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THE ROLE OF THE TSITSIKAMMA NATIONAL PARK IN THE MANAGEMENT OF FOUR SHORE-ANGLING FISH ALONG THE SOUTH-EASTERN CAPE COAST OF SOUTH AFRICA

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The role of the Tsitsikamma National Park (TNP) in the management of four important shore-angling fish (*Diplodus sargus capensis*, *Diplodus cervinus hottentotus*, *Pachymetopon grande* and *Dichistius capensis*) was evaluated using data obtained from two independent studies conducted over a similar time period, along the south-eastern Cape coast of South Africa. Shore-angling catches were analysed from (i) data gathered from roving creel surveys conducted in the open access areas from Kei Mouth to Stil Bay between April 1994 and February 1996, and (ii) monthly research fishing conducted in the TNP between February 1995 and January 1997. Results from a tag and release study conducted within a small area (c. 5 km) of the TNP revealed that the four study species were resident. Size frequency analyses revealed that the mean individual length (and mass) of the four species was significantly higher in the TNP than in the open access areas. Catch per unit effort data suggest that the species were between five and 21 times more abundant in the TNP. Analysis of anglers' daily catches revealed that the current bag limits (five per person per day) were seldom reached or exceeded even within the TNP, indicating the ineffective nature of this restriction. This study confirms the value of marine protected areas as an effective tool for the management of these and possibly other resident reef-associated fish that are vulnerable to overexploitation.

Key words: fish movement, marine protected areas, reef fish management, shore-angling fishery

Fisheries management worldwide has been under the spotlight in the past decade as startling evidence suggests that the global catch of wild marine fish has reached its ceiling and that almost 70% of individual fish stocks are fully to overexploited (Garcia and Newton 1997). Clearly, the challenge to cater for sustainable utilization has been vanquished by an insatiable demand for high protein, low-fat food. The scenario is, however, not confined to species exploited commercially, but also to those targeted by recreational fishers, particularly those species shared with the commercial sector. This cause for concern is relevant in South Africa, as a growing body of evidence suggests that a number of important shore-angling species are overexploited or in a process of decline. For example, species such as white steenbras *Lithognathus lithognathus* and dusky kob *Argyrosomus japonicus* have been exploited down to levels less than 20 and 10% of their pristine stock respectively (Bennett 1993, Griffiths 1997).

In South Africa, control measures (e.g. legal sizes and bag limits) for both recreational and commercial linefish species were introduced in December 1984. Since then, some new regulations have been added, whereas others have been amended as new evidence on the biology of individual species has come to light. The failure of these conventional fishery control measures to ensure sustainable utilization of many key recreational shore-angling species has been highlighted by several studies (Bennett *et al.* 1994, Attwood and Bennett 1995, Griffiths 1997). Therefore, the challenge is to provide alternative management options so that recreational anglers in South Africa can enjoy some degree of quality angling in the future. In an attempt to meet this challenge, a new approach to achieve sustainability was recently proposed. The new fisheries policy for South Africa proposed the application of Operational Management Procedures (OMPs) to all major fisheries, including linefish. It is envisaged that these OMPs will be based on a series of objectives linked to reference points that take into consideration, among others, the yield and reproductive capacity of the stock (see Penney *et al.* 1997, Griffiths *et al.* 1999). As part of the OMPs, the value of no-take marine protected areas (MPAs) has also been identified as a management option for slow-growing species with limited distribution, as well as for stock re-building of overexploited species. The inclusion of such a procedure follows numerous studies highlighting the success of this fishery management option (Attwood *et al.* 1997).

The Tsitsikamma National Park (TNP) is one of

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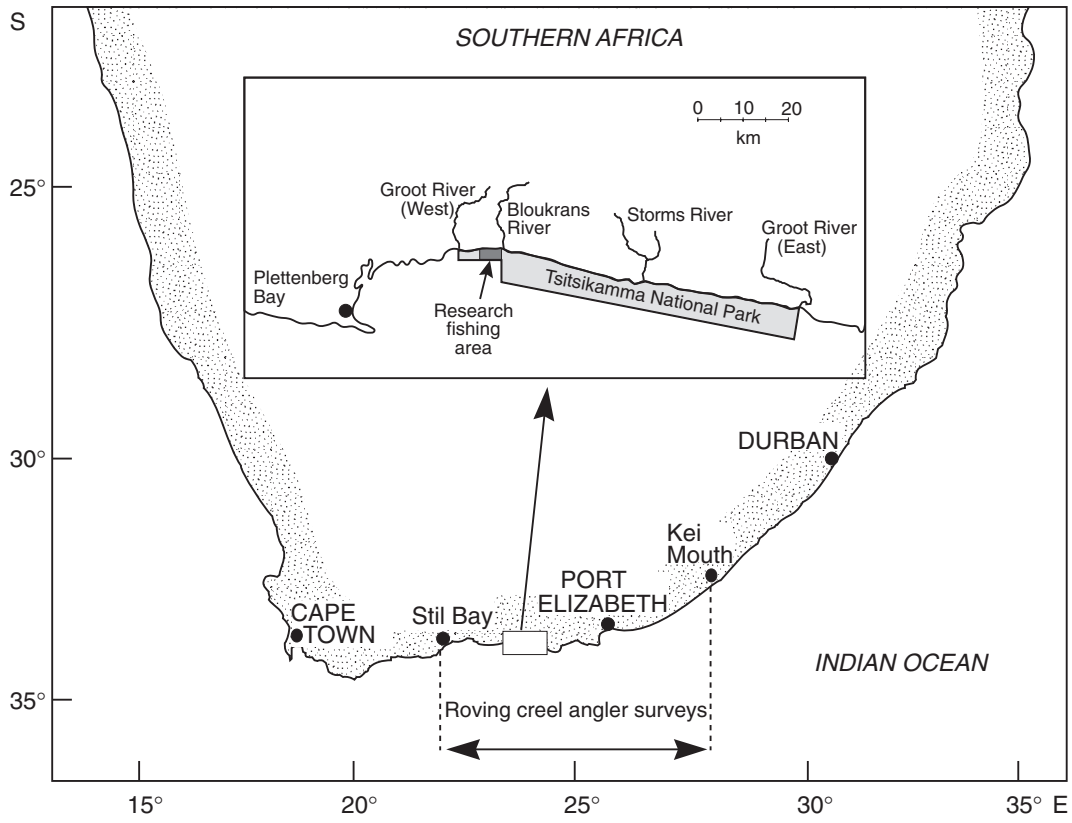

Fig.1: The southern African coastline showing the location of the study areas, and the research fishing area within the Tsitsikamma National Park (inset)

South Africa's largest MPAs, incorporating approximately 80 km of coastline from Groot River West (33°59´S, 23°34´E) to Groot River East (34°04´S, 24°12´E). Shore-angling in the TNP has been prohibited since 1978, with the exception of a 3 km open fishing area that borders the main restcamp at Storms River (Hanekom *et al.* 1997). In this paper, the role of the TNP in the management of four fish targeted by the recreational shore fishery is investigated. The species under consideration include three sparids (blacktail *Diplodus sargus capensis*, zebra *Diplodus cervinus hottentotus* and bronze bream *Pachymetopon grande*) and one dichistid (galjoen *Dichistius capensis*). Making use of information gathered from an ongoing tag and release programme in the TNP, attention was given to what extent these species are resident within this MPA. Catch per unit effort (*cpue*) data collected during the tag and release programme were compared with the results obtained from an independent study conducted in open access areas along the South-Eastern Cape coastline (Brouwer 1997). This comparison was aimed at elucidating the fishery protection role of the TNP. Furthermore, the two datasets were used to explore the effectiveness of the currently enforced bag limit restrictions for these species.

MATERIAL AND METHODS

Study sites

The study was based on catch and effort data from shore-angling in a protected area (TNP) and a fished area (Kei Mouth to Stil Bay), collected over a similar time (Fig.1). Data from the exploited area were collected as part of a national survey of linefish fisheries in South Africa (Brouwer *et al*. 1997, Lamberth *et al*.

Table I: Summary of mark-recapture details obtained for four angling species tagged within the research fishing area of the Tsitsikamma National Park (TNP)

Species	Number tagged	Number recaptured	% recaptured in the TNP	Mean time at liberty (days)
Diplodus sargus capensis	1 319	23	96	250
Diplodus cervinus hottentotus	234	5	100	134
Pachymetopon grande	278	22	100	101
Dichistius capensis	686	25	92	191

1997, Mann *et al*. 1997, McGrath *et al*. 1997). However, for the purposes of this investigation, data were extracted to cover the shore-based fishery from Stil Bay (34°25´S, 21°20´E) to Kei Mouth (32°41´S, 28°23´E – Fig. 1). The shoreline topography associated with this large area (c. 980 km long) is highly variable, with a range of habitats including long sandy beaches, sandy beaches interspersed with rocky outcrops, low-gradient rocky outcrops and steep-sloped, rocky headlands with cliffs.

The second dataset constitutes part of an ongoing tag and release programme, conducted in a small research fishing area (c. 5 km) within the boundaries of the TNP (Fig. 1). The general topography along the stretch of coastline within the park is rugged with high rocky cliffs. The shoreline consists of steep, rocky ridges with interlaying gullies, which are generally filled with either boulders or sand (Hanekom *et al*. 1997). With the exception of a few small bays, the coastline is exposed to strong wave action.

Fish movement patterns

The movement patterns of the four species were determined by tagging fish caught in the research fishing area of the TNP between February 1995 and February 1999. All fish >250 mm fork length (*FL*) were tagged with plastic dart tags (D-type: ORI/Sedgwick's/WWF national tagging programme), each inscribed with a postal address and a unique number. A sharp, hollow applicator was used to insert the tag into the dorsal region of the fish, ensuring that it hooked behind a dorsal vertebral spine. Extreme care was taken when handling the fish, following the methods described by Attwood (1998). Tag recoveries were made either by the research anglers within the research area of the TNP or by recreational anglers from other areas. The recapture effort, which determined the probability of obtaining recoveries, was moderate within the research fishing area, zero elsewhere in the TNP and high outside the park. The latter was, however, biased by a high rate (44%) of non-reporting (Brouwer 1997).

Catch and effort data

Catch and effort data from the exploited areas were obtained from roving creel surveys conducted during daylight between April 1994 and February 1996. Detailed descriptions of the methods are provided by Brouwer (1997) and Brouwer *et al*. (1997). In the protected area, catch and effort information was analysed from data collected between February 1995 and January 1997. Research fishing was carried out monthly during 4–5 day field trips by a group of 4–8 anglers. Fishing took place during daylight (mostly between 07:00 and 17:00), using a variety of baits and hook sizes. It is noteworthy that the *cpue* data from the TNP were collated from complete fishing trips, whereas *cpue* from the open access areas was calculated from mostly incomplete angler outings.

All fish recorded during both studies were measured to the nearest millimetre fork length (*FL*) and mean lengths from protected and exploited areas were compared by *t*-tests. Lengths were converted to mass using the relationships provided by Bennett and Griffiths (1986), Van der Elst and Adkin (1991) and Mann and Buxton (1997). For comparative purposes, *cpue* data from both studies were converted to gravimetric values (kg 100 angler-hours^{-1}). Ages were estimated from age-at-length relationships obtained from Bennett and Griffiths (1986), Buxton and Clarke (1992) and Mann and Buxton (1997).

RESULTS

Fish movement

In all, 2 517 fish were tagged, of which 75 were recaptured between February 1995 and February 1999 (Table I). A large majority (96%) of the tagged fish were recaptured within the designated research area of the TNP. Of the tagged *D. sargus capensis* recaptured (n = 23), only one was taken outside the research fishing area. This fish was caught near Van Stadens River mouth, approximately 145 km east of the initial

Table II: Catch rates of four angling species caught in the research fishing area of the Tsitsikamma National Park (TNP) and the open access areas of the South-Eastern Cape (SE Cape) between Stil Bay and Kei Mouth

Species	Mass (kg) 100 angler-hours^{-1}		Number of fish 100 angler-hours^{-1}	
	TNP	SE Cape	TNP	SE Cape
Diplodus sargus capensis	13.04	1.25	16.72	3.14
Diplodus cervinus hottentotus	4.19	0.60	4.50	0.57
Pachymetopon grande	7.78	3.12	5.61	1.16
Dichistius capensis	7.50	0.21	4.19	0.20

release site. Similarly, only two of the 25 recaptured *Dichistius capensis* were caught outside the designated research area. These individuals were recaptured approximately 130 km east and 715 km west, respectively, of the tagging area. All of the recaptured *Pachymetopon grande* (n = 22) and *D. cervinus hottentotus* (n = 5) were taken within the research area. Therefore, notwithstanding the rare individual that moved extensively, it appears that all four of the study species are highly resident within the TNP for fairly long periods. The maximum time at liberty was 1 126 days for *D. sargus capensis*, 224 days for *D. cervinus hottentotus*, 279 for *P. grande* and 443 days for *Dichistius capensis*.

Catch, effort and *cpue*

A total effort of 8 094 angler-hours was recorded during the creel surveys conducted between Stil Bay and Kei Mouth, and totals of 161 *D. sargus capensis*, 17 *D. cervinus hottentotus*, 82 *P. grande* and 23 *Dichistius capensis* were caught. In the TNP research area, a total of 3 175 angler-hours was achieved, yielding 531 *D. sargus capensis*, 143 *D. cervinus hottentotus*, 178 *P. grande* and 234 *Dichistius capensis*. The calculated *cpue* values, expressed gravimetrically (kg 100 angler-hours^{-1}) and numerically (fish 100 angler-hours^{-1}) for all species were higher in the TNP than in the open access areas along the South-Eastern Cape coast (Table II). Using *cpue* as an indication of abundance, these species were 5.3 (*D. sargus capensis*), 7.9 (*D. cervinus hottentotus*), 4.8 (*P. grande*) and 20.7 (*Dichistius capensis*) times more abundant in the TNP. Similarly, the catches in terms of mass ranged between 2.5 (*P. grande*) and 36.5 (*Dichistius capensis*) times higher in the protected area.

Mean individual length, mass and age

Comparisons of the catches revealed that the mean individual size and age for all four species were greater in the MPA (Table III). Mean individual lengths were significantly greater in the TNP for *D. sargus capensis* ($p < 0.001$), *D. cervinus hottentotus* ($p = 0.001$) and *Dichistius capensis* ($p < 0.001$), but not for *P. grande* ($p = 0.499$). In terms of mass, the two *Diplodus* species were almost twice as large in the TNP (*D. sargus capensis* = 1.98 times; *D. cervinus hottentotus* = 1.86 times), whereas *Dichistius capensis* were 1.57 times larger. On the other hand, *P. grande* were only marginally larger (1.03 times) in the TNP. Similarly, in terms of estimated mean individual age, *D. sargus capensis* at 12.4 years old were almost twice as old (1.82 times) in the TNP, whereas *D. cervinus hottentotus*, *P. grande* and *Dichistius capensis* were 2.8, 0.3 and 1.4 years older respectively in the TNP than in the open access areas of the South-Eastern Cape.

Table III: Mean individual length, mass and age of four angling species caught in the research fishing area of the Tsitsikamma National Park (TNP) and the open access areas of the South-Eastern Cape (SE Cape) between Stil Bay and Kei Mouth

Species	Mean fork length (mm)		Mean individual mass (g)		Mean individual age (years)	
	TNP	SE Cape	TNP	SE Cape	TNP	SE Cape
Diplodus sargus capensis	284	226	714	360	12.4	6.8
Diplodus cervinus hottentotus	303	248	711	383	11.3	8.5
Pachymetopon grande	358	354	1 322	1 278	8.2	7.9
Dichistius capensis	365	327	981	632	6.8 (M) 5.9 (F)	5.2 (M) 4.8 (F)

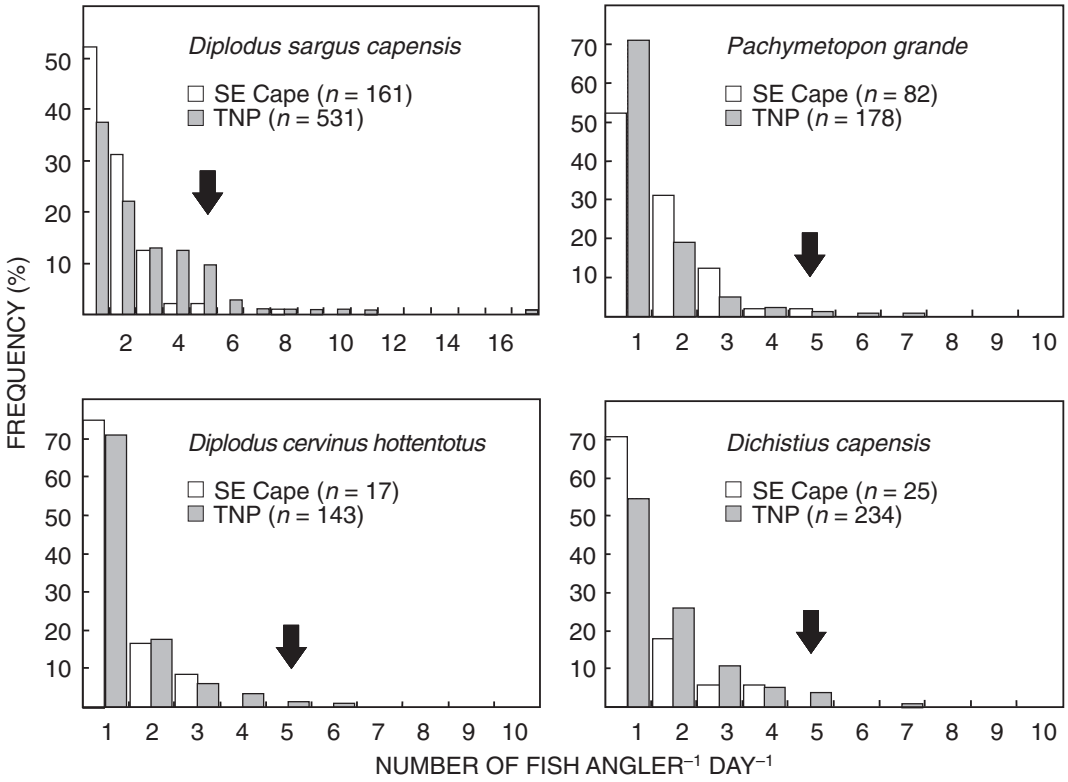

Fig. 2: Angler bag frequencies of four angling species caught in the research fishing area of the Tsitsikamma National Park (TNP) and the open access areas of the South-Eastern Cape between Stil Bay and Kei Mouth. Arrows indicate the legal bag limits

Angler bag frequencies

Angler bag frequencies (number of fish caught per person per day) from the TNP and the open access areas of the South-Eastern Cape coast are given in Figure 2. The maximum daily catch recorded for each species in the TNP by an individual angler was 17 (*D. sargus capensis*), 7 (*P. grande*), 6 (*D. cervinus hottentotus*) and 7 (*Dichistius capensis*), whereas from the open access area, it was 8, 5, 3 and 4 for the same species respectively. Despite being the most frequently recorded, days with zero catches were excluded from the analyses to eliminate the potential bias caused by anglers in the open access areas not targeting the four species. A catch rate of only 1 fish angler^{-1} day^{-1} was recorded on more than 50% of the outings from the open access areas of the South-Eastern Cape. This trend was also apparent within the TNP, with the exception of *D. sargus capensis*, where the frequency with which a daily catch rate of 1 fish angler^{-1} day^{-1} was achieved was <40%.

DISCUSSION

According to McGrath *et al.* (1997), the recreational shore-based fishery, with an estimated 412 000 participants (in 1995), was valued at R1 653 million and contributed approximately 1% to the gross geographic product of the South African coastal region. The economic sustainability of this fishery is dependent on the wise management of each of the targeted species. All the species under study are recognized as important components of the recreational shore-based fishery.

Table IV: Some life history characteristics important for the management of the four species under study

Parameter	*D. sargus capensis*	*D. cervinus hottentotus*	*P. grande*	*Dichistius capensis*
Observed maximum age (years)	21	33	38	13*
Length-at-50% sexual maturity (mm)	211 *FL*	280 *FL*	300 *FL*	≃312 *TL* (M) ≃285 *TL* (F)
Age-at-50% sexual maturity (years)	3	6	5.5	6
Source	Mann and Buxton (1997, 1998)	Mann and Buxton (1997, 1998)	Buxton and Clarke (1992)	Bennett and Griffiths (1986)

*20 years (C. G. Attwood, pers. comm.)
FL = Fork length
TL = Total length

D. sargus capensis is not a prime targeted species in the fishery, but it ranks within the top five species landed along the Southern Cape, Eastern Cape and KwaZulu-Natal coasts (Brouwer *et al.* 1997). *P. grande* is a species highly prized by shore-anglers along the entire southern and eastern seaboard of South Africa, particularly in the Eastern Cape, where it is ranked third in terms of landed biomass (Brouwer *et al*. 1997). It is also targeted by spearfishers in the Eastern and Western Cape, where it is only preceded by musselcracker *Sparodon durbanensis* in terms of targeting effort (Mann *et al*. 1997). *D. cervinus hottentotus* is probably the least targeted of the four species under study, but it is still considered to be an important component of the recreational shore-based fishery (Van der Elst and Adkin 1991). *Dichistius capensis* is South Africa's national fish and highly sought-after by shore-anglers throughout its distributional range, particularly in the South-Western Cape. Brouwer *et al*. (1997) showed it to be the primary targeted species on the West and Southern Cape coasts, where it is also well represented in the catch composition of shore-anglers. Furthermore, it is targeted and captured by spearfishers in KwaZulu-Natal and in the Eastern and Western Cape (Mann *et al*. 1997).

Sparids are renowned for slow growth, late age-at-sexual-maturity and sex reversal (Buxton 1993). The three sparid species included in this study are no exception, because they reach maximum ages in excess of 20 years and have an age at 50% maturity of at least three years (Table IV). The implications of these life-history characteristics are a lower yield per unit stock and a slower rate of recovery following overexploitation (Buxton and Clarke 1989). Spawner biomass levels are also rapidly reduced, even at low levels of fishing mortality. No stock assessment information is available for the above-mentioned species, but anecdotal reports from shore-anglers suggest that all three species are locally depleted along many areas of the South African coastline. Furthermore, making use of data from Clarke and Buxton (1989), Brouwer (1997) noted that catches of *D. sargus capensis* and *P. grande* in Port Elizabeth had declined by 43 and 29% respectively in seven years. In comparison with the sparid species under investigation, *Dichistius capensis* is relatively short-lived and attains 50% sexual maturity in its sixth year of life at a size of 340 mm total length (*TL*) for females and 310 mm *TL* for males (Bennett and Griffiths 1986). Those authors reported a maximum observed age of 13 years; however, more recently an individual of 640 mm *TL* was aged at more than 20 years (C. G. Attwood, Marine & Coastal Management [MCM], pers. comm.). Despite its potential for a better yield per unit stock (because it is relatively short-lived), indications are that *Dichistius capensis* is already overexploited (Bennett 1988).

Besides biological life-history characteristics, results of movement (tagging) studies are vital for the implementation of corrective fisheries management strategies. Based on the preliminary results obtained from the TNP tagging programme (Table I) and visual assessments (Mann 1992), it is suggested that *D. sargus capensis* are resident within the TNP. *P. grande* also display resident behaviour (Anon. 1995, Cowley 1999) and, despite the low number of recaptures, it appears that *D. cervinus hottentotus* are also highly resident with a small home range. The movement data obtained for *Dichistius capensis* from the TNP revealed a similar trend, and are comparable with the results of Attwood and Bennett (1994) from the De Hoop Marine Reserve. Those authors showed that 82% of recaptured fish were taken at the site of release (within 5 km), whereas the remainder displayed nomadic migratory habits with a maximum movement of 1 040 km.

The maximum time at liberty for the four species investigated here has not yet provided conclusive evidence that they are resident for their entire adult lives. The continuation of the TNP and De Hoop tag-and-release research programmes will hopefully, in the

future, provide insight as to whether the adults of these species live to maximum age and spawn repeatedly within a confined area (i.e. a resident home range).

The life history characteristics displayed by the four species, coupled with their apparent high degree of residency, makes them extremely vulnerable to localized stock depletion. Therefore, the management of these and other resident species is possibly best achieved by a suite of options, which effectively control or reduce localized fishing effort. These techniques include area restrictions and bag limit restrictions.

With respect to area restrictions, the *cpue* data in Table II suggest that the four species were up to 21 times more abundant in the TNP than in the open access areas of the South-Eastern Cape. The value of restricted areas is further highlighted when comparing *cpue* values from the research fishing area (this study) and the small open access fishing area near Storms River, within the boundaries of the TNP (Hanekom *et al.* 1997). The latter study reported *cpue* of 5.0–6.7 fish 100 angler-hours^{-1} for *D. sargus capensis*, 0.3–1.0 fish 100 angler-hours^{-1} for *D. cervinus hottentotus*, 1.3–2.0 fish 100 angler-hours^{-1} for *P. grande* and 2.8–3.9 fish 100 angler-hours^{-1} for *Dichistius capensis*. These values were all considerably lower than those obtained from the closed (no-take) research fishing area in the TNP (see Table II). Furthermore, the mean individual sizes of all species, except *P. grande*, were significantly higher in the research area than outside the MPA and, by inference, suggest that there are large mortality rate differences between the two areas. Therefore, indications are that even moderate fishing pressure, when applied throughout the population, is sufficient to collapse the spawner stock. The findings of this study therefore lend further support to other local and international studies with respect to the value of MPAs as a viable fishery management tool (e.g. Buxton and Smale 1989, Bennett and Attwood 1991, Dugan and Davis 1991).

A daily bag limit restriction potentially offers an effective means of reducing fishing mortality of overexploited species. However, several studies have shown that the currently enforced bag limits in South Africa have had little impact on reducing total catch for most shore-angling species (e.g. Bennett *et al.* 1994, Attwood and Bennett 1995). The ineffective nature of this fishery-control option, in its current form, has also been highlighted in this study. The legislated bag limit of 5 fish angler^{-1} day^{-1} was seldom reached for any of the four species, even within the boundaries of the protected TNP (Fig. 2). Similarly, Bennett (1991) showed that members of the Old Mutual Angling Club in the South-Western Cape caught *Dichistius capensis* on 8% of the days fished and on only 2% of occasions did the catch exceed 1 fish angler^{-1} day^{-1}. It is important to note that the data collected from the open access areas were based on incomplete trips, which may have underestimated the bag limit success in the area. Although the opposite may be true for the TNP data, because of the use of experienced (above-average) anglers, this limitation in the data collection strengthens the argument concerning the inadequacy of bag limits (i.e. even experienced anglers seldom exceed their bag limits).

The results obtained from the South-Eastern Cape roving creel surveys were further analysed to determine by what percentage directed effort could be reduced if the daily bag limits for the four species were altered (Fig. 3). A bag limit of three fish angler^{-1} day^{-1} would not reduce the directed effort on *D. cervinus hottentotus*, whereas the percentage effort reduction for *D. sargus capensis* would be only 19%. However, if the enforced bag limit was reduced to 1 fish angler^{-1} day^{-1}, the percentage effort reduction would be 37, 47, 70 and 48% for *D. sargus capensis*, *D. cervinus hottentotus*, *P. grande* and *Dichistius capensis* respectively. Clearly, a reduction of the currently enforced daily bag limit from five to anything more than 1 fish angler^{-1} day^{-1} is unlikely to improve stocks for any of the four species. Even then, the effective reduction of fishing effort would probably only be short-lived, because of the exponential increase in total effort in the South African shore-based fishery (van der Elst 1989, McGrath *et al.* 1997). The above evaluation therefore suggests that this fishery-control option has already reached a level at which it is no longer effective for these four species in the South-Eastern Cape. However, the ineffective nature of bag limits as a fishery-control option may be masked by the assumption that a reduction in bag limit is directly proportional to effort. Assuming that most of the fish are caught by a minority group of experienced anglers (i.e. those that take part in competitions and/or with local knowledge), then a bag limit may be more effective than shown above, because it reduces the catch of the more effective anglers. In other words, it is possible that a bag limit reduction is not directly proportional to effort, because targeting effort is not evenly applied.

Finally, based on the legacy of depleted fisheries, it is suggested that the management paradigm of computer-simulated population modelling is over-optimistic and that the use of MPAs to conserve fish stocks is under-rated (Walters and Maguire 1996, Rose 1997). The findings of this study, allied with numerous others (e.g. Huntsman 1994, Bohnsack and Ault 1996, Clark 1996), suggest that the manage-

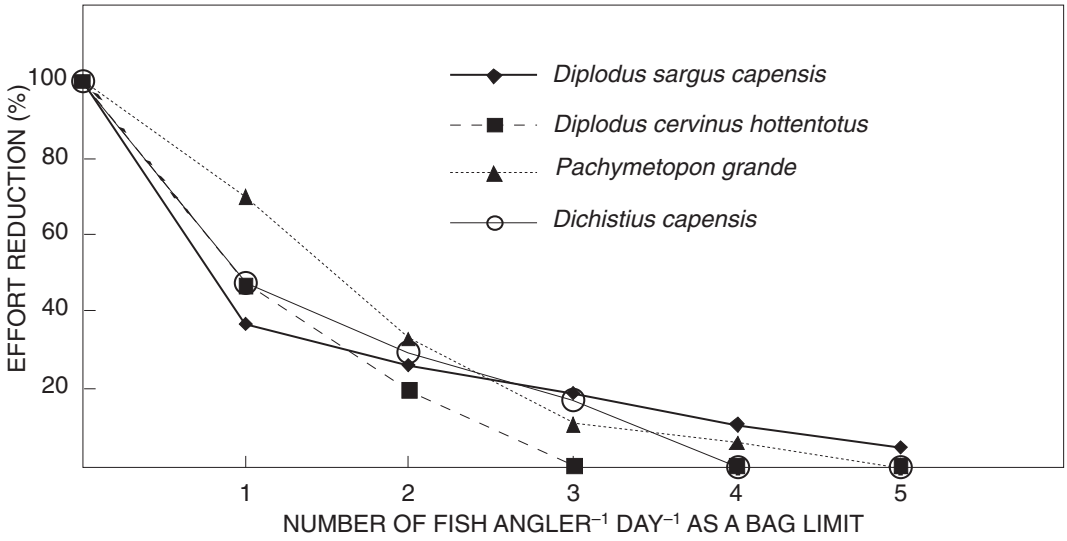

Fig. 3: The percentage effort reduction for daily bag limit restrictions of five fish and less, based on the bag frequencies obtained for four angling species in the South-Eastern Cape open access area

ment of the four species investigated here, as well as that of other resident species, is likely to depend on the provision of undisturbed habitats, where fish can live to maximum ages and spawn repeatedly. Therefore, because of the multispecies nature of the South African shore-based linefishery, it is recommended that future work should be directed towards elucidating the role of the TNP and other MPAs in the management of other important linefish species.

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