African Journal of Marine Science
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/tams20

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African Journal of Marine Science 2013, 35(1): 79–97
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AFRICAN JOURNAL OF MARINE SCIENCE
ISSN 1814-232X EISSN 1814-2338
http://dx.doi.org/10.2989/1814232X.2013.769907

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This study evaluates trends in participation, catch and effort in the KwaZulu-Natal offshore boat-based linefishery. Methods used included a random access-point survey and an associated questionnaire survey. The study was undertaken between February 2009 and April 2010. Total participation in all sectors (recreational, charter and commercial) ranged between 18 217 and 20 546 boat-fishers and between 2 582 and 3 326 boats. Similarly, total fisher effort in the offshore linefishery was estimated at 39 664 boat-outings y^{-1}. The commercial boat sector had the highest catch per unit effort (CPUE) both numerically (307.4 fish outing^{-1}) and by weight (235.6 kg outing^{-1}). In contrasting, the recreational boat sector had the lowest CPUE both numerically (8.6 fish outing^{-1}) and by weight (15.0 kg outing^{-1}). In total, 86 fish species, belonging to 27 families, were recorded in catches of boat-fishers (all sectors) during the study period. Catch composition was similar with *Chrysoblephus puniceus*, *Chrysoblephus anglicus* and *Lethrinus nebulosus* being represented in the top five species of all three fishery sectors. Analysis of overall CPUE, catch composition and total catch of the offshore boat-based linefishery in KZN suggested that the fishery is currently in a relatively stable condition and that little change has occurred over the past 13 years. However, specific CPUE values from this study together with those reported in the literature suggest that some species may be severely overexploited. It is recommended that stock assessments of the priority species should be conducted in the near future and steps should be taken to encourage rebuilding of overexploited species. This must include urgent regulation of the burgeoning charter boat-fishery as well as increased attempts to establish more marine protected areas.

Keywords: access-point surveys, boat-fishing, catch composition, catch per unit effort (CPUE), charter, commercial, fishing effort, fisher participation, recreational, total catch

Introduction

In comparison to the Western Cape where linefish have been exploited since the 18th century (Griffiths 2000), the offshore linefish resources of KwaZulu-Natal (KZN) have only been exploited for the past century (Garratt 1988, Penney et al. 1999). At first these resources were only accessed through a limited number of large lineboats (14–20 m in length) that operated out of Durban Harbour (Mann-Lang et al. 1997). However, with the development of the 'skiboat' after 1945 (Penney et al. 1999), offshore fishing effort expanded along the KZN coast. Although the distance range of skiboats was minimal (<25 nautical miles) compared to the lineboats (Mann-Lang et al. 1997), the number of skiboats operating off KZN increased rapidly. Skiboats were compact, trailer-able, beach-launched vessels, 4–6 m long, powered by twin outboard engines, and were more affordable, fuel-efficient and cheaper to run than large harbour-based vessels (Penney et al. 1999). One of the key advances/changes brought about by skiboats was the fact that anglers could launch from just about any reasonably protected beach (including river mouths) and access many productive fishing grounds that had previously not been exploited and had thus acted as refugia for resident reef fish.

The boat-based linefishery is the largest of its kind in KZN in terms of capital investment, accounting for approximately 35% of the total capital value of all fisheries in the province (McGrath et al. 1997, Penney et al. 1999). It also lands an estimated 40% of the total annual weight of marine fish caught in KZN (Penney et al. 1999). In terms of number of participants, it is the second largest marine fishery after shore-angling (Brouwer et al. 1997, Dunlop and Mann 2012). Currently, within the KZN offshore boat-based linefishery there are three sectors that compete directly for the same fish resources using similar vessels and fishing equipment: recreational, charter and commercial boat-fishers. Although not fully recognised as a separate facet of the offshore boat-based linefishery in terms of management under the Marine Living Resources Act (RSA 1998a), charter boat-fishing has become increasingly popular in KZN and has been shown to be driven by both recreational and commercial objectives (Pradervand and van der Elst 2008). For this reason, it was included as a separate sector in the current study. Considering the strong overlap in motivations between these three sectors and the fact that offshore boat-based linefishing is a ubiquitous activity targeting a wide range of species in both shallow and deep waters over diverse habitats, sector-specific management measures have been slow and difficult to develop (Sauer et al. 1997, Penney et al. 1999).

Although catch-and-effort data have been collected on the offshore boat-based linefishery sporadically over the past 100 years (Penney et al. 1999), management decisions for this fishery have traditionally been based on research that focused on specific life histories of the most important species (van der Elst and Garratt 1984, Sauer et al. 1997, Brouwer and Buxton 2002). However, in the past 30 years catch-and-effort data have formed an increasingly important component for assessing the efficacy of management and providing information for specific management actions and subsequent regulations (Sauer et al. 1997, Griffiths et al. 1999). Furthermore, long-term monitoring of catch and effort has provided indications of important trends in the fishery and has allowed for better informed management decisions to be made.

Although long-term catch-and-effort data, specifically from the National Marine Linefish System (NMLS), have been used to motivate offshore linefish management recommendations, the NMLS has also been heavily criticised as being biased (e.g. error in data sources) and inaccurate (e.g. lacks coverage of certain areas and sectors) (Mann-Lang 1996, Penney 1997, Sauer et al. 1997). For these reasons, the NMLS was thought to provide a relatively poor representation of the true nature of offshore linefishing in KZN. It is not surprising therefore that management measures based on this system have attracted much criticism. In light of the criticism surrounding the NMLS and based on requests for a revision of linefish management measures, a comprehensive 'snap-shot' survey on the KZN offshore boat-based linefishery was conducted between 1994 and 1996 (Mann et al. 1997) as part of a national linefish survey (Sauer et al. 1997). This survey provided a comprehensive assessment of the levels of participation in the two main sectors of the KZN offshore boat-based linefishery (i.e. recreational and commercial skiboat fishing). In particular, it generated information and recommendations that were valuable in improving management of the fishery. From this study it was realised that management should be evaluated periodically and assessed in terms of management objectives. Without periodic assessment of the efficacy of management, management itself becomes compromised. It was therefore proposed that fishery-independent snap-shot research surveys, such as the one conducted in 1994–1996, be carried out periodically (i.e. every 5 years) to evaluate the linefishery. Although there have been a few surveys focusing on certain aspects of offshore fishing in KZN since 1994–1996 (Jairam 2005, Pradervand and van der Elst 2008), no large-scale evaluations assessing fishery metrics, such as total fisher participation, fishing effort, catch composition and CPUE, have been carried out. Furthermore, several changes have taken place in the offshore fishery since the last survey, including the introduction of the national marine recreational fishing licence system (1999); declaration of an emergency in the linefishery (2000); a national ban of vehicles driving on the beach (2002); recognition and registration of subsistence fishers (2003); promulgation of stricter linefish regulations (2005); and a drastic cut in commercial fishing effort with the allocation of long-term rights in 2006. Considering these changes and the currently depressed status of many linefish resources, the overall objective of this study was therefore to evaluate the effectiveness of the management of the KZN offshore boat-based linefishery. Specific aims included: (1) to determine total offshore fisher participation and annual fishing effort; (2) to determine catch composition, CPUE and total catch; and (3) to make comparisons with other similar fishery-independent assessments previously conducted along the KZN coast.

Material and methods

Access-point survey

Catch-and-effort data were obtained using a stratified-random access-point survey, based on the techniques developed in South Africa (Smale and Buxton 1985, Hecht and Tilney 1989, Sauer et al. 1997, Fennessy et al. 2003, Pradervand et al. 2003, Pradervand and van der Elst 2008) and abroad (Robson and Jones 1989, Jones and Robson 1991, Wagner et al. 1991, Pollock et al. 1994, Steffe et al. 2008). As pointed out by Stanovick and Nielsen (1991), sampling all potential access-points (i.e. skiboat launch sites) uniformly may cause the access-point design to become ineffective as areas of low and high fishing intensity will be sampled equally. The survey design therefore focused on launch sites with high fishing effort to minimise the sampling bias; this information was obtained from launching effort statistics acquired from the KZN Boat Launch Site Monitoring System (BLSMS) in 2008 (see Khumalo et al. 2009). All launch sites were apportioned into existing EKZNW zones (Figure 1). Sampling within each zone was stratified according to the ratio of 6 weekdays: 6 weekend days/holidays per month based on the ratio determined by Clarke and Buxton (1989) and Mann et al. (1997). Peak school holidays (when the school holidays of all nine South African provinces coincided) and public holidays were treated as weekend days. However, as the boat-fishery is very weather dependent, boat sampling was confined to areas and days when boats had gone to sea.

All boats and their associated skippers that were encountered returning from sea (i.e. complete fishing trips) were checked and questioned about the time spent fishing, crew size and demographics, area fished and what fish they had caught (only fish that were retained were recorded in this study). Where large catches were made, such as on commercial vessels, all fish caught were counted but only a subsample of fish was measured and the total catch weight was estimated by using length/weight regressions (Mann 2000, Froese and Pauly 2010; ORI, unpublished data). In instances where large numbers of boats were encountered, a subsample routine was followed whereby boat skippers were checked randomly. However, all boats that were not checked were counted and apportioned into the different boat sectors (i.e. commercial, charter or recreational) according to their vessel registration number, which is a unique number that all small seagoing vessels must have clearly displayed on the side of the vessel. In instances where fish were kept but measurements of all fish could not be taken (i.e. uncooperative fishers), the species types and numbers caught were recorded and the length (and

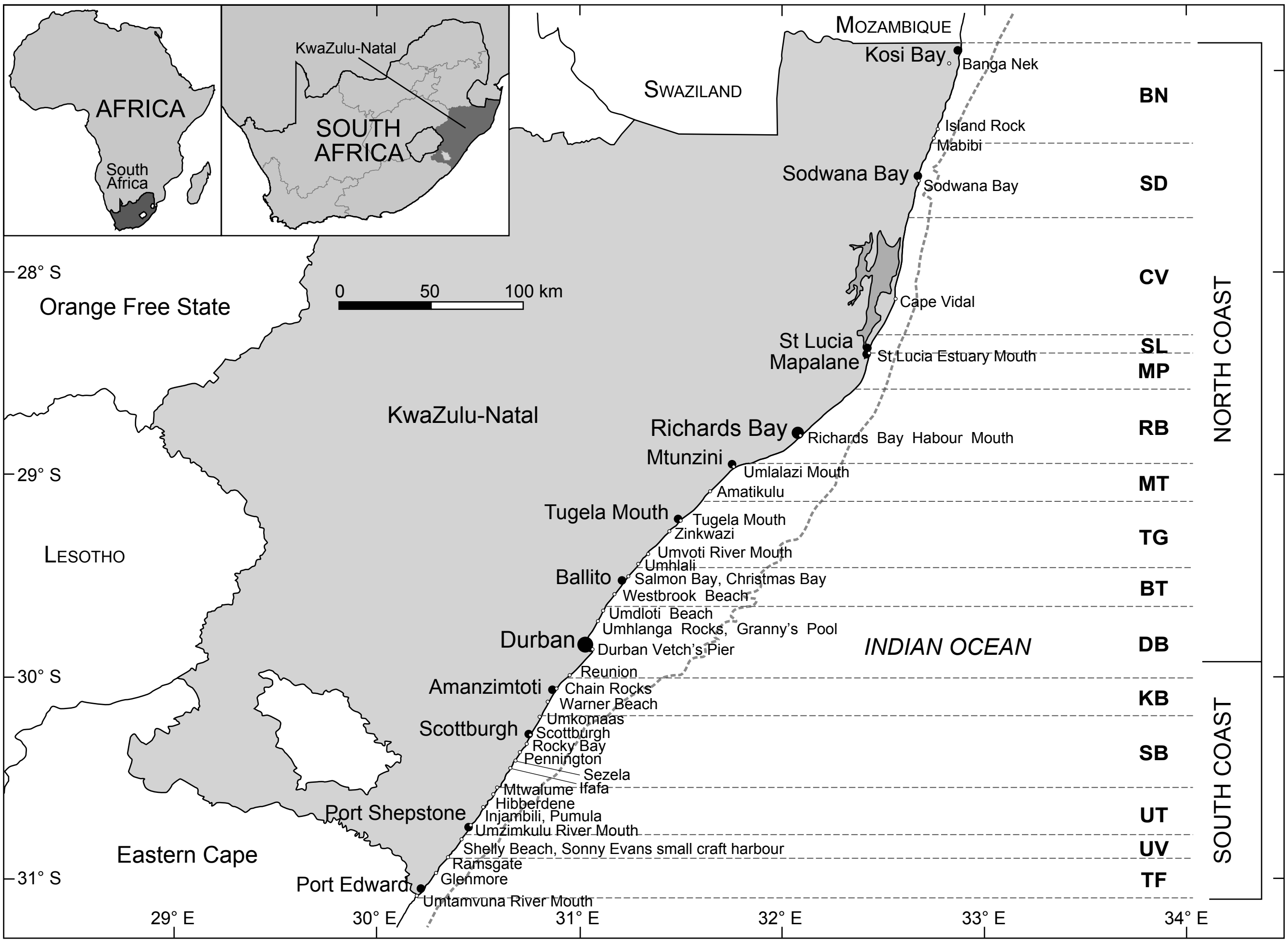

Figure 1: Map of the KZN coast showing the various skiboat launch sites and their associated EKZNW zones (BN = Bhanga-Nek, SD = Sodwana, CV = Cape Vidal, SL = St Lucia, MP = Mapelane, RB = Richards Bay, MT = Mtunzini, TG = Tugela, BT = Ballito, DB = Durban, KB = Kingsburgh, SB = Scottburgh, UT = Umtentweni, UV = Uvongo, TF = Trafalgar). Note that the Richards Bay Harbour mouth is made up of the following launch sites: Meerensee Skiboat Club (SBC), Richards Bay SBC and Richards Bay Small Craft Harbour. Similarly, Durban Harbour/Vetch's Pier includes Bluff Yacht Club, Bobbies Angling Club, Fynnlands Angling Club, Pompano Angling Club, Rod and Reel Club, Durban SBC and Durban Undersea Club

thus weight) was estimated using averages recorded for that species or its closest relative during the study period. It must be noted that few boats that launched in the late afternoon/evening and returned at night were sampled for logistical and safety reasons.

Due to the large number of launch sites (>45) spread along the KZN coast, additional catch-and-effort data were obtained from random access-point surveys carried out by two trained observers as part of a land-based fishery observer programme (funded by the Fisheries Branch of the Department of Agriculture, Forestry and Fisheries [DAFF]). This programme recorded boat-based catch-and-effort data (in the same manner as described above for the access-point surveys) at some of the major launch sites on the KZN north coast (i.e. Richards Bay Skiboat Club, Meerensee Skiboat Club and Richards Bay Small Craft Harbour) and on the lower south coast (i.e. Port Edward Skiboat Club, Glenmore Skiboat Club, Ramsgate Skiboat Club and Shelly Beach Skiboat Club) (Figure 1). Data from the programme were extracted for the period October 2008 to September 2009 because subsequent to this period the observer programme ceased for three months (October–December 2009). Data from the access-point surveys carried out by the authors for the period January–September 2009 were therefore pooled with DAFF's Linefish Observer Programme data and used for the catch-and-effort analysis. In addition to catch-and-effort data, a subsample of boat skippers were also interviewed using a detailed questionnaire (available as online supplementary material at http://dx.doi.org/10.2989/1814232X.2013.769907).

Estimation of total boat-fisher participation

Total annual effort in the South African commercial boat-based linefishery is monitored and regulated through rights allocated by DAFF under the Marine Living Resources Act (RSA 1998a). Total allowable effort (TAE) in terms of number of vessels was set at 52 vessels and 354 crew members for KZN during the long-term (i.e. eight years) rights allocation process in 2006 (Traditional Linefish Policy). Not all these rights are activated each year and information on the number of active commercial vessels along the KZN coast during the study period was obtained from DAFF (Y Snyders, DAFF, pers. comm.). In contrast, participation in the charter and recreational boat-fisheries is currently of an open-access nature. For this reason, three different methods were used to calculate total participation for the recreational boat sector. Firstly, as a requirement of the MLRA, all skippers of recreational fishing vessels (including charter vessels) must be in possession of a Code 10 recreational skipper's permit (note this permit type is an extra permit only required by the skipper of a recreational fishing vessel, which is in addition to the general recreational fishing permit required by all marine anglers in KZN). For this reason, total participation was calculated using the number of Code 10 skipper's permits sold in KZN during 2009 by the South African Post Office and through EKZNW outlets (DAFF, unpublished data) and scaled-up using the average crew size recorded for recreational boats in the current study (i.e. 3.13; Table 1). Note that this estimate excludes non-motorised fishing vessels such as paddle-skis (known locally as fishing-skis), which generally do not have to launch through registered launch sites (Mann et al. 2012). The second method calculated total participation of recreational boat-fishers by taking the total number of registered boats in KZN from the Natal Deep Sea Angling Association (NDSAA) and the South African Light Tackle Boat Anglers Association (SALTBAA) and multiplying this by the average crew size of the recreational boat sector. The third method calculated total participation by taking the total number of launches recorded in 2009 by recreational boat-fishers in the BLSMS (see below; Khumalo et al. 2010) and dividing it by the average number of times boats fished in a year (adjusted for avidity after Thompson 1991) obtained from the questionnaire survey.

Total participation for the charter boat sector was obtained from estimates made by Pradervand and van der Elst (2008). It is important to note that a large majority of fishers that fish off charter boats (i.e. charter clients) are not regular fishers and in most cases pay to fish on a once-off basis. In the Durban Harbour headboat-fishery it was found that 41% of charter clients had fished for the first time, and this proportion was used in estimating a more realistic total participation in terms of number of fishers in the charter boat sector (ORI, unpublished data).

Estimation of total annual boat-fishing effort

In January 2002, all small craft launch sites (except those within registered ports) had to be licensed in terms of environmental considerations with regard to the beach driving legislation (Regulation No. 1399 in Government Gazette No. 22960). These regulations were promulgated in terms of Section 44 of the National Environmental Management Act (RSA 1998b) and became effective on 20 January 2002. Through extensive stakeholder participation, this licensing initiative introduced a mandatory launch and catch register in 2004, locally known as the BLSMS register (Khumalo et al. 2010). Boat clubs operating out of ports (e.g. Durban and Richards Bay harbours) voluntarily agreed to comply with this initiative, thus providing good

Table 1: Average crew size and daily fishing hours from 1 318 boat inspections conducted along the KZN coast between October 2008 and September 2009. Standard deviation is given in parentheses

Parameter	Sector		
	Recreational	Charter	Commercial
Average number of crew	3.13 (1.43)	6.10 (2.24)	5.81 (1.04)
Average daily fishing hours	5.12 (1.59)	5.71 (1.45)	7.23 (1.50)

coverage of the whole KZN coast. Since skippers are obliged to record data such as date, launch time, beach time, crew number, purpose of trip, etc. for each boat-outing in the BLSMS register, total fisher effort (i.e. number of launches/outings per year) was determined by analysis of these records.

Estimation of total catch and catch per unit effort (CPUE)

CPUE was calculated per boat-outing and then averaged for the entire dataset. The following formula was used:

$$\mathrm{CPUE} = \frac{\sum_{i=1}^{n}(C_i)}{n} \qquad (1)$$

where C_i is the number or weight (kg) of fish retained by the ith boat-outing and n is the total number of boat-outings sampled. Boat-outings that had a duration of <0.5 h were excluded from the CPUE calculation to avoid influencing the variance of the catch-rate estimator by extreme catch rates that arise by chance during short fishing trips (Pollock et al. 1994). Released fish were not included in CPUE calculations because of the unreliability of angler-reports (Claytor and O'Niel 1991, Brouwer et al. 1997).

Total annual catch (C) was estimated by multiplying total annual effort (E) by the CPUE:

$$C_{\mathrm{total}} = \mathrm{CPUE} \times E_{\mathrm{total}} \qquad (2)$$

Results

Access-point survey

A total of 390 access point surveys were carried out at 32 of the ~45 registered skiboat launch sites along the KZN coast between 1 October 2008 and 30 September 2009. In all, 1 318 boat-outings/launches were inspected, which consisted of 561 recreational, 234 charter and 523 commercial boat-outings.

There was a significant difference (Kruskal-Wallis one-way ANOVA, $H = 674.99$, df = 2, $p < 0.001$) in the average number of crew per boat between the sectors (Table 1). However, according to Dunn's test, charter (6.2 crew; SD 2.2) and commercial (5.8 crew; SD 1.1) boats had on average a similar number of crew per vessel ($p > 0.05$), whereas recreational boats generally had fewer crew (3.1 crew; SD 1.4).

The average fishing trip duration (i.e. time spent fishing at sea) per sector was also significantly different (Kruskal-Wallis one-way ANOVA, $H = 412.39$, df = 2, $p < 0.001$; Table 1) between the sectors. Commercial boats (7.2 h;

SD 1.5) spent the longest period fishing at sea, whereas recreationals fished for the shortest period at only 5.1 h (SD 1.6).

Total boat-fisher participation

The total number of boat-fishers participating in the KZN offshore boat-based linefishery was estimated at between 18 217 and 20 546 fishers, made up of 7 662–9 991 recreational boat-fishers (Table 2), 10 283 charter boat-fishers and 272 commercial boat-fishers. The number of boats participating was estimated at between 2 582 and 3 326, comprising 2 448–3 192 recreational (Table 2), 96 charter and 38 commercial boats. Using the number of non-local KZN fishers interviewed (i.e. 10.6%, based on the questionnaire survey), it is estimated that between 812 and 1 059 recreational boat-fishers (260–338 boats) visit KZN from other provinces each year.

Total annual boat-fishing effort

Based on the BLSMS register (Khumalo et al. 2010), there were approximately 38 128 boat launches undertaken for the purpose of fishing along the KZN coast during 2009. This number was made up of 30 435 recreational, 5 898 charter and 1 795 commercial boat launches. However, a large proportion of commercial effort (54%) is not recorded on the BLSMS as many commercial boat-fishers neglect to fill in the register and/or launch from sites that are not registered (e.g. Richards Bay Harbour commercial slipway). For this reason, the number of outings reported by commercial fishers on the mandatory NMLS catch returns (known locally as ‘Blue Books’) was used as a more reliable indication of commercial launch effort. Based on these commercial returns (Y Snyders, unpublished data), a total of 3 331 commercial boat launches were recorded during 2009. Taking this more realistic value into account, total annual fishing effort in the KZN offshore boat-based linefishery during 2009 was estimated to be 39 664 launches for all three sectors included. Note that this estimate excludes non-motorised fishing vessels.

Temporal and spatial variation in fishing effort

Temporal boat-fishing effort is shown in Figure 2. Recreational and charter boat-fishers have similar seasonal variation in fishing effort, with both peaking in effort during school holiday periods (i.e. December, January, April and July). There was also a drop in fisher effort for both sectors from September to November (i.e. spring), the period when wind is strongest in KZN. Commercial boat-fishing effort is fairly high throughout the year, with a slight increase over winter (May–July) and summer (October–January).

Spatially, boat-fishing effort differed along the coast and between the sectors (Figure 3). Recreational boat-fishers generally launched from all zones except BN (refer to Figure 3 for abbreviations). Notably, the UV (2 211), DB (8 233), RB (5 546) and CV (2 764) zones had the highest recreational boat use. Charter boat-fishers generally launched along the south coast of KZN, with UV (1 918) and SB (1 101) zones having the highest usage. On the north coast, SL (829) and TG (473) zones also had relatively high charter boat usage. However, it should be noted that a few larger harbour-based charter vessels operating out of the Durban and Richards Bay harbours do not complete the BLSMS register and have therefore been omitted from this assessment. Commercial fishing effort according to the NMLS was highest in the RB (708) and TG (561) zones on the north coast and UT (455), UV (559) and TF (415) zones on the south coast. No commercial effort was recorded north of St Lucia as this area falls into the iSimangaliso Wetland Park, which includes two large contiguous marine protected areas (MPAs) where commercial fishing is prohibited.

Table 2: Estimates of total participation in the KZN recreational offshore boat-based linefishery in 2009 based on the three different methods (see Material and Methods for more detail)

Method	Total number of boats	Total number of fishers	Source
1	3 192	9 991	DAFF unpublished data
2	2 448	7 662	NDSAA*, SALTBAA**
3	2 665	8 341	BLSMS data

*R Hand, Chairman of NDSAA, pers. comm.
**B Else, Finnlands Skiboat Club Secretary, pers. comm.

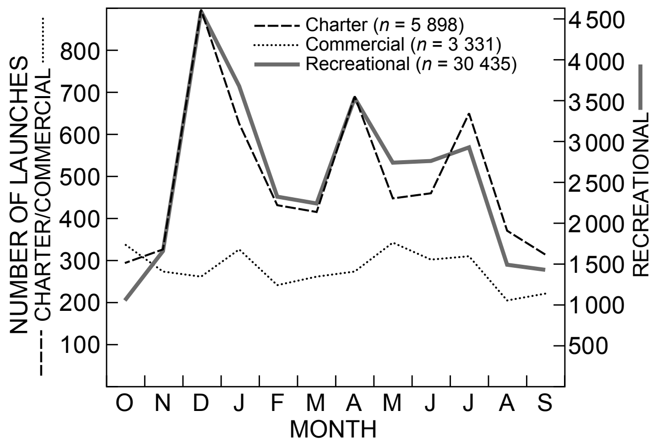

Figure 2: Temporal distribution of boat-fishing effort between recreational, charter and commercial boat-fishers along the KZN coast during 2009 based on the BLSMS and mandatory commercial NMLS returns

Catch per unit effort

During the current survey, a total of 1 318 boat-outings (from all three sectors) was inspected. These vessels had caught and retained a total of 171 814 fish, constituting a total of 141 346 kg during 39 584 hours of fishing. Overall, CPUE numerically (Kruskal-Wallis one-way ANOVA, H = 929.59, df = 2, $p < 0.001$) and by weight (Kruskal-Wallis one-way ANOVA, H = 856.18, df = 2, $p < 0.001$) was significantly different between the sectors of the KZN offshore boat-based linefishery (Table 3). The commercial boat sector had the highest CPUE both numerically ($p < 0.05$; 307.4 fish outing^{-1}) and by weight ($p < 0.05$; 235.6 kg outing^{-1}) compared to the other sectors. In contrast, the recreational boat sector had the lowest CPUE both numerically ($p < 0.05$; 8.6 fish outing^{-1}) and by weight

(p < 0.05; 15.0 kg outing^{-1}). The charter boat sector (p < 0.05; 26.6 fish outing^{-1} or 41.6 kg outing^{-1}), although far lower than commercial boats, had a CPUE slightly higher than the recreational boat sector. There was a similar trend between the number of fish caught per fisher-hour (Kruskal-Wallis one-way ANOVA, H = 816.53, df = 2, p < 0.001) and the weight of fish per fisher-hour (Kruskal-Wallis one-way ANOVA, H = 628.02, df = 2, p < 0.001) between the different sectors (Table 3). In general, commercial boat-fishers catch a lot more than charter and recreational boat-fishers; however, these fish are mostly smaller in size. Similarly, charter boat-fishers catch more fish per outing than recreational boat-fishers, but this is because they often target smaller reef fish species and have on average greater crew sizes.

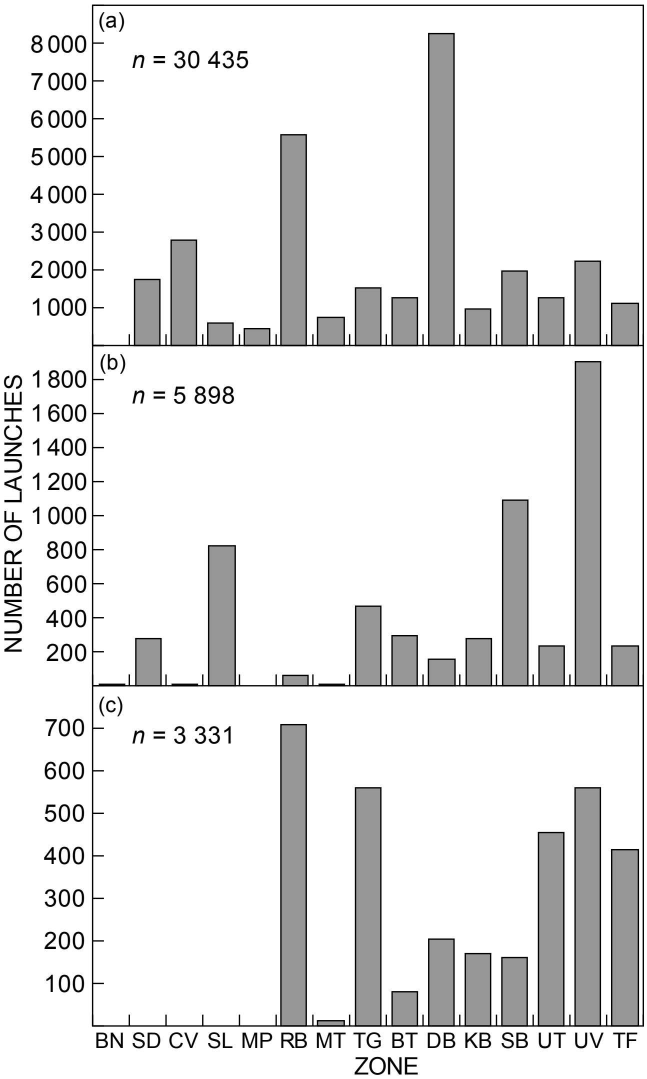

Figure 3: Spatial distribution of boat-fishing effort along the KZN coast between (a) recreational and (b) charter boat-fishers based on the BLSMS and (c) commercial boat-fishers based on mandatory commercial NMLS catch returns during 2008/2009 (BN = Bhanga-Nek, SD = Sodwana, CV = Cape Vidal, SL = St Lucia, MP = Mapelane, RB = Richards Bay, MT = Mtunzini, TG = Tugela, BT = Ballito, DB = Durban, KB = Kingsburgh, SB = Scottburgh, UT = Umtentweni, UV = Uvongo, TF = Trafalgar)

Numerically, CPUE (fish outing^{-1}) was not significantly different between months or austral seasons for any of the boat-based sectors (Figure 4). This may be explained by the high variation (i.e. standard deviation) in catches. Nonetheless, CPUE for all three sectors seems to be slightly higher during late spring (October–November) and from March through to July (autumn to winter). Specifically, recreational (9.5 fish outing^{-1}) and commercial (342.1 fish outing^{-1}) boat-fishers had a relatively higher CPUE during autumn. August and September generally had the poorest CPUE for all sectors during the year.

Monthly variation in CPUE by weight (kg outing^{-1}) for each sector between October 2008 and September 2009 along the KZN coast is shown in Figure 5. The only significant difference in CPUE by weight (kg outing^{-1}) between the austral seasons was for the recreational boat-fishery (Kruskal-Wallis one-way ANOVA, H = 41.5, df = 3, p < 0.001; Figure 5a), where CPUE during winter (11.0 fish outing^{-1}) was lower than during summer (18.0 fish outing^{-1}). Again, the high variation in catches from month to month may explain why there was no significant difference between the austral seasons for the other sectors. Nonetheless, charter boat-fishers showed a distinct peak in CPUE by weight in summer (54.7 kg outing^{-1}; Figure 5b), and to a lesser degree in autumn (42 kg outing^{-1}) and spring (45.6 kg outing^{-1}). Fish caught during January and February by charter boat-fishers were of a larger size as CPUE numerically was lowest at this time of year. CPUE by weight for commercials was highest from April (309.0 kg outing^{-1}) through to July (277.7 kg outing^{-1}).

In general, the monthly trends in commercial CPUE by weight and number were identical, showing four distinctive peaks throughout the year. This shows that commercial boat-fishers rely heavily on relatively small reef fish species when they are most abundant, whereas recreational and charter boat-fishers tend to target larger fish (i.e. pelagic gamefish). Nevertheless, there was a fairly high degree of overlap between the different sectors at certain times of the

Table 3: Summary of CPUE results from 1 318 boat inspections conducted along the KZN coast between October 2008 and September 2009. Standard deviation is given in parentheses

CPUE	Sector		
	Recreational	Charter	Commercial
Average number of fish outing^{-1}	8.58 (15.11)	26.61 (19.71)	307.41 (274.17)
Average weight of fish outing^{-1} (kg)	15.00 (17.75)	41.60 (41.26)	235.56 (193.46)
Average number of fish fisher^{-1} h^{-1}	0.58 (1.43)	0.82 (0.55)	6.71 (4.94)
Average weight of fish fisher^{-1} h^{-1} (kg)	1.04 (1.25)	1.35 (1.33)	5.18 (3.42)

year, suggesting that when a certain species is abundant, all sectors will target it (e.g. *Scomberomorus commerson* and *Coryphaena hippurus*).

It is difficult to clearly reflect spatial variation in CPUE along the KZN coast because charter and commercial boat-fishers do not operate from all launch sites (Figure 6). For this reason, zones on the north coast (from Bhanga-Nek to Ballito) and zones on the south coast (from Durban to Trafalgar) of KZN were combined for statistical analyses. Commercial boat-fishers on the north coast (438.6 fish outing^{-1}) had a significantly (Mann-Whitney *U*-test, U = 6 288.5, df = 521, $p < 0.001$) higher CPUE numerically than those on the south coast (107.2 fish outing^{-1}) of KZN (Figure 6a). In contrast, recreational boat-fishers on the south coast (9.9 fish outing^{-1}) had a numerical CPUE significantly (Mann-Whitney *U*-test, U = 31 541, df = 559, p = 0.018; Figure 6a) higher than those on the north coast (6.2 fish outing^{-1}). There was no significant difference in numerical CPUE between the north and south coasts of KZN for charter boat-fishers.

By weight, commercial boat-fishers on the north coast (324.6 kg outing^{-1}) had a significantly (Mann-Whitney *U*-test, U = 7 885, df = 521, $p < 0.001$) higher CPUE than those on the south coast (99.7 kg outing^{-1}) of KZN (Figure 6b). In contrast, charter boat-fishers on the south coast (42.7 kg outing^{-1}) had a significantly (Mann-Whitney *U*-test, U = 693.5, df = 232, p = 0.014; Figure 6b) higher CPUE by weight than those on the north coast (18.34 kg outing^{-1}). Similarly, recreational boat-fishers on the south coast (17.1 kg outing^{-1}) also had a CPUE by weight significantly (Mann-Whitney *U*-test, U = 28 866, df = 559, $p < 0.001$; Figure 6b) higher than those on the north coast (11.2 kg outing^{-1}).

Total catch and catch composition

Based on estimates of total annual fishing effort, the total annual catch for the KZN offshore boat-based linefishery

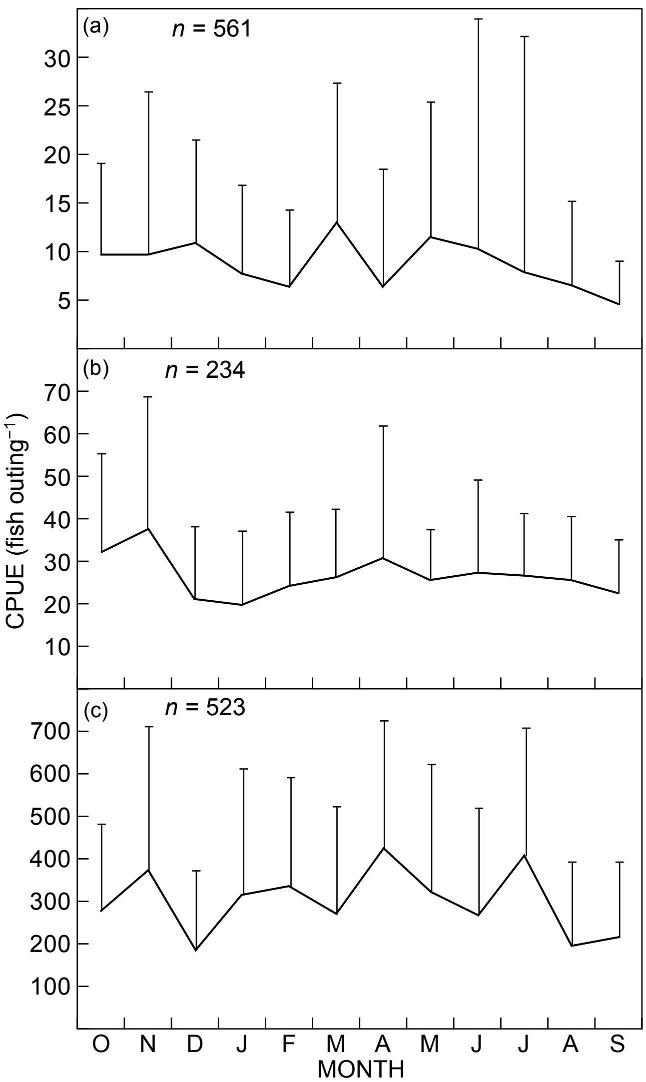

Figure 4: Monthly variation of mean CPUE numerically for (a) recreational, (b) charter and (c) commercial boat-fishers recorded along the KZN coast from 1 318 boat inspections conducted between October 2008 and September 2009. Error bars denote SD

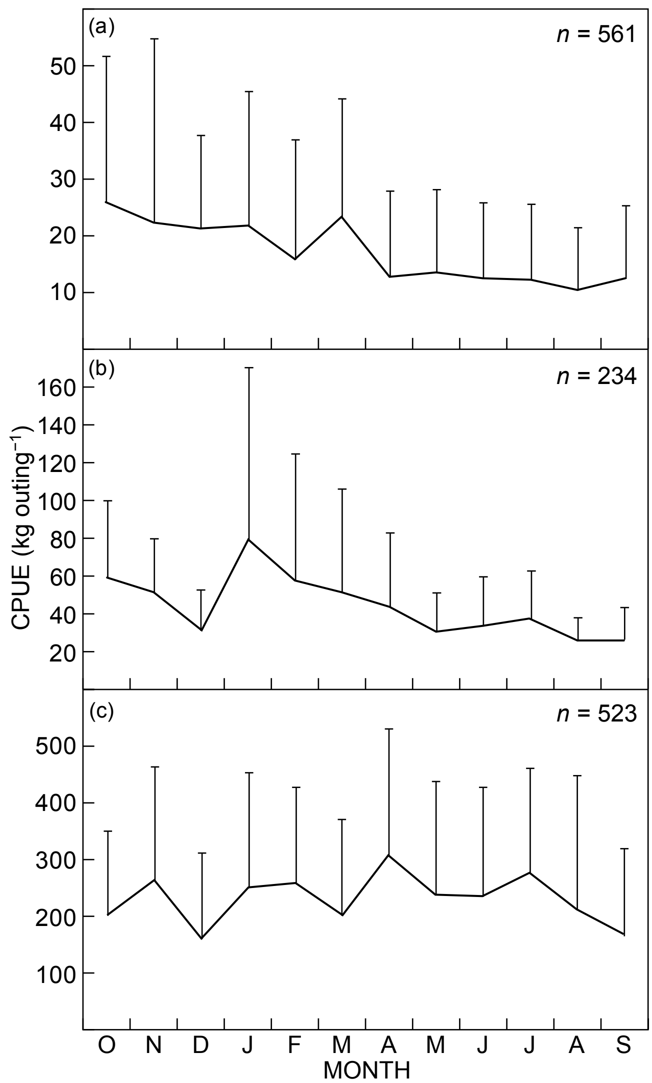

Figure 5: Monthly variation of mean CPUE by weight for (a) recreational, (b) charter and (c) commercial boat-fishers recorded along the KZN coast from 1 318 boat inspections conducted between October 2008 and September 2009. Error bars denote SD

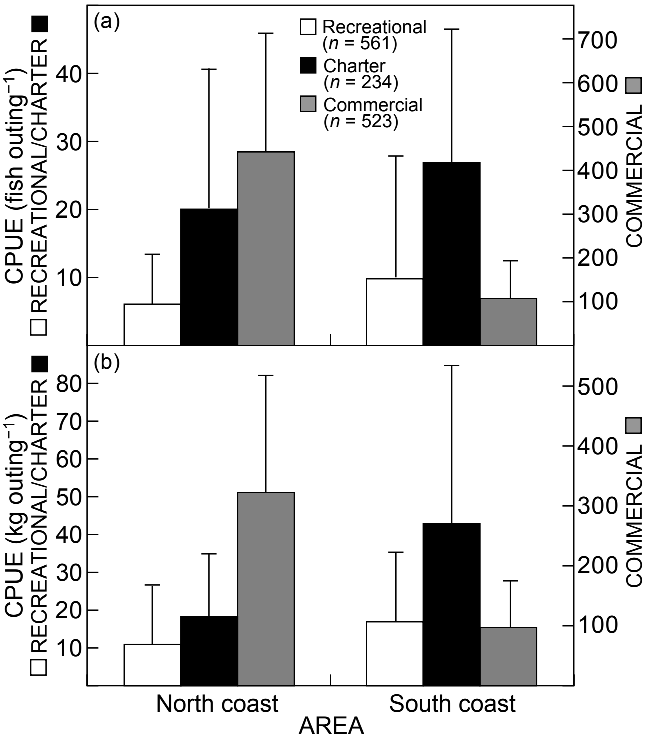

Figure 6: Mean spatial variation of CPUE: (a) numerically and (b) by weight for recreational, charter and commercial boat-fishers along the KZN coast from 1 318 boat inspections conducted between October 2008 and September 2009. Error bars denote SD

was estimated at 1 487 t y^{-1} (1 442 027 fish y^{-1}). More specifically, 457 t y^{-1} (261 132 fish y^{-1}) was caught by recreational fishers, 245 t y^{-1} (156 946 fish y^{-1}) by charters and 785 t y^{-1} (1 023 949 fish y^{-1}) by commercial boat-fishers.

In total, 84 teleost species, belonging to 26 families, and two cartilaginous species representing one family were recorded in catches of boat-fishers (all sectors) during the study period (Appendices 1–3). The top five species that comprised the bulk of the commercial catch numerically included *C. puniceus* (66.0%), *Cheimerius nufar* (22.4%), *Lethrinus nebulosus* (4.9%), *Pachymetopon aeneum* (1.9%) and *C. anglicus* (0.9%) (Appendix 1). Similarly, in terms of weight, the commercial catch was dominated by *C. puniceus* (53.0%), *C. nufar* (25.2%), *Epinephelus andersoni* (3.1%), *L. nebulosus* (3.3%) and *P. aeneum* (2.6%) (Appendix 1). Demersal reef fish species, particularly sparids and some soft-substrate species (e.g. Sciaenidae), play an important role in overall catches of commercial boat-fishers. For example, sparids alone contributed 91.9% and 85.3% of the catch by number and weight respectively. Pelagic gamefish were poorly represented in the commercial catches. Note that some sciaenid species, especially *Atractoscion aequidens* and *Argyrosomus japonicus*, would have been underrepresented because of the lack of sampling conducted at night.

Recreational catch composition by number was dominated by *C. puniceus* (33.9%), *L. nebulosus* (9.0%), *Thunnus albacares* (7.4%), *Scomber japonicus* (5.3%) and *C. anglicus* (4.4%) (Appendix 2). By weight, recreational catch composition was dominated by *T. albacares* (21.7%), *C. puniceus* (14.1%), *Coryphaena hippurus* (9.8%), *Cymatoceps nasutus* (5.1%) and *Euthynnus affinis* (4.9) (Appendix 2). Importantly, pelagic gamefish comprise a large percentage of the catch both by number and weight. However, demersal reef-fish species also make up an important component. Interestingly, *C. nasutus* made up an important component of catch composition by weight for recreational boat-fishers, whereas the species was of less importance in the other sectors. Compared to charter and commercial boat-fishers, recreational boat-fishers generally target and catch a wider variety of fish species.

The top five species numerically in charter boat-fishers' catches were *C. puniceus* (34.4%), *L. nebulosus* (16.7%), *T. albacares* (13.1%), *C. anglicus* (8.1%) and *P. aeneum* (4.6%) (Appendix 3). Similarly, by weight catch composition for charter boat-fishers was dominated by *T. albacares* (43.0%), *C. puniceus* (11.1%), *C. anglicus* (8.0%), *L. nebulosus* (7.0%) and *P. aeneum* (4.2%) (Appendix 3). As with commercial boat-fishers, demersal reef-fish species are an important component of catches both numerically and by weight; however, pelagic gamefish species, such as *T. albacares*, also form an important part of charter boat catches recorded from KZN especially during late summer (January–April).

Discussion

Survey techniques

The access-point sampling technique used in this study has remained the most suitable technique used by linefish researchers in South Africa for sampling boat-based linefishers (Smale and Buxton 1985, Sauer et al. 1997, Fennessy et al. 2003, Pradervand et al. 2003, Pradervand and van der Elst 2008). Similarly, internationally it remains the method of choice when the fishery of interest can be sampled via relatively few, well-defined public access sites/points (Robson and Jones 1989, Jones and Robson 1991, Wagner et al. 1991, Hilborn 1992, Pollock et al. 1994, Steffe et al. 2008, Hartill et al. 2010).

Alternative survey techniques, such as postal or telephone surveys, may work quite effectively (i.e. allow for a greater sample size and better spatial and temporal coverage of boat-fishers) in the boat-based fishery as the majority of boat-based fishers in KZN fall into the upper income group (i.e. have a telephone and/or mail address) (McGrath et al. 1997). However, in South Africa the access-point method still remains the preferred technique because surveys that tend to intercept anglers (i.e. face-to-face, on-site techniques) are more accurate than those that rely on simple angler-reports of harvests with associated angler recall bias (Mann-Lang 1996, Penney 1997, Sauer et al. 1997). Furthermore, on-site sampling allows for accurate identification of fish caught and measuring of length frequencies.

Total boat-fisher participation

The estimated total number of recreational and commercial boat-fishers (excluding charters) participating in the KZN offshore boat-based linefishery (7 934–10 263 fishers and 2 486–3 230 boats) was similar to that recorded in the 1994–1996 survey (i.e. 10 059 fishers and 3 103 boats) by

Mann et al. (1997). It would thus seem that there has been relatively little change in participation in the boat-based linefishery over the past 13 years in KZN. However, by taking a closer look at each sector of the fishery, some interesting results are apparent.

There were 173 commercial vessels in the KZN boat-based linefishery in 1994–1996 (Mann et al. 1997) and in 2009–2010 there were 51 (of which only 38 had activated their rights). Therefore, the commercial sector has decreased by 70% since 1994–1996. This is in line with the government decision to reduce the allocation of commercial rights and thus commercial linefishing effort between 2002 (medium-term rights) and 2006 (long-term rights). By contrast, the number of charter vessels operating in the boat-based linefishery has increased from <10 in 1995 (Pradervand and van der Elst 2008) to approximately 100 boats, estimated in the current study. This is an annualised rate of increase of 6.9% per year. It is likely that the reduction in the number of commercial fishing rights (i.e. abolishment of the old A- and B-licences[1]) resulted in unsuccessful commercial applicants opting to move into the charter boat sector. This applied particularly to the B-licence holders who did not solely rely on the linefishery as a source of income. Furthermore, many B-licence holders, although classified as semi-commercials at the time, were in fact running chartering businesses and also sold their catch. Over the years, charter fishing has become an increasingly popular activity among visitors to KZN and even for local fishers who do not have the opportunity to fish offshore (Pradervand and van der Elst 2008). This fact, as well as the diminishing returns from commercial boat-based linefishing (Mann et al. 2001), may have prompted the increased number of vessels moving into this sector.

Clearly, charter fishing has important implications for resource management, tourism and socio-economic development in KZN. Although a thorough assessment of the charter fishery was completed in 2003–2004 (Pradervand and van der Elst 2008), this sector has been allowed to grow without any direct resource management intervention. This is concerning as in many parts of the world, charter fisheries are known to take a large proportion of recreational landings due to their greater professionalism (i.e. inherently commercial nature) and therefore more efficient fishing practices (Figueira and Coleman 2010). A similar trend was observed in our study (see below) and while the reduction in commercial fishing effort was imperative, the uncontrolled increase in charter fishing effort will result in fish stocks being driven beyond the bio-economic equilibrium (Clark 1985), and thus effectively limit stock rebuilding. It is obvious that recreational fishing effort is less sensitive to diminishing returns than that of commercial and subsistence fisheries. Management efforts must therefore be focused on bringing this growing sector under control, both for economic reasons and to ensure the continued sustainable use of KZN's linefish resources. The currently well regulated and managed traditional commercial linefishery can be used as a guideline for this purpose.

[1] B-licence holders were essentially recreational fishers who subsidised their fishing to some degree by selling their catch. In contrast, A-licence holders relied exclusively on the fishery itself and did not have other sources of income (i.e. true commercial fishers)

Table 4: Number of Code 10 skipper's permits sold annually by the Post Office and EKZNW in KZN, 1999–2009

Year	Number of licences sold
1999	12 070
2000	4 716
2001	4 181
2002	3 868
2003	3 227
2004	3 028
2005	3 463
2006	3 524
2007	3 381
2008	3 538
2009	3 938

Based on permit sales, the recreational boat sector appears to have undergone several fluctuations in fisher numbers since 1994–1996. Historical permit sales data from KZN (i.e. the Code 10 permit required by skippers of recreational and charter boats; DAFF, unpublished data) suggest that the highest number of recreational boats participating in the fishery was in 1999 (Table 4). This, however, was likely due to a misunderstanding by boat-fishers on the requirements of a Code 10 boat skipper's fishing permit; when it was first introduced, most boat-fishers assumed they needed a Code 10 permit but only later did clarification take place that it was only required by the skipper of a recreational fishing vessel (AC Cockcroft, DAFF, pers. comm.). It is therefore likely that numbers of recreational fishing vessels have in fact remained reasonably constant over the past 13 years. This trend was predicted by McGrath et al. (1997), who stated that the demand for fishing trips will grow at a slower rate than the population growth rate and growth of income, with the result that relatively few 'new' boat-fishers were expected to enter the fishery.

Total annual boat-fishing effort

Total annual boat-fishing effort recorded in the current study (39 664 launches y^{-1}) was considerably lower than that estimated by Mann et al. (1997) during 1994–1996 (50 491 launches y^{-1}). However, the drastic cut in commercial linefishing effort can probably explain the overall lower effort recorded in this study. For instance, there were an estimated 15 491 launches by commercial boat-fishers in 1994–1996 (Mann et al. 1997) compared to the 3 331 recorded in the current study. The fact that commercial boat-fishers are no longer allowed to sell or transfer their fishing rights and move between the three identified geographical management regions (i.e. Port Nolloth–Cape Infanta, Cape Infanta–Port St Johns and KwaZulu-Natal) has also contributed to decreasing fishing effort within this sector. Furthermore, when commercial effort was capped, several commercial boat-fishers switched to recreational or charter boat-fishing, and as a result they now do not launch as often as they would have if they were still fishing commercially and relying on the fishery as a direct source of income. In addition to the reduction in commercial effort, since the cessation of hostilities in Mozambique in 1992, many recreational boat-fishers have turned their attention to that region, which has contributed to a reduction in the overall effort recorded by recreational boat-fishers in KZN (Penney et al. 1999). The fact that South Africans also no longer need a visa to enter Mozambique, and the anecdotal reports of good catches made in this region, has further encouraged the spread of fishing effort to Mozambique.

Temporal and spatial variation in fishing effort

This study found considerable overlap in temporal effort between the recreational and charter boat-fisheries. Whereas fishing effort for these two sectors was highly variable, there were noticeable peaks in December, April and May. Fishing effort for both these sectors was therefore strongly governed by popular holiday periods, favourable weather conditions and, to a lesser degree, by the seasonality of target fish species. Similar trends have been observed in the Eastern Cape (Smale and Buxton 1985, Hecht and Tilney 1989, Brouwer 1997) and in KZN during the last national linefish assessment (Mann et al. 1997). On the other hand, the commercial boat-fishery is influenced more by the seasonality of target species, favourable weather conditions and economic factors. Effort for the commercial boat-fishery is characteristically higher from May through to July (early winter) and October to January (early summer). The latter period corresponds with the good catch rates of several targeted linefish species, which often coincides with peak spawning activity (e.g. *A. aequidens* [Garratt 1988], *C. nufar* [Garratt 1985], *C. puniceus* [Garratt 1985] and *P. aeneum* [Garratt 1988]).

Regionally, according to the BLSMS, it appears that the majority of charter fishing effort takes place on the lower south (Shelly Beach and Rocky Bay) and upper north (Tugela, St Lucia and Sodwana Bay) coasts of KZN. This is a fairly accurate representation and is partly because these areas are popular holiday destinations. Similar results were reported in 2003–2004 for the charter boat sector in KZN by Pradervand and van der Elst (2008). However, it should be noted that Durban Harbour serves a large charter boat-fishery that was undersampled in the current study. In contrast, commercial fishing effort is highest in areas where there are large productive reef systems, such as off Richards Bay, Tugela and the lower south coast of KZN (Garratt 1985, 1988, Mann-Lang et al. 1997, Penney et al. 1999).

Recreational boat-fishing effort in KZN was more evenly spread along the coast than the other sectors with peaks in the SD, CV, RB and DB zones. The high recreational boat-fishing effort at SD and CV can be explained by these areas being popular holiday destinations (situated in the iSimangaliso Wetland Park), which attract a broad spectrum of recreational fishers from all over KZN, and inland during the holiday periods. Recreational boat-fishers fishing in the iSimangaliso Wetland Park between Cape Vidal and Kosi Bay are restricted to pelagic gamefish species, as no bottom (or reef) fishing is allowed in the MPAs. The peaks in recreational fishing effort at Richards Bay and Durban are a result of the large number of recreational boat-fishers that reside in these urban and peri-urban areas that utilise the fishery regularly. An important aspect of the Richards Bay and Durban Harbour (including Vetch's Pier, i.e. Durban Skiboat Club) is the fact that they are sheltered launch sites where boats can launch under most weather conditions, thereby increasing the number of possible fishing days and thus effort (Mann-Lang et al. 1997).

Catch per unit effort

The overall CPUE differed significantly between the three sectors of the offshore boat-based linefishery in KZN. This was expected and is related to the substantial variation in directed fishing effort as well as the extent to which income is derived from linefishing within each of the sectors. For example, recreational boat-fishers (8.6 fish outing^{-1} or 15.0 kg outing^{-1}) have an average CPUE considerably lower than that of commercial boat-fishers (307.4 fish outing^{-1} or 235.6 kg outing^{-1}) because among other reasons, their catch restrictions differ considerably and they do not directly rely on the fishery as a source of income. On the other hand, charter boat-fishers, who are essentially recreationally motivated, have a relatively high average CPUE (26.6 fish outing^{-1} or 41.6 kg outing^{-1}), threefold higher than the recreational boat-fishery. However, CPUE per fisher (0.82 fish fisher^{-1} h^{-1} or 1.35 kg fisher^{-1} h^{-1}) indicates that these patterns of average CPUE for charter boat-outings are largely driven by the higher number of fishers on the vessel rather than an increased catch rate per fisher. It must be noted, however, that charter operators do rely indirectly on fishery performance as they are profit driven (i.e. number of customers per trip and trip regularity) and past catches (i.e. catch rates on previous trips) have a strong influence on determining customer returns (Figueira and Coleman 2010).

Because CPUE differs significantly between the three sectors of the KZN offshore linefishery, comparative trends in CPUE for each sector are discussed separately. However, cognisance should be taken of the snap-shot nature of the survey(s) and elucidation of long-term trends in CPUE of target species was beyond the scope of this study.

Recreational boat-linefishery

The overall mean CPUE by number and weight in the KZN recreational boat-linefishery has changed very little since 1994–1996 (Mann et al. 1997) (Table 5). These catch rates were similar to those found in the Transkei region of the Eastern Cape (Fennessy et al. 2003), but were lower than those recorded in the southern part of the Eastern Cape (Brouwer and Buxton 2002, Donovan 2010) and higher than those in the Southern Cape and along the West Coast (Sauer et al. 1997).

There are a number of possible reasons why CPUE for recreational boat-fishers has changed very little since the 1994–1996 survey (Table 5). Firstly, there have been considerable improvements in the technology used in the boat-based fishery since the mid-1990s (i.e. effort-creep). For example, many recreational skiboat-fishers now use more efficient global positioning systems and three-dimensional fish finders, which can locate fish and reefs with ease. Moreover, several advancements in fishing gear, such as thinner, stronger braided lines, vertical jigs and scented plastic baits (drop shots/lead heads), have also taken place. Secondly, the sampling effort and hence the estimation of CPUE by Mann et al. (1997) during the previous survey

Table 5: Comparison of mean CPUE of several important linefish species (arranged alphabetically) caught and retained by boat-fishers from two independent linefish surveys conducted in KZN. Rec = recreational, Char = charter, Comm = commercial

Species	Current study (2008–2009)						Mann et al. 1997 (1994–1996)					
	CPUE (fish outing⁻¹)			CPUE (kg fisher-day⁻¹)			CPUE (fish outing⁻¹)			CPUE (kg fisher-day⁻¹)		
	Rec	Char	Comm	Rec	Char	Comm	Rec	Char	Comm	Rec	Char	Comm
Argyrosomus japonicus	0.03	<0.01	0.28	0.20	0.04	1.36	0.01	–	0.06	0.08	–	0.77
Argyrosomus thorpei	0.05	0.00	1.42	0.04	0.00	1.43	0.61	–	2.03	0.52	–	2.19
Atractoscion aequidens	0.27	0.29	1.12	0.12	0.53	5.77	0.05	–	0.77	0.43	–	5.84
Cheimerius nufar	0.30	0.66	68.92	0.30	0.46	59.24	0.40	–	5.20	0.32	–	3.47
Chrysoblephus anglicus	0.38	2.14	2.89	0.65	3.31	4.96	0.17	–	3.80	0.19	–	3.88
Chrysoblephus puniceus	2.91	9.15	202.74	2.12	4.60	124.89	0.80	–	55.89	0.50	–	30.13
Coryphaena hippurus	0.22	0.24	0.35	1.46	0.42	1.98	0.03	–	0.03	0.12	–	0.16
Dinoperca petersi	0.14	0.09	1.01	0.21	0.08	1.72	0.08	–	0.86	0.08	–	0.73
Epinephelus andersoni	0.27	0.33	2.01	0.65	0.67	7.36	0.54	–	3.23	1.05	–	6.32
Epinephelus rivulatus	0.17	0.53	1.74	0.09	0.39	0.59	0.04	–	2.23	0.02	–	1.06
Lethrinus nebulosus	0.77	4.45	15.17	0.54	2.93	7.74	0.11	–	12.66	0.04	–	4.54
Pachymetopon aeneum	0.26	1.21	5.80	0.29	1.75	6.03	0.01	–	2.94	0.01	–	2.55
Polysteganus praeorbitalis	0.19	0.78	0.85	0.23	0.94	1.45	0.11	–	1.40	0.11	–	1.98
Polysteganus coeruleopunctatus	0.08	0.61	0.59	0.08	0.36	1.20	0.00	–	3.77	0.00	–	3.02
Scomberomorus commerson	0.94	0.05	<0.01	0.51	0.13	0.01	0.53	–	0.31	4.37	–	3.14
Thunnus albacares	0.63	3.48	0.08	3.26	17.87	0.49	0.29	–	0.20	2.48	–	2.29
Overall CPUE*	8.58	26.61	307.41	15.00	41.60	235.56	6.85	–	104.43	13.37	–	88.10

* Overall mean CPUE from each study. Measure of variability not applicable

was temporally and spatially biased. For example, sampling during the year was not continuous (i.e. several months were undersampled). Furthermore, only 18 out of the 47 launch sites that were operating in KZN during 1994–1996 were inspected. Thus, overall CPUE may have been underestimated during the earlier survey (Mann et al. 1997) and therefore could have actually decreased in the last decade. Lastly, several shifts in directed effort may explain why catch rates do not appear to have decreased over the years. For example, catch rates of *Argyrosomus thorpei*, *C. nufar*, *E. andersoni* and *S. commerson* have decreased since 1994–1996, whereas catch rates of several other fish have increased (e.g. *C. puniceus*, *L. nebulosus*, *P. aeneum* and *Thunnus albacares*; Table 5). The sequential switching of target species based on catchability is a well-known phenomenon that has sustained catch rates in the KZN boat-based linefishery for many years (Penney et al. 1999).

In general, that CPUE in the recreational boat-based linefishery has changed very little over the past 13 years, even though there have been several changes in linefish regulations for this sector, suggests that either management interventions are working well or previous estimates of CPUE were unreliable. Although one of the stated aims of management intervention for the recreational linefishery was to facilitate the harvesting of fast-growing, migratory fish species, such as pelagic gamefish, it seems that when these fish are less abundant, recreational boat-fishers quickly switch to targeting the more vulnerable and easier to catch resident reef fish. This has serious implications for the management of the fishery, especially as there is strong competition between the various sectors of the boat-fishery.

Charter boat-linefishery

The charter boat-linefishery in KZN has historically suffered from a lack of information and knowledge of its extent. This is evident in that no categorised charter boat-fishers were interviewed in the 1994–1996 survey (Mann et al. 1997), whereas only a crude six-week survey of the Durban Harbour headboat-fishery (ORI, unpublished data) had been done prior to 2004. Note that while some charter boats were sampled in the 1994–1996 survey, most were registered as commercials (B-licence holders) and were subsequently included as part of the commercial sector in that study. Using the Durban Harbour headboat-fishery as a reference point, it would seem that CPUE has changed considerably since 1995 (Table 6). However, a more recent evaluation of the charter boat sector in 2003–2004 revealed similar results to those of the current study (Table 6). It is therefore likely that comparison of the headboat-fishing operation off Durban with skiboat-based charter fishing operating off the rest of the KZN coast is unrealistic. Since charter boat CPUE estimates exceed those of the recreational boat sector, any further uncontrolled increase in charter-fishing effort will place increasing pressure on the province's already overexploited linefish resources.

Commercial boat-linefishery

The overall mean CPUE by number and weight in the KZN commercial boat-linefishery has increased almost threefold since 1994–1996 (Mann et al. 1997) (Table 5). This increase is in direct contrast to historical trends in CPUE for commercial linefisheries in South Africa, which have declined considerably over the years (Attwood and Farquhar 1999, Penney et al. 1999, Griffiths 2000, Brouwer and Buxton 2002). However, a similar increase in overall CPUE was recorded by Donovan (2010) in the Port Alfred (Eastern Cape) commercial linefishery for the period 1998–2007. It would seem then that the reduction of commercial fishing effort by 70% during 2002–2006 has been largely successful in increasing the overall catch rate (i.e. suggesting a recovery of the fishery) of commercial linefishers in KZN. However, these results may be

Table 6: Summary of mean CPUE for charter boat-fishers from three independent linefish surveys conducted in KZN. Measure of variability not applicable

CPUE	1995 (ORI, unpublished data)	2003–2004 (Pradervand and van der Elst 2008)	2008–2009 (current study)
Fish fisher^{-1} h^{-1}	1.36	0.91	0.82
Kg fisher^{-1} h^{-1}	0.38	1.43	1.35

misleading and such a broad assumption needs to be carefully analysed. For example, it is a generally accepted fact that in most fisheries, 20% of the fishers catch 80% of the fish (Hilborn 1985, Smith 1990, Baccante 1995, Branch et al. 2006). In the long-term rights allocation process in 2006, it was only those applicants that could prove substantial reliance on the fishery that gained fishing rights. It is thus likely that although the commercial fishery in KZN was effectively reduced by 70% in terms of number of vessels, those that remained in the fishery were the better fishers. This in effect has resulted in an increase in CPUE for the commercial fishery as a whole.

Other reasons may explain the considerable differences in CPUE between 1994 and 1996 and the current study. Firstly, a shift towards targeting smaller, more abundant sparids and lethrinids (e.g. *C. nufar*, *C. puniceus*, *L. nebulosus*, *P. aeneum*, etc.) could explain the overall higher CPUE numerically associated with lower CPUE by weight. This is evident as catch rates of all of the abovementioned species, particularly *C. puniceus*, have increased since 1994–1996 (Table 5). Furthermore, since catch rates of some larger sciaenid (e.g. *A. thorpei*) and serranid (e.g. *E. andersoni*) species have decreased since the mid-1990s (Table 5), commercial fishers, particularly on the KZN north coast, now have no option but to target smaller, more abundant reef fish all year round. A similar shift in directed effort by commercial linefishers in KZN was recorded between the 1950s and 1985 (Penney et al. 1999). Secondly, as with the charter boat-linefishery, the sampling effort in 1994–1996 was biased by the inclusion of catch-and-effort data from B-licence vessels. In a sense, these licences ‘diluted’ the overall catch-and-effort results of the commercial sector. Thus, overall CPUE values may have been considerably underestimated during the 1994–1996 survey.

Total catch and catch composition

Although total effort and participation in the recreational boat-fishery was considerably higher than the commercial boat-fishery, total estimated catch by weight for the commercial boat-fishery (785 t) was almost double that estimated for the recreational boat-fishery (457 t). This was expected considering the characteristics of these two sectors. For example, commercial boat-fishers have a much longer average trip duration than recreational boat-fishers, and they generally have double the number of crew. It is also commonly known that commercial boat-fishers are generally more effective fishers than recreational boat-fishers (Smale and Buxton 1985, Figueira and Coleman 2010). Furthermore, the fact that recreational catch restrictions are much stricter than commercial catch restrictions also helps to explain the comparatively large catches made by commercial boat-fishers, even though their overall effort is much lower. Recreational boat-fishers also spend more time fishing for pelagic gamefish, which is less productive per unit effort than bottom fishing (Penney et al. 1999, Jairam 2005). Compared to the 1994–1996 survey (402–470 t vs 457 t), estimated total catch for the recreational boat sector has changed relatively little. In contrast, estimated total catch for the commercial sector has decreased quite substantially (1 364 t vs 785 t). It is therefore likely that the reduction in commercial effort between 2002 and 2006 has been partially successful in reducing the total landings made by this sector.

The estimated total catch of the charter boat sector in our study was very high (245 t) even though there were only about 100 boats participating in the charter fishery in 2008–2009. This is in contrast to the total catch of 456 t made by more than 2 000 recreational vessels for the same period, but is similar to the 300 t estimated for the charter boat-fishery in 2003–2004 in KZN (Pradervand and van der Elst 2008). The high total catch of this flourishing sector again highlights the urgent need for improved management. Importantly, from these results, it is evident that the charter boat-fishery represents a potential threat to the future conservation and management of the linefish resources of KZN.

Catch composition in 1994–1996 for the commercial boat sector was dominated numerically by *C. puniceus* (53.5%), *L. nebulosus* (12.1%), *C. nufar* (5%), *Polysteganus coeruleopunctatus* (3.6%) and *C. anglicus* (3.6%) (Mann et al. 1997). This composition was very similar to that of the current study. *Chrysoblephus puniceus* is still the most important linefish species caught by commercial boat-linefishers in KZN, as it has been since 1985 (Penney et al. 1999). However, the percentage composition of this species in catches is much higher than in previous studies, which could highlight an increased reliance on the species as catches of other important linefish species are lower. Interestingly, *P. coeruleopunctatus* appeared less important in catches during the current study and appears to have been replaced by *P. aeneum*. Although this could represent a decline in abundance of this species, it is more likely that during boat inspections *P. coeruleopunctatus* was misidentified by observers with the similar looking *C. nufar* (van der Elst 1993) and therefore was proportionally underestimated in the overall catch. By weight, *C. puniceus* (34.2%), *E. andersoni* (7.2%), *A. aequidens* (6.6%), *L. nebulosus* (5.2%) and *C. nufar* (3.9%) dominated catches in 1994–1996, as was the case in our study. Importantly, *A. aequidens* seemed to be less important in catches during the current study and appears to have been replaced by *P. aeneum*. The lower catch rates of *A. aequidens* concur with the findings of Griffiths and Hecht (1995), Griffiths (1999, 2000) and Hutton et al. (2001). However, it should be noted that this species (and other nocturnal species such as *A. japonicus*) was likely underreported in the current study due to limited sampling of vessels fishing at night when these species are known to aggregate to feed and spawn (Garratt 1988, Griffiths 1996). Overall, there seems to have been relatively little change in catch composition in the commercial boat sector since 1994–1996, with most differences being attributed to interannual variation in linefish abundances caused by natural processes.

In contrast, species composition in the recreational boat sector has changed considerably over the past two decades. In 1994–1996, *Decapterus* spp. (14.1%), *C. puniceus* (11.7%), *A. thorpei* (8.8%), *E. andersoni* (7.9%) and *S. commerson* (7.7%) dominated catches numerically, whereas by weight, *S. commerson* (32.7%), *T. albacares* (18.6%), *E. andersoni* (7.9%), *E. affinis* (6.1%) and *A. thorpei* (3.9%) dominated catches (Mann et al. 1997). In the present study, *Decapterus* spp., *A. thorpei* and *S. commerson* were considerably less abundant in catches, whereas *E. andersoni* still formed the sixth most important species caught. Although *Decapterus* spp. are traditionally underreported in catches, because they are regarded as a bait species, the lower abundances of *A. thorpei* and *S. commerson* are cause for concern. Historical trends reveal that both *A. thorpei* and *S. commerson* were important species in both the recreational and commercial boat sectors in the mid-1980s–1990s. However, recent catch trends show that catches have declined in importance (Sauer et al. 1997, Penney et al. 1999).

Although no charter boat-fishers were interviewed *per se* during the 1994–1996 survey, comparisons with data from the Durban Harbour headboat-fishery, conducted during the same period, revealed substantial differences in catch composition since 1995. However, this study was based on only five headboats operating out of Durban Harbour and the catches made on these vessels were not comparable to the skiboat-based charter operations surveyed in the current study. On the other hand, comparisons with the study conducted by Pradervand and van der Elst (2008) show that in the last six years there has been very little change in catch composition in the charter boat-fishery. Of the species recorded, only *C. nufar* has decreased in importance and has been replaced by *P. aeneum*. A similar trend was observed in the recreational sector. Reasons for this decreased importance are unclear but could be related to declines in abundance.

Conclusion

Overall, from the analyses of participation within the three sectors, it appears that there have been few new entrants into the boat-based linefishery since 1994–1996. Rather, there has been an associated shift in participation between the sectors associated with changes in licensing structure and the successful development of a tourism-based charter-fishing industry. Total effort on the other hand (especially in the commercial fishery) appears to have decreased substantially over the past two decades. Thus, management measures appear to have been partially effective in reducing fishing pressure on the linefish resources. This is important as the KZN offshore linefishery has historically been heavily overexploited (Mann-Lang et al. 1997, Penney et al. 1999). However, since the charter boat sector has no formal management regime in place and has both recreational and commercial objectives, it poses a threat to the biological sustainability and future economic development of the offshore boat-based linefishery. Furthermore, given that charter boat-fishing is subsidised by paying customers, the bio-economic equilibrium is exceeded and greater pressure is placed on fish stocks. To avert overexploitation of an already vulnerable linefishery, the charter boat sector needs to be recognised in terms of the MLRA and carefully regulated (see Pradervand and van der Elst 2008).

Analysis of overall CPUE, catch composition and total catch in the KZN offshore boat-based linefishery has shown it to be currently in a relatively stable condition. Furthermore, management measures within each sector, barring the charter sector, seem to have been effective in limiting total landings. However, the increased percentage composition of *C. puniceus*, *L. nebulosus* and *P. aeneum* recorded in the current catches of commercial boat-linefishers may reflect a decline in other target species. For this reason, it is advised that several stock assessments should be carried out on the species highlighted in this study as a matter of urgency (e.g. *S. commerson*, *C. nufar*, *C. puniceus* and *A. thorpei*). In this way, stock rebuilding of those species that are overexploited can be carried out before any further collapse occurs. Furthermore, more work is required on the biology of *P. aeneum* and *L. nebulosus*, which appear to be of increasing importance in this fishery (note that recent genetic analyses have revealed that the species referred to as *L. nebulosus* in this study may in fact be a previously undescribed lethrinid species [A Connell, South African Institute for Aquatic Biodiversity, pers comm.]). Although overall management of the different sectors needs to be carefully adjudicated, all the sectors operating within the fishery cannot be managed individually. Ultimately, any changes that occur within one sector of the offshore linefishery will have substantial effects on sustainable management of the marine resources as a whole, which will directly affect the other sectors involved.

Acknowledgements — This study was made possible by funding from the Fisheries Branch of the Department of Agriculture, Forestry and Fisheries (DAFF) through the National Research Foundation (NRF) and from the South African Association for Marine Biological Research (SAAMBR). We thank Chris Wilke and Yolanda Snyders of DAFF and Riaan Taljaard and Audrey De Jager (KwaZulu-Natal-based linefish observers) for collecting and allowing us to use data from the Linefish Observer Programme. We also express our thanks to the numerous people who assisted with fieldwork and data capture, especially Chris Wilkinson, Sipho Mselegu and Desmond Hayes, and all the boat skippers and fishers who cooperated so willingly during the survey. Two referees are thanked for their constructive comments on an earlier draft of this manuscript.

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Manuscript received July 2012; accepted August 2012

Appendix 1: Catch composition of 523 commercial boats checked along the KZN coast during 390 access-point surveys conducted between October 2008 and September 2009 (arranged in alphabetical order by family name). Note that released fish were not included in CPUE calculations

Family	Species	Common name	Number			Weight		
			Kept	%	CPUE*	Kept (g)	%	CPUE**
Carangidae	*Caranx* spp.***	Unspecified kingfish	1	<0.01	<0.001	2 000	<0.01	0.001
	Seriola lalandii	Giant yellowtail	3	<0.01	0.001	32 000	0.03	0.010
Coryphaenidae	*Coryphaena hippurus*	Dolphinfish	181	0.11	0.059	1 036 000	0.84	0.339
Dinopercidae	*Dinoperca petersi*	Cavebass	526	0.33	0.172	897 000	0.73	0.293
Haemulidae	*Plectorhinchus chubbi*	Dusky rubberlip	1	<0.01	<0.001	3 000	<0.01	0.001
	Plectorhinchus spp.***	Unspecified rubberlip	17	0.01	0.006	52 000	0.04	0.017
Labridae	*Bodianus bilunulatus*	Saddleback hogfish	1	<0.01	<0.001	1 000	<0.01	<0.001
Lethrinidae	*Lethrinus nebulosus*	Blue emperor	7 934	4.93	2.595	4 050 000	3.29	1.325
Lutjanidae	*Aprion virescens*	Green jobfish	1	<0.01	<0.001	7 000	0.01	0.002
	Lutjanus sanguineus	Blood snapper	15	0.01	0.005	22 000	0.02	0.007
	Lutjanus spp.***	Unspecified snapper	47	0.03	0.015	76 000	0.06	0.025
	Paracaesio xanthura	Protea bream	79	0.05	0.026	150 000	0.12	0.049
	Pristipomoides filamentosus	Rosy jobfish	110	0.07	0.036	164 000	0.13	0.054
Mullidae	*Parupeneus* spp.***	Unspecified goatfish	5	<0.01	0.002	6 000	<0.01	0.002
Sciaenidae	*Argyrosomus japonicus*	Dusky kob	148	0.09	0.048	709 000	0.58	0.232
	Argyrosomus thorpei	Squaretail kob	743	0.46	0.243	749 000	0.61	0.245
	Atractoscion aequidens	Geelbek	588	0.37	0.192	3 017 000	2.45	0.987
Scombridae	*Euthynnus affinis*	Eastern little tuna	2	<0.01	0.001	5 000	<0.01	0.002
	Scomberomorus commerson	King mackerel	2	<0.01	0.001	5 000	<0.01	0.002
	Thunnus albacares	Yellowfin tuna	43	0.03	0.014	254 000	0.21	0.083
Serranidae	*Epinephelus albomarginatus*	Captain fine rockcod	439	0.27	0.144	1 096 000	0.89	0.359
	Epinephelus andersoni	Catface rockcod	1 053	0.65	0.344	3 848 000	3.12	1.259
	Epinephelus marginatus	Yellowbelly rockcod	246	0.15	0.080	1 560 000	1.27	0.510
	Epinephelus rivulatus	Halfmoon rockcod	910	0.57	0.298	311 000	0.25	0.102
Sparidae	*Boopsoidea inornata*	Fransmadam	36	0.02	0.012	16 000	0.01	0.005
	Cheimerius nufar	Santer	36 045	22.42	11.791	30 982 000	25.15	10.135
	Chrysoblephus anglicus	Englishman	1 509	0.94	0.494	2 595 000	2.11	0.849
	Chrysoblephus cristiceps	Dageraad	15	0.01	0.005	37 000	0.03	0.012
	Chrysoblephus lophus	False englishman	24	0.01	0.008	29 000	0.02	0.009
	Chrysoblephus puniceus	Slinger	106 031	65.95	34.685	65 320 000	53.02	21.367
	Cymatoceps nasutus	Black musselcracker	140	0.09	0.046	1 456 000	1.18	0.476
	Diplodus hottentotus	Zebra	1	<0.01	<0.001	1 000	<0.01	<0.001
	Pachymetopon aeneum	Blue hottentot	3 035	1.89	0.993	3 153 000	2.56	1.031
	Pachymetopon grande	Bronze bream	82	0.05	0.027	149 000	0.12	0.049
	Polyamblyodon germanum	German	8	<0.01	0.003	14 000	0.01	0.005
	Polysteganus coeruleopunctatus	Blue skin	308	0.19	0.101	627 000	0.51	0.205
	Polysteganus praeorbitalis	Scotsman	444	0.28	0.145	758 000	0.62	0.248
	Porcostoma dentata	Dane	8	<0.01	<0.001	3 000	<0.01	0.001

* Fish fisher^{-1} h^{-1}

** Kg fisher^{-1} h^{-1}

*** Species that were only identifiable to genus level in the field

Appendix 2: Catch composition of 561 recreational boats checked along the KZN coast during 390 access-point surveys conducted between October 2008 and September 2009 (arranged in alphabetical order by family name). Note that released fish were not included in CPUE calculations

Family	Species	Common name	Number				Weight		
			Caught	Kept	%	CPUE*	Kept (g)	%	CPUE**
Ariidae	*Galeichthys trowi*	Natal seacatfish	17	9	0.19	0.005	18 146	0.22	0.010
Balistidae	*Sufflamen fraenatus*	Bridle triggerfish	2	0	<0.01	<0.001	0	<0.01	<0.001
Carangidae	*Caranx heberi*	Blacktip kingfish	5	4	0.08	0.002	14 548	0.17	0.008
	Caranx ignobilis	Giant kingfish	1	1	0.02	0.001	3 000	0.04	0.002
	Caranx sexfasciatus	Bigeye kingfish	2	0	<0.01	<0.001	0	<0.01	<0.001
	Caranx spp.***	Unspecified kingfish	3	3	0.06	0.002	34 000	0.40	0.019
	Lichia amia	Garrick	1	1	0.02	0.001	3 000	0.04	0.002
	Scomberoides tol	Needlescaled queenfish	3	0	<0.01	<0.001	0	<0.01	<0.001
	Seriola lalandii	Giant yellowtail	15	15	0.31	0.008	166 000	1.97	0.093
	Seriola rivoliana	Longfin yellowtail	3	2	0.04	0.001	2 154	0.03	0.001
	Trachurus delgoa	Maasbanker	99	27	0.56	0.015	2 003	0.02	0.001
Carcharhinidae	*Carcharhinus limbatus*	Blacktip shark	2	1	0.02	0.001	16 668	0.20	0.009
	Rhizoprionodon acutus	Milkshark	1	0	<0.01	<0.001	0	<0.01	<0.001
Clupeidae	*Etrumeus teres*	East coast roundherring	204	202	4.20	0.113	14 423	0.17	0.008
	Sardinops sagax	South African pilchard	6	6	0.12	0.003	656	0.01	<0.001
Coryphaenidae	*Coryphaena hippurus*	Dolphinfish	123	123	2.56	0.069	820 319	9.75	0.457
Dinopercidae	*Dinoperca petersi*	Cavebass	76	76	1.58	0.042	119 153	1.42	0.066
Elopidae	*Elops machnata*	Ladyfish	2	2	0.04	0.001	17 764	0.21	0.010
Ephippidae	*Platax teira*	Longfin batfish	1	0	<0.01	<0.001	0	<0.01	<0.001
Haemulidae	*Plectorhinchus* spp***.	Unspecified rubberlip	5	5	0.10	0.003	5 000	0.06	0.003
	Pomadasys kaakan	Javelin grunter	22	12	0.25	0.007	11 325	0.13	0.006
	Pomadasys olivaceum	Pinky/olive grunt	5	0	<0.01	<0.001	0	<0.01	<0.001
Istiophoridae	*Istiophorus platypterus*	Sailfish	1	1	0.02	0.001	32 000	0.38	0.018
	Makaira nigricans	Blue marlin	2	2	0.04	0.001	262 000	3.11	0.146
Labridae	*Thalassoma* spp.	Unspecified wrasse	1	1	0.02	0.001	2 000	0.02	0.001
Lethrinidae	*Lethrinus crocineus*	Yellowfin emperor	1	1	0.02	0.001	523	0.01	<0.001
	Lethrinus nebulosus	Blue emperor	432	432	8.98	0.241	304 000	3.61	0.169
	Lethrinus spp.***	Unspecified emperor	1	0	<0.01	<0.001	0	<0.01	<0.001
Lutjanidae	*Aprion virescens*	Green jobfish	5	5	0.10	0.003	12 000	0.14	0.007
	Paracaesio xanthura	Protea bream	15	15	0.31	0.008	25 008	0.30	0.014
	Pristipomoides filamentosus	Rosy jobfish	3	3	0.06	0.002	4 000	0.05	0.002
Mullidae	*Parupeneus rubescens*	Blacksaddle goatfish	1	1	0.02	0.001	387	<0.01	<0.001
	Parupeneus spp.***	Unspecified goatfish	11	11	0.23	0.006	9 000	0.11	0.005
Muraenidae	*Gymnothorax* spp.***	Unspecified eel	1	0	<0.01	<0.001	0	<0.01	<0.001
Pomatomidae	*Pomatomus saltatrix*	Elf	89	35	0.73	0.020	14 777	0.18	0.008
Rachycentridae	*Rachycentron canadum*	Prodigal son	1	0	<0.01	<0.001	0	<0.01	<0.001
Sciaenidae	*Argyrosomus japonicus*	Dusky kob	17	17	0.35	0.009	114 000	1.35	0.064
	Argyrosomus thorpei	Squaretail kob	29	29	0.60	0.016	24 000	0.29	0.013
	Atractoscion aequidens	Geelbek	13	13	0.27	0.007	68 490	0.81	0.038
	Otolithes ruber	Snapper kob	5	2	0.04	0.001	1 356	0.02	0.001
	Umbrina robinsoni	Tasselfish/baardman	1	1	0.02	0.001	3 000	0.04	0.002
Scombridae	*Acanthocybium solandri*	Wahoo	2	2	0.04	0.001	25 855	0.31	0.014
	Auxis thazard	Bullet tuna/frigate	2	2	0.04	0.001	564	0.01	<0.001
	Euthynnus affinis	Eastern little tuna	202	183	3.80	0.102	413 419	4.91	0.230
	Katsuwonus pelamis	Skipjack tuna	9	8	0.17	0.004	17 566	0.21	0.010
	Sarda orientalis	Striped bonito	5	5	0.10	0.003	7 000	0.08	0.004
	Scomber japonicus	Mackerel	258	256	5.32	0.143	30 393	0.36	0.017
	Scomberomorus commerson	King mackerel	45	45	0.94	0.025	286 528	3.40	0.160
	Scomberomorus plurilineatus	Queen mackerel	123	122	2.54	0.068	358 989	4.27	0.200
	Thunnus albacares	Yellowfin tuna	358	356	7.40	0.198	1 828 594	21.73	1.019
Serranidae	*Cephalopholis sonnerati*	Tomato rockcod	6	2	0.04	0.001	1 904	0.02	0.001
	Epinephelus albomarginatus	Captain fine rockcod	51	50	1.04	0.028	167 519	1.99	0.093
	Epinephelus andersoni	Catface rockcod	161	151	3.14	0.084	363 477	4.32	0.203
	Epinephelus flavocaeruleus	Yellowtail rockcod	1	1	0.02	0.001	6 000	0.07	0.003
	Epinephelus marginatus	Yellowbelly rockcod	41	36	0.75	0.020	140 488	1.67	0.078
	Epinephelus rivulatus	Halfmoon rockcod	95	93	1.93	0.052	50 508	0.60	0.028

Appendix 2: (cont.)

Family	Species	Common name	Number				Weight		
			Caught	Kept	%	CPUE*	Kept (g)	%	CPUE**
Sillaginidae	*Sillago sihama*	Silver sillago	3	0	<0.01	<0.001	0	<0.01	<0.001
Sparidae	*Boopsoidea inornata*	Fransmadam	6	6	0.12	0.003	3 000	0.04	0.002
	Cheimerius nufar	Santer	198	168	3.49	0.094	165 877	1.97	0.092
	Chrysoblephus anglicus	Englishman	211	211	4.38	0.118	362 589	4.31	0.202
	Chrysoblephus cristiceps	Dageraad	3	3	0.06	0.002	5 000	0.06	0.003
	Chrysoblephus lophus	False englishman	4	4	0.08	0.002	4 000	0.05	0.002
	Chrysoblephus puniceus	Slinger	1 647	1 631	33.89	0.909	1 190 056	14.14	0.663
	Cymatoceps nasutus	Black musselcracker	34	33	0.69	0.018	429 447	5.10	0.239
	Diplodus hottentotus	Zebra	3	2	0.04	0.001	2 000	0.02	0.001
	Diplodus capensis	Blacktail	2	2	0.04	0.001	1 568	0.02	0.001
	Pachymetopon aeneum	Blue hottentot	147	147	3.05	0.082	165 212	1.96	0.092
	Pachymetopon grande	Bronze bream	34	34	0.71	0.019	52 000	0.62	0.029
	Pagellus natalensis	Sand soldier	118	0	<0.01	<0.001	0	<0.01	<0.001
	Polyamblyodon germanum	German	10	10	0.21	0.006	12 074	0.14	0.007
	Polysteganus coeruleopunctatus	Blue skin	46	46	0.96	0.026	47 138	0.56	0.026
	Polysteganus praeorbitalis	Scotsman	108	108	2.24	0.060	131 157	1.56	0.073
	Polysteganus undulosus	Seventy-four	2	0	<0.01	<0.001	0	<0.01	<0.001
	Porcostoma dentata	Dane	36	36	0.75	0.020	20 467	0.24	0.011
	Rhabdosargus sarba	Natal stumpnose	2	0	<0.01	<0.001	0	<0.01	<0.001
Sphyraenidae	*Sphyraena jello*	Pickhandle barracuda	1	1	0.02	0.001	200	<0.01	<0.001
Synodontidae	*Saurida undosquamis*	Largescale lizardfish	1	0	<0.01	<0.001	0	<0.01	<0.001
Teraponidae	*Terapon jarbua*	Thornfish	4	0	<0.01	<0.001	0	<0.01	<0.001

* Fish $fisher^{-1}$ h^{-1}
** Kg $fisher^{-1}$ h^{-1}
*** Species that were only identifiable to genus level in the field

Appendix 3: Catch composition of 234 charter boats checked along the KZN coast during 390 access-point surveys conducted between October 2008 and September 2009 (arranged in alphabetical order by family name). Note that released fish were not included in CPUE calculations

Family	Species	Common name	Number				Weight		
			Caught	Kept	%	CPUE*	Kept (g)	%	CPUE**
Ariidae	*Galeichthys trowi*	Natal seacatfish	10	10	0.16	0.007	18 000	0.18	0.012
Carangidae	*Caranx* spp.***	Unspecified kingfish	11	11	0.18	0.008	21 000	0.22	0.014
	Seriola lalandii	Giant yellowtail	3	3	0.05	0.002	26 000	0.27	0.018
	Seriola rivoliana	Longfin yellowtail	1	1	0.02	0.001	3 000	0.03	0.002
Coryphaenidae	*Coryphaena hippurus*	Dolphinfish	15	15	0.24	0.010	99 000	1.02	0.068
Dinopercidae	*Dinoperca petersi*	Cavebass	21	21	0.34	0.014	19 174	0.20	0.013
Haemulidae	*Plectorhinchus chubbi*	Dusky rubberlip	6	6	0.10	0.004	8 357	0.09	0.006
	Plectorhinchus spp.***	Unspecified rubberlip	10	10	0.16	0.007	13 000	0.13	0.009
	Pomadasys kaakan	Javelin grunter	8	8	0.13	0.006	6 000	0.06	0.004
Istiophoridae	*Istiompax indica*	Black marlin	1	1	0.02	0.001	103 000	1.06	0.071
Labridae	*Bodianus bilunulatus*	Saddleback hogfish	6	6	0.10	0.004	7 000	0.07	0.005
Lethrinidae	*Lethrinus crocineus*	Yellowfin emperor	6	6	0.10	0.004	3 200	0.03	0.002
	Lethrinus nebulosus	Blue emperor	1 041	1 041	16.72	0.716	685 009	7.04	0.471
Lutjanidae	*Aprion virescens*	Green jobfish	8	8	0.13	0.006	46 000	0.47	0.032
	Paracaesio xanthura	Protea bream	64	64	1.03	0.044	102 406	1.05	0.070
	Pristipomoides filamentosus	Rosy jobfish	96	96	1.54	0.066	194 554	2.00	0.134
Mullidae	*Parupeneus cinnabarinus*	Redspot goatfish	1	1	0.02	0.001	362	<0.01	<0.001
	Parupeneus spp.***	Unspecified goatfish	32	32	0.51	0.022	34 000	0.35	0.023
Sciaenidae	*Argyrosomus japonicus*	Dusky kob	1	1	0.02	0.001	9 000	0.09	0.006
	Atractoscion aequidens	Geelbek	18	18	0.29	0.012	124 000	1.27	0.085
	Umbrina robinsoni	Tasselfish/baardman	3	3	0.05	0.002	11 000	0.11	0.008
Scombridae	*Euthynnus affinis*	Eastern little tuna	139	139	2.23	0.096	255 085	2.62	0.176
	Katsuwonus pelamis	Skipjack tuna	1	1	0.02	0.001	5 417	0.06	0.004
	Scomber japonicus	Mackerel	30	5	0.08	0.003	498	0.01	<0.001
	Scomberomorus commerson	King mackerel	3	3	0.05	0.002	30 771	0.32	0.021
	Scomberomorus plurilineatus	Queen mackerel	3	3	0.05	0.002	10 815	0.11	0.007
	Thunnus albacares	Yellowfin tuna	815	815	13.09	0.561	4 182 000	42.96	2.878
Serranidae	*Cephalopholis sonnerati*	Tomato rockcod	2	2	0.03	0.001	2 166	0.02	0.001
	Epinephelus albomarginatus	Captain fine rockcod	69	69	1.11	0.047	171 800	1.76	0.118
	Epinephelus andersoni	Catface rockcod	78	78	1.25	0.054	157 000	1.61	0.108
	Epinephelus marginatus	Yellowbelly rockcod	34	34	0.55	0.023	155 761	1.60	0.107
	Epinephelus rivulatus	Halfmoon rockcod	126	125	2.01	0.086	91 635	0.94	0.063
	Epinephelus spp.***	Unspecified rockcod	1	1	0.02	0.001	1 000	0.01	0.001
Sparidae	*Boopsoidea inornata*	Fransmadam	31	31	0.50	0.021	38 437	0.39	0.026
	Cheimerius nufar	Santer	155	155	2.49	0.107	107 123	1.10	0.074
	Chrysoblephus anglicus	Englishman	501	501	8.05	0.345	774 977	7.96	0.533
	Chrysoblephus cristiceps	Dageraad	18	18	0.29	0.012	49 000	0.50	0.034
	Chrysoblephus lophus	False englishman	7	7	0.11	0.005	7 000	0.07	0.005
	Chrysoblephus puniceus	Slinger	2 142	2 142	34.40	1.474	1 076 030	11.05	0.741
	Cymatoceps nasutus	Black musselcracker	33	33	0.53	0.023	316 000	3.25	0.217
	Diplodus hottentotus	Zebra	2	2	0.03	0.001	2 000	0.02	0.001
	Pachymetopon aeneum	Blue hottentot	284	284	4.56	0.195	408 661	4.20	0.281
	Pachymetopon grande	Bronze bream	5	5	0.08	0.003	6 970	0.07	0.005
	Polyamblyodon germanum	German	9	9	0.14	0.006	8 178	0.08	0.006
	Polyamblyodon gibbosum	Cristie	2	2	0.03	0.001	2 131	0.02	0.001
	Polysteganus coeruleopunctatus	Blue skin	142	142	2.28	0.098	83 648	0.86	0.058
	Polysteganus praeorbitalis	Scotsman	183	183	2.94	0.126	220 157	2.26	0.152
	Porcostoma dentata	Dane	73	73	1.17	0.050	35 305	0.36	0.024
Synodontidae	*Saurida undosquamis*	Largescale lizardfish	2	2	0.03	0.001	1 135	0.01	0.001

* Fish fisher^{-1} h^{-1}
** Kg fisher^{-1} h^{-1}
*** Species that were only identifiable to genus level in the field