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A summary of biology and commercial landings, and a stock assessment of the sea perches, *Helicolenus* spp. (Scorpaenidae) in New Zealand waters

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This series documents the scientific basis for stock assessments and fisheries management advice in New Zealand. It addresses the issues of the day in the current legislative context and in the time frames required. The documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

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1. EXECUTIVE SUMMARY

"Sea perch" (in Australia "ocean perch") includes the shallow water *Helicolenus percoides* and the deeper water *H. barathri*, the latter with geographical colour variants around New Zealand.

About 75% of New Zealand's sea perch catch is taken as a bycatch in trawl fisheries off the east coast of the South Island, including the Chatham Rise. A small catch is made in some central and southern line fisheries. Landings have increased from 400 t in the early 1980s to 1600 t in the mid 1990s; an unknown quantity is discarded. In QMA 3 a competitive quota of 1000 t imposed in 1991 may shortly be reached if the increase in reported landings continues.

H. percoides would have been taken by Maori. In the recreational fishery *H. percoides* is a poorly recorded bycatch species; catch estimates range from 56 000 to 247 000 fish.

Sea perch are widely distributed around New Zealand but rare on the Campbell Plateau. *H. percoides* occurs out to at least 50 m, while *H. barathri* occurs from 40 to 1200 m.

Because of identification problems there is limited information on size ranges. Currently accepted maximum sizes are 45 cm for *H. percoides* and 56 cm for *H. barathri*. Trawl surveys show sea perch size to vary with depth and locality, and presumably with species and/or population and stock; a common size range is 20–30 cm, sometimes 25–40 cm.

Biological information is limited. Ageing studies have not identified the species involved, but the maximum age of fish assumed to be *H. barathri* is about 40 years. Sea perch are viviparous, extruding small larvae in floating jelly-masses during an extended spawning season. Sea perch are opportunistic feeders on or close to the seafloor.

Biomass values are available only for the Chatham Rise, six trawl surveys during the 1990s giving estimates of about 3000 t, with *c.v.*s between 9% and 14%.

Currently there is so little information available on sea perch that estimates of MCY are highly uncertain. No estimates of current biomass are available for any stock and it is not possible to estimate CAY.

Future sea perch catches will depend on the level of fishing activity for other targeted species, and over-catching the sea perch TACC may be difficult to avoid if this is set conservatively low in view of the limited information available. Targeted overfishing is unlikely.

2. INTRODUCTION

2.1 Overview

This document presents the currently available information on the "sea perches", *Helicolenus barathri* and *H. percoides*, and on their fisheries, and provides estimates of sustainable yield. The code for both species in research and fisheries databases is SPE. Almost the entire commercial catch is of the deepwater species *H. barathri.*

2.2 Description of the Fishery

Sea perch are principally taken as a bycatch in several trawl fisheries around central and southern New Zealand, principally off the east coast of the South Island. Small quantities are taken as bycatch in line fisheries for groper and ling. Recorded landings have increased from 400 t in the early 1980s to 1600 t in the mid 1990s. The quantity caught but discarded is not known.

2.3 Literature Review

"Sea perch" is the name given to at least two marine fish species of the family Scorpaenidae in New Zealand. Strictly speaking, this common name usage is incorrect. Scorpaenids are more properly called scorpionfishes; in the United States many are known as rockfishes. Atlantic species of *Helicolenus* are also known as rosefishes, to distinguish them from redfishes in the related genus *Sebastes*. The name "sea perch" is usually, and more correctly, given to several members of the family Serranidae, also known as serranids, groupers, or sea basses. The two "sea perches" included in this present study also occur around southern Australia, where they are most commonly known as ocean perches.

There are also difficulties with the scientific identity and nomenclature of these species. At present, two species are recognised: a shallow water species, *Helicolenus percoides* (Richardson, 1842), and a deepwater species, *H. barathri* (Hector, 1875). The former has sometimes been listed as *H. papillosus*, and the latter has — until Paulin (1989) — generally been regarded as a deepwater "form" of *H. percoides*, although potentially a different species (Paulin 1982, Ayling & Cox 1982, Paul 1986). Amaoka *et al.* (1990) recognised only one species, *H. percoides*, with *H. barathri* synonymised, but this account was presumably prepared before the work by Paulin (1989) became available. The "species" currently recognised as *H. barathri*, however, has a number of colour variants in the New Zealand region. These occur in different geographical regions: north, south, east, west, and Chatham Rise. It is not known whether these are simply colour "forms" of the same species, are subspecies, or true species. This difficulty applies to species of *Helicolenus* elsewhere in the world, notably *H. dactylopterus,* which appears to be separated into subspecies (Barsukov 1979, Johansen *et al.* 1993), and *H. lengerichi* and *H. maculatus*, which appear to be separated into populations (Kuderskaya 1979, Kotlyar 1988, Golovan' *et al.* 1991). However, the issue is far from resolved, and two points made by Eschmeyer & Hureau (1971), who believed all species, subspecies, and populations of *Helicolenus* to be closely related, remain to be clarified: (1) some of the colour differences may be depth related, red replacing brown in deeper populations, and (2) "A study of the *dactylopterus*-like populations off Chile and Peru, in the Orient, and especially in the Australian-New Zealand region is needed in order to determine if there is but a single species-complex composed of several populations and sub-species."

It is important that the true identity of New Zealand "sea perch" be clarified. At present there are two nominal species, *Helicolenus percoides* and *H. barathri*. Almost all published studies on sea perch distribution and biology do not identify which of these was involved. Consequently, it is not possible to incorporate biological parameters in stock assessment procedures with any certainty. Even if the commercial catch is predominantly the deeper water *H. barathri*, it is possible that there are regional populations or subspecies with quite different life history characteristics, particularly growth, size at maturity, and longevity.

There are numerous references to "sea perch", to *Helicolenus percoides*, or *Helicolenus* sp. (subsequently *H. barathri*) in the literature on New Zealand fish and fisheries, but very little that is comprehensive. Most accounts of *H. percoides* do in fact refer to that common shallow water species. A large number are listings, or very general accounts; of the latter Graham (1956), Paulin & Roberts (1992), and Francis (1996) are among the more useful. From the 1960s onwards, accounts of *H. percoides* taken during trawl surveys predominantly if not exclusively refer to *H. barathri*.

Australian accounts of ocean perch, assumed to be *H. percoides*, are also either brief or general. Kuiter (1993) described *H. percoides* as "brown to bright red, depending on depth" and its habitat as "deep rocky reefs, 30–800 m", but conceded that similar little-studied species are present. Gomon *et al.* (1994) stated "Only a single species is currently recognised in Australia, although observations indicate this may be a species complex", and illustrated shallow and deep water forms of *H. percoides*. By analogy with New Zealand the latter could be *H. barathri*, though the photograph is not convincing. A study of the age and growth of "*H. percoides*" by Withell & Wankowski (1988), described in the age and growth section below, was made of fish caught in 450 m and 650 m depths, and is undoubtedly of the deepwater form more likely to be *H. barathri* or a close variant.

There are no previous accounts of the fishery for sea perch in New Zealand, but there are useful accounts of the Australian fishery for ocean perch (*Helicolenus* spp.) Stewart (1993) and Park (1994).

In this account the term "sea perch" is used for both species. Where a single species is referred to, its scientific name is used. Separate common names are available, but their use is not uniform. The shallow water *Helicolenus percoides* is known variously as Jock Stewart (or Stuart) from its tartan-like colouring, highlander (similarly), scarpee (from scarpen for scorpion), scroddie (small worthless fish?), fivefinger (from the pectoral fin rays), soldier (supposedly from its 'on guard' appearance and brisk movements (Graham 1956)), and Maori chief (in common with other fishes, from its head markings). The deepwater *H. barathri* has been given the name bigeye sea perch by Paulin *et al.* (1989).

3. REVIEW OF THE FISHERY

3.1 The Commercial Fishery

3.1.1 Catches and landings

Sea perch have probably been landed in small quantities since commercial fishing began. Graham (1956) recorded sea perch, almost certainly *H. percoides*, in the Dunedin markets in the early 1930s, and commented that it was a good product either smoked or fresh, but was not popular, and in other parts of the country regarded as worthless. There are no published records of sea perch catches or landings before 1980, when Paul (1986) estimated the "landings" at 460 t. Small quantities of *H. percoides* have always been caught and sold in some localities, but recorded within the category 'mixed species' or 'other roundfish'. Some *H. barathri*, not recognised as different, would have been taken by domestic longliners targeting groper (*Polyprion* spp.) and ling (*Genypterus blacodes*). Larger quantities of *H. barathri* would have been caught by the larger vessels, initially foreign owned, which began trawling and longlining in deeper waters around New Zealand from the mid 1960s. Records from this period are incomplete, particularly for bycatch species such as sea perch. Some of this catch was presumably retained for the Asian market, but significant quantities would have been discarded.

Even after 1980 the records of sea perch catches and landings are incomplete and unreliable. It is not clear whether the data represent catches or "landings", and therefore how much is discarded. Although there is a recording category for "discards", this is unlikely to be completed for small quantities of bycatch species such as sea perch. In the fishing years 1994–95 and 1995–96 about 30 t was reported as discarded, most of this in a single month in one area. (An added disincentive for reporting discards in recent years is the requirement to pay a levy on total reported catch.) These small unreported catches by many vessels could, cumulatively, be quite important.

The data on sea perch landings are summarised in Table 1. No subdivision by species is possible, and despite their wide overlap in depth range (*see* Distribution, below) it has to be assumed that much, perhaps most, of the commercial catch is of the deepwater *H. barathri*. (The subdivision of FSU data into "inshore" and "deepwater" is an artefact, reflecting the category of record form used and not a fishing depth. It cannot be used to estimate the likely species composition of the catch. Similarly, CELR forms are used by vessels fishing in shallow water as well as those fishing at the shelf edge and beyond.)

In general terms, reported landings between 1982–83 and 1995–96 have been between 300 and 1600 t. The trend has been upward, with some fluctuations, although these probably reflect irregularities in reporting as well as differences in catch. The true catch has almost certainly been higher than reported landings, particularly in the 1980s; and some of the apparent increase in landings may only be an increase in reporting.

As far as can be determined, sea perch are taken as a bycatch. There is a very small catch reported as targeted, which may be an anomaly. From December 1994 to May 1997 there were 65 tows (TCEPR database) listing SPE as the target species, with a combined catch of c. 50 t of sea perch, about 1% of the total landings for this period. These were made mainly by one vessel, with a few by three other vessels. In most (55) tows sea perch was the main component of the catch. These apparently targeted tows may simply represent retrospective recording of the main or most conspicuous fish in the catch as the target species.

There is no reliable information on catch by method. However, trawling is certainly the main method, with a small quantity taken by longline, and in some localities a much smaller quantity taken by setnet.

Because of the way the commercial catch databases are structured (e.g., landings of all species are not reported by area caught) it is difficult to determine catch by area for the minor fish species such as sea perch. The available information (Table 2), suggests that 40–70% of the reported sea perch catch is taken in QMA 3, 20–30% in QMA 4, and less than 5% in each of QMAs 1+9, 2, 5+6, 7, and 8. That is, about 75% is caught along the east coast of the South Island and on the Chatham Rise.

There is no clear seasonal pattern of landings (Figure 1), as might be expected for a bycatch species. There are strong fluctuations, presumably reflecting activity in the several target fisheries in which it is caught; they are not regular, but there is often a winter peak which may correspond to the main season for hoki. The strongest and most regular seasonal fluctuations, however, occur in QMA 3, at least in the CELR data (Figure 2); catches in the west coast hoki fishery (QMA 7) are relatively small (Figure 2, *see* Table 2).

The distribution of sea perch catch by depth has not been analysed, as data are available from only part of the fishery (TCEPR records) and would be biased towards deeper fishing activity, and by the depth range of the various target species with which sea perch were caught. There is no reason to believe, however, that the depth range would differ from that established by research trawl surveys (*see* Distribution, below).

The Australian commercial fishery for ocean perch was described by Stewart (1993), Lyle & Ford (1993), and Park (1994). As in New Zealand, it developed in the mid 1970s as trawlers began working deeper grounds, and landings were distinguished from "other species" in the late 1970s. It is taken there as a bycatch in the trawl fisheries for ling, hoki, and prawns, and about 20% of the catch is targeted. From 1977 to 1993 reported catches in the main fishery (the Southeast Trawl Fishery) were 190–400 t (Park 1994), with a mean of 250 t. Ocean perch are considered moderately valuable, but some catch is still discarded at sea. A CPUE analysis of NSW vessels which consistently caught ocean perch has shown regional declines (Park 1994), and there has been an accompanying decrease in mean fish size (Lyle & Ford 1993, Park 1994).

3.1.2 Effort

Because sea perch are taken almost exclusively as a bycatch there is no useful information on fishing effort, and hence CPUE.

3.1.3 Management

There are few management measures in place. In central and southern QMAs (i.e., all QMAs except 1 and 9) sea perch are included within the list of non-ITQ species which may be taken subject to competitive or individual quotas and method restrictions. This currently applies only in QMA 3, where a competitive quota of 1000 t was imposed in 1991. Landings data, if they fairly represent actual catches, indicate that this limit has not yet been reached. However, if reported landings continue to increase at their present rate this quota could be reached within a few years.

3.2 Traditional Maori Fishing

There is no available information. The shallow water sea perch, *Helicolenus percoides*, has the recorded Maori name pohuiakaroa, and would undoubtedly have been caught — probably by line — and used. The deepwater *H. barathri* can be line-caught from deep coastal reefs and could have been taken, but in much smaller quantities.

3.3 Recreational Fishery

Sea perch are seldom if ever targeted by recreational fishers, being smallish, spiny, and providing small bony fillets. However, they are caught in large numbers by anglers fishing over reefs and along rocky coastlines. Some of this catch is used for bait, and most of the remainder discarded (some fishers may keep the larger fish, which are perfectly edible). There is probably a reasonable survival of the discarded fish.

Recreational fishing surveys do not appear to provide good estimates of the recreational sea perch "catch" (Table 3). There are problems of identification (other scorpaenids and small serranid sea perches), nomenclature ("perch", "rock cod", "Maori chief," etc.), and the probable omission of unwanted species from diary records. Approximations derived by summing regional surveys give a total of 247 000 fish, while a single nationwide survey gives a lower total of 109 000. This difference may reflect the difficulties experienced in estimating "recreational bycatch" species. Most of the recreational catch was in QMAs 3 and 7.

The recreational catch is predominantly the shallow water *H. percoides*, although *H. barathri* would be caught at deeper reefs in some localities. There is probably little overlap with the commercial fishery based mainly on *H. barathri.*

4. RESEARCH

4.1 Distribution

Sea perch have been recorded during trawl surveys over the continental shelf and slope right around New Zealand (Figure 3). They are widely distributed across the Chatham Rise, but are most common on the western and central Rise, particularly between 176°E and 179°E (Figure 4). They are only rarely present on the Campbell Plateau and Bounty Platform, presumably being confined to subtropical water and the Subtropical Convergence. Although the specific identity of these fish was not recorded at the time, it is probable that most were *H. barathri*. The two species overlap widely in their depth range, but their relative abundance at different depths is unknown. Paulin (1989) recorded the range of *H. percoides* as 4–850 m, *H. barathri* as 40–1070 m. However, Paulin & Roberts (1992) gave a more restricted range of 0–50 m for *H. percoides*.

There is a similar lack of information on the individual depth range of these two species or forms off southern Australia. Lyle & Ford (1993) reported the depth range of ocean perch as 14 to 1015 m, but uncommon beyond 800 m. The commercial catch is taken between 50 and 700 m (Park 1994), with the main grounds in 350–550 m. Stewart (1993) and Park (1994) described the "shallow form" [= *H. ?percoides*] as more common in waters less than 300 m, and the "deep form" [= *H. ?barathri*] in greater depths, but emphasised the uncertain identity of these two forms and consequent uncertainty in their individual depth ranges.

The overall depth range of sea perch in New Zealand trawl surveys is 20–1300 m. Their main range is 100–800 m, with their greatest abundance at about 400 m.

Both species are Australasian, but their presence at mid-Tasman islands and the presence of at least *H. barathri* in suitable depths on the shallower parts of the Lord Howe Rise and the Louisville Ridge remain uncertain. A species of *Helicolenus* was recorded at 100–800 m on the Wanganella Bank (West Norfolk Ridge) by Clark (1988), one of several fishes whose distribution "covered broad intermediate depths of 500–100 m", the others being shovelnose dogfish, silver roughy, and ribaldo.

4.2 Stock Structure

"Sea perch" comprises two species, with an undefined but apparently wide overlap in geographical and depth distribution. Each species has colour variants, but morphological characters which might distinguish populations have not been found (Paulin 1989). Separate "stocks" almost certainly exist, but they cannot yet be defined.

4.3 Fish Size

Because most general accounts of sea perch do not distinguish the species, there is limited reliable information on the size range of each. Paulin (1989) gave the size range of his identified material as *H. percoides* (n = 61) 48–339 mm SL [c. 6–41 cm TL], *H. barathri* (n = 45) 72–387 mm SL [c. 9–46 cm TL]. Paulin & Roberts (1992), however, gave the maximum size of *H. percoides* as only 22 cm. The maximum size of sea perch taken during trawl surveys is 56 cm.

Average sizes vary with depth and locality, and presumably with species and/or population and stock. A common size range is 20–30 cm, sometimes 25–40 cm.

Samples with one or two strong size modes between 10 and 25 cm are frequently caught. These probably represent immature age groups, but there are anecdotal accounts of "small fish" being observed in spawning condition. It is possible that there are dwarf populations, perhaps even a dwarf species, with quite different life history parameters to the two species as currently known.

The size structure of sea perch samples at 25 m depth intervals between 25 and 400 m in trawl surveys around the South Island shows no clear relationship between fish size and depth. However, the apparent presence of at least two species, and the possibility of a dwarf form, would confound detailed analysis.

However, some broad generalisations can be made for the species-complex (or whatever the taxonomic situation resolves as) recorded as "sea perch". Size frequency distributions are available for three regional series of trawl surveys in the 1990s, the Stewart-Snares shelf and surrounding slope, the east coast of the South Island, and the Chatham Rise (Figures 5–7). These figures show the unscaled size frequency distribution for each survey, the combined size frequency for the region, and the relationship between the depth range of trawl tows in the region and the overall pattern of depth distribution determined from all New Zealand trawl surveys catching sea perch.

The Stewart-Snares survey (Figure 5) extended to 600 m, but most tows were at less than 200 m, in the shallow part of the sea perch's depth range. The modal size of fish in each survey was at 30–35 cm, and smaller modes were present but not distinct. There were few fish over 40 cm, and the maximum size was 49 cm. Although fish as small as 10 cm are caught, there are no clear modes which could be interpreted as juveniles.

The east Coast South Island survey (Figure 6) was shallow, extending to 400 m with most tows at 100 m or less. The modal size of fish in each survey was generally between 20 and 25 cm, with a slightly larger second mode in the 1994 survey. There were few fish over 35 cm, and the maximum size was 49 cm. Although fish as small as 10 cm were caught, there were no modes which could be interpreted as juveniles.

The Chatham Rise survey (Figure 7) extended from 200 m to 800 m, covering the central depth range of sea perch. The size distribution of sea perch was broader than in the previous two regions, and was more variable between surveys. The main size range was 20–40 cm, with two or three variably distinct size modes within this range. There were still moderate numbers of fish at 45 cm, and the largest fish was 53 cm. In some surveys there were size modes between 10 cm and 25 cm which could represent juvenile age groups.

The Chatham Rise survey was the only one which sampled the main depth range of sea perch, and had a broad size range of fish which probably included juveniles (although the possibility of different species, perhaps including a dwarf one, cannot be ignored). The pattern of size distribution by depth is shown in Figure 8. In general terms, size increased with depth, although small fish (< 25 cm) remained present in moderate numbers to 500 m. The modal size increased from 25 cm in 200–300 m to over 35 cm in depths greater than 500 m, although the numbers (catch rate) of fish decline beyond this depth.

The Chatham Rise samples were also examined for any difference in size distribution by sex (*see* Figure 7). No difference is apparent in the combined sample of over 9000 fish, and the mean size of males and females was almost identical.

In Australia, ocean perch reach 47 cm, with commercial landings (in NSW) dominated by 20–40 cm fish, but with relatively more larger (35–45 cm) fish present off Tasmania where fishing pressure has been lighter (Lyle & Ford 1993).

4.4 Length-weight relationships

Length-weight relationships have been determined for several samples of sea perch taken during trawl surveys, as listed in Table 4.

Lyle & Ford (1993) provided the following relationship for Australian *Helicolenus*, both forms (and sexes, which were not significantly different) combined:

$$W = 1.81 \times 10^{-2} L^{2.977} \quad (n = 276, r^2 = 0.981)$$

4.5 Age and Growth

There are no published studies of the age and growth of New Zealand sea perch. However, an archived trawl survey dataset located during this study included age readings of almost 600 sea perch taken during a 1976 research survey off the South Island's west coast. These fish came from 16 tows between 200 and 600 m, and are likely to be mainly, if not completely, *H. barathri*. The size structure of this total sample was similar to that of many sea perch samples measured in more recent trawl surveys. The main series of 582 "successful" age readings are from otoliths, immersed in oil and read entire using reflected light. A subsample of 22 otoliths had been re-read using the break and burn technique, which has the advantage of clarifying the rings visible in cross-section.

The recorded ages ranged from 2 to 17, with ages 4 to 10 being most common, and age 4 dominant. The subsample of otoliths which had been broken and burned was recorded as providing essentially similar ages to the pair of each otolith read whole. In one case the broken and burned reading was significantly higher than the whole-otolith reading (11 cf. 7), but the other differences were only ± 1, over the age range 5 to 11.

This otolith sample was located and re-examined to verify the rather low ages recorded, in light of much greater ages reported in an Australian study of "*Helicolenus percoides*" (Withell & Wankowski 1988). The otolith subsample which had previously been broken and burned was re-read; for two otoliths the same count of rings or annuli was obtained 10 and 11, but for thirteen others the new count was 20–150% (mean 61%) higher. (Seven otoliths in this previously prepared subsample were missing.) The presumed reason for the higher count was the acceptance of almost all visible rings as annual. In some otoliths there was a grouping of the outermost rings in a pattern which could have been interpreted as split-rings, and when read as such would have given lower ages. In most otoliths, however, the rings, although narrowly spaced, were sufficiently regular and complete (the same sequence being visible on several parts of the otolith) to justify their acceptance as annual.

Because these otoliths came from fish which are only assumed to have been *H. barathri*, but which may have been from a mixture of the two species, it was not considered appropriate to spend further time on ageing them. However, it was decided to derive a more reliable estimate of the maximum age of New Zealand "sea perch". It was clear that the older (12+) otoliths in the original subsample displayed the feature typical of many fish species, with the outermost rings being restricted to the medial (sulcal) surface of the otolith, not visible to a reader examining the lateral surface. The otoliths from 16 fish over 40 cm in length were broken and burned, and read in cross-section under reflected light. Counts of 18 to 39 rings were obtained, the latter being considered reliable to ± 2.

Results of the 1976 ageing work, and the revised ageing of the 1976 sample, are shown in Figure 9. The means of the 1976 ages form almost a straight line between ages 2 and 13, which is an unlikely growth pattern. The revised (1997) ages, comprising the original subsample plus the fish over 40 cm, form a more realistic growth curve. It is still not convincing, there being a discrepancy between the smaller/younger and larger/older fish. This may simply be a result of the small (probably biased) sample, or it may be an indication that two species are involved.

The Australian study (Withell & Wankowski 1988) was of eastern Bass Strait ocean perch, taken in depths of 450 and 650 m, and thus presumably from the Australian deepwater form (= *H. ?barathri*). Whole otoliths submerged in water viewed with reflected light were considered to give reliable readings to about age 10, and thin cross sections viewed with transmitted light generally provided acceptable ring counts for older fish. Most of their fish were less than an assumed age of 20 years (validation by marginal-increment and length frequency modes was unsuccessful), but older fish including one of about 42 years were present. Von Bertalanffy parameters suggested that growth of the two sexes was very similar, but females attained "a slightly larger (maximum theoretical) length". Continuing Australian work reported on by Park (1994) suggests a maximum age of 30 years for the inshore form and 47 years for the offshore form.

In combination, New Zealand ages are similar to those from Australian "*Helicolenus percoides*". Mean lengths at age from the Australian fish (Withell & Wankowski 1988, table 8) are in reasonable agreement with the 1976 New Zealand ages until about age 10, though forming a realistic growth curve rather than a straight line, and from age 15 to 30 are close to the 1997 New Zealand values.

Although further work on properly identified fish is clearly required in Australia and New Zealand, some general conclusions can be drawn from existing information. Sea perch are relatively slow growing and at least one species reaches a maximum age of about 40. Fish in the main size range of 20–30 cm are probably 5–20 years old, and the larger sea perch (30–50 cm), presumably of greatest commercial value in the fishery, are 10–40 years old. These moderately high ages are not surprising, given the longevity (50 to 100 years) and slow growth of a number of species in the related genus *Sebastes* (Bennett *et al.* 1982, Campana *et al.* 1990, Leaman 1991).

4.6 Reproduction

Fishes in the family Scorpaenidae are reproductively diverse; most subfamilies are oviparous, the normal teleost condition, while members of subfamily Scorpaenidae, to which the *Helicolenus* sea perches belong, are viviparous (Krefft 1961, Boehlert & Yamada 1991). They typically release fertilised eggs or developing larvae in a gelatinous and buoyant "egg mass".

Thomson (in Thomson & Anderton 1921) recorded the viviparity of *H. percoides*. Graham (1939b, 1956) also observed an aquarium-held *H. percoides* extrude jelly-like material which floated to the surface and dissolved to release some 90 000 small larvae. He suggested an extended spawning season, based on the presence of separate batches of eggs and all larval stages in single ovaries, and the occurrence of mature fish (though small numbers) in February, June, September, and December. Eggs and/or larvae were described and illustrated by Thomson & Anderton (1921) and Graham (1939b, 1956). Paulin & Roberts (1992) recorded a breeding season from early winter to late summer, possibly based on these observations. Graham (1956) and Paulin & Roberts (1992) stated that *H. percoides* is hermaphroditic, but provided no evidence for this. It is more likely that internal fertilisation occurs following courtship, as described or assumed for species of *Sebastes* (several papers in Boehlert & Yamada 1991). No information is available on the reproduction of *H. barathri* in New Zealand waters.

In Australia, work on reproduction in the two forms of *Helicolenus* was in progress when described by Lyle & Ford (1993) and Park (1994). Maturity was assumed from gonadosomatic indices to occur at about 30 cm. Mating in the inshore form was inferred to occur in June, and one to two months later in the offshore form, with development of the fertilised ova peaking in spring. The time of spawning was not recorded, but it was noted that the inshore fish retained larvae longer and until more fully developed than did the offshore fish.

4.7 Sex Ratios

The male to female sex ratio in the 1976 aged sample (233 fish sexed of 582) was 1 to 1.18, males to females. However, the sex ratio of fish used to derive length-weight relationships in trawl survey samples (Table 4) ranges from 1 to 0.67 to 1 to 0.93, the mean of these eight surveys being 1 to 0.83. This proved to be identical to the total number of fish sexed during these surveys. To check that it was not influenced by biased sexing of immature fish, i.e., some immature females being identified as immature males, sex ratios were calculated only for fish over 30 cm, the size assumed for maturity. This also gave a mean ratio of 1 to 0.83, males to females.

4.8 Feeding

Little information is available on the food of New Zealand *Helicolenus* spp. Graham (1939a, 1956) stated that the main diet of fish caught inside and outside Otago Harbour (presumably *H. percoides*) was benthic crustaceans, with small fishes sometimes taken. In captivity they were voracious feeders on fish scraps. Species of *Helicolenus* studied elsewhere have been predominantly benthic feeders, principally on crustaceans and fish (Froglia 1976, Kuderskaya 1980, MacPherson 1979, 1985). Seamount-dwelling *H. lengerichi* were found to feed predominantly on mesopelagic fishes (Golovan' *et al.* 1991), presumably because their elevated position placed them within this habitat. Kuderskaya (1980) recorded large *H. tristanensis* feeding mainly on pelagic tunicates, although this did not necessarily imply feeding far above the seafloor. It appears that *Helicolenus* are essentially opportunistic feeders on or very close to the seafloor.

4.9 Movement and Behaviour

Nothing is known of sea perch movements. It is assumed that they live on the seafloor itself, from their squat body form, large pectoral fins with free lower rays (used as "props"), and from observations of *Helicolenus percoides* in aquaria (Graham 1956) and of *H. lengerichi* on seamounts of the Nazca Ridge (Golovan' *et al.* 1991). As adults, they seem unlikely to undertake extensive movements. This may be one reason for the observed geographic difference in the colour pattern of populations, although other differences have yet to be demonstrated. Although viviparous, the larvae (of *H. percoides* at least) expelled in spawning are at a very early developmental stage and would presumably be subject to the same general processes as the eggs and larvae of most marine fishes, resulting in reasonably wide dispersal of juveniles.

5. STOCK ASSESSMENT

5.1 Biomass Estimates

This is the first stock assessment for sea perch.

The biomass estimates obtained from trawl surveys around the South Island are listed in Table 5. The estimates from the west and east coasts of the South Island, and the Stewart-Snares shelf, have high *c.v.*s and are derived from surveys which are strongly biased towards the shallowest end of the sea perch's distribution (*see* **4.3**). The surveys were not optimised for sea perch, and it is not possible to derive regional biomass values from them. It is not possible to compare the results from different vessels and from different seasons. All that can be concluded is that there is a greater biomass off the east coast of the South Island than in the other two regions. The Chatham Rise surveys cover the main depth distribution of sea perch, and although not optimised for this (or these) species have a reasonably low *c.v.* and (with one outlier) indicate a biomass on the surveyed area of the Rise of about 3000 t. The series of trawl surveys from 1994 to 1997 (*see* Figure 4) suggests a contraction of the area on the Rise where sea perch are most abundant, but the time series is too short for this to be considered as more than an appropriate topic for further investigation (earlier trawl surveys have been undertaken but it is not clear whether they are comparable), and future monitoring is recommended.

There is, however, no evidence that current levels of fishing have reduced the biomass of "sea perch" around the South Island and on the Chatham Rise as measured by the trawl surveys between 1991 and 1997 (*see* Table 5).

5.2 Estimation of Maximum Constant Yield (MCY)

Currently there is so little information available on sea perch that estimates of MCY are highly uncertain. However, a simple procedure for estimating MCY, i.e., MCY = cY_{av} (Method 4 in Annala & Sullivan 1997), could perhaps be applied to the post-QMS (1986–87 to 1995–96) sequence of reported landings (*see* Table 1). These average 1041 t, but it is very uncertain that they represent the real catch, the actual removals from the stock. Estimating the constant c is also difficult. An approximation can be derived if natural mortality (M) is known, but for sea perch this can only be estimated from the equation $M = \log_e(p)/A$, where p is the proportion of the population that reaches age A (Annala & Sullivan 1997). This can alternatively be stated as $M = \log_e(100)/A_{max}$, where A_{max} is the age reached by 1% of the population (Sparre *et al.* 1989). The maximum age is not clearly known for any defined species of New Zealand *Helicolenus*, but may be about 40 years (*see* **4.5** above). If A_{max} is assumed to be between 30 (as suggested for *H. percoides* by Park (1994)) and 50 years (Park (1994) suggests 47 years for the Australian offshore form (*H. ?barathri*), this gives a range of M between 0.09 and 0.15. This method of estimating MCY also requires reliable information on changes in fishing effort and/or mortality over the history of the fishery.

As each step of this procedure involves unacceptable uncertainty, MCY for sea perch cannot be determined. *As an exercise only*, accepting the mean catch value of 1041 t, and a c of 0.9 (from M = 0.09–0.15) gives a provisional MCY of 937 t.

An alternative procedure, Method 2 (for developed fisheries with historic estimates of biomass) in Annala & Sullivan (1997) was considered for the Chatham Rise fishery. This procedure requires an average historic recruited biomass, and a fishery which is assumed to have been fully exploited, i.e., with fishing mortality near the level that would produce the MAY (long-term average annual catch). Total biomass values for the Chatham Rise, averaging about 3000 t, are available for 1991 to 1997, but the proportion which would be considered "recruited" is not clear as the size and age structure of the commercially exploited population is not known. Although the biomass estimates have remained reasonably stable for 7 years, this is not considered to be long enough given the history of exploitation of the Chatham Rise (from at least the early 1980s) and the apparent longevity of sea perch (about 40 years). It is not known whether sea perch have been under-, fully, or over-exploited, as they have historically been a poorly-recorded bycatch over most of this region's fishing history. Despite some biomass estimates, it is not appropriate to use this procedure for estimating MCY for Chatham Rise sea perch.

5.3 Estimation of Current Annual Yield (CAY)

No estimates of current biomass are available for any stock and it is not possible to estimate CAY.

5.4 Factors Modifying Yield Estimates

Factors influencing yield estimates (species identification, catch history, biomass estimates, longevity/mortality, natural fluctuations in population size) are so poorly known for sea perch that they preclude any reliable yield estimates at the present time.

6. MANAGEMENT IMPLICATIONS

Sea perch will almost certainly remain as a bycatch "species", and moderately important only on the east coast of the South Island and the Chatham Rise. Catch levels will largely be determined by the level of fishing activity for the more valuable target species sought in this region, and thus considerably dependent on the catch levels (TACCs) set for them. Unless there is at-sea monitoring, or there is a market incentive to land sea perch despite any over-catch penalties, catches seem likely to be discarded when vessel or company quotas have been exceeded.

Because at-sea discarding and underreporting or misreporting has almost certainly occurred in most years, the recorded catch histories of fishers may understate the level of catch they will make once sea perch enters the QMS. This will probably affect all categories of participants in the fishery, from large trawlers to coastal line-fishing vessels.

The choice of Fishstock boundaries has not been addressed in this document. Sea perch, taken as bycatch, could be subjected to localised depletion during heavy target fishing for other species; the existence of sea perch Fishstock boundaries is unlikely to prevent this. To minimise the discarding and/or misreporting of sea perch it may be necessary to have only one Fishstock against which any quota is counted. Establishing regional Fishstock boundaries may become more appropriate, once the identity of sea perch species, subspecies, or separate "stocks" is properly established, and the regional distribution of commercial catches is more accurately known.

The level of risk to the stock by harvesting sea perch at recent catch levels cannot be determined. It is not known if recent catch levels are sustainable or at levels that will allow the stock to move towards a size which will support the MSY. However, there is no evidence that current levels of fishing have reduced the biomass of sea perch around the South Island and on the Chatham Rise as measured by the trawl surveys between 1991 and 1997.

7. ACKNOWLEDGMENTS

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Table 1: Reported landings (t) of sea perch by fishing year, from various sources. FSU, Fisheries Statistics Unit; CELR, catch, effort and landing return; TCEPR, trawl, catch, effort and processing return; CLR, catch landing return; LFRR, licensed fish receivers return. Fishing years are from 1 October to 30 September. This table follows the standard format for documentation of proposed new QMS species; – indicates that there are no relevant data for these columns. From 1982–83 to 1987–88 the FSU_{Total} values were used as the "best estimate". For the transitional year from FSU to the Quota Management System (QMS) data, 1988–89, the best estimate is the sum of the FSU and Licensed Fish Receivers Return (LFRR) data. From the 1989–90 fishing year onwards, the best estimate is the greater of either the LFRR or the sum of the Catch Landing Return (CLR) and the Catch, Effort, and Landing Return ($CELR_{Landed}$) data; the latter was used for 1994–95 and 1995–96

Year	FSU Inshore	FSU Deepwater	FSU Total	CELR Estimated	CELR Landed	TCEPR Estimated	TCEPR Processed	CLR	LFRR	Best estimate
1982–83	44	356	400	–	–	–	–	–	–	400
1983–84	50	238	288	–	–	–	–	–	–	288
1984–85	229	204	433	–	–	–	–	–	–	433
1985–86	235	380	615	–	–	–	–	–	–	615
1986–87	453	390	843	–	–	–	–	–	794	843
1987–88	351	375	726	–	–	–	–	–	1 198	726
1988–89	161	206	367	33	37	30	3	59	674	1 041
1989–90	–	–	–	244	239	291	296	329	746	746
1990–91	–	–	–	191	187	298	330	402	721	721
1991–92	–	–	–	284	309	495	342	686	1 027	1 027
1992–93	–	–	–	394	477	365	309	624	1 172	1 172
1993–94	–	–	–	460	587	269	180	360	968	968
1994–95	–	–	–	402	432	399	280	1 226	1 198	1 658
1995–96	–	–	–	342	494	433	358	1 016	1 195	1 510

Table 2: Reported landings (t) of seaperch, 1982–83 to 1995–96 (October to September fishing years), by QMA. Source: for fishing years 1982–83 to 1988–89, FSU Inshore (SPE + RRC) + Deepwater (SPE) data; for fishing years 1988–89 to 1994–95, QMS ($CELR_{estimated}$ + $TCEPR_{estimated}$) SPE data; for fishing years 1995–96 and 1996–97, QMS non-ITQ LFRR summaries. Values for 1988–89 were combined from FSU and QMS data. Note: the QMA values for 1982–83 to 1994–95, being estimated, do not sum to the full New Zealand total (taken from the "Best estimate" column in Table 1); the 1995–96 and 1996–97 data are total QMA values

QMA	?	1	2	3	4	5+6	7	8	9	QMA total	New Zealand total
1982–83	9	17	9	95	113	113	29	3	<1	389	400
1983–84	9	14	2	150	58	36	16	2	55	342	288
1984–85	18	10	2	290	70	26	14	1	2	433	433
1985–86	122	14	2	213	218	28	12	2	4	615	615
1986–87	211	19	2	507	71	19	11	3	1	844	843
1987–88	65	20	1	544	63	18	8	6	<1	726	726
1988–89	90	14	1	262	36	18	5	2	1	429	1 041
1989–90	38	2	6	287	177	9	14	1	<1	535	746
1990–91	6	4	9	256	202	10	3	1	<1	490	721
1991–92	6	8	7	406	337	10	7	<1	0	779	1 027
1992–93	2	9	13	473	235	16	8	3	<1	759	1 172
1993–94	2	6	43	517	126	14	19	2	<1	729	968
1994–95	6	12	27	449	180	15	38	73	<1	801	1 658
1995–96	17	24	51	1 017	290	56	85	7	2	1 548	1 510
1996–97	11	17	77	606	408	41	61	6	1	1 228	–

Table 3(a): Estimated number of sea perch harvested by recreational fishers by QMA and survey, and the corresponding QMA (potential harvest). The latter is given only as fish numbers; mean weights are not yet available from which to calculate a tonnage. Surveys were carried out in different years in the Ministry of Fisheries regions: South in 1991–92, Central in 1992–93, and North in 1993–94. The estimated harvest by QMA is indicative only, and was made by combining estimates from the different years

QMA	Survey	Number caught	*c.v.* (%)	QMA harvest (no.)	QMA
QMA 1 + 9	North	< 500	–	< 500	1+9
QMA 2	North	< 500	–		
QMA 2	Central	27 000	–	27 000	2
QMA 8	North	< 500	–		
QMA 8	Central	11 000	–	11 000	8
QMA 7	Central	65 000	40		
QMA 7	South	16 000	–	81 000	7
QMA 3	Central	< 500	–		
QMA 3	South	110 000	25	110 000	3
QMA 5	Central	< 500	–		
QMA 5	South	18 000	35	18 000	5
Total		247 000		247 000	

Table 3(b): Estimated number of sea perch harvested by recreational fishers by QMA, provisional values from a Ministry of Fisheries nationwide telephone survey and diary scheme in 1995–96. (Source: E. Bradford, unpubl. results.)

QMA	Number caught	*c.v.* (%)	QMA harvest (t)
1 + 9	2 000	–	–
2	25 000	–	–
8	11 000	–	–
7	40 000	17	21 (15–25)
3	28 000	17	17 (10–25)
5	3 000	–	–
Total	109 000		

Table 4: Length-weight relationships published for sea perch sampled during recent trawl surveys. The parameters describe the equation in the form $W = a.L^b$, where W is weight (g) and L is total length measured to the nearest centimetre below (cm). Sample sizes (n), length ranges, and sex ratio (where provided) are listed

Survey	a	b	n	Size range	Sex ratio M : F	Source
Stewart–Snares Shelf						
TAN9301	.0120	3.14	107	18–40	–	Hurst & Bagley 1994
TAN9402	.0087	3.24	268	16–56	1 : 0.79	Bagley & Hurst 1995
TAN9502	.0115	3.15	287	15–48	–	Bagley & Hurst 1996a
TAN9604	.0118	3.15	448	15–48	–	Bagley & Hurst 1996b
East Coast South Island						
KAH9105	.001902	3.64570	80	15–40	1 : 0.81	Beentjes & Wass 1994
KAH9205	.005791	3.3106	166	16–40	1 : 0.93	Beentjes 1995
KAH9618	.0262	2.92	210	07–42	–	Stevenson 1997
Chatham Rise						
TAN9212	.01005	3.133	224	12–48	1 : 0.91	Horn 1994
TAN9401	.012401	3.067271	194	14–46	1 : 0.93	Schofield & Horn 1994
TAN9501	.010740	3.101218	232	16–49	1 : 0.78	Schofield & Livingston 1995
TAN9601	.007767	3.219132	453	17–49	1 : 0.85	Schofield & Livingston 1996
TAN9701	.005876	3.299961	101	17–38	1 : 0.67	Schofield & Livingston 1997

Table 5: Estimated biomass (and *c.v.* %) of sea perch from recent South Island and Chatham Rise trawl surveys. Values from different vessels, and different times of the year, are not strictly comparable

Region	Survey	Date	Season	Biomass (t)	*c.v* (%)
West coast, South Island	KAH9204	Mar-Apr 1992	Autumn	293	24
	KAH9404	Mar-Apr 1994	Autumn	510	18
	KAH9504	Mar-Apr 1995	Autumn	667	23
	KAH9701	Mar-Apr 1997	Autumn	338	14
Southland (Stewart-Snares shelf)	TAN9301	Feb-Mar 1993	Summer	469	33
	TAN9402	Feb-Mar 1994	Summer	443	26
	TAN9502	Feb-Mar 1995	Summer	450	27
	TAN9604	Feb-Mar 1996	Summer	480	29
East coast, South Island	KAH9105	May-Jun 1991	Winter	1 802	30
	KAH9205	May-Jun 1992	Winter	2 288	27
	KAH9306	May-Jun 1993	Winter	3 348	30
	KAH9406	May-Jun 1994	Winter	2 327	29
	KAH9606	May-Jun 1996	Winter	1 671	26
	KAH9618	Dec-Jan 1996–97	Summer	4 041	47
	KAH9704	Dec-Jan 1997–98	Summer	1 638	25
Chatham Rise	TAN9106	Dec-Jan 1991–92	Summer	3 050	12
	TAN9212	Dec-Jan 1992–93	Summer	3 110	9
	TAN9401	Jan 1994	Summer	3 914	11
	TAN9501	Jan 1995	Summer	1 490	9
	TAN9601	Jan 1996	Summer	3 006	10
	TAN9701	Jan 1997	Summer	2 713	14

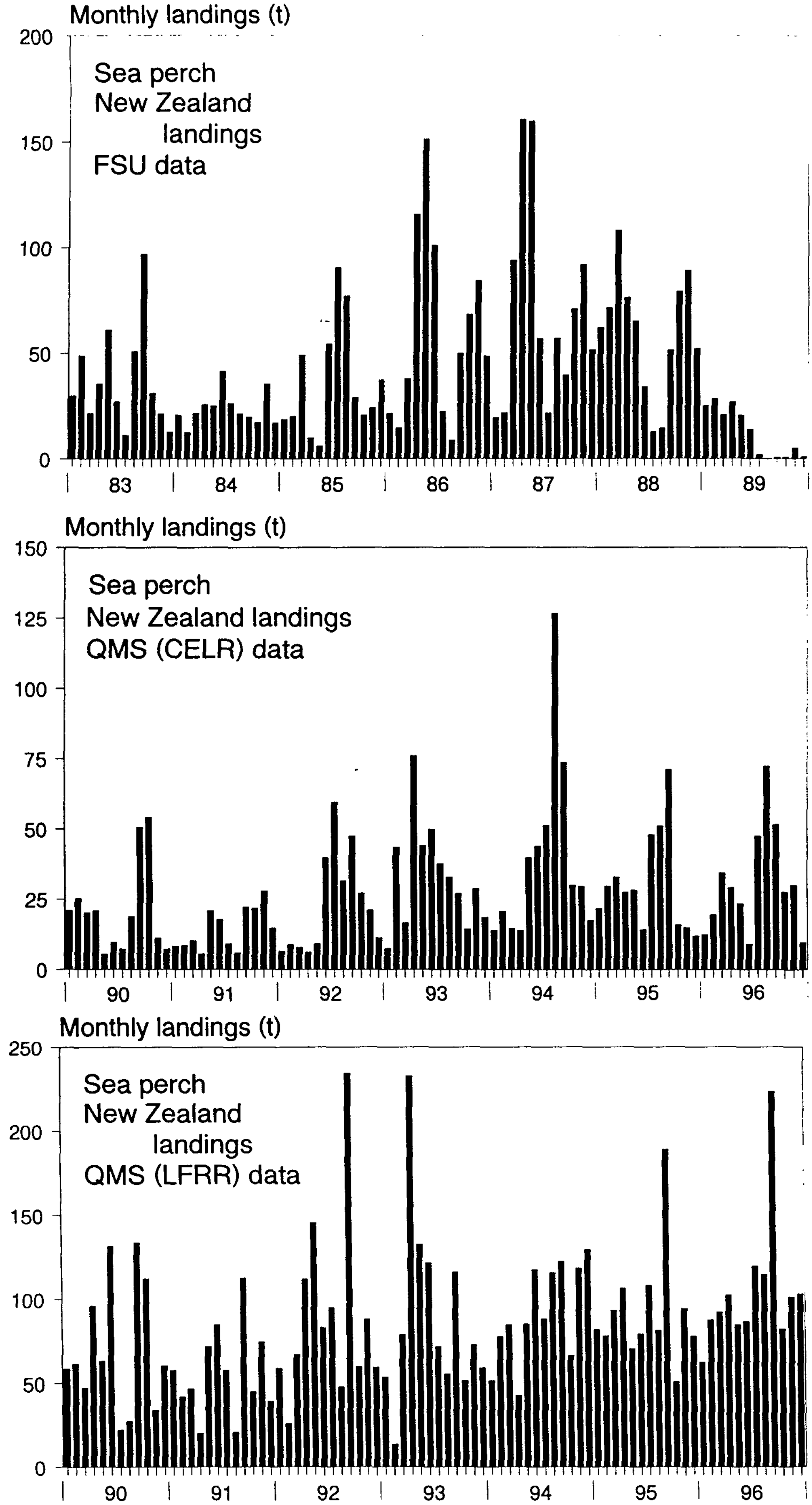

Figure 1: Reported total monthly landings (t) of sea perch for New Zealand, 1983 to 1996. (Top) FSU data, 1983 to 1989. (Centre) QMS CELR$_{estimated}$ data from coastal vessels, 1990 to 1996. (Bottom) QMS LFRR data from licensed fish receivers (wholesalers and processors), 1990 to 1996.

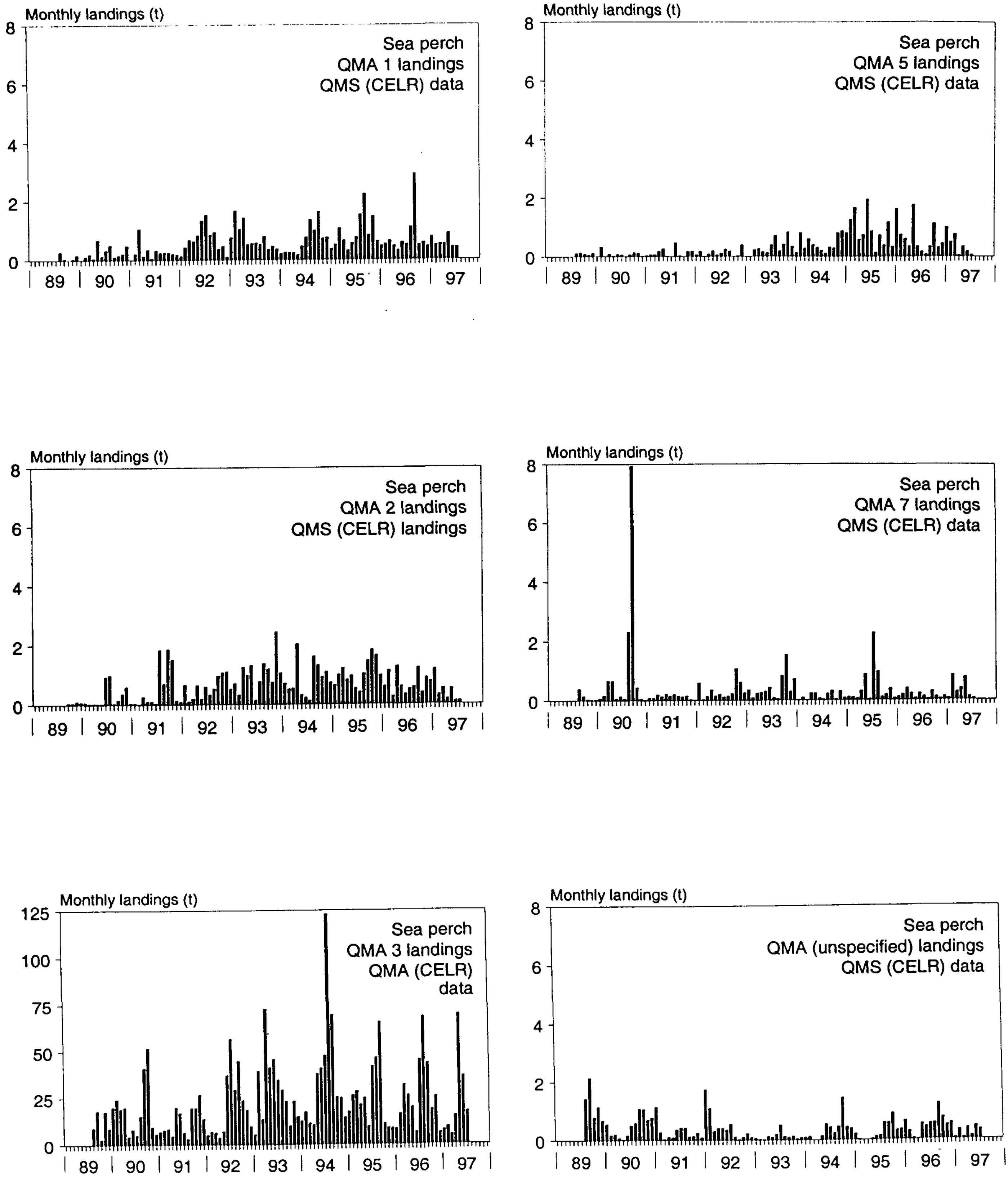

Figure 2: Reported total monthly landings (t) of sea perch by QMA, 1989 to 1997. QMS $CELR_{estimated}$ data from coastal vessels.

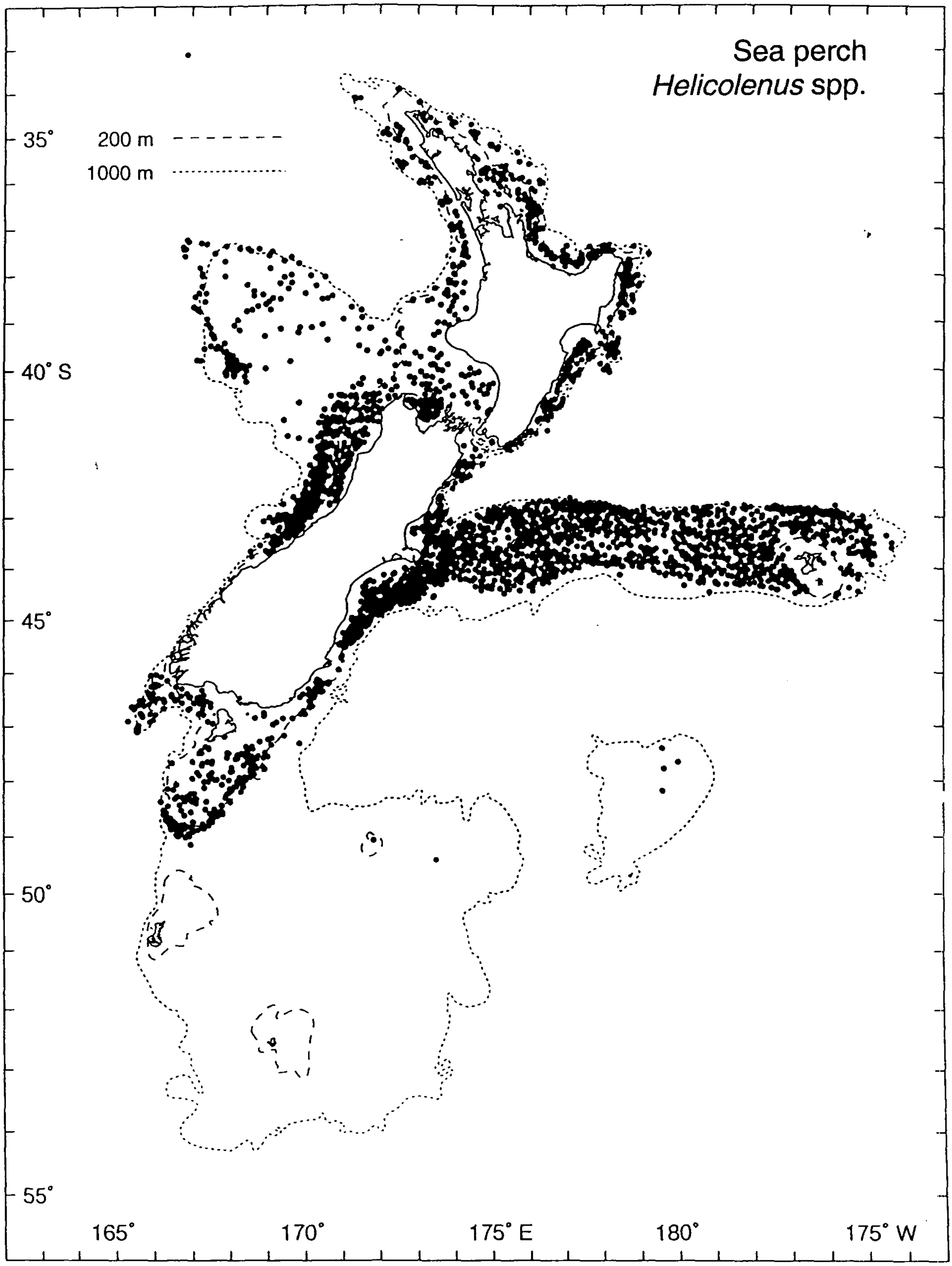

Figure 3: Distribution of sea perch in New Zealand waters, from recorded catches in the Ministry of Fisheries research trawl database. Depth contours at 200 m and 1000 m.

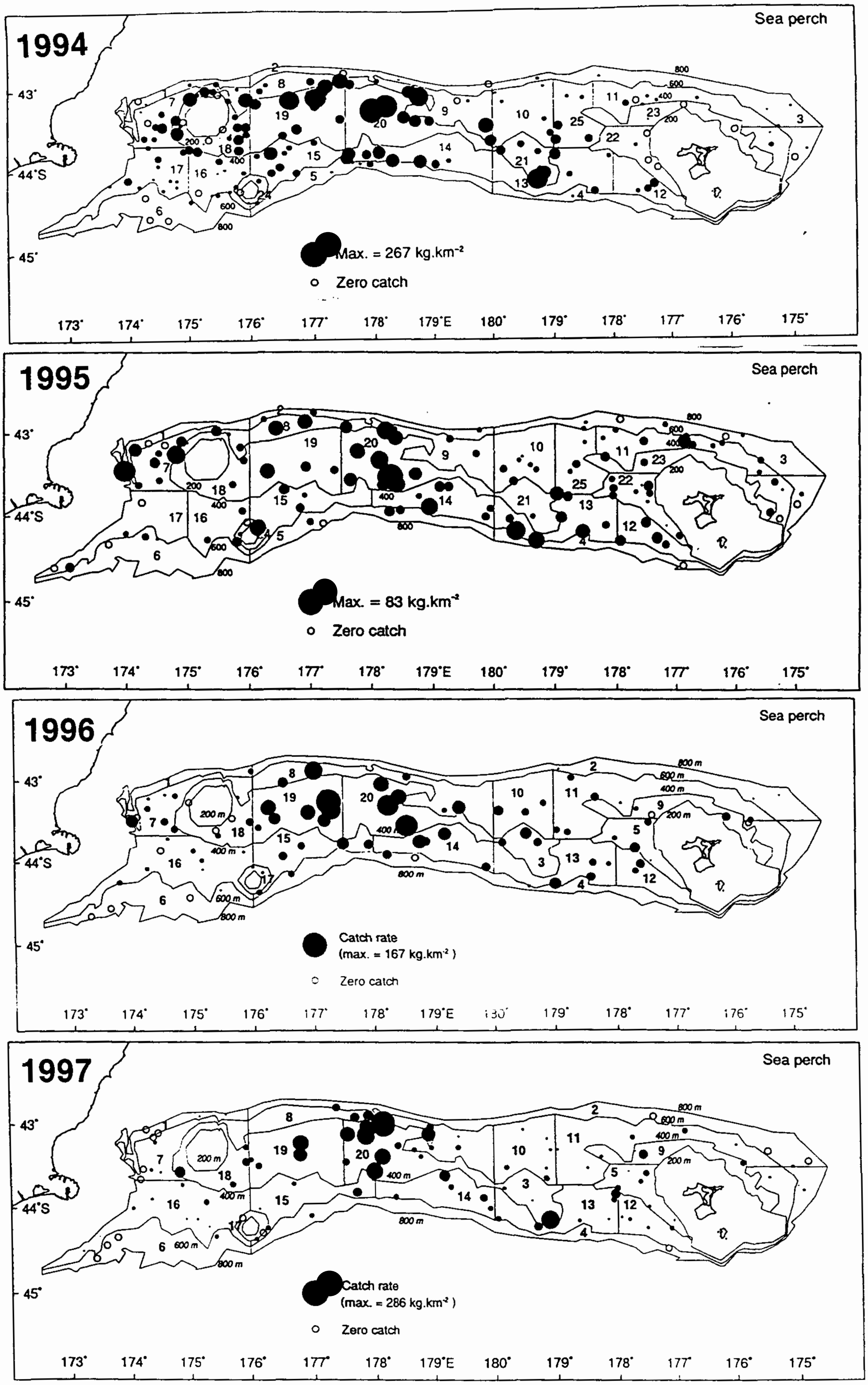

Figure 4: Catch rate (kg.km^{-2}) of sea perch on the Chatham Rise, determined from trawl surveys between 1994 and 1997. Derived from (top to bottom) Schofield & Horn (1994), Schofield & Livingston (1995, 1996, 1997.

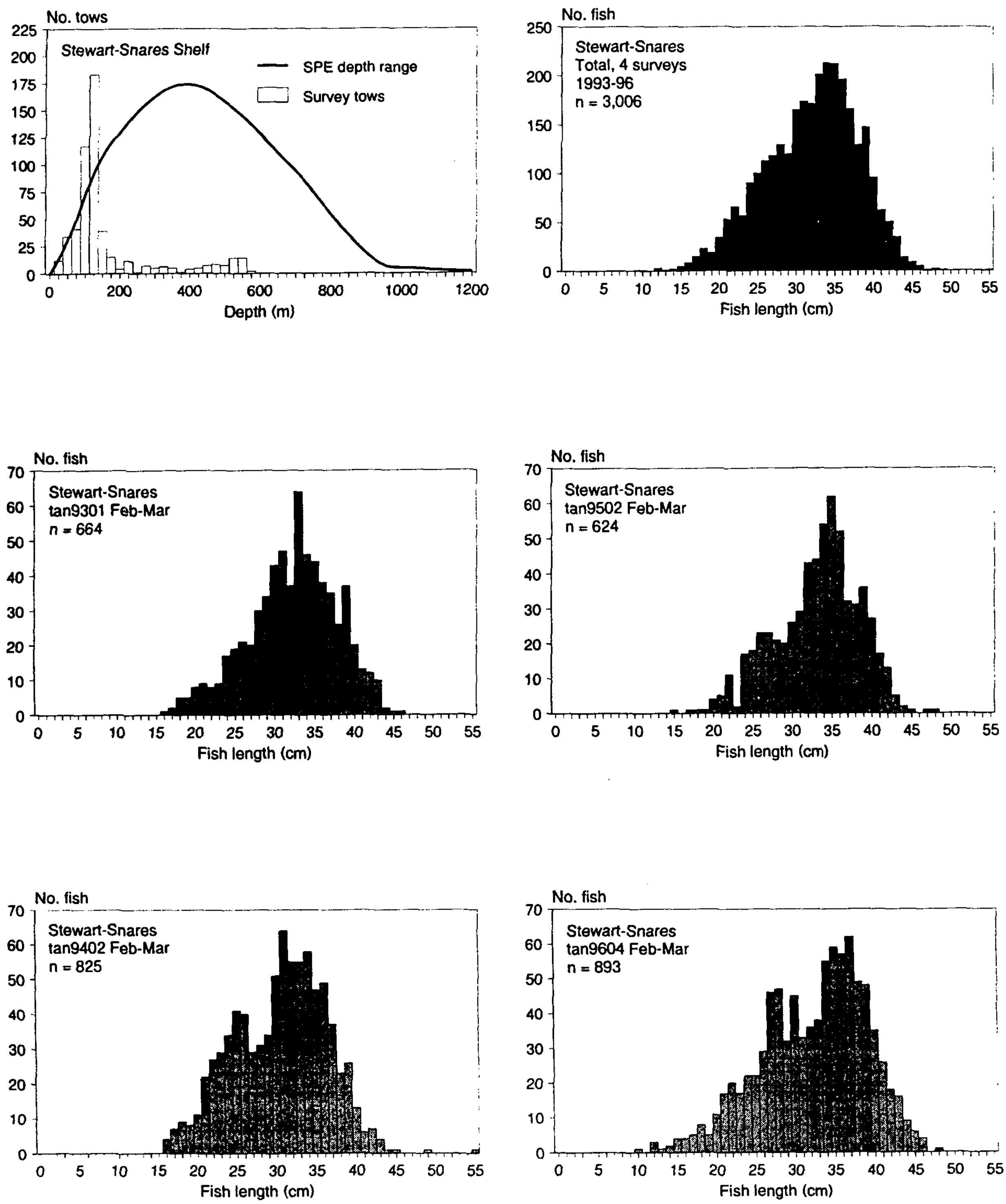

Figure 5: Size distribution of sea perch taken on four trawl surveys of the Stewart-Snares shelf, between 1993 and 1997. The top left panel shows the depth distribution of tows in these surveys, in relation to the overall depth range of sea perch established from all trawl surveys around New Zealand.

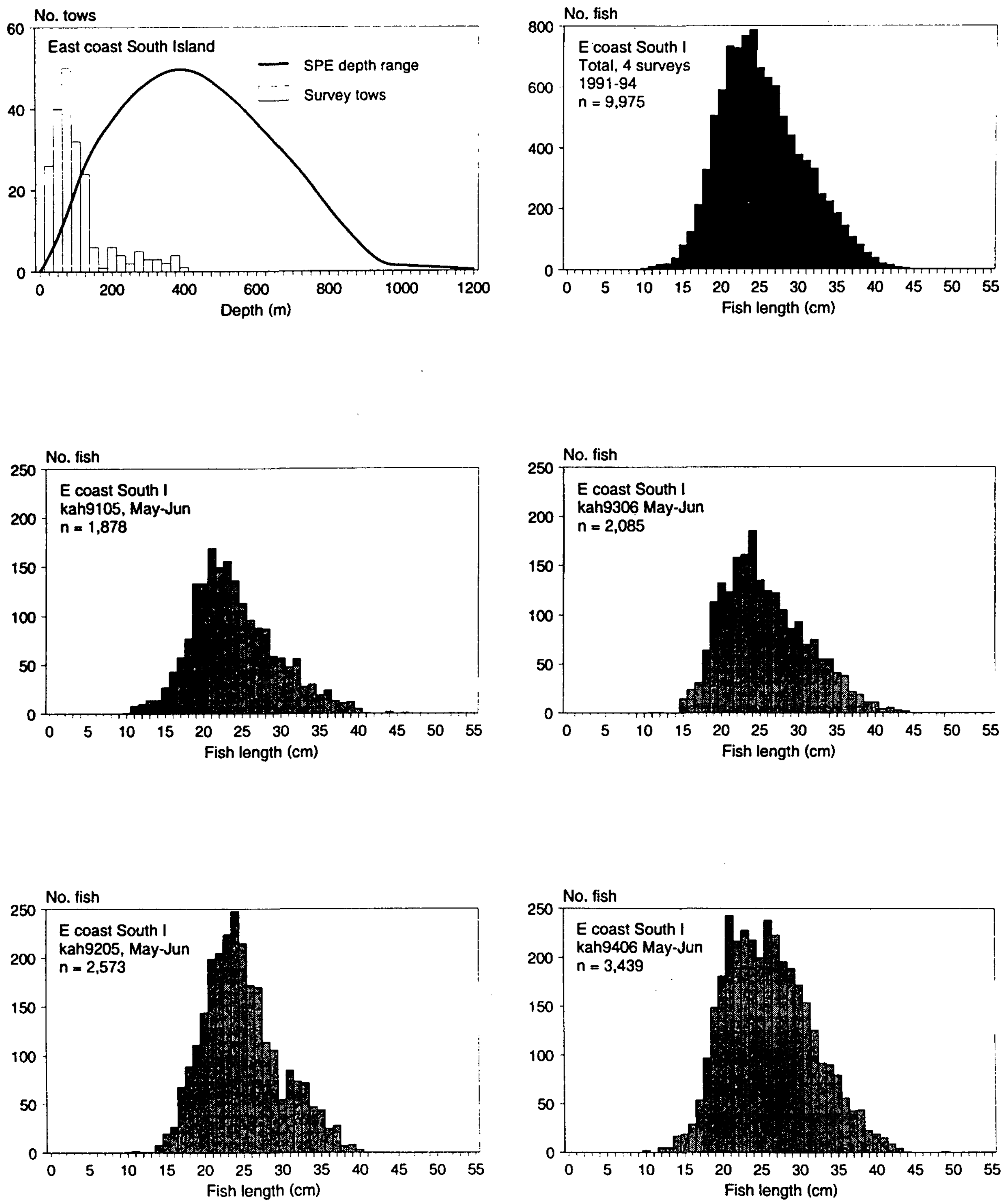

Figure 6: Size distribution of sea perch taken on four trawl surveys of the east coast South Island shelf, between 1991 and 1994. The top left panel shows the depth distribution of tows in these surveys, in relation to the overall depth range of sea perch established from all trawl surveys around New Zealand.

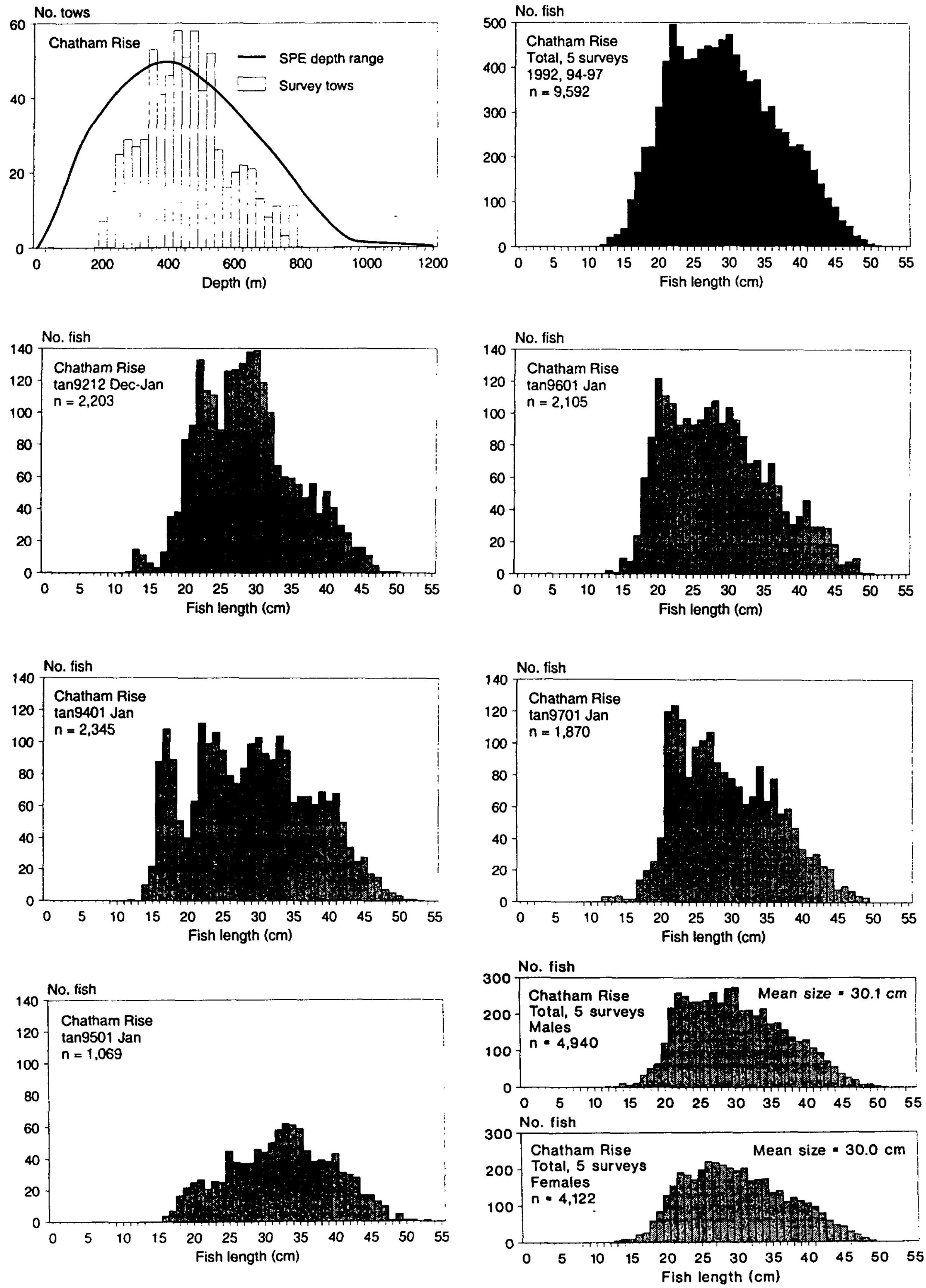

Figure 7: Size distribution of sea perch taken on five trawl surveys of the Chatham Rise, between 1992 and 1997. The top left panel shows the depth distribution of tows in these surveys, in relation to the overall depth range of sea perch established from all trawl surveys around New Zealand. The lower right panel shows the size distribution by sex of the five surveys combined.

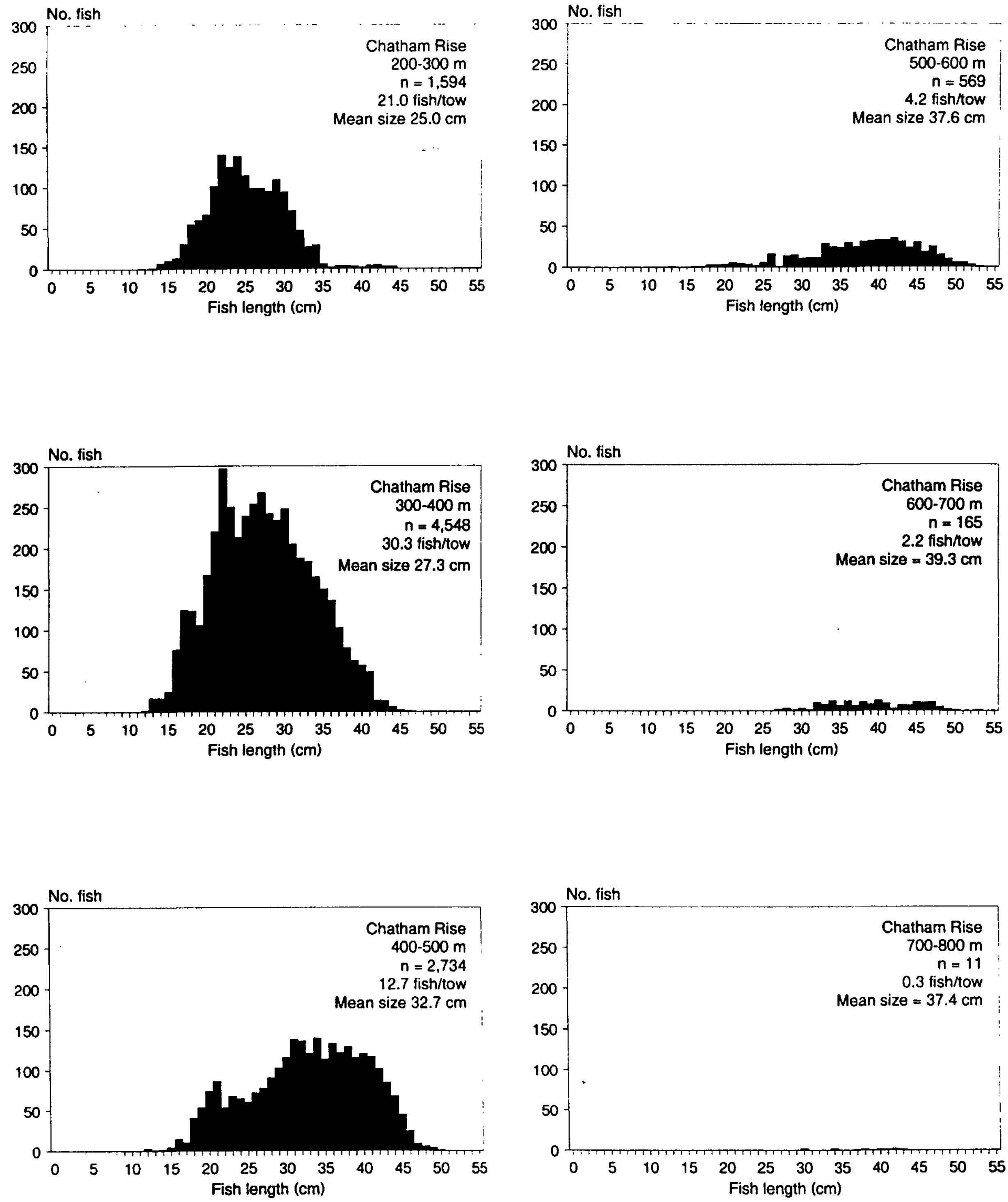

Figure 8: Size distribution of sea perch taken during five trawl surveys of the Chatham Rise, by 100 m depth intervals between 200 and 800 m, all surveys combined. For each depth interval the sea perch catch rate (fish per tow) and mean size of sea perch (cm) are given.

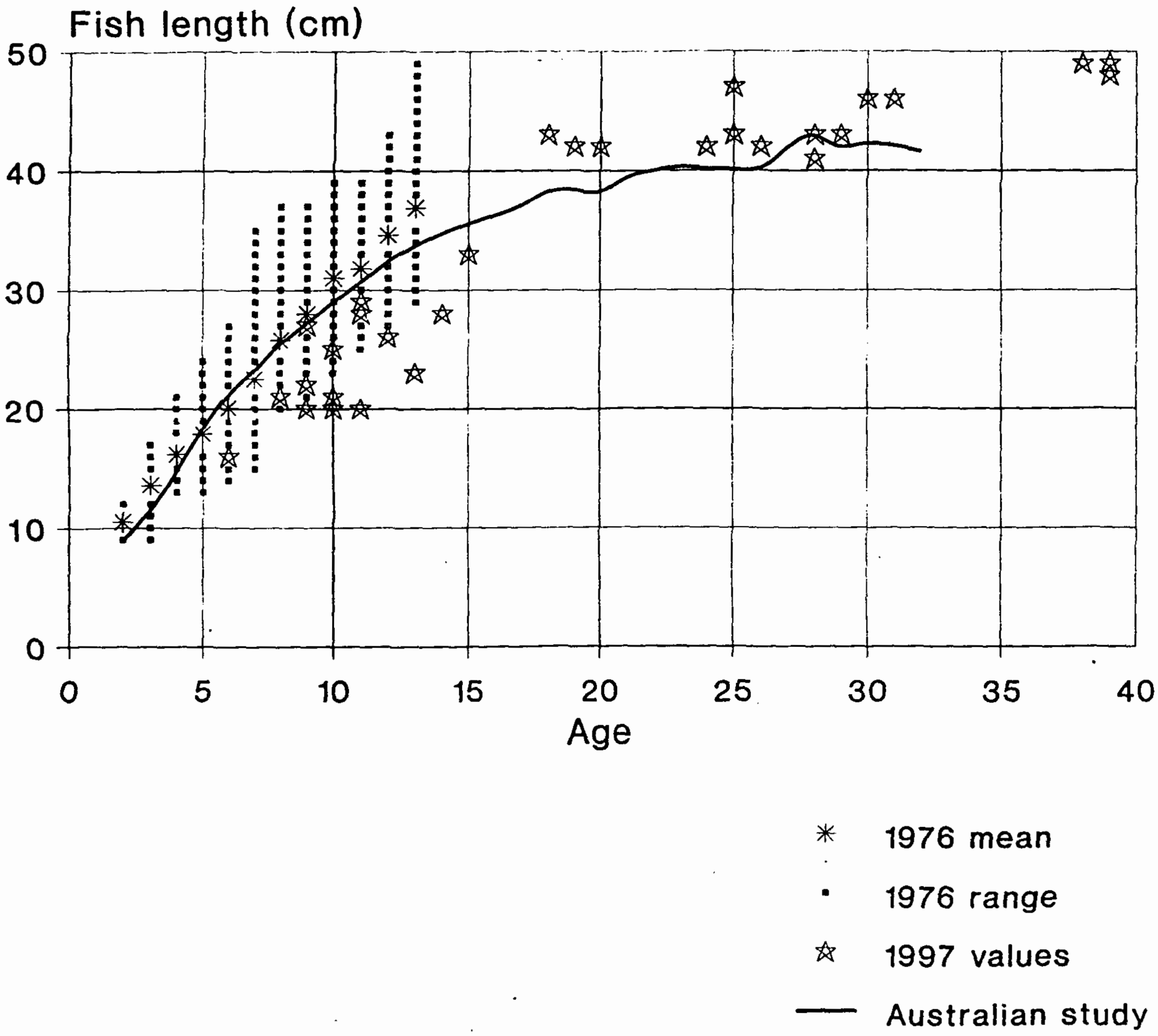

Figure 9: A summary of information on sea perch growth rate.

- Range and mean size at age of 582 unidentified South Island west coast "sea perch" (probably *Helicolenus barathri*), caught in 1976 and aged in that year. Age reading was done from surface ring counts of whole otoliths.

- Revised ages of the 1976 sample of fish, made in 1997. Ageing was done by breaking, burning, and reading otolith cross sections. Individual fish ages are shown; a subsample of the smaller fish, and all fish greater than 40 cm in length and 15 years in age, were aged.

- A growth curve to age 32 from Australian "sea perch" (also probably *H. barathri*) derived from the mean lengths at age listed in table 8 of Withell & Wankowski (1988); their ages were based on readings from whole otoliths of young fish, and from thin sections from fish older than 10–15 years.