SNOEK *THYRSITES ATUN* IN SOUTH AFRICAN WATERS: ASPECTS OF ITS BIOLOGY, DISTRIBUTION AND FISHERY

BY

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DECLARATION

Raw data used in this thesis, with the exception of the diet and certain other biological information in Chapter 3, were collected by the Sea Fisheries Research Institute. Extraction and analysis of data, except where otherwise indicated in the text or in the acknowledgements, were performed by myself. None of this material has been submitted by myself for any other thesis.

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ABSTRACT

The snoek *Thyrsites atun* is an important fish predator in the southern Benguela region. It is exploited by both a handline and a demersal fishery. A survey of the Cape line fishery revealed that snoek line fishing effort is changing from the traditional harbour-based line-boat to the nomadic ski-boat. It was widely claimed that snoek catches are declining and that migration patterns are changing. Snoek constitute a by-catch of the hake-directed demersal fishery but nevertheless are seasonally important. The principle prey of snoek caught by handline off the Cape Peninsula were anchovy and mantis shrimp. Snoek caught in midwater trawls offshore were feeding primarily on anchovy, with pilchard, euphausiids and amphipods also important. Snoek trawled demersally had a more diverse diet, dominated by redeye roundherring, lightfish, lanternfish, hake, buttersnoek and euphausiids. Snoek were caught in the demersal environment throughout daylight hours, but may come off the bottom at night. The small degree of overlap between the diet of snoek caught demersally offshore and that of snoek caught in the pelagic zone, both inshore and offshore, indicates that snoek do not seem to move extensively on a diurnal basis between the two zones. Over the period 1970 to 1985 availability of snoek to the handline fishery was strongly seasonal, with catches peaking from May to July, although the traditional winter snoek run is a declining phenomenon along the South African coast. At Dassen Island, for which catch data have only been available since 1981, peak months were from November to January. The snoek seems to move offshore from July and is trawled demersally until September. The presence of snoek larvae offshore between June and September indicates an offshore spawning migration. With the exception of the summer presence in the region of Dassen Island, snoek appear to be present in the southern Benguela region between April and September. Handline catches of snoek have declined markedly since 1978, but demersal catches have remained more stable.

CHAPTER ONE: INTRODUCTION

The snoek, *Thyrsites atun* (Euphrasen), has long been of commercial importance in South Arica, with published catch records from as long ago as 1897 (Nepgen 1979). Gilchrist (1924) described the snoek as being of great economic importance, and Rapson *et al*. (1944) stated that it was the most important species caught by the inshore (line) fishery of South Africa. Whilst the economic status of the snoek has now diminished relative to other species, it remains an important component of the Cape line fishery and also contributes to both the local fish processing and fish export industries. In addition, snoek is caught as a by-catch of the hake-directed demersal trawl industry of South Africa. With regard to the southeast Atlantic as a whole, catches reached a peak of 80 000 t in 1978 before dropping to 32 006 t in 1982, 95% of the 1982 catch being trawled either demersally or in midwater (Crawford 1985).

Ecologically, the snoek has been identified as a major predator of pelagic fish with an estimated annual consumption of 280 000 t (wet) of Cape anchovy *Engraulis japonicus* in the southern Benguela system (Bergh *et al*. 1985).

Thyrsites atun is restricted to the southern hemisphere (Nakamura 1986), being notably absent from northern hemisphere upwelling systems. Aspects of snoek biology have been researched in both Australia (Blackburn 1950, 1957, 1960, Blackburn and Gartner 1954, Cowper 1966, Anon 1966, 1968a, 1968b, Grant *et al*. 1978, Winstanley 1979) and New Zealand (Mehl 1969, 1970, 1971, Webb 1973, Ford and Gauldie 1979, Robertson and Eggleston 1979, Robertson and Francis 1979, Robertson and Mito 1979, Strüik and Bray 1979, Gauldie and Johnston 1980, Sullivan 1981, Hurst 1983, Hurst and Bagley 1984a, 1984b, 1984c, 1985). There are also publications from other areas where the snoek is found, such as Chile and Peru (Movillo and Bahamonde

1971, Tanaka et al. 1979) and St Paul and Amsterdam Islands (Beurois 1976).

Despite the importance of snoek in the southern Benguela region, research on the species in this area has been patchy. The earliest scientific publications seem to be those of Gilchrist (1914a, 1914b, 1914c), in which the importance of the snoek as a commercial species (Gilchrist 1914a), the variable nature of snoek catches (Gilchrist 1914b) and aspects of the biology and population dynamics of snoek (Gilchrist 1914c) are discussed.

The well-known phenomenon of "pap" snoek, a degenerate flesh condition, was attributed to the protozoan parasite Chloromyxum sp. by Gilchrist (1924). Biden (1930) wrote extensively in popular style about the snoek, providing a fisherman's perspective of the species and its fishery. Rapson et al. (1944) carried out an analysis of the head, liver and intestinal oils of the snoek, both for the purpose of evaluation as a commodity and also, indirectly, as a means of monitoring seasonal changes in condition. Similar analyses were carried out on the flesh of the snoek by Van Wyk (1944). Skaife (1949) summarised the development of marine research to that time in South Africa, and provided a valuable account of the methods of collecting catch statistics employed between 1897 and 1948. His estimate of an annual national snoek catch of 20 000 000 lb for 1948 falls in the middle of a 20 year gap in published catches.

Davies (1954) put forward an hypothesis regarding the migration of snoek, and De Jager (1955) cited the unpublished work of Marchand (1934) pertaining to the tagging of snoek off Namibia, and detailed recoveries of tagged snoek made between 1935 and 1938 off the Cape coast of South Africa. De Jager (1955) also described the embryological and larval development of snoek from artificially fertilized eggs.

Snoek stomach contents have been used as indicators of the movements or presence of pilchards _Sardinops ocellatus_ in areas outside the commercial fishing grounds (Davies 1956). De Jager _et al_. (1963) caught snoek incidentally while longlining for tuna, and, having carried out a tuna diet study, identified the snoek as a possible competitor.

The existence of a closed season for the snoek fishery was defended by Nepgen (1975) on the basis of a relative condition factor. Van Dalsen (1977) devised an improved method for subsampling snoek eggs for fecundity studies.

The first detailed diet analysis of the snoek was carried out by Nepgen (1979a) who studied the stomach contents of 2971 snoek caught between 1958 and 1974. Of these, all but 156 were handline-caught, the remainder being trawled. Nepgen (1979a) presented his results in the form of frequency of occurrence only, and so neither the number nor weight of food items were considered. Pelagic fish were identified as the most frequently occurring food of handline-caught snoek, with a changeover from pilchard to anchovy as the predominant species occurring between 1964 and 1965. This changeover reflected the switch in availability of the two species to the purse-seine fishery.

Nepgen (1979b) assessed the trends in the line fishery for snoek in waters off the western and southwestern Cape, for the years 1970 to 1978. He expressed catch as a function of effort for three Cape harbours, although effort data (in the form of non-standardized boat days) were only available for days on which snoek were caught. Nepgen (1979b) also discussed recovery of tagged snoek, variations in size composition and condition of experimental line catches, and length-weight relationships. He concluded that over the period 1970 to 1978 there was a general increase in annual availability of snoek, but between 1958 and 1975 a decrease in mean length of the population, which he attributed to exploitation pressure but not overfishing. These conclusions were based on the measurement of small numbers of fish. Nepgen (1979b) demonstrated an increasing trend in snoek catches on the Cape south coast, but did not relate this to effort in that area.

A snoek diet study specific to False Bay was conducted by Nepgen (1982). Again, only frequency of occurrence was assessed, and anchovy constituted a substantial majority, being found in 89% of all stomachs containing food.

The observation by Nepgen (1979b) that in the mid-1970s snoek catches increased to the east of Cape Point has a parallel in the case of red roman _Chrysoblephus laticeps_ which also appeared to have increased in catches along the southern Cape coast (Crawford and Crous 1982). Crawford and Crous (1982) hypothesized that this may have been due to a long-term drop in inshore water temperature. Red roman, like snoek, are generally restricted to cooler waters.

Engelhardt (1985) believed that the South African snoek fishery had in recent years been adversely affected by imports of cheap snoek from other southern hemisphere fishing grounds and by "excessive exploitation of the species" in Namibian waters by foreign trawlers (Engelhardt 1985, p35).

The dietary importance to snoek of pelagic shoaling fish, particularly pilchard and anchovy, was established by Nepgen (1979a, 1982). The implications of this were the subject of a study by Crawford and de Villiers (1985). They investigated relationships between the distribution and abundance of the pilchard and anchovy and that of the snoek in the Benguela system. Links between prey and predator were demonstrated, including a positive relationship between anchovy biomass and an index of anchovy mortality attributable to snoek.

Snoek biomass and the species' annual consumption of various prey in the southern Benguela system have been estimated by Bergh et al. (1985). It was assumed that the biomass was about five times the annual catch, that snoek spend half the year in the southern Benguela region, and that this time was divided equally between inshore pelagic and offshore midwater and demersal feeding. The species composition of the demersal diet of the snoek was very roughly apportioned. On the basis of these assumptions an estimated snoek stock of 75 000 t (wet) was estimated to consume annually 280 000 t of anchovy, 80 000 t of pilchard and 85 000 t each of juvenile hake Merluccius spp., lanternfish Lampanyctus hectoris, lightfish Maurolicus muelleri and crustacea (euphausiids, stomatopods and amphipods).

A snoek production model was devised by Crawford (1985), using handline and total ICSEAF (International Commission for the Southeast Atlantic Fisheries) snoek catches for the years 1970 to 1983. It appeared that the snoek stock size had decreased by about 56% between the mid-1970s and the early 1980s, and according to the model the maximum equilibrium yield was now just under 35 000 t per annum. As a result Crawford (1985) suggested a total international snoek quota of 34 000 t per annum for the southeast Atlantic. This proposal was adopted in the same year (ICSEAF 1986). Crawford et al. (1987) have described both the trawl and handline fisheries for snoek in the Benguela region as a whole, and have published catches up to and including 1984.

The broad aim of this thesis is to synthesize existing knowledge of the biology and distribution of the snoek in South African waters, as well as to reassess recent catch trends.

A survey of the snoek handline fishery included a questionnaire presented to professional line fishermen and interviews with harbour masters and fisheries inspectors. Representatives of the trawling and fish processing industries were also interviewed with the aim of elucidating their attitude to snoek as a commodity.

Knowledge of the life history and distributional ecology of the snoek in South African waters is re-examined in the light of unpublished sources of data. These include detailed monthly line catches, demersal and pelagic catches from research cruises, larval distributions, results of a long-term blanket net survey and occurrence of snoek in seabird diets.

Dietary studies have been conducted, the majority of samples having come from demersal research cruises but with some handline and midwater-trawled samples as well. Feeding data have been presented as numerical percentages (%N) and percentage by weight (%W) of food items, as well as the frequency of occurrence (%F) used by Nepgen (1979a, 1982). In addition the degree of digestion of certain food items has been estimated, and this, together with information on time and depth of catch, allows inferences on feeding patterns.

Other biological aspects of the snoek are considered, including a comparison of length-weight relationships of trawled snoek with those given by Nepgen (1979b) for handline-caught fish, and the calculation of an otolith-length/width to fish-length regression. Periodic gonad weight data collected during biannual demersal research cruises are presented.

Finally, trends in snoek stock size are assessed in the light of various sources of data. Probably the most comprehensive of these is a time series of catch and successful effort data for the South African handline fishery for the period 1971 to 1985, data being available both by harbour and by month. The remaining sources of data are South African commercial trawl catches and ICSEAF catch statistics.

CHAPTER TWO: A SURVEY OF THE SOUTH AFRICAN SNOEK FISHERY

The snoek *Thyrsites atun* (Euphrasen) has long been of commercial significance in South Africa. An export trade to Mauritius for dried, salted snoek was established as long ago as the 1880s (Gilchrist 1914a). The fishery has traditionally been handline based and was concentrated on the coast west of Cape Point. In the mid 1970s demersal trawlers using a 110 mm mesh net began fishing for snoek commercially, and a substantial snoek fishery, both handline and demersal-trawl, now exists both west and east of Cape Point. In 1982 the landed value of handline-caught snoek off the western Cape was R3,3 million, and that of the South African demersal fishery R21,3 million (Anon. 1983, cited by Crawford and de Villiers 1985). The snoek was the third most valuable constituent of the 1984 offshore demersal fishery, after hake and kingklip (Chief Director, Marine Development 1984). The nominal weight of snoek caught by the South African demersal fishery in 1985 was 5 387 t (2,9% of the total demersal catch) and the estimated total South African landing by commercial and recreational line-boats was 3 493 t (Chief Director, Marine Development 1985).

In view of the obvious importance of snoek as a commercial species, and bearing in mind an apparent 56% decrease in the Southeast Atlantic stock size between 1975-1978 and 1982-1983 (Crawford 1985) it was decided to obtain the viewpoint of the fishing industry, both handline and demersal, of snoek as a commodity, and to investigate something of the mechanics of the fishery.

2.1 THE HANDLINE FISHERY

Twenty two harbours between Port Nolloth and Waenhuiskrans (Arniston) were visited during a survey carried out in October and November 1985. The broad aims of the survey were twofold; to obtain improved handline effort

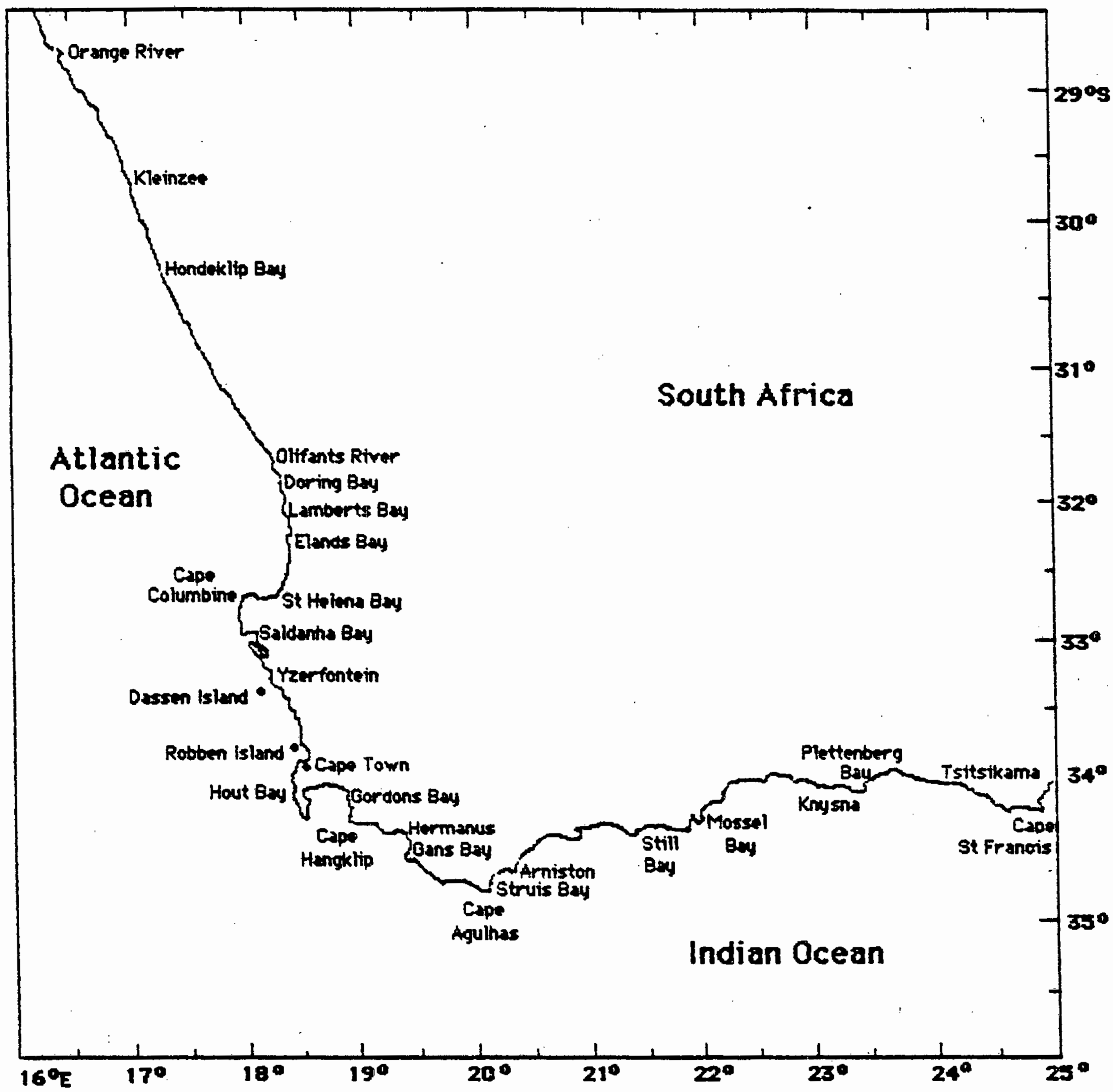


Fig. 2.1: The Cape west and south coasts, South Africa, with localities referred to in the text

information, and to question experienced fishermen on practical aspects of the snoek line fishery. The effort information is presented in Chapter 4.

Experienced line fishermen, or alternatively officials closely associated with the line fishery, were personally approached and interviewed following the guideline of a 55-point questionnaire which concerned both the snoek and the hottentot Pachymetopon blochii fisheries (see Appendix A). The hottentot survey is discussed elsewhere (Pulfrich in preparation)

A total of 36 people was interviewed, with individual experience in the line fishery ranging from 15 to 52 years. This was, of course, a survey of the subjective opinions of people closely associated with the fishery and it was decided not to quantify the information obtained. Instead, a synthesis of the responses is presented below, not to provide a definitive assessment of the snoek line fishery but rather to commit to paper the observations of those economically dependent, to a greater or lesser extent, on the species. Places mentioned in this and subsequent chapters are shown in Figure 2.1

2.1.1 SYNTHESIS OF SURVEY OF THE SNOEK LINE FISHERY

The handline fishery may be broadly divided into two groups according to boat type; the resident fleet at a harbour and the migratory ski-boat fleet. Resident fleets vary in composition from harbour to harbour, with boats ranging from 2-man dinghies, either with outboard motors or oars, through 6-10 man open motor boats to larger 16-24 man decked motor boats. On the west coast, most of these boats have a dual role, being primarily used for catching rock lobster Jasus lalandii during the months November to May. Some of the larger boats, such as those based at Lambert's Bay, are also involved in the tuna fishery. The fast and mobile ski-boat, with a crew of between 4 and 6 men, represents an important sector of the line fishery and is discussed in greater detail later in this chapter.

The fishermen interviewed had between them worked on each class of boat described above. The time spent each day travelling to the fishing grounds is locality dependent and varies between 10 and 135 minutes, with an average of approximately an hour. The distance travelled varies between 3 and 60 kilometers dependent upon the boat type. Some of the larger line-boats may translocate to a different harbour for a prolonged period, dependent upon the location of the snoek. Others may spend two or more days at sea, for example at Dassen Island, before returning to harbour.

In general no line-boat travels much more than 25 kilometers directly out to sea, with the average maximum being in the region of 6 kilometers. One ski-boat fisherman said he occasionally travelled in excess of 60 kilometers offshore, but this was unusual. In the region of Hout Bay and Witsand the narrowness of the continental shelf restricts snoek fishing to 2½ to 5 kilometers offshore. Snoek come right inshore, and may be caught from the shore at times although the best fishing occurs outside the kelp beds. The fish are not generally caught deeper than 35 fathoms (70 metres), although may be caught down to 100 fathoms (200 m). They occur throughout the water column, but are not caught as frequently on the bottom as in the midwater or at the surface. Shoals may be enticed off the bottom using baited hooks or lures. There seems to be no relationship between size of fish and depth of water in which they are found, within the inshore coastal waters in which most line-boats operate.

The time spent fishing each day, weather permitting, is extremely variable and may be anything from 2 to 11 hours, with an average of 6,5 h. This is dependent not only upon the quality of fishing on a particular day, but also on such factors as time travelling to and from the fishing grounds and the early afternoon deadline for offloading the day's catch for auctioning to the fish hawkers. Hawkers tend only to operate at harbours within relatively easy reach of Cape Town. The variability in time spent fishing renders the use of measures of effort such as "boat days" somewhat crude.

Snoek are generally caught either on baited hooks or with lures. Hook sizes are large, being in the region of 11/0 and 12/0 and occasionally 13/0. Bait used includes horse mackerel or maasbanker _Trachurus trachurus_, chub mackerel _Scomber japonicus_ and imported "Japanese pike", but mostly pilchard _Sardinops ocellatus_. The lure is known as a dolly or bokstang, and is a crude and gaudy construction consisting usually of brightly coloured strips of plastic attached to a lead weight and a hook (or hooks). Other versions use copper pipe, leather or shark skin as a lure. Sometimes a barbless hook may be used, enabling rapid removal of the fish, but this practice appears to be infrequent and is considered dangerous.

Snoek appear to feed throughout the day, although catches are often best in the early morning. They may also be caught at night, indicating day and night feeding. The west coast fishermen were virtually unanimous in identifying northerly to northwesterly winds which push in warm, clear water as providing optimal conditions, with easterly and southeasterly winds and cold, dirty water making for poor fishing. Warm, blue water is sometimes referred to as "snoek water".

With the exception of one interviewee, opinion was consistent that fishing has declined in recent years, particularly on the west coast. It must, of course, be borne in mind that it is the fisherman's habit to complain that things were better in the old days. Nevertheless in this case the claim appears valid in that Crawford (1985) reports a total South African handline catch of $10,7 \times 10^6$ snoek in the 4-year period 1976-1979, and only $3,2 \times 10^6$ snoek in the period 1980-1983. This represents a decline of 70%.

Despite the drop in catches, no decrease in size of fish was reported. Various reasons were put forward for the declining catches, including an increase in water temperature and altered patterns of migration. The most consistently blamed factor, however, was the activity of trawlers, both those fishing for snoek and those catching the principal food species of the snoek. Both local South African trawlers and "the Russians" off Namibia were considered culprits.

It should be pointed out that neither declining snoek catches nor the blaming of trawlers are unprecedented. Gilchrist (1914c) reports that there was a 15-year period, ending in 1907, when the snoek was very scarce, and one of the suggested reasons for this was the use of a single experimental Government trawler, the Pieter Faure. Snoek landings have fluctuated to a greater or lesser extent ever since records have been kept (Nepgen 1979b), making it difficult to ascertain whether decreases are due to natural causes or to exploitation.

The Cape fur seal Arctocephalus pusillus has long been a traditional enemy of the snoek fisherman (e.g. Gilchrist 1914c, Rand 1959). Mention of the seal during this survey never failed to elicit a fluent and voluble flow of vituperation. It appears that the major grievances of the fishermen are twofold. Although the seal is a natural predator of snoek (Rand 1959, David in press), it will also readily remove a snoek from a hook. Secondly, a fishing boat or fleet may have located a snoek shoal and be in the process of making large catches, when the subsequent arrival of one or more seals drives the shoal away. In addition, the practice of enticing a shoal to the surface is rendered impossible by the presence of seals. Regardless of the quantity of pelagic fish consumed by seals, and whether or not this significantly affects the fishing industry in any way, the disruptive influence of the seal on the line fishery deserves consideration.

Other piscivorous predators do not appear to be considered a threat to the snoek fishery. Dolphins are recognised as predators of pelagic fish, but only one interviewee cited the presence of dolphins as a negative influence on the catching of snoek. With regard to sea birds, neither penguins nor cormorants are considered to affect the fishery, and the gannet is widely recognised as an indicator of the presence of pelagic shoals on which snoek may be feeding.

Snoek are also reported to be readily identified by experienced fishermen with echo-sounders, a shoal of snoek producing a distinctive pattern resembling a collection of horizontal dashes.

2.1.2 MARKETING OF LINE-CAUGHT SNOEK

At every harbour visited, with the exception of Port Nolloth, snoek was said to be permanently in demand, with little difficulty encountered in selling a catch. The type of market, however, varied according to the locality of the harbour.

At many of the west coast harbours (i.e. west of Cape Point) the fishermen are dependent upon the local rock lobster factory for the provision of boats and, in some cases, fuel and bait. At such harbours the factory has first option on purchase of the catch, and in 1985 factories paid between R0.58 and R0.70 kg^{-1}. In 1985 sales direct to the public commanded prices of between R1.50 and R7.00 per fish (up to R2,50 kg^{-1}), dependent upon size of fish and proximity to Cape Town. Highest prices are paid in Cape Town.

Sales to the public are rarely made between St Helena Bay and Gans Bay. Instead, the fish are auctioned on the quayside to fish hawkers, who then sell to the public from the roadside in local urban centres. Fish-shop owners may also purchase at the auctions.

Fish processing factories in Cape Town used to purchase line-caught snoek for smoking, but no longer do so due to the high prices. Instead they now depend on fish caught by demersal trawl and snoek imported from New Zealand. Line-caught fish are still purchased by processors who dry and salt snoek for the export market, although the intermittent nature of catches renders this a difficult operation. Some of the line catch is frozen and transported inland where it is sold in the densely populated Reef area.

If one is to make a subjective and broad assessment of the economic importance of snoek to line fishermen, the picture varies according to geographic locality. The species diversity of line-fish on the west coast of South Africa is extremely low, with the only species occurring in any economically significant quantities being the snoek and the hottentot Pachymetopon blochii. This applies to the area between Port Nolloth and Cape Point, with the only exception being Saldanha Bay where catches of steenbras Lithognathus sp. and kob Argyrosomus hololepidotus are sometimes substantial. Other species caught throughout the area are either uncommon, such as chub mackerel Scomber japonicus and yellowtail Seriola lalandi, or unpopular, such as the jacopever (species uncertain; either Helicolenus dactylopterus or Sebastes capensis).

In addition to the low species diversity is the unpredictability of the movements of the snoek, a subject which is discussed below. As a result, few west coast line fishermen to the north of Cape Town depend totally upon snoek and hottentot for their livelihood. For the majority, secure income comes from the rock lobster industry, and line fishing is reduced to a supplementary role. This is not to underestimate the importance of the snoek as a valuable source of income during snoek "runs".

The situation is different on the Cape Peninsula and to the east where the number of full-time professional line fishermen increases markedly, although rock lobster remains extremely important on the west side of the Peninsula. To the east of Cape Point the number of commercially exploitable line species increases several-fold to include geelbek Atractoscion aequidens, kob, yellowtail, hottentot, carpenter Argyozona argyrozona and various red fishes, notably red stumpnose Chrysoblephus gibbiceps, red roman Chrysoblephus laticeps, and red steenbras Petrus rupestris, as well as snoek. The importance of snoek east of the Cape Peninsula diminishes with distance from Cape Town. The snoek is not a commercially important species east of Cape Agulhas, at least from the point of view of the inshore line fishery.

It is probably true to say that throughout the entire area between Port Nolloth and Cape Agulhas, if the snoek is present in large numbers it will form the prime target of the local line-fishery. This assumption is used in the calculation of successful effort for the handline fishery (Chapter 4).

2.1.3 THE SKI-BOAT

Ski-boats are defined as "partly decked motorized vessels with tilting propulsion gear so that they may be launched and brought ashore from beaches" (Chief Director, Marine Development 1982, p5). There are sufficient slip-ways in the western Cape to ensure that beach launching is normally unnecessary.

The significant feature of the ski-boat is its mobility. A trailer-borne boat may be rapidly towed to and launched at the harbour nearest to a reported concentration of snoek, and this constitutes a considerable advantage over the conventional line-boat. The ski-boat is not subject to the same geographical restrictions or fish distribution patterns as the more sedentary line-boat.

Although ski-boats have been in use locally for more than 20 years, it is only in the last few years that the number of commercial boats has begun to increase rapidly. Statistics relating to the number of licensed commercial fishing boats in South Africa are published annually (Chief Director, Marine Development 1984). Prior to 1980 there was no category for ski-boats specifically, but it was reported in 1976 and 1977 that there was increased registration of ski-boats along the Cape south and east coasts. For the area between Port Nolloth and Arniston the number of commercially licensed ski-boats increased by 48% from 579 in 1980 to 858 in 1984. Of the 1984 total, 74% are based in the vicinity of the Cape Peninsula, between Table Bay and Gordon's Bay, and a further 13% in the Saldanha Bay/St Helena Bay area.

Ski-boats are used by both commercial and recreational fishermen, with crews of approximately 6 and 4 respectively. It has been suggested that a growing interest in line-fishing as a sport, coupled with the need to partially recover costs by being able to sell catches, is largely responsible for the escalation in the number of commercial ski-boats. It has also been suggested that the economic recession of the 1980s has forced people into line-fishing as a means of making a living, and also that professional fishermen previously operating from the harbour-dependent conventional motor vessel have switched to the more efficient ski-boat.

The professional ski-boat operator is dependent upon snoek for a large proportion of his annual catch, and will travel considerable distances to launch his boat at the site of a reported snoek run. Harbour masters from as far apart as St Helena Bay, Gordon's Bay and Hermanus report queues of between 50 and 200 ski-boats waiting to use slip-way facilities.

It seems likely that this recently developed ability to concentrate intense fishing effort quickly and efficiently on a run of snoek may exert significant pressure on the stock. It should be remembered, however, that in the southeast Atlantic as a whole, handline catches only constituted 2,5% of the total 1982 snoek catch (Crawford 1985).

2.1.4 SNOEK MIGRATION PATTERNS AND ASSOCIATION WITH PELAGIC PREY

The main months for snoek fishing throughout most of the survey area are April and May, with catches declining in June. At several of the west coast harbours fishing was said to pick up earlier, i.e. in March. At Hermanus and Hawston, to the east of Cape Point, fishing is good until July. Large quantities of snoek were caught much further east, at Jeffreys and Plettenberg Bays, in October 1985, but this is an unusual occurrence.

A common thread in many of the interviews was that there has been an apparent change in the hitherto relatively predictable annual migration of the snoek. According to "traditional" snoek behaviour, in about February the fish move south from Namibian coastal waters into South African waters, where they move offshore in the region of Port Nolloth before being "blown" inshore further south, usually to the north of Lambert's Bay, by the northwesterly wind. The presence of a large seal colony at Kleinzee, just south of Port Nolloth, very low local water temperatures and poorly oxygenated water have all been proposed as reasons for the offshore evasion of the Port Nolloth region. From approximately Lambert's Bay the snoek continue to move southwest along the coast, being generally available in the western Cape and in prime condition in about March or April. They are thought to move offshore to spawn in late winter (June, July) before being "blown" back in, in vast numbers but in poor condition, in September and October. These are known as "maer" or "poor" snoek. The fish are believed to subsequently return to Namibian waters (Gilchrist 1914c, Biden 1930, Davies 1954, De Jager 1955).

It is now claimed that this pattern has been disrupted, with fish being available patchily and unseasonally, and even being present for most of the year in some areas. The line fishermen lay the blame for this disruption, if indeed it has occurred, squarely at the door of the trawling industry which is accused of netting "vast" quantities of snoek offshore, although only actually landing a proportion of this. Snoek is susceptible to a degenerative flesh condition which causes the flesh to become soft and milky, or "pap". The line fishermen believe that trawlers tow their nets for 3 to 4 hours resulting in much of the fish becoming crushed and pap, and that the damaged portion of the catch is then dumped. There is probably some substance to this allegation, but whether or not the practice is avoidable and whether the quantities concerned are substantial should be investigated.

At Dassen Island on the west coast the snoek is now caught virtually all year round, indicating the possible presence of a resident population. There is uncertainty as to whether the establishment of this "stock" is a recent development or merely reflects the fact that year-round fishing was not attempted previously. The current slip facilities at Yzerfontein, the nearest point on the mainland to Dassen Island, have only been in existence for the last few years. Prior to their construction, boats heading for Dassen came either from Saldanha Bay or Table Bay, or even further afield. At least one semi-professional fisherman believes that snoek have for a long time been perennially present at Dassen, and states that large line-boats from Hout Bay used to make infrequent trips to the island at various times of the year and were almost always guaranteed to catch snoek, weather permitting. Many professional ski-boat fishermen are heavily dependent on Dassen snoek catches, and would be affected if this "stock" were to collapse.

A second hypothesis with regard to the extended availability of snoek at Dassen Island is that the rocky and untrawlable ground constitutes shelter for the fish from trawlers. It has been postulated that the behaviour pattern of snoek has changed recently in that the fish are now scared off by the combined sounds of the engines of a fleet of line-boats, an apparent consequence of trawling pressure. One False Bay fisherman claims that the snoek now shelter on untrawlable grounds such as the area around Seal Island and "The Triangle" of rocks south of Cape Point.

It was also a relatively widely held idea amongst the fishermen interviewed that snoek now move in an onshore-offshore pattern rather than longshore.

A second "stock" which appears to be semi-resident and available to the fishery for much of the year is that present on the 72-mile bank off Struis Bay to the east of Cape Agulhas. This "stock" is exploited between November and May by large line boats which operate out of Hermanus and Kalk Bay and which remain at sea for several weeks at a time. The catch is cleaned and salted at sea, and then sold to fish processing factories. These fish are present during the time that the proposed northward migration (Crawford and De Villiers 1985) is thought to take place.

Occasional but substantial handline catches of snoek have been reported in the last 2 years from the Tsitsikama and Jeffreys Bay areas of the eastern Cape, areas well to the east of the commercial snoek line fishery. One line-boat skipper reported catching 4000 fish in 4 hours on the Tsitsikama Bank. Whether or not these catches continue remains to be seen, but it is interesting to note that Crawford and Crous (1982) report the eastward expansion of the ranges of other cold water species (e.g. red roman), and suggest the possibility of an environmental change resulting in cooler water temperatures along the southern Cape coast.

Another possible explanation of an eastward movement of the snoek, should such a movement in fact be taking place, may be diet related. The snoek preys heavily on pelagic fish such as the pilchard and the anchovy, and its distribution may be a direct reflection of those of these species, as suggested by Crawford and De Villiers (1985). It must be noted that eastern Cape fishermen are not traditionally snoek catchers, and it is the belief of some that the snoek have always been present in the summer in the Tsitsikama region but have simply never been exploited.

The question of whether snoek availability was directly linked to that of commercial purse-seine species was put to the fishermen. In all but one case it was categorically stated that there is no relationship between purse-seine catches and snoek catches i.e. if the purse-seine boats are making good catches in an area it does not follow that snoek are likely to be similarly abundant. It was, however, stated that the presence of birds feeding on a pelagic shoal does encourage fishermen to go and investigate the possible presence of snoek.

2.2 THE SNOEK IN THE DEMERSAL TRAWL AND FISH PROCESSING INDUSTRIES

The South African offshore demersal trawling industry is largely based on the Cape hakes *Merluccius paradoxus* and *M. capensis*, with other species being taken as by-catch. Apart from the hakes, the only other demersal species for which quotas are set are the sole *Austroglossus pectoralis* and, to the east of Cape Hangklip, the horse mackerel (A.I.M. Payne SFRI pers. comm.). In 1986 an international quota for snoek caught in the southeast

Atlantic was set at 34 000 t (ICSEAF 1986). Nevertheless substantial quantities of snoek are caught annually as a by-catch of the hake fishery, and are channelled into both local and export markets.

A representative from each of the different sections of the trawling industry and the fish-processing industry was interviewed informally. Each interviewee had a particular type of involvement and thus it would not be practical to report their information in a single account. Therefore the salient observations of each interviewee are presented separately. Finally, some of the interviewees asked that their company should not be named, and so all interviewees will for consistency remain anonymous.

2.2.1 Interviewee A: SA Deep Sea Trawling Association

Prior to 1974 there was no viable market for trawled snoek, largely as a result of prejudice against the species as a table fish. Snoek were, of course, caught by trawlers prior to 1974 as a by-catch, but only a small quantity was retained for the export market (salt snoek), the remainder being dumped. Large quantities of snoek were, however, caught as early as the mid-1960s by foreign trawlers operating off Namibia, and this apparently led to a drop in snoek handline catches.

Improved marketing has led to an increase in importance of the snoek to the trawl fishery. Snoek is now sold frozen, smoked or as prepared "braai-packs" on a national scale, made possible by the marketing infrastructure of the trawling company concerned. The individual line fisherman does not have the same capability, although he could theoretically sell to a processing company. In addition, while a line-caught fish is boated in better condition than the trawled fish, the superior handling capabilities of the trawl industry ensures that a superior product reaches the consumer.

Line fishing is a more marginal operation than trawling, and the semi-specialist snoek line fisherman is more susceptible to stock reductions and fluctuations than is the trawler. In short, it appears that the traditional handline fishery is in what may be a terminal decline, with the ski-boat representing the only healthy sector of the fishery.

It is the belief of some experienced fishermen that the line-caught and trawled snoek represent two separate stocks, the line-fish appearing to be generally bigger and in better condition. This has not been scientifically tested, and is inconsistent with the belief of the line fisherman that trawlers are responsible for the decline in line catches.

2.2.2 Interviewee B: Senior Representative of Large Trawling Company

Snoek has never been a target for the trawling industry. After earlier resistance by a broad sector of the consumer market to eating snoek, the species has become more generally accepted over the last decade. Despite this, only about 10% of the hake quota is permitted as by-catch. The trawling company is primarily geared for the hake fishery, and cannot afford to target in on minor species. Having said this, the prime season and areas for snoek catching are well known, and any snoek caught within the prescribed limit will be fully utilized, although not at the expense of the hake. The trawling industry has been warned that abuse of the by-catch regulations may result in a reduction of the hake quota, and state inspectors monitor catches as they are off-loaded.

During the past 2 years the South African Deep Sea Trawling Association has embarked upon a concerted campaign to educate the consumer into buying fish. Its status remains third behind red meat and chicken, but the gap appears to be closing. Virtually all species caught by the trawlers are marketed somehow. Earlier, unpopular species were distributed as rations for farm labourers or sold to lower income communities who were traditional fish eaters.

The snoek is a far less versatile consumer commodity than the hake, and is limited in the number of forms in which it can be marketed. It has nevertheless gained considerable popularity both in smoked form and as a candidate for the traditional South African "braai" or barbeque.

2.2.3 Interviewee C: Senior Representative of Second Large Trawling Company

The attitude of this company to the snoek could be summed up as "the less caught the better". Incidental by-catches of snoek are generally sold to fish processing companies, some of which export the fish in salted form.

The education of the public into eating fish pertains mainly to white fish (hake, kingklip *Genypterus capensis*) and not to snoek. The western Cape consumer buys whole line-caught snoek, whereas the average city-dwelling consumer in the remainder of the country is unfamiliar with the species. Thus the national market for snoek remains small, from the perspective of the large trading company.

2.2.4 Interviewee D: Major Snoek Export Company

This company is involved in the export of salt snoek to buyers such as Mauritius and Reunion. The snoek is "well cured", in that it is salted while lying on a stack for 4-6 weeks. At the end of this period it has lost most of its so-called "drip-and-running", in that it is not dry, but contains no "loose" moisture. It is usually marketed with a 40-45% moisture content. The flesh takes on a yellow-red colour, the shade being related to the oil content.

Traditionally, salted snoek for both the local and export markets came from the handline catches at Walvis Bay, Namibia. Namibian snoek is oilier and fatter, and on curing, redder than Cape snoek. In fact, buyers request "red, oily snoek". Cape snoek tends to be whiter and less oily, and generally in poorer condition.

The supply of handline-caught snoek from Walvis Bay has recently diminished substantially, apparently due to the activities of foreign trawlers. The fish available to this company now comes from the Cape line fishery or in frozen form from the trawl fishery. Trawled snoek is frequently "pap", and therefore a risk.

The apparent trend in the snoek export market has been that supply has decreased and prices have subsequently risen, with the result that the demand has dropped. Supply has now met demand on the export market. A recent casualty has been the Central African market, a former major customer. With poor handling and storage facilities this market was dependent upon rapid turnover to prevent the fish from spoiling, but the current high prices have increased turnover time beyond the critical level.

A further difficulty encountered by the exporter of salt snoek is price fluctuation resulting from supply fluctuation, rendering it impossible to establish a contract price with a customer.

2.2.5 Interviewee E: Major Fish-Processing Company

There has recently been a decline in snoek consumption in South Africa, probably due to reduced supply and hence increased prices. Despite this, local catches cannot meet the demand for processed snoek.

The South African stock size and the size of the fish have decreased in recent years. This is thought to be due to the activities of Russian and other trawlers off the Namibian coast. In the last few years a 3 kg line-caught snoek landed at Hout Bay has risen in price from R0.80 to R5.00-R7.00. A local up-market retail store chain is selling fresh snoek, cleaned but not boned, for R8.00 kg^{-1}, which places the snoek in the same price bracket as good quality red meat.

In past years this processing company could depend entirely upon fish landed in Hout Bay. In 1985, however, only 2-4 t of snoek were obtained there, amounting to one day's processing. This is partly due to the scarcity of snoek pushing up the price, such that the fish hawkers are now able to outbid the processor at quayside auctions. The willingness of the public to pay more for fresh fish has resulted in hawking becoming a lucrative business. Despite this, the handline catch of snoek is simply insufficient to keep the processors supplied. In addition, the South African trawlers cannot supply on demand, their prices are high and their quality tends to be poor.

This processing company has not relied upon the supply of South African snoek for the last three or so years. The bulk of their supply is trawled, either off Namibia by foreign (e.g. Portuguese) trawlers, or in New Zealand waters, the latter having predominated recently. Not only is the conspecific New Zealand snoek (barracouta) of a higher quality it has also, thus far, been a more predictable supply and less expensive. South African snoek has a far higher incidence of parasites such as Chloromyxum sp.

The importation of trawl-caught snoek from New Zealand has only taken place over the last 2-3 years, at a rate of about 100 t per year. Supply is potentially problematic because the New Zealand trawlers are concentrating on other species, so it is necessary to charter a boat to catch snoek. In 1985 the New Zealand snoek catch was not good, but it is still too early to comment on the long-term viability of the source.

The snoek constitutes about 25% of the product of this company. "Pap" and poor quality snoek is salted, with the prime snoek being used for up-market products. These include:

- Mild-cured - brined then frozen and sold in braai packs
- Smoked - hot and cold smoking, the former meaning that the fish is actually cooked
- Snoek biltong - salted and extensively dried

The recently increased acceptance of fish by the consumer is less a result of the ongoing education campaign by the S.A. Deep Sea Trawling Association than the vastly improved handling of the fish by the big trawling companies, particularly with regard to the hake. Shorter trawling times, faster hauling and regular and frequent discharge of the iced catch result in very high quality fish. In addition, attractive and convenient packaging of the ready-to-use product appearing on the retail market has improved the standing of fish in the eyes of the consumer. The big fish trading companies have recently developed an efficient system of trucking fresh fish to major inland markets, especially from Mossel Bay on the Cape south coast.

2.2.6 Interviewee F: Fishing Industry Research Institute (FIRI)

There is no law with regard to either inspection or specifications of salt snoek for the export market. There was a lengthy period prior to 1973 when the Fisheries Act required all exported snoek to be inspected and to have attained a particular standard of quality, but this is no longer in force.

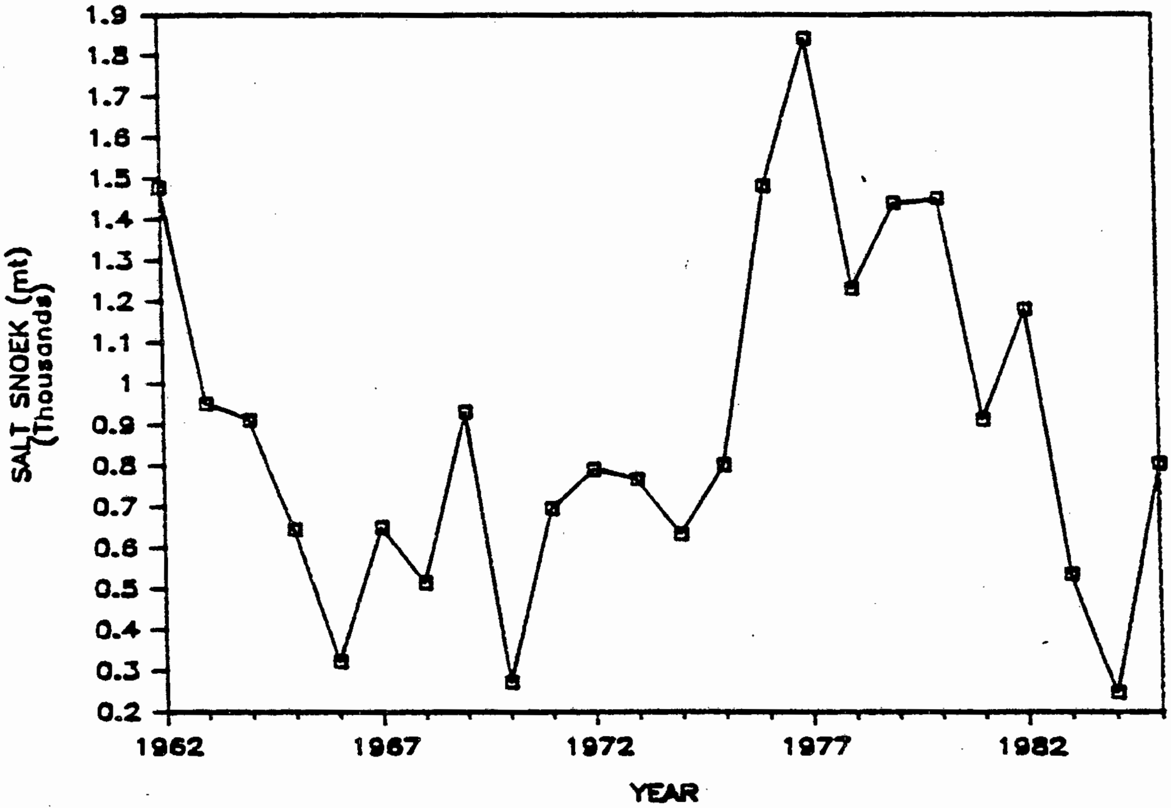


Fig. 2.2: Salt snoek inspected by the Fishing Industry Research Institute prior to export

The industry-backed FIRI is, however, sometimes approached by exporters to carry out inspections for a number of reasons:

i) Certain harbour authorities will not release containers for the packing of fish unless the fish have been inspected. This seems to have been a consequence of the Salmonella sp. scare of 1984, when consignments of the locally produced "rooibos" herbal beverage were found to contain the pathogen. Ironically, FIRI only inspects for halophilic decomposers and not pathogens.

ii) An inspection certificate clears the exporter of liability should a consignment spoil during shipment.

iii) Some importers demand an inspection certificate.

In addition to the major markets of Mauritius and Reunion, small quantities of salt snoek have been exported to Australia, Britain, France, Sri Lanka and Zimbabwe.

Zaire is one of the main importers of dried and salted fish from South Africa, but requires a moisture content of less than 35% due to the rapidity of decomposition in humid conditions. Snoek is not specifically dried, but merely salted and stacked, the pressure of the stacks forcing the moisture out. Hence the moisture content is not as low as 35%.

It is not possible to quantify the proportion of total salt snoek exports inspected by FIRI, nor whether this proportion remains relatively constant from year to year. Nevertheless the quantities of salted snoek sampled and passed for export by FIRI since 1962 are presented in Figure 2.2. It is interesting to note that there was in fact an upswing in inspected exports after 1973, coinciding with the period when inspections were no longer obligatory. The steady decline after 1977 follows the trend in decreasing South African catches discussed by Crawford (1985), and the 1985 increase may reflect the 1984 Salmonella sp. scare, with the consequent increase in demand for inspections.

2.3 CONCLUSIONS

The snoek is one of the two most important species in the west coast handline fishery, and periodically takes precedence to the east of Cape Point as well. The handline fishery may be broadly divided into two categories with regard to boat type; the conventional harbour-dependent dinghy and motor boat on the one hand, and the ski-boat on the other. Both categories operate inshore in the majority of cases, and the degree of economic reliance on the snoek, while variable, is relatively high.

The fishery is characterized by tradition and established technique. It is therefore reasonable to treat reports of declining catches and atypical distribution patterns with concern. While the broad pattern of seasonal availability still holds in general, with catches peaking in May and June in most areas, unseasonal catches and year-round availability appear to be on the increase. Only careful monitoring of catch statistics will confirm or refute these claims.

Cause of depletion of the South African snoek stocks was most widely attributed by the handline community to the activity in recent years of trawlers operating in Namibian and South African waters.

In the last ten or so years, relatively large quantities of snoek have been caught on handlines to the south and to the east of Cape Agulhas. Whether these fish have always been present but previously unexploited is unknown. Alternatively, the possibility cannot be ruled out that an eastward expansion of the distribution has occurred. It would be premature to draw conclusions, as incidental catches from Arniston and Still Bay are well known, and some from as far east as Port Elizabeth have been documented (Gilchrist 1914c).

The snoek is caught as a by-catch by the largely hake-directed South African demersal trawl fishery, and therefore only constitutes a few percent of the hake quota. It is nevertheless fully utilized when caught, and ranks third in value to the industry after hake and kingklip (Chief Director, Marine Development 1984).

An export market for salt snoek has been in existence since the last century. It appears that fluctuating and diminished supplies are having an adverse effect on this market.

Snoek products form a substantial portion of the output of local fish processing companies, with increasing consumer demand locally. High prices, poor quality and uncertain supply of locally caught snoek have resulted in the importation of the species in recent years from New Zealand.

CHAPTER THREE: SNOEK DIET IN SOUTH AFRICAN WATERS, WITH BRIEF CONSIDERATION OF OTHER BIOLOGICAL FACTORS

The most comprehensive study of snoek feeding in South African waters was conducted by Nepgen (1979a, 1982), who showed that anchovy *Engraulis japonicus* occurred most frequently in the diet of line-caught fish, and lantern fish *Lampanyctodes hectoris* and juvenile hake *Merluccius* spp. in the diet of trawled snoek. Nepgen (1979a) showed that changes in the abundance of three food items, pilchard *Sardinops ocellatus*, anchovy and mantis shrimp *Lysiosquilla armata capensis* were reflected in their frequency of occurrence in the food of line-caught snoek. Crawford and De Villiers (1985) also showed a relationship between the diet of the snoek and the abundance of its prey species.

The findings of Nepgen (1979a, 1982) have been used in an estimate of prey consumption by snoek (Bergh *et al*. 1985) and to obtain a relative index of prey consumption (Crawford and De Villiers 1985), although the work of Nepgen only refers to frequency of occurrence of prey species in snoek stomachs. Nepgen's results cover 2253 snoek stomachs from line-caught snoek containing food (Crawford and De Villiers 1985), but only 87 snoek stomachs containing food were studied from demersally trawled snoek.

In this study the contents of snoek stomachs obtained from research cruises conducted by the Sea Fisheries Research Institute (SFRI) using demersal and pelagic trawls were studied in order to supplement the work of Nepgen (1979b), and to provide a more quantitative analysis of the diet of trawled snoek. In addition, small samples of handline-caught snoek stomachs from three different localities were analysed.

Routine biological studies of snoek were carried out during demersal research cruises conducted by the SFRI. No more than ten snoek were sampled per trawl. Data were obtained from three summer cruises and three winter cruises conducted between January 1983 and January 1986. Length-weight relationships, sex ratios, gonad maturity indices and a total length (Lt) to fork length (Lf) relationship were calculated from these data and are presented here. Finally, otoliths extracted from the skulls of the trawled snoek used in the diet study were measured and regressions were calculated of otolith length/width to fish length.

3.1 SNOEK DIET

3.1.1 LABORATORY METHODS

Snoek caught in demersal and pelagic trawls were weighed whole and measured before the head and gut were removed and frozen. Demersal-trawled snoek came from two research cruises, one conducted in July 1985 and the other in January 1986. The distributions of the catches are shown in Figure 5.11. The samples from midwater trawls were obtained during three pelagic research cruises conducted in May 1985, May 1986 and June 1986 respectively. The approximate distributions of these catches are given in Figure 5.7. Stomachs from handline-caught snoek were obtained from fish hawkers either at Hout Bay harbour or, in the case of the sample from Yzerfontein, at a roadside selling point. No lengths or weights of the snoek were obtained in either of these cases. Finally, a sample from the Luderitz area was caught by handline during a research cruise, and was treated in the same manner as the trawled snoek.

Stomachs were defrosted in the laboratory and the total (wet) contents of each stomach were weighed on a top-pan balance to one hundredth of a gram. For the first one hundred stomachs each emptied stomach was cut along its length and washed out over a sieve to dislodge any loose otoliths or squid beaks. As no additional otoliths or beaks were obtained by this method the practice was discontinued. In fact, during the entire study (380 stomachs containing food), on only one occasion were otoliths found without additional accompanying remains of the fish prey. This suggests that for the prey species fed upon by snoek, the otolith may not be the most digestion-resistant part of the prey fish.

The wet stomach contents were then separated into species and each species was counted and weighed. Where possible the standard length (Lc) of teleost prey items was measured. Separation into species was possible even when a species was not immediately identifiable because in any one stomach sample generally only one, two, or occasionally three species were represented. In addition the low species diversity of prey items lent itself to ready recognition of all but extensively digested stomach contents. Otoliths were extracted from both identified and unidentifiable teleosts for later positive identification. Loose otoliths were also collected, and in view of the factors described above it was usually possible to match these with unidentified fish remains. Where this was not possible unidentifiable fish remains were recorded as such. The degree of digestion of teleost prey items was rated according to the scale given below.

Digestive State	Description
1	Intact
2	Greater than 50% intact and head recognizable
3	Greater than 50% intact and head not recognizable
4	Less than 50% intact
5	Spine separate with loose flesh in gut
6	Spine only with no loose flesh

The distinction between states 2 and 3 resulted from the fact that in the great majority of cases the heads of teleost prey items were digested first. There is subjectivity in the scale but all allocations were undertaken by the same person. Squid beaks, unlike otoliths, were retained in snoek stomachs after the remainder of the animal was digested. These were kept for identification.

All retained otoliths and squid beaks were sent to the Benguela Prey Identification Service at the Port Elizabeth Museum, as were a few whole fish, squid and crustaceans. Most of these were identified by staff of the P.E. Museum.

3.1.2 DATA ANALYSIS

The presence of prey items in snoek diet has been quantified in three different ways; by frequency of occurrence (%F), percentage by mass (%M) and percentage by number (%N) (e.g. Hyslop 1980, Smale 1983). In the first, %F, the number of snoek stomachs containing a particular prey species is expressed as a percentage of the total number of stomachs containing food. In the second, %M, the combined mass of a prey species from all stomachs is expressed as a percentage of the total mass of stomach contents. Finally, %N is the combined number of individuals of a prey species present in all stomachs in a sample expressed as a percentage of the total number of individual prey items.

Euphausia lucens and, in one case, *Parathemisto gaudichaudi*, were not included in %N calculations because the numbers concerned were two orders of magnitude greater than those for other secies. For example a single snoek contained over 2000 *E. lucens*. Squid beaks retained in a gut with no accompanying flesh were not included in %M calculations. They should strictly have been omitted from %N and %F as well, but were included to provide added information as to the variety of snoek diet.

Difficulties and biases exist in each of the three methods described above, as discussed critically by Hyslop (1980), and all three are used to provide maximum information. It is possible to combine the three values to obtain an index of relative importance, IRI, of each species (Pinkas et al. 1971), but Hyslop (1980) questions the value of the term as it simply combines various sources of error. IRI values have therefore not been calculated in this study.

Berg (1979) cites Hureau (1969) as defining the fullness index, Ir, of a fish stomach as

$$I_r = \frac{\text{weight of ingested food} \times 100}{\text{weight of fish}} \%$$

Fullness indices were calculated for all snoek on which routine biological measurements were made during six demersal trawl cruises of the RS Africana conducted between January 1983 and January 1986. (No biological studies of snoek were made during the January 1985 cruise). These Ir values were plotted separately against the time of day when the fish was caught and against the depth of the trawl in order to investigate feeding behaviour. For the purposes of this analysis no more than ten snoek were sampled per trawl, and empty stomachs were included.

A second method of investigating feeding time is to plot the degree of digestion of prey items in a snoek stomach against the time of day of the catch and against the depth of the catch. This was done for snoek caught by demersal trawl in July 1985, in January 1986, and for the combined catch of snoek by midwater trawl in the cruises of May 1985, May 1986 and June 1986.

A scatter plot of the standard lengths (Lc) of teleost prey items against predator fork length (Lf) was made. Data from the two demersal and three pelagic cruises mentioned above were combined in a single plot. Only those prey items which were directly measurable were used, i.e. no lengths obtained from otolith diameter to fish length regressions were included. The reason for this was that although the Benguela Prey Identification Service provided these lengths for all measurable otoliths sent to them, not all otoliths had been extracted from the snoek stomachs but only those required for the purposes of identification. (For the same reason reconstituted masses were not used in the calculation of %M).

3.1.3 RESULTS AND DISCUSSION

The occurrence of different prey species in the diet of snoek is expressed as %F, %M and %N (see Table 3.1). The stomach contents of snoek sampled by different means or at different times are expressed separately.

It is immediately apparent that the suite of prey species differs substantially between snoek caught by demersal trawl and snoek caught by midwater trawl or by handline. While some species were found in stomachs obtained by all three methods, little similarity exists between line-caught and demersally-trawled snoek, with midwater trawled snoek showing slightly more overlap than line-caught snoek with those caught demersally. It is likely that at least some snoek taken by demersal trawl will have been caught while the net traversed the pelagic zone on descent and ascent.

Smale (1983) regarded principal prey as those contributing more than 4% to the diet in more than one method of analysis. By this definition the principal prey of snoek caught by handline off the Cape Peninsula in the months of June and August 1985 numbered two or possibly three species, _Engraulis japonicus_, _Lysiosquilla armata capensis_ and possibly _Gonorhynchus gonorhynchus_, although the latter was not positively identified. The dominance of the anchovy agrees with the findings of Nepgen (1982) for the

Table 3.1: The prey of *Thyrsites atun* taken in various habitats and seasons between June 1985 and June 1986; totals are number of stomachs containing food (F), overall wet mass of prey (M)(g) and overall number of prey items (N).

Prey	Demersal July			Demersal January			Midwater May/June			Penins. line June/August			Yzerfontein line November			Luderitz line April		
	%F	%M	%N	%F	%M	%N	%F	%M	%N	%F	%M	%N	%F	%M	%N	%F	%M	%N
OSTEICHTHYES																		
Unidentified fish	9.2	2.0	2.6	17.5	2.4	9.5	5.4	1.6	0.6	17.6	2.3	4.2	14.3	17.4	4.8	16.7	5.3	23.5
Lampanyctodes hectoris	9.2	8.2	42.5	15.0	2.6	32.5												
Unidentified myctophidae	2.5	0.5	3.9	2.5	0.1	2.0												
Merluccius paradoxus	5.0	18.0	1.1	16.2	27.2	8.5												
Merluccius sp.	2.5	2.2	0.6	5.0	9.9	2.5												
Lepidopus caudatus	13.3	15.5	5.4	6.2	6.7	3.0												
Etrumeus whiteheadi	25.0	23.5	5.6	30.0	35.5	22.0	1.8	1.0	0.6	2.0	0.3	0.4				75.0	94.5	70.6
Maurolicus muelleri	25.8	4.6	33.1	6.2	0.2	6.5	2.7	2.9	12.9									
Merluccius capensis	3.3	5.0	0.7	1.2	0.3	0.5				3.9	1.8	0.8						
Engraulis japonicus	0.8	2.8	0.4				88.2	81.8	83.9	52.9	61.2	70.5				8.3	0.3	5.9
Sardinops ocellatus	2.5	3.7	0.6				4.5	5.5	0.7	3.8	3.0	1.5						
Chelidonichthys capensis	2.5	6.5	0.6							2.0	2.5	0.4						
Trachurus capensis							4.5	0.9	0.7	5.9	1.8	1.1						
Sufflogobius bibartus							2.7	2.4	0.4									
?Gonorhynchus gonorhynchus										5.9	4.5	1.1						
Diaphus sp.										2.0	1.7	0.4						
Scomberesox saurus				11.2	13.1	12.0												
CEPHALOPODA																		
Unident. squid	0.8	0.8	0.2															
Lolliguncula mercatoris							0.9	0.0	0.1	3.9	0.3	0.8						
Loligo vulgaris/reynaudi	1.7	0.4	0.4															
Unident. squid (beak only)	1.7	-	0.4							7.8	-	1.5						
Ommastrephes bartrami (beak)	0.8	-	0.2															
L. vulgaris/reynaudi (beak)	0.8	-	0.2															
CRUSTACEA																		
Unident. crustacean													9.5	0.2	2.4			
Unident. shrimp	0.8	-	0.2							3.9	0.7	1.1						
Unident. Hyperiidae	0.8	-	0.4															
Hyperiella sp.	0.8	-	0.2															
Lysiosquilla armata	1.7	0.3	0.4				1.8	0.2	0.2	29.4	20.1	16.1	57.1	58.4	92.8			
Euphausia lucens	21.7	5.8	-	12.5	1.5	-	5.4	3.5	-				28.6	24.0	-			
E. hansoni							0.9	0.0	0.1									
Parathemisto gaudichaudi				2.5	0.2	-	5.4	0.3	-									
Hermit crab	0.8	0.1	0.2															
ASCIDEA																		
Morula sp.				2.5	0.1	1.0												
TOTALS	120	5811	535	80	6272	200	110	3439	989	51	1342	261	7	473	42	12	324	17

years 1979 and 1980, but Nepgen (1982) found that the pilchard Sardinops ocellatus ranked second in frequency of occurrence which was not the case in this study. In a single small sample (seven stomachs) collected at Yzerfontein in November 1985 mantis shrimp and the euphausiid Euphausia lucens accounted for the bulk of the diet. The mantis shrimp was reported by Nepgen (1979a) as being important in 1971, but relatively insignificant in other years. The findings of this study indicate that mantis shrimp is again an important species in the diet of snoek in the inshore region.

A small sample of stomachs (12) from line-caught snoek obtained offshore of Luderitz, Namibia, contained redeye roundherring and anchovy.

The most important species in the diet of snoek caught in the pelagic zone by midwater trawls in the months of May 1985, May 1986 and June 1986 was the anchovy. This species constituted over 80% in each of %F, %M and %N. Other principal species were pilchard, euphausiids and the amphipod, Parathemisto gaudichaudi.

The diet of demersally-trawled snoek showed a greater species diversity and less dominance by one or two species. Important winter species were redeye roundherring Etrumeus whiteheadi, lightfish Maurolicus muelleri, lanternfish, the hakes, buttersnoek Lepidopus caudatus and the euphausiid E. lucens. In summer the same species dominated, although the relative importance of the species differed. The most notable change was a substantial drop in the importance of the lightfish. In winter redeye roundherring and lightfish were the most important species, and in summer redeye roundherring. An important species, not found at all in the winter sample, was garfish Scomberesox saurus. Anchovy and pilchard were completely absent in summer and rare in winter.

Line-caught snoek in Australian waters preyed principally upon the

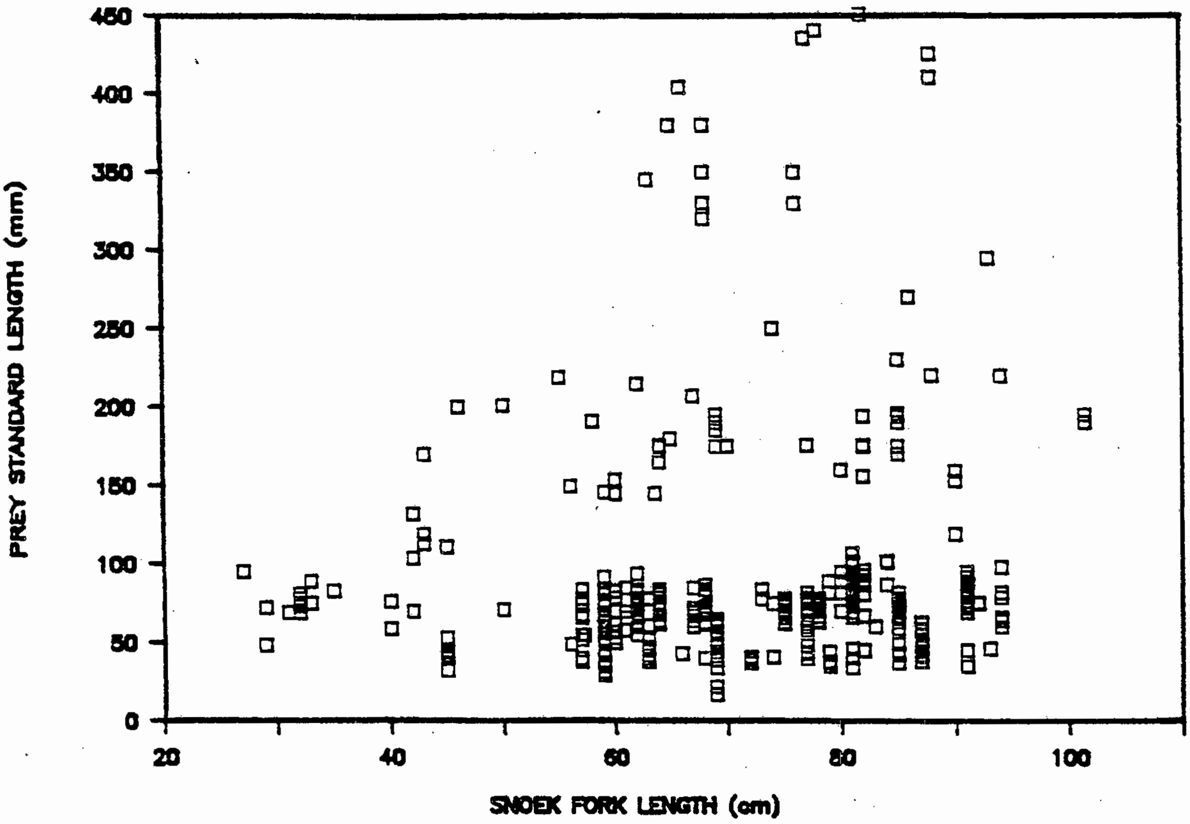


Fig. 3.1: Scatter diagram of teleost prey standard length against snoek fork length (n=484 data pairs)

euphausiid Nyctiphanes australis, anchovy Engraulis australis, young snoek and sprat Clupea bassensis (Blackburn 1957, Winstanley 1979). In New Zealand, snoek trawled in waters of between 80 and 240 m depth were found to be feeding primarily on N. australis in winter and the teleost Macruronus novae-zelandiae in summer (Mehl 1969). Beurois (1976) reported large numbers of the planktonic larvae of Jasus paulensis in line-caught snoek at St Paul and Amsterdam Islands, and also cited the work of Movillo and Bahamonde (1971) who found Clupea, Engraulis, Euphausia and Nyctiphanes dominating the diet of snoek caught off the Chilean coast.

A scatter diagram of the standard length (Lc) of teleost prey found in snoek stomachs against the fork length (Lf) of the snoek containing the prey reveals that the majority of teleost prey are between about 25 and 100 mm long regardless of predator size (Fig. 3.1). Prey items of this size range are taken by all snoek between about 30 and 95 cm, but longer prey tend only to be taken by the larger snoek and maximum prey size increases with predator (snoek) size.

In order to investigate snoek feeding with regard to time of day a scatter diagram of fullness index against time of catch was plotted (Fig. 3.2a). The data concern a total of 682 snoek sampled during biannual demersal research cruises conducted between July 1983 and January 1986. (No snoek biological data were collected during the January 1983 and January 1985 cruises). The percentage of stomachs containing food at hourly intervals throughout the day is shown in Figure 3.2b. While feeding appears to occur throughout the day there is an increase in the afternoon. No samples were collected between 18h00 and 06h00 so the night-time situation is unknown. It must be emphasized that these findings pertain to the demersal/bathypelagic environment only.

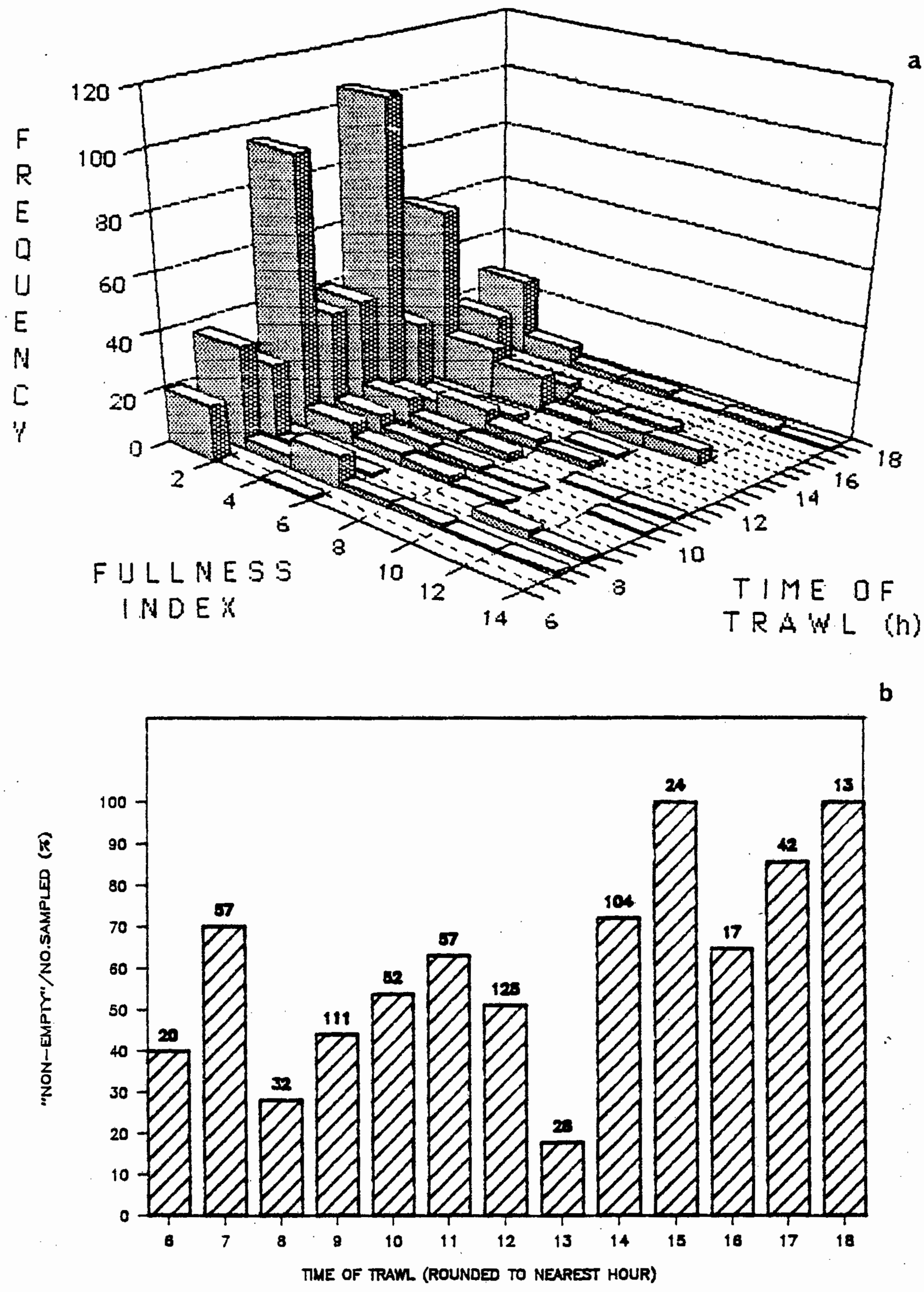


Fig. 3.2: (a) Scatter diagram of fulness index against time of catch; (b) percentage of stomachs containing food per hourly interval; figures above each histogram are sample sizes (Σn=628)

There does not appear to be much relationship between stomach fullness and depth of trawl within the demersal environment (Figs 3.3a,b). Although snoek are most abundant at a particular depth range (Chapter 5), they appear to feed at all depths at which they are found. There is a suggestion of greater stomach fullness (Fig. 3.3a) and of a greater proportion of stomachs containing food (Fig. 3.3b) at shallower depths, but there is much variability.

The digestive state of teleost prey items was related to the time and depth of the snoek catch (Figs 3.4 and 3.5). The data are from snoek caught during two demersal cruises, one in July 1985 and the other in January 1986. Ideally summer and winter should be considered separately but the sample sizes are too small to justify this. As can be seen (Fig. 3.4), all digestive states were found scattered between 06h00 and 18h00, which provides supporting evidence for the suggestion that feeding appears to occur throughout the day (Fig 3.2). Again, no samples were obtained during the night. Similarly all digestive states were found scattered over the depth range sampled, indicating that snoek feed over the whole range (Fig. 3.5).

A similar analysis of snoek feeding in midwater should prove fruitful. Nepgen (1979a) stated that handline-caught snoek feed in the early morning and then again in the evening, which is in poor agreement with the findings of this study in which all-day feeding with an increase in the afternoon was apparent. Snoek caught by handline are feeding in the epi/mesopelagic zones, whereas those in this study were feeding in the bathypelgic/demersal zones. Midwater research trawls are conducted both day and night, and with a larger data set it would be useful to compare the feeding cycle of snoek caught by these with the findings of Nepgen (1979a) and with those of this study.

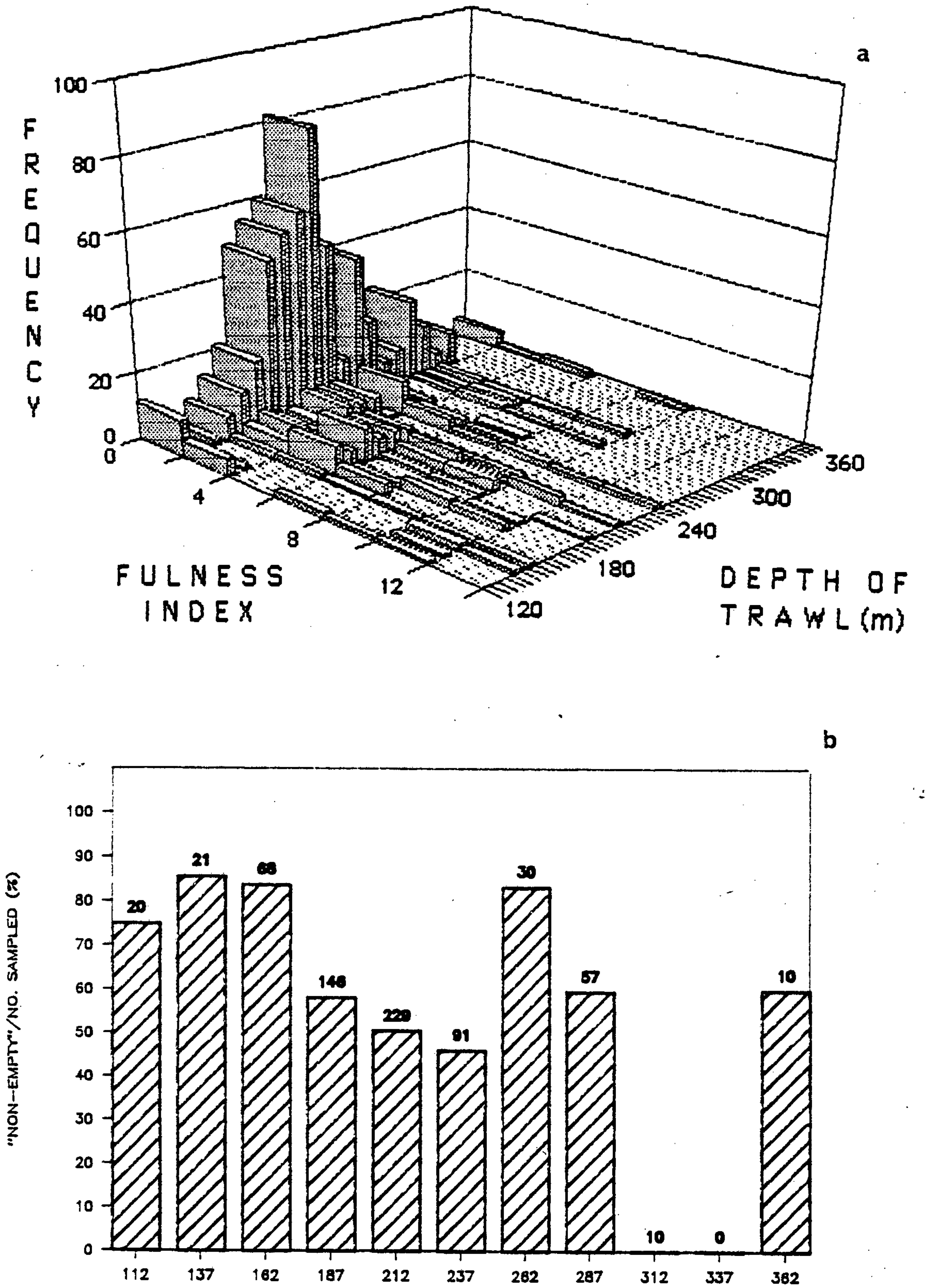


Fig. 3.3: (a) Scatter diagram of fulness index against depth of catch; (b) percentage of stomachs containing food per 25 m depth interval figures above each histogram are sample sizes ($\Sigma n=628$)

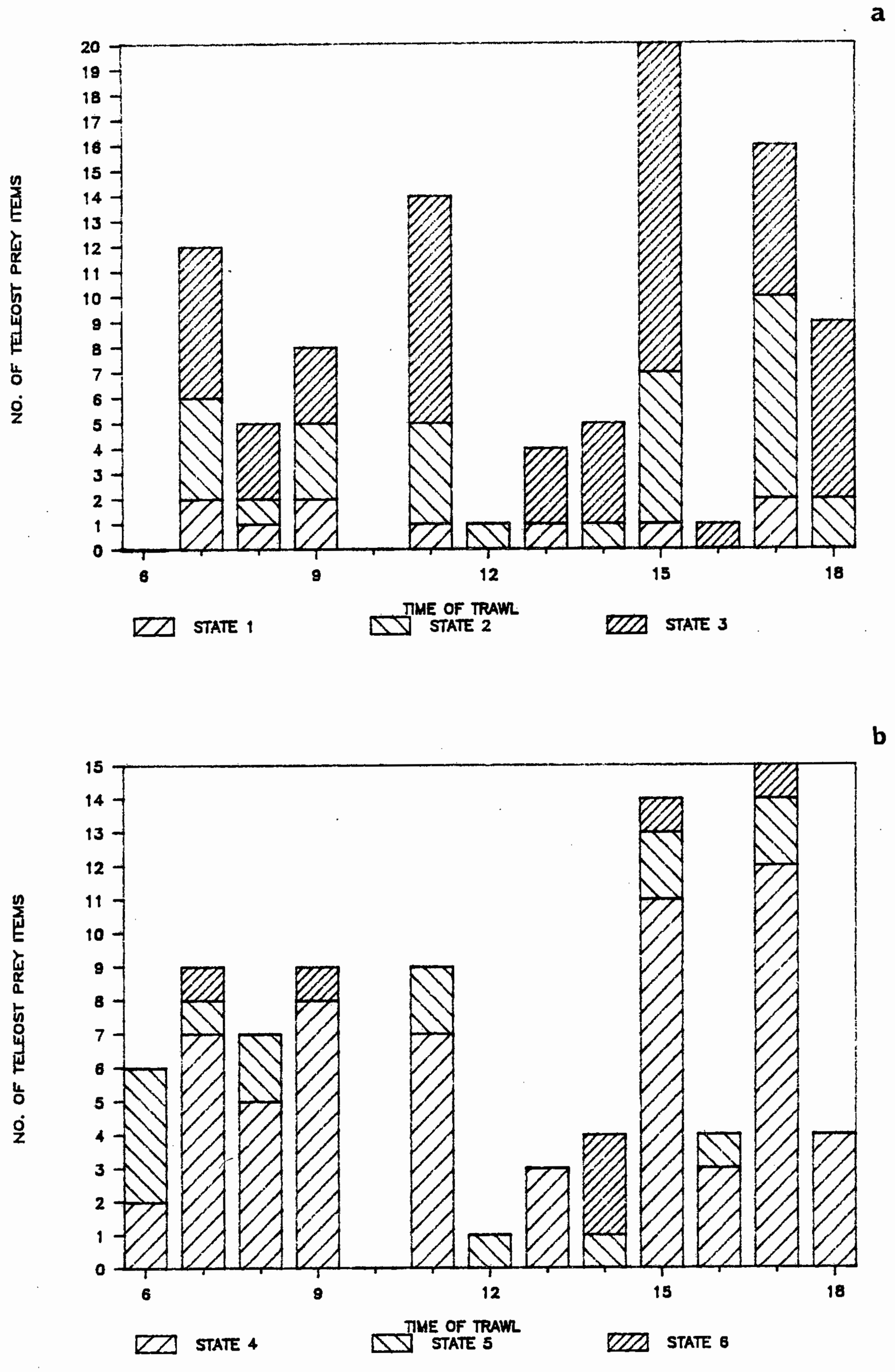
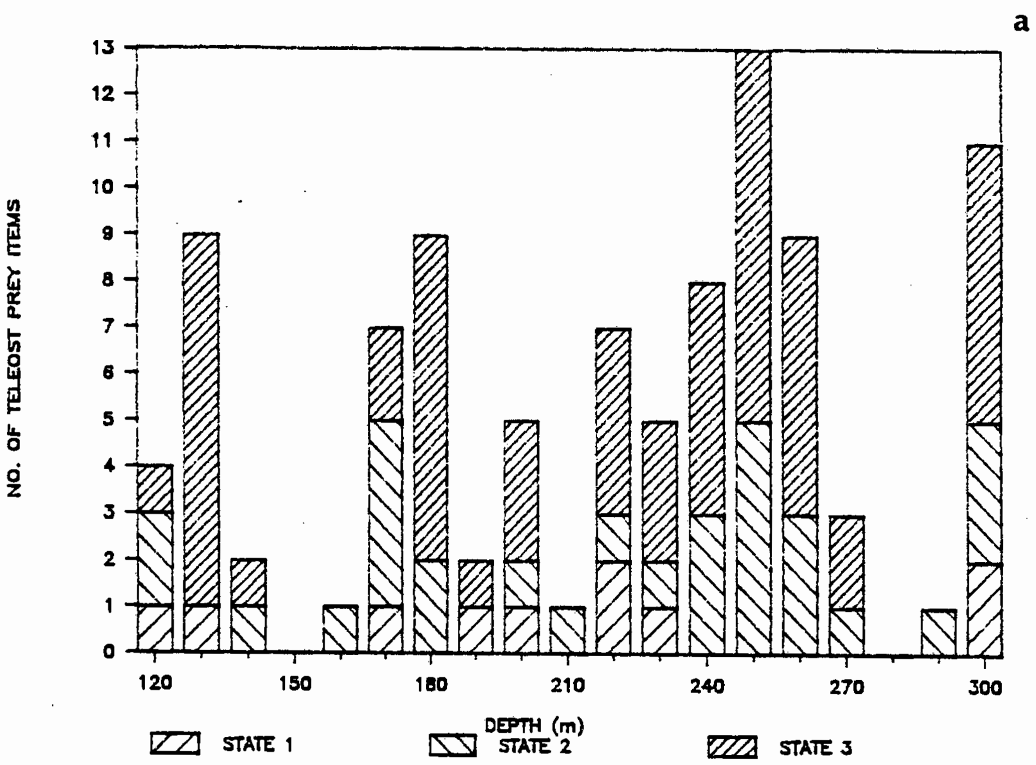


Fig. 3.4: Digestive states ((a) 1-3; (b) 4-6) of teleost prey items against time of catch (demersal trawls July 1985 and January 1986)



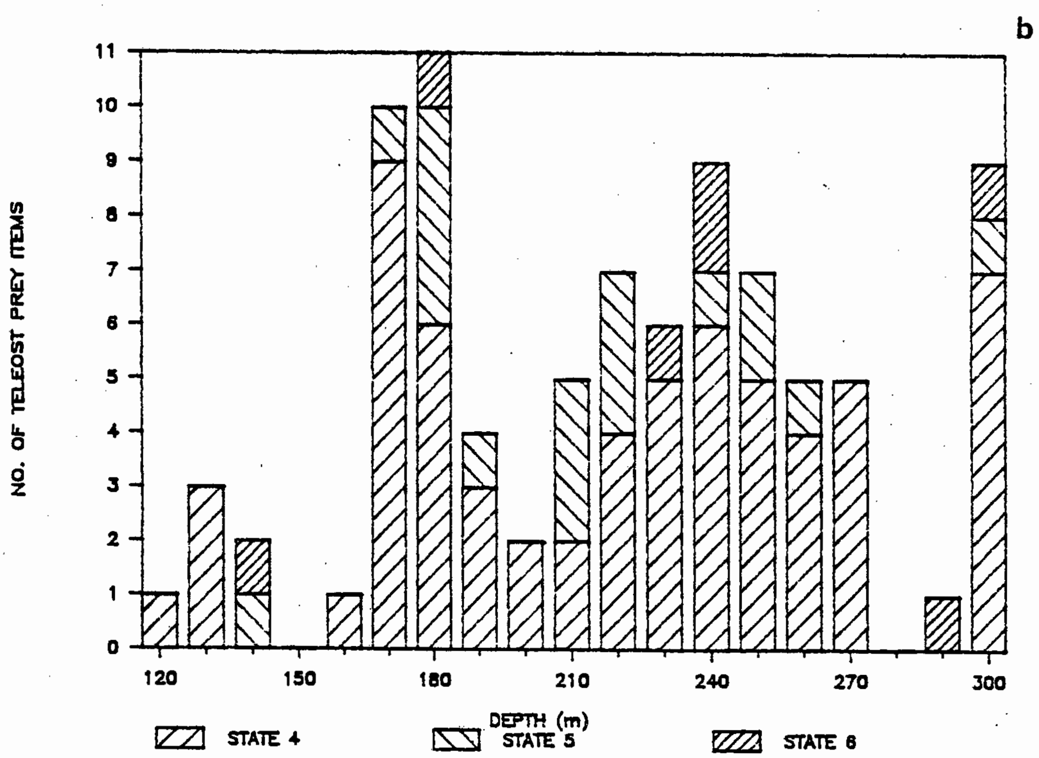


Fig. 3.5: Digestive states ((a) 1-3; (b) 4-6) of teleost prey items against depth of catch (demersal trawls July 1985 and January 1986)

Preliminary observations (the data are not shown here) of the diet of snoek trawled in midwater suggest that freshly eaten prey (digestion states 1 and 2) tend to be found in daylight hours with the more advanced states (3-5) being found both night and day. While this agrees with the above statement of Nepgen (1979a), it must be emphasized that the sample size is very small and would need to be increased substantially before any confidence could be attached to the findings. Snoek have been observed by myself feeding at 01h00 at the surface on garfish attracted to the floodlights of a ship, although the presence of the lights obviously rendered this an artificial situation.

3.1.4 CONCLUSIONS

The small degree of overlap between the diet of snoek caught demersally and that of snoek caught in the epi/mesopelagic zone indicates that the snoek may not move on a diurnal basis between the two regions. This is best illustrated by the very infrequent occurrence of anchovy in any state of digestion in the diet of demersal snoek in this study. The presence of the garfish *Scomberesox saurus*, a surface-dwelling species (Parin 1968), in snoek trawled in January 1986 provides an exception, and snoek have been observed in offshore waters feeding on garfish at night. This is consistent with the claim of Nakamura (1986) that snoek migrate to surface waters at night. Also consistent with this hypothesis is the fact that no snoek have been caught at night in demersal trawls conducted by the SFRI, although night-time trawling is infrequent. The question of vertical migration would best be addressed by an increase in research night trawling.

The resolution of the issue of vertical migration of snoek has major implications for the assessment of the impact of the snoek as a predator. Bergh *et al.* (1985) assumed that a single snoek stock spends an equal amount of time feeding in the pelagic and demersal zones. In the years

1981 and 1982 62% of the southeast Atlantic snoek catch was taken in the pelagic zone and 34,6% demersally, the remainder being unspecified (Crawford 1985). In South African waters no midwater trawling is done commercially, and the catch is split between handline fishing and demersal trawling. However the proportion of the total catch attributable to each type of fishing is not necessarily a reflection of the relative biomasses of snoek in the two zones. With regard to the winter presence of snoek it is probably valid to assume an equal split in feeding stock between the two. The summer availability to the inshore line fishery in the vicinity of Dassen Island may represent a stock feeding almost exclusively in the pelagic zone, although the snoek biomass is unknown.

Two main features of this study of snoek feeding are firstly the very low incidence of pilchard in snoek diet, presumably a direct consequence of poor pilchard availability, and secondly the importance of the redeye roundherring in the diet of demersally-caught snoek.

3.2 MISCELLANEOUS BIOLOGICAL MEASUREMENTS

3.2.1 METHODS

Routine biological measurements of snoek were made during six of the seven hake biomass research cruises (demersal trawling) conducted by the SFRI between January 1983 and January 1986. Cruises were conducted biannually, in January and in July. No biological measurements of snoek were made in January 1985. In general no more than 10 snoek were sampled per trawl and they were selected at random. Measurements included total length (Lt), fork length (Lf), total (fresh) weight, gonad weight and wet weight of total gut contents.

Total length was measured on a board from the tip of the snout to the end of the longest caudal ray when bent to maximum length. Fork length was measured from the tip of the snout to the end of the median caudal ray. Gonads were removed from freshly caught fish and weighed whole. Similar length measurements were made on snoek caught during midwater trawling conducted by the SFRI in 1986.

Gonad development indices, NI, were calculated according to the following equations (Nikolski 1954, cited by Prenski 1980):

$$NI = \frac{\text{Gonad weight} \times 100}{\text{Body weight}}$$

Otoliths were removed from the skulls of a sample of snoek and were measured under a stereo microscope fitted with a graduated eyepiece. The length was measured as a straight line from anterior to posterior tip, and the width was defined as the maximum width perpendicular to the length. This definition was necessary because some otoliths, especially those from older fish, had a curved long axis.

3.2.2 STATISTICAL METHODS

Length-weight relationships, using Lf (cm) and fresh whole weight (g), were calculated using a microcomputer statistical package, STATPRO. Power curves of the form $W = aL^b$ were fitted to the original data, but for the purpose of comparing slopes the data were log transformed and linear functional GM regressions were fitted. Slopes were compared by means of Student's t test (Zar 1984).

3.2.3 RESULTS AND DISCUSSION

Length-weight relationships differed between sexes within one season and within sexes between seasons (Table 3.2; comparison of regression slopes, Student's t test, $p<0,001$ for all four comparisons). It is therefore not possible to compare them with the relationships calculated by Nepgen

Table 3.2: Snoek length-weight data and gonad development indices (NI) from 6 demersal trawl cruises of the RS Africana conducted between January 1983 and January 1986.

Season	Sex	Max weight(g)	Min wt(g)	Max Lf(cm)	Min Lf(cm)	n	Length-weight W=aL^b a	b
Winter	F	5850	205	100	36	293	0.0060	2.9702
	M	4970	260	99	38	215	0.0204	2.6950
	F+M	-	-	-	-	508	0.0105	2.8441
Summer	F	4125	750	94	52	124	0.0060	2.9494
	M	3445	700	87	53	112	0.0090	2.9629
	F+M	-	-	-	-	236	0.0076	2.8980
Both	F+M	-	-	-	-	744	0.0059	2.9717

Season	Sex	Mean NI	n	s.e.
Winter	F	4.96	291	0.14
	M	6.62	215	0.16
Summer	F	1.08	124	0.05
	M	0.86	112	0.10

Table 3.3: Fork length (Lf) to total length (Lt) linear functional G.M. regression for snoek caught during demersal and pelagic cruises of the RS Africana conducted between 1982 and 1986.

n	Max Lt (cm)	Max Lf	Min Lt	Min Lf	Slope	Intercept	r^2
734	109	100	30	27	1.11	-0.441	0.996

Table 3.4: Otolith length/width (mm) to fork length (Lf; cm) regressions. Functional G.M. regression: Lf = m.(otolith dimension) + c

	Max ot. (mm)	Min ot. (mm)	Max Lf(cm)	Min Lf(cm)	n	Slope	Intercept	r^2
Otolith length	11.88	5.55	101.4	29	200	10.875	-31.616	0.80
Otolith width	7.22	2.89	101.4	27	213	20.314	-35.989	0.80

(1979b) for line-caught fish, because season was not specified. The values of the exponent are, however, similar to those reported by Nepgen (1979b) and support his finding that snoek in South African waters tend to be heavier per unit length (larger exponent) than those in waters off Australia (Blackburn 1960) and New Zealand (Mehl 1971).

The mean gonad development index was substantially higher for both females and males in winter than in summer (Table 3.2). While samples were only obtained in the months of January and July each year, findings nevertheless concur with those of the CELP survey (Chapter 5) that spawning peaks in winter months.

Linear functional GM regression equations (Ricker 1975, 1984) for fork length (Lf) to total length (Lt) (Table 3.3) and otolith length/width to fork length (Table 3.4) relationships are provided for reference.

CHAPTER FOUR: TRENDS IN THE SOUTH AFRICAN SNOEK FISHERY

Several authors have recently described trends in the southern African snoek fishery and some have provided initial estimates of biomass (Nepgen 1979b, Bergh et al. 1985, Crawford 1985, Crawford and De Villiers 1985). Attempts to obtain trends in catch per unit effort are hampered by the fact that while the line fishery is at times snoek-directed, effort data are poor, and conversely the demersal fishery has superior effort records but is not snoek-directed.

Nepgen (1979b) considered handline catch and "CPUE" trends at three South African harbours for the period 1970 to 1978. Unfortunately the effort data were in terms of number of boats of unspecified size, and as crew size could range between 2 and 20 per boat (Nepgen 1979b), the unit of effort was crude. What Nepgen (1979b) referred to as effort, implying total effort, was in fact only "successful" effort in that the number of boats fishing on any particular day was only reported on those days when snoek were caught (C. S. de V. Nepgen pers. comm.). Nepgen (1979b) concluded inter alia that over the period 1970-78 there was a) a trend towards increased availability to the east of Cape Point b) similarity between the trend in total (handline) catch and the trend in catch per (successful) boat-day and c) a general trend in the fishery towards increasing annual catches and catch per unit effort.

Bergh et al. (1985) pointed out that no good biomass estimates existed for snoek in the southeast Atlantic, and estimated the stock in the southern Benguela region (south of the Orange River and presumably including ICSEAF area 2.1) to be of the order of 75 000 t by multiplying the total annual catch by five.

An index of annual consumption of anchovy by snoek in western Cape waters was based on the assumption that handline catch of snoek reflected the number of snoek feeding on anchovy, and that the period during which snoek fed on anchovy was constant from year to year (Crawford and De Villiers 1985).

In a preliminary assessment of snoek in the southeast Atlantic Crawford (1985) used handline catches off South Africa and Namibia as an index of abundance. Total annual ICSEAF catches were divided by handline catches to provide an annual index of fishing effort. Crawford (1985) concluded that the overall ICSEAF TAC (total allowable catch) should not exceed 34 000 t annually. This TAC was subsequently adopted (ICSEAF 1986).

David (in press) has estimated the following annual consumption of snoek by seals; Cape Cross (Namibia) to Orange River 40 000 t, Orange River to Cape Point 6 000 t and Cape Point to Algoa Bay 1 700 t.

In this chapter the work of Nepgen (1979b), Crawford and De Villiers (1985) and Crawford (1985) is discussed in the light of new or unpublished information. Recent figures are available to supplement the time series of both demersal and handline catches. Effort for the South African handline fishery is presented in terms of man days.

4.1 DATA AND METHODS

Handline catch and effort data were extracted from two SFRI sources:

i. Monthly handline snoek catch returns for 1971-1983.

From 1971-1980 there was a closed season from August to November inclusive, except for 1980 when catches were permitted in August. From 1981 onwards fishing was permitted throughout the year. Information on these returns included the number of fish landed, the total number of boats of unspecified type at sea on days when snoek were caught and the total number of days each month when snoek were caught.

While returns were submitted from a total of 16 harbours, there was considerable variation in the number of returns per harbour over the entire period.

ii. Harbour returns. The period for which these are available varies from harbour to harbour, the maximum period being 1979-1985. These returns give total handline effort, but in order to obtain a time-series of comparable data only "successful" effort was extracted from the returns. The data are complicated by the fact that during this period a changeover from recording numbers to recording weight of fish took place.

Effort data from both the monthly snoek returns and the harbour returns were entered onto a micro-computer spreadsheet as "successful" boats and "successful" days. The assumption here was that on days when snoek were caught, all effort was snoek directed. The validity of this weakens from Kalk Bay eastwards, especially when catches are very low, so the effort for this region is overestimated.

In the years of overlap, i.e. when both types of monthly return were submitted (1979-1983, for certain harbours only), a mean was taken if data (e.g. weight) for a particular harbour differed.

At 2 harbours, Hout Bay and Hermanus, harbour return statistics are complicated by the fact that large line-boats fishing for several days at a time on the Agulhas Bank and elsewhere have in recent years offloaded their catch, frequently in the form of salt snoek (with a considerably reduced weight). Catch and effort data from Yzerfontein harbour have only been available since 1981. As the Yzerfontein fishery has become a major contributor in recent years to the total South African handline catch it would not be consistent to include Yzerfontein catches in a time series trend extending from 1971 to 1985. For these reasons figures are not included here for these three harbours, unless otherwise stated. Similarly the months which constituted the closed season prior to 1981 (August to November) were omitted from the CPUE time series for the entire period 1971 to 1985 to ensure comparability of data.

A major deficiency of the catch returns is that the effort data are simply in the form of "number of boat days". As a line-boat can be anything from a 2-man dinghy to a 24-man deck boat, this is obviously unsatisfactory. The following procedure was carried out with the "successful" effort data in order to convert boat days to man days:

During the line-fish questionnaire survey described in Chapter 2, either the fisheries inspector or the harbour master at each of the harbours visited was asked to estimate the size and composition of the active resident fleet of line-boats, as well as the average crew size of each type of boat in the fleet. From this a single estimated average crew size per boat for the resident fleet as a whole was calculated.

For each harbour and each month the number of boat days was divided by the number of days on which fishing took place, to give the average number of boats per day. This was then converted to the average number of men fishing per day by multiplying by the estimated average crew size. If the average "successful boats per day" for any month for a particular harbour was greater than the average resident fleet size, the balance was taken to be made up by the migratory ski-boat fleet with an estimated average crew size of 4,5 (both commercial and sport ski-boats). The resultant number of men per day was then multiplied by the number of days spent fishing to obtain the number of man days.

There were several exceptions to this procedure. Ski-boats rarely launch at Port Nolloth, Hondeklip Bay or Doring Bay. At these harbours the average crew size was 2, and this figure was used regardless of the number of boats per day. At Lambert's Bay, the average fleet composition is extremely difficult to estimate, and there is a large number of 2-man dinghies which, outside the crayfish season (1 November to 15 May), only go to sea during a snoek run (a large, localized concentration of snoek). Thus any effort over 80 boats per day was taken as consisting of 2-man dinghies. No ski-boats operate out of either the Cape Town docks or Kalk Bay, and all boats were estimated to have a crew size of 11 and 12,8 respectively. The fleet at Still Bay was assumed to be entirely commercial and to consist of small line-boats and ski-boats, with an average crew size of 7 men. A summary of estimated resident effort at each of the harbours included in this analysis is given in Table 4.1.

There are three additional complications in attempting to standardize effort as "successful man days". Firstly the resident fleet size and average crew size for each harbour were assumed to have been constant over the period 1971-1985, and secondly the ski-boat fleets were assumed to have been in operation at a constant level since 1971. Neither of these assumptions are strictly valid, but it would be almost impossible to quantify the change in the active (as opposed to registered) resident fleet sizes over the years, and extremely time-consuming to obtain a quantitative estimate of the evolution of the ski-boat fishery. In fact the ski-boat fleet has probably only been a significant factor in recent years, but for earlier years the mean number of boats per day for most harbours rarely exceeded the resident fleet size. The third assumption was that the movement of large line-boats from harbour to harbour in pursuit of seasonal snoek runs is not a significant factor in the calculation of resident fleet sizes. Again this is probably not strictly valid, but the movement of these vessels over the 15 year period (1971-1985) would be impossible to quantify.

Catch is expressed as number rather than weight of fish. For those records where weight was given, a conversion factor has been used. As the condition of snoek varies with season and snoek vary in size from shoal to shoal this factor is approximate. In only 49 handline records were both number and landed weight of snoek given simultaneously. In addition both numbers and weights given in these handline records are only estimates. The mean weight per snoek from the records was 2,090 kg (s.d. = 0,688, n = 49). However, accurate weights of snoek are available from the demersal research cruises conducted by the SFRI aboard the RS Africana. The mean weight of snoek caught during these cruises was 2,340 kg (s.d. = 0,937, n = 759). This mean weight has been used to convert all weights in the handline returns to numbers. The assumption was that demersal and handline catches generally represent the same stock and same size class. Another difficulty is that the Africana demersal catches are only made in January and July, whereas handline catches are made in several months of the year. The possibility that mean size has changed between 1971 and 1985 is partially circumvented because the period relevant to the conversion problem began in 1979, only four years earlier than initiation of demersal surveys conducted from the RS Africana. The SFRI has in the past tended to use an estimated mean weight of 2,2 kg for line-caught snoek (A.R. Penney SFRI pers. comm.). In the final analysis, however, the nature of the raw data is such that it would be unrealistic to attempt to achieve too fine a level of accuracy with regard to mean weight per snoek.

The result of using this conversion factor is that there is a continuous sequence of catch data in the form of numbers of snoek from 1971 to 1985. This is preferable to changing all numbers to weight, because of the possibility of size changes in the earlier years.

Catch per unit "successful" man day for the South African line fishery as a whole was calculated for each year by dividing the total catch by the total successful effort. The harbours of Yzerfontein, Hout Bay and Hermanus and the months August to November were excluded from the calculation for the reasons discussed above.

Table 4.1: Estimated average resident fleet size and crew size per harbour for the South African line fishery for snoek, 1971-1985. (Yzerfontein, Hout Bay and Hermanus harbours excluded; N/A implies migratory ski-boats not a factor; see text for explanation).

Harbour	Average resident fleet size (no. of boats)	Average crew size (no. of men)
Port Nolloth	N/A	2.0
Hondeklip Bay	N/A	2.0
Doring Bay	N/A	2.0
Lambert's Bay	80	4.4
Elands Bay	162	2.8
St Helena Bay	80	4.8
Saldanha Bay	58	7.4
Cape Town Docks	N/A	11.0
Kalk Bay	N/A	12.8
Gordon's Bay	6	10.2
Gans Bay	49	4.0
Arniston	12	7.0
Still Bay	(unknown; assumed N/A)	7.0

The ski-boat fishing effort at Yzerfontein has been monitored by inspectors

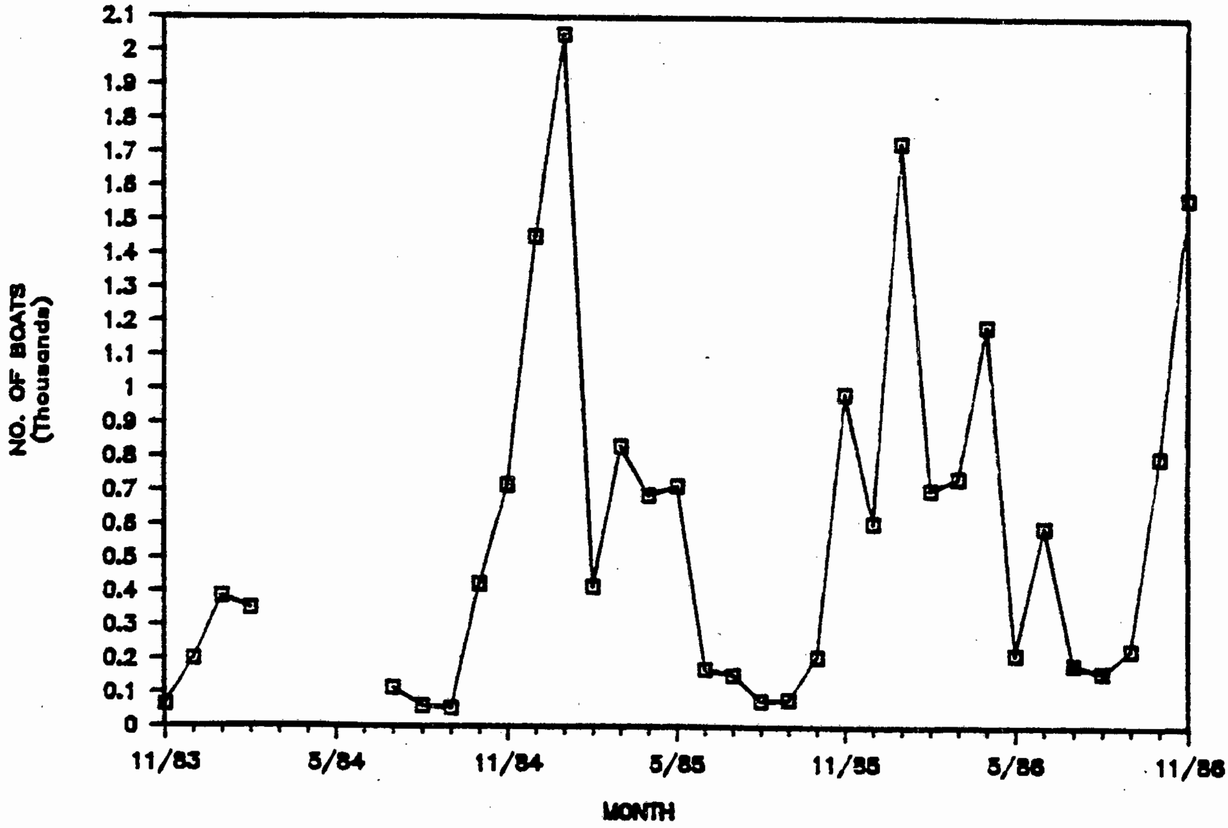


Fig. 4.1: Total monthly launchings of ski-boats at Yzerfontein on the Cape west coast

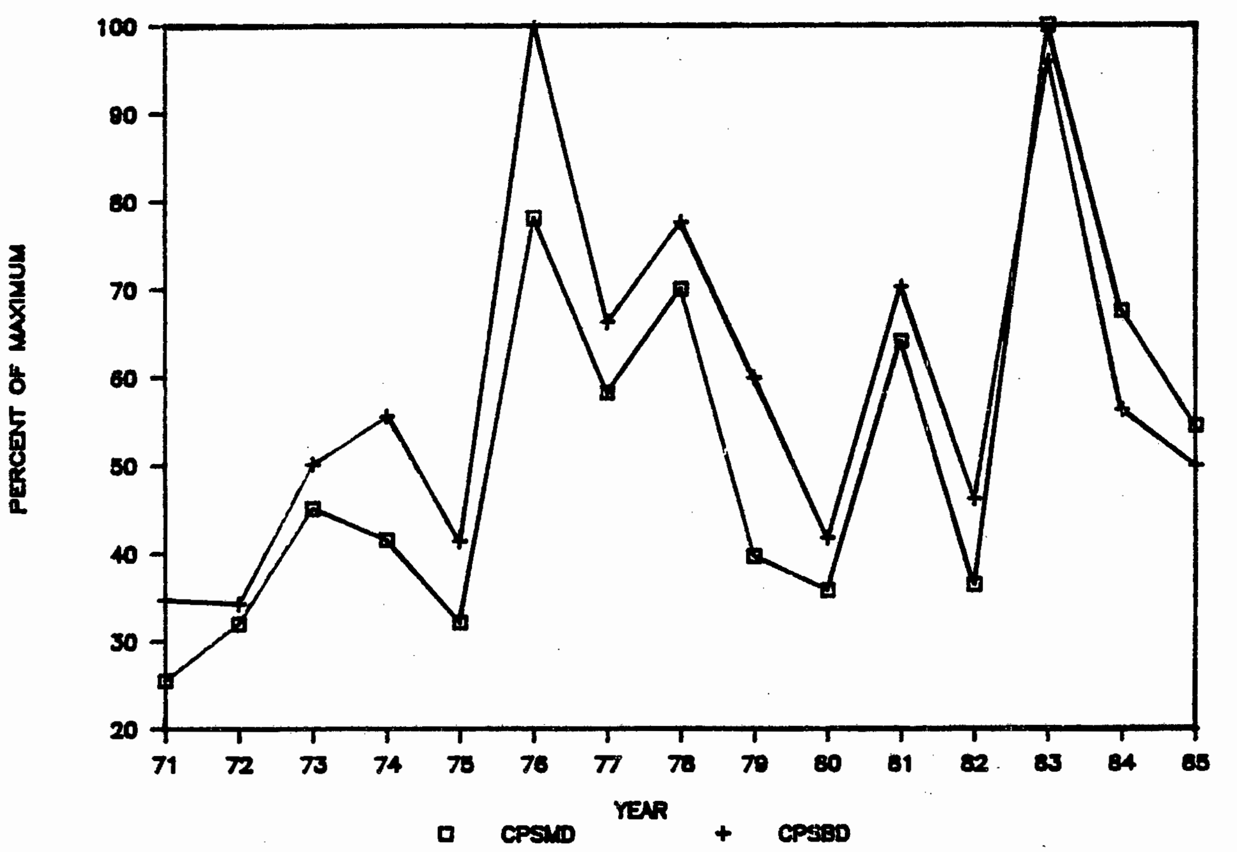


Fig. 4.2: The South African line fishery for snoek; trends in catch per successful man day (CPSMD) and catch per successful boat day (CPSBD) (data from the harbours listed in Table 4.1, with the months August-November exluded)

from the Marine Development Branch of the Department of Environment Affairs. A monthly tally of ski-boats launching at Yzerfontein has been kept for most months between November 1983 and November 1986 inclusive.

4.2 RESULTS AND DISCUSSION

The development of the nomadic ski-boat fleet in the 1980s has had a substantial impact on the South African line fishery for snoek. An indication of the numbers of boats involved is provided in Figure 4.1, which shows that there may be in excess of 2000 launchings from Yzerfontein in a single month.

There was good agreement between catch per successful boat day and catch per successful man day between 1971 and 1985 (Fig. 4.2), indicating that the non-standardized boat day would in this case be an adequate unit of successful effort. Successful effort and catches for which effort data are available are shown in Table 4.2. The values for catch per unit successful effort are under-estimates because on any particular day when snoek were caught, regardless of quantity, all effort on that day at the harbour concerned has been regarded as successful.

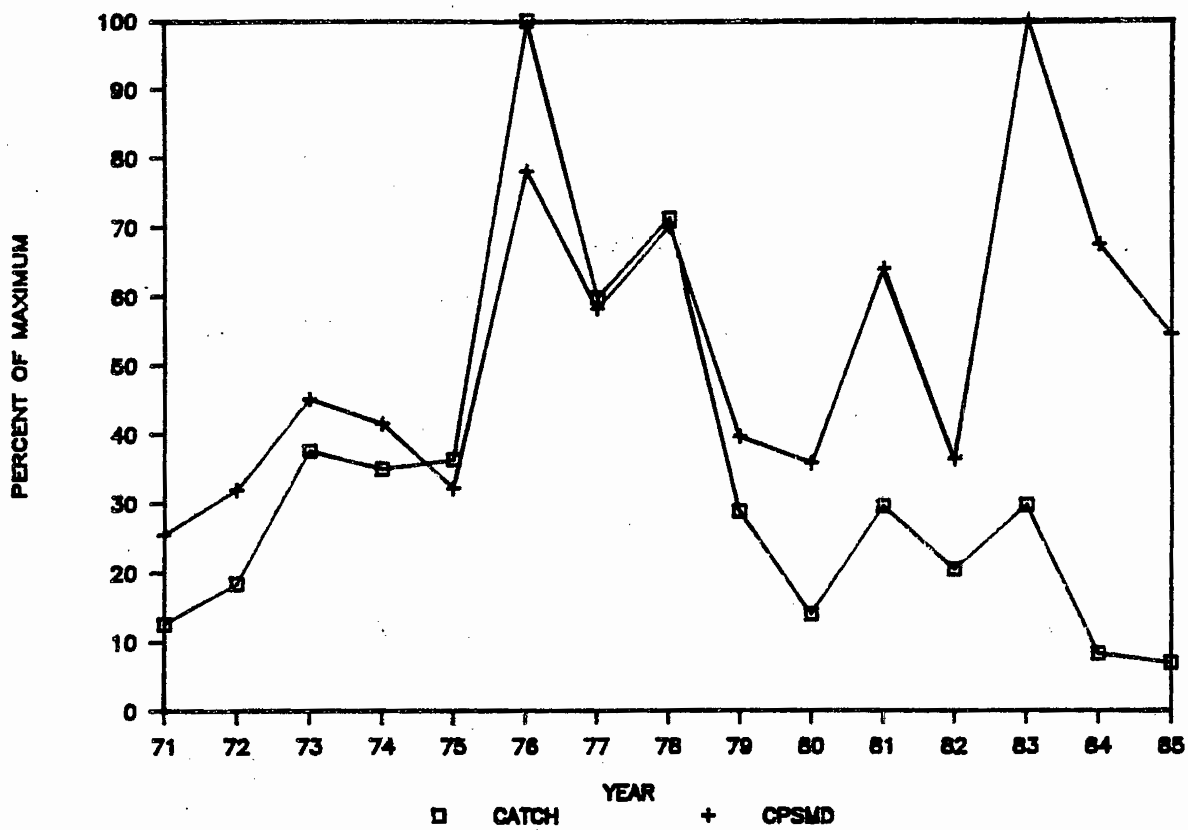


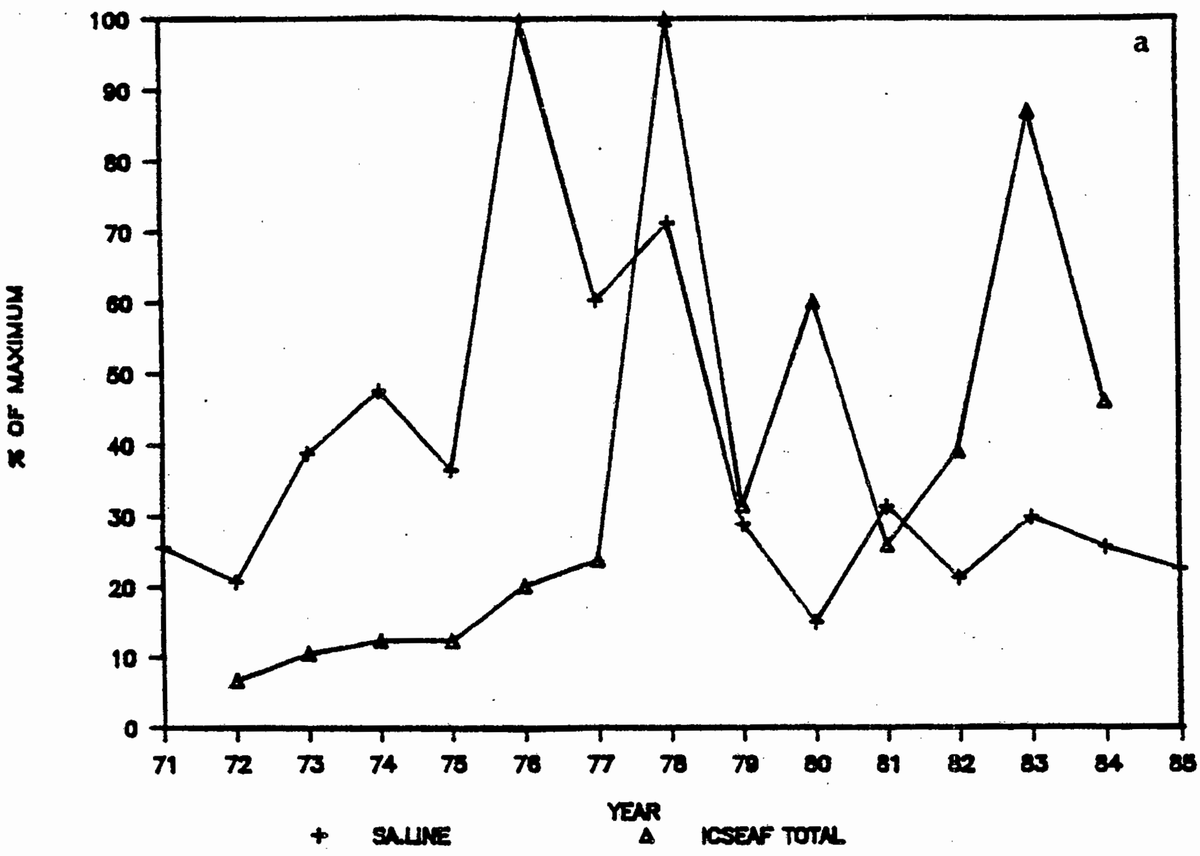
Fig. 4.3: The South African line fishery for snoek; comparison of trends in catch and catch per successful man day (CPSMD) (data from the harbours listed in Table 4.1, with the months August-November excluded)

Table 4.2: Successful effort and catches (number of snoek) for which associated effort data are available. Data were obtained from the harbours listed in Table 4.1 and exclude the months August to November, inclusive. (SBD - successful boat days; SMD - successful man days; CPSBD - catch per successful boat day; CPSMD - catch per successful man day)

YEAR	SBD	SMD	CATCH (number)	CPSBD	CPSMD
71	8821	62034	378135	42.87	6.10
72	13050	72251	551713	42.28	7.64
73	18133	104370	1124241	62.00	10.77
74	15214	105592	1045892	68.75	9.90
75	21228	141878	1085983	51.16	7.65
76	24179	160312	2986671	123.52	18.63
77	21820	128610	1785044	81.81	13.88
78	22198	127497	2129845	95.95	16.71
79	11632	91023	860046	73.94	9.45
80	8129	49182	418801	51.52	8.52
81	10176	57831	883038	86.78	15.27
82	10711	70425	610622	57.01	8.67
83	7497	37264	888229	118.48	23.84
84	3562	15388	247199	69.40	16.06
85	3356	15962	206804	61.62	12.96
TOTAL	199706	1239617	15202263	76.12	12.26

A comparison of trends in the line catch with catch per successful man day is shown in Figure 4.3. Prior to 1982 the trends were broadly similar but from 1982 onwards they diverged markedly, with catch continuing to decline but CPUE (successful) increasing. The most likely explanation for this is declining general availability of snoek to the line fishery but increased local availability (namely in the Yzerfontein region), coupled with increased efficiency of exploitation by the highly mobile ski-boat fleet. It should be emphasized that an increase in successful effort does not necessarily reflect an increase in total effort.

The similarity between the trends prior to 1982 is in agreement with the findings of Nepgen (1979b, p37), who concluded that "under these circumstances, the catch curve would appear to be a reliable indication of



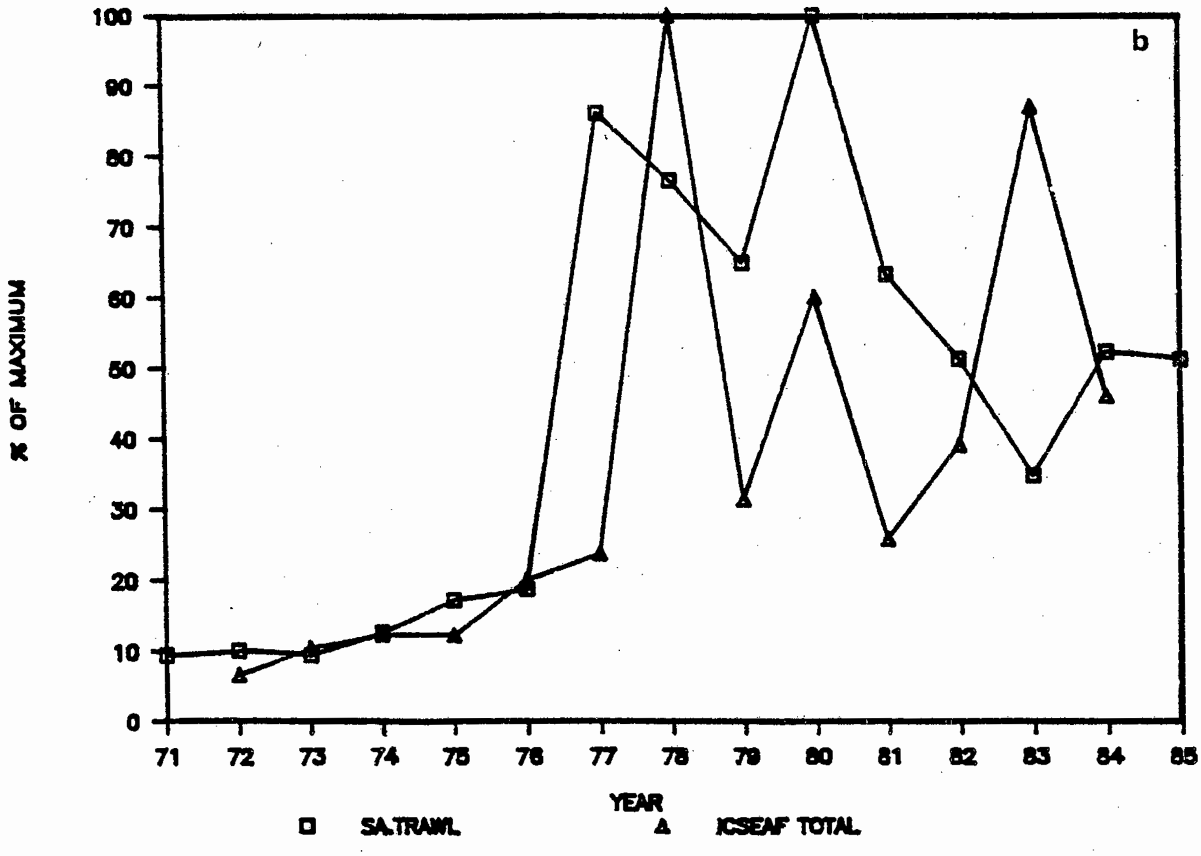


Fig. 4.4: Comparison of trends in the total ICSEAF snoek catch with (a) the South African line catch and (b) the South African demersal trawl catch (ICSEAF catches from ICSEAF statistical bulletins, line catches from monthly returns, demersal catches from Annual Reports of the Chief Directorate Marine Development and records of the SFRI)

abundance". If one assumes that CPUE is proportional to abundance, this would probably be a justifiable conclusion if the CPUE data pertained to total as opposed to successful effort. In the case of catch per unit successful effort, however, and assuming that successful effort was adequately reported, in order to draw the same conclusion the assumption must be made that the fishermen were always aware of the presence or absence of the snoek, and thus would only fish for snoek when the species was present. This may be the case but would be difficult to confirm.

The contribution by Yzerfontein catches to the total South African line catch in 1985 was in the region of 64%. Catch returns were not obtained from Yzerfontein from May 1983 to October 1984 but it is likely that catches were substantial during this period, and it appears from unconfirmed reports that the trend continued in 1986 and early 1987, although data have not yet been obtained. The consequences of this heavy exploitation by a localized fishery need to be assessed, although handline catches only constitute a small fraction of total ICSEAF catches (2.5% in 1982 (Crawford 1985)).

Crawford (1985) has used the combined South African and Namibian handline snoek catch as an index of snoek abundance in the southeast Atlantic. There is poor agreement between the South African line catch and the total ICSEAF catch (Fig. 4.4a), and the South African demersal catch (Fig. 4.4b) follows the total ICSEAF trend far more closely. Exceptions are the ICSEAF peaks in 1977, 1978 and 1983 which are not mirrored in the South African catch. The 1978 and 1983 peaks represent very large catches made in Namibian waters. However, as R.J.M. Crawford (SFRI pers. comm.) points out, total catches may influence rather than reflect stock size, which is why he developed a production model based on the line fishery (Crawford 1985).

The decline in South African line catch since 1976, and most notably since 1978, was tentatively and reasonably attributed by Crawford (1985) to the large catch made in Namibian waters in 1978. However a second peak ICSEAF catch in 1983 suggests that the stock was not necessarily adversely affected by the 1978 catch. It is possible that the variable South African line fishery may be more sensitive to stock perturbations than is the largely trawl-based ICSEAF fishery as a whole. Again there is danger in assuming that catches reflect stock size, and Crawford's (1985) production model remains the only quantitative assessment of the snoek fishery.

4.3 CONCLUSIONS

The traditional inshore line fishery for snoek is declining, and the development of the nomadic ski-boat fleet has made a large impact on the nature of the line fishery as a whole. Catches have declined since 1976, although increased efficiency of exploitation by ski-boats has probably slowed this decline. If the assumption is made that there is a single snoek stock in South African waters and that handline effort has not diminished, it is reasonable to conclude that this trend in handline catches indicates a declining stock.

Offshore demersal catch trends appear to bear little relationship to inshore trends, although demersal catches have decreased since 1980.

In the only quantitative assessment of the southeast Atlantic snoek fishery to date, Crawford (1985) stated that the stock decreased by 56% between 1974-1978 and 1982-1983. The large total ICSEAF catch made in 1983 suggests that the stock may not necessarily have decreased to this extent.

It is suggested that any future assessment be based on the demersal as opposed to the line fishery because the changing nature of the line fishery complicates the use of time series data spanning the period of change. In New Zealand, recent biomass estimates of the snoek stock have been based on demersal trawl surveys (Hurst 1983, Hurst and Bagley 1984c, 1985). Part of the demersal fishery in New Zealand is, however, snoek-directed and on two recent surveys 71% and 58% respectively of the catch consisted of snoek (Hurst and Bagley 1984c, 1985). In South African waters demersal effort is not snoek-directed, snoek simply constituting a by-catch of the hake fishery. Nevertheless the less variable nature of the demersal snoek fishery would probably render it more suitable than the line fishery for stock assessment purposes.

Alternative to CPUE-based methods are the direct methods currently in use by the SFRI to assess the South African anchovy fishery. These include an egg production method and an acoustic survey method, and it is possible that either or both of these may be appropriate for the snoek fishery.

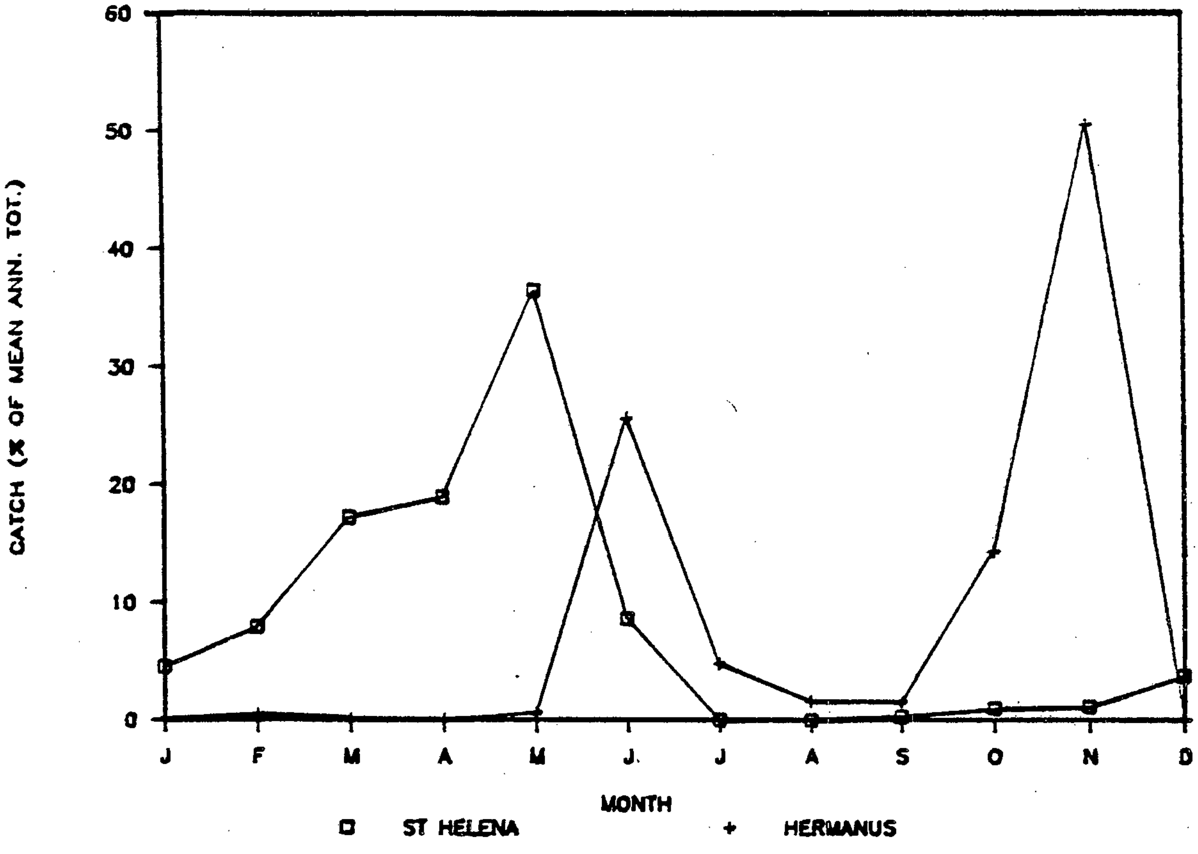


Fig. 5.1: Trends in mean monthly line catch of snoek at St Helena Bay and Hermanus for the period 1897-1904 (data from Gilchrist 1914c)

CHAPTER FIVE: SNOEK DISTRIBUTION, AVAILABILITY AND MIGRATION IN SOUTH AFRICAN WATERS

The seasonality of snoek abundance in South African waters was described by Gilchrist (1914b), who stated that the snoek is a migratory species affected in its distribution by water temperature. Snoek tended to be abundant and in good condition from January to June, were very scarce from mid-July to mid-September and re-appeared in poor condition but with large "ovaries" from mid-September to December (Gilchrist 1914c). This pattern, which was more or less constant from year to year, was thought to be strongly linked with the movements of the pilchard Sardinops ocellatus, an important food species (Gilchrist 1914c).

Although the snoek was considered to be a west coast species, monthly catch returns from 1897 to 1904 show small but relatively regular catches of snoek in the July to September period from places as far to the east as Mossel Bay, Plettenberg Bay and Jeffrey's Bay, and even Algoa Bay (Port Elizabeth) (Gilchrist 1914c). The mean monthly snoek catch between 1897 and 1904 has been plotted for two localities, the St Helena Bay area on the west coast and the Hermanus area on the south coast (Fig. 5.1). Although the coefficients of variation are extremely large (between 75 and 265%), the trend is nevertheless apparent that south coast catches lag those on the west coast.

The migration patterns of the snoek were discussed in greater detail by Biden (1930). The fish were present in large quantities north of Walvis Bay, Namibia, from November to April, with the condition of the fish being initially poor but improving by December. A southward movement brought the shoals to Port Nolloth in February and March and thence to Table Bay by April. Fishing remained good in the Table Bay region until the end of

June, but shoals of snoek nevertheless continued moving in a southeasterly to easterly direction and were caught at Hermanus, Mossel Bay and even further east until the end of August (Biden 1930)

The poor condition of snoek caught in western Cape waters in late winter and spring (Gilchrist 1914c, Biden 1930) was measured by Van Wyk (1944) and Rapson et al. (1944). Analyses of flesh and visceral composition showed a marked decline in oil content during this period, and this was attributed to coincidence with the snoek spawning season (Rapson et al. 1944).

Evidence for the suggested southerly migration of snoek was provided by De Jager (1955), who cited the tagging work of Marchand (1934). Of a total of 3 755 snoek tagged off Namibia in late 1934, 17 were recovered during the following 3½ years. Recoveries were scattered at various points between the tagging site and the Cape Peninsula, the most southerly point being False Bay. Fourteen of the recoveries were made in South African waters.

Davies (1954) suggested that a return northerly migration takes place in deeper offshore waters in the spring, but no direct evidence of this exists. He also suggested that spawning took place offshore during this time.

The use of a relative condition factor as a means of monitoring snoek condition in Cape waters confirmed a rapid decline in condition during July to a trough in August, with condition remaining poor until January (Nepgen 1975). Gonad examinations showed the spawning season to be between July and December (Nepgen 1975). On the basis of this and earlier evidence a closed season for snoek fishing which had been enforced from August or September to November, inclusive, since the 1940s (Van Wyk 1944) was retained until 1980.

Nepgen (1979b) reports a trend of increasing snoek catches to the east of Cape Point from 1974 to 1977, suggesting a trend of increased availability in this region. Crawford and Crous (1982) put forward the hypothesis that a possible long-term reduction in water temperatures along the southern Cape coast may explain increased abundance in this region of fish species usually found in cooler waters. Snoek in Australian waters are reported to prefer a temperature range of 13-18°C (Cowper 1966).

Snoek tagging carried out off the Cape Peninsula region in 1973 and 1974 yielded generally inconclusive results, with only local movement shown conclusively (Nepgen 1979b). It is noteworthy that snoek tagged in May 1974 were recovered in July 1974 at localities as far apart as St Helena Bay, on the west coast, and Gans Bay, on the south coast, indicating both northward and eastward movement.

The annual southward movement of snoek described above has been shown by Crawford and de Villiers (1985) to coincide relatively closely with the movements of prey species such as the horse mackeral _Trachurus_ spp., sardinellas _Sardinella_ spp., pilchard _Sardinops ocellatus_, anchovy _Engraulis japonicus_ and redeye roundherring _Etrumeus whiteheadi_. Although further evidence for the southward movement of snoek is provided by catch statistics from the International Commission for the Southeast Atlantic Fisheries (ICSEAF) (Crawford and de Villiers 1985), the hypothesised offshore return migration from South African to Namibian waters in spring remains unsupported by direct evidence.

Unpublished or re-examined sources of data pertaining to the distribution of adult snoek are examined here. These sources include handline catch data for a number of South Arican harbours, and records of bottom and midwater catches from research cruises carried out since 1982. Seasonality of recent commercial catches by demersal trawl in the southern ICSEAF area (South African waters only) is also discussed.

An extensive egg and larva survey of pelagic species was carried out by the South African Sea Fisheries Research Institute (SFRI) in southwestern Cape waters in 1977/78, and larval snoek data from this survey are included in this chapter.

Juvenile snoek have been sampled by two methods by the SFRI. A routine blanket net survey of four west coast inshore localities was carried out between 1955 and 1967/8, and regular diet sampling of west coast Cape gannet (Morus capensis) colonies was conducted between 1977 and 1985.

Length frequency data are available from all these sources with the exception of the handline and the commercial demersal data sets. Length frequency data for snoek caught by handline are, however, now being collected by the line-fish section of the SFRI (A.R. Penney SFRI pers. comm.)

The intention is to clarify further the movement of the snoek in South African waters, particularly in the light of a belief within the fishing industry that migration patterns have changed in recent years. In addition the data on larval and juvenile snoek contribute to understanding the life history of the species.

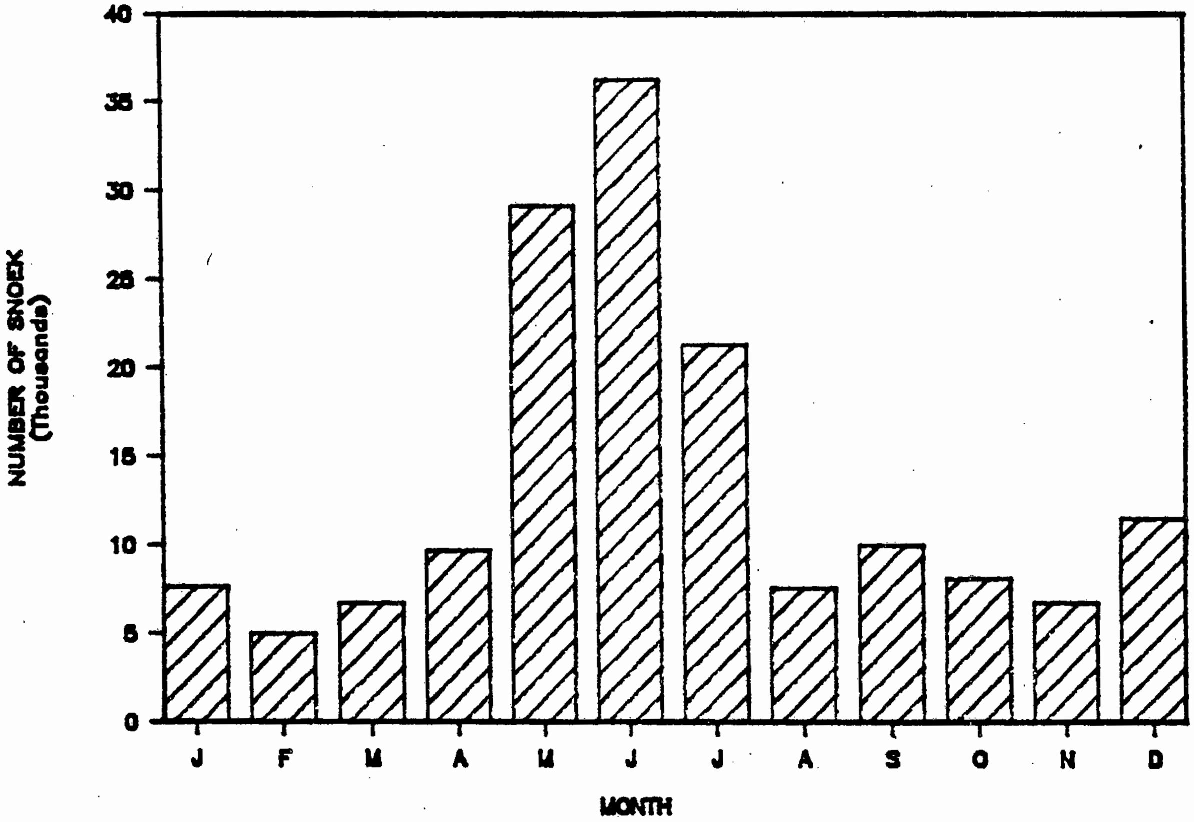


Fig. 5.2: Mean monthly line catch of snoek per harbour for the period 1970-1985 (data from the harbours listed in Table 4.1, with the addition of Yzerfontein, Hout Bay and Hermanus)

5.1 HANDLINE CATCHES

5.1.1 METHODS

Monthly handline snoek catch data, in the form of summarised catch returns, are available for the period 1970 to 1985 for each of a number of South African harbours between Port Nolloth and Still Bay. These data include number or weight of snoek landed at the harbour concerned. Initially snoek catches were reported in terms of number of snoek, but in the early 1980s a new system of harbour returns was implemented in which weights, rather than numbers, were recorded. In order to obtain a continuous sequence of comparable data, catch numbers are used throughout. Methods of converting weight to numbers and of standardising units of effort are discussed in Chapter 4. A closed season for snoek fishing was enforced between August and November during the years 1970 to 1980 inclusive, with the exceptions of August 1970 and August 1980.

5.1.2 RESULTS AND DISCUSSION

If all handline catches of snoek landed at South African harbours between Port Nolloth and Still Bay over the period 1970 to 1985 are combined and plotted as a mean monthly catch per harbour, a peak from May to July is clearly apparent (Fig. 5.2). The poor period from August to November coincides with the postulated offshore spawning season. The monthly means for these months only pertain to the period subsequent to the lifting of the closed season. The decrease from December to February, although slight, is a reversal of what one might expect from the hypothesis that the snoek are in Namibian waters in December, and begin to move southwards thereafter.

There is considerable interannual variation in the temporal distribution of catches in South African waters (Figs 5.3a-d). Although catches usually

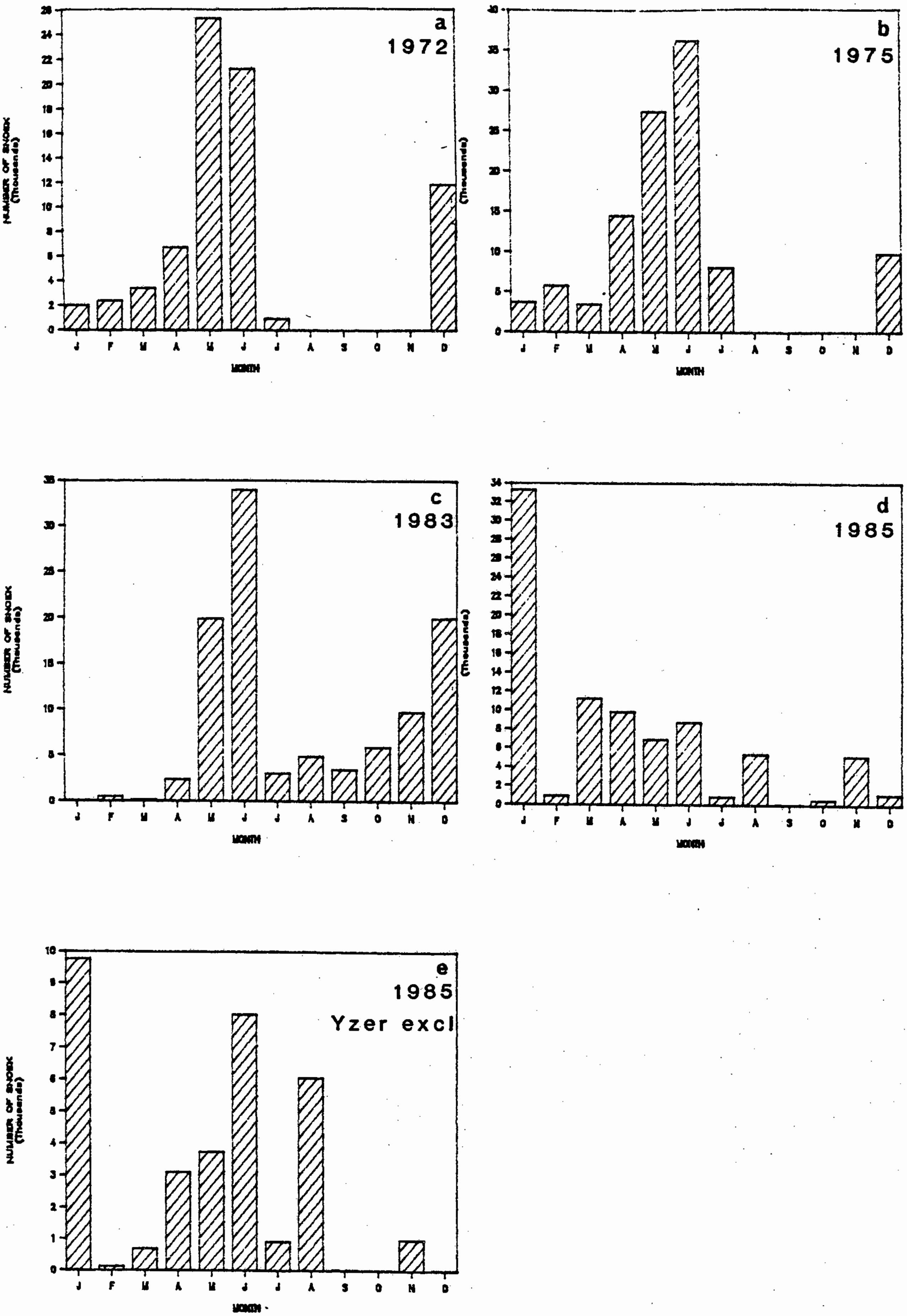


Fig. 5.3: Mean monthly line catch of snoek per harbour; (a) 1972; (b) 1975; (c) 1983; (d) 1985; (e) 1985-Yzerfontein excluded

peak during the period May-June, they are also frequently high in December-January. In fact in 1983 the December catch was equal to the May catch (Fig. 5.3c), and in 1985 the January catch was almost three times that of any other month (Fig. 5.3d). The 1985 picture changes substantially, however, if catches from Yzerfontein are omitted (Fig. 5.3e). While January remains the peak month, the relative importance of the winter months increases. This example illustrates the contribution made by Yzerfontein catches to the total South African snoek line fishery in recent years. Unfortunately very few catch returns were submitted from Yzerfontein in 1983 and 1984.

Catches of snoek during the period 1970-1985 were higher to the west of Cape Point than to the east (Figs 5.4a, b; mean annual catch per harbour $1,7x10^5$ and $1,5x10^5$ snoek respectively). While there was a strong peak in late autumn and early winter to the west (Fig. 5.4a), catches were more evenly spread to the east (Fig. 5.4b). A factor contributing to the strong west coast seasonality is the involvement of many line fishermen in the rock lobster fishery in summer. The pattern to the east of Cape Point is strongly influenced by Kalk Bay catches. When these are omitted (Fig. 5.4c) a clear winter peak is evident, although it lags that on the west coast by approximately a month. Again, it should be borne in mind that a closed season for snoek was in force over the period 1970-1980 from August to November, so the number of samples for these months is limited.

To investigate geographical variation in snoek catches the mean monthly catch data are plotted for a number of harbours for the maximum period for which data are available (Figs 5.5a-d). The harbours range from Lambert's Bay on the west coast to Still Bay on the south coast. At Lambert's Bay (Fig. 5.5a), catches peaked in May, although February was the only month between December and June when the mean catch fell below 10 000 snoek. Data for Yzerfontein are only available for the period 1981-1985 (Fig. 5.5b) and

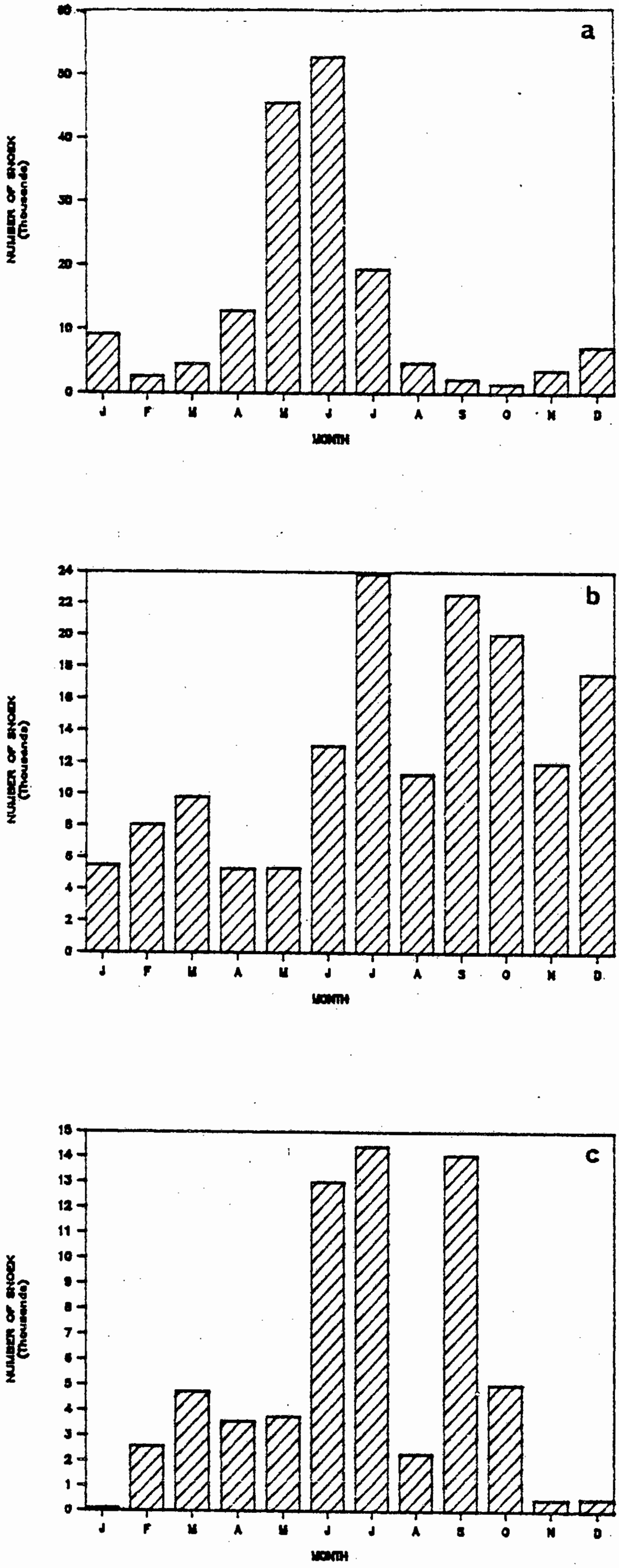


Fig. 5.4: Mean monthly line catch of snoek per harbour for the period 1970-1985; (a) Port Nolloth to Hout Bay; (b) Kalk Bay to Still Bay; (c) Gordon's Bay to Still Bay

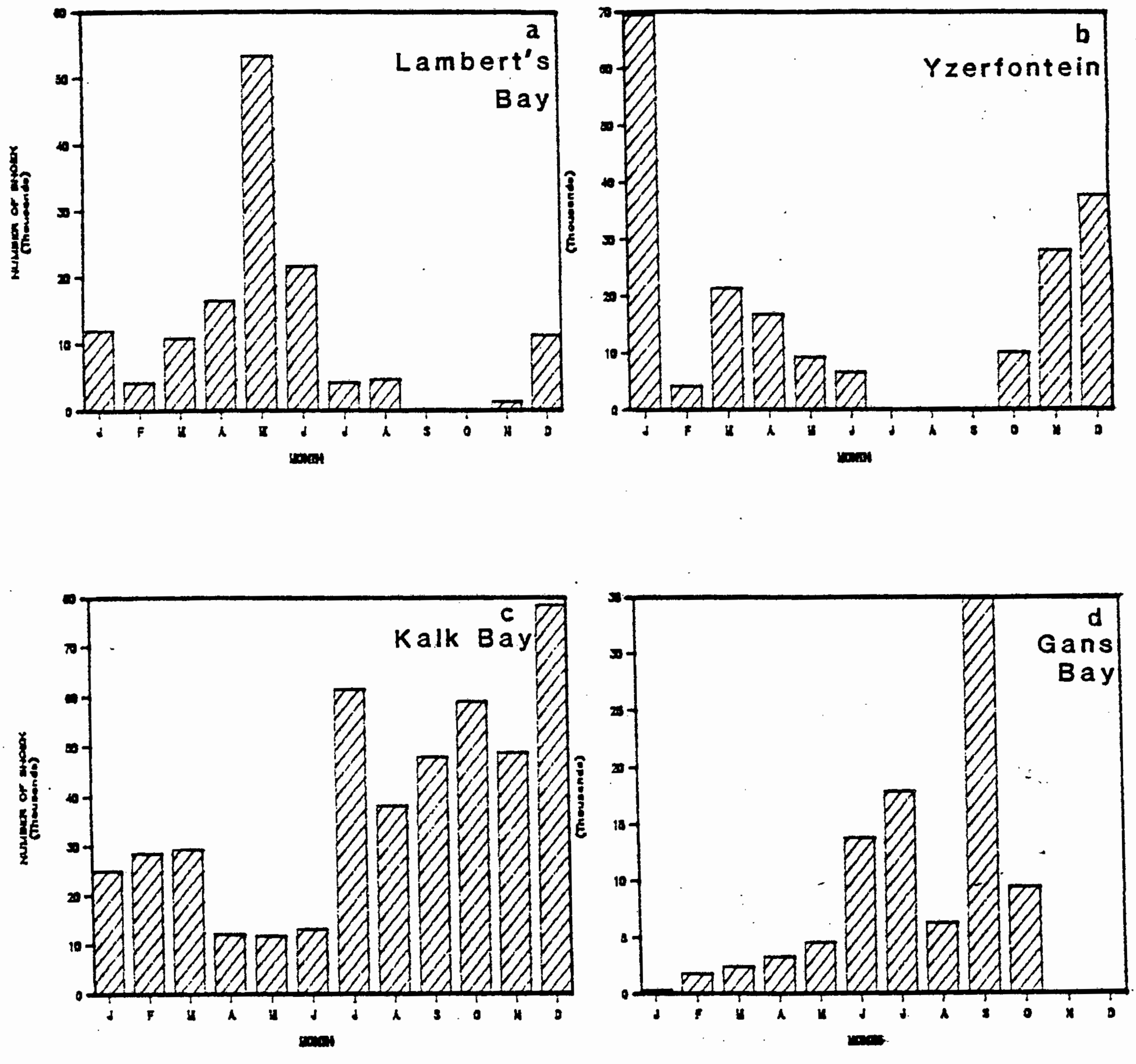


Fig. 5.5: Mean monthly handline catch of snoek; (a) Lambert's Bay 1970-1985; (b) Yzerfontein 1981-1985; (c) Kalk Bay 1970-1985; (d) Gans Bay 1970-1984

an anomalous trend is apparent here in that catches peaked in November-January, with winter catches relatively low. There was a notable trough in July-September, a period overlapping the previously enforced closed season. (The closed season was lifted in 1980).

At Kalk Bay (Fig. 5.5c) catches are consistently high from July to December, a pattern which cannot be readily explained by existing migration hypotheses. Gans Bay catches peak in September and are virtually nil in December (Fig. 5.5d). While this pattern differs markedly from that of Kalk Bay, the fact that the peak month (September) lags the general west coast peak (May-June) is consistent with the hypothesis of north-south migration.

In summary, it appears that for the period 1970 to 1985, while catches of snoek by the handline fishery in South African waters as a whole were highest in May-July, catches to the east of Cape Point lagged those to the west. An exception to this was Yzerfontein, for which data are only available for the 1980s, where catches peaked in summer. There is therefore a certain amount of evidence, at least in the form of available catch data for the inshore fishery, for the belief that availability of snoek peaks first on the west coast and last at Gans Bay, the eastern limit of the inshore commercial snoek line fishery. With regard to the more easterly harbours Arniston and Still Bay, catches were too poor to warrant their adding much weight to this discussion, but nevertheless the fact that catches at these harbours were largely restricted to May-July provides an exception to the east coast pattern. This, together with the fact that snoek catches on the 72-mile bank off Struis Bay take place between November and May, could suggest the existence of a resident sub-population on the east coast.

There is a belief amongst some local fishermen that there has in recent

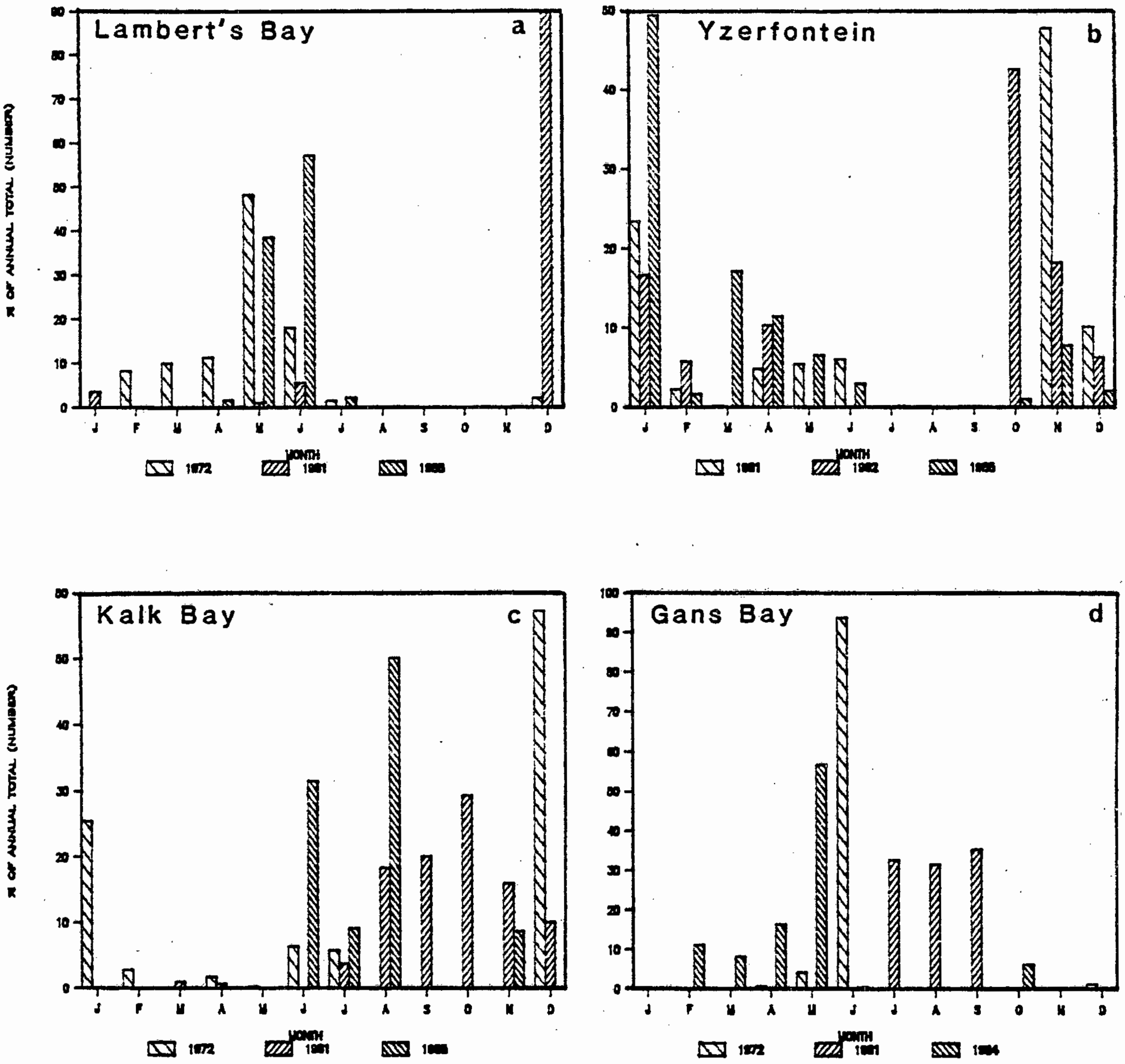


Fig. 5.6: Monthly handline catch of snoek; (a) Lambert's Bay; (b) Yzerfontein; (c) Kalk Bay; (d) Gans Bay

years been a switch of peak availability of snoek from mid-winter to mid-summer. As was evident in Figure 5.3, increased availability in December and January over the whole area occurs frequently, but is less consistent than the winter peak period. It was nevertheless apparent that in 1985 the January catch was approximately three times that of the next highest month (Fig. 5.3d). A consideration of monthly catches for three different years at four relatively widely spaced harbours provides additional information (Fig. 5.6). The year 1972 was chosen as being the first for which adequate data are available for all the chosen harbours, 1985 as the final year in the data series and 1981 as an intermediate year which succeeded the lifting of the closed season. At Lambert's Bay in 1972 snoek catches peaked in winter, in 1981 in summer and in 1985 in winter (Fig. 5.6a). At Kalk Bay (Fig. 5.6c) 1972 catches peaked in summer, 1981 in spring and 1985 catches in late winter. Data for Gans Bay are very patchy, but it is nevertheless apparent that the 1972 peak was in winter, 1981 in spring and 1984 (no data were available for 1985) in late winter (Fig. 5.6d). Thus at these three harbours for which comparable time series of data are available peak catches vary between winter, spring and early summer, but there is little evidence for a switch in seasonality.

Yzerfontein (Fig. 5.6b) is an unusual case, despite the fact that data are only available for recent years. Catches have peaked consistently in summer, and the recent emergence of Yzerfontein as a "mecca" for snoek fishermen may have contributed largely to the belief that the snoek has become a "summer" fish.

It is obvious from this consideration of the temporal and spatial distribution of handline snoek catches that there is considerable variation from year to year. Recent reports of changes in distributional behaviour may simply reflect "normal" variability, and only a lengthy time series of data will detect "real" changes. It is possible that the general migration

pattern of the snoek may not have changed substantially, and the consistently large summer catches of snoek in the Yzerfontein region in recent years may simply be influencing the fishermen's perception. Nevertheless, the traditional winter "snoek run" elsewhere on the Cape coast does appear to be a declining phenomenon. What has given rise to the development of the Yzerfontein fishery is unknown, although the snoek may always have been present but only exploited in recent years due to the construction of adequate harbour facilities and development of the highly mobile ski-boat fleet.

5.2 MIDWATER RESEARCH TRAWLS

5.2.1 METHODS

Midwater trawl surveys have been carried out in recent years by the Sea Fisheries Research Institute. These have taken place between southern Namibia and the Transkei, with the great majority of trawls being in waters off the southern and western Cape. The surveys were carried out using the research vessel R S Africana, towing an Engels 308 net with 12 mm mesh at 3½ knots. Duration and depth of tow were variable.

The cruises under consideration are as listed in Table 5.1.

Table 5.1: Anchovy recruitment cruises (midwater trawling) of the R S Africana.

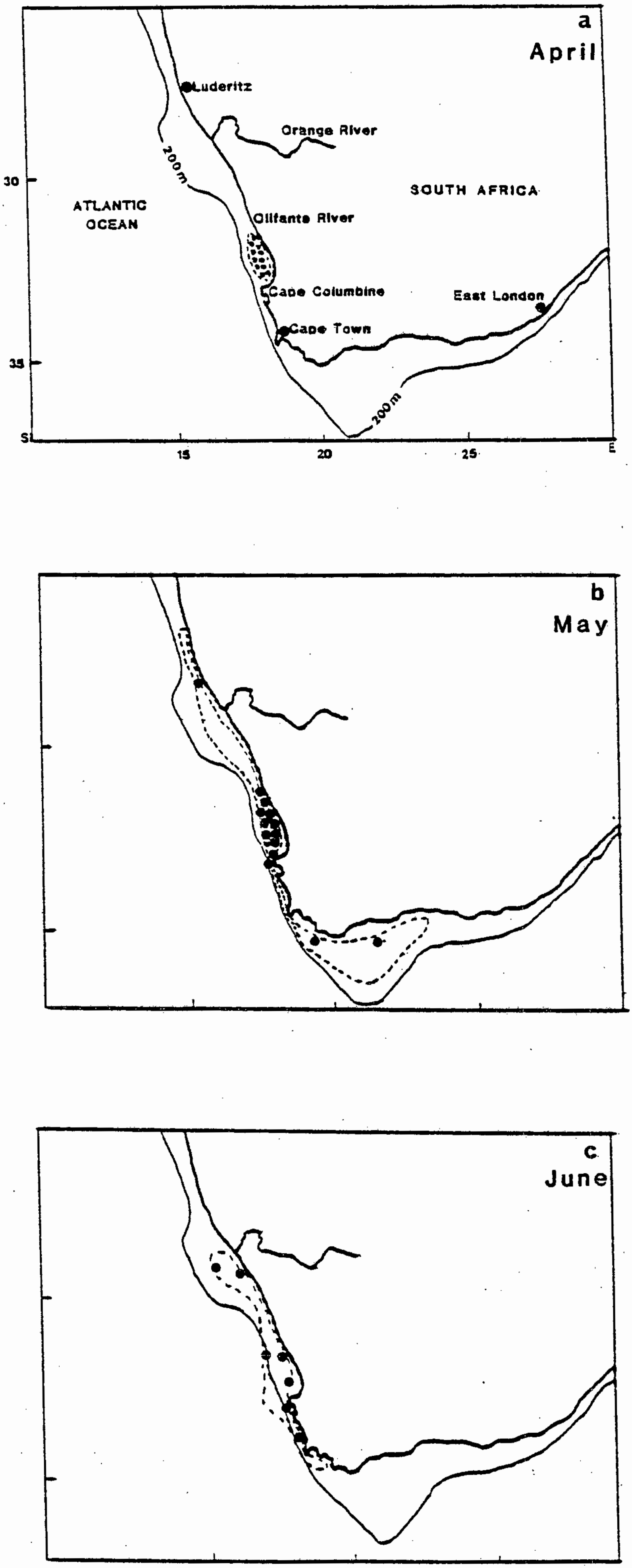
Dates	Area	No. of Trawls
5/5/82 - 28/5/82	Orange River - St Helena Bay	43
2/11/83 - 29/11/83	St Helena Bay - East London	60
10/4/84 - 17/4/84	Olifants River - St Helena Bay	33
22/5/84 - 28/5/84	Olifants River - St Helena Bay	27
6/11/84 - 20/11/84	St Helena Bay - Knysna	56
20/5/85 - 7/6/85	Southern Namibia - Still Bay	51
12/11/85 - 28/11/85	St Helena Bay - Knysna	56
15/5/86 - 22/5/86	Olifants River - Cape Agulhas	40
10/6/86 - 18/6/86	Orange River - Hermanus	37
4/8/86 - 24/8/86	Table Bay - Transkei	80

While the purpose of the surveys was primarily to monitor anchovy recruitment, snoek were caught periodically as "by-catch".

5.2.2 RESULTS AND DISCUSSION

In an attempt to investigate possible diurnal vertical migration, the number of snoek caught in each "successful" trawl was plotted against the depth of that trawl and separately against the time of day at which the trawl was carried out. In addition, time of day was plotted against depth of trawl for all trawls in which one or more snoek were caught. In none of the three cases was there any apparent relationship.

Catch distributions are given in Figure 5.7. Data were combined for all cruises in all years for each month of the year in which cruises were conducted. The number of trawls conducted in each month totalled over all the years (1982-1986) (Fig. 5.8) was divided by the number of trawls in which snoek were present, again for each totalled month to give a "success"


a
April
Luderitz
Orange River
200m
30
ATLANTIC
OCEAN
SOUTH AFRICA
Olifants River
Cape Columbine
East London
Cape Town
35
S
15
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E
200 m
b
May
c
June

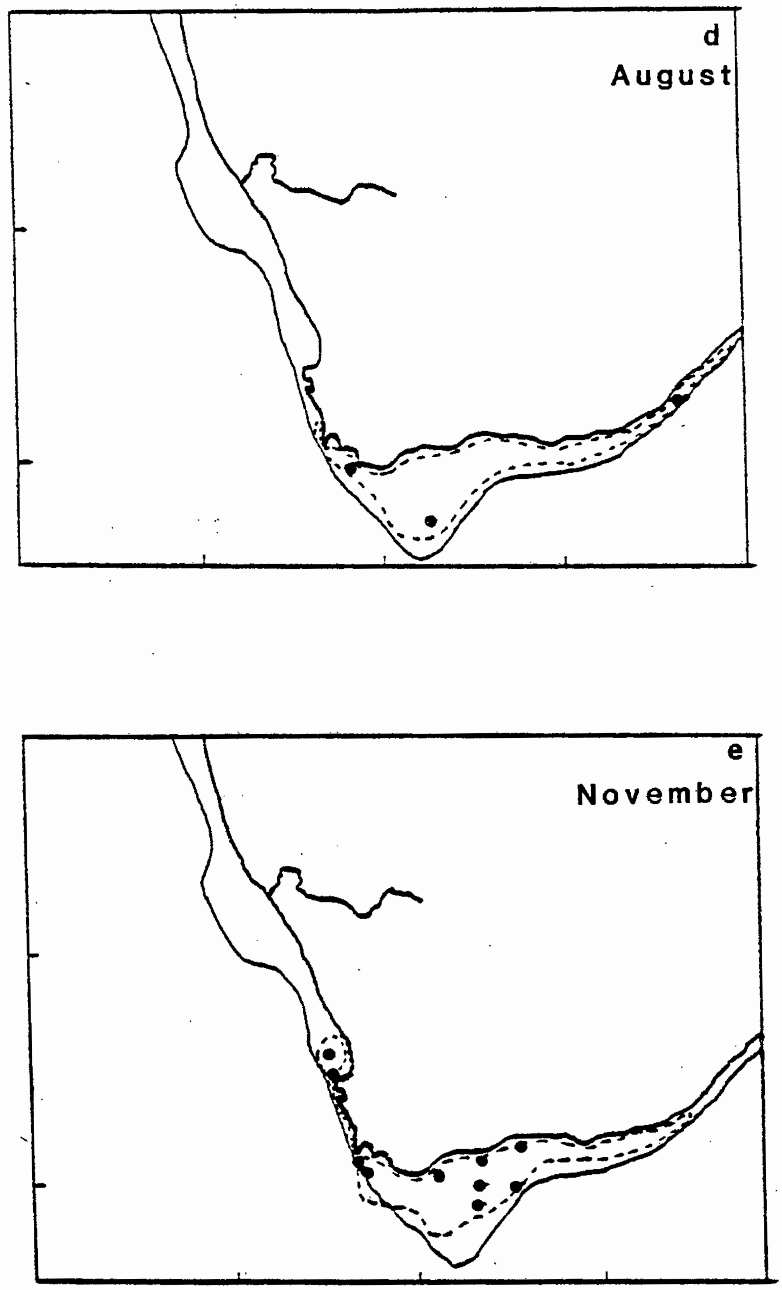


Fig. 5.7: Distribution of snoek catches during midwater trawl surveys of the RS Africana between 1982 and 1986; all cruises conducted in a particular month are combined; (a) April (1 cruise); (b) May (4 cruises); (c) June (1 cruise); (d) August (1 cruise); (e) November (3 cruises); dotted lines demarcate areas covered during surveys and dots represent catch localities

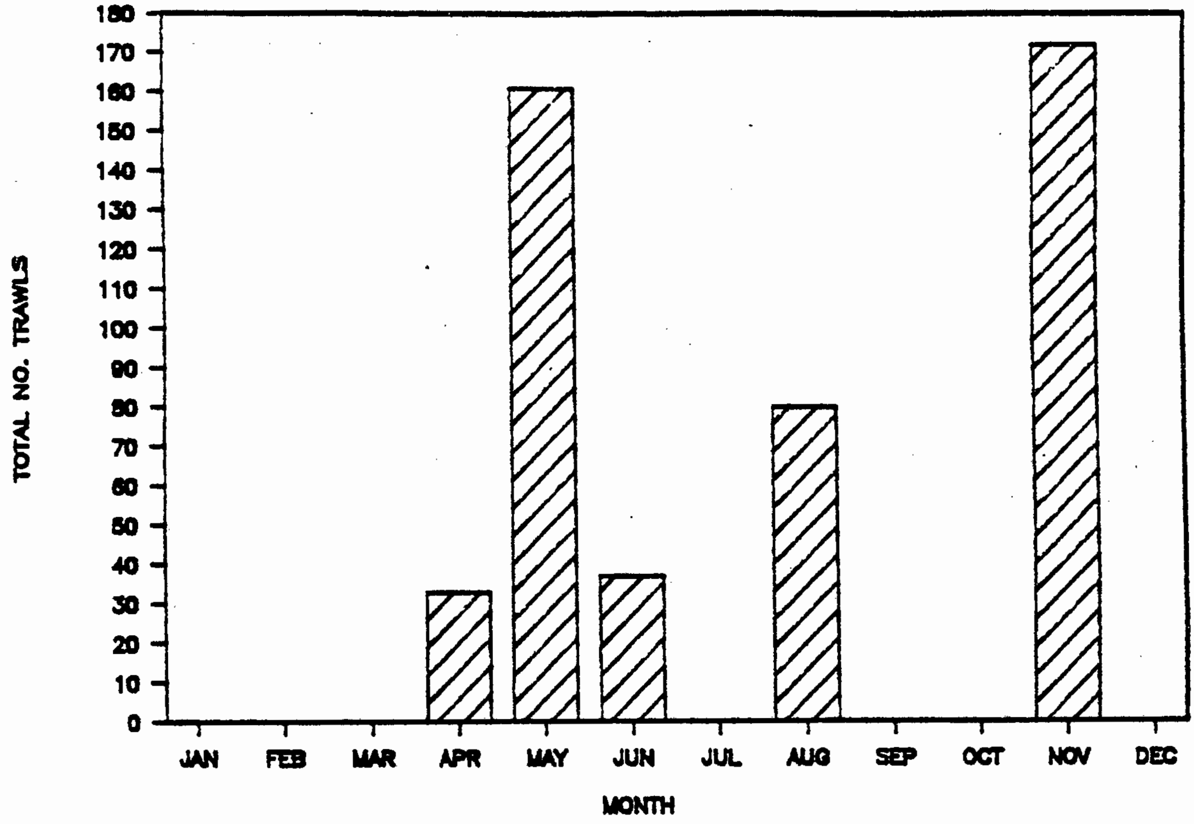


Fig. 5.8: Number of midwater trawls conducted by the SFRI using the RS Africana between May 1982 and August 1986

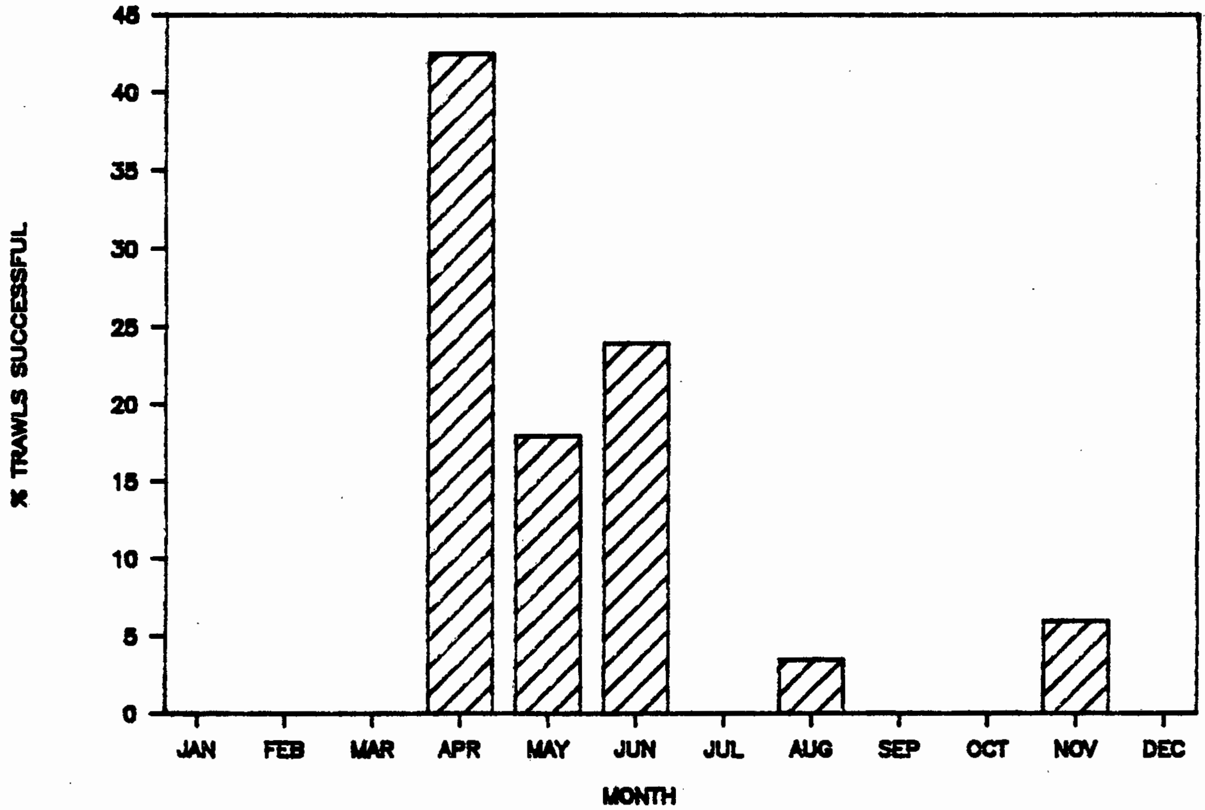


Fig. 5.9: Percentage of midwater trawls in which snoek were caught between May 1982 and August 1986-

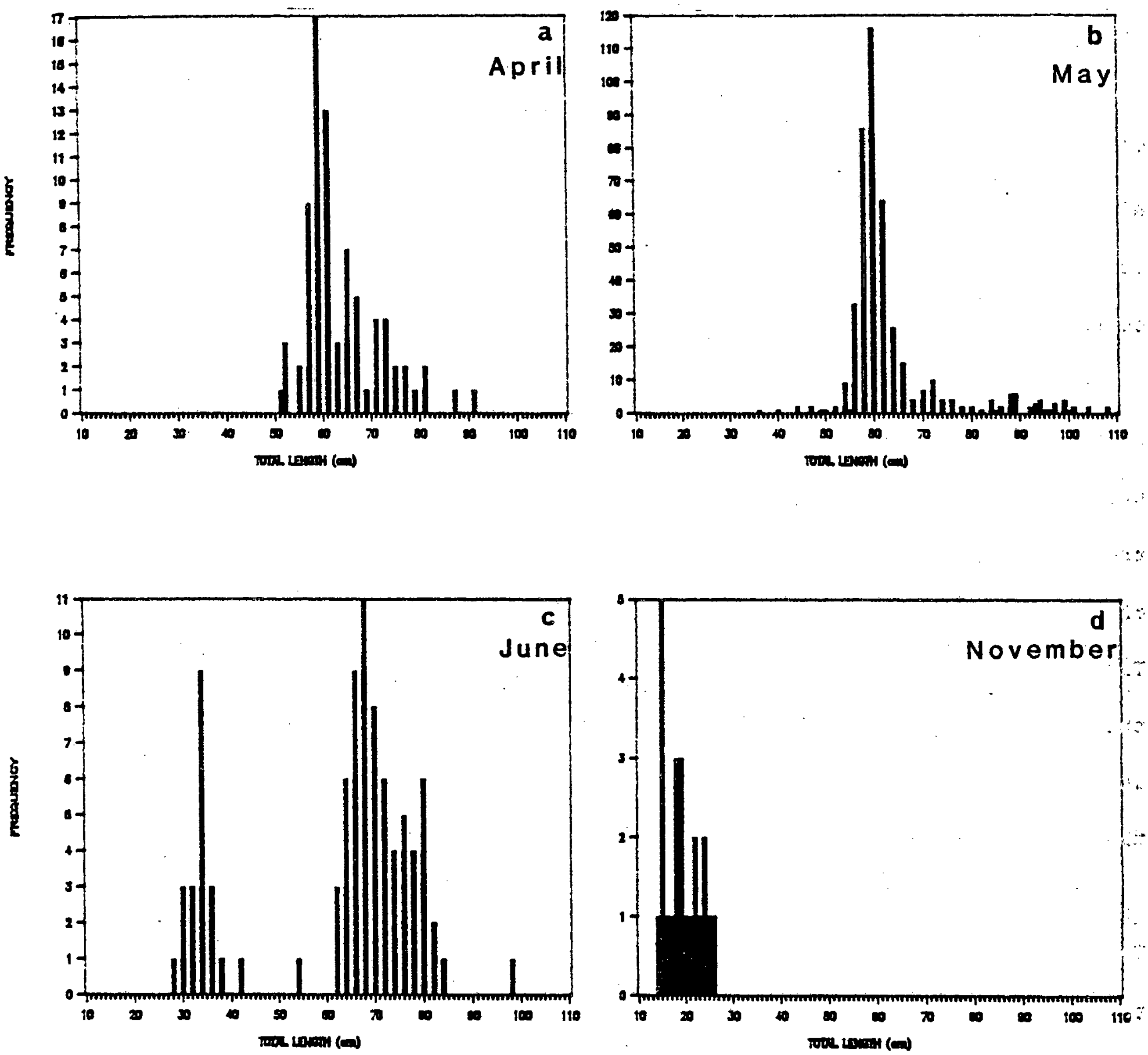


Fig. 5.10: Length frequency distributions of snoek caught during midwater trawls conducted by the SFRI; (a) April (n=78); (b) May (n=438); (c) June (n=88); (d) November (n=23) (very few snoek in August)

rate (Fig. 5.9), although it should be noted that the area of trawling changed from month to month. (Only one April cruise was conducted, and that was in the St Helena Bay area (Fig. 5.7a)).

The April success rate was almost twice that of the next highest month, although the small sample size and restricted sampling area bias these results heavily. There does however appear to have been a large concentration of snoek in the St Helena Bay area in April 1984.

Four May cruises covered between them an area extending from north of Luderitz in Namibia to the region of Knysna on the Cape south coast, with the area of common overlap being St Helena Bay (Fig. 5.7b). Again, catches of snoek were concentrated between St Helena Bay and the Olifants River. The single west coast June cruise revealed widespread distribution between the Orange River and Cape Hangklip (Fig. 5.7c), and the single south coast August cruise was notable for a success rate of less than 5% but also for the most easterly recorded snoek catch, at 33°13,9'S 27°53,0'E (Fig. 5.7d).

The area covered by the three November cruises extended from St Helena Bay to East London, snoek distribution appearing to be widespread to the west of Knysna, although the success rate was less than 10% (Figs 5.7e and 5.9).

Length frequency analyses are hampered by small sample sizes, but it appears that there may have been an increase in modal length from April to June (Figs 5.10a-c; no data are available for August). The April mode is 59 cm total length, May 60 cm and June 68 cm. The June distribution is bimodal (Fig. 5.10c), with a second mode at 34 cm. These smaller fish were caught in the region of the Orange River mouth (Fig. 5.7c).

Perhaps most important of the length frequency distributions is that for

November (Fig. 5.10d). Although the sample size is only 23, this consists of snoek caught in each of three years (1983-85), and all fall within the size range 14-26 cm total length. These fish would all have been spawned in the winter of the year in which caught (see discussion of blanket net survey in this chapter).

In summary, availability of snoek of commercially exploitable size (>60 cm total length) was greatest (in the months sampled) from April to June, and highest catch rates were achieved in the region between Cape Columbine and the Olifants River on the west coast. Catches of snoek on the Agulhas Bank were always sparse, with the feature that fish in the region of 60 cm total length were caught in May but smaller fish (ca 20 cm) were caught in November. The August sample was too small to warrant comment with regard to length distribution.

5.3 DEMERSAL RESEARCH TRAWLS

5.3.1 METHODS

Hake biomass assessment cruises have been conducted by the demersal section of the SFRI in South African waters each January and July since 1983. The grid is sampled on a stratified-random basis to ensure a scatter of samples within each depth stratum.

The gear used is a standard German bottom trawl with a 55 m foot-rope, and with a 75 mm mesh net lined at the cod-end with 27 mm "pilchard" mesh. Tows are generally standardized at 30 minutes duration, and are routinely carried out in daylight hours (A.I.L. Payne SFRI pers. comm.).

After each trawl the catch is separated into species and weighed. Certain species, including snoek, are subsampled for routine biological analyses (see Chapter 3). Parameters measured include fork and total lengths, which

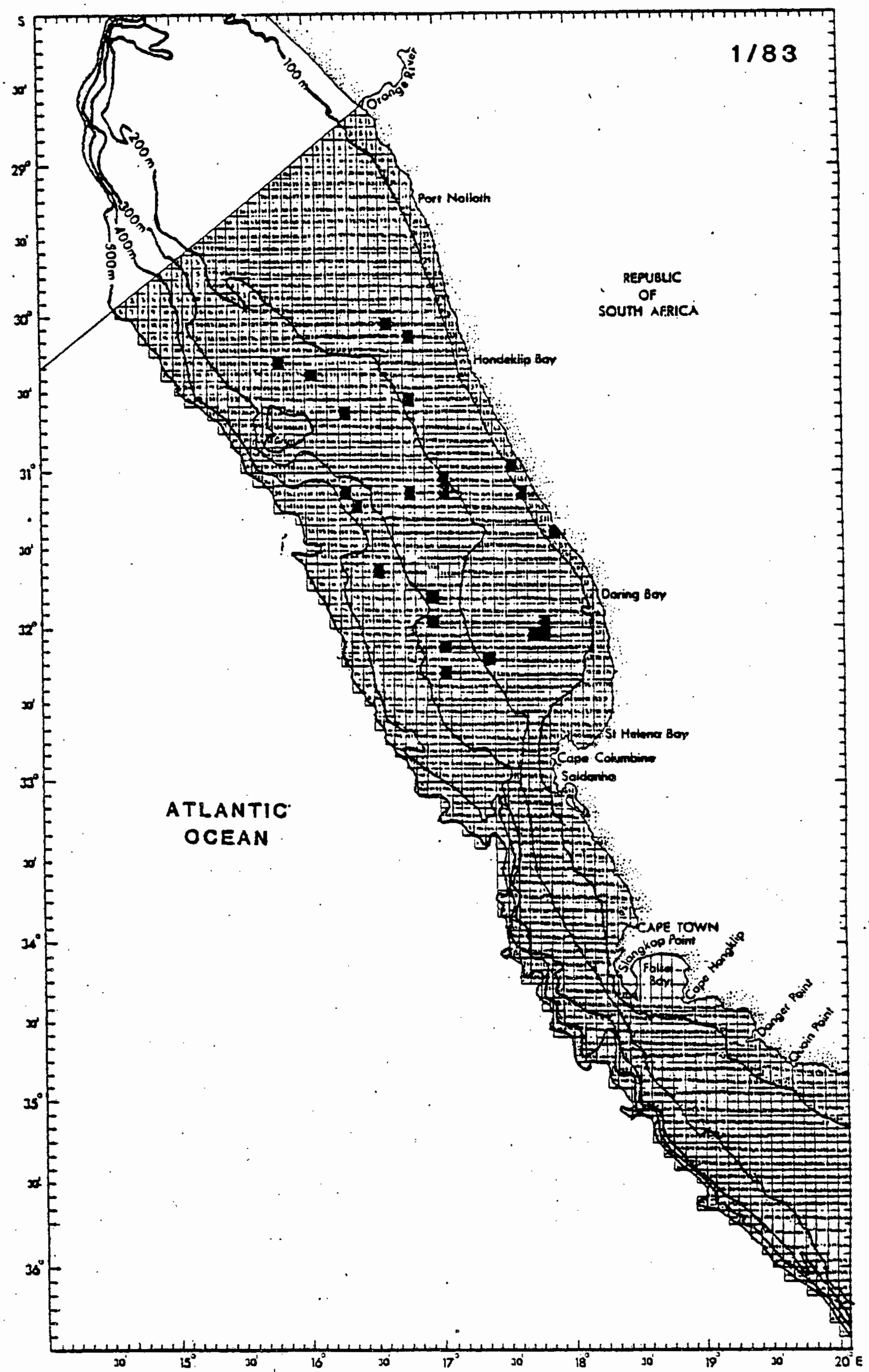


Fig. 5.11: (a) Distribution of snoek catches during the January 1983 demersal trawl survey conducted by the SFRI; the grid is divided into depth strata of 100 m interval and the strata are subdivided into grid squares of side 5 nm; each stratum is randomly sampled per cruise; black squares represent snoek catches (chart from SFRI, unpubl. material)

are considered below.

A total of 632 bottom trawls were completed during seven cruises between January 1983 and January 1986, four of the cruises being in summer and three in winter.

5.3.2 RESULTS AND DISCUSSION

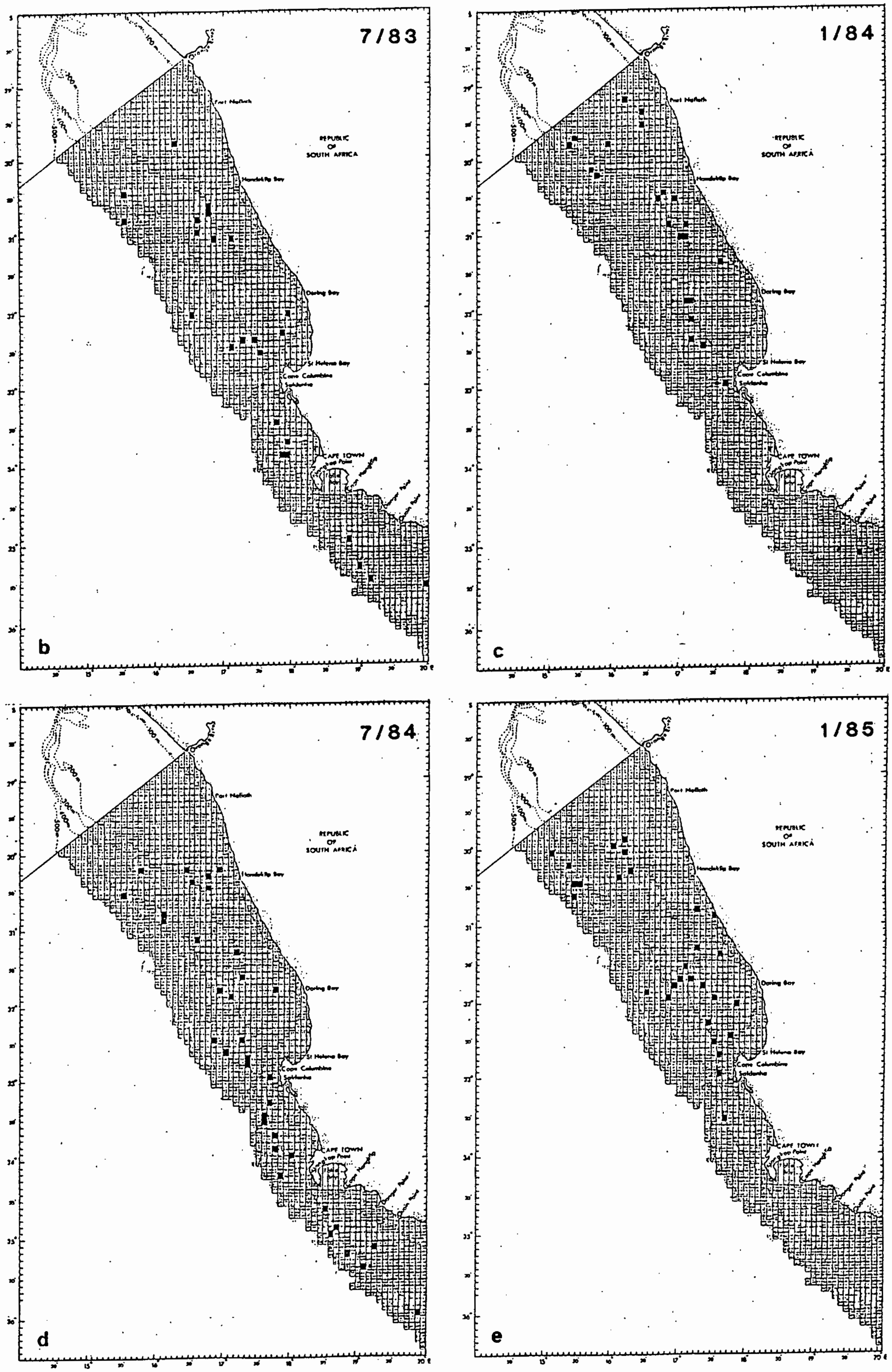
The summarized composition of the demersal program is given in Table 5.5. A "successful" trawl is defined as one in which snoek were caught. It is clear that the snoek is caught in a greater proportion of trawls in winter than in summer, and also that the average weight of snoek caught per "successful" trawl in winter is twice that in summer.

Table 5.2: Summary of research demersal trawls carried out in South African waters between January 1983 and January 1986.

	No. trawls	% trawls in which snoek present	Weight of snoek (kg)	Average weight per trawl (kg)	Av. wt. per succ. trawl
Winter	236	46	6529,0	27,66	60,45
Summer	396	26	3126,5	7,90	29,78
Total	632	36	9655,0	15,28	45,33

Spatial distribution

Snoek are distributed in a broadly consistent manner every January and July (Figs 5.11a-f). In January the fish are mostly found to the northwest of Cape Point, whereas in July they are distributed throughout the survey area. It must be remembered that the survey grid shown in Figure 5.11 is only subsampled each survey, with the distribution of grid squares sampled differing in detail from survey to survey. A scatter of trawls over the


7/83
1/84
7/84
1/85
Port Nolloth
REPUBLIC OF SOUTH AFRICA
Hondeklip Bay
Doring Bay
St Helena Bay
Cape Columbine
Saldanha
CAPE TOWN
Cape Point
b
c
d
e

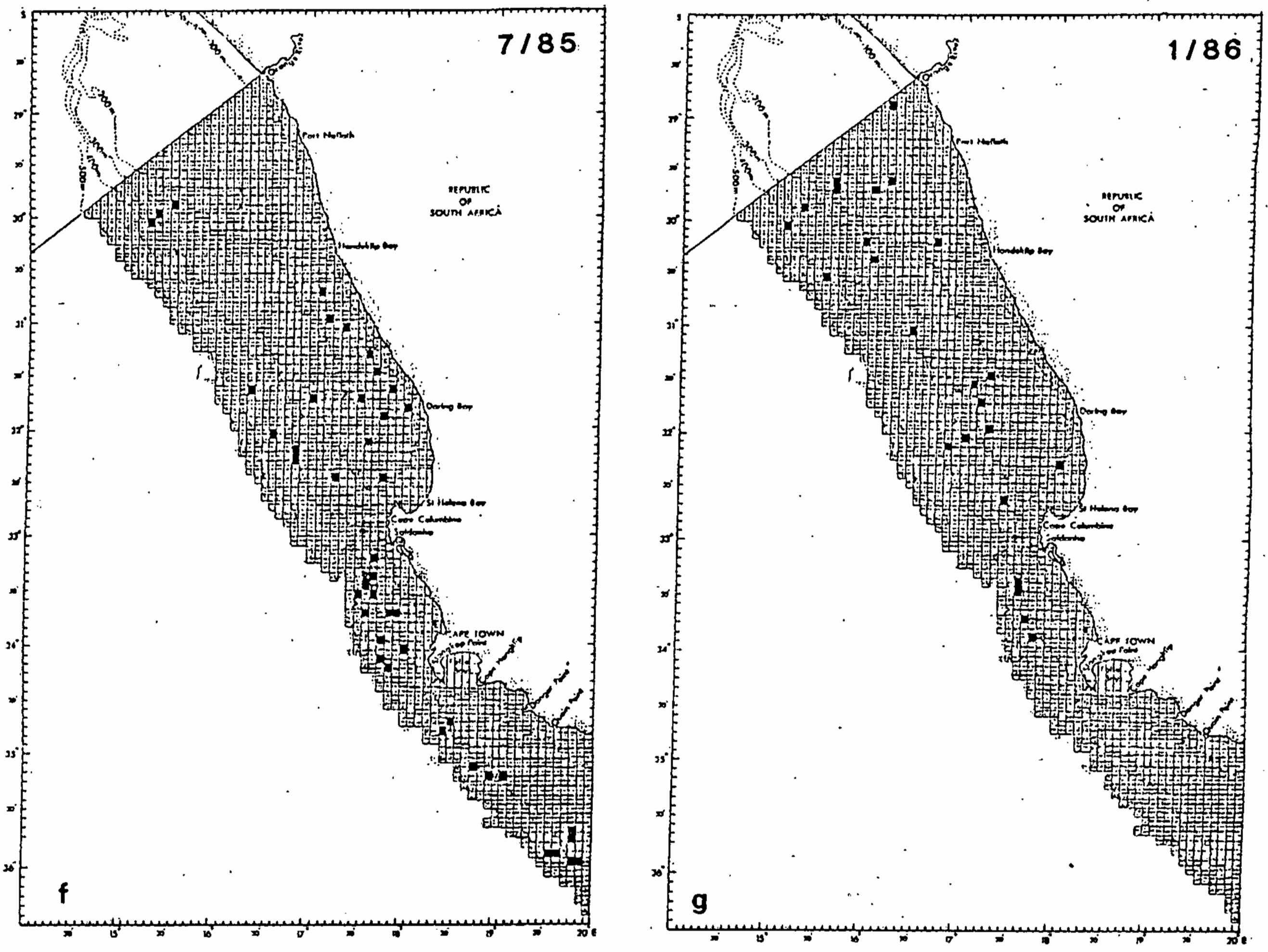


Fig. 5.11: Distribution of snoek catches during demersal trawl surveys; (b) July 1983; (c) January 1984; (d) July 1984; (e) January 1985; (f) July 1985; (g) January 1986
(cont.)

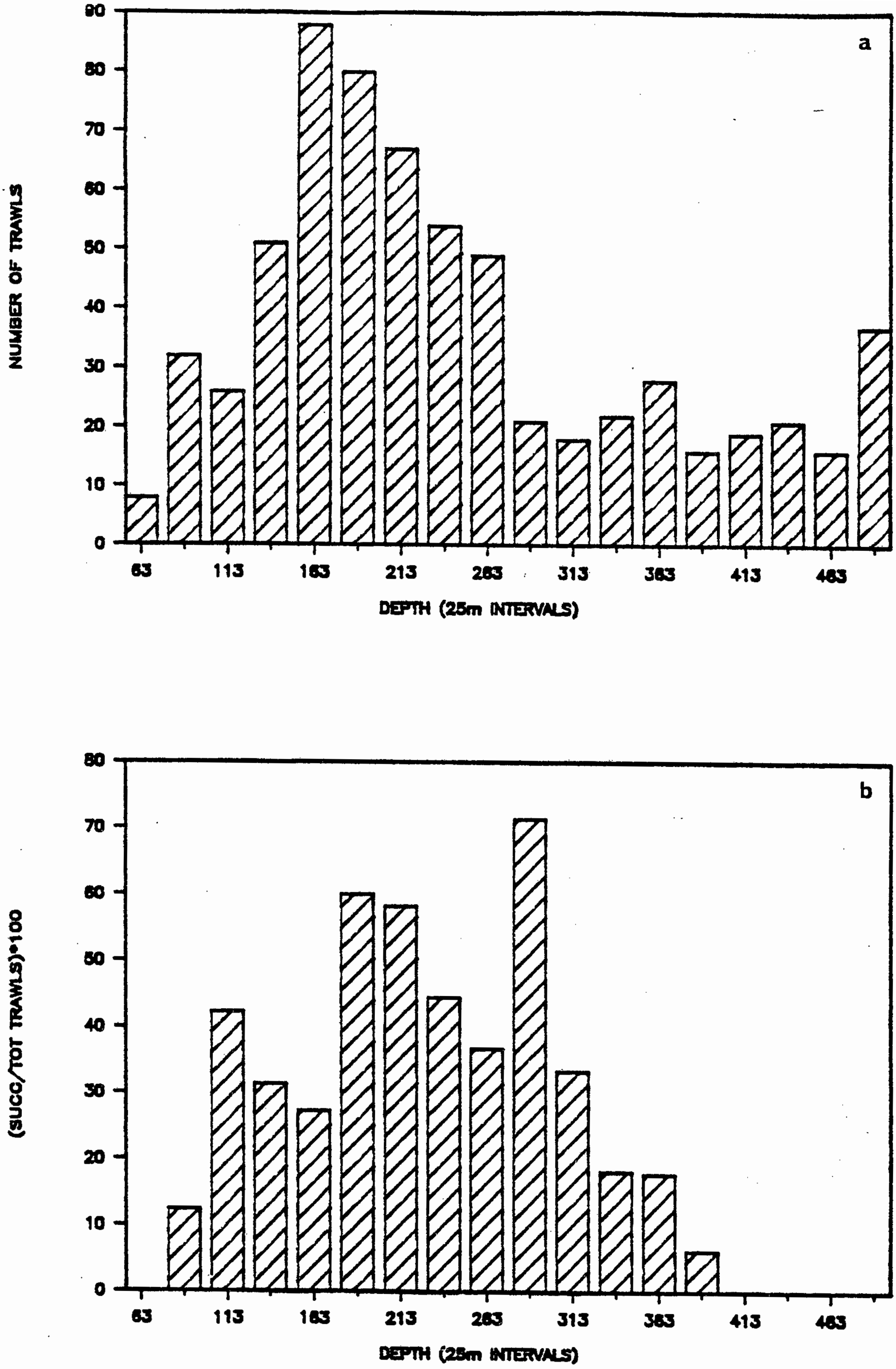


Fig. 5.12: Demersal trawl surveys (n=653 trawls); (a) depth distribution of trawls (b) percentage of trawls in which snoek were caught per 25 m depth interval

entire grid is, however, ensured on each survey.

The snoek are found some distance offshore, as well as relatively close inshore, in both January and July. For example in both July 1983 and January 1985 catches were made approximately 120 km west of Hondeklip Bay at depths greater than 300 m.

The distribution of trawls per 25 m depth interval is shown in Figure 5.12a, the range covered being between 50 and 826 m. All but 5% of trawls were shallower than 475 m. The expression of the number of "successful" trawls (ie. those in which snoek were present) as a percentage of the total number of trawls per depth interval reveals a clear trend (Fig. 5.12b). The greatest frequency of successful trawls is in the depth range 201-300 m, with the success rate declining relatively steadily to minima at the 76-100 m and 376-400 m intervals. Specifically, the shallowest and deepest snoek catches were made at 86 m and 384 m respectively;.

A seasonal summary of catch per unit "successful" effort (Fig. 5.13a-d) reveals a less clear trend, with pronounced peaks again being due to isolated very large catches. It is nevertheless apparent from Figure 5.13d that in winter the snoek exhibit a clear depth distribution. The magnitude of the mode is exaggerated, however, by a catch of 1297 kg at 253 m in July 1985.

Vertical migration

As in the case of the midwater research cruises described above, the temporal distribution of catches was investigated with a view to elucidating possible diurnal vertical migration. Unfortunately in the case of the demersal cruises the great majority of trawls were conducted during daylight hours (Fig. 5.14a). Times have been lumped so that, for example,

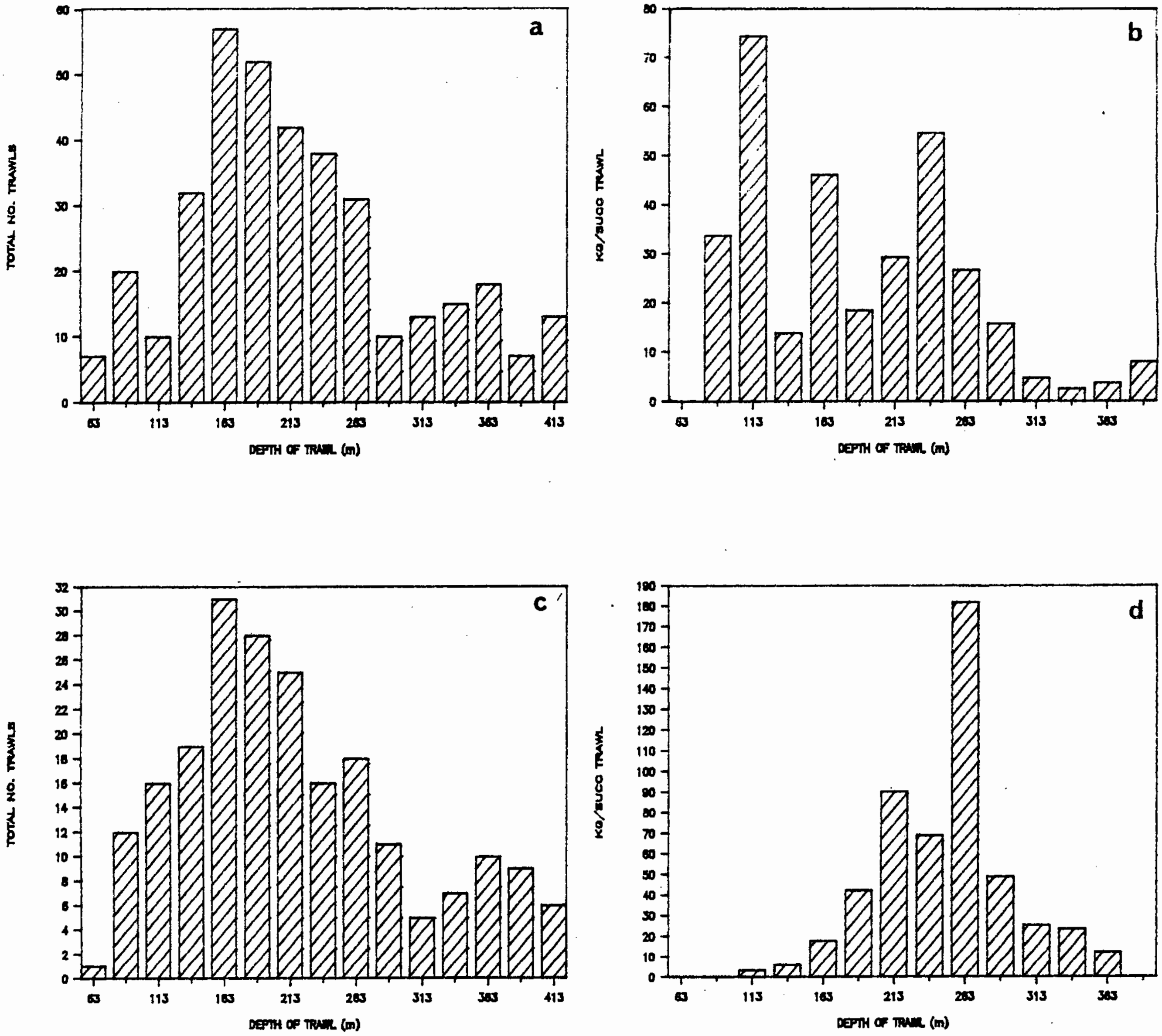


Fig. 5.13: Demersal trawl surveys; (a) depth distribution of summer trawls (to a maximum of 400m) (n=365 trawls); (b) mean weight of snoek per trawl in which snoek present; (c) (n=214 trawls) and (d) similarly for winter

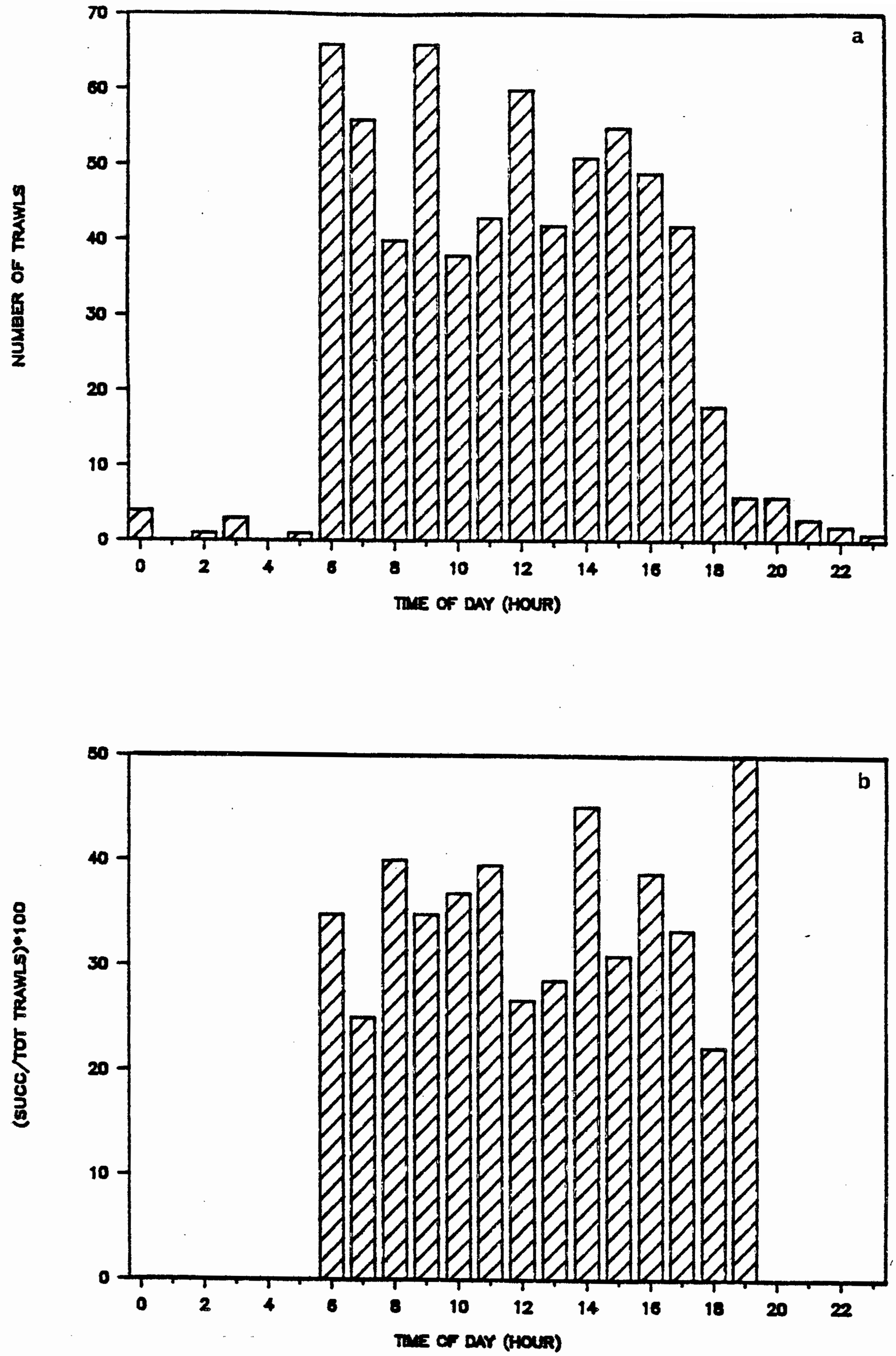


Fig. 5.14: Demersal surveys conducted every sixth months by the SFRI between January 1983 and January 1986 (n=653 trawls); (a) temporal distribution of trawls; (b) percentage of trawls per hourly interval in which snoek were caught

a histogram labelled hour 6 includes all trawls begun between 06h00 and 06h59.

The total number of trawls per hourly interval for both summer and winter cruises together was divided by the number of successful trawls for that interval and expressed as a percentage (Fig. 5.14b). During daylight hours (06h00-19h59), there appears to be no pattern in temporal distribution of successful trawls. While there is a peak of 50% success rate at 19h00, only 6 trawls were conducted during this interval. No snoek were caught between 20h00 and 05h59, albeit that very few trawls were made during this period. There is limited evidence, therefore, that snoek migrate off the bottom at night, but more night trawls are needed to verify this, as are more midwater trawls.

By separating the temporal (hourly) catch distribution into summer and winter and expressing the success rate as weight per "successful" trawl per time interval (Figs 5.15a-d), it can be shown that there is again little pattern. The peaks at 16h00 and 19h00 in summer and 09h00 and 10h00 in winter are due to isolated very large catches rather than consistently large catches.

<u>Length frequency distribution</u>

Length frequency data are presented in Figure 5.16. Geometric mean lengths were calculated for each distribution using the formula:

$$G.M.(X) = \text{antilog}\,[(\Sigma(\log X))/n] \qquad \text{(rewritten after Zar 1984)}$$

where X is the individual length

n is the number of fish measured.

(Geometric mean was used to remove bias due to lengths at the extremities of distributions).

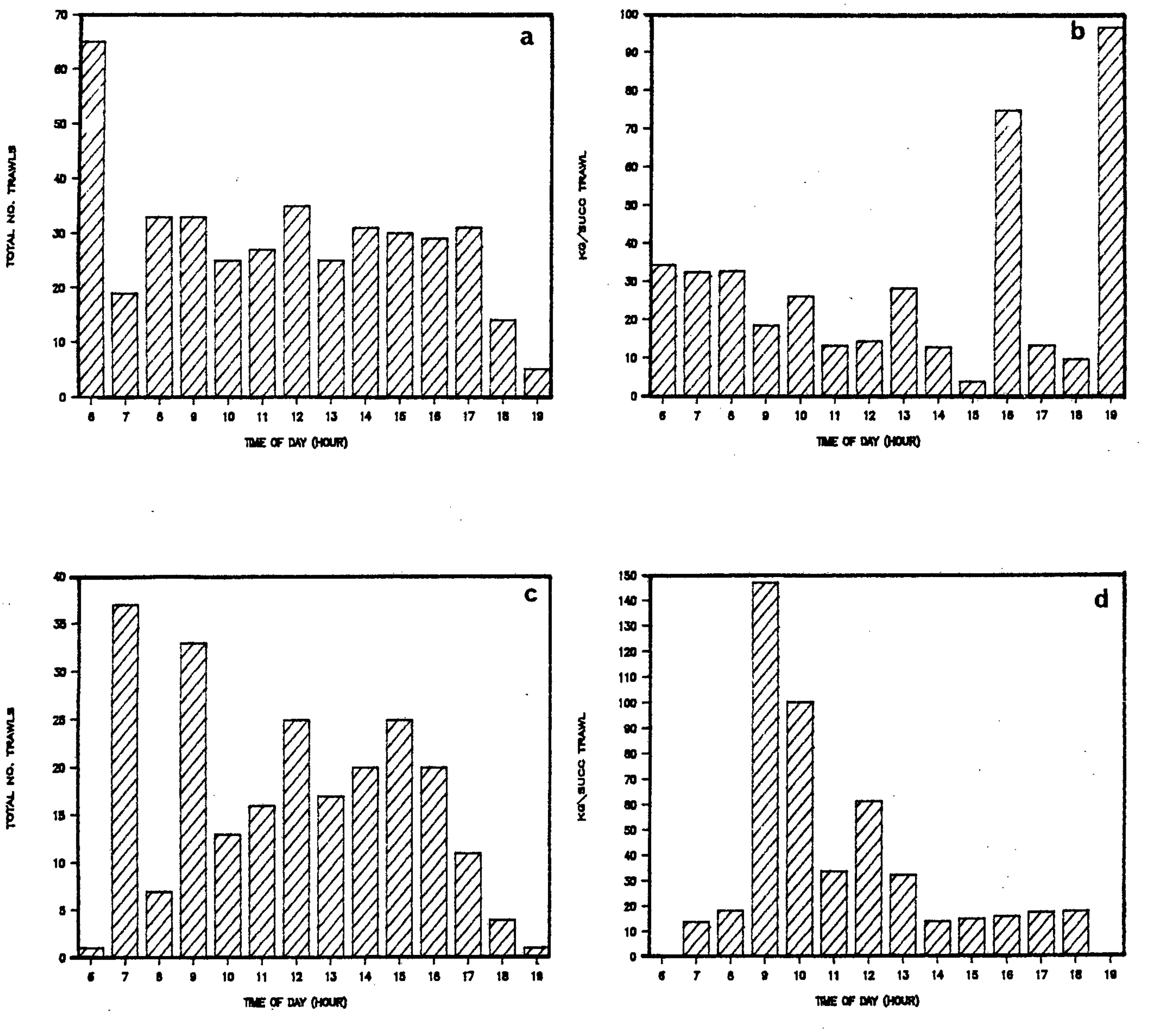


Fig. 5.15: Demersal trawl surveys; (a) temporal distribution of daylight summer trawls (n=402 trawls); (b) mean weight of snoek per trawl in which snoek present; (c) (n=230 trawls) and (d) similarly for winter

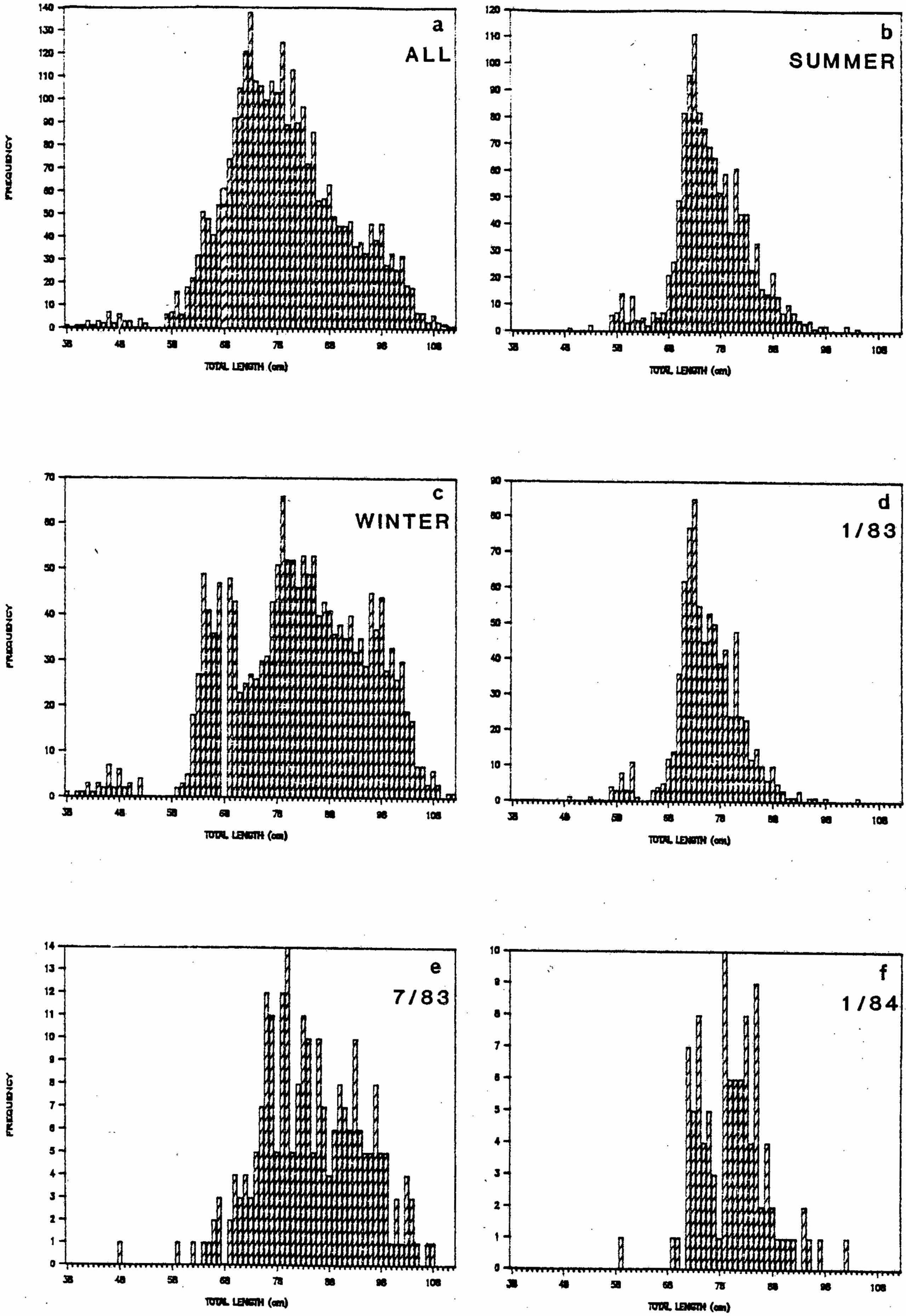
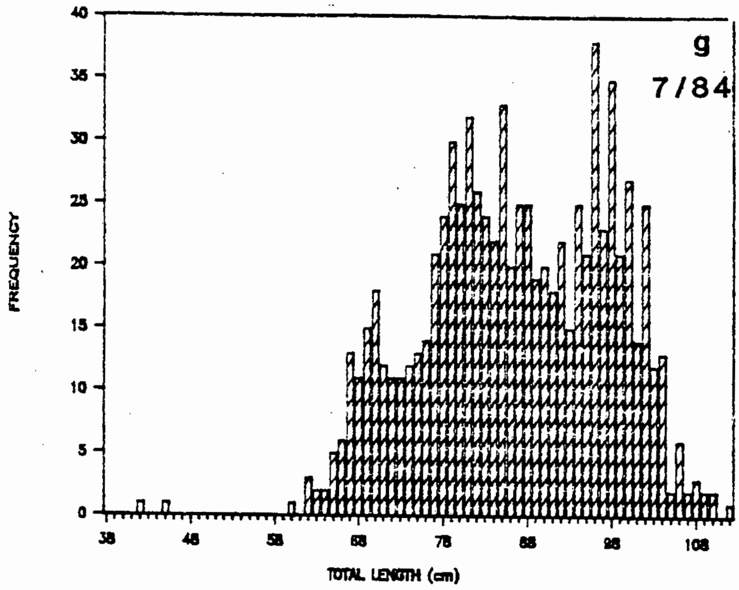
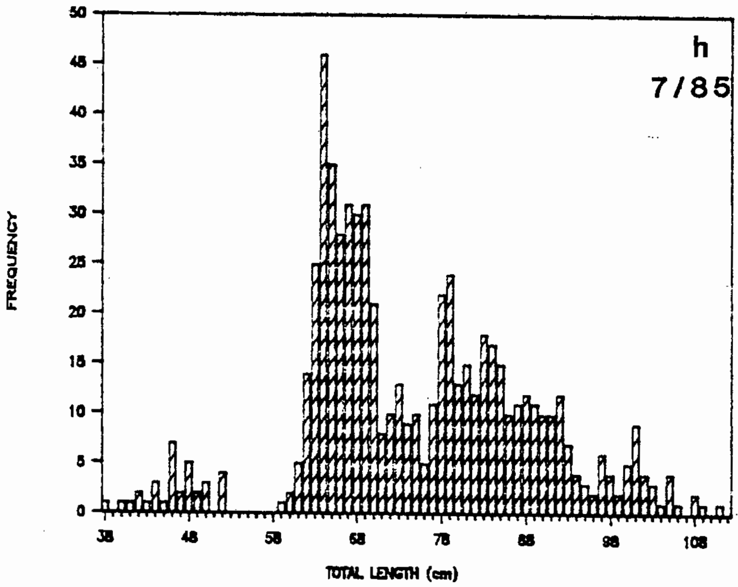
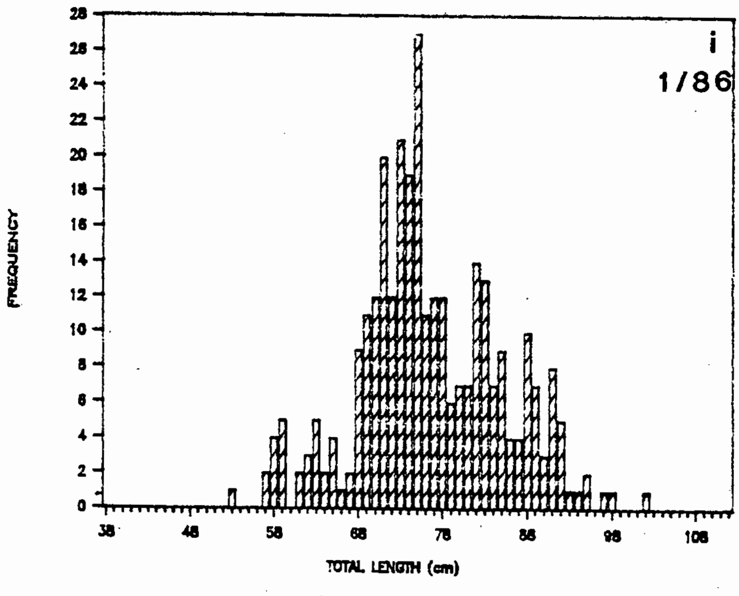


Fig. 5.16: Length frequency distributions of snoek caught during demersal trawl surveys; (a) all cruises (n=2915) except Jan 1985 (no data) (b) all summer cruises (n=1214); (c) all winter cruises (n=1701); (d) Jan 83 (n=804); (e) Jul 83 (n=238); (f) Jan 84 (n=102); (g) Jul 84 (n=824); (h) Jul 85 (n=639); (i) Jan 86 (n=308)


g
7/84
FREQUENCY
0 5 10 15 20 25 30 35 40
38 48 58 68 78 88 98 108
TOTAL LENGTH (cm)


h
7/85
FREQUENCY
0 5 10 15 20 25 30 35 40 45 50
38 48 58 68 78 88 98 108
TOTAL LENGTH (cm)


i
1/86
FREQUENCY
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28
38 48 58 68 78 88 98 108
TOTAL LENGTH (cm)

Snoek were measured during 6 out of 7 cruises, the exception being January 1985 (Table 5.3).

Table 5.3: Snoek measured during demersal research cruises of the R S Africana in the southern Benguela region, 1983-1986. (Snoek were not measured in January 1985).

Cruise	n	Geometric mean total length (cm)
1/83	804	75,23
7/83	238	84,03
1/84	102	80,13
7/84	824	85,90
7/85	639	73,66
1/86	308	76,04
Summer	1214	75,84
Winter	1701	80,83
Total	2815	78,95

Comparison of length frequency distributions was made using the Kolmogorov-Smirnov test which tests the null hypothesis that two samples come from populations with the same distribution (Sokal and Rohlf 1981, p445). Calculations were performed using STATPRO on a Sperry personal computer.

The combined (all cruises) size distribution of snoek caught in summer differs significantly (Kolmogorov-Smirnov test, $p<0,05$) from the winter distribution, with two conclusions arising from this fact (Figs 5.16b,c). Firstly, the winter length frequency distribution is far broader than that of summer, suggesting that within the sampling area as a whole a larger age distribution of snoek is available to the demersal fishery in winter than

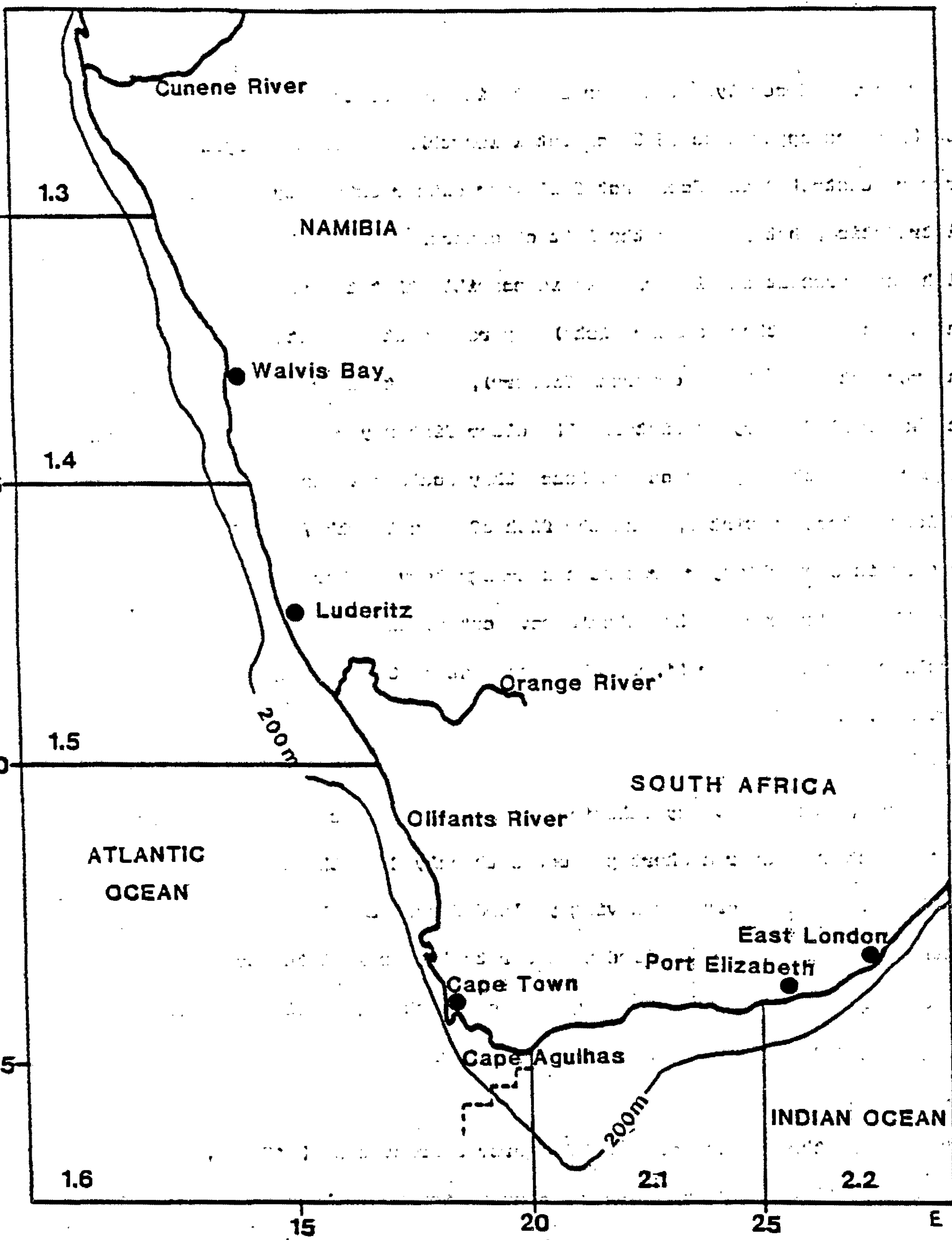


Fig. 5.17: ICSEAF fishing areas; the dotted line off Cape Agulhas represents the effective boundary between areas 1.6 and 2.1 for the purpose of South African demersal catch statistics (A. I. M. Payne SFRI pers. comm.)

variations in length of snoek from cruise to cruise in the same season (Table 5.3) have little significance.

5.3.3 Additional demersal research cruises

Two additional research cruises were carried out by the demersal section of the SFRI in 1985. These cruises took place on the Agulhas Bank between Cape Agulhas and Port Elizabeth, which is an area to the east of that covered by the hake biomass program discussed above.

The gear used was a 46 m German bottom (otter) trawl with the cod-end lined with 24 mm netting. The cruises were conducted in October and December 1985, the first surveying the 20 m to 100 m depth interval and the second the 30 m to 400 m interval.

Twenty six trawls were completed in October and no snoek were caught. Snoek were caught during four of the 50 December trawls, and all catches were made between 50 m and 100 m in the region between Still Bay and Knysna, the largest catch being only 14 kg.

Little can be concluded from these scanty data, except that they conform with the expectation that while snoek are generally scarce on the eastern Agulhas bank they are nevertheless occasionally present in December, a fact also displayed by reports of recent handline catches in the area.

5.4 COMMERCIAL DEMERSAL CATCH DISTRIBUTIONS

Snoek are caught largely as by-catch by the mainly hake-directed South African demersal trawl industry, although it is probable that the species is occasionally targetted when abundant. The four ICSEAF areas relevant to the distribution of snoek in South African waters are areas 1.5, 1.6, 2.1 and 2.2 (Fig. 5.17).

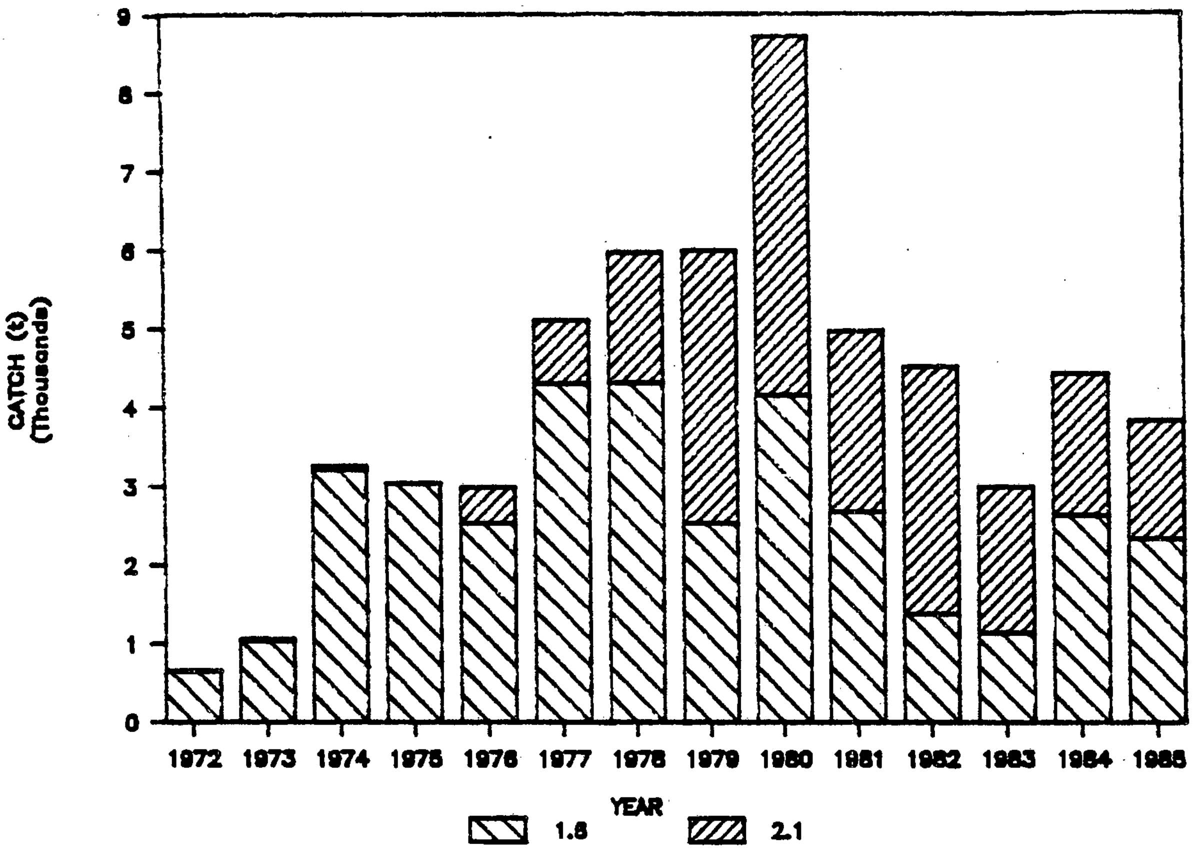


Fig. 5.18: Division of snoek catches by the South African demersal fishery between areas 1.6 and 2.1 (pre-1979 figures represent difference between total South African snoek catches (ICSEAF statistical bulletins) and area-specific line catches (monthly returns - catches converted to weight assuming 2,34 kg per snoek); post-1979 figures from records of the SFRI)

While catches of snoek to the east of Cape Agulhas are very small with regard to the handline fishery and demersal and pelagic research trawls, they are now a relatively large component in the commercial demersal fishery (Area 2.1). This may be partially an artefact of the fact that for the purposes of demersal catch returns the line dividing areas 2.1 and 2.2 does not run north-south at 20°E, but rather in a southwesterly direction from the coastline (A.I.L. Payne SFRI pers. comm.).

There has in fact been a shift in the distribution of commercial demersal snoek catches in ICSEAF areas 1.6 and 2.1. Prior to about 1978 the bulk of the total catch for these two areas was made in area 1.6, but since then area 2.1 has increased substantially in importance (Fig. 5.18). The summarised change is shown in Figure 5.19. Catches in area 2.1 are probably made mostly in the southwestern part of the region, bordering on area 1.6, but there does nevertheless appear to have been a southward shift in offshore snoek distribution. This may simply reflect a geographical change in fishing effort, an aspect which needs to be investigated.

Catch data for the South African demersal fishery have been reported monthly by ICSEAF area since January 1979. Snoek catch distribution was plotted by month by ICSEAF area for each year from 1979 to 1985, the catch for each month being expressed as a percentage of the area total. There was little variation from year to year for areas 1.5, 1.6 and 2.1, and the temporal distribution of catches can be adequately summarized in a single graph expressing the mean of all seven years (Fig. 5.20). It is apparent that little is caught between December and May, that catches begin to pick up in June, peak in August and that they then decline steadily to below 5% of the annual catch in November. There is no lag in catches in area 2.1 behind areas 1.5 and 1.6, contrary to what might be expected from the

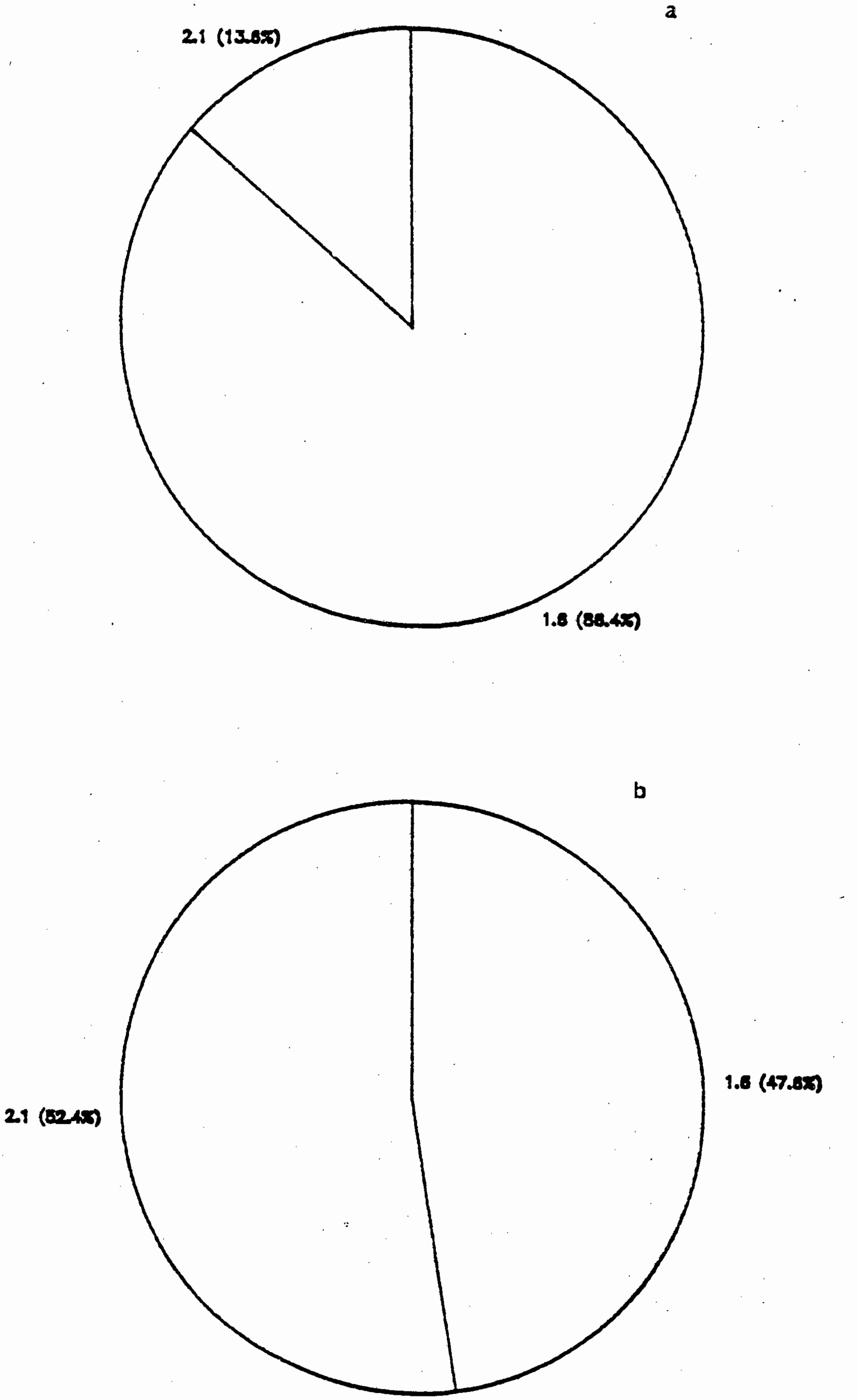


Fig. 5.19: Total South African demersal catches of snoek in areas 1.6 and 2.1; (a) 1972-1978; (b) 1979-1985

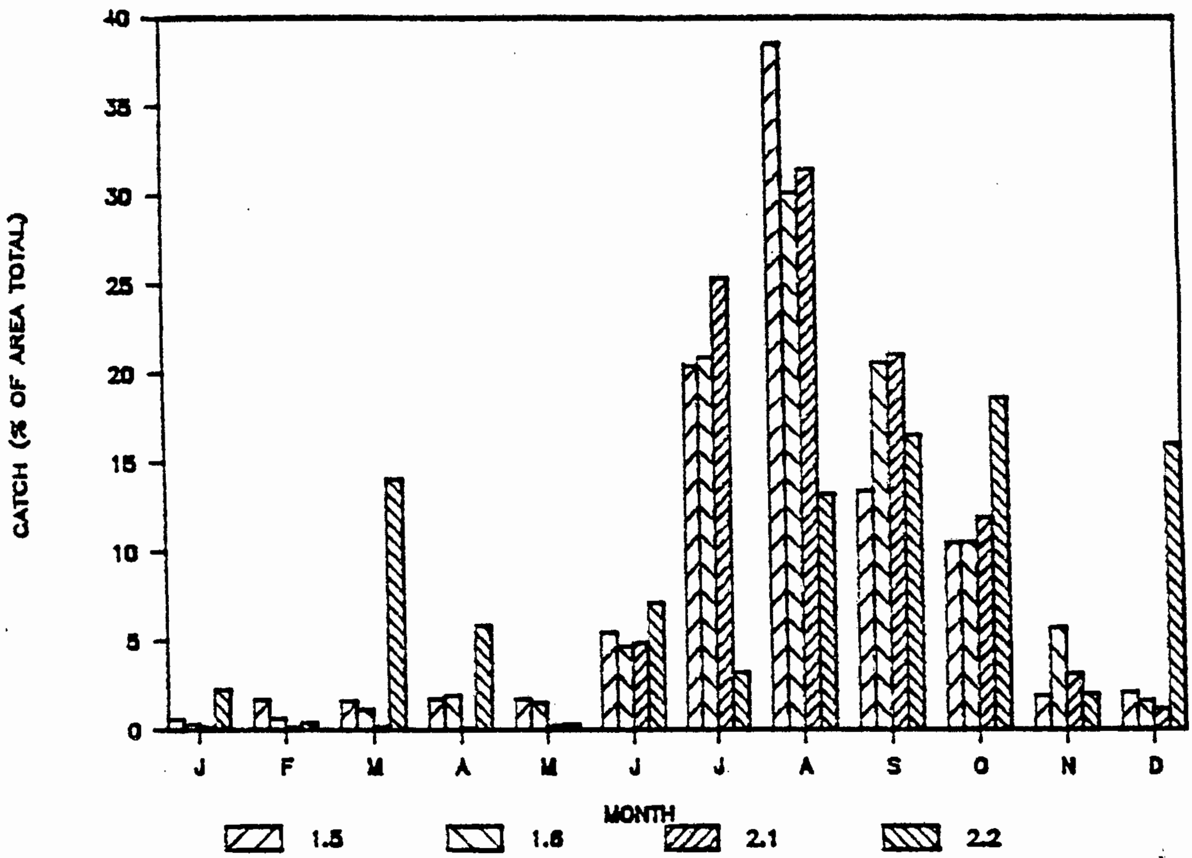


Fig. 5.20: Mean monthly distribution of South African demersal snoek catches in areas 1.5, 1.6, 2.1 and 2.2, 1979-1985

hypothesised migration patterns summarized by Crawford and de Villiers (1985). However, these authors did group areas 1.6 and 2.1 as a unit in their discussion of migration, and it is probable that the bulk of catches made in area 2.1 are from the region immediately adjacent to area 1.6.

It was also apparent from the individual annual distributions that the temporal distribution of demersal snoek catches, at least for the period for which data are available, is far more consistent than that of handline catches. Whether this is simply a reflection of the greater efficiency of the demersal trawler over the handline fishing boat, or whether it reflects large variability in inshore availability of snoek is unknown. A third possibility is that the demersal data are simply more reliable than the handline catch data. The handline fishery may be based on a peripheral portion of the main snoek stock, which may be subject to greater variability than a demersal "core" of the stock. It may even be possible that the two fisheries exploit quite distinct stocks, or alternatively behaviourally distinct phases of the same stock. If snoek simply move offshore to spawn, however, one would expect a relatively consistent lag of demersal catches behind handline catches, which is not the case. Whatever the reason for the difference, the line fishermen's belief that snoek behaviour has been disrupted by foreign trawlers operating off Namibia receives ambiguous support from the recent demersal catch distribution. While there has been a southward shift in geographical catch distribution during the period 1972-1985, the temporal catch distribution has remained stable since 1979. Unfortunately temporal data are not available for the period prior to 1979.

The temporal distribution of snoek catches in area 2.2 provides an exception to the pattern displayed in the other three areas (Fig. 5.20). Here the months of March, August, September, October and December each account for approximately 15-20% of the annual catch. March and December

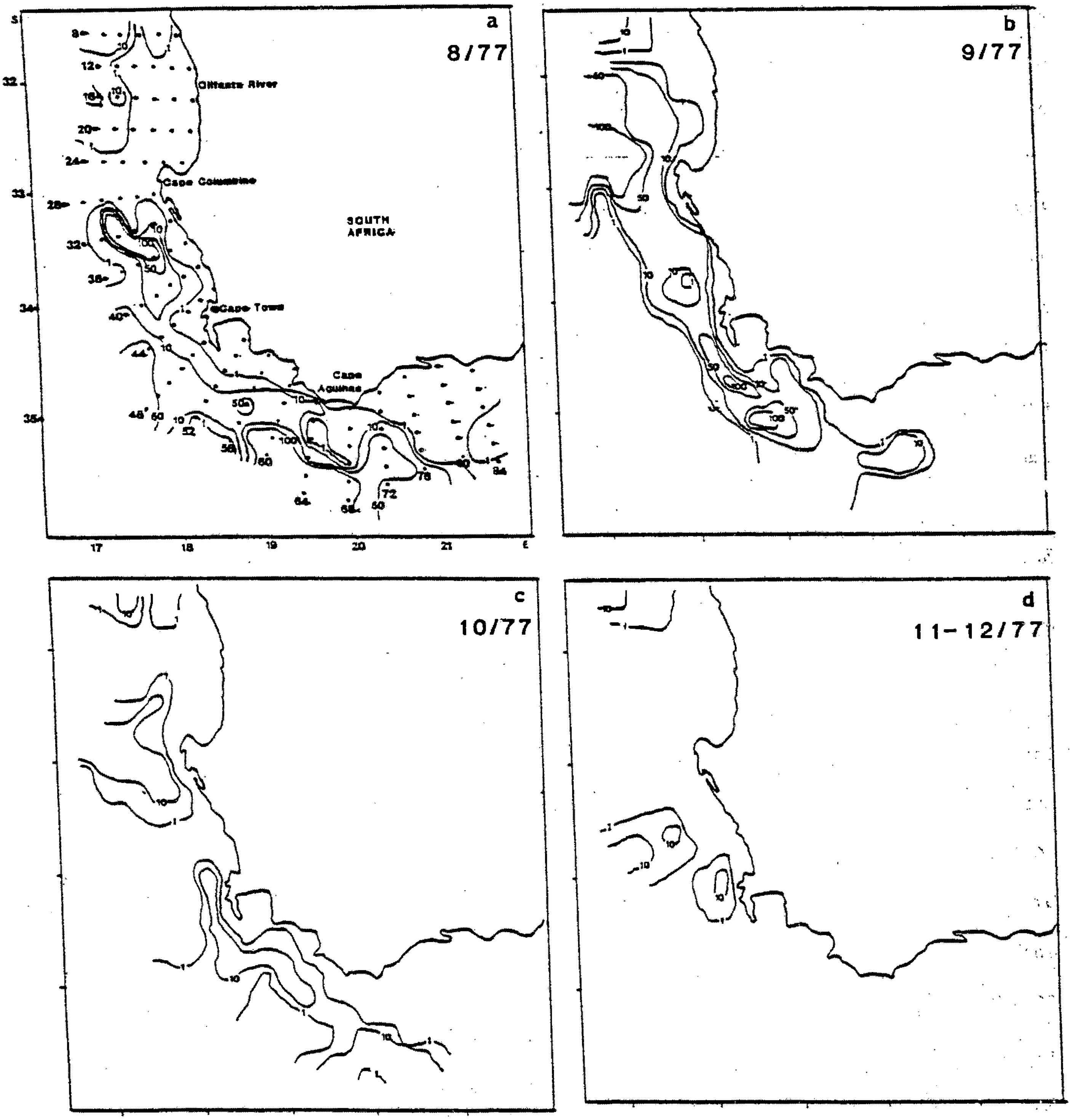


Fig. 5.21: (a) The CELP survey grid (lines 8-84) with distribution of snoek larvae in August 1977; (b) September 1977 distribution; (c) October 77; (d) November/December 77

are the unusual cases, and are difficult to explain by means of existing migration theory. They may suggest the presence of a small resident snoek population not associated with proposed migration patterns. Area 2.2 is well to the east of the normal eastern limit of commercial handline snoek catches.

Any speculation about the behaviour of snoek in area 2.2 must be treated with caution in the light of the fact that annual catches in this area are extremely small. Between 1979 and 1985 annual totals ranged from 0,2 t to 16,1 t, with the totals for four of the seven years being less than one ton. Thus the catching of snoek in this area can only be regarded as incidental, although some snoek is caught every year.

5.5 SNOEK LARVAL DISTRIBUTION IN SOUTH AFRICAN WATERS

5.5.1 METHODS

A one-year study was conducted by the Sea Fisheries Research Institute to investigate recruitment of important fish species in the southern Benguela Current region. This study, known as the Cape Egg and Larval Programme (CELP) ran from August 1977 to August 1978 and is comprehensively described by Shelton (1986). The CELP survey grid (Fig. 5.21) was immediately adjacent to the South African coastline, extending from approximately 31°40'S to 21°40'E, and consisted of 20 lines spaced 20 nautical miles apart, each line being composed of six stations 10 miles apart (Dudley *et al.* 1985).

Eggs and larvae were sampled monthly at each of the 120 stations by means of a double-oblique tow with a bongo net fitted with 300 µm mesh. Full details of sampling procedure are given by Shelton (1986).

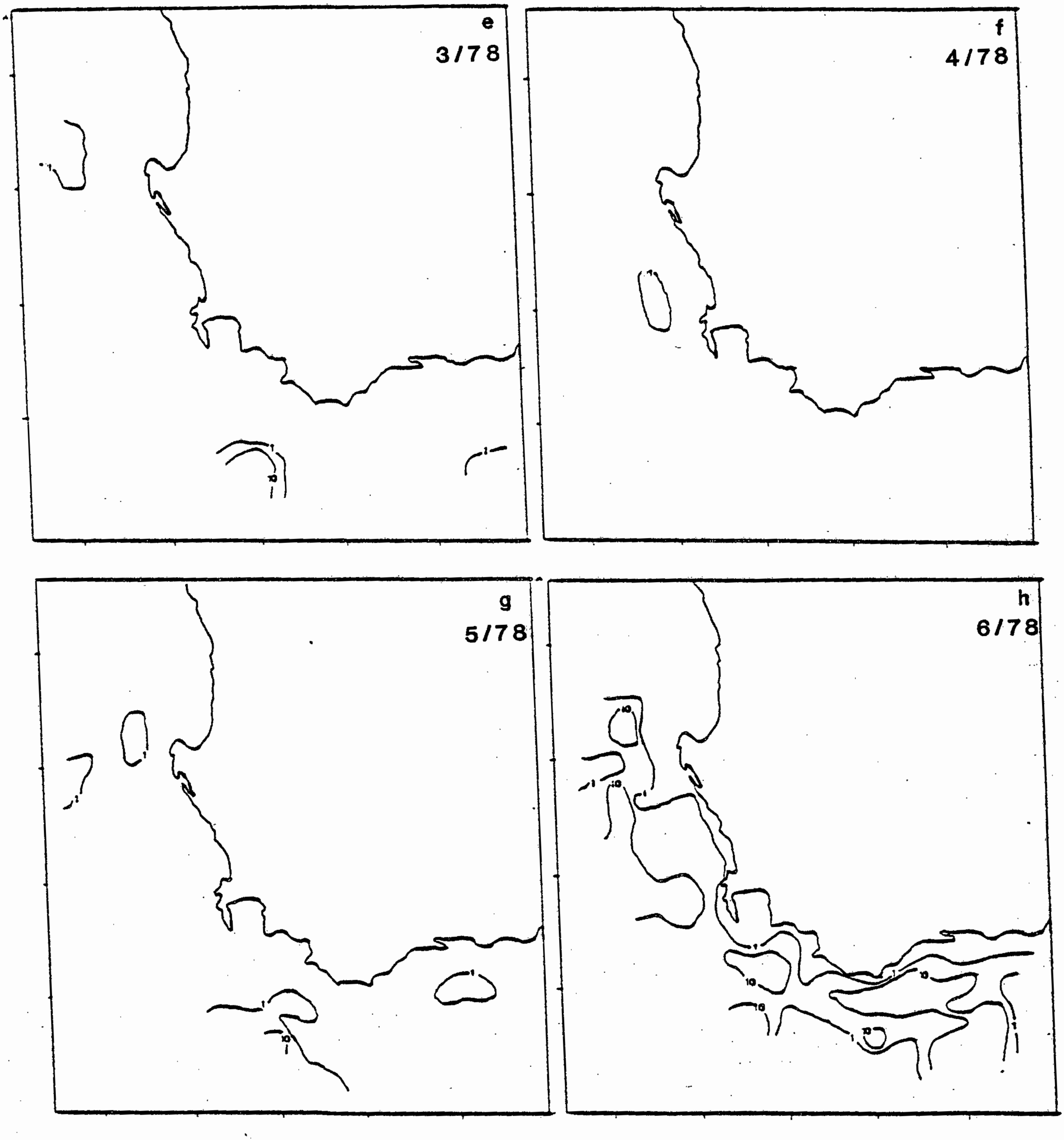


Fig. 5.21: (e) Snoek larval distribution, March 78; (f) April 78; (g) May 78; (h) June 78
(cont.)

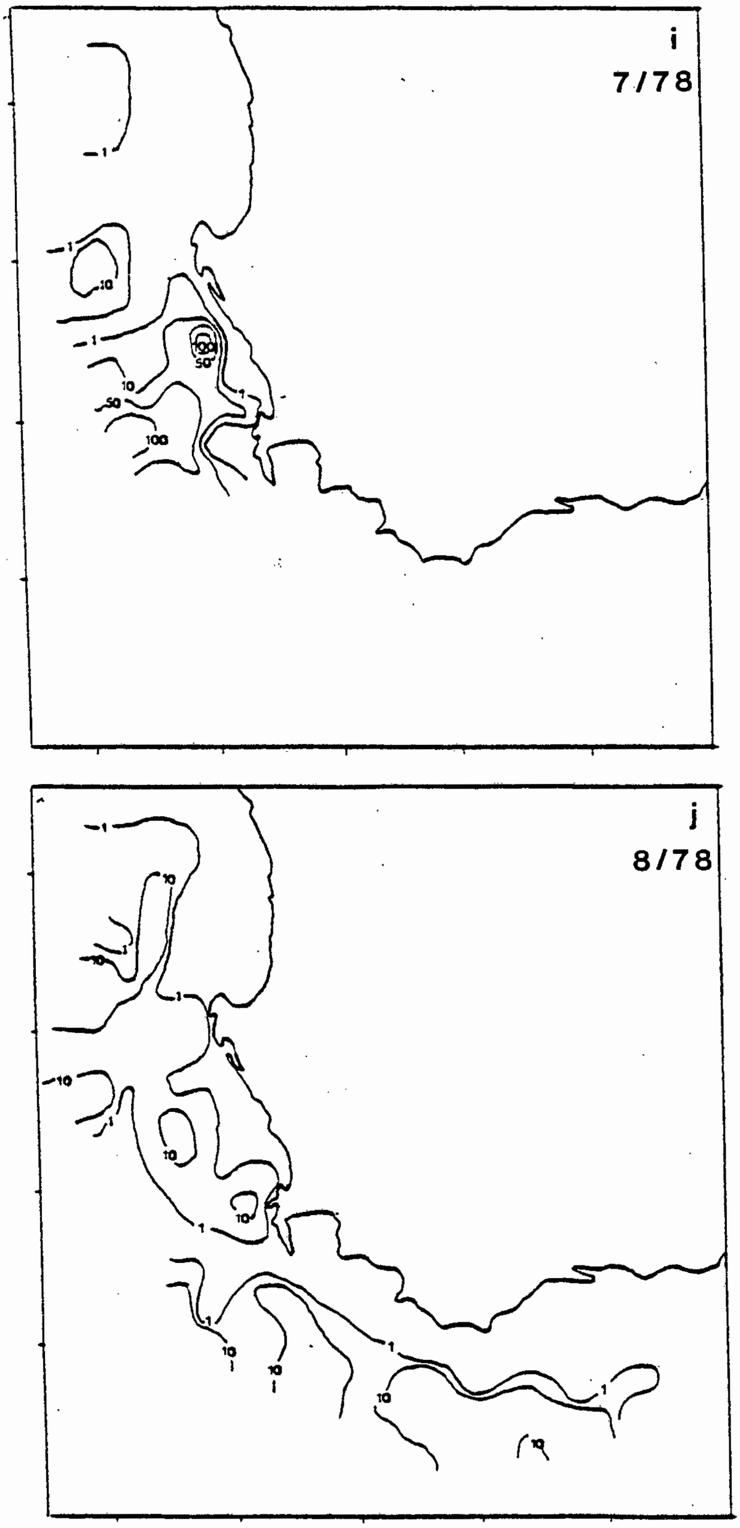


Fig. 5.21: (i) Snoek larval distribution, July 78; (j) August 78 (cont.)

Numbers of snoek larvae have been converted to number per 10 m^2, but the eggs were not counted in all cases (Shelton 1986). Thus only larval data are presented here.

Larval total lengths were measured under a stereo microscope fitted with a graduated eyepiece. Some were measured by technical staff of the SFRI and some by myself.

5.5.2 RESULTS AND DISCUSSION

The monthly distributions of snoek larvae are shown in Figure 5.21. The most widespread distribution and peak numbers of larvae occurred in August and September 1977, June and August 1978 and probably also July 1978. Only the western half of the grid was sampled in July 1978 but from the complete distributions of June and August it appears likely that the July pattern may have been similar. The area of peak density was between Cape Columbine and Cape Agulhas, and the highest larval concentrations each month tended to be 15 miles or further offshore. In New Zealand waters, no snoek eggs were found over the shelf (Robertson 1973, cited by Robertson and Mito 1979) but were found offshore at the surface in the region of the 500 m depth contour (Robertson and Mito 1979).

Extremely low larval densities were found from November to May, with none being found in January and February 1978. A feature of the distribution of larvae in months of low density was that there was frequently a small larval presence in the region betweeen Cape Columbine and the Cape Peninsula. This may reflect the presence of a resident population in the Dassen Island region.

A second feature of the larval distribution patterns is that in the months of peak densities the distribution of larvae extends well to the east of

Cape Agulhas, but generally some distance offshore. This ties in with the fact that while Cape Agulhas represents approximately the eastern limit of commercially viable inshore handline catches of snoek, substantial offshore catches are made further to the east. Handline catches are made at the 72 mile bank, southeast of Cape Agulhas, and commercial demersal trawlers catch large quantities of snoek in ICSEAF area 2.1, most of which is to the east of 20°E.

Shelton (1986) listed 82 larval taxa found in the CELP survey grid between August 1977 and August 1978. He stated, however, that 96% of all identified larvae consisted of a group of 9 taxa, in which the snoek was ranked ninth and contributed 0,7% to the overall total. Although snoek eggs were not always counted, these were considered to rank seventh (0,6% of the total) in abundance of identifiable or separable egg taxa (Shelton 1986).

In every month that snoek larvae were present the larvae showed an aggregated distribution pattern (Shelton 1986) as well as a high level of patchiness as assessed using Lloyd's patchiness index. In fact, snoek larval patchiness was the highest of all larval species tested (Shelton 1986).

Species association analyses were performed on the distribution data of the nine dominant species, pooled over four months chosen to represent the seasons (Shelton 1986). In neither dendrogram nor ordination analysis was the snoek closely associated with any other species.

For the purpose of plotting length frequency distributions the CELP grid was divided into two parts; "north" being from line 8 to line 48 inclusive and "south" from line 52 to line 84. Length frequency distributions were compared using the Kolmogorov-Smirnov test (Sokal and Rohlf 1981). A total of 23 pairs of comparisons were made as follows; between the northerly and

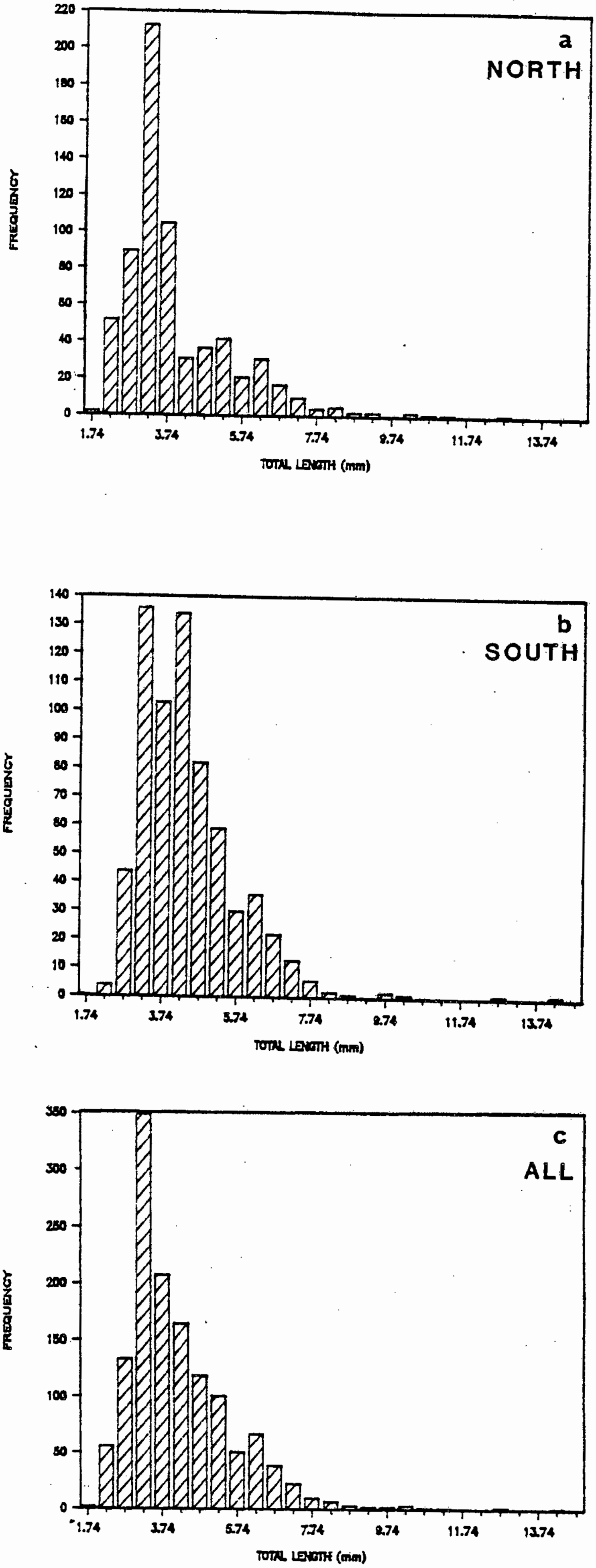


Fig. 5.22: Length frequency distributions of snoek larvae caught during the CELP survey; all larvae caught on (a) lines 8-48 (north; n=669); (b) lines 52-84 (south; n=677); (c) whole grid (n=1346)

southerly distributions for each month, between the northerly distributions for consecutive months and likewise southerly, between the total (lumped) distributions for consecutive months and between the northerly and southerly distributions of the entire data set. Of the 23 comparisons made, only four pairs of distributions were significantly different from each other at the 5% level, i.e. in only these four cases were the length frequency distributions of the populations different from each other. As it may be expected that 1 in 20 statistical comparisons would yield an incorrect result at the 5% level, these four cases cannot be regarded as conclusive.

The most significant of the four "differing cases" was the comparison of the combined northerly and the combined southerly distributions (Kolmogorov-Smirnov test, n_{north}=669, n_{south}=677, D=0,2667, D_{α}=0,0740, $p \leq 0,05$). Despite this, only two out of five intra-monthly comparisons between regions were significantly different.

Due to the general similarity of the majority of distributions, only the distributions of the total northern and the total southern data sets, as well as the total combined data set, are shown (Figs 5.22a-c). The fact that the geometric mean larval length for the northern area (3,72 mm) differs from that for the southern area (4,25 mm) may suggest slightly superior conditions for growth in the south.

The geometric mean length of snoek larvae for the entire area and period sampled was 3,98 mm. As length frequency distributions do not differ from month to month it appears that the snoek spawned in every month in which larvae were caught and that 3,98 mm larvae are less than a month old. This is in agreement with de Jager (1955) who found that snoek larvae raised in a laboratory attained a total length of 3.9 mm nine days after hatching.

The larger larval size classes were absent in months when no spawning took place which indicates that snoek larvae greater than a month old were not sampled by the CELP method, presumably due to net avoidance. It is assumed therefore that the presence of larvae in any particular month indicates that spawning occurred in that month.

5.6 BLANKET NET SURVEY - JUVENILE SNOEK

A survey of juvenile pelagic species was conducted by the Sea Fisheries Research Institute (SFRI) between September 1955 and March 1968. Monthly sampling was conducted over much of this period at four sites on the west coast, although between April 1961 and January 1964 sampling was reduced to four times a year (Stander and Le Roux 1968). Although the survey was aimed at investigating the commercial pelagic species, some juvenile snoek were also caught and data pertaining to these have been extracted from unpublished records of the SFRI.

5.6.1 METHODS

Methods were described by Davies (1957) and Stander and Le Roux (1968). Fishing was done at night only, and the fish were attracted to a submerged blanket net by means of a 500 W spotlight. The net was rigged on either 55 foot or 40 foot wooden poles, dependent upon the size of the research vessel, and was fitted with half inch (12,7 mm) mesh netting. The four localities sampled were situated in St. Helena Bay (2 stations), Saldanha Bay and Table Bay. Hauls were standardised at 30 minutes duration, and up to six hauls were made per night.

Notwithstanding the defects of the method discussed by Stander and Le Roux (1968), catch and length frequency data from the blanket net survey form one of only two sources of systematically collected data on juvenile snoek in South African waters, the other being gannet diet studies which are discussed later. These data are therefore presented below.

5.6.2 RESULTS AND DISCUSSION

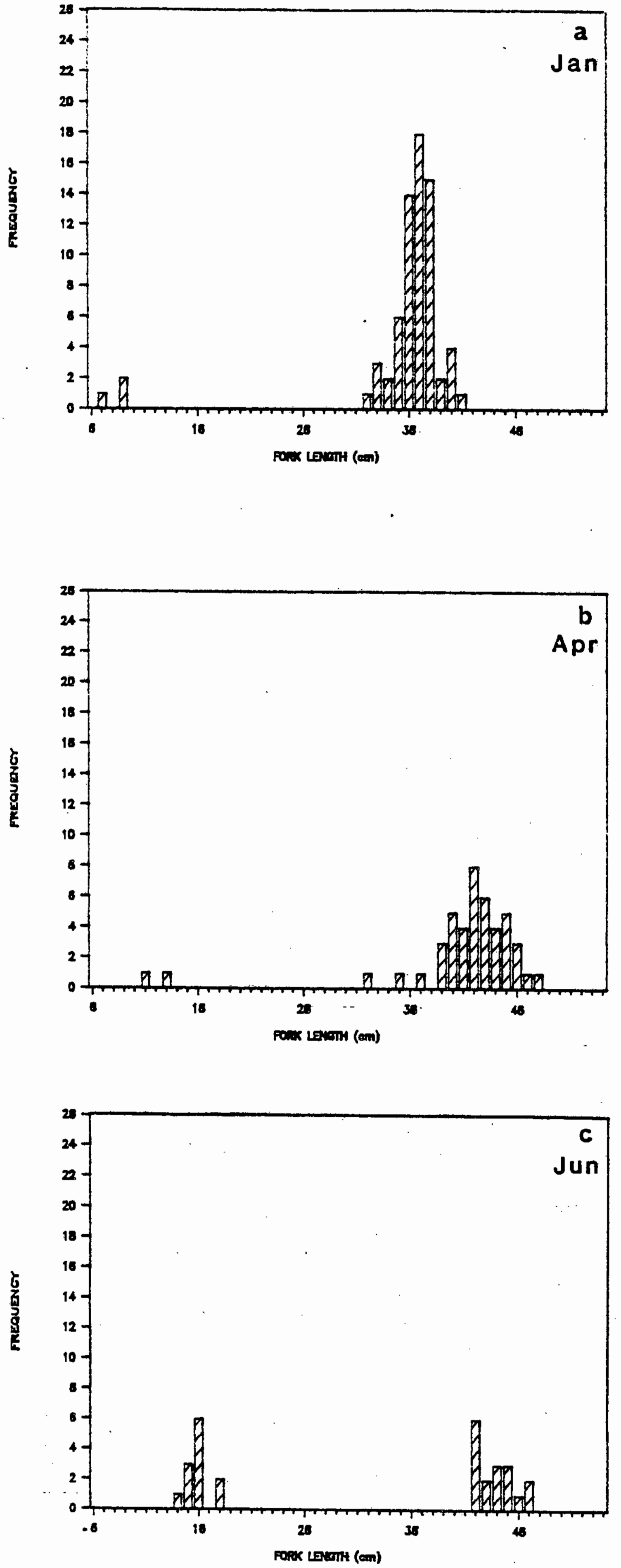
Catch data concerning snoek juveniles are presented in Table 5.4.

Table 5.4: Catches of juvenile snoek in a blanket net survey conducted between 1955 and 1958.

Site	Survey period	Total hauls	Total no. snoek	Catch per haul
Klein Tafelberg (St Helena Bay)	9/55-7/67	500	13	0,03
Stompneus (St Helena Bay)	9/55-7/67	535	26	0,05
Saldanha Bay	9/55-8/67	561	734	1,37
Table Bay	9/55-3/68	543	171	0,31

In view of the few snoek caught at the two St Helena Bay stations and at the Table Bay station, only the Saldanha Bay catches are considered further.

Monthly catch rates (catch per haul) were calculated for Saldanha as a mean for the whole survey period (Table 5.5). Length frequency data, summed for the whole period, were plotted (Figs 5.23a-g). Only distributions with n>20 are shown. Geometric mean lengths were calculated, and where the distribution was obviously bimodal, two means were calculated, GM_{short} and GM_{long} (Table 5.5).


a
Jan
FREQUENCY
FORK LENGTH (cm)
b
Apr
FREQUENCY
FORK LENGTH (cm)
c
Jun
FREQUENCY
FORK LENGTH (cm)

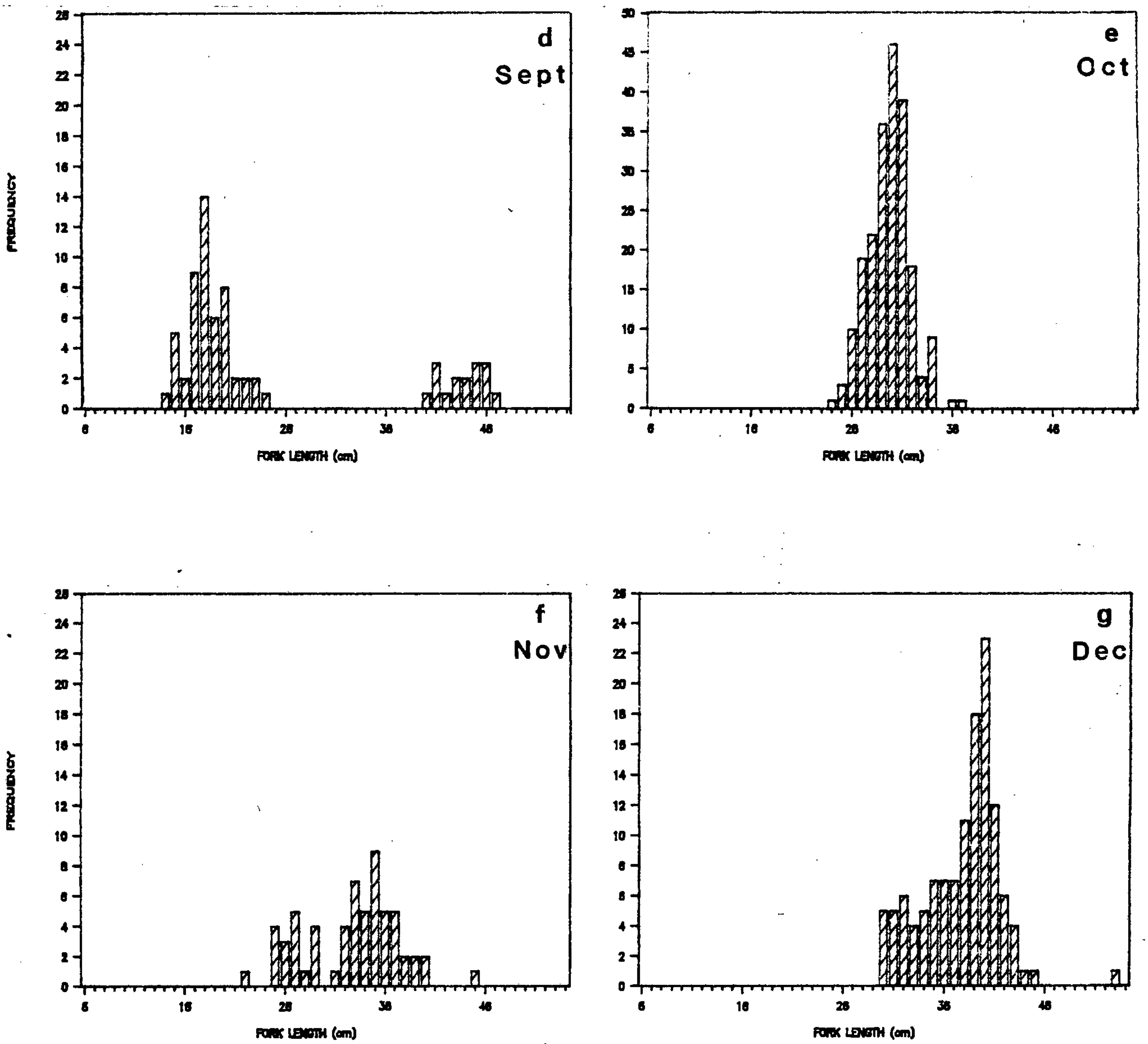


Fig. 5.23: Length frequency distributions of young snoek caught at Saldanha Bay during the blanket net survey conducted between 1955 and 1967; (a) January; (b) April; (c) June; (d) September; (e) October; (f) November; (g) December (see also Table 5.5)

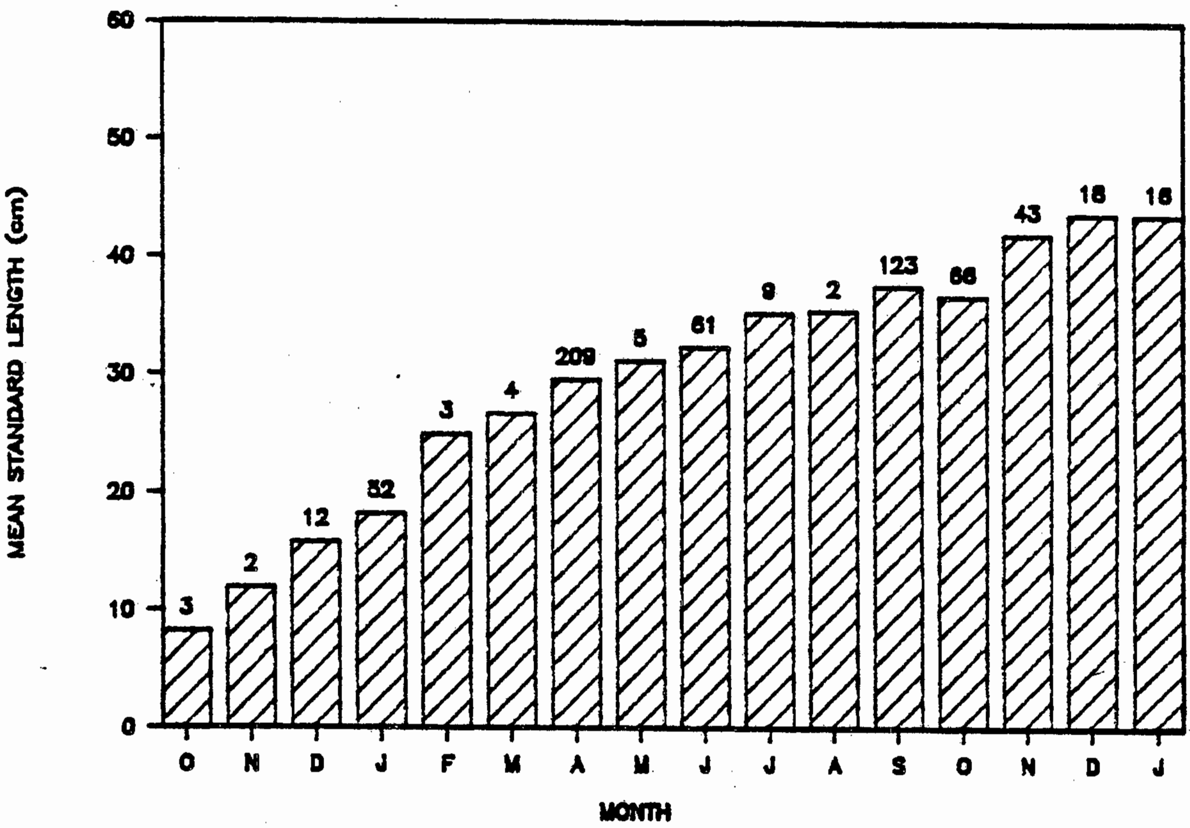


Fig. 5.24: Mean standard lengths of young snoek caught at Saldanha Bay during the blanket net survey conducted between 1955 and 1967; see text for rationale; figures above each histogram are sample sizes ($\Sigma n=628$)

Table 5.5: Monthly catch rates and geometric mean lengths of juvenile snoek caught at Saldanha Bay between 1955 and 1967.

Month	Catch per trawl (number)	Number of fish measured			Geometric mean standard length (cm)		
		n_{short}	n_{long}	n_{all}	GM_{short}	GM_{long}	GM_{all}
January	1,42	52	16	-	18,26	43,64	-
February	0,17	-	-	3	-	-	25,00
March	0,18	-	-	4	-	-	26,72
April	3,63	-	-	209	-	-	29,63
May	0,32	5	1	-	31,20	47,00	-
June	1,58	-	-	61	-	-	32,41
July	0,14	-	-	9	-	-	35,31
August	0,08	1	2	-	13,00	35,50	-
September	2,64	-	-	123	-	-	37,63
October	2,22	3	66	-	8,30	36,74	-
November	1,19	2	43	-	12,00	42,05	-
December	1,56	12	17	-	15,88	43,79	-

Kolmogorov-Smirnov analyses were performed on several pairs of length frequency distributions to determine whether they differed significantly from each other. Only distributions with n>20 were tested, and where distributions were bimodal, tests were performed on the entire distribution. Of the 10 comparisons made, five pairs proved to differ significantly at the 5% level.

Despite the fact that not all months differed significantly with regard to distribution of length frequencies, geometric mean lengths of all modes were plotted in ascending order (Fig. 5.24). It is clearly apparent that the means follow an ascending sequence over a period of 16 months. Of a total of 630 fish measured, two individual observations were omitted from the sequence on the grounds that they appeared to constitute outliers.

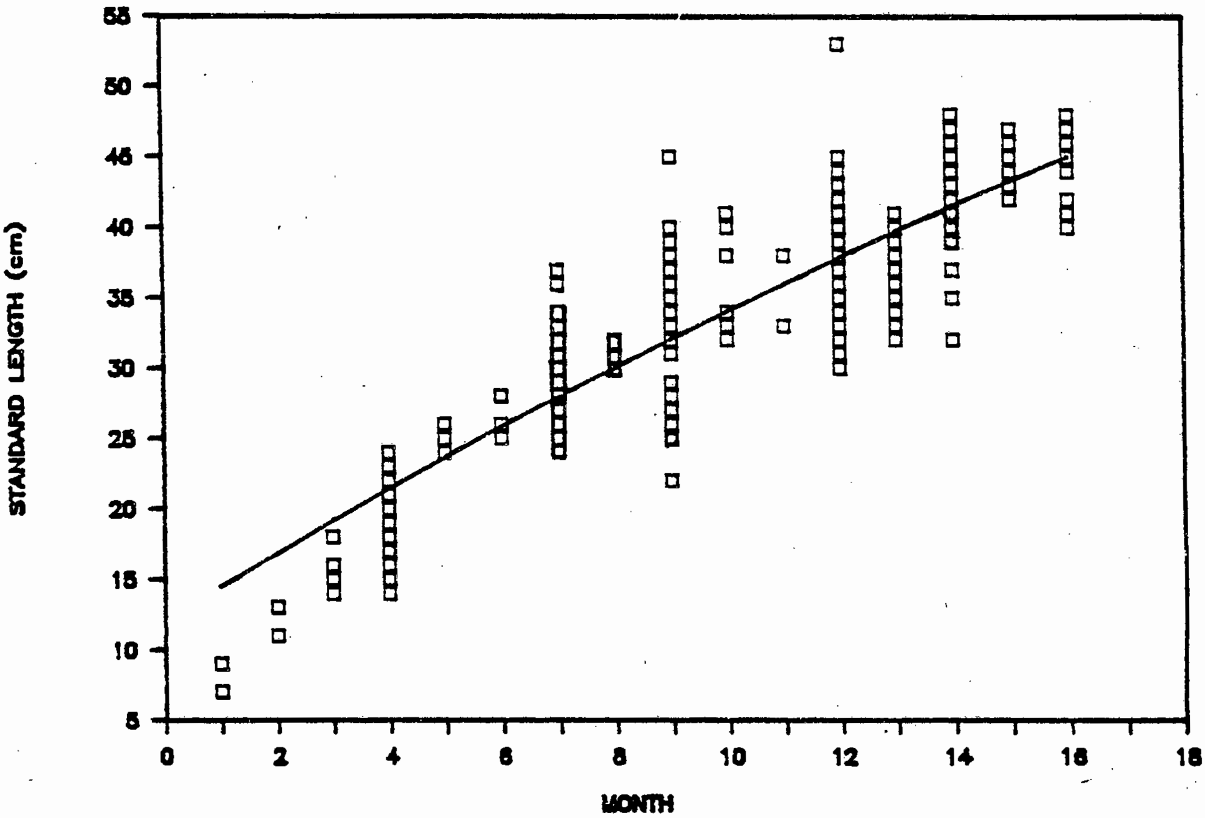


Fig. 5.25: Von Bertalanffy curve fitted to plot of standard lengths of young snoek caught during blanket net survey; L_∞ set at 120 cm (n=628 snoek)

These were a single fish of 13 cm standard length caught in August, and another of 47 cm caught in May. Whilst the May observation was not necessarily inconsistent with the ascendent trend, the fact that it represented a four month break in the temporal sequence (ie. the preceding value being 43,64 cm in January) was considered reasonable grounds for its omission.

A Von Bertalanffy growth curve of the form

$$L_t = L_\infty [1-e^{-\kappa(t-t_0)}]$$

was fitted to the raw data using BMDP on a mainframe computer, with L_∞ set at 120 cm but with no constraints on κ or t_0. The value of 120 cm for L_∞ was arbitrarily selected as the maximum length which could reasonably be expected for a locally caught snoek, based on the length weight relationships given in Table 3.2 and the South African angling record of 8,6 kg (Van der Elst 1981). The parameters obtained for the equation were

$$\kappa = 0,023$$

$$t_0 = -4,645 \text{ months}$$

The fitted curve is shown in Figure 5.25. It must be noted that the independent variable, t, represents time after entering the blanket net "fishery", and not age. The smallest mean length of juvenile snoek caught was 8,30 cm in October (month 1), and the largest (excluding the single May value) was 43,64 cm in January (month 16). As snoek larvae hatch at between 2 and 3 mm total length (CELP survey) and adult snoek grow to 200 cm (Nakamura 1986), the blanket net only sampled a section of the length range of the snoek population.

It appears from the CELP survey conducted in 1977/78 that the peak snoek spawning period extends between June and September. In view of this four month spread, it is perhaps surprising that the trend of increasing juvenile length with month is so smooth (Figs 5.24 and 5.25). This may indicate that in earlier years (1955-67) spawning was concentrated in a shorter time period, although this may only apply to "recruits" to the Saldanha Bay blanket net survey.

5.7 JUVENILE SNOEK IN GANNET DIET

A second source of information on juvenile snoek is provided by diet studies of the Cape gannet *Morus capensis*. Gannets feed on a size range of snoek not exploited by the commercial fishery, and as in the case of the blanket net survey such snoek may therefore be regarded as "pre-recruit".

5.7.1 METHODS

Methods of the gannet diet sampling program conducted by the Sea Fisheries Research Institute are described by Berruti (1987). The bulk of the sampling was conducted at two sites, Bird Island at Lambert's Bay and Malgas Island in Saldanha Bay. Bird Island gannets were sampled monthly from December 1977 to December 1985, with the exception of July 1981, and Malgas Island gannets monthly from September 1978 to December 1985, with the exception of April 1981, June 1980 and June 1981. At Bird Island 84% of the monthly samples consisted of at least 15 samples, and at Malgas Island 93% consisted of at least 20 (A. Berruti SFRI pers. comm.). In addition, 15 monthly samples were obtained at Ichaboe Island off Namibia (ca 15°00'E 26°30'S) between November 1978 and March 1983. All data described below were provided by the SFRI.

5.7.2 RESULTS AND DISCUSSION

The contribution of snoek to gannet diet is expressed in three ways, numerical percentage (%N), frequency of occurrence (%F) and percentage by weight (%W) (A. Berruti SFRI pers. comm.). A detailed discussion of each of these terms is provided by Hyslop (1980) and the terms themselves are

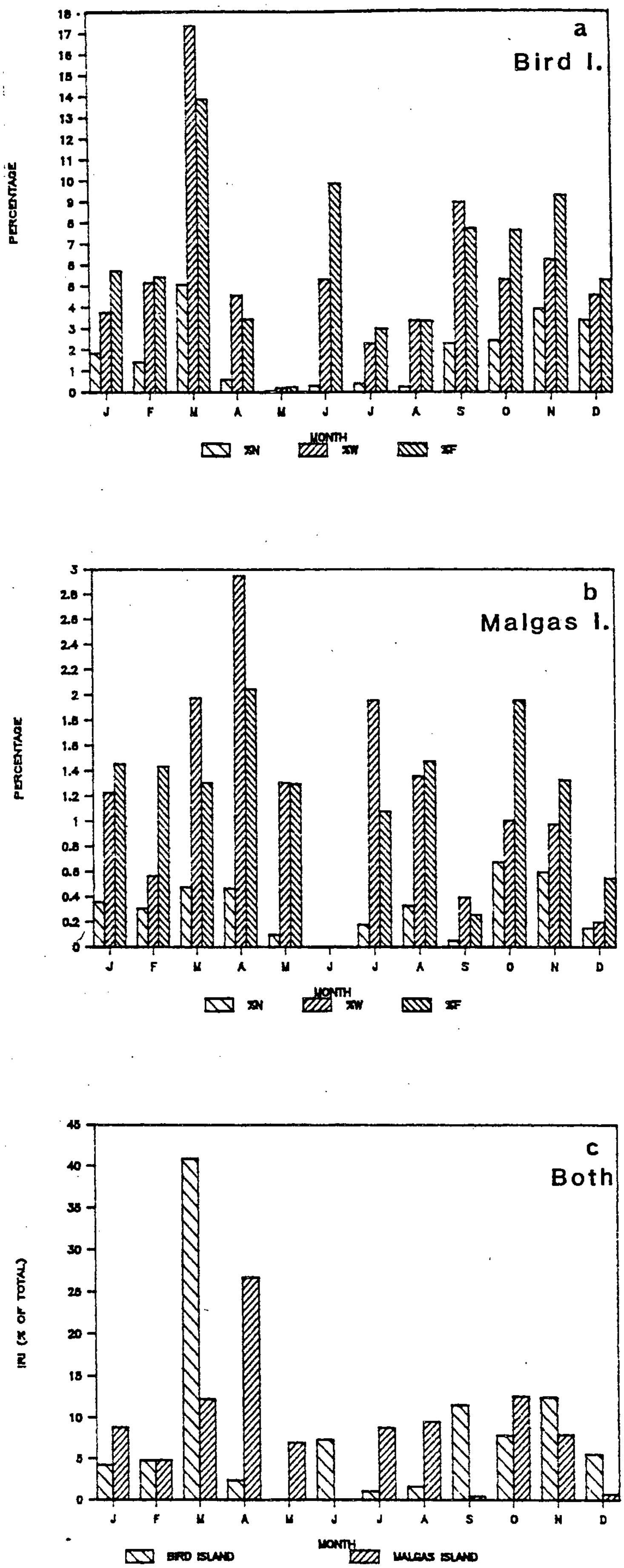


Fig. 5.26: Mean monthly percentage occurrence of snoek in gannet diet by numbers (%N), weight (%W) and frequency (%F) at (a) Bird Island, Lambert's Bay 1977-1985 and (b) Malgas Island, Saldanha Bay 1978-1985; (c) Index of relative importance (IRI) at Bird and Malgas Islands

defined in Chapter 3. The three results are combined to give an index of relative importance, IRI, where

$$IRI = (\%N + \%W) \times \%F$$ (after Pinkas et al. 1971)

Mean values for each index calculated for the whole sampling period are plotted monthly (Figs 5.26a-c). It is clear that snoek form a more substantial part of gannet diet at Bird Island (Fig. 5.26a) than at Malgas Island (Fig. 5.26b), whichever measure one considers. For both localities %N is consistently low with respect to both %W and %F, which is to be expected for a relatively large prey item.

Perhaps the best measure of change in seasonal importance of snoek to the gannet diet is given by %F, which reflects the proportion of the gannet population which is feeding on snoek. Little trend is apparent at Bird Island, with the only clear peak occurring in March, and a trough in May. Otherwise, summer values appear to be generally higher than winter values. Even less seasonality exists at Malgas Island, although the peak and trough months lag Bird Island by one.

Combination of the three separate dietary measures into a single IRI is slightly more illuminating (Fig. 5.26c). The relative importance of snoek in gannet diet follows a bimodal cycle at both sampling localities. At Bird Island the IRI peaks in March and November, and at Malgas in April and October.

Data from Ichaboe Island (Namibia) are scanty. No sampling was done between June and October, and samples were only collected once each in April, May and December. Of the months in which snoek were found (November to March inclusive), the February value for IRI constituted 73,2% of the summed IRI values, followed by March at 24%.

Little can be concluded from the above data, when viewed in isolation from the complete data set concerning gannet diet. It can be stated that snoek were on average not present in more than 13,9% (Bird Island) and 2,1% (Malgas Island) of gannet stomach samples in any one month. The bimodal cycle of IRI at both localities may reflect seasonal availability of juvenile snoek to the gannet, but is undoubtedly also influenced by the availability of other more important prey species such as pilchard and anchovy. The major IRI peak for Bird Island is in March, and for Malgas Island is in April, and it is possible that the peak for Ichaboe Island is in February. This would show a neat monthly lag between stations from north to south, suggesting a southward spatial progression of the inshore distribution of pre-recruit snoek.

Standard (caudal) lengths of snoek found in stomach samples were obtained when measurable. Data have been grouped into 2-month intervals, summed over the whole sampling period, and geometric mean lengths have been calculated (Table 5.6). Predicted lengths, calculated for the middle of each 2 month interval, have been estimated using the growth curve obtained from the blanket net data (Table 5.6), assuming that spawning occurred at the same time of year. In all but three of the 12 cases fewer than 10 snoek were measured, so no statistical significance can be attached to the mean lengths from the gannet data. It is nevertheless apparent that at both Bird and Malgas Islands the growth of juvenile snoek may follow a generally similar trend to that evinced by the snoek caught in the blanket net survey. There is a closer match between the Malgas Island lengths and the predicted lengths than between those of Bird Island and those predicted. The foraging range of gannets from Malgas Island (Berruti 1987) encompasses the Saldanha Bay site of the blanket net survey.

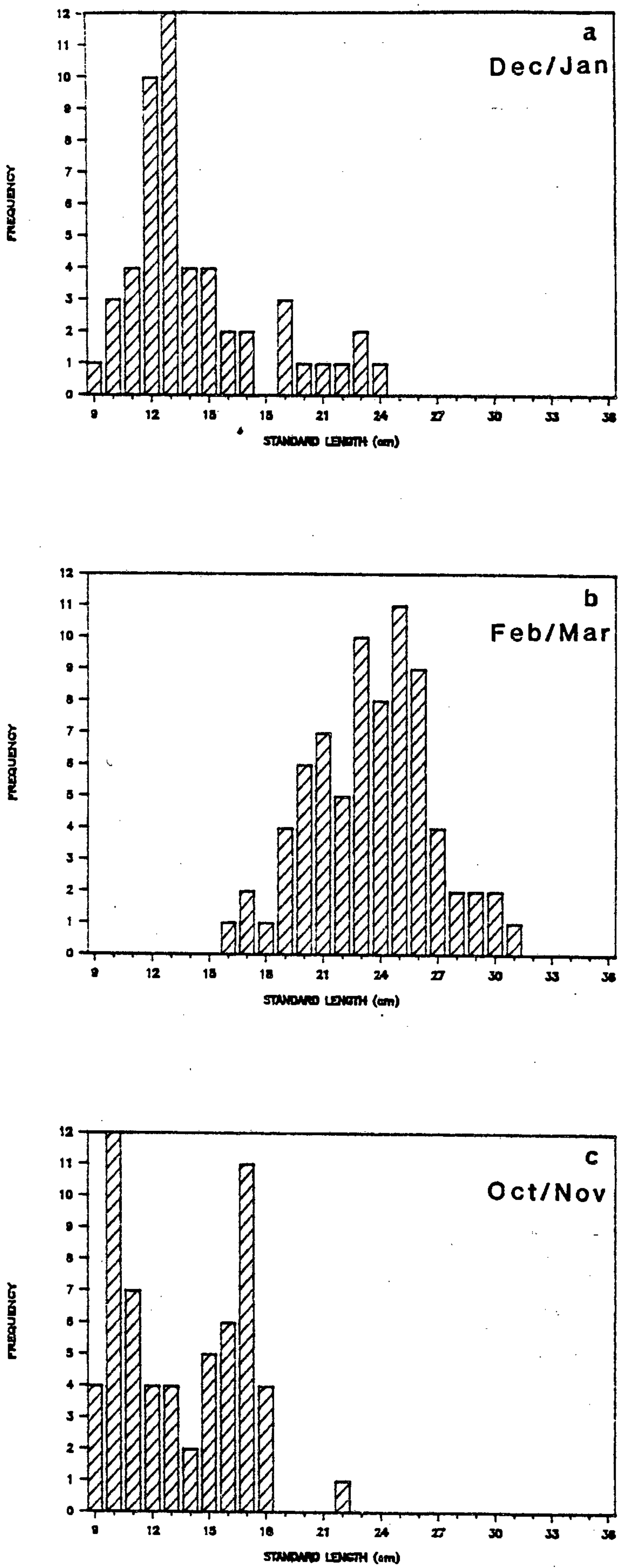


Fig. 5.27: Length frequency distributions of snoek in gannet diet at Bird Island; (a) December/January; (b) February/March; (c) October/November; (see also Table 5.6)

Table 5.6: Standard lengths of measurable snoek found in gannet stomach samples at Bird and Malgas Islands together with predicted lengths from the "blanket net" growth curve.

Period	Bird Island		Malgas Island		Predicted length
	n	Lc(mean)(cm)	n	Lc(mean)(cm)	Lc (cm)
Dec-Jan	51	13.43	6	18.74	17.81
Feb-Mar	75	23.31	2	27.50	24.82
Apr-May	4	25.64	2	31.75	30.20
Jun-Jul	3	27.31	0	-	34.33
Aug-Sep	2	11 and 30	0	-	37.50
Oct-Nov	60	13.17	3	12.12	8.65

Kolmogorov-Smirnov tests were performed on the three Bird Island length frequency distributions with n>20, with significance calculated at the 5% level. The December-January distribution (Fig. 5.27a) differed significantly from February-March (Fig. 5.27b), but not from October-November (Fig. 5.27c). Similarly, the February-March distribution differed from October-November. The lack of a clear trend in these results confirms that these data can only be used to supplement information from direct-sampling methods such as the blanket net survey.

5.8 CONCLUSIONS

Seasonal patterns

Analysis of snoek handline catch data over the period 1970 to 1985 shows that snoek availability in South African waters peaks in the period May to July, but that in recent years large catches have also been made in December and January. These summer catches have mostly been made in the vicinity of Yzerfontein on the west coast. Not only are Yzerfontein catches unseasonal with respect to those made elsewhere on the South

African coastline, the catches also tend to be larger.

There is evidence that snoek catches to the east of Cape Point lag those to the west. With the exception of the summer presence of snoek at Yzerfontein this is consistent with the hypothesis of a north to south migration in winter.

Snoek catch rates by midwater trawl were higher in April, May and June than in August and November, which is similar to the situation in most of the handline fishery. While catch rates in November were low, snoek were caught on a number of occasions to the east of Cape Agulhas. Demersal surveys carried out in January and July between Cape Agulhas and the Orange River revealed distribution patterns of snoek which were consistent to the extent that while snoek were caught throughout the survey area in winter, hardly any catches were made to the east of Cape Point in summer.

Seasonal distribution of commercial demersal snoek catches by ICSEAF area shows little variation during the years for which data are available (1979-85). Catches in areas 1.5, 1.6 and 2.1 are largely confined to the months July to October with the peak in August. This differs considerably from the handline catch for the same period, which peaks in May-June and which also shows far more inter-annual variability. A postulated offshore spawning movement beginning in about June would be consistent with this evidence, although there appears to be considerable variation from year to year. While there has been a marked increase in summer catches by the handline fishery in recent years, this has not been paralleled in the demersal fishery.

A summer presence, albeit small, of snoek on the eastern Agulhas bank has been shown by incidental reports of line catches and demersal catches, and also by midwater research trawls.

Diel and depth patterns

Little or no relationship between catch rate and time of day was identifiable for either midwater or demersal trawls, and similarly between catch rate and depth of trawl for midwater trawls. No snoek were caught at the bottom at night which suggests that diurnal, vertical migration occurs but as very little night-time demersal trawling took place this remains unconfirmed. There was, however, a clear relationship between catch rate and depth of trawl in the demersal case, with peak catch rate between 201 and 300 m, and no fish were caught shallower than 76 m or deeper than 400 m. The significance of this finding is that the handline fishery exploits snoek at depths almost exclusively shallower than 76 m (Chapter 2). This, together with the discrepancies in temporal distribution of catches, may imply that the stocks exploited by the handline and demersal fisheries differ in some way. The most probable explanation is that a single stock is exploited inshore by the handline fishery in early winter and then moves offshore to spawn where it becomes available to the demersal fishery. The inshore summer presence in the Dassen Island/Yzerfontein region is not explained by this pattern.

Migration

An offshore return migration from South African to Namibian waters has yet to be demonstrated and there is also doubt concerning whether the north-south migration has occurred in recent years. The feasibility of tagging snoek in both inshore and offshore waters of the southern Benguela region should be studied. Such tagging would serve the dual purpose of monitoring both inshore-offshore movements in the southern Benguela and south-north migration in the southeast Atlantic. It should, however, be borne in mind that recent snoek tagging programmes in South African waters (Nepgen

1979b) and in Namibian waters (J. D. Venter SFRI pers. comm.) have proved expensive and inconclusive. Alternatively, the feasibility of genetic determination of stock movement should be considered. Gauldie and Johnston (1980) have shown statistically significant genetic differences in snoek caught in different areas within New Zealand waters. Although this does not necessarily imply the existence of genetically isolated stocks (Gauldie and Johnston 1980), it would contribute to an understanding of snoek movement.

The CELP survey conducted from August 1977 to August 1978 revealed that maximum snoek spawning took place between Cape Columbine and Cape Agulhas in the months June to September and was generally concentrated at least 15 miles offshore. This conforms broadly with the findings of Nepgen (1975), based on gonad examinations, that the spawning season is between July and December, and also with the suggestion by Davies (1954) that snoek spawn offshore. The fact that snoek caught demersally during July cruises of the RS Africana had larger gonad development indices than those caught in January (Chapter 3) is also consistent with winter spawning. The occurrence of larvae offshore to the east of Cape Agulhas confirms the presence of spawning snoek stock in this region.

The independence of snoek from other pelagic larvae (Shelton 1986) may indicate a certain degree of independence from variability of local conditions. If so, this, coupled with the apparent ease of movement of the snoek between the demersal and pelagic environment, and also with the dietary versatility of the adult snoek (Chapter 3), suggests that the snoek may be well adapted to a variable environment.

Juvenile snoek growth

Snoek juveniles were sampled by two methods; a blanket net survey and a study of gannet diet. Of four west coast sites sampled by means of the blanket net, juvenile snoek were caught in greatest quantities in Saldanha Bay. The mean larval total length for the region of the CELP survey to the north of Cape Point was 3,72 mm. Juvenile snoek entered the blanket net catch in October with a mean standard length of 8,30 cm, and appeared to exhibit steady growth over a 16 month period to a length of 43,64 cm in January. Scanty data from gannet diet studies appear to suggest a similar growth trend, although the greatest mean standard length of juvenile snoek found in gannet diet was only 31,95 cm. Juvenile snoek (34 cm total length) were caught in midwater trawls off the Orange River mouth in June. These fish were probably spawned the previous winter. All snoek caught and measured during November midwater trawls were between 14 and 26 cm total length, and these were probably spawned in that year.

CHAPTER SIX: SUMMARY

Specific questions addressed in this thesis included:

a. What is the nature of the South African snoek fishery, both handline and demersal?

b. What species form the principal components of snoek diet?

c. How is the time spent feeding divided between the demersal and pelagic environments?

d. What is the trend in snoek catches in the Benguela region, with emphasis on the southern Benguela?

e. What proportion of the year do the snoek spend in the southern Benguela system?

6.1 METHODS

The study area consisted largely of ICSEAF areas 1.5, 1.6 and 2.1, both inshore and offshore.

a. Harbours between Port Nolloth and Arniston (Waenhuiskrans) were visited and professional line fishermen, fisheries inspectors and harbour masters were questioned on aspects of the line fishery for snoek. Members of the trawling and fish processing industries in Cape Town were interviewed with regard to the demersal snoek fishery and the marketing of snoek.

b. The contents of snoek stomachs were studied from demersal and pelagic trawl research cruises conducted by the Sea Fisheries Research Institute (SFRI) in order to supplement existing published work. A quantitative analysis (percentage frequency %F, percentage mass %M and percentage number %N) of the diet of trawled snoek was performed. In addition, small samples of handline-caught snoek stomachs were analysed from three different localities.

c. Snoek catch trends in the whole ICSEAF region for the period 1971-1984 were related to both handline and demersal catch trends in South African waters. Reported handline catch and effort data in terms of catch per successful boat day were refined to catch per successful man day.

d. Migration patterns and the amount of time spent in the study area were investigated using the following sources of information: (i) Monthly handline catch records from 16 South African harbours, the longest series being for the period 1971-1985. (ii) Monthly commercial demersal catch records by ICSEAF area for the period 1979-1985. (iii) Catches from research demersal and pelagic cruises for the period 1983-1986 (demersal) and 1982-1986 (pelagic). (iv) Published literature. (v) Questioning of experienced researchers and representatives of both the handline and trawl fisheries.

e. The results from studies b, c and d above, together with an analysis of the relationship between snoek feeding and depth and time of day in the demersal environment, were used to investigate the potential impact of the snoek as a predator in the demersal and pelagic environments.

f. The life history and biology of snoek in the study area were investigated using the following sources of data: (i) Routine biological studies carried out during research demersal cruises by the SFRI between 1983 and 1985. (ii) The Cape Egg and Larva Programme (CELP) conducted by the SFRI in 1977/78. (iii) Gannet diet studies at west coast colonies (SFRI, 1977-1985). (iv) A blanket net survey of recruitment of pelagic species (SFRI, 1955-1968).

6.2 FINDINGS

a. The nature of the fishery

Snoek line-fishing effort is changing from the traditional harbour-based line-boat to the nomadic ski-boat, which gives rise to both economic change in the line fishing community and to changes in the management of the fishery. It was widely claimed that total snoek catches are declining and that migration patterns are changing. Snoek constitutes a by-catch of the hake-directed demersal fishery but nevertheless is seasonally important. Processing of snoek is an established industry with the commodity gaining in consumer popularity, but processors complain of erratic supply.

b. Diet

Principal prey were defined as those contributing more than 4% to the diet in more than one method of analysis. The principal prey of snoek caught by handline off the Cape Peninsula in June and August 1985 were anchovy *Engraulis japonicus* and mantis shrimp *Lysiosquilla armata capensis*. Pilchard *Sardinops ocellatus* was notably not a principal species. Snoek from the important line-fishing area of Dassen Island were found to contain euphausiid *Euphausia lucens* and mantis shrimp. Principal species in the diet of snoek caught in midwater trawls were anchovy, pilchard, euphausiids and the amphipod *Parathemisto gaudichaudi*, although anchovy constituted over 80% of the diet in each of %F, %M and %N. Midwater sampling of snoek diet was probably biased however, as the trawls were directed at acoustic targets such as shoals of anchovy or redeye roundherring *Etrumeus whiteheadi*.

The diet of demersally trawled snoek showed a greater species diversity. Principal species included redeye roundherring, lightfish *Maurolicus muelleri*, lanternfish *Lampanyctodes hectoris*, the hakes *Merluccius* paradoxus and M. capensis, buttersnoek Lepidopus caudatus and the euphausiid E. lucens. The relative importance of each species changed from summer to winter, most notably the decrease in importance of lightfish in summer. An additional summer principal species was garfish Scomberesox saurus.

There was no overlap in principal teleost prey species between snoek caught in the pelagic and demersal environments.

c. Division of feeding between the pelagic and demersal environments .

No relationship between snoek catch rate and time of day was identifiable for either midwater or demersal research trawls, nor between catch rate and depth of trawl for midwater trawls. It must be noted, however, that the majority of demersal research trawls were conducted during daylight hours only. A clear relationship was, however, shown between demersal catch rate and depth of trawl, with peak rate between 201 m and 300 m, and no snoek were caught shallower than 76 m or deeper than 400 m. The significance of this finding is that the handline fishery exploits snoek at depths almost exclusively shallower than 76 m, which implies that the snoek remains resident in a particular environment for a prolonged period.

Further to the findings described above, the very small degree of overlap between the diet of snoek caught demersally offshore and that of snoek caught in the pelagic zone, both inshore and offshore, also indicates that the snoek does not seem to move extensively on a diurnal basis between the two zones. This is best illustrated by the very infrequent occurrence of anchovy in any state of digestion in the diet of snoek caught demersally. The presence of garfish, a surface-dwelling species, in the stomachs of snoek trawled demersally in January 1986 provides an exception. Vertical migration was further investigated by relating the degree of digestion of snoek stomach contents from demersally caught fish to the time and depth of catch. All states of digestion (as defined on an arbitrary scale) were found scattered throughout the day between 06h00 and 18h00, although in a separate study an increase in feeding in the afternoon was suggested by a decrease in the proportion of empty stomachs. No samples were obtained at night. All digestive states were found scattered over the depth range sampled, indicating that snoek feed over the whole range. No commercial midwater trawling occurs in South African waters and therefore the presence of snoek in the midwater region offshore remains largely unmonitored. Midwater trawling conducted by the SFRI in the ongoing anchovy recruitment programme may throw some light on this.

d. Trends in snoek catches

Total ICSEAF snoek catches for the period 1972 to 1984 showed a marked peak of 81 676 t in 1978, largely attributable to a catch of 64 311 t by the USSR. A second peak of 71 110 t was taken in 1983. South African handline catches have declined rapidly since 1978, and this would at first sight appear to have been a consequence of the large ICSEAF catch taken in that year. However, the second ICSEAF peak catch in 1983 indicated that the snoek in the southeast Atlantic as a whole (should a single stock exist) did not necessarily show a similar decline. In fact, over the period in question (1972-84) the trend in South African handline catch bore little resemblance to that of the ICSEAF total catch. The South African demersal catch mirrored the ICSEAF total far more closely, although neither the 1978 nor the 1983 peaks were reflected. While it is of questionable validity to assume that catch reflects stock size, it is possible that the large ICSEAF catches in the mid-1970s have had a deleterious effect on South African handline catches but not on demersal catches. It must also be noted that data for 1986 and the first half of 1987 have not been included in this analysis, and recent press reports suggest that snoek handline catches may be improving.

The catch trend of the South African handline fishery prior to 1982 was mirrored by the trend in catch per successful man day. In 1982, however, the trends began to diverge, with catch continuing to decline but CPUE (successful) increasing. This is probably due to the development of the nomadic and highly mobile ski-boat fleet, which is able to target on the apparently diminishing inshore stock. This may place increased pressure on an already ailing handline fishery, although line catches only form a small proportion of the ICSEAF total.

e. Time spent in the southern Benguela region

The monthly mean catch taken between Port Nolloth on the northern west coast and Still Bay on the south coast during the period 1970 to 1985 showed that while snoek were available to some extent throughout the year, strong seasonality was nevertheless apparent. Mean monthly catches by harbour were two to three times greater in May, June and July than in any other month, the other months all being similar to each other. Snoek were present to the west of Cape Point between April and July, and to the east between June and September. This provided tenuous support for the proposed north-south inshore migration of the snoek. There was however considerable variation from year to year and from harbour to harbour. At Kalk Bay on the Cape Peninsula, for example, the mean monthly catch was consistently high from July to December. At Yzerfontein on the west coast, for which data were only available since 1981, winter catches were very low and the peak months were from November to January. In fact, while the total South African line catch of snoek have declined since 1978, summer catches at Yzerfontein have been high since data became available. In 1985 Yzerfontein catches accounted for over 60% of the South African handline catch and the bulk of these fish were caught in summer. The traditional winter snoek run had been a declining phenomenon along the entire South African coast, although apart fom Yzerfontein and immediately adjacent areas, catches still peaked in winter. Thus it appears that the inshore distribution of snoek is currently in a state of flux, and both the apparently substantial presence of snoek in summer in the Yzerfontein region and the continued but declining winter presence of snoek elsewhere on the South African coast represent important changes in the fishery.

Offshore demersal catches by commercial trawlers in areas 1.5, 1.6 and 2.1 also occurred to some extent all year round. Catches were very low between November and May, began to improve during June and July to a peak in August and then declined again steadily to below 5% of the annual catch in November. It is apparent that the temporal distribution of demersal snoek catches differed considerably from that of handline catches for the period for which demersal data are available (1979-1985). There are various suggested explanations for this, including the possibilities that the two fisheries may be based on separate stocks or alternatively on behaviourally distinct phases of the same stock. The most likely explanation is an offshore spawning movement beginning in about June, although there appears to be considerable variation from year to year. The distribution of snoek larvae suggests offshore spawning in winter, and snoek trawled offshore in winter had well developed gonads.

6.3 <u>CONCLUSIONS AND RECOMMENDATIONS</u>

a. The traditional South African handline snoek fishery appears to be threatened, with the total handline catch following a steadily declining trend. The apparently large inshore concentration of snoek in the Yzerfontein/Dassen Island region seems to be under particularly heavy local pressure, although this is unlikely to have an effect on the stock as a whole.

b. Any estimate of the impact of snoek as a predator in the southern Benguela region needs to take into account the relative biomasses of snoek in both the pelagic and demersal zones. A biomass estimate based on the inshore handline fishery could not simply be extrapolated to the offshore demersal fishery. It is suggested that future assessments of the snoek stock in South African waters be based on the demersal rather than the line fishery because of superior research facilities and the greater reliability of commercial catches. The presence of snoek in the offshore pelagic environment needs to be investigated in terms of behaviour.

c. Growth and ageing studies of snoek should be undertaken to allow the development of an improved production model.

d. An offshore return migration from South African to Namibian waters has yet to be demonstrated and there is also doubt concerning whether the north-south migration has occurred in recent years. The feasibility of tagging snoek in both inshore and offshore waters of the southern Benguela region should be studied. Such tagging would serve the dual purpose of monitoring both inshore-offshore movements in the southern Benguela and south-north migration in the southeast Atlantic.

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APPENDIX A

QUESTIONNAIRE - "WHAT DO YOU KNOW ABOUT THE HOTTENTOT AND SNOEK FISHERY?"

1. How long have you been fishing?..................................

2. What craft do you fish from? (circle)

rowboat	i
dinghy with small outboard	ii
skiboat	iii
chukki	iv

3. What is the maximum number of crew that is actively involved in fishing on the vessel?..................................

4. What number of crew is usually fishing on the vessel?................

5. On average, how many days a month do you fish for

   a) Hottentot?................

   b) Other species? (Which species?)..............................

6. How long on average do you spend motoring to

   a) the hottentot fishing grounds?..................................

   b) the snoek fishing grounds?.....................................

7. How far do you usually travel when fishing for

   a) Hottentot?................................

   b) Snoek?.......................................

   c) Other species? (Which species?)..............................

8. What is the greatest distance from the shore you will go to find snoek?...

9. What is the closest distance to the shore you will find snoek?

....

10. How long do you spend fishing each day?.............................

11. Do you specifically go out to catch hottentot?

Always i

Sometimes ii

Never iii

12. If you answered SOMETIMES or NEVER, what fish do you go out to catch, and does this change depending on the time of year?

....

....

13. If you are fishing for other species, do you switch to hottentot if you do not catch other species?.................................

14. During the crayfishing season, do you continue to fish for

a) Hottentot?..................

b) Snoek?.......................

c) Other species? (Which species?)..................................

15. After the traps have been put down, do you fish for

a) Hottentot? ....

b) Snoek? ....

c) Other species? (Which species?)..................................

16. Is there always a demand for fish, and if not, how does it vary?

a) Hottentot...

b) Snoek...

17. Who do you sell your catch to? (circle)

	a) Hottentot	b) Snoek
Fishing company	i	i
Direct to public	ii	ii
Fish hawkers	iii	iii
Do not sell catch	iv	iv

18. Of the total boat catch, how much is kept by the crew for

	a) Hottentot	b) Snoek
i) own consumption?	....	....
ii) own sale?	....	....

19. Does this depend upon the price offered, by the company or the hawkers?

YES NO

20. What price do you get for your fish?

a) Hottentot...

b) Snoek..

21. Does the price remain fairly constant for

a) Hottentot?..............

b) Snoek?..................

22. If you answered NO, does the price rise when catches are poor?

a) Hottentot..............

b) Snoek..................

23. What tackle do you use when fishing for

a) Hottentot?..

....

b) Snoek?..

....

24. What kind of sinkers do you use for hottentot?......................

25. What size hooks do you use for (circle)

a) Hottentot?

<#2	1/0
#2	2/0
#1	>2/0

b) Snoek?

<8/0	11/0
8/0	12/0
9/0	>12/0
10/0	

26. Have you changed your tackle over the years for

a) Hottentot? YES NO

b) Snoek? YES NO

27. If you answered YES, in what way has it been changed?

	a) Hottentot	b) Snoek
Increased hook size	i	i
Decreased hook size	ii	ii
Changed bait	iii	iii
Changed thickness of line	iv	iv

Other - specify...

28. What type of bait do you use most frequently?

	a) Hott.	b) Snoek		a) Hott.	b) Snoek
Redbait	i	i	Pilchard	vi	vi
Octopus	ii	ii	Other fish bait	vii	vii
Chokka	iii	iii	Black mussel	viii	viii
Kreuwel	iv	iv	White mussel	ix	ix
Crayfish	v	v			

29. Do you use different bait at different times of the year

a) For Hottentot?..

b) For Snoek?..

30. When you are actually catching snoek, do you ever catch other fish at the same time, using the same hooks and the same bait? If so, what species?

....

31. What maximum depth do you fish to

a) For hottentot?..

b) For snoek?..

32. What is the minimum depth at which you fish

a) For hottentot?..

b) For snoek?...

33. Do you catch larger fish in deep or shallow water?

	a) Hott.	b) Snoek
DEEP	i	i
SHALLOW	ii	ii
BOTH	iii	iii

34. Do you catch small fish in deep or shallow water?

	a) Hott.	b) Snoek
DEEP	i	i
SHALLOW	ii	ii
BOTH	iii	iii

35. Where do you catch the most fish?

	a) Hott.	b) Snoek
In the kelp beds	i	i
Just outside the kelp beds	ii	ii
In deep water far from kelp	iii	iii

36. In what actual depth of water do you usually catch snoek?

....

37. Where do you think most fish are?

	a) Hott.	b) Snoek
On the bottom	i	i
In midwater	ii	ii
In the surface water	iii	iii

38. Which were the best years for fish? Rate the years as as well as possible.

a) Hottentot...

b) Snoek...

39. If catches have increased or decreased, what do you think the reasons are for this?

a) Hottentot...

....

b) Snoek...

....

40. Has the size of the fish caught changed over the years? If so, how?

a) Hottentot...

....

b) Snoek...

....

41. Do you think the hottentot move? YES NO

42. Are hottentot always equally available?..............................

43. When the fish are available, do they always bite equally well?

a) Hottentot...................

b) Snoek......................

44. If not - why? Under what conditions do they bite well or poorly?

a) Hottentot...

....

b) Snoek...

....

45. What is the best time of day for catching snoek?...................

46. Do you fish for snoek in different places and at different depths, depending on the time of day?...................................

....

47. In what months of the year do you fish for snoek, provided there is no closed season?..

48. What time of year do you catch the most fish, and why?

a) Hottentot...

....

b) Snoek...

....

49. Do seals take fish from your hooks?

a) Hottentot...

b) Snoek...

50. Do penguins, gannets, dolphins or seals have any other effect on snoek fishing?..

....

....

51. Do you think the minimum size limit is

	a) Hottentot	b) Snoek
Too large?	i	i
Too small?	ii	ii
Correct?	iii	iii

52. How do you know where to look for snoek? What signs tell you where the snoek are?..

....

....

53. What signs, if any, will tell you that it will be a good snoek season? For example, if the purse-seiners are catching a lot of pilchard and anchovy, will this tell you anything about how much snoek there is? Are there any other signs?...

....

....

....

54. If you have good catches of snoek, then nothing for a few days, then good catches again, where do you think the snoek go during those days in between?...

....

....

55. Do you catch big snoek at one time of the year and small (young) snoek at another time, or can big and small snoek be present at the same time?..