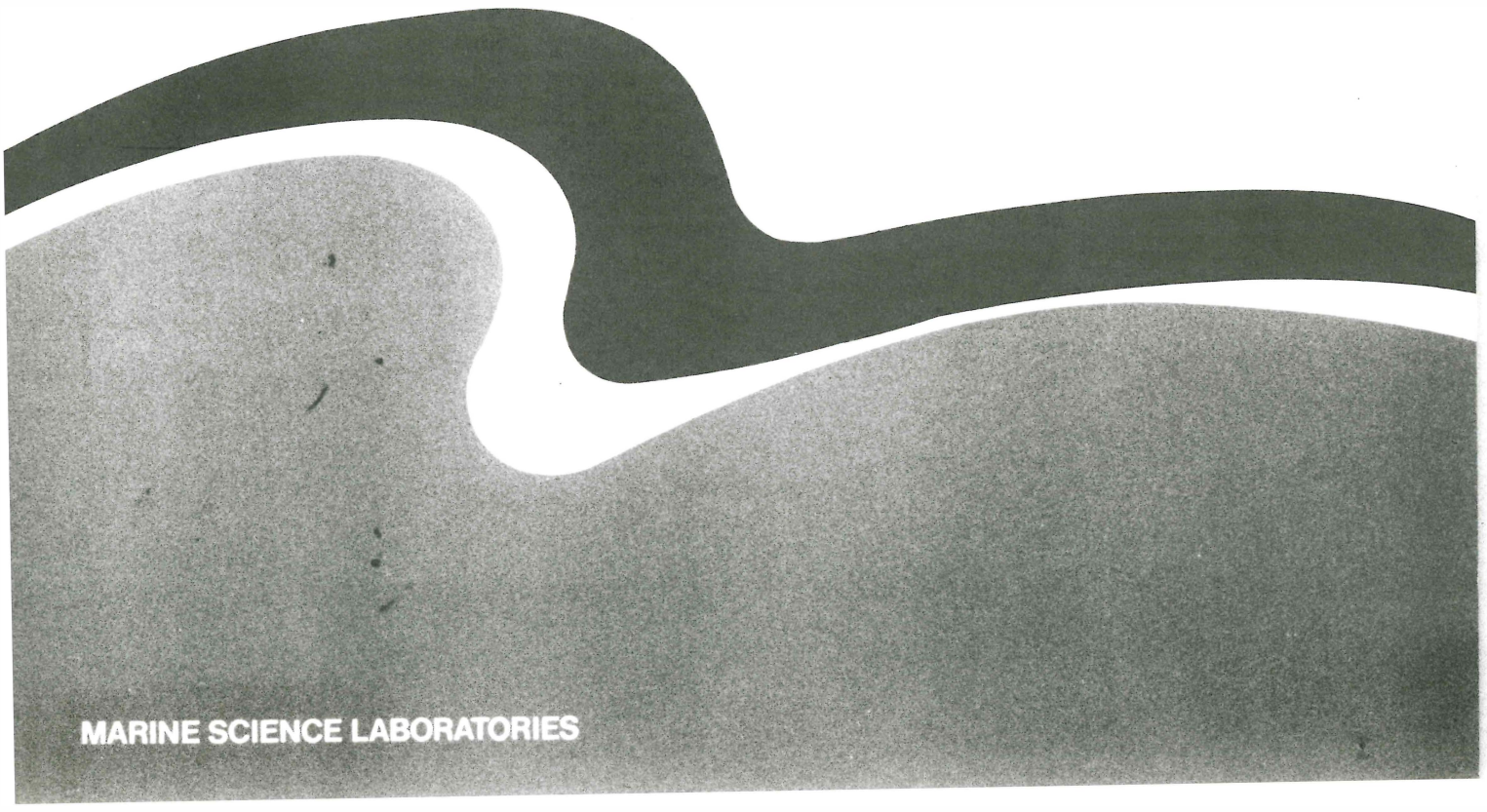
Department of Conservation and Natural Resources
Victorian Fisheries Research Institute

Assessment of the Trawl and Gillnet Fisheries for Warehous

Final Report
to
Fisheries Research & Development Corporation
Project 90/11

David Smith, Paul McCoy and Jason Cottier

November 1994



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Summary

Blue and spotted warehou have rapidly become important species in the South East Fishery, with combined landings in excess of 4,000 t in 1990 and 1991. There remains uncertainty regarding the correct proportion of each species recorded in trawl catches and this is a potential source of error in the assessment of the fishery.

Trawl catches and catch rates of blue warehou, in eastern Bass Strait, have declined since 1990. There was also a concurrent decline in gillnet catches These results indicate that blue warehou abundance is lower and suggest that the fishery is impacting on the population. The rate of this decline is of concern. In western Bass Strait, however, there is no clear trend in catch statistics. Reasons for the difference in areas is unknown.

Catches and catch rates of spotted warehou were variable and there were no apparent trends during the period 1986 to 1993, supporting industry observations of variable availability and/or abundance. The implications of the large increase in the spotted warehou TAC in 1993 are unknown but catches should be closely monitored.

The trawl catch comprises a significant proportion of juveniles. Apart from the impact of this on potential egg production which is unknown, yield-per-recruit analyses show that fishers would gain from taking the fish at a larger size.

Age and length data from commercial catches from both the trawl and non-trawl sectors should be closely monitored to provide the information required for further assessment, particularly age-structured models such as VPAs. A further 2-3 years data would enable this to be carried out. Determining stock structure and size, and validating age estimates should be accorded a high priority. A project to develop tagging methods for both species has recently been funded by FRDC and, if successful, will go some way to meeting these needs.

The objectives of this study have been met. Catch and effort statistics have been described and best estimates of landings of each species provided. The gillnet fishery for blue warehou has been extensively examined for the first time and compared with the trawl sector. In addition the status of the fisheries for blue and spotted warehou were, in terms of catch rates and optimum size at first capture, determined. The results of this study have been extensively reported to the Demersal and Pelagic Fish Research Group and the South East Fisheries Stock Assessment Group. Results have been made available to managers and industry and used in the TAC setting process.

INTRODUCTION

Blue warehou (*Seriolella brama*) and spotted warehou (*S. punctata*) are common on the continental shelf and upper slope of south-eastern Australia and New Zealand. Spotted warehou also occur off both coasts of South America (Gomon et al 1994). They are taken throughout the South East Fishery (SEF), formerly the South East Trawl Fishery (SET) and in gillnets by fishermen engaged in the Southern Shark Fishery, mostly from the waters of eastern Bass Strait. Blue warehou are caught in depths to 500 m but the bulk of the catch comes from depths less than 300 m. Spotted warehou are taken in depths to about 650 m and trawl catches are often taken in waters deeper than blue warehou (Smith 1989). Catches increased rapidly during the 1980s particularly from the gillnet fishery reaching a combined catch of approximately 3000 tonnes in 1988.

The degree of overlap between the fisheries caused concern to be expressed by some members of industry regarding the potential conflict on SET resources. Consequently, at the South East Trawl Fishery Management Advisory Committee (SETMAC) Meeting No 17 (15/12/88) a working group was established in conjunction with the Southern Shark Management Advisory Committee (SSFMAC) to examine the impact of gillnetting on trawl operations. The group reported that specific management action was not warranted but some members considered there was a potential problem with gillnetters taking increasing quantities of trawl species. The major species for which a significant overlap occurs is blue warehou.

Some data were available for trawl caught warehous (Smith 1989a) and subsequently analysed by Smith (1991, 1994a,b) but no biological information was available on warehous taken in the gillnet fishery. Also it is not known whether the populations of these species in south-eastern Australia are unit stocks. For the purposes of management, however, both species are regarded as single stocks in south-eastern Australia.

Application was made to FIRDC in 1989 by the Victorian Department of Conservation and Environment for a three year research project to assess the warehou fisheries. Although the proposal was favourably viewed, budget constraints did not allow full funding. A grant of $55,000 was made for 1990/91. It was suggested that this be used to describe the fishery and establish a database.

Within the modified study, priority was given to the following:

1 Examination of catch and effort statistics.

2 Description of fishing practices, particularly for the gillnet component.

3 Field sampling for biological and population parameters, particularly for blue warehou.

A technical officer was employed to conduct field work and the project commenced in December 1990.

After the commencement of this study, the warehous were included in the 16 species to which individual transferable quotas (ITQs) were applied in the SEF. Because of past confusion between species in recorded catches (see below) the species were initially lumped under a common total allowable catch (TAC) of 2000 tonnes. This led, reportedly, to some catches of the lower value spotted warehou being discarded in favour of blue warehou. Separate TACs were established in 1993 to overcome this problem. Results of this study were used extensively in the TAC setting process. No TAC has been applied to the non-trawl sector.

Much of the data collected on warehous and reported here are summarised in two species synopses published in a Bureau of Resource Sciences Bulletin (Smith 1994a,b) and South East Fishery Species Assessment Reports (Smith in press a,b).

Greatest emphasis was given to obtaining data on blue warehou because this is the main species taken by the gillnet component. This report, which summarises data collected during 1991, reflects this. Additional data collected during 1992, 1993 and early 1994 as part of "routine monitoring" are included where appropriate. These data are used to make a preliminary assessment of stock status. Uncertainties in the data are discussed and recommendations to improve data quality are made.

DATA SOURCES AND METHODS

Catch and Effort Statistics

Trawl Component

Prior to the introduction of the SET logbook in 1986, catch statistics for warehous are limited in extent and complicated by the close similarity of the species which often saw them "lumped", generally as "Tasmanian trevally" or "snotty trevalla". No reliable estimates of total catch, either for spotted and blue warehou combined or individually are available. Some fragmented data, however, are available and are reported in Smith (1989a,b, 1994a,b)

The most comprehensive catch information for these species is that contained in the SET logbook data base. Comparison of these data (for combined species) with landing figures taken from cooperatives and processors indicates that catches recorded in the logbook data are reasonably accurate (Carter and Smith 1989).

SET logbook catch and effort statistics were examined for the species combined and separately for the period 1986 to 1993. For effort, only those shots in which either species was caught was used, and catch rates were expressed as kilograms per hour. The

trawl fishery for the warehous is distinctly seasonal (Smith 1989a,b). For this reason, catch, effort and CPUE data were examined for each season. To assess whether trends in abundance were consistent across the fishery, data were examined separately for each major area in the fishery (designated using Neil Klaer's SET partition, as defined by Tilzey 1994) (Figure 1).

Gillnet Component

Smith (1989a) showed that Lakes Entrance was the major port of landing for warehous taken by gillnet vessels. Catch statistics were extracted from the records of Lakes Fishermen's Cooperative for the period 1986-1991, during routine field trips. Summaries for 1992 and 1993 are also included.

Catch statistics recorded in the Southern Shark Fishery Database (SSFD) at the Victorian Fisheries Research Institute (Fishers engaged in fishery are required to complete logbooks recording catch and effort details) and Tasmanian gillnet catch data from the Division of Sea Fisheries Tasmania. were also examined. These data were used to supplement Lakes Entrance data to give overall landings for the fishery.

In the assessment of the Southern Shark Fishery, unstandardised kilometre lifts or kilometre hours are used for fishing effort (Walker 1992). The SSFD was examined to determine whether similar measures of effort could be used for the warehou component of the catch.

Field Sampling

Biological information was collected from gillnet catches during approximately monthly field trips to Lakes Entrance, the major port of landing. Trawl catches were sampled at Portland and also at Lakes Entrance and Eden. Sampling at Lakes Entrance and Portland was undertaken with the help of fish measurers based at these ports. All length frequency distributions were scaled by catch and summed across vessels.

Emphasis was given to obtaining representative length frequency distribution for each species by method. Fish were sampled on-board vessels as well as from landed catches. In addition, where possible, otoliths were taken from approximately 100 fish randomly sampled with length, weight and sex recorded.

Fishing practices were described from at-sea observations and from discussions with skippers.

Blue Warehou Age Composition and Total Mortality

Methods used to age blue and spotted warehou are described by Smith (1989) and growth curves by Smith (1991). Briefly, age was determined from examination of whole otoliths. Other methods such as breaking and burning, and sectioning are of little benefit for either species and do not warrant the extra resources required in preparation.

The relative age composition of trawl and gillnet catches was computed by applying age-length keys to the appropriate length-frequency distributions. Total mortality was computed using catch curves.

Yield-per-Recruit

Yield per recruit (YPR) was computed using a simple age-structured model for a range of mortalities and ages-at-first capture. Natural mortality (M) is a necessary parameter for per recruit analyses but is not known for blue or spotted warehou. An approximate estimate was obtained from the relationship $\ln(100)/T_{max}$, where T_{max} is the maximum age. This "rule of thumb" assumes that the maximum age is the age 1% of the population reach in the unexploited state. Length and weight at age were derived from Smith (1994a,b).

Fishers often grade warehous (small, medium and large) as prices are generally higher for large fish, particularly for blue warehou. To assess potential of increasing returns to industry a relative value dollars-per-recruit ($PR) was also computed. The size limits for small, medium and large grades were determined from port-based sampling and from discussions with industry. Relative prices were obtained from Melbourne Fish Market.

RESULTS

Catch and Effort Statistics

Data quality

Trawl

The problem of lumping or incorrect identification has been a significant problem in the SEF, particularly when market prices for the two species are similar, resulting in many catches not being sorted. As part of the quota setting process industry were required to give verified catch details for the 16 species over the allocation period. Comparison of these data with the logbook breakdown by species for 1986 to 1989 (Table 1) indicates that incorrect identification of the two species is a major problem. The proportion of each species recorded is generally the reverse in verified catch data when

compared to the logbook data. Overall, however, combined catches are similar. Although it is difficult to be categorical about which data source is most accurate, catches of blue and spotted warehou recorded logbook data do appear to reflect their known distribution, particularly depth. In addition, during recent port meetings in Eden, Lakes Entrance and Portland, industry commented that because blue warehou are generally higher in value than spotted warehou the verified catch data may well be biased.

An additional problem with data for both species is that substantial quantities were declared as being caught in State waters in 1993. These were included in total catches.

Reported Tasmanian inshore trawl catches prior to 1989 are not reliable and from 1989 to 1993 suffer from the problem of lumping and/or misreporting (J Lyle Marine Resources Division, Tasmania pers com).

Gillnet

Gillnet catches of blue and spotted warehou are reported separately by Lakes Entrance Fishermen's Cooperative Limited (LEFCOL) and thus catch statistics accurately reflect landings. Blue warehou make up the bulk of landings (see below). There were, however, problems with catch records in the SSFD and Tasmanian databases. There was confusion between the warehous and also with silver trevally (*Psuedocarynx dentex*). Because warehous were often recorded as Tasmanian trevally in logbooks they were sometimes wrongly coded. Silver trevally is, generally, not a major target species for gillnet fishers it was possible to correct these errors. Care also had to be taken when extracting data from Tasmania to avoid double-counting catches of vessels that landed fish at Lakes Entrance but filled in Tasmanian returns. A more serious problem, however, was that not all warehou catches were recorded in logbooks. Blue warehou catches extracted from LEFCOL were much greater than those from logbooks. For example, in 1986 and 1987 the SSFD blue warehou catch for the entire fishery was about half that landed at Lakes Entrance alone.

Effort statistics for the gillnet component are incomplete. Examination of logbook data for 1988-92 showed that Tasmanian records of blue warehou were recorded as monthly totals only and no (or inadequate) effort details (ie number and duration of shots) given. These data were, therefore, inadequate for any CPUE considerations. For the Victorian catch and effort database only those vessels that landed considerable quantities of blue warehou were used in the analyses. Because sharks are also major target species, some problems were encountered determining blue warehou effort. Using only data in which blue warehou made up over 50% of total landings accounted for 80% of records. However, the Victorian data represents only part of the fishery and catches extracted from the database were generally less than reported through LEFCOL.

General

Total catches for the species combined are shown in Table 2 In 1984 total landings were 1,260 tonnes of which trawl contributed almost 90%. The proportion taken by the gillnet sector increased considerably so that in 1990, the gillnet sector contributed almost 50% of the total landing of about 4,200 tonnes. Since 1990 the proportion taken by the gillnet sector has fallen. Total landings peaked in 1991 at almost 4,400 tonnes.

For reasons discussed above, determining the total catch of each species is complicated by uncertainties in the trawl data. Prior to 1986, data were not available to separate trawl catch by species with any confidence but spotted warehou are thought to have dominated catches during this period. For the period 1986-1989, the "verified" trawl catch is used as the best estimate of total warehou landings but adjusted by the annual proportion of each species in logbook records. For 1992, logbook records are used and for 1993, the total catch is derived from landings recorded by Quota Monitoring System (QMS) plus catches declared in State waters. However, it is important to note that for catch by area and trends in catch rates, the SET logbook remains the best data source.

Tasmanian inshore trawl catches are for the species combined. Overall they contributed under 1% of total trawl landings between 1989 and 1993. The breakdown by species is unknown but the bulk are thought to be spotted warehou (J Lyle DSF pers comm). In the absence of any other information, the annual SET logbook ratio is applied to these catches.

Gillnet catches of each species landed at Lakes Entrance recorded by LEFCOL are accurate. Anecdotal evidence indicates that the species composition in gillnet catches from other areas are similar. Victorian and Tasmanian gillnet warehou catches were subsequently apportioned to species based on Lakes Entrance landings.

The best estimates of landings of blue and spotted warehou separately, 1986 to 1993, are given in Table 3.

Trawl Component

Warehous were first landed in quantity during the late seventies, predominantly taken in the Eastern Sector of the fishery. By 1983/84, almost 500 tonnes were landed at Eden alone (Smith 1989b).

From 1986 to 1991 trawl catches of the species combined increased steadily to in excess of 2700 tonnes (Figure 2). In 1992 the catch was lower at 1650 tonnes but recovered to 3,130 tonnes in 1993. The latter two years were effected by the introduction of quotas and subsequent quota increases which are discussed elsewhere. Catches of blue warehou increased steadily between 1986 and 1991 and, in 1991, made-up about 50% of combined

landings (Figure 2, Table 3). Catches of spotted warehou were more variable, ranging from about 800 to 1650 tonnes per annum (Figure 2).

According to logbook records, between 1986 and 1993, the greatest catches of both species were taken in western Bass Strait (West) and Eastern Sector B accounting for 39% and 30% blue warehou, and 31% and 39% spotted warehou, respectively. Eastern Sector A contributed 14% of blue warehou and 12% of spotted warehou. South-eastern Tasmania was important for blue warehou (13%) and south-western Tasmania for spotted warehou (14%). Landings by zone for each species are given in Table 4 and Figure 3.

Seasonal catch, effort (in terms of numbers of hours) and catch rates (kilograms/hour) for blue warehou (1986-1993) are shown in Figure 4 (Eastern Sector B) and Figure 5 (West). Catches were generally highest in winter and spring and catch rates (kg/hr) generally reflected this. In Eastern Sector B, catches and catch rates declined in winter and spring from 1990 to 1993. Catch rates in western Bass Strait were relatively stable in winter but catches and catch rates in spring have declined considerably from a high in 1991.

Catches and catch rates (kg/hr) of spotted warehou were highest in winter. In Eastern Sector B (Figure 6) and West (Figure 7), catches and catch rates were variable and there were no apparent trends during the period 1986 to 1993. Industry observations also suggest variable availability and/or abundance.

Logbook data also indicate that an increased proportion of the catches of both species are being taken outside the areas and seasons that have traditionally been targeted.

On-board Observations and By-catch

On-board sampling and observations were made on two trips; in May 1991 and in July 1991. During both trips, vessels were targeting blue warehou on known grounds about 30 nm from Portland. Catches of retained and discarded species were recorded. Blue and spotted warehou were sampled from each shot (see Size Composition section).

During trip 1, 5 shots (total duration 10.45 hours bottom time) were completed in depths ranging from 200-220 m and the total retained catch was approximately 9 tonnes. Blue warehou made up about 80% and spotted warehou 4% of the catch. Other significant catches were squid (10%), morwong (2%) and barracouta (1.5%). The remaining species each made up less than 1%. About 400 kg was discarded; mostly dogfish (50%) but also small red dory, flathead and barracouta.

During trip 2, 7 shots (total duration 11.30 hours bottom time) were completed in depths from 220-300 m and the total retained catch was 11 tonnes. Blue warehou made up 66% and spotted warehou 9% of the catch. Other species were squid (10%), barracouta (10%) and flathead (1%). 3.5 tonnes was discarded; mostly dogfish (80%) but also small red dory and barracouta.

During both cruises, the spotted warehou caught were generally smaller than the blue warehou. (see below).

Gillnet Component

Total landings by the gillnet sector peaked at almost 2000 tonnes in 1990 but have subsequently declined. Most warehous were taken by gillnet vessels operating from Lakes Entrance (Table 2); about 83% of the 6148 t of gillnet warehou caught between 1989 and 1993. Overall, Tasmanian inshore gillnet vessels accounted for about 14% of landings during the same period but the annual proportion has recently increased following the decline in gillnet catches from eastern Bass Strait. A small amount was also taken by other Victorian gillnet vessels.

The Lakes Entrance gillnet fishery for warehous came to prominence in 1987 when catches increased dramatically from 237 tonnes in 1986 to 960 tonnes (Table 2, Figure 8). Prior to this the gillnet vessels concentrated almost exclusively on school and gummy shark. Landings peaked at 1711 tonnes in 1990 and have since declined.

In 1991, there were 16 gill-net vessels regularly operating out of Lakes Entrance. This varied seasonally, however, due to some vessels fishing locally and in Port Phillip Bay for scallops. Several vessels constantly targeted blue warehou landing approximately 63% and 81% of landings at Lakes Entrance in 1990 and 1991, respectively. Other vessels alternated between warehou and shark fishing.

Records of Lakes Entrance Fishermen's Cooperative shows that blue warehou are by far the dominant species in landings. For example in 1990, blue warehou made up 98.8% of the total. However, landings of spotted warehou have increased, from 315 kg in 1987 to 50 tonnes (6.6%) in 1991 (Figure 8, Table 3).

The Lakes Entrance gillnet fishery, unlike the trawl fishery, does not show strong seasonal trends. Monthly catches between 1986 and 1991 vary between years (Figure 9). Apart from 1989, monthly catches tended to be highest in late summer and autumn and lowest in late winter and early spring.

Blue warehou catch rates, summed across vessels, ranged from 164 to 448 kg/kilometer lift. Trends were consistent between vessels with catch rates peaking in 1990 followed by a decline. Catch rates for one vessel increased in 1993 which caused the slight increase in 1993 seen in the aggregate data (Figure 10).

On-board Observations and By-catch

Unlike trawlers, gill-net vessels operate on hard bottom when fishing for blue warehou. Several well known reefs in eastern Bass Strait consistently produced large quantities of blue warehou. The areas fished include South-east Reef, Cape Everard, Gabo Island, Point Hicks, New Zealand Star Banks and Smithy's Corner.

Up to 3500m of net is used, often split into 3 fleets of equal length. The mesh size is 6 inches (156 mm), and the net is 20 to 25 meshes deep. With a hanging coefficient of approximately 0.5, this gives a vertical drop of up to 3m. . Due to the large quantities of fish that can be caught, extra floats have been added to the headline and weights to the leadline. This allows the nets to still stand upright when laden with fish, maintaining its spread.

Depending on the type of reef, nets are either set directly upon them or on the fringes, and usually parallel to each other. A north-east, south-west direction is preferred for most shots due to a combination of prevailing currents, tidal influence and bottom formation. Depths fished range from 60-280m. The nets are set so that they are in place 1-2 hours before dawn and similarly at dusk. The duration of shots varies considerably.

On-board sampling and observations were made on two trips; in April 1991 and July 1991. Details are summarised in Table 5. Blue warehou was the target species during both trips. Other species taken varied between these trips primarily because of different depths fished. Blue warehou made up about 97% of the retained catch during the April trip (depth range 120-140 m). Of the 8579 kgs catch, only 6 kg were spotted warehou. Jackass morwong was the main by-catch species (1%). Other species were silver trevally (0.3%), redfish (0.3%), John dory (0.7%), gemfish (0.3%) and yellowtail kingfish (0.1%). Discarded species were dogfish and wobbegong.

The depths fished during the July trip were 145-240 m and the species composition of catches reflected this. Blue warehou made up 77% of the retained catch of 11, 907 kg but the catch of spotted warehou was much greater (21%). According to fishers catches of spotted warehou are usually higher in winter. Other species retained included blue grenadier (0.2%), ling (0.2%), jackass morwong (0.1%), and trumpeter (0.3%). Discarded species were dogfish and jack mackerel.

Although these data were for only two trips, the species composition recorded were consistent with gillnet vessel scale fish catches in 1989 and 1990 (Table 6).

Catches of school and gummy shark were very low during both trips indicating the targeted nature of the gillnet fishery for blue warehou.

Size Composition

Blue warehou landed by Portland trawlers ranged in size from 25 to 56 cm LCF (Figure 11). Length frequency distributions were variable but fish less than 40 cm (approximately the size at maturity; Smith 1994a) made up a significant part of the catch. This was particularly evident in 1992 and in the first half of 1994 (Note: the 1993 sample size was relatively small). Blue warehou sampled at Eden, in August 1991, also showed a considerable component of the catch were juveniles (Figure 12).

An interesting feature of the Portland samples in 1991 was that larger fish were taken earlier in the season (Figure 13). By comparison the 1994 length frequency is for the period January to June but is predominantly small fish (Figure 11).

Length frequency distributions for gillnet caught fish, landed at Lakes Entrance (1991-1994), are much more consistent with most fish between 40 to 55 cm with a mode at about 50 cm (Figure 14). Unlike Portland landings, in 1991 there were no indications that the size of fish caught changed during the year.

Length frequency distributions for trawl caught spotted warehou landed at Portland distributions were more variable (Figure 15). A significant component of the catch were juveniles (<40 cm LCF) but this is not as marked as for blue warehou. Length frequency distributions for gillnet fish are similar to those for blue warehou, with one dominant mode at about 50 cm LCF (Figure 16).

Blue and spotted warehou were sampled on trawlers engaged in targeted fishing for blue warehou during 1991 (see above). Length frequency distributions were catch adjusted and summed across shots. Blue warehou showed the same shift to smaller fish seen in port samples. Spotted warehou, taken largely as a by-catch, were predominantly juveniles (Figure 17).

Blue warehou age composition

As assigned ages have to be validated there is uncertainty about growth and mortality estimates. It is unlikely, however, the data presented are grossly in error.

The percentage age compositions for blue warehou caught by Portland trawlers and Lakes Entrance gillnet in 1991 and 1992 are shown in Figure 18. Trawl catches were dominated by 2-4 year olds whereas for gillnet catches it was 4-6 year olds. The maximum age was 7 and 9 for trawl and gillnet, respectively.

The instantaneous coefficient of total mortality (Z) was estimated from the right-hand limb of the catch curves (Figure 19). For Portland, Z was 1.7 and 2.3 and for Lakes Entrance gillnet 1.0 and 1.5 for 1991 and 1992, respectively. However, the age composition of catches from both methods is effected by selectivity.

Yield-per-recruit analyses

For both species, yield-per-recruit was calculated for fishing mortalities (F) ranging from 0.1 to 1.4 and ages of first capture (tc) from 2 to 4. Fish were assumed to come into contact with the gear first at age 2 and recruitment was knife-edge.

The average prices ($) paid for small, medium and large warehous by one trader at the Melbourne Fish Market, in 1993, were as follows:

	Total Quantity (t)	Grade Small	Medium	Large
Blues	158	1.36	2.34	2.97
Spotted	147	1.41	1.60	1.64

Because the price differential between grades for spotted warehou was very small, only yield-per-recruit analyses were conducted for this species.

For blue warehou, the mean size (LCF) and weight (kg) of each grade was determined from sorted catches landed at Portland. Small, medium and large were 31cm and 0.6 kg, 36cm and 1.0 kg, and 42cm and 1.6 kg, respectively. In terms of age, 2s were regarded as smalls, 3s as mediums and 4s as a combination of medium and large. The older ages were regarded as large.

Inputs to the yield per recruit models were as follows:

Blue warehou

M=0.46

Age	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Length	20	30	35.69	41.71	46.08	51.06	52.95	56.5	57
Wt	157.5	538.2	911.0	1460.5	1975.1	2696.2	3010.1	3664.2	3763.3
Rel Value	0	1	1.7	1.9	2.2	2.2	2.2	2.2	2.2

Spotted warehou

M=0.40

Age	1	2	3	4	5	6	7	8	9	10	11
Length	20	30.1	37.6	42.9	46.5	49.1	50.9	52.1	53	53.6	54
Wt	116.8	444.5	919.9	1416	1842.8	2201.7	2476.7	2672.8	2826.8	2932.8	3005

Results for blue warehou are given in Figure 20. In the absence of fishing, the maximum cohort biomass occurs at ages 3 and 4. Yield per recruit was slightly greater for an age at first capture of 3 at high fishing mortalities but similar at low fishing mortalities (Figure 20b). However, in terms of relative value, considerable benefits would arise from an age at first capture of 3 (Figure 20c).

For spotted warehou, the maximum cohort biomass occurs at ages 3 and 4 (Figure 21a). Yield per recruit was greater for an age at first capture of 3 (Figure 21b).

DISCUSSION

Blue and spotted warehou have rapidly become important species in the South East Fishery, with combined landings in excess of 4,000 t in 1990 and 1991. There remains uncertainty regarding the correct proportion of each species recorded in trawl catches but the analysis of logbook data and comments by industry supports the use of logbook data to provide the best estimate of the proportion of each species in trawl catches. Considerable time was spent during this study to obtain the best estimates of catches by species and method but the uncertainty regarding catches is a potential source of error in the assessment of the fishery.

Trawl catches and catch rates of blue warehou, in eastern Bass Strait, have declined since 1990. There was also a concurrent decline in gillnet catches and, although the effort statistics are limited, catch rates have also so declined. This is consistent with the observations of gillnet fishers. These results indicate that blue warehou abundance is lower and the fishery is impacting on the population. The rate of this decline is of concern. The gillnet sector has suggested that seismic surveys by the oil industry and the taking of juveniles by trawlers may also have contributed to decreased gillnet catches. There are currently no data to determine whether these factors have had an impact or not. In western Bass Strait, however, there is no clear trend in catch statistics. Reasons for the difference between areas are unknown but certainly more fish have been caught in the east.

Catches and catch rates of spotted warehou were variable and there were no apparent trends during the period 1986 to 1993. This supports industry observations of variable availability and/or abundance.

Current trawl catches are regulated by TACs but catches by the gillnet sector is unregulated. The blue warehou TAC has remained at 1000 t since separate TACs were established in 1993. The TAC for spotted warehou, however, has increased substantially. It was set at 2000 t in 1993 and increased to 2500 t in 1994. The implications of the large increase in the TAC of spotted warehou are unknown but catches should be closely monitored.

There have been no studies on the stock structure of warehous in Australian waters. For assessment and management purposes, blue warehou in south-eastern Australia are currently assumed to be a single stock. The stock structure of warehous is also unknown in New Zealand waters (Annala 1994). Blue warehou are assumed to be a single stock but there are suggestions that there may be a central and southern New Zealand stock (Annala 1994).

The question of stock structure is fundamental to assessment. It is particularly important for blue warehou because of the differential response to fishing east and west of Bass Strait. There have been no studies of the migration or movement of blue warehou in Australia which might indicate the degree of mixing between east and west Bass Strait and Tasmania. However, the seasonal nature of trawl catches (which reflects spawning Smith 1989a), the movement of adult blue warehou into shallow water during summer/autumn in Tasmanian waters (J. Lyle, Sea Fisheries Tasmania pers comm), and the population structuring with juveniles tending to be at shallower depths than adults, all suggest some migration and/or aggreggation occurs. In addition, from inferences drawn from feeding studies, Gavrilov and Markina (1979) reported that both species in New Zealand undertake major migrations. The seasonal pattern of blue warehou landings in New Zealand also suggest coastal migration (Annala 1994).

Length at first maturity for females occurs at about 40 cm LCF (Smith 1989a; Annala 1994). A significant proportion of the trawl catch, therefore, comprises juveniles. The impact this has on potential egg production is unknown. The preliminary yield per recruit analyses, using M inferred from life history characteristics, indicates that fishers would gain from taking the fish at a larger size. However, catches of juvenile spotted warehou may be inevitable. Results from this study and Tasmania (Lyle and Ford 1993) show there is a marked relationship between size and depth for spotted warehou with larger fish being taken in deeper water. Spotted warehou in the main blue warehou depths are predominatly 30-40 cm LCF.

Considerable differences occured in the length and age composition of catches between methods. This could be due to two factors. First, it may reflect population structuring such that only mature fish are found on the reefs exploited by gillnet fishers or second, it is a function of gillnet selectivity. Gillnet mesh selectivity studies (Cottier et al 1993a,b) have shown that this is primarily due to the latter as smaller fish do occur on these reefs (Figure 22). These studies also show that 5" (127 mm) is the optimal mesh size, at least in terms of catch rates. Currently, the gillnet fishery is regulated for gummy and school sharks and the minimum mesh size is 6" (152 mm). Given the decline in abundance in eastern Bass Strait discussed above, the current mesh size is, in effect, a conservative management strategy for blue warehou.

The differences between the two sectors also make it extremely difficult to determine mortality rates for the population. The age composition of catches in each sector do not fully reflect the population. Notwithstanding this, and the uncertainty about M, the results

do indicate that fishing mortality of blue warehou is at least equal to and most likely greater than natural mortality. Currently, a number of methods to reconstruct population size structure from the catches of meshes of different size are being investigated.

The objectives of this study have been met. Catch and effort statistics have been described and best estimates of landings of each species (no small task) provided. The gillnet fishery for blue warehou has been extensively examined for the first time and compared with the trawl sector determined. In addition the status of the fisheries for blue and spotted warehou were, in terms of catch rates and optimum size at first capture, determined. The results of this study have been extensively reported to the Demersal and Pelagic Fish Research Group and the South East Fisheries Stock Assessment Group. Results have been made available to managers and industry and used in the TAC setting process.

Research needs and recommendations

There is still the potential that catch statistics for the trawl contain significant misreporting of species. Although this is likely to be less of a problem now given the differential prices between species and greater awareness of industry, it is crucial catches should be recorded correctly. Continued collection of catch data by the Scientific Monitoring Program (SMP) should enable the extent of the problem to be quantified.

The inadequate effort data for the gillnet fishery of concern. It is obvious from the data, that there has not been enough follow-up or interest shown in the scalefish catch of gillnet vessels. It is recommended that gillnet fishers be required to complete detailed logbooks for scale fish catches and that this be given a high priority. In the meantime, the best approach would be to extract catch and effort statistics from fishers own records and several have agreed to making them available.

The use of hours as a proxy for trawl effort is not adequate and further work is needed. There is a considerable literature concerning apportioning effort in multi-species fisheries (eg. Hilborn and Walters 1992). Klaer and Tilzey (1989) identified target and by-catch ratios for the trawl sectors but the extent of the analyses was limited. SEFSAG has identified the analysis of logbook catch and effort statistics as high research priority for most species in the SEF. Preliminary analyses using GLM procedures have been undertaken and results are in general agreement with results, however, a dedicated research project is required.

Age and length data for all sectors should be closely monitored especially taking into account temporal and spatial factors. Again, SMP data will be invaluable. The Central Ageing Facility (CAF) is "routinely" ageing both species and this will provide the necessary information required for further assessment, particularly using age-structured models such as VPAs. A further 2-3 years data would enable this to be carried out. Determining stock structure and size, and validating age estimates should be accorded a

high priority. A project to develop tagging methods for both species has recently been funded by FRDC and, if successfull will go some way to meeting these needs.

Acknowledgments

Many people have contributed to this study. Neil Klaer and Phil Stewart, BRS, provided SET logbook data. Tasmanian catch data was provided by Jeremy Lyle and Dorothea Huber, Sea Fisheries. Tom Davies and his staff at LEFCOL were particularly helpful during the study. Members of DPFRG and SEFSAG are thanked for their comments and advice. Finally we thank the skippers and crew of vessels for their assistance during at sea monitoring and those trawl and gillnet fishers for their comments and insights concerning warehou populations.

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Table 1 Comparison of blue and spotted warehou catches recorded in the SET logbook and from the verified catch history database.

Year	SET			Verified		
	Blue	Spotted	Total	Blue	Spotted	Total
1986	212	1159	1369	989	486	1475
1987	406	782	1188	1067	648	1715
1988	544	1650	2194	1211	924	2135
1989	776	939	1715	1242	640	1882

Table 2. Warehou combined species annual catch (tonnes).

Year	SET	Lakes Gillnet	Other Vic	Tas Gillnet	Other Trawl	Total
1984	1128	60	20	52	13	1273
1985	1422	140	26	138	0.5	1727
1986	1475	237	17	165	38	1932
1987	1715	960	73	278	27	3053
1988	2135	778	61	172	2	3148
1989	1882	1005	74	55	1	3017
1990	2231	1711	56	175	12	4185
1991	2724	1399	35	161	12	4331
1992	1651	*751	12	267	56	2737
1993	3146	430	27	184	33	3820

Data Sources:

SET: SET logbook; verified

Lakes Gillnet: Lakes Entrance Cooperative - includes landings by Lakes vessels in other ports except 1992 (*).

Other Victoria: Southern Shark Database

Tas Gillnet and Trawl: Division of Sea Fisheries Tasmania. Note: prior to 1989, Tasmania catch statistics less reliable

Table 3 "Best estimates" of blue and spotted warehou landings, 1986-1993

Year	Blue warehou SEF	Other Trawl	Lakes Gillnet	Other Gillnet	Total	Spotted warehou SEF	Other Trawl	Lakes Gillnet	Other Gillnet	Total
1986	228	6	237	182	653	1247	32	0.2	0	1279
1987	586	9	960	351	1906	1129	18	0.3	0	1147
1988	529	0.5	774	231	1535	1606	1	4	2	1613
1989	852	0.5	987	126	1965	1030	0.5	18	3	1052
1990	881	5	1690	228	2804	1350	7	21	3	1381
1991	1277	5	1351	189	2822	1447	7	48	7	1509
1992	933	30	701	261	1925	718	26	50	18	812
1993	992	10	400	195	1597	2154	23	30	16	2223

Data sources:

SEF - 1986-89 verified; 1990-92 SET logbook; 1993 Quota Monitoring System

Other Trawl - Sea Fisheries, Tasmania.

Lakes Gillnet - LEFCOL

Other Gillnet - Sea Fisheries, Tasmania & SSD

Table 4 Blue and spotted warehou trawl catch (t) by year by zone.
Source: SET Logbook

Blue Warehou	Area 10 East A	20 EastB	30 SETas	40 SWTas	50 West	60 Bass
Year						
1986	106	34	0	9	63	0
1987	96	83	8	7	211	1
1988	115	229	1	27	171	2
1989	142	252	280	79	17	0
1990	67	413	82	14	292	1
1991	123	315	121	17	711	0
1992	79	212	155	38	447	1
1993	129	119	212	49	318	1

Spotted Warehou	Area 10 East A	20 EastB	30 SETas	40 SWTas	50 West	60 Bass
Year						
1986	148	345	2	68	583	4
1987	33	225	19	190	314	1
1988	294	595	57	165	536	3
1989	25	281	58	367	207	1
1990	229	765	52	120	181	3
1991	116	572	73	110	566	1
1992	119	336	51	124	86	1
1993	259	646	128	402	369	15

Table 5 Summary details of on-board sampling trips, Lakes Entrance gillnet vessels.

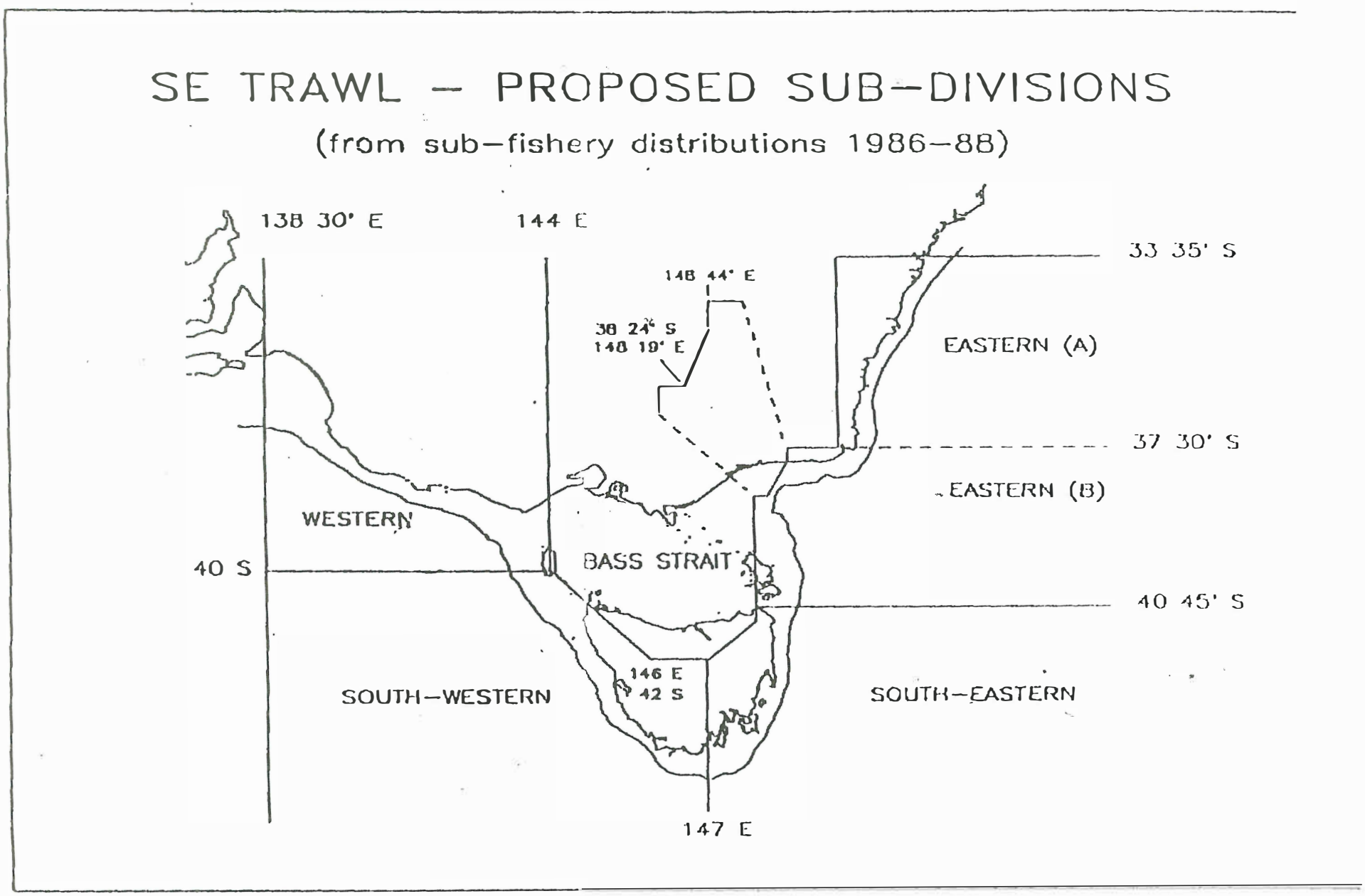
Trip 1	Shot Details					Retained Catch (kg)										Discarded Catch (kg)	
Date	Shot No	Net No	Start Time	Dur'n (hrs)	Depth (m)	Blue Warehou	Spotted Warehou	Silver Trevally	Redfish	Jackass Morwong	Gemfish	John Dory	School Shark	Saw Shark	Y'tail K'fish	Dogfish	Wobegong
16-Apr	1	1	1815	12	140-120	1800	0	0	0	15	0	7	0	0	8	20	15
17-Apr	2	1	1130	22	140-120	1350	0	15	0	12	0	8	0	0	0	30	20
	2	2	1145	24	140-120	450	0	15	10	10	0	7	12	0	0	15	10
18-Apr	3	1	1545	8	140-120	700	0	0	8	7	6	10	0	6	0	10	10
	3	2	1600	10.15	"	850	0	0	2	5	7	7	0	3	0	5	10
19-Apr	4	1	1715	9.45	"	1800	0	0	5	10	3	6	0	0	0	5	20
	4	2	1730	12.3	"	1350	0	0	0	7	10	0	0	0	0	10	5
20-Apr	5	1	330	19	"	8	6	0	0	0	0	5	5	2	0	2	0
	5	2	600	5.45	"	30	0	0	0	0	0	2	0	0	0	0	0
					Total	8338	6	30	25	66	26	52	17	11	8	97	90

Trip 2	Shot Details					Retained Catch (kg)								Discarded Catch (kg)	
Date	Shot No	Net No	Start Time	Dur'n (hrs)	Depth (m)	Blue Warehou	Spotted Warehou	Blue Gren	Ling	Trump-eter	Morwong	School Shark	Gummy Shark	Dogfish	Jack Mack
22-Jul	1	1	1600	4	150-230	2300	165	6	7	0	0	6	0	20	15
	1	2	1630	5.3	150-240	2100	270	6	6	0	0	9	0	12	0
	1	3	1700	8.15	145-235	245	460	5	0	8	6	0	0	15	15
23-Jul	2	2	45	9	150-240	350	290	0	0	0	0	20	0	8	35
	2	1	100	18.3	150-230	1450	350	2	4	10	0	0	0	15	10
	2	3	245	19.15	145-235	760	360	0	0	2	0	10	15	10	5
23-Jul	3	2	1115	13	150-240	2020	640	3	4	10	8	0	0	12	10
					Total	9225	2535	22	21	30	14	45	15	92	90

Table 6 Scalefish catch (tonnes) by Lakes Entrance gillnet vessels, 1989&1990

Species	Year 1989	1990
Blue warehou	986.8	1690.1
Spotted warehou	18.3	21.3
Silver trevally	49.3	18.5
Ling	17.6	20.6
Blue-eye trevalla	18.1	4.6
Trumpeter	10.3	19.8
Jackass morwong	3.4	3.8
Gemfish	7.1	1.2
Blue grenadier	2.6	0.6
John dory	0.1	0.2

Figure 1


SE TRAWL – PROPOSED SUB–DIVISIONS
(from sub–fishery distributions 1986–88)
138 30' E
144 E
148 44' E
38 24' S
148 19' E
33 35' S
EASTERN (A)
37 30' S
EASTERN (B)
WESTERN
40 S
BASS STRAIT
40 45' S
146 E
42 S
SOUTH–WESTERN
SOUTH–EASTERN
147 E

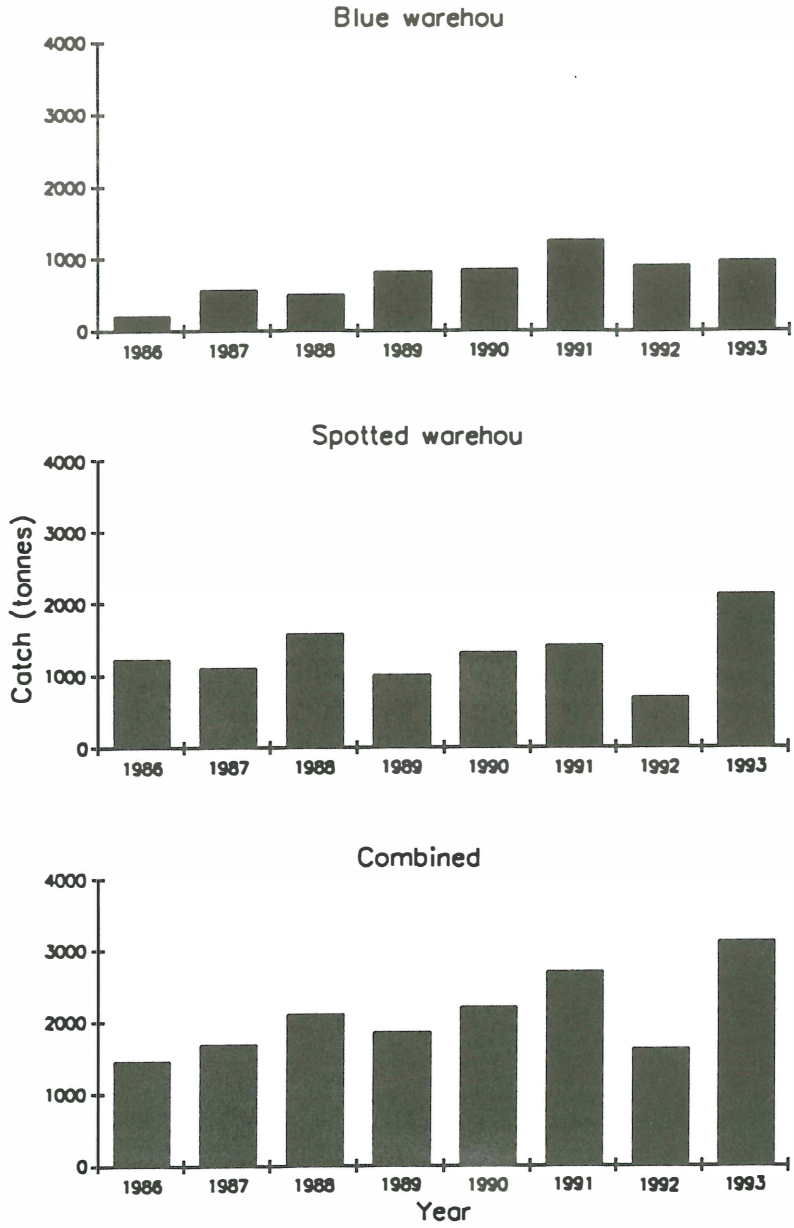


Figure 2 Annual landings of blue and spotted warehou by trawlers, 1986–93.

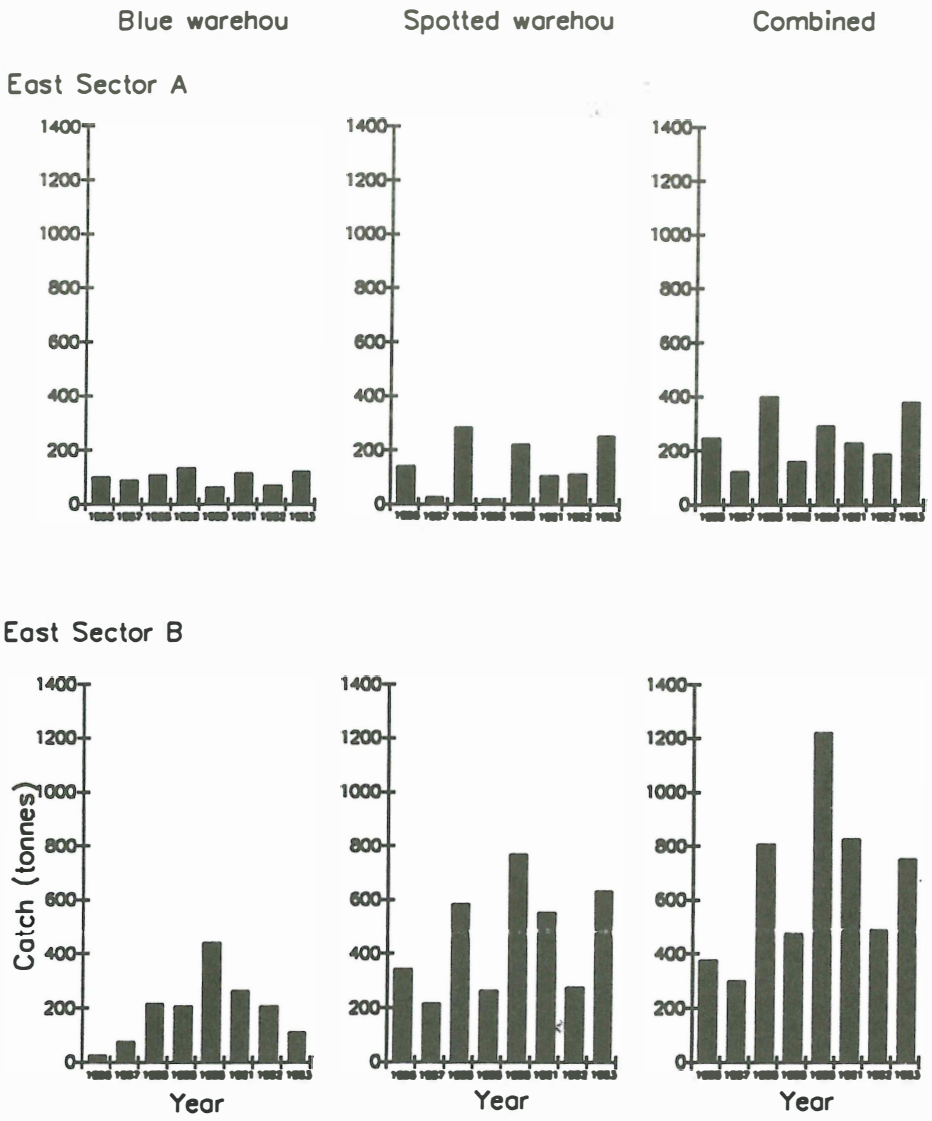


Figure 3 Annual trawl catch (tonnes) of blue and spotted warehou and the species combined by zone. (Source SET Logbook database)

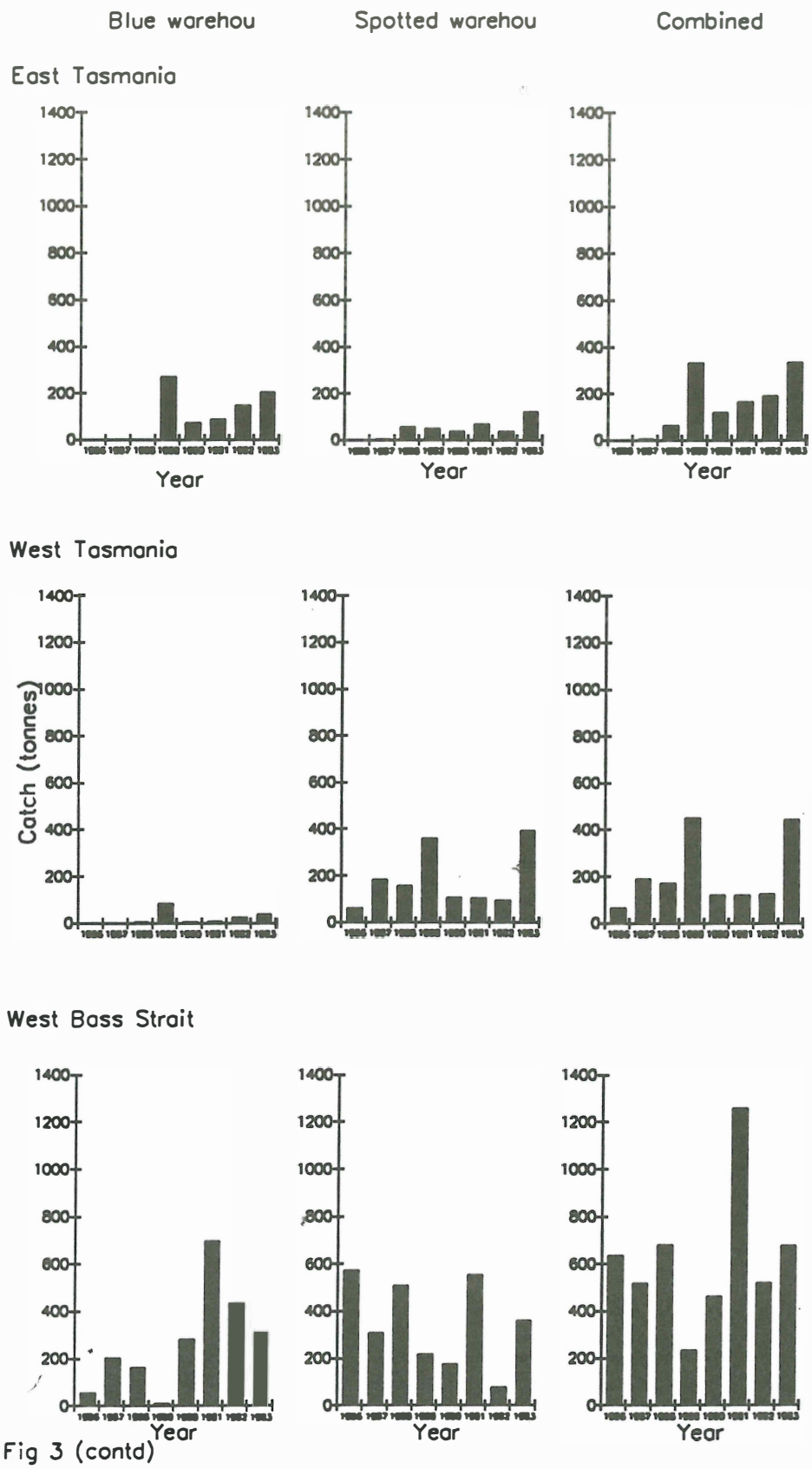

Blue warehou
Spotted warehou
Combined
East Tasmania
West Tasmania
West Bass Strait
Catch (tonnes)
Year
1400
1200
1000
800
600
400
200
0

Fig 3 (contd)

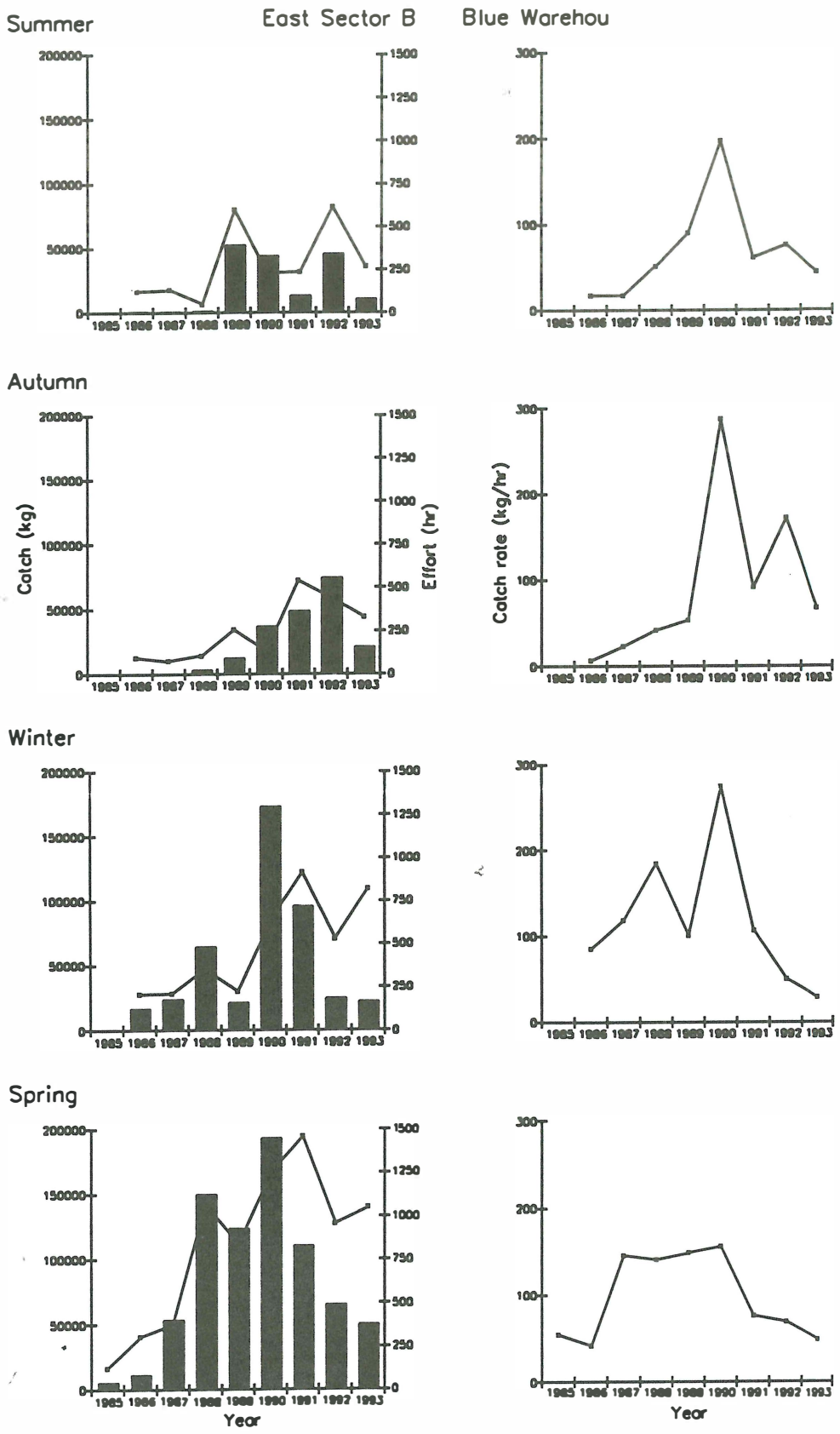


Figure 4 Blue warehou seasonal catch (kg), effort (hr) and catch rate (kg/kr), East Sector B, 1986–1993.

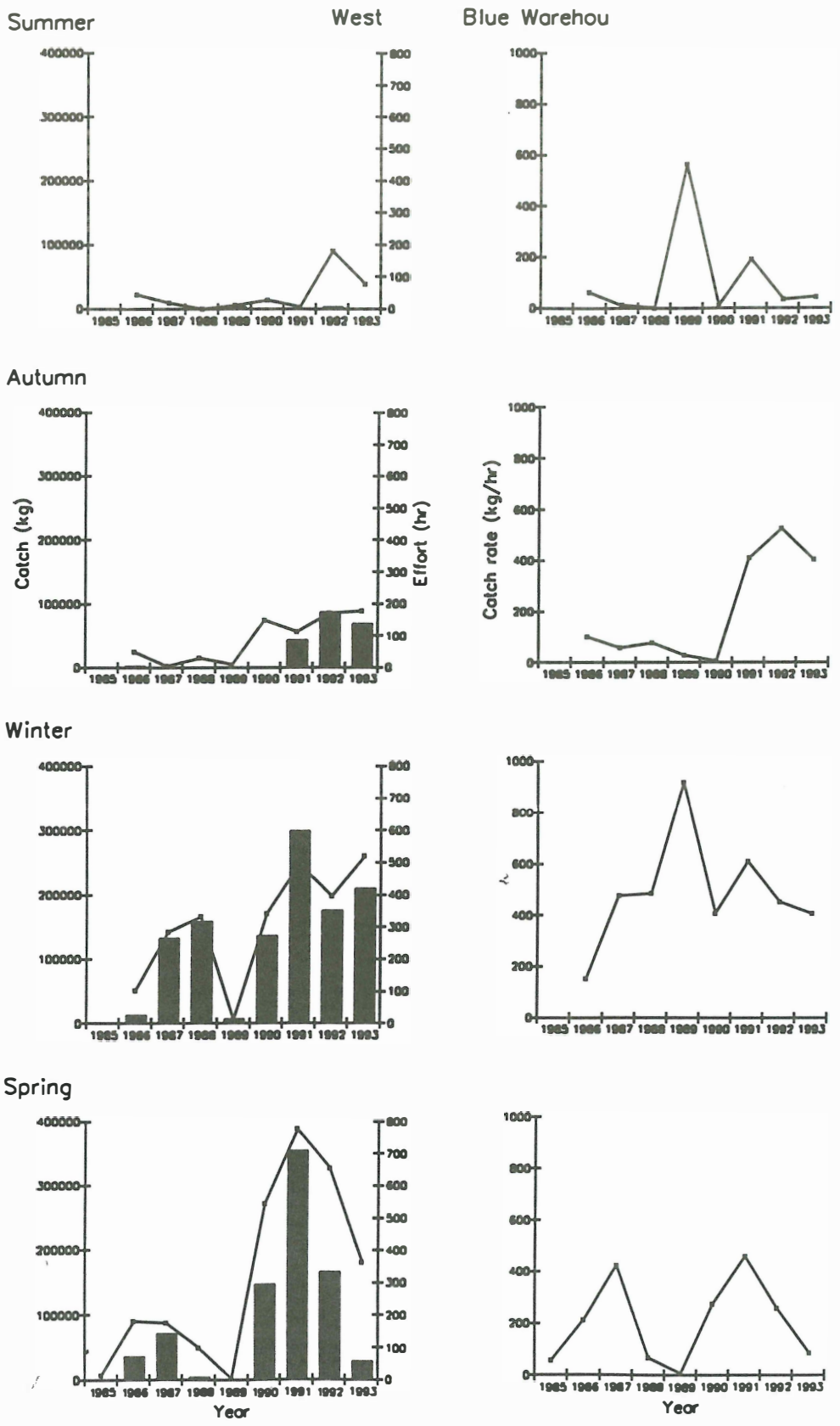


Figure 5 Blue warehou seasonal catch (kg), effort (hr) and catch rate (kg/hr), West, 1986–1993

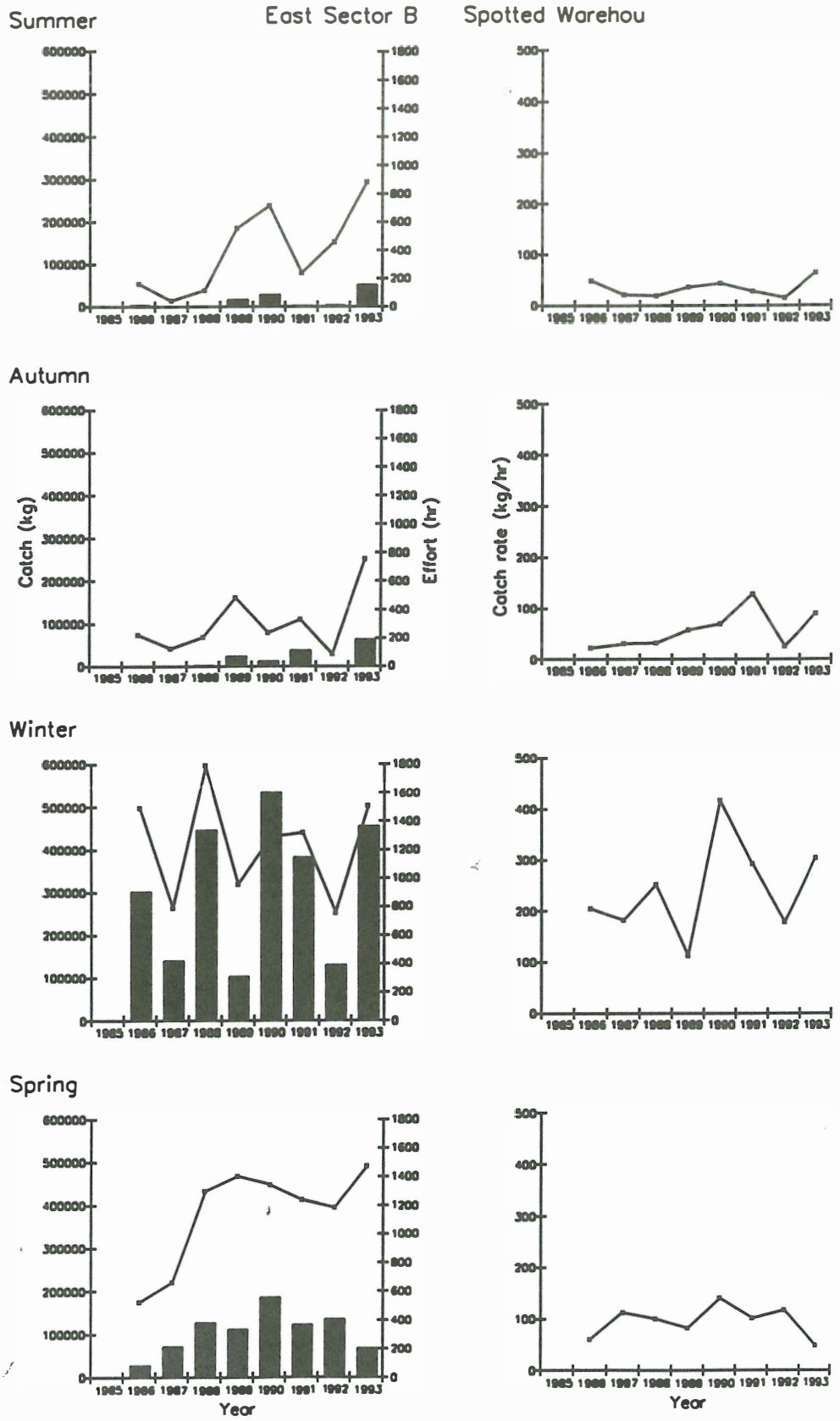


Figure 6 Spotted warehou seasonal catch (kg), effort (hr) and catch rate (kg/kr), East Sector B, 1986–1993.

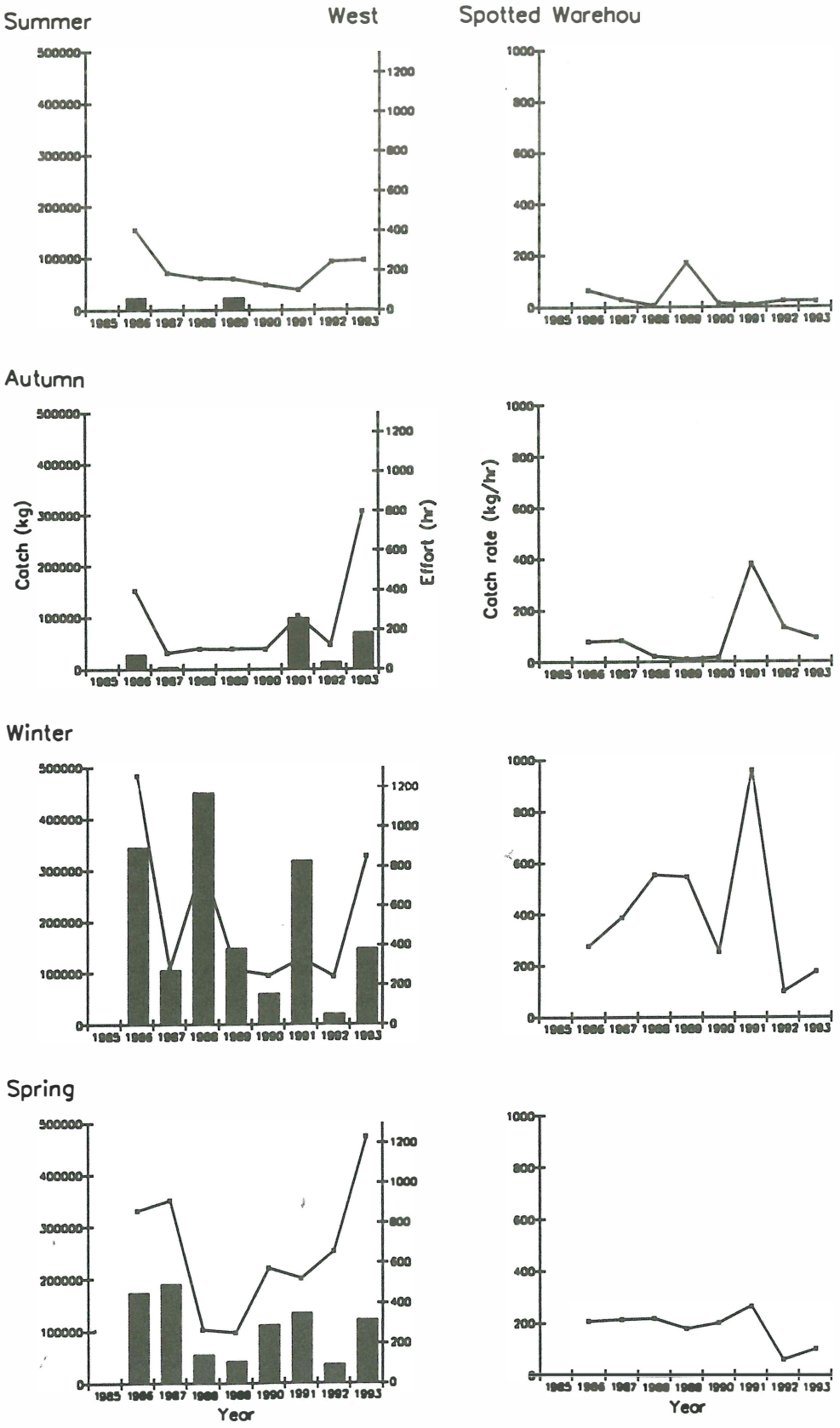


Figure 7 Spotted warehou seasonal catch (kg), effort (hr) and catch rate (kg/hr), West, 1986–1993

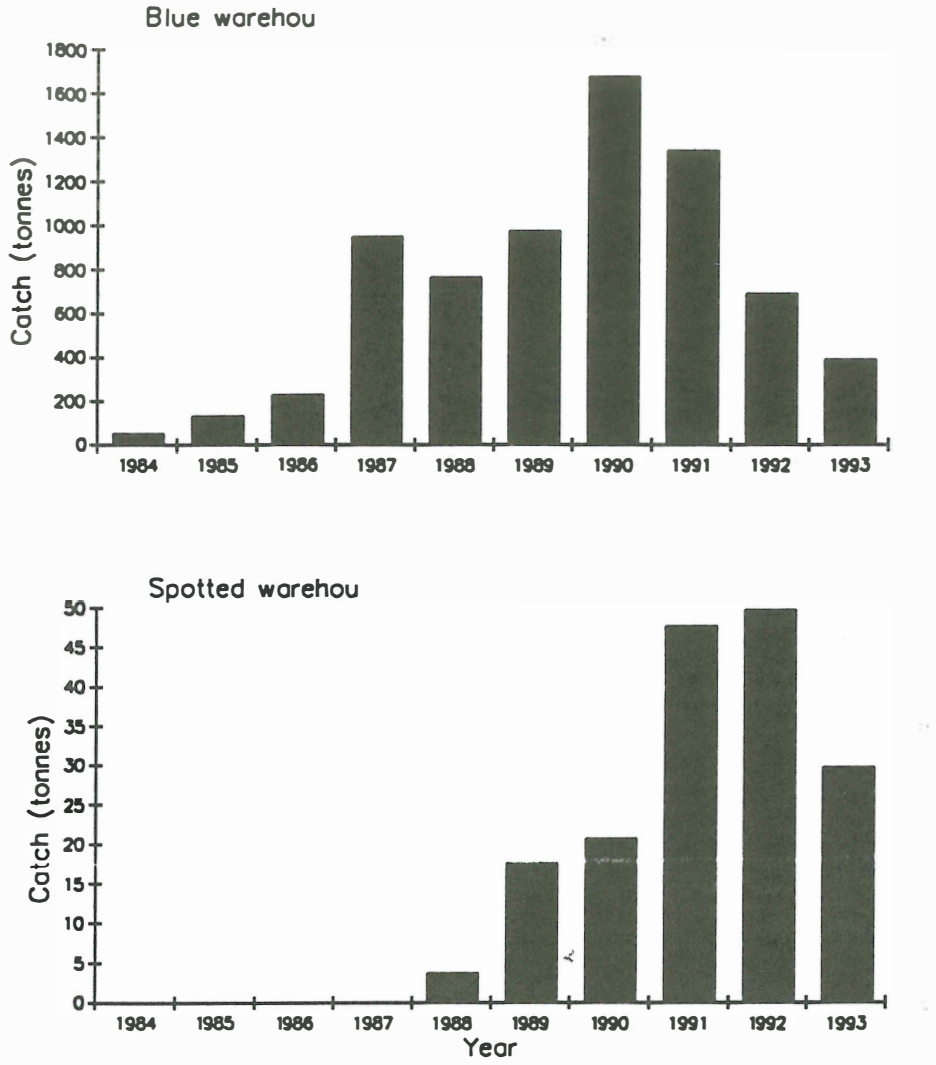


Figure 8 Annual landings (tonnes) of blue and spotted warehou by gillnet vessels, Lakes Entrance 1984–1993.

Source: Lakes Entrance Fishermen's Cooperative Limited.

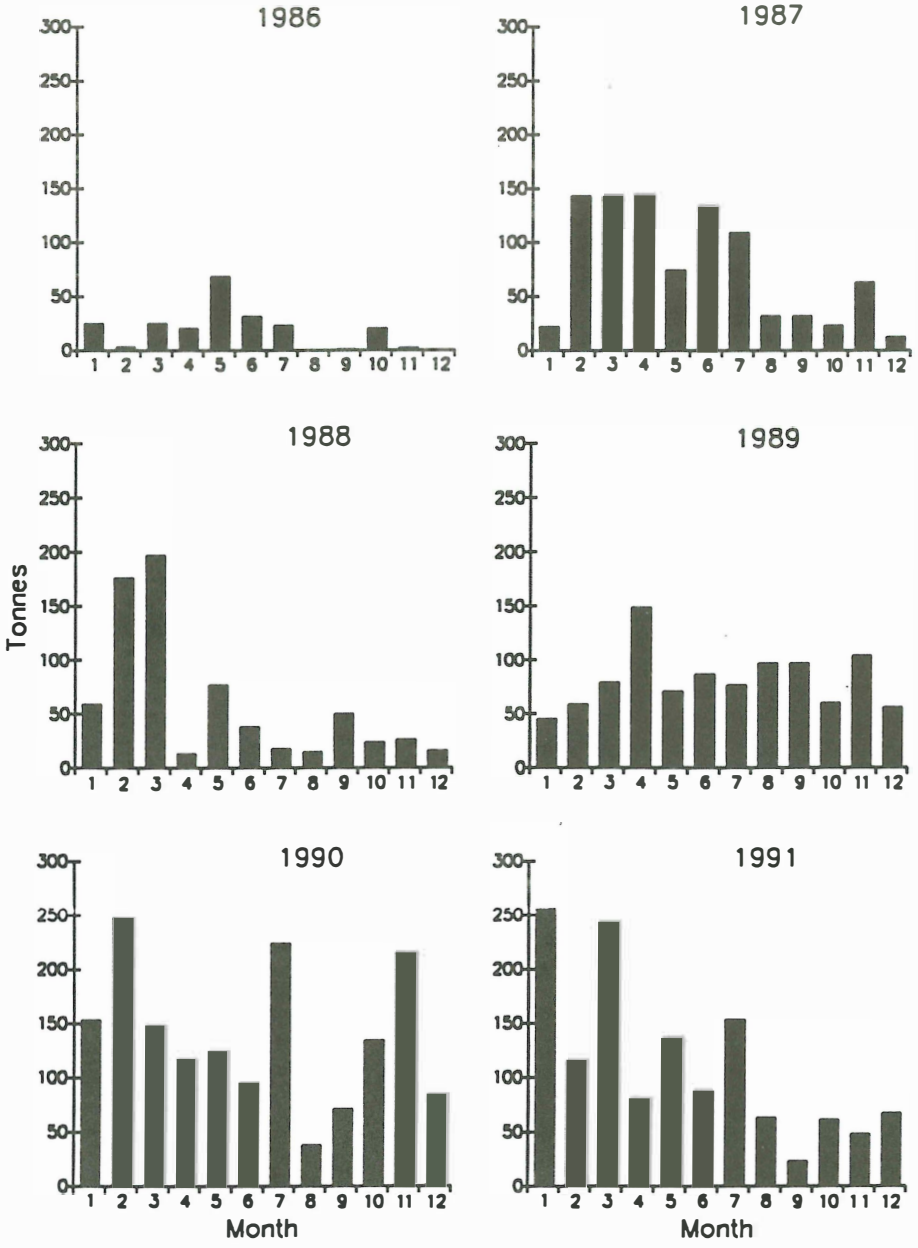


Figure 9 Blue warehou landings (tonnes) by month, Lakes Entrance gillnet vessels 1986–1991

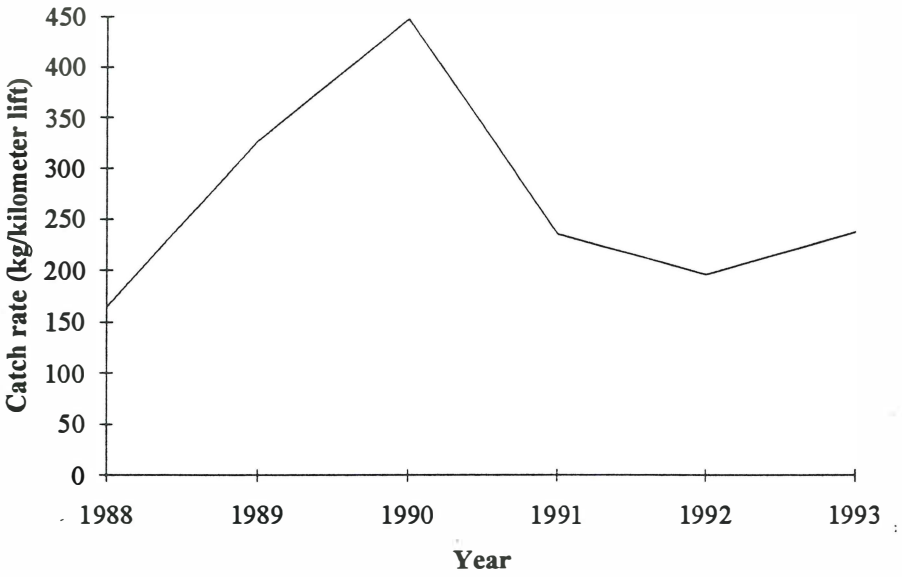


Figure 10 Annual aggregate catch rates (kg/kilometer lift) for blue warehou taken by Lakes Entrance gillnet vessels, 1988-1993.

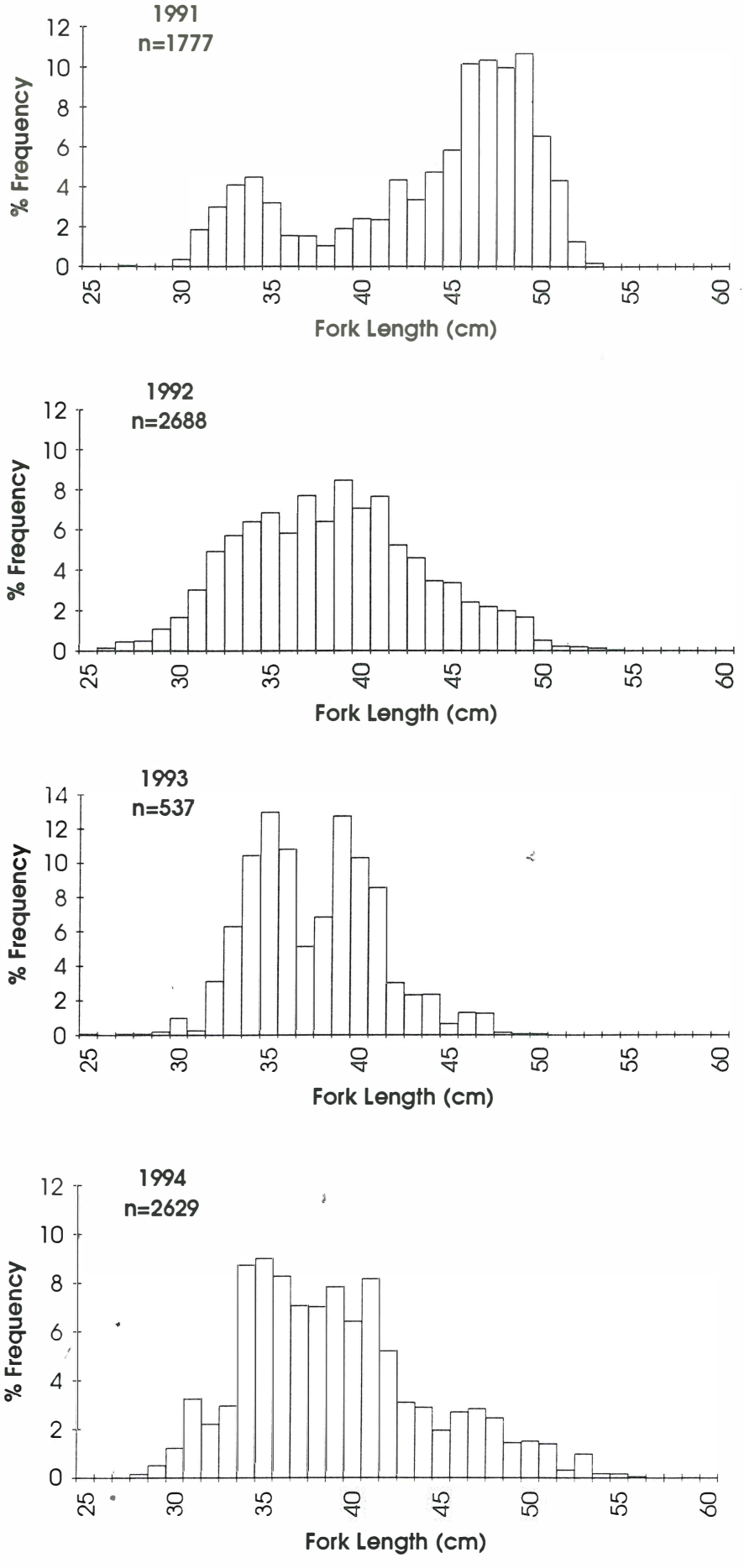


Figure 11 Percentage length-frquency distributions for blue warehou caught by trawl, Portland

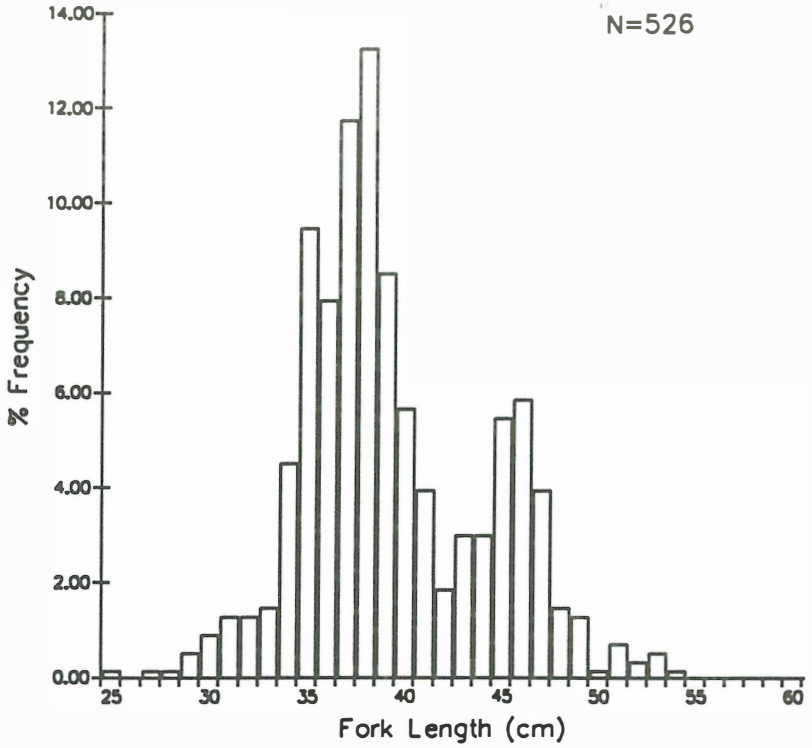


Figure 12 Percentage length frequency distribution for blue warehou, Eden August 1991.

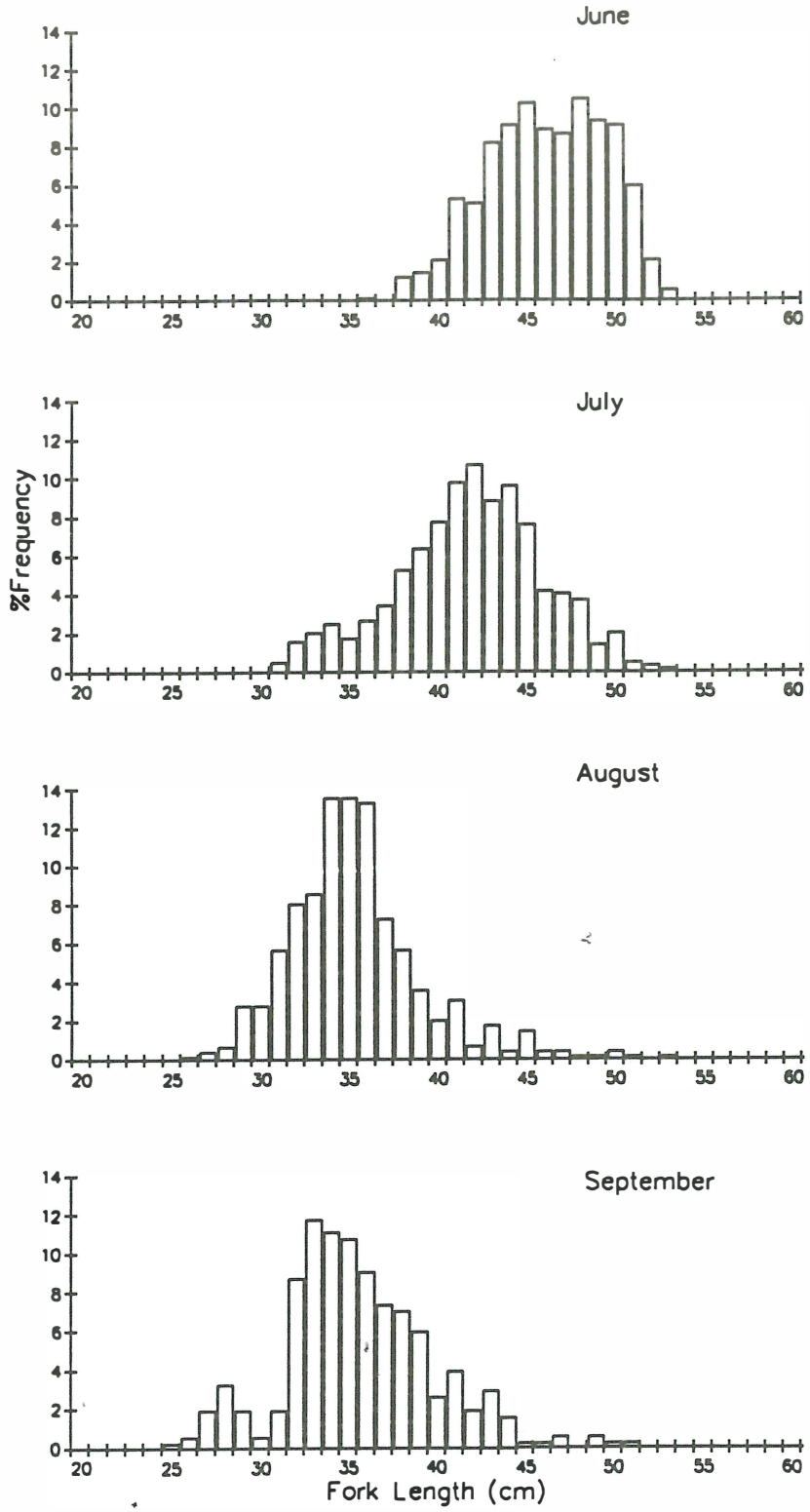


Figure 13 Percentage length frequency distributions for blue warehou landed Portland, June–September 1991.

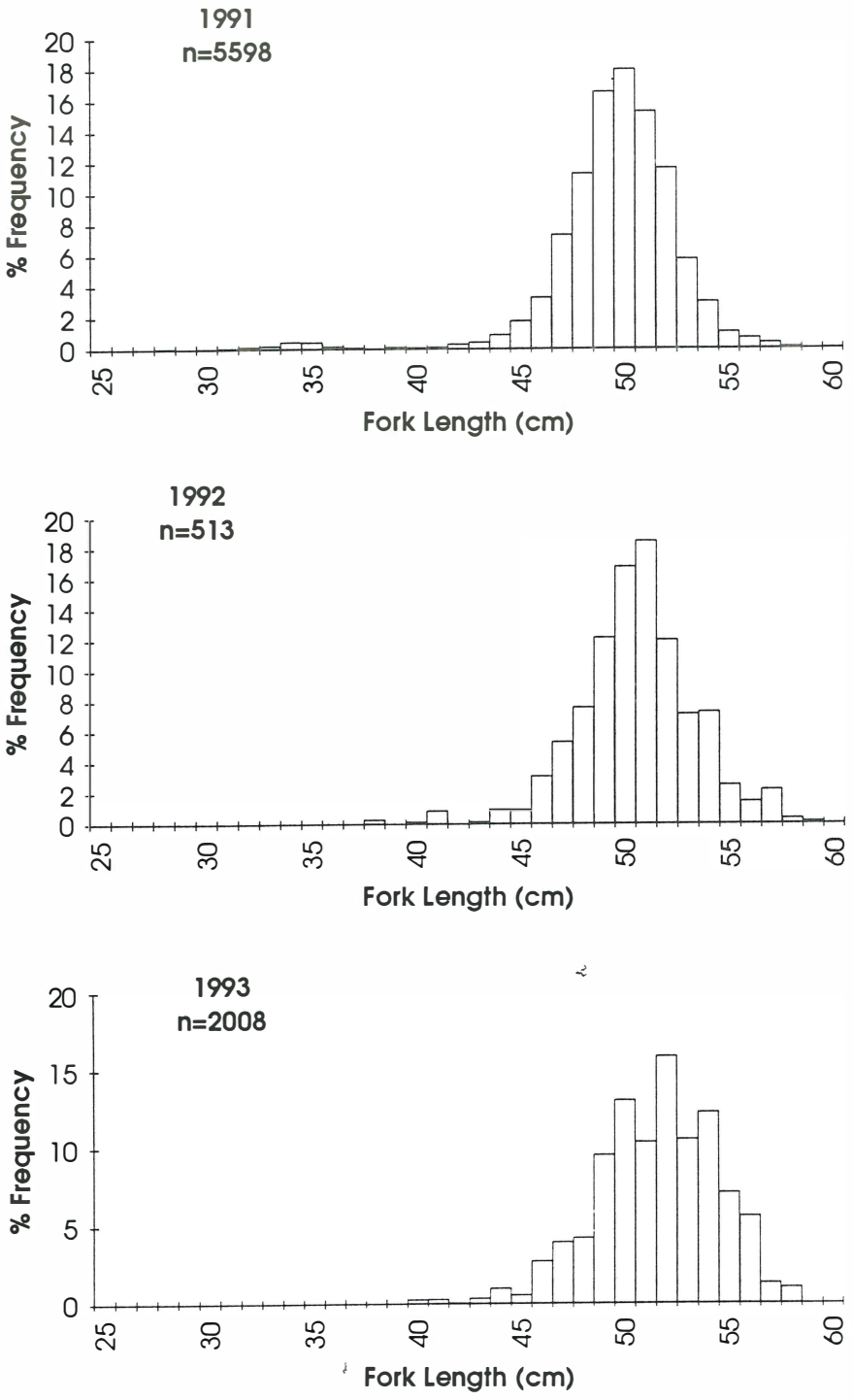


Figure 14 Percentage length frequency distributions for blue warehou caught by gillnet, Lakes Entrance

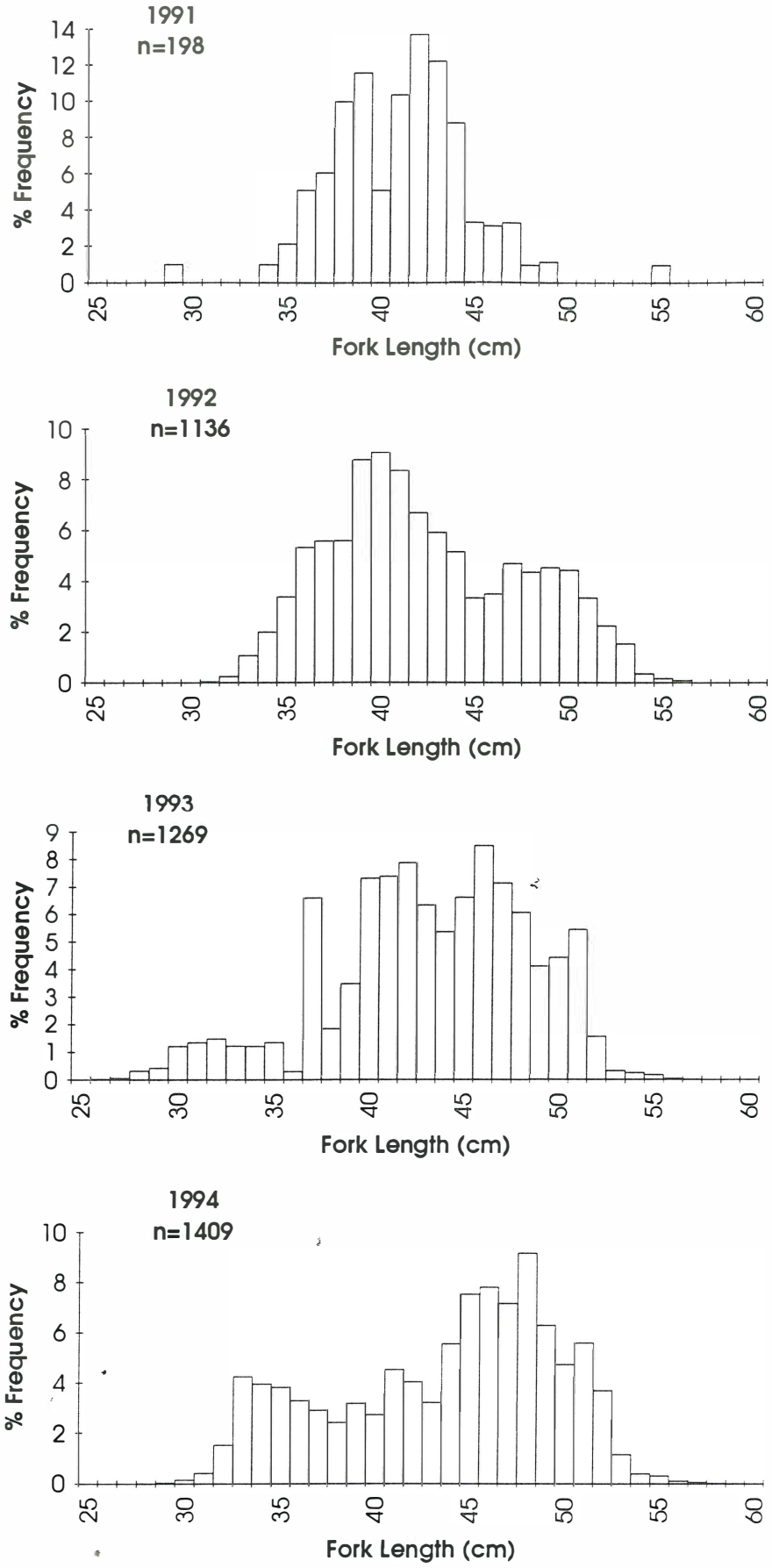


Figure 15 Percentage length-frequency distributions for spottec warehou caught by trawl, Portland.

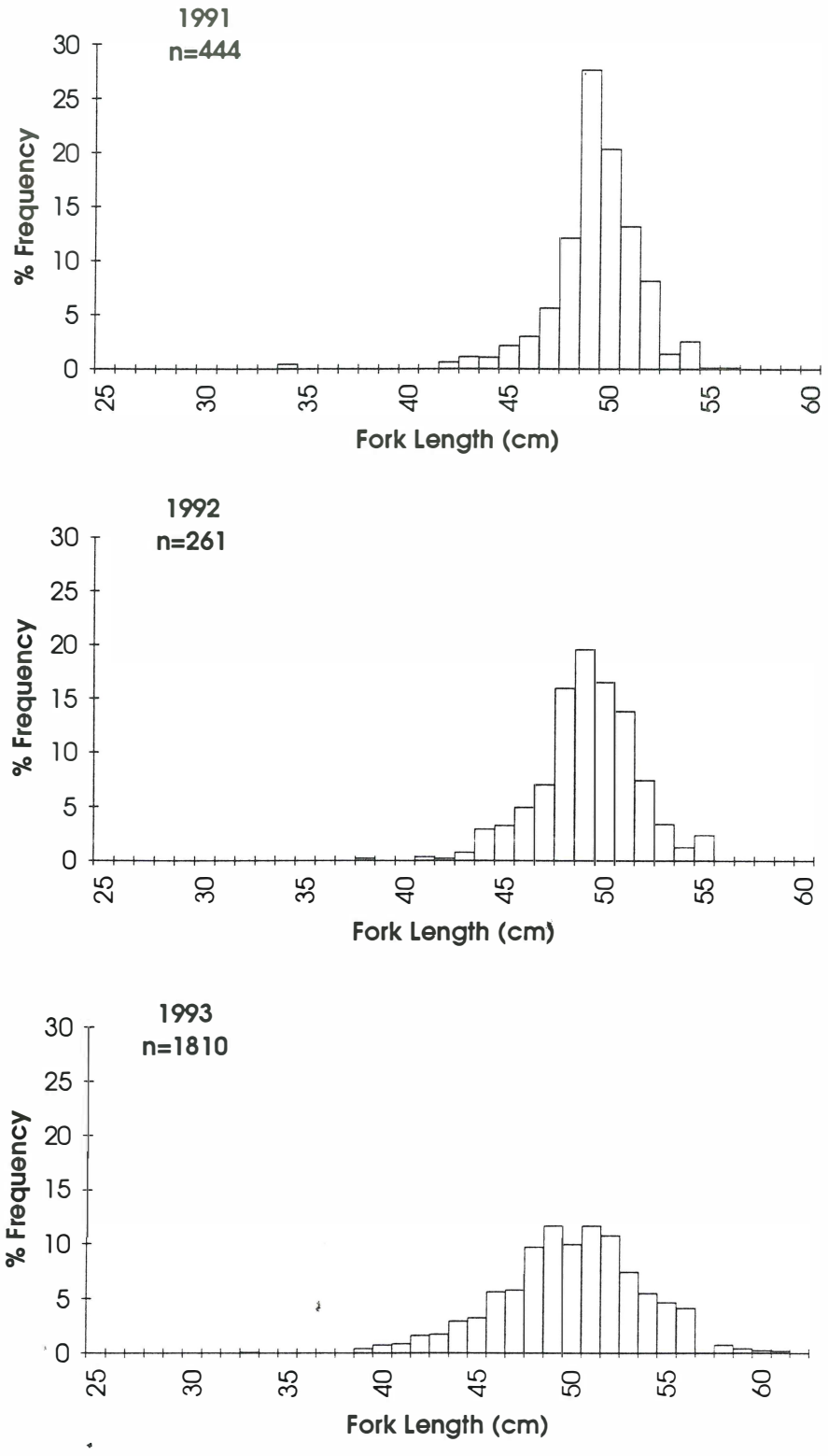


Figure 16 Percentage length-frequency distributions for spotted warehou caught by gillnet, Lakes Entrance.

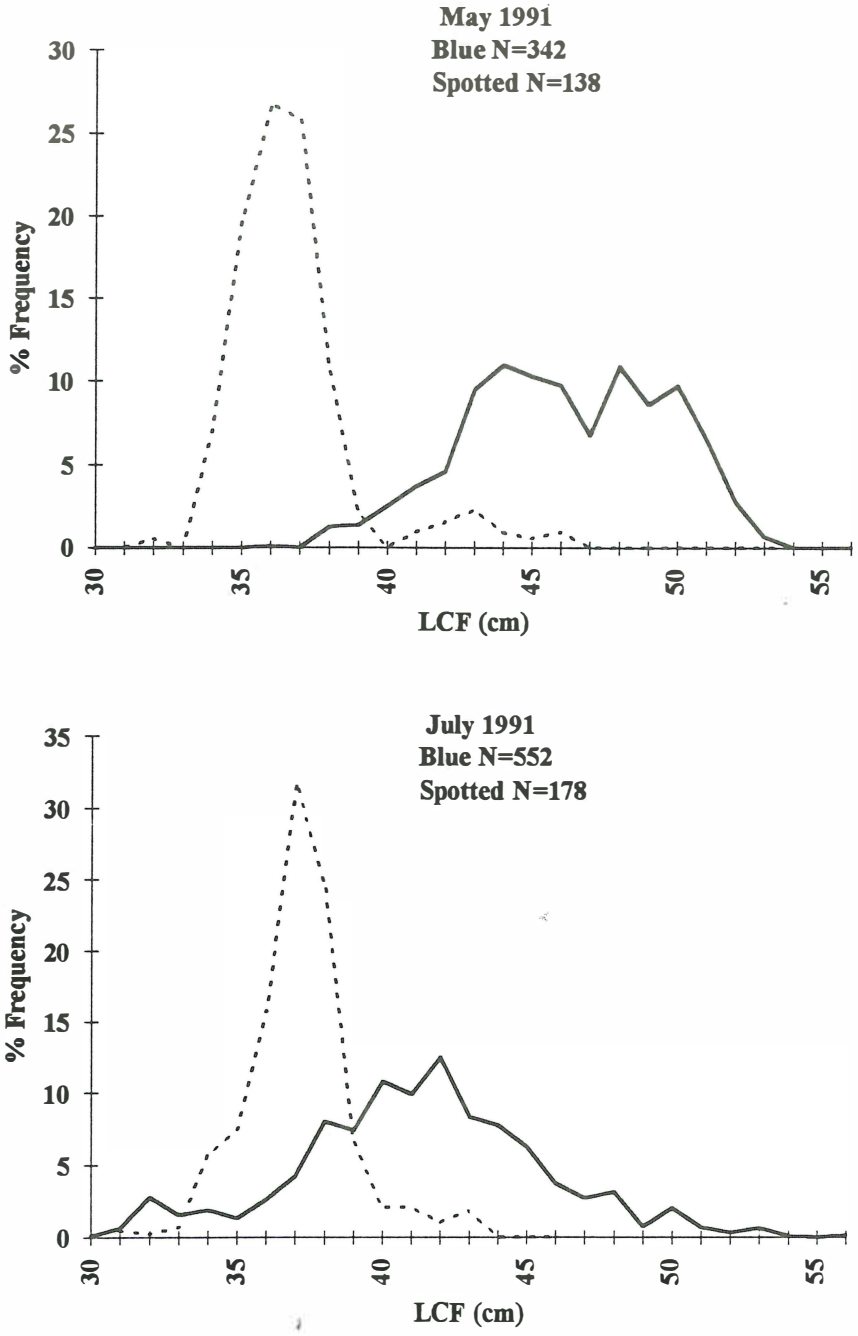


Figure 17 Percentage length-frequency distributions for blue warehou (solid line) and spotted warehou (broken line) sampled on-board, Portland trawlers 1991.

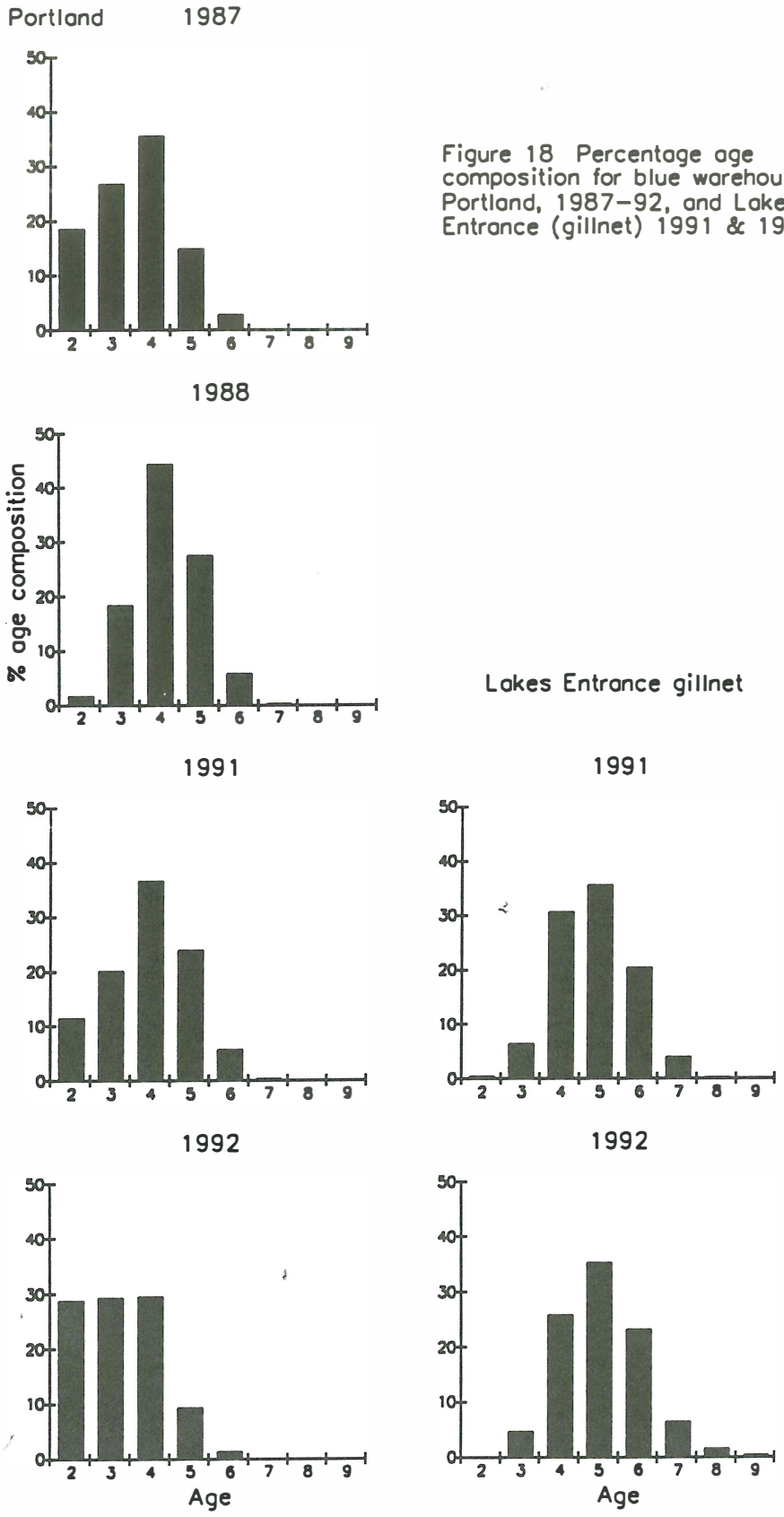


Figure 18 Percentage age composition for blue warehou, Portland, 1987–92, and Lakes Entrance (gillnet) 1991 & 1992.

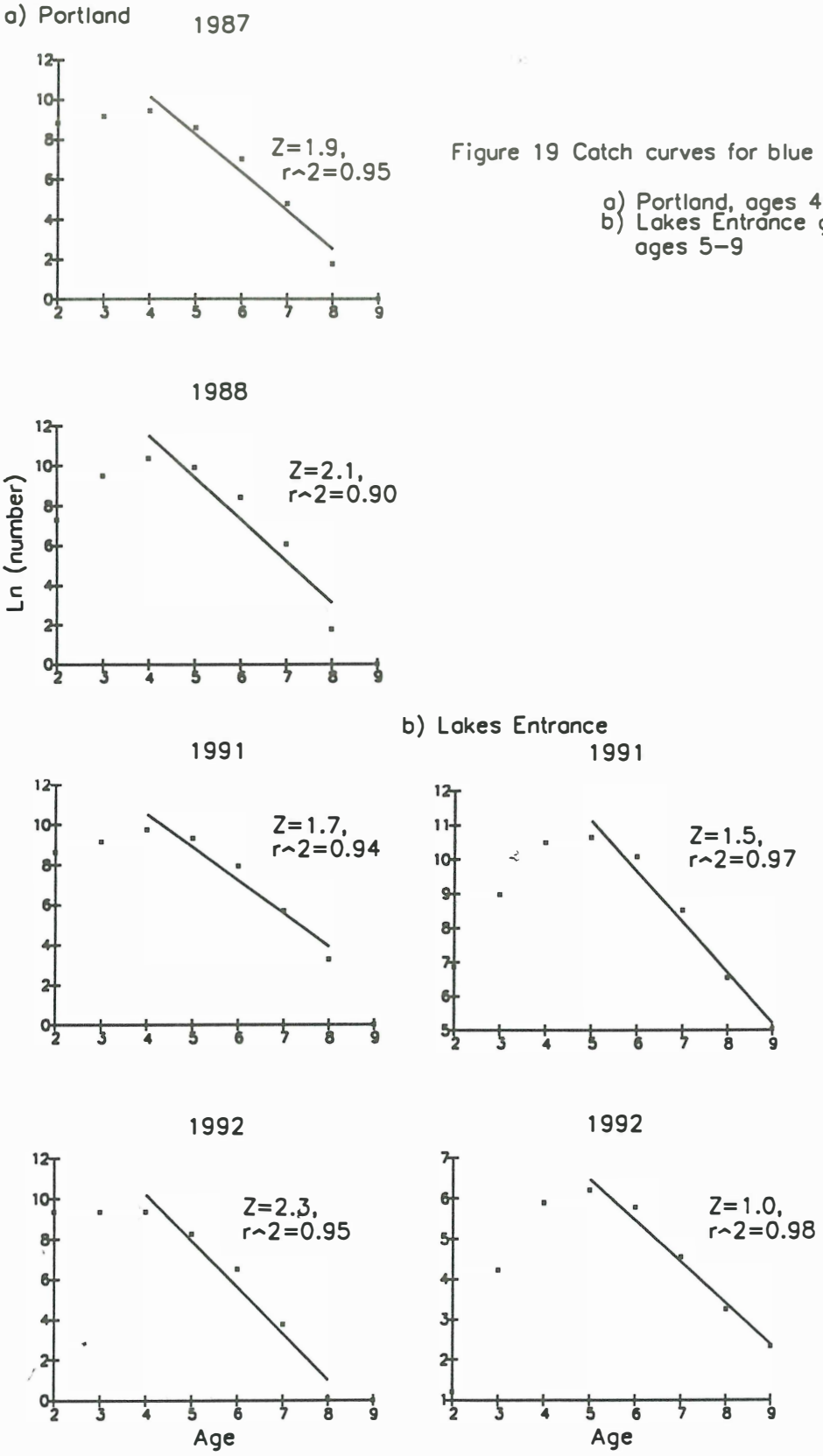


Figure 19 Catch curves for blue warehou.

a) Portland, ages 4–8
b) Lakes Entrance gillnet, ages 5–9

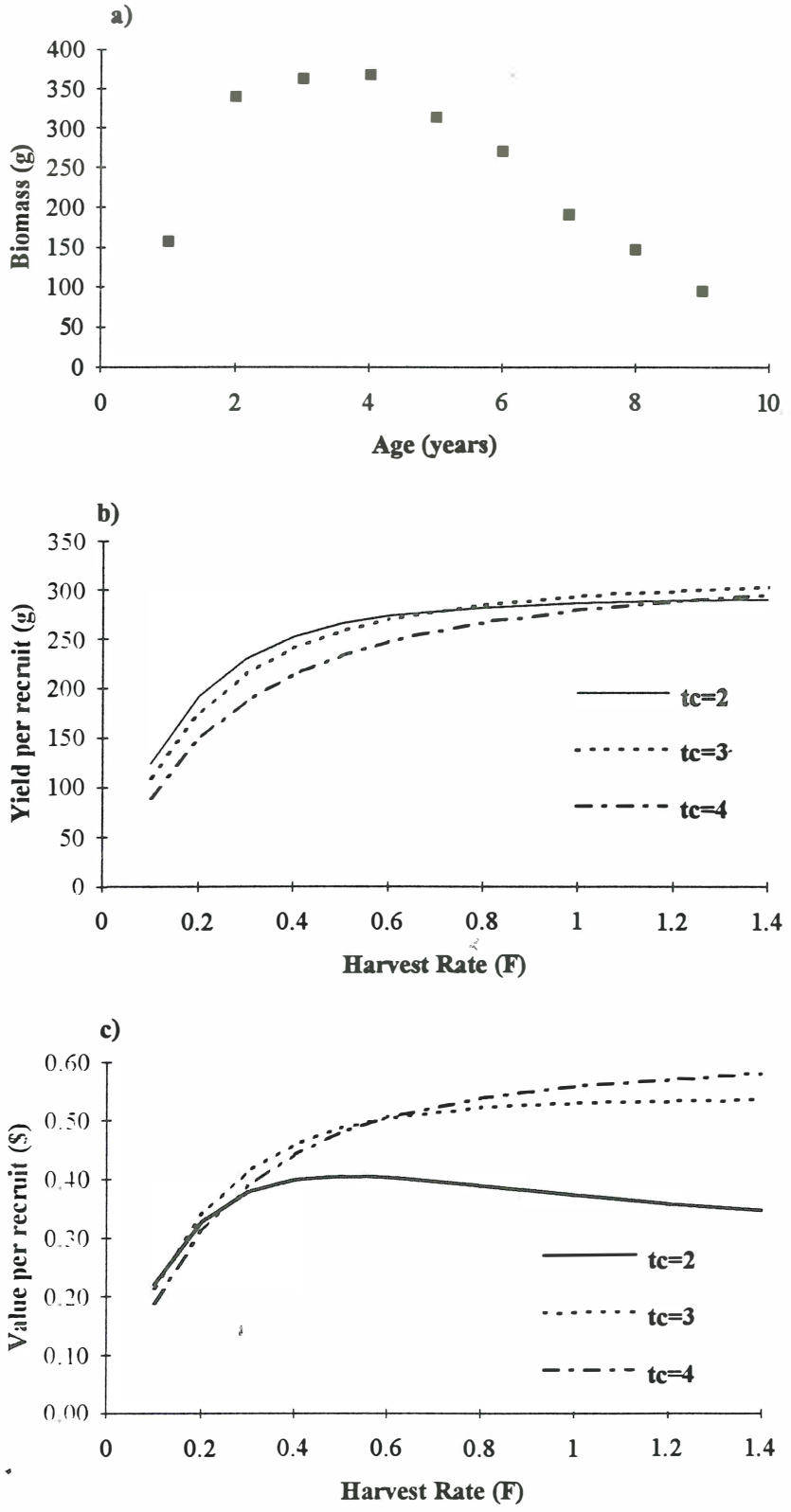


Figure 20 Yield per recruit analyses for blue warehou
(see text for details)

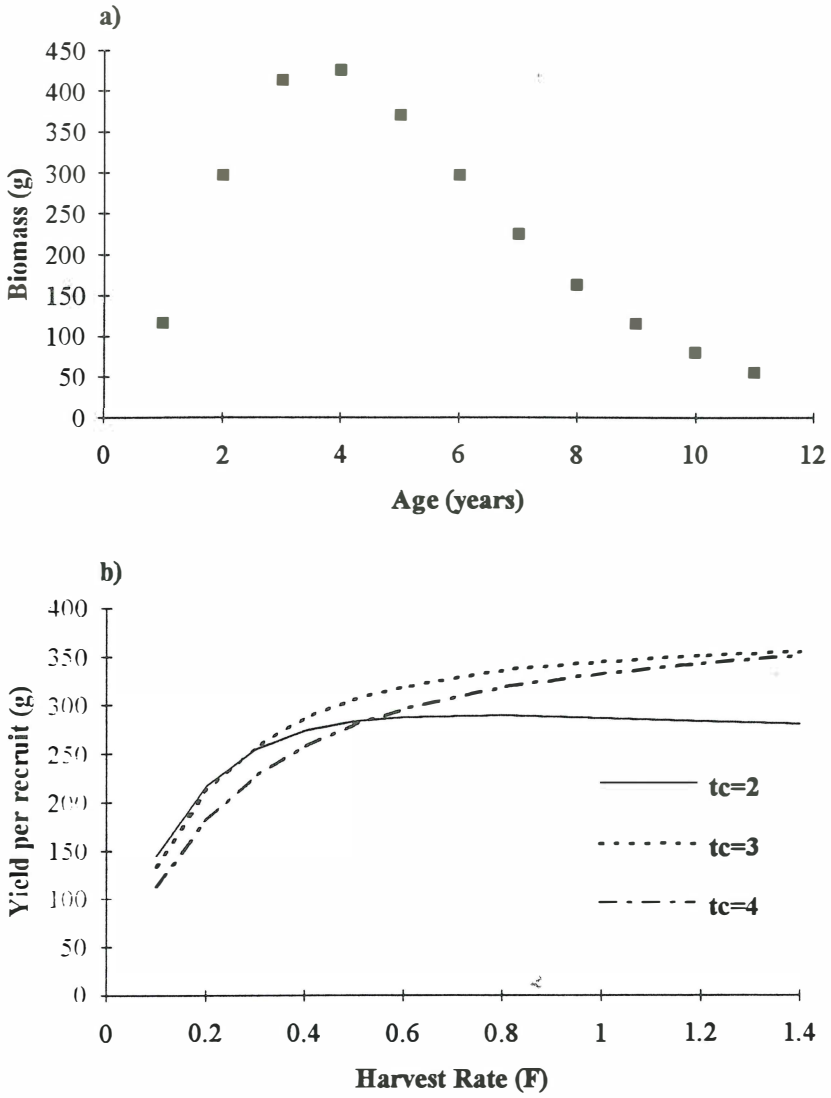


Figure 21 Yield-per-recruit for spotted warehou.
(see text for details)

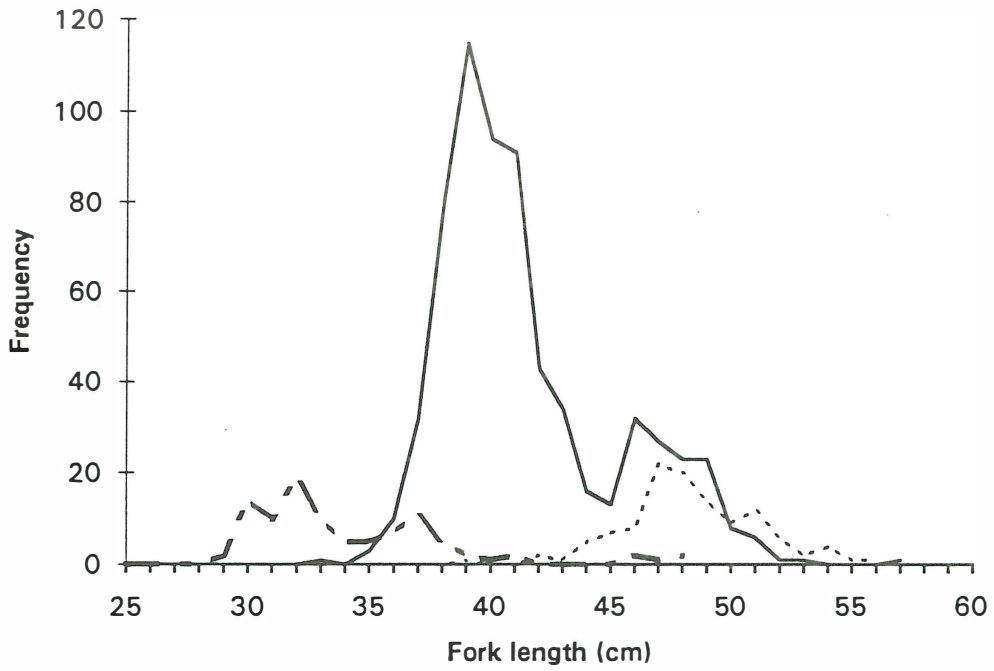


Figure 22 Length frequency distributions for blue warehou caught by gillnets with 4" (⊢ - -⊣), 5" (⊢——⊣) and 6" (- - -) meshes.

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