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AN EVALUATION OF ATTITUDES AND RESPONSES TO MONITORING AND MANAGEMENT MEASURES FOR THE SOUTH AFRICAN BOAT-BASED LINEFISHERY

W. H. H. SAUER, A. J. PENNEY†, C. ERASMUS†, B. Q. MANN‡, S. L. BROUWER*, S. J. LAMBERTH¶ and T. J. STEWART§*

The boat-based linefishery in South African waters was investigated between 1994 and 1996. Methods involved a combination of access point and questionnaire surveys to collect catch and effort data, and to assess responses to management measures by the commercial and recreational fishing sectors. Compulsory catch returns submitted from commercial vessels were validated from direct observations. Results revealed substantial errors in compulsory catch returns; where over-reporting was high, it was not possible to quantify these statistically because of the high variance obtained when combining these data with both nil returns and under-reporting. Where over-reporting was negligible, statistical assessment was possible for some key species and areas. These were calculated to be under-reported by an overall factor of 2.87± 0.94. The inclusion of the recreational component of the overall catch provides the most comprehensive coverage of that sector to date. The results indicate that increased attention should be paid to monitoring recreational and "subsistence" fisheries, particularly in the Cape. Most fishermen agreed with the current regulations governing the linefishery, but many did not know or obey those pertaining to the species they had landed at the time of being interviewed. Although most respondents had been inspected by the local fisheries inspectorate at least once during the previous 12 months, these results clearly indicate the inspection rate to be inadequate. Regionally, between 22 and 58% of recreational fishermen admitted to selling their catch, a conservative estimate because of the reluctance of many fishermen to admit to breaking the law. Considering the high levels of bias and inaccuracy of data currently captured onto the National Marine Linefish System, there seems to be motivation for phasing out existing compulsory and voluntary submitted catch and effort returns (both commercial and recreational) and replacing them with data collected at key landing sites by trained coastal observers. Also, observer efforts should be focused on species, areas and sectors dictated by management requirements. In addition, law enforcement and education of the various fishery sectors must receive priority if the future management of the linefishery is to be effective.

The South African hook-and-line fishery consists of a number of commercial (full-time and part-time) and recreational (shore-angling, spearfishing, estuarine and offshore boat-angling) facets, which compete to a varying degree for the line-caught species exploited in the region. Of these, the commercial and recreational boat sectors compete most directly, using similar vessels and equipment to target the same species at the same time and place. In fact, within both the commercial and recreational boat-fishing sectors, there is a cline gradation from fishermen who fish occasionally for recreation or to supplement an existing income, to those who fish on a fairly permanent, commercial basis, particularly when migratory, shoaling linefish species are available. This overlap in motivations between these two sectors has complicated past efforts to develop specific management measures tailored to the supposed requirements of the commercial and recreational linefishing sectors.

Efforts to collect long-term catch and effort data from the various facets of the South African linefishery started in the early 1970s with the development of separate commercial and recreational catch and effort data-collection systems in the Cape and KwaZulu-Natal respectively. These efforts progressed independently until 1982, when they were merged to form the National Marine Linefish System (NMLS), a centralized catch and effort database under the administration of the Chief Directorate: Sea Fisheries. While many data have since been captured onto the NMLS for various recreational and commercial linefishing sectors, questions have arisen regarding their coverage and quality. In particular, efforts to use catch and effort data off the NMLS to develop and motivate linefish management recommendations have been hampered by poor coverage of certain sectors and

* Department of Ichthyology and Fisheries Science, Rhodes University, P.O. Box 94, Grahamstown 6140. South Africa. E-mail: ihws@warthog.ru.ac.za
† Sea Fisheries Research Institute, Private Bag X2, Rogge Bay 8012, Cape Town, South Africa
‡ Oceanographic Research Institute, P.O. Box 10712, Marine Parade, Durban 4000, South Africa
¶ Formerly Marine Biology Research Institute, Department of Zoology, University of Cape Town, Rondebosch 7701; now Sea Fisheries Research Institute, Private Bag X2, Rogge Bay 8012, South Africa
§ Dept of Statistical Sciences, University of Cape Town, Rondebosch 7701, South Africa

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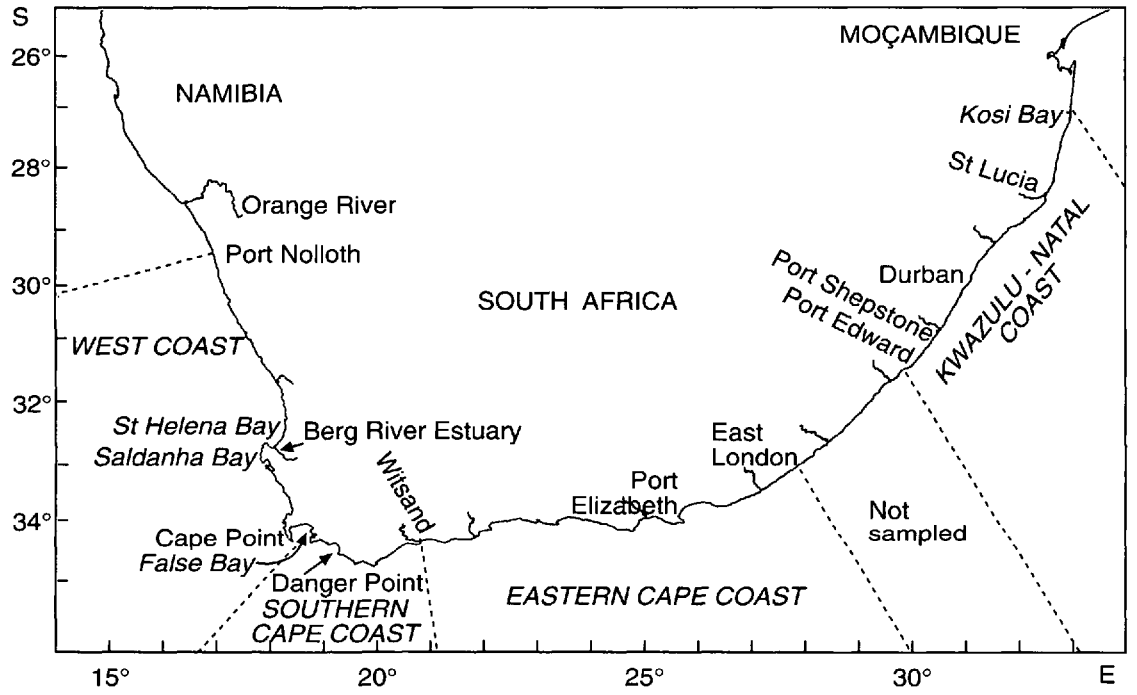

Fig. 1: Map of South Africa showing the four study regions and other places mentioned in the text

allegations of bias or error in certain data sources.

Prior to 1985, there were few management measures for the South African linefishery. The only national controls were minimum size limits for a few species, but those were not based on species biology or stock assessment studies. There were no limits placed on effort, and entry to the commercial and recreational fisheries was unrestricted. As a consequence of steadily increasing fishing effort on targeted linefish species, obvious and substantial declines in mean size and catch rate became evident for many linefish species by the early 1980s, prompting calls from all linefishery sectors for the introduction of more "effective" management measures. These resulted in the ministerial appointment of the National Marine Linefish Committee in 1985 to make recommendations on linefish management measures. The work of this Committee resulted in the introduction of a comprehensive suite of linefish management measures, including revised minimum size limits, implementation and limitation of licences for commercial fishermen, division of important linefish species into management categories, based on their status, and implementation of species-category bag limits for part-time commercial and recreational fishermen.

Many of the linefish management measures introduced in 1985 were based on limited scientific data, and were the result of a compromise between competing linefishery sectors. It is therefore not surprising that these management measures have attracted criticism. In particular, the process initiated to develop a revised national fisheries policy for South Africa has resulted in calls for the substantial revision of various aspects of the current linefish management. In view of the increasing questions regarding the validity of NMLS catch and effort data used to motivate linefish management measures, and increasing requests for the revision of linefish manage-ment measures, a coordinated nationwide survey was initiated to provide national estimates of participation in the linefishery, to estimate fishing effort and catch composition by the various linefishery sectors, to attempt some assessment of the validity of catch returns to the NMLS and to determine the attitudes of participants in the various linefishery sectors to current management measures. The study was conducted from 1994 to 1996, and this paper specifically focuses on data validity and responses to management measures by the commercial and recreational boat fishing sectors.

MATERIAL AND METHODS

Study area

For the purposes of this study, the South African coastline was sub-divided into four regions (Fig. 1), the West Coast (Port Nolloth to Cape Point), the Southern Cape coast (Cape Point to Witsand on the Breede river mouth), the Eastern Cape coast (Still Bay to East London) and the KwaZulu-Natal coast (Port Edward to Kosi Bay). The former Transkei and Ciskei regions were excluded from the study, because these areas fell outside South African jurisdiction at the start of the study, and manpower and funding limitations precluded adequate attention to these areas.

Survey methods

One of the major challenges faced was to conduct a survey that would include adequate respondents in order to provide meaningful estimates of the parameters to be quantified, within tight manpower and budgetary constraints. After evaluating various options, an Access Point Survey (APS) was decided upon. This was based on methodologies developed by Malvestuto *et al.* (1978) and Wagner et al. (1991), in order to minimize deficiencies resulting from sampling methodology and non-sampling factors. The survey design criteria included the need for direct observations of catches and accessibility of fishing sites. Stanovick and Nielsen (1991) noted that, if uniform probability sampling was used, APSs could become ineffective because equal effort is spent sampling areas of high and low fishing intensity. The survey therefore focused on sampling in known fishing areas and excluded seldom used sites, using a stratified sampling protocol. However, at selected sampling sites, vessels were checked at random as they returned to the landing site.

Catch and effort estimation

Where possible, all fish seen on the surveys were identified and measured to the nearest millimetre total length. Fish mass was subsequently estimated from length/mass regression equations, according to Van der Elst and Adkin (1991). For large catches, or when fishermen did not allow all fish in a catch to be measured, a random sample was taken, or the catch was estimated visually. Boat names and permit numbers of registered commercial vessels were recorded to provide a link with returns submitted to the NMLS.

To obtain an estimate of the importance of the recreational sector in three of the regions, the recreational catch and effort was calculated from the ratio of commercial to recreational vessels recorded at the sampling sites. Numbers of commercial vessels registered in each region were obtained from official boat registration records of the Chief Directorate: Sea Fisheries. The number of registered commercial vessels in KwaZulu-Natal (KZN) is small compared to the recreational sector, and therefore the above method would have been statistically unacceptable. Recreational effort for the KZN region was therefore estimated by conducting a telephone survey (Mann-Lang *et al.* 1997) to estimate the total number of ski-boat launches at 38 clubs along the KZN coast. Crude estimates of the catch per unit effort (*cpue*) for the recreational boat fishing sector was determined from the APS conducted in each region.

Validation of commercial catch returns

To evaluate the accuracy of the compulsory daily catch returns from commercial vessels captured onto the NMLS, catch data from the APS were compared with returns on the NMLS for each vessel checked. Data on the NMLS were checked seven days either side of the date of the APS to allow for incorrect date reporting by the permit-holder. Entries where both NMLS and APS data were zero (whether a nil return or no return) were considered to be accurate, and were excluded from subsequent analyses. The remaining data were separated by species and area and sub-divided into two categories:

(a) records with a catch registered by the APS, but the NMLS data were either zero or missing;
(b) records with a catch registered by the APS and a catch recorded on the NMLS.

In some instances, catches reported on the NMLS were not recorded by the APS, i.e. reporting a catch where none was observed. Where these were substantial no statistical analysis was attempted because it was not possible to produce meaningful results. The decision as to when such discrepancies were substantial was based on whether the effect was of a similar order of magnitude to the standard errors. Insignificant cases of over-reporting were considered to be accurate with a reporting error of zero.

Two factors influence possible under-reporting on the NMLS returns: non-reporting of actual catches, and inaccurate reports of the size of the catch (deliberate or otherwise). Estimates of each of the factors were combined into a point estimate for the ratio (R), of actual catch to total catch reported in the NMLS (per

Table I: Number of boat inspections and questionnaires carried out in the four study regions

Parameters	West Coast	Southern Cape coast	Eastern Cape coast	KwaZulu-Natal coast
Number of boat inspections	2 058	248	395	248
Number of recreational questionnaires	57	8	118	174
Number of commercial questionnaires	194	45	96	32

species and area). In principle, the total NMLS catch report could be multiplied by this factor to obtain an estimate of true catches.

In order to develop the estimates the following nomenclature is defined:

- N is the number of entries (for a particular species and area) in which the APS provided a non-zero report, but the NMLS data are either zero or missing (Category a observations);
- X is the average catch size estimated from the APS for entries in Category a;
- M is the number of entries (for a particular species and area) in which non-zero NMLS returns were provided (Category b observations);
- Y is the average catch size estimated from the APS for entries in Category b.

The total catch estimated by the APS during the sampling period is $NX+MY$, of which only MY corresponds to reported returns. If it is assumed that the NMLS catch returns are accurate (or at least unbiased estimates), then the ratio of total to reported catches could be estimated from

$$\frac{NX+MY}{MY} = 1 + \frac{NX}{MY} \quad .$$

However, a correction has to be made for the possibility that the reported catches themselves are systematically biased. Such bias can be estimated by fitting a regression line with zero intercept, of the form $z=ay$ (where z is the NMLS report and y the inspected value for the corresponding boat and day). The slope a estimates the proportion of catch reported when returns are actually made. The overall estimate of the ratio of actual catches to catches recorded in the NMLS for the species and area under consideration is thus given by

$$R = \frac{1 + \frac{NX}{MY}}{a} \quad .$$

This is a point estimate only. Standard errors on the estimates of X, Y and a can be obtained as standard errors of the means or regression coefficients. Exact computation of a standard error for R is difficult, but an approximation based on a first-order Taylor series for R as a function of X, Y and a gives an estimated variance of estimation as

$$\left[\frac{N}{MYa}\right]^2 Var(X) + \left[\frac{NX}{MY^2a}\right]^2 Var(Y) + \left[\frac{MY+NX}{MYa^2}\right]^2 Var(a) \quad .$$

In order to assess the accuracy of the reported catch from a single landing site, a specific comparison of catches for the Port Alfred commercial skiboat fishery in the Eastern Cape was conducted. This site was chosen because the linefishery in this region was evaluated fairly recently (Hecht and Tilney 1989), and the commercial and recreational boat fishermen in the area have had regular contact with local marine scientists explaining the value of the submitted catch records. Only the most common species in the catch, kob *Argyrosomuss* sp., was evaluated. An estimate of days fished per year (obtained from the APS) was multiplied by the average *cpue* per man per outing,

Table II: Catches and catch per unit effort (*cpue*) for the recreational fishery, based on the Access Point Survey for the four study regions

Parameters	West Coast	Southern Cape coast	Eastern Cape coast	KwaZulu-Natal coast
Total fish number	485	240	2 879	1 459
Total fish mass (kg)	505	121	4 866	2 848.6
Mass of fish per outing (kg)	8.86	8.6	31.96	13.37

Table III: Number of commercial and recreational vessels for 1995

Parameters	West Coast	Southern Cape coast	Eastern Cape coast	KwaZulu-Natal coast
Ratio commercial: recreational	0.04	0.06	0.73	Not available
Number of registered commercial vessels	1 507	882	549	173
Calculated number of recreational vessels	60	53	401	2 930

and by the average crew per vessel, to obtain an independent estimate of the total kob catch. This estimate was then compared with the submitted catch data on the NMLS.

Angler attitudes and awareness

Questionnaires were developed to evaluate the commercial and recreational sectors of the fishery simultaneously (see Appendix). These were completed during the APS, or during specific visits to landing sites to obtain additional data. A pilot questionnaire, tested in the field for the first three months, was revised for use during the remainder of the study. Separate sections addressed catch and effort data, economic information (McGrath *et al.* 1997) and attitudes towards fishery regulations. In order to assess the awareness of, and attitudes to, current linefish management measures, specific questions were used to determine the respondents' knowledge of the regulations. For example, interviewees were asked to give the size limit, bag limit and the closed season for the three most common species in their catch and/or target species.

RESULTS

The number of boat inspections and questionnaires carried out per area during the survey is given in Table I.

Recreational catch and *cpue* estimation

Catch and *cpue* for the recreational fishery as recorded by the APS are shown in Table II. An estimate of the number of recreational and commercial vessels in the boat-based linefishery in 1995 in South African waters is given in Table III. In view of the fact that coverage of the fishery was good in some areas but poor in others, a total catch for this sector (by simply multiplying *cpue* of selected species by the number of recreational vessels) was not attempted. Estimating the catch for selected areas and species where coverage may have been sufficient enough to cover such factors as seasonal effects was also not attempted here.

Validation of commercial catch returns

A total of 2 387 commercial boat observations was conducted during the APS. Comparison of the results with returns submitted by the vessels to the NMLS revealed a variety of discrepancies between the two. These differences (summarized by region in Table IV) include overall non-reporting of catches (or nil returns), non-reporting of certain species, under-reporting and over-reporting of all or some species.

Results of the APS show a number of observations where a commercial catch was reported to the NMLS when, according to the APS, no catch was made. This applied to both the targeted and non-targeted species. It is possible that, in some cases, the APS data are incorrect, because the less important species

Table IV: Number of commercial catches observed during the Access Point Survey (APS) in the four study regions, showing the types of discrepancies observed between the APS and NMLS data

Parameter	West Coast		Southern Cape coast		Eastern Cape coast		KwaZulu-Natal coast	
	Main target species	Other	Main target species	Other	Main target species	Other	Main target species	Other
Number checked	1 955	835	236	236	184	184	276	276
Number correct (10%)	167	1	1	3	54	5	74	57
Number under-reported	687	11	82	77	58	99	77	86
Number over-reported	288	10	6	9	33	41	32	40
Number not submitted	813	813	147	147	39	39	93	93

Table V: Results of statistical analysis of the accuracy of the compulsory commercial catch returns for different fish species caught in the four study regions

Parameter	West Coast		Southern Cape coast		Eastern Cape coast		KwaZulu-Natal coast
	Thyrsites atun	*Pachymetopon blochii*	*Rhabdosargus globiceps*	*Seriola lalandi*	*Merluccius capensis*	*Argyrozona argyrozona*	*Chrysoblephus puniceus*
Zero inspected value and zero return							
Number	146.68	521	610	112	119	108	15
Non-zero inspected value and no or zero return							
Number	343	98	23	77	30	37	32
Percentage of non-zero inspections	69.3	87.5	76.6	62	57.7	57.8	84.2
Mean estimated catch	364	20.5	65.4	82.5	35.03	23.59	31.1
Standard error of mean	18.68	2.86	9.34	11.5	9.13	6.32	4.68
Non-zero returns							
Number	152	14	7	47	22	27	6
Percentage of non-zero inspections	30.7	12.5	23.3	37.9	42.3	42.2	15.7
Mean estimated catch (kg)	442	34.9	78.1	196.50	44.79	27.88	86.5
Standard error of mean	29.2	9.92	31.64	35.28	12.72	10.29	48.09
Regression estimate of ratio (NMLS:inspected)							
Estimate	0.94	0.76	0.98	0.48	0.76	0.92	1.18
Standard deviation of estimate	0.04	0.23	0.05	0.04	0.1	0.08	0.02
Ratio true:reported catches							
Estimate	3.0	6.7	3.8	3.5	2.7	2.3	2.5
Standard error of estimate	0.21	2.66	1.22	0.44	0.65	0.61	0.94

Table VI: Questionnaire data for the four study regions, showing the percentage of commercial and recreational anglers that agree, obey and have knowledge of the current regulations governing the linefish resources in South African waters

Parameters	Frequency (%)					
	Commercial			Recreational		
	Agree	Obey	Knowledge	Agree	Obey	Knowledge
		n = 194	*West Coast*		*n* = 57	
Size limit	91	61	63	83	67	36
Bag limit	60	51	86	62	50	50
Closed season	67	62	83	75	55	51
Reserves	83	81	–	88	90	–
		n = 45	*Southern Cape coast*		*n* = 8	
Size limit	29	60	91	86	43	38
Bag limit	69	51	51	57	86	62
Closed season	31	58	48	57	43	14
Reserves	58	56	–	100	71	–
		n = 96	*Eastern Cape coast*		*n* = 118	
Size limit	83	42	54	82	30	50
Bag limit	75	88	61	62	56	55
Closed season	86	85	70	90	79	54
Reserves	92	92	–	93	84	–
		n = 32	*KwaZulu-Natal coast*		*n* = 174	
Size limit	97	56	88	89	64	47
Bag limit	81	94	97	79	70	68
Closed season	75	81	100	87	79	92
Reserves	84	97	–	97	98	–

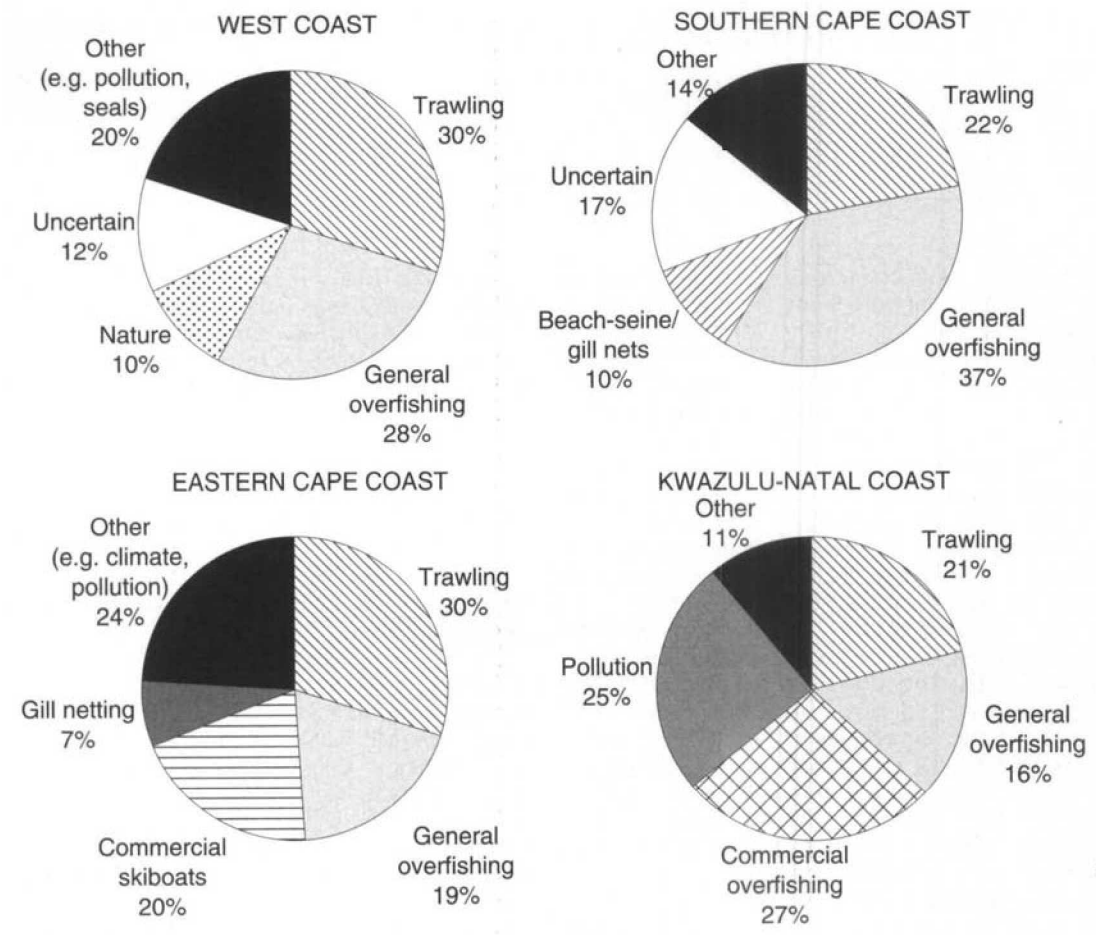

Fig. 2: Primary reasons given by interviewees for the decline in linefish catches in the South African boat-based linefishery for the four study regions

may have been placed in areas for the vessel where they were not observed. Nevertheless, considerable over-reporting does appear to exist, particularly for non-target species. For species where this was large, statistical analysis was not possible. Statistical analysis of the degree of under-reporting therefore focused on a few selected target species, for which adequate APS records were available, and the degree of over-reporting was low (Table V). The CVs of the estimated reporting error ratios were large (30–50% in most cases), but it is interesting to note that, excluding hottentot *Pachymetopon blochii* (under-reported by 6.7 times), the under-reporting ratio estimates fall between 2.3 and 3.8, the overall estimate of under-reporting being calculated as 2.87 ($SE = 0.47$).

Effort and catch estimation for the Port Alfred fishery gave a calculated estimate of 2 718 days fished per year, a *cpue* of 8.8 kg·angler^{-1} for kob and an average of 4.8 crew per boat. This gives an annual kob catch estimate of 92 025 kg for 1995. The catch reported by the NMLS for the same period was 76 054 kg, a difference of 16 tons, or 21%. Considering the crude estimation procedure used, this result indicates that catch returns submitted to the NMLS fairly accurately reflect catches from the Port Alfred area.

Angler attitudes and awareness

The majority of fishermen interviewed indicated support for the types of control measures currently used in management of the linefishery (Table VI). An exception was in the Southern Cape, where only 29% of commercial fishermen supported minimum size limits and 31% supported closed seasons. Marine reserves received the highest acceptance

Table VII: Percentage of recreational fishermen admitting to selling their catch and willing to pay an annual licence fee (and the average acceptable fee) for the four study regions

Parameters	West Coast	Southern Cape coast	Eastern Cape coast	KwaZulu-Natal coast
Percentage selling catch	22	22	58	54
Percentage agreement	83	78	44	78
Average acceptable fee (Rand)	32	119	86	74

from both the commercial and recreational sectors, receiving 100% support from the Southern Cape recreational sector.

Although most fishermen interviewed indicated support for the existing regulations, a large percentage in all regions did not know or obey them (see Table VI). For example, in the Eastern Cape, 70% of recreational fishermen interviewed retained undersize fish and, in the Southern Cape, 57% admitted to retaining fish in the closed season. When tested on their knowledge of the regulations governing the fish species they landed most frequently, 64% of the West Coast recreational fishermen interviewed did not know the size limits for those species. This contrasts with the KZN commercial and recreational fishermen, where 88 and 47% respectively knew the size limits for their main target species. Commercial fishermen appeared to have a better knowledge of the regulations than the recreational sector. Between 22 and 58% of recreational fishermen also admitted to selling their catches (Table VII), which is illegal under current regulations, although this is probably an underestimate of the true percentage because of fishermen's likely reticence to admit to illegal activities.

Most fishermen interviewed reported a decline in fish caught, except those on the West Coast (only 43% citing a decline), where the snoek fishery has been particularly successful over the past few years (Table VIII). The reasons offered in explanation varied (Fig. 2), but general overfishing and "trawling" were cited as major causes in all regions. Most recreational respondents (with the exception of the Eastern Cape) indicated that they were willing to pay for an annual licence fee to fish recreationally, with the average acceptable price varying between regions from R32 to R119 (Table VII). However, most emphasized that they would only be prepared to pay an annual licence fee on condition that the funds generated were used to enhance the fishery for their benefit. The rates of inspection by fisheries patrol officers were also found to differ markedly between areas (Table IX), with the highest average annual inspection rates on the West Coast (12 checks per commercial vessel per year) and the lowest in the Southern Cape (one check per vessel per year).

DISCUSSION

Characteristics of the South African boat-based linefishery

The South African linefishery is an important economic and social contributor to the South African community (McGrath *et al.* 1997). In 1996, an estimated 13 800 offshore boat fishermen participated in South African recreational linefisheries, while 18 126 crew were registered in the commercial linefishery (boat registration data, Chief Directorate: Sea Fisheries). In the marine, boat-based linefishery, anglers and fishermen operated off an estimated 3 444 (probably an underestimate because of limited sampling) recreational and 2 998 registered commercial vessels. The vessels range from outboard-engined dinghies and skiboats <4 m long to large, decked vessels more than 20 m long.

There are relatively few natural, sheltered harbours or launch sites along South Africa's rugged 3 000 km of coastline, and these are not evenly distributed. This has had a fundamental effect on the type of vessel used in the various coastal areas. Historically, boat-based linefishing first flourished in the Cape, where a number of partially sheltered bays allowed for the construction of dedicated fisheries harbours or slipways. Regarding their distribution, there is a clear

Table VIII: Questionnaire data on perception of changes in fishing success for the four study regions

Parameters	West Coast	Southern Cape coast	Eastern Cape coast	KwaZulu-Natal coast
Percentage yes	43	89	88	80
Percentage no	5	10	12	18
Percentage unclaimed	52	1	0	2

Table IX: Average number of inspections per vessel by law enforcement officials over the previous 12 months for the four study regions

Number of inspections	West Coast	Southern Cape coast	Eastern Cape coast	KwaZulu-Natal coast
Recreational	4	1	2.7	3
Commercial	12	1	4.8	8

declining trend in the number of such facilities from west to east, with 13 fisheries harbours or slipways along the West Coast (Orange River to Cape Point), 11 along the South-Western Cape, five along the Southern and South-Eastern Cape coast and only two in KwaZulu-Natal.

As a direct result of this trend in availability of fisheries harbours, there is an inverse trend in the extent to which fishing vessels rely on geographic features such as river mouths or sheltered beaches as launch sites. As a consequence, when fishermen started introducing larger, powered, decked vessels to replace the original sail-powered open boats used in South African linefisheries prior to the First World War, this principally occurred in the Cape, where suitable harbours were available (Pulfrich and Griffiths 1988). Few of these vessels were introduced in KZN, where they could only operate out of Durban Harbour. In contrast, the development of river-mouth or beach-launched, trailable, outboard-engined skiboats following the Second World War principally resulted in an escalating deployment of these smaller linefishing vessels along the East Coast (Mara 1986). Although substantial numbers of those craft have now been deployed along the entire South African coastline, there is still a higher proportion of them along the KZN and Eastern Cape coasts (Penney *et al.* 1995).

Another factor that had a fundamental effect on the characteristics of the boat-based linefishery in the various coastal regions was that of responsibility for control of access to launch facilities. At the time of the formation of the Union of South Africa in 1910, only Natal opted to retain control of the coastline at provincial level. Along much of the Natal coast, the Natal Provincial Administration subsequently delegated control of beach use to the various coastal municipalities. As those beaches became increasingly used for launching skiboats, municipalities delegated control over beach launches to the increasing number of recreational skiboat clubs. In many of those clubs, formal commercial fishing activities were discouraged, or even prohibited in terms of the municipal lease agreements. As a result, most skiboat operators refrained from registering their vessels for commercial fishing in order to retain access to the club-controlled launch sites. This tendency was exacerbated by strict safety requirements imposed on commercial (but not recreational) vessels by the Department of Transport. In particular, the smaller skiboats favoured by many KZN fishermen did not qualify for commercial safety certificates, further reducing incentives to register commercially.

In contrast, the fisheries harbours and slipways constructed along the Cape coast by the national government were planned to foster development of commercial fisheries. Registered commercial vessels enjoyed certain privileges in such harbours, the most important of which was the right to sell fish on the quayside or slipway. Prior to 1985, there were no restrictions placed on commercial registration for linefishing. As a result, the majority of regular boat fishermen in the Western Cape registered their vessels in order to gain access to fisheries harbours and the right to sell their catches. As a result of these two opposing forces, there remains a clear trend along the South African coast from the Western Cape, where the majority of linefishing vessels are commercially registered, to a very small proportion of registered commercial linefishing vessels in KZN.

However, it must be noted that this geographic trend in proportional commercial registration is not a reliable indicator of the extent to which linefishermen in the various regions rely on linefishing to supplement their incomes. In KZN, many of the "recreational" skiboats are operated on a commercial basis, particularly when migratory, shoaling linefish species become available, and a high proportion of the "recreationally" caught fish are sold. In comparison, many of the linefish craft used predominantly for sport- or game-fishing in the Western Cape are commercially registered. It is therefore almost impossible to develop unambiguous definitions of the various boat linefishery sectors, and past comparisons between the "commercial" and "recreational" linefishing sectors have often foundered on inconsistencies in expected motivations and fishing practices in these inaccurately defined "sectors".

Monitoring of the South African linefishery

Independent initiatives to collect data from commercial fishermen in the Cape and from recreational fishermen in KwaZulu-Natal were started in the

early 1970s by the then Sea Fisheries Branch in Cape Town and the Oceanographic Research Institute in Durban respectively. Early commercial data sources included returns from fisheries harbours, purchase records from major linefish dealers and voluntary monthly catch returns from a few fishing areas that did not have fisheries harbours. In contrast, recreational data collection efforts in KwaZulu-Natal focused on voluntary catch logs or cards from clubs or individuals, angling competition returns from the various recreational facets and shore-angling records collected by the Natal Parks Board during beach patrols. In 1982, Sea Fisheries accepted the responsibility for merging these various linefish data-collection efforts into a centralized, computerized database, and the National Marine Linefish System (NMLS) was established. Since then, the NMLS has served as a national repository for long-term linefish catch and effort data series, providing a central database and summary service for use in linefish research and management, as well as to those fishery sectors providing data.

As a consequence of its diverse origins and data sources, the NMLS is characterized by considerable flexibility with regard to data sources (Penney 1993). The wide range of data sources captured has made the NMLS useful in supporting a number of scientific publications and management decisions (Van der Elst and Penney 1995). However, a less desirable consequence of such flexibility has been the relatively low level of validation of many of the captured data sources. Various efforts have been made to validate existing data sources, or to provide comparative data since the implementation of the system (Penney 1994). In KZN, beach patrols and monthly effort censuses were introduced to supplement and validate club catch returns. Voluntary catch cards and competition returns have been compared in an effort to determine the relative coverage, strengths and weaknesses of each data source. Dealer and harbour returns were introduced in an effort to obtain total catch indices in the absence of complete return coverage, and a number of research projects (e.g. Hecht and Tilney 1989) have compared NMLS data with independent data sources.

Results confirmed that data on the NMLS range from accurately weighed and reported data, such as those from certain competition returns and dealers, to highly unreliable data, such as some of the voluntary or compulsory returns, which are subject to non-reporting, under-reporting and even over-reporting. A further, perhaps more serious problem is the extent to which certain linefishery sectors are inadequately covered by existing NMLS data sources. In particular, almost no recreational data are collected outside KZN, and the increasingly significant "subsistence" sector, defined in the recent White Paper on Marine Fisheries for South Africa (Anon. 1997) as fishing to live, by taking out only what one requires for oneself or for one's immediate family or community, is not represented as such in any of the existing data. This raises questions regarding the scientific basis for existing management measures for these sectors.

Linefish research in South Africa has tended to focus on the biology and life history of important commercial and recreational species (e.g. Smale 1988, Buxton and Smale 1989, Griffiths and Heemstra 1995). Those authors have noted that stock assessment of these species has been complicated by the need to make use of unreliable estimates of catch and effort. As Hilborn (1992) notes, there is often an unfortunate division of effort in fisheries agencies. Those who collect the data often do not have the technical skills to analyse them, and those who analyse them often have little field experience regarding the difficulties of data collection. This study has confirmed the importance of a knowledge of the limitations of catch return systems, and the need for a mechanism to check the accuracy of returns.

The low level of accuracy in catch returns analysed in this study made the estimation of total regional catch impossible, except for a few of the main linefish target species. The large standard errors obtained result from a variety of sources. First, the scope of the study limited the number of observations, and it is possible that observers missed some of the catch, resulting in subsequent "over-reporting" by the permit-holder. Numerous reasons exist for inaccurate returns sent in by the permit-holders. These include the fear of income tax implications or a wilful breaking of regulations such as bag limits or closed seasons. However, perhaps the most important is apathy as a result of the lack of catch return validation and follow-up of incorrect or missing returns. Mann-Lang (1996) noted 13 sources of bias in KZN recreational catch and effort data captured on the NMLS, many of which were determined to substantially affect the quality of certain data sources. Similarly, a number of specific sources of inaccuracy are known in the commercial catch returns:

(i) The most common problem appears to be the consistent submission of nil (no effort, no catch) returns, even when catches are made. For example, in 1994, 55% of the monthly returns received from registered commercial vessels were nil returns (Wilke 1995).
(ii) In some areas, fish are reported in numbers rather than mass, despite instructions to furnish the latter. This is a particular problem for snoek *Thyrsites atun* on the Cape west coast. The

average conversion factor used to convert snoek numbers to mass is 2.2 kg per fish, which undoubtedly contributes to the estimated under-reporting ratio of 3.0 for this species.

(iii) In all areas, less important by-catch species are often left off catch returns. For example, hottentot on the Cape west coast (estimated to be under-reported by 6.7 times) are often not reported when fishermen target on snoek. Hottentot only tend to be reported on those few trips when they constitute the main target. This is known to be a particular problem with sharks in the Southern Cape, where returns seldom reflect shark catches, even when substantial catches have been observed.

(iv) In many traditional fishing areas, a number of fish are kept by the crew as part-payment for the day's fishing. Referred to as "fries", these are also often not included in returns submitted by boat owners. In areas such as Struis Bay, the "fries" have been reported to reach up to one-third of the total catch (L. Knobel, Struis Bay, pers. comm.), and on days of poor fishing, the share taken by the crew in Arniston can sometimes constitute the entire catch (Hutton and Lamberth in prep.). This factor probably accounts for much of the estimated 21% under-reporting estimated for the kob catch in Port Alfred.

Current commercial linefish permit conditions allow for the withdrawal of permits from fishermen who fail to submit returns. Although there have not yet been attempts to reduce commercial effort by withdrawing permits from non-performing vessels, this possibility does appear to have become a concern to some fishermen, prompting the submission of false catch returns when vessels are inactive. Finally, a further complicating factor is that many permit holders tend to lump particular species (e.g. "Redfish"), making species-specific analyses difficult.

Despite the problems encountered, the NMLS has provided the only source of catch and effort data for the linefishery, and has been used for many purposes, including:

(i) tracking interannual trends in catch and effort for various species and sectors;
(ii) determining seasonal trends in abundance or availability of particular species;
(iii) investigating geographic distribution patterns of important linefish species and, coupled with seasonal distributions, inferring migration patterns and stock distributions;
(iv) comparing the impact of various fishery sectors in various seasons and areas;
(v) assessing performance levels of vessels in the squid and tuna fisheries.

The extent to which NMLS data can reliably be used for such summaries depends on the degree of inaccuracy in the data and, equally important, how consistent any inaccuracies are over time. Current problems with data accuracy need to be resolved if linefish catch and effort data are to serve their rightful role in the development and motivation of effective, long-term management plans for South African linefisheries. In particular, recent initiatives to develop assessment-based operational management procedures and management reference points for key linefish species (Griffiths 1997) have focused attention on the need for data to support such assessments, particularly age-length data and accurate indices of fishing mortality rate and *cpue*. The following linefishery monitoring issues therefore need to be addressed.

(i) Data-collection efforts for the South African linefishery should be specifically focused on providing data required for the development of assessment-based operational management procedures and management reference points for important linefish species.
(ii) Considering their high level of bias and inaccuracy, existing compulsory and voluntary submitted catch-and-effort returns (both commercial and recreational) should either be validated continuously through a dedicated observer programme or be phased out entirely in favour of data collected at key landing sites by trained coastal observers.
(iii) Observer efforts should be focused on species, areas and sectors as management requirements dictate. In particular, increased attention should be paid to monitoring recreational and "subsistence" fisheries in the Cape.
(iv) Should the existing compulsory and voluntary submitted catch-and-effort returns be phased out, systems should be implemented to regularly review and validate data sources. For example, occasional national surveys, such as that conducted during this study, could be used to validate data collected by the permanent coastal observers, or to provide regional or national estimates of total catch and effort when required.
(v) A coastal catch-and-effort observer system should be integrated with the existing KZN shore patrol and boat-inspection efforts and the length-frequency sampling programme. A coastal observer programme must provide accurate, long-

term indices of catch and effort for use in assessments.

Management of the South African linefishery

Prior to 1985, the only linefish management measures implemented nationally in South Africa were minimum size limits on a few species. With the exception of a regional closed season and bag limit on elf *Pomatomus saltatrix* in KwaZulu-Natal, and a closed season to prevent landing of poor quality snoek in the Cape, there were no other restrictions. By the mid 1980s, declining catch rates and mean sizes for many important linefish species prompted calls from linefishery sectors for development of effective management for the fishery. As a first response, the then South African National Committee for Oceanographic Research (SANCOR) Linefish Steering Committee initiated efforts in 1984 to standardize minimum size and bag limits country wide.

In 1985, a broadly representative National Marine Linefish Committee was appointed ministerially to provide recommendations on the management of the linefishery. As a result of the recommendations of that committee, a comprehensive linefish management framework was implemented in 1985, laying the foundation for the promulgation of a suite of linefish management measures in ensuing years. The most important of these were the introduction of a two-tiered licence system for full- and part-time commercial linefishermen, the capping of commercial effort at the 1985 level, the introduction of minimum size limits, based on sizes at 50% maturity for many important linefish species, the division of linefish species into categories, based on perceived stock status, with associated bag limits for commercial and recreational fishermen and the introduction of national closed seasons for certain species.

As a direct result of the broad representation on the National Marine Linefish Committee, most of the management measures introduced were a result of a compromise between the commercial, recreational, scientific and enforcement sectors. Most sectors were generally not entirely accepting of many of the measures, particularly where the objective scientific basis for recommendations had been based on poor or disputed data. The non-affiliated recreational and subsistence sectors were also not represented on the National Marine Linefish Committee, or on the subsequent South African Marine Linefish Management Association (SAMLMA), with the result that many of those fishermen did not welcome the management measures introduced.

Over the past decade, this dissatisfaction with many of the linefish management measures has resulted in calls for their revision, and many size limits, bag limits and closed seasons have been revised as a result of debate between fishery sectors and industry representatives, scientists and managers. More recently, the national process to develop a new fisheries policy for South Africa has fueled calls for substantial revision of existing linefish management measures. However, most recommendations have resulted from specific research projects and compromises between sector viewpoints, and efforts to develop more appropriate management measures for the various sectors in the linefishery are hampered by the lack of basic data on aspects such as sector participation, distribution, fishing effort and catch composition. There is certainly a need for the development of assessment-based operational management procedures with clearly defined reference points performed on a species basis, upon which future management recommendations can be based (Griffiths 1997), and data requirements prioritized.

Management is complicated by the multispecies, multi-user nature of the fishery. Although the 10 most important species make up the bulk of the catch, linefishermen often cannot target species, particularly when fishing on the sea bed. Management measures must take account of more than 120 species with different requirements, of which at least 20 are commercially important (Penney *et al.* 1995). Fisheries managers have also tended to ignore the dynamic response of fishermen to regulations, as is apparent in the results of the questionnaire data. A fishery consists of both fish and fishermen and cognizance must be taken of both. Knowledge gained from a questionnaire survey as carried out in this study can provide insight valuable to re-addressing some of the current regulations.

Knowledge and agreement with the current regulations by the commercial sector in this study was fairly high, so the low level of compliance is mostly intentional. There is also a negative correlation between acceptance and the effectiveness of the regulations, the least effective regulations having the most support. As expected, the recreational sector does not share the same knowledge of the regulations as the commercial sector, and further education of this sector is essential. This could take place through popular literature and possibly also a permanent public relations appointment to handle the dissemination of scientific and management information to the fishermen.

Marine reserves and closed seasons appear to be particularly acceptable to fishermen, although there is some argument about the effectiveness of closed seasons for long-lived and migratory species, such as the geelbek *Atractoscion aequidens* (Griffiths and

Hecht 1995). Although a closed season is supposed to reduce effort on a species, this effort may merely be concentrated on the same species at another time, or switched to other vulnerable species. Marine Protected Areas (MPAs), on the other hand, have been shown to be a successful management option for linefish species caught from the shore and off boats. Increased abundance and size of linefish species such as galjoen *Dichistius capensis* (Attwood and Bennett 1994), roman *Chrysoblephus laticeps*, dageraad *Chrysoblephus cristiceps*, red steenbras *Petrus rupestris* (Buxton and Smale 1989) and slinger *Chrysoblephus puniceus* (Punt *et al.* 1993) have been recorded within South Africa's MPAs compared to adjacent exploited areas. Suitably designed and sited MPAs also have the potential to seed adjacent exploited areas (reservoir function) by emigration of adults and dispersal of eggs and larvae (Roberts and Polunin 1991). It therefore seems clear that the use of MPAs to protect certain overexploited South African linefish species, particularly overexploited endemic sparids and serranids, should receive increased attention.

Although most fishermen expressed acceptance of bag limits and size limits, they appear to be poorly complied with throughout the study area, and further enforcement is a necessity for such regulations to be effective. Unfortunately, barotrauma creates problems when returning many deep-water linefish species (Feathers and Knable 1993). In many instances, it is not possible to target particular species, and problems also occur with high grading, where fishermen discard fish only after catching a larger specimen. These issues are discussed at length in Penney *et al.* (1995), who concluded that it will take time before efficacy of any of the measures can be assessed and management adjusted. However, results from the present study suggest that revision of the above regulations should be addressed with some urgency.

It is encouraging that many recreational linefishermen are willing to pay a licence fee. Past discussions with the recreational sector on the implementation of such a licence have foundered on the assumption that funds thus accrued would be absorbed into central treasury accounts, where they would become unavailable for any fisheries research or management activity. In fact, the Sea Fishery Fund has always been available for the accumulation of levies from various fishing sectors. The fund has to date been dedicated to funding fisheries research and development, but not for control. The recent White Paper on a Marine Fisheries (Anon. 1997) has proposed a general angling permit, and recommends an expanded role for the Sea Fishery Fund, with all permit fees being deposited into it, so making it available to fund many of the recurrent costs of research, administration, management, control and development.

In conclusion, this study has clearly identified the need for an in-depth review of the management objectives, and attendant fishery data requirements, for the South African linefishery. Clearly defined operational management procedures are required for important linefish species and sectors, with associated monitoring and data-collection requirements. A crucial part of these monitoring requirements must be the implementation of systems to maximize data quality, and to validate data continually to ensure they meet the management requirements. Every effort must be made to minimize waste of limited funding and manpower by focusing monitoring efforts on reliable data collection systems. Of equal importance, implementation of existing or revised management measures must be addressed. These implementation efforts will have to address both education of the various fishery sectors and improved enforcement by fisheries enforcement agencies. A coordinated effort is required to address these factors if management initiatives are to address the real requirements for effective management of South African linefish resources in the future.

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APPENDIX

Commercial and recreational boat fishing questionnaire

SECTION A: (to be completed by interviewer)

Locality: _____ Date: _____ Time: _____ Boat registration no.: _____

Own boat? YES/NO	Deckboat	1	Commercial	A	Bait:	Sardine
	Skiboat	2	Semicommercial	B		Squid
	Inflatable	3	Charter	C		Prawn
	FW/Est	4	Recreational	D		Other

Number of rods:____ Crew size: ___ Estimated ages: <20 20–40 >40 Crew composition: 1 2 3 4 5
M
F

SECTION B: (Catch and effort – Skipper interview)

Skipper age: _____ code: _____ Where did you launch from? _____

Where did you fish? _____

What time did you start fishing? _____ What time did you stop fishing? _____

What type of fish were you targeting? Gamefish
Reef-fish
Billfish
Baitfish

How many days have you spent fishing in the last week? _____, month ____ and in the last 12 months? _____

Is your vessel night rated? _____ If YES, how often have you been night fishing in the last 12 months? _____

Which fishing club do you belong to? _____

How many years have you been skiboat fishing? _____

SECTION C: (Attitude to management)

Which of the following regulations, in your opinion, are effective in managing our fish stocks? (YES/NO)

Minimum size limits? _____ Bag limits? _____ Closed seasons? _____ Marine reserves? _____

(Ask each regulation specifically, e.g. have you kept undersize fish? have you kept more than your bag limit?)

Minimum size limits? _____ Bag limits? _____ Closed seasons? _____ Marine reserves? _____

Have you ever sold your catch? _____

	Target 1	Target 2
Species:		
Minimum size:		
Bag limit:		
Closed season:		

Has your catch ever been inspected? YES/NO. If YES, how often in the last month? _____ 12 months? _____
While fishing, have you ever reached your bag limit? YES/NO. If YES, specify for which species _____

SECTION D: (Economics)

What is your occupation? (Write in detail) _____

If unemployed/retired, what was your last occupation? _____

Where do you live (postal code)? _____

Are you on an overnight, weekend or longer trip/holiday? (i.e. Staying away from home) YES/NO

If YES (i.e. holiday makers, trippers), where are you staying? (Postal code) _____

What method of transport did you use to come on this trip? (Describe vehicle type, model etc.) _____

How many people came with you on this trip? _____ How many of this group will be fishing? _____

How many days will you spend away from home on this trip?

How many days of this trip will you spend fishing?

What is the estimated cost of your trip/holiday? (All members excluding transport) _____

How far did you travel to come fishing today? (Kilometers one way) _____

What method of transport did you use? (describe vehicle type, model etc.) _____

Specify number of people in vehicle _____ How many of this group will be fishing? _____

How much did you spend on this outing:

Bait?____ Boat fuel? ____ Refreshments? _____ How much did you spend on general tackle last month? ___

Expenditure on rods or reels in the last 12 months? _____

What is the estimated value of your skiboating equipment? (What would you sell it for?)

Tow vehicle: _____ Boat (plus accessories): _____ Motors: _____ Trailer: _____

Rods: _____ Reels: _____ Tackle: _____

Do you use your vehicle exclusively for towing your boat? _____

What do you spend on licencing, storage and maintenance of your skiboat per year? _____

Why do you fish? Food _____ Recreation _____ Competition _____ Livelihood _____ Other (specify) _____

COMMERCIAL

How many crew do you employ? _____ How much do you pay your crew per person per month? ____

Do you ever take charters? YES/NO. If YES, how many times in the last 12 months? _____

On average, how many fishermen/divers do you take? _____ What do you charge per person? _____

SECTION E: (General)

Have you ever caught a tagged fish? YES/NO. If YES, what happened to the tag? (Specify) _____

Has fishing deteriorated over the years? YES/NO. If YES, what is the cause of this decline?

Pollution ___ Siltation ___ Seine-netting ___ Gill-netting ___ Trawling ___ Overfishing (commercial) _____

Overfishing (recreational) _____ Other (specify) _____

Would you be prepared to pay for a marine angling licence to provide funds for fisheries conservation?

YES/NO (Give reason for answer) _____

If YES, how much would you be prepared to pay for a licence of this nature? _____

Do you participate in any other forms of fishing? _____

SPECIES	NO.	TOTAL LENGTH