The exploitation of *Upogebia africana* (Crustacea: Thalassinidae) for bait in the Knysna Estuary

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The activities of people collecting *Upogebia africana* for bait at six popular collecting sites in the Knysna Estuary were monitored from February 1995 until April 1996. Three groups of bait harvesters were identified on the basis of their source of income: subsistence fishers who rely on bait collecting and fishing for their income; supplementary fishers who catch fish to supplement their income; leisure anglers who draw no income from fishing. Two groups of collectors were identified based on methods of collecting bait and fishing: leisure anglers who collect bait using a prawn pusher or pump and fish using a rod and tackle; non-leisure fishers who collect using tin cans and fish with hand or planted lines. The average harvest of bait per collecting trip by leisure anglers was 59 mud prawns, whereas non-leisure fishers took 101 animals, twice the legal limit. The numbers of bait collectors present per mud bank were found to be highest on public holidays ($\bar{x}$ = 43.5) and higher during the summer holidays ($\bar{x}$ = 16.5) than during the spring/summer ($\bar{x}$ = 8.6) and autumn/winter ($\bar{x}$ = 4.6) periods. Most collectors spent 11–30 minutes on the mud banks. It was estimated that 1.86×10^6 *U. africana* or about 740 kg (dry mass) was removed by bait collectors annually from the six bait-collecting sites studied. This represented about 8.5% of the mud prawn stocks at these sites and about 0.9% of the entire estuary stock. 85% of the mud prawns taken as bait was removed by 77% of the bait collectors who were the non-leisure fishers.

INTRODUCTION

Most studies on the harvesting of infaunal invertebrate bait organisms have been on northern hemisphere species (e.g. Klawe & Dickie, 1957; Blake 1979a,b; Jackson & James, 1979; McLusky *et al*., 1983; Hruby, 1987). In South African estuaries the thalassinidian mud prawn, *Upogebia africana* (Ortmann), is extensively exploited as bait by recreational and subsistence fishers. Despite concerns that this crustacean was being overexploited in some estuaries (Siegfried, 1962; Hill, 1967), no studies were undertaken to quantify the effect of bait collecting on estuarine populations. Martin (1988) briefly described the possible secondary effects of illegal bait harvesting on the birds of the Swartkops Estuary. The most detailed studies on infaunal bait harvesting in South Africa were by Wynberg & Branch (1991, 1994) who assessed this activity in Langebaan Lagoon on the west coast. In addition, they examined the effect of disturbances associated with bait collecting on the biota of the intertidal sand flats. Whilst many of their findings are undoubtedly applicable to estuaries, present management strategies and bait regulations for these ecosystems are not based on empirical data.

The aims of this study were to: determine the present extent and intensity of the exploitation of *U. africana* in the Knysna Estuary; examine some aspects of the bait collecting and resource utilisation practices of various sectors of the fishing community. Knowledge of both the resource and resource users is essential in establishing management recommendations to ensure the sustainable use of the resource.

MATERIALS AND METHODS

Bait collecting occurs throughout the Knysna Estuary during the entire day and to a lesser extent at night (R. Cretchley, pers. obs.). It was not possible, therefore, to monitor the whole estuary. Six popular bait-collecting sites were chosen from those observed to be frequently exploited (Figure 1; see also Table 1 responses to question 7) and were monitored during the daylight low-tide periods. This sub-sample of collecting activity was used to estimate the extent of bait collection in the estuary.

At each site the activities and numbers of bait collectors were monitored over four-hour periods of low tide. It was therefore possible to monitor one site only per low tide (see Table 6 for number of observation days per site). During the 14 month study period, from February 1995 to April 1996, bait collecting was observed on 52 occasions; 24 days during spring/summer (excluding the summer holiday season, mid-December to mid-January), 16 days during autumn/winter, nine days in the summer holiday season, three public holidays. In total bait collecting was observed during 26 neap tides and 26 spring tides. To determine which sectors of the population were using the bait resource, information recorded included demographic details e.g. the race, sex and approximate age group (estimates as: youth = <20 years old; adult = 20 to 55 years old; elderly = >55 years old) of the collector. The implement of bait collection used, catch per unit effort or efficiency (number of pumps needed to catch an animal), and time spent collecting bait (minutes active on the mud bank) were also recorded for each bait collector. The

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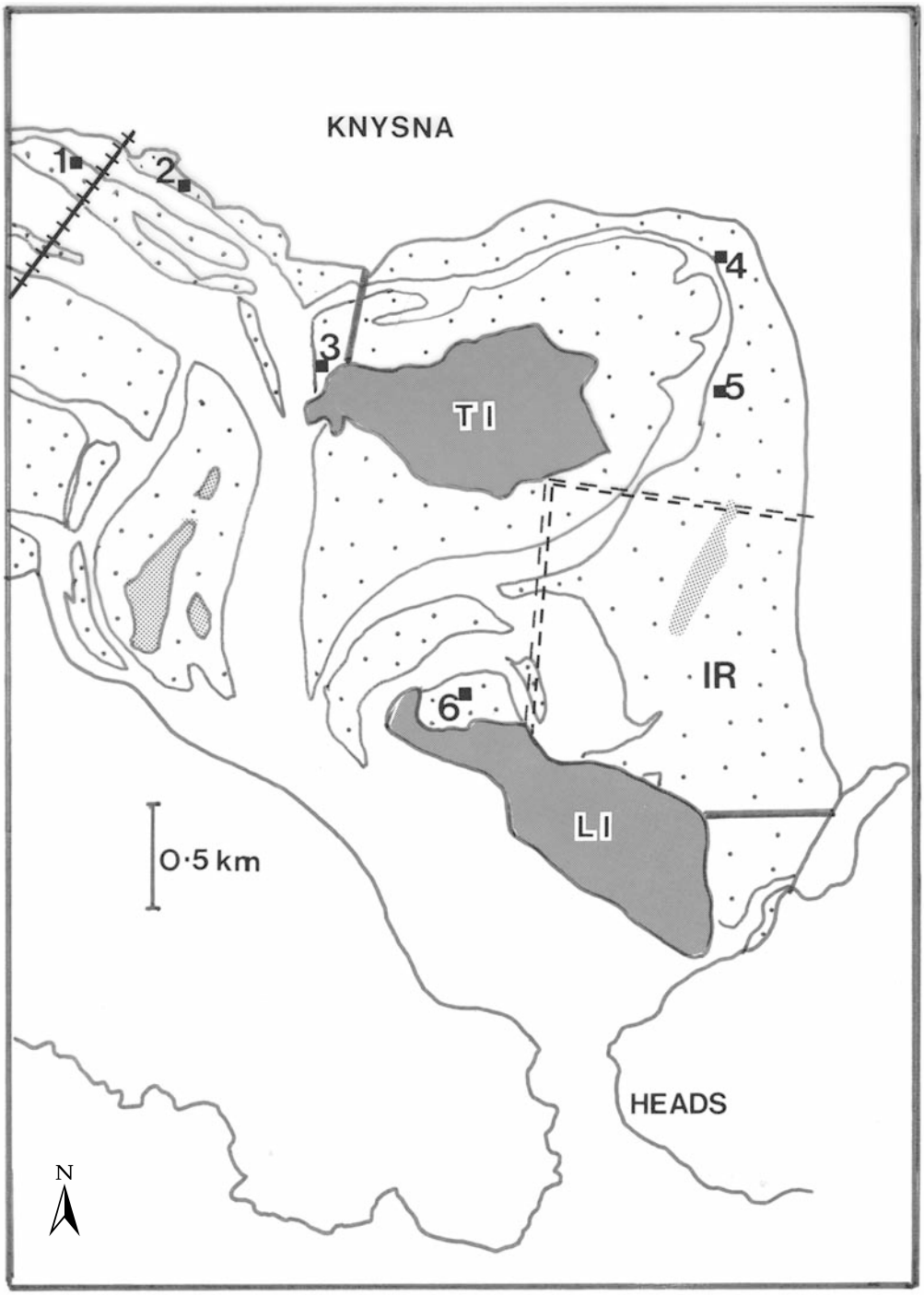

Figure 1. Map of the Knysna Estuary showing the position of the six bait-collecting sites. 1, Railway bridge; 2, KADA; 3, Thesen Island; 4, Ashmead; 5, Lourie Park; 6, Leisure Isle. IR, Invertebrate Reserve; LI. Leisure Isle; TI, Thesen Island. Light stipple, mud banks and saltmarsh areas; = = = boundary of Invertebrate Reserve.

number of *Upogebia africana* collected per bait collector was determined from a sub-sample of 100 individuals.

A questionnaire was compiled with the assistance and advice of the Environmental Evaluation Unit at the University of Cape Town and the Rhodes University Sociology Department. Some collectors were interviewed to gain more information about their activities. 46 local fishers and 31 tourists were interviewed at various popular bait-collecting sites while they were gathering bait. The demographic details of the collectors interviewed are presented in Table 2.

All statistical analyses were undertaken using Statgraphics version 7.0.

RESULTS

Fishing and bait-collecting practices

Based on questionnaire responses, three income groups of bait collectors were identified (Table 3). Those collectors who replied that fishing and bait collecting were their only means of income were classed as subsistence fishers. Those whose income was partly supplied by fishing and bait collecting were grouped as supplementary fishers, whilst those who had full-time jobs and drew no income from angling were classified as recreational fishers (leisure anglers).

Table 1. Summary answers to questionnaires; responses expressed as percentage of total.

Question	Local (n = 46)	Tourist (n = 31)
FISHING PRACTICES		
1. Where/how do you fish most often?		
a. Boat	6.5	51.6
b. Railway Bridge	8.7	9.7
c. Thesen Jetty	34.0	6.4
d. Belvedere	2.1	0
e. Loerie Park	13.0	0
f. Ashmead	4.4	0
g. Leisure Isle	4.4	0
h. KADA	18.3	0
i. Point	8.6	3.2
j. Heads	0	12.9
k. Coney Glen	0	16.2
2. Transportation to fishing/launch site		
a Walk	69.5	6.5
b. Cycle	4.4	6.5
c. Car	8.7	51.6
d. Boat	2.2	35.4
e. Taxi	15.2	0
3. Time spent fishing per outing (minutes)		
a. 5–29	0	0
b. 29–59	0	0
c. 60–119	6.5	9.7
d. 120–239	50	54.8
e. >240 minutes	43.5	35.5
4. Fishing method used		
a. Hand line (“tol”)	73.9	0
b. Planted lines	17.4	0
c. Rod	8.7	100
5. Do you catch anything you don’t use?		
a. Yes	78	84
b. No	22	16
6. What do you do with unwanted catch?		
a. Throw back	94	100
b. Leave on bank	6	0
BAIT COLLECTING AND USAGE PRACTICES		
7. Where do you collect bait most often?		
a. Leisure Isle	8.7	29.0
b. Lourie Park	8.7	0
c. Ashmead	8.7	0
d. Thesen Island	52.1	32.3
e. KADA	6.5	9.7
f. Railway Bridge	8.7	6.5
g. Middle banks	0	0
h. Wherever fishing	6.6	22.5
8. What bait do you collect/use most often?		
a. *Upogebia africana*	97.8	90
b. *Callianassa kraussi*	2.2	0
c. *Polybrachiorhynchus dayi*	0	3.3
d. *Arenicola loveni*	0	3.3
e. Other polychaetes	0	3.4
9. Method of bait collecting		
a. Tin can	91.3	20.0
b. Pusher	6.6	56.7
c. Pump	2.1	23.3
d. Fork	0	0
e. Spade	0	0

Table 1 cont. Summary answers to questionnaires; responses expressed as percentage of total.

Question	Local (n = 46)	Tourist (n = 31)
BAIT COLLECTING AND USAGE PRACTICES cont.		
10. Time spent collecting bait		
a. One or two minutes when bait needed	10.8	0
b. 5–14 minutes	2.2	10.0
c. 15–29 minutes	17.4	16.7
d. 30–59 minutes	45.7	70.0
e. 60–129 minutes	19.5	0
f. The entire low tide	4.4	0
11. What do you do with unused bait?		
a. Don't have unused bait	52.2	29.0
b. Discard	6.6	19.3
c. Put in water	21.7	35.4
d. Put in holes	0	6.5
e. Sell	0	0
f. Keep for following trip	2.2	9.8
g. Give away	17.3	0
12. Are you aware of bait restrictions?		
a. Yes	95.6	87.0
b. No	4.4	13.0
13. Is the allowed amount bait?		
a. Enough	28.3	80.6
b. Not enough	71.7	12.9
c. Too much	0	6.5
14. Is it reasonable to have bait restrictions?		
a. Yes	28.3	90.3
b. No	43.5	8.7
c. Don't know	28.2	1.0
15. What should restrictions (per day) for *U. africana* be?		
a. <50	4.4	16.1
b. 50 (present bag limit)	23.9	67.7
c. 100	32.7	9.7
d. 150	13.0	0
e. 200	6.5	6.5
f. 300	6.5	0
g. Don't know	13.0	0
16. Why are there collecting restrictions?		
a. Don't know	28.3	0
b. To protect stocks	30.4	41.9
c. So that everyone can have	6.5	9.7
d. Prevent wastage	23.9	32.3
e. Protect the environment	4.3	16.1
f. Don't want us to make money from bait sales	6.6	0
17. Do you think that your activities have an effect on the mud banks?		
a. Positive	0	9.7
b. No	91.3	83.9
c. Negative	8.7	6.4
18. What fishing/bait-collecting activity do you think causes most environmental damage to the lagoon?		
a. Pushing prawns	10.8	9.7
b. General trampling	4.5	3.2
c. Digging	34.8	12.9
d. Littering	15.2	48.3
e. Damaging vegetation	0	9.7
f. Boating	6.5	16.2
g. Don't know	28.2	0

Table 2. Summary of the demographic details of the locals and tourists interviewed. Results expressed as percentage of number interviewed (n = 46, local collectors; n = 31, tourist collectors).

	Locals	Tourist
RACE		
Black	39.1	0
Coloured	52.2	0
White	8.7	87.1
Asian	0	12.9
GENDER		
Male	63	93.5
Female	37	6.5
AGE GROUP		
Adult	93.5	58.1
Elderly	6.5	9.6
Youth	0	32.3

The associations between the categories of angler identified and the demographic details of the bait collectors interviewed were determined using a Chi-square contingency table. There is a strong correlation between the race of bait collectors and the category of fisher, based on economic factors (Table 3). All of the black and Coloured bait collectors interviewed, were subsistence or supplementary fishers, while the majority of the white and Asian collectors interviewed (87%) were found to be recreational fishers (Table 3). The women who were interviewed were predominantly subsistence (75%) and supplementary (15%) fishers, while the men were mainly recreational (49%) and subsistence (40%) fishers. All the youths (<20 years old) interviewed were recreational anglers (Table 3).

As the majority (93%) of local bait collectors were non-leisure (subsistence and supplementary) fishers, and all the tourists were leisure anglers, the questionnaire responses of locals and tourists have been used to compare fishing and bait-collecting practices of non-leisure fishers and leisure anglers respectively. Furthermore, as both groups collected mainly *Upogebia africana* as bait (Table 1 responses to question 8), discussion of results will be restricted to this species.

Non-leisure fishers and leisure anglers used different methods of collecting bait and fishing (Table 1, questions 4 & 9). All recreational anglers fish with a rod and tackle, and the majority (80%) use commercially purchased stainless steel (or plastic) prawn pumps or pushers to collect *U. africana*. The majority of non-leisure fishers fish with hand or planted lines (91%), and use tin cans (91%) as pumps to collect mud prawns. Although the majority of bait collectors said that they spent up to 60 minutes collecting bait, 24% percent of the non-leisure group would spend up to 2 hours collecting and some were active for the entire low tide (Table 1, question 10). The recreational anglers were more likely to use a boat when fishing than the supplementary and subsistence anglers (Table 1, question 1). Both groups of fishers released any unwanted catch.

Nearly all bait collectors were aware of the bait restrictions. 87% of recreational anglers believed that the allowed number of 50 prawns per person per day was enough or too many and that it was reasonable to have bait restrictions. 42% of the leisure group released unused bait. By contrast, 71% of the supplementary and subsistence anglers believed that the bait limit was too little (Table 1, question 13) although there was no consensus as to what the limit should be (Table 1, question 15). 64% of this group did not have any bait remaining after fishing or what remained was given to another fisher (Table 1, question 11). The non-leisure group also had divided opinions as to whether it was reasonable to have bait restrictions (Table 1, question 14).

Both groups of bait collectors did not think that their collecting activities had any effect on the mud banks (Table 1, question 17). Littering and digging were perceived to cause the greatest environmental damage (Table 1, question 18).

Exploitation of *U. africana*

The utility of the bait-collecting method employed, for predicting the two groups of fisher (non-leisure and leisure), was tested in a Chi-square contingency table. There was a highly significant relationship between the bait-collecting method used and the two groups identified ($p<0.0001$). This indicator, therefore, was used to categorise all the bait collectors who were not interviewed, but were observed collecting bait, as leisure anglers or non-leisure fishers. Of the bait collectors observed at the six sites studied (Figure 1), 22.16% were leisure anglers and 77.84% were non-leisure fishers (n = 546).

An examination of the bait catches of the collectors revealed that there was a significant difference ($p < 0.05$, ANOVA) in the mean number of *U. africana* taken by leisure ($\bar{x} = 59.03$; n = 32) and non-leisure ($\bar{x} = 101.37$; n = 68) fishers. Although non-leisure fishers collected nearly twice as many mud prawns using tin cans, as leisure anglers do using pushers or pumps, there was no significant difference in the time spent pumping by anglers using different implements ($p>0.05$, ANOVA; Table 4). The majority of collectors took 11–30 minutes to collect bait but occasionally would spend more than two hours gathering bait (Figure 2). These observations lend support to the accuracy of the answers given during interviews (Table 1, question 10).

During low tide, the mean number of bait collectors active per mud bank, per half hour of low tide, ranged from one to three,

Table 3. Summary of the demographic details of bait collectors interviewed analysed by economic category (subsistence, supplementary or recreational bait collectors). p values indicate the significance level of the economic categories to the responses to a specific question: Chi-square contingency table.

		% Subsistence	% Supplement	% Recreational	Sig. level
RACE	Non-white	91	9	0	
	White + Asian	0	12.9	87.1	$p = 7.62 \times 10^{-3}$
SEX	Male	40.4	10.5	49.1	
	Female	75	15	10	$p = 4.67 \times 10^{-3}$
AGE	Elderly	33.3	16.7	50	
	Adult	59	13.1	27.9	
	Youth	0	0	100	$p = 6.32 \times 10^{-4}$

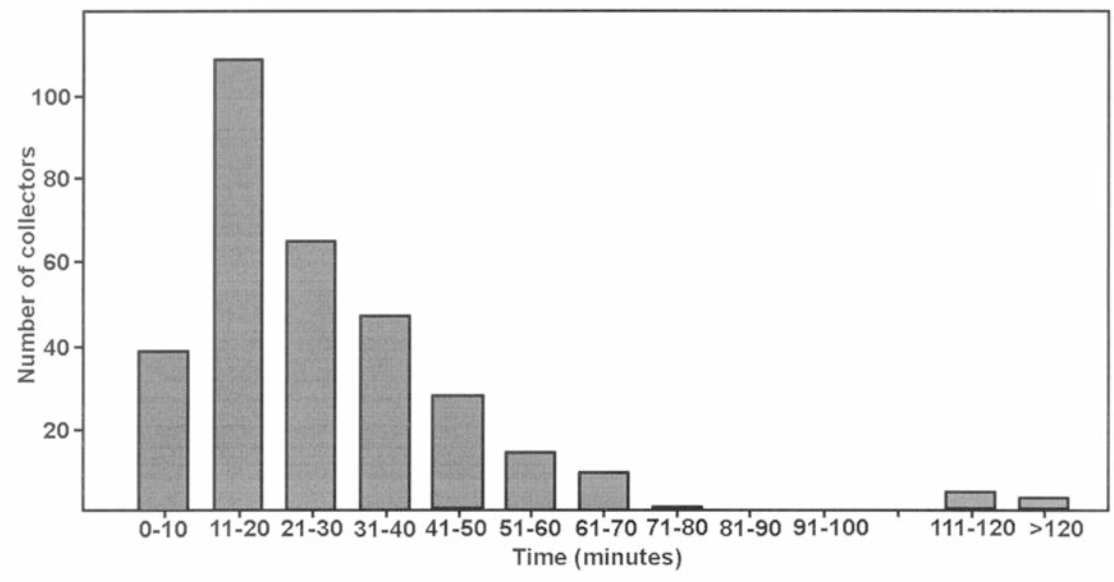

Figure 2. Frequency of times spent collecting *U. africana* per outing by bait collectors (n = 52 low-tide observation periods).

with numbers highest when the tide was at its lowest (Figure 3). The total numbers of bait collectors on a mud bank varied between seasons (during spring/summer and autumn/winter) and the holiday periods (summer holidays and public holidays) (Table 5). The mean number of bait collectors present per mud bank during the spring/summer ($\bar{x}$ = 8.6) was double those present during the autumn/winter months ($\bar{x}$ = 4.6). During the summer holiday season, the number of bait collectors per mud bank ($\bar{x}$ = 16.5) was double the number present during the spring/summer months ($\bar{x}$ = 8.6) which was significantly higher than numbers present during autumn/winter ($p<0.0001$, MANOVA; Table 5). The number of bait collectors was highest on public holidays ($\bar{x}$ = 43.5 – holidays on which observations were made: 14 March 1995, Good Friday; 31 May 1995, Republic Day; 21 March 1996, Human Rights Day) and significantly higher than during any other time period ($p<0.0001$, MANOVA; Table 5). On 21 March 1996, 58 people were observed collecting *U. africana* on one mud bank.

Although there was a significant difference in the number of bait collectors active per low tide between sites ($p<0.005$, MANOVA), this difference is due to the significantly greater number of collectors at Thesen Island ($\bar{x}$ = 26.5) than at Ashmead ($\bar{x}$ = 14.5) (Table 6). There was no significant difference in the numbers of anglers collecting bait on a neap ($\bar{x}$ = 7.5; n = 26 tides) and spring tides ($\bar{x}$ = 13.5; n = 26 tides) ($p>0.05$, ANOVA).

A prawn pusher was the most efficient implement for collecting *U. africana*. The catch per unit effort (CPUE) with a pusher ranged from 0.1 (at a mud prawn density of 40 m^{-2}) to 1 (at a density of 90 m^{-2}). By contrast, at the aforementioned mud prawn densities, the CPUE for tin cans and prawn pumps varied from 0.1 to 0.3 and 0.08 to 0.12 respectively. The poor efficiency of prawn pumps, when compared to pushers and tin cans, is reflected in the fact that non-leisure fishers who use the latter implements harvest twice as much bait (about 100 vs. 50 mud prawns) in the same amount of time (about 30 minutes, Table 4) as leisure anglers using prawn pumps.

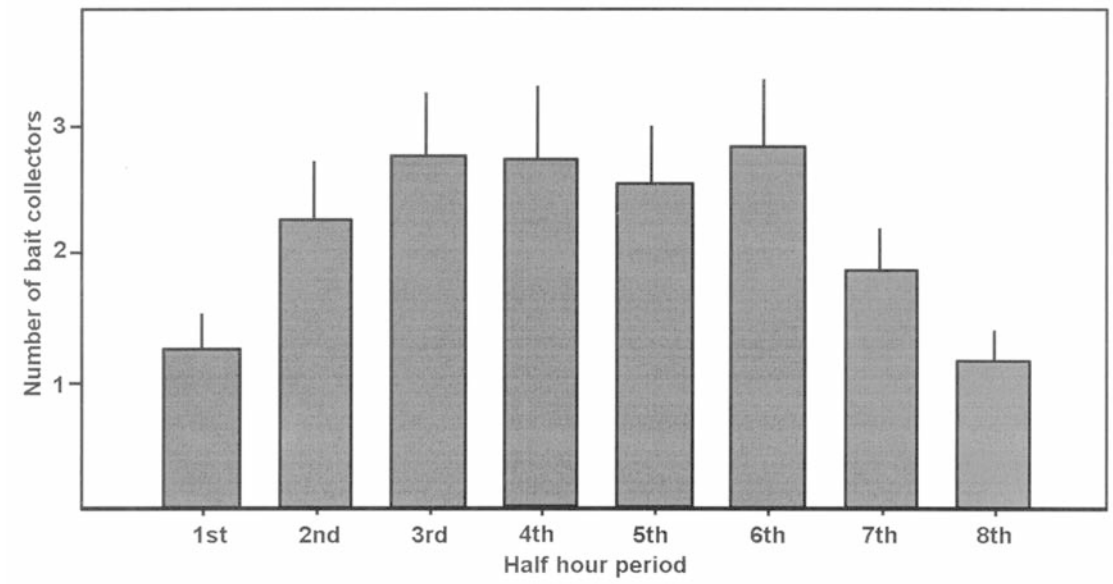

Figure 3. Bait-collecting activity, expressed as mean number of collectors active per mud bank (from 6 mud banks) per half- hour period of low tide (n = 52 low-tide observation periods). Standard errors of the means are shown.

Table 4. Results of a Scheffe's Multiple range analysis to determine whether there were any significant differences in the time spent pumping by bait collectors using tin cans, pushers and prawn pumps. X's in same columns indicate no significant difference.

Implement	n (collectors)	Mean time (min.)	Homogeneous groups
Prawn pusher	54	27.13	X
Tin can	242	30.66	X
Prawn pump	25	37.20	X

A note on illegal bait collecting

Although the prevalence and effects of illegal bait collecting was not quantified in this study, some observations were made on the effects of this activity. Illegal collecting by digging with a garden fork or spade occurs at night. Collectors dig trenches 8–20 cm deep, and about 2–3 m long × 1 m wide. Trenches more than twice this size (7 × 2 m) have been recorded. Uprooting of *Spartina maritima* is another illegal method of obtaining bait. Areas disturbed by such activity were still apparent one year later (A.N. Hodgson, pers. obs.).

DISCUSSION

From the data collected, an estimate of the total numbers and biomass of *Upogebia africana* taken by bait collectors at the six sites studied can been calculated. Although such calculations can only be approximate, they nevertheless provide an indication of the intensity of exploitation of this bait resource by humans.

As the numbers of bait collectors present per mud bank in different seasons and the numbers of prawns taken by anglers were highly variable, these factors were taken into account in the calculations. The number of bait collectors in all these data are, if anything, under-estimates as the values used in these calculations were from observations during four hours of daytime low tides only. Bait collectors were observed (R. Cretchley, pers. obs.) to take bait during high tide in the *Spartina* beds, during the early outgoing and later incoming tides, as well as within the estuary at night.

If the mean number of bait collectors present per site per low tide during autumn/winter, spring/summer, summer holidays and public holidays (Table 5) is multiplied by the number of days in each "season", about 3367 collection outings for *U. africana* occur at each site annually. For the six sites studied, the number of bait collections per annum is therefore about 20 200. Since it was estimated that 77% of collectors were non-leisure fishers who remove a mean of 101 prawns per person per day, the number of mud prawns taken annually by this group would be 1.59×10^6. The 23% of bait collectors who were leisure anglers removed about 2.64×10^5 mud prawns per annum. An estimated 1.85×10^6 of *U. africana* were collected, therefore, as bait from the six sites studied in one year. Based on an average dry weight of 0.4 g for an adult mud prawn (Cretchley, 1997), bait collectors were harvesting about 740 kg (dry weight) of *U. africana* from the six sites.

Non-leisure fishers, who comprise 77% of bait collectors, used 86%, while recreational anglers removed 14%, of the mud prawns taken. From the data of standing stocks of *U. africana* (Hodgson *et al*., 2000) it is estimated that the total number of mud prawns removed would represent 8.5% of the prawn stock at the six sites studied. Assuming an annual P/B ratio of 0.8 (Hanekom & Baird, 1982), about 6% of the annual somatic production is removed by bait collectors. Removal from the six sites represents about 0.9% (0.7 tonnes dry mass) of the standing biomass (estimated total = 82 tonnes) of the entire estuary. As mud prawns are collected at other sites within the estuary, this level of exploitation must be an under-estimate. The underestimated level of exploitation is nevertheless greater than the level reported for Langebaan Lagoon, where bait collectors were found to remove annually less than 0.01% of the *Callianassa kraussi* and *U. africana* populations (Wynberg & Branch, 1991). At Langebaan, however, most bait were collected on the central banks where about 800 000 mud and sand prawns were removed per annum, which amounted to about 3.2% of the population (Wynberg & Branch, 1991).

U. africana has been shown to be a very important food for several species of estuarine fish and bird (Marais, 1984; Martin, 1988). Hanekom & Baird (1982) determined that in the Swartkops River Estuary 13% and 5% of the somatic production of *U. africana* was consumed by birds and fish respectively, whereas only 2% was removed by humans. It is not known how the level of human exploitation of *U. africana* in the Knysna Estuary compares to that of predatory fish and birds. It is possible that, as in the Swartkops, consumption of mud prawns in the Knysna Estuary by fish and birds currently far outweighs that of humans.

It is not possible to determine unequivocally whether the population of *U. africana* in the Knysna Estuary is threatened by bait collecting. There are no historical records of when bait collecting began in the Knysna Estuary. In addition, there were no detailed studies previous to that of Hodgson *et al*. (2000) which assessed quantitatively the density of *U. africana* in this estuary although some estimates can be obtained from the work of Day *et al.* (1952) and Day (1967). Thus it is not possible to compare statistically present densities with previous empirical data. There is, however, indirect evidence which suggests that *U. africana* is currently not over-exploited. Firstly, many densities estimated by Hodgson *et al*. (2000) are similar to the density ranges given by Day *et al*. (1952) and Day (1967). Secondly, bait collectors do not experience trouble collecting sufficient large mud prawns for bait. Thirdly, the size of prawns within the

Table 5. Results of a Scheffe's Multiple range analysis to determine whether there are any significant differences in the numbers of bait collectors during autumn/winter and spring/summer as well as holiday periods. Bait collectors are expressed as mean number of collectors per mud bank (n = 6 sites). X's in same columns indicate no significant difference.

	n (days)	Mean number of collectors	Homogenous groups			
Autumn/winter*	16	4.6	X			
Spring/summer**	24	8.6		X		
Summer holidays	9	16.5			X	
Public holidays	3	43.5				X

* Excludes two public holidays

** Excludes days of the summer holiday period and a public holiday

Table 6. Results of a Scheffe's Multiple Range Analysis to determine whether there were any significant differences in the number of bait collectors present between sites during the year. X's in same columns indicate no significant difference.

Site	n (low tides)	Mean number of collectors	Homogenous groups	
Ashmead	9	14.46	X	
KADA	8	16.09	X	X
Railway Bridge	8	16.76	X	X
Loerie Park	8	17.42	X	X
Leisure Isle	9	18.42	X	X
Thesen Island	10	26.51		X

estuary has not declined in the last 20 years, Hill (1977) recording a mean carapace length of 15 mm for female *U. africana* which is similar to that reported by Hodgson *et al.* (2000) for females in1996. Finally, Cretchley (1997) has estimated that the level of recruitment is more than adequate to replace animals removed.

The relative efficiencies of the three types of bait-collecting implement used (pusher > tin can > pump) can, in part, be explained by the differences in area of mud covered by each. A prawn pump has a diameter of 60 mm, the most frequently used tin cans are 75 mm in diameter, whereas the diameter of prawn pushers vary from 150–200 mm. A pusher is therefore large enough to cover numerous holes and bait collectors with the larger-diameter pushers have been observed to collect up to 4 prawns with each attempt. The better CPUE of the non-leisure fishers (who use mainly tin cans and harvest a mud prawn at every third attempt) must also be due to their experience as collectors, and the skill by which they use the collecting implement. Leisure anglers often use prawn pumps incorrectly with a harvest of one mud prawn every 10 attempts.

Although we suggest that the mud prawn populations are currently not over-exploited, the secondary effects of bait collecting need to be investigated. The disturbances associated with bait removal can be more profound, resulting in changes in infaunal community composition (Jackson & James, 1979; McLusky *et al*., 1983; Wynberg & Branch, 1994). Although most bait collectors have some understanding of why restrictions exist, it is of concern that most do not believe that their activities can have environmental effects. Collection of bait by illegal methods (digging with a spade or fork) appears to be increasing in the Knysna Estuary (A.N. Hodgson, pers. obs.) and unless checked could have severe implications for the ecology of the system. On a more positive note, most bait collectors do see a need for the presence of a regulatory organisation in the estuary as 83% of non-leisure fishers and 97% of leisure anglers interviewed saw the need of the National Parks board.

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