The Age Composition of Ling Catches

and

Ling Stock Assessment Workshop

Final Report

Fisheries Research & Development Corporation
Project Number 94/148

David Smith, Sandy Morison, Simon Robertson

and Murray MacDonald

June 1996

FISHERIES RESEARCH & DEVELOPMENT CORPORATION

DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

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Victorian Fisheries Research Institute

PO Box 114
Queenscliff, Victoria 3225

Contents

Non-technical Summary

Ling (*Genypterus blacodes*) catches are an increasing component of the South East Fishery. There is increasing pressure to raise the trawl sector TAC for ling and there has been a substantial increase in catch by the non-trawl sector, particularly line, which is currently unregulated. Despite the increasing importance of ling in the SEF, population parameters were poorly understood.

Ageing studies were carried out by the Central Ageing Facility to provide a comparison of the current age composition of catches by different sectors and enable a refinement of growth and estimation of mortality rates. The age composition of current and historical trawl catches were compared as a preliminary basis for an evaluation of the impacts of fishing on the population. A workshop, through the SEFSAG process, was convened to undertake a stock assessment of ling using the ageing data, catch statistics and other relevant biological information.

The greatest catches of ling are taken in Eastern Sectors A and B, with lesser amounts taken off the west coast of Tasmania and in western Bass Strait. Catch rate data for the period 1986 to 1994 were relatively stable in all areas. However, there were marked differences in the seasonality of catches between areas.

Unlike the previous Australian growth study which indicated differences with New Zealand, revised growth curves were consistent with New Zealand studies; and ageing methods and interpretation were identical. The maximum age in Australian samples was 28 years but catches were dominated by 3 to 6 year olds except for catches from the west coast of Tasmania and longline catches which had relatively more old fish. There was a marked decline in the proportion of older fish in recent samples from Eden and Ulladulla and an associated increase in total mortality compared to data from the mid to late 1980s. Results from all years suggested that natural mortality was higher for ages 3-10 (approx 0.3) than for older fish (approx 0.1).

Considerable progress was made at the ling workshop. Results indicated that recent mortality rates in the eastern sector of the fishery were high. However, these were not consistent with catch rate data and were considered most likely due to unrepresentative sampling. Comprehensive age and size information if collected during 1995/96 will clarify this. In addition, the proposed 1995/96 age/length data together with the results of the workshop will enable the estimation of current and virgin biomass.

Background

Ling (*Genypterus blacodes*) catches are an increasing component of the trawl fishery and catches by other methods, particularly line, have also increased significantly in recent years. The basic biology of the species, however, is poorly understood (Tilzey 1995). The age composition of current catches by trawl or non-trawl methods are unknown. No mortality estimates are available for ling in Australia.

Only limited research has been directed at ling. Withell and Wankowski (1989) presented age and growth estimates for ling from trawl catches taken in eastern Bass Strait. The method used to age ling is well described but the sample size was relatively small (377 fish). A maximum age of 21 years was estimated although ages have yet to be validated. They also concluded that there was no significant growth differences between sexes. However, Horn (1993) found that in New Zealand, females grow faster and attain a greater size than males. The maximum reported age was 35 years. The difference between reported studies in New Zealand and Australia is difficult to renconcile, and certainly indicates further work is required in Australia. It is worth noting that Withell and Wankowski (1989) reached quite erroneous conclusions about growth in gemfish.

The SETMAC Research Sub-committee has accorded ling a high research priority. Research issues included basic fisheries biology, stock structure, and catch sampling and monitoring from trawl and non-trawl sectors. The SEFSAG Upper Slope Working Group identified determining the age composition of current catches and ageing historical otolith collections as a high priority.

The ageing studies will provide for a comparison of the current age composition of catches by different sectors and enable a refinement of growth and estimation of total mortality. Comparison of the age composition of current and historical trawl catches will form the basis for an evaluation of the impacts of fishing on the population.

This proposal is for the Central Ageing Facility to conduct the ageing work and for a workshop, through the SEFSAG process, to undertake a stock assessment of ling using the ageing data, catch statistics and other relevant biological information.

Need

There is increasing pressure to raise the trawl sector TAC for ling and there has been a substantial increase in catch by the non-trawl sector, particularly line, which is currently unregulated. Despite the increasing importance of ling in the SEF, population parameters are poorly understood and the implications of a greater catch cannot be assessed.

The SETMAC Research Sub-committee has accorded ling a high research priority. Research issues included basic fisheries biology, stock structure, and catch sampling and monitoring from trawl and non-trawl sectors. The SEFSAG Upper Slope Working Group identified determining the age composition of current catches and ageing historical otolith collections as a high priority.

There are also other information, including size distributions, catch statistics and biomass estimates that have not properly been reviewed and potential for stock assessment evaluated.

Objectives

1. To refine growth estimates and provide mortality estimates for ling.

2. To compare the age composition of ling catches from different sectors and determine appropriate sample sizes for production ageing.

3. To assess change in mortality rates by comparing the age composition of current ling catches with catches taken during the 1980s.

4. To hold a ling stock assessment workshop.

Methods

Detailed methods are desribed in the appended Ling Stock Assessment Report (Appendix 1).

Ling were sampled from commercial landings during 1994/95. Otoliths were collected from 1041 fish together with other biological information including fish length (total length), fish weight and sex. Additional length frequency data were obtained from port and onboard sampling.

Ling otoliths (about 1500 in total) were collected by Victoria and Tasmania during the 1980s. The age composition of catches from these samples was determined and compared with that from the current fishery to assess whether there has been any change in total mortality over the last 10 years.

A Workshop was held at the Victorian Fisheries Research Institute, from 5-7 June 1995 to review the results of the ageing study and conduct a stock assessment of ling using all available information. Participants included representatives from industry, AFMA, BRS, State institutions, CSIRO and MAF Fisheries New Zealand.

Data used for the age composition of catches

The annual coverage of length frequency data is most complete for the mid 1980s and for recent years. Specifically, length frequency data were available from:

NSW;	FRV 'Kapala', 1975-77 & 1979-81
	Sydney Fish Market, 1986-88 & 1990
	Port measuring (Ulladulla), 1994
	SMP, 1993 & 1994

Victoria;	Portland, 1987& 1988, 1994 Beachport, 1987 &1988 WBS trawl surveys, 1987-89 Lakes Entrance, 1991 SMP, 1994
Tasmania	Port samples 1981-86 Long-line samples west Tas 1993 SMP 1993,1994

Otoliths were available from:

VFRI, 1987-1989 (western Bass Strait)
MRDTas, 1982-86 (Tasmania)
Central Ageing Facility, 1994, 1995 (NSW, Victoria)

The Central Ageing Facility provided ling age-length keys by sex for these periods and areas. These data were used to:

- derive growth parameters for ling in Australian waters
- provide the age composition of catches from each sector
- estimate mortality rates.

Changes from Methods described in the orginal application

In the original application it was anticipated that ling taken by the non-trawl sector, fish would be sampled at Tasmanian-based fish processors. A similar sampling regime worked effectively for orange roughy otolith collections. Due to reasons beyond control of the project it did not prove possible to sample non-trawl landings.

It was proposed to exchange otoliths with workers in New Zealand to ensure consistency of interpretation. This was not necessary because Peter Horn of MAFFish, who led New Zealand studies, attended the ling stock assessment workshop.

Detailed Results

Results of the study are given in detail in the attached Stock Assessment Report Appendix 1). Age determination and growth, and age composition and mortality rates are summarised below. Results of the workshop summarised here, are reported as a species summary in Chesson (1996).

Age determination and growth

Ling were aged by examination of transverse sectioned sagittal otoliths. Age estimates were relatively unambigous with similar estimates between readers. Inter-reader variability, as measured by Beamish and Fournier's (1981) average percent error was 3.5 % and between readers 3.2%. A small sample was read by Peter Horn (MAFFisheries) after the workshop which confirmed that ageing methods and interpretation by New Zealand workers and CAF were identical (Note: APE = 2.5%). Horn (1993) validated the ageing method by using the progression of modal peaks in length frequencies and by analysing otolith marginal increments.

A new method of ageing fish otoliths which uses precise measurements of the levels of radioactive carbon present in otolith cores (Kalish 1993) was used to independently assess the age of 31 samples previously aged from sectioned otoliths. Close correspondence between the ages assigned by both methods gives confidence that the ages estimated from sections are accurate. The otoliths chosen for this comparison was selected to cover a size range (80 to 117 cm total length) and an estimated age range of seven to twenty eight years. Estimates between the radio carbon and transverse sagittal sections agreed closely (John Kalish personal communication).

Over 2,000 ling were aged. The maximum age in samples was 28 years

Females grow faster than males and to a slightly greater age (Figure 10). Parameters of the von Bertalanffy growth curve were:

Area/year	Sex	K	L_{inf}	t_o	N
WBS	Female	0.15	102.0	-2.96	519
87-89	Male	0.13	98.0	-4.06	462
Tas	Female	0.21	100.0	-1.84	147
82-86	Male	0.23	90.0	-2.04	182
Current	Female	0.11	127.3	-1.93	469
94-95	Male	0.14	102.0	-1.97	408

The difference in parameters between samples reflects differences in the relative proportion of older fish. The 1994/95 samples (current) had relatively few larger fish which gives a higher estimate of L_{inf}. Unlike the previous Australian growth study which indicated no significant differences between males and females revised growth curves and estimates of longevity are more consistent with New Zealand studies.

Age composition and mortalities

To derive age compositions for Kapala and SFM data, the WBS ALK was applied to the appropriate length frequency. Catches were dominated by 3 to 5 year olds except for ling from the west coast of Tasmania and longline catches which had relatively more old fish. This is considerably different from the New Zealand fishery where ling are not fully recruited to the fishery until 8-12 years depending on the area.

There was a marked decline in the proportion of older fish in recent samples from Eden and Ulladulla.

Mortality estimates are shown if Figure 12. As ling catches prior to 1980 were relatively small, results for the Kapala samples are regarded as being indicative of a lightly fished population. Mortality rates estimated from these data are, therefore, roughly equivalent to natural mortality. Results also indicate natural mortality is higher for ages 3-10 (approx 0.3) than for older fish (approx 0.1). For all ages greater than 2 an estimate of M of 0.17 is derived which is similar to that of New Zealand workers. Mortality estimates for Eden and Ulladulla (1993, 1994) are considerably higher compared to data from the mid to late 1980s.

LING STOCK ASSESSMENT SUMMARY

from

Chesson, J. (ed) (1996) *The South East Fishery 1995*. Fishery Assessment Report compiled by the South East Fishery Assessment Group, Australian Fisheries Management Authority Canberra. pp 131-139

1. AFMA'S MANAGEMENT OBJECTIVES, STRATEGIES AND PERFORMANCE INDICATORS

Objectives

Ongoing

1. To ensure that the ling resource is utilised in a manner consistent with the principles of ecologically sustainable development.

Immediate objectives

2. To maintain the recruited biomass at the current (1995) level

   - to be reviewed after the 1996 stock assessment

   [Note: the TAC increased in 1995 in accordance with the 1994 immediate objective, which indicated scope for expansion]

3. To manage ling as a multi-sector fishery

   [Note: current jurisdictional boundaries and varying approaches to management by the States and Commonwealth need to be reconciled and noting that hook and gillnet operators have a significant interest in the fishery]

4. To maximise the economic efficiency of the ling fishery.

5. To implement effective and efficient fisheries management on behalf of the Commonwealth.

Strategies

The above objectives will be achieved by:

1. setting a TAC (including trawl and non-trawl sectors) for the Commonwealth managed portion of the fishery that:
   - maintains catch per unit effort (CPUE) at or above its lowest annual average level from 1986 to 1994

   (objectives 1,2 & 3)

2. managing all sectors of the ling fishery in a complementary manner

   (objectives 1 & 5)

3. prioritising ling research in relation to other SEF quota species:

   - SETMAC has given a high research priority rating to this species

   (objectives 1, 2, 3, 4 & 5)

4. data collection

   (i) determine recent and current annual catches by each sector of the fishery, including changes in patterns of catch (catch, catch rates, shifts in effort and changes in fishing practices)
   (ii) obtain representative length/age distributions of commercial catches (1995-96) by 1996 obtain estimates of:
   (iii) the recruited biomass at the onset of significant commercial fishing (year to be determined)
   (iv) the recruited biomass of the fishery in 1995

   (objectives 1,2 & 3)

5. undertaking economic research on the fishery to calculate GVP and determinants of market prices for ling.

   (objective 4)

Performance indicators

1. That the current annual CPUE is above its lowest annual average level from 1986 to 1994

   (strategy 1)

2. That all sectors of the fishery are managed in a complementary manner

   (strategy 2)

3. Data relevant to the annual assessment of ling has been collected and analysed, and considered by SEFAG

   (strategies 3, 4 & 5)

4. The actual trawl catch relative to the trawl TAC.

   (strategy 1)

2. STOCK STRUCTURE AND LIFE HISTORY

Nothing is known of stock structure within Australia. At this time, a common SEF stock is assumed for management purposes.The life history of ling is poorly understood. Spawning is thought to occur in winter-spring but little is known of spawning sites or larval life history. Recent ageing of fish sampled from Australian waters indicates a maximum age of 28 years. It is probable that growth differs between sexes. No mortality estimates are available for Australia, but natural mortality has been estimated for New Zealand ling.

3. THE FISHERY

Current situation

The ling TAC was increased, from 700 t in 1992 to 800 t in 1993, then to 1 000 t in 1994. Although the 1992 catch of 632 t was below the TAC, the 1993 catch of 1 035 t (which included 111 t claimed as caught from State waters) exceeded the TAC by 28%. The 1994 catch was 1047 t, which includes 146 t declared as caught in State waters.

Industry have commented that ling were apparently more abundant (i.e. easier to catch) in 1993 than in previous years, particularly larger fish. The increased catches in ling have resulted directly from the absence of gemfish and increased targeting although only minor modifications have been made to the gear.

The non-trawl catch in 1994 was similar to that in 1993 at about 400 t.The gross value to fishers of recorded trawl fishery landings of ling in 1994 was estimated to be about $3.2 million. This was higher than previous years due largely to increased recorded landings.

4. PREVIOUS ASSESSMENTS

There have been no formal assessments of ling in Australian waters. Some biomass estimates are available and limited biological data. No trends in CPUE were evident using 1986-1991 SEF logbook data.

5. 1995 ASSESSMENT

Recent developments

Recent logbook data were incorporated. Results of a FRDC-funded project on the age composition of ling catches were presented. Peter Horn from New Zealand MAF provided data on the New Zealand fishery.

Assessment process

A FRDC-funded Ling Stock Assessment Workshop was held at VFRI, Queenscliff, 5-7 June 1995.

Methods

Data

SEF logbook catch and effort statistics were examined for the period 1986 to 1994. Only those shots in which the species was caught were used to calculate effort. Catch rates were expressed as kilograms per hour. Data were examined separately for each major area in the fishery and by season. SMP data were examined to determine discard rates.

Size composition and ageing data collected since the late 1970s were used to examine changes in age composition and mortality rates were estimated from catch curve analysis. Revised growth parameters were derived.

Results

The greatest catches of ling are taken in Eastern Sectors A and B, with lesser amounts taken off the west coast of Tasmania and in western Bass Strait. Catch rate data for the period 1986 to 1994 were relatively stable in all areas. However, there were marked differences in the seasonality of catches between areas.

Unlike the previous Australian growth study which indicated differences with New Zealand, revised growth curves were consistent with New Zealand studies; and ageing methods and interpretation were identical. The maximum age in Australian samples was 28 years but catches were dominated by 3 to 6 year olds except for catches from the west coast of Tasmania and longline catches which had relatively more old fish. There was a marked decline in the proportion of older fish in recent samples from Eden and Ulladulla and an associated increase in total mortality compared to data from the mid to late 1980s. Results from all years suggested that natural mortality was higher for ages 3-10 (approx 0.3) than for older fish (approx 0.1).

Uncertainties in assessment

The major uncertainty concerns the increased mortalities seen in fish landed at Eden and Ulladulla. This was inconsistent with catch rates which were stable. Sample sizes from SMP were relatively low and may have been unrepresentative. Also industry reported considerable discarding of small ling but this was not evident in SMP data. It is unclear if improved catches were attributable to changes in fish abundance, catchability, improved targeting practices, or a combination of all these factors. Current stock status is still uncertain. Little is known about the size of the resource and the implications of the spatial structuring can not adequately be addressed at this time.

6. IMPLICATIONS FOR MANAGEMENT

CPUE data for the period 1986-1994 have been relatively stable suggesting that ling abundance has not significantly altered over this period. However, catches have increased markedly in recent years. The 1994 catch from all sectors is approximately

1400 tonnes and the 1995 catch is expected to be higher. These catches are significantly greater than historic levels.

Current stock status is uncertain. Little is known about the size of the resource and the implications of the spatial structuring can not adequately be addressed at this time. The impact of increased catches is unknown and requires a more rigorous assessment than is possible through evaluation of CPUE data alone.

There was a marked increase in non-trawl catches during 1992-93 but recorded catches in 1994 did not increase further. Non-trawl catches are not limited by a TAC. Catch and effort data from the non-trawl sector are poor and this hampers the assessment. The proposed non-trawl logbook should resolve this.

Considerable progress was made at the ling workshop. Results indicated that recent mortality rates in the eastern sector of the fishery were high. However, these were not consistent with catch rate data and were considered most likely due to unrepresentative sampling. Comprehensive age and size information if collected during 1995/96 will clarify this. In addition, the proposed 1995/96 age/length data together with the results of the workshop will enable the estimation of current and virgin biomass.

7. RESEARCH NEEDS

Ling has been accorded a high research priority by the SETMAC Research Sub-committee. The highest priorities are:

- to obtain a representative age-length key for 1995/96
- re-analysis of +Kapala+ data (including ageing) and Sydney Fish Market length data;
- undertake a more rigorous analysis of SEF1 logbook data to include spatial
- patterns, and species composition and interactions.

These data, together with results from the 1995 Ling Workshop will form the basis for a catch-at-age analysis providing estimates of virgin and current biomass.

Other research needs include:

- A project on the biology of ling and factors that influence their behaviour which are poorly understood and limits interpretation of trends in catch rates and size composition.
- Evaluation of harvest strategies for species such as ling which are often caught as a component of a suite of species and/or a major by-catch of other species; and are a multi-sector species.
- Stock structure is unknown and this may prove to be important if assessments are shown to be sensitive to assumptions about stock structure.

Benefits

The major beneficiaries of this research is the South East Fishery.

Industry (and ultimately the community) will benefit from management based on a better understanding of the status of the resource.

Intellectual Property

No intellectual property has arisen from this research that is likely to significant commercial benefits, patents or licences. Intellectual proporty associated with the project will be shared between VFRI and FRDC.

Further Developments

The Ling Stock Assessment Workshop identified a range of research needs for the fishery which are given elsewhere in this report. The Species Summery was published in Chesson (1996) and the Stock Assessment Report is due for publication in 1996.

Staff and Acknowledgments

David Smith Ph.D (5%)	Principal Investigator
Sandy Morison M.Sc (10%)	Manager Central Ageing Facility
Ken Smith (10%)	Senior Technical Officer

Central Ageing Facility staff - as required
Scientific Monitoring Program staff - as required

Ling Stock Assessment Workshop Participants

David Smith (VFRI) - Chair
Sandy Morison (VFRI)
Simon Robertson (VFRI)
Murray MacDonald (VFRI)
Cory Green (VFRI)
Peter Horn (MAF, NZ)
Richard Tilzey (BRS)
Jeremy Prince (Industry scientist)
Nic Bax (CSIRO)
Chris OBrien (BRS)
Ros Priest (AFMA)
John Sealy (Industry)

Kevin Rowling and Ken Graham (NSW FRI) provided the Sydney Fish Market and Kapala length frequency distributions, respectively. Jeremy Lyle provided the Tasmanian data. Ken Smith (VFRI) coordinated 1994/95 ling otolith collections.

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Final Cost

	Allocated	Expenditure
FRDC		
Salaries and on costs	0	0
Travel	10,650	9,645
Operating	37,250	38,255
Total FRDC	**47,900**	**47,900**
VFRI		
Salaries and on costs	25,000	25,000
Operating	0	0
Total VFRI	**25,000**	**25,000**
TOTAL BUDGET	**72,900**	**72,900**

Distribution

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Stock Assessment Report

Ling

1995

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for the

South East Fishery Assessment Group

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This series of Stock Assessment Reports documents general fishery assessment issues dealt with by the Fishery Assessment Working Groups established by Commonwealth Fishery Management Advisory Committees. It addresses the issues of the day in the current legislative context and in the time frames required. The documents are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

CONTENTS

ACKNOWLEDGMENTS

This report was developed following a FRDC-funded Ling Stock Assessment Workshop held at VFRI, Queenscliff, 5-7 June 1995

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Nic Bax (CSIRO)
Chris OBrien (BRS)
Ros Priest (AFMA)
John Sealy (Industry)

Kevin Rowling and Ken Graham (NSW FRI) provided the Sydney Fish Market and Kapala length frequency distributions, respectively. Dr Jeremy Lyle provided the Tasmanian data. Ken Smith (VFRI) coordinated 1994/95 ling otolith collections.

INTRODUCTION

This is a report produced for the South East Fishery Assessment Group (SEFAG) under the stock assessment process initiated by the Australian Fisheries Management Authority (AFMA).

The SEFAG will produce an annual Fishery Assessment Report and individual Stock Assessment Reports for each major species within the fishery. The content and format of these reports is standardised across fisheries. This report conforms to those standards.

The report begins with a Stock Assessment Summary that will be extracted and included in the Fishery Assessment Report. Since the summary is intended to stand alone, it is somewhat more detailed than a normal report summary.

Statements of AFMA's objectives, strategy and performance criteria were provided by AFMA and are repeated verbatim. Appendixes include unpublished data and written materials used in the assessment that would not otherwise be accessible to the reader. In most cases, they are reproduced in the form provided by the original contributor without editing, or other changes.

STOCK ASSESSMENT REPORT

1. AFMA'S MANAGEMENT OBJECTIVES, STRATEGY AND PERFORMANCE CRITERIA

Objectives

Ongoing

1. To ensure that the ling resource is utilised in a manner consistent with the principles of ecologically sustainable development.

Immediate objectives

2. To maintain the recruited biomass at the current (1995) level

   – to be reviewed after the 1996 stock assessment

   [Note: the TAC increased in 1995 in accordance with the 1994 immediate objective, which indicated scope for expansion]

3. To manage ling as a multi-sector fishery

   [Note: current jurisdictional boundaries and varying approaches to management by the States and Commonwealth need to be reconciled and noting that hook and gillnet operators have a significant interest in the fishery]

4. To maximise the economic efficiency of the ling fishery.

5. To implement effective and efficient fisheries management on behalf of the Commonwealth.

Strategies

The above objectives will be achieved by:

1. setting a TAC (including trawl and non-trawl sectors) for the Commonwealth managed portion of the fishery that:

   - maintains catch per unit effort (CPUE) at or above its lowest annual average level from 1986 to 1994

   (objectives 1,2 & 3)

2. managing all sectors of the ling fishery in a complementary manner

   (objectives 1 & 5)

3. prioritising ling research in relation to other SEF quota species:

- SETMAC has given a high research priority rating to this species

(objectives 1, 2, 3, 4 & 5)

4. data collection

(i) determine recent and current annual catches by each sector of the fishery, including changes in patterns of catch (catch, catch rates, shifts in effort and changes in fishing practices)

(ii) obtain representative length/age distributions of commercial catches (1995-96)

by 1996 obtain estimates of:

(iii) the recruited biomass at the onset of significant commercial fishing (year to be determined)

(iv) the recruited biomass of the fishery in 1995

(objectives 1,2 & 3)

5. undertaking economic research on the fishery to calculate GVP and determinants of market prices for ling.

(objective 4)

Performance indicators

1. That the current annual CPUE is above its lowest annual average level from 1986 to 1994

(strategy 1)

2. That all sectors of the fishery are managed in a complementary manner

(strategy 2)

3. Data relevant to the annual assessment of ling has been collected and analysed, and considered by SEFAG

(strategies 3, 4 & 5)

4. The actual trawl catch relative to the trawl TAC.

(strategy 1)

2. STOCK STRUCTURE AND LIFE HISTORY

Taxonomic note

In Australia, the closely related rock ling (*G. tigerinus*) is often confused with, and recorded as, ling. Rock ling have a similar distribution range as ling, but are much less abundant and occupy shallow (<60m) coastal areas only (Last *et al.* 1983). A few rock ling are known to be caught by Danish seiners and inshore trawlers but this species undoubtedly comprises only a very small proportion of the recorded SEF *G. blacodes* catch.

In the previous assessment report (Tilzey 1995), it was suggested that there may be two 'forms' of *G. blacodes* , one on the shelf (i.e. <200m depth) and one in deeper slope waters. A distinguishing characteristic is the orange (as against pink) colouration of the shelf form. However, recent allozyme and meristic studies have shown that the two "forms" are the same species and also are not separate stocks (Daley unpublished data). The juveniles in shallower water are orange and the adults pink.

Ling also occur in New Zealand and off southern South America (Paul 1986). It is not related to the northern hemisphere 'ling'.

Stock structure

Nothing is known of stock structure in Australia. In the New Zealand EEZ, stocks in the Subantarctic and to the south of the South Island appear to differ from those west of the South Island and on the Chatham Rise (Annala 1993).

At this time, a common SEF stock is assumed for management purposes.

Distribution

Ling occur throughout southern Australian shelf and upper slope waters from southern W.A. across to NSW. In the east, the northern limit of their distribution is around Crowdy Head, NSW (K. Graham-pers. com.). They occur in the GAB (Newton & Klaer 1988) and a fish survey of W.A. slope waters found them as far north as 33°06'S (Williams 1992). Ling inhabit a variety of substrates ranging from soft mud, in which they may burrow, to rugged reefs where they often occupy caves.

Ling are widely distributed, occuring over broad depth range. May and Maxwell (1986) cited a depth range of 20 to 750 m. Lyle and Ford (1993) recorded a depth range of 22 to 1 000 m for Tasmanian waters. In western Bass Strait ling were found in depths ranging from 132 to 915 m (Smith et al 1995). Juveniles are more common in the shallower depths (Last *et al.* 1983; Smith et al 1995).

Woodward (1987) found catches south of 37°S to be largely confined to the 457-640 m depth range during 1979-1984. More recent analyses of these data (Lyle 1989) examined catch distribution by 50 m depth strata and showed the greatest catches to be from the 550-600 m stratum. Smith et al (1995) found the highest abundance of ling in western Bass Strait were in depths from 400 to 599 m. However, SET logbook data show that about 85% of the total catch was taken from the 300-550m zone, with catches extending down to 699 m only (Tilzey 1995). The maximum catch (22% of 1986-1991 total) occurred in the 400-449 m stratum and maximum CPUE in the 500-549 m stratum. This was shallower than for the earlier SW Sector data and suggest that the 1979-1984 fish were taken largely as a by-catch of targeting blue grenadier (Tilzey 1995).

Life history and biology

Little is known of their reproductive biology in Australia. GSI data were collected from western Bass Strait (Smith et al 1995) and these imply that spawning probably occurs in winter/spring. Examination of the relationship beween GSI and length for female ling indicated that the size at maturity occurs at about 60 cm TL (Smith et al 1995). For males it was not clear with little variation in GSI for all size classes. Lyle and Ford (1993) recorded the highest GSI values in September and noted that changes in GSI with length suggested that females mature at about 72 cm (TL). In New Zealand waters spawning occurs between August and October (Paul 1986).

Little is known of fecundity, spawning sites or larval life history. Fecundity appears to be moderately low. The fact that small fish mainly occur in shelf waters suggests that juveniles may move (or be carried, if there is a planktonic larval phase) into shallower coastal waters if spawning occurs in outer shelf or upper slope waters. Data from the SEF logbook indicate seasonal changes in catch rates and there are anecdotal accounts from industry of ling 'schooling-up' in the SEF, particularly in the 'Horseshoe' area of north-eastern Bass Strait. Also, demersal longline catch rates off western Tasmania peak in late winter and spring. This seasonality may be associated with spawning behaviour. In New Zealand, aggregating behaviour by ling has been reported (Roberts 1987)

Withell and Wankowski (1989) reported age and growth value, using whole otolith annuli. Age was not validated and growth estimates were therefore based on assumed annuli only. The following values were obtained; maximum age - 21 years, K = 0.095 and L_{inf} = 135.5 cm. No significant growth difference between sexes was observed, although Withell and Wankowski (1989) noted that in *Genypterus capensis* (the South African kingklip), the only other member of this genus for which age/growth studies are available (Payne 1977, 1985), females are significantly larger than males. The F : M ratio in Withell & Wankowski's (1989) survey was 2 : 1. Japp (1990), in a more recent study of *G. capensis*, derived L_{inf} values ranging from 125.4 cm to 130.1 cm for males and 132.9 cm to 141.5 cm for females, with respective K values being 0.148-0.149 and 0.135-0.138.

In New Zealand, a growth study of ling from four areas found females to grow faster and attain a greater size than males in all areas (Horn 1993). Less than 0.2% of the fish successfully aged were older than 30 years. See Appendix E for details of parameters.

No mortality estimates were available in Australia. In New Zealand, Horn (1993) derived a mean M of 0.18 (range 0.17-0.20) from five samples of age data.

Little is known of ling migrations in Australian or New Zealand waters. The results of a trawl survey in western Bass Strait in 1987-88 suggested that ling to move into deeper waters in summer (Smith et al 1995). Targeting practices may have influenced the logbook data. Anecdotal evidence from SEF fishers suggest that ling move off reefs to trawlable ground during certain phases of the moon, and that sub-adults occasionally school. In New Zealand, anecdotal evidence suggests that ling may be relatively sedentary and hence susceptible to localised depletion. Ling are at times caught well above the bottom in New Zealand waters, often when feeding on juvenile blue grenadier (Annala 1993).

Nothing is known of stock-recruitment relationships The SFM length frequencies suggest that ling first recruit to the NSW component trawl fishery at age 1 and are fully recruited at ages 3-4.

In South Africa landings from the kingklip (*Genypterus capensis*, a closely related species) trawl fishery declined from > 3000 tpa during the 1970's and early 1980's to 1300 tpa in 1990 following the development of a demersal longline fishery from 1983 onwards. Catches from this line fishery peaked at 8700 tonnes in 1986 and it was phased out in 1990. South African fisheries authorities have adopted a stock rebuilding target of 50% of estimated virgin biomass for kingklip following this over-exploitation (Punt and Japp in press).

3. THE FISHERY

Brief history

Because ling are essentially an upper-slope species, they were not caught in significant quantities during the early 'shelf-only' phase of the SEF. The smaller *G. tigerinus* would probably have been the main ling species caught. For example, Roughley (1951) noted "it grows to a length of about 18 inches and is not highly prized as a food-fish". As the trawl fleet started to fish slope waters, catches of *G. blacodes* increased (Table 1). Ling now comprise an important component of the SEF, with annual catches during 1985-1992 ranging from 632 to 838t (Tilzey 1995).

Table 1: Pre-SEF catch records (kg) for ling (after Stewart *et al.* 1991)

YEAR	NSW	VIC	S.A.	TAS	TOTAL
1976/77	41 024	N.D.	N.D.	678	41 702
1977/78	107 272	N.D.	300	380	107 952
1978/79	121 321	36 000	N.D.	2 065	159 386
1979/80	180 486	48 000	N.D.	2 311	230 797
1980/81	279 736	68 000	N.D.	1 082	348 818
1981/82	321 954	108 000	N.D.	1 656	431 610
1982/83	361 881	99 000	N.D.	13 580	474 461
1983/84	475 633	107 000	49	42 798	625 480
1984/85	527 000	113 000	29	100 272	740 301

N.D. = no data

DATA SOURCES NSW: 76/77 to 80/81 - NSW FISH 1980/81 Annual Report
81/82 - ABS
82/83 to 83/84 - NSWAF unpublished final
84/85 - estimated from AFS 'verified' catch data
VIC: 78/79 to 84/85 - VICDCE
S.A.: 77/78 and 83/84 to 84/85 - SADF
TAS: 76/77 to 79/80 - ABS
80/81 to 84/85 - TDPI

Ling flesh is of excellent quality and commands a high price on domestic markets, especially since it was identified as the species most commonly marketed as "barramundi" during the publicity surrounding the fish-substitution scandal of the early 1980s. The mean price of ling at the Sydney and Melbourne fish markets was $3.04 in 1994, significantly higher than prices for many other SEF quota species.

Only 34.9% of the SEF ling catch was estimated to be targeted (Klaer and Tilzey 1989), with ling mainly being taken as a by-catch of targeting blue grenadier, gemfish and royal red prawn. Tilzey (1994) commented that catch rates were very similar throughout the SEF upper slope (300-550- m depth) waters.

1992 and 1993 saw a sharp rise in the non-trawl catch from the South West Sector because of increased targeting by Commonwealth endorsed ('shark') mesh-netters and the commencement of an automated demersal long-lining venture. The non-trawl sector catch in 1993 was about 550 tonnes. The total recorded catch by all methods for 1993 (about 1 500 t) was markedly higher than the previous annual maximum (880 t in 1987).

G. blacodes is rarely taken by recreational fishermen. *G. tigerinus* is occasionally caught by recreational 'reef' fishermen.

Current situation

The ling SEF TAC was increased, from 700 t in 1992 to 800 t in 1993, then 1 000 t in 1994. Although the 1992 catch of 632 t was below the TAC, the 1993 catch of 1 035 t (which included 111 t claimed as caught from State waters) exceeded the TAC by 28%. The 1994 catch was 1047, which includes 146 t declared in state waters, and the 1995 TAC is 1500t.

The non-trawl catch in 1993 was 550 t and in 1994 about 350 t..

The gross value (to fishers) of recorded landings of ling (trawl fishery) in 1994 was estimated to be about $3.2 million. This was higher than previous years due largely to increased recorded landings. The total 1994 South East Australian catch was worth about $4.0 million.

.Market prices in Sydney and Melbourne fluctuate substantially over the year. Market prices appear to bottom in the winter months, but there is no apparent peak price period. Market prices over 1993 ranged from about $2.60/kg to about $4.65/kg. The average price received by operators in 1994 (net of marketing charges) was estimated to be about $3.04, 13 per cent higher than in 1993.

In 1992, about 468 tonnes (product weight) of ling fillets were imported from New Zealand. About 402 tonnes (product weight) were imported in the first nine months of 1993. New Zealand exporters were receiving about NZ$6.75/kg for the fillets.

Industry perspective

Industry's perspective is derived from comments made at port meetings (27-31 March 1995) and from discussions with industry prior to the workshop which were summarised by Jeremy Prince. The following comments and issues represent individual opinions and may or may not apply to the majority of industry members:

- ling were apparently more abundant (i.e. easier to catch) in 1993 than in previous years, particularly larger fish.
- the increased catches in ling have resulted directly from the absence of gemfish
- fish run in November/December and also before the gemfish season
- there was increased targeting although only minor modifications have been made to the gear.
- fishermen note that the more a ground is fished the higher the catch rates. Reasons could be increased food from discards.
- size of ling is related to depth, with smaller fish in close. 2-4t shots can be expected with fish of uniform size.
- the further north, the more seasonal the fishery.
- during August-November larger fish are caught, thought to be spawning stock.
- trawlers catch their fish on the bottom, whereas ling on droplines are taken several hooks up.
- daylight shots are best 2.5-3 hour shots

4. PREVIOUS ASSESSMENT

There have been no formal assessments of ling in Australian waters. Some biomass etimates are available and limited biological data. Two biomass estimates are available. Wankowski and Moulton (1986) estimated standing stock in depth zones 300-599m and 600-799m in eastern Bass Strait to be 600kg/km^2 in 1984/85. Smith et al (1995) estimated standing stock in western Bass Strait during 1987-1989 to be:

	Summer	Autumn	Winter	Spring	Overall
Biomass	1229	848	954	976	1055
SE	269	100	140	293	97

The 1992 - 1994 assessments were based solely on historic catch data. No trends in CPUE were evident using logbook data. Although such CPUE data are at best only a rudimentary indicator of ling abundance these data suggested no significant change in abundance over the period 1986-1993.

5. THE 1995 ASSESSMENT

Recent developments

Recent logbook data were incorporated. Results of a FRDC-funded project on the age composition of ling catches were presented. Peter Horn from MAFFisheries, Greta Point provided data on the New Zealand fishery.

Assessment process

Ling were assessed at a FRDC-funded Ling Stock Assessment Workshop held at VFRI, Queenscliff, 5-7 June.

Methods

Data

Catch and effort data

SEF logbook catch and effort statistics are available for the period 1986 to 1994. For effort, only those shots in which the species was caught were used, and catch rates were expressed as kilograms per hour. Data were examined separately for each major area in the fishery and by season (designated using Neil Klaer's SEF partition; Tilzey 1994).

SMP data were examined to determine discard rates

Data from the non-trawl sector were also summarised.

Length frequency data

The annual coverage of length frequency data is most complete for the mid 1980s and for recent years. Specifically, length frequency data were available from:

NSW;	FRV 'Kapala', 1975-77 & 1979-81 Sydney Fish Market, 1986-88 & 1990 Port measuring (Ulladulla), 1994 SMP, 1993 & 1994
Victoria;	Portland, 1987& 1988, 1994 Beachport, 1987 &1988 WBS trawl surveys, 1987-89 Lakes Entrance, 1991 SMP, 1994
Tasmania	Port samples 1981-86 Long-line samples west Tas 1993 SMP 1993,1994

Ageing data

Otoliths were available from:

VFRI, 1987-1989 (western Bass Strait)
MRDTas, 1982-86 (Tasmania)
Central Ageing Facility, 1994, 1995 (NSW, Victoria)

The Central Ageing Facility provided ling age-length keys by sex for these periods and areas.

Data quality

Estimates of total catch, prior to the introduction of the logbook in 1986, are derived from several sources. Effort statistics are few for this period. Catch and effort data for 1986-94 are derived from the SET logbook. These data are comprehensive for the trawl sector but could be biased by over- or under-reporting. Data for the non-trawl sector are limited.

Length and age data are patchy both in time and by area. There are also few data for the non-trawl sector.

Analytical techniques

Annual and monthly trends in catch rates were examined. Von Bertalanffy growth curves were fitted to the length and age by non-linear least squares regression. Curves were fitted to data for each sex separately and for the sexes combined. Age composition was derived by combining age (as age-length keys - ALKs) and length frequency data. Mortality rates were estimated using catch curve analyses (Ln (abundance) vs age).

Results

Catch and effort

The total catch for ling peaked in 1993 at about 1600 tonnes of which 550 tonnes were from the non-trawl sector (primarily gillnet and long-line) (Appendix A.1). The 1994 SEF trawl catch was 1047, which includes 146 t declared in state waters. The non-trawl sector catch was 353 t.

The greatest trawl catches of ling are taken in Eastern Sectors A and B, with lesser amounts taken off the west coast of Tasmania and in western Bass Strait (Table 1). Catch rate data for the period 1986 to 1994 were relatively stable in all areas (Figure 1). However, there were marked differences in the seasonality of catches between areas (Figure 2). In Eastern Sector A, catch rates were highest during May and June, and again in November. This pattern is repeated to a lesser extent in Eastern Sector B. Off western Tasmania, catch rates are highest in Spring. Catch rates in western Bass Strait were more consistent and because of the low landings from east Tasmania it is difficult to draw any conclusions from this area.

Length frequency distributions

The length frequency distribution for ling caught by FRV 'Kapala' off NSW and north-east Victoria during 1980-82 is shown in Figure 3. Fish ranged in size from 26 to 127 cm TL but most were between 45 and 115 cm. There was a dominant mode at 55 cm followed by a long 'tail'. Sydney Fish Market length frequencies were similar but the proportion of large (> 80 cm) was lower (Figure 4). Recent SMP length frequencies for NSW and eastern Bass Strait are shown in Figure 5. Although samples were relatively small, the proportion of large fish was low in all samples except Ulladulla 1993. There is also considerable variation between samples.

Fish landed at Portland, during 1987 and 1988, ranged in length from 32 to 117 cm TL but most were 50 to 100 cm. There were relatively fewer large fish (> 80cm) in 1988 samples

(Figure 6). Samples from Portland landings could also include fish caught off the west coast of Tasmania. Ling landed at Beachport ranged in length from 46 to 110 cm TL. The distributions were different from ling sampled at Portland being composed predominantly of fish in the middle size classes (55-90 cm). There were relatively fewer small fish (<60cm) and large fish (>80cm). Recent SMP measurements of ling caught in western Bass Strait (Figure 7) were generally similar to Beachport landings.

Ling sampled from trawls off the west coast of Tasmania during 1993 and 1994 ranged in length from 47 to 121 cm TL but the bulk were in the 65-90 cm size classes (Figure 8). There was a greater proportion of large ling compared to the other areas.

Long line caught ling were predominantly large fish, ranging in length from 48 to 132 cm with most from 70 to 110 cm TL (Figure 9).

Some historical samples of ling were measured to standard length rather than total length. The relationship between the two is given by the following:

Standard length = 0.969 total length + 0.109; $R^2 = 0.998$, n=466

Age and growth

Ling were aged by examination of transverse sectioned otoliths (full details are given in Appendix F. Age estimates were unambigous with similar estimates between readers. Inter-reader variability, as measured by Beamish and Fournier's (1987) average percent error was 3.5 % and between readers 3.2%. A small sample was read by Peter Horn after the workshop which confirmed that ageing methods and interpretation by New Zealand workers and CAF were identical (Note: APE = 2.5%). Horn (1993) validated the ageing method by using the progression of modal peaks in length frequencies and by analysing otolith marginal increments.

A new method of ageing fish otoliths which uses precise measurements of the levels of radioactive carbon present in otolith cores (Kalish 1993) was used to independently assess the age of 31 samples previously aged from sectioned otoliths. Close correspondence between the ages assigned by both methods gives confidence that the ages estimated from sections are accurate. The otoliths chosen for this comparison was selected to cover a size range (80 to 117 cm total length) and an age range of seven to twenty eight. Estimates between the radio carbon and transverse sagittal sections agreed closely (John Kalish personal communication).

Over 3,000 ling were aged. The maximum age in samples was 28 years

Females grow faster than males and to a slightly greater age (Figure 10). Parameters of the von Bertalanffy growth curve were:

Area/year	**Sex**	**K**	L_{inf}	t_o	**N**
WBS	Female	0.15	102.0	-2.96	519
87-89	Male	0.13	98.0	-4.06	462

Tas	Female	0.21	100.0	-1.84	147
82-86	Male	0.23	90.0	-2.04	182
Current	Female	0.11	127.3	-1.93	469
94-95	Male	0.14	102.0	-1.97	408

The difference in parameters between samples reflects the relative proportion of older fish. The 1994/95 samples (current) had relatively few larger fish. This biases growth curves toward young fish and gives a higher L_{inf}. Unlike the previous Australian growth study which indicated no significant differences between males and females revised growth curves were consistent with New Zealand studies as is longevity.

Age composition and mortalities

To derive age compositions for Kapala and SFM data, the WBS ALK was applied to the appropriate length frequency. Catches were dominated by 3 to 5 year olds except for ling from the west coast of Tasmania and longline catches which had relatively more old fish. This is considerably different from the New Zealand fishery where ling are not fully recruited to the fishery until 8-12 years depending on the area.

There was a marked decline in the proportion of older fish in recent samples from Eden and Ulladulla (Figure 11).

Mortality estimates are shown if Figure 12. As ling catches prior to 1980 were relatively small, results for the Kapala samples are regarded as being indicative of a lightly fished population. Mortality rates estimated from these data are, therefore, roughly equivalent to natural mortality. Results also indicate natural mortality is higher for ages 3-10 (approx 0.3) than for older fish (approx 0.1). For all ages greater than 2 an estimate of M of 0.17 is derived which is similar to that of New Zealand workers. Mortality estimates for Eden and Ulladulla (1993, 1994) are considerably higher compared to data from the mid to late 1980s.

Uncertainties in assessment

The major uncertainty concerns the increased mortalities seen in fish landed at Eden and Ulladulla. This was inconsistent with catch rates which were stable. Sample sizes from SMP were relatively low and may have been unrepresentative. Also industry reported considerable discarding of small ling but this was not evident in SMP data.

The sensitivity of Kapala and SFM mortality estimates to application of WBS ALKs is unknown.

It is unclear if improved catches were attributable to changes in fish abundance and/or catchability, improved targeting practices, or a combination of same.

Current stock status is still uncertain. Little is known about the size of the resource and the implications of the spatial structuring can not adequately be addressed at this time.

6. IMPLICATIONS FOR MANAGEMENT

CPUE data for the period 1986-1994 have been relatively stable suggesting that ling abundance has not significantly altered over this period. However, catches have increased markedly in recent years. The 1994 catch from all sectors is approximately 1400 tonnes and the 1995 catch is expected to be higher. These catches are significantly greater than historic levels.

Current stock status is uncertain. Little is known about the size of the resource and the implications of the spatial structuring can not adequately be addressed at this time. The impact of increased catches is unknown and requires a more rigorous assessment than is possible through evaluation of CPUE data alone.

There was a marked increase in non-trawl catches during 1992-93 but recorded catches in 1994 did not increase further. Catches are not limited by a TAC. Catch and effort data from the non-trawl sector are poor and this hampers the assessment. The proposed non-trawl logbook should resolve this.

Considerable progress was made at the ling workshop. Results indicated that recent mortality rates in the eastern sector of the fishery were high. However, these were not consistent with catch rate data and were considered most likely due to unrepresentative sampling. Comprehensive age and size information if collected during 1995/96 will clarify this. In addition, the proposed 1995/96 age/length data together with the results of the workshop will enable the estimation of current and virgin biomass.

7. RESEARCH NEEDS

Ling has been accorded a high research priority by the SETMAC Research Sub-committee. The highest priorities are:

- to obtain a representative age-length key for 1995/96
- re-analysis of 'Kapala' data (including ageing) and Sydney Fish Market length data;
- undertake a more rigorous analysis of SET logbook data to include spatial patterns, and species composition and interactions.

These data, together with results from the 1995 Ling Workshop will form the basis for a catch-at-age analysis providing estimates of virgin and current biomass.

Other research needs include:

- A project on the biology of ling and factors that influence their behaviour which are poorly understood and limit interpretation of trends in catch rates and size composition.

- Evaluation of harvest strategies for species such as ling which are often caught as a component of a suite of species and/or a major by-catch of other species; and are a multi-sector species.

- Stock structure is unknown and this may prove to be important if assessments are shown to be sensitive to assumptions about stock structure.

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APPENDIX C

TABLES

Table 1. Ling catch (tonnes) by zone and year - SET Logbook

Year	East A	East B	East Tas	West Tas	West	Total
1986	366	184	2	51	63	679
1987	319	212	3	154	55	765
1988	241	207	5	53	42	567
1989	231	233	9	138	45	672
1990	197	269	11	99	48	669
1991	187	222	31	125	99	735
1992	223	195	7	47	66	567
1993	300	267	21	118	114	883
1994	379	210	31	133	113	895

APPENDIX D

FIGURES

Appendix A.1: Recorded Commercial Catch History within the SEF Area (tonnes) - Ling

Year	Commonwealth Records							State Records				Estimated total catch within SEF area[3]	Estimated discarded catch[1]
	TAC		Retained Catch					Retained Catch					
	Agreed	Allocated	SEF2 Commonwealth	SEF 2 State Waters	SEF 1	Other	Total[4]	NSW	Vic	Tas	S.A.		
1976								100				100	
1977								150				150	
1978								200				200	
1979								200				200	
1980								300				300	
1981								400				400	
1982								350				350	
1983			SEF not Established					450				450	
1984						762	762					762	
1985						680	680			30		710	
1986					679	677	677		14	36		727	
1987					765	838	838		16	7		861	
1988					567	717	717		15	10		742	
1989					672	760	760		20	12		792	
1990					668		668		16	13		697	
1991					735		735		25	15		775	
1992	700	780	622	33	567		655		110	103		868	
1993	800	809	917	119	883		1036		290	268		1594	
1994	1000	995	925	122	895		1047		101	252		1400	

Commonwealth records:
- 1984 - 1989 verified catch history
- 1990 - 1991 SEF Logbook
- 1992 - 1994 AFMA quota monitoring unit

State records:
- 1984-93 Tasmanian landings
- 1986-91 Victorian inshore

1. Estimated from the SMP
2. State location
3. Estimated by totaling Commonwealth and State records.
4. Total of shaded cells

Abbreviations:
- N/A = Not Applicable
- ND = No Data Available
- ? = Available data not received

Appendix A.2 Recorded Commercial Catch History outside the SEF area (tonnes) - Ling

Year	Outside SEF Area: GAB	S.A.	NSW - North of Barrenjoey	Other[2]	Estimated total catch[3]	Estimated discarded catch[1]
1976						
1977						
1978						
1979						
1980						
1981						
1982						
1983						
1984						
1985						
1986						
1987			11		11	
1988	16		10		26	
1989	8		12		20	
1990	8		9		17	
1991	2		4		6	
1992	<1		1		1	
1993	<1		1		1	
1994	1		1		2	

Outside SEF Data:
1988-91 NSW north of Barranjoey
1988-93 GAB

1. Estimated from the SMP
2. State location
3 Tasmanian longline.

Abbreviations:
N/A = Not Applicable
ND = No Data Available
? = Available data not received

Appendix A.3 Combined catch history - Ling

Year	Commercial: Within SEF Area – Retained	Commercial: Within SEF Area – Discarded[1]	Commercial: Outside SEF Area – Retained	Commercial: Outside SEF Area – Discarded[1]	Other relevant overlappiong fishery – Retained	Other relevant overlappiong fishery – Discarded[1]	Estimated total catch[2] – Retained	Estimated total catch[2] – Discarded[1]	Recreational[3]
1976	100						100		
1977	150						150		
1978	200						200		
1979	200						200		Rarely caught by
1980	300						300		recreational
1981	400						400		anglers
1982	350						350		
1983	450						450		
1984	762						790		
1985	710						700		
1986	727						720		
1987	861		11				870		
1988	742		26				770		
1989	792		20				810		
1990	697		17				710		
1991	775		6				780		
1992	868		1				870		
1993	1594		1				1590		
1994	1400		2				1400		

Abbreviations:
N/A = Not Applicable
ND = No Data Available
? = Available data not received

1. Estimated from the SMP
2. DPFRG estimates until 1994
3. S = Significant, M = Moderate, N = None

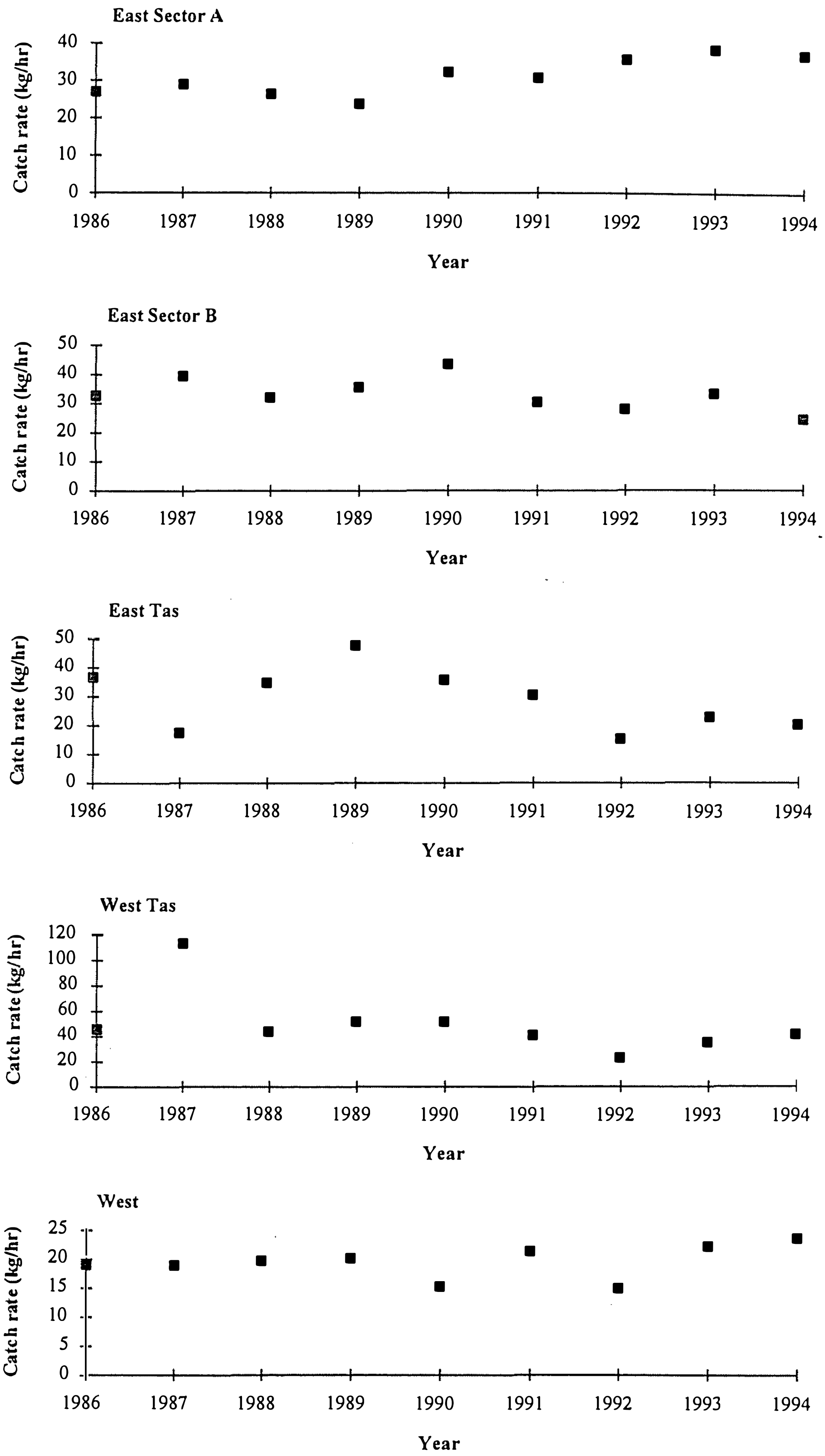


Figure 1. Annual catch rate (kg/hr) by area. Source: SET Logbook.

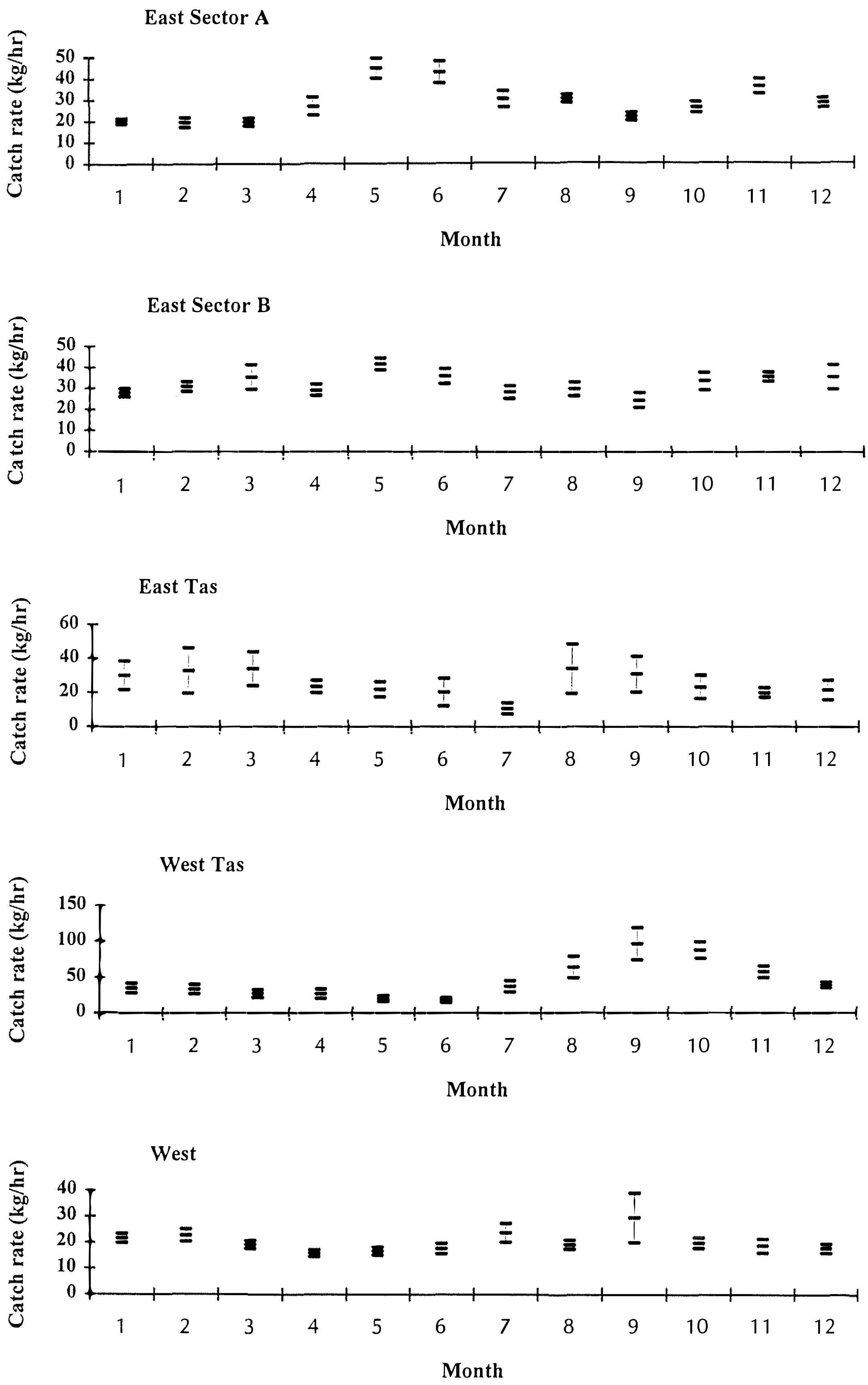


Figure 2 Mean monthly cath rate (+/- 1 SE) by area. Source SET logbook

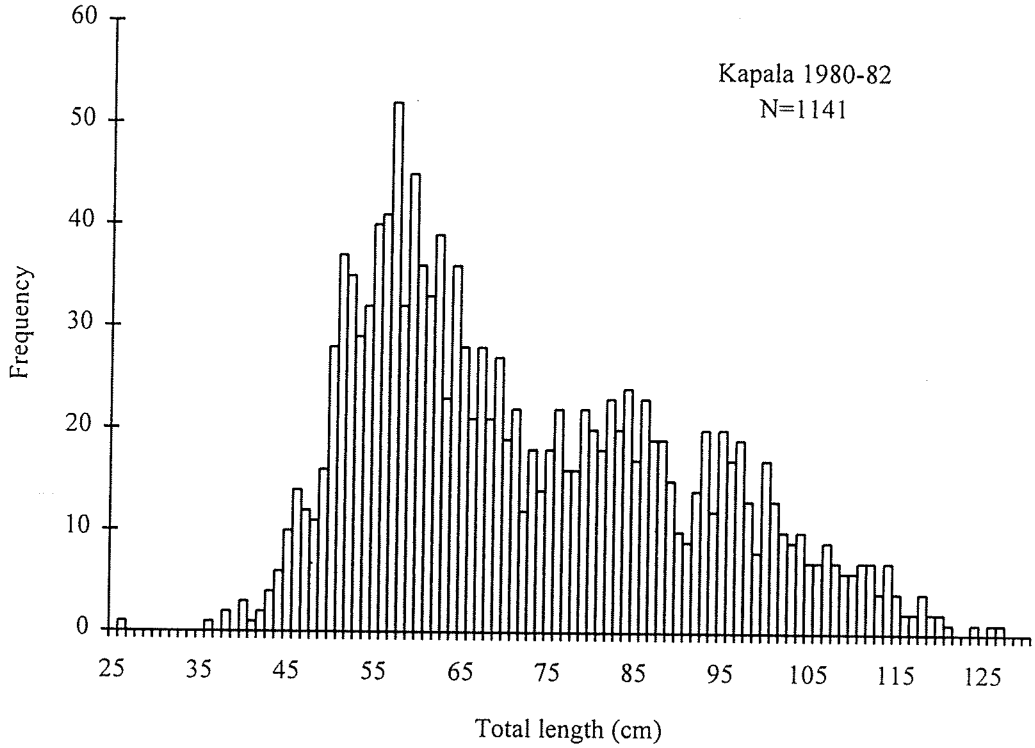


Figure 3. Length frequency distribution for ling, FRV 'Kapala' 1980-82.

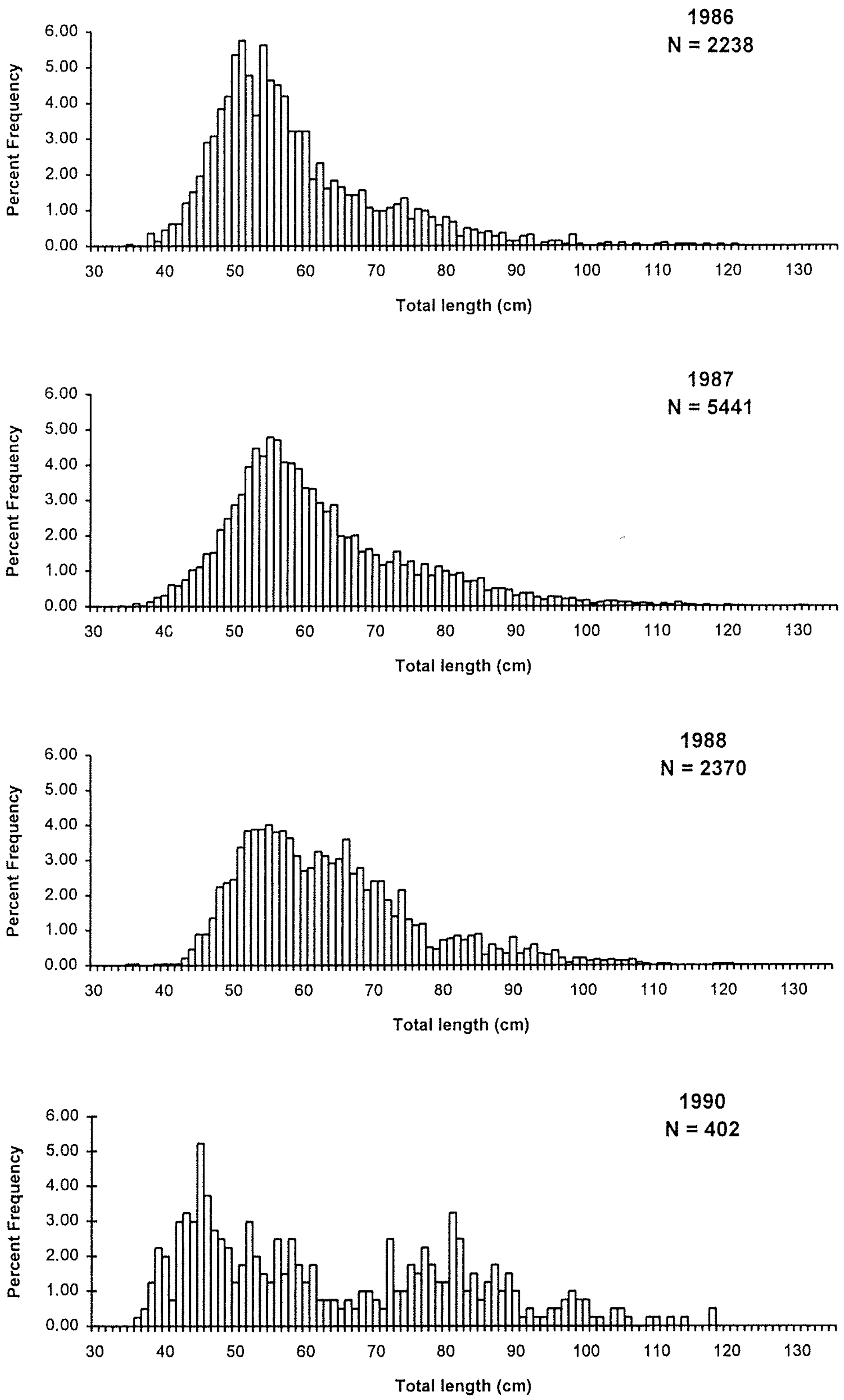
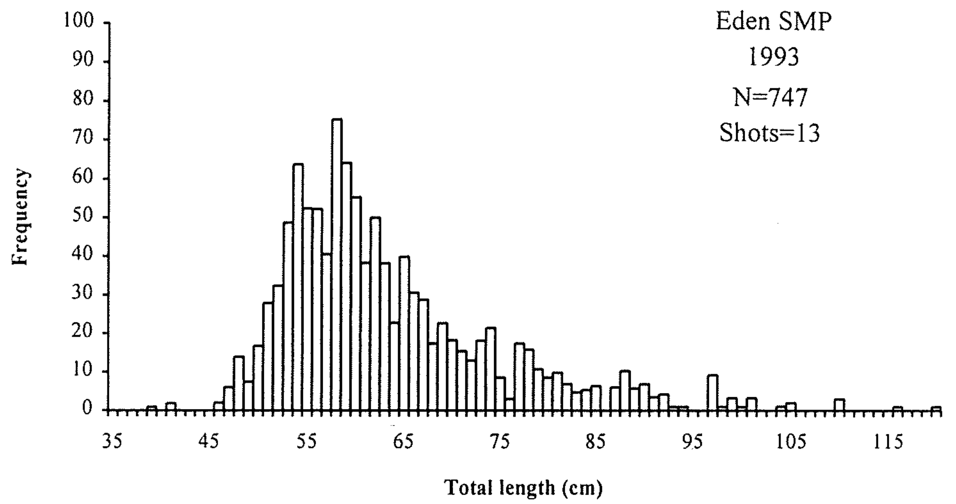


Figure 4 Length frequency distributions for pink ling, measured at the Sydney Fish Market. Separate samples were combined but not weighted.



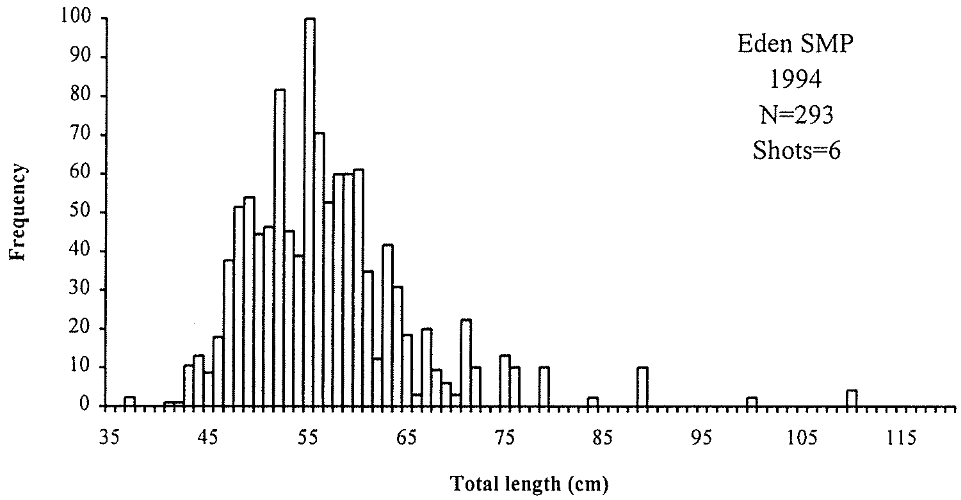
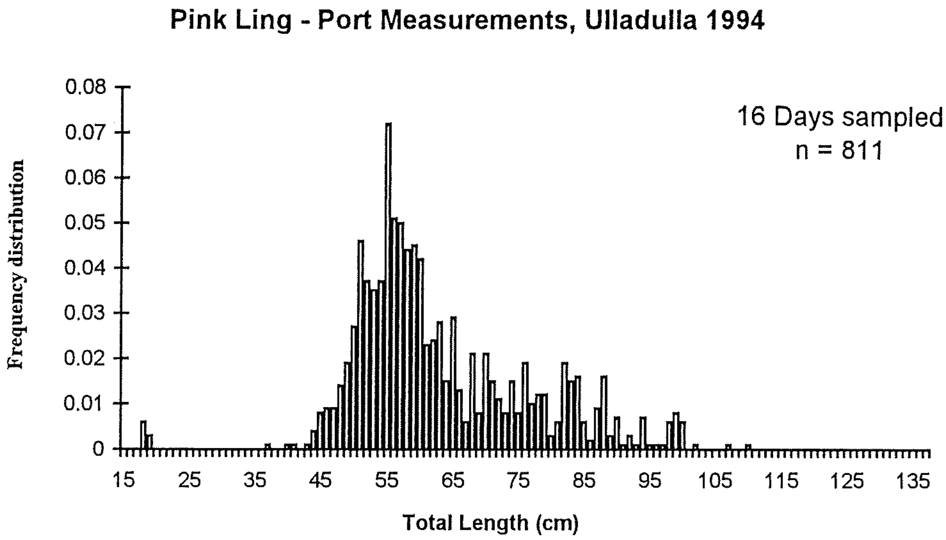
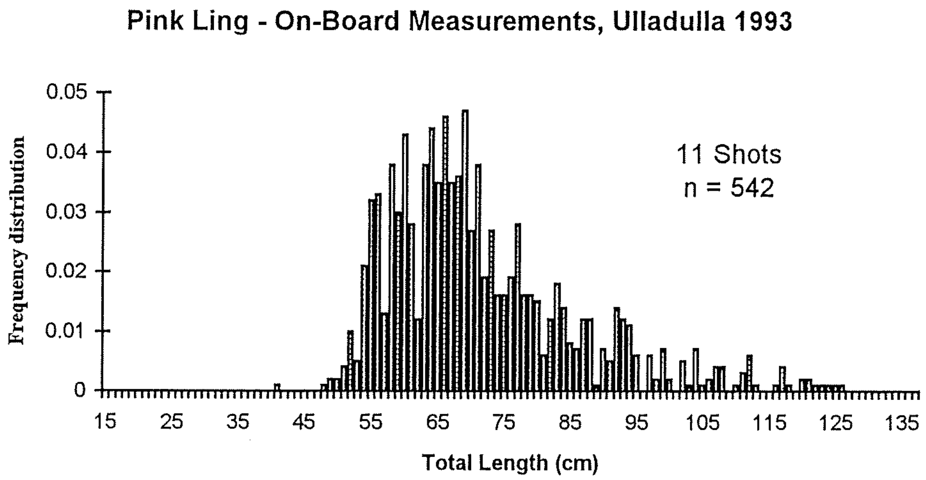


Figure 5. Length frequency distributions for trawl caught ling. , 1993-1994.





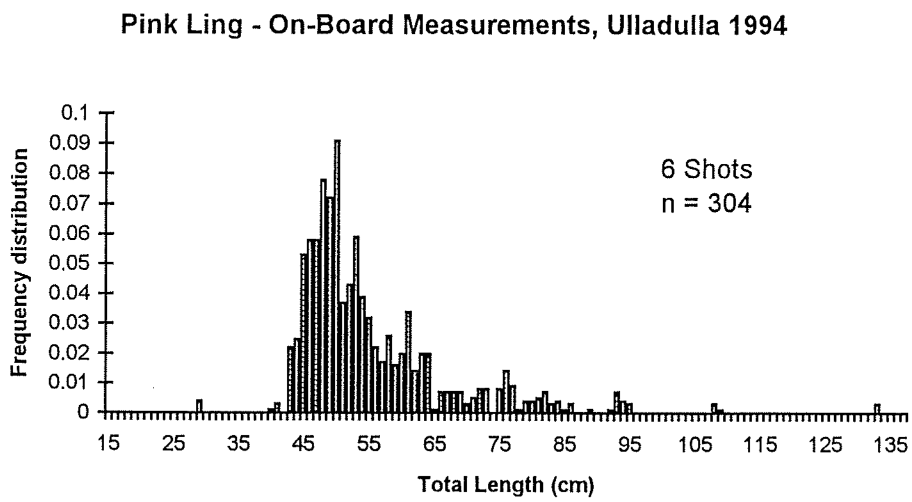


Figure 5 Continued

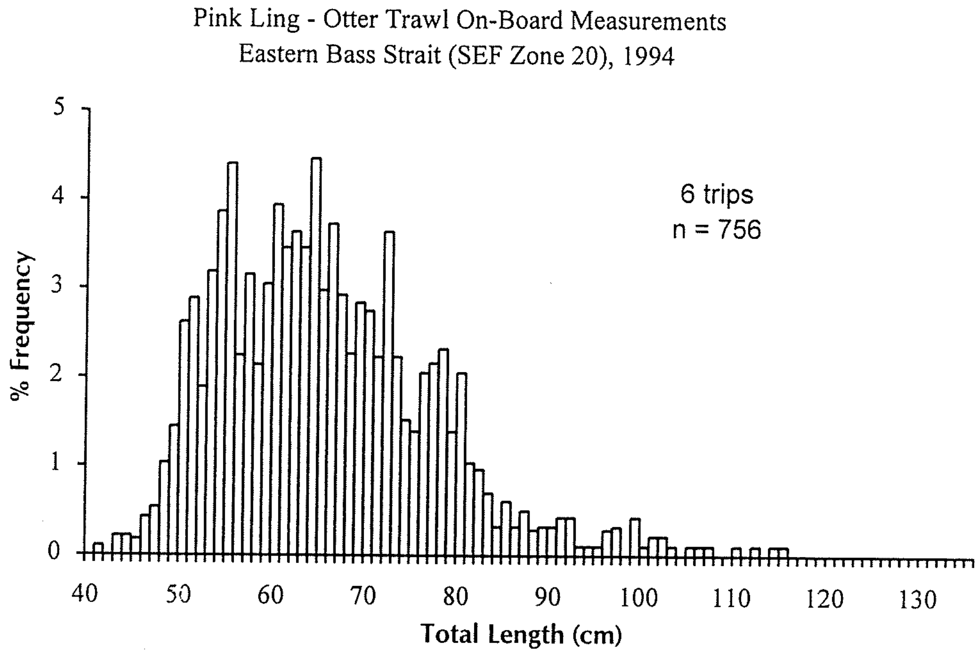


Figure 5 Continued

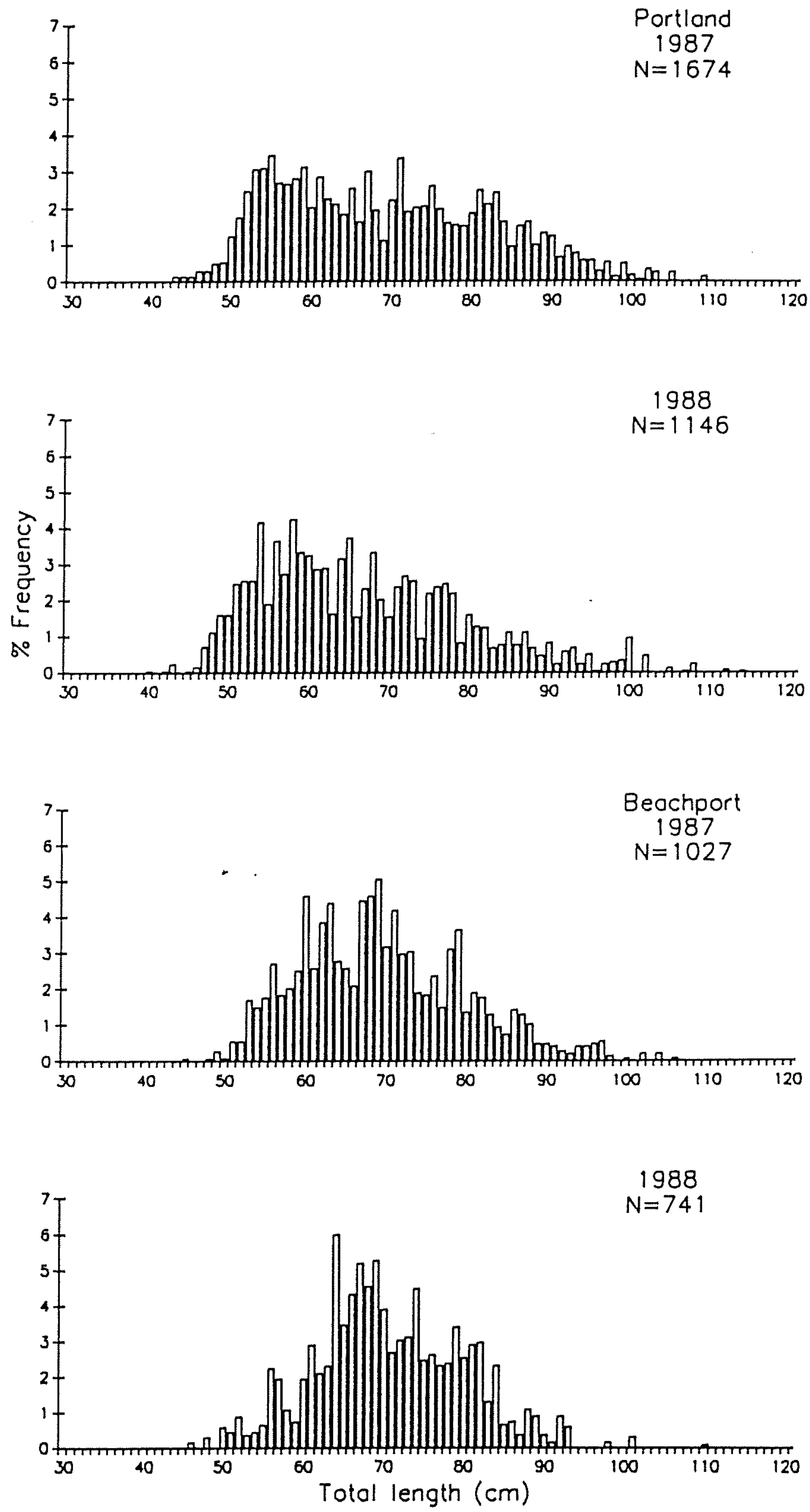


Figure 6 Percentage length frequency distribution for ling landed at Portland and Beachport 1987, 1988

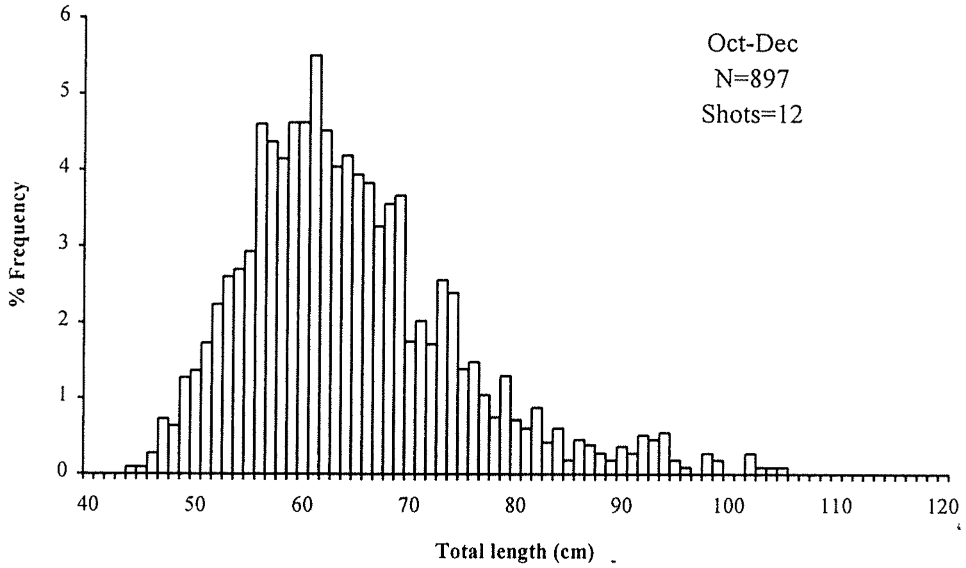
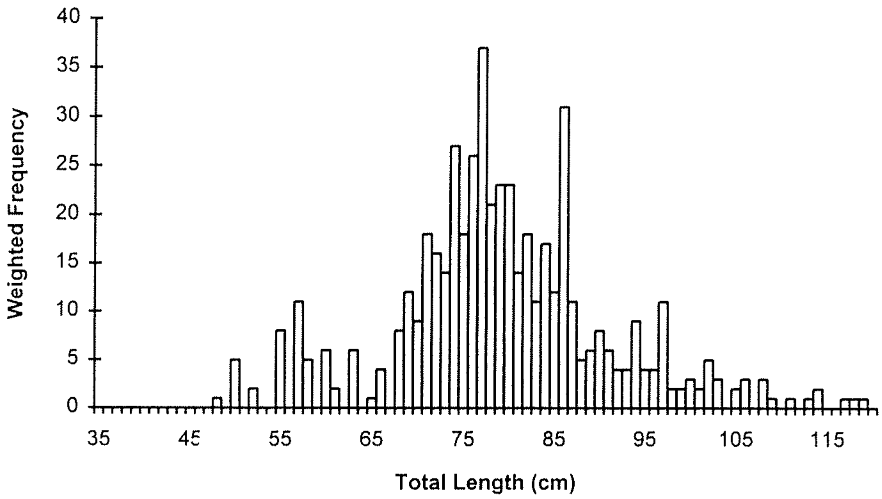


Figure 7 Percentage length frequency distribution for ling taken by trawl, WBS 1994

Tas West Coast - SMP Trawl 1993



Tas West Coast - SMP Trawl 1994

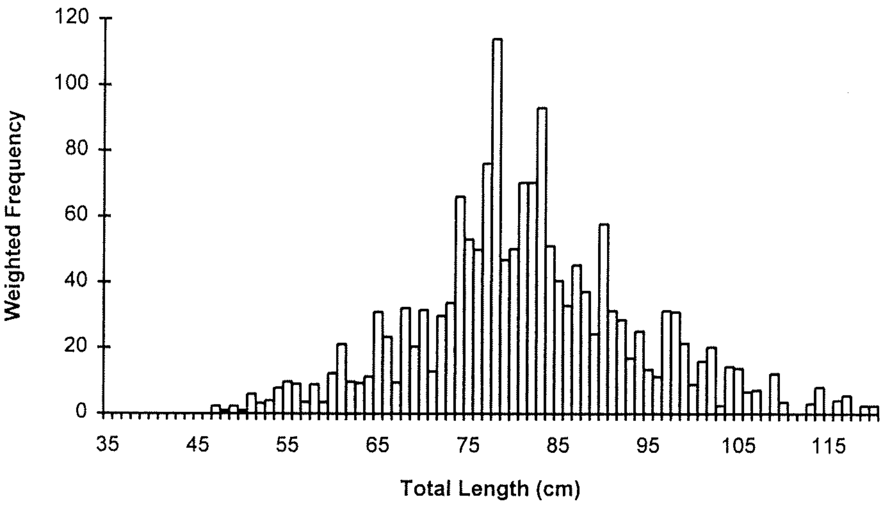


Figure 8 Length frequency distributions for ling, west coast Tasmania 1993-94

Tasmania West Coast, December 1993

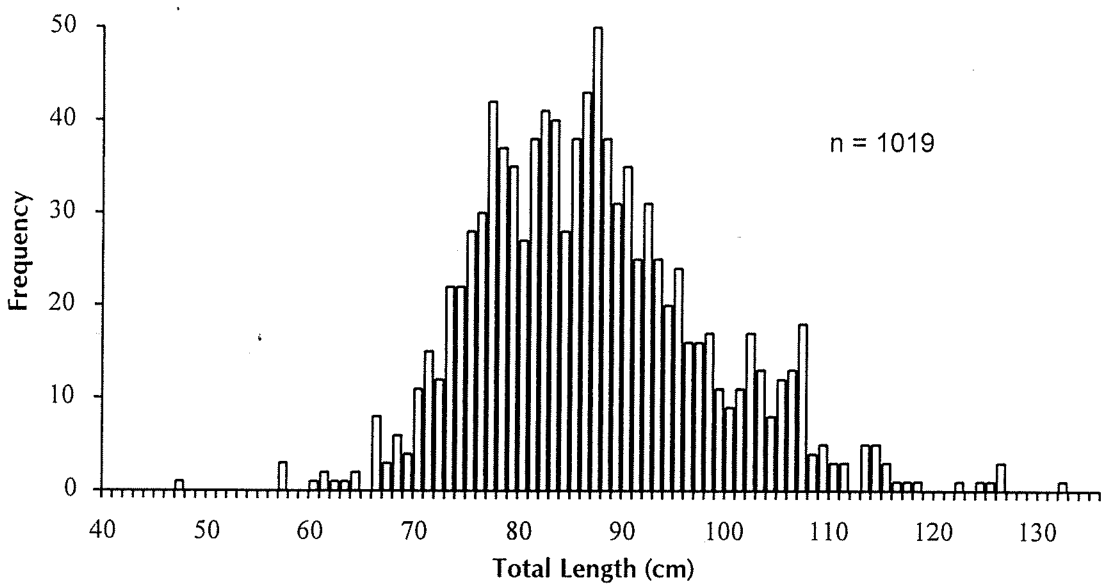
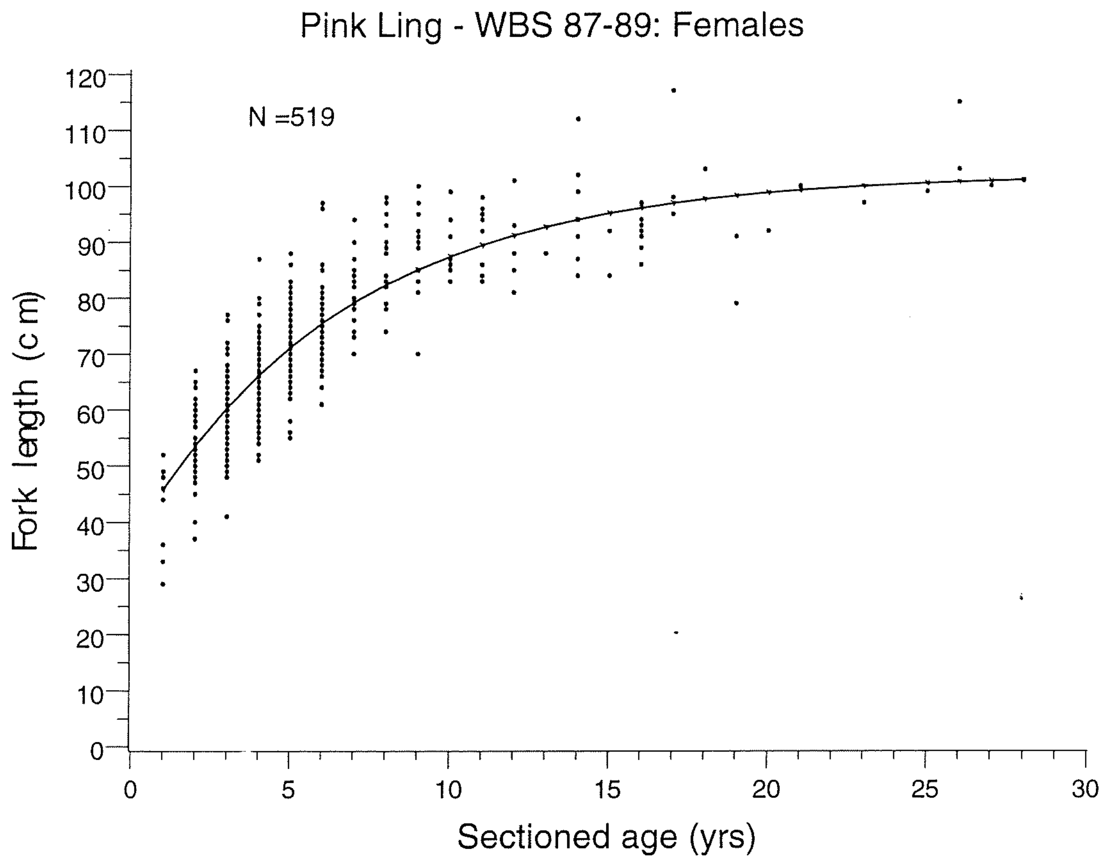


Figure 9 Length frequency distribution for ling taken by long line, west Tasmania December 1993.



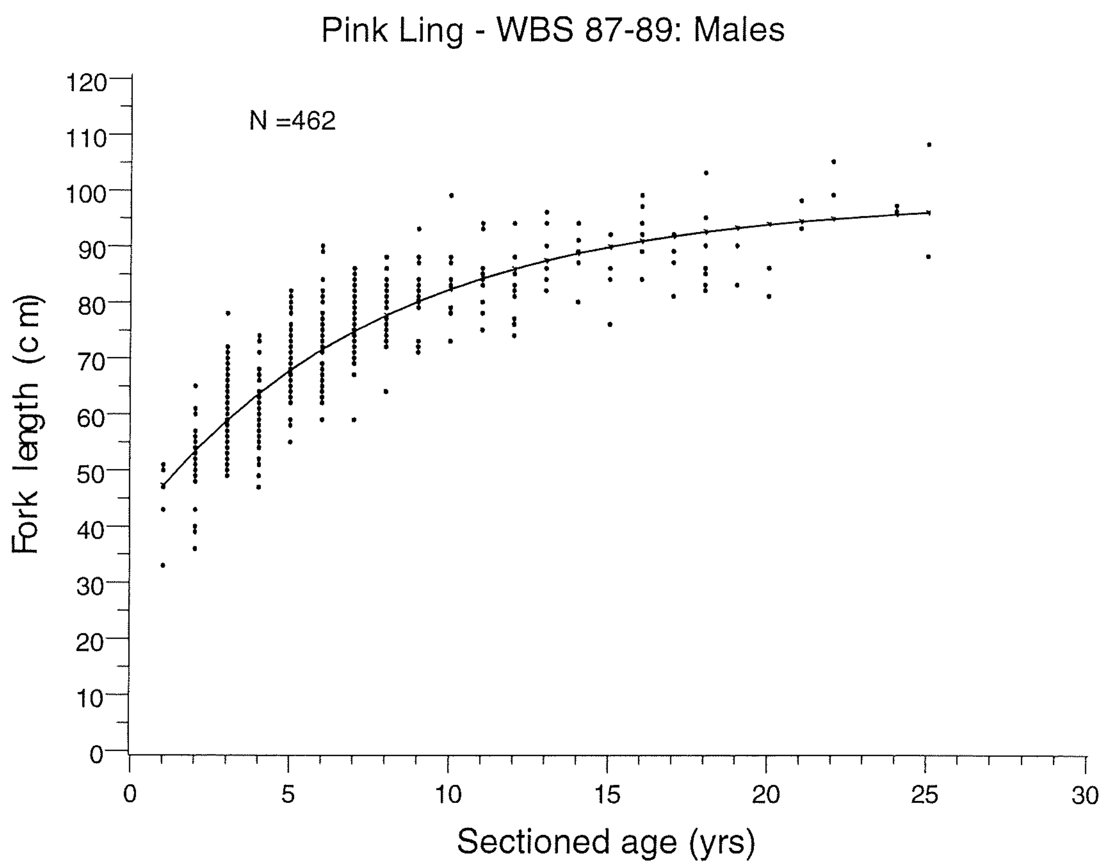


Figure 10. Von Bertalanffy growth curves for ling, Western Bass Strait., 1987-89.

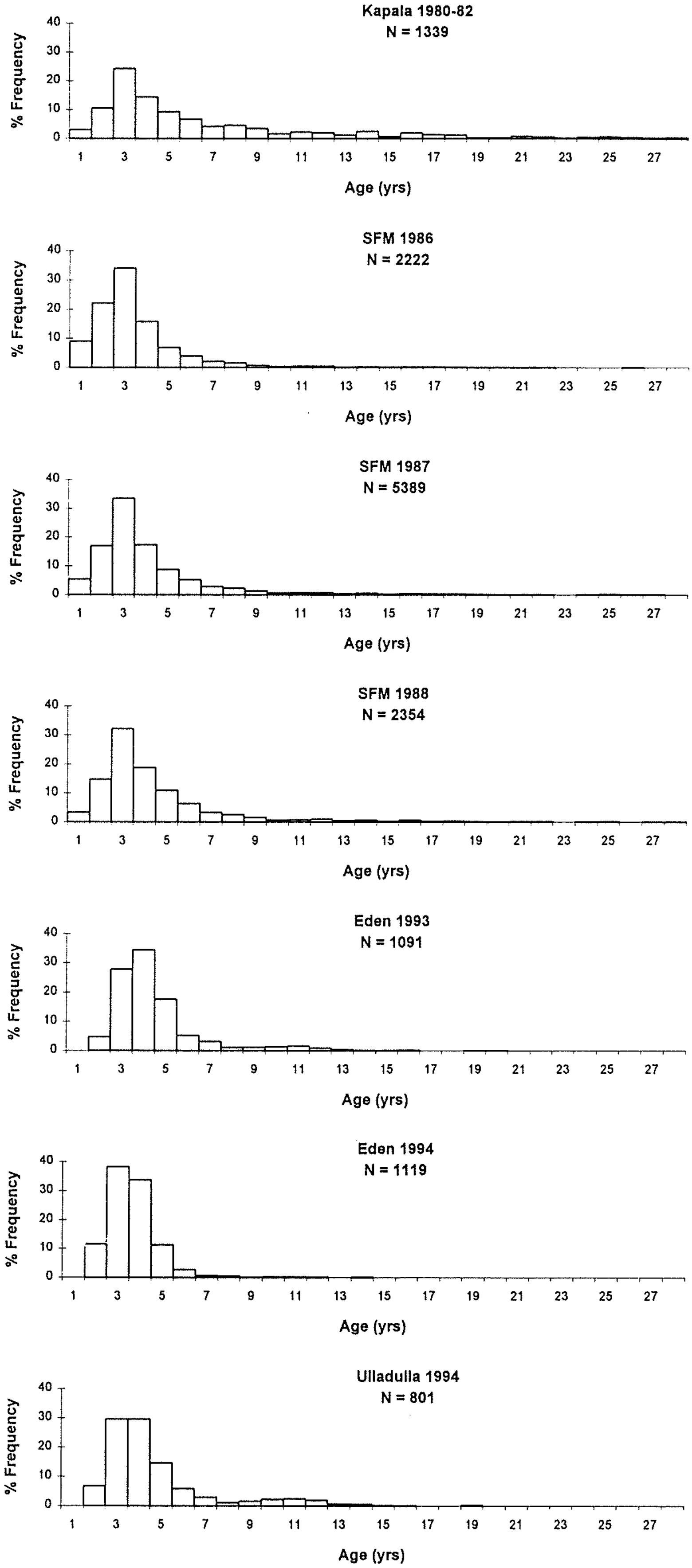
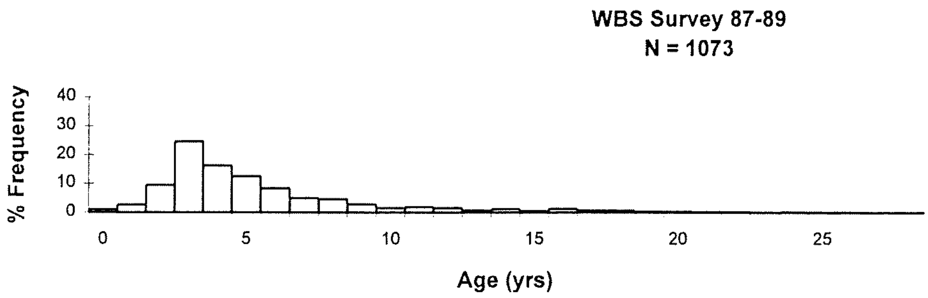
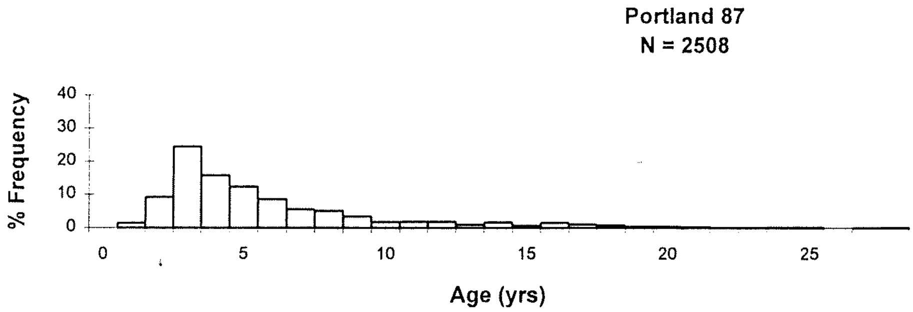
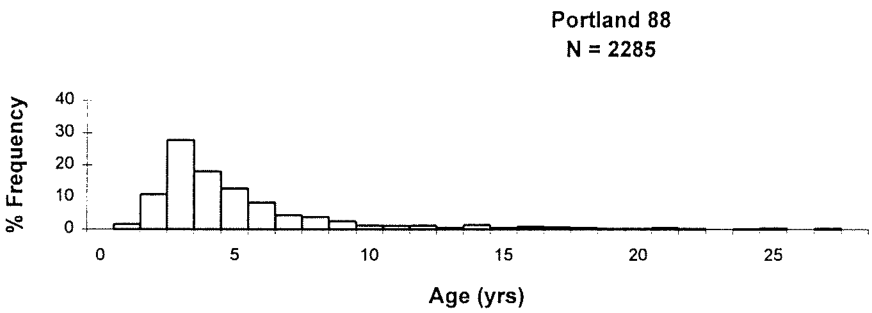


Figure 11 Percentage age composition for ling, Kapala 1980-82, SFM 1986-88, Eden 1993-94 and Ulladulla 1994.







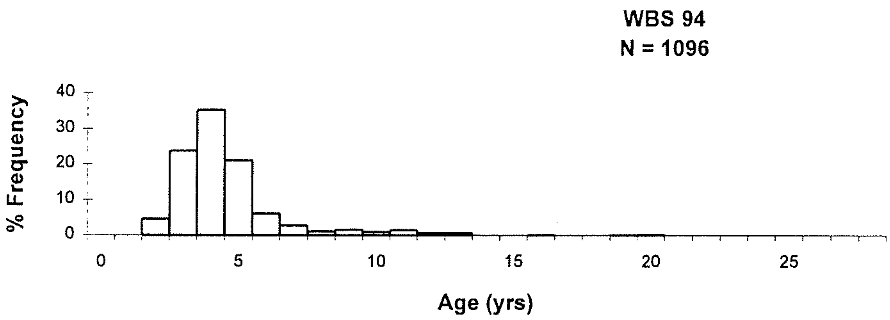


Figure 11 Continued Western Bass Strait 1987-89, Portland 1987-88 and WBS 1994

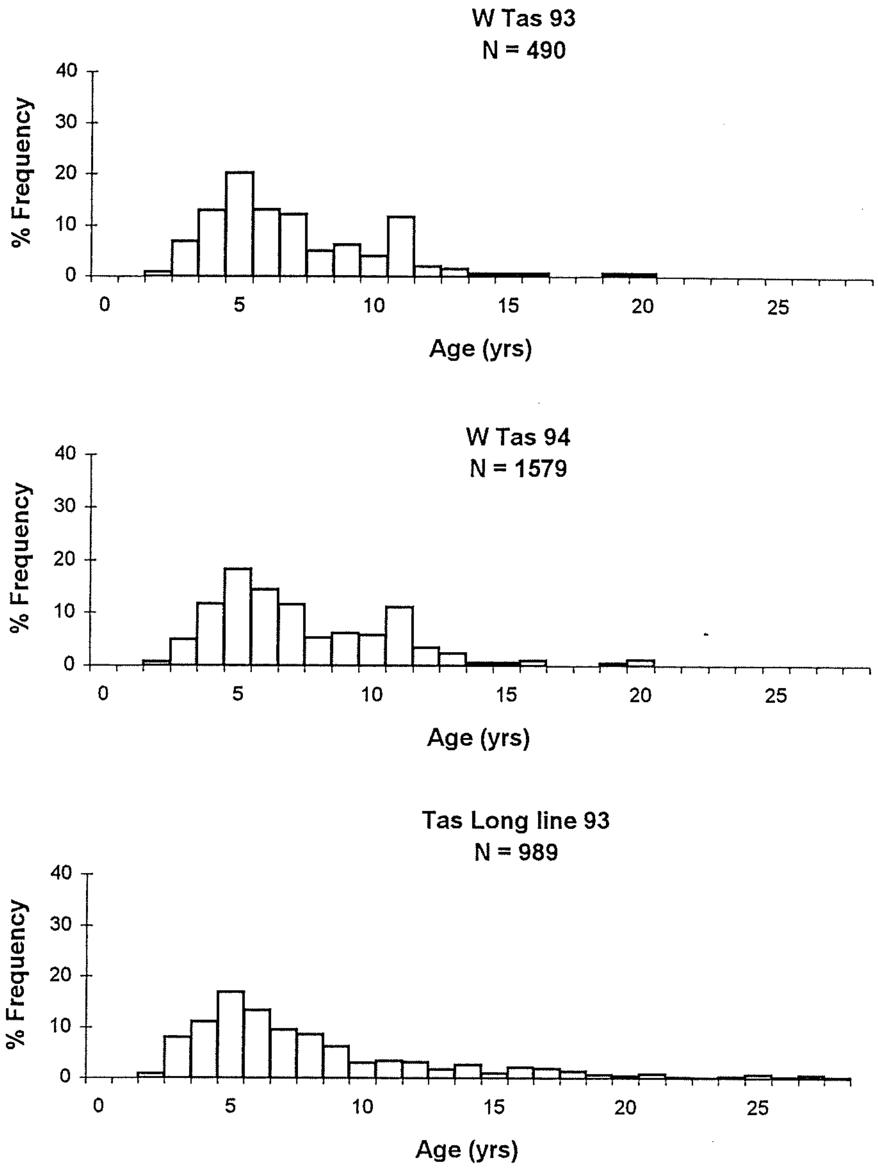


Figure 11 Continued. West Tasmania 1993-94 and Tasmania long line 1993.

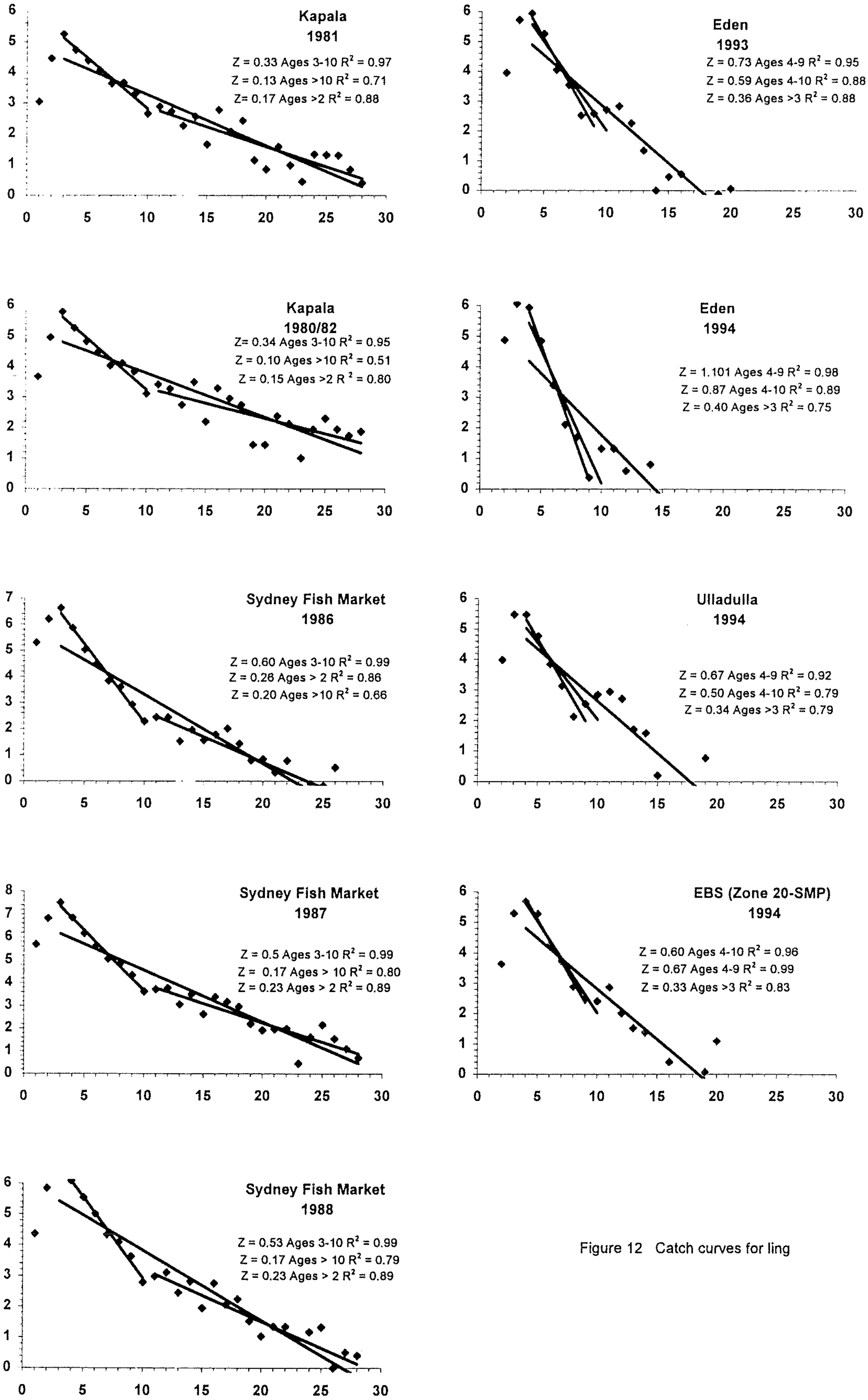
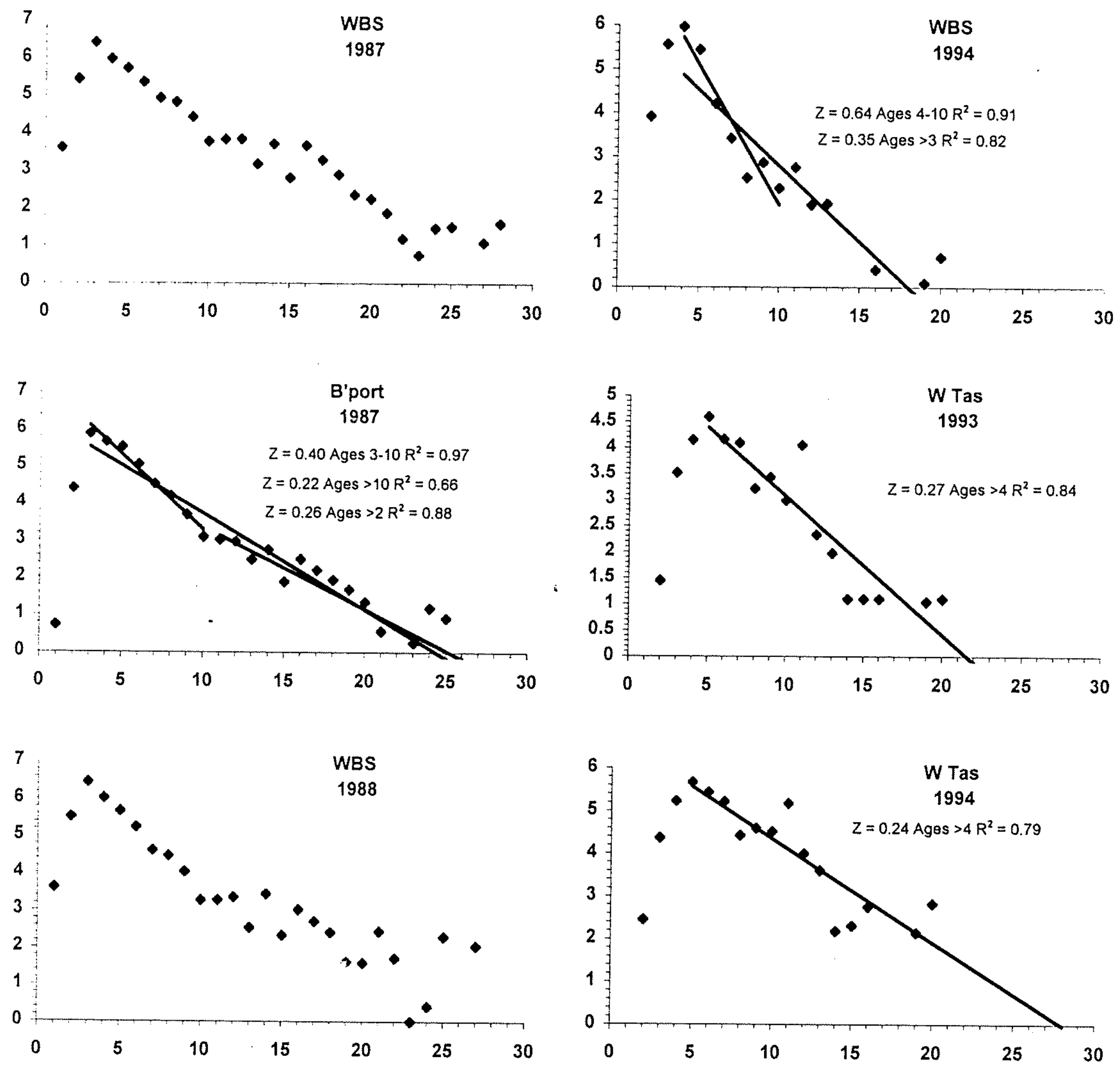


Figure 12 Catch curves for ling



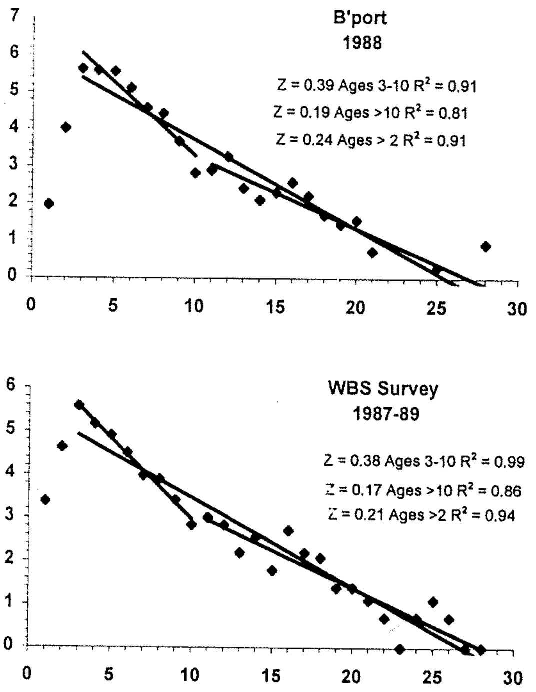


Figure 12 Continued Catch curves for ling

APPENDIX E

The Fishery and Stock Assessment for Ling in New Zealand

Peter Horn

The Fishery

Ling are widely distributed throughout all the New Zealand EEZ, and are particularly common south of latitude 40°S. The main fishery areas are in depths of 200-800m on the Chatham Rise, Southern Plateau, Bounty Platform, and the west coast of the South Island (Figure 1). Ling is currently ranked in the top five finfish in terms of annual landings (15-20,000 tonnes) and value (NZ $35-40 million). Ling are managed in eight stock areas, each with a TAC, although most landings are from areas 3-7 (Figure 1).

Prior to 1975 the fishery was small with annual landings probably being less than 2000t (caught mainly by foreign trawlers). From 1975-1980 a substantial longline fishery was conducted primarily on the Chatham Rise; annual landings from this fishery peaked at 29,000t. A target trawl fishery on the Chatham Rise and some areas of the Southern Plateau also developed during this time, and continued to produce most of the ling landings throughout the 1980s. Ling also became a major by-catch of the hoki (blue grenadier) fishery which developed in the mid 1980s. Major developments in the 1990s have been the introduction of large auto-longliners fishing mainly on the Chatham Rise, Bounty Platform and Southern Plateau, and some expansion of the target trawl fishery particularly in stock area 6. A summary of annual landings is given in Table 1.

Biology

Ling are common around the South Island in depths of 100-900m but are most abundant in 200-600m. They occur over rough and smooth sea bed, and are generally demersal but sometimes feed in midwater. Trawl surveys have provided evidence of seasonal migration (possibly related to the movement of ling to rough, untrawlable areas for spawning in spring and summer). A relatively long spawning season is indicated by gonad stage data, and supported by a wide variation in the size of the first otolith ring. Recruitment appears to be relatively constant between years. Many fish are taken by the trawl fishery at about age 5-7 years, but recruitment is not complete until about age 8 on the Southern Plateau and age 10-12 on the Chatham Rise and west coast South Island. Sexual maturity occurs at about age 8 in all areas.

An examination of length-frequencies, sex ratios, otolith and cranial morphology, and growth rates indicates that there are at least four ling stocks in New Zealand waters, ie Chatham Rise, Bounty Platform, Southern Plateau, west coast South Island. At least 12 spawning areas have been identified ranging between latitudes 37° and 53°S. Growth rates are significantly different between all four areas, and females grow significantly faster than males in all areas.

Estimates of instantaneous mortalities (M, Z and F) were derived as follows:

i Using $M=\log_e 100/A_{max}$ (where A_{max} is the age reached by 1% of fish in a virgin polulation), M was considered to be in the range 0.15 to 0.20.

ii The slope of the relationship between age and log (frequency)was taken as an estimate of Z. From 5 samples, Z ranged from 0.18 to 0.23.

iii Using F=Z-M, F probably ranges from 0 to 0.08 on the various grounds.

Stock Assessment

No estimates of absolute biomass are available for any stock. Estimates of virgin biomass (B_0) and current biomas (B_c) were obtained in 1992 using backward projections of stock reduction analyses. Parameters used in the analyses are shown in Table 2.

i Chatham Rise (Areas 3 and 4)

Mean F for this stock is likely to be at the high end of the range as the Chatham Rise has been consistently fished since 1974, and heavily fished in the 1970s. To obtain a mean F of 0.06 since 1975 required a B_0 of 45,000t (area 3) and 70,000 t (area 4), and indicated values of B_c to be 30,000 (area 3) and 55,000t (area 4).

ii Southern Plateau (Areas 5 and 6)

From trawl surveys we know that the biomass on the Southern Plateau is double that on the Chatham Rise, and that it is split between areas 5 and 6 in the ratio 15:85. To obtain a B_c double that on the Chatham Rise (ie 170,000t) split 15:85 between areas 5 and 6, required a B_0 of 45,000 (area 5, mean F=0.07) and 160,000t (area 6, mean F<0.01). The indicated values of mean F are consistent with known patterns of exploitation. Area 5 is relatively small and has been consistently fished since the mid 1970s, producing a mean annual catch of 2400t. Area 6 is very large, but has produced a mean annual catch of only 1300t since the mid 1970s.

iii West coast South Island (Area 7)

This area has probably been less exploited than areas 3, 4, and 5, but has still been consistently fished. A mean F of 0.03 was assumed, and required a B_0 of 75,000t.

It must be stressed that these estimates of B_0 are highly uncertain, based as they are on uncertain values of F and M, and trawl biomass indices. Small changes in parameters have large effects on biomas estimates. However, it is considered that the values calculated above are probably conservative. Estimates of F in 1992 were all <0.1, except in area 5 where F=0.13.

Maximum constant yields (MCY) were estimated using

$$MCY=0.25\ F_{0.1}\ B_0$$

($F_{0.1}$ is a level of fishing mortality widely believed to produce a high level of sustainable yield. It is estimated from a yield per recruit analysis, as the level of F where the slope of the YPR curve is 0.1 times the slope at F=0.)

$F_{0.1}$ was estimated independently for each stock (because of different growth parameters), was found to be relatively insensitive to variations in M, and was greater than current F in all stock areas. Calculated MCYs were comparable to the current TACs in all stock areas, so it is likely that all stocks are still in the fishing down phase.

Future Directions

Routine annual collections of length-frequency data and otoliths are being made from the four main fishing grounds. This will enable future age-based studies.

An adaptive management scheme (where TACs are increased, and the fishing industry pays for increased monitoring or research to gauge the effects of the increase) has been introduced for ling in areas 3 and 4 (Chatham Rise). TACs were increased by 30% from the current fishing year. It is calculated that this level of increase should allow a decline in biomass to be detected within 5 years using trawl surveys producing biomass indices with a CV of 10%. (Past surveys of this area have had CVs in the range 6-10%).

Analyses of catch effort data are planned. Longline data are available for 3-4 years, which is probably not yet long enough to show useful trends. The trawl data series is much longer (since 1982) and several areas have been consistently fished. These data will be analysed by area when they have been cleaned.

Table 1. Approximate landings of ling (tonnes) from all stock areas combined, from 1975 to 1994.

Year	**Domestic**	**Foreign Licensed**		**Grand Total**
		Trawl	**Longline**	
1975	500	2 200	9 300	12 000
1976	400	6 400	19 400	26 200
1977	500	5 900	28 600	35 000
1978	700	3 800	8 900	13 400
1979	3 500	4 300	3 500	11 300
1980	3 500	3 500	-	7 000
1981	4 000	2 400	-	6 400
1982	4 600	1 300	-	5 900
1983	4 200	1 100	-	5 300
1984	5 200	2 500	-	7 700
1985	4 800	2 100	-	5 900
1986	5 100	2 100	-	7 200
1987	5 600	1 300	-	6 900
1988	7 200	700	-	7 900
1989	8 400	-	-	8 400

1990	9 000	-	-	9 000
1991	13 500	-	-	13 500
1992	17 800	-	-	17 800
1993	19 100	-	-	19 100
1994	16 000	-	-	16 000

Figure 1. The four main fishing grounds for ling, and the fishery management areas (numbered 3-7) from which most of the New Zealand ling catch is taken.

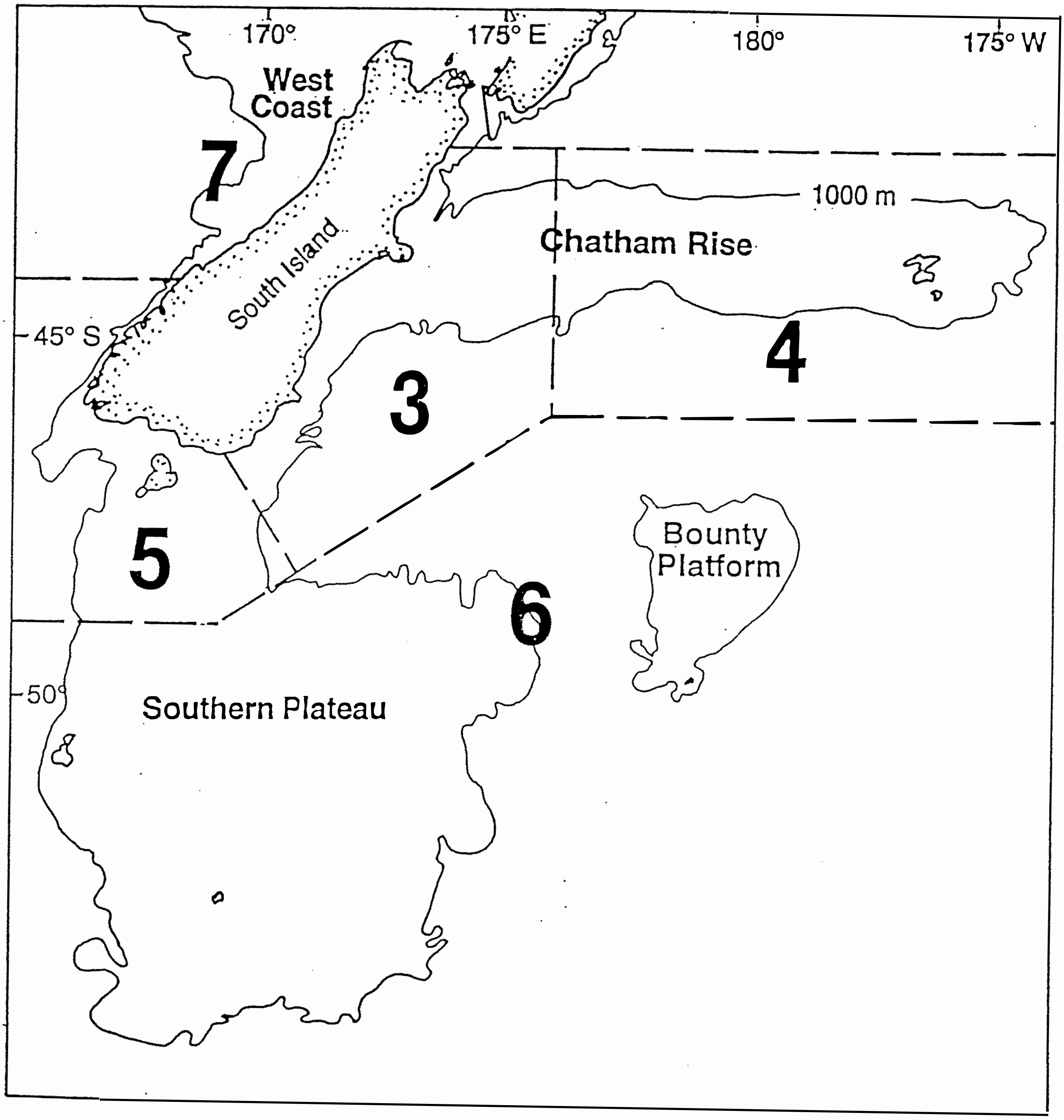
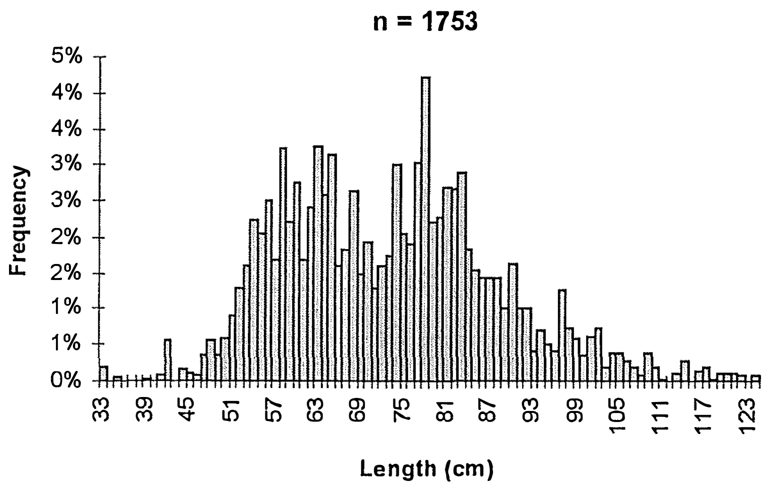


Table 2. Parameters used in stock reduction analyses for ling stocks 3, 4, 5, 6 and 7. a and b are length-weight coefficients, Δ = steepness, A_r = age at recruitment, A_m = age at maturity.

Parameter	LIN 3 & 4	LIN 5 & 6	LIN 7
Male			
L_{inf}	119.0	95.1	146.1
k	0.108	0.194	0.087
t_0	-1.24	0.16	-0.13
Female			
L_{inf}	160.1	125.7	165.9
k	0.076	0.113	0.090
t_0	-1.05	-0.67	0.22
M	0.18	0.18	0.18
a	0.00126	0.00139	0.00126
b	3.29	3.27	3.29
Δ	0.95	0.95	0.95
A_r	8	8	8
A_m	8	8	8



Length frequency of ling for 1993

Appendix F

Ling Age determination - Draft

Otolith description

The otoliths of ling are oviod in shape and exhibit no pronounced rostrum or anti-rostrum. The otolith is concave in the anterior posterior plane and relatively thick in the proximal distal axis. The maximum otolith weight in the ling otolith collection at the CAF, which was sampled from a specimen 124cm total length, is 1.07g while the otolith length, width and depth are 20.21mm, 12.3mm and 3.28mm respectively.
{Photograph x - of otolith under refected light}

Preparation of the Sagittae for Age Estimation

All otoliths were weighed using an electonic balance to 0.001 grams

Sagittae were examined both whole and after preparation of thin sections. Ling otoliths develop in the proximal distal axis early in the life history of the fish (approximately three years). Consequently, when viewed whole from the distal surface using reflected light, the otoliths are predominantly opaque although fine incremental structure can be observed on the margin.. This thickening makes examination of the whole otoliths for age estimation unreliable as incremental counts are commonly under estimated, and necessitates sectioning the otoliths.

Sagittal otoliths were embedded in clear polyester casting resin. The moulds contained two rows of five otoliths per block. Four sections of approximately 0.25 mm thick were cut from each block to insure the primordium of the sagittae was sampled. Sections were cut using a modified gem-cutting saw, blade thickness of 0.15 mm. Sections were then mounted on microscope slides under coverslips with polyester resin as the mountant. The slides were viewed using a stereo dissecting microscope at 6x or 10x magnification. The section containing the primordium was used for age estimation. One reader, who was experienced in interpreting structure in sectioned otoliths, examined all sections and estimated ages. A second reader examined a subsample of the sections to determine the intra reader variability.

When viewed in transverse section under transmitted light, the sectioned otoliths exhibit alternating translucent and opaque zones. This pattern was clearest on either side of the sulcus.

A customized image analysis system was used to process the sections, this involved marking increments, and measure their positions. A frame grabber in a personal computer captured an image from a video camera mounted on the dissecting microscope, and displayed it on the computer monitor. Using the screen cursor, a transect was drawn on the otolith image from the primordium to the edge of the section. The position of the transect was standardised along the ventral side of the sulcus. The positions of the first 10 increments along this transect, and the distance from the primordium to the edge of the section were then marked with the cursor. The image analysis system then recorded the number of increments marked, and the distances from the primordium to each increment and to the edge of the otolith directly to an MS excel speadsheet via dynamic data exchange.

All counts were made without knowledge of fish size, sex, or location or date of capture, to avoid the potential for biasing age estimates or marginal increment measurements. {Photograph 2 - Sectioned otolith with marked zones}

Precision of the age estimates

A subsample of otoliths was read by the secondary reader and the index of average percent error (APE) between the primary and secondary reader was (Beamish and Fournier 1987) calculated. The distributions of the differences between repeat readings were also inspected as another indicator of ageing errors, and of any bias between readings. The APE is calculated as:

$$APE = \frac{100}{N}\sum_{j=1}^{N}\left[\frac{1}{R}\sum_{i=1}^{R}\frac{|X_{ij}-X_j|}{X_j}\right]\%$$

where N is the number of fish aged, R is the number of times fish are aged, X_{ij} is the ith determination for the jth fish, and X_j is the average estimated age of the jth fish.

Inter-reader was variability 3.5 % and the intra-reader variability APE was 3.2% based on 309 samples re aged by the secondary reader.

The second reading was regressed against the first reading and the slope and intercept were not significantly different from one and zero:

	Coefficients	Lower 95% C.I	Upper 95% CI	Standard Error
Slope	**0.991**	**0.97**	**1.01**	**0.008**
Intercept	**0.066**	**-0.07**	**0.2**	**0.069**
R^2	**0.978**			
N	**309**			

The distribution of the primary reader's estimate versus the secondary reader's estimates show a mode of zero and a normal distribution of error indicating no bias in interpretation between readers.

A small sample was read by Peter Horn after the workshop which confirmed that ageing methods and interpretation by New Zealand workers and CAF were identical (Note: APE = 2.5%).

A new method of direct age estimation for fish otoliths using precise measurements of the levels of radioactive carbon present in otolith cores (Kalish 1993) was used to independently assess the age of 31 samples for which the sister otolith had been aged from a sagittal section. Close correspondence between the ages assigned by both methods gives confidence that the ages estimated from sections are accurate. The otoliths chosen for this comparison was selected to cover a size range (80 to 117 cm total length) and an age range of seven to twenty eight. Estimates between the radio carbon and transverse sagittal sections agreed closely (Kalish, 1995. personal communication).

Otolith weight was linearly related to age (Figure 3):

Tasmania 1982-86, ages 6 - 26

	Coefficients	Lower 95% C.I	Upper 95% CI	Standard Error
Slope	0.0271	0.0249	0.0293	0.0011
Intercept	0.175	0.151	0.199	0.012
R^2	0.67			
N	304			

WBS 1987-89, ages 6 - 28

	Coefficients	Lower 95% C.I	Upper 95% CI	Standard Error
Slope	0.0276	0.0260	0.0291	0.0007
Intercept	0.159	0.142	0.177	0.009
R^2	0.78			
N	355			