Also see:
Dudley, R.G., Aghanashinikar, A.P., Brothers, E.B., 1992. Management of the Indo-Pacific Spanish mackerel (*Scomberomorus commerson*) in Oman. *Fisheries research* **15**(1-2), 17-43.

LARGE PELAGICS
FINAL REPORT

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Large Pelagics Final Report

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I. Executive Summary of Activities, Results and Accomplishments

Activities in the large pelagics section have centered on management oriented studies of kingfish[1], *Scomberomorus commerson* and longtail tuna, *Thunnus tonggol*. Preliminary work with eastern bonito, *Sarda orientalis* and kawakawa, *Euthynnus affinis* was also carried out. Research emphasized length based stock analysis of these species aimed at generating basic growth and population parameters supplemented by aging fish with otoliths. This information was used to determine the status of stocks of these species in Omani waters.

We have found that kingfish become an important component of the catches at less than one year of age, well before their size at first spawning. Because of this, and because kingfish are growing very rapidly during the first year, mesh regulations to protect young kingfish, if they could be instituted, would lead to an overall increase in the kingfish catch. Although kingfish are migratory, genetic stock analysis revealed that Omani populations are different from those in Djibouti and Dubai. This leads to the conclusion that, for the present, management actions regarding Omani kingfish can proceed without undue concern that the benefits will be derived elsewhere.

Longtail tuna enter catches at less than one year of age, but are not very abundant at this size. Most longtail in the catches are 3 years old or older. Length based analysis of longtail tuna is of limited value, and consequently little information regarding survival rates of this species was obtained. However, it is believed that the fishery for this species is currently at a reasonable level.

Three studies were carried out by consultants to the project which were directly related to large pelagics work. Electrophoretic stock identification studies with kingfish assisted in determining the existence of sub-stocks within the region and the extent to which Omani kingfish are shared with adjacent areas. Otoliths from kingfish and longtail tuna examined via electron microscopy assisted in determining the growth pattern for these species. After obtaining advice on the use and purchase of a system to receive sea surface temperature data via satellite the program acquired this system for the MSFC.

Omani counterparts have learned basic data collection techniques and research assistants have each carried out independent projects, consistent with their abilities, under the direction of the Senior Scientist. Each has written a short paper resulting from this research and gave a presentations of the research to both the Marine Science and Fishery Center staff, and to regional fisheries workshops sponsored by the Indo-Pacific Tuna Program.

Summary of Major Accomplishments:

> Establishment of an ongoing data collection program carried out by Omani staff which resulted in more than three years of excellent length frequency data.

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[1]The internationally accepted English common names for this species are Indo-Pacific Spanish mackerel or narrow barred Spanish mackerel. However, the name kingfish is widely used in Oman and will be used in this document.

Definition of growth patterns of longtail tuna and kingfish based on length frequency and otolith data.

Creation of a simple interactive model of Omani kingfish populations to examine possible changes in fishing regulations.

Specification of initial recommendations regarding kingfish gillnet mesh sizes.

Active participation by Omani men and women staff in research projects.

Preparation of research papers by Omani research assistants for presentation at two regional workshops.

Completion of stock identification studies with kingfish.

II. Introduction and Section Overview

A. Mission

Large pelagic fishes in Oman include several tuna species and the Indo-pacific Spanish mackerel (kingfish). This group of fish is extremely important in terms of both landings and value. During the past few years these fishes accounted for 30 to 40 percent of Oman's catch and over 50 percent of its landed value. The primary mission of the Large Pelagic Section is to provide a basis for scientifically sound management of Oman's resources of tuna, kingfish, and similar species. In order to serve this function the fisheries project has taken an approach of carrying out research to provide initial management advice while building the Marine Science and Fishery Center as a research institution. This approach has emphasized techniques in which Omani counterparts, most with only limited training, could participate.

B. Section Objectives:

Section Objectives as stated in the original (June 1987) and revised (August 1988, October 1989) implementation plans are:

to establish an ongoing research program with large pelagic fishes,

to obtain initial research results of importance to the management of the large pelagic fishery resources, and

to assist qualified Omani staff members in initiating and continuing research programs with large pelagic fishes.

More specifically, work within the section has centered around applying the above objectives to two important species: kingfish (*Scomberomorus commerson*) and longtail tuna (*Thunnus tonggol*). Several studies with these species are underway and research was extended (in late 1987) to include eastern bonito (*Sarda orientalis*) and kawakawa (*Euthynnus affinis*).

C. Duties of the Section Head

In his capacity as Section Head, Dr. Richard Dudley's task was to work to attain the above objectives. To do this he has carried out biological studies of large pelagic fishes to provide information useful for their management in Oman, and has worked with Omani staff to assist them in carrying out research projects of their own. These projects are detailed below.

Dr. Dudley also acted as Chief Scientist of the Marine Science and Fisheries Center. In this role he has had primary responsibility for providing advice to the Director of the Center, coordinating activities of the various sections, and serving as the primary scientific contact (along with the Director) between the Center and other agencies.

Dr. Dudley was also Chief of Party for the Oregon State University Project. In this capacity he was responsible for all in-country activities of the Oregon State University/CIFAD project including purchasing of equipment and supplies, personnel matters, in-country financial matters, and official communications with the Ministry of Agriculture and Fisheries and the Omani American Joint Commission. Prior to October 1989 there was no in-country administrative assistant, or secretary, assigned to the project, so many routine administrative duties had to be carried out by him. Approximately 40 percent of Dudley's time was spent on large pelagics research.

D. General Description of Large Pelagic Resources and Their Importance

Much of the information reported in this section was also presented in Al-Barwani et al (1989).

1. Kingfish Scomberomorus commerson

a) Fishery:

This is a species of significant importance in Oman. Fishing for it is pursued from a variety of coastal boats from small (up to 10 m) fiberglass and wooden vessels, to large dhows. Gillnets are the primary means of catching *S. commerson*. Some of these are set in a trap configuration, especially along the Batinah coast. Drift gillnetting at night from dhows with one to two thousand meters of net is common in the area from Sur to Duqm, especially in the Masirah area. Although kingfish are caught throughout the year, catches are highest in September through early December and again in late February through April. During these periods fishing is carried out at night with the night's catch landed the following morning. During the less favorable periods some dhows make longer (7 to 14 day) trips keeping fish iced in the hold and in a large box on deck.

Kingfish are primarily a coastal species reaching a maximum size of 2 meters and about 40 kg. Fish larger than 1.5 meters are uncommon at present and most fish in the catch are between 60 and 120 cm.

Kingfish in Oman are usually marketed whole, ungutted. Many are exported, iced, by road to other gulf countries. A small quantity is exported frozen from fish processing companies.

b) Recent Catch Levels:

Between 15,000 and 30,000 metric tons of kingfish have been reported in Oman's catch statistics in recent years[2]. Reported kingfish catches for 1985 (18,500 mt), 1986 (14,300 mt), 1987 (25,500 mt) and 1988 (27,000 mt) seemed to indicate that the fishery was expanding, although improved statistics could have caused increases in reported landings. However, statistics for 1989 indicated that the kingfish catch had dropped to about 12,000 mt. Regional statistics indicate that Oman lands considerably more kingfish than adjacent countries. It is likely that year to year fluctuations in abundance occur regularly.

c) Management / Development Concerns:

There are several development and management concerns related to the kingfish fishery. It is a primary component of Oman's catch and a major source of income for traditional fishermen. Any development programs aimed at increasing kingfish catches must be very carefully considered.

Based on our present knowledge and research findings we believe that there is little room for expansion in this fishery. This finding is based on our studies which indicate that:

- Five to twelve month old kingfish (40 cm to 80 cm) are a major component of the catch.

- the fishery is dependent on only two or three ages of fish (especially fish 6 to 30 months old). This situation might lead to serious problem if one year yielded a poor spawning.

- there are significant fluctuations in catches from year to year.

- the fishing mortality may be fairly high.

Also, fisheries for closely related species elsewhere in the world have declined as a result of overfishing. Our research indicates that this species must be managed carefully. It appears that moderate increases in kingfish landings could be obtained by establishing minimum mesh sizes.

2. Small tunas

a) Fishery

Small tunas also comprise one of the major groups of fish species caught in Oman. These are caught by the same methods that are used to catch kingfish, primarily gillnets fished from small boats up to 10 meters in length.

The most abundant of the small tunas is the longtail tuna (*Thunnus tonggol*) which accounts for a major portion of the catch in Oman. Other small tunas which are relatively abundant in the catches are kawakawa or eastern little tuna (*Euthynnus affinis*), and eastern bonito (*Sarda orientalis*). Skipjack (*Katsuwonus pelamis*) occurs in the catches occasionally and may be more abundant in offshore waters.

[2]The fisheries statistics program has been supported by another part of the Omani American Joint Commission funded Fisheries Development Project. Statistical reports since 1985 were prepared by employees of Resources Development Associates: Tony Rasch, Robert McClure, Elie Moussalli, and Mahmood Bouhlel.

b) Recent Catch Levels

Separate catch statistics for small tunas were not available until recently, but total tuna catches during 1985, 86 and 87 were reported as 7,000, 12,000, and 26,500 mt respectively. In 1987 a reported 65 percent (17,000 mt) of the tuna catch was longtail tuna. The remainder was mostly yellowfin. Longtail accounted for approximately 16,000 mt in 1988. Catch levels for eastern bonito and kawakawa are not known, but both are seasonally abundant.

c) Management / Development Concerns

Like kingfish, small tunas (especially longtail) are a major component of Oman's fish catch. This tuna, like kingfish, is primarily a coastal, migratory species. As such it is subject to the nearshore fishery in several countries probably including Yemen (PDRY), the United Arab Emirates, Iran, and Pakistan. Catches of longtail tuna in the North Arabian Sea and Gulf of Oman are about 25,000 to 30,000 mt annually.

It is possible that this species is nearing its optimum fishing potential and that only limited expansion of the fishery, at least for longtail tuna, is possible. This conclusion is based on a preliminary study of longtail tuna growth and population parameters carried out over the past two and one half years. These results are approximate, and further studies are needed. However, another, approximate, estimation technique, based on expected catch rates per unit area of continental shelf waters (Yesaki 1988), supports this finding.

Thus, one of the management concerns is to balance the desire for expansion of the tuna fishery with the need to manage the resource of longtail tuna carefully. Eventually this will have to be done on a regional basis.

3. Yellowfin tuna

a) Fishery

Yellowfin tuna (*Thunnus albacares*) are now a target for industrial scale fishing based in Oman. During past years traditional catches of yellowfin have been sporadic, with several years passing without significant catches, but with occasional years of good catches. At present most yellowfin in the traditional sector are caught by handline from small boats. Some are caught by gillnet. This fishery takes place primarily between November and March. The considerable discussion concerning development of an industrial scale yellowfin tuna fishery culminated in 18 longliner licenses being issued in late 1989.

Until recently most yellowfin tuna were marketed locally at prices well below the world market price. Most fish sold locally are still sold at relatively low prices, but some increases in prices paid to fishermen occurred during the 1988 - 1989 season. Fishing companies purchased several thousand tons of tuna from traditional fishermen for export during the 1988-89 and 1989-90 seasons.

b) Recent Catch Levels

That yellowfin catches in Oman vary considerably from year to year is apparent both in the statistical data and in interviews with traditional fishermen. Catches during the 1987-88 and 1988-89 season were good, and attracted attention of potential buyers from within and outside of Oman. Prior to 1988 separate catch statistics were not collected for yellowfin, but in 1987 landings were estimated at about 6,000 mt. Catches during 1988 and 1989 season were about 15,000 and 16,000 mt.

Indian Ocean catches of yellowfin have been rising steadily and reached 130,000 mt in 1987. This represented an increase of almost 100,000 in five years due entirely to increases in purse seine catches. In 1987 approximately half the Indian Ocean catch was taken by 46 vessels (of which 20 were from France and 17 from Spain). A recent report (Pitcher and Hemphill 1989) indicates that this fishery is currently over exploited.

c) Management / Development Concerns

Because yellowfin tuna are highly migratory, management of them must be done on a regional basis. It is unlikely that any management actions (either restrictive or developmental) taken within Omani waters will have a significant effect on stocks of this species. On the other hand it is quite possible that the expanding yellowfin fishery in the Indian Ocean could affect Omani catches in the future.

For the present, catches of yellowfin from Omani waters, especially from the traditional fishery, will depend to a large extent on variations in the annual migratory pattern. Fishing further offshore will perhaps be less subject to the annual fluctuations.

Yellowfin tuna research in Oman has not been emphasized because significant other sources of information about yellowfin biology in the Indian Ocean are available, and because means of carrying out such research were seriously limited until commercial longliners started fishing here in late 1989.

Nevertheless, first steps have been taken to develop a program to look into possible oceanographic causes of the inter-annular fluctuations in traditional catches. This included a consultancy to examine the possibilities of using satellite obtained sea surface temperature data to record and examine conditions which might affect yellowfin distribution and migrations.

4. Other large pelagic resources.

Several other categories of large pelagic fisheries exist in Omani waters. These include billfishes, several members of the Jack (Carangidae) family and several other species. These species reportedly make up less than 10 percent of the Omani catch. Many sharks might also be considered large pelagic fishes. Shark catches also represent about 10 percent of the catch. A significant trade in shark fin exists. No specific research efforts have been directed at these groups of fishes yet. Of these groups, shark, sailfish and selected Carangidae are the most likely targets for future research.

E. Research Situation at Start of Project.

1. Summary of previously completed research.

Studies of large pelagic fishes in Omani waters were very limited at the start of this project. Although several stock assessment surveys had been carried out since the early 1970s, these gave only cursory treatment to large pelagic fishes. Because of their rapid movement, schooling, and highly migratory nature, most of these species are not readily assessed by hydro-acoustic, catch per unit area, or short term catch per unit effort survey techniques. In most cases, comments regarding large pelagic fishes have been limited to sightings of schools of fish and to data collected from fish caught incidentally during fishing operations for other species.

Some studies of kingfish in Djibouti (Bouhlel 1985), Saudi Arabia-Red Sea (Kedidi and Talal 1987), and India (Deveraj 1981, 1983) had been completed, but virtually no data for the kingfish stocks in Omani waters were available. Biological studies of yellowfin tuna from the central Indian Ocean and elsewhere were available. Relatively little biological, stock status or other studies were available for longtail tuna, in Oman or regionally, in spite of its commercial importance. Yesaki (1987) has provided a summary of biological data for this species.

Reliable catch statistics for Oman were not available prior to 1985-86. Summaries of regional catch data were available via the Indo-Pacific Tuna Program, but these are highly dependent on information submitted by member countries and were thus of limited use.

No research directed at large pelagic species in Oman was underway at the start of the project.

2. Available Data Sources

At the start of the project data regarding Oman's large pelagic species were limited to that found in information from regional and nearby country studies (see above). Some cursory information is included in a number of "survey" reports about Omani fish stocks. In addition, the Indo-Pacific Tuna Program provided catch data from participating countries in the region. This data, however, is based on reports which the countries submit and, at the start of the project, only very approximate figures were available from Oman. Several other participating countries have only approximate catch data for this group of species. Descriptions and some data from the traditional fishery for large pelagics was available in several consultancy reports.

3. Limitations of Available Information, Research, and Skills at the Start of the Project.

Data available at the start of the project were insufficient to support fishery management decisions. Data were limited by their scarcity, the temporary and short-term nature of the "survey" projects and the fact that studies from adjacent areas provide information of only limited value in managing Oman's fishery.

No assessment of the balance between fishing activity and stock size was available for any of the large pelagic species. No studies of the population parameters (which could be used for such an assessment) were available from Oman. Thus, no assessment of the status of these fish stocks was available and no research based management and development program could be formulated.

No Omani staff with degree program training in fisheries were available as counterparts at the start of the project. With the exception of one Indian national (Arundati) with an MSc. in fisheries, MSFC staff had limited training and that training was in other fields.

F. Summary of Research Situation the End of the Project

In contrast with the above, significant advances have been made in providing practical research findings of use in managing large pelagic fisheries.

Under the project a regular program for collection of large pelagics data has been established which can be continued with existing staff. Over three years of accurate length frequency data for major species is now available. Additionally, information related to gillnet selectivity, fecundity and views of traditional fishermen has been collected. This data has been used to provide a reasonable first assessment of the status of kingfish and longtail tuna stocks. These activities were expanded to include work with eastern bonito and kawakawa.

Specific recommendations have been made for management of the important kingfish fishery based on a simple model using information derived from our research activities.

In addition, Omani staff capabilities have improved significantly. They have been trained to regularly collect several types of data from and about large pelagic fishes (e. g. length frequency data, girth measurements, extraction of otoliths). They are capable of identifying major species of fish and have a general understanding of fisheries issues. They participate in ongoing research programs, and have presented papers, based on their own research projects, at Indo-Pacific Tuna Program Workshops held in Muscat in February 1989 and Indonesia in August of 1989.

III. Summary of Activities

A. Direction of Research

In view of the virtual absence of basic biological and stock data about large pelagic fishes in Oman, research programs were aimed at providing information which could form a preliminary basis for management of these species.

Because of the extreme importance of kingfish and longtail tuna in the Omani fisheries, work with these two species has been emphasized. As progress was made with these two species work was extended to eastern bonito and kawakawa.

Because of the shortage of trained Omani staff and the lack of suitable vessels for extended at sea programs, research projects were designed which made use of market sampling of commercial catches. In order to allow full participation of Omani staff with limited scientific skills, relatively simple data collection techniques were used.

B. Brief Description of Projects

1. Growth and Population Studies of Large Pelagic Fishes

This grouping includes the following research projects listed in the revised Project Implementation Plans: Otolith Based Growth Studies of Large Pelagic Species, Collection and Analysis of Length Frequency Data from Large Pelagic Fishes in Oman, and Stock Assessment of Large Pelagic Fishes Using Growth and Population Parameters.

The overall objective of these activities was to determine growth and mortality rates of major species and to use these in conjunction with other information to provide initial advice regarding the management of those species.

Initially it was expected, based on previous studies in India (Deveraj 1981), that otoliths[3] could be used to determine age and growth of target species. Toward this end otoliths from over 200 kingfish and over 200 longtail tuna were extracted from fish skulls and preserved. Preliminary microscopic analysis of these indicated that they were not suitable for standard age and growth studies using annular growth rings. Subsequently a sample of the otoliths was sent to a consultant (Dr. E. B. Brothers) in the U. S. for analysis using daily, as opposed to annular, growth rings via electron microscopy. Brothers (1990) found that otoliths of both species can be used for aging by using either annular growth rings or daily growth rings, but that special techniques must be used in either case. In general, he found that use of electron microscopy was more accurate, but that high power light microscopy could be used. He also reported that both species show very rapid growth during the first year. This finding agrees with recent studies for both tunas (Yamanaka 1990) and kingfish (Dayaratne 1989) but is in direct disagreement with earlier studies.

Because of difficulties encountered with the use of otoliths toward the start of the project, a program to collect length data from key commercial species was also started. Field sampling was originally intended to cover the major fish landing places with monthly trips to Sur, Al-Ashkarah and Masirah. This sampling program could not be followed given available staff and logistic support. Thus, a scaled down sampling plan was instituted which emphasized sampling at the Capitol area fish market with ad hoc sampling at Duqm, Masirah, Sur and Musandam.

The length data for kingfish appeared to be particularly good for growth and survival estimation because this species in Oman has a restricted spawning period and the length data exhibits very clear modes through the end of its second year. Analysis of otolith and length data revealed that much of the catch is composed of fish between 6 and 30 months of age.

Otolith and length data from kingfish was used with a simple computer model to develop management recommendations for this species. Most important of these recommendations was that protection of young kingfish could lead to an overall increase in kingfish catches.

Length analysis techniques for longtail tuna were less appropriate for the data available, but the fishery for this species appears to be approaching optimal exploitation levels.

[3]Otoliths are small bones from the inner ear which, like other bones of a fish, often contain growth marks which can sometimes be used to determine the age of a fish.

2. Investigation of Kingfish and Tuna Sub-Stocks

Because large pelagic species are quite migratory, it is essential to know the extent to which Omani stocks are shared with other countries. It was originally hoped that a program to tag kingfish and study their migratory pattern would be possible. This plan was not feasible and a program to investigate possible sub-stocks of kingfish via electrophoresis was initiated with the help of a U. S. based consultant (Dr. James Shaklee). Subsequently, a study of longtail tuna gill raker counts was carried out by staff member Shama Zaki (Shama Zakialdeen Abduhaleem). The purpose of these two studies was to investigate methods of identifying sub-stocks of major species in the region.

With the help of Juma Al-Mamry and other Omani staff muscle, liver and eye tissue samples were collected from 120 kingfish at each of the following locations: Masirah Island in Oman, Djibouti[4], and Dubai, United Arab Emirates. These were frozen, and shipped to the U. S. for analysis.

In their report Shaklee and Shaklee (1990, Appendix LP1) states that the kingfish from the three locations are not randomly interbreeding though some gene flow between the stocks is occurring. From a management point of view this means that Oman's stocks of kingfish are less likely to be affected by fishing in adjacent areas than was previously thought, and that Oman's management efforts are more likely to benefit Oman's fishermen and traders.

Research Assistant Shama Zaki carried out a study of gill raker counts of longtail tuna and compared them to counts from specimens from India reported in the scientific literature. This study indicated that, at least over a large geographic area, gill raker counts can be used as a means of separating stocks of this species (Abduhaleem 1989, Appendix LP2).

3. Factors Affecting Catch Rates of Major Large Pelagic Species

Several activities were carried out under this project (listed as tentative in the August 1988 Implementation Plan).

A study to learn about the knowledge of traditional fishermen was carried out by research assistant Juma Al-Mamry. He was encouraged to pursue this line of research and was provided with informal training in interview techniques. His work resulted in two papers which were presented at Indo-Pacific Tuna Program workshops.

Little progress was made on a proposed study to do experimental gillnetting to carry out mesh selection studies for kingfish and longtail tuna. A related sub-project investigating the girth (distance around a fish's body) of major species was started in mid 1989 instead. The purpose of both these studies was to gather information essential to the development of gillnet mesh regulations. Some experimental light fishing for kingfish (as is done in Djibouti and Japan) was also attempted.

A third activity coming partly under this project heading was advice regarding the purchase and use of system to acquire satellite transmitted sea-surface temperature data. Large pelagic species, in particular, tend to be associated with certain oceanographic features. These features can be identified from satellite images and thus the location of large pelagic species predicted.

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[4]Samples from Djibouti were collected by consultant Oliver Custer.

In March of 1989, a consultant oceanographer (Dr. Steve Neshyba) provided information and advice regarding possible uses of satellite imagery for fisheries. Subsequently Dr. Neshyba assisted the project in selecting an appropriate system for receiving the images.

The system to acquire satellite images was purchased and was received in March 1990, and a procedure to archive several images per day for later analysis has been established by Steven Hare (Demersal Finfish Scientist). This relatively inexpensive system is very robust since it is designed to be used on-board commercial tuna vessels. The images received are quite clear and are easily manipulated for analysis of oceanic temperature patterns.

C. Brief Description of On The Job or Other Training, with Examples of Changes in Omani Staff Capabilities

Via on the job training, Omani staff in the section have learned to carry out, in an organized manner, the regular monthly collection, recording and processing of various type of data.

They have learned to correctly identify major species, measure and record length, weight and girth of fish, determine the sex and maintain computerized data files of this information. They have learned to present these data in graphs, and now know how to give a general interpretation of the results. Omani staff have also learned to extract otoliths from several species and have maintained appropriate files for these data.

Both Omani research assistants in the section have carried out an independent research project. Both wrote a short scientific paper and presented that paper at an international workshop. These projects (interviews with traditional fishermen, longtail tuna gillraker counts) were relatively simple yet provided the staff with an opportunity to learn, and to expand their capabilities.

Although Omani staff assigned to the section have actively participated in the research program, none have formal training in fisheries. However, with some care in supervision and with specific assignments, they will be able to make significant contributions to the research program.

Formal degree program training was not a part of this project and (with the exception of the Deputy Director) no Center staff have completed any fisheries degree programs during the period of the project. Thus, the lack of formal degree program training in fisheries is still a major impediment to establishment of a research program carried out by Omani staff.

IV. Specific Research Projects

A. Kingfish Research (Scomberomorus commerson) Based on Length and Otolith Data

1. Introduction and Summary of Earlier Project Supported Research

a) The Importance of Kingfish in Oman

Kingfish (*Scomberomorus commerson*) are one of the major target species of the traditional fishermen of Oman. For this reason, and for resource protection reasons, no industrial fishery for them has been encouraged. Reported catches from 1985 through 1988 showed an increasing trend, but dropped from a peak of 27,000 mt in 1988 to 12,000 in 1989 (Rasch and McClure 1986, McClure and Moussalli 1987, Moussalli and Bouhlel 1989). There is some indication that significant variations in spawning success and subsequent yearclass strength occur. These variations as well as overfishing could have contributed to the decrease in catch.

Our research has recently revealed that kingfish grow rapidly as juveniles, and that a large part of the catch probably consists of non-reproducing fish less than 18 months old.

The kingfish fishery is at a critical point in its development. It is one of Oman's major traditional fisheries and there is interest in increasing Oman's total fish catch. It is unlikely that kingfish can contribute significantly to this expansion of the industrial fishery. Traditional catches of kingfish could benefit from minimum mesh regulations.

b) General Approach of Kingfish Research

Several approaches have been taken to provide an accurate view of kingfish biology and management in Oman. Limitations of staff and support were partly overcome by using relatively simple sampling techniques. Starting in February of 1987 length data was collected at the Capitol Area fish market during the first ten days of each month. The fork length of kingfish at the market were measured to the nearest cm. Usually, all kingfish at the market were measured unless they were very abundant in which case a random sample of specimens were measured. Supplemental collections of length data were collected irregularly at Masirah Island, Sur, Duqm, Musandam and other locations. On various occasions weights were also measured and gonads were collected for analysis. The methods used have been described in Dudley and Arundhati (1988 and 1989). Three years of length frequency data are summarized in Table 1.

c) Summary of Results as of December 1987

In Dudley and Arundhati (1988) we provided approximate parameters for the Von Bertalanffy growth function (VBGF) (von Bertalanffy 1938) and used these parameters to make some general recommendations regarding the management of kingfish in Oman.

The growth parameter L_{inf} was estimated from the length of the largest fish in the catch which was 202 cm. We used an approximate value of 200 cm for L_{inf}. We assumed also that two very well defined modes, in the monthly length frequency data collected to date, represented fish of one year age difference. This assumption coupled with the L_{inf} allowed us to estimate k as 0.27. The growth curve thus generated fit the modes in the length frequency data quite well and length at given ages agreed with reported sizes from adjacent areas (e.g. Devaraj 1981, Bouhlel 1985).

The natural mortality rate, M, was estimated using the method suggested by Pauly (1980). We used a value of M=.44. This information was used as input to a Beverton and Holt yield per recruit model and general conclusions drawn. Available catch statistics were used along with growth parameters to provide gross estimates of kingfish population size and catches which could be expected from the fishery.

The approach taken was to bracket the parameters and recent catch estimates with probable values and to use these estimates as input for the Baranov catch function to arrive at gross upper and lower limits of population size. A range of reasonable fishing mortality rates (from the Beverton Holt analysis) were then used with these population size estimates to give a range of possible safe catch levels. Using the above information, an internal memo for the Director MSFC was prepared in December of 1987. The memo suggested that maximum catches should be in the range of 16,000 to 25,000 mt and that no expansion of the fishery should take place.

Given that Oman was in the process of rearranging and developing the industrial sector of the fishery in late 1987, it was important that this, admittedly very approximate, information be provided in order to protect kingfish stocks. This information was used by the Ministry as evidence to reserve the kingfish fishery for the traditional sector. The drop in reported catch from 27,000 mt (1988) to 12,000 mt (1989) suggests that this advice was justified. This drop may have been due to natural causes or to fishing.

d) Summary of Information Reported in 1989

Dudley and Arundhati (1989) (Appendix LP3) provided a more detailed analysis of kingfish biology in Oman based primarily on 24 months of length data coupled with other observations. Analysis of the data was carried out using the ELEFAN computer package (Gayanilo et al 1988, reviewed by Pauley 1987).

Growth parameters of the VBGF (L_{inf}, k) were estimated from the length data. In this case we estimated parameters for two seasonally oscillating growth curves: one which the program identified as the best fit (L_{inf}=164, k=0.34, C=0.36, WP=0.10) and one which fit slightly less well but also accounted for the larger fish in the catches (L_{inf}=203, k=0.23, C=0.28, WP=0.13). We also fit a non-oscillating curve to the data (L_{inf}=170, k=0.301).

The information from both oscillating growth curves was used, with corresponding estimates of natural mortality based on Pauly's (1980) method, in applying standard length converted catch curve techniques to the length data. We used more than one set of input parameters in order to report a range of probable values and to emphasize the preliminary nature of the report.

This analysis resulted in estimates of total mortality (Z), from which the fishing mortality (F) can be derived if an estimate of natural mortality (M) is known. The analysis also yields estimates of relative catch at different fishing levels which provides an estimate of the optimal fishing level (or level of fishing mortality).

The results of this analysis were different for the two growth functions used, but lead to somewhat similar results. At one extreme the analysis indicated that a minor expansion of the fishery might be possible, especially if the length at which fish are first captured is increased. At the other extreme the fishery should be curtailed somewhat.

Our general conclusion was that fishing for kingfish should not be increased, and that kingfish smaller than 80 cm should be protected at some future date when such regulations were feasible. At the time the paper was completed (December 1988) the most recent statistics reported kingfish catches of 25,000 mt (for 1987).

2. Growth Information from Otoliths

At the start of the project we intended to use otoliths to determine the growth rates of kingfish following the methods of Deveraj (1981). Otoliths were collected from several hundred kingfish, but upon examining them we felt that apparent annual marks on them, as seen by low power microscope, were not consistent enough to be used for aging. Subsequently, a small sample of otoliths, was sent to a consultant (Dr. E. B. Brothers) for analysis.

The project to collect and examine otoliths of kingfish was started in early 1987. Obtaining skulls, from which we could extract otoliths, was hindered because kingfish are expensive and are marketed whole. Skulls were collected from the Muttrah market, where fish are butchered for individual customers, and from Oman Fishing Company. Many of the specimens from the market consisted of the skull only with no length measurement. In these cases fork length of the specimen was estimated from the upper jaw length which was a good predictor of fork length (Fork length=8.65*Jawlength + 4.18). An effort was also made to identify fish sex from various head measurements, but this effort was unsuccessful.

The consultant (Brothers 1990) sectioned the otoliths and examined them with both high power light and scanning electron microscopy. Apparent daily growth rings and apparent annular marks were easily distinguished by this method and these measurements were provided in his report (Report is available from the MSFC library).

In general kingfish growth, as calculated from otoliths, is extremely rapid during the first 3 to 5 months of life, and remains very rapid until an age of about 2 years. According to this information, kingfish reach 60 cm at an age of six months and approximately 75 to 80 cm at an age of one year (in June).

Sizes at given ages estimated from otoliths do not agree with ages estimated from length data. For young fish, our length data predicted ages a year older than that estimated from otoliths. Length data analysis designates ages of 18 months and 2 years for fish 60 cm and 75 to 80 cm.

Similar extremely rapid growth of young kingfish has been reported recently by Dayaratne (1989), but other published reports of kingfish growth assume much slower growth comparable with what we had reported earlier (Dudley and Arundhati 1989). At present it appears that this rapid growth phase does occur in Omani kingfish, but research in this area should be continued.

Analysis of annular rings on otoliths of larger specimens indicated that growth is quite slow after the fish reach an age of 2 (between 100 and 110 cm). However, it is possible that "false annuli" could make fish appear older than their true age. Thus the apparent slow growth of these older fish should be considered a preliminary finding.

3. Definition of a Kingfish Growth Pattern

Prior to this study a wide variety of kingfish growth parameters are reported in the literature (see Thiagarajan 1989, Cheunpan, 1988 for summaries) with L_{inf} ranging from 47 to 187.

From our work two sets of data were available for the investigation of a kingfish growth pattern: otolith data and length frequency data. The otolith data consists of daily growth ring information and annulus (yearly ring) information. The length frequency information consists of the raw length frequency data (Table 1) and of the means and variances of normal curves which were fitted to the length frequency modes using the Bhattacharya (1967) method. For the latter purpose only clearly definable modes were used (Table 2, Figure 1).

Kingfish length frequency data included in this analysis covers three years: February 1987 through January 1990 including that reported in Dudley and Arundhati (1989). Methods of data collection followed those outlined in that paper.

The clear progression of length frequency modes reveal a clear growth pattern during the time the kingfish are between 45 and about 120 cm. The otolith data permitted us to assign absolute ages to these modes. When this is done the otolith daily ring data and length frequency size at age data coincide for length frequency modes between 40 and 110 cm or ages of six months to two years (Figure 2).

The spawning time of kingfish agrees well with the start of otolith growth. Our observations indicate fish ripening in March and April while the otolith derived ages for individual specimens indicate fertilization dates between April 15 and July 15 with a mean spawning date of 15 June. Thus kingfish entering the fishery in September through November are spawned in April through July and are 4 to 6 months old.

Analysis, with ELEFAN, of the raw length frequency data collected over three years yields the following parameters for the von Bertalanffy growth function (von Bertalanffy 1938): L_{inf}=226.5, k=0.208. By using a t_0 value of -0.85, the growth curve derived using the ELEFAN technique can be adjusted to coincide with the 15 June starting date suggested by the otolith data.

A second technique was used to fit a VBGF to the data. A nonlinear curve fitting technique (Saila et al 1988) was applied to a combined set of otolith (daily and annulus information) and length frequency modal progression data (Table 2). The best fitting curve has the following parameters: L_{inf}=132.9, k=0.5825, t_0=-0.487.

The relatively low L_{inf} of 132.9 cm (the theoretical maximum length the fish can attain) is somewhat troublesome given that kingfish in Oman attain a size in excess of 200 cm and are fairly common up to a size of 150 cm. This discrepancy could be due to natural variations in growth, since the parameters are mean values, but other explanations are possible. One explanation is that apparent annular marks on the otoliths may include some "false annuli" which would make the fish appear older at a given size than they really are. Such a situation could be due to multiple spawning marks on the otoliths, for example. In his report, however, Brothers (1990) felt that there was reasonable agreement between the daily and annular counts.

A second possibility, for the discrepancy between the L_{inf} values and the existence of larger fish, is that the VBGF may not be an appropriate growth model for this species. Yamanaka (1990) found, for example, that yellowfin tuna growth was better described by two conjoined regression lines (segmented regression) rather than the VBGF. Also, Brothers (1990) found that incremental growth of kingfish continued throughout the life of the fish. Consequently, a conjoined segmented regression line was fitted to the same data set used above.

While all the possible growth curves are in general agreement when predicting size at age below a length of about 110 cm, their predictions of size at age for larger fishes differ considerably. Although many of the fish in the catch are below this size, the potential for growth, and catches of fish, above this size is an important management consideration. The VBGF fitted to the otolith and length frequency mode data predicts very little growth for fish above 110 cm. The VBGF fitted using ELEFAN predicts only gradual slowing of growth. The segmented regression model predicts continued but slow growth, fits the available data well, and accounts for the existence of large kingfish.

For the present, we can conclude that the segmented regression best describes the growth of kingfish. This model allows for the very rapid growth prior to reaching an age of two years, followed by a much slower but continuing growth. This growth pattern should be confirmed with more detailed studies of otoliths.

A summary of the different growth curves is given in table 3.

4. Summary of Findings

An accurate description of kingfish growth is necessary to predict the effects of various management actions. Two approaches were taken to learn about kingfish growth: careful collection of length data from the commercial catch, and the examination of otoliths (bones from the fishs' ear) for examination of daily and annual growth marks. Some differences between the two methods were resolved when the absolute age of the fish was determined from the otoliths. There remains some question regarding the rate of growth of fish above 110 cm. In general kingfish grow to about 80 cm in one year and to about 108 cm in two years. After this the growth rate slows considerably.

5. Recommendations

a) Recommendations for Management

For the present it is suggested the very rapid growth through age two be accepted as correct. The implications of this are that kingfish enter the fishery at an age somewhat less than six months, and that many of them are caught prior to reaching age 1. Fishery management implications of this are given at the end of the next section (A Simple Spreadsheet Yield Model for Kingfish). Basically protection of young kingfish is desirable for the fishery. It is also recommended that the segmented regression be used as the appropriate model of kingfish growth until more accurate growth rates for larger kingfish are available.

b) Recommendations for Future Research

The Marine Science and Fishery Center should acquire the ability to examine otolith microstructure on a regular basis. This will require that arrangements be made to use high power microscopes and, preferably, an electron microscope. This could be done via cooperation with Sultan Qaboos University. When qualified MSFC staff are available, they should be given training in appropriate micro technique skills. It is not recommended that an electron microscope be purchased by the MSFC.

B. A Simple Spreadsheet Yield Model for Kingfish

1. Introduction

A simple yield model outlined by Ricker (1975) was used to briefly investigate possible management stategies for kingfish. The approach suggested by Ricker has the benefit of extreme flexibility allowing one to examine the consequences of varying fishing rates over the life span of the fish. Also various patterns of natural mortality and growth can be easily investigated. This is important for investigating the kingfish fishery since there is a strong seasonal component in the catches with significantly more fish landed in September through December of each year. Also, the effects of limiting fishing on the youngest fish (known locally as "khabat") can be easily investigated.

This approach is basically a "table model" with the primary inputs of: length at age, fishing mortality at age, natural mortality at age, and a length weight relationship. The primary output is catch (or yield) for each age group entered. Although prepackaged computer programs for this approach are available (e. g. Saila et al 1988), the approach is ideal for implementation as a spreadsheet using commercially available software which some of the staff already use.

A computer spreadsheet version of this yield model was created using the following approach.

2. Methods

A spreadsheet table was set up following the format of Ricker (1975). Monthly lengths at age, initially taken from the segmented regression model of kingfish growth, were input through the end of year 6 after which lengths at each year were used. The length weight relationship $W(kg)=1.72*10^{-6}\ L(cm)^{3.31}$ based on our data was used to convert length to weight (Figure 3).

The primary output from the model is yield in weight vs age group (by month through year 6 and by year through age 18).

Yield in numbers was also estimated (yield divided by mean weight within each age group) to allow comparisons with actual length frequency data. In calculating these the yield (weight or numbers) vs length, the yield value in each length interval was divided by the width of the length interval to allow a comparison of yield per length group on a common basis (y/cm). In real life lengths of fish at a given age are distributed about a mean length value for that age; in the model all fish are assumed to have the mean length for their age. This makes the yield of each age group appear in a narrower length category than would actually occur in nature. Note that yield vs age group is the normal output of this model.

The model was set up to allow manipulations of the parameters while watching graphs of the various outputs on screen.

Note that all predicted yields, or catches, from the model are relative, not actual or recommended, values. However, if the model is correct and adequately mimics the real world, then changes induced in the model (caused by changes in fishing intensity for example) should predict relative changes in the fishery.

A "Seasonality" sub-table was set up to adjust fishing mortality rates automatically for seasonal changes in abundance in the Omani kingfish fishery. These values, which can be adjusted by the user, automatically adjust the values of fishing mortality prior to those being incorporated into the main yield table. The starting values for the "season ratios" were derived from monthly kingfish catch statistics for 1988 and 1989 (Table 6, Figure 5).

A sub-table for "Fishing Intensity" permits simultaneous adjustment of fishing mortality in six month blocks (August through January and February through July) which roughly correspond to the major fishing seasons. This allows the investigation of possible regulations during different seasons and for different age groups of fish. This table can be used to test possible management strategies such as the protection of young kingfish. This table also allows adjustment of natural mortality rates (Table 5).

Also a sub-table for "Khabat Selection" permits entry of multipliers to adjust the gradual entry of young kingfish (khabat) into the size range vulnerable to the fishing gear (Table 6).

In general the annual fishing mortality rates entered in the fishing intensity table are multiplied by the seasonality factor and khabat factor prior to entry into the main table on a monthly or yearly basis. If desired, fishing and natural mortality rates can be entered directly for each month (or year) in the main table.

3. Results

After adjustment of the input parameters for the model, the starting point given in the example table was selected (Table 7). The only change from the above comments was the downward adjustment of size at age during the first 6 months to conform more closely with what is actually seen in the fishery. The output from these values is assumed to correspond roughly to the current situation, and was used as the basis for comparison with other possible fishing levels.

The model output resulting from the basic inputs is shown in Figures 6 through 9. The length frequency distribution (Figure 8) mimics the actual annual length frequency distribution in the fishery (Figure 4). Predicted monthly catches (Figure 9) also mimic the actual catch (Figure 5). Using the base inputs, catches of fish larger than 80 cm make up most of the catch by weight, but catch by numbers has a significant proportion of smaller kingfish caught during the fall season. Relative catch in weight was 32,008 units.

A reasonable management action, from a biological point of view, would be to protect young kingfish (khabat) which are still growing fast. This allows them to add more weight to the population for harvest at a future date. This possibility was tested with the model. Two approaches were used: one which would protect khabat during the fall season, and one which would protect fish during their entire first year (through July). The first is more realistic of the two from a social perspective, but either could be accomplished via enforcement of minimum mesh regulations for kingfish gillnets.

Test A1 - Protection of khabat: Protection of Khabat during the fall season (August through January) would result in an increase in catch of 23 percent. In spite of this limitation in the fall season, which could be accomplished with restrictions on gillnet mesh size, the catch during the fall season would actually increase, starting the following fall, since the catch of two year old fish would go up. (Figures 10 through 13, Table 8 - Test A1).

Test A2 - Protection of kingfish throughout their first year: If it were possible to protect fish during their entire first year, using larger mesh regulations, then an catch increase of 34 percent would be realized. This increase would be due to the same reasons given above: the protected fish are growing rapidly and would be available for harvest the following year at a much larger size (Figures 14 through 17, Table 8 - Test A2).

The starting point for the above comparison are assumed to be somewhat like those occurring in the fishery now. The fishing mortality F and natural mortality M are not known. However, any reasonable guess of current fishing and natural mortality levels would lead to the same conclusion: Protection of young kingfish will lead to an increase in kingfish catch. One can also conclude that the more intense the fishing, the more beneficial the protection of young fish will be (Table 8, Tests A through E). In general lower natural mortality rates would also make the protection of young kingfish from fishing more beneficial (Table , Tests F through H). This occurs because fish are not being removed from the population by natural causes.

In the absence of fishing the critical size (the size at which a cohort has its maximum biomass) of Omani kingfish is 108 cm at an age of about 2 years. However, at the assumed base fishing and natural mortality levels relatively little benefit would be derived from protecting fish beyond approximately one year of age and a length of 80 cm.

The model considers only numbers and fish size. It does not deal with variations in reproductive success. Some Omani kingfish spawn at the end of their first year at a size of 80 cm, but a large proportion spawn later. Also, larger fish have more eggs. Based on Devaraj's (1983) findings we can conclude that 1 year old (80 cm) kingfish spawn an average of 590,000 eggs while age 2 fish (110 cm) spawn about 1,500,000. Thus, protection of young kingfish also enhances the stocks reproductive success.

4. Summary of Findings

A simple model of the kingfish fishery revealed that increases in the weight of the total catch would be obtained by protecting young kingfish so they can grow rapidly to a larger size prior to harvest. The finding is valid for a wide range of assumed fishing and natural mortality rates. The establishment of minimum mesh regulations could accomplish this protection, and would also allow more kingfish to reach spawning age. Such regulations are probably feasible in the present fishery.

5. Recommendations

a) Management Recommendations

It would be beneficial to protect young kingfish. This can be done by regulating mesh sizes in nets used primarily for kingfish although some small kingfish would continue to be caught in other nets.

A minimum mesh regulation requiring stretch mesh sizes of 4.75 inches[5] or 12 cm would protect some young kingfish (khabat) during the fall season. This is close to what is normally used except in special khabat nets. Better would be a 5 inch regulation (12.7 cm) which would provide more protection for these young fish. In order to provide protection for most fish during their entire first year a 5.5 inch (14 cm) mesh regulation would be needed. This would provide the most benefit to the fishery although even a 6 inch (15.24 cm) regulation could be considered. Although it might be difficult to convince fishermen of the benefits of a 5.5 inch minimum mesh regulation it should be possible if the idea is discussed with them in advance and the benefits explained.

These minimum mesh size suggestions will have little negative impact on catches of another important species: longtail tuna (see page 23, **Girth Studies**). Effects on catches of other species should be assessed, but are believed to be minimal.

For the present serious consideration should be given to the gradual introduction of a 5 inch (12.7 cm) minimum mesh regulation for kingfish nets. In the future this might be increased to 5.5 inches (14 cm).

b) Research Recommendations

The current MSFC staff have relatively limited, but improving, computer skills and a fairly limited understanding of the principles of fishery management. The above model serves an example of the type of simple model which can be used to improve the staffs' understanding of both. It can also serve to illustrate how the field data is used in assisting in management decisions. It is recommended that, under the leadership of the Director, selected Omani staff be given stepwise training in this approach to fishery management using Omani fishery examples. This model might be used as a first example since many staff are now familiar with computer spreadsheets.

Research directed at the development of better management recommendations needs to be carried out as well. These should include: better gillnet selectivity and girth studies, additional studies of the views of local fishermen and, especially, studies of causes and extent of kingfish yearclass fluctuations including studies of factors affecting spawning success.

[5] Gillnets are often sold in inch rather than centimeter categories.

C. Longtail Tuna Research

1. Summary

Studies with longtail tuna paralleled those carried out with kingfish. A report covering the research carried out in 1987 and 1988 was presented in February of 1989 (Arundhati and Dudley 1989, Appendix LP4). This document reported on our progress using length based methods to assess longtail tuna stocks and also pointed out possible weaknesses of that approach. That length based stock analysis yielded a growth function with the parameters L_{inf}=133.6 cm and k=0.228. Associated survival estimates indicated that the stock was heavily fished. This assessment agreed with comments made by Yesaki (1988a, 1988b) regarding longtail in the region. Length frequency data collected through January of 1990 is presented in Table 9.

A small sample of longtail tuna otoliths were examined using electron microscopy and the results reported by Brothers (1990). This information was used to estimate growth parameters for longtail for comparison with similar parameters obtained from the length based analysis. The otolith data (Figure 18) yields the following: L_{inf}=78.5, k=0.679 and T_0=-0.49.

The length analysis and the otolith analysis do not agree. This disagreement was not unexpected for longtail, but the very low L_{inf} from the otolith data is definitely questionable as well. Many larger longtail occur in Oman and most values of L_{inf} reported in the literature are higher.

If the otolith data are correct then the majority of fish caught in Oman are made up of several older year classes (ages 2 through 5 or 6). Our length based analysis suggested that most fish were only 3 and 4 years old. Techniques to estimate survival rates using the available data would have to make use of the growth function and would thus be questionable.

Based on length and otolith data we can say that small numbers of longtail tuna enter Omani catches at an age of 5 to 6 months and grow rapidly. They disappear from the catches shortly before the end of their first year and reappear at a size of about 60 cm and an age of about 2 years. The young are not abundant in Oman's catches.

2. Recommendations

Longtail tuna are an important species in Oman. Compared to other parts of the world the average size of longtail in the catches is very large. It appears unlikely that this species is being overfished, but its exact status is unclear at present. Yesaki (1988) concluded that the species was nearing its optimum catch potential in this region. Juveniles of this species are not abundant in the catches, and no special measures for their protection are necessary.

Better information on the growth of these species is needed, but will be hard to get. Otoliths from a representative sample of about 200 to 300 fish should be examined to assess the age composition of the population. This may be expensive and time consuming since sectioning of the otoliths and probable use of scanning electron microscope will be needed. This is a possible area of cooperation between the MSFC, Sultan Qaboos University and the Kuwait Institute for Scientific Research.

D. Work with Other Species

Section staff have started work with bonito (*Sarda orientalis*) and kawakawa (*Euthynnus affinis*). Length frequency samples have been collected since December of 1987. Only cursory length based analysis of these species has been attempted and that is not reported here. The length frequency data for both species appears to be valuable for analyzing size structure of the younger portion of the population and the data are presented in Tables 10 and 11.

E. Factors Affecting Large Pelagic Catches

1. Interviews with Traditional Fishermen

a) Summary

Research Assistant Juma Al-Mamry completed a project to collect traditional knowledge from local fishermen. He carried out open ended taped interviews with 20 fishermen in the Sur area of Oman after receiving training in this technique.[6] These interviews discovered several beliefs of local fishermen which were of interest to fishery research and management personnel. For example fishermen believe that kingfish migrate toward the Gulf of Oman and Arabian Gulf to spawn in the spring and that they don't return to the Arabian Sea until September and October.

This study also stimulated interest in the subject of traditional knowledge, and Al-Mamry is planning follow-up studies in Musandam and elsewhere. His presentation at the Indo-Pacific Tuna Program meeting in Muscat stimulated interest in this subject, in adjacent countries, and Al-Mamry gave a follow-up presentation (Colfer and Al-Mamry 1989), describing the methodology, at the IPTP meeting in Bali.

This work is described in detail in Al-Mamry (1989) and the methods used were described by Colfer and Al-Mamry (1989) (Appendices LP5 and LP6). Tapes resulting from the interviews are on file at the MSFC library.

b) Recommendations

After receiving appropriate training using Colfer and Al-Mamry (1989, appendix LP6) as a guide, several MSFC staff could continue to carry out this type of study. The objectives should be 1) to learn about traditional knowledge of fishermen regarding species and fishing activities and 2) to learn the views of traditional fishermen which would be helpful in managing fisheries in Oman. The latter category might discover such things as traditional management systems and locally enforced regulations. These in turn might be incorporated into current national fishery management which would be more acceptable to the traditional sector.

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[6]Dr. Carol J. P. Colfer of Sultan Qaboos University and Dr. Dawn Chatty kindly provided this training.

2. Girth Studies

a) Summary

A study of girth measurements of kingfish and longtail tuna was carried out during 1988, 1989 and 1990. This work was initiated in lieu of a full scale gillnet selectivity study which was not possible given available staffing.

Section staff measured fish on a monthly basis at the Muttrah fish market. Fork length and girth at three points on the fish's body at which entanglement in nets would be likely were measured. These points were at the eye, back of the head, and most importantly just in front of the second dorsal fin. On kingfish this latter measurement was made at a slight diagonal from the front of the second dorsal fin to the front of the anal fin. Girth measurements were measured with a custom built device consisting of a loop of heavy monofilament line which passed through a hole in a metal rectangle to a metric measuring scale. Using this device the staff measured one-half the girth to the nearest half centimeter. Half girth is comparable to the maximum stretch mesh size which would catch the fish at this point.

Girth measurements at the front of the second dorsal fin of kingfish (Figure 19) were used to recommend mesh regulations for this species. This location on kingfish has been identified in earlier studies as the major site of gillnet entanglement. Although a small proportion of kingfish are caught by the head or jaws most similar species are caught between the back of the head and the front of the second dorsal fin (e.g. Ehrhardt and Die 1988). Consequently the mesh regulations discussed above (see page 20 Recommendations) were based on this measurement.

Longtail tuna girth at the back of the head is slightly wider than at the front of the second dorsal fin (Figure 20) but the difference is small. Because small size longtail are not important in Omani catches, mesh regulations for kingfish will not have an adverse effect on longtail catches.

b) Recommendations

Girth studies are important for setting mesh regulation and should be continued. The current study has provided the necessary basic information for formulation of gillnet mesh recommendations, but should be continued. More information on the selectivity curve for young kingfish during the fall season should be carried out with more accurate measurements.

Concurrent gillnet selectivity studies should be carried out if possible by fishing fleets of multimesh gillnets.

A thorough survey of the sizes of nets used for different species and in different areas should also be carried out. This must involve actual measurement of gillnets on board fishing boats not just discussions with fishermen.

3. Kingfish Yearclass Fluctuations

a) Summary

A study of fluctuations of the young of kingfish was not a planned research project, but our monthly length frequency data suggests that significant year to year fluctuations in the abundance of young kingfish occur. Fluctuations in overall kingfish catches also occur.

It is very possible that fluctuations in kingfish spawning success or juvenile survival are directly responsible for fluctuations in the kingfish catch. Young kingfish (age 6 to 30 months) make up a large portion of the catch. Decreased spawning success during any May and June will be observable starting the following September and would last for about 15 to 16 months until the next year class becomes dominant.

Spawning in 1989 (April through July) resulted in few young fish entering the fishery in October November and December. This could have been due to late spawning, poor spawning success, or both.

An example of these fluctuations, revealed by our length frequency data, is given in Figure 21.

b) Recommendations

Because length frequency data for kingfish is an excellent indicator of the stock structure for younger ages, it is recommended that a length frequency data collection program for kingfish be continued.

Ideally this program should include stratified sampling in major landing areas with a minimum of 200-300 fish being measured in each area each month. If this is not possible a scaled down program should be carried out with a minimum of monthly data collection at the Muttrah market.

In addition, a special effort to estimate the abundance of young kingfish in the catches in September through December should be made. This should include the standard length sampling program, but might be expanded to included special sampling areas along the Batinah coast, at Masirah and elsewhere. This program could be carried out in conjunction with the statistics sampling program.

Center fishery workers should always be alert for any kingfish smaller than 40 cm since virtually none of these have been seen in Oman. According to our studies these should be abundant somewhere in July through September.

F. Stock Identification Studies

1. A Biochemical Genetic Assessment of Stock Structure of Kingfish (*Scomberomorus commerson*) in Oman (Carried out by consultant James B. Shaklee and Margaret A. Shaklee)

a) Background

Accurate identification of kingfish stocks is important because Omani kingfish may be shared with adjacent countries. The extent to which such sharing occurs will influence the effectiveness of fishery management development activities in Oman. For example, if Omani kingfish are regularly harvested in the Arabian Gulf then stock conservation measures in Oman will be less effective. Consequently a knowledge of stock structure and migratory pattern are essential to the proper management of this species.

At the start of the project it was thought that a full scale kingfish tagging project could be carried out. This was not possible. Instead a biochemical genetic study of kingfish from different regions was started. Muscle, liver, and retina samples were obtained from three locations (Djibouti, Masirah Island, Oman and Dubai, United Arab Emirates) over the course of 18 months.

Samples were immediately frozen and were shipped to a consultant in the U.S.A. for analysis. The consultants' report (Shaklee and Shaklee 1990, Appendix LP1) gives the full details of the analysis and results.

b) Summary

In general biochemical analysis using electrophoresis is based on the following principles: various enzymes are extracted from the target tissues, a enzyme sample is subjected to an electric field which separates various forms of the enzyme, the ratio of the different forms of each enzyme is determined for each population, and this ratio is then compared across the various sampling locations. Also a composite picture of each population is created using the results for many enzymes, and this composite is compared with other populations. The details of this analysis are in the consultants' report (Appendix LP1).

The results of the consultants report indicate that kingfish populations at the three locations are somewhat genetically distinct, but that the differences are relatively small. They recommend, however, that for management purposes the stocks be considered separate.

c) Recommendations

From a fishery management point of view the above finding implies that the kingfish fishery in Oman is less likely to be affected by actions taken in other areas, and that management actions taken in Oman will be more likely to benefit Omani fishermen. It is thus suggested that management of Omani kingfish proceed with less concern for what other countries might do.

This study should be considered a first look at kingfish stock structure in the region since several questions remain unanswered. During this study we were unable to obtain samples from Pakistan and Yemen. Consequently, a follow-up study is recommended which would include samples from these two countries. Ideally a regional project to tag kingfish should be carried out. Such a project should not be attempted until sufficient funding and trained personnel are available.

2. Gill Raker Counts: a Possible Means of Stock Separation for Longtail Tuna (*Thunnus tonggol*) in the Indian Ocean

a) Summary

Under project direction Research Assistant Shama Zaki carried out a study of gill rakers of longtail tuna. Her study used a simple technique to investigate possible differences in longtail tuna stocks. She found that gillraker counts from longtail in Omani waters differ significantly from those reported from Sri Lanka. Details of the study are in her report (Abduhaleem 1989, Appendix LP2).

b) Recommendations

Techniques like this can be carried out by current MSFC staff. Given the importance of longtail tuna in the region, correspondence with colleagues in nearby countries seems an appropriate means of following up on this subject.

Also, other meristic and morphometric characteristics may also be appropriate. This approach may be appropriate with yellowfin tuna as well since several new techniques of analyzing morphometric measurements are now available. For example, Schaefer (1989) found distinct geographic variation in northern and southern groups of yellowfin tuna from the eastern Pacific Ocean.

V. Other Research Activities

A. Publications, Reports and Papers Presented

The following reports were prepared by, or under the direction of the Section Head. With one exception (Dudley 1987) which was only an oral presentation, these were all oral presentations accompanied by a written paper which was later reproduced in the proceedings of the meeting in question.

Abduhaleem, Shama Zakialdeen. 1989. Gill Raker Counts: a possible means of stock separation for longtail tuna (*Thunnus tonggol*) in the Indian Ocean. in Report of the Workshop on Tunas and Seerfishes in the Arabian Sea Region. Indopacific Tuna Program Workshop. Muscat, Oman. February 1989. (Appendix LP2).

Al-Mamry, Juma. 1989. Interviews with traditional fishermen near Sur, Oman. in Report of the Workshop on Tunas and Seerfishes in the Arabian Sea Region. Indopacific Tuna Program Workshop. Muscat, Oman. February 1989. (Appendix LP5).

Arundhati Prabhaker Aghanashiniker and Richard G. Dudley. 1989. Age, growth, and mortality rates of longtail tuna *Thunnus tonggol* (Bleeker) in Omani waters based on length data. in Report of the Workshop on Tunas and Seerfishes in the Arabian Sea Region. Indopacific Tuna Program Workshop. Muscat, Oman. February 1989. (Appendix LP4).

Colfer, C. J. P. and Juma Al Mamry. 1989. An Introductory Method for Gaining Access to the Indigenous Knowledge of Fishermen. Report of the 3rd Southeast Asian Tuna Conference. Denpasar, Indonesia, 22-24 August. IPTP/89/GEN/17 (**Presented by Al-Mamry**) (Appendix LP6).

Dudley R. G. 1987. Linkage Between Technical Assistance and Fishery Management. Invited Talk at the Annual Meeting of the American Fisheries Society. Winston-Salem, North Carolina. September 1987.

Dudley, R. G. and Arundhati Prabhakar Aghanashinikar. 1988. Preliminary studies of *Scomberomorus commerson* and *Thunnus tonggol* in Omani Waters. in IPTP, 1988 Report of Workshop on small Tuna, Seerfish and Billfish in the Indian Ocean.Dec.9-11, 1987. IPTP/87/GEN/13

Dudley, Richard G. and Arundhati Prabhaker Aghanashiniker. 1989. Growth and population characteristics of *Scomberomorus commerson* in Oman based on length data. in Report of the Workshop on Tunas and Seerfishes in the Arabian Sea Region. Indopacific Tuna Program Workshop. Muscat, Oman. February 1989. (Appendix LP3).

Dudley, R. G. 1989. Oman's large pelagic species: management and research considerations. Report of the 3rd Southeast Asian Tuna Conference. Denpasar, Indonesia, 22-24 August. IPTP/89/GEN/17 (Appendix LP7).

Dudley, R. G. 1989. Kingfish and small tunas in Oman: Assessment and management considerations. Paper presented at the International Agriculture and Fisheries Symposium held in Muscat, Oman. October 1989. (Appendix LP8).

B. Conferences Attended

All Section research assistants and Dudley attended and presented papers at the Indo-Pacific Tuna Program workshop which was held in Muscat in February of 1989.

The project also supported Dudley's attendance at the Tuna Workshop held in Sri Lanka in 1987 when he accompanied Ministry representative Rashid Al-Barwani, and the Tuna Workshop held in Indonesia in 1989 when he accompanied participant trainee Juma Al-Mamry.

See above, Publications and Reports, for a list of papers presented at these meetings.

C. Displays

A display describing kingfish research was prepared by Section Staff and was on display in the Marine Science and Fishery Center lobby for about two years. Assistance was also provided for displays at the Fisheries and Agriculture Exhibition held in November 1988.

D. Other.

Several internships with technical school students were carried out at the Marine Science and Fishery Center. Usually these students worked with the section staff for one to two weeks.

Dudley helped team teach a fishery biology course for Sultan Qaboos University students with other project staff.

VI. Summary of recommendations resulting from project activities

This section summarizes recommendations made throughout this document.

A. Recommendations for Management

1. Kingfish Mesh Regulations

Kingfish enter the fishery at six months, and many are caught prior to reaching age one. Protection of young kingfish is desirable to allow them to grow to a larger size and to allow them to reach spawning age. This protection can be accomplished by regulating mesh sizes in nets used primarily for kingfish.

A minimum mesh regulation requiring stretch mesh sizes of 5 inches (12.7 cm) would provide sufficient protection for young kingfish during the fall season. These fish would then grow to a larger size before being harvested. In order to provide protection for most kingfish during their entire first year, a 5.5 inch (14 cm) mesh regulation would be needed. This would provide the most benefit to the fishery although even a 6 inch (15.24 cm) regulation could be considered.

For the present, serious consideration should be given to the gradual introduction of a 5 inch (12.7 cm) minimum mesh regulation for kingfish nets. In the future this might be increased to 5.5 inches (14 cm).

2. Stock Identification

Based on the stock genetics study, fishery managers can assume that kingfish in Oman are reasonably distinct from those in other regions. This means that, for the present, they can assume that Omani management actions will benefit Omani fishermen. Thus, management of Omani kingfish should proceed with less concern for what other countries might do. Follow-up stock identification studies are needed.

3. Fishing Levels

The kingfish and longtail tuna fisheries should be stabilized at present levels. Some expansion of the longtail fishery may be possible but this should await a better estimate of stock age composition. Mesh regulations proposed for kingfish will not adversely affect the longtail fishery. Juveniles of longtail tuna are not abundant in the catches, and no special measures for their protection are necessary.

B. Recommendations for Future Research

1. Length Frequency Data Collection

Because length frequency data for kingfish is an excellent indicator of the stock structure for younger ages, it is recommended that a length frequency data collection program for kingfish be continued.

Ideally this program should include stratified sampling covering major landing areas with a minimum of 200-300 fish being measured in each area each month. If this is not possible a scaled down program should be carried out with a minimum of monthly data collection at the Muttrah market.

2. Kingfish Yearclass Fluctuations

Studies of causes and extent of kingfish yearclass fluctuations including studies of factors affecting timing and success of spawning are extremely important. Studies aimed at learning more about these fluctuations should be designed and carried out. These studies should include egg and larval distribution, and studies of stock fecundity.

In addition, a special effort to estimate the abundance of young kingfish in the catches in September through December should be made. This should include the standard length sampling program, but might be expanded to include special sampling areas along the Batinah coast, at Masirah and elsewhere. This program could be carried out in conjunction with the statistics sampling program.

3. Age Composition of Longtail Tuna Stocks

It is recommended that otoliths from a representative sample of about 200 to 300 longtail tuna should be examined, using high power light and scanning electron microscopy, to assess the age composition of the population. This is a possible area of cooperation between the MSFC, Sultan Qaboos University and the Kuwait Institute for Scientific Research.

4. Preliminary Training in Modeling Techniques

It is recommended that, under the leadership of the Director, selected Omani staff be given stepwise training in the use of simple models for fishery management using Omani fishery examples. The spreadsheet model presented here might be used as a first example since many staff are now familiar with computer spreadsheets.

5. Studies with Traditional Fishermen

After receiving appropriate training using Colfer and Al-Mamry (1989, appendix LP6) as a guide, several MSFC staff could carry on interviews with local fishermen. The objectives should be: 1) to learn about traditional knowledge of fishermen regarding species and fishing activities and 2) to learn the views of traditional fishermen which would be helpful in managing fisheries in Oman. The latter category might discover such things as traditional management systems and locally enforced regulations. These in turn might be incorporated into current day management which would be more acceptable to the traditional sector.

6. Gillnet Selectivity Studies

Gillnet selectivity studies should be carried out, if possible, by fishing fleets of multimesh gillnets. These studies should be aimed toward obtaining more accurate information on the selectivity curve for young kingfish during the fall season, and at learning about the selectivity curves of other species.

A thorough survey of the sizes of gillnets used for different species and in different areas should also be carried out.

7. Stock Identification Studies

Additional biochemical genetic stock identification studies of kingfish and tuna in the region are needed since several questions remain unanswered. Any follow-up study should include samples from Pakistan and Yemen.

Simpler stock identification techniques like that carried out using longtail tuna gillraker counts can be continued by current MSFC staff. Given the importance of longtail tuna in the region, at least work with this speies should be continued. Correspondence with colleagues in nearby countries seems an appropriate means of following up on this subject.

Other meristic and morphometric characteristics may be appropriate targets for this type of study with both longtail and yellowfin tuna.

Ideally a regional project to tag kingfish (and tunas) should be carried out. Such a project should not be attempted until sufficient funding and trained personnel are available.

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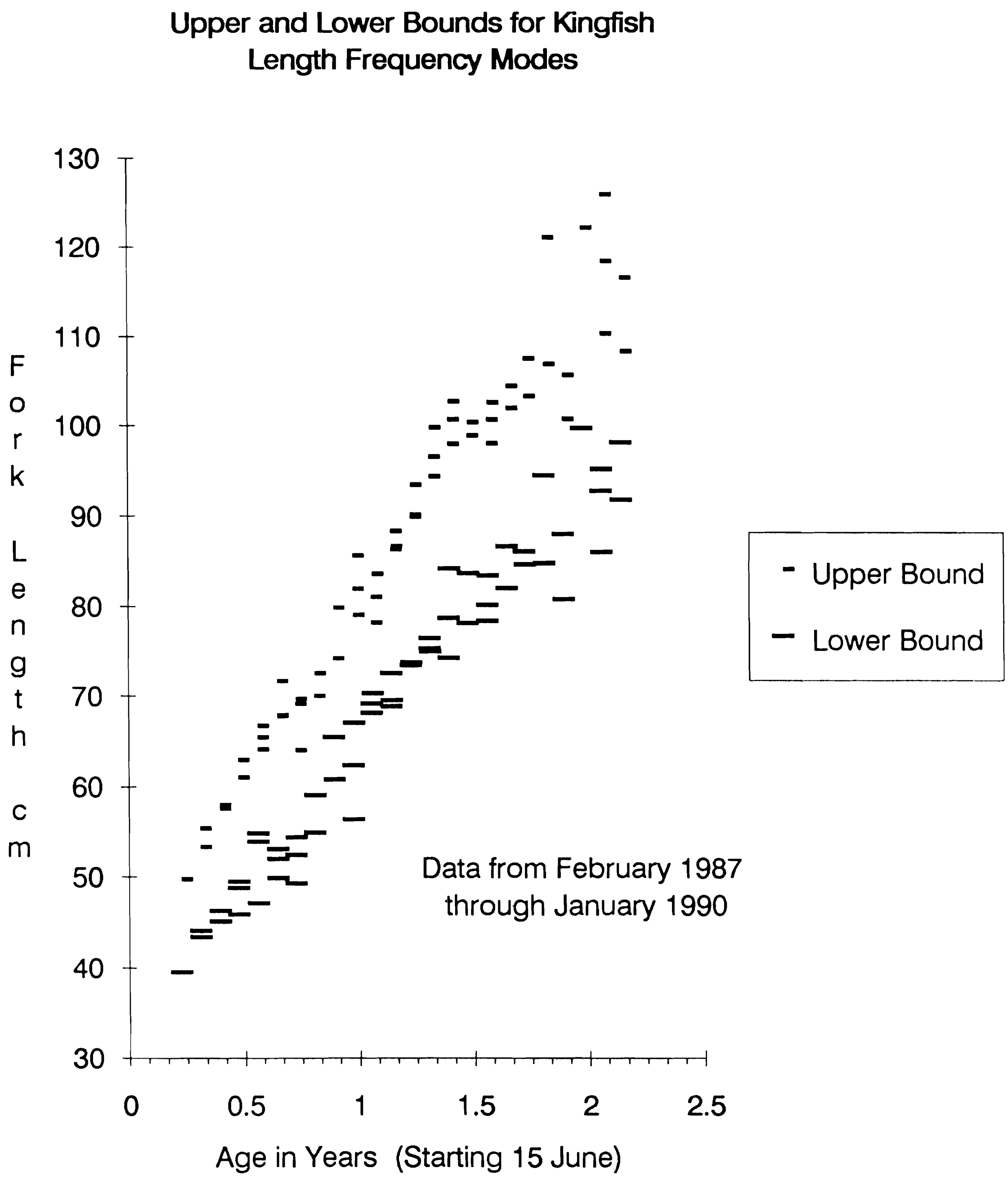
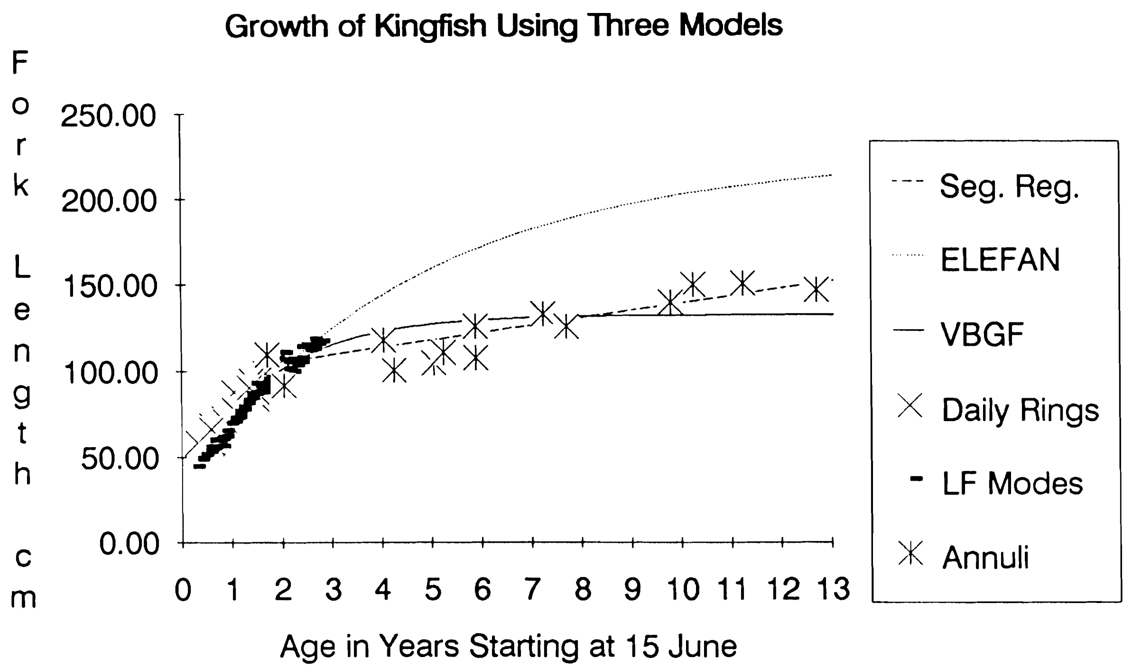


Figure 1. Upper and lower bounds for kingfish length frequency modes. Normal curves were fitted to each obvious mode using the Bhattacharya (1967) method. Bounds shown here are the mean plus or minus 1.96 SD.



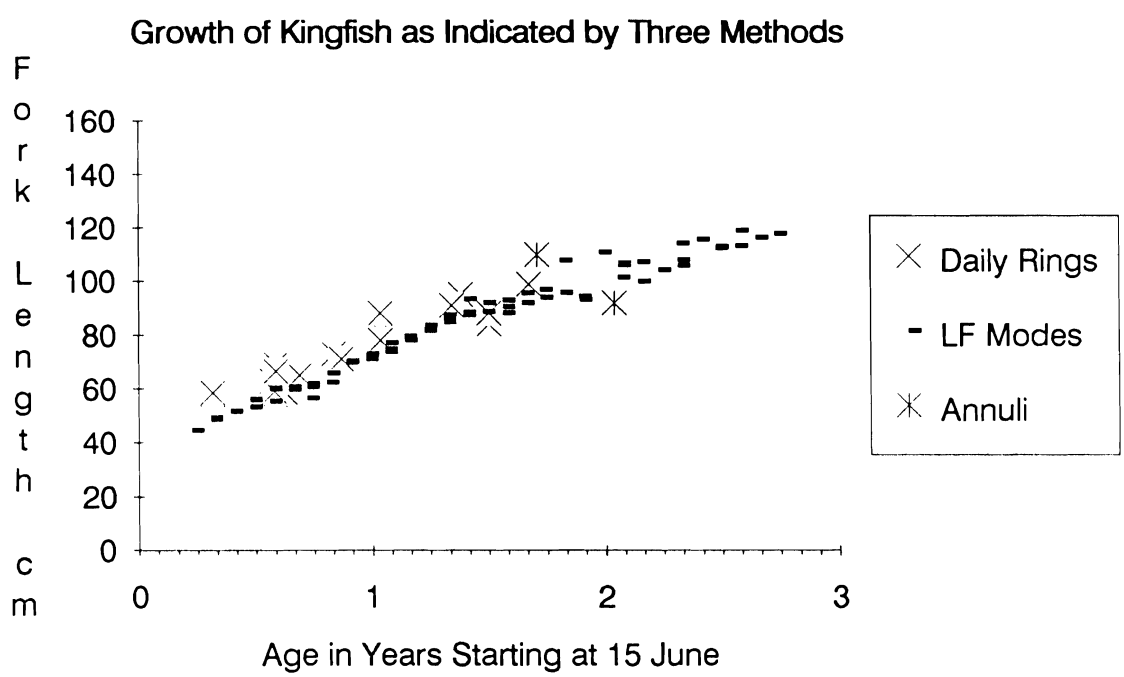


Figure 2. Growth of kingfish using three curve fitting methods. Methods used length frequency data with ELEFAN, and two curve fitting routines with a mixture of otolith daily ring counts, otolith annulus counts, and length frequency modal data. See text.

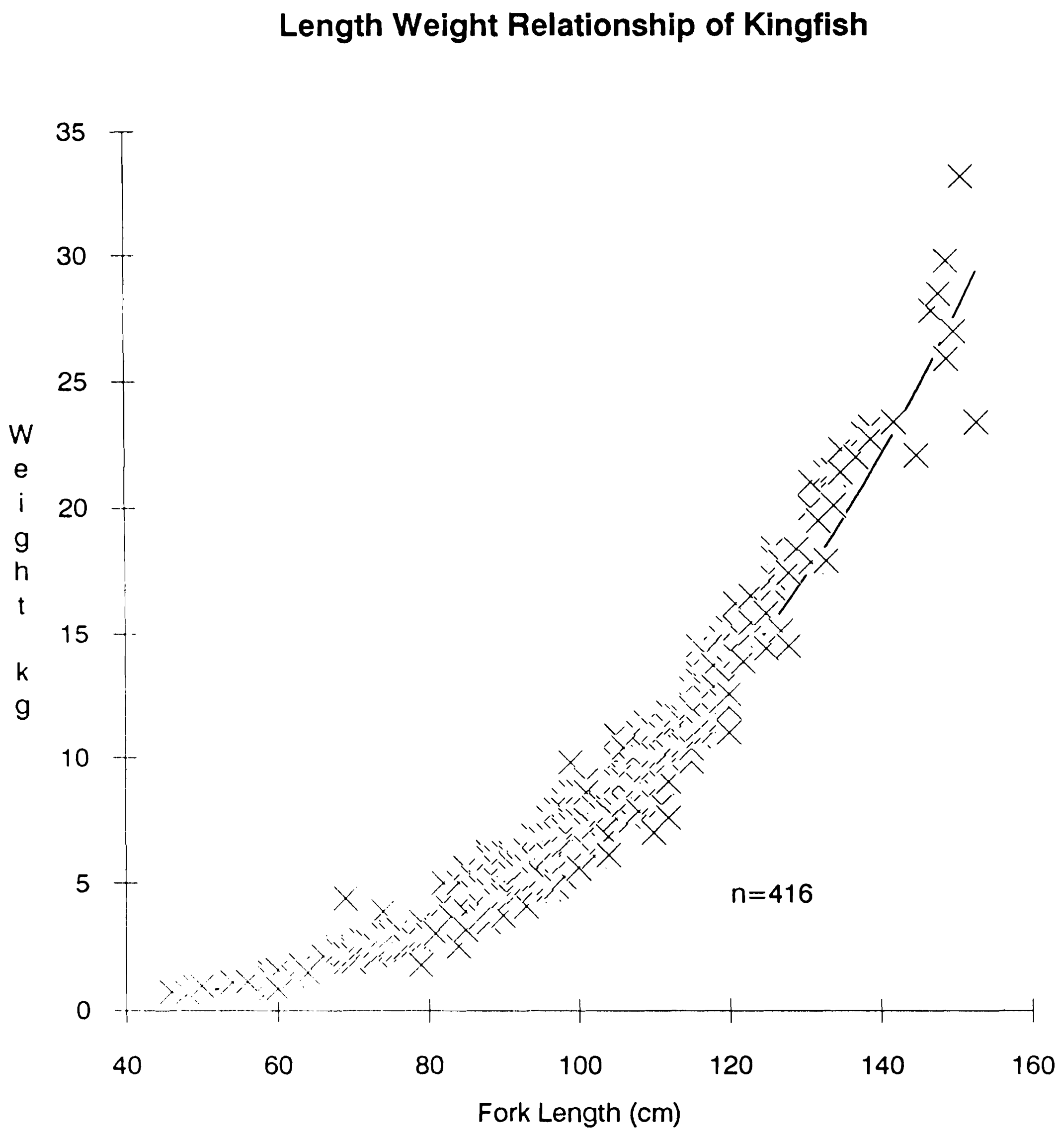
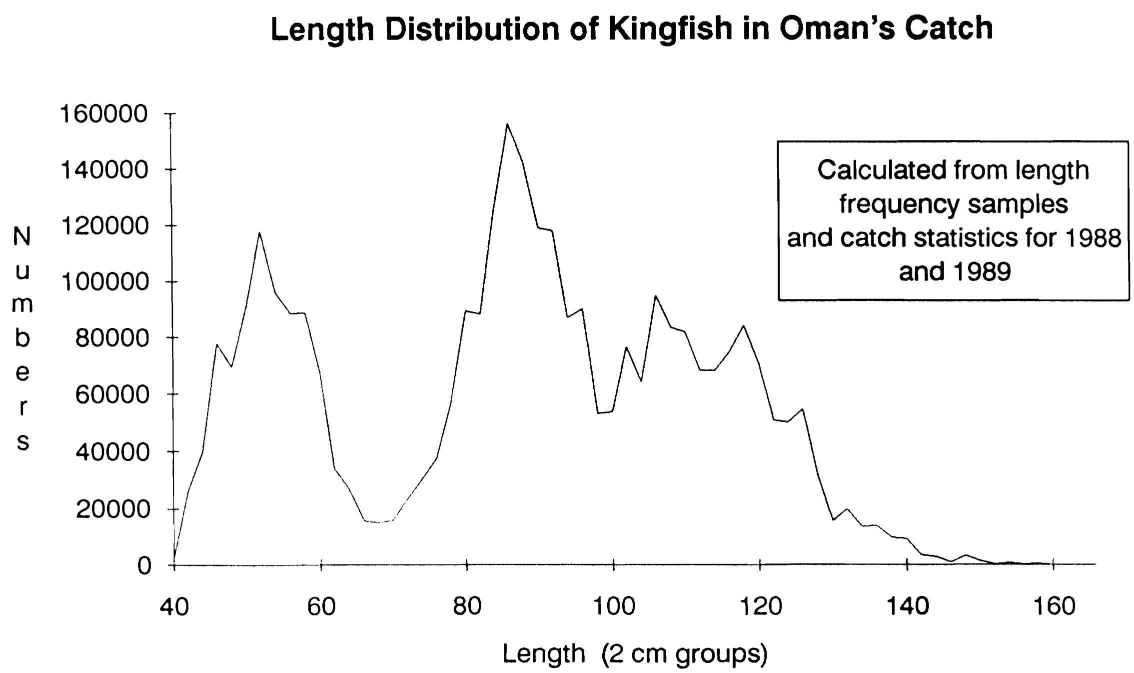


Figure 3. Length weight relationship of kingfish:
W(kg)=1.72 ^ 10^{-6}*L(cm)$^{3.31}$. Data was collected at Duqm in March of 1988 and April of 1989.



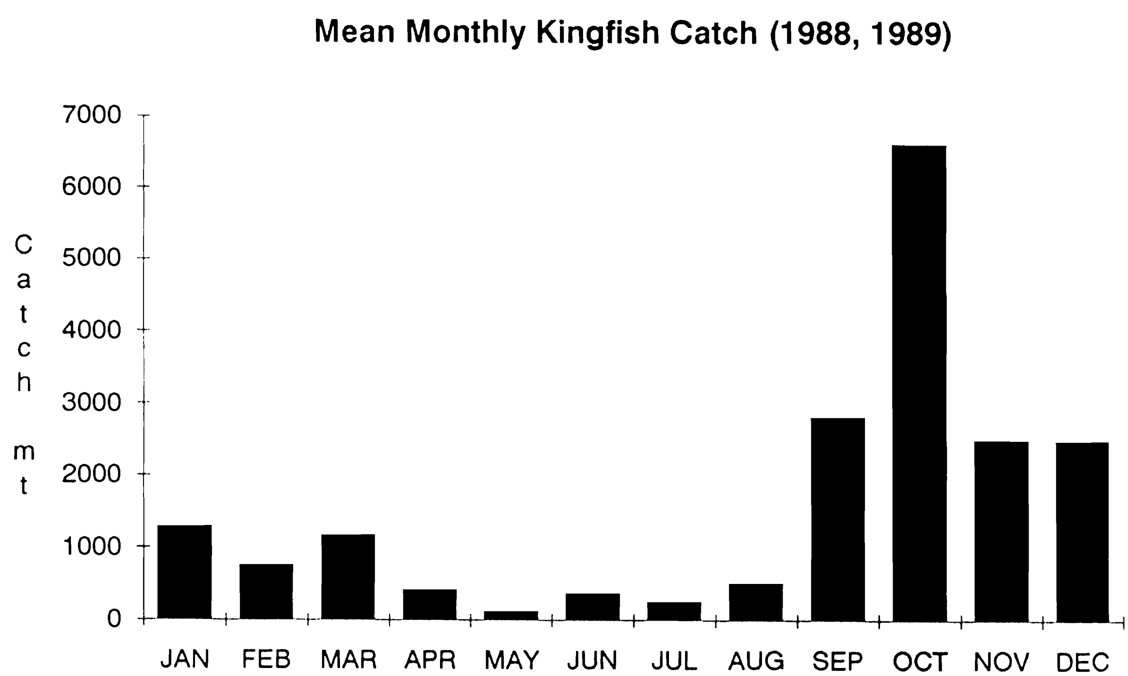
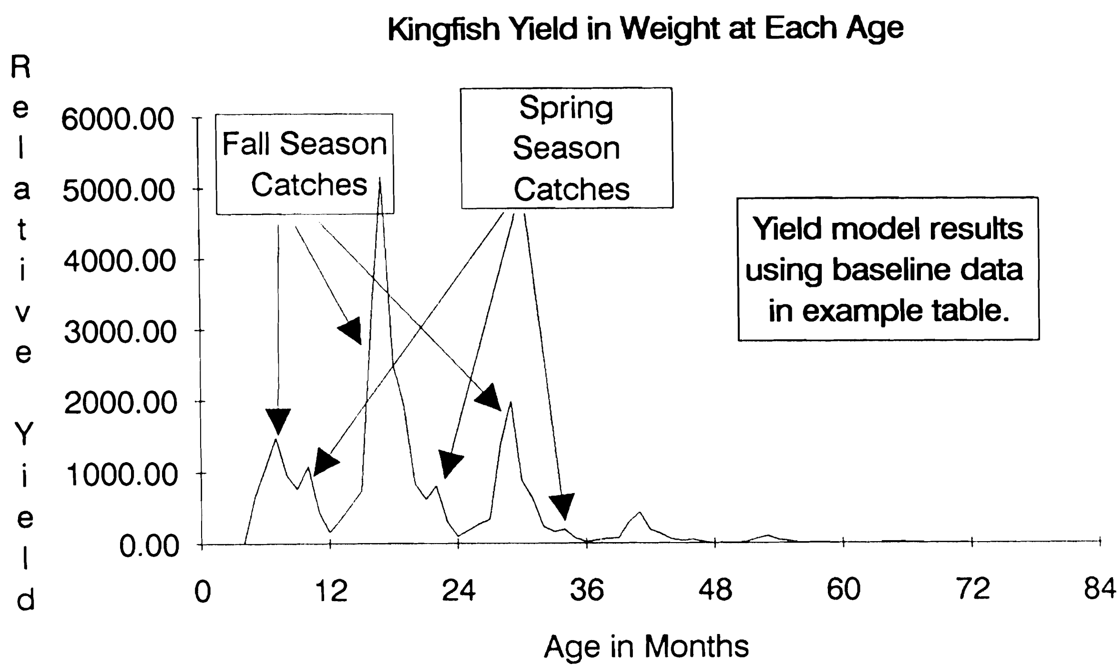


Figure 4. Length distribution of kingfish in Oman's catch during 1988 and 1989. Based on length frequency data expanded to total numbers for each year. Mean of the two years is plotted here.

Figure 5. Mean monthly kingfish catch reported by the statistics section. Mean monthly value for the two years is plotted here.



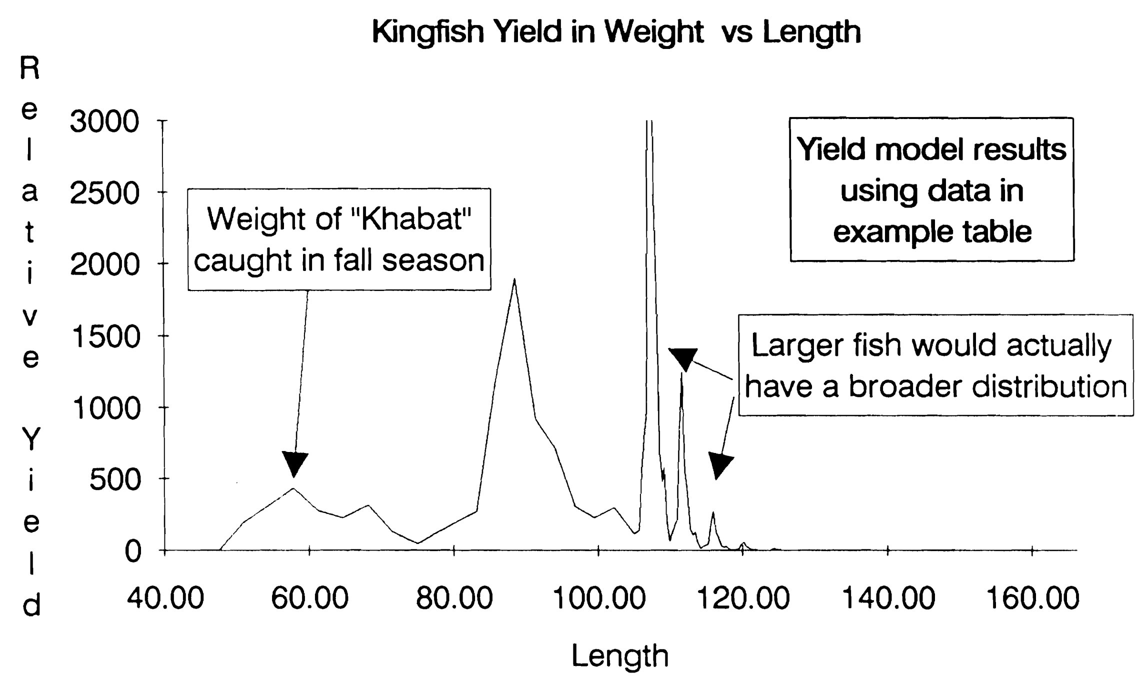
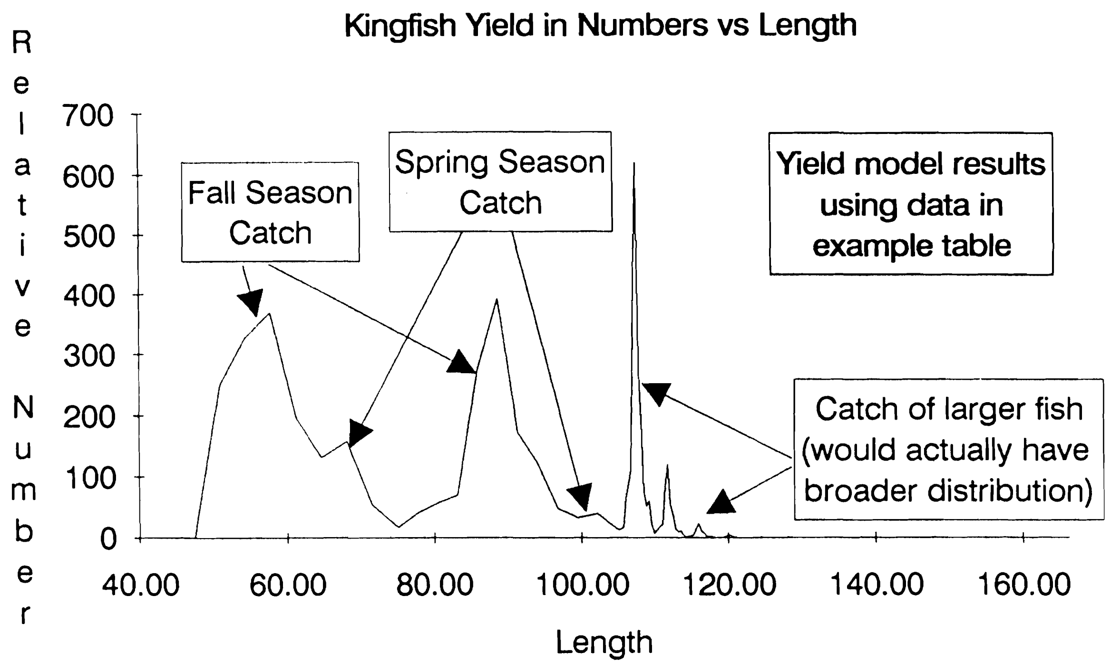


Figure 6. Yield model results using baseline data. Yield in weight at each age.

Figure 7. Yield model results using baseline data. Yield in weight at each length.



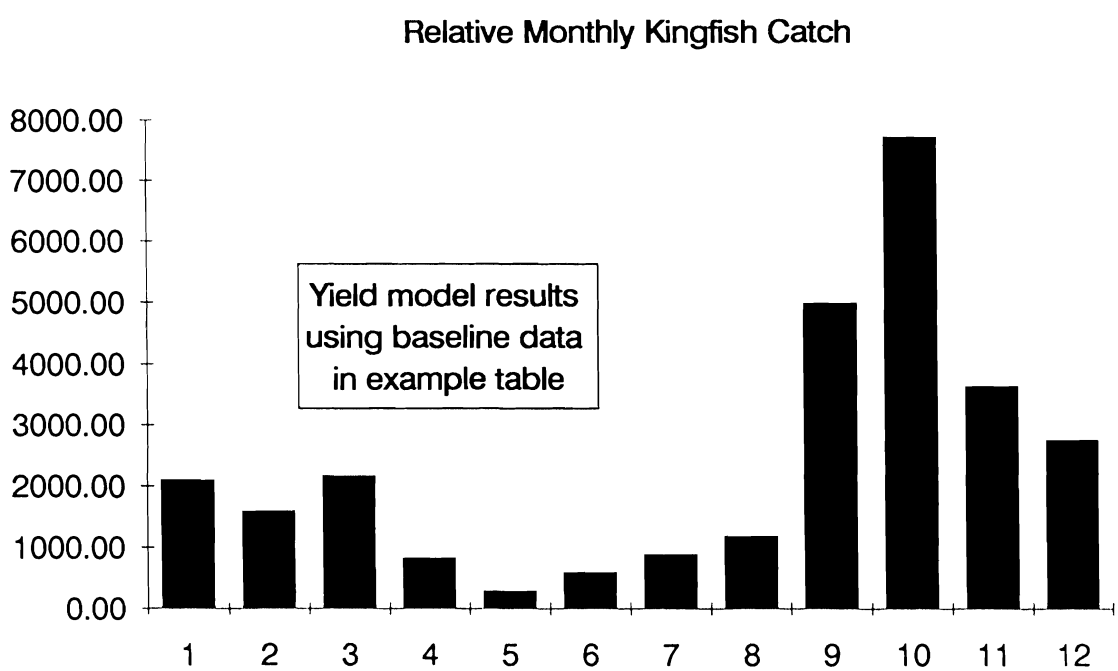
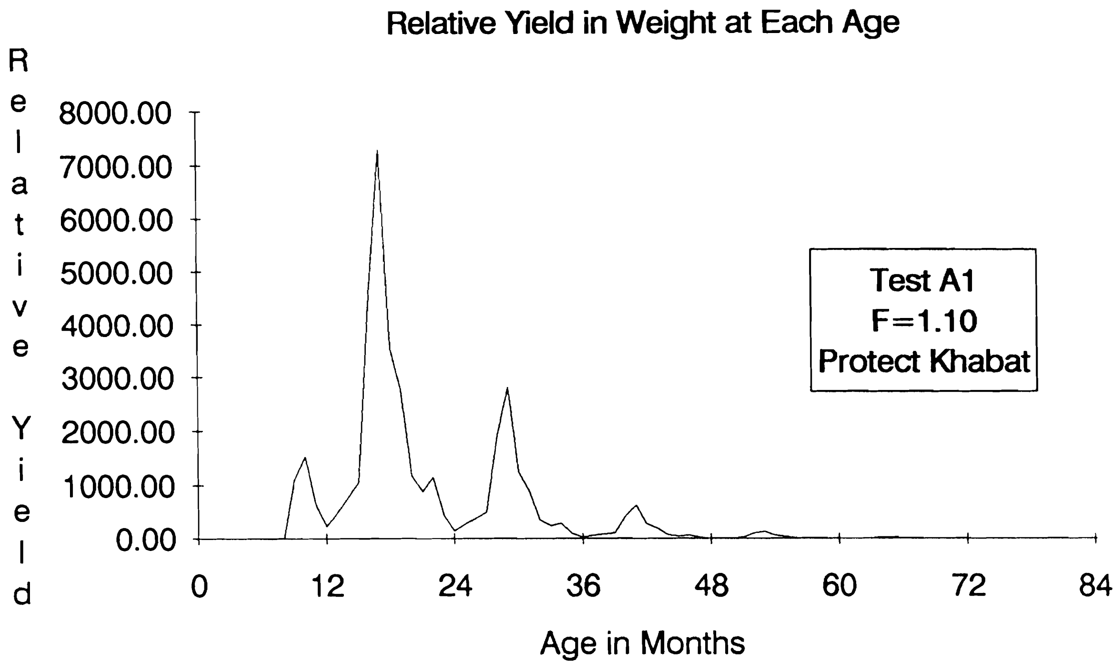
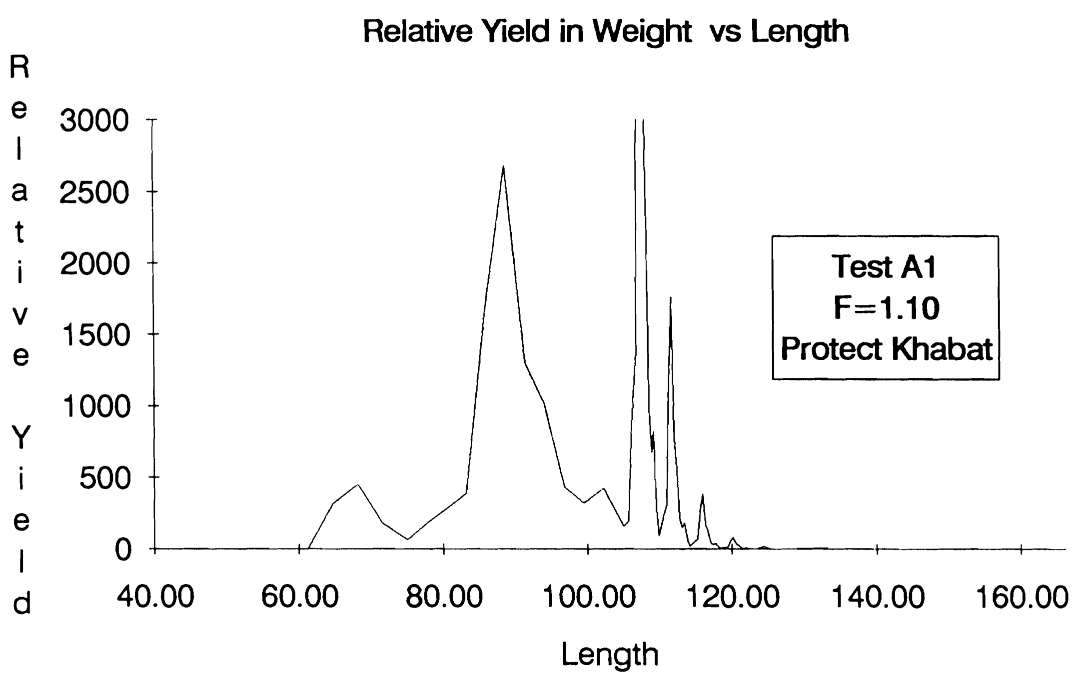


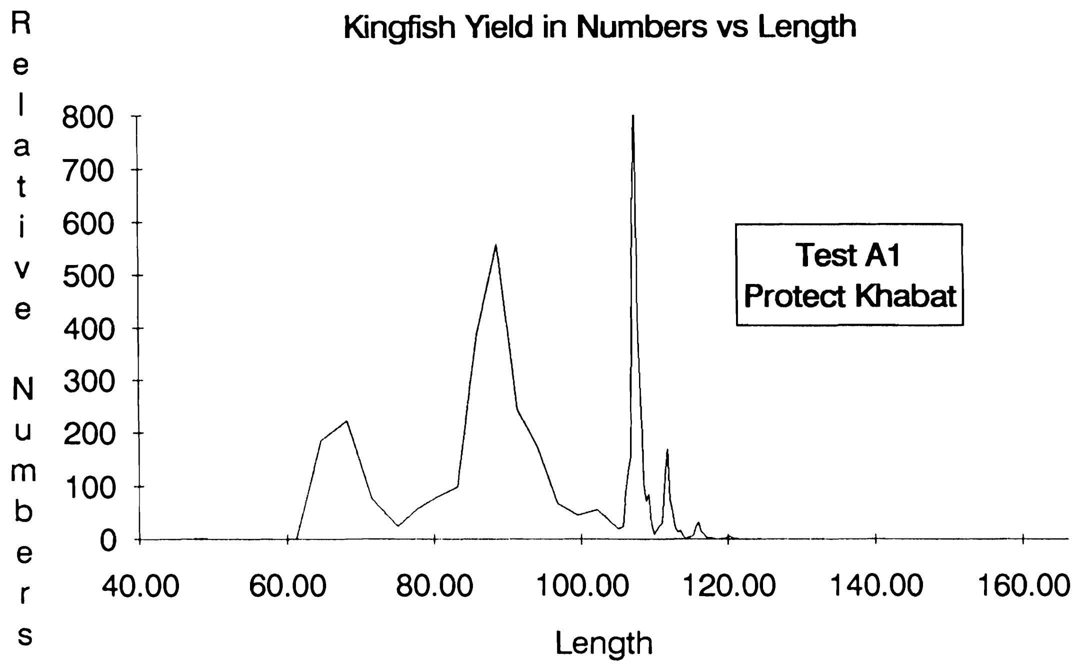
Figure 8. Yield model results using baseline data. Yield in numbers at each length. Method used does not account for variations in growth within an age group.

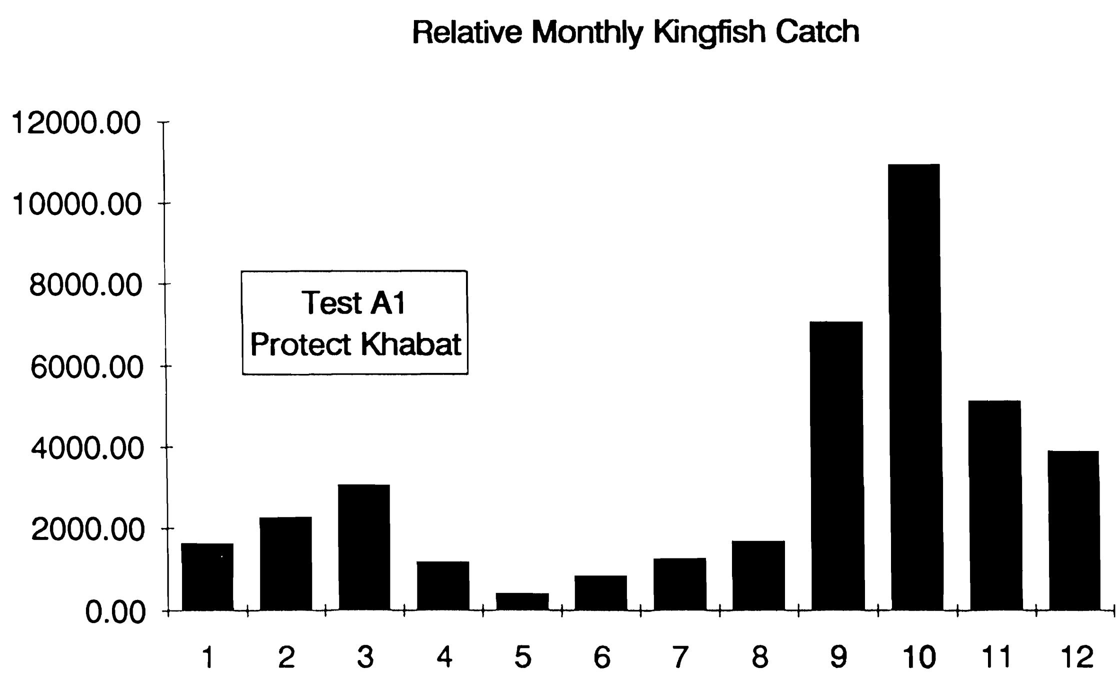
Figure 9. Yield model results using baseline data. Predicted kingfish catch for each month.



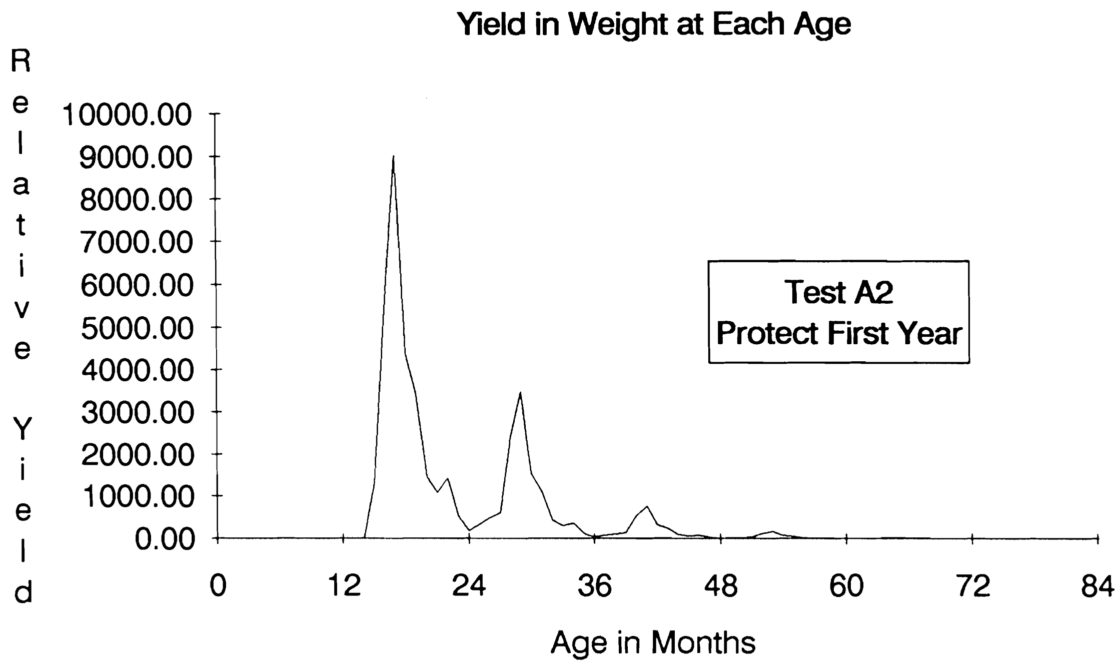


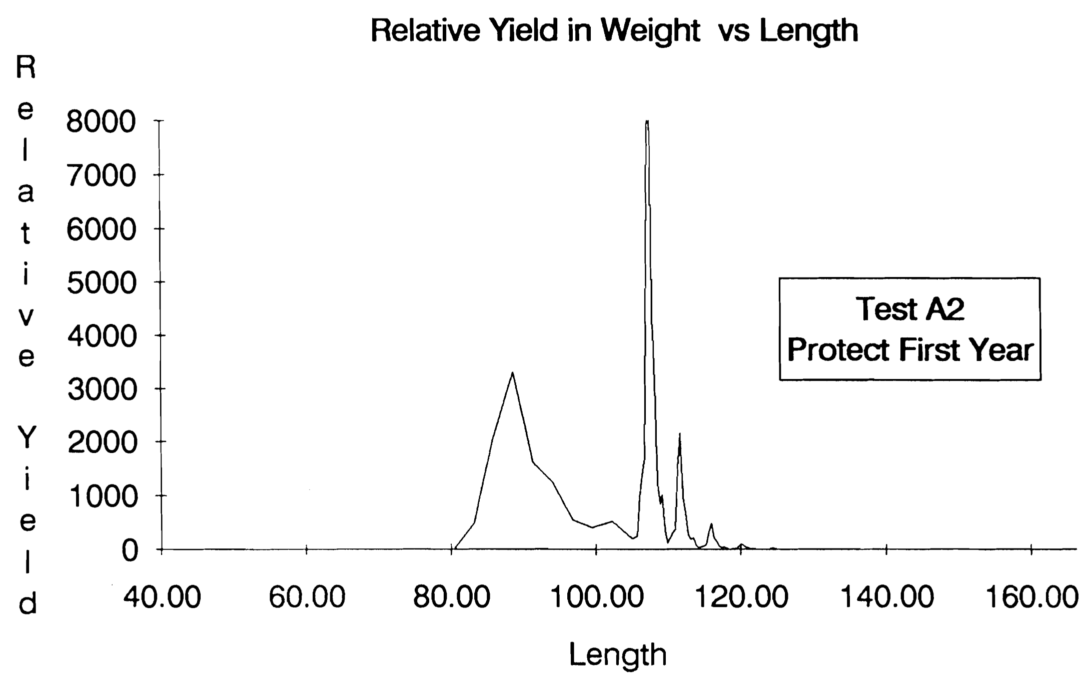
Figures 10 and 11. Yield model results from test A1: protection of young kingfish during fall season.



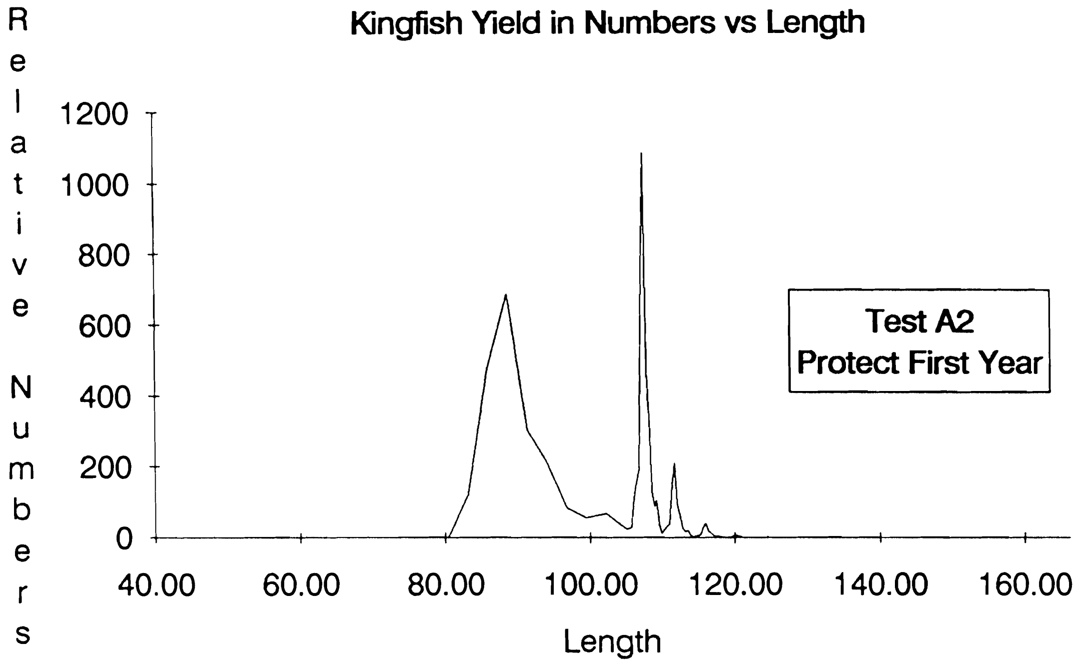


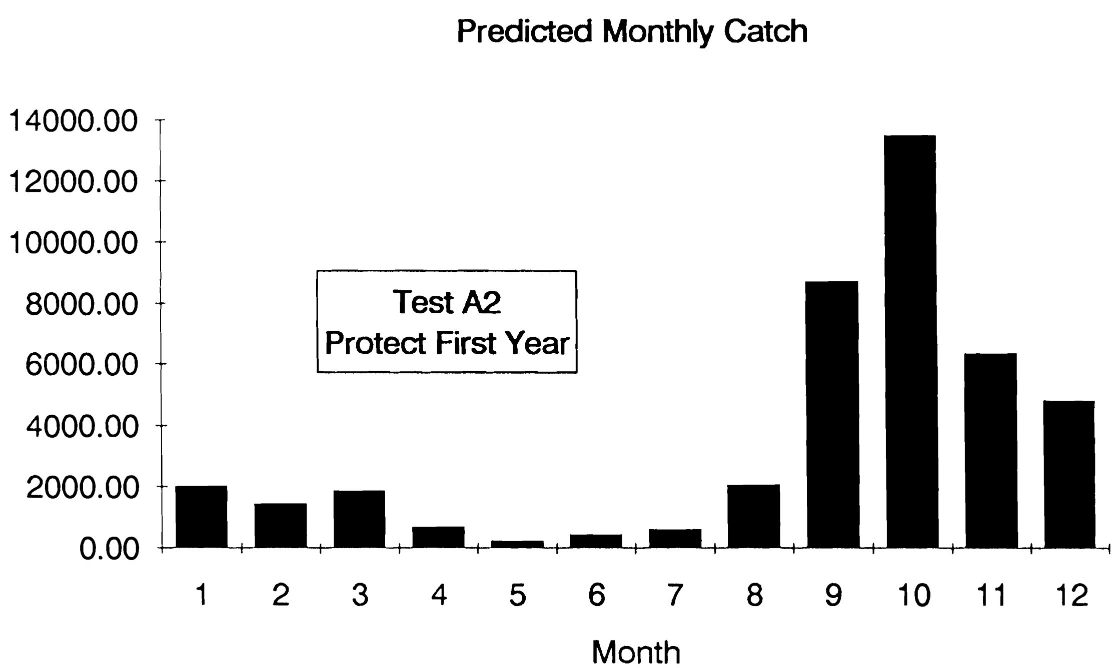
Figures 12 and 13. Yield model results from test A1: protection of young kingfish during fall season.





Figures 14 and 15. Yield model results from test A2: protection of kingfish during their first year.





Figures 16 and 17. Yield model results from test A2: protection of kingfish during their first year.

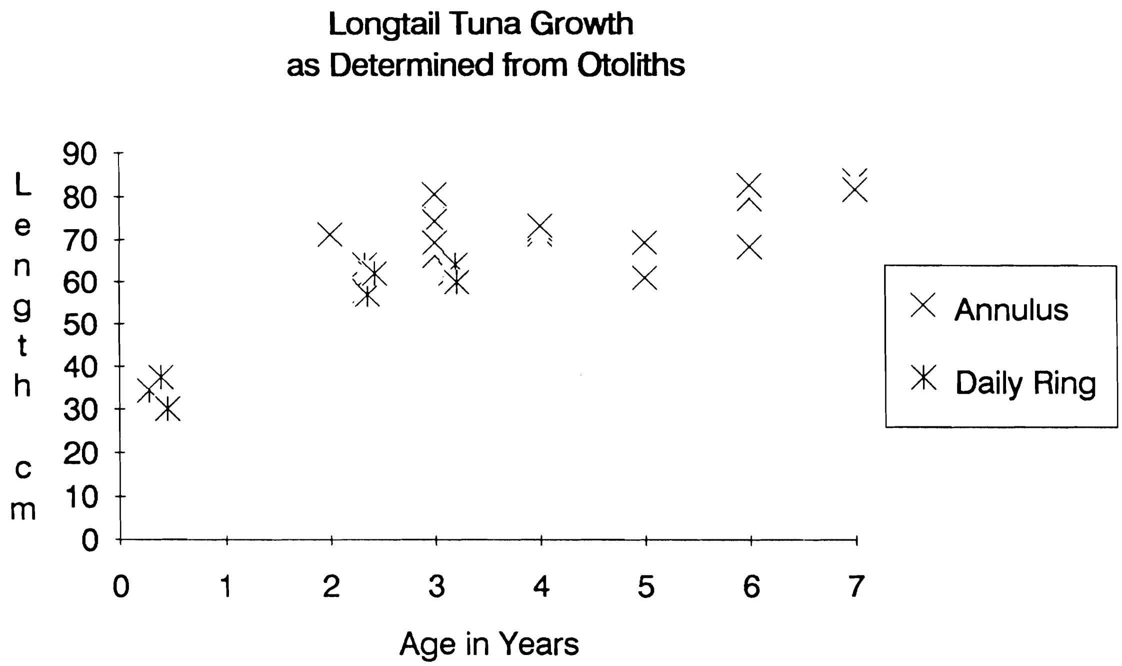
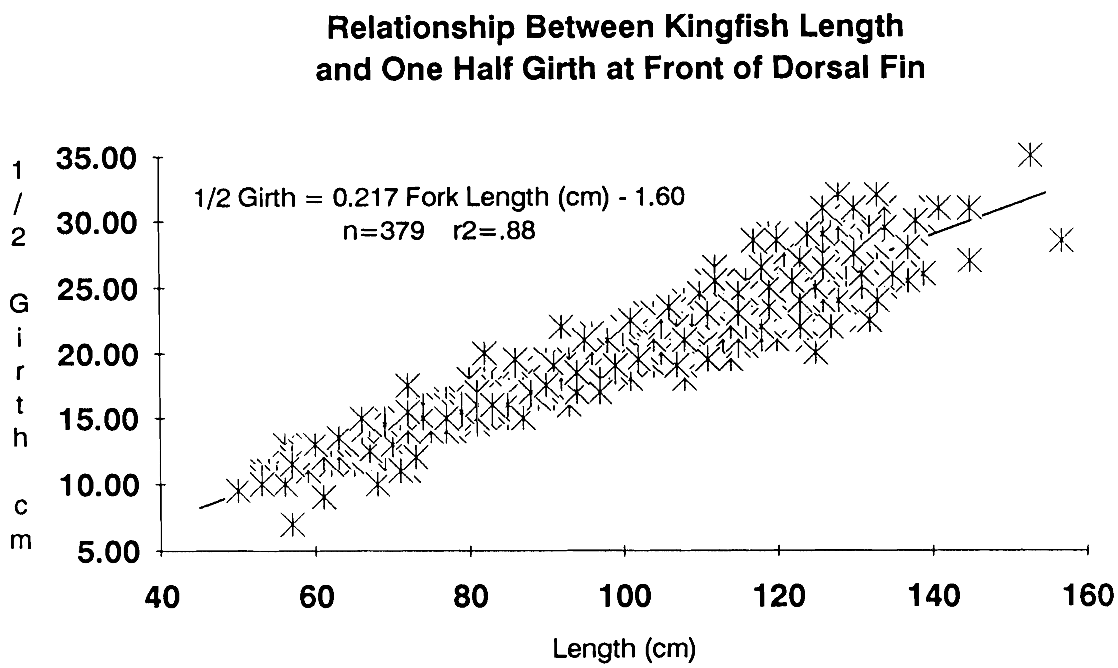


Figure 18. Longtail tuna growth as determined from otolith microstructure.



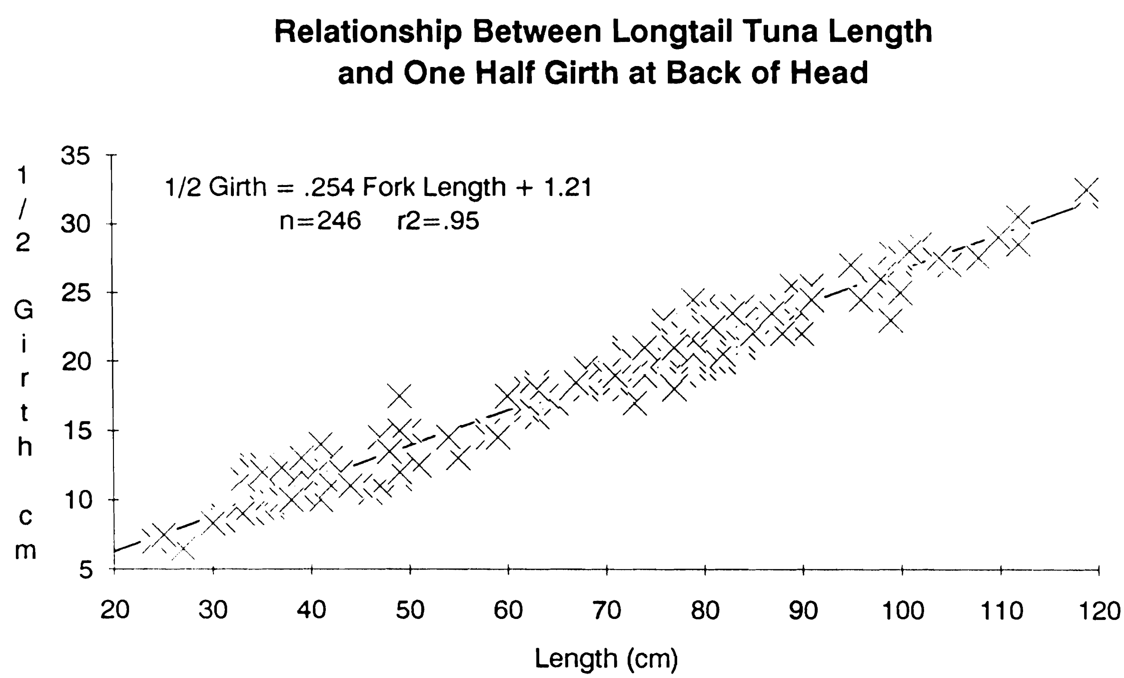


Figure 19. Kingfish girth measurements used in making mesh recommendations. One half girth is the approximate largest stretch mesh size which would catch a fish.

Figure 20. Tuna girth measurements. One half girth is the approximate largest stretch mesh size which would catch a fish.

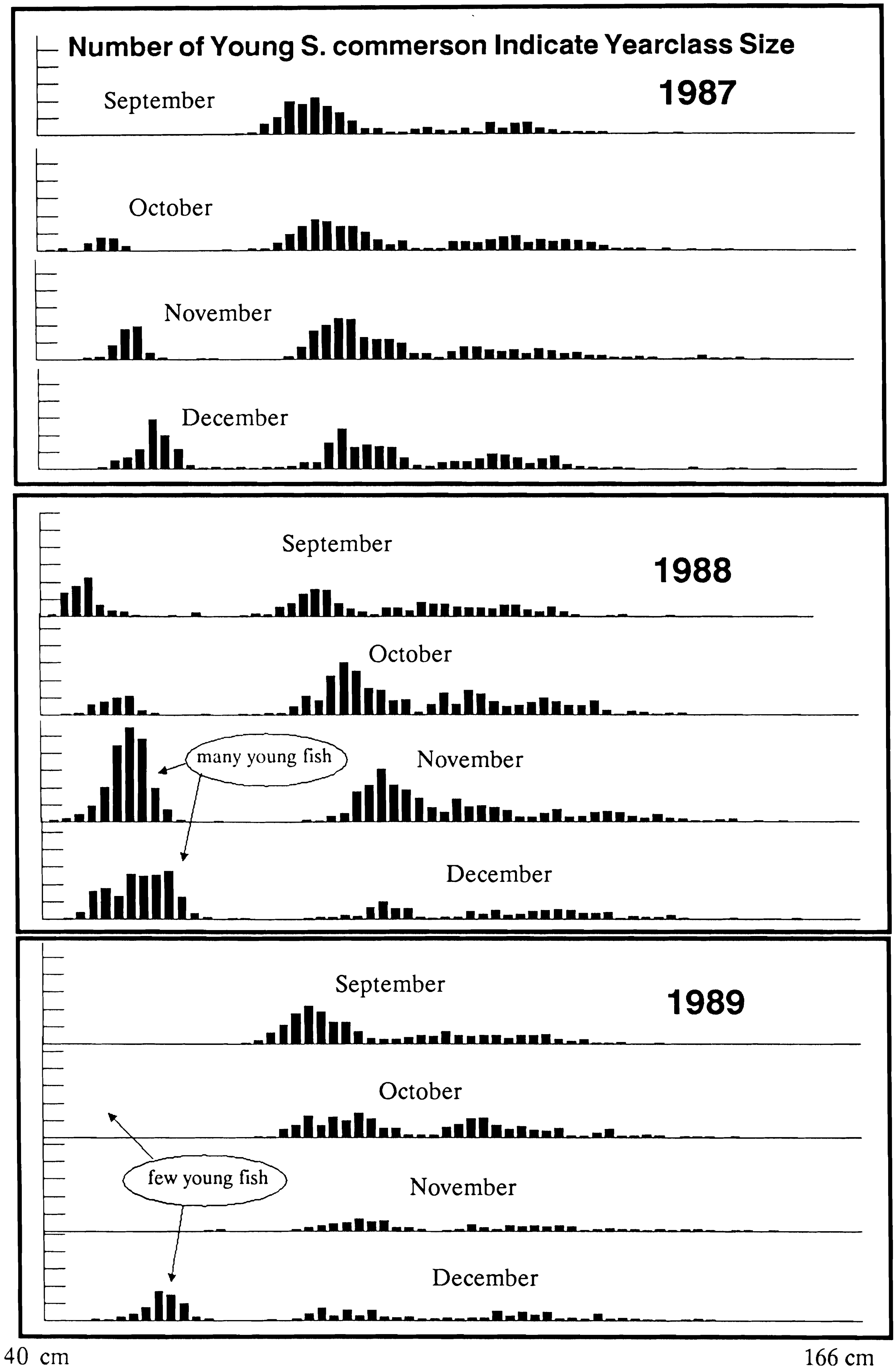


Figure 21. One indicator of the number of *S. commerson* entering the population in any year is the number of young fish which are caught in September, October, November and December. Significant variations in numbers of young fish are apparent in catches from recent years. This fact may be useful in predicting fishing success a year in advance.

Table 1. Summary of kingfish length frequency data.

Fork Length (cm)	1987 FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
40	0	0	0	0	0	0	0	0	1	0	0
42	0	0	0	0	0	0	0	0	4	0	0
44	0	0	0	0	0	0	0	0	0	0	0
46	0	0	0	0	0	0	0	0	9	3	0
48	0	0	0	0	0	0	0	0	16	4	2
50	0	1	0	0	0	0	0	0	15	17	10
52	0	2	1	0	0	0	0	0	6	35	13
54	0	3	1	0	0	0	0	0	0	39	23
56	2	12	3	0	0	0	0	0	0	8	58
58	8	30	7	0	0	0	0	0	0	3	40
60	14	34	12	0	0	0	0	0	0	0	23
62	4	24	27	0	0	1	0	0	0	0	5
64	1	20	29	1	0	0	0	0	0	1	1
66	3	7	23	0	0	0	1	0	0	1	2
68	1	5	5	5	3	2	0	0	1	0	1
70	0	2	4	5	5	4	1	1	0	0	3
72	0	5	1	3	5	11	11	2	2	0	1
74	1	1	0	1	3	13	11	12	2	0	3
76	0	2	1	3	5	10	31	20	9	0	2
78	0	0	0	0	1	9	36	39	19	4	4
80	0	0	0	0	0	2	33	35	28	14	8
82	1	0	0	0	0	2	19	43	35	33	8
84	0	2	0	0	0	2	17	33	33	40	31
86	0	1	0	0	0	0	7	25	28	47	47
88	5	3	0	0	0	0	5	16	28	46	25
90	5	8	4	2	0	0	2	7	21	26	29
92	14	10	3	3	0	0	4	7	12	23	27
94	8	22	5	3	0	2	3	2	7	23	25
96	11	11	5	2	2	2	0	3	11	19	13
98	19	14	2	5	2	6	4	6	2	7	5
100	8	15	7	1	1	2	1	8	2	7	4
102	6	6	9	0	3	9	3	5	3	3	8
104	10	6	14	3	7	4	5	4	10	9	9
106	9	4	9	0	6	5	2	7	10	15	9
108	10	10	7	0	4	9	4	2	9	14	12
110	9	8	20	0	7	8	8	13	12	11	18
112	13	7	16	0	10	7	2	7	16	9	17
114	10	9	4	0	5	11	3	12	17	11	13
116	10	4	6	0	8	7	11	13	9	7	7
118	8	5	1	0	7	5	5	7	12	12	12
120	5	6	2	0	4	4	12	5	10	10	16
122	0	5	2	0	0	1	8	2	12	7	6
124	0	6	0	0	1	0	0	3	11	8	4
126	0	2	1	0	3	2	2	2	9	5	2
128	0	6	1	0	2	0	7	3	6	5	1
130	0	2	2	0	1	1	3	0	2	3	2
132	0	2	0	0	1	0	1	0	3	3	1
134	0	5	0	0	0	1	0	0	2	4	0
136	0	3	1	0	1	0	0	1	0	2	0
138	0	1	1	0	1	0	0	0	2	0	0
140	0	0	1	0	0	0	0	1	0	1	0
142	0	2	0	0	0	1	0	0	1	1	2
144	0	1	0	0	0	0	0	0	0	5	0
146	0	0	0	0	0	1	0	0	1	1	0
148	0	0	0	0	0	0	0	0	1	1	1
150	0	0	0	0	0	0	0	0	0	3	1
152	0	0	0	0	0	1	1	0	0	0	0
154	0	0	0	0	0	0	0	0	0	1	0
156	0	0	0	0	0	0	0	0	0	0	1
158	0	0	0	0	0	0	0	0	0	0	0
160	0	1	0	0	0	0	0	0	0	0	0
162	0	0	0	0	0	0	0	0	0	0	0
164	0	0	0	0	0	0	0	0	0	0	0
166	0	0	0	0	0	0	0	0	0	0	0
Total	195	335	237	37	98	145	263	346	449	551	555

Table 1 (continued). Summary of kingfish length frequency data.

Fork Length (cm)	1988 JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
40	0	0	0	0	0	0	0	0	2	0	2	0
42	0	0	0	0	0	0	0	0	28	1	5	1
44	0	0	0	0	0	0	0	0	35	3	9	8
46	0	0	0	0	0	0	0	0	45	12	19	32
48	0	0	0	0	0	0	0	0	13	16	41	35
50	0	0	0	0	0	0	0	0	7	20	89	27
52	0	2	0	0	0	0	0	0	6	22	110	52
54	2	7	3	0	0	0	0	0	1	6	97	50
56	12	9	7	0	0	0	0	0	0	2	40	51
58	25	27	15	1	1	0	0	0	0	0	14	55
60	38	36	23	1	0	1	0	0	1	0	3	26
62	12	37	25	9	3	0	0	0	0	0	0	7
64	6	20	15	15	15	0	0	0	5	1	0	2
66	6	10	10	11	17	0	0	1	0	0	1	0
68	4	4	8	13	25	5	0	0	0	0	0	1
70	4	1	1	4	29	7	2	6	0	1	0	1
72	2	3	2	3	38	16	0	12	1	1	0	0
74	4	2	2	0	10	10	2	26	4	3	0	0
76	1	4	0	0	10	10	1	52	3	3	0	0
78	1	1	0	0	7	4	3	73	11	10	0	0
80	4	1	0	2	5	0	1	72	16	22	2	1
82	6	5	0	0	2	1	1	45	27	17	1	3
84	11	7	1	3	3	0	2	21	32	45	7	2
86	17	22	5	4	2	1	0	6	31	60	10	5
88	24	29	11	16	4	0	0	4	16	51	35	4
90	25	28	15	23	5	2	0	4	9	31	43	13
92	27	43	14	26	6	0	2	4	6	29	62	20
94	26	33	12	42	8	0	2	13	2	17	43	12
96	17	18	21	33	5	6	3	19	10	18	38	12
98	11	6	10	30	8	1	5	15	10	4	28	3
100	6	9	9	28	5	1	6	19	7	12	17	1
102	1	4	3	15	1	2	2	15	17	26	11	2
104	1	4	6	22	0	0	4	11	15	12	27	3
106	8	1	3	15	0	3	5	13	15	29	18	9
108	8	3	8	20	1	1	3	11	11	24	19	6
110	14	6	13	21	1	2	5	19	10	16	17	10
112	15	5	17	35	1	4	6	18	10	10	13	5
114	14	10	13	22	1	4	2	27	9	11	6	6
116	8	8	32	17	0	1	3	13	13	15	6	9
118	11	12	16	12	0	11	2	12	13	20	10	10
120	7	7	22	6	0	7	1	14	8	16	14	11
122	8	6	17	5	0	2	4	8	6	11	6	10
124	6	4	13	3	0	6	2	6	11	11	7	7
126	6	0	11	3	0	3	0	1	6	17	11	7
128	1	1	2	1	0	0	2	2	3	6	12	8
130	0	0	3	3	0	1	0	2	0	1	11	1
132	2	1	2	0	0	2	0	2	0	5	7	4
134	1	0	1	0	0	1	0	0	1	4	5	2
136	4	2	3	0	0	1	0	0	2	1	9	2
138	3	0	1	0	0	0	2	0	0	2	5	5
140	0	0	0	0	0	0	0	1	0	3	4	1
142	0	0	0	0	0	0	0	0	0	0	1	0
144	0	0	0	0	0	0	0	0	1	0	1	0
146	1	0	0	0	0	0	0	0	0	0	2	0
148	1	0	1	0	0	0	0	0	0	0	4	1
150	0	0	1	0	0	0	1	0	0	0	0	0
152	0	0	0	0	0	0	0	0	0	0	1	0
154	0	1	0	0	0	0	0	0	0	0	0	0
156	0	0	0	0	0	0	0	0	0	0	1	0
158	0	0	0	0	0	0	0	0	0	0	0	1
160	0	0	0	0	0	0	0	0	0	0	0	0
162	0	0	0	0	0	0	0	0	0	0	0	0
164	0	0	0	0	0	0	0	0	0	0	0	0
166	0	0	0	0	0	0	0	0	0	0	0	0
Total	411	439	397	464	213	116	74	567	479	647	944	544

Table 1 (continued). Summary of kingfish length frequency data.

Fork Length (cm)	1989 JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	1990 JAN	Numbers
40	0	0	0	0	0	0	0	0	0	0	0	0	0	5
42	0	0	0	0	0	0	0	0	0	0	0	0	0	39
44	1	0	0	0	0	0	0	0	0	0	0	0	0	56
46	6	1	0	0	0	0	0	0	0	0	0	2	0	129
48	30	2	0	0	0	0	0	0	0	0	0	1	0	160
50	53	12	9	0	0	0	0	0	0	0	0	5	0	265
52	52	25	24	0	0	0	0	0	0	0	0	8	0	358
54	40	25	47	0	0	0	0	0	0	0	0	16	3	363
56	40	10	47	0	0	0	0	0	0	0	0	34	8	343
58	55	16	38	4	1	0	0	0	0	0	0	30	14	384
60	39	15	9	13	4	1	0	0	0	0	0	20	25	338
62	17	17	10	10	13	1	0	0	0	0	0	5	22	249
64	11	10	4	6	14	1	0	0	0	0	1	2	6	187
66	2	10	2	0	19	7	1	0	0	0	2	0	3	139
68	3	12	1	5	15	10	1	0	0	0	0	0	0	130
70	1	8	1	2	7	19	5	7	1	0	0	0	1	133
72	1	4	0	4	11	11	27	11	5	1	0	0	0	194
74	1	1	0	2	12	6	20	19	13	1	0	1	0	186
76	0	2	0	5	8	8	12	33	22	10	0	0	0	267
78	0	0	0	1	10	7	6	23	35	14	2	2	0	322
80	1	0	0	0	10	3	4	22	44	25	5	8	6	374
82	1	1	0	2	2	3	1	10	38	15	7	14	9	352
84	3	1	1	0	0	4	0	9	26	24	9	6	19	394
86	9	1	0	1	1	1	1	6	26	20	10	12	13	419
88	14	2	1	2	0	0	0	3	15	29	14	6	18	426
90	11	9	7	2	1	3	1	2	7	22	11	12	29	419
92	11	5	11	9	0	3	2	0	6	11	12	5	16	433
94	27	8	13	20	0	3	0	0	6	11	5	4	10	417
96	18	13	13	28	0	2	3	1	8	4	5	5	6	385
98	16	13	17	35	6	4	6	0	10	4	2	2	3	321
100	8	9	18	55	2	5	8	2	9	4	0	3	4	303
102	3	10	12	47	1	6	9	4	14	12	1	4	5	282
104	7	7	18	38	2	4	17	4	10	16	3	3	3	318
106	7	16	34	34	2	2	9	2	9	22	8	4	10	354
108	13	6	24	34	0	6	6	6	10	23	5	4	11	344
110	13	10	35	33	1	6	12	5	10	15	2	11	11	412
112	9	8	31	30	0	3	13	6	7	10	7	6	8	381
114	4	13	35	26	0	5	15	1	10	13	6	10	12	370
116	7	3	24	18	0	5	5	7	10	9	7	7	21	330
118	3	13	18	13	0	8	2	3	11	8	6	10	13	311
120	13	14	19	13	0	7	7	5	6	11	7	3	14	306
122	6	11	18	3	0	9	3	2	4	2	6	4	14	208
124	9	18	18	6	0	10	1	1	6	3	1	2	17	201
126	4	8	17	8	0	9	4	0	1	6	2	8	19	179
128	7	9	12	1	0	2	0	0	1	10	4	3	10	128
130	4	6	5	2	0	5	1	0	2	3	3	4	11	84
132	1	7	4	1	0	6	0	0	0	2	3	3	4	67
134	0	4	6	1	0	3	1	0	0	4	1	1	5	53
136	0	3	1	0	0	2	1	0	1	2	3	1	8	54
138	1	2	1	0	0	1	1	0	0	0	1	0	5	35
140	0	2	3	1	0	0	2	0	0	1	3	1	2	27
142	0	1	1	0	0	0	0	0	0	1	2	2	3	18
144	0	0	2	0	0	0	0	0	0	1	1	1	3	16
146	0	0	0	0	0	0	0	0	0	0	0	0	2	8
148	0	1	0	0	0	0	0	0	0	1	1	0	1	14
150	1	1	0	0	0	1	0	0	0	0	1	0	0	10
152	0	0	0	0	0	0	0	0	0	0	0	0	1	4
154	0	0	1	0	0	0	0	0	0	0	1	0	0	4
156	0	0	0	0	0	0	0	0	0	0	0	0	0	2
158	0	0	0	0	0	0	0	0	0	0	0	0	0	1
160	0	0	0	1	0	0	0	0	0	0	0	0	0	2
162	0	0	0	0	0	0	0	0	0	0	0	0	0	0
164	0	0	0	0	0	0	0	0	0	0	0	0	0	0
166	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	583	405	612	516	142	202	207	194	383	370	170	295	428	13013

Table 2. Kingfish (Scomberomorus commerson) otolith and length frequency modal data used in growth calculations. In cases where specimens were not available for measurement, upper jaw length was used as a predictor of fork length.

Otolith Data

Number Daily Rings	Number of Annuli	Date of Capture	"Age" Years	Fertilization Date	Length: Upper Jaw	Length: Actual Total	Length: Calculated Total
Data from Daily Growth Rings							
165	0	13-Jan-87	0.45	1-Aug-86	6.2		57.8
165	0	29-Jan-87	0.45	17-Aug-86	6.3		58.7
186	0	14-Jan-88	0.51	12-Jul-87	7.2		66.5
190	0	8-Jan-87	0.52	2-Jul-86	6.8		63.0
190	0	14-Jan-88	0.52	8-Jul-87	6.7		62.1
190	0	12-Jan-88	0.52	6-Jul-87	6.7	59	59.0
192	0	8-Oct-87	0.53	30-Mar-87	6.2		57.8
197	0	8-Oct-87	0.54	25-Mar-87	6.3		58.7
200	0	29-Jan-87	0.55	13-Jul-86	6.7		62.1
200	0	14-Jan-88	0.55	28-Jun-86	7.3		67.3
212	0	14-Jan-88	0.58	16-Jun-87	7.1		65.6
220	0	14-Jan-88	0.60	8-Jun-87	7.5		69.1
233	0	21-Feb-88	0.64	3-Jul-87	7.3	65	65.0
240	0	14-Jan-88	0.66	19-May-87	7.5		69.1
271	0	15-Apr-87	0.74	18-Jul-86	9.2	73	73.0
300	0	27-Apr-87	0.82	1-Jul-86	8.2	71	71.0
360	1	27-Jun-87	0.99	2-Jul-86	8.5	78	78.0
365	1	27-Jun-87	1.00	27-Jun-86	9.7		88.1
430	1	31-Oct-87	1.18	27-Aug-86	9.9	95	95.0
445	1	16-Oct-88	1.22	29-Jul-87	10.2	91	91.0
450	1	27-Jun-87	1.23	3-Apr-86	8.9		81.2
470	1	15-Feb-88	1.29	2-Nov-86	9.1	99	99.0
480	1	15-Dec-87	1.32	22-Aug-86	9.3	88	88.0
483	1	15-Dec-87	1.32	19-Aug-86	9.3	84	84.0
Data from Sectioned Otolith Annuli							
2147	5	17-Feb-87	5.88		12		108.0
2148	5	18-Feb-87	5.88		14.1		126.1
744	2	15-Apr-87	2.04		10.2	92	92.0
1474	4	15-Apr-87	4.04		13.1	118	118.0
1839	5	15-Apr-87	5.04		11.6	105	105.0
2642	7	27-Jun-87	7.24		14.6	133	133.0
1547	4	27-Jun-87	4.24		10.5	101	101.0
4102	11	27-Jun-87	11.24		18.9	151	151.0
3737	10	27-Jun-87	10.24		17.8	150	150.0
1912	5	27-Jun-87	5.24		12.1	111	111.0
623	1	15-Dec-87	1.71		10.9	110	110.0
2813	7	15-Dec-87	7.71		13.8	126	126.0
4638	12	15-Dec-87	12.71		17.3	147	147.0
3573	9	14-Jan-88	9.79		15.7		140.0

Length Frequency Modes

Date of Capture	Days from June 15	Age Years	Length	SD
5-Sep-88	82	0.22	44.7	2.60
5-Oct-87	112	0.31	48.7	2.36
5-Oct-88	112	0.31	49.4	3.05
5-Nov-87	143	0.39	51.9	2.88
5-Nov-88	143	0.39	51.5	3.26
5-Dec-87	173	0.47	55.9	3.61
5-Dec-88	173	0.47	53.4	3.85
5-Dec-89	173	0.47	56.2	3.42
5-Jan-88	204	0.56	60.1	2.71
5-Jan-89	204	0.56	55.6	4.34
5-Jan-90	204	0.56	60.3	3.27
5-Feb-87	235	0.64	59.9	4.03
5-Feb-88	235	0.64	60.5	3.79
5-Feb-89	235	0.64	60.8	5.57
5-Mar-87	263	0.72	60.8	4.26
5-Mar-89	263	0.72	56.6	3.76
5-Mar-88	264	0.72	62.1	3.91
5-Apr-87	294	0.81	62.5	3.86
5-Apr-88	295	0.81	65.8	3.44
5-May-87	324	0.89	69.9	2.23
5-May-88	325	0.89	70.4	4.87
5-Jun-87	355	0.97	71.0	7.46
5-Jun-89	355	0.97	72.2	5.02
5-Jun-88	356	0.98	73.1	3.06
5-Jul-87	385	1.05	74.6	3.30
5-Jul-89	385	1.05	73.7	2.30
5-Jul-88	386	1.06	77.0	3.40
5-Aug-87	416	1.14	79.5	3.51
5-Aug-89	416	1.14	78.6	4.97
5-Aug-88	417	1.14	78.1	4.36
5-Sep-87	447	1.22	81.8	4.25
5-Sep-89	447	1.22	81.7	4.19
5-Sep-88	448	1.23	83.6	5.01
5-Oct-87	477	1.31	84.8	4.85
5-Oct-89	477	1.31	86.5	5.11
5-Oct-88	478	1.31	87.4	6.32
5-Nov-87	508	1.39	87.5	6.74
5-Nov-89	508	1.39	88.3	4.89
5-Nov-88	509	1.39	93.5	4.72
5-Dec-87	538	1.47	88.5	5.30
5-Dec-88	539	1.48	92.1	4.25
5-Jan-88	569	1.56	90.4	5.23
5-Jan-90	569	1.56	88.2	4.99
5-Jan-89	570	1.56	93.0	4.89
5-Feb-87	600	1.64	95.6	4.54
5-Feb-88	600	1.64	92.0	5.08
5-Mar-87	628	1.72	96.8	5.48
5-Mar-88	629	1.72	94.0	4.76
5-Apr-87	659	1.81	107.8	6.80
5-Apr-88	660	1.81	95.9	5.62
5-May-87	689	1.89	94.4	3.24
5-May-88	690	1.89	93.3	6.33
5-Jun-87	720	1.97	111.0	5.75
5-Jul-87	750	2.05	101.5	4.49
5-Jul-88	751	2.06	106.0	10.20
5-Jul-89	751	2.06	106.9	5.95
5-Aug-87	781	2.14	107.4	4.72
5-Aug-88	782	2.14	100.1	4.24
5-Sep-88	813	2.23	104.1	3.49
5-Oct-87	842	2.31	114.3	9.07
5-Oct-88	843	2.31	105.8	6.05
5-Oct-89	843	2.31	108.0	3.92
5-Nov-89	874	2.39	115.8	4.19
5-Dec-87	903	2.47	112.6	6.71
5-Dec-89	904	2.48	113.0	5.68
5-Jan-88	934	2.56	113.2	5.91
5-Jan-90	935	2.56	119.0	6.85
5-Feb-88	965	2.64	116.3	5.22
5-Mar-88	994	2.72	117.8	6.73

Table 3. Summary of growth curves for kingfish (Scomberomorus commerson).

Method	Type	Linf	k	C	wp	To
ELEFAN (two years length data)	Von Bertalanffy	170	0.301			
	Ocillating 1	164	0.34	0.36	0.10	
	Ocillating 2	203	0.23	0.28	0.13	
ELEFAN (three years length data)	Von Bertalanffy	226	0.208			(-0.85) (estimated)
Least Squares (Otolith and lf modes)	Von Bertalanffy R square = .91	133	0.583			-0.487
Least Squares (Otolith and lf modes)	Segmented Regression Break Point=1.93 years Segment 1: Length=32.69 Age + 42.33 Segment 2: Length=4.238 Age + 97.24 R square = .94					

Table 4. Monthly kingfish catch during 1988 and 1989. (Data kindly supplied by Elie Moussalli, Fisheries Statistics Section).

	Month											
Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1988	1740	823	1496	583	119	565	344	478	4225	11628	3290	2292
1989	841	702	843	262	128	193	176	556	1393	1604	1704	2691
Mean	1291	762	1169	422	123	379	260	517	2809	6616	2497	2492

Table 5. Starting basic inputs used for spreadsheet yield model. Annual rates (M and F) are natural and fishing mortality respectively.

Age of Fish		Annual Rates	
Year	Months	M	F
Khabat (1	Oct-Jan	0.6	1.1
1	Feb-July	0.6	1.1
2	Aug-Jan	0.5	1.1
2	Feb-July	0.5	1.1
3	Aug-Jan	0.5	1.1
3	Feb-July	0.5	1.1
4	Aug-Jan	0.5	1.1
4	Feb-May	0.5	1.1
5, 6, +		0.5	1.1

Table 6. Multipliers used to modify fishing mortality prior to entry into main table of model. Season ratios adjust catches to conform to current fishing intensities in Oman. Khabat selection factors adjust fishing intensity for the current approximated mesh selection for young kingfish.

Month	Season Ratios	Khabat Selection Factors
1	0.80	1.00
2	0.60	xxxxx
3	0.80	xxxxx
4	0.30	xxxxx
5	0.10	xxxxx
6	0.20	xxxxx
7	0.30	xxxxx
8	0.40	xxxxx
9	1.80	xxxxx
10	3.40	0.20
11	2.00	0.50
12	1.75	0.75

Table 7 . Example inputs for Ricker type yield model. Boldface columns are input variables. See Ricker (1975) for methods of calculation.

Yield During this Month	Age in Months	Age	Length	Weight kg	G	M	F	G-F-M	Weight Change Factor	Weight of Stock (kg)	Avg Weight Kg	Yield (kg)	Yield in Numbers
Oct	(4)	0.33	47.45	0.608						10000.00		0.10	
10	5	0.42	50.89	0.766	0.232	0.050	0.062	0.120	1.127	11270.61	10635.307	662.93	400.36
11	6	0.50	54.33	0.952	0.217	0.050	0.092	0.075	1.078	12149.46	11710.035	1073.42	544.37
12	7	0.58	57.78	1.167	0.203	0.050	0.120	0.033	1.034	12558.51	12353.984	1486.34	651.52
1	8	0.67	61.22	1.413	0.192	0.050	0.073	0.068	1.071	13446.38	13002.448	953.51	363.71
2	9	0.75	64.67	1.694	0.181	0.050	0.055	0.076	1.079	14510.38	13978.380	768.81	253.33
3	10	0.83	68.11	2.011	0.172	0.050	0.073	0.048	1.050	15230.23	14870.303	1090.49	313.40
4	11	0.92	71.55	2.368	0.163	0.050	0.028	0.086	1.090	16594.31	15912.269	437.59	109.76
5	12	1.00	75.02	2.769	0.157	0.050	0.009	0.097	1.102	18291.73	17443.020	159.89	34.63
6	13	1.08	77.74	3.116	0.118	0.050	0.018	0.050	1.051	19224.27	18758.000	343.90	66.69
7	14	1.17	80.47	3.493	0.114	0.050	0.028	0.036	1.037	19938.85	19581.561	538.49	94.35
8	15	1.25	83.19	3.899	0.110	0.042	0.037	0.032	1.032	20584.49	20261.674	742.93	118.65
9	16	1.33	85.92	4.338	0.107	0.042	0.165	-0.100	0.905	18625.31	19604.903	3234.81	489.88
10	17	1.42	88.64	4.811	0.103	0.042	0.312	-0.250	0.779	14505.23	16565.269	5162.84	798.40
11	18	1.50	91.36	5.317	0.100	0.042	0.183	-0.125	0.883	12803.29	13654.256	2503.28	402.89
12	19	1.58	94.09	5.861	0.097	0.042	0.160	-0.105	0.900	11529.02	12166.156	1951.65	313.18
1	20	1.67	96.81	6.441	0.094	0.042	0.073	-0.021	0.980	11294.78	11411.904	836.87	130.40
2	21	1.75	99.54	7.061	0.092	0.042	0.055	-0.005	0.995	11240.53	11267.655	619.72	91.23
3	22	1.83	102.26	7.721	0.089	0.042	0.073	-0.026	0.975	10956.11	11098.317	813.88	113.46
4	23	1.92	104.99	8.423	0.087	0.042	0.028	0.018	1.018	11153.48	11054.795	304.01	39.94
5	24	2.00	105.72	8.619	0.023	0.042	0.009	-0.028	0.972	10846.76	11000.122	100.83	13.07
6	25	2.08	106.07	8.714	0.011	0.042	0.018	-0.049	0.952	10328.49	10587.623	194.11	25.08
7	26	2.17	106.42	8.811	0.011	0.042	0.028	-0.058	0.943	9744.88	10036.681	276.01	35.71
8	27	2.25	106.78	8.908	0.011	0.042	0.037	-0.067	0.935	9110.02	9427.446	345.67	45.01
9	28	2.33	107.13	9.006	0.011	0.042	0.165	-0.196	0.822	7490.52	8300.266	1369.54	185.80
10	29	2.42	107.48	9.104	0.011	0.042	0.312	-0.342	0.710	5318.54	6404.527	1996.08	302.77
11	30	2.50	107.83	9.204	0.011	0.042	0.183	-0.214	0.807	4293.30	4805.920	881.09	152.34
12	31	2.58	108.19	9.304	0.011	0.042	0.160	-0.191	0.826	3545.91	3919.609	628.77	118.22
1	32	2.67	108.54	9.405	0.011	0.042	0.073	-0.104	0.901	3194.99	3370.451	247.17	49.12
2	33	2.75	108.89	9.506	0.011	0.042	0.055	-0.086	0.918	2931.95	3063.471	168.49	34.31
3	34	2.83	109.25	9.609	0.011	0.042	0.073	-0.104	0.901	2641.60	2786.779	204.36	42.63
4	35	2.92	109.60	9.712	0.011	0.042	0.028	-0.058	0.943	2491.54	2566.575	70.58	14.98
5	36	3.00	109.95	9.816	0.011	0.042	0.009	-0.040	0.961	2393.41	2442.478	22.39	4.75
6	37	3.08	110.31	9.921	0.011	0.042	0.018	-0.049	0.952	2278.08	2335.746	42.82	9.06
7	38	3.17	110.66	10.026	0.011	0.042	0.028	-0.059	0.943	2148.45	2213.265	60.86	12.90
8	39	3.25	111.01	10.133	0.011	0.042	0.037	-0.068	0.934	2007.64	2078.045	76.19	16.26
9	40	3.33	111.37	10.240	0.011	0.042	0.165	-0.196	0.822	1650.05	1828.846	301.76	67.10
10	41	3.42	111.72	10.348	0.010	0.042	0.312	-0.343	0.710	1171.11	1410.582	439.63	109.34

Table 7 (con't). Example inputs for Ricker type yield model. Boldface columns are input variables. See Ricker (1975) for methods of calculation.

Yield During this Month	Age in Months	Age	Length	Weight kg	G	M	F	G-F-M	Weight Change Factor	Weight of Stock (kg)	Avg Weight Kg	Yield (kg)	Yield in Numbers
11	42	3.50	112.07	10.456	0.010	0.042	0.183	-0.215	0.807	944.97	1058.042	193.97	55.01
12	43	3.58	112.43	10.566	0.010	0.042	0.160	-0.192	0.826	780.15	862.561	138.37	42.69
1	44	3.67	112.78	10.676	0.010	0.042	0.073	-0.105	0.901	702.66	741.403	54.37	17.74
2	45	3.75	113.13	10.787	0.010	0.042	0.055	-0.086	0.917	644.55	673.603	37.05	12.39
3	46	3.83	113.49	10.899	0.010	0.042	0.073	-0.105	0.901	580.49	612.518	44.92	15.39
4	47	3.92	113.84	11.012	0.010	0.042	0.028	-0.059	0.943	547.29	563.890	15.51	5.41
5	48	4.00	114.19	11.125	0.010	0.042	0.009	-0.041	0.960	525.53	536.411	4.92	1.72
6	49	4.08	114.55	11.239	0.010	0.042	0.018	-0.050	0.951	500.01	512.770	9.40	3.27
7	50	4.17	114.90	11.354	0.010	0.042	0.028	-0.059	0.943	471.37	485.692	13.36	4.66
8	51	4.25	115.25	11.470	0.010	0.042	0.037	-0.068	0.934	440.31	455.841	16.71	5.87
9	52	4.33	115.60	11.587	0.010	0.042	0.165	-0.197	0.822	361.74	401.026	66.17	24.23
10	53	4.42	115.96	11.705	0.010	0.042	0.312	-0.343	0.709	256.65	309.195	96.37	39.48
11	54	4.50	116.31	11.823	0.010	0.042	0.183	-0.215	0.807	207.01	231.828	42.50	19.87
12	55	4.58	116.66	11.942	0.010	0.042	0.160	-0.192	0.825	170.84	188.924	30.31	15.42
1	56	4.67	117.02	12.062	0.010	0.042	0.073	-0.105	0.900	153.81	162.324	11.90	6.40
2	57	4.75	117.37	12.183	0.010	0.042	0.055	-0.087	0.917	141.04	147.424	8.11	4.47
3	58	4.83	117.72	12.305	0.010	0.042	0.073	-0.105	0.900	126.97	134.006	9.83	5.56
4	59	4.92	118.08	12.428	0.010	0.042	0.028	-0.059	0.942	119.67	123.321	3.39	1.95
5	60	5.00	118.43	12.551	0.010	0.042	0.009	-0.041	0.960	114.87	117.268	1.07	0.62
6	61	5.08	118.78	12.676	0.010	0.042	0.018	-0.050	0.951	109.25	112.058	2.05	1.18
7	62	5.17	119.14	12.801	0.010	0.042	0.028	-0.059	0.942	102.95	106.102	2.92	1.68
8	63	5.25	119.49	12.927	0.010	0.042	0.037	-0.069	0.934	96.14	99.545	3.65	2.12
9	64	5.33	119.84	13.054	0.010	0.042	0.165	-0.197	0.821	78.95	87.544	14.44	8.75
10	65	5.42	120.20	13.181	0.010	0.042	0.312	-0.344	0.709	56.00	67.474	21.03	14.26
11	66	5.50	120.55	13.310	0.010	0.042	0.183	-0.215	0.806	45.15	50.572	9.27	7.17
12	67	5.58	120.90	13.440	0.010	0.042	0.160	-0.192	0.825	37.25	41.198	6.61	5.57
1	68	5.67	121.26	13.570	0.010	0.042	0.073	-0.105	0.900	33.52	35.385	2.59	2.31
2	69	5.75	121.61	13.701	0.010	0.042	0.055	-0.087	0.917	30.73	32.126	1.77	1.62
3	70	5.83	121.96	13.833	0.010	0.042	0.073	-0.105	0.900	27.65	29.192	2.14	2.01
4	71	5.92	122.31	13.966	0.010	0.042	0.028	-0.060	0.942	26.05	26.855	0.74	0.71
5	72	6.00	122.67	14.100	0.010	0.042	0.009	-0.041	0.960	25.00	25.528	0.23	0.22
6	73	6.08	123.02	14.235	0.010	0.042	0.018	-0.050	0.951	23.77	24.385	0.45	0.43
7	74	6.17	123.37	14.371	0.009	0.042	0.028	-0.060	0.942	22.39	23.081	0.63	0.61
8	75	6.25	123.73	14.507	0.009	0.042	0.037	-0.069	0.933	20.90	21.648	0.79	0.77
9	76	6.33	124.08	14.645	0.009	0.042	0.165	-0.197	0.821	17.16	19.032	3.14	3.16
10	77	6.42	124.43	14.783	0.009	0.042	0.312	-0.344	0.709	12.17	14.664	4.57	5.15
11	78	6.50	124.79	14.923	0.009	0.042	0.183	-0.216	0.806	9.81	10.987	2.01	2.59
12	79	6.58	125.14	15.063	0.009	0.042	0.160	-0.193	0.825	8.09	8.947	1.44	2.01

Table 7 (con't). Example inputs for Ricker type yield model. Boldface columns are input variables. See Ricker (1975) for methods of calculation.

Yield During this Month	Age in Months	Age	Length	Weight kg	G	M	F	G-F-M	Weight Change Factor	Weight of Stock (kg)	Avg Weight Kg	Yield (kg)	Yield in Numbers
1	80	6.67	125.49	15.204	0.009	0.042	0.073	-0.106	0.900	7.28	7.682	0.56	0.84
2	81	6.75	125.85	15.346	0.009	0.042	0.055	-0.087	0.916	6.67	6.972	0.38	0.58
3	82	6.83	126.20	15.489	0.009	0.042	0.073	-0.106	0.900	6.00	6.334	0.46	0.72
4	83	6.92	126.55	15.633	0.009	0.042	0.028	-0.060	0.942	5.65	5.825	0.16	0.25
5	84	7.00	126.91	15.778	0.112	0.500	0.009	-0.397	0.673	16.81	11.232	0.19	0.16
		8.00	131.14	17.590	0.109	0.500	1.100	-1.491	0.225	3.78	10.299	11.33	10.07
		9.00	135.38	19.543	0.105	0.500	1.100	-1.495	0.224	0.85	2.317	2.55	3.71
		10.00	139.62	21.642	0.102	0.500	1.100	-1.498	0.224	0.19	0.519	0.57	1.37
		11.00	143.86	23.894	0.099	0.500	1.100	-1.501	0.223	0.04	0.116	0.13	0.50
		12.00	148.10	26.304	0.096	0.500	1.100	-1.504	0.222	0.01	0.026	0.03	0.19
		13.00	152.33	28.879	0.093	0.500	1.100	-1.507	0.222	0.00	0.006	0.01	0.07
		14.00	156.57	31.625	0.091	0.500	1.100	-1.509	0.221	0.00	0.001	0.00	0.03
		15.00	160.81	34.548	0.088	0.500	1.100	-1.512	0.221	0.00	0.000	0.00	0.01
		16.00	165.05	37.655	0.086	0.500	1.100	-1.514	0.220	0.00	0.000	0.00	0.00
		17.00	169.29	40.951	0.084	0.500	1.100	-1.516	0.220	0.00	0.000	0.00	0.00
		18.00	173.52	44.444	0.082	0.500	1.100	-1.518	0.219	0.00	0.000	0.00	0.00
												32006.82	

Table 8. Summary of results from kingfish spreadsheet model. Three types of tests are displayed here: Tests of different levels of F, tests of different levels of M, and tests of two types of protection given to young kingfish.

				Percent Change From	
Test	Type	Yield in Weight	Change	Current Base Value	Original Base Value
Different Base F Levels					
Base	Base F = 1.10	32,007		0	0
A1	Protect Khabat	39,401	7,394	23	23
A2	Protect first year	42,811	10,805	34	34
New Base	Base F =0.75	33,694	1,688	0	5
B1	Protect Khabat	38,881	5,187	15	21
B2	Protect first year	41,034	7,339	22	28
New Base	Base F=0.50	33,059		0	3
C1	Protect Khabat	36,260	3,201	10	13
C2	Protect first year	37,390	4,331	13	17
New Base	Base F=1.50	29,336			-8
D1	Protect Khabat	38,557	9,221	31	20
D2	Protect first year	43,151	13,814	47	35
New Base	Base F=2.00	26,264		0	-18
E1	Protect Khabat	37,053	10,789	41	16
E2	Protect first year	42,850	16,585	63	34
Different Base M Levels					
New Base	Base M=0.3	44,834		0	40
F1	Protect Khabat	57,228	12,394	28	79
F2	Protect first year	63,792	18,957	42	99
New Base	Base M=0.4	39,103		0	22
G1	Protect Khabat	49,266	10,136	26	54
G2	Protect first year	54,325	15,195	39	70
New Base	Base M=0.5	34,397		0	7
H1	Protect Khabat	42,676	8,279	24	33
H2	Protect first year	46,532	12,135	35	45

Table 9. Summary of longtail tuna length frequency data.

cm	1987 Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
24	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	6	0	0
28	0	0	0	0	0	0	0	0	13	7	0
30	0	0	0	0	0	0	0	0	4	8	0
32	4	0	0	0	0	0	0	0	7	10	0
34	6	0	0	0	0	0	0	0	3	3	0
36	11	9	1	0	0	0	0	0	1	2	0
38	7	7	3	0	0	0	0	0	0	0	0
40	1	4	6	1	0	0	0	0	0	0	0
42	0	3	0	10	1	1	0	0	0	0	0
44	0	5	10	22	10	0	0	0	0	0	0
46	0	6	3	32	12	0	0	0	0	0	0
48	0	1	2	31	1	0	0	0	0	0	0
50	0	2	0	4	0	0	0	0	0	0	0
52	1	2	0	1	2	4	0	0	0	0	0
54	0	1	0	3	0	0	3	0	0	0	0
56	7	11	0	1	0	0	1	0	0	1	1
58	21	29	5	3	10	2	1	0	0	4	3
60	33	52	25	6	40	14	3	6	0	1	1
62	18	37	27	15	30	43	8	17	1	1	2
64	11	7	17	8	31	24	11	37	2	12	4
66	11	4	22	23	25	16	13	41	9	21	17
68	6	3	23	20	35	36	25	46	29	33	23
70	3	1	17	24	43	30	28	58	45	63	34
72	10	0	6	13	21	22	18	31	75	100	74
74	10	5	3	5	15	18	33	24	36	97	81
76	10	5	2	7	25	25	38	36	31	55	26
78	12	4	0	5	18	11	30	19	24	34	22
80	6	0	2	0	5	4	12	11	14	9	9
82	0	0	0	0	4	1	7	5	3	1	2
84	0	0	0	0	0	0	1	5	0	0	0
86	0	0	0	0	1	1	1	2	1	0	2
88	0	0	1	0	0	0	3	1	0	0	0
90	0	0	0	0	0	1	2	1	0	0	0
92	0	0	1	0	1	0	3	0	0	0	0
94	0	0	0	0	0	0	1	1	0	0	0
96	0	0	0	0	0	0	1	0	0	0	0
98	0	0	0	0	0	0	1	1	0	0	0
100	0	0	0	0	0	0	2	0	0	0	0
102	0	0	0	0	0	0	0	0	0	0	0
104	0	0	0	1	0	0	0	1	0	0	0
106	0	0	0	0	0	0	1	0	0	0	0
108	0	0	0	0	0	0	0	0	0	0	0
110	0	0	0	0	0	0	0	0	0	0	0
112	0	0	0	0	0	0	0	0	0	0	0
114	0	0	0	0	0	0	0	0	0	0	0
116	0	0	0	0	0	0	0	0	0	0	0
118	0	0	0	0	0	0	0	0	0	0	0
Total	188	198	176	235	330	253	247	343	304	462	301

Table 9 (continued). Summary of longtail tuna length frequency data.

cm	1988 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
24	0	0	0	0	0	0	0	0	0	1	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	1	0
30	0	0	0	0	0	0	0	0	0	1	4	0
32	4	1	0	0	0	0	0	0	0	3	8	2
34	7	4	2	0	0	0	0	0	0	5	11	7
36	2	4	22	10	0	0	0	0	0	5	4	9
38	7	13	9	20	0	0	0	0	0	3	7	17
40	15	16	3	25	4	0	0	0	0	1	3	5
42	16	5	0	12	8	0	0	0	0	1	2	1
44	3	0	1	3	6	0	0	0	0	0	1	0
46	3	0	0	0	1	0	1	0	0	1	0	0
48	1	0	0	1	0	0	1	0	0	0	0	0
50	1	0	0	0	0	0	5	0	0	0	0	0
52	0	1	0	0	0	0	3	0	0	0	0	1
54	0	0	0	1	1	2	6	0	1	0	0	2
56	0	1	0	0	0	11	3	0	1	0	0	2
58	0	5	0	2	8	41	1	2	2	0	0	0
60	0	12	3	16	17	65	2	2	4	4	0	0
62	1	31	21	36	25	62	6	3	15	4	0	1
64	2	61	28	81	39	62	8	6	30	9	0	0
66	10	84	29	57	31	78	8	14	64	30	1	0
68	20	63	41	62	18	44	9	21	53	67	0	1
70	39	48	74	67	78	38	36	41	22	79	9	11
72	46	40	122	82	98	27	75	56	14	68	10	15
74	30	27	80	36	71	24	101	66	11	49	29	51
76	13	14	30	11	28	18	100	51	16	40	72	93
78	4	9	15	4	16	16	92	35	23	44	116	90
80	2	2	4	2	3	3	58	11	16	42	96	69
82	1	0	0	3	2	8	25	7	3	31	52	49
84	0	0	0	3	3	0	9	3	0	18	13	10
86	1	0	0	0	1	0	3	1	0	6	5	1
88	0	0	0	5	0	0	4	0	1	2	2	0
90	0	0	0	1	0	0	2	0	0	1	3	1
92	0	0	0	2	0	0	0	0	0	0	0	0
94	0	0	0	0	0	0	1	0	0	0	0	0
96	0	0	0	0	1	0	2	0	0	0	1	0
98	0	0	0	0	0	0	1	0	0	0	0	0
100	0	0	0	0	1	0	0	0	0	0	0	0
102	0	0	0	0	0	0	0	0	0	0	0	0
104	0	0	0	0	0	1	0	0	0	0	0	0
106	0	0	0	0	2	0	0	0	0	1	0	0
108	0	0	0	0	2	0	0	1	0	0	0	0
110	0	0	0	0	0	0	0	0	0	0	0	0
112	0	0	0	0	1	0	1	0	0	0	0	0
114	0	0	0	0	0	0	0	0	0	0	0	0
116	0	0	0	0	1	0	0	0	0	0	0	0
118	0	0	0	0	0	0	0	0	0	0	0	0
Total	228	441	484	542	466	500	563	320	276	516	450	438

Table 9 (continued). Summary of longtail tuna length frequency data.

cm	1989 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	1990 Jan
24	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	3	0	0	0
32	0	0	0	0	0	0	0	0	0	8	0	0	0
34	0	0	0	0	0	1	0	0	0	4	3	0	0
36	4	0	0	0	0	0	0	0	0	5	2	0	0
38	28	0	0	0	1	1	0	0	0	2	1	0	0
40	44	0	0	0	10	3	0	0	0	1	0	0	1
42	29	1	0	0	6	7	0	0	0	0	0	0	1
44	18	1	0	0	7	7	0	0	0	0	0	0	0
46	10	0	0	0	1	3	0	0	0	0	0	0	7
48	6	0	0	0	1	1	0	0	0	0	0	0	5
50	3	1	0	0	0	0	0	0	0	0	0	0	1
52	4	0	0	0	0	0	0	0	0	0	0	0	0
54	1	0	0	0	0	0	0	0	0	0	0	0	0
56	1	0	0	0	0	0	0	0	0	1	0	0	7
58	0	0	0	1	0	1	0	0	0	1	0	0	13
60	1	3	0	0	0	6	0	0	0	0	1	0	6
62	0	9	0	0	0	15	0	0	0	1	1	0	4
64	1	2	1	1	1	13	0	0	0	1	1	0	7
66	0	3	0	6	8	9	1	1	6	5	0	0	2
68	5	5	3	17	12	10	2	4	8	12	1	1	1
70	11	2	7	71	4	18	4	21	10	24	0	0	0
72	37	16	27	144	17	11	6	34	23	22	5	1	0
74	35	29	41	112	42	28	15	26	25	22	15	4	4
76	38	20	33	49	64	65	44	36	17	14	59	13	9
78	34	34	30	25	77	82	84	74	26	29	113	34	18
80	22	12	17	10	55	78	83	80	54	98	98	45	23
82	7	1	5	4	34	51	71	61	49	97	64	24	22
84	2	2	0	2	9	26	29	22	14	55	11	15	28
86	0	0	0	0	2	20	16	3	5	12	1	1	21
88	0	0	1	0	2	2	4	1	3	1	1	0	13
90	0	0	4	0	0	6	2	2	2	0	1	0	5
92	0	1	3	0	0	3	3	0	0	0	0	0	3
94	0	0	1	0	0	1	3	0	0	0	0	0	1
96	0	0	0	0	0	2	0	0	2	0	0	0	2
98	0	1	1	0	1	0	1	1	0	0	0	0	4
100	0	0	0	0	0	3	1	0	0	0	0	0	2
102	0	0	0	0	0	1	3	0	0	0	0	0	0
104	0	0	0	0	1	1	1	0	0	0	0	0	0
106	0	0	0	0	0	1	0	0	0	0	0	0	0
108	0	0	1	0	1	2	0	0	0	0	0	0	0
110	0	0	0	0	0	1	1	0	0	0	0	0	1
112	0	0	0	0	0	0	0	0	0	0	0	0	0
114	0	0	0	0	0	0	1	0	0	0	0	0	0
116	0	0	0	0	0	1	2	0	0	0	0	0	1
118	0	0	0	0	0	0	1	0	0	0	0	0	1
Total	341	143	175	442	356	480	378	366	244	418	378	138	213

Table 10. Kawakawa (Euthynnus affinins) length frequency data summary.

	1987	1988											
cm	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
20	0	0	0	0	0	0	0	0	0	0	1	0	0
22	0	0	0	0	0	0	0	0	0	2	0	0	0
24	0	0	0	0	0	0	0	0	0	16	0	0	0
26	0	0	0	0	0	0	0	0	0	37	3	0	0
28	0	0	0	0	0	0	0	0	0	27	10	1	0
30	0	0	0	0	0	0	0	0	0	37	21	6	0
32	0	0	0	0	0	0	0	1	2	94	20	23	0
34	0	0	0	0	0	0	0	1	5	162	27	9	0
36	8	7	0	0	0	0	0	0	10	36	29	3	0
38	5	10	2	0	0	0	0	0	0	14	63	6	2
40	1	12	15	17	0	0	0	0	0	13	38	7	3
42	9	6	17	32	0	2	0	0	0	1	0	5	6
44	18	25	13	39	7	1	0	0	0	0	1	9	24
46	10	28	7	35	3	2	0	0	0	0	0	4	69
48	1	6	0	18	8	15	2	7	0	0	0	0	54
50	0	8	0	4	1	22	23	36	20	1	1	0	12
52	0	1	0	1	1	26	41	68	66	2	4	0	11
54	0	5	1	0	1	11	14	24	63	1	6	3	4
56	0	3	3	2	1	3	4	3	44	5	6	5	13
58	0	8	3	26	2	4	5	2	20	2	0	1	15
60	2	38	8	21	11	9	11	3	29	2	0	0	6
62	2	70	11	6	2	2	2	2	27	0	0	0	1
64	2	42	5	0	3	2	2	2	12	0	0	1	1
66	0	24	7	1	0	1	3	4	17	1	0	0	1
68	1	7	1	2	6	2	2	0	16	1	0	0	0
70	0	3	0	1	5	3	0	1	9	0	0	0	0
72	0	2	0	0	1	0	1	0	4	0	0	0	2
74	0	1	0	0	1	1	0	0	0	0	0	0	0
76	0	0	0	0	1	0	0	0	0	0	0	0	0
78	0	0	0	0	0	0	0	0	1	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0	0
82	0	0	0	0	0	0	0	0	1	0	0	0	0
84	0	0	0	0	0	0	0	0	0	0	0	0	0
86	0	0	0	0	0	0	0	0	0	0	0	0	0
88	0	0	0	1	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	59	306	93	206	54	106	110	154	346	454	230	83	224

Table 10 (continued). Kawakawa (Euthynnus affinins) length frequency data summary.

	1989												1990	
cm	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	6	1	0	0	0	0	0
24	0	0	0	0	0	0	0	20	3	0	0	0	0	0
26	0	0	0	0	0	0	0	7	22	2	0	0	0	0
28	0	0	0	0	0	0	0	6	57	2	0	0	0	0
30	0	0	0	0	0	0	0	9	16	18	0	2	1	0
32	0	0	0	0	0	0	0	4	24	43	3	1	0	0
34	0	0	1	0	0	0	0	8	13	48	11	0	1	0
36	2	0	1	0	0	0	0	11	5	39	64	0	0	0
38	1	0	3	0	0	0	0	8	2	33	59	25	2	0
40	3	3	17	2	0	0	0	1	1	15	41	71	7	1
42	10	1	28	4	2	0	1	1	1	8	14	71	10	4
44	16	3	17	4	9	2	2	1	0	1	0	24	12	10
46	57	17	23	6	13	3	6	0	0	0	1	3	2	4
48	66	63	22	1	10	6	10	10	0	0	0	2	1	1
50	61	60	19	3	8	7	30	10	2	0	0	0	0	3
52	11	21	4	1	16	13	28	7	16	0	0	0	0	2
54	6	1	1	2	10	7	34	7	18	1	0	0	1	1
56	5	1	12	4	24	7	32	5	14	1	0	3	0	4
58	7	0	50	19	81	20	57	5	36	7	0	3	0	13
60	11	3	42	16	89	20	87	9	52	10	0	0	1	13
62	8	0	25	8	38	11	33	6	26	4	0	1	0	4
64	4	1	4	4	10	5	22	1	8	1	0	2	0	4
66	3	0	1	0	3	2	13	0	3	0	0	0	0	1
68	3	0	0	0	5	0	10	2	4	0	0	0	0	0
70	2	0	0	0	5	0	5	0	2	0	0	0	0	0
72	2	0	0	0	0	0	3	0	0	0	0	0	0	0
74	0	0	0	0	0	0	1	0	0	0	0	0	0	0
76	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78	0	0	0	0	0	0	1	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0	0	0
82	0	0	0	0	0	0	0	0	0	0	0	0	0	0
84	0	0	0	0	0	0	0	0	0	0	0	0	0	0
86	0	0	0	0	0	0	0	0	0	0	0	0	0	0
88	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	278	174	270	74	323	103	375	144	326	233	193	208	38	65

Table 11. Bonito (Sarda orientalis) length frequency data summary.

	1987	1988											
cm	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
20	0	0	0	0	0	0		1		0	0	0	0
22	0	0	0	0	0	0		0		1	0	0	0
24	0	0	0	0	0	0		11		0	0	0	0
26	0	0	0	0	0	0		1		31	3	0	0
28	0	0	0	0	0	0		0		87	18	0	0
30	0	0	0	0	0	0		0		77	120	3	0
32	0	1	0	0	0	0		0		10	173	7	1
34	1	0	0	0	0	0		0		0	56	65	2
36	5	9	0	0	0	0		0		0	7	101	49
38	25	39	15	25	0	0		0		1	1	43	274
40	26	66	54	84	0	1		0		0	3	19	108
42	26	50	78	130	0	2		0		0	0	20	53
44	4	12	19	78	0	13		0		0	0	13	10
46	2	3	0	12	2	3		0		0	0	7	2
48	1	3	2	1	1	11		0		0	0	1	6
50	2	16	8	1	2	12		0		0	0	3	2
52	4	45	18	1	5	30		0		0	0	14	6
54	5	48	27	4	8	44		0		0	0	7	8
56	1	22	11	0	6	44		0		0	0	6	17
58	1	3	2	0	2	20		0		0	0	1	10
60	0	1	0	0	3	4		0		0	0	0	4
62	0	0	0	0	2	2		0		0	0	0	1
64	0	1	0	0	1	0		0		0	0	0	0
66	0	0	0	0	0	0		0		0	0	0	0
68	0	0	0	0	0	0		0		0	0	0	0
70	0	0	0	0	0	0		0		0	0	0	0
72	0	0	0	0	1	0		0		0	0	0	0
Total	103	319	234	336	33	186		13		207	381	310	553

Table 11 (continued). Bonito (Sarda orientalis) length frequency data summary.

	1989												1990	
cm	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB
20	0	0	0	0	0			1			0	0	0	0
22	0	0	0	0	0			2			0	0	0	0
24	0	0	0	0	0			5			0	0	0	0
26	0	0	0	0	0			1	1		0	0	0	0
28	0	0	0	0	0			1	1		0	0	0	0
30	0	0	0	0	0			0			8	0	0	0
32	0	0	0	0	3			0			22	5	1	0
34	0	0	0	0	4			15			10	10	0	0
36	34	4	2	0	1			8			2	42	28	0
38	174	78	14	3	0			0			3	82	129	6
40	105	149	203	21	0			0			45	89	93	24
42	8	68	311	116	0			0			37	207	61	46
44	1	14	84	66	1			0			2	43	18	30
46	3	5	13	7	1			1			0	2	4	6
48	1	7	7	2	0			3			1	0	0	0
50	1	3	3	1	0			1			1	0	3	0
52	3	5	1	2	0			1			1	0	0	0
54	0	6	0	4	0			0			0	1	1	0
56	8	6	0	8	0			0			1	0	1	0
58	6	2	0	13	0			0			1	0	0	0
60	2	0	1	5	0			0			0	0	0	0
62	0	1	0	0	0			0			0	0	0	0
64	0	1	0	0	0			0			0	0	0	0
66	0	0	0	0	0			0			0	0	0	0
68	0	0	0	0	0			0			0	0	0	0
70	0	0	0	0	0			0			0	0	0	0
72	0	1	0	0	0			0			0	0	0	0
Tota	346	350	639	248	10			39	2		134	481	339	112