THE COMMERCIAL BEACH-SEINE FISHERY IN FALSE BAY, SOUTH AFRICA

by

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Master of Science

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To my mother

Joan Lamberth

DECLARATION

This study was initially commissioned by the Sea Fisheries Research Institute as an investigation of the highly controversial beach-seine fishery in False Bay. The sheer volume of work involved caused it to be subdivided, the candidate assuming responsibility for the commercial aspect and B.M. Clark the juvenile aspect of the fishery. The work presented in this thesis is the sole responsibility of the candidate although the published chapters are co-authored by my supervisor Dr B.A. Bennett and colleague B.M. Clark. The exceptions are Chapters 5 and 6 of which B.M. Clark is the senior author and which were included to provide continuity to the story of the commercial beach-seine fishery in False Bay. This work has not been submitted for a degree at any other university.

Stephen J. Lamberth

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ABSTRACT. Lamberth, S.J. 1994. *The commercial beach-seine fishery in False Bay, South Africa.* M.Sc thesis, University of Cape Town

This study was initiated in response to allegations by the conservation lobby that the commercial beach-seine fishery in False Bay was jeopardizing fish stocks and detrimentally affecting the ecology of the Bay. Its main aims were to quantify the current catch and place it in an historical perspective, to describe seasonal patterns in catches and effort and to assess the impacts of netting on juvenile fish and benthic organisms. The overall objective was to provide a "scientific" basis for the resolution of the controversy surrounding this fishery.

Commercial beach-seine hauls in False Bay were monitored intensively during the period January 1991 to December 1992. A total of 726 447 fish representing 66 species from 39 families was recorded in 311 hauls. *Liza richardsonii* was numerically dominant, providing 86 % of the total catch. The remainder of the catch included 13 teleost species which shore-anglers regard as "angling" species, not a "legitimate target" of the seine fishery. The landed proportion of this "by-catch" was dominated by *Seriola lalandi*, *Pomatomus saltatrix*, *Lithognathus lithognathus*, *Argyrosomus hololepidotus* and *Umbrina canariensis*. Examination of historical records revealed that angling species were an important component of the seine-net catch around 1900, thus seine fishermen are justified in claiming a traditional right to exploit them. Seine catches and effort in False Bay were strongly seasonal, with 93% of the total catch being taken in the spring, summer and autumn months. Catch per haul of the target species *L. richardsonii* in May (autumn) and October (spring) was double that of summer, despite lower effort. Effort was largely dependent on the frequency of occurrence of patches of the surf-zone diatom *Anaulus birostratus* on which *L. richardsonii* feed and around which the nets were set.

Mean juvenile catch for all teleost species was 125 per haul or 74 000 individuals per year. Escapement, as measured by setting a small-mesh net behind the commercial net was high, 95% of the combined numerical catch being caught in the cover net. Escapees were numerically dominated by the "baitfish" species *Engraulis capensis* (52%) and *Atherina breviceps* (36%). Juvenile teleosts constituted <6% of the total commercial catch, considerably less than the proportion of juveniles in other South African commercial and recreational fisheries. For most species, seine-net mortality was calculated to be insignificant when compared to natural mortality for juvenile teleosts. However, annual seine catches of juvenile *L. lithognathus* made up a significant proportion (>30%) of the total surf-zone standing stocks, indicating that this species may be under considerable threat because they are also caught in large numbers by shore-anglers. The increase in mesh-size needed to reduce the by-catch of these juvenile "angling" species would drastically lower the total catch of the targeted *L. richardsonii*.

The ichthyofaunas of two estuaries and their adjacent surf-zones were sampled with an experimental net. Fish densities in the estuaries (3.2 & 5.0 fish.m^{-2}) were considerably higher than recorded in their adjacent surf-zones (0.4 & 0.6 fish.m^{-2}). Catches in all four localities were dominated by a few species, 2-3 species making up 92-97% of the total numbers of fish caught. Juvenile fish were abundant in all areas, numerically constituting 48 and 97% of the estuarine and surf-zone samples respectively. Statistical analyses of the density distribution of marine and estuarine fish in the surf-zone indicate that beach-seine hauls in the area of estuary mouths were potentially no more harmful to these fish than those farther away.

A total of 31 invertebrate and 14 macrophyte species were recorded in the commercial bycatch. *Ecklonia maxima* (22%), *Codium fragile capense* (16%) and *Gracilaria verrucosa* (9%) dominated the total macrophyte catch of 14.9t. The invertebrate bycatch was dominated by the ascidian *Pyura stolonifera* (18.3t) and 10 339 individuals of the brachyuran *Ovalipes trimaculatus*. Large macrophyte and invertebrate catches were infrequent, with the bulk of the total catch being made in 10% of the hauls. Dive surveys found no significant differences in abundance or species composition between sites inside and outside the seine area. The beach-seine bycatch did not make a significant contribution to the composition or biomass of material deposited along the driftline

The results indicate that commercial beach-seining is not having a severely detrimental impact on most fish stocks, or on the ecology of False Bay. Despite these findings, the controversy will not be resolved until management assesses the relative value of seine and recreational fisheries in terms of socio-economic criteria.

ACKNOWLEDGEMENTS

I greatfully acknowledge financial support for this project from the Sea Fisheries Research Fund, Foundation for Research and Development and the University of Cape Town. This project would not have materialised were it not for the insight and intuition of Dr Bruce Bennett. Thanks go to both my supervisors Dr Bruce Bennett and Prof Charles Griffiths for their enthusiasm and support throughout this project.

Barry Clark accompanied me for the full duration of the monitoring period, was not too adverse at waking at 3 am in the morning and provided an adequate hulking mass to ward off an often antagonistic public. This failing, Charlotte Heijnis added that extra element of terror and her services as a scribe *par excellence*.

Boatmen Barry Clark, Yves (dont rock the boat) Lechanteur, and haulers Charlotte Heijnis, Cameron Smith, Dave Glassom, Walter Meyer and Nigel Stepto were all invaluable during early morning mesh-selectivity hauls. Yes I lied, you do get 2m breakers at Fish Hoek.

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Thanks go to the Cape Nature Conservation inspectors, Pat Stacey, Keith Thompson, Brett Witchalls and Bernard Liedemann for their help, tolerance and patience, especially at the times they were called out to "arrest" us and had to explain our presence to an irate public. In turn, special thanks go to Vic Kabalin, Roger Topliss, Howard Shakleton and Hymie Steyn without whom this project would not have been possible (or necessary?).

None of this work would have been possible without the co-operation and assistance of the members of the False Bay Trek-fishermens Association and their crews in allowing us to monitor their catches, often delaying their operations by measuring and dissecting fish. Thanks particularly to the trek-fishermen J.J. "Naartjie" Dirkse-van Schalkwyk, Jeff Petty, "Boere" Achmat, "Sonny" Rykliff and "Bollie" Albertyn.

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Thanks go to all my friends and colleagues, including those I have not mentioned. Thanks go to Jane Turpie for aiding me with her exceptional talents as an editor, tolerating my early morning rises for three years and from whom I could always rely on for much needed support. Finally I would like to thank my family for their love, tolerance and often financial support.

GENERAL INTRODUCTION

The beach-seine fishery in False Bay has caused considerable concern among conservation-minded members of the South African public in recent years. They saw beach-seine catches as jeopardising the stocks of numerous species and considered the decline in anglers' catches as being directly attributable to beach-seining activities. Of further concern to this lobby were the catches of invertebrates, juveniles of angling species, cartilaginous and other non-target species, which they considered to have had detrimental effects on the perceived fragile ecology of False Bay.

As a result of these concerns considerable pressure was brought to bear on the management authorities to reduce the impact of beach-seining and the number of beach-seine licences in False Bay was reduced from 102 in 1974 to seven in 1990. The remaining permit holders had, by the commencement of this study, also been subjected to numerous restrictions in terms of where and when they could fish and in the gear and methods that they were permitted to use. The seine-fishermen claimed that these restrictions were not justified because, in their view, beach-seine catches were not significantly detrimental to recreational or commercial line catches or to any ecological processes. They also considered the restrictions to be in violation of their traditional rights and to seriously impair the financial viability of their operations.

When imposing the recent restrictions on beach-seining, the managers responsible realised that they were doing so largely in the absence of valid scientific information. They decided, however, rather to err on the side of caution and to impose the restrictions which could later be reviewed once the relevant information became available. These restrictions, and the hardship to fishermen which resulted, were therefore largely the product of political pressure that was brought to bear on management. They were not made on the basis of sound scientific data suggesting that beach-seining was harmful.

This three year study was initiated in January 1991 the main aim being to intensively monitor commercial beach-seine catches. In doing so an assessment of the seine-fishery could be made, the objectives being to provide a scientific basis for the management of the fishery and the long-term resolution of the "beach-seine controversy". This was done by examining the claims of the environmental lobby who were striving to curtail beach-seining activities in False Bay.

To achieve these objectives the following key questions were asked:

- What are the direct causes of the conflict between the seine-fishery and the commercial and recreational linefishery? Are any of the sectors involved justified in claiming "traditional rights" to certain species?

- What is the total annual beach-seine catch in False Bay and how does this compare with catches made by other commercial and recreational fisheries?

- How vulnerable to beach-seining are the fish that occur in the surf-zone of False Bay? What species are these and of what value are they to other sectors?

- What is the seasonal pattern of species composition and abundance of fish in the inshore area of False Bay accessible to beach-seines and when are they most vulnerable to capture by the nets?

- How do catches in the immediate vicinity of river mouths compare with those made further away and do catches vary according to whether or not the rivers are open to the sea?

- What is the species composition and quantity of the benthic flora and fauna caught in the nets? What are the lifestyles of the different species and how does the catch compare with the composition of the driftline?

These key questions are all dealt with either separately or in parts in each of the seven chapters of this thesis. A brief outline of the research surrounding each of these chapters follows.

Thesis outline

Chapter 1 introduces, and presents the history of the beach-seine fishery in False Bay. Historical records, paybooks and personal records of seine fishermen, Sea Fisheries Research Institute (SFRI) records, monitored hauls and the literature are examined in order to determine the causes of the conflict between seine-fishermen and the recreational and commercial linefisheries. Long term trends in catches are discussed in the light of the competing fisheries claims of traditional rights to certain species.

Chapter 2 describes the catch composition of the commercial beach-seine fishery in False Bay reflected by hauls monitored between January 1991 and December 1992. Catch returns submitted by the seine-fishermen to the SFRI were compared to monitored hauls in order to assess their accuracy. Seine catches are compared with those of the commercial and recreational linefisheries in terms of their relative contribution to the total catch in False Bay.

In chapter 3, the vulnerability of fish to capture by the commercial beach-seine nets is estimated. To achieve this a small meshed experimental net was set behind a commercial beach-seine net to estimate the number of fish that escape from the latter. The merits of an increased mesh-size in reducing the vulnerability of different species to capture are discussed.

Chapter 4 describes the seasonal variation of catch and effort of the False Bay seine fishery according to commercial beach-seine hauls monitored during 1991 and 1992. Seasonal changes in fish abundance are discussed in relation to seasonal changes in physical and biological variables. Seasonal fluctuations in catch and effort are used to guage the merits of closed periods as a management option.

Chapter 5 discusses the juvenile component of commercial beach-seine catches in False Bay with the emphasis on teleosts that are also targeted by anglers. The proportions of juvenile teleosts in beach-seine catches and those of other South African commercial and recreational fisheries are compared and discussed. Beach-seine fishing mortality is compared with natural mortalities reported in the literature.

In Chapter 6 the ichthyofaunas of an estuary open intermittently (Zandvlei) and one permanently open (Eerste) and of the surf-zones of beaches adjacent to their mouths are compared. These sites were sampled quarterly using a small meshed experimental beach-seine net. The results were used to assess whether commercial netting was potentially more harmful in the vicinity of river mouths.

Chapter 7 presents the results of an investigation into the effects that beach-seine nets have on benthic organisms. Dive surveys were conducted to determine whether the benthic flora and invertebrate fauna differed in abundance and species composition between sites inside and outside the seine-areas. A video camera was used to record the passage of the commercial net over the seafloor. The species composition and biomass of macrophytes and invertebrates available in the seine-area, caught in the nets and deposited on the driftline are compared and discussed.

Results from the above chapters pertinent to the management of the False Bay seine fishery and the conflict surrounding it are summarized in the concluding chapter.

CHAPTER 1

THE BEACH-SEINE-NET FISHERY IN FALSE BAY: PRESENT AND PAST CATCHES AND CONFLICT WITH THE COMMERCIAL AND RECREATIONAL LINEFISHERIES

INTRODUCTION

Beach-seine fishermen have been active in the southwestern Cape for at least 300 years. For over 200 years this fishery was the major source of fresh fish to the South African market. The increased use of modern fishing methods since about 1900 has caused the importance of beach-seining to wane considerably. With the ever increasing popularity of recreational shore and boat angling as well as the emergence of various conservation groups in False Bay, conflict between these sectors and the beach-seine fishermen has increased steadily over the years. The seine-fishermen stand accused of depleting stocks of "angling" species such as yellowtail (*Seriola lalandi*), kob (*Argyrosomus hololepidotus*), elf (*Pomatomus saltatrix*) and white steenbras (*Lithognathus lithognathus*) as well as being responsible for the deaths of innumerable juvenile fish and "inedible" cartilagenous species. As a result of these concerns, beach-seine permits are now issued exclusively for the capture of harders (*Liza richardsoni*) and St Joseph shark (*Callorhinchus capensis*)- all other fish must either be returned to the water unharmed or, if dead, surrendered to the local authorities. Exemption has, however, been granted in False Bay where "angling" species may be taken throughout the year. This exemption came about due to claims by the False Bay seine fishermen that they had traditionally targetted certain "angling" species, without which they could not maintain a viable income (Wiley, 1985). The counterclaim by those groups opposed to beach-seining is that species such as yellowtail and white steenbras are "traditional" angling/linefish species, while harders are the "traditional" target of the seine-fishery (Grobbler, 1986). Further, they claim that it is only when harders are in short supply that the beach-seine fishermen resort to "untraditional" methods (eg. a heavily weighted "Russman" net) (Haynes, 1983) to catch "untraditional" fish. Whether certain fish or fishing methods are traditional or customary is a difficult issue to decide, for those benefitting from a custom merely have to produce enough witnesses to attest to its existence, but those decrying its practice, "do know of it but will not admit it" (Swift & Streeten, 1921). However, the use of the word "traditional" by those groups for or against the continued use of beach-seines in False Bay implies that the catches of or the methods used by the fishery have, at least until recently, not changed much. In light of the above, this chapter presents the history of the beach-seine fishery and examines the relative importance of different species in catches over the years. Recent and historical catch compositions of the seine fishery are compared with those of the commercial and recreational line-fisheries in order to identify species for which they are currently in competition and on which they historically or "traditionally" relied.

METHODS

Long term trends in the beach-seine and commercial line-fishery were determined by extracting data from Gilchrist (1899-1907), paybooks and personal records of the seine-fishermen, Sea Fisheries Research Institute (SFRI) records, the literature and catches monitored by the authors over a two year period (1991-1992). Data on recreational angling catches was obtained from historical records kept by the Liesbeeck Park and Old Mutual angling clubs.

RESULTS AND DISCUSSION

Historical overview

Possibly the first to cast their nets in Cape waters were Phoenician seafarers who according to Herodotus, circumnavigated the African continent in 610 BC (Thompson, 1913). Over 2000 years later in 1652 Jan van Riebeeck arrived at the Cape and one of his first acts was to send a boat ashore to seine some fresh fish for his crew (Thom, 1952). Three days later the first Cape fisheries regulation came into being, the commander's edict containing a provision that "no fishing and therefore no throwing of nets shall be allowed except by consent of the commander after having consulted with the Council" (Thom, 1952). The reported hauls that were made by the commander's men wer similar to the present, for his journal states "In the evening God Almighty again gave us a fine haul of fish, 1400 or 1500 harders, highly required". In 1687 the first incursion into False Bay began when the Council of Policy and Justice allowed the burghers of Stellenbosch district to fish at the Eerste river mouth, under certain conditions. The first complaint as regards beach-seining came not from False Bay but from Port Elizabeth in 1883 (Gilchrist & Williams 1910). Netting in the Swartkops estuary caused much conflict between anglers and netters, the former complaining that the nets killed immature fish and those coming into the estuary to spawn. The result of these complaints was the Zwartkops Fish Protection act which provided for a closed season with regards to netting as well as prohibiting the dynamiting of fish (Act no. 7 of 1883, Gilchrist & Williams 1910). It is interesting to note that the Fishery Advisory Board for 1909 (26 years later!) regarded this decision as only temporary "pending much needed scientific investigation of the spawning habits of our valuable food fishes and of how far they make use of the estuaries of tidal rivers for this purpose" (Gilchrist & Williams, 1909). In 1898 there were 36 beach-seine operators in False Bay (Gilchrist, 1899) crew size being similar to the present with an average of 12 men hauling a net. There were, at that time, no restrictions save for a minimum mesh size (1.25 inches), one witness claiming that he seined yellowtail (*Seriola lalandi*) up to 1.5 miles (2.4 km) offshore. Fisheries officers even at that stage expressed concern at the capture of juvenile and spawning fish, pollution and declining harder catches (Gilchrist, 1899, Gilchrist, 1900).

The abolition of the office of Government Biologist in 1907 saw the end of scientific investigation into problems connected with the fishing industry (Du Toit, 1908). In 1908 disputes between seine-netters and set (gill)-netters were settled by prohibiting the use of set-nets within a 2 mile radius of any seine-netting ground (Du Toit, 1909). In 1914 Van Breda of Simonstown sued Wentwich for seining a shoal of fish that his crew had seen first. He won the case, for it was established that it was customary for those who saw the fish first to have first haul. Six years later Jacobs sued Van Breda (Swift & Streeten, 1921) for breach of custom for a similar incident in which Van Breda had encircled fish that Jacobs had seen first. In this instance Van Breda claimed that there was no such custom and, not surprisingly, lost the case. It was established however that the right to fish was common to all ie. no one owned a fish before it was caught, although it was customary for first to arrive to have first haul. This finding has relevance in present conflict between seine-fishermen and other sectors of the fishery.

No further official information is available on the state of the beach-seine fishery until 1966, except that there were 140 seine-nets (62 in False Bay) and 17 "Roosman" nets operating in the Cape Province in 1922 (Anon., 1922). The "Roosman" or "Russman net" which was developed by Russian fishermen, possibly to catch sturgeon, is a negatively buoyant net which is hauled over the sea-floor and was introduced to Cape fishermen sometime in the last century.

In the next fifty years the only new regulation in the beach-seine fishery was the raising of the minimum mesh size to 44mm (De Villiers, 1987).

The Yeats commission (Yeats *et al.* 1966) recommended that the catching of white steenbras, galjoen, geelbek and yellowtail by nets be prohibited in the area between Cape Point and Danger Point. Although this recommendation was not followed up, it was the first official expression of disquiet at the catching of "linefish" by seine-net fishermen. Over the next 16 years complaints from anglers and conservation bodies over beach-seine catches of linefish, as well as complaints from professional netters about there being too many amateurs, were addressed by various investigations (Stander, 1991), the Treurnicht Commission (Treurnicht *et al.* 1980) and Theart Committee (Theart *et al.* 1983). As a result, by the end of 1983 the following management measures were in force:

1. A permit system had been introduced stipulating specific beach-seine areas and for which only *bona fide* fishermen were eligible to qualify. Permits became non-transferable.
2. Monthly catch returns had become compulsory with the withdrawal of permits from those not submitting them.
3. The length of a beach-seine net was restricted to 275 metres and the minimum mesh size raised to 50 millimetres. Rope lengths in False Bay were restricted to 150 metres.
4. Net permits were issued solely for the capture of harders and St Joseph sharks. The capture of "angling" fish was prohibited.
5. Seine netting was prohibited between sunset and sunrise in False Bay and Walker Bay.
6. Seine operators at the Strand had their permits cancelled and the future issue of new permits in False Bay and Walker Bay was not allowed.
7. Management policy to decrease beach-seine effort had been effective in reducing the number of seine operators in False Bay from well over 100 in the 1960's to only 15 in 1983.

A delegation of False Bay seine-fishermen met the Deputy Minister of Environment Affairs in March 1984 to air their grieviances concerning the new restrictions (Petty *et al.* 1984). They claimed that the 150 metres of rope allowed was too dangerous in the wide surf-zone of False Bay, the 50mm mesh size was too large (and expensive for them to implement) and that they had traditionally targeted on so called "angling" fish. The Minister responded by waiving the restrictions on rope length and allowing the seining of "traditional angling fish" within an open season between the 1st December and 31st May of the following year. The 50mm mesh size was investigated and later reduced back to 44mm (J. Petty, pers. comm.).

The Diemont commission (Diemont *et al.* 1986) found that the drastic cut (by 34 %) in beach-seine permits since 1974 had not significantly reduced harder catches but felt that the fishery should not be further restricted. The commission observed that "the pressure from conservationists and anglers who wish to see an end to this traditional fishery must not be underestimated". The warning sounded by the Diemont commission was well founded, as beach-seine-fishermen came under increasing attack from articles in the media. Large catches of yellowtail in 1988 led to articles such as "Seaside Slaughter" (Stansfield, 1988) and "The Killing Waters" (Clark, 1988). Anglers and conservation groups increasingly voiced their concern at large catches of juvenile and adult "angling" fish and blamed seine fishermen for their declining catches. Netting in the vicinity of river mouths was claimed to result in unnecessary motalities of spawning aggregations and of juvenile fish entering or leaving the estuarine nursery area. Further claims were: that the nets scraped the sea floor damaging benthic life, that large scale mortalities of cartilaginous species caused ecological imbalances within False Bay and that seine operations were intruding into marine reserves.

As a result, the regulations governing beach-seining in False Bay were amended in 1990. The use of the Russman method was banned, buffer zones were demarcated between marine reserves and seine areas, rope lengths were reduced to 200 metres, 30 dead angling fish per day were allowed to be caught in the closed season and seining was prohibited within 500 metres of any river mouth. The closed season was now between the 1st May and 30th October of each year. The number of seine-operators in False Bay had by this time been reduced to seven.

The seine-fishermen responded to the new regulations by claiming that certain individuals, predominately recreational anglers and ski-boaters, had, under the guise of conservation "conducted a calculated media and other campaign with the objective of eradicating trek-fishing completely", and were close to succeeding (Cameron-Dow, 1990).

When the new restrictions on beach-seining were implemented, management acknowledged the lack of valid scientific information on which to base them. In circumspect, they imposed the restrictions which could later be reviewed once the relevant information became available. This study was initiated in 1991, the overall objective being to provide management with a scientific basis for the long term resolution of the "trek-netting controversy".

As the results of this study became available and as a consequence of continued representions to management by the seine-fishermen, certain regulations were amended in October 1992. Rope lengths were extended to 600 metres, limited use of the Russman method was again allowed as well as the year round targetting of "angling" fish which beach-seine fishermen claimed they had "traditionally" exploited.

It had never, however, been determined what these "traditional" species were, or for that matter whether they existed. Current legislation permits beach-seine fishermen to catch "angling" fish in "traditional quantities", which one assumes is as much as they are capable of catching.

When is an "angling" fish not an angling fish?

This question is best answered by examining the claims and counter claims concerning "traditional" species of the beach-seine and linefisheries in order to assess the validity of the arguments presented by the two opposing groups. To achieve this aim, recent and historical data concerning the composition of the beach-seine, rock and surf and commercial linefisheries are examined so that the species for which they are currently in competition, and on which they historically relied, may be identified.

Recent catches

The contributions by mass of a number of species to the catches made by beach-seine, recreational shore angling and commercial line fisheries over the period 1977-1992 are shown in Figure 1.1. From this figure it is clear that the three fisheries share a number of species and therefore there is scope for conflict between them. The composition of beach-seine and commercial linefishing catches, however, differ quite substantially as 74% of the beach-seine catch consists of harders and 70% of the commercial linefish catch is "other" species such as snoek (*Thyrsites atun*) and hottentot (*Pachymetopon blochii*). In addition, the areas fished by the seine-fishery (surf-zones of sandy beaches) and commercial line fishery (deeper and calmer water) seldom overlap, resulting in little visible contact between the two fisheries. Thus, as these two fisheries rely to a large extent on species and fishing areas that are not shared, there is little conflict between them.

The situation is somewhat different as far as recreational shore angling is concerned. In this fishery 86% of the total catch is provided by elf, white steenbras, white stumpnose (*Rhabdosargus globiceps*), kob and galjoen (*Coracinus capensis*), all species that they share with beach-seine and commercial line fishermen. The lack of a significant contribution by one or more species unique to the rock and surf fishery means that they are in competition with the other two fisheries for a substantial proportion of their catch. Anglers' catches have declined substantially over the years (Van der Elst, 1989; Bennett, 1991a), therefore some degree of conflict between recreational anglers and commercial fishermen is inevitable.

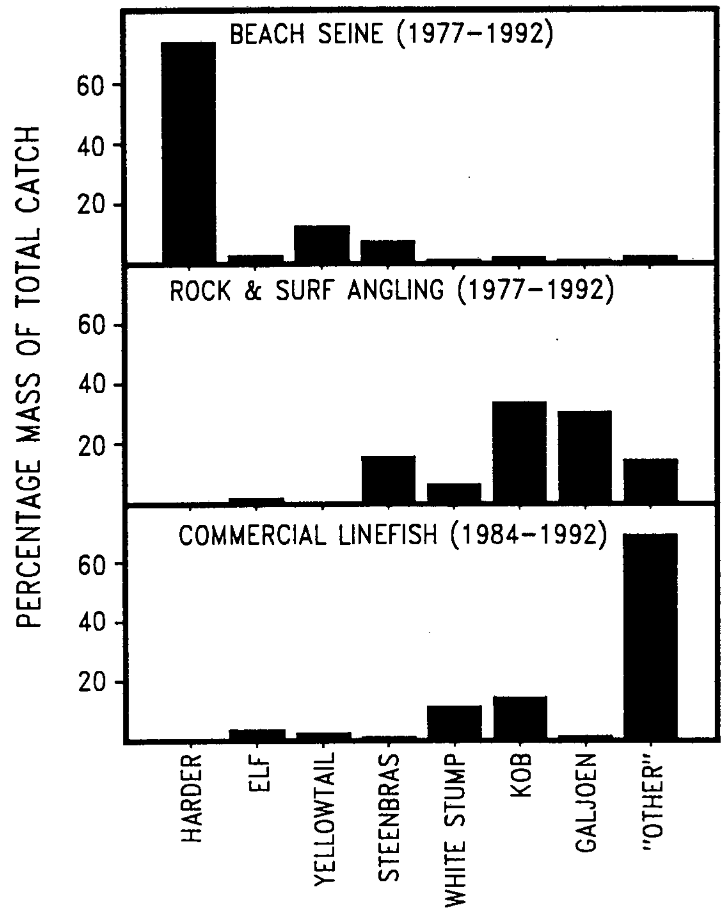
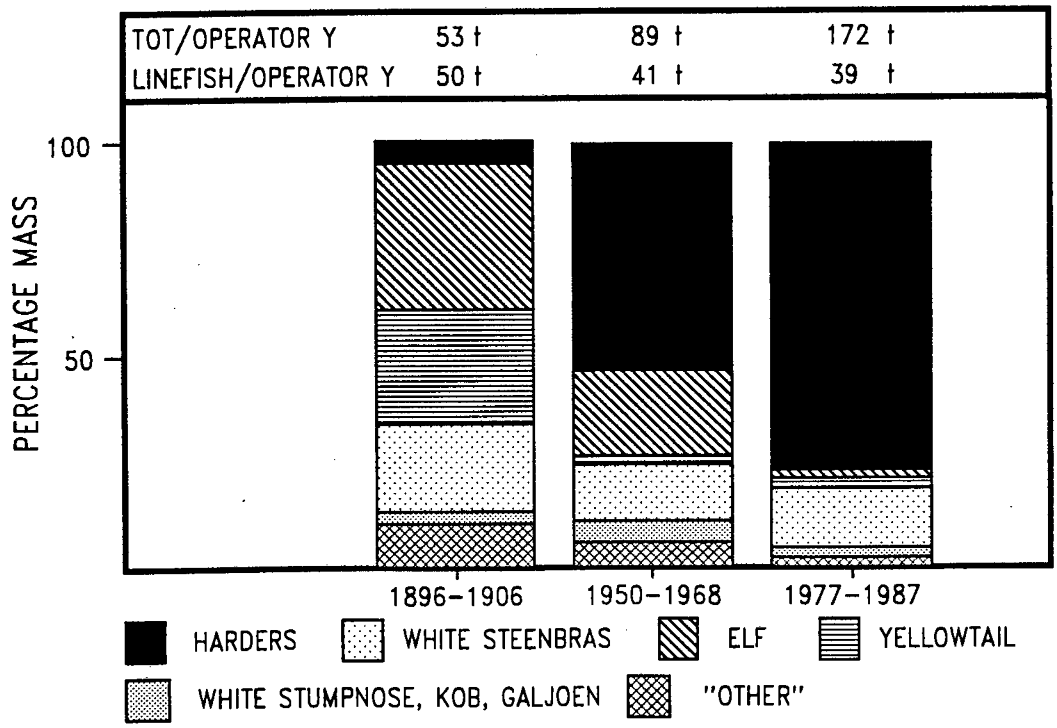


Fig. 1.1. Catch composition of the beach-seine (personal records of seine-fishermen), rock and surf angling (Liesbeeck Park and Old Mutual angling club records) and commercial line fisheries in False Bay (National Marine Linefish System).

Historical catches

Around the turn of this century harders provided 5%, and elf, yellowtail, white steenbras, white stumpnose , kob and galjoen 84% of the total mass of the beach-seine catch (Figure 1.2). The proportion of harders had increased substantially by the years 1950-1968 (53%) until they comprised 77% of the catch by mass during the period 1977-1987. Elf (20%) and white steenbras (13%) decreased in importance but remained a substantial part of the 1950-1968 catches. The proportion of yellowtail (2%) had declined by this period. Between 1977 and 1987, white steenbras (14%) remained important but elf (2%) and yellowtail (2%) no longer constituted major portions of the beach-seine catch. Annual catches of linefish per operator by mass have not changed substantially since the turn of the century, but the overall tonnage per operator has increased, as greater amounts of harders have been caught over time (Fig 1.2). There has, however, been a substantial decrease in the catch per unit effort of linefish from 1 ton per haul in the 1896-1906 years to 0.24 tons per haul in 1977-1987. These data clearly indicate that the beach-seine fishery relied almost exclusively on "angling" species during the early years of this century and that harders have become more important since then.



turn of the century. 1896-1906 (Gilchrist, 1897-1907), 1950-1968 and 1977-1987 (personal records and paybooks of beach-seine fishermen).

Data collected by Bennett (1991a), shows that the catch composition of shore anglers has changed markedly over the last forty years (Figure. 1.3). In the period 1950-1959 anglers catches were dominated by yellowtail, geelbek (*Atractoscion aequidens*), red stumpnose (*Chrysoblephus gibbiceps*) and red roman (*Chrysoblephus laticeps*). By the years 1976-1986 these species had almost completely disappeared from the catches, to be replaced by galjoen, white steenbras, kob and dassie (*Diplodus sargus*). The most likely reason for this change in catch composition are that in the 1950-1959 period anglers were fishing on the eastern and western shores of False Bay, where rocky substrata and deep water was easily accessible close to the shore, whereas during the latter period effort was concentrated on the surf-zone of sandy and mixed shores. This change in the spatial distribution of effort was facilitated by the advent of offroad vehicles, improvements in fishing gear and the introduction of the prawn pump. It is also likely that an important factor contributing to this change in fishing locality was that catches had declined in the areas previously fished, forcing anglers to move to new areas in order to maintain catch rates. It was inevitable, therefore, that the move by anglers onto the sandy beaches of False Bay brought them into competition and consequently into conflict with the beach-seine fishermen. However, it is equally clear that this situation became more serious after 1960.

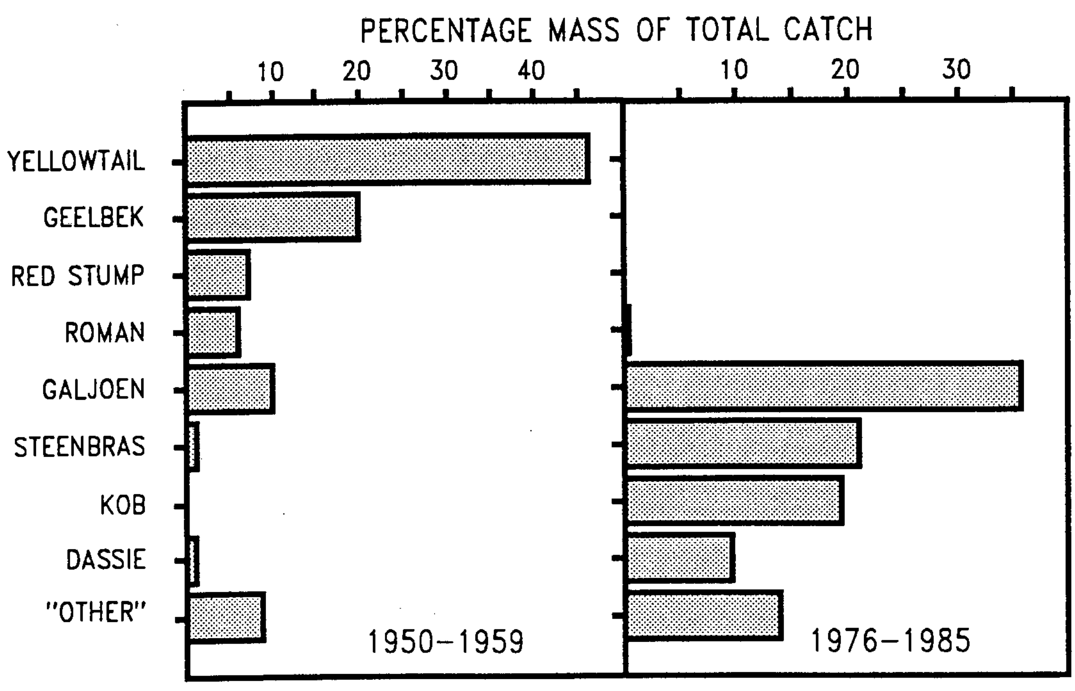


Fig. 1.3. The composition of catches made in the southwestern Cape during competitions of the Liesbeeck Park Angling Club during the periods 1950-1959 and 1976-1985 (After Bennett 1991a).

CONCLUSION

Historically, it can be seen that clashes between beach-seine fishermen and anglers are not a new occurrence. The conflict has merely intensified in recent years, largely due to the exponential increase in the number of anglers. It is obvious, that until recently, management measures were politically motivated and not based on solid scientific information.

Species currently dominating the catches of shore anglers in False Bay cannot be considered as exclusively or "traditionally" angling species as they provided the bulk of beach-seine catches long before they became important in the catches of shore anglers. It is also true that harders are not the "traditional" target species of the beach-seine fishery of False Bay as they have only relatively recently come to dominate the catch of this fishery. On the basis of the evidence presented it appears, therefore, that beach-seine fishermen are justified in claiming a "traditional right" to the species which, in recent years, have been referred to as "angling" species.

CHAPTER 2

THE CATCH COMPOSITION OF THE COMMERCIAL BEACH-SEINE FISHERY IN FALSE BAY, SOUTH AFRICA

ABSTRACT

A total of 726 447 fish representing 66 species from 39 families was recorded in 311 commercial beach-seine hauls made in False Bay between January 1991 and December 1992. Numerically, *Liza richardsonii* was the most important species, providing 86 % of the total catch. The remainder of the catch included 13 teleost species which shore anglers regard as angling species and hence not a "legitimate target" of the beach-seine fishery. The landed proportion of this "by-catch" was dominated by *Seriola lalandi*, *Pomatomus saltatrix*, *Lithognathus lithognathus*, *Argyrosomus hololepidotus* and *Umbrina canariensis*. The reporting of catches by beach-seine fishermen differed in accuracy between species. Accuracy ranged from < 1% (*Dichistius capensis*) to 89% (*L. richardsonii*).

INTRODUCTION

Beach-seining has been a contentious issue in the Cape for at least 100 years. Clashes between anglers and net fishermen occurred as far back as 1883 (Gilchrist & Williams 1910) and complaints about the catching of immature and spawning fish were recorded in 1898 (Gilchrist 1899). The increased popularity of recreational shore and boat angling over the last fifty years (Van der Elst 1989, Bennett 1991a), and the recent emergence of various conservation groups, has resulted in steadily increasing conflict between these interest groups and the beach-seine fishermen (Penney 1991, Chapter 1).

Anglers' catches in False Bay have declined substantially in recent years (Bennett 1991a) and the groups opposed to beach-seining claim that these declines are directly attributable to exploitation by the seine fishery. Of particular concern to the angling/conservation lobby are what they consider to be excessively large catches of adults and juveniles of "angling" species such as *Pomatomus saltatrix, Seriola lalandi* and *Lithognathus lithognathus*. Cartilagenous species, increasingly important in competition angling, are also regarded as being under threat (V. Taylor, Western Province Rock and Surf Angling Association, pers. comm.).

Management responded to these concerns by restricting beach-seine permits solely to the capture of *Liza richardsonii* and *Callorhinchus capensis* except in False Bay where species such as *S. lalandi* and *L. lithognathus* are claimed as "traditional" and legitimate targets by the seine fishermen (Wiley 1985). In order to reduce catches of "angling" species in False Bay, management imposed a number of gear, area and time restrictions on the beach-seine fishery. The seine fishermen in turn complained that some of the new restrictions were too harsh and that as a consequence many of them would have to terminate their operations. Groups opposed to seine-netting maintained that the new regulations were easy to circumvent and that the concession to catch angling species was open to abuse. Additional claims were that reporting of beach-seine catches, although compulsory, was not accurate and that this fishery caught a disproportionate quantity of "angling" species relative to the recreational and commercial linefisheries. Management, under increasing pressure to curtail beach-seine activities, initiated an investigation into this fishery in 1991 in order to resolve the controversy surrounding it.

In this chapter, data is given on the species and size composition of beach-seine catches monitored over a two year period in False Bay. The total annual catch is then estimated and used to guage the relative impacts of the fishery on the respective species. The accuracy of compulsory beach-seine catch returns reported to the Sea Fisheries Research Institute (SFRI)
are assessed and catches are compared and discussed relative to those of the commercial line and recreational angling fisheries.

METHODS

False Bay, which is approximately 1 080 km^2 in extent (Figure 2.1) and the largest true bay in South Africa, has been described in detail by Day (1970) and Spargo (1991). Beach-seine fishermen are physically able to operate only from sandy shores which include much of the northern shore and a few small sandy beaches on the rocky eastern and western shores of the bay. The operations of each permit holder are, however, restricted to specific areas or beaches. In all, approximately 10 km of the 116 km of False Bay coastline are worked by beach-seine fishermen.

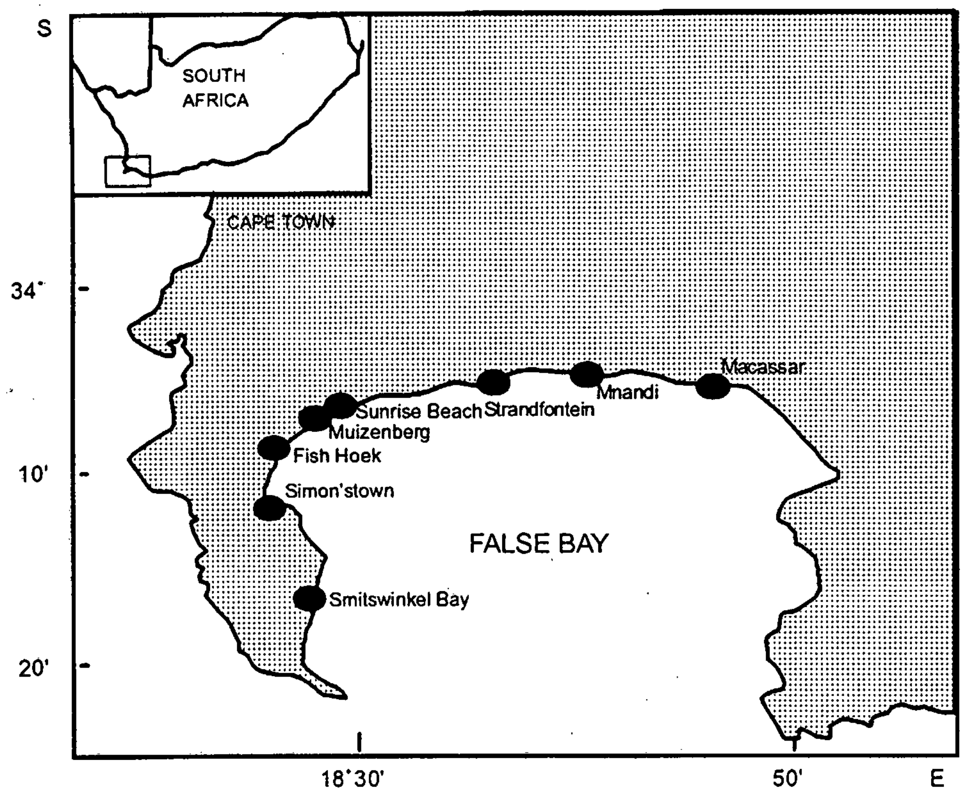


Fig. 2.1. Map of False Bay showing the localities at which beach-seine fishermen operate and some other places mentioned in text.

The commercial beach-seine nets monitored in this study were 275 m long, 5 m deep with stretched mesh sizes that ranged from the legal minimum of 44 to 90 mm. Each net had a central bag approximately 5 m wide by 10 m long. Hauling ropes are restricted by law to 600 m long and the net was set at any distance between 50 and 600 m offshore. The nets were rowed out into the surf on a boat 3-5 m long, leaving the end of the trailing rope on the shore. The net was then shot around a shoal of fish or a likely area for occurrence of fish and the leading rope brought back to shore. The net was hauled beachwards by a crew of approximately 14 persons, with the ends being drawn together as it approached the shore.

Seven beach-seine permit holders operate in False Bay. One operator at Simonstown was inactive throughout the study period and catches at Smitswinkel Bay (see Fig. 1)were not monitored directly because of time and distance constraints. The five remaining operators were monitored intensively.

Commercial beach-seine activities were monitored between January 1991 and December 1992 on almost every day that weather permitted seining to take place.

Locality, date, time and total catch of all fish and invertebrates in each haul were recorded. As much as possible of the catch of each species was measured, except for large catches from which a representative subsample of no fewer than 120 fish was taken. The numbers and species discarded on each occasion were noted.

Beach-seine permit holders submit monthly reports in which their daily hauls and catches are recorded. In order to assess the accuracy of these catch records, monitored beach-seine hauls were compared individually, where possible, with those reported in written catch returns. Monitored and reported catches of individual species were compared separately using the paired-sample t-test (Zar 1984). The monthly total catches of each permit-holder according to their written returns were also compared to those on the Sea Fisheries Research Institute (SFRI) database.

Mean annual catch of the beach-seine fishery was calculated after reported catches from 1985-1992 were corrected for under-reporting. Because most beach-seine and angling catches were reported numerically, it was decided to compare them with those of the commercial line fishery by number rather than by mass. Mean annual commercial lineboat catches were converted into numbers of fish directly from catch masses reported to the SFRI. These catch masses were not verified, but for the purpose of this study were assumed to be accurate. Angler numbers were obtained from random counts made during the 1991/1992 monitoring period. Annual shore-angling effort was estimated by multiplying the mean number of anglers along the False Bay coastline at any one time by 6 hours, the mean daily amount of time spent fishing by each angler (Bennett 1993a). Annual catch was calculated by multiplying this total effort by the annual catch per unit effort of each species determined from angling club records (Bennett *et al.* 1994).

RESULTS

During the study period, 311 commercial hauls were monitored, an average of almost one every two days. From interviews with seine fishermen it is estimated that a total of approximately 1 000 beach-seine hauls were made in False Bay during the two year period of the study.

The species composition, frequency of occurrence and abundance of adult and juvenile fish caught in all the hauls observed are summarized in Table 2.1. A total of 726 447 fish representing 66 species from 39 families, was caught. Of these, 670 071 individuals of 26 species were retained and 56 376 (8.4 %) were released. *Liza richardsonii* was by far the most numerous species, accounting for 86.5 % of the total numerical catch. The 13 teleosts that could be considered to be angling species were represented by 47 484 individuals and provided 6.5 % of the catch. Of the 22 738 angling fish retained, *S. lalandi*, (7 641), *P. saltatrix* (6 832), *L. lithognathus* (2 768), *Argyrosomus hololepidotus* (2 264) and *Umbrina canariensis* (1 143) were numerically the most important. The 46 724 immature fish that were caught comprised 6.4 % of the catch but only 5 511 of these (0.76 % of the total catch) were retained. In all, 687 cartilagenous fish were retained, 94 % of which were *Callorhinchus capensis*.

Of the species caught, including those targetted (Table 2.1), 26 were kept and 40 were discarded. *Seriola lalandi*, *Trachurus trachurus*, *Sardinops sajax* and *Sarpa salpa* were represented by infrequent large (> 50 per haul) catches and occurred in less than 20 % of the hauls. Landed catches of "angling" species, notably *P. saltatrix*, *A. hololepidotus*, *U. canariensis*, *Diplodus sargus* and *Rhabdosargus globiceps*, were small (< 50 specimens per haul) but frequent, occurring in more than 20 % of all hauls. *Lithognathus lithognathus* was characterized by both infrequent large and frequent small catches. *Liza richardsonii* was the only species of which frequent large catches were made.

Size frequency distributions of the 10 most abundant "angling" species are shown in Figure 2.2. The catch of *R. globiceps* was dominated (95 %) by immature individuals. Large *R. globiceps* (> 30 cm) only occured in hauls made directly after sunrise. Catches of *S. lalandi*, *D. sargus*, *A. hololepidotus*, *Pomadasys commersonni* and *U. canariensis* were predominately (≥ 90 %) adult fish. The size distributions of *P. saltatrix* and *L. lithognathus* both showed a bimodal pattern. For *P. saltatrix*, fish < 20 cm, although not fully selected for by the mesh, were well represented, as were legal sized fish of > 30 cm. In the case of *L. lithognathus*, large (70 + cm) individuals were caught at Simonstown and Macassar Beach, whereas small (<40cm) fish were caught almost exclusively in the Muizenberg-Strandfontein area (Figure 2.1). *Lithognathus lithognathus* in the 40-60 cm size range were most often observed in early morning hauls at Sunrise Beach (Figure 2.1). With the exception of *Callorhinchus capensis* and *Mustelus mustelus* the cartilagenous catch was dominated by immature fish (Figure 2.3).

Table 2.1. Summary of information on species composition, abundance, number retained, size and length at maturity of Osteichthyes and Chondrichthyes caught in a total of 311 beach-seine hauls during the period January 1991 to December 1992. Skates and rays were measured in dorsal width. Angling species marked with an asterisk.

			Number caught	Percentage of total catch	Percentage occurrence	Number retained	Size range (cm)	Length at maturity (cm)	Percentage immature
OSTEICHTHYES									
Ariidae	*Galeichthyes feliceps*	Barbel	194	0.027	19.3	34	16-45	31.5[a]	62
Atherinidae	*Atherina breviceps*	Cape silverside	3121	0.430	12.5	0	8-13	4.3[b]	0
Carangidae	*Decapterus macrosoma*	Slender scad	1	<0.001	0.3	0	17		
	*Lichia amia**	Leervis	214	0.029	6.8	0	10-101	60[c]	22
	*Seriola lalandi**	Yellowtail	7641	1.052	6.8	7641	34-110	70[d]	10
	Trachurus trachurus	Maasbanker	13903	1.914	17.0	10942	8-29	20[e]	18
Clinidae	*Clinus agilis*	Agile klipvis	32	0.004	0.6	0	3-7	4.5[f]	19
	Clinus latipennis	False Bay klipvis	13	0.002	3.2	0	8-16	4.5[f]	0
	Clinus superciliosus	Super klipvis	5	0.001	0.6	0	5-8	6.5[g]	20
Clupeidae	*Sardinops sajax*	Pilchard	7407	1.020	12.2	7407	13-28	21[h]	<0.1
Coracinidae	*Dichistius capensis**	Galjoen	40	0.006	7.7	0	14-45	31[i]	45
Cynoglossidae	*Cynoglossus capensis*	Sand tonguefish	20	0.003	2.6	0	17-26		
Diodontidae	*Lophodiodon calori*	Fourbar porcupine fish	1	<0.001	0.3	0	10		
Elopidae	*Elops machnata**	King springer	3	<0.001	0.3	3	95-100		
Engraulidae	*Engraulis capensis*	Cape anchovy	70	0.010	1.3	0	6-12	9[j]	10
Gobiesocidae	Undescribed ?	Suckerfish	1	<0.001	0.3	0	1		
Haemulidae	*Pomadasys commersonni**	Spotted grunter	43	0.006	2.9	39	39-61	36[k]	0
Kuhliidae	*Kuhlia mugil*	Barred flagtail	1	<0.001	0.3	0	16		
Monacanthidae	*Aluterus monoceros*	Unicorn leatherjacket	2	<0.001	0.6	0	12-22		
	Cantherhines pardalis	Honeycomb filefish	2	<0.001	0.6	0	8-12		
	Stephanolepis auratus	Porky	1	<0.001	0.3	0	10		
Mugilidae	*Liza richardsonii*	Harder	628125	86.465	85.9	619769	4-30	23[l]	2
	Mugil cephalus	Springer	26	0.004	4.5	26	35-55	34[m]	0
Parascorpididae	*Parascorpis typus*	Jutjaw	1	<0.001	0.3	0	10		
Pomatomidae	*Pomatomus saltatrix**	Elf	17264	2.376	62.1	6832	5-85	24[n]	55
Sciaenidae	*Argyrosomus hololepidotus**	Kob	3610	0.497	45.7	2264	9-157	34[o]	11
	*Atractoscion aequidens**	Geelbek	1	<0.001	0.3	0	27	59[p]	100
	*Umbrina canariensis**	Belman	1396	0.192	21.9	1143	7-75	30[q]	3.6
Scombridae	*Scomber japonicus*	Slimy mackerel	1	<0.001	0.3	1	30	47[r]	100
Soleidae	*Austroglossus microlepis*	West coast sole	1	<0.001	0.3	1	47		
	Heteromycteris capensis	Cape sole	5	0.001	1.6	0	12-16	4.5[q]	0
	Solea bleekeri	Blackhand sole	51	0.007	8.4	0	12-20	10[s]	0
	Solea fulvomarginata	Lemon sole	3	<0.001	1.0	1	15-30		
Sparidae	*Diplodus sargus capensis**	Dassie	1772	0.244	33.4	1396	12-56	18[t]	1
	*Lithognathus lithognathus**	White steenbras	4258	0.586	56.6	2768	13-108	65[u]	44
	Lithognathus mormyrus	Sand steenbras	39	0.005	3.2	1	9-36	19[v]	18
	Pterogymnus laniarius	Panga	2	<0.001	0.3	0	25-28	28[w]	50
	*Rhabdosargus globiceps**	White stumpnose	11203	1.542	68.8	648	3-49	31[x]	95
	Rhabdosargus holubi	Cape stumpnose	39	0.005	3.2	4	8-32	18[g]	22
	Sarpa salpa	Strepie	8192	1.128	7.1	8135	16-32	18[t]	0
	Spondyliosoma emarginatum	Steentjie	132	0.018	2.9	100	12-26	22[c]	87
Sphyraenidae	*Sphyraena acutipinnis*	Sharpfin barracuda	2	<0.001	0.6	0	10-18		
Stromateoidae	*Stromateus fiatola*	Blue butterfish	273	0.038	8.7	199	12-50		
Syngnathidae	*Syngnathus acus*	Pipefish	6	0.001	1.0	0	12-19	12.5[h]	20
Tetraodontidae	*Amblyrhynchotes honckenii*	Blaasop	6806	0.937	64.6	0	5-21	8[g]	0.2
Triglidae	*Chelidonichthyes capensis*	Cape gurnard	143	0.020	6.8	30	7-44	30.5[y]	79
Zeidae	*Zeus faber*	John Dory	12	0.002	1.3	0	12-24		
CHONDRICHTHYES									
Callorhinchidae	*Callorhinchus capensis*	St Joseph	1640	0.226	40.2	646	12-101	58[z]	34
Carcharhinidae	*Carcharhinus brachyurus*	Bronze whaler	100	0.014	15.1	0	48-305	200[aa]	95
Dasyatidae	*Dasyatis brevicaudata*	Shorttail stingray	3	<0.001	1.0	0	46-200		
	Dasyatis chrysonota	Blue stingray	1073	0.148	29.6	0	15-80	58[ab]	92
	Gymnura natalensis	Diamond ray	18	0.002	4.5	18	106-180	100[ab]	0
Lamnidae	*Carcharodon carcharias*	Great white shark	1	<0.001	0.3	0	195	240[aa]	100
Myliobatidae	*Myliobatis aquila*	Bullray	1524	0.210	35.0	0	14-116	54[ab]	92
	Pteromylaeus bovinus	Duckbill ray	4	0.001	1.3	0	50-114	120[ab]	100
Narkidae	*Narke capensis*	Onefin electric ray	6	0.001	1.9	0	6-17		
Odontaspididae	*Carcharias taurus*	Spotted ragged tooth	2	<0.001	0.3	0	176-197	220[aa]	100
Rajidae	*Raja alba*	Spearnose skate	18	0.002	2.6	0	20-45	90[ac]	100
	Raja miraletus	Twineye skate	1	<0.001	0.3	0	28.5	45[ac]	100
	Raja straeleni	Biscuit skate	56	0.008	7.1	23	8-70	80[ac]	100
Rhinobatidae	*Rhinobatos annulatus*	Lesser guitarfish	4607	0.634	73.3	0	15-95	70[ad]	89
Scyliorhinidae	*Halaelurus natalensis*	Tiger catshark	1	<0.001	0.3	0	46	42[aa]	0
	Haploblepharus edwardsii	Puffadder shyshark	9	0.001	1.0	0	30-58	41[aa]	33
	Poroderma africanum	Pyjama shark	3	<0.001	0.6	0	48-80	58[aa]	66
Torpedinidae	*Torpedo fuscomaculata*	Electric ray	1	<0.001	0.3	0	40		
Triakidae	*Mustelus mustelus*	Houndshark	1299	0.179	36.3	0	21-160	70[aa]	49
	Triakis megalopterus	Spotted gully shark	4	0.001	1.0	0	140-180	140[aa]	0

a. Tilney (1990), b. Bennett (1989), c. vd Elst (1988), d. Penney *et al.*(1989), e. Geldenhuys (1973), f. Prochazka pers comm, g. Day *et al.* (1981), h. Davies (1956)[1], i. Bennett & Griffiths (1986), j. Armstrong & Thomas (1989), k. Winter (1979)[1], l. De Villiers (1987)[2], m. Whitfield & Blaber (1978), n. vd Elst (1976), o. Griffiths (1993), p. Van der Elst & Adkin (1991), q. Pers obs., r. Baird (1977)[1], s. Wallace (1975), t. Joubert (1981b), u. Bennett (1993b), v. Lasiak (1982)[1], w. Hecht (1976), x. Talbot (1955)[1], y. Hecht (1977), z. Freer & Griffiths (1993)[2], aa. Compagno (1984), ab. Wallace (1967a), ac. Wallace (1967b), ad. Wallace (1967c)

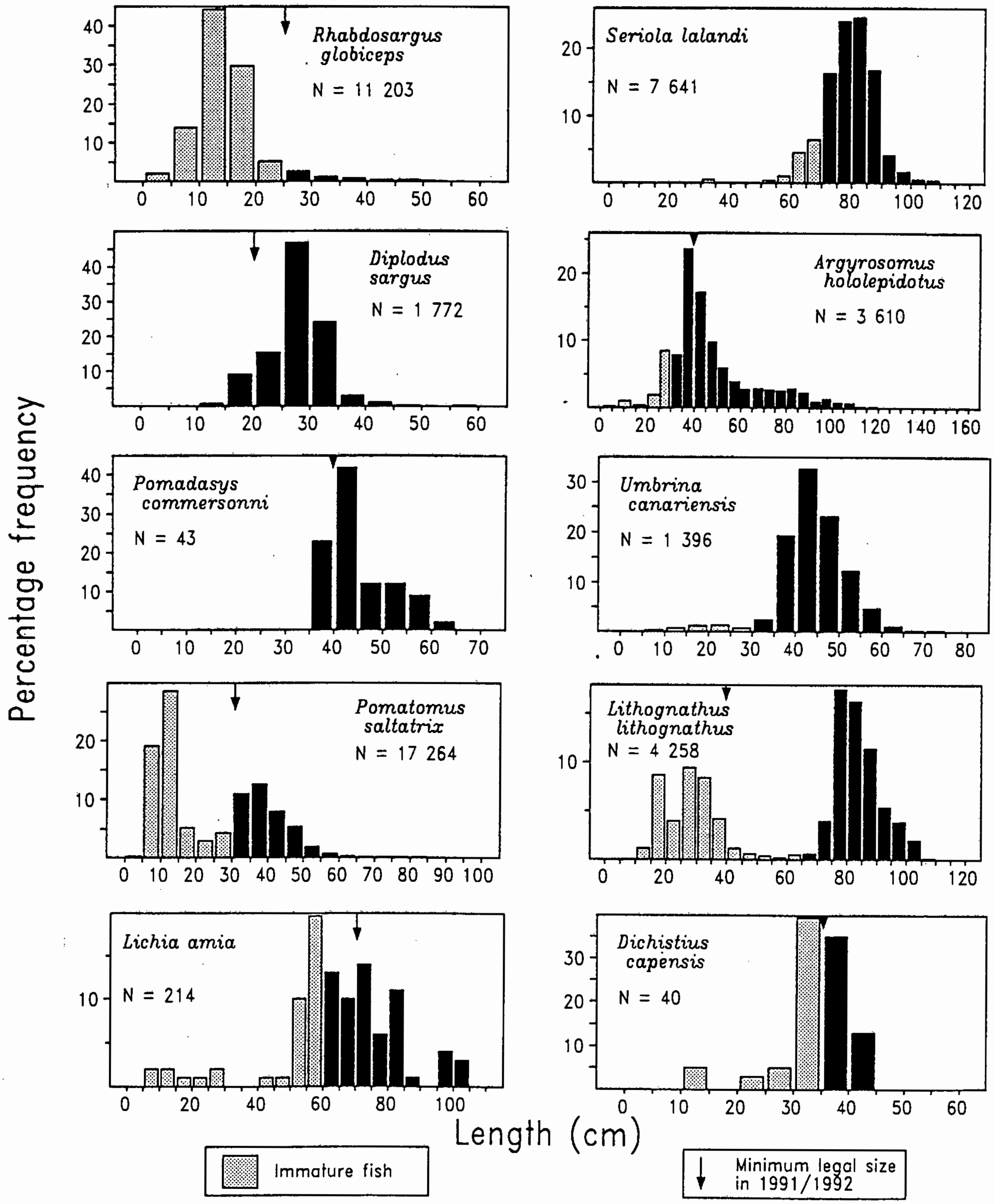


Fig. 2.2. Size frequency distributions for the 10 most abundant angling species caught in 311 commercial beach-seine hauls between January 1991 and December 1992

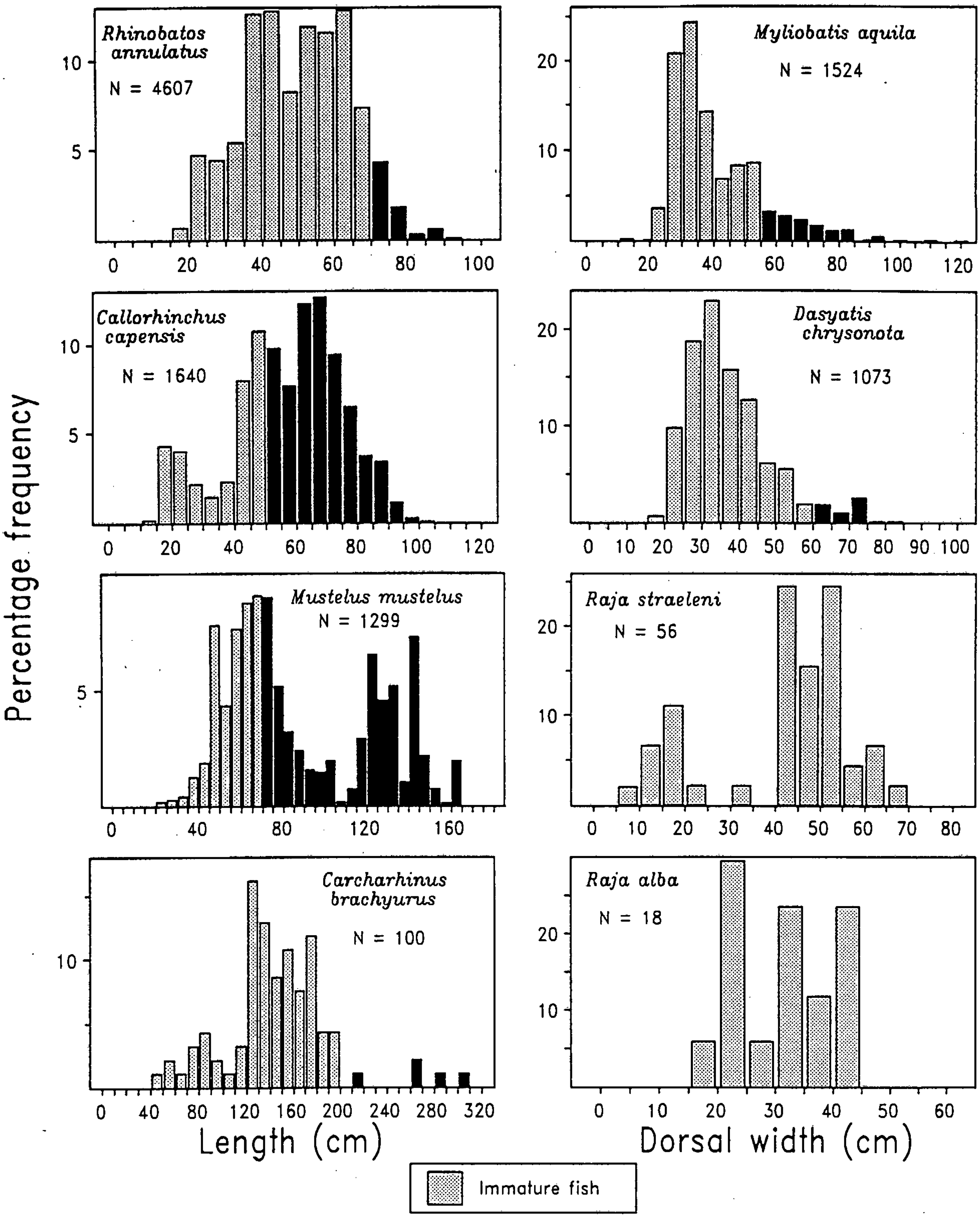


Fig. 2.3. Size frequency distributions for the 10 most abundant cartilaginous species caught in 311 commercial beach-seine hauls between January 1991 and December 1992

Table 2.2. Landed beach-seine catches (numbers) in False Bay for the years 1991 and 1992 calculated from monitored hauls and according to submitted catch returns and SFRI catch summaries respectively.

	Monitored hauls		Submitted returns		SFRI summaries		% of catch
	1991	1992	1991	1992	1991	1992	reported
Seriola lalandi	23 364	24 442	13 298	10 620	13 084	10 999	50
Pomatomus saltatrix	8 322	2 937	3 510	1 305	3 412	1 351	43
Lithognathus lithognathus	1 067	4 388	705	2 246	320	2 457	43
Argyrosomus hololepidotus	1 356	2 348	785	1 251	705	1 080	49
Rhabdosargus globiceps	1 450	1 017	44	70	29	61	4
Diplodus sargus	959	1 484	389	377	355	371	31
Umbrina canariensis	1 420	137	867	82	866	78	59
Dichistius capensis	50	50	2	0	0	0	0
Liza richardsonii	1 215 761	1 174 705	1 168 446	963 275	1 154 973	986 752	89
"Other"	213 550	19 333	8 348	1 059	4 271	580	2

A total of 253 of the monitored beach-seine catches were matched up with those submitted in written catch returns from January 1991 to December 1992. There was no significant difference between monitored and reported versions of *L. richardsonii* catches ($P(|t| \geq 0.033) > 0.05$). However, catches of *S. lalandi* ($P(|t| \geq 2.223) < 0.05$), *P. saltatrix* ($P(|t| \geq 2.955) < 0.005$), *L. lithognathus* ($P(|t| \geq 2.493) < 0.02$), *A. hololepidotus* ($P(|t| \geq 2.500) < 0.02$), *R. globiceps* ($P(|t| \geq 4.249) < 0.001$), *D. sargus* ($P(|t| \geq 3.263) < 0.002$) and *U. canariensis* ($P |t| \geq 2.218) < 0.05$) were all significantly greater than those reported in catch returns. Reporting of "angling" fish (Table 2.2) ranged from <1% *(Dichistius capensis)* to 59 % *(U. canariensis)* of the true catch of each species, but 89% of the *L. richardsonii* catch was reported. For the beach-seine fishery, the degree of under-reporting of the most abundant "angling" species was assumed to have been constant for the years 1985 to 1992. The under reporting factors obtained from the catches monitored in 1991 and 1992 were used to correct the SFRI returns for the years 1985 to 1992 and the mean annual catch was calculated over this eight-year period (Table 2.3).

In all, 176 counts were made of angler numbers along the False Bay coastline during this study. Numbers peaked at high tide and three hours before and after sunset. Anglers were often concentrated at nodes of activity (easily accessible and popular sites) especially on the northern shore of False Bay. The largest count of anglers was 6 000 recorded during a run of *P. saltatrix* within the area bounded by Strandfontein Pavillion and Mnandi Beach. Peak angling activity, excluding weekends, did not coincide with peak beach-seine activity. It is estimated that there was a daily average of 451 shore anglers along the False Bay coastline, each of whom fished for an average of six hours per day. This amounts to a total of 2 706 angler-hours expended per day or 987 690 angler-hours expended per year in False Bay. Angler numbers concurred with estimates made by Van Herwerden *et al.*(1989). The six 6 hour angler day observed in this study is similar to that of five hours for anglers on the Natal coast (Joubert 1981a). The average annual angling catches are summarized in Table 2.3.

Table 2.3. Contribution to the mean annual catch (numbers) of important angling species by the beach-seine, commercial line and recreational shore-angling fisheries in False Bay for the years 1985-1992. Values given as mean ± standard error.

	Beach-seine (%)	Commercial line (%)	Shore angling (%)	Total number caught
Seriola lalandi	77±7.20	21±6.92	2±0.44	28 597
Lithognathus lithognathus	40±8.25	1±0.18	59±8.23	13 957
Umbrina canariensis	15±4.20	-	85±4.20	2 462
Rhabdosargus globiceps	12±3.56	85±3.38	3±1.62	163 158
Pomatomus saltatrix	10±3.48	48±4.15	42±2.77	68 683
Argyrosomus hololepidotus	2±0.75	80±1.62	18±1.67	77 894
Diplodus sargus	2±0.55	4±0.41	94±0.68	30 080
Dichistius capensis	1±0.22	1±0.22	98±0.41	17 076

In total the beach-seine, commercial line and recreational shore-angling fisheries were calculated to account for 14, 60 and 26% of the catch of important "angling" species respectively (Table 2.3). The beach-seine fishery was responsible for 77 % of the annual catch of *S. lalandi* and 40 % of the *L. lithognathus* catch. Most *P. saltatrix* (48

%), *R. globiceps* (84 %) and *A. hololepidotus* (79 %) were caught by commercial line boats while most of the *L. lithognathus* (59 %), *D. sargus* (94 %), *U. canariensis* (85 %) and *D. capensis* (99 %) catches are made by shore-anglers. Overall, 86% of the beach-seine catch is *L. richardsonii*, 68 % of the commercial line catch is "other" fish (eg. *Thyrsites atun* & *Pachymetopon blochii*) whereas 88 % of the shore-angling catch was the "angling" species shown in Table 2.3.

DISCUSSION

Previous descriptions of beach-seine catches in South Africa have been derived largely from experimental seine-net hauls (eg. Lasiak 1984a,b, Bennett 1989a, Romer 1986). Such studies gave a general idea of the structure of surf-zone fish assemblages along the South African coastline. There is, however, no real basis for comparisons between those experimental catches and the catches monitored in commercial beach-seines during this study, because the gear used differed considerably.

De Villiers (1987) dealt extensively with the commercial beach-seine fishery along the South African coastline, describing it as a well-managed fishery with stable catches. His work was, however, confined exclusively to *L. richardsonii* and did not take into account the "by-catch" of this fishery, the species that were the cause of some controversy at the time. Penney (1991) reviewed the beach-seine, purse-seine and line fisheries in False Bay, but he stressed that the catch reports on which the study had been based had not been validated. The current study, in which individual beach-seine catches were observed directly, has provided the opportunity to verify reported catches.

Three species, namely *L. richardsonii*, *L. lithognathus* and *S. lalandi*, are targetted directly by the beach-seine fishery in False Bay, and are located visually or through a sound knowledge of the locations and environmental conditions under which occur. All the other species in the catches are incidental, so forming a by-catch. The frequent small catches of non-targeted "angling" fish, when combined, may on occasion equal or exceed the total catch of targeted species.

The discrepencies between monitored catches, written catch returns and SFRI reports (Table 2.2) may have a number of causes, for instance a lack of faith by the fishermen in the confidentiality of their reports, or a fear that catch restrictions would result from the reporting of large catches. Small catches, although frequent, are seldom reported as they are not regarded as of any importance by the seine fishermen. Some 5-10% of the "missing" catches may be attributed to mistakes by those collating the information or to arbitrary numbers assigned to reported catch masses. For example, the individual mass of all cartilagenous fish was assumed to be 1 kg. *Liza richardsonii* was the only species for which catches were reported correctly. This is a likely result of its targeting being actively encouraged by the management authorities.

All the "angling" species in Table 2.3 have at some time in their exploitation history been classified as vulnerable to overfishing or have experienced declines as a result of overfishing (Van der Elst & Adkin 1991, Bennett 1993a). Anglers share a substantial proportion of the species in their catch with those in the commercial net- and line fisheries in False Bay (Table 2.3, Chapter 1). The absence of any significant species unique to the catches of shore-anglers is a major cause of the conflict between the three fisheries (Chapter 1.). Shore-anglers do, however, account for over half the annual catches of *L. lithognathus*, *D. sargus*, *U. canariensis* and *D. capensis* by these combined fisheries in False Bay. In turn, the beach-seine fishery is responsible for large proportions of the *S. lalandi* (77 %) and *L. lithognathus* (40 %) catches (Table 2.3). Further, it must be mentioned that the combined catches of other fish, eg. *T. trachurus capensis*, *S. sagax* and *S. salpa*, both numerically and by mass, may in some years equal or exceed catches of *L. richardsonii*.

Beach-seine catches of *S. lalandi* (3.2%), *L. lithognathus*, *P. saltatrix* and *A. hololepidotus* (0.4%) represent a small portion of the national line catches of these species, but they are a significant part of the False Bay catch (Penney 1991). Beach-seine catches of *L. lithognathus* (25%) are a significant portion of the national catch (Bennett 1993a). Considered in isolation, the beach-seine fishery of False Bay may be very important, because the catch of some species by this fishery exceeds that of the other fisheries combined. The degree to which this localised effect is significant will depend primarily on the movement patterns of the species concerned, resident fish being the most vulnerable. *Seriola lalandi*, *P. saltatrix*, *A. hololepidotus*, adult *L. lithognathus* and possibly *U. canariensis* are all migratory (Van der Elst 1988, Penney *et al.* 1989, Bennett & Attwood 1991, Bennett 1993b) and move into and out of False Bay. *Diplodus sargus*, *D. capensis* and sexually immature *L. lithognathus* are widespread, but individuals are predominately resident (Bennett & Attwood 1991, Bennett 1993b). The concentrations of adult *L. lithognathus* in specific areas in False Bay during summer may, in fact, be a large proportion of the sexually mature population (Bennett 1993b). As a consequence, the stock decline that has occurred may be a result of over-exploitation by the beach-seine fishery (Bennett 1993a).

Barring the effects of mesh selectivity, the catch compositions of commercial beach-seine hauls in False Bay are representative of the surf-zone fish assemblage. However, direct targeting of *L. richardsonii*, *S. lalandi* and *L. lithognathus* is likely to inflate their relative numerical importance in the surf-zone. With the exception of *L. richardsonii* the eight most important species in observed beach-seine catches were all species which recreational fishermen regard as "angling" fish. Two of these, *S. lalandi* and *L. lithognathus*, are targeted directly by the beach-seine fishery, while the rest form part of incidental catches. The multispecies nature of the beach-seine fishery has made it extremely difficult to manage and control. Observed catches have provided a valuable insight into the fishery and its impact relative to recreational shore-angling and the commercial linefishery. Unfortunately, the paucity of data on the recreational boat-based linefishery has meant that the total catch, nationally or locally, of most species has never been quantified. Consequently, the relative contribution by the beach-seine fishery to the total catch of these species could not be assessed accurately.

CHAPTER 3

THE ONES THAT GET AWAY: THE VULNERABILITY OF FISH TO CAPTURE BY COMMERCIAL BEACH-SEINE NETS IN FALSE BAY, SOUTH AFRICA

ABSTRACT

An experimental net was set behind a commercial beach-seine net to estimate the number of fish that escape from the latter. Escapement was high, 95% of the combined numerical catch being caught in the cover net. Escapees were numerically dominated by the "baitfish" species *Engraulis capensis* (52%) and *Atherina breviceps* (36%). A relatively low proportion of "angling" species was lost from the commercial net. These species, namely *Lithognathus lithognathus*, *Rhabdosargus globiceps*, *Pomatomus saltatrix* and *Diplodus sargus capensis* become vulnerable to capture by the commercial beach-seines well before they reach two years of age and long before maturity. It is argued that the substantial increase in mesh size needed to reduce the by-catch of these juvenile "angling" species would drastically lower the total catch of *Liza richardsonii*, the principal target species of the commercial beach-seine fishery.

INTRODUCTION

Since *circa* 1983, the official status of the commercial beach-seine fishery along the Cape coast of South Africa has been that of a single species fishery targeting the southern mullet (harder) *Liza richardsonii*. St Joseph sharks *Callorhynchus capensis*, are permitted as a bycatch, but the targeting and keeping of all other species is prohibited. However, beach-seine fishermen in False Bay are exempt from this restriction and are permitted to catch and retain species such as white steenbras *Lithognathus lithognathus*, white stumpnose *Rhabdosargus globiceps*, elf *Pomatomus saltatrix* and yellowtail *Seriola lalandi*, provided that they all exceed the legal minimum size.

This exemption has caused much chagrin amongst anglers and conservation groups, who claim that the small-meshed commercial nets allow no escape, and capture all fish in their paths (eg. Borden 1988, Kirsch 1993). In response to this, the minimum mesh size was increased from 44 to 50mm (Theart *et al.* 1983, Stander 1991), but the decision was rescinded when seine fishermen claimed that the increased mesh size would result in too many fish being gilled, longer handling time and greater mortality of those released (Mc Hugh 1960, Petty *et al.* 1984).

Several studies have investigated the mesh selectivity and capture efficiency of commercial and experimental nets (eg. McHugh 1960, Botha *et al.* 1971, Hamley 1975, Jones 1982, Pierce *et al.* 1990). Investigations into the selective properties of commercial trawl, gill and beach-seine nets have, in most cases, determined that the optimum and ideal mesh size was that currently in use (Botha 1971, Grant 1981, Jones 1982, De Villiers 1987).

Escape from a beach-seine will depend on the behavioural and morphological characteristics of the fish, on the dimensions and properties of the net and on the nature of the substratum over which the net is hauled. Important characteristics of the fish include fright response, typical position in the water column, girth and streamlining, all of which may vary temporally and with age (Hamley 1975, Trent & Pristas 1977, Lyons 1986, Parsley *et al.* 1989). Influential features of the net include mesh size, length, depth, elasticity, strength, visibility and the way it is hung (Hamley 1975, Parsley *et al.* 1989). Escape is generally more frequent over coarse, heterogenous substrata than over fine, snag-free substrata (Parsley *et al.* 1989, Pierce *et al.* 1990)

The aim of the present study was to describe and quantify escapement and vulnerability to capture of fish in commercial beach-seine nets in False Bay. Experimental and commercial catches in this and another study are compared and discussed.

METHODS

The study was conducted at Fish Hoek Beach (34°08'S,18°27'E), on the western shore of False Bay. This beach is sheltered by steep rocky headlands on it's northern and southern ends, is 1.3 km long, has a gentle gradient and an average wave height of 0.95 metres (Bennett 1989a). The outer breaker line varies between 50-200 m from the shore. This site was chosen because it is relatively sheltered in comparison to the exposed beaches on False Bay's northern shore and hence easier to sample. In addition, it was the only beach-seine area in which commercial hauls, set at approximately the same distance from the shore, were made consistently each morning at sunrise.

Two commercial beach-seine permit holders operating from Fish Hoek Beach use nets 275 m long, 5m deep with a stretched mesh size of 44 mm, which they set between 400 and 600 metres offshore. The commercial net was hauled by 14-20 crew. The experimental net was 30 m long and 2 m deep with a stretched mesh size of 12 mm. The experimental net was hauled by four persons two on each 100m hauling rope. As the bag of the commercial net approached 100 metres from the shore, the experimental net (cover net) was rowed out on a dinghy and shot around the commercial net. The cover net was hauled up onto the beach behind the commercial net. Two other experimental hauls (control hauls) set at 100m from the beach were made 100m either side of, and before and after, each commercial haul.

Whenever possible, the entire catch of each net was counted and the total length of each fish was measured to the nearest millimetre. If more than 1 000 individuals of a species were caught, a representative subsample of at least 250 fish was measured. Body depth in a few selected species was measured. Length-frequency distributions for each species were calculated from the combined cover and commercial net catches (excluding the control nets).

The selectivity of the commercial net was determined using both cover-net and alternate-haul techniques (Pope 1966). Using the cover-net method, the selectivity for a species was determined by plotting the proportion of the combined catch in the commercial net against total fish length (Pope 1966, Jones 1982). The length at which 50% of a size-class were retained was then read from the plot.

The alternate-haul method of Pope (1966) was applied to length frequency data collected from 311 commercial and 264 experimental net hauls monitored in False Bay between January 1991 and July 1993. Following the methodology of Pope (1966), the fish caught in the experimental net were, after being corrected for variations in catching efficiency between the two nets, assumed to be representative of the natural population, at least over the mesh selection range,. The ratio of commercial to experimental catch in each size-class gave the proportion of fish retained by the commercial net. The number of fish retained was plotted against total length-classes.

The results of the cover net and alternative haul methods were described using the logistic curve

$$P = 1/[1+e^{-k(L-L_{50\%})}],$$

where P is the proportion retained by the commercial net, k is related to the length range over which the selectivity changes from 0 to values near 1, L is the length-class midpoint and $L_{50\%}$ is that length corresponding to 50% retention (Butterworth *et al.* 1989).

RESULTS

A total of 11 commercial beach-seine hauls was monitored and covered with the experimental net during February and March 1993. The combined catch of the commercial and cover nets totalled 70 727 fish, representing 43 species and 27 families (Table 3.1). Of this total, 95% was caught in the cover net. Further, 17 species recorded in the cover net were not retained by the commercial net and 12 species caught by the commercial net did not escape into the cover net. Only 1% of the cartilaginous catch was recorded in the cover net. Horse mackerel *Trachurus trachurus capensis* and slender scad *Decapterus macrosoma* were the most abundant species in the commercial net. Anchovy *Engraulis capensis* and Cape silverside *Atherina breviceps* were the two most abundant species in the cover net. The largest sizes of leervis *Lichia amia*, santer *Cheimerius nufar*, dassie *Diplodus sargus capensis*, red tjor-tjor *Pagellus bellottii natalensis* and steentjie *Spondyliosoma emarginatum* in the cover net were all less than their smallest sizes in the commercial net (Table 3.1). The size ranges of the ten remaining species overlapped for both nets (Table 3.1).

The control hauls netted a total of 8 248 fish of 15 species from 11 families. The catch per haul of 14 of these species was up to three orders of magnitude less than that of the cover net (Table 3.1), even though the same net was used and the area swept was constant. The control catch per haul of *Liza richardsonii* was greater than that of the cover hauls (Table 3.1).

Table 3.1. Summary of information on the species composition, abundance and size of Osteichthyes and Chondrichthyes caught in 11 commercial and experimental cover beach-seine net hauls made at Fish Hoek Beach during February and March 1993. Control net catches are not included in the total catch. Angling species are marked with an asterisk. Skates and rays measured in dorsal width.

		Total catch	Size range of commercial haul (mm)	Size range of cover haul (mm)	% total catch in cover net	N/haul of cover net	N/haul of control net
OSTEICHTHYES							
Ariidae	*Galeichthyes feliceps*	82	210-369				
Atherinidae	*Atherina breviceps*	24431		84-118	100	2221	88
Callionymidae	*Draculo celetus*	1		50	100	<1	<1
Carangidae	*Alectis ciliaris**	1		34	100	<1	
	Decapterus macrosoma	3255	100-190	118-176	90	266	<1
	*Lichia amia**	3	220-240	172	33	<1	<1
	Trachurus trachurus capensis	5254	50-230	25-202	65	308	<1
	Unidentified	5		32-112	100	<1	<1
Clupeidae	*Sardinops sajax*	1	230				
Cynoglossidae	*Cynoglossus capensis*	5	195-250				
Dactylopteridae	*Dactyloptena peterseni*	1		81	100	<1	
Engraulidae	*Engraulis capensis*	35002	113-115	105-144	>99	3182	
Gobiesocidae	*Psammogobius knysnaensis*	1		70	100	<1	
Monacanthidae	*Aluterus monoceros*	1	104			<1	
	Stephanolepis auratus	1		88	100	<1	
Mugilidae	*Liza richardsoni*	164		32-166	100	15	44
	Mugil cephalus	1		136	100	<1	<1
Mullidae	*Parupeneus rubescens*	19		57-78	100	2	
Ostraciidae	*Ostracion* spp.	2		7-14	100	<1	
Pomatomidae	*Pomatomus saltatrix**	15	130-135	49-166	87	1	<1
Sciaenidae	*Argyrosomus hololepidotus**	1	450				
	*Umbrina canariensis**	7		24-48	100	<1	<1
Soleidae	*Heteromycteris capensis*	55	110-152	32-148	87	4	
	Synaptura marginata	1	230				
Sparidae	*Cheimerius nufar**	8	112	50-92	88	<1	
	*Diplodus sargus capensis**	20	295	26-40	95	2	<1
	*Lithognathus lithognathus**	4	810-1010				
	Lithognathus mormyrus	75		20-148	100	7	6
	Pagellus bellottii natalensis	13	160-164	41-159	54	<1	
	*Rhabdosargus globiceps**	1303	40-320	22-105	87	103	45
	Sarpa salpa	1		100	100	<1	
	Spondyliosoma emarginatum	164	140-292	28-74	34	5	
Sphyraenidae	*Sphyraena acutipinnis*	13		125-154	100	1	
Synodontidae	*Trachinocephalus myops*	1		65	100	<1	
Tetraodontidae	*Amblyrhynchotes honckenii*	281	109-210	17-128	4	1	<1
	Pelagocephalus marki	1		26	100	<1	
Triglidae	*Chelidonichthyes capensis*	193	130-350	35-189	27	5	<1
CHONDRICHTHYES							
Callorhinchidae	*Callorhinchus capensis*	76	190-950	175-190	5	<1	
Myliobatidae	*Myliobatis aquila*	58	230-440				
Rajidae	*Raja straeleni*	18	115-600				
Rhinobatidae	*Rhinobatos annulatus*	34	210-920				
Scyliorhinidae	*Haploblepharus edwardsii*	11	300-570	450	9	<1	
	Haploblepharus pictus	1	290				
Triakidae	*Mustelus mustelus*	143	415-1750				

Table 3.2. Summary of results conforming to the selectivity curve $P = 1/[1+e^{-k(L-L50\%)}]$, body depth to length ratios (BD/L) ± S.E., body depth at 50% retention ($BD_{50\%}$) and lengths at 1 year old and maturity of species caught in commercial beach-seine nets in False Bay. Length and body depth are measured in mm. $L_{50\%}$ given as ± S.E.

	k	$L_{50\%}$	r^2	n	BD/L	$BD_{50\%}$	$L_{1\ year}$	$L_{maturity}$
Diplodus sargus	0.073	105 ± 2.750	0.82	50	0.294±0.007	31	105[a]	264[a]
Lithognathus lithognathus	0.120	166 ± 0.308	0.96	50	0.277±0.002	46	160[b]	650[b]
Rhabdosargus globiceps	0.082	138 ± 0.183	0.98	50	0.238±0.002	33	82[c]	310[c]
Umbrina canariensis	0.019	144 ± 10.840	0.61	60	0.296±0.002	43		30[d]
Pomatomus saltatrix	0.021	160 ± 3.100	0.47	60	0.222±0.004	36	170[e]	240[e]
Trachurus trachurus	0.076	163 ± 0.651	0.82	50	0.193±0.003	32	83[f]	200[f]

a. Mann (1992); b. Bennett (1993); c. Talbot (1955); d. unpublished data; e. Van der Elst (1976); f. Geldenhuys (1973)

The 50% retention length of *T. trachurus capensis* in the cover net experiment was 163mm (Table 3.2). Insufficient catches within the selection ranges of the commercial and cover-net hauls prevented the use of the cover method being used to construct selectivity curves for any of the other species. Instead, the alternate haul method was used to determine the selection curves of elf *Pomatomus saltatrix*, white stumpnose *Rhabdosargus globiceps*, white steenbras *Lithognathus lithognathus*,belman *Umbrina canariensis* and *Diplodus sargus capensis* (Table 3.2). Size frequency distributions of these species are shown in Figure 3.1.

The relationships between body depth and length for all species in this study were assumed to be linear owing to the limited size-ranges over which measurements were made. These ratios were used to determine body depth at 50% retention (Table 3.2). Excluding *L. lithognathus*, the body depth at 50% retention of all species was less than the 44mm mesh size of the commercial net (Table 3.2).

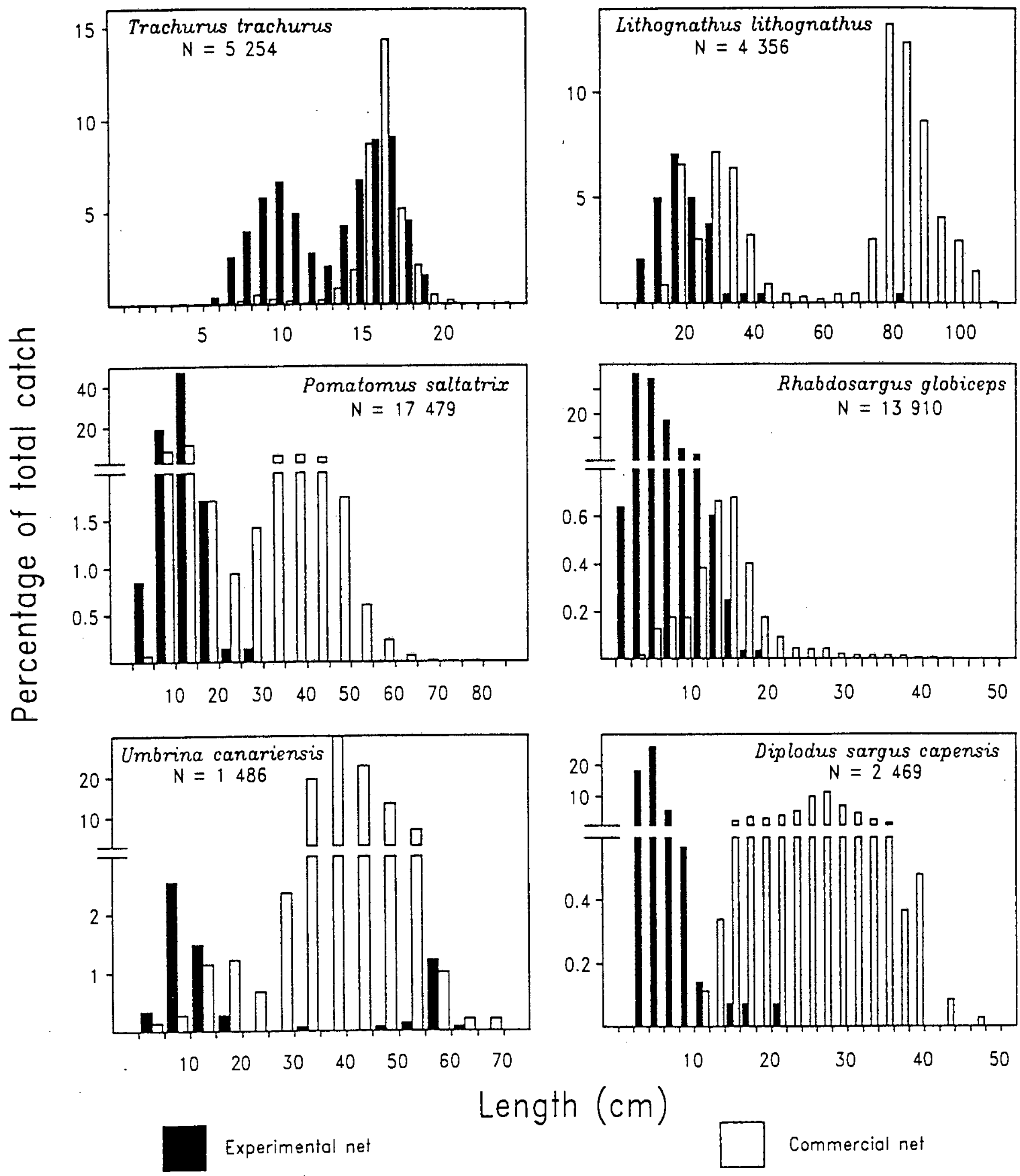


Fig. 3.1. Size frequency distributions of five "angling" species abundant in 311 commercial and 264 experimental net hauls made between January 1991 and July 1993. Included is the size frequency distribution of *Trachurus trachurus capensis* caught in 11 covered commercial hauls during February and March 1993.

DISCUSSION

The 43 species caught in the 11 combined commercial/cover hauls during this study represent more than double the 20 species representing 12 families previously recorded at Fish Hoek by Bennett (1989a). However, the 15 species from 11 families recorded in the control hauls are comparable with those of Bennett's (1989a) study. Catch per haul of the control net, which averaged 187 fish per haul, was, however, considerably lower than the 1550 fish per haul recorded by Bennett (1989a).

Differences in gear, excluding personnel efficiency (Aneer and Nelling 1977), cannot explain the difference in catch per haul of the control net and Bennett's (1989a) study, because net lengths and mesh sizes were similar in both studies. As the area swept by the control net was twice that swept in Bennett's (1989a) study, a larger catch would have been expected. Disturbance by the net and boat could have been a factor, and the doubled area through which the net was hauled could have allowed the fish more time to escape (Kuipers 1975, Aneer and Nelling 1977). Hauls in this study were also conducted in the two hours spanning daybreak, as opposed to those of Bennett's (1989a) study which were made during daylight. The small catch per haul of the control net in this study could also be attributed to small and juvenile fish not having re-occupied the surf-zone after their nocturnal absence (Romer 1986, Romer and McLachlan 1986). Bennett (1989a) confined his hauls to the southern corner of Fish Hoek Beach and larval and post-larval fish abundance has been shown to vary laterally in the surf-zone (Lyons 1986, Whitfield 1989a). In addition, time of day, tides, wave height, wind speed, water temperature and wind direction are all known to influence fish abundance directly or indirectly (Lasiak 1984a, Ross *et al.* 1987, Romer 1986, Bennett 1989a). It is possible that the differences in catch size between this and Bennett's (1989a) study reflect spatial and temporal changes in absolute abundance of the ichthyofaunal assemblage at Fish Hoek Beach. However, this statement cannot be substantiated because the capture efficiency of the nets (Lyons 1986, Parsley *et al.* 1989, Pierce *et al.* 1990), a parameter essential to the estimation of absolute abundance, was not determined in either of the two studies.

The 32 species recorded in the cover net included all of the 15 recorded in the control net. This suggests that the additional 17 species possibly originated from beyond the first 100 m of surf zone. The comparatively high catch per haul in the cover net was a result of fish being herded in front of the commercial net until they were within 100m of the shore, whereupon fish escaped *en masse* through the mesh of the commercial net (pers.obs).

In all, 12 species caught in the cover net during this experiment had not been recorded in 311 commercial hauls monitored during 1991 and 1992 in False Bay (Chapter 2). At least one of them, *Draculo celetus*, was a new distribution record for the South-Western Cape (P.C. Heemstra, J.L.B. Smith Institute of Ichthyology, pers comm.). Therefore, the method of hauling a cover net behind a commercial net may be a viable way of sampling ichthyofauna (juveniles & adults) over a wider area of surf-zone without a corresponding increase in labour intensity. In turn, the species composition of the cover-net catch when compared to that of the control net, warns of the dangers of extrapolating the results of inshore experimental netting to include the outer surf-zone.

The high proportion of fish (95%) that escaped from the commercial net during this study may have been atypical. A total of 286 fish caught in the 11 commercial hauls was of "edible size", and five of them (*L. lithognathus* and kob *A. hololepidotus*) were of commercial value. Catches of *L. richardsonii* were below average (approximately 2019 per haul, Chapter 2) and their smaller numbers may have allowed a greater proportion of escapees. In addition, there were no catches of detrital macrophytes, which frequently line the commercial nets (pers. obs.) and effectively reduce mesh size, so preventing the escape of small and juvenile fish, during this study. In turn, large quantities of macrophyte material in the surf-zone would offer refugia to, and so increase the abundance of, certain species in the seine area and net (Pierce *et al.* 1990). However, large quantities of detrital material in the net cause it to roll up and lift off the sea floor, allowing fish to escape under the leadline (pers. obs., Pierce *et al.* 1990).

Based on gill-net selectivity experiments, *Liza richardsonii* is recruited into the gill and beach-seine fisheries at a length of 208 mm, just less than it's length at 50% maturity (Ratte 1976, De Villiers 1987). However, gill nets are hung to the full extent of their mesh size, whereas the 44 mm meshes of the commercial seine nets in this study were observed to be vertically reduced by the tension on the hauling ropes. As a result, the mean girth of fish at the 50% retention level is slightly above and slightly below the mesh size for gill and beach-seine nets respectively (Hamley 1975, Table 3.2).

The 50% retention lengths of the "angling" species *L. lithognathus*, *D. sargus*, and *P. saltatrix* are below or approximately at their lengths at one year of age (Van der Elst 1976, Mann 1992, Bennett 1993b). The 50% retention of *Rhabdosargus globiceps* was before two years of age (Talbot 1955). Although these estimates of 50% retention are crude, they suggest that most of the "angling" fish component of beach-seine catches become vulnerable to capture within their first two years of life, well before they are sexually mature. Moreover, as they are well below minimum legal size, most of these fish are released.

The Theart Committee (Theart *et al.* 1983) recommended that the minimum mesh size of commercial beach-seine nets be raised from 44 to 50mm to reduce the catch of juvenile "angling" fish (J.V. Petty, False Bay Trek-Fishermens Association, per. comm.). Assuming that the ratio of body depth to mesh size remains more or less constant, it is likely that "angling" species such as *L. lithognathus* and *P. saltatrix* would still be recruited into the beach-seine fishery well before they reached two years of age. The 50% retention length for *Liza richardsonii* by 44 mm mesh is ideal in that it corresponds to the species' length at 50% maturity (De Villiers 1987). The low ratio of body depth to length of *L. richardsonii* would ensure that its 50% retention length would be raised by at least 30mm if a 50mm mesh size were to be implemented, the likely result being a substantial reduction in the commercial catch of this species. It is also likely that there would be a decrease in the catch of juvenile "angling" fish. However, the fishermen could attempt to compensate for their smaller catches of *L. richardsonii* by increasing their targeting of adult "angling" species to make up for the reduction in the *L. richardsonii* catch. The overall result might well be an increase, as opposed to the intended reduction, of the landed catch of "angling" species.

CHAPTER 4

SEASONALITY AND OTHER FACTORS INFLUENCING BEACH-SEINE CATCHES IN FALSE BAY WITH AN ASSESSMENT OF CLOSED PERIODS AS A MANAGEMENT OPTION

ABSTRACT

Commercial beach-seine catches and effort in False Bay are strongly seasonal, with 93% of the total catch being taken in the spring, summer and autumn months. Catch per haul of the target species *Liza richardsonii* in May (autumn) and October (spring) was double that of summer despite lower effort. Effort was largely dependent on the frequency of occurrence of patches of the surf-zone diatom *Anaulus birostratus* on which *L. richardsonii* feed and around which the nets were set. It is concluded that the present winter closed season for "angling" fish is not having the desired effect of reducing the total catch of these species, as they are more abundant in the summer months. Most of the individuals caught in winter were released due to existing minimum size regulations. A possible alternative to the present partially closed season, is completely closed weekends during which no seine-netting would be allowed and which may reduce the total catch by 30 %.

INTRODUCTION

Studies of commercial and recreational fisheries and surf-zone and near-shore ichthyofaunas nearly always report some degree of seasonal variation in numbers of fish and species composition, diversity and abundance, as well as in fishing effort (eg. Marais and Baird 1980, Modde 1980, Lenanton, 1982, Ross *et al.* 1987, Hecht and Tilney 1989, Tilmant 1989, Bennett and Attwood 1993). Only in a few cases do such studies report no important seasonal changes in abundance or species (eg. Iglesias 1981, Lasiak 1984b).

Peaks in fish abundance in summer are reported by most studies on surf-zone and near-shore ichthyofaunas with the seasonal change in physical conditions, notably water temperature, being seen as the determining factor (eg. Modde and Ross 1981, Peters and Nelson 1987, Ross *et al.* 1987). Seen as of lesser importance or having a more short term influence are salinity, turbidity and wind speed and direction (Lasiak 1984a, Hook 1991). Cycles in fish abundance may not be due to seasonal changes in physical conditions, but merely a result of recruitment and mortality and or food availability (Modde and Ross 1987, Gibson *et al.* 1993).

A knowledge of the seasonal changes in the abundance or behaviour of a particular fish species or even a group of species is vital to the fishermen who target them, and to fishery managers who seek to utilize a resource wisely. Seasonal variations are often taken into consideration by management when implementing closed periods. Closed seasons are proclaimed either to limit total fishing effort or to protect a particular species over a vulnerable portion of its lifetime (Buxton 1993). Problems arise when, in multi-species fisheries which use non-selective methods, the closed season of one species interferes with the catching of another.

The beach-seine fishery in False Bay is the oldest commercial fishery in South Africa and for its first 250 years the fishermen were relatively unrestricted as to where and when they could operate (Chapter 1). In recent years, however, anglers and conservation groups have increased their pressure on management to curb what they perceive to be excessive catches of "angling" fish by the seine fishery. Management responded by implementing amongst other restrictions, a closed season during which only harders *Liza richardsonii* and St Joseph sharks *Callorhinchus capensis* could be caught. Management acknowledged that this was done without any prior knowledge as to what its impact on the fish and fishery would be.

In light of the above, this study describes the seasonal variation in catches and effort of the beach-seine fishery in False Bay. The importance of certain biological and physical variables in determining fish abundance and beach-seine effort are discussed. In turn, the merits of the present closed season and an alternative are compared and assessed.

METHODS

Commercial beach-seine fishermen are physically able to operate only from sandy shores, which include much of the northern shore and a few small sandy beaches on the rocky eastern and western shores of False Bay. Each permit holder is restricted to operating in daylight hours and to specific areas or beaches, so that in all, approximately 10 km of the bay's 116 km perimeter are worked by beach-seine fishermen (Chapter 2).

The commercial beach-seine nets monitored in this study were 275 m long, 5 m deep with stretched mesh sizes that ranged from the legal minimum of 44 to the 90 mm of the negatively buoyant "Russman" net. Sampling methods are described in detail in Chapter 2.

Five of the seven commercial beach-seine operators in False Bay were monitored between January 1991 and December 1992. Their activities were observed on almost every day that weather permitted seining to take place. The locality, date, time and total catch of all fish and invertebrates in each haul were recorded. As much as possible of the catch of each species was measured. For large catches a representative subsample of not less than 120 fish was taken. The number and species discarded on each occasion were noted. Water temperatures (°C) were recorded and wind speed (Knots), wind direction, area swept by the net and turbidity were estimated at the time of each haul. Turbidity was measured in Formazin Turbidity Units (FTU), where 1 FTU = 1 NTU when made with a nephelometer, using a portable Hach DR/2000 spectrophotometer. In addition, the target species and whether or not the nets were set around surf-zone phytoplankton *Anaulus birostratus* patches (as defined by Campbell & Bate 1991) were noted. Turbidity measurements were taken from the surface layer of water. Turbidity readings in *A. birostratus* patches were interpreted as measures of patch intensity.

Additional information on seasonal fluctuations of catches, effort and targeting, as well as changes in environmental conditions were obtained from the daily logbook (1974-1987) of one of the seine fishermen. This information, together with that from this study and catch records on the National Marine Linefish System (corrected as suggested in Chapter 2) was used to estimate catches with and without closed periods.

Size frequency distributions were constructed for the most abundant "angling" species. Multivariate analyses were conducted following the methodology of Field *et al.* (1982). Monthly samples were grouped using complementary classification and multi-dimensional scaling techniques. These were based on root-root transformed catch per unit effort data with the Bray-Curtis measure of similarity.

RESULTS

Approximately 1000 commercial beach-seine hauls were made in False Bay during the period under review. Of these, 311 were monitored. A total of 726 447 fish, representing 67 species from 39 families was recorded.

Multivariate analysis separated the monthly samples into three seasonal groups based on their species composition and number per haul. Although these groups straddle the defined ambits of the seasons, they correspond loosely with summer (November to March), winter (June to September),autumn (April to May) and spring (October) respectively (Figure 4.1.)

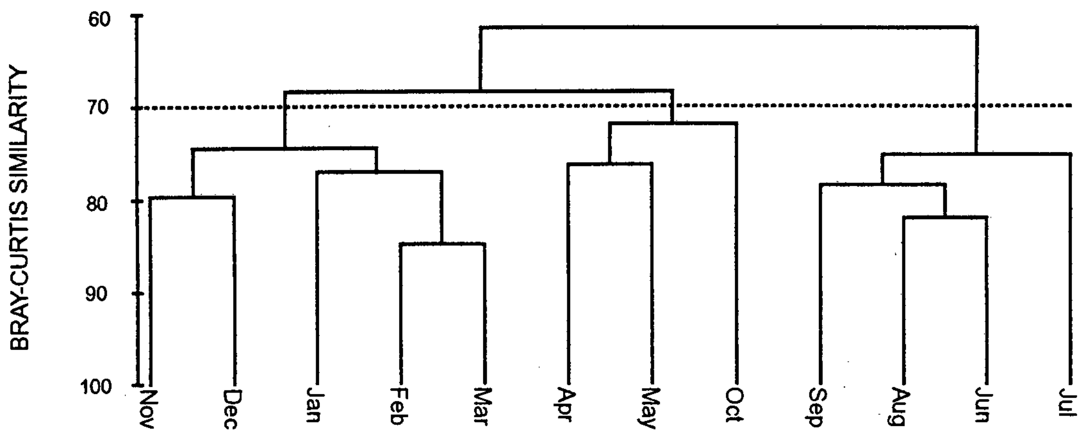


Fig. 4.1. Dendrogram showing similarities between monthly catch per haul of all species caught by the commercial beach-seine fishery in False Bay.

The monthly catch per haul of adult and juvenile fish caught in all the hauls observed are summarized in Table 4.1. The monthly catch per haul of these fish categorized into *L. richardsonii*, "angling" and "baitfish" species is shown in Figure 4.2. Of the 67 species recorded, only five, Cape silverside *Atherina breviceps*, horse mackerel *Trachurus trachurus capensis*, pilchard *Sardinops sajax*,anchovy *Engraulis capensis* and porky *Stephanolepis auratus* (1 specimen) were more abundant during the May-September period. With the exception of *L. richardsonii*, catch per haul of all the other species were greater from October to March. Catch per haul of *L. richardsonii* was greatest in the autumn and spring months of May and October respectively. Mean number of species per haul varied from 10.3 per haul in March to 5.5 per haul in July and September (Table 4.1).

Table 4.1. Monthly catch (number) per haul of all species recorded in 311 commercial beach-seine catches between January 1991 and December 1992. "Angling" fish marked with an asterisk.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
OSTEICHTHYES													
Ariidae	*Galeichthyes feliceps*	0.70	0.56	0.57	0.13	0.23	0.44	0.15	0.85		2.13	1.23	0.29
Atherinidae	*Atherina breviceps*	8.05	6.39	2.08	1.25	2.50	10.11		92.31	62.00	0.13	9.19	14.42
Carangidae	*Decapterus macrosoma*											0.03	
	*Lichia amia**	2.73	0.04	0.12		0.08			0.15	17.80	0.13	0.03	0.04
	*Seriola lalandi**		48.40	35.37								53.87	58.67
	Trachurus trachurus	14.65	7.07	6.92	0.83	76.92	1.11	0.08	15.77		244.31	170.71	46.83
Clinidae	*Clinus agilis*				1.33								
	Clinus latipennis	0.08	0.04	0.04	0.13	0.08							0.04
	Clinus superciliosus				0.21								
Clupeidae	*Sardinops sajax*		0.02		0.42	0.27	279.22	136.46	177.77	156.20	0.38	0.10	0.04
Coracinidae	*Dichistius capensis**	0.48	0.05	0.06	0.13	0.04		0.08	0.15	0.40	0.19		0.13
Cynoglossidae	*Cynoglossus capensis*		0.02	0.04							0.13	0.06	0.54
Diodontidae	*Lophodiodon calori*		0.02										
Elopidae	*Elops machnata**			0.06									
Engraulidae	*Engraulis japonicus*	0.03	0.02									2.19	
Gobiesocidae	Undescribed ?				0.04								
Haemulidae	*Pomadasys commersonni**	0.60	0.21	0.14									
Kuhliidae	*Kuhlia mugil*		0.02										
Monacanthidae	*Aluterus monoceros*	0.03											
	Cantherhines pardalis	0.05											
	Stephanolepis auratus								0.08				
Mugilidae	*Liza richardsoni*	2478.60	1917.98	1215.88	2397.21	4404.62	1513.89	1383.23	2418.77	2625.20	4585.94	202.19	897.00
	Mugil cephalus		0.19	0.06	0.04	0.04	0.89				0.06		0.04
Parascorpididae	*Parascorpis typus*											0.03	
Pomatomidae	*Pomatomus saltatrix**	144.93	76.26	70.00	10.96	17.23	3.78	0.92	15.15	7.40	12.38	27.26	63.17
Sciaenidae	*Argyrosomus hololepidotus**	23.68	1.54	10.43	1.25	1.31	0.89	1.23	2.38	0.20	24.63	15.39	43.83
	*Atractoscion aequidens**					0.04							
	*Umbrina canariensis**	7.15	2.42	17.94	0.04	0.77	0.44	0.08	0.15	0.20	0.31	0.39	0.46
Scombridae	*Scomber japonicus*		0.02										
Soleidae	*Austroglossus microlepis*		0.02										
	Heteromycteris capensis		0.02			0.04						0.10	
	Solea bleekeri		0.28	0.29	0.21	0.12	0.22					0.16	0.21
	Solea fulvomarginata	0.03	0.02		0.04								
Sparidae	*Diplodus sargus capensis**	10.63	5.49	6.51	2.46	0.46	0.22	1.85	0.54		19.81	1.45	9.93
	*Lithognathus lithognathus**	46.65	5.02	2.55	5.33	0.42	4.56	18.92	11.92	2.80	13.31	14.23	30.29
	Lithognathus mormyrus		0.33		0.50						0.06	0.23	
	Pterogymnus laniarius		0.04										
	*Rhabdosargus globiceps**	44.15	73.88	29.69	44.38	9.81	11.78	8.46	15.38	13.00	10.31	16.68	51.21
	*Rhabdosargus holubi**	0.08	0.04	0.04								0.87	0.21
	Sarpa salpa	0.70	0.23	0.18	0.04							262.26	0.46
	Spondyliosoma emarginatum				0.04							2.90	1.71
Sphyraenidae	*Sphyraena acutipinnis*											0.03	0.04
Stromateoidae	*Stromateus fiatola*	0.05	2.47	0.78	0.04	0.58	0.67		2.15			0.10	1.54
Syngnathidae	*Syngnathus acus*				0.25								
Tetraodontidae	*Amblyrhynchotes honckenii*	24.43	21.19	7.29	4.04	3.50	13.56	3.08	11.38	49.00	69.63	32.32	57.92
Triglidae	*Chelidonichthyes capensis*	0.03	0.05	0.27	0.75	0.27			0.31			1.13	2.54
Zeidae	*Zeus faber*			0.14	0.21								
CHONDRICHTHYES													
Callorhinchidae	*Callorhinchus capensis*	1.30	11.49	4.10	3.33	7.58	1.44	2.85	1.15	0.20	1.44	10.19	1.75
Carcharhinidae	*Carcharhinus brachyurus*	0.10	0.53	0.76	0.25	0.08		0.08				0.26	0.42
Dasyatidae	*Dasyatis brevicaudata*		0.04	0.02									
	Dasyatis marmorata	3.50	5.58	9.22	0.21	3.85					0.50	0.71	0.42
	Gymnura natalensis	0.03	0.16	0.14									0.04
Lamnidae	*Carcharodon carcharias*		0.02										
Myliobatidae	*Myliobatis aquila*	3.83	9.84	9.71	2.79	5.04	0.22		0.23	0.40	1.50	0.81	2.54
	Pteromylaeus bovinus	0.03	0.02	0.02								0.03	
Narkidae	*Narke capensis*		0.02	0.04	0.04				0.08				0.04
Odontaspididae	*Carcharias taurus*											0.06	
Rajidae	*Raja alba*	0.10		0.20	0.04	0.04							0.08
	Raja miraletus					0.04							
	Raja straeleni	0.18	0.09	0.24	0.54	0.42						0.16	0.13
Rhinobatidae	*Rhinobatos annulatus*	46.65	5.02	2.55	5.33	0.42	4.56	18.92	11.92	2.80	13.31	14.23	30.29
Scyliorhinidae	*Halaelurus natalensis*												0.03
	Haploblepharus edwardsii			0.02								0.26	
	Poroderma africanum	0.03										0.06	
Torpedinidae	*Torpedo fuscomaculata*			0.02									
Triakidae	*Mustelus mustelus*	2.68	6.02	10.31	1.58	4.46			0.15		0.25	1.94	4.29
	Triakis megalopterus	0.05	0.02			0.04							
TOTAL		2867.99	2209.20	1444.80	2486.37	4541.30	1848.00	1576.39	2778.74	2937.60	5000.84	843.84	1321.59
MEAN NUMBER OF SPECIES		8.80	8.70	10.30	6.80	6.00	7.30	5.50	8.90	5.50	8.60	8.80	9.40

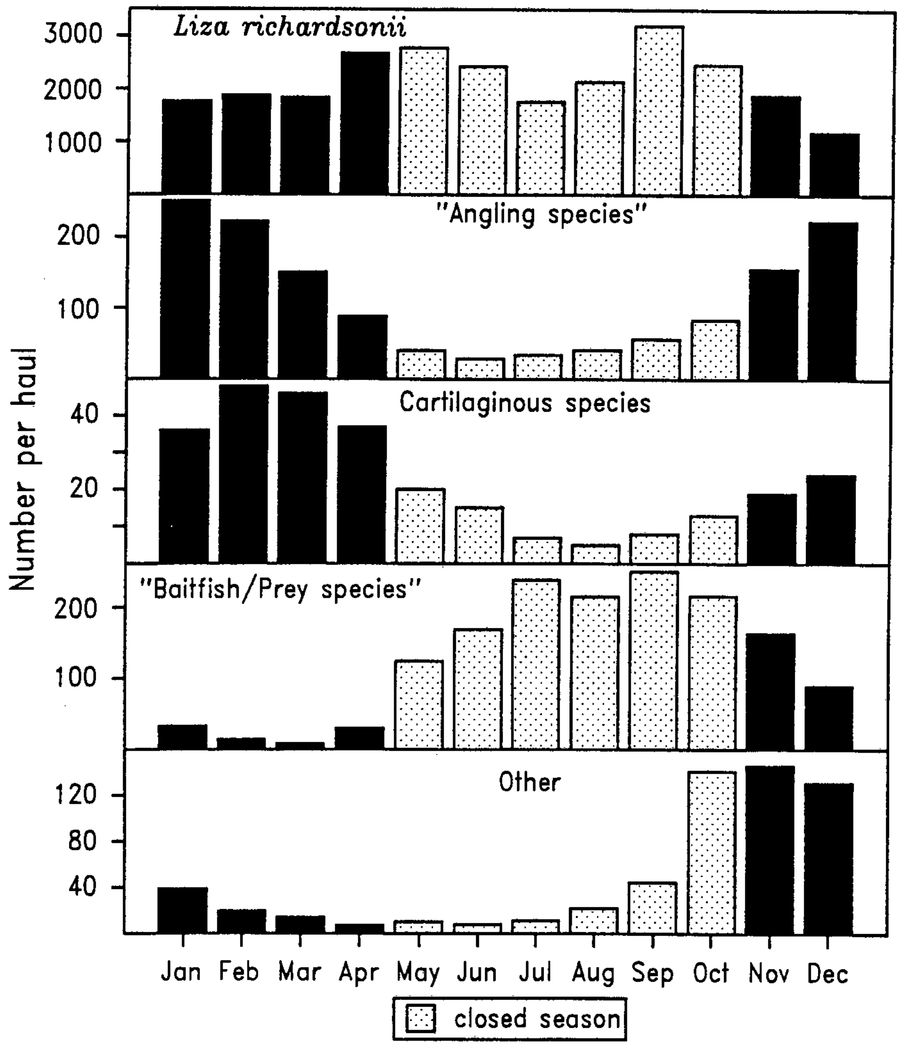


Fig. 4.2. Monthly catch per haul of *Liza richardsonii*, "angling", cartilaginous, and "baitfish" (*Sardinops sajax*, *Trachurus trachurus*, *Engraulis capensis*, *Atherina breviceps*) species plotted as a three month running mean and according to 311 monitored commercial beach-seine hauls made in False Bay during the period January 1991 to December 1992. "Angling" species are those referred to in Table 4.1.

Catch per haul of *L. richardsonii* peaked in May and October (Table 4.1). Shoals of *L. richardsonii* were observed to be larger but less frequent in May and October than they were from November to April. In turn, shoals observed from June to August were of similar size to those seen during November-April, but less frequent.

Of the 13 species in beach-seine catches which could be considered angling species, three, yellowtail *Seriola lalandi* (6.8%), leervis *Lichia amia* (6.8%) and galjoen *Dichistius capensis* (7.7%) occurred in more than 5% of the hauls monitored (Chapter 2). Catch per haul of *L. amia* peaked in September due to the netting of one large shoal, but together with *D. capensis*, this species was characterised by infrequent small catches for the rest of the year. *Seriola lalandi* were caught infrequently but occurred in large (> 35 per haul) numbers in February, March, November and December (Table 4.1). Six angling species, namely white steenbras *Lithognathus lithognathus* (56%), belman *Umbrina canariensis* (21.9%), white stumpnose *Rhabdosargus globiceps* (68.8%), elf *Pomatomus saltatrix* (62.1%), kob *Argyrosomus hololepidotus* (45.7%) and dassie *Diplodus sargus* (33.4%) each had a high frequency of occurrence (Chapter 2), were present throughout the year, but were more abundant during November-March (Table 4.1).

Monthly size-frequency distributions of the six most abundant angling species in monitored beach-seine hauls are shown in Figure 4.3. The size distributions of *L. lithognathus* are bimodal from October to May (Figure 4.3a). Adult *L. lithognathus* (>65cm total length, Bennett 1993b) are almost completely absent from June to September. The few adult *L. lithognathus* caught in August showed minimal gonadal development (Unpublished data). *Lithognathus lithognathus* of 10-15 cm (approximately 1 yr old, Bennett 1993) appeared in catches from June to October.

Adult *P. saltatrix* (>24cm, Van der Elst 1976) were abundant in catches of this species from November to January (Figure 4.3b). The January and March size distributions of *P. saltatrix* are bimodal, two year old fish (20-30cm, Van der Elst 1976) being under-represented in all months except for October, when they dominated catches. The monthly length frequency distributions of *Diplodus sargus* were similar and dominated by mature fish (> 18 cm,Joubert 1981b) throughout the year (Figure 4.3c). The size distributions of *A. hololepidotus* (Figure 4.3d)and *U. canariensis* (Figure 4.3e) were very variable, but dominated by mature individuals throughout the year. Immature fish made up almost the entire catch of *R. globiceps*, hauls of adults (>31 cm, Talbot 1955) being largely confined to the months October-April (Figure 4.3f).

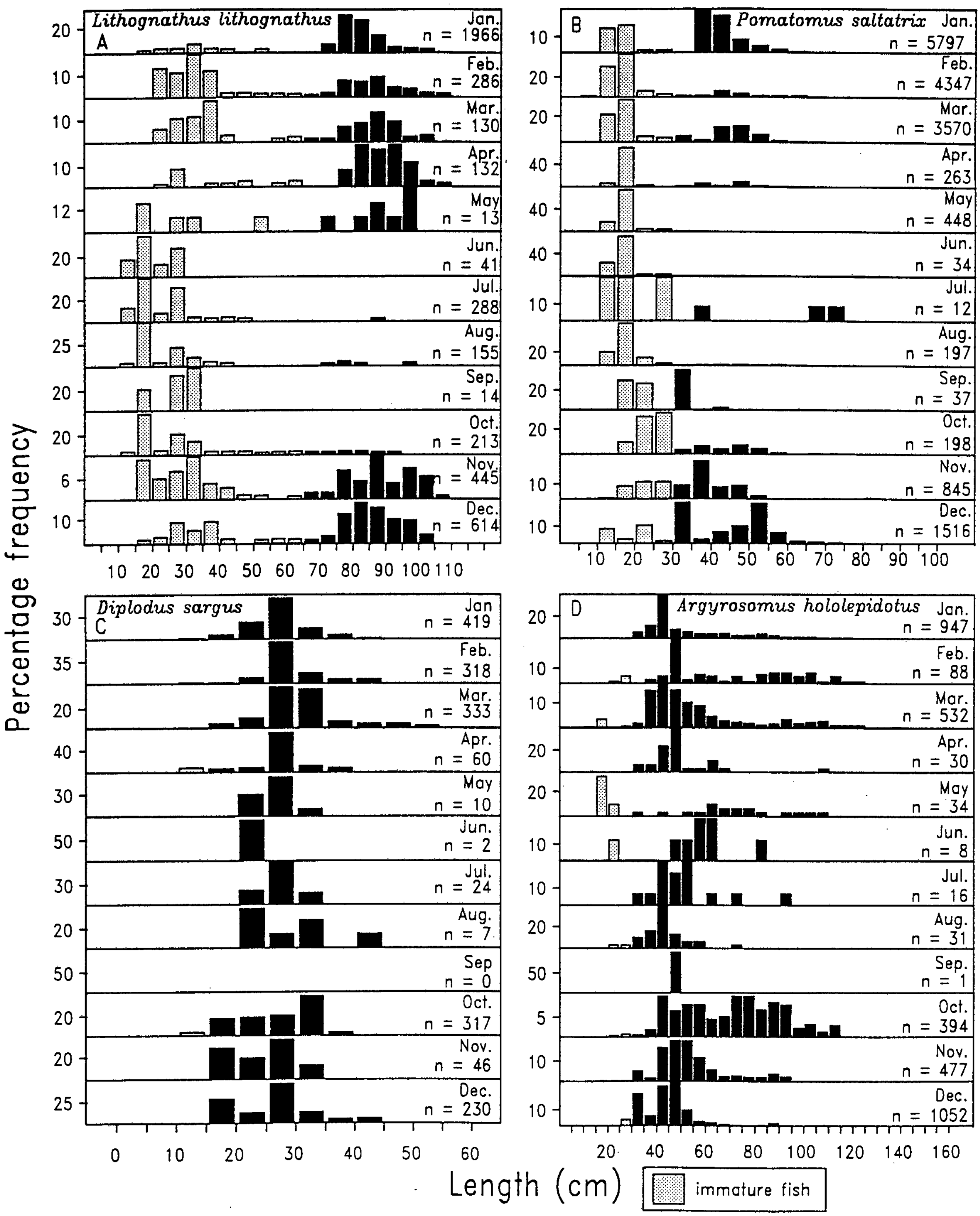


Fig. 4.3. Monthly size frequency distrributions of the six most abundant "angling" species in commercial beach-seine hauls monitored between January 1991 and December 1992.

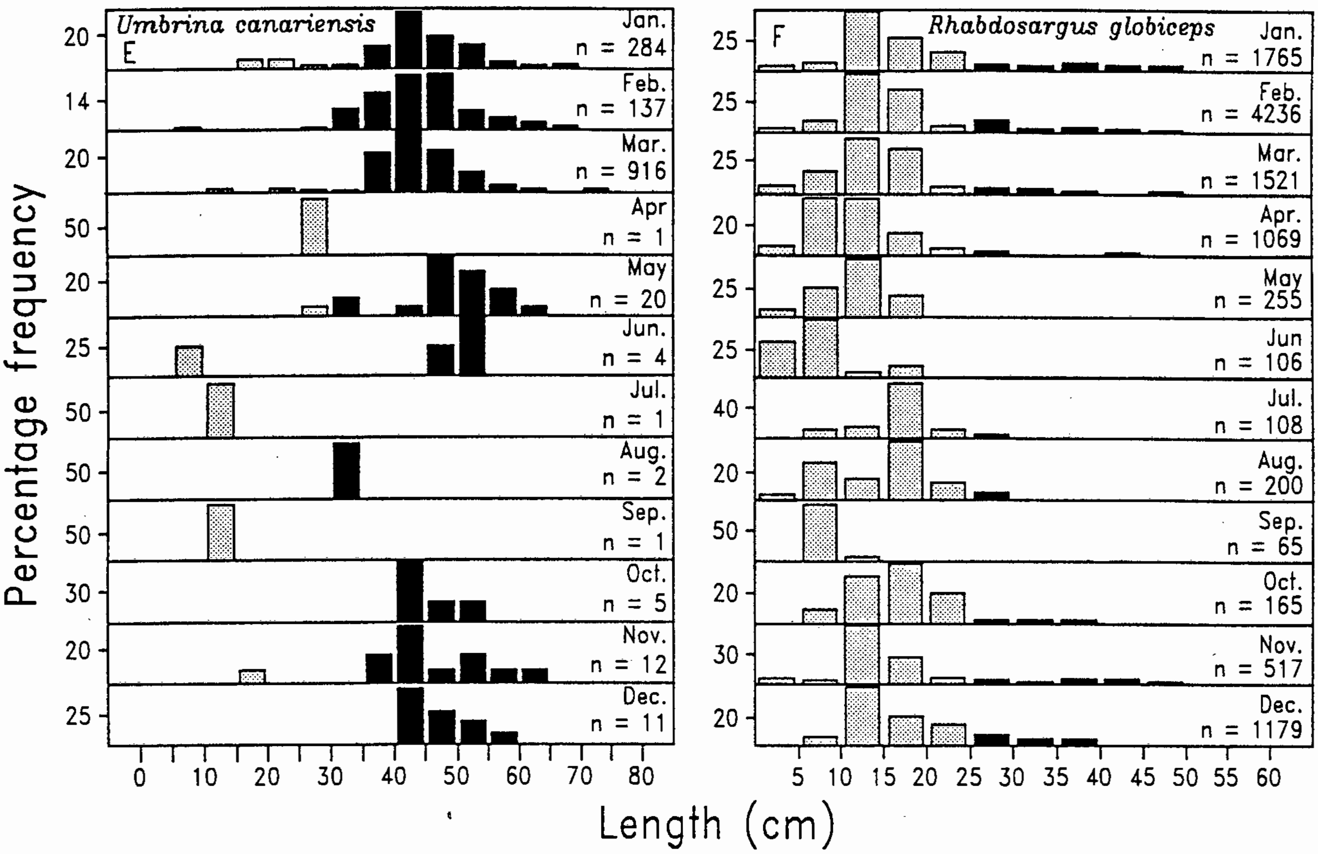


Fig. 4.3. continued.

Mean monthly wind speed (knots) and wind direction (proportion blowing onshore) recorded at the time of each of the 311 observed hauls are shown in Figure 4.4. The prevailing winds at 73% of the hauls were onshore and ranged between ESE and WSW. Mean wind speeds recorded at the time of each haul were highest in February (9.4 knots) and lowest in July (4.1 knots) (Figure 4.4a). Northerly or offshore winds occurred more often during hauls made from May to July. January (87%) and October (86%) had the highest incidence of onshore winds (Figure 4.4b).

Mean monthly sea temperatures recorded at the site of each haul showed a smooth seasonal pattern, being highest in January and February (20°C) and lowest in July (14°C) (Figure 4.4c).

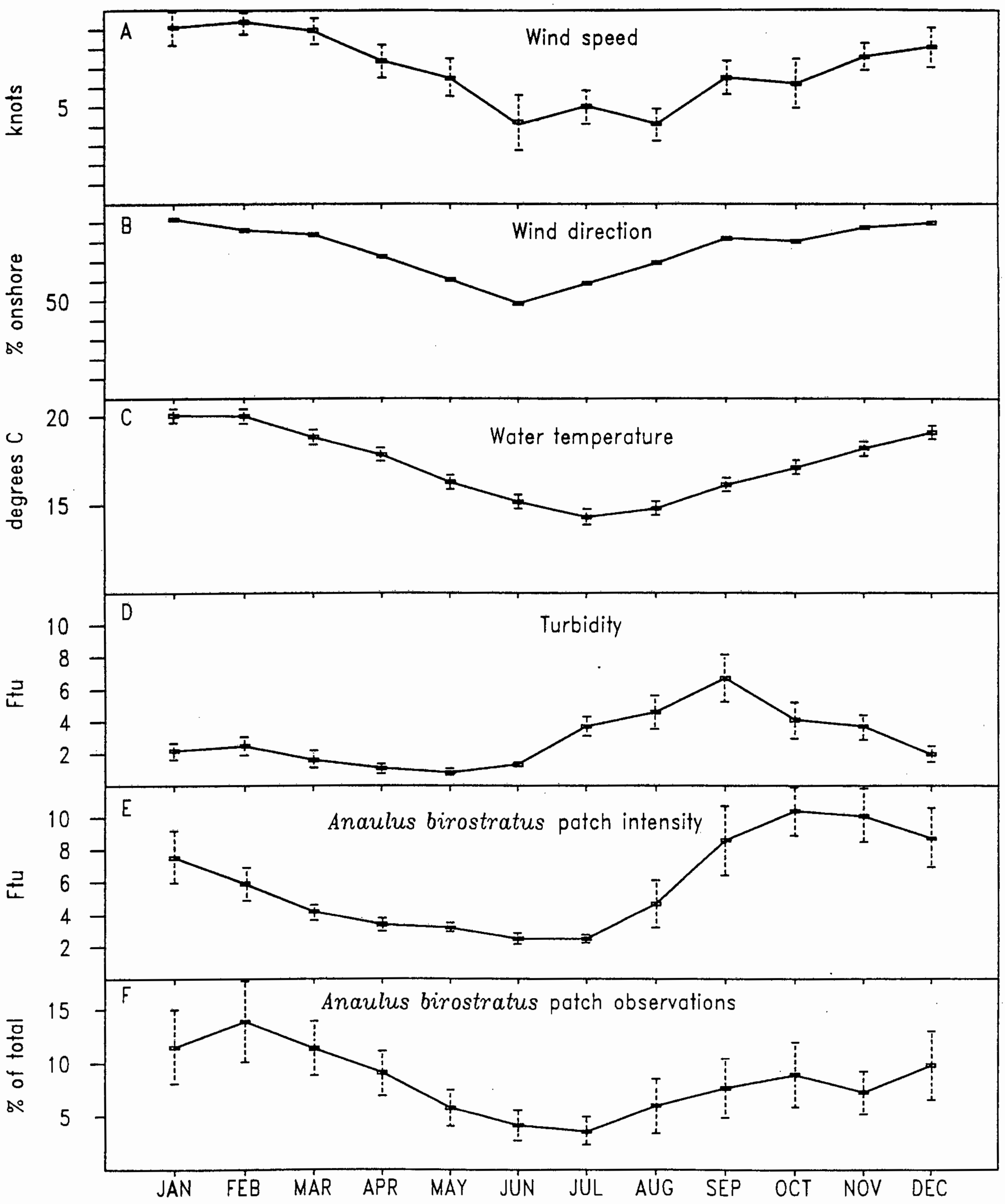


Fig. 4.4. Physical and biological variables recorded at the time of commercial beach-seine hauls monitored in False Bay during the period January 1991 to December 1992. A, B, C, D and E recorded during this study, and F, this study and the personal records of seine-fishermen 1977-1987.

Mean monthly turbidity readings were at their lowest (0.8 FTU) and highest (6.7 FTU) in May and September respectively (Figure 4.4d). Turbidity in *A. birostratus* patches was at a minimum (2.5 FTU) during June and July and at a maximum (10.4 FTU) in October (Figure 4.4e). The monthly percentage of the total annual sightings of *A. birostratus* patches recorded during the years 1974-1987 and 1991-1992 are shown in Figure 4.4f. Occurrence was highest (13.9%) in February and lowest (3.6) in July.

Fishing effort varied seasonally, with the maximum number of hauls (86) being made in January and February and the minimum (18) in July and August (Figure 4.5a). Five of the seven seine-net operators were not active at all over the winter period. The mean area swept by the net on each haul was highest in April (49 151 m^2) and lowest in June (8 753 m^2) (Figure 4.5b).

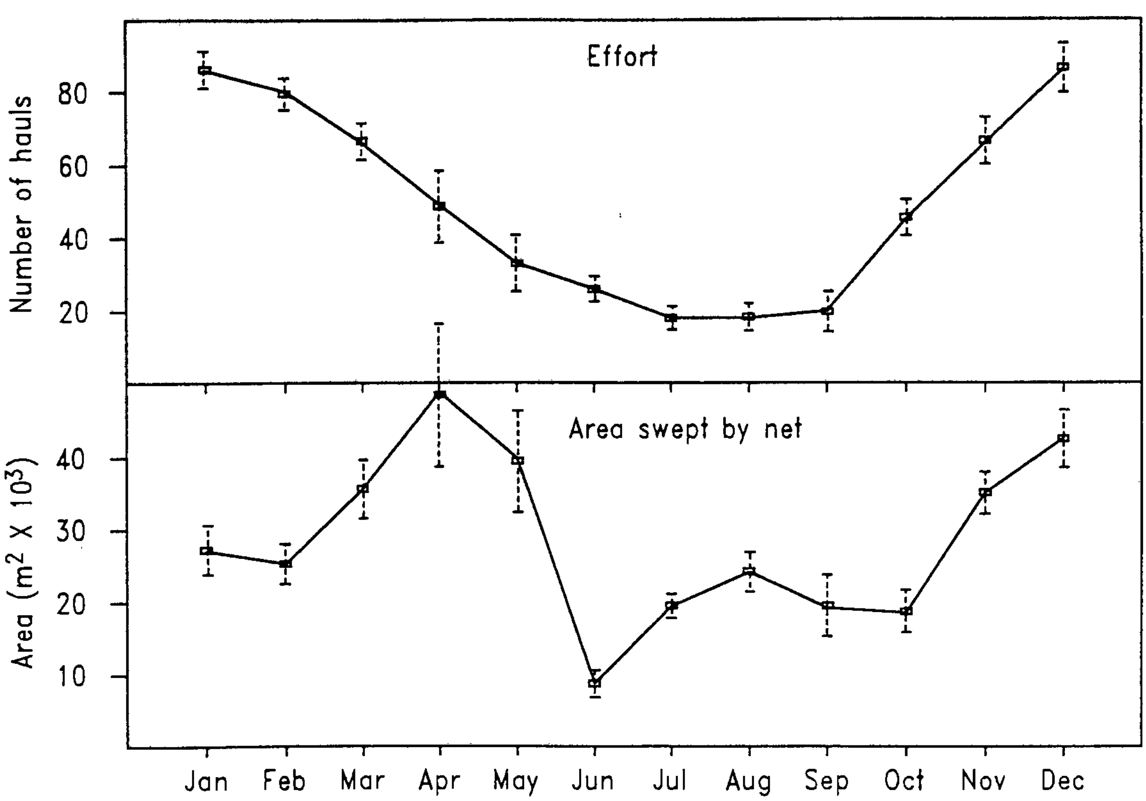


Fig. 4.5. Monthly effort (this study, SFRI unpublished catch returns 1985-1993, personal records of seine fishermen 1977-1987) and area swept by the net according to monitored hauls. Standard error included.

DISCUSSION

Catches and effort of the commercial beach-seine fishery in False Bay are strongly seasonal with most fish (93%) being caught in the late spring, summer and early autumn months and only four species being more abundant during winter . These results are supported by a previous experimental net study in False Bay in which catches in summer were numerically twice those in winter (Bennett 1989a). In turn, it contrasts with another South African study conducted in Algoa bay which found no seasonal trends in numerical or species abundance (Lasiak 1984b). Worldwide, however, most other studies report seasonal variations with a summer peak in fish abundance (eg. Modde and Ross 1981, Ross *et al.* 1987, Peters and Nelson 1987). The strength of these variations depend on the magnitude of seasonal changes in physical conditions, which ultimately depend on latitude (Bennett 1989a).

Most seasonality studies have reported temperature as the deciding factor in fish abundance with salinity, turbidity and wind being of secondary importance (eg.Mc Farland 1963, Senta and Kinoshita 1985, Ross *et al.* 1987). Gibson *et al.* (1993) argue that, even though fluctuations in abundance and species richness may mirror changes in temperature and salinity, seasonal cycles are for the most part a result of recruitment and mortality, rather than of immigration and emigration in response to physical factors. The trend in most of these previous studies has been to attempt to identify a single cause (eg.temperature change) of variations in the composition of surf-zone ichthyofaunas. Unfortunately, this was often done at the expense of other important factors being ignored.

In this study, seasonal variations in wind speed, wind direction, water temperature, turbidity and the occurrence and intensity of surf-zone diatom patches all, to some extent, mirror the fluctuations in catches and effort of the beach-seine fishery. The catches of commercial beach-seine hauls in False Bay are numerically dominated by *L. richardsonii*, which makes up 86% of the total catch (Chapter 2). Two other species, *L. lithognathus* and *S. lalandi* are targeted directly, but infrequently and compromise less than one percent of the total catch. Targeting of *L. richardsonii* may inflate its numerical importance but it is characteristic of surf-zone ichthyofaunas that they are dominated by few species (Modde and Ross 1981). The remaining species all compromise the bycatch of the fishery and catches thus reflect their abundance in the surf-zone (Chapter 2).

Ninety percent of all hauls in False Bay are directed towards *L. richardsonii*. In turn, 87% of *L. richardsonii*, 86% of the total catch and 50% of the bycatch landed on the northern shore of False Bay (SFRI unpublished catch returns, Chapter 2). It follows, that the nature of this fishery is largely a reflection of what happens on the north shore.

Approximately eighty percent of all hauls on the northern shore are set around patches of the diatom *A. birostratus*, on which *L. richardsonii* is seen to be feeding (this study, personal records of beach-seine fishermen, Romer and McLachlan 1986). This agrees with Romer (1986) who found centres of abundance of *L. richardsonii* associated with these diatom patches which form due to the accumulating effects of physical processes namely wave action, currents and onshore winds (Romer 1986). Summer winds in False Bay are predominantly onshore, diatom patches are numerous and up to six commercial hauls may be set around them each day. Towards autumn, the speed and onshore component of the wind diminishes and the frequency and intensity of the diatom patches decreases. At that time *L. richardsonii* was seen to form large running shoals of 25 000 to 100 000 individuals which were not in or feeding on the patches. Thus even though effort declined, catch per haul increased at this time of year. During the winter months, the wind's onshore component and speed are low, with a corresponding low in diatom patch intensity and frequency. Spring sees the "return" of large shoals of *L. richardsonii* equivalent in size to those of autumn. Effort is still low, but catch per haul again doubles that of the summer months. With the onset of summer winds the large shoals "disperse" into the numerous diatom patches and effort is once again determined by the frequency of these patches. It appears therefore, that wind and it's effects on the formation of diatom patches are the major forces governing beach-seine catches and effort in False Bay.

Monthly catches of the six most abundant "angling" species in beach-seine hauls are due partly to the amount of effort directed towards *L. richardsonii* and partly to their abundance in the surf-zone. This abundance may or may not be influenced by diatom patches. *Pomatomus saltatrix* and *A. hololepidotus* are piscivirous and may aggregate to feed on prey such as *L. richardsonii* (Whitfield and Blaber 1978a, Smale and Bruton 1985, van der Elst 1976). *Rhabdosargus globiceps*, *L. lithognathus*, *U. canariensis* and *D. sargus* are predominantly omniverous benthic feeders, but may be attracted to crustaceans such as *Macropetasma africana* which also feed on *A. birostratus* patches (Coetzee 1986, Bennett 1993b, Lasiak 1984c, Buxton and Kok 1983, Romer 1986). Escape from predation through turbidity or the shading effects of the diatom patches may also concentrate small and juvenile fish (Robertson and Lenanton 1984, Gregory 1993). However, the extent to which diatom patches influence the vulnerability of bycatch species to capture, could not be determined, as commercial hauls were being monitored and no control hauls were made for comparison. The winter absence of a large proportion of the adults and juveniles of *L. richardsonii* and angling species could be linked to low water temperature and or food availability, some species being more susceptible to these factors than others (Modde and Ross 1981, Ross *et al.* 1987). Some are known to migrate elsewhere during winter, the adults of *P. saltatrix* and *L. lithognathus* spawning up the east coast at this time (van der Elst 1976, Bennett 1993b).

During 1984, in an attempt to reduce beach-seine catches of "angling" species, management imposed a closed season from the May-October. During this period only *L. richardsonii* and St Joseph sharks *Callorhinchus capensis* were allowed to be caught, all other fish to be released. This study has shown that the restriction was ineffective as catches of the "angling" fish that it was designed to protect were strongly seasonal, with only 7.4% of the annual catch being made during the closed season (Figure 4.2). Most of this catch was in any event released as a result of existing minimum size regulations. An additional major drawback of the closed season was that it was difficult to police as it applied only to certain species.

A possible alternative to the closed season is that of closed weekends and public holidays in which no netting is permitted. Assuming that an increase in effort during weekdays is not likely to occur as effort is largely dictated by fish availability, it is possible that approximately 30% of the catch of "angling" fish would not occur. Added advantages would be that, the degree of conflict between seine fishermen and anglers, most of whom are "weekenders", would be considerably reduced and policing of catches would be simplified as all weekend hauls would be illegal.

CHAPTER 5

AN ASSESSMENT OF THE IMPACT OF COMMERCIAL BEACH-SEINE NETTING ON JUVENILE TELEOST POPULATIONS IN THE SURF-ZONE OF FALSE BAY, SOUTH AFRICA

ABSTRACT

A total of 311 commercial beach-seine hauls monitored in False Bay between January 1991 and December 1992 yielded 38 930 juvenile teleosts from 31 species and 18 families. Eight teleost species important in anglers' catches in the southwestern Cape together provided nearly 60% of the total juvenile catch, of which *Rhabdosargus globiceps* (22.8%) and *Pomatomus saltatrix* (20.3%) were the most abundant. Mean juvenile catch per haul for all species was 125 individuals, mean annual catches of juvenile teleosts so amounting to approximately 74 000 individuals. Juvenile teleosts constitute <6% of the total beach-seine catch in False Bay, considerably smaller than the proportion of juveniles in other South African commercial and recreational fisheries. When compared to published estimates of natural mortality for juvenile teleosts frequenting nearshore sandy beach habitats, potential seine net mortality was calculated to be insignificant for most of the species considered. However, estimated annual catches of juvenile *Lithognathus lithognathus* make up a significant proportion (>30%) of the total surf-zone standing stocks, and it is thought that juveniles of this species in False Bay may be under considerable threat because they are also caught in large numbers by shore-anglers.

INTRODUCTION

Surf-zones of sandy beaches are recognised as being important nursery areas for juvenile fish throughout the world (Warfel and Merriman 1944, McFarland 1963, Gibson 1973, Lasiak 1981a, Robertson and Lenanton 1984, Bennett 1989a, Wright 1989). Catches by commercial beach-seine fishermen operating in False Bay of juvenile "angling" fish have been a source of considerable concern to recreational shore and boat anglers for a number of years (Chapter 1). Concern has been stimulated by the marked reductions in anglers' catch rates in the area over recent decades, a situation attributed, at least in part, to mortalities of juvenile teleosts resulting from commercial beach-seining. Numerous restrictions have been imposed on the seine-netters by management authorities in response to these and other concerns (e.g. Theart *et al.*

1983). Many of these were subsequently revoked, however, because they were considered overly stringent and were not based on any scientific evidence showing that seine-netting was, harmful (e.g. Walker 1993).

The results of several recent investigations, now permit scientific evaluation of the alleged conflicts between recreational anglers and commercial netters. Penney (1991) documented the composition of and long term fluctuations in catches made by purse-seine, beach-seine and commercial line-fishermen in False Bay. Chapter 1 briefly outlined the history of the conflict surrounding the commercial beach-seine net fishery in False Bay and Chapter 2 documented the composition of the catches, whereas Chapter 6 will provide an assessment of the effects of beach-seining on the nursery function of estuaries for fish in False Bay. The current study describes the species composition and abundance of juvenile teleosts captured by beach-seine fishermen in False Bay. These data are compared with estimates of the total numbers of these juveniles in the surf-zone, and should help to resolve the issue of whether or not commercial beach-seining has a detrimental impact on juvenile teleost populations in the False Bay surf-zone.

METHODS

Catches made by five of the seven commercial beach-seine net operators currently active on the False Bay coastline were surveyed over a two year period, January 1991-December 1992. Nets used by these fishermen are 275 m long by 5 m deep, with stretched mesh sizes of 44-90 mm. During deployment, small boats are used to row these nets between 50 and 600 m offshore, where they were laid around shoals of fish or likely areas, and then hauled shorewards by 14-20 crew.

Total length (TL) of each fish was measured to the nearest 1 cm, except when hauls were very large, in which case a subsample of at least 120 fish was measured. The numbers of juvenile teleosts in each haul were estimated by calculating the numbers of individuals of each species smaller than the size at 50% maturity, as reported in the literature (Appendix). Owing to the limited time available following each haul, gonad analysis was restricted to those less common species for which published information was not available. The mean number of beach-seine hauls made per year in False Bay was calculated from personal records provided by the beach-seine fishermen and from catch returns submitted to the Sea Fisheries Research Institute between 1985 and 1992.

Mean values are listed in the text as ± the standard error (SE) of the mean, where appropriate.

Estimates of the actual abundance of juvenile teleosts in the False Bay surf-zone were obtained from a two-year experimental fine-mesh beach-seine netting programme consisting of 264 hauls at 11 sites in False Bay, as documented by Clark (in prep.). Mean densities of juvenile fish in the surf-zone were calculated by dividing the total number of individuals of each species captured per haul by the area netted (estimated as the distance at which the net was laid off-shore, multiplied by the mean width of the haul). An estimate of the total surf-zone area (14.97 ± 1.35 km^2) was obtained by multiplying the mean width of the surf-zone (137.3 ± 12.4 m) by the total length of sandy beach and mixed-shore coastline in False Bay (109 km) (calculated from Hockey *et al.* 1983, Bally *et al.* 1984, Spargo 1991). Estimates of the total annual catches of juvenile teleost species made by anglers in False Bay were calculated by multiplying the proportion of juveniles in anglers' catches (Bennett & Attwood 1993) by angler catch per unit effort (*cpue*) for each species (Bennett *et al.* 1994) by total annual effort, estimated at 0.99 x 10^6 angler $h.yr^{-1}$ in Chapter 2. Mean annual catches of each species of juvenile teleost recorded in the beach-seine catches were calculated by multiplying the mean annual effort (591 ± 23 hauls) by the mean catch-per-haul for each species (Table 5.1).

RESULTS

Sampling of 311 commercial beach-seine net hauls made in False Bay between January 1991 and December 1992 yielded a total catch of 38 390 juvenile teleosts from 31 species and 18 families, as listed in Table 5.1. In terms of numbers, three species, southern mullet (harder) *Liza richardsonii* (26.9%), white stumpnose *Rhabdosargus globiceps* (22.8%) and elf *Pomatomus saltatrix* (20.3%) dominated the catches. Four other species (horse mackerel *Trachurus trachurus*, white steenbras *Lithognathus lithognathus*, yellowtail *Seriola lalandi* and kob *Argyrosomus hololepidotus*) each made up ≥1% of the total catch. Four species, *L. richardsonii*, *R. globiceps*, *P. saltatrix*, and *L. lithognathus*, were present throughout the year, each occurring in >40% of the hauls. A further 3 species occurred in >5% of the hauls, while the remaining 24 species occurred only sporadically. Juveniles of eight teleost species targeted by anglers off the southwestern Cape were present in the catches (Table 5.1). Together these species comprised 59.8% of the total juvenile catch or 23 287 individuals. *R.*

Table 5.1. Composition, abundance, frequency of occurence and mean catch per haul (± SE) of juvenile teleost species recorded in 311 commercial beach-seine hauls made in False Bay between January 1991 and December 1992. Mean densities (± SE) and mean standing stocks (from Clark in prep.) of 15 species and the mean annual catches made by all beach-seine net operators in False Bay are also listed. Species important in anglers' catches off the southwestern Cape are marked with an asterisk.

		Commercial beach seine catches					Standing stocks		Catch as a
		Number caught	%N	%F	Catch per haul	Catch per year	Density (number.100m^{-2})	Mean stock	% standing stock yr^{-1}
Ariidae	*Galeichthyes feliceps*	120	0.30	13.6	0.39 ± 0.10	228			
Carangidae	*Lichia amia*	47	0.10	3.6	0.15 ± 0.09	89	0.46 ± 0.01	6 843	1.3
	*Seriola lalandi**	764	2.00	3.2	2.47 ± 0.95	1 460			
	Trachurus trachurus	2 503	6.40	8.1	8.10 ± 2.99	4 787			
Clinidae	*Clinus agilis*	6	<0.05	0.3	0.02 ± 0.02	11			
	Clinus superciliosus	1	<0.05	0.3	<0.01 ± 0.00	2	0.10 ± 0.20	1 437	0.1
Clupeidae	*Sardinops sajax*	3	<0.05	0.6	0.01 ± 0.00	6			
Coracinidae	*Dichistius capensis**	18	<0.05	4.9	0.06 ± 0.01	34	0.18 ± 0.10	2 745	1.3
Monocanthidae	*Aluterus monoceros*	2	<0.05	0.6	0.01 ± 0.00	4			
	Cantherhines pardalis	1	<0.05	0.3	<0.01 ± 0.00	2			
Mugilidae	*Liza richardsonii*	12 562	32.30	85.9	40.39 ± 4.73	23 711	275.96 ± 4.48	4 139 399	0.6
Parascorpididae	*Parascorpis typus*	1	<0.05	0.3	<0.01 ± 0.00	2			
Pomatomidae	*Pomatomus saltatrix**	9 495	24.40	44.7	30.53 ± 5.63	18 161	11.38 ± 0.71	170 723	10.6
Scianidae	*Argyrosomus hololepidotus**	397	1.00	11.0	1.26 ± 0.35	754			
	Atractoscion aequidens	1	<0.05	0.3	<0.01 ± 0.00	2			
	*Umbrina canariensis**	50	0.10	4.5	0.16 ± 0.07	95	0.71 ± 0.02	10 603	0.9
Scombridae	*Scomber japonicus*	1	<0.05	0.6	<0.01 ± 0.00	2			
Sparidae	*Diplodus sargus capensis**	46	0.10	1.9	0.15 ± 0.01	35	7.68 ± 0.22	115 153	<0.1
	*Lithognathus lithognathus**	1 874	4.80	46.6	6.03 ± 1.87	3499	0.70 ± 0.02	10 524	33.3
	Lithognathus mormyrus	7	<0.05	1.3	0.02 ± 0.01	13	0.18 ± 0.01	2 692	0.5
	Pterogymnus laniarius	1	<0.05	0.3	<0.01 ± 0.00	2			
	*Rhabdosargus globiceps**	10 643	27.30	66.0	34.22 ± 4.50	20 354	27.77 ± 0.49	416 615	4.9
Sparidae	*Rhabdosargus holubi*	9	<0.05	0.3	0.03 ± 0.02	12	0.06 ± 0.00	938	1.8
	Sarpa salpa	82	0.20	1.9	0.26 ± 0.00	6	5.15 ± 0.31	77 294	<0.1
	Spondyliosoma emarginatum	115	0.30	2.6	0.37 ± 0.19	219			
Sphyraenidae	*Sphyraena acutipinnis*	2	<0.05	0.6	0.01 ± 0.00	4	0.01 ± 0.00	144	2.6
Stromateoidae	*Stromateus fiatola*	39	0.10	3.6	0.13 ± 0.06	71			
Syngnathidae	*Syngnathus acus*	1	<0.05	0.3	<0.01 ± 0.00	2	0.01 ± 0.00	212	0.9
Tetraodontidae	*Amblyrhynchotes honckenii*	14	<0.05	1.3	0.05 ± 0.01	24	1.92 ± 0.05	28 758	0.1
Triglidae	*Chelidonichthyes capensis*	113	0.30	6.5	0.36 ± 0.14	219	0.30 ± 0.01	4 524	4.8
Zeidae	*Zeus faber*	12	<0.05	1.3	0.04 ± 0.02	23			
All species		38 930			125.18 ± 21.77	73 980			

globiceps and *P. saltatrix* were the most abundant angling species caught, but significant numbers (≥1% of the total catch) of *L. lithognathus*, *S. lalandi* and *A. hololepidotus* were also caught.

Mean catch-per-haul for all juveniles combined was 125.18, and the mean annual juvenile catch for all species was 73 980 individuals. Mean densities and total surf-zone standing stocks were calculated for 16 of the 31 juvenile teleost species recorded, for which reliable data were available (Table 5.1). The proportion of the total standing stocks of these species captured annually by beach-seine fishermen in False Bay could thus be calculated (annual catch/standing stocks). Values were greatest for *L. lithognathus* (33.3% y^{-1}), *P. saltatrix* (10.6% y^{-1}) and *R. globiceps* (4.9% y^{-1}). Only six of the other species each accounted for >1% of standing stocks per year.

Although the intensity of the monitoring program varied little over the two year sampling period, the number of hauls recorded per month (Fig. 5.1a) displayed a clear seasonal trend. Number of hauls recorded was greatest during summer (November-March) and smallest during winter (June-September). The number and species composition of juvenile teleosts in the beach-seine hauls also showed strong seasonal variation (Fig. 5.1b). In terms of numbers, most (>60%) of the juvenile teleosts were caught between January and March, whereas few (<7%) were caught during winter. Similarly, the numbers of species recorded were highest between January and April (12-17) and lowest between June and September (4-9).

DISCUSSION

The total catch made by the commercial beach-seine fishermen monitored in False Bay comprised 38 930 juvenile teleosts from 31 species. Catches displayed strong seasonal trends and were dominated by few species, five species providing >80% of the total number recorded. Although a substantial portion (>80%) of the juvenile catch was returned to the sea (Chapter 1), estimates of fishing mortality given here are based on total catch, because post-release mortality was not assessed. The effects of beach-seine fishing given are therefore maximal ones and are almost certainly overestimated, perhaps by a considerable proportion. Estimates of surf-zone standing stocks of 16 of the juvenile teleost species recorded in the commercial catches, obtained from a fine mesh beach-seine survey comprising 264 hauls conducted over a two year period by Clark (in prep.), are considered to be reliable. With only one exception (*T.trachurus*

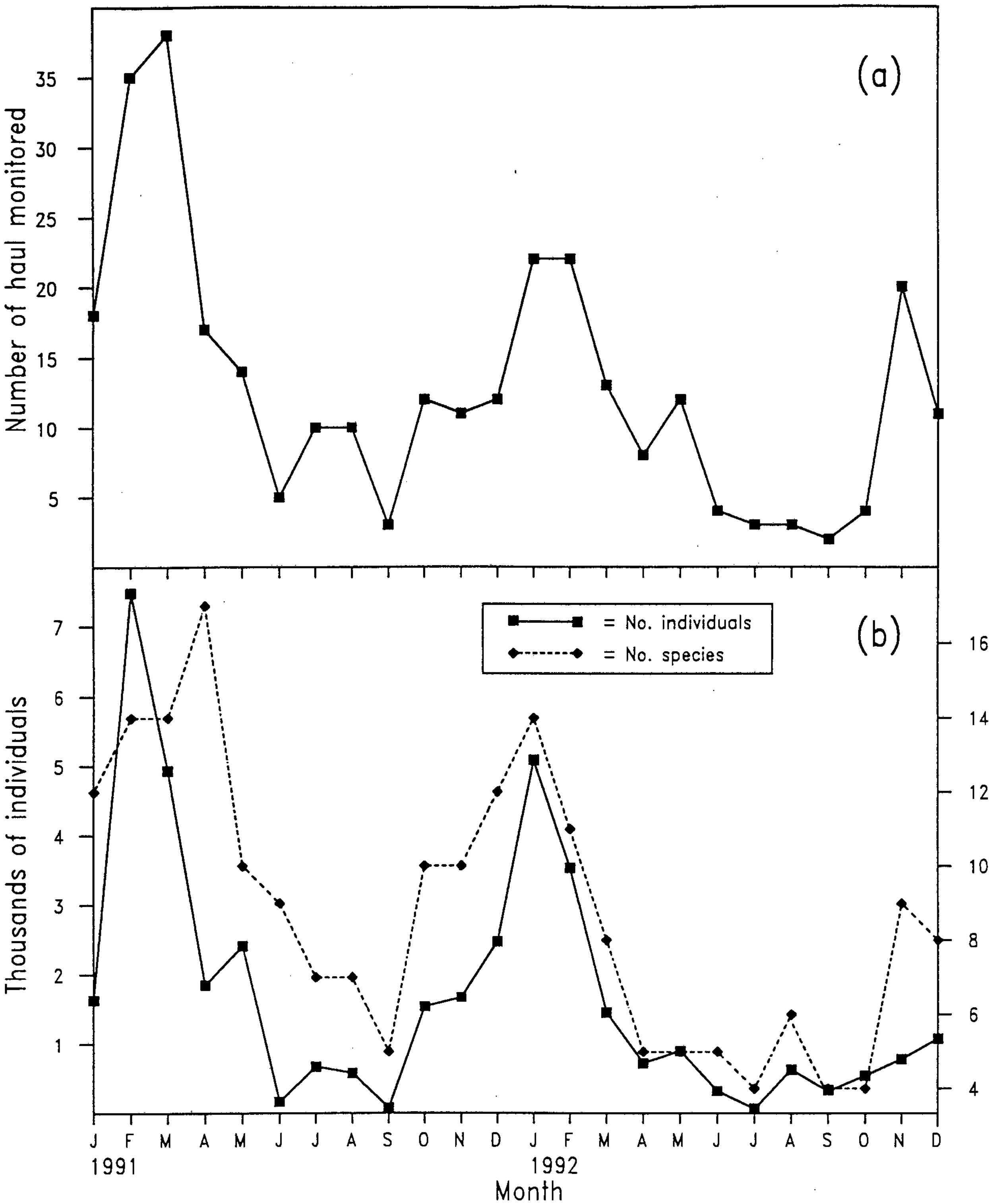


Fig. 5.1. Seasonal fluctuations in (a) commercial beach-seine net effort and (b) number of juvenile teleosts and juvenile teleost species in monitored commercial beach-seine hauls made in False Bay during 1991 and 1992.

capensis, 5.3%N), experimental population estimates are available from False Bay for juveniles of all species providing ≥2% of juvenile teleosts recorded in the commercial catches.

Estimates of natural mortality for juvenile teleosts captured by the beach-seine fishermen were impossible to calculate during this study and are regrettably available for only one of the species under consideration, viz. Cape stumpnose ***Rhabdosargus holubi***. Natural mortality of this species in the West Kleinmond Estuary in the southeastern Cape, was estimated by Blaber (1973) to be around 30% of total standing stocks per month. Estimates of the rates of natural mortality of juvenile flatfish species of similar age-classes frequenting near shore sandy beach habitats in the northern hemisphere are of a similar magnitude, ranging between 31 and 62% of existing standing stocks per month (Table 5.2). These data suggest that the mortality rate of 30% used in this study is reasonable. Comparisons between mean annual beach-seine catches and standing stocks of juvenile teleosts in the False Bay surf-zone therefore indicate that mortality attributable to this source is at most 10% of the natural mortality, and in most cases less than 0.5%, even if all the fish returned to the surf perished.

Table 5.2 Natural mortalities (% standing stocks per month) of juvenile teleosts frequenting nearshore sandy beach habitats in the northern hemisphere.

Locality	Author	Mortality
Firemore Bay, Scotland	Edwards & Steele (1968)	56
Firth of Forth, Scotland	Poxton & Nasir (1985)	53
Clyde Sea, Scotland	Poxton *et al.*(1982)	50
Port Erin Bay, Irish Sea	Riley & Corlett (1966)*	38
Red Warf Bay,	Macer (1967)*	42
Filey Bay, North Sea	Bannister *et al.* (1974)*	53
Balgzand, Wadden Sea	Van der Veer (1986)	30
Balgzand, Wadden Sea	Zijlstra *et al.* (1982)	38

* Cited in Poxton *et al.* (1982)

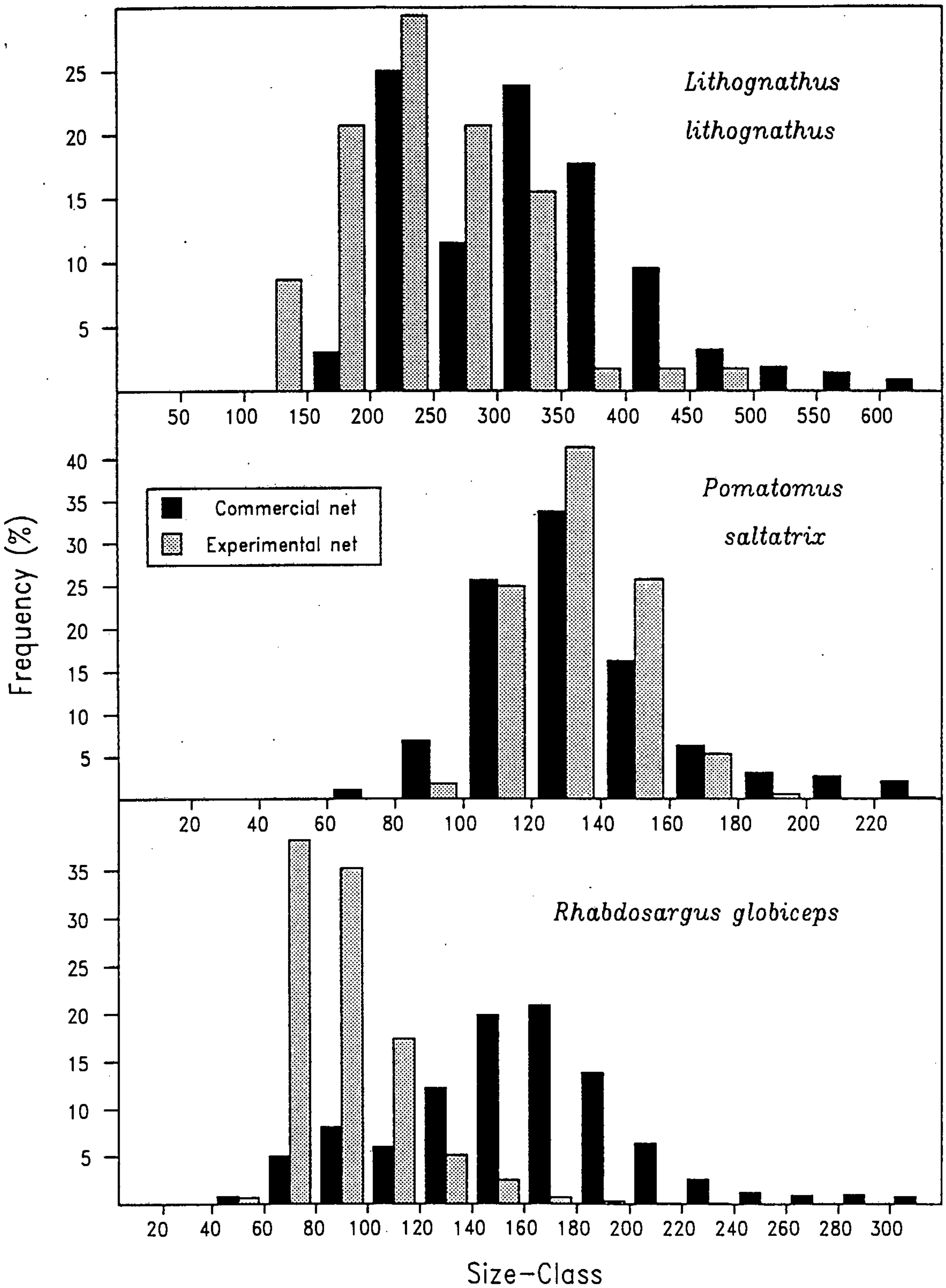


Fig. 5.2. Size frequency distributions of (a) *Lithognathus lithognathus* (b) *Potatomus saltatrix*, and (c) *Rhabdosargus globiceps* in commercial (1991 and 1992) and experimental (1991 - 1993) beach-seine hauls made in False Bay.

Although beach-seine fishermen capture a substantial proportion (10.6%) of the mean standing stocks of juvenile *P. saltatrix* in False Bay annually, juveniles of this species are abundant in south and west coast estuaries (Van der Elst 1976, Winter 1979, Smale & Kok 1983, Whitfield & Kok 1992,) and on inshore (5-50 m depth) sandy bottom areas along the south coast (Smale 1984, Wallace *et al.* 1984). Beach-seine catches are therefore unlikely to inflict significant mortality on overall stocks of this migratory species. On the other hand, mortalities of juvenile *L. lithognathus*, which account for 33.3% of juvenile standing stocks per year, may be significant, because this species is already under heavy pressure as a result of human activities. Juveniles are entirely dependent on estuarine nursery areas in southern Africa during their first year of life and adult stocks are being overexploited by both anglers and beach-seine fishermen (Bennett 1993a, b). Data collected by Bennett (1993b) further suggests that juvenile *L. lithognathus* are resident in the surf-zone of particular areas from 1-5 years of age, indicating that seining activities may result in significant local depletions of these age classes in False Bay.

A factor possibly introducing bias into stock assessment calculations made in this paper may be differences in the selectivity of the experimental and commercial nets employed during this study. A comparison between the size frequency distributions of commercial and experimental seine-net catches of the three species in the commercial catche which provided the greatest proportion of standing stocks (Fig. 5.2) indicates similar distributions for all except *R. globiceps*. This suggests that, although one would assume intuitively that catches made with the fine-mesh gear would tend to be skewed towards smaller fish for most species than are obtained with the coarse-mesh commercial gear, this is in fact not the case for the two species of greatest concern (*L. lithognathus* and *P. saltatrix*).

Published data on the size composition of teleost species caught by recreational and other commercial fishermen in South Africa allow a simple comparison to be drawn between the proportions of juvenile teleosts taken by beach-seining and other fisheries (Table 5.3). Of the total of 726 447 fish of all types recorded in the commercial beach-seine hauls monitored during this study (Chapter 2.), only 5.4% (38 930 individuals) were juvenile teleosts. By contrast, juvenile fish make up between 73 and 97% of the five major species targeted by the purse-seine fishery in South Africa (Crawford *et al.* 1978), between 12 and 71% of catches of important commercial linefish species (Nepgen 1977, Garratt 1985, Smale 1986, Penney 1990) and between

12 and 17% of anglers' catches (Coetzee 1978, Bennett & Attwood 1993). The proportion of juvenile teleosts in beach-seine catches is therefore well below those in several other South African fisheries. Further, the proportion of immature fish in line catches presented here are probably underestimates, because they do not include mortalities of undersized fish from handling or barotrauma. These fish are discarded before the catch is landed.

Table 5.3. Proportions of immature fish of various species in the catches of important South African commercial and recreational fisheries.

	% Immature	Reference
	Purse-seine	
Scomber japonicus	88.8	Crawford *et al.* (1978)
Trachurus trachurus	76.2	Crawford *et al.* (1978)
Sardinops sajax	96.5	Crawford *et al.* (1978)
Etrumens terres	93.1	Crawford *et al.* (1978)
Engraulis japonicus	72.6	Crawford *et al.* (1978)
	Linefish	
Petrus rupestrus	70.8	Smale (1986)
Ephinephelus guaza	71.0	Smale (1986)
Polysteganus preorbitalis	42.0	Smale (1986)
Cheimerius nufar	12.0	Smale (1986)
Cheimerius nufar	25.0	Garratt (1985)
Chysoblephus puniceps	50.0	Garratt (1985)
Seriola lalandi (offshore)	14.0	Penney (1990)
Seriola lalandi (inshore)	50.5	Penney (1990)
Argyrozona argyrozona	28.4	Nepgen (1977)
Pachymetopon blochii	29.0	Nepgen (1977)
	Angling	
Various spp.	17.3	Bennett & Attwood (1993)
Various spp.	12.0	Coetzee (1978)
	Beach-seine	
Various spp.	5.4	This study

Considerable overlap exists between species targeted by anglers and commercial beach-seine fishermen in False Bay, and anglers often accuse the beach-seine fishermen of being responsible for the documented declines in catch rates (Bennett 1991a, Penney

1991, Chapter 1). The analysis by Bennett *et al.* (1994) of the composition of anglers' catches in the southwestern Cape revealed that six species (*L. lithognathus*, *Dichistius capensis*, *Diplodus sargus capensis*, *Argyrosomus hololepidotus*, *Umbrina canariensis* and *R. globiceps*) provided numerically the bulk (>85%) of the catches. Juveniles of these six species, together with another two moderately important species (*P. saltatrix* and *Seriola lalandi*), jointly constituted almost 60% of the total juvenile teleost catch in beach-seine hauls monitored during the current survey, indicating considerable scope for conflict between the two fisheries. Examination of the proportions of immature fish from a number of these species in beach-seine catches (Table 5.1) and anglers' catches (from Bennett & Attwood 1993), however, allows their impact on juvenile stocks in False Bay to be compared (Table 5.4). Proportions of immature *D. sargus capensis*, *D. capensis* and *U. canariensis*, were the same (the first) or slightly higher (the last two) in beach-seine catches, whereas immature *P. saltatrix* and *A. hololepidotus* are rarely caught by anglers. However, the proportion of *L. lithognathus* in anglers' catches is considerably higher than for the beach-seine fishery. More important, however, is the total annual catch of juveniles of these six species made by beach-seine fishermen and anglers in False Bay, also shown in Table 5.4. Total annual beach-seine catches of immature *P. saltatrix*, *A. hololepidotus* and *U. canariensis* exceed anglers' catches, although total catches remain small for all except *P. saltatrix*. The reverse is true for the other three species, anglers' catches of *L. lithognathus* and *D. capensis* being very much greater than those of the seine-net fishery.

Table 5.4. Proportions of immature fish and estimated total annual juvenile catch of a number of teleost species by beach-seine fishermen and anglers in False Bay (calculated from Bennett & Attwood 1993, Bennett *et al.* 1994).

	% Immature		Annual juvenile catch	
	Beach-seine	Anglers	Beach-seine	Anglers
Pomatomus saltatrix	55	<1	18 161	
Diplodus sargus capensis	1	1	35	280
Lithognathus lithognathus	44	77	3 499	6300
Dichistius capensis	45	29	34	4900
Argyrosomus hololepidotus	11	<1	754	
Umbrina canariensis	4	3	95	50

In conclusion, therefore, it appears that, although beach-seine fishermen in False Bay capture a considerable number of juvenile teleosts each year, these form only a small proportion of the total beach-seine catch, a proportion which is considerably less than that for several other South African commercial and recreational fisheries. Natural mortalities of juvenile teleost species frequenting surf-zone habitats are high, probably exceeding 30% per month, and mortality attributable to beach seining is therefore likely to be relatively insignificant for most of the affected juveniles. Historically, this may not always have been the case, however, and therefore the general reduction in commercial beach-seining effort in the late 1970s and early 1980s was probably entirely justified. Annual beach-seine catches of juvenile *L. lithognathus* still, however, make up a considerable portion (>30%) of total surf-zone standing stocks of the species in False Bay. Beach-seine catches of juveniles of this species, together with that of anglers', calculated to be almost double that of the beach-seine catch, may collectively pose a significant threat to juvenile stocks of this endemic species. On the basis of the above, therefore, any sanctioned increase in beach-seine effort in the foreseeable future would appear to be ill-advised.

APPENDIX

Sizes at 50% maturity (TL) of teleost fish caught in commercial beach-seine nets in False Bay, as reported in the literature. Measurements are all in mm.

		Length at 50% maturity	Reference
Ariidae	*Galeichthyes feliceps*	315	Tilney (1990)
Carangidae	*Lichia amia*	600	Van der Elst (1988)
	Seriola lalandi	700	Penney *et al.*(1989)
	Trachurus trachurus	200	Geldenhuys (1973)
Clinidae	*Clinus agilis*	45	Chapter 1.
	Clinus superciliosus	65	Day *et al.* (1981)
Clupeidae	*Sardinops sajax*	210	Davies (1956)*
Coracinidae	*Dichistius capensis*	310	Bennett & Griffiths (1986)
Mugilidae	*Liza richardsonii*	230	De Villiers (1987)╬
Pomatomidae	*Pomatomus saltatrix*	240	Van der Elst (1976)
Sciaenidae	*Argyrosomus hololepidotus*	340	Griffiths & Hecht (1993)
	Atractoscion aequidens	590	Van der Elst & Adkin (1991)
	Umbrina canariensis	300	Chapter 1.
Scombridae	*Scomber japonicus*	470	Baird (1977)*
Sparidae	*Diplodus sargus capensis*	180	Joubert (1981)
	Lithognathus lithognathus	650	Bennett (1993b)
	Lithognathus mormyrus	190	Lasiak (1982)*
	Pterogymnus laniarius	280	Hecht (1976)
	Rhabdosargus globiceps	310	Talbot (1955)*
	Rhabdosargus holubi	180	Day *et al.* (1981)
	Sarpa salpa	180	Joubert (1981)
	Spondyliosoma emarginatum	220	Van der Elst (1988)
Syngnathidae	*Syngnathus acus*	125	Bennett (1989b)
Tetraodontidae	*Amblyrhynchotes honckenii*	80	Day *et al.* (1981)
Triglidae	*Chelidonichthyes capensis*	305	Hecht (1977)

╬ Corrected from FL to TL, * Corrected from SL to TL

CHAPTER 6

THE ICHTHYOFAUNA OF TWO FALSE BAY ESTUARIES AND ADJACENT SURF ZONES, WITH AN ASSESSMENT OF THE EFFECTS OF BEACH-SEINING ON THE NURSERY FUNCTION OF ESTUARIES

ABSTRACT

The ichthyofaunas of an estuary open intermittently (Zandvlei) and one permanently open (Eerste) and of the surf-zones of beaches adjacent to their mouths, Muizenberg and Macassar respectively, were sampled quarterly by beach seining. Fish densities in the Zandvlei and Eerste estuaries (5.0 and 3.2 fish.m^{-2}) were considerably higher than those recorded in the adjacent surf-zones (0.6 and 0.4 fish.m^{-2}). Catches in all four localities were dominated by a few species, 2-3 species making up 92-97% of the total numbers of fish caught. Juvenile fish were abundant in all areas, numerically constituting 48 and 97% of the estuarine and surf-zone samples respectively. Statistical analyses of the density distribution of marine and estuarine fish in the surf-zone indicate that, although these estuaries are extensively utilized by juveniles of many species, beach-seine hauls in the vicinity of estuary mouths are potentially no more harmful to these fish than those farther away.

INTRODUCTION

Research worldwide has shown that estuarine fish communities are dominated by juveniles of marine species (Gunter 1938, Day *et al.* 1981, Wallace *et al.* 1984, Claridge *et al.* 1986, Potter *et al.* 1990). Life cycles of these marine species typically comprise a juvenile phase, which is largely estuarine, and an adult phase which is primarily marine (Wallace & Van der Elst 1975, Whitfield 1990). After being spawned at sea, juveniles enter estuaries, where rapid growth takes place in the sheltered, food rich and highly productive environments (Wallace 1975, Claridge *et al.* 1986, Potter *et al.* 1990, Whitfield and Kok 1992). Larvae, postlarvae and small juveniles are believed to enter estuaries either actively or by passive drift with incoming tides (Weinstein *et al.* 1980, Beckley 1985a, Whitfield 1989a), after accumulating in the vicinity of the mouths (Whitfield 1989b, Potter *et al.* 1990). The species sometimes return to the sea within a year, but they may remain for longer periods (Gunter 1938, Wallace and Van der Elst 1975, Beckley 1984, Claridge *et al.* 1986, Whitfield 1990).

The importance of estuaries to commercial and recreational fisheries, both as a prime fishing ground and in terms of the numbers of larger marine species that use estuaries as nursery areas, has been highlighted by numerous authors both in southern Africa and elsewhere (e.g. Caputi 1976, McHugh 1976, Pollard 1976, 1981, Marias & Baird 1980, Miller *et al.* 1984, Lenanton & Potter 1987, Van der Elst 1988). Indeed, juveniles of many commercially and recreationally important fish species in southern Africa are considered to be entirely (e.g. white steenbras *Lithognathus lithognathus*, leervis *Lichia amia*, Cape stumpnose *Rhabdosargus holubi*) or partially (e.g. white stumpnose *Rhabdosargus globiceps*, elf *Pomatomus saltatrix*, dassie *Diplodus sargus*) dependent on estuaries as nursery areas (Wallace & Van der Elst 1975, Day *et al.* 1981, Wallace *et al.* 1984, Bennett 1993b). The accumulations of juvenile fish that may occur in the vicinity of estuary mouths during migrations between marine and estuarine environments make juveniles of these species potentially vulnerable to capture and disruption by beach-seiners operating there.

Dramatic declines in these and other rock-and-surf-angling species in False Bay over the last 50 years (Bennett 1991a,b) are a source of considerable concern among anglers and conservationists, who attribute, them largely to commercial beach-seining activities (Chapter 1). One of the main areas of concern is netting in the vicinity of river mouths, which is believed to disrupt the nursery function of estuaries. Reductions in the numbers of seine-net permits issued, as well as the introduction of numerous restrictions on remaining permit-holders by management authorities, have been implemented in an effort to reduce the impact of beach-seining and have resulted in considerable hardship among the fishermen participating in this relatively small-scale fishery. These restrictions (which include a ban on beach-seining within 500 m of any river mouth in False Bay), were formulated largely in the absence of sound scientific data and are considered to be too stringent and largely unjustified by the seine fishermen. Given the importance of estuaries in the life cycles of numerous marine species and the indisputed importance of the South African shore-angling fishery (Van der Elst 1989, Bennett 1991a), data are urgently needed for the resolution of this controversy.

In this paper, the species composition and abundance of fish populations inhabiting two estuaries in False Bay and their adjacent surf-zones, are documented in an attempt to examine the potential impact of beach-seining in the immediate vicinity of estuary mouths. Data are used to evaluate the justification for a 500 m limit implemented on beach-seining.

MATERIALS & METHODS

Study Areas

Zandvlei (34°05'S 18°28'E) is an intermittently closed estuary in the north-western corner of False Bay with a total surface area of 121.0 ha (Fig. 6.1). It is made up of three components: a relatively shallow main vlei basin (57.4 ha), the Marina da Gama canal system (32.6 ha) and the Westlake wetland (31.0 ha)-(Morant and Grindley 1982). The main vlei (where all samples were collected) is approximately 2.5 km long with a maximum width of 0.5 km and a maximum depth of about 1.5 m (Begg 1981, Morant and Grindley 1982). Three influent streams (Sand, Westlake and Keysers) drain a catchment area of 85 km^2. The mouth of the estuary was open when the August and May samples were collected, but closed during the other two periods of sampling.

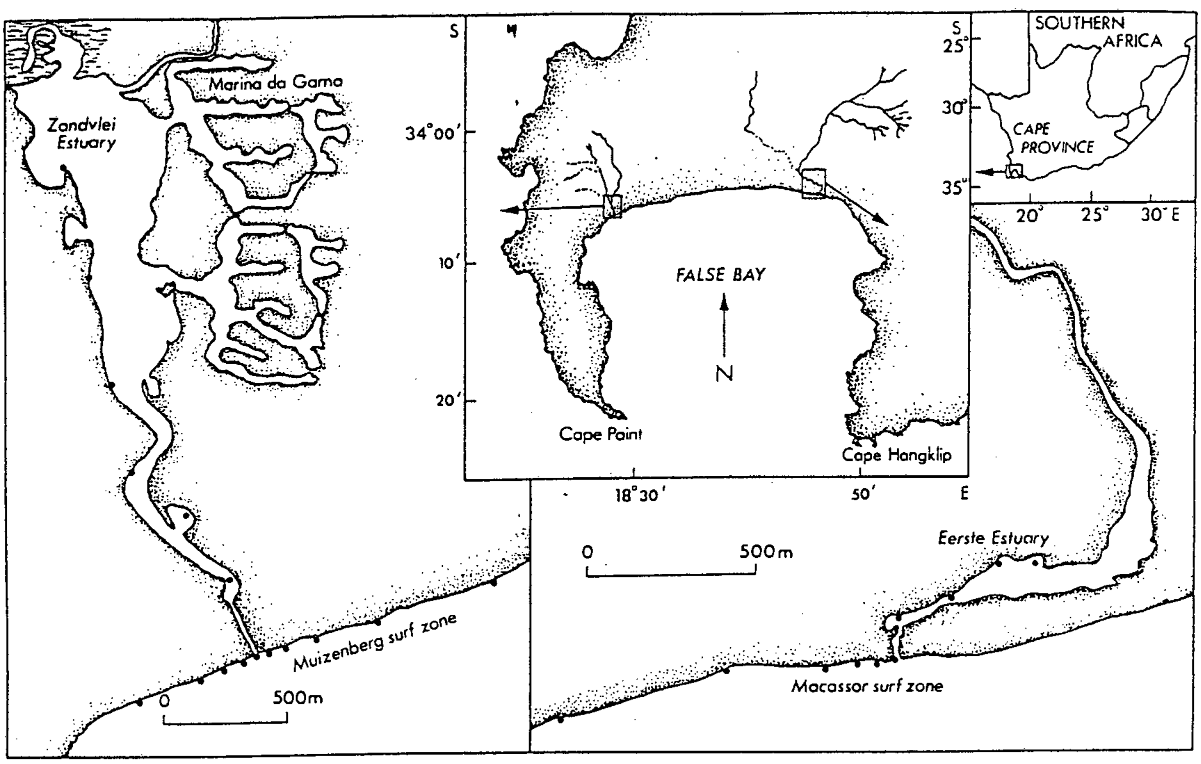


Fig. 6.1. Map of southern Africa and the southwestern Cape (insets) and the location of the sampling sites in the two estuaries and adjacent surf-zone areas sampled.

The Eerste (34°05'S 18°46'E) is a small estuary in the north-eastern part of False Bay (Fig. 6.1), the major feature of which is an elongated lagoon approximately 650 m long and 100 m wide (Grindley, 1982). The influent Eerste River and tributaries drain a catchment area of approximately 660 km^2, which are augmented by the influx of treated sewage and discharges from various industries situated upstream (Grindley, 1982). This estuary was open to the sea throughout the sampling period.

Muizenberg beach, which flanks the mouth of the Zandvlei estuary (Fig. 6.1), has a gently sloping intertidal profile (2°) and is moderately exposed, experiencing a mean estimated wave height of 0.9 m. Sampling in the surf-zone adjacent to the Eerste estuary was undertaken on Macassar beach, which extends westwards from the mouth of the estuary (Fig. 6.1). The shore there is more exposed, having a steeply sloping upper portion (7°) which changes abruptly into a more gently sloping lower portion (2.1°). Waves breaking on the shore there (estimated mean height 1.4 m) were considerably larger than those observed at Muizenberg.

The average water temperatures and turbidities measured are given in Table 6.1. Water temperatures ranged from 12.5-15°C during winter (August and May), to 19-24°C during summer (November and January). Estuarine turbidity remained relatively constant throughout the sampling period, but varied in the surf-zone depending on the location of diatom plumes, wind direction, wave height and distance from the estuary mouth. It was usually higher immediately opposite open estuary mouths in the surf-zone owing to the input of turbid estuarine water.

Table 6.1. Mean temperature and turbidity readings taken in the Zandvlei and Eerste estuaries and Muizenberg and Macassar surf-zones during four seasonal sampling periods.

	Temperature (°C)				Turbidity (FTU)			
	August 1991	November 1991	January 1992	May 1992	August 1991	November 1991	January 1992	May 1992
Zandvlei	14.5	23.0	24.0	14.5	38	40	33	24
Eerste	12.5	20.0	24.0	15.0	18	18	26	21
Muizenberg-Sunrise	13.5	20.0	22.0	14.0	5	3	4	3
Macassar	14.0	19.0	21.0	15.0	5	4	2	3

Sampling and Data analysis

Sampling of the estuarine and surf-zone ichthyofauna was undertaken on four occasions (August & November 1991, January & May 1992). Four and six hauls were made in the Eerste and Zandvlei estuaries respectively during each period. Sampling of the surf-zone was undertaken at six distances (0, 50, 100, 200, 500 and 1000 m) from the river mouths. A sample was taken on either side of the Zandvlei mouth at each distance, whereas both samples at each distance were collected from the western side of the Eerste, as access to its eastern area was not permitted. All sampling was undertaken with a 30 by 2 m, 12-mm stretched mesh net fitted with a weighted foot rope and a 2 m deep bag at its midpoint. The net was laid parallel to the shore between 20 and 50 meters offshore in water approximately 1 m deep. It was hauled by four persons, one holding each end of the net and one holding each rope. The size of the area seined (estimated as distance offshore multiplied by the mean width of the haul) was determined primarily by depth, and ranged from 225-900 m^2.

All samples were sorted into species and counted. The total length (TL) or disc width (DW, for the Myliobatidae only) of each fish was measured to the nearest 1 mm, except where samples were very large, in which case measurements were restricted to a subsample of 200 individuals per species.

Species were subdivided into three major groups based on the classification of Lenanton & Potter (1987). Species were classified as either marine - species that spawn in the marine environment (M); estuarine - species that spend their entire lifecycles in estuaries (E); or freshwater - freshwater species straying into estuaries (F). The marine species were further subdivided into species found predominantly in estuaries during the first year of life (M1); species frequently abundant in estuaries and inshore marine environments (M2); and species that rarely, if ever, enter estuaries (M3). This classification corresponds essentially to categories of southern African estuarine-associated fish species indentified by Wallace *et al.* (1984), because Category 1 of their classification is equivalent to the "estuarine species", category II to category M1, categories III and IV to category M2, and category V to category M3. Numbers of juvenile fish in each species were estimated by calculating the number of individuals smaller than the size at 50% maturity reported in the literature for each species. Estimates, based on gonad condition, were made for those less common species for which published information was not available.

One-way analysis of variance (ANOVA) was used to test for the existence of a significant relationship between distance from the estuary mouth and fish density at the 95% confidence level. Turbidity of surf-zone and estuarine waters was measured in formazin turbidity units (FTU), where 1 FTU = 1 NTU when made with a nephelometer, by means of a Hach DR/2000 spectrophotometer.

RESULTS

A total of 41 402 fish representing 15 species was captured in the Zandvlei estuary during the four sampling periods (Table 6.2). *Gilchristella aestuaria* (49.1%), *Liza richardsonii* (42.0%), *Atherina breviceps* (6.8%) and *Psammogobius knysnaensis* (1.0%) were numerically the most abundant species, together constituting 97.9% of the total catch. Three estuarine species (*G. aestuaria*, *P. knysnaensis* and *Caffrogobius multifasciatus*) made up 50.1% of the total number of fish caught. Seven marine species (categories M1-M3) were captured, together making up 49.5% of the total catch. Three freshwater species (*Cyprinus carpio*, *Oreochromis mossambicus* and *Tilapia sparrmanii*) were also captured. Mean fish density in the Zandvlei Estuary was calculated as 5.0 fish m^{-2}. Juveniles of all 15 fish species sampled were present in the catches, together providing 48.2% of the total number of fish caught.

A total of 30 335 fish representing 13 species was captured in the Eerste estuary (Table 6.2). *Liza richardsonii* (85.8%), *Liza dumerilli* (6.9%), *Mugil cephalus* (2.7%), *G. aestuaria* (2.2%) and *P. knysnaensis* (2.0%) were the only species to contribute more than 1% of the catch. Seven species contributed <0.05%. Two estuarine species (*G. aestuaria,* and *P. knysnaensis*) made up 4.2% of the total. Marine fish (Categories M1-M3) totalled nine species, together providing 95.7% of the catch. Two freshwater species (*Cyprinus carpio* and *Clarias gariepinus*) were also found. Average density was approximately 3.2 fish.m^{-2}, and 12 of the 13 species sampled were represented by juveniles, together making up 96.2% of the sample.

A total of 17 816 individuals of 15 species were netted in the surf-zone adjacent to the Zandvlei mouth (Table 6.3). *Liza richardsonii* (75.6%) was the most abundant species, followed by *A. breviceps* (20.7%), *G. aestuaria* (1.5%) and *Pomatomus saltatrix* (1.0%). In all, 10 species contributed <0.05% of the total catch. Juveniles of five marine species (categories M1-M3) captured in this area accounted for 83.0% of the total catch. Mean density was 0.6 fish.m^{-2}.

Netting in the surf-zone adjacent to mouth of the Eerste River yielded a total of 7 394 fish from 13 species (Table 6.3). In terms of abundance, 58.3% of these were juvenile marine species of Categories M1-M3. Juveniles of 8 species in these categories were present. *Liza richardsonii* was again the most abundant species, making up 54.0% of the total catch, with *A. breviceps* providing 37.9%. Mean density in this area was calculated to be 0.4 fish.m^{-2}, similar to the figure for the Muizenberg surf-zone.

Length frequency distributions of *Liza richardsonii*, *Atherina breviceps* and *Rhabdosargus globiceps* captured in the estuarine and surf-zone sampling areas are depicted in Fig. 6.2. Numbers of larger *L. richardsonii* (>120 mm) were considerably

Table 6.2. Species composition, abundance and length ranges (TL) of fish captured in 40 seine-net hauls from the Zandvlei and Eerste estuaries. Species are categorised as being estuarine (E), marine (M1-M3) or freshwater (F), as described in text.

			Zandvlei		Eerste		Zandvlei & Eerste		Length	Size at	%
		Class	All samples	% Numbers	All samples	% Numbers	All samples	% Numbers	range (mm)	maturity (mm)	Juveniles
Atherinidae	*Atherina breviceps*	M2	2 836	6.80	1	<0.05	2837	4.00	26-77	43[a]	19.3
Carangidae	*Scomberoides* sp.	M3	1	<0.05			1	<0.05	43		100
Clariidae	*Clarias gariepinus*	F			1	<0.05	1	<0.05	630	820[h]	100
Cichlidae	*Oreochromis mossambica*	F	34	0.10			34	0.05	33-215	200[c]	97.1
	Tilapia sparrmanii	F	101	0.20			101	0.10	23-125	~50[d]	38.6
Clupeidae	*Gilchristella aestuaria*	E	20 349	49.10	682	2.20	21 031	29.30	22-80	34[a]	8.2
Cyprinidae	*Cyprinus carpio*	F	31	0.10	3	<0.05	34	0.05	66-946		14.7
Gobiidae	*Caffrogobius multifasciatus*	E	8	<0.05			8	<0.05	38-88	60[a]	12.5
	Psammogobius knysnaensis	E	401	1.00	615	2.00	1 016	1.40	18-70	37[a]	18.4
Mugilidae	*Liza dumerilii*	M2			2 108	6.90	2 108	2.90	41-115	200[c]	100
	*Liza richardsonii**	M2	17 411	42.00	26 042	85.80	43 453	60.60	17-356	230[f]	99.7
	Liza tricuspidens	M2			35	0.10	35	0.05	43-122	400[c]	100
	Mugil cephalus	M1	21	0.05	831	2.70	852	1.20	54-445	450[g]	100
Pomatomidae	*Pomatomus saltatrix*	M2	4	<0.05	4	<0.05	8	<0.05	109-135	240[h]	100
Soleidae	*Heteromycteris capensis*	M2			3	<0.05	3	<0.05	43-64	~45[d]	66.7
	Solea bleekeri	M2	14	<0.05	5	<0.05	19	<0.05	32-90	100[c]	100
Sparidae	*Lithognathus lithognathus*	M1	12	<0.05			12	<0.05	100-212	650[i]	100
	Lithognathus mormyrus	M3	1	<0.05			1	<0.05	47	190[i]	100
	Rhabdosargus globiceps	M2	179	0.40	5	<0.05	184	0.30	26-127	310[k]	100
Total			41 402		30 335		71 738				68.4
Number of species			15		13		20				
Total area seined (m^2)			8 250		9 375		17 625				
Number of fish m^{-2}			5.0		3.2		4.0				

* may include low numbers of other Mugilidae because of difficulties in identifying specimens <50 mm

a. Bennett (1989a) b. Quick & Bruton (1984) c. Bruton et al. (1982) d. Pers. obs e. Wallace (1975) f. De Villiers (1987)[1] g. Day *et al.* (1981) h. Van der Elst (1976) i. Bennett (1993) j. Lasiak (1982)[2] k. Talbot (1955)[2].

1. measurement corrected from FL to TL

2. measurement corrected from SL to TL

greater in the surf-zone than in the estuarine catches. Individuals >70 mm which constituted the bulk of the *A. breviceps* surf-zone sample, were poorly represented in the estuarine catches, in which no individuals >80 mm were captured. Length frequency distributions of the *R. globiceps* catches, composed entirely of juvenile fish, were similar for the two environments.

The variation in mean density of estuarine and marine fish in the surf with distance from the estuary mouths is shown in Fig. 6.3. Densities of estuarine and Category 1 marine individuals were considerably lower (≤ 1 fish.m^{-2}) than for Category 2 marine species, which ranged up to 35 fish.m^{-2}. No relationships were evident between fish density and distance from the estuary mouths in this analysis (Table 6.4, ANOVA $P>0.05$).

Table 6.3. Species composition, abundance and length ranges (TL/DW) in mm of fish captured in 96 seine-net hauls from the Muizenberg and Macassar surf-zones. Species are categorised as being estuarine (E) or marine (M1-M3), as described in text. Myliobatidae measured in disc width.

			Muizenberg		Macassar		Muizenberg & Macassar		Length	Size at	%
			All	%	All	%	All	%	range	maturity	Juveniles
		Class	samples	Numbers	samples	Numbers	samples	Numbers	(mm)	(mm)	
Atherinidae	*Atherina breviceps*	M2	3 690	20.70	2 802	37.90	6 492	25.80	28-124	43[a]	16.3
Blenniidae	*Parablennius cornutus*	M3	1	<0.05			1	<0.05	60	42[h]	0
Carangidae	*Lichia amia*	M1			2	<0.05	2	<0.05	78-89	600[c]	100
	Scomberoides spp.	M3	1	<0.05			1	<0.05	44		100
	Trachinotus botla	M3			1	<0.05	1	<0.05	56		100
Clupeidae	*Gilchristella aestuarius*	E	276	1.50	39	0.50	315	1.20	27-62	34[a]	11.1
Coracinidae	*Coracinus capensis*	M3	3	<0.05			3	<0.05	26-29	310[d]	100
Coryphaenidae	*Coryphaena hippurus*	M3	3	<0.05			3	<0.05	43-47		100
Engraulidae	*Engraulis japonicus*	M3	1	<0.05			1	<0.05	58		0
Mugilidae	*Liza dumerilii*	M2			5	0.10	5	<0.05	46-108	200[e]	100
	*Liza richardsonii**	M2	13 463	75.60	4 028	54.00	17 491	69.40	19-347	230[f]	98.5
	Liza tricuspidens	M2			2	<0.05	2	<0.05	125-127	400[e]	100
	Mugil cephalus	M1	2	<0.05	3	<0.05	5	<0.05	98-113	450[g]	100
Myliobatidae	*Myliobatis aquila*	M3	2	<0.05			2	<0.05	530-860	540[h]	50.0
Pomatomidae	*Pomatomus saltatrix*	M2	177	1.00	459	6.20	636	2.50	32-180	240[i]	100
Rhinobatidae	*Rhinobatos annulatus*	M3	17	0.10			17	0.07	250-720	700[j]	94.1
	Rhabdosargus holubi	M1			1	<0.05	1	<0.05	86	180[g]	100
Soleidae	*Heteromycteris capensis*	M2			4	0.05	4	<0.05	64-88	~50[k]	0
Sparidae	*Rhabdosargus globiceps*	M2	153	0.90	9	0.10	162	0.06	25-143	310[l]	100
Tetratodontidae	*Amblyrhynchotes honkenii*	M3	26	<0.05	39	0.05	65	0.30	26-187	80[g]	23.1
	Arothron stellatus	M3	1	<0.05			1	<0.05	18		100
Total			17 816		7 394		25 210				76.1
Total number of species			15		12		21				
Total area seined (m^2)			29 175		20 625		49 800				
Number of fish m^{-2}			0.6		0.4		0.5				

* may include low numbers of other Mugilidae because of difficulties in identifying specimens <50 mm.

a. Bennett (1989a) b. Eyberg (1984) c. Van der Elst (1988) d. Bennett and Griffiths (1986) e. Wallace (1975) f. De Villiers (1987)[1] g. Day *et al.* (1981) h. Wallace (1967a) i. Van der Elst (1976) j. Wallace (1967b) k. Pers. obs. l. Talbot (1955)[2].

1. measurement corrected from FL to TL

2. measurement corrected from SL to TL

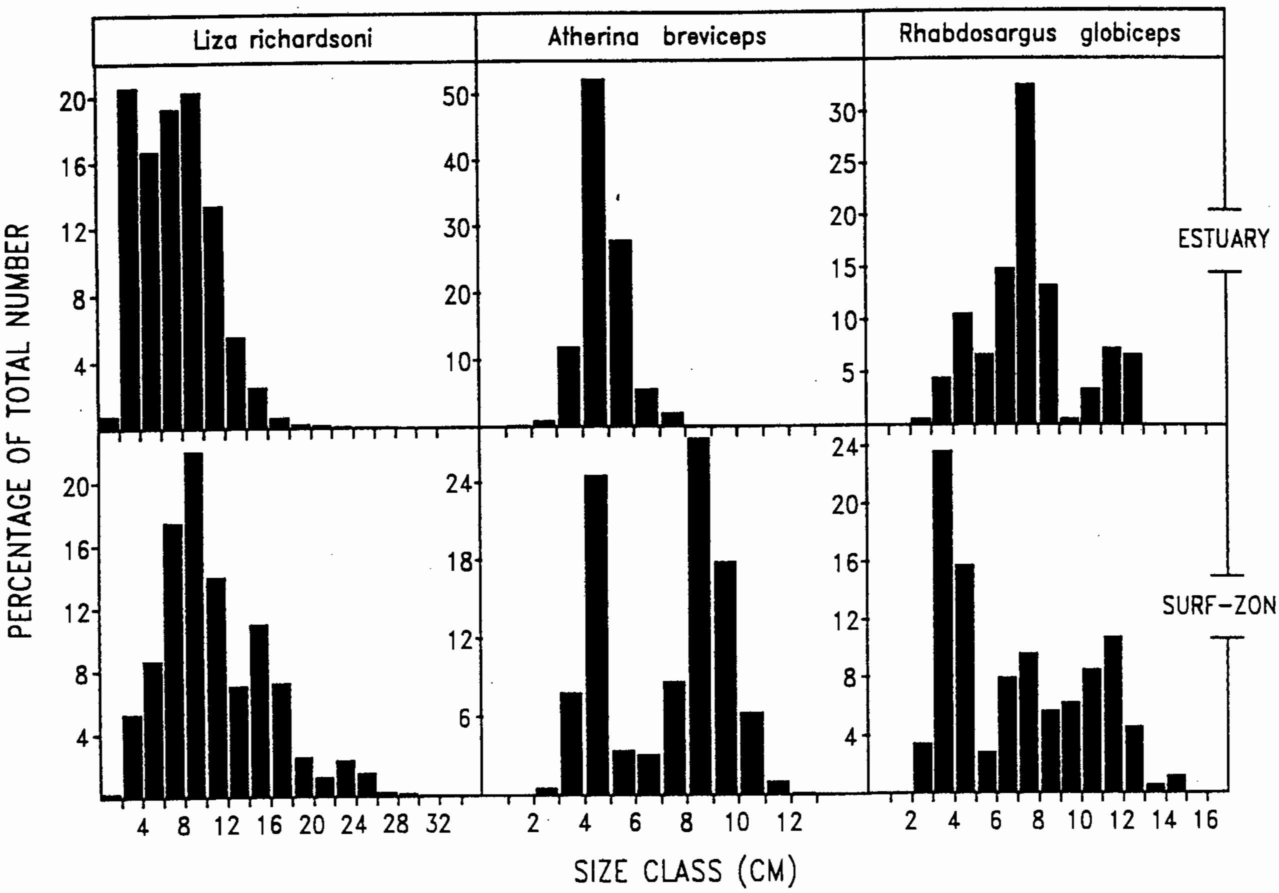


Fig. 6.2. Size distribution of Liza richardsonii, Atherina breviceps and Rhabdosargus globiceps in the Zandvlei and Eerste estuaries and the Muizenberg and Macassar surf-zones.

Table 6.4. One sample analysis (ANOVA) of the variation in estuarine (E) and marine (M1 and M2) fish density in the surf-zone with distance from the Zandvlei and Eerste estuary mouths.

Class*	d.f.	F	Significance Level
Category E	95	0.47	0.80
Category M1	95	1.20	0.32
Category M2	95	0.98	0.44
Category M1+M2	95	0.71	0.62

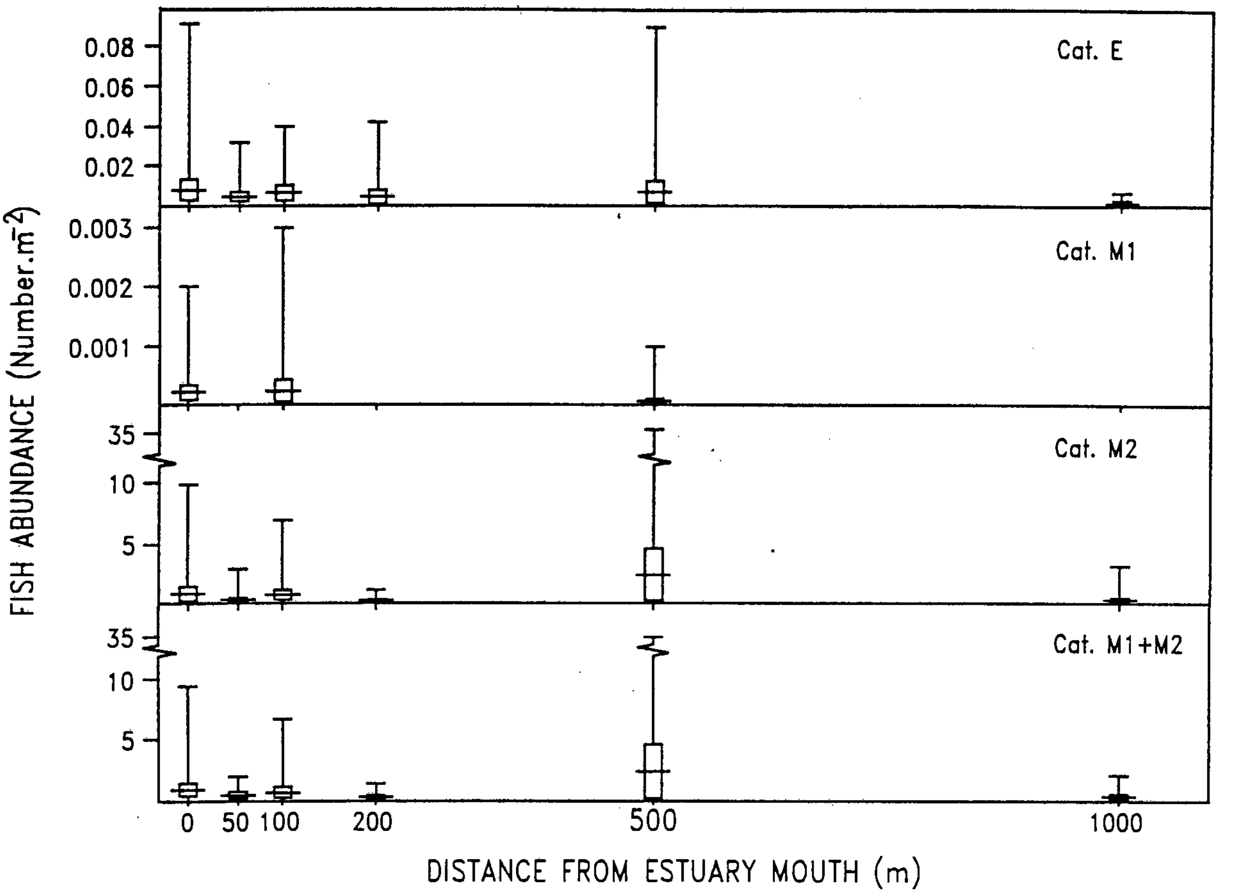


Fig. 6.3. Box-and-whisker plots depicting density distribution patterns of marine and estuarine fish fauna in the surf-zone at increasing distances from the estuary mouth. Horizontal lines represent the mean, boxes the standard error and vertical lines the range in fish density in 96 seine-net hauls made during the four sampling periods during 1991 and 1992.

DISCUSSION

Ichthyofaunal assemblages

The total number of species captured and mean densities of fish in Zandvlei (15 species, 5.0 fish m^{-2}) and Eerste estuaries (13 species, 3.2 fish m^{-2}) were similar. Both assemblages were dominated by a few species. *Gilchristella aestuaria, Liza richardsonii* and *Atherina breviceps* made up 97.9% of the Zandvlei catches, while *L. richardsonii* and *L. dumerilii* made up 92.7% of the Eerste catches. Of a total of 20 species, nine occurred in both areas. Estuarine and marine species made up approximately equal portions in the intermittently open Zandvlei estuary (50.1 and 49.5% respectively), whereas the abundance of marine migrants in the permanently open Eerste estuary (95.7%) was far greater than that of resident species (4.2%). These differences can be related to differences in the duration of connection between these estuaries and the sea (Bennett 1989b, Whitfield and Kok 1992), because the formation of a sandbar across the mouth of the Zandvlei Estuary effectively terminates the influx of marine species into this estuary.

Comparison between the seine-net samples from the Muizenberg and Macassar surf-zones reveals little difference between the fish communities inhabiting these areas. *Liza richardsonii* and *A. breviceps* dominated the catches from both areas, together making up 96.3 and 91.9% of the Muizenberg and Macassar samples respectively. Both the mean density and total number of species captured in each area (Muizenberg: 0.6 fish.m^{-2}, 15 species; Macassar: 0.4 fish.m.$^{-2}$, 12 species) were similar. Although only seven of the 21 species sampled were captured in both areas, none of the remaining species made up more than 0.1% of the total sample, and together they provided only 0.2% of the total.

Numbers of species and average standing stocks (densities) of fish in the Zandvlei and Eerste are similar to those found by Bennett (1989b), who undertook seine net surveys in the nearby Bot (14 species, 2.2. fish m^{-2}), Kleinmond (18 species, 1.4 fish m^{-2}) and Palmiet estuaries (15 species, 1.4 fish m^{-2}), all situated in the southwestern Cape. A great deal of similarity is also evident in the overall species compositions and in those species recorded as numerical dominants (*L. richardsonii*, *A. breviceps*, *G. aestuaria*, *L. dumerilii*) in the five estuaries considered either here or by Bennett (1989b). The number of species and mean standing stocks of fish recorded in the Muizenberg and Macassar surf-zones were very low compared to those noted by Bennett (1989a) at nearby Fishoek beach (20 species, 1.9 fish m^{-2}). Species dominating the Muizenberg and Macassar catches (*L. richardsonii* and *A. breviceps*) were among the three most abundant at Fishoek beach. A number of other species (*Lithognathus mormyrus*, *Pomadasys olivaceum* and *Diplodus sargus*), well represented in the catches made by Bennett (1989a), were however notably absent from the surf-zone areas sampled during this survey.

Numerical domination of both estuarine and exposed surf-zone assemblages by a few species appears to be a common occurrence throughout the world (e.g. Gibson 1973, Warburton 1978, Quin 1980, Ross 1983, Lasiak 1984a,b, Claridge *et al.* 1986, Al-Daham and Yousif 1990). Another characteristic common to the fish populations in the estuarine and surf-zone areas sampled was the abundance of juveniles in the catches.

Juveniles made up 68.4 and 76.1% of the total number of individuals, while 100% and 86% of the species were recorded as juveniles in the surf-zone and estuarine catches respectively. This is a characteristic common to a great variety of inshore and nearshore habitats, such as mangrove forests, intertidal rock pools, inshore reefs, estuaries and the surf-zones of sandy beaches. It has led to the recognition of many of these habitats as juvenile nursery areas (Gunter 1938, Gibson 1973, Wallace & Van der Elst 1975, Lasiak 1981a,b, 1986, Berry It *et al.* 1982, Lenanton 1982, Beckley 1985a,b, Bennett 1987, 1989a,b, Robertson & Lenanton 1984, Ross *et al.* 1987).

Examination of the size compositions of estuarine and surf-caught *L. richardsonii*, *R. globiceps* and *A. breviceps* (Fig 6.2), show that both the surf-zone and estuarine habitats are utilized extensively by these species as nursery areas. The first two species (*L. richardsonii* and *R. globiceps*) spawn in the marine environment (Talbot 1955, Wallace 1975, Day *et al.* 1981) whereas *A. breviceps* spawns in estuaries (Day *et al.* 1981, Bennett 1989b) and probably the sea as well (Bennett 1989a). 0+ and 1-year-old *L. richardsonii* (i.e. <120 mm, Ratte 1977) were captured in abundance in both estuaries and surf-zones, making up 91 and 67% of these catches respectively. Individuals >160 mm (i.e. 2-year-old fish, Ratte 1977) were virtually absent from the estuarine samples (<1%), but remained important in the surf-zone, where they provided 15% of the catch. *Rhabdosargus globiceps* catches made during this survey consisted entirely of juveniles, the size compositions being similar to those noted by other authors who have sampled in similar habitats (e.g. Talbot 1955, Lasiak 1986, Bennett 1989a). Distinct differences are evident in the maximum sizes and size compositions of estuarine- and surf-caught *A. breviceps* (Fig. 6.2). Estuarine individuals reach a maximum size of approximately 80 mm total length TL, while those in the surf reach c. 130 mm TL.

Estuarine and adjacent surf-zone ichthyofaunal assemblages are clearly similar in several respects, sharing numerous species and other important characteristics. One important difference evident in the results of this survey, however, merits further attention. Fish densities (no. m^{-2}) were calculated to be, on average, almost an order of magnitude greater in estuaries (Zandvlei 5.0, Eerste 3.2) than in the surf-zone (Muizenberg 0.6, Macassar 0.4). While these differences may in part be attributed to the difficulties associated with seining in exposed surf-zone areas (Schaefer 1967, McLachlan 1983, Romer 1986, Bennett 1989a), they probably also reflect real differences. Factors listed by Potter *et al.* (1990) as contributing to the quality of estuaries as areas for utilization by juvenile marine fish, which include high spring and summer temperatures, low incidence of piscivores, protection offered by turbid waters and the reduced costs of osmoregulation in the less saline estuarine waters, could all conceivably contribute to the greater fish densities in estuaries.

Impact of beach-seining on the nursery function of estuaries

It is clear from the results gathered during this survey that marine fish (Categories M1-M3) are abundant in the Zandvlei and Eerste estuaries. These fish totalled 12 species (60% of the total) and made up approximately 69% of the total number of fish caught. Those fish would have been spawned in the marine environment and at some stage have migrated through (or from) the surf-zone into the estuaries. The majority of the surviving migrants would, after having spent varying lengths of time in these habitats (Wallace 1975, Potter *et al.* 1990, Whitfield and Kok 1992), have undertaken a return migration back through or into the surf-zone. If such fish were to accumulate in the plumes of estuarine water found immediately in front of the mouths during their migrations, it could conceivably enhance their susceptibility to netting operations conducted in these areas.

Comparisons between the species composition of the Zandvlei and Eerste catches with those from the surf-zones immediately adjacent to their mouths, reveals that a number of fish species were indeed common to both areas. Most (8) of these were marine species (Categories M1-M3), whereas only one (*Gilchristella aestuaria*) was an estuarine resident. Examination of the density distribution patterns of these individuals in the surf-zone with distance from the river mouth (Fig. 6.3) failed, however, to reveal any relationship between these variables, either when all species were lumped together or when separated into estuarine and marine categories. Statistical analysis of these distribution patterns (Table 6.4) corroborated these results, indicating that no relationship existed between fish density and distance from the river mouths (ANOVA $p>0.05$).

Results presented in this paper therefore indicate no accumulations of estuarine-associated fish fauna occurred in the surf-zones immediately adjacent to the estuary mouths during the survey periods. Also, densities did not attenuate with distance from the mouths. Although larvae and small juveniles of some species would almost certainly have been poorly sampled by the meshes of the net used for this survey (12-

mm stretched mesh), these would undoubtedly also pass through the meshes of a commercial beach-seine net (≥44 mm stretched mesh). Larger individuals may accumulate for short periods during times of peak emigration, following a flood for example. However, as commercial seiners avoid seining in the vicinity of river mouths at these times, because debris (leaves, branches and reeds) tends to wash out, foul, and damage the nets, such aggregations would be of little consequence. In addition, because the abundance of species undoubtedly originating in the estuarine environments, viz. the estuarine species, does not attenuate with distance from the mouths (Fig. 6.3), horizontal transport attributable to the efflux of estuarine waters and the physical processes in the surf-zone must be strong enough to ensure that these accumulations are of very short duration only. Furthermore, examination of the seasonal distribution of netting effort reveals that the greatest number of seine hauls >80%, are made during summer, when the predominantly seasonal estuaries are cut off from the sea.

In the light of these results, it is apparent that commercial beach-seines conducted in the immediate vicinity of river mouths are potentially no more harmful to marine fish utilising estuaries than those made farther away. Declines in the abundance of estuarine-associated angling species are therefore likely to be attributable to other factors, such as degradation and destruction of estuarine habitats, such as is occurring on a large scale in southern Africa (Heydorn 1979, Blaber *et al.* 1984). Overexploitation of these vulnerable fish stocks, which is reflected in changing catch compositions and declining catch rates (Van der Elst 1988, 1989, Bennett 1991a,b, Bennett and Attwood 1993), is almost certainly contributing to these declines.

CHAPTER 7

GETTING TO THE BOTTOM OF THE MATTER: THE IMPACT OF BEACH-SEINE NETTING ON THE BENTHIC FLORA AND FAUNA OF FALSE BAY

ABSTRACT

A total of 31 invertebrate and 14 macrophyte species were recorded in the bycatch of 311 commercial beach-seine hauls made in False Bay between January 1991 and December 1992. *Ecklonia maxima* (22%), *Codium fragile capense* (16%) and *Gracilaria verrucosa* (9%) dominated the total macrophyte catch of 14.9t. The invertebrate bycatch was dominated by the ascidian *Pyura stolonifera* (18.3t) and 10 339 individuals of the brachyuran *Ovalipes trimaculatus*. Large macrophyte and invertebrate catches were infrequent with the bulk of the total catch being made in 10% of the hauls. Dive surveys found no significant differences in abundance or species composition between sites inside and outside the seine area. The beach-seine bycatch did not make a significant contribution to the composition or biomass of material deposited along the driftline. It was concluded that commercial beach-seine netting is not having a significant detrimental effect on the benthic flora and invertebrate fauna of False Bay.

INTRODUCTION

Concern over fishing methods and their impact on benthic life is as old as their inception and has prompted numerous studies (eg. Graham 1955, Caddy 1973, de Groot 1984 and Hall et al. 1993). Most of these studies are centred around the effects of various trawl and dredging methods (see Messieh *et al.* 1991 for review). Few, if any, studies have investigated the effect of beach-seining on benthic life.

Graham, (1955) found no difference in the numbers or species composition of benthic animals between areas inside or outside trawling grounds. Differences in an infaunal community could not be attributed to the absence or presence of trawling activity, but the epifauna could be more vulnerable (Hall *et al.* 1993). By contrast, in other studies, trawling has been found to cause large mortalities to benthic invertebrates and to alter benthic habitats, resulting in an overall shift in abundance and species composition (Riesen and Reise 1982, de Groot 1984).

The effects of fishing on a benthic community, will depend on the type of gear used, the nature of the substratum and the intrinsic vulnerability of the individual species concerned (de Groot 1984, Messieh *et al.* 1991). The possible direct effects of a net being dragged over the seafloor include mechanical damage to sedentary organisms or entrapment and removal of living organisms, drift algae or inanimate objects, such as rocks and shells (Graham 1955, Caddy 1973). Indirect effects are increased predation pressure due to the exposure of infaunal species, alteration of substratum texture, therefore reducing habitat suitability and sediment resuspension with it's resultant clogging of gills and smothering capabilities (de Groot 1979, Churchill 1989, Messieh *et al.* 1991,)

As early as 1898, False Bay line-fishermen expressed disquiet that beach-seine fishermen were netting large quantities of benthic organisms, namely the ascidian *Pyura stolonifera*, which they used as bait (Gilchrist 1899). In recent years, anglers and conservation groups have equated beach-seining to trawling (Haynes 1986). They claimed that the seine-nets were not only scraping the seabed of all forms of marine life, but depositing it on the shore and therefore polluting the beaches (Kirsch 1993, Petty 1993). In doing so, the nets were percieved to be removing a vital source of production from the surf-zone and to be altering the benthic habitat.

This chapter presents results of a survey aimed at estimating the abundance and species composition of macrophytes and invertebrates captured in commercial beach-seine hauls. The abundance and species composition of benthic macrophytes and invertebrates remaining in areas inside and outside that swept by the nets, and the corresponding driftline, are also compared and discussed.

METHODS

Study sites and seining methods

The effects of beach-seining on the benthic flora and fauna were studied at two sites, these being the northern shore and Simon's Bay on the western shore of False Bay (Fig. 7.1). This was done because the two areas, differ considerably in their physical parameters as do the seining methods used at each site.

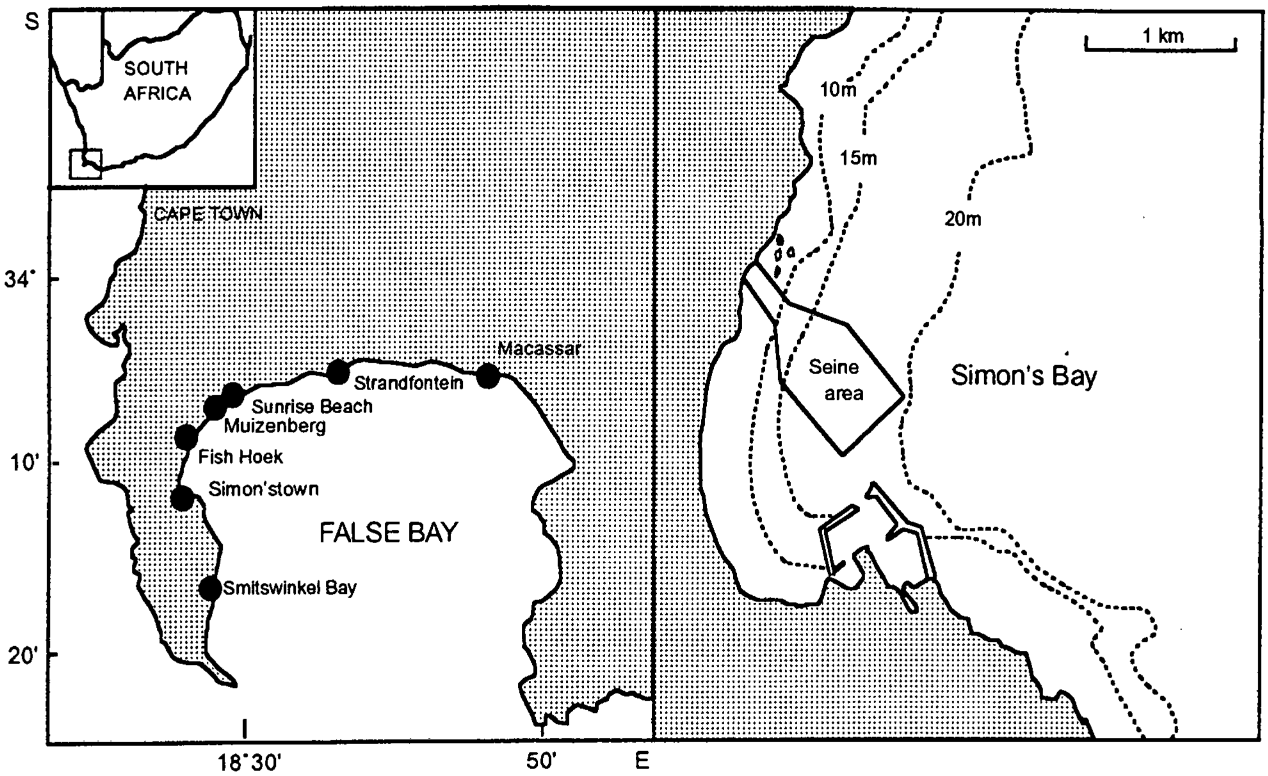


Figure 7.1. Map of False Bay and Simon's Bay showing study sites.

Seven commercial beach-seine teams operate from False Bay's northern and western shores (Fig 7.1). The northern shore is exposed to the predominantly north-east swell entering the bay and has a beach-slope of roughly 1:50, seine-areas seldom exceeding four metres in depth. The western shore is relatively sheltered and the beach-slope is approximately 1:10. Simon's Bay on the western shore of False Bay is a small bay of three kilometres in diameter with a maximum depth of eighteen metres.

Most nets conform to the permit specifications of a length of 275m, depth 5m, minimum mesh size of 44mm and hauling rope length of 600m. These specifications are characteristic of seine-nets used on the northern shore. Simon's Bay seine operators use a net that is "modified" to catch white steenbras *Lithognathus lithognathus*. This "Russman" net is heavily weighted such that it sinks to just above the sea floor, has a mesh size of 90mm, a length of 175m, depth of 3m, and is typically set at 750-1 500m from the shore. All the nets are set from boats rowed out through the surf-zone and are hauled shorewards at approximately four metres per minute. Operators on the north shore are mobile and have access to approximately 7km of beach. The Simon's Bay "Russman" operation is stationary and the net is set within a fixed area.

Monitoring of catches

Commercial beach-seine operations in False Bay were monitored between January 1991 and December 1992. In each observed haul, all fish and the invertebrate and algal bycatch were quantified and identified as far as possible. Algal subsamples were taken and sorted, weighed and identified in the lab. Wind speeds were recorded at the time of each seine and for the week preceeding each Simon's Bay haul.

Video recording

An underwater video camera was used to record the passage of the Russman net over the Simon's Bay seafloor. Filming started as the net was set and continued until the net was hauled up onto the beach.

Diving survey

A diving survey (using SCUBA) was conducted in Simon's Bay in order to compare the species composition and biomass of benthic invertebrates and macrophytes inside and outside the area swept by the net. In addition, the availability of benthic material to the seine-nets could be determined. Four areas were sampled, two inside and two outside the seine-area (Fig 7.1). Two samples were taken at each of the depths of 3, 8, 13 and 17 metres within each of the four areas. Each sample consisted of a diver swimming along a 25m leadline and collecting whatever epibenthic material that could be seen one metre to one side of the line.

An additional dive survey was conducted in the surf-zone between Muizenberg and Strandfontein on the north shore. This was done by swimming four 200 by 1m transects perpendicular to the shore, collecting all macrophyte material and recording all invertebrates seen.

Drift composition

The algal composition of the Simon's Bay driftline was monitored daily during April and May 1991. The beach was divided into four 64 by 1m transects along which all macrophyte material was recorded and subsampled. The time and extent to which discarded seine material was resuspended and washed out to sea was noted.

Multivariate analyses were conducted according to the methodology of Field *et al.* (1982). Samples from the seine catches, inside seine area, outside seine area and driftline were grouped using complementary classification and multi-dimensional scaling techniques using species composition and biomasss data with the Bray-Curtis measure of similarity. The Mann-Whitney U-test was used to compare total algal biomass inside and outside the seine area.

RESULTS

Three hundred and eleven commercial beach-seine hauls, were monitored during the period January 1991 to December 1992. These include 26 hauls by the Russman net at Simonstown. The mean area swept by the net was 59 826 $\pm$ 1 298 m^2 s.e. and 28 774 $\pm$ 1 160m^2 s.e. at Simon's Bay and the northern shore respectively. There was a significant positive correlation between the amount of weed netted and the mean wind speed for two days prior to seining (Spearman Rank Coefficient 0.68, $p<0.05$)

Fourteen macrophyte species were identified in a total algal bycatch of 14.9t. The average macrophyte catch amounted to 76,6 $kg.haul^{-1}$ and 47.2 $kg.haul^{-1}$ at Simon's Bay and the northern shore respectively. This catch was dominated by *Ecklonia maxima* (22%), *Codium fragile capense* (16%) and *Gracilaria verrucosa* (9%) (Tables 7.1 & 7.2). The invertebrate bycatch was dominated by the red bait *Pyura stolonifera* (18.3t) and 10 339 individuals of the sand crab *Ovalipes trimaculatus* (Table 7.1). Large macrophyte and *P. stolonifera* catches were infrequent, the bulk of the total catch being made in less than 10% of the hauls (Figure 7.2.). *Ovalipes trimaculatus* catches were relatively frequent, occuring 80% of the time, but few hauls captured more than 60 individuals per haul (Figure 7.2) Invertebrates of less than 1cm in length eg Amphipoda, were not quantified and therefore do not appear on the list. Also not included is one reptile species, the yellow-bellied seasnake *Pelamis platurus*, of which a single individual was caught.

Video footage taken of the Russman net at Simon's Bay showed that it sank to the bottom, whereupon it rose to about 10-20cm from the seafloor at the commencement of the haul. The net maintained this position throughout the haul and did not scrape the

Table 7.1. Summary of information on species composition, abundance and occurrence of all macrophytes and invertebrates caught in a total of 311 beach-seine hauls during the period January 1991 to December 1992. Algae and *Pyura stolonifera* measured in kilograms.

		Total	Number per haul	% Occurrence
MACROPHYTES				
	All spp.	14 865	47.80	44.69
INVERTEBRATES				
Annelida				
Polychaeta	*Pectinaria capensis*	10	0.03	0.32
Ascidiacea				
	Pyura stolonifera	18 256	58.70	42.77
Bryozoa				
	Unidentified spp.	124	0.40	1.29
Crustacea				
Decapoda	*Carcinus maenas*	1	<0.01	0.32
	Jasus lalandii	2	0.01	0.64
	Dehaanius dentatus	162	0.52	1.93
	Ovalipes trimaculatus	10 339	33.24	81.03
	Planes minutus	12	0.04	1.29
	Macropetasma africana	40	0.13	0.64
	Unidentified sp.	8	0.03	2.25
Isopoda	*Paridotea reticulata*	300	0.96	0.64
Cnidaria				
Scyphozoa	*Chrysaora hysoscella*	572	1.84	32.48
	Rhizostoma sp.	2 859	9.19	39.87
	Unidentified spp.	1 000	3.22	30.23
Hydrozoa	*Physalia utriculus*	940	3.02	2.25
	Velella sp.	47	0.15	0.11
Echinodermata				
Asteroidea	*Marthasterias glacialis*	239	0.77	5.47
Holothuroidea	Unidentified sp.	1	<0.01	0.32
Ophiuroidea	Unidentified spp.	420	1.35	0.64
Mollusca				
Bivalvia	*Atrina squamifera*	63	0.20	2.57
	Choromytilus meridionalis	1160	3.73	9.97
	Donax serra	26	0.08	1.29
	Mactra glabrata	5	0.02	0.32
	Scissodesma spengleri	917	2.95	14.15
Cephalopoda	*Loligo vulgaris reynaudii*	57	0.18	3.22
	Octopus vulgaris	23	0.07	3.86
	Sepia vermiculata	8	0.03	1.93
Gastropoda	*Aplysia oculifera*	131	0.42	2.89
	Glaucus atlanticus	2	0.01	0.32
	Janthina janthina	1	<0.01	0.32
Porifera				
	Unidentified spp.	1014	3.26	9.32

Table 7.2. Species composition and biomass of beach seine-net catches, inside and outside seine areas and driftline in Simon's Bay and north shore of False Bay. Inside-outside seine area and north shore available biomass determined from dive surveys. Simon's Bay available biomass is the mean of the inside and outside seine areas. Macrophytes that originate from rocky substrata either adjacent to or further away from the seine area marked with an asterisk.

	SIMON'S BAY					NORTH SHORE	
	monitored hauls $gm^{-2}haul^{-1}$	inside seine area gm^{-2}	outside seine area gm^{-2}	available gm^{-2}	driftline gm^{-2}	monitored hauls $gm^{-2}haul^{-1}$	available gm^{-2}
MACROPHYTES							
Chlorophyta							
*Caulerpa filliformus**	<0.01	0.01	0.11	0.06		0.02	0.63
*Codium fragile capense**	0.34	6.30	5.82	6.03	1.04	0.13	0.34
*Codium papenfussii**						0.01	
*Codium stephensiae**	0.15	0.04	0.06	0.05	1.13	0.13	1.31
Ulva spp.	0.02	1.63	2.70	2.13	0.47	0.03	
Phaeophyta							
*Ecklonia maxima**	0.47	6.81	1.29	4.20	468.75	0.20	8.51
*Sargassum heterophyllum**	<0.01					0.01	
*Sargassum longifolium**					1.13	0.01	
*Splachnidium rugosum**					0.83		
Rhodophyta							
*Gigartina radula**	<0.01	0.24		0.13	0.20	0.06	
Gracilaria verrucosa	0.28	2.42	4.74	3.50	0.85		
*Hypnea spicifera**	<0.01	0.14	0.02	0.08	0.37	0.07	0.69
*Nemastoma lanceolata**						0.68	
*Plocamium corallorhiza**	<0.01	0.19	0.02	0.11		0.11	4.11
*Pterosiphonia cloiophylla**					0.43	0.06	1.89
*Trematocarpus flabellatus**					0.06		
Other	0.01	0.99	0.29	0.67	0.70	0.12	51.03
Total	1.28	18.77	15.05	16.96	475.96	1.64	68.51
INVERTEBRATES							
Ascidiacea							
Pyura stolonifera	1.13					0.04	78.00
Bryozoa							
Unidentified spp.						0.11	23.49
Cnidaria							
Scyphozoa spp.	0.01	0.14	0.05	0.09		0.14	18.00
Crustacea							
Ovalipes trimaculatus	0.02	0.09		0.05		0.06	172.08
Echinodermata							
Marthasterias glacialis	0.015	1.01	0.93	0.97		<0.01	
Porifera							
Unidentified spp.	0.02					0.09	4.23

bottom, nor was it observed to disturb the burrows of infaunal species such as *Callianassa kraussi* which occur in high densities in the bay. The only time that the net was observed to scrape the bottom was as it approached to within approximately 20m of the shore and the depth of the net exceeded that of the water column

There were no significant differences between species composition and biomass of either macrophytes or invertebrates at corresponding depths inside and outside the Simon's Bay seine area (Mann-Whitney U-test, Table 7.3). Multivariate analyses revealed no distinct groupings corresponding to depth or to position relative to the seine area. *Ecklonia maxima, C. fragile capense* and *G. verrucosa* comprised 85% and 82% of the Simon's Bay seine and dive survey macrophyte samples (Table 7.2). Seine catches (1.28$gm^{-2}haul^{-1}$) amounted to 7.5% of the available macrophyte material (16.96gm^{-2}) in Simon's Bay (Table 7.2). Catches of *O. trimaculatus* represented 36% of those available (Table 7.2). Although caught in the seine, no *P. stolonifera* or Porifera were observed during the dive survey.

The dive survey on False Bay's northern shore indicated an available macrophyte biomass four times that of Simon's Bay (Table 7.2). *Gracilaria verrucosa*, dominant in Simon's Bay catches, was recorded in neither seine catches nor dive surveys on the north shore. In turn, the proportion of the available macrophyte biomass (2.4%) removed by each haul was a third that of Simon's Bay (7.5%) (Table 7.2). The available invertebrate biomass on the northern shore was three orders of magnitude greater than Simon's Bay (Table 7.2). *Ovalipes trimaculatus* dominated at three individuals or 172.1gm^{-2}. *Pyura stolonifera* followed at 78.0gm^{-2}. The invertebrate biomass removed by each haul on the north shore amounted to 0.15% of that available within the area swept by the net.

Cluster analysis separated the Simon's Bay seine catch and drift composition into two distinct groups (Figure 7.3). *Ecklonia maxima* (98%) dominated the drift biomass which was one and three orders of magnitude greater than that available or that recorded in seine catches respectively (Table 7.2). In turn, the Simon's Bay drift biomass (476gm^{-2}) was double that of the northern shore (238gm^{-2}) (Westridge Cleansing Depot, unpublished records).

Observations of macrophyte material that was discarded after each seine haul, indicated that 78% of the catch was resuspended and carried out to sea within 24 hours.

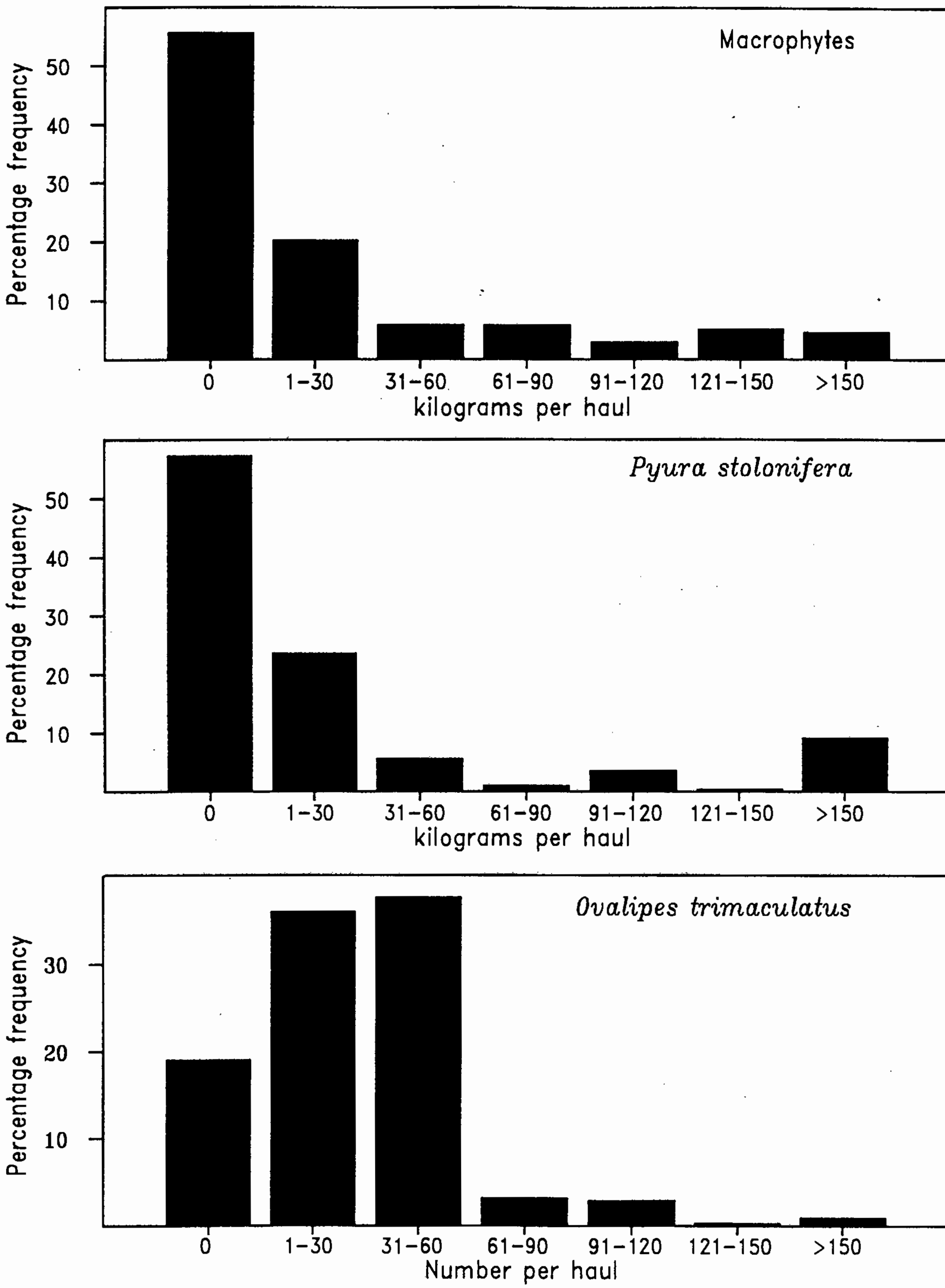


Fig. 7.2. Catch-size frequency distribution of macrophytes and the two most abundant invertebrate species in 311 commercial beach-seine hauls made in False Bay during the period January 1991 to December 1992.

OUTSIDE SEINE AREA Depth (m)	INSIDE SEINE AREA Depth (m) 3	8	13	17
3	1.5 (0.10)	2.2 (0.03)	2.2 (0.03)	2.2 (0.03)
8	1.6 (0.10)	0.4 (0.70)	0.4 (0.70)	0.7 (0.50)
13	0.4 (0.66)	1.9 (0.06)	1.9 (0.06)	2.2 (0.03)
17	1.6 (0.10)	1.6 (0.10)	0.7 (0.50)	0.7 (0.50)

Table 7.3. Summary of results of Mann-Whitney U-test testing for differences between samples from inside and outside the seine area. Test statistic and (significance level).

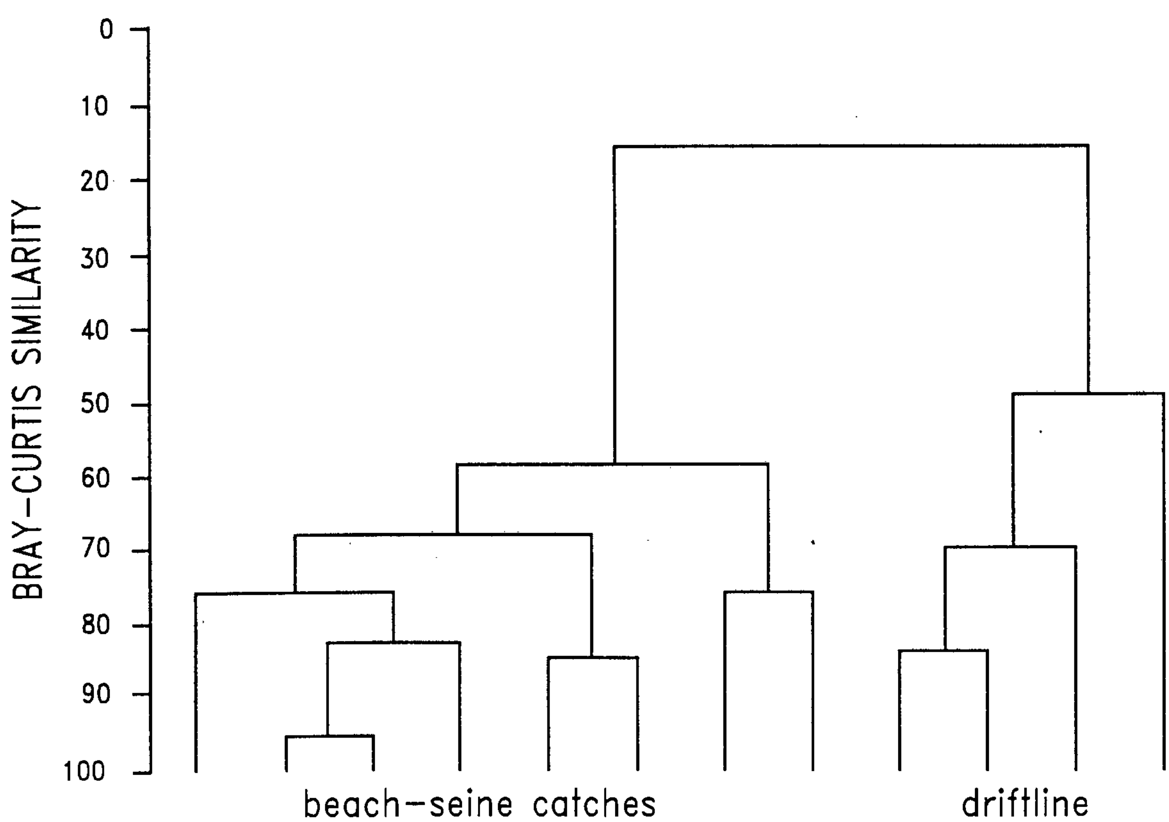


Fig. 7.3. Dendrogram showing similarities between Simon's Bay beach-seine catch composition and that of the driftline.

DISCUSSION

Beach-seine fishermen avoid netting at times and in areas where there are large quantities of suspended macrophyte and other material. Large macrophyte loads slow down the speed of the haul, cause the net to twist and roll and also facilitate the escape of the targeted fish (Pierce et al. 1990).

The presence and abundance of most macrophytes and invertebrates in the surf-zone is extremely patchy and variable in time and space (Robertson and Hansen 1982,van der Merwe and McLachlan 1987). This is borne out by the observation that the bulk of the macrophytes and *P.stolonifera* caught during this study were made in under 10% of the hauls, even though similar or identical areas were being seined. In addition, excluding *G. verrucosa* and *Ulva* spp., all the macrophyte species in this study originate from rocky and mixed shores away from the seine area (Branch *et al.* 1994). All macrophytes observed in this study were detached and therefore mobile.

The sessile invertebrate *P. stolonifera* is not a "resident" of the sandy-beach surf-zone where it occurs in the form of uprooted pods washed from adjacent rocks or deeper waters and occurred in similar quantities and frequencies to the macrophyte material caught. This suggests, that the presence and abundance of *P. stolonifera* and detached marophytes in the surf-zone, are determined by the same factors, namely wind and current. The three spot swimming crab *O. trimaculatus* was the only invertebrate species resident in the surf-zone which was caught frequently and in consistent quantities. The catch per haul of this species on the northern shore was 0.03% of it's available biomass, which amounted to approximately 86 000 individuals over the area seined in a single haul. Few invertebrate species including *O. trimaculatus* were observed in the Simon's Bay benthic survey, which suggests that densities were lower or that they escaped observation through being buried. Infaunal species were not sampled during this study as prior observations and video footage indicated that the nets, "Russman" seine included, did not drag along, but rode approximately 10-20cm above the sea floor. Burrows of organisms such as the sand pawn *Callianassa kraussi* were undisturbed by the net's passage and no individuals of this species were ever caught. In turn infaunal species such as the bivalves *Donax serra* and *Scissodesma spengleri* were abundant in the surf-zone, did appear in small numbers in seine-net catches, but were not counted in the visual surveys, since they are normally buried beneath the sand surface.

Hall *et al.* (1993) point out that the problem with comparisons between areas which are fished and unfished is that the latter are not fished precisely because they differ in the habitat requirements that attract the fish in the first place. They suggest that the only viable way to undertake a net-fishery study of this sort is to find a protected area within the fishing ground. In this study beach-seine nets were excluded from the unfished areas by a wreck and mooring buoys, both anthropogenic in origin and therefore not natural features of the bay. There was no difference in biomass, species composition or abundance of macrophytes and invertebrates between areas in Simon's Bay which were or were not seined. The two "resident" macrophytes *G. verrucosa* and *Ulva* spp. were more abundant outside the seine-area, but not significantly so. Beach-seine netting does not appear to have altered the benthic habitat or community structure in Simon's Bay.

Macrophyte material decays in the surf-zone with a half life of approximately 8 days (van der Merwe and McLachlan 1987). Assuming exponential decay, it follows that 28% of the standing or average macrophyte biomass is imported daily. Using a conversion ratio of 1:4.43 (dw:ww) and 0.3 $gC.gdw^{-1}$, macrophyte imports on the north shore amount to approximately 19.2 $gww.m^{-2}d^{-1}$ or 4.3 $gdw.m^{-2}d^{-1}$ or 1.3 $gC.m^{-2}d^{-1}$ imported into the surf-zone (Field *et al.* 1980, Levitt 1987). Detached macrophytes are still actively photosynthetic (Robertson and Hansen 1982). The production of these macrophytes is approximately 6.5 $gC.gdw^{-1}yr^{-1}$ (Levitt 1993). On the north shore this amounts to 100.6 $gC.m^{-2}yr^{-1}$. Thus, on the north shore, the import and *in situ* production of detached macrophytes is approximately 575.6 $gC.m^{-2}y^{-1}$. Although a crude estimate, this value is insignificant when compared to north shore surf-zone phytoplankton production of 150 X 10^3 $gCm^{-1}y^{-1}$ (Bate and Campbell 1990). It follows that even in the extreme event of seine frequency increasing to the extent of removing all macrophyte material from the surf-zone, production is unlikely to be significantly effected. The only likely effect of removing all this macrophyte material could be the loss of the role it plays in acting as a refuge and or attracting foraging species (Robertson and Lenanton 1984, Wright 1989).

There was a marked difference between seine catches and driftline composition of macrophyte material. The biomass of "floating" macrophytes namely *E. maxima* was an order of magnitude greater along the driftline than in seine-catches or within the seine-area. In turn, most seined macrophytes were resuspended within a short period, which suggests that seine-catches do not make a significant contribution to diftline biomass.

In conclusion, macrophyte and invertebrate by-catches are infrequent by beach-seine fishermen who make every attempt to avoid such catches, since they interfere with fishing operations. The removal by beach-seines of macrophyte material from the surf-zone that does occur is unlikely to effect production. In turn, most seined macrophyte material is resuspended within a short period, does not contribute significantly to the driftline and therefore does not "pollute" the beaches. There is no difference in the species composition or biomass of benthic flora and fauna between fished and non-fished areas and therefore no evidence to suggest that beach-seine netting is having a severely detrimental effect on the benthic flora and invertebrate fauna of False Bay.

CONCLUSIONS

TOWARDS THE RESOLUTION OF THE FALSE BAY BEACH-SEINE CONTROVERSY

The abundance, species and size composition of fish caught by commercial seine-nets is thought to be a reasonable reflection of surf-zone fish assemblages in False Bay (Chapter 2). It is likely that this study provides a comparatively accurate view of these assemblages as it includes both adult and juvenile fish, whereas previous investigations of surf-zone fish assemblages in South Africa were largely directed towards juveniles (eg. Lasiak 1984, Romer 1986, Bennett 1989). These studies used shorter nets with a smaller mesh-size, and were deployed less frequently than were the commercial nets in this study. Thus, direct comparisons with these other studies is difficult. In addition, the present sampling program was not confined to the inner, but extended to the outer surf-zone. Although it has been noted that surf-zone fish assemblages are characteristically dominated by only a few species (Modde and Ross 1981), the numerical importance of the targeted species is thought to be overestimated. The dominance of the surf-zone ichthyofauna by harders *Liza richardsonii* is ultimately the reason that seine-fishermen consider it commercially viable to target this species.

Several species-specific factors determine the vulnerability of a fish to capture and/or overexploitation (Chapter 3). These include visibility and spatial or temporal predictability. The visibility of surface shoals or predictability of large aggregations of species such as *L.richardsonii*, yellowtail *Seriola lalandi* and white steenbras *Lithognathus lithognathus* make them more susceptible to capture than species such as kob *Argyrosomus hololepidotus* and white stumpnose *Rhabdosargus globiceps*. In turn, the frequent visibility of shoals of undesirable or "illegal" species such as elf *Pomatomus saltatrix* and maasbanker *Trachurus trachurus* allows the seine-fishermen to avoid them. The degree of residency of a particular species in the surf-zone will also affect their vulnerability to overexploitation and species which migrate elsewhere for a substantial part of the year (eg. *L. lithognathus* and *P. saltatrix*), will obviously escape netting pressure at this time.

The proportion of individuals that escape from the seine-nets is relatively high (Chapter 3). However, escapees are numerically dominated by elongate "baitfish" species whereas a relatively low proportion of "angling" fish escape. These "angling" fish become vulnerable to capture within their first two years of life, well before they reach sexual maturity. Although the majority of these immature fish are under legal size and are returned to the water, mortality caused by capture is unknown. If they do survive, there is still a good chance that they will be recaptured, as the juveniles of most of the "angling" species are known to show some degree of residency in the surf-zone (Bennett 1989). That some fish do survive capture is evidenced by the recapture of tagged belman *Umbrina canariensis* and *L. lithognathus* by the same nets, seven and three months after their release respectively (unpublished data).

Commercial beach-seine catches and effort in False Bay are strongly seasonal and mirror fluctuations in both physical (water temperature, wind speed and direction) and biological (*Anaulus birostratus* patch intensity and frequency) variables (Chapter 4). Catch peaks in the summer months which concurs with experimental net studies made elsewhere (eg. Modde and Ross 1981, Ross *et al.* 1987, Peters and Nelson 1987). The strength of seasonal variations in fish abundance depend largely on the magnitude of seasonal changes in physical conditions, which ultimately depend on latitude (Bennett 1989). The seasonal predictability of certain species may make them more vulnerable to capture and overexploitation. For instance, the seine-fishermen increase their effort in the summer months when *A. birostratus* patches occur more frequently and the catching of *L. richardsonii* becomes more likely (Chapter 4). Simon's Bay "Russman" net operators cease fishing in the winter months due to the known absence of *L. lithognathus* from this area at this time of year. The overiding observation is that the False Bay surf-zone supports a greater abundance of fish in the summer as opposed to winter months and that many of the species are absent from this area during winter. This implies that seasonal migrations do occur for the majority of the ichthyofauna. These migrations may occur laterally in the surf-zone or onshore-offshore in response to physical and biological changes such as temperature and food availability.

The vulnerability of "angling" fish to capture at an early age (Chapter 3) is highlighted by the observation that 60% of the total beach-seine juvenile catch consists of species belonging to this group (Chapter 5). However, assuming that the entire catch was killed, seine-mortality of most species (excluding *L. lithognathus*) was found to be insignificant when compared with natural mortality (Chapter 5). Surf-zones and estuaries are recognized as important nursery areas for the juveniles of many species (eg. McFarland 1963, Mc Hugh 1976, Miller *et al.* 1984, Robertson and Lenanton 1984, Lenanton and Potter 1987, Bennett 1989). Estuarine and surf-zone experimental net catches were dominated by juvenile fish with densities being an order of magnitude higher in estuaries than in the surf-zone of False Bay (Chapter 6). Densities were, however, not elevated in the surf-zones adjacent to the estuary mouths. Aggregations of juvenile fish entering or leaving the estuaries may be more vulnerable to capture, but as they are in transit, this condition is likely to be of short duration.

The need for the preservation of the surf-zone habitat is linked to concern over the effect that nets have on benthic life. The commercial nets were found to neither scrape the seafloor nor to remove a significant source of production from the surf-zone. There was no evidence that either the benthic habitat or its community structure were altered by frequent netting (Chapter 7). Most of the macrophyte material brought up by the seine-nets was drift algae, which was resuspended within a short time. However, the effects of its temporary removal on foraging species is unknown (Robertson and Lenanton 1984, Wright 1989). In turn, the transient nature of this detrital macrophyte material in the surf-zone (Van der Merwe and McLachlan 1987) is likely to be reflected in the behaviour of the species that utilize it.

Although not the primary aim of this study, the intensive monitoring of commercial beach-seine catches provided an invaluable insight into the surf-zone ichthyofauna of False Bay. A knowledge of the behaviour and biological interactions of fish in the surf-zone environment provides a greater understanding of the possible consequences of their continued exploitation by the beach-seine fishery. This greater understanding should help towards wiser management and hopefully the long term resolution of the beach-seine controversy.

Present and future prospects for the seine-fishery

As far back as 1883 the late J.D.F. Gilchrist attempted to solve disputes between beach-seine fishermen and anglers (Chapter 1). Since then, angler numbers have increased and the conflict has escalated. Over the years, numerous gear and catch restrictions have been implemented in response to allegations levelled against the seine-fishery, and the number of seine-net teams in False Bay has been reduced from well over 100 to the present seven (Chapter 1). Conflict between seine-fishermen and anglers is therefore not a new occurrence but it has escalated in recent years.

The current situation is that anglers and conservation groups are applying pressure on management to curtail seine-netting because of the following perceptions:

1. Harders *L. richardsonii* are the "traditional" catch of the beach-seine fishery and targeting on "angling" species is a relatively recent practice.
2. Anglers' catches have declined because beach-seine catches of shared species are sufficiently large to have resulted in significant stock depletions.
3. Netting in the vicinity of river mouths results in undue mortalities on spawning aggregations, and on juvenile fish entering and leaving the estuarine nursery areas.
4. Large catches, and consequently high mortalities, of juveniles result in reduced recruitment to the exploited stock.
5. Large scale mortalities of cartilaginous and other non-target species cause ecological imbalances within False Bay.
6. The nets scrape the seabed, thereby resulting in mortalities of non-target organisms and in degradation of the benthic habitat.

This study was commissioned to investigate these allegations and to provide a "scientific basis" for the resolution of the "beach-seine controversy" (Chapter 1). This thesis reports the results of this investigation. A summary of the findings relevant to the claims of the groups opposed to beach-seining are presented below:

1. *Liza richardsonii* are not the "traditional" catch of seine-net fishermen and targeting of "angling" species is not a recent phenomenon (Chapter 1). Historical records indicate that seine-net fishermen were targeting "angling" fish in the late 1890's and early 1900's with *P. saltatrix* (35%), *S. lalandi* (27%) and *L. lithognathus* (21%) making up 83% of the total mass caught at that time whereas *L. richardsonii* only accounted for 5%. Since then the proportion of *L. richardsonii* has increased, in the 1960's they provided approximately half the catch and, since the late 1970's, they have comprised more than 85% of the total catch.

2. The seine-net catch of the majority of "angling" species represents less than 10 % of the total national catch of these species (SFRI unpublished data, Chapter 2). Fishing mortality due to this method therefore is small relative to total fishing mortality. Only for *L. lithognathus*, for which the seine-net catch is estimated as approximately 25% of the national catch, do seine-net catches provide cause for concern (Bennett 1993).

3. Evidence from both commercial and experimental netting at varying distances from estuary mouths indicate that neither spawning nor juvenile fish aggregations occur

in the vicinity of estuary mouths in False Bay (Chapter 6). Although *L. lithognathus* are more abundant off the Eerste River mouth than elsewhere along the northern shore of False Bay, this is considered to be because sediment characteristics offer better feeding conditions there (Bennett 1993). This species does not spawn in the southwestern Cape (Bennett 1993).

4. The standing stock of juvenile fish of all species in the False Bay surf-zone is estimated at 4.3 x 10^6 fish and the mean monthly number of juvenile fish caught in the nets is 7 400 (Chapters 2 and 5). Thus, even assuming that the entire catch is killed, fishing mortality is only 0.2% of standing stock per month. When one considers that natural mortality is likely to be in the region of 30% per month, mortality due to seine-netting would appear relatively insignificant (Chapter 5).

5. Seine-netting is unlikely to be having a significant detrimental impact on ecological interactions in False Bay through mortality on cartilaginous species. During 1991 and 1992 only approximately 200 cartilaginous fish (2% of the non - St. Joseph *Callorhynchus capensis* cartilaginous fish catch), were retained each year and all were primarily consumers of benthic invertebrates (Chapter 2). The extent of mortality on released fish is unknown but is likely to be small. Also unknown is the extent of mortality due to seine-netting relative to other fisheries, but this is also considered to be very small.

6. Diving observations and video footage revealed that the nets did not scrape the bottom but rode over the substratum, leaving the sediment undisturbed and passing over the majority of algae and invertebrates lying on it (Chapter 7). This has no measurable effect on the benthos as no significant differences in numbers or biomass of any epibenthic or benthic invertebrate or algal taxa were found between areas that were frequently and never swept by the nets.

These research findings indicate that seine-netting does not have any major detrimental effects on most fish stocks, nor on the ecological interactions in False Bay. Further, commercial beach-seine fishermen in False Bay are entitled to claim a historical right to "angling" species (Chapter 1).

Despite the fact that the results presented in this thesis indicate that seine-netting is not overly harmful, allowing the seine-fishermen to continue fishing as they have in the past would not resolve the conflict between this group and recreational anglers. The reason for this is that the allegations investigated in this study are not the underlying causes of the conflict. The conflict exists primarily because there is considerable overlap in the species composition of the catches of anglers and seine-fishermen, with 86% of the catches of shore-anglers consisting of species which are shared with the seine-fishery (Chapters 1 and 2). Catch rates achieved by anglers in False Bay and elsewhere on the South African coast have declined substantially over the past 20-30 years and, as seine-netting is a highly conspicuous operation which frequently results in much larger catches than any individual angler can hope to make (Bennett 1991, Chapter 1), it is blamed by anglers for their declining catches (Chapter 1). The majority of the species forming the "angling" component of the seine-net catch are currently considered to be in danger of overexploitation (Van der Elst and Adkin 1991), thus the crux of the conflict is that there are too many fishermen competing for a limited and diminishing resource.

The beach-seine and recreational fisheries are both justified in claiming access to the resource for which they are competing. A management policy needs to be formulated which takes into account the relative merits of each of these two fisheries in terms of their impact on the resource, value and number of participants. The current low proportion of the total catch attributable to seine-netting is a relatively recent phenomenon. This is so because of the exponential increase in angling effort, the reduction in the number of seine-net operators, and the outlawing of catches of "angling" species in all areas except False Bay in recent decades (Chapter 1). This means that mortality due to seine-net fishing may well have been a significant source of mortality that led to stock declines in the past. The lack of subsequent recovery may well be attributable to the increase in angling effort (Chapter 2).

The situation faced by managers is that the number of seine-net fishermen benefitting from a resource which is shared with the recreational fishery is relatively very small, only 7 operators and approximately 100 full time crew (Chapters 1 and 2). The total annual value of their catch in False Bay is also low, probably not having exceeded R 1.5×10^6 during the last 10 years (Unpublished data). Seine-netting in False Bay is not economically viable without "angling" fish which provide over 60% of the total value of the catch. In comparison, angling is an extremely important pastime both in financial terms and as a recreational pursuit (Van der Elst 1989). The number of South Africans who consider themselves recreational anglers is doubling approximately every

12 years and is currently estimated at 750 000 (Van der Elst and Adkin 1991) and there seems to be no acceptable way of curtailing this increase.

From the forgoing discussion it is clear that the controversy surrounding the False Bay beach-seine fishery will not be easily resolved. Management of this fishery is a complex issue which cannot be considered in isolation from the recreational and commercial linefisheries. The relative value of each of these fisheries in terms of socio-economic criteria needs to be assessed before the results of this study are used to allot proportions of catch and effort to them. The linefishery in the southwestern Cape is a multispecies, multi-user fishery and it is unlikely that an individual "culprit" will be found to be responsible for the decline of any species.

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