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DOCTOR OF PHILOSOPHY

The ecology and exploitation of yellowfin tuna, Thunnus albacares (Bonnaterre 1788) in the Pemba Channel, Kenya.

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Award date:
1995

Awarding institution:
Bangor University

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The Ecology and Exploitation of Yellowfin Tuna, *Thunnus albacares* (Bonnaterre 1788) in the Pemba Channel, Kenya

A thesis presented for the degree of Doctor of Philosophy, University of Wales

by

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SUMMARY

This thesis evaluates the utility of a sport fishery for yellowfin tuna, *Thunnus albacares*, in the Pemba Channel, Kenya, in providing ecological information relevant to commercial fishery assessment and management. Age, growth, reproductive status and diet are measured, together with an innovative assessment of the Indian Ocean yellowfin tuna stock.

Catch/effort and weight data from the records of the sport fishery from 1963-1995 demonstrate a decline in tuna mean weight since the advent of purse seining in 1984. A periodicity of 5-6 years was detected in the Indian Ocean longline fishery catches, and in the sport fishery catch/effort and mean weights.

Samples were taken from tuna caught in the sport fishery from 1981-88. Sport-fished samples were more random in size, age and sex (ratio = 1:1) than catches from any of the three major commercial fisheries.

The total mortality rate of cohorts deconvoluted from weight-frequencies in the sport fishery catch over 6 years was used in a Caddy & Csirke analysis. Maximum Sustainable Yield estimates of the Indian Ocean stock were 113,000 tonnes (new method), 110-160,000 tonnes (Walters' method); compared with only 40-52,000 tonnes using the standard equilibrium method.

Tuna (1653 over 7 years) were successfully aged using length frequency analysis and by a novel method based on clusters from a Principal Components Analysis of morphometric measures. Juvenile growth was fast, 3.1 cm/month, whereas adults grew at about 2 cm/month.

Gonads (>1500) were staged for 5 years and histologically examined for 2 years. Female yellowfin mature earlier than males, but males become ripe earlier in the season. The spawning stock consists of females >120 cm FL.

Diet was scored over 4 years and evaluated volumetrically over 2 years. Juvenile tuna eat fish, but adults opportunistically consume fish, cephalopods and crabs, depending on availability. Catchability by gear in both the sport and commercial fisheries is likely influenced by the currently abundant food.

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ACKNOWLEDGEMENTS

I would like to thank Professor Tony Pitcher for encouraging me to start the Ph.D. research in the beginning and, for his advice, assistance and encouragement throughout. I would also like to thank Dr Norman Runham for taking on the job of supervisor after Professor Pitcher left the United Kingdom. Thanks are due also to Dr Gavin Gatehouse of the School of Biological Sciences, Bangor and to the Dr John Perkins of the Administration Department, Bangor for allowing me an extension. I am also very grateful to the Fisheries Centre, University of British Columbia for support that made it possible for me to complete the writing up. Also to Alida Bundy for her comments on Chapter 6 and to Martin Esseen for his assistance.

Throughout the course of this research I have received assistance from various quarters whom I should like to thank. Firstly, my wife Tina for her encouragement and support and help with the recording of the data; my parents for their support and help with the data collection and my father for having kept such meticulous records since 1963. I am sincerely grateful to Mr James Adcock for supplying the data for the Mtwapa sport fishery, and Peter and Janey Ready for the Malindi Sea Fishing Club data.

I would also like to thank Dr Norma Blackstock for teaching me the histology techniques described in Chapter 5; Dr Segundo Coello for his advice and assistance with the histology; Mr I.G. Jones of the Computer Department for all his help with DFACT.

Thanks are also due to Dr R.W. Ingle and Mr Fred Naggs of the British Natural History Museum for identifying species from the tuna food. Also to Mr David Gibson of the Ministry of Agriculture, New Zealand for his photographs of tuna livers, and Mrs Cornelia Nauen, Mr R.C. Anderson, and Mr Sivasubramaniam all formerly with the FAO for copies of FAO publications.

CHAPTER 1

Introduction: Biological and Fisheries Information from a Sport Fishery

In this thesis I attempt to show how sport fishery data may be useful in providing biological and fishery information, with particular reference to yellowfin tuna. The bulk of this sport fishery data has been obtained from a company operated by my family, based at Shimoni, Kenya at the northern entrance to the Pemba Channel, from 1963-1994. A sport fishery presents an opportunity for someone with biological training to collect data on the various aspects of the ecology and exploitation of yellowfin tuna. Data on an average annual catch of 400 yellowfin tuna and about 750 other fish has been carefully and accurately recorded since 1963 by myself and my father and it was felt that with 32 years of catch data and the opportunity to take samples it would be possible to use it to: (a) provide biological information about yellowfin tuna stocks in the Indian Ocean; (b) provide information useful in assessing the commercial fishery for yellowfin tuna in the Indian Ocean, and (c) provide information on changes in the top predator community.

The yellowfin tuna, *Thunnus albacares* (Bonnaterre 1788) is a member of the Family Scombridae, Order Perciformes, and Class Actinopterygii. The yellowfin tuna is a pelagic, oceanodromous species that may be found world-wide in all the tropical and sub-tropical seas apart from the Mediterranean. They form large monospecific or multispecific schools primarily by size in near surface waters of 18-31°C. The yellowfin tuna is an important species in many fisheries world-wide taken by drift nets, gill nets, handlines, longline, pole-and-line, purse seine, and sport fisheries. The total reported global catch of this species increased from 866,546 tonnes in 1987 to 1,011,764 tonnes in 1991. The total Indian Ocean catch was 163,444 tonnes in 1991, which represents 16% of the global catch.

The 1980's saw a rapid development in the Indian Ocean yellowfin tuna fishery with the introduction of industrial purse seiners, mainly from France and Spain. There is an urgent need for a re-assessment of this fishery as current catch levels

have for some time far exceeded previous estimated levels of Maximum Sustainable Yield.

The sport fishery has provided me with the opportunity to take samples to study growth, maturation and food of yellowfin tuna. The literature reveals controversies regarding the growth of yellowfin tuna, particularly that of the juveniles, with two schools of thought, one proposing a slow rate and the other a higher rate of growth which may or may not fit a von Bertalanffy growth model. Controversy also occurs as to when yellowfin tuna reach sexual maturity and when they spawn for the first time. Much of this controversy seems to stem from the lack of standardisation of the term sexual maturity. There is also little information on the possible influence of the liver in the maturation of tuna gonads. Very few studies on food of yellowfin tuna reported in the literature have used accurate volumetric methods: most concentrating only on recording the organisms found within the stomach. The nature of the food and its abundance are likely to influence the availability of yellowfin tuna in an area and may affect their catchability by certain gears.

Throughout the thesis reference is made to the "fishing season", which in the case of the Shimoni sport fishery commences on 1st August and ends on 31st March of the subsequent year. The season may extend beyond this time scale at some of the other sport fishery operations discussed, but the number of days fished and the number of fish caught are always small during those times.

Chapter 2 describes the Kenyan sport fishery with special emphasis on yellowfin tuna, *Thunnus albacares.* Data on catch and effort from all of the main Kenyan sport fishery operators is presented and analysed in an attempt to provide information useful in a fishery assessment.

Chapter 3 describes the commercial fisheries for yellowfin tuna in the Indian Ocean; attempts equilibrium and non-equilbrium assessments for the fishery and presents an unconventional assessment using data derived from the Shimoni sport fishery

In Chapter 4 the ages, growth rates and mortality of samples of yellowfin tuna caught in the Shimoni sport fishery are examined using two methods: (1) mixture analysis of annual length-frequency data and by a simple inspection of modes of monthly data and (2) a Principal Components Analysis of morphometric data.

In Chapter 4 the ages, growth rates and mortality of samples of yellowfin tuna caught in the Shimoni sport fishery are examined using two methods: (1) mixture analysis of annual length-frequency data and by a simple inspection of modes of monthly data and (2) a Principal Components Analysis of morphometric data.

Spawning frequency and age of maturity are critical determinants of the status of exploited fish stocks. Chapter 5 evaluates these factors for yellowfin tuna in the Western Indian Ocean using data from over 1500 gonads sampled from the Shimoni sport fishery over 5 years.

In Chapter 6, I examine the food of yellowfin tuna over six years and discuss the importance of the various components in the diet of yellowfin tuna. The first part of the study from 1981/82-1983/84 and 1985/86 represents the qualitative sample. A more quantitative sample was collected during 1986/87 and 1987/88. As well as the traditional frequency-of-occurrence methods I used a volumetric technique in the latter study. Prey size, behaviour and catchability of yellowfin tuna relative to food type are discussed for sport fishing and commercial gears.

In the final chapter I evaluate the contributions that sport fishery data and samples may have in yielding biological data and estimates for an assessment of the commercial yellowfin tuna fishery, particularly where a sport fishery operator has biological training.

CHAPTER 2

The Kenyan Sport Fishery: Analysis of Catches and Effort

This chapter describes the Kenyan sport fishery with special emphasis on yellowfin tuna, *Thunnus albacares.* Data on catch and effort is presented and analysed in an attempt to provide information useful in a fishery assessment.

2.1 Introduction

Sport fishing is the capture of fish by rod and line for recreation. The breaking strength of the line and the size of the fish determines the level of skill required by the fishermen. With sport fishing the emphasis is on catching the largest fish on the lightest line, rather than the total catch weight of fish taken per day as with commercial fisheries. This has further implications in that larger fish take longer to subdue than smaller ones, and smaller fish tend to be more voracious than larger fish. While the boat is stationary fighting a fish one is not able to catch other fish until the one that is being played is either boated, or lost. Further to this, if there is a strong current, which during the SE monsoon in Kenyan coastal waters is running at approximately four knots, then the boat may drift out of the area during the fight. There is therefore a time lag while the boat motors back into position. An experienced crew and angler can reduce this delay to a minimum, but still a 45 kg yellowfin tuna may take anything from 10-60 min. to land on 24 kg test line.

Sport fishing is a popular and growing sport within Kenya and is not restricted to the coast. The many rivers and dams offer good trout fishing, and the Nile perch, *Lates niloticus*, in Lakes Turkana and Victoria, only recently recognized by the International Game Fish Association (IGFA) for world record purposes, has become very popular. However, this thesis is concerned only with the marine sport fishery of Kenya.

As with all sports, there are both professional and amateur sectors. The professionals are generally referred to as charter fishermen and the boats they operate as charter boats. Much of the Kenyan sport fishery catch is from charter operators and only a very small proportion from the amateur sector. Amateur fishermen are likely to fish only over the occasional week-end due to job

commitments. An important difference between commercial fishermen and professional sport fishermen is that whereas a commercial fishermen makes a living by selling the catch, and so catch rate determines income, the sports charter operator makes a living from the punter who pays to go fishing. But the sport fishery catch rate has an indirect effect on income; if you cannot find fish the punter may not return and may go elsewhere probably advertising the fact to his friends or his club. Therefore, it is still catch rate statistics that brings business. However, in the Kenyan sport fishery most operators, apart from Sea Adventures Ltd., supplement their charter rates by selling the catch.

Sport fishing is not a new sport in Kenya. There have been sport fishermen in East Africa virtually since the white man arrived on the coast. But it was not until after the Second World War that serious big game fishing really got underway in Kenya. Much of the exploratory big game fishing took place out of Mtwapa, although boats also fished out of Malindi, Kilifi and Mombasa. Charter boats were available at all these centres, and some were even operating before the War. The 1950's saw the formation of the Mnarani Fishing Club, Kilifi and the Malindi Sea Fishing Club. Towards the end of the 1950's and early 1960's the sport began to grow with the formation of the Pemba Channel Fishing Club, Shimoni and the Bahari Club, Mombasa. These clubs were important in promoting the sport, and it was during this period that charter fishermen began to market Kenya as a sport fishing destination for tourists. As the Kenyan tourist industry has expanded so sport fishing has followed. Since the 1980's there has been another phase of expansion with a further increase in the number of charter fishermen and an even greater increase in the number of private fishing boats.

Sport fishing is practiced from nearly every port and most beaches from Kiwaihu Island in the north to Shimoni in the south (Fig. 2,1). Until fairly recently, sport fishing in Kenya was almost entirely restricted to the European community, but there has been a very rapid growth in the number of Asian and Goan sport fishermen. Very few Africans have become involved in the sport, possibly because those with the wherewithal to spend on recreational activities are largely from inland tribes who frequently have a natural fear of the sea.

Rod and line sport fishing comes in many forms, such as fly fishing, spin casting, bottom fishing and deep sea fishing. All these, apart from deep sea fishing, do not necessarily require the use of a boat. This chapter is concerned with the sport fishery for yellowfin tuna, which is usually carried out by means of deep sea fishing. It must be added that there are anglers who fish for the larger pelagic species, such as tuna, by fly or spinning, but the numbers of fish taken by these methods are comparatively small.

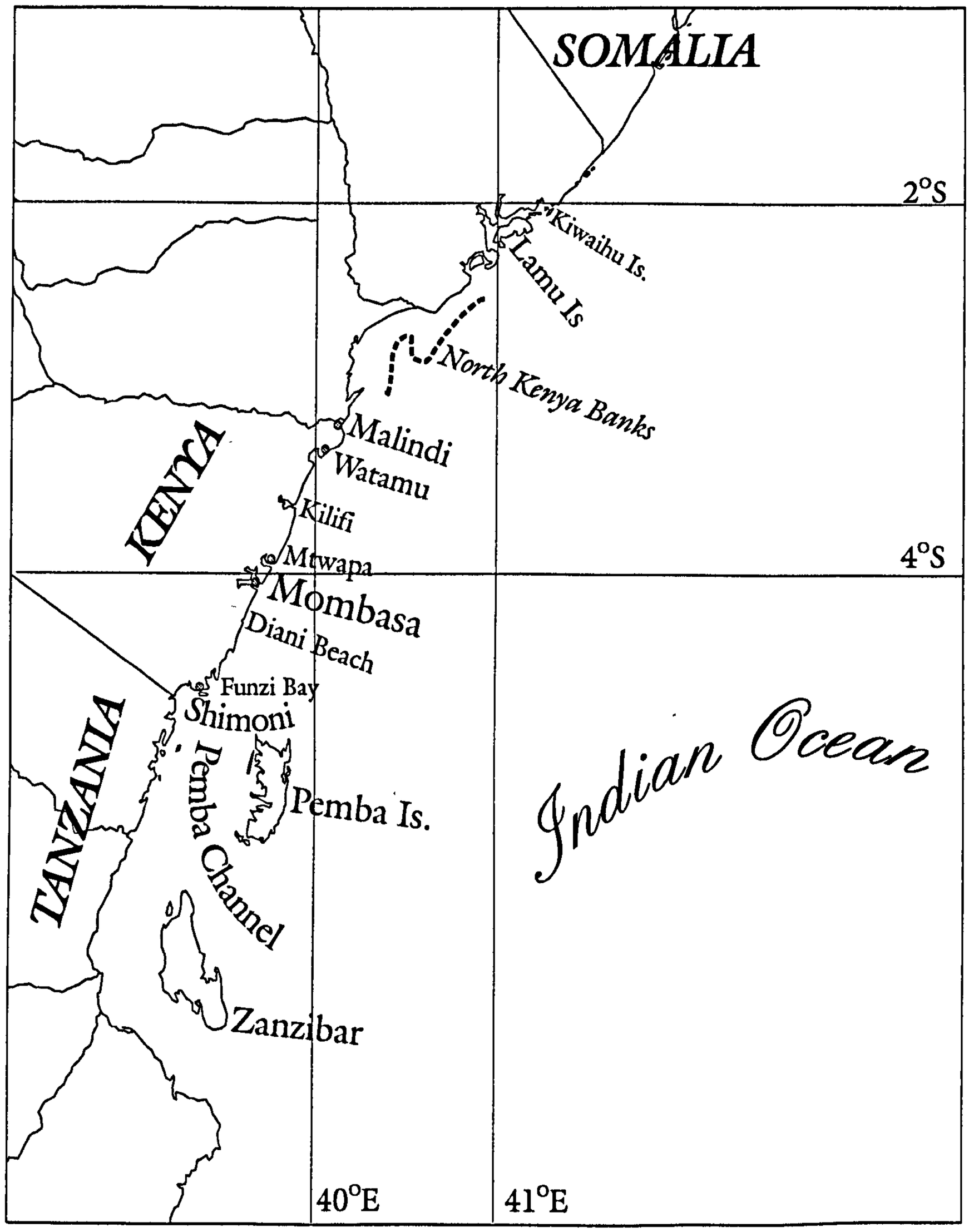

Figure 2,1. Map of the Western Indian Ocean showing locations in Kenya and Tanzania mentioned in the text.

DEEP SEA FISHING

This part of the sport has become increasingly popular in Kenya, not only with amateurs, but also as an important earner of foreign exchange for the country. It is undoubtedly the most expensive form of the sport as the angler must not only possess the necessary tackle, but also own or hire a boat. The nature and size of the quarry being sought and level of dedication to the sport will determine the financial outlay. Like many other sports, the level of input in terms of time, finance and effort is directly proportional to the output in the form of successful fishing trips.

The popularity of the Kenya coast as a tourist destination has led to the setting up of a large number of charter fishing operations. Tourists and local residents are able to charter a boat with all the necessary equipment supplied and with a professional crew to run the craft. Unfortunately, due to the poor enforcement of licensing and safety regulations, there are a few unprofessional operators whose boats, equipment and crews are of poor quality. Tourists are strongly advised to use only those charter operators recommended by the Kenya Association of Sea Angling Clubs (KASAC).

KASAC was established 32 years ago to co-ordinate sport fishing in Kenya and to maintain sport fishing records of the major game fishes. KASAC is affiliated to the IGFA and the Game Fish Union of Africa (GFUA).

The major deep sea fishing centres are marked on Fig. 2,1. The number and size of craft at each location is determined by their accessibility by road or air, their proximity to the major towns and tourist resort areas, and to the nature of the anchorage.

Sites

Kiwaihu Island: There is a tourist lodge on the island from where there was at least one charter boat operating, but its inaccessibility has led to these boats being forced to spend much of the season working out of, either Watamu or Malindi. Tourists must charter a light aircraft, first to Lamu from Mombasa or Nairobi, and then hire a boat to get to Kiwaihu. The resulting cost of this on top of international air fares and the fishing charter are prohibitive for many in view of the competition from the other more accessible resort areas. Tag and release, particularly of billfish, is the norm here, and the catch statistics have been recorded together with those of Lamu.

Lamu: There are a number of private and professional boats operating from the island and data has been supplied to KASAC since 1984/85. Despite a large number of charter flights to the island the additional cost makes the fishing boat

hire prohibitive for some. As with Kiwaihu some of the charter boats are forced to sub-charter through Hemingways Hotel. Fishing in this area is very good in view of its proximity to the North Kenya Banks (N.K.B.), believed to be one of the richest fishing grounds on the east coast of Africa (pers. comm. G. Losse to P.D. Hemphill, c. 1974).

Malindi: A well-known and popular tourist resort with an international reputation that has been built up on the large numbers of sailfish, *Istiophorus platypterus,* that abound there. There are many boats, both charter and private, of varying sizes that operate from Malindi. In recent years the opening up of the N.K.B. has led to an increase in the diversity of the Malindi sport fishery. Sport fishermen here have, traditionally concentrated their efforts on sailfish, tunas mainly being caught as a by-catch.

The N.K.B. has yielded large catches of yellowfin tuna, marlin, mako sharks and swordfish, as well as many of the other game fishes described in Chapter 7. The banks are part of the continental shelf area (Fig. 2,1), much of it being less than 100 fathoms with very steep drop-offs to more than 300 fathoms on the outside. The banks are very rich feeding grounds for tunas, and the yellowfin tuna appear to be less fastidious than elsewhere on the coast in the type of lure, or bait they will take. Since the true potential of this area has been realized some of the fleet have switched to targeting yellowfin tuna on the N.K.B. during the SE monsoon months. As all Malindi boats keep the catch to supplement their charter income they will switch rapidly to targeting tuna even if schools are found within the sailfish grounds.

Watamu: Despite its poor anchorage and difficult entrance through the reef, Watamu is the home to the largest sport fishing fleet on the coast. The importance of this zone increased tremendously during the mid- to late 1980's with the opening of Hemingway's Hotel and the subsequent increase in the size and quality of the sport fishing fleet. If the tuna are about the Hemingway charter boats will divert their full attention to them, and one boat has been known to fish up to 13 lines. Most boats fish between six and eight.

Kilifi: Most of the data for this area comes from private boat owners, although some years, but not all include data from the Mnarani Hotel (African Safari Club) charter boats. In the late 1980's African Safari Club have moved their fleet south to Mtwapa where they own more hotels.

Mtwapa: The proximity of Mtwapa to Mombasa and the increasing number of large tourist hotels in the vicinity has made Mtwapa a popular base. Data was only available for the operation owned and run by James Adcock until 1987/88, and although this only accounts for a small proportion of the charter and private boats operating out of Mtwapa, it is undoubtedly the most professional and

successful outfit. Since 1987/88 the KASAC statistics have combined the data for Mtwapa with that for Mombasa. Within the last five years another professional outfit, Hall Mark Charters commenced operations with two good boats. For the purpose of this analysis of the Kenyan sport fishery I have combined the data for Mtwapa and Mombasa pre-1987/88.

Mombasa: This is a very popular base more for convenience than for the number of fish caught. Most of the boats are small outboard powered craft of 5-7m length, many of them fishing only at the weekends. There is, however one very good boat with twin inboard diesels that began operations within the past five years.

Diani Beach: Boats, some of them for hire, have to be anchored inside the reef in the lagoon and their size and form of propulsion are severely restricted by the depth of water. Diani Beach is a major tourist resort with a beautiful beach and approximately 18 large hotels.

Funzi Bay: There was a single operator with two large charter boats based there until about 1993, but no data was made available to KASAC. Operations have since ceased and the boats sold.

Shimoni: Situated at the northern entrance to the Pemba Channel, an area that has gained an international reputation in sport fishing circles. Fewer boats operate from Shimoni than from any of the other centres, apart from Kiwaihu, Lamu and Funzi despite the excellent fishing, its natural harbour and its simple entrance. However, the road to Shimoni is very poor, until 1992 there was no mains electricity, and the nearest major tourist hotel is 30km to the north.

Boats

These vary widely in size from less than 5m to 15m in length. To catch yellowfin tuna a large boat is not strictly necessary, but as the bigger fish tend to be farther offshore, a larger more seaworthy craft is preferable. Possibly as many as 80% of the sport fishing boats off the Kenyan coast remain within sight of land for much of the time.

The last decade has seen an increase in the number of large, modern craft, mostly imported from either the United States or the United Kingdom. These vessels have much more powerful engines, and many are capable of 30 knots, or more. This has led to boats fishing further afield and getting to the fishing grounds in a shorter time. These new boats have led to the opening up of the N.K.B. and in Malindi and Watamu large, fast boats have become essential to the charter operators survival. The southern extremity of the N.K.B. is approximately 60 km. from Malindi harbour, and 100 km. from Watamu.

Tackle

This can be separated into boat tackle and fishing tackle.

Boat tackle includes the fighting chair, which is a heavy duty chair with gimbal and foot rest that is mounted in the cockpit. The chair turns on an axle enabling the angler to be facing the fish irrespective of the boat's heading. An angler, however, may play the fish standing up on light tackle using a rod belt, which is a belt with a gimbal on it. The boat also carries a selection of gaffs for securing the fish once it is brought to the boat.

Fishing tackle: Regulations regarding fishing tackle are set by the IGFA and not KASAC. Lines are classified according to their breaking strain. The line classes are 60kg, 37kg, 24kg, 15kg, 10kg, 8kg, 6kg, 4kg, 3kg, 2kg, and 1kg. The most commonly used line classes are 37kg, 24kg and 15kg.

The terminal tackle is the trace, hook and lure or bait that is attached to the end of the line. The trace can be of wire or nylon, and of unlimited breaking strength, but the length of the trace is restricted depending on the line class. Yellowfin tuna are caught mostly using artificial lures, such as plastic imitation octopus of various colours and sizes, or 'rapalas', but bait such as fresh squid or halfbeaks (*Hemirhamphidae*) are also used.

Search and Location of Tuna Schools.

Off Kenya, sport fishermen rely heavily on visually spotting the tuna schools, and upon experience. Until only the last five years or so, few boats were equipped with fish finders, and of those, very few had the experience to make full use of the gear. Most of the major charter boats are now also equipped with Global Positioning System (GPS), which are increasingly being used to mark fishing areas. The fish finders are of particular use in locating drop-offs and other changes in the sea bottom contours, which may be positions of high fish concentrations. The flocks of terns that feed on the small sardines and squids chased to the surface by the tuna are the most important signs. Whereas the splashing produced by a school of small tuna may not be visible from very far, particularly when the sea is choppy, flocks of terns can be seen from a distance, even from quite small boats. However, the schools of large adult yellowfin tuna in the Pemba Channel are very often not accompanied by birds and the fishermen must rely upon spotting the fish jumping.

Yellowfin tuna jump and splash while they are feeding. This may be either as a result of chasing their prey from the depths to the surface, in which case one

often sees the small fish or squid leaping ahead of the tuna, or from taking prey off the surface. This is further discussed in Chapter 6.

Once the school has been located, the lures must be dragged across the path of the fish without disturbing the school with the boat. Very often, if the boat gets too close to the school, the tuna will take fright and sound, thereby ending the chances of a strike.

With the larger tuna the exact position, shape and size of the school can only be guessed at from the position and heading of the fish breaking the surface. Usually only a small proportion of the fish in the school jump. This is further complicated when the fish appear to be feeding on squid (see Chapter 6) as the yellowfin tuna chase the squid to the surface, jumping into the air after them, the squid then making a further dash for the depths followed by the tuna. The schools of yellowfin tuna may only remain on the surface for one or two minutes. So it requires a lot of luck to be in the right place at the right time. With the modern fish finders one can often locate the school deep down, but with our gear be powerless to reach them, unless they are within the top 30m or so.

CATCH DATA

Until 1990 monthly sport fishing catch returns had to be filed with the Department of Fisheries by each and every fishing club. Data was segregated into the catches of charter and private boats and indicated the number and weight of each species, and the number of boat-days. However, the data is not freely available and it is doubtful whether any serious analysis has, or will ever be done. Certainly no reports have been published.

Catch data is recorded at the end of the fishing day by the weigh master. As most charter operators supplement their charters from the sale of the catch there is an interest in seeing that the weights and numbers of fish are recorded accurately. Any error is likely to result from the transfer of these data to long-term storage and in the completion of the catch returns. There is likely to be less error in the submission of data to KASAC than in the completion of the government forms. There is no way to measure the error in the data used in this analysis, but it is felt that it is probably fairly small.

Annual catch statistics of the major game fishes are supplied by each member fishing club and associate member to KASAC, which are then published in the annual Kenya Sport fishing Records. Unfortunately, attempts to get clubs to include effort data were fruitless until the 1993/94 season. At many of the clubs, particularly those with private boats, no log is maintained of fishing trips, especially where such trips are unsuccessful. Such effort data included on the Fisheries returns are therefore likely to be inaccurate.

Effort data in this type of sport fishery is recorded as the number of boat-days. However, the length of a boat-day may vary considerably from four hours to as many as eleven hours. At Shimoni a fishing day is a standard nine hours, which is fished by all boats, but farther north charter operators offer a "day's" fishing from a minimum of four or six hours. With such short trips, the area of search is severely limited and the emphasis is usually on small reef-associated game fish, small school tuna with the occasional sailfish. Private boat owners are even more flexible in the number of hours they fish.

In Section 2,2 a simple analysis of the catches of yellowfin tuna taken by the Kenyan sport fishery between 1979/80 and 1993/94 is given. Data for the Kenyan sport fishery catches was obtained from the annual Kenya fishing records (1983, 1986, 1990, & 1994). Contributory catches by the major fishing clubs are also shown. In Section 2,3 a more detailed analysis is carried out on catches from Shimoni, where accurate catch and effort data have been maintained since 1963.

The Shimoni yellowfin tuna data applies to catches landed at the Pemba Channel Fishing Club (PCFC), and Sea Adventures Ltd.. From 1963 until 1984 the PCFC was the only charter operation in Shimoni. In 1984 the Shimoni Reef Fishing Lodge came into being with two sport fishing boats. However, although their catch figures, except effort, have been made available to KASAC, the catches were far smaller than those of the Pemba Channel Fishing Club (Between 1984/85 and 1989/90 the PCFC averaged 5,700 kg and the Reef Lodge, 380 kg per annum). The Shimoni Reef Lodge ceased fishing operations in 1990. In April 1990 my family sold the PCFC and set up a much smaller two boat operation under the name, Sea Adventures Ltd.. The same careful record keeping has continued, as well as a log of effort data for all boats operating out from Shimoni. These have been kept in my personal diary along with reports from all hourly radio calls.

The analysis of the Shimoni data is carried out on all seasons from 1963/64 to 1994/95. The entire eight month fishing season was initially used, but because for much of this time yellowfin tuna are only caught incidentally, the main analysis is limited to the SE monsoon months of August to November. Maturing and adult yellowfin tuna migrate through the Pemba Channel during the SE monsoon and are specifically targeted over this period. Although the tuna have normally passed through by November, this month has been included as there have been occasions when they have remained in the area due to an overabundance of food (see Chapter 6).

2.2 The Kenyan Sport fishery for Yellowfin Tuna

The total recorded Kenyan sport fishery catch for yellowfin tuna has showed an increasing trend from 1979/80 to 1993/94 with a temporary decline in 1987/88 (Fig. 2,2). The total catch increased by 16.8 tonnes in two seasons from just 6.9 tonnes in 1979/80 to 23.6 tonnes in 1981/82, then remaining fairly stable until 1985/86. There was a big drop in catches in 1987/88 to the pre-1981/82 level followed by a dramatic increase in 1988/89 by 29 tonnes, and from 1989/90 to 1993/94 the Kenyan yellowfin tuna catch has doubled.

SEASON	*Total (tonnes)*	*% Malindi*	*% Watamu*	*% Mtwapa*	*% Shimoni*	*% Combined*
1979/80	6.864	22.5	26.0	12.8	30.6	91.8
1980/81	15.137	28.0	23.1	15.5	24.8	91.4
1981/82	23.641	18.8	17.8	10.4	49.1	96.1
1982/83	24.521	22.5	12.1	2.7	47.5	84.9
1983/84	22.586	34.4	17.1	5.0	27.3	83.9
1984/85	23.820	41.2	36.2	2.1	12.9	92.4
1985/86	26.692	37.9	23.8	6.4	16.2	84.3
1986/87	37.463	30.1	16.7	4.0	26.6	77.4
1987/88	19.868	42.9	22.5	3.5	20.8	89.7
1988/89	48.853	50.6	24.9	2.6	7.9	86.0
1989/90	38.765	35.7	42.9	3.1	10.3	92.0
1990/91	50.102	36.0	42.0	2.1	13.3	93.3
1991/92	71.107	28.8	49.0	3.8	7.8	89.4
1992/93	74.831	28.0	51.3	5.4	10.5	95.2
1993/94	80.502	38.3	48.0	3.2	8.4	97.9
Total	564.752	34	36.1	4.4	16.2	90.7
Mean	37.650	33.1	30.2	5.5	20.9	89.7
sd	22.311	8.6	13.3	4.1	13.5	5.5
COV, %	60.6	26.1	44.1	74.9	64.4	6.1

Table 2,1. The total catch of the Kenyan sport fishery for yellowfin tuna and the proportions taken at the four major locations along the coast from north to south, together with their combined influence, are tabulated from 1979/80-1993/94. The means and their standard deviations along with the COV's are also given.

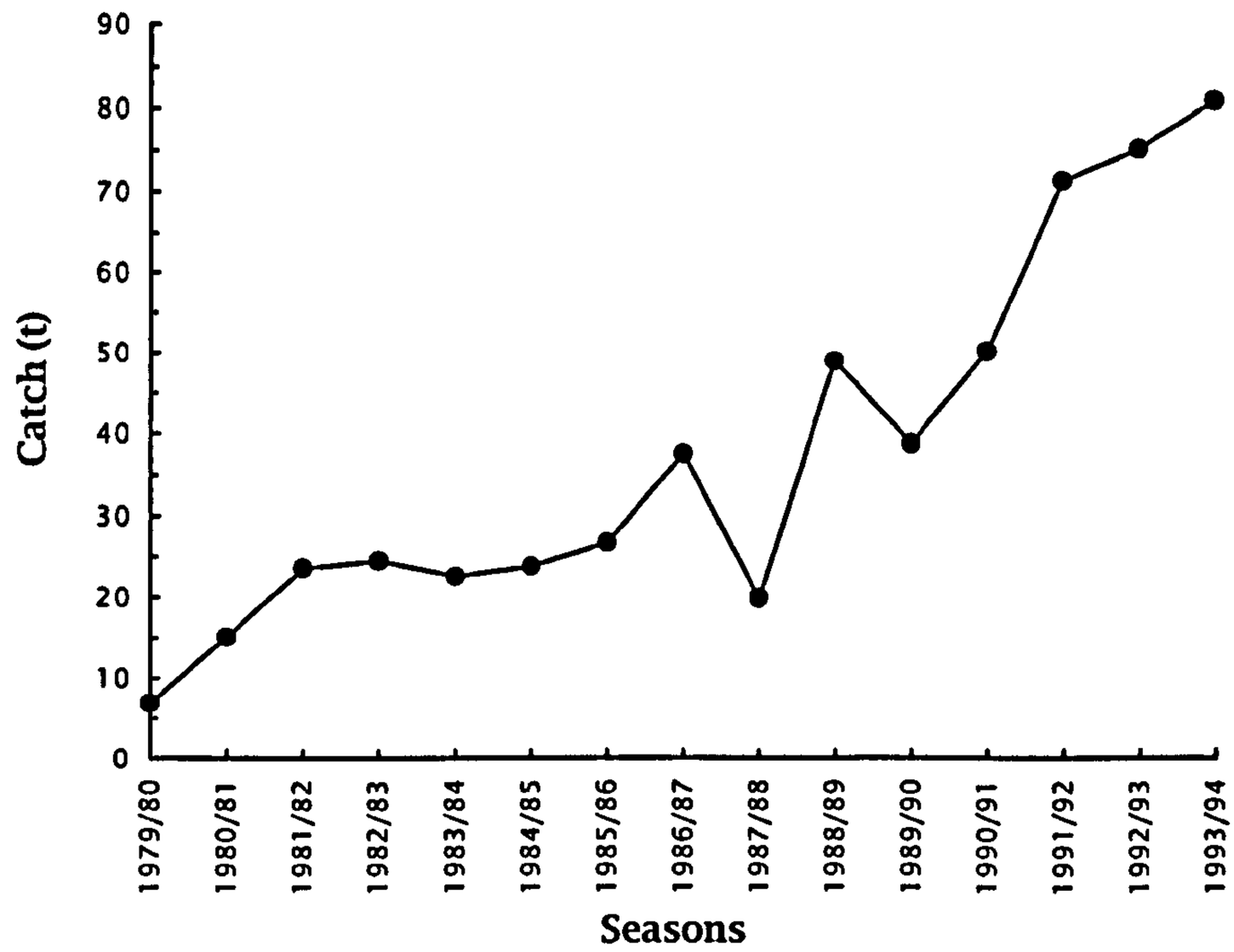

Figure 2,2. The total catch of yellowfin tuna taken by the Kenyan sport fishery, 1979/80-1993/94.

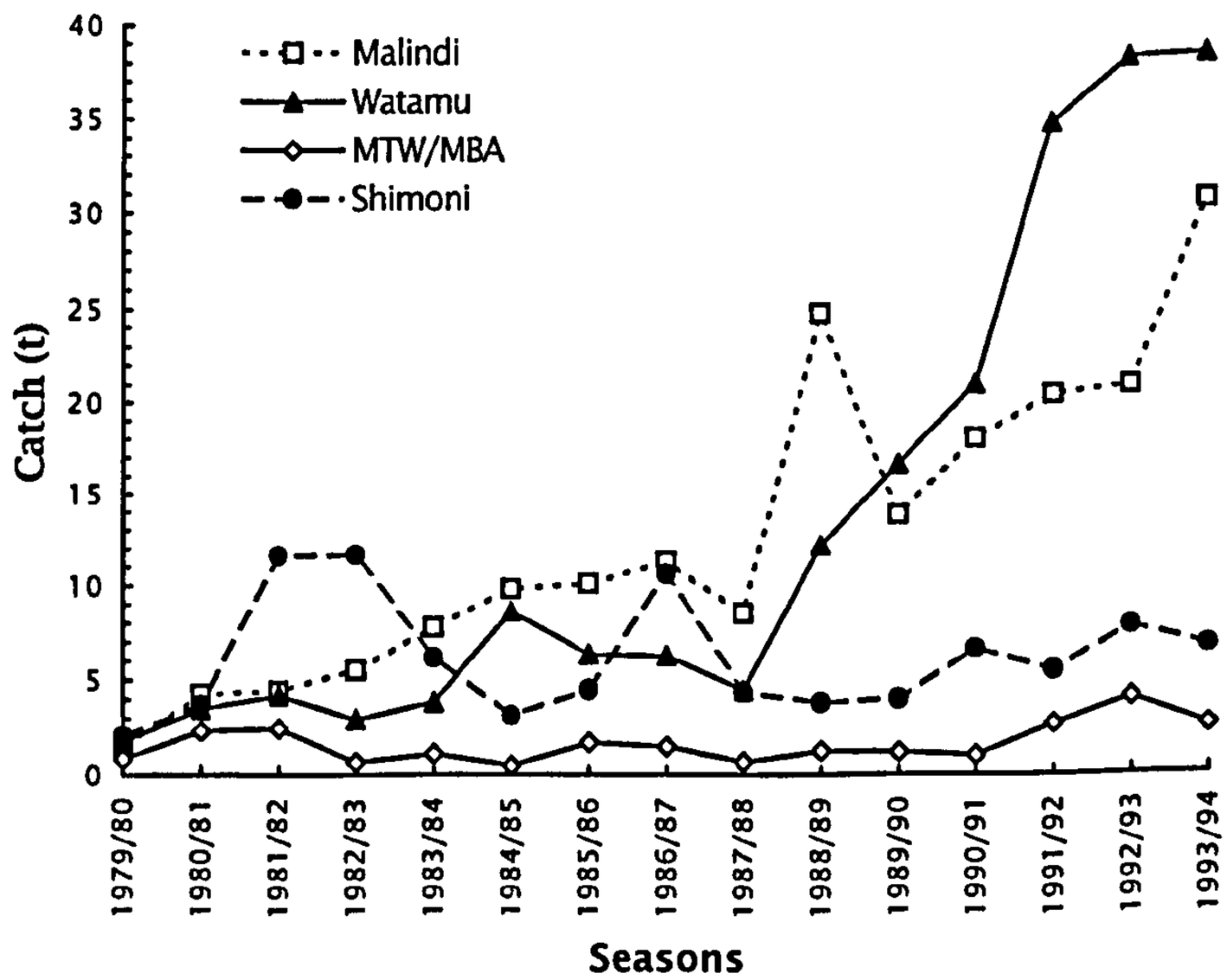

Figure 2,3. The Kenyan sport fishery of yellowfin tuna by location. These are the four major harbours where the sport fishery fleets are based, from north to south, as described in the text, 1979/80-1993/94.

Catches of yellowfin tuna are shown for four major areas on the Kenyan coast Malindi, Watamu, Mtwapa/Mombasa, and Shimoni (Fig. 2,3). These accounted for an average 89.7±5.5 % of the entire Kenyan sport fishery catch of yellowfin tuna (Table 2,1). This is despite there being an increase in the number of member clubs and associate members of KASAC over the 15 seasons, and the maximum was in 1993/94 when these four locations accounted for 97.9% of the yellowfin tuna catch.

Malindi: There has been an increase in catches from 1979/80-1993/94 with a large peak in 1988/89 (Fig. 2,3). 1988 was a very good year in the commercial catches of yellowfin tuna in the Western Indian Ocean (see Chapter 3). Much of the increase in catch in the 1990's reflects the opening up of the N.K.B. There are some large, fast boats from both Malindi and Watamu that operate daily charters to the N.K.B.

Watamu: Catches at Watamu remained fairly stable from 1979/80 to 1987/88 with a small peak in 1984/85 (Fig.2,3). The dramatic increase in catches of yellowfin tuna after 1987/88 may largely be explained by the opening of Hemingway's Hotel and a subsequent increase in the size and quality of the sport fishing fleet in Watamu.

Mtwapa/Mombasa: This area accounted for an average of 5.5±4.1% of the total Kenyan sport fishery catch of yellowfin tuna (Table 2,1.). Catches remained fairly stable from 1979/80 to 1990/91 with small fluctuations followed by a dramatic increase in catch in this area up until 1992/93 (Fig. 2,3). There was a further drop in catches in 1993/94.

Shimoni: Shimoni has a reputation for catches of the larger sizes of yellowfin tuna. The catches by weight (Fig. 2,3) show little correlation to the total Kenyan catch (Fig. 2,2) and demonstrate more peaks and troughs. There was a tremendous increase in 1981/82 and 1982/83, followed by a slump over the following two seasons. As in Fig. 2,2, 1986/87 was a good season and the poor year of 1987/88 is also mirrored in the Shimoni figures. But, at Shimoni catches showed no improvement until 1990/91.

The major target group of the sport fishery is the billfish*, and at all four areas a certain number of lines in use at any one time are likely to be set for billfish. But, all boats will actively target yellowfin tuna if they are in the area at the time. Most boats will troll a range of lures to cover different species and sizes of fish. At certain times of the year, usually during the SE monsoon yellowfin tuna do become the major target species. The catch is random in that the initiative is with the fish to take the lure, but with experience a skipper will not only fish areas where the chances of finding the big tuna are greatest, but will also make good use of the most successful lures, or baits. Commercial fishing for tuna is less

*(Makaira mazara, Makaira indica, Tetrapturus audax, and Istiophorous platypterus)

random, particularly with purse seining. The seines are not set at random in the sea, nor are longlines, but all available experience and knowledge are used in conjunction with the latest technology available.

AVERAGE WEIGHT

The Kenyan catch: The average weight of yellowfin tuna taken by the sport fishery varied from 5.4 kg to 10.9 kg over the 15 seasons, with a peak in 1982/83 and a smaller one from 1985/86 to 1987/88 (Fig. 2,4a). Since 1988/89 there has been a steady increase in mean weight of yellowfin tuna.

By Area: Up until 1989/90 there was very little variation in the mean weight of yellowfin tuna at either Malindi, Watamu or Mtwapa/Mombasa, but there was considerable variation at Shimoni (Fig. 2.5). The mean weight of Shimoni yellowfin tuna varied from 5.9 kg to 26.4 kg the latter occurring in 1982/83. The trend of the Kenyan catch (Fig. 2,4a) up until 1988/89 appears to reflect the Shimoni trend. Beyond 1989/90 the Kenyan trend reflects that of the large Watamu catch.

YELLOWFIN TUNA AS A PROPORTION OF THE TOTAL CATCH

The importance of yellowfin tuna in the total catch by numbers has oscillated between 21.1% and 43.4% (Fig. 2,4b). The trend is approximately the mirror image of the mean weights (Fig. 2,4a). The major deviation from this is that 1979/80 was a poor year for yellowfin tuna, big or small and that in 1993/94 relative importance increased along with an increase in average weight.

The importance of yellowfin tuna by weight in the total sport fishery catch also infers that 1979/80 was a very poor season for yellowfin tuna (Fig. 2,4c). On the contrary, in 1981/82 yellowfin tuna were important both by numbers and by weight. Beyond 1981/82 the proportion of yellowfin tuna by weight shows a decreasing trend up to 1987/88 after which there has been a recovery. The catch of yellowfin tuna was very poor in 1987/88 (Fig. 2,2) and accounted for only 12.5% by number, and 21.1% by weight of the total catch of all species (Fig. 2,4.). The decreasing trend in the proportion of yellowfin tuna by weight and the increase in the catches of yellowfin tuna (Fig. 2,2) reflects an increase in the catches of other species.

In the majority of instances, yellowfin tuna account for a greater proportion of the total sport fishery catch by numbers than they do by weight. In the Shimoni catches the trend of the proportion by number and by weight are very similar, although that by number peaked in 1980/81 and that by weight in 1982/83 (Fig. 2,6). During the latter season, yellowfin tuna were of greater importance by weight than by number. As with the Kenya catch, there is a suggestion of a decrease of importance of yellowfin tuna after 1982/83.

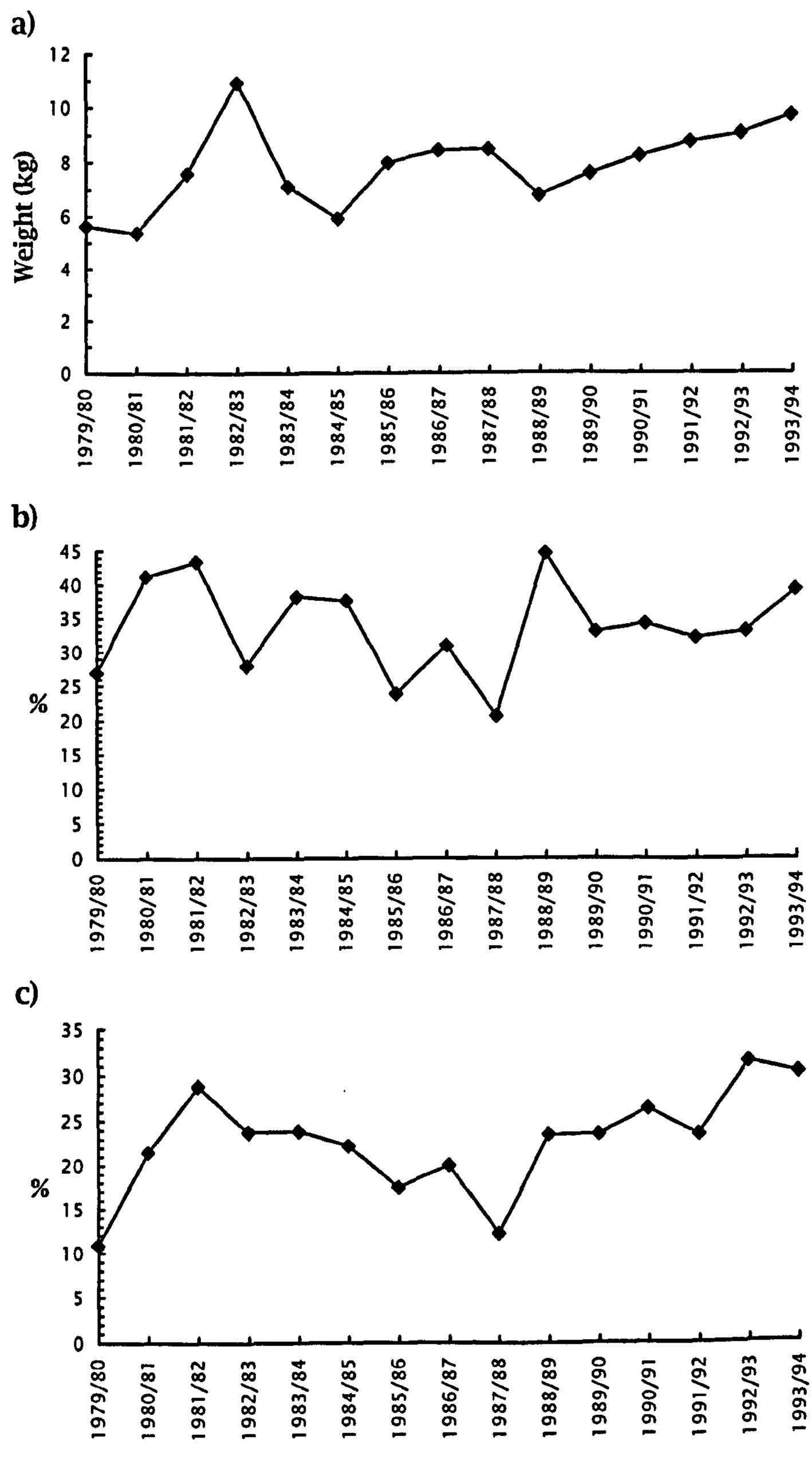

Figure 2,4. The Kenyan sport fishery catch for yellowfin tuna, 1979/80-1993/94 illustrating:

a) The average weight of yellowfin tuna recorded by the fishery;
b) The proportion of the entire sport fishery for all species that is comprised of yellowfin tuna by numbers;
c) The proportion, by weight of the sport fishery catch for all species that is made up of yellowfin tuna.

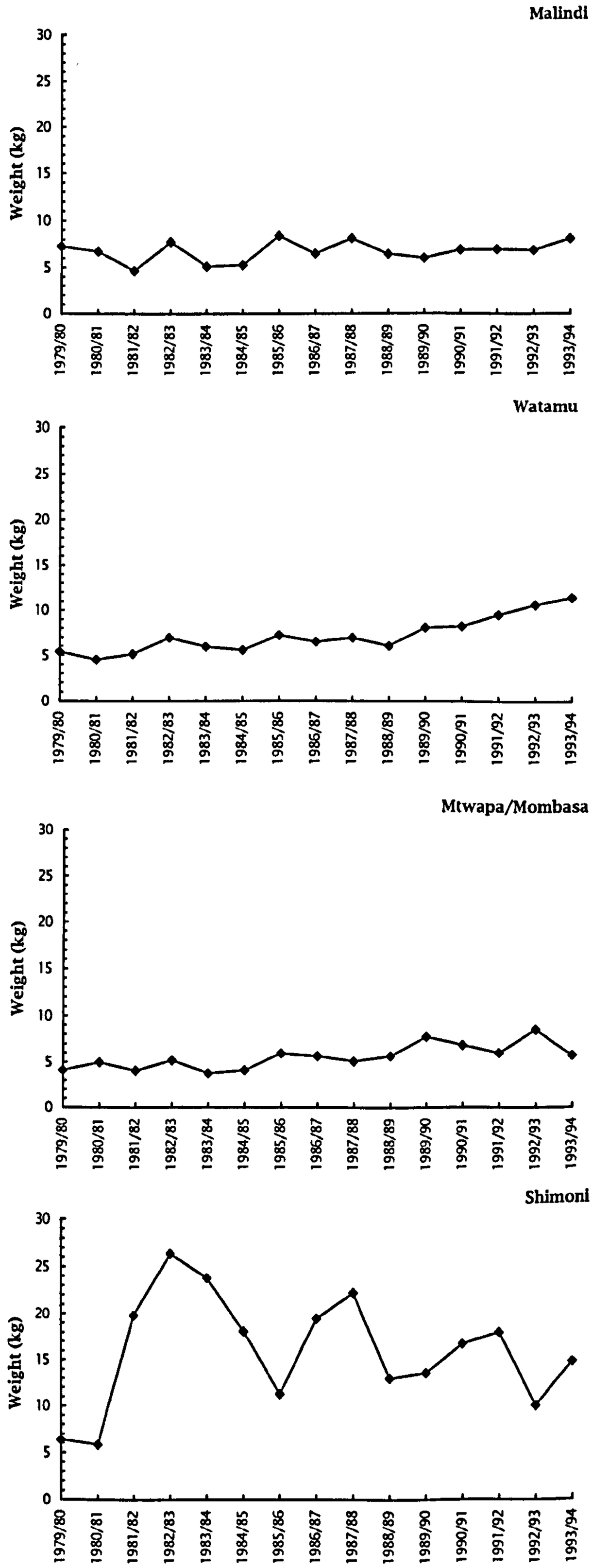

Figure 2,5. The mean weights of sport fishery-caught yellowfin tuna landed at the four major fishing harbours on the Kenya coast, 1979/80-1993/94.

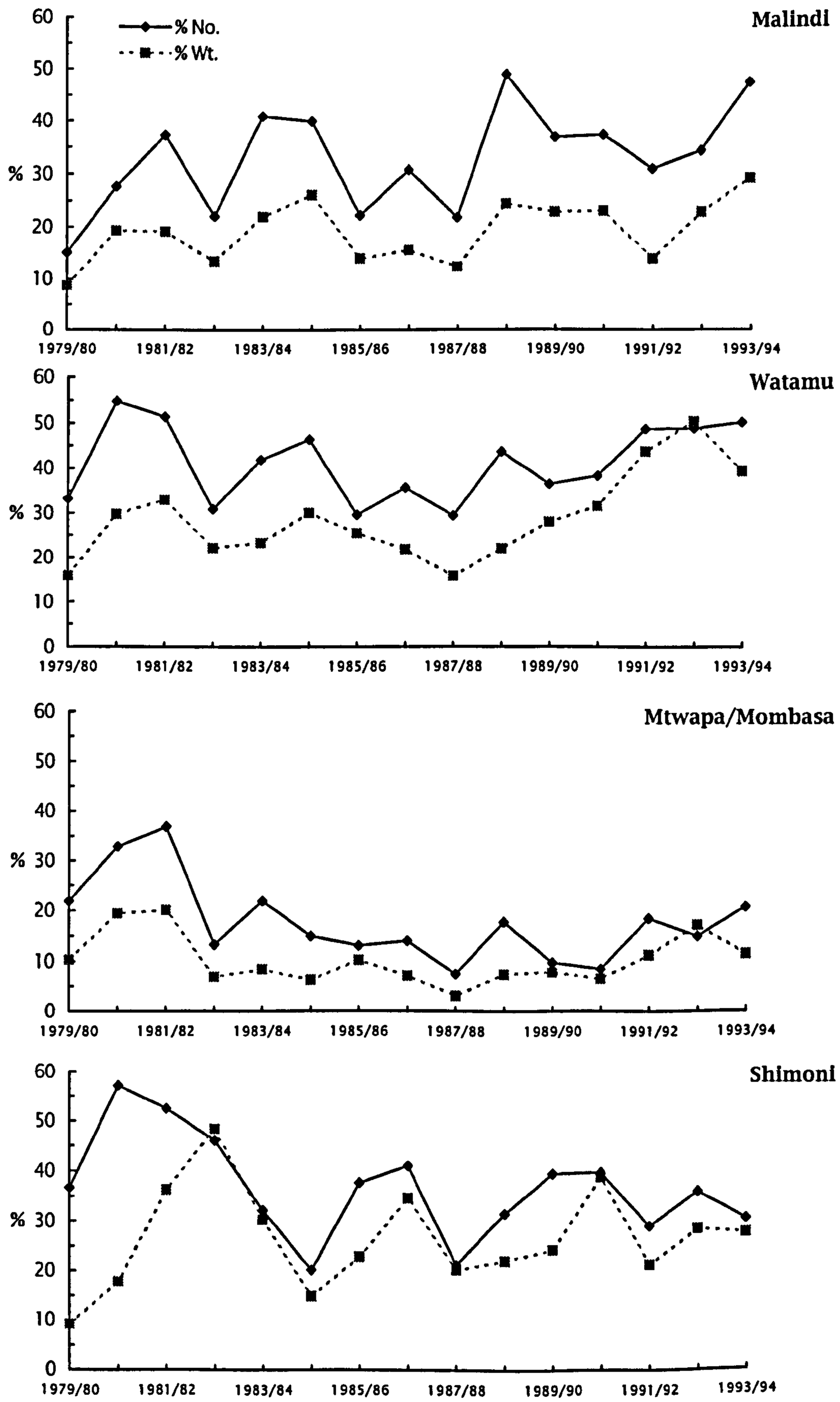

Figure 2,6. The proportion of the total sport fishery catch of all species that is comprised of yellowfin tuna, by weight and by numbers, at the four major fishing locations along the Kenya coast from 1979/80-1993/94.

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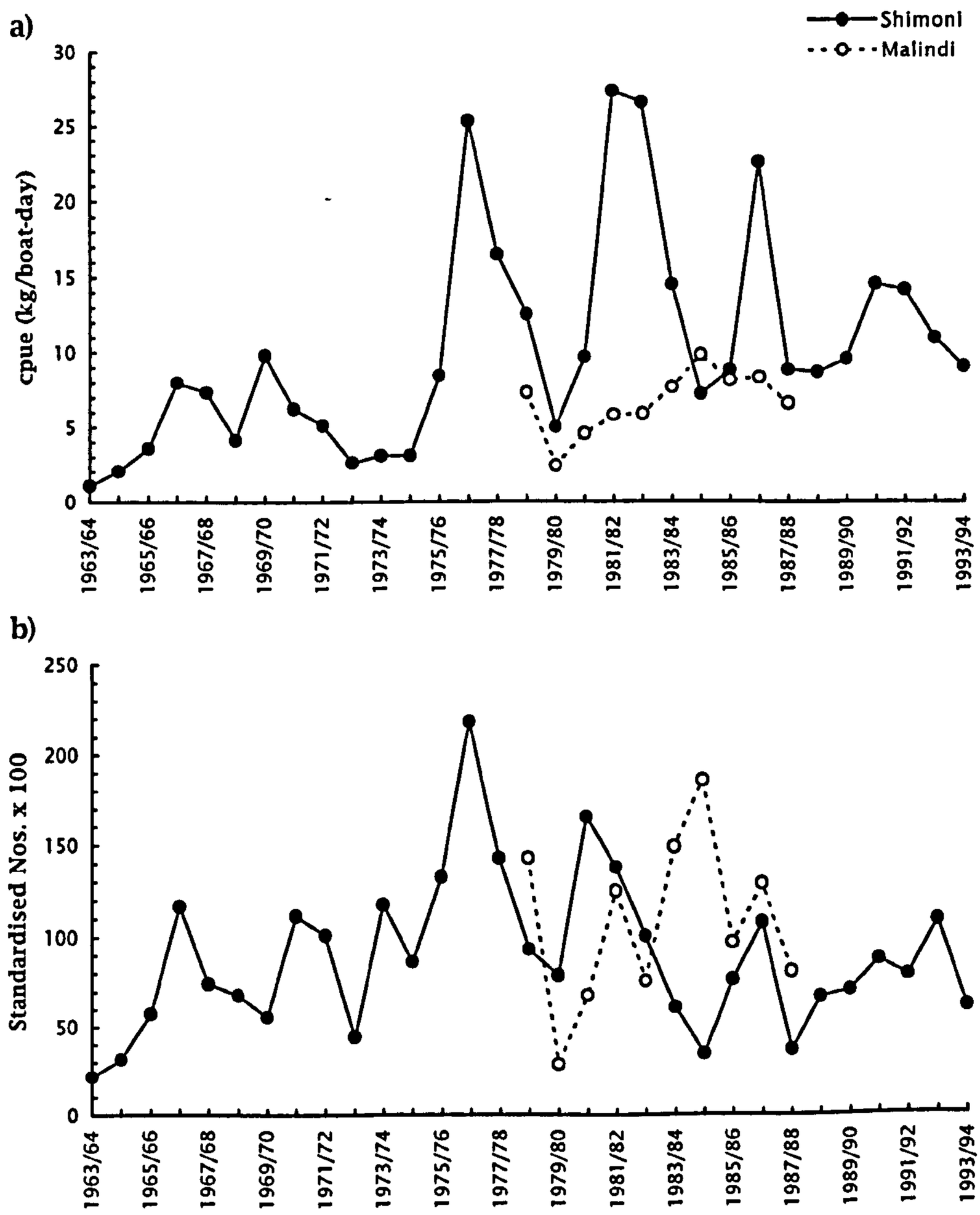


Figure 2,7. The trend of the Shimoni sport fishery catch of yellowfin tuna from 1963/64-1993/94 is shown together with the Malindi catch from 1978/79-1987/88, for:

a) Catch-per-unit effort in kilogrammes per fishing boat-day, and
b) Numbers of yellowfin tuna per fishing boat-day.

2.3 The Shimoni Yellowfin Tuna Catch

ANNUAL CATCH

The catch-per-unit effort (kg/boat-day) and standardized numbers (numbers/ boat-days) are shown for the entire 31 years (Fig. 2,7). Data for Malindi has been included for 1978/79 to 1987/88 as a comparison.

The cpue remained low until 1974/75 apart from two small peaks in 1966/67 to 1967/68 and 1969/70. Over this same period, standard numbers show much larger peaks in 1966/67 and 1970/71 to 1971/72 and again in 1974/75. Pre-1966/67 could be regarded as the early learning curve, as the area and the types of fish that could be caught there were only just being fished seriously for the first time. Until 1970, big yellowfin tuna were caught in close proximity to Pemba Island when two boats were arrested by the Tanzanian Navy. After this, the tuna fishing grounds were believed out of bounds and Pemba was given a wide berth. It was not until August 1976 that schools of large tuna appeared within only a few miles of Shimoni and it was then realized that the big yellowfin tuna were not restricted to Pemba waters. Thereafter boats began to search more determinably the central channel waters for tuna from August to October. 1976/77 was the best season in terms of numbers and one of the three best by weight. Catches then dropped off to 1979/80 both in numbers and weight.

The very low catches in 1979/80 explain the poor catches for the Kenyan catch in Fig. 2,2. The KASAC data began in a trough.

Since 1976/77, with more intensive effort being directed towards the large yellowfin tuna in the SE monsoon, the catches have fluctuated greatly with peaks and troughs (Fig. 2,7). 1981/82 and 1982/83 were the two best tuna years in terms of catch-per-unit effort recorded at Shimoni. There then followed peaks in 1986/87 and 1991/92-1992/93, but these peaks demonstrate a downward trend since 1982/83. These fluxes may be the result of variations in the abundance of yellowfin tuna, and certainly in some cases variation in the vulnerability of the tuna to current fishing methods.

The downward trend of the cpue's since 1982/83 may reflect a decrease in the yellowfin tuna stock biomass in the Western Indian Ocean as a result of the rapid expansion in the commercial fishery since the early 1980's. The mean weight in the stock must have been affected by the increased catch of yellowfin tuna in the commercial fishery and there is a suggestion of a decrease in the mean weight of yellowfin tuna in the annual Shimoni sport fishery data (Fig. 2,5).

The cpue's of yellowfin tuna at Malindi follow the Shimoni trend, but do not vary as much, nor did they peak in 1986/87 (Fig. 2,7a). The Malindi standard numbers

closely match the Shimoni trend, except for 1984/85 (Fig. 2,7b). 1984/85 appears to have been the best season for yellowfin tuna at Malindi, both for cpue and standard numbers, whereas it was a very poor season at Shimoni. Large concentrations of schooling yellowfin tuna have not been seen off Shimoni for many years, but have been observed within the sailfish fishing areas at Malindi close to shore. The mean weight of yellowfin tuna off Malindi in 1984/85 was 5.3 kg and 18.1 kg off Shimoni (Fig. 2,5).

SE monsoon period: The cpue's for the months August to November show an almost identical pattern to that of the entire fishing season, further confirming the importance of this period for yellowfin tuna (Fig. 2,8a). There was a further small peak in 1973/74 not evident in the annual data. The annual data demonstrates a drop in cpue from 1991/92-1993/94 (Fig. 2,7a), but in the SE monsoon the cpue has increased since 1992/3. Data for 1994/95 has been included for the SE monsoon.

The standard numbers reveal a much reduced variation during the first ten seasons (Fig. 2,8b). During these earlier years there may have been a greater abundance of small school yellowfin tuna during the NE monsoon. This is borne out by observations made by my father who remembers seeing on occasions vast acreages of small tuna during the 1960's. Such numbers have not been observed since.

As with the annual data a downward trend is suggested by both cpue's and standardized numbers (Fig. 2,8). The cpue's show a decrease since 1982/83, but the standard numbers downward trend began earlier from 1976/77. By incorporating a five year moving average the oscillations in the plots have been ironed out to reveal the trends in the Shimoni yellowfin tuna sport fishery from 1963/64-1994/95. Up until about 1973/74 the cpue and standard numbers remained fairly stable at between 10-20 kg/boat-day and less than two yellowfin tuna per day fished (Fig. 2,8). There was a rapid increase in cpue in 1976/77 when the Shimoni sport fishermen really began targeting yellowfin tuna in earnest. The cpue's remained fairly stable from 1976/77 until 1984/85 at 30-40 kg/boat-day following which there has been a decrease in cpue despite the fishery still targeting the yellowfin tuna in the SE monsoon. There is a suggestion that the decline might have stabilized in the 1990's. The standard numbers on the other hand demonstrate a decline in the catch since 1978/79, but the fall in numbers may have stabilized since 1985/86.

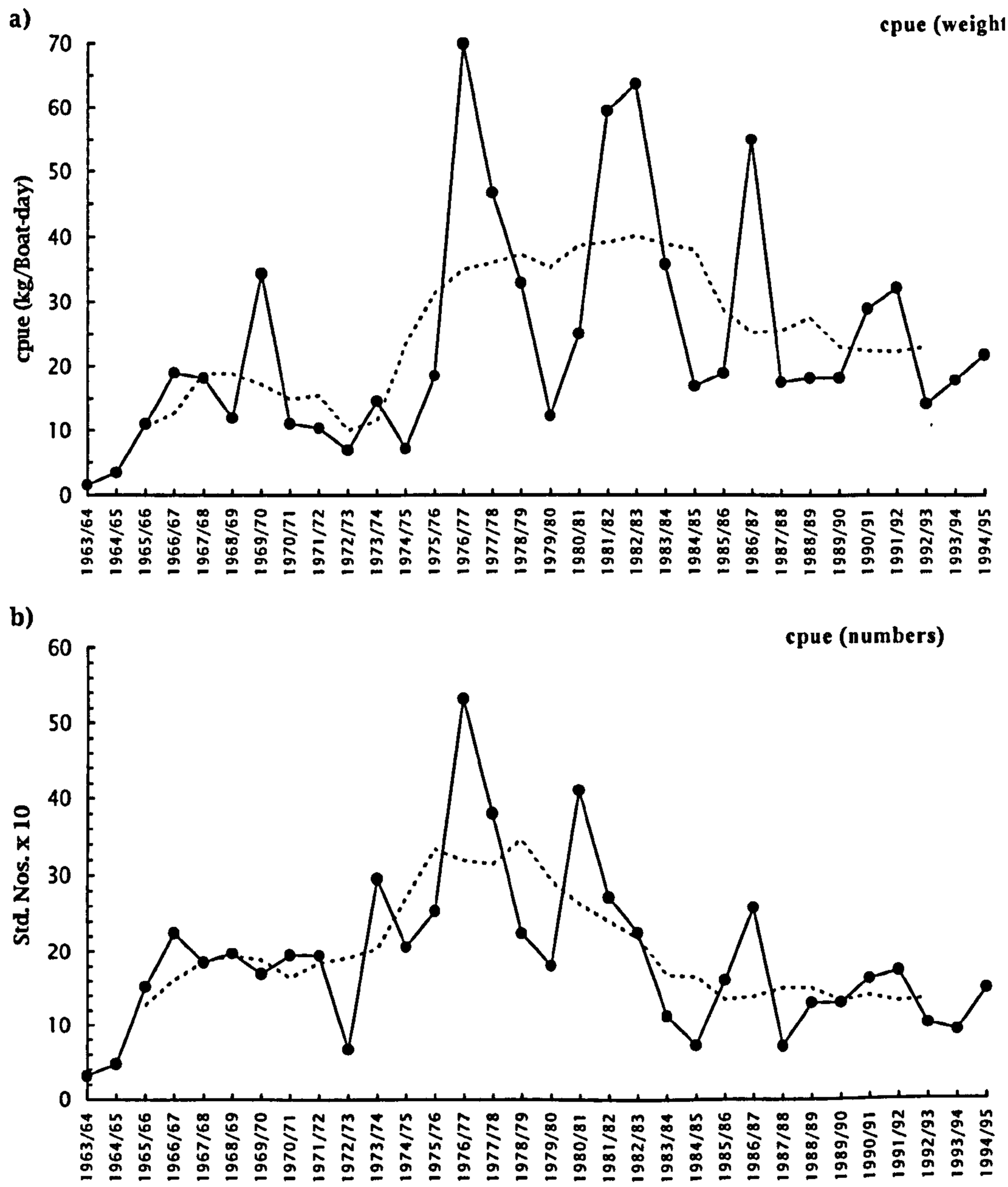


Figure 2,8. Changes in the Shimoni yellowfin tuna catch taken during the SE monsoon months of August through October from 1963/64-1994/95 are illustrated using:

a) Catch-per-unit effort in kilogrammes per fishing boat-day, and
b) Numbers standardized by effort.

For both cpue plots, trends are indicated by 5-point moving averages (dashed lines).

From 1963/64 until 1977/78 only two boats were operating from the PCFC with a third being introduced in 1978 (Fig. 2,9). Since 1978, the effort has steadily increased as a result of the successful marketing of August to October as a prime time for yellowfin tuna. Up until 1978/79 the effort was very steady. In 1991/92 a fourth boat entered the fishery with a fifth in July 1992. Two new boats purchased from the United States will start fishing in August 1995. After March 1992 catch data by month was not available for the PCFC, so that calculations of cpue and standard numbers were made from my own operation, Sea Adventures Ltd. using just two boats. However, accurate effort data for the entire Shimoni fishery was recorded, and this is shown in Fig. 2,9.

The average weights of yellowfin tuna are illustrated together with a five year moving average to demonstrate the trends in the Shimoni sport fishery (Fig. 2,10). Average weights introduce a further difference between commercial fisheries and sport fisheries. The larger the fish, the longer the time required to land that fish, and consequently fewer fish may be caught in a given boat-day. Also, the smaller fish tend to be more voracious feeders, and the larger tuna more wary and suspicious of the boat. The average weight of yellowfin tuna remained fairly stable at 5-10 kg until about 1978/79, after which they increased rapidly, more than doubling by 1983/84. Since 1984/85 the average weight of yellowfin tuna has fallen to approximately 15 kg. The increase in fishing effort in the commercial fishery since 1984/85 would be expected to affect the mean weight of the fish in the stock, and the decrease in mean weight of yellowfin tuna in the Shimoni sport fishery may reflect this.

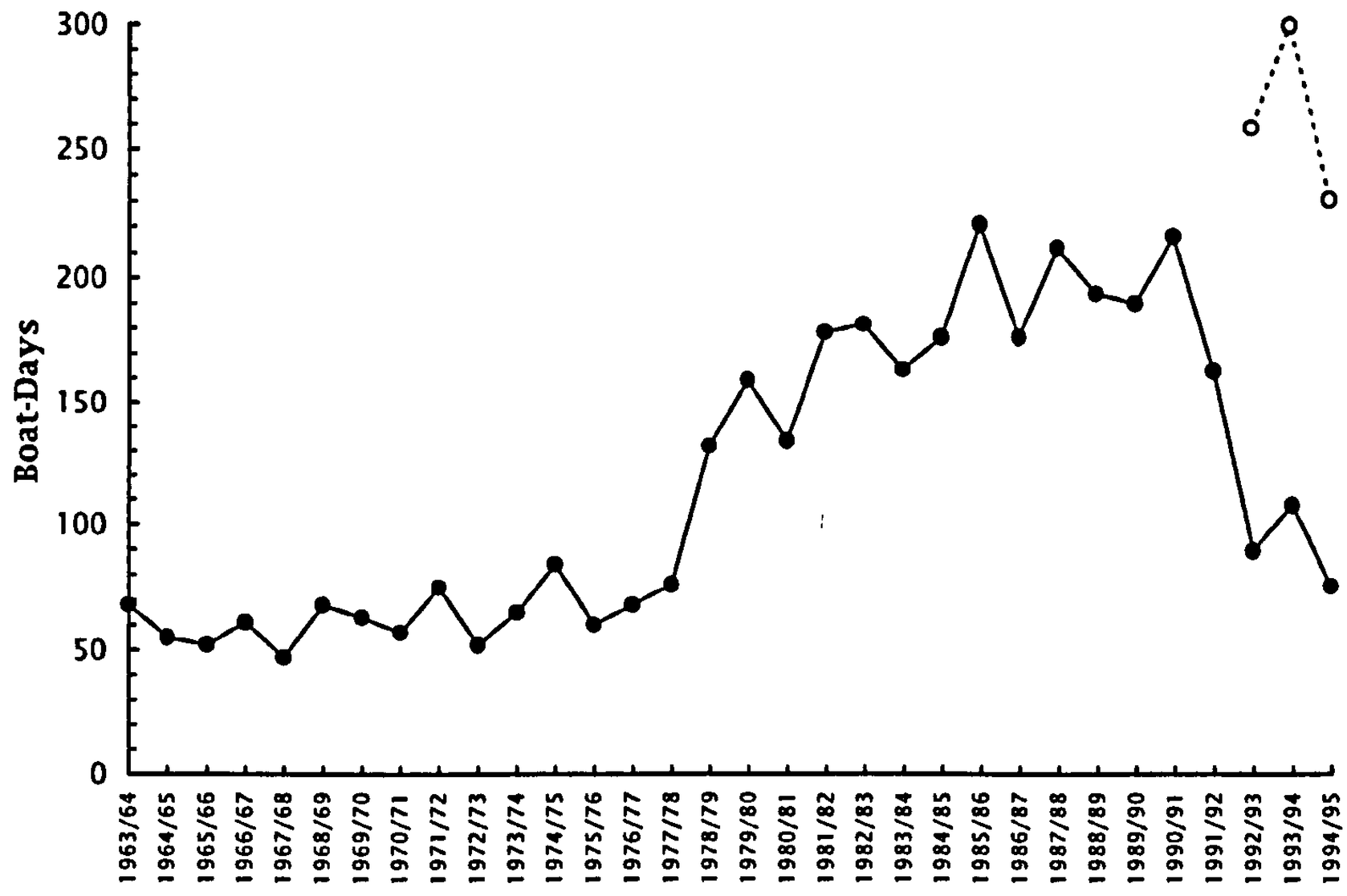


Figure 2,9. The total effort in boat-days during the SE monsoon by the Shimoni sport fishery, from 1963/64-1994/95. From 1992/93 to 1994/95 catch data for the entire Shimoni fleet during the SE monsoon was not available so that for calculations of catch-per unit effort over these years only our own effort data was used as described in the text. Effort data for the entire Shimoni sport fishery fleet from 1992/93-1994/95 is indicated by the broken line.

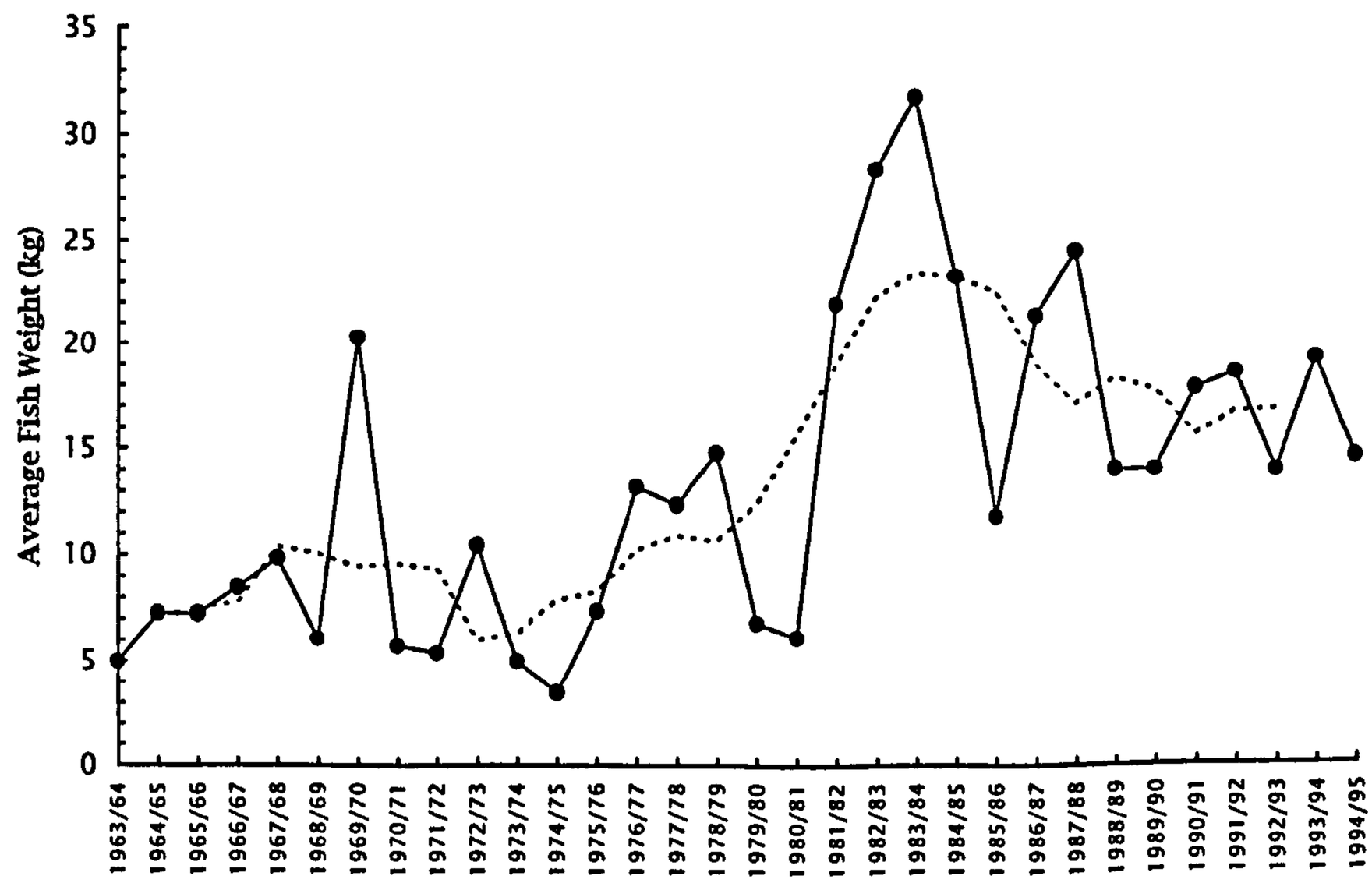


Figure 2,10. The average weight (solid line and circles) of yellowfin tuna landed by the Shimoni sport fishery from 1963/64-1994/95 during the SE monsoon. Broken line shows 5-year moving average to indicate trends more clearly.

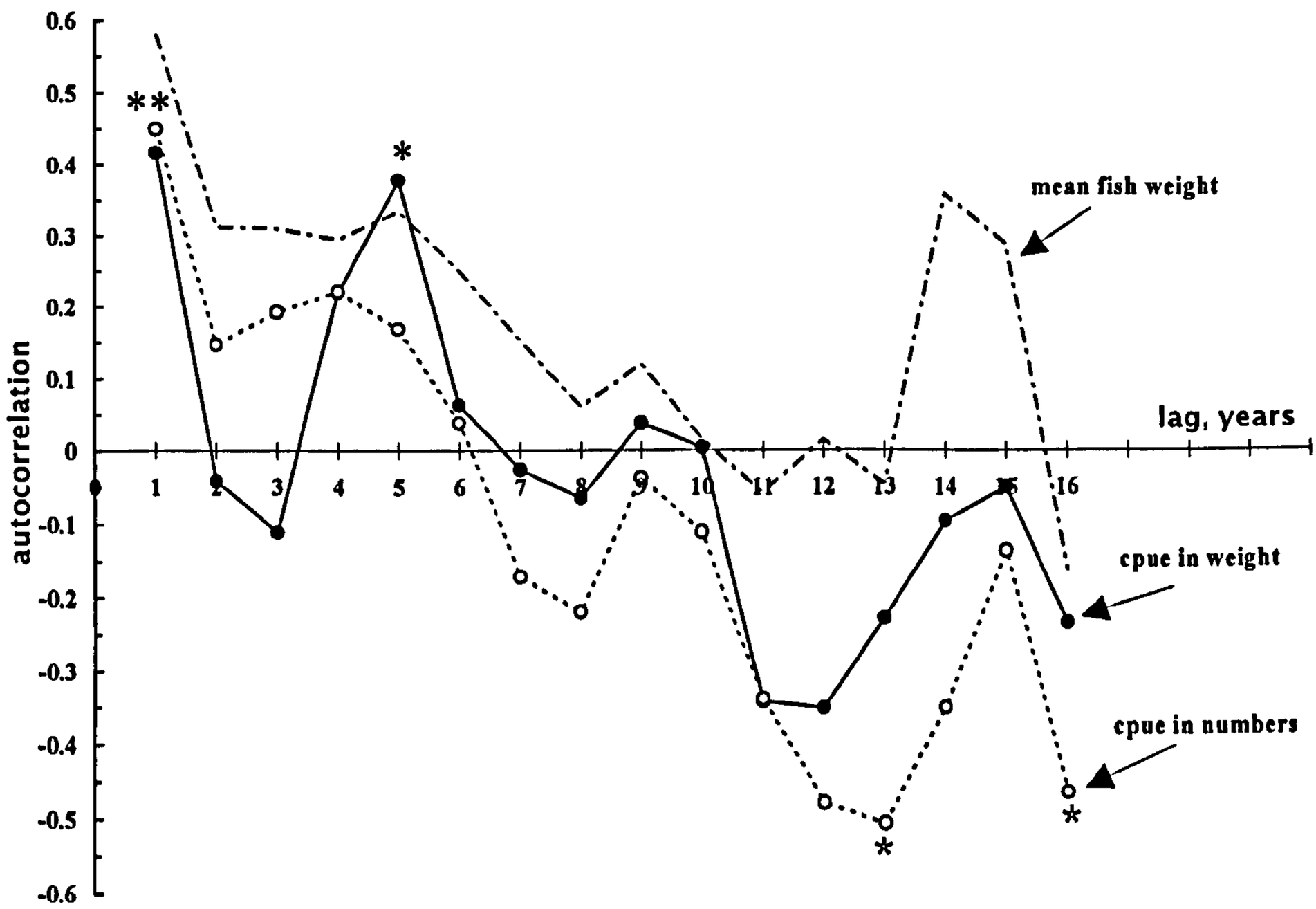


Figure 2,11. Autocorrelations of cpue data for yellowfin tuna caught at Shimoni from 1963/4 to 1994/5. Lag values up to 16 years. Stars indicate significant autocorrelations.

cpue in weight: solid line and circles
cpue in numbers: broken line, open circles
mean weight of fish: dashed line

PERIODICITY ANALYSIS

A time series analysis, using auto-correlations was carried out on the cpue, standard numbers and mean weights of yellowfin tuna in the Shimoni sport fishery over the SE monsoon months (Fig. 2,11). The cpue demonstrate a significant correlation with a five year lag (P=0.05) and the standard numbers at 13 and 16 year lags (P=0.05). All three parameters revealed significant correlations (P=0.01) at a single year time lag. Mean weights showed no other significant time lags.

The five year time lag for cpue would appear to fit the data very neatly starting at the peak of 1976/77 (Fig. 2,8a). Plus five years reveals the peak season of 1981/82, plus a further five years the peak of 1986/87 and then to the peak of 1991/92. It is since 1976/77 that yellowfin tuna have been seriously targeted during the SE monsoon in the Pemba Channel.

CATCH AND EFFORT ANALYSIS

A plot of the catch against effort is shown in Fig. 2,12a. A straight line was drawn through the points which indicates an increase in catch will result from an increase in effort. The plot is clearly in the ascending limb of the catch/effort relationship. A sport fishery is unable to fish a stock anywhere near the Maximum Sustainable Yield (MSY) particularly where the effort is so small.

It is appreciated that a linear regression is not entirely valid in Fig. 2,12 as the two variables are not completely independent of one another.

Relative fishing power was estimated by standardizing the effort data to take into account the increase in fishing efficiency and experience over the 32 years. (1) The season, 1987/88 was chosen as the base level from which new values of effort were calculated for all 32 years (Fig. 2,12b). (2) As the sport fishery for yellowfin tuna really took off in 1976/77, a 5% increase in fishing efficiency was assumed per annum after this date (Fig. 2,12c). Neither of these estimates appear to have any great affect upon the plot of catch against effort.

The cpue's calculated using the new estimates of effort are plotted against fishing season (Fig. 2,13). There is little difference between them except that estimate 2 has depressed the peak of 1976/77. Both estimates still suggest the decline in cpue has taken place since 1976/77.

A Leslie plot of cpue against cumulative catch (Fig. 2,14) and a De Lury plot of cpue versus cumulative effort are also shown using the two estimates of standardized effort. The DeLury and Leslie plots confirm that the sport fishery is in the ascending limb of the catch/effort relationship.

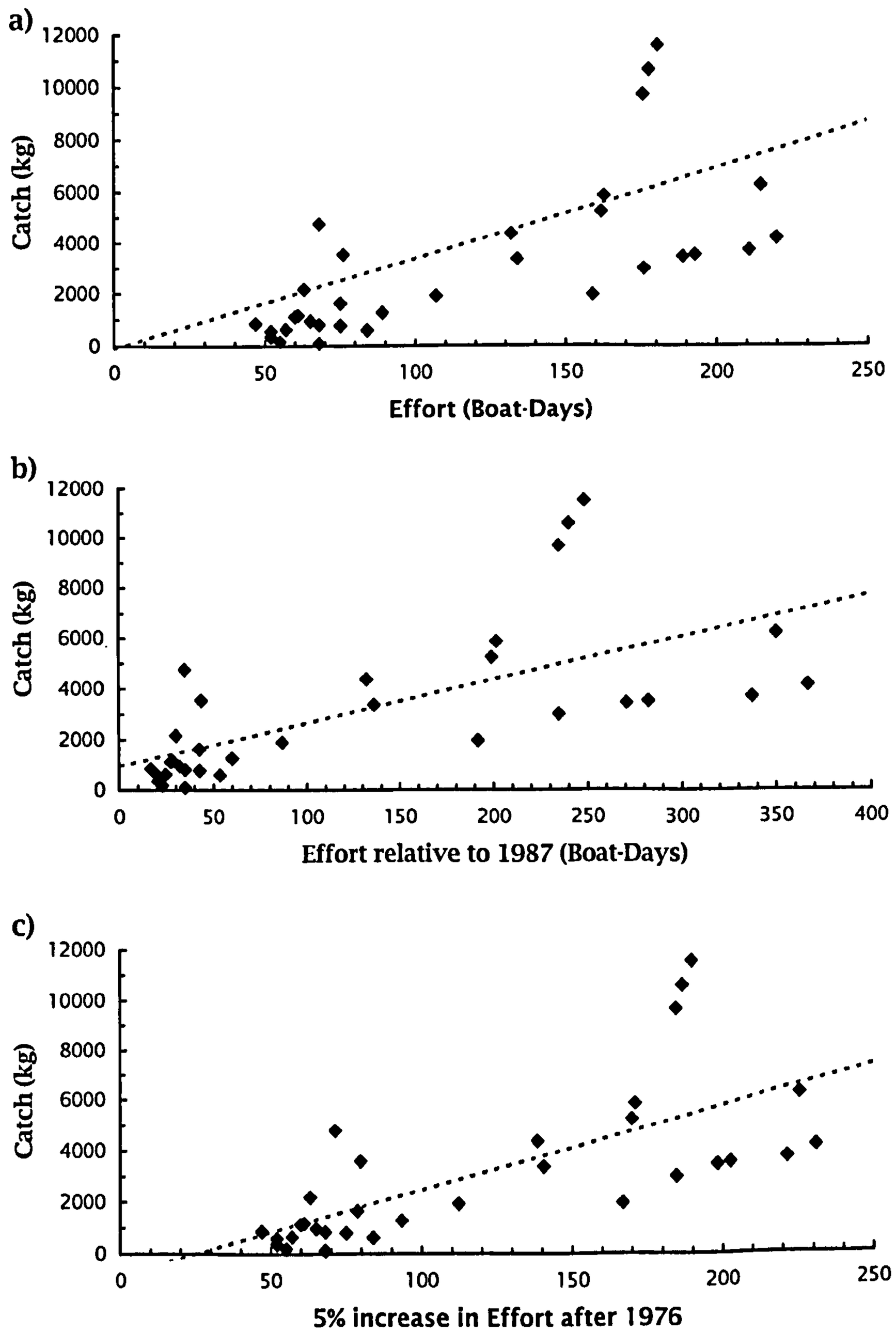


Figure 2,12. The Shimoni sport fishery catch of yellowfin tuna plotted against effort using three estimates of effort. Broken lines show linear regressions through data.

a) Original unmodified effort data
b) Effort data calculated relative to 1987/88;
c) Effort data calculated relative to 1976/77.

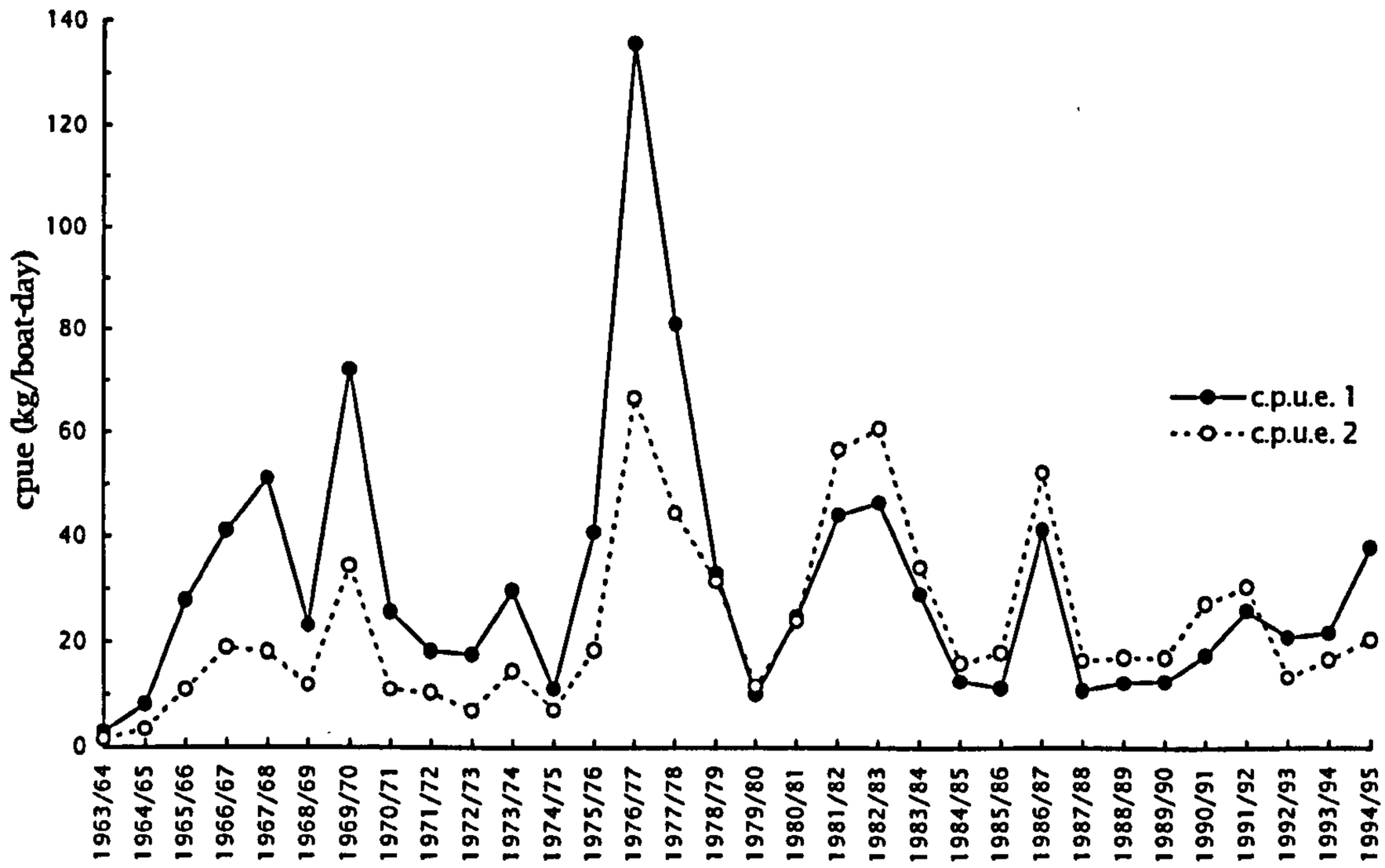


Figure 2,13. The catch-per-unit effort of the SE monsoon Shimoni sport fishery for yellowfin tuna has been adjusted to cater for assumed improvements in fishing techniques, and the introduction of satellite navigation and depth sounders in recent years.

c.p.u.e. 1: Utilizes effort relative to 1987/88, and
c.p.u.e. 2: Allows for a 5% increase in effort after 1976/77.

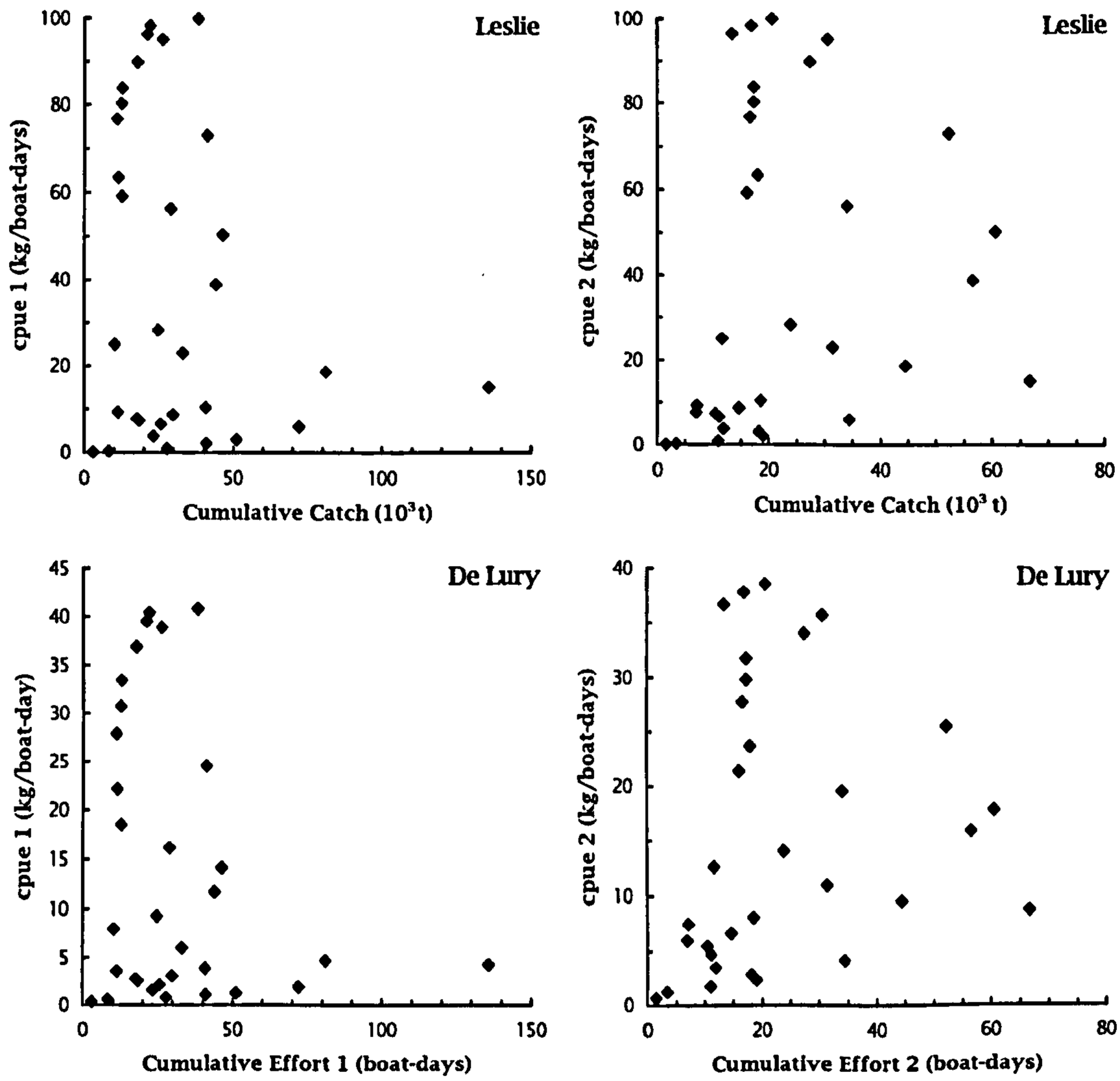


Figure 2,14. Leslie and De Lury plots are shown for the Shimoni yellowfin tuna sport fishery, 1963/64-1994/95. Two estimates of standardized effort were used in an attempt to cater for the increase in experience and relative fishing power over the 32 years. The first, Effort 1 uses 1987/88 as the base year, and Effort 2 assumes a 5% increase per annum after 1976/77 in relative fishing power.

Conclusions to Chapter 2

The catches of yellowfin tuna in the Kenyan sport fishery were analysed using available data from 1979/80-1993/94. As effort data is not available for the Kenyan sport fishery as a whole I was limited to descriptive analysis. Four major locations were used for comparisons, and the trends in the respective fisheries discussed. The catch of yellowfin tuna by the Kenyan sport fishery is rising with an increasing number of boats targeting yellowfin tuna.

The four locations chosen were, from north to south, Malindi, Watamu, Mtwapa/Mombasa and Shimoni. They account for an average of 89.7±5.5% of the total Kenyan yellowfin tuna sport fishery catch. The catch of yellowfin tuna has more than quadrupled at Watamu since 1987/88, and doubled at Malindi since 1990/91. It is considered that the opening up of the North Kenya Banks has greatly contributed to this increase.

A more detailed analysis was carried out on the Shimoni sport fishery, for which accurate catch and effort data is available since 1963/64. The Shimoni sport fishery really began targeting yellowfin tuna during the SE monsoon of 1976. Since 1984/85 there has been a decrease in the catch-per-unit effort, although this decline may have stabilized in recent years. Changes in the Shimoni sport fishery for yellowfin tuna may well reflect the effects of the increase in effort in the commercial fishery in the Western Indian Ocean following the introduction of full scale purse seining in 1984. There has been a decrease in the cpue, standard numbers and mean weight of yellowfin tuna in the Shimoni fishery since 1984/85.

The attempt at assessing the sport fishery with conventional catch/effort methods used for commercial fishery data has been unsuccessful. The sport fishery is on the ascending limb of the catch/effort relationship. The total effort for the Indian Ocean would have to be used to gain an insight in to the status of the yellowfin tuna stock. This is further discussed in Chapter 3.

An interesting periodicity of around 5 years in several measures from the sport fishery data was detected using autocorrelations with a time lag of up to 16 years. This periodicity particularly fits the data since 1976/77 when yellowfin tuna became actively targeted by the sport fishery.

CHAPTER 3

Indian Ocean Yellowfin Tuna Fisheries: History, Status and Assessment

This chapter describes the commercial fisheries for yellowfin tuna in the Indian Ocean; attempts equilibrium and non-equilbrium assessments for the stock and presents an unconventional assessment using data from the Shimoni sport fishery. As most yellowfin tuna in the Western Indian Ocean are believed to pass along the East African coast during the SE monsoon as part of their annual migration (Williams, 1962; Morita & Koto, 1971) the Pemba Channel sport fishery may provide data for alternative and independent assessment.

3.1 The Status of the Major Yellowfin Tuna Fisheries in the Indian Ocean

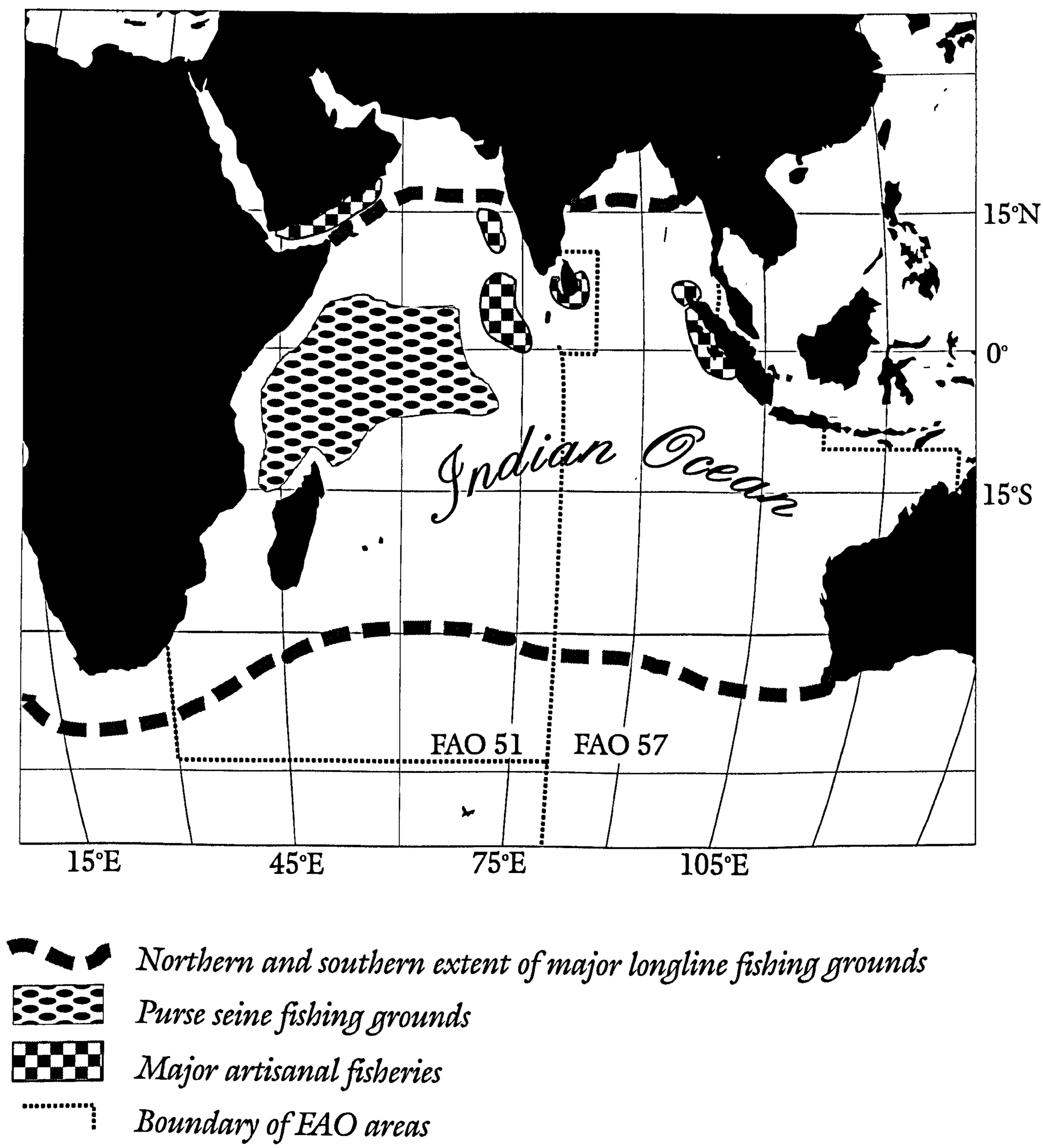
INTRODUCTION

The tuna fishery in the Indian Ocean may be divided into three categories: industrial, artisanal and sport fisheries. The latter is covered in detail in Chapter 2. Although this chapter is concerned with the fisheries in the whole Indian Ocean, it gives special reference to the western half. The Indian Ocean is divided into two FAO zones by the line of 80°E longitude (Fig. 3,1). The area to the west of 80°E and including the waters around Sri Lanka is the Western Indian Ocean (FAO 51) and that to the east, the Eastern Indian Ocean (FAO 57).

The industrial fisheries are made up of two major gear types, longlining and purse seining, with a third type, gill netting, of relatively minor importance. Longlining has been carried out since the early 1950's, but it was not until the early 1980's that purse seining was introduced into the Indian Ocean on a commercial scale. Purse seining has resulted in dramatic increases in the total catch of yellowfin tuna from, particularly, the Western Indian Ocean. This has brought about an urgent need for an up-dated stock assessment of yellowfin tuna and other major tunas. The impact that these increases in catch might have on other fisheries is of considerable concern, particularly to those nations with important artisanal or sport fisheries.

Although it is likely that there exists more than one stock of yellowfin tuna in the Indian Ocean, in the absence of conclusive studies on the stock structure, just a single stock is assumed by the FAO and in this thesis. Based on the distribution of longline hook rates, Morita and Koto (1971) suggested the existence of two

Figure 3.1. Map of the Indian Ocean showing the division into east and west FAO zones and the approximate extent of the principal commercial and artisanal fisheries for yellowfin tuna.



sub-populations, one on either side of the 100°E longitude. However, the geographical distribution of longline catch-per-unit effort does not seem to support the theory of two stocks (Miyabe & Koido, 1985).

I estimate that the sport fisheries in the Indian Ocean catch from 300-1000 tonnes of yellowfin tuna per annum. This is still only 0.2-0.6% of the commercial catch of yellowfin tuna in the Indian Ocean. I reached this estimate by taking the Kenyan sport fishery catch of around 300 tonnes per year as a baseline and then estimating probable catches of yellowfin tuna in those parts of the Indian Ocean where sport fisheries exist; Australia, Maldives, Mauritius, Mozambique, Seychelles, South Africa, Sri Lanka, and Tanzania.

Sport fisheries generally target the same sizes of yellowfin tuna that the commercial fisheries exploit and in some cases a more varied size range. Sport fishermen fish for whatever size of tunas are available at the time, although they are always hoping and trying to catch big fish. On the other hand, longliners with their deep lines catch only large yellowfin tuna, purse seiners work the surface schools of yellowfin tuna, which are usually the smaller size-classes except at those times of the year when the large yellowfin tuna school on the surface (January-February in the Seychelles area), and pole-and-line vessels catch small schooling yellowfin tunas.

THE INDUSTRIAL FISHERIES

Longlining: Longlining began in the Indian Ocean with exploratory fishing by the Japanese in the area to the south of the Lesser Sunda Islands in 1952. There followed a rapid expansion of the fishing grounds into the Bay of Bengal and the Central Indian Ocean by 1954. In 1956, longlining took place along the East African coast, with a further expansion towards the higher latitudes. The Koreans began prospecting in 1957 and by the early 1960's had commenced full commercial operations. The Taiwanese also entered the fishery during the mid-1950's (Miyabe & Koido, 1985), although they did not commence commercial operations in the Indian Ocean until 1963 (Liu & Hsu, 1991).

The shift of Japanese operations towards higher latitudes during the 1960's reflects the change in demand for tunas for an export market to a domestic sashimi market. There has been a tendency for the Japanese vessels to target southern bluefin tuna in the higher latitudes and yellowfin and bigeye tunas in tropical areas.

The Taiwanese initially concentrated more on albacore until 1986, and the Koreans on bigeye and yellowfin tuna. In 1987 yellowfin tuna was the major species in the Taiwanese longline catch followed by bigeye tuna, but in 1988 this order was reversed (Liu & Hsu, 1991).

The total longline catch exhibits a cyclical pattern between 1952 and 1968 with a minor peak occurring four years after a major one and another major peak two years hence (Fig. 3,2a). Longlining catches reached a maximum of 77,100 tonnes in 1968, whereupon they fell to a very low level of 18,900 tonnes in 1976. Apart from 1977, catches have fluctuated between 19,600 and 36,300 tonnes since 1976, and were stable from 1986 to 1988 with a fall in catches in 1989. The longline catches in 1991 were the lowest recorded since longlining began in the early 1950's.

The targeting by longlining nations of specific tuna species has been largely made possible by the introduction of the deep longline. Deep longlines may be classified as those with more than nine branch lines per unit basket, while those with less than seven are defined as regular longlines (Koido, 1985). (Longlines are divided up into sections, called baskets, which are a non-standard unit of convenience used by longliners. The line is coiled in a basket with the baited hooks hung over the edge, and many baskets are usually joined together separated by buoys during fishing. There is a heavy main line that runs from one buoy to the next and the fishing lines are suspended from this.) The more lines per basket, the deeper the effective fishing depth. The deep longlines have been shown to be significantly more effective for bigeye tuna, but there appears to be little difference between the deep and regular lines for catching yellowfin tuna (Koido, 1985). The deep longline was introduced by the Japanese during the early 1970's in the equatorial Pacific and to the Indian Ocean in 1975. In 1982, about 50% of the hooks are estimated to have been of the deep type. The Koreans introduced the deep longline in 1978 and now it is commonly applied throughout the Korean fleet. The underlying criteria in the importance of the deep longline is that bigeye tuna hold a higher commercial value than yellowfin tuna on the world market.

The total effective longline effort has been estimated to take into consideration the multi-species nature of the catch and fishing area. The nominal effort has been standardized by a technique devised by Honma (1974) in which the effort is multiplied by an index of effectiveness. The index of effectiveness is the ratio of average catch-per-unit efforts in each 5° square by month against the annual average catch-per-unit effort for the area, taking into account the apparent changes in the monthly availability of the stock.

The estimated annual effective effort in 10^6 hooks, for the entire longline fishery is shown in Fig. 3,2b (Suzuki, 1988 and Miyabe & Suzuki, 1991). The total effective effort increased steadily from 1952 to 1968. There followed a phase of reduced effort between 1968 and 1973, with the exceptionally low effort in 1973 most likely the result of the high oil prices in the mid-1970's. From 1976 to 1988 the total effective effort shows considerable variation with a peak in effort for

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yellowfin tuna in 1982. The fluxes in this part of the curve are therefore the result of variations in total longline effective effort rather than in actual stock biomass (Fig. 3,2a).

The catch-per-unit effort (number of fish/100 hooks) of longline-caught yellowfin tuna peaked in 1955 at 4.35 yellowfin tuna per 100 hooks and has followed a decreasing trend ever since, apart from a small increase in 1968 (Fig. 3,2c). The catches of 1968 were most likely the result of an exceptionally good year class. In recent years, longline catch-per-unit efforts have stabilized at approximately 0.5 yellowfin tuna per 100 hooks.

Up until the early 1970's the major share of the total longline catch of yellowfin tuna was accounted for by the Japanese. However, in 1972 the Korean catch exceeded that of the Japanese and Korea remained the dominant nation until 1987 in terms of yellowfin tuna catches (Fig. 3,3). The Korean catches peaked in 1978 then declined, and it has been suggested that this was due to a reduction in the number of fishing vessels (Yang & Park, 1988). Korean effort then increased from 81 vessels in 1987 to 112 in 1988, but has since been reduced to only 77 vessels in 1990 (Park et al., 1991). Due to the stagnation of world market prices for tuna, some vessels changed their gear to drift nets for targeting squid. Although the Korean catch picked up briefly in 1982 the catches have decreased since falling to pre-1972 levels in 1991.

The Taiwanese longline catch of yellowfin tuna suddenly increased in 1986, and from 1987 to 1990 Taiwan claimed the major share of the longline-caught yellowfin tuna in the Indian Ocean (Fig. 3,3). This suggests that at least a portion of the Taiwanese fleet might have redirected its effort towards yellowfin and bigeye tunas in recent years. This is confirmed in the National Report of Taiwan (1991) that between 1986 and 1990 the Taiwanese longliners changed over to the deep longline to target yellowfin and bigeye tunas. However, in 1991 both the Korean and the Taiwanese catches fell farther, dropping below that of the Japanese. This decline explains the very low catches recorded for longlining in 1991 (Fig. 3,2a).

Purse seining: Commercial purse seining began in December 1979 in the Western Indian Ocean when a Japanese seiner flying the Mauritian flag began operations. Towards the end of 1980 the French began exploratory fishing in this part of the ocean. At about the same time a Japanese seiner began fishing around Sumatra and in 1983 it moved further west to fish the area between the Seychelles and the Chagos Archipelago.

The French began seining on a commercial scale in November 1982 when four seiners arrived in the Seychelles waters from the Atlantic. The number of seiners based in the Seychelles fluctuated from five to seven from December 1982 to

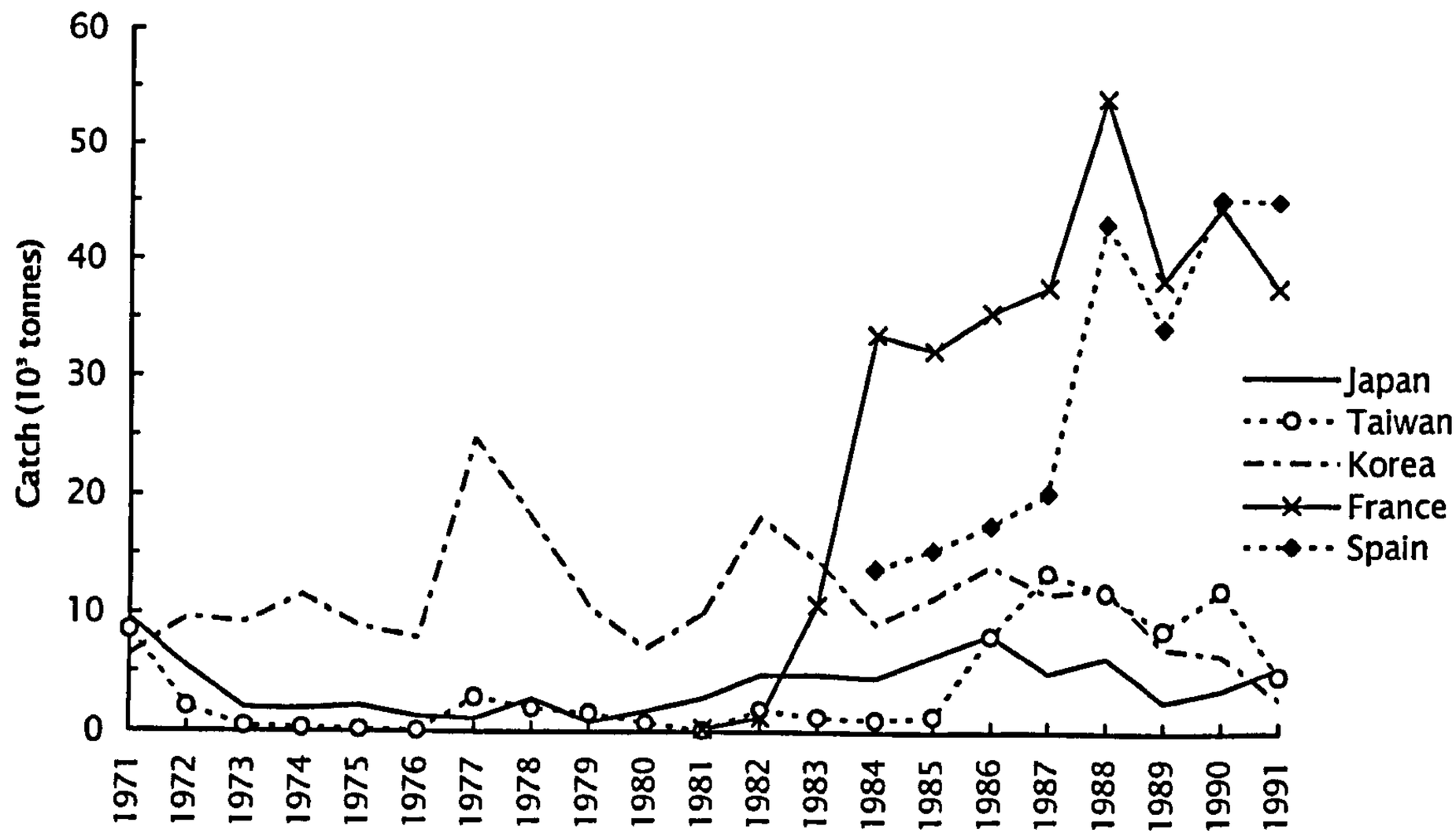

Figure 3,3. The total catch of yellowfin tuna in the Western Indian Ocean by the major industrial nations, 1971-1991.

October 1983 and then towards the end of 1983 the number rose to fifteen. The Spanish began fishing operations in March 1984 (Cort, 1985) and by the end of that year there were 49 seiners in the Western Indian Ocean. From December 1984 to December 1987 the total number of seiners fluctuated between 28 and 49. The total number of seiners dropped to 38 in 1986 largely as a result of poor fishing experienced in previous years during the rough weather of the SE monsoon (May to August). However, during that year new fishing grounds were found in the Mozambique Channel and to the south and north west of the Seychelles. The number of seiners increased to a maximum of 52 vessels in 1989 (Lablache, 1991). Mauritius acquired a second seiner which began operations in April 1987.

The purse seiners operating in the Western Indian Ocean came from the Atlantic, where very low catch rates of yellowfin tuna were experienced in 1983 and 1984 (Fonteneau, 1988). This exodus of vessels from the Atlantic resulted in a considerable reduction in the total fishing effort in that ocean. The catch rates returned to normal in 1985 and some vessels have returned, emphasizing the point that industrial fishing fleets may be transferred from one ocean to another depending on the fishing conditions prevalent at the time.

The purse seiners operating in the Western Indian Ocean are mostly of French and Spanish nationality with 20 and 23 vessels respectively, in December 1989 (Lablache, 1991). The number of French seiners remained constant, but there was an increase in the Spanish effort in 1988 and 1989. Both these fleets, along with up to four Russian, three Japanese and one Panamanian seiner are based in Victoria, Mahé, the main island of the Seychelles. The seiners from the Ivory Coast, present from January 1984 to March 1986 and a United Kingdom registered vessel present in 1985 and 1986 have since returned to the Atlantic.

The initial fishing activity was concentrated in the area between the Seychelles and the Chagos from 0° to 10°S and towards the end of 1984 the fishing grounds expanded to the north of the Mozambique Channel in May and June, and to the west of Somalia in September and October (Hallier & Marsac, 1985). During July and August 1984 the major catches were to the north of the Seychelles and within the Seychelles EEZ. It has been estimated that the purse seine fishing grounds expanded from 2,669 x 10^3 sq. km in 1983 to 6,340 x 10^3 sq. km in 1985 (Lablache & de Lestang, 1988). The size of the fishing grounds has since stabilized.

Since 1984 the fishing grounds appear to have been limited to the tropical areas to the west of 80°E. The area of 0° to 15°S and 45 to 70°E appears to be fished year round by the seiners with an expansion into the higher latitudes during the second and third quarters, and to the north-west part of the ocean in the last quarter.

The purse seiners have been classified into three categories by the International Commission for the Conservation of Atlantic Tunas (ICCAT):

Category 5: 450 to 800 tonnes, with a freezer capacity of 350 to 500 tonnes;
Category 6: 800 to 1200 tonnes with a freezer capacity of approximately 800 tonnes;
Category 7: More than 1200 tonnes with a freezer capacity of 1,000 to 2,000 tonnes.

Categories 1 to 4 are not relevant to vessels used in the Indian Ocean.

The Spanish fleet is comprised largely of Category 7 vessels with a few of Category 6, and the French fleet a mixture of Categories 5 and 6 (Stéquert & Marsac, 1986). The majority of the Category 5 and 6 seiners are French, and 96% of the Category 7 seiners are Spanish (Lablache, 1991).

The total catch of yellowfin tuna in the Indian Ocean doubled between 1983 and 1988 as a direct result of purse seining in the Western Indian Ocean (Fig. 3,4). The catches of yellowfin tuna in the Eastern Indian Ocean remained relatively stable between 3,292 and 12,941 tonnes from 1971 to 1988 with an increase from 1988 (9,737 tonnes) to 1989 (18,420 tonnes). The catches in the Western Indian Ocean increased from 48,540 tonnes in 1983 to 170,319 tonnes in 1988. However, catches declined to 137,717 tonnes during 1989. The purse seine catches increased to 56,344 tonnes in 1984 from 11,830 tonnes in 1983 and remained between 56,124 tonnes and 58,916 tonnes through 1986 (Fig. 3,5). However in 1987 the total catch of yellowfin tuna was 66,571 tonnes and there then followed a further large increase in 1988 to 106,362 tonnes, with a fall to 79,183 tonnes in 1989. Since then purse seine catches have stabilized at approximately 100,000 tonnes, and the total Indian Ocean catch by all gears at between 163,000-176,000 tonnes.

The purse seine fishery basically exploits two species; yellowfin tuna and skipjack tuna, *Katsuwonus pelamis*. Skipjack tuna are not caught by the longliners and the stock was previously only exploited by the artisanal fisheries and the small number of gill net vessels. Annual catches for the purse seine fishery increased from 11 tonnes per fishing day in 1983 to 18 tonnes per fishing day in 1987 as a result of the increase in importance of skipjack tuna in the catches (Lablache & de Lestang, 1988). In 1988 catch rates reached a record high of 22 tonnes per fishing day, but fell back to 18 tonnes per fishing day in 1989 (Lablache, 1991).

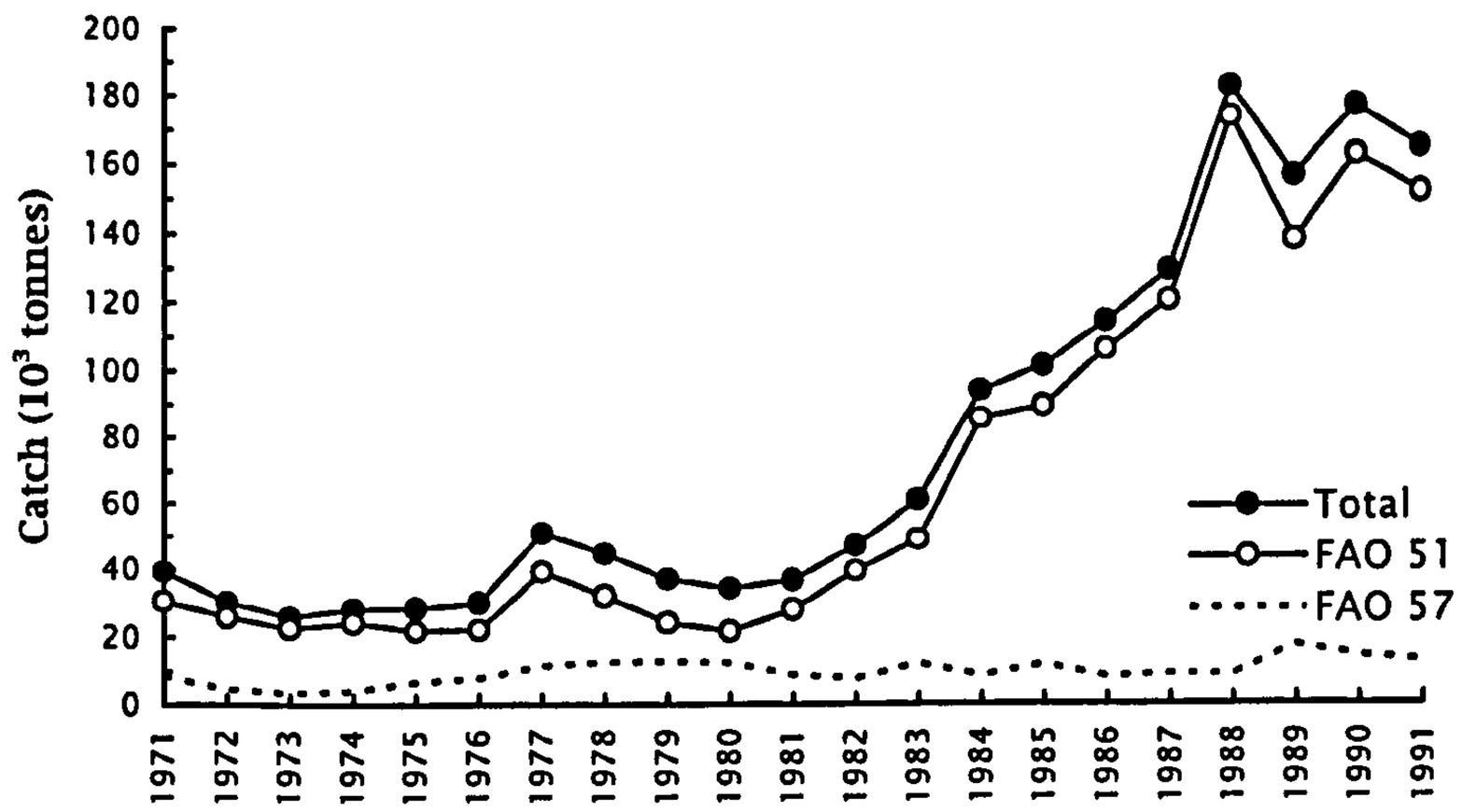

Figure 3,4. The total catch of yellowfin tuna in the Indian Ocean by FAO area, 1971-1991. (For location of FAO areas, see Figure 3,1.)

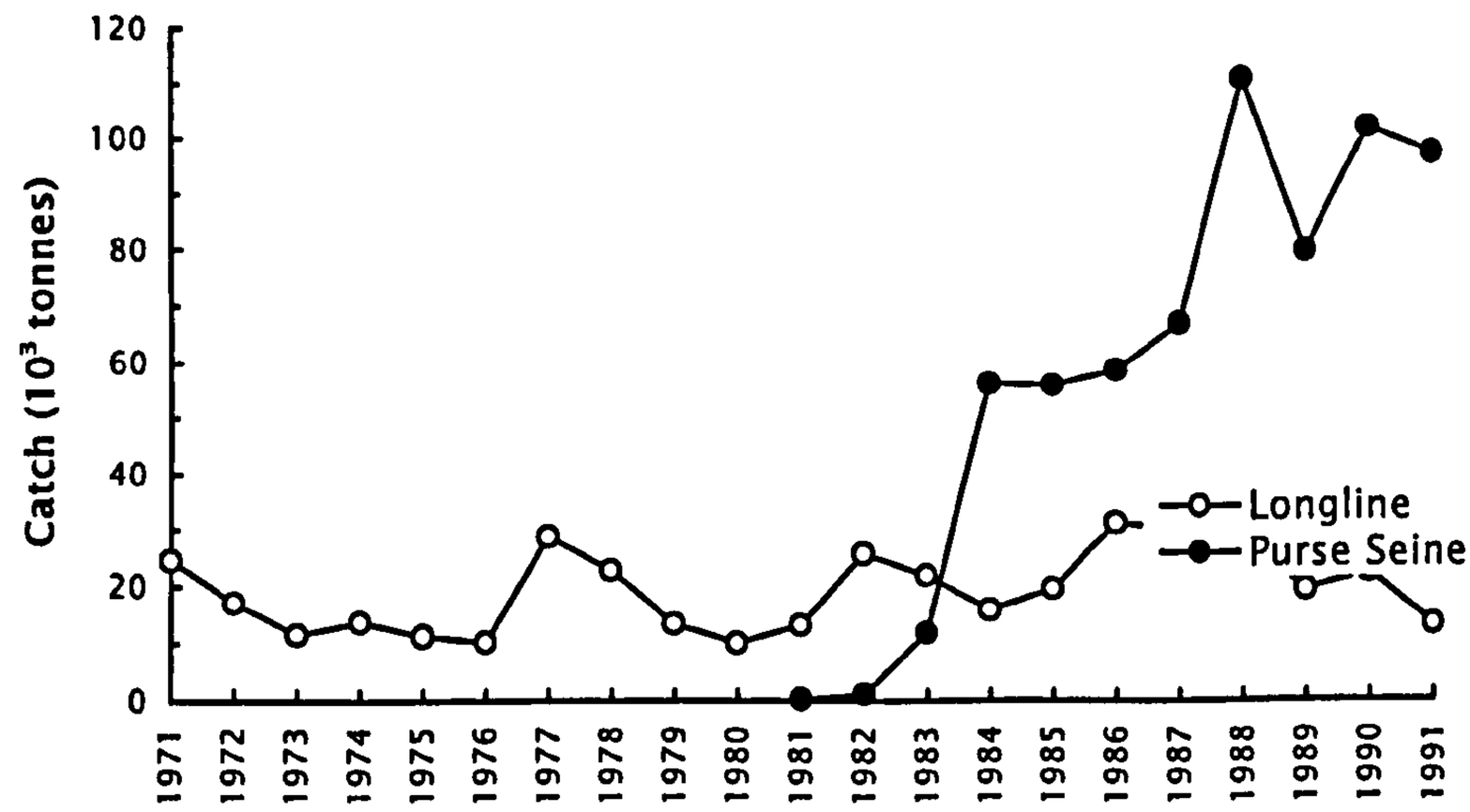

Figure 3,5. The catch of yellowfin tuna in the Western Indian Ocean by gear type, 1971-1991.

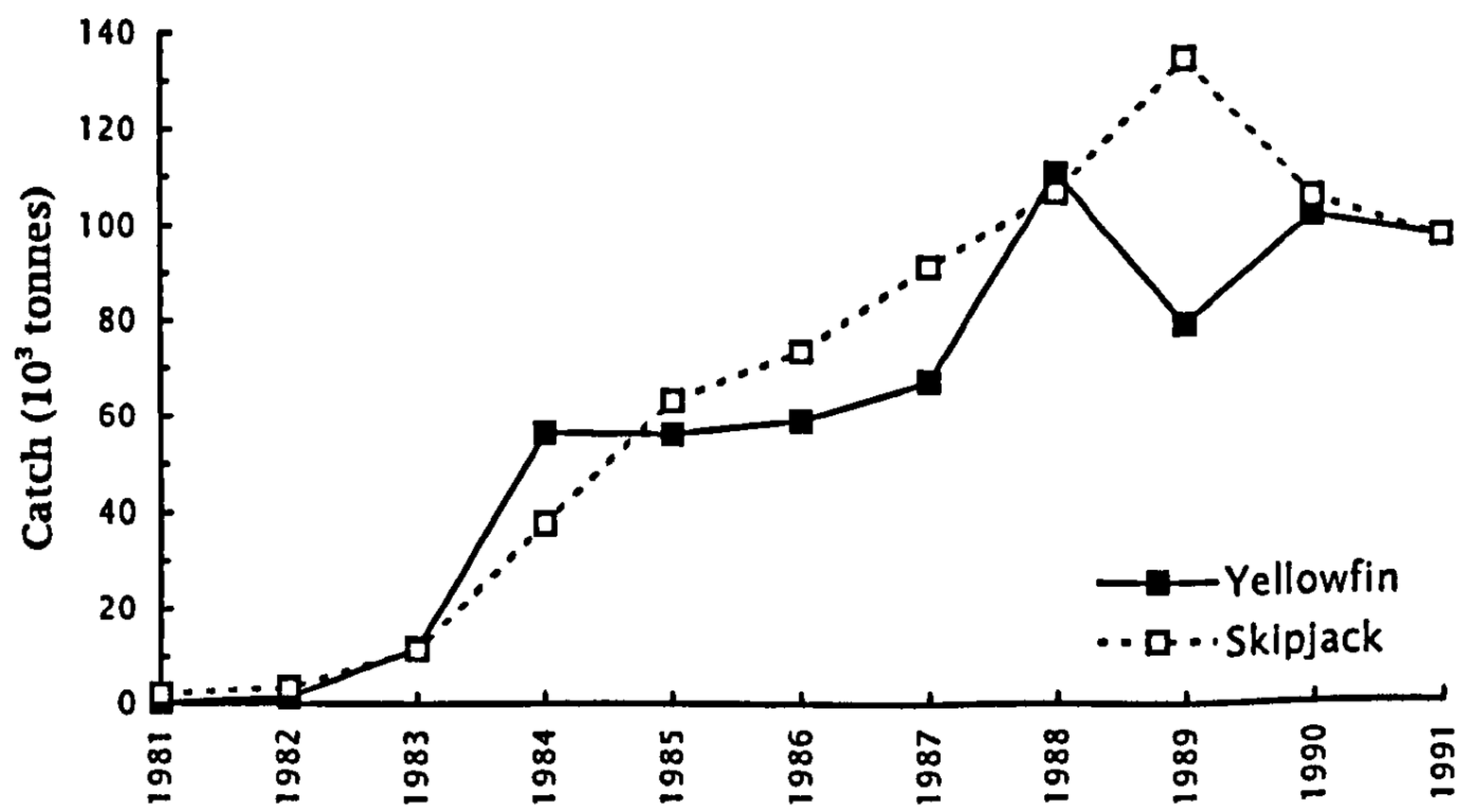

Figure 3,6. The purse seine catch of yellowfin and skipjack tunas in the Western Indian Ocean, 1981-1991.

The catch of skipjack tuna in the Western Indian Ocean showed a constant increase from 1982 to 1989, without the period of stable catches from 1984 to 1986 seen in the yellowfin tuna catches (Fig. 3,6). From 1984 to 1987 the catch of skipjack tuna exceeded that of yellowfin tuna, but both were approximately equal in 1988. Following the bumper harvest of yellowfin tuna in 1988 catches fell off in 1989 only to rally again in 1990. Skipjack tuna catches, on the other hand reached a peak in 1989 of 134,000 tonnes before falling in 1990-1991 to 97,000 tonnes.

The Japanese and the Mauritian vessels catch a larger proportion of skipjack tuna than those of the French largely as a result of a greater use of fish aggregating devices, FAD's, by these fleets (Table 3,1). From 1983 to 1989 skipjack tuna have comprised on average 56.1% of the total purse seine catch from the Western Indian Ocean. There was an increase in the proportion of skipjack tuna in the 1989 catches by the French, Spanish and Panamanian fleets. In 1991 the catch of the Panamanian registered vessels only consisted of 28.3% of skipjack tuna implying a greater emphasis on free swimming schools.

	Proportion of the catch							
Year	*France*	*Japan*	*Mauritius*	*Panama*	*Spain*	*UK*	*USSR*	*Total*
1981	44.7		100					88.2
1982	38.6		96.6					70.9
1983	48.3		50.7					48.6
1984	42.1		62.9	37.5	35.3	11.4		42
1985	48.4	65.8	54.9	47.9	59.4	56		50.8
1986	50.2	65	64.9	57.3	57.6	52.4		53.2
1987	54.5	70.3	65.9	52.4	61.4		56.1	57.3
1988	44.1	78.3	72.8	57	53.5		37.9	49.7
1989	50.6	71.3	67.8	62.8	67.5		44.6	60.2
1990	38.2		64.9	54.4	55.4			49.2
1991	53.7		63.3	28.3	42.6			47.2

Table 3,1. The proportion of skipjack tuna within purse seine catches, by country in the Western Indian Ocean 1981-1991.

The proportion of catches made on debris-associated schools showed an increase in 1985 from 42% in 1984 to 61% in 1985, but stabilized at approximately 56% for the Franco-Ivorian fleet during 1986 and 1987 (Lablache & de Lestang, 1988). As skipjack tuna is the dominant species taken around flotsam this may explain to some extent the stable yellowfin tuna catches from 1984 to 1986.

Prior to 1985, purse seine fishing activity was dependent on the oceanographic conditions prevailing at the time. Best catches were from January to April and September to December. These periods coincide with the NE monsoon period of December to March and the inter-monsoonal periods of September to November and April when weather conditions are usually good. Catch rates fall off drastically with the onset of the SE monsoon. As a result of this decrease in catch rate, ten vessels left for the Atlantic at the end of April 1985 (Lablache & de Lestang, 1985). However, during the SE monsoon period of 1985, the fleet moved into the Mozambique Channel where excellent catches of skipjack tuna were obtained. This pattern has persisted and for the months of May to July the vessels fish in the Mozambique Channel and trans-ship their catch from Antsirane, Madagascar.

The purse seining effort peaked at 10,037 fishing days in 1985 and showed a slight decreasing trend through 1986 and 1987 (Fig 3,2b). There was a further increase in fishing effort in 1988, and was approximately 12,000 fishing days in 1989 (Lablache, 1991). The number of fishing days are the total number of days spent at sea less the days spent drifting due to breakdown or other work stoppages.

There has also been a visible increase in the efficiency of the purse seiners in recent years (Montaudouin & Lablache, 1991). Apart from the expected improvements in efficiency that comes with increasing experience and knowledge of the fishing grounds and seasons, there have been improvements made in the purse seiner's equipment. The introduction of better sonar and bird radars has enabled the seiners to detect tuna schools from a greater distance (Hallier & Marsac, 1988). The use of larger scoops (5-6 tonnes from 2-3 tonnes), and of more powerful derricks and winches has significantly reduced the set times. The Spanish fleet appears to be the most efficient with both their Category 7 and 6 seiners recording shorter set times than the French Category 6 and 5 vessels (Montaudouin & Lablache, 1991).

The catch-per-unit efforts remained high and stable from 1983 to 1987 (Fig. 3,2c). However, there was a further increase in catch-per-unit effort in 1988 followed by a decline in 1989 to the lowest level since the start of commercial purse seining in the Western Indian Ocean.

Artisanal Fisheries: The major artisanal fisheries for tuna of the Indian Ocean are situated in the Maldives, Sri Lanka and Indonesia. The relevant gear types for these areas are pole-and-line and trolling for the Maldives, and gill netting from Sri Lanka and Indonesia. In 1986 the catches from the Maldives and Sri Lanka accounted for 66% of the total artisanal catch of yellowfin tuna in the Indian Ocean.

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A major problem with all artisanal fisheries is the lack of catch and effort data. Catch figures for the Maldivian, Sri Lankan and Indonesian fisheries are published in the IPTP data summaries, but often the relevant gear type is excluded. The catch and effort figures from 1970 to 1987 for the Maldivian pole-and-line fishery were obtained from Hafiz and Anderson (1988).

The Maldivian pole-and-line vessels, known as *masdhoni* went through a mechanization stage during the mid- to late-1970's (Fig. 3,7). The motorized masdhoni are able to fish further off-shore and are better able to catch up with fast-moving tuna schools.

The catches of yellowfin tuna by the Maldivian pole-and-line vessels peaked in 1973 and then fluctuated between 3,214 tonnes and 4,470 tonnes from 1974 to 1982 despite the increasing number of the more efficient boats. In 1983 there was a large increase in the catch from 3,771 tonnes in 1982 to 5,984 tonnes in 1983. The catches peaked in 1984 at 6,894 tonnes and in 1987 were at 6,531 tonnes. Since 1988 catches have fallen to 5,400 tonnes in 1990, but 1991 yielded the best catches in the history of the fishery at 7,710 tonnes.

The total effort peaked in 1973 and then slumped to a low in 1981 of 97,583 fishing days (Fig. 3,7). The increased efficiency of the mechanized fleet is apparent as the catches remain stable throughout the transitionary period. With the virtual completion of the mechanization, the total effort increased. This increased effort then resulted in a subsequent increase in the catches. The effort appears to have stabilized at approximately 160,000 fishing days. However, it must be emphasized here that the effective effort of the two types of masdhoni cannot be directly compared in terms of just numbers of fishing days, i.e., 160,000 days of mechanized effort must be more efficient than 160,000 days of sail-powered effort.

The total catch-per-unit effort (tonnes/100 days fishing) increased from 1970 to 1981 where it peaked at 5.14 tonnes/100 fishing days (Fig. 3,7). There was a fall in catch-per-unit effort from 1983 to 1986, but there followed an increase in 1987 to just over 4 tonnes/100 fishing days. Since 1978 the total cpue has been determined by the mechanized effort, and although some sailing masdhoni have continued to operate their cpue has fallen since 1979 suggesting that these vessels are operated by less experienced fishermen.

There does not appear to have been any obvious deleterious effect on the Maldivian pole-and-line fishery by the rapidly-expanding purse seine catches. The increase in catches in 1991 may be the result of an increase in effort with more mechanized masdhoni joining the fishery, or the result of an increase in the abundance of yellowfin tuna in that area during 1991.

3.2 Status of the Yellowfin Tuna Stock in the Indian Ocean

Stock assessments of Indian Ocean yellowfin tuna have been carried out by Honma & Suzuki (1972), FAO (1980), Miyabe & Koido (1985) and Miyabe & Suzuki (1991), but using only longline-caught data. That of FAO (1980) estimated the MSY to lie between 39,000 and 58,000 tonnes based on production model analysis. Miyabe & Koido (1985), also using production model analysis, estimated MSY at 44,000 tonnes when m=0 and with an infinite amount of effort. However, the degree of fit to the model was poor and they concluded that the estimated equilibrium curve does not represent a real relationship between catch and effort. They also point out that in view of the very high catches by purse seining in the Western Indian Ocean, stock assessments based on longline data are becoming more and more pointless.

Wang and Tanaka (1987) carried out a multi-cohort analysis on the historical Japanese data from 1952 to 1980 in order to estimate recruitment and fishing mortality. They showed a significant decrease in recruitment level from 22.6 x 10^6 for the 1949-1952 year classes, to a low of 2.9 x 10^6 for the 1974-1977 year classes. This latter recruitment level resulted in an average yellowfin tuna age 3 population of 719 x 10^3 fish, but from 1984 to 1987 the commercial and artisanal fisheries landed 1,226 x 10^3 yellowfin tuna. The result of Wang and Tanaka (1987) further emphasizes the point that longline catch-per-unit efforts are not a reliable index of abundance for yellowfin tuna (Hallier & Marsac, 1988).

THE HISTORICAL LONGLINE DATA, 1952 TO 1988

A plot of catch-per-unit effort (tonnes/1000 hooks) against effort is shown in Fig. 3,8 with the parameters for the equilibrium curve in Table 3,2. The combined catch of the Japanese, Korean and Taiwanese fleets was used with standardized effective effort, in 10^6 hooks (Suzuki, 1988 and Miyabe & Suzuki, 1991).

Although the longline catch-per-unit effort is normally expressed in numbers of fish per 100 hooks, the alternative measure of tonnes per 10^3 hooks has been used here. The catch data are in tonnes of fish, and weight is the most commonly used parameter in other fisheries.

The equilibrium curve is shown in Fig. 3,9. The estimated MSY of 40,348 tonnes is comparable to former estimates (FAO, 1980; Miyabe & Koido, 1985; Miyabe & Suzuki, 1991) and although it may fit the longline data it cannot be regarded as reflecting total yellowfin tuna abundance.

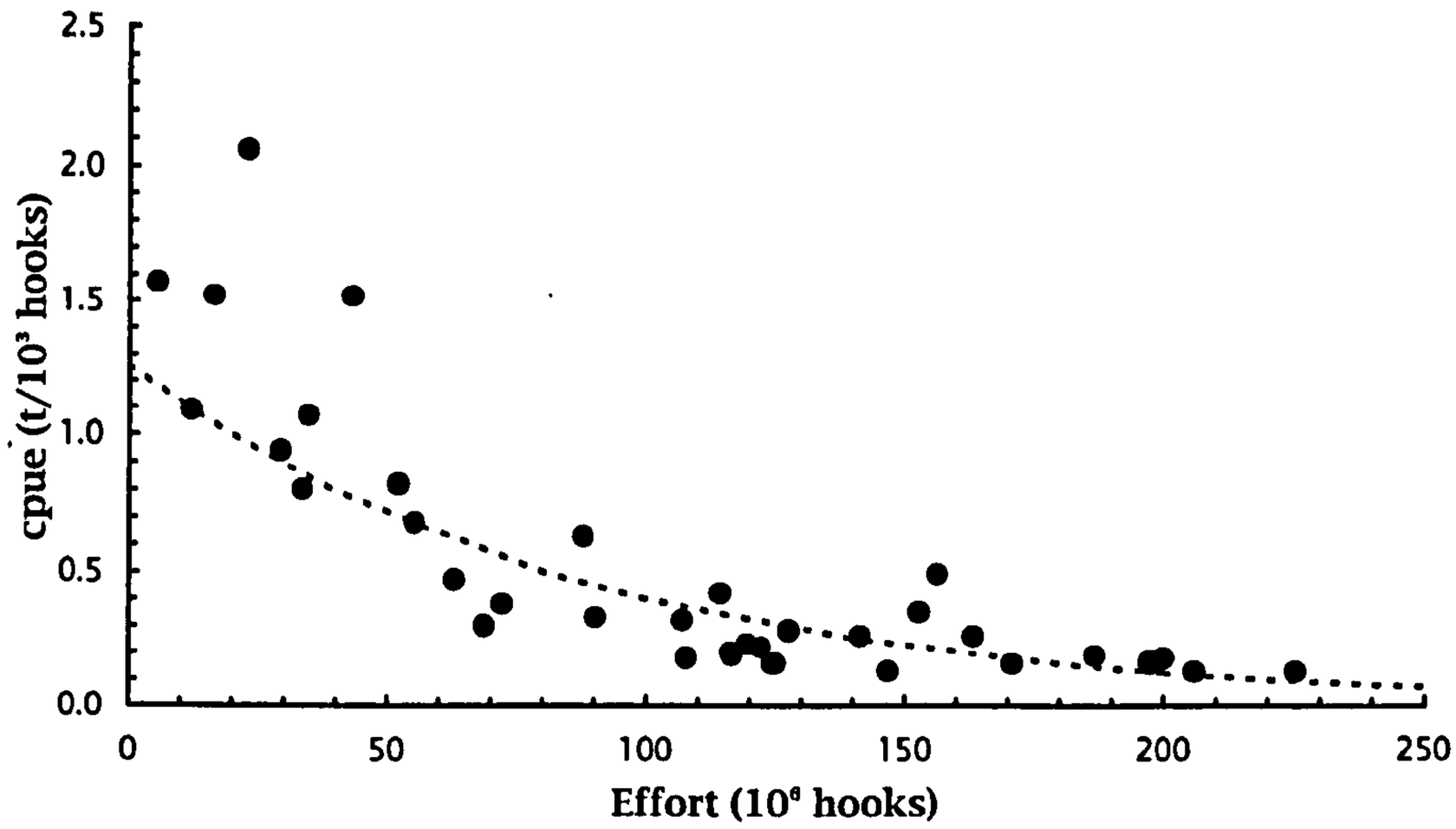

Figure 3,8. The historical longline catch of yellowfin tuna in the Indian Ocean, 1952-1988, as analysed according to Fox's method (Fox, 1975). The equilibrium equation is shown:

$$\text{Ln(cpue)} = 0.228 - 1.145\text{x}10^{-2}\ \text{(effort)}$$

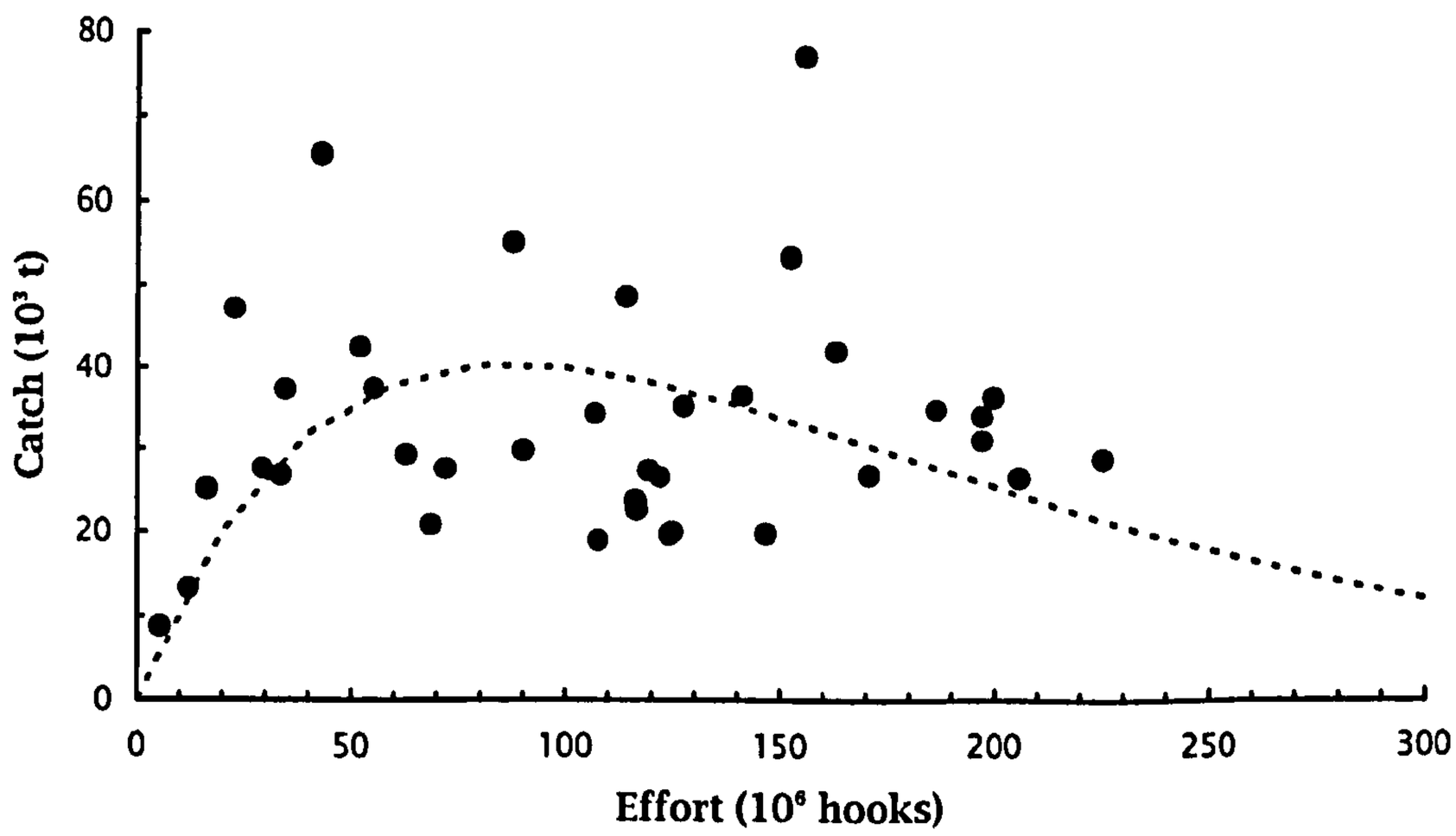

Figure 3,9. The equilibrium curve for the historical longline catch of yellowfin tuna in the Indian Ocean, 1952-1988. Parameters from the Fox Surplus production model are given in Table 3,2.

Parameter	*Value*	*Confidence Limits*	
U_∞	1.26	0.94	1.67
U_{opt}	0.47	0.35	0.61
f_{opt}	87.34	72.83	109.17
Y_{max}	40.36	25.31	67.04
q/k	1.14×10^{-2}	1.37×10^{-2}	0.916×10^{-2}

Table 3,2. Parameters from the analysis of the historical longline catch in the Indian Ocean, 1952-1988, using the Fox Surplus production model with their 95% confidence limits. A standard equilibrium version of the model has been used.

U - Catch-per-unit effort in tonnes/10^3 hooks;
f - Fishing effort in 10^6 hooks;
Y - Catch in 10^3 tonnes
q - Catchability coefficient;
k - a population growth parameter

THE COMBINED FISHERIES

In order to examine the combined longline and purse seine data it was necessary to standardize the effort as the two fisheries utilize different units. Longline effort is in 10^6 hooks and the purse seine effort in numbers of fishing days. Catch and effort data for the Japanese, Korean and Taiwanese longline fleets and of the purse seine fleets was obtained from Suzuki (1988) and Miyabe & Suzuki (1991), bearing in mind that there are some small discrepancies between these data and the catch data from the IPTP data summaries (Table 3,3). Longline catches for 1989 were taken from the IPTP data summary number 11 (FAO, 1991) and it was assumed that the 1989 longline effort was the same as in 1988 rather than the catch-per-unit effort remaining the same. Preliminary estimates for 1989 suggest that the hook rates were the lowest since 1983 (Miyabe & Suzuki, 1991).

The efforts of both fisheries were standardized using Gulland's method as described in Sparre et al. (1989), where a relative cpue is calculated by dividing the cpue for each gear type for each year by the average cpue for that gear type. The sum of the relative cpue's weighted by the yields and divided by the total yield of the combined fishery for each year gives the relative cpue for the combined data. A relative effort was then obtained and this was then normalized by dividing by the mean of the relative efforts.

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The relative cpue was plotted against the cumulative catch (Leslie Plot) for the combined fisheries (Fig. 3,10). The highest cpue's occurred at approximately 100,000 tonnes cumulative catch, which was within a few years of the start of full scale longlining in the Indian Ocean. The cpue's decreased rapidly with increasing catch, but picked up again with cumulative catches of over 11 x 10^5 tonnes. This coincides with the introduction of purse seining in the early 1980's. Despite the increase in catches of yellowfin tuna in the Indian Ocean since the start of industrial purse seining the cpue has never returned to the level of cpue in the early part of the fishery. The de Lury plot of cpue against cumulative effort follows a similar pattern with the highest cpue at low cumulative effort (Fig. 3,11). Although the introduction of purse seining has led to an increase in cpue, it has never returned to the levels of cpue at the start of the fishery.

The equilibrium curve (Fox model) for the combined longline and purse seine data fitted using standard equilibrium methods (Sparre et al. 1989) gives an approximate MSY for the two fisheries of just over 50,000 tonnes, which is still far below current catch levels (Fig. 3,12). The longline data is only from the fleets of Japan, Korea and Taiwan and does not include the catches by minor fleets. The catches by artisanal fisheries and those by the Taiwanese drift netters have also not been included. The latter, although on the increase, catch a very small proportion of yellowfin tuna. The artisanal fisheries are not likely to have any deleterious effect on the stock abundance, but their catches may be dependent upon the total effort of the industrial fishing fleets.

The historical trend of the Indian Ocean yellowfin tuna fishery is also depicted in Fig. 3,12. The longline catch of 1968 was very high and at a similar level to the combined longline and purse seine catches of 1984. The estimated equilibrium curve using the standard production model (Fox, 1975) gives an unrealistic representation of the fishery. Recent developments in the fishery imply that the real value of MSY for the two fisheries must at least lie from 80,000 to 100,000 tonnes. The close proximity of the 1985 to 1987 and 1989 catches suggest that at current levels of effort these catches may represent a long-term sustainable yield of the yellowfin tuna biomass. The exceptionally good catch of 1988 is likely to be either the result of a strong year class, or of an increase in catchability, or a combination of the two (Marsac & Hallier, 1991).

The high catch of 1988 was largely the result of an increase in the catch of yellowfin tuna greater than 30 kg. (Marsac & Hallier, 1991). These larger yellowfin tuna are usually exploited over just a short season (January to February), but during 1988 they remained on the surface for much longer and could be exploited from January to August. This may have been the result of higher than normal sea surface temperatures and a shallower than normal thermocline. Marsac & Hallier (1991) suggest that the high catches of 1988 may have been the

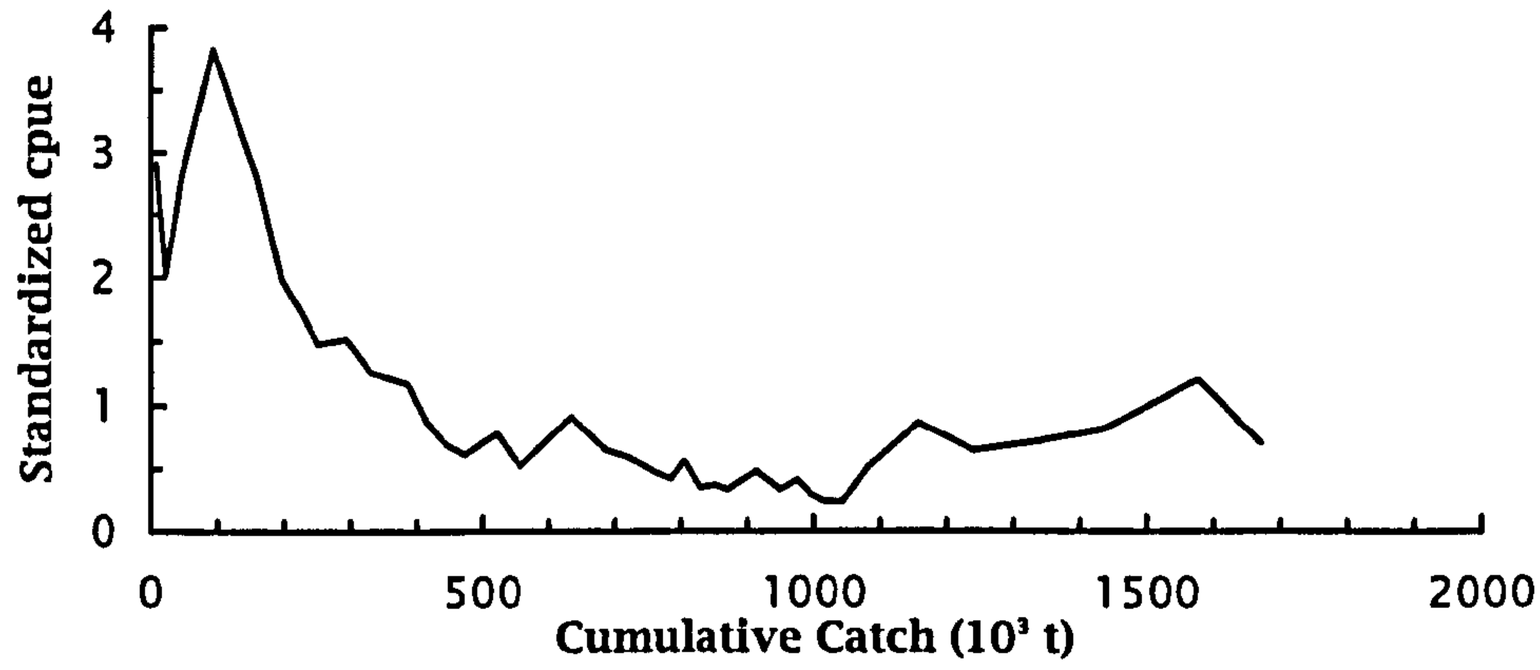

Figure 3,10. Leslie Plot for the combined catch by purse seine and longline in the Indian Ocean of yellowfin tuna, 1952-1989.

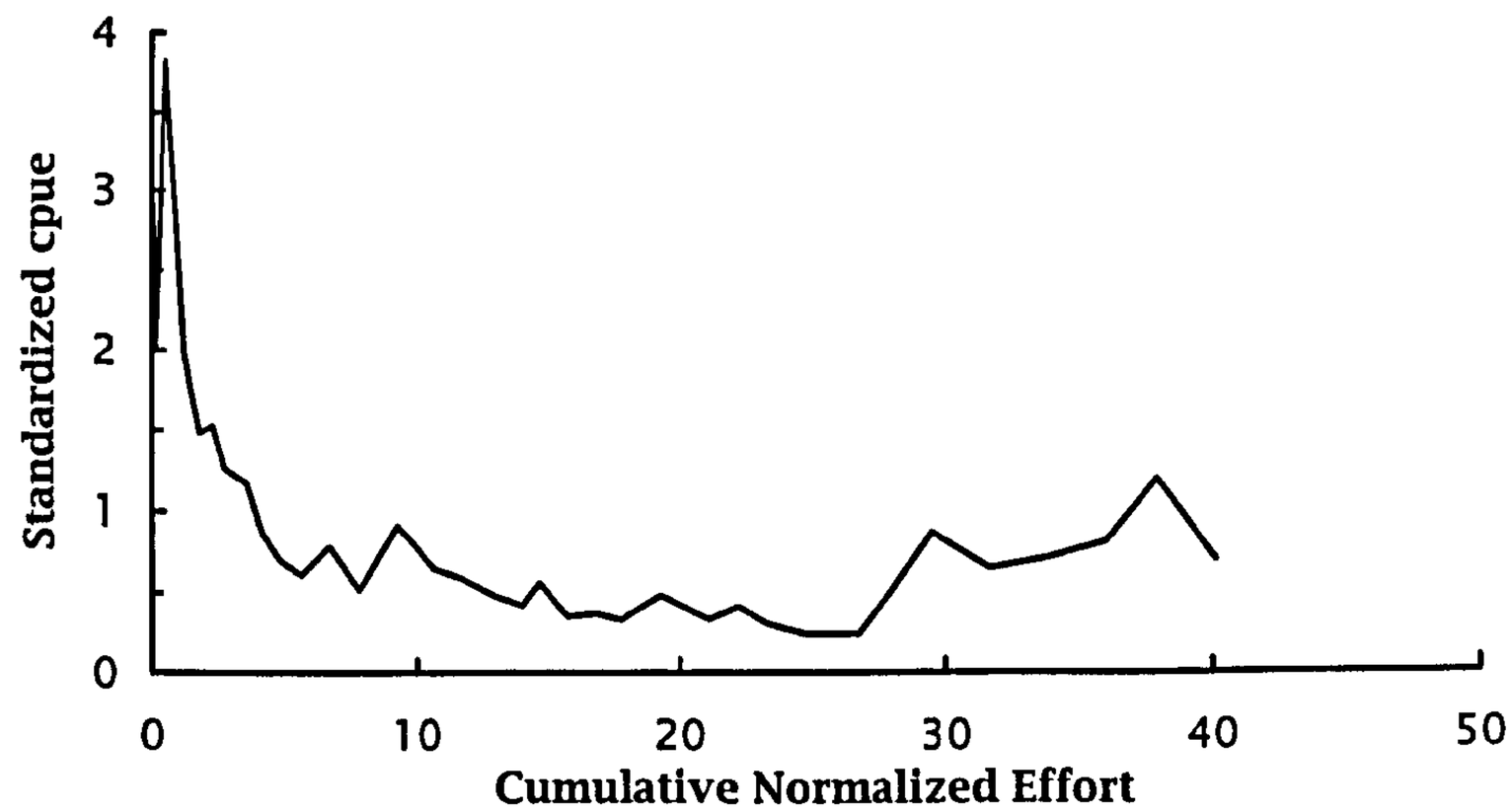

Figure 3,11. De Lury Plot for the combined purse seine and longline catch of yellowfin tuna in the Indian Ocean, 1952-1988. Effort was normalized using the Gulland's method for the two fisheries and a standardized cpue calculated as described in the text (Sparre et al., 1989).

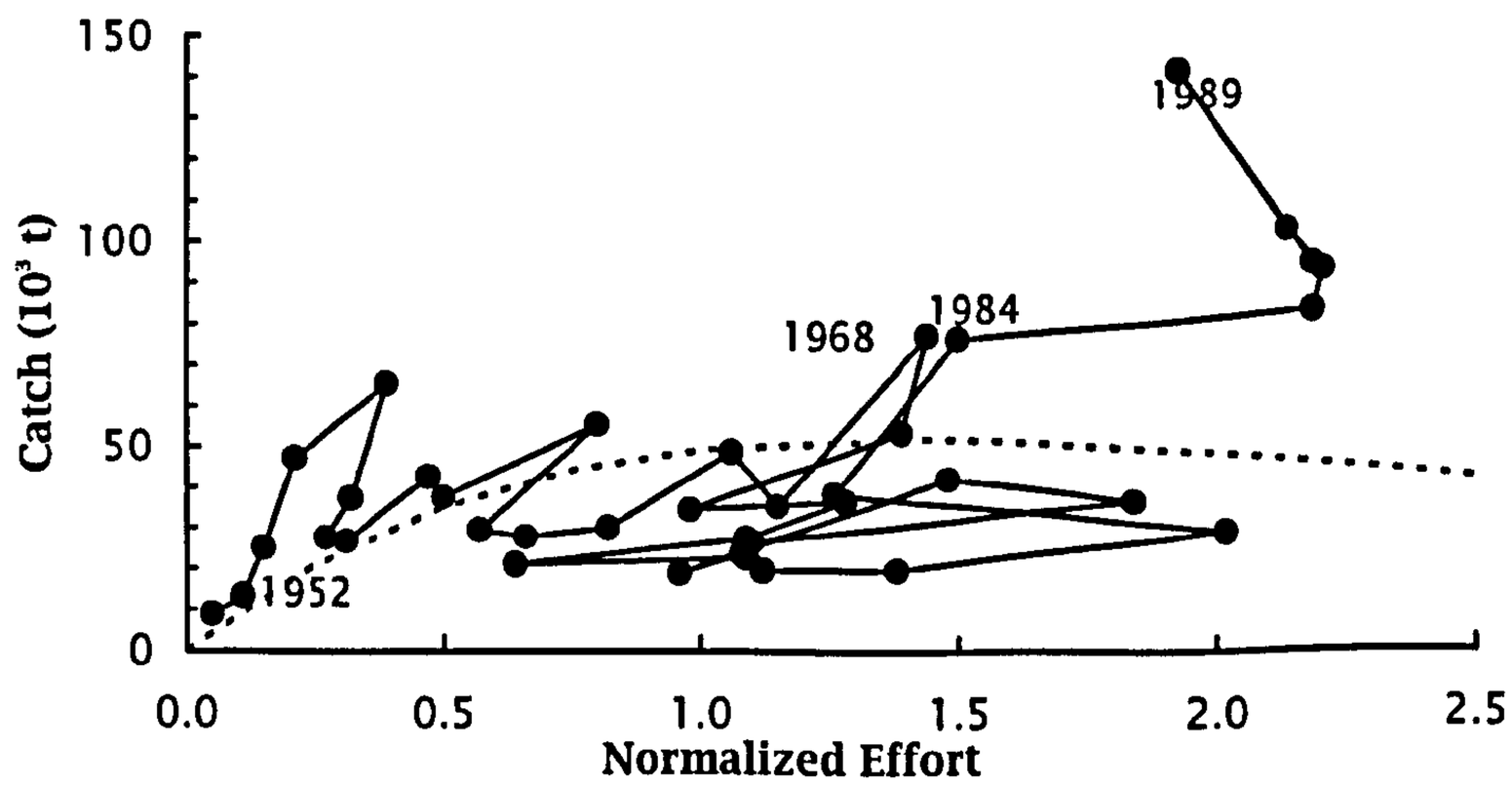

Figure 3,12. The historical trend of the combined longline and purse seine fisheries in the Indian Ocean using a standardized effort, 1952-1989. The longline data was restricted to the fleets of Japan, Korea, and Taiwan. The equilibrium curve (Fox model) is also shown with an estimated Maximum Sustainable Yield of 51,720 tonnes.

result of strong recruitment and increased catchability associated with environmental conditions.

It has been noted that if the floor of the tuna school is well above the designed fishing depth of the net upon initiation of pursing, the catch rates are higher than when the tuna habitat extends below the net (Sharp, 1979). During the 1973 yellowfin tuna study (Sharp, 1978), greatest productivity by purse seining coincided with the emergence of the 15°C isotherm above the lower limit of the net. Water temperatures warmer than 22°C are the preferred habitat of yellowfin tuna, although they do make short excursions into deeper, cooler water (Sharp, 1979). The depth of the 20°C isotherm approximates the bottom of the thermocline (Marsac & Hallier, 1991).

The graphical method of Walter (Walter, 1986) fits a non-equilibrium surplus production model and may be a useful tool to enable us to identify the approximate position of the true sustainable yield curve. Walter plots are shown for three sets of catch and effort data for the period 1978 to 1989 (Fig. 3,13). The first uses the normalized standardized effort of purse seining in fishing days and longline effort in 10^6 hooks (Fig. 3,13a). The second uses catch and effective effort of yellowfin tuna from Marsac & Hallier (1991) with their primary correction of fishing efficiency (Fig. 3,13b), and the third employs Marsac & Hallier's secondary correction assuming an annual 5% increase in purse seining efficiency (Fig. 3,13c). The data is shown in Table 3,4.

All three data sets agree that the 1988 catch was abnormally high and that the equilibrium curve is likely to pass well below this limit. The normalized standardized effort has not been adjusted for fishing efficiency and the 1985 to 1987 and 1989 catch/effort points are in close proximity (Fig. 3,13a). Walter's method suggests that the curve should pass above the 1987 catch level, but below that of 1984. The 1985 catch/effort point lies on the ascending slope of the curve. Using the normalized effort MSY would lie between approximately 110,000 and 130,000 tonnes.

The 1986 to 1989 analysis shows much greater separation using Marsac & Hallier's data (Fig. 3,13b & c). With both their estimates of effort two possible fits have been drawn (Fig. 3,13b & c). One curve passes below the catch levels of 1987 and 1989 yielding an estimated MSY of 110,000-120,000 tonnes, whereas the second passes above these two years resulting in a higher estimate of 140,000-160,000 tonnes.

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Interactions: Up until 1988 there was no indication that the high level of purse seining effort was having any adverse effects on the longline fishery (Miyabe & Suzuki, 1991). The same was true for the Maldivian pole-and-line fishery. However, the very low hook rate (number of fish/100 hooks) observed in the purse seine fishing grounds in 1989 may be the result of fishery interaction. A drop in catches was also observed in the Sri Lankan gill net fishery for 1989 (FAO, 1991).

IMPLICATIONS FOR THE COMMERCIAL FISHERY

The yellowfin tuna fishery of the Indian Ocean has reached a critical point in its development, with the decline in cpue by all gear types suggesting that fishing effort might have overstepped sustainable levels. The question that must be answered is: "Were the 1989 catches the result of overfishing, or some oceanographic changes (Marsac & Hallier, 1991)?" If it is a result of environmentally-related catchability, then the oceanographic changes appear to have reduced the catchability by all gear types and not just purse seining. Although the catches in 1990 showed a recovery no effort data was available.

The results of my study suggest that the true level of MSY lies between extremes of 110,000-160,000 tonnes for the combined longline and purse seine fisheries. From this it may be concluded that MSY has been exceeded and that in the absence of farther data a mean level of 135,000 tonnes is suggested. It is believed that this catch level would represent a sustainable harvest of the yellowfin tuna biomass even during a year of poor recruitment.

To obtain sustainable catches, effort levels should be maintained but further developments in the purse seine fishery avoided. However, Indian Ocean countries are likely to show a willingness to join the fishery in the future. Mauritius already operates two seiners and three more of 510 to 725 tonnes joined them in 1987 (Hallier & Marsac, 1988). As these other countries become involved, the total effort will further increase unless the fleets of distant water nations become reduced. For this a lot will depend upon the governments of the Seychelles and other nations where these fleets are based under fishing license agreements.

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3.4. Periodicity in the Commercial Catch Data

The historical longline catch data reveals cycles of peaks and troughs. By using autocorrelations with time lags of up to 17 years significant autocorrelations were found for lags of one year (p=0.01), and for a time lag of six years (p=0.05) (Fig.3,16). Suhendrata & Bahar (1986) also detected a five year cycle in Japanese longline catches in Indonesian waters, and a similar periodicity (p=0.05) of five years was detected in the sport fishery cpue (in weight) and was noticed in the sport fishery mean weights (see Chapter 2). Some other data appears to have a similar cycle: a periodicity of four years was detected in correlations between the total Kenyan marine fish catch and rainfall recorded at Mombasa, and between catch and river discharge from the Tana River Delta (McClanahan, 1988). A four to five year oscillation in the El Niño Southern Oscillation (ENSO) has also been detected using sea surface temperatures, wind and sea level pressure data from several areas in the Pacific (Rasmusson et al., 1990).

3.5 Conclusions for Chapter 3

The commercial yellowfin tuna fishery in the Indian Ocean was described from the start of longlining by the Japanese in 1952 up until 1989 with special emphasis on the western side of the ocean. A detailed description was also given of the Maldivian pole-and-line fishery.

An analysis was carried out using the historical longline data from 1952 to 1988 giving an MSY of approximately 40,000 tonnes. This compares well with previous estimates.

An analysis was carried out on the combined longline and purse seine data using standardized effort. Using standard surplus yield methods, this gave an MSY of just over 50,000 tonnes. Due to the short time-series of the purse seine data, this assessment is heavily biased by the historical longline data. The equilibrium surplus yield model gives an unrealistic representation of the Indian Ocean yellowfin tuna fishery.

The estimates of MSY from estimates of Z from sport fishery weight-frequency data are more than twice previous ones, but still less than current catch levels. However, an MSY of 113,000 tonnes for the entire Indian Ocean yellowfin tuna catch compares well with the suggestions from Walter's method for just the longline and purse seine fishery.

I estimated MSY to lie between 110-160,000 tonnes using Walter's surplus production method for the combined longline and purse seine fisheries. I suggest

that a catch level of 135,000 tonnes would represent a sustainable harvest of the yellowfin tuna biomass even during a year of poor recruitment. It was demonstrated that it is difficult to conflate data from these two major fisheries even with standardization. Standardizing has the significant disadvantage of introducing noise into the data. Marcille (1985) suggested that the purse seiners may exploit a different part of the stock to the longliners.

The periodicity in the longline and sport fishery data reported here and elsewhere could have serious implications on the fishery if current levels of catch and effort are maintained. There is an urgent need for research to be directed towards studying this aspect and the possible causes.

As most yellowfin tuna in the Western Indian Ocean are believed to pass along the East African coast during the SE monsoon as part of their annual migration (Williams, 1962; Morita & Koto, 1971) the Pemba Channel sport fishery may provide data for alternative and independent assessment. Even a cautious interpretation of these results suggests that current catch levels in the Indian Ocean now exceed MSY by a dangerous margin.

CHAPTER 4

Population Parameters: Age and Growth of Yellowfin Tuna

In this Chapter the ages, growth rates and mortality rates of yellowfin tuna, *Thunnus albacares* sampled in the Pemba Channel, Kenya, by a sport fishery, are estimated using two methods: (1) mixture analysis of annual length-frequency data and by a simple inspection of modes of monthly data and (2) a Principal Components Analysis of morphometric data.

4.1 Introduction

LENGTH-FREQUENCY ANALYSIS

Mixture analysis is used to identify the age class structure of seven samples of sport fishery length frequency data, collected between 1981-1988. Growth rates are calculated and compared with those of other workers. A simple inspection of modes from monthly size-frequency data is also carried out to test the implied growth rates from mixture analysis. Growth rates are discussed in context with observations from practical experience in the Pemba Channel, evidence from gonad maturity studies (see Chapter 5), and food studies (see Chapter 6).

The appearance of modes in a size-frequency distribution of samples of animal populations has for a long time been interpreted as representing age groups. A wide range of methods have been used by biologists to determine the mean size and proportion of the sample within each component distribution, most depending upon some sort of graphical interpretation. The shape of the size-frequency distribution is the result of recruitment, growth, mortality and sampling bias, with the additional effect of the time of recruitment and variation in individual growth rates (Macdonald, 1987).

The most basic techniques rely upon a simple inspection of modes, often referred to as the "Petersen" methods (Petersen, 1891; Tesch, 1968). Pauly & David (1981) and Shepherd (1986) introduced alternative non-parametric techniques in which the modes are fitted according to a von Bertalanffy growth curve. This set of techniques has not been employed here because juvenile tuna growth does not fit this model.

Probability paper and other parametric methods are all based upon plotting the cumulative frequencies from left to right with the number of inflections usually being one more than the number of component age-groups. For many years, these methods were the most frequently used ones for analysing fisheries length-frequency distributions, with those of Cassie (1954) and Bhattacharya (1967), being the best known.

The appearance of modes in a size-frequency histogram will depend upon a combination of the distances between the means, the magnitude of variances, the proportion of the population in each age group, and the overall sample size. Macdonald & Pitcher (1979) have demonstrated polymodality to be unreliable as a guide for revealing age-groups, particularly when the distribution is not obviously polymodal.

Although statistical methods were used as early as 1894 by Pearson to distinguish between two overlapping crab populations, it was not until the advent of modern computers that some departure was made from the graphical methods. Hasselblad (1966) described and developed a computer program using maximum likelihood to distinguish between a number of overlapping distributions. Hasselblad's method failed to displace the graphical techniques, which continued to be the most frequently used for age determination. Macdonald & Pitcher (1979) described a mixture analysis technique that uses a maximum-likelihood estimation for grouped data.

Maximum-likelihood works by matching areas under the fitted distribution to areas under the sample length-frequency histogram. Macdonald & Pitcher (1979) have demonstrated it to be more powerful, and more convenient than the graphical methods. This method formed the basis of the MIX program (Macdonald & Green, 1985) and is used here for annual sport fishery data.

The major shortcoming of the graphical methods is the ambiguous nature of the results. It is quite feasible for two workers to produce quite different results from the same set of data. Hasselblad's method led to some improvement, but when the number of age-groups is large, and older fish with different ages have similar lengths, this method may give rise to many competing solutions. Macdonald & Pitcher (1979) have attempted to overcome this by allowing constraints to be placed on some of the parameters, especially the standard deviations.

Macdonald & Green's (1985) MIX computer program marketed by Icthus Data Systems is an easy one to use, and an efficient technique for decomposing size-frequency data. {*NOTE: Recently it has become possible to implement the* MIX *technique using the Solver optimisation routines in the Microsoft EXCEL 5 spreadsheet, but this thesis was completed before this facility became available.*}

Since Macdonald & Pitcher's 1979 paper, this method has been used to age mountain brook Lamprey, *Ichthyomyzon greelyi* (Medland & Beamish, 1987); abalone, *Haliotis rubra* (Prince *et al.*, 1988); by Davenport & Stevens (1988) to age two species of sharks, *Carcharhinus tilstoni* and *C. sorrah*, and lanternfish, *Lampanyctodes hectoris* (Myctophidae) (Young *et al.*, 1988) among others. In this study I use the MIX program to decompose yellowfin tuna, *Thunnus albacares* length-frequency distributions.

Davenport & Stevens (1988) found good agreement between the results from MIX and by vertebral readings for the first three year-classes of *Carcharinus tilstoni*, except for a disparity in estimates of length at birth. However, although ageing by vertebral readings for the first two year-classes of *Carcharinus sorrah* were supported by length-frequency analysis, MIX was unable to reveal clear age components beyond this point. Young *et al.*, (1988) used the Macdonald and Pitcher analysis to validate the ageing of the lanternfish, *Lampanyctodes hectoris* (Myctophidae) from eastern Tasmania by otoliths. Growth rates were similar for the two methods, but otoliths were more useful in separating 1+ and 2+ fish as the lengths were very similar.

It must be stressed that no method exists that will be able to unequivocally determine how many age-groups are represented in the data. In fisheries research the number of age-groups present together with rough estimates of means and variances can often be determined by ageing a small sub-sample by conventional biological methods (Macdonald & Pitcher, 1979). This is particularly necessary where the size-frequency histogram is not clearly polymodal.

AGEING AND GROWTH OF YELLOWFIN TUNA

In the Indian Ocean, growth has been studied using length-frequency analysis (Anderson, 1988; Maldeniya & Joseph, 1985; Marcille & Stéquert, 1976; Marsac, 1991; Marsac & Lablache, 1985; Mohan & Kunhikoya, 1985; Sivasubramanium, 1985; Yesaki, 1991), by tagging (Wang and Tanaka, 1986) and by studying the annular rings on scales (Huang *et al.*, 1973) and using vertebrae (Romanov & Korotkova, 1988).

Elsewhere, yellowfin tuna have been aged using scales (Yabuta *et al.*, 1960; Yang *et al.*, 1969), dorsal fin ray sections (Draganik and Pelczarski, 1983), otoliths (Uchiyama & Struhsaker, 1981; Wild, 1986; Wild & Foreman, 1980; Yamanaka, 1987 & 1988), by tag-recapture studies (Bard, 1983 & 1984; Bayliff, 1973; Fontenau, 1979; Miyabe, 1983; Schaefer *et al.*, 1961), spawning and recruitment (Le Guen *et al.*, 1969), and by length-frequency analysis (Davidoff, 1963; Hennemuth, 1961; Le Guen and Sakagawa, 1973; Moore, 1951; Wankowski, 1981).

The interpretation of marks on hard parts has led to some variation in the estimates of growth. Yabuta *et al.* (1960) indicated that mark formation on scales occurs twice annually in the Western Pacific, but other studies also in the Western Pacific (see Shomura, 1966; Suzuki, 1971) suggest that they underestimated growth. Yang *et al.* (1969) read the scales of 296 yellowfin tuna from the Atlantic longline fishery, but their estimates of growth rate were substantially smaller than those obtained by length-frequency analysis (Le Guen & Sakagawa, 1973). Draganik & Pelczarski (1983) used sections of the first ray of the first dorsal fin to age 171 yellowfin tuna caught by a Polish research vessel longlining in the Central Atlantic. However, their estimates of length at age differ from those by length-frequency analysis and otoliths.

As a pilot study I examined the leading dorsal spine of over ten yellowfin tuna but was unable to see any marks that could be interpreted. Moreover, I was quite unable to find yellowfin tuna otoliths despite many abortive attempts to dissect them out.

The reliability of a method for determining age-groups can only be realized after strict age-validation techniques have been imposed for each species. Recently, Beamish & McFarlane (1983) stressed the importance of age-validation.

The majority of researchers have attempted to interpret the growth of yellowfin tuna using the classical model of von Bertalanffy. There has been some divergence within the estimates of growth rate and the parameters of the von Bertalanffy equation. Le Guen & Sakagawa (1973) examined these differences and concluded that they could be attributed to three prime causes: (1) Differences in the source of data, distribution of lengths or reading of hard parts. (2) Differences in adjusting to the von Bertalanffy parameters. (3) Differences in the size ranges of the samples.

Until fairly recently most workers assumed growth was according to the classical von Bertalanffy equation. This assumption has been brought into question during the past decade. Wild (1986) found that this model does not adequately fit the data, or describe the growth of yellowfin tuna. He found the Gompertz equation to be a more satisfactory growth model for describing yellowfin tuna growth. To test his hypothesis, Wild refitted the data of Le Guen & Sakagawa (1973), and with some modifications also those of Moore (1951), Hennemuth (1961) and Davidoff (1963). For this he retained Hennemuth's assumption that yellowfin tuna of 70 cm FL are 20 months old. In the present study I calculated the parameters of the Gompertz equation, and compare them to those published by Wild.

A study of the literature reveals that two schools of thought have emerged concerning the growth of yellowfin tuna and in particular, juvenile tuna. The

first, based on tagging studies, in the Eastern Tropical Atlantic (Bard, 1983 & 1984; Fonteneau, 1979; Miyabe, 1983) suggests a slow juvenile growth rate of 1.4-1.6 cm/month up to 60.0-65.0 cm FL, whereupon the rate accelerates to approximately 3.0 cm/month. The second based on otolith studies in the Pacific (Uchiyama & Struhsaker, 1981; Wild, 1986; Wild & Foreman, 1980; Yamanaka, 1987 & 1988), and on tagging studies also in the Pacific (Schaefer *et al.*, 1961 and Bayliff, 1973), supports a hypothesis of fast juvenile growth throughout.

PRINCIPAL COMPONENTS ANALYSIS OF THE MORPHOMETRICS

A Principal Components Analysis (PCA) of the morphometrics is examined as a new technique for revealing age classes from samples of sport fishery-caught yellowfin tuna from the Pemba Channel, Kenya. The same samples of yellowfin tuna are used for both the length-frequency analysis and the PCA.

An increase in a fish's fork length leads to a roughly proportionate increase in the size of the other morphometrics but, as a result of changes in the allometric growth each age may be distinguished by its own set of relationships, such as shape. Whereas length-frequency analysis studies the frequency occurrence of just a single variable, a PCA examines the more complex relationships between, in this case, 4-16 different morphometric characters, and dissects the data into age-specific "shape" clusters.

The species specificity of the PCA plots is examined by the inclusion of small samples of skipjack tuna into two of the data sets. Turner *et al.* (1989) used a similar multivariate analysis of Chambo (*Oreochromis spp.*) in Lake Malawi. These fish are not easily differentiated by just a single character. They were able to demonstrate this method to be useful in this capacity.

The two methods are compared and the results from both techniques are discussed along with those from previously published growth studies. Particular emphasis is put on the controversy mentioned above.

4.2 Materials & Methods

DATA COLLECTION

Each fish was weighed on a 300 lb 'AVERY' beam scale to the nearest ¼ lb (113g). The weights were converted to kilos by multiplying by 0.45359. The scales are tested annually by a recognized body, as required by the International Game Fish Association regulations (IGFA, 1989).

A measuring board was constructed to simplify the measuring of the fork length (Fig. 4,1). A scale was carved out of the base taken from a metric tape measure with 0.5 cm graduations. This same tape measure was used for all the girth and fin measurements throughout the study period.

Each fish was placed, left side uppermost upon the measuring board, and with the mouth held closed the snout was pushed against the headboard.

From 5 to 16 morphometric measurements were recorded from 1,494 yellowfin tuna between 1st August 1981 and 31st March 1988 (See Fig. 4,2). The measurements recorded during each season are illustrated in Table 4,1. The morphometric data is recorded in Appendix B.

Measurement	1981	1982	1983	1984	1985	1986	1987
FL	*	*	*	*	*	*	*
PG	*	*	*	*	*	*	*
AG		*	*	*	*	*	*
PF	*		*	*	*	*	*
2DF	*	*	*	*	*	*	*
AF	*	*	*	*	*	*	*
M			*	*	*		
E				*	*		
S-DF			*	*	*		
S-2DF			*	*	*		
S-AF			*	*	*		
S-VF				*	*		
HL				*	*		
S-E				*	*		
V-T				*	*		
KW				*	*		

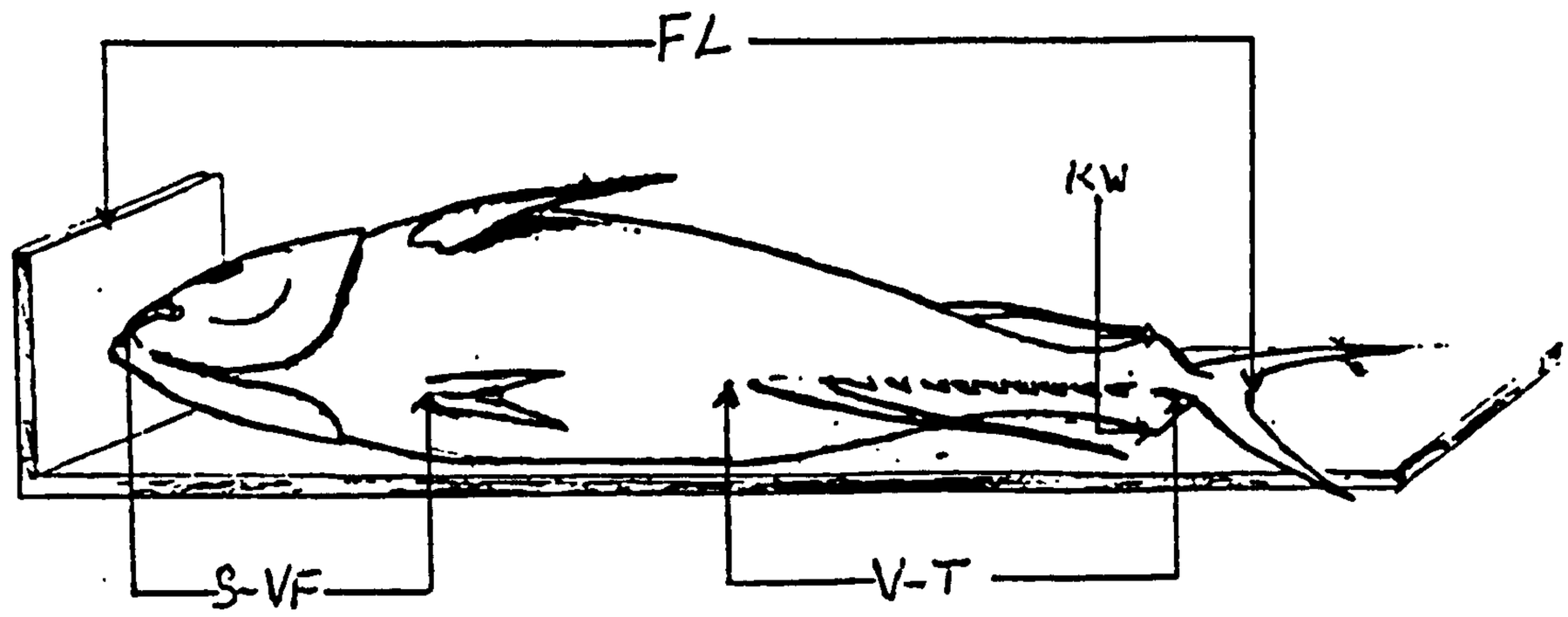
Table 4,1. The morphometric measures recorded over seven seasons in the Shimoni sport fishery. '*' denotes that the measurement was recorded. [FL - fork length; PG - pectoral girth; AG - anal girth; PF - pectoral fin length; 2DF - height of second dorsal fin; AF - height of anal fin; M - mouth size; E - orbital diameter; S-DF - snout to first dorsal fin; S-2DF - snout to second dorsal fin; S-AF - snout to anal fin; S-VF - snout to ventral fin; HL - head length; S-E - snout to orbit; V-T - snout to caudal fin, and KW - keel width.]

The morphometrics recorded were as follows:

Fork length or short length (FL) is defined as the distance from the tip of the snout to the fork of the tail. Care was taken to keep the fish in a horizontal plane and not to force the tail down onto the board (Fig. 4,1).

Pectoral girth (PG) was measured over the curve of the body to the nearest 0.5 cm from the dorsal fin slot to the mid-ventral line, posterior to the base of the pectoral fin and then doubled (Fig. 4,2).

Anal girth (AG) was measured as for the pectoral girth, but from the anterior side of the base of the second dorsal fin to the vent (Fig. 4,2).



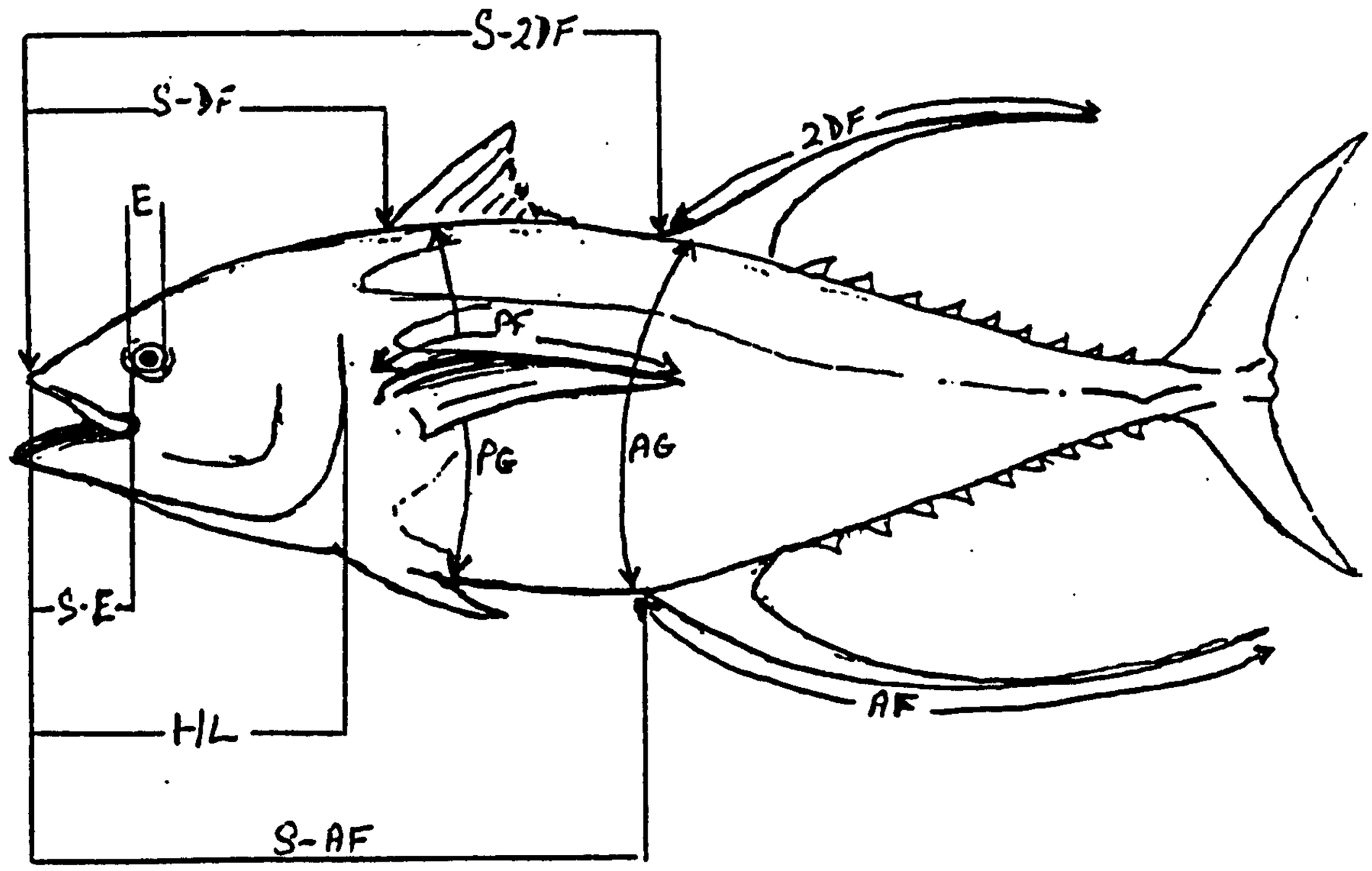


Figure 4,1. (Top) The measuring board was constructed to facilitate the measuring of the fork length. With the mouth closed the fish was placed on its right side and pushed forward until the snout touched the head board. The fork length was read off the scale on the board.

Figure 4,2. (Bottom) A side-view of a yellowfin tuna *(Thunnus albacares)* illustrating some of the morphometric measures used. For all the snout measures the mouth was held closed, and only the left side of the fish was used in all cases.

A full description of all the morphometric measures shown in both figures is given in section 4,2. with a list of those ones used in each season in Table 4,1.

Pectoral fin length (PF) was taken over the outer curve of the pectoral fin from the base to the tip (Fig. 4,2). The measurement was simplified if an assistant supported the fin out from the side of the body.

Height of the second dorsal fin (2DF) was measured as for the pectoral fin (Fig. 4,2). As with all fin measurements, if the fin was damaged, the measurement was discarded.

Height of the anal fin (AF) was recorded as for the other fins (Fig. 4,2).

For all the remaining measurements calipers were used.

Mouth size (M) was measured in all cases with the mouth held closed and using a pair of dividers. Each needle of the dividers were inserted just under the maxillary bone on either side and then transferred to a metric ruler to record the size to the nearest millimetre.

Orbital diameter (E) is the horizontal length of the bony orbit (Fig. 4,2).

Snout to first dorsal fin (S-DF) is the distance from the tip of the snout to the most anterior limit of the base of the first dorsal fin (Fig. 4,2).

Snout to second dorsal fin (S-2DF) is the distance from the snout to the front of the second dorsal fin base (Fig. 4,2).

Snout to ventral fin (S-VF) is taken from the snout to the origin of the pelvic fin (Fig. 4,1).

Head length (HL) is measured from the tip of the snout to the most posterior limit of the operculum (Fig. 4,2).

Snout to eye (S-E) is the distance from the snout to the nearest limit of the bony orbit (Fig. 4,2)

Vent to tail (V-T) is the distance from the vent to the anterior ventral limit of the caudal fin (Fig. 4,1).

Keel width (KW) is the greatest distance across the top of the keel, perpendicular to the fish's vertebrae (Fig. 4,1). Measuring was facilitated if the keel was supported on the palm of the hand as it often became bent during storage of the fish.

ANALYSIS OF THE LENGTH-FREQUENCY DATA

(a) Annual data: Histograms were constructed for each season's data using 5 cm classes. The length-frequency distributions were analysed by mixture analysis (Macdonald and Pitcher, 1979) using the computer program MIX (Macdonald & Green, 1985) from Ichthus Data Systems, on a 'Sigmex' graphics terminal linked to the VAX mainframe computer of the University of North Wales.

A data file was formed from within MIX for each season. Starting values had to be given by the user for the number of components and the proportions, means and standard deviations of each of them. The starting value for the components was

synonymous with the number of modes on the histograms. Then by a choice of options the parameters could be re-calculated and either a normal, lognormal, or gamma distribution selected for.

MIX estimates the means, proportions and standard deviations of each component along with their standard errors. A Chi-squared goodness-of-fit was also calculated and the options were used to reduce this value.

If the data contained classes with zero counts, then the goodness-of-fit was likely to be poor. Too many empty classes render the fit invalid by making the degrees of freedom, and hence the computed P-value higher than is warranted (Macdonald & Pitcher, 1979). These zero counts were removed by erasing the relevant right boundaries using option 8, and so coalescing two or more size-classes.

MIX was initially fitted to the data as it occurs in the histogram. The table of observed and expected counts was then used as a guide as to which right boundary to remove.

If the proportion of a given component was very small, the model would not yield a good fit. In such cases it was found better to combine two or more size-classes and reduce the number of components estimated.

Powell's method (Powell, 1979) as discussed in Wetherall *et al.* (1987) was used to estimate L_{inf}. The same length classes that yielded the best fit to MIX were used here. The method also gives estimates of Z/k. The estimates of L_{inf} were then incorporated into a growth model and used to estimate the growth constant, k.

(b) Monthly data: The monthly length-frequency distributions demonstrate very clearly defined modes, which enabled me to identify the components (a to b) simply by eye (Fig. 4,3). The monthly sample sizes were too small to allow for a mixture analysis of the data (Macdonald & Pitcher, 1979) using MIX.

The means and standard deviations of each component were calculated together with their standard errors. Individual fork lengths of the fish along with their date of capture were known. The mean date of capture of a component group was estimated for each month with its standard error. In some months a fifth component was apparent and unlike the annual data, the fourth and fifth components were not combined to increase the size of the former.

Wherever possible "growth rates" were estimated as the increase in fork length per number of days between the mean dates of capture of the respected months to give a monthly rate.

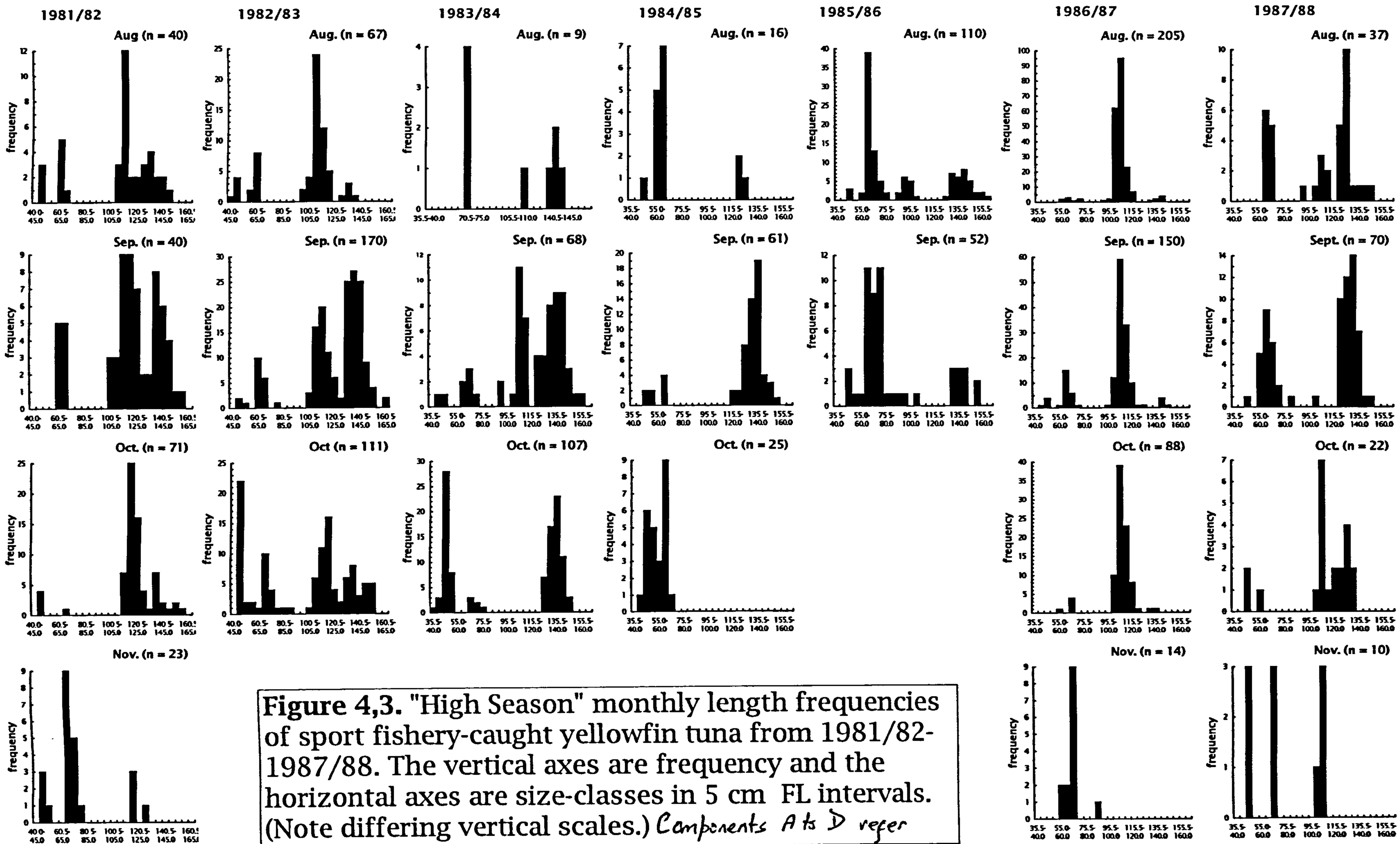


Figure 4,3. "High Season" monthly length frequencies of sport fishery-caught yellowfin tuna from 1981/82-1987/88. The vertical axes are frequency and the horizontal axes are size-classes in 5 cm FL intervals. (Note differing vertical scales.) Components A to D refer to the modes but are not specifically labelled.

ANALYSIS OF THE MORPHOMETRICS

Each season's data was subjected to a Principal Components Analysis (PCA) using the program, DFACT on first the DEC-10 and subsequently on the VAX mainframe computers of the University of North Wales. This is a branch of factor analysis that is used here to reduce the complex relationships of from 4-16 morphometric variables into the interaction of fewer and simpler factors (Sokal & Rohlf, 1981). The data may be seen as clouds of points describing hyperellipsoids in a multidimensional space. With a PCA we are thus taking successive cuts at right angles through the hyperellipsoid, each extracting the maximum range among the data. The first principal component-axis gives the maximum variability, the second principal component-axis the next most variable at 90° to the first, and so forth.

Two different analyses were carried out:

(a) The raw morphometric data was used, with the fork length excluded from the analysis.
(b) Each variable was transformed to a proportion of the fork length in order to reduce the influence of fish size and to make the variables more independent of one another. The aim was to see if clustering would still occur even with the influence of allometric growth severely reduced.

DFACT carries out an R-type analysis based on the correlation matrix of the data file, and extracts all the roots accounting for more than a given percentage of the total variation. All the information required by DFACT must be contained within a data file.

Each row of data must terminate in a row identification number that DFACT uses to label the points on the graphs of transformed co-ordinates. A command row must be included ahead of the first row of data containing the following details required by DFACT: (1) A number representing the percentage of the total variation above which all roots must be extracted; (2) the size of the plots to be printed; (3) the number of rows of data; (4) the number of columns of data excluding the row identification number and (5) either "1" if the data is to be transposed, or "0" if not. However, until modifications were made to the program by Mr I. G. Jones of the University of North Wales computer department, the program would not work if the "1" option was selected. A second command line instructing DFACT as to the number and nature of the plots required must be included at the end of the data file.

The output from DFACT includes the original data file if required, a correlation matrix, a matrix of vectors for each root extracted and a complete list of transformed co-ordinates for the roots extracted.

Polygons were drawn by eye about the clusters and the means and their standard errors calculated and compared using a t-test with those obtained by a mixture analysis of the length-frequencies. Means and standard errors were calculated for males and females separately and any differences were tested using the relevant significance tests.

Small samples of skipjack tuna, *Katsuwonus pelamis*, were included with the yellowfin tuna data of 1985/86 and 1987/88 in order to test the species-specificity of the PCA clusters. The skipjack tuna were of a similar size to the juvenile yellowfin tuna.

4.3 Results

LENGTH-FREQUENCY ANALYSIS

Annual Data: The length-frequency distribution of sport fishery caught yellowfin tuna from the Pemba Channel for 1981/82 to 1987/88 each reveal four clear modes, although the third component was poorly represented in 1984/85 (Fig. 4,4.).

The position of the modes relative to the FL-axis is consistent, although the third component was comprised of smaller fish in 1985/86.

There was an absence of 75.0-100.0 cm FL fish in all but the 1985/86 season when no 105.0-125.0 cm FL fish were caught. In Chapter 3, I investigated the possibility of a missing age class when calculating mortality rates, but found no evidence, so the 'anomaly' is likely caused by growth changes in the juveniles.

Mixture analysis: The MIX program of Macdonald & Green (1985) identified four component distributions in each of the seven samples. The program converged well on all but one data set with particularly good fits for 1981/82, 1983/84 and 1984/85; full details are given below.

Although the components were assumed to be normally distributed, a log-normal or gamma distribution fitted the data equally well, and in some cases resulted in a better fit, particularly in cases where a normal distribution produced a high chi-squared value. The log-normal component distributions show a slight right skew and possess a relatively small coefficient of variation. With each data set the first fit to the model gave an invalid goodness-of-fit, resulting from five to eleven expected counts of less than one. Much of this stemmed from the absence of 75.0-100.0 cm FL fish mentioned above.

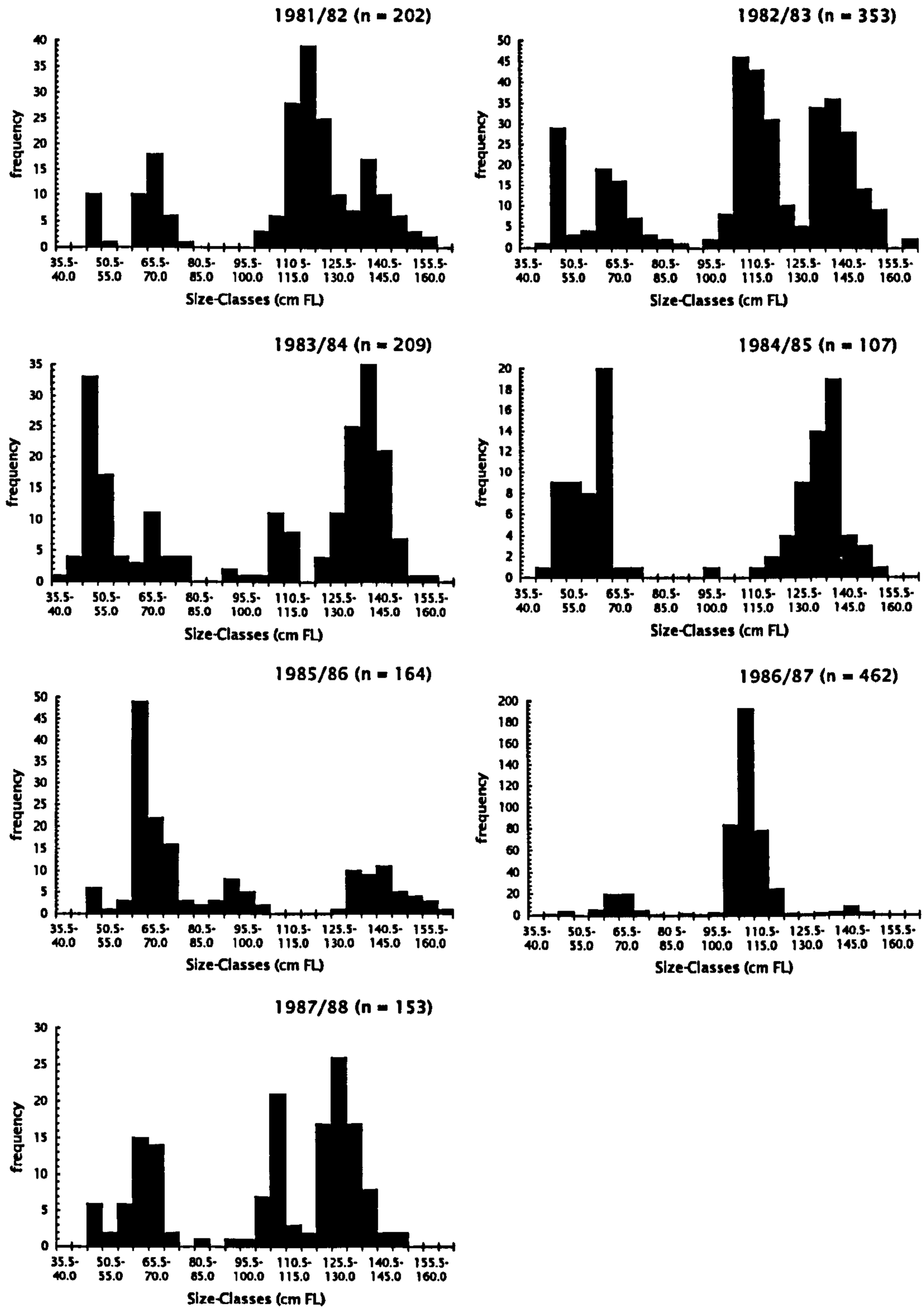


Figure 4,4. The annual length-frequencies of sport fishery-caught yellowfin tuna from Shimoni, Kenya, 1981/82-1987/88.

The right-hand tail of the histograms are formed of a smear of more than one age class with very small proportions, which are treated here as a single component. There were neither sufficient numbers nor the available information to allow for the separation of this component into more than one age class. As a result the mean and standard deviation of the fourth component will be slightly overestimated.

1981/82:- The initial fit gave a chi-squared = 9.60 (14df) and P = 0.79. The table of expected counts revealed eight classes with less than one count rendering the goodness-of-fit invalid. After the removal of the 50.0 cm, 80.0 cm, 85.0 cm, 90.0 cm, 95.0 cm and 155.0 cm FL right boundaries the model converged well (Fig. 4,5).

Year	Mean±se	Prop±se	sd±se	n	Chisq	df	P
1981	45.79±3.00	0.05±0.02	2.28	202	6.67	8	0.57
	66.94±0.67	0.17±0.03	3.34				
	117.17±0.66	0.54±0.04	5.84				
	140.20±1.25	0.23±0.03	6.99				
	constant COV = 0.05±0.17						
	45.79 FIX	0.05 FIX	2.28	202	6.67	12	0.88
	66.94 FIX	0.17 FIX	3.34				
	117.17±0.66	0.54±0.03	5.84				
	140.20±1.25	0.23±0.03	6.99				
	constant COV = 0.05±0.17						
1982	47.63±0.58	0.09±0.02	1.42±0.31	353	19.25	8	0.01
	66.30±1.04	0.15±0.02	6.11±0.99				
	111.64±0.52	0.39±0.03	5.14±0.49				
	138.88±0.74	0.37±0.03	7.16±0.60				
	47.63 FIX	0.09 FIX	1.42±0.27	353	19.25	15	0.20
	66.30 FIX	0.15 FIX	6.11±0.86				
	111.64 FIX	0.39 FIX	5.14±0.45				
	138.88 FIX	0.37 FIX	7.16±0.55				

Table 4,2. The estimates and their standard errors of the mean lengths (cm FL), proportions of the total sample size and standard deviations (cm FL) using MIX (Macdonald & Green, 1985).

The best fit was found by selecting for a constant coefficient of variation = 0.05 (SE = 0.17) and without any constraints on the means and proportions (Table 4,2). The program would not converge if the standard deviations were also left free. By fixing the proportions and means of the first and second components and by selecting for a constant coefficient of variation the P-value was raised from P = 0.57 to P = 0.88, but this had no effect upon the chi-squared. Both a log-normal distribution (chi-squared = 6.77), and a gamma distribution (chi-squared = 6.71) fitted these data equally well.

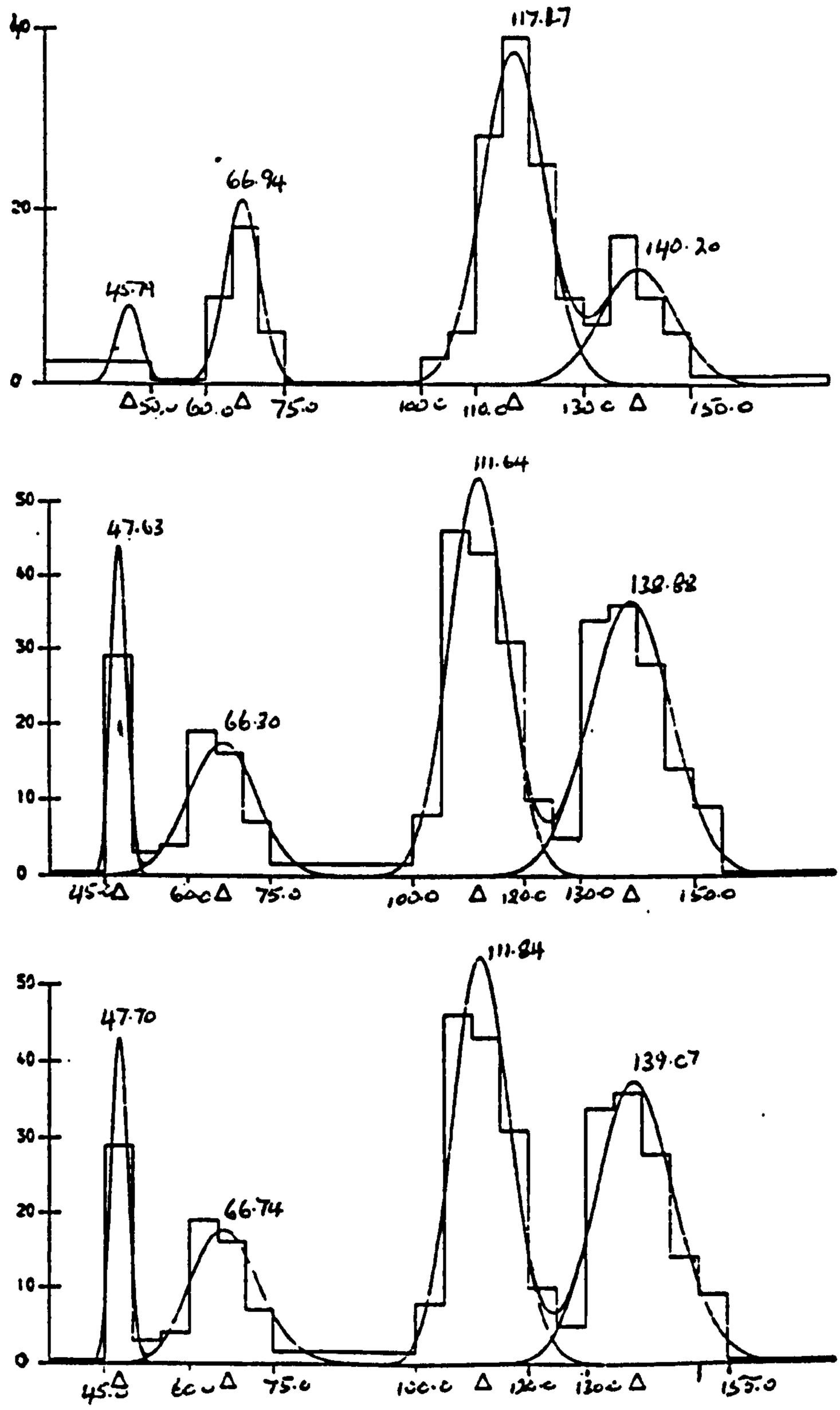


Figure 4,5. (Top) 1981/82: MIX converged well fitting four normally distributed components. The means are indicated above the distribution peaks and the parameters are given in Table 4,2.

Figure 4,6. (Middle) 1982/83: MIX converged well with all the restraints lifted, with Chisq. = 19.25. The component means are given above the distribution peaks and the parameters in Table 4,2.

Figure 4,7. (Bottom) 1982/83: A log-normal distribution gave a slightly better Chisq. = 16.48. The component means are given above the distribution mixtures

The horizontal axis is fork fength (cm FL) and the vertical axis is frequency.

1982/83:- A very high chi-squared = 73.41 (16df), P = <0.01 resulted from five expected counts of less than one. The 80.0 cm, 85.0 cm, 90.0 cm, 95.0 cm and 160.0 cm FL right boundaries were removed (Fig. 4,6). In this case it was possible to lift all the constraints including the standard deviations as all four components show up as distinct modes on the histogram. By fixing the means and proportions of all four components the probability was improved from P = 0.01 to P = 0.20 (Table 4,2).

A log-normal distribution gave a slightly better chi-squared of 16.48 (8df), and P = 0.35 (Fig. 4,7). A gamma distribution gave a chi-squared = 17.40 (8df).

1983/84:- Following the removal of the 40.0 cm, 80.0 cm, 85.0 cm, 95.0 cm and 155.0 cm FL right boundaries the chi-squared was reduced from 41.21 (16df), P = <0.01, to 16.30 (8df), P = 0.04 with all the constraints lifted. The removal of the 90.0 cm boundary improved the chi-squared to 6.47 (7df), P = 0.49. By then combining the two classes from 115.5 cm to 125.0 cm FL the chi-squared was further reduced to 4.86 (6df). P = 0.56 (Fig. 4,8).

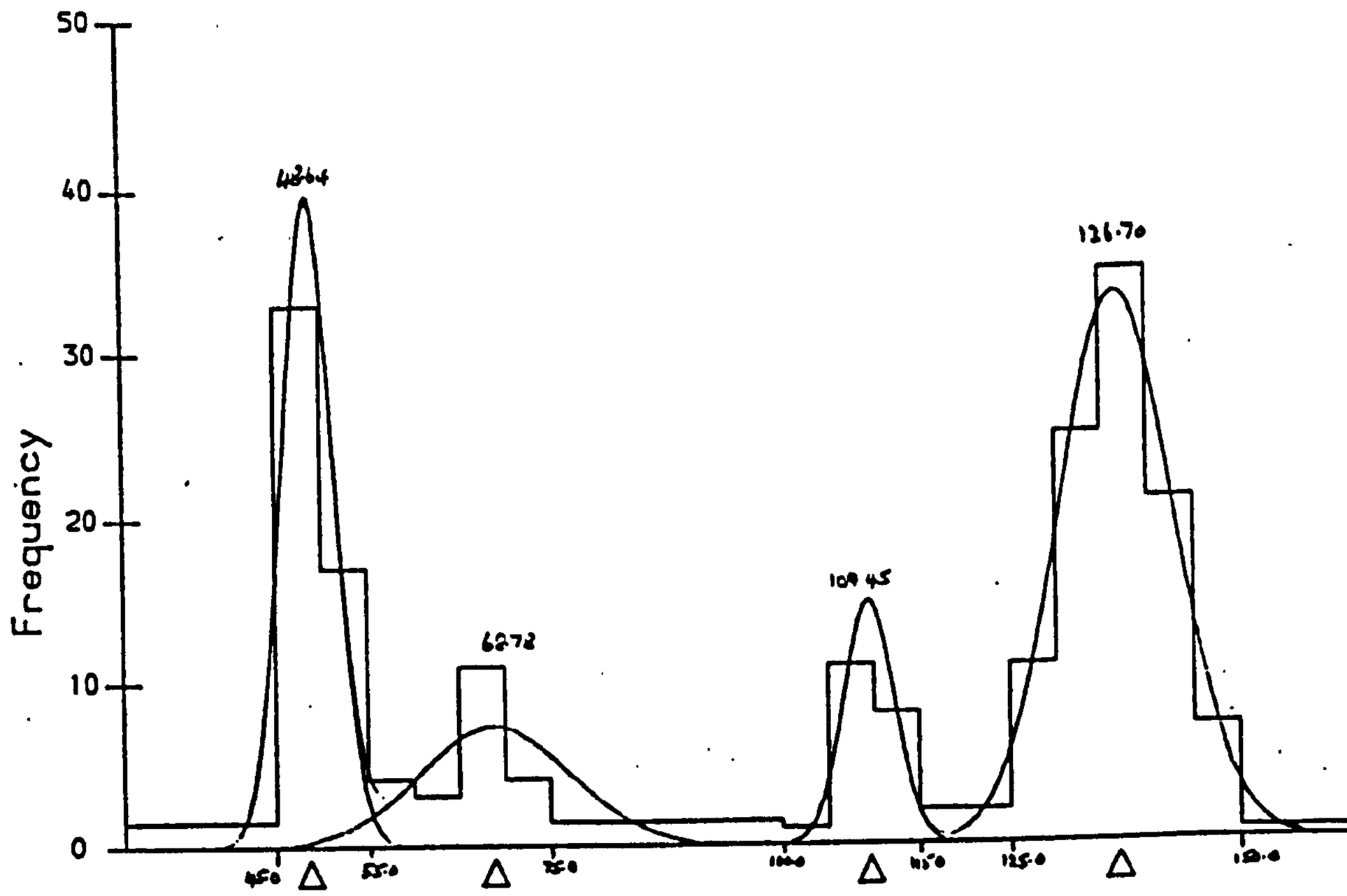
I then tried a different approach. Firstly, the 90.0 cm boundary was kept as a barrier between the second and third components and the 100.0 cm boundary removed. Secondly, instead of removing the 120.0 cm boundary, I combined the two classes from 110.5 cm to 120.0 cm FL (Fig. 4,9). This yielded a slightly better fit to the model with a chi-squared = 4.73 (6df), P = 0.58 (Table 4,3).

Then by fixing the proportions and means and leaving the standard deviations free for all four components the P value was raised to P = 0.98.

1984/85:- The intact data gave a chi-squared = 15.16 (14df), P = 0.37, but there were eleven expected counts less than one rendering the goodness-of-fit invalid. The first two and the last two classes were combined and the 70.0 cm, 80.0 cm, 85.0 cm, 90.0 cm, 100.0 cm, 105.0 cm and 110.0 cm FL right boundaries were removed. By leaving all the means and proportions free and constraining the standard deviations to a constant coefficient of variation we get a good chi-squared = 4.92 (5df), P = 0.43 (Table 4,3). The zero expected count in the 75.5-95.0 cm class was left as a divider between the second and third components, as the removal by the erasure of the 75.0 cm or 95.0 cm boundaries had no effect upon the goodness-of-fit, but reduced the P-value.

If all the means and proportions were fixed, it was possible to leave the standard deviations free (Fig. 4,10). This further reduced the chi-squared to 4.14 (9df), P = 0.90 (Table 4,3).

Because the third mode on the histogram is very small I tried fitting just three components. With the means and proportions free and a constant coefficient of



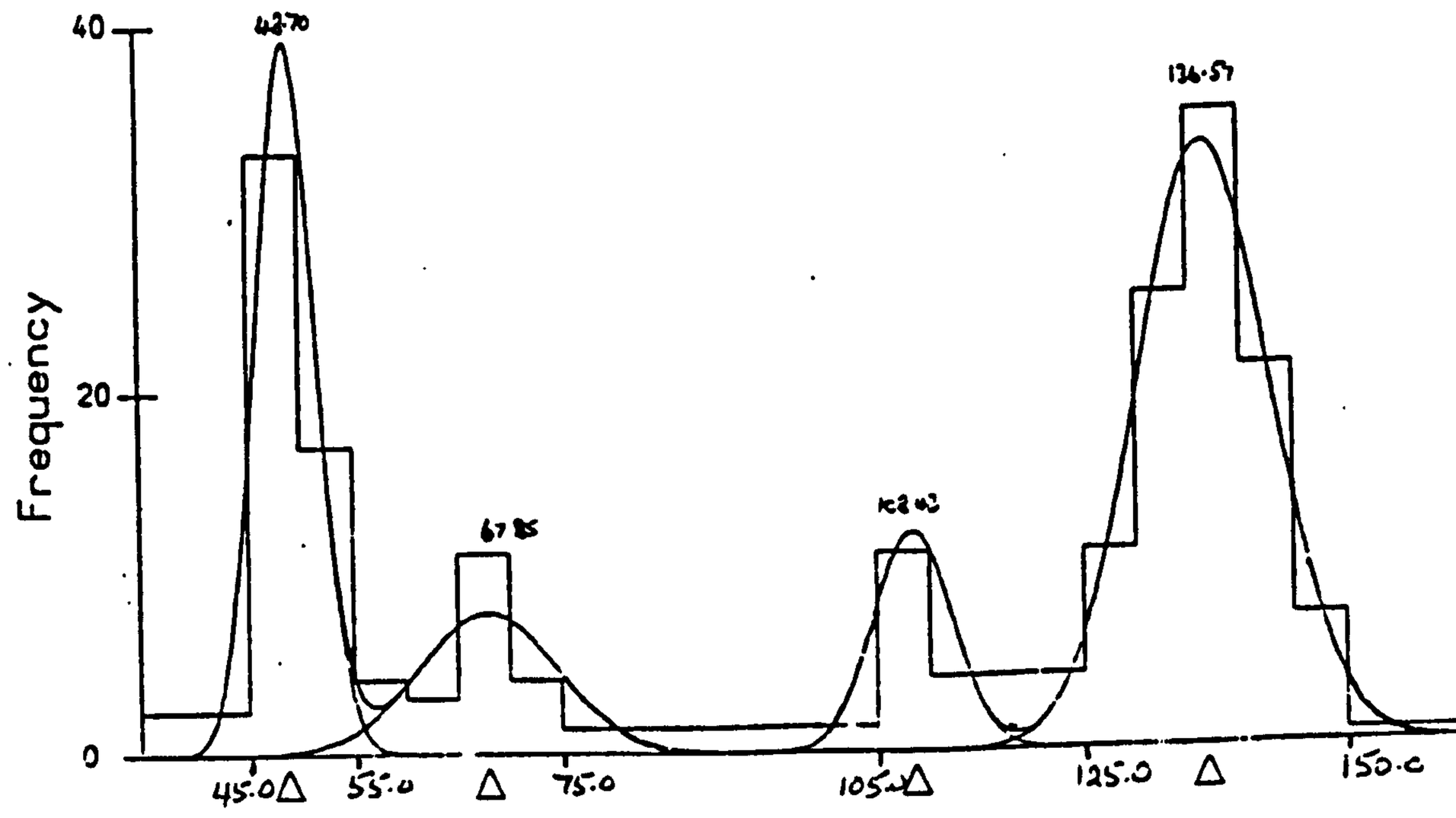


Figure 4,8. (Top) 1983/84: With the 40.0, 80.0, 85.0, 90.0, 95.0 and 155.0 cm FL right boundaries removed, the 115.5-125.0 cm FL classes combined, and all the constraints lifted four normally distributed components were fitted with a Chisq. = 4.86. The means are given above the component distributions.

Figure 4,9. (Bottom)1983/84: The best fit to this data resulted from replacing the 90.0 cm FL right boundary, removing the 100.0 cm FL boundary, and combining the 110.5-120.0 cm FL classes. The parameters are given in Table 4,3. and the component means are shown above the normal distributions.

Horizontal axis is fork length (cm).

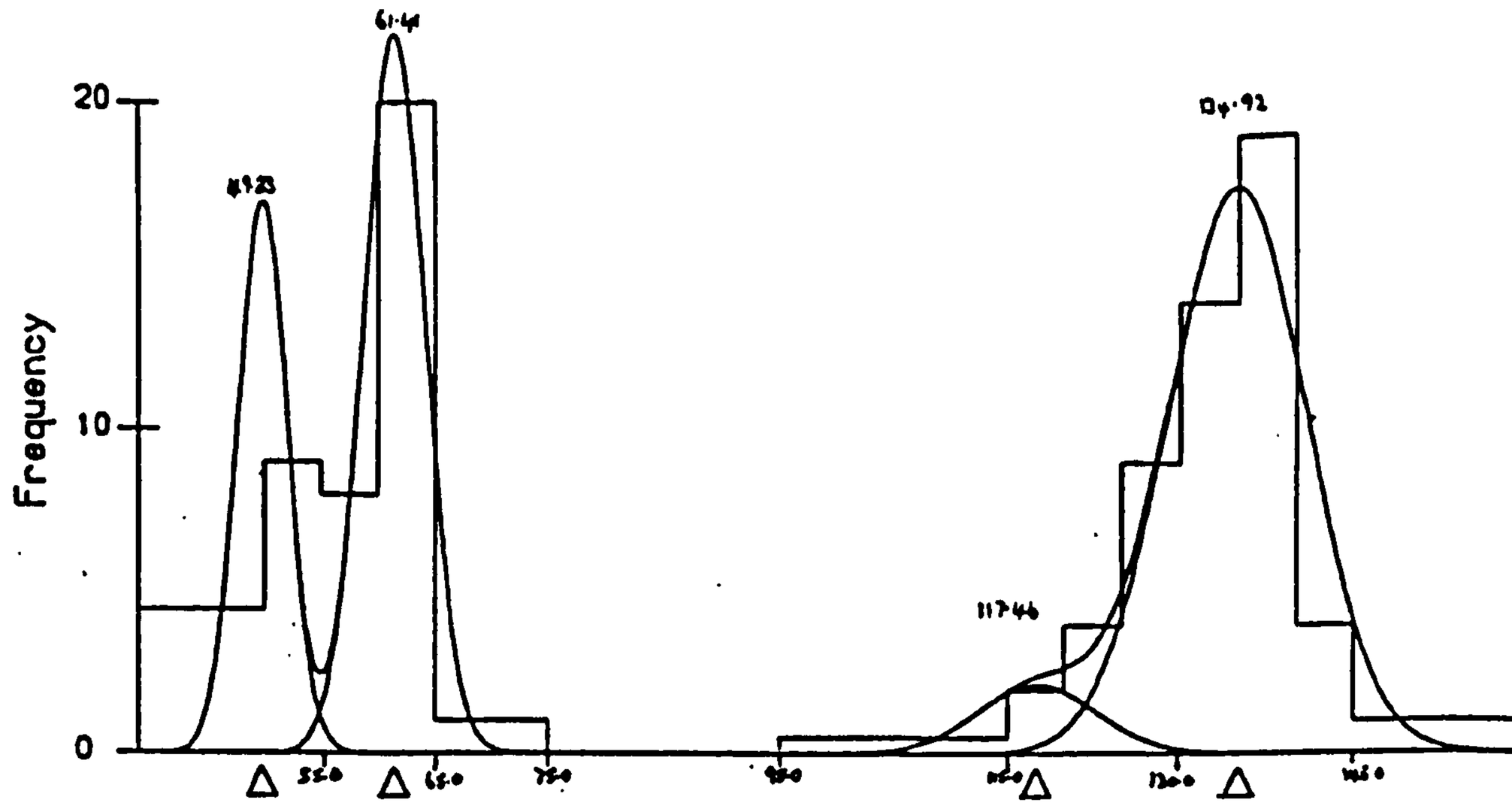
variation = 0.06 (se = 0.26) a chi-squared = 11.77 (6df), P = 0.07 resulted. By then fixing all the means and proportions I was able to leave the standard deviations free which gave an improved chi-squared = 6.42 (Table 4,5 and Fig. 4,11).

Year	Mean±se	Prop±se	sd±se	n	Chisq	df	P
1983	48.70±0.48	0.26±0.03	2.81±0.44	209	4.73	6	0.58
	67.85±1.73	0.12±0.02	6.68±1.62				
	108.43±0.91	0.11±0.02	3.71±0.95				
	136.57±0.65	0.50±0.03	6.32±0.51				
	48.70 FIX	0.26 FIX	2.81±0.40	209	4.73	13	0.98
	67.85 FIX	0.12 FIX	6.68±1.42				
	108.43 FIX	0.11 FIX	3.71±0.93				
	136.57 FIX	0.50 FIX	6.32±0.50				
1984	49.83±0.66	0.18±0.04	2.20	107	4.92	5	0.43
	61.41±0.59	0.28±0.04	2.72				
	117.46±4.18	0.05±0.03	5.19				
	134.92±1.05	0.49±0.06	5.97				
		constant COV = 0.04±0.26					
	49.83 FIX	0.18 FIX	2.08±4.25	107	4.14	9	0.90
	61.41 FIX	0.28 FIX	2.36±0.45				
	117.46 FIX	0.05 FIX	6.65±4.96				
	134.92 FIX	0.49 FIX	6.31±0.81				

Table 4,3. The estimates and their standard errors for the mean lengths (cm FL), proportions (of the total sample), and standard deviations (cm FL) for four components for 1983/84 and 1984/85 using MIX (Macdonald & Green, 1985).

Year	Mean±se	Prop±se	sd±se	n	Chisq	df	P
1985	45.59 FIX	0.04 FIX	2.44±2.83	164	30.00	14	0.01
	65.57 FIX	0.57 FIX	4.43±0.43				
	92.74 FIX	0.12 FIX	5.76±1.37				
	141.84 FIX	0.27 FIX	8.31±1.03				
1986	46.58 FIX	0.01 FIX	2.06±1.80	462	15.71	10	0.11
	64.93 FIX	0.11 FIX	4.23±0.56				
	108.00 FIX	0.84 FIX	4.17±0.17				
	141.04 FIX	0.03 FIX	3.41±0.99				
1987	48.35 FIX	0.05 FIX	1.91±1.39	153	11.43	11	0.49
	64.20 FIX	0.25 FIX	4.24±0.67				
	106.17 FIX	0.21 FIX	3.16±0.53				
	129.12 FIX	0.49 FIX	6.30±0.62				

Table 4,4. The estimates and their standard errors for the mean lengths (cm FL), proportions (of the total sample), and standard deviations (cm FL) for four components for 1985/86, 1986/87 and 1987/88 using MIX (Macdonald & Green, 1985).



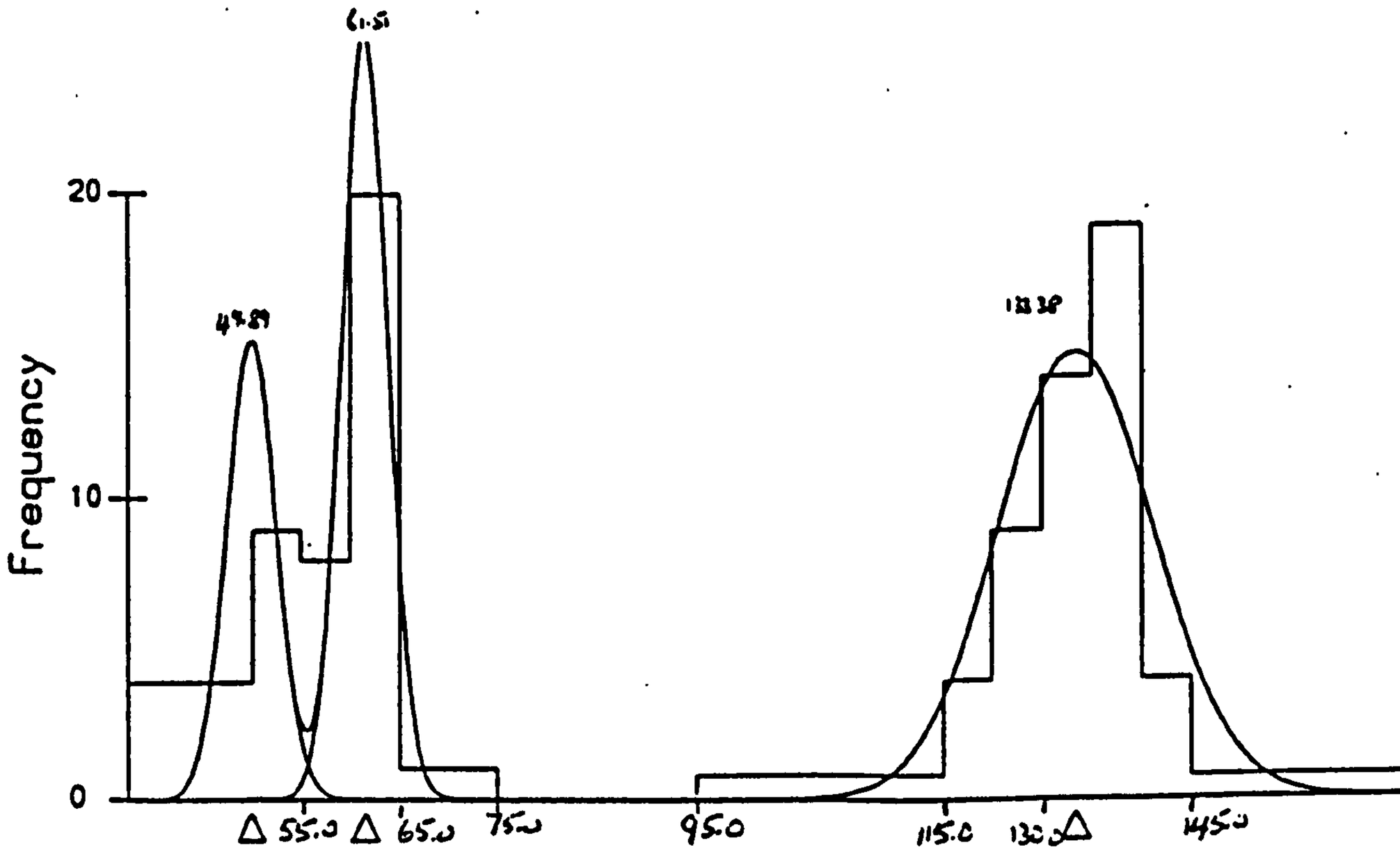


Figure 4,10. (Top) 1984/85: By fixing the means and proportions and leaving the standard deviations free, MIX fitted four normally distributed components with a Chisq. = 4.14. The horizontal axis is fork length (cm). The means of each component are given above the fitted components, and all parameters are given in Table 4,3.

Figure 4,11. (Bottom) 1984/85: By fitting only three normally distributed components an improved Chisq = 6.42 was yielded. Component means are given above the fitted distributions. The parameters are given in Table 4,5.

The horizontal axis is fork length (cm).

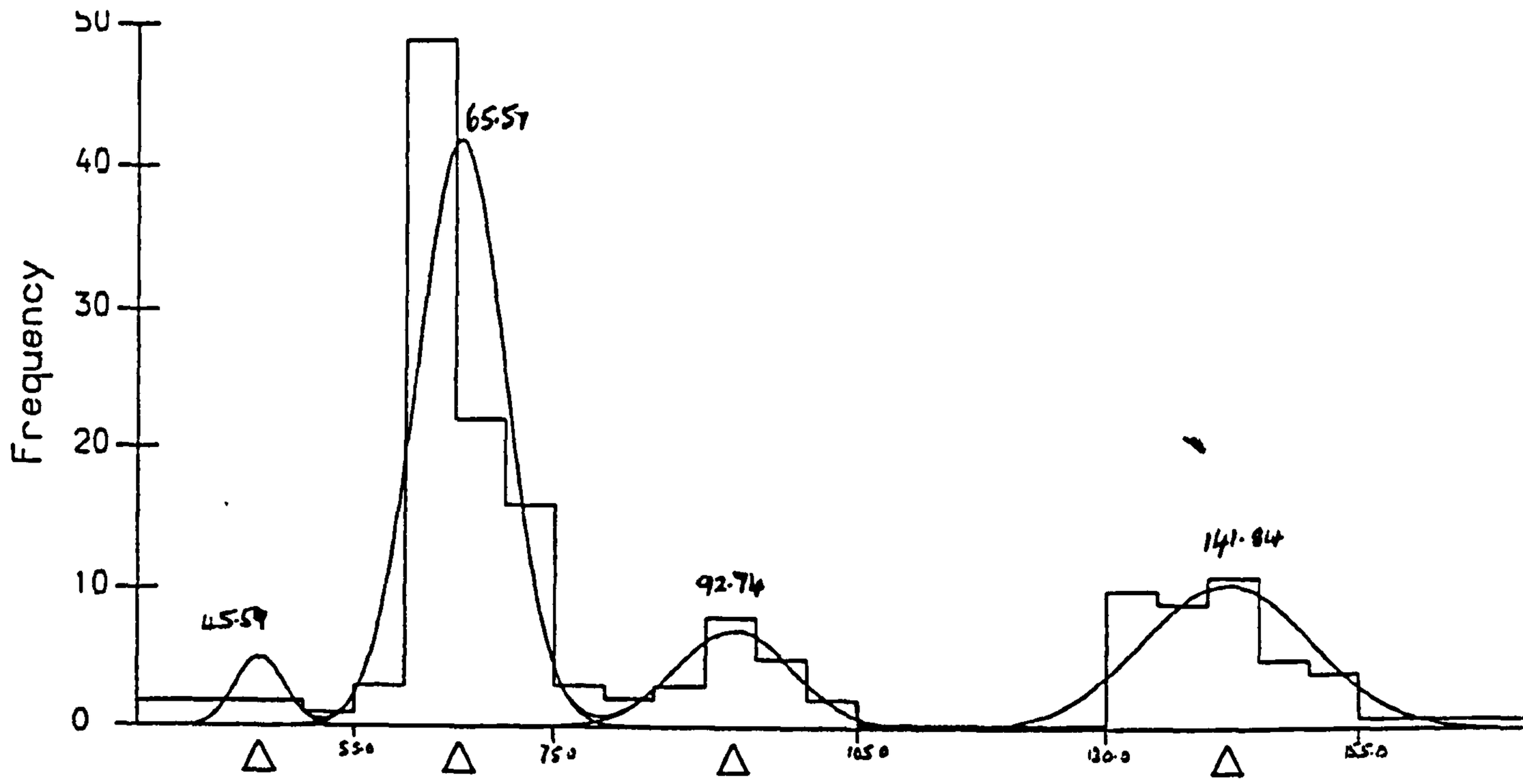
1985/86:- This yielded the only poor fit to the model because the proportion of the first component was so small. With the initial fit there were five expected counts of less than one. All the classes from 105.5 cm to 130.0 cm FL were combined and the 160.0 cm FL boundary was removed. The best fit resulted by fixing the means and proportions and leaving the standard deviations free giving a chi-squared = 30.00 (14df), P = 0.01 (Table 4,4 and Fig. 4,12).

Year	Mean±se	Prop±se	sd±se	n	Chisq	df	P
1984	49.89 FIX	0.18 FIX	2.54±2.82	107	6.42	9	0.70
	61.51 FIX	0.28 FIX	2.33±0.46				
	133.38 FIX	0.54 FIX	7.80±0.81				
1985	65.07 FIX	0.61 FIX	4.79±0.43	164	22.34	13	0.05
	92.87 FIX	0.12 FIX	5.62±1.33				
	141.84 FIX	0.27 FIX	8.31±1.03				
1986	64.26±0.67	0.12±0.02	4.75±0.60	462	15.98	4	<0.01
	108.00±0.22	0.84±0.02	4.17±0.17				
	141.09±0.98	0.03±	3.40±1.00				

Table 4,5. The estimates and their standard errors for three components of the mean lengths (cm FL), proportions (of the total sample), and standard deviations (cm FL) for 1984/85, 1985/86 and 1986/87 using MIX (Macdonald & Green, 1985).

A better fit resulted when the first and second components were combined by removing the 50.0 cm and 55.0 cm FL right boundaries and only three components selected for (Table 4,5 and Fig. 4,13). This gave a chi-squared = 22.32 (13df), P = 0.05, but a log-normal distribution rendered a slightly better fit with a chi-squared = 18.91 (13df), P = 3.13 (Fig. 4,14).

1986/87:- The histogram reveals a very large third component, in contrast to very small first and last modes (Fig. 4,4) and fitting four components was possible only after removing the 50.0 cm, 75.0 cm, 80.0 cm, 90.0 cm, 130.0 cm and 135.0 cm FL right boundaries. By fixing the means and proportions and leaving the standard deviations free, a satisfactory chi-squared = 15.71 (10df), P = 0.11 resulted (Table 4,4 and Fig. 4,15). However, it would not converge if all the parameters were left free. As the first component formed only one percent of the entire catch, the first two components were combined by removing the 45.0 cm and 55.0 cm FL boundaries. Three components were then fitted. Here it was possible to leave all the parameters free, but the resultant chi-squared = 15.98 (4df) was no better than that for four components (Table 4,5 and Fig. 4,16). The fourth component was also very small, however, the P-value was not as good as for four components. A log-normal distribution again improved the goodness-of-fit with a chi-squared = 11.85 (4df), P = 0.02 (Fig. 4,17). A gamma distribution resulted in a chi-squared = 13.09 (4df).



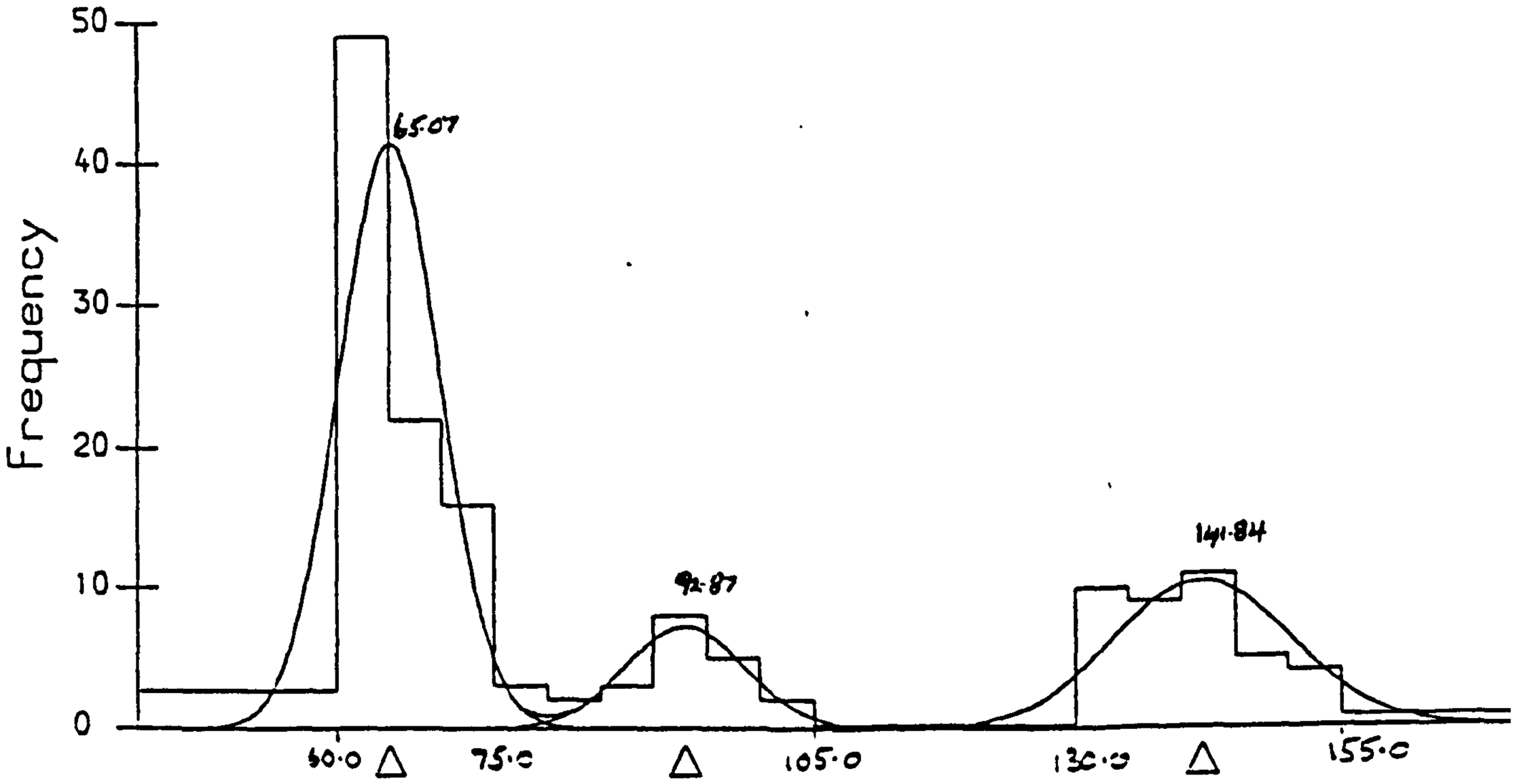


Figure 4,12. (Top) 1985/86: MIX fitted four normally distributed components, but gave a poor Chisq. = 30.00. The component means are indicated above the distribution mixtures and the parameters are given in Table 4,4.

Figure 4,13. (Botom) 1985/86: By combining the first two components and fitting just three components yielded a better fit with a Chisq. = 22.34. The component means are given above the fitted mixtures and the full parameters in Table 4,5.

*The horizontal axis is fork length (cm).*f

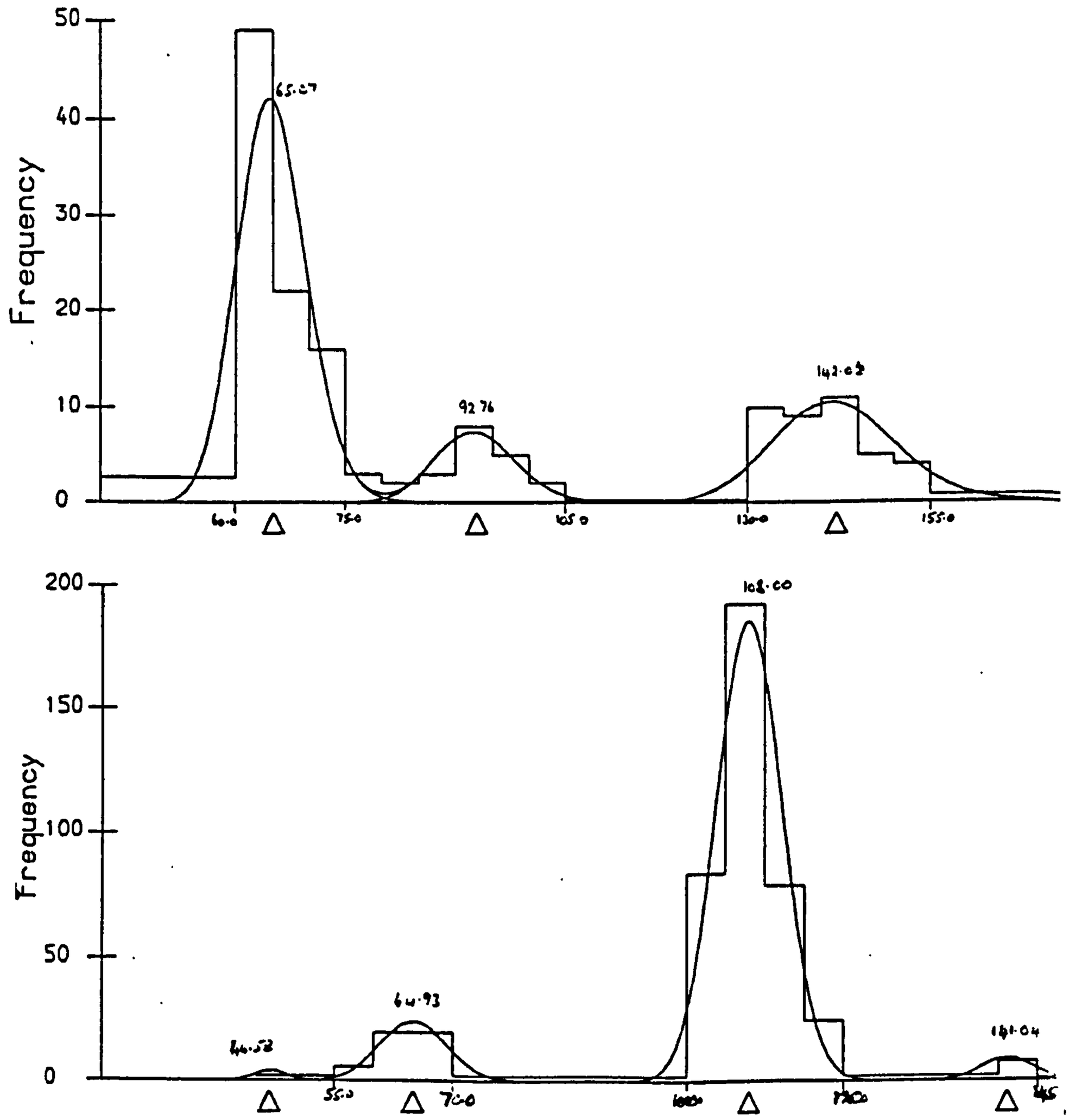
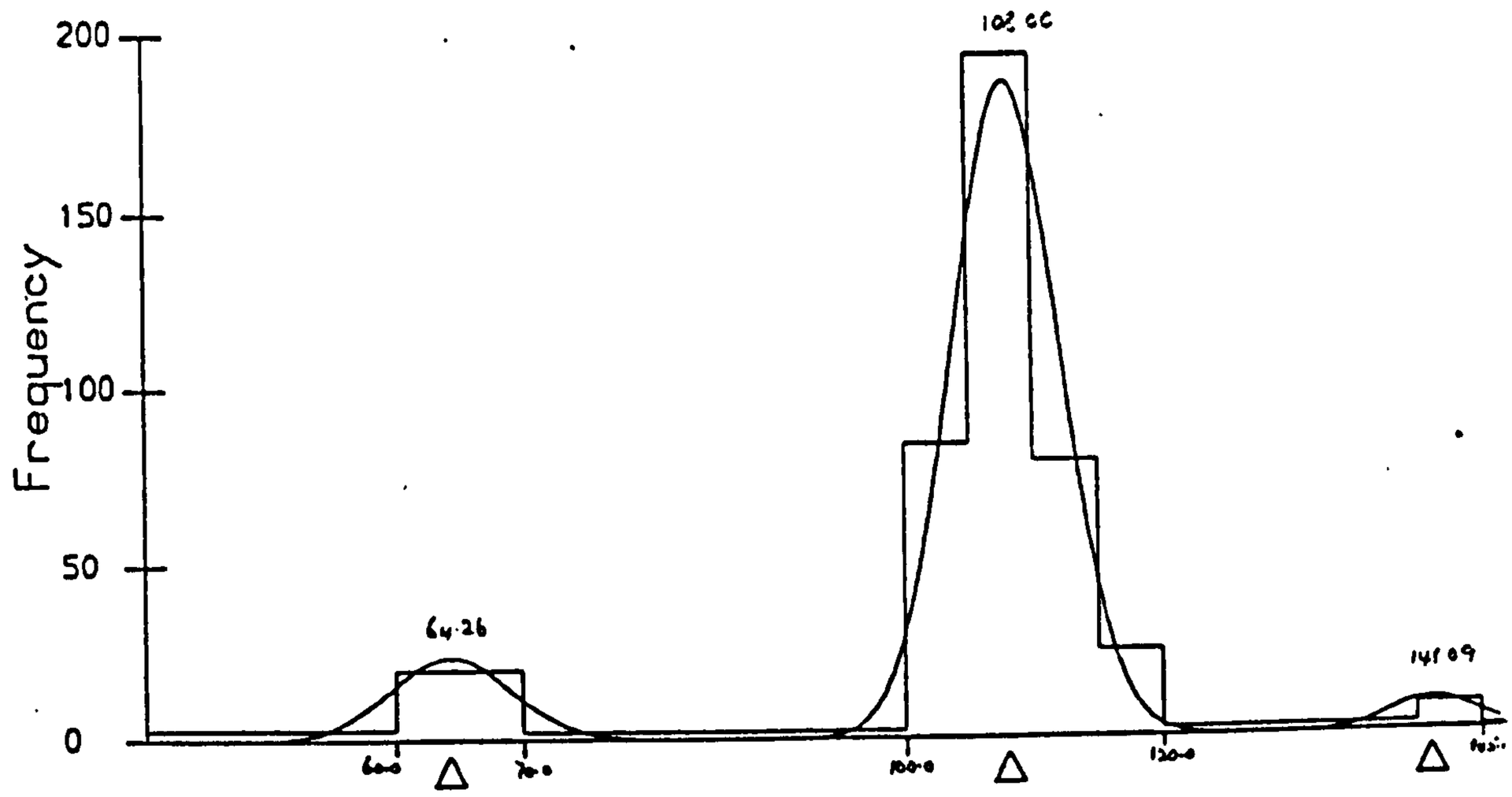


Figure 4,14. (Top) 1985/86: A log-normal distribution gave the best fit to this data with a Chisq. = 18.91 (13df). The component means are given above the fitted mixtures.

Figure 4,15. (Bottom) 1986/87: Despite the first component being very small MIX converged well on four components, but only with the means and proportions fixed. The means are given above the fitted mixtures and the parameters in Table 4,4.

The horizontal axis is fork length (cm).



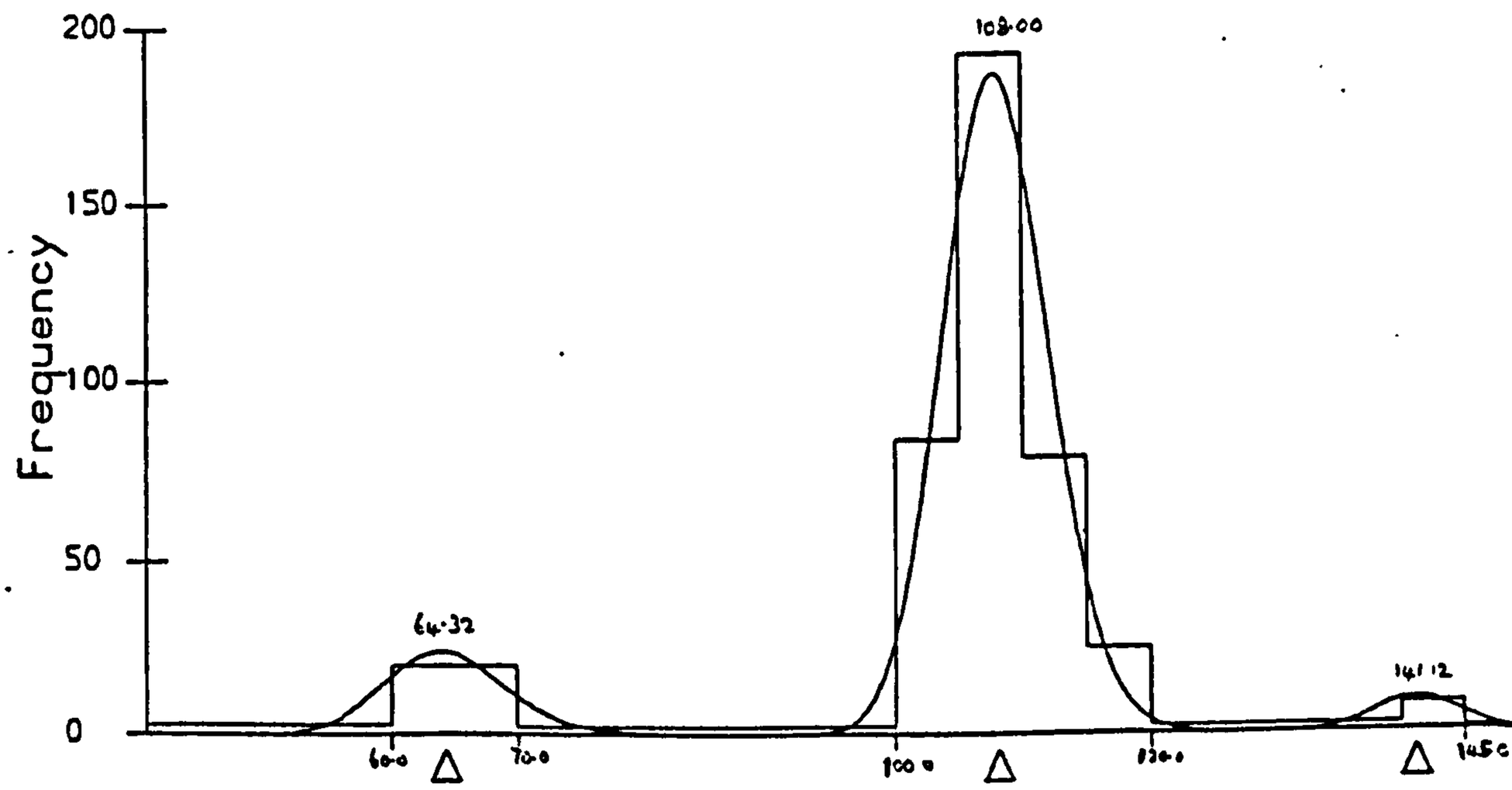
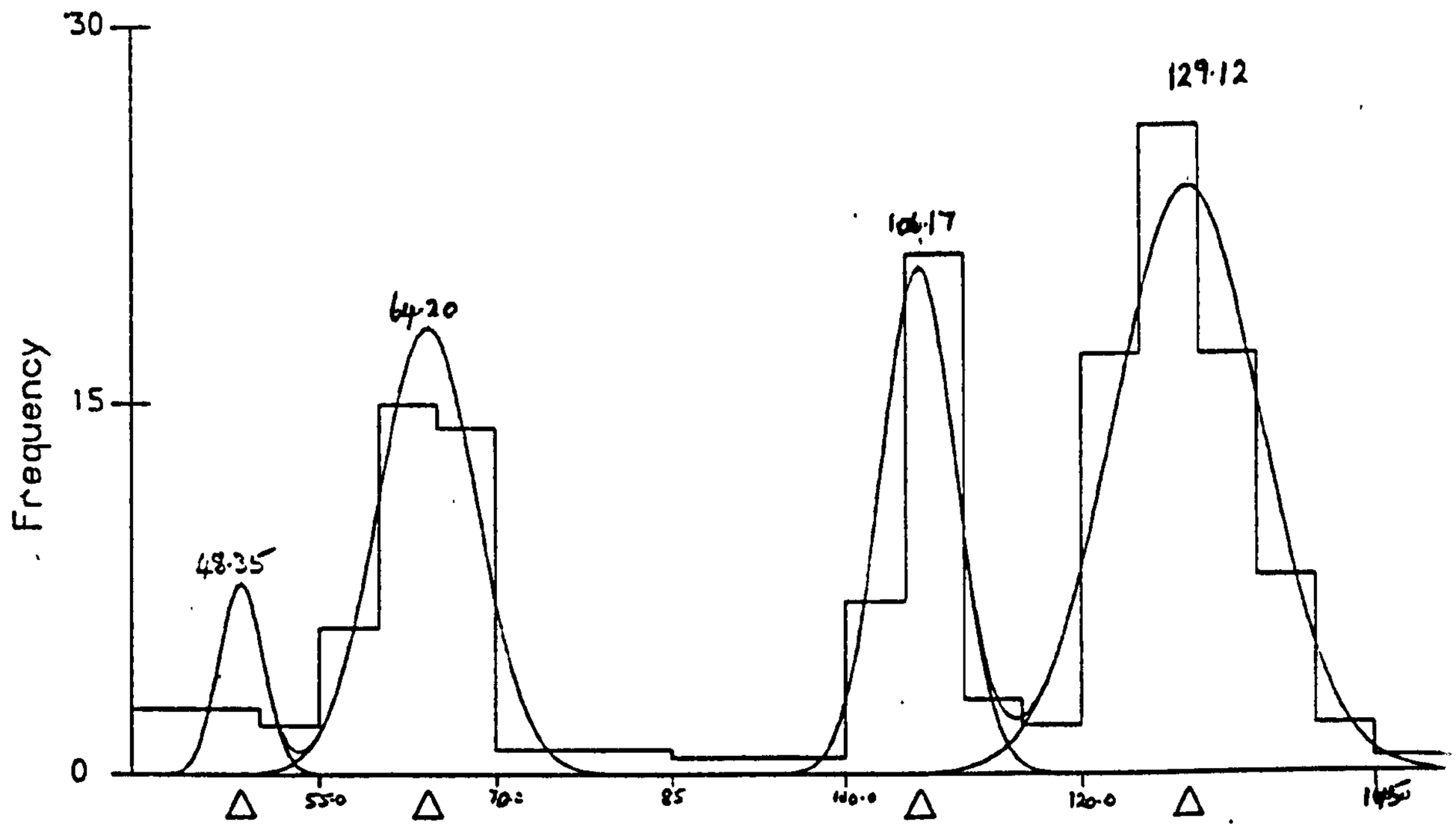


Figure 4,16. (Top) 1986/87: The first two age-classes were coalesced and just three components fitted, but with no improvement in the Chisq. as the fourth component is also very small. The component means are given above the fitted mixtures and all the parameters in Table 4,5.

Figure 4,17. (Bottom) 1986/87: A log-normal distribution with three components yielded a slightly better fit to the data. The component means are indicated above the fitted mixtures.

The horizontal axis is fork length (cm).



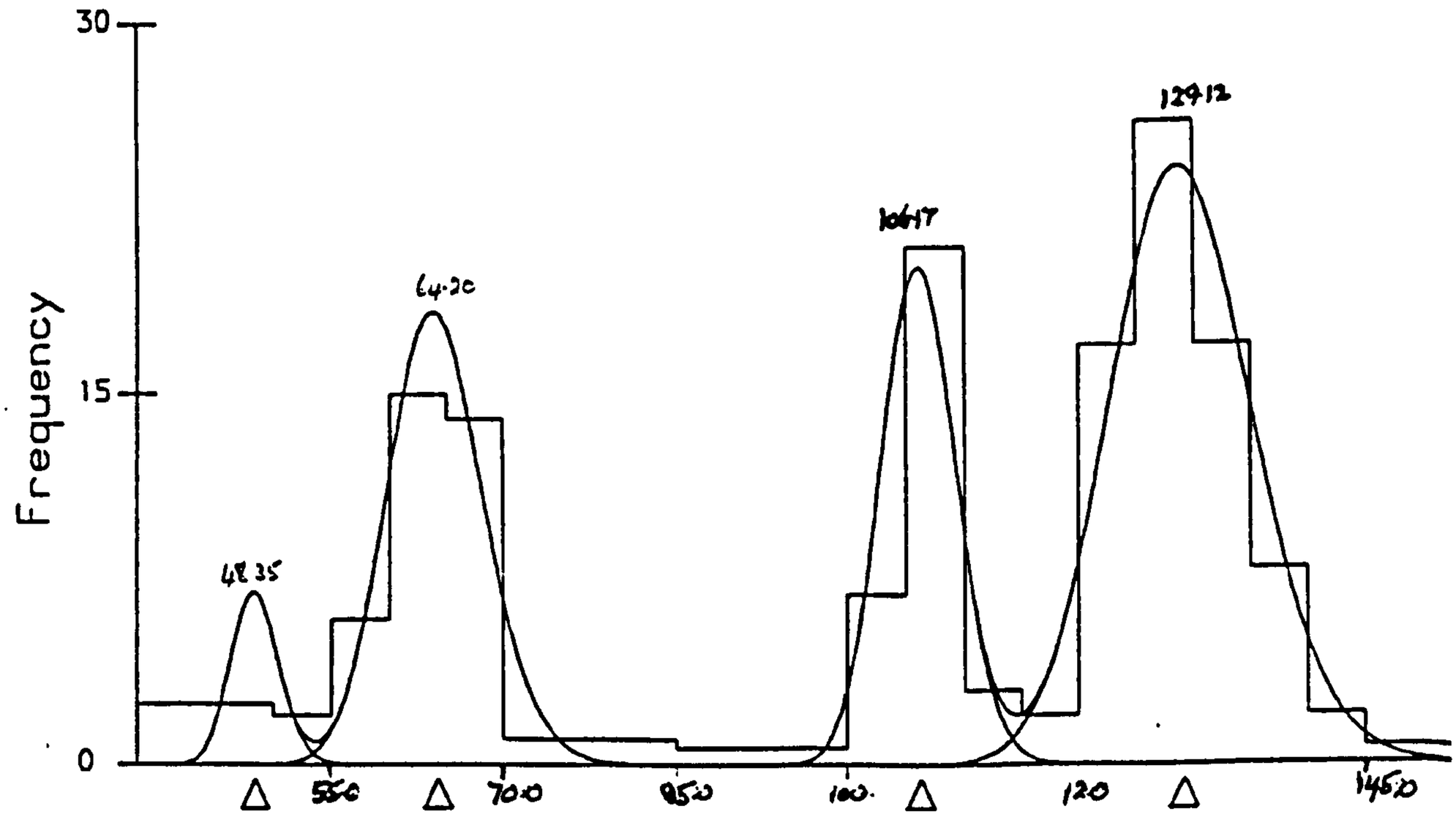


Figure 4,18. (Top) 1987/88: The four components were each well represented, but MIX would only converge if all the component means and proportions were fixed. The component means are indicated above the fitted mixture and all the parameters are given in Table 4,4.

Figure 4,19. (Bottom) 1987/88: A log-normal distribution resulted in an equally good fit to the data with four components. The component means are indicated above the fitted mixtures.

The horizontal axis is fork length (cm).

1987/1988:- Fitting a normal distribution resulted in a good fit, but the model would not converge if all the parameters were left free. The best fit resulted with just the 75.5 cm, 80.0 cm, 90.0 cm, and 95.0 cm right boundaries removed and with the proportions and means for all four components fixed and the standard deviations free (Table 4,4 and Fig. 4,18). A log-normal distribution, although the chi-squared = 10,34 (12df) was only slightly less, the probability (P = 0.59) was improved (Fig. 4,19).

Growth : If the mean lengths were constrained to lie on a growth curve, the fits to the data were poorer. The assumed progression of modes (Fig. 4,20) points to either an accelerated phase of growth between approximately 65.0 cm FL and 110.0 cm FL, or a missing age class, or that the assumption of a year between each component may not be valid. The third component of 1985/86 to the fourth component of 1986/87 appears as the only anomaly to the pattern (Fig. 4,20). However as this component was no smaller than expected in 1986/87 it is not likely to have been the result of depressed growth. The Powell plots are shown in Fig. 4,21 and the linear regression statistics, together with their confidence limits and the estimates of L_{inf} and Z/k are shown in Table 4,6.

	Slope	(conf. limits)	Intercept	(conf. limits)	L_{inf}	Z/k
1981/82 (n = 202)						
	[a] -0.36	(-0.45, -0.27)	57.47	(46.54, 68.40)	158.76	1.76
	[b] -0.31	(-0.39, -0.23)	5.95	(41.04, 60.86)	163.08	2.20
	[c] -0.28	(-0.37, -0.20)	47.02	(36.17, 57.87)	166.15	2.53
	[d] -0.39	(-0.59, -0.20)	62.24	(36.13, 88.36)	157.97	1.54
1982/83 (n = 353)						
	-0.27	(-0.36, -0.17)	44.24	(31.11, 57.34)	165.19	2.74
1983/84 (n = 209)						
	[a] -0.71	(-0.82, -0.61)	102.64	(89.84, 115.44)	143.66	0.40
	[b] -0.51	(-0.73, -0.28)	75.68	(45.82, 105.53)	149.56	0.98
	[c] -0.62	(-0.85, -0.38)	89.86	(59.19, 120.51)	145.40	0.62
1984/85 (n = 107)						
	-0.71	(-0.85, -0.56)	99.55	(80.87, 118.24)	141.20	0.42
1985/86 (n = 164)						
	[a] -0.29	(-0.41, -0.17)	49.21	(32.36, 66.05)	171.13	2.48
	[b] -0.28	(-0.35, -0.21)	47.76	(37.48, 58.04)	172.42	2.61
1986/87 (n = 462)						
	-0.71	(-0.96, -0.45)	102.37	(69.71, 135.03)	145.04	0.42
1987/88 (n = 153)						
	[a] -0.49	(-0.61, -0.37)	70.36	(55.79, 84.93)	144.28	1.05
	[b] -0.22	(-0.42, -0.22)	34.83	(9.27, 60.40)	159.22	3.57

Table 4,6. Linear regression statistics and the estimates of L_{inf} and Z/k for seven seasons using the Powell method (Powell, 1979) (see page 72). Superscripts indicate estimates for the cut-off points shown in Fig 4,21. L` is the chosen value of length for each calculation of ave.L - L`.

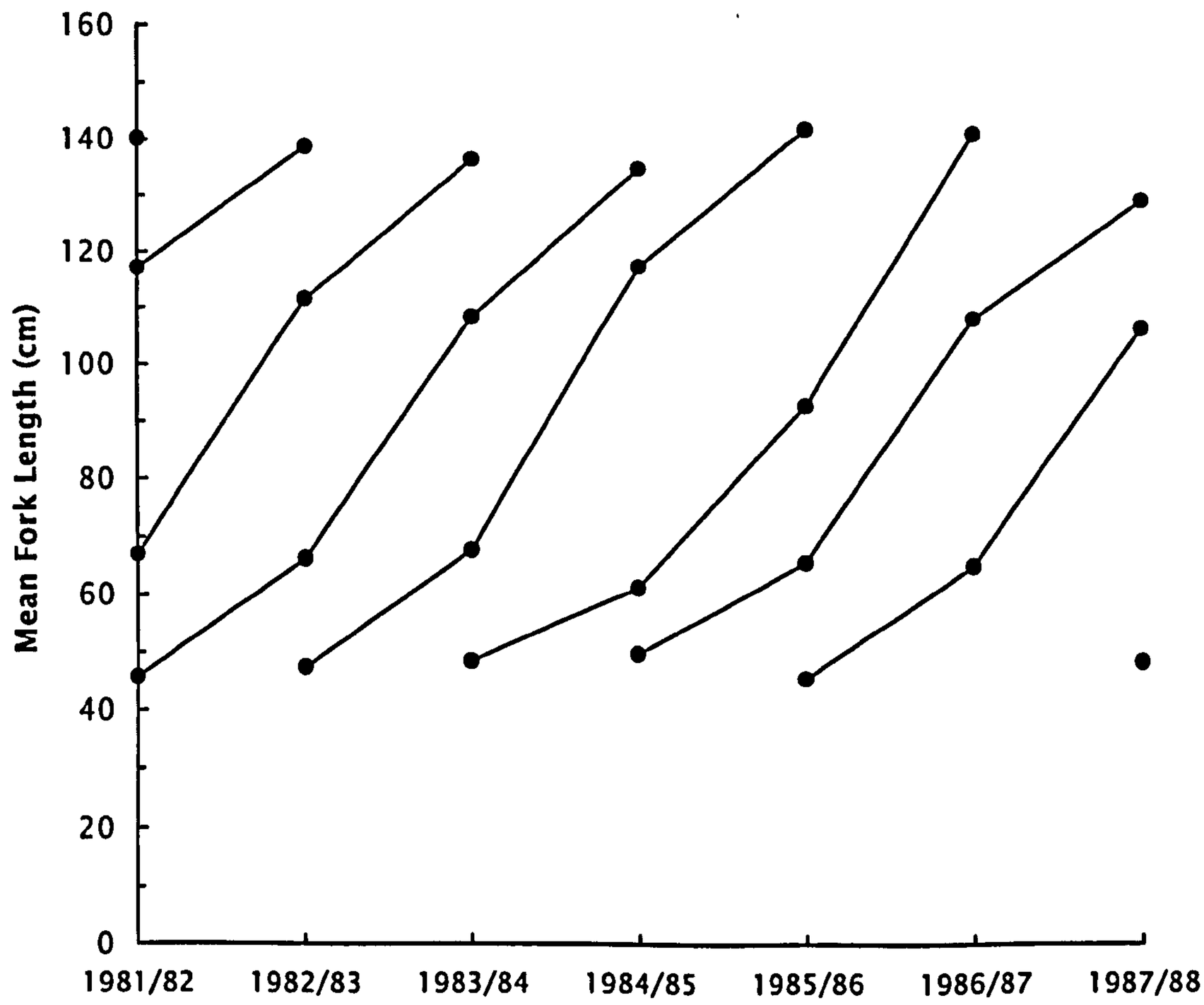


Figure 4,20. The assumed progression of modes between 1981/82-1987/88 for sport fishery-caught yellowfin tuna from the Pemba Channel, Kenya. The modal means were estimated by mixture analysis using the computer program MIX (Macdonald & Green, 1985).

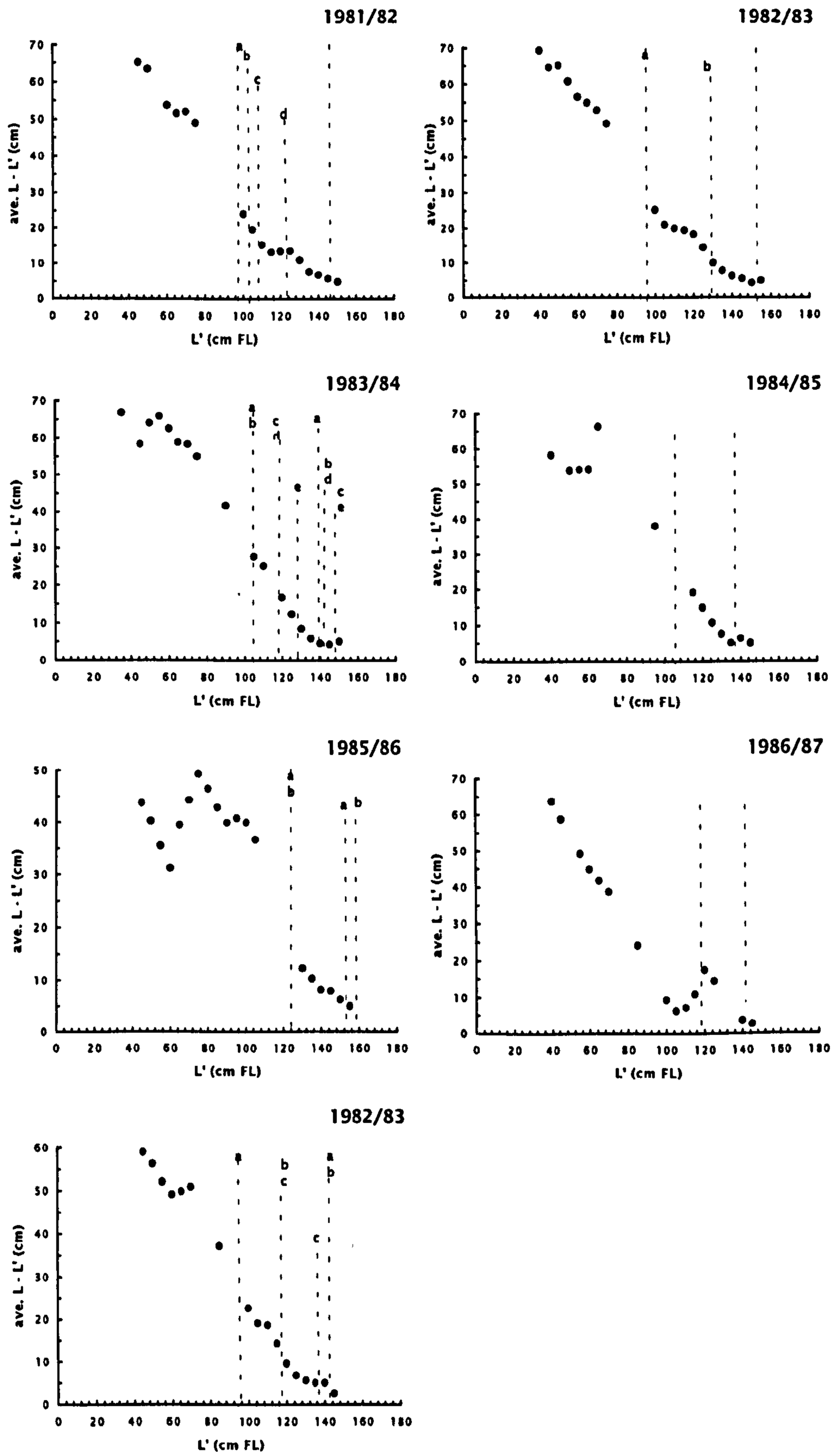


Figure 4,21. Powell plots for 1981/82-1987/88. The same length classes that yielded the best fits to the 'MIX' program (Macdonald & Green, 1985) were used for the cut-off lengths. The points that were used in the regression to calculate L_{inf} and k/Z are separated by broken lines. The regression statisics and estimates of L_{inf} and k/Z are given in Table 4,6.

Not all the data sets gave good estimates of L_{inf} and Z/k. Estimates of L_{inf} range from 141.20 cm FL to 172.42 cm FL and 0.04 to 3.57 for Z/k (Table 4,6). Most of the variation stems from the shape of the fourth component distribution. Where the fourth component is broad with an extended right-tail Z/k is high, as in 1981/82, 1982/83, 1985/86 and 1987/88. On the other hand, if the fourth component is either small or without the extended right-tail Z/k is less than 1.00 implying very high mortality, as in 1983/84, 1984/85 and 1986/87. Where it was possible to calculate more than one estimate of L_{inf} and Z/k these are shown in Table 4,6 unless the confidence limits were very wide.

	Proportion of annual catch			
Season	August	September	October	Total
1981/82	19.8	32.2	34.7	86.6
1982/83	19.3	47.9	31.4	98.6
1983/84	4.3	32.5	51.2	88.0
1984/85	15.0	58.9	23.4	97.2
1985/86	67.1	31.7	-	98.8
1986/87	44.4	32.5	19.0	95.9
1987/88	24.2	45.8	14.4	84.3

Table 4,7. The proportion of the total annual yellowfin tuna sample taken during the 'High Season' (August to October) by the Shimoni sport fishery. The 'Total' column represents the aggregate proportion of the annual catch landed during these months.

Monthly data: From between 86.6% to 98.8% of the total sport fishery catch of yellowfin tuna were landed during the months of August, September and October from 1981/82 to 1987/88 (Table 4,7). These three months are referred to as the 'High Season' for yellowfin tuna in the Pemba Channel, Kenya. The monthly length-frequency distributions demonstrate clearly defined modes consistent with those on the annual length-frequency histograms (Fig. 4,3). The total column refers to the proportion of the annual catch that was landed between 1st August and 31st October.

The estimates and their standard errors for the mean length of yellowfin tuna and the mean date of capture for each month are shown in Table 4,8 for component A fish, Table 4,9 for component B, Table 4,10 for component C and Table 4,11 for component D. High standard errors for the mean catch dates correspond to small sample sizes spread throughout the month.

		Component A	
		Fork Length Mean±se	Catch Date Mean±se
1981	Aug:	47.3±0.66	26.0
	Oct:	48.7±0.88	15.3±4.66
	Nov:	49.4±0.51	9.2±1.02
1982	Aug:	45.8±0.64	24.6±3.92
	Sep:	49.5±1.04	26.3±2.67
	Oct	49.0±0.53	21.2±1.64
1983	Sep:	46.8±2.75	14.0
	Oct:	48.3±0.45	26.5±0.85
1984	Aug:	49.5	2.0
	Sep:	50.3±0.97	25.8±2.53
	Oct:	49.4±0.78	20.8±2.24
1985	Aug:	49.2±0.44	29.7±0.66
	Sep:	48.3±0.78	16.5±6.65
1986	Sep:	47.2±0.66	12.0±2.45
1987	Sep:	47.0	5.0
	Oct:	47.5±0.50	21.0
	Nov	48.7±0.88	5.0

Table 4,8. The estimations and standard errors of mean fork lengths (cm) and mean catch dates for component A fish. If a given month was unrepresented it was not included in the table.

		Component B	
		Fork Length Mean±se	Catch Date Mean±se
1981	Aug:	64.7±0.99	20.8±4.0
	Sep:	65.8±0.53	1.0
	Oct:	69.0	24.0
	Nov:	70.0±0.41	14.1±1.46
1982	Aug:	62.9±0.73	19.4±3.12
	Sep:	64.7±0.56	7.6±1.38
	Oct:	69.2±0.88	14.8±2.61
1983	Aug:	66.8±0.33	31.0
	Sep:	67.7±1.14	12.0±3.75
1984	Aug:	61.9±0.56	7.4±1.44
	Sep:	63.5±0.89	30.0
	Oct:	62.7±0.69	17.3±1.92
1985	Aug:	65.0±0.39	22.6±0.89
	Sep:	67.5±0.77	8.3±1.57
1986	Aug:	64.7±1.83	19.5±2.64
	Sep:	64.8±0.52	15.0±1.90
	Oct:	64.6±1.54	5.0±1.00
	Nov:	65.0±0.86	13.5±0.80
1987	Aug:	65.0±0.79	19.7±2.72
	Sep:	64.0±0.87	6.8±0.64
	Nov:	67.7±0.44	2.3±1.33

Table 4,9. Estimated mean fork lengths (cm) and capture dates with standard errors for component B fish. If a given month was unrepresented it was not included in the table.

		Component C	
		Fork Length Mean±se	Catch Date Mean±se
1981	Aug:	113.2±0.64	20.4±1.58
	Sep:	115.2±1.05	18.7±1.30
	Oct:	119.9±0.50	18.2±1.11
	Nov:	119.0±0.58	1.0
1982	Aug:	109.6±0.61	15.7±0.31
	Sep:	112.7±0.69	13.3±1.31
	Oct:	115.0±0.77	11.0±0.78
1983	Aug:	115.0	14.0
	Sep:	108.9±0.66	10.5±0.75
1984	Aug:	125.0	27.0
	Sep:	121.8±1.65	19.5±3.69
1985	Aug:	105.0	27.0
	Sep:	104.0	2.0
1986	Aug:	107.2±0.26	20.1±0.40
	Sep:	110.0±0.37	11.1±0.76
	Oct:	110.0±0.49	12.3±0.65
1987	Aug:	115.5±2.52	18.9±1.48
	Sep:	101.5	27.0
	Oct:	109.2±1.32	14.6±3.25
	Nov:	106.3±1.55	9.5±5.17

Table 4,10. Estimated mean fork lengths (cm) and capture dates with standard errors for component C fish. If a given month was unrepresented it was not included in the table.

		Component D	
		Fork Length Mean±se	Catch Date Mean±se
1981	Aug:	134.6±1.64	20.6±2.86
	Sep:	138.2±1.16	16.9±1.91
	Oct:	138.3±0.77	16.0±2.11
	Nov:	127.0	1.0
1982	Aug:	132.9±1.94	18.6±3.14
	Sep:	137.8±0.48	16.1±0.71
	Oct:	136.4±1.06	10.8±1.62
1983	Aug:	138.0±2.74	22.0±0.58
	Sep:	135.0±1.14	20.2±1.44
	Oct:	136.3±0.58	5.6±0.48
1984	Aug:	130.0	27.0
	Sep:	135.1±0.61	15.3±1.34
1985	Aug:	137.6±1.02	22.4±1.74
	Sep:	138.6±1.68	15.0±3.38
1986	Aug:	140.3±1.3	22.0±1.88
	Sep:	143.0±0.71	13.0±5.18
	Oct:	135.5±1.50	13.0
1987	Aug:	129.2±0.95	22.3±1.88
	Sep:	130.4±0.83	17.1±0.51
	Oct:	128.5±1.12	3.4±0.37

Table 4,11. Estimated mean fork lengths and capture dates with standard errors for component D fish. If a given month was unrepresented it was not included in the table.

Estimated growth rates for component A fish are given in Table 4,12. Only the 1981 and 1982 samples yielded estimates apart from one each for 1983 and 1987. Sample sizes tended to be very small and catches of component A fish are often over a relatively short period.

Most years gave good growth estimates for component B, although those from 1986 were very small (Table 4,13). 1981 and 1982 appear to have given the best estimates for all the components. 1986 again yielded very small estimates for component C (Table 4,14). Component D resulted in rather more negative estimates of growth, which are most likely because this component is formed of more than one age class (Table 4,15).

	Growth Rates (cm/yr)					
	Aug-Sep	Aug-Oct	Aug-Nov	Sep-Oct	Sep-Nov	Oct-Nov
1981	n.d	(10.2)	(10.2)	n.d	n.d	(10.3)
1982	(41.3)	(20.3)	n.d	-	n.d	n.d
1983	n.d	n.d	n.d	(12.9)	n.d	n.d
1984	n.d	n.d	n.d	-	n.d	n.d
1985	-	n.d	n.d	n.d	n.d	n.d
1986	n.d	n.d	n.d	n.d	n.d	n.d
1987	n.d	n.d	n.d	n.d	n.d	(29.2)

Table 4,12. Estimated annual growth "rates" for component A fish. Estimates in parentheses represent samples of less than ten fish; n.d stands for no data; and '-' represents a negative growth rate.

	Growth Rates (cm/yr)					
	Aug-Sep	Aug-Oct	Aug-Nov	Sep-Oct	Sep-Nov	Oct-Nov
1981	(35.8)	n.d	(22.7)	n.d	20.7	n.d
1982	34.2	40.8	n.d	44.2	n.d	n.d
1983	(22.7)	n.d	n.d	n.d	n.d	n.d
1984	(10.9)	(4.1)	n.d	-	n.d	n.d
1985	54.6	n.d	n.d	n.d	n.d	n.d
1986	(1.4)	-	(1.3)	-	1.2	3.3
1987	-	n.d	(13.2)	n.d	(21.3)	n.d

Table 4,13. Estimated annual growth "rates" for component B fish. Estimates in parentheses represent samples of less than ten fish; n.d stands for no data; and '-' represents a negative growth rate.

	Growth Rates (cm/yr)					
	Aug-Sep	Aug-Oct	Aug-Nov	Sep-Oct	Sep-Nov	Oct-Nov
1981	24.9	41.6	(29.+2)	(58.2)	(32.0)	-
1982	39.6	35.0	n.d	30.3	n.d	n.d
1983	n.d	n.d	n.d	n.d	n.d	n.d
1984	n.d	n.d	n.d	n.d	n.d	n.d
1985	-	n.d	n.d	n.d	n.d	n.d
1986	48.1	19.2	n.d	-	n.d	n.d
1987	n.d	-	-	n.d	n.d	-

Table 4,14. Estimated annual growth "rates" for component C fish. Estimates in parentheses represent samples of less than ten fish; n.d stands for no data; and '-' represents a negative growth rate.

	Growth Rates (cm/yr)					
	Aug-Sep	Aug-Oct	Aug-Nov	Sep-Oct	Sep-Nov	Oct-Nov
1981	48.1	23.9	-	-	-	-
1982	(62.8)	(24.0)	n.d	-	n.d	n.d
1983	-	-	n.d	30.8	n.d	n.d
1984	n.d	n.d	n.d	n.d	n.d	n.d
1985	(15.5)	n.d	n.d	n.d	n.d	n.d
1986	(44.8)	-	n.d	-	n.d	n.d
1987	17.0	-	n.d	-	n.d	n.d

Table 4,15. Estimates annual growth "rates" for component D fish. Estimates in parentheses represent samples of less than ten fish; n.d stands for no data; and '-' represents a negative growth rate.

4.6. A PRINCIPAL COMPONENTS ANALYSIS OF THE MORPHOMETRICS

(a) The Untransformed Data: A Principal Components Analysis (PCA) of the morphometrics of sport fishery-caught yellowfin tuna from the Pemba Channel, Kenya revealed clusters of points separated by clear, or near clear zones (Figs. 4,22 and 4,23).

The first principal component-axis was responsible for more than 90% of the trace within all seven of the data sets (Table 4,16). Within this axis all the variables were of equal importance irrespective of whether there were as few as four, or as many as sixteen morphometric characters (Fig. 4,24).

However, the second and subsequent axes were always dominated by one or more variables. In all but 1984/85 and 1985/86 the variation within the second component was explained by the fin measurements, PF, 2DF and AF. The PF was slightly more important in 1981/82 and 1987/88, whereas the 2DF and AF were of greater importance in 1983/84 and 1986/87. In 1982/83 the PF was not recorded and the 2DF and AF were only slightly more important than the girth measurements. However, E was the dominant variable in both 1984/85 and 1985/86 with the fins exerting their influence on the third component. Increasing the number of variables had the effect of reducing the influence of the second component, but had little effect upon that of the first.

The third component-axis was responsible for less than 1% of the variation within the trace of all but 1986/87. Increasing the number of variables had the effect of reducing the influence exerted by the girths. The 2DF and AF exert strong influence on 1984/85 and 1985/86, but show opposite effects in 1982/83. The PF was the dominant variable in 1986/87 and 1987/88, and M was particularly strong in 1983/84.

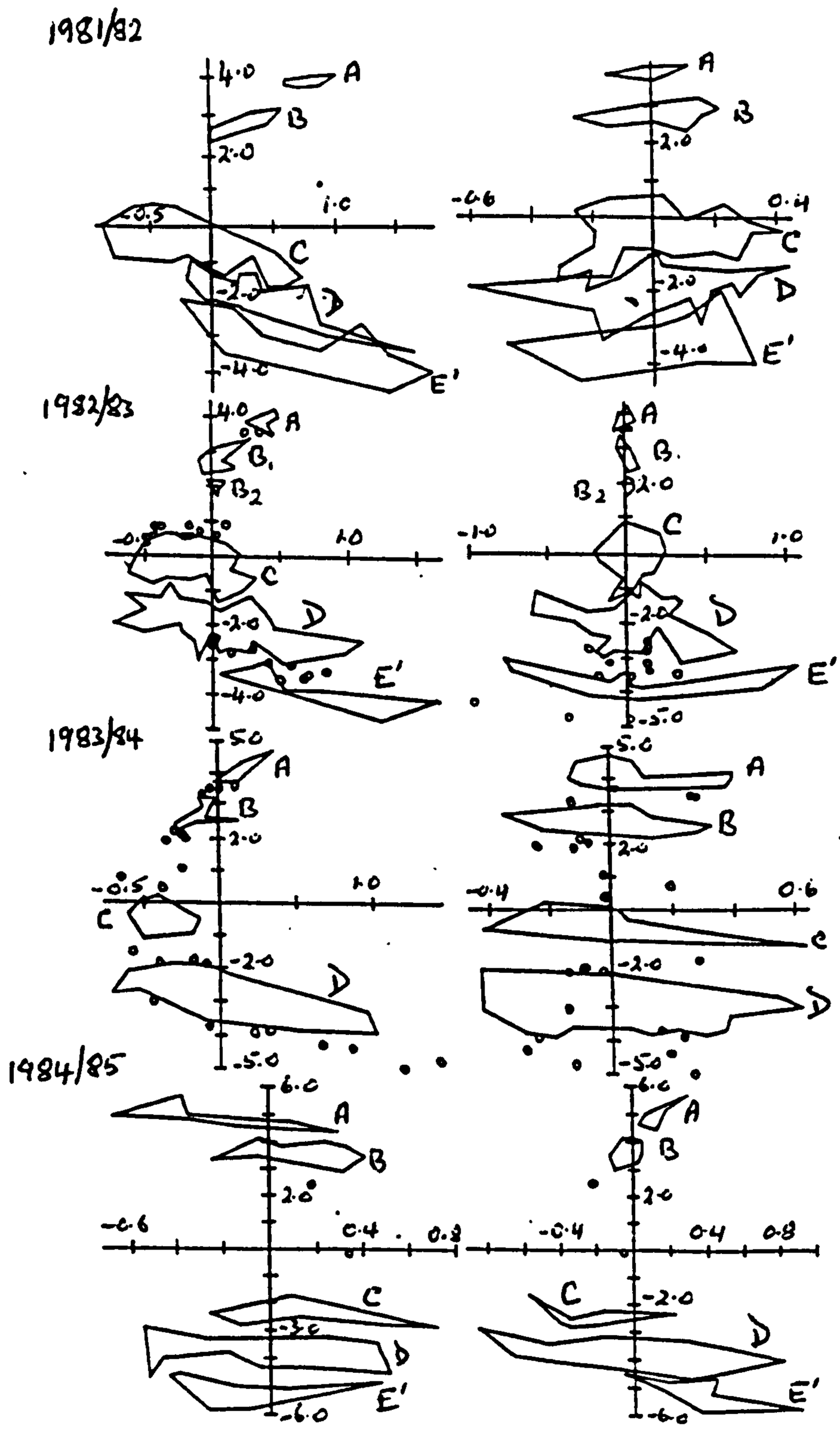


Figure 4,22. The plots resulting from a Principal Components Analysis of the raw morphometric measures with fork length excluded, 1981/82-1984/85. The polygons are labeled A to E′ and the size-ranges within each are given in Table 4,17. The polygons were drawn about the clusters joining up the most extreme members of each group as according to the modes on the length frequency histograms. Data points that did not fit obviously into a cluster were left out as outlying points. For each season the plot to the left is the first Principal Component axis versus the second, and on the right is the first plotted against the third Principal Component axis

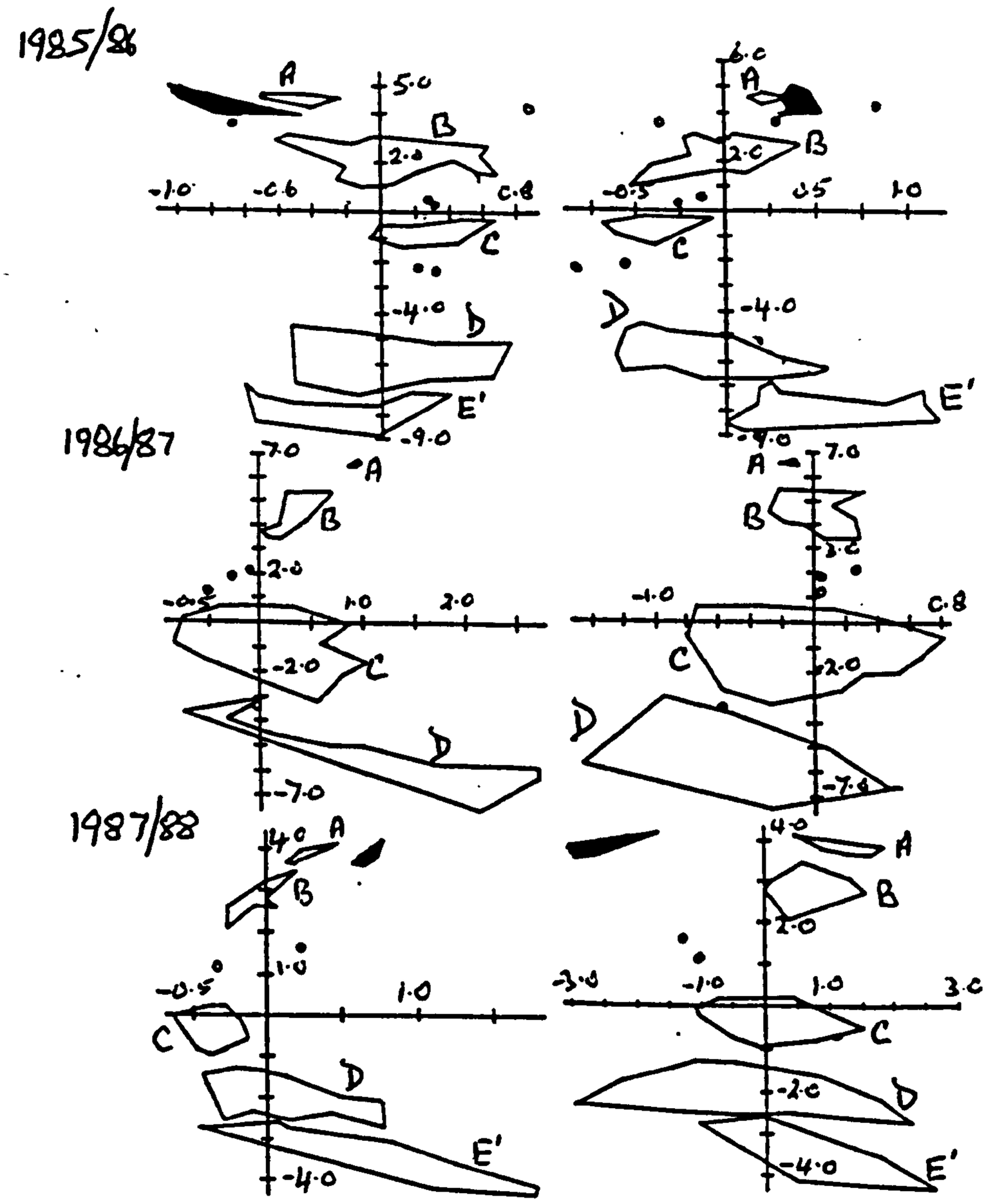


Figure 4,23. The plots resulting from a Principal Components Analysis of the raw morphometric measures with fork length excluded, 1985/86-1987/88. The polygons are labelled A to E' and the size-ranges within each are given in Table 4,17. The polygons were drawn about the clusters joining up the most extreme members of each group according to the modes on the length frequency histograms. Data points that did not fit obviously into a cluster were left out as outlying points. For each season the plot to the left is the first component axis versus the second, and on the right is the first plotted against the third Principal Component axis. The small samples of skipjack tuna, *Katsuwonus pelamis* polygons (shaded) are separated from the yellowfin tuna polygons (unshaded).

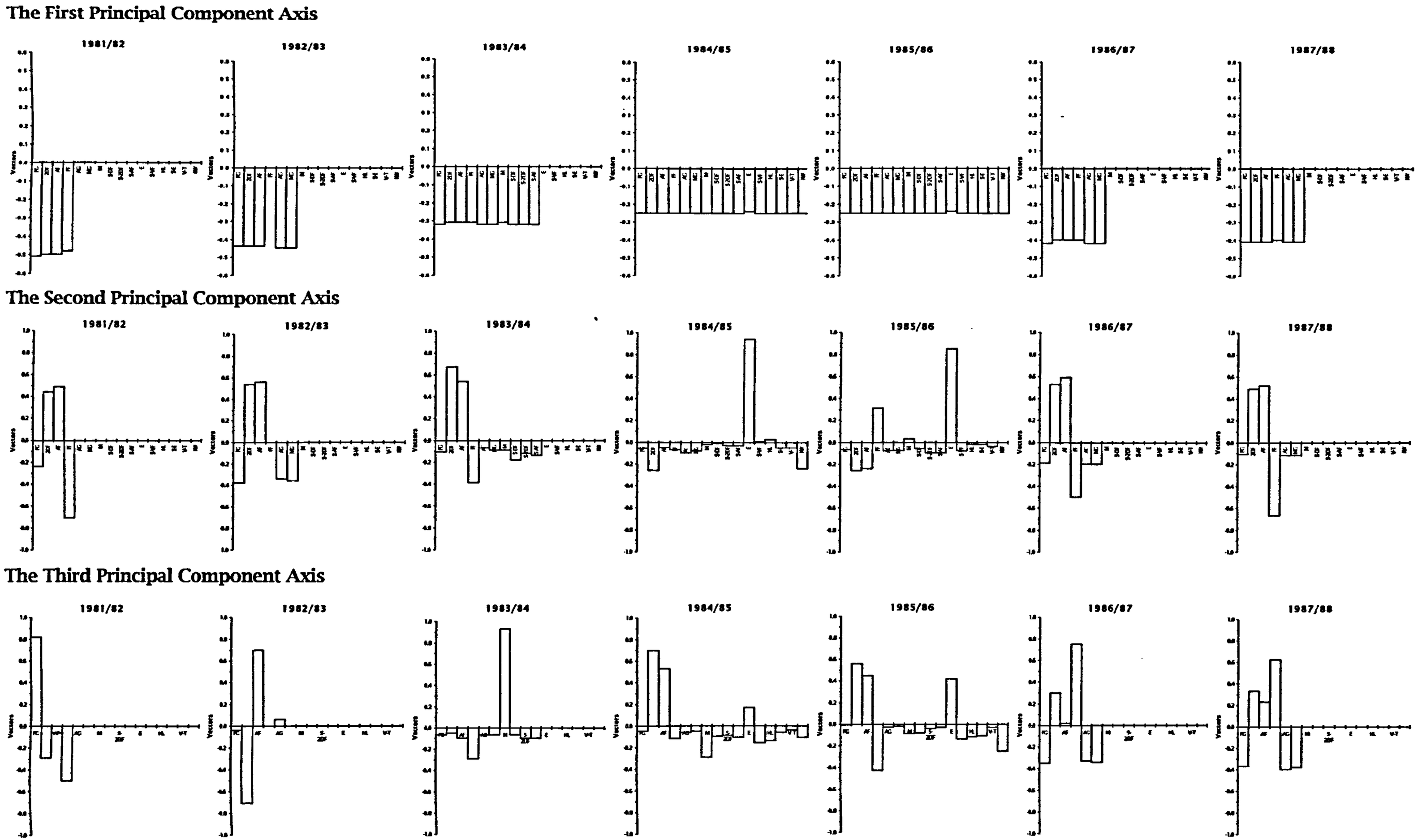


Figure 4,24. The vectors resulting from a principle components analysis of the raw morphometric measurements of sport fishery-caught yellowfin tuna, with fork length excluded from 1981/82-1987/88. The first three PCs are given. The number of morphometrics measured varied from one season to another and a list of those used is given in Table 4,1. Loadings of the morphometric measures are, from left to right: PG; 2DF; AF; PF; AG; MG; M; S-DF; S-2DF; S-AF; E; S-VF; HL; S-E; V-T, and KW. A full description of these measures is given in the methods, section 4.2.

All the untransformed morphometrics were very highly correlated with one another, implying that an increase in yellowfin tuna FL leads to a proportionate increase in the other morphometrics (see Appendix C).

All but the PF, 2DF and AF are directly proportional to the FL (Fig. 4,25). The FL is directly proportional to the $\log_e$ 2DF and $\log_e$ AF. Because the actual heights of the second dorsal and anal fins were used, a crescent-shaped plot was produced by whichever axis was strongly influenced by them. As a result the second principal component-axis causes this shape in all but the 1984/85 and the 1985/86 data sets, where the third component-axis was responsible. However, this effect was not produced by the third component of 1982/83 because these two morphometrics showed equally strong opposing vectors. The PF, on the other hand is proportional to the $\log_e$ FL.

The clusters were best separated by a plot of the first principal component versus the third in all, but the 1984/85 and 1985/86 data sets. In the latter two seasons the best results were produced by a plot of the first versus the second component axes where the fin length measurements do not complicate the plot with the crescent-shape. Variability in length of the 2DF and AF of larger yellowfin tuna may be dependent upon factors other than FL, such as gonad maturity.

Polygons drawn about the clusters corresponding to the modes on the length-frequency histograms (Fig. 4,4) are illustrated in Figs. 4,22 and 4,23. Plots are shown for both the primary axis against the second principal component axis, and the first versus the third principal component axes.

	% Trace		
Season	**1**	**2**	**3**
1981/82	92.71	6.20	0.68
1982/83	97.02	2.31	0.54
1983/84	97.78	1.25	0.45
1984/85	98.28	0.55	0.44
1985/86	97.02	0.95	0.71
1986/87	94.05	3.99	1.28
1987/88	96.30	2.60	0.81

Table 4,16. The relative importance of each of the three major axes following a Principal Components Analysis of the untransformed morphometrics of sport fishery-caught yellowfin tuna from the Pemba Channel, Kenya, with the fork length excluded.

1981/82: A plot between the first two axes clearly demonstrates the crescent-shape mentioned above (Fig. 4,22). The polygons in the plot of the first versus the third axes are arranged along the first component axis according to the FL (Fig. 4,22). The two groups of juvenile yellowfin tuna are separated from one another

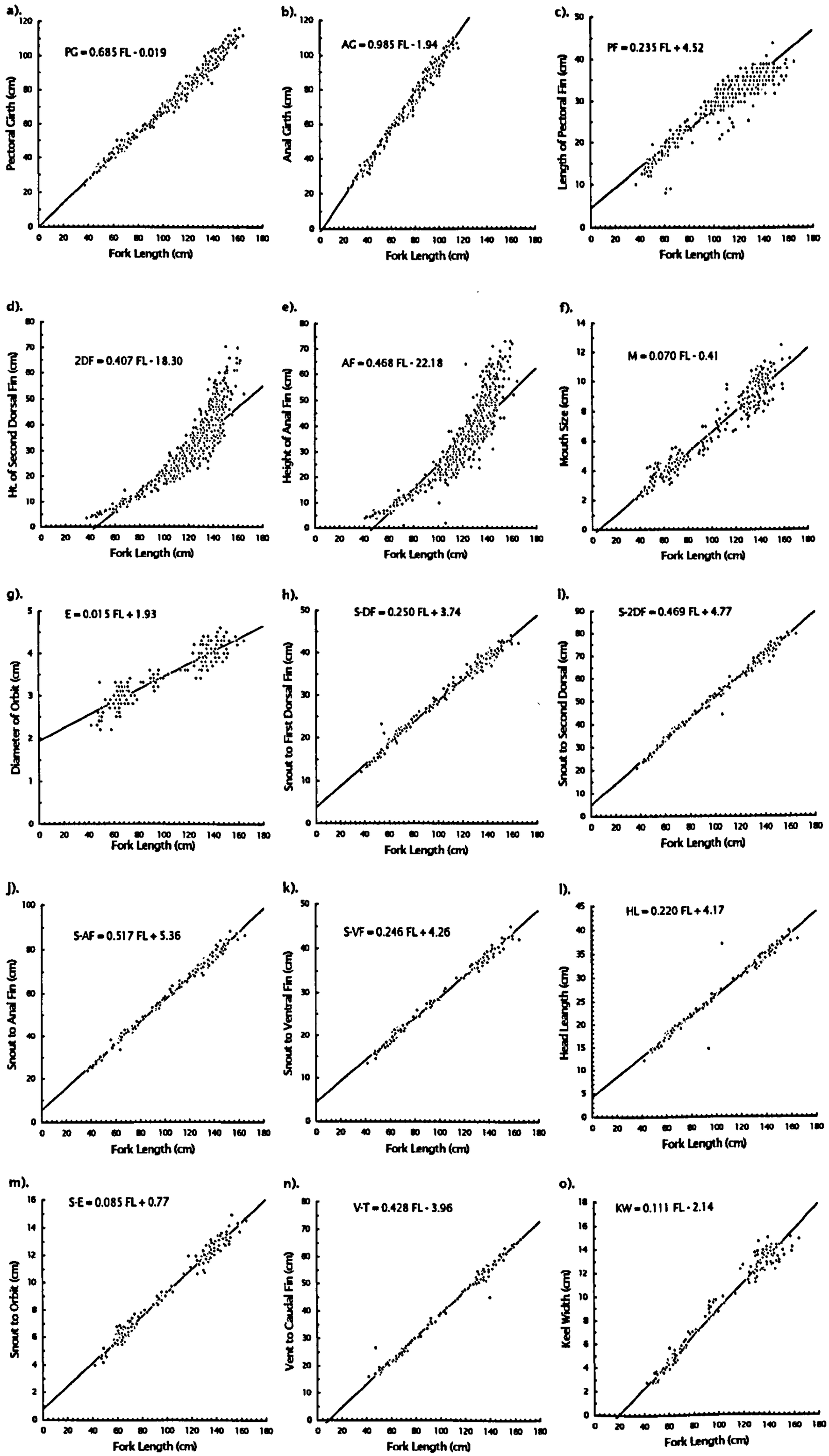


Figure 4,25. The linear regressions with fork length of the morphometric measurements of yellowfin tuna used in the Principal Components Analysis. The regression equations are also given. [a). Pectoral girth (PG); b). Anal girth (AG); c). Pectoral fin (PF); d). Second dorsal fin (2DF); e). Anal fin (AF); f). Mouth size (M); g). Diameter of orbit (E); h) Snout to first dorsal fin (S DF); i). Snout to second dorsal fin (S-2DF); j). Snout to anal fin (S-AF); k). Snout to ventral fin (S-VF); l). Head length (HL); m). Snout to orbit (S-E); n). Vent to caudal fin (V-T); o). Keel width (KW).

without any overlap, but those of the older age groups, although clearly arranged along the primary axis do show some degree of overlap.

1982/83: The first two axes again demonstrate the crescent shape (Fig. 4,22), but the modes from the histogram are arranged along the primary component axis. The plot of the first principal component versus the third possibly illustrates a clearer picture without the contaminating effect of the 2DF and the AF (Fig. 4,22). The PCA implies that the right-hand tail of the second mode on the histogram may belong to a different cluster, or age class. The right-hand tail of the fourth mode also appears as a separate cluster, although there are outlying points between these polygons. However, these polygons do clearly demonstrate that the PCA dissects the morphometrics according to FL and arranges them along the most important axis.

1983/84: The histogram demonstrates four very clear modes (Fig. 4,4) and these each appear as distinctly separate polygons on the PCA plots (Figs. 4,22). The plot of the first principal component versus the third is the clearer of the two graphs.

1984/85: In this case it is the plot of the first principal component versus the third that produces the crescent-shape (Fig. 4,22). The histogram only suggests three modes, and the separation between the first two is not obvious (Fig. 4,4). However, both these groups are clearly separated on the PCA plots (Fig. 4,22). The last mode on the histogram shows extended left and right tails, both of which appear as separate clusters on the PCA plots.

1985/86: As with 1984/85 the first principal component versus the third demonstrates the crescent-shape (Fig. 4,23). However, the other plot also shows a slight reverse crescent because the 2DF and the AF exert a slight opposite effect on the second principal component (Fig. 4,23). The histograms suggest five modes and all of these are illustrated by individual polygons on the PCA plots.

1986/87: As with 1981/82, 1982/83, 1983/84 and 1987/88 the crescent-shape is demonstrated by the first principal component versus the second (Fig. 4,23). All four modes on the histogram (Fig. 4,4) are represented by polygons on the PCA plots (Fig. 4,23). The size of the polygon is not indicative as to the size of the mode on the histogram.

1987/88: The histogram indicates four modes (Fig. 4,4), but the PCA plots show the right tail of the fourth mode as a separate cluster (Fig. 4,23). Each of the clusters are very clearly separated from one another.

Season	Size-Class (cm FL) A	B	C	D	E'
1981/82	46.0-51.0	62.0-79.0	103.0-129.0	132.0-144.0	146.0-159.0
1982/83	42.0-55.0	60.0-74.5[1] 77.0-87.5[2]	106.0-125.0	125.5-145.0	151.0-155.0
1983/84	41.0-54.5	61.5-73.5	105.0-113.0	126.0-145.0	
1984/85	42.0-53.5	57.0-68.0	114.0-125.0	126.0-140.0	142.0-151.0
1985/86	47.0-50.5	60.0-79.0	89.5-100.0	130.0-145.0	146.0-165.0
1986/87	45.0-49.0	58.5-77.0	98.5-124.0	135.0-149.0	
1987/88	47.0-52.5	56.0-73.0	100.0-118.0	120.0-125.5	137.0-149.0

Table 4,17. The size-ranges of the polygons, labeled A-E' in Figures 4,22 and 4,23. These groups do not necessarily agree with the ages identified in Figure 4,28 as with the larger classes more than one age-class may have been combined in a single cluster. Two clusters were identified for group B fish in 1984/85 and have been labeled B_1 and B_2 in Figure 4,22.

b) Morphometrics Transformed to a Proportion of FL: Polygons were drawn utilizing the same size-classes that were used for the raw morphometrics in the previous section. Only the plots of the first principal component versus the second are shown (Figs. 4,26). Despite a greater degree of overlapping clustering was still apparent.

Season	% Trace 1	2	3
1981/82	64.53	23.14	11.42
1982/83	57.67	32.68	8.41
1983/84	53.24	21.58	9.57
1984/85	68.96	13.29	5.82
1985/86	54.28	14.01	10.05
1986/87	44.70	36.71	10.62
1987/88	44.35	32.72	16.27

Table 4,18. The relative importance of each of the three major axes following a Principal Components Analysis of yellowfin tuna morphometrics transformed to a proportion of fork length, with fork length subsequently removed.

The transformation of the morphometrics considerably reduced the correlations between the variables (see Appendix D). However, strong relationships still occurred between the girths and with the 2DF and AF.

With length removed, the dominance of the first principal component was reduced with greater importance passing to the second and third components (Table 4,18). As with the untransformed data, increasing the number of morphometric measurements reduced the influence of the second component.

For each of the principal axes the nature of the dominant variables depended upon the number and type of morphometrics included within the data sets (Fig.

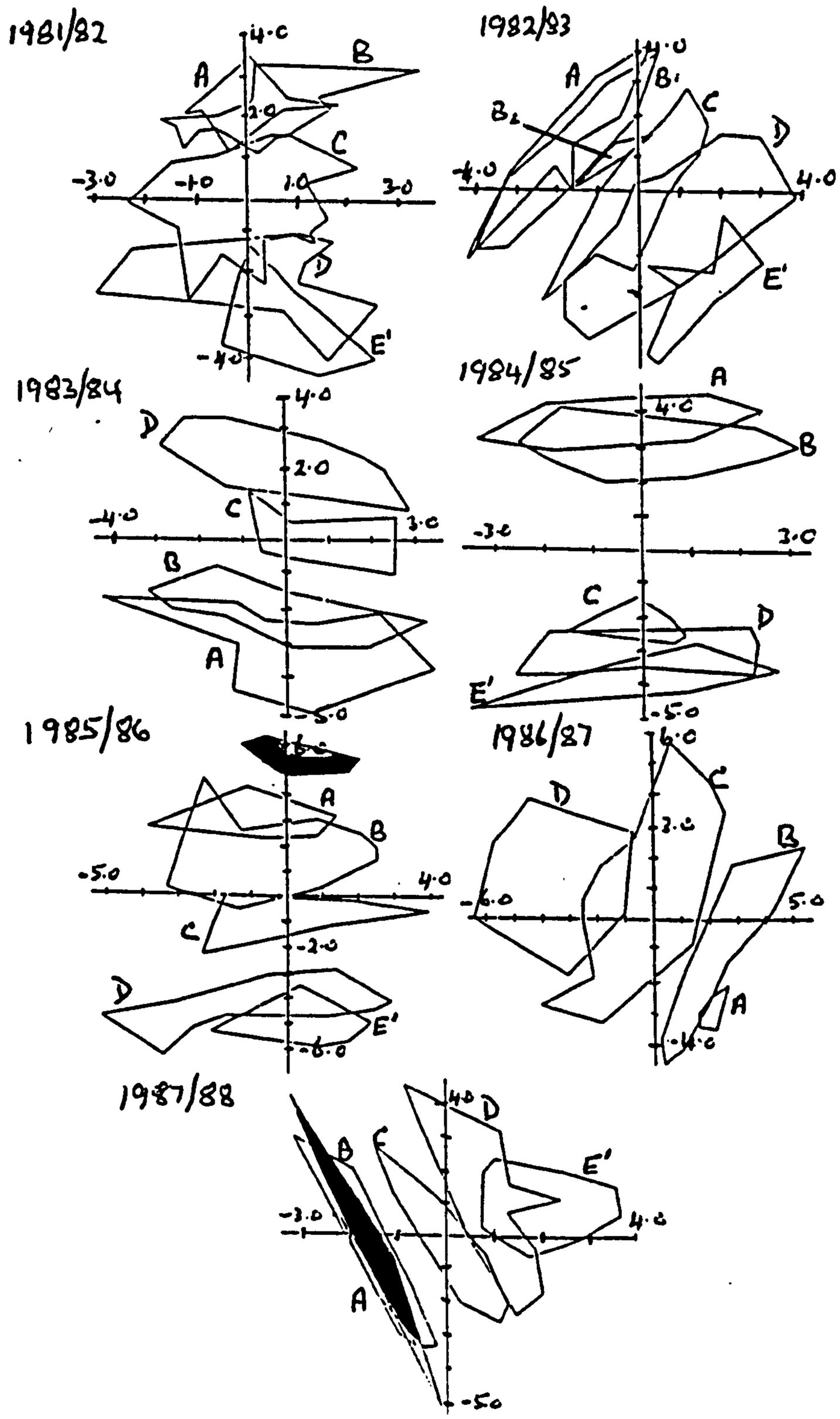


Figure 4,26. Plots resulting from a Principal Components Analysis of the yellowfin tuna morphometrics transformed to a proportion of fork length, 1981/82-1987/88. Only the plots of the first (vertical axes) versus the second component (horizontal) axes are shown. The polygons are labeled A to E′ and the size-ranges within each are given in Table 4,17. The polygons were drawn about the clusters of points by joining up the most extreme members of each group, which represent the modes on the length frequency histograms. The polygons representing the small samples of skipjack tuna in 1985/86 and 1987/88 are shown shaded.

4,27). Usually more than one variable was important within the first component. In 1981/82 the 2DF and AF dominated with a strong opposing effect from the PF, and in 1982/83 all the variables had a strong influence apart from the PG. The snout to fin measurements were very important in 1983/84, 1984/85 and 1985/86.

Although the same morphometrics may have been recorded in two separate seasons the vectors frequently differed. For example, in 1984/85 the influence of the PF was stronger than in 1985/86 and in 1986/87, the three girth measurements show as strong negative vectors, and in 1987/88 they are equally strong positive vectors. The strength of the influence of a given character is likely to depend upon the age structure of the sample.

The girths exerted the strongest influence on the variation within the second component with the exception of 1982/83, 1986/87 and 1987/88 when the 2DF and AF were of equal importance.

The third component was dominated by a single variable in all but the 1982/83 season when the PG and AG exerted equally strong opposite effects. The PF was the most important variable in 1981/82, 1985/86, 1986/87 and 1987/88 and M in 1983/84 and 1984/85. Again the 1984/85 and 1985/86 data sets contained the same morphometrics, but different dominant variables.

1981/82: Although there is a great deal of overlap, it is still apparent that the data points are arranged along the first principal component axis according to FL (Fig. 4,26).

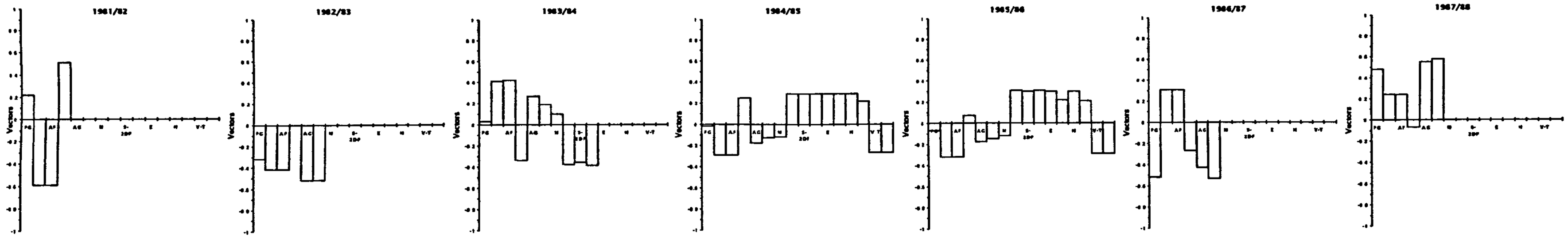
1982/83: The first two groups overlap considerably, whereas the polygons representing the larger size classes appear fairly well separated from one another with only a small degree of overlap (Fig. 4,26).

1983/84: The plot shows only a small degree of overlap between the first two groups and none between the two larger size classes (Fig. 4,26). It is interesting that this plot appears as the reverse of the other plots with the largest fish having the largest first principal component transformed co-ordinates.

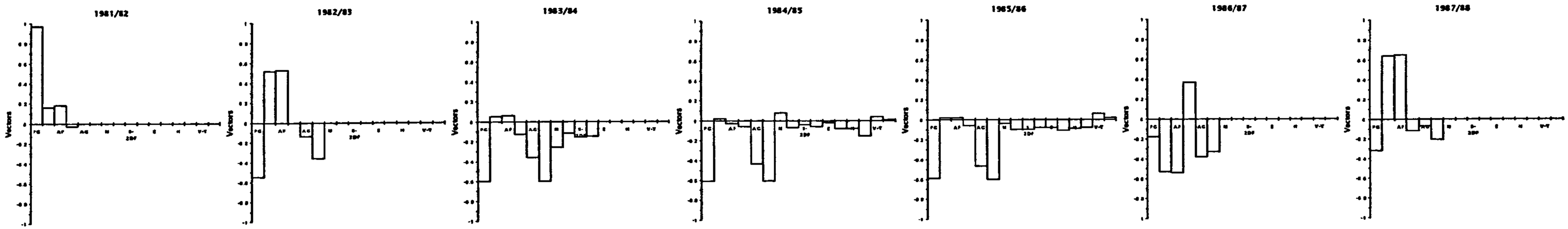
1984/85: Although the polygons do show a greater degree of overlap, the wide gap between the second and third size classes is still very obvious (Fig. 4,26).

1985/86: The gap on the histogram between the third and fourth modes is still apparent on the transformed PCA plot (Fig. 4,26). The polygons of this data set demonstrate a relatively small degree of overlap.

The First Principal Component Axis



The Second Principal Component Axis



The Third Principal Component Axis

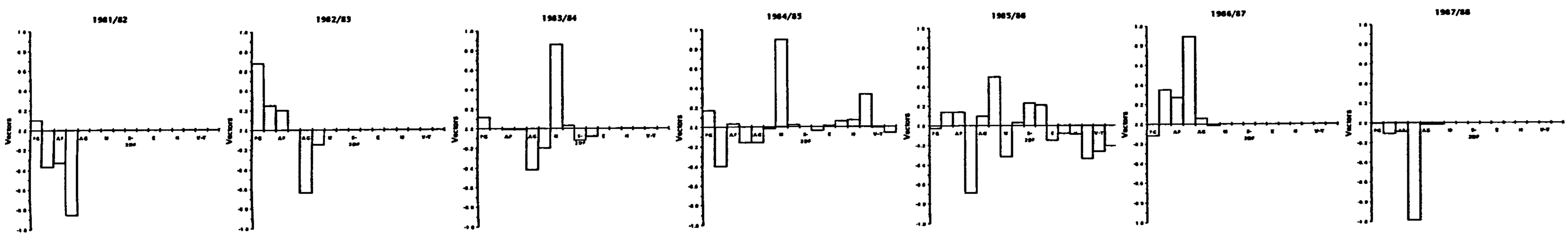


Figure 4,27. The vectors resulting from a principle components analysis of the morphometric measurements divided by fork length of sport fishery-caught yellowfin tuna, with fork length excluded from 1981/82-1987/88. The first three PCs are given. The number of morphometrics measured varied from one season to another and a list of those used is given in Table 4,1. Loadings of the morphometric measures are, from left to right: PG; 2DF; AF; PF; AG; MG; M; S-DF; S-2DF; S-AF; E; S-VF; HL; S-E; V-T; KW. A full description of these measures is laid out in the methods, section 4.2.

1986/87: The polygons illustrate a very small degree of overlap and show a clear gap between the second and third size groups (Fig. 4,26).

1987/88: Only a small degree of overlap is apparent, with a particularly good separation between the third and fourth polygons (Fig. 4,26).

The Identification of Age Classes: Apart from 1984/85 and 1985/86 the plots of the first principal component against the third were considered the most useful for purposes of identifying age classes. The first and second principal components were used for 1984/85 and 1985/86 to avoid the strong influence of the 2DF and the AF.

Polygons were drawn about the clusters as before, but not necessarily in concordance with the modes from mixture analysis. Polygons were drawn free-hand on the plots by drawing around the concentrations of points that obviously made up the clusters. The FL's of the yellowfin tuna within each polygon were extracted from the data files and used to calculate means and standard errors for each age-class.

The mean lengths of each cluster were compared to the results from MIX using a t-test. Points that were distanced from any particular cluster or that could belong equally well to either of two neighbouring polygons were left as outliners.

The assumed age classes were labeled as A, B, C, D, E′ and F to correspond to the component groups identified by MIX for ease of comparison, with A corresponding to the smallest size group, B the next size up, and so forth.

1981/82: Six clusters were identified and there were no outliers (Fig. 4,28). Polygons A, B, E′ and F were particularly well isolated. It is possible that two people working independently of one another might draw polygons C and D slightly differently, but it is unlikely that the resultant means would be significantly different (Table 4,19).

1982/83: This was one of the largest data sets with possibly the best range in sizes. There were appreciable numbers of both small and larger yellowfin tuna. Seven polygons were drawn with four outlying points, two between polygons A and B, and two beyond polygon F (Fig. 4,28). Polygons B_1 and B_2 were not separable using MIX. The means and their standard errors for each polygon are shown in Table 4,20.

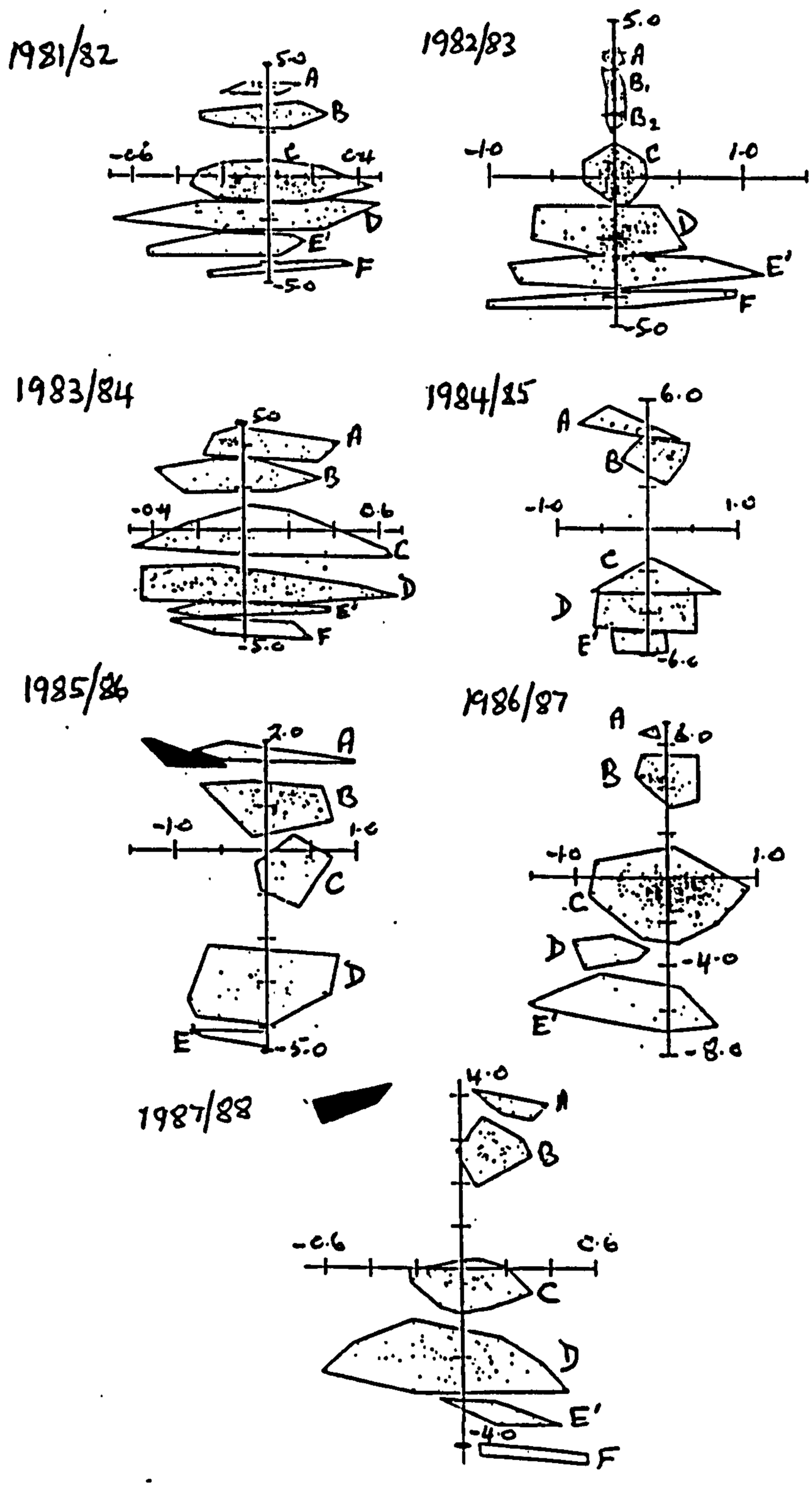


Figure 4,28. Polygons of apparent age groups of yellowfin tuna are shown following a Principal Components Analysis of the raw morphometrics with fork length excluded. The first (vertical axis) versus the third component (horizontal) axis has been used in all but 1984/85 when the first versus second axes were used. The polygons have been labeled A to F and their parameters are given in Tables 4,18 to 4,24. The shaded polygons in the 1985/86 and 1987/88 samples represent small groups of skipjack tuna.

Year	Polygon	n	Mean	s	se
1981	A	10	48.6	1.52	0.48
	B	35	68.2	3.55	0.60
	C	106	117.8	5.56	0.54
	D	33	136.2	6.32	1.10
	E	9	145.9	4.77	1.59
	F	4	155.5	3.42	1.71

Table 4,19 The means, standard deviations (s) and standard errors (se) of seven age groups identified from the plot of the first principal component against the third following a Principal Component Analysis of the 1981/82 yellowfin tuna morphometrics.

Year	Polygon	n	Mean	s	se
1982	A	33	48.1	1.86	0.32
	B_1	39	65.3	3.33	0.53
	B_2	11	77.4	4.98	1.50
	C	135	112.3	5.15	0.44
	D	88	136.6	4.92	0.52
	E′	27	145.1	4.33	0.83
	F	6	154.0	4.29	1.75

Table 4,20. The means, standard deviations (s) and standard errors (se) of seven age groups identified from the plot of the first principal component against the third following a Principal Component Analysis of the 1982/83 yellowfin tuna morphometrics.

1983/84: A PCA clearly distributed this data set along the primary axis into six clusters (Fig. 4,28). Between polygons C and D one data point was left out as it appeared to lie halfway between the two clusters. The means and their standard errors are shown in Table 4,21.

1984/85: Within this data set there was a very large gap between polygons B and C with just a single fish. It was only possible to draw five polygons (Fig. 4,28), and their means and standard errors are shown in Table 4,22.

Year	Polygon	n	Mean	s	se
1983	A	55	49.1	3.29	0.44
	B	23	69.4	5.13	1.07
	C	22	106.9	5.77	1.23
	D	76	135.0	4.93	0.57
	E′	14	144.1	2.79	0.74
	F	4	152.8	4.27	2.14

Table 4,21. The means, standard deviations (s) and standard errors (se) of six age groups identified from the plot of the first principal component against the third following a Principal Components Analysis of the 1983/84 yellowfin tuna morphometrics.

Year	Polygon	n	Mean	s	se
1984	A	18	49.9	2.47	0.58
	B	29	62.0	3.28	0.61
	C	8	122.2	4.39	1.55
	D	36	135.2	4.20	0.70
	E′	5	146.8	3.49	1.56

Table 4,22. The means, standard deviations (s) and standard errors (se) of five age groups identified from the plot of the first principal component against the second following a Principal Components Analysis of the 1984/85 yellowfin tuna morphometrics.

1985/86: There was a very clear separation between polygons A and B, although two data points were left as outliers (Fig. 4,28). All five polygons were clearly isolated from one another, although three other outlying points were left between polygons B and C. The means and standard errors of each polygon are shown in Table 4,23.

1986/87: There were five polygons identified with two outliers between polygons B and C and one larger than the group E' fish (Fig. 4,28). The means and standard errors of the polygons are shown in Table 4,24.

Year	Polygon	n	Mean	s	se
1985	A	7	48.6	1.28	0.48
	B	88	66.2	4.01	0.43
	C	17	93.6	6.04	1.47
	D	37	140.5	6.54	1.07
	E'	3	160.8	3.69	2.13

Table 4,23. The means, standard deviations (s) and standard errors (se) of five age groups identified from the plot of the first principal component against the second following a Principal Components Analysis of the 1985/86 yellowfin tuna morphometrics.

Year	Polygon	n	Mean	s	se
1986	A	5	47.2	1.48	0.66
	B	52	65.4	3.81	0.53
	C	280	108.6	4.44	0.27
	D	6	130.0	7.56	3.09
	E'	11	142.5	3.24	0.98

Table 4,24. The means, standard deviations (s) and standard errors (se) of five age groups identified from the plot of the first principal component against the third following a Principal Components Analysis of the 1986/87 yellowfin tuna morphometrics.

1987/88: Clusters very clearly separated from one another and six polygons were drawn with just two outliers between polygons B and C (Fig. 4,28). If we remove the lower four data points of polygon C into a separate group the mean of C is reduced to 106.5±0.51 (Table 4,25). However, a test of significance between the two means gives a value of $t_{(0.05)} = 1.263$, which at 60 degrees of freedom is not significant. and therefore these four points have been left within polygon C.

Year	Polygon	n	Mean	s	se
1987	A	8	49.1	2.24	0.79
	B	37	64.2	3.84	0.63
	C	33	107.6	3.93	0.68
	D	63	128.8	4.38	0.55
	E'	5	139.1	1.02	0.46
	F	3	147.5	2.29	1.32

Table 4,25. The means, standard deviations (s) and standard errors (se) of six age groups identified from the plot of the first principal component against the third following a Principal Components Analysis of the 1987/88 yellowfin tuna morphometrics.

Differentiation of Species: The small samples of skipjack tuna *Katsuwonus pelamis* included with the yellowfin tuna data in 1985/86 and 1987/88 formed distinctly separate clusters. The third component of the transformed data was particularly useful in separating out the two species.

i) The untransformed data: The 1985/86 sample of skipjack tuna ranged from 48.5-50.5 cm FL, overlapping in size the 47.0-50.5 cm FL yellowfin tuna. The two species did show some overlap in both the plots of the first principal component versus the second and that of the first versus the third component axis (Fig 4,23).

The skipjack tuna of 1987/88, 52.0-61.0 cm FL were more comparable in size to the second cluster of yellowfin tuna, 56.0-73.0 cm FL. Only a single skipjack tuna overlapped with the first group of yellowfin tuna in terms of size only. In both the plots of Fig. 4,23 the skipjack tuna polygon is very clearly separated from those of the yellowfin tuna. This is particularly apparent in the plot of the first component axis against the third (Fig. 4,23).

ii) Morphometrics as a proportion of fish size: The first principal component axis versus the second separated the two species in 1985/86 only (Fig. 4,26). That of 1987/88 shows the skipjack tuna polygon completely overlapping that of the 57.0-73.0 cm FL yellowfin tuna (Fig. 4,26)

However, the plot of the first principal component versus the third completely isolated the two species from one another for both 1985/86 and 1987/88 (Fig. 4,29).

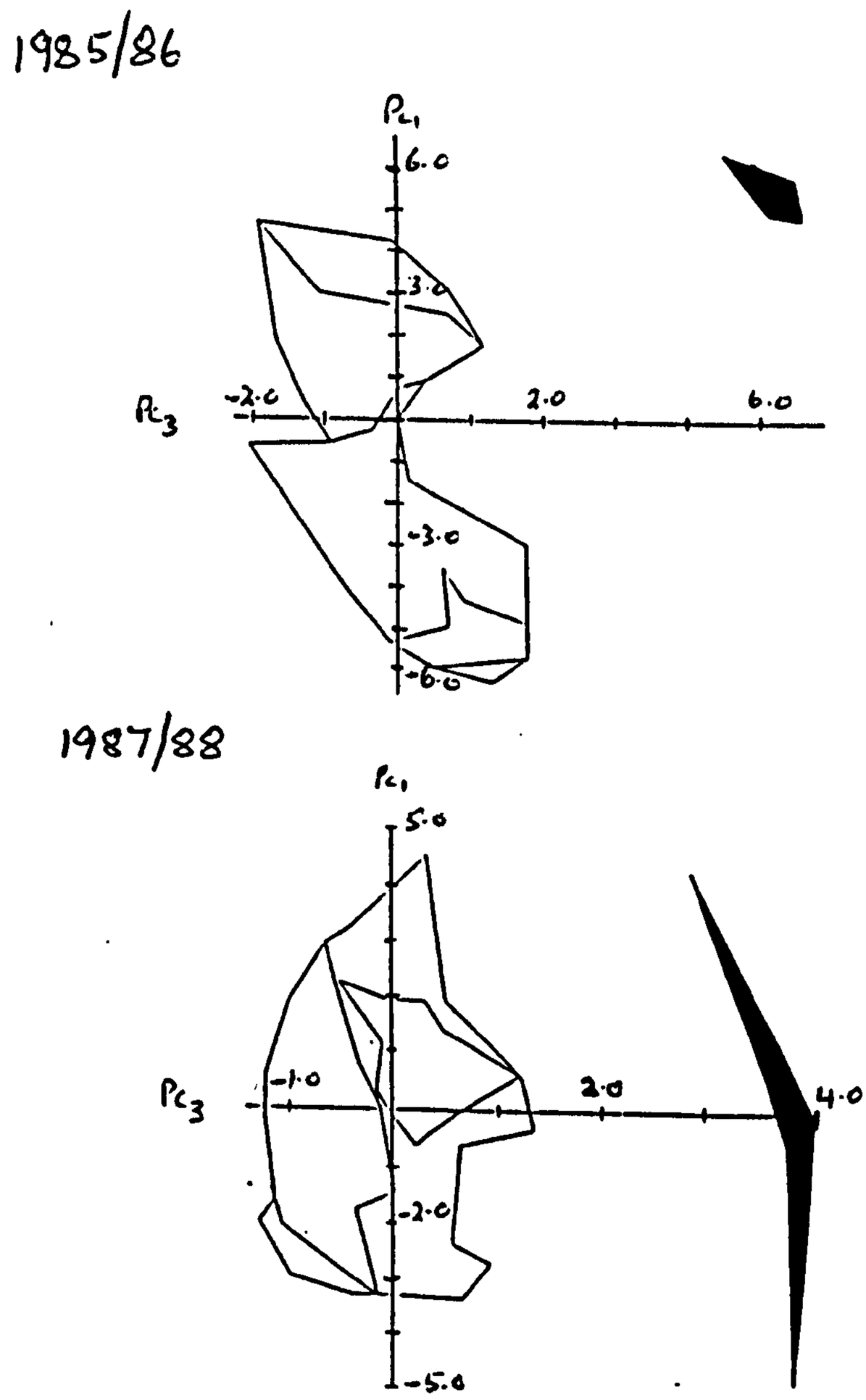


Figure 4,29. Small samples of skipjack tuna were clearly separated from the yellowfin tuna data by a Principal Components Analysis of the morphometrics. The clearest segregation resulted from a plot of the first (vertical axes) versus the third Principal Component (horizontal axes) using the morphometric measures transformed to a proportion of fork length. The skipjack tuna polygons are shaded, and the yellowfin tuna polygons, unshaded.

4.4 Discussion

LENGTH-FREQUENCY ANALYSIS

The component means, identified by mixture analysis showed very little variation from 1981/82 to 1987/88 with the only exception being component C in 1985/86 (Table 4,26). This supports the hypothesis that the modes on the histograms do represent age-classes.

	Component Means (cm FL)			
Sample	A	B	C	D
1981/82	45.79	66.94	117.17	140.20
1982/83	47.63	66.30	111.64	138.88
1983/84	48.70	67.85	108.43	136.57
1984/85	49.83	61.41	117.46	134.92
1985/86	45.59	65.57	92.74	141.84
1986/87	46.58	64.93	108.00	141.04
1987/88	48.35	64.20	106.17	129.12

Table 4,26. Estimated means (cm FL) for each of the four component age groups resulting from a mixture analysis (Macdonald & Pitcher, 1979) of seven length-frequency samples of sport fishery-caught yellowfin tuna from the Pemba Channel, Kenya.

Yellowfin tuna size-frequency distributions demonstrate clear polymodality, enabling MIX to converge well, although the sample sizes of some of the components were occasionally very small. An aged sub-sample from, for example otoliths, or a PCA of the morphometrics (see later section) may be useful to decompose the fourth component further.

PRINCIPAL COMPONENTS ANALYSIS OF THE MORPHOMETRICS

A Principal Components Analysis was successfully used to dissect the morphometric data of sport fishery-caught yellowfin tuna from the Pemba Channel, Kenya into clusters of similarly-sized individuals.

The results illustrate that more than 90% of the variation is explained by the first principal component, and that all the morphometric variables are strongly correlated with one another. Because of the strong relationships between the morphometrics and fork length, the data is arranged into clusters of points according to fish size.

It has been clearly demonstrated that these clusters closely resemble the modes on the length-frequency histograms. The first principal component axis may be called the "Fork Length Axis".

Clustering is still observed, albeit with more overlapping, when the data is transformed to a proportion of FL. The purpose of this was to reduce the influence of fish size by weakening the relationships between the morphometric variables, and to see if the data still formed clusters. The transformation also had the effect of increasing the importance of the secondary axes.

The number of morphometric characters ranged from as few as four in 1981/82 to sixteen in 1984/85 and 1985/86, and clustering was observed in each case. The sample sizes also varied from 97 to 353 with at least five clusters identifiable in all cases.

Identification of Age Classes - Best results were obtained using the untransformed morphometric data, with fork length excluded. The clearest plots are those between the "Fork Length Axis" and either the second, or third component axes. The choice between the latter two depends upon which one is not influenced by the 2DF and the AF. These two characters were shown to complicate the plot with a crescent-shaped arrangement of clusters.

The means and the relative proportions of the assumed age groups resulting from both a Mixture Analysis of the length-frequencies and from a Principal Components Analysis of the morphometrics are shown in Table 4,27. The pairs of means for each polygon were compared using a t-test and the results are illustrated in Table 4,28.

A PCA of the morphometrics revealed more component age groups than was possible using MIX. MIX was not able to converge if more than four components were selected for, and with at least one data set, the model was unable to converge with any confidence on as many as four groups. All the older fish had to be grouped together into a single component by MIX, whereas a PCA is able to split this 'fourth' component into between two and four smaller age groups.

COMPARISON OF THE COMPONENT MEANS IDENTIFIED FROM THE TWO METHODS: MIXTURE ANALYSIS OF LENGTH-FREQUENCIES AND PRINCIPAL COMPONENTS ANALYSIS OF MORPHOMETRICS

A t-test was used to test for any significant difference between the means attained by the two separate methods for each component group (Table 4,28). For 1981 there was very good agreement between the two methods for components B and C. However, the mean for component A was significantly lower than that calculated from the PCA plot. MIX was only able to detect a single fourth component, whereas DFACT revealed three smaller groups and the means of even the smallest of these were significantly different to that from MIX.

	MIX			DFACT		
Year	Mean±se	Prop.	n	Mean±se	Prop.	n
1981	45.79±3.00	0.05	202	48.6±0.48	0.05	197
	66.94±0.67	0.17		68.2±0.60	0.18	
	117.17±0.66	0.54		117.8±0.54	0.54	
	140.20±1.25	0.23		{136.2±1.10	0.17	
				{145.9±1.59	0.05	
				{155.5±1.71	0.02	
1982	47.63±0.58	0.09		48.1±0.32	0.10	343
	66.30±1.04	0.15		{65.3±0.53	0.11	
				{77.4±1.50	0.03	
	111.64±0.52	0.39		112.3±0.44	0.39	
	138.88±0.74	0.37		{136.6±0.52	0.26	
				{145.1±0.83	0.08	
				{154.0±1.75	0.02	
				{157.0±4.00	0.01	
1983	48.70±0.48	0.26	209	49.1±0.44	0.28	195
	67.85±1.73	0.12		69.4±1.07	0.12	
	108.43±0.91	0.11		106.9±1.23	0.11	
	136.57±0.65	0.50		{135.0±0.57	0.39	
				{144.2±0.80	0.07	
				{152.8±2.14	0.02	
1984	49.83±0.66	0.18	107	49.9±0.58	0.19	97
	61.41±0.59	0.28		62.0±0.61	0.30	
	117.46±4.18	0.05		122.2±1.55	0.05	
	134.92±1.05	0.49		{135.2±0.70	0.37	
				{146.8±1.56	0.05	
1985	45.59	0.04	164	48.6±0.48	0.05	154
	65.57	0.57		66.2±0.43	0.57	
	92.74	0.12		93.6±1.47	0.11	
	141.84	0.27		{140.5±1.07	0.24	
				{160.8±2.13	0.02	
1986	46.58	0.01	462	47.2±0.66	0.01	357
	64.93	0.11		65.4±0.53	0.15	
	108.00	0.84		108.6±0.27	0.78	
	141.04	0.03		{130.0±3.09	0.02	
				{142.5±0.98	0.03	
1987	48.35	0.05	153	49.1±0.79	0.05	151
	64.20	0.25		64.2±0.63	0.25	
	106.17	0.21		107.6±0.68	0.22	
	129.12	0.49		{128.8±0.55	0.42	
				{139.1±0.46	0.03	
				{147.5±1.32	0.02	

Table 4.27. The means and the relative proportions of the component age groups resulting from a Mixture Analysis of the length-frequencies (MIX) and a Principal Components Analysis (DFACT) of yellowfin tuna morphometrics from the Shimoni sport fishery. The curly brackets denote the further decomposition of the fourth MIX component by DFACT into from two to four components.

	MIX		DFACT		STUDENT T-TEST		
Year	Mean	n	Mean	n	t(0.05)	df	sig
1981	45.8	10	48.6	10	3.249	18	SIG
	67.0	34	68.2	35	1.513	67	NS
	117.2	109	117.8	106	0.811	213	NS
	140.2	46	{136.2	33	2.606	77	SIG
			{145.9	9	2.333	53	SIG
1982	47.7	32	48.1	33	1.142	63	NS
	66.3	53	65.3	39	0.925	90	NS
	111.6	138	112.3	135	1.060	271	NS
	138.9	130	136.6	88	2.600	216	SIG
1983	48.7	54	49.1	55	0.682	107	NS
	67.8	25	69.4	23	0.896	46	NS
	108.4	23	106.9	22	1.063	43	NS
	136.6	105	135.0	76	1.804	179	NS
1984	49.8	19	49.9	18	1.108	35	NS
	61.4	30	62.0	29	0.795	57	NS
	117.5	5	122.2	8	1.608	11	NS
	134.9	53	135.2	35	0.231	86	NS
1985	45.6	7	48.6	7	2.890	12	SIG
	65.6	93	66.2	88	1.001	179	NS
	92.7	20	93.6	17	0.443	35	NS
	141.8	44	140.5	37	0.795	79	NS
1986	46.6	5	47.2	5	0.547	8	NS
	64.9	51	65.4	52	0.593	101	NS
	108.0	388	108.6	280	1.786	666	NS
	141.0	14	{130.0	6	4.718	19	SIG
			{142.5	11	1.086	23	NS
1987	48.4	8	49.1	8	0.721	14	NS
	64.2	38	64.2	37			NS
	106.2	32	107.6	33	1.614	63	NS
	129.1	75	128.8	63	0.340	136	NS

Table 4,28. Student's t-test comparison of the component means estimated by a Mixture Analysis of length-frequencies (MIX) and by a Principal Components Analysis (DFACT) of yellowfin tuna morphometrics from the Shimoni sport fishery.

The results of the t-tests show that there is very good agreement between the two methods. For the smallest fish only the means of 1981/82 and 1985/86 were significantly different at $t_{(0.05)}$. All the means corresponding to the second and third MIX components were in agreement, except that the PCA plots for 1982/83 imply that the second MIX age group may in fact be made up of two groups and not one (Table 4,20).

Whereas MIX was only able to detect a single fourth component, the PCA plots revealed from two to four age groups within this component. As a result the mean size estimated by MIX did not always agree with those calculated from the PCA polygons. A PCA of the 1981/82 data split this group into three clusters and none of the respective means corresponded with that estimated by MIX. The same was true for 1982/83. However, of three clusters identified within this group for 1983/84, there was good agreement between the mean from MIX and that for the first of the three clusters. Similarly for 1984/85, although a small group of older

fish were separated out by the PCA the remaining cluster of fish still had a similar mean size to that estimated by MIX. The remaining three data sets showed similar results to that above.

One of the major problems encountered using MIX was the relatively small sample sizes used, and in particular the small numbers of very small and very large fish. MIX did converge very well on some of the data sets, but in no case was it possible to detect more than four age-classes. On the other hand, a Principal Components Analysis of the morphometrics yielded very good results with these sport fishery samples. Too large a sample would obscure the plots and make it difficult to detect clusters.

As with MIX a wide range of sizes is required. Data sets such as that of 1986/87 where 78% of the sample was of a single age class, are of little use for the detection of age classes, irrespective of which method is being used. The best data set was that of 1982/83 in which eight age classes were detected.

It must be noted that the dominance of a single age class in the catches is not necessarily the result of a biased sampling. For example, during 1986/87, most of the yellowfin tuna schools in the Pemba Channel were of polygon C fish (mean FL = 108.6±0.27) and very few other size groups were either represented in the sample or seen in clear observations of surface schools.

A useful attribute of the sport fishery and the Principal Components Analysis method is that it is easy to monitor. Landed catches tend to be smaller than from commercial fleets and more time is available for the collection of data from each fish. A PCA has also been shown to work best on smaller samples of 100-400 individuals than other methods of ageing.

However, as these results illustrate, it is not necessary to collect more than four morphometrics from each fish. The length of time required to measure a group of fish for a PCA would be no longer than that needed to measure the fork length of a far greater number of fish for length-frequency analysis.

Errors in measuring are rapidly detected by a PCA. Such fish form outlying points often well away from the rest of the data. Because DFACT identifies each fish by an identification number, it is a simple matter to check the data file and locate where the problem lies. Likewise typing mistakes made while entering the data file are often easily detected.

The program DFACT is a simple to use tool for ageing. Although entering the data file can be time consuming, as can the calculations of the means and standard errors, which had to be done by hand in the present study. The running of the program is very simple. The options are set in the command lines at the

beginning and end of the data file. Empty classes cannot render the fit invalid as with MIX and there is no need to coalesce two or more size classes.

Separation of Species: The results from the PCA of the morphometrics suggest that the pattern of clusters may be species-specific. The small group of skipjack tuna included within the yellowfin tuna data were isolated from the yellowfin tuna pattern by the PCA.

The plot of the first and third principal components of the morphometrics transformed to a proportion of fork length resulted in the most striking separation of the two species. This was despite the skipjack tuna being of a similar size to the yellowfin tuna. Turner *et al.* (1989) used a multivariate analysis with some success in separating out the different species of chambo (*Oreochromis spp.*) from Lake Malawi.

This may well identify another useful attribute of the PCA as a tool for ageing samples of yellowfin tuna. It appears that a PCA may be able to identify contamination by other species within a sample. Existing length-frequency methods are unable to do this. Samples of skipjack and yellowfin tunas are simple enough to distinguish between in the field, but it would be particularly useful if a PCA is able to isolate bigeye tuna (*Thunnus obesus*) from yellowfin tuna samples. It is often very difficult to distinguish between these two species without examining the liver. As the livers of all yellowfin tuna were examined to confirm species identification no bigeye tuna were caught by the Shimoni sport fishery between 1981 and 1988 (see Chapter 5).

GROWTH OF YELLOWFIN TUNA

As mentioned earlier, there is some controversy in the literature regarding the growth of juvenile yellowfin tuna. Much of the evidence for slow juvenile growth has come from work carried out in the Gulf of Guinea, where there seems to be a permanent concentration of 35.0-70.0 cm FL yellowfin tuna (Fonteneau, 1979). Fonteneau collected size-frequency samples from the cannery at Tema, in Ghana, between 1973-1976. From studies of monthly modal progressions using Petersen's method, he detected a regular transfer of modes from recruitment to the fishery at approximately 43.0 cm FL to their disappearance from the fishery at 60.0 cm, 12 months later. This gave a mean growth rate of 1.42 cm/month. Fonteneau confirmed the results from modal progression with a tag-recapture study in the Gulf of Guinea, which yielded very similar estimates. Tagging suggests a slow growth phase for fish less than 70.0 cm of 1.40 cm/month, and a faster rate above 70.0 cm FL of 3.11 cm/month. Bard (1983) suggested a linearised growth rate of 1.48 cm/month for fish of 35.0-65.0 cm followed by an increase in growth rate at approximately 65.0 cm FL from further tagging studies

in the Gulf of Guinea. Miyabe (1983) supports these results with a mark-recapture study in the same area.

Evidence for the slow growth of juvenile yellowfin tuna is not restricted to the Gulf of Guinea. Marsac & Lablache (1985) sampled the Franco-Ivorian purse-seine fleet in the Western Indian Ocean and using Petersen's method, they estimated growth at 1.6 cm/month for fish of 39.0-57.0 cm FL with an abrupt acceleration in rate within the 57.0-76.0 cm FL interval to 3.1 cm/month

However, Anderson (1988) emphasized the shortcomings of the Petersen method in a study of length-frequency distributions of yellowfin tuna from the area around the Maldives, Sri Lanka and Southern India. He was able to suggest two possible growth rates, a 'slow' rate of 1.5±0.1 cm/month and a 'fast' rate of 2.9±0.4 cm/month for yellowfin tuna of 30.0-70.0 cm FL.

In contrast, the work of Wild & Foreman (1980) and Wild (1986) using otoliths marked with tetracycline, in the Eastern Pacific did not reveal evidence of slow juvenile growth. They deduced that yellowfin tuna of 40.0-110.0 cm FL grow at a linear rate of 3.21±0.04 cm/month. Marcille & Stéquert (1976) estimated growth at approximately 3.0 cm/month for 45.0-70,0 cm FL yellowfin tuna from the area off the NW coast of the Malagasy Republic, using Petersen's method. However, Anderson (1988) claims that it is possible to re-draw Marcille and Stéquert's data to produce a slow rate, or those of Marsac & Lablache (1985) to give a faster rate. Two recent studies in the Western Indian Ocean on the growth of yellowfin tuna, both using the Bhattacharya routine assuming von Bertalanffy growth for dissecting size frequency data, have yielded quite different results. Marsac (1991) supports the hypothesis of a slow juvenile growth rate of 1.5 cm/month for yellowfin tuna of less than 70 cm FL whereupon the rate increases to 4.0 cm/month. On the other hand, Yesaki (1991) estimated a growth rate of 2.8 cm/month for yellowfin tuna in the 30-90 cm FL interval..

Wang & Tanaka (1986) from the tag-recapture of 19 yellowfin tuna in the Indian Ocean estimated growth at 3.32 cm/month. Their fish varied from 35.0-72.0 cm FL at the time of release and 54.0-106.0 cm FL at recapture. However, their size ranges could sit either side of the inflection point suggested by Fonteneau (1979), Bard (1983), Miyabe (1983) and Marsac & Lablache (1985), which might be expected to bias their growth estimates. Wang and Tanaka (1986) also calculated growth from the analysis of scale rings by Huang *et al.* (1973) from longline-caught fish to be 3.39 cm/month for 52.0-92.0 cm FL fish.

Wild (1986) suggests that the rate of 3.21±0.04 cm/month might be applicable to fish of less than 40.0 cm FL. However, both Uchiyama & Struhsaker (1981) and the more recent study of Yamanaka (1988) suggest that this may not be the case. Uchiyama & Struhsaker (1981) studied the otoliths of 14 yellowfin tuna from the

Central Pacific and detected a faster rate of 4.2 cm/month for yellowfin tuna of 0-64.2 cm FL, whereupon the growth rate apparently slows down to 2.7 cm/month for 64.2-93.0 cm FL yellowfin tuna. Yamanaka (1988) aged 157 yellowfin tuna of 15.4-79.0 cm FL in the Philippines by electron microscopy of the otoliths. The results indicated two linear stanzas of growth with an inflection point at 33.5 cm FL. A very fast daily growth rate of 0.229 cm (6.87 cm/month) was detected for 15.4-33.5 cm FL fish and above the inflection point the growth rate slows considerably to 0.097cm/day (2.91 cm/month), which is comparable to that suggested by Wild (1986).

The pattern of yellowfin tuna growth suggested by Uchiyama & Struhsaker (1981) and Yamanaka (1988) is the complete opposite to that proposed by Fonteneau (1979), Bard (1983), Miyabe (1983) and Marsac and Lablache (1985).

All parties seem to agree on the growth rate of yellowfin tuna larger than 60.0-70.0 cm FL. The rate of 3.21±0.04 cm/month proposed by Wild (1986) for yellowfin tuna of 40.0-110.0 cm FL is similar to that suggested by proponents of the slow phase of juvenile growth for fish longer than 60.0-70.0 cm FL.

Evidence from my data

Growth from mixture analysis: As each season's sample was collected from 1st August to 31st October, we might assume that the component age groups of a cohort have a spacing of one year. This would imply a slow phase of growth for juvenile yellowfin tuna (47.5±0.60 cm FL - 65.3±0.80 cm FL) of 18.69±2.00 cm/year (1.56±0.70 cm/month), followed by an accelerated phase between components B and C (65.3±0,80 cm FL - 108.8±3.16 cm FL) of 44.02±3.37 cm/year (3.67±0.13 cm/month) (Table 4,29). The growth rate then drops beyond component C to 23.73±2.26 cm/year (1.98±0.08 cm/month). The starting year of a cohort is taken as one year prior to that of component A for simplicity only. The possible age of component A fish is discussed in a later section.

The rate of 1.56±0.07 cm/month for yellowfin tuna between components A and B compares very closely with those proposed by Fonteneau (1979), Bard (1983), Miyabe (1983) and Marsac & Lablache (1985), but depends on the assumption of one year between these two components. On the other hand, if we assume that there is only six months between them, then a similar rate to that proposed by Wild (1986) is realized.

Growth from monthly data: A study of the progression of modes of monthly length-frequency distributions suggests a slow phase of growth of 1.60±0.38 cm/month (19.2 cm/year) for component A (40.0-55.0 cm FL) fish (Table 4,30), which is very similar to that determined from the annual data between

components A and B and supports the hypothesis of a year between these two component age groups.

Starting Year of a Cohort	Growth (cm/year) A-B	B-C	C-D
1978			21.71
1979		44.70	24.93
1980	20.51	42.13	26.49
1981	20.22	49.61	24.38
1982	(12.71)	(31.33)	(48.30)
1983	15.74	42.43	21.12
1984	19.34	41.24	
1985	17.62		
Mean growth[a]	17.69	41.91	27.82
s.e	1.23	2.45	4.18
Mean growth[b]	18.69	44.02	23.73
s.e	0.89	1.51	1.01

Table 4,29. Growth in fork length for each cohort is taken as one year prior to that of component A. Mean growth[a] is calculated using all the available estimates, and mean growth[b] ignores the 1982 cohort.

Estimates of monthly growth rates point to an acceleration in growth beyond, or within the 60.0-75.0 cm FL interval, followed by a slight reduction in rate between components C and D (Table 4,30).

The results of the present study, both by a mixture analysis of the annual size-frequency data and from a simple inspection of the modes of the monthly length-frequency distributions seem to support the hypothesis of a slow juvenile growth phase and annual cohorts.

	Mean Growth Rates (cm/month) A	B	C	D
Size-Range	**40.0-55.0**	**60.0-75.0**	**105.0-125.0**	**130.0-145.0**
ESTIMATES:				
All	1.60±0.38	1.76±0.37	2.98±0.30	2.78±0.49
Only n > 10	-	2.37±0.65	3.09±0.37	2.50±0.56

Table 4,30. Estimated monthly growth rates of components A to D by the simple inspection of modes of the monthly length-frequency histograms.

Length at age: The estimates of length at age are not all reliable as many of the growth curves depend upon some assumption or other to anchor them to the time-axis. Moore (1951) made assumptions regarding the birth month and, Hennemuth (1961) assumed that fish of 70.0 cm FL are 20 months old, an assumption retained by Davidoff (1963), and Le Guen & Sakagawa (1973) made assumptions regarding the time of spawning and recruitment to the fishery (Le Guen *et al.*, 1969).

Despite this, most workers do seem to agree on the age of the component B fish (60.0-75.0 cm FL) as being approximately 18 months old. Yang *et al.*, (1969) studying the annular rings on scales from the Atlantic estimated fish of 66.1 cm FL to be 18 months old and results from the otolith study of Wild (1986) in the Eastern Pacific estimate that at this age, male yellowfin tuna have a mean FL of 67.9 cm and females 70.0 cm. Romanov & Korotkova (1988), who aged yellowfin tuna by counting annular rings on the vertebrae in the north-western part of the Indian Ocean, estimated the mean FL's of males and females at 18 months to be 66.8 cm and 70.2 cm respectively.

However, Yabuta *et al.*, (1960) using scales from yellowfin tuna in the Western Pacific appear to have underestimated growth (Suzuki, 1971), whereas Draganik & Pelczarski (1983) using sections of the first dorsal fin ray in the Central Atlantic seem to have overestimated growth. The latter suggested that at 18 months yellowfin tuna are 82.1 cm FL.

It is with the other size-classes where the disagreement lies. Whereas Fonteneau (1979) and my study estimate approximately one year between components A and B, the work on otoliths (Wild, 1986 and Yamanaka, 1988), and vertebral sections (Romanov & Korotkova, 1988) estimate the gap at only six months. Wild (1986) estimated the mean size at one year for males and females to be 46.4 cm FL and 50.9 cm FL, respectively and Romanov & Korotkova (1988) estimated them to be 47.1 cm FL and 49.4 cm FL, respectively. Yamanaka (1987) estimated yellowfin tuna at six months to be 38.0 cm FL and 50.0 cm FL at one year. On the other hand, Draganik & Pelczarski (1983) suggest that at a mean size of 46.8 cm FL yellowfin tuna in the Central Atlantic are nine months old.

Observations in the Pemba Channel indicate that yellowfin tuna of components A and B occur throughout the fishing season with peak periods from August to October and in February and March. During the latter they are targeted, only for bait (see Chapter 7). Occasionally very small yellowfin tuna, less than 30.0 cm FL are caught during February. These, however are usually used immediately for bait and therefore were not available to include in this analysis.

Spawning of yellowfin tuna is known to occur over an extended period from results on gonad maturity (Shung, 1973, Maldeniya & Joseph, 1986), and from studies on larval distribution (Nishikawa *et al.*, 1985). Observations in the Gulf of Guinea (Le Guen *et al.*, 1969, Albaret, 1977 and Fonteneau, 1979) and those from my study indicate that there are frequently peak-spawning months.

Observations on gonad maturity in the Pemba Channel point to an increase in yellowfin tuna gonadal activity from the end of October to February (see Chapter 5). The presence of very small yellowfin tuna of less than 30.0 cm FL during

February would seem to support this. At no other stage during the year are these very small fish seen, bearing in mind that no fishing is carried out from 1st April to 31st July.

It is possible that there may be more than one peak during an extended spawning season. Catch statistics indicate that schools of component A fish are most frequently seen during the months of February and October in the Pemba Channel.

If one follows the assumption that component A fish are a year old, then component B fish must be two years old, using the 'slow' rate of 1.6 cm/month; or by assuming that component B fish are eighteen months old, then component A fish must be six months old. Group A fish in February would have been spawned the previous February, assuming A to be a year old, or in October if six months are assumed. However, we would expect age classes between components A and B and between components B and C to appear in the catches, unless the two spawning sets behaved as separate stocks with February spawned stock only returning in February. This would tend to lead to separate gene pools with possibly different characteristics between the February and October fish. No such differences have been detected from the morphometrics.

Neither the mixture analysis of length-frequencies, nor a PCA of the morphometrics show any intermediate groups between components A, B, or C. The PCA of 1982/83 does suggest a small group of fish just larger than component B and the smaller size of component C in 1985/86 are exceptions.

On the other hand, taking the component A fish as one year old and using Wild's growth rate of 3.21 cm/month, the group B fish would be 18 months old. Group A fish in October would then be the result of the previous October spawning and could well explain the presence of fish less than 30.0 cm FL seen during February. Group A fish in February would appear as group B fish six months later. Two year old fish of 85.0-90.0 cm FL are seen close to shore during October and November, and two and a half year olds of approximately 104.0 cm FL are taken throughout the "high season", which supports Wild's theory regarding growth rates and age at length. An assumption that group A fish are six months old would again imply that there is just a single peak in the spawning season, which is not consistent with gonad maturity studies (see Chapter 5).

Catch statistics and gonad maturity studies in the Pemba Channel support the hypothesis of Wild (1986), Yamanaka (1988), and Romanov & Korotkova (1988) that component A fish are approximately one year old and that component B fish are 18 months old. If we now recalculate the growth rate between components A and B we get a rate of 3.11±0.15 cm/month, which is comparable to that estimated by Wild (1986).

These studies suggest that spawning commences at the beginning of the NE monsoon and may extend into the SE monsoon. However, the onset of spawning and the timing of peak spawning activity will vary from one year to the next, depending on the favourability of the conditions.

The appearance of 85.0-100.0 cm FL yellowfin tuna during August 1985 either implies that they were the result of late spawning during 1983, or that they were in fact two and a half year-olds, but that growth had been at a reduced rate. The concentration of food during 1984 in the Pemba Channel (see Chapter 6) may not have been able to support a higher growth rate, but as already mentioned this cohort was no smaller than expected during August-October 1986.

Growth curves: Following the work of Wild (1986), I fitted the sport fishery data from the Pemba Channel, Kenya to a Gompertz equation:

$$Lt = L_{inf} \exp[-e^{-k(t-t^*)}]$$

The value of t* has been fixed here at 1.5 yrs, being the age agreed on by most workers. However, it may well fit the data from age one, the assumed age of the component A yellowfin tuna. The growth rate of yellowfin tuna is likely to vary from one year to the next depending on environmental conditions and fishing pressure. The increased fishing effort in the Western Indian Ocean is likely to have an effect on the age class structure of the population. The present study has demonstrated that the estimate of L_{inf} depends on the age structure of the landed sample.

I used the estimates of L_{inf} from the Powell plots and the means from mixture analysis to calculate estimates of k from the Gompertz equation. As the Powell plot depends on the Von Bertalanffy equation this may have introduced a small amount of bias. Component B fish are assumed to be 18 months old, component C as two and a half years and Component D as three and a half year. However, component C in 1985/86 were considerably smaller than during the other seasons, which may imply they are nearer two years old, or the result of reduced growth.

The 1983/84, 1984/85 and 1986/87 samples were not considered to have yielded reliable estimates of $L_{inf.}$. Estimates of k range from 0.882-0.891 (Table 4,31). The mean of the fourth component in the 1987/88 sample of 129.12 cm FL may be nearer three years (Wild, 1986). If k is recalculated using this figure, k = 0.857 for both estimates of L_{inf}. The estimates of k are similar to those published in Wild (1986), especially those from Moore (1951), Le Guen & Sakagawa (1973) and Wild (1986). However, they do not compare well with those of Hennemuth (1961), or Davidoff (1963).

Season	L_{inf}	k
[a]1981/82	158.76	0.882
[b]	163.08	0.887
[c]	166.15	0.887
[d]	157.97	0.887
1982/83	165.19	0.887
[a]1985/86	171.13	0.892
[b]	172.43	0.889
[a]1987/88	144.28	0.891
[b]	159.22	0.891

Table 4,31. Estimates of k for the Gompertz equation using estimates of L_{inf} from the Powell plots, and the component means resulting from a mixture analysis (Macdonald & Pitcher, 1979) of annual length-frequency data.

Sexual dimorphism: Estimation of growth is likely to be biased by sexual dimorphism (Wild, 1986). Davidoff (1963) believed that both sexes grow indistinguishably up to 130.0 cm FL, but Wild found evidence of sexual dimorphism in terms of fork length, weight and the otolith counting path. At one year females are larger than males and as age increases, so female growth rate diminishes relative to that of males. Romanov & Korotkova (1988) supported the evidence of sexual dimorphism by a study of yellowfin tuna vertebrae, although their growth curves suggest that at four years females are still larger than males.

Unfortunately, the sample sizes in the current study were not large enough to allow for a separate mixture analysis of male and female yellowfin tuna. The distribution of male and female yellowfin tuna by 5 cm intervals is shown in Fig. 4,30, which demonstrates that although males grow to a larger size than do females, the latter have been recorded up to 153.0 cm FL by the sport fishery in the Pemba Channel. Males do not appear to dominate the catches until beyond 150.0 cm FL. At 140.0 cm FL female growth rate is only slightly less than that of males and it is suggested that an increase in their natural mortality is the cause of their disappearance from the catches beyond 140.0 cm FL rather than a reduction in growth rate (Wild, 1986). However, Romanov & Korotkova (1988) believe there is a decrease in growth rate of females. They suggest that this might be the result of the large energetic demands necessary for oogenesis.

Means and their standard errors were calculated for each polygon of the PCA plots for males and females separately (Table 4,32). Calculations were only made for polygon C fish and larger, as the majority of polygon A and B fish are immature. It is not possible to distinguish between the sexes of immature fish without microscopic assistance (see Chapter 5).

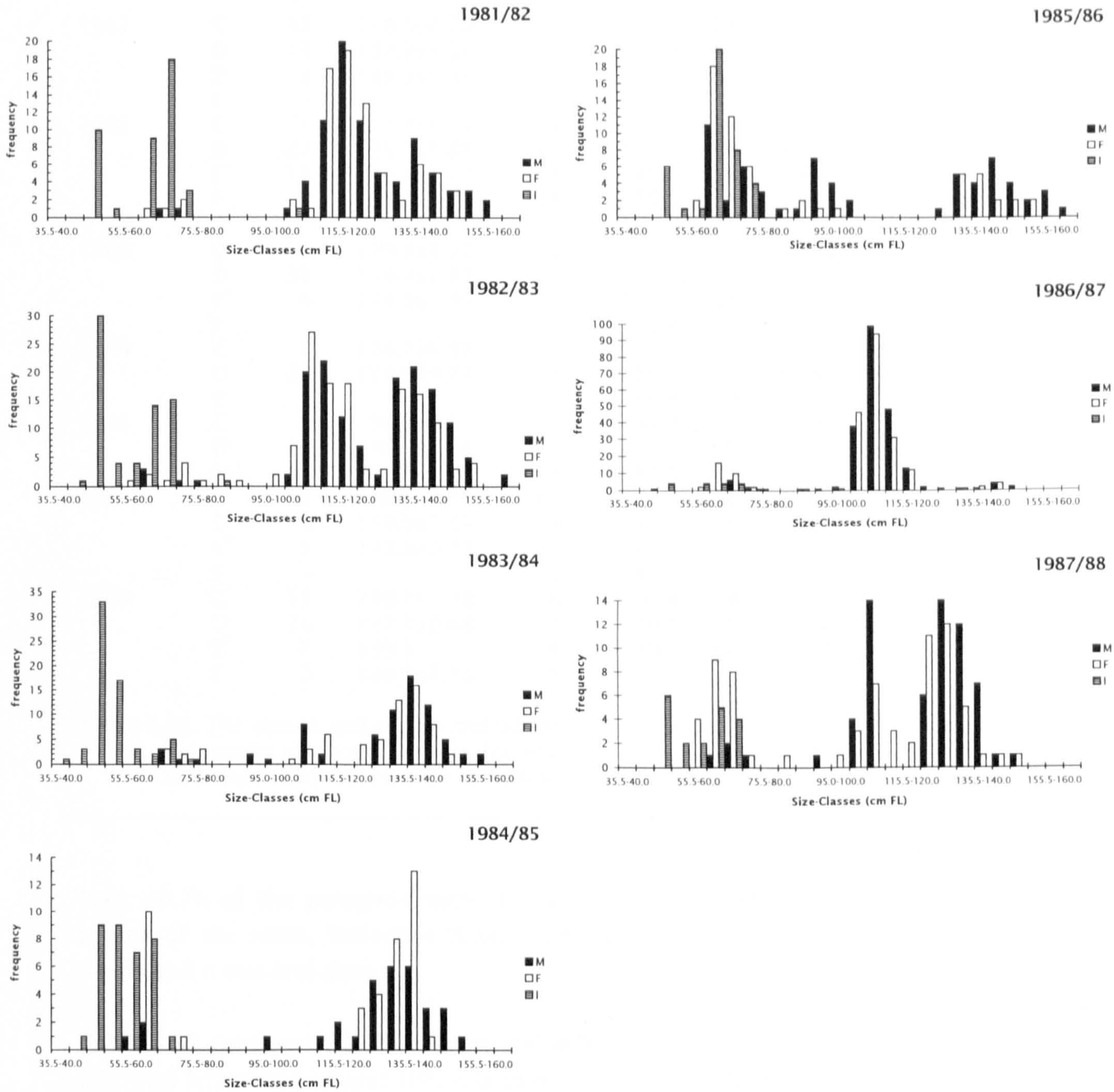


Figure 4,30. Sexual dimorphism of yellowfin tuna caught by the sport fishery based in Shimoni, Kenya from 1981/82-1987/88.

Solid bars represent males;
Open bars, females;
Hatched bars are those fish of indeterminate sex.

Season	Age Group	FEMALES n	FEMALES Mean±se	MALES n	MALES Mean±se	t(0.05)	df	
1981	C	56	118.0±0.70	50	117.6±0.83	0.369	104	NS
	D	13	137.2±1.66	20	135.6±1.48	0.703	31	NS
	E'	4	145.3±1.89	5	146.4±2.62	0.367	7	NS
	F	-	-	4	155.4±1.71	-	-	-
1982	C	71	111.8±0.65	64	112.9±0.59	1.243	133	NS
	D	37	135.3±0.88	51	137.4±0.60	2.047	86	SIG
	E'	13	144.8±1.27	14	145.8±0.98	0.642	25	NS
	F	2	151.0	4	155.5±2.33	1.727	3	NS
	G	-	-	2	157.0±4.00	-	-	-
1983	C	10	109.9±1.02	12	104.5±1.84	2.422	20	SIG
	D	38	134.3±0.83	38	135.7±0.76	1.259	74	NS
	E'	4	144.3±1.49	10	144.0±0.91	0.146	12	NS
	F	-	-	4	152.8±2.14	-	-	-
1984	C	3	124.7±0.33	5	120.7±2.29	1.296	6	NS
	D	22	134.9±0.77	14	135.8±1.36	0.642	34	NS
	E'	-	-	5	146.8±1.56	-	-	-
1985	C	5	90.8±2.89	12	94.8±1.65	1.278	15	NS
	D	16	140.0±1.78	21	140.9±1.35	0.406	35	NS
	E'	-	-	3	160.8±2.13	-	-	-
1986	C	133	108.3±0.36	147	108.8±0.38	1.075	278	NS
	D	3	130.0±5.51	3	130.0±4.16	-	-	NS
	E'	5	142.8±0.73	6	142.0±1.71	0.398	9	NS
	F	-	-	1	149.0	-	-	-
1987	C	15	109.1±1.28	18	106.4±0.54	2.043	31	SIG
	D	26	127.1±0.68	37	129.9±0.75	2.668	61	SIG
	E'	1	139.5	4	139.0±0.58	0.771	3	NS
	F	2	146.5±1.50	1	149.5	1.633	1	NS

Table 4,32. The means and their standard errors of male and female yellowfin tuna and the results of a t-test between the sexes. Polygon A and B, as they mainly contain immature yellowfin tuna are not shown.

Only 40.7% of the polygons show any significant difference ($t_{0.05}$) between the means of the sexes, including those older age classes where all the fish were males and n was less than 5.

Table 4,32 confirms that the larger yellowfin tuna tend to be males. In all, but 1987/88 where the largest fish was only 149.5 cm FL the fish in the oldest age groups are males. Many of the data sets show very little difference between the sexes up to this age group. In 1981/82, there was no significant difference detected in either polygons C, D or E', but the males in Polygon D were significantly larger in 1982/83. However, this was not the case in either polygons E, or F, and both the fish in polygon G were males.

In 1983/84, the females of polygon C were larger, but no difference was detected in either D, or E', although all four fish in polygon F were males. No difference was detected in polygons C and D of 1984/85, and yet again all five fish of E' were males. 1985/86 and 1986/87 demonstrate a similar pattern.

In 1987/88, the females of polygon C were significantly larger, but this was reversed in polygon D with males being significantly larger. However, no subsequent differences were detected in either polygons E or F.

4.4 Conclusions to Chapter 4

Seven samples of yellowfin tuna were collected from the sport fishery in the Pemba Channel, Kenya from 1981-1988. Each sample was aged, first by a mixture analysis of the length-frequencies (Macdonald & Pitcher, 1979) using the computer program MIX (Macdonald & Green, 1985), and secondly by a Principal Components Analysis of the morphometrics using the program, DFACT.

Mixture analysis of the length-frequencies. MIX was shown to be an easy to use and efficient tool for decomposing yellowfin tuna length-frequencies from sport fishery catches. However, the sample sizes were frequently too small to enable MIX to converge with any confidence on the smallest age class, or to separate out the older age groups.

Four component age classes were identified from each sample. The oldest age groups were coalesced into a single fourth component. Due to the small numbers of fish in the right-hand tail of the histogram MIX was unable to distinguish between the older age classes.

MIX converged well on all the data sets with the exception of 1985/86. Particularly good fits were obtained for 1981/82, 1983/84 and 1984/85.

The Powell method was used to estimate L_{inf} and Z/k from each of the data sets because MIX was unable to constrain the means to lie on a growth curve. The growth constant, k was then calculated from the Gompertz equation.

Monthly progressions of length-frequency modes were used to estimate the apparent growth of yellowfin tuna. Dates of capture and fork lengths of individual fish were available.

MIX calculated the means, standard deviations and proportions of each component. Apart from the single anomaly of the third component of 1985/86, the same size groups appeared in each season supporting the hypothesis that the modes on the length-frequency histograms represent age classes.

Principal Components Analysis of the morphometrics. A principal components analysis of between four and sixteen morphometrics was carried out on the same

samples of yellowfin tuna subjected to MIX. Clustering of data points was observed and it was demonstrated that these clumps correspond very closely to the components identified from the length-frequency histograms.

The Principal Components Analysis decomposed the data into up to seven separate clusters. The best separation was obtained using the untransformed data where the correlation coefficients between the variables were very high. When the morphometrics were transformed to a proportion of the fork length to reduce the influence of the fork length and the relationships between the variables, clustering was still observed, albeit with more overlapping.

The first principal component axis was termed the "Fork Length Axis" as all the variables were of equal importance and the variation reflected changes in the fork length. The 2DF and the AF caused a crescent-shaped plot and it was found necessary to use an axis that was not dominated by either of these variables. It is recommended that any future studies use the logarithm of these variables.

The proportion and the mean fork length were calculated for each cluster and these values were compared to those from MIX. Very good agreement was shown between the two methods, but the Principal Components Analysis was able to decompose the data further than MIX.

Means and their standard errors were calculated for males and females within each cluster independently and the differences between them tested using the appropriate tests of significance. Males do not appear to dominate the catches until beyond 153.0 cm FL.

The Principal Components Analysis separated samples of yellowfin and skipjack tunas from one another. The transformed data was particularly useful in this respect. The present study demonstrates a principal components analysis of the morphometrics to be a useful and efficient guide to the number of age classes within a sample of yellowfin tuna. This method revealed a number of advantages over mixture analysis as a means of identifying age classes

(a) Up to six age classes were identified by a PCA of the morphometrics, whereas MIX only converged on four.
(b) Age classes were more clearly separated by a PCA than by MIX.
(c) DFACT works best on smaller samples than does MIX.
(d) Errors in measuring or typing are more easily discernible by a PCA.
(e) DFACT is very easy to use, although entering in the data maybe time consuming. Instructions for DFACT are contained in just two command lines of the data file and it is not possible for two workers to get different results.

(f) Yellowfin tuna size-frequency distributions tend to contain classes with zero counts, which render the goodness-of-fit invalid for MIX. Such classes are beneficial to the PCA in that they help to isolate clusters from one another.

(g) If the proportion of a component age group is very small, the goodness-of-fit to the MIX model is generally poor. Such small proportions do not affect the pattern of clusters resulting from a PCA.

(h) The results suggest that PCA may be useful in identifying contaminants in a data set. The small samples of skipjack tuna were easily isolated from the yellowfin tuna. It would be particularly useful if a PCA were able to distinguish between samples of juvenile yellowfin and bigeye tuna (*Thunnus obesus*). These two species are frequently not distinguished between in commercial catches without an examination of the liver. Examination of the livers confirmed that no bigeye tunas were contained in the samples.

The advantage of using sport fishery data. The results of this study clearly demonstrate that a sport fishery catch is not biased in favour of large yellowfin tuna. The PCA of the morphometrics was able to distinguish between up to six age classes.

Normally a large sample size is required for length-frequency analysis as demonstrated by the results from MIX. A sport fishery does not provide sufficient data for MIX to distinguish between the older ages. However, the results of the PCA clearly indicate that a good guide to the number of age classes represented in a sample may be obtained from smaller sample sizes, so long as there is a good range of sizes available. The results, particularly those of 1982/83 demonstrate that this requirement has been fulfilled by the sport fishery in the Pemba Channel, Kenya.

Growth of yellowfin tuna. Although the results from mixture analysis do at first seem to support the theory of a slow juvenile growth phase this relies upon the assumption that there is one year between components A and B. However this assumption is not supported by either gonadal maturity studies (see Chapter 5), catch statistics, or professional observations of yellowfin tuna activity in the Pemba Channel, Kenya.

This study therefore supports the theory of six months between components A and B, which yields a growth rate of 3.11±0.15 cm/month. This is comparable to the rate of 3.21±0.04 cm/month suggested by Wild (1986) using otoliths. The present study implies that the growth between components B and C is slightly faster at 3.67±0.13 cm/month, and thereafter slows considerably to 1.98±0.08 cm/month.

The results of this study demonstrate that it may not be feasible to discuss growth rates from modal progression alone. Other factors, such as gonad maturity must be considered in conjunction with the results from length-frequency analysis. The results also demonstrate that any assumptions made, such as the age of a given component, must be considered very carefully. Multiple spawnings and prolonged periods of spawning are likely to complicate patterns of modal progression.

CHAPTER 5

Reproductive Parameters: Evaluation of the Reproductive Status of Yellowfin Tuna, 1981–1988

Spawning frequency and age of maturity are critical determinants of the status of exploited fish stocks. This Chapter evaluates these factors for yellowfin tuna in the Western Indian Ocean using data from more than 1500 gonads sampled from the Shimoni sport fishery over seven years.

5.1 Introduction

An understanding of reproductive parameters is an important part of any stock assessment. Reproduction determines recruitment and forms an integral part in any management policy. It is essential to know where a species spawns, how frequently, and at what size and age spawning begins. Recruitment overfishing may only be prevented by protecting spawning areas or by increasing the size of the spawning stock (Cushing, 1983).

Yellowfin tuna pass along the East African coast line during the SE monsoon and it is important that the reproductive status of the stock is assessed at this time. The sport fishery provides a good opportunity to sample the yellowfin tuna in the Western Indian Ocean, and assists us in determining the factors controlling their distribution within the East African zone. The stock is exploited by the Shimoni-based sport fishery during the months of August, September and October (see Chapter 2).

Studies of the reproductive status of a stock have either looked at the development of the ovary, or at the presence or absence of eggs and larvae in the plankton. No studies of the latter type related to this region of the Western Indian Ocean were found in the literature. It is still not possible to distinguish between the eggs of tuna and other scombrids, although the larvae of tunas have been described in detail.

Most studies on the development of tuna gonads have used a maturity scale based on gross morphological criteria (Albaret, 1977; Baglin, 1982; Chur *et al.*, 1979; Hassani & Stéquert, 1991; Karpinski & Hallier, 1988; Schaefer & Orange, 1956; Shung, 1973; Stéquert, 1976; Williams, 1962). These scales of maturity demonstrate considerable variation and the distinction of one stage from another is often subjective (Albaret, 1977). Other methods that have been used to support

the scales are measuring the diameter of oocytes (Albaret, 1977; Baglin, 1982), a Gonad-Somatic Index (GSI) (Albaret, 1977; Hassani & Stéquert, 1991; Karpinski & Hallier, 1988; Schaefer, 1987; Shung, 1973; Stéquert, 1976) and histology (Baglin, 1982; Schaefer, 1987; Stéquert, 1976).

Maturity scales based on gross morphological criteria have used size, superficial vascularisation, colour, transparency of the ovarian lining, consistency, and the visibility of the individual ova. Maturity stages of the testes are largely based on the presence or absence of milt. Albaret (1977) reports that the difficulty of elaboration and application of a scale of maturity to males is well known.

The majority of authors who have measured the diameter of the oocytes have used Gilson's fluid to separate the oocytes from the ovarian tissue. However Gilson's fluid causes severe shrinking of the oocytes by up to 25% of the most advanced (pre-spawning) ones (Albaret, 1977). Diameters measured in this way may not be directly comparable.

The gonad-somatic index, also known as the gonad index, gonado-somatic index or gonadal-somatic index has been used by a number of researchers as a gross indicator of maturity (Albaret, 1977; Baglin, 1982; Hassani & Stéquert, 1991; Karpinski & Hallier, 1988; Knudsen, 1977; Schaefer, 1987; Schaefer & Orange, 1956; Shung, 1973; Stéquert, 1976; Sudarsan *et al.*, 1991; Yesaki, 1983). These indices have two forms, one based on weight and the other on the cube of the fish's length. GSI generally reaches a maximum value just prior to spawning.

The liver is believed to play an important role in the maturation of the gonads by storing essential ingredients for vitellogenesis. The participation of the liver in vitellogenesis has been described by Krivobok (1964) for the Baltic herring, *Clupea harengus membras*. A hepato-somatic index (HSI) has been used as another indicator of spawning activity (Stéquert, 1976). Stéquert (1976) found a strong correlation (r=0.813) between the HSI and GSI for female skipjack tuna.

Most workers have noted the sex-ratio of the yellowfin tuna catches in all oceans and many note a predominance of males, particularly for the larger sizes. Reports of sex-ratios from the Indian Ocean are:

Hirano & Tagawa (1956)	by longline	1.45:1
Maldeniya & Joseph (1986)	trolling, gill net	1.21:1
Karpinski & Hallier (1988)	purse seine	1.27:1
Hassani & Stéquert (1991)	purse seine	1.26:1
Sudarsan *et al.* (1991)	longline	2.73:1
Timochina & Romanov (1991)	13 research cruises 1966-1990	
40-100 cm FL		1.36:1
100-140 cm FL		1.09:1
140-200 cm FL		1.70:1

Mimura and staff at the Nankai regional fisheries research laboratory (1963) noted that in the Indian Ocean the sex-ratio varied with latitude. Males apparently dominate north of 10°S, and especially north of 10°N. From 10°S to 15°S the two sexes appear equal and females dominate south of 15°S. He also noted that fish smaller than 120.0 cm FL showed an even sex-ratio, larger than 150.0 cm FL a predominance of males and between 120.0 cm FL and 150 cm FL the sex-ratio varies with latitude, male predominance increasing towards the north. There appears to be a greater deviation from the 1:1 ratio for longline-caught yellowfin tuna as this fishery catches mainly large individuals (Albaret, 1977). The sex-ratio obtained by Sudarsan *et al.* (1991) is considerably higher than any other recorded in the literature. Their data was obtained from longline-caught yellowfin tuna from Indian seas and they observed no less than 65% males in all size classes from 60-200 cm FL. Purse seiners catch mainly small fish, but also large ones, and so have a ratio closer to 1:1. Catches by pole-and-line fisheries catch only small fish and show a predominance of females. Some authors have noticed a predominance of females in *size class*es less than 95.0 cm FL and Schaefer & Orange (1956) attributed this to immature males being more difficult to identify.

The plurimodal distribution of oocyte diameters has been taken as an indication of multiple spawning in tunas (Hempel, 1979): Ova mature in batches which are spawned successively during the reproductive season (Nikolsky, 1963). As a result they have become known as batch, fractional, multiple or serial spawners (Bagenal & Braum, 1971; Hempel, 1979; Nikolsky, 1963; Schaefer, 1987; Snyder, 1983; Uktolseja *et al.*, 1991). The number of groups of oocytes in an ovary from a fish with a high GSI that have reached an advanced stage of maturity is in general a maximum of three (Albaret, 1977).

Where all tunas spawn successively within the reproductive season, the length of this season varies within the taxon. Skipjack tunas are believed to spawn year round as supported by the absence of fish of a length greater than that of first maturity with resting ovaries (Stéquert, 1976). All researchers throughout the geographical range have reported yellowfin tuna ovaries in periods of rest. The spawning season has been defined in other areas, but not sufficiently well in the Indian Ocean.

The possible spawning seasons for the Western Indian Ocean yellowfin tuna population are discussed with reference to results from longline, purse seine and pole-and-line fisheries.

Schaefer *et al.* (1963) reported that yellowfin tuna spawn during all months of the year, with the peak of spawning activity occurring at different times of the year, throughout the Tropical Pacific. Larvae occur year-round in equatorial waters (Cole, 1980). However, Alekseev & Alekseeva (1979) found that the duration of the individual reproductive periods for oceanic and neritic tunas of the Tropical

Atlantic did not exceed a half year. They suggest that the "year-round" pattern exhibited by bigeye and yellowfin tunas result from combining the spawning seasons of the groupings from the Northern and Southern Hemispheres where the sexual cycles are in opposite phase.

Monthly variations in GSI have been used in the Pacific to define the area and time of spawning by Batts (1972); Hu & Yang (1972); Kikawa (1966); Mori (1970); Shung (1973) and Yoshida, 1964, and in the Atlantic by Albaret (1977); Hisada (1973) and Honma & Hisada (1971).

The length at first maturity has been reported by many authors but there has been a lack of homogeneity in their definition of the term, 'first maturity' (Albaret, 1977). The length at which the first matured individuals may be found was used by Otsu & Uchida (1959); Postel (1955); Simmons (1969); Ueyanagi (1957) and Yoshida (1964). The length at which 50% of the individuals are mature was used by Batts (1972) and Shung (1973) and the length at which all the individuals have reached sexual maturity by Albaret (1977); Fontana & Pianet (1973); Legand (1960) and Stéquert (1976).

length at first maturity (cm FL)	*smallest mature individual (cm FL)*	*definition*	*Author*
Eastern Atlantic Ocean:			
108.6	91.4	2	Albaret (1977)
Pacific Ocean:			
	57.0	1	Buñag (1956)
110.0		3	Kikawa (1966)
120.0	80.0-100.0	?	Orange (1961)
	86.0	1	Otsu & Hansen (1962)
	89.1	1	Otsu & Uchida (1959)
120.0	80.0	2	Shung (1973)
	87.0	1	Ueyanagi (1957)
120.0	70.0	2	Yuen & June (1957)
Indian Ocean:			
110.0-115.0	68.0	2	Hassani & Stéquert (1991)
108.0		3	Karpinski & Hallier (1988)
	98.0	1	Kikawa & Ferraro (1966)
101.0		3	Maldeniya & Joseph (1986)
120.0-139.0	<80.0	1,2,3	Shung (1973)

Table 5,1. Summary of estimates of length at first maturity from the literature for yellowfin tuna. Definition 1 = length at which first matured individuals found; definition 2 = length at which 50% of individuals are mature; definition 3 = length at which all individuals mature

Albaret (1977) defined the onset of maturity by stage III of the scale used by Orange (1961). Stage II it was felt was too far removed from spawning to be of sufficient value. Albaret (1977) estimated the length at first maturity to be 108.6

cm FL in the Eastern Atlantic. Kikawa (1966) estimated it at 110.0 cm FL from the Pacific and Orange (1961), Shung (1973) and Yuen & June (1957), also in the Pacific estimated it at 120.0 cm FL.

The histology of tuna ovaries has been described by Albaret, 1979; Alekseev & Alekseeva, 1981; Baglin, 1982; Batts, 1972; Cayré & Ferrugio, 1986; Hirota *et al.*, 1976; Hunter *et al.*, 1986; Partlo, 1955; Schaefer, 1987 and Stéquert, 1976. Apart from the work of Schaefer (1987) these reports are only fragmentary. Many of these authors have hypothesized, with little statistical foundation, on the size at maturity, duration of the spawning season, type of spawning and the number of batches of eggs produced.

The aims of my histological study on yellowfin tuna from the Pemba Channel are to describe the status of the ovaries, to check the validity of using a maturity scale based only upon gross morphological criteria, the GSI and HSI, to examine the reproductive status of the stock as it enters the Pemba Channel including evidence of imminent or recent spawning, and to estimate the length at sexual maturity.

5.2 Methods

Every yellowfin tuna that was weighed at the Shimoni sport fishery scales between August 1981 and March 1988 was sexed, irrespective of size, and the stage of sexual maturity was determined by gross examination of the gonads. As with many other species this is the only positive means of sexing yellowfin tuna.

The procedure that was used for the determination of sexual maturity is outlined and a description of the two types of gonad and of each stage is also given. This schedule was used on all yellowfin tuna from 1981 through 1987.

Gonad-somatic indices (GSI) and the hepato-somatic index (HSI) were calculated. The differences between the livers of yellowfin and bigeye tunas are also discussed.

During 1987 a sample of ovaries covering the full spectrum of stages were collected and examined further by histology at the University College of North Wales, Bangor. The collection of the samples and the histological techniques used are described.

SEXING AND COLLECTION OF THE GONADS

Upon completion of the collection of morphometric measurements (see Chapter 4) the ventral cavity of each fish was opened and the contents thereof removed

for weighing. This weight was termed the 'gut weight' and includes the stomach, intestines and associated organs, liver and gonads. Prior to the removal of the latter the sex of the fish was noted. The gutted weight was used in all calculations involving fish weight in order to reduce the influence of the gonads, liver and stomach contents.

After determination of the 'gut weight' a preliminary examination of the gonads was carried out to determine its stage of development, and then they were placed in a labeled plastic bag along with the liver. Initially these were stored in the deep freezer until either the following Friday, when normally there was no fishing, or into October when there was usually a lull in business. This system worked perfectly until 1984 when one of the freezers broke down and a member of staff at the fishing club threw out a large number of samples. From 1985 to 1987 all further examination of the gonads was carried out on the day of capture.

All the excess mesovaria was removed and the weight of each gonad was recorded separately to the nearest gramme on a 'Sartorius' electronic balance. During the first few years the length of each gonad was also recorded in millimeters. Initially the volume displacement of the gonads was measured, but because the correlation between this and the weight were so high (Fig.5,1) the volume measurements were discontinued.

The gonads were further checked by gross examination for stage of development. Smears of ova were collected from within the ovaries with large ova to determine their degree of translucency. A sample of ovaries in 1987/88 were examined by histology as described in a later section.

GONADAL STAGEING BY EXTERNAL CRITERIA

Immature: In both sexes these appear thread-like and the two sexes can, on occasions be distinguished by rolling the gonads between the fingers. The ovary is tubular in cross-section, whereas the testes is always flattened. However particularly with the smallest group of yellowfin tuna (less than 50.0 cm FL) it is not possible to distinguish between the sexes. For this reason the immature fish are treated as 'indeterminate sex'.

The East African Marine Fisheries Organization (EAMFRO) scale of maturity is very similar to that reported in Orange (1961) without the initial stage Is. For the purposes of this study it was considered more appropriate to use just a single immature stage as there is likely to be a wide margin of error in the distinction of the sexes of immature fish.

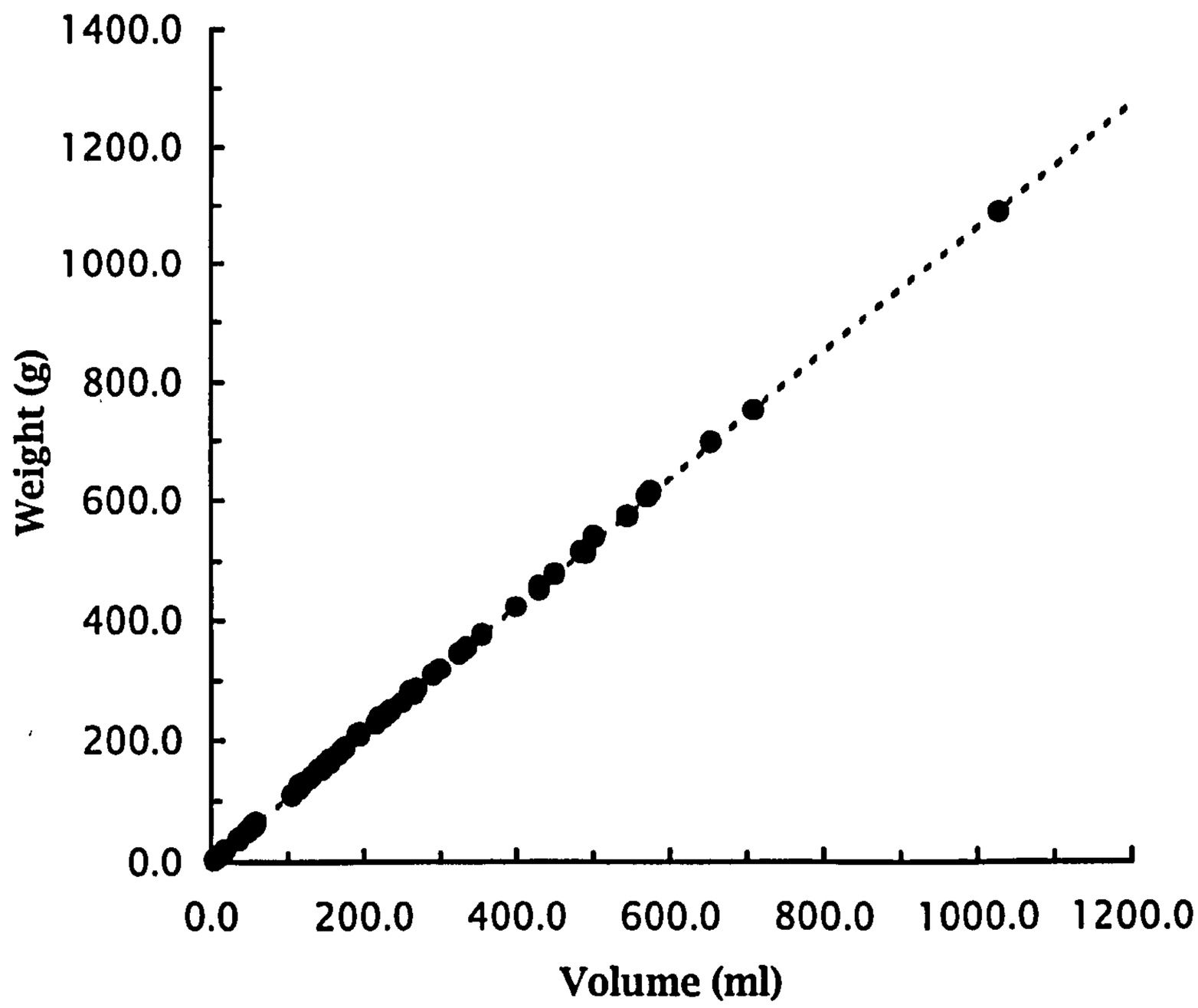


Figure 5,1. The weight of the ovary is very strongly correlated (r=1.00) with its volume. All stage I fish have been excluded. The broken line indicates the fitted regression, where the slope = 1.061, $P < 0.0001$, Rsquare = 1.00, and n = 66.

Testes: The testes of tuna always appear as a flattened, smooth solid body, which is anaemic brown in colour. The major distinction between the stages of the testes is the presence or absence of milt. As the testes develops they become enlarged and increasingly full of milt. The distinction between stages II and III often requires that the testes be cut to reveal the milt. An intermediate stage (Stage II+), absent in the EAMFRO schedule (Table 5,1), was included to represent those individuals where milt may be extruded, but only on cutting and squeezing.

Ovary: Stage II - The ovaries appear firm, tubular and pink in colour. This stage not only includes those fish maturing for the first time, but also those in a recovery state after spawning. Some of the fish included within this stage had slightly flaccid ovaries, and often blackened towards the external opening. The distinction between this stage and that of stage VII was made on the degree of blackening and flaccidity. The blackening was caused by internal bleeding within the ovary, and it is possible that some of this damage occurred during capture and storage, or from the last spawning session.

MALE

I	Immature - testes very small, thread-like, no milt present.
II	Mature unripe - testes small, flattened and pale brown in colour, no milt extruded on cutting and squeezing.
II+	Mature intermediate - milt extruded with difficulty upon cutting and squeezing.
III	Mature ripe - Testes enlarged and milt extruded on squeezing.
IV	Mature ripe 'running' - as above but milt extruded with or without light pressure to the flanks.
V	Mature spent - testes crinkled and shrunken, little milt, much blood.

FEMALE

I	Immature - Ovaries very small, thread-like.
II	Mature virgin or recovery - ovaries small to moderate, eggs microscopic, usually translucent.
III	Mature ripening - Ovaries moderate, ova visible to naked eye, opaque.
IV	Mature nearly ripe - ovaries enlarged, eggs clearly visible, opaque.
V	Mature ripe - ovaries enlarged and distended, tunica breaks easily, some eggs are translucent.
VI	Mature ripe 'running' - as above, most ova are transparent and extruded on slight pressure to flanks.
VII	Mature spent - ovaries flaccid, shrunken, some residual eggs, much blood.

Table 5.2. Gonad maturity stages using only external criteria for yellowfin tuna as developed from the East African Marine Fisheries Research Organization (EAMFRO) definition of stages (see Williams, 1962).

Stages III to V - As the ovary develops it becomes enlarged and there is an increase in the vascularisation on the surface of the ovary. The ovary changes from being pink to orange with the development of the ova. Smears of ova were checked under the microscope in order to determine their degree of translucency. In stages III and IV the ova are all opaque, but in stage V some appear translucent and the tunica breaks very easily.

Stage VI is very short and may only last 24 hours. The probability of catching a yellowfin tuna in the act of spawning is very small.

THE GONAD-SOMATIC AND HEPATO-SOMATIC INDICES

The gonad-somatic index (GSI) was calculated in two ways:

$$GSI_w = W_g \div W_f,$$

where W_g = weight of the gonad in grammes and,
W_f = gutted weight of the fish in kilogrammes.

$$GSI_L = (W_g \div L^3)10^4,$$

where L = fork length in cm.

The weight of the liver was also recorded and the hepato-somatic index (HSI) calculated:

$$W_L \div W_f,$$

where W_L = weight of liver in grammes.

The liver of every specimen was examined closely to confirm the species identification. Particularly with the juvenile individuals it is the only concrete means of distinguishing between the yellowfin tuna and the bigeye tuna (*Thunnus obesus*). Tuna livers are tri-lobed and in the bigeye the central lobe is equal to or longer than the left or right lobes. On the other hand the right lobe of the yellowfin tuna liver is much longer than either of the other two. Further to this, the ventral surface of the bigeye tuna liver shows prominent striations, whereas that of the yellowfin tuna is smooth (Collette & Nauen, 1983).

HISTOLOGY

Blocks of $1cm^3$ were cut from the ovaries and fixed in either buffered formalin or Susa. Most samples were taken from the central portion of the left ovary, this usually being the larger of the two. In almost every case one ovary was bigger than the other and on one occasion there was just a single ovary in the ventral cavity. The occurrence of just one ovary has also been reported in the dab, *Limanda limanda* (Htun-Han, 1978). The difference in size between the two

ovaries has been reported for other tunas, such as albacore, *Thunnus alalunga* (Otsu & Uchida, 1959), and black skipjack, *Euthynnus lineatus* (Schaefer, 1987), as well as dab (Htun-Han, 1978), and the Atlantic mackerel, *Scomber scombrus* (Bara, 1960; Coello & Grimm, 1989). However, no such difference was found between the left and right ovaries in skipjack tuna (Uktolseja *et al.*, 1991).

There was no significant difference in the stage of development between anterior, middle, or posterior portions of the same ovary, or between the two ovaries in black skipjack (Schaefer, 1987), or in the Atlantic mackerel (Maridueña, 1984). There was no significant difference between six zones of the ovary for oocytes greater than 200 µm for advanced stages of maturation of yellowfin tuna (Albaret, 1977). Uktolseja *et al.* (1991) also reported no significant difference in the distribution of oocyte diameters between the right or left ovaries of skipjack tuna.

Fixation: a) Buffered formalin - Samples were immersed in buffered formalin for 24 hours and then dehydrated through 30%, 50% and finally 70% alcohol in which they were stored.

b) Susa - Blocks fixed in Heidenhain's Susa for 24 hours were then transferred direct to 95% alcohol. After a further 24 hours the solution was changed and the blocks were stored in 95% alcohol.

The blocks stored in alcohol were carried to UCNW, Bangor some 6 months later for embedding and sectioning. All subsequent histology work was carried out in the School of Animal Biology and that of Plant Biology at UCNW.

Infiltration: All the samples had first to be transferred out of alcohol. All my samples were considered too large and therefore had to be cut in half to facilitate infiltration.

The LKB 2218-500 Historesin embedding kit was used. This is a Glycol Methacrylate method (GMC) incorporating a water-soluble polymerizing resin, glycol methacrylate. GMC has a number of advantages over other embedding mediums, such as 1) in the sectioning of yolked ovaries; 2) it produces very little tissue distortion; 3) very thin sections are feasible, and 4) the resin is hydrophilic. The main disadvantage is that some of the established staining routines do not work as well as on paraffin-embedded sections (Coello, 1989). However, there are some new routines that work well and these are described later in this part of the chapter.

All the samples were further dehydrated down to 95% alcohol by gradual changes from 70%, 80%, 90% and 95%. The latter was changed once, with each stage lasting approximately one hour.

The samples were put into a 50:50 solution of alcohol:infiltration solution for 8-12 hours. The alcohol used was industrial methylated spirit, which is approximately 96% alcohol. After approximately 12 hours the solution was replaced by 100% infiltration fluid. The solution was changed daily for four days. The solution removed during changes could be used again for subsequent samples, but the final stage must be clean infiltration fluid. The first 100% infiltration fluid was used to make the 50:50 solution for the next batch.

Embedding: This was done in small plastic tops, the size selected to suit the tissue sample. The Historesin was mixed in a 15:1 ratio of infiltration solution to hardener. The maximum mixed at any one time was 15ml infiltration solution to 1ml hardener as larger quantities will go off very quickly. As with most two pot resins insufficient mixing will prevent the resin from setting. In this case the resin was mixed in a beaker with a magnetic stirrer and stirred for one minute.

The resin was pipetted off into the smaller tops and then to the larger ones. A large quantity of resin tends to get very hot and goes off quicker. The tops were filled to the brim.

The tissue was removed from the infiltration solution using forceps and added to the resin and each top labeled. Because larger quantities of resin tend to get hot the bigger tops had to be placed in the refrigerator. The tissue was centralized in the tops using cocktail sticks. The small tops which contained approximately 1ml were stored at room temperature (approximately 20°C) and these generally took 3-4 hours to set. The larger tops with approximately 3ml resin took up to a day in the refrigerator. Once the resin was hard they were moved to the oven at 60°C.

All the glassware had to be cleaned immediately with alcohol as historesin will stick to glass.

Once the resin was hard the plastic tops were cut away and a coarse saw used to remove the excess resin. Only small slivers could be removed with either a razor blade or a coping saw as the historesin tends to shatter.

The block was mounted on a mounting block using Radiospares cyanoacrylate adhesive ('Gluematic': Loctite corp.).

Cutting sections: Initially, a 2218 Historange microtome made by LKB Bromma, Sweden was used to cut sections. This uses disposable steel knives with a cutting speed of 8-20 mm/sec for this type of resin.

In order to cut ribbon sections, the shortest faces were cut parallel and one was presented to the knife to reduce the impact on the block of resin. The microtome was set to cut 4-5 µm sections.

The sections had a tendency to roll into a cigar shape as they came off the knife. The trick was to catch them with clean dry forceps before they rolled. Microscope slides were cleaned in a bath of alcohol and 1% hydrochloric acid to remove any grease. Plenty of distilled water was put onto the slide and the section dropped onto the water. Excess water was then sucked up with a pipette and paper towel. Sections were checked with toluidine blue.

The Historange microtome in the School of Animal Biology was unable to cut this tissue cleanly due to the yolked oocytes, so the Reichert-Jung 2050 microtome in Plant Biology was used instead with a tungsten carbide knife. The difficulty came in selecting unused portions of the blade. The knife badly needed re-sharpening but the department had insufficient funds to allow for this. As a result many of the sections had bad scratch marks on them.

Solution	*Time (min)*	*Purpose*
1% Periodic acid	10	
Running water	5	stain carbohydrates
Schiff's reagent*	10	(yolk vesicles)
Running water	5	
Bromophenol blue †	15	
0.5% acetic acid	20	stain proteins
Running water	3	(yolk granules)
Ehrlich's haematoxylin	20	highlight
Buffer solution pH 7.4-8.0‡	2 washes	previtellogenic oocytes

Table 5,3. The staining schedule for the triple stain.
* *Schiff's reagent according to Barger and De Lamater (1948, cited by Pearse, 1968).*
† *0.1% bromophenol blue in 95% alcohol.*
‡ *BDH buffer tablets.*

Sections were dropped onto the surface of a water bath from where they were picked up using a slide. Sections were glued to the slide permanently using Meyer's glysterine albumen adhesive.

Staining: Two stains were used for the ovary tissue, a triple stain of Schiff's reagent, bromophenol blue and Ehrlich's haematoxylin (Coello, 1989); and a polychrome stain. The schedules are shown in Tables 5,3 and 5,4 respectively.

The results of the triple stain were as follows:

Previtellogenic oocytes	deep purple cytoplasm, light grey nucleus, dark blue nucleoli.

Vitellogenic oocytes	carbohydrate-containing yolk - pink; protein-containing yolk - dark green; lipid-containing yolk - unstained (white).
Zona pellucida	blue.
Nucleus	light blue.

The pH of the final rinse has to be precise because it controls the colour that Erhlich's haematoxylin gives to the tissue. Acid or alkaline solutions produce respectively purple or deep blue colours, masking the periodic acid or Schiff's reagent (PAB).

If the fixative used was Susa I first removed the mercury by:

0.5% iodine in 70% alcohol	3 min.
Running water	1 min
5% sodium thiosulphate until sections are bleached.	
Running water	3 min

Staining procedure:

1% Alcian blue in 3% acetic acid pH 2.5	30 min
Running water	5 min†
1% periodic acid freshly prepared	10 min*
Running water	5 min*
Schiff's reagent in the dark	10 min*
Running water	5 min*†
Iron alum mordant	30 min
Heidenhain's haematoxylin	30 min
Running water	
Iron alum:	differentiate with microscopical control
Running water†	
Acid fuchsin/Xylidine ponceau counterstain	5 min
Rinse in water	
Dry slides and then mount in DPX.	

Table 5,4. Staining schedule for the Polychrome stain used for yellowfin tuna ovaries.
* *The timing of these steps was critical and they must be carried out consecutively.*
† *At this point the staining procedure could be interrupted and the slides left to dry.*

OOCYTE DIAMETERS.

With the aid of a camera lucida attached to a microscope 100 ova of each stage of development were drawn*. The periphery of the ovum was traced and the starting point marked. Using a digitizing tablet linked to a RM Nimbus microcomputer the area of each ova was calculated. The areas were subsequently converted to diameters using MINITAB on the VAXA mainframe computer at UCNW. The following stages of oocyte development were measured: oogonia; primary oocytes; early perinucleoli; late perinucleoli; yolk vesicle stage; yolk granule stage.

*Only those ova sectioned through the nucleus were measured.

Gonad Stages

1981/82

Size-Class (cm FL)	MALES I	II	II+	III	IV	V	FEMALES II	III	IV	V	VI	VII
≤ 50.0	10	-	-	-	-	-	-	-	-	-	-	-
50.5-80.0	31	2	-	-	-	-	4	-	-	-	-	-
80.5-100.0	-	-	-	-	-	-	-	-	-	-	-	-
100.5-120.0	1	26	10	-	-	-	26	13	-	-	-	-
120.5-140.0	-	16	10	6	-	-	12	7	4	3	1	1
> 140.0	-	2	4	7	-	-	-	3	2	2	1	-

1982/83

Size-Class (cm FL)	I	II	II+	III	IV	V	II	III	IV	V	VI	VII
≤ 50.0	31	-	-	-	-	-	-	-	-	-	-	-
50.5-80.0	37	4	1	-	-	-	8	1	-	-	-	-
80.5-100.0	-	-	-	-	-	-	2	3	-	-	-	-
100.5-120.0	1	41	13	2	-	-	61	9	1	-	-	1
120.5-140.0	-	30	8	11	-	-	11	13	11	-	-	1
> 140.0	-	14	5	15	1	-	2	2	13	1	-	-

1983/84

Size-Class (cm FL)	I	II	II+	III	IV	V	II	III	IV	V	VI	VII
≤50.0	36	-	-	-	-	-	-	-	-	-	-	-
50.5-80.0	28	5	-	-	-	-	8	1	-	-	-	-
80.5-100.0	-	1	-	1	1	-	-	-	-	-	-	-
100.5-120.0	-	10	-	-	-	-	10	-	-	-	-	-
120.5-140.0	-	2	7	17	10	-	10	14	8	5	2	-
> 140.0	-	-	2	13	5	-	-	1	7	2	-	-

1984/85

Size-Class (cm FL)	I	II	II+	III	IV	V	II	III	IV	V	VI	VII
≤ 50.0	10	-	-	-	-	-	-	-	-	-	-	-
50.5-80.0	28	-	-	-	-	-	11	-	-	-	-	-
80.5-100.0	-	1	-	-	-	-	-	-	-	-	-	-
100.5-120.0	-	-	1	2	-	-	-	-	-	-	-	-
120.5-140.0	-	-	6	10	-	-	23	4	2	-	-	1
> 140.0	-	-	3	1	3	-	1	-	-	-	-	-

1985/86

Size-Class (cm FL)	I	II	II+	III	IV	V	II	III	IV	V	VI	VII
≤ 50.0	6	-	-	-	-	-	-	-	-	-	-	-
50.5-80.0	44	7	-	-	-	-	38	-	-	-	-	-
80.5-100.0	-	10	1	-	-	-	3	-	-	-	-	-
100.5-120.0	-	-	2	-	-	-	-	-	-	-	-	-
120.5-140.0	-	-	4	3	4	-	4	2	-	-	-	2
> 140.0	-	1	6	9	-	-	2	1	-	-	-	3

1986/87

Size-Class (cm FL)	I	II	II+	III	IV	V	II	III	IV	V	VI	VII
≤ 50.0	5	-	-	-	-	-	-	-	-	-	-	-
50.5-80.0	13	8	-	-	-	-	30	-	-	-	-	-
80.5-100.0	-	3	-	-	-	-	1	-	1	-	-	-
100.5-120.0	-	136	9	33	18	-	174	2	8	-	-	-
120.5-140.0	-	-	-	1	4	-	-	2	-	-	-	1
> 140.0	-	-	3	-	2	-	1	2	-	-	-	1

1987/88

Size-Class (cm FL)	I	II	II+	III	IV	V	II	III	IV	V	VI	VII
≤ 50.0	6	-	-	-	-	-	-	-	-	-	-	-
50.5-80.0	15	3	-	-	-	-	20	-	-	-	-	-
80.5-100.0	-	1	-	-	-	-	1	-	1	-	-	-
100.5-120.0	-	1	1	8	8	-	7	2	4	2	-	-
120.5-140.0	-	8	4	13	7	-	14	6	5	-	-	3
> 140.0	-	-	-	-	1	-	1	-	-	-	-	-

Total

Size-Class (cm FL)	I	II	II+	III	IV	V	II	III	IV	V	VI	VII
≤ 50.0	104	-	-	-	-	-	-	-	-	-	-	-
50.5-80.0	196	29	1	-	-	-	119	2	-	-	-	-
80.5-100.0	-	16	1	1	1	-	7	3	2	-	-	-
100.5-120.0	2	214	36	45	26	-	278	26	13	2	-	1
120.5-140.0	-	56	39	61	25	-	74	48	30	8	3	9
> 140.0	-	17	23	45	12	-	7	9	22	5	1	4

Table 5,5. The results from the stageing of the gonads by gross criteria, of 648 male and 673 female sport fishery-caught yellowfin tuna.

5.3 Results

STAGEING BY GROSS EXAMINATION OF THE GONADS

The results of the stageing by gross examination of 1,623 gonads are tabulated in Table 5,5 for 1981/82 through 1987/88. All the stage I fish were grouped together as 'indeterminate sex'. There were no mature yellowfin tuna in the smallest size category of less than 50.0 cm FL and there were two fish in the 100.0-120.0 cm FL range which were immature, one in 1981/82 and the other in 1982/83. These fish were either very late developers, or were possibly sterile. The first three seasons and 1987/88 yielded very good catches with a wide size range and a high proportion of fish of both sexes with ripening gonads. During the other three years there were few mature females. In both sexes the proportion of fish advanced beyond stage II increases with fish size.

Males: Very few yellowfin tuna of less than 100.0 cm FL showed any signs of possessing milt (Fig. 5,2). The proportion of testes with milt increased with size of fish until 82% of testes from fish of over 140.0 cm FL contained milt, with 59% yielding milt on gentle squeezing without cutting.

During the seven seasons of this study no male yellowfin tuna of stage V was caught implying that either this stage is not a real one in yellowfin tuna, or that because tuna spawn over an extended period portions of the testes may be in a recovery state while other regions are still producing milt. This stage may be expected to occur more in cold water species where the importance lies more in producing as much milt as possible in as short a time as possible so that the fry might take advantage of the spring plankton blooms.

Females: In the 100.5-120.0 cm FL *size class* 87% of the females were still only stage II (Fig. 5,2). Beyond this the proportion of stage II females dropped to just 15% in the largest *size class* and the proportion of the more advanced ovaries increased with fish size.

During some seasons the female yellowfin tuna appeared to be in a more advanced state than in others throughout the main months of August to October. The first three seasons and 1987/88 exhibit a greater proportion of advanced ovaries with an average of 24% greater than stage III, compared to an average of 7% from 1984/85 - 1986/87 (Fig. 5,3). In terms of developed ovaries 1983/84 was the best season with 35% of all female yellowfin tuna advanced beyond stage III, whereas there were only 5% in 1986/87. A significant difference ($P = 0.028$) between these two groups of years was found using a Mann Whitney U-test.

The onset of spawning activity is likely to be affected by other external factors such as water temperature and food availability. Adverse weather conditions,

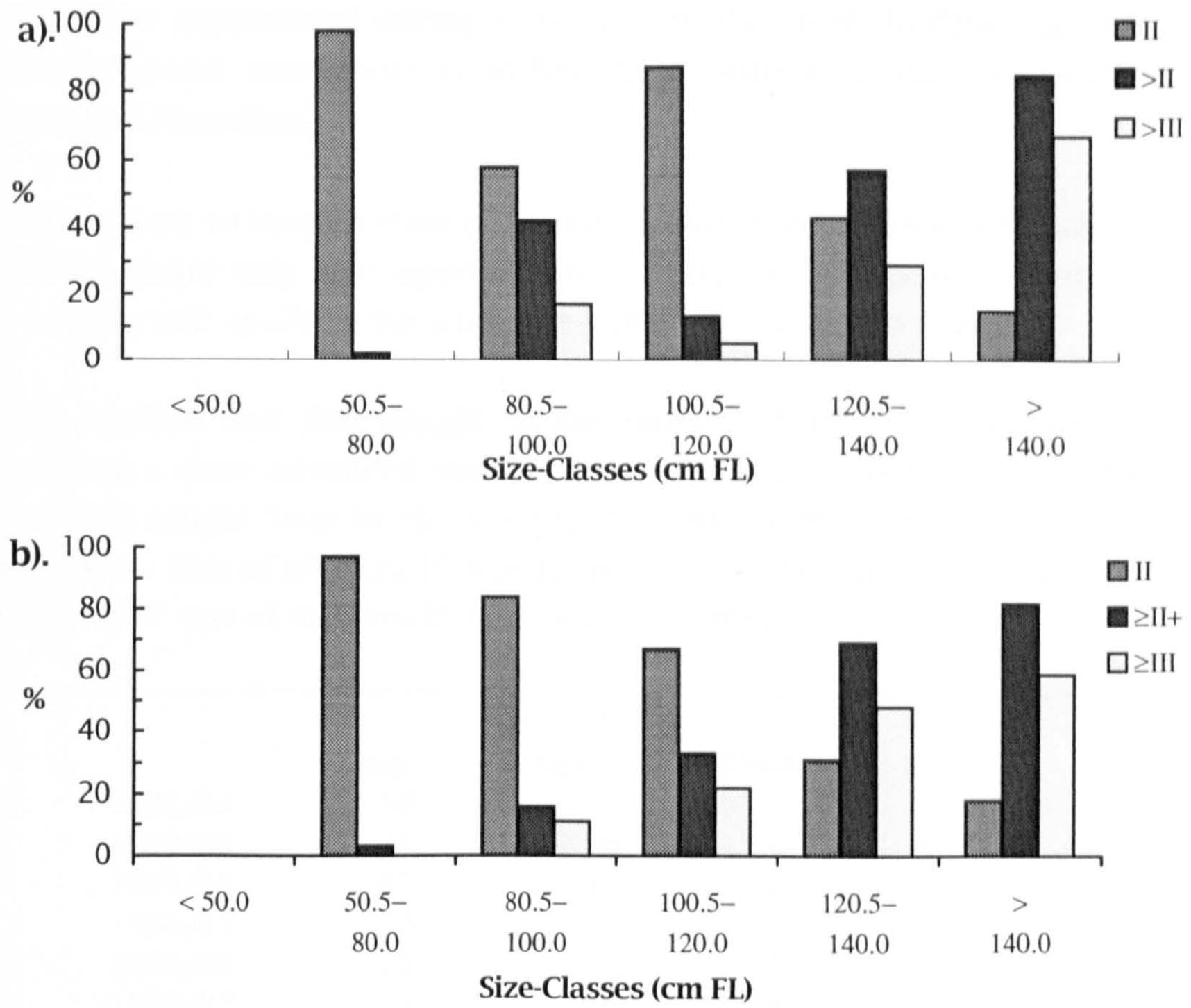


Figure 5,2. The proportion of early maturing or recovering, maturing and mature yellowfin tuna are shown by size class for the entire seven seasons from August 1981 until March 1988, for a) Females, and b) Males.

Figure 5,3. The proportions of mature female yellowfin tuna advanced beyond stage III demonstrate the variation in sexual development from one season to another during the months of August through October in the Shimoni-based sport fishery.

such as would be experienced during a cyclone are also likely to delay spawning. Part of the yellowfin tuna route is within the cyclone belt, such as Northern Madagascar, and Mauritius.

Males would appear to reach a state of sexual readiness in advance of females. As stage VI of the ovary only lasts approximately 24 hours., it appears essential for the male to have milt available for when the females are ready to spawn.

It was also noticed that fish caught in the latter half of September or in to October were in a more advanced state than in August or early September (Table 5,6). Those fish caught later in the season often had well developed gonads. In November 1986 a fish of 86.0 cm FL was found to possess ovaries in stage IV and in December 1987 one of 98.0 cm FL was also at stage IV.

	Aug.	*Sep-a*	*Sep-b*	*Oct.*
1981/82	50	80	33	46
1982/83	26	39	56	44
1983/84	67	11	92	88
1984/85	0	7	40	-
1985/86	70	0	25	-
1986/87	5	10	29	53
1987/88	17	33	83	50
Total	*15*	*13*	*59*	*69*

Table 5,6. The percentage of female yellowfin tuna of at least 100.0 cm FL whose ovaries were stage III or more.

SEX-RATIOS

(a) Including stage I fish: There were significantly more males than females over the entire seven seasons, but only 1982/83 and 1983/84 showed a significant deviation from the 1:1 ratio with more males than females. (Table 5,7a).

(b) Excluding fish of indeterminate sex: The overall sex-ratio was 1 male:1 female for all fish greater than 50.0 cm FL (Table 5,7b). Only 1984/85 deviated significantly from the 1:1 ratio with a higher proportion of females. There were nearly twice as many females as males in the 120.5-140.0 cm FL class in 1984/85 which was rather unusual. Most of the other seasons showed a predominance of males for this group.

There were four times as many females as males in the 50.5-80.0 cm FL class. Such a high proportion of females to males has not previously been reported for yellowfin tuna. However, it is noted that where the stage I fish are included in the analysis the rate is reduced to 0.84:1.0 of males:females (Table 5,7a). From this I deduce that females mature earlier than do males.

a)

Size Class (cm FL)	1981/82 M	1981/82 F	1982/83 M	1982/83 F	1983/84 M	1983/84 F	1984/85 M	1984/85 F	1985/86 M	1985/86 F	1986/87 M	1986/87 F	1987/88 M	1987/88 F	Total M	Total F
< 50.0	6	4	29	2	26	10	6	4	2	4	3	2	2	4	74	30
50.5-80.0	21	16	28	23	20	23	14	25	45	50	21	32	14	25	163	194
80.5-100.0	0	0	0	5	3	0	1	0	13	4	4	2	1	2	22	13
100.5-120.0	37	39	57	72	10	10	3	0	2	0	196	184	18	15	323	320
120.5-140.0	32	28	49	36	36	39	16	30	11	9	5	2	41	25	190	169
> 140.0	13	8	35	18	20	10	7	1	18	6	6	3	1	2	100	48
Total	109	95	198	156	115	92	47	60	91	73	235	225	77	73	872	774
Ratio	1	0.87	1	0.79	1	0.80	1	1.28	1	0.80	1	0.96	1	0.95	1	0.89
Z (binomial)	0.98		2.23		1.60		-1.26		1.41		0.47		0.33		2.42	
P, sig	0.84	ns	0.99	**	0.95	*	0.10	ns	0.92	ns	0.68	ns	0.63	ns	0.99	**

b)

Size Class (cm FL)	1981/82 M	1981/82 F	1982/83 M	1982/83 F	1983/84 M	1983/84 F	1984/85 M	1984/85 F	1985/86 M	1985/86 F	1986/87 M	1986/87 F	1987/88 M	1987/88 F	Total M	Total F
< 50.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50.5-80.0	2	4	5	9	5	9	0	11	7	38	8	30	3	20	30	121
80.5-100.0	0	0	0	5	3	0	1	0	13	4	4	2	1	2	22	13
100.5-120.0	36	39	56	72	10	10	3	0	2	0	196	184	18	15	321	320
120.5-140.0	32	28	49	36	36	39	16	30	11	9	5	2	41	25	190	169
> 140.0	13	8	35	18	20	10	7	1	18	6	6	3	1	2	100	48
Total	83	79	145	140	74	68	27	42	51	57	219	221	64	64	663	671
Ratio	1	0.95	1	0.97	1	0.92	1	1.56	1	1.12	1	1.01	1	1.00	1	1.01
Z (binomial)	0.31		0.30		0.50		-1.81		-0.58		-0.10		0.00		-0.22	
P, sig	0.62	ns	0.62	ns	0.69	ns	0.04	*	0.28	ns	0.46	ns	0.50	ns	0.41	ns

Table 5,7. The sex ratios for 1,646 sport fishery-caught yellowfin tuna from August 1981 to March 1988. Sex ratios are tested against equal numbers of males and females using the Binomial test, Z. P values and significance level are listed in the last row of each years data.

a) including stage I fish
b) excluding those individuals of indeterminate sex.

The 80.5-100.0 cm FL class is biased by a small sample size (n=35). The 100.5-120.0 cm FL group exhibits a close 1:1 ratio and above 120.0 cm FL the proportion of males increases until twice as many yellowfin tuna over 140.0 cm FL are males.

GONAD-SOMATIC INDEX

Females: The weight of the ovaries relative to the size of the fish increases very rapidly up to approximately 80.0 cm FL whereupon the rate decreases (Fig. 5,4a). In general terms the larger the fish the heavier the gonads. Further increases in weight of the ovary will occur with the development of the ova and production of yolk for spawning.

Males: There is a suggestion that the opposite happens with the testis (Fig. 5,4b). It would appear that the testis grows very slowly until the yellowfin tuna reaches between 80.0-90.0 cm FL whereupon there is an increase in the growth rate with fish size, but thereafter growth is rapid. The slope of the regression for the immature males was not significant possibly due to the small sample size (n=14).

Females: The GSI based on weight has a straight line relationship with that based on length (Fig. 5,5) with a correlation of 1.0. As a result the index based on weight was selected as being the one most used on yellowfin tuna in the Indian Ocean (Hassani & Stéquert, 1991; Yesaki, 1983).

A high GSI_w value infers an advanced reproductive state. Of the group, 50.5-80.0 cm FL only three fish stand out (Fig. 5,6a). Whereas the main group all have a GSI_w of less than 5.0, three fish of: a) 70.0 cm FL taken in January 1984 with a GSI_w of 7.75; b) 73.5 cm FL from January 1985 with a GSI_w of 6.99 and c) 77.0 cm FL from the end of October 1983 with a GSI_w of 7.39. The first of these was diagnosed as being stage III, whereas the other two were stage II.

Even including the largest size-groups the bulk of the fish possessed a GSI_w of less than 7.0. Of the 80.5-100.0 cm FL there was one fish that stands out. This was an 86.0 cm fish caught in November 1986 with a GSI_w of 19.04 which was estimated to be stage IV (Table 5,8).

Those fish which were estimated to be stage VII did not record high values for GSI_w. In stage VII the ovary has either spawned its ova or re-absorbed the yolk and the ovary becomes shrunken. However not all those fish that were diagnosed as being stage IV yielded high GSI's.

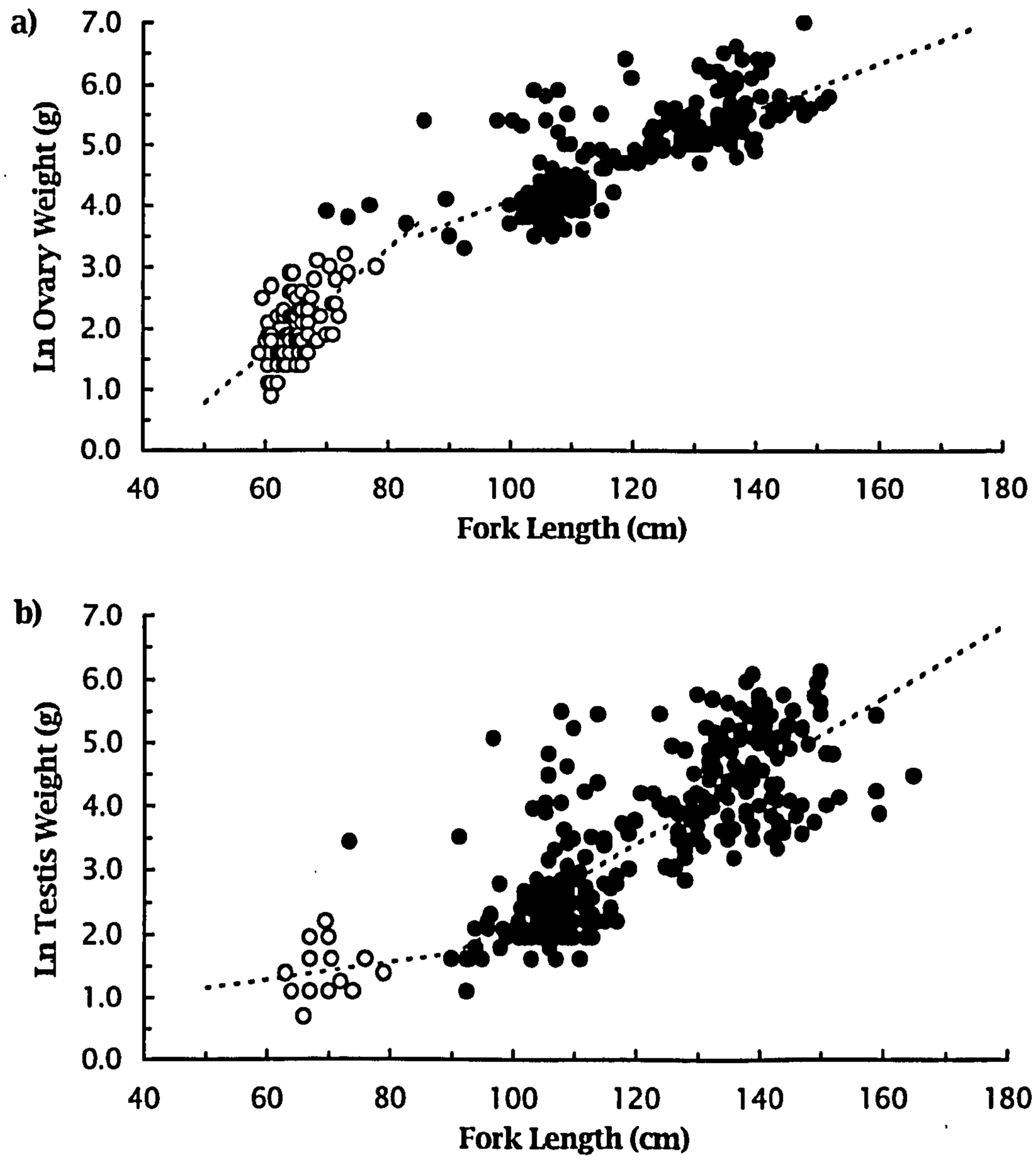


Figure 5,4. Relationship between the log weight of the gonads and fish length for immature (open circles) and mature (filled circles) yellowfin tuna. Broken lines indicate fitted regressions to data for immature and mature fish.

(a) Ovary:
immature fish: slope = 0.084, P < 0.0001, Rsquare = 0.25, n = 85
mature fish; slope = 0.038, P < 0.0001, Rsquare = 0.60, n = 621

(b) Testes:
immature fish: slope = 0.013, P = 0.73 (*ns*), Rsquare = 0.03, n = 16
mature fish: slope = 0.058, P < 0.0001, Rsquare = 0.61, n = 303

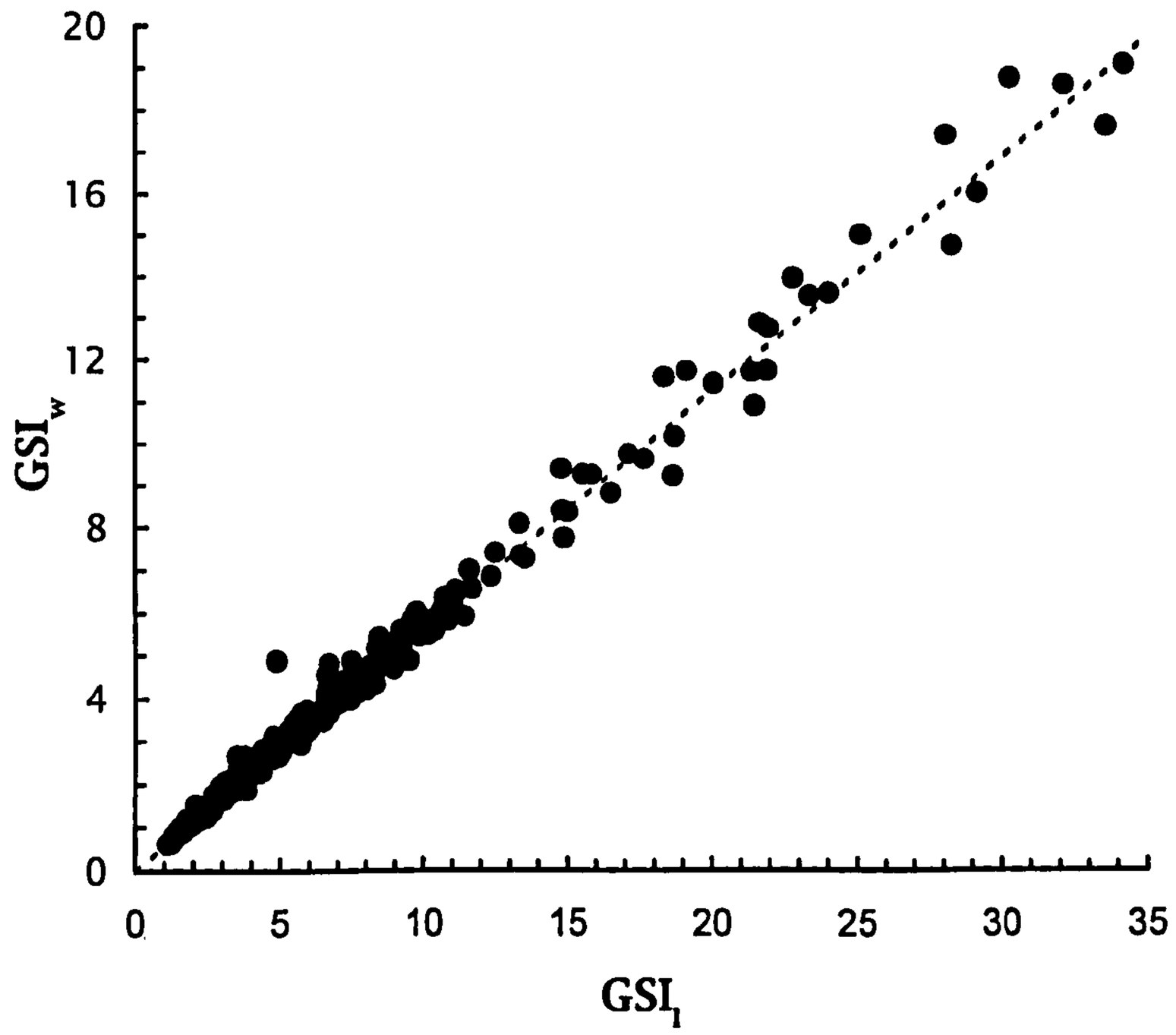


Figure 5,5. The two Gonad-Somatic Indices are very strongly correlated (r=1.00) with one another for yellowfin tuna. The broken line indicates the fitted regression with a slope = 0.561, $P < 0.0001$, Rsquare = 0.99, and n = 345.

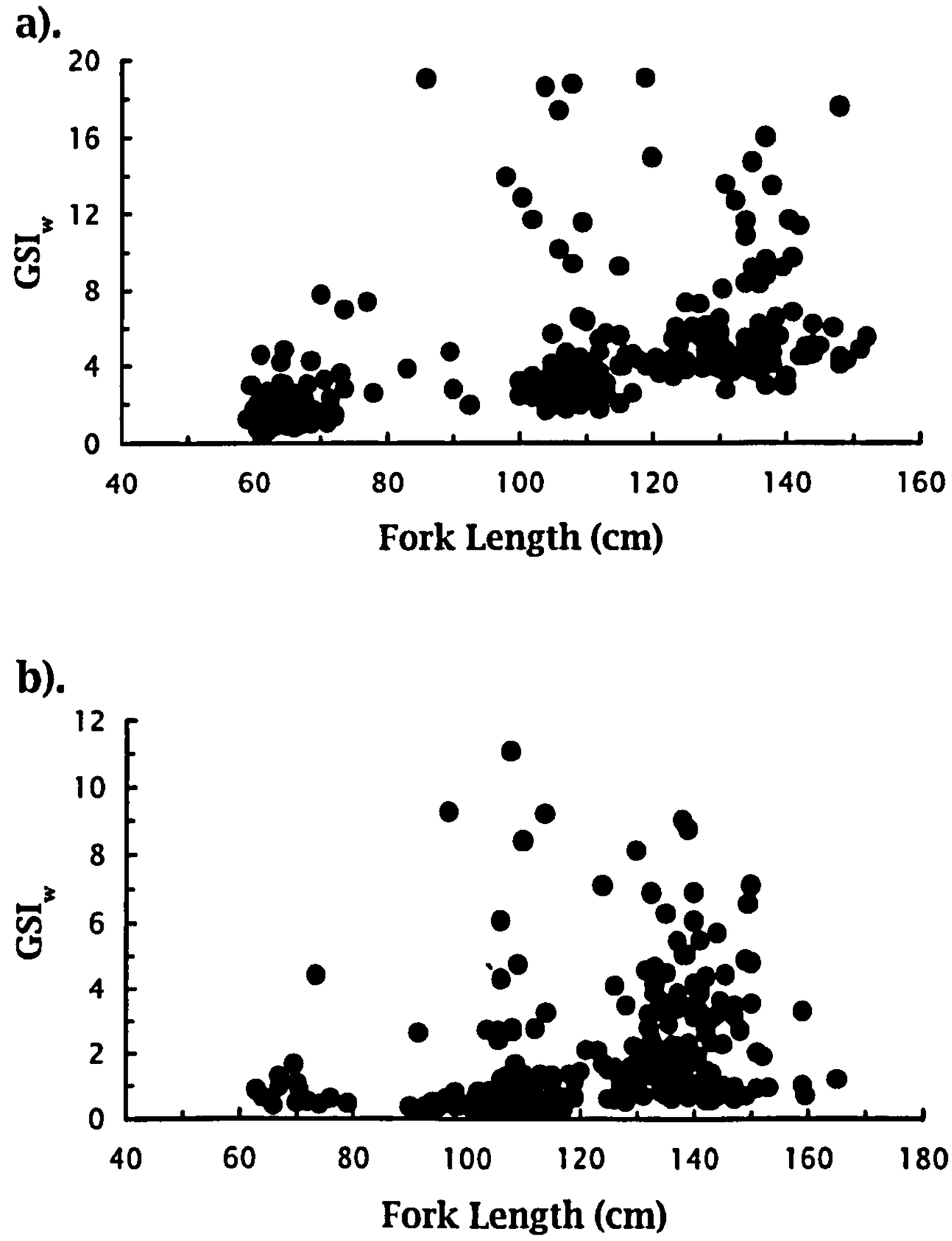


Figure 5,6. Demonstrates the relationship between fork length and the Gonad-Somatic Index for (a) Female, and (b) Male sport fishery-caught yellowfin tuna.

GSI	(cm) Fish Lt	Stage	Date
19.06	119.0	IV	Oct '86
19.04	86.0	IV	Nov '86
18.72	108.0	IV	Dec '87
18.56	104.0	V	Dec '87
17.60	148.0	V	Jan '84
17.38	106.0	IV	Oct '86
16.00	137.0	VI	Oct '83
14.98	120.0	IV	Oct '86
14.74	135.0	V	Oct '83
13.94	98.0	IV	Dec '87
13.59	131.0	IV	Oct '83
13.53	138.0	IV	Sep (b) '83
12.85	100.5	IV	Jan '88
12.73	132.5	III	Oct '87
11.71	140.5	V	Oct '83
11.70	102.0	IV	Jan '88
11.68	134.0	IV	Sep (b) '83
11.55	109.5	IV	Dec '87
11.40	142.0	IV	Oct '83
10.88	134.0	V	Oct '83
10.14	106.0	IV	Oct '86

Table 5,8. Records the GSI_w values greater than 10.00 for female yellowfin tuna and illustrates how these high values represent, with only one exception, stage IV and V fish. Also all but two of these fish were taken during October, or later.

Four fish were diagnosed as being stage VI, two in late September, early October 1981, and the other two in October 1983. The former pair were before the weight of the ovaries was recorded. The smears of ova viewed under the microscope indicated a large number of translucent ova. This stage is only transitory so it was very lucky to have viewed it. Their observance would also imply that spawning was imminent and within the area. However, only one of these had a high GSI_w (Table 5,8). The second fish (138.5 cm FL) had a value of just 6.59. It is possible that the translucent ova were in fact residual hyaline oocytes and that this fish had recently spawned. Either way the implication is that spawning was about to, or had already taken place within the vicinity during October 1983. These were the only four fish over the seven seasons that suggested spawning might occur within the area.

Those fish taken later on in to the tuna season are likely to be closer to spawning than those taken nearer the beginning. All fish taken during August had a GSI_w of less than 5.00, with a few yielding values of 6.00 - 8.00 during the first half of September (Fig. 5,7). During the second half of September a few fish returned values in excess of 10.00, but this number increased in October. The very high values of over 15.00 were not recorded until October or later still (Table 5,8). In

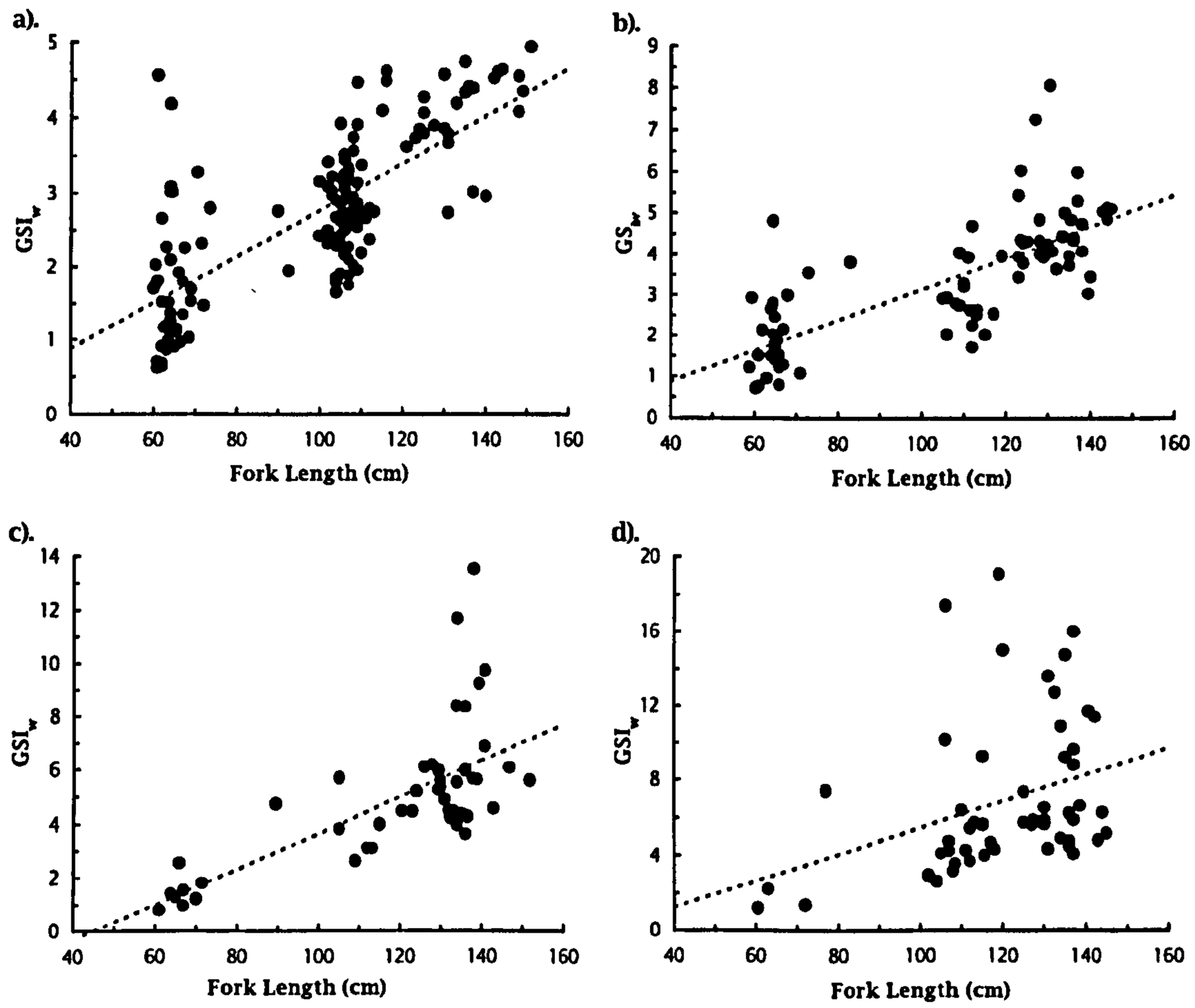


Figure 5,7. Shows the variation by month of the gonad-somatic index, based on weight against fork length for sport fishery-caught yellowfin tuna. Broken lines denote fitted regressions.

a) August: slope = 0.031, P < 0.0001, Rsquare = 0.56, and n = 143;
b) 1st - 15th September: slope = 0.038, P < 0.0001, Rsquare = 0.57, and n = 82;
c) 16th - 30th September: slope = 0.067, P < 0.0001, Rsquare = 0.46, and n = 48;
d) October: slope = 0.071, P = 0.071 (NS), Rsquare = 0.11, and n = 55

September the only fish recording high GSI_w's were large females over 130.0 cm FL. The smaller fish attain a high state of sexual activity later in the season. The implication is that the larger fish that have already spawned before are able to reach a state of spawning readiness earlier than the smaller fish who will be spawning for the first time. This further suggests that the *size class* of 80.5-100.0 cm FL may represent the virgin spawning stock.

GSI	*(cm) Fish Lt*	*Stage*	*Date*
11.05	108.0	IV	Dec '87
9.23	97.0	III	Nov '83
9.17	114.0	III	Dec '84
8.98	138.0	IV	Oct '86
8.72	139.0	IV	Oct '83
8.37	110.0	IV	Dec '87
8.09	130.0	IV	Oct '83
7.08	124.0	IV	Oct '86
7.07	150.0	IV	Oct '83
6.88	140.0	III	Oct '83
6.87	132.5	III	Oct '83
6.54	149.5	IV	Sep (a) '87

Table 5,9. Shows the top dozen GSI_w's for male yellowfin tuna recorded from August 1983 to March 1988.

Males: As with the females, larger fish are more likely to have a high GSI_w, and only one fish less than 100.0 cm FL had one greater than 6.50 (Table 5,9). The majority of male yellowfin tuna caught in the sport fishery yielded a GSI_w of less than 5.00 (Fig. 5,6b). All those fish yielding high GSI_w's were at least stage III, but that not all those identified as being stage IV had high values of GSI_w. All but one fish with a GSI_w greater than 6.0 were taken during October or later in the breeding season (Table 5,9). As with the ovaries those fish greater than 120.0 cm FL became sexually active earlier in the season than those males of shorter length.

HEPATO-SOMATIC INDEX

The weight of the liver increases with fish size irrespective of sex (Fig. 5,8a & b), and there is a suggestion of a similar change in growth rate at approximately 70.0 cm FL as seen in the ovary (Fig.5,4), but only in the female liver (Fig. 5,8a). However a separate regression was not computed as there were only five points. A higher rate of growth of juvenile female livers would imply that in yellowfin tuna the liver is of greater importance in the build up to first time maturation of the ovary than in vitellogenesis.

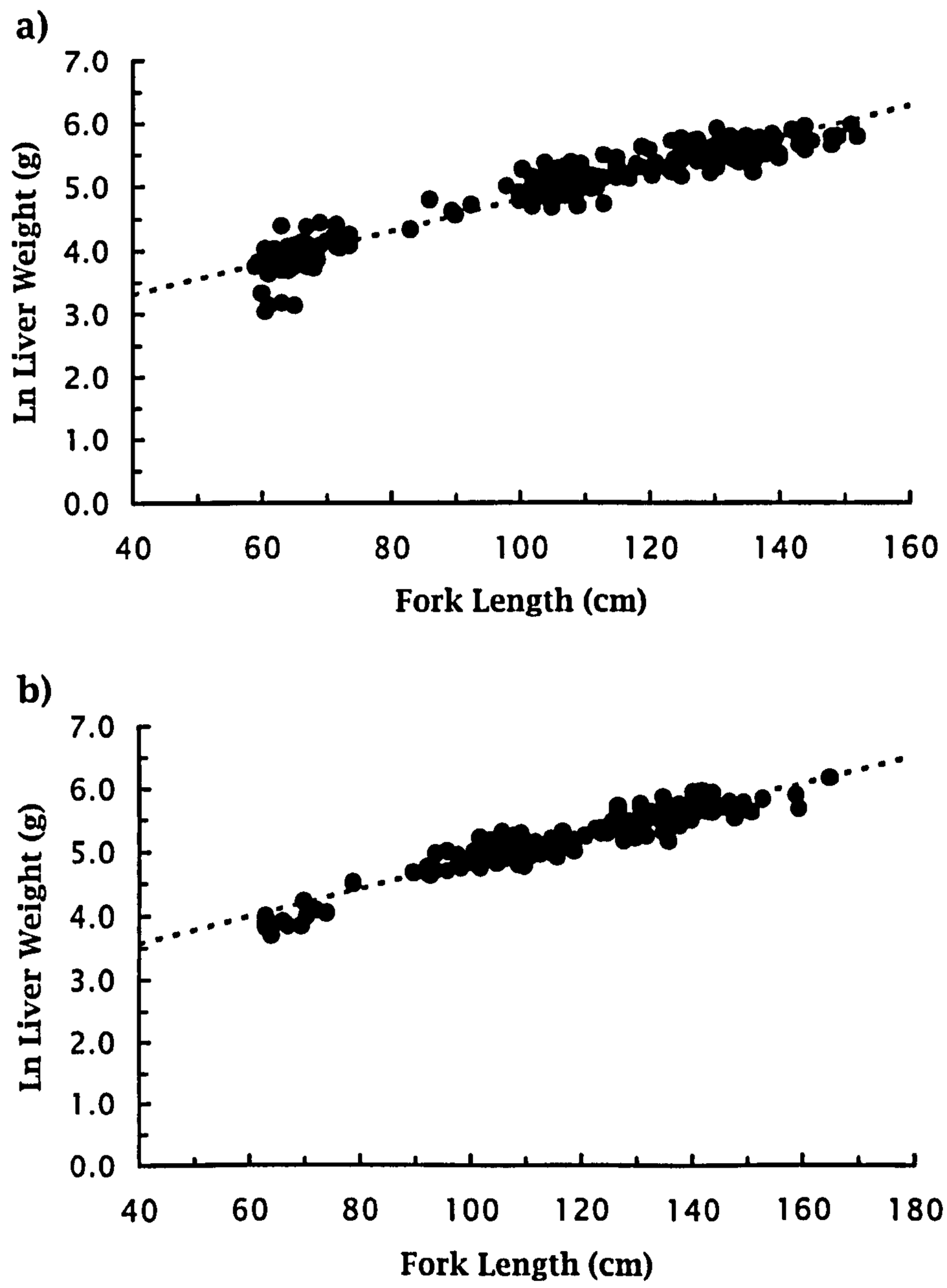


Figure 5,8. The liver increases in weight with increasing fish size in both female (a), and (b) male yellowfin tuna. The broken lines indicate the fitted regressions:

(a) Females - slope = 0.025, $P < 0.0001$, Rsquare = 0.93, n = 278
(b) Males - slope = 0.021, $P < 0.0001$, Rsquare = 0.89, n = 223

Females: The hepato-somatic index falls with increasing fish size and there appears to be a greater variation within the smallest *size class* than with the larger females (Fig. 5,9a). Within the 50.5-80.0 cm FL yellowfin tuna the HSI varies from 17.42 to 4.95, whereas for fish greater than 100.0 cm FL, the variation is from 11.39 to 4.23.

Males: Illustrate a similar decrease in HSI with fish size, but there is less of a variation within the smaller size class (Fig. 5,9b). The implication is that the liver is not important in males for the storing of proteins for the production of sperm, and so the relative importance of the liver as a proportion of total weight falls with increasing fish size.

Those fish with a very high HSI have a low GSI value which is not surprising as they are small fish. Those with a high GSI have a medium HSI of 8.00-12.00 (Fig. 5,10a & b). It appears to be only those fish with a high GSI which separate away from the main group, and that the HSI is of little help in highlighting individuals that might be ready to spawn.

The juvenile fish with a high HSI were all caught in August with a few in the first half of September (Fig. 5,11). This coincides with the period before the main gonad activity of October onwards illustrated by the GSI_w results in Fig. 5,7. The implication is that the liver plays a major part in storing valuable nutrients that will be required in the build up to the maturation of the ovaries. The relative influence of the liver reduces beyond maturation. The positive regression slope shown for October was not significant and resulted from there being only two fish less than 100 cm FL (Fig. 5,11d). It is noted that in both the second half of September and in October there were some stage II yellowfin tuna with very low HSI which may imply that these individuals were not close to reaching maturity at their time of capture. The liver had not yet begun to build up nutrients.

OVA DIAMETERS

All the stages of development that were measured yielded a plurimodal distribution (Fig. 5,12). This is in line with the theory that yellowfin tuna are multiple spawners. An ovary includes ova in many stages of development at the same time. I used mixture analysis, and assuming normal distributions, estimated the means, standard deviations and proportions for three components for each oocyte type. Estimates of Chi-squared and P are also given (Fig. 5,12). At least two normal components were fitted for each stage. Three components were fitted to all but the late perinuclei for which only two could be fitted. The suggestion being that as one batch is spawned another is building up ready to spawn.

The normal distributions of the different oocyte stages demonstrate considerable overlapping between them.

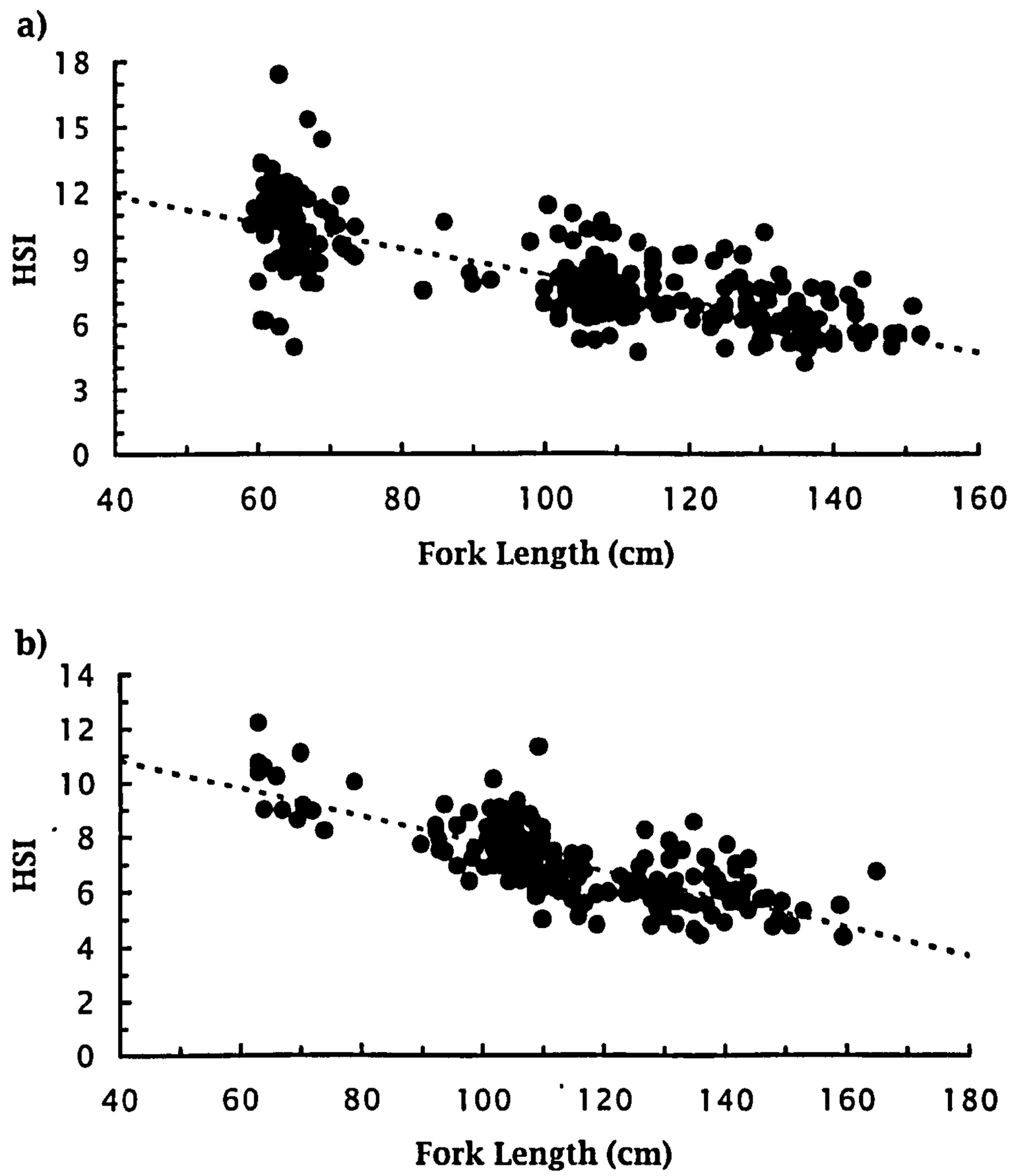


Figure 5,9. Illustrates the relationship between the hepato-somatic index and fork length for sport fishery-caught yellowfin tuna. The broken lines indicate fitted regressions for males and females.

(a) Females: slope = -0.059, P < 0.0001, Rsquare = 0.55, n = 278, r = -0.74.
(b) Males: slope = -0.051, P < 0.0001, Rsquare = 0.54, n = 223, r = -0.73.

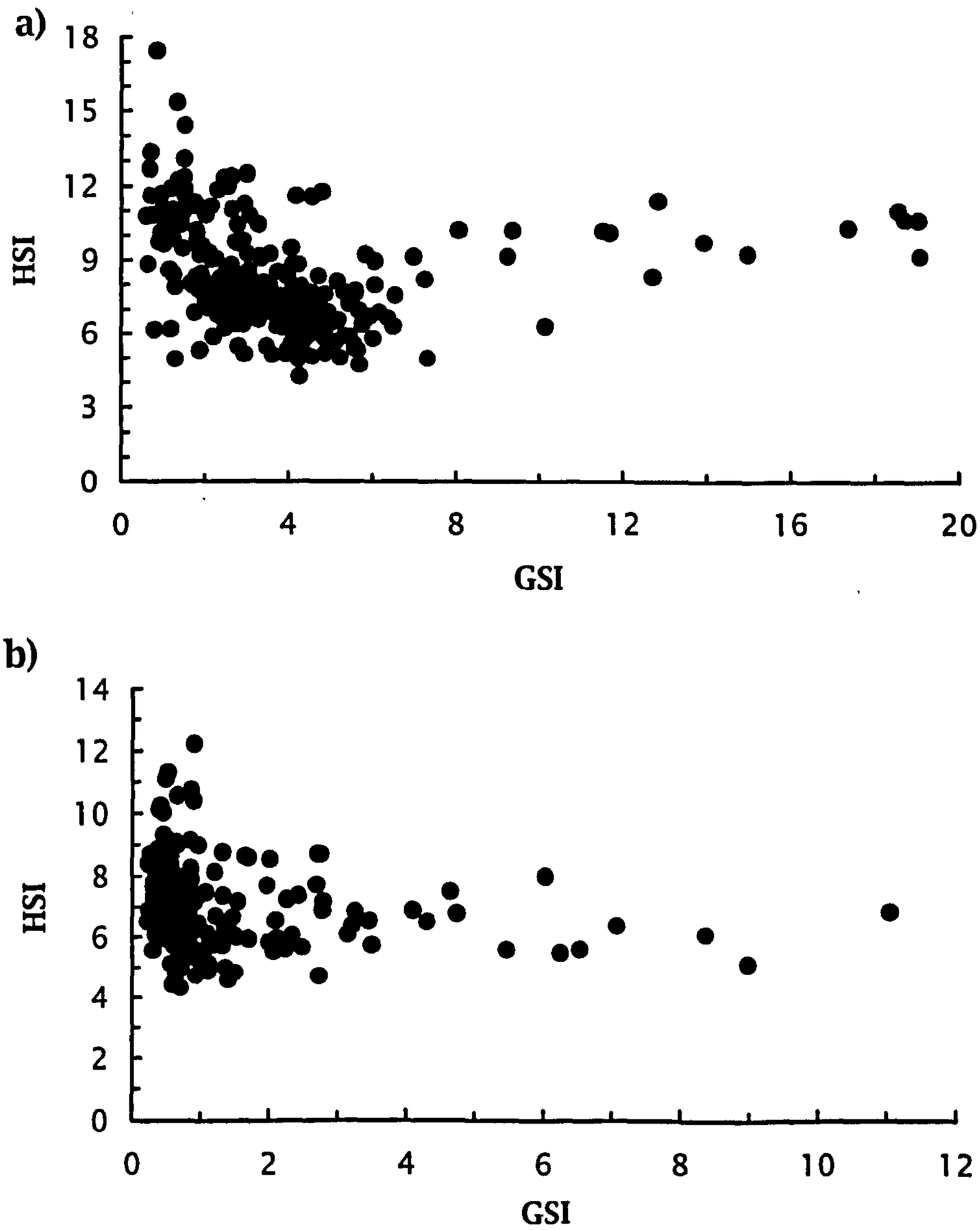


Figure 5,10. The relationship between the hepato-somatic index and the gonad-somatic index for, (a) female, and (b) male yellowfin tuna. High GSI values are characterised by low HSI values.

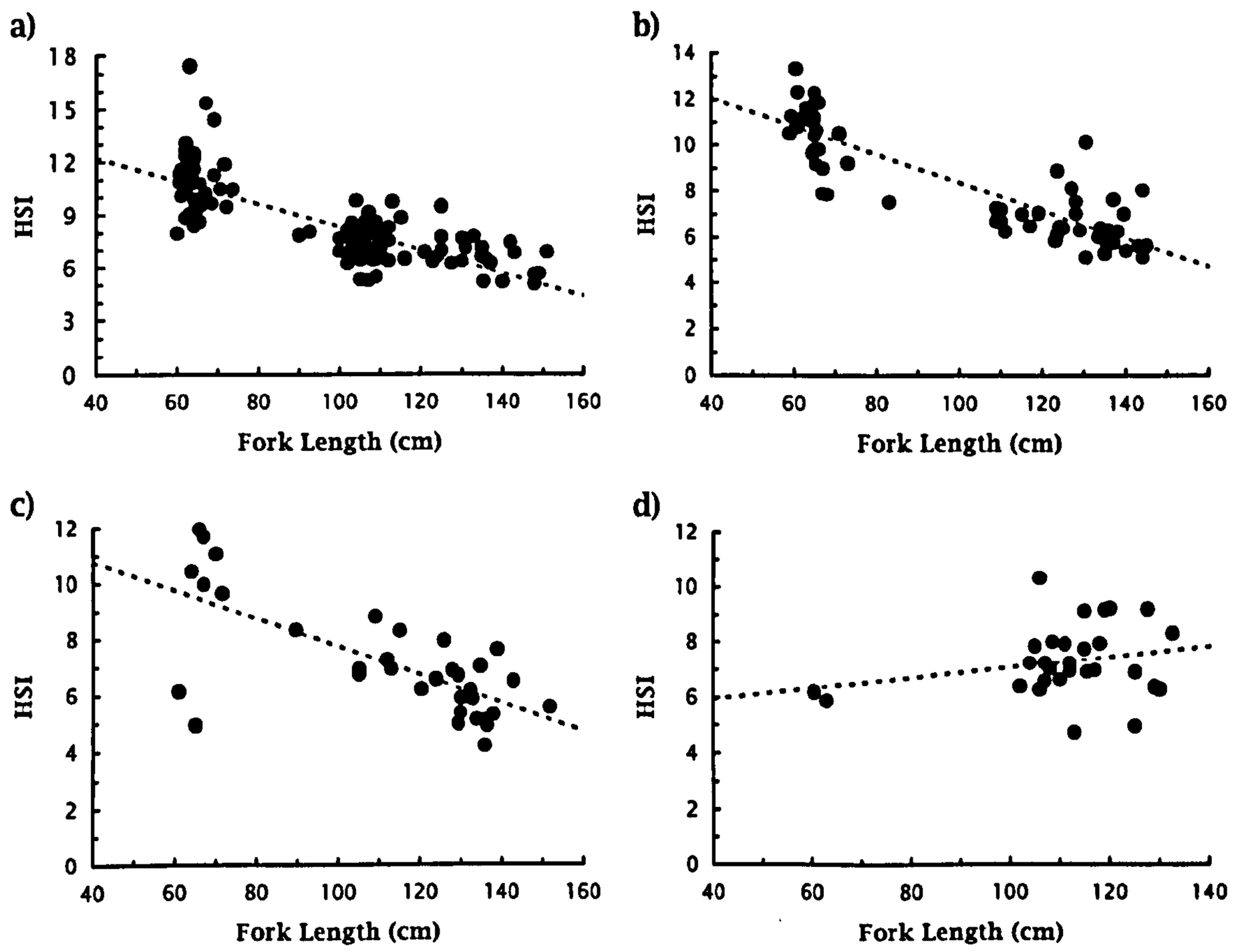


Figure 5,11. Illustrates the variation of the hepato-somatic index with fish size by month of capture. The broken lines indicate the fitted regressions:

a) August: slope = -0.066, P < 0.0001, Rsquare = 0.60, and n = 139;
b) 1st - 15th September: slope = -0.061, P < 0.0001, Rsquare = 0.74, and n = 61;
c) 16th - 30th September: slope = -0.050, P < 0.0001, Rsquare = 0.49, and n = 36;
d) October: slope = 0.019, P = 0.21 (NS), Rsquare = 0.06, and n = 29.

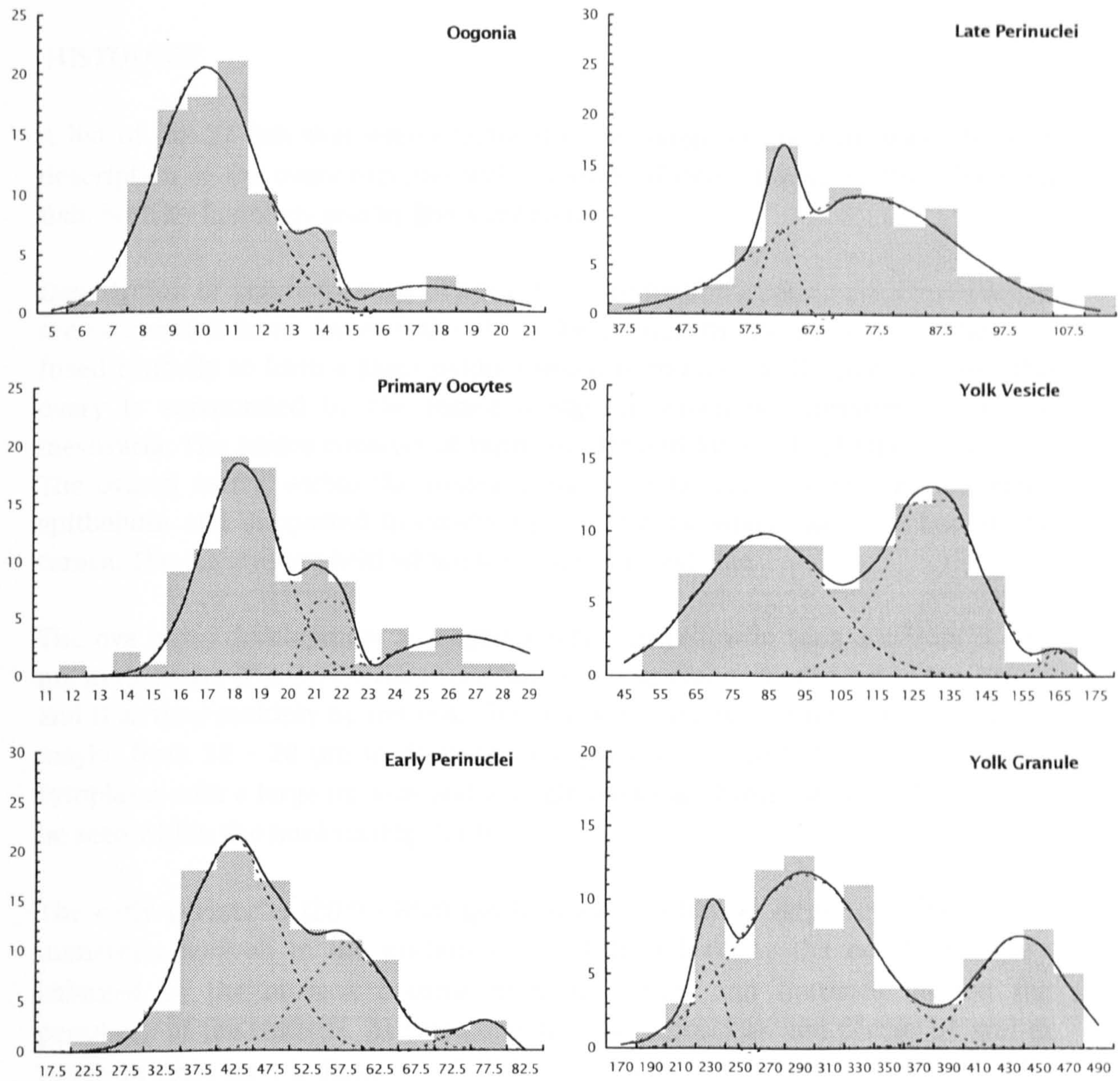


Figure 5.12. Measured oocyte diameter distributions of 100 oocytes from each of six stages from yellowfin tuna ovaries. Superimposed curves show fitted mixtures of three Normal distributions as described in the text. X-axes labels are midpoints of oocyte diameter classes in mu, Y-axes are frequency, solid lines are fitted distribution mixtures, dashed lines are fitted Normal components. Means, standard deviations and proportions of the fitted mixtures are tabulated below, together with Chisquare goodness-of-fit tests. # indicates that only two components could be fitted.

	Means (mu)			Standard Deviations (mu)			Proportions			Fit		
	1	2	3	1	2	3	1	2	3	Chisq	df	P
oogonia	10.1	17.5	13.5	1.67	1.97	0.05	0.832	0.105	0.063	4.5	7	0.72
primary oocytes	18.2	21.5	26.5	1.42	0.19	2.30	0.676	0.127	0.197	6.6	9	0.68
early perinuclei	42.1	57.9	75.4	5.92	5.33	1.00	0.651	0.303	0.047	4.8	4	0.31
late perinuclei	60.9	75.2	#	0.73	14.76	#	0.097	0.903	#	4.3	7	0.74
yolk vesicle	83.5	130.3	165.7	17.27	12.06	0.83	0.503	0.478	0.019	1.5	4	0.83
yolk granule	223.4	293.3	438.2	3.14	43.54	28.65	0.066	0.655	0.278	3.8	7	1.00

HISTOLOGY

A list of the 27 fish that were examined by histology as given in Appendix E. A description of the ovary together with its stage of development is given for each fish, both by histology and by gross criteria.

Description of yellowfin tuna ovaries: They are fusiform paired structures which are suspended from the dorsal wall of the coelum by the mesovaria. They are fused caudally to form a short oviduct which terminates at the genital pore. The ovary is surrounded by the tunica albuginea, which is continuous with the mesovaria. The tunica consists of both circular and longitudinal smooth muscle. The ovarial cavity, within the tunica, consists of lamellae covered by a surface epithelium and supported internally by the stroma, which are branches of the tunica. The oocytes are held within the ovigerous lamellae.

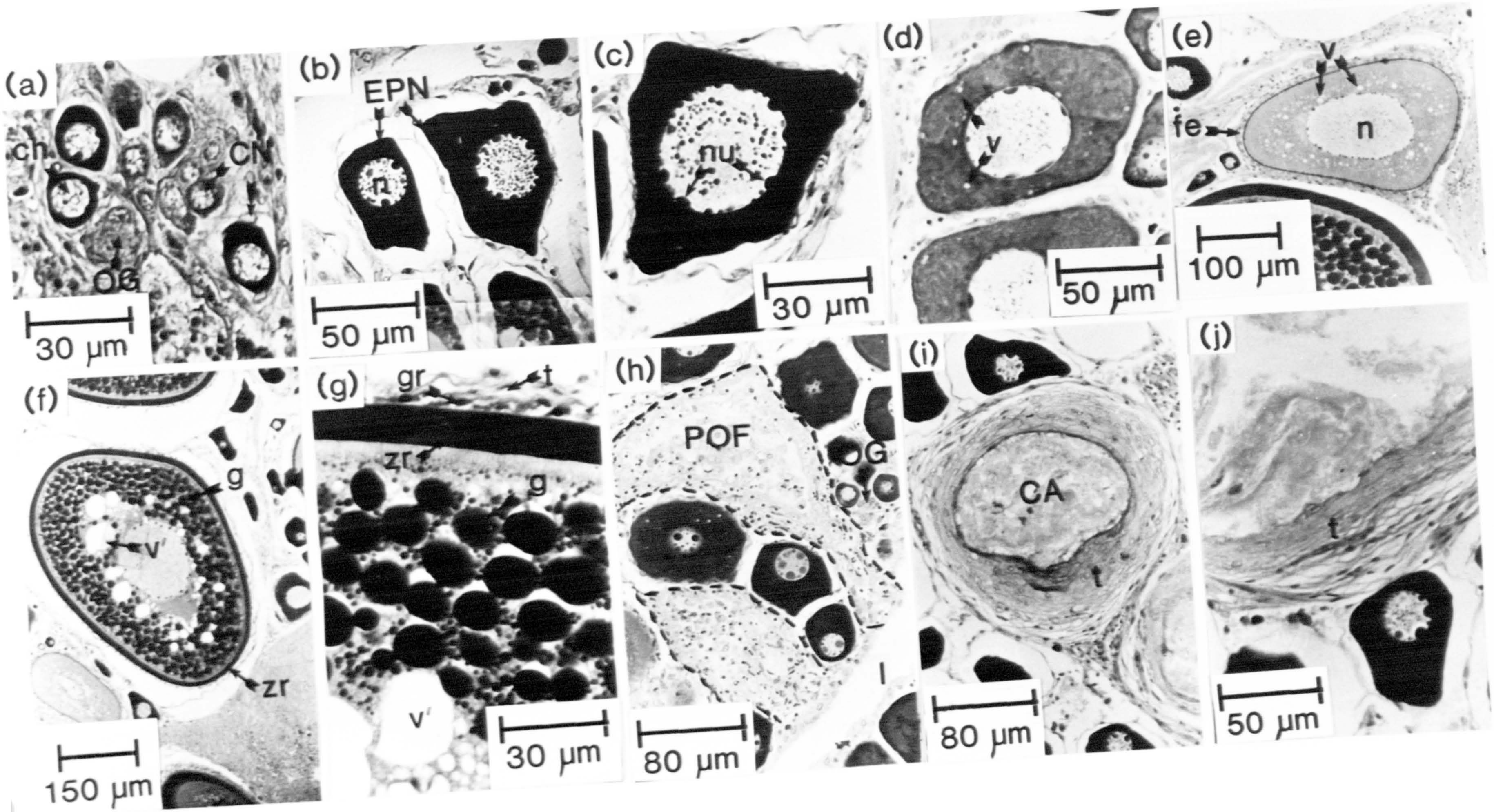
The ova begin development as oogonia, which in yellowfin tuna are from 6 - 20 µm in diameter (Fig. 5,12). These are found in oogonial nests as seen in Fig. 5,13(a and i) as they multiply by mitosis. The next stage are the primary oocytes, which maybe from 12 - 28 µm in diameter and possess a narrow basophilic staining cytoplasm with a large nucleus and a single nucleolus.Chromatin strands may also be seen within the nucleus (Fig. 5,13a).

The early perinuclei (20.0 - 80.0 µm in diameter) have a larger cytoplasm with numerous nucleoli in the nucleus (Fig. 5,13b and c). As the oocyte becomes enlarged so the nucleoli become more numerous and flattened around the periphery of the nucleus. At this point they are known as late perinuclei and in yellowfin tuna have a diameter of 35.0 - 115.0 µm. The oocyte is surrounded by an inner layer of cuboidal granulosa cells with an outer layer of flat thecal cells.

The next stage marks the start of vitellogenesis where the size of the oocyte increases and yolk becomes laid down in the cytoplasm. The first yolk to be laid down is carbohydrate which forms vesicles, and this stage is appropriately known as the yolk vesicle stage (Fig. 5,13d). These cells in yellowfin tuna are 50.0 - 170.0 µm in diameter (Fig. 5,12). At this stage the oocyte is surrounded by a thin follicular envelope of zona radiata, granulosa and theca from the inside out (Fig. 5,13e).

Figure 5,13. Sections through yellowfin tuna ovaries at various stages in the development of the oocyte, as described in the text, are illustrated opposite.
Abbreviations used are as follows:

ch - chromatin strands;
OG - Oogonial nests;
CN - Chromosomes;
n - Nucleus;
EPN - Early perinuclei;
nu - Nucleoli;
V - Yolk vesicles;
fe - Follicular envelope;
g - Yolk granules;
zr - Zona radiata;
gr - Granulosa;
t - thecal cells;
POF - Post-ovulatory follicle;
CA - Atretic cell.
V' - Lipid globule


(a)
ch
CN
OG
30 µm
(b)
EPN
n
50 µm
(c)
nu
30 µm
(d)
v
50 µm
(e)
v
fe
n
100 µm
(f)
g
v
zr
150 µm
(g)
gr
t
zr
g
v
30 µm
(h)
POF
OG
l
80 µm
(i)
CA
t
80 µm
(j)
t
50 µm

After this stage endogenous yolk vesicles are not apparent. The oocyte then enters into an active phase of formation of yolk granules. The yolk granule stage had a diameter of 180.0 - 480.0 μm (Fig. 5,13f and g). This stage is characterized by a prominent zona radiata, which actually consists of two layers although these were not discernible (Fig. 5,13g). Concurrent with yolk granule production is the deposition of lipid globules (Fig. 5,13f and g).

Stage	*Description*
Immature (I)	Well defined genital ridges in the lumen, densely staining cytoplasm, large number of oogonia, primary oocytes,and perinuclear oocytes.
Early maturing (II)	Early vitellogenic stage. Number of oogonia and primary oocytes decrease. Predominantly perinuclear oocytes and yolk vesicle stage. Genital ridges still well defined.
Maturing (III)	Late vitellogenic stage. Prominent zona radiata, densely staining yolk granules and larger lipoid vesicles.
Mature (IV)	Characterized by nucleus moving towards the animal pole and the uptake of fluids (hyaline stage).
Spawning (V)	Ruptured follicles. Other stages present particularly oocytes in stage IV.
Spent (VI)	Post-ovulatory follicles, and residual maturing oocytes degenerating. Increase in oogonia and primary oocytes.

Table 5,10. A summary of the classification of ovarian development used for the histological sections of yellowfin tuna ovaries.

After this the nucleus, known as the germinal vesicle, migrates to the animal pole. This stage was not observed in the 1987/88 sample. When the germinal vesicle reaches the micropyle at the animal pole the nuclear membrane breaks down and the contents spill out into the cytoplasm. The yolk granules then fuse into platelets and the oocyte hydrates. During the later stages of hydration the yolk platelets form a homogenous mass.

At spawning the oocyte is released into the lumen of the ovary and from there into the sea. What is left is the post-ovulatory follicle which consists of an inner epithelioid layer of granulosa cells and an outer connective tissue layer of thecal cells (Fig. 5,13h). This stage is transitory and is rapidly re-absorbed.

During all stages of development some oocytes will be re-absorbed for some reason or other. Also at the end of the spawning season those cells not needed

for spawning are re-absorbed and these are termed atretic oocytes. An example of advanced atretia is illustrated in Fig. 5,13i. There are in fact three types of atretia, α-atretia, β-atretia and χ-atretia, but it was considered beyond the scope of this study to go into the different types of atretia. The atretic oocyte is characterized by a thick thecal layer (Fig. 5,13j) and very often bits of cytoplasm or phagocytic granulosa cells.

The sectioned ovaries were examined and compared to the stageing by gross characteristics. The classification of ovary stages used in the histology is summarized in Table 5,10.

5.4. Discussion

STAGEING BY GROSS CHARACTERISTICS

The sexual activity of the Pemba Channel yellowfin tuna stock varied from one season to another over the same months. Fish reproduction is almost always cyclical, and even in the tropics where the environmental conditions seem stable, there may still exist a cycle of gonadal maturation imposed by the energy demands of maturing a batch of eggs (Hoar, 1969). However spawning activity is likely to be affected by such factors as food availability and water temperature and the actual onset of spawning maybe early or slightly delayed. The production of a large batch of eggs imposes serious energy demands on the fish, and this energy must come from food ingested. If food supply is low then the reproductive cycle is likely to be inhibited and the fish must search for an area of high food availability.

During the tuna season of 1981/82 and 1982/83 food was readily available as crabs, fish and squid (Chapter 6) and hence there were many females of at least stage III. Two fish also contained a significant number of hydrated oocytes indicating that spawning was imminent, and within the area. On the contrary, during 1985/86 the conditions were very calm and there was very poor food availability. As a result there were no stage IV or V females. Presumably there was not sufficient energy left over from metabolism to put into egg production.

The proportion of the catch which was mature will also depend on the mean size of the tuna passing through the Pemba Channel during that season. If there are a large number of fish greater than 120.0 cm FL there is a greater chance of catching a fish that is preparing to spawn. During 1986/87 the main size-range was 100.0-120.0 cm FL and only 4% of these were beyond stage III.

Having followed the Shimoni sport fishery for seven seasons it has been possible to notice the above variation. Where data is collected over a more limited period the results may not reflect an accurate picture of the stock. It is not only the number of fish sampled but the time period over which this is done to cover possible cycles.

SIZE AT FIRST MATURITY

The smallest fish of at least stage III was a 70.0 cm FL fish taken on the 2nd January 1984. A number of other fish less than 100 cm FL were also found to be stage III and a fish of 86.0 cm FL was taken in 1986 with stage IV ovaries. Buñag (1956) described a yellowfin tuna from the Philippines of 56.7 cm FL with an ovary pair weight of 129 g which was nearly ripe. Yellowfin tuna inhabiting coastal areas or waters close to islands attain sexual maturity at a different size than those found in offshore waters of the Pacific (Cole, 1980).

Albaret (1977) selected stage III as his base level of maturity, but by doing so is ignoring those individuals that have attained maturity, possibly spawned and are now in a state of recovery. Albaret called this, stage VI but in the present study it was felt that this was too easily confused with stage II. A slight bias might exist in the assessment of the immature and mature fraction of females, within length classes, since without histological analysis of the ovarian tissue some of the post spawners are indistinguishable from the immature females (Schaefer, 1987). Recent post-spawners may be identified by the presence of residual hyaline oocytes found within the ovarian lumen. Schaefer (1987) considered this bias to be only slight. But, these will be reabsorbed and will not remain in the lumen for long. Particularly if the resting period prior to the next spawning season is long there maybe no residual oocytes within the ovarian lumen.

After completion of spawning the ovary will lose weight, become flaccid and discoloured, but after a period of recovery it will revert back to its original shape, pink colour, firmness and resemble a freshly developing ovary. A stage II ovary of a past-spawner is likely to demonstrate a higher degree of vascularisation than that of a fish maturing for the first time.

The presence or absence of post-ovulatory follicles is also not a good indicator as these are transitory (Bara, 1960; Goldberg *et al.*, 1984; Hunter & Goldberg, 1980; Wheeler, 1924; Yamamoto & Yoshioka, 1964;) and within 24 hr those of skipjack tuna cannot be accurately identified (Hunter *et al.*, 1987).

During the present study there was insufficient time available to open each ovary and examine it microscopically for the presence of residual oocytes. The time available for data collection each day was limited by business demands. The separation of the food items for Chapter 6 also took up a lot of time.

Kikawa (1966) and Suzuki *et al.* (1978) have postulated that the spawning potential of yellowfin tuna less than 100.0 cm FL has been underestimated. The results of my study were not able to support this hypothesis in any of the seven seasons as only two females less than 100.0 cm FL were stage IV. In 1986/87 and 1987/88 six individuals of 100.0-110.0 cm FL were recorded of stage IV. In fisheries science we are concerned with the size at which the majority reach sexual maturity rather than that at which a few individuals do so. My results suggest that the majority of females longer than 120.0 cm FL have matured and may be considered to form the bulk of the spawning stock. The main replenishment for this stock will come from the 100.0-120.0 cm FL group.

My results concur with those of Shung (1973) and Timochina & Romanov (1991), but many of the other workers estimated that the size at which 100% of females had reached stage III to be within the 110.0-120.0 cm FL class. Timochina & Romanov (1991) found that stage III was represented by a mean length of 120.0 cm FL.

SEX-RATIOS

When all sizes of fish are considered for various pelagic species, particularly the tunas, the sex-ratios are almost always close to the expected 1:1. In the larger size classes males usually dominate as has been shown for albacore, *Thunnus alalunga* (Otsu & Sumida, 1968), bigeye, *Thunnus obesus* (Kume & Joseph, 1966; Pereira, 1984), kawakawa, *Euthynnus affinis* (Williamson, 1970), skipjack tuna, *Katsuwonus pelamis* (Brock, 1954; Marr, 1948; Raju, 1964), and yellowfin tuna (Karpinski & Hallier, 1988; Lenarz & Zweifel, 1979; Murphy & Shomura, 1972; Orange, 1961). The differentials in sex-ratios with respect to size classes between males and females has been suggested to be due to differences in growth rate, mortality or vulnerability to fishing gear. The almost complete lack of females in the very largest size classes of tuna seems to be caused by differential natural mortality, rather than differences in growth rate or availability to capture (Schaefer, 1987). Sexually dimorphic growth has been shown with respect to fork length in yellowfin tuna (Wild, 1986), but Schaefer argues that these differences are only very slight and not enough to explain the disappearance of female yellowfin tuna beginning in the length interval 130.0-140.0 cm FL.

Several theoretical studies have demonstrated the link between reproduction and mortality, as both rates often increase with body weight and age during the later stages of the life cycle (Ware, 1984). Hirschfield (1980) stated that individual fish may allocate insufficient energy to maintenance costs while reproductively active, even at the cost of an increased probability of mortality. Spawning stress mortality maybe a significant part of senescent mortality in all fish (Andersen & Ursin, 1977; Laevastu & Larkins, 1981). A yellowfin tuna that has completed

spawning and is described as spent does not look outwardly any different. There are no descriptions in the literature of thin and emaciated yellowfin tuna.

These results illustrate an even sex-ratio for 100.0-120.0 cm FL fish and an increase in the males above 120.0 cm FL apart from in 1983/84 and 1984/85 when there were more females than males. Over the entire seven seasons these results do concur with Mimura *et al.* (1963) in that males dominate in fish over 120.0 cm FL.

The 1:1 ratio yielded by the sport fishery data suggest that the predominance of males in previous studies in the Indian Ocean may result from, either the inclusion of immature individuals, or a biased sample of mainly large individuals. As has been discussed in an earlier section the differentiation between the sexes at this stage is unreliable. On the other hand it may also suggest that the sport fishery is a fair means of collection for this type of data. It also demonstrates that the sport fishery does not just take large individuals, but samples the complete spectrum of available sizes unlike most of the commercial gear types, such as longline, purse seine and pole-and-line.

GONAD-SOMATIC INDEX

GSI is a useful guide to reproductive activity as shown by this study. The main bulk of immature and resting individuals show a low GSI albeit an increase with fish size. Those sexually active individuals demonstrate a high GSI.

Schaefer (1987) examined the relationship between the GSI and the diameter of the most advanced group of oocytes for black skipjack, *Euthynnus lineatus* in the Eastern Pacific. He noted that for the low and intermediate 'most advanced group of oocytes' the GSI's tend to be greater for the largest fish, whereas for the highest 'most advanced group of oocytes' greater values of GSI resulted from the small and intermediate fish. de Vlaming (1982) concluded that GSI may not be an accurate guide to gonadal activity.

The results of this study illustrate that some individuals estimated to be of stage IV actually possessed low GSI's, but none of those with high GSI greater than 10.0 were less than stage III implying that a high GSI is an indication of high gonadal activity. However GSI alone is not an accurate indicator of reproductive activity and it should be validated with histology and/or oocyte diameter measurements (Schaefer, 1987).

HEPATO-SOMATIC INDEX

The HSI is not a good indicator of sexual activity in yellowfin tuna when looked at over a long time period. However it maybe an indicator of the seasonal activity of

early maturation in pre-spawning yellowfin tuna. Likewise, in the dab, *Limanda limanda* HSI peaked during the pre-spawning and early spawning periods (Htun-Han, 1978). The greatest variation in HSI was noted in the 50.0-80.0 cm FL *size class* with August and early September showing the highest activity. The implication is that the liver plays a major role in the early maturation of the ovaries and that those fish returning high values during August and early September will likely reach maturation later in the season. Possibly those fish within this size category showing a low HSI will not reach maturity during that season.

Vitellogenesis occurs with the participation of the liver and as soon as the oocytes reach a certain size and yolk is no longer stored the liver reduces in size (Krivobok, 1964). Krivobok noted that in the Baltic herring, *Clupea harengus membras*, the average weight of the liver increased as a proportion of the total fish weight with maturity of the gonads, but in yellowfin tuna there was a decrease in the relative weight of the liver with increasing fish size. Krivobok demonstrated that under the influence of folliculin deposited by the ovaries the size and activity of the liver increased sharply at the commencement of ovarian maturation. The amount of protein, extractive and amine nitrogen in the liver reached a maximum at the transition of stage III to IV in Baltic herring and thereafter the quantities of both reverted back to levels prior to the start of maturation.

HISTOLOGY

A comparison of the stageing by gross characteristics and that using histology demonstrated a difficulty in the interpretation of stage IV. The stageing by the former method is a useful tool in the field, but lacks precision (Albaret, 1977) and wherever possible should be supported by histology. However, it is not always convenient, nor are the necessary equipment and facilities always available to carry out a histological survey.

The inference from the results of the 1987/88 sample is that spawning was not taking place within the Pemba Channel during that time period, but was likely to be taking place farther on into the migration route. However, I feel sure that had this survey been carried out during either of the first three seasons the fish would have appeared to be in a more active state.

SPAWNING SEASON

Kikawa & Ferraro (1966) tentatively suggested that the peak spawning month for yellowfin tuna in the Western Indian Ocean is February. Conand & Richards (1982) collected tuna larvae in the Western Indian Ocean between Madagascar and the equator. They found some isolated zones of abundance of yellowfin tuna larvae in

the northern end of the Mozambique Channel and to the east of Madagascar, with zones of smaller density to the north-east of the island during November to April. Unfortunately, they did very few plankton hauls close to the East African coast.

Karpinski & Hallier (1988) suggested the area between the Seychelles and the Chagos to be a major spawning ground for the Western Indian Ocean from December to at least February or March. Hassani & Stéquert (1991) identified a main period of intense sexual activity from November to April with a peak in January to February around the Seychelles. They suggested that there might exist a smaller peak around July. Mature, gravid and spent fish are to be found around the coast of Sri Lanka during most months of the year with highest levels of sexual activity from February to May and September to October (Maldeniya & Joseph, 1986). Results based on longline data point to a peak period of January to March (Shung, 1973). Timochina & Romanov (1991) also noted well defined periods of sexual activity for yellowfin tuna within the fishing zone of the Seychelles falling within the months from November to February. The period January to September, on the other hand appeared to be a time of sexual inactivity.

Yellowfin, bluefin (*Thunnus thynnus*), and skipjack tunas probably spawn at least twice a season (Baglin, 1982; Knudsen, 1977; Matsumotu *et al.*, 1984).

Results from my study would seem to agree with those from former studies on the reproductive parameters of yellowfin tuna within the Western Indian Ocean. Yellowfin tuna caught later into the season are more sexually advanced than those taken during August or early September. The increase in sexual activity in the 80.0-100.0 cm FL class from November to March also points to this period as being the major spawning season in the Western Indian Ocean.

There is little evidence to suggest that the Pemba Channel itself is a major spawning ground for yellowfin tuna. In 1981/82 and in 1983/84 four fish with hydrated oocytes were seen implying that some spawning may occur here if the conditions are suitable. Talbot & Penrith (1960) noted that spawning or spent fish are occasionally taken off Kenya and Zanzibar in July.

Post-spawning female skipjack tuna may reactivate their ovaries later in the year if their physiological condition favours reproduction (Hunter *et al.*, 1986). Evidence from northern anchovy, *Engraulis mordax*, indicates that the transition from post-spawning to spawning states and vice versa can occur rapidly. Under laboratory conditions at 16°C they can reabsorb all the advanced oocytes within a few weeks (Hunter & Macewicz, 1985) and can produce an active ovary in 30 days (Hunter & Leong, 1981). Considering the higher water temperature and high rate of metabolism tuna are probably capable of a much faster turn around.

Given the favourable ecological conditions of August to October of 1981/82, 1982/83, and 1983/84 it is possible that the yellowfin tuna had reactivated their gonads outside of the normal spawning season to take advantage of these conditions. Hence the increase in the number of advanced ovaries and the sighting of four specimens with hydrated oocytes. Nakamura (1969) promoted the hypothesis that the current system in which the fish are found should be treated as distinct habitats and not just as transporters of water or as regulators of temperature. Therefore the ecological conditions which persist within the habitat at any given time will determine the behaviour of the tuna living within that habitat.

5.5. Conclusions to Chapter 5

Data on gonads, liver and other material was collected from 1,653 yellowfin tuna between August 1981 and March 1988 from the Shimoni-based sport fishery in the Pemba Channel, Kenya. During 1987/88 a sample of ovaries was used for a histological study.

An overall sex ratio of 1:1 for males:females was observed: all yellowfin tuna of less than 50 cm FL were of indeterminate sex. There was a predominance of males in fish over 120 cm F.

Variation was noted in the reproductive status of the stock from one season to another over the equivalent months. No spent males were observed implying that gonad Stage V is not a real stage in male yellowfin tuna. Throughout the study period 87% of female yellowfin tuna between 100-120 cm FL were of stage II, with the proportion decreasing to 15% in those over 120 cm FL.

Sexual maturation begins earlier in females but male yellowfin tuna reach a state of sexual preparedness ahead of females. Yellowfin tuna caught in October or later were more advanced sexually than those caught earlier in the season with past spawners reaching a state of sexual readiness earlier than first time spawners. The proportion of mature individuals will also depend upon the dominant size class of yellowfin tuna caught during that season. The smallest mature female recorded was only 70 cm FL. The bulk of the spawning stock appears to be composed of females greater than 120 cm FL, while the 100-120 cm FL size class forms the 'virgin spawners'.

Both male and female gonads increase in weight with increasing fish size but the pattern of growth differs between the two sexes. Ovaries increase in size rapidly until the fish is approximately 80 cm in FL, whereupon there follows a decrease in growth rate.

On the other hand, the testes demonstrate slow juvenile growth up to the onset of maturity, when the increase in weight rapidly.

The Gonad-Somatic Index is a useful guide to the reproductive activity of yellowfin tuna. A high GSI implies an advanced reproductive status whereas all immature and resting individuals possess low GSI values.

Although the liver increases in size with increasing fish size, the relative weight of the liver decreases with fish size. My work shows that the Hepato-Somatic Index is not a good indicator of sexual activity in mature yellowfin tuna, but may signal early maturation in pre-spawning yellowfin tuna. The liver appears to be of importance in the early maturation of the ovary, but not of the testes. Seasonal estimates of the HSI indicate that maturation of the ovary occurs during August and early September in preparation for advanced maturation in October and beyond.

Stageing by gross criteria is a useful tool in the field, but lacks precision and can be subjective, and therefore whenever possible should be supported by oocyte diameter measurement and/or histology. There was some error in the identification of Stage IV ovaries using only gross criteria as oocyte data showed many to be still in Stage III.

The size distribution and sex ratio of the sport fishery catch presented here demonstrate that the sport fishery can be an unbiased medium for the collection of samples to determine the reproductive status and measure reproductive parameters of yellowfin tuna. To avoid bias from ecological cycles, data should be collected over a minimum of five years. Significant variations were noted between years, and a periodicity of 4-6 years was also noted in other data (See Chapter 2 and 3).

CHAPTER 6

Trophic Parameters: Assessment of the Diet of Yellowfin Tuna, 1981-1988

In this chapter I examine the food of yellowfin tuna over six seasons and discuss the importance of the various components in the diet of yellowfin tuna. The first part of the study from 1981/82-1983/84 and 1985/86 represents the qualitative sample. A more quantitative sample was collected during 1986/87 and 1987/88. As well as the traditional frequency-of-occurrence methods I used a volumetric technique in the latter study. Prey size, behaviour and catchability of yellowfin tuna relative to food type are discussed for sport fishing and commercial gears.

6.1 Introduction

A thorough knowledge of food and feeding habits is important to an understanding of regional and local aggregations of tunas and to their behaviour (Alverson, 1963a; King & Ikehara, 1956; Reintjes & King, 1953). Kornilova (1981) states that it is a prerequisite for successful tuna fishing that (a) the times at which tunas form concentrations and (b) features of their feeding habits in individual seasons should be established. Likewise a knowledge of the feeding habits of yellowfin tuna during their migration through the Pemba Channel is essential to an understanding of the ecology of the species and their impact on the marine ecosystem in the Western Indian Ocean.

The abundance, size range and catchability of yellowfin tuna within the Pemba Channel varies seasonally (see Chapters 2, 4 and 7) and it is likely that the abundance and nature of the food supply may play a significant role. Food is recognized as an important environmental factor that influences the distribution of fish (Reintjes & King, 1953). Alverson (1960, 1963b) noted that an adequate supply of food in the Eastern Tropical Pacific did not necessarily ensure the presence of tunas, but the chances of finding them were greater in areas of abundant food organisms. If food is in short supply then it becomes the limiting factor on growth (Kitchell *et al.*, 1978) and a temporary shortage of food will adversely affect their hunting capabilities (Brill, 1985; Boggs, 1986).

It is vital that yellowfin tuna move to areas rich in food and with favourable temperatures (Stretta, 1986). Tuna require a high intake rate of food in order to maintain their high metabolic rate, which is estimated to be two to three times

greater than for other fishes swimming at similar speeds per body length (Gooding *et al.*, 1981; Stevens & Dizon, 1982; Boggs, 1984). Using three methods, (i) stomach contents and gastric evacuation; (ii) bioenergetics, and (iii) a cesium estimate, Olson & Boggs (1986) estimated the daily ration for yellowfin tuna to lie between 3.9% and 6.7% of the body mass.

The food of yellowfin tuna has been studied throughout their geographical range. In his review of both published and un-published reports on the feeding of seven species of tuna, Dragovich (1969) noted that most of the data was non-quantitative and the majority of authors concentrated on identifying individual food items. However, the level of identification varied considerably, largely depending on the degree of digestion, and he found that it was not possible to perform a quantitative analysis of the combined data. Borodulina (1982) felt that the identification of food organisms at the species level was often subject to doubt.

Food studies have also been carried out in the Western Indian Ocean by Koga (1958), Williams (1966) and Kornilova (1981). Williams (1966) examined the food of 107 yellowfin tuna taken by longline within 30 miles of the East African coast. Koga (1958) and Kornilova (1981) collected data from a wider geographical range, also by longline.

In my study on food and feeding habits of yellowfin tuna in the Pemba Channel, data was collected from 1981/82 to 1987/88. During the period, 1981/82 - 1983/84 and 1985/86 the data recorded were restricted to noting the occurrences of the different food types present in each stomach. A more quantitative study involving the measuring of each category volumetrically was made in 1986/87 and 1987/88. No data were recorded for 1984/85.

The composition of the diet varies not only from year to year, or season to season but also daily. The nature of the ingested food depends upon the composition and amount of available food (Pillay, 1952). In the same way that yellowfin tuna have specific environmental requirements, the distribution and abundance of the prey will be determined by often quite different environmental requirements. All the results published in the literature indicate that yellowfin tuna are highly opportunistic predators. When the conditions are favourable to both predator and potential prey the latter may become available as food items. Dragovich and Potthoff (1972) found significant differences between their results and those of Sund and Richards (1967) for the same area of the Gulf of Guinea. These variations in food type are discussed with respect to the current study together with their influence on the sport fishery.

Watanabe (1958) studied regional differences in food consumption by tunas and marlins in the Western Equatorial Pacific and found variations in food type from

region to region. Koga (1958) believed that the quantity of food in the Western Indian Ocean was richer than in other sea areas, but this may have been the result of peak seasons of food abundance during Koga's study in the Indian Ocean. Kornilova (1981) in his study on the feeding of yellowfin and bigeye tunas in the equatorial zone of the Indian Ocean during the Northern Hemisphere summer found that the highest indices of stomach fullness for the yellowfin tuna coincided with the zones of maximum temperature gradients. These gradients extend as a narrow strip from 10°S at the Mozambique Channel north-eastward to 10°N.

Most authors agree that tunas are opportunistic and active predators that take whatever is available depending on prey size (Dragovich, 1969; Stretta, 1986; Roger, 1988). The distribution and abundance of maturing and adult yellowfin tuna are unlikely to be determined by the occurrence of specific food items, but rather by the total volume of food in the area at the time (Reintjes & King, 1953). As tunas are opportunistic predators and their migration is not determined by concentrations of specific prey items exhaustive lists of species are therefore not very meaningful (Roger, 1988) unless one is using the tunas as collectors of marine organisms. A complete identification of food items is therefore not considered necessary for the present thesis on the ecology and exploitation of yellowfin tuna in the Pemba Channel, Kenya. A few specific items were identified to the species level at the Natural History Museum, London, however, due to their relative importance in the yellowfin tuna diet. Identification of food items beyond family and order is often very difficult and depends on the degree of digestion and mechanical damage (Pelczarski, 1987). Reintjes & King (1953) point out that engulfment of the prey often separated the head from the body, mutilated fins, skin and lateral line and removed scales making identification very difficult. In Williams' (1966) study in the East African region a large proportion of the food fell into an 'unidentifiable remains' category.

The 'Preferred food' may be defined as that prey item which if available will be selected for by the predator in preference to other available, potential food items. However the preferred food may not be the most abundant food at the time. According to Stretta (1986) tuna vary their food but do not have a preference. The level of food preference would be very difficult to measure but is likely to be related to the rate of digestion for a specific item, the energy required to catch the prey, and to prey size. In this study I investigate whether yellowfin tuna have food preferences, or not.

The term, 'Most important food', or 'Main food' has been used by many authors to refer to that food item that occurs most frequently in the diet. However, Berg (1979) suggested a new definition, "'The most important food' for a fish is that food item which, if absent from the available nutrient supply, would have the greatest negative influence on growth and survival of the fish in the biocoenosis."

However, due to the non-selective feedings of tunas, Berg's definition is not considered to be relevant to tunas and so the first definition is retained for my study.

Different foods may be digested and evacuated at different rates (Olson, 1981) and may have quite different caloric values (Berg, 1979). Fish with a high lipid content are evacuated at a slower rate than fish or squids with lower lipid contents (Olson & Boggs, 1986). The rate of digestion determines how rapidly the energy from the ingested food will become available to the predator for metabolism. The size and speed of locomotion of the prey will determine how much energy the tuna must expend in its quest to capture that item. The size of the prey is also an important consideration because the smaller the prey item the larger the number of items the predator must consume to reach satiation, but conversely the larger the prey item the smaller the relative surface area of the food that is available for digestive action. These factors are discussed relative to the food categories used in the present study, alongside observations on the behaviour of yellowfin tuna in the Pemba Channel, Kenya.

The maximum prey size is likely to be determined by mouth size, diameter of the oesophagus and stomach size. The size of the gill rakers determine the minimum size of food components that may be retained by the mouth (Magnuson & Heitz, 1971). Reintjes & King (1953) estimated the maximum prey size to be equal to one third of the body length for yellowfin tuna. Prey size is discussed relative to yellowfin tuna fork length, as are the ranges of prey sizes observed in a single stomach.

According to the literature, there is no significant sexual differentiation in the feeding habits of yellowfin tuna (Chi & Yang, 1971; Yesaki, 1983; Barut, 1988). Consequently separate analyses were not carried out for males and females in the Pemba channel study.

The catchability and accessibility of yellowfin tuna to sport fishing surface trolling methods are discussed in relation to the feeding habits of yellowfin tuna, that is food type, food preference, feeding or non-feeding mode, prey size, time of feeding and abundance of food. Likewise yellowfin tuna behaviour in terms of feeding, schooling, rate of swimming and temperature tolerance is believed to be partly dependent on the nature of the food. This is discussed for the Pemba Channel data and from observations recorded in my personal log-book.

The methods section includes a short review of the methods used in other feeding studies. The reasons for the use or non-use of these methods in the current study are discussed.

6.2 Methods

Food data from sport fishery-caught yellowfin tuna in the Pemba Channel, Kenya were recorded from August 1981 - March 1988. During 1981/82 - 1983/84 and 1985/86 the data collected was in a non-quantitative form with a more quantitative study being carried out in 1986/87 and 1987/88. No food data were recorded for 1984/85.

The stomach contents of yellowfin tuna were examined upon completion of recording the morphometric measurements. Following the requirements of the local fish market all fish were gutted and the gut weights recorded to the nearest ¼ lb (113g). The term, 'gut' includes the stomach, intestines and associated organs, liver and gonads.

The non-quantitative food data was recorded on site. The relative fullness of the stomach was noted, although it was difficult to standardize on a scale from one day to the next. Any such scale is subjective and could not be repeated by another person. The stomach contents were sorted by eye into six categories, fish, cephalopods, prawns, crabs, other very small crustacea and extraneous items.

No attempt was made to identify individual items, apart from two items discussed in a later section, to the species level in either study. The very small crustacea consisted largely of larval forms and other very small adult crustacea that did not fit obviously into either the prawns or crab categories. The extraneous items included such items as seaweed and pieces of plastic. This latter group was not used in any of the analyses.

The cephalopod section includes the squids, octopuses and cuttlefishes, but also the lone member of the Spirulidae, *Spirula spirula* Linnaeus of the order: Sepioidae, subclass: Coleoidae. A specimen was kindly identified for me by Mr Fred Naggs at the British Museum of Natural History.

The crab category consisted almost entirely of the brown swimming crab, *Charybdis smithii* McLeay (1838) which is one of the few portunids which swarm in surface waters at considerable distances off shore. This species plays an important role in the diet of yellowfin tuna in the Western Indian Ocean (Zamorov *et al.*, 1991). *Charybdis smithii* undergoes mass seasonal migrations from continental and island shelves into the pelagic realm of the Western Indian Ocean where they become food for pelagic fishes (Losse, 1969; Zamorov *et al.*, 1991). Identification of this species was carried out by Dr R.W. Ingle of the Department of Zoology at the British Museum of Natural History. A single specimen of another unidentified portunid was included in this category.

During the seasons 1981/82 - 1985/86 inclusive, the major components of the food were recorded. The dominant food was recorded as that category that accounted for the greater proportion of the total stomach contents by volume, as measured by eye. The prey item size and the number of frigate mackerel, *Auxis thazard* in the food were also noted. Specimens of *Auxis thazard* were positively identified from Collette & Nauen (1983).

A quantitative study of the stomach contents from 257 sport fishery-caught yellowfin tuna in 1986/87 and 1987/88 was done by volumetric displacement using the same categories as above. The stomach contents from a sample of the day's catch were collected, and in all cases were examined the same day. The food was rinsed in water to remove excess digestive juices and bile. Sorting of the food was carried out in a large dish and care was taken to prevent farther mechanical damage to the prey items. The sorting process was particularly difficult where digestion was in an advanced state and the food had to be very carefully separated to reveal the very small crustacea. The crustaceans were the most easily identifiable due to their hard exo-skeletons.

The volume displacement of each category was measured with the aid of three volumetric flasks: 10 ml, 100 ml and 1,000 ml. Individual items were measured to give a range of prey sizes for each category. Where individual items were too large for even the largest flask the weight was recorded to the nearest gramme using an electronic 'Sartorius' balance. The assumption of Dragovich & Potthoff (1972) that 1.0 ml of stomach contents is approximately equivalent to 1.0 g was followed in this study.

METHODS OF ANALYSIS

The methods that have been used in food and feeding studies of tunas are reviewed here and the reasons for their inclusion, or exclusion from my study are discussed.

The Numerical Method (% N)- This involves counting the number of individual food items present, with each food item evaluated as a proportion of the total number of all food items. Most authors present the number of items of each species with their data, but the % N of food species is only valid if the food is not fragmented during intake, and if the particle dimensions do not differ too much (Pillay, 1952). No attempt was made to count the individual items in the current study as this method places considerable emphasis on those items with resistant parts, does not take into account the size of prey items and cannot be carried out with any degree of accuracy especially where digestion is in an advanced stage.

Frequency-of-Occurrence Method (% F-value)- Each food item or category is expressed as a percentage computed by dividing the number of stomachs

containing the food item by the total number of stomachs examined (Hynes, 1950). This method is quoted by most authors as a useful measure of the availability of a particular prey. But, according to Berg (1979) it does have two serious disadvantages. Firstly, it does not take into account the quantity of food, nor does it discriminate between the availability of food and preferential selection by a predator. However, yellowfin tuna are considered to be largely non-selective in their feeding.

The % F-value was used here since it is very simple to compute. The % F-value gives an indication of prey species variability in predator diets (Macdonald & Green, 1983), and it can also be used for both quantitative and non-quantitative data because it ignores quantities.

Food Dominance- The calculation of dominance of a food item is the percentage of stomachs containing that item as the dominant food component (Pillay, 1952). This calculation has been used for the non-quantitative Pemba Channel data only. It was not used for the more detailed study as the Mean Volumetric Ratio Measurement was considered to give a better estimate. It does have the disadvantage that it does not take into account small quantities of the prey element that might occur in some stomachs (Berg, 1979).

The Volumetric or Weight Methods- The displacement volume or the weight of each food item or category is expressed as a percentage of the total volume or weight of the stomach contents. This is probably the most reliable indicator of relative importance of various food items. The volumetric method was used in the quantitative study on the feeding of yellowfin tuna in the Pemba Channel.

This is the only method that takes into account the size of the food item, and reduces the overevaluation of items with resistant parts to a minimum. However unavoidable errors are possible due to different digestive rates of various food components, loss of food items due to regurgitation on board the vessel, and to the food of previously digested prey items.

The volumetric data may be used in several ways to evaluate the amount of each kind of food present:

The aggregate-total-volume method (Martin, Gensch and Brown, 1946) - This is computed by dividing the total volume of food of each kind by the total volume of all the stomachs examined, and expressed as a percentage. This method reflects the volumetric importance of an item regardless of how much other food is present.

Average-percentage method- Percentage equivalents are calculated for each food item or category with each stomach termed 100% regardless of fullness. The variation in total volume does not influence the results.

'Most Important Food'- Some authors have attempted to combine the numerical and volume or mass proportions mathematically. Tester (1932) combined the % F-value and the volumetric methods graphically. However, it is debatable whether a single formula can give a true relative importance of a food element of a fish as most are based on assumptions (Berg, 1979). It is also usually not possible to recalculate one of the factors from the index value alone, and Berg (1979) argues that it may be better to present the factors separately to provide more parameters for comparison.

Index of Relative Importance (IRI) (Pinkas *et al.*, 1971) - This method combines the numerical, frequency-of-occurrence and volumetric methods into a single formula:

IRI = (% N + % V) % F
where, % N = numerical %,
% V = volumetric %,
% F = % F-value.

I decided to exclude the numerical proportion from the IRI because of the difficulties involved in counting individual items in the field, as Yesaki (1983) had done.

Mean Volumetric Ratio Measurement (MVRM) (Ankenbrandt, 1985) - This is a variation of the IRI to illustrate the biomass importance of prey items without the numerical exaggeration implicit in the IRI. Ankenbrandt (1985) used the MVRM together with the Kruskal-Wallis test.

MVRM = mean rj x 100 - mean volumetric %, r of prey j to the total volume of n guts.

where, N = number of stomachs examined or in a strata.

V*ij =	volume of prey j in stomach i.
Vi = SUM of V*ij	total volume of stomach i
r*ij = V*ij/Vi	Ratio of Prey j to the total volume of stomach i.
mean rj = SUM r*ij/n	Mean volumetric ratio of prey j to the total volume of n stomachs.

The MVRM was used for the data of 1986/87 and 1987/88 in conjunction with the Kruskal-Wallis non-parametric analysis of variance method to test for variations in food consumption by size of tuna and month-of-capture. The Kruskal-Wallis non-parametric method tests for deviations from the null hypothesis that the MVRM of a particular food type is the same for all sizes of yellowfin tuna and is eaten by the yellowfin tuna in the same relative proportions throughout August to November.

L'indice de réplétion (Ir) (Hureau, 1969)- This index of fullness is expressed as a percentage and computed by dividing the weight of the ingested food by the weight of the fish, although in the current study the volume of ingested food was substituted for the weight. However, it must be realized that different foods may have quite different caloric values (Berg, 1979) and so quantity may not necessarily reflect the amount of energy that will become available to the fish as a result of digestion.

'Points' Method- This method has been used most by the Soviet scientists (for example, Zharov, 1965; Sokolov, 1967) using an arbitrary scale to measure the degree of fullness of tuna stomachs.

This method was used here not as a measure of stomach fullness, but rather as a quick and easy alternative means of measuring the relative importance of each food category during 1986/87 and 1987/88. A simple and repeatable five point scale was assigned to each category in respect to volume. The most dominant category was assigned five points and from four to one point to subsequent groups in order of their volumetric importance. Only those categories represented in the food were allocated points.

The use of statistical tests varies considerably in the literature. King & Ikehara (1956) did not use any tests of significance. They state that it is likely that neither the volume of food per stomach, nor the % F-value, nor the proportion of the total volume of the organism are normally distributed. To apply meaningful tests of significance transformation of the data would be necessary. The majority of authors have not transformed their data nor have they contested King & Ikehara's hypothesis. In the present study non-parametric statistical methods have been employed.

Due to the limitations of each of the indices described it is not practical to use just a single index, or method in a study of the food of fishes. In the current study I have utilized a wide selection of indices in an attempt to gain a fuller understanding of the feeding habits of yellowfin tuna in the Pemba Channel.

6.3 Results

A DESCRIPTION OF THE FOOD FROM 1981/82-1985/86

Each data set was stratified into four size classes of yellowfin tuna from the modes on the length-frequency histograms, A to D (Table 6,1).

SEASON	Size classes, means±se's (cm FL) A	B	C	D
1981/82				
Range:	46.0-51.0	62.0-79.0	103.0-129.0	132.0-157.0
Mean±se	48.6±0.48	69.6±0.83	117.9±0.52	139.9±1.02
1982/83				
Range:	44.0-53.0	57.0-87.5	97.0-125.5	128.0-162.0
Mean±se	48.1±0.36	67.6±1.03	112.3±0.48	140.1±0.59
1983/84				
Range:	37.0-59.0	61.5-80.0	91.5-115.0	123.0-159.0
Mean±se	49.2±0.52	69.9±1.05	107.3±1.23	137.1±0.64
1985/86				
Range:	47.0-50.5	58.0-84.0	89.5-105.0	130.0-165.0
Mean±se	48.6±0.48	66.7±0.51	95.2±1.13	141.8±1.29

Table 6,1. The stratification of the yellowfin tuna sampled into four size classes of yellowfin tuna with means and standard errors. Size classes were determined as per modes on the length-frequency histograms.

1981/82: Catches of yellowfin tuna began on 1st August, 1981 and the stomachs of the larger fish (109.0-149.0 cm FL) contained a number of frigate mackerel, *Auxis thazard* together with a few small fish, cephalopods, prawns and very small crustacea. The smaller tuna were feeding upon small fish, cephalopods, prawns and crustacea. During August the food supply appeared to be variable from day to day, which may have been partly due to the unsettled weather conditions. From late August into early September the food of all sizes of yellowfin tuna contained mainly sardines and small cephalopods.

The first occurrence of the crab, *Charybdis smithii* was on 14th September, 1981 and this item dominated the food throughout much of September. There were a few frigate mackerel, but often only crabs. From 29th September to 10th October 1981 the food was more mixed with crabs, fish and cephalopods. However, crabs again dominated from 11th to 18th October. From this date cephalopods, small fish and the occasional frigate mackerel occurred with the crabs.

The last large yellowfin tuna were caught on 1st November, 1981 as a quadruple strike (all four hooked simultaneously). Of these, two were fairly full with just crabs, and two were full with a mixture of sardines, squids, crabs and prawns. Yellowfin tuna of the two smaller size groups were caught after 1st November and contained a mixture of small fish, cephalopods and prawns.

1982/83: The first large yellowfin tuna was not taken until the 14th August, 1982. Both the smaller and larger yellowfin tuna appeared to be feeding on small fish and cephalopods, and many of them were fairly full. The first crab was seen

on 6th September, 1982, but they did not occur in significant numbers until 13th September 1982. During early September the stomachs contained a few frigate mackerel, and a number of what appeared to be juvenile wahoo, *Acanthocybium solandri.* These wahoo occurred in quite large numbers in the larger size classes of yellowfin tuna.

After 13th September, 1982 crabs became very important in the food, and continued to dominate into early October. Throughout August, September and early October the quantity of food was very rich, not just with respect to crabs, but also fish, cephalopods and prawns.

Beyond the middle of October with the onset of the hot, calm weather the quantity of food appeared to become reduced and frigate mackerel occurred more frequently. On 17th October, 1982 a 146 cm FL yellowfin tuna contained six frigate mackerel. By the end of the month many fish were empty when caught.

1983/84: There were only a few large yellowfin tuna taken in mid-August 1983, although there appeared to be a fairly good quantity of small cephalopods, fish and prawns. However, in early September none of the fish were full and the food mostly consisted of the very small crustacea, frigate mackerel, small cephalopods, small fish and prawns. There appeared to be a good variety of available food, but very little in quantity. In the middle of September 1983 crabs made their appearance and began to dominate the food, although the variety of food continued to be good. Many fish were full. Crabs were very abundant in early to mid-October. The last large yellowfin tuna was taken on 19th October, 1983, although there appeared to be plenty of crabs available. After 20th October the smaller yellowfin tuna were mostly empty.

1985/86: The first large yellowfin tuna were caught on the 5th and 11th August, 1985 and were fairly full of large sardines of about five to six inches long and a few squid. However, after 11th August the food supply appeared to dry up and very little was found in the stomachs. The larger yellowfin tuna were feeding mainly on frigate mackerel and the smaller fish were mostly empty. There was similarly very little food in September. Crabs did make an appearance in the stomachs on 23rd and 24th September, but after this no large yellowfin tuna were caught.

During this season the fish were much closer to the Kenyan continental shelf than in any other season and larger yellowfin tuna appeared to be migrating rapidly south. These two observations maybe attributed to the lack of available food in the Pemba Channel.

PERCENTAGE FREQUENCY-OF-OCCURRENCE AND PERCENTAGE FOOD DOMINANCE BY SIZE OF YELLOWFIN TUNA

a). Non-Quantitative Data. Only those fish containing food in their stomachs were used. The 1985/86 data for example, were not included in Fig. 6,1 since six out of seven stomachs were empty.

The results are presented for each size group as defined in Table 6,1:

Size group A: Fig. 6,1 illustrates that fish occurred in just over 50% of the stomachs of size group A tuna and fish were the most important category throughout the first three seasons. Both cephalopods and prawns were present in near equal occurrences in 1981/82 and 1982/83, although the former were of greater importance in terms of food dominance. Crabs only occurred in the 1982/83 sample, and the very small crustacea only in the 1983/84 sample.

The absence of the very small crustacea in these non-quantitative samples may be due to their being overlooked. During the more detailed study of 1986/87 and 1987/88 this group was difficult to separate from the other food components when the volume of other food present was large, and particularly when the fish component was in an advanced state of digestion.

Size group B: Fish were found in at least 75% of the stomachs of the 1981/82 and 1983/84 samples of Group B fish and in just over half of the 1982/83 sample (Fig. 6,2). Apart from 1985/86 fish were the most frequently occurring prey. In the 1985/86 sample cephalopods occurred in slightly more Group B stomachs than either fish or crustacea. Crabs were only present in a very small proportion of the 1981/82 and 1982/83 samples. The very small crustacea showed an increased frequency-of-occurrence in 1985/86, which may have been due to a lack of other available food.

Fig. 6,2 suggests that fish were by far the most important food for this size of yellowfin tuna in 1981/82 and 1983/84, but the cephalopods were more important 1985/86.

Size-group C: The % F-values shown in Fig. 6,3. suggest that the fish and cephalopod components increased in availability from 1981/82 to 1983/84, whereas the crab category shows a steady decrease in importance from 1981/82 to 1985/86. During 1981/82 crabs were the most important food in terms of food dominance, but as with frequency-of-occurrence their importance decreased to being unavailable in 1985/86. Fish were the dominant food in both 1983/84 and 1985/86.

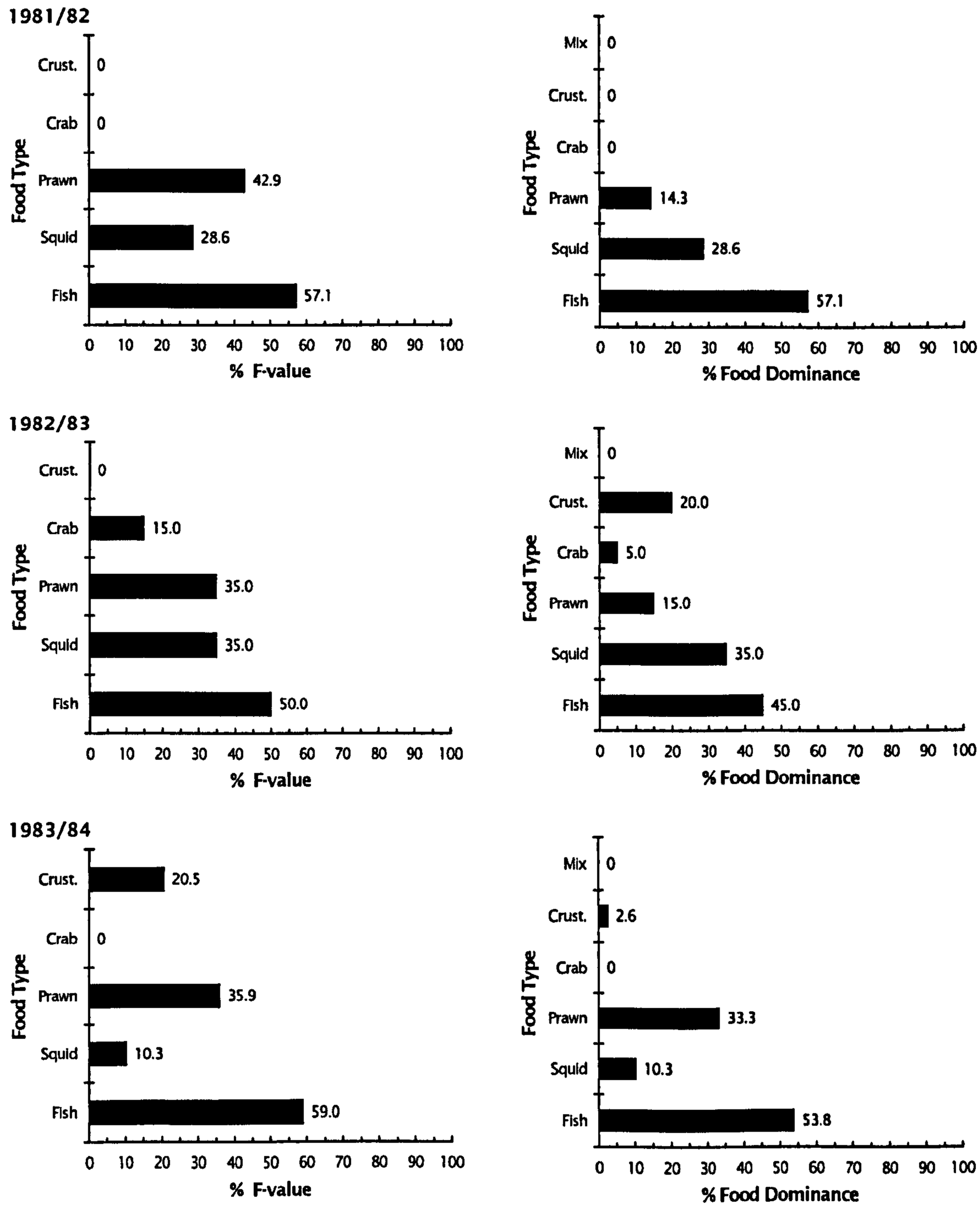


Figure 6,1. Size-group A yellowfin tuna, 1981/82-1983/84: The % frequency-of-occurrence (% F-value) plots (on the left) and % Food Dominance (right-hand plots) for six food categories. In 1985/86, as only a single stomach contained food it was not included here. The 'mix' component represents those fish where no one category was dominant. The size ranges and sample size for each season are:

1981/82: 46.0-51.0 cm FL; mean = 48.6±0.48 cm FL; n = 10 (3 empty);
1982/83: 44.0-53.0 cm FL; mean = 48.1±0.36 cm FL; n = 29 (9 empty);
1983/84: 37.0-59.0 cm FL; mean = 49.2±0.52 cm FL; n = 57 (18 empty).

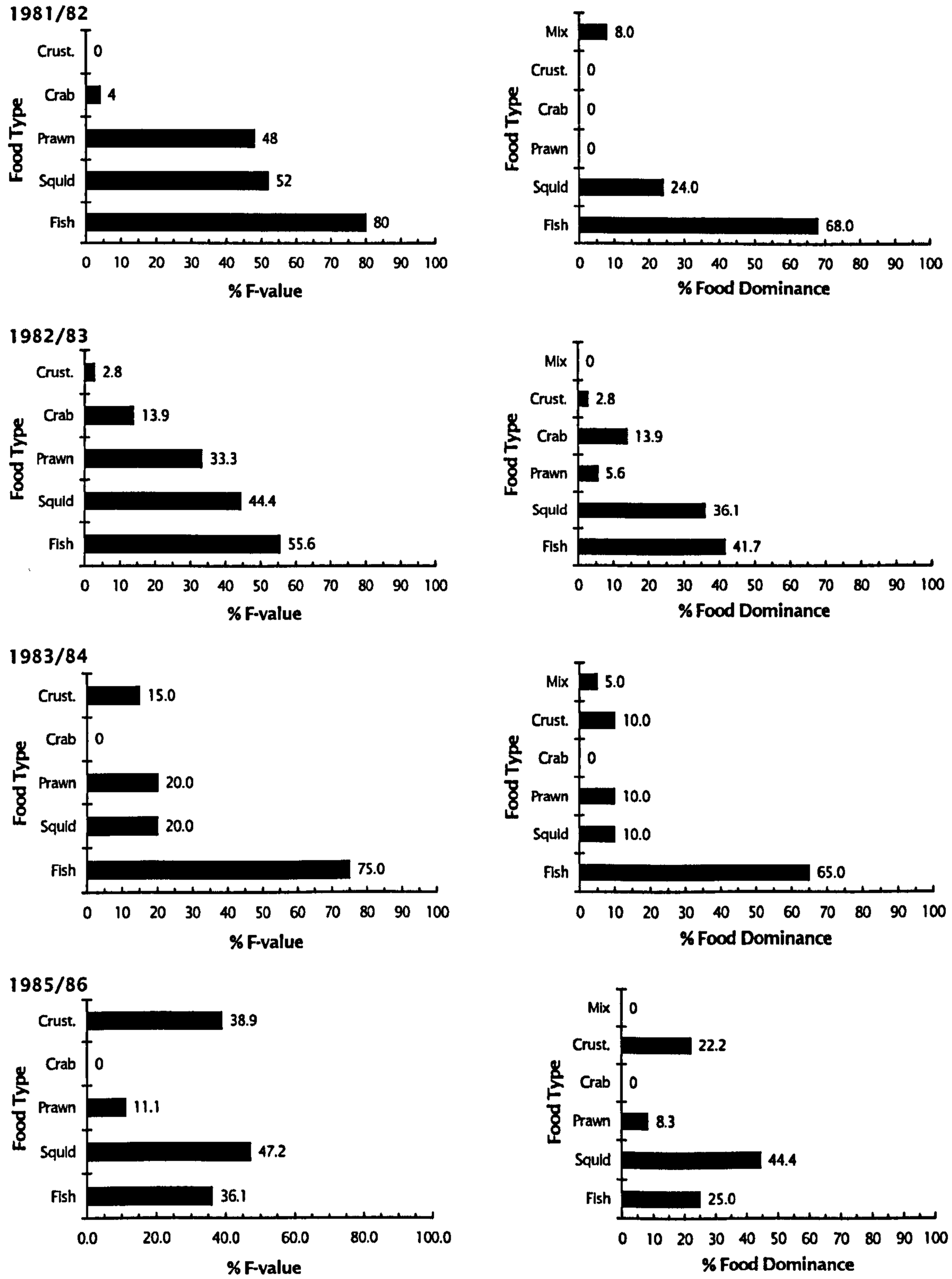


Figure 6,2. Size group B yellowfin tuna, 1981/82-1983/84 and 1985/86: The % frequency-of-occurrence (% F-value) on the left and % food dominance (right hand plots) for six food categories. The 'mix' component represents those fish where no one category was dominant. The size ranges and sample size for each season are:

1981/82: 62.0-79.0 cm FL; mean = 69.6±0.83 cm FL; n = 26 (1 empty);
1982/83: 57.0-87.5 cm FL; mean = 67.6±1.03 cm FL; n = 39 (3 empty);
1983/84: 61.5-80.0 cm FL; mean = 69.9±1.05 cm FL; n = 21 (1 empty);
1985/86: 58.0-84.0 cm FL; mean = 66.7±0.51 cm FL; n = 87 (51 empty).

Size group D: Cephalopods, and to a lesser extent crabs, showed an increased frequency-of-occurrence from 1981/82 to 1983/84, whereas fish were present in 40.0% to 46.8% of the stomachs in each of these samples (Fig. 6,4). In 1985/86 fish occurred in 68.3% of the stomachs that contained food.

Crabs were the most important food in terms of quantity from 1981/82 to 1983/84, but were of very much reduced dominance in 1985/86 when fish were the most important food type. Although, cephalopods were present in 95.2% of the stomachs in 1983/84 they were only the major food in 30.8%.

b). Quantitative Data. Size groups A and B were combined as the sample size of the former was very small. The size classes with their means and standard errors are shown in Table 6,2.

	Size classes, means±se's (cm FL)		
SEASON	A/B	C	D
1986/87			
Range:	45.0-73.0	98.0-124.0	135.0-148.0
Mean±se	62.4±1.65	109.0±0.44	141.2±1.10
1987/88			
Range:	47.0-83.0	98.0-125.0	126.0-149.5
Mean±se	62.1±1.37	111.3±1.25	132.9±1.21

Table 6,2. The stratification of the sampled yellowfin tuna into three size classes as described in the text for 1986/87 and 1987/88 with means and standard errors.

Very small crustacea were found in the majority of stomachs of group B yellowfin tuna, and although they occurred less frequently in the stomachs of older fish they were still eaten by even the largest yellowfin tuna (Fig. 6,5). Fish were present in at least 76.9% of stomachs of all three groups, and the cephalopods appeared to be taken more frequently by groups C and D. Prawns showed a very high frequency of occurrence in the group C fish.

Crabs occurred in very few of the 1986/87 sample and then only in size-groups C and D. However, in 1987/88 crabs occurred in all three groups (a single crab was found in a 67.5 cm FL yellowfin tuna) and the frequency-of-occurrence increased with size of yellowfin tuna.

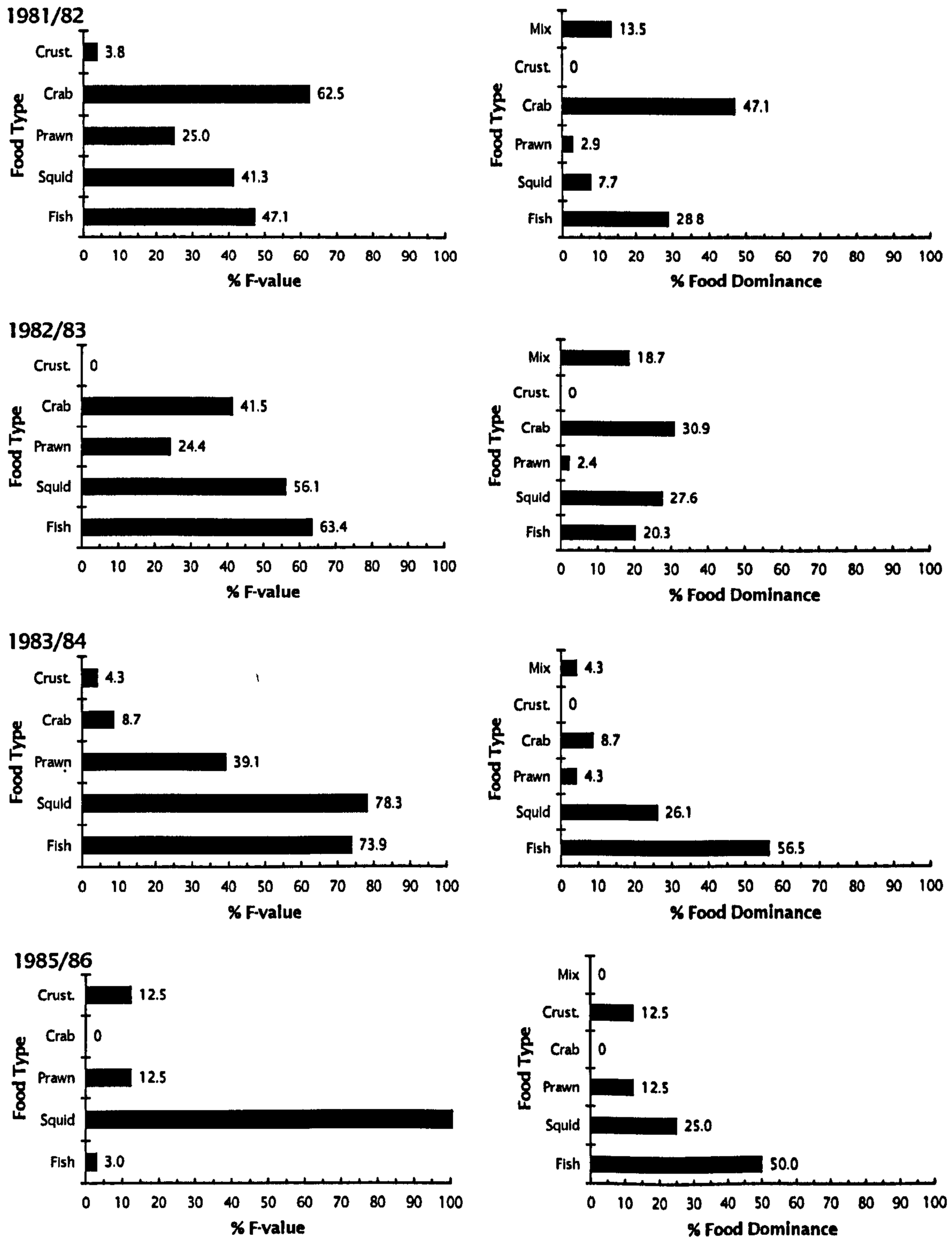


Figure 6,3. Size group C yellowfin tuna, 1981/82-1983/84 and 1985/86: The % frequency-of-occurrence (% F-value) on the left and % food dominance (on the right) for six food categories. The 'mix' category represents those stomachs where no single component was dominant. The size ranges and sample size for each season are:

1981/82: 103.0-129.0 cm FL; mean = 117.9±0.52 cm FL; n = 108 (4 empty);
1982/83: 97.0-125.5 cm FL; mean = 112.7±0.48 cm FL; n = 123 (0 empty);
1983/84: 91.5-115.0 cm FL; mean = 107.3±1.23 cm FL; n = 23 (0 empty);
1985/86: 89.5-105.0 cm FL; mean = 95.2±1.13 cm FL; n = 17 (9 empty).

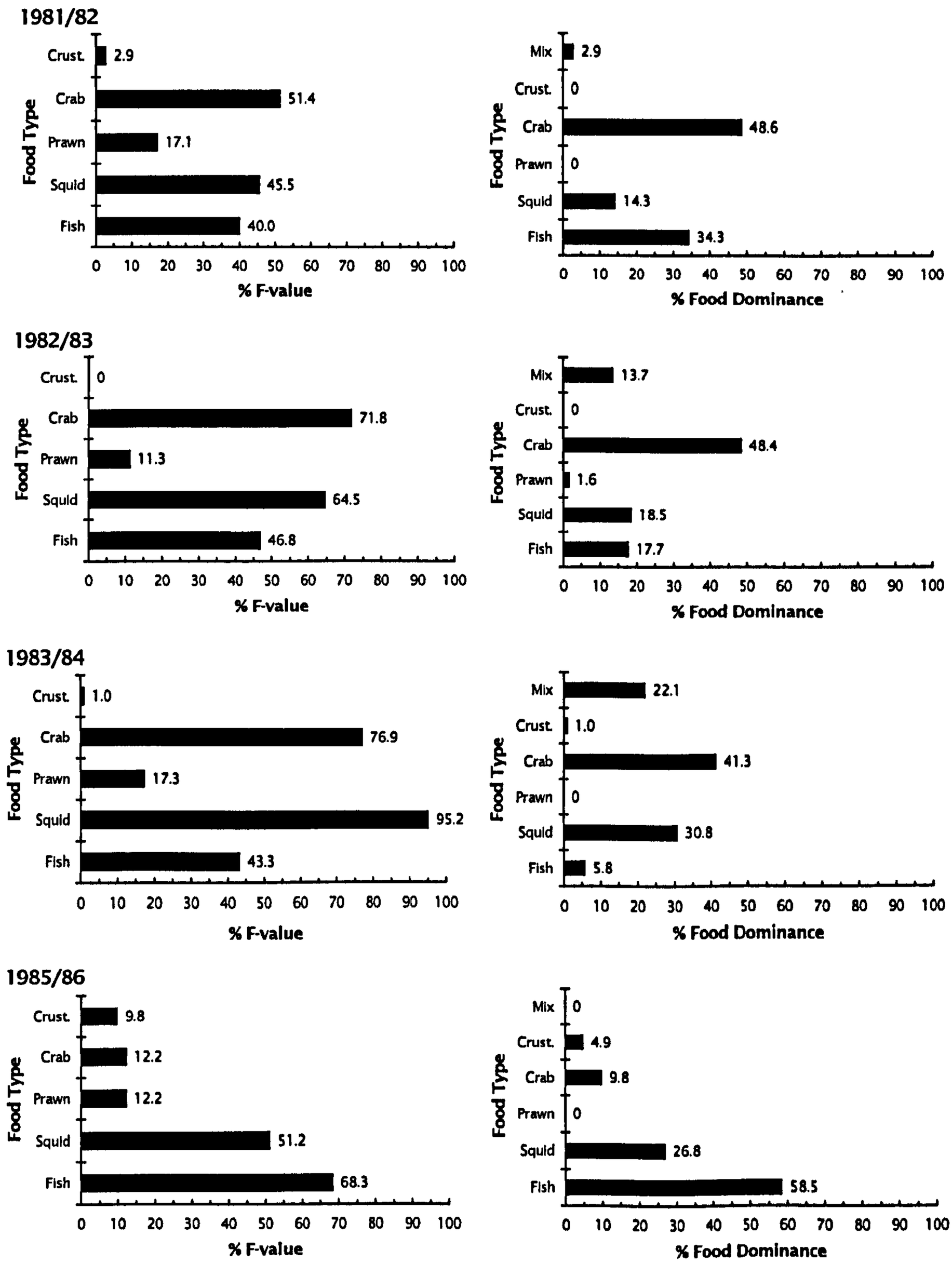


Figure 6,4. Size group D yellowfin tuna, 1981/82-1983/84 and 1985/86: % frequency-of-occurrence (% F-value) and % food dominance for six food categories. The 'mix' component represents those stomachs where no single food category was dominant. Size ranges and sample sizes for each season are:

1981/82: 132.0-157.0 cm FL; mean = 139.9±1.02 cm FL; n = 35 (0 empty);
1982/83: 128.0-162.0 cm FL; mean = 140.1±0.59 cm FL; n = 124 (0 empty);
1983/84: 123.0-159.0 cm FL; mean = 137.1±0.64 cm FL; n = 105 (1 empty);
1985/86: 130.0-165.0 cm FL; mean = 141.8±1.29 cm FL; n = 42 (1 empty).

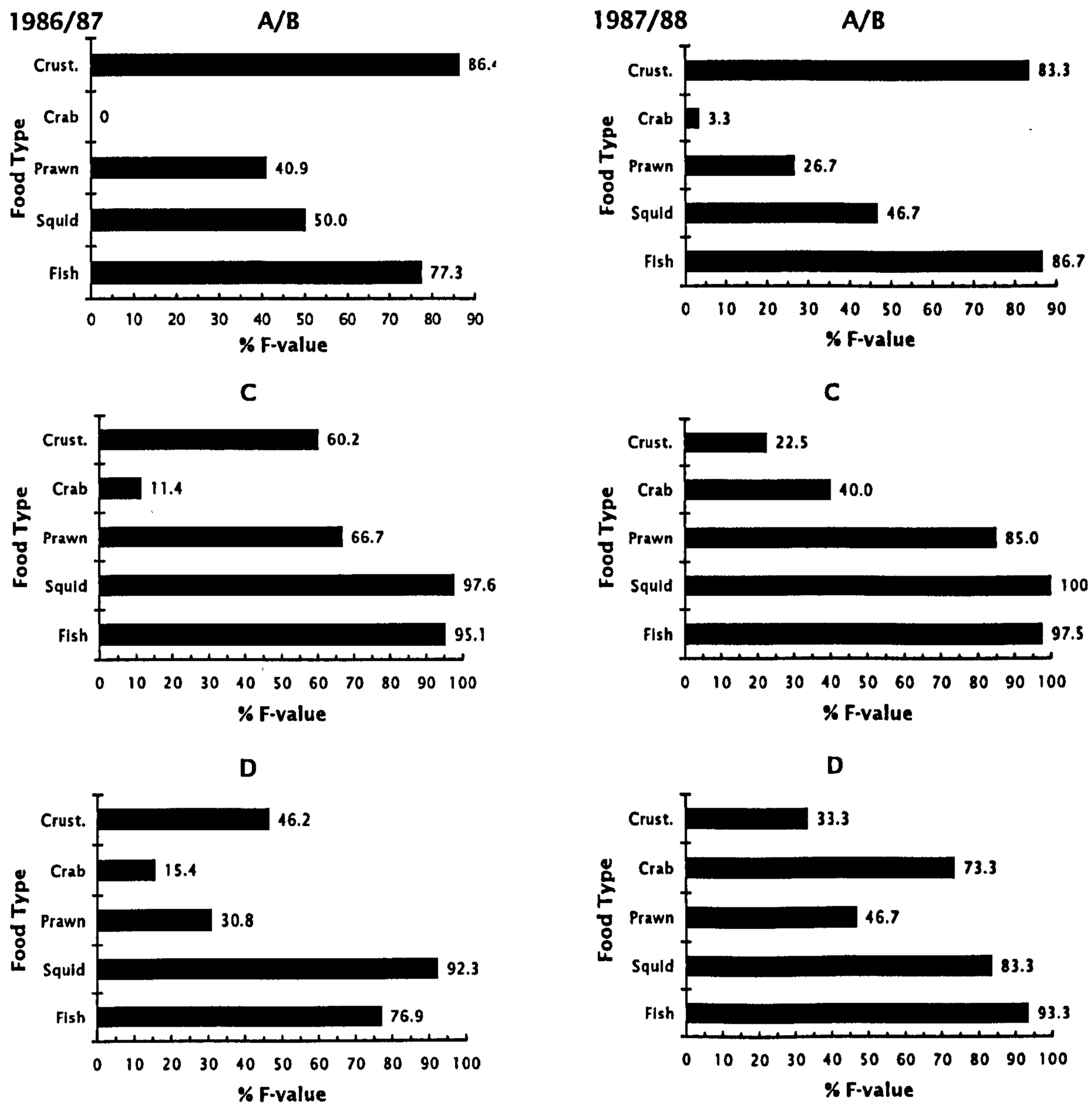


Figure 6,5. The % frequency-of-occurrence (% F-value) for five categories of food and three size classes of yellowfin tuna. The sample size of A was very small so it was combined with the group B fish in both seasons.

A/B: 1986/87 - 45.0-73.0 cm FL; mean = 62.4±1.65 cm FL; n = 23 (1 empty);
1987/88 - 47.0-83.0 cm FL; mean = 62.1±1.37 cm FL; n = 32 (2 empty);
C: 1986/87 - 98.0-124.0 cm FL; mean = 109.0±0.44 cm FL; n = 124 (1 empty);
1987/88 - 98.0-125.0 cm FL; mean = 111.3±1.25 cm FL; n = 40 (0 empty);
D: 1986/87 - 135.0-148.0 cm FL; mean = 141.2±1.10 cm FL; n = 13 (0 empty);
1987/88 - 126.0-149.5 cm FL; mean = 132.9±1.21 cm FL; n = 30 (0 empty).

PERCENTAGE FREQUENCY-OF-OCCURRENCE AND PERCENTAGE FOOD DOMINANCE BY MONTH-OF- CAPTURE

a). Non-Quantitative Data

1981/82: During August fish was the most important food category in terms of both frequency-of-occurrence (Fig. 6,6) and quantity (Fig. 6,7). Crabs were a very important source of food during September and October and prawns, although the % F-value was high they were of little importance in terms of volume. Fish dominated the food of yellowfin tuna in November.

1982/83: In August the majority of stomachs contained both fish and cephalopods (Fig. 6,6), but the latter were present in greater quantities. Crabs again appeared in September, but the frequency-of-occurrence was lower than the 1981/82 sample. However, in October crabs were the dominant food in 67.1% of the stomachs (Fig. 6,7).

1983/84: Fish was the most important food category in terms of both frequency-of-occurrence (Fig. 6,6) and quantity in August (Fig. 6,7). Although, crabs did appear in the food in September they did not occur as often as either fish or cephalopods. Fish, cephalopods and crabs were of near equal dominance in September, and 25% of the stomachs showed no single dominant group. During October although cephalopods occurred in rather more stomachs, crabs were the major food.

1985/86: Bar charts are only shown for August and September as very few yellowfin tuna were taken after the end of September. Fish and cephalopods were the most frequent food (Fig. 6,6) and the former were only slightly more important by volume in both months (Fig. 6,7).

b). Quantitative Data

Fish were present in at least 79% of the stomachs in all the months shown of both 1986/87 and 1987/88 (Fig. 6,6). During 1986/87 cephalopods occurred equally as frequently as fish from August to October, but were present in slightly fewer stomachs in August and November/December of 1987/88. Prawns were found in from 53% to 67% of stomachs in 1986/87, but Fig. 6,6 suggests a rather more variable availability in 1987/88. Prawns show a lower degree of occurrence in August and September and a particularly high occurrence in October and November/December.

In 1986/87 crabs were only present during October, where they occurred in over 50% of the stomachs. However, they made an earlier appearance in the food of

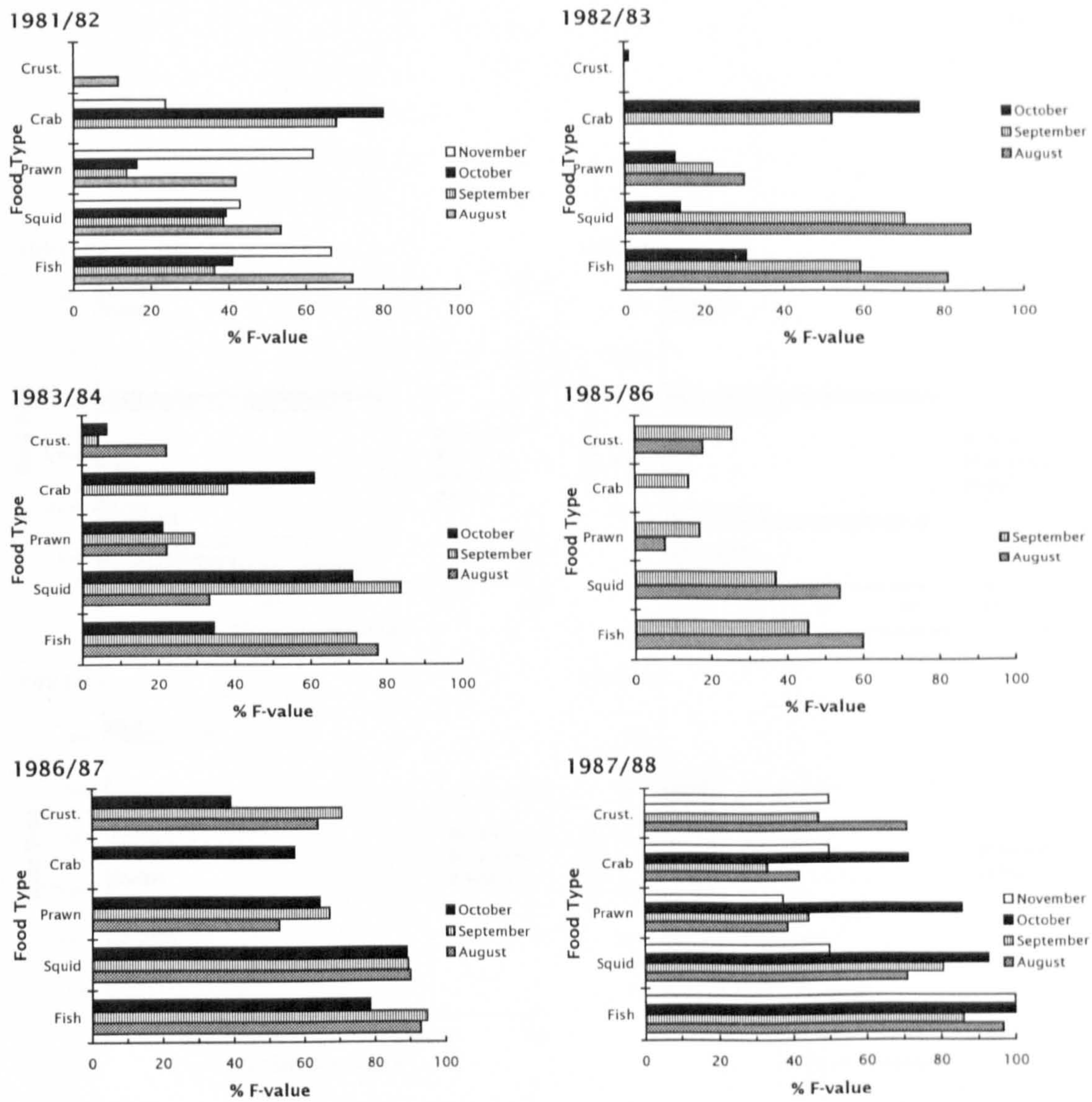


Figure 6,6. % frequency-of-occurrence (% F-value) for five food categories by month-of-capture from 1981/82-1983/84, and 1985/86-1987/88.

1981/82: Aug - mean = 108.2±4.35 cm FL; n = 44 (1 empty);
Sep - mean = 121.7±1.70 cm FL; n = 44 (0 empty);
Oct - mean = 120.6±2.51 cm FL; n = 65 (4 empty);
Nov - mean = 75.7±4.77 cm FL; n = 23 (2 empty);
1982/83: Aug - mean = 99.0±3.51 cm FL; n = 53 (0 empty);
Sep - mean = 123.0±1.98 cm FL; n = 162 (0 empty);
Oct - mean = 102.8±3.72 cm FL; n = 94 (9 empty);
1983/84: Aug - mean = 103.8±12.01 cm FL; n = 9 (0 empty);
Sep - mean = 119.1±3.14 cm FL; n = 68 (0 empty);
Oct - mean = 100.0±4.18 cm FL; n = 107 (17 empty);
1985/86: Aug - mean = 91.6±3.41 cm FL; n = 105 (55 empty);
Sep - mean = 85.6±4.77 cm FL; n = 47 (12 empty);
1986/87: Aug - mean = 105.5±1.94 cm FL; n = 73 (1 empty);
Sep - mean = 101.2±3.40 cm FL; n = 59 (1 empty);
Oct - mean = 111.1±2.28 cm FL; n = 28 (0 empty);
1987/88: Aug - mean = 108.7±5.04 cm FL; n = 31 (0 empty);
Sep - mean = 100.2±5.69 cm FL; n = 38 (2 empty);
Oct - mean = 104.4±6.85 cm FL; n = 14 (0 empty);
Nov - mean = 78.1±9.05 cm FL; n = 8 (0 empty).

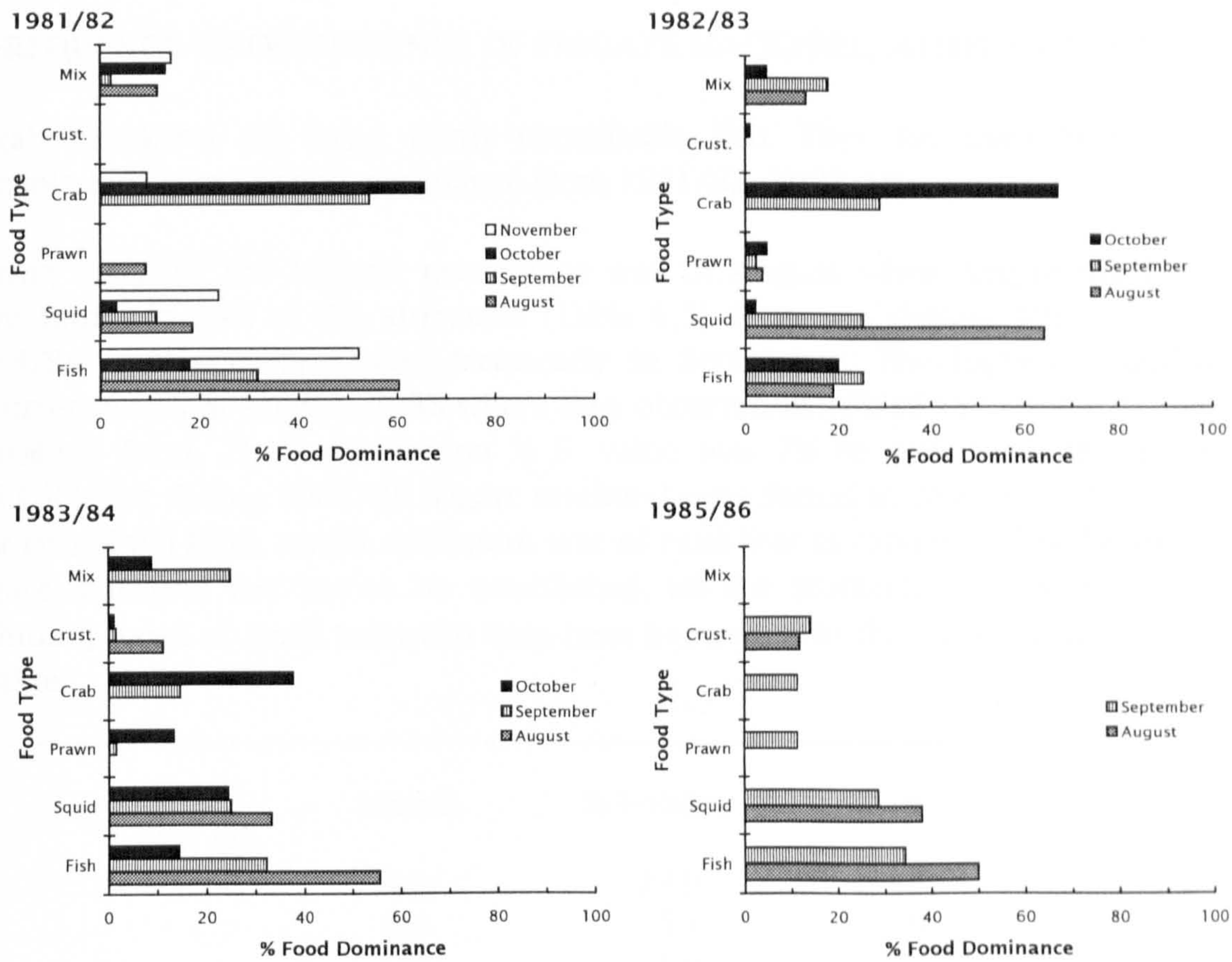


Figure 6,7. The most important foods per month over four fishing seasons is shown. The 'mix' category denotes those fish where no single food category was dominant.

1981/82: Aug - mean = 108.2±4.35 cm FL; n = 44 (1 empty);
Sep - mean = 121.7±1.70 cm FL; n = 44 (0 empty);
Oct - mean = 120.6±2.51 cm FL; n = 65 (4 empty);
Nov - mean = 75.7±4.77 cm FL; n = 23 (2 empty);
1982/83: Aug - mean = 99.0±3.51 cm FL; n = 51 (0 empty);
Sep - mean = 123.0±1.98 cm FL; n = 162 (0 empty);
Oct - mean = 102.8±3.72 cm FL; n = 94 (9 empty);
1983/84: Aug - mean = 103.8±12.01 cm FL; n = 9 (0 empty);
Sep - mean = 119.1±3.14 cm FL; n = 68 (0 empty);
Oct - mean = 100.0±4.18 cm FL; n = 107 (17 empty);
1985/86: Aug - mean = 91.6±3.41 cm FL; n = 105 (55 empty);
Sep - mean = 85.6±4.77 cm FL; n = 47 (12 empty).

yellowfin tuna in 1987/88 than previously noted, but it was not until October that the % F-value exceeded 50%. On the other hand the very small crustacea in 1986/87 were present in 64% and 72% of fish in August and September, respectively with a reduced presence in October. In 1987/88 they occurred in a large proportion of the August stomachs, in a smaller number of the September sample and not at all in October and November/December samples.

% FREQUENCY-OF-OCCURRENCE OF FRIGATE MACKEREL, *AUXIS THAZARD*

Frigate mackerel are large, easily identifiable fish. They are used here as a possible indicator of food abundance from 1981/82 -1987/88.

During 1981/82 the highest occurrence was in August when frigate mackerel were found in 28% of the stomachs (Table 6,3). However, during 1982/83 and 1983/84 they occurred most frequently in September. The highest monthly occurrence was in August, 1985 where they occurred in 36% of the stomachs that contained food. The total season % F- value was 7% to 10% for 1981/82 to 1983/84, but during 1985/86 frigate mackerel were found in 24% of all stomachs that contained food. As the minimum size of tuna that is capable of swallowing a frigate mackerel has yet to be established, all the stomachs containing food, including those of small yellowfin tuna have been used in the calculation of the % F-value.

	Month	% F-value	n
1981/82:			
	Aug	27.9	12
	Sep	9.1	6
	Oct	1.6	1
	Nov	-	-
	Total	9.9	19
1982/83:			
	Aug	-	-
	Sep	11.7	21
	Oct	3.5	8
	Total	7.3	29
1983/84:			
	Aug	-	-
	Sep	23.5	17
	Oct	-	-
	Total	9.1	20
1985/86:			
	Aug	36.0	32
	Sep	8.6	3
	Total	24.4	35

Table 6,3. The % Frequency-of-Occurrence values and the total numbers of frigate mackerel, *Auxis thazard* found in yellowfin tuna stomachs from the Shimoni sport fishery for 1981/82 - 1985/86.

THE VOLUMETRIC METHODS

Pie charts for the % Aggregate-Total Volume are illustrated in Fig. 6,8 for the 1986/87 and 1987/88 samples stratified into the three size classes shown in Table 6,2. Size groups A/B and C are dominated by the fish component for both seasons. Fish were of particular importance in group A/B of 1987/88 where 72.4% of the total food volume was fish. Fish and cephalopods contribute equal proportions (41%) to the Group D yellowfin tuna in 1986/87, whereas in 1987/88 the Group D % Aggregate-Total Volume consists of crab (41%), fish (36%) and squid (20%).

Fig. 6,8 also illustrates that, although the prawns and very small crustacea may be important in terms of occurrence they are of little importance in terms of volume. For example the % frequency-of-occurrence of the very small crustacea in the Group B sample was 86.4% in 1986/87 and 83.3% in 1987/88 (Fig. 6,5), but they only accounted for 21.6% of the total volume in 1986/87 and 14.3% in 1987/88. Similarly prawns did not account for more than 5.1% of the total volume in any of the size classes, in either sample.

The Mean Volumetric Ratio Measurement: Ratios of each food category within each stomach are shown in Appendix F for 1986/87 and 1987/88. These two samples were divided into up to seven size classes as shown in Tables 6,4 and 6,5. The 1986/87 catch was dominated by a single age class of yellowfin tuna (see Chapter 4) and this sample has been split into rather more size classes than in 1987/88 in order to reduce the influence of this age class. The aim was to test for differences in the importance of the various food categories with increasing fish size and between the months. The mean volumetric ratios by size class of yellowfin tuna for each food category are shown in Table 6,4 for 1986/87 and Table 6,5 for 1987/88.

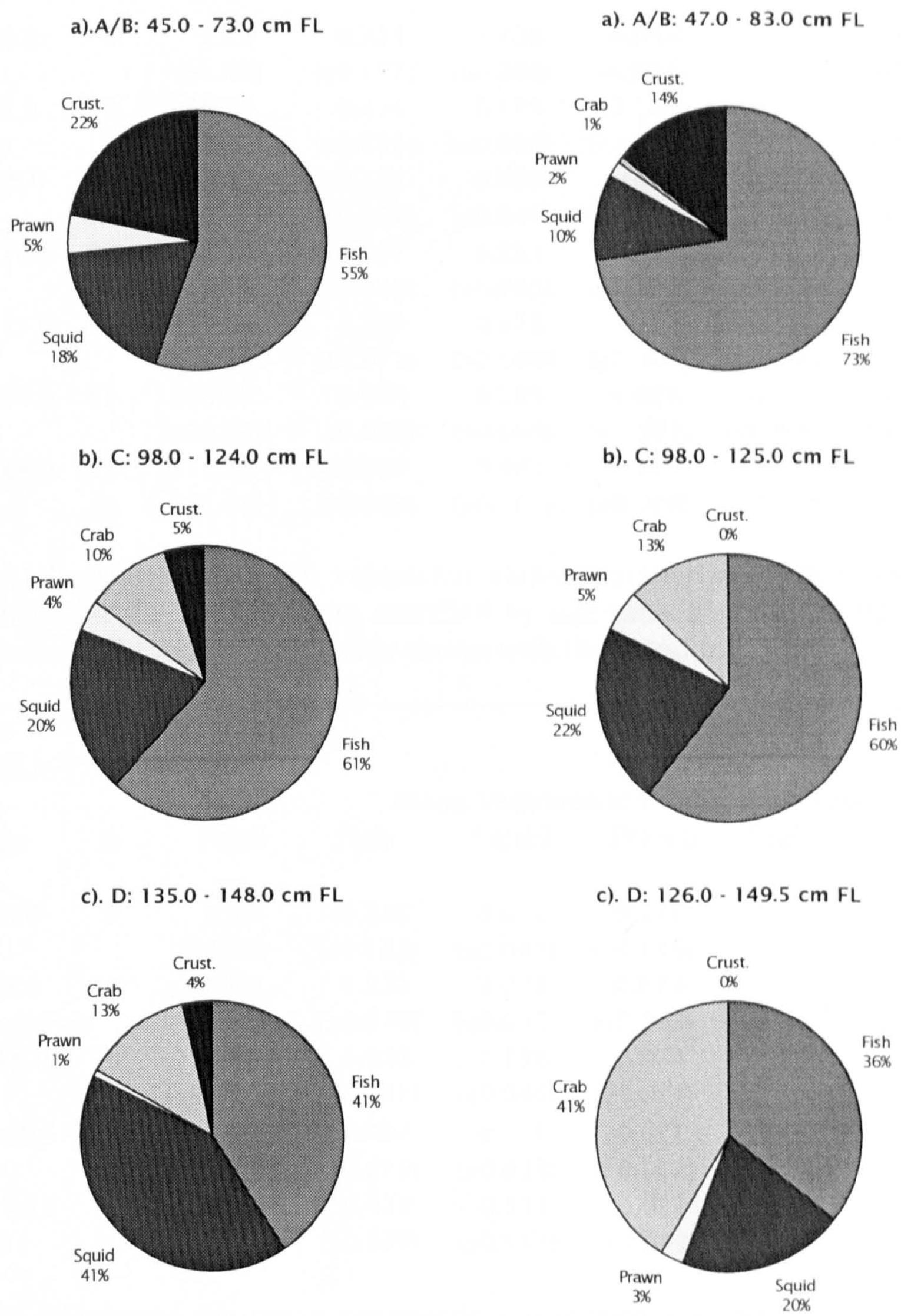


Figure 6,8. Pie charts of the % Aggregate Total Volume by food category for three size-classes of yellowfin tuna from 1986/87 and 1987/88.

(cm FL) Size Range	n	(ml) Total Food	Mean Volumetric Proportions (±se's) Fish	Squid	Prawn	Crab	Crust
45.0-49.0	4	3.25	0.325	0.208	0.083	0	0.117
		(±1.56)	(±0.172)	(±0.208)	(±0.083)		(±0.069)
60.0-73.0	19	36.52	0.426	0.179	0.126	0	0.270
		(±9.28)	(±0.075)	(±0.056)	(±0.063)		(±0.069)
98.0-105.0	28	162.23	0.387	0.273	0.063	0.035	0.206
		(±27.89)	(±0.052)	(±0.046)	(±0.018)	(±0.035)	(±0.059)
106.0-110.0	57	183.64	0.537	0.262	0.045	0.065	0.091
		(±19.16)	(±0.040)	(±0.033)	(±0.010)	(±0.030)	(±0.028)
111.0-115.0	24	245.68	0.557	0.316	0.024	0.067	0.039
		(±44.84)	(±0.072)	(±0.069)	(±0.005)	(±0.044)	(±0.019)
116.0-124.0	15	268.83	0.544	0.255	0.006	0.191	0.004
		(±70.57)	(±0.095)	(±0.069)	(±0.003)	(±0.098)	(±0.002)
135.0-148.0	13	315.88	0.298	0.481	0.014	0.145	0.063
		(±111.45)	(±0.092)	(±0.107)	(±0.009)	(±0.098)	(±0.041)

Table 6,4. Illustrates the mean volumetric ratios together with their standard errors for the 1986/87 data stratified by size class of yellowfin tuna. The mean total food volume is also shown with the standard errors.

(cm FL) Size Range	n	(ml) Total Food	Mean Volumetric Proportions (±se's) Fish	Squid	Prawn	Crab	Crust
47.0-50.0	5	6.48	0.318	0.073	0.376	0	0.033
		(±4.18)	(±0.122)	(±0.045)	(±0.149)		(±0.031)
56.0-83.0	27	21.94	0.532	0.092	0.004	0.011	0.322
		(±4.62)	(±0.070)	(±0.032)	(±0.002)	(±0.011)	(±0.071)
98.0-118.0	30	380.47	0.526	0.288	0.074	0.105	0.005
		(±37.16)	(±0.051)	(±0.049)	(±0.074)	(±0.036)	(±0.003)
120.5-129.5	25	435.89	0.407	0.120	0.021	0.446	0.003
		(±49.25)	(±0.079)	(±0.033)	(±0.007)	(±0.086)	(±0.001)
132.0-149.5	15	474.19	0.429	0.331	0.028	0.211	0.001
		(±84.67)	(±0.077)	(±0.061)	(±0.015)	(±0.086)	(±0.001)

Table 6,5. Illustrates the mean volumetric ratios together with their standard errors for the 1987/88 data stratified by size class of yellowfin tuna. The mean and standard errors of the total food volume are also shown.

Results from the Kruskal-Wallis tests:

a) Between the size classes: The smallest size class from both seasons was not used in the Kruskal-Wallis test because the sample sizes were too small.

		Kruskal-Wallis values H/D				
SEASON	df	Fish	Squid	Prawn	Crab	Crust
1986/87	5	11.77*	10.14	3.35	45.38***	23.59***
1987/88	3	1.89	27.31***	33.91***	28.72***	49.33***

Table 6,6. Summary of Kruskal-Wallis tests among four sizes of yellowfin tuna. The smallest size class of each season was not included. ['*' denotes 0.05 > P > 0.01, '**' denotes 0.01 > P > 0.001, '***' denotes P < 0.001].

The results illustrate the differences that exist in food availability from one season to the next. The biggest differences existed between the squid and prawn components and to a lesser extent the fish. There was a variation (< P = 0.05) in the proportion of fish in the food of different size yellowfin tuna only for 1986/87 (Table 6,6). On the other hand neither the cephalopod nor the prawn component ratios differed significantly (P = 0.05) between the size classes in 1986/87, but in 1987/88 the proportion of both groups appears to have varied widely with tuna size (P < 0.001).

The results imply that the proportion of crab and very small crustacea in the food of yellowfin tuna in the Pemba Channel is likely to be specific to the size of tunas (P < 0.001). Crabs were eaten more by the larger sizes (> 98.0 cm FL) of yellowfin tuna, and the very small crustacea were of greater importance volumetrically to the smaller tuna (< 98.0 cm FL). However, different size classes may pass through the Pemba Channel at different times and they will tend to feed upon the food that is available at that time, depending on prey size.

b) By month-of-capture: The results from the Kruskal-Wallis test are shown in Table 6,7. The mean MVRM's by month of capture for 1986/87 and 1987/88 are given in Table 6,8.

Fish: During 1986/87 there appears to have been considerable variation in the abundance of fish between August and October (Table 6,7). This is accentuated by the removal of the 60.0-73.0 cm FL yellowfin tuna from the analysis with the highest MVRM during September 1986 at 0.591±0.04 (Table 6,8). During 1987/88 the MVRM's were not significantly different (P < 0.05).

Squid: During 1986/87 the ratio of cephalopods in the food fell from August to October (P < 0.05), but in this case the removal of the smaller fish does not increase the departure from the null hypothesis. During 1987/88 there was no noticeable variation (P < 0.05) between the months.

SEASON	df	Kruskal-Wallis values H/D Fish	Squid	Prawn	Crab	Crust
1986/87[1]	2	12.09**	6.15*	1.18	82.98***	12.53**
[2]	2	17.67***	8.89*	2.60	72.89***	11.65**
1987/88[1]	4	2.76	8.92	19.31***	10.03*	20.28***
[2]	3	2.38	3.97	18.23***	6.74	17.44***
[3]	2	0.62	3.94	8.73*	5.15	-14.36***

Table 6,7. Summary of Kruskal-Wallis tests on the Mean Volumetric Ratio Measurements by month-of-capture for 1986/87 and 1987/88. 1986/87[1] uses the data from August to October for 60.0-148.0 cm FL yellowfin tuna; 1986/87[2] excludes the 60.0-73.0 cm FL class; 1987/88[1] uses the data from August to December; 1987/88[2] combines November and December's data and 1987/88[3] uses only August to October. The 1987/88 data includes all the size classes from 56.0-149.5 cm FL. ['*' denotes 0.05 > P >0.01, '**' denotes 0.01 > P > 0.001 and '***' denotes P < 0.001].

Month	n	(ml) Total Food	Mean Volumetric Ratios (±se's) Fish	Squid	Prawn	Crab	Crust
1986/87:							
Aug.	73	150.97 (±19.87)	0.419 (±0.035)	0.316 (±0.034)	0.063 (±0.019)	0	0.189 (±0.034)
Sep.	59	210.19 (±33.49)	0.591 (0.040)	0.279 (±0.036)	0.040 (±0.009)	0	0.072 (±0.021)
Oct.	28	226.06 (±32.13)	0.387 (±0.071)	0.175 (±0.047)	0.033 (±0.009)	0.395 (±0.083)	0.013 (±0.008)
1987/88							
Aug.	31	236.98 (±45.27)	0.465 (±0.064)	0.120 (±0.031)	0.018 (±0.006)	0.300 (±0.076)	0.093 (±0.040)
Sep.	38	279.06 (±48.99)	0.447 (±0.058)	0.210 (±0.037)	0.022 (±0.007)	0.109 (±0.041)	0.159 (±0.051)
Oct.	14	451.66 (±71.09)	0.512 (±0.082)	0.138 (±0.025)	0.130 (±0.063)	0.221 (±0.079)	0
Nov.	8	175.08 (±76.25	0.641 (±0.093	0.084 (±0.038)	0.095 (±0.056)	0.156 (±0.065)	0.024 (±0.019)
Dec.	7	419.51 (±86.06)	0.542 (±0.107)	0.305 (±0.100)	0.153 (±0.104)	0	0

Table 6,8. The mean volumetric ratios (±se's) by month-of- capture for 1986/87 and 1987/88. The mean (±se) of the total food volume is also shown.

Prawns: The quantity of prawns in the food was consistently low in 1986/87. However, there was considerable variation between August and December in the 1987/88 data (P < 0.001). However, the variation was reduced by excluding November and December (P < 0.05) as the highest MVRM for prawns was in November.

Crabs: These did not occur in the food before October 1986 and only the larger fish contained crabs. During 1987 they occurred from August to November and it was only when all five months were considered that a variation was noted ($P < 0.05$).

Very small crustacea: The proportion of the very small crustacea was highest in August 1986, falling thereafter ($P < 0.01$). There appears to have been a greater variability between the months in 1987 ($P < 0.001$) in the abundance of the very small crustacea. In the case of August to October only, the value of H/D = -14.36 is significant at $P < 0.001$ when a two tailed test is used.

STOMACH FULLNESS

The % L'Indice de réplétion for 1986/87 and 1987/88 are shown in Fig. 6,9. These indicate the considerable variation that may be found in stomach fullness for each size class of yellowfin tuna. Fig. 6,9 illustrates a larger number of fish with a % Ir > 3.0 for 1987/88.

PREY SIZE

The maximum prey size found in each stomach of the combined data was plotted against fork length (Fig. 6,10). The mean size of prey is considerably smaller than either the largest items identified from each size class of tuna, or than the largest items that they are believed capable of swallowing.

The largest item of food removed from a yellowfin tuna was a 754g skipjack tuna, *Katsuwonus pelamis* from a 115.0 cm FL fish on 6th September, 1986. Frigate mackerel, *Auxis thazard* of between 150 ml and 415 ml volume displacement were occasionally found in stomachs of yellowfin tuna of more than 100.0 cm FL. On one occasion a 146.0 cm FL fish in October 1982 contained six of these fish. In October 1978, a yellowfin tuna of 54.4 Kg (approx. 145.0 cm FL) was landed on a live skipjack tuna bait of 2.0-2.5 Kg, which it had ingested.

Fish were not the only large prey. Squid of at least 308.0 ml volume displacement were also encountered, usually separated into head, body and tentacles.

The smallest prey were at least as little as 0.1 ml volume displacement and these were found in both small and large yellowfin tuna. Of the yellowfin tuna that had food in their stomachs, 83.8% in 1986/87 and 34.7% in 1987/88 contained items of less than 1.0 ml volume displacement.

POINTS TEST

The results of the points test are shown in Table 6,9 for 1986/87 and Table 6,10 for 1987/88. Fish was the most important food category irrespective of size of yellowfin tuna followed by cephalopods during both seasons. The only major

variation between the seasons appears to be with respect to crabs, which were more abundant in 1987.

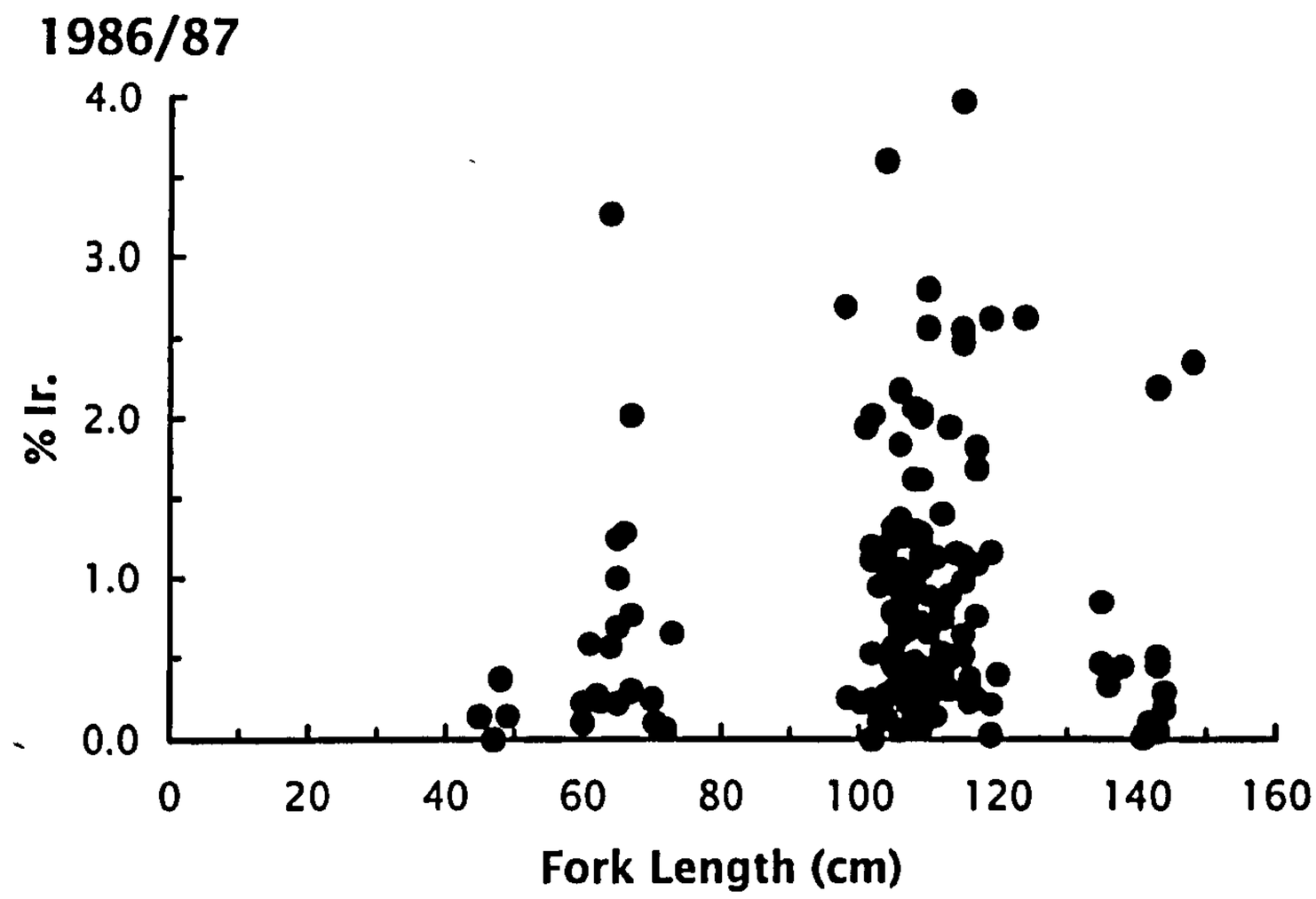
Fish were the most important food for each size group, except for yellowfin tuna greater than 116.0 cm FL in 1986 and greater than 132.0 cm FL in 1987 where cephalopods dominated. Crabs were not taken by fish less than 98.0 cm FL in 1986 and only by one yellowfin tuna less than 83.0 cm FL in 1987. On the other hand the very small crustacea were generally of little importance by volume for fish greater than 98.0 cm FL, although they were of greater importance in 1986 than 1987.

(cm FL) Size-Range	n	Mean (±se) Points Scored Fish	Squid	Prawn	Crab	Crust
45.0-49.0	4	3.50 (±1.19)	1.25 (±1.25)	1.25 (±1.25)	0	1.75 (±1.03)
60.0-73.0	19	3.42 (±0.49)	2.16 (±0.50)	1.47 (±0.44)	0	3.37 (±0.34)
98.0-115.0	109	4.31 (±0.10)	3.84 (±0.10)	2.04 (±0.14)	0.42 (±0.13)	1.92 (±0.17)
116.0-124.0	15	3.73 (±0.51)	4.00 (±0.32)	1.40 (±0.41)	1.27 (±0.56)	1.13 (±0.38)
135.0-148.0	13	3.38 (±0.55)	4.08 (±0.38)	0.92 (±0.40)	0.77 (±0.52)	1.54 (±0.51)
Total:	160	4.06 (±0.12)	3.61 (±0.12)	1.80 (±0.13)	0.47 (±0.11)	1.98 (±0.14)

Table 6,9. Summary of points test for 1986/87. Points were assigned as follows: 5 = most abundant category by volume displacement; 4-1 in order of decreasing volume; 0=- not present in food.

(cm FL) Size-Range	n	Mean (±se) Points Scored Fish	Squid	Prawn	Crab	Crust
47.0-50.0	5	3.40 (±0.87)	1.40 (±0.87)	3.60 (±0.98)	0	1.00 (±0.63)
56.0-83.0	27	3.85 (±0.37)	1.56 (±0.36)	0.33 (±0.16)	0.15 (±0.15)	3.48 (±0.32)
98.0-118.0	30	4.40 (±0.20)	3.90 (±0.15)	2.73 (±0.21)	1.33 (±0.34)	0.33 (±0.15)
120.5-129.5	25	4.16 (±0.17)	3.20 (±0.31)	1.68 (±0.33)	3.00 (±0.45)	0.96 (±0.22)
132.0-149.5	15	3.87 (±0.45)	3.87 (±0.34)	1.33 (±0.40)	2.40 (±0.51)	0.20 (±0.14)
Total:	102	4.06 (±0.14)	2.97 (±0.17)	1.67 (±0.16)	1.55 (±0.21)	1.33 (±0.17)

Table 6,10. Summary of points test for 1987/88. Points were assigned as follows: 5 = most abundant category by volume displacement; 4-1 in order of decreasing volume; 0 = not present in food.



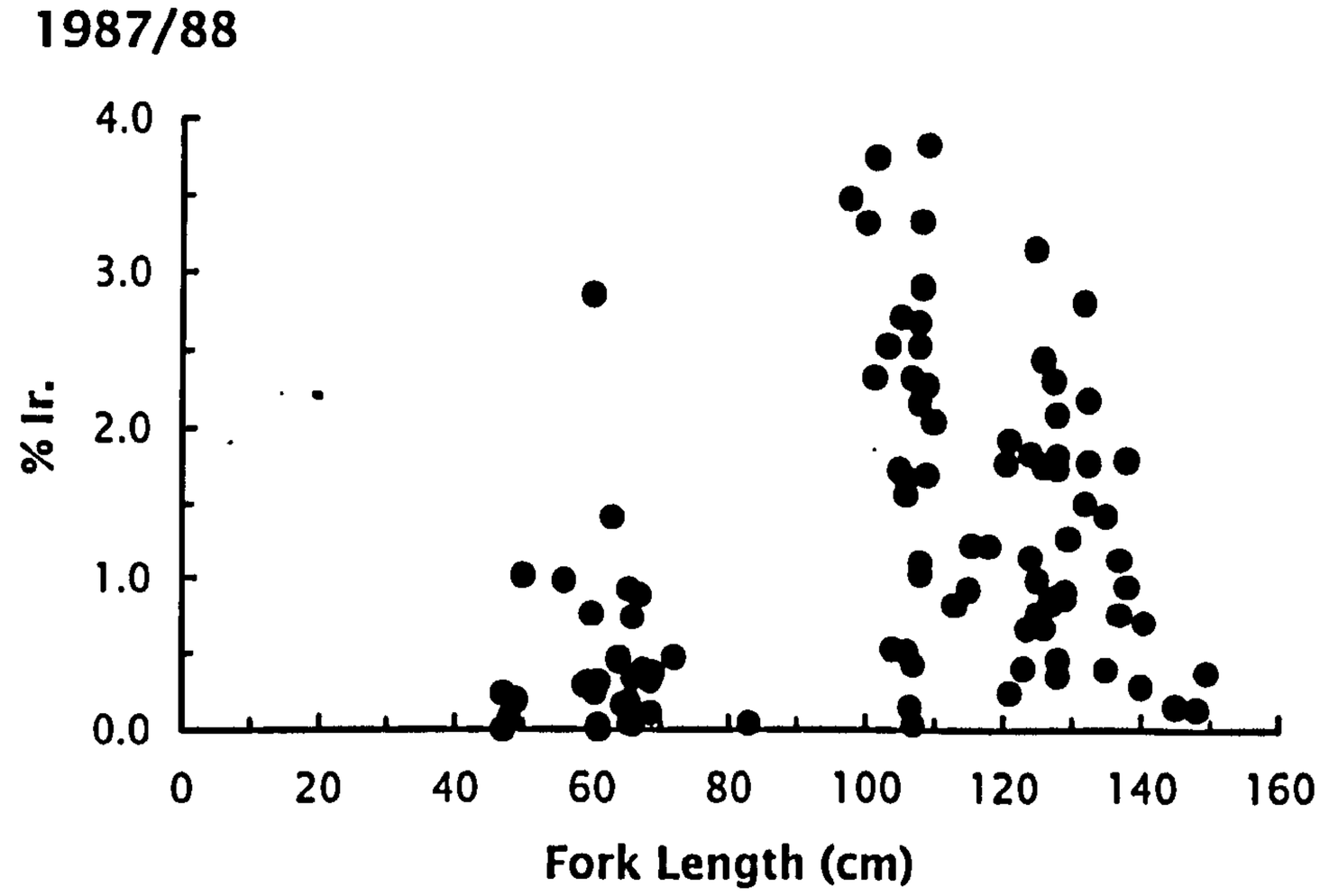


Figure 6,9. The % L'Indice de repletion (% Ir.) for yellowfin tuna stomachs in 1986/87 (n = 160), and 1987/88 (n = 102).

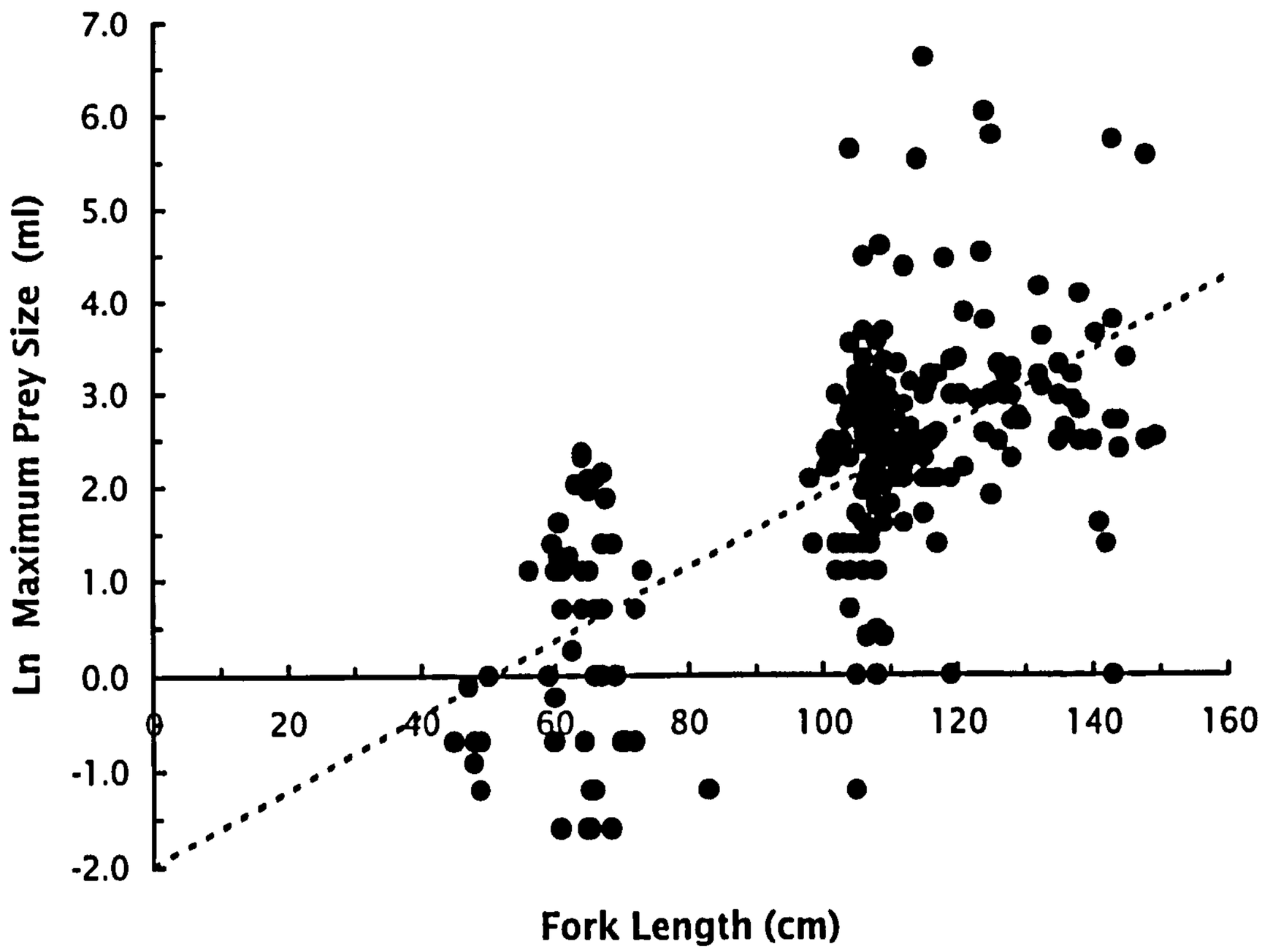


Figure 6,10. The maximum prey size that was found in the stomach contents of 257 sport fishery-caught yellowfin tuna during 1986/87 and 1987/88 are shown plotted against fork length. The broken line indicates the fitted linear regression.

Ln Prey Size = 0.039 x Ln FL - 1.988;
P = <0.0001; Rsquare = 0.423.

6.4 Discussion

The results of the food study of yellowfin tuna in the Pemba Channel, Kenya carried out from August 1981 to March 1987 reveal considerable variation not only between the fishing seasons, but also from one month to another. This poses serious questions as to the validity of using data collected over a number of years and combined into a single sample as has been frequently reported in the literature.

FOOD TYPE

Fish were by far the most important category of food for juvenile yellowfin tuna less than 57.0 cm FL both in terms of frequency-of-occurrence and volume. Fish were again the most important food for 57.0-87.5 cm FL tuna except in 1985/86 where cephalopods dominated. Very small crustacea were very important in 1986/87 and 1987/88, but by occurrence only.

Of the larger yellowfin tuna (> 87.5 cm FL) fish, cephalopods and crabs were all important by volume depending on availability. Prawns and the very small crustaceans contributed little to the overall food volume, being generally of very small size. Crabs were of particular importance from 1981/82 to 1983/84 and 1987/88.

According to the points test (Tables 6,9 and 6,10) fish were the most important food for all size classes of yellowfin tuna less than 116.0 cm FL in 1986 and 132.0 cm FL in 1987. Cephalopods appeared to be of slightly greater importance in these larger size classes. The points test suggests that all the other food categories were of minor importance in the food of yellowfin tuna during 1986 and 1987.

Crabs accounted for a large proportion of the food of yellowfin tuna in the Pemba Channel in agreement with recent studies in the Western Indian Ocean by Zamorov *et al.* (1991). They found that *Charybdis smithii* occurred in up to 90% of yellowfin tuna stomachs from September to December, and hardly at all from April to July from 1978-1987 which agrees with the results of my study. In all six seasons studied in the Pemba Channel crabs were of little importance before the second week of September. The proximity of the sampling area to the coast may influence the importance of crabs in the diet of yellowfin tuna. Kornilova (1981) noted that crustacea increased in importance in the food of yellowfin tuna in those regions closer to the East African coast. Pelczarski (1987) found that crustacea only accounted for 1.0% of the total food by weight in the Central Atlantic.

The composition of the food varied within the seasons as well as between them. Fish and cephalopods were usually the most important foods during August and crabs also became important in September and October.

FOOD ABUNDANCE

From August to October of 1981 and 1982 there was an abundant supply of food and good catches of yellowfin tuna and many of the other major gamefish were realized (see Chapter 7). On the other hand during August and September of 1985 there was a poor availability of food. The stomachs, when examined contained very little food and the yellowfin tuna schools were always observed migrating rapidly south, presumably in an attempt to locate an abundant food supply elsewhere. The results and observations support the hypothesis of Reintjes & King (1953) that the distribution and abundance of maturing and adult yellowfin tuna are likely to be influenced by the total volume of food present in an area.

If food is short it may become the limiting factor on growth (Kitchell *et al.*, 1978), but an over abundance of food may outweigh other potential limiting factors, such as temperature. Adult yellowfin tuna usually depart from the Pemba Channel area in mid-October when the doldrums begin to set in and the temperature rises. During 1981, however large numbers of yellowfin tuna remained in the area until early November despite water temperatures of 28-30°C. It is believed that the abundance of crabs, a slow-moving prey that requires little energy to catch was present in sufficient quantities to outweigh the limiting effect of high temperatures.

The number of empty stomachs may be an indication of food abundance. The largest number of empty stomachs was observed during 1985/86 and the least during 1986/87 and 1987/88 (Table 6,11). The probable explanation for the higher number of empty stomachs observed in 1981/82 and 1982/83 compared to the quantitative study is that during the latter period stomachs were only considered empty when no particles of food were present even if the total volume was only 0.1 ml. Table 6,11 supports the theory of a decrease in food abundance from 1981 to 1985.

(cm FL)	No. of Empty Stomachs					
Size class	1981	1982	1983	1985	1986	1987
≤55.0	3	9	18	6	1	1
≤87.5	1	3	1	51	0	1
88.0-125.0	4	0	0	9	1	0
>125.0	0	0	1	1	0	0
Total:	8	12	20	67	2	2
n:	179	315	206	153	160	102

Table 6,11. The number of yellowfin tuna with empty stomachs observed in the Pemba Channel food study.

There is a greater incidence of empty stomachs in the smaller size classes than in the larger fish (Table 6,11). Alverson (1963a) noted a positive relationship between the proportion of empty stomachs in an area and the ratio of fish in the food. However, this is not borne out in the present study. For the size class 57.0-87.5 cm FL there was a considerably lower % F-value and % Food Dominance for fish in 1985/86 than in 1981/82 (Fig. 6,2). However, there was a high % Food Dominance for fish in the smallest size class in 1983/84 with an appreciable number of empty stomachs.

Alverson (1963a) also found that the higher the proportion of crustacea in the food the lower that of empty stomachs. In the present study this cannot be evaluated as far as crabs are concerned as the smaller tuna stomachs seldom contained them, but his findings certainly agree with the % F-values for prawns which occurred in 48.0% of the stomachs in 1981/82 and only 11.1% in 1985/86 (Fig. 6,2). The very small crustacea, however show the reverse both for % F-value and % Food Dominance.

Stretta (1986) comments that there is considerable variation in the proportion of yellowfin tuna with empty stomachs as reported in the literature. He suggests that this variation may be related to the nature of the fishery under study, or to the manner in which the stomachs are collected. Bard and Pézennec (1990) studied the food of yellowfin tuna over 10 kg taken by purse seining in the Gulf of Guinea and recorded a very large number of empty stomachs. They suggest that this may be related to the length of time the tuna remain in the seine, and possibly stress causes them to regurgitate their food. Pelczarski (1987) compared his results, collected by longlining in the Central Atlantic with other studies using purse seining (Dragovich & Potthoff, 1972). He found that the weight of the stomach was higher in his study. Purse seining may not be a valid means of collecting data for use in food and feeding studies of yellowfin tuna.

The results of Yesaki (1983) of the food studies of yellowfin tuna caught around payaos in the Philippines by handline also indicate very few empty stomachs (5%). However, his results also emphasize the importance of chum in the food of tunas around payaos where a commercial handline fishery is in progress. Such results are only of limited value as they do not give a true picture of tuna feeding in the wild, but rather are biased by how much chum the fishermen use, the nature of the chum and the strength of the current, which determines as to whether the chum reaches the fish, or is swept away. Highest incidences of prey items in the food occurred during periods of bad weather and strong currents.

A sport fishery, therefore may be an ideal means of studying the natural food and feeding habits of yellowfin tuna in the wild. The small number of empty stomachs recorded suggests that rod and line does not exert sufficient stress to cause regurgitation of the food. Capture of even the largest tuna was usually within the

hour from the time of hook-up, and once boated the fish were swiftly killed. Regurgitation did occur occasionally upon boating, but in all cases the items of food regurgitated showed no signs of digestion and one may conclude that these items were being preyed upon at the time of capture. Yesaki (1983) concluded from studies on yellowfin tuna taken by pole-and-line around payaos in the Philippines that the high volumes and the fresh state of the food indicated that regurgitation was minimal.

FEEDING OR NON-FEEDING MODE

The stomach of a fish that is in a non-feeding mode is usually empty and firm. Very few fish were observed in this mode, and all of them were small, juvenile yellowfin tuna. Sport fishing relies upon the fish actively taking the lure, or bait presumably with the intention of eating it. The majority of yellowfin tuna, therefore are likely to be in a feeding mode when caught. All but 1.4% of yellowfin tuna greater than 88.0 cm FL caught during the study period contained food in their stomachs. It is suggested that feeding by yellowfin tuna may be continuous with a high rate of digestion (King & Ikehara, 1956; Bard & Pézennec, 1990). The length of time that a food item remains in the stomach depends on the nature of that item and the presence or absence of a hard exoskeleton. Those food organisms with a hard exoskeleton, such as crabs, prawns, and the very small crustacea are less likely to become broken during capture and swallowing, and are more resistant to digestive action. On the other hand, soft bodied organisms, such as the cephalopods and fish were frequently damaged during capture and swallowing and will be digested more rapidly. By breaking up during swallowing the rate of digestion is speeded up as a greater surface area becomes available for digestive action. Therefore crabs, prawns and the other small crustacea may remain in the stomach for many hours, whereas within a short time span most fish will be hard to identify. The larger fish, such as *Auxis thazard* will remain longer as the surface area for digestion is relatively small, but the skin will disappear very rapidly.

Tunas tend to eat additional food even after their stomach is half-filled rather than when it is empty (Magnuson, 1969). The best fishing for yellowfin tuna using rod and line very often occurs when the yellowfin tuna are in a voracious feeding mode, and under such circumstances their stomachs often already contain substantial quantities of food when they strike the fishing lure, or bait.

FOOD RATION

The larger the yellowfin tuna the greater the variation in the range of total food volume (Reintjes & King, 1953; Fig. 6,11). The mean and maximum observed total food volume increases proportionately with fork length of yellowfin tuna (Tables 6,4; 6,5 and Fig. 6,11). The fish of 1987/88 contained on average over 100.0 ml

more food than in 1986/87. During 1986/87 the mean food volume was 185.95±16.43 ml (Mean FL = 104.9±1.60 cm), and 294.60±27.52 ml (Mean FL = 102.2±2.93 cm) in 1987/88.

The capacity of the stomach has been estimated at 7.0% for yellowfin and skipjack tunas (Magnuson, 1969; Dragovich, 1970). In my study the highest degree of fullness recorded was 4.0% and 3.8% of the gutted weight of yellowfin tuna for 1986/87 and 1987/88, respectively. These figures of maximum fullness are similar to the estimate of 3.9% by Olson & Boggs (1986) for the daily food ration using stomach contents and gastric evacuation rates. However, feeding by yellowfin tuna is believed to be continuous, and rapid digestion has been demonstrated for skipjack tuna (Kitchell *et al.*, 1978), although different food types will be digested and evacuated at different rates (Olson, 1981).

PREY SIZE

The range of prey sizes taken by yellowfin tuna increases with FL. These results confirm that, although larger yellowfin tuna may take larger prey, they also eat the same size items as smaller tuna. Reintjes & King (1953) estimated that the maximum size of prey for a yellowfin tuna was equal to one third of the body length. However, the length of prey may be misleading as the volume may not be proportional to the length. The results of this study imply that yellowfin tuna seldom eat prey that approach the maximum size for that size tuna.

The mean maximum prey size was far less than the largest item found in the stomachs. The present study suggests that the size of the largest item in a stomach may not only increase with size of yellowfin tuna, but also with reduced availability of food in the area at that time.

The frigate mackerel, *Auxis thazard* was the most frequently occurring large prey item together with a few large squid and the occasional skipjack tuna, *Katsuwonus pelamis*. Olson (1981) concluded that frigate mackerel play a major role in the feeding of yellowfin tuna in the Eastern Pacific, and Bard & Pézennec (1990) came to similar conclusions in the Gulf of Guinea. However, the results of the present study suggest that although frigate mackerel are eaten by yellowfin tuna in the Pemba Channel they only play a major role in the feeding when the abundance of other smaller prey becomes limiting.

During 1981 the highest % F-value for frigate mackerel was in August. Although the stomachs contained a wide variety of food items many were less than half-full. Towards the end of August and into September the stomachs were full of sardines and small squids, and latterly crabs. Frigate mackerel and other large items seldom occurred during September and October. There appeared to be a good availability of food from August to October 1982 and all items were small.

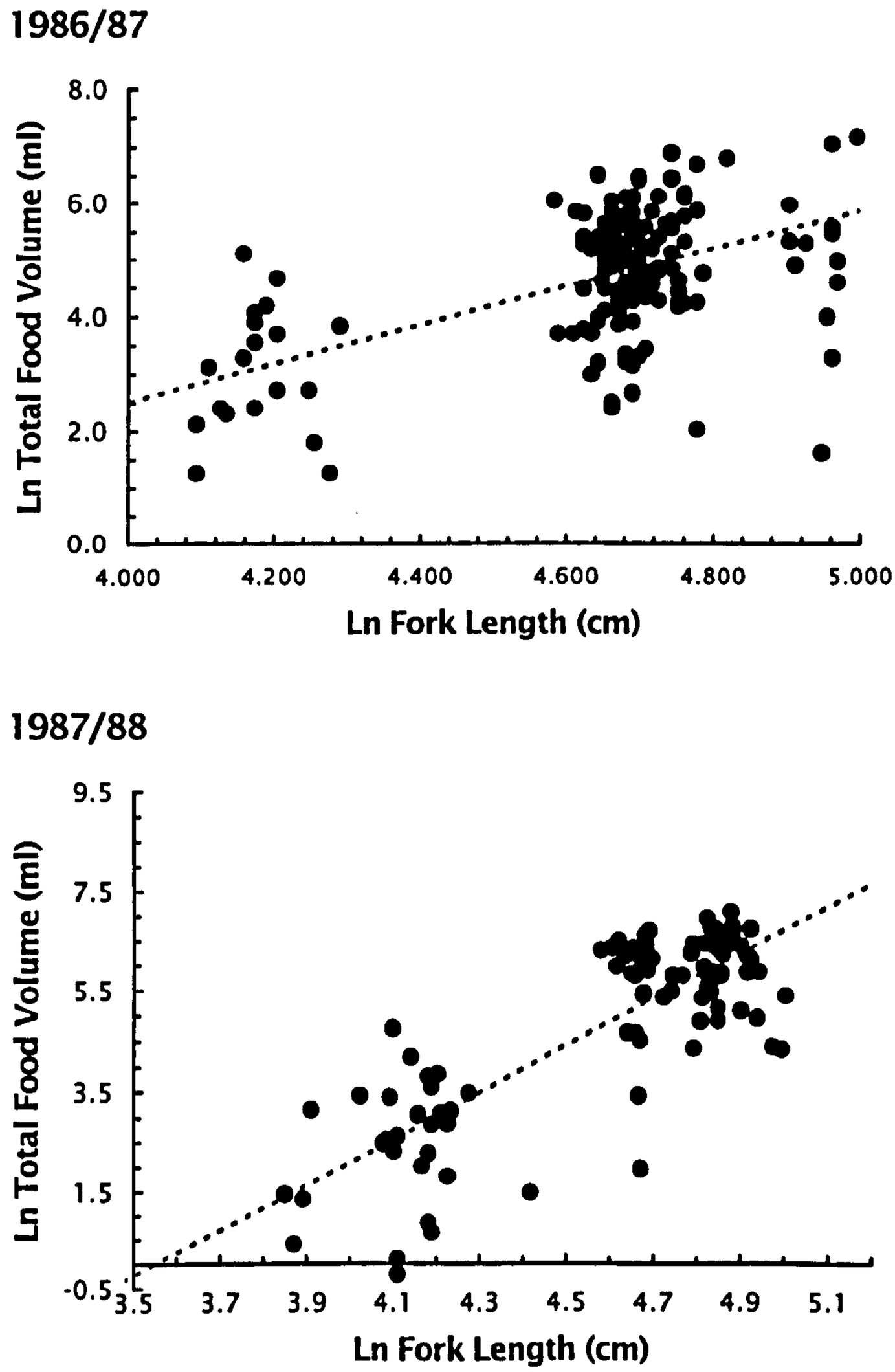


Figure 6,11. The variation in total food volume in the stomachs increased with fish size. The broken lines represent the fitted linear regressions.

1986/87: Ln Vol. = 3.33 x Ln FL - 10.81; P = <0.0001
Rsquare = 0.338; n = 158
1987/88: Ln Vol. = 4.60 x Ln FL - 16.33; P = <0.0001;
Rsquare = 0.658; n = 100.

Some frigate mackerel, a few large squid and a single skipjack tuna were present but the % F-value for frigate mackerel was half that of August 1981. During September 1983 the % F-value for frigate mackerel was high despite an apparent abundance of other food. However, the average size of yellowfin tuna (119.1±3.14) was higher than in 1981 or 1982. In October 1983 the abundance of food was rich and the majority of the prey items were small. During August 1985 the stomachs of adult tuna contained only frigate mackerel and a few small crustacea. During 1986 and 1987 large items were taken, but usually when either the other available food was very small, or limiting.

Larger prey, such as frigate mackerel, skipjack tuna and large squids are capable of higher swimming speeds than smaller prey. Capturing fast moving quarry requires that either the predator ambushes its prey, or that it must outswim it. Catching large prey is therefore more costly in energy terms.

PREY HANDLING TIME CONSTRAINTS

Once the tuna has caught a large prey item it must prepare it for swallowing. Large prey must be turned and swallowed head first in order that the fins and spines do not stick in the throat. The larger the item the more difficult it becomes for the predator to restrain it while turning and swallowing. A tuna that has caught, but not swallowed a large item is very vulnerable to predation itself, not only because it is restricted in its mobility, but the prey's struggles would be a signal to other predators, such as the mako shark, *Isurus oxyrinchus*, the oceanic white-tip shark, *Carcharhinus longimanus*, the Indo-Pacific blue marlin, *Makaira mazara*, and the black marlin, *Makaira indica*.

Small items do not require turning and hence do not impede the general mobility of the predator. If there is an ample supply of smaller, slower moving prey available a predator may chose to ignore larger, faster, more difficult to swallow items. In the case of the brown swimming crabs tunas have a reasonably sized, very slow moving food, although with the disadvantage that they are more difficult to digest.

FOOD PREFERENCE

Most authors agree that yellowfin tuna are active, opportunistic feeders that take whatever is most abundant in the area at the time, depending on prey size (Dragovich, 1969; Stretta, 1986; Roger, 1988). During the present study, in the Pemba Channel there was evidence that this may not always be the case.

It is suggested that when the crab, *Charybdis smithii* swarms in surface waters maturing and adult yellowfin tuna will actively select for this prey. Zamorov *et al.* (1991) suggest that yellowfin tuna in the Western Equatorial Indian Ocean will seasonally switch to this decapod prey, and that this likely influences the migration characteristics of the fishes. When crabs were very abundant the stomach contents consisted almost entirely of crabs. Zamorov *et al.* (1991)

suggested that when feeding on crabs the stomachs were fuller than when feeding upon other prey. This was not necessarily the case in the Pemba Channel samples with both fish and cephalopods being taken in considerable quantities at certain times. Zamorov *et al.* (1991) gave no break down of the sizes of yellowfin tuna in their samples, nor did they measure by volume. Because of their hard exoskeletons it is possible that crabs may accumulate in the stomach for longer periods than either fish or cephalopods. The abundance of the crabs varied from day to day and between seasons, most likely depending on the environmental requirements of the crab.

Farther evidence on prey selection by yellowfin tuna in the Pemba Channel comes from sport fishing itself. When crabs are swarming in surface waters experience has led to an adjustment of sport fishing techniques for yellowfin tuna. Strikes from the larger yellowfin tuna are limited to a pale brown plastic cuttlefish lure of approximately five to six inches length. This colour is similar to that of the crabs. The use of lures of other sizes and colours yields far fewer strikes. On the other hand when crabs are not abundant other colours work equally well. Smaller lures are, however still usually selected in preference to larger ones. On rare occasions tuna will take indiscriminately of colour or size. In those seasons where crabs are not an important part of the diet of yellowfin tuna better strike rates may be had using baits, or lures that mimic fish, such as 'rapalas' very often trolled deep on a down rigger.

Unfortunately crabs were not present in such large numbers in 1986/87 or 1987/88 as they were during September and October of 1981 and 1982 to enable the testing of these hypotheses more quantitatively. The crabs appear to swarm on the surface particularly during very heavy rain. Although the crab swarms were observed every year, their abundance was variable. It is possible that this maybe related to the lack of rain during September and October in latter years. Further study is needed to assess the population dynamics and biology of this potentially important species.

BEHAVIOUR

The behaviour of yellowfin tuna depends directly upon the nature of their major prey at any one time. Fish and cephalopods are more gregarious and active than crabs. It is believed that when feeding upon a more widely dispersed prey, the individual tuna within the schools become more widely distributed. Likewise, when they are feeding upon fish and cephalopods the tuna are more closely associated with one another within the school.

Observations made during the past ten years suggest that the brown swimming crabs do not form schools, but are dispersed over a wide area. Under such conditions individual tuna schools are not obvious, as the yellowfin tuna are as widely distributed as the crabs.

Also when the crabs are swarming on the surface the tuna exhibit an almost lazy motion as they 'porpoise' along the surface feeding upon the crabs. Sport fishermen have found that to catch yellowfin tuna under such circumstances a very slow trolling speed must be adopted. If the boat is speeded up no strikes result regardless of colour or size.

When the yellowfin tuna are feeding predominantly on fish and cephalopods the schools are more compact and faster moving and consequently a faster trolling speed is often called for. However care must be taken to keep the boat clear of the school or the fish will sound demonstrating clear vessel avoidance.

Further observations on tuna behaviour relate to weather conditions. During September and October of 1981 to 1983 yellowfin tuna were more abundant on the surface during either overcast, or rainy conditions. However, in latter years this pattern has altered with fish often being caught in sunny conditions. The behaviour of yellowfin tuna in 1981 to 1983 is believed to have been directly related to that of the crabs which were the most important category in 41.3-48.6% in the Group D yellowfin tuna stomachs during those years (Fig. 6,4.).

CATCHABILITY

For yellowfin tuna to be accessible to sport fishing gear they must be within the surface layers. None of the boats used during the study period possessed advanced electronics to aid in the detection of the tuna schools. Sport fishermen in the Pemba Channel rely upon experience, locating the yellowfin tuna schools visibly and on chance.

The catchability of yellowfin tuna by sport fishing is greatest during those periods when they are feeding upon crabs. The more widely dispersed nature of the tuna schools increases the probability of a yellowfin tuna encountering a lure. Fish and cephalopods frequently form sub-surface schools with the yellowfin tuna showing on the surface less frequently. Cephalopod schools may make rapid vertical migrations to evade the yellowfin tuna, which means that the tuna schools are on the surface for very short, infrequent periods. Crabs are not capable of such rapid migrations and so the tuna positions are more predictable.

The effect of food-type and supply on the catchability of yellowfin tuna by commercial gears

The nature of the food of yellowfin tuna will also play an important role in their catchability by commercial gears, such as longline, pole-and-line and purse seining.

Longliners target the larger sizes of yellowfin tuna which generally concentrate on or near the thermocline making only brief excursions to the surface. This is the only one of the three gear types that relies on the tuna taking a bait. Longlines use baited hooks, which therefore rely on the fish being in a feeding mode as well as within the vicinity of the hooks. If the tuna are concentrating on the surface, feeding on crabs, then fewer will be available to the longline hooks. If, however the main prey is fish or cephalopods then there will be greater chance of the yellowfin tuna spotting and taking a longline bait. Both of the other gear types rely on the tuna schooling on the surface.

Pole-and-line vessels usually target small school tuna which inhabit the surface layers and will depend upon the ability of the pole-and-liners to initiate a feeding frenzy using chum.

Purse seining needs not only the tuna schools to be on the surface but to be there long enough for the seine to be set. If, as has been observed in the Pemba Channel the tuna are feeding upon cephalopods, and the schools of prey and predator are making frequent and rapid vertical migrations the seiner will have difficulty in setting the net about the school. On the other hand, if they are feeding on *Charybdis smithii* the yellowfin tuna will be on the surface much longer and the depth of the school is likely to be much shallower. The large yellowfin tuna are normally available to the seiners during January-February in the Western Indian Ocean around the Seychelles, but during 1988 they were on the surface for much longer (January to August) with very high catches recorded. It was suggested that the reason for this might have been temperature-related (Marsac & Hallier, 1991), but it is unlikely that temperature alone would have kept the yellowfin tuna on the surface. It was more likely to have been a result of an abundant food supply, possibly crabs. For much of the year purse seiners target small school tuna, which remain in the surface layer and maintain their schooling behaviour as they do not feed on crabs. Food type is therefore not of major importance in the catchability of this category by purse seining.

6.5 Conclusions to Chapter 6

The food of yellowfin tuna from the Shimoni sport fishery was collected in two sets of samples: a largely qualitative study for four years from 1981/2 to 1983/4 and 1985/6, and a quantitative study using a range of scoring techniques over two years, 1986/87 and 1987/88.

The abundance of food in the diet varied considerably between and within fishing seasons. The numbers of yellowfin tuna in the Pemba Channel area appears to be determined by the food supply. During 1981/82, 1982/3, 1986/7 and 1987/8,

and to a lesser extent in 1983/4, judging from the diet, there was plentiful food with correspondingly high sport fishery catches of maturing and adult yellowfin tuna. But during 1985/6, food seemed to be in short supply and the larger size classes of yellowfin tuna did not remain in the Pemba Channel area.

The proportion of empty stomachs may be a useful indication of food availability. Throughout the study, there was greater incidence of empty stomachs in juvenile yellowfin tuna than in adults.

Not all types of fishery samples are valid for use in food studies. Capture methods that restrain the fish in a net for extended periods may cause regurgitation, and hence incomplete estimates of food consumption. Capture methods that rely on the use of chum ('ground bait') such as around payaos, may yield biased data, as the presence of large numbers of tuna may be the result of conditioning to constant supply of chum, rather than to natural food. Sport fisheries that do not employ chum may present a useful opportunity to sample the natural food of yellowfin tuna and other fishes. Regurgitation did occur in the sport fishery, but only when the stomach was distended with food, and in all cases the regurgitated food comprised the most recently eaten items.

Sport-fishery caught yellowfin tuna were almost always in a feeding mode: non-feeding fish were always juveniles. The best catches in the sport fishery occurred when the stomachs already contained substantial quantities of food.

The maximum degree of fullness observed was 4.0% and 3.8% of the mean gutted weight in 1986/7 and 1987/88 respectively. The mean volume of stomach contents in 1986/87 was 185.9 ± 16.4 ml (mean FL = 104.9 ± 1.6 cm) and 294.6±27.5 ml (mean FL =102.2±2.9 cm) in 1987/88.

Fish was the most important category of food for juvenile yellowfin tuna less than 57 cm FL. For yellowfin tuna of 57-87.5 cm FL, fish was the major food each year of the study except for 1985/86, when cephalopods dominated the diet. Of the larger yellowfin tuna, fish, cephalopods and crabs were all important in the diet depending on apparent availability. The small crustacea and prawns were of little importance volumetrically. In the Pemba Channel, fish and cephalopods were the most important foods during August, and crabs became of major significance in September and October, particularly during 1981 and 1982.

The range of prey sizes within the diet increased with size of yellowfin tuna. Although large tuna may take larger prey than do smaller ones, the same sizes of food items taken by smaller tuna may be found in the stomach contents of adults. The incidence of large prey items in the food was highest when there was reduced apparent availability of smaller foods.

My study supports the contention that yellowfin tuna are active opportunistic predators when the predominant foods are not crabs. In the Pemba Channel, when the swimming crab, *Charybidis smithii* is present in large numbers near the surface, yellowfin tuna evidently become selective feeders.

Observations in this sport fishery suggest that the behaviour of yellowfin tuna in terms of swimming speed, swimming depth, incidence of vertical migration and schooling, seems to depend upon the nature of the most abundant food source at the time. Yellow fin tuna , to be accessible to sport fishery gear, must be within the surface layers: the swimming crab increases their catchability . These observations suggest that the nature of the current food may play an important role in the catchability of yellowfin tuna by longline and by purse seines in commercial fisheries.

CHAPTER 7

The Value of Information from a Sport Fishery

This chapter examines the usefulness of a sport fishery in yielding biological data and in assessing the commercial fishery for yellowfin tuna in the Indian Ocean. I look at the major findings from each chapter in turn and finish with an evaluation of the contribution that sport fisheries might make, along with the conditions that would make this possible.

This thesis demonstrates how the sport fishery at Shimoni, Kenya, has been used to gather data useful for both biological and fisheries assessments of yellowfin tuna in the Indian Ocean. In Chapters 4 and 5 I show that the sport fishery catch data represents a more random sample by size, sex and age of yellowfin tuna than any of the three commercial fisheries. In angling the initiative is with the fish, and as yellowfin tuna of all sizes prefer smaller baits or lures (see Chapter 6), the gear is available to both small and large tuna. Moreover, the 1:1 sex ratio noted in Chapter 5 supports the random nature of the catch. Most other fishing methods are biased towards either small or large fish: longlines catch mainly large yellowfin tuna, while pole and line and purse seines target the smaller size-classes (Chapter 3). Commercial fisheries, such as longliners and purse seiners may have some advantages in being able to follow the yellowfin tuna migrations, whereas the sport fishery catch is taken from one area of the Western Indian Ocean through which the yellowfin tuna stock migrates regularly each year providing an opportunity to sample the stock at the same time each year over a number of years.

In Chapter 2, catch-per-unit effort, standardized numbers, and average weight of yellowfin tuna in the Shimoni-based sport fishery declined since 1984/85, corresponding with the start of large-scale purse seining in the Western Indian Ocean.

In Chapter 3, I used weight-frequencies of yellowfin tuna from the Shimoni sport fishery to estimate total instantaneous mortality, Z which was then used to

estimate MSY from the Csirke & Caddy (1983) method. The sport fishery data gave an estimated MSY of 113,000 tonnes for the Indian Ocean yellowfin tuna catch, which compared well with estimates from Walter's surplus production method for all gear types in the Western Indian Ocean yellowfin tuna fishery of 110-160,000 tonnes. Both these methods give more realistic values for MSY than conventional equilibrium MSY values that have been published, which are only 25-50% of the average catch over the past 10 years. Experience from the Pacific suggests that the true MSY is three to four times that estimated using longline data alone.

In Chapter 4, I used data from the Shimoni-based sport fishery for ageing and for estimating growth rates of yellowfin tuna. A conventional length-frequency analysis method, mixture analysis, was used to detect four age-classes. Due to the small sample sizes of some of the components the model was unable to converge with any confidence on the smallest and largest size-classes. However good fits were obtained for all but one out of seven years of samples. A novel type of ageing method using Principal Components Analysis (PCA) of morphometric measures identified up to six age-classes from sport fishery-caught yellowfin tuna. There was good agreement between the age-class component means for the two methods. A number of advantages were noted for using the PCA method over mixture analysis: age groups were clearly separated into clusters and more older ages were distinguished. Conventional length-frequency methods require large sample sizes, whereas a PCA performs well on sample sizes of 100-400 individuals easily obtained from a sport fishery. A PCA also clearly distinguished skipjack tuna from yellowfin tuna.

From the sport fishery data juvenile yellowfin tuna growth was estimated at 3.11±0.15 cm/month and this compares well with the 3.21±0.04 cm/month estimated by Wild (1986) from otoliths, assuming that yellowfin tuna growth follows the Gompertz equation rather than the classical von Bertalanffy model. My data yielded a slightly faster rate for maturing yellowfin tuna and a reduced rate of 1.98±0.08 cm/month for the older, mature yellowfin tuna.

In Chapter 5, I report how the sport fishery was used to collect biological data for a study of reproductive parameters. It was demonstrated that the sport fishery produced a more random sample than many commercial fisheries. An equal balance between males and females was noted, with all fish of less than 50 cm FL being of indeterminate sex. It is suggested that females begin sexual maturation

earlier than males, but males reach a state of sexual preparedness earlier. The 'spawning stock' is comprised of females greater than 120 cm FL and the 100-120 cm FL size-class makes up the 'virgin spawning stock'. The sport fishery also demonstrated that fish caught later in the season are likely to be sexually more advanced, and that past spawners will reach a state of sexual readiness earlier than first time spawners.

It was noted that the liver is only important in the early maturation of the ovary, but not of the testes. From the hepato-somatic index no connection between the liver and vitellogenesis was noted. A detailed histological study of sport fishery yellowfin tuna ovaries was made in 1987/88. Analysis of oocyte diameters showed clear polymodality in each stage of development.

In Chapter 6, a detailed study of the food of yellowfin tuna from the Shimoni sport fishery is described. Sport fisheries may present an effective means of collecting data for food studies as those gears that restrain the fish in a net may cause a high degree of regurgitation and those involving the use of chum are likely to be biased. My results show that yellowfin tuna are opportunistic predators and the nature of the food is dependent upon availability. The sport fishery data suggests that the yellowfin tuna abundance in an area is also dependent on the availability of an abundant food supply. The nature of the food and its abundance may affect the catchability of yellowfin tuna by gears other than sport fishing. It is suggested that if the main food item is the brown swimming crab, *Charybdis smithii*, a species that swarms on the surface at certain times of the year, the catchability of the yellowfin tuna by surface gears are likely to be increased. On the other hand if the main food is cephalopods, which congregate deeper, the catchability by these gears is likely to be reduced.

Periodicity was detected in the Shimoni catch-per-unit efforts of yellowfin tuna with a five year cycle (Chapter 2), and a similar cycle of six years was analysed in the historical longline catches of yellowfin tuna in the Indian Ocean (Chapter 3). Some other fishery data appears to have a similar cycle: a periodicity of four years was also detected between the total Kenyan fish catch with the annual rainfall

measured at Mombasa and between fish catch and river discharge from the Tana River (McClanahan, 1988). A four to five year oscillation in El Niño Southern Oscillation (ENSO) has also been detected using sea surface temperatures, wind and sea level pressure data from several areas in the Pacific (Rasmusson *et al.*, 1990). As yet we cannot assess the significance of this trend, but suggest that future research on Indian Ocean fisheries address this aspect.

Sport fisheries for top predators like yellowfin tuna provide an opportunity to sample large numbers of fish for population characteristics, such as growth, mortality, food, reproductive status. Although sport fishery cpue cannot be used directly, much of this information can provide valuable fisheries assessments. Tagging by recreational fishermen is the normal practice in many sport fisheries and on the increase in most others providing information on growth and migration. The tagging program in Kenya is co-ordinated by the African Billfish Foundation, which is affiliated to the International Billfish Foundation. In 1992 the African Billfish Foundation received the annual Conservation Award presented by the international body in recogntion of its tagging program. Moreover, where sport fishery operators have biological training this information can be obtained at very low cost compared to conventional biological research cruises, such as the R/V *Dr. Fridtjof Nansen.*

Recreational fisheries throughout the world contribute significantly to local tourism economics, as well as providing health benefits in a modern stressful society. This work provides an example of how biologically trained sport fishery operators could contribute to the conservation and management of fishery resources.

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APPENDIX A

Published Paper from FISHBYTE

Pitcher, T.J. and Hemphill, S.C. (1989) Stock assessment of Indian Ocean yellowfin tuna (*Thunnus albacares*) based on data from a sport fishery. *Fishbyte* 7(3): 15-17.

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APPENDIX B

Morphometric Measures of Sport Fishery-Caught Yellowfin Tuna as Described in Chapter 4

No.	(kg.) Wt.	(cm.) F.L.	(cm.) PG	(cm.) AG	(cm.) MG	(cm.) PF	(cm.) 2DF	(cm.) AF	(mm.) M	(mm.) E	(mm.) S-DF	(mm.) S2-DF	(mm.) S-AF	(mm.) S-VF	(mm.) HL	(mm.) S-E	(mm.) Y-T	(mm.) KW	SEX	Year
1	45.81	138.5	89.0	-	-	34.0	36.0	36.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
2	5.67	69.0	46.0	-	-	20.0	10.5	10.5	-	-	-	-	-	-	-	-	-	-	F	1981/2
3	25.86	114.0	74.0	-	-	33.0	23.0	26.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
4	49.78	140.0	84.0	-	-	38.0	41.0	44.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
5	56.93	142.0	100.0	-	-	35.0	57.0	61.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
6	43.89	135.0	98.0	-	-	36.0	36.0	40.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
7	38.90	122.0	88.0	-	-	38.0	36.0	39.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
8	39.69	127.0	82.0	-	-	33.0	39.0	42.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
9	23.70	109.0	74.0	-	-	34.0	23.0	23.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
10	24.04	110.0	74.0	-	-	32.0	22.0	23.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
11	40.60	132.0	86.0	-	-	35.0	37.0	39.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
12	32.09	124.0	84.0	-	-	32.0	27.0	41.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
13	23.13	114.0	76.0	-	-	33.0	25.0	26.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
14	25.40	115.0	74.0	-	-	31.0	23.0	22.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
15	23.70	110.0	74.0	-	-	31.0	22.0	23.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
16	60.33	149.0	98.0	-	-	34.0	45.0	58.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
17	27.22	115.0	76.0	-	-	33.0	23.0	24.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
18	27.44	119.0	76.0	-	-	34.0	25.0	26.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
19	24.15	113.0	74.0	-	-	35.0	20.0	24.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
20	27.33	112.0	81.0	-	-	36.0	24.0	25.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
21	24.83	112.0	76.0	-	-	32.0	26.0	28.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
22	25.40	113.0	80.0	-	-	35.0	20.0	21.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
23	23.81	111.0	72.0	-	-	33.0	22.0	24.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
24	5.22	65.0	46.0	-	-	23.0	9.0	10.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
25	4.76	62.0	45.0	-	-	19.0	8.0	8.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
26	2.67	48.0	34.0	-	-	16.0	5.0	5.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
27	1.93	46.0	33.0	-	-	14.0	4.0	5.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
28	2.67	48.0	34.0	-	-	15.0	4.0	4.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
29	5.22	64.0	46.0	-	-	20.0	8.0	9.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
30	5.44	65.0	47.0	-	-	20.0	9.0	9.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
31	4.76	63.0	45.0	-	-	17.0	8.0	9.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
32	51.60	142.0	98.0	-	-	36.0	45.0	54.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
33	37.42	128.0	92.0	-	-	33.0	34.0	34.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
34	43.77	134.0	95.0	-	-	36.0	40.0	41.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
35	46.15	133.0	94.0	-	-	32.0	32.0	40.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
36	29.71	118.0	84.0	-	-	32.0	25.0	28.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
37	27.56	113.0	80.0	-	-	32.0	22.0	24.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
38	28.24	114.0	78.0	-	-	34.0	23.0	27.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
39	24.15	112.0	78.0	-	-	30.0	22.0	22.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
40	37.54	129.0	86.0	-	-	34.0	25.0	35.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
41	5.10	63.0	50.0	-	-	20.0	9.0	9.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
42	5.56	67.0	50.0	-	-	19.0	8.0	9.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
43	5.56	67.0	48.0	-	-	19.0	9.0	10.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
44	5.10	68.0	48.0	-	-	20.0	9.0	9.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
45	5.10	65.5	48.0	-	-	19.0	9.0	8.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
46	5.10	68.0	48.0	-	-	21.0	9.0	9.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
47	5.10	65.0	48.0	-	-	20.0	9.0	9.5	-	-	-	-	-	-	-	-	-	-	M	1981/2
48	4.76	64.0	46.0	-	-	19.0	8.0	9.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
49	5.10	65.0	46.0	-	-	19.0	10.0	10.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
50	5.10	65.0	46.0	-	-	20.0	9.0	9.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
51	55.79	142.0	96.0	-	-	37.0	42.0	45.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
52	25.40	112.0	76.0	-	-	34.0	24.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
53	22.45	111.0	70.0	-	-	31.0	21.0	22.5	-	-	-	-	-	-	-	-	-	-	M	1981/2
54	47.85	137.0	86.0	-	-	35.0	29.0	34.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
55	23.24	118.0	80.0	-	-	33.0	24.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
56	26.42	113.0	80.0	-	-	33.0	21.0	27.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
57	72.35	159.0	110.0	-	-	40.0	61.0	70.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
58	51.94	143.0	94.0	-	-	36.0	46.0	44.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
59	25.40	113.0	72.0	-	-	33.0	23.0	24.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
60	49.90	140.0	95.0	-	-	36.0	31.0	37.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
61	43.21	138.0	92.0	-	-	38.0	39.0	42.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
62	29.26	117.0	82.0	-	-	32.0	23.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
63	42.87	134.0	90.0	-	-	36.0	37.0	40.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
64	63.50	148.0	102.0	-	-	44.0	48.0	55.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
65	21.89	109.0	74.0	-	-	32.0	24.0	26.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
66	21.32	103.0	73.0	-	-	31.0	23.0	24.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
67	21.32	105.0	73.0	-	-	31.0	19.0	20.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
68	50.80	143.0	96.0	-	-	35.0	39.0	-	-	-	-	-	-	-	-	-	-	-	F	1981/2
69	51.82	140.0	102.0	-	-	35.0	-	43.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
70	56.81	144.0	100.0	-	-	37.0	40.0	37.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
71	65.89	151.0	110.0	-	-	37.0	60.0	67.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
72	59.76	148.0	103.0	-	-	36.0	53.0	64.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
73	55.79	149.0	104.0	-	-	39.0	46.0	52.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
74	52.39	141.0	95.0	-	-	38.0	42.0	44.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
75	31.98	124.0	80.0	-	-	35.0	25.0	27.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
76	27.44	117.0	78.0	-	-	33.0	24.0	25.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
77	25.29	110.0	78.0	-	-	33.0	21.0	23.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
78	27.67	118.0	80.0	-	-	36.0	21.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
79	48.54	139.0	93.0	-	-	37.0	39.0	41.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
80	28.80	118.0	80.0	-	-	35.0	26.0	28.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
81	31.53	121.0	86.0	-	-	32.0	25.0	30.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
82	20.41	103.0	74.0	-	-	32.0	19.0	20.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
83	29.37	115.0	82.0	-	-	33.0	25.0	30.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
84	30.05	117.0	79.0	-	-	34.0	25.0	28.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
85	32.09	121.0	83.0	-	-	35.0	22.0	24.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
86	27.78	113.0	82.0	-	-	34.0	23.0	26.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
87	48.54	137.0	97.0	-	-	36.0	33.0	37.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
88	31.64	121.0	82.0	-	-	33.0	26.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
89	27.78	117.0	80.0	-	-	33.0	25.0	29.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
90	25.86	112.0	76.0	-	-	32.0	20.0	26.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
91	53.75	140.0	96.0	-	-	38.0	44.0	50.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
92	32.43	124.0	84.0	-	-	35.0	26.0	28.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
93	27.67	114.0	80.0	-	-	34.0	25.0	26.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
94	29.60	118.0	80.0	-	-	33.0	25.0	28.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
95	46.83	136.0	96.0	-	-	34.0	35.0	39.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
96	37.54	128.0	90.0	-	-	35.0	28.0	33.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
97	24.27	112.0	72.0	-	-	31.0	22.0	23.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
98	31.75	120.0	82.0	-	-	34.0	25.0	26.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
99	23.81	109.0	74.0	-	-	32.0	18.0	20.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
100	59.54	148.0	100.0	-	-	37.0	36.0	48.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
101	34.59	127.0	87.0	-	-	35.0	38.0	43.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
102	35.04	123.0	88.0	-	-	34.0	33.0	34.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
103	43.43	135.0	89.0	-	-	38.0	37.0	38.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
104	34.25	123.0	84.0	-	-	35.0	28.0	34.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
105	57.04	144.0	98.0	-	-	38.0	39.0	-	-	-	-	-	-	-	-	-	-	-	F	1981/2
106	34.02	123.0	84.0	-	-	30.0	35.0	32.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
107	28.58	119.0	84.0	-	-	34.0	25.0	27.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
108	30.28	119.0	83.0	-	-	35.0	25.0	27.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
109	30.96	119.0	81.0	-	-	33.0	26.0	27.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
110	30.73	118.0	81.0	-	-	36.0	25.0	28.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
111	71.10	157.0	110.0	-	-	35.0	61.0	65.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
112	33.79	122.0	84.0	-	-	36.0	35.0	38.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
113	30.05	115.0	83.0	-	-	33.0	25.0	32.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
114	45.93	136.0	91.0	-	-	32.0	38.0	44.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
115	2.49	50.0	34.0	-	-	15.0	6.0	6.0	-	-	-	-	-	-	-	-	-	-	F	1981/2

No.	(kg.) Wt.	(cm.) F.L.	(cm.) PG	(cm.) AG	(cm.) MG	(cm.) PF	(cm.) 2DF	(cm.) AF	(mm.) M	(mm.) E	(mm.) S-DF	(mm.) S2-DF	(mm.) S-AF	(mm.) S-VF	(mm.) HL	(mm.) S-E	(mm.) Y-T	(mm.) KW	SEX	Year
116	49.22	140.0	92.0	-	-	35.0	33.0	38.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
117	47.63	135.0	96.0	-	-	35.0	33.0	35.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
118	37.42	129.0	84.0	-	-	36.0	28.0	29.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
119	32.77	120.0	82.0	-	-	35.0	23.0	28.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
120	54.89	146.0	100.0	-	-	38.0	35.0	40.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
121	73.14	155.0	112.0	-	-	36.0	52.0	73.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
122	34.36	124.0	83.0	-	-	36.0	28.0	30.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
123	49.33	138.0	94.0	-	-	38.0	40.0	50.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
124	28.69	116.0	81.0	-	-	33.0	21.0	25.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
125	31.41	122.0	83.0	-	-	36.0	26.0	29.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
126	29.03	117.0	78.0	-	-	33.0	25.0	28.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
127	29.60	115.0	82.0	-	-	32.0	25.0	28.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
128	33.68	123.0	83.0	-	-	35.0	29.0	64.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
129	32.55	123.0	82.0	-	-	33.0	26.0	28.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
130	58.06	141.0	104.0	-	-	36.0	49.0	53.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
131	67.25	154.0	106.0	-	-	38.0	50.0	58.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
132	43.66	136.0	94.0	-	-	34.0	-	38.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
133	30.73	121.0	84.0	-	-	35.0	25.0	26.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
134	29.94	119.0	82.0	-	-	34.0	28.0	31.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
135	30.28	119.0	82.0	-	-	34.0	24.0	27.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
136	29.37	118.0	80.0	-	-	36.0	25.0	27.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
137	28.69	119.0	82.0	-	-	34.0	25.0	29.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
138	47.29	136.0	92.0	-	-	36.0	35.0	40.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
139	33.45	121.0	84.0	-	-	34.0	27.0	29.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
140	26.99	115.0	78.0	-	-	34.0	25.0	27.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
141	26.54	115.0	80.0	-	-	34.0	24.0	28.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
142	32.55	122.0	82.0	-	-	30.0	29.0	30.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
143	32.89	122.0	83.0	-	-	32.0	28.0	29.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
144	34.70	125.0	84.0	-	-	33.0	31.0	36.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
145	33.91	123.0	81.0	-	-	32.0	25.0	30.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
146	28.12	117.0	80.0	-	-	33.0	28.0	29.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
147	34.47	122.0	88.0	-	-	35.0	25.0	29.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
148	30.96	119.0	82.0	-	-	33.0	26.0	27.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
149	2.15	49.0	33.0	-	-	14.0	5.0	5.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
150	2.04	47.0	34.0	-	-	13.0	5.0	5.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
151	30.05	122.0	82.0	-	-	34.0	28.0	28.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
152	32.55	118.0	84.0	-	-	34.0	26.0	30.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
153	35.04	129.0	88.0	-	-	35.0	24.0	27.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
154	52.84	142.0	100.0	-	-	35.0	41.0	44.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
155	31.98	118.0	88.0	-	-	35.0	25.0	29.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
156	31.19	117.0	82.0	-	-	33.0	22.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
157	29.82	117.0	82.0	-	-	33.0	25.0	27.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
158	27.56	114.0	79.0	-	-	34.0	26.0	33.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
159	24.95	115.0	75.0	-	-	31.0	25.0	28.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
160	53.18	140.0	98.0	-	-	37.0	38.0	46.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
161	6.12	69.0	49.0	-	-	20.0	10.0	11.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
162	32.89	122.0	86.0	-	-	35.0	30.0	28.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
163	27.33	115.0	80.0	-	-	33.0	26.0	29.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
164	31.53	119.0	81.0	-	-	33.0	30.0	33.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
165	33.79	120.0	83.0	-	-	36.0	30.0	30.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
166	31.19	120.0	80.0	-	-	30.0	25.0	28.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
167	31.41	120.0	82.0	-	-	34.0	24.0	27.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
168	2.61	49.0	34.0	-	-	-	5.5	5.5	-	-	-	-	-	-	-	-	-	-	M	1981/2
169	38.22	126.0	87.0	-	-	38.0	27.0	28.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
170	39.01	127.0	87.0	-	-	34.0	38.0	44.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
171	47.51	139.0	92.0	-	-	35.0	37.0	44.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
172	29.37	117.5	82.0	-	-	32.0	25.0	26.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
173	32.32	125.0	82.0	-	-	34.0	24.0	27.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
174	32.43	117.0	83.0	-	-	32.0	27.0	29.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
175	29.14	117.0	80.0	-	-	33.0	26.0	27.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
176	29.48	119.0	84.0	-	-	32.0	23.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
177	38.56	127.0	90.0	-	-	34.0	23.0	24.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
178	30.05	118.0	80.0	-	-	34.0	28.0	30.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
179	31.75	120.0	82.0	-	-	33.0	26.0	28.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
180	29.71	119.0	82.0	-	-	33.0	27.0	26.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
181	2.15	49.0	34.0	-	-	12.0	5.0	5.5	-	-	-	-	-	-	-	-	-	-	F	1981/2
182	2.15	48.0	36.0	-	-	14.0	6.0	7.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
183	6.92	72.5	50.0	-	-	22.0	10.0	11.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
184	6.69	71.0	48.0	-	-	21.0	10.0	10.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
185	2.61	51.0	37.0	-	-	15.0	6.0	6.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
186	5.90	69.0	50.0	-	-	20.0	10.0	10.5	-	-	-	-	-	-	-	-	-	-	M	1981/2
187	6.35	71.0	50.0	-	-	19.0	10.0	11.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
188	5.90	69.0	50.0	-	-	19.0	9.0	10.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
189	5.67	69.0	48.0	-	-	19.0	9.0	10.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
190	8.73	79.0	56.0	-	-	23.0	11.0	11.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
191	5.90	69.0	46.0	-	-	20.0	8.0	9.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
192	6.92	73.0	50.0	-	-	22.0	10.0	12.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
193	5.78	68.0	48.0	-	-	21.0	10.0	11.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
194	6.01	68.0	49.0	-	-	21.0	9.0	10.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
195	2.49	50.0	36.0	-	-	15.0	6.0	5.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
196	5.90	69.5	49.0	-	-	21.0	10.0	10.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
197	6.35	70.0	48.0	-	-	22.0	10.0	11.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
198	5.90	69.5	47.0	-	-	21.0	9.0	10.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
199	6.35	71.0	50.0	-	-	21.0	11.0	11.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
200	7.14	74.0	50.0	-	-	23.0	11.0	11.0	-	-	-	-	-	-	-	-	-	-	F	1981/2
201	6.01	70.0	48.0	-	-	21.0	10.0	10.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
202	5.56	70.0	46.0	-	-	22.0	10.0	10.0	-	-	-	-	-	-	-	-	-	-	M	1981/2
203	4.54	62.0	40.0	38.0	39.0	-	8.0	8.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
204	4.20	60.0	42.0	34.0	38.0	-	8.0	7.5	-	-	-	-	-	-	-	-	-	-	F	1982/3
205	3.97	58.0	40.0	32.0	36.0	-	9.0	8.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
206	4.65	63.0	42.0	36.0	39.0	-	8.0	8.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
207	23.59	108.0	74.0	68.0	71.0	-	22.0	24.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
208	23.93	112.0	74.0	70.0	72.0	-	24.0	26.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
209	23.25	108.0	74.0	68.0	71.0	-	22.0	23.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
210	21.89	105.0	74.0	70.0	72.0	-	-	21.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
211	17.69	97.0	68.0	64.0	66.0	-	19.0	21.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
212	19.85	100.0	72.0	64.0	68.0	-	17.0	19.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
213	21.21	104.0	70.0	64.0	67.0	-	21.0	22.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
214	21.77	107.0	72.0	66.0	69.0	-	21.0	24.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
215	24.15	111.0	74.0	68.0	71.0	-	20.0	20.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
216	22.79	107.0	70.0	68.0	69.0	-	-	23.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
217	23.13	108.0	74.0	66.0	70.0	-	22.0	22.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
218	26.20	110.0	76.0	74.0	75.0	-	21.0	22.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
219	25.06	110.0	75.0	70.0	72.5	-	23.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
220	42.18	135.0	92.0	84.0	88.0	-	33.0	36.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
221	24.72	111.0	76.0	72.0	74.0	-	19.0	23.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
222	24.49	108.0	74.0	70.0	72.0	-	23.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
223	22.45	108.0	74.0	68.0	71.0	-	24.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
224	23.02	108.0	72.0	70.0	71.0	-	20.0	24.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
225	23.93	109.0	72.0	66.0	69.0	-	24.0	27.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
226	24.27	112.0	77.0	68.0	72.5	-	21.0	24.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
227	21.21	104.5	72.0	66.0	69.0	-	29.0	25.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
228	23.70	109.0	72.0	70.0	71.0	-	23.0	24.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
229	27.22	114.0	76.0	70.0	73.0	-	23.0	25.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
230	23.25	108.0	75.0	68.0	71.5	-	21.0	24.0	-	-	-	-	-	-	-	-	-	-	F	1982/3

No.	(kg.) Wt.	(cm.) F.L.	(cm.) PG	(cm.) AG	(cm.) MG	(cm.) PF	(cm.) 2DF	(cm.) AF	(mm.) M	(mm.) E	(mm.) S-DF	(mm.) S2-DF	(mm.) S-AF	(mm.) S-VF	(mm.) HL	(mm.) S-E	(mm.) Y-T	(mm.) KW	SEX	Year
231	25.52	113.0	78.0	70.0	74.0	-	22.0	24.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
232	22.23	107.0	74.0	70.0	72.0	-	22.0	24.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
233	26.65	115.0	78.0	72.0	75.0	-	23.0	23.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
234	1.81	46.0	32.0	29.0	30.5	-	5.0	5.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
235	1.59	44.0	30.0	28.0	29.0	-	4.0	4.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
236	47.63	139.0	92.0	89.0	90.5	-	37.0	41.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
237	21.32	107.0	74.0	68.0	71.0	-	22.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
238	22.34	108.0	74.0	68.0	71.0	-	20.0	21.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
239	21.77	107.0	74.0	68.0	71.0	-	22.0	23.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
240	21.89	105.0	72.0	67.0	69.5	-	20.0	23.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
241	41.73	132.0	89.0	86.0	87.5	-	37.0	41.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
242	22.23	109.0	74.0	67.0	70.5	-	23.0	24.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
243	25.52	110.0	77.0	70.0	73.5	-	24.0	26.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
244	26.42	113.0	78.0	70.0	74.0	-	26.0	30.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
245	22.68	108.0	76.0	68.0	72.0	-	23.0	24.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
246	21.43	107.0	74.0	65.0	69.5	-	22.0	23.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
247	25.52	113.0	79.0	72.0	75.5	-	22.0	24.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
248	27.33	117.0	78.0	72.0	75.0	-	24.0	26.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
249	23.59	108.0	75.0	70.0	72.5	-	23.0	26.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
250	23.02	110.0	75.0	70.0	72.5	-	24.0	25.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
251	23.59	109.0	74.0	71.0	72.5	-	22.0	24.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
252	28.35	117.0	80.0	74.0	77.0	-	21.0	23.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
253	22.34	116.0	77.0	-	-	-	20.0	25.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
254	36.74	131.0	84.0	80.0	82.0	-	34.0	38.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
255	26.76	117.0	80.0	72.0	76.0	-	22.0	25.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
256	24.15	112.0	74.0	69.0	71.5	-	23.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
257	24.38	112.0	73.0	69.0	71.0	-	22.0	24.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
258	24.95	116.0	77.0	74.0	75.5	-	20.0	26.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
259	4.76	64.0	44.0	41.0	42.5	-	9.0	8.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
260	4.76	65.0	44.0	40.0	42.0	-	8.0	8.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
261	4.76	63.5	45.0	39.0	42.0	-	8.0	8.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
262	25.17	115.0	76.0	70.0	73.0	-	21.0	23.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
263	39.58	127.5	92.0	84.0	88.0	-	36.0	38.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
264	4.99	65.0	44.0	38.0	41.0	-	8.0	8.5	-	-	-	-	-	-	-	-	-	-	M	1982/3
265	4.88	65.0	44.0	38.0	41.0	-	8.5	9.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
266	4.54	63.5	45.0	38.0	41.5	-	8.0	7.5	-	-	-	-	-	-	-	-	-	-	M	1982/3
267	2.15	48.0	34.0	30.0	32.0	-	5.0	5.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
268	1.81	45.5	32.0	28.0	30.0	-	4.5	5.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
269	1.93	45.5	32.0	29.0	30.5	-	4.5	4.5	-	-	-	-	-	-	-	-	-	-	M	1982/3
270	23.25	107.0	74.0	68.0	71.0	-	20.0	21.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
271	25.86	116.0	77.0	72.0	74.5	-	25.0	28.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
272	24.61	113.0	76.0	70.0	73.0	-	22.5	25.5	-	-	-	-	-	-	-	-	-	-	F	1982/3
273	5.56	69.0	47.0	42.0	44.5	-	9.0	9.5	-	-	-	-	-	-	-	-	-	-	F	1982/3
274	21.32	107.5	73.0	66.0	69.5	-	21.0	21.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
275	4.42	62.0	43.0	38.0	40.5	-	8.5	8.5	-	-	-	-	-	-	-	-	-	-	F	1982/3
276	5.10	65.0	45.0	42.0	43.5	-	8.5	9.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
277	4.88	63.5	44.0	40.0	42.0	-	8.0	9.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
278	4.99	65.0	46.0	41.0	43.5	-	9.0	9.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
279	4.88	63.5	44.0	40.0	42.0	-	8.0	9.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
280	44.45	137.0	88.0	88.0	88.0	-	49.0	52.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
281	26.42	113.0	77.0	75.0	76.0	-	26.0	28.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
282	24.49	116.0	77.0	68.0	72.5	-	21.0	21.5	-	-	-	-	-	-	-	-	-	-	M	1982/3
283	26.31	117.0	76.0	72.0	74.0	-	24.0	24.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
284	18.94	101.5	70.0	66.0	68.0	-	18.0	19.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
285	21.77	107.0	72.0	66.0	69.0	-	23.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
286	19.28	104.5	70.0	64.0	67.0	-	22.0	24.5	-	-	-	-	-	-	-	-	-	-	F	1982/3
287	5.22	66.0	46.0	40.0	43.0	-	8.0	8.5	-	-	-	-	-	-	-	-	-	-	M	1982/3
288	48.53	138.0	94.0	88.0	91.0	-	-	47.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
289	45.13	131.0	92.0	86.0	89.0	-	-	34.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
290	22.91	107.0	75.0	68.0	71.5	-	23.0	25.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
291	24.27	110.0	76.0	68.0	72.0	-	23.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
292	19.73	106.0	73.0	65.0	69.0	-	20.0	22.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
293	22.23	108.0	74.0	71.0	72.5	-	24.0	25.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
294	24.49	113.0	76.0	69.0	72.5	-	25.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
295	45.81	136.0	90.0	87.0	88.5	-	34.0	39.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
296	5.67	68.0	46.0	42.0	44.0	-	9.5	9.5	-	-	-	-	-	-	-	-	-	-	M	1982/3
297	5.67	67.0	47.0	42.0	44.5	-	9.5	9.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
298	8.96	79.0	55.0	48.0	51.5	-	13.0	15.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
299	25.06	111.0	76.0	73.0	74.5	-	21.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
300	20.53	107.0	72.0	64.0	68.0	-	20.0	24.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
301	40.60	136.0	88.0	83.0	85.5	-	37.0	42.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
302	45.47	137.0	93.0	87.0	90.0	-	33.0	36.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
303	46.95	139.0	94.0	89.0	91.5	-	35.0	40.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
304	21.55	106.0	73.0	68.0	70.5	-	21.0	24.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
305	26.99	115.0	78.0	74.0	76.0	-	23.5	25.5	-	-	-	-	-	-	-	-	-	-	M	1982/3
306	59.31	146.0	102.0	96.0	99.0	-	50.0	59.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
307	41.50	130.0	90.0	86.0	88.0	-	33.0	42.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
308	31.30	121.5	83.0	76.0	79.5	-	27.0	29.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
309	17.80	101.0	67.0	60.0	63.5	-	21.0	22.5	-	-	-	-	-	-	-	-	-	-	F	1982/3
310	19.50	106.0	74.0	66.0	70.0	-	21.0	23.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
311	22.91	106.0	74.0	68.0	71.0	-	20.0	20.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
312	26.88	115.5	78.0	70.0	74.0	-	27.0	28.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
313	24.27	113.0	77.0	68.0	72.5	-	24.0	24.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
314	24.04	110.0	76.0	68.0	72.0	-	20.5	21.5	-	-	-	-	-	-	-	-	-	-	F	1982/3
315	24.49	111.0	73.0	67.0	70.0	-	21.0	26.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
316	24.38	109.0	75.0	70.0	72.5	-	19.0	21.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
317	23.25	110.0	75.0	70.0	72.5	-	21.0	-	-	-	-	-	-	-	-	-	-	-	F	1982/3
318	23.70	112.0	75.0	69.0	72.0	-	22.0	26.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
319	45.36	135.0	90.0	87.0	88.5	-	35.0	44.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
320	45.59	135.0	92.0	88.0	90.0	-	34.0	39.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
321	55.45	142.0	100.0	96.0	98.0	-	33.0	38.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
322	42.87	134.0	92.0	86.0	89.0	-	33.0	23.5	-	-	-	-	-	-	-	-	-	-	F	1982/3
323	46.38	137.0	94.0	87.0	90.5	-	38.0	40.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
324	23.47	110.0	74.0	70.0	72.0	-	23.0	30.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
325	29.03	116.0	80.0	74.0	77.0	-	32.0	35.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
326	48.08	136.0	96.0	87.0	91.5	-	37.0	41.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
327	44.91	138.0	91.0	86.0	88.5	-	37.0	42.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
328	42.98	134.0	91.0	94.0	87.5	-	39.0	43.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
329	42.87	133.5	92.0	86.0	89.0	-	35.0	43.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
330	25.74	114.0	75.0	72.0	73.5	-	22.0	23.5	-	-	-	-	-	-	-	-	-	-	M	1982/3
331	46.61	140.0	92.0	88.0	90.0	-	41.0	46.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
332	50.80	145.0	96.0	88.0	92.0	-	37.0	45.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
333	47.97	139.0	95.0	83.0	91.5	-	39.0	42.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
334	51.03	147.0	99.0	90.0	94.5	-	37.0	-	-	-	-	-	-	-	-	-	-	-	M	1982/3
335	58.74	147.0	102.0	96.0	99.0	-	42.0	49.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
336	56.59	143.0	102.0	94.0	98.0	-	41.0	52.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
337	59.54	150.0	102.0	96.0	99.0	-	47.0	55.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
338	49.90	145.0	94.0	90.0	92.0	-	36.0	39.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
339	48.08	141.0	94.0	90.0	92.0	-	40.0	43.5	-	-	-	-	-	-	-	-	-	-	M	1982/3
340	38.56	132.0	86.0	82.0	84.0	-	34.0	39.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
341	52.16	142.0	95.0	95.0	95.0	-	47.0	54.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
342	60.33	148.0	104.0	97.0	100.5	-	-	48.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
343	49.22	141.0	96.0	89.0	92.5	-	40.0	36.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
344	43.09	131.0	87.0	86.0	86.5	-	30.0	40.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
345	26.08	114.0	78.0	70.0	74.0	-	24.0	26.0	-	-	-	-	-	-	-	-	-	-	M	1982/3

No.	(kg.) Wt.	(cm.) F.L.	(cm.) PG	(cm.) AG	(cm.) MG	(cm.) PF	(cm.) 2DF	(cm.) AF	(mm.) M	(mm.) E	(mm.) S-DF	(mm.) S2-DF	(mm.) S-AF	(mm.) S-VF	(mm.) HL	(mm.) S-E	(mm.) Y-T	(mm.) KW	SEX	Year
346	29.14	116.0	82.0	74.0	78.0	-	26.0	27.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
347	49.33	138.0	95.0	93.0	94.0	-	42.0	45.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
348	27.44	115.0	78.0	75.0	76.5	-	26.0	31.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
349	31.30	121.0	82.0	76.0	79.0	-	27.0	30.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
350	26.42	112.5	78.0	70.0	74.0	-	22.0	27.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
351	4.65	62.5	43.0	39.0	41.0	-	8.0	8.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
352	45.93	135.0	93.0	89.0	91.0	-	36.0	41.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
353	45.59	133.0	92.0	89.0	90.5	-	36.0	39.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
354	22.91	109.0	74.0	70.0	72.0	-	25.0	26.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
355	5.56	65.5	44.0	42.0	43.0	-	9.0	9.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
356	4.99	60.5	45.0	41.0	43.0	-	8.0	8.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
357	5.44	65.0	46.0	43.0	44.5	-	9.0	9.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
358	5.44	65.5	47.0	42.0	44.5	-	8.0	8.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
359	5.22	64.0	47.0	40.0	43.5	-	7.0	7.5	-	-	-	-	-	-	-	-	-	-	F	1982/3
360	5.10	63.0	45.0	40.0	42.5	-	8.0	7.5	-	-	-	-	-	-	-	-	-	-	M	1982/3
361	52.73	142.0	95.0	95.0	95.0	-	41.0	45.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
362	51.71	142.0	100.0	90.0	95.0	-	34.0	48.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
363	45.81	134.0	93.0	90.0	91.5	-	34.0	41.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
364	46.15	136.0	94.0	90.0	92.0	-	37.0	43.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
365	26.20	113.0	78.0	74.0	76.0	-	29.0	32.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
366	69.35	154.0	109.0	102.0	105.5	-	53.0	43.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
367	50.69	143.0	98.0	90.0	94.0	-	43.0	43.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
368	48.42	140.0	95.0	90.0	92.5	-	50.0	54.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
369	48.20	141.0	94.0	94.0	94.0	-	40.0	42.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
370	41.84	132.0	88.0	86.0	87.0	-	29.0	36.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
371	51.60	138.0	99.0	92.0	95.5	-	40.0	43.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
372	54.54	143.0	100.0	93.0	96.5	-	48.0	49.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
373	50.12	141.0	95.0	93.0	94.0	-	35.0	39.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
374	46.95	137.0	94.0	88.0	91.0	-	37.0	40.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
375	61.24	151.0	101.0	98.0	99.5	-	54.0	43.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
376	47.51	140.0	94.0	89.0	91.5	-	40.0	41.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
377	46.49	137.0	93.0	90.0	91.5	-	39.0	44.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
378	48.08	139.0	96.0	92.0	94.0	-	38.0	44.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
379	42.53	134.0	92.0	87.0	89.5	-	37.0	43.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
380	76.32	162.0	116.0	104.0	110.0	-	65.0	52.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
381	53.98	141.0	100.0	96.0	98.0	-	49.0	51.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
382	34.70	125.5	84.0	82.0	83.0	-	27.0	31.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
383	48.76	145.0	95.0	89.0	92.0	-	40.0	31.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
384	45.02	135.0	92.0	90.0	91.0	-	39.0	42.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
385	43.32	134.0	92.0	91.0	91.5	-	36.0	27.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
386	52.62	143.0	99.0	97.0	98.0	-	40.0	42.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
387	41.73	133.0	100.0	88.0	94.0	-	31.0	39.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
388	45.25	133.0	92.0	92.0	92.0	-	37.0	40.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
389	51.71	143.0	95.0	99.0	97.0	-	38.0	42.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
390	58.51	147.0	102.0	96.0	99.0	-	40.0	47.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
391	43.09	134.0	92.0	91.0	91.5	-	39.0	41.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
392	42.64	135.0	94.0	90.0	92.0	-	34.0	36.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
393	43.55	134.0	94.0	92.0	93.0	-	37.0	32.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
394	54.77	145.0	97.0	99.0	98.0	-	43.0	46.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
395	45.47	133.0	94.0	91.0	92.5	-	38.0	43.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
396	53.75	144.0	100.0	96.0	98.0	-	35.0	41.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
397	48.76	140.0	95.0	95.0	95.0	-	37.0	40.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
398	47.97	137.0	96.0	92.0	94.0	-	38.0	42.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
399	55.91	148.0	102.0	100.0	101.0	-	48.0	60.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
400	55.45	142.0	99.0	97.0	98.0	-	43.0	49.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
401	50.46	144.0	100.0	90.0	95.0	-	39.0	43.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
402	31.53	124.0	83.0	76.0	79.5	-	26.0	32.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
403	46.38	139.0	92.0	86.0	89.0	-	38.0	43.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
404	40.37	132.0	90.0	84.0	87.0	-	34.0	37.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
405	2.15	47.5	34.0	30.0	32.0	-	5.0	5.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
406	56.93	141.0	100.0	96.0	98.0	-	41.0	52.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
407	45.81	137.0	94.0	88.0	91.0	-	36.0	40.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
408	73.82	161.0	111.0	104.0	107.5	-	64.0	72.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
409	47.97	144.0	94.0	88.0	91.0	-	40.0	43.5	-	-	-	-	-	-	-	-	-	-	F	1982/3
410	32.21	121.0	84.0	80.0	82.0	-	25.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
411	31.75	121.0	84.0	76.0	80.0	-	26.0	28.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
412	28.58	118.0	80.0	75.0	77.5	-	24.0	27.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
413	28.01	117.0	80.0	74.0	77.0	-	26.0	26.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
414	32.77	122.0	84.0	76.0	80.0	-	26.5	29.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
415	61.46	151.0	104.0	96.0	100.0	-	63.0	69.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
416	45.47	135.0	94.0	86.0	90.0	-	32.0	38.5	-	-	-	-	-	-	-	-	-	-	F	1982/3
417	60.78	148.0	104.0	96.0	100.0	-	48.0	51.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
418	27.90	115.0	81.0	76.0	78.5	-	26.0	29.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
419	46.83	134.0	94.0	92.0	93.0	-	31.0	37.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
420	29.37	114.0	84.0	79.0	81.5	-	27.0	29.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
421	50.69	138.0	94.0	94.0	94.0	-	36.0	42.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
422	28.12	116.0	78.0	76.0	77.0	-	25.0	28.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
423	30.16	117.0	79.0	77.0	78.0	-	28.0	31.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
424	69.06	155.0	108.0	105.0	106.5	-	44.0	67.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
425	2.61	50.0	35.0	32.0	33.5	-	5.0	5.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
426	2.61	51.0	35.0	34.0	34.5	-	5.0	5.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
427	50.58	141.0	96.0	94.0	95.0	-	38.0	-	-	-	-	-	-	-	-	-	-	-	M	1982/3
428	62.60	144.0	104.0	104.0	104.0	-	40.0	51.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
429	51.48	138.0	95.0	92.0	93.5	-	48.0	53.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
430	55.34	148.0	100.0	94.0	97.0	-	46.0	46.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
431	49.10	136.0	93.0	94.0	93.5	-	38.0	41.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
432	55.00	140.0	96.0	98.0	97.0	-	43.0	48.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
433	42.30	134.0	91.0	85.0	88.0	-	27.0	36.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
434	26.42	115.0	79.0	73.0	76.0	-	21.0	25.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
435	27.44	114.0	78.0	76.0	77.0	-	21.0	24.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
436	25.17	112.0	76.0	74.0	75.0	-	23.0	28.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
437	31.30	118.0	84.0	82.0	83.0	-	23.0	27.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
438	28.69	113.0	80.0	77.0	78.5	-	25.0	23.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
439	26.20	115.0	79.0	74.0	76.5	-	27.0	28.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
440	51.14	146.0	95.0	93.0	94.0	-	40.0	44.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
441	41.73	129.0	91.0	88.0	89.5	-	35.0	43.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
442	39.69	132.0	89.0	84.0	86.5	-	35.0	41.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
443	62.26	149.0	103.0	100.0	101.5	-	36.0	63.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
444	68.61	154.0	105.0	104.0	104.5	-	53.0	61.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
445	68.95	153.0	107.0	103.0	105.0	-	46.0	51.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
446	31.53	120.0	83.0	78.0	80.5	-	23.0	25.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
447	30.73	121.0	82.0	81.0	81.5	-	-	26.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
448	56.13	146.0	100.0	94.0	97.0	-	39.0	46.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
449	26.00	116.0	78.0	72.0	75.0	-	23.5	27.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
450	21.55	107.0	72.0	67.0	69.5	-	19.0	21.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
451	9.19	81.0	56.0	50.0	53.0	-	13.0	14.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
452	6.12	70.0	48.0	46.0	47.0	-	8.0	9.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
453	6.12	69.0	49.0	45.0	47.0	-	9.0	9.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
454	8.28	77.0	54.0	50.0	52.0	-	12.0	13.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
455	7.14	73.0	51.0	48.0	49.5	-	10.0	12.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
456	5.78	68.0	47.0	44.0	45.5	-	9.5	9.5	-	-	-	-	-	-	-	-	-	-	F	1982/3
457	3.40	56.0	39.0	35.0	37.0	-	6.5	6.5	-	-	-	-	-	-	-	-	-	-	M	1982/3
458	70.88	151.0	108.0	108.0	108.0	-	55.0	63.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
459	52.84	140.0	99.0	92.0	95.5	-	40.0	44.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
460	60.44	145.0	102.0	96.0	99.0	-	44.0	57.0	-	-	-	-	-	-	-	-	-	-	F	1982/3

No.	(kg.) Wt.	(cm.) F.L.	(cm.) PG	(cm.) AG	(cm.) MG	(cm.) PF	(cm.) 2DF	(cm.) AF	(mm.) M	(mm.) E	(mm.) S-DF	(mm.) S2-DF	(mm.) S-AF	(mm.) S-VF	(mm.) HL	(mm.) S-E	(mm.) Y-T	(mm.) KW	SEX	Year
461	43.32	137.0	92.0	84.0	88.0	-	36.0	42.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
462	39.24	125.0	88.0	84.0	86.0	-	35.0	36.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
463	30.05	120.0	82.0	74.0	78.0	-	25.5	27.5	-	-	-	-	-	-	-	-	-	-	F	1982/3
464	44.57	128.0	93.0	91.0	92.0	-	34.0	37.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
465	44.00	133.0	91.0	91.0	91.0	-	36.0	34.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
466	48.54	136.0	94.0	93.0	93.5	-	39.0	44.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
467	30.84	118.0	83.0	80.0	81.5	-	33.0	37.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
468	5.90	68.0	46.0	44.0	45.0	-	9.0	9.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
469	44.91	138.0	93.0	91.0	92.0	-	28.0	37.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
470	22.34	109.0	74.0	73.0	73.5	-	22.0	28.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
471	26.31	114.0	79.0	74.0	76.5	-	22.0	26.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
472	56.59	142.0	100.0	97.0	98.5	-	42.0	45.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
473	26.76	113.0	78.0	76.0	77.0	-	25.0	29.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
474	29.03	116.0	82.0	80.0	81.0	-	24.0	26.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
475	23.25	109.0	74.0	68.0	71.0	-	27.0	29.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
476	56.59	143.0	100.0	100.0	100.0	-	36.0	54.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
477	24.04	109.0	75.0	73.0	74.0	-	23.0	24.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
478	26.65	113.0	78.0	74.0	76.0	-	26.0	28.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
479	27.67	113.0	78.0	75.0	76.5	-	22.0	25.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
480	62.71	151.0	105.0	102.0	103.5	-	61.0	63.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
481	32.43	117.0	82.0	81.0	81.5	-	26.0	30.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
482	35.27	122.0	86.0	83.0	84.5	-	27.0	30.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
483	29.14	118.0	80.0	77.0	78.5	-	27.0	29.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
484	2.38	49.0	33.0	34.0	33.5	-	5.5	6.5	-	-	-	-	-	-	-	-	-	-	M	1982/3
485	22.68	106.0	76.0	70.0	73.0	-	22.0	25.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
486	30.62	118.0	80.0	77.0	78.5	-	29.0	30.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
487	28.92	116.0	81.0	76.0	78.5	-	28.0	28.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
488	55.79	140.0	103.0	94.0	98.5	-	36.0	37.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
489	29.26	116.0	82.0	74.0	78.0	-	25.5	27.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
490	2.49	50.0	36.0	32.0	34.0	-	5.0	4.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
491	1.81	47.0	32.0	28.0	30.0	-	4.0	4.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
492	26.76	112.0	81.0	76.0	78.5	-	24.0	26.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
493	27.22	113.0	79.0	78.0	78.5	-	25.0	27.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
494	6.01	66.0	48.0	45.0	46.5	-	8.5	9.5	-	-	-	-	-	-	-	-	-	-	F	1982/3
495	6.01	67.0	48.0	47.0	47.5	-	9.0	9.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
496	2.72	53.0	35.0	34.0	34.5	-	6.0	6.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
497	2.27	48.5	33.0	31.0	32.0	-	6.0	5.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
498	6.12	69.5	46.0	44.0	45.0	-	9.0	10.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
499	2.38	48.0	35.0	34.0	34.5	-	5.5	5.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
500	2.27	46.5	34.0	32.0	33.0	-	5.0	5.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
501	2.27	50.0	34.0	31.0	32.5	-	5.5	5.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
502	33.11	120.0	82.0	81.0	81.5	-	29.0	31.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
503	24.95	111.0	77.0	73.0	75.0	-	23.0	25.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
504	28.69	116.0	79.0	75.0	77.0	-	28.0	29.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
505	32.89	122.0	83.0	82.0	82.5	-	26.0	29.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
506	30.16	119.0	81.0	79.0	80.0	-	26.0	30.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
507	28.80	118.0	82.0	73.0	77.5	-	25.0	29.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
508	29.14	119.0	82.0	74.0	78.0	-	22.0	26.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
509	28.48	116.0	82.0	74.0	78.0	-	23.5	24.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
510	28.80	115.0	81.0	74.0	77.5	-	26.0	27.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
511	26.08	113.0	77.0	70.0	73.5	-	24.0	25.5	-	-	-	-	-	-	-	-	-	-	F	1982/3
512	26.20	113.0	79.0	71.0	75.0	-	25.0	27.5	-	-	-	-	-	-	-	-	-	-	M	1982/3
513	63.04	146.0	105.0	102.0	103.5	-	50.0	56.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
514	21.55	104.0	72.0	71.0	71.5	-	21.0	22.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
515	43.66	137.0	93.0	84.0	88.5	-	-	42.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
516	49.90	140.0	96.0	89.0	92.5	-	39.0	43.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
517	1.93	48.0	32.0	29.0	30.5	-	5.0	5.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
518	25.74	114.0	79.0	70.0	74.5	-	26.0	27.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
519	65.55	147.0	102.0	102.0	102.0	-	53.0	55.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
520	70.76	153.0	112.0	106.0	109.0	-	66.0	66.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
521	49.67	137.0	97.0	95.0	96.0	-	38.0	39.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
522	43.43	131.0	90.0	88.0	89.0	-	37.0	42.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
523	49.33	134.0	95.0	94.0	94.5	-	43.0	46.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
524	1.93	46.5	31.5	28.5	30.0	-	5.0	5.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
525	2.27	49.0	33.0	31.5	32.3	-	5.0	5.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
526	6.35	71.5	49.0	43.0	46.0	-	9.0	10.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
527	44.91	135.0	94.0	86.0	90.0	-	43.0	49.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
528	45.13	135.0	91.0	86.0	88.5	-	31.0	38.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
529	4.42	62.0	43.0	38.0	40.5	-	8.0	8.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
530	2.04	47.5	34.0	36.0	35.0	-	5.0	5.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
531	1.93	48.5	32.0	28.0	30.0	-	5.0	5.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
532	1.81	45.5	32.0	29.0	30.5	-	5.0	5.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
533	6.58	72.0	48.0	45.0	46.5	-	10.0	10.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
534	5.33	67.0	45.0	40.0	42.5	-	9.0	9.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
535	3.29	57.0	37.0	35.0	36.0	-	7.0	7.5	-	-	-	-	-	-	-	-	-	-	M	1982/3
536	23.36	110.0	74.0	69.0	71.5	-	22.0	27.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
537	4.99	65.5	44.0	40.0	42.0	-	9.0	9.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
538	11.45	87.5	59.0	54.0	56.5	-	16.0	17.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
539	1.93	47.0	32.0	29.0	30.5	-	5.0	5.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
540	1.81	47.0	31.0	30.0	30.5	-	5.0	5.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
541	5.90	69.0	48.0	44.0	46.0	-	10.0	10.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
542	6.69	72.0	50.0	44.0	47.0	-	11.0	12.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
543	2.38	50.5	36.0	31.0	33.5	-	5.0	5.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
544	2.67	49.0	34.0	31.0	32.5	-	6.0	5.5	-	-	-	-	-	-	-	-	-	-	M	1982/3
545	2.04	48.0	32.0	30.0	31.0	-	5.5	5.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
546	2.04	49.5	33.0	30.0	31.5	-	5.0	5.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
547	1.93	46.5	32.0	29.0	30.5	-	5.0	5.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
548	2.67	49.0	34.0	31.0	32.5	-	5.0	5.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
549	2.15	48.0	33.0	30.0	31.5	-	5.0	5.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
550	2.67	49.5	34.0	30.0	32.0	-	5.0	5.5	-	-	-	-	-	-	-	-	-	-	M	1982/3
551	6.80	72.0	51.0	45.0	48.0	-	11.0	13.0	-	-	-	-	-	-	-	-	-	-	M	1982/3
552	2.15	49.0	34.0	30.0	32.0	-	5.5	5.5	-	-	-	-	-	-	-	-	-	-	F	1982/3
553	8.28	74.5	54.0	48.0	51.0	-	11.0	12.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
554	9.87	82.5	56.0	52.0	54.0	-	14.0	16.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
555	9.07	79.0	56.0	50.0	53.0	-	13.5	14.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
556	6.85	73.5	50.0	44.0	47.0	-	11.5	12.0	-	-	-	-	-	-	-	-	-	-	F	1982/3
557	26.20	115.0	78.0	70.0	74.0	-	26.0	28.0	-	-	-	-	-	-	-	-	-	-	M	1983/4
558	46.27	140.0	98.0	88.0	93.0	-	45.0	48.0	-	-	-	-	-	-	-	-	-	-	M	1983/4
559	53.98	144.0	96.0	96.0	96.0	-	48.0	52.0	-	-	-	-	-	-	-	-	-	-	F	1983/4
560	42.30	137.0	93.0	84.0	88.5	-	45.0	53.0	-	-	-	-	-	-	-	-	-	-	F	1983/4
561	41.73	131.0	90.0	84.0	87.0	-	39.0	41.0	-	-	-	-	-	-	-	-	-	-	F	1983/4
562	5.78	67.5	46.0	43.0	44.5	21.0	10.0	11.0	42.5	-	220	385	430	-	-	-	-	-	F	1983/4
563	5.56	66.5	46.0	44.0	45.0	21.0	11.0	11.5	49.0	-	215	370	410	-	-	-	-	-	F	1983/4
564	5.67	66.0	48.0	43.0	45.5	20.0	10.0	10.0	50.0	-	210	380	410	-	-	-	-	-	M	1983/4
565	5.67	67.0	47.0	43.0	45.0	20.5	9.5	10.0	54.0	-	215	375	415	-	-	-	-	-	M	1983/4
566	5.33	66.0	46.0	43.0	44.5	20.0	9.5	9.5	34.0	-	215	365	405	-	-	-	-	-	F	1983/4
567	41.28	130.0	90.0	88.0	89.0	35.0	42.0	46.0	83.0	-	378	645	719	-	-	-	-	-	F	1983/4
568	43.43	132.0	90.0	88.0	89.0	36.5	38.0	39.0	85.0	-	394	678	750	-	-	-	-	-	F	1983/4
569	36.40	123.0	84.0	83.0	83.5	34.0	34.0	39.5	82.0	-	373	629	703	-	-	-	-	-	F	1983/4
570	4.65	64.5	41.0	40.0	40.5	18.0	8.5	8.5	39.0	-	208	341	382	-	-	-	-	-	M	1983/4
571	47.74	138.0	95.0	93.0	94.0	35.0	35.0	51.5	85.0	-	392	704	780	-	-	-	-	-	F	1983/4
572	68.61	150.0	108.0	104.0	106.0	36.0	70.5	65.0	102.0	-	427	755	845	-	-	-	-	-	M	1983/4
573	58.17	145.5	100.0	97.0	98.5	35.0	33.5	41.5	98.0	-	400	710	815	-	-	-	-	-	M	1983/4
574	24.95	113.0	78.0	72.0	75.0	34.0	26.0	29.0	98.0	-	327	575	640	-	-	-	-	-	F	1983/4
575	22.11	108.0	74.0	70.0	72.0	35.0	23.0	24.0	67.0	-	315	555	595	-	-	-	-	-	M	1983/4

No.	(kg.) Wt.	(cm.) F.L.	(cm.) PG	(cm.) AG	(cm.) MG	(cm.) PF	(cm.) 2DF	(cm.) AF	(mm.) M	(mm.) E	(mm.) S-DF	(mm.) S2-DF	(mm.) S-AF	(mm.) S-VF	(mm.) HL	(mm.) S-E	(mm.) Y-T	(mm.) KW	SEX	Year
576	22.45	108.0	76.0	68.0	72.0	32.0	21.0	23.0	75.0	-	305	548	610	-	-	-	-	-	F	1983/4
577	20.64	108.0	73.0	64.0	68.5	32.0	21.0	23.0	71.0	-	310	565	600	-	-	-	-	-	M	1983/4
578	23.13	112.0	78.0	65.0	71.5	32.0	25.0	27.0	72.0	-	312	560	628	-	-	-	-	-	F	1983/4
579	22.11	107.0	74.0	70.0	72.0	33.0	23.0	24.0	74.0	-	314	535	595	-	-	-	-	-	M	1983/4
580	19.39	106.0	72.0	65.0	68.5	31.5	21.0	23.0	63.0	-	289	442	593	-	-	-	-	-	F	1983/4
581	22.79	106.0	74.0	68.0	71.0	32.0	22.5	26.0	67.0	-	301	555	635	-	-	-	-	-	M	1983/4
582	14.86	95.0	66.0	60.0	63.0	29.0	15.0	16.0	70.0	-	270	478	530	-	-	-	-	-	M	1983/4
583	23.25	108.0	73.0	68.0	70.5	32.0	23.0	26.0	72.0	-	323	550	600	-	-	-	-	-	M	1983/4
584	35.49	124.0	82.0	82.0	82.0	35.0	32.5	38.0	83.0	-	350	635	685	-	-	-	-	-	F	1983/4
585	36.29	123.0	86.0	85.0	85.5	35.5	27.0	40.0	86.0	-	349	635	688	-	-	-	-	-	F	1983/4
586	6.69	70.0	50.0	46.0	48.0	21.0	10.0	10.5	51.0	-	216	383	420	-	-	-	-	-	M	1983/4
587	4.99	65.0	45.0	42.0	43.5	20.0	9.0	10.0	48.0	-	205	355	388	-	-	-	-	-	F	1983/4
588	51.03	139.0	95.0	92.0	93.5	36.0	45.5	50.0	94.0	-	380	710	769	-	-	-	-	-	M	1983/4
589	25.63	113.0	73.0	72.0	72.5	34.0	22.0	28.0	95.0	-	321	577	630	-	-	-	-	-	M	1983/4
590	56.36	143.0	100.0	96.0	98.0	37.0	55.0	66.0	96.0	-	394	710	818	-	-	-	-	-	M	1983/4
591	29.90	112.0	77.0	76.0	76.5	29.0	27.0	31.0	86.0	-	329	579	642	-	-	-	-	-	F	1983/4
592	38.90	128.0	87.0	90.0	88.5	25.5	29.0	40.0	89.0	-	350	643	706	-	-	-	-	-	F	1983/4
593	41.15	131.0	88.0	88.0	88.0	35.5	42.0	45.0	95.0	-	365	662	732	-	-	-	-	-	F	1983/4
594	22.79	107.0	74.0	70.0	72.0	32.0	22.5	25.0	75.0	-	310	559	600	-	-	-	-	-	M	1983/4
595	20.98	105.0	70.0	69.0	69.5	29.5	21.0	24.0	71.0	-	301	544	594	-	-	-	-	-	F	1983/4
596	21.66	106.0	71.0	69.0	70.0	31.0	23.0	25.0	70.0	-	314	551	595	-	-	-	-	-	M	1983/4
597	27.90	112.0	78.0	73.0	75.5	32.5	26.0	27.0	78.0	-	341	607	657	-	-	-	-	-	F	1983/4
598	20.19	111.5	76.0	71.0	73.5	34.0	26.5	28.0	68.0	-	320	578	627	-	-	-	-	-	F	1983/4
599	21.66	107.0	74.0	70.0	72.0	32.5	28.0	30.0	67.0	-	312	545	600	-	-	-	-	-	M	1983/4
600	2.38	49.5	36.0	33.0	34.5	16.0	5.0	5.0	31.0	-	159	275	300	-	-	-	-	-	M	1983/4
601	1.70	44.0	30.0	30.0	30.0	13.0	4.5	4.0	30.0	-	137	239	273	-	-	-	-	-	F	1983/4
602	21.09	106.0	70.0	66.0	68.0	28.0	19.5	20.5	68.0	-	307	548	610	-	-	-	-	-	F	1983/4
603	26.08	113.0	77.0	73.0	75.0	33.0	26.0	28.0	72.0	-	320	586	650	-	-	-	-	-	F	1983/4
604	46.15	135.0	95.0	88.0	91.5	35.0	42.0	44.0	82.0	-	368	680	721	-	-	-	-	-	F	1983/4
605	52.16	141.0	98.0	92.0	95.0	37.5	56.0	59.5	99.0	-	386	706	767	-	-	-	-	-	F	1983/4
606	56.02	142.0	98.0	98.0	98.0	38.0	51.0	54.5	96.0	-	391	716	783	-	-	-	-	-	M	1983/4
607	59.31	145.0	104.0	96.0	100.0	36.0	47.5	49.5	97.0	-	400	740	805	-	-	-	-	-	M	1983/4
608	53.98	147.0	98.0	92.0	95.0	36.5	44.0	51.5	84.0	-	397	712	778	-	-	-	-	-	F	1983/4
609	43.32	127.0	90.0	86.0	88.0	35.0	38.5	41.5	83.0	-	368	658	730	-	-	-	-	-	M	1983/4
610	73.37	159.0	112.0	104.0	108.0	36.0	66.0	67.0	115.0	-	440	785	845	-	-	-	-	-	M	1983/4
611	56.02	142.0	100.0	98.0	99.0	36.0	48.0	58.0	105.0	-	398	720	760	-	-	-	-	-	M	1983/4
612	6.80	70.0	51.0	46.0	48.5	23.0	10.5	10.5	51.0	-	224	375	406	-	-	-	-	-	M	1983/4
613	61.46	145.0	98.0	99.0	98.5	39.0	52.0	54.5	94.0	-	383	760	840	-	-	-	-	-	M	1983/4
614	13.15	91.5	59.0	57.5	58.3	26.0	18.0	18.5	60.0	-	264	477	530	-	-	-	-	-	M	1983/4
615	6.80	70.5	48.0	46.0	47.0	22.0	11.0	12.0	46.0	-	212	379	423	-	-	-	-	-	M	1983/4
616	66.68	152.0	103.0	102.0	102.5	38.0	53.0	64.0	97.0	-	428	776	835	-	-	-	-	-	M	1983/4
617	50.80	142.0	99.0	90.0	94.5	36.0	40.0	45.0	96.0	-	392	712	770	-	-	-	-	-	M	1983/4
618	49.56	138.0	96.0	90.0	93.0	35.0	40.0	43.0	110.0	-	387	700	765	-	-	-	-	-	M	1983/4
619	46.61	134.0	94.0	90.0	92.0	39.0	35.0	42.0	88.0	-	382	688	740	-	-	-	-	-	F	1983/4
620	47.85	136.0	92.0	90.0	91.0	36.0	39.0	42.0	95.0	-	373	682	753	-	-	-	-	-	M	1983/4
621	39.01	126.0	88.0	86.0	87.0	35.0	33.0	37.5	88.0	-	367	648	713	-	-	-	-	-	M	1983/4
622	53.52	141.0	97.0	93.0	95.0	37.0	32.0	48.0	95.0	-	395	711	792	-	-	-	-	-	F	1983/4
623	57.15	144.5	96.0	96.0	96.0	-	52.5	55.0	101.0	-	400	725	799	-	-	-	-	-	M	1983/4
624	48.08	134.0	100.0	88.0	94.0	36.0	38.0	47.0	95.0	-	365	680	740	-	-	-	-	-	F	1983/4
625	48.54	136.0	98.0	88.0	93.0	36.0	44.0	52.0	90.0	-	370	688	750	-	-	-	-	-	F	1983/4
626	36.51	123.0	86.0	80.0	83.0	32.0	25.0	31.0	90.0	-	353	630	685	-	-	-	-	-	F	1983/4
627	51.26	136.0	98.0	94.0	96.0	32.0	42.0	46.0	109.0	-	375	678	756	-	-	-	-	-	F	1983/4
628	46.95	133.0	93.0	90.0	91.5	35.5	30.0	40.0	107.0	-	381	680	764	-	-	-	-	-	F	1983/4
629	48.08	135.5	93.0	92.0	92.5	34.0	41.5	44.0	83.0	-	386	690	759	-	-	-	-	-	M	1983/4
630	45.36	134.0	91.0	93.0	92.0	36.0	41.0	46.0	100.0	-	378	670	735	-	-	-	-	-	F	1983/4
631	49.90	139.5	96.0	93.0	94.5	34.0	47.5	46.5	91.0	-	391	710	766	-	-	-	-	-	F	1983/4
632	42.64	132.0	90.0	89.0	89.5	35.5	32.0	39.0	93.0	-	358	650	720	-	-	-	-	-	M	1983/4
633	48.89	138.0	93.0	92.0	92.5	35.0	46.0	50.0	102.0	-	380	700	760	-	-	-	-	-	F	1983/4
634	54.09	140.0	98.0	94.0	96.0	35.0	30.0	36.0	100.0	-	395	710	785	-	-	-	-	-	M	1983/4
635	61.80	150.0	104.0	98.0	101.0	37.0	56.0	65.0	110.0	-	412	775	836	-	-	-	-	-	M	1983/4
636	54.43	144.0	96.0	94.0	95.0	35.5	45.0	53.0	92.0	-	385	728	790	-	-	-	-	-	M	1983/4
637	58.74	144.0	104.0	101.0	102.5	38.0	42.0	48.0	97.0	-	401	722	791	-	-	-	-	-	M	1983/4
638	51.48	135.0	98.0	95.0	96.5	35.5	41.0	49.0	85.0	-	368	682	758	-	-	-	-	-	F	1983/4
639	48.20	140.0	94.0	89.0	91.5	34.0	36.0	42.0	87.0	-	380	700	767	-	-	-	-	-	M	1983/4
640	66.79	150.0	104.0	103.0	103.5	38.0	48.0	53.0	95.0	-	405	752	825	-	-	-	-	-	M	1983/4
641	51.31	137.0	94.0	94.0	94.0	34.5	38.0	44.0	109.0	-	386	699	770	-	-	-	-	-	F	1983/4
642	58.29	145.0	98.0	97.0	97.5	38.0	49.5	58.0	105.0	-	405	731	806	-	-	-	-	-	F	1983/4
643	48.31	136.0	90.0	90.0	90.0	32.0	26.0	35.0	88.0	-	378	684	759	-	-	-	-	-	F	1983/4
644	44.23	133.5	90.0	86.0	88.0	35.0	37.0	39.0	88.0	-	371	672	759	-	-	-	-	-	M	1983/4
645	42.64	130.0	90.0	88.0	89.0	35.0	37.5	42.0	90.0	-	356	656	725	-	-	-	-	-	M	1983/4
646	49.67	137.0	96.0	94.0	95.0	35.0	37.0	40.0	86.0	-	371	675	754	-	-	-	-	-	M	1983/4
647	43.32	129.5	92.0	89.0	90.5	35.0	37.0	36.0	87.0	-	361	657	724	-	-	-	-	-	M	1983/4
648	48.99	137.0	92.0	92.0	92.0	35.5	38.0	42.0	108.0	-	377	684	762	-	-	-	-	-	M	1983/4
649	44.57	131.5	90.0	88.0	89.0	35.0	39.0	43.0	97.0	-	363	666	743	-	-	-	-	-	M	1983/4
650	49.90	138.5	93.0	92.0	92.5	33.0	34.0	42.0	86.0	-	378	696	762	-	-	-	-	-	F	1983/4
651	54.32	140.5	94.0	90.0	92.0	36.0	45.0	47.0	101.0	-	392	712	786	-	-	-	-	-	F	1983/4
652	54.54	143.0	96.0	96.0	96.0	36.5	55.0	58.0	109.0	-	393	739	806	-	-	-	-	-	F	1983/4
653	43.09	133.0	90.0	88.0	89.0	36.0	33.0	37.0	85.0	-	372	669	764	-	-	-	-	-	M	1983/4
654	55.45	141.0	99.0	96.0	97.5	37.0	54.5	54.5	101.0	-	383	712	785	-	-	-	-	-	M	1983/4
655	55.11	141.0	99.0	96.0	97.5	37.0	47.5	54.0	110.0	-	402	721	785	-	-	-	-	-	M	1983/4
656	46.95	133.0	92.0	90.0	91.0	35.0	36.5	42.0	85.0	-	369	691	768	-	-	-	-	-	M	1983/4
657	42.41	133.5	87.0	86.0	86.5	36.0	42.5	47.0	103.0	-	355	666	736	-	-	-	-	-	M	1983/4
658	41.05	131.0	89.0	86.0	87.5	37.0	31.5	40.0	96.0	-	355	658	738	-	-	-	-	-	F	1983/4
659	38.56	127.0	85.0	86.0	85.5	35.5	36.0	39.0	85.0	-	346	630	697	-	-	-	-	-	M	1983/4
660	44.57	133.0	90.0	90.0	90.0	37.0	35.0	34.0	92.0	-	368	658	734	-	-	-	-	-	M	1983/4
661	42.41	130.0	88.0	88.0	88.0	35.0	30.5	37.0	78.0	-	356	668	711	-	-	-	-	-	F	1983/4
662	46.49	132.5	93.0	92.0	92.5	36.0	-	43.0	91.0	-	369	682	738	-	-	-	-	-	M	1983/4
663	48.81	137.0	89.0	87.0	88.0	34.0	33.0	38.0	85.0	-	389	698	759	-	-	-	-	-	F	1983/4
664	47.29	138.5	92.0	89.0	90.5	36.5	36.5	39.0	98.0	-	370	697	761	-	-	-	-	-	M	1983/4
665	47.40	136.0	90.0	91.0	90.5	34.0	47.0	51.5	93.0	-	382	689	762	-	-	-	-	-	F	1983/4
666	49.44	140.0	91.0	92.0	91.5	37.0	40.0	48.5	101.0	-	381	698	782	-	-	-	-	-	M	1983/4
667	41.96	131.0	89.0	85.0	87.0	35.0	36.0	39.0	77.0	-	355	667	742	-	-	-	-	-	F	1983/4
668	40.14	127.0	85.0	85.0	85.0	36.5	32.0	40.0	80.0	-	340	634	705	-	-	-	-	-	F	1983/4
669	50.35	134.0	93.0	92.0	92.5	35.5	45.0	-	83.0	-	379	692	742	-	-	-	-	-	F	1983/4
670	55.57	143.0	100.0	96.0	98.0	37.0	54.0	-	96.0	-	398	720	796	-	-	-	-	-	M	1983/4
671	45.13	134.0	94.0	87.0	90.5	35.5	36.0	41.5	102.0	-	380	675	750	-	-	-	-	-	M	1983/4
672	53.18	142.0	95.0	95.0	95.0	34.0	42.5	51.5	98.0	-	390	707	776	-	-	-	-	-	F	1983/4
673	52.05	139.0	95.0	95.0	95.0	34.0	43.0	40.5	95.0	-	380	695	784	-	-	-	-	-	M	1983/4
674	38.90	130.0	87.0	85.0	86.0	36.0	30.0	39.0	75.0	-	352	645	712	-	-	-	-	-	F	1983/4
675	54.09	144.0	100.0	92.0	96.0	36.0	45.0	50.0	-	-	387	713	789	-	-	-	-	-	F	1983/4
676	49.78	139.0	97.0	90.0	93.5	37.0	36.0	40.0	82.0	-	381	703	772	-	-	-	-	-	M	1983/4
677	52.05	135.0	93.0	95.0	94.0	37.0	40.0	42.5	100.0	-	380	680	764	-	-	-	-	-	F	1983/4
678	48.08	137.5	91.0	90.0	90.5	36.0	36.0	41.0	94.0	-	390	694	766	-	-	-	-	-	M	1983/4
679	49.67	134.0	97.0	96.0	96.5	33.5	39.0	44.0	84.0	-	383	698	766	-	-	-	-	-	F	1983/4
680	49.30	137.0	93.0	94.0	93.5	35.0	36.0	41.0	84.0	-	382	695	746	-	-	-	-	-	M	1983/4
681	53.87	140.0	97.0	96.0	96.5	35.0	42.0	44.0	106.0	-	392	725	776	-	-	-	-	-	M	1983/4
682	47.63	140.0	92.0	91.0	91.5	36.0	41.0	50.0	86.0	-	373	695	771	-	-	-	-	-	M	1983/4
683	2.49	49.5	35.0	32.0	33.5	15.0	6.0	5.5	31.0	-	157	279	310	-	-	-	-	-	M	1983/4
684	44.57	132.0	91.0	89.0	90.0	36.0	32.0	33.0	99.0	-	388	679	760	-	-	-	-	-	M	1983/4
685	41.73	130.0	88.0	86.0	87.0	35.0	38.5	42.0	87.0	-	357	652	715	-	-	-	-	-	M	1983/4
686	46.95	137.0	90.0	88.0	89.0	38.0	41.0	44.0	84.0	-	377	695	768	-	-	-	-	-	M	1983/4
687	45.47	136.0	90.0	88.0	89.0	36.5	41.0	43.0	103.0	-	382	681	745	-	-	-	-	-	F	1983/4
688	61.12	147.0	99.0	100.0	99.5	38.0	49.0	54.0	108.0	-	399	727	808	-	-	-	-	-	M	1983/4
689	53.75	141.0	93.0	96.0	94.5	35.5	46.5	51.0	103.0	-	376	713	779	-	-	-	-	-	M	1983/4
690	46.49	135.0	91.0	90.0	90.5	35.0	38.0	41.0	90.0	-	382	684	758	-	-	-	-	-	M	1983/4

No.	(kg.) Wt.	(cm.) F.L.	(cm.) PG	(cm.) AG	(cm.) MG	(cm.) PF	(cm.) 2DF	(cm.) AF	(mm.) M	(mm.) E	(mm.) S-DF	(mm.) S2-DF	(mm.) S-AF	(mm.) S-VF	(mm.) HL	(mm.) S-E	(mm.) Y-T	(mm.) KW	SEX	Year
691	43.43	132.5	91.0	86.0	88.5	38.0	39.5	43.5	91.0	-	374	668	743	-	-	-	-	-	M	1983/4
692	49.90	136.0	93.0	92.0	92.5	36.0	53.5	59.0	91.0	-	377	687	762	-	-	-	-	-	F	1983/4
693	48.08	137.0	94.0	94.0	94.0	36.0	42.0	47.0	100.0	-	378	665	738	-	-	-	-	-	F	1983/4
694	50.12	137.0	94.0	90.0	92.0	37.0	45.5	55.0	91.0	-	383	674	768	-	-	-	-	-	F	1983/4
695	2.95	53.5	37.0	34.0	35.5	17.0	6.5	6.5	33.0	-	170	295	328	-	-	-	-	-	F	1983/4
696	2.61	51.0	35.0	33.0	34.0	15.0	6.0	6.0	33.0	-	165	280	314	-	-	-	-	-	F	1983/4
697	48.88	137.0	98.0	93.0	95.5	38.0	-	48.0	104.0	-	380	688	744	-	-	-	-	-	F	1983/4
698	6.35	67.0	50.0	43.0	46.5	20.0	10.0	9.0	55.0	-	212	373	403	-	-	-	-	-	M	1983/4
699	6.35	68.0	48.0	46.0	47.0	22.0	14.5	15.0	42.0	-	207	366	404	-	-	-	-	-	M	1983/4
700	1.81	45.5	30.0	29.0	29.5	13.5	5.0	-	27.0	-	150	258	278	-	-	-	-	-	M	1983/4
701	2.27	48.5	32.0	32.0	32.0	14.0	5.0	5.5	30.0	-	160	269	293	-	-	-	-	-	F	1983/4
702	2.04	46.5	32.0	31.0	31.5	16.0	4.5	4.5	29.0	-	146	259	290	-	-	-	-	-	M	1983/4
703	1.81	46.0	30.0	29.0	29.5	13.0	4.5	4.5	25.0	-	145	243	296	-	-	-	-	-	F	1983/4
704	1.93	48.0	31.0	30.0	30.5	13.5	5.0	4.5	28.0	-	152	270	299	-	-	-	-	-	M	1983/4
705	0.91	37.0	24.0	23.0	23.5	10.0	3.5	-	21.0	-	121	210	236	-	-	-	-	-	?	1983/4
706	2.72	53.5	36.0	34.0	35.0	16.0	6.0	6.0	35.0	-	168	297	323	-	-	-	-	-	F	1983/4
707	2.27	49.0	34.0	33.0	33.5	14.5	5.5	5.0	35.0	-	158	275	306	-	-	-	-	-	F	1983/4
708	2.84	53.5	37.0	33.0	35.0	17.0	6.0	6.0	39.0	-	170	299	321	-	-	-	-	-	M	1983/4
709	7.60	73.5	52.0	48.0	50.0	22.0	10.0	12.0	54.0	-	227	395	439	-	-	-	-	-	M	1983/4
710	3.18	53.0	39.0	37.0	38.0	16.5	6.5	6.0	36.0	-	174	300	327	-	-	-	-	-	M	1983/4
711	2.61	51.5	35.0	34.0	34.5	15.0	6.0	6.0	33.0	-	164	284	318	-	-	-	-	-	F	1983/4
712	2.61	51.0	35.0	33.0	34.0	-	5.5	5.5	37.0	-	165	284	318	-	-	-	-	-	F	1983/4
713	2.84	53.0	38.0	34.0	36.0	15.0	5.0	5.0	45.0	-	169	293	325	-	-	-	-	-	M	1983/4
714	7.14	72.0	54.0	46.0	50.0	22.0	10.0	11.0	49.0	-	224	392	431	-	-	-	-	-	F	1983/4
715	1.81	47.0	33.0	30.0	31.5	14.0	5.0	5.0	27.0	-	152	262	284	-	-	-	-	-	M	1983/4
716	1.93	47.0	32.0	30.0	31.0	14.0	5.0	4.5	29.0	-	151	265	287	-	-	-	-	-	F	1983/4
717	2.15	48.5	34.0	32.0	33.0	14.0	5.5	5.5	29.0	-	152	280	297	-	-	-	-	-	M	1983/4
718	2.27	49.5	34.0	31.0	32.5	15.5	5.5	5.0	31.0	-	164	288	310	-	-	-	-	-	M	1983/4
719	2.15	47.5	33.0	32.0	32.5	14.0	5.0	5.0	30.0	-	153	269	289	-	-	-	-	-	M	1983/4
720	2.04	48.5	33.0	31.0	32.0	14.5	5.0	5.0	30.0	-	152	270	295	-	-	-	-	-	F	1983/4
721	2.04	48.0	33.0	31.0	32.0	13.5	5.0	5.0	28.0	-	157	269	298	-	-	-	-	-	F	1983/4
722	2.15	49.0	33.0	31.0	32.0	14.0	5.0	5.0	30.0	-	159	277	305	-	-	-	-	-	M	1983/4
723	2.15	48.0	33.0	31.0	32.0	15.0	5.0	5.0	30.0	-	155	263	291	-	-	-	-	-	M	1983/4
724	2.27	48.5	33.0	31.0	32.0	15.0	5.5	5.5	30.0	-	161	276	302	-	-	-	-	-	M	1983/4
725	1.59	45.5	31.0	28.0	29.5	13.5	4.0	4.0	29.0	-	149	256	276	-	-	-	-	-	M	1983/4
726	1.59	44.0	29.0	28.0	28.5	12.5	4.0	4.0	27.0	-	137	239	270	-	-	-	-	-	M	1983/4
727	1.36	41.0	28.0	27.0	27.5	12.5	4.0	4.0	26.0	-	131	236	250	-	-	-	-	-	M	1983/4
728	2.15	48.0	33.0	31.0	32.0	15.0	5.5	5.0	29.0	-	157	271	302	-	-	-	-	-	M	1983/4
729	1.93	47.0	32.0	30.0	31.0	14.0	5.0	5.0	28.0	-	153	266	298	-	-	-	-	-	M	1983/4
730	1.81	45.5	31.0	30.0	30.5	13.5	4.5	4.5	28.0	-	142	252	287	-	-	-	-	-	F	1983/4
731	1.93	47.0	32.0	31.0	31.5	14.0	5.0	5.0	28.0	-	152	264	296	-	-	-	-	-	M	1983/4
732	1.81	46.0	32.0	30.0	31.0	13.0	5.0	5.0	28.0	-	151	264	292	-	-	-	-	-	M	1983/4
733	1.81	46.0	31.0	30.0	30.5	14.0	5.0	4.5	27.0	-	148	259	293	-	-	-	-	-	M	1983/4
734	1.59	44.0	30.0	29.0	29.5	13.5	4.5	4.5	29.0	-	143	241	280	-	-	-	-	-	M	1983/4
735	1.93	47.5	32.0	30.0	31.0	13.5	5.0	4.5	28.0	-	156	268	295	-	-	-	-	-	M	1983/4
736	6.80	70.0	50.0	47.0	48.5	20.5	10.0	10.5	49.0	-	218	383	419	-	-	-	-	-	M	1983/4
737	8.16	77.0	51.0	49.0	50.0	24.0	12.5	13.0	50.0	-	232	410	436	-	-	-	-	-	F	1983/4
738	2.15	49.5	33.0	31.0	32.0	14.0	6.0	5.0	31.0	-	163	286	304	-	-	-	-	-	F	1983/4
739	2.15	47.5	34.0	32.0	33.0	14.5	5.0	5.5	31.0	-	148	253	298	-	-	-	-	-	M	1983/4
740	2.15	50.0	33.0	31.0	32.0	15.0	5.5	5.0	33.0	-	161	274	303	-	-	-	-	-	M	1983/4
741	7.14	71.0	51.0	47.0	49.0	22.0	10.5	10.0	42.0	-	217	395	429	-	-	-	-	-	F	1983/4
742	3.52	57.0	42.0	36.0	39.0	16.0	6.0	7.0	45.0	-	182	312	344	-	-	-	-	-	M	1983/4
743	2.15	48.5	36.0	30.0	33.0	14.0	6.0	5.0	43.0	-	155	270	297	-	-	-	-	-	M	1983/4
744	1.93	46.0	34.0	30.0	32.0	14.0	5.5	4.5	42.0	-	145	254	290	-	-	-	-	-	M	1983/4
745	8.85	76.0	54.0	47.0	50.5	23.0	10.5	12.0	48.0	-	225	410	437	-	-	-	-	-	M	1983/4
746	17.69	97.0	69.0	66.0	67.5	27.0	18.0	21.5	65.0	-	286	501	555	-	-	-	-	-	M	1983/4
747	3.18	56.0	39.0	34.0	36.5	16.0	7.0	7.0	36.0	-	174	305	340	-	-	-	-	-	F	1983/4
748	2.84	55.5	38.0	34.0	36.0	17.0	6.0	6.5	45.0	-	211	301	334	-	-	-	-	-	F	1983/4
749	2.84	53.5	36.0	33.0	34.5	15.5	5.0	6.0	36.0	-	232	307	325	-	-	-	-	-	F	1983/4
750	2.49	51.5	36.0	32.0	34.0	15.0	5.5	5.0	41.5	-	155	282	322	-	-	-	-	-	M	1983/4
751	3.86	61.5	40.0	38.0	39.0	20.0	7.5	7.5	43.5	-	194	339	368	-	-	-	-	-	M	1983/4
752	4.08	59.0	43.0	40.0	41.5	19.0	7.0	7.0	37.0	-	184	340	360	-	-	-	-	-	F	1983/4
753	2.72	52.5	36.0	33.0	34.5	15.0	6.0	5.5	34.0	-	167	304	329	-	-	-	-	-	F	1983/4
754	2.15	48.0	33.0	31.0	32.0	14.0	5.0	5.0	33.0	-	150	270	301	-	-	-	-	-	F	1983/4
755	2.15	49.0	33.0	31.0	32.0	15.0	6.0	5.5	29.0	-	154	271	301	-	-	-	-	-		1983/4
756	2.95	54.5	38.0	33.0	35.5	15.0	6.5	6.5	43.0	-	170	306	332	-	-	-	-	-	M	1983/4
757	2.49	52.0	34.0	32.0	33.0	15.0	5.0	5.5	38.0	-	155	275	308	-	-	-	-	-	M	1983/4
758	7.03	70.0	50.0	46.0	48.0	21.5	10.0	10.0	56.0	-	219	370	415	-	-	-	-	-	F	1983/4
759	65.43	148.0	103.0	103.0	103.0	36.0	40.5	50.0	104.0	-	397	745	823	-	-	-	-	-	F	1983/4
760	8.39	78.0	52.0	50.0	51.0	24.0	13.0	14.5	46.0	-	243	422	451	-	-	-	-	-	F	1983/4
761	9.53	80.0	52.0	50.0	51.0	24.0	12.0	13.0	50.0	-	250	425	470	-	-	-	-	-	F	1983/4
762	2.84	53.5	34.0	32.0	33.0	15.0	6.0	6.0	34.0	-	173	308	331	-	-	-	-	-	F	1983/4
763	2.84	52.0	34.0	34.0	34.0	16.0	6.0	5.5	30.0	-	165	295	322	-	-	-	-	-	M	1983/4
764	2.61	51.5	34.0	32.0	33.0	15.0	5.5	5.5	34.0	-	162	288	322	-	-	-	-	-	F	1983/4
765	2.61	51.5	33.0	33.0	33.0	15.0	5.5	5.5	31.0	-	164	292	323	-	-	-	-	-	F	1983/4
766	4.54	62.0	42.0	40.0	41.0	20.0	8.0	8.0	40.0	-	192	337	370	-	-	60	-	46	F	1984/5
767	2.38	49.5	34.0	32.0	33.0	14.0	5.5	5.0	31.0	-	155	262	302	-	-	48	-	37	F	1984/5
768	3.52	61.0	40.0	38.0	39.0	18.0	7.5	7.0	37.0	27	189	332	360	188	175	55	230	44	F	1984/5
769	3.52	62.0	44.0	41.0	42.5	18.0	7.5	8.5	40.0	30	193	331	380	207	185	67	233	46	F	1984/5
770	4.20	59.5	42.0	38.0	40.0	18.0	8.0	8.0	40.0	30	195	330	357	193	180	68	212	48	M	1984/5
771	3.74	62.0	43.0	40.0	41.5	19.0	8.0	8.0	39.0	30	194	335	373	197	185	69	221	46	F	1984/5
772	3.97	61.0	40.0	38.0	39.0	17.0	7.5	8.0	38.0	29	185	332	366	192	176	63	226	42	M	1984/5
773	4.42	60.0	39.0	38.0	38.5	18.0	7.5	8.0	38.0	28	185	320	361	186	175	55	221	42	M	1984/5
774	4.20	60.5	41.0	40.0	40.5	19.0	7.0	7.5	36.0	29	188	330	365	192	174	61	228	43	F	1984/5
775	4.65	57.5	38.0	36.0	37.0	16.0	7.0	7.5	38.0	29	181	312	346	179	165	58	208	43	M	1984/5
776	4.20	58.0	39.0	36.0	37.5	17.0	7.0	7.0	39.0	27	182	313	350	183	165	57	214	42	M	1984/5
777	5.10	65.0	46.0	38.0	42.0	19.0	10.0	9.5	42.0	31	195	345	380	190	185	63	237	52	F	1984/5
778	4.08	60.0	43.0	36.0	39.5	18.0	7.0	7.5	38.0	30	181	322	350	181	176	61	212	45	F	1984/5
779	37.19	125.0	84.0	84.0	84.0	34.0	27.0	37.0	84.0	42	346	621	712	361	321	105	505	114	M	1984/5
780	36.63	125.0	84.0	84.0	84.0	33.0	30.0	31.0	75.0	38	341	613	702	349	310	106	501	120	F	1984/5
781	40.37	130.0	89.0	85.0	87.0	35.0	41.0	42.0	93.0	42	360	643	716	350	324	109	504	112	F	1984/5
782	40.82	130.5	86.0	87.0	86.5	36.0	45.0	37.0	70.0	38	358	663	724	359	325	118	513	136	F	1984/5
783	46.38	135.0	89.0	92.0	90.5	36.0	42.0	48.0	92.0	40	362	690	755	365	332	120	543	134	F	1984/5
784	44.23	137.0	91.0	88.0	89.5	33.0	48.0	53.0	80.0	43	380	666	742	368	336	120	560	132	F	1984/5
785	45.13	133.5	92.0	90.0	91.0	39.0	41.0	45.0	86.0	37	372	670	742	366	335	121	523	130	F	1984/5
786	47.17	138.0	92.0	90.0	91.0	37.0	42.0	-	86.0	40	378	690	752	385	351	130	550	130	F	1984/5
787	55.34	142.0	97.0	98.0	97.5	39.0	49.0	55.0	98.0	41	409	710	792	386	352	133	575	140	M	1984/5
788	45.13	135.0	92.0	91.0	91.5	37.0	40.0	46.0	88.0	40	372	671	752	379	340	126	527	128	M	1984/5
789	46.61	135.0	90.0	88.0	89.0	35.0	34.0	39.0	83.0	36	369	680	756	370	325	115	548	134	M	1984/5
790	40.14	130.0	87.0	85.0	86.0	35.0	40.0	43.0	82.0	38	360	650	730	360	319	120	534	125	M	1984/5
791	48.53	140.0	92.0	91.0	91.5	35.0	40.0	44.0	95.0	41	387	720	787	390	351	128	547	136	F	1984/5
792	49.33	137.0	94.0	93.0	93.5	33.0	34.0	41.0	97.0	40	379	685	753	389	346	128	555	127	M	1984/5
793	46.72	135.5	91.0	91.0	91.0	36.5	32.0	53.0	103.0	42	372	677	750	377	340	125	539	133	F	1984/5
794	46.27	136.0	89.0	89.0	89.0	35.0	36.5	41.0	97.0	40	375	682	758	383	345	125	524	124	F	1984/5
795	43.20	134.0	88.0	87.0	87.5	35.0	34.0	31.5	95.0	37	363	665	730	367	324	126	526	130	F	1984/5
796	39.92	129.0	86.0	85.0	85.5	34.0	35.0	42.0	86.0	40	354	643	727	368	318	119	502	119	F	1984/5
797	59.19	145.0	104.0	102.0	103.0	35.0	46.0	64.0	102.0	40	401	724	795	398	357	133	584	135	M	1984/5
798	47.97	135.0	93.0	92.0	92.5	37.0	41.0	44.0	88.0	37	370	682	763	374	336	128	545	136	M	1984/5
799	64.30	151.0	105.0	99.0	102.0	38.0	51.0	65.0	112.0	41	422	762	836	425	378	141	590	145	M	1984/5
800	49.56	138.0	98.0	94.0	96.0	36.5	42.0	51.0	90.0	40	374	690	748	389	353	129	557	122	M	1984/5
801	53.76	143.0	97.0	93.0	95.0	36.0	44.0	51.0	96.0	44	390	727	791	411	355	128	561	135	F	1984/5
802	40.82	130.0	88.0	86.0	87.0	37.0	45.0	45.5	79.0	42	362	659	719	365	322	116	520	122	M	1984/5
803	41.50	130.0	88.0	87.0	87.5	-	34.0	40.5	89.0	36	369	644	735	366	335	123	518	133	M	1984/5
804	47.63	136.0	92.0	92.0	92.0	36.0	36.5	43.0	87.0	39	371	684	747	376	339	120	552	132	F	1984/5
805	37.31	125.0	84.0	83.0	83.5	33.0	35.5	35.0	91.0	37	345	631	698	347	320	116	495	111	F	1984/5

No.	(kg.) Wt.	(cm.) F.L.	(cm.) PG	(cm.) AG	(cm.) MG	(cm.) PF	(cm.) 2DF	(cm.) AF	(mm.) M	(mm.) E	(mm.) S-DF	(mm.) S2-DF	(mm.) S-AF	(mm.) S-VF	(mm.) HL	(mm.) S-E	(mm.) Y-T	(mm.) KW	SEX	Year
806	49.90	137.0	96.0	91.0	93.5	-	57.5	61.0	89.0	40	388	704	781	385	352	130	558	122	F	1984/5
807	58.17	147.0	100.0	97.0	98.5	37.0	47.0	51.0	104.0	42	387	720	795	400	360	129	609	141	M	1984/5
808	44.68	136.0	91.0	90.0	90.5	36.5	40.0	42.0	98.0	36	368	675	747	368	330	122	532	128	M	1984/5
809	41.84	132.0	90.0	88.0	89.0	36.0	33.5	45.5	84.0	39	361	659	730	372	324	119	523	138	M	1984/5
810	45.02	134.0	91.0	89.0	90.0	35.5	38.0	43.0	87.0	42	360	669	736	369	335	122	539	122	F	1984/5
811	46.49	136.0	92.0	91.0	91.5	36.0	39.0	40.0	80.0	40	379	687	765	378	337	122	540	138	F	1984/5
812	41.73	130.0	90.0	88.0	89.0	37.0	44.0	46.0	96.0	39	363	658	724	369	327	120	517	134	F	1984/5
813	40.94	129.0	92.0	90.0	91.0	32.0	32.0	39.5	78.0	39	359	640	718	357	323	112	525	136	M	1984/5
814	31.98	118.0	81.0	79.0	80.0	32.0	36.0	39.0	67.0	36	341	604	654	334	302	119	472	123	M	1984/5
815	36.17	124.0	88.0	83.0	85.5	34.0	24.0	40.5	82.0	40	348	623	680	345	318	119	496	114	F	1984/5
816	41.96	132.5	90.0	87.0	88.5	-	37.5	38.0	86.0	44	371	667	754	375	336	127	520	147	F	1984/5
817	48.99	138.0	95.0	92.0	93.5	34.0	42.0	51.0	93.0	43	378	698	763	390	341	122	570	128	F	1984/5
818	2.27	48.0	33.0	31.0	32.0	15.0	5.5	5.5	32.0	24	154	275	302	155	142	47	167	34	F	1984/5
819	5.22	-	45.0	38.0	41.5	19.0	9.5	9.0	43.0	33	201	354	371	205	192	63	230	50	F	1984/5
820	4.08	-	43.0	36.0	39.5	19.0	8.5	8.0	39.0	30	190	331	346	194	176	57	215	44	F	1984/5
821	2.72	52.5	36.0	34.0	35.0	15.5	6.0	6.0	30.0	26	155	290	318	165	150	50	188	36	M	1984/5
822	44.00	132.0	90.0	88.0	89.0	35.0	39.0	52.0	78.0	42	360	659	747	360	327	117	530	135	F	1984/5
823	43.66	132.0	92.0	89.0	90.5	35.0	39.0	44.0	77.0	39	365	655	735	374	319	116	534	-	F	1984/5
824	46.27	134.0	91.0	91.0	91.0	37.0	37.0	-	88.0	38	373	671	734	365	330	115	546	127	M	1984/5
825	45.81	134.0	91.0	90.0	90.5	34.0	36.5	39.5	92.0	41	367	669	760	380	335	117	535	130	M	1984/5
826	68.04	149.0	108.0	105.0	106.5	36.0	57.5	64.0	96.0	43	408	744	816	402	370	137	605	144	M	1984/5
827	47.06	137.0	94.0	91.0	92.5	35.0	32.0	-	90.0	40	375	675	760	378	337	129	556	127	F	1984/5
828	50.35	136.5	97.0	93.0	95.0	34.0	31.5	39.5	96.0	38	385	684	760	382	347	123	532	135	F	1984/5
829	57.83	147.0	98.0	93.0	95.5	37.0	44.0	48.0	102.0	38	390	698	783	395	351	127	572	130	M	1984/5
830	50.92	136.5	96.0	94.0	95.0	37.0	41.0	53.0	98.0	44	378	685	752	375	340	124	552	137	F	1984/5
831	55.79	140.0	99.0	96.0	97.5	38.0	46.0	55.0	89.0	38	378	710	783	390	344	130	549	150	M	1984/5
832	53.30	143.0	97.0	94.0	95.5	41.0	55.5	44.0	87.0	39	390	706	789	390	350	126	572	127	M	1984/5
833	49.90	136.5	96.0	90.0	93.0	35.0	35.0	-	97.0	42	381	686	754	383	340	131	558	130	F	1984/5
834	51.26	139.0	95.0	92.0	93.5	34.0	37.5	49.0	97.0	40	374	700	780	391	346	120	530	139	F	1984/5
835	47.63	136.0	94.0	92.0	93.0	35.0	34.5	45.0	79.0	38	370	680	751	381	338	121	533	139	F	1984/5
836	32.32	120.0	81.0	79.0	80.0	33.0	29.0	37.0	68.0	36	335	609	690	334	303	111	479	127	M	1984/5
837	39.92	129.5	88.0	87.0	87.5	36.0	38.5	38.0	86.0	36	357	645	718	355	319	113	518	137	F	1984/5
838	38.67	126.5	90.0	86.0	88.0	35.0	29.0	31.0	93.0	34	361	647	712	365	323	113	500	125	M	1984/5
839	2.38	49.5	35.0	34.0	34.5	15.5	6.0	6.0	29.0	22	149	268	303	164	143	52	176	33	M	1984/5
840	2.61	51.0	33.0	32.0	32.5	15.0	6.0	5.5	33.0	25	156	286	315	163	145	51	182	32	F	1984/5
841	5.10	65.0	42.0	40.0	41.0	19.5	9.5	9.5	44.0	29	198	358	390	207	188	63	240	51	F	1984/5
842	4.20	61.0	41.0	40.0	40.5	18.0	8.0	8.0	38.0	28	189	334	362	192	177	59	216	43	F	1984/5
843	5.22	64.5	44.0	43.0	43.5	20.0	9.5	10.0	38.0	27	202	350	385	200	182	60	238	55	M	1984/5
844	4.76	63.5	43.0	42.0	42.5	19.0	8.5	9.0	36.0	31	196	345	382	199	182	60	224	48	M	1984/5
845	2.61	50.0	35.0	33.0	34.0	15.0	5.5	5.5	28.0	24	166	286	308	162	148	50	180	34	F	1984/5
846	2.49	49.0	34.0	33.0	33.5	16.0	5.5	6.0	30.0	24	154	262	294	154	144	46	182	33	M	1984/5
847	2.38	49.0	34.0	33.0	33.5	14.5	5.0	5.5	28.0	25	157	273	305	160	149	49	175	33	M	1984/5
848	3.86	60.5	40.0	37.0	38.5	18.0	8.0	8.0	36.0	30	191	337	365	188	175	58	209	57	F	1984/5
849	4.08	60.5	42.0	40.0	41.0	18.0	8.0	7.0	33.0	30	192	323	369	195	179	65	218	39	M	1984/5
850	4.54	63.0	42.0	41.0	41.5	19.5	9.5	9.0	40.0	30	199	347	381	196	180	60	230	49	F	1984/5
851	4.76	64.0	43.0	41.0	42.0	20.0	9.0	9.0	41.0	29	199	344	379	203	182	66	231	47	M	1984/5
852	4.65	61.5	43.0	41.0	42.0	18.0	8.0	8.0	45.0	30	193	337	379	200	185	63	224	47	F	1984/5
853	4.08	60.0	42.0	40.0	41.0	19.0	8.5	8.5	33.0	28	185	333	356	187	173	55	220	45	F	1984/5
854	3.52	51.0	35.0	34.0	34.5	14.5	5.5	6.0	32.0	26	157	279	318	163	149	46	169	31	F	1984/5
855	2.38	42.0	28.0	27.0	27.5	12.5	4.5	4.5	23.0	23	133	235	263	134	122	40	159	28	M	1984/5
856	5.67	68.0	46.0	43.0	44.5	20.0	10.0	10.0	44.0	31	209	367	402	211	195	63	255	53	F	1984/5
857	4.54	63.0	43.0	41.0	42.0	20.0	8.5	9.0	39.0	28	194	338	372	200	182	63	225	46	F	1984/5
858	4.65	63.0	42.0	40.0	41.0	20.5	9.0	9.0	35.0	30	198	344	377	196	176	62	228	46	M	1984/5
859	4.42	61.5	43.0	40.0	41.5	19.0	8.5	8.5	38.0	29	191	337	370	197	176	62	219	46	F	1984/5
860	3.97	59.0	41.0	38.0	39.5	18.0	8.0	8.0	35.0	28	186	328	355	187	172	62	218	45	M	1984/5
861	4.54	62.0	43.0	39.0	41.0	20.0	8.5	9.0	35.0	31	195	346	379	199	176	58	224	47	M	1984/5
862	2.95	53.5	37.0	33.0	35.0	17.0	6.5	6.0	33.0	29	165	297	325	172	150	52	193	37	M	1984/5
863	3.29	57.0	38.0	35.0	36.5	17.0	7.0	7.0	36.0	27	176	309	343	184	164	56	210	39	M	1984/5
864	2.49	50.5	34.0	33.0	33.5	19.5	5.5	5.5	31.0	27	164	281	305	164	148	50	184	29	F	1984/5
865	2.15	48.5	33.0	31.0	32.0	14.5	6.0	6.0	27.0	23	152	265	286	155	141	44	174	31	F	1984/5
866	2.38	50.5	34.0	32.0	33.0	15.5	6.0	5.5	33.0	27	158	281	301	158	144	48	193	35	M	1984/5
867	2.38	50.5	34.0	31.0	32.5	15.0	5.5	5.5	33.0	27	163	282	304	166	149	52	182	35	F	1984/5
868	2.27	49.0	33.0	31.0	32.0	14.5	5.5	5.5	36.0	25	155	275	302	160	143	52	182	34	M	1984/5
869	2.27	49.0	34.0	33.0	33.5	15.0	6.0	5.0	28.0	24	152	269	301	156	142	48	170	33	M	1984/5
870	2.61	52.5	36.0	34.0	35.0	15.5	5.5	5.5	33.0	26	165	288	322	168	153	51	187	36	F	1984/5
871	2.49	51.5	35.0	34.0	34.5	15.0	5.5	6.0	30.0	26	157	280	316	166	147	50	176	35	M	1984/5
872	16.90	96.5	66.0	63.0	64.5	29.0	21.5	26.0	55.0	36	284	506	558	287	266	90	360	97	M	1984/5
873	7.26	73.5	50.0	48.0	49.0	24.0	11.0	12.0	49.0	31	226	394	418	220	202	67	270	57	F	1984/5
874	26.31	114.0	78.0	76.0	77.0	31.0	24.0	28.0	82.0	36	324	589	649	334	297	106	446	102	M	1984/5
875	57.61	142.0	102.0	102.0	102.0	38.0	53.5	59.0	105.0	40	405	727	818	400	364	134	564	-	M	1985/6
876	5.33	67.0	44.0	40.0	42.0	20.0	9.0	9.5	45.0	30	210	372	390	206	186	62	241	50	F	1985/6
877	3.18	56.0	38.0	38.0	38.0	16.0	6.5	6.0	41.0	28	163	304	382	171	154	54	204	36	F	1985/6
878	4.99	63.5	44.0	42.0	43.0	20.0	8.5	9.0	38.0	28	190	333	335	200	183	58	234	48	F	1985/6
879	4.20	60.0	42.0	40.0	41.0	19.0	7.5	7.5	36.0	28	189	330	361	189	176	58	215	43	M	1985/6
880	72.96	159.5	106.0	105.0	105.5	38.0	70.0	73.0	95.0	42	420	800	874	423	377	137	650	142	M	1985/6
881	50.01	135.0	96.0	96.0	96.0	37.0	44.0	50.0	88.0	39	369	680	737	363	333	127	557	123	M	1985/6
882	48.76	135.5	94.0	95.0	94.5	37.0	39.5	43.0	87.0	38	376	697	762	383	341	126	538	136	F	1985/6
883	42.64	132.0	88.0	87.0	87.5	39.0	41.0	43.0	83.0	37	354	657	733	366	334	119	535	-	M	1985/6
884	62.14	149.0	102.0	102.0	102.0	-	51.0	52.0	113.0	40	404	727	802	405	375	131	612	129	M	1985/6
885	52.05	143.0	104.0	104.0	104.0	36.0	50.0	52.0	80.0	40	369	702	764	382	346	127	572	136	M	1985/6
886	4.31	60.5	42.0	39.0	40.5	19.0	8.5	9.0	40.0	30	189	328	368	196	179	62	215	46	F	1985/6
887	5.22	65.0	46.0	43.0	44.5	20.0	9.0	9.5	44.0	31	200	362	388	205	186	60	236	48	M	1985/6
888	4.54	63.0	43.0	41.0	42.0	20.0	8.5	8.5	42.0	32	198	341	377	198	177	61	227	48	M	1985/6
889	4.42	63.5	42.0	41.0	41.5	19.0	8.0	8.0	38.0	29	194	341	382	200	183	55	233	43	F	1985/6
890	47.74	137.0	102.0	101.0	101.5	38.0	47.0	57.0	81.0	43	386	712	776	389	350	121	513	129	F	1985/6
891	4.99	63.0	45.0	40.0	42.5	18.5	7.5	7.5	37.0	30	197	347	374	195	183	58	233	42	M	1985/6
892	5.67	69.0	44.0	43.0	43.5	21.0	9.5	10.0	43.0	28	214	361	414	222	196	65	240	53	F	1985/6
893	4.76	63.0	44.0	41.0	42.5	18.5	8.5	9.0	36.0	30	193	348	380	196	181	62	227	46	M	1985/6
894	4.54	63.0	43.0	41.0	42.0	19.0	8.0	8.0	38.0	30	186	340	383	196	180	57	225	47	F	1985/6
895	4.88	65.5	43.0	41.0	42.0	19.5	9.0	9.0	41.0	30	200	358	390	200	182	57	238	45	F	1985/6
896	4.31	62.5	41.0	38.0	39.5	19.5	8.0	9.0	42.0	25	195	344	383	197	182	59	224	46	M	1985/6
897	4.76	63.5	43.0	42.0	42.5	21.0	9.0	9.5	42.0	31	199	345	382	214	181	60	232	53	M	1985/6
898	61.58	151.0	104.0	101.0	102.5	37.0	54.0	61.5	88.0	39	415	755	840	412	374	130	618	140	M	1985/6
899	4.88	64.0	46.0	40.0	43.0	20.0	8.0	8.0	42.0	28	204	362	384	205	184	58	225	51	M	1985/6
900	4.76	63.0	44.0	40.0	42.0	19.0	8.0	8.5	40.0	29	195	342	378	193	173	63	223	46	F	1985/6
901	62.14	149.0	103.0	101.0	102.0	37.0	58.0	64.0	106.0	44	426	754	820	393	369	135	601	131	F	1985/6
902	59.65	147.0	102.0	98.0	100.0	37.0	44.0	58.0	98.0	43	399	732	812	400	365	128	605	144	M	1985/6
903	4.88	61.5	44.0	38.0	41.0	17.5	7.5	8.0	43.0	33	195	347	374	196	177	60	217	47	M	1985/6
904	4.88	63.0	44.0	40.0	42.0	19.0	8.0	8.0	42.0	28	200	352	381	197	184	63	227	48	M	1985/6
905	54.43	144.0	96.0	96.0	96.0	37.0	47.0	55.0	98.0	43	392	674	800	390	354	131	577	128	M	1985/6
906	38.22	130.0	85.0	84.0	84.5	36.0	36.0	42.0	82.0	34	351	634	694	351	320	114	546	115	M	1985/6
907	75.98	165.0	112.0	110.0	111.0	39.5	52.0	57.0	116.0	43	421	796	865	421	381	145	666	149	M	1985/6
908	41.62	131.0	87.0	87.0	87.0	36.0	32.0	45.0	90.0	40	375	661	725	363	335	116	506	127	F	1985/6
909	5.56	67.0	45.0	44.0	44.5	20.0	10.0	9.0	45.0	29	208	359	405	209	194	67	247	48	F	1985/6
910	4.88	64.0	44.0	42.0	43.0	20.0	9.0	9.0	40.0	30	196	355	391	205	189	61	231	50	F	1985/6
911	4.76	62.0	44.0	42.0	43.0	19.0	9.0	9.0	36.0	29	190	347	377	194	178	63	224	45	F	1985/6
912	4.88	64.0	44.0	42.0	43.0	20.0	9.0	8.5	36.0	29	203	349	373	204	186	60	233	52	M	1985/6
913	4.76	63.5	44.0	41.0	42.5	18.0	8.5	9.0	39.0	28	198	356	372	196	183	62	231	49	M	1985/6
914	4.99	63.0	44.0	43.0	43.5	19.5	9.0	9.0	43.0	31	191	356	386	201	180	63	228	44	F	1985/6
915	4.20	61.0	42.0	40.0	41.0	17.5	7.0	7.0	40.0	29	193	335	372	186	177	63	216	49	M	1985/6
916	6.46	69.0	47.0	46.0	46.5	21.0	10.5	10.0	45.0	30	206	365	402	206	192	61	261	54	F	1985/6
917	4.76	63.0	44.0	36.0	40.0	18.0	8.0	7.5	40.0	25	193	332	382	200	175	60	235	50	F	1985/6
918	4.76	63.0	44.0	38.0	41.0	18.0	8.0	7.0	45.0	32	202	351	385	198	182	63	218	52	M	1985/6
919	4.20	62.0	42.0	36.0	39.0	18.0	8.0	8.0	44.0	25	189	337	369	194	170	59	228	49	M	1985/6
920	45.47	135.0	93.0	90.0	91.5	37.0	42.0	59.0	90.0	41	367	685	760	383	347	117	526	128	F	1985/6

No.	(kg.) Wt.	(cm.) F.L.	(cm.) PG	(cm.) AG	(cm.) MG	(cm.) PF	(cm.) 2DF	(cm.) AF	(mm.) M	(mm.) E	(mm.) S-DF	(mm.) S2-DF	(mm.) S-AF	(mm.) S-VF	(mm.) HL	(mm.) S-E	(mm.) Y-T	(mm.) KW	SEX	Year
921	47.40	139.0	93.0	92.0	92.5	35.0	35.0	40.0	99.0	38	387	689	745	397	347	124	567	130	M	1985/6
922	58.06	142.0	97.0	98.0	97.5	32.0	35.5	43.0	108.0	40	386	723	820	393	359	122	570	138	M	1985/6
923	60.10	142.0	103.0	101.0	102.0	38.0	47.0	52.0	103.0	39	389	712	805	394	350	123	577	141	M	1985/6
924	42.86	131.0	87.0	87.0	87.0	34.0	35.0	39.5	77.0	38	368	690	684	367	331	117	533	125	F	1985/6
925	46.49	134.0	91.0	90.0	90.5	36.0	37.5	41.0	91.0	38	378	692	756	369	344	121	538	128	M	1985/6
926	41.96	131.0	90.0	85.0	87.5	37.0	32.0	42.0	83.0	36	353	666	727	353	321	107	532	121	M	1985/6
927	20.07	98.0	69.0	68.0	68.5	27.5	20.0	21.0	65.0	34	289	523	570	285	258	90	383	97	M	1985/6
928	6.92	71.0	47.0	46.0	46.5	22.0	10.5	11.0	43.0	29	217	388	428	216	199	67	262	63	F	1985/6
929	17.12	96.0	65.0	65.0	65.0	28.0	19.0	19.0	60.0	32	293	505	547	285	250	93	368	95	M	1985/6
930	4.88	64.5	43.0	42.0	42.5	19.0	7.5	7.5	31.0	28	198	346	407	207	190	65	226	50	M	1985/6
931	6.24	68.5	46.0	45.0	45.5	21.0	9.5	10.0	40.0	30	205	375	405	213	190	62	255	52	F	1985/6
932	4.99	64.5	43.0	41.0	42.0	19.0	8.5	8.0	33.0	30	196	359	393	209	187	58	235	46	M	1985/6
933	5.33	66.5	45.0	43.0	44.0	19.0	9.0	10.0	40.0	29	200	374	402	205	190	60	246	47	M	1985/6
934	5.56	67.5	45.0	44.0	44.5	21.0	10.0	10.0	41.0	31	204	363	401	211	190	63	245	55	M	1985/6
935	5.90	66.0	47.0	46.0	46.5	19.0	8.5	9.0	44.0	33	188	362	393	201	190	62	242	50	M	1985/6
936	4.65	64.0	41.0	40.0	40.5	19.5	8.5	8.0	41.0	31	189	353	383	207	187	65	235	48	F	1985/6
937	4.99	64.5	42.0	41.0	41.5	19.0	8.5	8.5	42.0	31	208	353	386	189	182	60	230	45	F	1985/6
938	5.44	66.5	44.0	42.0	43.0	20.0	9.0	9.0	38.0	32	200	367	413	218	193	64	241	52	F	1985/6
939	21.32	105.0	70.0	70.0	70.0	31.0	18.0	23.0	81.0	35	293	524	606	310	371	93	412	94	M	1985/6
940	18.82	100.0	67.0	67.0	67.0	28.0	17.0	20.5	60.0	34	284	532	585	284	266	93	392	87	F	1985/6
941	18.48	96.0	67.0	66.0	66.5	30.0	18.0	19.0	60.0	35	293	521	558	282	255	87	362	84	M	1985/6
942	13.83	93.0	61.0	59.0	60.0	28.0	19.0	-	51.0	34	267	471	533	274	244	83	365	89	M	1985/6
943	4.65	64.0	43.0	42.0	42.5	18.5	9.0	7.0	41.0	30	201	357	390	199	181	62	236	43	F	1985/6
944	5.10	62.0	42.0	40.0	41.0	18.0	8.5	8.5	35.0	29	191	340	380	196	180	59	223	45	F	1985/6
945	4.54	63.5	42.0	41.0	41.5	18.0	8.0	8.0	39.0	31	197	352	393	203	184	58	217	45	M	1985/6
946	4.76	62.0	43.0	40.0	41.5	20.5	8.0	8.0	43.0	31	195	345	382	194	175	62	226	46	F	1985/6
947	8.73	77.0	53.0	51.0	52.0	25.0	11.0	12.0	43.0	30	225	411	469	232	215	75	292	68	M	1985/6
948	9.41	79.0	52.0	51.0	51.5	25.5	12.5	13.0	47.0	29	235	421	463	243	222	78	300	70	M	1985/6
949	13.15	92.5	58.0	56.0	57.0	28.0	16.0	17.0	70.0	34	267	482	524	269	243	90	351	89	M	1985/6
950	6.24	69.0	46.0	44.0	45.0	21.0	10.0	10.0	39.0	32	211	381	415	213	195	67	250	52	M	1985/6
951	4.76	64.0	42.0	40.0	41.0	21.0	9.5	9.5	38.0	28	192	355	389	200	185	63	229	45	F	1985/6
952	4.54	62.0	42.0	40.0	41.0	19.0	8.5	8.0	37.0	29	194	346	384	202	180	60	224	47	F	1985/6
953	4.99	64.0	43.0	41.0	42.0	18.0	8.0	8.0	42.0	31	195	351	383	203	180	61	232	50	F	1985/6
954	4.99	64.5	43.0	41.0	42.0	20.0	8.5	9.0	37.0	30	196	346	393	204	187	63	226	47	M	1985/6
955	14.63	92.5	61.0	59.0	60.0	27.0	15.0	17.0	53.0	35	262	483	533	271	246	90	373	81	F	1985/6
956	17.80	99.0	65.0	64.0	64.5	29.0	21.0	23.0	62.0	-	278	515	578	285	264	90	384	-	M	1985/6
957	12.93	90.0	58.0	58.0	58.0	27.0	14.0	14.5	55.0	34	268	478	527	276	237	83	340	83	F	1985/6
958	7.37	71.5	50.0	48.0	49.0	22.0	11.0	12.0	49.0	31	215	388	430	222	204	70	263	61	F	1985/6
959	89.87	143.0	102.0	97.0	99.5	37.5	52.5	60.0	100.0	42	398	747	814	409	365	127	567	144	M	1985/6
960	41.50	136.0	88.0	87.0	87.5	34.0	36.0	45.0	90.0	40	357	675	730	382	332	118	546	124	M	1985/6
961	15.76	93.0	65.0	63.0	64.0	28.0	18.5	19.5	57.0	32	272	492	544	281	247	87	354	96	M	1985/6
962	15.08	92.5	61.0	60.0	60.5	28.0	15.5	19.0	59.0	32	270	494	541	275	247	85	362	92	M	1985/6
963	14.29	90.0	61.0	60.0	60.5	28.5	18.0	21.0	54.0	33	268	486	535	275	244	84	350	82	M	1985/6
964	7.37	73.5	48.0	47.0	47.5	22.0	10.5	11.0	45.0	34	216	403	445	220	200	70	273	64	F	1985/6
965	7.26	73.0	49.0	46.0	47.5	22.0	10.0	10.0	44.0	30	228	402	434	222	204	68	255	60	F	1985/6
966	5.44	66.0	44.0	42.0	43.0	20.0	9.5	9.0	38.0	29	204	371	413	211	188	65	228	51	F	1985/6
967	6.58	71.5	47.0	46.0	46.5	20.0	-	10.5	36.0	32	222	382	428	225	198	65	272	55	M	1985/6
968	5.44	65.0	44.0	43.0	43.5	19.0	9.0	8.0	31.0	25	198	358	400	201	187	61	233	45	F	1985/6
969	4.99	64.5	43.0	42.0	42.5	20.0	8.0	9.0	36.0	27	199	358	415	202	183	65	232	44	F	1985/6
970	5.67	66.5	44.0	44.0	44.0	20.5	9.0	9.5	32.0	28	209	368	400	214	190	61	234	-	F	1985/6
971	5.10	64.0	43.0	43.0	43.0	19.5	8.5	9.0	39.0	31	203	359	380	196	181	62	224	47	M	1985/6
972	4.76	65.0	42.0	40.0	41.0	20.0	9.0	9.0	38.0	32	192	351	379	195	183	60	238	52	F	1985/6
973	2.27	50.0	33.0	31.0	32.0	14.0	5.5	5.0	27.0	24	154	282	302	162	145	47	179	32	M	1985/6
974	55.11	146.0	99.0	96.0	97.5	37.0	56.0	62.0	92.0	46	404	720	804	400	366	132	575	123	M	1985/6
975	15.54	94.0	63.0	62.0	62.5	28.0	16.0	18.0	55.0	33	272	503	555	271	147	88	355	91	M	1985/6
976	2.27	49.0	33.0	32.0	32.5	15.0	5.0	5.0	32.0	33	146	260	308	155	141	43	174	32	M	1985/6
977	51.82	140.0	94.0	90.0	92.0	35.0	42.0	47.5	87.0	37	381	727	786	379	350	124	452	133	M	1985/6
978	61.35	151.0	101.0	95.0	98.0	37.0	62.5	64.0	102.0	45	408	754	828	413	375	128	612	139	F	1985/6
979	62.14	148.0	100.0	100.0	100.0	35.0	50.0	59.0	87.0	38	409	753	825	404	361	127	607	134	F	1985/6
980	69.63	159.0	105.0	102.0	103.5	-	64.0	62.5	98.0	43	431	790	875	430	395	143	638	138	M	1985/6
981	54.88	144.0	97.0	94.0	95.5	37.0	44.0	50.0	85.0	45	391	720	798	383	354	123	573	136	M	1985/6
982	48.08	139.0	92.0	92.0	92.0	36.0	42.0	52.0	91.0	40	387	702	776	370	342	123	559	142	M	1985/6
983	52.16	142.0	93.0	92.0	92.5	34.0	49.0	47.5	101.0	41	387	720	800	395	356	124	557	129	F	1985/6
984	2.15	48.5	32.0	31.0	31.5	14.5	5.0	5.0	33.0	24	146	261	307	145	143	42	173	28	F	1985/6
985	6.80	71.5	48.0	45.0	46.5	22.0	9.5	10.0	50.0	33	224	392	440	223	204	68	259	59	M	1985/6
986	4.65	62.0	43.0	41.0	42.0	19.0	8.0	8.0	36.0	26	192	345	381	196	175	62	222	47	M	1985/6
987	4.76	64.5	43.0	40.0	41.5	21.0	9.0	9.0	43.0	32	198	358	382	199	183	66	231	48	M	1985/6
988	4.54	63.0	42.0	39.0	40.5	19.0	8.5	8.5	39.0	26	200	353	389	204	186	67	228	49	M	1985/6
989	4.76	64.5	42.0	41.0	41.5	19.0	8.5	9.0	38.0	29	195	352	389	201	182	60	232	50	F	1985/6
990	21.43	104.0	74.0	68.0	71.0	30.0	21.0	23.0	73.0	35	315	555	620	304	275	97	392	100	M	1985/6
991	5.10	64.5	44.0	42.0	43.0	19.0	8.0	8.0	45.0	29	198	356	394	205	189	61	224	51	M	1985/6
992	5.22	65.5	44.0	41.0	42.5	19.0	9.0	8.5	35.0	31	198	357	392	203	185	62	237	50	F	1985/6
993	4.54	63.0	43.0	39.0	41.0	18.0	8.0	8.0	40.0	31	196	338	378	188	175	61	232	43	F	1985/6
994	49.78	139.0	93.0	92.0	92.5	36.0	47.5	56.0	84.0	43	382	717	765	384	352	126	554	133	M	1985/6
995	5.22	65.0	45.0	42.0	43.5	20.0	8.5	8.5	42.0	29	207	357	402	211	192	68	234	49	F	1985/6
996	4.88	65.0	43.0	41.0	42.0	20.0	9.0	9.0	42.0	29	192	351	394	206	184	60	232	45	M	1985/6
997	5.44	67.0	44.0	43.0	43.5	21.0	10.0	10.0	46.0	32	200	365	406	215	190	66	245	52	F	1985/6
998	5.56	66.0	44.0	43.0	43.5	20.0	9.0	9.0	40.0	28	202	363	400	207	188	62	235	51	F	1985/6
999	53.30	144.0	95.0	93.0	94.0	36.0	33.0	48.0	114.0	40	392	723	790	401	363	134	587	134	M	1985/6
1000	4.99	63.5	44.0	41.0	42.5	20.0	9.0	9.5	40.0	30	201	346	398	202	183	63	229	47	F	1985/6
1001	5.25	64.0	45.0	41.0	43.0	19.0	9.0	9.5	39.0	30	201	360	380	201	187	61	235	47	F	1985/6
1002	56.70	145.0	95.0	94.0	94.5	36.0	51.5	56.5	96.0	39	395	742	790	401	367	136	574	136	F	1985/6
1003	67.70	153.0	105.0	100.0	102.5	34.0	46.0	55.0	107.0	43	423	779	884	423	384	149	612	135	M	1985/6
1004	6.80	71.0	48.0	46.0	47.0	20.5	10.0	10.0	51.0	30	217	389	417	217	199	69	265	62	F	1985/6
1005	6.12	69.0	47.0	46.0	46.5	20.0	10.0	10.0	48.0	30	211	374	414	210	199	65	260	55	M	1985/6
1006	6.46	71.5	46.0	45.0	45.5	21.5	10.0	10.5	41.0	30	216	383	432	223	202	67	268	58	M	1985/6
1007	6.01	69.0	46.0	43.0	44.5	22.0	9.5	9.5	46.0	-	212	370	414	218	197	72	255	56	M	1985/6
1008	6.35	70.5	46.0	44.0	45.0	20.0	9.5	10.0	45.0	29	214	384	427	224	201	67	261	54	M	1985/6
1009	3.63	58.0	39.0	37.0	38.0	19.0	7.0	7.0	38.0	22	177	324	357	175	165	56	201	41	F	1985/6
1010	4.08	64.5	44.0	41.0	42.5	19.0	8.0	8.5	34.0	26	197	354	395	205	182	60	225	52	F	1985/6
1011	2.38	50.5	34.0	33.0	33.5	15.0	6.0	6.0	35.0	25	154	279	310	162	148	49	183	35	M	1985/6
1012	2.15	48.0	32.0	31.0	31.5	14.0	5.5	5.5	30.0	23	153	273	302	162	141	47	173	36	F	1985/6
1013	6.46	72.0	48.0	45.0	46.5	22.0	11.0	10.5	45.0	28	219	391	433	220	203	74	262	59	F	1985/6
1014	6.24	69.0	47.0	43.0	45.0	21.0	10.0	11.0	48.0	30	217	373	419	209	200	64	260	54	M	1985/6
1015	15.20	93.0	63.0	61.0	62.0	30.0	16.5	18.5	54.0	31	274	494	543	266	243	84	355	86	M	1985/6
1016	8.50	75.5	52.0	51.0	51.5	23.0	11.0	11.5	52.0	28	232	397	444	231	211	70	283	70	M	1985/6
1017	10.43	82.0	55.0	54.0	54.5	23.0	13.0	14.5	48.0	33	252	440	490	259	224	80	305	72	F	1985/6
1018	47.85	139.0	100.0	97.0	98.5	35.0	39.0	43.0	86.0	38	397	713	770	394	350	125	542	127	F	1985/6
1019	7.03	71.0	49.0	46.0	47.5	21.0	10.5	10.5	49.0	31	222	396	422	216	200	67	263	58	F	1985/6
1020	6.92	72.5	48.0	43.0	45.5	21.0	10.5	11.0	44.0	31	222	391	427	215	202	71	274	58	M	1985/6
1021	12.93	89.5	60.0	58.0	59.0	26.0	16.5	17.0	52.0	36	260	469	517	263	234	84	336	83	F	1985/6
1022	7.03	72.0	50.0	46.0	48.0	21.5	10.5	11.0	52.0	30	221	389	428	217	203	70	271	62	M	1985/6
1023	5.78	67.0	47.0	44.0	45.5	20.0	9.0	10.0	45.0	30	204	369	408	212	198	67	244	-	F	1985/6
1024	6.58	71.5	47.0	46.0	46.5	21.0	10.5	11.0	37.0	30	215	382	431	211	192	68	263	56	F	1985/6
1025	6.35	70.0	47.0	45.0	46.0	22.0	11.0	10.5	43.0	30	212	378	431	222	197	71	258	59	F	1985/6
1026	5.90	69.0	45.0	44.0	44.5	20.0	9.5	10.0	46.0	30	210	382	417	214	197	67	250	53	M	1985/6
1027	52.39	143.0	96.0	90.0	93.0	38.0	44.0	54.0	87.0	38	405	731	768	401	361	131	575	135	M	1985/6
1028	46.27	132.0	91.0	89.0	90.0	35.0	30.0	43.0	82.0	37	372	672	740	350	327	117	-	129	M	1985/6
1029	63.28	152.0	102.0	100.0	101.0	38.0	54.5	63.0	112.0	40	404	748	843	401	370	133	632	139	F	1985/6
1030	47.97	139.0	94.0	88.0	91.0	35.0	43.0	50.0	104.0	41	385	703	788	394	351	128	545	129	F	1985/6
1031	41.50	131.0	87.0	85.0	86.0	34.0	34.0	39.0	85.0	43	374	675	723	358	331	120	537	116	F	1985/6
1032	49.90	135.0	97.0	95.0	96.0	35.0	40.0	48.0	102.0	42	392	700	755	370	342	122	517	123	F	1985/6
1033	7.37	74.0	50.0	47.0	48.5	21.0	11.0	12.0	46.0	30	224	409	436	227	210	77	276	59	M	1985/6
1034	2.27	47.0	34.0	32.0	33.0	14.0	5.0	5.5	29.0	23	150	265	293	155	143	45	170	28	F	1985/6
1035	2.04	47.5	33.0	30.0	31.5	14.0	5.0	5.0	29.0	26	153	271	302	157	146	47	264	30	F	1985/6

No.	(kg.) Wt.	(cm.) F.L.	(cm.) PG	(cm.) AG	(cm.) MG	(cm.) PF	(cm.) 2DF	(cm.) AF	(mm.) M	(mm.) E	(mm.) S-DF	(mm.) S2-DF	(mm.) S-AF	(mm.) S-VF	(mm.) HL	(mm.) S-E	(mm.) Y-T	(mm.) KW	SEX	Year
1036	7.37	70.5	47.0	45.0	46.0	23.0	10.0	10.0	48.0	29	217	384	422	224	203	72	254	55	M	1985/6
1037	11.45	84.0	59.0	56.0	57.5	24.0	12.0	14.0	55.0	33	261	457	493	245	233	78	307	71	M	1985/6
1038	77.56	158.0	115.0	107.0	111.0	39.0	55.0	58.0	125.0	44	427	802	874	450	399	143	645	151	M	1985/6
1039	20.87	103.0	70.0	68.0	69.0	31.0	19.0	22.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1040	19.16	100.5	69.0	66.0	67.5	31.0	24.0	23.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1041	20.98	104.5	71.0	68.0	69.5	32.0	24.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1042	16.90	98.5	65.0	64.0	64.5	30.0	22.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1043	21.55	108.0	70.0	68.0	69.0	32.0	22.0	27.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1044	20.07	104.0	67.0	66.0	66.5	29.0	23.0	24.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1045	20.53	106.0	71.0	66.0	68.5	30.0	23.0	21.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1046	24.61	112.0	74.0	72.0	73.0	32.0	21.0	24.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1047	20.41	105.0	68.0	65.0	66.5	31.0	20.0	23.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1048	21.09	108.0	72.0	68.0	70.0	31.0	20.0	23.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1049	19.73	105.0	70.0	64.0	67.0	31.0	22.0	23.5	-	-	-	-	-	-	-	-	-	-	M	1986/7
1050	18.48	102.0	68.0	64.0	66.0	29.0	21.0	19.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1051	18.82	103.0	68.0	64.0	66.0	31.0	23.0	26.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1052	21.32	108.0	74.0	66.0	70.0	29.0	24.0	25.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1053	20.87	109.0	72.0	66.0	69.0	32.0	26.0	28.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1054	19.05	102.0	70.0	62.0	66.0	29.0	18.0	21.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1055	4.08	60.0	42.0	31.0	36.5	19.0	8.0	9.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1056	3.86	60.0	40.0	38.0	39.0	17.0	7.0	7.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1057	18.60	109.5	73.0	70.0	71.5	30.0	21.0	22.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1058	18.48	102.0	68.0	66.0	67.0	30.0	21.0	23.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1059	23.25	106.0	76.0	72.0	74.0	32.0	22.0	27.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1060	22.68	111.0	71.0	68.0	69.5	32.0	26.0	30.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1061	20.87	107.0	73.0	70.0	71.5	31.0	23.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1062	22.57	105.0	72.0	69.0	70.5	31.0	24.0	25.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1063	22.91	109.0	70.0	69.0	69.5	31.0	24.0	27.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1064	19.96	107.0	69.0	66.0	67.5	33.0	21.5	25.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1065	23.81	109.0	73.0	72.0	72.5	33.0	23.0	29.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1066	21.77	112.0	71.0	71.0	71.0	33.0	25.0	29.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1067	23.47	110.0	70.0	68.0	69.0	32.0	23.0	27.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1068	20.07	105.0	70.0	68.0	69.0	32.0	22.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1069	25.29	112.0	76.0	74.0	75.0	31.0	24.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1070	19.39	104.0	68.0	66.0	67.0	29.0	23.0	25.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1071	19.16	104.0	70.0	66.0	68.0	30.0	22.0	23.5	-	-	-	-	-	-	-	-	-	-	F	1986/7
1072	22.34	108.0	70.0	68.0	69.0	32.0	24.0	26.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1073	22.34	106.0	73.0	72.0	72.5	29.0	22.0	23.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1074	22.00	108.0	70.0	67.0	68.5	30.0	20.0	22.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1075	19.39	102.0	68.0	68.0	68.0	30.0	18.0	20.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1076	22.45	109.5	72.0	71.0	71.5	33.0	24.0	27.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1077	22.23	107.0	71.0	69.0	70.0	33.0	25.0	28.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1078	19.73	103.0	69.0	67.0	68.0	31.0	24.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1079	20.75	109.0	67.0	66.0	66.5	32.0	25.0	27.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1080	4.08	61.5	40.0	38.0	39.0	19.0	6.0	6.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1081	22.45	110.0	71.0	68.0	69.5	32.0	24.0	26.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1082	16.44	94.0	64.0	61.0	62.5	29.0	15.0	18.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1083	22.68	106.0	72.0	71.0	71.5	31.0	22.0	24.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1084	22.45	108.0	71.0	68.0	69.5	31.0	25.0	25.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1085	20.41	103.0	70.0	67.0	68.5	28.0	19.0	21.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1086	21.89	108.0	70.0	68.0	69.0	31.0	23.0	23.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1087	20.87	108.0	70.0	67.0	68.5	31.0	18.0	24.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1088	19.28	104.0	68.0	66.0	67.0	29.0	26.0	30.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1089	19.96	107.0	69.0	66.0	67.5	32.0	20.0	22.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1090	19.16	106.0	69.0	66.0	67.5	32.0	22.0	24.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1091	20.98	104.0	71.0	68.0	69.5	31.0	19.0	22.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1092	20.53	106.0	70.0	66.0	68.0	31.0	20.0	22.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1093	48.53	140.0	94.0	88.0	91.0	35.0	52.0	61.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1094	53.41	142.0	96.0	94.0	95.0	35.0	52.0	64.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1095	21.32	105.0	71.0	67.0	69.0	29.0	24.0	27.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1096	20.53	105.0	70.0	68.0	69.0	31.0	23.0	24.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1097	19.96	105.0	68.0	65.0	66.5	31.0	20.0	22.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1098	18.60	101.0	68.0	66.0	67.0	30.0	20.0	21.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1099	19.84	103.0	68.0	68.0	68.0	32.0	23.0	24.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1100	22.57	105.0	70.0	68.0	69.0	30.0	23.0	23.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1101	19.73	102.0	70.0	68.0	69.0	31.0	21.0	23.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1102	20.41	106.0	68.0	66.0	67.0	32.0	21.0	23.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1103	54.32	143.0	95.0	96.0	95.5	38.0	49.0	55.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1104	22.00	106.0	70.0	68.0	69.0	31.0	25.0	25.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1105	21.77	107.0	71.0	68.0	69.5	30.0	23.0	27.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1106	21.55	106.0	71.0	67.0	69.0	29.0	20.0	24.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1107	19.73	103.0	68.0	65.0	66.5	30.0	23.0	26.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1108	21.43	106.0	70.0	68.0	69.0	31.0	25.0	25.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1109	19.73	102.0	68.0	66.0	67.0	33.0	18.0	21.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1110	23.36	109.0	72.0	71.0	71.5	31.0	25.0	24.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1111	24.27	111.0	74.0	71.0	72.5	32.0	31.0	38.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1112	22.45	107.0	72.0	71.0	71.5	32.0	25.0	26.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1113	20.18	102.0	69.0	67.0	68.0	30.0	19.0	21.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1114	19.73	105.0	70.0	65.0	67.5	31.0	22.0	28.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1115	23.59	107.0	74.0	71.0	72.5	31.0	24.0	25.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1116	23.70	110.0	75.0	73.0	74.0	30.0	22.0	23.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1117	22.68	106.0	73.0	70.0	71.5	30.0	24.0	26.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1118	22.34	106.0	74.0	70.0	72.0	32.0	21.0	23.5	-	-	-	-	-	-	-	-	-	-	M	1986/7
1119	19.96	104.0	69.0	67.0	68.0	30.0	19.0	23.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1120	22.68	107.0	73.0	69.0	71.0	32.0	23.0	24.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1121	22.00	108.0	70.0	69.0	69.5	30.0	22.0	24.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1122	19.16	103.0	66.0	65.0	65.5	30.0	19.0	20.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1123	22.91	106.0	72.0	71.0	71.5	32.0	24.0	24.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1124	20.87	104.0	71.0	68.0	69.5	34.0	21.0	24.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1125	23.13	109.0	72.0	70.0	71.0	31.0	24.0	24.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1126	20.87	106.0	70.0	67.0	68.5	31.0	24.0	24.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1127	4.76	62.5	44.0	40.0	42.0	19.0	8.0	8.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1128	6.69	72.0	48.0	44.0	46.0	22.0	11.0	11.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1129	6.80	70.0	49.0	45.0	47.0	21.0	9.0	11.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1130	46.15	135.0	95.0	92.0	93.5	35.0	31.0	37.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1131	18.71	102.0	70.0	66.0	68.0	30.0	18.0	22.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1132	24.72	110.0	75.0	71.0	73.0	31.0	25.0	28.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1133	22.68	110.0	71.0	71.0	71.0	32.0	23.0	27.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1134	24.38	108.0	75.0	74.0	74.5	32.0	22.0	26.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1135	23.02	107.0	73.0	71.0	72.0	30.0	-	25.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1136	22.91	108.0	73.0	71.0	72.0	28.0	19.0	22.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1137	24.83	113.0	74.0	71.0	72.5	31.0	25.0	28.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1138	20.75	106.0	71.0	69.0	70.0	30.0	25.0	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1139	20.98	103.0	71.0	69.0	70.0	32.0	21.0	22.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1140	20.75	107.0	70.0	67.0	68.5	30.0	21.0	23.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1141	22.00	107.0	72.0	68.0	70.0	31.0	23.0	26.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1142	25.63	111.0	76.0	73.0	74.5	31.0	21.0	24.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1143	20.75	106.0	70.0	69.0	69.5	31.0	19.0	23.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1144	25.17	112.0	75.0	73.0	74.0	32.0	23.0	25.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1145	24.38	111.0	73.0	72.0	72.5	34.0	25.0	28.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1146	24.72	109.0	74.0	72.0	73.0	32.0	22.0	38.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1147	21.32	105.0	71.0	67.0	69.0	31.0	24.0	27.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1148	25.74	113.0	75.0	72.0	73.5	32.0	27.0	35.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1149	23.25	110.0	71.0	70.0	70.5	29.0	24.0	27.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1150	22.45	110.0	70.0	67.0	68.5	32.0	24.0	26.0	-	-	-	-	-	-	-	-	-	-	M	1986/7

No.	(kg.) Wt.	(cm.) F.L.	(cm.) PG	(cm.) AG	(cm.) MG	(cm.) PF	(cm.) 2DF	(cm.) AF	(mm.) M	(mm.) E	(mm.) S-DF	(mm.) S2-DF	(mm.) S-AF	(mm.) S-VF	(mm.) HL	(mm.) S-E	(mm.) Y-T	(mm.) KW	SEX	Year
1151	21.77	105.0	71.0	70.0	70.5	32.0	19.0	21.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1152	24.83	112.0	73.0	72.0	72.5	32.0	23.0	24.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1153	18.26	100.0	66.0	66.0	66.0	27.0	19.0	22.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1154	18 82	102.0	68.0	63.0	65.5	31.0	23.0	23.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1155	22.91	108.0	72.0	70.0	71.0	33.0	20.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1156	20.41	105.0	68.0	67.0	67.5	31.0	20.0	22.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1157	22.57	107.0	70.0	70.0	70.0	31.0	20.0	23.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1158	21.89	105.0	70.0	67.0	68.5	30.0	22.0	24.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1159	19.96	105.0	68.0	66.0	67.0	33.0	28.0	26.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1160	20.07	103.0	67.0	67.0	67.0	30.0	21.0	24.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1161	21.43	106.0	71.0	69.0	70.0	30.0	20.0	23.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1162	22.23	112.0	75.0	74.0	74.5	34.0	27.0	30.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1163	26.31	107.0	72.0	70.0	71.0	30.0	27.0	29.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1164	22.23	106.0	70.0	68.0	69.0	32.0	23.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1165	20.64	110 0	71.0	68 0	69.5	32.0	25.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1166	22.91	106.0	75.0	72.0	73.5	31.0	23.0	25.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1167	21.32	108.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1168	22.91	108.0	73.0	70.0	71.5	34.0	26.0	30.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1169	20.07	102.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1170	24.15	112.0	74.0	70.0	72.0	32.0	25.0	29.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1171	29.48	116.0	78.0	77.0	77.5	32.0	28.0	36.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1172	23.36	107.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1173	20.18	104.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1174	24.27	108.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1175	21.55	106.0	70.0	67.0	68.5	30.0	22.0	23.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1176	25.06	110.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1177	28.12	116.0	78.0	77.0	77.5	30.0	25.0	27.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1178	23.02	107.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1179	28.24	116.0	76.0	76.0	76.0	32.0	25.0	25.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1180	22.00	110.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1181	21.21	104.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1182	22.79	104.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1183	21.89	107.0	71.0	67.0	69.0	32.0	23.0	22.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1184	24.15	108.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1185	22.34	108.0	71.0	70.0	70.5	30.0	21.0	17.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1186	23.02	108.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1187	25.63	115.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1188	21.32	105.0	70.0	69.0	69.5	31.0	21.0	24.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1189	22.00	105.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1190	23.02	108.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1191	24.72	114.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1192	30.73	117.0	78.0	78.0	78.0	32.0	28.0	32.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1193	26.08	113.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1194	21.55	106.0	70.0	68.0	69.0	32.0	22.0	24.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1195	41.96	136.0	88.0	86.0	87.0	33.0	23.0	44.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1196	22.34	107.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1197	24.04	110.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1198	23.34	105.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1199	26.54	114.0	75.0	75.0	75.0	32.0	26.0	26.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1200	21.43	106.0	73.0	71.0	72.0	-	22.0	27.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1201	21.32	107.0	70.0	67.0	68.5	31.0	21.0	23.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1202	19 85	104.0	70.0	68.0	69.0	30.0	21.0	22.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1203	20.41	104.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1204	19 85	103.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1205	25.74	113.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1206	22.79	110.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1207	19.85	104.0	70.0	68.0	69.0	30.0	22.0	22.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1208	22.00	108.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1209	20.64	106.0	71.0	66.0	68.5	32.0	20.0	24.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1210	20.07	102.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1211	24.49	109.0	74.0	72.0	73.0	31.0	22.0	24.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1212	22.34	106.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1213	19 05	101.0	67.0	64.0	65.5	31.0	23.0	23.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1214	23.13	111.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1215	20.64	103 0	69.0	68.0	68.5	29.0	19.0	21.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1216	21.66	106.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1217	21.32	105.0	70.0	66.0	68 0	31.0	22.0	28.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1218	20.19	105.0	68.0	68 0	68.0	30.0	23.0	24.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1219	22.79	107.0	71.0	69.0	70.0	33.0	25.0	26.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1220	22.68	109.0	73.0	70.0	71.5	32.0	26.0	26.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1221	29.03	117.0	77.0	74.0	75.5	33.0	32.0	36.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1222	24.15	109.0	74.0	72.0	73.0	32.0	21.0	23.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1223	22.11	105.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1224	19.73	104.0	71.0	64.0	66.5	25.0	20.0	23.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1225	23.93	111.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1226	21.09	108 0	71.0	68.0	69.5	31.0	22.0	25.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1227	25.63	113.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1228	23.13	109.0	72.0	69.0	70.5	30.0	24.0	27.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1229	23.81	111.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1230	21.21	106.0	72.0	71.0	71.5	32.0	21.0	22.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1231	27.67	117.0	76.0	75.0	75.5	34.0	29.0	31.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1232	22.11	109.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1233	28.35	119.0	74.0	71.0	72.5	35.0	27.0	30.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1234	20.07	104.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1235	54.32	143.0	96.0	96.0	96.0	39.0	54.0	58.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1236	6.69	70.5	48.0	48.0	48.0	22.0	10.0	11.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1237	53.87	143.0	98.0	94.0	96.0	35.0	48.0	53.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1238	21.89	108.0	73.0	67.0	70.0	31.0	21.0	23.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1239	21.55	106.0	71.0	70.0	70.5	31.0	24.0	27.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1240	4.20	61.0	42.0	40.0	41.0	19.0	8.0	9.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1241	26.42	111.0	76.0	74.0	75.0	32.0	23.0	28.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1242	19.96	105.0	69.0	66.0	67.5	30.0	23.0	24.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1243	21.55	107.0	72.0	68.0	70.0	31.0	24.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1244	24.27	110.0	74.0	70.0	72.0	29.0	20.0	25.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1245	54.09	144.0	94.0	93.0	93.5	37.0	52.0	63.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1246	25.63	110.0	75.0	72.0	73.5	31.0	23.0	23.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1247	23.13	107.0	71.0	68.0	69.5	32.0	22.0	23.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1248	5.10	65.0	43.0	41.0	42.0	19.0	8.0	9.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1249	26.08	112.0	74.0	72.0	73.0	32.0	24.0	26.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1250	22.34	108.0	71.0	69.0	70.0	32.0	26 0	28 0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1251	23.13	107.0	72.0	70.0	71.0	33.0	24.0	27.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1252	23.81	110.0	73.0	72.0	72.5	32.0	24.0	27.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1253	23.25	106.0	74.0	70.0	72.0	32.0	25.0	2.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1254	22.79	110.0	70.0	68.0	69.0	30.0	24.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1255	22.23	109.0	70.0	64.0	67.0	31.0	20.0	23.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1256	24.15	113.0	70.0	67.0	68.5	26.0	24.0	30.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1257	22.68	108.0	70.0	68.0	69.0	29.0	24.0	26.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1258	26.99	116.0	74.0	72.0	73.0	31.0	24.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1259	23.70	109.0	72.0	70.0	71.0	32.0	23.0	24.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1260	32.55	119.0	83.0	78.0	80.5	33.0	30.0	29.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1261	23.36	109.5	74.0	70.0	72.0	29.0	26.0	31.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1262	23.93	109.0	74.0	70.0	72.0	30.0	22.0	23.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1263	26.76	116.0	75.0	74.0	74.5	32.0	28.0	32.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1264	5.56	65.0	46.0	43.0	44.5	19.0	9.0	9.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1265	5.44	65.0	45.0	42.0	43.5	19.0	8.0	9.0	-	-	-	-	-	-	-	-	-	-	F	1986/7

No.	(kg.) Wt.	(cm.) F.L.	(cm.) PG	(cm.) AG	(cm.) MG	(cm.) PF	(cm.) 2DF	(cm.) AF	(mm.) M	(mm.) E	(mm.) S-DF	(mm.) S2-DF	(mm.) S-AF	(mm.) S-VF	(mm.) HL	(mm.) S-E	(mm.) Y-T	(mm.) KW	SEX	Year
1266	7.71	73.0	49.0	48.0	48.5	24.0	12.0	12.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1267	21.89	108.0	72.0	70.0	71.0	31.0	22.0	23.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1268	28.01	117.0	78.0	76.0	77.0	33.0	26.0	29.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1269	22.23	108.0	71.0	68.0	69.5	29.0	23.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1270	25.06	113.0	75.0	70.0	72.5	32.0	25.0	31.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1271	30.50	119.0	78.0	79.0	78.5	31.0	23.0	27.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1272	24.04	109.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1273	18.71	102.0	69.0	66.0	67.5	28.0	17.0	20.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1274	24.49	112.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1275	21.77	108.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1276	27.67	115.0	77.0	74.0	75.5	33.0	28.0	28.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1277	25.06	114.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1278	27.44	116.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1279	22.79	110.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1280	2.38	49.0	33.0	32.0	32.5	15.0	5.0	5.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1281	2.15	47.0	33.0	31.0	32.0	14.0	5.0	5.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1282	26.76	113.0	76.0	75.0	75.5	33.0	19.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1283	25.97	115.0	76.0	73.0	74.5	32.0	24.0	26.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1284	21.66	108.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1285	24.15	111.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1286	22.23	105.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1287	23.13	107.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1288	25.40	114.0	74.0	72.0	73.0	34.0	25.0	28.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1289	23.25	109.0	73.0	69.0	71.0	31.0	23.0	26.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1290	24.72	110.0	74.0	72.0	73.0	31.0	25.0	27.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1291	23.36	108.0	74.0	70.0	72.0	33.0	24.0	26.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1292	25.06	112.0	72.0	70.0	71.0	32.0	27.0	29.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1293	21.89	107.0	69.0	66.0	67.5	31.0	23.0	26.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1294	23.13	107.0	72.0	70.0	71.0	32.0	23.0	27.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1295	23.59	106.0	73.0	69.0	71.0	31.0	23.0	18.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1296	21.66	104.0	72.0	69.0	70.5	33.0	22.0	24.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1297	19.50	102.0	68.0	67.0	67.5	31.0	24.0	27.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1298	24.61	110.0	73.0	71.0	72.0	31.0	22.0	27.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1299	23.81	110.0	70.0	68.0	69.0	33.0	26.0	23.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1300	24.27	110.0	74.0	72.0	73.0	33.0	23.0	26.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1301	24.61	110.0	74.0	73.0	73.5	30.0	24.0	25.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1302	23.25	110.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1303	21.32	107.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1304	25.63	112.0	75.0	74.0	74.5	32.0	21.0	22.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1305	24.49	109.0	74.0	73.0	73.5	31.0	23.0	21.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1306	22.79	107.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1307	25.17	109.0	74.0	74.0	74.0	31.0	28.0	30.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1308	25.40	113.0	75.0	74.0	74.5	33.0	24.0	27.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1309	20.87	106.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1310	22.79	110.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1311	21.21	105.0	69.0	67.0	68.0	21.0	21.0	24.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1312	22.91	106.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1313	21.32	104.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1314	23.93	107.0	75.0	70.0	72.5	22.0	22.0	26.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1315	21.43	107.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1316	57.49	148.0	106.0	99.0	102.5	38.0	38.0	52.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1317	4.54	62.0	43.0	40.0	41.5	9.0	9.0	8.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1318	4.99	64.0	45.0	42.0	43.5	9.0	9.0	9.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1319	51.71	144.0	100.0	90.0	95.0	38.0	38.0	49.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1320	26.31	112.0	78.0	75.0	76.5	23.0	23.0	28.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1321	26.42	116.0	78.0	72.0	75.0	24.0	24.0	26.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1322	4.88	61.0	44.0	40.0	42.0	8.0	8.0	8.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1323	29.82	115.0	80.0	79.0	79.5	25.0	25.0	27.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1324	5.56	65.0	46.0	44.0	45.0	9.0	9.0	11.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1325	5.78	65.0	46.0	43.0	44.5	20.0	10.0	11.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1326	21.43	106.0	73.0	70.0	71.5	33.0	24.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1327	28.69	116.0	79.0	76.0	77.5	33.0	29.0	34.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1328	28.24	117.0	80.0	76.0	78.0	34.0	26.0	27.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1329	32.43	119.0	84.0	78.0	81.0	35.0	32.0	35.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1330	25.06	111.0	77.0	73.0	75.0	30.0	23.0	23.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1331	21.66	103.0	72.0	69.0	70.5	30.0	20.0	21.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1332	23.13	109.0	74.0	69.0	71.5	30.0	24.0	27.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1333	5.56	67.0	46.0	42.0	44.0	22.0	10.0	10.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1334	23.25	108.0	74.0	73.0	73.5	32.0	22.0	23.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1335	26.31	113.0	77.0	75.0	76.0	33.0	24.0	26.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1336	23.13	110.0	73.0	71.0	72.0	31.0	20.0	25.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1337	31.75	121.0	83.0	80.0	81.5	33.0	31.0	37.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1338	4.88	64.0	44.0	42.0	43.0	20.0	9.0	9.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1339	28.24	115.0	78.0	76.0	77.0	32.0	25.0	26.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1340	3.97	60.0	42.0	39.0	40.5	18.0	7.0	7.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1341	4.88	64.0	44.0	42.0	43.0	20.0	9.0	9.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1342	24.27	109.0	74.0	73.0	73.5	31.0	25.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1343	26.31	115.0	76.0	75.0	75.5	35.0	30.0	32.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1344	24.04	112.0	75.0	73.0	74.0	32.0	25.0	30.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1345	26.99	115.0	79.0	73.0	76.0	33.0	27.0	29.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1346	24.04	110.0	74.0	70.0	72.0	32.0	24.0	30.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1347	20.19	106.0	70.0	67.0	68.5	31.0	21.0	23.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1348	22.91	108.0	74.0	71.0	72.5	32.0	24.0	27.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1349	22.79	110.0	74.0	71.0	72.5	33.0	24.0	26.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1350	23.25	108.0	74.0	72.0	73.0	31.0	25.0	23.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1351	23.13	107.0	75.0	72.0	73.5	31.0	26.0	28.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1352	5.44	65.0	46.0	42.0	44.0	20.0	9.0	9.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1353	5.33	65.0	46.0	41.0	43.5	20.0	9.0	9.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1354	22.00	110.0	74.0	71.0	72.5	32.0	24.0	27.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1355	-	112.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1356	24.95	110.0	78.0	73.0	75.5	32.0	27.0	29.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1357	23.13	107.0	74.0	71.0	72.5	31.0	22.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1358	25.06	112.0	75.0	74.0	74.5	30.0	21.0	23.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1359	2.15	48.0	33.0	32.0	32.5	14.0	5.0	5.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1360	1.93	45.0	31.0	30.0	30.5	14.0	4.0	4.5	-	-	-	-	-	-	-	-	-	-	F	1986/7
1361	2.15	47.0	32.0	31.0	31.5	14.0	5.0	5.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1362	17.12	98.0	67.0	66.0	66.5	29.0	-	19.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1363	54.89	143.0	98.0	97.0	97.5	37.0	53.0	60.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1364	22.34	109.0	73.0	71.0	72.0	33.0	23.0	26.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1365	19.73	102.0	72.0	67.0	69.5	30.0	21.0	22.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1366	19.39	104.0	71.0	68.0	69.5	33.0	21.0	23.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1367	39.12	128.0	88.0	88.0	88.0	35.0	27.0	42.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1368	23.47	110.0	73.0	72.0	72.5	31.0	25.0	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1369	4.99	63.0	46.0	42.0	44.0	19.0	8.5	8.5	-	-	-	-	-	-	-	-	-	-	F	1986/7
1370	5.10	66.0	45.0	42.0	43.5	20.0	9.0	10.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1371	4.76	64.0	45.0	41.0	43.0	20.0	9.0	9.5	-	-	-	-	-	-	-	-	-	-	M	1986/7
1372	21.09	105.0	72.0	68.0	70.0	28.0	21.0	23.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1373	23.81	109.0	74.0	71.0	72.5	32.0	23.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1374	21.89	106.5	73.0	70.0	71.5	31.0	21.0	24.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1375	5.67	67.0	46.0	45.0	45.5	21.0	10.0	10.5	-	-	-	-	-	-	-	-	-	-	F	1986/7
1376	53.52	141.0	95.0	94.0	94.5	36.0	34.0	43.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1377	19.96	101.0	70.0	68.0	69.0	28.0	19.0	10.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1378	24.49	112.0	74.0	71.0	72.5	31.0	23.0	25.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1379	24.72	112.0	74.0	73.0	73.5	33.0	25.0	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1380	21.32	105.0	72.0	69.0	70.5	29.0	20.0	22.0	-	-	-	-	-	-	-	-	-	-	F	1986/7

No.	(kg.) Wt.	(cm.) F.L.	(cm.) PG	(cm.) AG	(cm.) MG	(cm.) PF	(cm.) 2DF	(cm.) AF	(mm.) M	(mm.) E	(mm.) S-DF	(mm.) S2-DF	(mm.) S-AF	(mm.) S-VF	(mm.) HL	(mm.) S-E	(mm.) Y-T	(mm.) KW	SEX	Year
1381	24.83	112.0	75.0	71.0	73.0	33.0	23.0	28.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1382	26.99	115.0	75.0	75.0	75.0	33.0	28.0	29.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1383	25.97	115.0	75.0	72.0	73.5	32.0	25.0	28.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1384	26.20	112.0	76.0	74.0	75.0	-	22.0	28.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1385	27.33	115.0	76.0	75.0	75.5	34.0	27.0	30.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1386	26.20	113.0	76.0	74.0	75.0	32.0	29.0	30.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1387	23.81	112.0	73.0	72.0	72.5	32.0	25.0	29.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1388	24.27	112.0	72.0	69.0	70.5	30.0	25.0	28.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1389	20.98	106.0	70.0	67.0	68.5	32.0	22.0	25.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1390	5.56	66.0	45.0	42.0	43.5	19.0	9.0	9.5	-	-	-	-	-	-	-	-	-	-	F	1986/7
1391	5.44	65.5	46.0	42.0	44.0	21.0	9.0	9.5	-	-	-	-	-	-	-	-	-	-	F	1986/7
1392	5.33	64.0	45.0	42.0	43.5	20.0	9.0	9.5	-	-	-	-	-	-	-	-	-	-	F	1986/7
1393	5.56	66.0	46.0	44.0	45.0	20.0	9.0	9.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1394	22.68	109.0	72.0	71.0	71.5	32.0	19.0	23.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1395	23.36	110.0	72.0	71.0	71.5	34.0	25.0	27.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1396	5.67	67.0	45.0	43.0	44.0	20.0	9.0	10.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1397	24.04	110.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1398	21.77	106.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1399	21.77	107.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1400	23.47	109.0	73.0	72.0	72.5	31.0	24.0	28.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1401	23.02	106.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1402	24.61	109.0	76.0	73.0	74.5	31.0	24.0	24.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1403	22.23	105.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1404	22.57	108.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1405	20.41	105.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1406	22.79	107.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1407	21.89	106.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1408	19.85	102.0	69.0	67.0	68.0	31.0	22.0	24.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1409	26.31	113.0	77.0	72.0	74.5	31.0	26.0	29.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1410	23.47	110.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1411	25.06	113.0	74.0	72.0	73.0	32.0	23.0	27.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1412	22.79	109.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1413	21.43	104.0	72.0	69.0	70.5	29.0	20.0	21.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1414	24.04	112.0	73.0	70.0	71.5	32.0	26.0	28.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1415	5.44	65.5	45.0	44.0	44.5	21.0	9.0	10.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1416	5.33	66.0	44.0	44.0	44.0	19.0	9.0	9.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1417	5.56	66.0	45.0	44.0	44.5	20.0	8.5	9.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1418	3.86	58.5	40.0	38.0	39.0	17.0	7.0	7.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1419	25.97	115.0	76.0	73.0	74.5	32.0	25.0	29.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1420	23.81	112.0	72.0	70.0	71.0	33.0	24.0	24.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1421	23.13	109.0	72.0	71.0	71.5	30.0	21.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1422	24.95	112.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1423	31.30	120.0	78.0	80.0	79.0	33.0	29.0	35.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1424	46.27	138.0	92.0	91.0	91.5	37.0	28.0	35.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1425	28.24	118.0	77.0	74.0	75.5	31.0	33.0	27.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1426	23.36	107.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1427	23.36	110.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1428	22.00	108.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1429	27.56	114.0	76.0	76.0	76.0	34.0	31.0	34.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1430	33.00	119.0	88.0	80.0	84.0	32.0	31.0	37.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1431	26.08	113.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1432	21.32	104.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1433	48.42	135.0	92.0	92.0	92.0	37.0	44.0	46.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1434	21.09	104.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1435	20.98	108.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1436	28.35	116.0	79.0	76.0	77.5	32.0	32.0	37.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1437	27.90	115.0	76.0	76.0	76.0	29.0	21.0	23.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1438	24.49	110.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1439	21.32	106.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1440	20.87	106.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1441	20.41	105.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1442	22.68	111.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1443	22.79	107.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1444	25.63	114.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1445	24.95	111.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1446	23.59	108.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1447	25.63	112.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1448	20.07	105.0	69.0	66.0	67.5	32.0	20.0	23.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1449	24.49	114.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1450	25.63	113.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1451	20.98	106.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1452	23.93	111.0	74.0	69.0	71.5	31.0	23.0	24.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1453	24.49	115.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1454	26.99	115.0	76.0	73.0	74.5	32.0	27.0	29.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1455	23.36	111.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1456	20.07	103.0	70.0	66.0	68.0	32.0	22.0	23.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1457	23.23	108.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1458	24.27	109.0	72.0	70.0	71.0	32.0	28.0	29.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1459	24.38	111.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1460	23.13	109.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1461	20.75	107.0	69.0	66.0	67.5	32.0	23.0	26.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1462	24.15	110.0	74.0	73.0	73.5	32.0	28.0	32.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1463	23.25	106.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1464	28.12	117.0	78.0	76.0	77.0	33.0	28.0	28.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1465	22.23	108.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1466	23.02	111.0	73.0	70.0	71.5	32.0	23.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1467	22.68	107.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1468	21.89	106.0	72.0	71.0	71.5	28.0	21.0	19.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1469	22.11	110.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1470	29.26	118.0	77.0	76.0	76.5	33.0	27.0	29.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1471	21.77	106.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	1986/7
1472	20.75	105.0	71.0	70.0	70.5	31.0	23.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1473	36.29	124.0	86.0	84.0	85.0	34.0	33.0	41.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1474	31.64	118.0	81.0	80.0	80.5	33.0	26.0	30.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1475	20.53	107.0	71.0	66.0	68.5	30.0	23.0	27.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1476	22.45	107.0	72.0	70.0	71.0	32.0	25.0	28.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1477	27.90	115.0	78.0	74.0	76.0	32.0	23.0	27.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1478	23.02	111.0	72.0	70.0	71.0	30.0	23.0	23.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1479	28.69	117.0	78.0	68.0	73.0	33.0	25.0	28.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1480	21.77	106.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1481	21.77	106.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	1986/7
1482	5.22	66.0	45.0	43.0	44.0	21.0	9.0	10.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1483	5.44	67.0	46.0	44.0	45.0	21.0	9.0	10.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1484	5.33	66.0	45.0	43.0	44.0	20.0	9.0	10.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1485	5.67	67.0	45.0	43.0	44.0	20.0	10.0	10.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1486	5.67	66.5	46.0	44.0	45.0	22.0	10.0	11.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1487	4.20	60.5	41.0	39.0	40.0	19.0	8.0	9.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1488	5.10	65.5	44.0	43.0	43.5	20.0	9.0	9.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1489	5.22	63.0	46.0	41.0	43.5	19.0	9.0	9.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1490	4.08	60.0	41.0	38.0	39.5	19.0	8.0	8.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1491	5.67	65.5	45.0	44.0	44.5	19.0	9.0	9.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1492	4.08	60.0	41.0	40.0	40.5	18.0	8.0	7.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1493	12.25	86.0	60.0	58.0	59.0	27.0	16.0	15.0	-	-	-	-	-	-	-	-	-	-	F	1986/7
1494	6.01	69.5	47.0	45.0	46.0	21.0	10.0	11.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1495	5.67	68.0	46.0	44.0	45.0	20.0	10.0	10.0	-	-	-	-	-	-	-	-	-	-	M	1986/7

No.	(kg.) Wt.	(cm.) F.L.	(cm.) PG	(cm.) AG	(cm.) MG	(cm.) PF	(cm.) 2DF	(cm.) AF	(mm.) M	(mm.) E	(mm.) S-DF	(mm.) S2-DF	(mm.) S-AF	(mm.) S-VF	(mm.) HL	(mm.) S-E	(mm.) Y-T	(mm.) KW	SEX	Year
1496	8.05	77.0	51.0	48.0	49.5	23.0	12.0	13.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1497	6.24	71.0	46.0	43.0	44.5	21.0	10.0	9.5	-	-	-	-	-	-	-	-	-	-	M	1986/7
1498	6.80	74.0	48.0	45.0	46.5	21.0	11.0	11.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1499	11.79	86.0	57.0	55.0	56.0	27.0	15.0	16.5	-	-	-	-	-	-	-	-	-	-	M	1986/7
1500	63.96	149.0	105.0	102.0	103.5	38.0	54.0	64.0	-	-	-	-	-	-	-	-	-	-	M	1986/7
1501	55.45	145.0	100.0	94.0	97.0	35.0	60.0	71.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1502	14.17	95.0	63.0	59.0	61.0	25.0	14.5	16.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1503	38.78	130.0	86.0	85.0	85.5	32.0	36.0	42.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1504	33.11	121.0	83.0	84.0	83.5	32.0	31.0	38.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1505	5.44	65.5	46.0	44.0	45.0	20.5	9.5	10.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1506	5.67	68.5	45.0	43.0	44.0	20.0	9.0	9.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1507	6.24	69.0	47.0	45.0	46.0	22.0	10.0	11.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1508	5.67	67.0	46.0	43.0	44.5	20.0	9.0	10.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1509	5.22	65.0	44.0	41.0	42.5	21.0	10.0	10.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1510	4.99	64.0	43.0	41.0	42.0	20.0	8.0	9.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1511	59.87	148.0	100.0	99.0	99.5	37.0	57.0	60.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1512	20.98	106.0	70.0	68.0	69.0	29.0	19.0	22.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1513	26.88	113.0	77.0	76.0	76.5	33.5	27.0	26.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1514	27.22	115.0	75.0	74.0	74.5	33.0	26.5	20.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1515	35.49	125.0	85.0	81.0	83.0	30.0	-	-	-	-	-	-	-	-	-	-	-	-	F	1987/8
1516	39.46	127.0	86.0	86.0	86.0	34.0	35.0	44.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1517	44.00	133.0	89.0	89.0	89.0	35.0	32.0	39.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1518	50.12	138.0	95.0	92.0	93.5	36.0	50.0	58.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1519	35.83	124.0	86.0	80.0	83.0	35.0	33.0	34.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1520	36.06	125.0	84.0	82.0	83.0	35.0	34.0	35.5	-	-	-	-	-	-	-	-	-	-	F	1987/8
1521	39.12	129.0	89.0	85.0	87.0	35.0	35.0	40.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1522	39.58	129.0	90.0	86.0	88.0	36.0	32.0	36.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1523	37.88	128.0	87.0	83.0	85.0	36.0	35.0	36.5	-	-	-	-	-	-	-	-	-	-	M	1987/8
1524	36.29	126.0	83.0	80.0	81.5	32.0	31.5	38.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1525	33.91	123.0	84.0	81.0	82.5	35.0	31.0	35.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1526	21.09	105.0	73.0	68.0	70.5	31.0	22.0	25.5	-	-	-	-	-	-	-	-	-	-	M	1987/8
1527	22.00	107.0	70.0	70.0	70.0	30.0	25.0	25.5	-	-	-	-	-	-	-	-	-	-	M	1987/8
1528	21.55	106.5	71.0	70.0	70.5	29.0	21.5	23.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1529	4.76	64.0	44.0	42.0	43.0	19.0	8.5	9.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1530	38.56	128.0	86.0	85.0	85.5	33.0	34.0	39.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1531	36.63	128.0	87.0	83.0	85.0	35.0	31.0	38.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1532	4.31	61.0	43.0	40.0	41.5	20.0	8.0	8.5	-	-	-	-	-	-	-	-	-	-	F	1987/8
1533	4.54	61.0	42.0	40.0	41.0	20.0	8.5	9.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1534	4.76	64.0	43.0	42.0	42.5	19.0	8.0	9.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1535	5.10	66.0	45.0	44.0	44.5	20.0	9.0	9.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1536	41.73	127.0	90.0	88.0	89.0	33.0	34.0	35.5	-	-	-	-	-	-	-	-	-	-	M	1987/8
1537	38.90	127.5	88.0	86.0	87.0	36.0	34.0	38.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1538	4.31	60.5	42.0	39.0	40.5	18.0	8.0	8.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1539	4.88	63.0	44.0	41.0	42.5	19.0	8.5	8.5	-	-	-	-	-	-	-	-	-	-	M	1987/8
1540	5.10	65.5	45.0	43.0	44.0	20.0	9.0	9.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1541	4.31	59.5	42.0	40.0	41.0	19.0	7.5	7.5	-	-	-	-	-	-	-	-	-	-	F	1987/8
1542	4.08	60.0	41.0	38.0	39.5	18.0	7.0	7.5	-	-	-	-	-	-	-	-	-	-	F	1987/8
1543	4.20	61.0	42.0	39.0	40.5	20.0	8.0	8.5	-	-	-	-	-	-	-	-	-	-	F	1987/8
1544	2.04	47.0	32.0	32.0	32.0	15.0	5.0	5.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1545	4.31	61.0	42.0	40.0	41.0	19.0	8.0	8.5	-	-	-	-	-	-	-	-	-	-	F	1987/8
1546	5.44	66.0	46.0	43.0	44.5	19.0	9.0	8.5	-	-	-	-	-	-	-	-	-	-	M	1987/8
1547	5.22	66.0	45.0	43.0	44.0	20.0	8.5	9.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1548	7.03	72.0	49.0	47.0	48.0	22.0	10.0	1.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1549	4.99	64.5	44.0	41.0	42.5	19.0	8.5	8.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1550	5.67	65.5	47.0	44.0	45.5	20.0	9.0	9.5	-	-	-	-	-	-	-	-	-	-	F	1987/8
1551	10.66	83.0	56.0	56.0	56.0	20.0	16.0	17.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1552	4.31	60.5	42.0	40.0	41.0	18.0	7.0	7.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1553	4.42	59.0	43.0	40.0	41.5	18.0	7.5	7.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1554	5.10	64.5	44.0	41.0	42.5	21.0	9.0	10.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1555	3.63	58.5	40.0	39.0	39.5	18.0	7.0	7.5	-	-	-	-	-	-	-	-	-	-	F	1987/8
1556	7.48	73.0	51.0	50.0	50.5	23.0	11.0	12.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1557	5.67	68.0	45.0	43.0	44.0	20.0	9.0	10.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1558	5.22	64.5	45.0	43.0	44.0	19.0	8.0	8.5	-	-	-	-	-	-	-	-	-	-	M	1987/8
1559	5.44	67.0	44.0	42.0	43.0	20.0	10.0	10.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1560	49.90	138.0	97.0	92.0	94.5	39.0	46.0	46.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1561	40.60	127.0	89.0	84.0	86.5	37.0	35.0	38.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1562	44.45	131.0	90.0	91.0	90.5	35.0	35.0	43.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1563	35.15	125.0	83.0	78.0	80.5	32.0	30.0	34.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1564	44.45	132.0	91.0	88.0	89.5	39.0	37.0	40.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1565	48.31	132.5	95.0	93.0	94.0	34.0	33.0	35.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1566	4.88	64.0	43.0	41.0	42.0	20.0	9.0	9.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1567	49.21	139.5	92.0	92.0	92.0	34.0	49.0	50.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1568	36.97	128.0	84.0	82.0	83.0	35.0	37.0	38.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1569	34.25	123.0	83.0	81.0	82.0	35.0	28.0	32.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1570	38.10	124.0	87.0	83.0	85.0	35.0	36.0	41.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1571	60.89	149.5	100.0	98.0	99.0	32.0	60.0	65.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1572	40.82	132.0	90.0	84.0	87.0	29.0	41.0	42.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1573	39.01	130.5	87.0	85.0	86.0	37.0	38.0	42.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1574	37.42	126.0	87.0	84.0	85.5	34.0	29.0	36.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1575	35.15	128.0	85.0	81.0	83.0	34.0	30.0	36.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1576	35.83	123.0	86.0	80.0	83.0	33.0	39.0	36.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1577	39.92	130.0	90.0	85.0	87.5	36.0	37.0	39.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1578	52.73	140.0	94.0	95.0	94.5	38.0	36.0	48.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1579	40.48	131.0	88.0	86.0	87.0	33.0	33.0	40.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1580	40.37	128.0	89.0	87.0	88.0	33.0	32.0	39.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1581	40.82	127.0	89.0	88.0	88.5	33.0	32.0	39.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1582	32.66	123.5	83.0	78.0	80.5	33.0	35.0	38.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1583	39.69	129.0	88.0	85.0	86.5	35.0	46.0	51.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1584	37.19	123.5	87.0	81.0	84.0	32.0	37.0	44.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1585	43.32	135.0	91.0	89.0	90.0	38.0	36.0	40.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1586	41.73	129.5	87.0	86.0	86.5	35.0	35.0	30.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1587	44.91	135.0	89.0	88.0	88.5	36.0	34.0	40.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1588	33.91	121.0	83.0	80.0	81.5	32.0	29.0	31.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1589	44.00	132.0	91.0	89.0	90.0	34.0	27.0	39.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1590	35.04	124.0	85.0	83.0	84.0	36.0	39.0	42.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1591	44.57	135.0	91.0	90.0	90.5	37.0	35.0	40.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1592	48.08	137.0	95.0	92.0	93.5	35.0	40.0	42.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1593	42.18	133.0	89.0	86.0	87.5	35.0	38.0	42.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1594	37.65	125.0	87.0	86.0	86.5	34.0	42.0	43.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1595	31.75	120.5	84.0	78.0	81.0	33.0	32.0	39.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1596	45.47	137.5	91.0	90.0	90.5	36.0	39.0	42.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1597	41.73	131.0	90.0	88.0	89.0	38.0	36.0	40.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1598	40.37	130.0	87.0	85.0	86.0	34.0	37.0	42.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1599	50.80	140.0	95.0	93.0	94.0	34.0	47.0	63.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1600	38.10	126.0	86.0	84.0	85.0	33.0	30.0	41.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1601	51.94	140.5	95.0	93.0	94.0	39.0	36.0	38.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1602	39.46	128.0	88.0	86.0	87.0	34.0	33.0	38.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1603	43.09	132.0	88.0	87.0	87.5	37.0	37.0	40.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1604	44.79	135.0	92.0	89.0	90.5	35.0	38.0	42.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1605	46.04	137.0	93.0	89.0	91.0	36.0	39.0	43.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1606	18.60	101.5	69.0	65.0	67.0	29.0	20.0	24.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1607	3.29	56.0	38.0	36.0	37.0	16.0	7.0	7.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1608	40.60	130.0	89.0	86.0	87.5	32.0	31.0	34.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1609	24.04	112.0	74.0	71.0	72.5	32.0	22.0	28.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1610	44.11	132.5	93.0	87.0	90.0	35.0	33.0	48.0	-	-	-	-	-	-	-	-	-	-	F	1987/8

No.	(kg.) Wt.	(cm.) F.L.	(cm.) PG	(cm.) AG	(cm.) MG	(cm.) PF	(cm.) 2DF	(cm.) AF	(mm.) M	(mm.) E	(mm.) S-DF	(mm.) S2-DF	(mm.) S-AF	(mm.) S-VF	(mm.) HL	(mm.) S-E	(mm.) Y-T	(mm.) KW	SEX	Year
1611	38.56	125.0	87.0	84.0	85.5	31.5	32.0	35.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1612	40.94	133.0	87.0	85.0	86.0	36.0	35.0	36.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1613	38.33	126.0	89.0	86.0	87.5	35.0	39.0	42.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1614	39.46	129.0	87.0	86.0	86.5	34.0	34.0	41.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1615	37.88	127.5	87.0	84.0	85.5	33.0	37.0	40.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1616	28.69	115.5	78.0	77.0	77.5	33.0	27.0	28.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1617	22.34	108.0	71.0	68.0	69.5	30.0	24.0	26.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1618	23.13	105.5	75.0	72.0	73.5	31.0	21.0	21.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1619	28.24	118.0	77.0	76.0	76.5	32.0	24.0	29.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1620	35.49	125.0	84.0	82.0	83.0	32.0	30.0	38.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1621	3.63	58.5	40.0	39.0	39.5	17.5	7.0	7.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1622	2.04	48.0	32.0	31.0	31.5	16.0	6.0	6.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1623	1.93	47.0	32.0	31.0	31.5	14.0	5.0	5.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1624	22.23	107.0	72.0	70.0	71.0	31.0	25.0	27.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1625	24.04	108.5	74.0	72.0	73.0	31.0	23.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1626	22.79	109.0	72.0	70.0	71.0	33.0	25.0	29.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1627	22.68	108.5	73.0	69.0	71.0	29.0	22.0	24.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1628	20.53	103.5	71.0	67.0	69.0	31.0	22.0	26.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1629	22.91	105.5	74.0	70.0	72.0	30.0	20.0	21.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1630	5.78	68.5	47.0	43.0	45.0	20.0	11.0	12.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1631	5.78	67.5	46.0	44.0	45.0	22.0	9.0	9.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1632	22.79	108.0	72.0	71.0	71.5	31.0	26.0	28.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1633	23.59	109.0	74.0	71.0	72.5	31.0	22.0	25.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1634	5.56	67.0	45.0	43.0	44.0	21.0	9.0	9.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1635	21.89	106.0	72.0	71.0	71.5	29.0	23.0	25.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1636	2.49	50.0	34.0	33.0	33.5	15.0	5.5	6.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1637	2.27	49.0	32.0	31.0	31.5	13.0	5.0	6.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1638	2.04	47.0	31.0	30.0	30.5	12.0	5.0	5.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1639	21.09	102.0	71.0	70.0	70.5	30.0	21.0	26.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1640	22.00	106.0	74.0	71.0	72.5	32.0	22.0	22.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1641	23.81	110.0	74.0	72.0	73.0	31.0	24.0	28.5	-	-	-	-	-	-	-	-	-	-	M	1987/8
1642	17.01	98.0	67.0	63.0	65.0	28.0	-	-	-	-	-	-	-	-	-	-	-	-	F	1987/8
1643	20.98	104.0	70.0	69.0	69.5	30.0	21.0	21.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1644	23.47	108.0	74.0	71.0	72.5	32.0	25.0	21.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1645	23.13	109.5	73.0	70.0	71.5	32.0	27.0	30.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1646	22.45	108.0	73.0	70.0	71.5	32.0	25.0	30.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1647	22.68	108.0	72.0	71.0	71.5	30.0	20.0	21.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1648	2.72	52.0	35.0	33.0	34.0	16.0	6.0	6.5	-	-	-	-	-	-	-	-	-	-	M	1987/8
1649	18.94	100.5	70.0	64.0	67.0	30.0	20.0	23.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1650	19.16	102.0	70.0	67.0	68.5	30.0	22.0	21.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1651	21.55	107.0	72.0	70.0	71.0	31.0	19.0	21.0	-	-	-	-	-	-	-	-	-	-	F	1987/8
1652	2.61	52.5	35.0	33.0	34.0	17.0	6.5	6.0	-	-	-	-	-	-	-	-	-	-	M	1987/8
1653	21.32	108.0	71.0	70.0	70.5	31.0	23.0	28.0	-	-	-	-	-	-	-	-	-	-	F	1987/8

APPENDIX C

The Correlations between the Raw Morphometric Measures

a) 1981/82

	PG	PF	2DF	AF
PF	0.95			
2DF	0.92	0.83		
AF	0.92	0.81	0.98	

b) 1982/83

	PG	AG	MG	2DF	AF
AG	0.99				
MG	1	1			
2DF	0.94	0.95	0.95		
AF	0.94	0.95	0.94	0.97	

c) 1983/84

	PG	AG	MG	PF	2DF	AF	M	S-DF	S-2DF	S-AF
AG	1									
MG	1	1								
PF	0.98	0.98	0.98							
2DF	0.96	0.96	0.96	0.92						
AF	0.97	0.97	0.97	0.94	0.99					
M	0.97	0.97	0.98	0.96	0 94	0.95				
S-DF	0.99	0.99	0.99	0.98	0.95	0.96	0.97			
S-2DF	0.99	0.99	1	0.98	0.95	0.97	0.97	0.99		
S-AF	1	1	1	0.98	0.95	0.97	0.97	1	1	

d) 1984/85

	PG	AG	MG	PF	2DF	AF	M	E	S-DF	S-2DF	S-AF	S-VF	HL	S-E	V-T	KW
AG	1															
MG	1	1														
PF	0.99	0.99	0.99													
2DF	0.97	0.97	0.97	0.97												
AF	0.98	0.98	0.98	0.96	0 97											
M	0.98	0.98	0.98	0.97	0.95	0.96										
E	0.95	0.95	0.95	0.94	0.92	0.94	0.94									
S-DF	1	1	1	0.99	0.97	0.98	0.98	0.96								
S-2DF	1	1	1	0.99	0.97	0.98	0.98	0.95	1							
S-AF	1	1	1	0.99	0.97	0.98	0.98	0.95	1	1						
S-VF	1	1	1	0.99	0.97	0.97	0.98	0.96	1	1	1					
HL	1	1	1	0.99	0.97	0.97	0.98	0.96	1	1	1	1				
S-E	0.99	0.99	0.99	0.98	0.97	0.98	0.98	0.95	0.99	0.99	0.99	0.99	0.99			
V-T	1	1	1	0.99	0.97	0.98	0.98	0.95	1	1	1	1	1	0.99		
KW	0.99	0.99	0.99	0.98	0.96	0.97	0.97	0.94	0.99	0.99	0.99	0.99	0.99	0.99	0.99	

e) 1985/86

	PG	AG	MG	PF	2DF	AF	M	E	S-DF	S-2DF	S-AF	S-VF	HL	S-E	V-T	KW
AG	1															
MG	1	1														
PF	0.96	0.96	0.96													
2DF	0.97	0 97	0.97	0.91												
AF	0.98	0.98	0.98	0.92	0.99											
M	0.97	0.97	0.97	0.94	0.94	0.95										
E	0.92	0.92	0.92	0.91	0.9	0.9	0.91									
S-DF	0.99	0.99	0.99	0.96	0.96	0.97	0.97	0.92								
S-2DF	1	0.99	1	0.96	0.97	0.98	0.97	0.91	1							
S-AF	0.99	0.99	0.99	0.95	0.97	0.98	0.97	0.91	1	1						
S-VF	0.97	0.97	0.97	0.94	0.95	0.95	0.96	0.9	0.98	0.98	0.98					
HL	0.99	0.99	0.99	0.96	0.96	0.97	0.97	0.92	0.99	0.99	0.99	0.98				
S-E	0.99	0.99	0.99	0.96	0.96	0.97	0.97	0.92	0.99	0.99	0.99	0.98	0.99			
V-T	0.99	0.99	0.99	0.96	0.97	0.97	0.97	0.92	0.99	0.99	0.99	0.97	0.99	0.99		
KW	0.99	0.99	0.99	0.97	0.95	0.96	0.97	0.91	0.99	0.99	0.99	0.97	0.99	0.99	0.99	

f) 1986/87

	PG	AG	MG	PF	2DF	AF
AG	0.99					
MG	1	1				
PF	0.94	0.94	0.94			
2DF	0.91	0.91	0.91	0.85		
AF	0.91	0.91	0.91	0.83	0.97	

g) 1987/88

	PG	AG	MG	PF	2DF	AF
AG	1					
MG	1	1				
PF	0.95	0.95	0.95			
2DF	0.96	0.95	0.95	0.89		
AF	0.96	0.95	0.96	0.88	0.98	

APPENDIX D

The Correlations of the Morphometric Measures Transformed by Fork Length.

a) 1981/82

	PG	PF	2DF	AF
PF	0.22			
2DF	-0.21	-0.63		
AF	-0.19	-0.64	0.96	

b) 1982/83

	PG	AG	MG	2DF	AF
AG	0.44				
MG	0.76	0.9			
2DF	-0.01	0.45	0.31		
AF	-0.03	0.46	0.31	0.95	

c) 1983/84

	PG	AG	MG	PF	2DF	AF	M	S-DF	S-2DF	S-AF
AG	0.28									
MG	0.78	0.82								
PF	0.12	-0.39	-0.18							
2DF	0	0.52	0.33	-0.74						
AF	-0.01	0.53	0.33	-0.75	0.98					
M	0.33	0.11	0.27	-0.14	0.18	0.17				
S-DF	0.06	-0.42	-0.24	0.65	-0.8	-0.82	-0.1			
S-2DF	0.07	-0.3	-0.15	0.57	-0.73	-0.76	-0.14	0.76		
S-AF	0.06	-0.36	-0.2	0.66	-0.85	-0.87	-0.15	0.82	0.82	

d) 1984/85

	PG	AG	MG	PF	2DF	AF	M	E	S-DF	S-2DF	S-AF	S-VF	HL	S-E	V-T	KW
AG	0.41															
MG	0.79	0.88														
PF	-0.01	-0.42	-0.29													
2DF	0.05	0.53	0.38	-0.76												
AF	0.12	0.58	0.45	-0.81	0.95											
M	0.01	0.11	0.09	-0.44	0.34	0.4										
E	-0.04	-0.58	-0.41	0.8	-0.93	-0.93	-0.4									
S-DF	0.01	-0.5	-0.33	0.82	-0.9	-0.91	-0.38	0.94								
S-2DF	-0.04	-0.51	-0.37	0.81	-0.89	-0.91	-0.39	0.94	0.95							
S-AF	-0.05	-0.45	-0.33	0.77	-0.91	-0.92	-0.42	0.94	0.92	0.94						
S-VF	0	-0.47	-0.31	0.79	-0.93	-0.93	-0.36	0.94	0.94	0.94	0.95					
HL	0.04	-0.51	-0.32	0.8	-0.93	-0.94	-0.37	0.96	0.96	0.93	0.93	0.96				
S-E	0.16	-0.35	-0.16	0.57	-0.63	-0.63	-0.16	0.68	0.72	0.68	0.67	0.74	0.75			
V-T	0.01	0.51	0.36	-0.76	0.86	0.87	0.36	-0.88	-0.85	-0.87	-0.87	-0.87	-0.89	-0.63		
KW	0.07	0.49	0.37	-0.71	0.86	0.89	0.31	-0.91	-0.85	-0.84	-0.85	-0.89	-0.89	-0.6	0.82	

e) 1985/86

	PG	AG	MG	PF	2DF	AF	M	E	S-DF	S-2DF	S-AF	S-VF	HL	S-E	V-T	KW
AG	0.55															
MG	0.85	0.9														
PF	0.04	-0.1	-0.04													
2DF	0.18	0.46	0.37	-0.37												
AF	0.17	0.46	0.38	-0.37	0.98											
M	0.17	0.1	0.15	0.05	0.28	0.3										
E	-0.06	-0.39	-0.28	0.39	-0.85	-0.87	-0.22									
S-DF	-0.02	-0.41	-0.27	0.15	-0.84	-0.85	-0.29	0.78								
S-2DF	-0.06	-0.35	-0.25	-0.07	-0.78	-0.79	-0.38	0.72	0.89							
S-AF	-0.11	-0.35	-0.27	-0.04	-0.79	-0.8	-0.37	0.74	0.85	0.89						
S-VF	-0.01	-0.25	-0.16	0.17	-0.55	-0.56	-0.18	0.53	0.59	0.53	0.57					
HL	-0.08	-0.37	-0.27	0.28	-0.85	-0.85	-0.21	0.81	0.81	0.76	0.8	0.58				
S-E	-0.02	-0.3	-0.19	0.4	-0.57	-0.59	-0.08	0.54	0.58	0.48	0.47	0.49	0.54			
V-T	0.11	0.36	0.28	0.09	0.73	0.73	0.37	-0.68	-0.81	-0.86	-0.86	-0.49	-0.71	-0.4		
KW	0.14	0.4	0.32	0.05	0.71	0.73	0.34	-0.78	-0.74	-0.78	-0.8	-0.48	-0.74	-0.36	0.76	

f) 1986/87

	PG	AG	MG	PF	2DF	AF
AG	0.55					
MG	0.87	0.89				
PF	0.17	0.02	0.11			
2DF	-0.2	0.07	-0.07	-0.46		
AF	-0.19	0.07	-0.06	-0.51	0.92	

g) 1987/88

	PG	AG	MG	PF	2DF	AF
AG	0.58					
MG	0.88	0.89				
PF	-0.01	-0.07	-0.05			
2DF	-0.06	0.23	0.1	-0.1		
AF	-0.07	0.24	0.1	-0.12	0.97	

APPENDIX E

Detailed Description of Yellowfin Tuna Examined Using Histology

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THE 1987/88 SAMPLE

Fish (1) Length: 47.0 cm FL; Date of capture: 21.10.87; Stage: I; Description of external characteristics: Thin ribbon-like, tubular in cross-section.
Description by histology: Confirmed that it was female, and was largely made up of oogonia and primary oocytes with a sprinkling of early perinuclei and well defined genital ridges in the lumen.
Stageing by histology: Confirmed stage I, immature.

Fish (2) Length: 49.0 cm FL; Date of capture: 5.11.87; Stage: I; Description of external characteristics: Thin ribbon-like, but tubular in section.
Description by histology: Well defined genital ridges in the lumen and predominantly oogonia and primary oocytes.
Stageing by histology: Confirmed female and immature stage I.

Fish (3) Length: 68.5 cm FL; Date of capture: 1.11.87; Stage: II; Description of external characteristics: Slightly flaccid and pink with no ova visible.
Description by histology: Predominantly perinuclei in fairly early stages.
Stageing by histology: Just beginning the maturation process for the first time. Stage II.

Fish (4) Length: 67.0 cm FL; Date of capture: 5.11.87; Stage: II; Description of external characteristics: No ova visible but slightly flaccid and almost brownish in colour.
Description by histology: Almosy entirely early perinuclei with no large oocytes.
Stageing by histology: Stage I given that vitellogenesis had not yet begun.

Fish (5) Length: 139.5 cm FL; Date of capture: 14.9.87; Stage: II; Description of external characteristics: The ovary was pink in colour, but slightly flaccid. No ova were visible to the naked eye.
Description by histology: Very largely perinuclei with some in a late stage. Some very early vitellogenic ocytes with paler staining cytoplasm and small vesicles, but still with the nucleoli pressed around the periphery of the nucleus.
Stageing by histology: Stage II. This Fish was just in the very early stages of maturing, or considering its size in a recovery state.

Fish (6) Length: 124.0 cm FL; Date of capture: 14.9.87; Stage: II; Description of external characteristics: This Fish was taken on the same day as Fish (c) and showed very similar characteristics with slightly flaccid ovary and no ova visible to the naked eye.

Description by histology: Plenty of perinuclei in all stages and some early yolk vesicle stage at the commencement of vitellogenesis.

Stageing by histology: Recovery stage II.

Fish (7) Length: 133.0 cm FL; Date of capture: 21.9.87; Stage: II; Description of external characteristics: The ovary was firm and pink in colour, but no ova visible.

Description by histology: Predominantly perinuclei but also some early yolk vesicle stage.

Stageing by histology: Recovery stage II.

Fish (8) Length: 120.5 cm FL; Date of capture: 21.9.87; Stage: II; Description of external characteristics: The ovary was firm and pink in colour, but no ova visible.

Description by histology: Mainly early and late perinuclei and a few early yolk vesicle stage, but also contained some post-ovulatory follicles implying that this Fish might have spawned recently.

Stageing by histology: Recovery stage II.

Fish (9) Length: 107.0 cm FL; Date of capture: 10.2.88; Stage: II; Description of external characteristics: Slightly flaccid, but blackened in colour towards the open end. No ova visible.

Description by histology: A lot of perinuclei and yolk vesicle stage. Some of the latter were quite advanced, but there were none in the yolk granule stage.

Stageing by histology: Stage II.

Fish (10) Length: 127.5 cm FL; Date of capture: 3.10.87; Stage: II; Description of external characteristics: Slightly flaccid and very dark in colour.

Description by histology: Plenty of perinuclei with quite a few oocytes in the early stages of vitellogenesis, late yolk vesicle stage.

Stageing by histology: This ovary was at stage II recovery and was now commencing vitellogenesis again.

Fish (11) Length: 118.0 cm FL; Date of capture: 5.10.87; Stage: II; Description of external characteristics: Slightly flaccid, particularly the smaller ovary, pink in colour, but black towards the open end. No individual ova were visible.

Description by histology: Mainly late perinuclei, but there were also a few larger oocytes showing most stages of vitellogenesis including very early lipid vesicle stage.
Stageing by histology: Stage III.

Fish (12) Length: 115.5 cm FL; Date of capture: 3.10.87; Stage: II; Description of external characteristics: No ova visible and slightly flaccid.
Description by histology: Mainly perinuclei, but some advanced yolk vesicle stage oocytes.
Stageing by histology: Stage II, probably recovery.

Fish (13) Length: 123.5 cm FL; Date of capture: 15.9.87; Stage: III; Description of external characteristics: Firm, pink and with small ova visible.
Description by histology: Plenty of early perinuclei with some more advanced and a few yolk vesicle stage.
Description by histology: This Fish is still stage II as vitellogenesis has only just commenced.

Fish (14) Length: 130.0 cm FL; Date of capture: 21.9.87; Stage: III; Description of external characteristics: Orange in colour, firm and well vascularised with visible ova.
Description by histology: Quite a few large oocytes, including some in the yolk granule stage. Early and late perinuclei are also present. Also appeared to be a fair degree of atretia present.
Stageing by histology: Stage III, maturing ovary.

Fish (15) Length: 128.0 cm FL; Date of capture: 21.9.87; Stage: III; Description of external characteristics: Slightly flaccid, orange in colour and ova visible.
Description by histology: A few early yolk vesicle stage, and a large number of perinuclei. Appears to be a high degree of atretia.
Stageing by histology: Recovery stage II

Fish (16) Length: 132.5 cm FL; Date of capture: 3.10.87; Stage: III; Description of external characteristics: Firm and orange in colour. Ova visible.
Description by histology: Some early yolk granule stage and advanced yolk vesicles.
Stageing by histology: Maturing stage III given the evident progress of vitellogenesis.

Fish (17) Length: 125.0 cm FL; Date of capture: 3.10.87; Stage: III; Description of external characteristics: Firm, orange with ova visible.
Description by histology: A section was taken from each of the two ovaries to see if there was any difference in development between them considering that the right one was much shorter. The left ovary weighed 196g whereas the

right one weighed just 65g.The larger left gonad contained plenty of large oocytes, both yolk vesicle and yolk granule stages and still a fair number of smaller oocytes as well. The smaller one also contained quite a few early yolk granule stage, but also lots of perinuclei. The larger gonad did appear to have more bigger oocytes and it would seem that one ovary maybe dominant in yellowfin.

Stageing by histology: Stage III

Fish (18) Length: 109.0 cm FL; Date of capture: 4.11.87; Stage: III; Description of external characteristics: Orange, fairly well vascularised and with visible ova.

Description by histology: Quite a few large vitellogenic oocytes of the yolk granule stage with small lipid vesicles.

Stageing by histology: Stage III

Fish (19) Length: 108.0 cm FL; Date of capture: 14.12.87; Stage: III; Description of external characteristics: Firm, well vascularised with visible ova.

Description by histology: Mainly oocytes of yolk granule stage with some quite large lipid vesicles.

Stageing by histology: Stage III.

Fish (20) Length: 100.5 cm FL; Date of capture: 19.1.88; Stage: III; Description of external characteristics: Firm and orange in colour.

Description by histology: Advanced vitellogenesis with the yolk granule stage showing large lipid vesicles combining to to form larger ones.

Stageing by histology: Stage III.

Fish (21) Length: 102.0 cm FL; Date of capture: 30.1.88; Stage: III; Description of external characteristics: Firm, orange and well vascularised.

Description by histology: Plenty of advanced yolk granule stage oocytes with large lipid vesicles, but with perinuclei and the yolk vesicle stage also present.

Stageing by histology: Stage III.

Fish (22) Length: 108.0 cm FL; Date of capture: 3.3.88; Stage: III; Description of external characteristics: Ovary slightly flaccid, but orange and with individual oocytes visible to the naked eye.

Description by histology: Plenty of the yolk granule stage, but the lipid vesicles are still small individual ones which haven't started combining yet.

Stageing by histology: Stage III.

Fish (23) Length: 130.0 cm FL; Date of capture: 3.10.87; Stage: III; Description of external characteristics: Firm and orange with visible ova.

Description by histology: A large number of perinuclei, but some late yolk vesicle and early yolk granule stages.

Stageing by histology: Stage III.

Fish (24) Length: 98.0 cm FL; Date of capture: 7.12.87; Stage: IV; Description of external characteristics: Slightly flaccid, orange and well vascularised.
Description by histology: Advanced vitellogenesis with plenty of the yolk granule stage and large lipid vesicles. Also quite a few perinuclei, and there appeared to be a high degree of atretia.
Stageing by histology: Stage III. There was no evidence of yolked oocytes with the nucleus having moved towards the animal pole. In all instances the nucleus was in the centre of the cell.

Fish (25) Length: 127.0 cm FL; Date of capture: 15.9.87; Stage: IV; Description of external characteristics: Well vascularised, with individual ova visible to the naked eye. In colour the ovaries were purplish, but orange towards the closed end.
Description by histology: Quite a bit of vitellogenesis with the yolk vesicle and yolk granule stages, but the latter not very advanced. There were also plenty of perinuclei.
Stageing by histology: Stage III.

Fish (26) Length: 129.5 cm FL; Date of capture: 17.9.87; Stage: IV; Description of external characteristics: Firm and pink in colour but appeared to be full of opaque ova.
Description by histology: Plenty of large oocytes, mainly yolk vesicle and early yolk granule stage. The latter were not as advanced as expected. Still plenty of late perinuclei.
Stageing by histology: Stage III.

Fish (27) Length: 104.0 cm FL; Date of capture: 7.12.87; Stage: IV; Description of external characteristics: Firm, orange in colour and well vascularised. The ova appeared to be separating away from one another.
Description by histology: Advanced vitellogenesis with the lipid vesicles in the yolk granule stage amalgamating into a single large vesicle. However, the nucleus was still not near the periphery of the oocyte.
Stageing by histology: Stage III.

APPENDIX F

Mean Volumetric Ratio Measurements for Quantitative Monthly Diet Samples of Sport Fishery-Caught Yellowfin Tuna from 1986/87 and 1987/88 as Described in Chapter 6

	(cm) Fish Length	(Kg) Gutted Weight	(ml) Food Volume	% Ir	Ratio Fish	Ratio Squid	Ratio Prawn	Ratio Crab	Ratio Crust
1986/87									
August:	60.0	3.74	8.3	0.222	0	0.072	0.723	0	0.205
	60.0	3.52	3.5	0.099	0	0	1.000	0	0
	61.0	3.86	22.6	0.585	0.442	0.531	0	0	0.027
	62.5	4.31	10.0	0.232	0	0	0	0	1.000
	70.0	6.12	15.0	0.245	0.667	0	0	0	0.333
	70.5	6.12	6.0	0.098	0.767	0	0.167	0	0.067
	72.0	6.12	3.5	0.057	0.571	0	0	0	0.429
	98.5	15.76	40.0	0.254	0.300	0.400	0	0	0.300
	100.5	18.03	40.0	0.222	0.050	0.950	0	0	0
	101.0	17.69	345.0	1.950	0.667	0.072	0.261	0	0
	102.0	16.58	87.5	0.528	0.057	0.017	0	0	0.926
	102.0	18.14	43.0	0.237	0.279	0.023	0.186	0	0.512
	102.0	17.12	191.9	1.121	0.245	0.750	0.003	0	0.002
	102.0	18.60	0.0	0.000	0	0	0	0	0
	103.0	19.96	40.0	0.200	0	0.200	0.163	0	0.638
	103.0	17.92	19.7	0.110	0.203	0.533	0.036	0	0.228
	103.0	18.48	177.0	0.958	0.395	0.605	0	0	0
	104.0	18.94	24.0	0.127	0.604	0.229	0	0	0.167
	104.0	19.50	52.5	0.269	0.400	0.552	0	0	0.048
	104.0	18.48	50.0	0.271	0.680	0.040	0.280	0	0
	104.0	18.37	662.0	3.604	0.483	0.474	0.038	0	0.005
	104.0	18.14	218.0	1.202	0.459	0.367	0.161	0	0.014
	104.5	20.07	100.0	0.498	0.335	0.400	0.090	0	0.175
	105.0	19.28	87.0	0.451	0.287	0.299	0	0	0.414
	105.0	18.82	150.6	0.800	0.080	0.027	0.004	0	0.890
	105.0	21.09	280.5	1.330	0.553	0.446	0	0	0.002
	105.0	18.82	146.5	0.778	0.024	0.061	0	0	0.915
	105.0	21.21	121.5	0.573	0.296	0.148	0.029	0	0.527
	105.0	18.71	238.0	1.272	0.714	0.172	0.113	0	0
	106.0	19.39	11.0	0.057	0.273	0.273	0	0	0.455
	106.0	21.89	206.0	0.941	0.024	0.976	0	0	0
	106.0	20.19	129.0	0.639	0.178	0.101	0	0	0.721
	106.0	21.32	147.0	0.689	0.476	0.490	0	0	0.034
	106.0	19.28	265.5	1.377	0.866	0.122	0.011	0	0
	106.0	20.19	215.0	1.065	1.000	0	0	0	0
	106.0	20.07	12.0	0.060	0.500	0.250	0.250	0	0
	106.0	19.28	420.0	2.178	0.738	0.190	0.071	0	0
	107.0	19.96	135.0	0.676	0.452	0.541	0.004	0	0.004
	107.0	21.09	268.0	1.271	0.254	0.284	0.049	0	0.414
	107.0	22.23	71.5	0.322	0.196	0.741	0	0	0.063
	107.0	21.32	181.0	0.849	0.856	0.072	0	0	0.072
	107.0	21.66	85.0	0.392	0.365	0.635	0	0	0
	107.0	19.96	78.0	0.391	0.846	0.154	0	0	0
	107.0	21.43	76.5	0.357	0.915	0.046	0.039	0	0
	108.0	20.19	79.0	0.391	0.095	0.785	0.019	0	0.101
	108.0	19.96	81.0	0.406	0.086	0	0.025	0	0.889
	108.0	19.96	69.8	0.350	0.158	0.143	0.062	0	0.638
	108.0	20.64	28.0	0.136	0.429	0.286	0	0	0.286
	108.0	21.77	285.0	1.309	0.965	0.035	0	0	0
	108.0	20.75	148.0	0.713	0.324	0.676	0	0	0
	108.0	20.07	326.6	1.627	0.444	0.092	0.459	0	0.005
	109.0	19.73	88.0	0.446	0.057	0.068	0	0	0.875
	109.0	22.00	450.0	2.045	0.733	0.267	0	0	0
	109.0	21.77	14.2	0.065	0.775	0.141	0.042	0	0.042
	109.0	22.68	261.0	1.151	0.805	0.096	0.096	0	0.004
	109.0	21.09	342.0	1.622	0.901	0.060	0.025	0	0.015
	109.0	22.11	284.5	1.287	0.844	0.123	0.033	0	0
	109.0	20.30	70.0	0.345	0.786	0.193	0.021	0	0
	109.5	17.24	124.2	0.720	0.193	0.805	0.002	0	0
	110.0	21.32	141.0	0.661	0.674	0.319	0.007	0	0
	111.0	21.32	30.5	0.143	0.098	0.689	0.016	0	0.197
	111.0	25.06	75.0	0.299	0.453	0.080	0.027	0	0.427
	112.0	23.25	93.0	0.400	0	1.000	0	0	0
	116.0	27.67	64.0	0.231	0.797	0.203	0	0	0
	116.0	26.88	101.2	0.376	0.257	0.741	0	0	0.002
	117.0	28.92	317.2	1.097	0.914	0.085	0.001	0	0
	117.0	26.99	67.3	0.249	0.386	0.594	0.004	0	0.015
	135.0	43.21	201.9	0.467	0.082	0.916	0	0	0.002
	136.0	39.01	132.0	0.338	0.152	0.758	0	0	0.091
	142.0	51.48	53.0	0.103	0.283	0.623	0	0	0.094
	143.0	51.60	233.0	0.452	0.365	0.090	0	0	0.545

	(cm) Fish Length	(Kg) Gutted Weight	(ml) Food Volume	% Ir	Ratio Fish	Ratio Squid	Ratio Prawn	Ratio Crab	Ratio Crust
	143.0	50.80	1118.0	2.201	0.237	0.761	0.002	0	0
	143.0	50.69	258.5	0.510	0.774	0.174	0.052	0	0
September:	45.0	1.81	2.5	0.138	0.800	0	0	0	0.200
	47.0	1.93	0.0	0.000	0	0	0	0	0
	48.0	2.04	7.5	0.368	0.333	0	0.333	0	0.267
	49.0	2.15	3.0	0.140	0.167	0.833	0	0	0
	62.0	4.20	11.0	0.262	0	0.591	0.091	0	0.318
	64.0	4.65	26.5	0.570	0.245	0.547	0.057	0	0.151
	64.0	4.99	163.0	3.267	0.785	0.184	0.018	0	0.012
	65.0	4.65	58.0	1.247	0	0	0	0	1.000
	65.0	4.99	34.5	0.691	0.406	0.522	0	0	0.072
	65.0	4.88	49.0	1.004	0.235	0.612	0	0	0.153
	65.0	4.99	11.0	0.220	0.455	0	0	0	0.545
	66.0	5.10	65.5	1.284	0.855	0.092	0.038	0	0.015
	67.0	5.10	15.0	0.294	0.933	0.067	0	0	0
	67.0	5.22	40.0	0.766	0.325	0	0.300	0	0.375
	73.0	7.03	46.0	0.654	0.609	0.174	0	0	0.217
	98.0	15.65	421.4	2.693	0.902	0.071	0.021	0	0.006
	102.0	16.58	335.6	2.024	0.760	0.223	0.015	0	0.002
	105.0	19.84	59.5	0.300	0.546	0.168	0.286	0	0
	106.0	21.77	292.0	1.341	0.719	0.240	0.007	0	0.034
	106.0	18.94	239.5	1.265	0.885	0.069	0.046	0	0
	106.5	20.41	205.0	1.004	0.576	0.176	0.161	0	0.088
	108.0	20.30	24.5	0.121	0.449	0.102	0.163	0	0.286
	108.0	20.53	198.0	0.964	0.884	0.030	0.086	0	0
	108.0	20.64	99.0	0.480	0.374	0.586	0.030	0	0.010
	109.0	20.64	23.0	0.111	0.478	0.391	0.043	0	0.087
	109.0	22.45	70.5	0.314	0.284	0.667	0.028	0	0.021
	109.0	21.66	264.7	1.222	0.801	0.181	0.017	0	0
	109.0	20.53	150.0	0.731	0.800	0.187	0.013	0	0
	109.0	21.66	435.5	2.011	0.579	0.315	0.100	0	0.007
	110.0	24.38	105.2	0.432	0.523	0.475	0	0	0.002
	110.0	21.32	27.0	0.127	0.574	0.426	0	0	0
	110.0	22.91	640.5	2.796	0.824	0.169	0.002	0	0.005
	110.0	23.47	600.4	2.558	0.974	0.017	0.008	0	0.001
	111.0	23.02	262.0	1.138	0.916	0.053	0.017	0	0.013
	112.0	23.25	174.0	0.748	0.736	0.241	0.011	0	0.011
	112.0	23.13	190.0	0.821	0.842	0.032	0.032	0	0.095
	112.0	23.02	103.0	0.447	0.777	0.175	0.049	0	0
	112.0	24.49	345.0	1.409	0.420	0.574	0.006	0	0
	112.0	22.45	120.0	0.535	0.750	0.167	0.042	0	0.042
	113.0	22.91	70.5	0.308	0.220	0.738	0	0	0.043
	113.0	23.25	454.0	1.953	0.947	0.022	0.026	0	0.004
	113.0	24.49	120.2	0.491	0.541	0.416	0.042	0	0.002
	115.0	26.08	258.0	0.989	0.775	0.155	0.066	0	0.004
	115.0	24.15	961.5	3.981	0.954	0.045	0.001	0	0.001
	115.0	24.38	622.4	2.553	0.916	0.067	0.016	0	0.001
	115.0	24.61	608.0	2.471	0.987	0.008	0.005	0	0
	115.0	25.40	165.2	0.650	0.091	0.908	0	0	0.001
	116.0	25.40	68.4	0.269	0.848	0.146	0	0	0.006
	116.0	25.06	82.5	0.329	0.485	0.485	0	0	0.024
	117.0	26.20	200.5	0.765	0.948	0.020	0.032	0	0
	117.0	26.20	478.5	1.826	0.940	0.054	0.005	0	0
	119.0	31.30	68.0	0.217	0.471	0.515	0	0	0.015
	119.0	28.58	7.5	0.026	0.333	0.667	0	0	0
	119.0	30.16	790.0	2.619	0.886	0.076	0.034	0	0.004
	141.0	50.12	5.0	0.010	0	1.000	0	0	0
	143.0	51.48	26.0	0.051	0.962	0	0	0	0.038
	144.0	51.82	97.0	0.187	0.072	0.928	0	0	0
	144.0	48.31	141.0	0.292	0.163	0.674	0.113	0	0.050
	148.0	53.41	1259.0	2.357	0.782	0.207	0.011	0	0
October:	67.0	5.22	105.5	2.021	0.796	0	0	0	0.204
	102.0	18.14	218.2	1.203	0.742	0.220	0.037	0	0.001
	104.0	19.50	212.5	1.090	0.781	0.179	0.038	0	0.002
	105.0	18.48	180.4	0.976	0	0.011	0.002	0.987	0
	106.0	19.05	351.0	1.843	0.085	0.017	0.214	0.684	0
	106.0	19.28	159.6	0.828	0.627	0.357	0.013	0	0.004
	106.0	22.00	205.0	0.932	0.098	0.083	0	0.820	0
	107.0	21.09	47.0	0.223	0.745	0.170	0.085	0	0
	107.0	20.98	60.1	0.286	0.632	0.060	0.025	0.283	0
	108.0	21.55	445.5	2.067	0.001	0.011	0	0.988	0
	109.0	21.09	225.4	1.069	0.909	0.013	0.062	0	0.015

	(cm) Fish Length	*(Kg)* Gutted Weight	*(ml)* Food Volume	% Ir	Ratio Fish	Ratio Squid	Ratio Prawn	Ratio Crab	Ratio Crust
	109.0	22.79	99.5	0.437	0.905	0.040	0.050	0	0.005
	109.0	21.43	49.2	0.230	0.203	0.711	0.081	0	0.004
	110.0	22.00	156.0	0.709	0.455	0.436	0.090	0	0.019
	110.0	22.45	201.4	0.897	0.002	0.050	0	0.943	0
	111.0	21.43	85.7	0.400	0.222	0.228	0.047	0.502	0.002
	112.0	22.00	118.4	0.538	0.253	0.743	0	0	0.003
	113.0	24.27	219.0	0.902	0.822	0.114	0.064	0	0
	113.0	24.38	127.2	0.522	0.629	0.157	0.094	0.110	0.094
	114.0	23.93	277.5	1.160	0.953	0	0.007	0.040	0
	115.0	24.04	124.5	0.518	0.076	0.924	0	0	0
	115.0	25.52	291.7	1.143	0.001	0.038	0.002	0.960	0
	117.0	26.20	444.4	1.696	0	0.009	0.001	0.990	0
	119.0	30.28	353.0	1.166	0	0.014	0	0.986	0
	120.0	29.03	115.0	0.396	0	0.209	0.009	0.783	0
	124.0	33.34	875.0	2.624	0.897	0	0	0.103	0
	135.0	45.02	387.0	0.860	0	0.083	0	0.917	0
	138.0	43.55	195.0	0.448	0	0.036	0	0.964	0
1987/88									
August:	61.0	4.08	0.8	0.020	0	0	0	0	1.000
	61.0	4.31	13.4	0.311	0.933	0	0	0	0.067
	64.0	4.53	20.3	0.448	0.936	0	0	0	0.064
	64.0	4.53	21.0	0.463	0.905	0.024	0	0	0.071
	65.5	5.21	9.5	0.182	0.526	0	0	0	0.474
	66.0	4.87	35.8	0.735	0.810	0.028	0.056	0	0.106
	68.5	5.44	6.0	0.110	0.333	0	0	0	0.667
	69.0	5.90	22.0	0.373	0.727	0	0	0	0.227
	105.0	19.62	336.1	1.713	0.738	0.134	0.060	0.065	0.003
	106.0	19.85	101.0	0.509	0.426	0.465	0	0	0.064
	106.5	20.64	29.8	0.144	0.705	0.084	0.151	0	0.060
	107.0	20.98	88.5	0.422	0.367	0.520	0.102	0	0.011
	113.0	25.18	208.0	0.826	0.601	0.399	0	0	0
	115.0	25.41	235.0	0.925	0.936	0.026	0.038	0	0
	121.0	31.52	75.3	0.239	0.611	0.173	0	0.120	0.020
	123.0	32.21	128.3	0.398	0.094	0.156	0	0.740	0.010
	124.0	33.56	610.4	1.819	0.451	0.493	0.056	0	0.001
	125.0	32.54	1018.5	3.130	0.975	0.015	0.010	0	0
	125.0	33.79	332.3	0.983	0.169	0.028	0	0.797	0
	126.0	34.36	229.3	0.667	0.031	0.052	0	0.916	0.001
	127.0	37.08	307.0	0.828	0.977	0.005	0.015	0	0.003
	127.0	39.46	341.9	0.866	0.097	0	0.010	0.892	0.001
	127.5	35.95	822.0	2.286	0.066	0.008	0.001	0.925	0
	128.0	35.84	315.2	0.879	0.078	0.162	0	0.755	0.005
	128.0	36.86	167.1	0.453	0.039	0	0	0.958	0.004
	128.0	34.02	612.0	1.799	0.005	0.007	0	0.989	0
	129.0	37.08	320.5	0.864	0.002	0.006	0	0.992	0
	129.0	37.54	340.7	0.908	0.001	0	0	0.998	0.001
	138.0	47.63	447.0	0.939	0.485	0.492	0.022	0	0
	145.0	52.73	78.0	0.148	0.769	0.199	0.022	0	0.010
	148.0	57.38	73.8	0.129	0.607	0.230	0	0.163	0
September:	47.0	1.93	0.0	0.000	0	0	0	0	0
	56.0	3.06	30.0	0.979	0.600	0.267	0	0	0.133
	59.0	4.08	11.7	0.287	1.000	0	0	0	0
	59.5	4.08	12.5	0.306	0.400	0.360	0	0	0.240
	60.0	3.85	29.2	0.758	0.685	0.151	0.014	0	0.151
	60.5	3.97	112.8	2.841	0.816	0.084	0.009	0	0.091
	60.5	4.20	10.0	0.238	0.350	0.650	0	0	0
	61.0	3.97	0.0	0.000	0	0	0	0	0
	61.0	3.97	1.1	0.028	0.182	0	0	0	0.818
	63.0	4.54	63.7	1.403	0.903	0.055	0	0	0.042
	64.5	4.65	7.4	0.159	0.270	0.054	0	0	0.676
	65.5	4.76	43.8	0.920	0.731	0.068	0.023	0	0.178
	65.5	5.33	2.3	0.043	0	0	0	0	1.000
	66.0	5.10	17.1	0.335	0.526	0.351	0	0	0.123
	66.0	4.88	1.9	0.039	0	0	0	0	1.000
	72.0	6.69	31.5	0.471	0.063	0.381	0	0	0.556
	83.0	10.21	4.3	0.042	0	0	0	0	1.000
	101.5	16.79	387.5	2.309	0.968	0.019	0.013	0	0
	120.5	28.92	508.5	1.759	0.905	0.068	0.028	0	0
	121.0	31.64	603.5	1.907	0.981	0.007	0.012	0	0
	123.5	30.62	204.0	0.666	0.735	0.206	0.059	0	0
	124.0	33.57	381.1	1.135	0.800	0.055	0.108	0.034	0.002

	(cm) Fish Length	(Kg) Gutted Weight	(ml) Food Volume	% Ir	Ratio Fish	Ratio Squid	Ratio Prawn	Ratio Crab	Ratio Crust
	126.0	34.92	607.7	1.740	0.987	0	0.013	0	0
	128.0	34.02	705.0	2.072	0.121	0.241	0	0.638	0
	128.0	32.20	555.5	1.725	0.010	0.612	0	0.378	0
	128.0	37.88	131.2	0.346	0.480	0.381	0.130	0	0.009
	129.5	39.24	493.8	1.259	0.618	0.160	0.063	0.132	0.028
	132.0	41.50	1155.5	2.784	0.407	0.173	0.221	0.199	0
	132.0	41.05	612.0	1.491	0.699	0.229	0.059	0.013	0
	132.5	44.79	786.6	1.756	0.057	0.089	0.001	0.852	0.001
	135.0	40.83	158.0	0.387	0.823	0.108	0.070	0	0
	135.0	42.19	596.0	1.413	0.705	0.295	0	0	0
	137.0	45.36	342.5	0.755	0.394	0.606	0	0	0
	137.0	42.52	476.0	1.119	0	0	0	1.000	0
	138.0	46.38	824.0	1.776	0	0.360	0	0.640	0
	140.0	49.78	137.0	0.275	0.511	0.474	0	0.015	0
	140.5	49.22	345.5	0.702	0.240	0.622	0.030	0.107	0
	149.5	58.06	214.0	0.369	0.028	0.855	0	0.117	0
October:	47.0	1.82	4.2	0.231	0.214	0.167	0.619	0	0
	48.0	1.93	1.5	0.078	0.267	0	0.733	0	0
	103.5	18.94	475.0	2.508	0.701	0.274	0.025	0	0
	105.5	20.98	565.0	2.693	0.283	0.055	0.060	0.602	0
	107.0	20.42	470.5	2.305	0.531	0.044	0.149	0.278	0
	108.0	20.07	533.5	2.658	0.843	0.146	0.010	0	0
	108.5	21.89	725.0	3.313	0.658	0.152	0.072	0.119	0
	108.5	20.75	599.0	2.886	0.851	0.078	0.068	0.003	0
	109.0	21.32	358.5	1.682	0.014	0.223	0.060	0.703	0
	115.5	25.97	317.1	1.221	0.851	0.088	0.003	0.057	0
	118.0	26.43	320.6	1.213	0.296	0.303	0.008	0.393	0
	125.0	33.45	254.4	0.761	0.090	0.063	0.006	0.841	0
	126.0	34.36	832.0	2.421	0.853	0.100	0.005	0.042	0
	132.5	40.14	867.0	2.160	0.714	0.234	0	0.052	0
November:	49.0	2.04	3.8	0.186	0.368	0	0.474	0	0.158
	50.0	2.26	22.9	1.012	0.742	0.197	0.052	0	0.009
	67.0	5.22	46.0	0.881	1.000	0	0	0	0
	67.5	5.44	21.2	0.390	0.684	0	0	0.307	0.009
	68.5	5.44	17.2	0.316	0.988	0	0	0	0.012
	106.0	20.42	340.0	1.665	0.559	0.038	0.059	0.344	0
	108.0	21.09	452.5	2.146	0.287	0.212	0.059	0.442	0
	109.0	22.00	497.0	2.259	0.503	0.227	0.119	0.151	0
December:	98.0	15.42	534.0	3.462	0.833	0.081	0.086	0	0
	100.5	17.13	566.0	3.305	0.090	0.862	0.048	0	0
	104.0	19.51	102.5	0.525	0.156	0.073	0.771	0	0
	106.0	20.53	320.0	1.559	0.594	0.375	0.031	0	0
	108.0	22.00	225.5	1.025	0.501	0.492	0.007	0	0
	108.0	20.41	511.5	2.506	0.567	0.295	0.138	0	0
	109.5	20.86	794.5	3.808	0.921	0.049	0.030	0	0
	110.0	22.11	448.6	2.029	0.223	0.767	0.010	0	0
January:	102.0	17.35	646.3	3.726	0.433	0.552	0.014	0	0
	107.0	20.64	7.0	0.034	0	1.000	0	0	0
	108.0	19.85	218.5	1.101	0.357	0.613	0.030	0	0