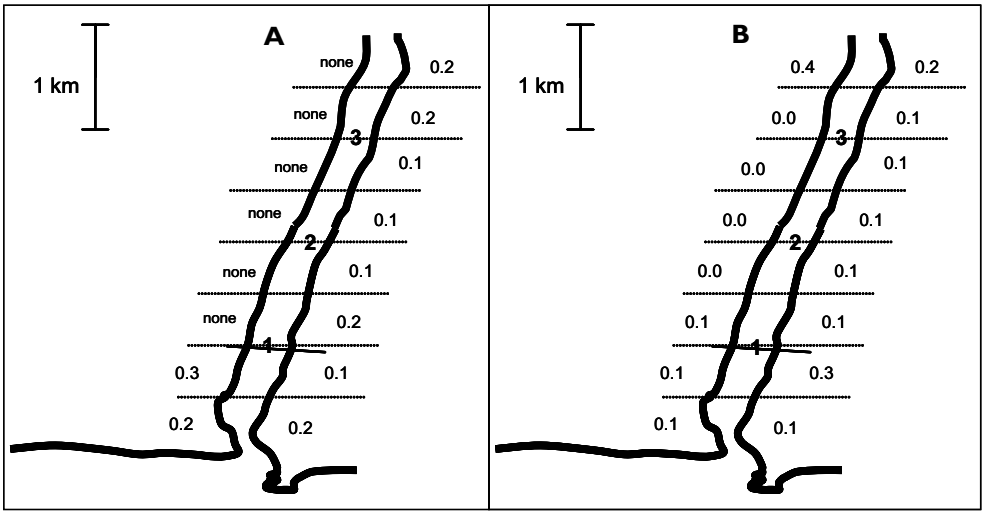

***Figure 15**. Cpue of shore fishers in the Great Fish Estuary between a) March 2001 and February 2002 and b) October 2003 and September 2004. Dotted lines indicate 500 m intervals. None = no fishing effort registered in these zones.*

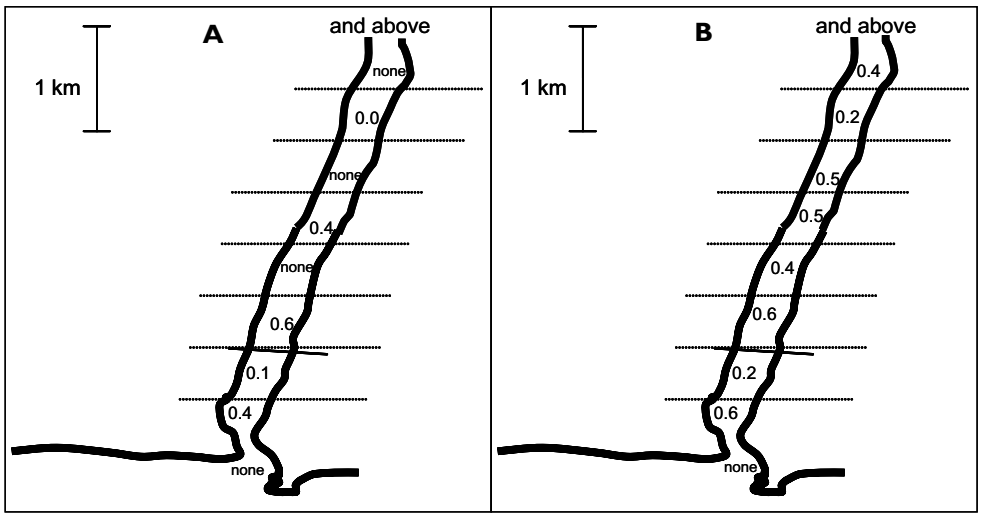

***Figure 16**. Cpue of boat fishers in the Great Fish Estuary between a) March 2001 and February 2002 and b) October 2003 and September 2004. Dotted lines indicate 500 m intervals. None = no fishing effort registered in these zones.*

***Table 8.** Catch per unit effort (fish/angler-hour) for the different groups of fishers on the Great Fish Estuary between March 2000 - February 2001 (study period one) and October 2003 – September 2004 (study period two).*

	1st study	2nd study	p
Subsistence	0.22 ± 0.79	0.10 ± 0.15	0.05
Recreational boat	0.31 ± 0.28	0.45 ± 0.78	0.53
Recreational shore	0.19 ± 0.58	0.17 ± 0.54	0.49

***Table 9.** Comparison of the estimated fish catch of the different groups of fishers in the Great Fish Estuary between March 2000 and February 2001 (study period one) and October 2003 and September 2004 (study period two).*

	1st study Total catch	%	2nd study Total catch	%
Subsistence	8406	65.9	8209	43.5
Recreational boat	735	5.8	5458	28.8
Recreational shore	3611	28.3	5311	28.0
Total	12752		18978	

of fishers both bought and collected bait during the first and second study, respectively.

A variety of bait organisms were used by fishers in both studies (**Table 10**). Seventy-five and 68 % of fishers used mud prawn (*Upogebia africana*) in the first and second study, respectively. Pilchard (*Sardinops sagax*) was the second most popular bait, followed by sand prawn (*Callianasa krausii*) (**Table 10**).

A total of 13107 and 49333 mud prawns were collected during the surveys days in the first and second study periods, respectively. Subsistence fishers accounted for 84 % of the mud prawns collected during the first study period and 66 % during the second study period. The estimated annual harvest of mud prawn by all user groups was 131000 and 238000 during the first and second study period, respectively. During the days of the first study period, 2011 sand prawn were collected, compared with 6232 during the second period. Subsistence fishers accounted for 60 % of the sand prawn collected during both studies. An estimated total of 20000 sand prawns were collected during the first and 31000 during the second study period, respectively.

3.11 Law enforcement

Law enforcement officials were observed during 11 (15 %) of the 72 sampling days in the second study period (**Table 11**). Officials were affiliated either to Marine and Coastal Management (MCM), the Department of Environmental Affairs and Tourism's Nature Conservation Arm (NC), or the South African Police Service's Water Wing (SAPS). Fishers were most frequently inspected for their fishing permits (9), while catches were only inspected for undersize fish on one of the occasions. Fishers were never checked to see if they had exceeded their bag limits. Fish and/or fishing tackle were confiscated from fishers for failing to produce a permit on two occasions (**Table 11**). Subsistence fishers were requested not to construct shelters on the estuary banks during one of the inspections. The subsistence and recreational shore sector were inspected most frequently (8.3 % of survey days), while the occupants of one boat were inspected on one of the survey days. The areas of inspection were restricted to the R72 road bridge, a small section of the Great Fish Wetlands Reserve and a small area above the road bridge on the eastern shore (**Figure 17**). Fishers operating from the Fish River Diner Caravan Park were never inspected (**Figure 17**).

Table 10. *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 September 2004 (study period two).*

Species	Common name	Fishers using bait organism (%) 1st study	Fishers using bait organism (%) 2st study
Upogebia Africana	Mudprawn	75.0	68.2
Callianassa krausii	Sandprawn	12.9	23.9
Mugilidae spp.	Mullet	1.9	5.3
Sardinops sagax	Pilchard	21.0	31.5
Loligo vulagaris reynauldii	Chokka squid	3.0	11.5
Arenicola loveni	Bloodworm	0.2	2.9
Solen capensis	Pencil bait	0.2	1.7
Polybrachiorhynchus dayi	Tapeworm	0.0	0.9
Octopus vulgaris	Octopus	0.5	1.3
Gunnarea capensis	Rockworm	3.7	2.2
Various species	Pinkprawn	1.2	1.2
	Artificial lures	1.4	0.5

3.12 Optimising the data collection protocol

The monthly fishing effort estimates calculated from three or six survey days were not significantly different ($R^2 < 0.01$, $F(1,22) = 0.09$, $p = 0.76$) (**Figure 18**). In addition, the estimated annual fishing effort on the Great Fish Estuary was similar at 108 720 and 113 790 hours when data from 3 and 6 survey days per month was used, respectively. The *cpue* of subsistence, recreational shore and recreational boat fishers were also similar when calculated from three or six survey days per month (**Table 12**). In addition, estimates of *cpue* for all user groups were not significantly different ($R^2 < 0.01$, $F(1,2550) = 0.28$, $p = 0.60$) when calculated from three or six survey days per month (**Table 12**).

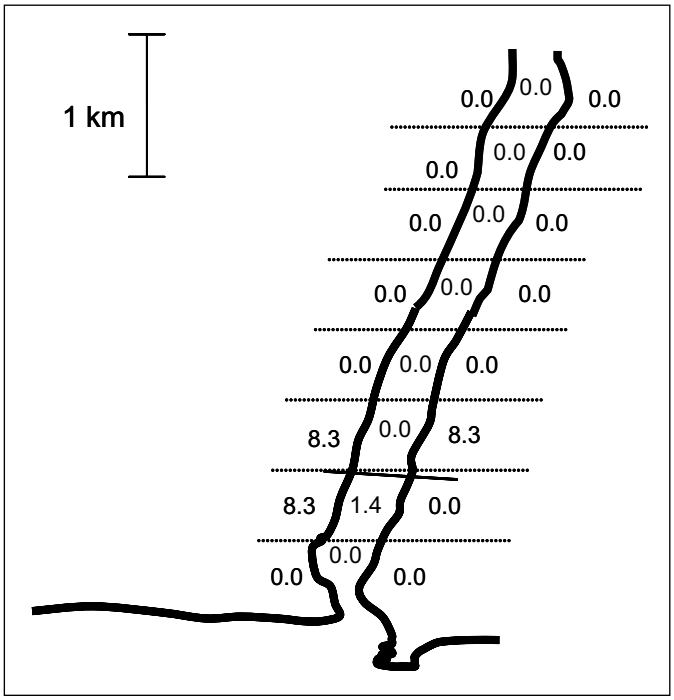

***Figure 17**. Distribution and percent inspected of law enforcement patrols on the Great Fish Estuary during the fishery survey days between October 2003 and September 2004. Dotted lines indicate 500 m intervals.*

***Table 11.** Fishery law enforcement observed between October 2003 and September 2004 on the Great Fish Estuary. MCM = Marine and Coastal Management, NC = Department of Environmental Affairs and Tourism's Nature Conservation Arm, and SAPS = South African Police Service's Water Wing.*

Date	Affiliation	User group	Permits	Undersize	Bag limit	Selling	Shelter	Confiscation
7 Nov 03	NC	RS	Y	N	N	N	N	N
8 Nov 03	NC	RS	Y	N	N	N	N	N
19 Feb 04	NC	RS	Y	N	N	N	N	N
20 Feb 04	SAPS	SUB	N	Y	N	N	N	N
4 Mar 04	NC	SUB	Y	N	N	Y	N	Y
26 Mar 04	MCM+NC	SUB	Y	N	N	Y	N	N
26 Mar 04	NC	RS	Y	N	N	N	N	N
27 Mar 04	NC	RS	Y	N	N	N	N	N
15 Apr 04	MCM+NC	SUB	Y	N	N	Y	N	N
4 Jun 04	MCM+NC	SUB	Y	N	N	Y	N	N
3 Jul 04	MCM+NC	SUB	N	N	N	N	Y	Y
29 Sep 04	NC	RS+RB	Y	n	N	N	N	N

***Table 12.** Average catch per unit effort (cpue) of the different groups of fishers on the Great Fish Estuary calculated from three and six survey days per month between October 2003 and September 2004.*

Surveys per month	Recreational shore	Subsistence	Recreational boat	Total
3	0.14 ± 0.59	0.11 ± 0.17	0.46 ± 0.80	0.18 ± 0.52
6	0.16 ± 0.54	0.10 ± 0.15	0.45 ± 0.78	0.19 ± 0.60

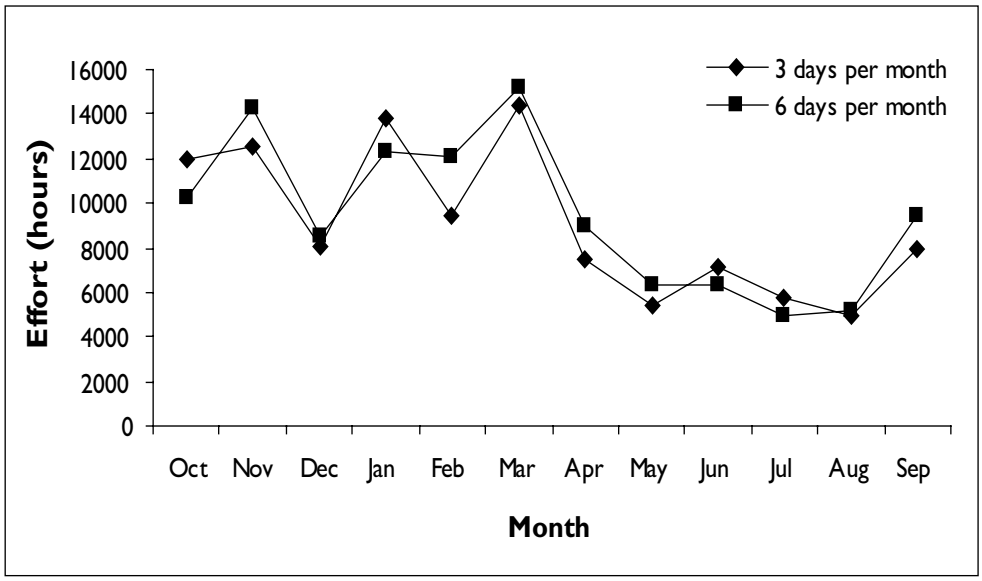

Figure 18. *Monthly fishing effort estimates on the Great Fish Estuary using three and six survey days per month between October 2003 and September 2004.*

4 Discussion

4.1 Angler demographics

The Great Fish Estuary is situated in a rural area of the Eastern Cape Province and was formerly the border to the Ciskei "homeland". Consequently, the presence of large numbers of subsistence fishers is likely, as observed during both study periods. Pradevand and Baird (2002) conducted a resource survey on the Great Fish Estuary between January 1996 and April 1997, and although they did not differentiate between recreational and subsistence shore fishers, they also observed a reasonable proportion of black shore fishers (29 %). The racial composition of the fishers in the study of Pradevand and Baird (2002) was similar to that observed during our second study period in 2003 - 2004, with white fishers dominating (67 % - Pradevand and Baird (2002), 65 % - 2nd study period). In contrast, black fishers were the most dominant race group (45 %) during our first study period 2001 -2002. Pradevand and Baird (2002) also noted a high proportion of boat fishers (41 %) during their surveys compared with 5 % and 24 % during the first and second study periods, respectively. The differences in the racial composition and proportion of boat fishers may, however, be explained by examining the sampling protocol of each study. Fifty three 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. 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 and will be discussed later.

There were a far greater proportion of younger fishers from both the subsistence and recreational groups in our second study. 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.

Catch composition

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) in a fish species composition study 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 species was also most frequently captured in six of the eight Eastern Cape estuaries surveyed by Pradevand and Baird (2002). In Kwazulu-Natal spotted grunter 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).

Size composition

A high percentage of all fish caught 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 trend observed in both study periods, however, was the high percentage of undersize fish that were retained by the fishers. With the exception of spotted grunter in the second period, more that half of all undersize fish landed were retained. Although minimum size limits, in theory, have the potential to reduce fishing mortality, it appears that the reluctance of fishers to return undersize fish prevents this management option from offering an effective means of reducing fishing mortality without frequent control by fisheries officers.

Bag limits

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. 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 19**). 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 50 % reduction in the retained catch of this species. However, as with the size limit regulations, this catch-control option will only function if the regulations are effectively implemented.

Fishing effort

There was a large increase in fishing effort and a difference in fisher distribution between the two study periods. The total effort estimate for all user groups was twice as high in the second study period. The largest change in the distribution of fishers was the marked increase (6 % to 25.6 %) 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 38.1 % in the first to 8.7 % 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. In addition, some advertising (internet site) has been conducted for the Great Fish River Wetlands Reserve. 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. Boat fishers concentrated their effort between the bridge and the estuary mouth during both studies. However, unlike during the first study period, boat fishers during the second study period also focussed on an area between 4.0 and 8.0 km upriver.

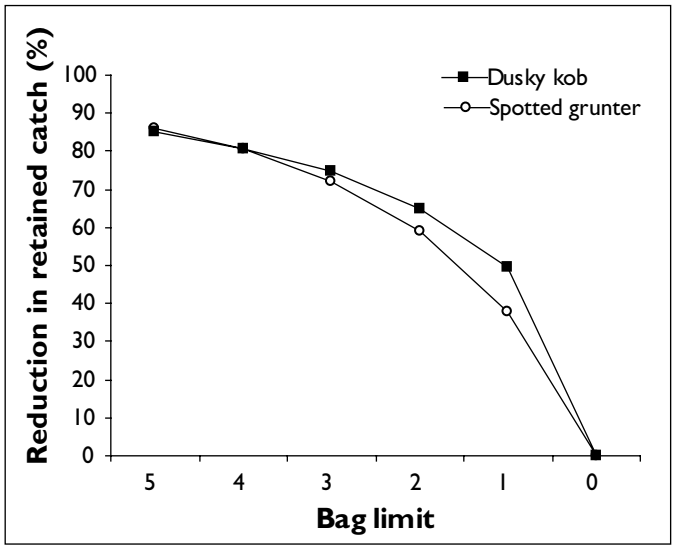

***Figure 19**. The percentage of retained fish for daily bag limit restrictions of five or less spotted grunter or dusky kob, based on bag frequencies collected in the second study period (October 2003 – September 2004) in the Great Fish Estuary.*

The increase in the distribution of effort throughout the estuary, the high *cpue* in previously closed areas (Kapriver Reserve) and the large increase in effort from all user groups, 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.

The *cpue* (fish/angler-hour) of fishers in the Great Fish Estuary during the first (0.22) and second (0.19) 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. Although the fishing effort during the second study period was twice as high as the first, the overall catch was only one-thirds higher than recorded during the first period. The estimated annual catch (in numbers) in the first period was approximately 20 % lower than that for the nearby Kowie Estuary over the same period. Subsistence fishers captured the majority and a very similar number 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 7 times the number captured during the first study period.

Bait fishery

The bait used in the fishery was 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 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 may alleviate some of the pressure on the fish resource. However, when dealing with the rural poor, it would be irresponsible to attempt to develop a small-scale commercial fishery that, in the long-term, would not be profitable and sustainable for the individual fishers involved. A good guiding principle for any subsistence enterprise is for the fisher to obtain the minimum rural wage, which in South Africa currently equates to R 10 440 per year (R 870 per month). At the current rate of R 10 for 50 sand or mud prawns, a fisher would have to harvest a minimum of 4 350 sand prawns or mud prawns per month. Since the current annual harvest of mud prawns is 238 643, the addition of one small scale commercial fisher selling mud prawns would increase the mud prawns harvest by 22 % of current levels. With five small-scale prawn sellers, the number of prawns harvested could increase by 110 %. Although this paints a bleak picture, and may be unsustainable, it is logical that many of the recreational fishers that buy prawns will no longer harvest prawns themselves, thus alleviating the pressure on the resource. However, the option of buying prawns will in many cases increase the amount of fishing time of recreational shore and boat fishers. Since these users have a higher *cpue* than subsistence fishers, this will increase the pressure on the fish resource. In addition, the impact of doubling the harvest of mud prawns is unclear and it is possible that these organisms will not sustain themselves at this level of effort. Therefore it is recommended that precautionary principals be applied if a small-scale commercial prawn fishery is initiated. These should include an experimental fishery that is closely monitored in terms of its economic viability as well as its social and biological influence. In addition, a closed area is suggested which can also be used to compare the effect of the additional harvest of mud or sand prawns and secure the future production of these organisms.

Law enforcement

Few fisheries law enforcement officers were observed during the second survey period. In addition, the area of the estuary controlled by these officials was limited and in most cases, the fishermen's catches were not inspected. With the exception of one occasion, recreational boat fishers were never intercepted by law enforcement officers. Given that the *cpue* in this sector was three times higher than the recreational shore fishers and four times higher than the subsistence fishers, there is also a need to monitor this fishery sector.

Two access points, a boom gate at the entrance to the Great Fish Wetlands Reserve and the boom gate at the Fish River Diner Caravan Park (see Figure 2) provide sites where all recreation boat and the majority of recreational shore fishers can be intercepted upon their departure. To monitor the recreational fishery effectively, it is suggested that law enforcement officials check the fisher's permits and catches at the two access points. Since recreational fishing effort was significantly higher on weekend days, the efficiency of enforcement would be enhanced if one or two randomly chosen weekend days were selected for monitoring each month. Furthermore, since most recreational fishers depart on Sunday mornings between 08:00 and 13:00, monitoring these two access points during this time is likely to be the most efficient method of law enforcement for recreational fishers.

There is also a need to monitor the subsistence fishery since this sector accounts for most of the fishing effort in the estuary. The results from this survey indicate that there are more subsistence fishers on weekdays than on weekend days. In addition, this sector is limited almost exclusively to the eastern shore above the road bridge (see Figure 2). The most efficient enforcement method would be to check the permits and catches of fishers above the bridge on the eastern shore once or twice monthly on weekdays. The value of law enforcement would be that fishers are aware that they may be checked, at any time. This should decrease the number of individuals retaining undersize fish.

Recommendations of study designs

A number of results from this study have implications for the design of future estuarine fisheries surveys. These include the similar estimates of total fishing effort and *cpue* calculated from three and six survey days using the same data set, the changes in the proportion of the various user groups from weekday to weekend days and the difference in the average number of fishers between the different days of the week.

The first recommendation for the design of fisheries surveys is that the ratio of weekday and weekend day surveys be proportionate to the same day type in a calendar year (ie. a ratio of two weekdays to every one weekend day or public holiday). This would ensure that the number of subsistence or recreational users is not over or underestimated. This approach was adopted during the first study period (March 2000 - February 2001). When compared to the second study period, this survey design also simplified the calculation of effort, *cpue* and total catch considerably.

During the second study, the point count surveys showed that there was a difference between average number of fishers between Mondays and Fridays when compared with the other weekdays. These differences must be considered and therefore future surveys should be designed so that any weekday (including both Mondays and Fridays) is selected randomly.

The survey design during the second study period ensured that the fishery was monitored for a high proportion (one fifth) of the year. This survey was therefore a costly exercise. In an ideal sampling design, the eventual data collection should yield the highest return for the time and money expended without compromising the accuracy of the results. In the case of the second study period, the costs and time spent in the field could have been halved with very little difference to the overall results of the survey. This suggests that a three day per month survey is likely to be the optimal survey design for determining trends in the resource utilisation of estuaries. In addition, two samples per month should be conducted on randomly selected weekdays (Monday – Friday) and one sample per month should be conducted on a Saturday, Sunday or public holiday.

During the first survey period, a number of boat fishers were not interviewed since access point surveys were not conducted. This may have resulted in an underestimate of boat fishing effort. This highlights the need to optimise the field survey procedure 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.

The results of this study have highlighted changes in the Great Fish Estuarine fishery over the last few years. These include changes in the effort, distribution of effort, *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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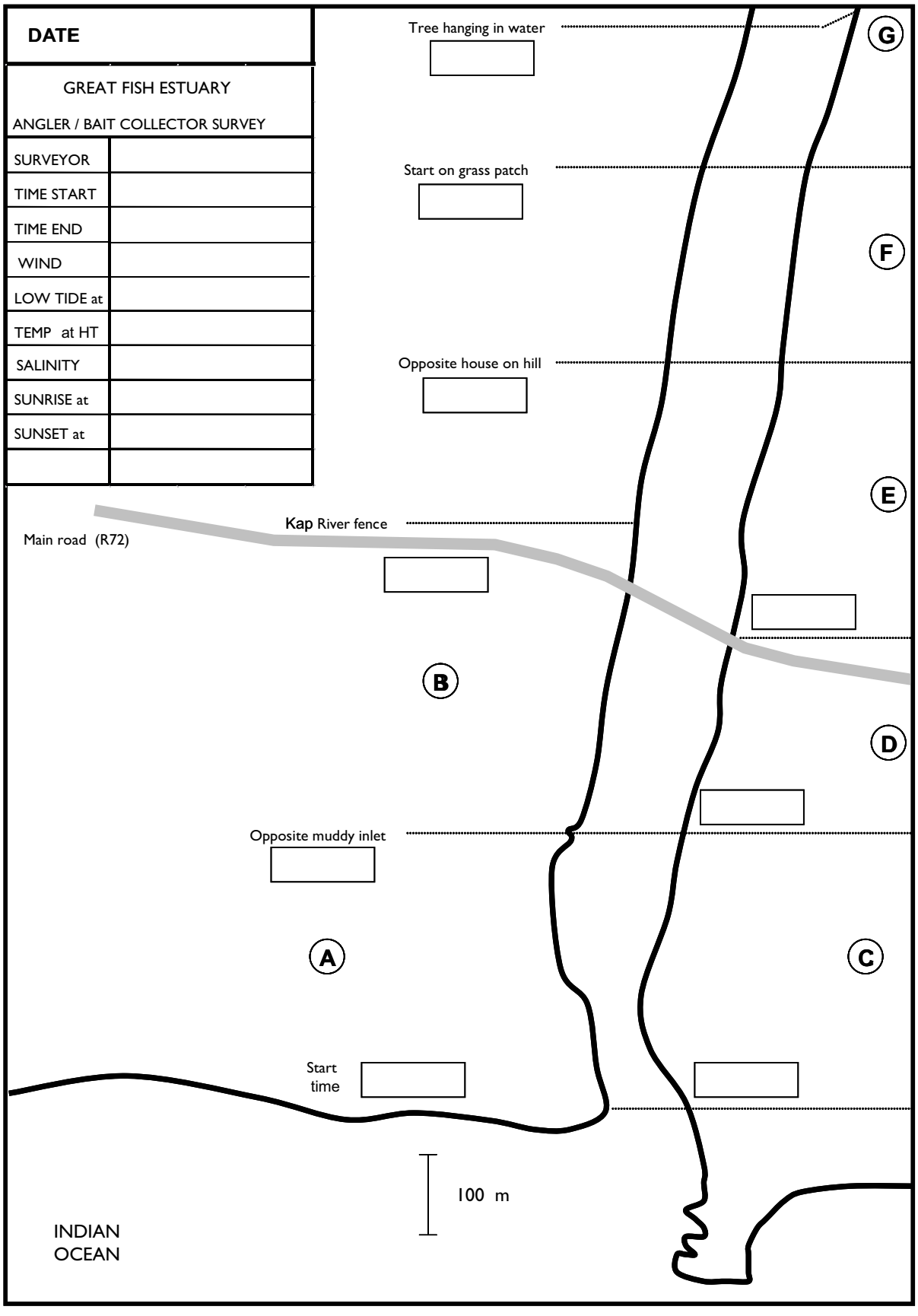
Appendix 1. The data sheet used to record the exact location of each fisher and the progress of the survey clerk during the roving creel surveys on the Great Fish Estuary from March 2002 to February 2003 and October 2003 to September 2004.



Appendix 2. The data sheet used to record information obtained from the fishery interviews in the Great Fish Estuary from March 2002 to February 2003 and October 2003 to September 2004.

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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