MOR-00191

NIWA
Taihoro Nukurangi

Areas of importance for spawning, pupping or egg-laying, and juveniles of New Zealand coastal fish

R.J. Hurst, M.L. Stevenson, N.W. Bagley, L.H. Griggs,
M.A. Morrison, M.P. Francis

Final Research Report for
Ministry of Fisheries Research Project ENV1999/03
Objective 1

National Institute of Water and Atmospheric Research

December 2000

Areas of importance for spawning, pupping or egg-laying, and juveniles of New Zealand coastal fish

R. J. Hurst
M. L. Stevenson
N. W. Bagley
L. H. Griggs
M. A. Morrison
M. P. Francis
C. A. Duffy

NIWA Technical Report

Draft: December 2000

Abstract

This report summarises information on important areas for spawning, pupping, egg-laying, and juveniles of 35 important fish species which occur in under 200 m depth. Data came from published and unpublished literature, as well as Ministry of Fisheries research and commercial scientific observer databases. Some data were also provided from research programmes funded by the Foundation of Research, Science and Technology and the Department of Conservation.

Data summaries include distribution maps of ripe, running ripe and spent fish, monthly proportions of gonad maturity stages by area, distribution maps of juveniles and adults, catch rate plots of juveniles from research trawl survey time series, catch rate plots of juveniles from beach seine surveys of northern harbours, results of dive surveys in the Marlborough Sounds.

To enable some assimilation of the data presented, summaries of spawning and juvenile abundance are provided, by species and area. These summaries can be used to examine similarities between species (e.g., elephantfish, rig, and school shark all appear to show some similarity in their preference to pup or lay eggs in shallow water and for very young juveniles to be found in shallow coastal areas). The summaries can also be used to determine which areas are important as nursery grounds for which species (e.g., juvenile barracouta, jack mackerel (*Trachurus novaezelandiae*), kahawai, rig, and snapper are all relatively abundant, at least occasionally, in the inner Hauraki Gulf).

Overall conclusions from the study are: that most areas around New Zealand in less than 200 m depth are important for either spawning or juveniles of one or more coastal species; that some of these areas are also important for juveniles of deeper spawning species (e.g., hake and ling); and, conversely, that some "coastal" species extend into depths over 200 m, either as juveniles, or to spawn (e.g., red cod, giant stargazer).

Introduction

The Environmental Principles of the 1996 Fisheries Act require that habitat of particular significance for fisheries management should be protected. Evidence is increasing that habitat availability and structure may be critical for successful recruitment of many fish stocks (Nack *et al.* 1993, Gibson 1994, Blaber *et al.* 1995, Wilson, 1997, Parrish *et al.* 1997). Areas suitable for juvenile, spawning and pupping fish may be spatially limited in extent, but exert strong influences on final adult population sizes (and hence sustainable yields). Alteration of such habitats through fishing impacts, or more general environmental modifications (sedimentation, pollution, and urban development) may adversely affect their productivity.

For coastal species, sheltered estuaries and embayments may be critical habitats for juveniles, spawning fish or shark pupping, but they are potentially very vulnerable to human activities. Juvenile, spawning and pupping fish in offshore areas may also be vulnerable to high levels of mortality caused by non-selective fishing methods. Identification of critical habitats is essential if management and/or mitigation measures are to be effective.

Many New Zealand and overseas fisheries specifically target spawning fish, which are often more aggregated and more easily caught than non-spawning fish. At large stock sizes, and low fishing mortality, this may have minimal impact on recruitment, which is often driven more by environmental factors than spawning stock biomass (Francis *et al.* 1997, Livingston 1997). However, at high levels of fishing mortality and/or low stock size, such fishing could lead to reduced recruitment through disruption of spawning and dispersal of the schools.

Sharks and related cartilaginous species have low fecundity and low juvenile natural mortality rates, because the young are relatively large at birth or hatching. As a result, sharks are unable to sustain large increases in mortality, and consequently their populations may be particularly sensitive to loss of nursery grounds. Shark nursery areas are attracting much research attention overseas, with studies often leading to their protection from fishing. Most emphasis has been placed on estuarine and shallow coastal nurseries (Williams and Schaap 1992, Castro 1993, Holland *et al.* 1993, Simpfendorfer and Milward 1993, Freer and Griffiths 1993, Manire and Hueter 1995, Carrier and Pratt 1998), but attention is also being devoted to offshore nurseries (Holts and Bedford 1993). In New Zealand, there have been no specific studies to identify pupping or egg laying areas, but the presence of pregnant females and new-born young of rig and elephantfish provides a good guide to their location (Gorman 1963, Briggs 1980, Jones and Hadfield 1985, Francis and Francis 1992, Francis 1997). Pregnant female school sharks enter northern bays and estuaries in spring–summer, and pupping is thought to occur there (L. J. Paul, unpubl. data).

If juvenile nurseries can be identified, it may be possible to derive recruitment indices from these grounds for inclusion in stock assessment modeling (Ings *et al.* 1997). In New Zealand, this approach has been successful for snapper, hoki and southern blue whiting (Francis 1993, Francis *et al.* 1997, Livingston 1997, Annala *et al.* 1998, Hanchet 1998a, Ballara *et al.* 1998). Surveying important juvenile areas may be a cost-effective means of predicting changes in stock size several years in advance.

There was one objective for this project:
To review literature and existing data for all QMS species that are regularly encountered out to the 200 m contour within the New Zealand EEZ to:
a) determine areas of important juvenile fish habitat;
b) determine areas of importance to spawning fish populations; and
c) determine areas of importance for shark populations for pupping or egg laying.

For the purposes of this project, juveniles are defined as sexually immature fish. The main data sources were published and unpublished literature (including university theses and local body reports) and the Ministry of Fisheries research trawl survey and commercial scientific observer biological databases (referred here to as *Res* and *Obs*). These databases contain catch records from most parts of the New Zealand Exclusive Economic Zone (EEZ) (see Anderson *et al.* 1998, Bagley *et al.* 2000), although the Fiordland coast, the Kermadec Ridge, and parts of the Challenger Plateau were not well sampled. Data were also made available from Foundation of Research, Science and Technology (FRST) funded programmes on fish usage of northern harbours and estuaries, and a Department of Conservation (DoC) subtidal diver survey of the Marlborough Sounds. elephant fish. This project (ENV199903) was funded by the Ministry of Fisheries.

Methods:

1. Individual species data analysis and presentation

Species selection

We identified 35 commercially important species that are found regularly in depths less than 200 m, and for which there were 1) sufficient length-frequency measurements on *Res* and *Obs* databases to enable juveniles to be determined, or 2) juveniles were recorded in the FRST programmes surveying northern harbours and estuaries. These species and the sources of data are listed in Table 1. Some of these species (e.g., ling, hake, silver warehou, gemfish) are most abundant and spawn in water deeper than 200 m, but their juvenile distributions are included here because they are known to inhabit shallower water. One QMS species, trumpeter, is rarely caught in trawl surveys, and there were insufficient data to identify juvenile habitats.

Literature review

Published and unpublished literature was reviewed for information on the distribution and habitat requirements of spawning adult, planktonic egg and juvenile stages of the 35 species listed above. Data sources included a bibliography of New Zealand fish and fisheries compiled by Mr L. J. Paul, NIWA, computerised bibliographic searches, unpublished university theses, regional council reports, and environmental impact reports. The last three were particularity useful for information on the use of estuarine and near-shore environments by juvenile fishes.

Areas of important juvenile fish habitat

Presence / absence of juveniles:

The main source of information on the distribution of juvenile fishes inside the 200 m depth contour was the Ministry of Fisheries trawl survey database. This database contains about 23,000 research trawl tows made during the last 40 years, mostly bottom trawls but including midwater and prawn trawls. Other sources of data were the Ministry of Fisheries commercial scientific observer and tuna longline observer databases.

The general distribution of the main fish and squid species contained on these databases has already been determined and presented in 2 atlases (Anderson *et al.* 1998, Bagley *et al.* 2000) as part of a FRST-funded project on fish communities in New Zealand. A third atlas (Hurst *et al.* 2000) gave distributions of juveniles for 53 species from the first two atlases for which there were sufficient length measurements for these to be determined. Of the distributions presented here, 27 have been repeated from Hurst *et al.* (2000); plots for the remaining eight species (banded stargazer, blue cod, blue moki, kingfish, grey mullet, New Zealand sole, sea perch, and yellow-eyed mullet) were produced using the same methods described by these authors. Details on the databases and possible sources of error or uncertainty relevant to the distribution data extracted can be found in Anderson *et al.* (1998) Bagley *et al.* (2000), and Hurst *et al.* (2000). The dates for extraction of data for juvenile plots presented here are: up to January 1999 (*Res*) and March 1990 to November 1998 (*Obs*), as in Hurst *et al.* (2000).

Juvenile is defined here as those fish below the 50% length at maturity. For some elasmobranch species, this was determined separately for each sex. To determine the distribution of individual juvenile age classes, which often tend to grow rapidly, a theoretical birthday was assigned and length frequencies were used to determine the average maximum length within appropriate monthly groups (usually 3 or 6-monthly). Where possible, these data were verified using published information, but some averaging to allow for between-sex or area differences was often required. For some species, arbitrary length cutoffs had to be used to determine either size groups or juveniles. Data used to determine these lengths and age classes are given in Table 2.

The distribution of the juveniles is presented in conjunction with that of the adults (Section 1.1), so that the areas where juveniles do not occur can also be determined. The grey background on each adult plot shows all positions where the species has been caught (thereby indicating where the species occurs but may not have been measured).

Additional information on juvenile distributions is also available from the FRST-funded programme entitled "Fish usage of estuarine and coastal habitats". Four harbours were sampled around the Auckland region – three on the east coast (Whangateau, Matakana, Mahurangi) and one on the west coast (Pahurehure Inlet, Manukau Harbour). Sampling was carried out seasonally, from June 1999–April 2000. A 12 metre wide beach seine (9 mm mesh) was used for sampling within 1.5 hours either side of the high tide. Note, however, that recent work has demonstrated that the presence and abundance of some juveniles in the intertidal is less during high tides. Only one species reported on here, the New Zealand sole, is strongly affected by this. Almost all fish were less than 150 mm total/fork length, representing mostly 0+ animals. Only data for those species where more than 25 individuals were sampled across the four seasons are presented.

Abundance of juveniles

To determine abundance of juveniles, data were restricted to the main research trawl survey times series. This was because catchability of juveniles would vary between different surveys and gear types. Surveys selected for this part of the report are listed in Table 3, species are listed in Table 1.

Length cut-offs for juvenile fish were the same as those used for the presence/absence distributions. Catch rates were determined from the area swept by the trawl, using the doorspread width multiplied by the distance towed. These catch rates are expressed as either tonnes (t) or kilograms (kg) per square kilometre (km) and represented in the catch rate figures as circles, with circle size proportional to trawl catch rate.

Plots of juvenile abundance are shown in Section 1.2. There are two sets of plots: inshore surveys by *Kaharoa* (Section 1.2.1) and middle depth surveys by *Tangaroa* and *Akebono Maru No.73* (Section 1.2.2). On the *Kaharoa* plots, data are presented separately where different trawls were used. North and South Island are separate, and within the North Island plot, data from the south-east are represented by a different symbol (open circle) to represent the different trawl used in that area. Surveys around the South Island used the same trawl although East Coast South Island surveys since December 1996 have a used a smaller cod-end mesh size (28 mm compared to 74 mm previously). These 28 mm mesh stations are indicated by a different symbol (open circle). On middle depth survey plots, *Tangaroa* and *Akebono Maru No.73* data are represented by different symbols (closed and open circles, respectively). These symbols are described in figure captions at the start of each section. Reference plots for where each species was caught are shown on left-hand pages.

Additional information on juvenile abundance, by season, was also available from the FRST-funded programme that sampled four harbours around the Auckland region (see above). Only data for those species where more than 25 individuals were sampled across the four seasons are presented.

Areas of importance to spawning fish

The two main data sources for this activity were the same as for the juvenile distributions: the *trawl* and *obs_lfs* databases, referred here to as *Res* and *obs*. Scientific staff aboard trawl surveys and scientific observers aboard commercial fishing vessels, have collected data on fish gonad maturity stages for important species.

Scientific observers have used a 5-stage scale for gonads since the start of the Observer Programme. Research staff have used a variety of staging methods for different various species, but these stages are translatable into the 5-stage scale and have been done so here for comparability (*see* Table 4). Only female data were used, as males often appear to be running ripe over longer periods of time and thus may not be good indicators of peak spawning times or areas. Running ripe females are the best indication of spawning in the immediate vicinity, but this stage of some species is relatively rarely caught, presumably because changes in behaviour of spawning fish make them unavailable to bottom trawl gear, or because the process of ovulation, hydration and spawning is rapid. Therefore, we also used ripe and spent fish as likely indicators of the presence of spawning fish.

Of the 35 species considered here, three (ling, silver warehou and hake) spawn in depths greater than 200 m, and were not included in the analysis. Reproductive data for female sharks (school shark, rig, elephantfish and spiny dogfish) are not routinely recorded in the research and observer databases and were analysed separately. Seven other species had no or minimal gonad stage data (grey mullet, kingfish, lemon sole, New Zealand sole, sand flounder, yellow-belly flounder and yellow-eyed mullet), and the number of gonad stage records for arrow squid (67) was insufficient for analysis. Sea perch are viviparous, giving birth to live young. None of the gonad staging schemes record the presence of eyed larvae in the ovaries, so the available data did not adequately identify spawning sea perch. Gonad stage summaries presented here include the remaining 19 species (Section 2). The dates for extraction of data for spawning summaries presented here are: up to 4 April 2000 (*Res*) and 20 December 1999 (*Obs*).

Two types of gonad data summaries are presented here. The first gives the location and number of tows (including bottom, midwater, research and commercial data) where actively spawning (Ripe and Running ripe) and Spent females have been recorded. They grey background scale on the distribution figures represents where gonad stage information has been collected from, thus identifying areas that have not been sampled to date. The second provides a summary, by appropriate Fisheries Management Areas (FMA), of the monthly proportion of each of the 5 gonad stages and number of fish sampled.

It was anticipated that a FRST-funded programme entitled "Fish usage of estuarine and coastal habitats" might provide data on distribution of spawning adults which could be presented in the same format as juveniles (see below) sampled by this project. However, to date, few adults have been caught for most species. Yellowbelly flounder were the most commonly caught, but even their numbers were only in the 10s per season, for the two bigger harbours. These data have therefore not been presented here.

Areas of importance to sharks for pupping and egg-laying

Sharks and other cartilaginous fishes reproduce either by depositing leathery egg cases on the seabed, or by giving birth to live young (often known as pups). Pupping and egg laying areas can be identified directly, by the location of deposited eggs and 0+ pups, or indirectly, from the presence of pregnant females carrying full-term embryos, or egg cases ready for extrusion.

Existing data sources on the location of shark pupping and egg-laying areas are few. The *trawl* database contains gonad stage data for small numbers of school shark and rig, and moderate numbers of elephantfish, but the data are *maturity* stages on a scale from one to three. This scale does not distinguish between pregnant and non-pregnant females, and nor does it record embryo length, so the data were not useful. The same applied to the small amount of gonad stage data for spiny dogfish on *obs_lfs*. Records of female rig and school shark with near-term embryos (over 24 cm length) have been plotted (*see* Section 3).

Indirect evidence of elephantfish egg-laying areas comes from distribution of egg cases. The Department of Conservation conducted extensive subtidal diver surveys of the Marlborough Sounds mainly during 1989 and 1990. These data were analysed by DoC and a detailed report is presented in Section 3, along with a summary plot of the distribution of egg cases.

2. Area and species summaries

Summaries of the data contained in Sections 1-3 are provided in Section 4. This section provides a quick visual guide as of the most important areas for spawning and juvenile fish, and the most important months for spawning. It encompasses information from the literature review and the new data presented here, as well as highlighting gaps in our knowledge. The split of areas into sub-areas within FMA and into at least two depth ranges (inner and out shelf) also allows for identification of areas which might be important for more detailed sampling of habitat, or appropriate for sampling to index recruitment of selected species.

Results:

The literature review and text summarising data contained in sections 1-3 is given below. Plots containing the data summaries referred to are in the following sections:

Section 1: Distribution of juvenile fish
- 1.1 Presence/absence of juveniles
- 1.2 Abundance of juveniles
  - 1.2.1 Kaharoa trawl survey time series
  - 1.2.2 Tangaroa Middle depth trawl survey time series and Akebono Maru No. 73
  - 1.2.3 Northern Harbour beach seine surveys

Section 2: Location and monthly occurrence of spawning fish
Section 3: Location of shark pupping and egg-laying areas
Section 4: Tabulated summaries of data in Section1-3, by area and species.

Species summaries

Aldrichetta forsteri Yelloweyed mullet

1. Literature review:

Yelloweyed mullet have been recorded in research trawls in shallow inshore areas off the northern North Island and Tasman and Pegasus Bays (Anderson *et al.* 1998).

1.1 Spawning areas
Spawning occurs over summer from late Dec to mid-March (Annala *et al.* 1999), although in the Avon-Heathcote Estuary (east coast South Island) a biennial spawning with peaks in summer and winter is likely (Webb 1972b). No spent or post-spawned fish were found in Pauatahanui Inlet (south-west coast North Island) by Healy (1980), who suggested that adults went out to sea to spawn. Eggs are spawned close to shore (McDowall 1978).

1.2 Juvenile Distribution
Larvae and juveniles are found in the neuston (the very surface waters of the ocean), up to at least 18 km from the shoreline (Kingsford 1986, Tricklebank 1988, Kingsford & Choat 1989), and are most abundant in open water and around drift algae from November to March (Tricklebank 1988). High densities have also been observed in the slicks of internal waves, which has been suggested as a mechanism promoting on-shore movements (Kingsford & Choat 1986). Neustonic juveniles have observed being predated on by the tern *Sterna striata* (Kingsford & Choat 1986). No larval fish were caught during fourteen month of sampling at a Whangateau Harbour estuary entrance (Roper 1986), suggesting that most planktonic forms of this species develop away from shore, and return at a size where they are able to avoid sampling by plankton nets (Kingsford & Choat 1986, Kingsford & Tricklebank 1991).

Juveniles are a ubiquitous and cosmopolitan component of most estuarine fish assemblages. Juveniles have been recorded from the east coast South Island (Avon-Heathcote, Webb 1972a; Waimakariri Estuary, Eldon & Kelly 1985; Kakanui Estuary, Jellyman *et al.* 1997), south-west coast North Island (Pauatahanui Inlet, Healy 1980), south-east coast North Island (Ahuriri Estuary, Kilner & Akroyd 1978) and the north eastern Whangateau Harbour (Morrison 1997). Schools of small fish were first observed in the Waimakariri (Eldon & Kelly 1985) and Ahuriri Estuaries (Kilner & Akroyd 1978) in February. Yelloweyed mullet reach maturity at 18–25 cm (Taylor 1998)

2. Data summaries:

2.1 Spawning areas
Insufficient data.

2.2 Juvenile distribution
Immature fish have been recorded in trawl surveys from inshore areas around the northern North Island, particularly the Bay of Plenty, Hauraki Gulf, and off western harbours, mostly in under 50 m depth. Fish from the Tasman Bay area were not measured. In the four Auckland harbours sampled by beach seine, immature yellow eyed mullet were common and a dominant component of the small fish assemblage.

2.3 Juvenile abundance – Auckland harbours
In Pahurehure Inlet and the Mahurangi Harbour, they occurred in high numbers in the four seasons sampled. In Whangateau and Matakana they were in low abundance in winter and spring, compared to summer and autumn. No obvious spatial patterns were present in any of the four harbours, and this species seems to be cosmopolitan in such environments.

Arripis trutta Kahawai

1. Literature review:

Kahawai have been recorded in research trawls in inshore to mid-shelf areas, mainly off the northern North Island, but extending south to about 45°S (Anderson *et al.* 1998).

1.1 Spawning areas
Kahawai spawn on the seabed (60–100 m water depth) in open water. Spawning females are caught in January and February in trawl bycatch off the north coast of the North Island (Annala *et al.* 1999). Eggs are pelagic, and have been found in February off the northern North Island, in the Hauraki Gulf (Annala *et al.* 1999). Larvae tentatively identified as kahawai have been caught in the neuston of the Hauraki Gulf in May–June (Tricklebank *et al.* 1992).

1.2 Juvenile Distribution
Juveniles (0+/1+) are common off sandy beaches, both in estuaries and on the coast, including off the east coast South Island (Avon-Heathcote Estuary, Webb 1972a; Waimakariri Estuary, Eldon & Kelly 1985), Tasman and Golden Bays (Gerring & Bradford 1998), south-west North Island (Pauatahanui Inlet, Healy 1980; Wellington Harbour and south coast, Stevens & Kalish 1998) and around the nothern North Island (Manukau Harbour, Tauranga Harbour, Waitamata Harbour (Gerring & Bradford 1998, Saunders 1999; and the Whangateau Harbour, Morrison 1997. Healy (1980) noted that in the Pauatahanui inlet juveniles seemed to prefer clear water with a firm bottom (sand, shale, rock). Gerring & Bradford (1998) tentatively noted that there was some evidence that a particular beach profile might be preferred by juvenile kahawai, where the beach shelved quite quickly into deeper water, and was exposed to prevailing winds. This tended to stir up sediment, and may have produced better feeding conditions. Kahawai reach maturity at 35-40 cm or 4-5 years of age (Francis 1996).

2. Data summaries:

2.1 Spawning areas
The gonad state of only a few kahawai caught in research trawls has been recorded. Four fish were recorded as ripe or running ripe off the Wairarapa coast and Hokitika. Nine spent fish have been

recorded from the same areas, as well as off East Cape. All fish in spawning condition were caught between February and March.

2.2 Juvenile distribution
Few 0+ juveniles have been caught but records in Tasman Bay and off the north-west coast of the North Island are additional to areas where fish in spawning condition have been caught by research trawls. Age 1+ juveniles and all immature fish combined occur around the northern North Island, in South Taranaki Bight and in Tasman Bay. The depth distribution is mainly less than 50 m. Adults are caught in deeper water, out to about 100 m, and also along the east and west coasts of the South Island.

2.3 Juvenile abundance
Juvenile kahawai have been caught on *Kaharoa* trawl surveys in 285 inshore tows around the North Island, but not off the South Island. Largest catch rates, up to 2.0 $t.km^{-2}$, were from Hauraki Gulf with moderate catch rates off west Auckland harbours.

Callorhinchus milii Elephantfish

1. Literature review

Elephantfish have been recorded in research trawls, mainly in inshore water out to about 150 m depth off the east and west coast of the South Island. They have been occasionally recorded also off Southland, Tasman Bay and East Cape (Anderson *et al.* 1998).

1.1 Egg laying areas
Elephantfish lay large leathery egg cases, containing a single egg, on the seabed during spring–summer, and the young elephantfish hatch 5–10 months later (Waite 1909, Graham 1956, Gorman 1963). There is a major egg laying ground in Pegasus Bay – large migrations of mature female elephantfish enter this bay in spring each year to lay their eggs (Gorman 1963, Sullivan 1977). Eggs are laid on sand or mud, from the surf zone to about 40 m deep (Gorman 1963, Allison & Coakley 1973). Large numbers of egg cases, mostly empty but occasionally containing embryos, wash up on Christchurch beaches after storms (Graham 1956, Gorman 1963).

Elephantfish also lay their eggs in many parts of the Marlborough Sounds, on sand or mud in 6–20 m of water (McClatchie & Lester 1994, Didier *et al.* 1998). Other known egg laying sites are Wellington Harbour, Canterbury Bight, and inshore Otago waters including Blueskin Bay (Waite 1909, Graham 1956, Jones & Hadfield 1985).

1.2 Juvenile distribution
Newly-hatched and older juveniles inhabit the inner continental shelf along the east coast South Island between Kaikoura and Canterbury Bight, mostly shallower than 80 m; 0+ elephantfish are mostly restricted to water less than 30 m deep (Gorman 1963, Allison & Coakley 1973, McClatchie & Lester 1994, Francis 1997). Small juveniles (0+ and 1+) have also been recorded from Blueskin Bay (Otago) (Malcolm Francis, NIWA, pers. comm). Juveniles in Pegasus Bay and Canterbury Bight have different modal lengths and grow at different rates during the first three years of life, indicating that there is little or no movement around Banks Peninsula (Francis 1997). Newly hatched and larger juvenile elephantfish have also been found in Porirua and Pauatahanui Inlets for much of the year, although the numbers declined in winter (Healy 1980, Jones & Hadfield 1985). Elephantfish reach maturity at 52 cm for males and 71 cm for females (Gorman 1963).

2. Data summaries

2.1 Egg-laying areas
Egg-laying data are not recorded on trawl surveys. Information presented in Section 3 has come from a Department of Conservation survey of 363 sites in the Marlborough Sounds. Egg cases were found at 21 locations in the inner Queen Charlotte and Pelorus Sounds.

2.2 Juvenile distribution
The distribution of 0+ and 1+ juveniles restricted mainly to inshore area off the east coast South Island, both in Canterbury Bight and Pegasus Bay. A few have been caught off the west coast South Island and East Cape. Most catches are in less than 50 m depth. Immature fish combined and adults have similar distributions but extending slightly deeper (to 100 m depth) and down to Southland. The few fish caught in Tasman Bay were not measured.

2.3 Juvenile abundance
Juvenile elephantfish have been caught on *Kaharoa* trawl surveys off the south-east coast of the North Island (in 10 tows) and east and west coasts of the South Island (in 258 tows). Largest catch rates, up to 1.1 $t.km^{-2}$, were from the east coast South Island, often in the shallower part of the species depth range.

Chelidonichthys kumu Red gurnard

1. Literature review

Red gurnard have been recorded in research trawls, mainly in shelf waters less than 200 m depth, all around New Zealand and at the Chatham Islands. The southern limit of catches is Stewart Island (Anderson *et al.* 1998).

1.1 Spawning areas
Red gurnard are widespread throughout much of New Zealand and occur over muddy or sandy bottoms. They are most common in shallow coastal waters, and sometimes can be found in depths of 180 m (Elder 1976). Red gurnard have a long spawning period that extends through spring and summer (Elder 1976, Robertson 1980) and they are believed to be partial spawners (Elder 1976). They spawn in shallow and mid-shelf areas (Robertson 1980, McGregor & Voller 1985). Robertson (1973, 1975, 1980) suggested that this species spawns around all or most of the New Zealand coastline, as eggs are found occasionally in most coastal mid-shelf waters (including off Otago, Kaikoura, Castlepoint, Bay of Islands and Milford Sound) during summer and autumn. Graham (1939) noted that gurnard usually spawn in March in the Otago region and Parsons (1999) recorded eggs and larvae from inner shelf waters off Otago. Egg and larval development occurs in surface waters, and there is a period of drift for about 8 days before feeding begins (Robertson 1980).

1.2 Juvenile distribution
The scarcity of small gurnard in trawl catches suggests that they inhabit grounds that are unsuitable for trawling such as rough or weed covered ground, which may provide cover (Elder 1976). Small juveniles can be found in shallow harbours (Paul 1986). In the Hauraki Gulf, nursery grounds have been found near Colville Bay and the Firth of Thames (Elder 1976). Elsewhere, juveniles have been reported from Pegasus Bay (Staples 1971) and as seasonal inhabitants in Pauatahanui – Porirua inlets (Healy 1980). Red gurnard reach maturity at 2–4 years old (Elder 1976), with females reaching maturity one year later than males. Based on these ages, the length at maturity increases southwards: North Island fish mature at about 20–33 cm (Hanchet 2000); South Island fish at 25–45 cm (*after* Sutton 1997).

2. Data summaries

2.1 Spawning areas
Gonad state has been recorded from most areas around New Zealand (except the lower North Island), but not from fish caught at the Chatham Islands. Ripe and running ripe fish have been caught in all areas except from the Hauraki Gulf. Spent fish have a similar distribution but were less commonly recorded. Seasonal coverage is sporadic. There appears to be spawning activity throughout the year. Peak months (i.e., with more than 40% of fish ripe, running ripe or spent) were December to February in all areas except the west coast South Island and Tasman Bay, where March and April were the peak months.

2.2 Juvenile distribution
Juveniles are distributed around the mainland in less than 100 m depth. They probably also occur at the Chatham Islands but have not been measured. although relatively infrequently off the central east coast and Southland. Adults have a similar distribution to juveniles, although they extend slightly deeper (up to about 150 m) and there are also 3 fish measured from around the Chatham Islands.

2.3 Juvenile abundance
Juvenile red gurnard have been caught on *Kaharoa* trawl surveys mainly of the northern half of the North Island (in 1484 tows) and east and west coasts of the South Island (in 484 tows). Catches were relatively evenly distributed. Largest northern North Island catch rates occurred along the west coast, up to 0.8 $t.km^{-2}$. South-east North Island catch rates peaked in Hawke Bay (0.2 $t.km^{-2}$). South Island catch rates were highest in Tasman Bay and off Westland, up to 0.6 $t.km^{-2}$. Juveniles were often most abundant in the shallower part of the depth range where the species was caught.

Juvenile red gurnard have been recorded also on *Tangaroa* middle depth trawl surveys off the Southland (in 32 tows). Catches were mainly inshore and catch rates were low and were dominated by one "large" catch (84 $kg.km^{-2}$) off western Stewart Island. Distribution on the Chatham Rise was not able to be determined. The *Tangaroa* did not trawl in under 200 m depth and red gurnard caught around the Chatham Islands by *Akebono Maru 73* were not measured.

Galeorhinus galeus School shark

1. Literature review

School shark have been recorded in research and commercial trawls, mainly in shelf waters less than 200 m depth, all around New Zealand and in shallower areas across the Chatham Rise. The southern limit of the main distribution the Snares shelf, although there are a few records from the Sub-Antarctic (Anderson *et al.* 1998). Commercial tuna longlines have also caught school shark, well offshore to the west of the South Island and east of East Cape, over water depths of several thousand meters (Bagley *et al.* 2000).

1.1 Pupping areas
School sharks produce live young of about 30 cm total length during spring and summer (Seabrook-Davison *et al.* 1985, Paul 1986, 1988). Pregnant females are thought to move into inshore waters in spring, and pup along "shallow (usually sandy) coastlines or in harbours and estuaries" (Seabrook-Davison *et al.* 1985). Graham (1956) reported a pregnant female carrying 24-cm embryos in Otago waters, but otherwise no specific details of pregnant or recently-pupped females have appeared in the literature. Seabrook-Davison *et al.* (1985) stated that new-born pups occur in shallow inshore waters in summer, but again no details were provided.

1.2 Juvenile distribution
Small juveniles (0+ – 2+ year classes, up to 70 cm total length) are widespread in inshore waters of northern and central New Zealand (especially Hauraki Gulf, west coast North Island between New Plymouth and Kaipara Harbour, Tasman and Golden Bays, Pegasus Bay, Canterbury Bight, and west coast South Island), but they are rare around Northland and the southern South Island (Francis & Mulligan 1998, Hurst *et al.* 1999). Small juveniles (0+ and 1+) have also been recorded from very shallow inshore waters of Kenepuru Sound (Marlborough), Lyttelton and Akaroa Harbours and Blueskin Bay (Otago)(Malcolm Francis, NIWA, pers. comm).

Older juveniles appear to disperse more widely throughout shelf waters, and some tagged juveniles have migrated to Australia (though it is not clear whether they were still juveniles at the time of migration) (Seabrook-Davison *et al.* 1985, Hurst *et al.* 1999). Juveniles reach maturity at about 125 cm for males and 135 cm for females (Francis & Mulligan 1998, Hurst *et al.* 1999).

2. Data summaries

2.1 Pupping areas
Reproductive status of female school shark is rarely recorded on trawl surveys as few females are caught and any fish in healthy condition have usually been tagged and returned. Three females with embryos larger than 24 cm have been recorded from off Otago and North Taranaki Bight (see Section 3).

2.2 Juvenile distribution
Young (0+ and 1+) juveniles occur mainly in less than 100 m depth around the northern North Island and northern South Island. Immature fish combined are distributed all around the mainland, Southland and in shallower pockets on the Chatham Rise, mainly out to about 400 m depth. Adults are less frequently caught (by bottom trawls) and generally have a deeper and more offshore distribution, mainly 50–450 m depth. Both immature and adult school shark are also caught by tuna longlines in offshore areas.

2.3 Juvenile abundance
Juvenile school shark have been caught on *Kaharoa* trawl surveys around the North Island (in 398 tows) and South Island (in 700 tows). Catch rates were relatively patchy. The largest northern North Island catch occurred in the North Taranaki Bight (0.6 $t.km^{-2}$). South-east North Island catch rates were highest (up to 0.1 $t.km^{-2}$) off East Cape and Hawke Bay and South Island catch rates were highest (up to 1.1 $t.km^{-2}$) around Banks Peninsula. High catch rates occurred from close inshore out to about 200 m depth.

Juvenile school shark have been recorded also on *Tangaroa* middle depth trawl surveys off Southland and on the Chatham Rise (in 216 tows) and on *Akebono Maru 73* surveys at the Chatham Islands (in 20 tows). Catch rates were mainly over shelf areas and catch rates by both vessels were low and patchy (*Tangaroa* up to 127 $kg.km^{-2}$; *Akebono Maru 73* up to 166 $kg.km^{-2}$)

Genypterus blacodes Ling

1. Literature review

Ling have been recorded in research and commercial trawls, mainly 200–800 m depth, all around New Zealand, on the Challenger Plateau, on the Chatham Rise and in the Sub-Antarctic. They also occur across the shelf, particularly in southern areas (Anderson *et al.* 1998).

1.1 Spawning areas
Spawning is known to occur off the west coast of the South Island, and Puysegur Bank (Patchell & McKoy 1985, Colman 1988), the east coast of the South Island and the Chatham Rise (Horn 1993a) and in Cook Strait and on the Campbell Plateau (Horn & Ballara 1999). Ling in spawning condition have been reported in spring and early summer (Annala *et. al.* 1999). Ling in ripe condition have been noted in the Otago region in September (Graham 1939) and a few larvae have been recorded from inner shelf waters in December (Parsons 1999). Pre-spawning aggregations of ling have been recorded in Northland, but it is not known whether these fish remain in the area to spawn (Roberts 1987).

1.2 Juvenile distribution
Little is known about the distribution of juveniles until they are about 40 cm in total length when they begin to appear in trawl samples over most of the adult range (Annala *et. al.* 1999). Horn (1993b) reported 2 year olds (mean length 34.9 cm) on the Chatham Rise and Southern Plateau (Horn 1993b). Adult ling are widely dispersed over the New Zealand region, especially south of 40°C, in 200–700 m depth (Annala *et al.* 1999). Most ling reach maturity at about ages 6 (30%) and 7 (75%) (Annala *et al.* 1999).

2. Data summaries

2.2 Spawning areas
Not described here as ling spawning extends beyond 200 m depth.

2.2 Juvenile distribution
There are some records of 0+ juveniles in shallow inshore areas but most occur from 200 to 500 m depth. Main areas include the Bay of Plenty and central east coasts of the North and South Islands. A few have been recorded from the west coast South Island, Chatham Rise, Southland and the Auckland Islands. This pattern may reflect the larger cod-end mesh (i.e., 60 mm or greater) used in areas where they appear to be less common. Juveniles up to 2 years old have a similar distribution but are now common on the west coast South Island, the Chatham Rise and in the Sub-Antarctic. Immature fish combined are found extensively throughout the EEZ, mostly from 200-800 m depth, including a few around the northern North Island and the Challenger Plateau. Distribution around the North Island may be under-represented due to the minimal amount of trawling in the 200-800 m depth range. Adults have a similar distribution to the juveniles combined but tend to be less common in inshore shelf areas, except for Southland where they are more commonly caught than juveniles.

2.3 Juvenile abundance
Juvenile ling have been caught on *Kaharoa* trawl surveys in the Bay of Plenty (in 18 tows), off the south-east coast of the North Island (in 167 tows) and off the east and west coast of the South Island (in 742 tows). A high proportion (88%) of catches with ling contained juveniles. Catch rates were relatively patchy. The largest North Island catch (0.1 $t.km^{-2}$) was east of Cook Strait and the largest South Island catch rates (up to 1.5 $t.km^{-2}$) were on the shelf in Canterbury Bight.

Juvenile ling have been recorded also on *Tangaroa* middle depth trawl surveys mainly on the Chatham Rise, but also off Southland (925 tows total). Catches were widespread on the Chatham Rise, although one large catch (0.7 $t.km^{-2}$) dominated the distribution. The distribution of juveniles inside the 200 m contour at the Chatham Islands was not able to be determined as ling were not measured on *Akebono Maru 73* tows. Off Southland, catches were restricted to the south-eastern shelf edge and around Puysegur Bank, unlike the larger fish which were more widespread across the shelf.

Helicolenus percoides Sea perch

1. Literature review

Sea perch are widespread around New Zealand from North Cape to the Snares, and across the Chatham Rise (Paulin 1989). They have been recorded and measured in research trawls, mainly 50–800 m depth, all around New Zealand, on the Challenger Plateau and Chatham Rise, but not extending into the Sub-Antarctic (Anderson *et al.* 1998). "Sea perch" were thought to include the shallow water *Helicolenus percoides*, out to 50 m depth, and the deeper water *H. barathri*, found in 40–1200 m depth (Paul 1998, Paulin 1989). However, recent genetic studies have not found evidence of separate species in the New Zealand EEZ, at least in the 20-450 m depth range (Smith 1998)

1.1Spawning areas

There is no published information on spawning areas (Paul 1998). Sea perch are viviparous, and extrude small larvae in floating jelly masses throughout an extended spawning season (Graham 1939, Paul 1998). There can be 90,000 of these larvae (Graham 1939), and they are expelled in a very early developmental stage, so would probably be subject to the same general processes as the eggs and larvae of most marine fishes, resulting in a reasonably wide dispersal of juveniles (Paul 1998). Larvae have been recorded from inner shelf waters off Otago from spring to autumn (Parsons 1999).

1.2 Juvenile distribution

The size and age at maturity is not clear, and there are often are no modes which could be interpreted as individual juvenile cohorts. Fish as small as 10 cm have been caught in surveys of the Stewart–Snares shelf and east coast South Island. In some Chatham Rise surveys, there were size modes between 10 and 25 cm which could represent juvenile age groups. In Australia, maturity in sea perch occurs at about 30 cm (Paul 1998). Size at maturity in New Zealand fish may be slightly lower (L. Paul, NIWA, Wellington, pers. comm.).

2. Data summaries

2.1 Spawning areas

Insufficient data.

2.2 Juvenile distribution

Immature fish (assumed to be those less than 25 cm length) have been recorded from all areas, although few fish have been measured around the North Island and on Challenger Plateau. Most are caught in under 500 m, but some extend out to about 750 m depth.

2.3 Juvenile abundance

Juvenile sea perch have been caught on *Kaharoa* trawl surveys around the northern North Island (in 88 tows) and off the east and west coast of the South Island and in Tasman Bay (in 494 tows). They occur mainly over the outer shelf and catch rates are relatively patchy. The largest North Island catch (0.2 $t.km^{-2}$) was in the Bay of Plenty and the largest South Island catch rates (up to 2.0 $t.km^{-2}$) were in Pegasus Bay and the Canterbury Bight.

Juvenile sea perch have been recorded also on *Tangaroa* middle depth trawl surveys on the Chatham Rise and off Southland (610 tows total). Catches were relatively evenly distributed and widespread on the Chatham Rise. The distribution of juveniles inside the 200 m contour at the Chatham Islands was not able to be determined as sea perch were not measured on *Akebono Maru 73* tows. Catch rates of juveniles were patchy off Southland dominated by one "large" catch (0.2 $t.km^{-2}$).

Kathetostoma giganteum Giant stargazer

1. Literature review

Giant stargazer are found throughout New Zealand coastal waters and are most abundant in depths of 50–300 m around the east and south of the South Island, and the Chatham Islands, in sandy or muddy substrates (McGregor 1988). They also extend out into deeper water (about 750 m depth), across the Challenger Plateau, the Chatham Rise and into northern parts of the Sub-Antarctic, including the Auckland and Bounty Islands and the Pukaki Rise (Anderson *et al.* 1998).

1.1 Spawning areas
Stargazers are believed to spawn in winter; fish from the Chatham Rise were observed to be maturing or running ripe in June–July (McGregor 1988). Spawning probably occurs in mid and outer shelf waters all around New Zealand (Annala *et. al.* 1999). Eggs are found occasionally along the southeast coast of the South Island in spring (Robertson 1975). Sexual maturity is reached at length 45–50 cm (TL) at age 4–7 years (Sutton 1999).

1.2 Juvenile distribution
No published information was available.

2. Data summaries

2.1 Spawning areas
Gonad state has been recorded mainly from the Chatham Rise (but not the Chatham Islands), the west coast South Island, Southland and the Auckland Islands. Ripe, running ripe and spent fish have been caught in all these areas. They have also been recorded from the south-east coast of the North Island and sporadically off the northern North Island. Areas not well sampled are the east coast of the South Island, Tasman Bay and most of the North Island. Most activity takes place from mid to outer shelf.

There appears to be spawning activity throughout the year. The proportion of resting fish only occasionally reaches 90% in a few areas and the proportion of ripe, running ripe and spent fish rarely exceeds 40%. The highest proportions of spawning fish occur in the following months and areas (where sample sizes and seasonal coverage are sufficient): west coast of the South Island (FMA7), June to September; east cost of the North Island (FMA2), December to February; east Chatham Rise (FMA3), April and September; Southland (FMA5) August to October; Auckland Islands (FMA6), July to September and April.

2.2 Juvenile distribution
Young (0+) juveniles occur mainly around the South Island, with a few on the Chatham Rise, in up to about 300 m depth. Juveniles up to 2 years old have similar distribution, but extend slightly more offshore, particularly off Southland and south to the Auckland Islands. Immature fish combined are found out to about 600 m depth and are more commonly recorded on the Chatham Rise, Challenger Plateau and on the Pukaki Rise. This may be partly related to the lack of sampling in shallower waters (less than 200 m) in some of the areas. Adults have a similar distribution but are slightly deeper, out to about 700 m.

2.3 Juvenile abundance
Juvenile giant stargazer have been caught on *Kaharoa* trawl surveys around the northern North Island (in 83 tows), of the south-east coast of the North Island (in 27 tows) and off the east and west coast of the South Island and in Tasman Bay (in 805 tows). They occur both in shallow and on the outer shelf around the North Island but are mostly mid to outer shelf around the South Island. The largest North Island catch (0.1 $t.km^{-2}$) was in the western Bay of Plenty, catch rates off the south-east coast were low (up to 9 $kg.km^{-2}$). South Island catch rates were relatively evenly spread, although tended to be largest in the South Canterbury Bight, up to 0.3 $t.km^{-2}$.

Juvenile giant stargazer have been recorded also on *Tangaroa* middle depth trawl surveys on the Chatham Rise and off Southland (472 tows total). On the Chatham Rise, catches of juveniles were patchy compared to the distribution of all fish (which were mostly measured). They were concentrated mainly on shallower areas (200–300 m) of the western Rise, with some around the Chatham Islands. The distribution of juveniles in under 200 m depth was not able to be determined as the *Tangaroa* did not trawl in under 200 m and stargazers were not measured on *Akebono Maru 73* tows. Off Southland, juveniles occurred over most of the trawlable area but were concentrated west of Stewart Island in less than 200 m depth (up to 0.1 $t.km^{-2}$).

Kathetostoma sp. Banded stargazer

1. Literature review

Banded stargazer have been recorded in research and a few commercial trawls, mainly 30–300 m depth, almost exclusively off Southland. Research records include two tows from the Chatham Island and commercial records include a few tows off the Wairarapa coast and the Auckland Islands (Anderson *et al.* 1998). The species identification along the Wairarapa coast has yet to be verified.

No published information on spawning or juvenile distribution was available. Length at maturity was assumed here to be 45 cm, as for giant stargazer.

2. Data summaries

2.1 Spawning areas
Gonad state has been recorded from about 60% of tows where this species has been recorded. They spawn on the Southland shelf, mainly along the shelf edge, and one record of a spent fish has been made at the Chatham Islands. Most Southland records were in February and March, when up to about 50% of fish were ripe, running ripe or spent.

2.2 Juvenile distribution
This species only occurs commonly off Southland. Immature fish have been caught in most trawlable areas over the Southland shelf (in 75 to 350 m depth) except for the north-east area south of Otago Peninsula.

2.3 Juvenile abundance
Juvenile banded stargazer have been recorded only from *Tangaroa* middle depth trawl surveys (55 tows) and mainly off Southland. Catch rates were relatively low, but peaked (up to 56 $kg.km^{-2}$) west of Solander Island.

Latridopsis ciliaris Blue moki

1. Literature review

Blue moki have been recorded in research trawls, mainly in under 250 m depth on the east coast of the North and South Islands and off Stewart Island. There are sporadic records off the west coast of both main islands (Anderson *et al.* 1998).

1.1 Spawning areas
Blue moki comprise a single stock on the east coast of New Zealand, between East Cape and Banks Peninsula, and the South Taranaki Bight (Horn 1988). The fish make an annual spawning migration, swimming north from Kaikoura in autumn (May–June) to reach Gisborne, where spawning begins

from August–September. Gonads progress rapidly though developing, ripe and spent and the presence of developing eggs as well as ripe eggs indicates that moki are partial spawners, releasing batches of eggs as they ripen (Francis 1981a). The highest gonad indexes were recorded in mid-August for both sexes: males, 4.35-30.76; females, 2.39-14.11 (Francis 1981a). Spent fish then return, passing Kaikoura again in October. Summer feeding grounds are unknown (Francis 1981a, Horn 1988).

1.2 Juvenile distribution
Eggs spawned near Gisborne are likely to be carried south by the East Cape Current and juveniles have not been found north of East Cape (Francis 1985). The East Cape Current flows eastwards towards the Chatham Islands, which may carry larvae and postlarvae away from the New Zealand coast. However, upwelling of branches of the East Cape Current in Cook Strait and Kaikoura is likely to return some larvae to coastal regions (Francis 1981a).

Juveniles are found inshore, usually associated with rocky reefs, as distinct from adults that generally school offshore (Francis 1985). Juveniles are found on the east coast, from East Cape to Stewart Island, especially south of Wellington (M. Francis, NIWA, Wellington, pers. comm., Ayling & Cox 1982). They are usually found swimming near the bottom in large groups (Ayling & Cox 1982). Blue moki reach sexual maturity at a fork length of about 40 cm and an age of 5-6 years (Francis 1981b).

2. Data summaries

2.1 Spawning areas
Gonad state has been recorded from only 15 tows catching blue moki. Of these, 4 tows had spent fish in February and March; 3 from East Cape to Wairarapa, and one off Stewart Island. The record off Stewart Island suggests the possibility of another spawning area other than the east coast North Island.

2.2 Juvenile distribution
Immature fish have been caught rarely. They occurred close inshore, mostly off the Otago coast and around Stewart Island, but there is also one record from the Bay of Plenty.

2.3 Juvenile abundance
Insufficient data.

Merluccius australis Hake

1. Literature review

Hake have been recorded in research and commercial trawls, mainly in under 250–1200 m depth around the South Island, on the Challenger Plateau and Chatham Rise, and in the Sub-Antarctic. They also have been caught along the south-east coast of the North Island and in the few deep tows around the northern North Island (Anderson *et al.* 1998).

1.1 Spawning areas
Colman (1998) gave evidence for at least three distinct hake spawning grounds. On the west coast South Island, spawning takes place from June onwards, peaking in September. The main centre of activity appears to be a small patch just to the north of the Hokitika Canyon in 600–700 m depth. To the northwest (about 70 n.miles) of the Chatham Islands, spawning appears to take place in September and October (Colman 1998), as it also does in the region between the Auckland and Snares Islands. The status of Puysegur Bank as a spawning ground is uncertain as running ripe females are only found here occasionally (Colman 1998). Hake have been observed to aggregate before spawning off the west coast of the South Island and also on the Chatham Rise (Patchell 1981, 1987).

1.2 Juvenile distribution
The distribution of juveniles is similar to that of spawning adults – off the west coast of the South Island, the Chatham Rise, and the Campbell Plateau (Colman 1988). Immature fish, 25-40 cm long, are widespread in water shallower than 100 m around the South Island (Patchell 1981). There is a west coast South Island hake nursery ground between Cook Canyon and Bruce Bay. Other known nursery areas are Pegasus Bay on the east coast of the South Island, and the east side of Campbell Island (Patchell 1981). Ayling & Cox (1982) also report that hake of 30 cm in length are found commonly in Tasman Bay in shallow water. Female hake mature at 50-60 cm when they are 5-6 years old (Patchell 1981), but size at maturity varies with area, and west coast South Island fish appear to reach maturity at a smaller size than those of the Chatham Rise and the Southern Plateau. Males reach maturity about a year before females (Colman 1998).

2. Data summaries

2.1 Spawning areas
Not described here as hake spawn in over 200 m depth (see above).

2.2 Juvenile distribution
Young (0+) juveniles occur inshore, in less than 200 m depth, mainly off the west coast of the South Island and in Tasman and Pegasus Bays. Juveniles up to 2 years old occur considerably deeper and have been found around Mernoo Bank, the Chatham Islands, and on the Challenger Plateau, but have been rarely caught south of 43°S. Juveniles (1+) have also been found in midwater tows on the west coast of the South Island (*see* Hurst *et al.* 2000). Immature fish combined are found in all the areas where adult occur, extending deeper and south into the Sub-Antarctic, as well as north along the south-east coast of the North Island. In contrast to the 0+ juveniles, adults most commonly occur in over about 350 m depth.

2.3 Juvenile abundance
Juvenile hake have been caught on *Kaharoa* trawl off the east and west coast of the South Island and in Tasman Bay (in 293 tows). They occurred in a high proportion (96%) of tows and from shallow out to the shelf edge. Catch rates were highest the west coast, reaching up to 6.2 $t.km^{-2}$, but one large catch (over 1 $t.km^{-2}$) was also recorded in Pegasus Bay.

Juvenile hake have been recorded also on *Tangaroa* middle depth trawl surveys on the Chatham Rise and off Southland (580 tows total). Catch rates were highest (up to 0.2 $t.km^{-2}$) on the Chatham Rise in the north-west around the Mernoo Bank. All trawling was deeper than 200 m. The distribution of juveniles inside the 200 m contour at the Chatham Islands was not able to be determined as hake were not measured on *Akebono Maru 73* tows. Off Southland, where trawling included depths less than 200 m, juveniles were only caught deeper than 200 m, and catch rates were lower and less frequent than on the Chatham Rise.

***Mugil cephalus* Grey mullet**

1. Literature review

Grey mullet have been rarely caught in research trawls; a few records exist from Hauraki Gulf (Anderson *et al.* 1998).

1.1 Spawning
Females have been caught in Ahuriri Estuary in February with ripe and running gonads (Akroyd & Kilner 1978), which was thought might represent a seasonal run into the estuary to spawn. However, Annala *et al.* (1999) state that this species is likely to spawn at sea, as running ripe females have only been caught off coastal beaches or in inshore waters and eggs and larvae are a component of the

offshore coastal plankton. They also note that spawning occurs off northern New Zealand from November to February.

1.2 Juvenile distribution
Little is known of the juvenile ecology of this species other than that they are found only in sheltered North Island estuaries and harbours, including Pauatahanui Inlet (Healy 1980), Ahuriri Estuary (Akroyd & Kilner 1978), Upper Waitamata Harbour (Saunders 1999), Manukau Harbour (Anon 1989), and the Whangateau Estuary (Morrison 1997). The importance of different harbours and estuaries as nursery habitat appears to vary greatly. Juveniles appear to prefer soft mud habitats in areas of shallow turbid water.

2. Data summaries

2.1 Spawning areas
Not able to be determined from available data.

2.2 Juvenile distribution
The few immature fish caught in trawls were close inshore in the north-western Hauraki Gulf. Immature fish were also caught in beach seines in Pahurehure Inlet, on the west coast off Auckland. They were absent or rare in the other three east coast harbours sampled.

2.3 Juvenile abundance – Auckland harbours
Catch rates in Pahurehure Inlet were highest in winter. It was likely that as these fish grew in size they were better able to avoid the beach seines, and may also have moved off into deeper habitats within the area. No clear spatial patterns were apparent.

Mustelus lenticulatus **Rig**

1. Literature review

Rig have been recorded in research and commercial trawls, mainly in under 300 m depth around the New Zealand shelf. Mernoo Bank is the only offshore area where they have been recorded (Anderson *et al.*. 1998).

1.1 Pupping areas
Rig give birth in spring–summer to live young that are about 25–32 cm total length (Graham 1956, Francis & Mace 1980, Massey & Francis 1989, Francis & Francis 1992). Pupping has not been observed, and the exact location of pupping areas is uncertain. However, the capture of (a) pregnant females carrying full-term embryos (greater than 25 cm total length and/or lacking external yolk sacs), (b) females that have recently pupped (judging by distension and high vascularisation of their uteri), and (c) newly-born 0+ pups (identifiable by their unhealed umbilical scars and/or small size), indicates that pupping occurs either in very shallow coastal and estuarine waters, or close enough to such areas for the new-born young to migrate there (see "Juvenile habitat" below). Pregnant females with full-term embryos have been reported from upper Waitemata Harbour, Porirua and Pauatahanui Inlets, Tasman and Golden Bays, Pegasus Bay, Kaikoura, and Otago Harbour (Graham 1956, Briggs 1980, Francis & Mace 1980, Healy 1980, King 1984, Massey & Francis 1989, Francis & Francis 1992). Recently-pupped females have been reported from Porirua and Pauatahanui Inlets, Tasman and Golden Bays, Kaikoura and Pegasus Bay (Francis & Mace 1980, King 1984, Massey & Francis 1989, Francis & Francis 1992). Newly-born rig have been found in Waikare Inlet in the Bay of Islands, upper Waitemata Harbour, Firth of Thames, Poverty Bay, Porirua and Pauatahanui Inlets, Pegasus Bay, Avon-Heathcote Estuary, Akaroa Harbour, Lyttleton Harbour and Blueskin Bay, Otago (Graham 1956, Webb 1973, Briggs 1980, Healy 1980, Francis 1985, Jones & Hadfield 1985, Francis & Francis 1992).

1.2 Juvenile distribution

New-born and 0+ rig inhabit estuarine and shallow coastal areas from birth (which occurs mainly in spring) until autumn when water temperatures drop, by which time they have grown to about 45–50 cm (Briggs 1980, Jones & Hadfield 1985, Francis & Francis 1992). The juvenile nurseries are widespread throughout New Zealand (see "Pupping areas" above), including very shallow inshore waters of Kaipara Harbour, Waikare Inlet (Bay of Islands), Lyttelton and Akaroa Harbours (Malcolm Francis, NIWA, pers. comm). The rig then emigrate from these habitats, but their destination is unknown. Presumably they disperse widely over the inner continental shelf because larger juveniles (particularly females) are frequently caught in commercial set net and trawl fisheries throughout inshore waters of New Zealand (Francis & Mace 1980, Francis & Smith 1988, Massey & Francis 1989, Francis & Francis 1992).

2. Data summaries

2.1 Pupping areas

Reproductive data are not recorded on the research trawl database. Female rig with embryos over 24 cm long have been recorded from the west and north-east coast of the North Island, Golden and Tasman Bays, Kaikoura, Pegasus Bay, off Otago and the south-west of the South Island (see Section 3).

2.1 Juvenile distribution

Young (0+) juveniles have been caught around the northern North Island, Tasman Bay and the east and west coasts of the South Island, in less than 100 m depth. Age 1+ fish have a similar distribution but have also been caught around the southern North Island. Immature fish combined extend down to Southland and are mostly caught in less than 150 m depth. Adults have a similar distribution but are caught out to about 350 m depth. There is only one record of a rig capture on the Chatham Rise and none in the Sub-Antarctic.

2.2 Juvenile abundance

Juvenile rig have been caught on *Kaharoa* trawl surveys, in shallow waters around the North and South Islands. Around the northern North Island, juveniles occurred in 88% (532) of tows containing rig and were most abundant in the Hauraki Gulf (up to 2.5 $t.km^{-2}$). Off the south-east coast of the North Island, juveniles occurred in 67% (130) of tows containing rig and were more evenly distributed, reaching 0.1 $t.km^{-2}$. Around the South Island, juveniles occurred in 82% (417) of tows containing rig catch rates were relatively evenly spread, except for one large catch (0.7 $t.km^{-2}$) in the south Canterbury Bight.

Nemadactylus macropterus Tarakihi

1. Literature review

Tarakihi have been recorded in research and commercial trawls, mainly in under 400 m depth around the New Zealand shelf, but including shallower areas of the Chatham Rise, particularly the Chatham Islands (Anderson *et al.* 1998).

1.1 Spawning areas

Tarakihi are serial spawners (Tong and Vooren 1972) that spawn in summer-autumn (Robertson 1978). Numerous spawning grounds for tarakihi have been reported: Cape Runaway to East Cape, the east coast of the South Island particularly the deep water off Cape Campbell, Kaikoura Peninsula, Pegasus Bay and the Canterbury Bight, and the west coast of the South Island near Jackson Bay (Vooren 1975, Annala 1987). Juveniles from the North Taranaki Bight nursery are believed to have arisen from adult stock spawning off the west coast of the Auckland district (Vooren 1975). Robertson (1978) found tarakihi eggs in Milford and Dusky Sounds (Fiordland), in March, but did not find evidence off eggs off Otago during an extensive sampling programme (Robertson 1973). Only one larva was recorded off Otago, in April (Parsons 1999), suggesting tarakihi eggs are very rare in this area. Eggs have also been recorded off the south-west of the Chatham Islands near the shelf edge (D. Robertson, NIWA Wellington, pers. comm.).

1.2 Juvenile distribution

The larval stage is followed by a 9–12 month pelagic postlarval stage. Postlarvae have been recorded from the west coast of the South Island (Greymouth, Jackson Bay, Farewell Spit, Puysegur Point), off the Otago coast, the western Chatham Rise, New Plymouth and Castlepoint (Vooren 1972, Tong & Saito 1977). Postlarvae then metamorphose into bottom-living juveniles, at a fork length of 70–90 mm.

Vooren (1975, 1977) listed the following nursery grounds for tarakihi: the south-west coast of the North Island, Tasman Bay, the entire eastern coast of the South Island, especially off Kaikoura Peninsula, in the Canterbury Bight and Blueskin Bay, and around the Chatham Islands. He also noted the occurrence of juveniles in North Taranaki Bight and in various east coast North Island areas (e.g., Bay of Plenty, off Castlepoint) but noted the lack of well-defined eastern nursery areas. He noted that these nurseries occurred at depths of 20–100 m, usually 10–30 km from the shore, and had a dense and varied invertebrate benthic epifauna dominated by sponges, worms, echinoderms, molluscs and small corals. Tasman Bay was the shallowest nursery ground (20–45 m); at Kaikoura, young tarakihi are found at depths exceeding 80 m (Vooren 1975). Annala (1987) suggested that juvenile tarakihi are probably abundant in many rocky inshore areas around New Zealand, where they are not available to sampling by trawls.

Vooren (1975) described movements of juveniles in Tasman Bay. Fish appeared to make seasonal movements within the nursery ground in response to water temperature and started to move towards the northern deeper parts of the nursery in the third and fourth years. They migrated out of the nursery area in their fourth to seventh year when they attain sexual maturity. Tarakihi generally mature between 4–6 years, at 23–36 cm (Tong & Vooren 1972, Vooren & Tong 1973).

2. Data summaries

2.1 Spawning areas

The best coverage of gonad state sampling has been off the south-east coast of the North Island and the west coast of the South Island. Other areas have been poorly sampled. Ripe and running ripe fish have been recorded from all around New Zealand but not the Chatham Islands. Spent fish have been recorded from similar areas, including the Chatham Islands.

Seasonal coverage of sampling is poor in most areas. On the west coast of the South Island (FMA7), most samples are from March April when about 20% of fish were resting and up to 20% of fish were spawning or spent. Most fish sampled in August to November were resting. Off the south-east coast of the North Island (FMA2), most sampling was February to April. Only 20% of fish were resting during this period, with up to 20% spawning or spent in February. Again, most fish were resting in November. Off Southland (FMA5) the pattern was similar, with fish sampled in February–March up to 30% spawning or spent. Off the west coast North Island (FMA8&9), fish were sampled mostly from November to January and changed from mostly resting to mostly maturing during this period. In summary, for areas where there are sufficient data, it appears that late summer/autumn is a common spawning period across most areas and that most fish are resting in spring. There are two areas which do not appear to fit this pattern: the east coast South Island, where fish are mostly resting in February and mostly maturing in May–June, suggesting late autumn/early winter spawning; and the Chatham Islands, where about 15% of fish were spent in December suggesting perhaps a spring spawning season.

2.2 Juvenile distribution

Tarakihi 0+ juveniles have been caught in bottom trawls mainly off the east coast of the South Island in less than 100 m depth. Juveniles up to 2 years old are more widespread, occurring around the mainland and at the Chatham Islands, also in less than 100 m depth. Immature fish combined are well represented in all mainland areas and at the Chatham Islands and occur slightly deeper, but still mostly less than 150 m depth. Adults have a similar areal distribution to 1+ fish, although they are also caught around the Mernoo area on the Chatham Rise and are deeper, 50–300 m.

2.3 Juvenile abundance
Juvenile tarakihi have been caught on *Kaharoa* trawl surveys, in mainly mid to outer shelf waters around the North and South Islands. Around the northern North Island, juveniles occurred in 143 tows and were most abundant in the Bay of Plenty (up to 0.25 $t.km^{-2}$). Off the south-east coast of the North Island, juveniles occurred in 126 tows and were most abundant off East Cape (up to 0.1 $t.km^{-2}$). Around the South Island, including Tasman Bay, juveniles occurred in 484 tows. Catch rates were dominated by one large tow (4.9 $t.km^{-2}$) in mid-Canterbury Bight, but there were also areas of moderate abundance in Tasman Bay, Pegasus Bay and south Canterbury Bight.

Juvenile tarakihi have been recorded also on *Tangaroa* middle depth trawl surveys off Southland (80 tows) and in *Akebono Maru 73* tows around the Chatham Islands (27 tows), mainly in inshore waters. Off Southland, catch rates were mainly restricted to inshore waters around Stewart Island and peaked at 0.8 $t.km^{-2}$. Catch rates around the Chatham Islands were highest (up to 47 $kg.km^{-2}$) to the east. Catch rates in depths under 200 m were not able to be determined for other parts of the Chatham Rise.

Nototodarus gouldi & sloanii Arrow squid

1. Literature review

Arrow squid have been recorded in research and commercial trawls, mainly in waters less than 400 m depth around the New Zealand shelf, on the Challenger Plateau and Chatham Rise and in the Sub-Antarctic (Anderson *et al.* 1998). *Nototodarus gouldi* are generally found around mainland New Zealand, north of the subtropical convergence, while *N. sloanii* are found in and to the south of the convergence (Smith *et al.* 1987, Uozumi 1997).

1.1 Spawning areas
Individuals of both species live for about a year, spawn once, and die (Mattlin *et al.* 1985, Uozumi 1997). Spawning peaks in spring and autumn (Mattlin & Colman 1988).

Uozumi (1997) noted that there was no direct evidence of spawning grounds for *N. gouldi* but that the distributions of mature adults and paralarvae (up to 50-60 days old) suggest one main spawning area for this species on the shelf in North Taranaki Bight. He also reviewed evidence for spawning areas of *N. sloanii* and suggested they do not undergo large-scale along-shore migrations, but that mature females migrate inshore and may spawn in less than 50 m depth. Paralarvae were found around the South Island, the Auckland Islands, Mernoo Bank, and the Chatham Islands, from July to September.

1.2 Juvenile distribution
Uozumi (1997) described the distribution of juvenile squids around central and southern New Zealand. During July to September, juvenile *N. gouldi* were found mainly from North Taranaki Bight down to Westport, and juvenile *N. sloanii* were found to the east and south of the South Island, Mernoo and the Chatham Islands. As juveniles grow they appear to extend their range, but whereas *N. gouldi* remain mostly in under 200 m depth, a high proportion (up to more than 50%) of *N. sloanii* appear to migrate into deeper water. Juveniles were generally found in similar areas to adults.

2. Data summaries

Identification of *Nototodarus* to species level on the trawl database may not have been precise and consistent over time. Therefore, records of each species (NOS, NOG) were combined to produce distribution maps of juveniles for the EEZ. Within smaller areas (e.g., Taranaki Bight, Southland etc.), records can reasonably be assumed to be mostly (but not exclusively) one or the other species, depending on the area (*see* Uozumi 1997).

2.1 Spawning areas
There were few (67) records of squid maturity stages on the trawl database and they were therefore not summarised here.

2.2 Juvenile distribution
Arrow squid have a short life span and spawn only once. Therefore, most of the squid caught are juveniles. This is reflected in the wide distributional range of squid under 31 cm, which is similar to that of larger squid. Arbitrary split by size, into 2 juvenile groups, shows that the smallest group (<15 cm) occur all around the mainland, the Auckland Is and in pockets around shallower features on the Chatham Rise. As the squid grow, they expand their offshore distribution onto the Chatham Rise and into the Sub-Antarctic. The apparent predominance of juveniles off the north-east of the North Island, cannot be confirmed from Uozumi's (1997) study as his sampling did not extend that far north.

2.3 Juvenile abundance
Juvenile arrow squid have been caught on *Kaharoa* trawl surveys, in shallow to outer shelf waters around the North and South Islands including Tasman Bay. Around the northern North Island, juveniles occurred in 342 tows and were most abundant on the east coast (up to 0.25 $t.km^{-2}$) but not in the Hauraki Gulf. Off the south-east coast of the North Island, juveniles occurred in 123 tows and were relatively evenly distributed except for a large catch (0.5 $t.km^{-2}$) off eastern Cook Strait. Catch rates on the east coast of the South Island were larger than off the west coast and were largest along the outer shelf (up to 2.4 $t.km^{-2}$) in Canterbury Bight.

Juvenile arrow squid have been recorded also on *Tangaroa* middle depth trawl surveys on the Chatham Rise and off Southland (892 tows) and in *Akebono Maru 73* tows around the Chatham Islands (70 tows). Juveniles occurred across the Chatham Rise, but regional differences in abundance are probably not well determined by *Tangaroa* tows due to the lack of trawling inside 200 m depth. At the Chatham Islands, juveniles were commonly caught by *Akebono Maru 73* in mid to outer shelf depths and catch rates peaked (3.0 $t.km^{-2}$) to the south. Off Southland, *Tangaroa* catches were also mainly mid to outer shelf depths and were higher than those in deeper water on the Chatham Rise. Catch rates peaked at 4.6 $t.km^{-2}$ and were highest at the southern edge of the shelf, south of Otago Peninsula, and to the west of Stewart Island.

Pagrus auratus Snapper

1. Literature review

Snapper have been recorded from research trawls, mainly from around the North Island and northern South Island, in leass than 150 m depth (Anderson *et al.* 1998).

1.1 Spawning areas
Snapper are serial spawners, and release many batches of eggs over a period of several months. Most information comes from the Hauraki Gulf, where spawning is concentrated along the western side in an arc from Waiheke Island to Kawau Island, in depths of greater than 20 m (Crossland 1980). Spawning occurs when water temperatures are around 15–16 °C, mainly over the months of November–December (Cassie 1956a, b, Crossland 1977, 1980, Scott & Pankhurst 1992). No spawning occurs in very turbid or estuarine (low salinity) areas (Crossland 1981).

Other known spawning ground grounds on the east coast North Island are Rangaunu Bay, Doubtless Bay, Bay of Islands, Bream Head, between Little Barrier and Great Barrier Islands, and the eastern Bay of Plenty. Spawning also occurs off the main harbours on the west coast of the North Island and in Tasman Bay.

Eggs are planktonic, and float freely in the sea until hatching, with the egg phase lasting from 36–54 hours, depending on the water temperature (Crossland 1981). Eggs form dense patches and Crossland (1980) consistently found concentrations east of Tiri Tiri Matangi Island and around Flat Rock (Hauraki Gulf). Roper (1986) found larvae from October through to March (peaking in December) in the entrance to the Whangateau Harbour (Roper 1986). Through the use of back-calculations from daily rings on the otoliths of benthic phase snapper, Francis (1994) showed the duration of the larval phase to be 18–32 days, with longer periods being recorded for snapper spawned earlier in the season, when water temperatures were low.

1.2 Juvenile distribution

Small juvenile snapper are found over shallow soft bottom sediments (Francis 1985), shallow rocky reefs (Kingett & Choat 1981) and over eelgrass beds (Paul 1976). Paul (1976) found small benthic phase snapper of 2–4 cm in beach seines in shallow harbours and bays of the south-west Gulf in February–March. On soft sediment habitats in Kawau Bay (north-western Hauraki Gulf), Francis (1985) found small scale patchiness associated with changes in micro-habitat, a preference for muddy substrates, and seasonal cycles of catch rates in some areas (peaking in spring). He found no evidence of any seasonal migrations of juvenile snapper from shallow to deeper waters over the year (Francis 1985). However, Kingett & Choat (1981) did find evidence of a seasonal inshore-offshore migratory pattern in a shallow rocky reef habitat, also in the Hauraki Gulf. The abundance of 0+ and 1+ fish was low during winter, with a marked increase during spring and summer. Small scale preferences for micro-habitat (coralline turf) were also evident. A seasonal cycle of abundance for 1+ to 3+ fish was also found in the Whangateau Estuary, with fish only being present in the estuary over the late summer months (Morrison 1997). On larger spatial scales, 1+ fish have been found to be most abundant in the shallow south-western waters of the Hauraki Gulf during both spring and summer, with 2+ snapper being more widely distributed throughout the Gulf (Paul 1976).

Horn (1986) suggested a nursery ground for juvenile snapper in the north Taranaki Bight, while Paul & Tarring (1980) suggested another to exist in waters of less than 50 m depth in the East Cape region.

2. Data summaries

2.1 Spawning areas

Gonad state has been recorded from most areas where it has been caught, except the offshore part of the southern Taranaki Bight. Ripe and running ripe fish have been recorded from the northern North Island, down to Taranaki and Napier. Spent fish have also been recorded a single tow off the west coast South Island.

Seasonally, most coverage is for spring, summer or both. Off the north-east North Island (FMA1), the highest proportion (about 60%) of spawning fish occurs in November. Maturing fish are present through to February. Off the north-west coast of the North Island (FMA8&9), peak spawning is in December (about 50%) and appears to be finishing in February. Off the east Cape area (FMA2), samples from February to April suggest spawning took place earlier. Similarly for the west coast South Island (FMA7), the few samples in March and April suggest an earlier spawning.

In summary, most spawning activity for snapper is in spring in northern areas (FMAs 1, 8&9). Spawning locations and times were not well determined for other areas (FMAs2, 7) but may be similar.

2.2 Juvenile distribution

Young 0+ and 1+ juveniles occur mainly in less than 50 m depth around the northern North Island and in Tasman Bay. The distribution of immature fish combined is similar. Adults are also caught in southern North Island areas and occasionally on the west coast of the South Island, extending out to about 100 m depth.

Juvenile abundance
Juvenile snapper have been caught on *Kaharoa* trawl surveys, mainly in shallow waters around the northern North Island (in 1285 tows) and rarely off the south-east coast of the North Island (1 tow) and northern South Island (4 tows). Around the northern North Island, juveniles were most abundant in the Hauraki Gulf (up to 10.5 $t.km^{-2}$) and moderately abundant in the bay of Plenty.

Parapercis colias **Blue cod**

1. Literature review

Blue cod have been recorded in research and a few commercial trawls, mainly in under 200 m depth around the northern North Island, Tasman Bay, east and southern South Island and the Chatham Islands. They have occasionally been caught around Taranaki, Mernoo Bank and off the west coast South Island (Anderson *et al.* 1998).

1.1 Spawning areas
Blue cod spawn from late winter to spring and in both Northland and Southland the GSI was found to peak in September (Pankhurst and Conroy 1987; Carbines 1998). Individual fish are involved in multiple spawning episodes (Pankhurst and Conroy 1987) and spawning aggregations have been reported within inshore and mid shelf waters. Eggs and larvae have been recorded from both inner (Parsons 1999) and outer (Robertson 1975, 1980) shelf waters off Otago. Graham reports the departure of ripe fish from the Otago region in June, and the return of spent fish in September (Graham 1939). However, running ripe fish are found throughout the Marlborough Sounds (Blackwell 1998) where they are considered to spawn locally (Rapson 1956). It appears that spawning behavior of blue cod may differ between regions dependent upon local hydrological processes (Carbines & McKenzie, in press).

1.2 Juvenile distribution
Eggs are pelagic for about 5 days after spawning, as are the larvae before settling on the seabed (McGregor 1988). In some areas juveniles are thought to migrate from shelf waters to shallow areas inshore (Rapson 1956). Young fish appear on shallow reefs in summer (Paul 1986). However, juvenile blue cod have also been observed in shallow waters in both the Marlborough Sounds and Paterson Inlet (Southland). Size and age at sexual maturity varies by location: Northland, 10–19 cm or 2 years old (Mutch 1983); Marlborough Sounds, 21–26 cm or 3–6 years (Blackwell 1998); and Southland, 26–28 cm ort 4–5 years (Carbines 1998).

2. Data summaries

The full distribution of blue cod is not well determined from trawls as much of the population occurs over untrawlable ground. The few records of blue cod at the Auckland Islands from commercial trawls may have been misidentified notothenid cod and have been deleted from the plots.

2.1 Spawning areas
Gonad state has been recorded mainly from fish off the east coast South Island (FMA3) and Southland (FMA5). Ripe and running ripe fish have been recorded from both areas and spent fish from FMA5. Records from the Auckland Islands are presumed to have been misidentified. In FMA5, at least 50% of fish were spawning or spent from January to March. In FMA3, spawning and spent fish made up 50 to 90% of fish sampled in January, May and December. This suggests summer and autumn spawning in both areas, but activity during the rest of the year cannot be determined.

2.2 Juvenile distribution
Blue cod have been caught in many research tows around New Zealand, including the Chatham Islands, but rarely on the south-east coast of the North Island and west coast of the South Island. Records from the Auckland Islands are presumed to have been misidentified. Immature blue cod have been recorded mainly from the Hauraki Gulf, Bay of Plenty, Tasman Bay, off Otago and Southland.

2.3 Juvenile abundance
Juvenile abundance was not determined, as trawls surveys are not an appropriate method.

Pelotretis flavilatus lemon sole

1. Literature review

Lemon sole have been recorded in research trawls, mainly in under 150 m depth, but extending out to 400 m. They occur mainly around New Zealand, extending south to Stewart Island, and on shallower parts of the Chatham Rise (Anderson *et al.* 1998).

1.1 Spawning areas
Rapson (1940) described aspects of the spawning behaviour of lemon sole off the northern South Island. Spawning is known to occur off Croseilles Harbour (Tasman Bay) and in Admiralty Bay (Pelorus Sound). In Tasman Bay, spawning schools may move about considerably and their position may vary by 10 miles or more from one season to the next, and by several miles from day to day. Spawning extends over a period of about 6 months, with the season usually commencing in June, and continuing until December. Rapson (1940) also suggested that fish may migrate from deeper into shallower water to spawn. Males tend to congregate on the spawning grounds before females and to remain there for a longer time. Larger fish spawn before smaller fish, and more fish spawn in the afternoon than the morning.

Off the northern South Island, Rapson (1940) found three important centres of egg distribution were found in Croisilles Harbour, Admiralty Bay, and Beatrix Bay (Pelorus Sound). These were mostly close inshore in sheltered bays. Eggs and larvae have been recorded off Otago (Robertson 1973, Parsons 1999) and a few larvae in Otago Harbour (Roper & Jillet 1981). Eggs have also been recorded from Pegasus Bay (Robertson 1973). In the northern Hauraki Gulf, peak larval abundance was found from April to July (Roper 1986).

1.2 Juvenile distribution
Juveniles have not been found in other studies of the juvenile fish fauna of harbours, suggesting that such areas are not nurseries for this species.

2. Data summaries

2.1 Spawning areas
Not able to be determined because of insufficient data.

2.2 Juvenile distribution
The youngest (0+) juveniles have been caught mainly in inshore (less than 100 m depth) in Hauraki Gulf and the Bay of Plenty, and rarely in Tasman Bay and Canterbury Bight. Immature fish (mostly 0+) are more frequently around the South Island than 0+ fish. Age 1+ fish (mostly mature) extend deeper (to about 150 m) than 0+ fish and occur all around New Zealand, except there are few records on the Chatham Rise. Most of the Chatham Rise records are of larger adults that extend down to 400 m depth.

2.3 Juvenile abundance
Juvenile lemon sole have been recorded on *Kaharoa* inshore trawl surveys around the northern half of the North Island and around the South Island. Catch rates are very low, peaking at 7 $kg.km^{-2}$ in the Hauraki Gulf.

Peltorhamphus novaezeelandiae New Zealand sole

1. Literature review

New Zealand sole have been caught in research trawls mainly around the northern North Island and east and west coasts of the South Island, including Tasman Bay, mainly in less than 100 m depth (Anderson *et al.* 1998).

1.1 Spawning areas
Eggs of this species have been recorded from Pauatahanui Inlet (Healy 1980) and off the Otago coast from autumn to spring (Robertson 1973, Parsons 1999).

1.2 Juvenile distribution
Adults of this species are widespread in coastal waters (Anderson *et al.* 1998). Estuaries provide nursery grounds for this species, with juveniles being recorded from Pauatahanui Inlet (Healy 1980), Ahuriri Estuary (Kilner & Akroyd 1978), the Avon-Heathcote Estuary (Webb 1972a) and the Manukau Harbour (Pearks 1985, Morrison 1998). However, not all estuaries may provide a nursery function, as juveniles were not recorded from Waimakariri Estuary (Eldon & Kelly 1985), Kakanui Estuary (Jellyman *et al.* 1997), Otago Harbour, Papanui Inlet, or Hoopers Inlet (Roper & Jillett 1981).

Use of estuaries by juveniles is quite seasonal. In Pahurehure Inlet (Manukau Harbour), over summer juveniles (25–100 mm) were present at high densities on low-tide channel bank edges, while larger juveniles (75–150 mm) were found in low densities in adjacent low tide channels (Morrison 1998). By autumn, all of these juveniles had disappeared from the area. Pearks (1985) found a similar seasonal pattern for an area on the western side of the Manukau Harbour, with juveniles being most common from September–March.

2. Data summaries

2.1 Spawning areas
Not able to be determined because of insufficient data.

2.2 Juvenile distribution
Juveniles have been caught by trawlers all areas where the species has been recorded. They occur close inshore in less than 75 m. Pahurehure Inlet was the only one of the four harbours sampled by beach seine to contain significant numbers of juveniles of this species.

2.3 Juvenile abundance – Auckland harbours
This species was only present in Pahurehure Inlet in autumn, consistent with previous sampling in this area that has shown them to be absent from the system in the winter months, both in the intertidal fringe and in the adjacent subtidal channels. All animals were of the 0+ cohort (<100 mm).

Polyprion oxygeneios Hapuku

1. Literature review

Adults are widely distributed around New Zealand, mainly on rough ground (ledges, cliffs, pinnacles and reefs) in 100–400 m depth (Paul & Davies 1988, Anderson *et al.* 1998). Their range extends along the Chatham Rise to the Chatham Islands, but apart from a single record they are not known from the Campbell Plateau (Paul 1986, Roberts 1986, Anderson *et al.* 1998, Hurst *et al.* 2000).

1.1 Spawning

Tagging studies and seasonality of catches suggest that hapuku may move long distances to spawn, and that they may return periodically to specific spawning sites (Johnston 1983a, 1983b, 1992, Beentjes & Francis 1999). Spawning occurs in winter but spawning grounds have not been identified (Paul & Davies 1988, Beentjes & Francis 1999). Ripening fish have been caught off Otago in July-August (Graham 1939) and Kaikoura and Cook Strait in May-July (Johnston 1983a, 1983b, Roberts 1986). Spent fish reappear in Cook Strait in October, and in Kaikoura in October-December (Johnston 1983b, Roberts 1986). These observations suggest that spawning occurs in or near Cook Strait. Separate hapuku stocks may occur elsewhere in New Zealand, but nothing is known about their spawning locations.

1.2 Juvenile habitat

Hapuku have a pelagic juvenile phase (Roberts 1986, 1996). These juveniles are rarely caught and their distribution is poorly known (Paul 1986, Paul & Davies 1988). When they are about 40–50 cm (3–4 years), they switch from a pelagic to a demersal life style (Francis *et. al.* 1999). Juveniles less than 51 cm long have been recorded mainly from the continental shelf of the east coast of South Island and at the Chatham Islands in depths shallower than 200 m (Hurst *et al.* 2000). Larger juveniles (51-60 cm) occur in the same areas, but they are also relatively common on the Stewart-Snares Shelf, and along the east coast of North Island between Cook Strait and East Cape, and range into deeper waters (to about 400 m) (Hurst *et al.* 2000). Two juveniles (53, 56 cm long) were also caught by longlines off East Cape in over 2500 m bottom depth (Michael 1988). Both sexes mature at about 10–13 years, at length 85 cm for males, 88 cm for females (Johnston 1983b, Francis *et al.* 1999).

2. Data summaries

The distribution of adult fish is not well determined by trawls, as much of the population would be over untrawlable ground.

2.1 Spawning areas

Gonad state has been recorded mainly from fish off the east coast North Island (FMA2), the west coast South Island (FMA7), and Southland (FMA5), and sporadically elsewhere. Ripe and running ripe fish have been recorded from all areas except the northern North Island. Spent fish also occur in 3 of the same areas. Samples from each area are too small to be able to determine seasonal patterns by area. Across all areas, it appears that maturing are found throughout the year and that most spawning and spent fish are recorded from July to October.

2.2 Juvenile distribution

Young (under 50 cm) juveniles occur mainly off the east and southern coasts of the South Island in less than 200 m depth, with a few records of the east coast North Island and at the Chatham Islands. Records from midwater trawls and tuna longlines were relatively rare and not reported by Hurst *et al.* (2000). By 60 cm length, hapuku juveniles are caught deeper (up to about 400 m) and northwards. Immature fish (up to 86 cm length) have a similar distribution, extending up to North Cape and off the west coast. Adults occur in the same general areas, but are deeper and less common.

2.3 Juvenile abundance
Juvenile hapuku have been recorded on *Tangaroa* middle depth trawl surveys on the Chatham Rise and off Southland (369 tows) and in *Akebono Maru 73* tows around the Chatham Islands (111 tows). Most (over 75%) tows with hapuku contained juveniles. Juveniles were patchy across the Chatham Rise in depths over 200 m, occurring mainly east of the Mernoo Bank and west of the Chatham Islands. Abundance inside 200 m depth was not able to be determined from *Tangaroa* tows. At the Chatham Islands, juveniles were commonly caught by *Akebono Maru 73* in mid to outer shelf depths. One large catch of 0.9 $t.km^{-2}$ occurred to the west, but catch rates were more consistently high to the east of the Islands. Off Southland, juveniles were widespread in trawlable areas, although catch rates were higher in inshore waters. Catch rates were also higher (up to 0.3 $t.km^{-2}$) than those by *Tangaroa* in deeper water on the Chatham Rise.

Pseudocaranx dentex Trevally

1. Literature review

Trevally have been recorded from research trawls around the North Island and north-west South Island, mainly in less than 100 m depth (Anderson *et al.* 1998).

1.1 Spawning areas
No published information is available on the possible spawning grounds of this species. Trevally are serial spawners that spawn during summer months (Annala *et al.* 1999). Eggs and larvae have been recorded north of 38° S (James 1976). Sampling of the neuston of the northern Hauraki Gulf over a year recorded only 1 larvae (Tricklebank *et al.* 1992).

1.2 Juvenile distribution
Juveniles enter a demersal phase from about one year old until they reach sexual maturity. Fish of up to two years age are found in shallow inshore areas including harbours and estuaries (Annala *et al.* 1999). Schools of 0+ fish are often observed over shallow areas of rocky reef habitat by divers. Seasonal sampling in the Whangateau Harbour found 1+ trevally to be present in the harbour only over the summer period, suggesting seasonal migrations into and out of the harbour (Morrison 1997). A trevally nursery ground in shallow waters of the North Taranaki Bight was suggested by Horn (1986), although catch rates were relatively modest in this area compared to later trawl surveys carried out further north on the same coast. Juveniles were caught in most parts of Pauatahanui Inlet, with a suggestion that shallow sandy areas were especially favoured (Healy 1980).

2. Data summaries

2.1 Spawning areas
Gonad state has been recorded from 125 tows and 502 fish from the south-east North Island (FMA2) only. Ripe, running ripe and spent fish have been found throughout the area, mainly in February (40%), but also in March and April. There are no records for other months.

2.2 Juvenile distribution
Juveniles (0+ and 1+) occur mainly in less than 50 m depth around the northern North Island and occasionally off east Cape, in South Taranaki Bight and in Tasman Bay. The distribution of immature fish combined is similar. Adults are also caught in southern North Island areas and occasionally on the west coast of the South Island, extending out to about 100 m depth.

2.3 Juvenile abundance
Juvenile trevally have been caught on *Kaharoa* trawl surveys, mainly in shallow waters around the northern North Island (in 557 tows) but also off the south-east coast of the North Island (56 tows).

Around the northern North Island, catch rates were largest on the north-west coast (up to 2.4 $t.km^{-2}$). On the north-east coast, catches were highest in the Bay of Plenty. Catch rates off the south-east coast of the North Island were in the north and reached 0.2 $t.km^{-2}$.

Pseudophycis bachus Red cod

1. Literature review

Red cod have been caught in research and commercial trawls all around New Zealand, across the Chatham Rise and in shallower areas of the Sub-Antarctic, down to about 500 m depth (Anderson *et al.* 1998).

1.1 Spawning areas
Red cod from the Canterbury Bight spawn from August to October, although fish that appeared to be in maturing condition have been recorded in January. Spawning aggregations or grounds have not been located but are believed to be in deeper water (Habib 1975, Beentjes 1992). Off Otago, fish in ripe condition were observed to leave harbour and inshore areas of Otago for deeper waters of North Reef (Graham 1939). A few larvae have been found in inner shelf waters off Otago (Parsons 1999). On Puysegur Bank, running ripe fish were caught in 600 m in February 1994 (Annala *et. al.* 1999).

1.2 Juvenile distribution
There are no known red cod nursery grounds although juveniles have been caught in deep water after the spawning period. Plankton studies have failed to find red cod eggs or larvae over the continental shelf and it is likely that these stages exist in deeper water (Beentjes 1992). Graham (1939) found juveniles in Otago Harbour (Graham 1939). Red cod reach maturity and spawn at around 50cm, which equates to about 3 years old (Beentjes 1992).

2. Data summaries

2.1 Spawning areas
Gonad state has been recorded from most areas in most months. Areas not well covered are the northern North Island (FMA1), Chatham Islands (FMA4), and Sub-Antarctic areas other than the Auckland Islands (FMA6). Ripe and running ripe fish have been recorded throughout the areas sampled except for FMA 1&2 where there is only 1 tow. Spent fish have been recorded in the same areas and in FMA2.

Seasonally, there is not much evidence of spawning in FMA 1&2. Off the east coast of the South Island (mainly FMA3), most spawning stage fish are caught in October, although there is some suggestion of activity also in April–May. Off the west coast of the South Island and South Taranaki Bight (FMA7&8), more than 20% of fish are actively spawning from July to September, and there is some evidence of activity April. Off Southland (FMA5), most activity is in September with some in February to April. Around the Auckland Islands (FMA6), there is evidence of activity from September through to January, but the peak is not well determined.

In summary, the data suggest there is little spawning activity around the North Island; spawning activity around the South Island is mainly in late winter/early spring, but with a secondary peak in autumn; and that spawning in the Sub-Antarctic may be slightly later in spring/summer.

2.2 Juvenile distribution
Young (0+) juveniles have been caught around the mainland, although relatively infrequently around North Cape, South Taranaki Bight, and off Southland. The depth of capture is mostly less than 250 m but includes up to about 450 m. Juveniles up to 2 years old have similar distribution, although they are also commonly caught on the Chatham Rise, off Southland and around the Auckland Islands. A

higher proportion was caught in the deeper (200–450 m) part of the range. Immature fish combined includes mainly 0+ and 1+ fish and is therefore similar. Adults have a similar distribution to 1+ fish.

2.3 Juvenile abundance

Juvenile red cod have been caught on *Kaharoa* trawl surveys, mainly around the South Island (in 1045 tows) but also along the south-east coast of the North Island (in 226 tows). They occurred from inshore to the shelf edge and were most abundant in the South Canterbury Bight (up to 21.8 $t.km^{-2}$). On the south-east coast of the North Island, large catch rates were patchy, up to 2.4 $t.km^{-2}$. Juveniles were not recorded around the northern North Island, even though adults were present in 121 tows.

Juvenile red cod have been recorded also on *Tangaroa* middle depth trawl surveys on the Chatham Rise and off Southland (347 tows) and in *Akebono Maru 73* tows around the Chatham Islands (3 tows). Juveniles occurred in the shallower depths sampled across the Chatham Rise (i.e., mainly 200–300 m), to the east of the Mernoo Bank and west of the Chatham Islands. Abundance inside 200 m depth was not able to be determined from *Tangaroa* tows. At the Chatham Islands, juveniles were rarely caught by *Akebono Maru 73* and catch rates peaked at 0.5 $t.km^{-2}$. Off Southland, juveniles were occasionally caught, mainly in mid to outer shelf depths, and the largest *Tangaroa* catch rate (12.1 $t.km^{-2}$) occurred on the southern edge of the shelf.

Rexea solandri Gemfish

1. Literature review

Gemfish have been caught in research and commercial trawls around New Zealand, occasionally on the Challenger Plateau and Chatham Rise and rarely in the Sub-Antarctic. They occur mainly in less than 500 m depth (Anderson *et al.* 1998).

1.1 Spawning areas

Hurst (1998) suggested that there are two stocks of gemfish, a southern/west coast stock and a northern/east coast stock. The northern/east cape stock, which is caught mainly on the east coast of the North Island in spring through to autumn, is thought to migrate to the Bay of Plenty and North Cape to spawn in winter (Hurst & Bagley 1998). The exact location of the spawning ground is not known. The southern/west coast stock, caught in the southern area from spring to autumn, is thought to migrate to the west coast of the South Island to spawn, where they are caught in August–September (Hurst & Bagley 1998). Absence of Southland gemfish in June trawl surveys supports the hypothesis of migration out of the Southland area to spawn (Hurst & Bagley 1998).

1.2 Juvenile distribution

Adult gemfish are widely distributed around New Zealand on the continental shelf and slope down to 500 m depth (Hurst & Patchell 1985). Juveniles and adults occur together, in most areas, with schools occurring seasonally on some grounds (Paul 1986). The length and age at which gemfish reach sexual maturity has not been accurately determined. It appears that most fish probably reach sexual maturity by age 5, although some may spawn as early as age 2 (Hurst & Bagley 1998).

2. Data summaries

2.1 Spawning areas

Gonad state has been recorded from the north-east North Island (FMA1&2) and off Southland (FMA5) in most months. Coverage in other areas is more sporadic and is minimal from the north-west North Island (FMA8&9). Ripe and running ripe fish have been recorded mainly from FMA 1 and FMA 7. Spent fish have been recorded in all areas where gemfish have been sampled, except FMAs 8&9. The depth of spawning appears to be mostly outside 200 m.

Seasonally, there are few ripe and running ripe fish recorded. Most of them were taken in July in FMA 1. However, there is clear evidence of maturation of fish throughout most areas in autumn months and a high proportion of resting fish in spring and summer.

In summary, the data suggest there is spawning activity in winter on the north-east coast of the North Island and west coast of the South Island, but the exact localities and timing are not able to be determined from these data.

2.2 Juvenile distribution

The distribution of 0+ juveniles is consistent with the 2 main spawning areas recorded. Juveniles in the Bay of Plenty have possibly been carried south from the North Cape area in the East Auckland current. They occur in relatively deeper (200–400 m depth) offshore areas. Juveniles up to 2 years old are more commonly recorded and have extended their range down the east coast of the North Island and along the west coast of the South Island. Immature fish combined have a similar distribution to adults, also offshore in 200–400 m depth, but extending along the east coast of the South Island and into Southland. Adult distribution is similar, with a few records also on the Chatham Rise.

2.3 Juvenile abundance

Juvenile gemfish have been caught on *Kaharoa* trawl surveys, almost exclusively on the east coast of the North Island and the west Coast of the South Island. Catch rates were relatively patchy; they peaked at 200 $kg.km^{-2}$ on the east coast (in the Bay of Plenty and off the Wairarapa coast) and at 100 kg. on the west coast (off Hokitika).

Juvenile gemfish have been recorded also on *Tangaroa* middle depth trawl surveys, but only in a few (14) tows off Southland. Catch rates were low, peaking at only 95 $kg.km^{-2}$ at Puysegur. Catches of gemfish (adult or juvenile) were rare on the Chatham Rise.

Rhombosolea leporina Yellowbelly flounder

1. Literature review

Yellowbelly founder have been caught in research trawls in shallow (less than 50 m) inshore areas, mainly around the northern North Island and in Tasman and Pegasus Bays (Anderson *et al.* 1998).

1.1 Spawning areas

In the Hauraki Gulf, spawning occurs during September–October in a belt extending from Tapu on the eastern side of the Firth of Thames, north-westwards towards Ponui Island (Colman 1973b). Juveniles disperse onto the spawning grounds from shallower waters during winter, and spawn for the first time as two-year-olds. Spawning takes place in water depths of 18–27 m (Colman 1973a). Ripe and spent fish have been recorded also from Pauatahanui Inlet (Healy 1980), and from the Avon-Heathcote Estuary (Webb 1972a), where they have a short breeding season in winter and spring (Webb 1972b).

Rhombosolea spp. larvae have been sampled in the northern Hauraki Gulf through August to November (Tricklebank *et al.* 1992), probably consisting of sand and yellow-belly flounder individuals. Eggs of this species have been recorded from the Manukau Harbour from September through to December, with a peak in October (Pearks 1985). Eggs and larvae have been recorded from Pauatahanui Inlet (Healy 1980). Larvae were recorded off Otago from autumn to spring (Parsons 1999).

1.2 Juvenile distribution
Juveniles appear to be exclusively limited to sheltered harbours and estuaries and have been found in Waimakariri Estuary (Eldon & Kelly 1985), Pauatahanui Inlet (Healy 1980), Ahuriri Estuary (Kilner & Walsh 1978), the southern end of the Firth of Thames (Colman 1973a, b), the upper Waitemata Harbour (Saunders 1999), and the Manukau Harbour (Pearks 1985, Morrison 1998). Abundance is highest over the summer months (Healy 1980, Pearks 1985, Morrison 1998).

Seasonal sampling in the Pahurehure Inlet, Manukau Harbour found high densities of small juveniles (25–100 mm) in summer along low-tide channel bank edges (Morrison 1998). Much lower densities of larger animals (75–150 mm) were present in the adjacent low-tide channels. Through autumn and winter the density of juveniles on the edge of the banks dropped substantially, while densities out in the channels proper increased. The average size of fish on the bank edges showed no change over a six month period, suggesting a combination of continued recruitment of smaller fish and emigration of larger fish. By winter, the highest densities of animals were located in 5–10 m water depth. This was taken to be evidence of an ontogenetic shift with age/size between estuarine habitats from shallow to deeper waters (Morrison 1998).

2. Data summaries

2.1 Spawning areas
Not able to be determined because of insufficient data.

2.2 Juvenile distribution
Immature fish (mainly 0+) have been caught in a few (22) trawls in shallow inshore areas, less than 50 m, in the Hauraki Gulf, Bay of Plenty, and Tasman Bay. Age 1+ (mainly mature) fish and adults also have been caught in these shallow areas, as well as in the Canterbury Bight and sporadically along the west coast of the North Island. Pahurehure Inlet was the only one of the four northern harbours sampled by beach seine to contain significant numbers of juveniles of this species.

2.3 Juvenile abundance – Auckland harbours
Highest catches in Pahurehure Inlet were made in summer and autumn, representing 0+ fish. Few were caught in winter and spring, consistent with previous work that has shown these fish to move offshore into the deeper channel waters in the colder months, where they are not vulnerable to capture by beach seine. No clear spatial patterns were evident.

Rhombosolea plebeia Sand flounder

1. Literature review

Sand founder have been caught in research trawls in inshore (less than 100 m depth) areas, mainly around the northern North Island and in Tasman, but extending down the South Island to Otago (Anderson *et al.* 1998).

1.1 Spawning areas
Sand flounder in the Hauraki Gulf have been found to spawn from June to November in waters to the east of Waiheke and Ponui Islands, at the northern end of the Firth of Thames (Colman 1973b). Spawning takes place in water depths of 27–36 m. Off Canterbury, sand flounder probably spawn in two locations; near Akaroa Heads, and in the vicinity of Timaru (Colman 1978). A general southward movement of adult sand flounders off the east coast of the south island presumably has the effect of maintaining flounder populations over the same stretches of coast, since planktonic eggs and larvae must be carried northwards by the Southland current (Tunbridge 1966, Heath 1972, Coleman 1978). In Wellington Harbour, the presence of new recruits (< 25 mm) over most of the year (Smith &

Francis 1984) supports observations of a long spawning period for this species in Wellington Harbour (Mines 1975, Wilkinson 1977). Pulses of new recruits indicated both summer and winter spawning.

Robertson & Raj (1971) described the eggs and embryonic development for this species. *Rhombosolea spp.* larvae have been sampled in the northern Hauraki Gulf through August to November (Tricklebank *et al.* 1992), probably consisting of sand and yellow-belly flounder individuals. Sampling at the entrance to Whangateau Harbour, known to support populations of juvenile sand flounders (Grogan 1982, Park 1984), found larvae to be present from June to February, with a peak in November (Roper 1986). Larvae have also been recorded from Otago Harbour, Papanui Inlet, and Coopers Inlet in low numbers by Roper & Jillet (1981), from Pauatahanui Inlet (Healy 1980), and from the Avon-Heathcote Estuary (Knox & Kilner 1973).

1.2 Juvenile distribution

Juveniles are seasonally very abundant in sheltered estuaries and harbours, including Otago Harbour, Papanui Inlet, Coopers Inlet (Roper & Jillet 1981), Avon-Heathcote Estuary (Mundy 1968, Webb 1972a), Akaroa Harbour, Lyttelton Harbour (Mundy 1968, Colman 1978), Waimakariri Estuary (Eldon & Kelly 1985), Ahuriri Estuary (Kilner & Akroyd 1978), Wellington Harbour (Smith and Francis 1984), Pauatahanui Inlet (Healy 1980), the southern end of the Firth of Thames (Colman 1973a, b), Manukau Harbour (Pearks 1985, Morrison 1998). upper Waitemata Harbour (Saunders 1999), and the Whangateau Harbour (Grogan 1982, Park 1984). Juveniles are generally confined to the shallow tidal flats and along the shores near stream mouths. Increases in juvenile abundance were found over summer and winter in Wellington Harbour (Smith & Francis 1984), in October–December, and May–August in Pauatahanui Inlet (Healy 1980), while no seasonal trends were apparent in Waimakariri Estuary (Eldon & Kelly 1985).

Seasonal sampling in the Pahurehure Inlet (Manukau Harbour) found high densities of small juveniles (25–100 mm) in summer along low-tide channel bank edges (Morrison 1998). Much lower densities of larger animals (75–150 mm) were present in the adjacent low-tide channels (consistent with findings by Smith *et al.* 1980 in Wellington Harbour). Through autumn and winter the density of juveniles on the edge of the banks dropped substantially, while densities out in the channels proper increased. The average size of fish on the bank edges showed no change over a six month period, suggesting a combination of continued recruitment of smaller fish and emigration of larger fish. By winter, the highest densities of animals were located in 5–10 m water depth. This was taken to be evidence of an ontogenetic shift with age/size between estuarine habitats from shallow to deeper waters (Morrison 1998).

On a larger spatial scale, large number of juvenile fish were tagged in the Avon-Heathcote Estuary, Akaroa Estuary and Lyttelton Harbour, and subsequently recaptured through commercial trawling as adults out on the open coast, demonstrating that large scale movements from estuaries to coastal waters occur (Mundy 1968, Colman 1978). Movement occurred mainly from August to November, when the fish were two years old. This is the best documented example in New Zealand waters of the link between juvenile fish nurseries in harbours and estuaries, and adult populations in more open coastal waters.

2. Data summaries

2.1 Spawning areas

Not able to be determined because of insufficient data.

2.2 Juvenile distribution

Juveniles (all 0+) have been caught mainly in inshore (less than 100 m depth) areas around the northern North Island, with a few off the east coast of the South Island. Age 1+ fish (all mature) and all adults combined have been caught in Tasman Bay and on the west coast of the South Island in similar depths. In the four Auckland harbours sampled by beach seine, immature sand flounder were most common in Pahurehure Inlet, Mahurangi estuary contained only occasional individuals, and there were few caught in the Whangateau and Matakana estuaries (data not presented).

2.3 Juvenile abundance – Auckland harbours
Juveniles (0+) were most abundant in Pahurehure Inlet in summer and autumn. Few were caught in winter and spring, consistent with previous work that has shown these fish to move offshore into the deeper channel waters in the colder months, where they are not vulnerable to capture by beach seine. No clear spatial patterns were evident.

Scomber australasicus Blue mackerel

1. Literature review

Blue mackerel have been caught mainly in research and commercial trawls around the North Island, but extending down the east and west coasts of the South Island. They have been caught rarely off Southland and on the Chatham Rise (Anderson *et al.* 1998).

1.1 Spawning areas
No published information is available.

1.2 Juvenile distribution
Larval fish have been sampled in the neuston (the immediate surface of the sea) over November, and January – June, in the northern Hauraki Gulf (Roper 1986, Tricklebank *et al.* 1992). Anecdotal evidence suggests that juveniles are seasonally abundant in inshore waters, with larger fish being found further offshore.

2. Data summaries

2.1 Spawning areas
Gonad state has been recorded only from a few tows off Tasman Bay and Taranaki (FMA7,8&9). Ripe, running ripe and spent fish have all been caught in January and February, suggesting summer spawning. However, the proportion of maturing fish was also high in July so late winter/spring spawning cannot be discounted.

2.2 Juvenile distribution
There are no data on ageing for blue mackerel so immature fish were arbitrarily split into 2 size groups (which may represent ages 1+ and 2+). Fish less than 29 cm occur in relatively shallow (less than 100 m depth) inshore areas around the northern North Island and in Tasman Bay. Juveniles up to 39 cm are less frequently caught but have a similar distribution, extending slightly deeper. The distribution of immature fish combined includes all fish less than 36 cm and is therefore similar. Adults are relatively infrequently caught, but appear to have a slightly more offshore distribution, extending down to the central South Island and occasionally to Southland and shallower parts of the Chatham Rise

2.3 Juvenile abundance
Juvenile blue mackerel have been caught in small amounts on *Kaharoa* trawl surveys off the North Island. The one large catch rate of 360 $kg.km^{-2}$ was recorded from the outer Hauraki Gulf.

Seriola lalandi Kingfish

1. Literature review

Kingfish have been caught in research trawls, mainly in the Bay of Plenty and along the south-east coast of the North Island, in less than 150 m depth. They have been caught occasionally off the north and west coasts of the South Island (Anderson *et al.* 1998).

1.1 Spawning areas
Kingfish are widely distributed around the North Island and the northern end of the South Island. Tagging studies indicate that most kingfish do not move far from the area that they were tagged (McGregor 1995a). During the summer their distribution may extend further southwards (Ayling & Cox 1982). Anecdotal evidence suggests that kingfish spawn anywhere from deep water to estuaries (C. Poortenaar, NIWA, Auckland, pers. comm.). Running ripe fish have been reported at the Ranfurly Bank off East Cape in mid January (McGregor 1995b).

Gonosomatic index was highest between November to January, from 1998 to 2000, indicating they were spring-summer spawners (Poortenaar *et. al.* 2000). Australian kingfish also appear to be spring-summer spawners (Gillanders et. al. 1997).

1.2 Juvenile distribution
Little is known about the juvenile habitat of kingfish. There have been very few sightings around New Zealand, but some were caught around the Poor Knights and in light traps set up around Leigh Marine Laboratory (C. Poortenaar, NIWA, Auckland, pers. comm.). Very small kingfish have been found in the outer Hauraki Gulf in late January and juveniles can be found well offshore under seaweed mats or other floating debris (McGregor 1995b). (Poortenaar *et. al.* 2000) found 50% of females mature at 94 cm and 50% of males at 81 cm. This is different to the mature size range of 58–67 cm reported by McGregor (1995a), but Poortenaar *et al.* (2000) was not able to be reconcile the difference because "mature" was not defined by McGregor (1995a).

2. Data summaries

Kingfish distribution is probably not well determined by trawling as they are fast swimmers.

2.1 Spawning areas
Not able to be determined because of insufficient data.

2.2 Juvenile distribution
Juvenile kingfish have been recorded from around the North Island, mainly off the east coast, in less than 150 m depth.

2.3 Juvenile abundance
Juvenile kingfish have been caught in small amounts on *Kaharoa* trawl surveys off the east coast of the North Island. The one large catch rate of 140 kg.km^{-2} was recorded from the Bay of Plenty.

Seriolella brama Blue warehou

1. Literature review

Blue warehou have been caught in research and commercial trawls, mainly around New Zealand and rarely on the Chatham Rise and in the Sub-Antarctic. They occur mainly in less than 300 m depth (Anderson *et al.* 1998).

1.1 Spawning areas

Blue warehou are semi-pelagic schooling fish which are believed to migrate substantial distances to spawn. Warehou appears to be primarily a spring spawner, with spawning activity starting in late winter, continuing through until late summer (Robertson 1980). Known spawning areas are off the west coast of the South Island, in August–September, east and west of Stewart Island in November (Hurst 1985, Jones 1988), Kaikoura (in March–May), the south-east coast of the North Island (including Wellington) in winter–early spring (Bagley *et. al.* 1998) and Hawke Bay in August and September (Jones 1988, Bagley *et. al.* 1998). A north-west population may also spawn off New Plymouth in winter–spring (Bagley *et. al.* 1998). Spawning activity has also detected on the east coast from Nugget Point to Castlepoint. Eggs and larvae have been found in central and southern mid-shelf waters in spring to autumn off Otago and Kaikoura (Robertson 1973, 1975, Parsons 1999).

1.2 Juvenile distribution

Young fish are often found in small schools in the shallow waters of harbours and bays (Ayling & Cox 1982). Robertson (1980) recorded juveniles from Otago waters in summer. The 50% length at maturity is reached at about 36 cm (Bagley *et al.* 1998).

2. Data summaries

2.1 Spawning areas

Gonad state has been recorded from many tows off Southland (FMA5) but only sporadically elsewhere. Ripe and running ripe fish have been recorded off Southland (mainly around Stewart Island) and the west and northern coasts of the South Island (FMA7&8). Spent fish have a similar distribution.

Off Southland, a high proportion of fish are maturing during winter, ripe and running ripe fish peak in October (over 90%) to December, and are present in low numbers from January to March. This clearly suggests a spring spawning. Off the west coast of the South Island (FMA7), sampling has taken place from July to September, when over 20% of fish were ripe or running ripe. Sampling is minimal north of Tasman Bay, but a similar pattern is suggested, with about 50% of fish caught in October ripe or running ripe.

2.2 Juvenile distribution

Young (0+) juveniles occur in very shallow (less than 75 m depth) inshore areas around the north of the North Island, the west and east coasts of the South Island. However, they are absent from the central east coast and Southland. This may be a reflection of minimal sampling in less than 30 m depth in these areas. Juveniles up to 2 years old and all immature fish combined have similar distributions to 0+ fish, but extend slightly more offshore. Occurrences off the central east coast and Southland are also rare. These areas are included in the distribution of adult blue warehou. In general, adults extend deeper (out to about 400 m bottom depth) but are rare on the Chatham Rise and in the Sub-Antarctic, explaining the lack of spawning records in these areas.

2.3 Juvenile abundance

Juvenile blue warehou have been caught on *Kaharoa* trawl surveys, around the North and South Islands, mainly in inshore areas. Large catch rates were patchy and peaked at 0.2 $t.km^{-2}$ in the Bay of Plenty, 0.1 $t.km^{-2}$ off Gisborne and 0.7 $t.km^{-2}$ in Pegasus Bay.

Juvenile blue warehou have been recorded also on *Tangaroa* middle depth trawl surveys, but only in a few (12) inshore tows off Southland. Catch rates peaked at only 0.4 $t.km^{-2}$ to the west of Stewart Island. There were no catches of blue warehou of any size on the Chatham Rise

Seriolella punctata Silver warehou

1. Literature review

Silver warehou have been caught in research and commercial trawls, mainly around New Zealand and across the Chatham Rise. They have been recorded occasionally on the Challenger Plateau and in the Sub-Antarctic. They occur mainly in 100–600 m depth (Anderson *et al.* 1998).

1.1 Spawning areas
Spawning silver warehou have been recorded from the west coast of the South Island in winter, Mernoo Bank in winter and spring, and at the Chatham Islands in spring and summer, and there is some evidence of possible spawning on the Stewart/Snares shelf in early spring (Livingston 1988). They also spawn on the east coast of the North Island (Annala *et. al.* 1999). Eggs have been recorded off Kaikoura in autumn (Robertson 1975) and off Otago from spring to autumn (Parsons pers. comm.). Eggs hatch after about 6 days (146 hours at 10–13°C) and emergent yolk-sac larvae are about 3 mm long (Grimes & Robertson 1981).

1.2 Juvenile distribution
Juveniles have been reported to occur throughout the year in South Island shelf areas, in particular on the Pegasus Bay shelf and Canterbury Bight (Garilov 1979). They inhabit shallow water (less than 200 m depth) and remain apart from sexually mature fish (Annala *et. al.* 1999). Garilov & Markina (1970) described the progression of juveniles into deeper water with increasing size and in relation to the distribution of their prey. Very young fish of 12–14 cm long feed on plankton, juveniles 14.0–15.5 mm feed on Amphipoda and Chaetognatha in coastal waters. At 24–31 cm they move into the deeper part of the shelf, feeding on zooplankton especially salps. Fish greater than 30 cm long are feeding on macroplanktonic organisms of the slope region of the shelf; and as they become larger they enter the sexually mature part of the population. Silver warehou become sexually mature at 4–6 years, at about 47 cm (Horn & Sutton 1995, 1996).

2. Data summaries

2.1 Spawning areas
Not determined for this report as spawning extends beyond 200 m depth.

2.2 Juvenile distribution
Young (0+) juveniles occur mainly in less than 200 m depth around the mainland (except for northern North Island) and on the Chatham Rise. Juveniles up to 2 years old occur the same areas but are more commonly caught in deeper water (200–450 m). Adults rarely occur on the continental shelf and are most commonly caught 200–600 m depth. Occurrence in the Sub-Antarctic, on the Challenger Plateau and around the North Island (except the Wairarapa coast) are sporadic.

2.3 Juvenile abundance
Juvenile silver warehou have been caught on *Kaharoa* trawl surveys off the south-east coast of the North and around the South Island, from inshore to outer shelf. Off the south-east North Island, catch rates were small, up to only 24 $kg.km^{-2}$ around Cook Strait. Larger catch rates around the South Island were patchy, occurred in Canterbury Bight and Tasman Bay, towards the mid and outer shelf. They peaked at 0.6 $t.km^{-2}$.

Juvenile silver warehou have been recorded also on *Tangaroa* middle depth trawl surveys on the Chatham Rise and off Southland (526 tows) and in *Akebono Maru 73* tows around the Chatham Islands (113 tows). Juveniles occurred in the shallower depths sampled across the Chatham Rise (i.e., mainly 200–400 m). Catch rates were relatively even except for 3 larger catches. Abundance inside 200 m depth was not able to be determined from *Tangaroa* tows. At the Chatham Islands, juveniles were caught by *Akebono Maru 73*, mainly to the west of the Islands on the shelf edge, and peaked at

2.7 t.km^{-2}. Off Southland, juveniles were caught, mainly in mid to outer shelf depths, and the largest *Tangaroa* catch rate (5.1 t.km^{-2}) occurred to the south of Otago Peninsula.

Squalus acanthias Spiny dogfish

1. Literature review

Spiny dogfish have been caught in research and commercial trawls, mainly around New Zealand (except the north-east of the North Island) on the Chatham Rise and in the Sub-Antarctic. They have not been recorded from the Challenger Plateau. They occur mainly in 30–600 m depth (Anderson *et al.* 1998, Bagley *et al.* 2000)

1.1 Pupping areas
Spiny dogfish produce live young about 18–30 cm total length (Hanchet 1986, 1988b). Graham (1939, 1956) stated that they are born in summer, but more comprehensive data compiled by Hanchet (1986, 1988b) shows that pupping occurs from March to September, peaking in July–August. The presence of females carrying full-term embryos, and recently-pupped females, indicates that pupping occurs near the edge of the continental shelf along the east coast South Island, between Kaikoura and Foveaux Strait, in 200–300 m of water (Hanchet 1986, 1988b). Graham (1939, 1956) suggested that, although pupping usually occurs at greater depths, some spiny dogfish may also be born in the shallow waters of Blueskin Bay and Otago Harbour, based on the capture of new-born young at the former location, and a full-term pregnant female at the latter.

1.2 Juvenile habitat
Small 0+ juveniles (less than 45 cm total length) have been reported from shallow inshore waters along the east coast South Island, including Banks Peninsula, Canterbury Bight, Blueskin Bay, and Otago Peninsula (Graham 1939, 1956, Hanchet 1986). These 0+ young are mostly found shallower than 20 m, though they have been reported out to 60 m depth. Larger juveniles tend to associate with mature males and sub-adult females in depths greater than 30 m, extending out to 100 m (Hanchet 1986). Sub-adult females associate with mature fish, and extend out to the edge of the continental shelf in 200 m. Juveniles are rare on the Stewart–Snares Shelf and on the Chatham Rise (Hanchet & Ingerson 1997).

2. Data summaries

2.1 Pupping areas
Maturity of female spiny dogfish is not recorded on the research database.

2.2 Juvenile distribution
Young (0+) juveniles occur around the South Island in less than 100 m depth, mainly off the east coast, but also occasionally off the west coast and Southland. Juveniles up to 2 years old have the same distribution but extend slightly deeper (to about 150 m). The lack of juveniles recorded around the Chatham Islands is probably because spiny dogfish were not measured on surveys which included less than 200 m depth. Immature fish combined extend across the Chatham Rise, up the west coast of the North Island and down into the Sub-Antarctic. They are caught over a wide depth range, mainly from 50–600 m, but extending to over 1000 m. Adults have a similar distribution.

2.3 Juvenile abundance
Juvenile spiny dogfish have been caught on *Kaharoa* trawl surveys around the South Island (804 tows) but only on the west coast of the northern North Island (28 tows). Northern catch rates peaked at 0.1 t.km^{-2} whereas southern catch rates peaked at 26.2 t.km^{-2} off the east coast. The larger catch rates were over the mid to outer shelf.

Juvenile spiny dogfish have been recorded also on *Tangaroa* middle depth trawl surveys on the Chatham Rise and off Southland (648 tows). The distribution of juveniles inside the 200 m contour on the Chatham Rise was not able to be determined as spiny dogfish were not measured on *Akebono Maru 73* tows and the *Tangaroa* did not trawl in under 200 m depth. Juveniles did occur in the shallower depths sampled (200–400 m) across the Chatham Rise. Catch rates were relatively even except for the occasional larger catches. Off Southland, catch rates were higher (up to 53.2 $t.km^{-2}$) than on the Chatham Rise and occurred mainly inshore water to the north of the area.

Thyrsites atun Barracouta

1. Literature review

Barracouta have been caught in research and commercial trawls all around New Zealand, across shallower parts of the Chatham Rise and occasionally in the Sub-Antarctic. They occur mainly from shallow inshore depths out to about 400 m (Anderson *et al.* 1998, Bagley *et al.* 2000).

1.1 Spawning areas

Known areas of spawning include: the east coast from Kaikoura to the Bay of Plenty and the west coast of the North and South Islands in August–September; Mernoo Bank and Southland in October–November; and the Chatham Islands in November–December. The boundaries between these spawning areas are not clear (Mehl 1971, Robertson & Mito 1979, Hurst & Bagley 1987, Hurst 1988a). Tagging results have confirmed that east coast South Island fish make extensive spawning migrations (up to 500 n.miles) to the east coast of the North Island during autumn and winter. A few also migrated to the west coast North Island. These migrations are consistent with seasonal patterns in fisheries and known spawning areas and seasons. The migration patterns of west coast South Island spawning fish are not known, but these fish may be continuous with the Southland spawning group. Considerable movement of fish away from Southland at spawning time suggests that these fish may move north to the west coast South Island spawning grounds (Hurst 1988a). Migration of barracouta away from the surface waters of the Otago region was also observed in July (Graham 1939). Barracouta eggs are found in central and southern New Zealand waters in spring to autumn (Robertson 1975).

1.2 Juvenile distribution

Juveniles have been recorded, mostly from less than 100 m depth, all around mainland New Zealand, Mernoo Bank and the Chatham Islands (Robertson & Mito 1979, Paul 1986, Annala *et. al.* 1999). Graham (1939) noted the inward migration of juveniles into Otago Harbour in summer and autumn.

2. Data summaries

2.1 Spawning areas

Gonad state has been recorded from most areas except the north-west of the North Island. Ripe and running ripe fish have been recorded in all areas sampled and spent fish have a similar distribution.

Seasonally, the best covered areas are around the South Island (east coast, FMA3; Southland, FMA5; and west and north coasts, FMAs7,8&9). In FMAs7, 8&9, most spawning activity is in July to October, with a secondary peak in January to March. A similar trend is apparent off Southland, where the main peak is October, but activity continues through to March. In FMA3, November to February are also peak months. The next best coverage is from the Auckland Island, where mainly spent fish are recorded from January to May, but June to December is not sampled. Off the east coast of the North Island (FMA1&2), ripe and running ripe fish comprise more than 20% in September. At the Chatham Islands, few fish were recorded as ripe or running ripe but most fish were maturing in December and January.

In summary, peak spawning of barracouta appears to be in late winter or spring around most of New Zealand, but there is evidence of some activity through to the end of summer, sometimes a secondary peak in February. Peak spawning in northern and western areas (FMAs 1,2,7,8&9) appears to be in August/September, which is one or two months earlier than to the south and east (FMAs 3&5), where the peak is October/November. The extent and peak of the spawning season is not well determined for barracouta at the Chatham and Auckland Islands from these data.

2.2 Juvenile distribution
Young (0+) juveniles occur in relatively shallow (less than 200 m depth) inshore areas around the mainland, on Mernoo Bank and at the Chatham Islands. Juveniles up to 2 years old have a similar distribution, but extending slightly more offshore. The distribution of adult barracouta also follows this pattern, extending deeper (out to about 400 m bottom depth) and offshore to include the Auckland Islands.

2.3 Juvenile abundance
Juvenile barracouta have been caught on *Kaharoa* trawl surveys around the North and South Islands, in most of the areas and depths where adults occur, although the highest catch rates were inshore. Around the northern North Island, juveniles occurred in 270 tows and catch rates peaked at 1.2 $t.km^{-2}$ in the Hauraki Gulf. Off the south-east coast of the North Island, juveniles occurred in 171 tows and catch rates peaked at 1.6 $t.km^{-2}$. Around the South Island juveniles occurred in 805 tows and catch rates were highest in Canterbury Bight, reaching 7.1 $t.km^{-2}$.

Juvenile barracouta dogfish have been recorded also on *Tangaroa* middle depth trawl surveys on the Chatham Rise and off Southland (147 tows) and on *Akebono Maru 73* tows around the Chatham Islands (118 tows), mainly in inshore waters. Juveniles were rarely caught in the shallower depths sampled by *Tangaroa* across the Chatham Rise, which were all outside 200 m. Most of the catches were relatively small and occurred to the west of the Chatham Islands. Catch rates of juveniles by *Akebono Maru 73* were highest in less than 200 m depth to the east of the Islands (up to 8.9 $t.km^{-2}$). Off Southland, *Tangaroa* catch rates peaked at 0.6 $t.km^{-2}$ and were highest off Otago Peninsula, with a secondary peak to the west of Stewart Island.

Trachurus declivis Jack mackerel

1. Literature review

T. declivis have been recorded in research and commercial trawls all around New Zealand and occasionally on the Chatham Rise, in mainly 30–300 m depth (Anderson *et al.* 1998, Bagley *et al.* 2000).

1.1 Spawning areas
T. declivis is a serial spawner that spawns three batches of eggs at intervals of a month or more, resulting in a long spawning period (Horn 1991). Reproductively active and spent fish are found in the central west coast area in spring (Horn 1991, 1993), east Northland area in summer (P. Taylor, NIWA, Wellington, pers. comm.), off Otago in February, and Golden Bay/Tasman Bay in December and January (Jones 1990). Eggs have also been recorded from Taranaki Bight in January (Jones 1990), the Hauraki Gulf and east Northland (Crossland 1982).

1.2 Juvenile distribution
Small *Trachurus* are often found in association with floating objects such as drift algae, gelatinous zooplankton or flotsam (Kingsford 1993) and may therefore not be well sampled by bottom trawls. Juveniles have been recorded from North Taranaki Bight (1+) in 125-150 m depth, off the central west coast and about 300 miles northeast of East Cape (Jones 1990, Horn 1991, 1993 *T. declivis* mature at 26–30 cm FL at age 2–4 years (Horn 1991).

2. Data summaries

2.1 Spawning areas

Gonad state has been recorded mainly from the central west coast of New Zealand and occasionally from the western Chatham Rise and Southland. Ripe and running ripe fish have been recorded from the central west coast and from one tow on Mernoo Bank. Spent fish have been recorded from the central west coast and from one tow off Southland.

Seasonally, the best covered area is the central west coast (FMAs7,8&9). The proportion of actively spawning fish peaks in November but is also about 20% from January to March. The months on either side of November were not sampled so the full extent and peak are not well determined. Most fish were resting from April to July, suggesting spawning may be confined to spring and summer months. Most of the remaining samples came from Southland (FMA5) during February–March. There is also evidence of tail-end spawning activity in February, with about 20% of fish spent.

2.2 Juvenile distribution

The distributions of 0+, 1+, and all juveniles combined are consistent with known spawning areas. They occur mainly around the North Island, with a few off the northern parts of the South Island, in up to about 200 m depth. Adults have been caught also on the Chatham Rise and off Southland, down to about 350 m depth.

2.3 Juvenile abundance

Juvenile *T. declivis* have been caught on *Kaharoa* trawl surveys around the North and South Islands, mainly over the mid shelf Around the northern North Island, juveniles occurred in 114 tows and catch rates peaked at 6.0 t.km^{-2} outside the Hauraki Gulf. Off the south-east coast of the North Island, juveniles occurred in 70 tows and catch rates peaked at 0.1 t.km^{-2} off the Wairarapa coast. Around the South Island juveniles occurred in 131 tows and catch rates were highest in Tasman Bay, reaching 0.1 t.km^{-2}.

Trachurus novaezelandiae Jack mackerel

1. Literature review

T. novaezelandiae have been recorded in research and commercial trawls, mainly around the North Island and occasionally around the northern South Island. They occur mainly from inshore out to 200 m depth (Anderson *et al.* 1998, Bagley *et al.* 2000).

1.1 Spawning areas

T novaezelandiae is a serial spawner a protracted spawning season (Horn 1991). Reproductively active and spent fish have been found in the central west coast area in spring and east Northland in summer (Horn 1991, P. Taylor, NIWA, Wellington, pers. comm.). Eggs have been recorded from the inner and outer Hauraki Gulf in spring–summer (Crossland 1981, 1982), off east Northland, particularly the outer Bay of Islands and off Bream Head in October–December, and in Exhibition Bay in December (Crossland 1982). Larvae are very abundant in the Hauraki Gulf, close to the eggs, but displaced a few miles, and peaking in November (Crossland 1981). Larvae were recorded, but not common, in east Northland (Crossland 1982). They have been taken in plankton tows in the South Taranaki Bight (Jones 1990).

1.2 Juvenile habitat

Small *Trachurus* are often found in association with floating objects such as drift algae, gelatinous zooplankton or flotsam (Kingsford 1993) and may therefore not be well sampled by bottom trawls. Juveniles have been caught in Wellington Harbour, Pauatahanui – Porirua inlets, Tasman Bay, Golden Bay, South Taranaki Bight, Bay of Plenty and Hauraki Gulf and in the central west coast area (Healy

1980, Jones 1990, Horn 1991). *T. novaezelandiae* mature at 26–30 cm FL at age 3–4 years (Horn 1991).

2. Data summaries

2.1 Spawning areas
Gonad state has been recorded only from the central west coast of New Zealand (FMAs7,8&9). Ripe, running ripe and spent stages have all been found. The proportion of actively spawning fish peaks in November but is also about 20% in February. In March, about 20% of fish are spent. The months on either side of November were not sampled so the full extent and peak are not well determined. Most fish were resting from May to July, suggesting spawning may be confined to spring and summer months.

2.2 Juvenile distribution
The distributions of 0+, 1+, and all juveniles combined are consistent with known spawning areas and the distribution of the adults. They occur mainly around the North Island, with a few off the northern parts of the South Island, in up to about 150 m depth.

2.3 Juvenile abundance
Juvenile *T. novaezelandiae* have been caught on *Kaharoa* trawl surveys around the North and South Islands, mainly in inshore and mid shelf areas. Around the northern North Island, juveniles occurred in 659 tows and catch rates peaked at 3.4 $t.km^{-2}$ inside the Hauraki Gulf. Off the south-east coast of the North Island, juveniles occurred in 138 tows and catch rates peaked at 0.3 $t.km^{-2}$ off East Cape. Around the South Island juveniles occurred in 77 tows and catch rates were highest in Tasman Bay, reaching 0.4 $t.km^{-2}$.

Trachurus symmetricus murphyi Murphy's mackerel

1. Literature review

Murphy's mackerel (also known as the Chilean or Peruvian mackerel) invaded New Zealand waters from South America. It was first observed in the mid-1980's and has established a local spawning population (Taylor 1999a). They have been recorded in research and commercial trawls, mainly around the South Island, the Chatham Rise and southern North Island, and occasionally at the Auckland Islands, in 30–400 m depth (Anderson *et al.* 1998). The extent around the northern North Island is not well determined by trawl surveys as jack mackerel are not always identified to species, but they have been recorded off the north-east coast of the North Island from aerial sightings (Bagley *et al.* 2000). *T. s. murphyi* appears to be the predominant mackerel species in JMA 3 (east coast South Island) and East Northland (Taylor 1999b).

1.1 Spawning areas
Fish in maturing or spawning condition have been caught by trawl or purse-seine in the Bay of Plenty, east coast of Northland, central west coast area, part of the west coast of the South Island, the Stewart-Snares area, and on the Chatham Rise (Taylor 1999a).

1.2 Juvenile habitat
Juveniles of less than 30 cm have been recorded from the east coast of the North Island, South Taranaki Bight and a few from the west coast South Island (Taylor 1999a).

2. Data summaries

2.1 Spawning areas
Gonad state has been recorded mainly from the central west coast of New Zealand and Southland, with occasional records from the Chatham Rise and the Auckland Islands. Ripe, running ripe and spent fish have been recorded from all these areas except the Chatham Islands.

Seasonally, the best coverage is from the central west coast (FMAs7,8&9). The proportion of actively spawning fish exceeds 20% in July, September, and December to February, and most fish during these months are maturing. It is likely that most fish sampled in July came from the west coast South Island (during the hoki fishery) and the later spawners came from the south Taranaki Bight Area. The highest proportion of spent fish occur in February and resting stage fish dominate in May and June. This suggests spawning occurs from late winter through to summer.

Across the Chatham Rise (FMAs 3&4), samples are from November to May. Spawning activity peaks in November (about 60%) and there is some evidence of activity through to April. Spawning activity during winter/early spring is not able to be determined. Off Southland and the Auckland Islands, samples are from December to April. Most fish were resting although maturing fish are present from January to April. The extent of spawning activity in these areas is not well determined from these data.

2.1 Juvenile distribution
The few records of immature fish are mainly from around the central North Island, with a few from around the South Island and the Chatham Rise, in up to about 350 m depth. Adults have been more frequently caught in similar areas, but also occur further north, more extensively across the Chatham Rise, and off Southland, down to about 350 m depth.

2.2 Abundance
There are only two tows from Tangaroa time series trawl surveys that caught juvenile *T. s. murphyi* in very low abundance (up to 3 kg.km^{-2}).

Zeus faber John dory

1. Literature review

John dory have been recorded mainly from around the North Island and northern South Island, with occasional records further south as far as Stewart Island. They occur mainly from inshore to 200 m depth (Anderson *et al.* 1998, Bagley *et al.* 2000), but are most common to depths of 50 m (Hore 1985). They occupy a range of demersal habitats from reefs to open sand or mud bottoms.

1.1 Spawning areas
Spawning of John Dory occurs between December and April on the north-east coast. They are serial spawners (Hore 1985). Individuals are generally solitary, but large aggregations are known to occur in mid-water, possibly for spawning (Morrison 1996). Eggs are large and planktonic and take 12–14 days to hatch (Hore 1985). Running ripe adults were caught in mid shelf waters between East Cape and Cape Runaway in March 1971 and April 1972 (D. Robertson, NIWA, Wellington, pers. comm.)

1.2 Juvenile habitat
Juveniles of 10–25 cm length are common over inshore grounds (Paul 1986). Maturity is reached in 3–4 years (Paul 1986) at about 36 cm (Hanchet & Francis, unpublished results).

2. Data summaries

2.1 Spawning areas
Gonad state has been recorded mainly from the northern North Island, with a few records in Hawke Bay and south Taranaki Bight. Ripe and running ripe fish have been recorded from these areas but there are no records of spent fish. Seasonal coverage spans a few months in spring and summer. Off the north-east North Island (FMA1), the highest proportion (about 60%) of spawning fish occurs in February, with most fish in October and November maturing. Off the north-west coast of the North Island (FMA7, 8&9), over 20% of fish are ripe in December and January, with most fish in October and November maturing.

2.2 Juvenile distribution
The distribution of 0+, 1+ and all juveniles combined is consistent with known spawning areas and the adults. They occur mainly around the northern North Island, with a few extending down to Tasman Bay, mostly in less than 100 m depth. Adults are extend slightly further south on the west coast of the South Island and are caught occasionally off the east cost South Island and Southland.

2.3 Juvenile abundance
Juvenile fish have been caught on *Kaharoa* trawl surveys, mainly around the North Island, but occasionally off the north and west coasts of the South Island. They occurred from inshore to outer shelf but were more common inshore. Around northern North Island, juveniles occurred in 1057 tows and catch rates peaked at 0.3 $t.km^{-2}$ inside the Hauraki Gulf, but were also high in the western Bay of Plenty. Off the south-east coast of the North Island, juveniles occurred in 51 tows but catch rates were low (up to 15 $kg.km^{-2}$). Around the South Island juveniles occurred in 42 tows, mainly in Tasman Bay (up to 36 $kg.km^{-2}$).

Acknowledgments

We thank the many fisheries researchers and scientific observers who have taken the time to measure fish and identify gonad stages. We also thank Glen Carbines, Carolyn Poortenaar, and Paul Taylor for making available additional unpublished information and Richard O'Driscoll for refereeing the draft manuscript.

References

Allison, F. R., & Coakley, A. 1973: The two species of *Gyrocotyle* in the elephant fish *Callorhynchus milii* (Bory). *Journal of the Royal Society of New Zealand 3*: 381-392.

Anderson, O. F., Bagley, N. W., Hurst, R. J., Francis, M. P., Clark, M. R., & McMillan, P. J. 1998: Atlas of New Zealand fish and squid distributions from research bottom trawls. *NIWA Technical Report 42*.303 p.

Andrianov, D.P. 1985: Study on the reproduction of Peruvian scad, *Trachurus murphyi* (Carangidae), of the Peruvian shelf. *Journal of Ichthyology 25(2)*: 32–40.

Annala, J. H. 1987: The biology and fishery of tarakihi, *Nemadactylus macropterus* in New Zealand waters. *Fisheries Research Division Occasional Publication No. 51.* 15p.

Annala, J. H. 1988: Tarakihi. New Zealand Fisheries Assessment Research Document 88/28. 31p. (Draft report held in NIWA library, Wellington).

Annala, J. H., Sullivan, K. J., O'Brien, C. J., & Iball, S. J. (Comps.) 1998: Report from the Fishery Assessment Plenary, May 1998: stock assessment and yield estimates. 409 p. (Unpublished report held in NIWA library, Wellington).

Annala, J. H., Sullivan, K. J. & O'Brien, C. J. (Comp.) 1999: Report from the Fishery Assessment Plenary, April 1999: stock assessments and yield estimates. 430 p. (Unpublished report held in NIWA Greta Point library, Wellington).

Anon. 1989: Effects of commercial fishing on the fisheries of the Manukau Harbour and lower Waikato River (Unpublished MAF Fisheries North internal report, held at NIWA Auckland).

Ayling, T. & Cox, G. J. 1982: Collins guide to the sea fishes of New Zealand. Collins, Auckland. 343 p.

Bagley, N. W., Ballara, S. L., Horn, P. L. & Hurst, R. J. 1998: A summary of commercial landings and a validated ageing method for blue warehou, *Seriolella brama* (Centrolophidae), in New Zealand water, and a stock assessment of the southern (WAR 3) fishstock. New Zealand Fisheries Assessment Research Document 98/20. 45p. (Draft report held in NIWA library, Wellington).

Bagley, N. W., Anderson, O. F., Hurst, R.. J., Francis, M. P., Taylor, P. R., Clark, M. R. and Paul, L. J. 2000: Atlas of New Zealand fish and squid distributions from midwater trawls, tuna longline sets, and aerial sightings. *NIWA Technical Report 72*: 171 p.

Ballara, S. L.; Cordue, P. L.; & Livingston, M. E. 1998: A review of the 1996-97 hoki fishery and assessment of hoki stocks for 1998. New Zealand fisheries assessment research document 98/25. 58 p. (Draft report held in NIWA library, Wellington).

Beentjes, M. 1992: Assessment of red cod based on recent trawl survey and catch sampling data. New Zealand Fisheries Assessment Research Document 92/16. 41p. (Draft report held in NIWA library, Wellington).

Beentjes, M. P. & Francis, M. P. 1999: Movement of hapuku (*Polyprion oxygeneios*) determined from tagging studies. *New Zealand Journal of Marine and Freshwater Research 33*: 1–12.

Blaber, S. J. M.; Brewer, D. T.; & Salini, J. P. 1995: Fish communities and the nursery role of the shallow inshore waters of a tropical bay in the Gulf of Carpentaria, Australia. *Estuarine, coastal and shelf science 40*: 177-193.

Blackwell, R. G. 1988: Blue cod. New Zealand Fisheries Assessment Research Document 88/23. 18p. (Draft report held in NIWA library, Wellington).

Blackwell, R. G. 1998: Abundance, size and age composition, and yield-per-recruit of blue cod in the Marlborough Sounds, September 1996. *NIWA Technical Report 30*. 47 p.

Briggs, I. 1980: Upper Waitemata Harbour - interim fish survey. *Upper Waitemata Harbour Catchment Study Working Report 17*. 28 p.

Carbines, G. D. 1998: Blue cod age validation, tagging feasibility and sex-inversion. Final Research Report for Ministry of Fisheries Project SOBC04. 77 p.

Carbines, G. & McKenzie J. in press: Movement patterns and stock mixing of blue cod in Southland (BCO5). Final Research Report for Ministry of Fisheries Project BCO9702.

Carrier, J. C.; & Pratt, H. L. 1998: Habitat management and closure of a nurse shark breeding and nursery ground. *Fisheries research 39*: 209-213.

Cassie, R. M. 1956a: Early development of the snapper, *Chrysophrys auratus* Forster. *Transactions of the Royal Society of New Zealand. 83(4)*: 705–713.

Cassie, R. M. 1956b: Spawning of the snapper, *Chrysophrys auratus* Forster in the Hauraki Gulf. *Transactions of the Royal Society of New Zealand. 84(2)*: 309–328.

Castro, J. I. 1993: The shark nursery of Bulls Bay, South Carolina, with a review of the shark nurseries of the southeastern coast of the United States. *Environmental biology of fishes 38*: 37-48.

Colman, J.A. 1972: Size at first maturity of two species of flounders in the Hauraki Gulf, New Zealand. *New Zealand Journal of Marine and Freshwater Research 6*: 240–245.

Colman, J. A. 1973a: Causes of yield fluctuations in Thames flounders. *Fisheries Research Division Information Leaflet No. 5*. 5 p.

Colman, J. A. 1973b: Spawning and fecundity of two flounder species in the Hauraki Gulf, New Zealand. *New Zealand Journal of Marine and Freshwater Research. 7*: 21–43.

Colman, J. A. 1978: Tagging experiments on the sand flounder, *Rhombosolea plebia* (Richardson), in Canterbury, New Zealand, 1964 to 1966. *Fisheries Research Bulletin 18*. 42 p. New Zealand Ministry of Agriculture and Fisheries.

Colman, J. A. 1988a: Hake. New Zealand Fisheries Assessment Research Document 88/31. 22p. (Draft report held in NIWA library, Wellington).

Colman, J. A. 1988b: Ling. New Zealand Fisheries Assessment Research Document 88/32. 14p. (Draft report held in NIWA library, Wellington).

Colman, J. A. 1998: Spawning areas and size and age at maturity of hake (*Merluccius australis*) in the New Zealand Exclusive Economic Zone. New Zealand Fisheries Assessment Research Document 98/2. 17p. (Draft report held in NIWA library, Wellington).

Crossland, J. 1977: Seasonal reproductive cycle of snapper *Chrysophrys auratus* (Forster) in the Hauraki Gulf. *New Zealand Journal of Marine and Freshwater Research. 11*: 37–60.

Crossland, J. 1980: The number of snapper *Chrysophrys auratus* (Forster) in the Hauraki Gulf, New Zealand, based on egg surveys in 1974–75 and 1975–76. *Fisheries Research Bulletin No. 22*. 38 p. New Zealand Ministry of Agriculture and Fisheries.

Crossland, J. 1981a: The biology of the New Zealand snapper. *Fisheries Research Division Occasional Publication No. 23*. 16 p.

Crossland, J. 1981b: Fish eggs and larvae of the Hauraki Gulf, New Zealand. *N.Z. Ministry of Agriculture and Fisheries Fisheries Research Bulletin No. 23*. 61p.

Crossland, J. 1982: Distribution and abundance of fish eggs and larvae from the spring and summer plankton of north-east New Zealand. *N.Z. Ministry of Agriculture and Fisheries Fisheries Research Bulletin No. 24*. 59p.

Didier, D. A., Leclair, E. E., & Vanbuskirk, D. R. 1998: Embryonic staging and external features of development of the chimaeroid fish, *Callorhinchus milii* (Holocephali, Callorhinchidae). *Journal of Morphology 236*: 25-47.

Elder, R. D. 1976: Studies on age and growth, reproduction, and population dynamics of red gurnard, *Chelidonichthys kumu* (Lesson and Garnot), in the Hauraki Gulf, New Zealand. *Fisheries Research Bulletin No. 12*. 77p.

Eldon, G. A. & Kelly, G. R. 1985: Fishes of the Waimakariri Estuary. Fisheries Environmental Report No. 56. 59 p.

Francis, M. P. 1981a: Spawning migration of moki (*Latridopsis ciliaris)* off eastern New Zealand. *New Zealand Journal of Marine and Freshwater Research 15*: 267–273.

Francis, M. P. 1981b: Age and growth of moki (*Latridopsis ciliaris)* off eastern New Zealand. *New Zealand Journal of Marine and Freshwater Research 15*: 47–49.

Francis, M.P. 1985a: Blue Moki. In Colman, J.A., McKoy, J.L. & Baird, G.G. (Comps. & Eds.), Background papers for the 1985 Total Allowable Catch recommendations, p. 43–58. Fisheries Research Division, N.Z. Ministry of Agriculture and Fisheries. (Unpublished report, held in Fisheries Research Centre library, Wellington).

Francis, M. P. 1985b: Rig. *In* Colman, J. A.; McKoy, J. L.; Baird, G. G. (Eds). Background papers for the 1985 Total Allowable Catch recommendations, p. 145-169. Fisheries Research Division, New Zealand Ministry of Agriculture and Fisheries, Wellington.

Francis, M. P. 1993: Does water temperature determine year class strength in New Zealand snapper (*Pagrus auratus*, Sparidae)? *Fisheries oceanography 2(2)*: 65–72.

Francis, M. P. 1994: Duration of larval and spawning periods in *Pagrus auratus* (Sparidae) determined from otolith daily increments. *Environmental Biology of Fishes. 39*: 137–152.

Francis, M. P. 1995: Spatial and seasonal variation in the abundance of juvenile snapper (*Pagrus auratus*) in the north-western Hauraki Gulf. *New Zealand Journal of Marine and Freshwater Research. 29*: 565–579.

Francis, M. P. 1996: Coastal Fishes of New Zealand. An identification guide. Reed Books, 2nd edition. 72 p.

Francis, M. P. 1997: Spatial and temporal variation in the growth rate of elephantfish (*Callorhinchus milii*). *New Zealand Journal of Marine and Freshwater Research 31*: 9-23.

Francis, M. P., & Francis, R. I. C. C. 1992: Growth rate estimates for New Zealand rig (*Mustelus lenticulatus*). *Australian Journal of Marine and Freshwater Research 43*: 1157-1176.

Francis, M. P., & Mace, J. T. 1980: Reproductive biology of *Mustelus lenticulatus* from Kaikoura and Nelson. *New Zealand Journal of Marine and Freshwater Research 14*: 303-311.

Francis, M. P., & Mulligan, K. P. 1998: Age and growth of New Zealand school shark, *Galeorhinus galeus*. *New Zealand Journal of Marine and Freshwater Research 32*: 427-440.

Francis, M. P., & Smith, D. W. 1988: The New Zealand rig fishery: catch statistics and composition, 1974-85. *New Zealand Fisheries Technical Report 7*. 30 p.

Francis, M. P.; Langley, A. D.; & Gilbert, D. J. 1997: Prediction of snapper (*Pagrus auratus*) recruitment from sea surface temperature. *In*: p. 67–71, Hancock, D. A., Smith, D. C., Grant, A. and Beumer, J. P. Developing and sustaining world fisheries resources: the state of science and management. Second World Fisheries Congress, Brisbane 1996. CSIRO Publishing, Melbourne.

Francis, M. F., Mulligan, K. P., Davies, N. M. & Beentjes, M. P. 1999: Age and growth estimates for New Zealand hapuku, *Polyprion oxygeneios. Fishery Bulletin 97(2)*: 227-242.

Freer, D. W. L.; & Griffiths, C. L. 1993: The fishery for, and general biology of, the St Joseph *Callorhinchus capensis* (Dumeril) off the South-western Cape, South Africa. *South African journal of marine science 13*: 63–74.

Garilov, G. M. 1979: *Seriolella* of the New Zealand plateau. [TINRO report. In Russian; English translation (FRC translation No. 204) held in NIWA library, Wellington]

Garilov, G. M. & Markina, N. P. 1970: The feeding ecology of fishes of the *Seriolella* (fam. Nomeidae) on the New Zealand plateau. *Journal of Ichthyology 19(6)*: 128–135.

Gerring, P.K., & Bradford, E. 1998: Juvenile kahawai recruitment index feasibility study. *NIWA Technical Report 36*. 14 p.

Gibson, R. N. 1993: Impact of habitat quality and quantity on the recruitment of juvenile flatfishes. *Netherlands journal of sea research 32*: 191-206.

Gilbert, D. 1988: Trevally. New Zealand Fisheries Assessment Research Document 88/29. 28 p. (Draft report held in NIWA library, Wellington).

Gillanders, B. M., Ferrell, D. J. & Andrew, N. L. 1997: Determination of ageing in kingfish (Seriola lalandi) in New South Wales. NSW Fisheries. Canberra fisheries research and development corporation. Project No: 95/128.

Gorman, T. B. S. 1963: Biological and economic aspects of the elephant fish *Callorhynchus milii* Bory in Pegasus Bay and the Canterbury Bight. *New Zealand Marine Department Fisheries Technical Report 8*. 54 p.

Graham, D. H. 1939: Breeding habits of the fishes of Otago Harbour and adjacent seas. *Transactions and Proceedings of the Royal Society of New Zealand 69*: 361-372.

Graham, D. H. 1956: A treasury of New Zealand fishes. Second edition. Wellington, Reed. 424 p.

Grimes, P. J. & Robertson, D. A. 1981: Egg and larval development of the silver warehou, *Seriolella punctata* (Pisces: Centrolophidae). *New Zealand Journal of Marine and Freshwater Research 15*: 261–266.

Grogan, E. T. 1982: Activity patterns of two flounder species in the Whangateau Harbour. Unpublished MSc thesis, University of Auckland, Auckland, New Zealand.

Habib, G. 1975: Red cod and related species. *New Zealand's nature heritage 4(51)*: 1405-1408.

Harley, S., Horn, P. L., Hurst R. J., & Bagley, N. W. 1999: Analysis of commercial catch and effort data and age determination and catch-at-age of barracouta in BAR 5 New Zealand Fisheries Assessment Research Document 99/39. 39 p. (Draft report held in NIWA library, Wellington).

Hanchet, S. M. 1986: The distribution and abundance, reproduction, growth and life history characteristics of the spiny dogfish (*Squalus acanthias* Linnaeus) in New Zealand. Ph.D. thesis, University of Otago, Dunedin. 314 p.

Hanchet, S. M. 1998a: Southern blue whiting (*Micromesistius australis*) fishery assessment for the Bounty Platform and Pukaki Rise for 1998 and 1999. New Zealand fisheries assessment research document 98/32. 33 p. (Draft report held in NIWA library, Wellington).

Hanchet, S. M. 1988b: Reproductive biology of *Squalus acanthias* from the east coast, South Island, New Zealand. *New Zealand Journal of Marine and Freshwater Research 22*: 537-549.

Hanchet, S. M. 2000: Assessment of red gurnard (*Chelidonichthyes kumu*) stocks GUR1 and GUR2. *New Zealand fisheries assessment report 2000/40*. 51 p.

Hanchet, S. M., & Ingerson, J. K. V. 1997: A summary of biology and commercial landings, and a stock assessment of spiny dogfish (*Squalus acanthias*). *New Zealand Fisheries Assessment Research Document 97/6*. 46 p.

Healy, W. B. 1980: Pauatahanui Inlet - an environmental study. *New Zealand Department of Scientific and Industrial Research, DSIR Information Series 141*. 198 p.

Holland, K. N.; Wetherbee, B. M.; & Peterson, J. D.; Lowe, C. G. 1993: Movements and distribution of hammerhead shark pups on their natal grounds. *Copeia 1993*: 495-502.

Holts, D. B.; & Bedford, D. W. 1993: Horizontal and vertical movements of the shortfin mako shark, *Isurus oxyrinchus*, in the southern California Bight. *Australian journal of marine and freshwater research 44*: 901-909.

Hore, A. 1985: John Dory. In Colman, J.A., McKoy, J.L. & Baird, G.G. (Comps. & Eds.), Background papers for the 1985 Total Allowable Catch recommendations, p. 43–58. Fisheries Research Division, N.Z. Ministry of Agriculture and Fisheries. (Unpublished report, held in Fisheries Research Centre library, Wellington).

Horn, P. L. 1986: Distribution and growth of snapper *Chrysophrys auratus* in the North Taranaki Bight, and management implications of these data. New Zealand Journal of Marine and Freshwater Research. 20: 419–430.

Horn, P. L. 1988: Blue Moki. New Zealand Fisheries Assessment Research Document 88/10. 11p. (Draft report held in NIWA library, Wellington).

Horn, P. L. 1991: Trawl survey of Jack mackerels (*Trachurus* spp.), off the central west coast, New Zealand, February-March 1990. *New Zealand Fisheries Technical Report No. 28.* 39p.

Horn P. L. 1993a: Assessment of ling *(Genypterus blacodes)* stocks (LIN 3,4,5,6 and 7) off the South Island, New Zealand. New Zealand Fisheries Assessment Research Document 93/9. 29p. (Draft report held in NIWA library, Wellington).

Horn, P. L. 1993b: Growth, age structure and productivity of Jack mackerels (*Trachurus* spp.), in New Zealand waters. *New Zealand Journal of Marine and Freshwater Research 27*: 145–155.

Horn P. L. 1993c: Growth, age structure, and productivity of ling, *Genypterus blacodes* (Ophidiidae), in New Zealand waters. *New Zealand Journal of Marine and Freshwater Research 27*: 385–397.

Horn, P. L. 1996: Age and growth of red cod *(Pseudophycis bachus)* off the south coast of South Island, New Zealand. *New Zealand Journal of Marine and Freshwater Research 30*: 151–160.

Horn, P. L. 1997: An ageing methodology, growth parameters and estimates of mortality for hake *(Merluccius australis)* from around the South Island, New Zealand. *Marine and Freshwater Research 48*: 20–209.

Horn P. L. & Ballara, S. L. 1999: Analysis of longline CPUE, and stock assessment of ling *(Genypterus blacodes)* off the northwest coast of the South Island (Fishstock LIN 7). New Zealand Fisheries Assessment Research Document 99/27. 31p. (Draft report held in NIWA library, Wellington).

Horn, P. L. & Hurst R. J. 1999: Age and stock structure of gemfish (*Rexea solandri*) in New Zealand waters. *Marine and Freshwater Research 50:* 103–115.

Horn, P. L. & Sutton, C.P. 1995: An ageing methodology, and growth parameters for the silver warehou *(Seriolella punctata)* from off the southeast coast of the South Island, New Zealand. New Zealand Fisheries Assessment Research Document 95/15. 16p. (Draft report held in NIWA library, Wellington).

Horn, P. L. & Sutton, C.P. 1996: Validated ages, growth, and productivity for silver warehou *(Seriolella punctata)* from off the south and east coasts of South Island, New Zealand. *New Zealand Journal of Marine and Freshwater Research 30*: 301–312.

Hurst, R.J. 1985: Common Warehou. In Colman, J.A., McKoy, J.L. & Baird, G.G. (Comps. & Eds.), Background papers for the 1985 Total Allowable Catch recommendations, p. 63–65. Fisheries Research Division, N.Z. Ministry of Agriculture and Fisheries. (Unpublished report, held in Fisheries Research Centre library, Wellington).

Hurst, R.J. 1988a: Barracouta. New Zealand Fisheries Assessment Research Document 88/8. 29p. (Draft report held in NIWA library, Wellington).

Hurst, R.J. 1988b: Gemfish. New Zealand Fisheries Assessment Research Document 88/14. 19p. (Draft report held in NIWA library, Wellington).

Hurst, R.J. 1988c: The barracouta, *Thyrsites atun*, fishery around New Zealand: historical trends to 1984. New Zealand Fisheries Technical Report 5. 40p.

Hurst, R. J. & Bagley, N. W. 1987: Results of a trawl survey of barracouta and associated finfish near the Chatham Islands, New Zealand, December 1984. *New Zealand Fisheries Technical Report 3.* 44p.

Hurst, R. J. & Bagley, N. W. 1989: Movements of possible stock relationships of the New Zealand barracouta, *Thyrsites atun*, from tag returns. *New Zealand Journal of Marine and Freshwater Research 23*: 105–111.

Hurst, R. J. & Bagley, N. W. 1998: A summary of biology and commercial landings, and a stock assessment of southern (SKI 3 and SKI 7) gemfish *Rexea solandri* (Gemphylidae) in New Zealand waters. New Zealand Fisheries Assessment Research Document 98/3. 61p. (Draft report held in NIWA library, Wellington).

Hurst, R. J. & Patchell G. J 1985: Gemfish. In Colman, J.A., McKoy, J.L. & Baird, G.G. (Comps. & Eds.), Background papers for the 1985 Total Allowable Catch recommendations, p. 79–81. Fisheries Research Division, N.Z. Ministry of Agriculture and Fisheries. (Unpublished report, held in Fisheries Research Centre library, Wellington).

Hurst, R. J., Coburn, R. P., Hanchet, S. M., Horn, P. L., Langley, A. D., & Bagley, N. W. 1998: Assessment of northern gemfish stocks (SKI 1 and SKI 2) for 1998. N.Z. Fisheries Assessment Research Document 98/31. 55 p. (Draft report held in NIWA library, Wellington).

Hurst, R. J., Bagley, N. W., McGregor, G. A., & Francis, M. P. 1999: Movements of the New Zealand school shark, *Galeorhinus galeus*, from tag returns. *New Zealand Journal of Marine and Freshwater Research 33*: 29-48.

Ings, D. W.; Schneider, C. P.; & Methven, D. A. 1997: Detection of a recruitment signal in juvenile Atlantic cod (*Gadus morhua*) in coastal nursery areas. *Canadian journal of fisheries and aquatic sciences 55, supplement 1*: 25-29.

James, G. D. 1976: Eggs and larvae of the trevally *Caranx georgianus* (Teleostei: Carangidae). *New Zealand Journal of Marine and Freshwater Research 10(2)*: 301–310.

James, G. D. 1984: Trevally *Caranx georgianus* : age determination, population biology and fishery. *Fisheries Research Bulletin No. 25*. 51 p.

Jellyman, D. J., Glova, G. J., Sagar, P. M., & Sykes, J. R. E. 1997: Spatio-temporal distribution of fish in the Kakanui estuary, South Island, New Zealand. *New Zealand Journal of Marine and Freshwater Research 31*: 103 – 118.

Johnston, A. D. 1992: Groper tag recovery exceeds 10 years. *New Zealand Professional Fisherman 6(7)*: 59.

Johnston, A.D. 1983a: Groper fishery surveyed. *Catch 10(9)*: 10-12.

Johnston, A.D. 1983b: The southern Cook Strait groper fishery. *Fisheries Technical Report No. 159.* 33p.

Jones, J. B. 1988: Blue warehou. New Zealand Fisheries Assessment Research Document 88/11. 21p. (Draft report held in NIWA library, Wellington).

Jones, J. B. 1990: Jack mackerels (*Trachurus* spp.) in New Zealand waters. *New Zealand Fisheries Technical Report No. 23*. 28p.

Jones, J. B., & Hadfield, J. D. 1985: Fishes from Porirua and Pauatahanui Inlets: occurrence in gill nets. *New Zealand Journal of Marine and Freshwater Research 19*: 477-484.

Kilner, A.R., & Akroyd, J.M. 1978: Fish and Invertebrate Macrofauna of Ahuriri Estuary, Napier. *Fisheries Technical Report No. 153*. Ministry of Agriculture and Fisheries, Wellington. 79 p.

King, K. J. 1984: Changes in condition of mature female rig (*Mustelus lenticulatus*) from Golden Bay in relation to seasonal inshore migrations. *New Zealand Journal of Marine and Freshwater Research 18*: 21-27.

Kingett, P. D., & Choat, J. H. 1981: Analysis of density and distribution patterns in *Chryophrys auratus* (Pisces: Sparidae) within a reef environment: an experimental approach. *Marine Ecology Progress Series. 5*: 283–290.

Kingsford, M. J., & Choat, J. H. 1986: Influence of surface slicks on the distribution and onshore movements of small fish. *Marine Biology. 91*: 191–171.

Kingsford, M. J., & Tricklebank, K. A. 1991: Ontogeny and behaviour of *Aldrichetta forsteri* (Teleostei: Mugilidae). *Copeia. 1991(1)*: 9–16.

Kingsford, M. J. 1986: The distribution patterns of fish during the planktonic phase of their life history. Unpublished PhD thesis, University of Auckland, Auckland, New Zealand.

Kingsford, M. J. 1993: Biotic and abiotic structure in the pelagic environment: importance to small fishes. *Bulletin of Marine Science 53(2)*: 393-415.

Kingsford, M. J., & Choat, J. H. (1989). Horizontal distribution patterns of presettlement reef fish: are they influenced by the proximity of reefs? Ibid. 101: 285–298.
Know, G. A., & Kilner. A. R. 1973: The ecology of the Avon-Heathcote Estuary. Unpublished report to the Christchurch Drainage Board by the Estuarine Research Unit, University of Canterbury, Christchurch, New Zealand.
Langley, A. 1993: The distribution of juvenile snapper within the Auckland Fisheries Management Area. *MAF Fisheries North internal report 13*. 33 p.
Livingston, M. A. 1988: Silver warehou. New Zealand Fisheries Assessment Research Document 88/36. 18p. (Draft report held in NIWA library, Wellington).
Livingston, M. E. 1997: Links between climate variation and year class strength of New Zealand hoki (*Macruronus novaezelandiae*) Hector. *New Zealand Journal of Marine and Freshwater Research* 34: 56-69.
MacDiarmid, A. B. 1988: Red cod. New Zealand Fisheries Assessment Research Document 88/22. 16p. (Draft report held in NIWA library, Wellington).
Manire, C. A.; & Hueter, R. E. 1995: Human impact on the shark nursery grounds of Tampa Bay. *Florida scientist 58*: 107.
Massey, B. R., & Francis, M. P. 1989: Commercial catch composition and reproductive biology of rig (*Mustelus lenticulatus*) from Pegasus Bay, Canterbury, New Zealand. *New Zealand Journal of Marine and Freshwater Research 23*: 113-120.
Mattlin, R. H. and Colman, J. A. 1988: Arrow squid. New Zealand Fisheries Assessment Research Document 88/34. 16p. (Draft report held in NIWA library, Wellington).
Mattlin, R. H., Scheibling, R. E. & Forch, E. C. 1985: Distribution, abundance, and size structure of arrow squid (*Nototodarus* sp.) off New Zealand. *Northwest Atlantic Fisheries Organisation Scientific Council Studies, 9*: 39–45.
McClatchie, S., & Lester, P. 1994: Stock assessment of the elephantfish (*Callorhinchus milii*). New Zealand Fisheries Assessment Research Document 94/6. 17 p. (Draft report held in NIWA library, Wellington).
McDowall, R.M. 1978: New Zealand Freshwater Fishes. Heinemann, Auckland.
McGregor, G. A. 1988a: Blue cod. New Zealand Fisheries Assessment Research Document 88/41. 11p. (Draft report held in NIWA library, Wellington).
McGregor, G. A. 1988b: Stargazer. New Zealand Fisheries Assessment Research Document 88/43. 5p. (Draft report held in NIWA library, Wellington).
McGregor, G. A. 1995a: Stock assessment of the kingfish (*Seriola lalandi lalandi*). Draft New Zealand Fisheries Assessment Research Document. 26p.
McGregor, G. A. 1995b: Is the northern region the kingfish capital of the Pacific? *Seafood New Zealand 3(6)*: 15-18.
McGregor, G. & Voller, R. W. 1985: Gurnard. In Colman, J.A., McKoy, J.L. & Baird, G.G. (Comps. & Eds.), Background papers for the 1985 Total Allowable Catch recommendations, p. 101–109. Fisheries Research Division, N.Z. Ministry of Agriculture and Fisheries. (Unpublished report, held in Fisheries Research Centre library, Wellington.
Mehl, J. A. P. 1971: Spawning and length-weight of barracouta (Teleostei: Gemphylidae) from eastern Cook Strait. *New Zealand Journal of Marine and Freshwater Research 5*: 300–317.
Michael, K. 1988: Unusual longline catches and observations. *Catch 15(11)*: 16.
Mines, A. N. 1975: Aspects of the reproductive biology of some demersal fish species in Wellington Harbour, New Zealand. Unpublished MSc thesis, Victoria University of Wellington, New Zealand.
Morrison, M. A. 1996: John Dory. *Seafood New Zealand 4(7)*: 19-20.
Morrison, M. A 1997: Utilisation of the Whangateau Harbour by juvenile fish. Report on a PGSF research programme. NIWA report AK97080.
Morrison, M. A. 1998: Yellow belly flounder and other flatfishes habitat usage in the Manukau Harbour, northwestern New Zealand. NIWA report, held at NIWA Auckland.
Mundy, A. R. 1968: A study of the biology of the sand flounder *Rhombosolea plebia* (Richardson) off the Canturbury Coast. Unpublished PhD thesis, University of Canterbury, Caturbury, New Zealand. 151 p.

Mutch, P. G. 1983: Factors influencing the density and distribution of the blue cod *(Paraercis colias)* (Pisces: Mugiloididae). Master of Science thesis, University of Auckland, Auckland. 76 p.

Nack, S. B.; Bunnell, D.; Green, D. M.; & Forney, J. L. 1993: Spawning and nursery habitats of largemouth bass in the tidal Hudson River. *Transactions of the American Fisheries Society 122*: 208-216.

Pankhurst, N. W. & Conroy, A. M. 1987: Seasonal changes in reproductive condition and plasma levels of sex steroids in the blue cod, *Parapercis colias* (Bloch and Schneider) (Mugiloididae). *Fish Physiology and Biochemistry 4(1)*: 15-26.

Park, S. G. 1984: Biology of O-group flatfish in Auckland sandflats. Unpublished MSc thesis, University of Auckland, Auckland, New Zealand.

Parrish, F. A.; DeMartini, E. E.; & Ellis, D. M. 1997: Nursery habitat in relation to production of juvenile pink snapper, *Pristipomoides filamentosus*, in the Hawaiian Archipelago. *Fishery bulletin 95*: 137-148.

Parsons, M. J. D. 1999: An investigation into the spatial and temporal distribution patterns of ichthyoplankton off the Otago caost, south-eastern New Zealand. Unpublished MSc.(Marine Science) Thesis University of Otago, Dunedin.

Patchell, G. J. 1981: The Westland Hake Fishery. *Fisheries Research Division Occasional Publication No. 31.* 18p.

Patchell, G. J. 1987: Collected reports on fisheries for ling, hoki and hake. *Fisheries Research Centre Internal Report No. 66.* 51p. (Draft report held in NIWA Greta Point library, Wellington).

Patchell G. J. & McKoy, J.L. 1985: Ling. In Colman, J.A., McKoy, J.L. & Baird, G.G. (Comps. & Eds.), Background papers for the 1985 Total Allowable Catch recommendations, p. 123–135. Fisheries Research Division, N.Z. Ministry of Agriculture and Fisheries. (Unpublished report, held in Fisheries Research Centre library, Wellington).

Paul, L. J. 1976: A study on age, growth, and population structure of the snapper, *Chrysophrys auratus* (Forster) in the Hauraki Gulf, New Zealand. *New Zealand Ministry of Agriculture and Fisheries. Fisheries Research Bulletin No. 13.* 45 p.

Paul, L. J. 1986:New Zealand fishes An identification guide. Reed Methuen Publishers, Auckland. 184 p.

Paul, L. J. 1988: School shark. New Zealand Fisheries Assessment Research Document 88/27. 32 p. (Draft report held in NIWA library, Wellington).

Paul, L. J. 1998: A summary of the biology and commercial landings, and a stock assessment of the sea perch, *Helicolenus* spp. (Scorpaenidae) in New Zealand waters. New Zealand Fisheries Assessment Research Document 98/29. 30p. (Draft report held in NIWA library, Wellington).

Paul, L. J. & Davies, N. M. 1988: Groper. New Zealand Fisheries Assessment Research Document 88/15. 27p. (Draft report held in NIWA library, Wellington).

Paul, L. J., & Tarring, S. C. 1980: Growth rate and population structure of snapper, *Chrysophrys auratus*, in the East Cape region, New Zealand. *New Zealand Journal of Marine and Freshwater Research 14*: 237–247.

Paulin, C. D. 1989: Redescription of *Helicolenus percoides* (Richardson) and *H. barathri* (Hector) from New Zealand (Pisces, Scorpaenidae). *Journal of the Royal Society of New Zealand 19(3)*: 319-325.

Pearks, D. S. J. 1985: *Rhombosolea leporina* of the Manukau Harbour. Unpublished MSc Thesis, University of Auckland, Auckland, New Zealand. 144 p.

Poortenaar, C., Hooker, S & Sharp, N. 1999: Update on kingfish aquaculture research. *Seafood New Zealand 7(7)*: 33-34.

Poortenaar, C., Hooker, S & Sharp, N. 2000 (in press): Assessment of yellowtail kingfish (*Seriola lalandi lalandi*) reproductive physiology, as a basis for aquaculture development. Submitted to *Aquaculture* (29/06/00)

Rapson, A. M. 1940: The reproduction, growth and distribution of the Lemon Soles (*Pelotretis flavatus* Waite) of Tasman Bay and Marlborough Sounds. *New Zealand Marine Department Fisheries Bulletin No. 7.* 56 p.

Rapson, A. M. 1956: Biology of the blue cod *(Parapercis colias forster)* of New Zealand. Doctor of Science thesis, Victoria University, Wellington. 53 p.

Renwick, J. A., Hurst R. J. and Kidson J. W. 1998: Climatic influences on the recruitment of southern gemfish (*Rexea solandri,* Gempylidae) in New Zealand waters. *International Journal of Climatology.18(15)*: 1655–1667

Roberts, C. D. 1986: Systematics of the percomorph fish genus *Polyprion* Oken, 1817. Unpublished Ph.D. thesis, Victoria University of Wellington.

Roberts, C. D. 1987: First records of demersal fishes from the North Cape – Three Kings area of New Zealand, with a record of a prespawing aggregation of ling, *Genypterus blacodes. New Zealand Journal of Marine and Freshwater Research 21*: 157–161.

Roberts, C. D. 1989: Reproductive mode in the percomorph fish genus *Polyprion* Oken. *Journal of Fish Biology (34)*: 1-9.

Roberts, C. D. 1996: Hapuku and bass: the mystery of the missing juveniles. *Seafood New Zealand 4(1)*: 17-21.

Robertson, D. A. 1973: Planktonic eggs and larvae of some New Zealand marine teleosts. Unpublished PhD. Thesis, University of Otago, Dunedin, New Zealand. 480 p.

Robertson, D. A.1975: A key to the planktonic eggs of some New Zealand marine teleosts. *Fisheries Research Division Occasional Publication No. 9.* 19p.

Robertson, D. A. 1978: Spawning of tarakihi (Pisces: Cheilodactylidae) in New Zealand waters. *New Zealand Journal of Marine and Freshwater Research 12(3)*: 277–286.

Robertson, D. A. 1980: Hydrology and the quantitative distribution of planktonic eggs of some marine fishes of the Otago coast, southeastern New Zealand. *New Zealand Ministry of Agriculture and Fisheries, Fisheries Research Bulletin 21*:1-69.

Robertson, D. A. & Mito, S. 1979: Sea surface ichthyoplankton off Southeastern New Zealand, summer 1977-78. *New Zealand Journal of Marine and Freshwater Research 13(3)*: 415–424.

Robertson, D. A., & Raj, U. 1974: Egg and yolk sac stages of the sand flounder (Teleostei: Pleuronectidae). *New Zealand Journal of Marine and Freshwater Research 5(3&4)*: 404–414.

Roper, D. S. 1986: Occurrence and recruitment of fish larvae in a northern New Zealand estuary. *Estuarine and Coastal Shelf Science 22*: 705–717.

Roper, D. S, & Jillet, J. B. 1981: Seasonal occurrence and distribution of flatfish (Pisces: Pleuronectiformes) in inlets and shallow water along the Otago Coast. *New Zealand Journal of Marine and Freshwater Research. 15(1)*: 1–13.

Saunders, J. E. H. 1999: Patterns in the abundance and distribution of juvenile fishes and invertebrate benthos in intertidal estuarine habitats. Unpublished MSc thesis, University of Auckland, Auckland, New Zealand. 136 p.

Scott, S. G., & Pankhurst, N. W. 1992: Interannual variation in the reproductive cycle of the New Zealand snapper *Pagrus auratus* (Bloch & Schneider) (Sparidae). *Journal of Fish Biology. 41*: 685–696.

Seabrook-Davison, M., Paul, L. J., & Hurst, R. J. 1985: School shark. *In* Colman, J. A.; McKoy, J. L.; Baird, G. G. (Eds). Background papers for the 1985 Total Allowable Catch recommendations, p. 170-182. Fisheries Research Division, New Zealand Ministry of Agriculture and Fisheries, Wellington.

Simpfendorfer, C. A.; & Milward, N. E. 1993: Utilisation of a tropical bay as a nursery area by sharks of the families Carcharhinidae and Sphyrnidae. *Environmental biology of fishes 37*: 337-345.

Smith, P. J. 1998: Molecular identification of sea perch species. Ministry of Fisheries Final Research Report October 1998

Smith, P. J., & Francis, R. I. C. C. 1984: Glucosephosphate isomerase genotype frequencies, homozygous excess and size relationships in the sand flounder *Rhombosolea plebeia. Marine Biology. 79*: 93–98.

Smith, P. J., Benson, P. G., & Frentzos, A. A. 1980: Electrophoretic identification of larval and O-group flounders (*Rhombosolea* spp.) from Wellington Harbour. *New Zealand Journal of Marine and Freshwater Research 14(4)*: 401–404.

Smith, P. J., Mattlin, R. H., Roeleveld, M. A. & Okutani, T. 1987: Arrow squids of the genus *Nototodarus* in New Zealand waters: systematics, biology and fisheries. *New Zealand Journal of Marine and Freshwater Research 21*: 315–326.

Stepien, C.A. & Rosenblatt, R.H. 1996: Genetic divergence in antitropical pelagic marine fishes (*Trachurus*, *Merluccius*, and *Scomber*) between North and South America. *Copeia 1996(3)*: 586–598.

Stevens, D. W. & Kalish, J. M. 1998: Validated age and growth of kahawai (*Arripis trutta*) in the Bay of Plenty and Tasman Bay. *NIWA Technical Report 11*. 19 p.

Staples, D. J. 1971: Growth of red gurnard (Teleostei: Triglidae) from Pegasus Bay, Canterbury, New Zealand. *New Zealand Journal of Marine and Freshwater Research 6(3)*: 365–374.

Sullivan, K. J. 1977: Age and growth of the elephant fish *Callorhinchus milii* (Elasmobranchii: Callorhynchidae). *New Zealand Journal of Marine and Freshwater Research 11*: 745-753.

Sutton, C. P. 1997: Growth parameters and estimates of mortality for red gurnard (*Chelidonichthys kumu*) from the east and west coasts of the South Island. New Zealand Fisheries Assessment Research Document 97/1.15 p. (Draft report held in NIWA library, Wellington)

Sutton, C. P. 1999: Ageing methodology, growth parameters, and estimates of mortality for giant stargazer (*Kathetostoma giganteum*) from the east and south coasts of the South Island. New Zealand Fisheries Assessment Research Document 99/15. 19p. (Draft report held in NIWA library, Wellington).

Taylor, P. R. 1998: A summary of the biology, recreational and commercial landings and stock assessment of yellow-eyed mullet *Aldrichetta forsteri* (Cuvier & Valenciennes, 1836) (Mugiloidei: Mugilidae). New Zealand Fisheries Assessment Research Document 98/17: 34 p. (Draft report held in NIWA library, Wellington)

Taylor, P.R. 1999a: Stock structure & population biology of the jack mackerel, *Trachurus symmetricus murphyi*. Final Research Report for Ministry of Fisheries Project JMA9802. 83 p.

Taylor, P.R. 1999b: Species composition and seasonal variability of jack mackerel *Trachurus declivis*, *T. symmetricus murphyi* and *T. novazelandie*, in JMA 1, JMA 3 and JMA 7. *New Zealand Fisheries Assessment Research Document 99/49*. 21p.

Tong, L. J. & Elder, R. D. 1968: Distribution and abundance of demersal fish from trawl stations in the Bay of Plenty, New Zealand. *New Zealand Journal of Marine and Freshwater Research* 2: 49–66

Tong, L. J. & Saito, R. 1977: Further postlarvae of tarakihi in New Zealand waters. *New Zealand Journal of Marine and Freshwater Research 11(1)*: 159–162.

Tong, L. J. & Vooren, C. M. 1972: The biology of the New Zealand tarakihi, *Cheilodactylus macropterus* (Bloch and Schneider). *N.Z. Ministry of Agriculture and Fisheries Fisheries Research Bulletin No. 6*. 60p.

Tricklebank, K. A. 1988: Distribution and abundance of neustonic icthyoplankton. Unpublished MSc thesis, University of Auckland, Auckland, New Zealand.

Tricklebank, K. A, Jacoby, C. A., & Montgomery, J. C. 1992: Composition, distribution and abundance of neustonic icthyoplankton off northeastern New Zealand. *Estuarine, Coastal and Shelf Science. 34*: 263–275.

Tunbridge, B. R. 1966: Growth and movements of tagged flatfish in Tasman Bay. *Fisheries Technical Report No. 13*. 19 p. New Zealand Marine Department

Uozumi, Y. 1997: Fishery Biology on Arrow Squids, *Nototodarus gouldi* and *N. sloanii*, in New Zealand waters., National Research Institute of Far Seas Fisheries, Shimazu, Japan. Unpublished PhD. thesis. 224 p.

Uozumi, Y., Koshida, S. & Kotoda, S. 1995: Maturation of arrow squids *Nototodarus gouldi* and *N. sloanii* with age in New Zealand waters. *Fisheries Science 61(4)*: 559–565.

Vooren, C. M. & Tong, L. J. 1973: A survey of the tarakihi, *Cheilodactylus macropterus* (Bloch and Schneider), in the East Cape area, New Zealand, 26-30 March 1971. *N.Z. Ministry of Agriculture and Fisheries Fisheries Research Bulletin No. 9*. 28p.

Vooren, C. M. 1972: Postlarvae and juveniles of the tarakihi (Teleostei: Cheilodactylidae) in New Zealand. *New Zealand Journal of Marine and Freshwater Research 6(4)*: 602–618.

Vooren, C. M. 1975: Nursery grounds of tarakihi (Teleostei: Cheilodactylidae) around New Zealand. *New Zealand Journal of Marine and Freshwater Research 9(2)*: 121–158.

Vooren, C. M. 1975: Nursery grounds of tarakihi (Teleostei: Cheilodactylidae) around New Zealand. *New Zealand journal of marine and freshwater research 9*: 121-158.

Vooren, C. M. 1977: Growth and mortality of tarakihi (Pisces: Cheilodactylidae) in lightly exploited populations. *New Zealand Journal of Marine and Freshwater Research 11*: 1–22.
Waite, E. R. 1909: Scientific results of the New Zealand Government trawling expedition, 1907. Wellington, Government Printer. 116 p.
Webb, B. F. 1972a: Fish populations of the Avon-Heathcote Estuary. 1. General ecology, distribution, and length-frequency. *New Zealand Journal of Marine and Freshwater Research. 6(4)*: 570–601.
Webb, B. F. 1972b: Fish populations of the Avon-Heathcote Estuary. 2. Breeding and gonad maturity. *New Zealand Journal of Marine and Freshwater Research 7*: 45–66.
Webb, B. F. 1973: Fish populations of the Avon-Heathcote Estuary. 5. Records of less common species. *New Zealand Journal of Marine and Freshwater Research 7*: 307-321.
Wilkinson, A. 1977: The early development and occurrence of flatfish (Teleostei: Pleuronectidae) in Wellington Harbour. Unpublished BSc (Hons) thesis, Victoria University of Wellington, New Zealand.
Williams, H.; & Schaap, A. H. 1992: Preliminary results of a study into the incidental mortality of sharks in gill-nets in two Tasmania shark nursery areas. *Australian journal of marine and freshwater research 43*: 237-250.
Wilson, M. T. 1997: Walleye pollock (*Theragra chalcogramma*) in the western Gulf of Alaska: the importance of nursery areas. *In*: Forage fishes in marine ecosystems. American Fisheries Society.

Table 1. List of species (by common and scientific names) and data sources *Res*, Ministry of Fisheries research trawl database; *Obs*, Ministry of Fisheries scientific observer database; *Ins*, Inshore *Kaharoa* surveys; *MD*, Middle depth *Tangaroa* and *Akebono Maru 73* surveys; *Frst*, Foundation of Research, Science and Technology funded programme; *DoC*, Department of Conservation; +, reproduced from *Hurst et al.* (2000); *, extracted since Hurst *et al.* 2000;

Species		Data sources								
Common name	Scientific name	Juvenile distributions			Juvenile abundance			Spawning distributions		
		Res	*Obs*	*Frst*	*Ins*	*MD*	Frst	*Res*	*Obs*	*DoC*
Yelloweyed mullet	*Aldrichetta forsteri*	+*		+			+			
Kahawai	*Arripis trutta*	+		+	+		+	+		
Elephantfish	*Callorhinchus milii*	+			+					+
Red gurnard	*Chelidonichthys kumu*	+			+	+		+		
School shark	*Galeorhinus galeus*	+	+		+	+				
Ling	*Genypterus blacodes*	+	+		+	+				
Sea perch	*Helicolenus percoides*	+*			+	+				
Giant stargazer	*Kathetostoma giganteum*	+	+		+	+		+	+	
Banded stargazer	*Kathetostoma sp.*	+*	+*			+		+		
Blue moki	*Latridopsis ciliaris*	+*						+		
Hake	*Merluccius australis*	+	+		+	+				
Grey mullet	*Mugil cephalus*	+*		+			+			
Rig	*Mustelus lenticulatus*	+	+		+					
Tarakihi	*Nemadactylus macropterus*	+	+		+	+		+		
Arrow squid	*Nototodarus gouldi & sloanii*	+	+		+	+				
Snapper	*Pagrus auratus*	+			+			+		
Blue cod	*Parapercis colias*	+*	+*					+		
Lemon sole	*Pelotretis flavilatus*	+			+					
New Zealand sole	*Peltorhamphus novaezeelandiae*	+*								
Hapuku	*Polyprion oxygeneios*	+	+		+	+		+	+	
Trevally	*Pseudocaranx dentex*	+			+			+		
Red cod	*Pseudophycis bachus*	+	+		+	+		+	+	
Gemfish	*Rexea solandri*	+	+		+	+		+	+	
Yellowbelly flounder	*Rhombosolea leporina*	+		+			+			
Sand flounder	*Rhombosolea plebeia*	+		+	+		+			
Blue mackerel	*Scomber australasicus*	+	+		+			+		
Kingfish	*Seriola lalandi*	+*			+					
Blue warehou	*Seriolella brama*	+	+		+	+		+	+	
Silver warehou	*Seriolella punctata*	+	+		+	+				
Spiny dogfish	*Squalus acanthias*	+	+		+	+				
Barracouta	*Thyrsites atun*	+	+		+	+		+	+	
Jack mackerel	*Trachurus declivis*	+	+		+			+	+	
Jack mackerel	*Trachurus novaezelandiae*	+	+		+			+	+	
Murphy's mackerel	*Trachurus symmetricus murphyi*	+	+			+		+	+	
John dory	*Zeus faber*	+			+			+		
Total species		35	20	5	27	17	5	19	9	1

Table 2: **Lengths (cm) used to separate age classes (by season) and maturity stages, based on database extracts and published age and length at maturity and growth data. Seasonal divisions (up to four periods) were made for species that are fast growing or have multiple or extended spawning seasons (i.e. where 1 period is indicated this represents a 12 month season; 2 periods represent 6 month seasons; 4 periods represent 3 month seasons). Divisions start at the assumed birthday which is the first day of the month indicated. Where growth is very slow or unknown, age groups have not been determined. Length measurement methods are: F, fork; G, snout tip to posterior end of dorsal fin; M, mantle; P, pelvic; S, standard; T, total. The length at maturity is the length at which 50% of fish are mature (averaged across sexes where appropriate), or an approximation of this, as indicated. M, male; F, female; SOP, Scientific Observer Programme; –, not determined**

Species	Length method	Length (cm) at maturity	Birth	Age/ group	Maximum length (cm) by season				Length at maturity source	Growth/age data source
					1	2	3	4		
Aldrichetta forsteri	F	21							Taylor 1998	
Arripis trutta	F	38	Feb	0	10	14			Francis 1996: 35–40 cm (4–5 years)	Francis 1996
				1	21	25				
Callorhinchus milii	F	M: 52	May	0	15	20	23	29	Gorman 1963	Francis 1997
		F: 71		1	32	32	38	40		
Chelidonichthys kumu[1]	F	30	Jan	0	18	22			Annala *et al.* 1998: 2–3 years	Francis 1996, Sutton 1997
				1	30	35				
Galeorhinus galeus[2]	T	130	Oct	0	35	40	44	50	Hurst *et al.* 1999	Francis & Mulligan 1998
				1	50	54	59	61	Francis & Mulligan 1998	
Genypterus blacodes	T	68	Oct	0	26	28			Annala *et al.* 1998: 30% at age 6, 75% at age 7	Horn 1993a
				1	38	40				
Helicolenus percoides	T	25							Larry Paul pers. comm (NIWA)	
Kathetostoma giganteum	T	45	Mar	0	10	16			Sutton 1999	Sutton 1999
				1	19	23				
Kathetostoma sp.	T	43							Assumed same as *K. giganteum*	
Latridopsis ciliaris	F	40							Annala *et al.* 1998	
Merluccius australis	T	76	Oct	0	22	25	18	25	Annala *et al.* 1998	Horn 1997
				1	40	45	45	44		
Mugil cephalus	F	34							Annala *et al.* 1998	
Mustelus lenticulatus	T	M:87	Sep	0	45	50			Francis & Francis 1992	Francis & Francis 1992
		F: 102		1	65	70				
Nemadactylus macropterus	F	31	Mar	0	–	11			Tong & Vooren 1972	Vooren 1975, 1977 (recruit to the bottom at about 10 cm
				1	15	17				

Table 2 — continued

Species	Length Method	Length (cm) at maturity	Birth	Age/ group	Maximum length (cm) by season 1	2	3	4	Length at maturity source	Growth/age data source
Nototodarus gouldi & N. sloanii	M	31	Oct	i	14	15	13	14	Derived from Uozumi *et al.*	Arbitrary, based on length
				ii	19	21	20	20	1995, Uozumi 1997	frequency modes
Pagrus auratus	F	24	Jan	0	8	12			Crossland 1981a, Francis 1996	Francis 1994
				1	16	18				
Parapercis colias	T	19							Annala *et al.* 1998	
Pelotretis flavilatis	T	18	Aug	0	11	15			Rapson 1940	Rapson 1940 (age 1 may
				1	25	28				Include some age 2 fish)
Peltorhamphus novaezeelandiae	T	18							Assumed same as *Pelotretis flavilatis*	
Polyprion oxygeneios	T	86	Jul	i	50				Annala *et al.* 1998	Arbitrary, smaller fish represent
				ii	60					several age classes
Pseudocaranx dentex	F	36	Jan	0	14	17			Annala *et al.* 1998	Gilbert 1988, James 1984
				1	25	27				
Pseudophycis bachus	T	51	Oct	0	14	22			Annala *et al.* 1998	Horn 1996
				1	35	45				
Rexea solandri	F	65	Oct	0	20	20	35	28	Derived from Hurst *et al.* 1998	Horn & Hurst 1999
				1	34	39	39	44		
Rhombosolea leporina	T	21	Jan	0	15	20			Colman 1972	
				1	23	29				
Rhombosolea plebeia	T	18	Jan	0	10	19			Colman 1972	Colman 1978
				1	25	28				
Scomber australasicus	F	36	Aug	i	22	28			Research and SOP data: F:	Arbitrary, groups i & ii may
				ii	33	39			35–42, M: no data	represent ages 1 & 2
Seriola lalandi	F	65							Elizabeth Bradford pers. comm. (NIWA)	
Seriolella brama	F	36	Oct	0	13	17	10	20	Bagley *et al.* 1998: age 4	Bagley *et al.* 1998
				1	24	28	26	30		
Seriolella punctata	F	47	Oct	0	20	24	25	28	Horn & Sutton 1996	Horn & Sutton 1996
				1	30	33	35	36		

Table 2 — continued

Species	Length Method	Length (cm) at maturity	Birth	Age/ group	Maximum length (cm) by season				Length at maturity source	Growth/age data source
					1	2	3	4		
Squalus acanthias	T	M: 58	Jul	0	28	30	32	35	Hanchet 1988b	Hanchet 1986
		F: 72		1	33	37	37	42		
Thyrsites atun	F	56	Oct	0	20	25	30	32	Annala *et al.* 1998	Harley *et al.* 1999
				1	36	40	42	45		
Trachurus declivis	F	31	Jan	0	13	19			Horn 1991	Horn 1993b
				1	22	28				
Trachurus symmetricus murphyi	F	39	–	–					Andrianov 1985	
Trachurus novaezelandiae	F	27	Jan	0	13	15			Horn 1991	Horn 1993b
				1	19	22				
Zeus faber	T	36	Jan	0	25	30			Francis 1996, Hanchet &	Hanchet & Francis
				1	35	40			Francis unpubl. results	unpubl. results

Notes:

1. Red gurnard length at maturity varies across New Zealand. For the juvenile abundance plots, 30 was used as the cut-off for North Island and 36 for South Island fish.
2 School shark fork length measurements from tuna longline data were converted to total length using TL = 3.311 + 1.138 FL (Simpfendorfer, pers. comm)

Table 3: List of research trawl survey vessels, gear and years used to determine the abundance of juveniles. Years represent the start and end of the time series and are not necessarily annual. NI, North Island; SI, South Island

Area	Depth range (m)	Vessel	Gear type	Survey years
NI: west coast	10–200	*Kaharoa*	Snapper	1986–1999
NI: Hauraki Gulf	10–150	*Kaharoa*	Snapper	1984–1997
NI: Bay of Plenty	10–250	*Kaharoa*	Snapper	1983–1999
NI: south-east coast	20–400	*Kaharoa*	South-east coast NI	1993–1996
SI: west coast	20–400	*Kaharoa*	SI (74 mm codend)	1992–2000
SI: Tasman & Golden Bays	20–70	*Kaharoa*	SI (74 mm codend)	1992–2000
SI: east coast	30–400	*Kaharoa*	SI (74 mm codend)	1991–1996
SI: east coast	10–400	*Kaharoa*	SI (28 mm codend)	1996–1999
Southland	30–600	*Tangaroa*	Hoki	1993–1996
Chatham Rise	200–800	*Tangaroa*	Hoki	1992–2000
Chatham Islands	50–400	*Akebono Maru 73*	*Akebono Maru 73*	1984, 1985

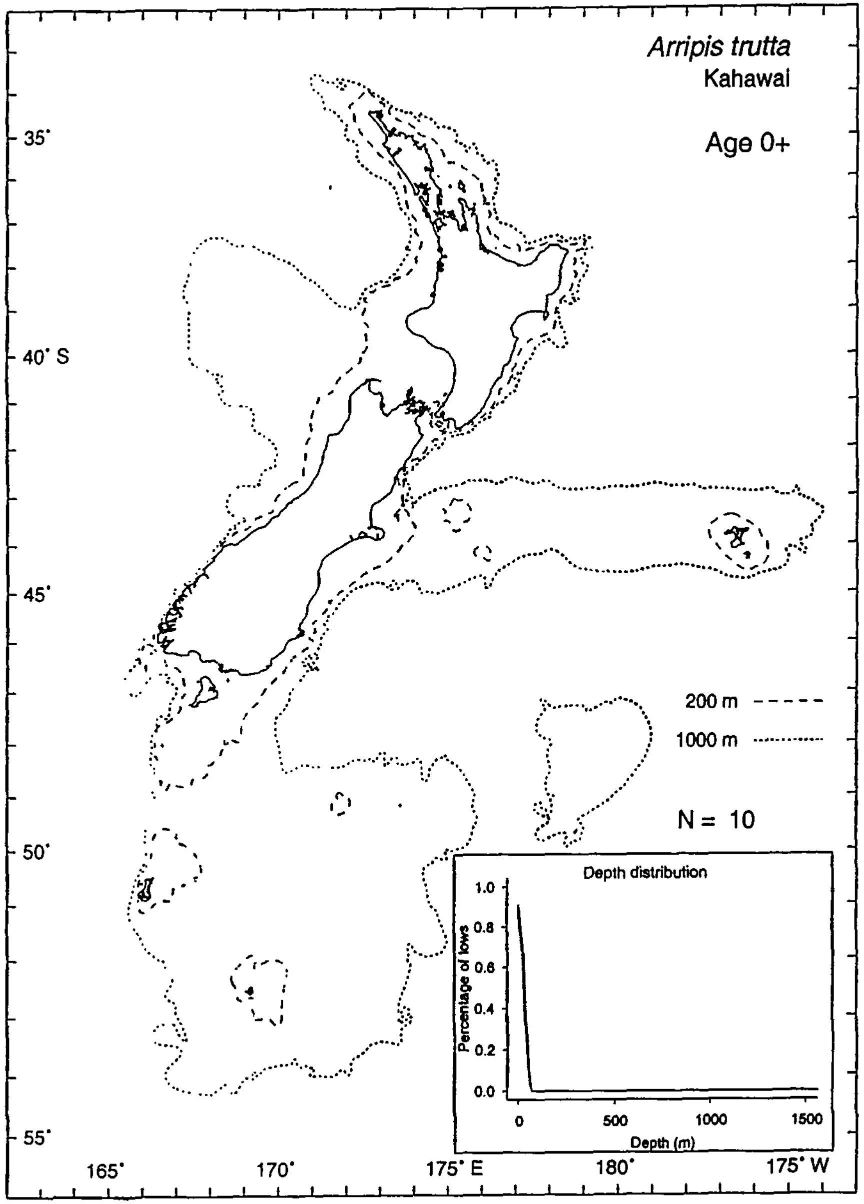
Table 4: Method for converting various female stages scales used by NIWA Auckland and Middle Depths staff to the 5-stage scale used by other NIWA staff and scientific observers

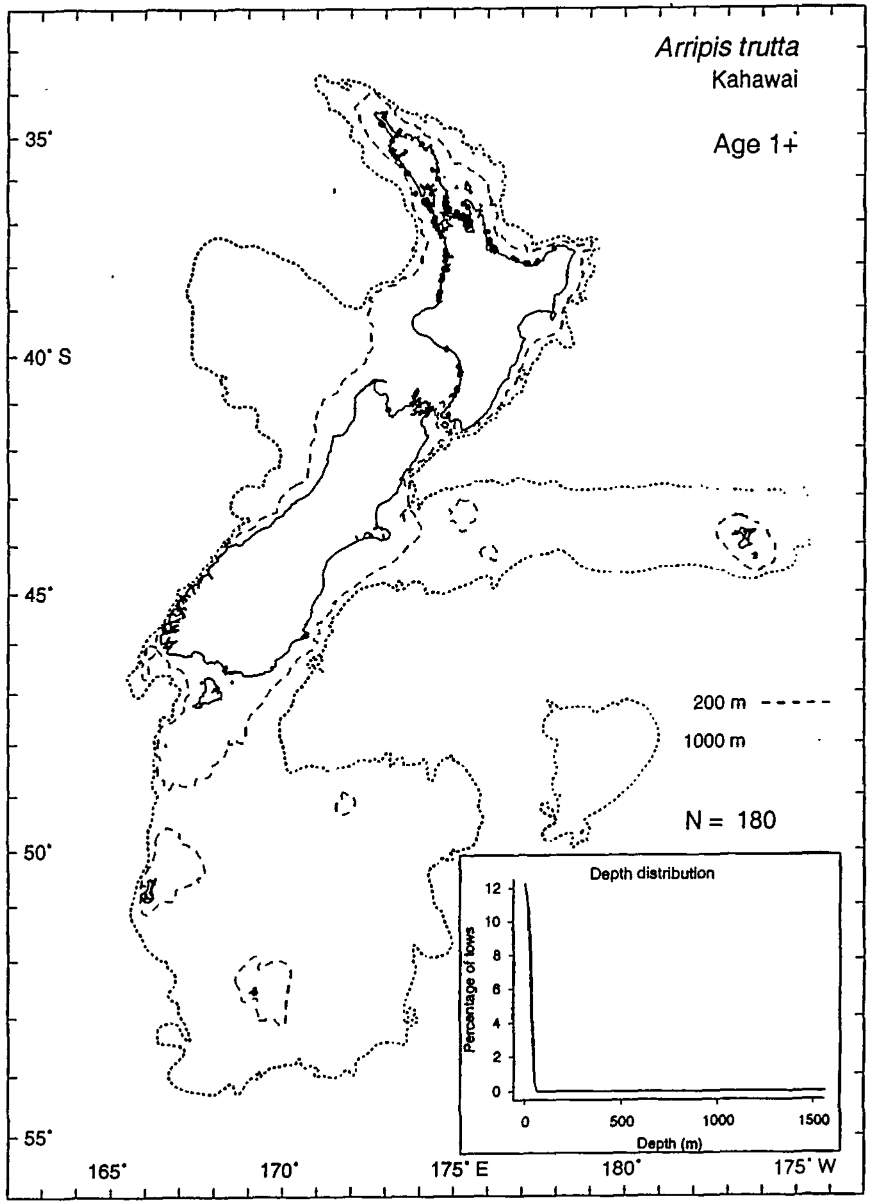
Scientific observers		Auckland		Middle Depth	
1	Immature / resting	{1	Immature	{1	Immature
		{2	Resting (regressed)	{2	Resting (regressed)
2	Maturing (vitellogenic)	3	Maturing (vitellogenic)	3	Maturing (vitellogenic)
3	Ripe (hydrated eggs)	4	Ripe (hydrated eggs)	{4	Ripe (hydrated eggs)
				{6	Partially spent (batches)
4	Running ripe	5	Running ripe	5	Running ripe
5	Spent	6	Spent	7	Spent

1.1 Juvenile distributions

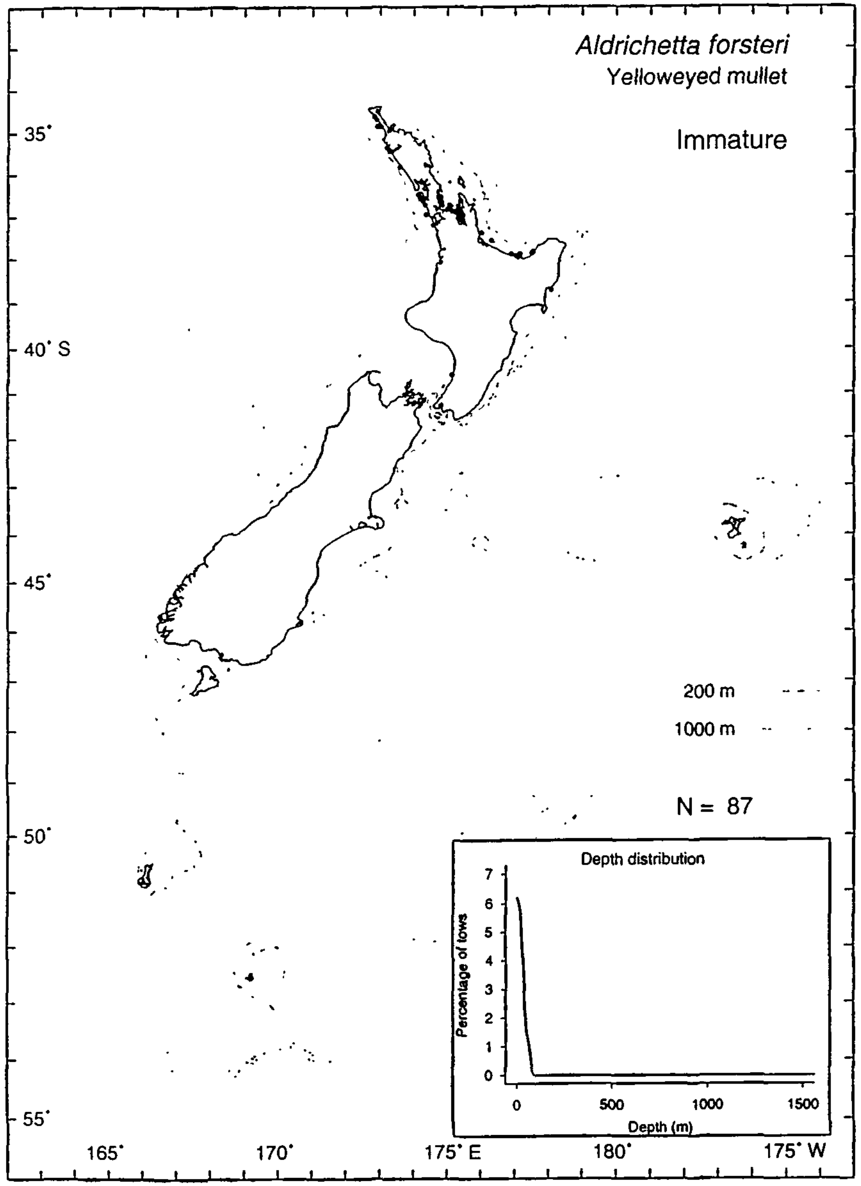
Key to symbols and shading in the distribution plots

●	Research trawl
□	Scientific Observer trawl
Black	Position where life history stage occurred
Grey	Position where the species has been recorded in research or commercial trawls

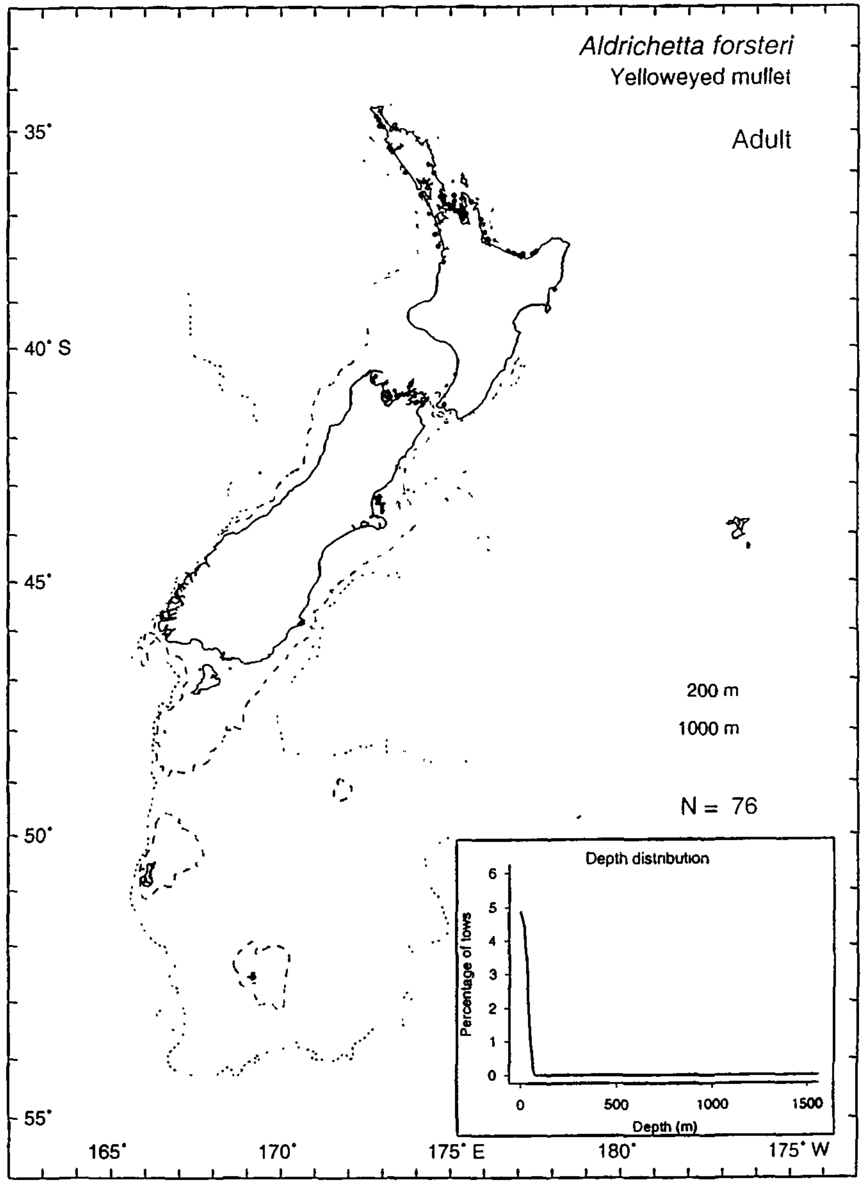




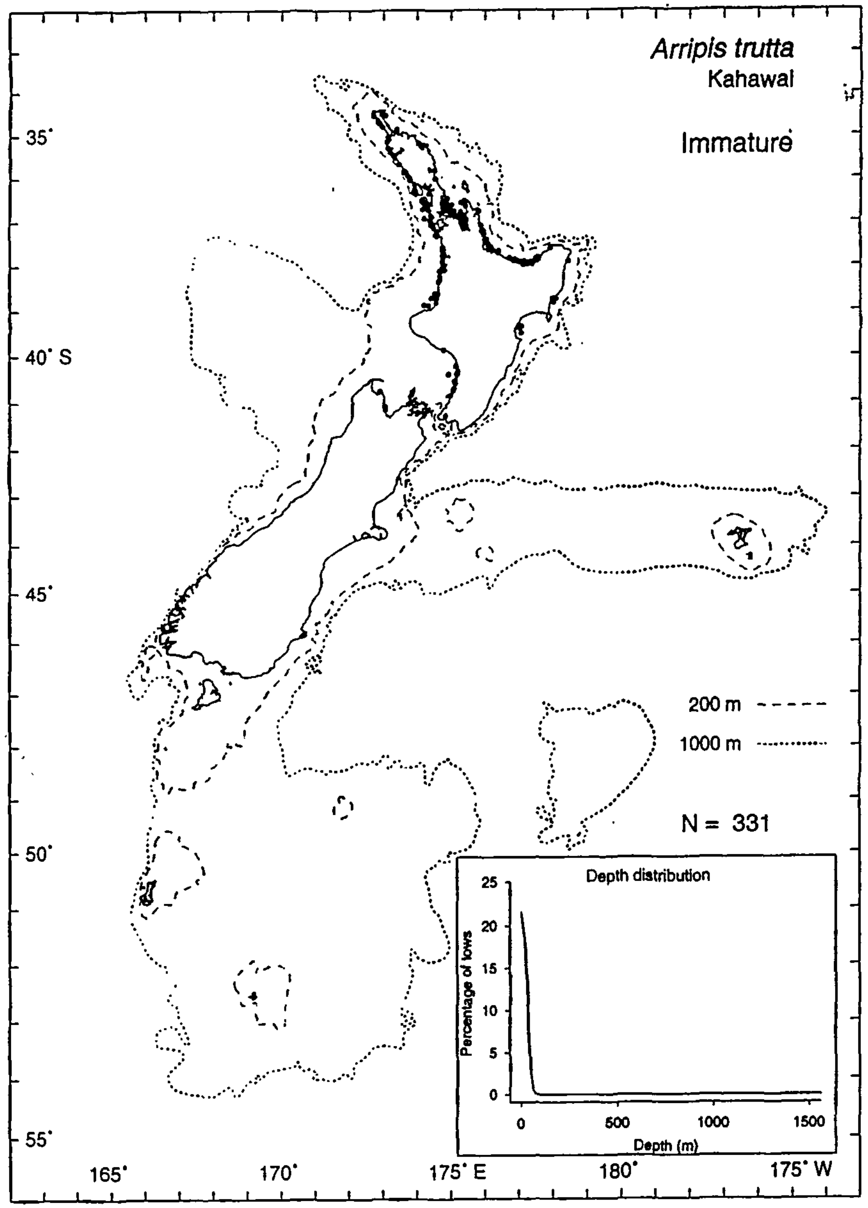
Juvenile plots are not presented for this species.

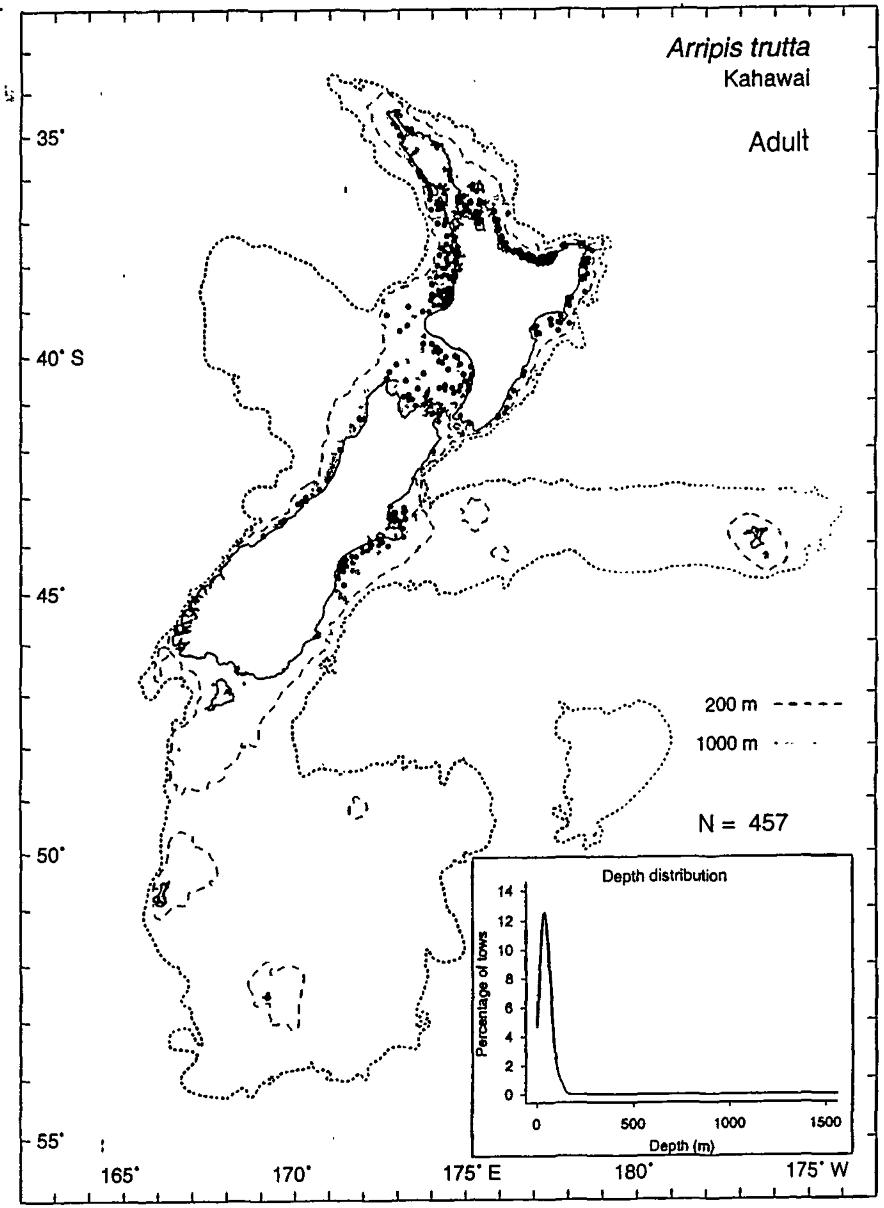


Aldrichetta forsteri
Yelloweyed mullet
Immature
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 87
Depth distribution
Percentage of tows
Depth (m)
0
500
1000
1500

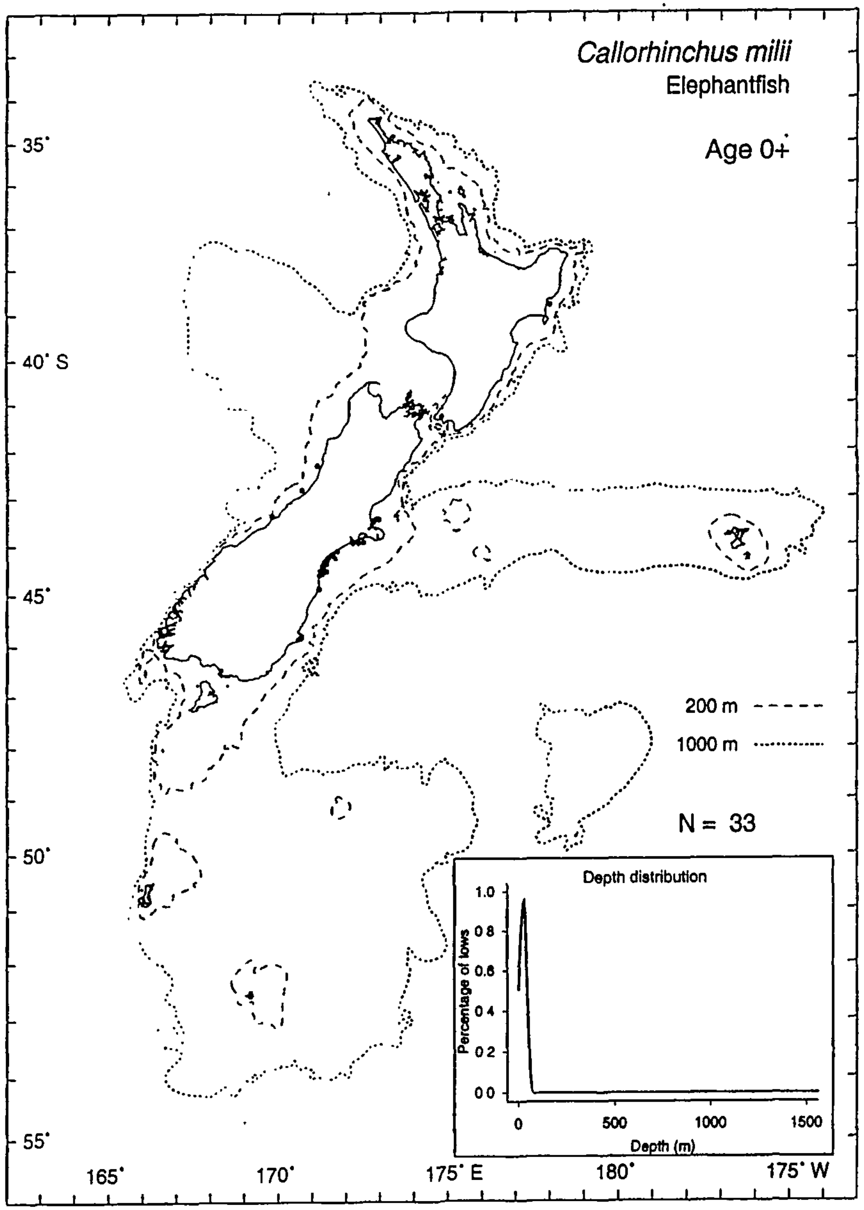


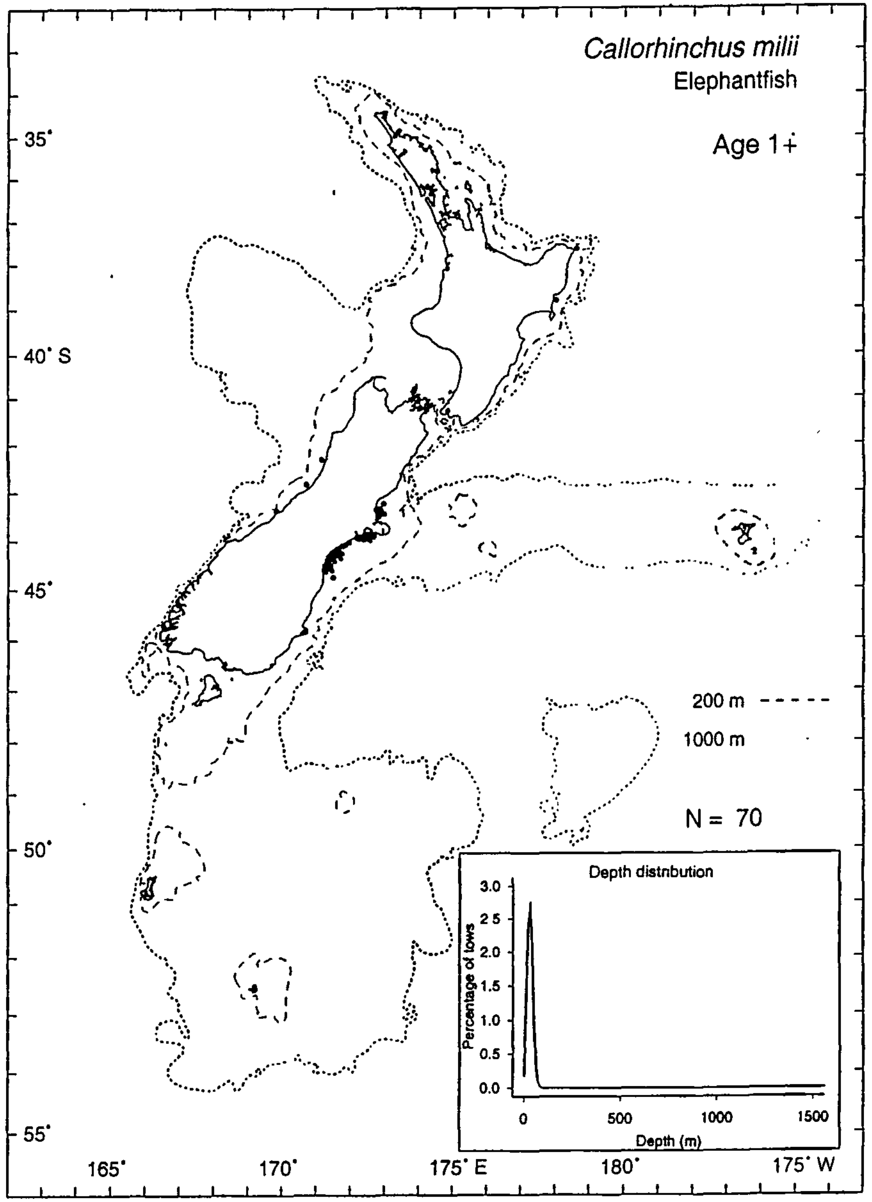
Aldrichetta forsteri
Yelloweyed mullet
Adult
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 76
Depth distribution
Percentage of tows
Depth (m)
0
500
1000
1500

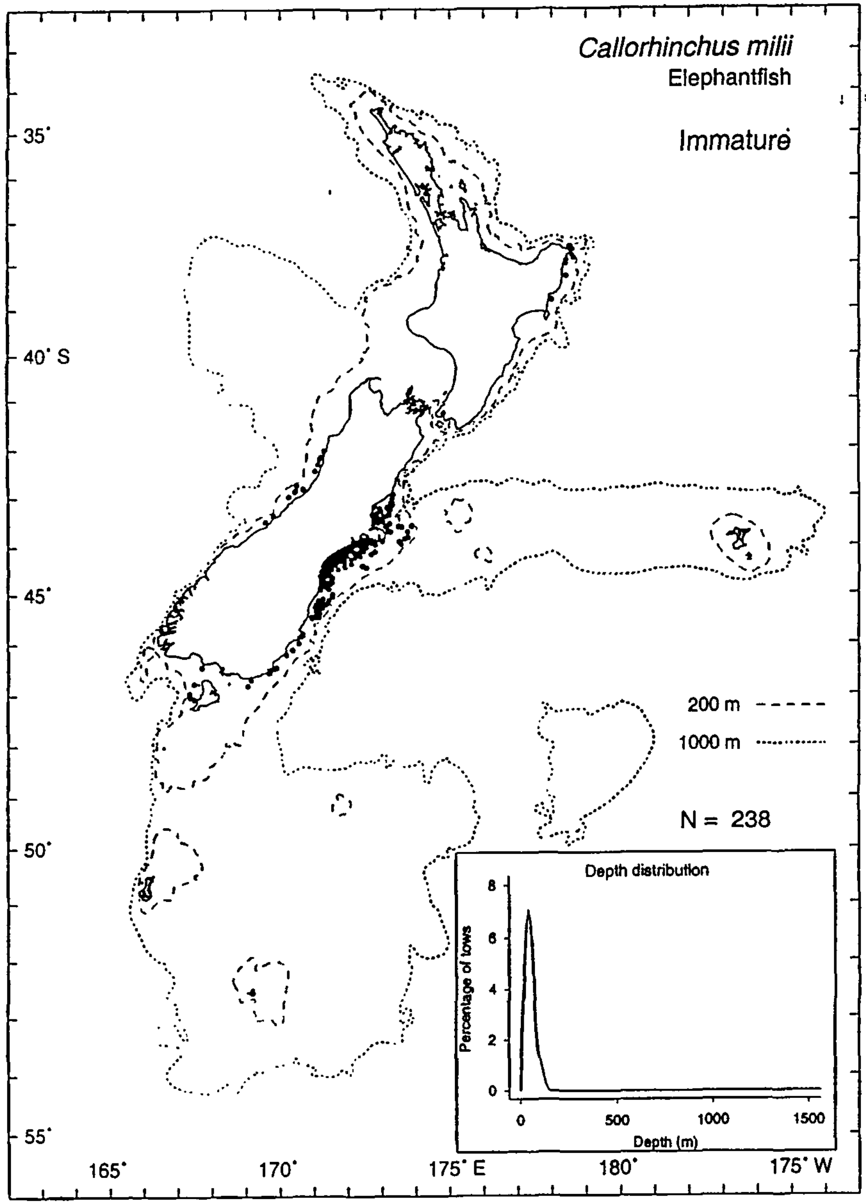


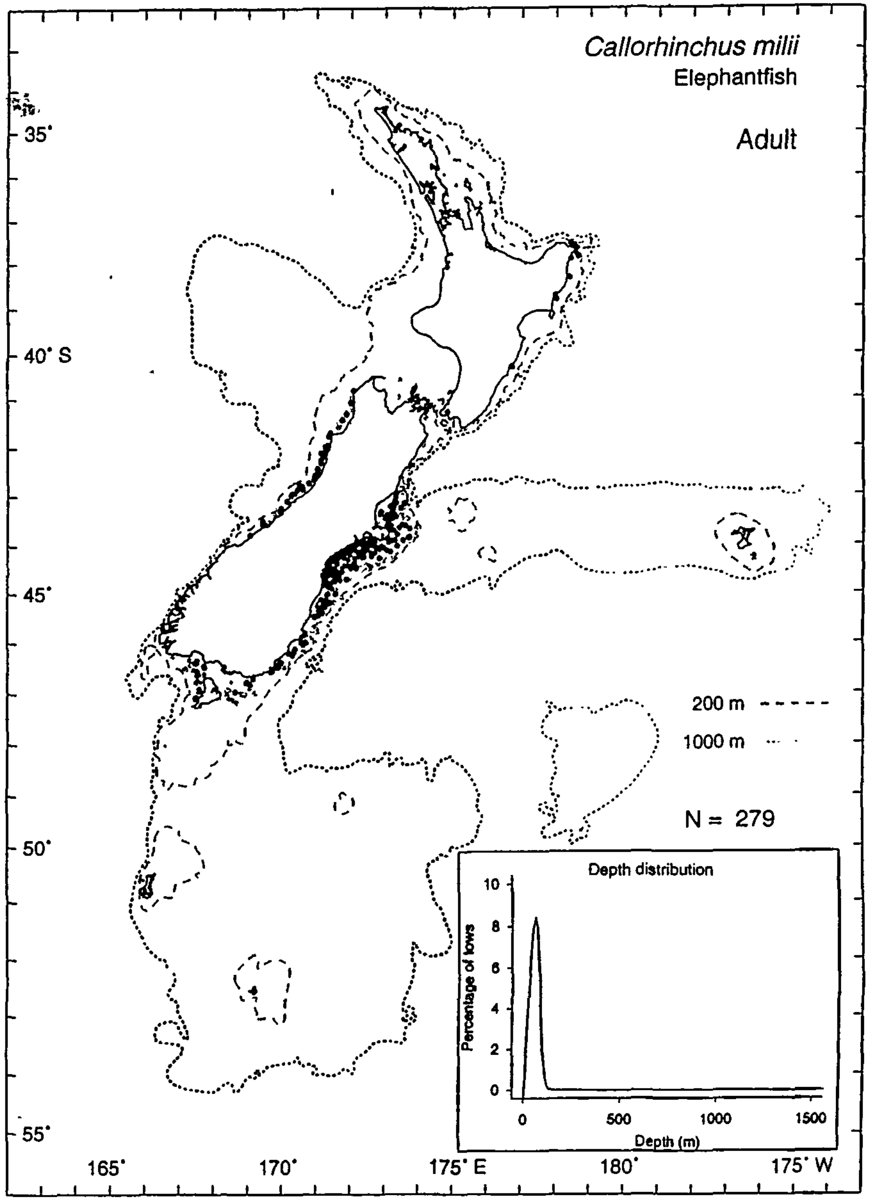


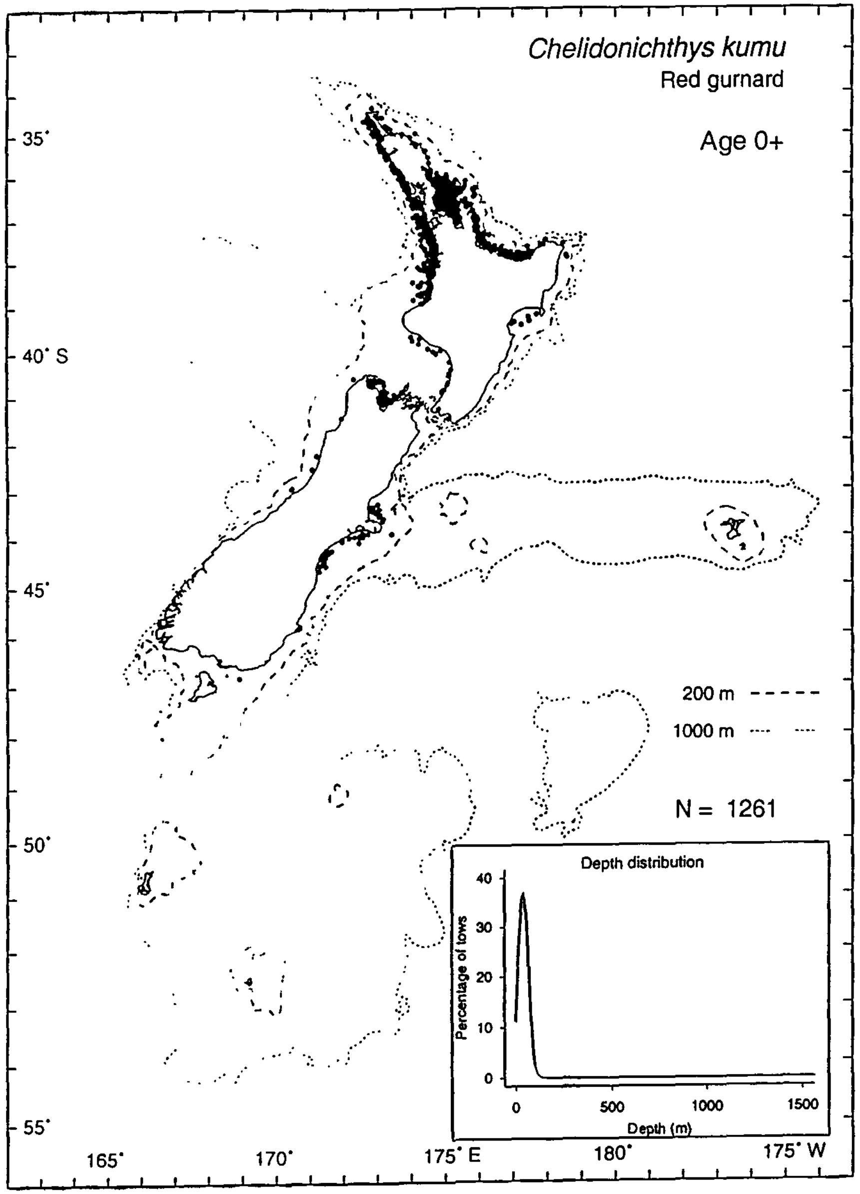
Juvenile plots are not presented for this species.


Callorhinchus milii
Elephantfish
Age 0+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 33
Depth distribution
Percentage of tows
Depth (m)
0
500
1000
1500
0.0
0.2
0.4
0.6
0.8
1.0

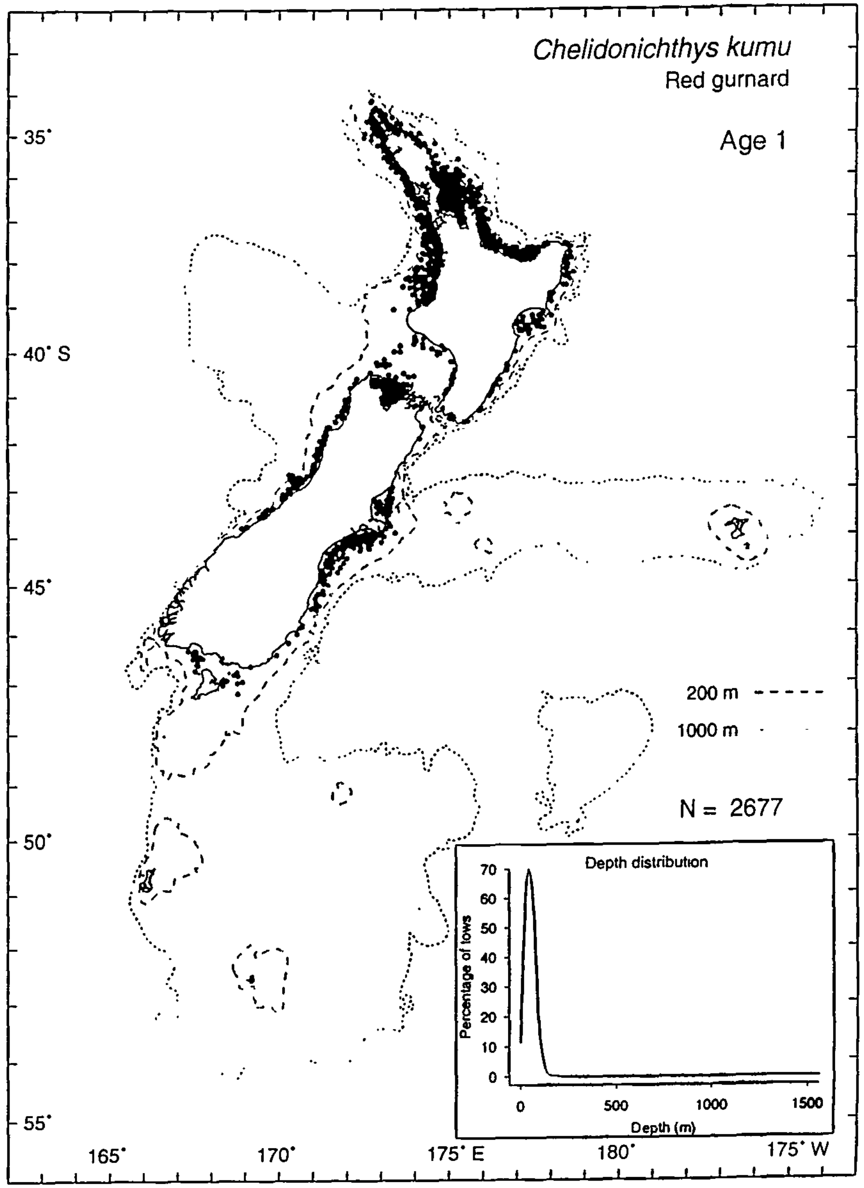

Callorhinchus milii
Elephantfish
Age 1+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 70
Depth distribution
Percentage of tows
Depth (m)
0
500
1000
1500
0.0
0.5
1.0
1.5
2.0
2.5
3.0


Callorhinchus milii
Elephantfish
Immature
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 238
Depth distribution
Percentage of tows
Depth (m)
0
500
1000
1500
0
2
4
6
8

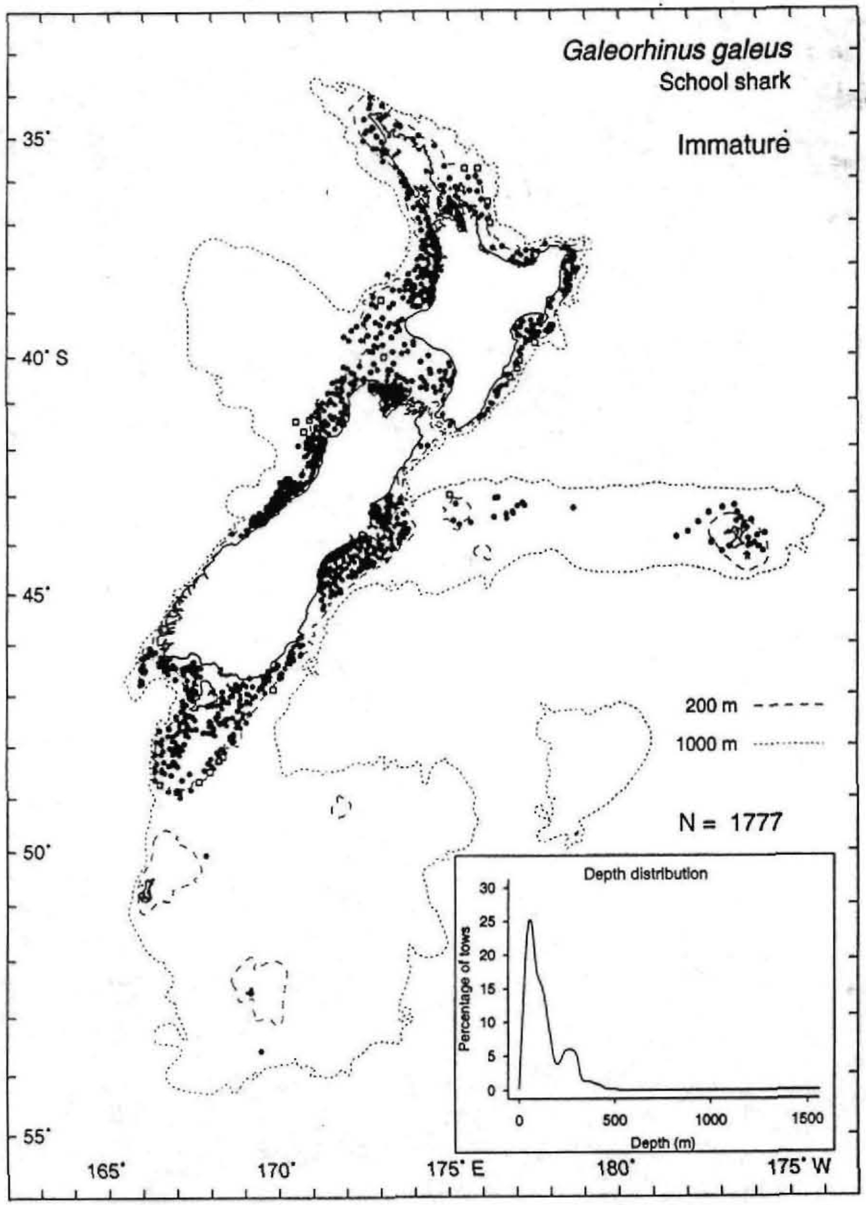

Callorhinchus milii
Elephantfish
Adult
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 279
Depth distribution
Percentage of tows
Depth (m)
0
500
1000
1500
0
2
4
6
8
10



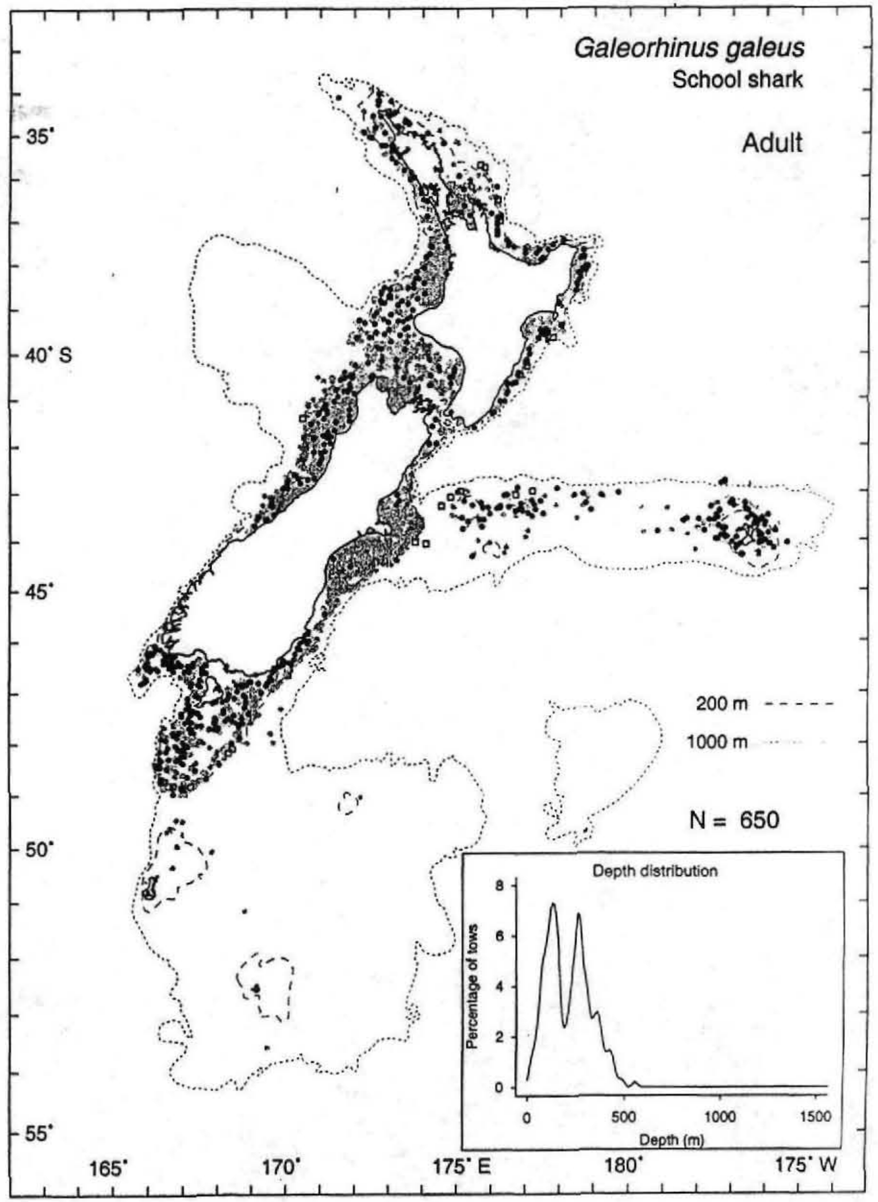
Chelidonichthys kumu
Red gurnard
Age 0+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 1261
Depth distribution
Percentage of tows
Depth (m)
0
10
20
30
40
500
1000
1500



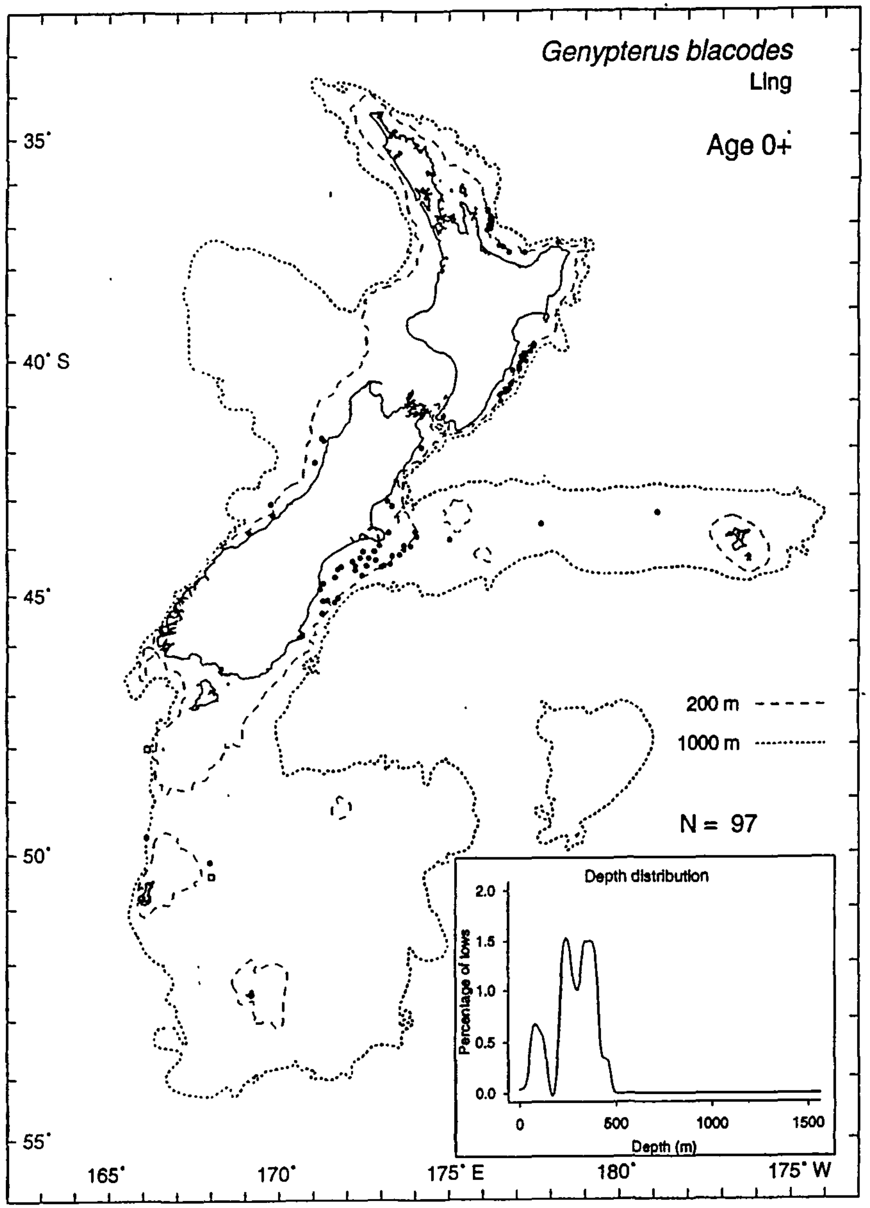
Chelidonichthys kumu
Red gurnard
Age 1
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 2677
Depth distribution
Percentage of tows
Depth (m)
0
10
20
30
40
50
60
70
500
1000
1500

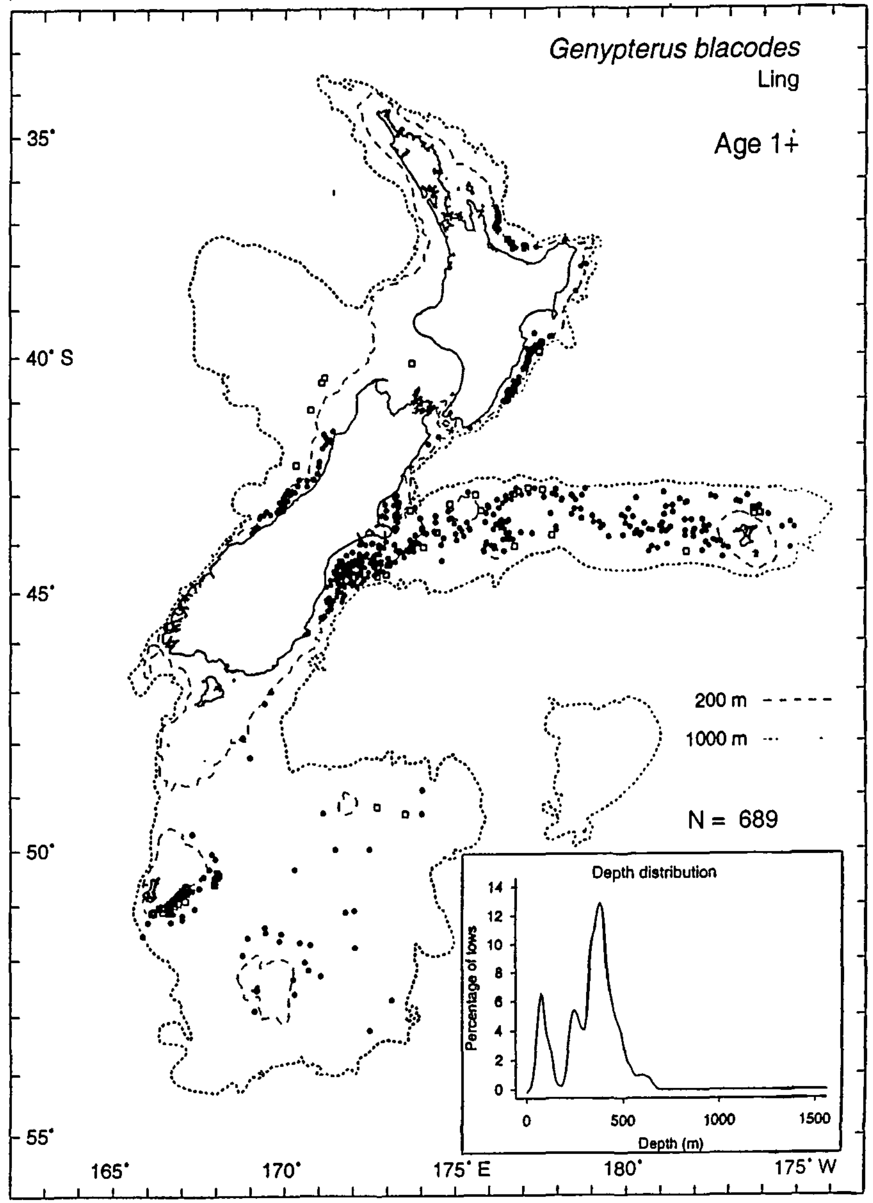


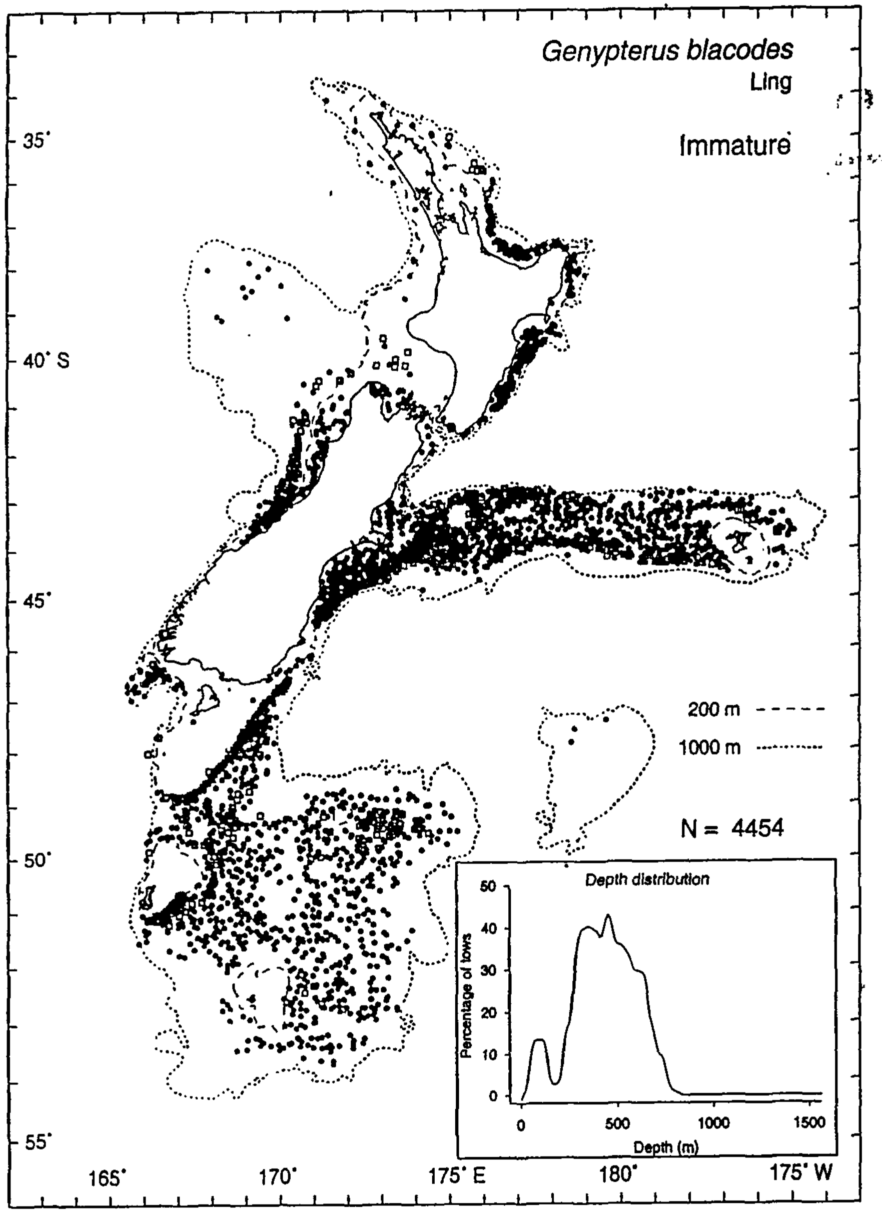
Galeorhinus galeus
School shark
Immature
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 1777
Depth distribution
Percentage of tows
Depth (m)



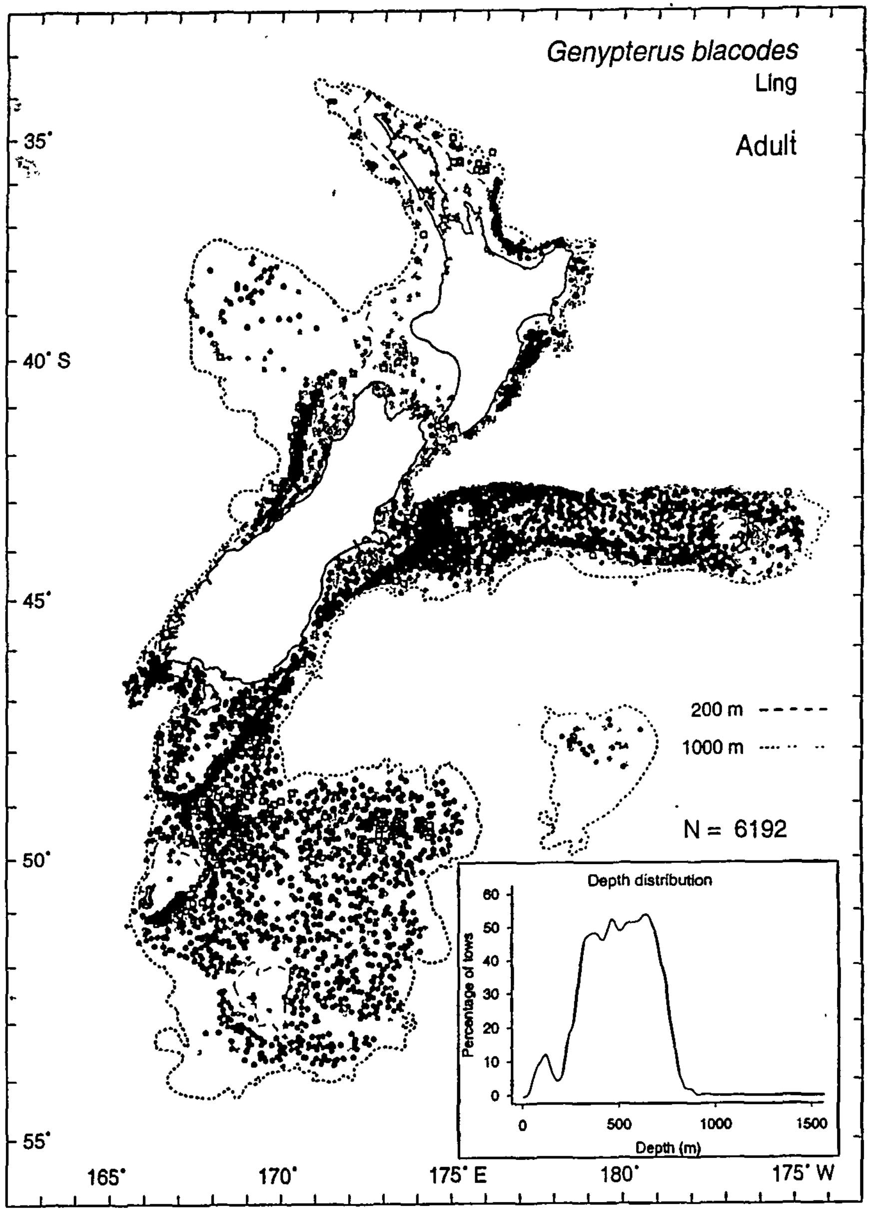
Galeorhinus galeus
School shark
Adult
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 650
Depth distribution
Percentage of tows
Depth (m)


Genypterus blacodes
Ling
Age 0+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 97
Depth distribution
Percentage of tows
Depth (m)

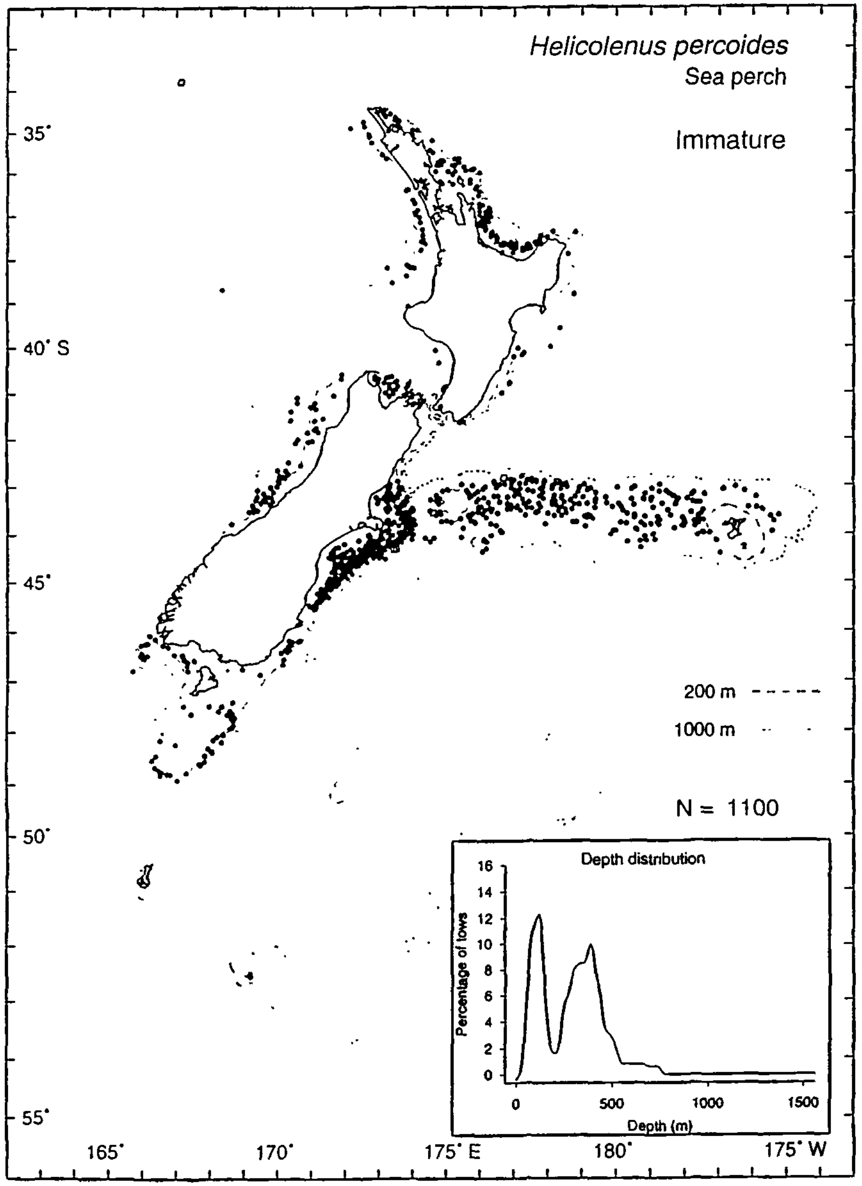

Genypterus blacodes
Ling
Age 1+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 689
Depth distribution
Percentage of tows
Depth (m)

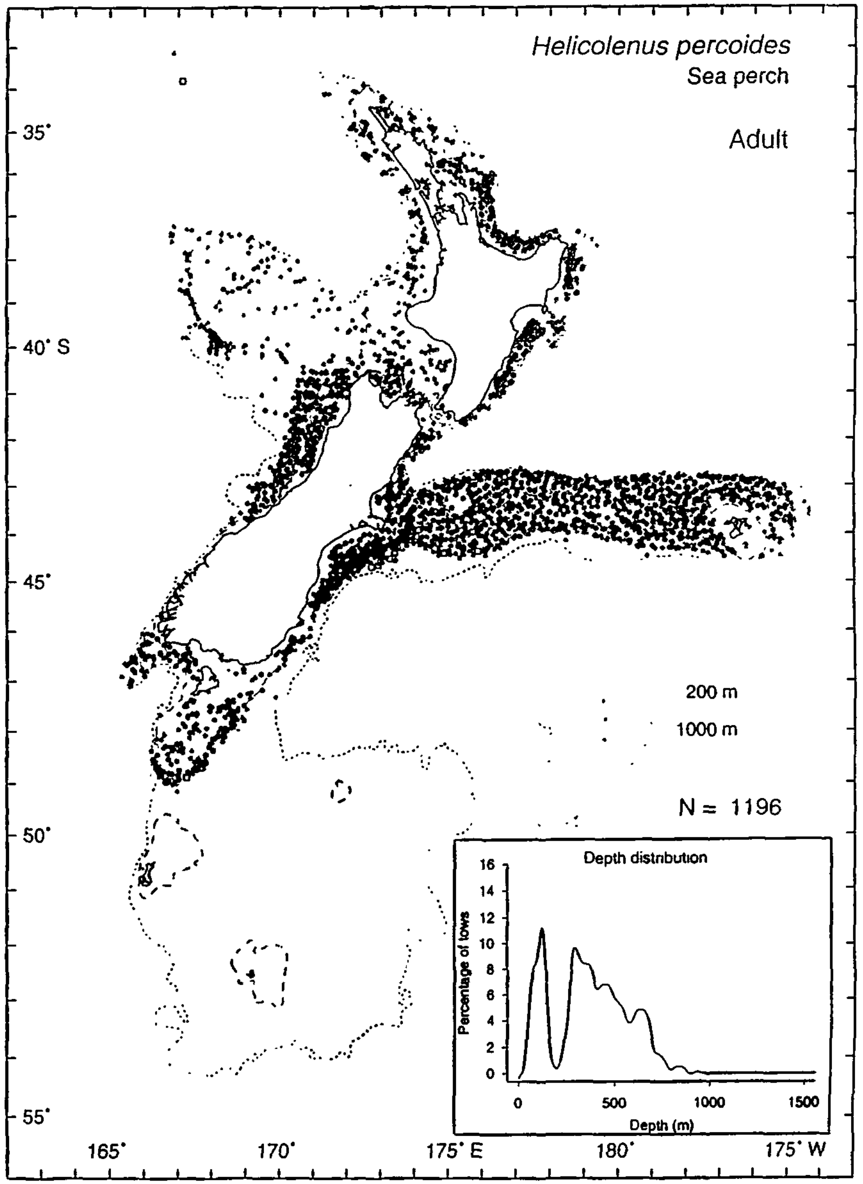


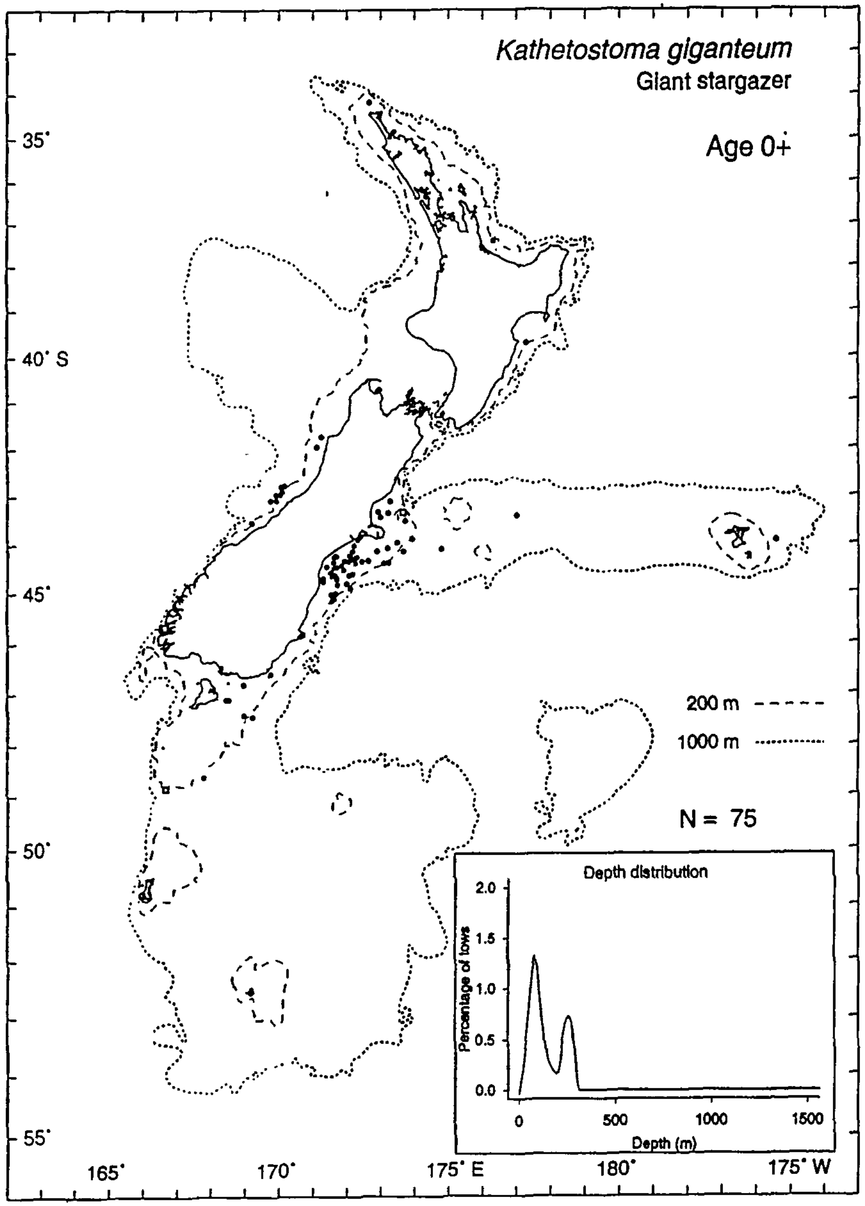
Genypterus blacodes
Ling
Immature
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 4454
Depth distribution
Percentage of tows
Depth (m)

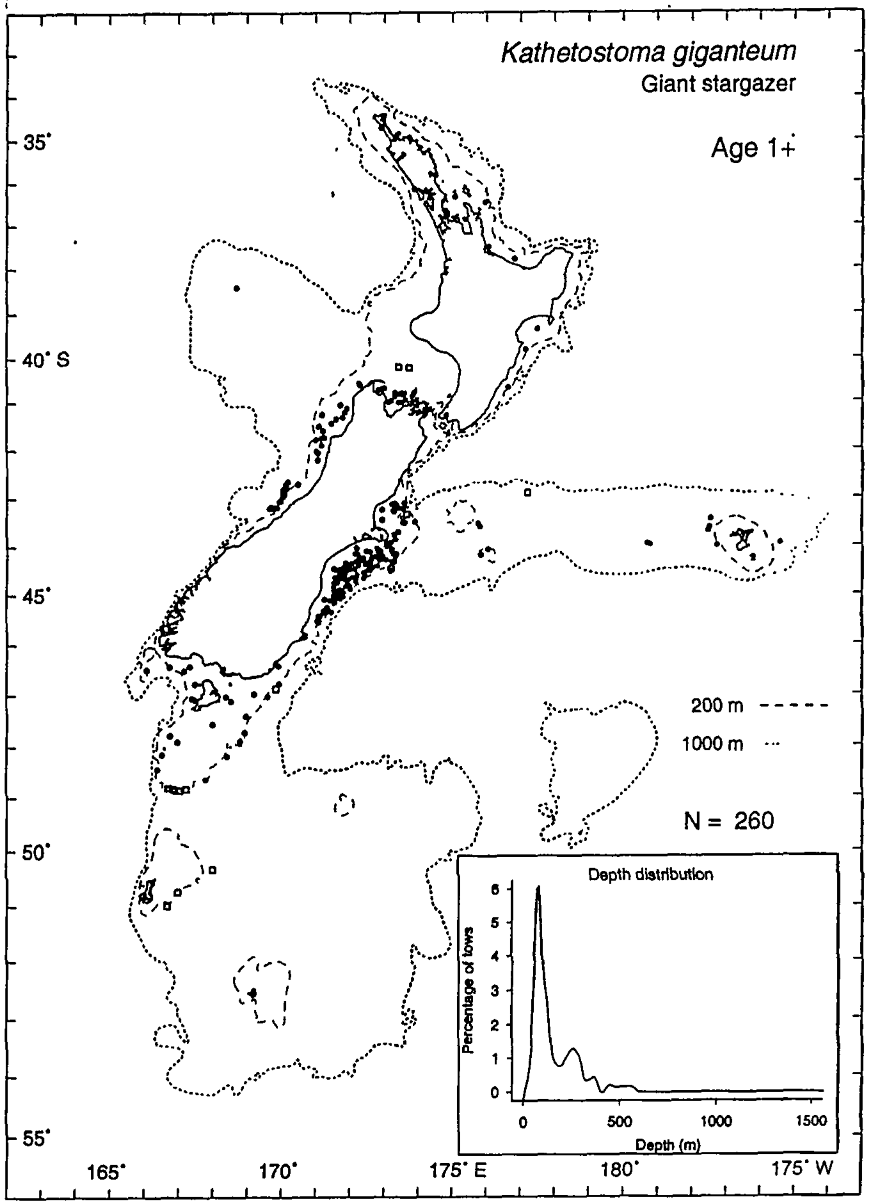


Genypterus blacodes
Ling
Adult
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 6192
Depth distribution
Percentage of tows
Depth (m)

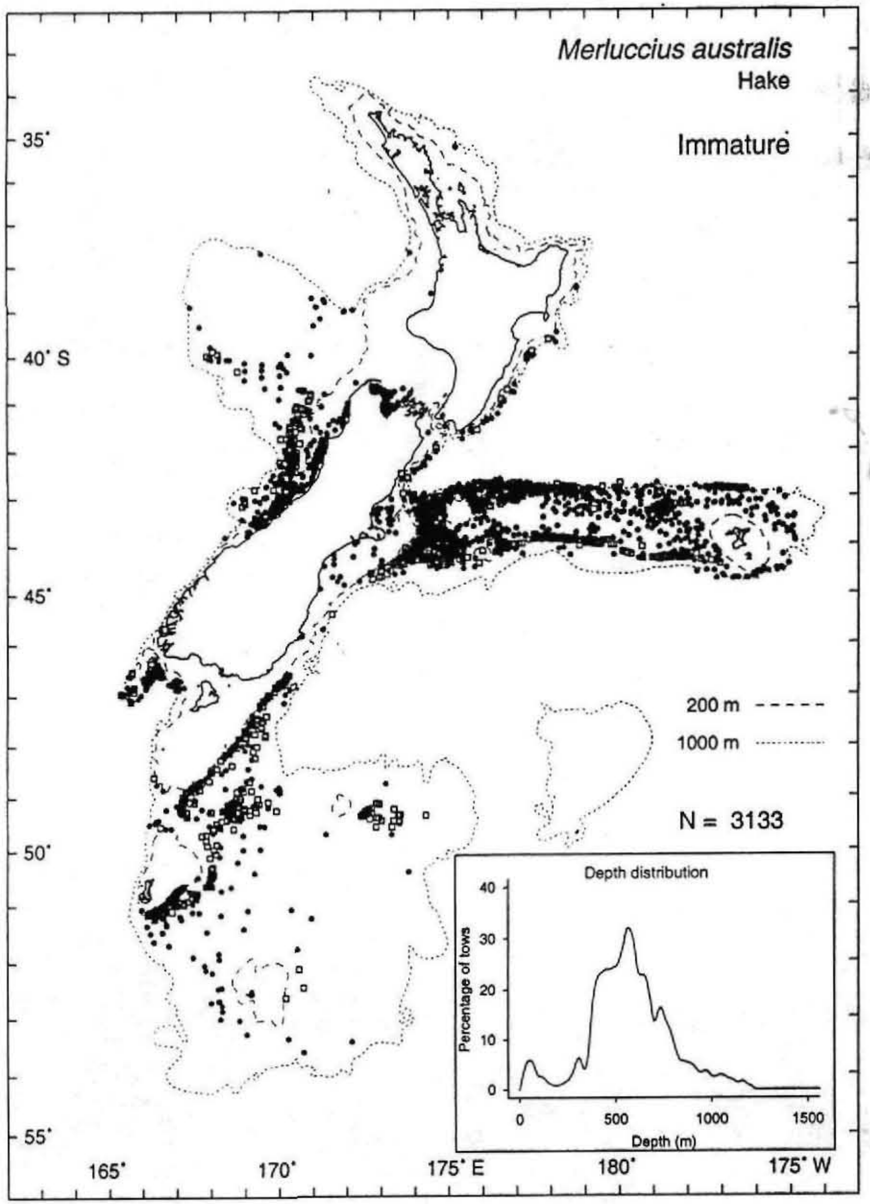

Helicolenus percoides
Sea perch
Immature
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 1100
Depth distribution
Percentage of tows
Depth (m)
0
500
1000
1500

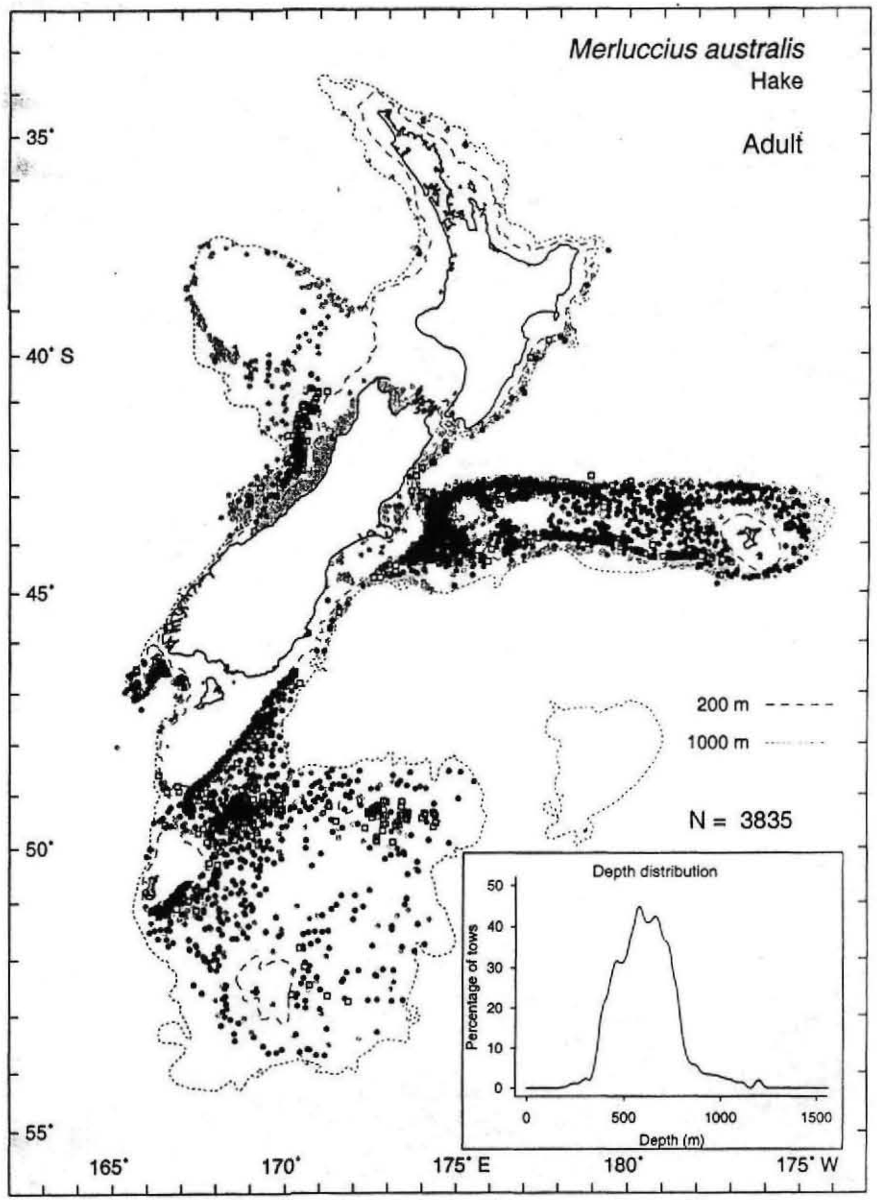

Helicolenus percoides
Sea perch
Adult
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 1196
Depth distribution
Percentage of tows
Depth (m)
0
500
1000
1500

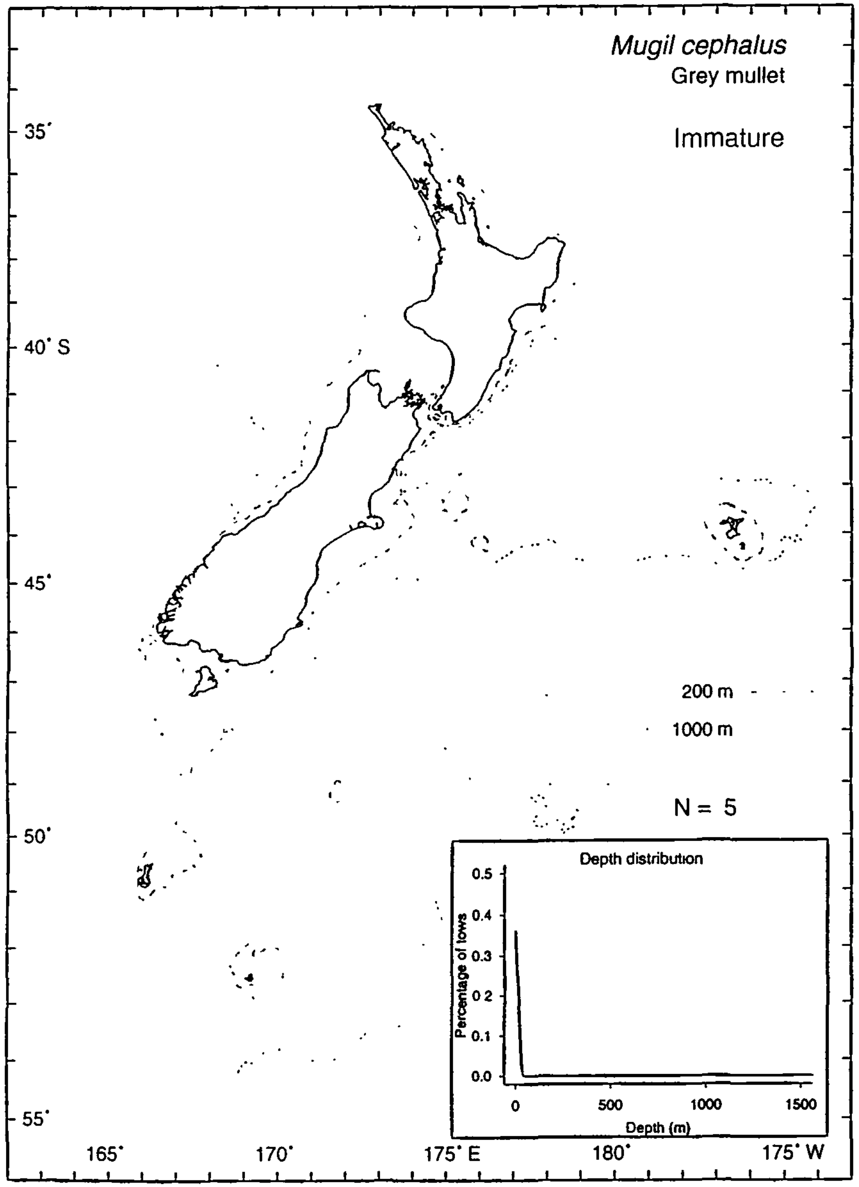




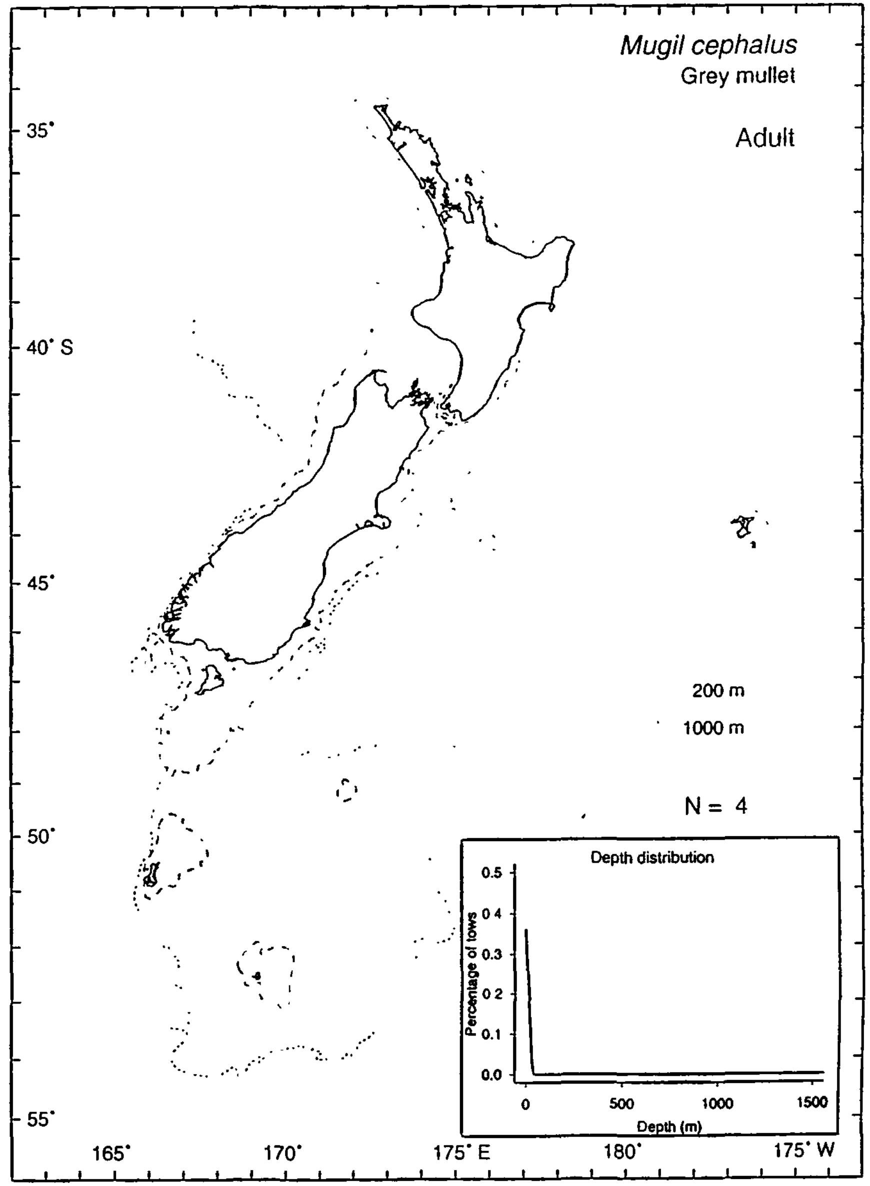
Some records represent other stargazer species, particularly the banded stargazer, *Kathetostoma* sp., which was not recorded separately until 1986.


Merluccius australis
Hake
Immature
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 3133
Depth distribution
Percentage of tows
Depth (m)

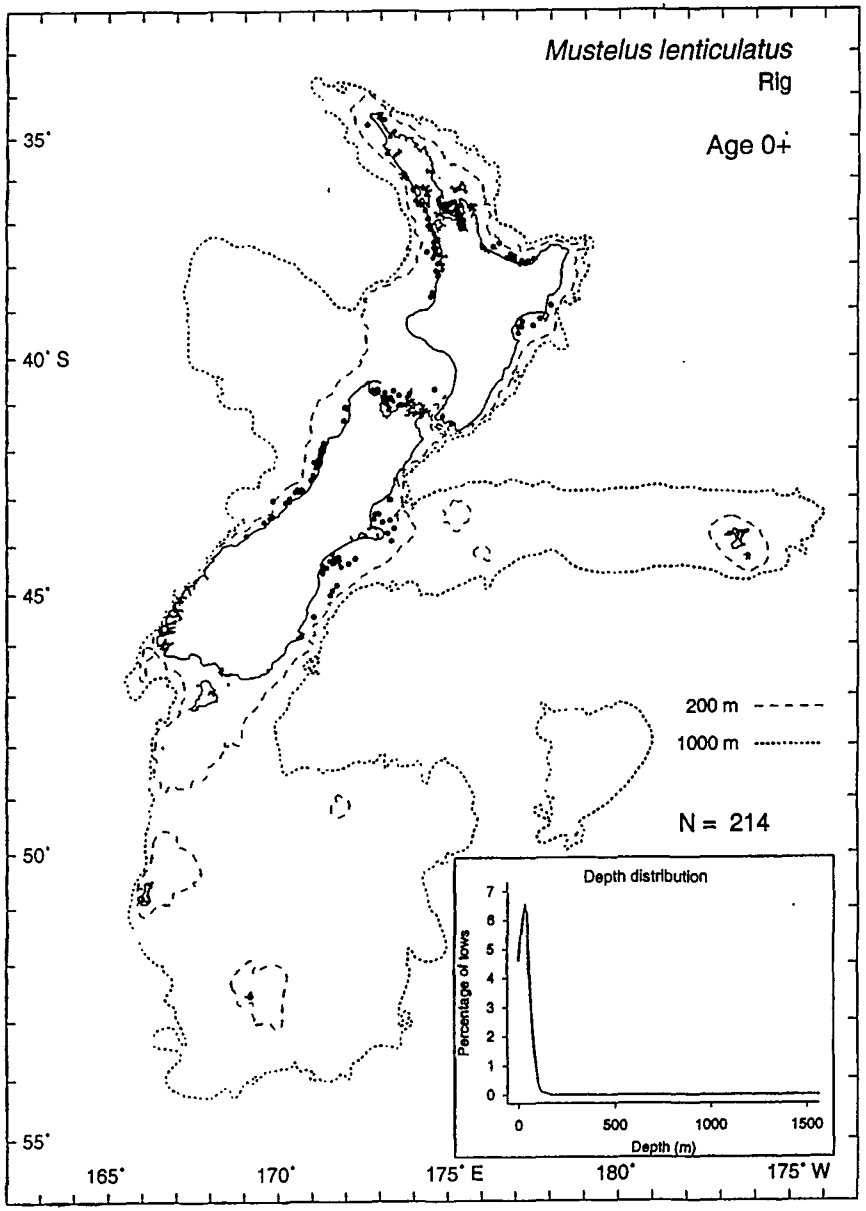

Merluccius australis
Hake
Adult
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 3835
Depth distribution
Percentage of tows
Depth (m)



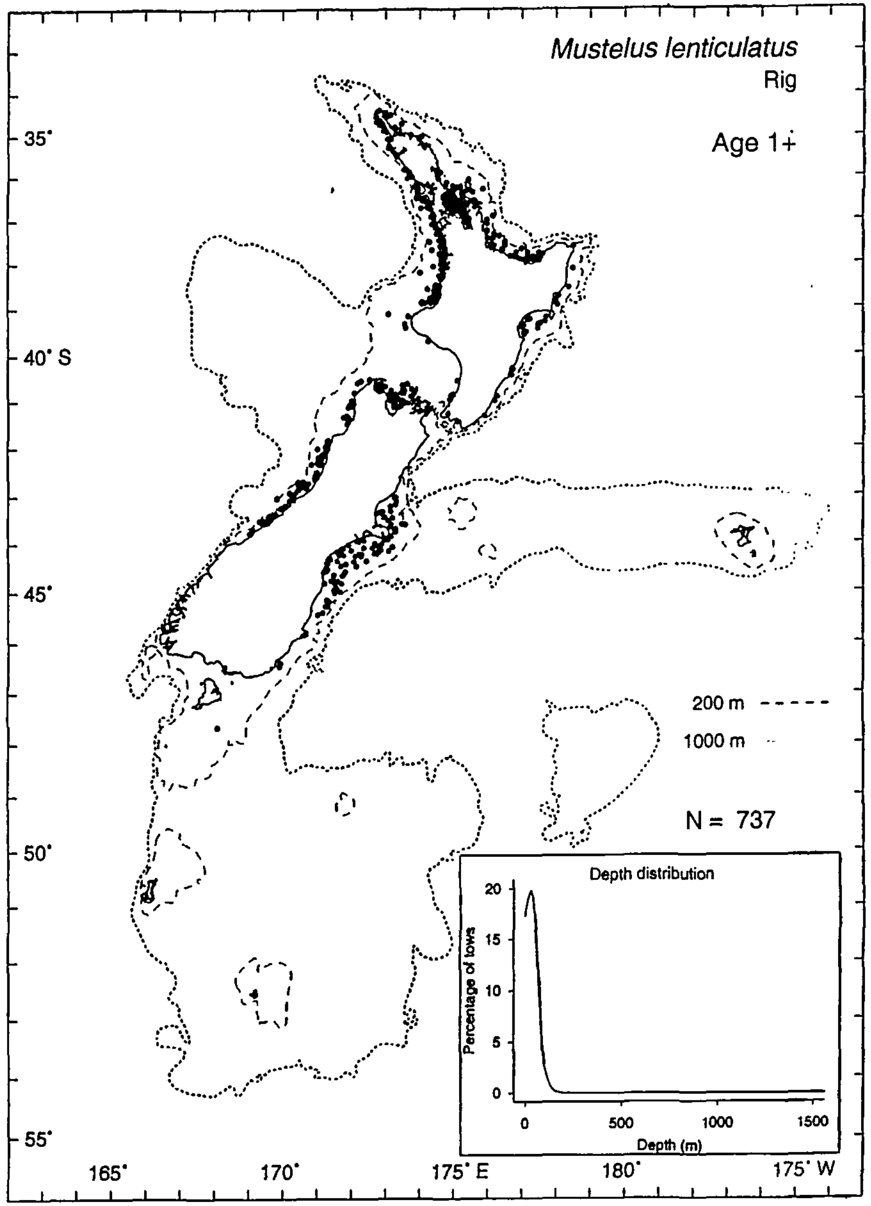
Mugil cephalus
Grey mullet
Immature
200 m
1000 m
N = 5
Depth distribution
Percentage of tows
Depth (m)
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W



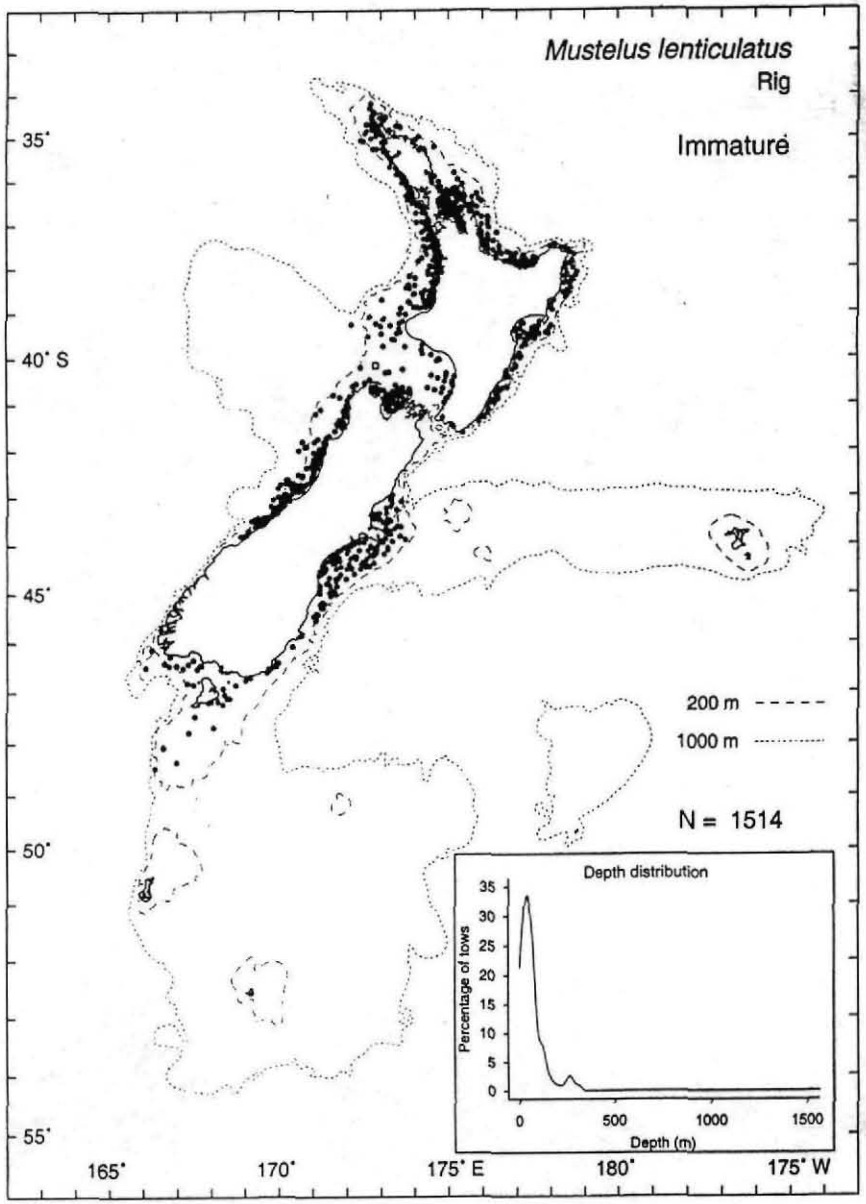
Mugil cephalus
Grey mullet
Adult
200 m
1000 m
N = 4
Depth distribution
Percentage of tows
Depth (m)
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W

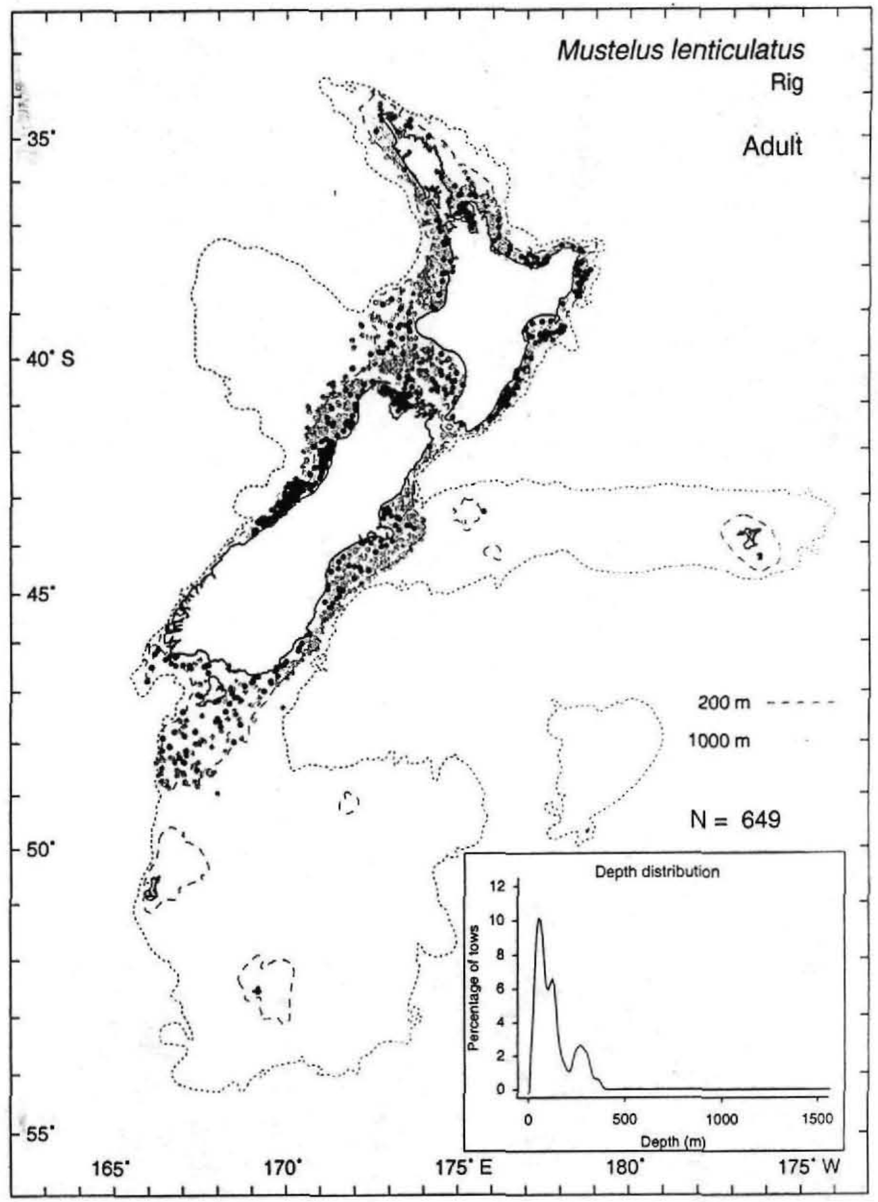


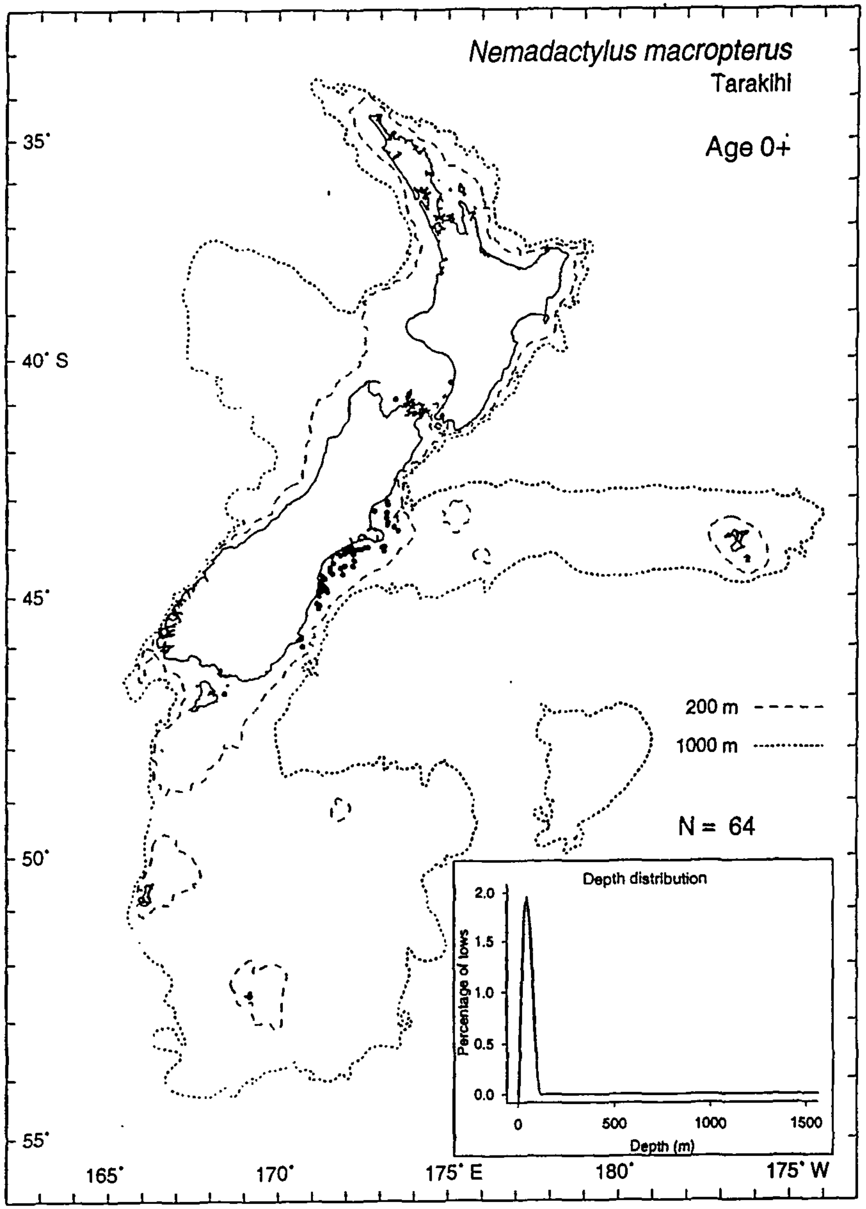
Mustelus lenticulatus
Rig
Age 0+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 214
Depth distribution
Percentage of tows
Depth (m)
0
500
1000
1500

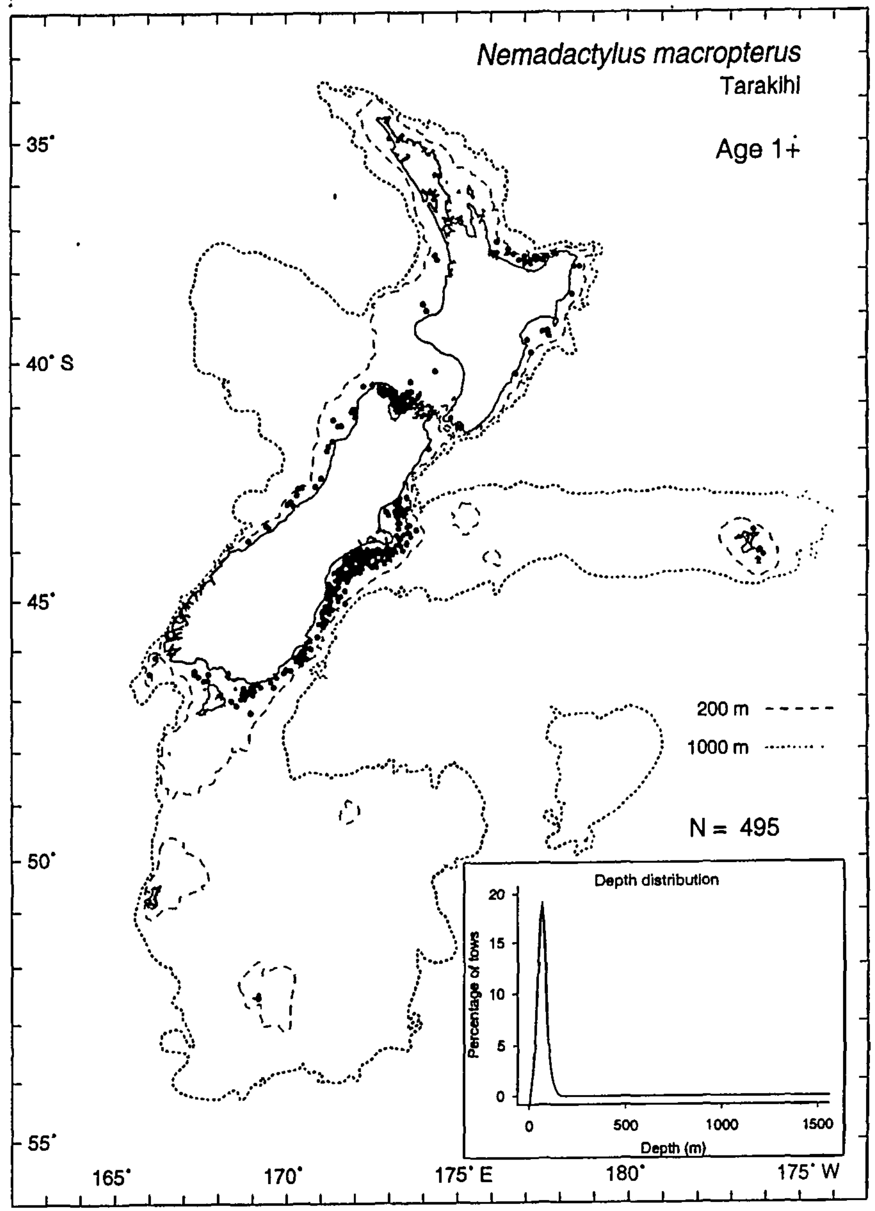


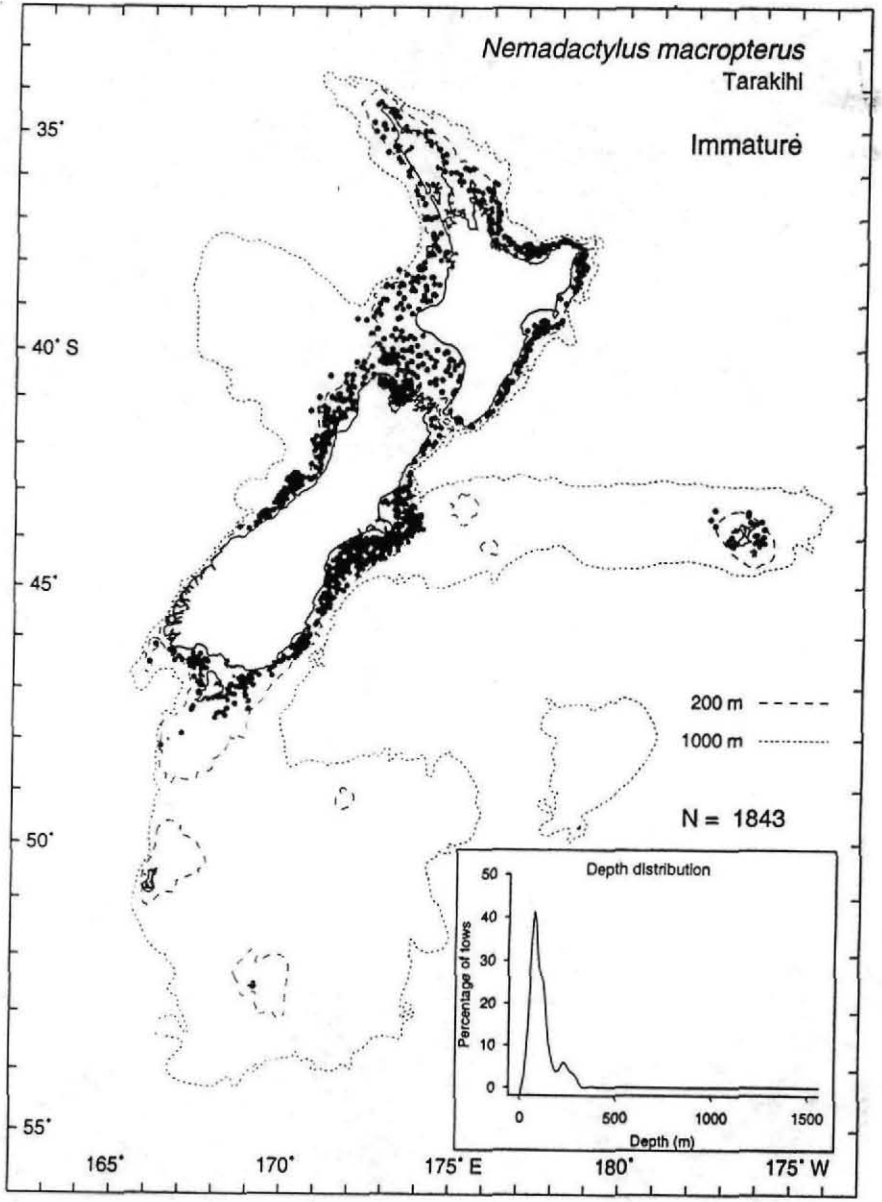
Mustelus lenticulatus
Rig
Age 1+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 737
Depth distribution
Percentage of tows
Depth (m)
0
500
1000
1500


Mustelus lenticulatus
Rig
Immature
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 1514
Depth distribution
Percentage of tows
Depth (m)
0
500
1000
1500

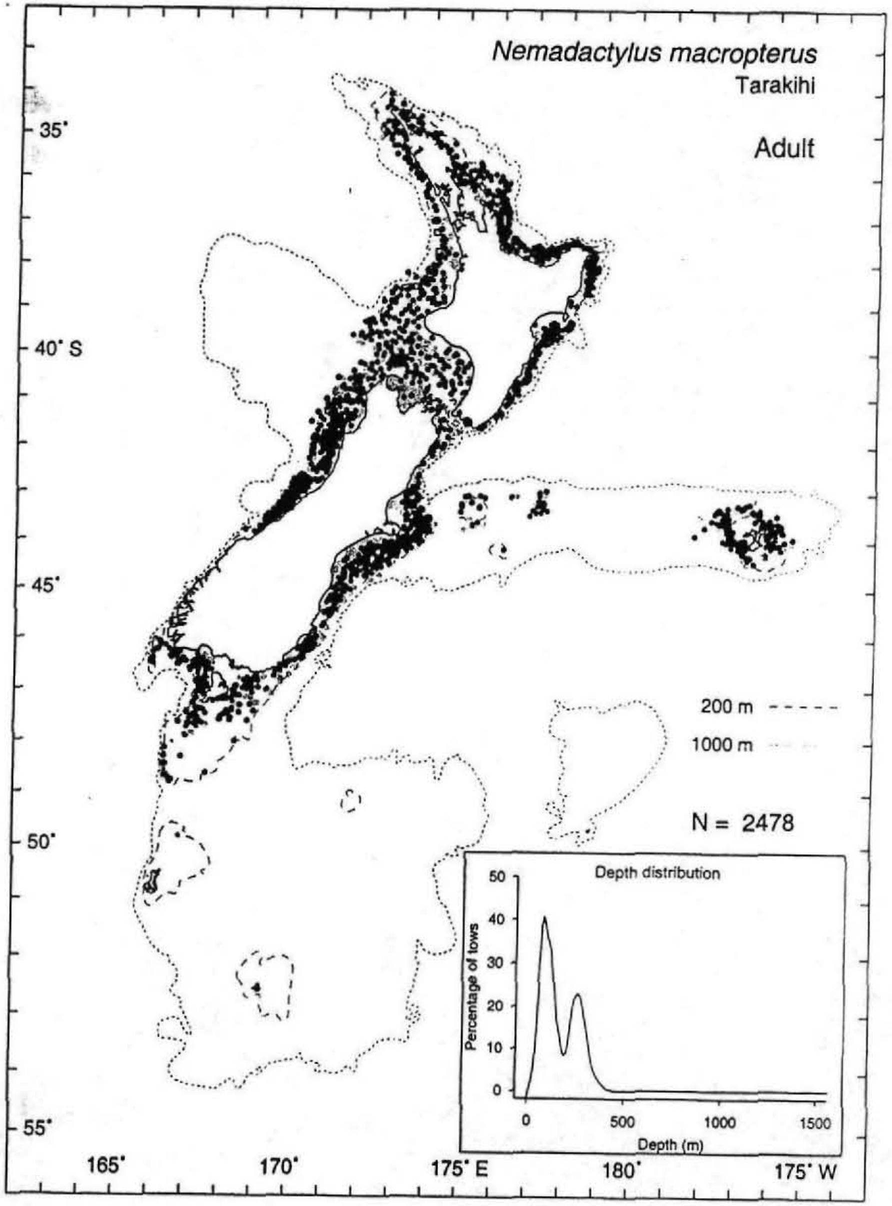

Mustelus lenticulatus
Rig
Adult
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 649
Depth distribution
Percentage of tows
Depth (m)
0
500
1000
1500


Nemadactylus macropterus
Tarakihi
Age 0+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 64
Depth distribution
Percentage of tows
Depth (m)
0
500
1000
1500
0.0
0.5
1.0
1.5
2.0

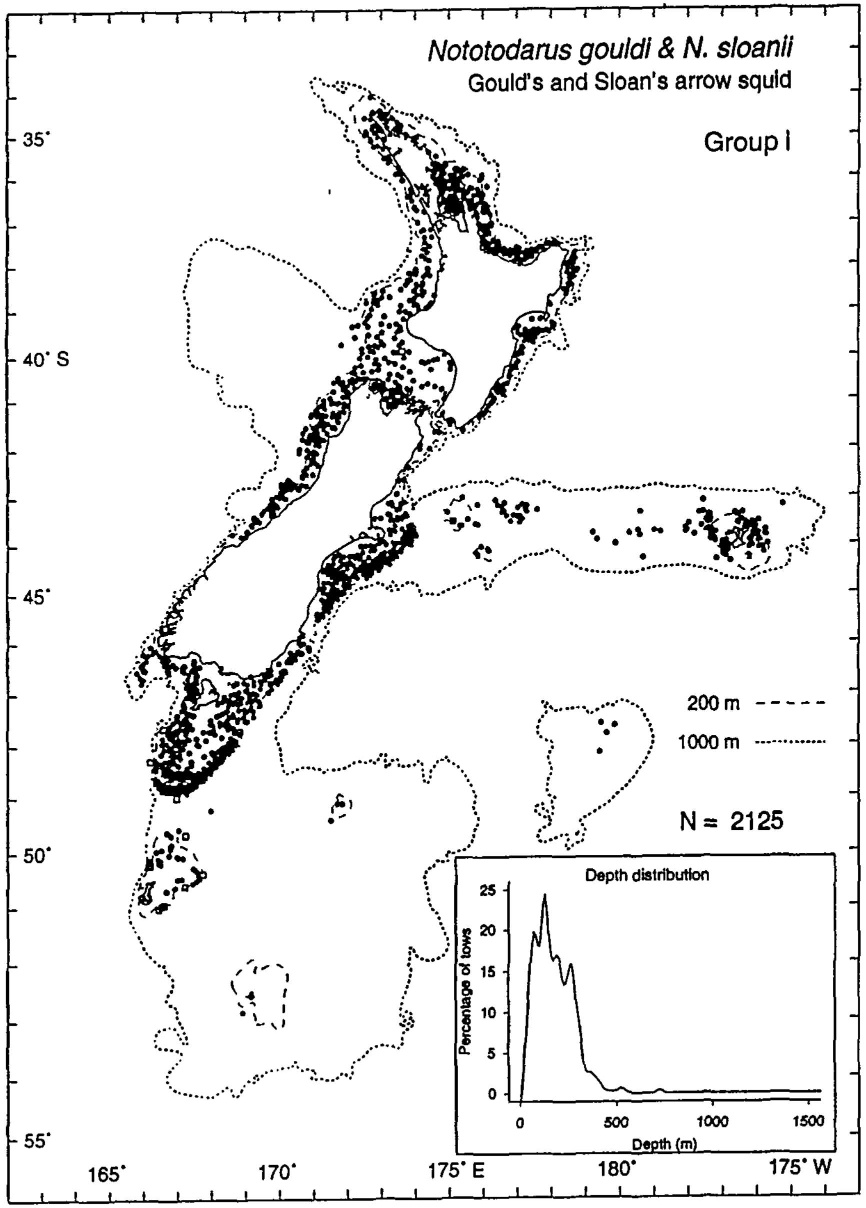

Nemadactylus macropterus
Tarakihi
Age 1+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 495
Depth distribution
Percentage of tows
Depth (m)
0
500
1000
1500
0
5
10
15
20

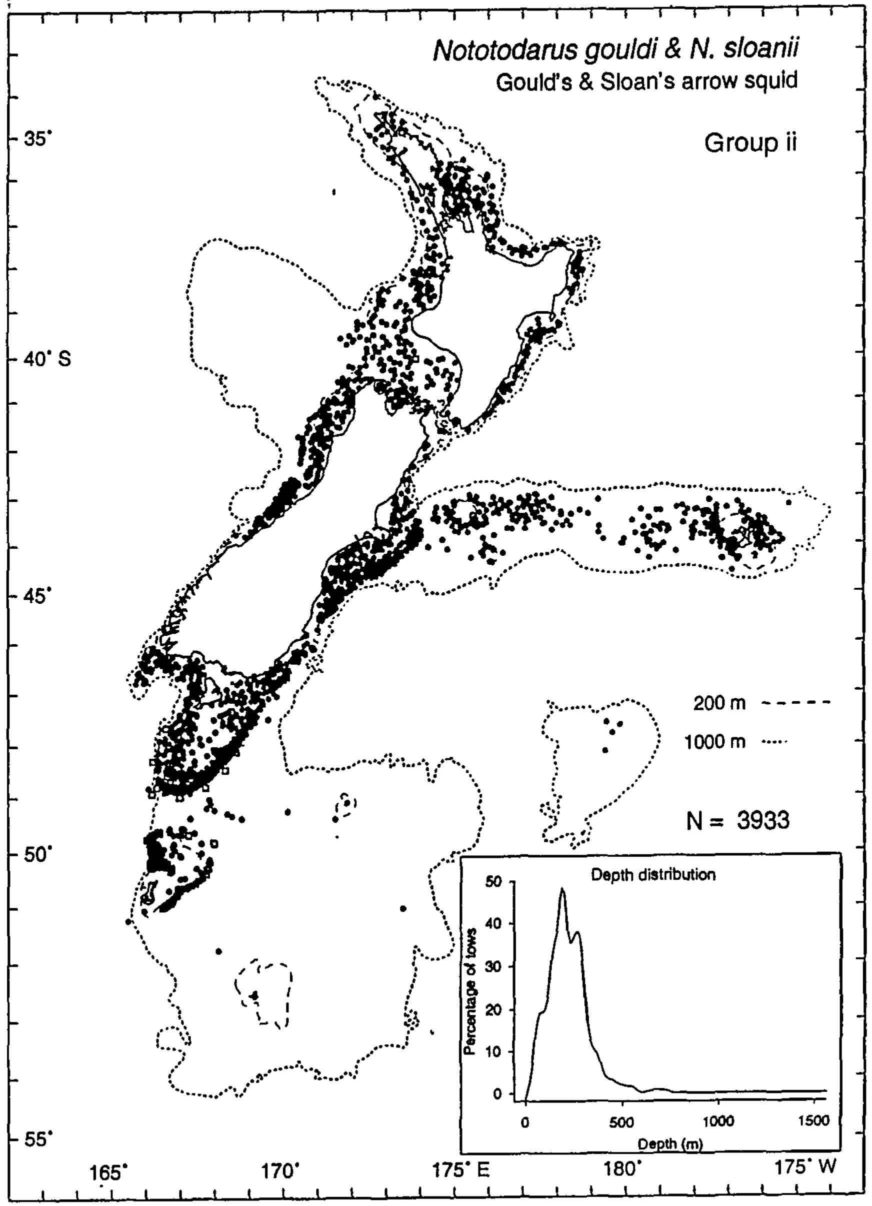


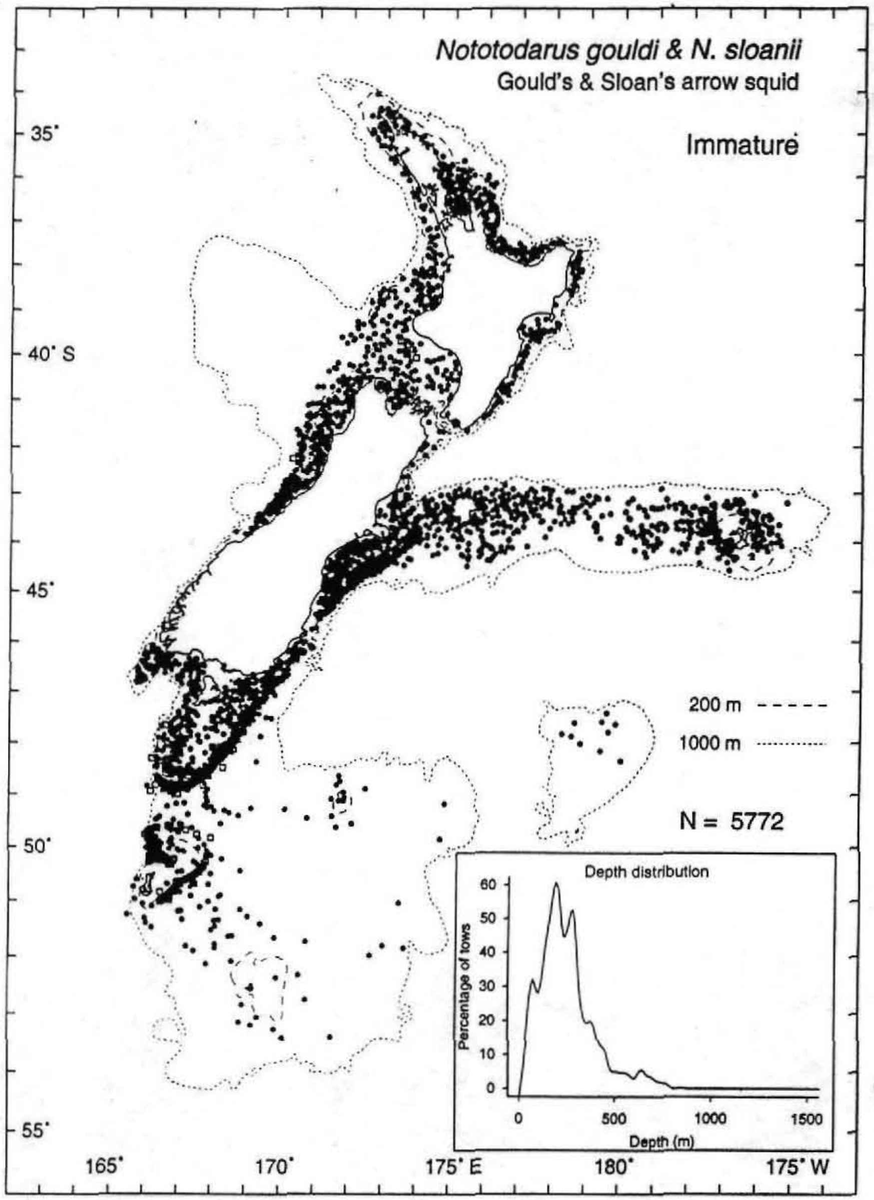
Nemadactylus macropterus
Tarakihi
Immature
200 m
1000 m
N = 1843
Depth distribution
Percentage of tows
Depth (m)
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W



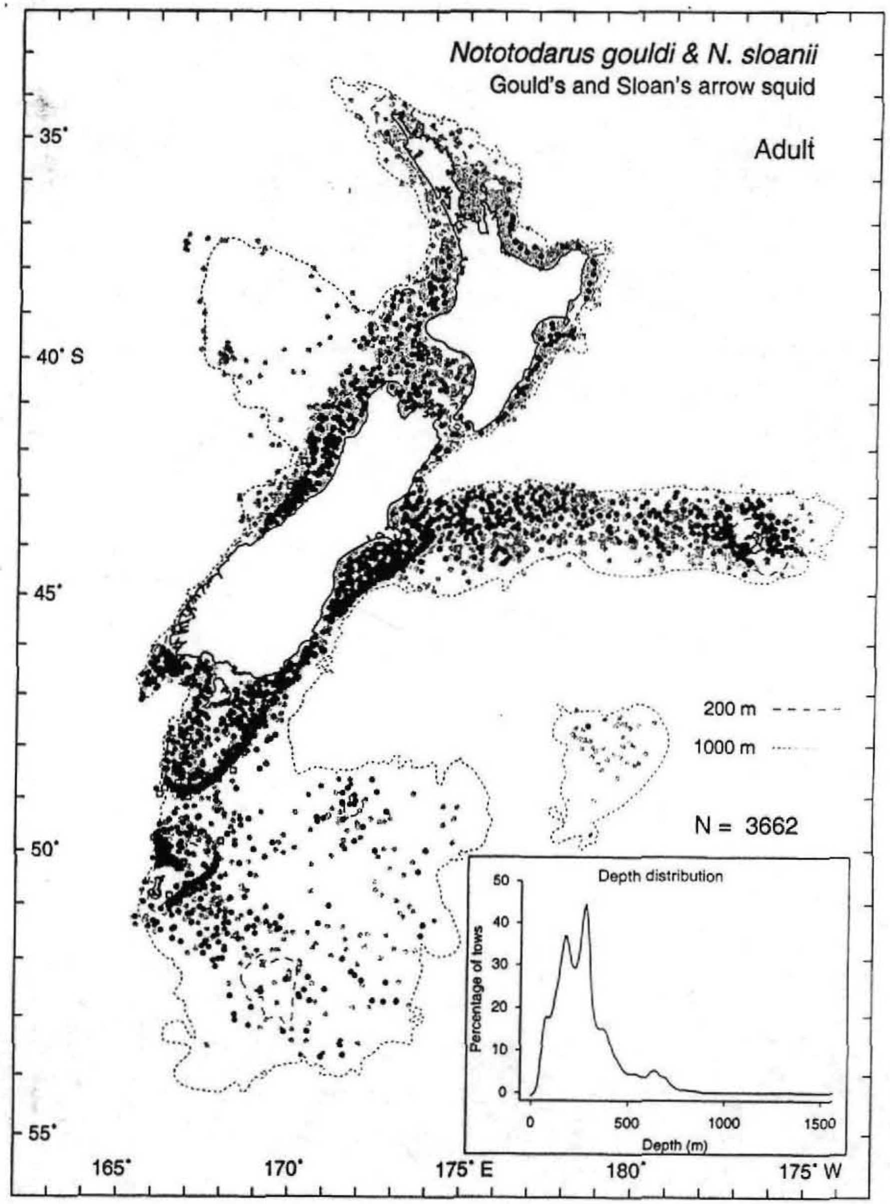
Nemadactylus macropterus
Tarakihi
Adult
200 m
1000 m
N = 2478
Depth distribution
Percentage of tows
Depth (m)
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W


Nototodarus gouldi & N. sloanii
Gould's and Sloan's arrow squid
Group I
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 2125
Depth distribution
Percentage of tows
Depth (m)

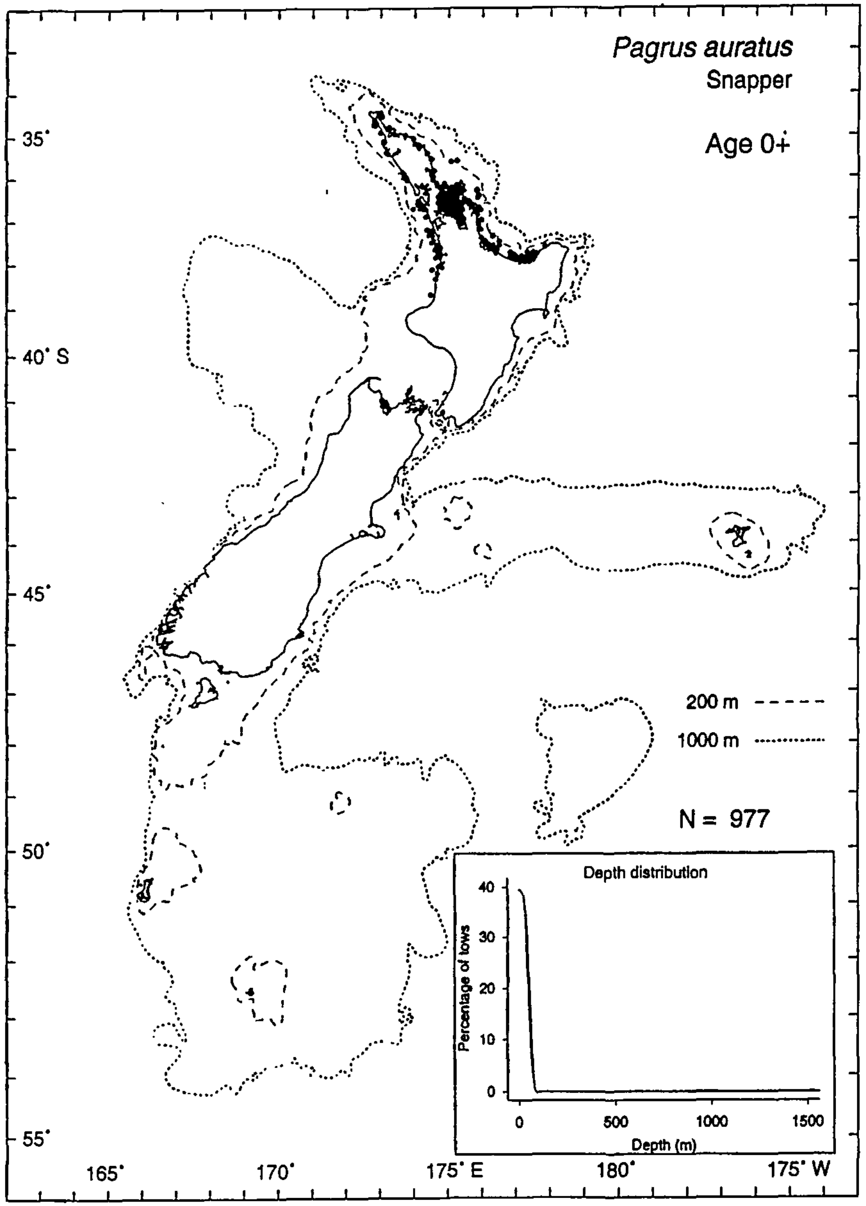

Nototodarus gouldi & N. sloanii
Gould's & Sloan's arrow squid
Group ii
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 3933
Depth distribution
Percentage of tows
Depth (m)



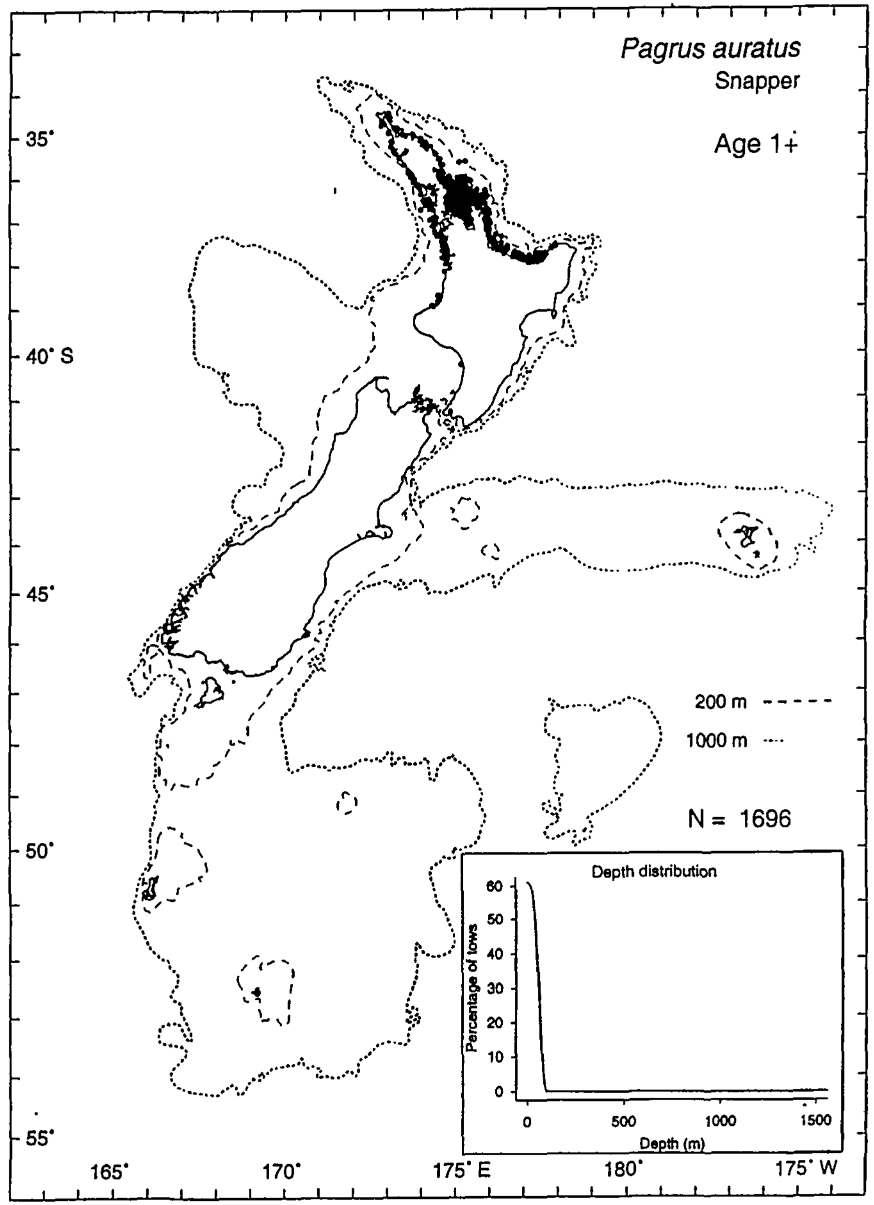
Nototodarus gouldi & N. sloanii
Gould's & Sloan's arrow squid
Immature
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 5772
Depth distribution
Percentage of tows
Depth (m)



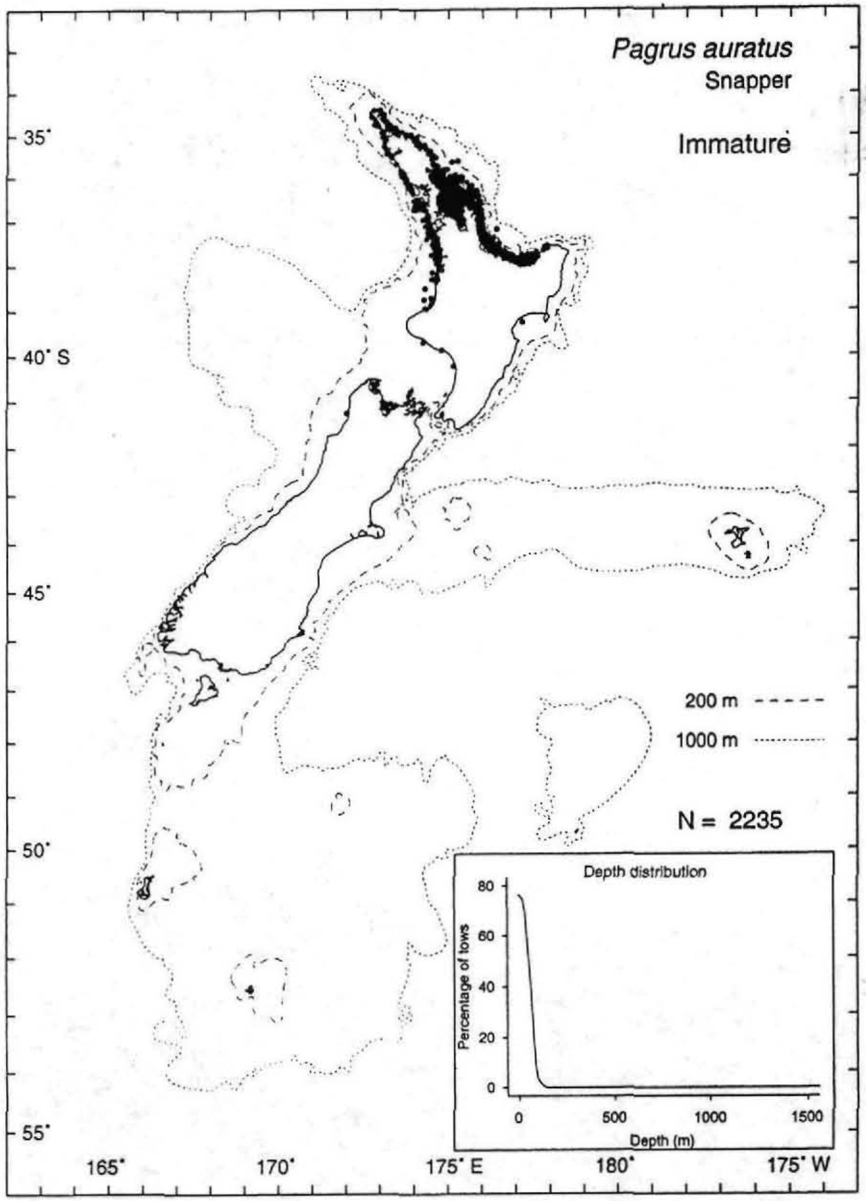
Nototodarus gouldi & N. sloanii
Gould's and Sloan's arrow squid
Adult
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 3662
Depth distribution
Percentage of tows
Depth (m)

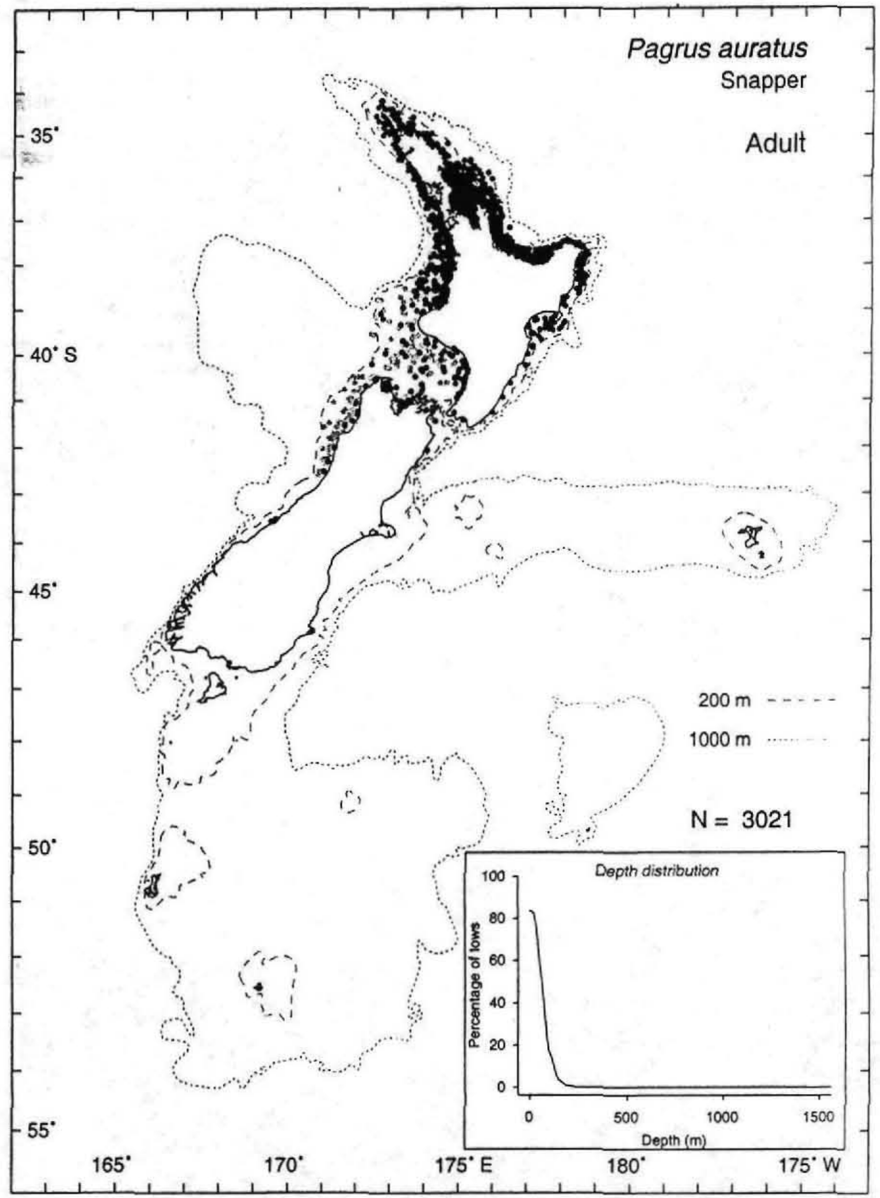


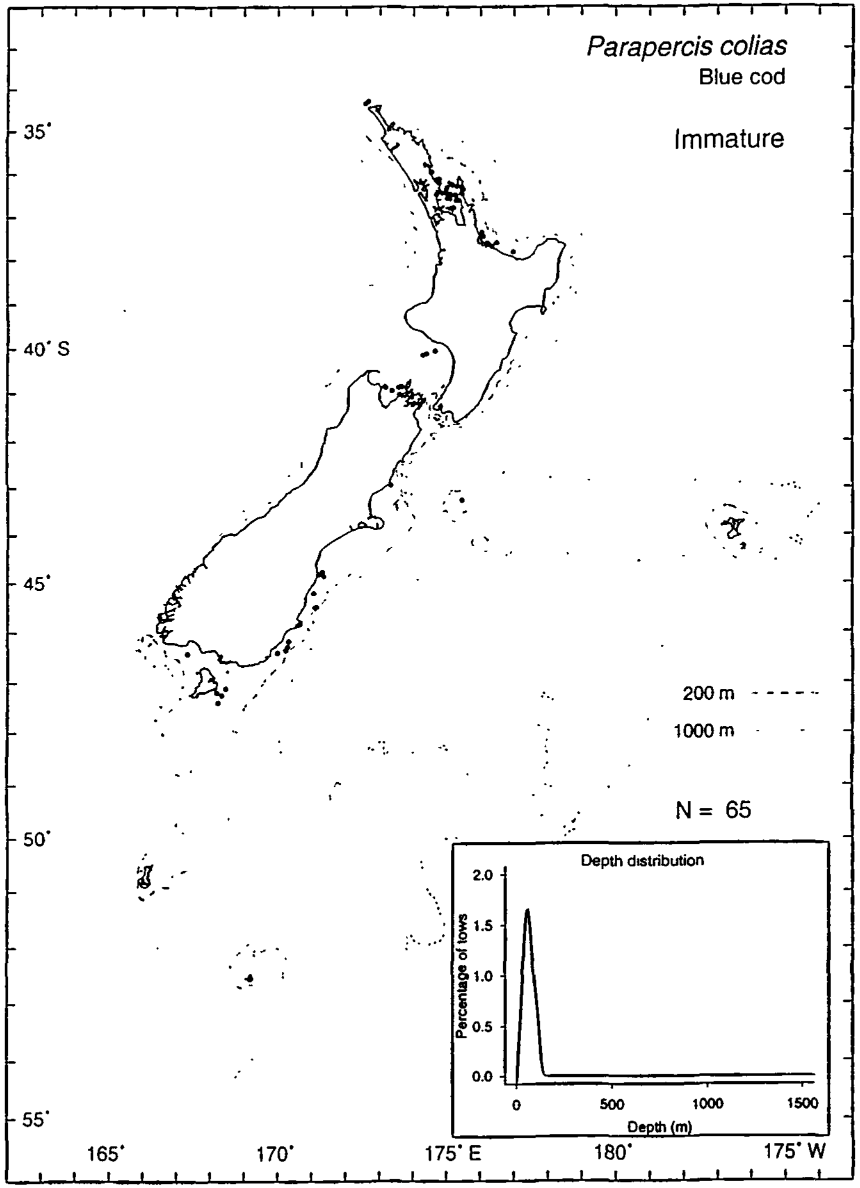
Pagrus auratus
Snapper
Age 0+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 977
Depth distribution
Percentage of tows
Depth (m)
0
10
20
30
40
500
1000
1500



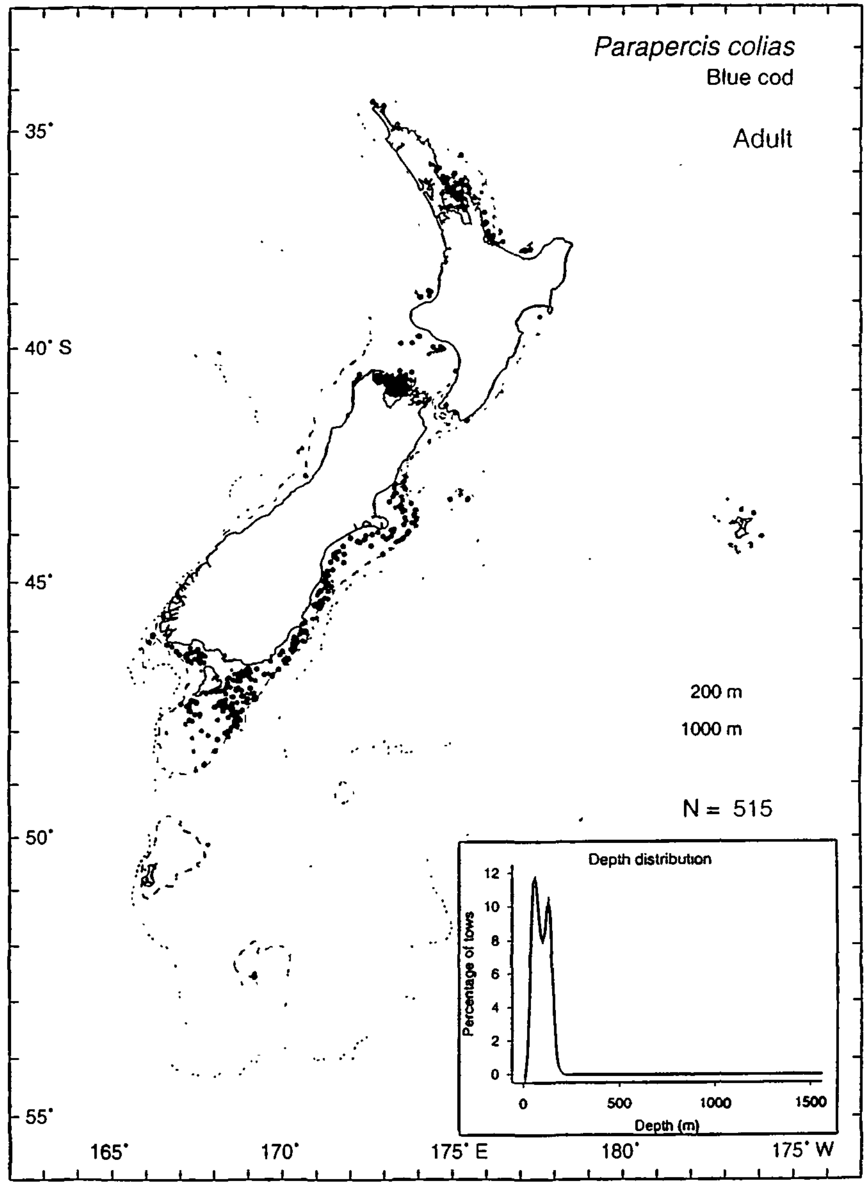
Pagrus auratus
Snapper
Age 1+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 1696
Depth distribution
Percentage of tows
Depth (m)
0
10
20
30
40
50
60
500
1000
1500


Pagrus auratus
Snapper
Immature
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 2235
Depth distribution
Percentage of tows
Depth (m)
0
20
40
60
80
500
1000
1500

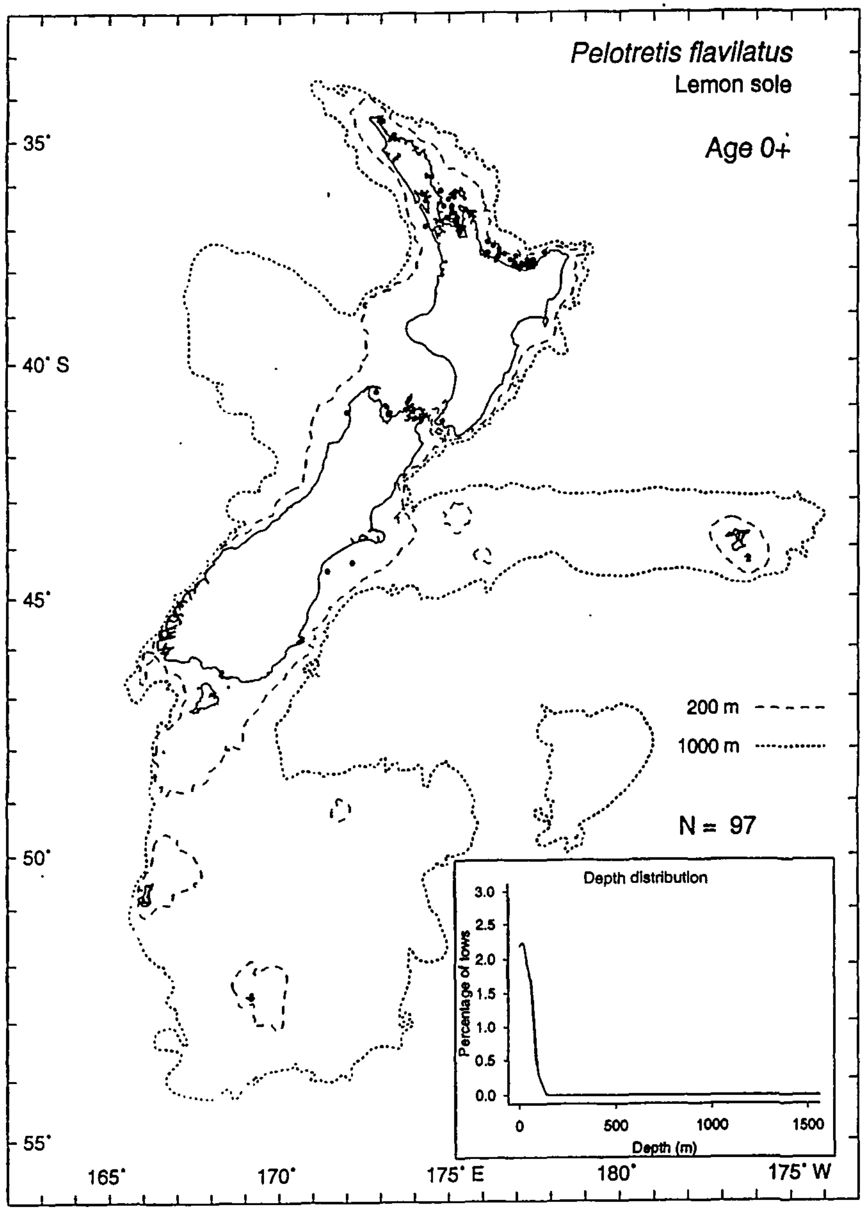

Pagrus auratus
Snapper
Adult
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 3021
Depth distribution
Percentage of tows
Depth (m)
0
20
40
60
80
100
500
1000
1500



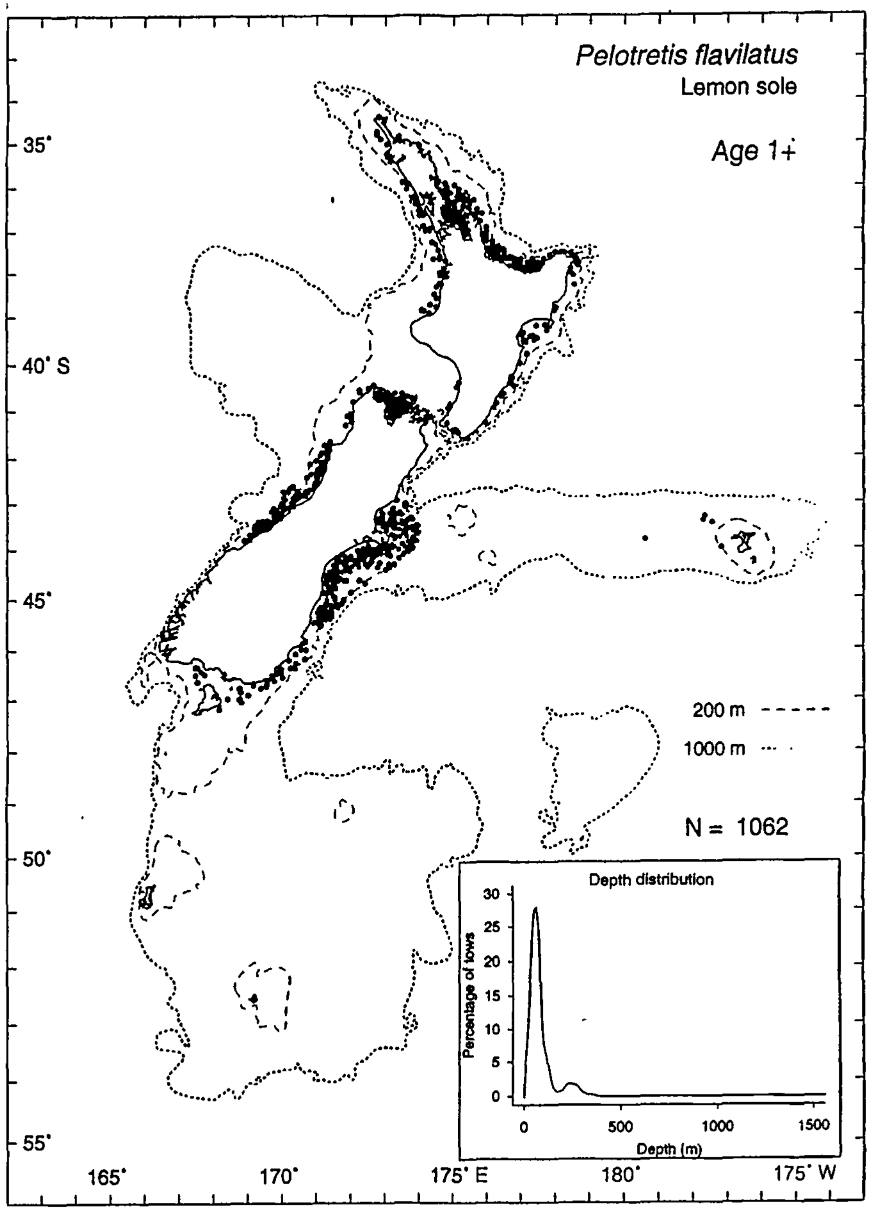
Parapercis colias
Blue cod
Immature
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 65
Depth distribution
Percentage of tows
Depth (m)
0.0
0.5
1.0
1.5
2.0
0
500
1000
1500



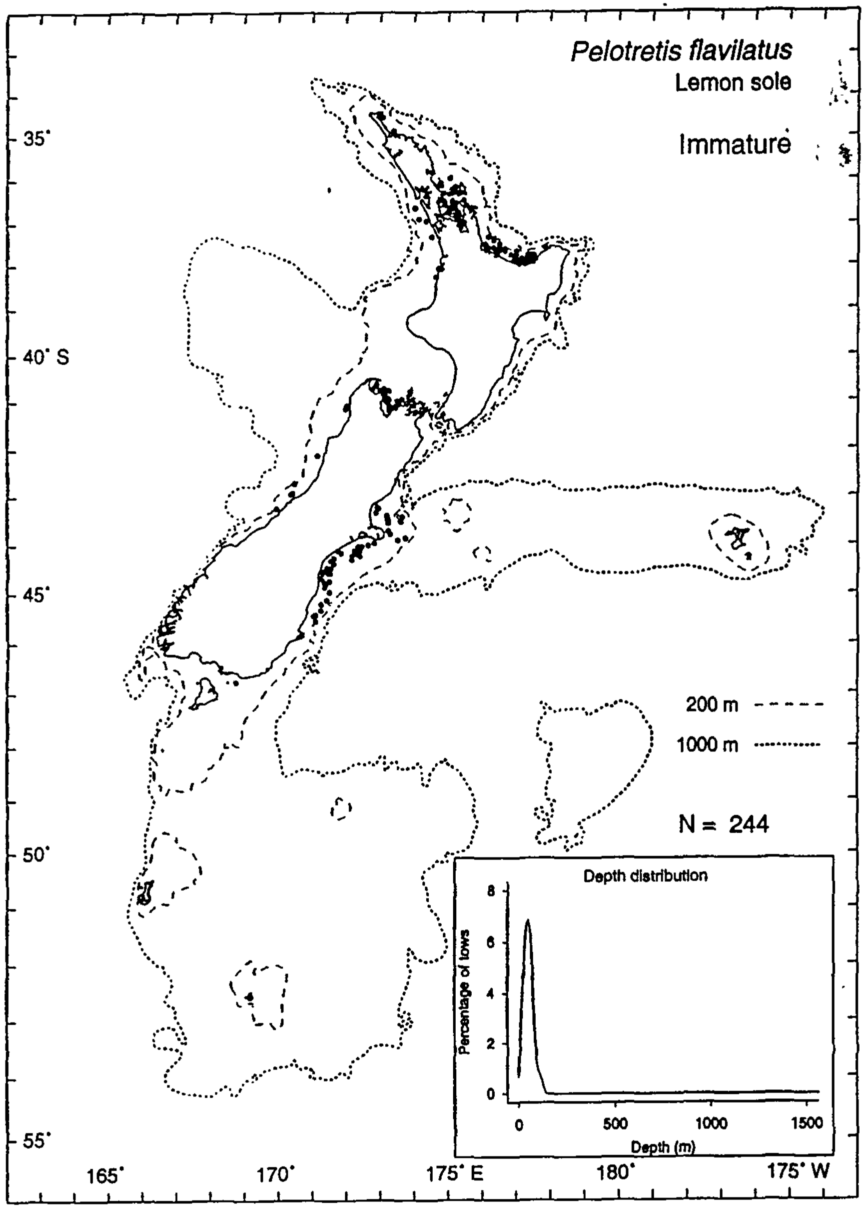
Parapercis colias
Blue cod
Adult
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 515
Depth distribution
Percentage of tows
Depth (m)
0
2
4
6
8
10
12
0
500
1000
1500



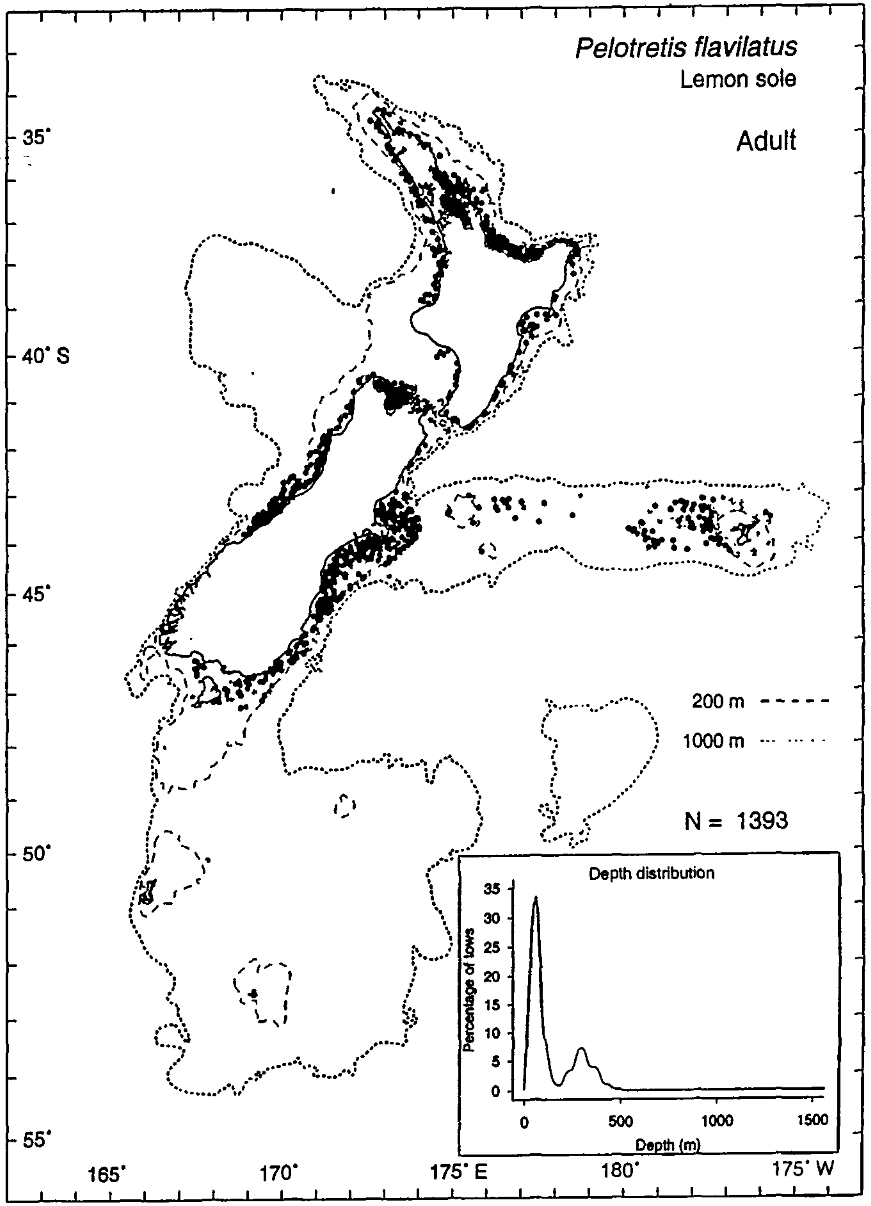
Pelotretis flavilatus
Lemon sole
Age 0+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 97
Depth distribution
Percentage of tows
Depth (m)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
0
500
1000
1500



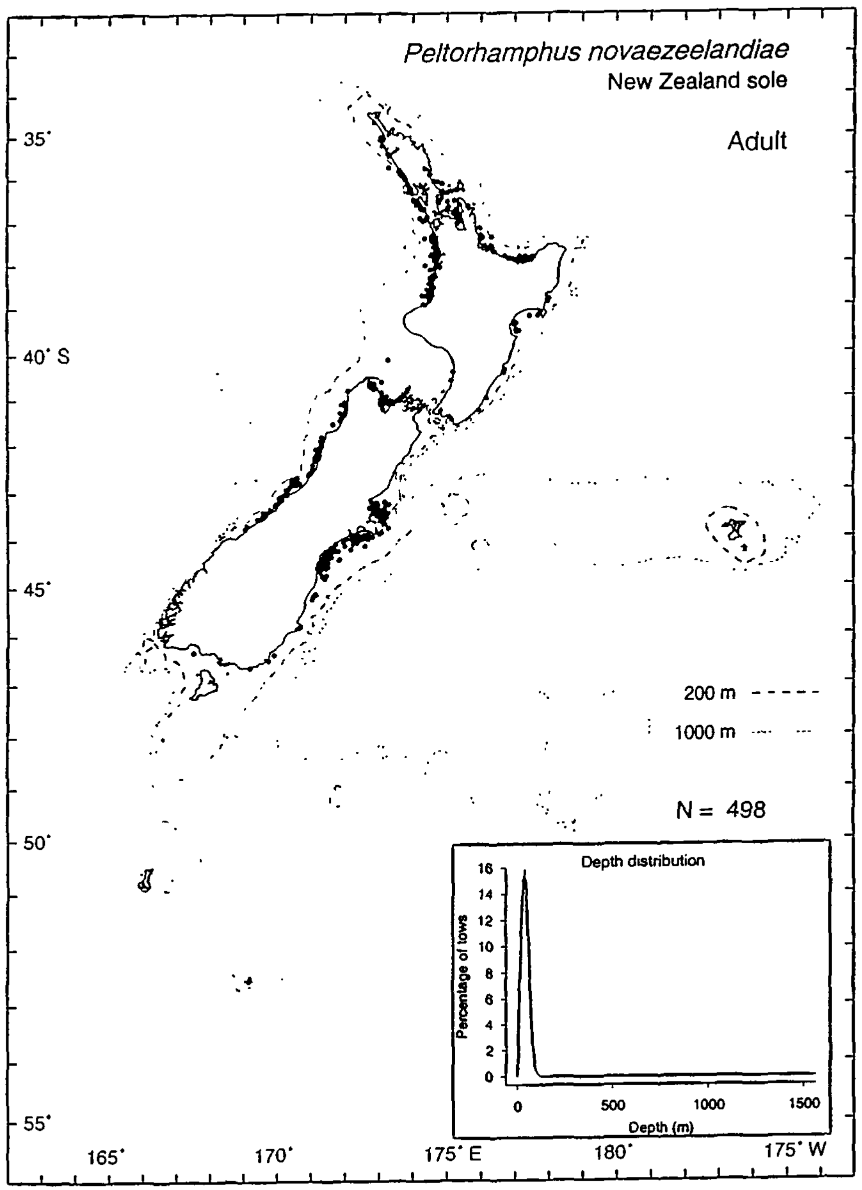
Pelotretis flavilatus
Lemon sole
Age 1+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 1062
Depth distribution
Percentage of tows
Depth (m)
0
5
10
15
20
25
30
0
500
1000
1500



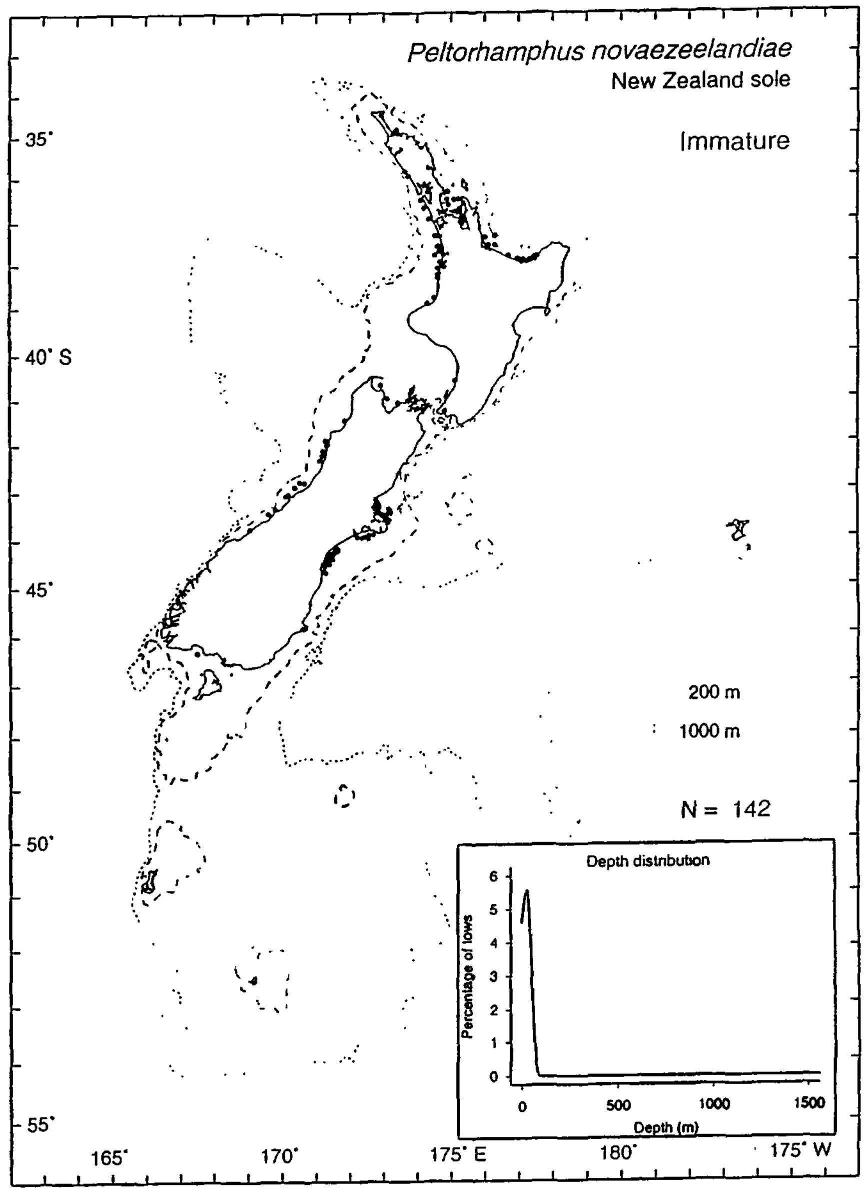
Pelotretis flavilatus
Lemon sole
Immature
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 244
Depth distribution
Percentage of tows
0
2
4
6
8
0
500
1000
1500
Depth (m)



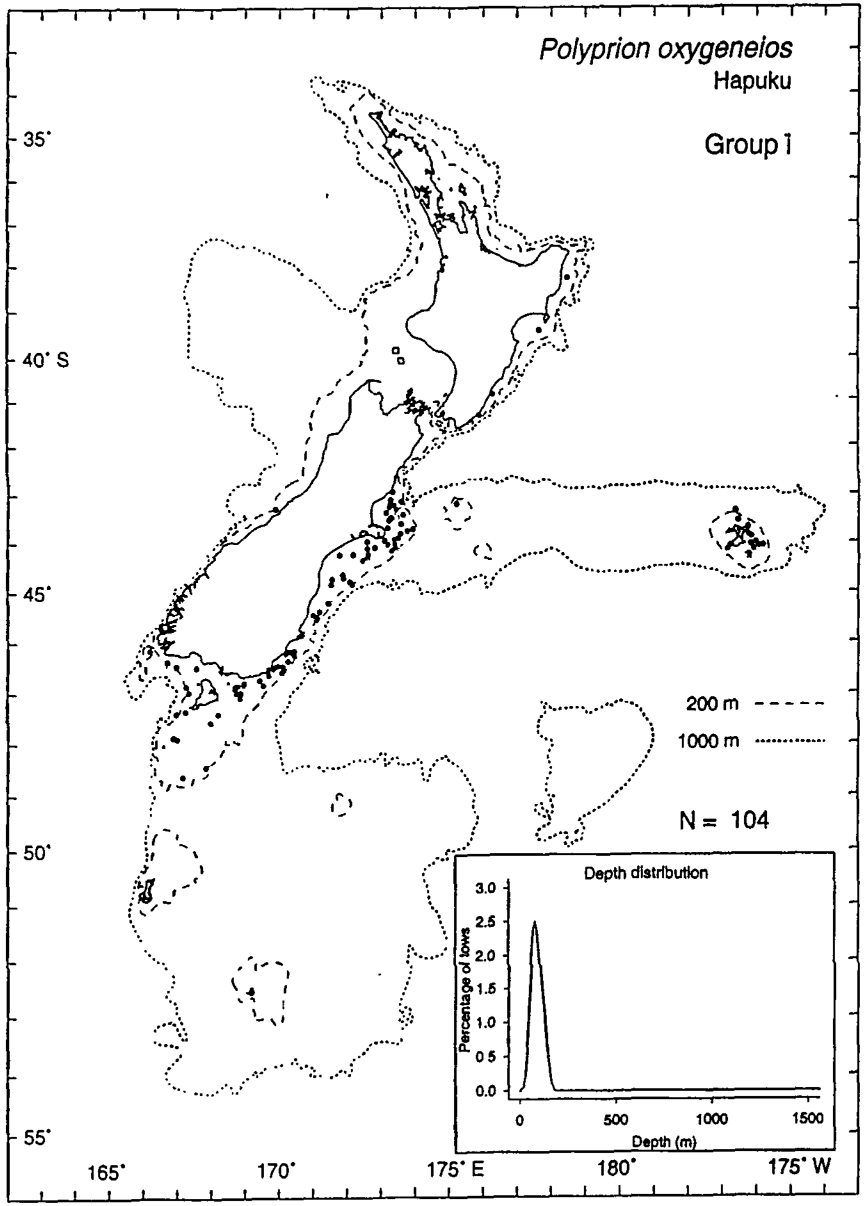
Pelotretis flavilatus
Lemon sole
Adult
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 1393
Depth distribution
Percentage of tows
0
5
10
15
20
25
30
35
0
500
1000
1500
Depth (m)

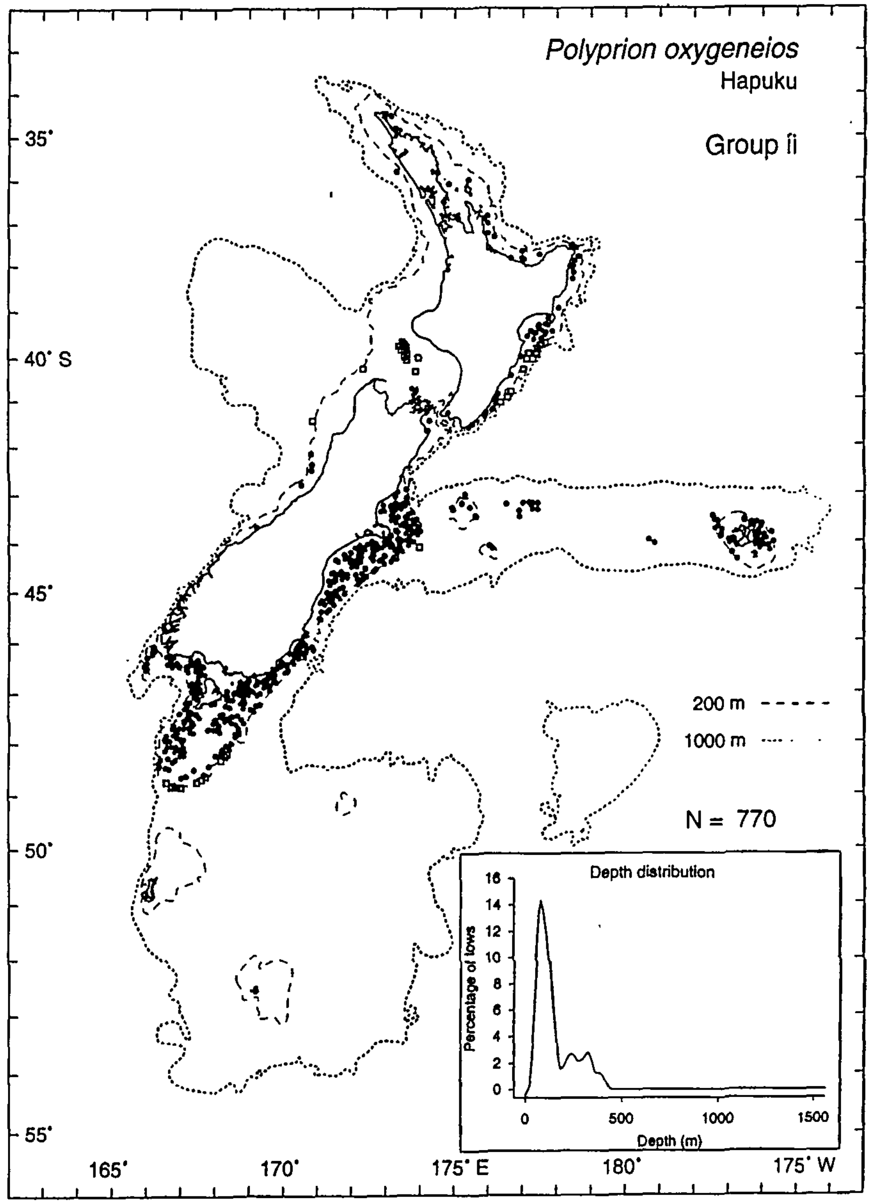


Peltorhamphus novaezeelandiae
New Zealand sole
Adult
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 498
Depth distribution
Percentage of tows
Depth (m)

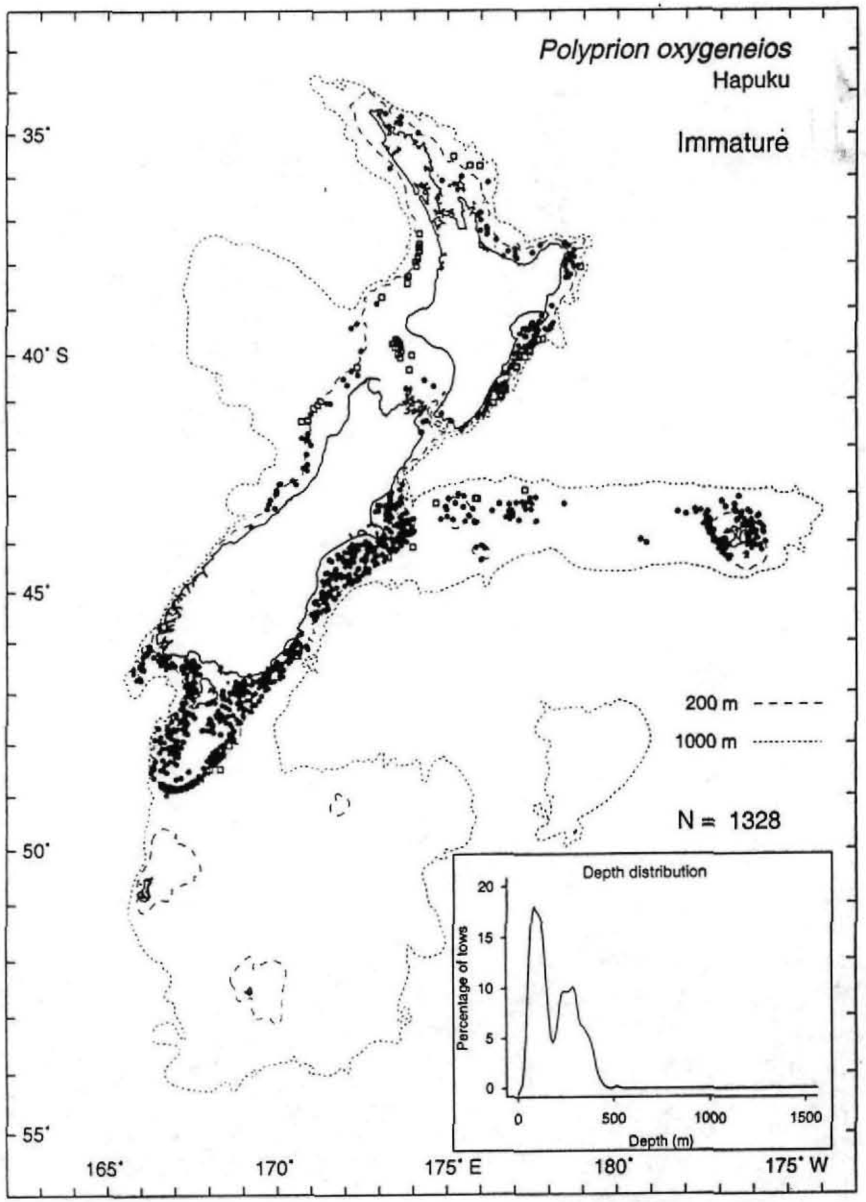


Peltorhamphus novaezeelandiae
New Zealand sole
Immature
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 142
Depth distribution
Percentage of tows
Depth (m)

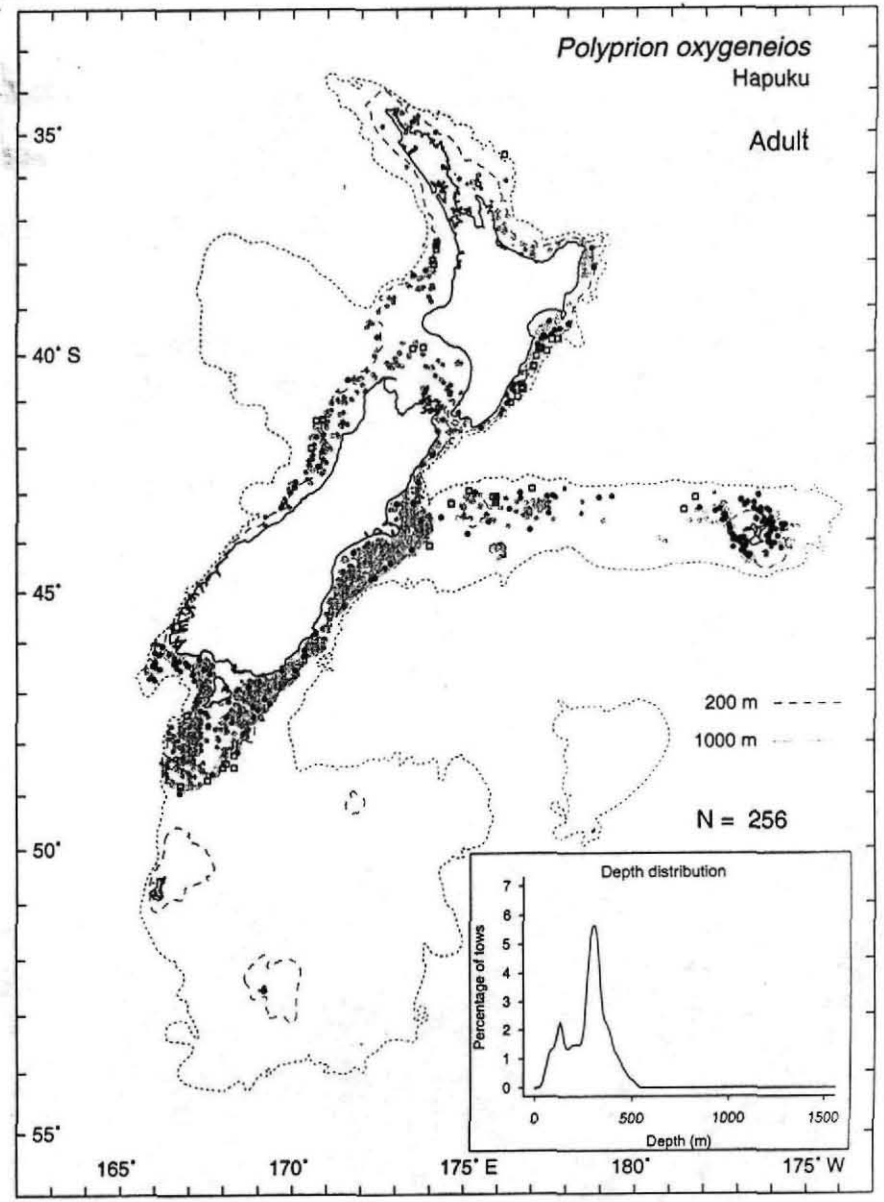




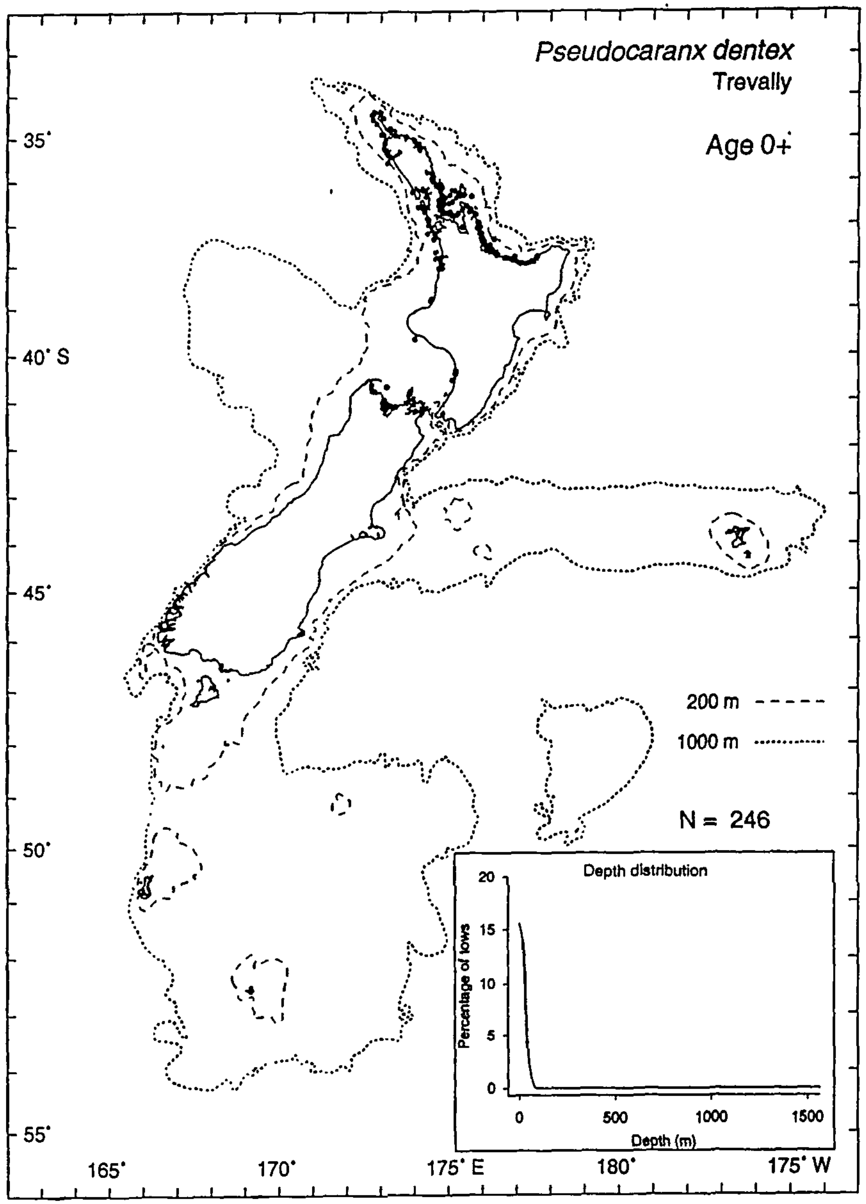
Groups i and ii are arbitrary and each may represent several year classes.

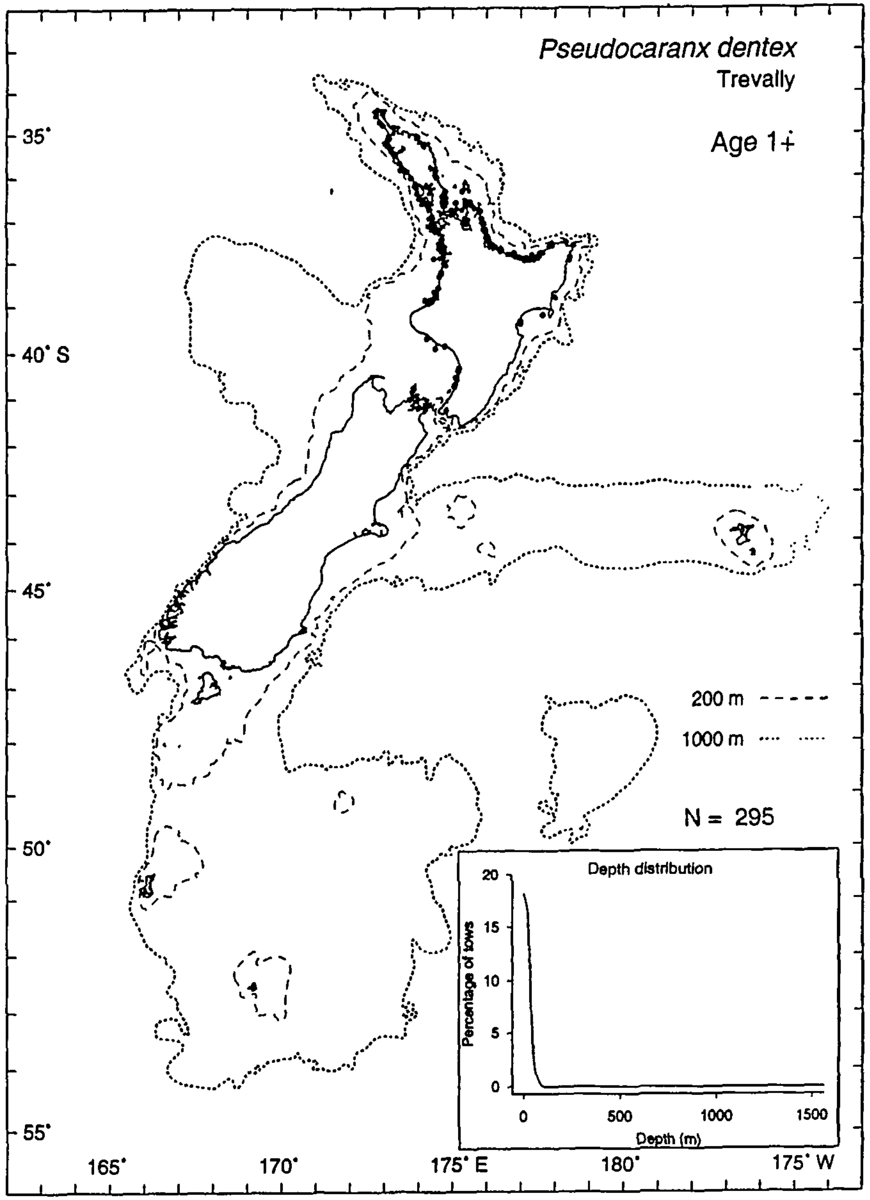


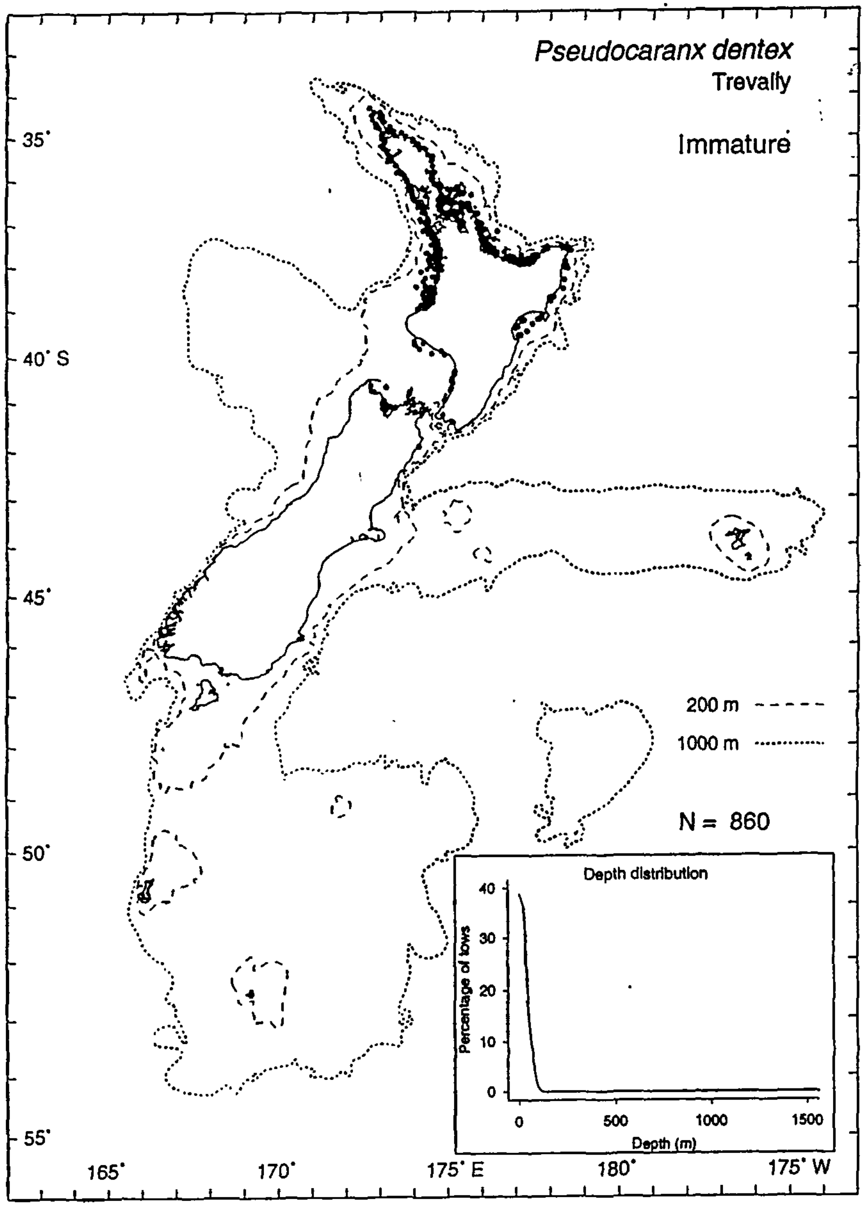
Polyprion oxygeneios
Hapuku
Immature
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 1328
Depth distribution
Percentage of tows
Depth (m)

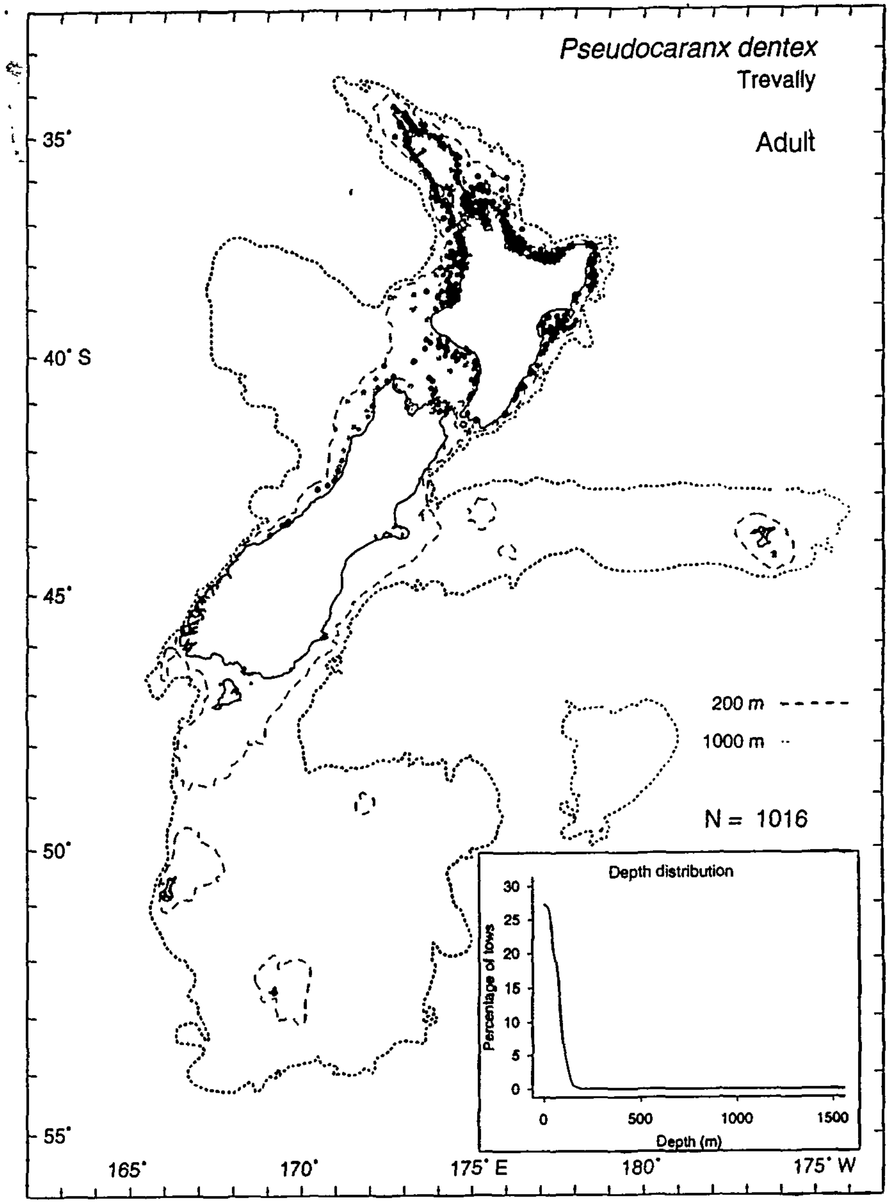


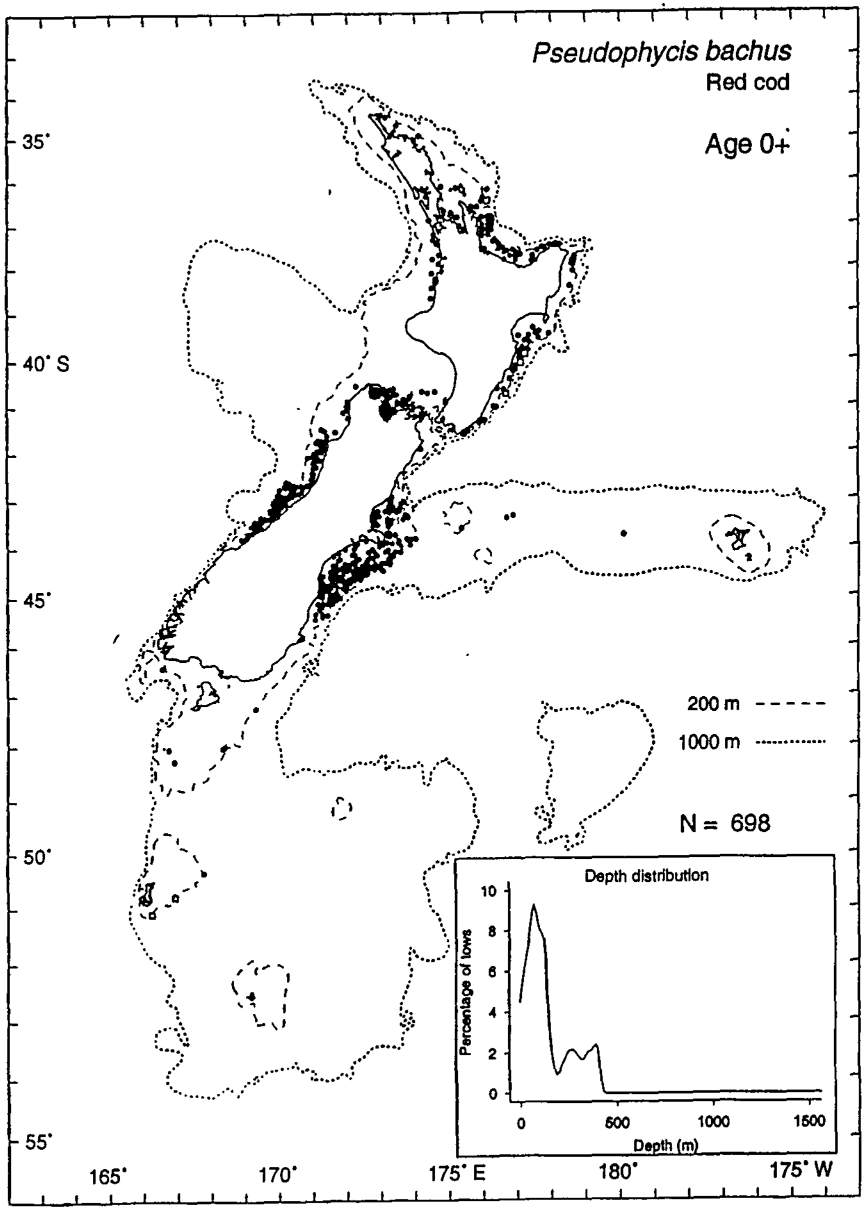
Polyprion oxygeneios
Hapuku
Adult
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 256
Depth distribution
Percentage of tows
Depth (m)


Pseudocaranx dentex
Trevally
Age 0+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 246
Depth distribution
Percentage of tows
20
15
10
5
0
0
500
1000
1500
Depth (m)

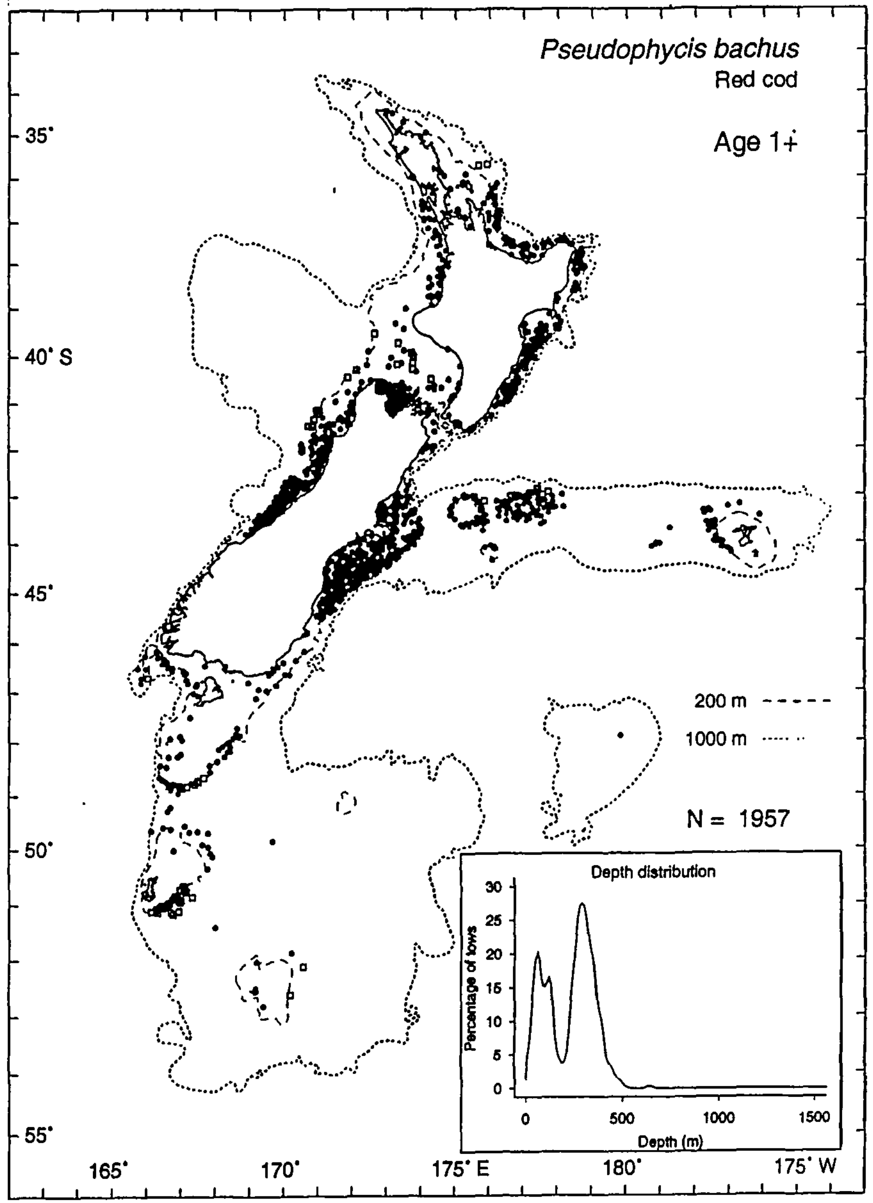

Pseudocaranx dentex
Trevally
Age 1+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 295
Depth distribution
Percentage of tows
20
15
10
5
0
0
500
1000
1500
Depth (m)


Pseudocaranx dentex
Trevally
Immature
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 860
Depth distribution
Percentage of tows
Depth (m)
0
10
20
30
40
0
500
1000
1500

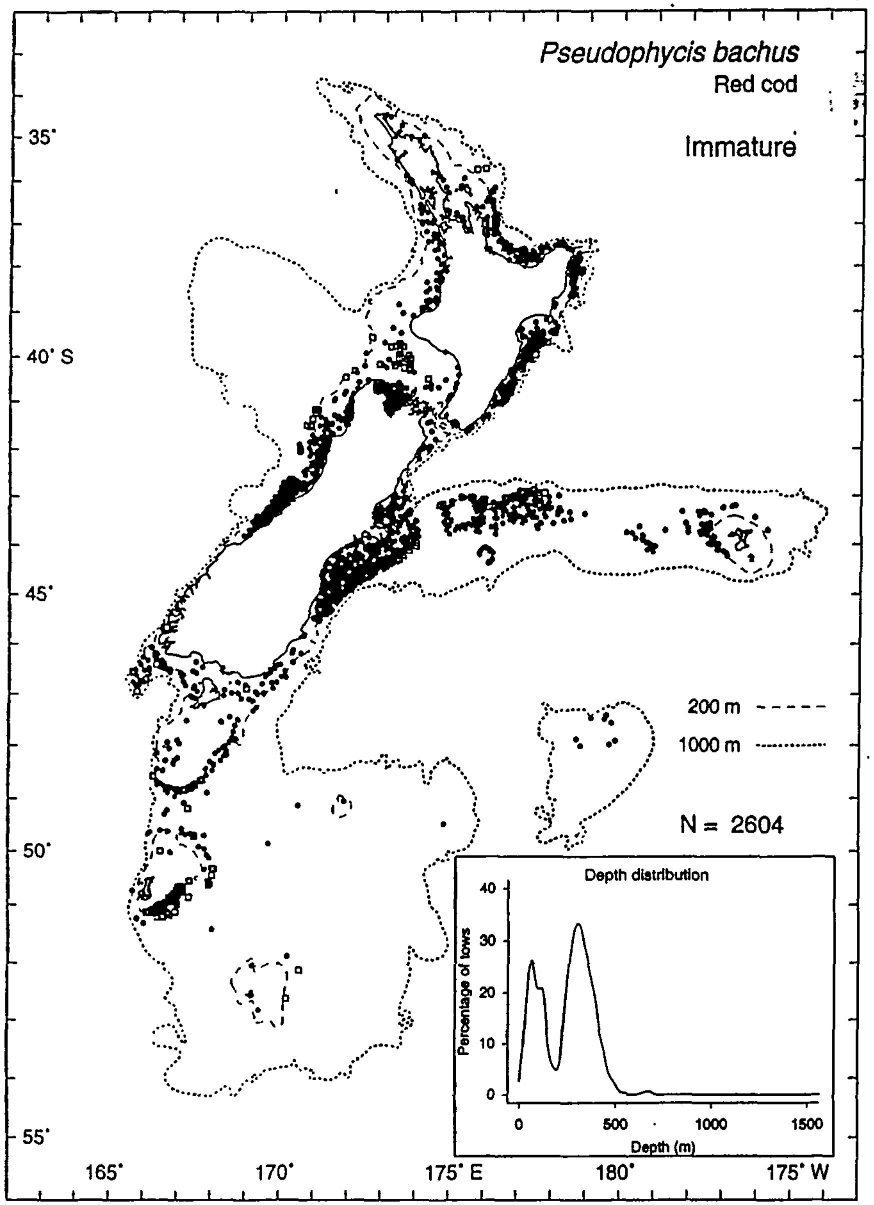

Pseudocaranx dentex
Trevally
Adult
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 1016
Depth distribution
Percentage of tows
Depth (m)
0
5
10
15
20
25
30
0
500
1000
1500

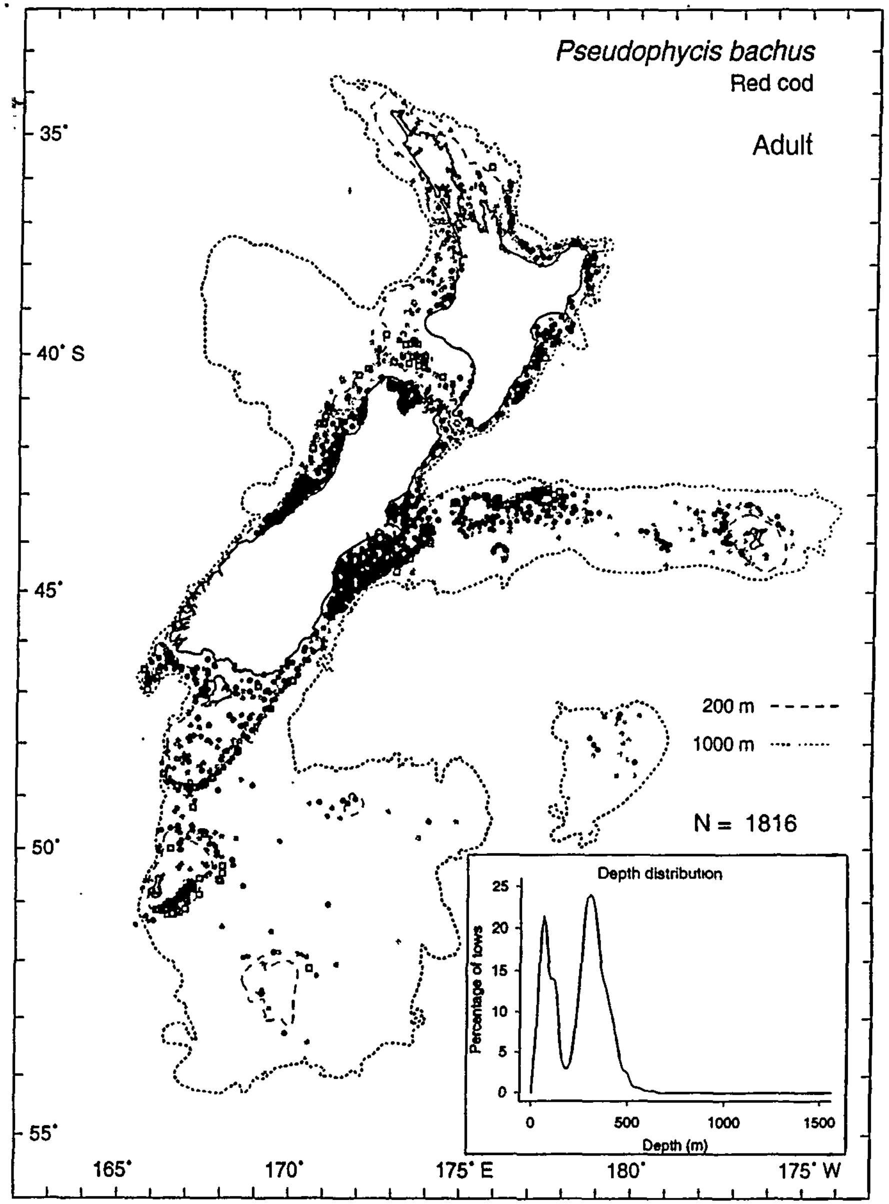


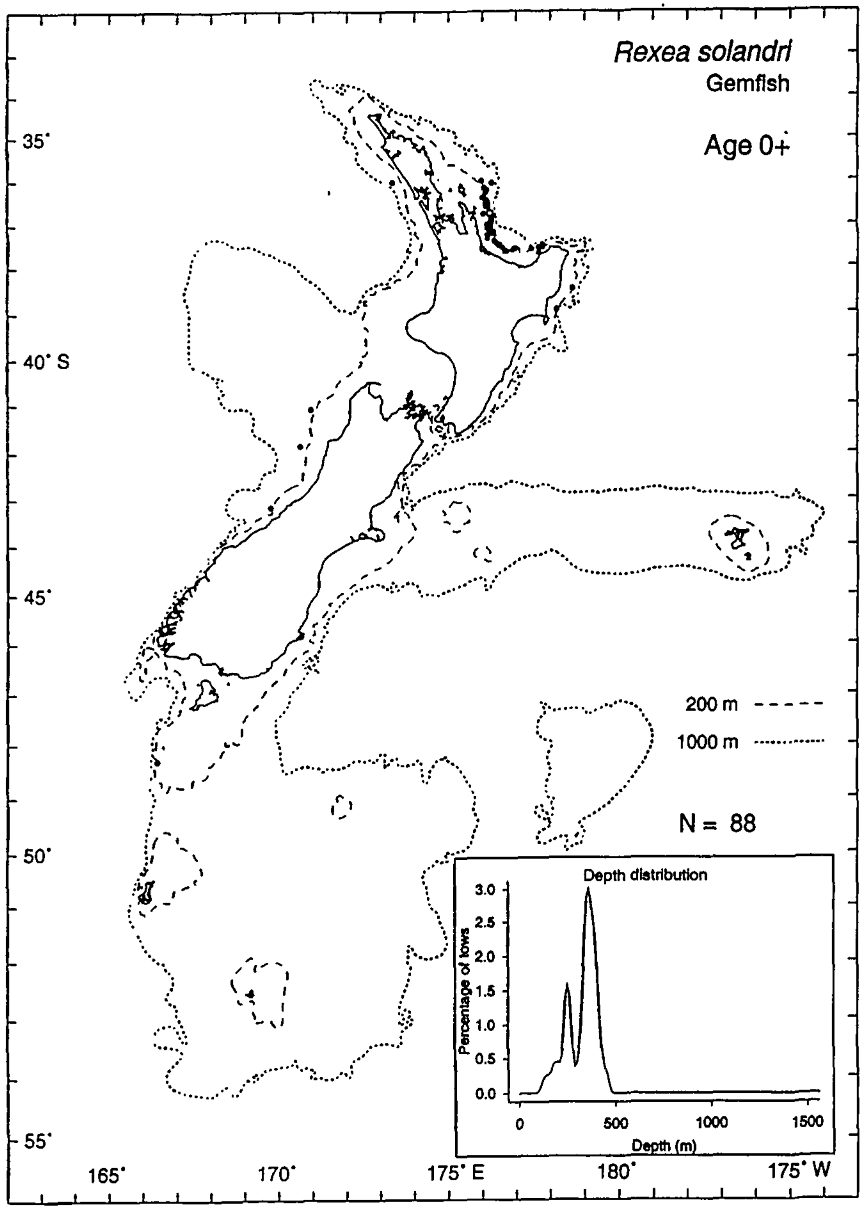
Pseudophycis bachus
Red cod
Age 0+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 698
Depth distribution
Percentage of tows
Depth (m)

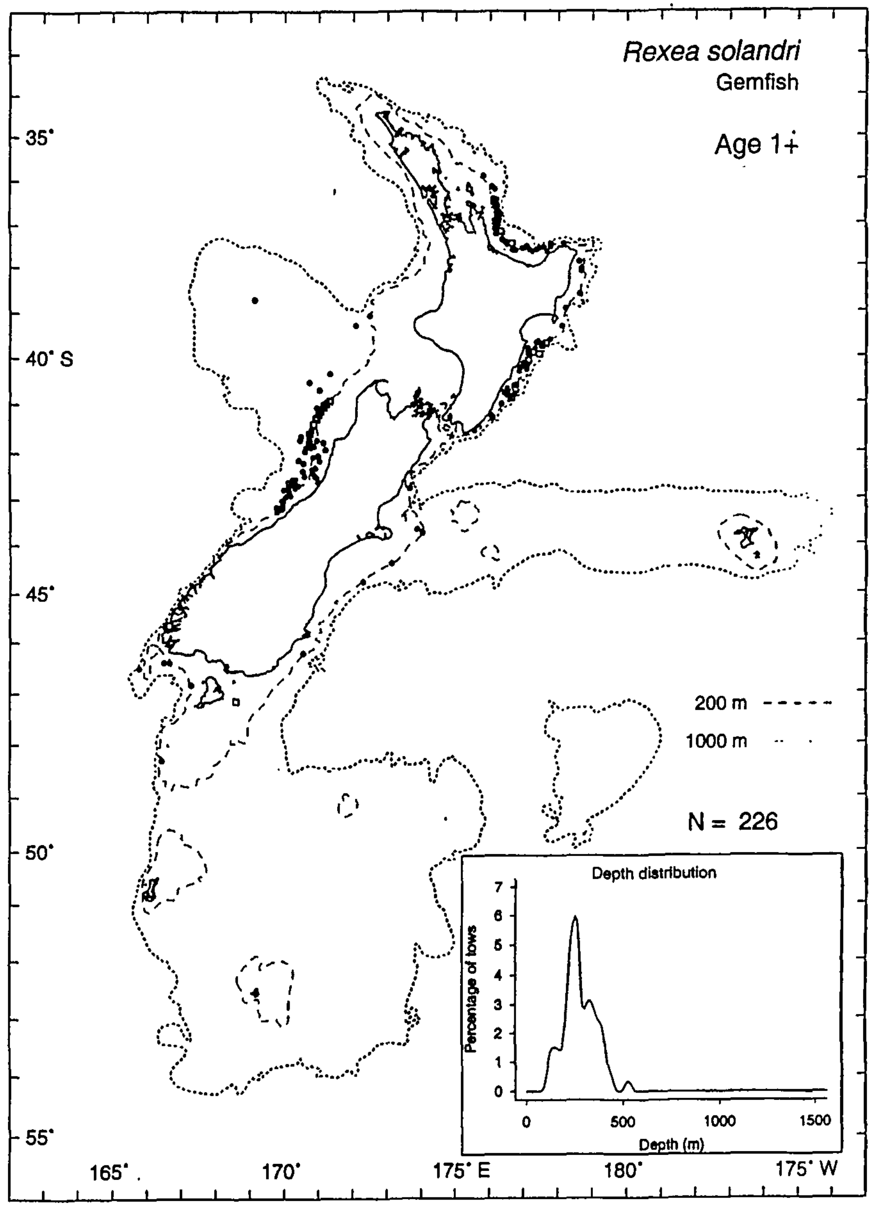


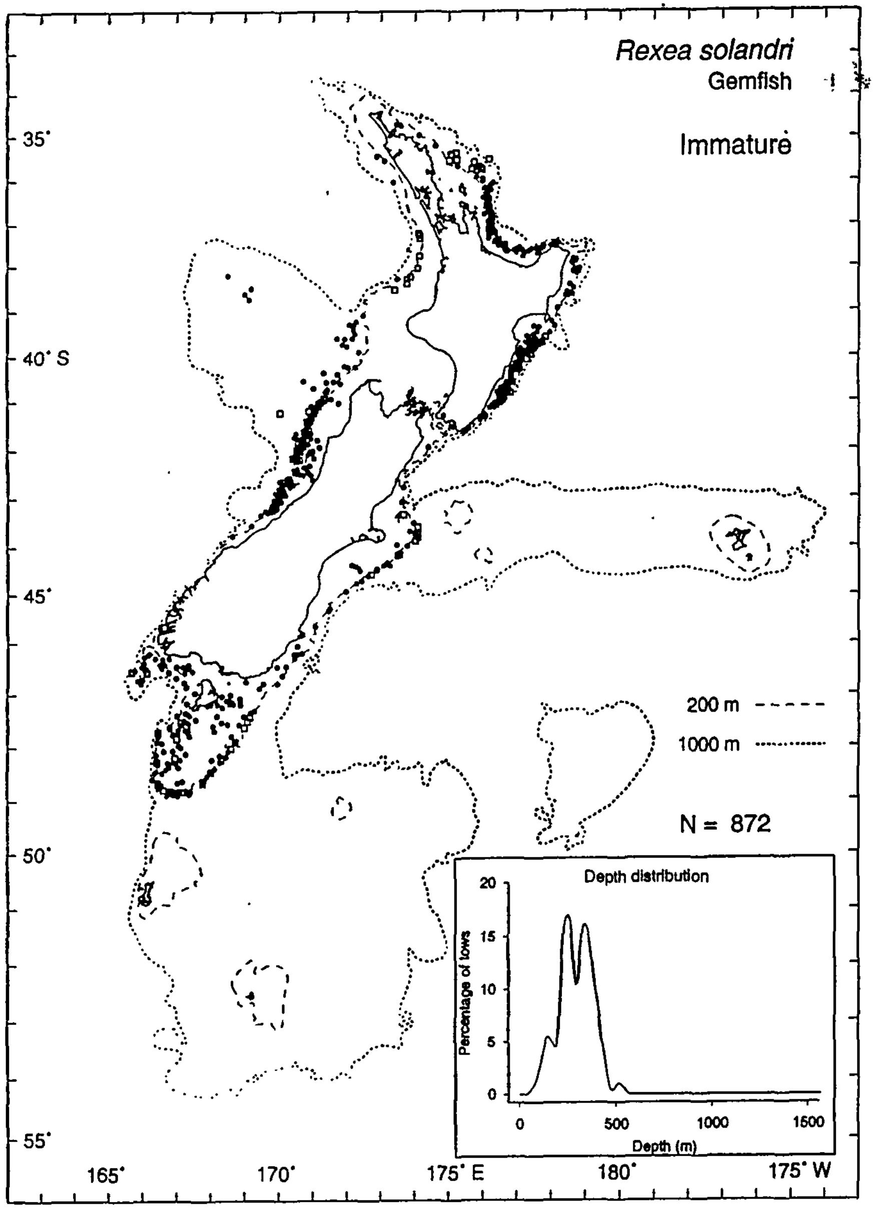
Pseudophycis bachus
Red cod
Age 1+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 1957
Depth distribution
Percentage of tows
Depth (m)


Pseudophycis bachus
Red cod
Immature
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 2604
Depth distribution
Percentage of tows
Depth (m)
0
500
1000
1500
0
10
20
30
40

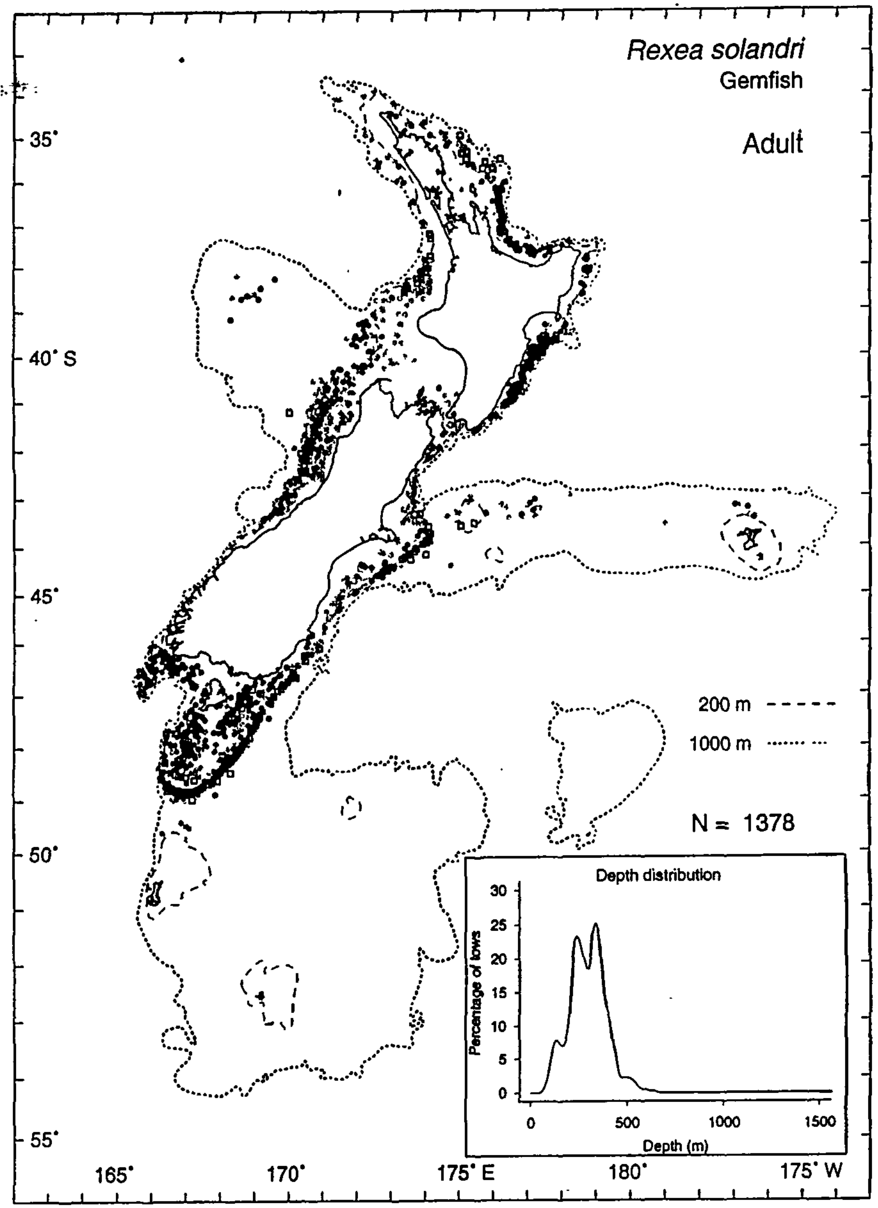

Pseudophycis bachus
Red cod
Adult
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 1816
Depth distribution
Percentage of tows
Depth (m)
0
500
1000
1500
0
5
10
15
20
25


Rexea solandri
Gemfish
Age 0+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 88
Depth distribution
Percentage of tows
Depth (m)
0
500
1000
1500
0.0
0.5
1.0
1.5
2.0
2.5
3.0

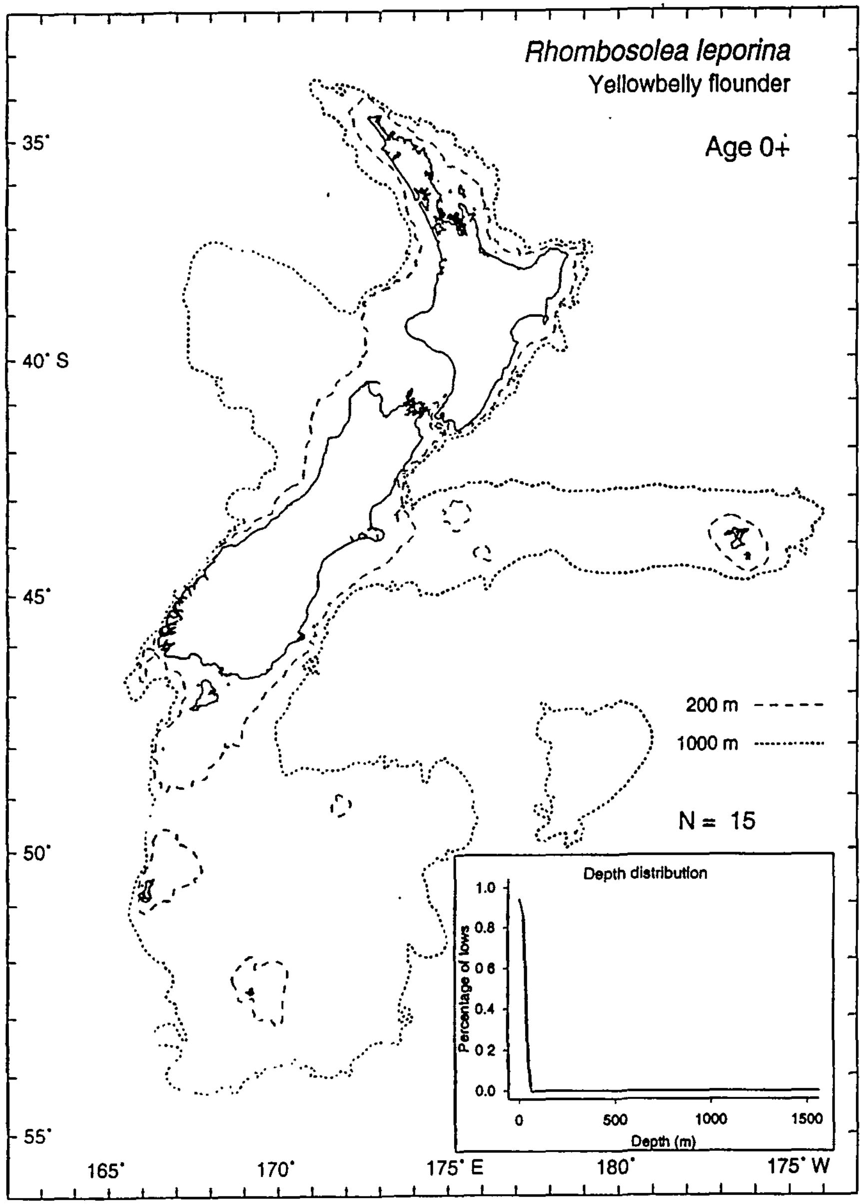

Rexea solandri
Gemfish
Age 1+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 226
Depth distribution
Percentage of tows
Depth (m)
0
500
1000
1500
0
1
2
3
4
5
6
7



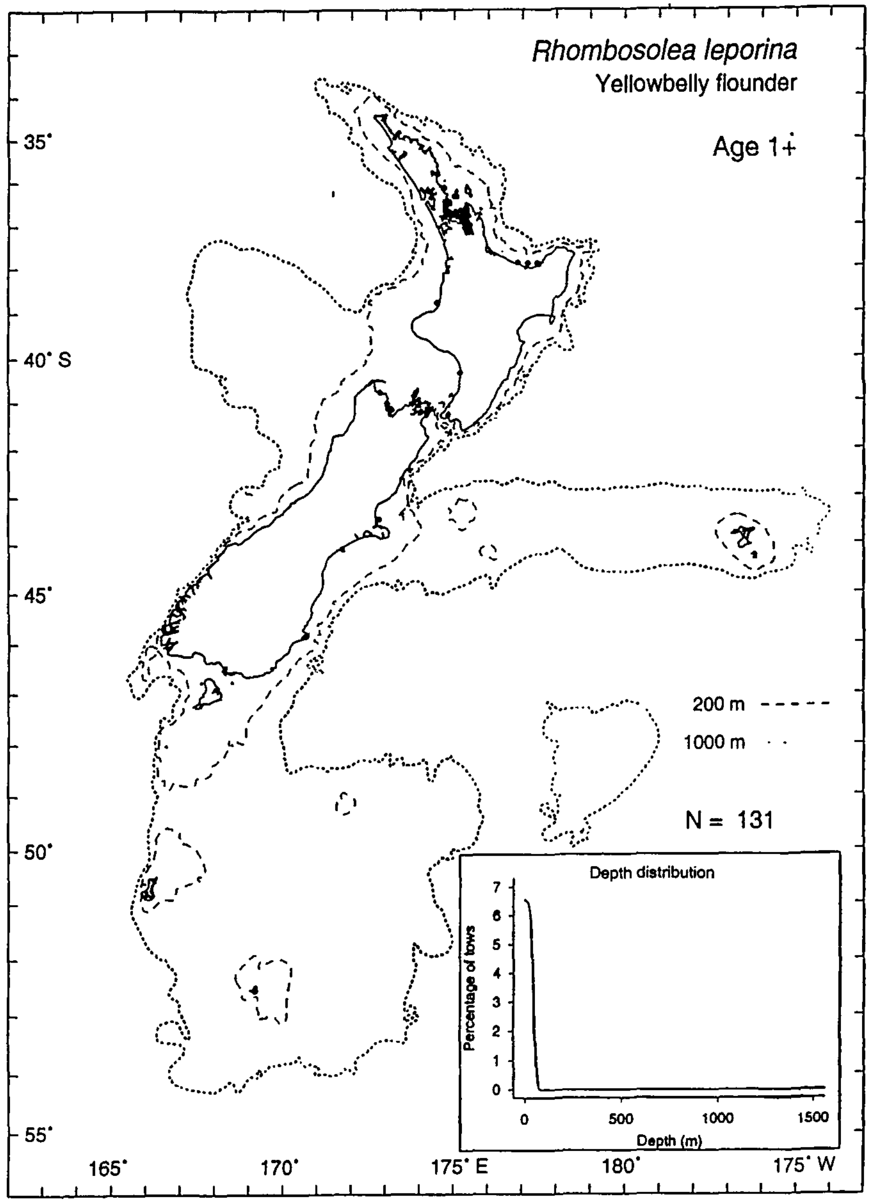
Rexea solandri
Gemfish
Immature
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 872
Depth distribution
Percentage of tows
Depth (m)



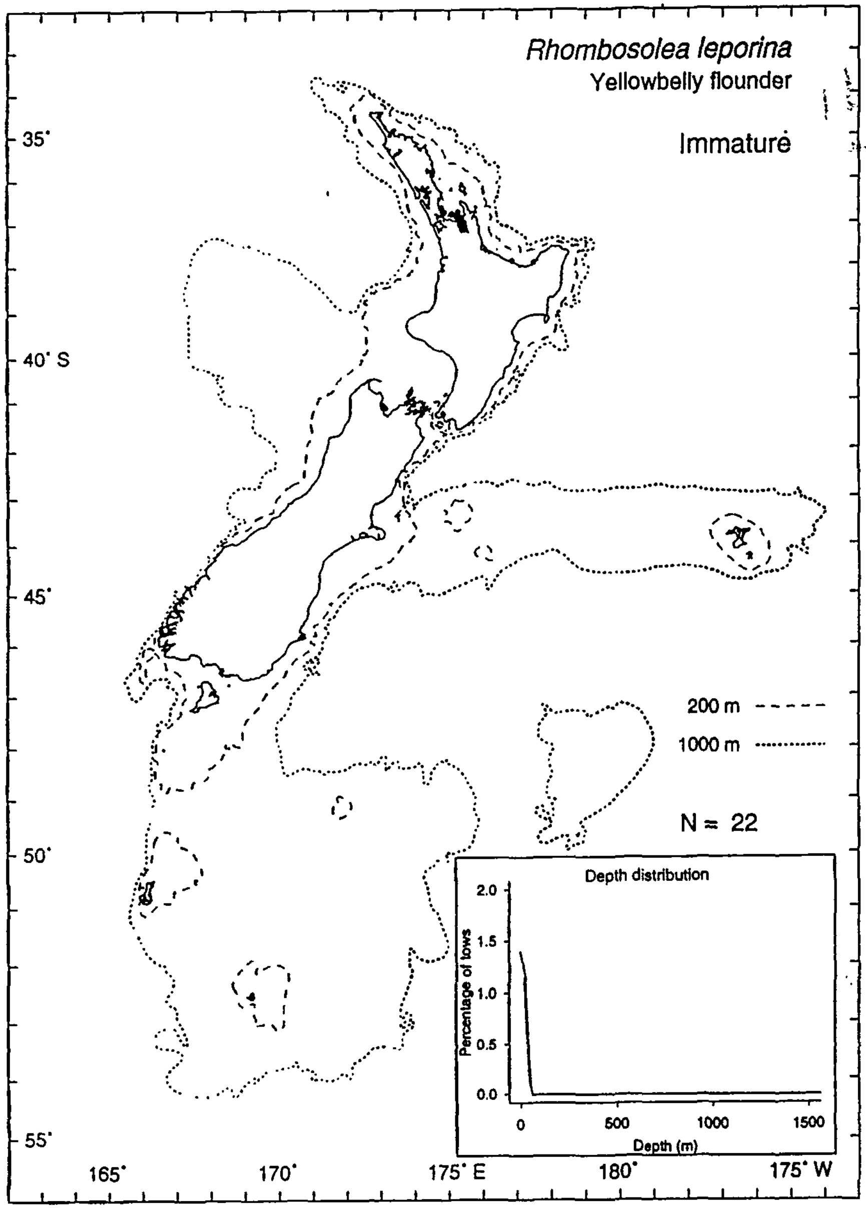
Rexea solandri
Gemfish
Adult
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 1378
Depth distribution
Percentage of tows
Depth (m)



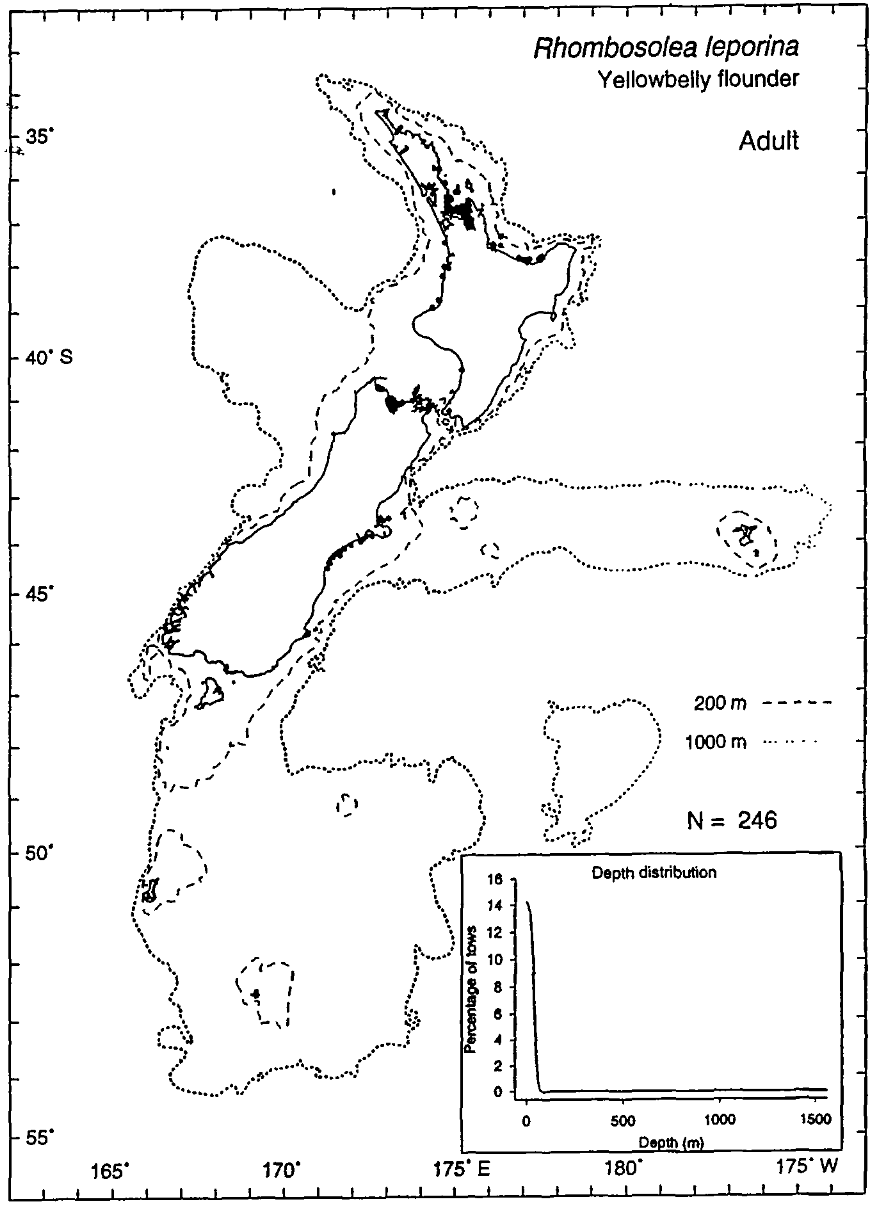
Rhombosolea leporina
Yellowbelly flounder
Age 0+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 15
Depth distribution
Percentage of tows
1.0
0.8
0.6
0.4
0.2
0.0
0
500
1000
1500
Depth (m)



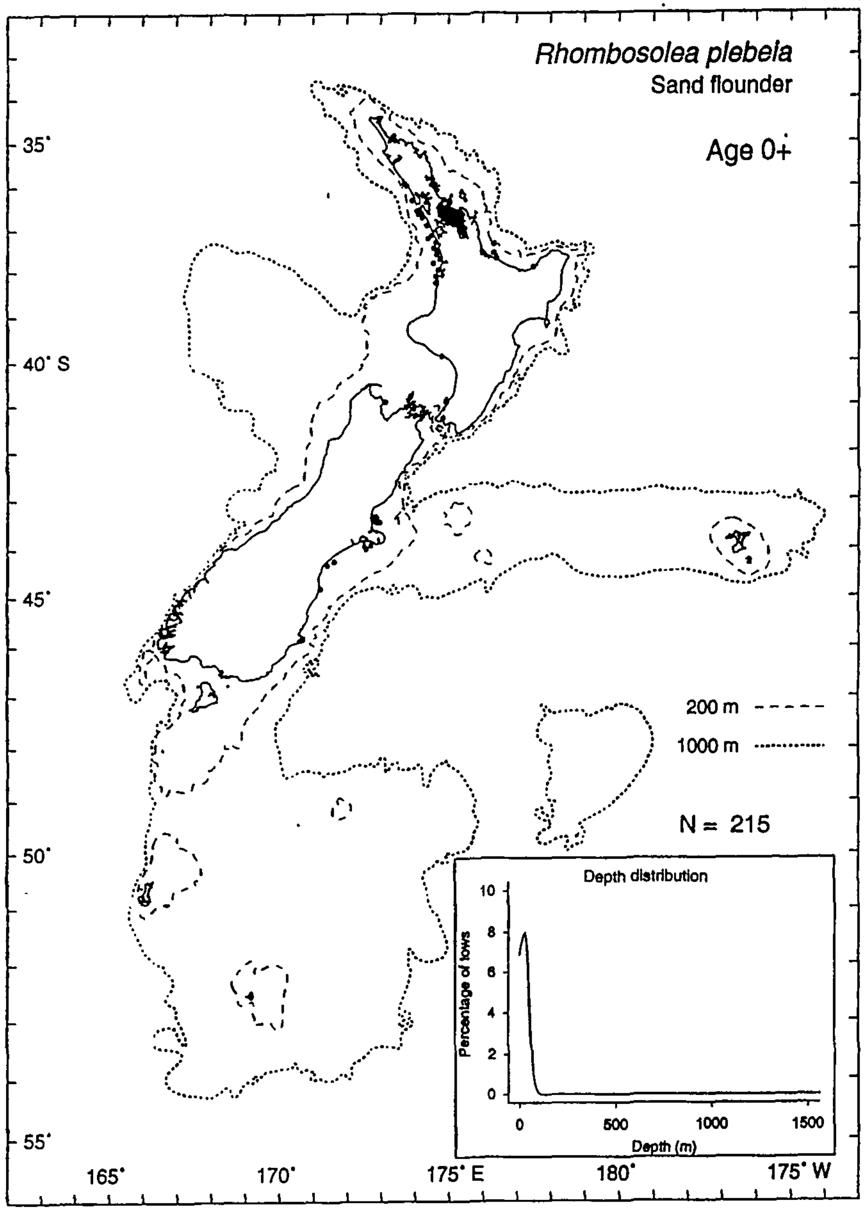
Rhombosolea leporina
Yellowbelly flounder
Age 1+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 131
Depth distribution
Percentage of tows
7
6
5
4
3
2
1
0
0
500
1000
1500
Depth (m)



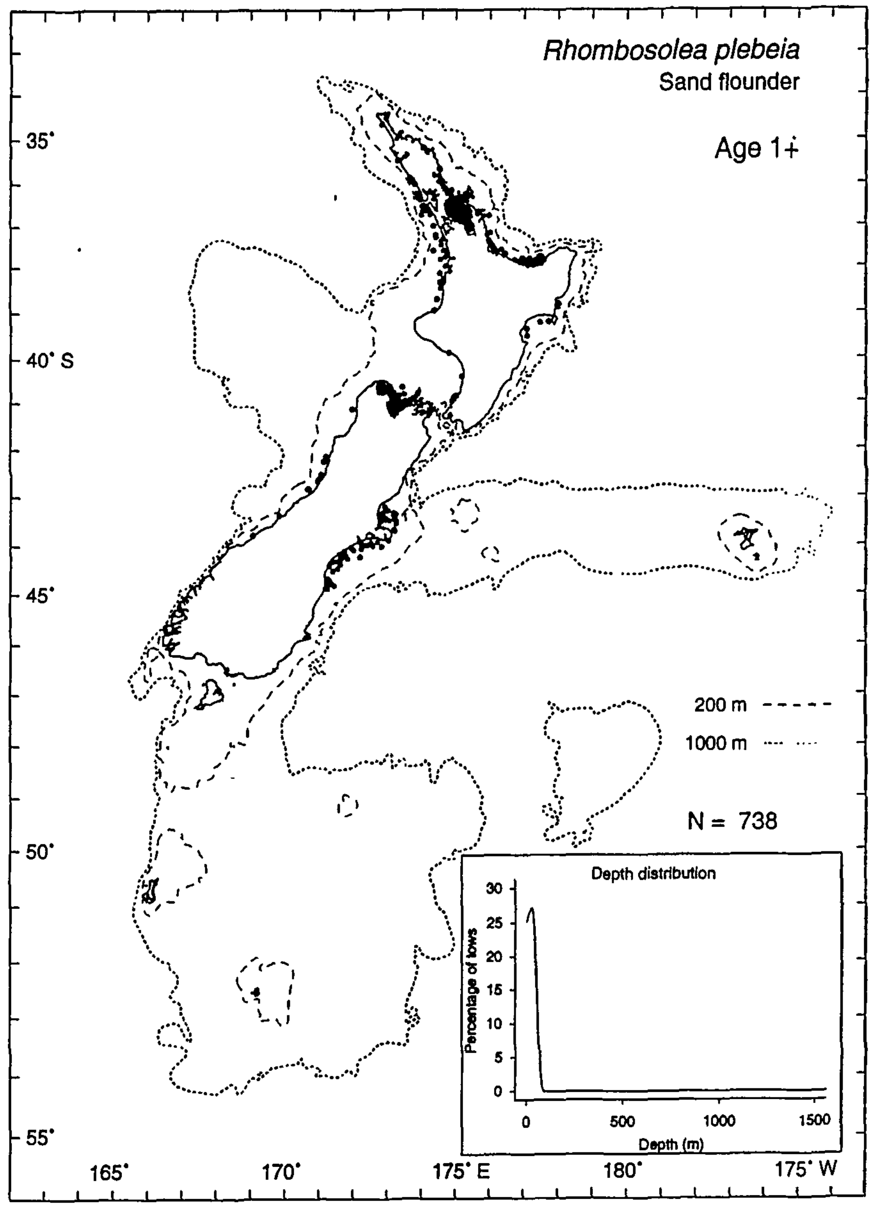
Rhombosolea leporina
Yellowbelly flounder
Immature
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 22
Depth distribution
Percentage of tows
Depth (m)



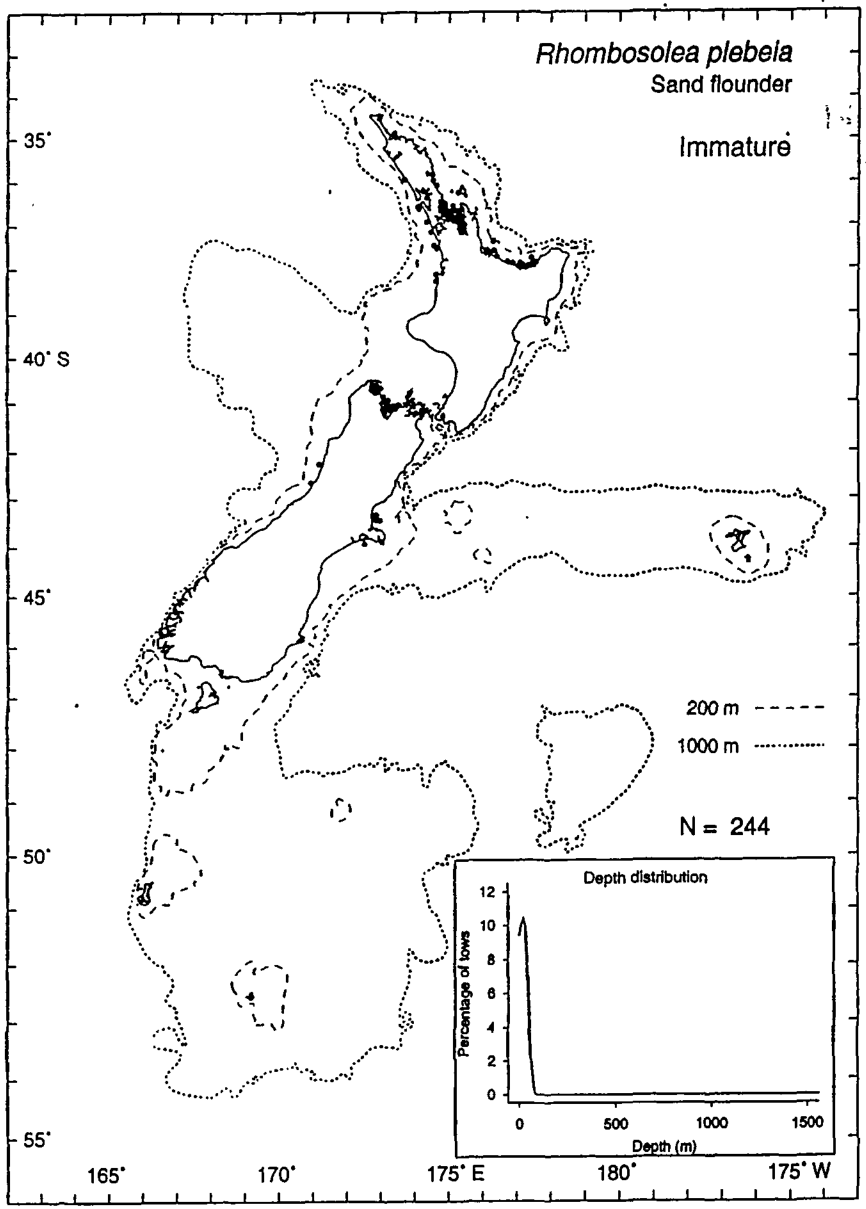
Rhombosolea leporina
Yellowbelly flounder
Adult
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 246
Depth distribution
Percentage of tows
Depth (m)

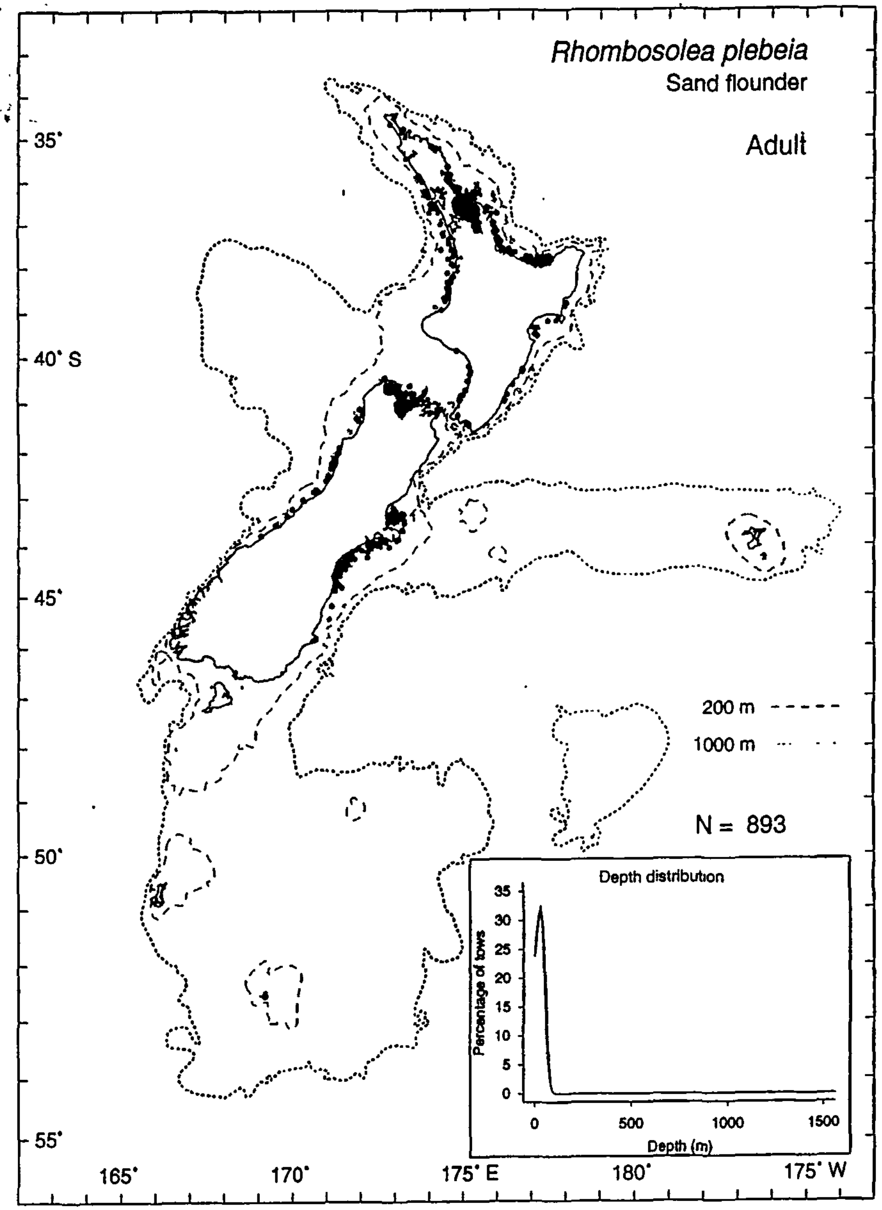


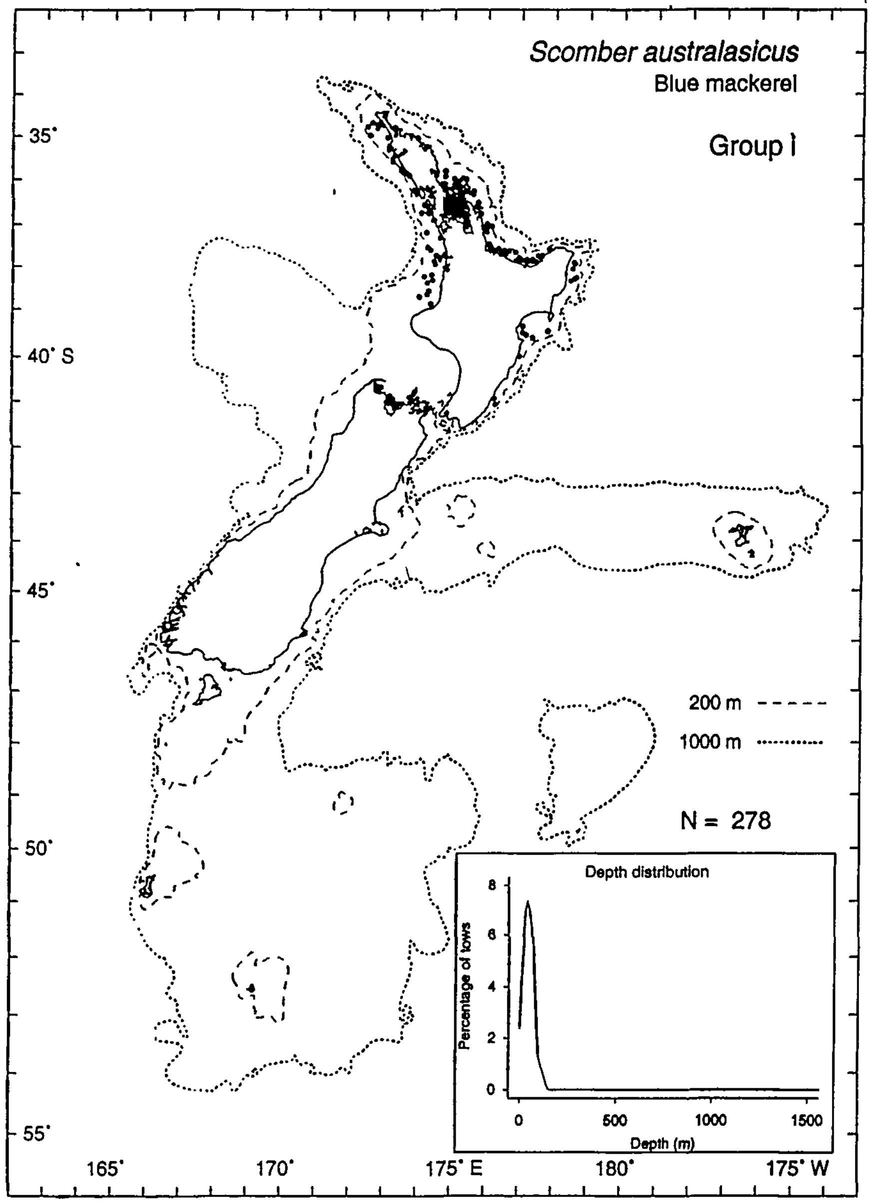
Rhombosolea plebeia
Sand flounder
Age 0+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 215
Depth distribution
Percentage of tows
Depth (m)

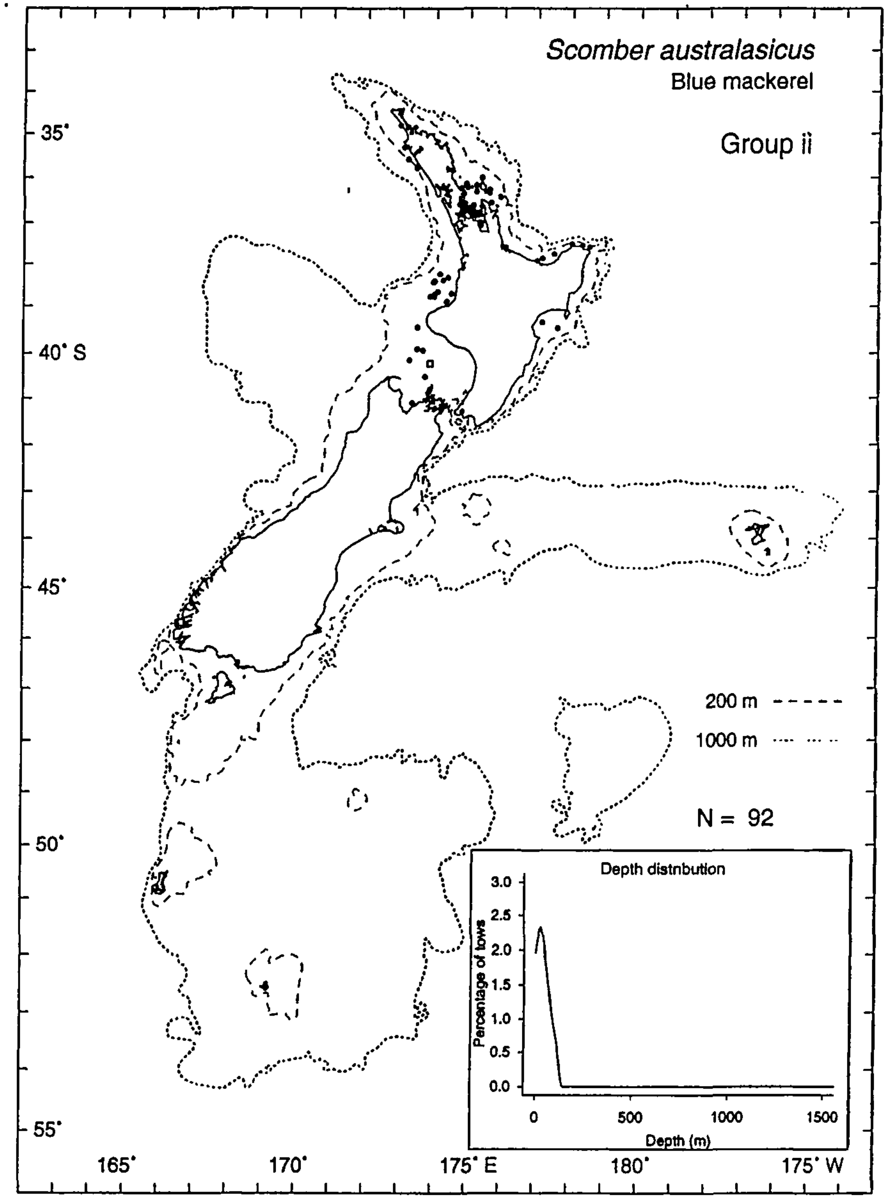


Rhombosolea plebeia
Sand flounder
Age 1+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 738
Depth distribution
Percentage of tows
Depth (m)

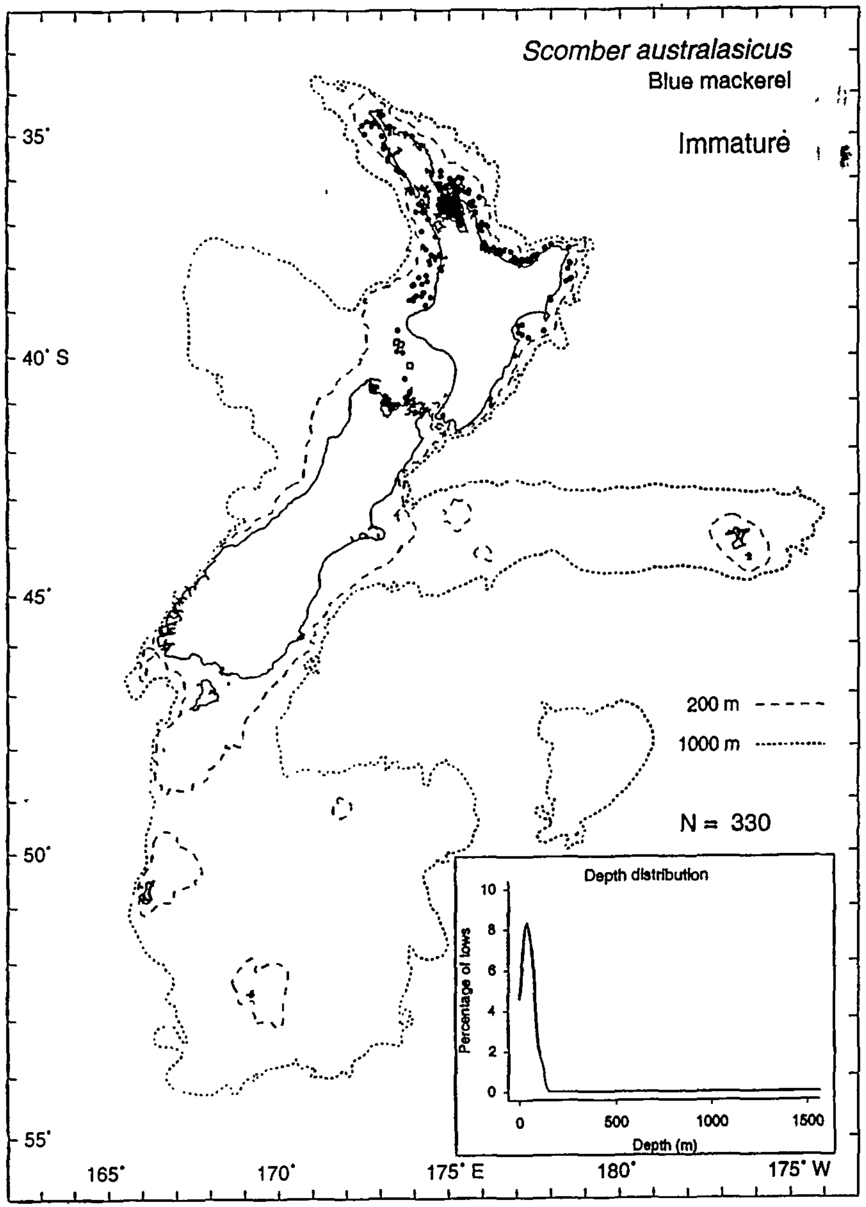

Rhombosolea plebeia
Sand flounder
Immature
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 244
Depth distribution
Percentage of tows
Depth (m)
0
500
1000
1500

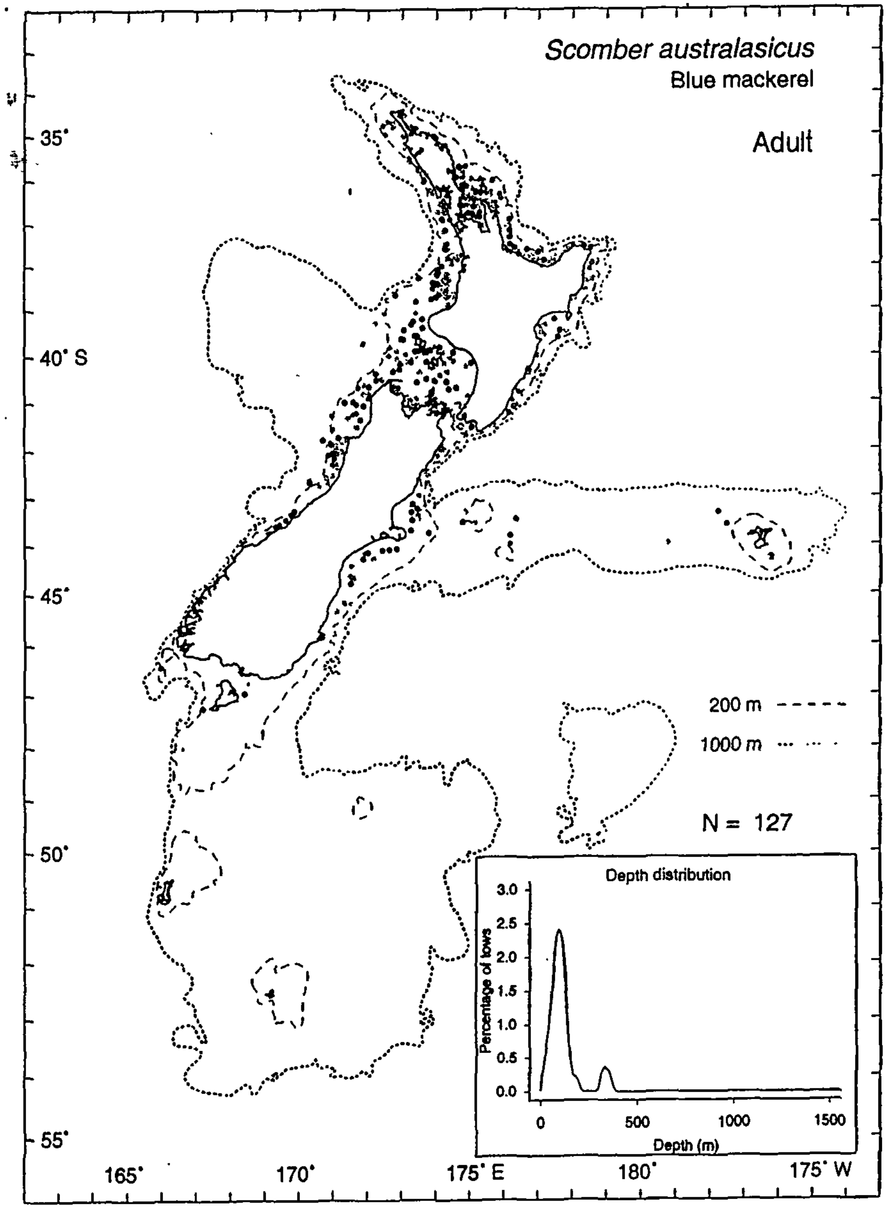

Rhombosolea plebeia
Sand flounder
Adult
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 893
Depth distribution
Percentage of tows
Depth (m)
0
500
1000
1500

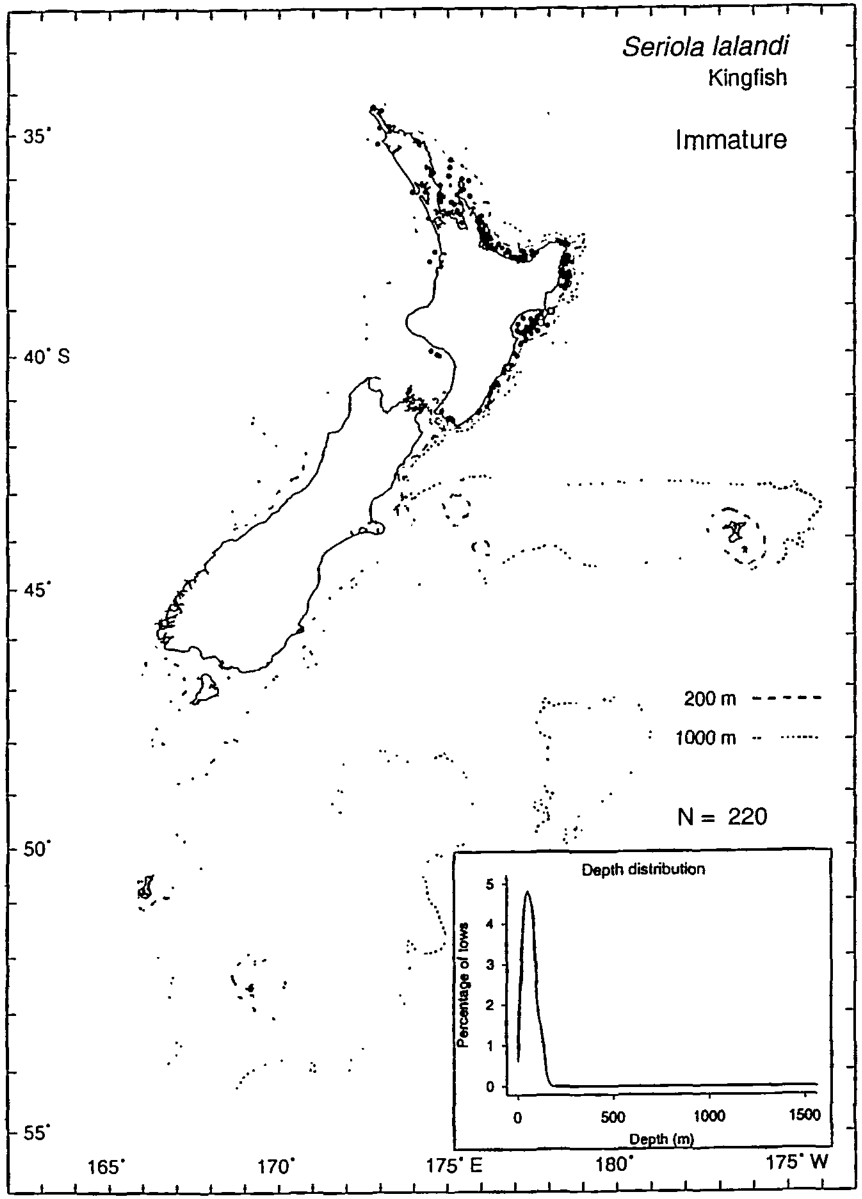


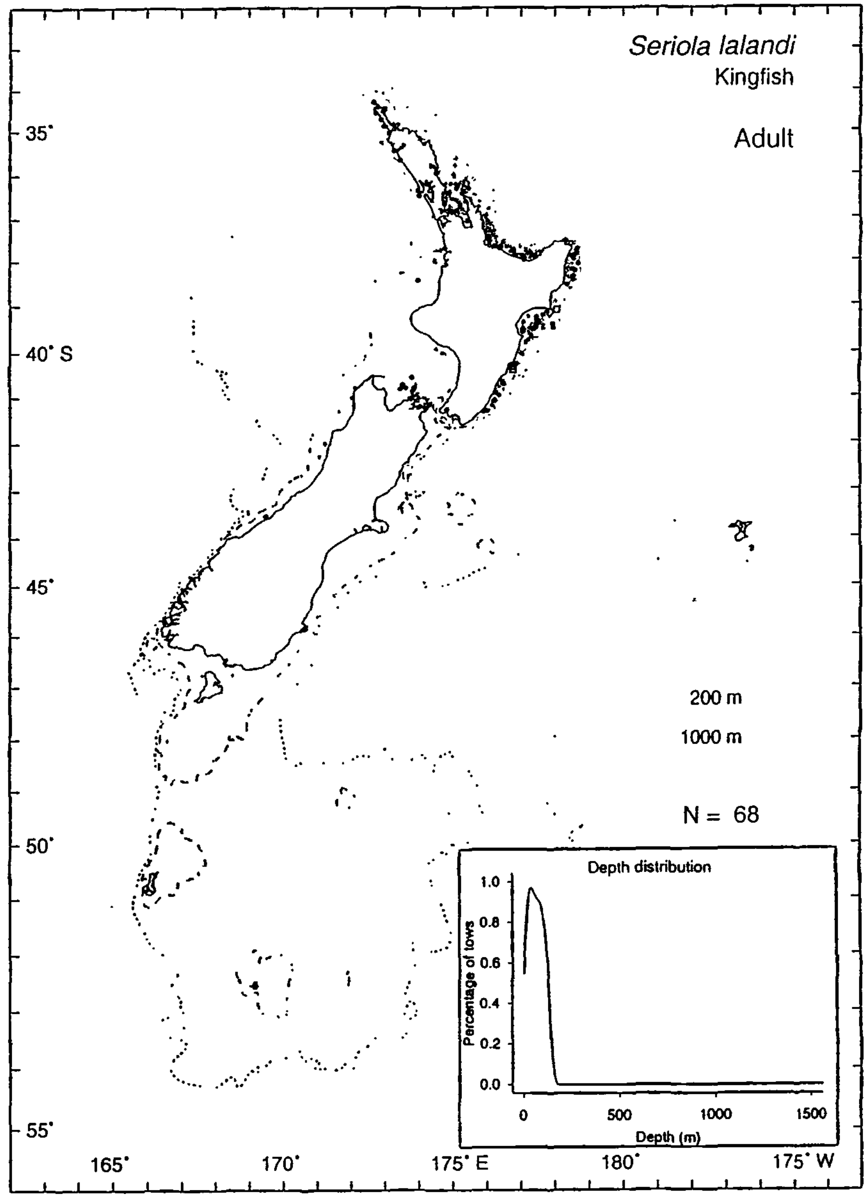


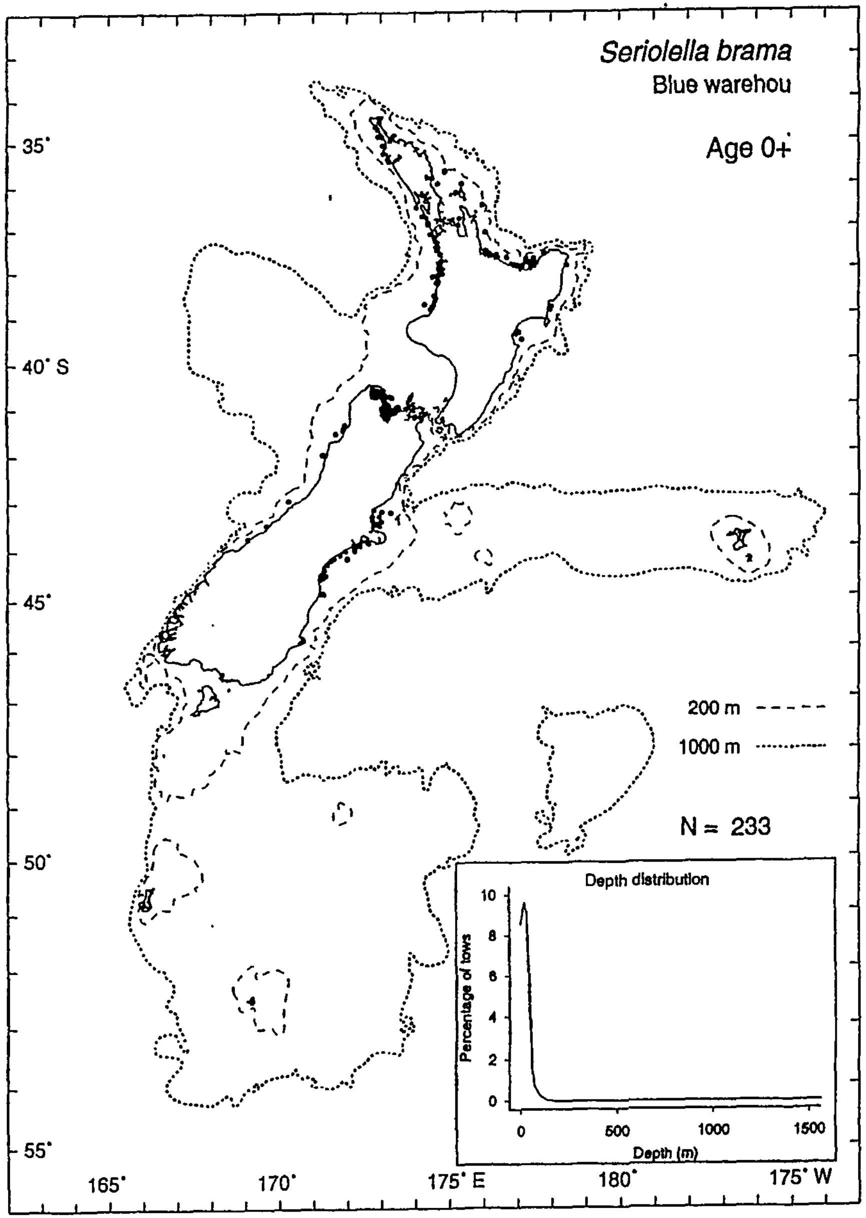
Groups i and ii may approximate ages 0+ and 1+.


Scomber australasicus
Blue mackerel
Immature
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 330
Depth distribution
Percentage of tows
Depth (m)
0
2
4
6
8
10
500
1000
1500

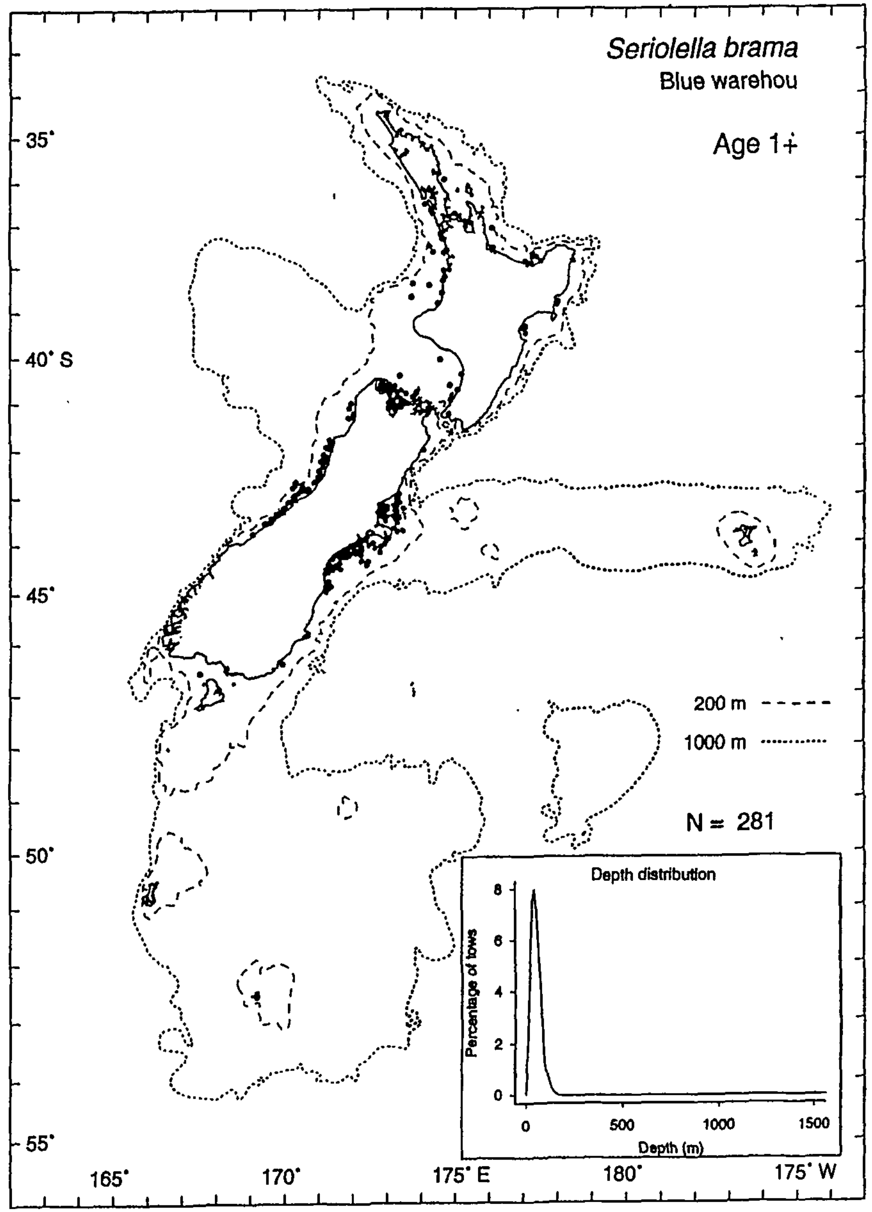

Scomber australasicus
Blue mackerel
Adult
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 127
Depth distribution
Percentage of tows
Depth (m)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
0
500
1000
1500


Seriola lalandi
Kingfish
Immature
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 220
Depth distribution
Percentage of tows
Depth (m)
0
1
2
3
4
5
500
1000
1500


Seriola lalandi
Kingfish
Adult
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 68
Depth distribution
Percentage of tows
Depth (m)
0.0
0.2
0.4
0.6
0.8
1.0
0
500
1000
1500

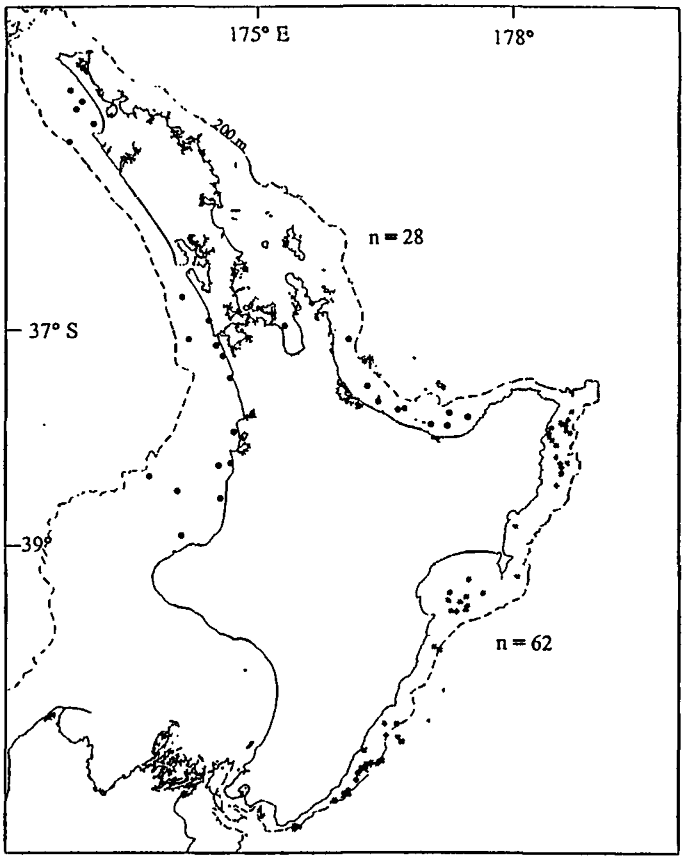


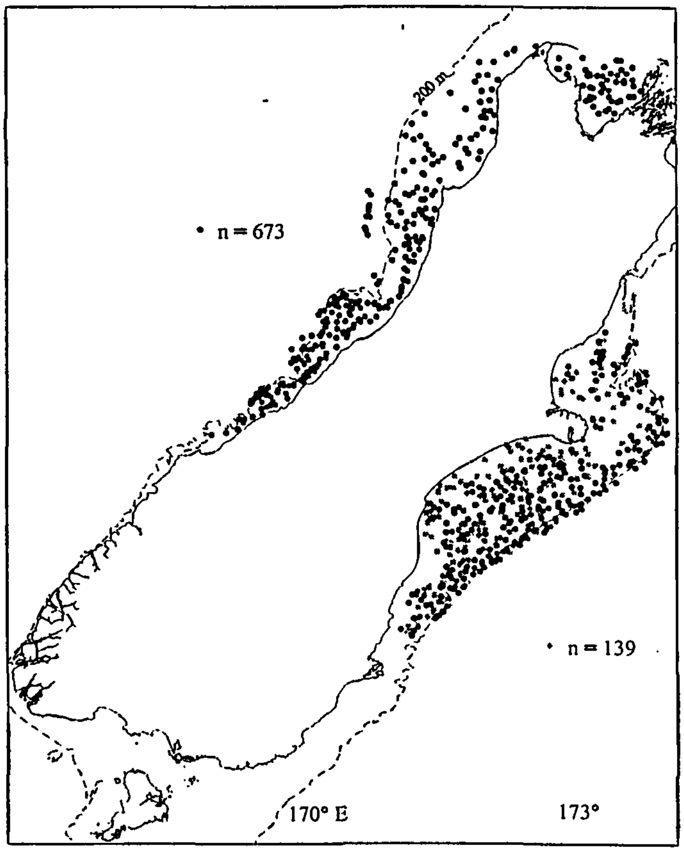
Seriolella brama
Blue warehou
Age 0+
200 m
1000 m
N = 233
Depth distribution
Percentage of tows
Depth (m)
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W



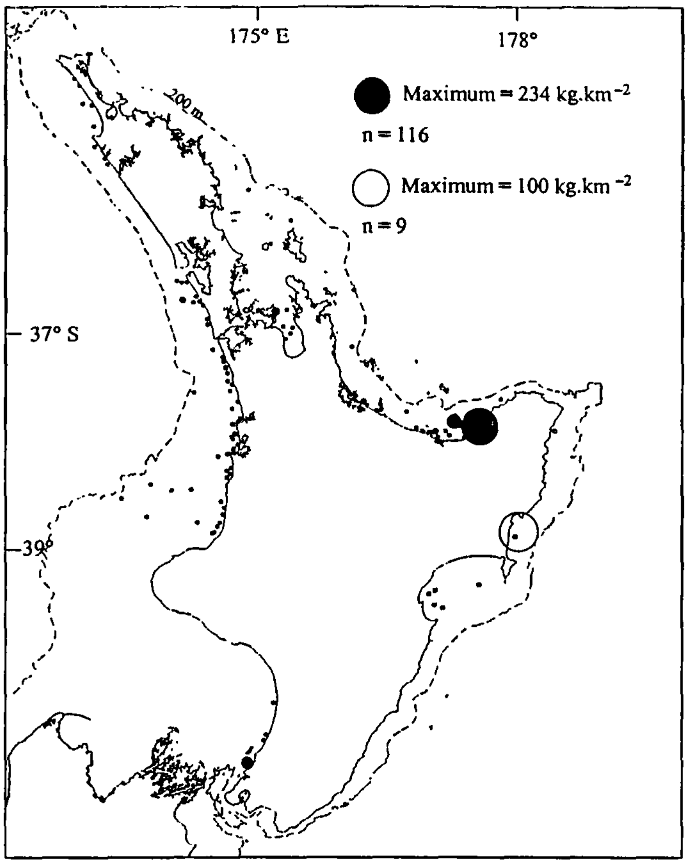
Seriolella brama
Blue warehou
Age 1+
200 m
1000 m
N = 281
Depth distribution
Percentage of tows
Depth (m)
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W

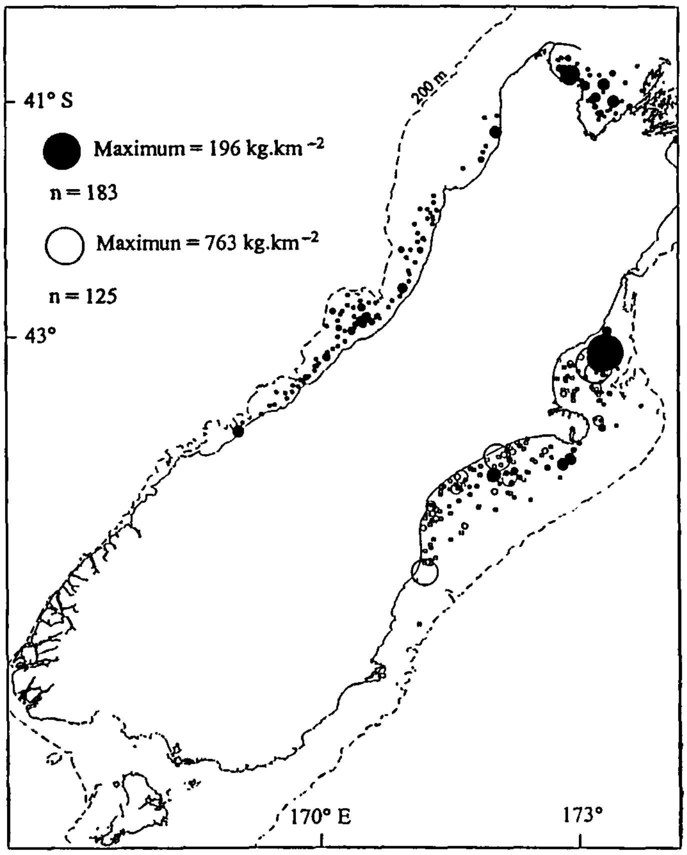
Seriolella punctata



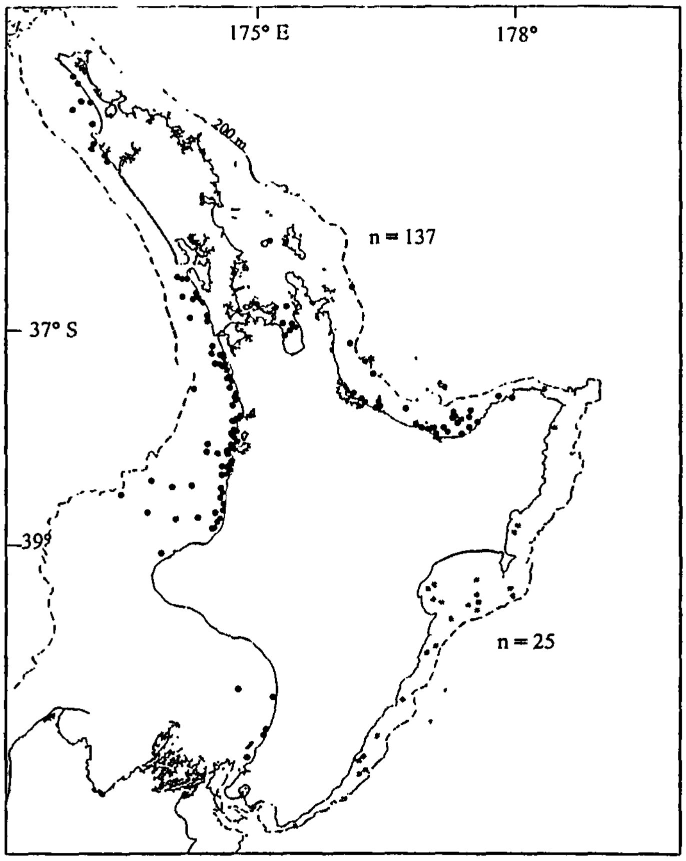


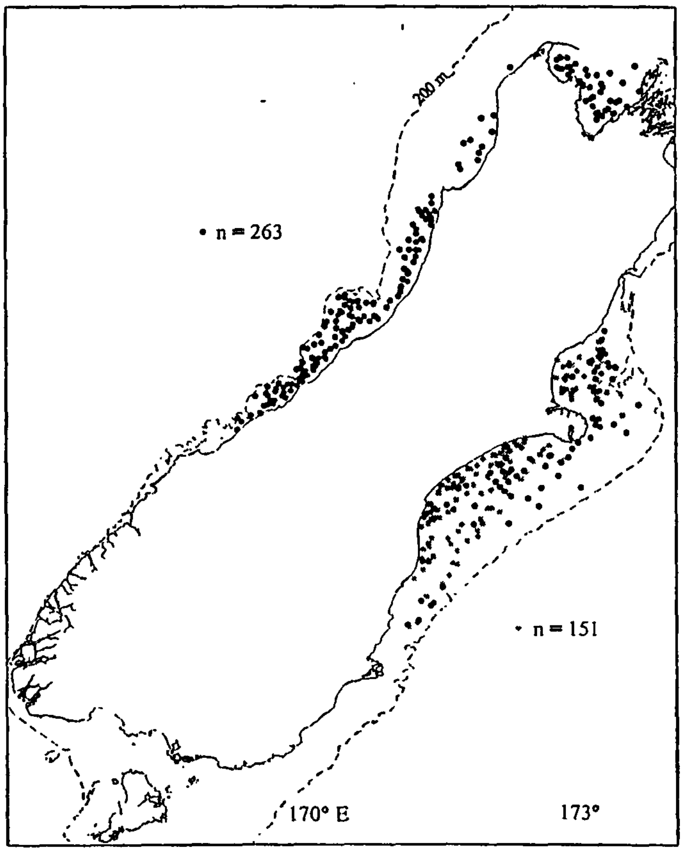
Seriolella brama



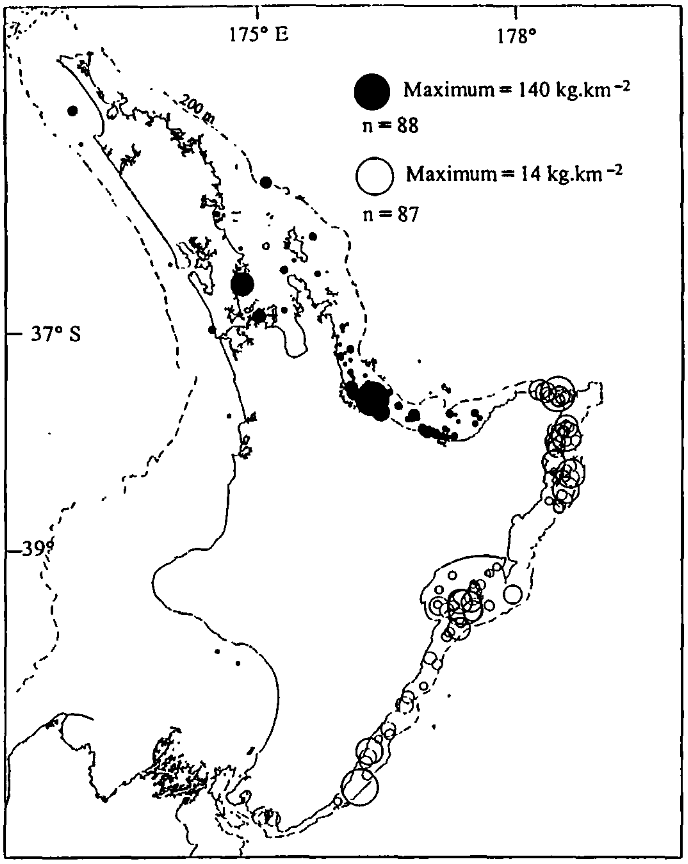


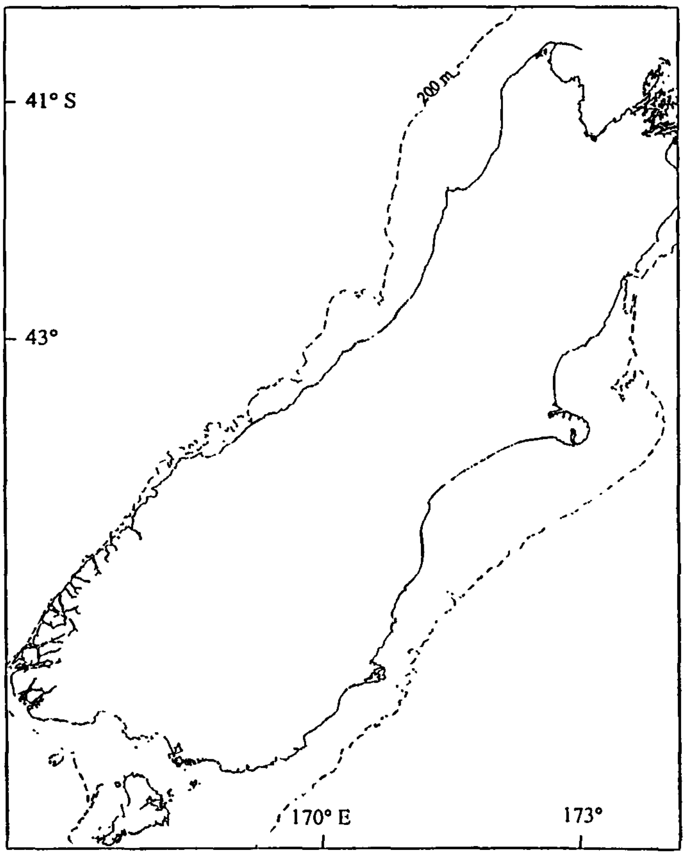
Seriolella brama



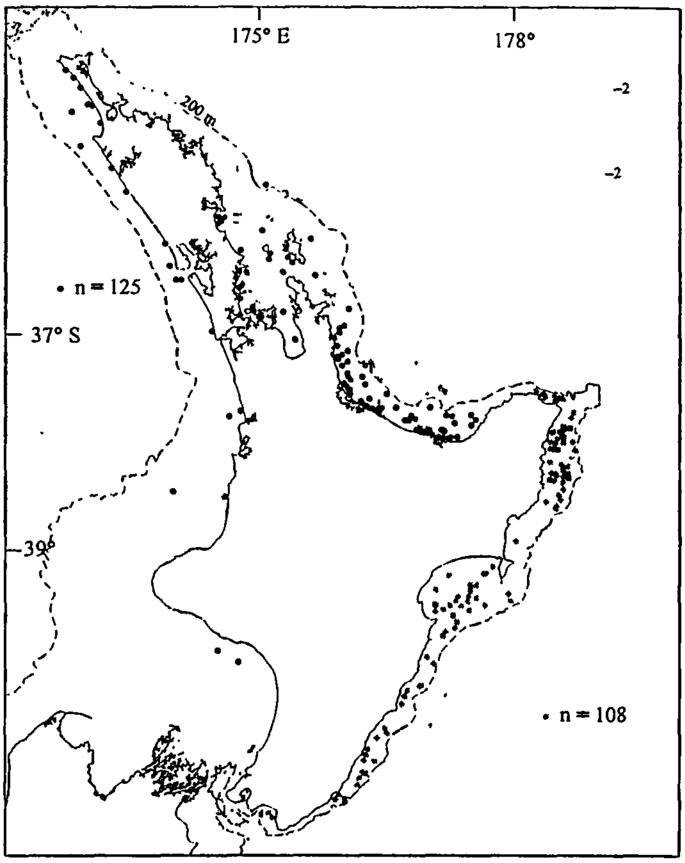


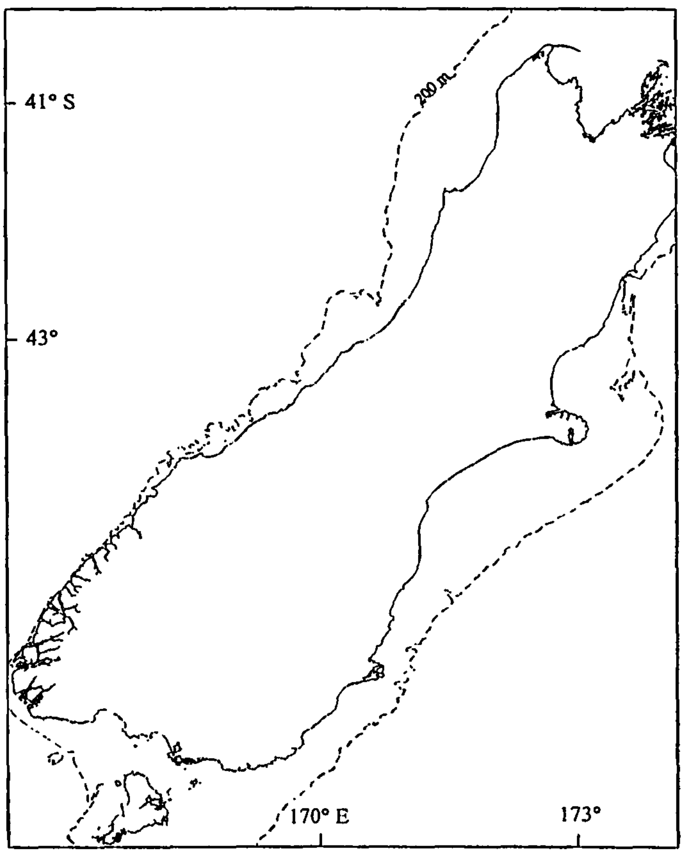
Seriola lalandi



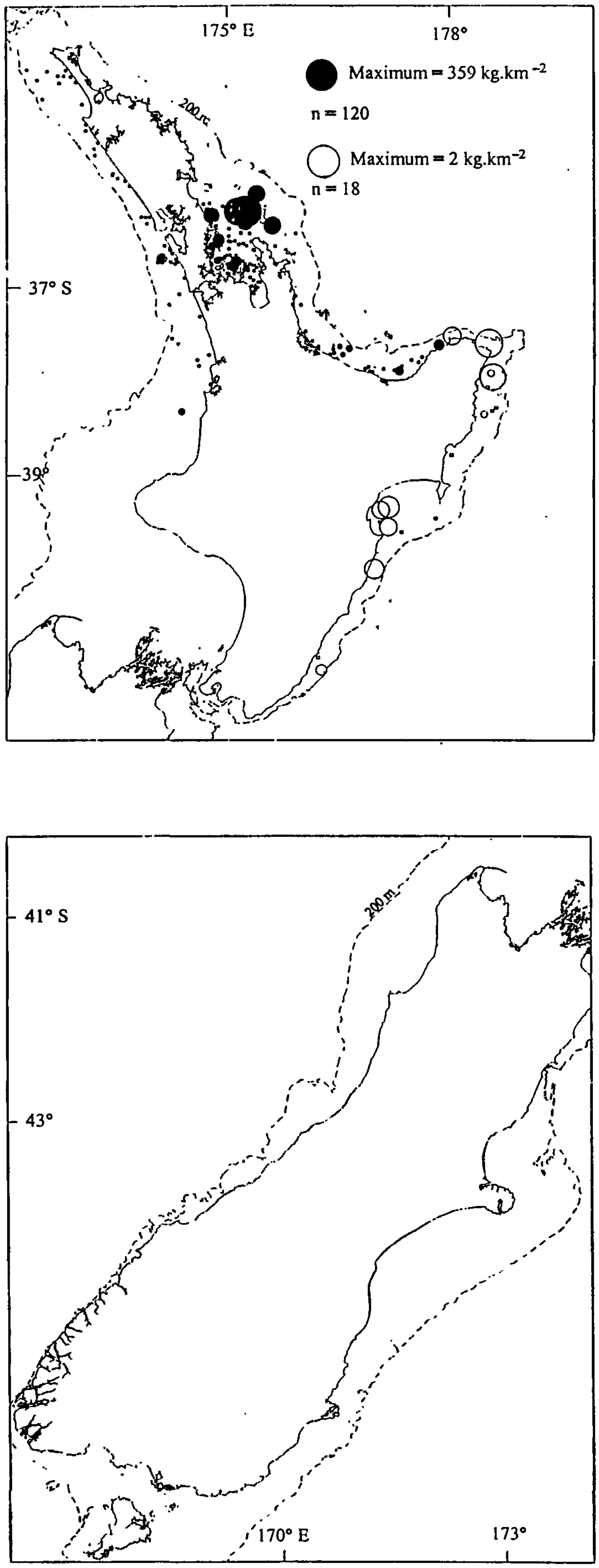


Seriola lalandi

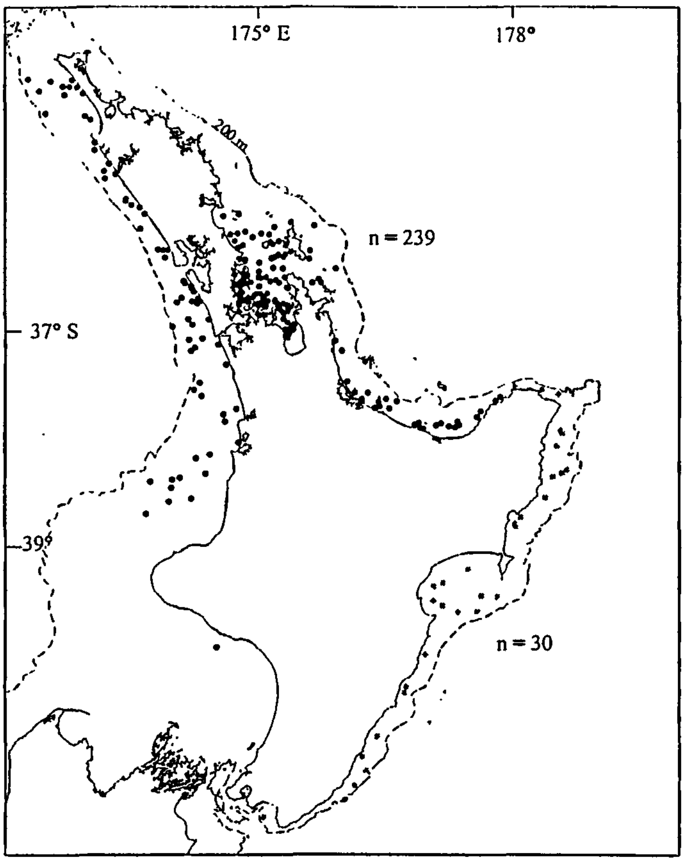


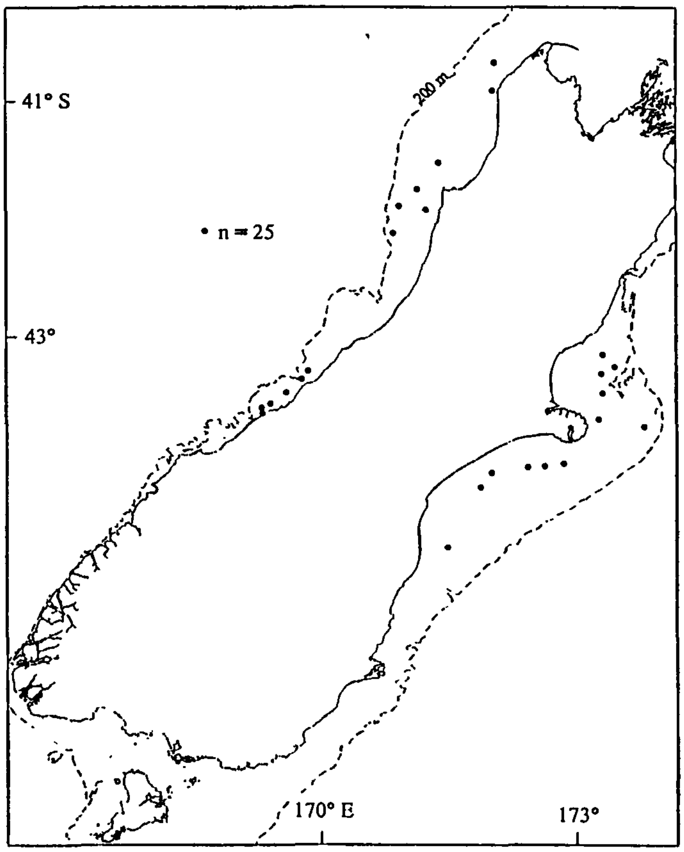


Scomber australasicus

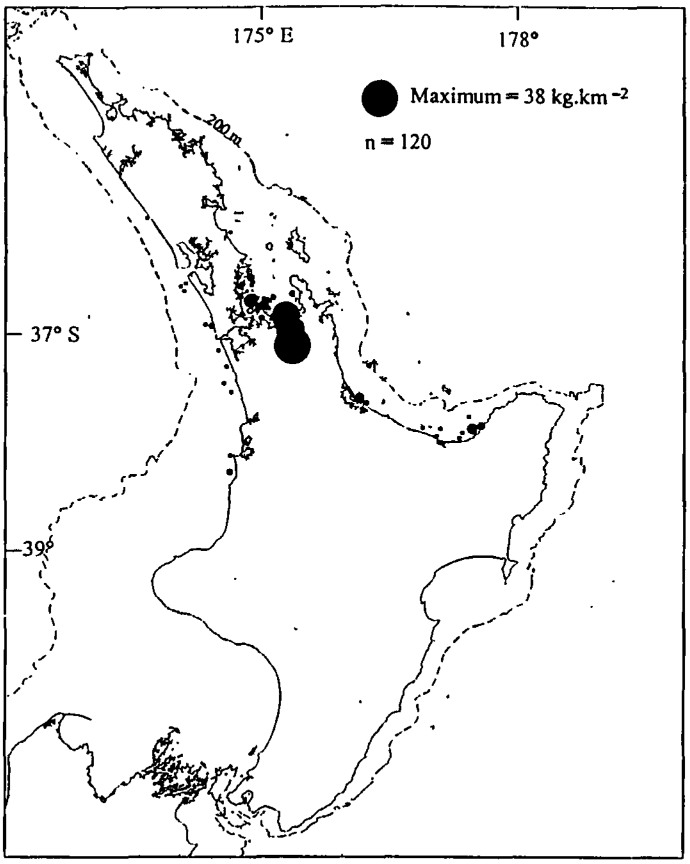


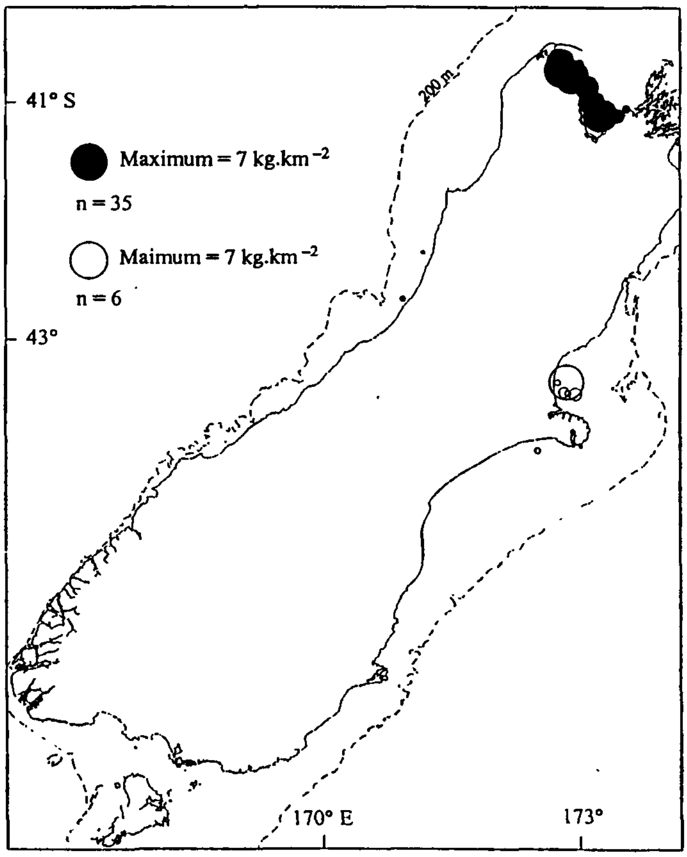
Scomber australasicus



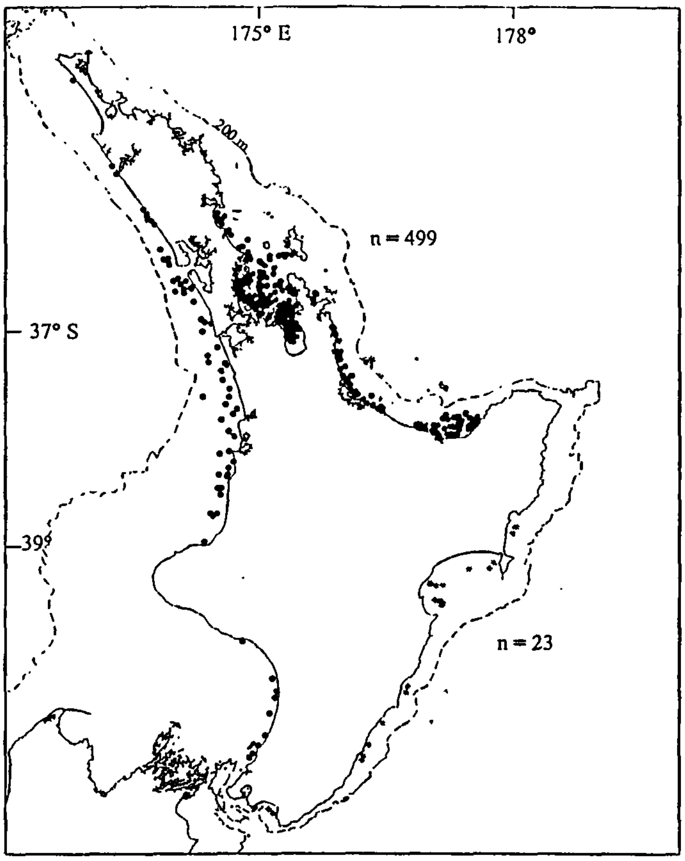


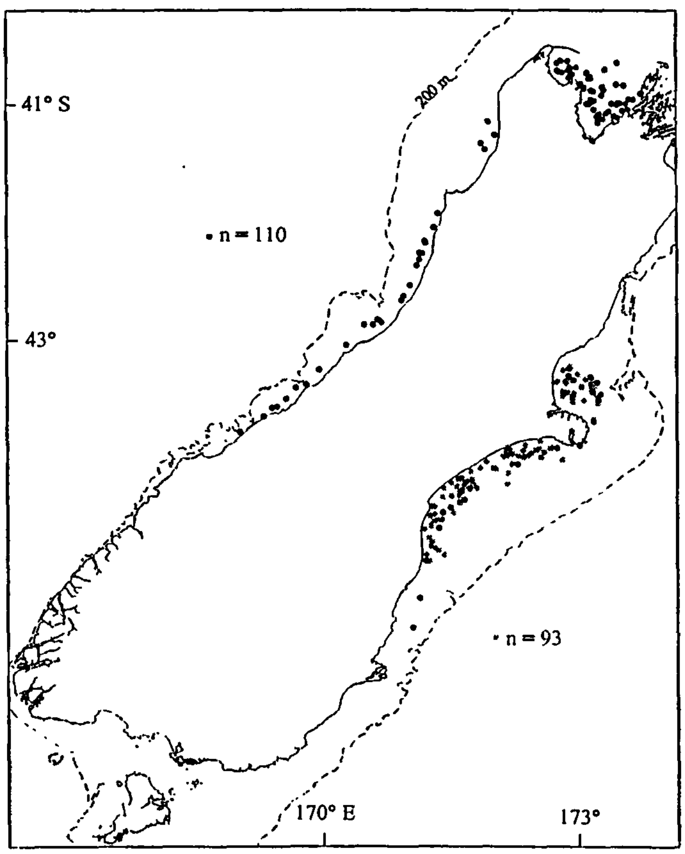
Rhombosolea plebeia



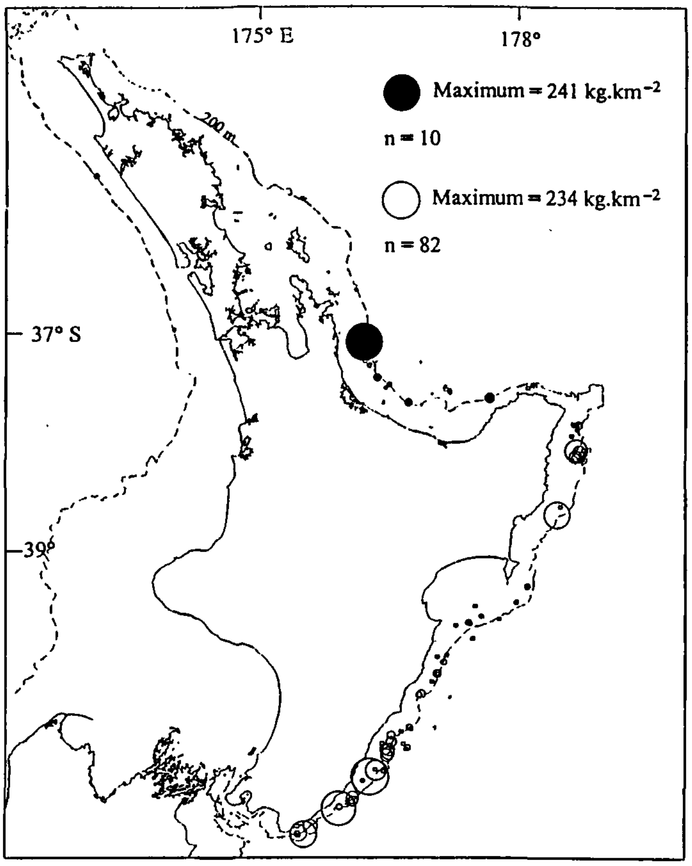


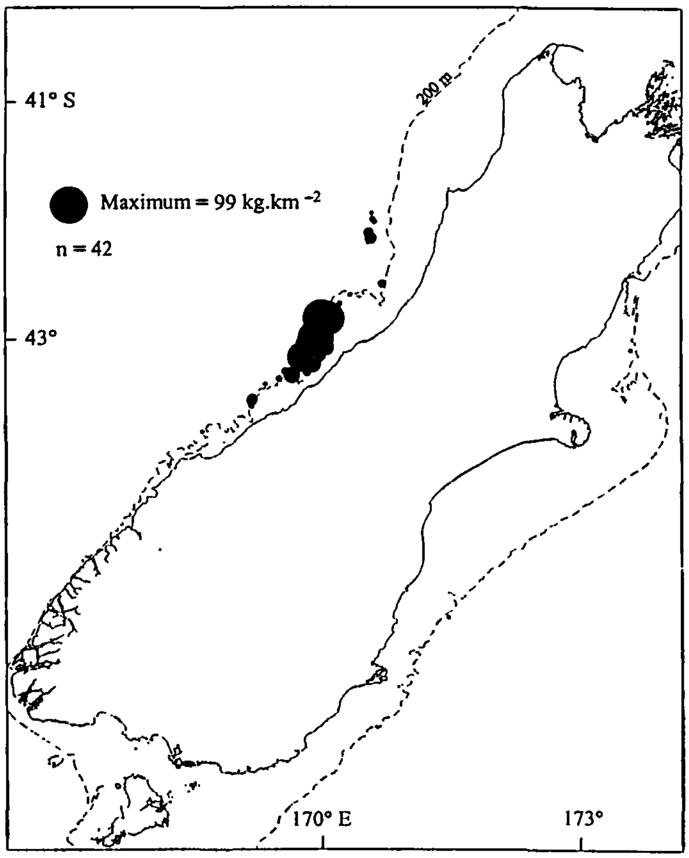
Rhombosolea plebia



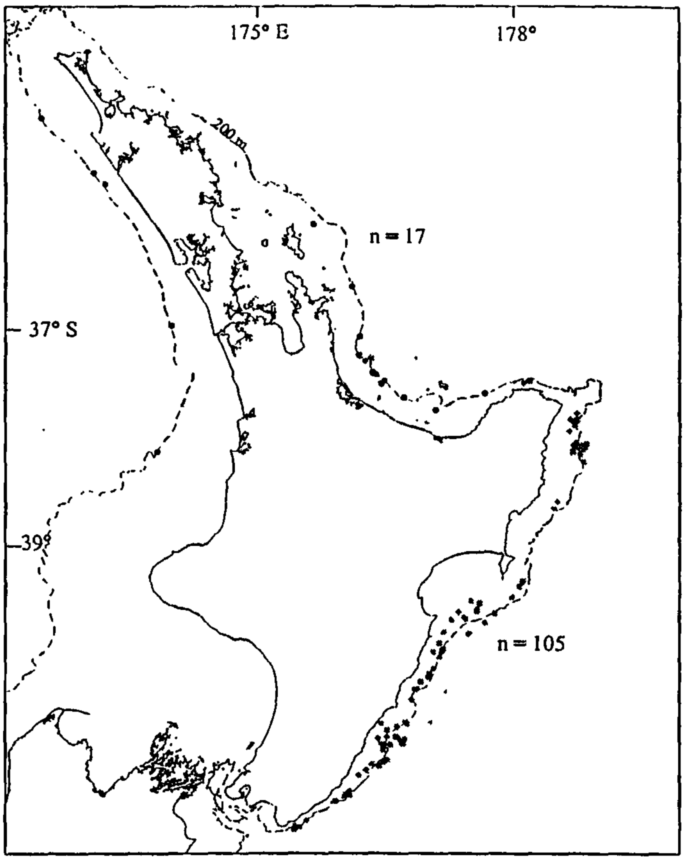


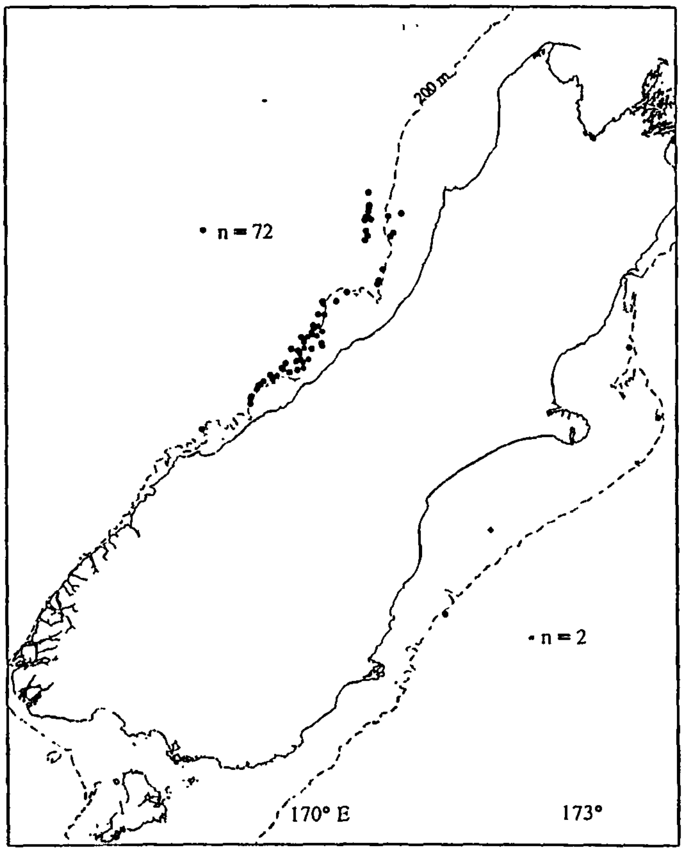
Rexea solandri



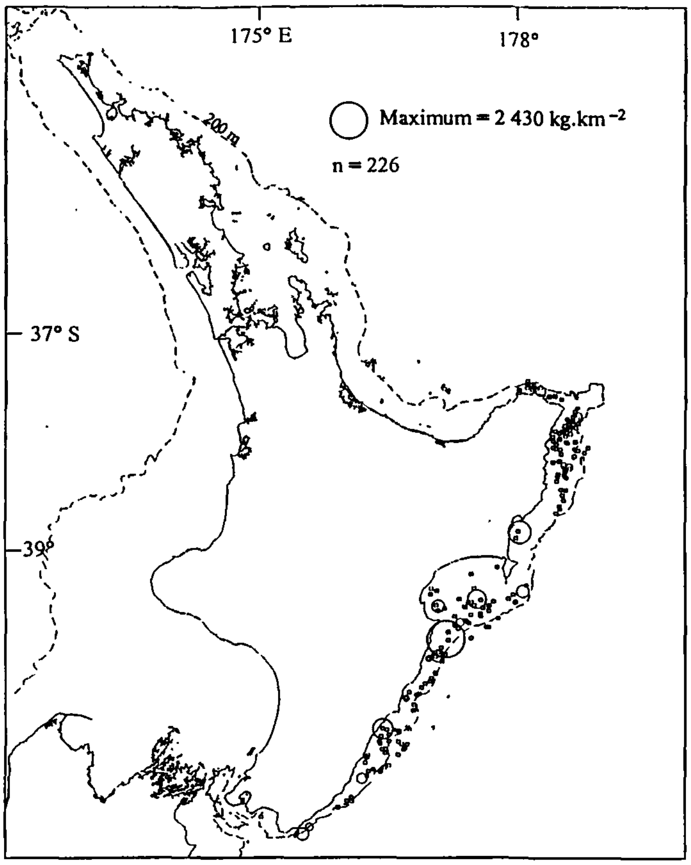


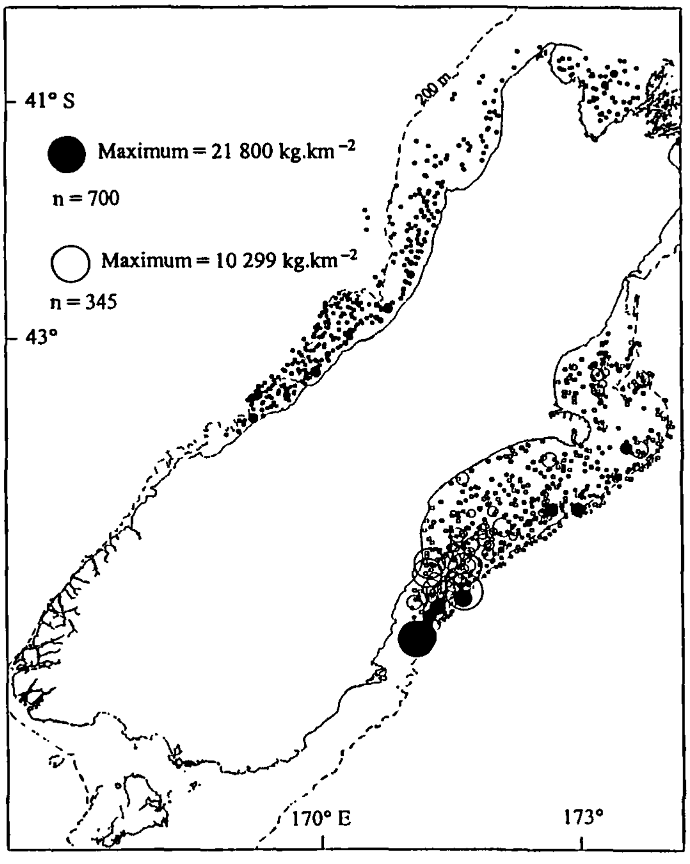
Rexea solandri



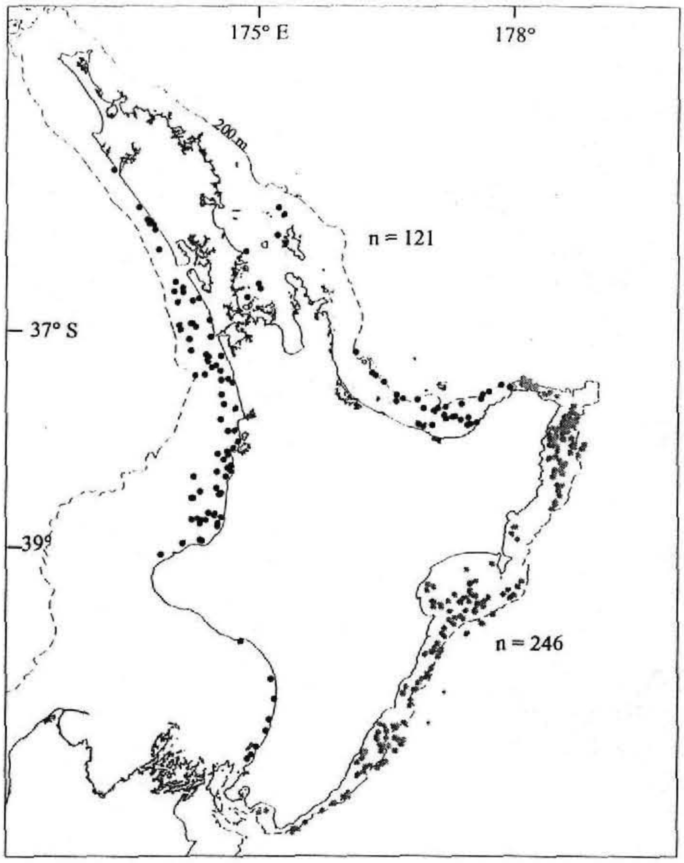


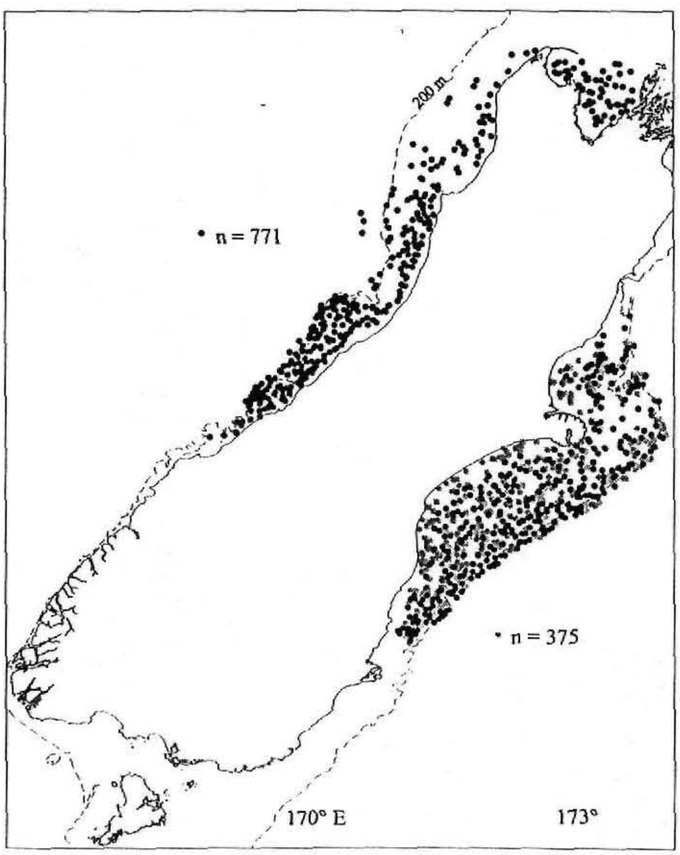
Pseudophycis bachus



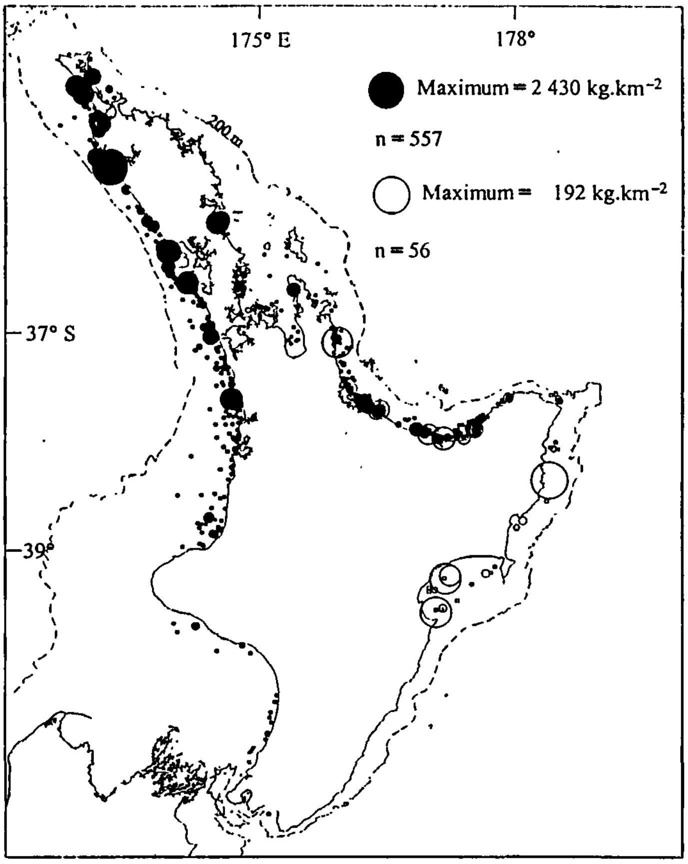


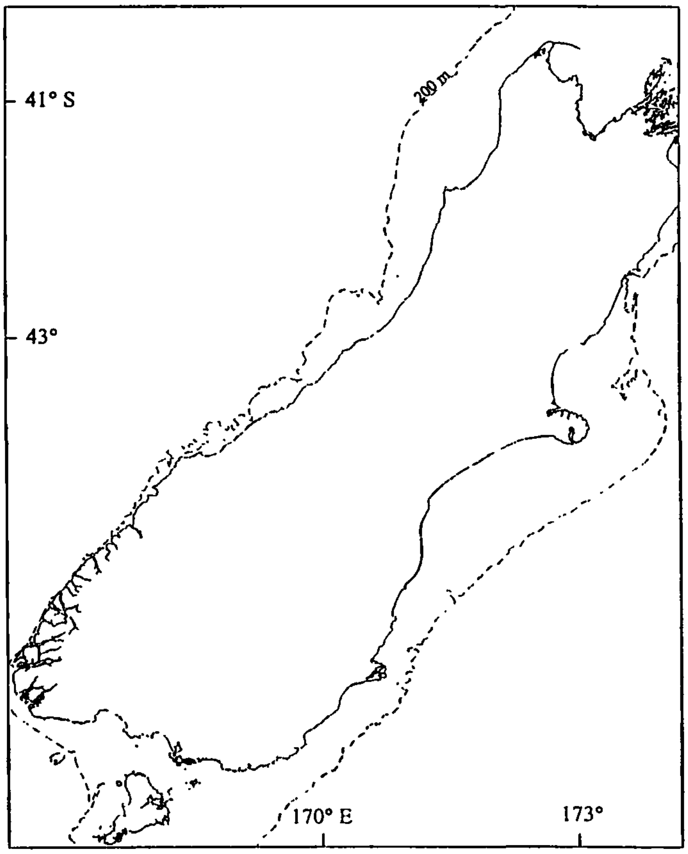
Pseudophycis bachus



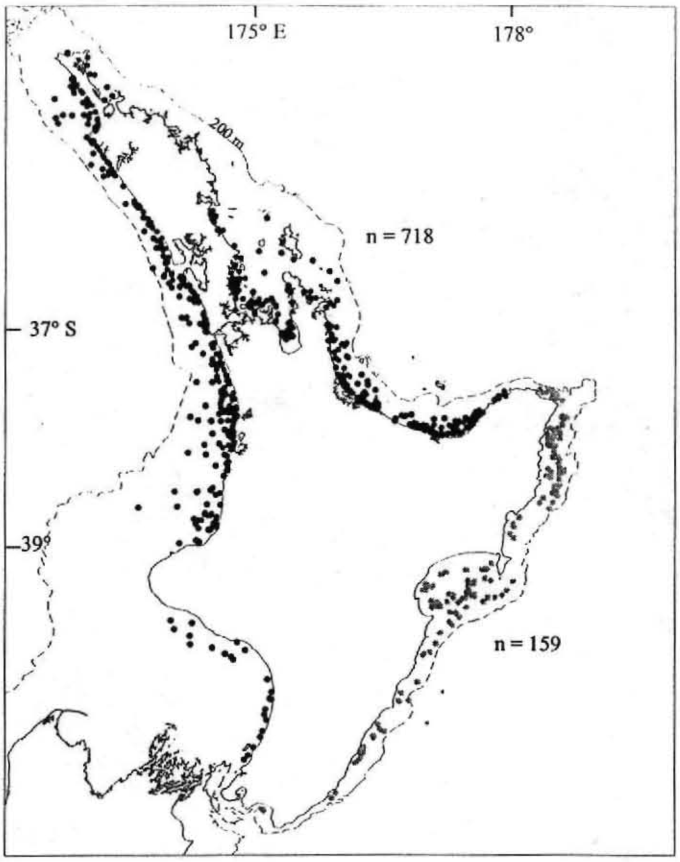


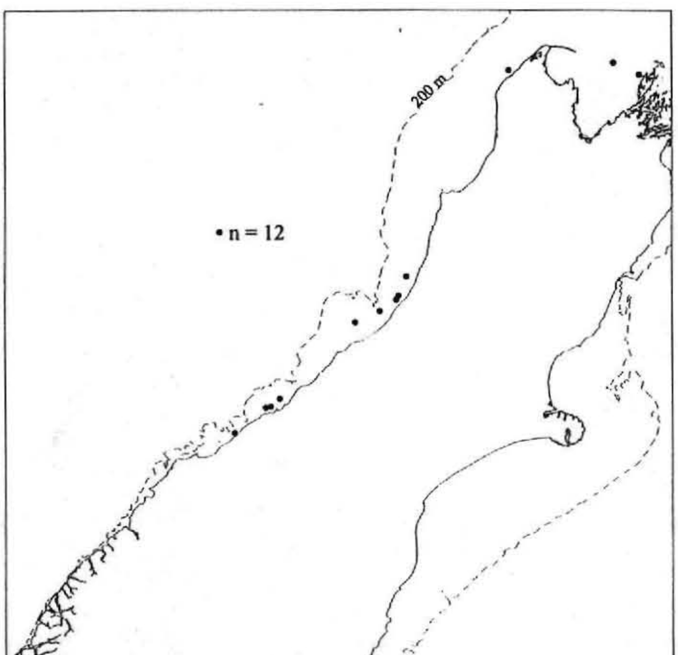
Pseudocaranx dentex



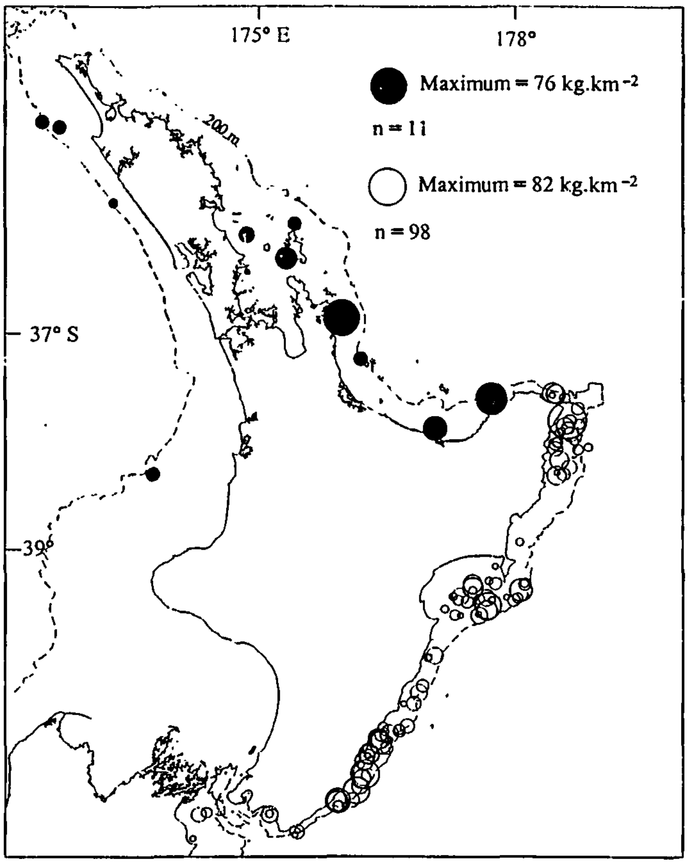


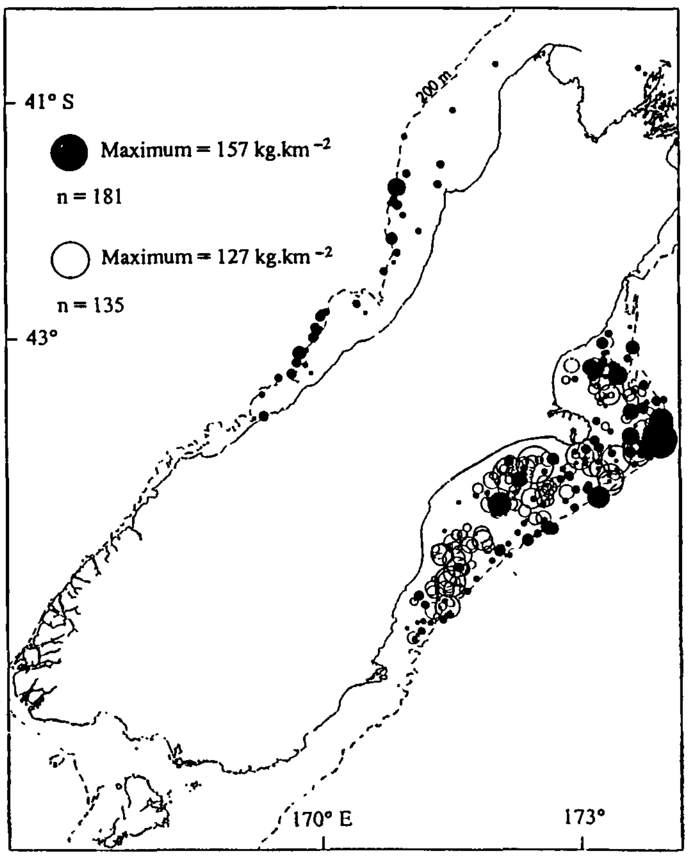
Pseudocaranx dentex



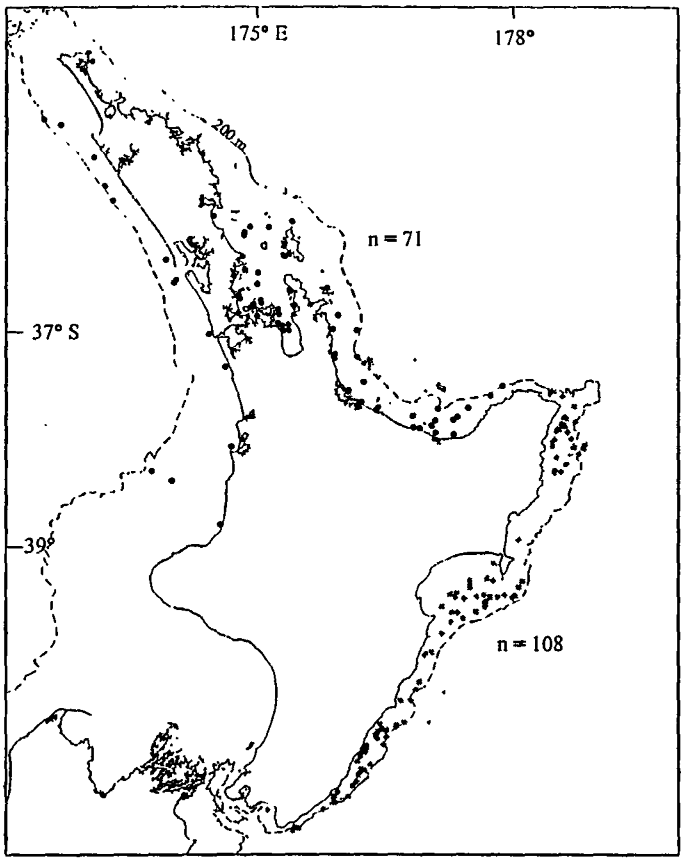


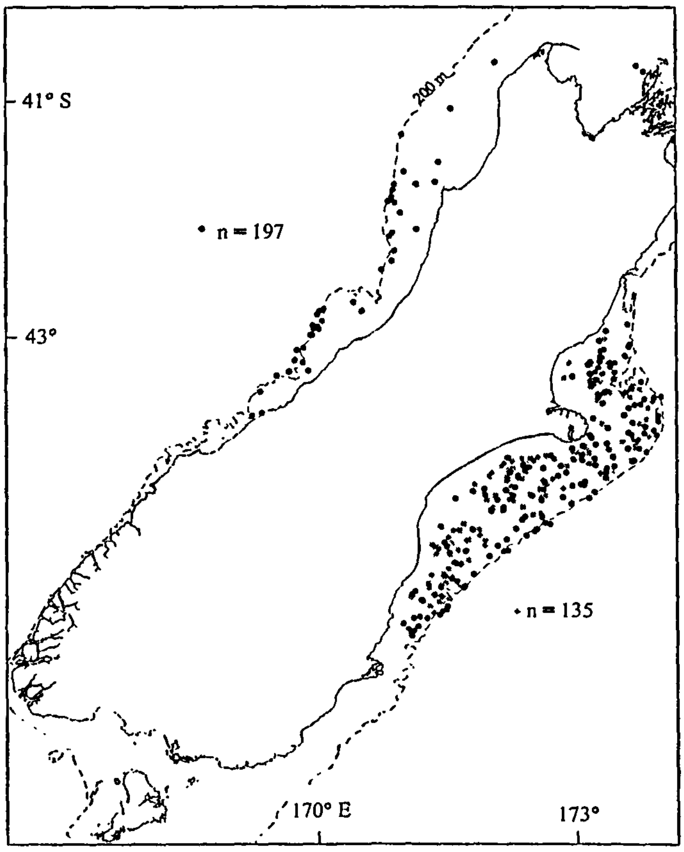
Polyprion oxygeneios



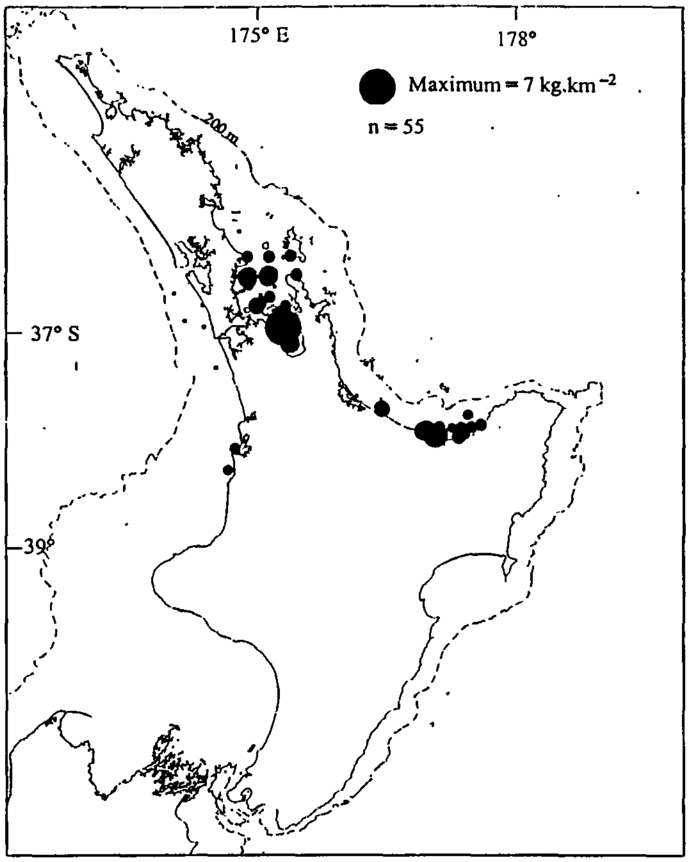


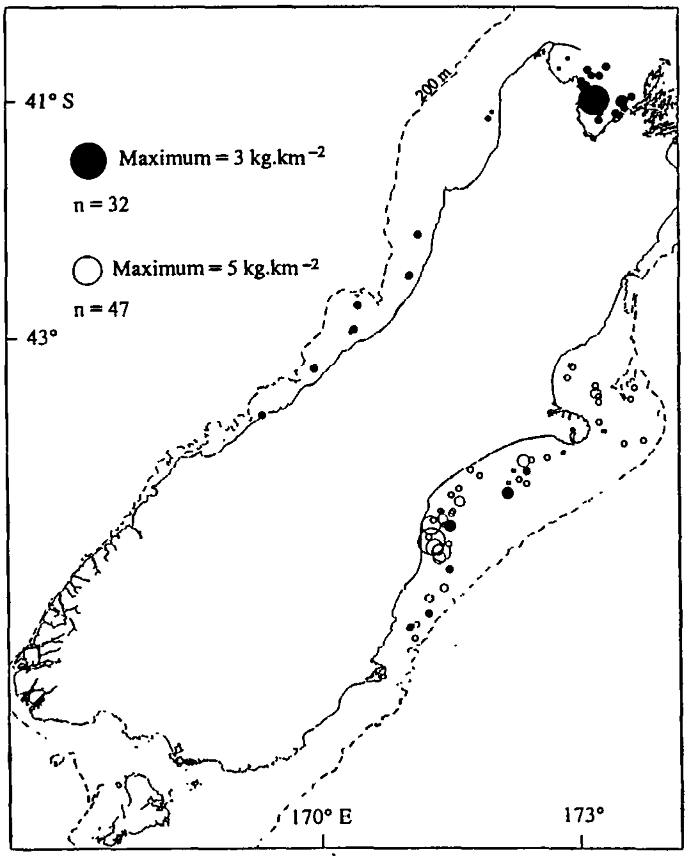
Polyprion oxygeneios



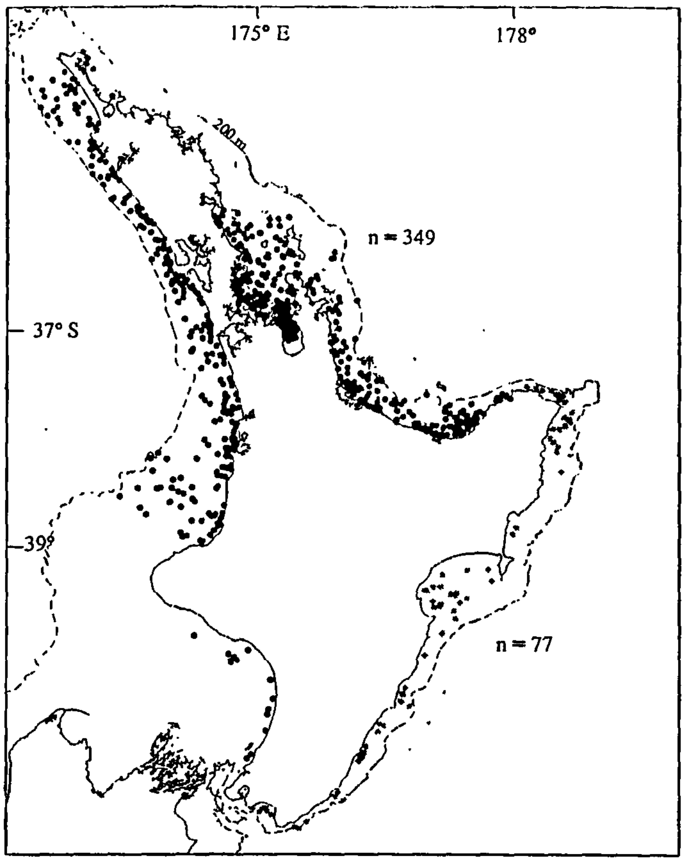


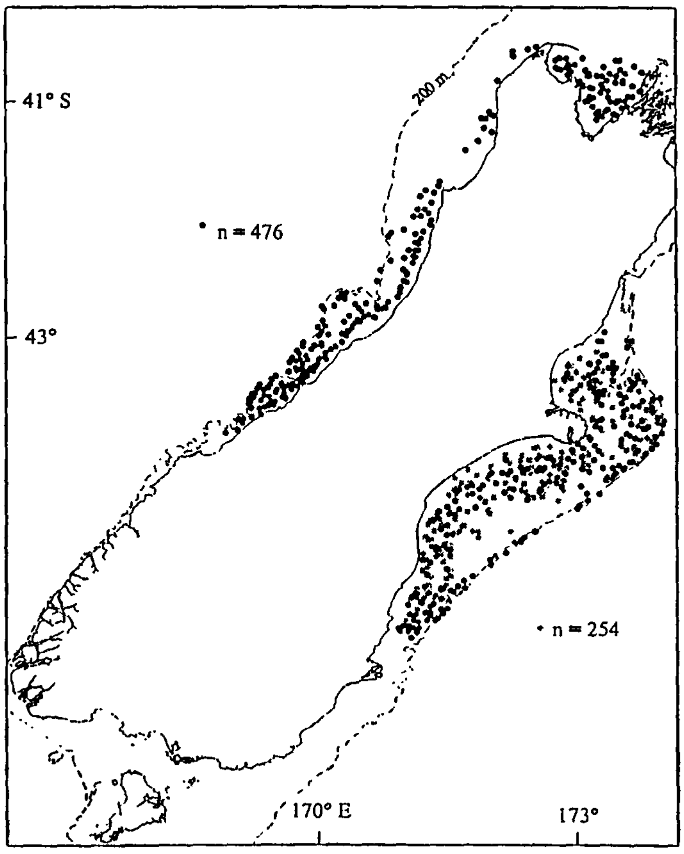
Pelotretis flavilatus



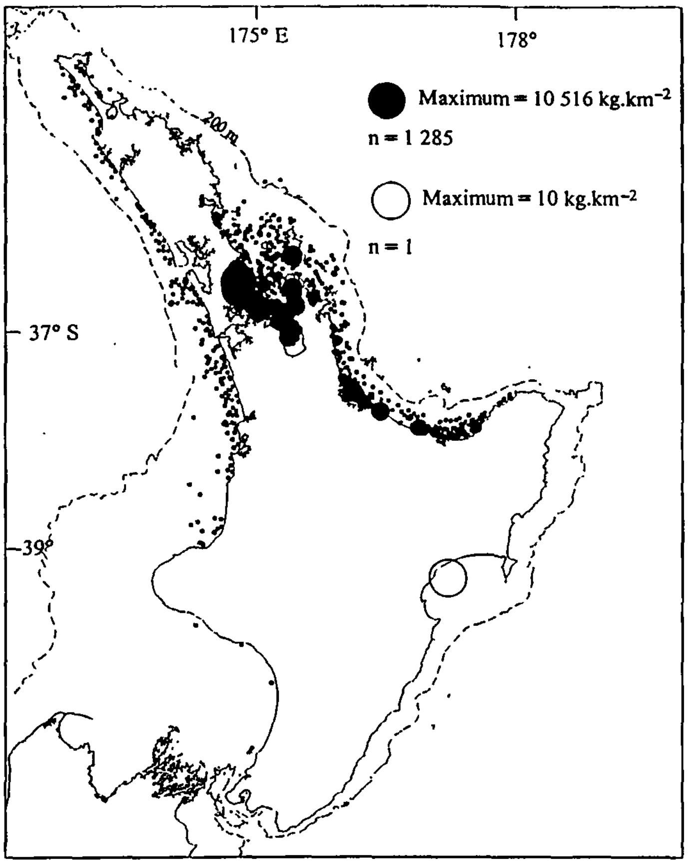


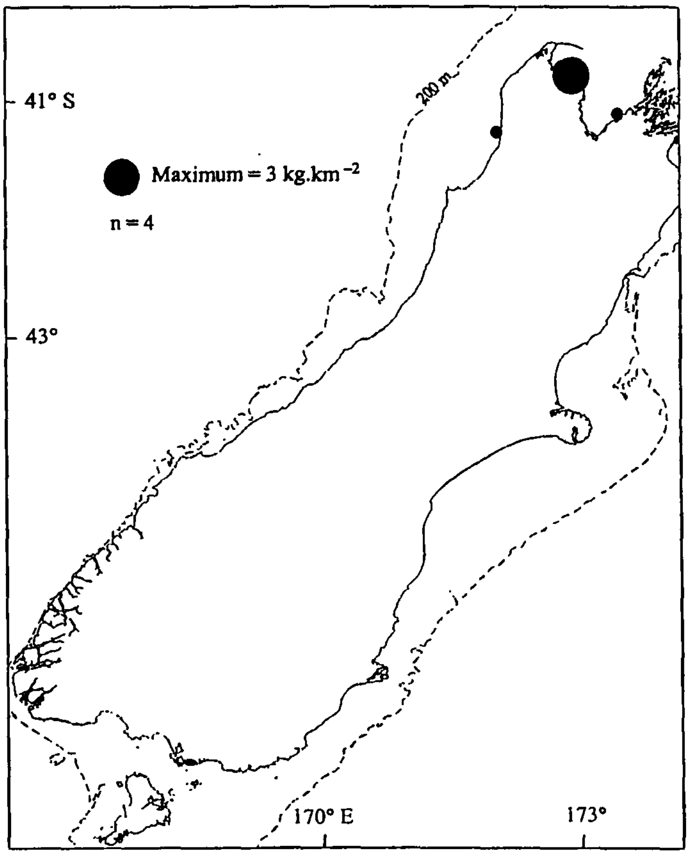
Pelotretis flavilatus



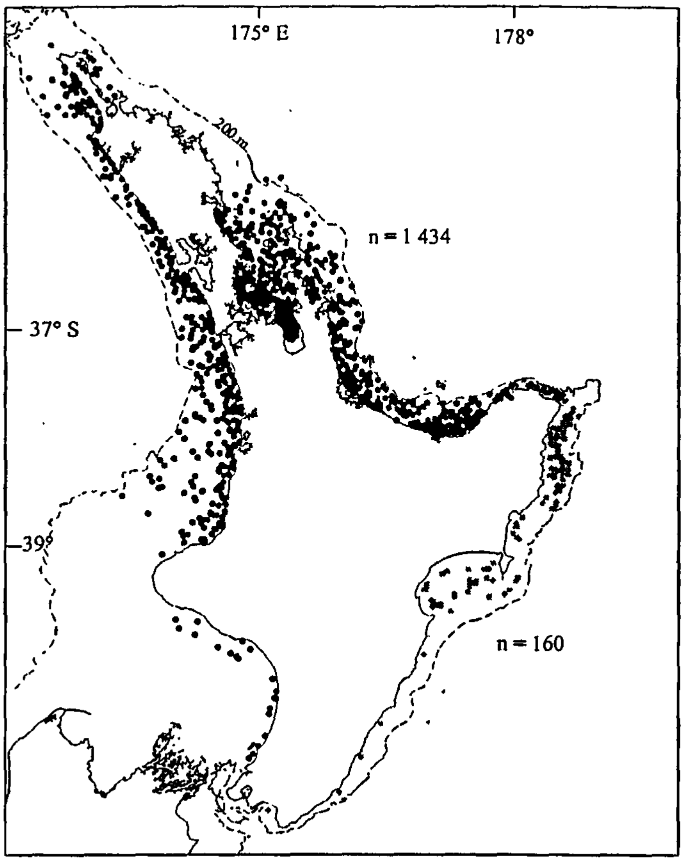


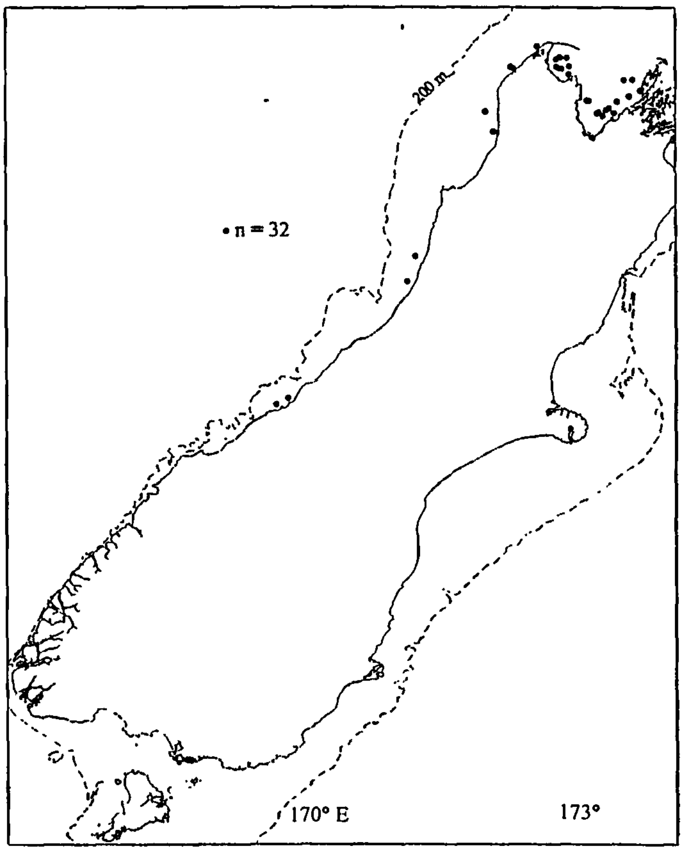
Pagrus auratus



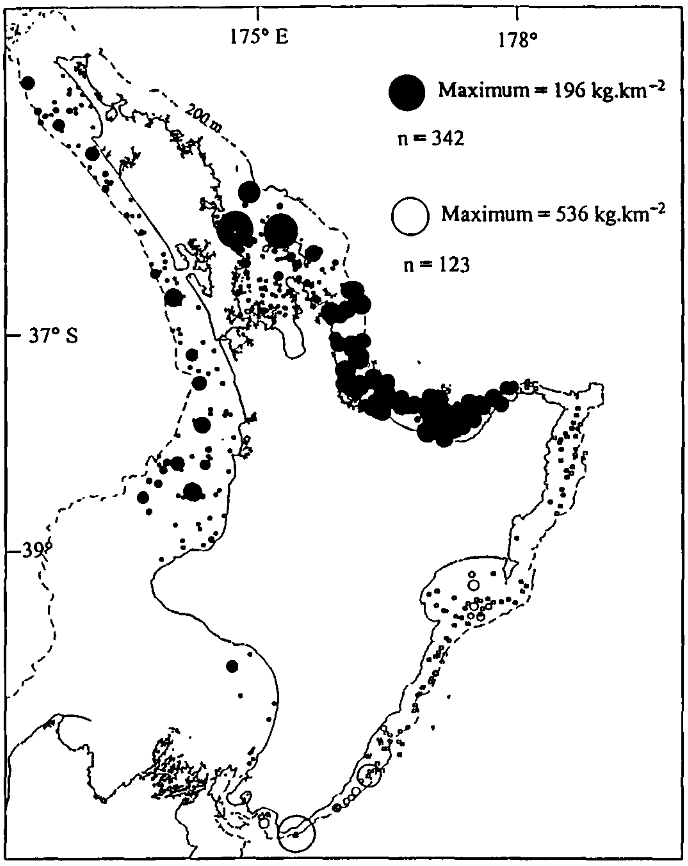


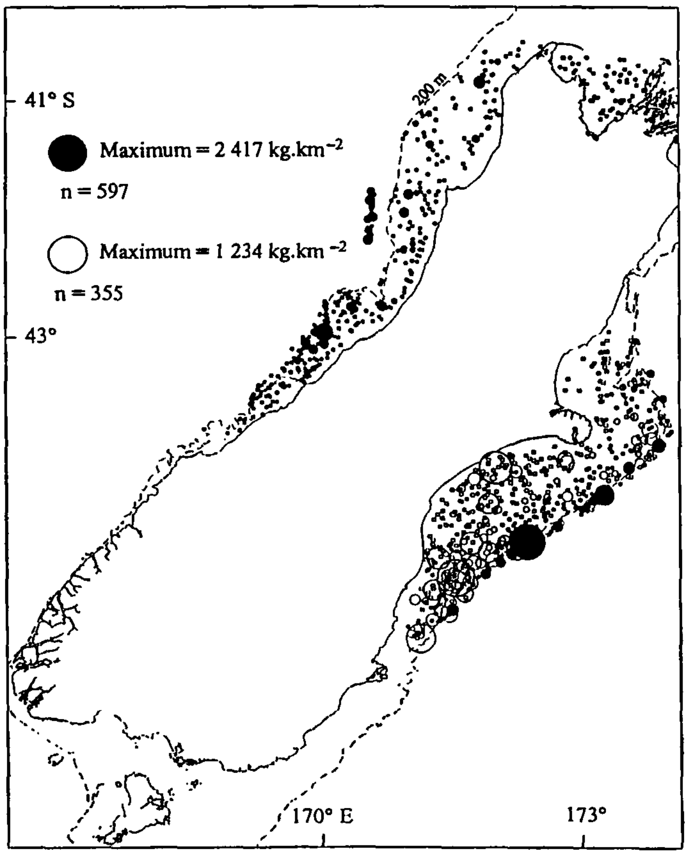
Pagrus auratus



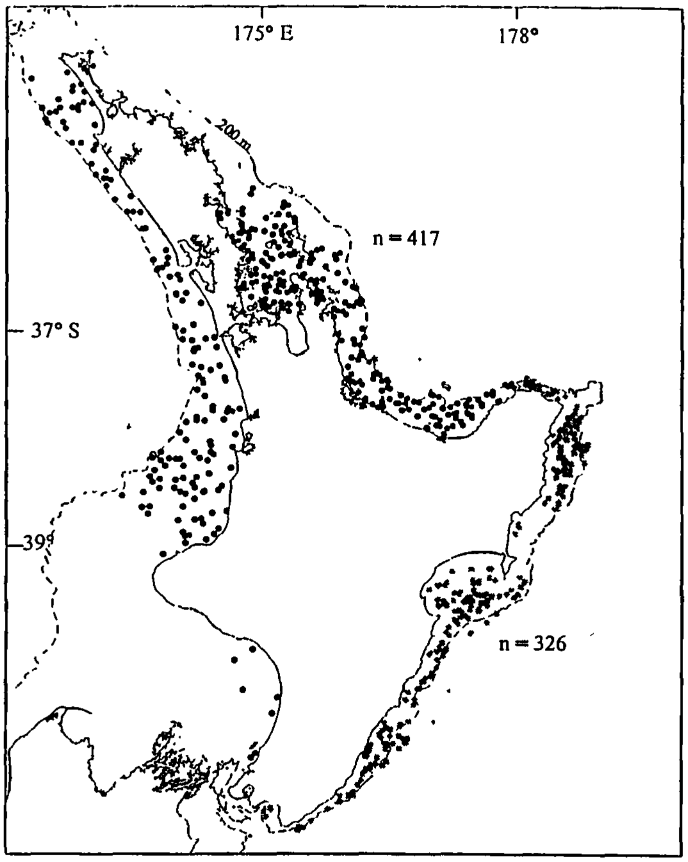


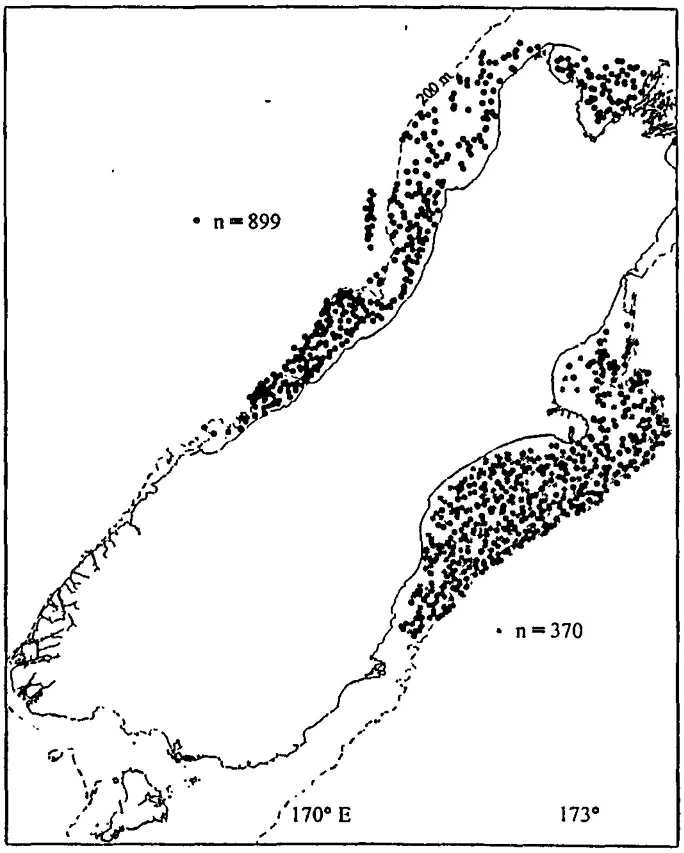
Nototodarus gouldi & N. sloanii



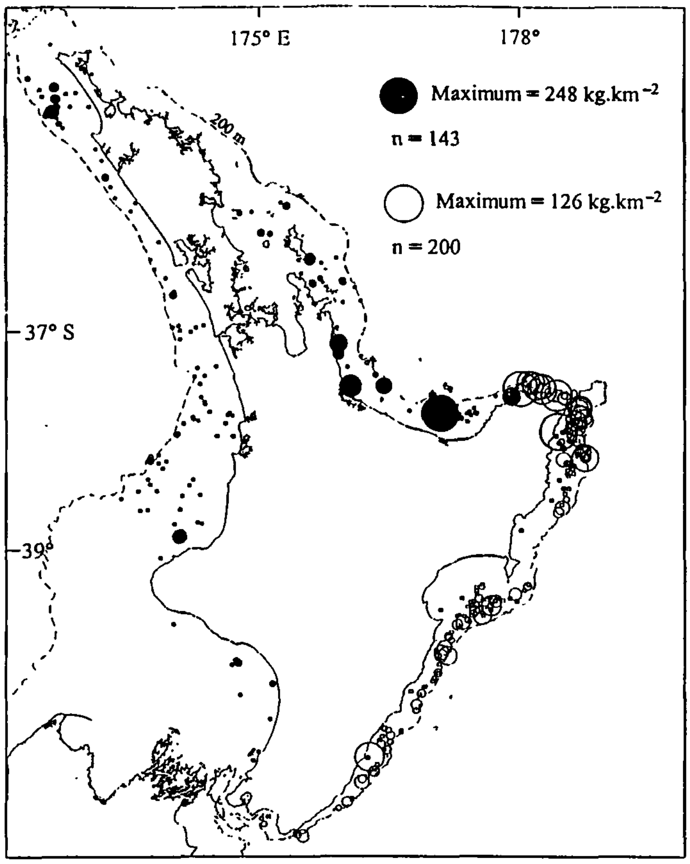


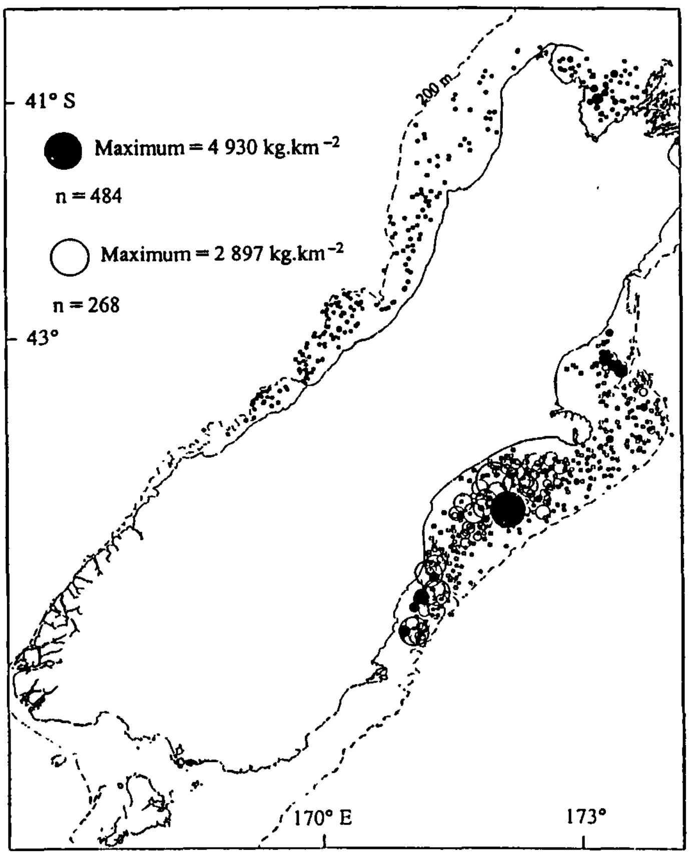
Nototodarus gouldi & N. sloanii



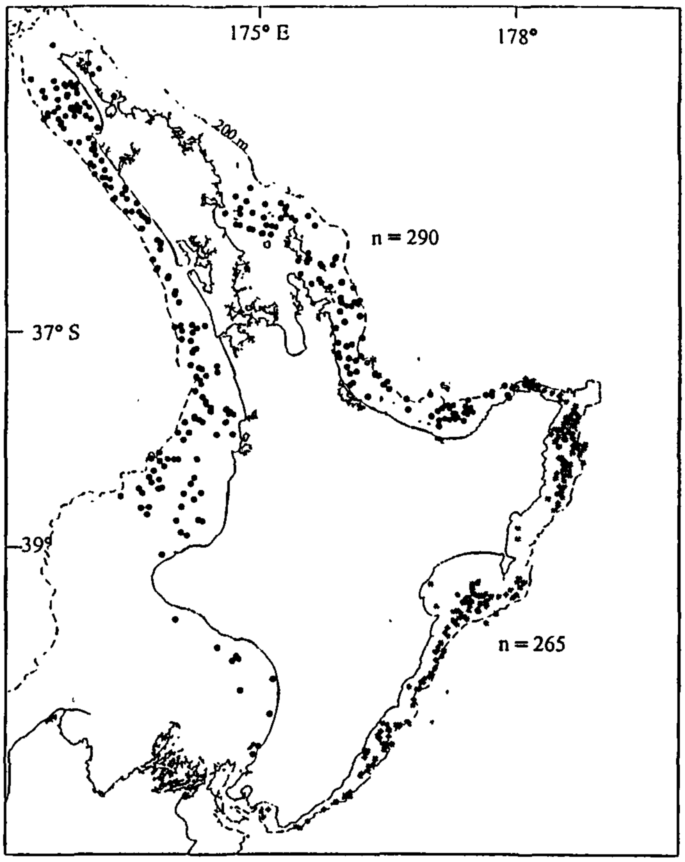


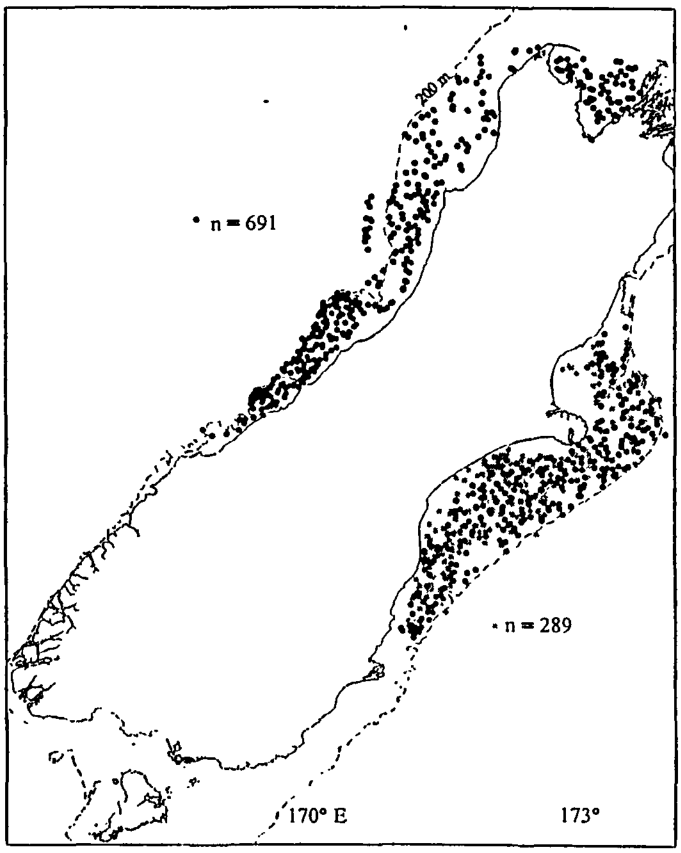
Nemadactylus macropterus



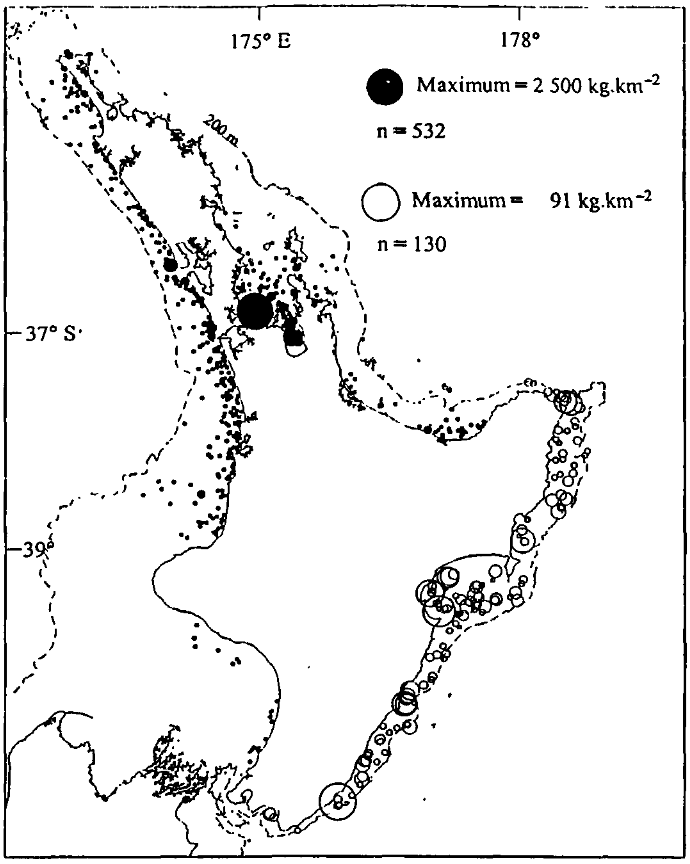


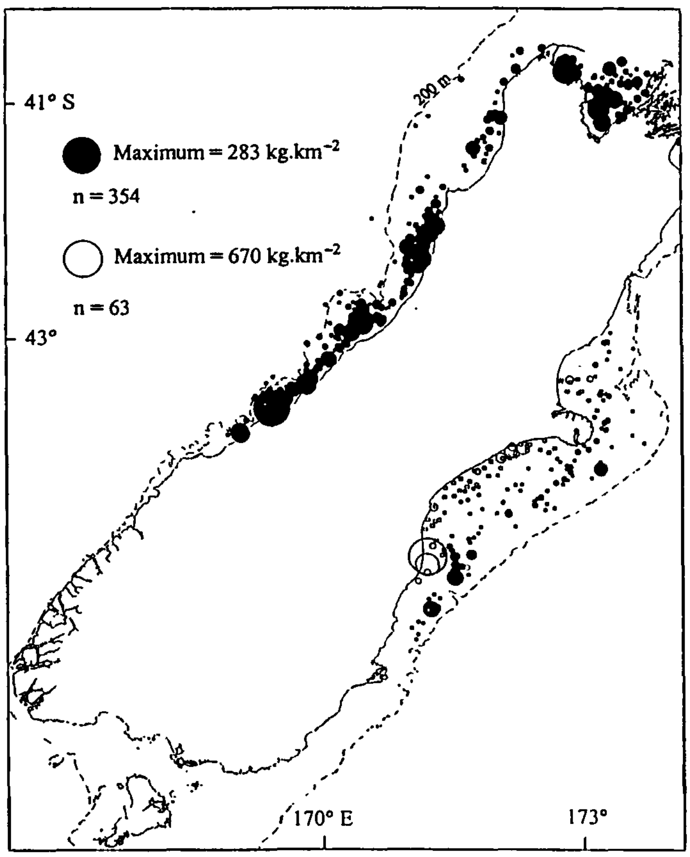
Nemadactylus macropterus



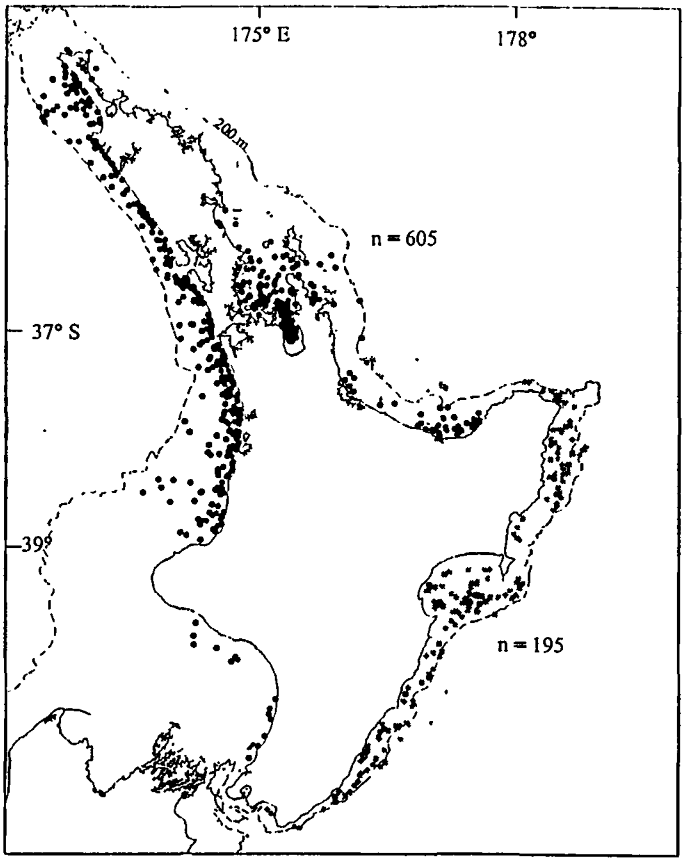


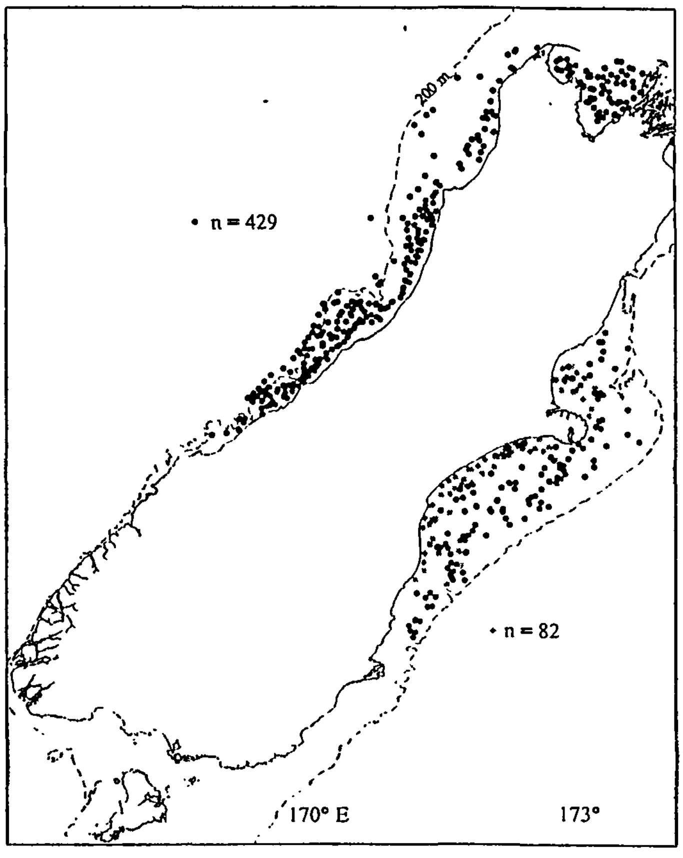
Mustelus lenticulatus



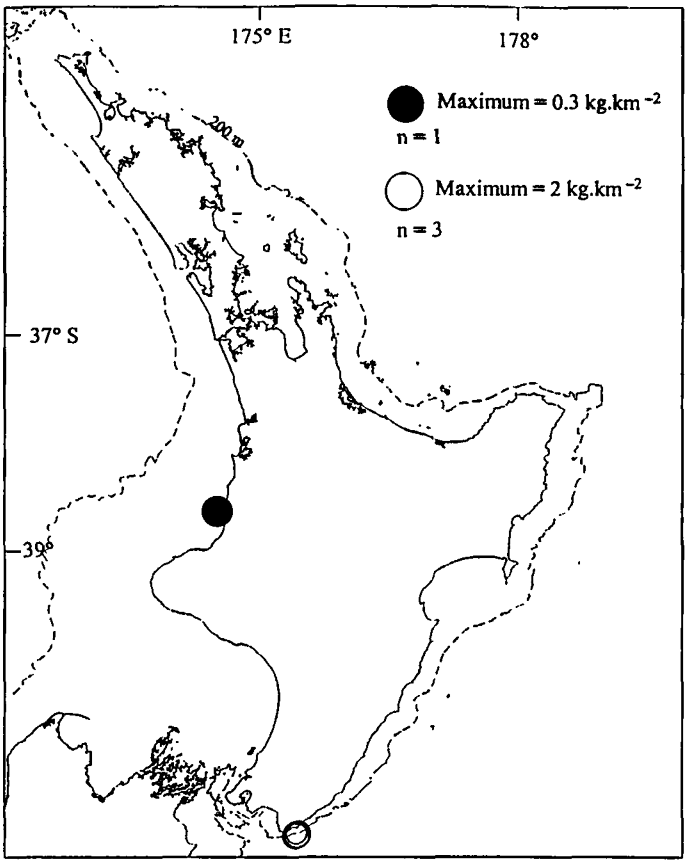


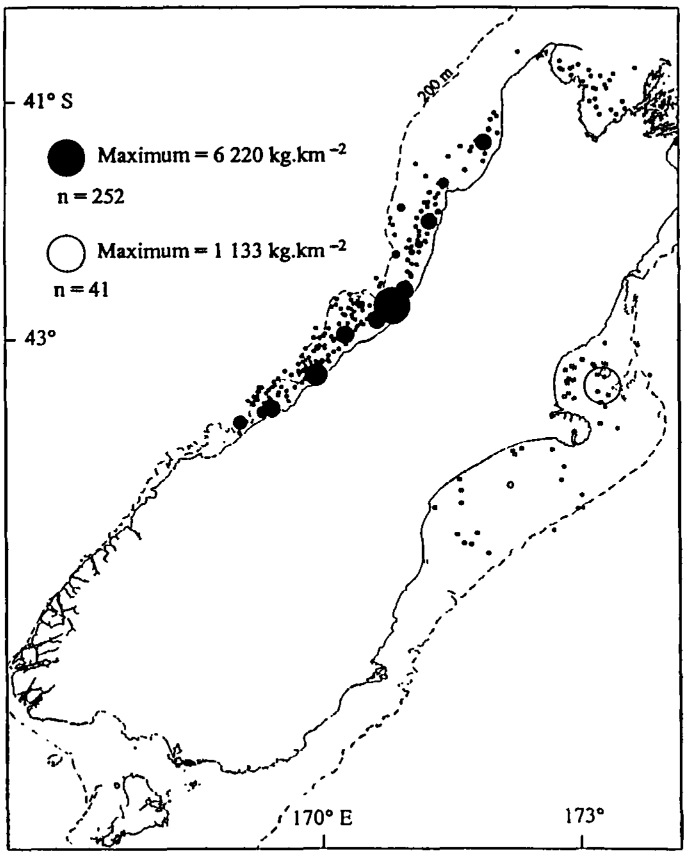
Mustelus lenticulatus



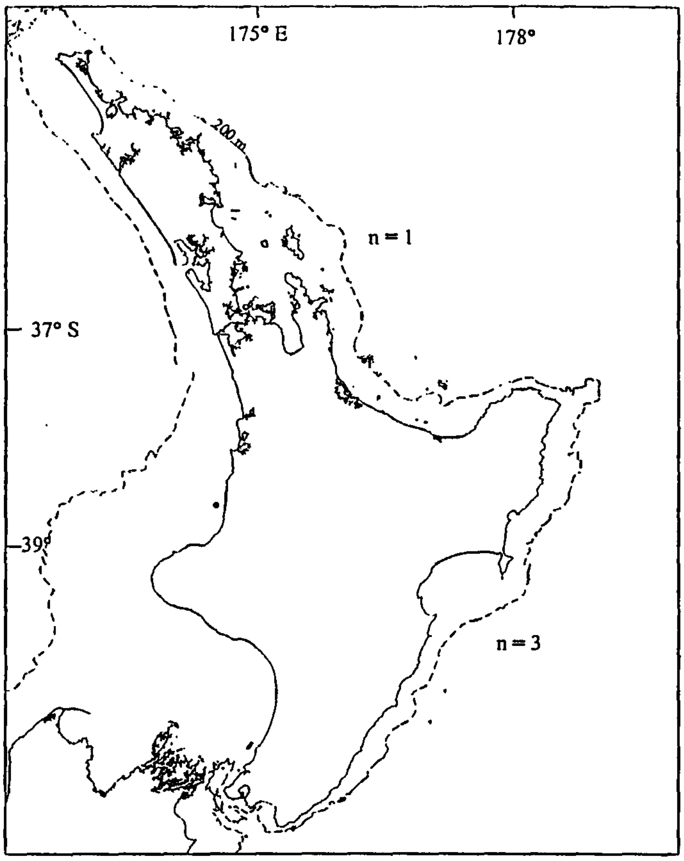


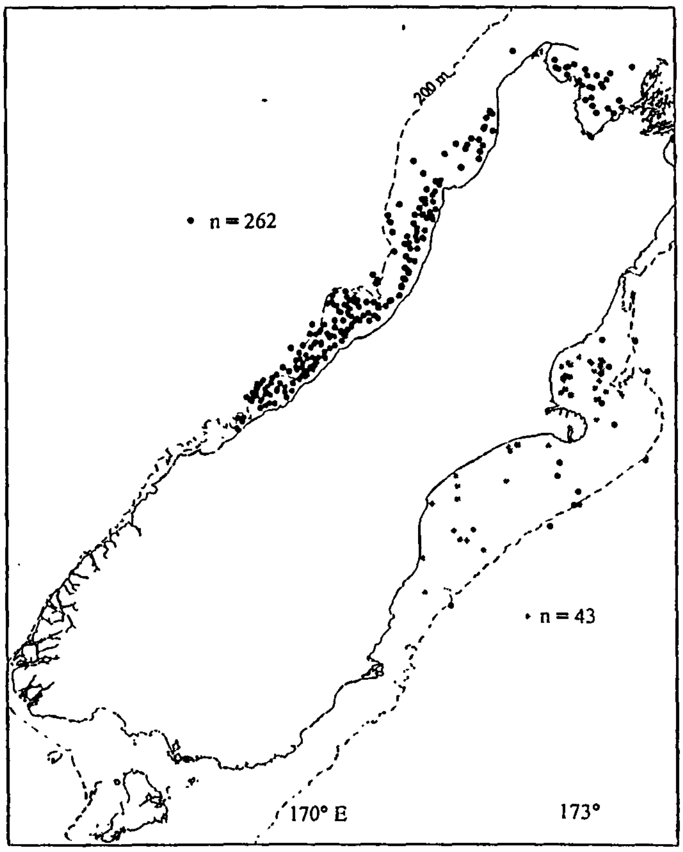
Merluccius australis



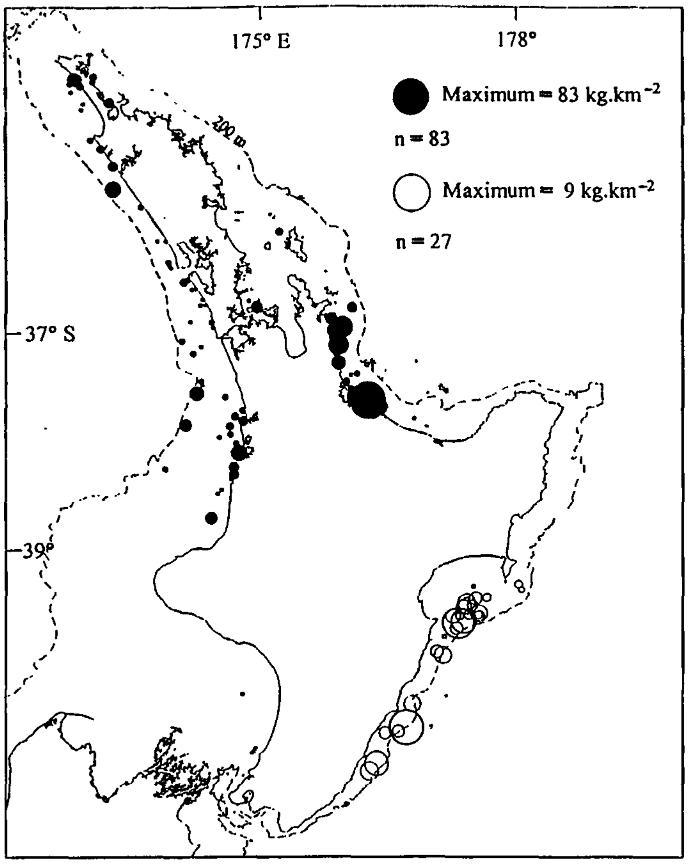


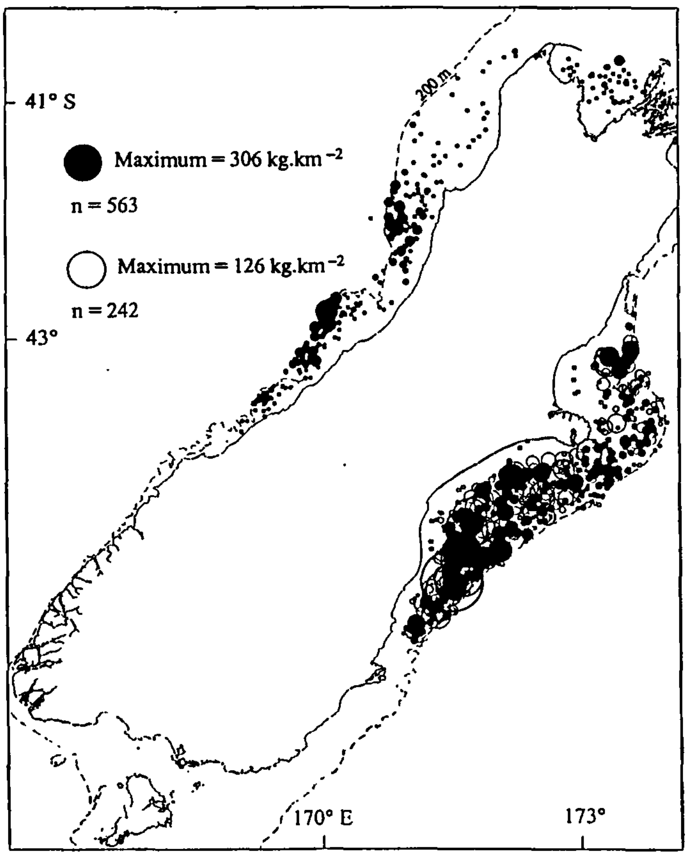
Merluccius australis



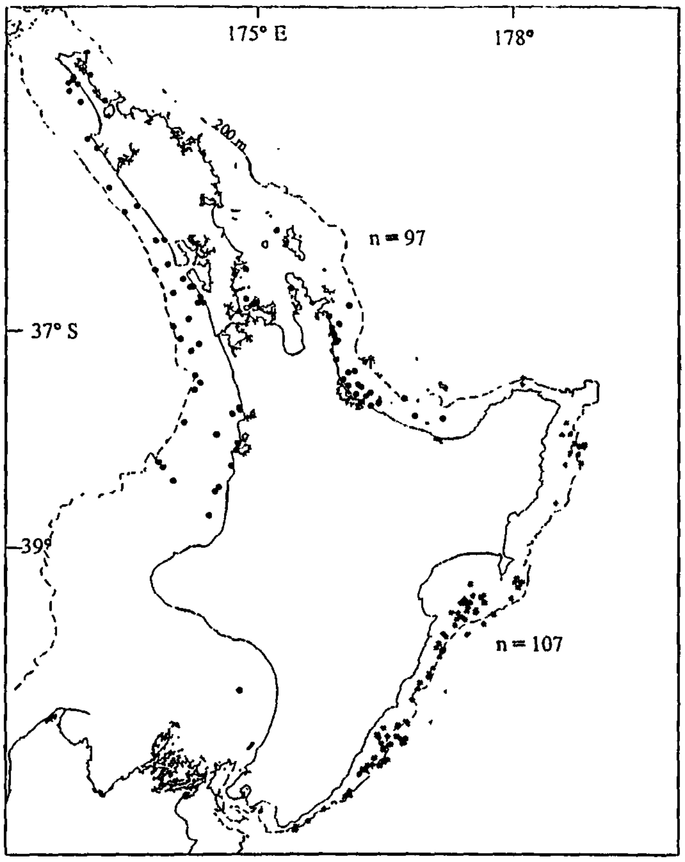


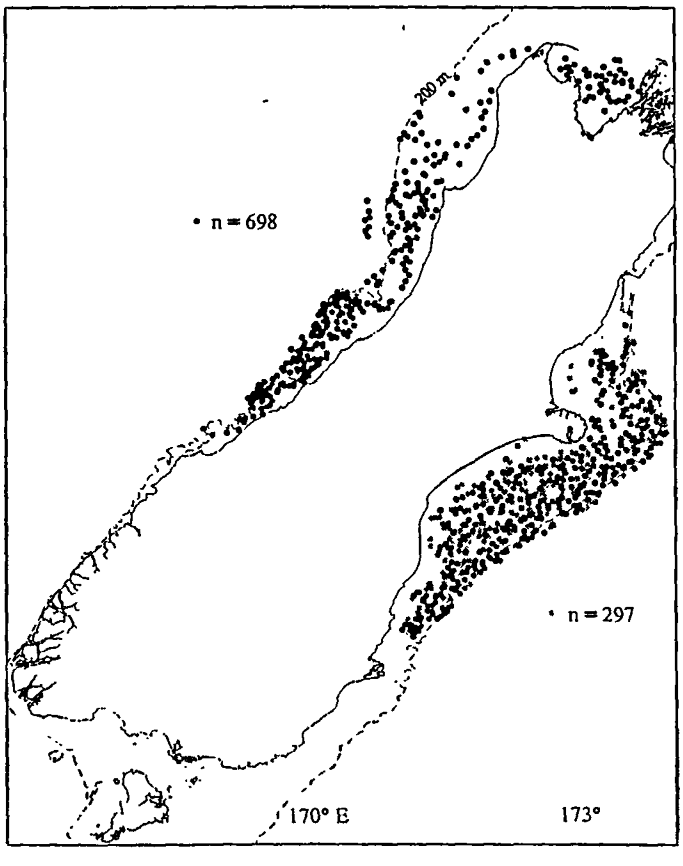
Kathetostoma giganteum



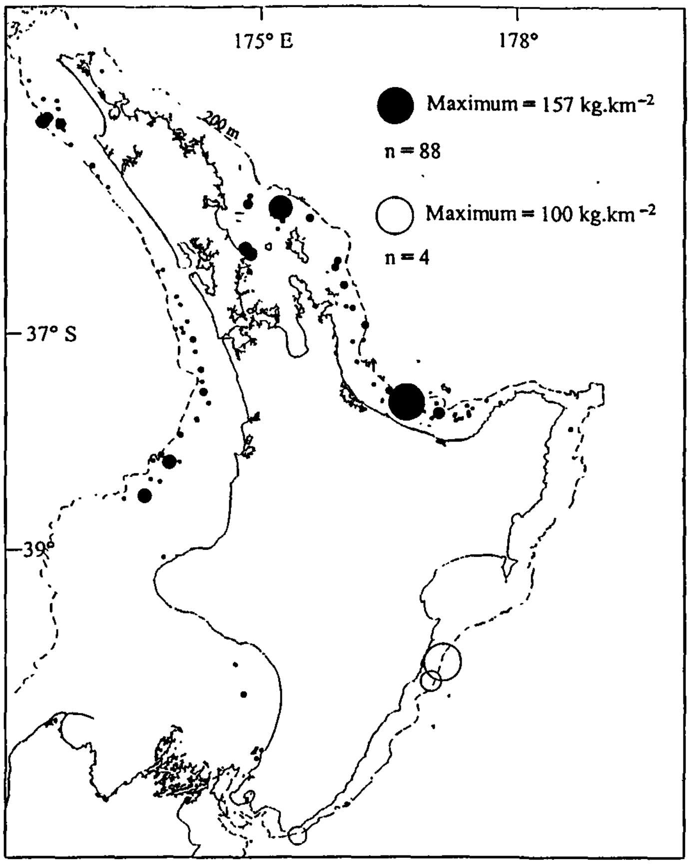


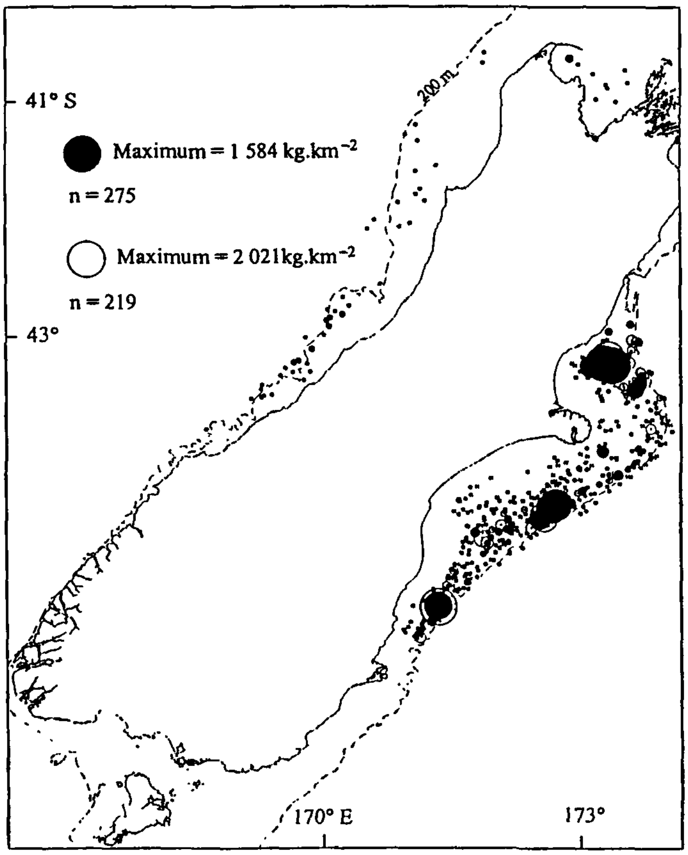
Kathetostoma giganteum



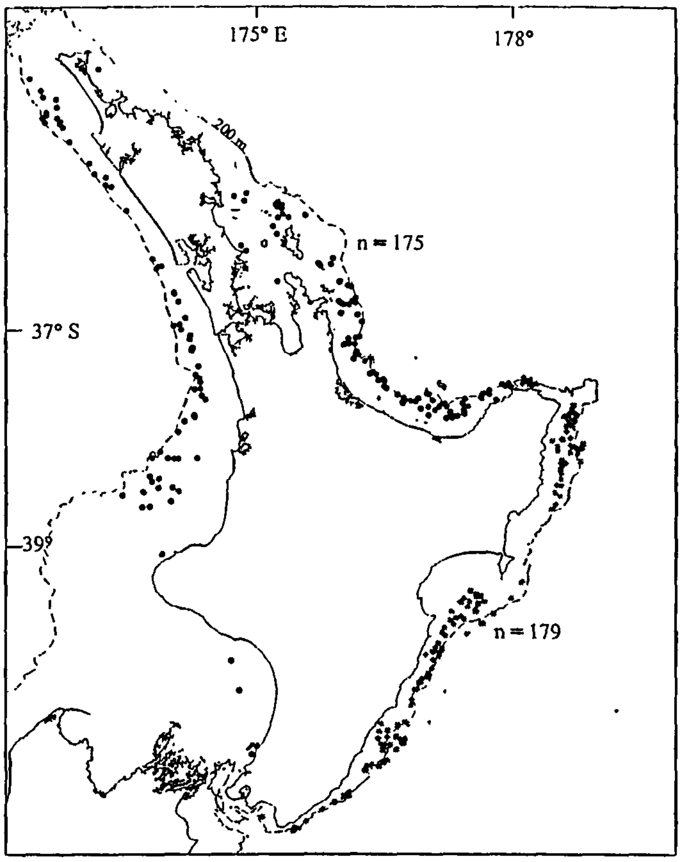


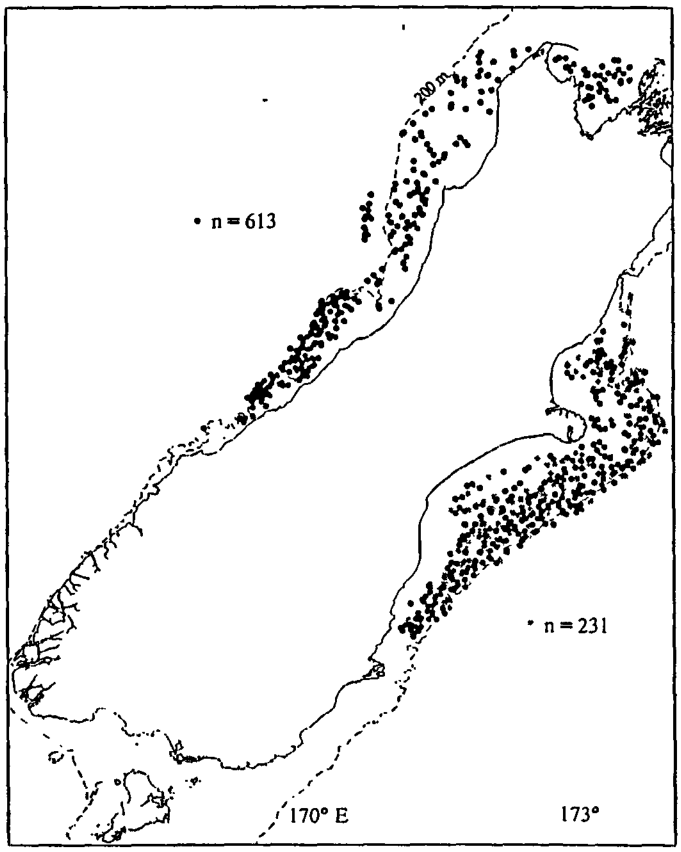
Helicolenus percoides



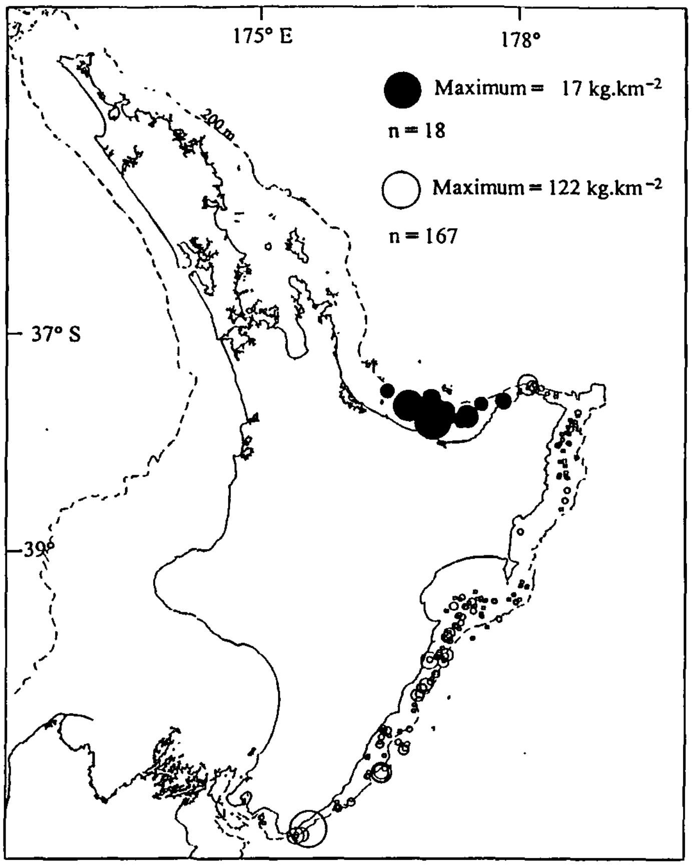


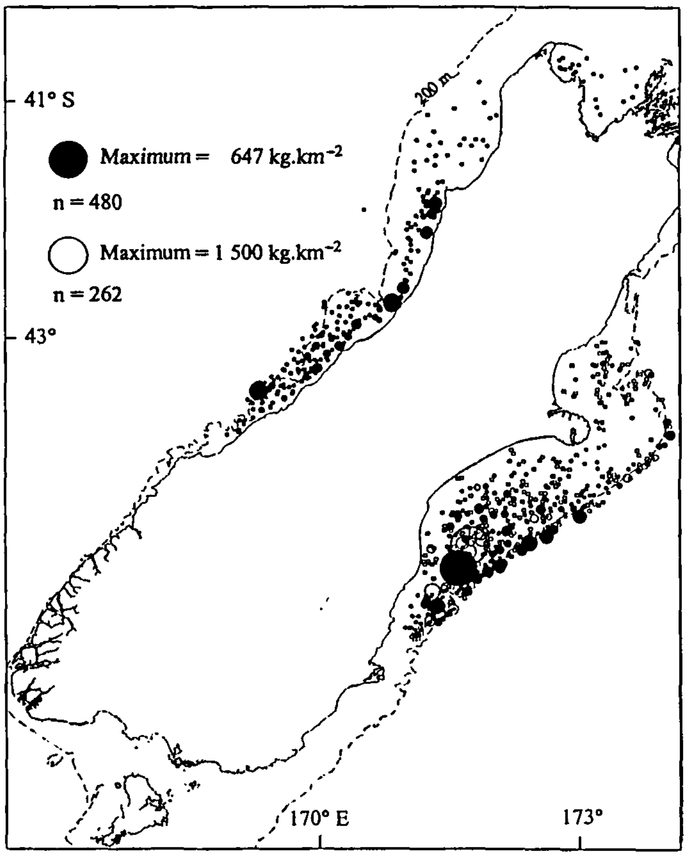
Helicolenus percoides



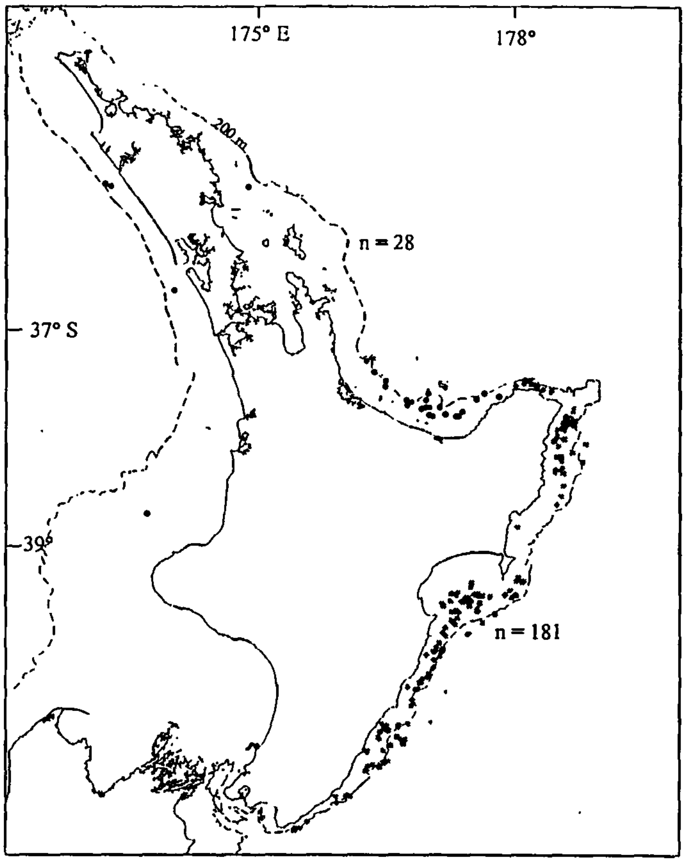


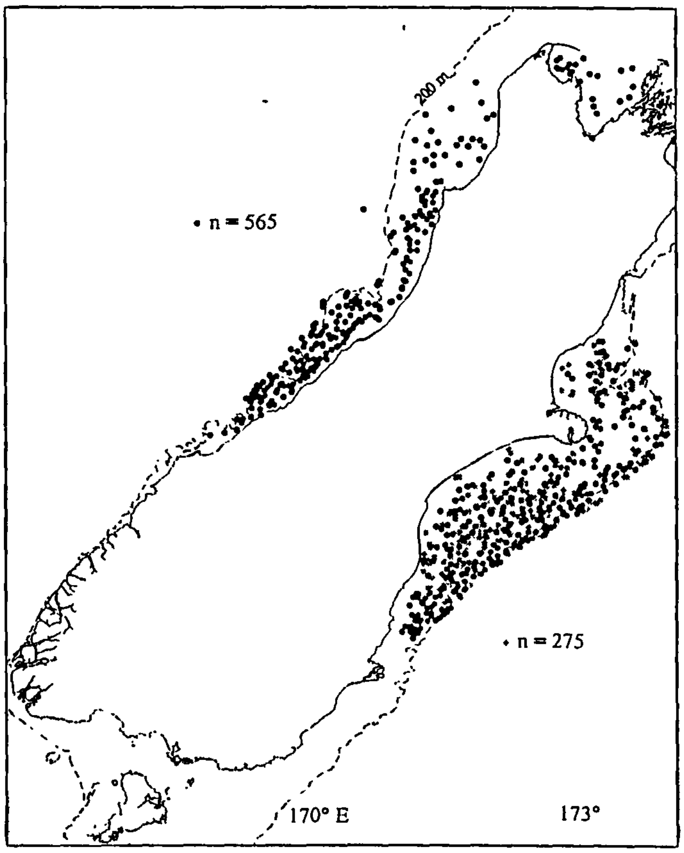
Genypterus blacodes



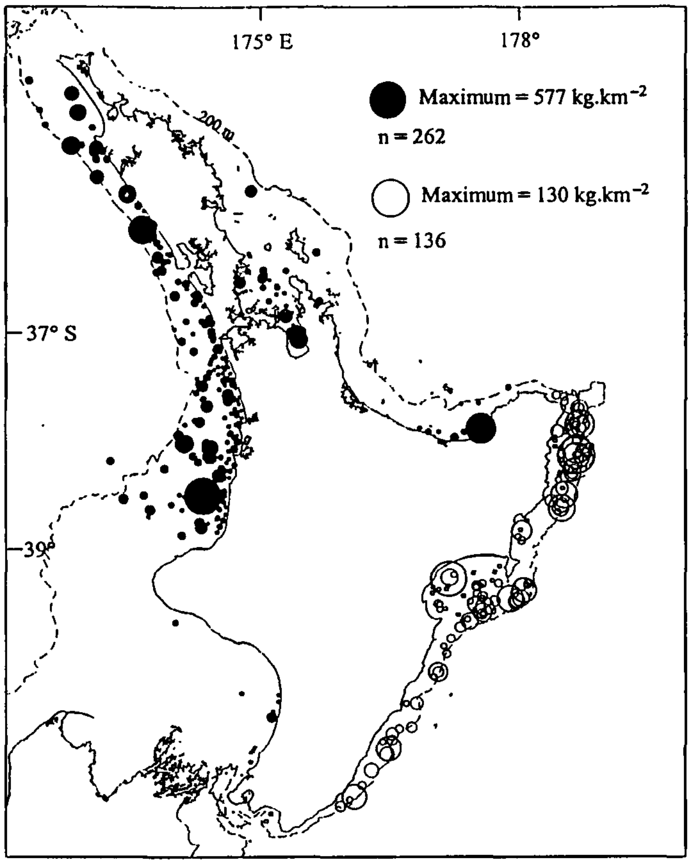


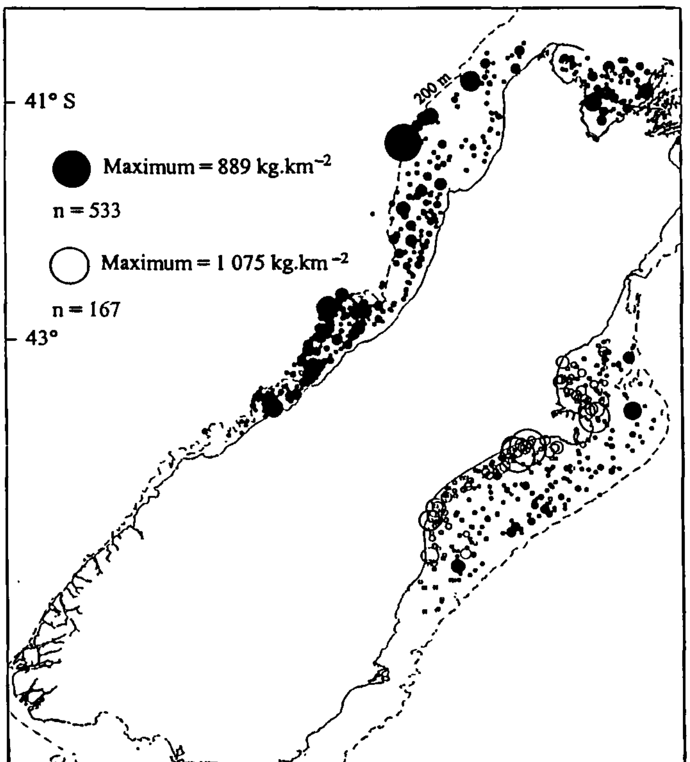
Genypterus blacodes



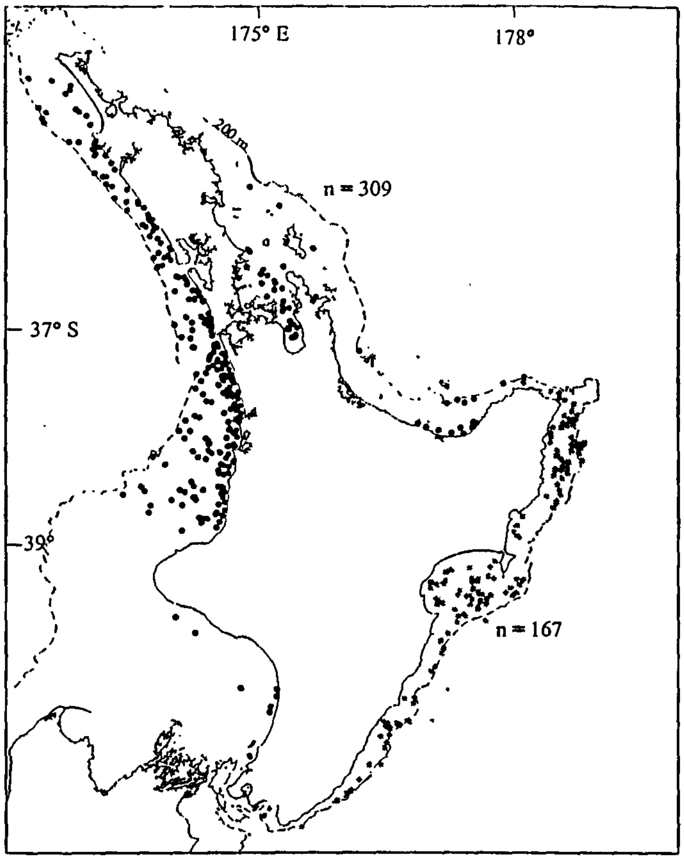


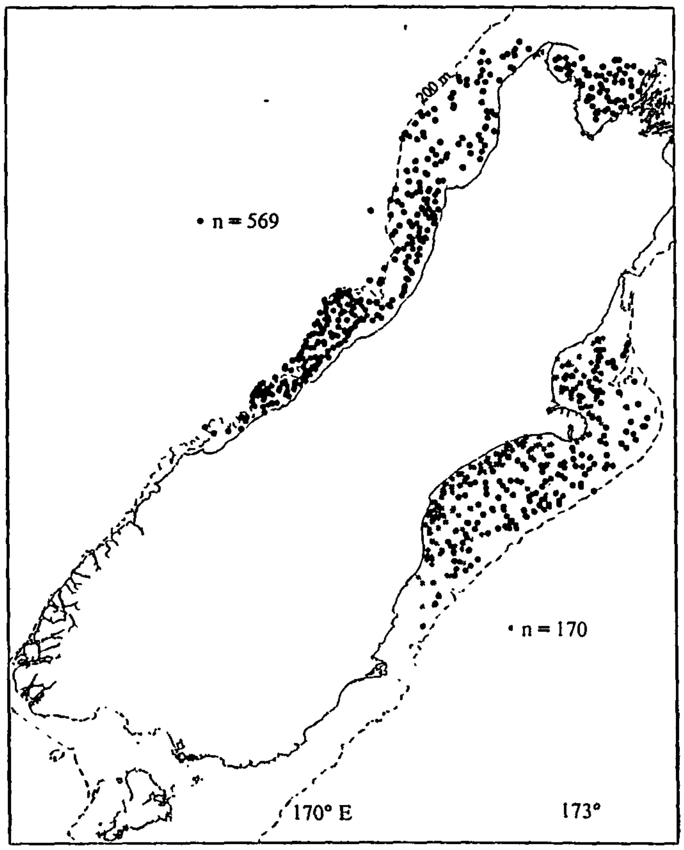
Galeorhinus galeus



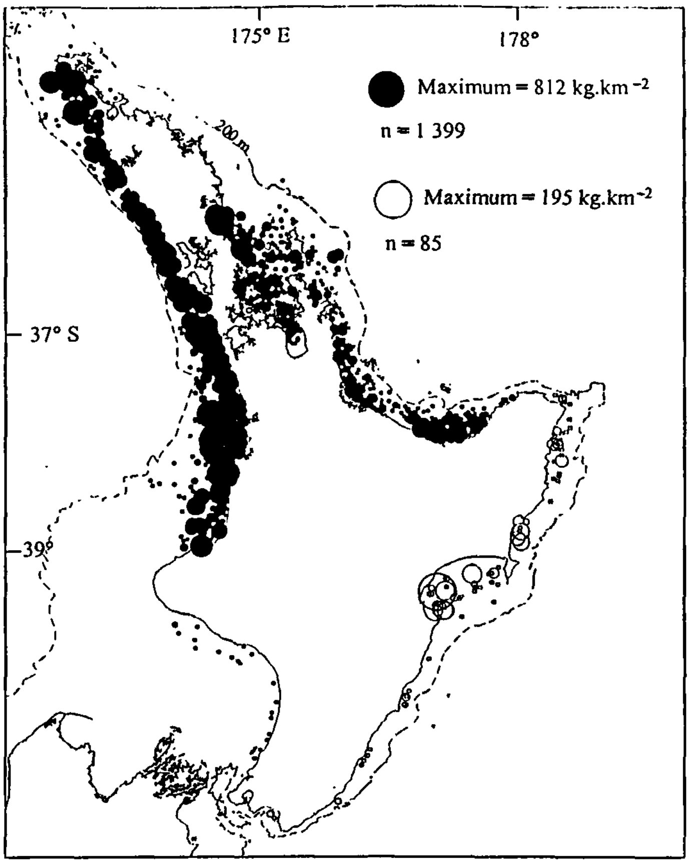


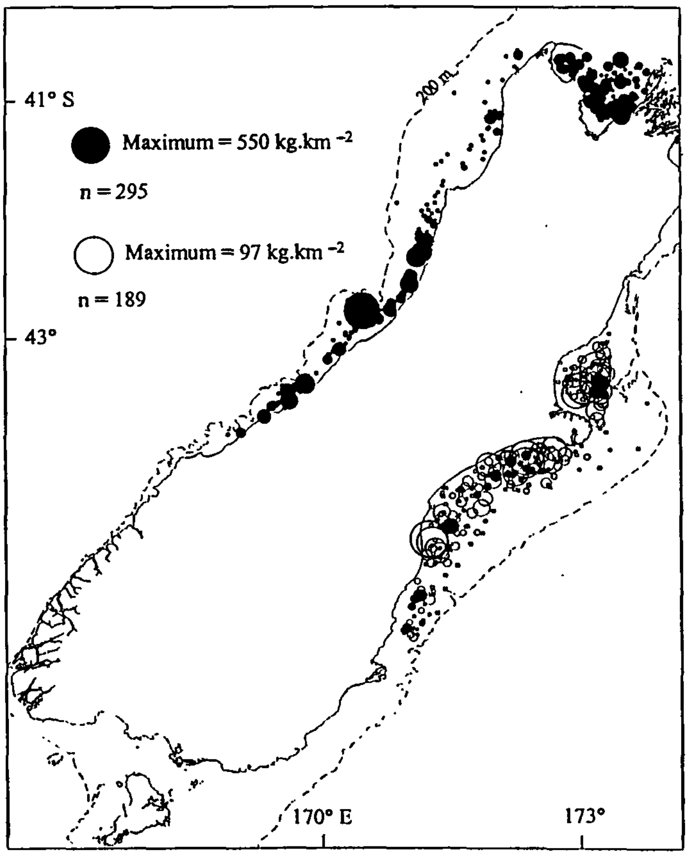
Galeorhinus galeus



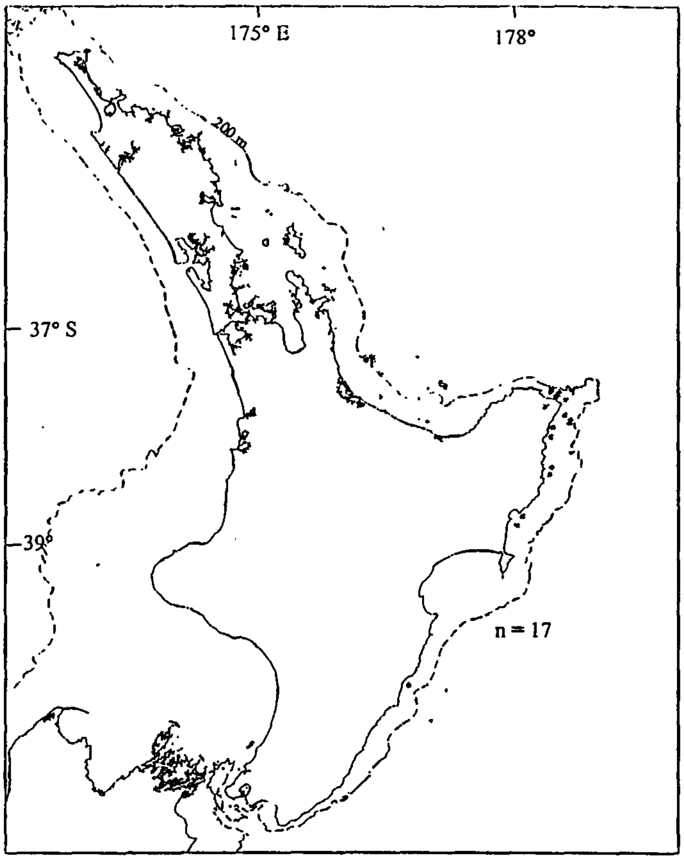


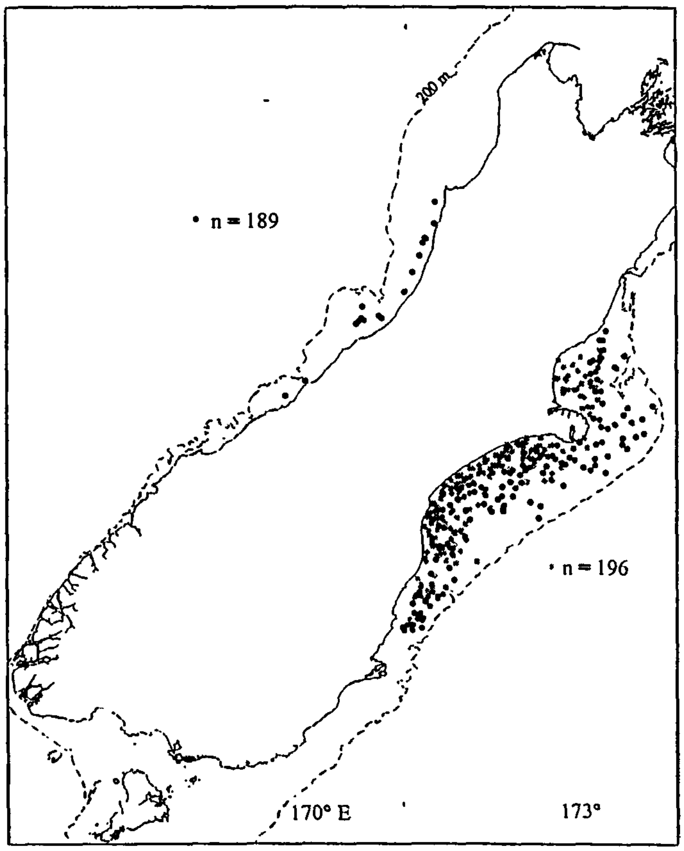
Chelidonichthys kumu



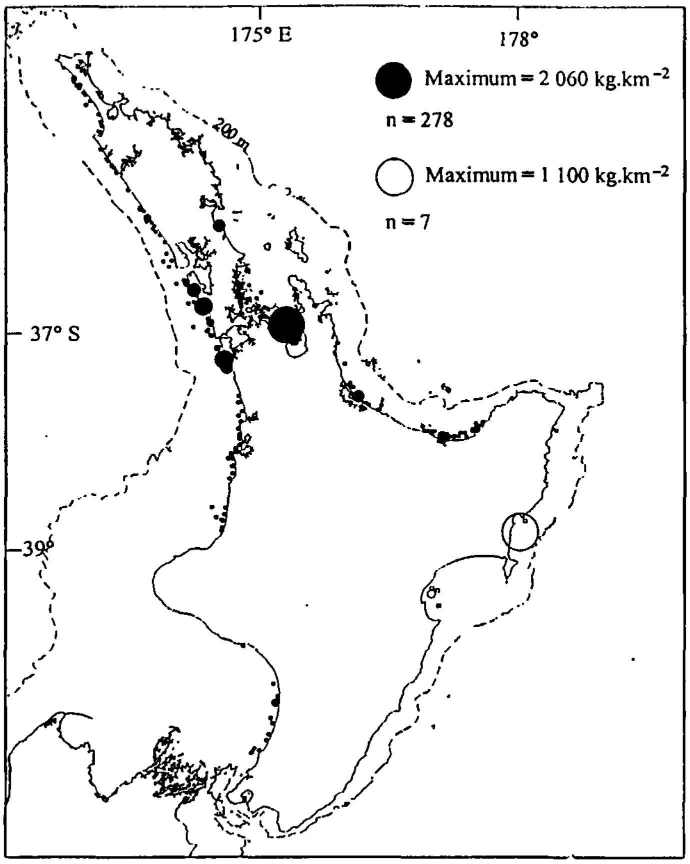


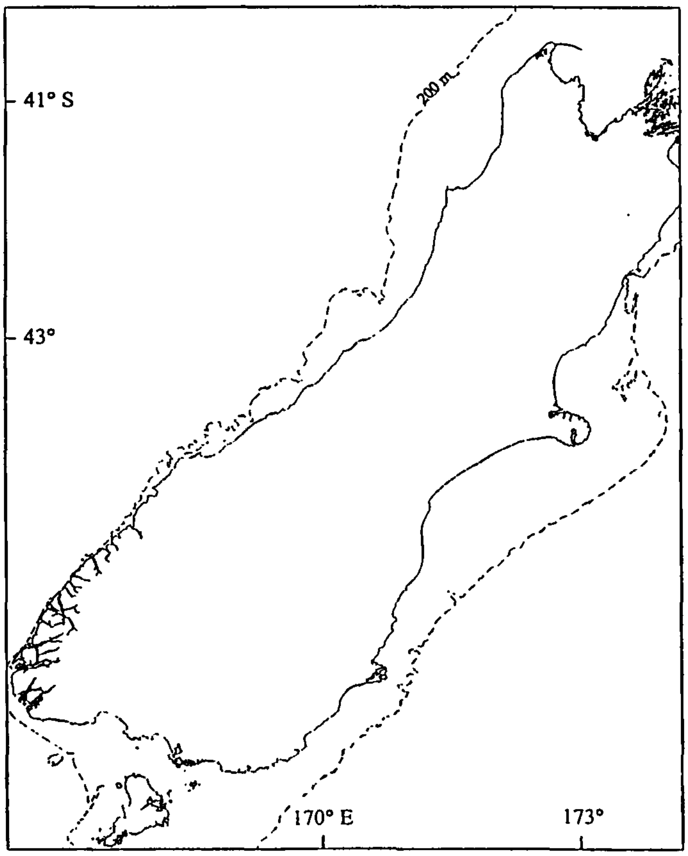
Callorhinchus milii

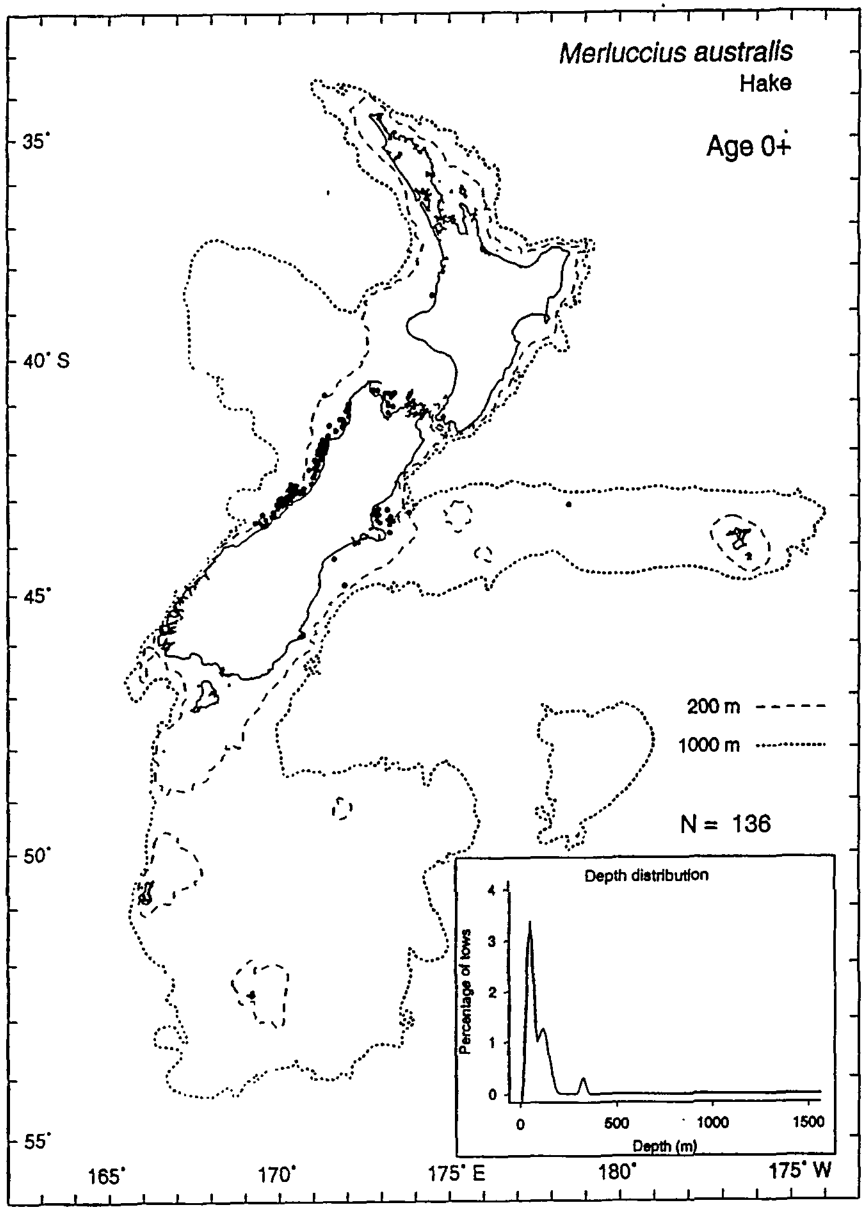




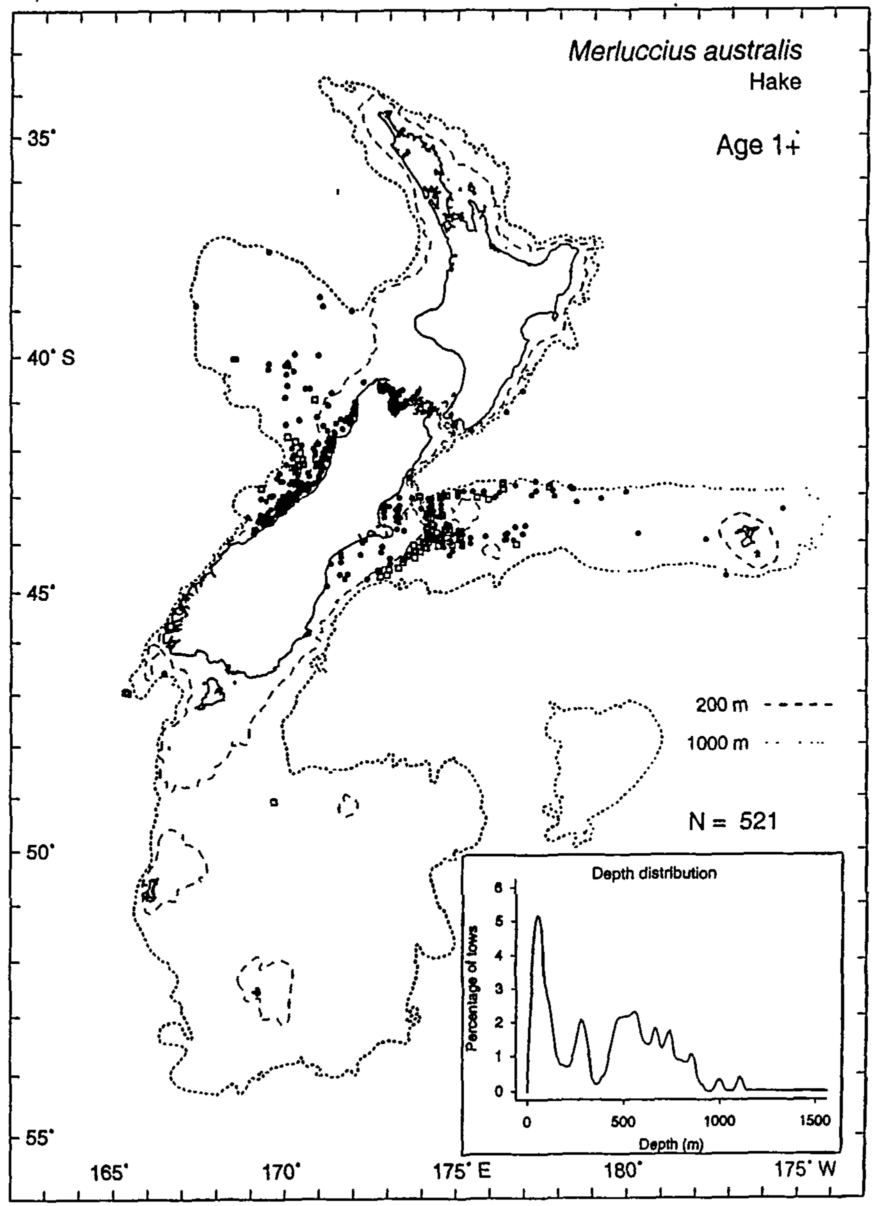
Arripis trutta



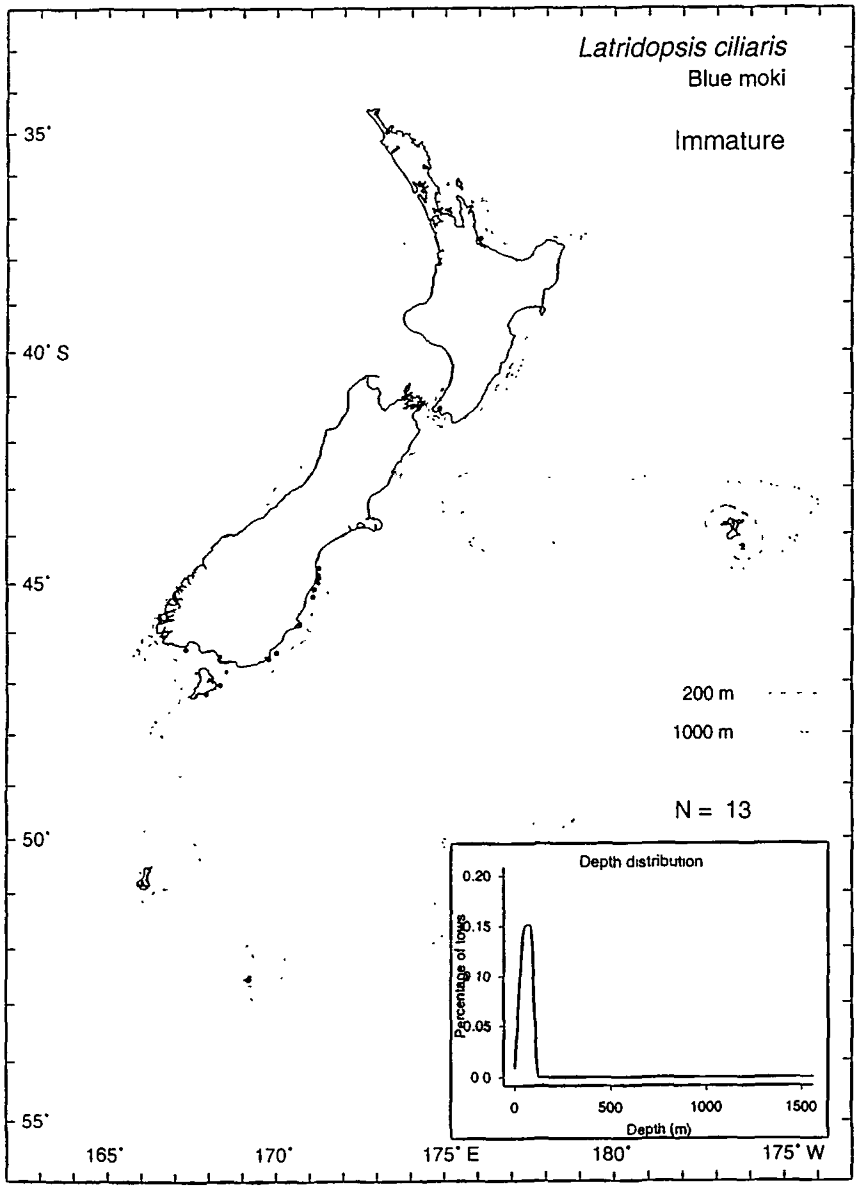


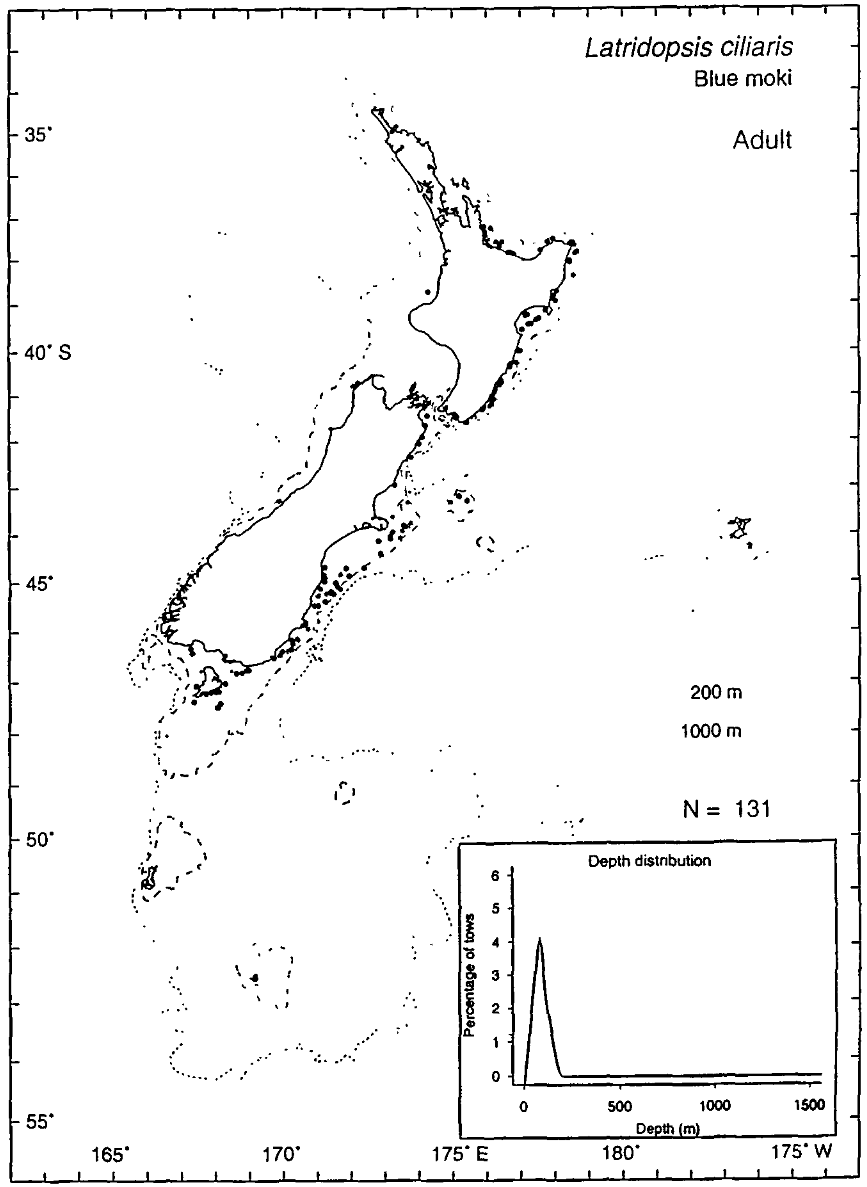


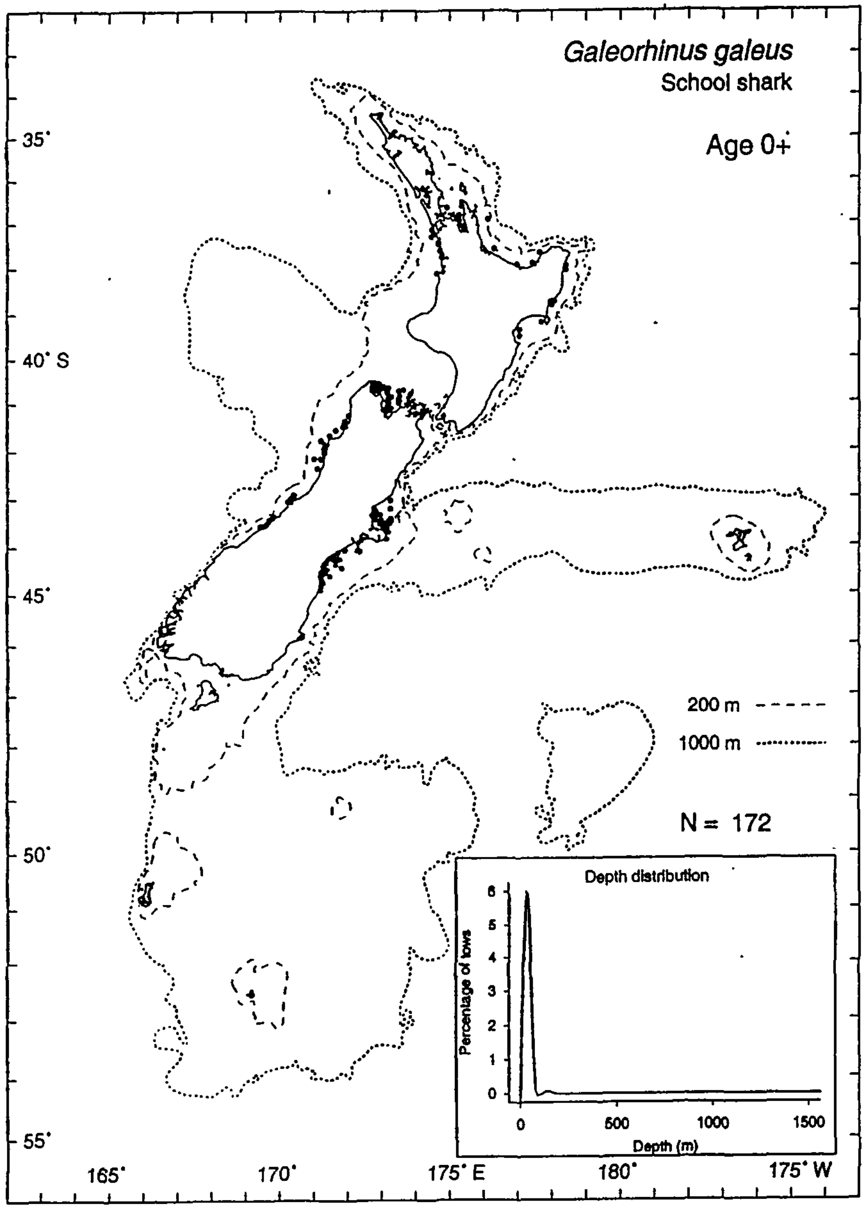
Merluccius australis
Hake
Age 0+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 136
Depth distribution
Percentage of tows
Depth (m)
0
500
1000
1500



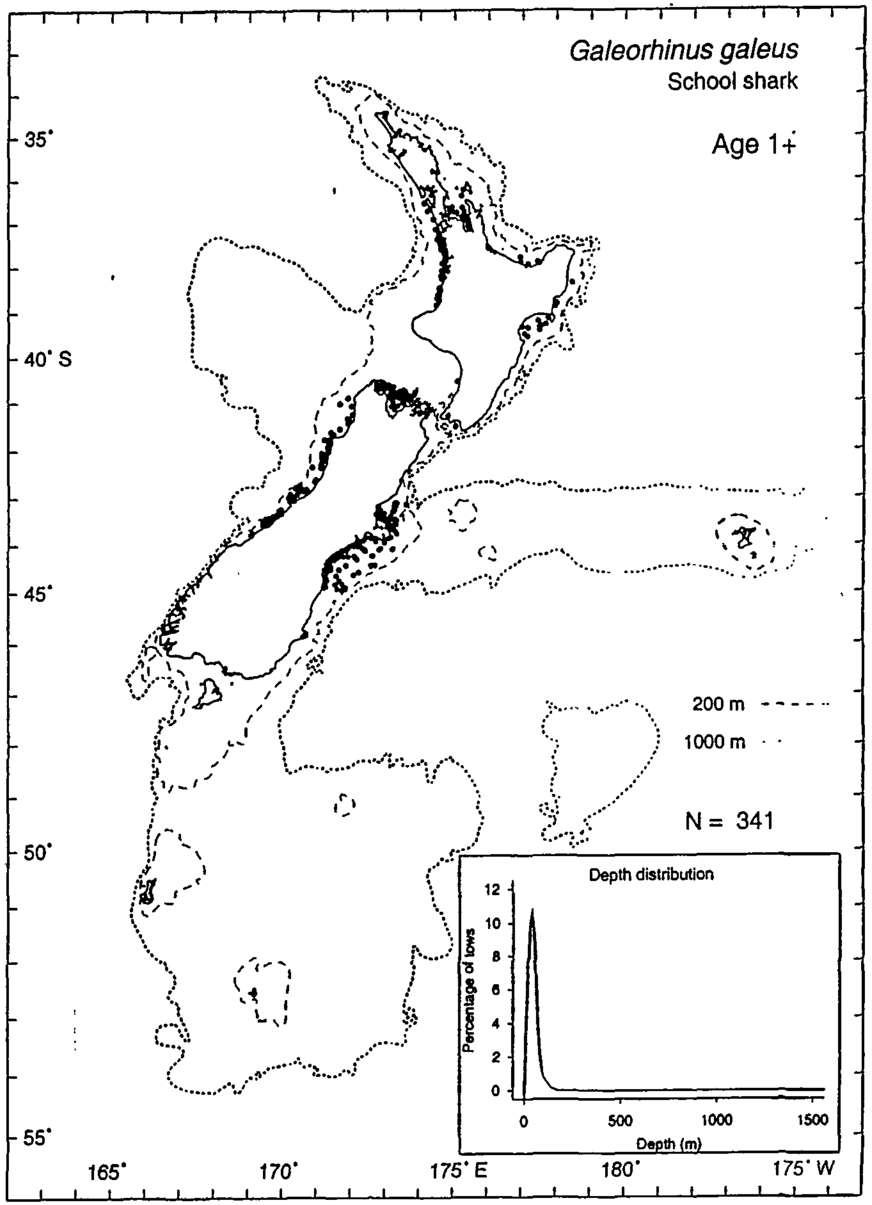
Merluccius australis
Hake
Age 1+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 521
Depth distribution
Percentage of tows
Depth (m)
0
500
1000
1500


Latridopsis ciliaris
Blue moki
Immature
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 13
Depth distribution
Percentage of tows
0.20
0.15
0.10
0.05
0.0
0
500
1000
1500
Depth (m)

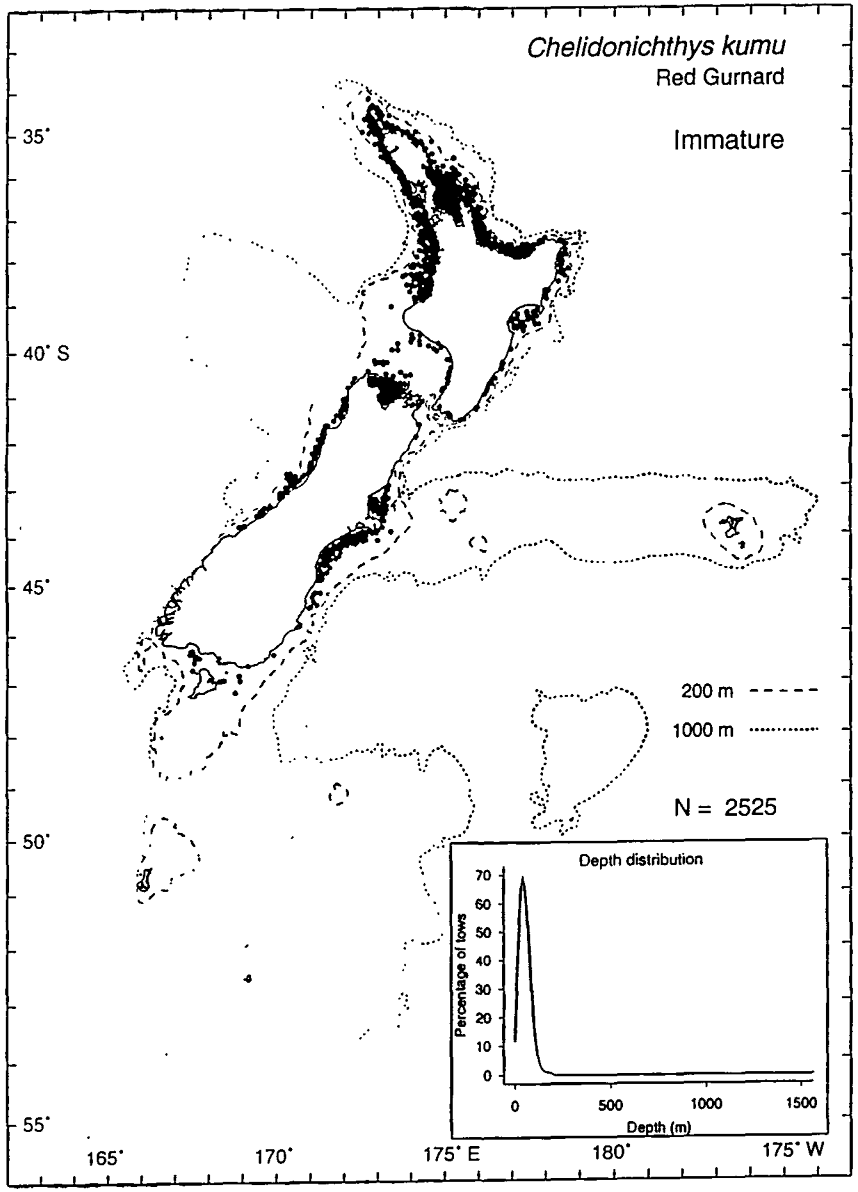

Latridopsis ciliaris
Blue moki
Adult
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 131
Depth distribution
Percentage of tows
6
5
4
3
2
1
0
0
500
1000
1500
Depth (m)

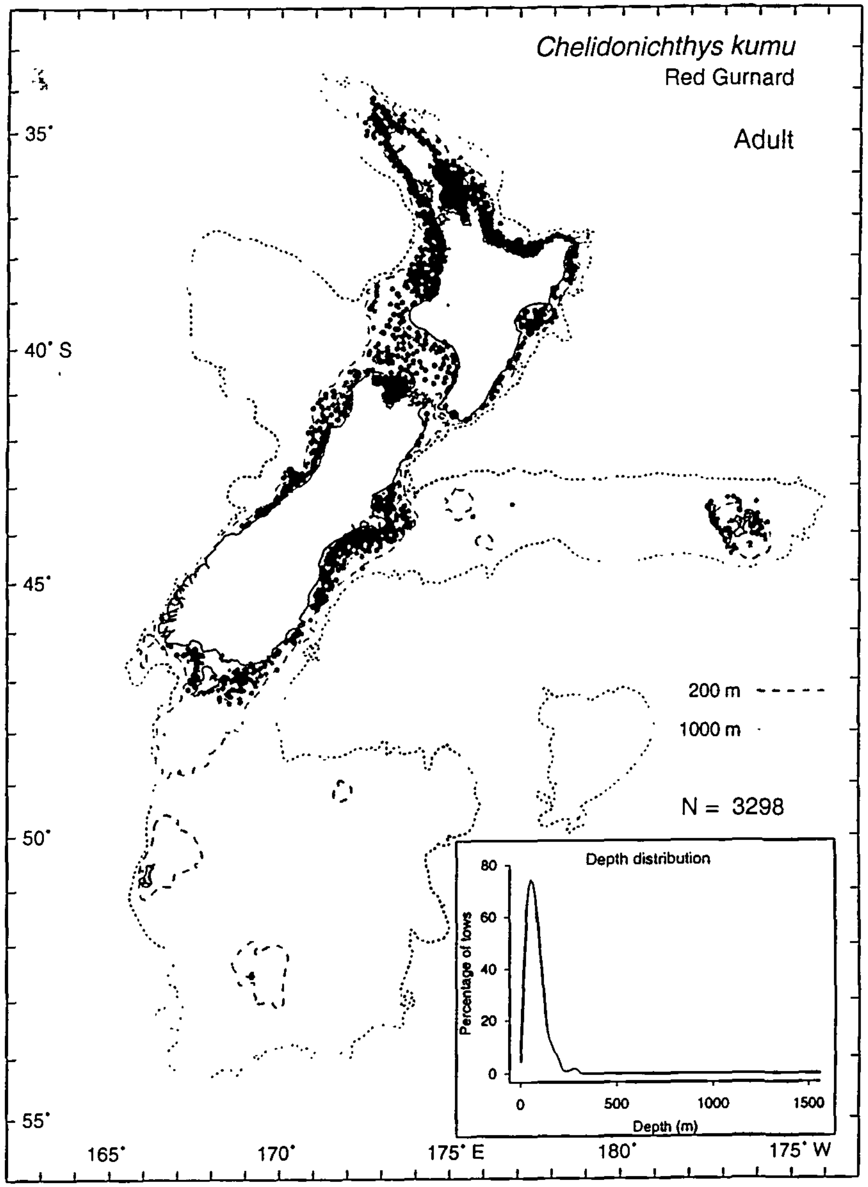


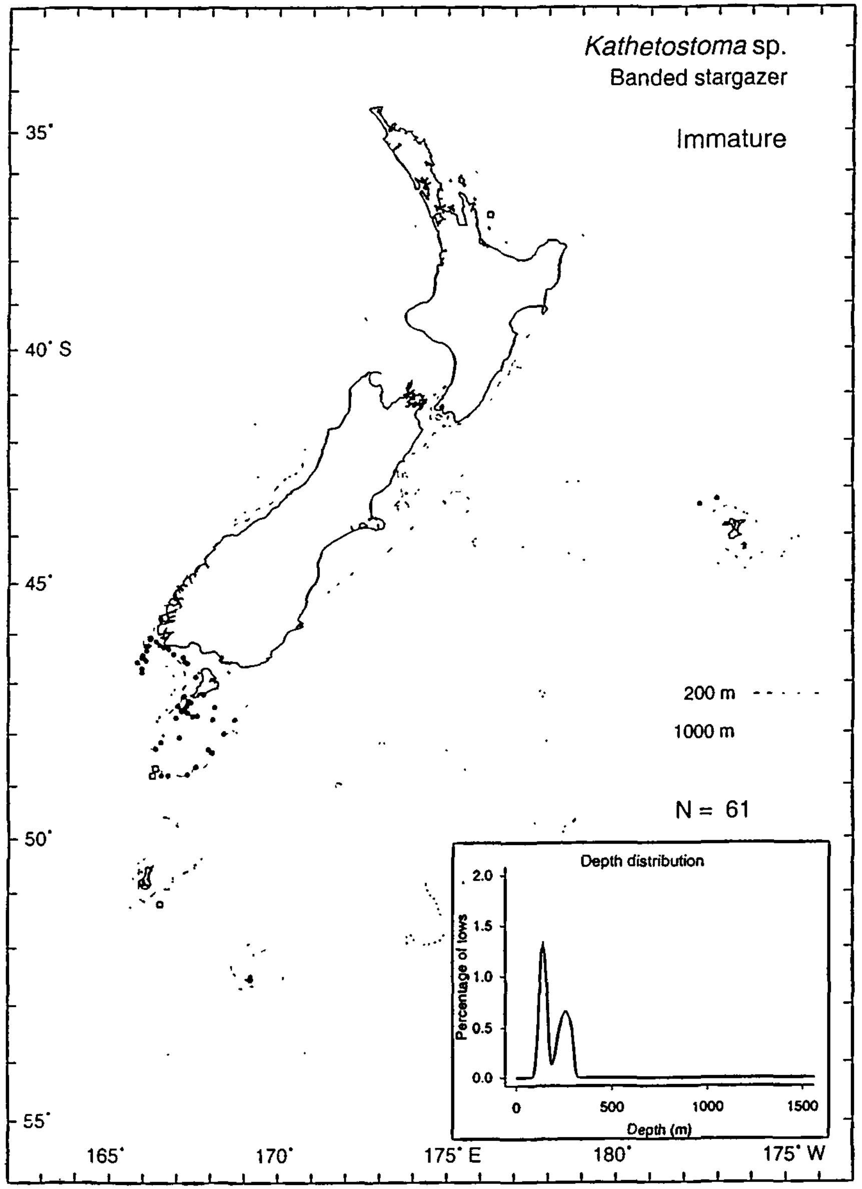
Galeorhinus galeus
School shark
Age 0+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 172
Depth distribution
Percentage of tows
Depth (m)
0
500
1000
1500



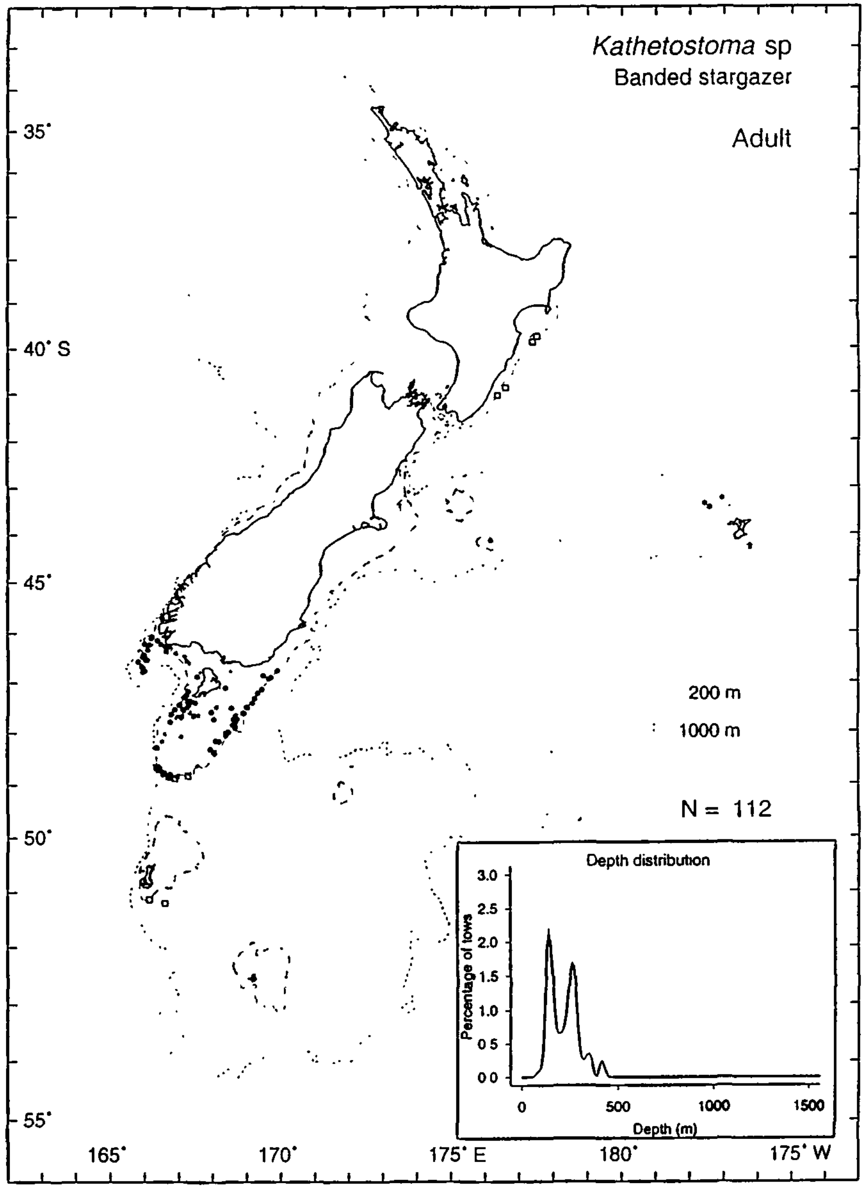
Galeorhinus galeus
School shark
Age 1+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 341
Depth distribution
Percentage of tows
Depth (m)
0
500
1000
1500


Chelidonichthys kumu
Red Gurnard
Immature
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 2525
Depth distribution
Percentage of tows
Depth (m)

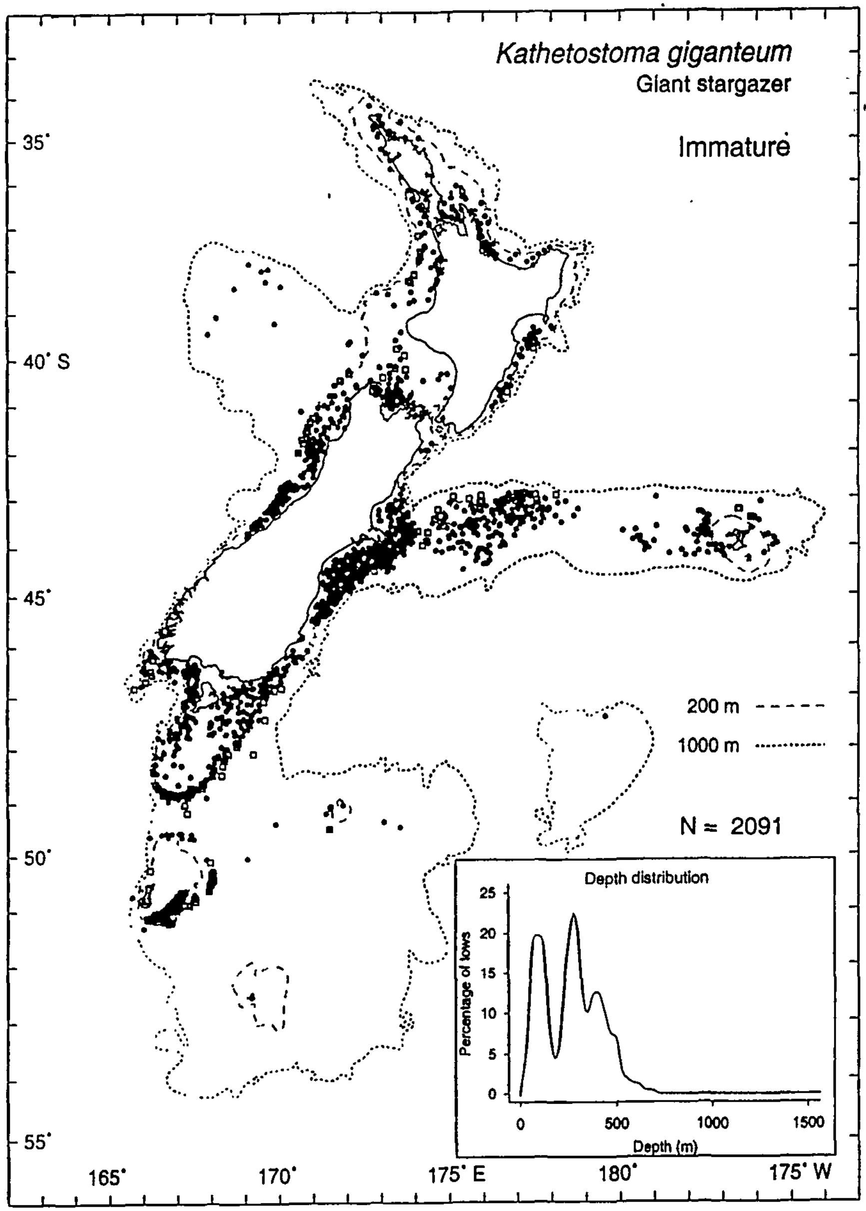

Chelidonichthys kumu
Red Gurnard
Adult
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 3298
Depth distribution
Percentage of tows
Depth (m)



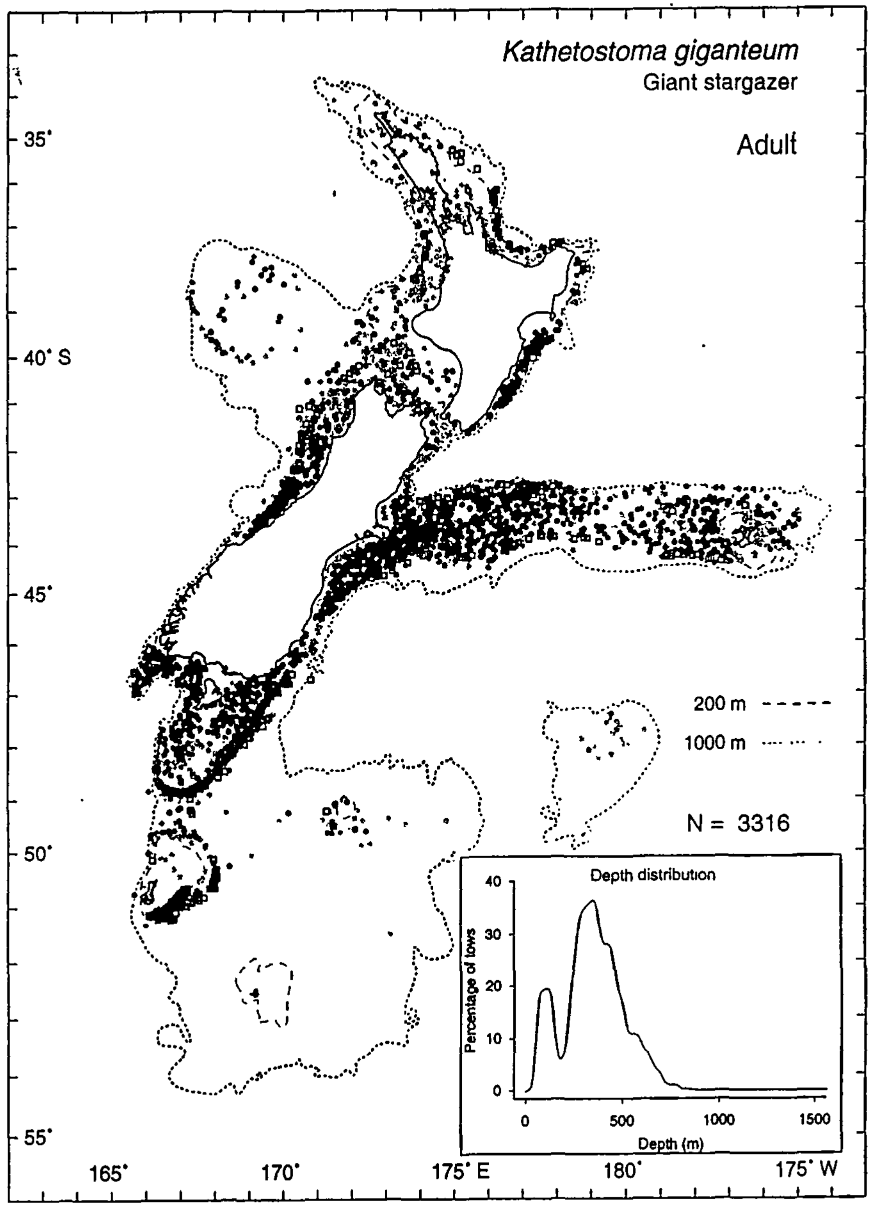
Kathetostoma sp.
Banded stargazer
Immature
35°
40° S
45°
50°
55°
200 m
1000 m
N = 61
Depth distribution
Percentage of tows
Depth (m)
0.0
0.5
1.0
1.5
2.0
0
500
1000
1500
165°
170°
175° E
180°
175° W



Kathetostoma sp
Banded stargazer
Adult
35°
40° S
45°
50°
55°
200 m
1000 m
N = 112
Depth distribution
Percentage of tows
Depth (m)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
0
500
1000
1500
165°
170°
175° E
180°
175° W

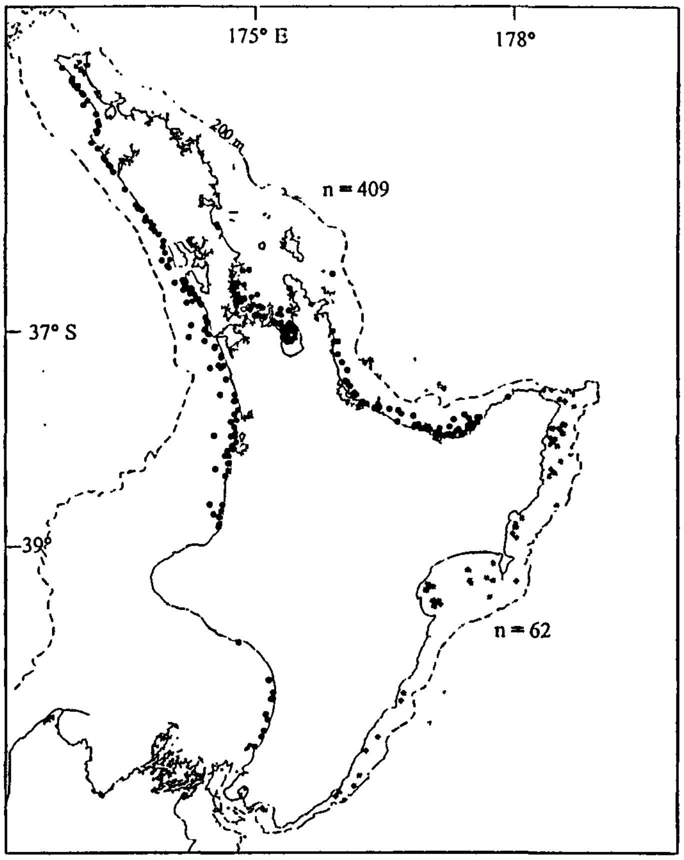


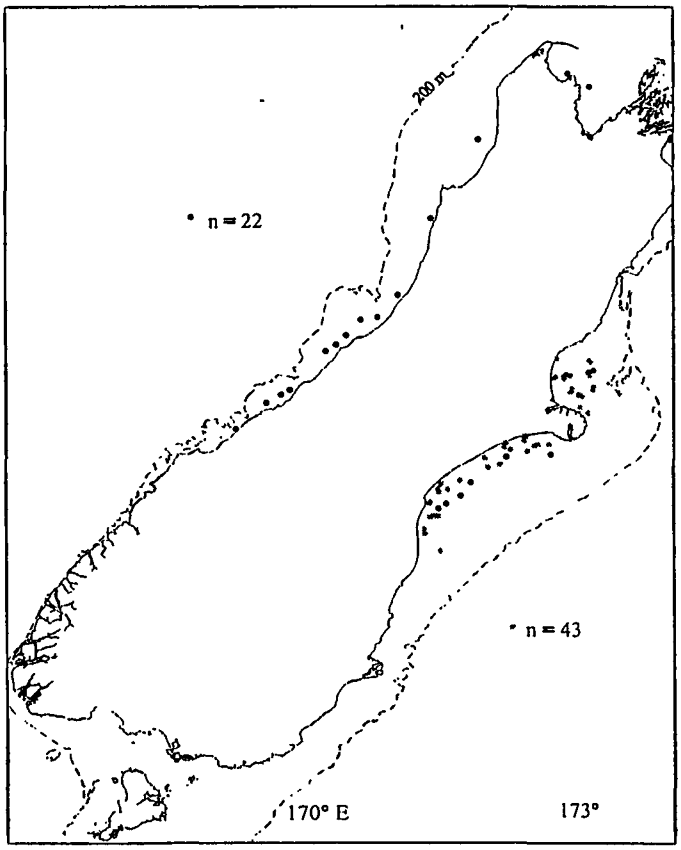
Kathetostoma giganteum
Giant stargazer
Immature
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 2091
Depth distribution
Percentage of tows
Depth (m)



Kathetostoma giganteum
Giant stargazer
Adult
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 3316
Depth distribution
Percentage of tows
Depth (m)

Arripis trutta

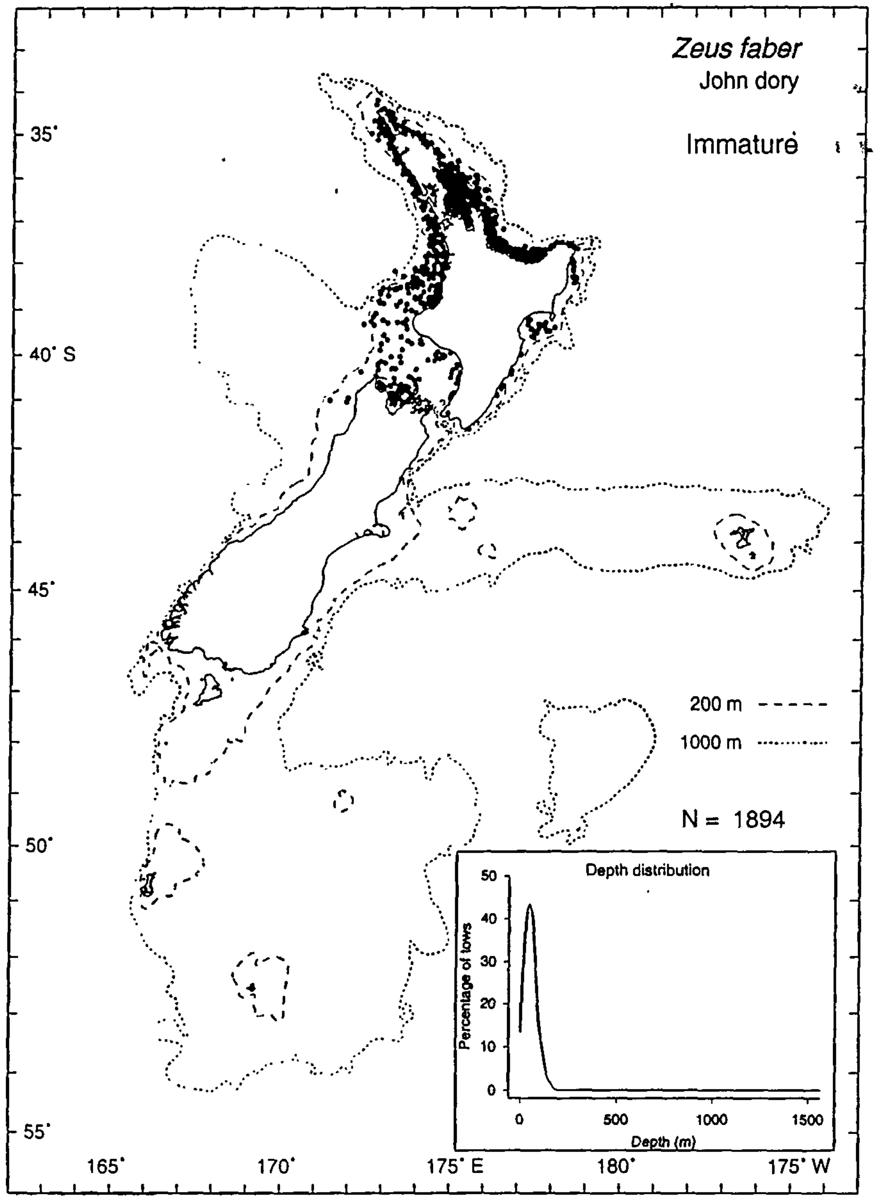


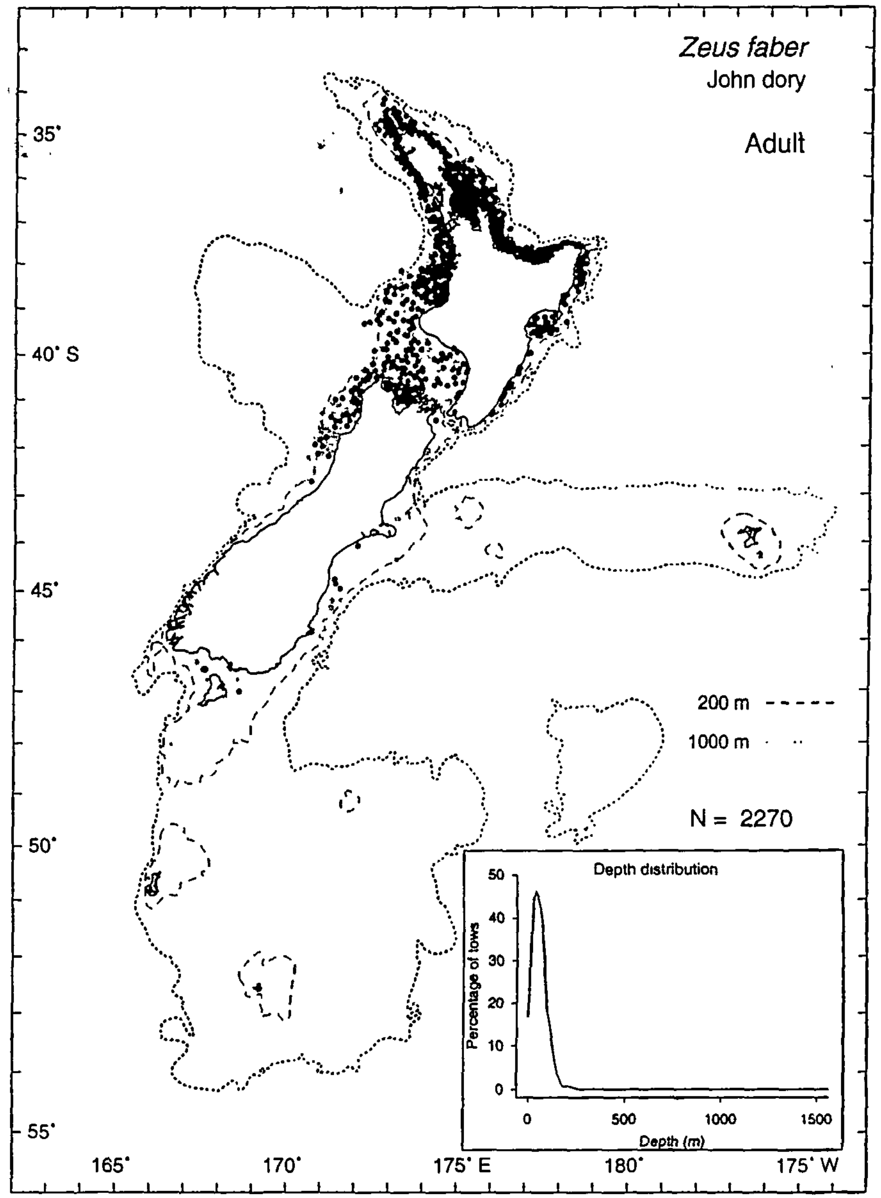


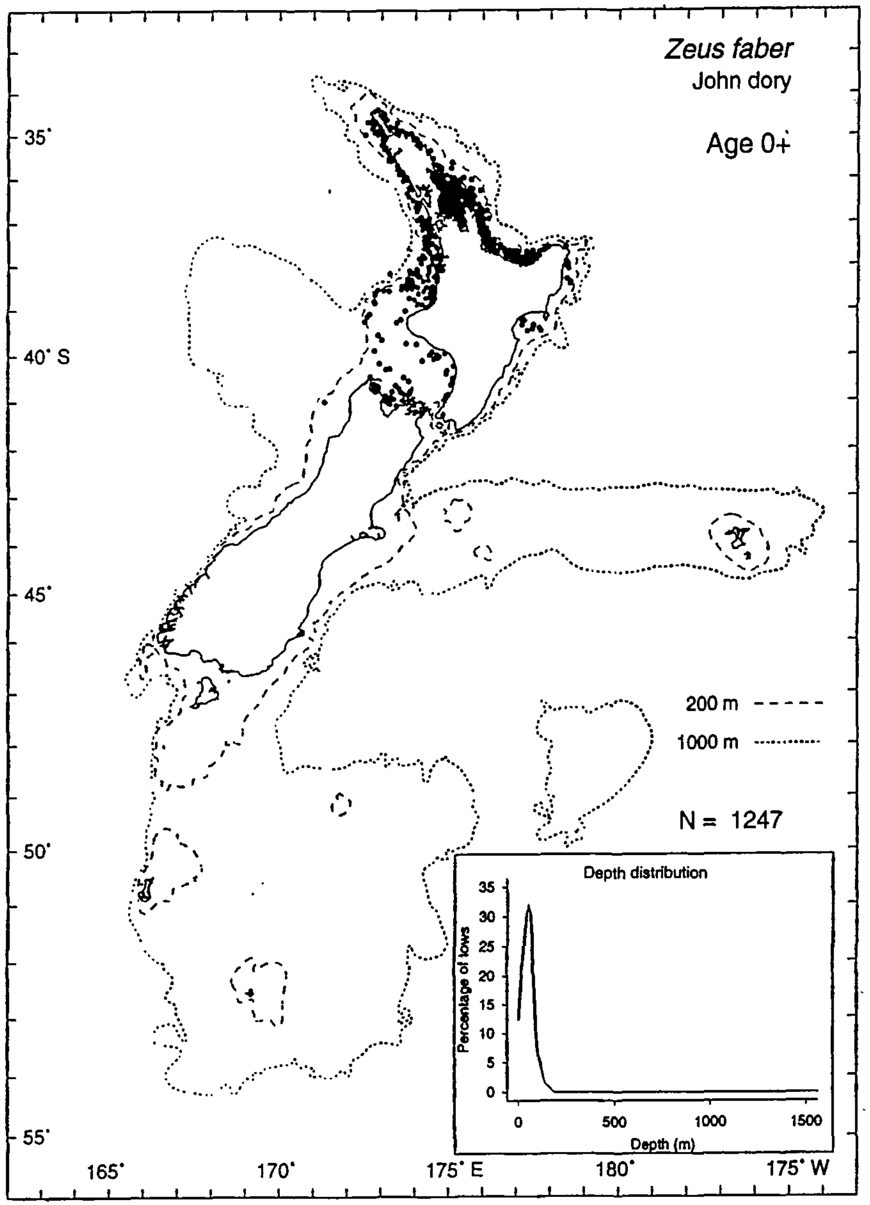
Key to interpretation of *Kaharoa* distribution plots

Left page	Reference plots of where the species was caught	
Right page	Catch rates of juveniles. Circle size is proportional to the maximum catch rate indicated	
North Island	●	Snapper trawl
	O	South-east coast North Island trawl
South Island	●	South Island trawl (74 mm codend)
	O	South Island trawl (28 mm codend)

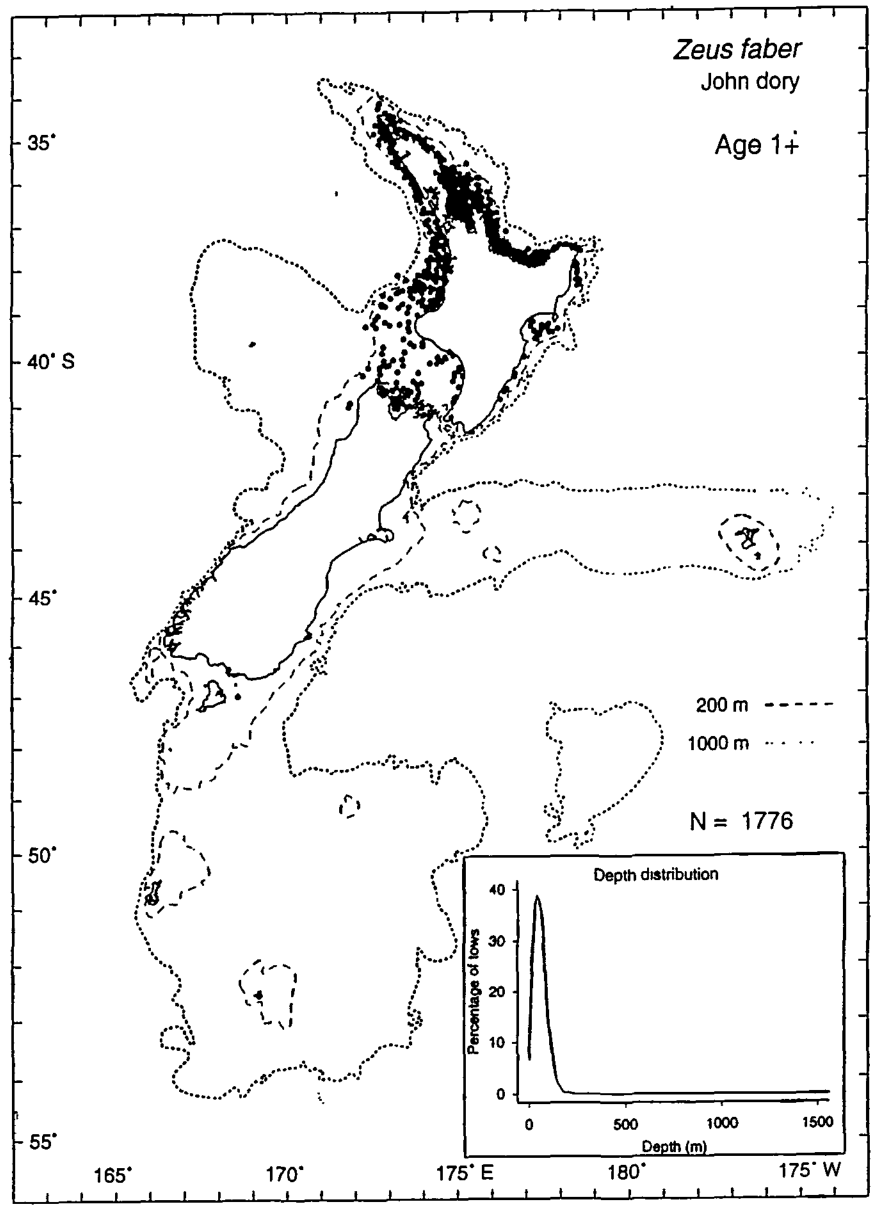
1.2.1 Juvenile abundance Kaharoa surveys


Zeus faber
John dory
Immature
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 1894
Depth distribution
Percentage of tows
Depth (m)
0
10
20
30
40
50
500
1000
1500

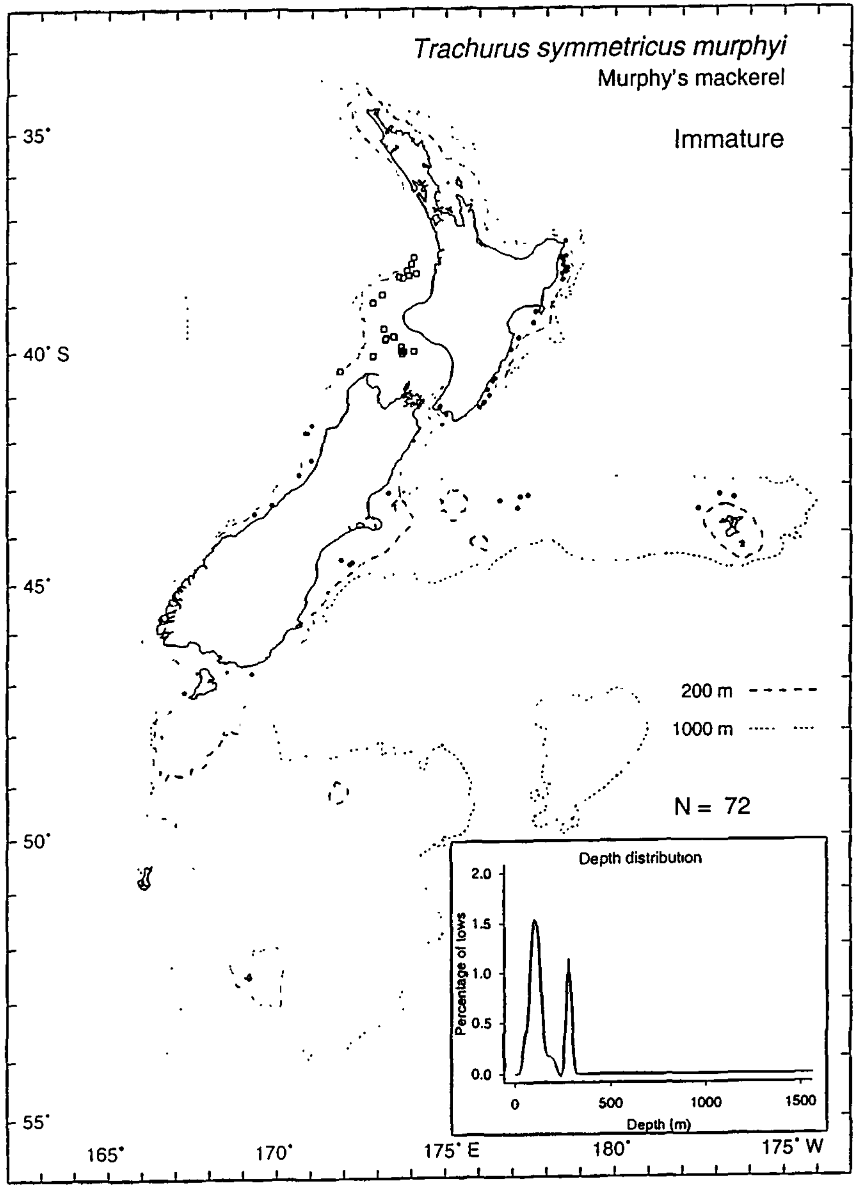

Zeus faber
John dory
Adult
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 2270
Depth distribution
Percentage of tows
Depth (m)
0
10
20
30
40
50
500
1000
1500

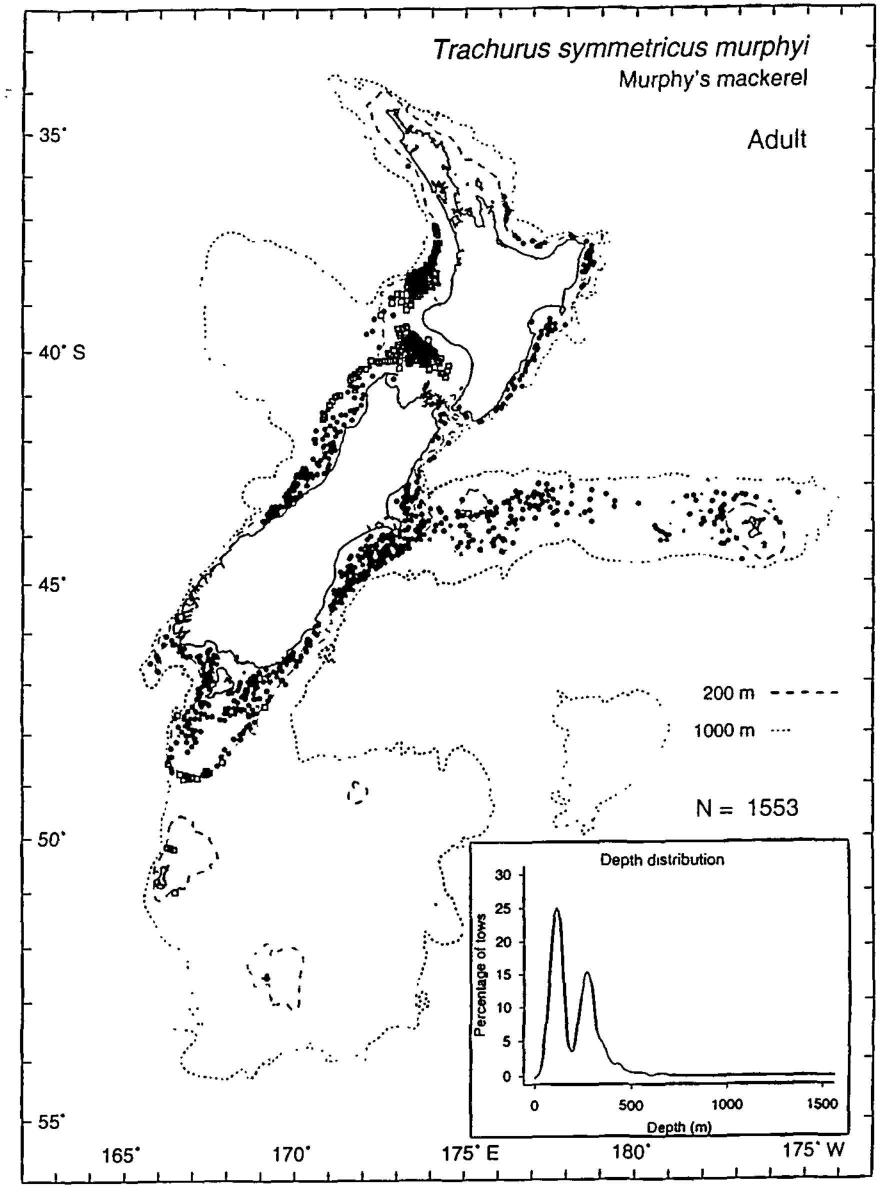


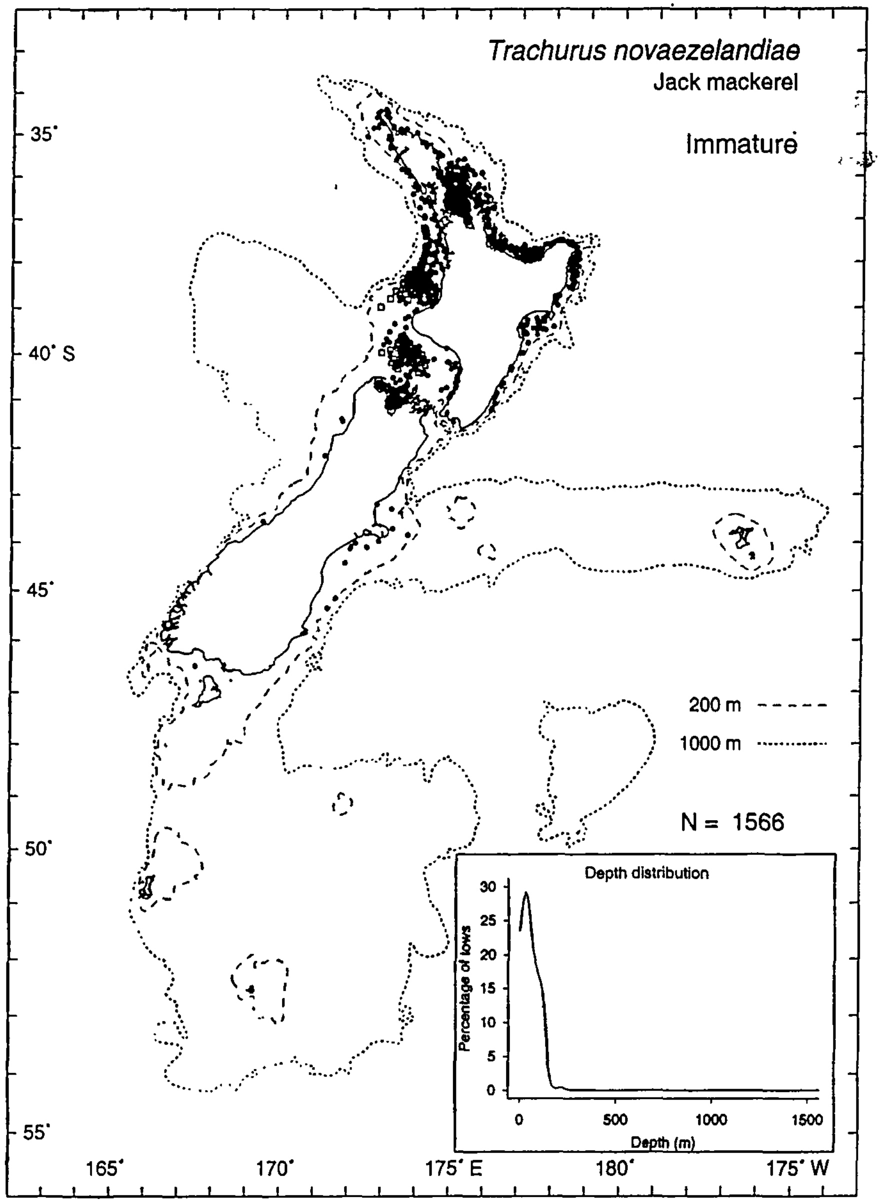
Zeus faber
John dory
Age 0+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 1247
Depth distribution
Percentage of tows
Depth (m)
0
500
1000
1500



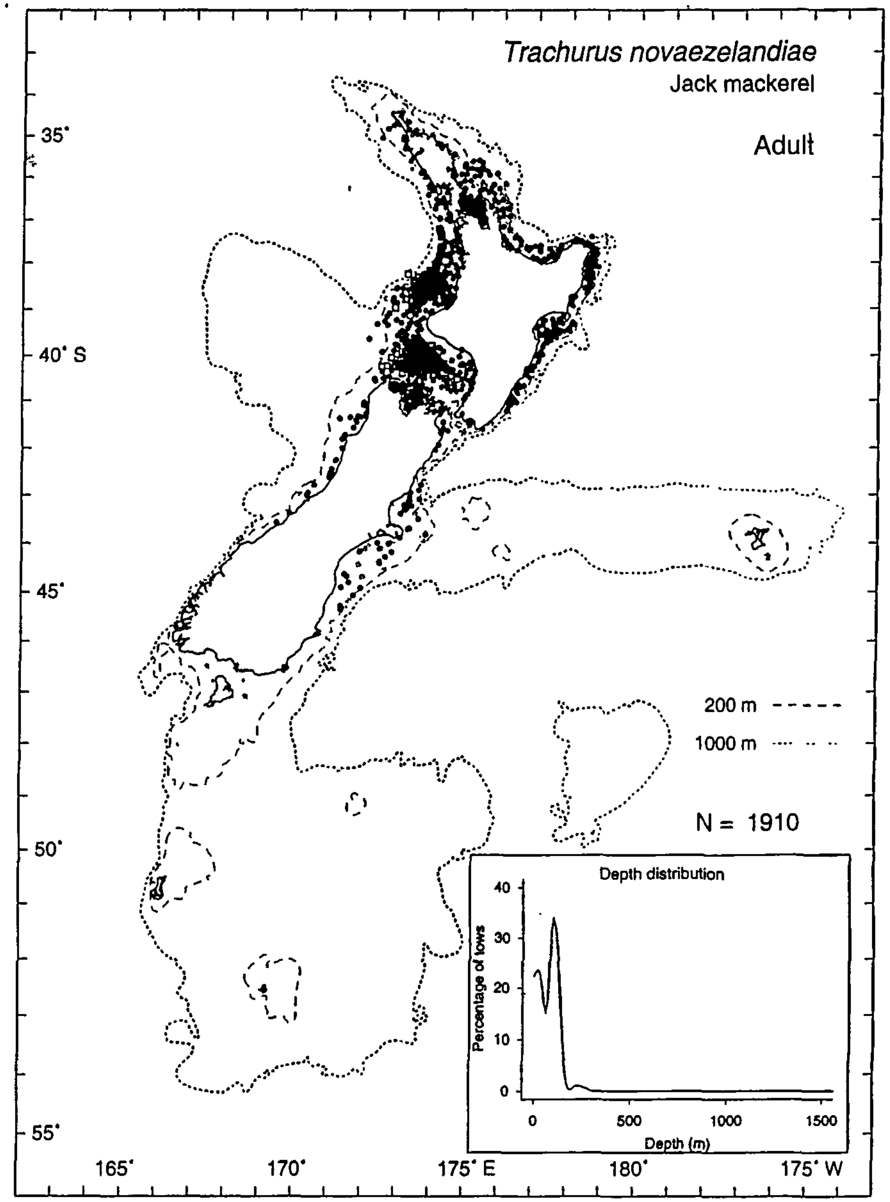
Zeus faber
John dory
Age 1+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 1776
Depth distribution
Percentage of tows
Depth (m)
0
500
1000
1500


Trachurus symmetricus murphyi
Murphy's mackerel
Immature
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 72
Depth distribution
Percentage of tows
Depth (m)
0.0
0.5
1.0
1.5
2.0
0
500
1000
1500

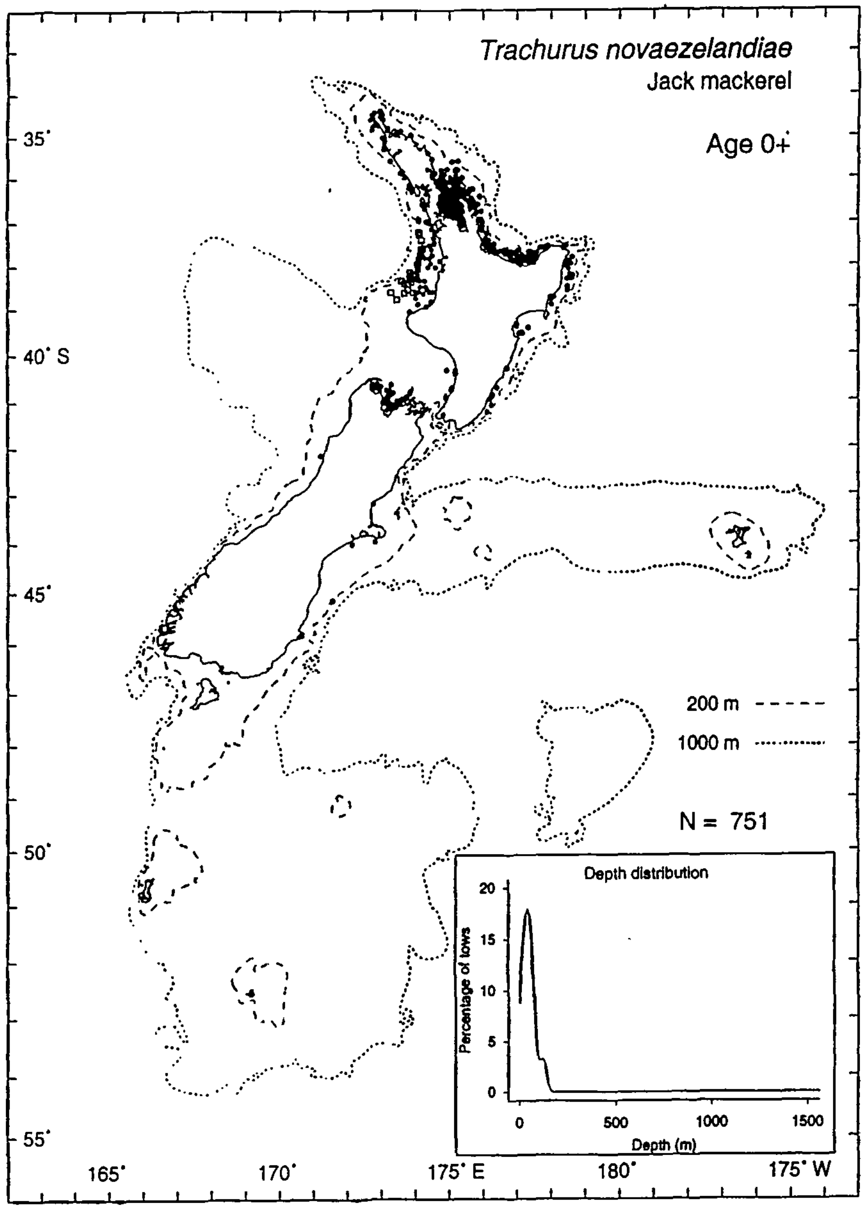

Trachurus symmetricus murphyi
Murphy's mackerel
Adult
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 1553
Depth distribution
Percentage of tows
Depth (m)
0
5
10
15
20
25
30
0
500
1000
1500

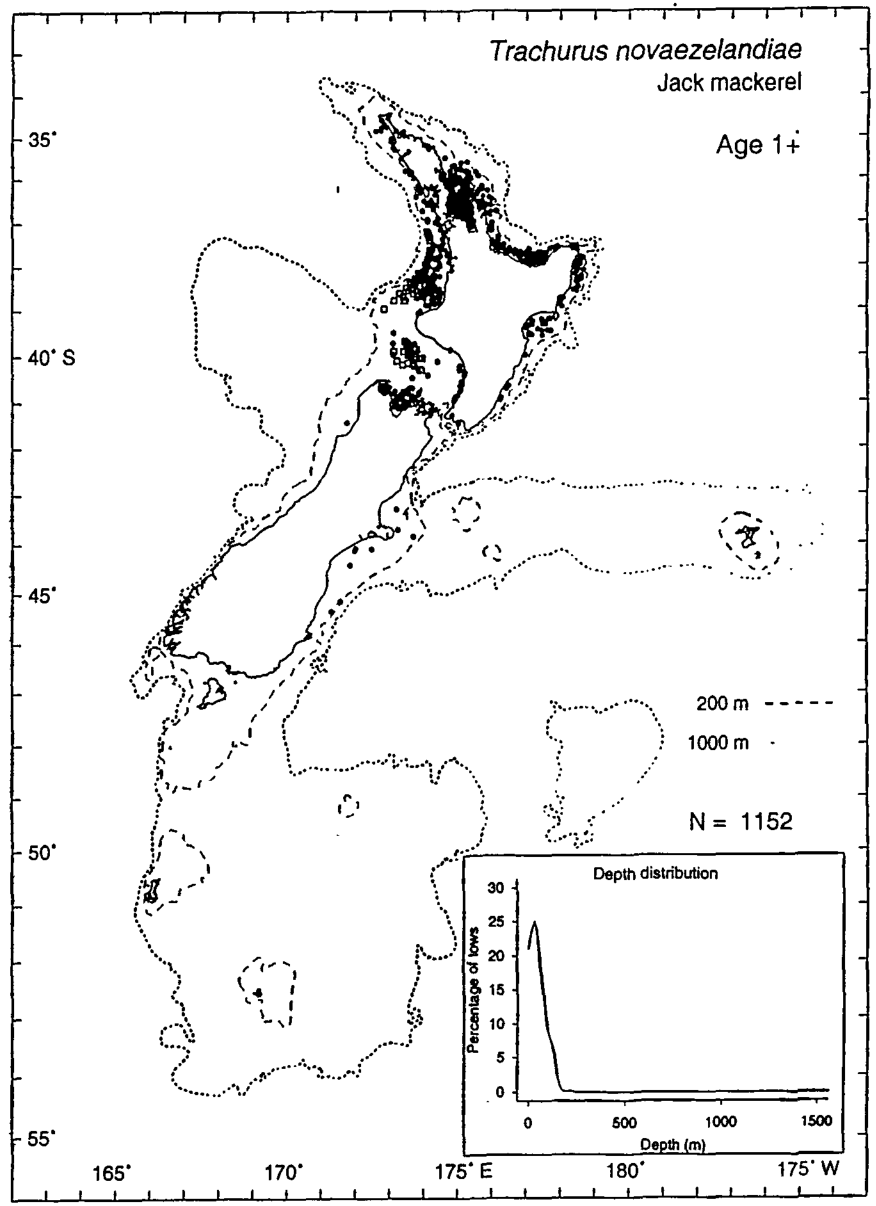


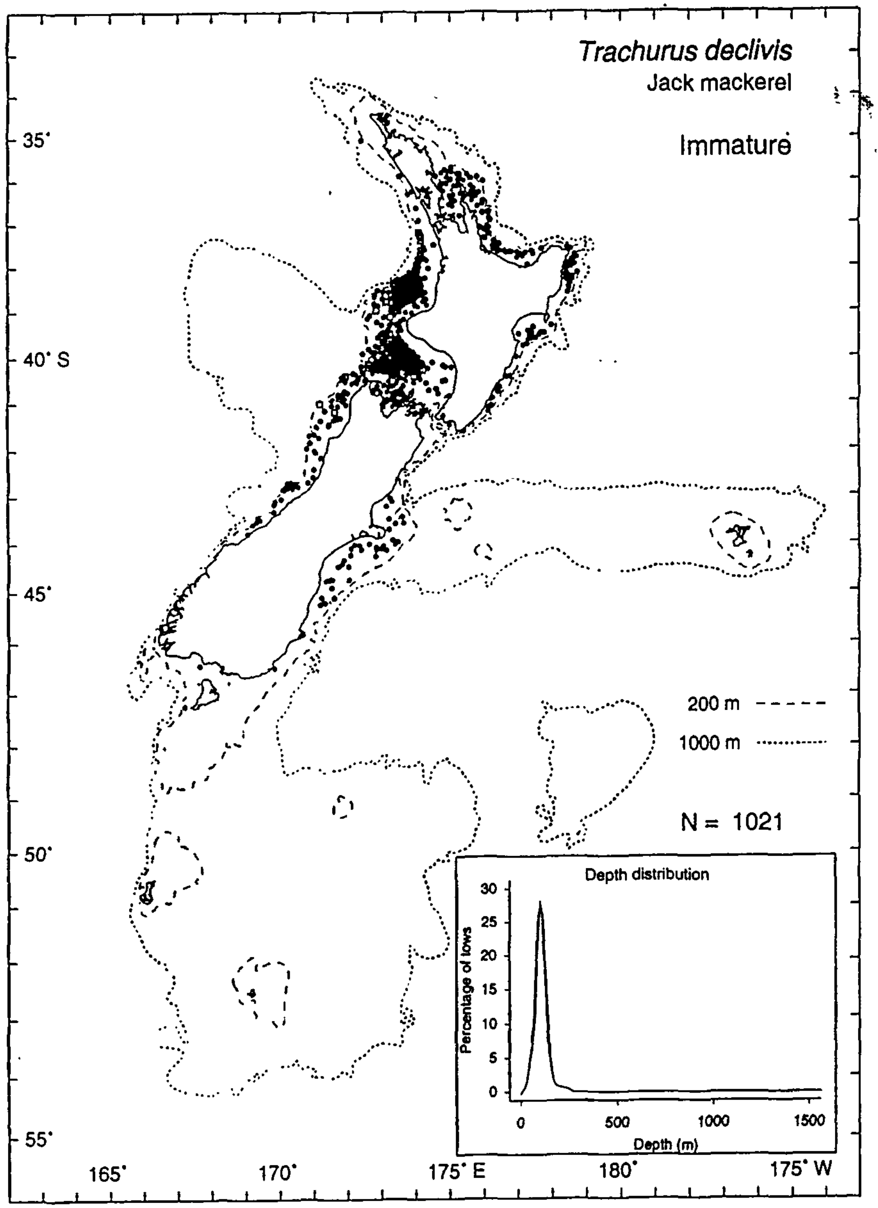
Trachurus novaezelandiae
Jack mackerel
Immature
200 m
1000 m
N = 1566
Depth distribution
Percentage of tows
Depth (m)
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W



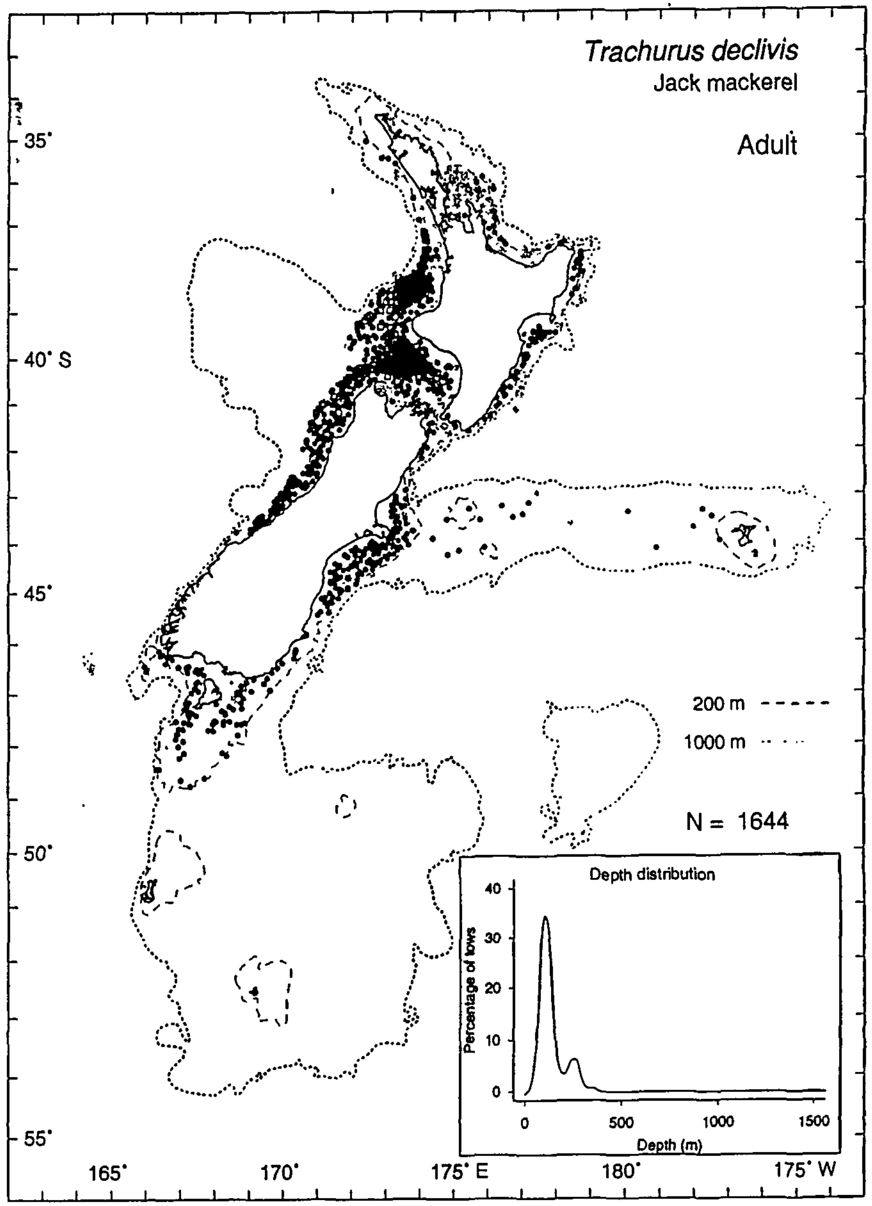
Trachurus novaezelandiae
Jack mackerel
Adult
200 m
1000 m
N = 1910
Depth distribution
Percentage of tows
Depth (m)
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W


Trachurus novaezelandiae
Jack mackerel
Age 0+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 751
Depth distribution
Percentage of tows
Depth (m)
0
500
1000
1500
0
5
10
15
20

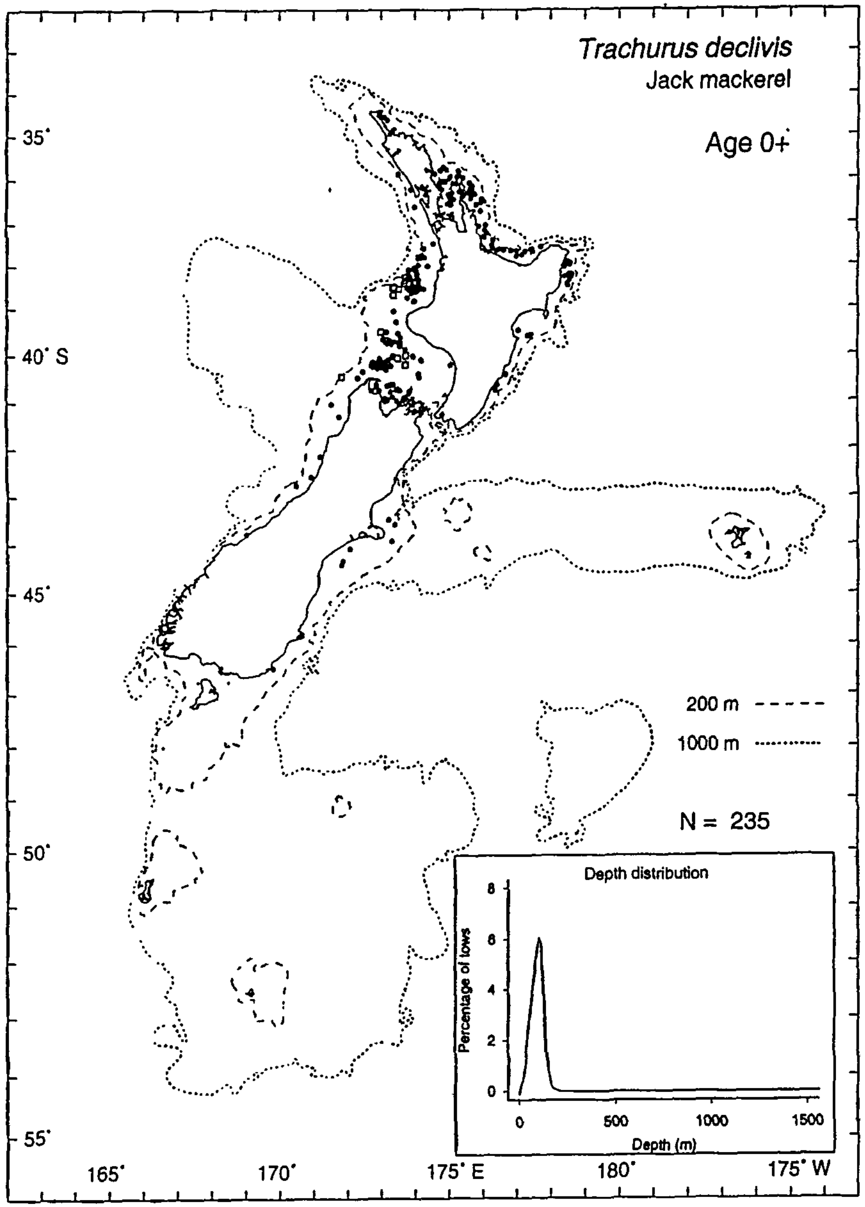

Trachurus novaezelandiae
Jack mackerel
Age 1+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 1152
Depth distribution
Percentage of tows
Depth (m)
0
500
1000
1500
0
5
10
15
20
25
30



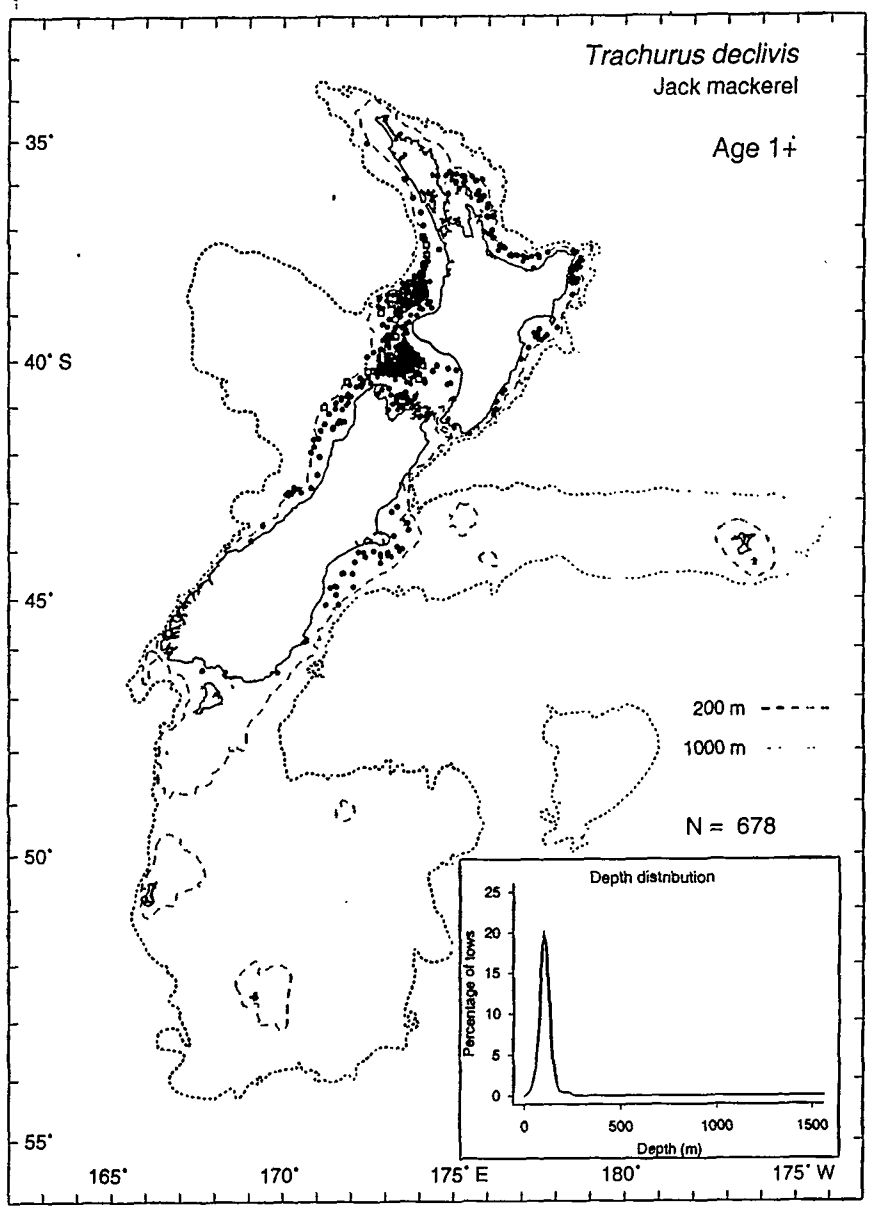
Trachurus declivis
Jack mackerel
Immature
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 1021
Depth distribution
Percentage of tows
Depth (m)



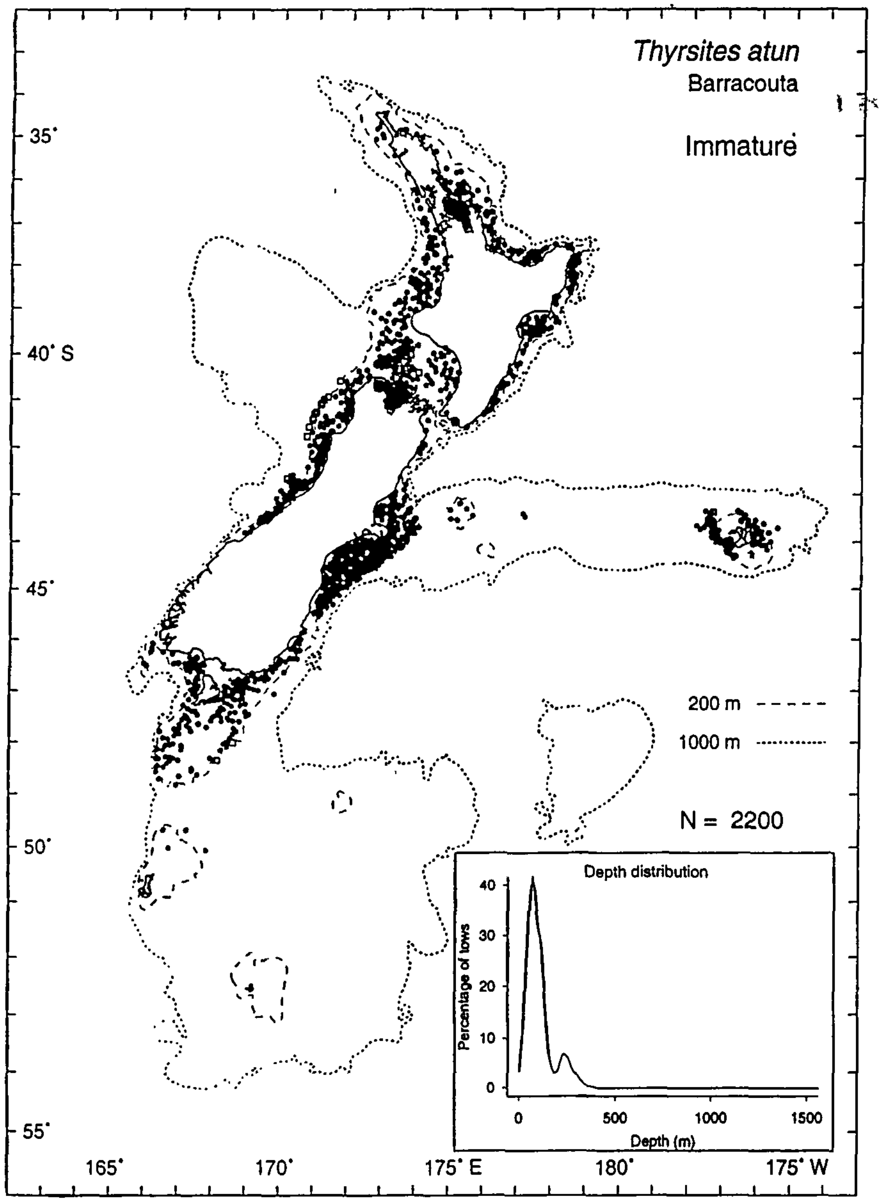
Trachurus declivis
Jack mackerel
Adult
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 1644
Depth distribution
Percentage of tows
Depth (m)



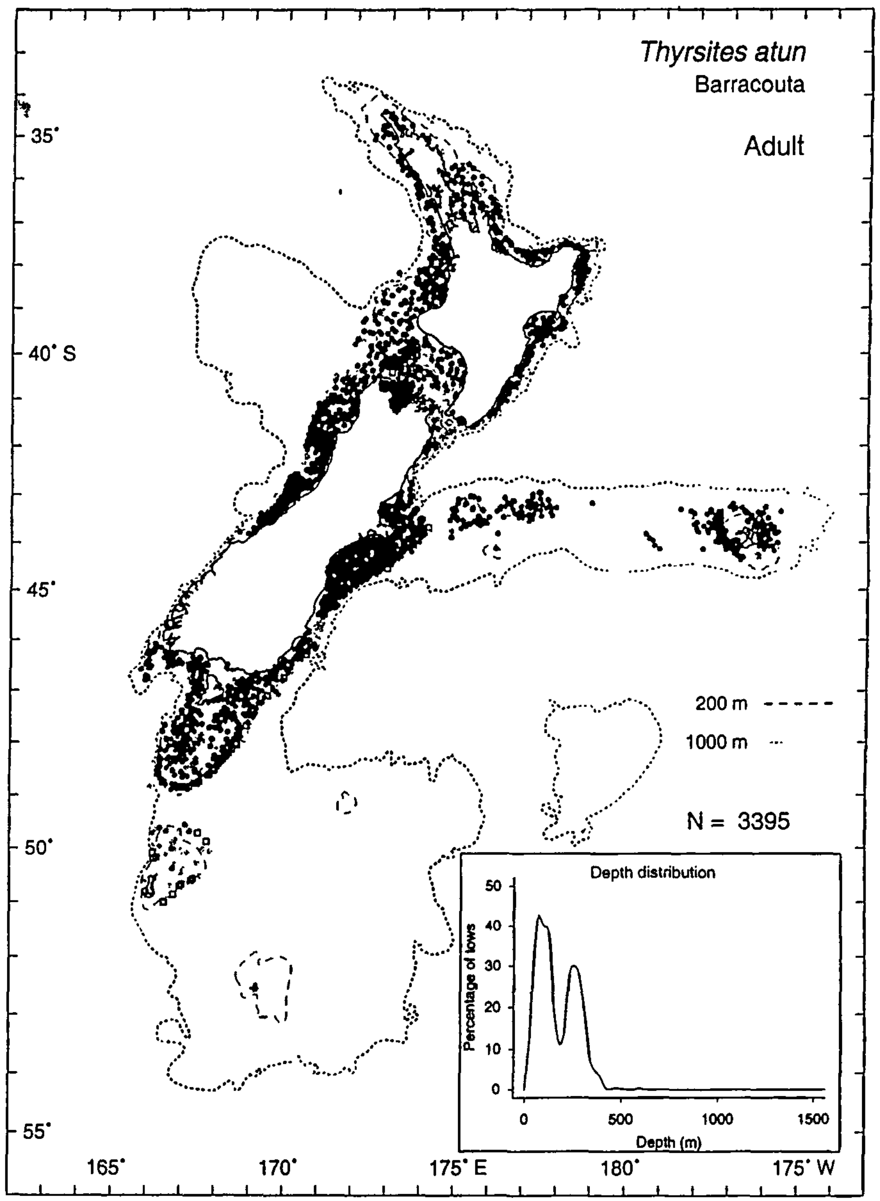
Trachurus declivis
Jack mackerel
Age 0+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 235
Depth distribution
Percentage of tows
Depth (m)
0
2
4
6
8
500
1000
1500



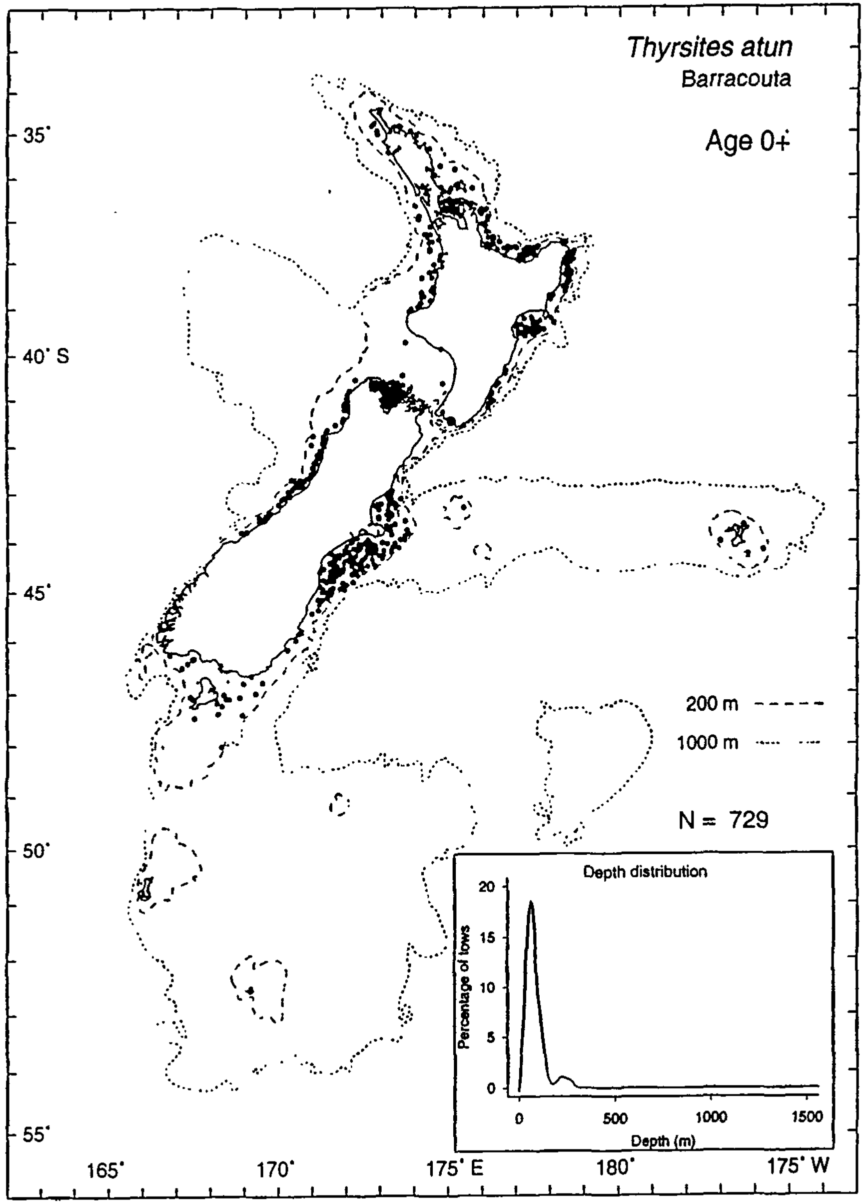
Trachurus declivis
Jack mackerel
Age 1+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 678
Depth distribution
Percentage of tows
Depth (m)
0
5
10
15
20
25
500
1000
1500

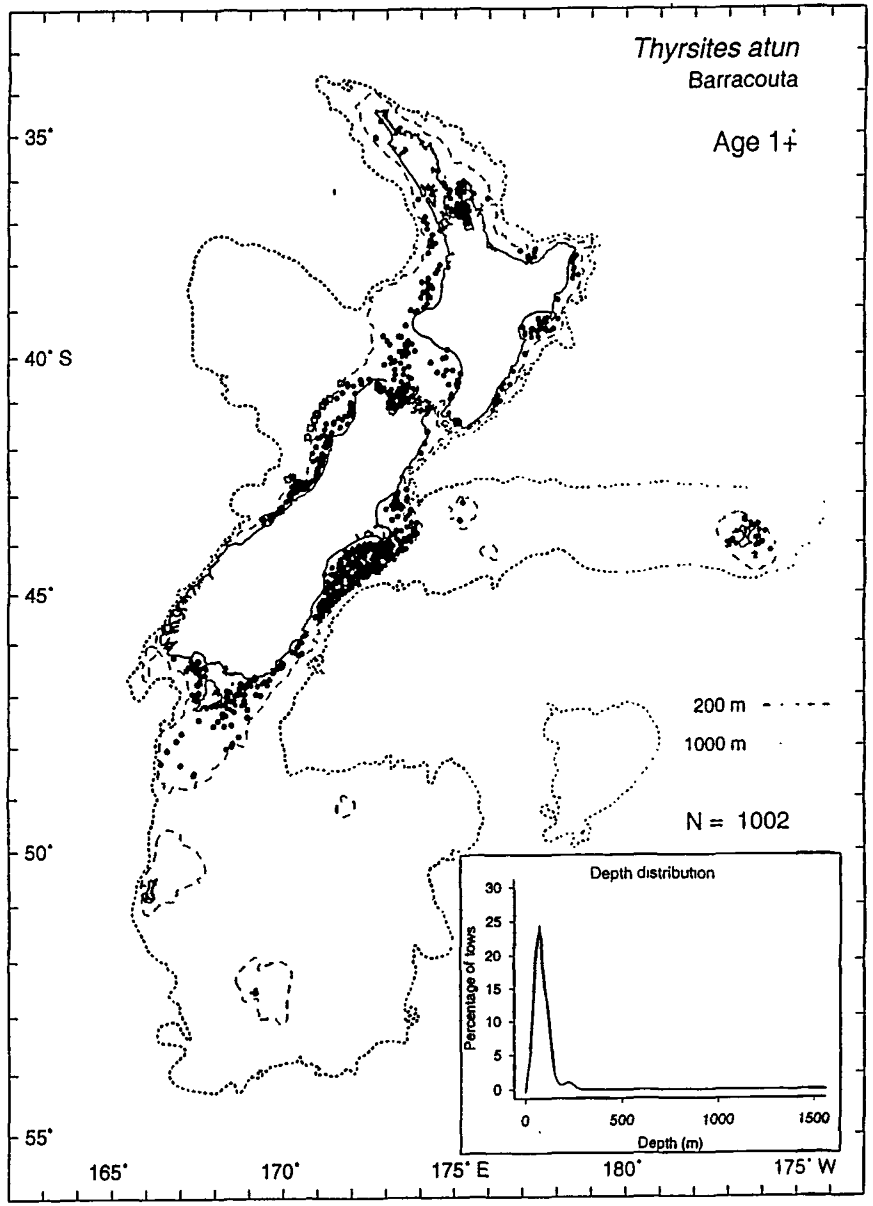


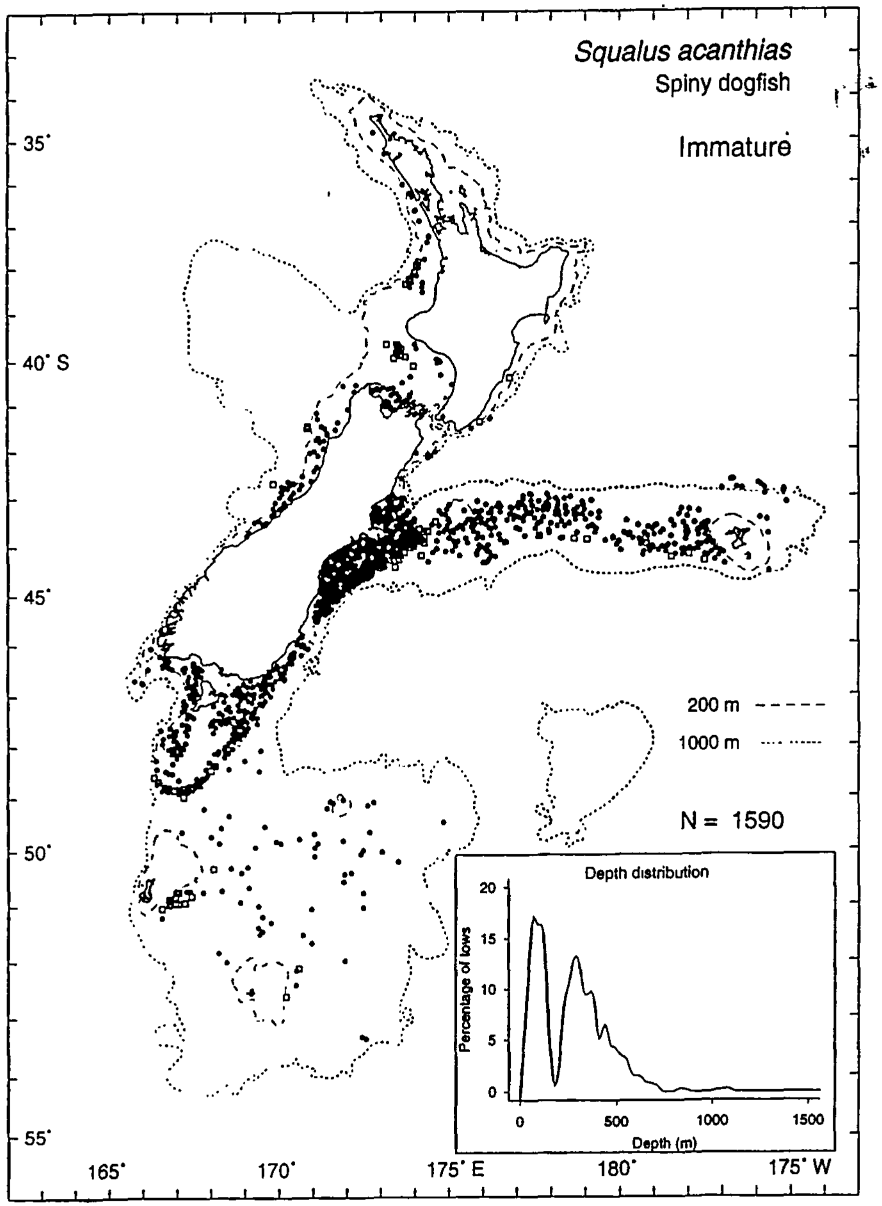
Thyrsites atun
Barracouta
Immature
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 2200
Depth distribution
Percentage of tows
Depth (m)



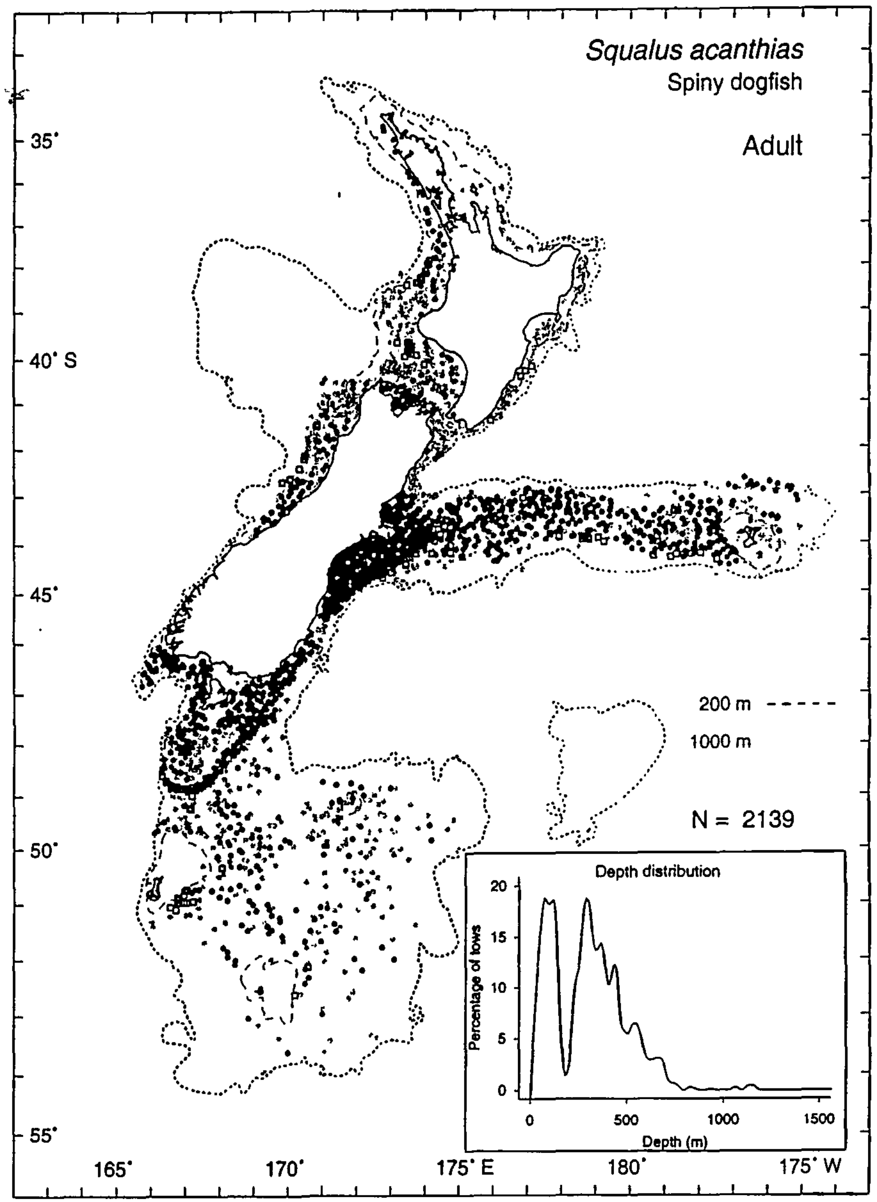
Thyrsites atun
Barracouta
Adult
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 3395
Depth distribution
Percentage of tows
Depth (m)


Thyrsites atun
Barracouta
Age 0+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 729
Depth distribution
Percentage of tows
Depth (m)
0
500
1000
1500
0
5
10
15
20

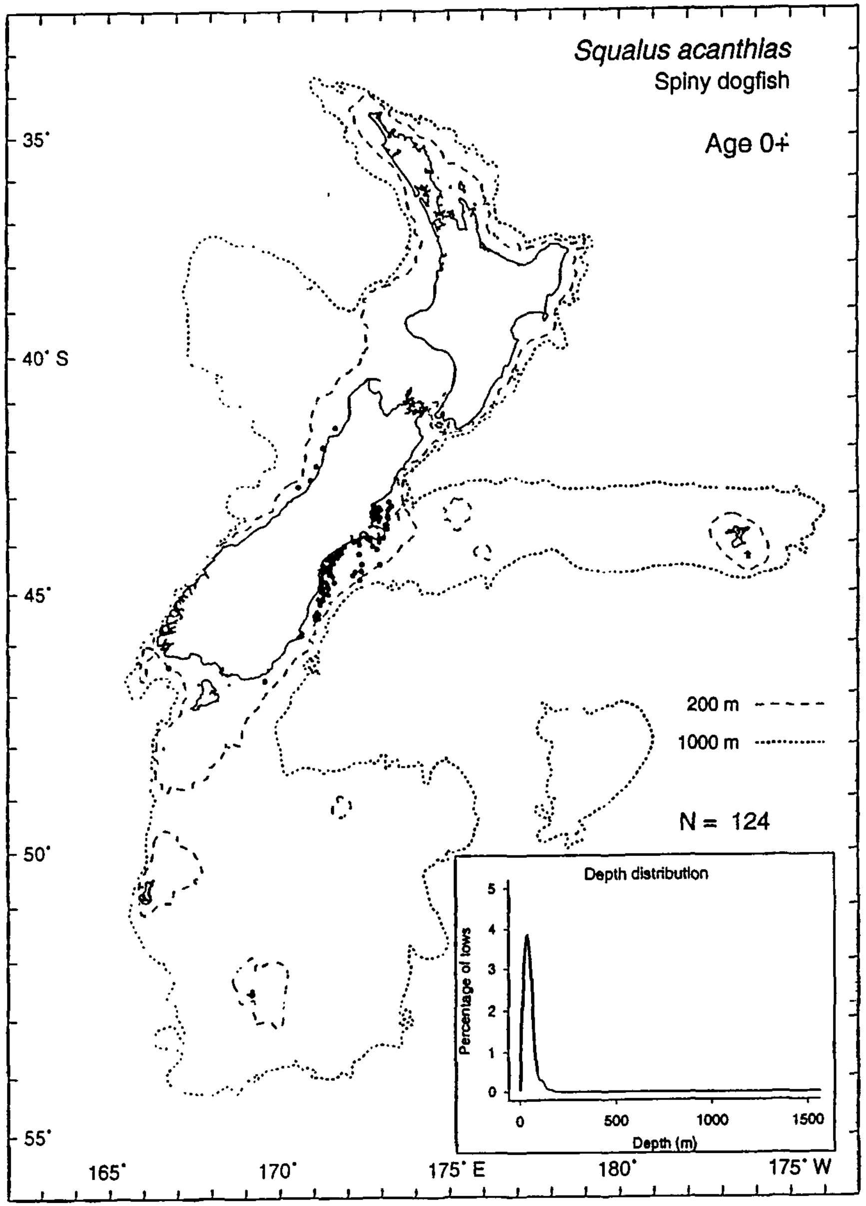

Thyrsites atun
Barracouta
Age 1+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 1002
Depth distribution
Percentage of tows
Depth (m)
0
500
1000
1500
0
5
10
15
20
25
30



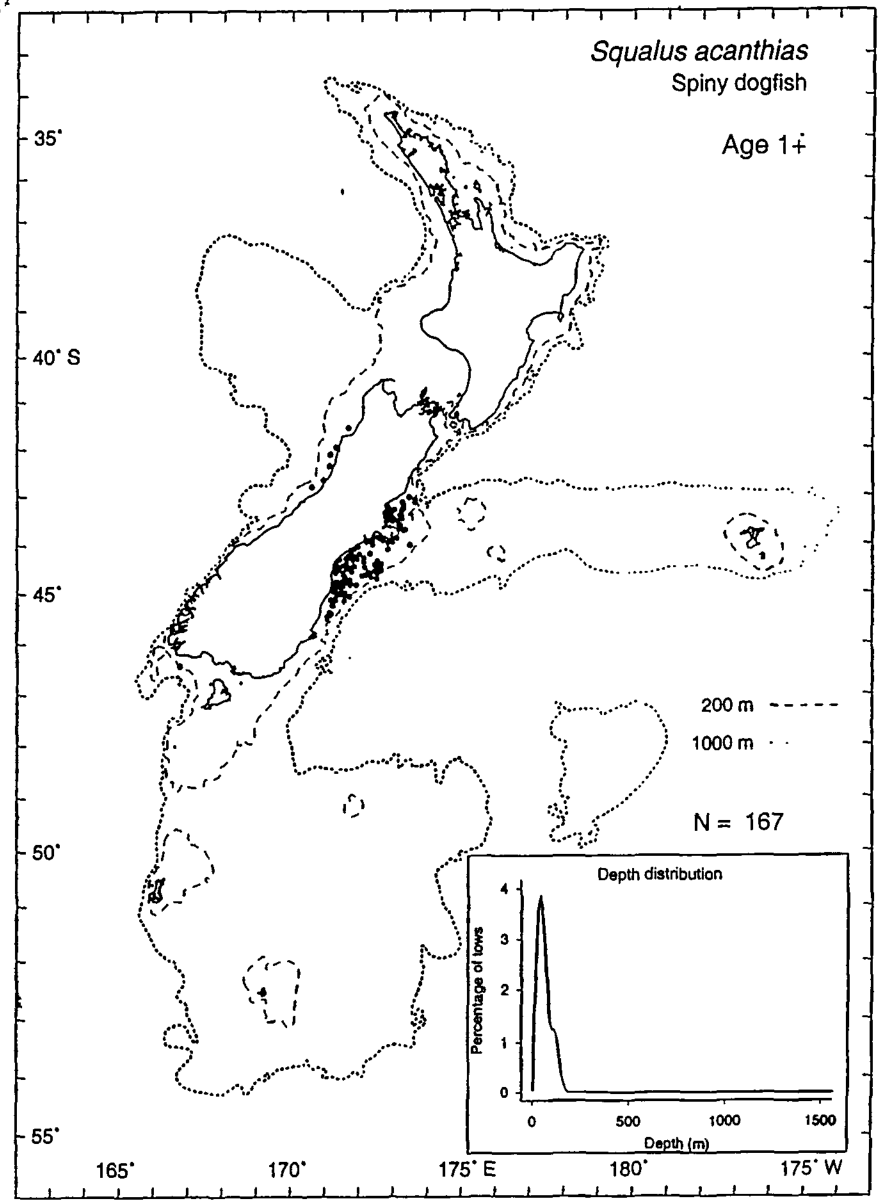
Squalus acanthias
Spiny dogfish
Immature
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 1590
Depth distribution
Percentage of tows
Depth (m)



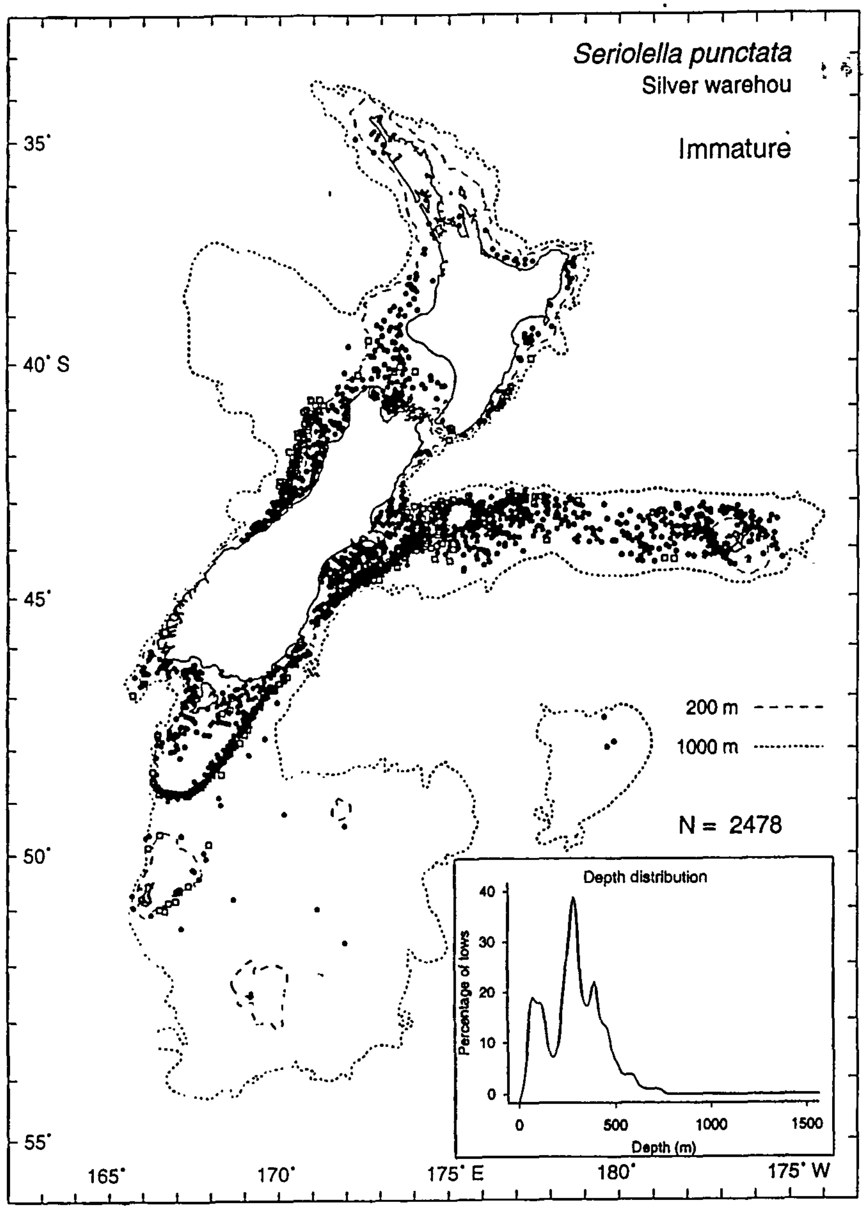
Squalus acanthias
Spiny dogfish
Adult
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 2139
Depth distribution
Percentage of tows
Depth (m)



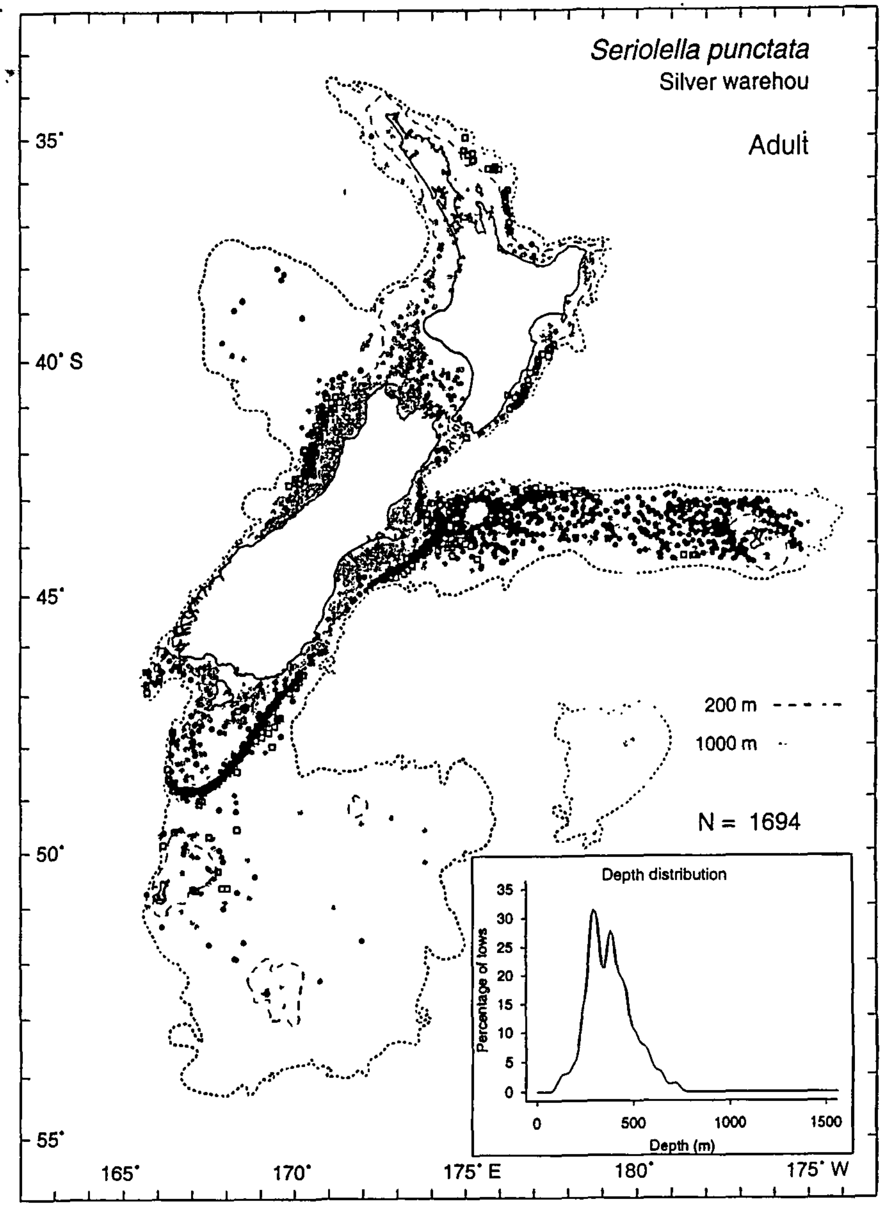
Squalus acanthias
Spiny dogfish
Age 0+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 124
Depth distribution
Percentage of tows
Depth (m)



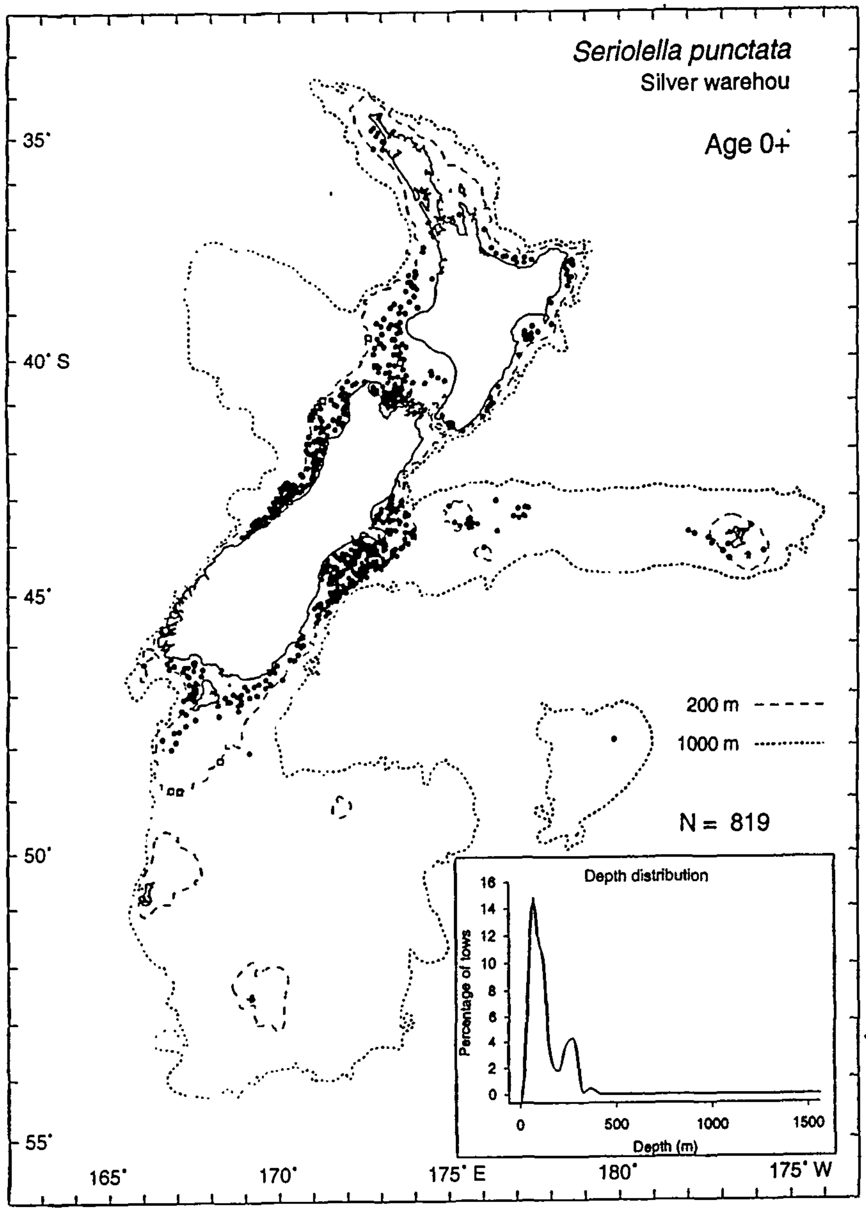
Squalus acanthias
Spiny dogfish
Age 1+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 167
Depth distribution
Percentage of tows
Depth (m)



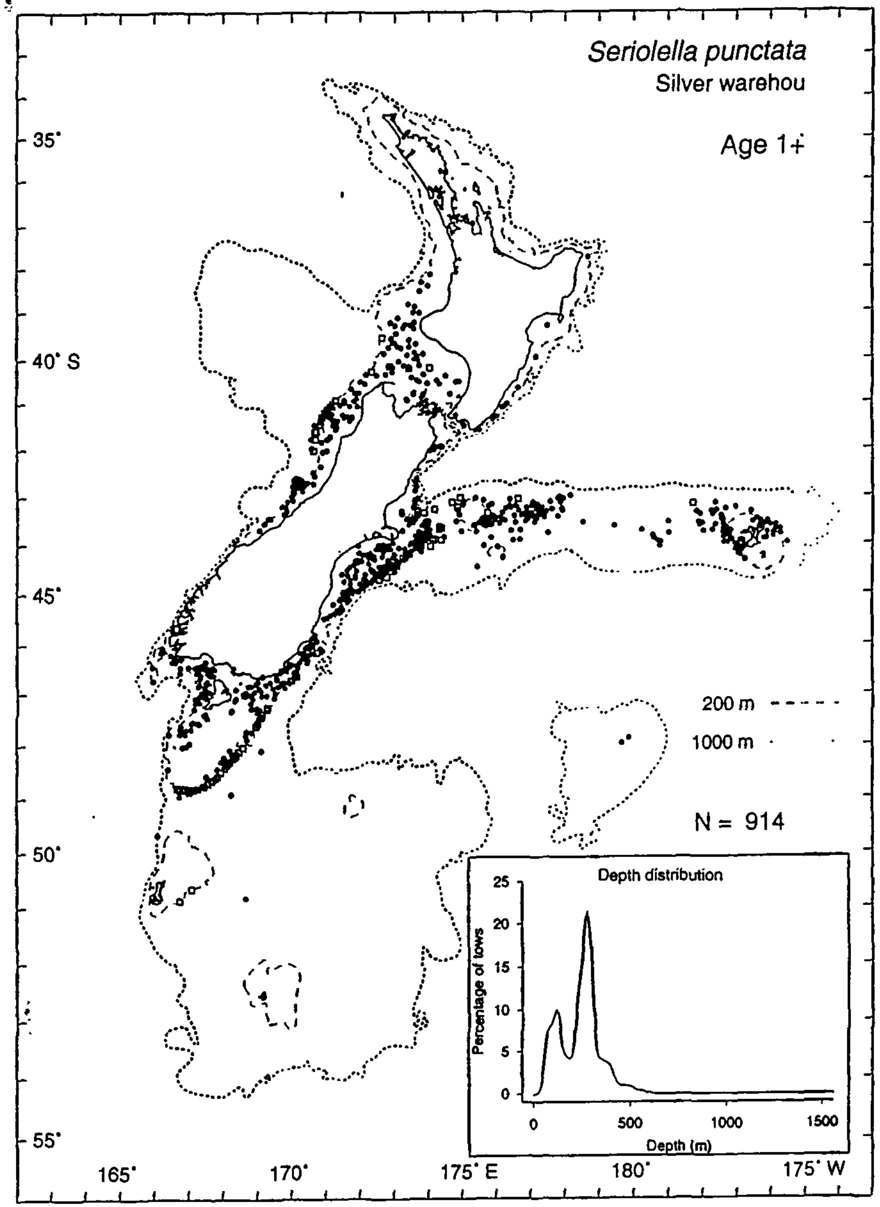
Seriolella punctata
Silver warehou
Immature
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 2478
Depth distribution
Percentage of tows
Depth (m)
0
500
1000
1500
0
10
20
30
40



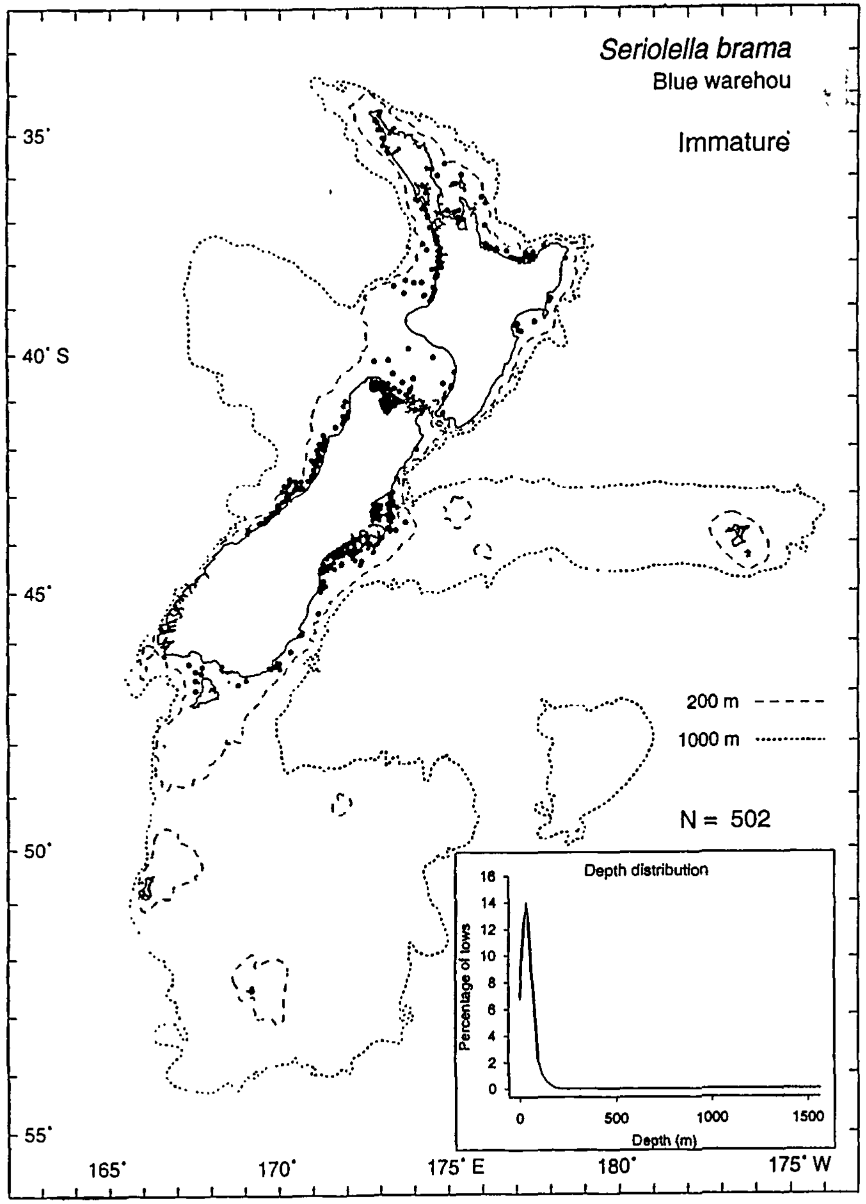
Seriolella punctata
Silver warehou
Adult
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 1694
Depth distribution
Percentage of tows
Depth (m)
0
500
1000
1500
0
5
10
15
20
25
30
35

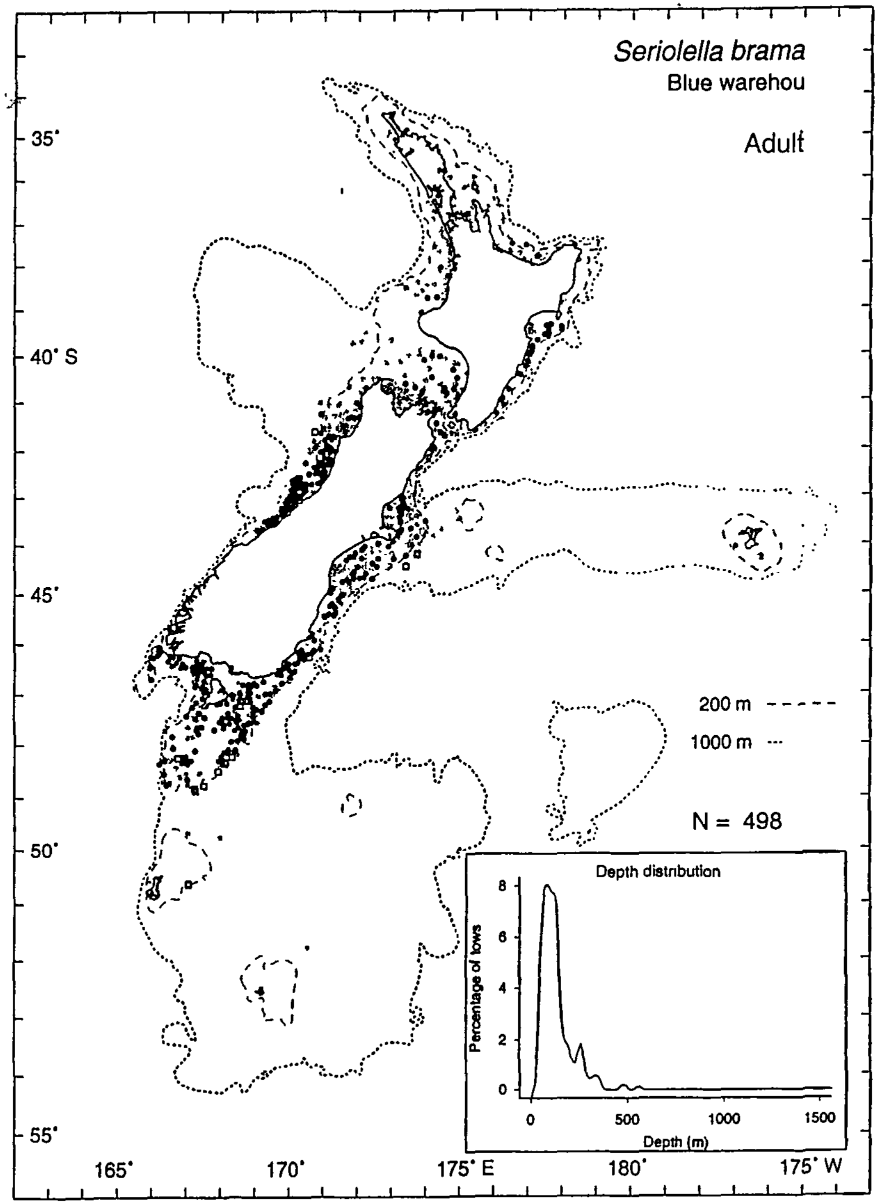


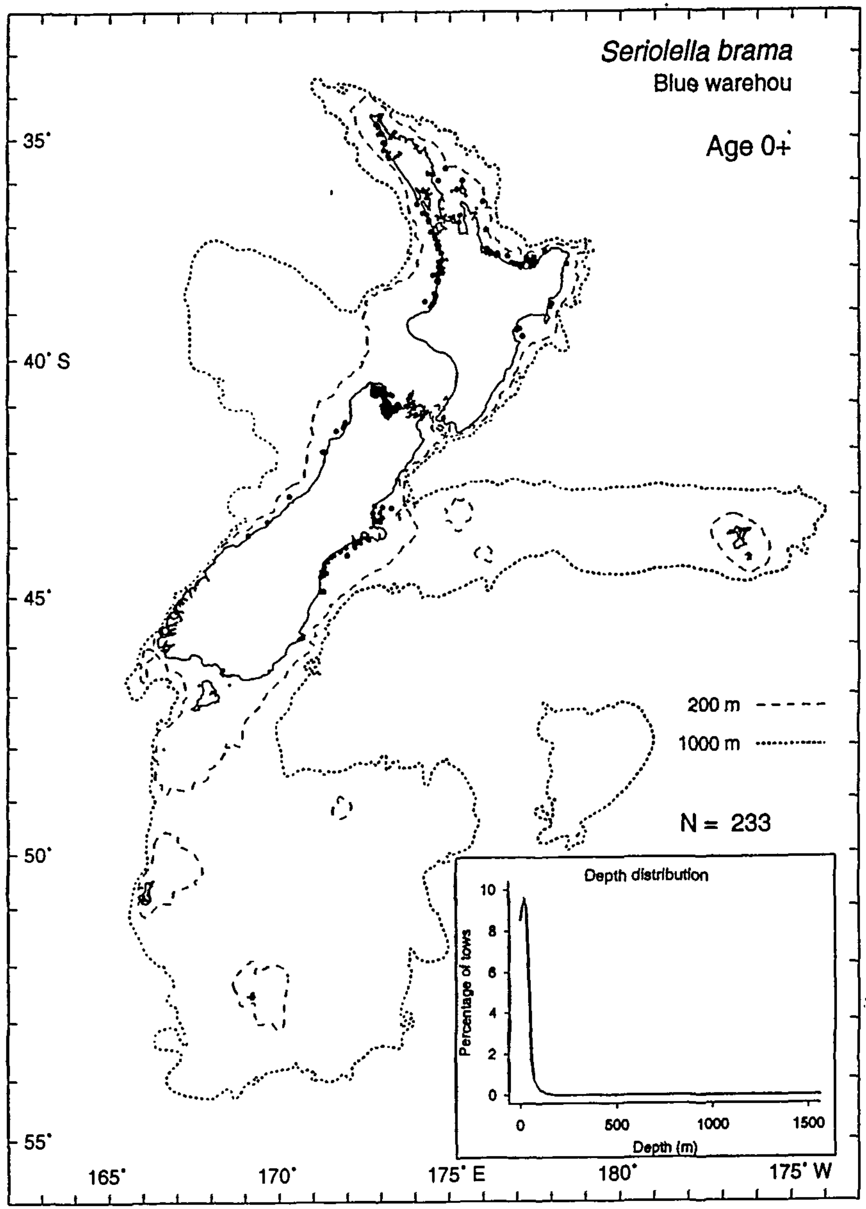
Seriolella punctata
Silver warehou
Age 0+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 819
Depth distribution
Percentage of tows
Depth (m)



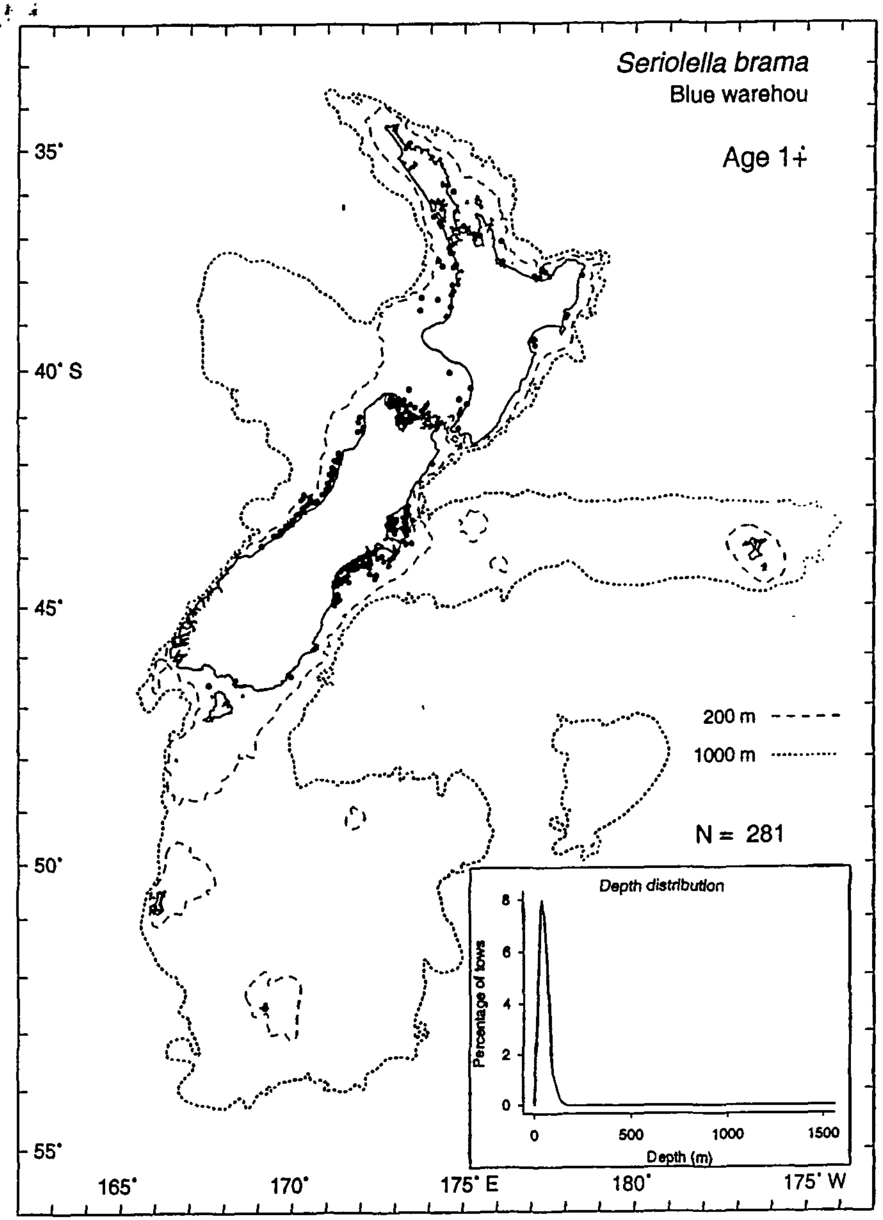
Seriolella punctata
Silver warehou
Age 1+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 914
Depth distribution
Percentage of tows
Depth (m)


Seriolella brama
Blue warehou
Immature
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 502
Depth distribution
Percentage of tows
Depth (m)
0
500
1000
1500

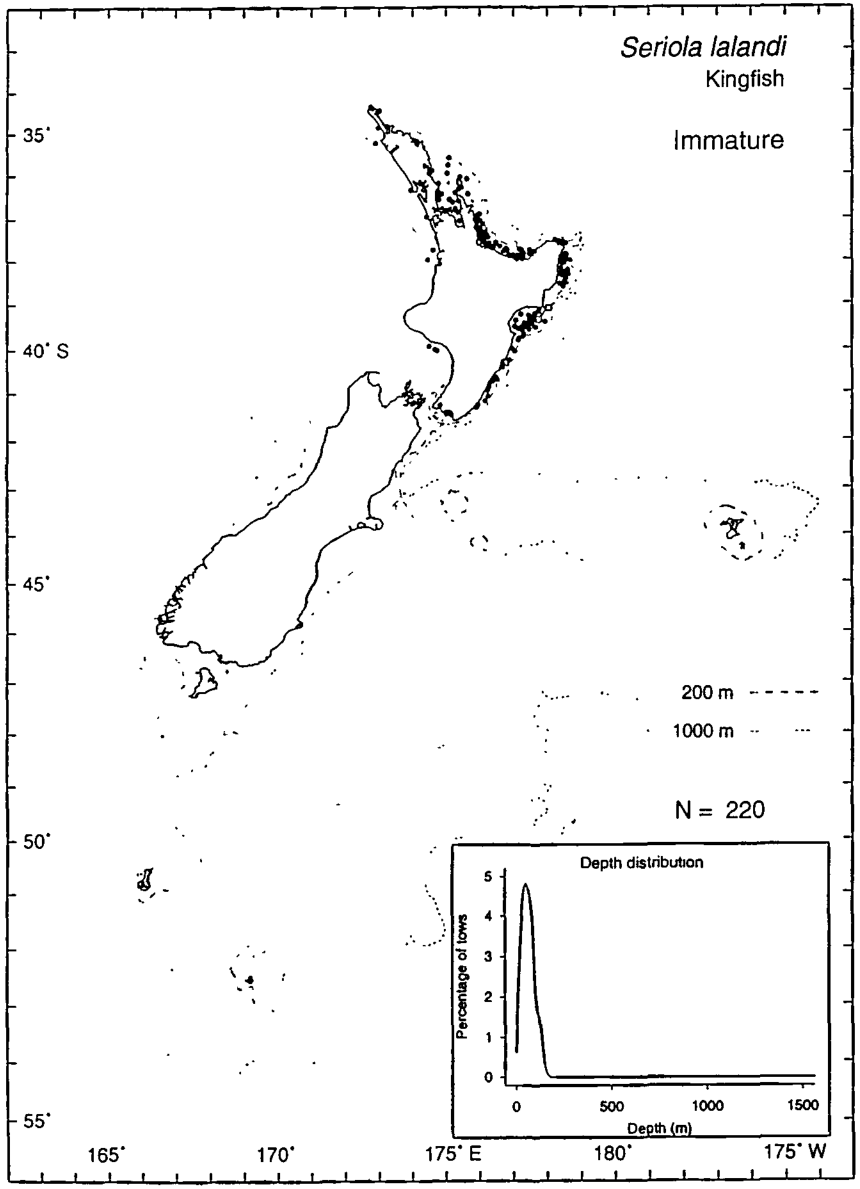

Seriolella brama
Blue warehou
Adult
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 498
Depth distribution
Percentage of tows
Depth (m)
0
500
1000
1500



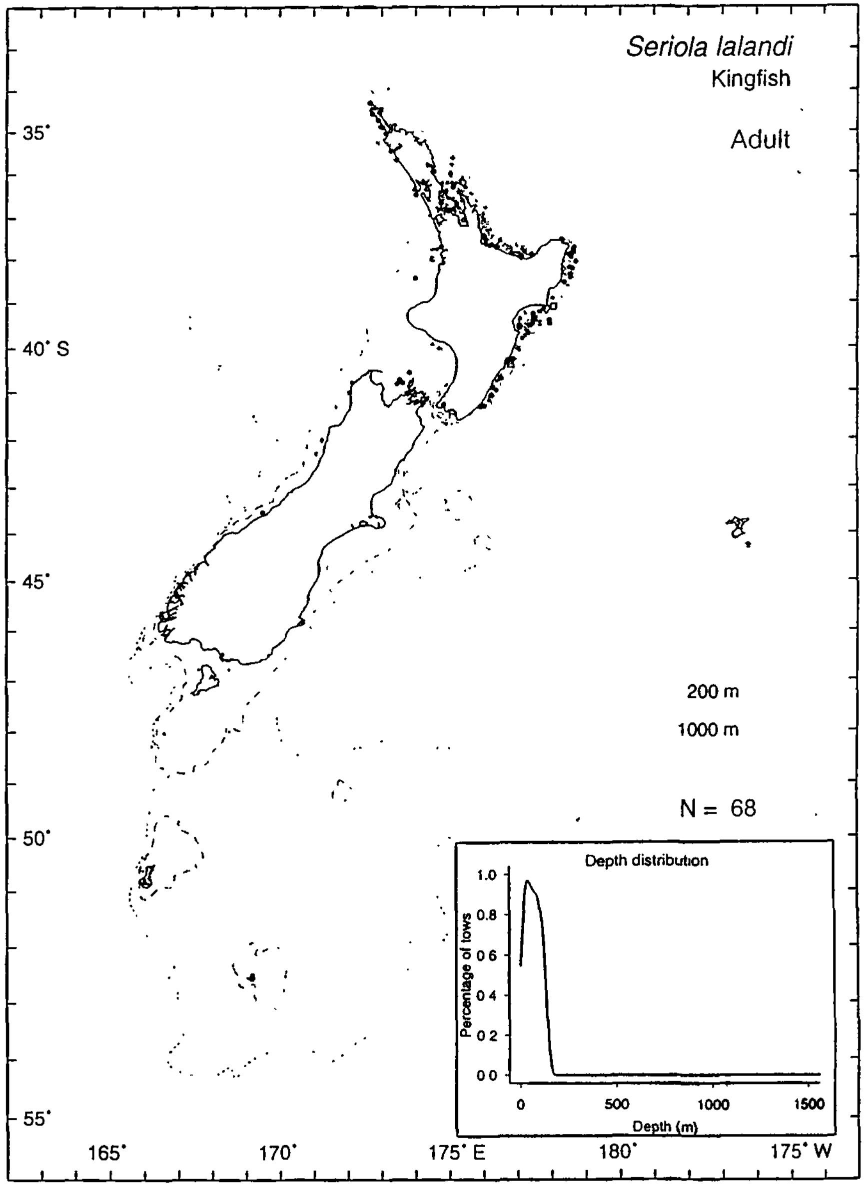
Seriolella brama
Blue warehou
Age 0+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 233
Depth distribution
Percentage of tows
Depth (m)
0
2
4
6
8
10
500
1000
1500



Seriolella brama
Blue warehou
Age 1+
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 281
Depth distribution
Percentage of tows
Depth (m)
0
2
4
6
8
500
1000
1500

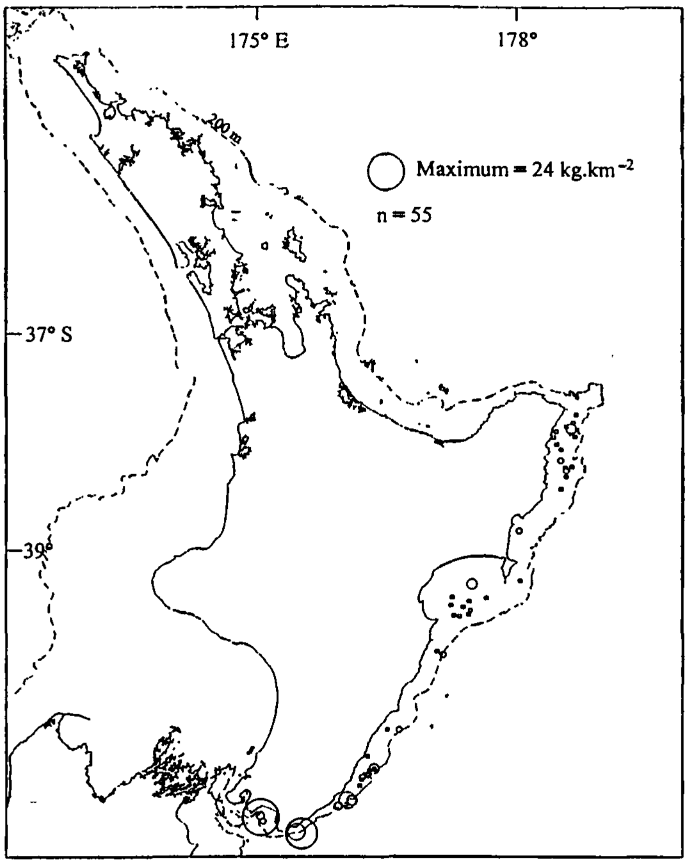


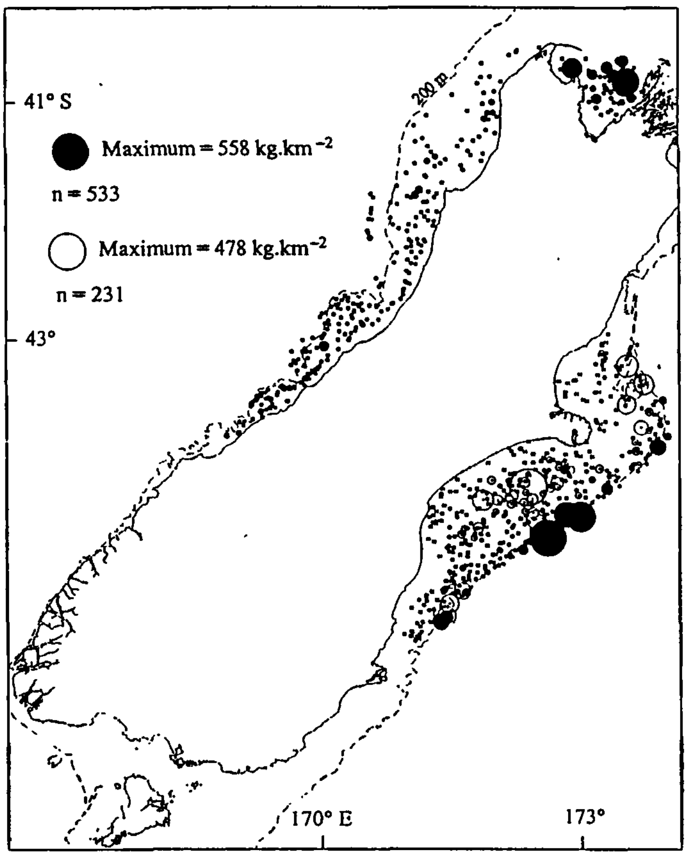
Seriola lalandi
Kingfish
Immature
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 220
Depth distribution
Percentage of tows
Depth (m)
0
500
1000
1500



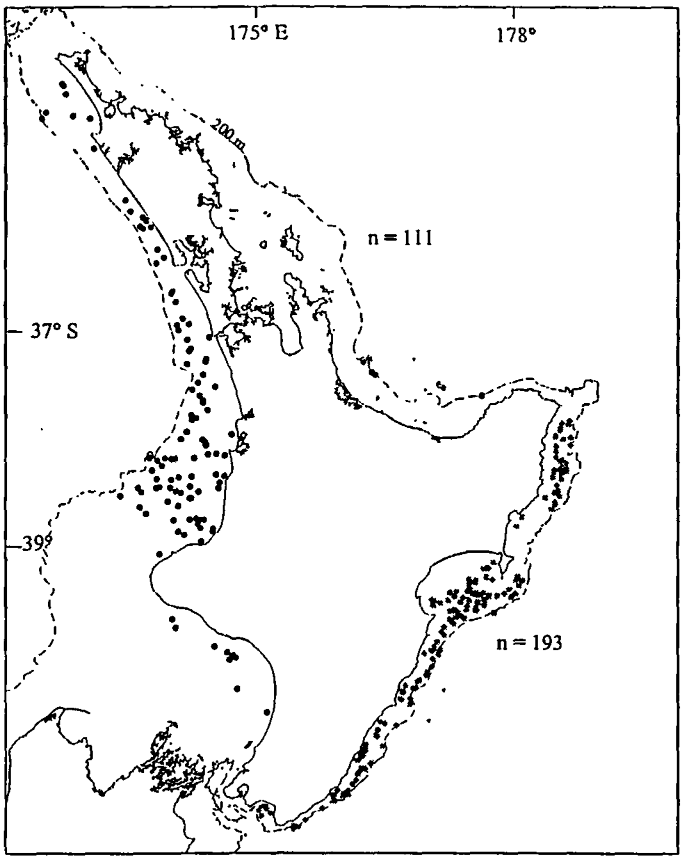
Seriola lalandi
Kingfish
Adult
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 68
Depth distribution
Percentage of tows
Depth (m)
0
500
1000
1500

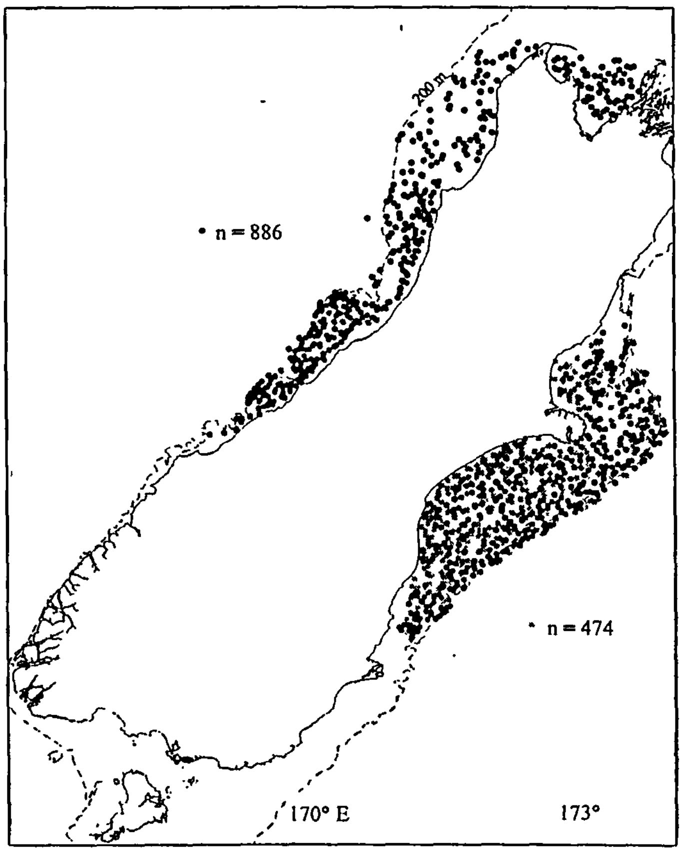
Seriolella punctata



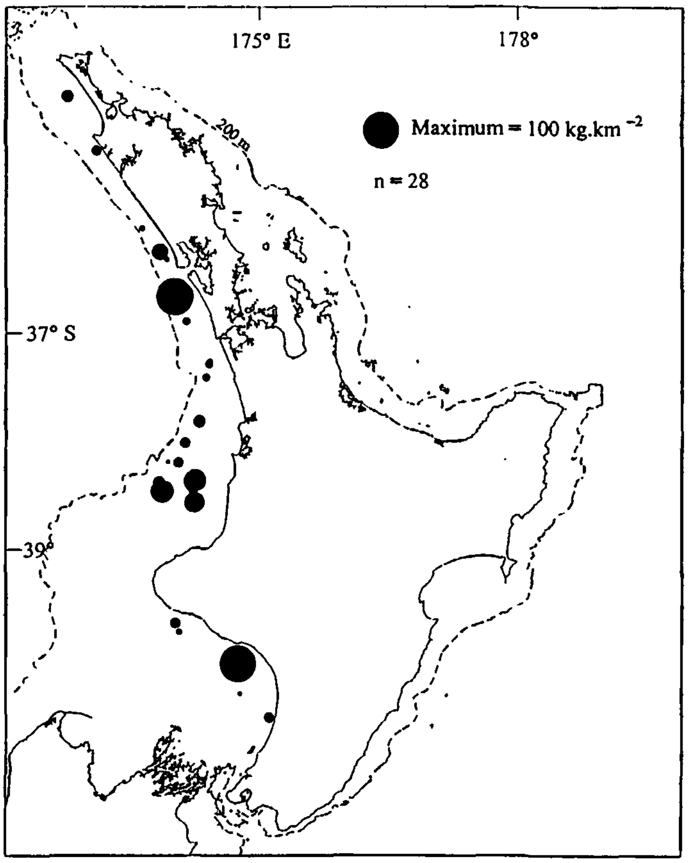


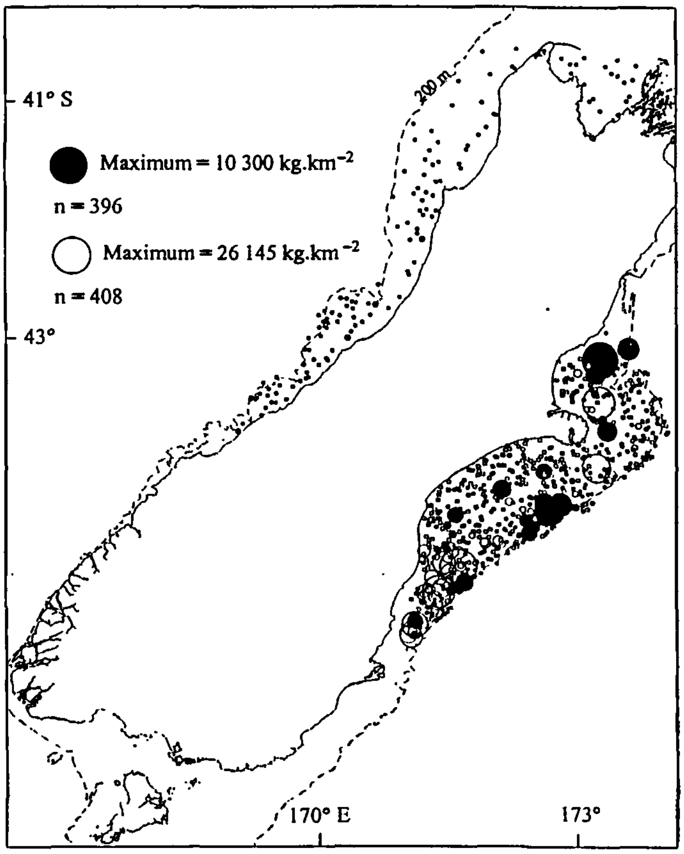
Squalus acanthias



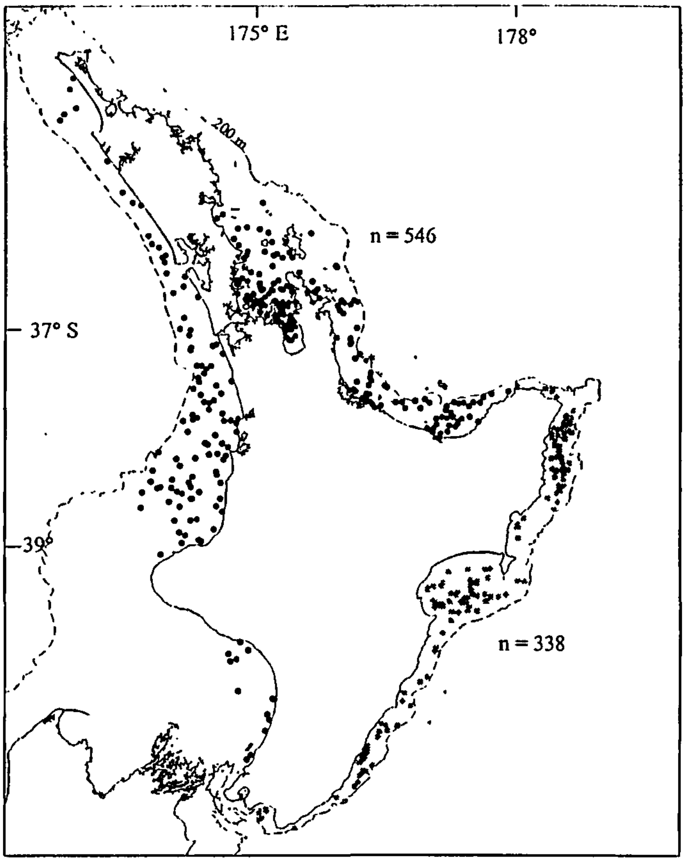


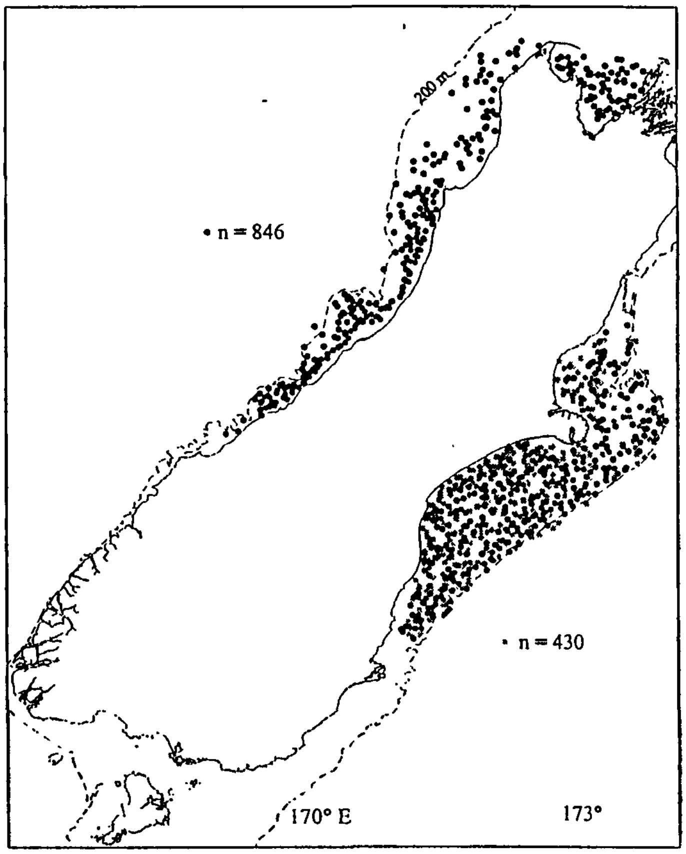
Squalus acanthias



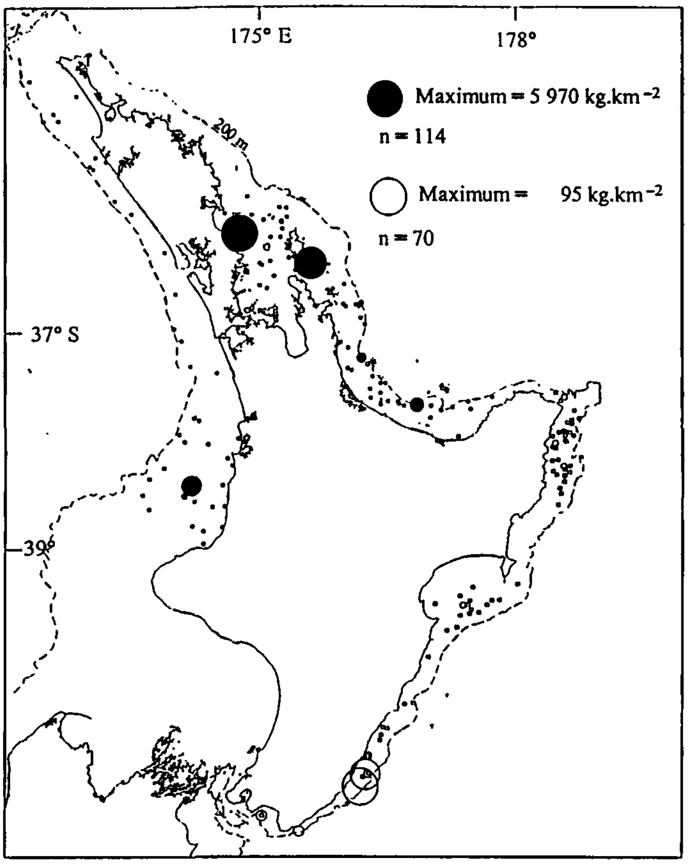


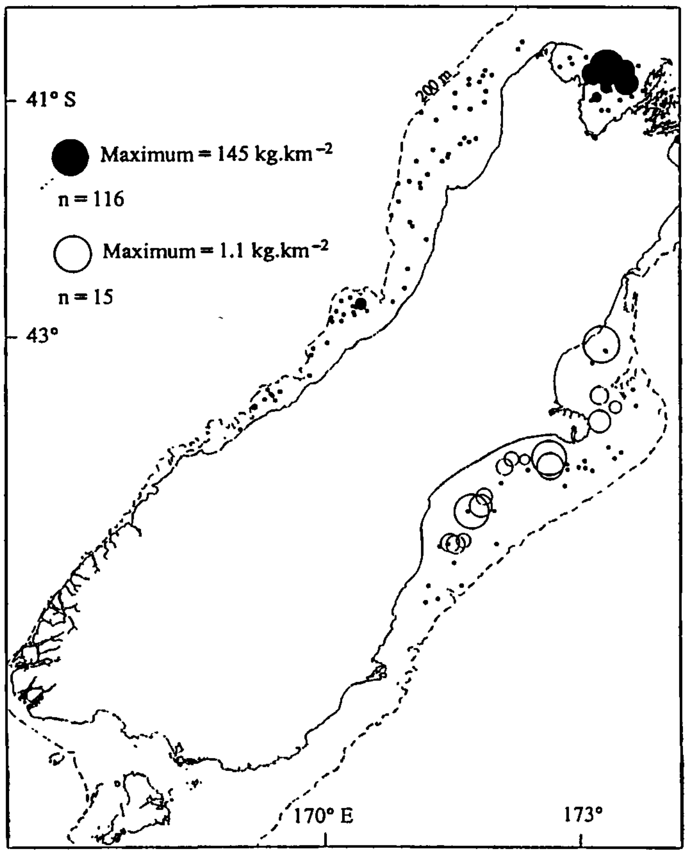
Thyrsites atun



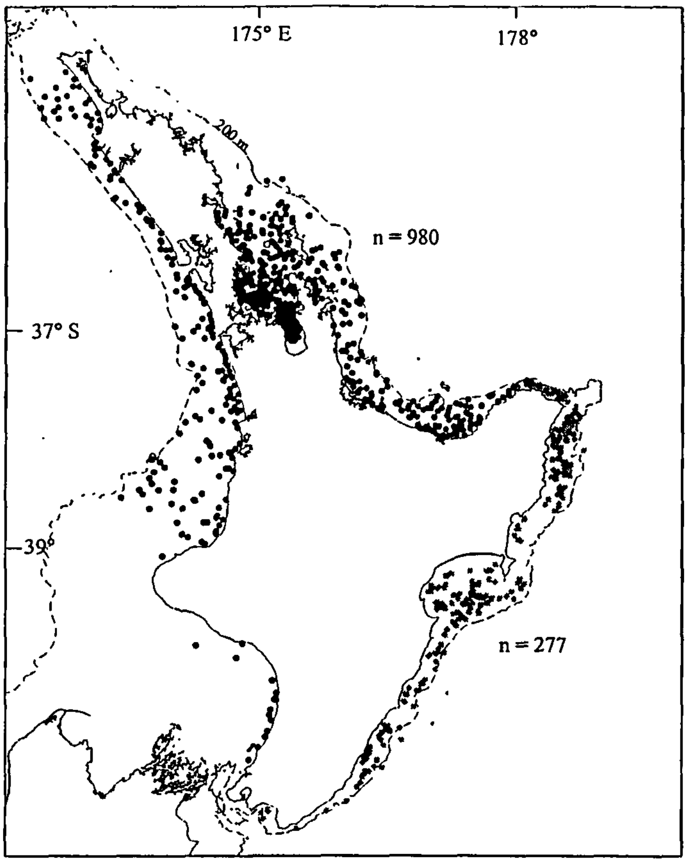


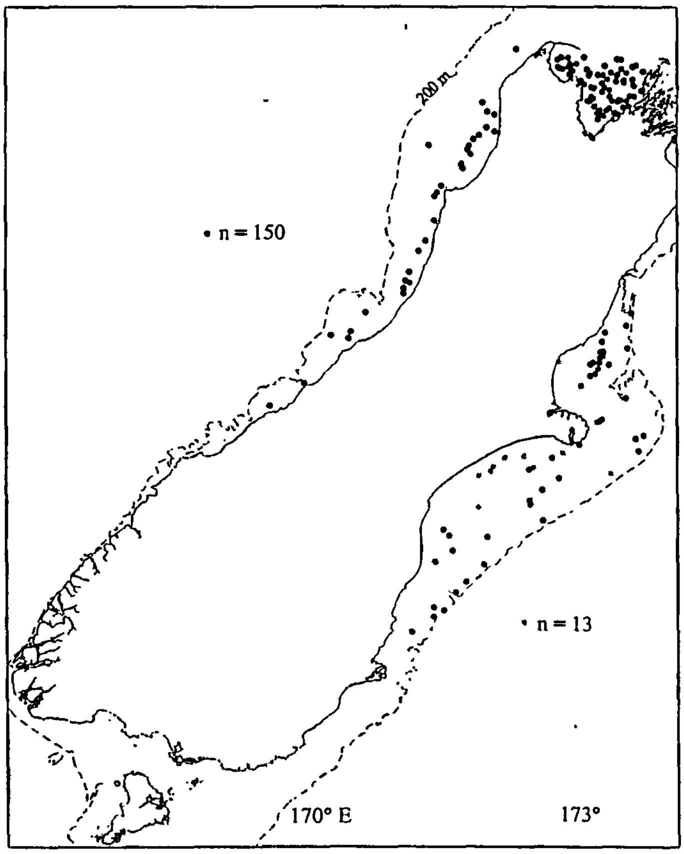
Trachurus declivis



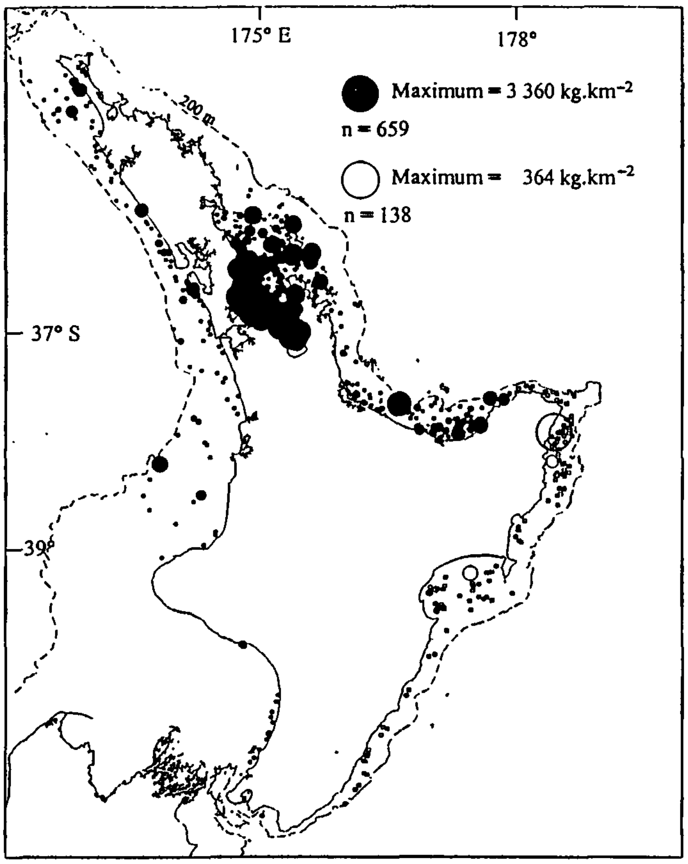


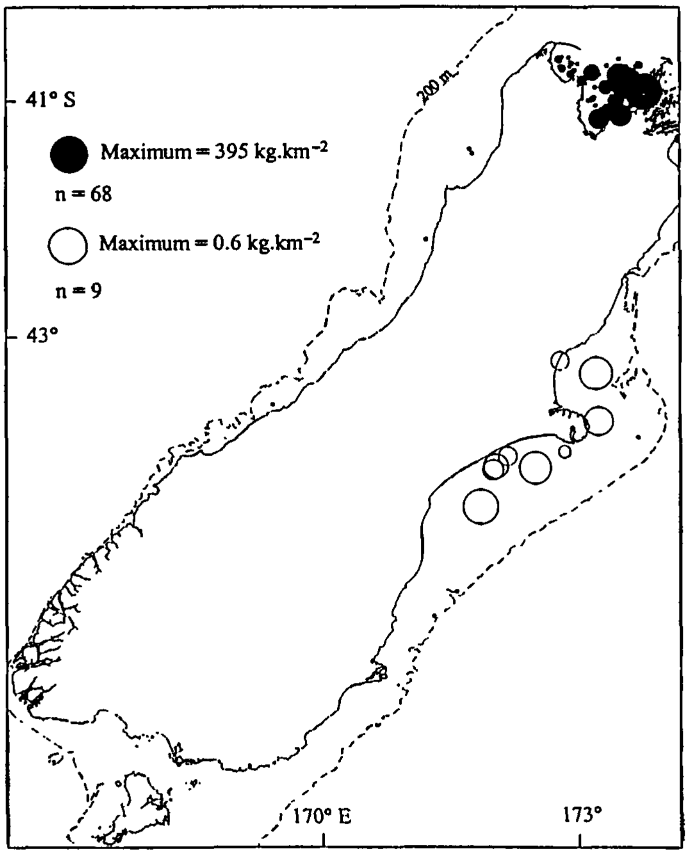
Trachurus novaezelandiae



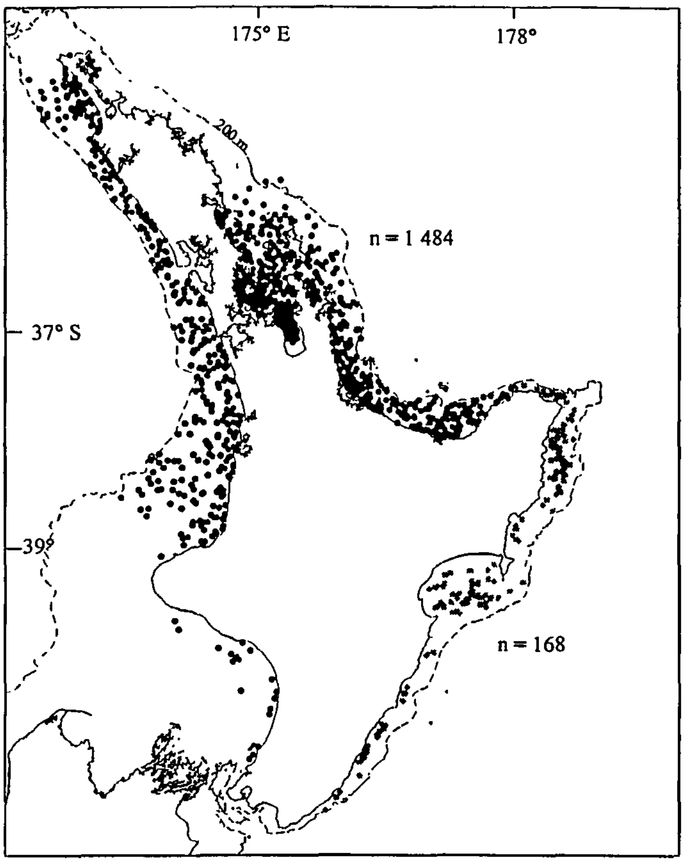


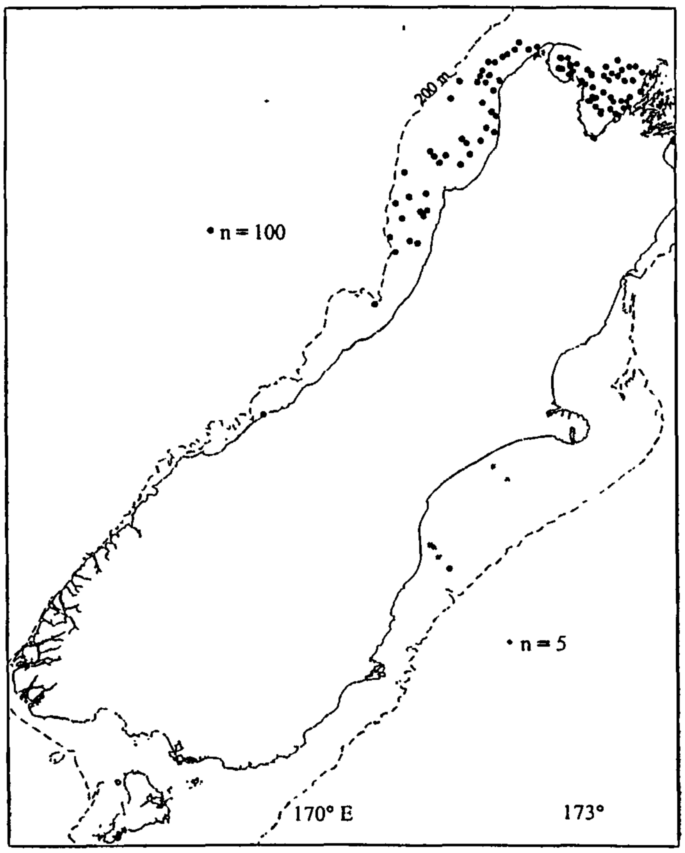
Trachurus novaezelandiae



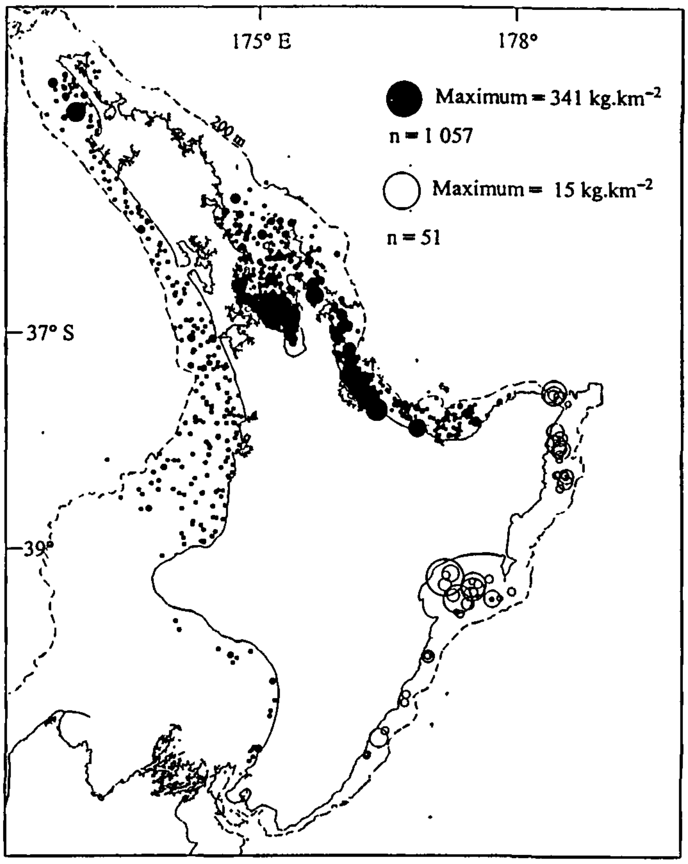


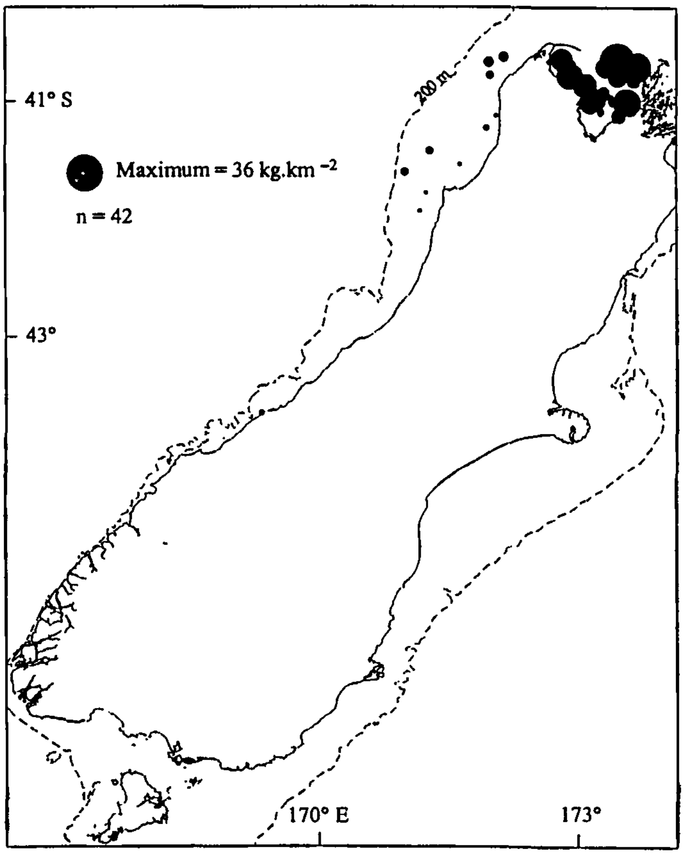
Zeus faber



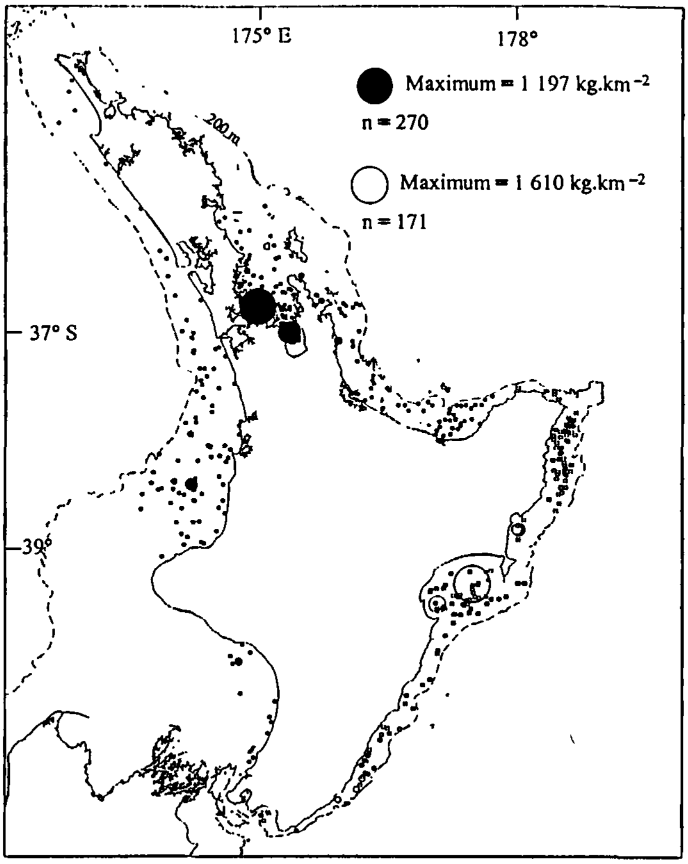


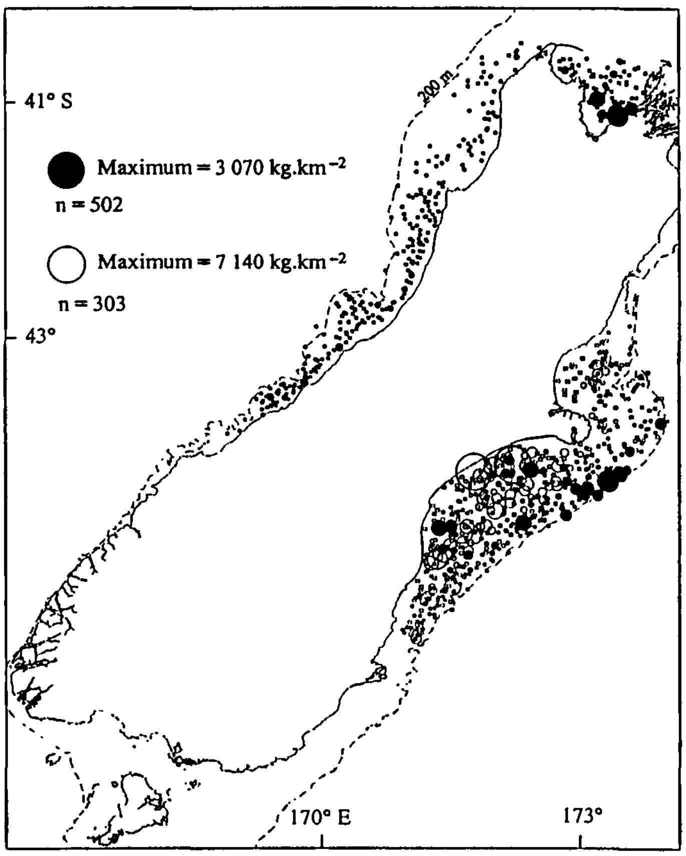
Zeus faber


175° E
178°
Maximum = 341 kg.km^{-2}
n = 1 057
Maximum = 15 kg.km^{-2}
n = 51
200 m
37° S
39°

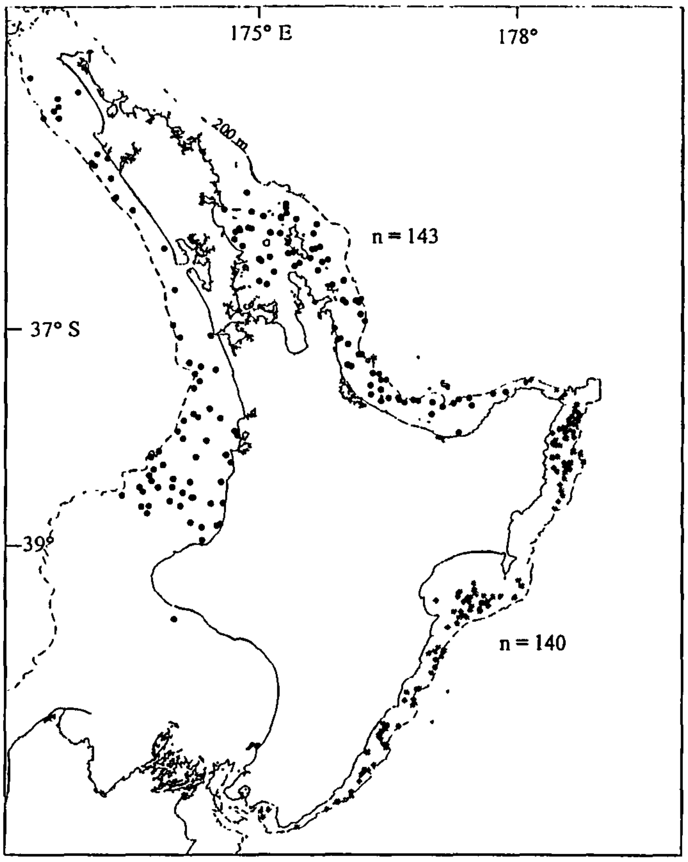

200 m
41° S
Maximum = 36 kg.km^{-2}
n = 42
43°
170° E
173°

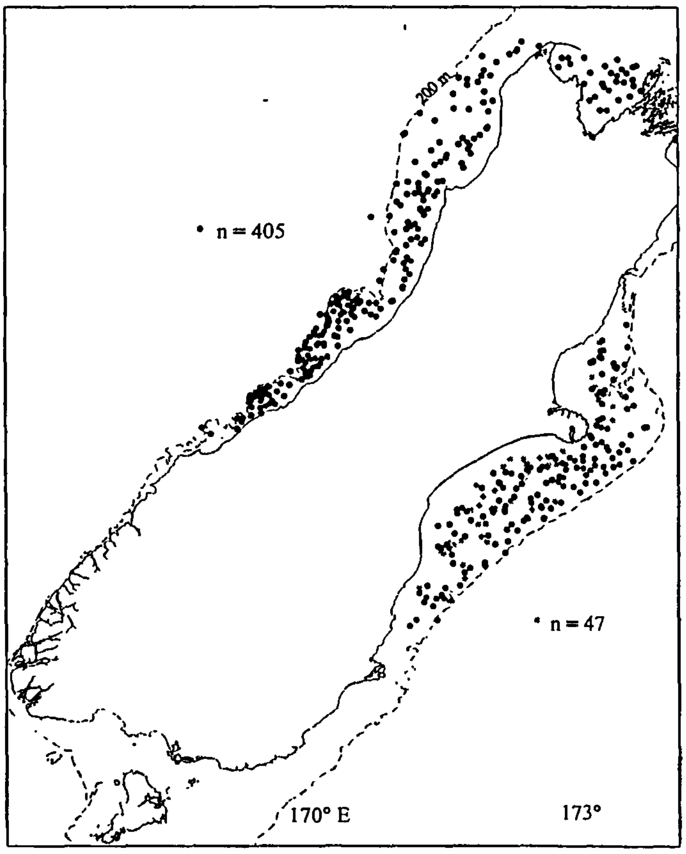
Thyrsites atun





Trachurus declivis





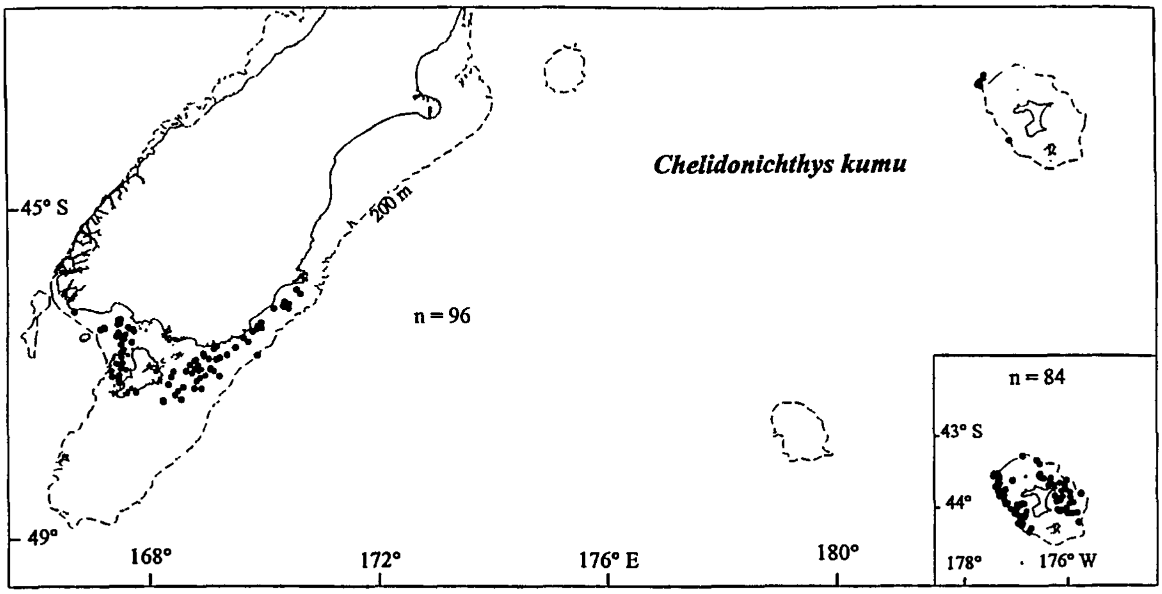
1.2.2 Juvenile abundance Tangaroa and AM73 surveys

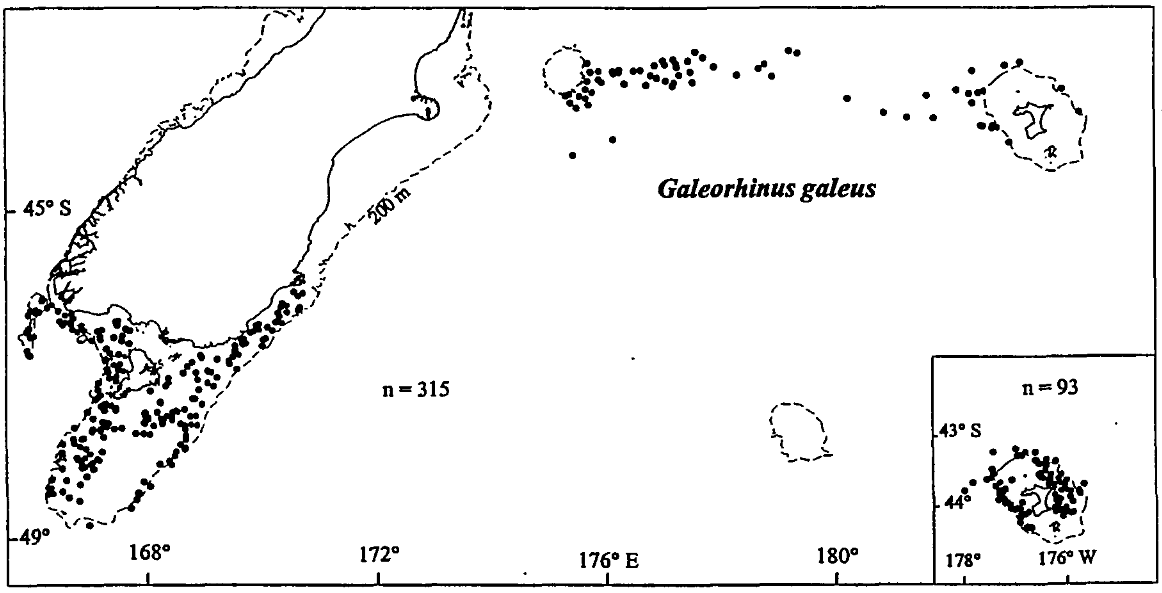
Key to interpretation of *Tangaroa and Akebono Maru No.73 (AM73)* distribution plots

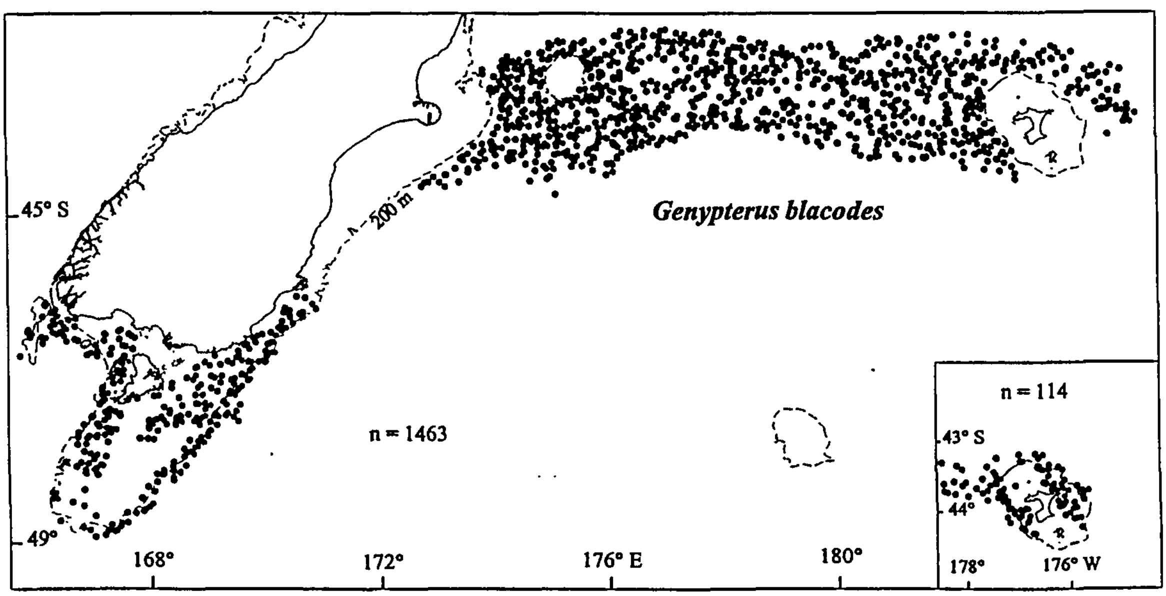
Left page	Reference plots of where the species was caught
Right page	Catch rates of juveniles. Circle size is proportional to the maximum catch rate indicated

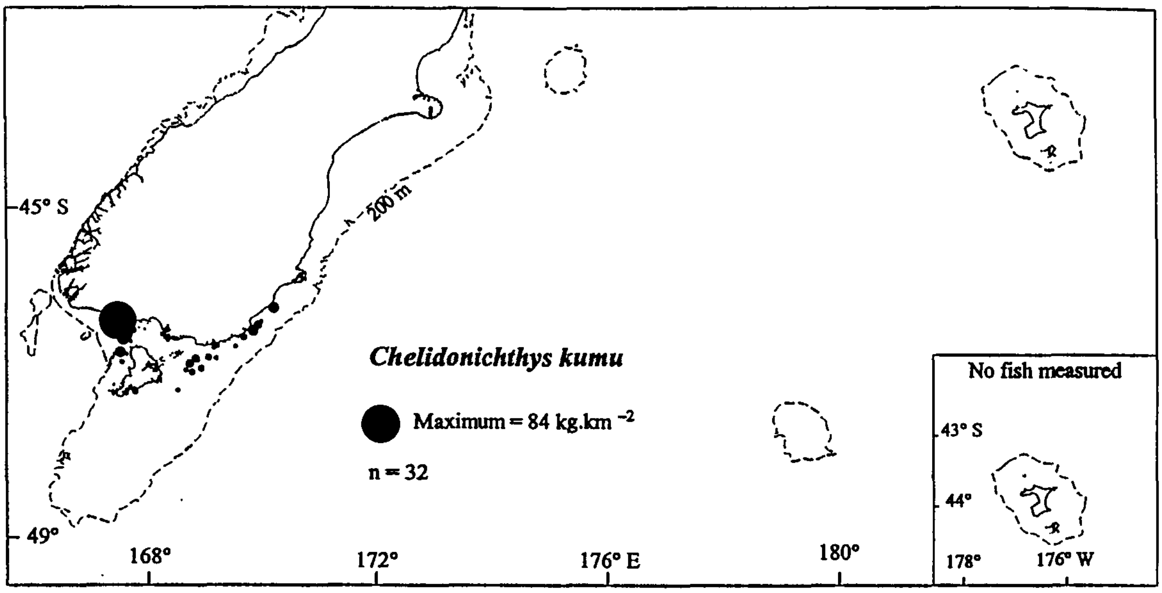
● *Tangaroa*

O *Akebono Maru No.73*

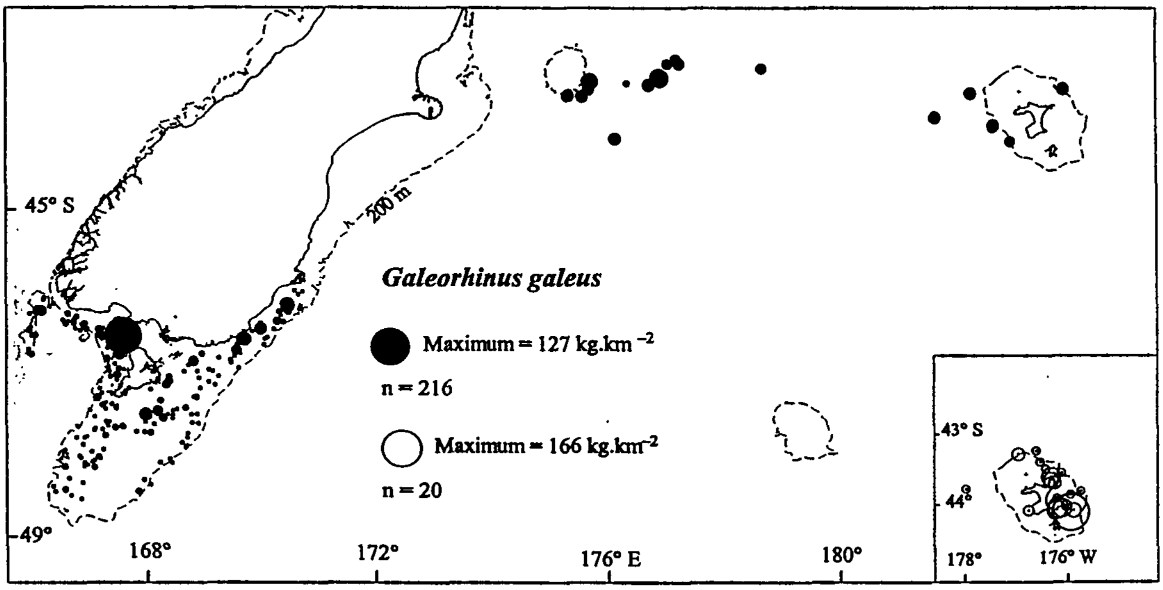

Chelidonichthys kumu
45° S
200 m
n = 96
49°
168°
172°
176° E
180°
n = 84
43° S
44°
178°
176° W


Galeorhinus galeus
45° S
200 m
n = 315
49°
168°
172°
176° E
180°
n = 93
43° S
44°
178°
176° W

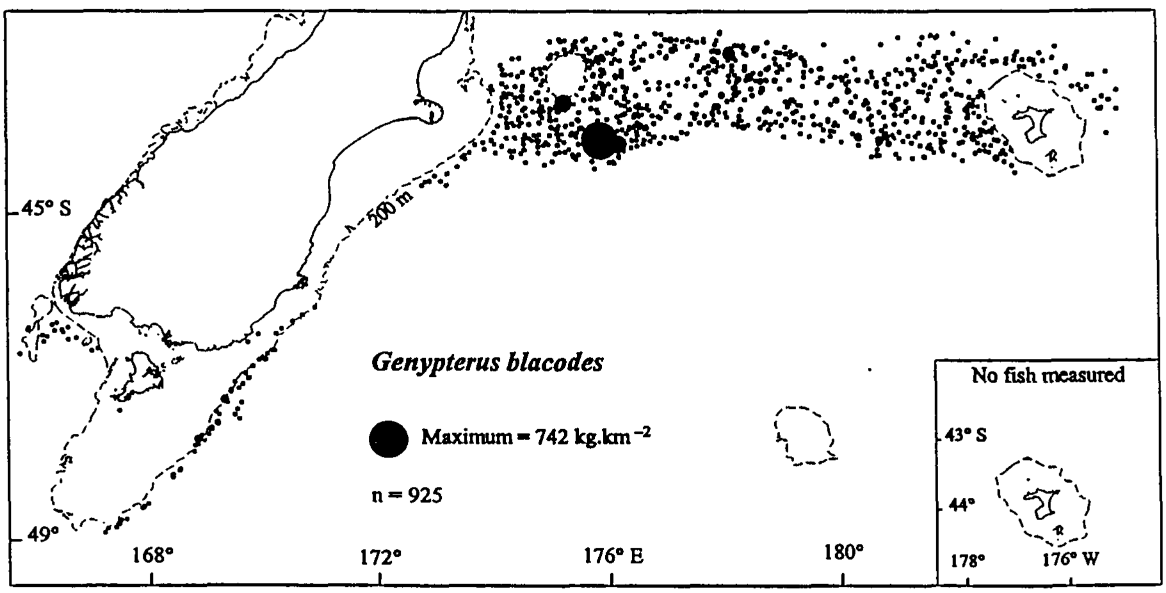

Genypterus blacodes
45° S
200 m
n = 1463
49°
168°
172°
176° E
180°
n = 114
43° S
44°
178°
176° W



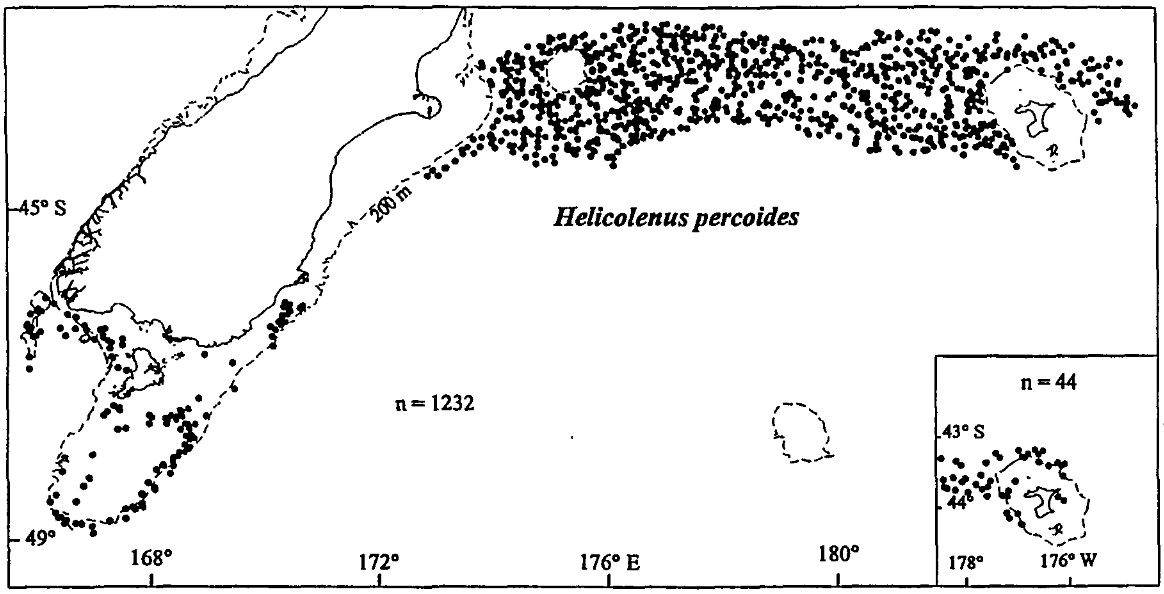
45° S
49°
168°
172°
176° E
180°
200 m
Chelidonichthys kumu
Maximum = 84 kg.km $^{-2}$
n = 32
No fish measured
43° S
44°
178°
176° W

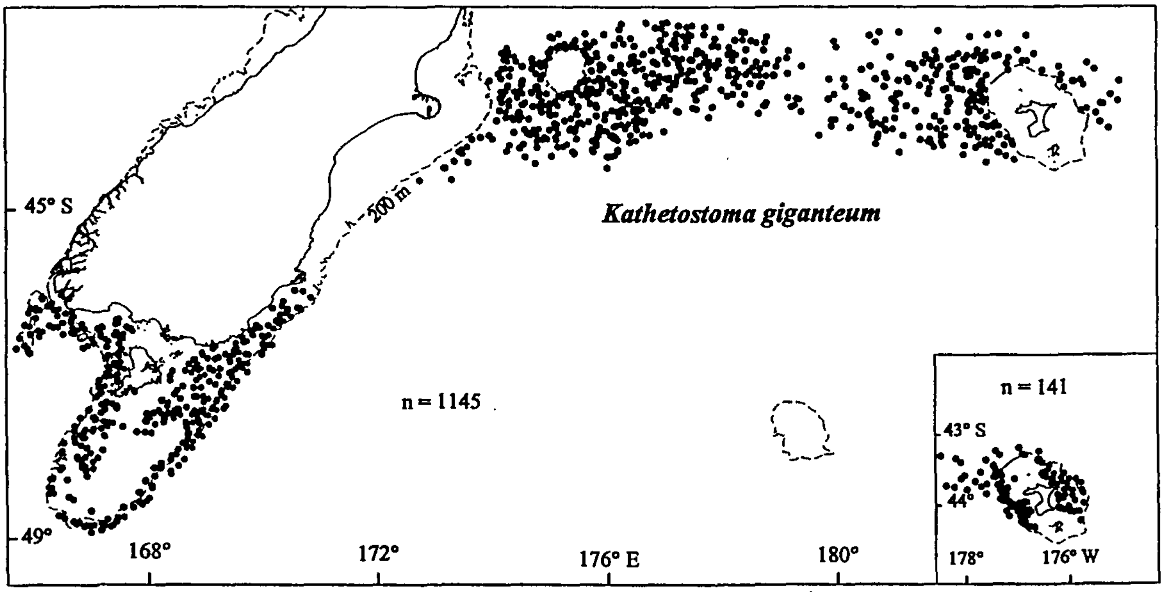


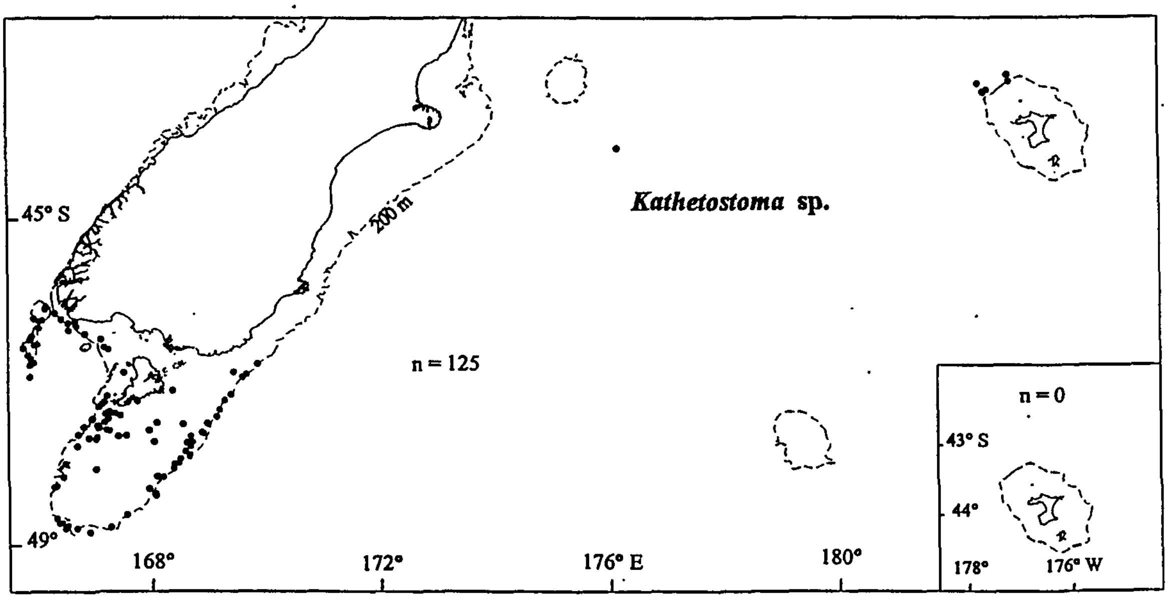
45° S
49°
168°
172°
176° E
180°
200 m
Galeorhinus galeus
Maximum = 127 kg.km $^{-2}$
n = 216
Maximum = 166 kg.km $^{-2}$
n = 20
43° S
44°
178°
176° W

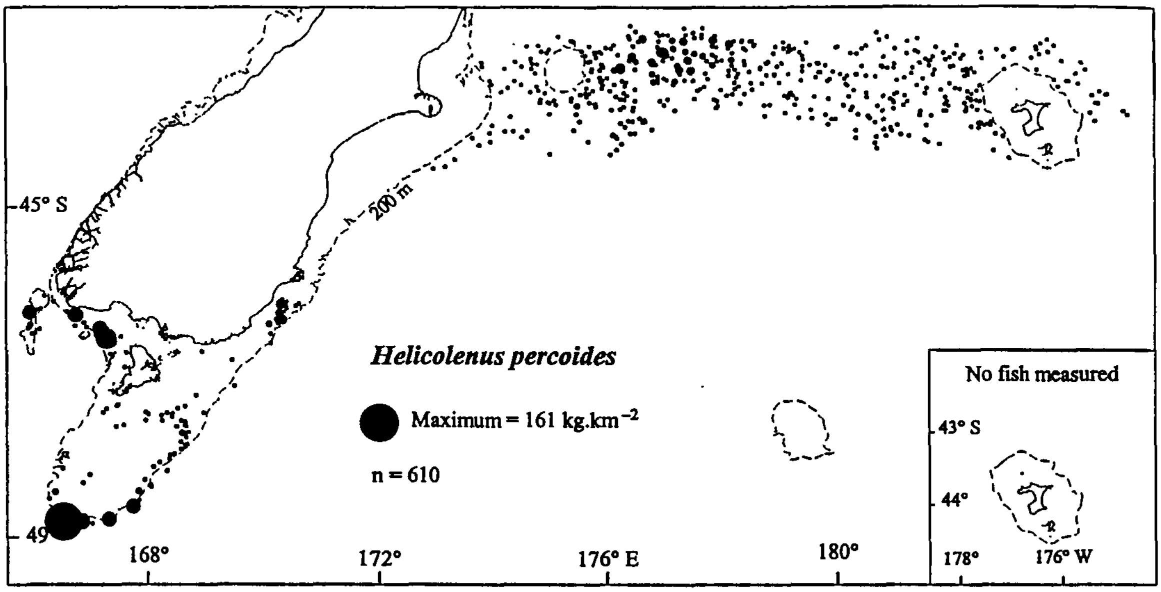


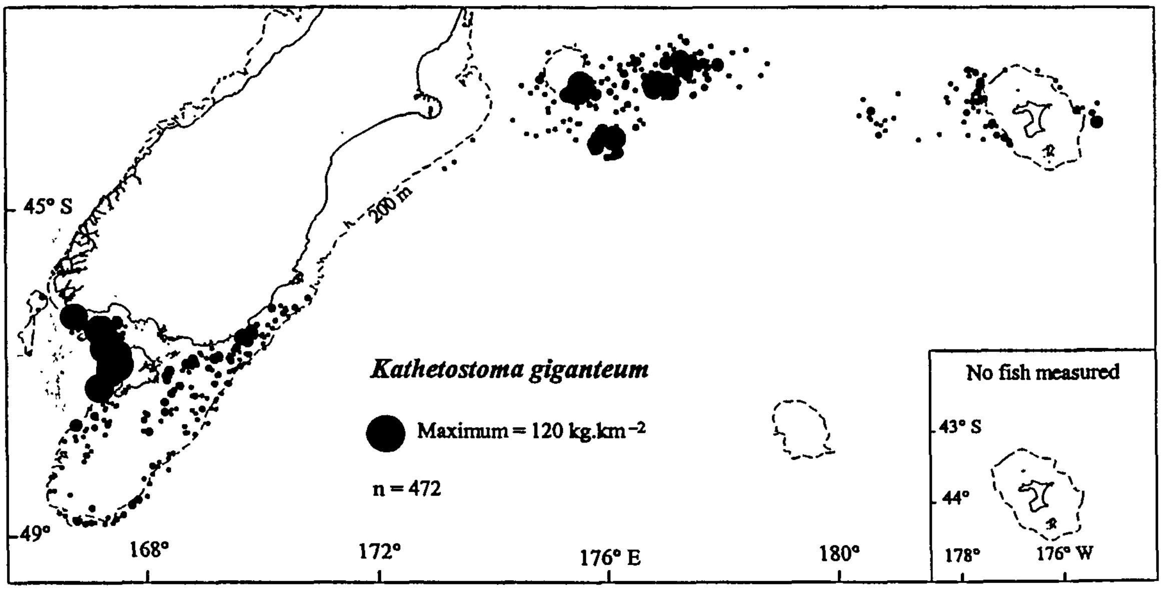
45° S
49°
168°
172°
176° E
180°
200 m
Genypterus blacodes
Maximum = 742 kg.km $^{-2}$
n = 925
No fish measured
43° S
44°
178°
176° W

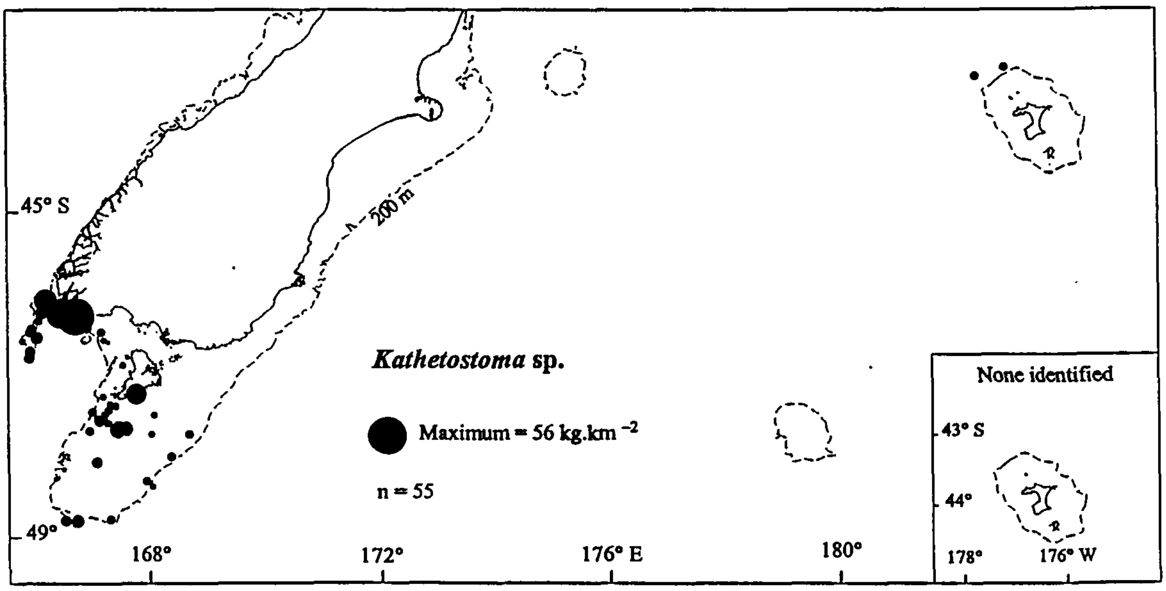

Helicolenus percoides
n = 1232
n = 44
45° S
49°
43° S
44°
168°
172°
176° E
180°
178°
176° W
200 m

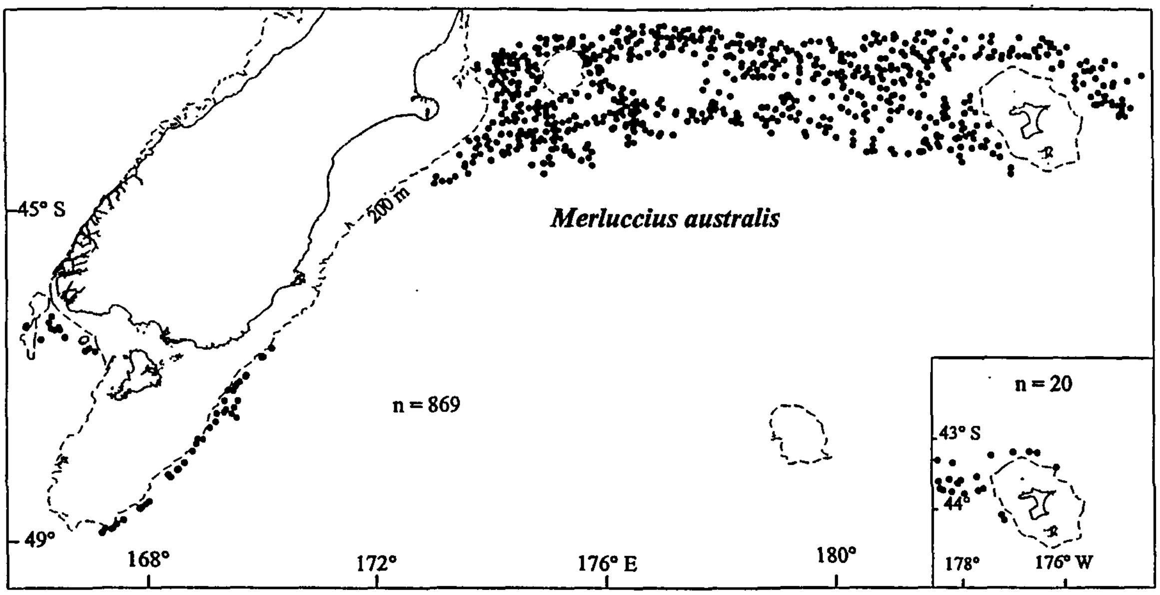

Kathetostoma giganteum
n = 1145
n = 141
45° S
49°
43° S
44°
168°
172°
176° E
180°
178°
176° W
200 m

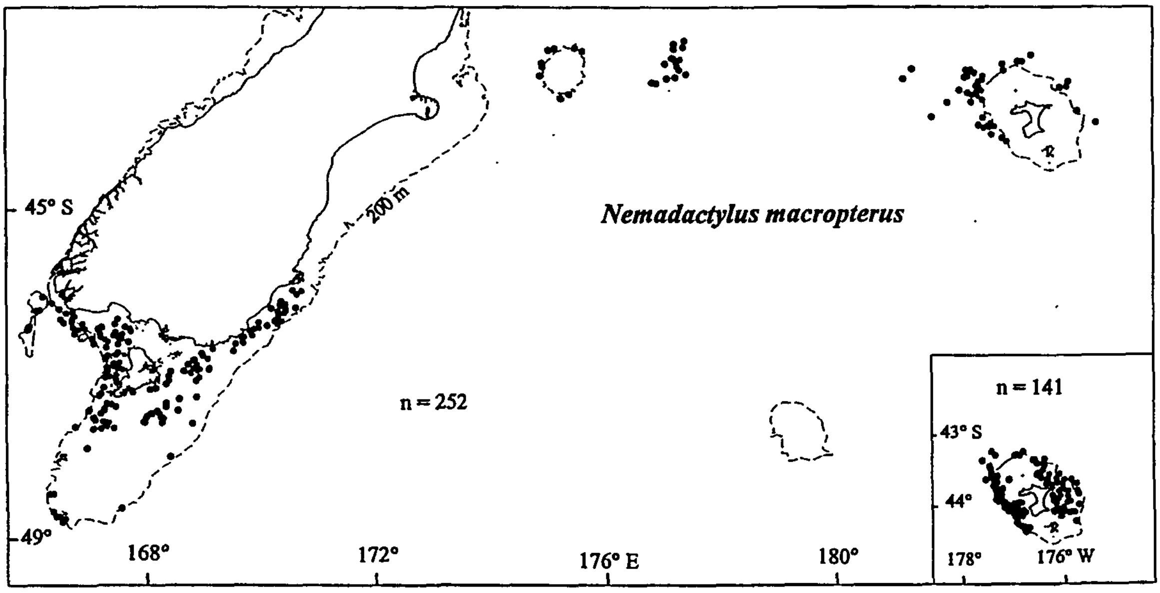

Kathetostoma sp.
n = 125
n = 0
45° S
49°
43° S
44°
168°
172°
176° E
180°
178°
176° W
200 m

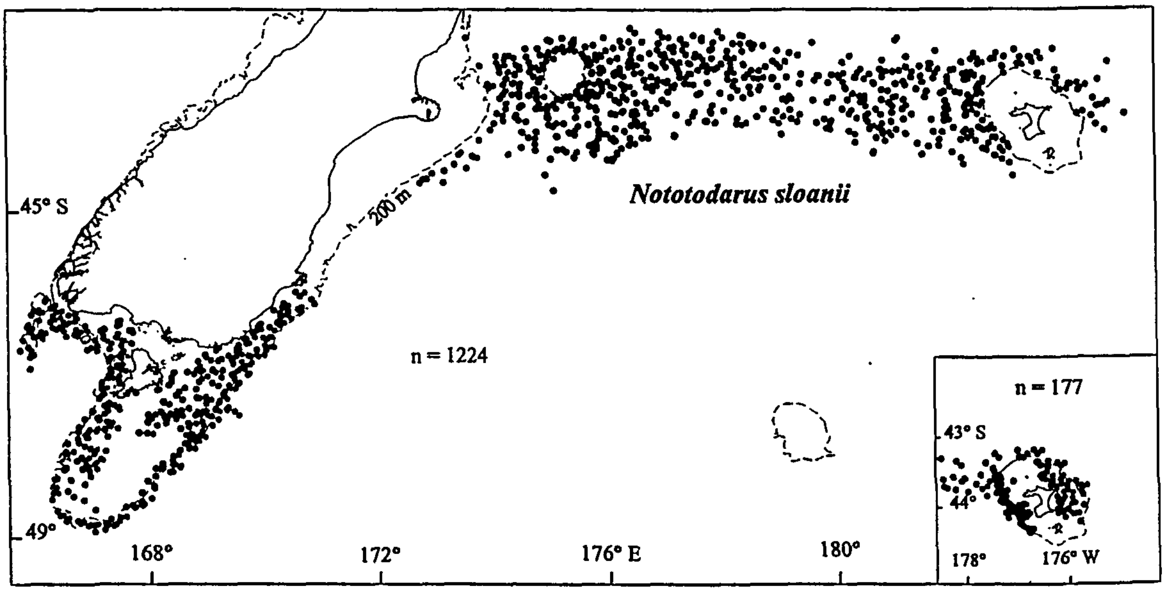

45° S
200 m
Helicolenus percoides
Maximum = 161 kg.km⁻²
n = 610
49°
168°
172°
176° E
180°
No fish measured
43° S
44°
178°
176° W

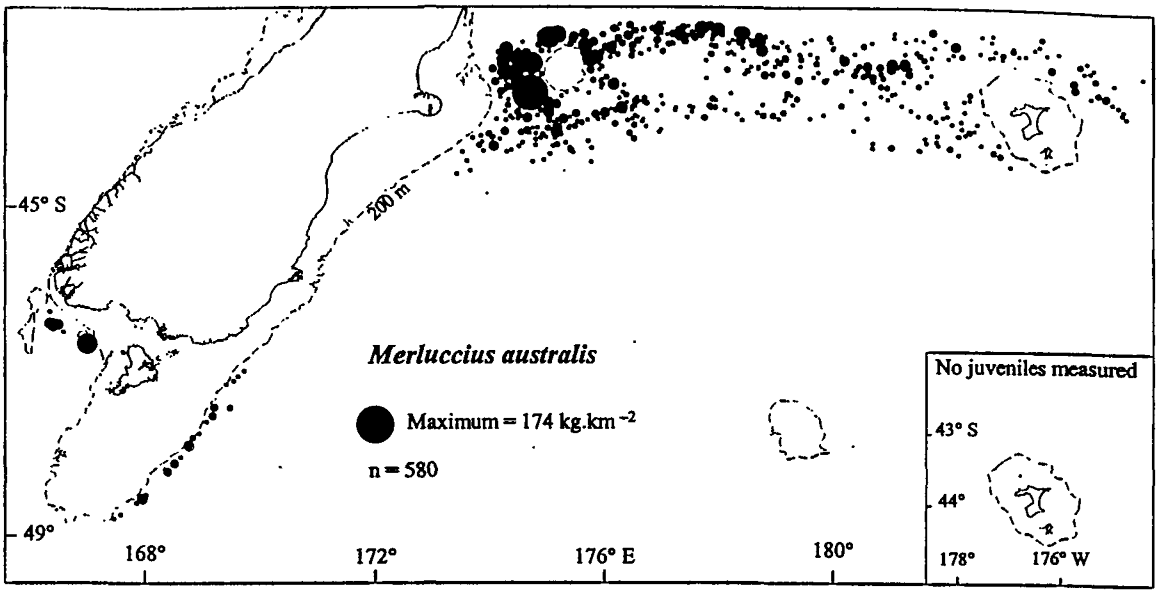

45° S
200 m
Kathetostoma giganteum
Maximum = 120 kg.km⁻²
n = 472
49°
168°
172°
176° E
180°
No fish measured
43° S
44°
178°
176° W


45° S
200 m
Kathetostoma sp.
Maximum = 56 kg.km⁻²
n = 55
49°
168°
172°
176° E
180°
None identified
43° S
44°
178°
176° W

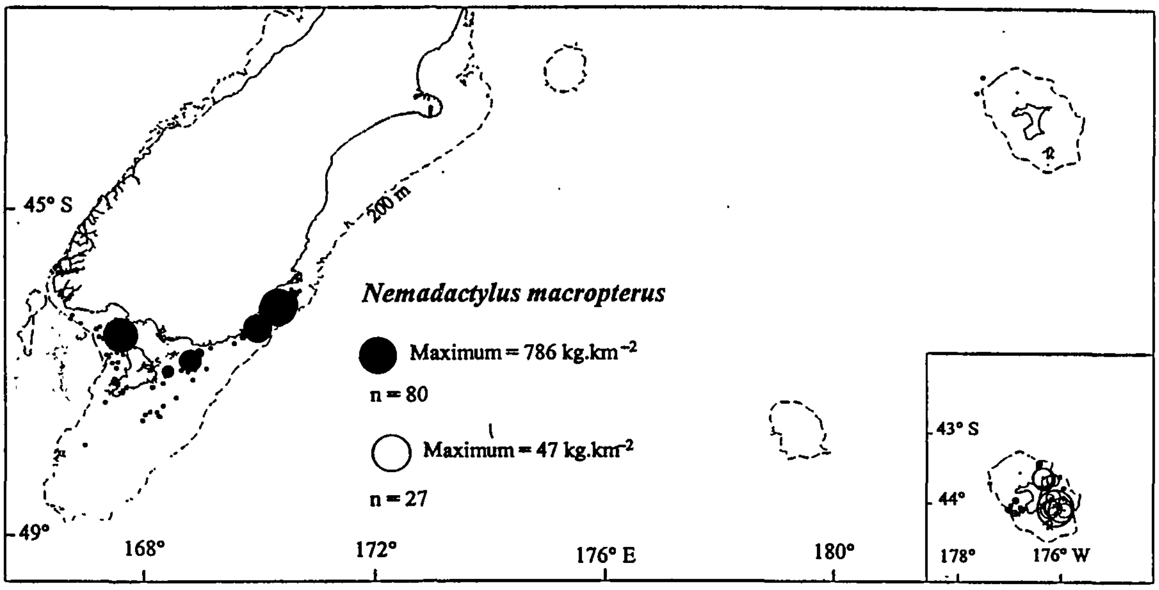

Merluccius australis
n = 869
n = 20
200 m
45° S
49°
168°
172°
176° E
180°
43° S
44°
178°
176° W


Nemadactylus macropterus
n = 252
n = 141
200 m
45° S
49°
168°
172°
176° E
180°
43° S
44°
178°
176° W

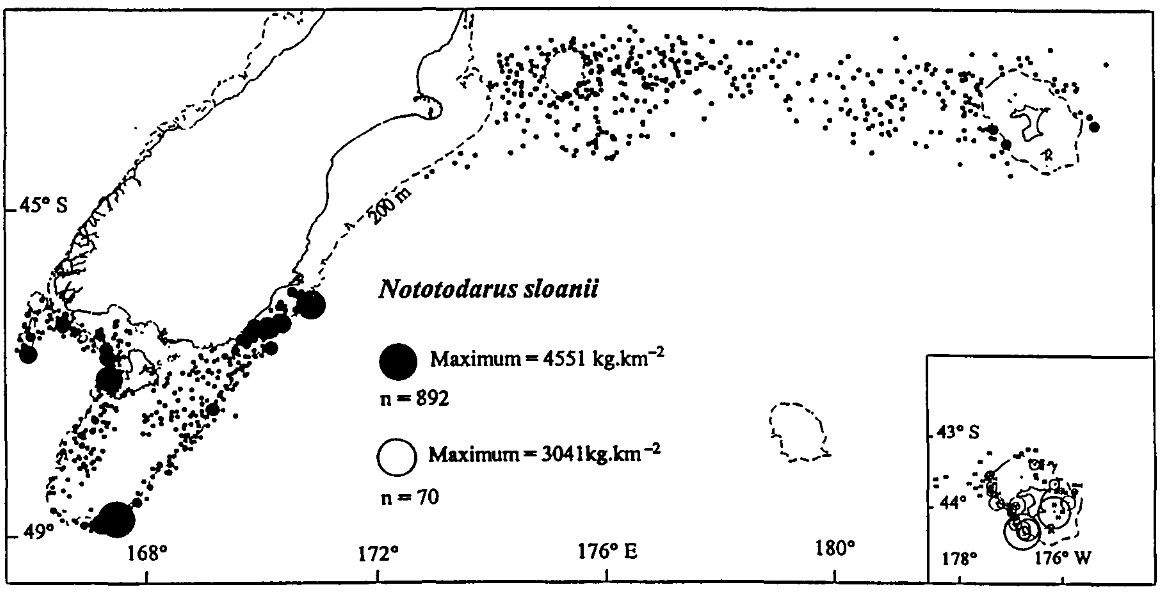

Nototodarus sloanii
n = 1224
n = 177
200 m
45° S
49°
168°
172°
176° E
180°
43° S
44°
178°
176° W



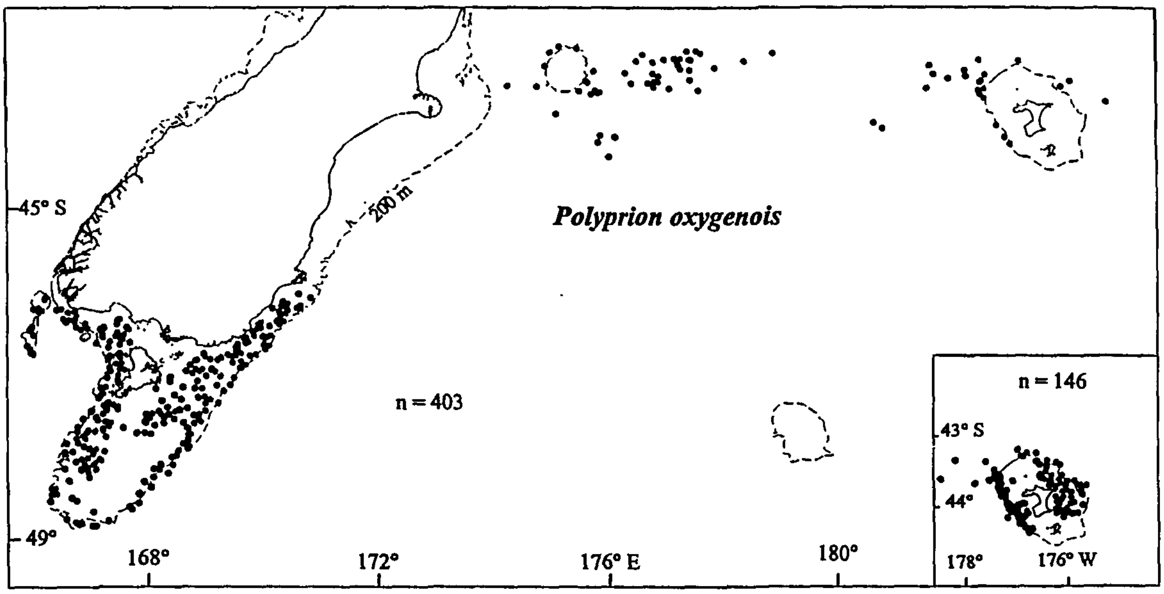
45° S
49°
168°
172°
176° E
180°
200 m
Merluccius australis
Maximum = 174 kg.km⁻²
n = 580
No juveniles measured
43° S
44°
178°
176° W



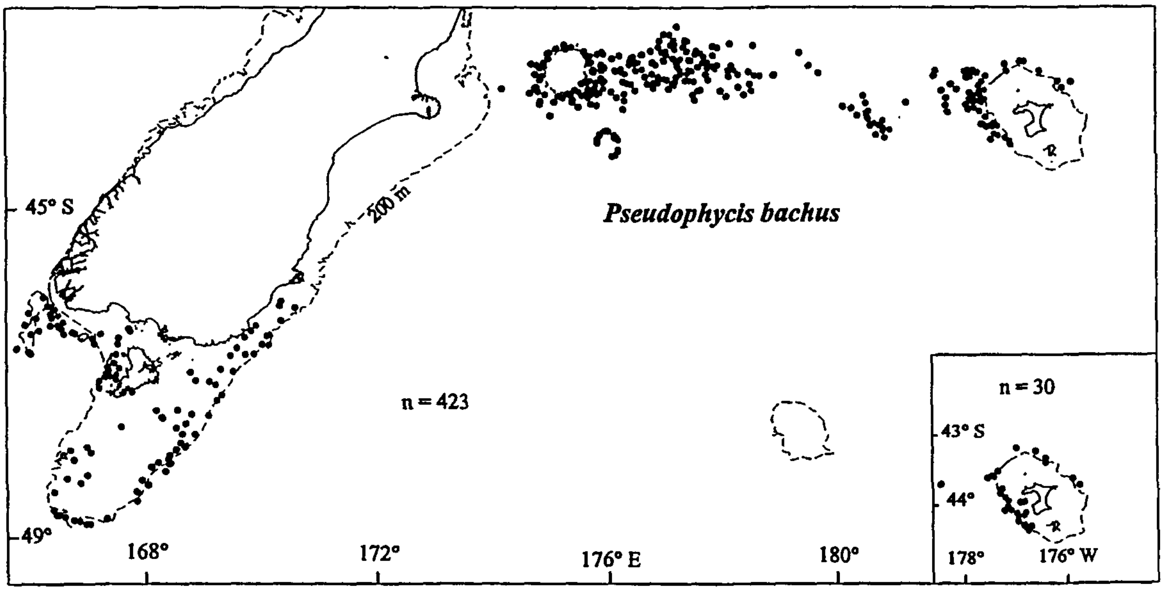
45° S
49°
168°
172°
176° E
180°
200 m
Nemadactylus macropterus
Maximum = 786 kg.km⁻²
n = 80
Maximum = 47 kg.km⁻²
n = 27
43° S
44°
178°
176° W



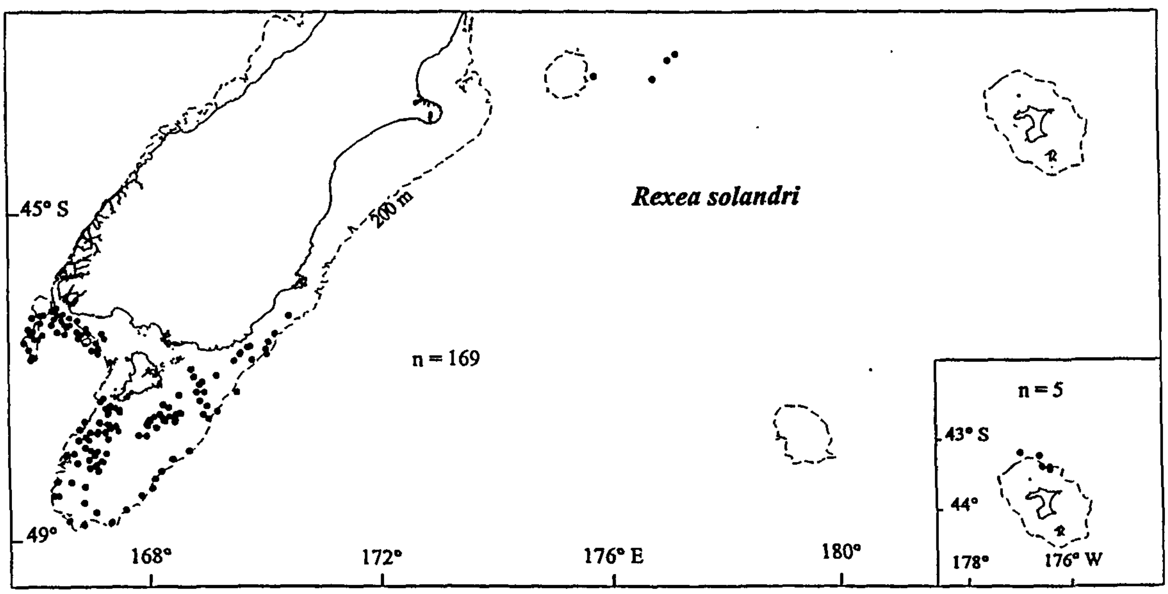
45° S
49°
168°
172°
176° E
180°
200 m
Nototodarus sloanii
Maximum = 4551 kg.km⁻²
n = 892
Maximum = 3041kg.km⁻²
n = 70
43° S
44°
178°
176° W



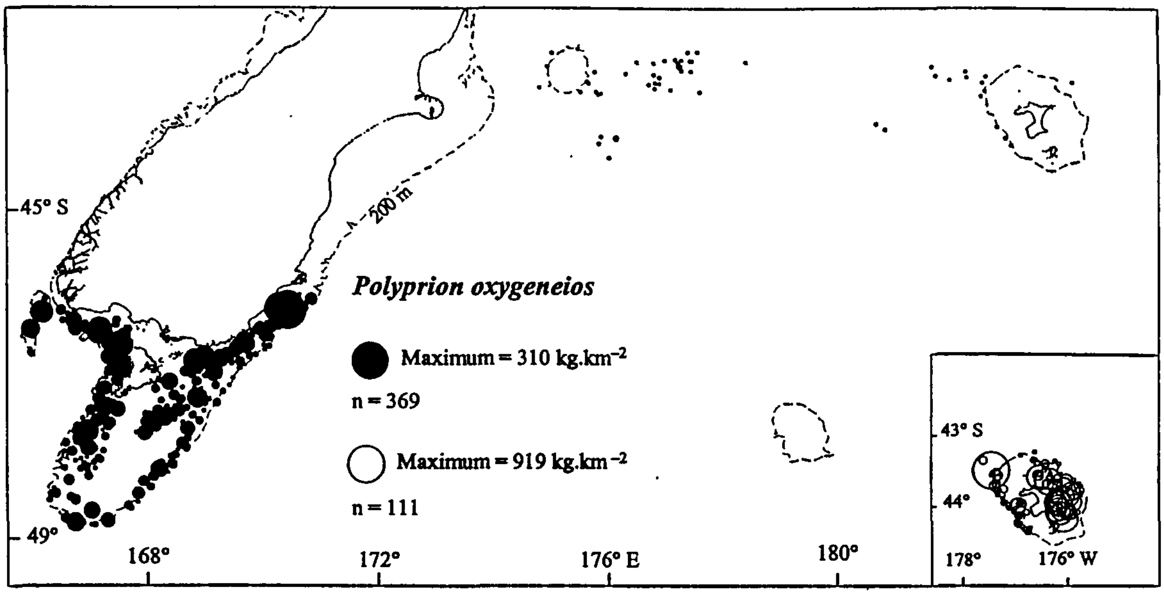
Polyprion oxygenois
45° S
49°
168°
172°
176° E
180°
200 m
n = 403
n = 146
43° S
44°
178°
176° W



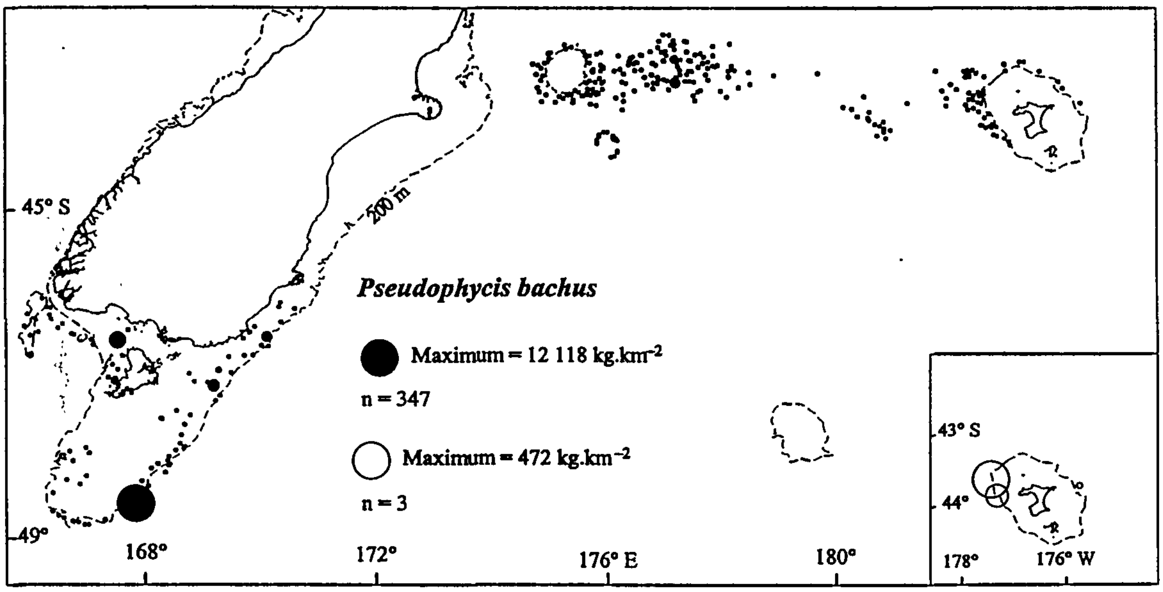
Pseudophycis bachus
45° S
49°
168°
172°
176° E
180°
200 m
n = 423
n = 30
43° S
44°
178°
176° W



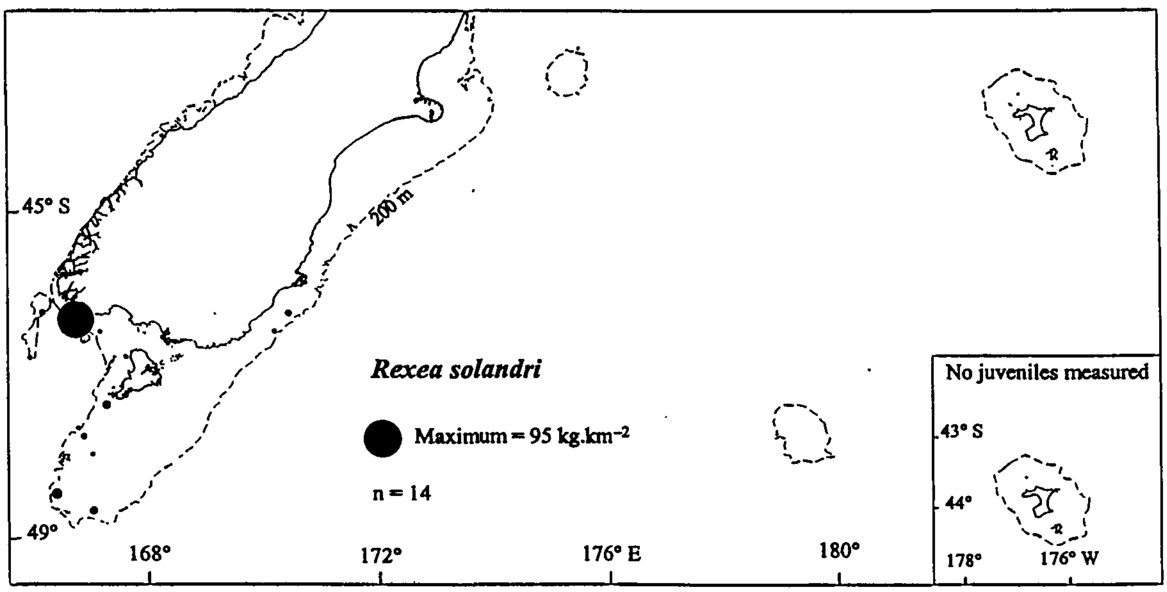
Rexea solandri
45° S
49°
168°
172°
176° E
180°
200 m
n = 169
n = 5
43° S
44°
178°
176° W



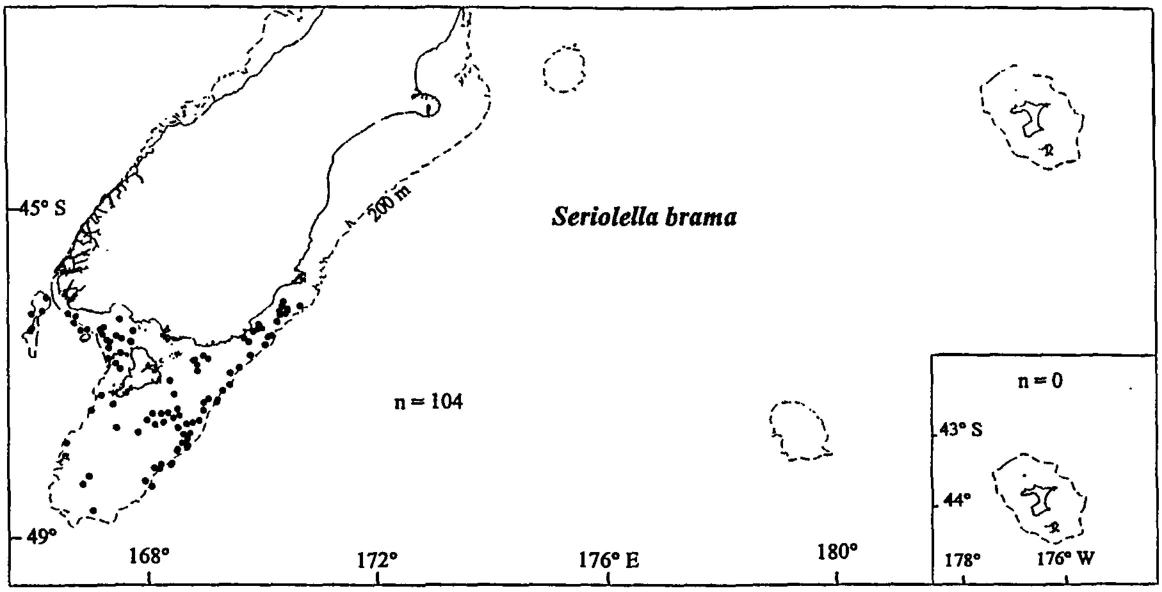
45° S
200 m
Polyprion oxygeneios
Maximum = 310 kg.km⁻²
n = 369
Maximum = 919 kg.km⁻²
n = 111
49°
168°
172°
176° E
180°
43° S
44°
178°
176° W

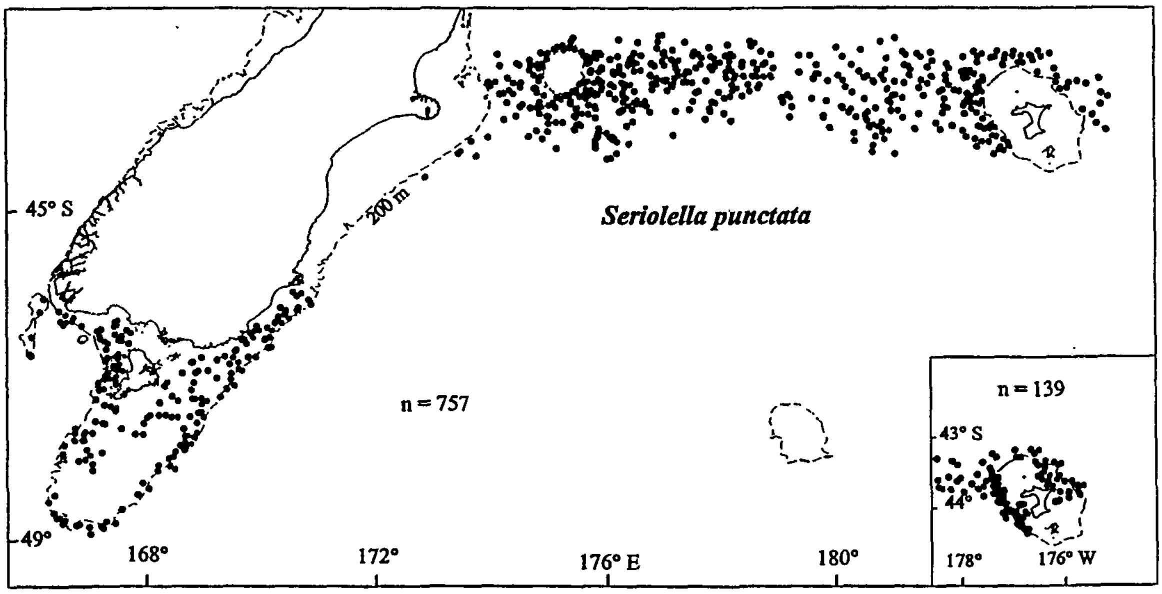


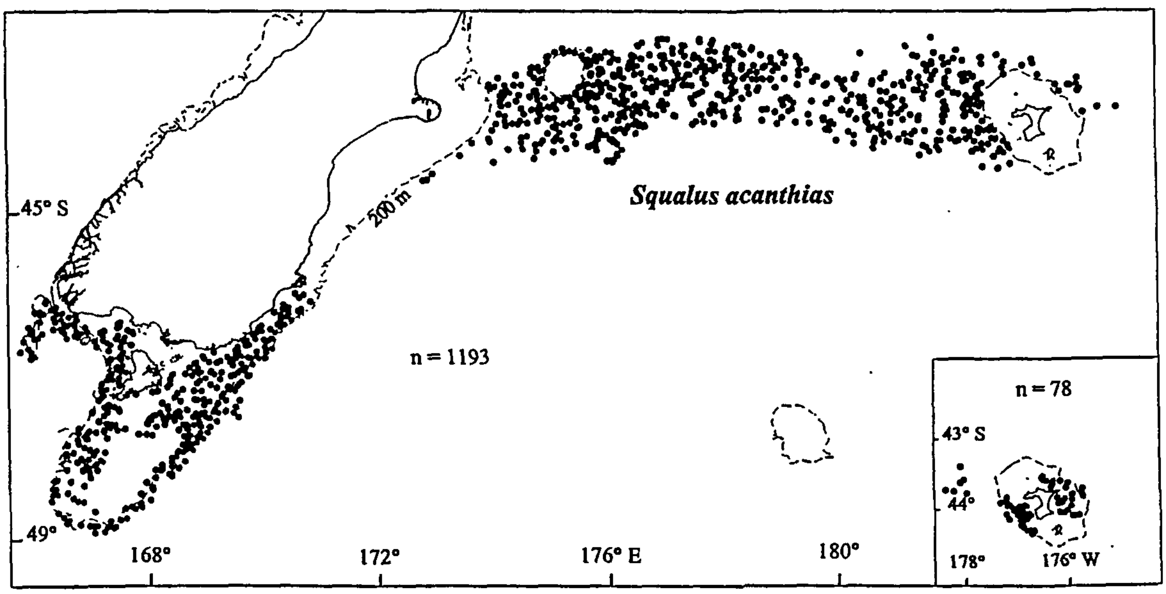
45° S
200 m
Pseudophycis bachus
Maximum = 12 118 kg.km⁻²
n = 347
Maximum = 472 kg.km⁻²
n = 3
49°
168°
172°
176° E
180°
43° S
44°
178°
176° W

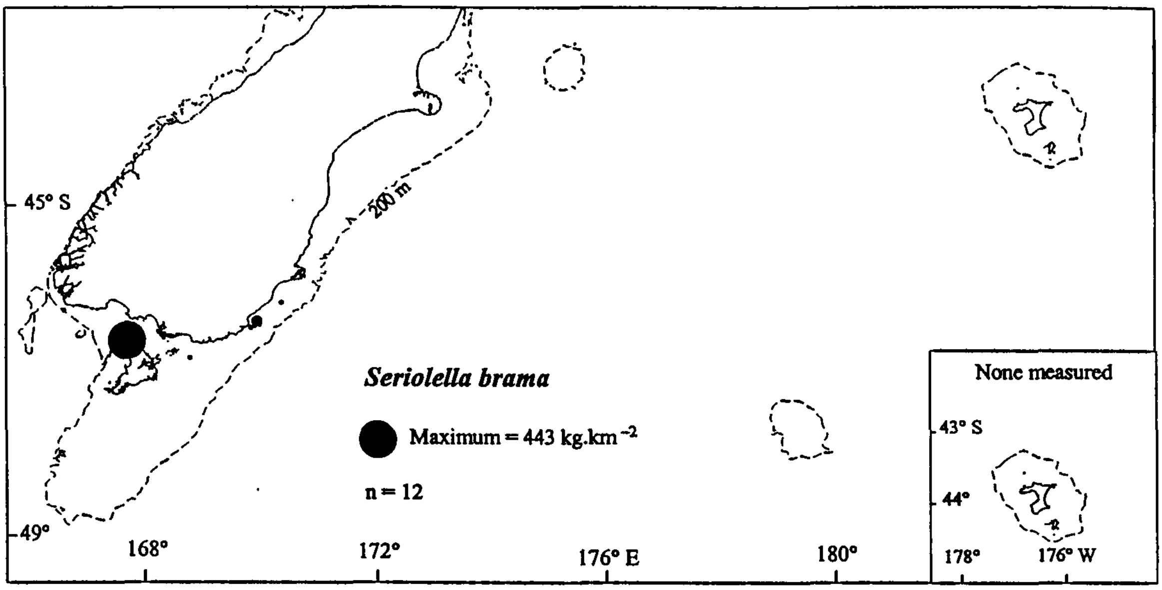


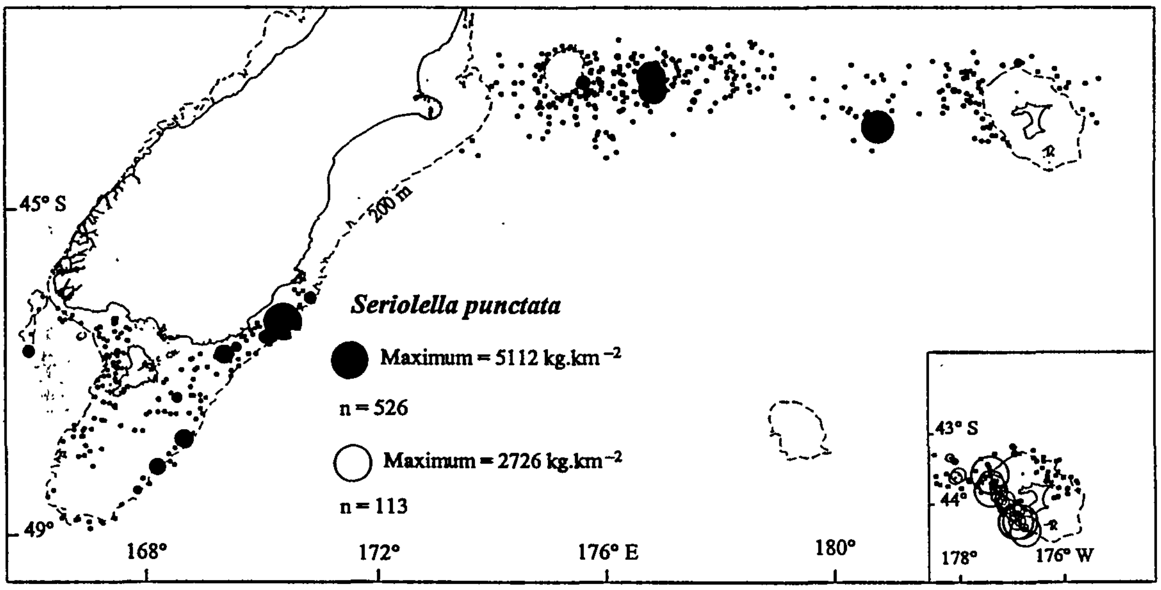
45° S
200 m
Rexea solandri
Maximum = 95 kg.km⁻²
n = 14
49°
168°
172°
176° E
180°
No juveniles measured
43° S
44°
178°
176° W

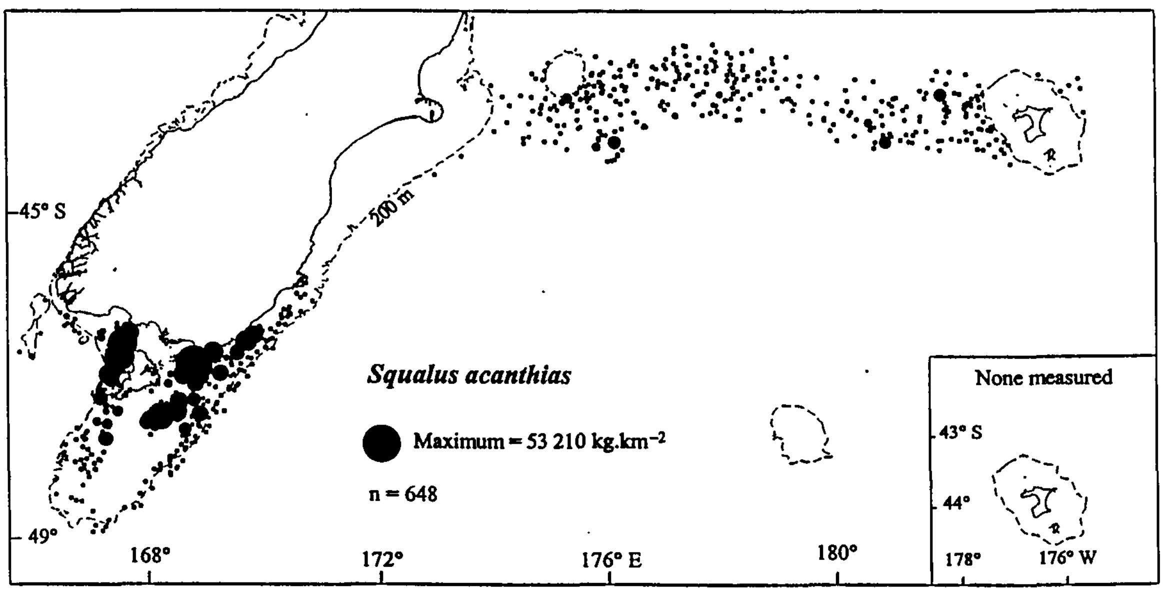

Seriolella brama
n = 104
200 m
45° S
49°
168°
172°
176° E
180°
n = 0
43° S
44°
178°
176° W

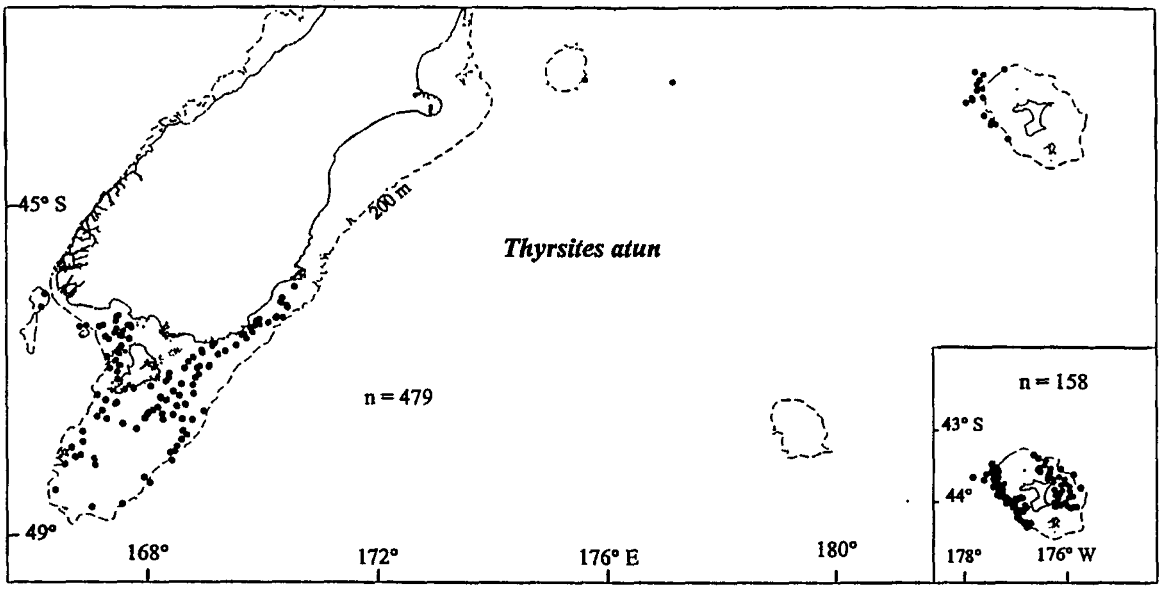

Seriolella punctata
n = 757
200 m
45° S
49°
168°
172°
176° E
180°
n = 139
43° S
44°
178°
176° W


Squalus acanthias
n = 1193
200 m
45° S
49°
168°
172°
176° E
180°
n = 78
43° S
44°
178°
176° W

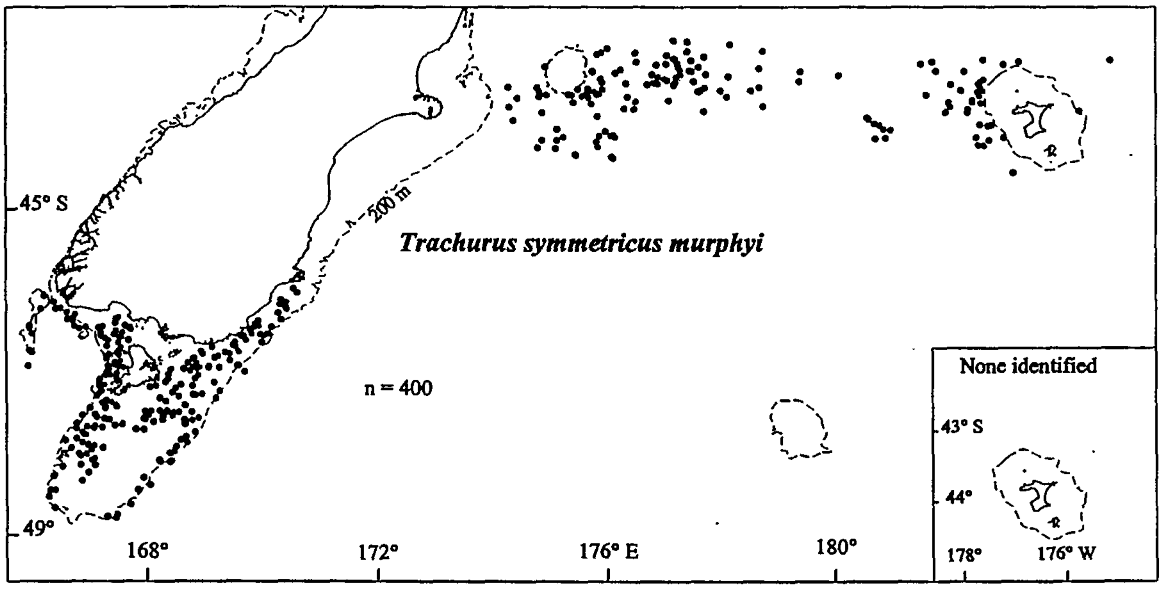

45° S
200 m
Seriolella brama
Maximum = 443 kg.km⁻²
n = 12
49°
168°
172°
176° E
180°
None measured
43° S
44°
178°
176° W


45° S
200 m
Seriolella punctata
Maximum = 5112 kg.km⁻²
n = 526
Maximum = 2726 kg.km⁻²
n = 113
49°
168°
172°
176° E
180°
43° S
44°
178°
176° W

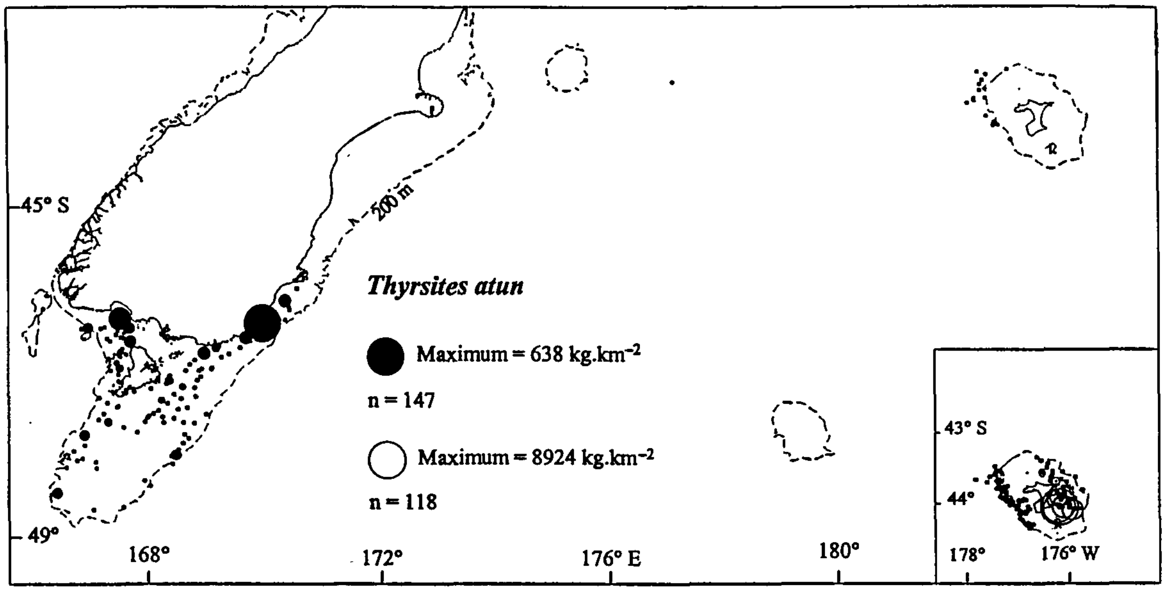

45° S
200 m
Squalus acanthias
Maximum = 53 210 kg.km⁻²
n = 648
49°
168°
172°
176° E
180°
None measured
43° S
44°
178°
176° W



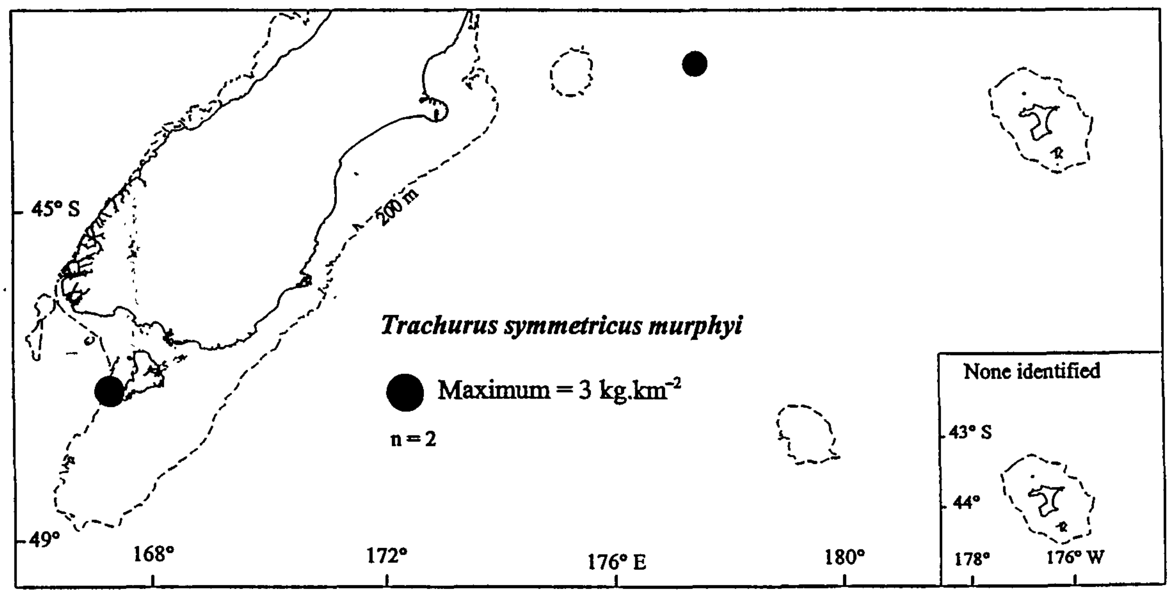
45° S
49°
168°
172°
176° E
180°
200 m
Thyrsites atun
n = 479
n = 158
43° S
44°
178°
176° W



45° S
49°
168°
172°
176° E
180°
200 m
Trachurus symmetricus murphyi
n = 400
None identified
43° S
44°
178°
176° W

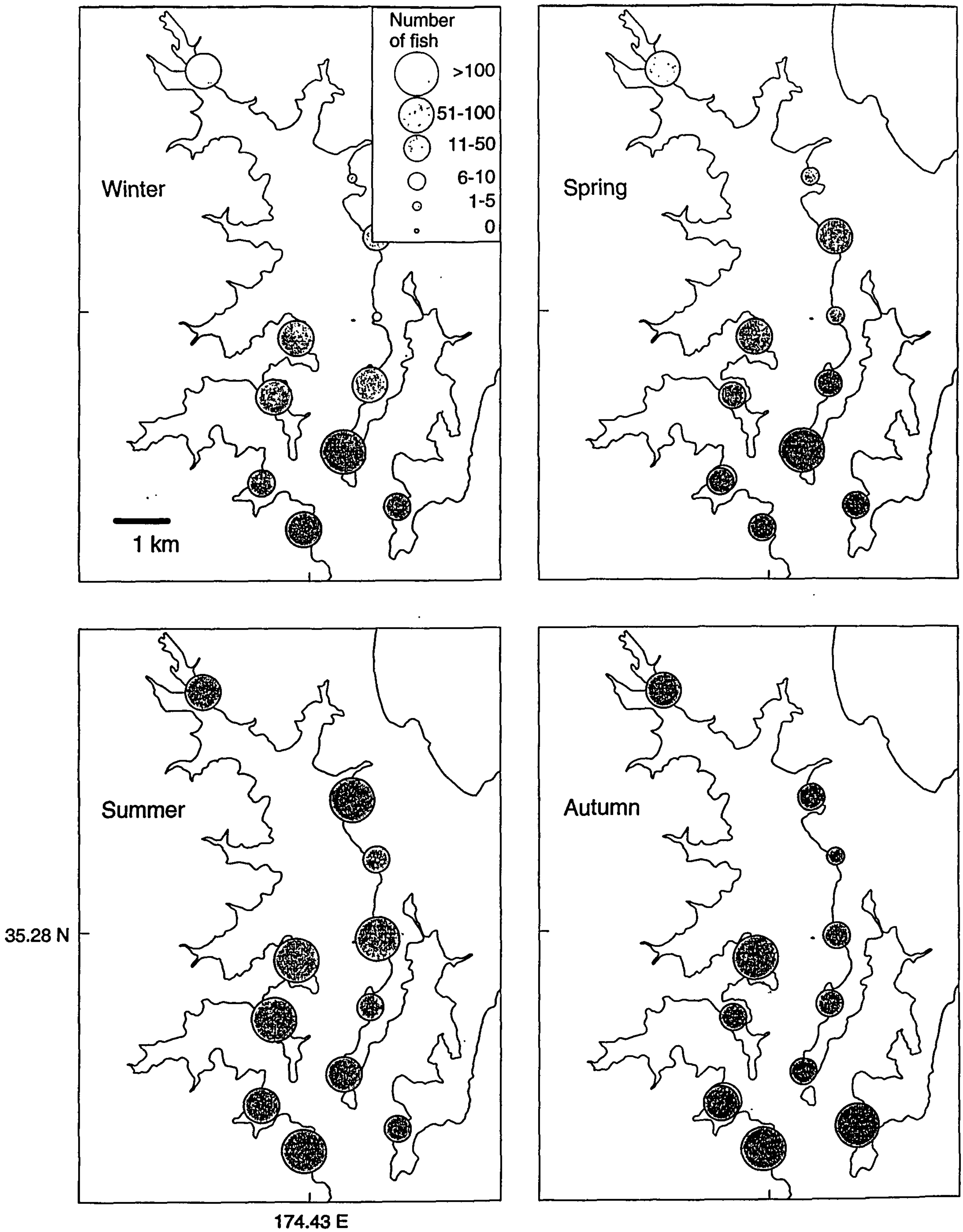


45° S
49°
168°
172°
176° E
180°
200 m
Thyrsites atun
Maximum = 638 kg.km-2
n = 147
Maximum = 8924 kg.km-2
n = 118
43° S
44°
178°
176° W

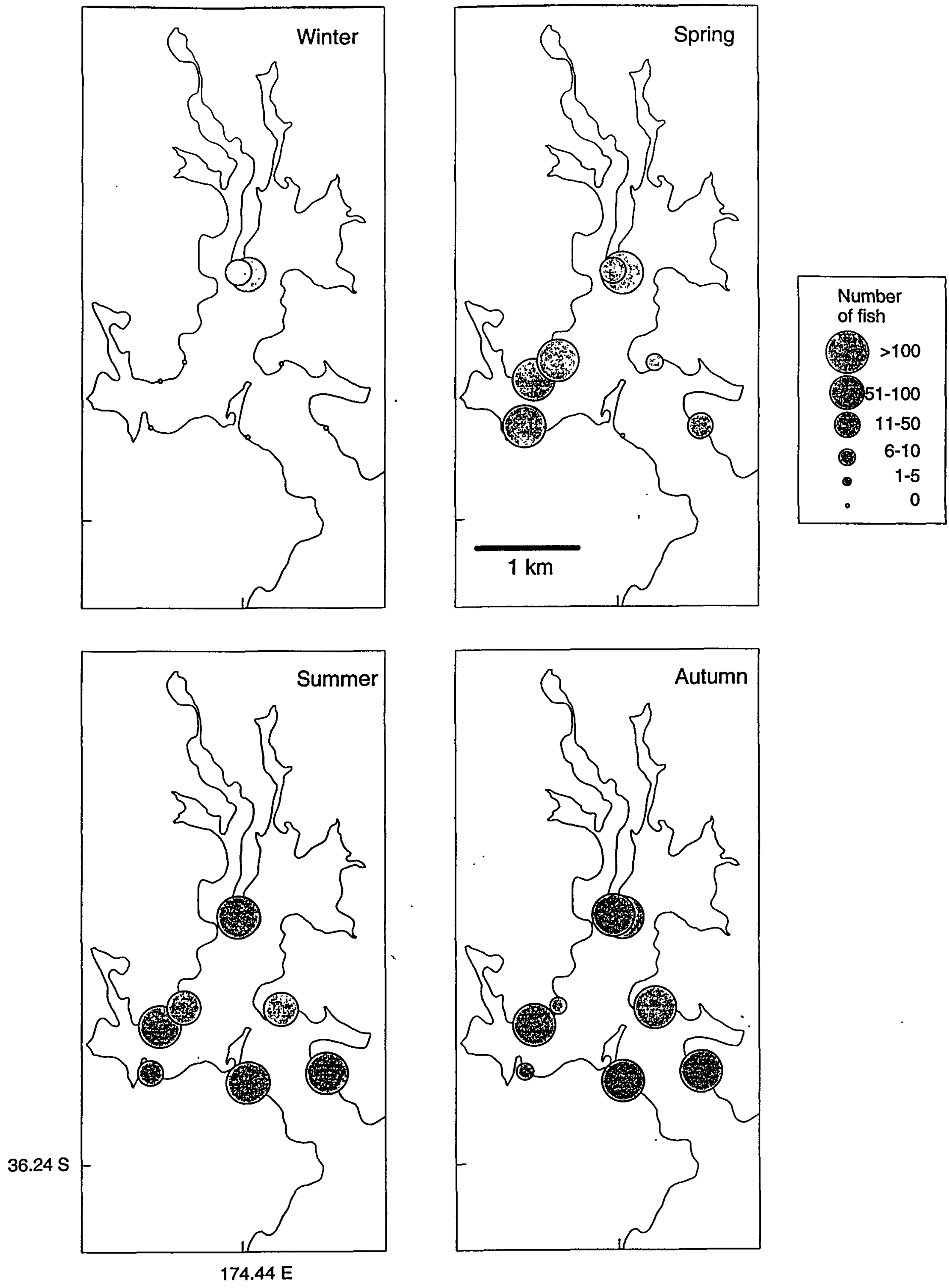


45° S
49°
168°
172°
176° E
180°
200 m
Trachurus symmetricus murphyi
Maximum = 3 kg.km-2
n = 2
None identified
43° S
44°
178°
176° W

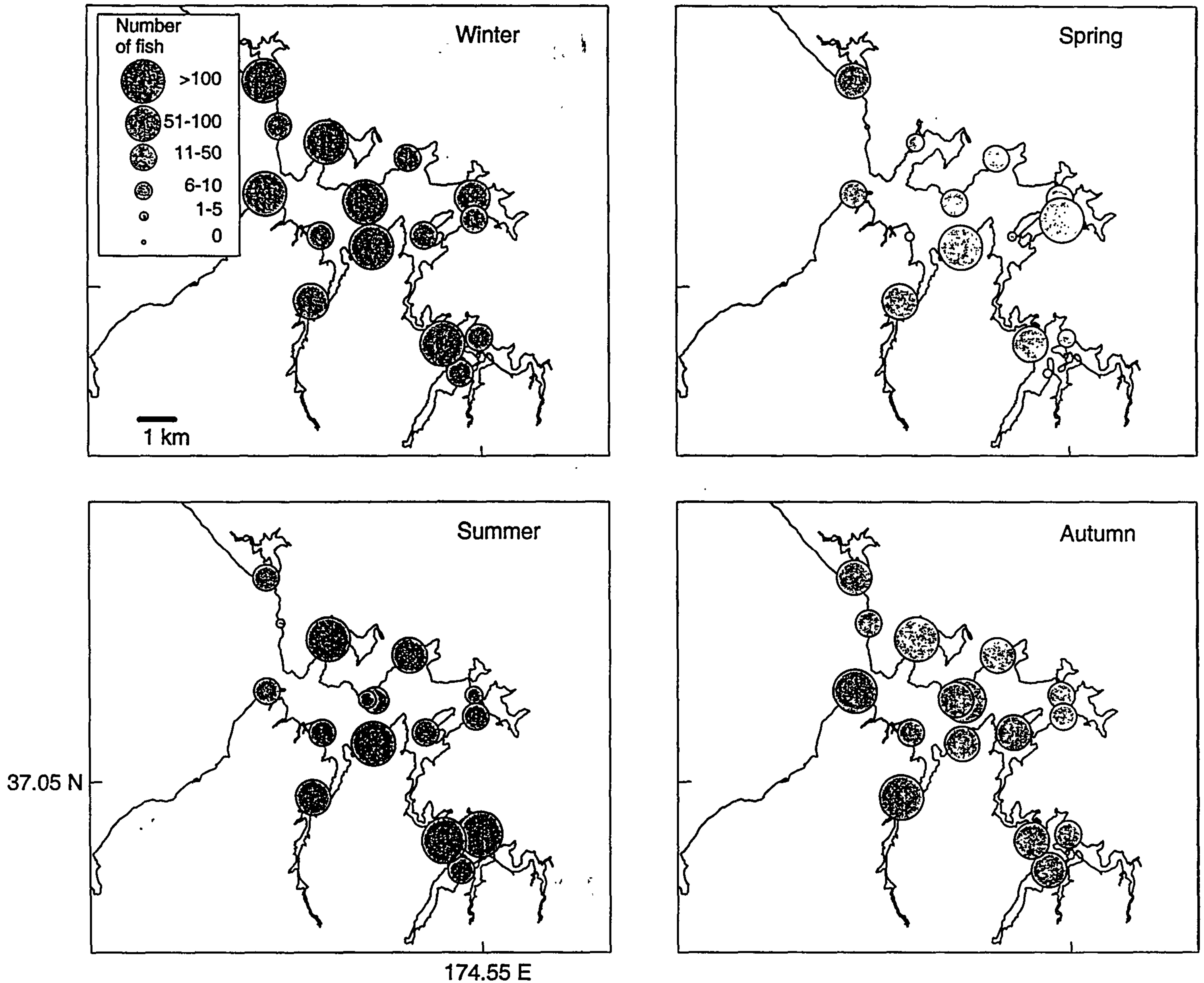
1.2.3 Juvenile abundance Northern harbours



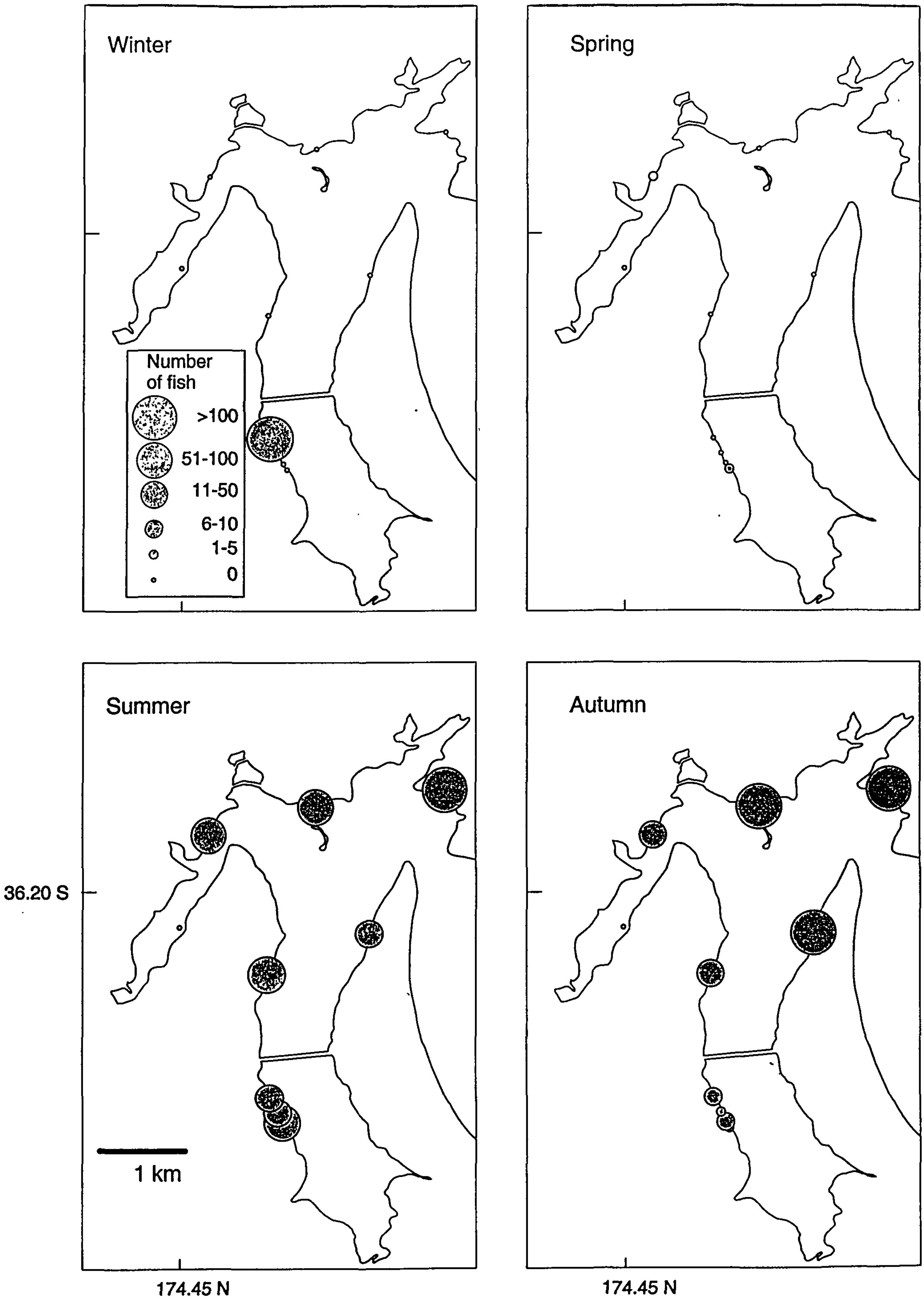
Aldrichetta forsteri **(yelloweyed mullet) in Mahurangi Estuary.**



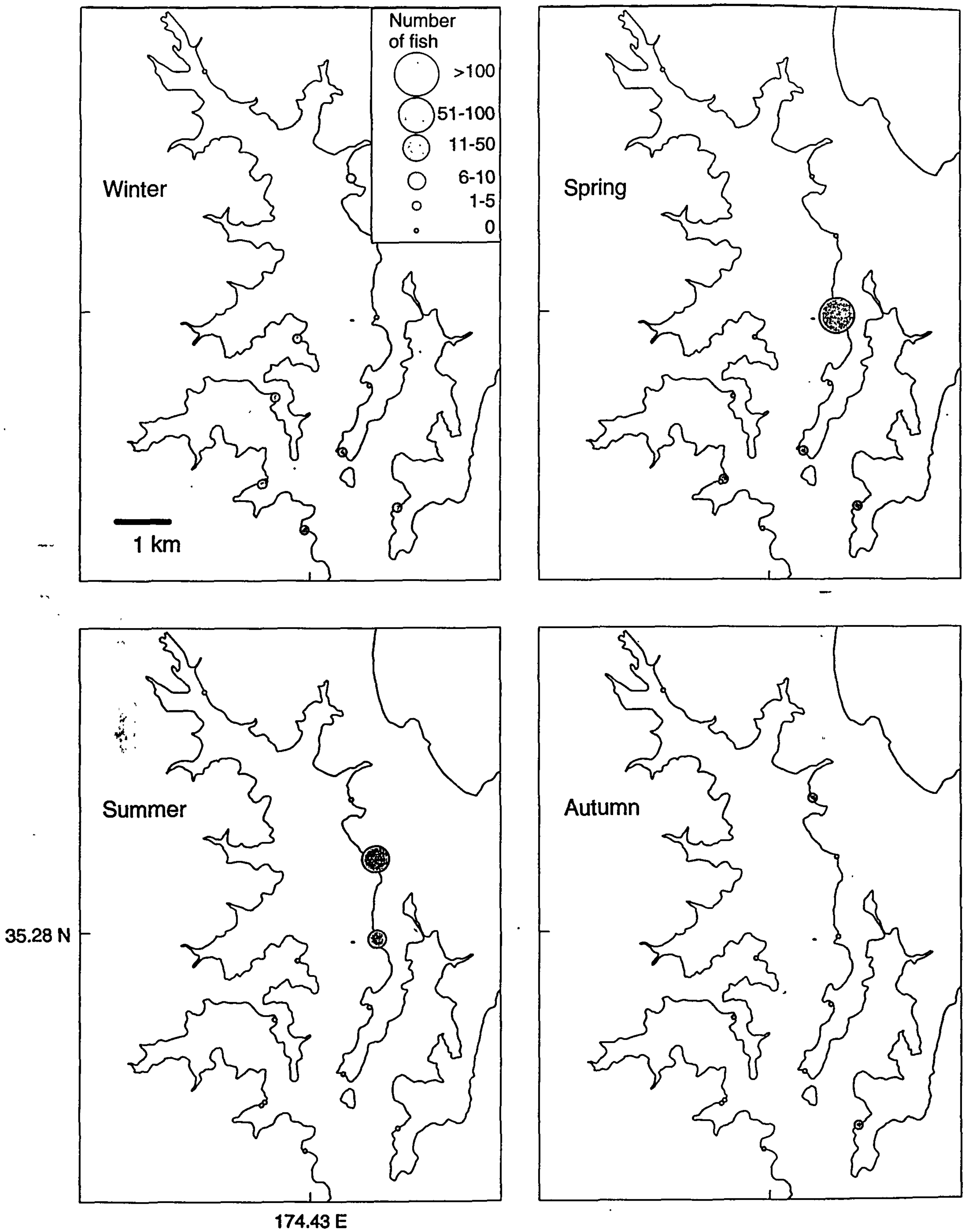
Aldrichetta forsteri (yelloweyed mullet) in Matakana Estuary.



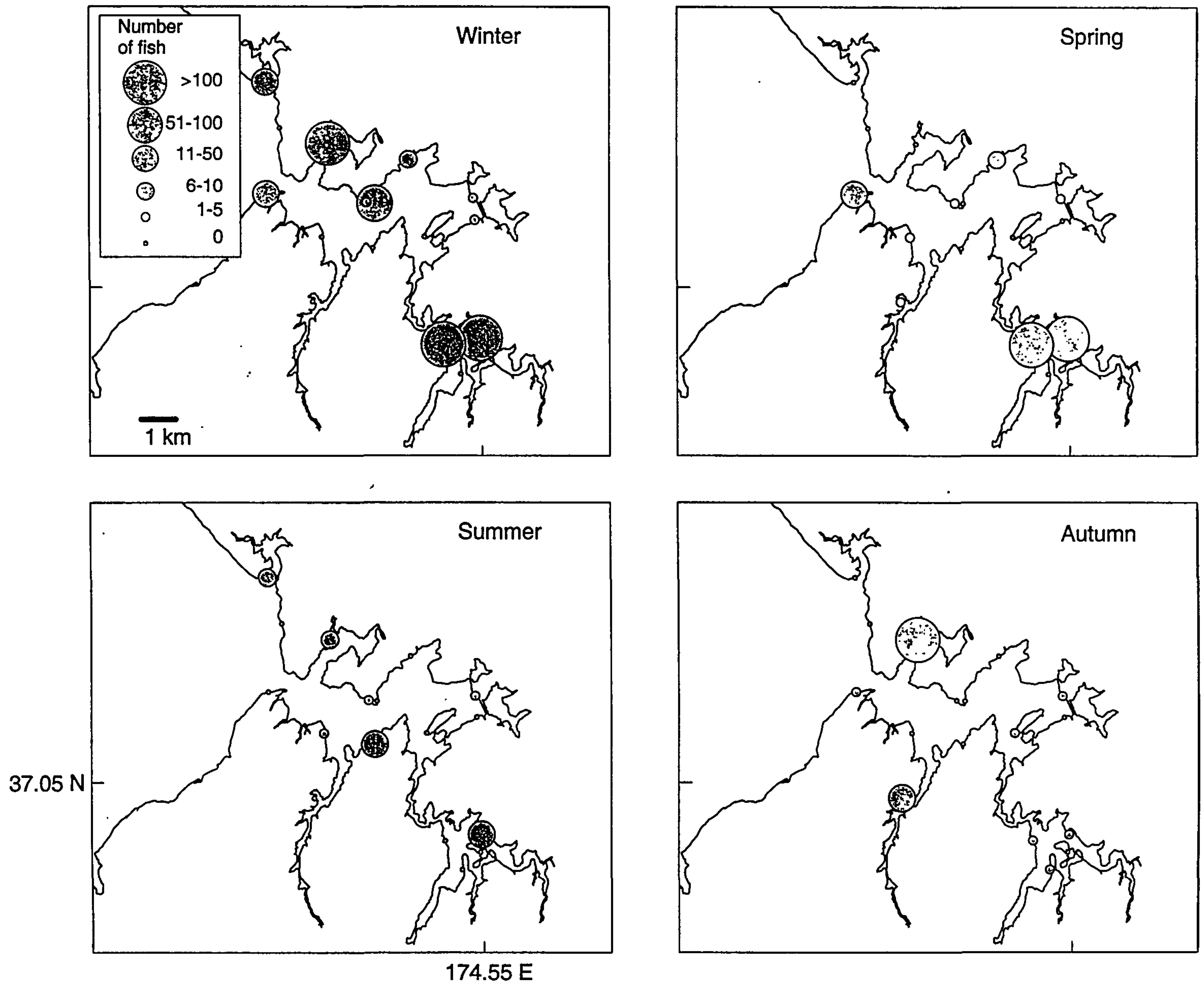
Aldrichetta forsteri **(yelloweyed mullet) in Pahurehure Inlet (Manukau Harbour).**



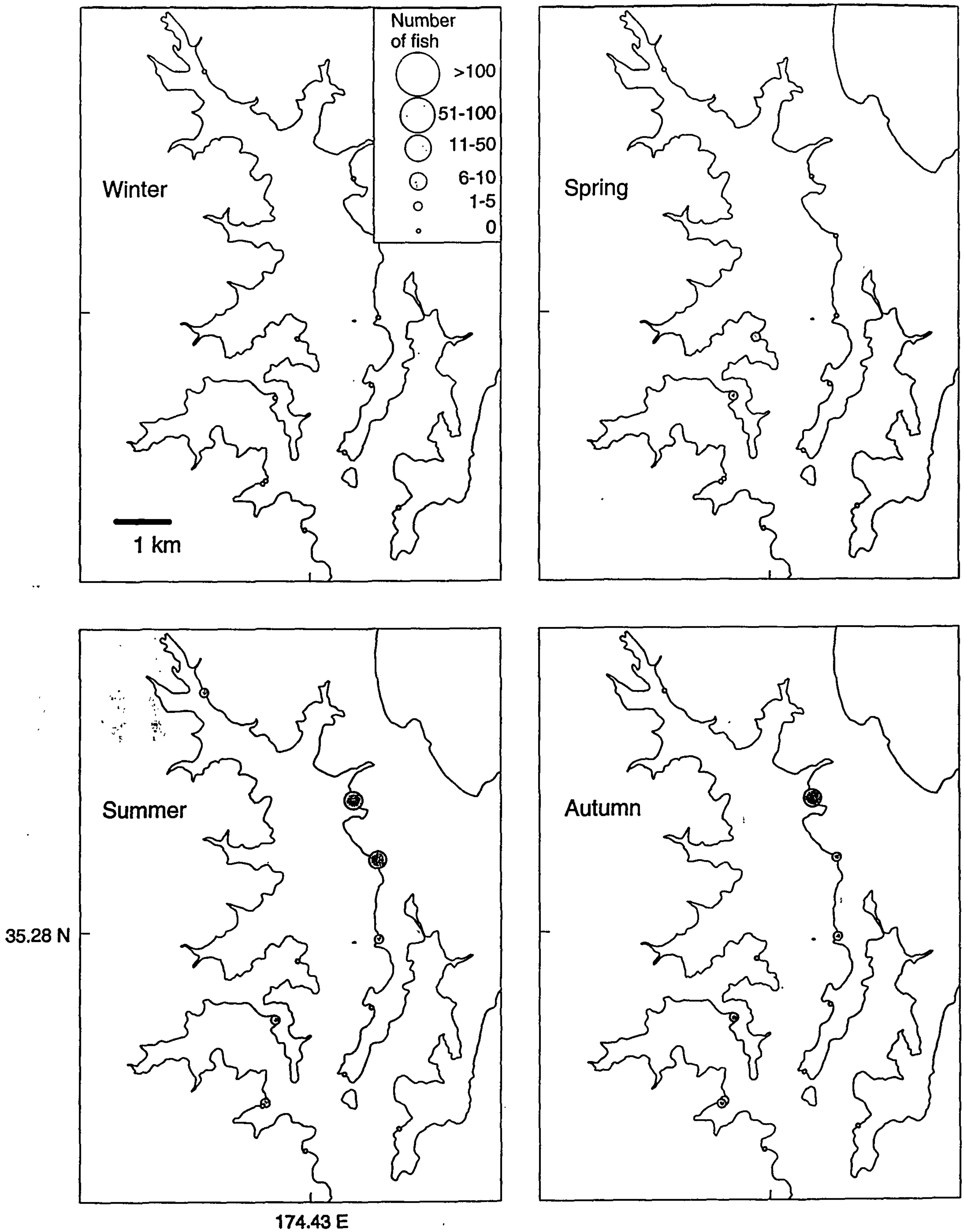
***Aldrichetta forsteri* (yelloweyed mullet) in Whangateau Harbour.**



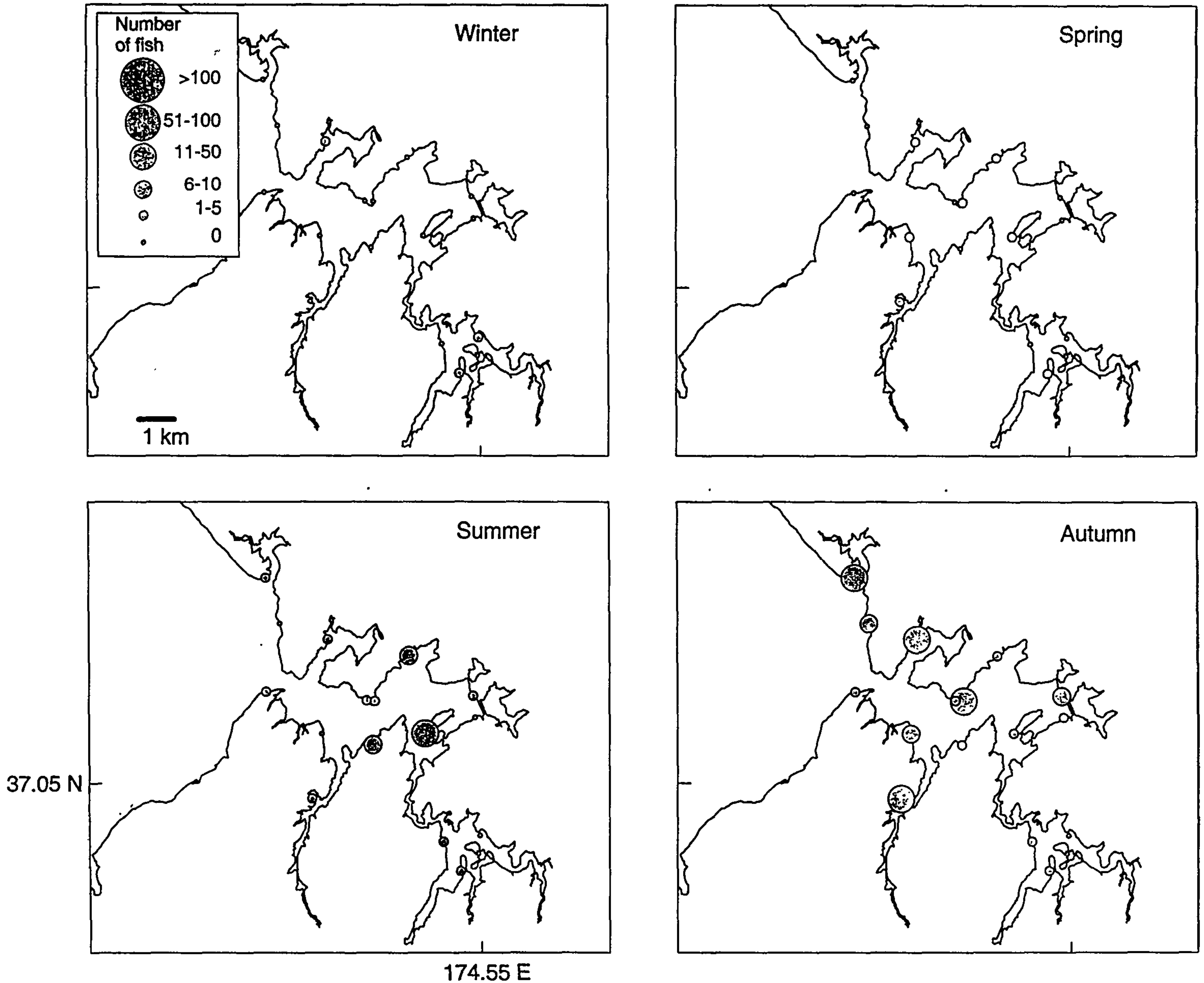
Arripis trutta **(kahawai) in Mahurangi Estuary.**



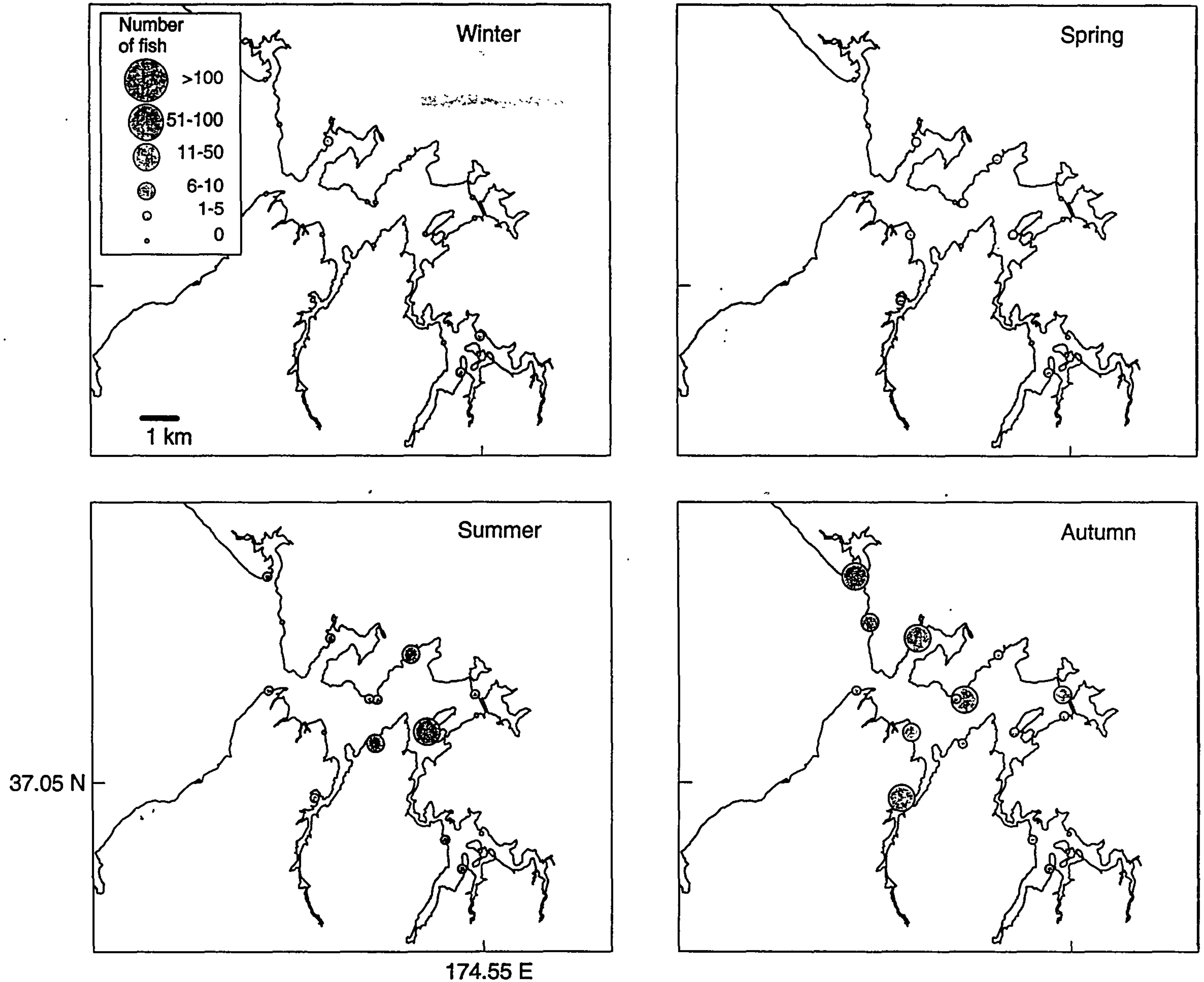
***Mugil cephalis* (grey mullet) in Pahurehure Inlet (Manukau Harbour).**



Rhombosolea plebia **(sand flounder) in Mahurangi Estuary.**



***Rhombosolea leporina* (yellow belly flounder) in Pahurehure Inlet (Manukau Harbour).**



Rhombosolea plebia **(sand flounder) in Pahurehure Inlet (Manukau Harbour).**

2 Spawning fish

Key to symbols and shading in the spawning distribution plots

● Ripe or running ripe stage fish

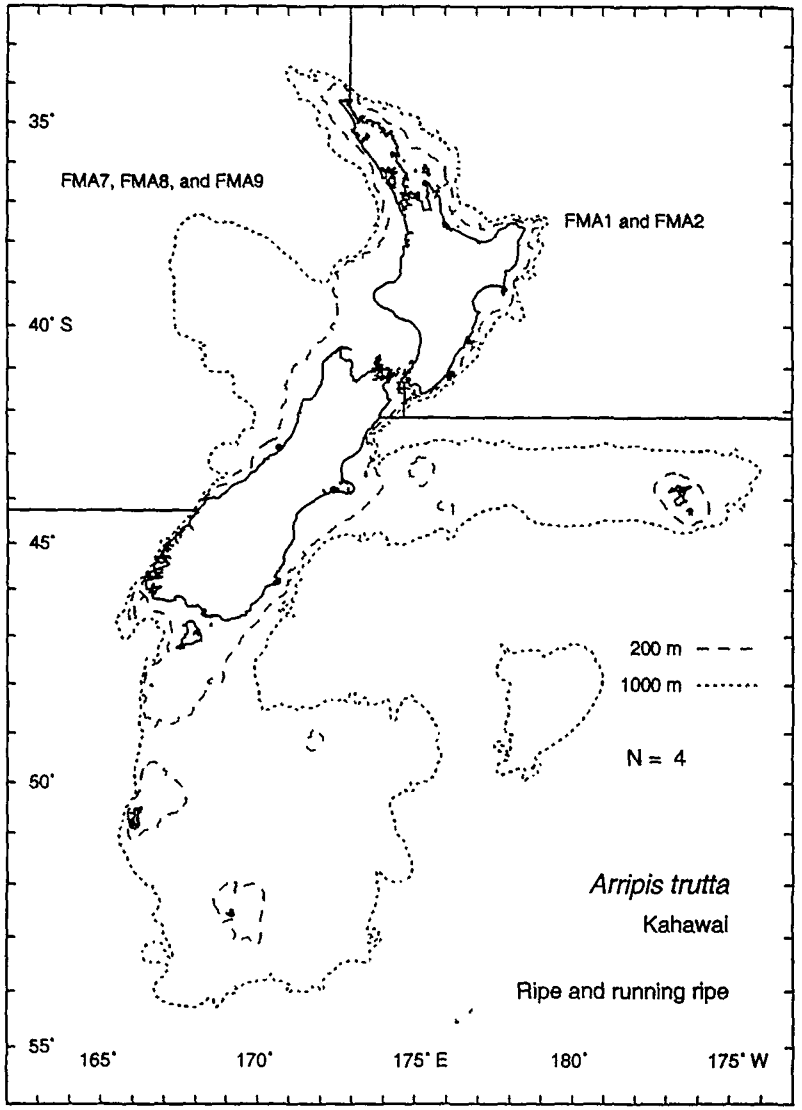
▲ Spent fish

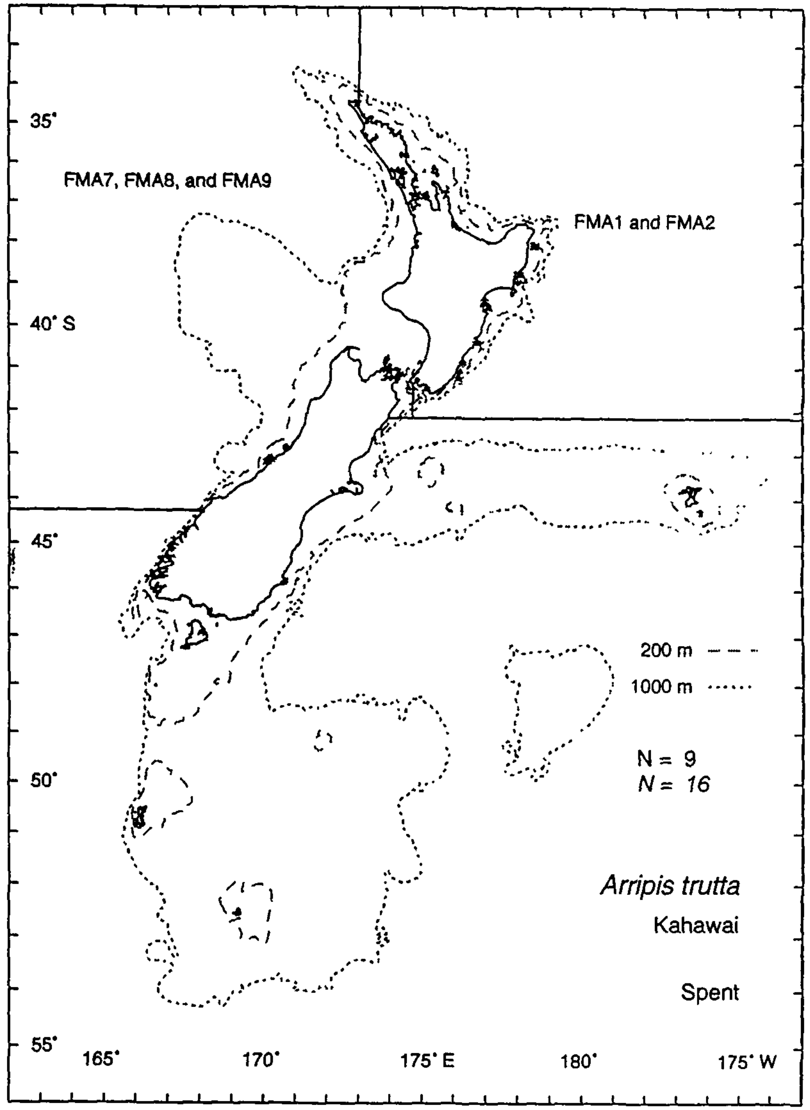
Grey Position where the species has been recorded and gonads have been staged

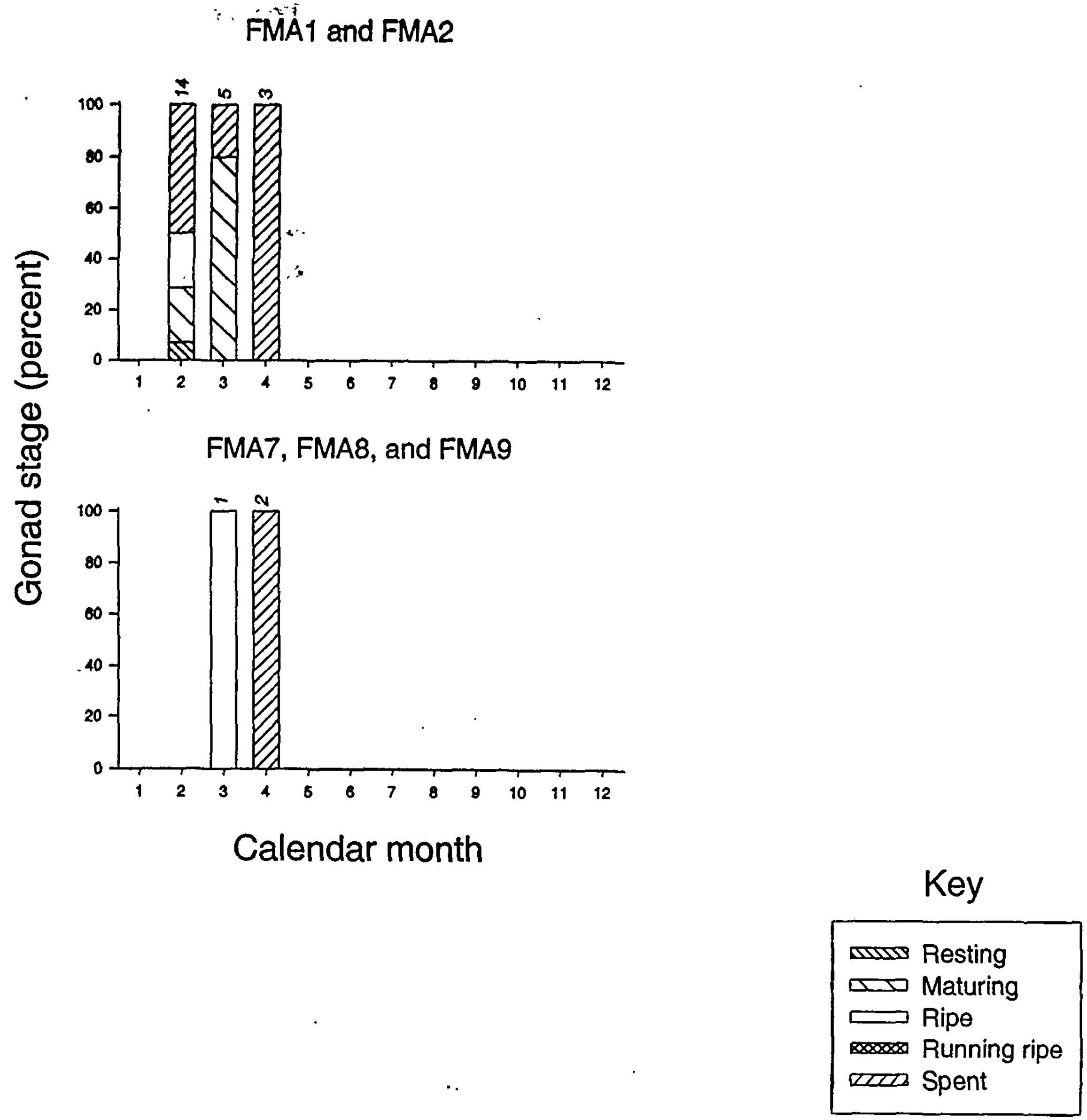
FMA Fisheries Management Area

N Number of fish at this stage

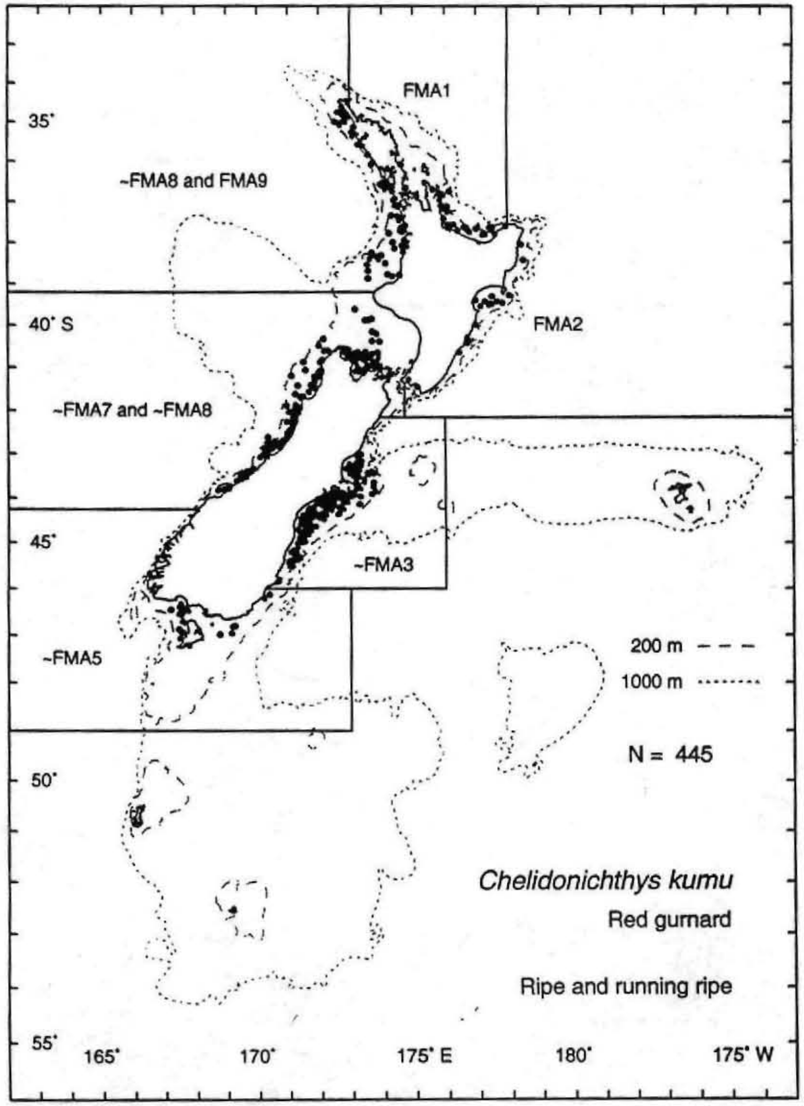
N Number of fish staged

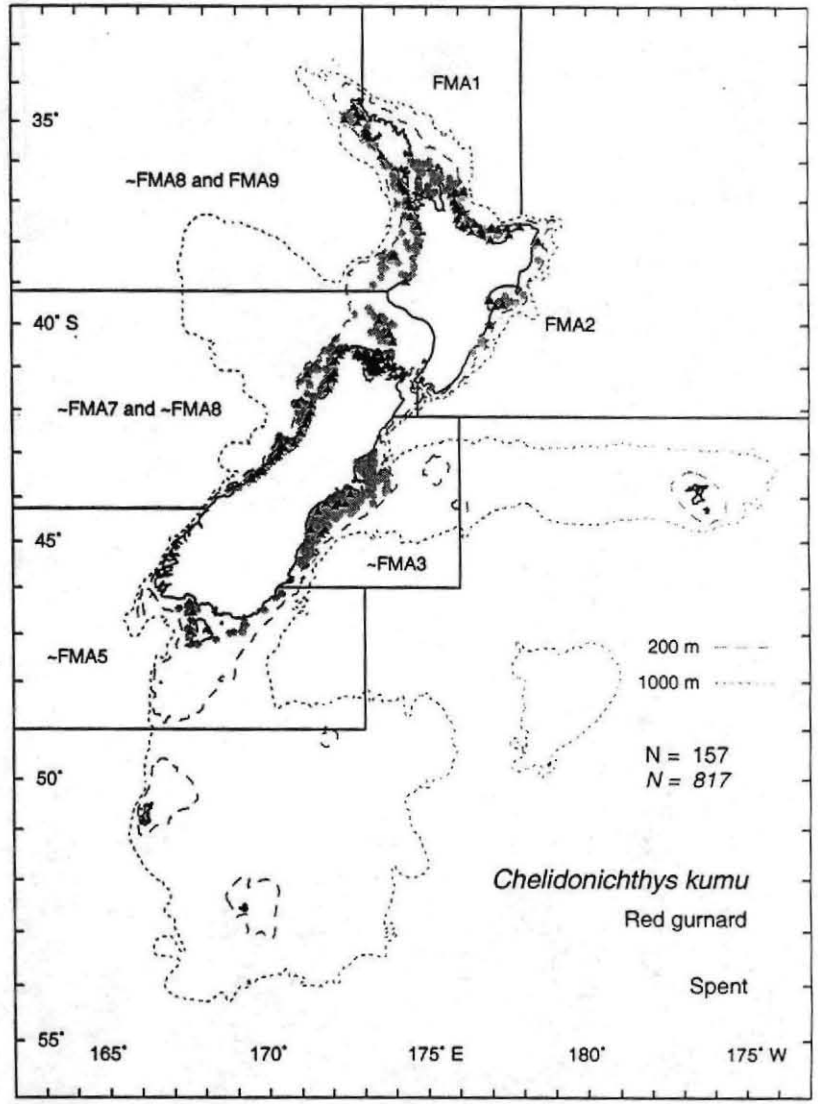

35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
FMA7, FMA8, and FMA9
FMA1 and FMA2
200 m
1000 m
N = 4
Arripis trutta
Kahawai
Ripe and running ripe

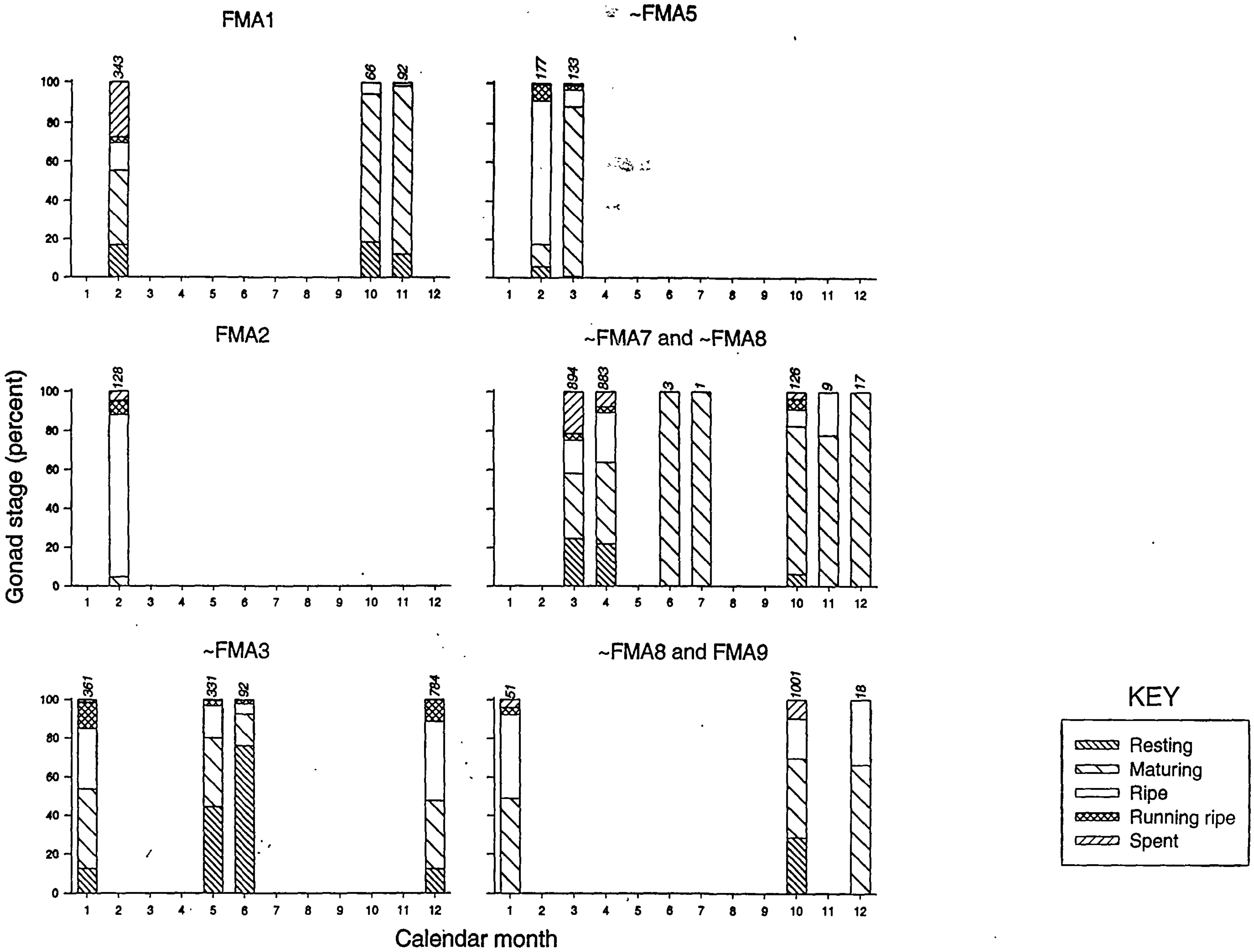

35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
FMA7, FMA8, and FMA9
FMA1 and FMA2
200 m
1000 m
N = 9
N = 16
Arripis trutta
Kahawai
Spent



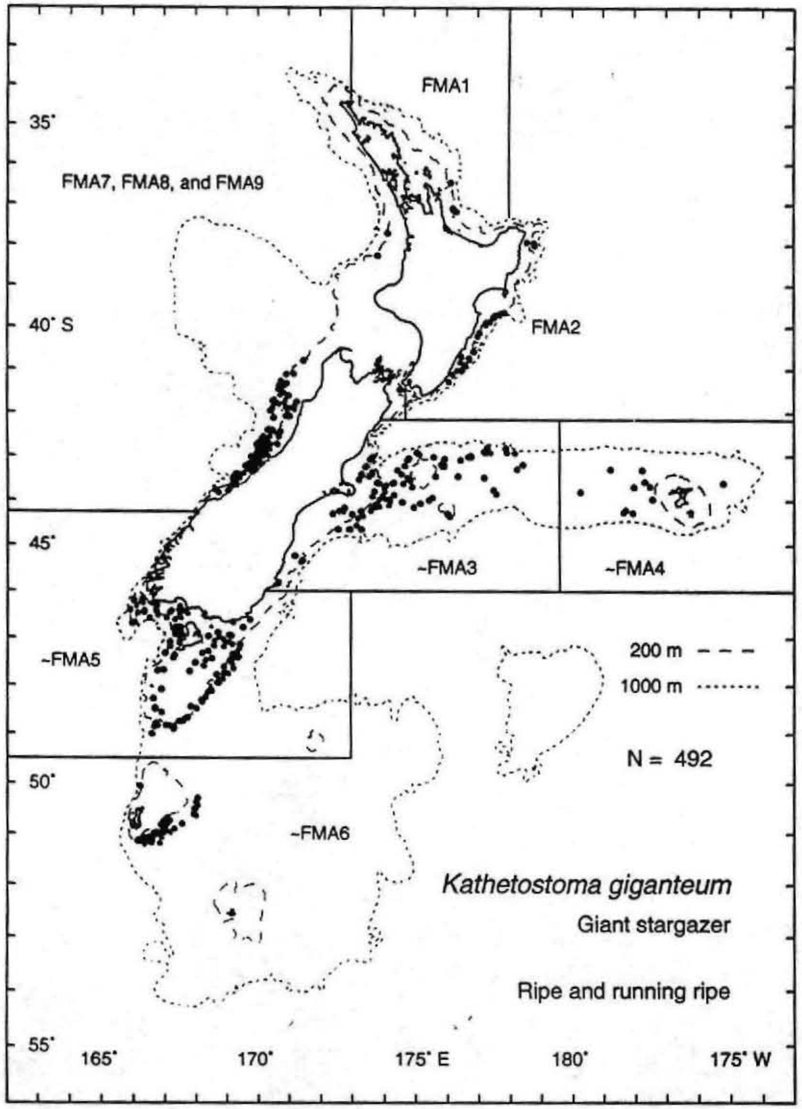
Kahawai female gonad stages by area by month. See distribution figure on page opposite for definition of areas. Numbers in italics are the numbers of mature sized female fish staged per month.


FMA1
35°
~FMA8 and FMA9
40° S
FMA2
~FMA7 and ~FMA8
45°
~FMA3
~FMA5
200 m
1000 m
N = 445
50°
Chelidonichthys kumu
Red gurnard
Ripe and running ripe
55°
165°
170°
175° E
180°
175° W

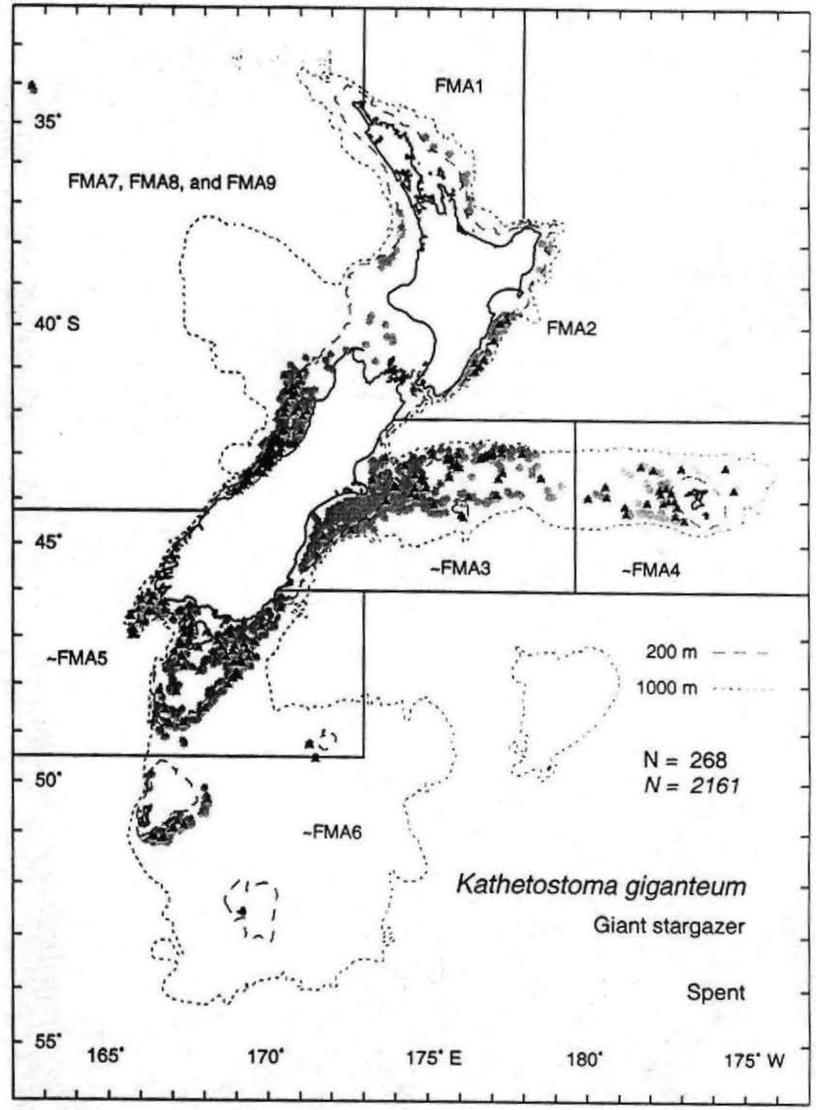

FMA1
35°
~FMA8 and FMA9
40° S
FMA2
~FMA7 and ~FMA8
45°
~FMA3
~FMA5
200 m
1000 m
N = 157
N = 817
50°
Chelidonichthys kumu
Red gurnard
Spent
55°
165°
170°
175° E
180°
175° W



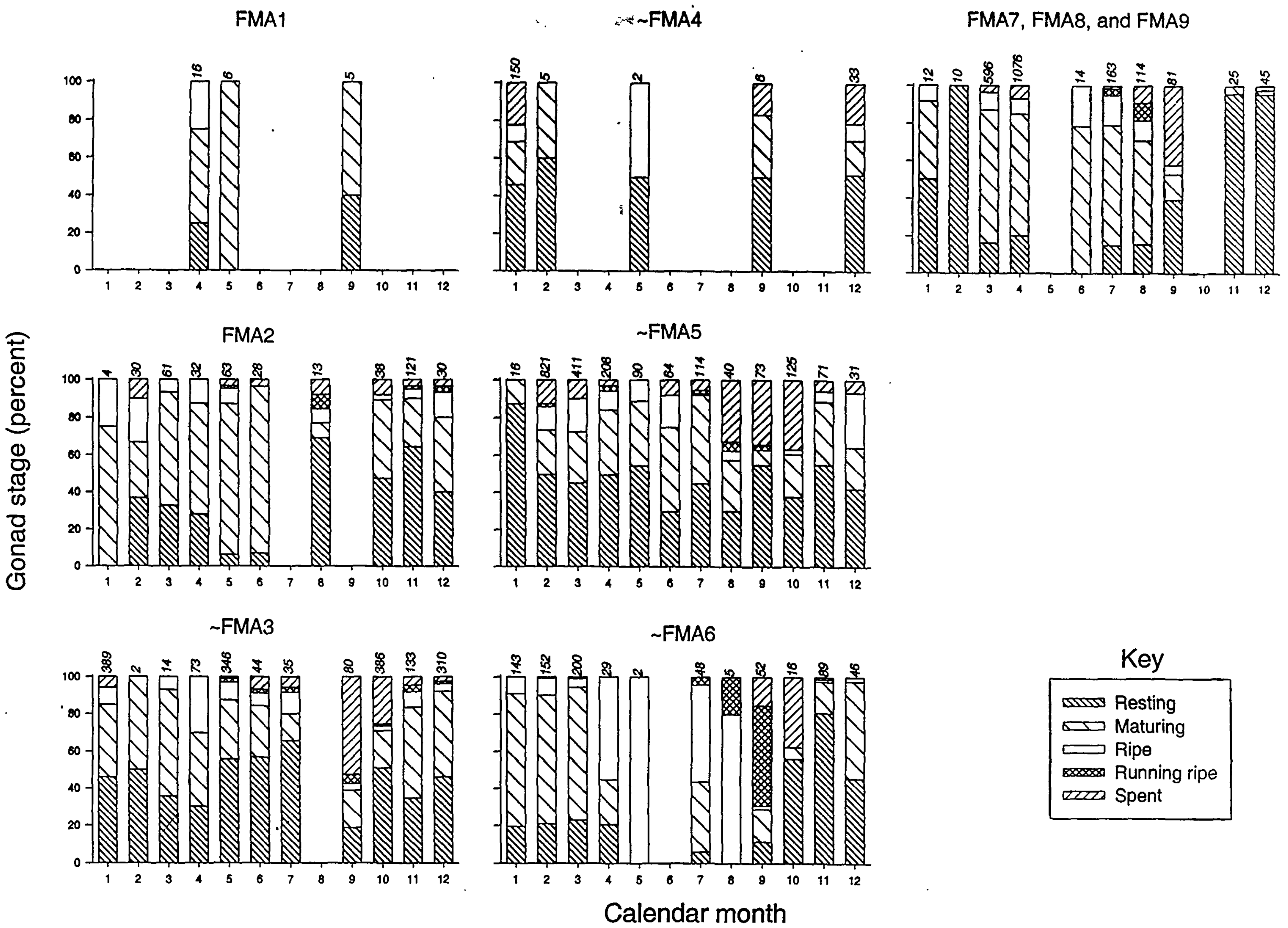
Red gurnard gonad stages by area by month. See distribution figure on page opposite for definition of areas. Numbers in italics are the numbers of mature sized fish staged per month.



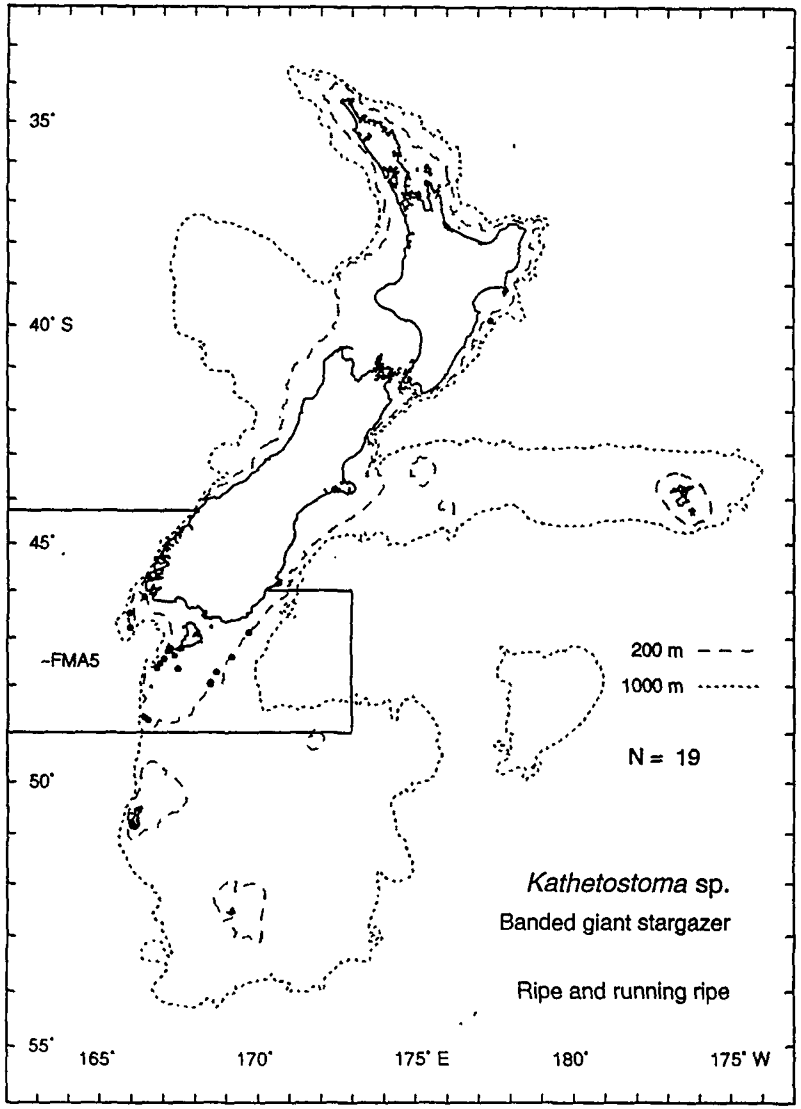
FMA1
35°
FMA7, FMA8, and FMA9
40° S
FMA2
~FMA3
~FMA4
45°
~FMA5
200 m
1000 m
N = 492
50°
~FMA6
Kathetostoma giganteum
Giant stargazer
Ripe and running ripe
55°
165°
170°
175° E
180°
175° W

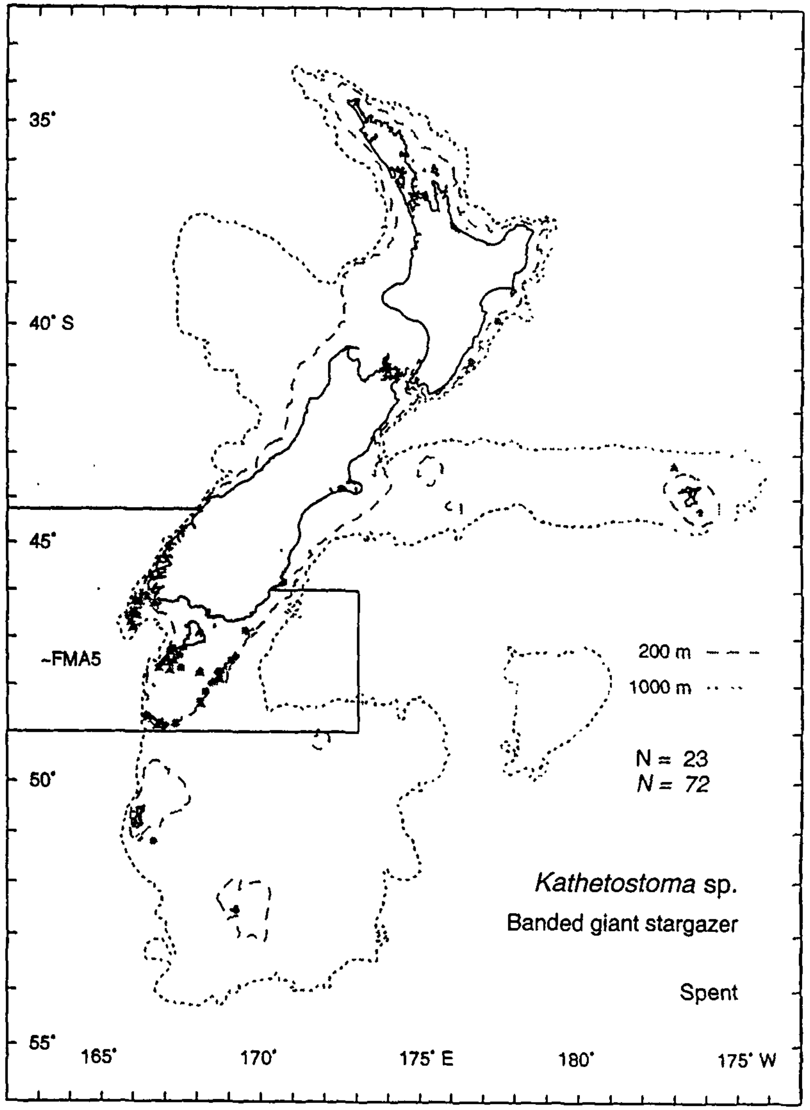


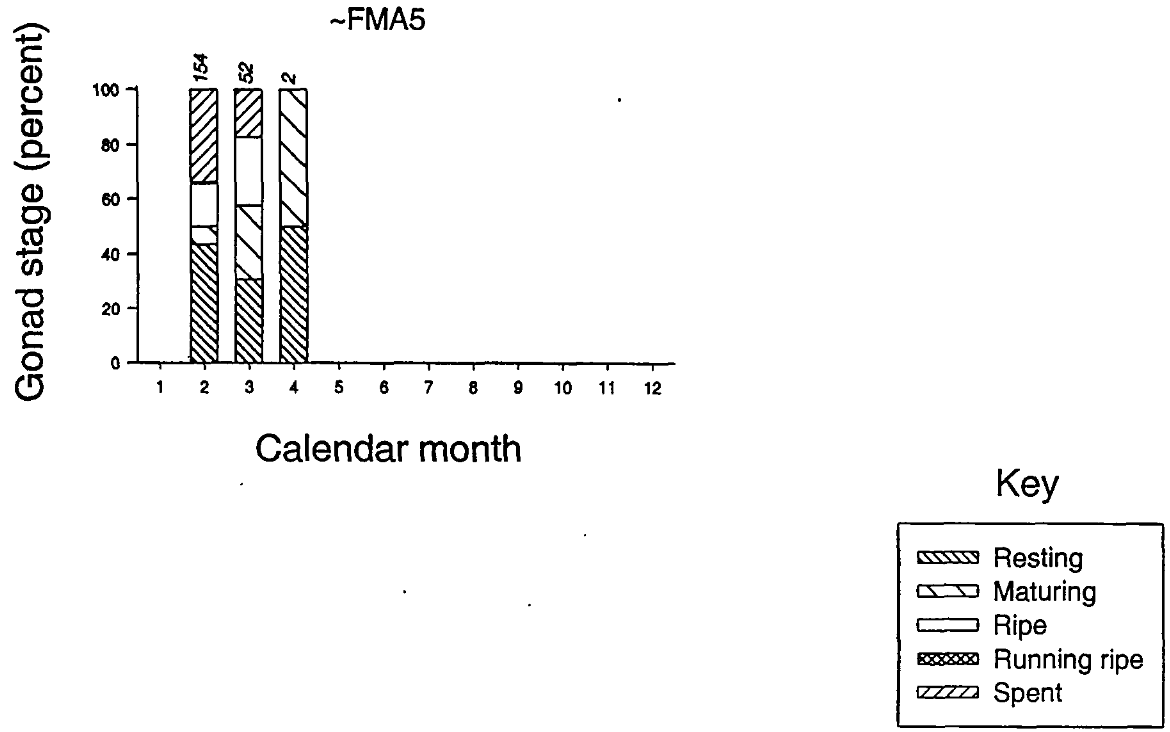
FMA1
35°
FMA7, FMA8, and FMA9
40° S
FMA2
~FMA3
~FMA4
45°
~FMA5
200 m
1000 m
N = 268
N = 2161
50°
~FMA6
Kathetostoma giganteum
Giant stargazer
Spent
55°
165°
170°
175° E
180°
175° W



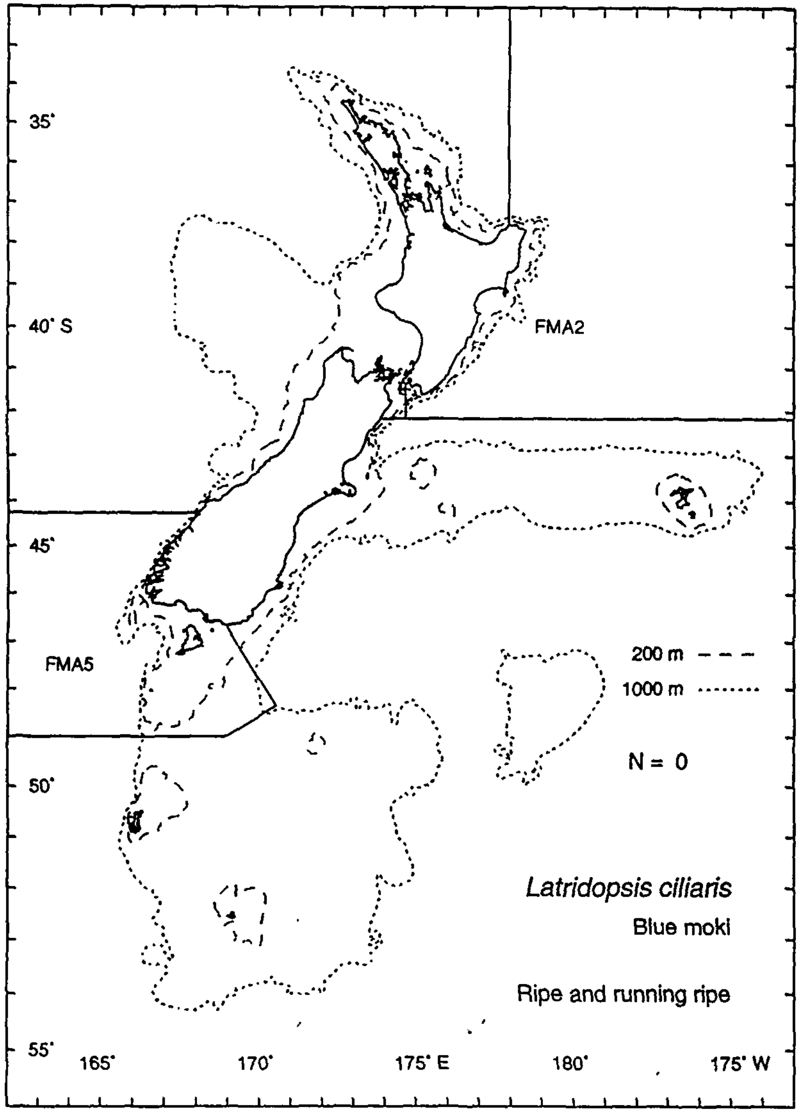
Giant stargazer gonad stages by area by month. See distribution figure on page opposite for definition of areas. Numbers in italics are the numbers of mature sized fish staged per month.

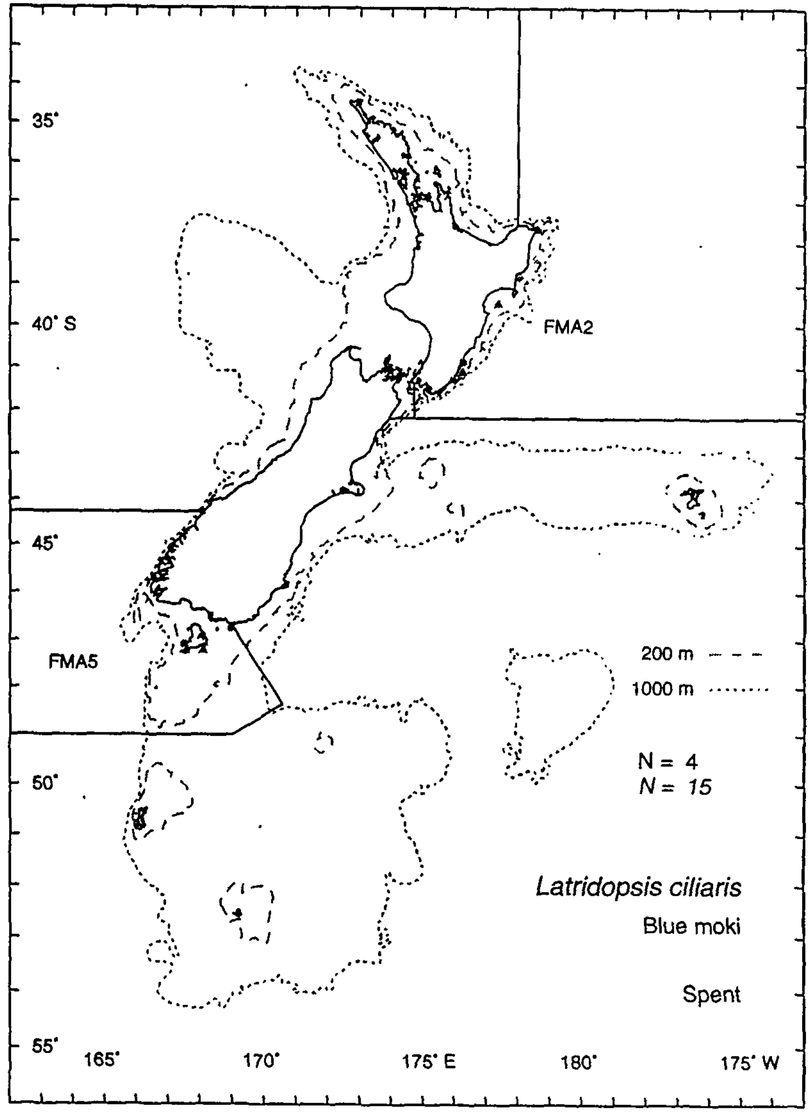

35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
~FMA5
200 m
1000 m
N = 19
Kathetostoma sp.
Banded giant stargazer
Ripe and running ripe

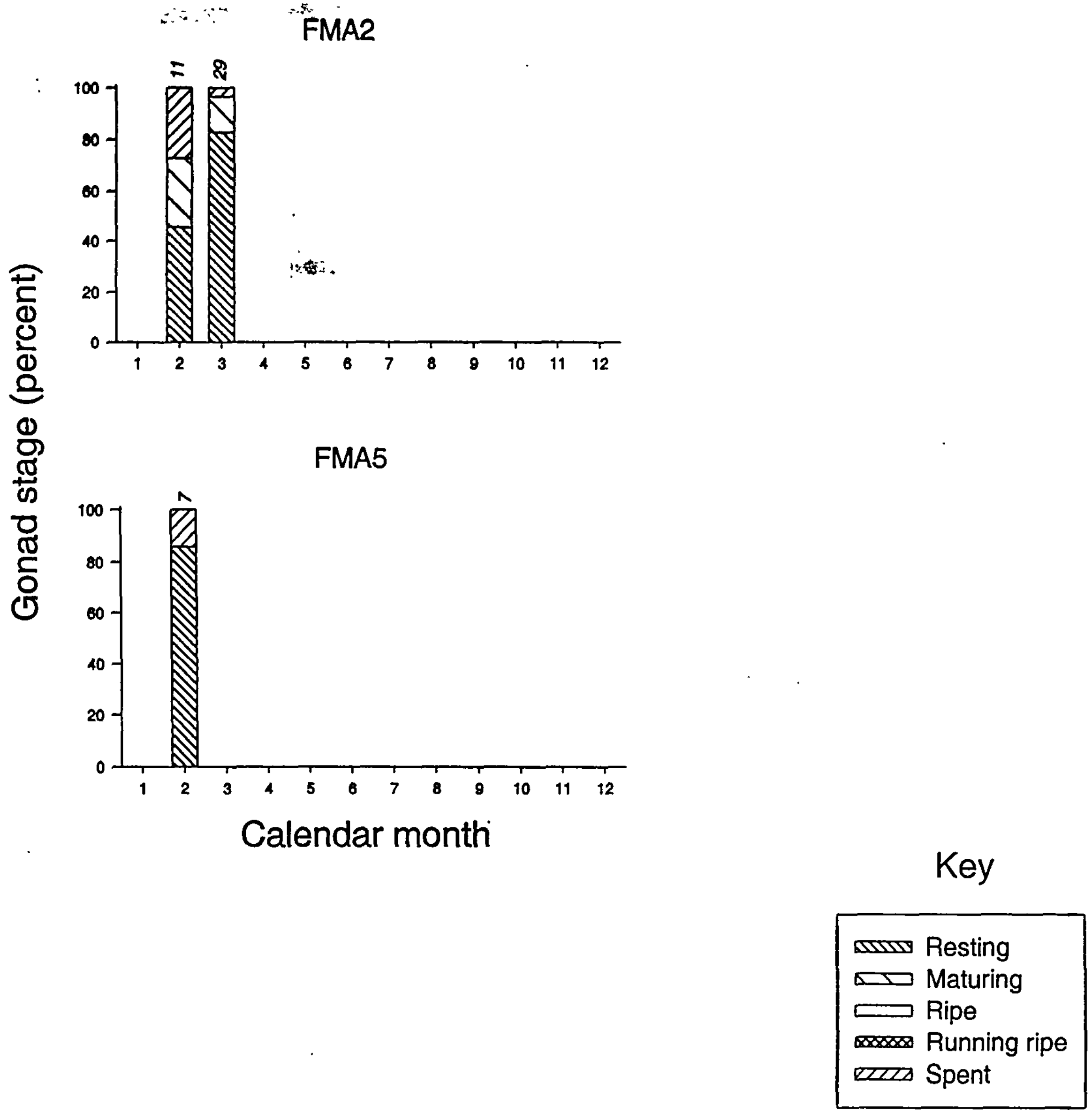

35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
~FMA5
200 m
1000 m
N = 23
N = 72
Kathetostoma sp.
Banded giant stargazer
Spent



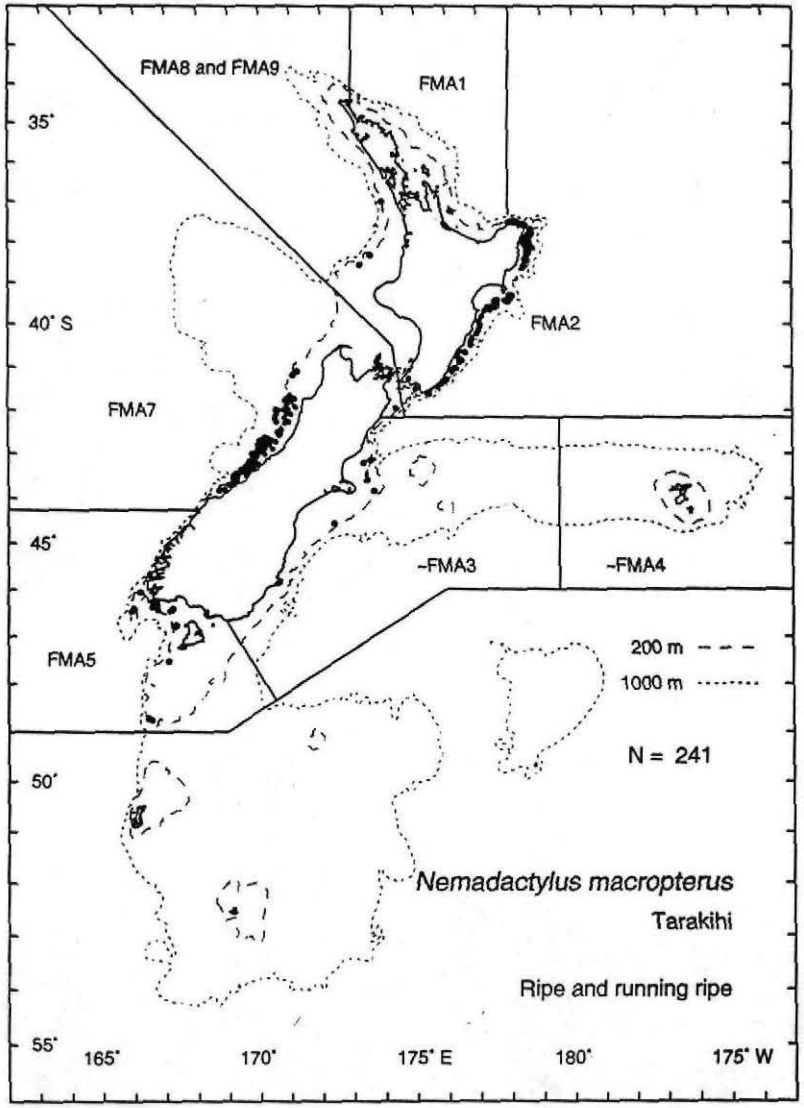
Banded stargazer female gonad stages by area by month. See distribution figure on page opposite for definition of areas. Numbers in italics are the numbers of mature sized female fish staged per month.

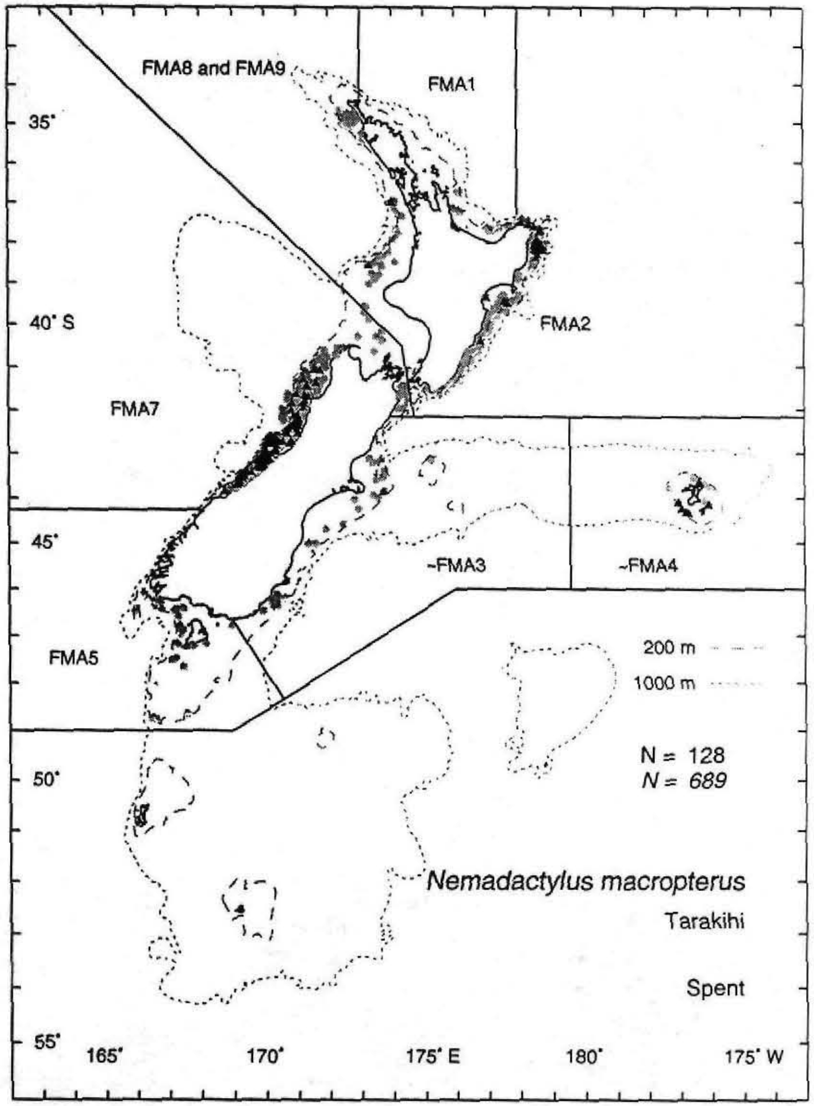

35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
FMA2
FMA5
200 m
1000 m
N = 0
Latridopsis ciliaris
Blue moki
Ripe and running ripe

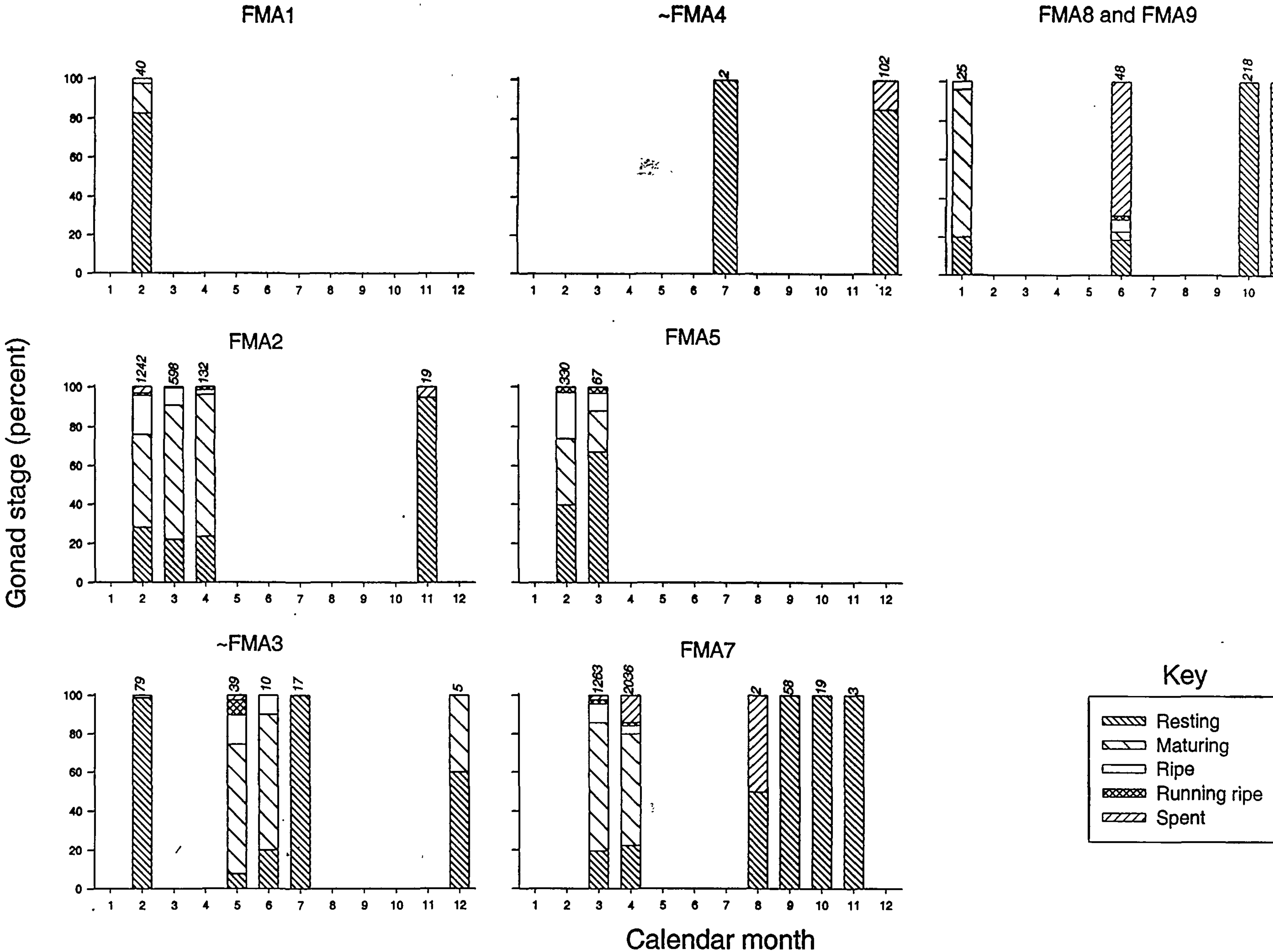

35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
FMA2
FMA5
200 m
1000 m
N = 4
N = 15
Latridopsis ciliaris
Blue moki
Spent



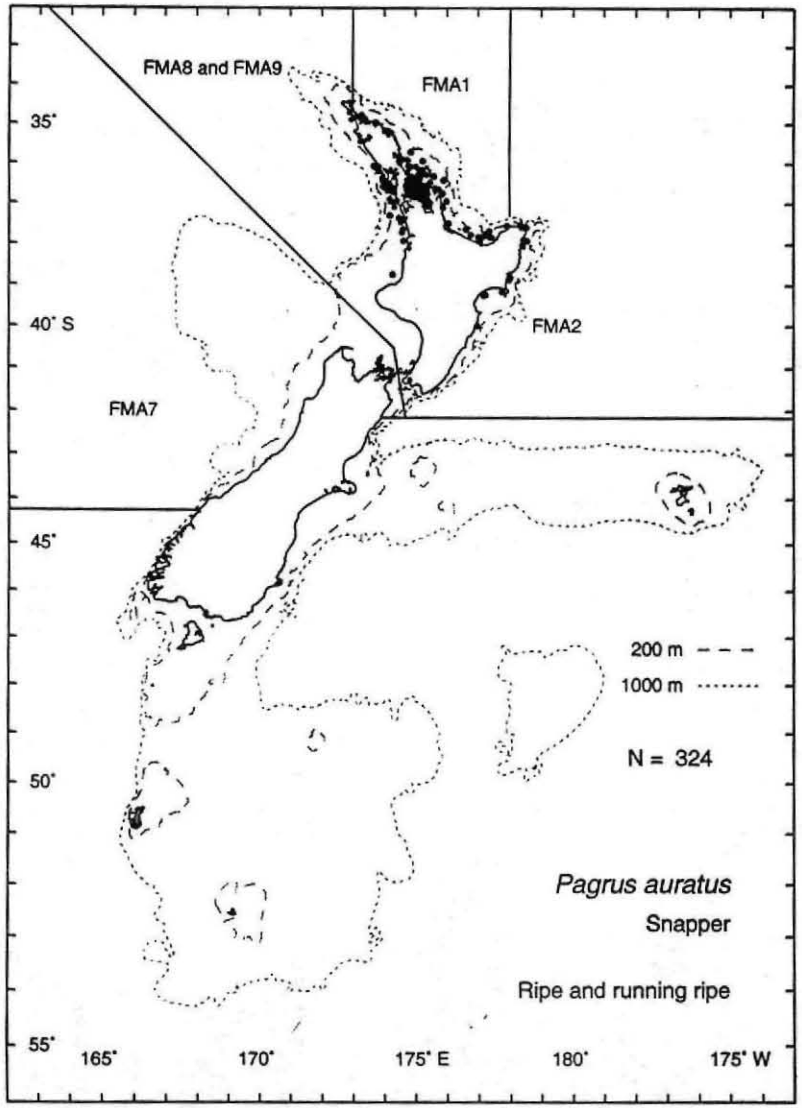
Blue moki female gonad stages by area by month. See distribution figure on page opposite for definition of areas. Numbers in italics are the numbers of mature sized female fish staged per month.


FMA8 and FMA9
FMA1
FMA2
FMA7
FMA3
FMA4
FMA5
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 241
Nemadactylus macropterus
Tarakihi
Ripe and running ripe

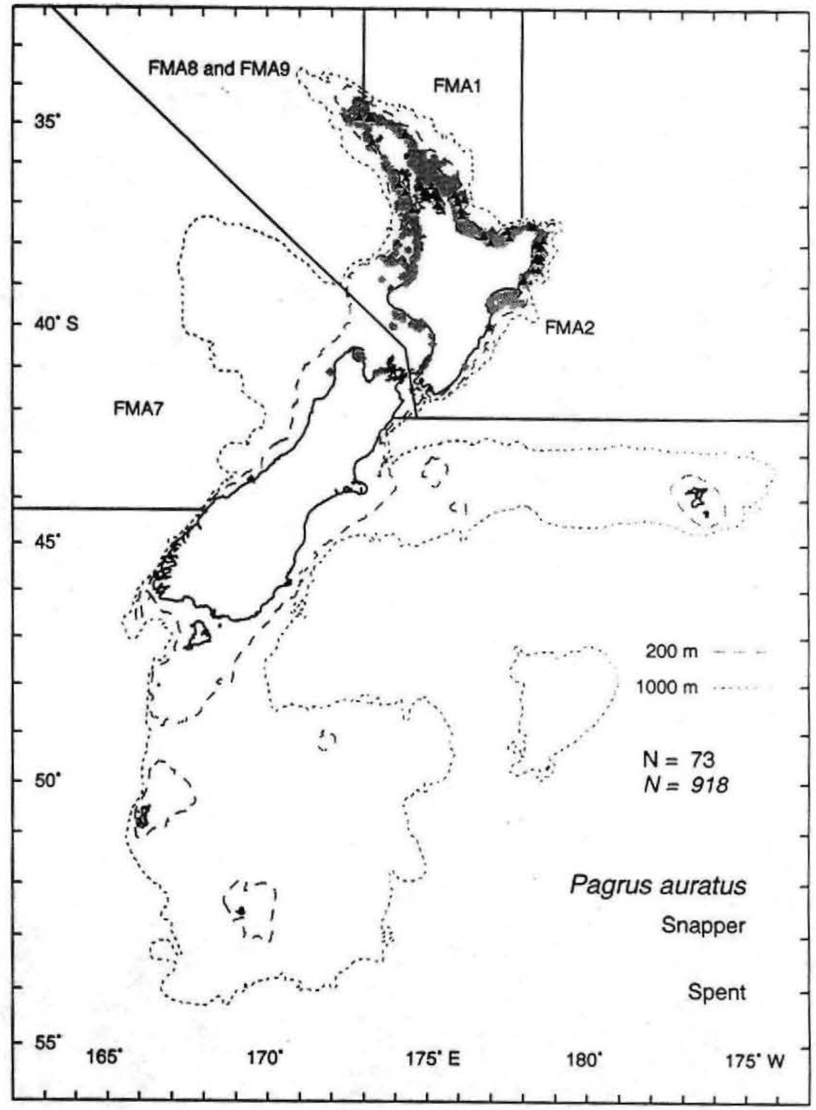

FMA8 and FMA9
FMA1
FMA2
FMA7
FMA3
FMA4
FMA5
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 128
N = 689
Nemadactylus macropterus
Tarakihi
Spent



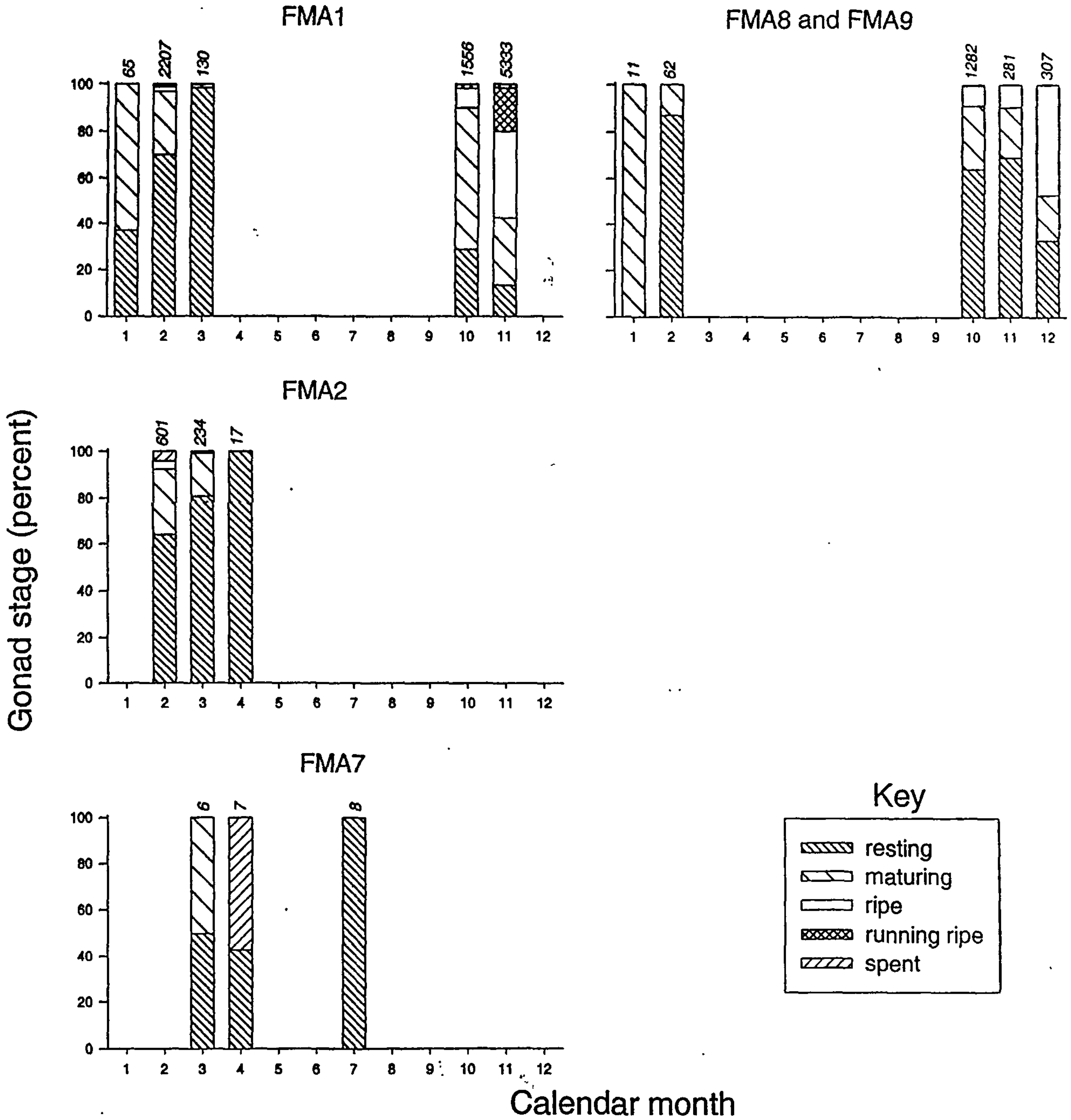
Tarakihi gonad stages by area by month. See distribution figure on page opposite for definition of areas. Numbers in italics are the numbers of mature sized fish staged per month.



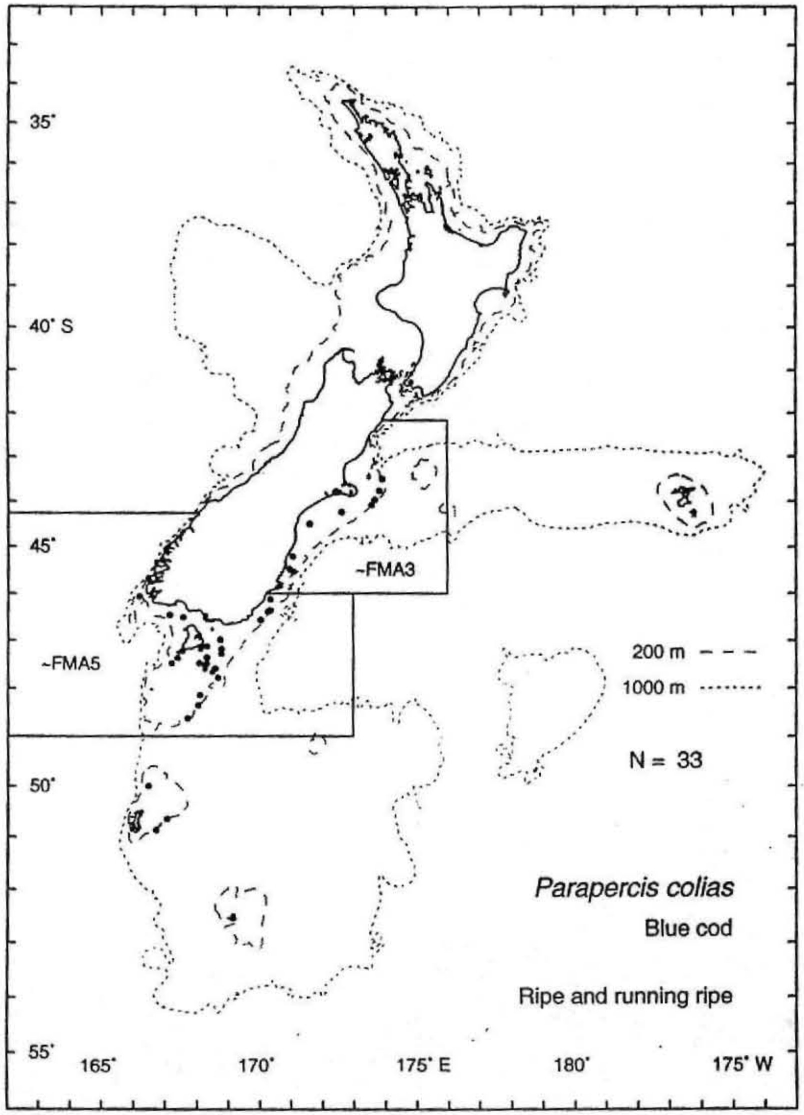
FMA8 and FMA9
FMA1
35°
40° S
FMA2
FMA7
45°
200 m
1000 m
N = 324
50°
Pagrus auratus
Snapper
Ripe and running ripe
55°
165°
170°
175° E
180°
175° W

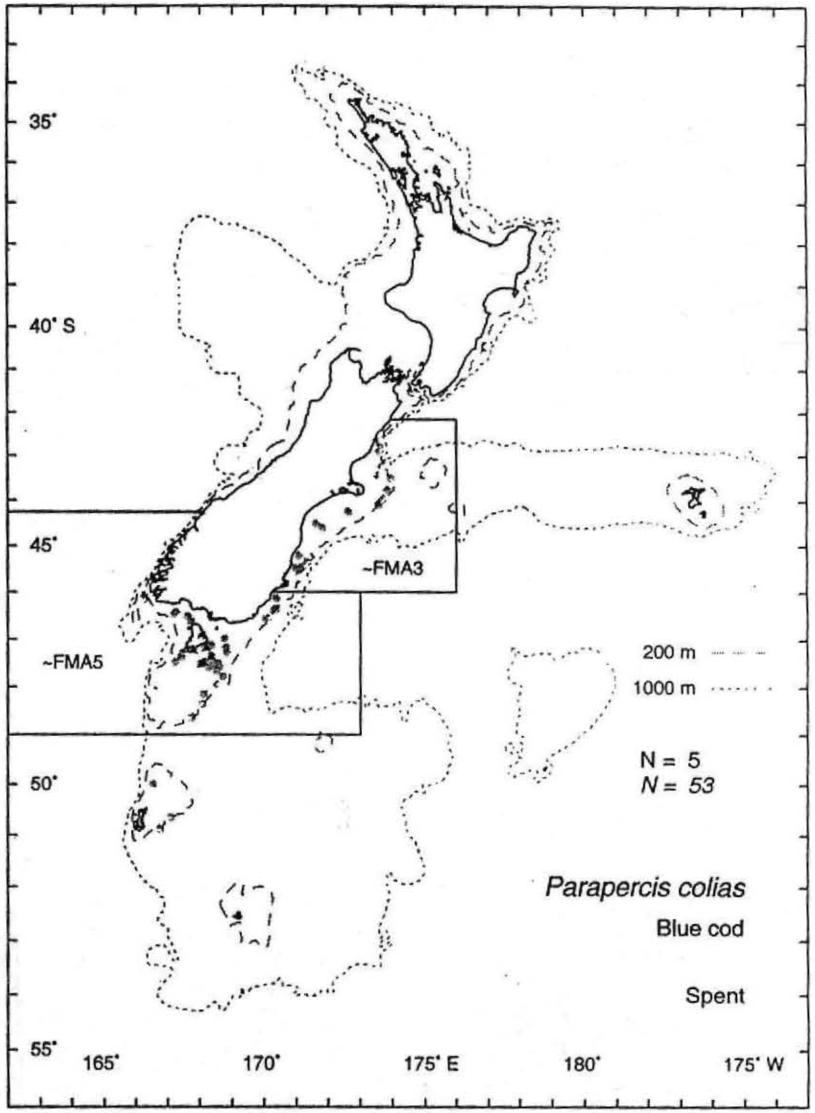


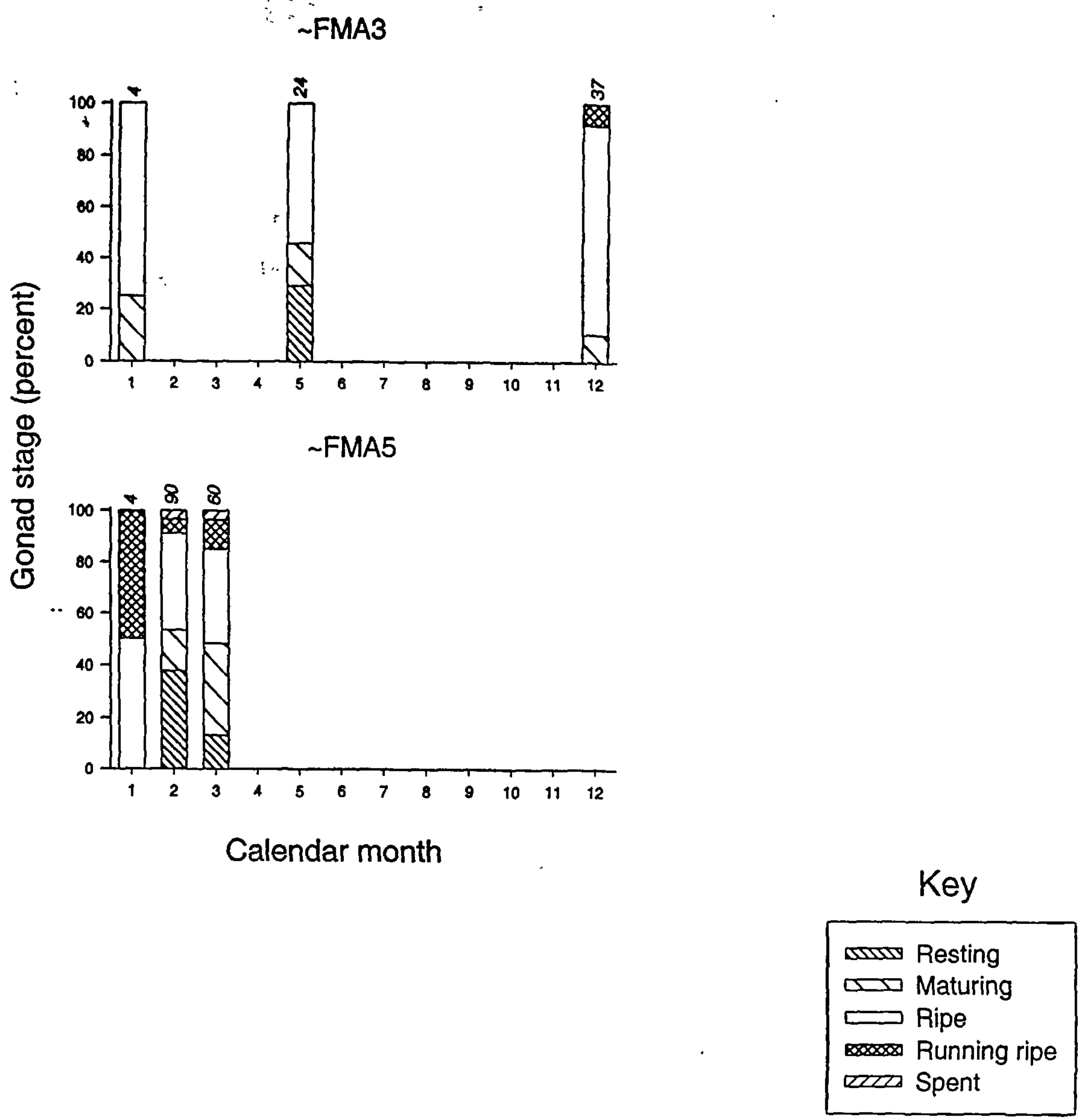
FMA8 and FMA9
FMA1
35°
40° S
FMA2
FMA7
45°
200 m
1000 m
N = 73
N = 918
50°
Pagrus auratus
Snapper
Spent
55°
165°
170°
175° E
180°
175° W



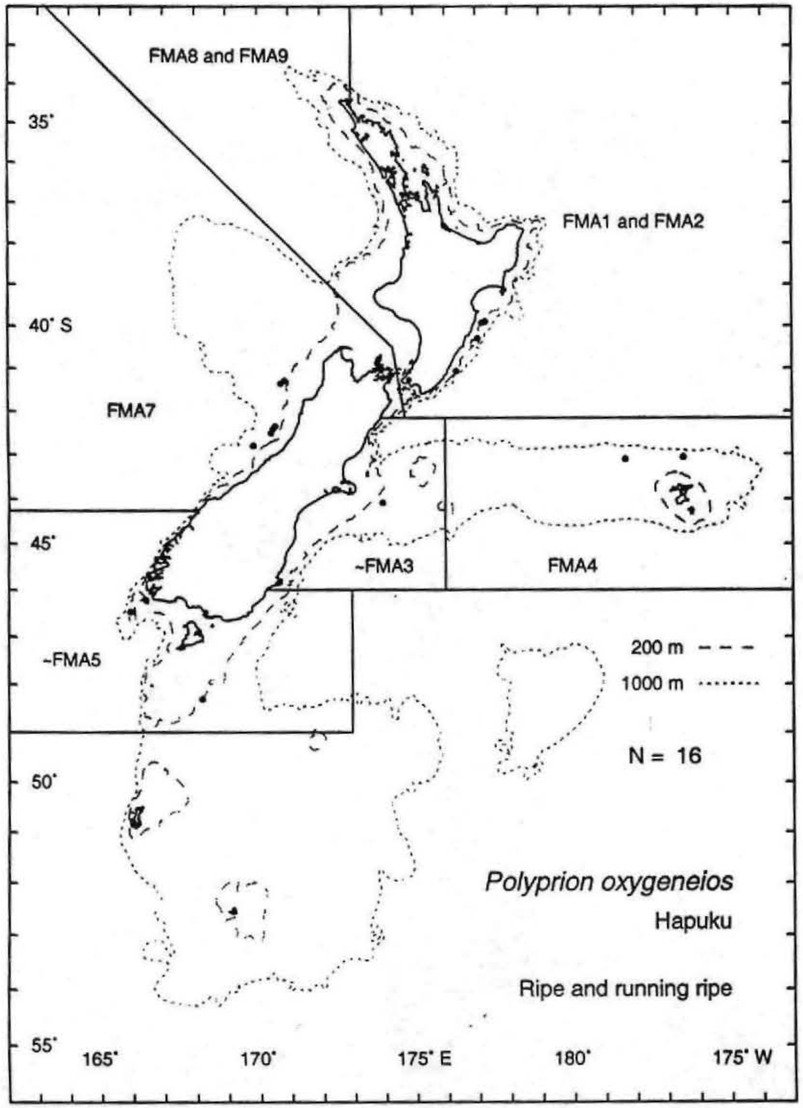
Snapper gonad stages by area by month. See distribution figure on page opposite for definition of areas. Numbers in italics are the numbers of mature sized fish staged per month.


35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
~FMA3
~FMA5
200 m
1000 m
N = 33
Parapercis colias
Blue cod
Ripe and running ripe

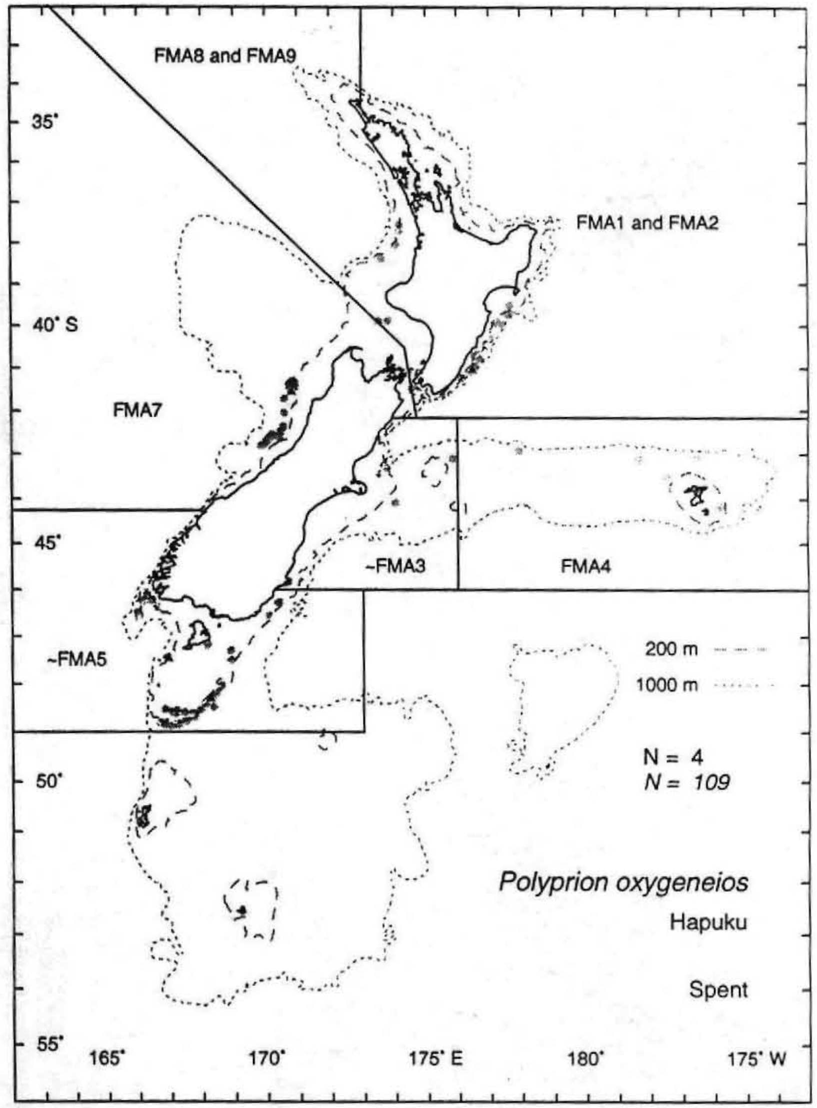

35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
~FMA3
~FMA5
200 m
1000 m
N = 5
N = 53
Parapercis colias
Blue cod
Spent



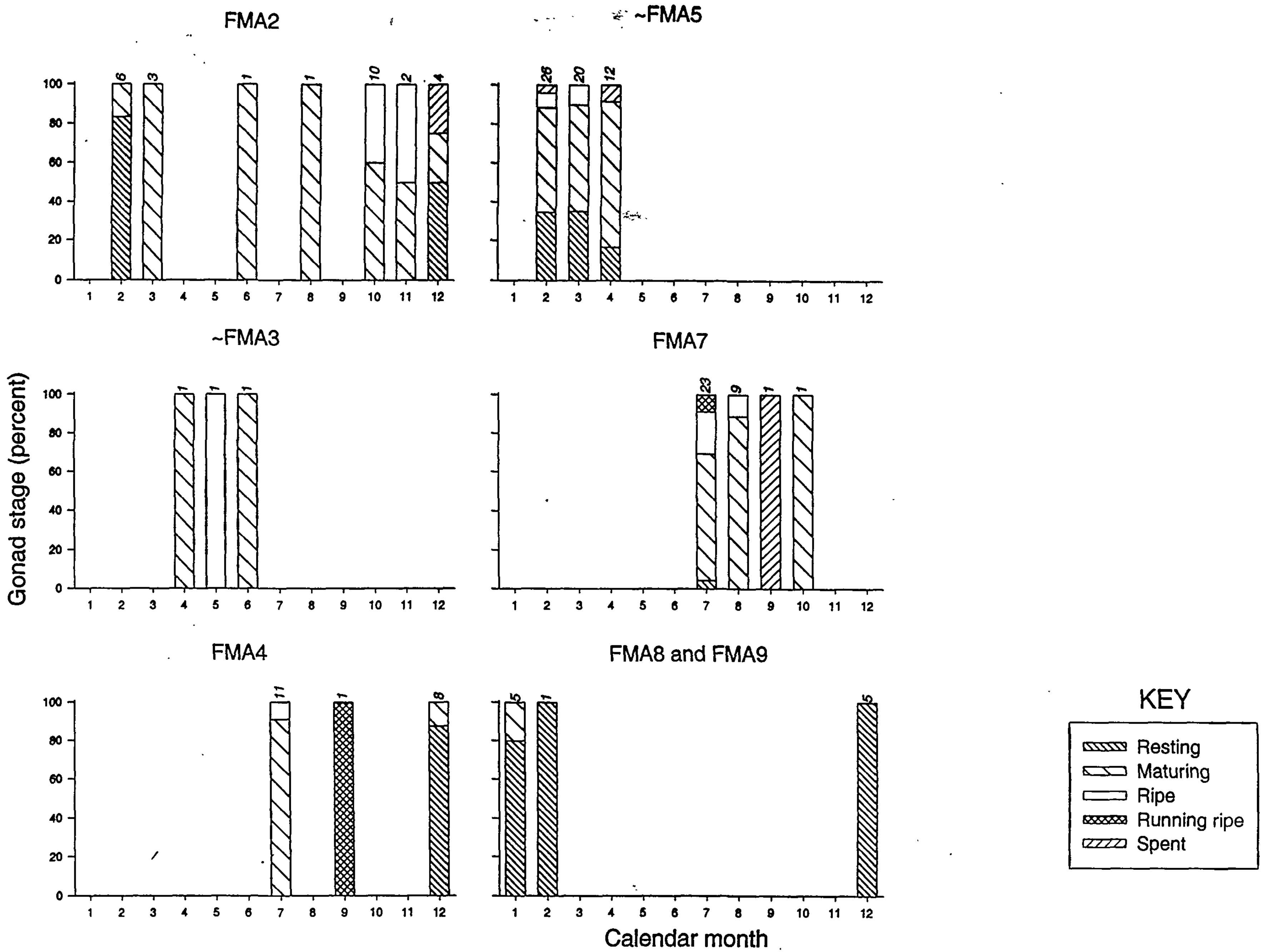
Blue cod female gonad stages by area by month. See distribution figure on page opposite for definition of areas. Numbers in italics are the numbers of mature sized female fish staged per month.



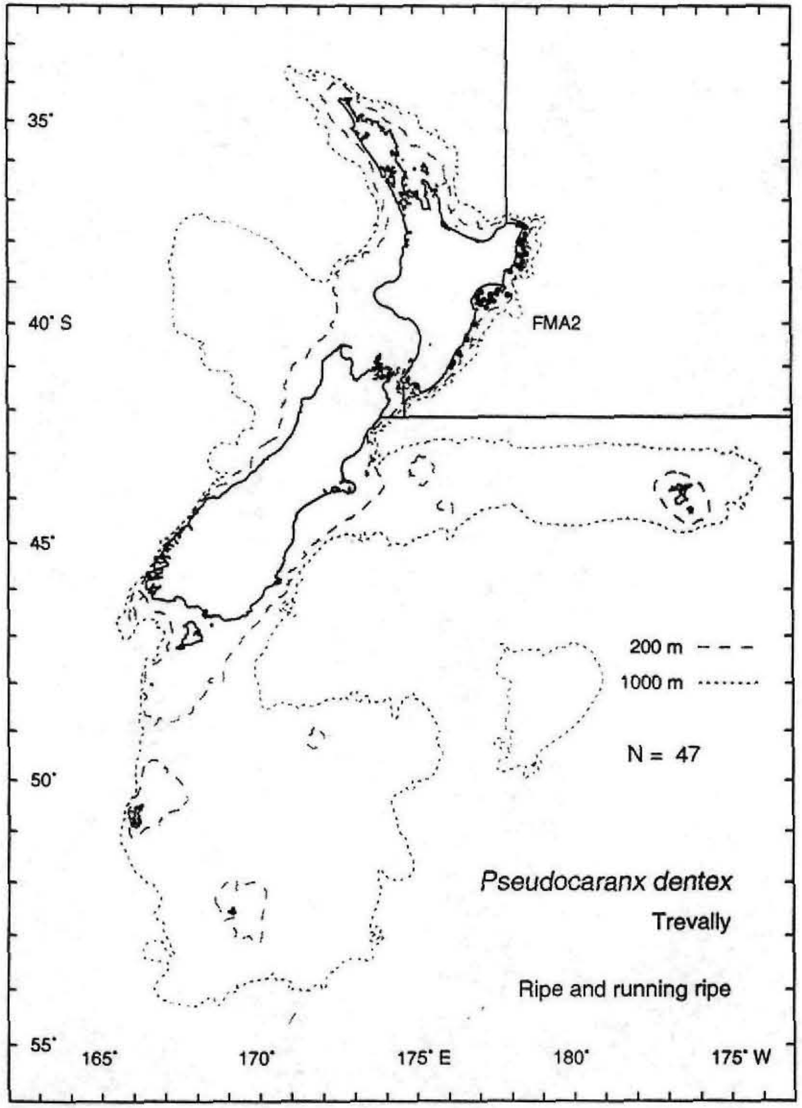
FMA8 and FMA9
FMA1 and FMA2
FMA7
~FMA3
FMA4
~FMA5
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 16
Polyprion oxygeneios
Hapuku
Ripe and running ripe

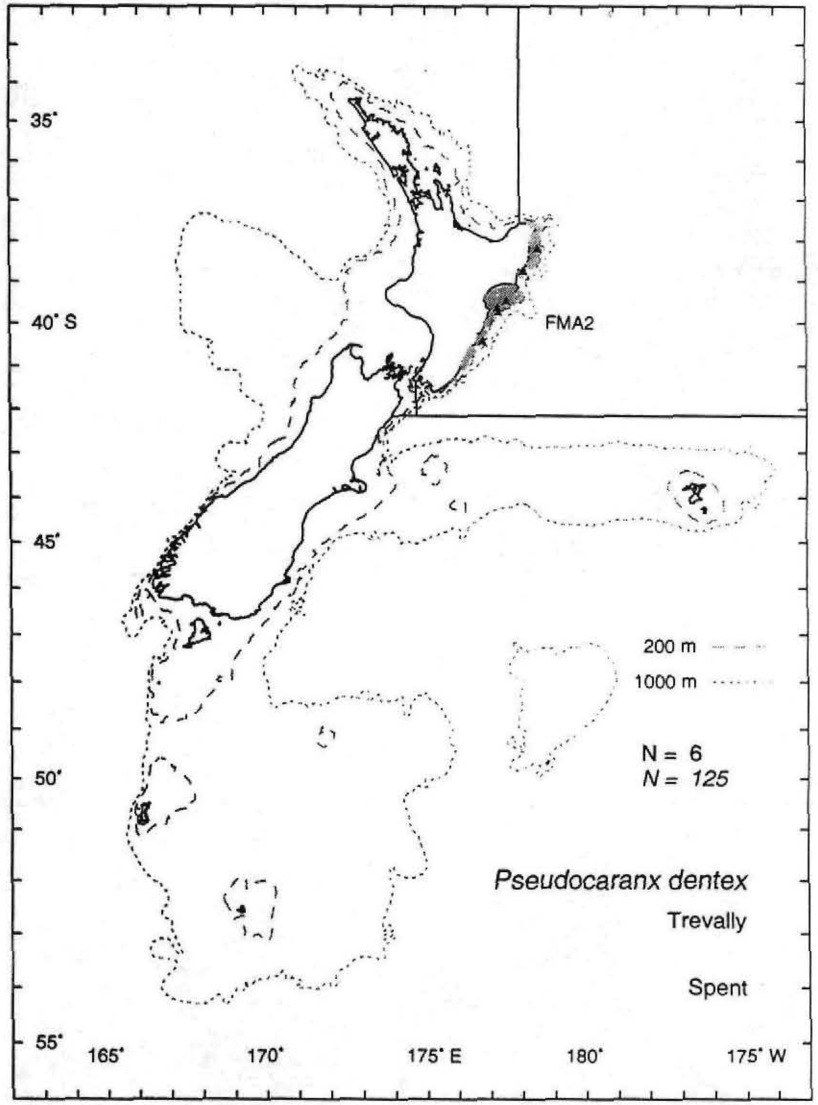


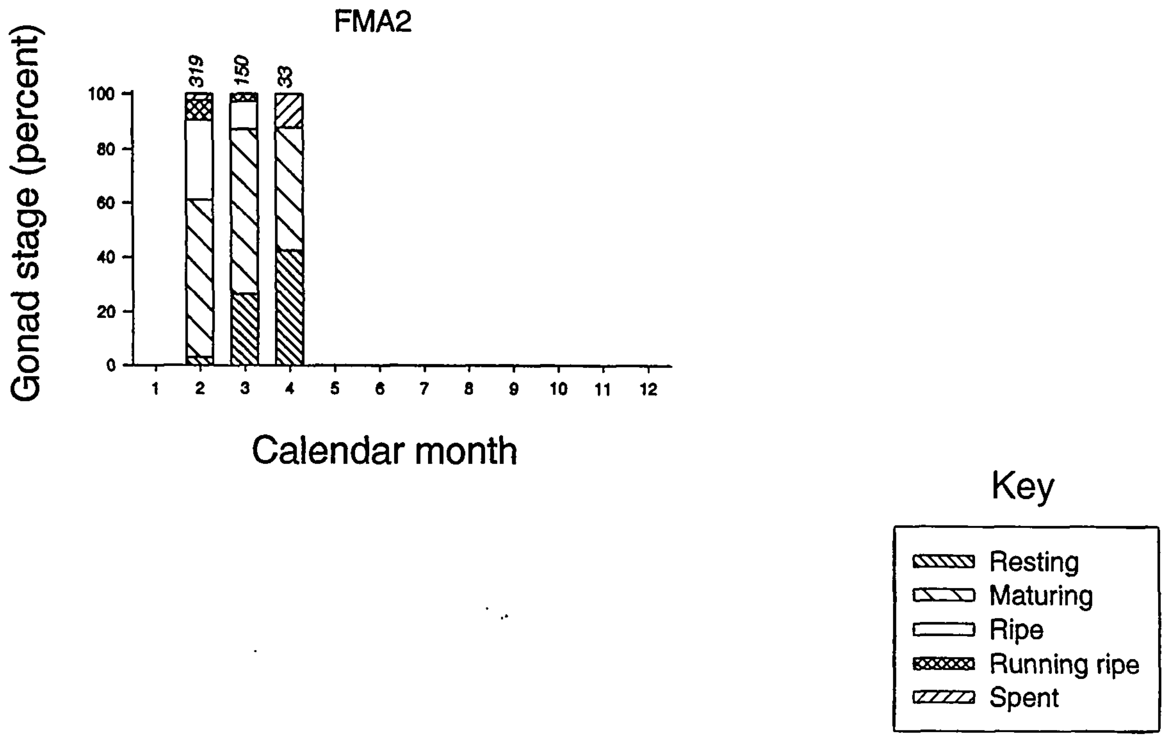
FMA8 and FMA9
FMA1 and FMA2
FMA7
~FMA3
FMA4
~FMA5
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
200 m
1000 m
N = 4
N = 109
Polyprion oxygeneios
Hapuku
Spent



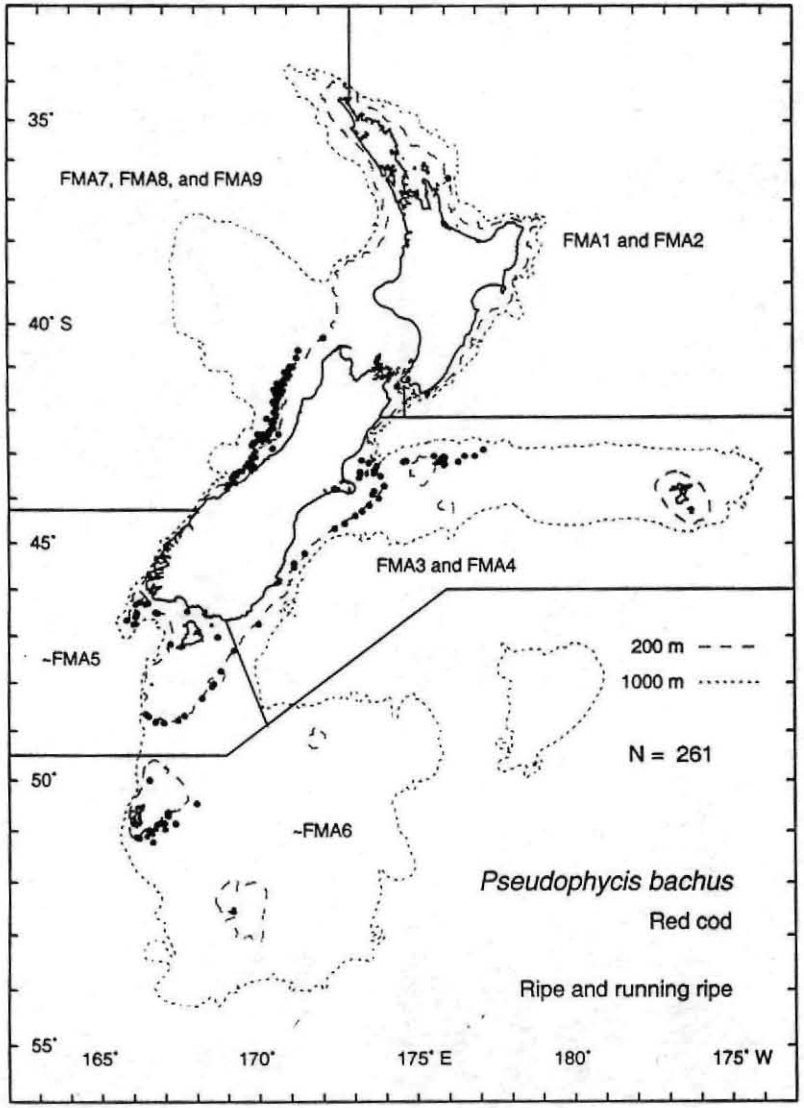
Hapuku gonad stages by area by month. See distribution figure on page opposite for definition of areas. Numbers in italics are the numbers of mature sized fish staged per month.


35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
FMA2
200 m
1000 m
N = 47
Pseudocaranx dentex
Trevally
Ripe and running ripe

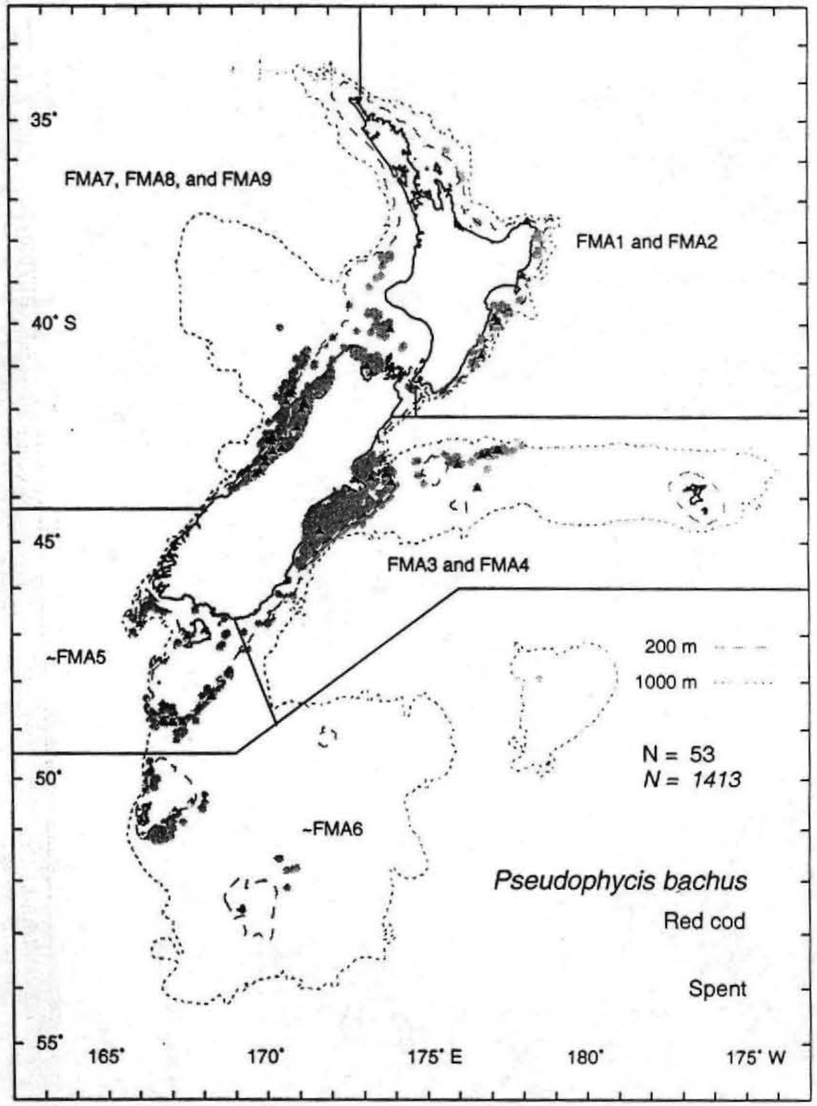

35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
FMA2
200 m
1000 m
N = 6
N = 125
Pseudocaranx dentex
Trevally
Spent



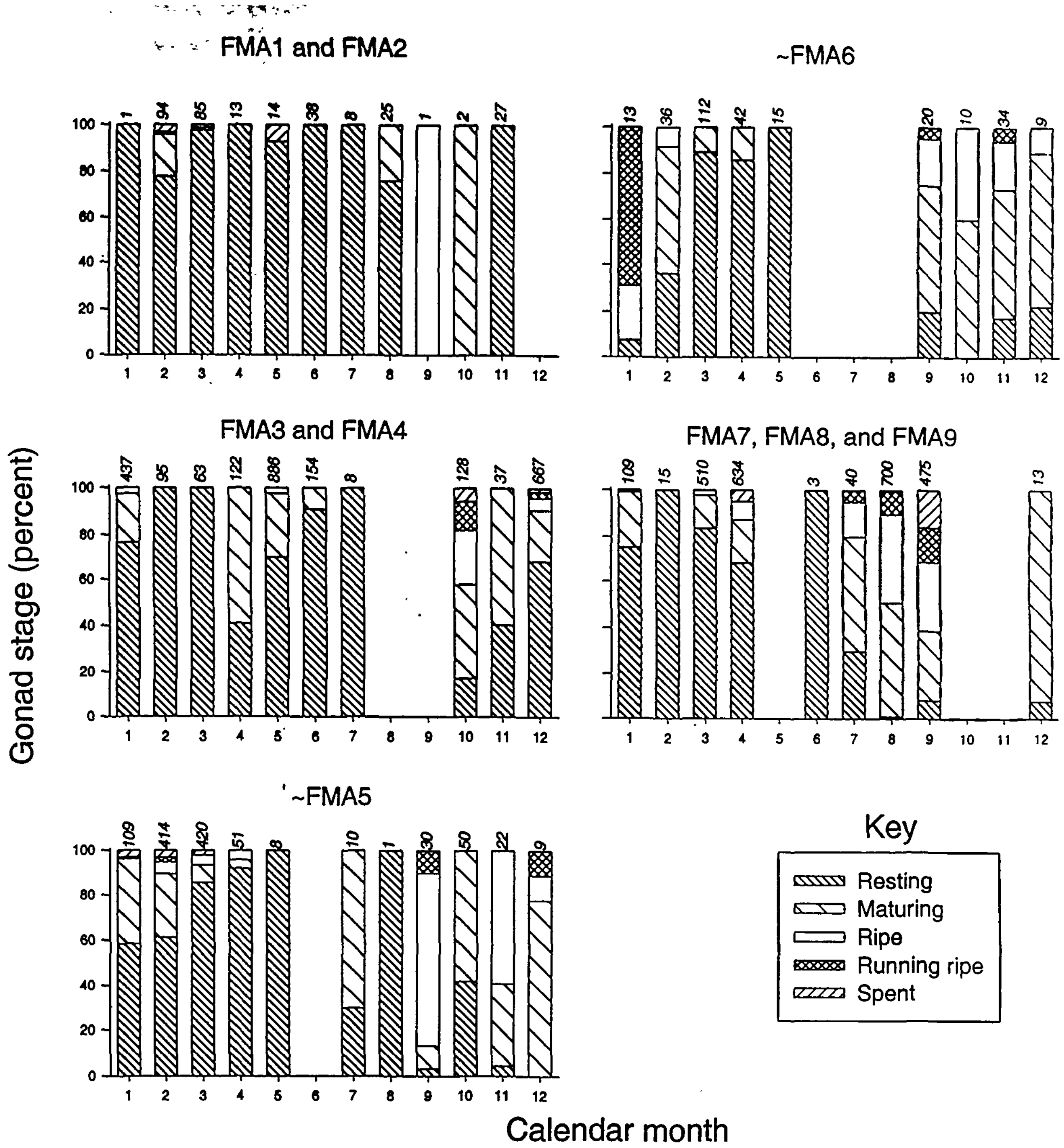
Trevally female gonad stages by area by month. See distribution figure on page opposite for definition of areas. Numbers in italics are the numbers of mature sized female fish staged per month.



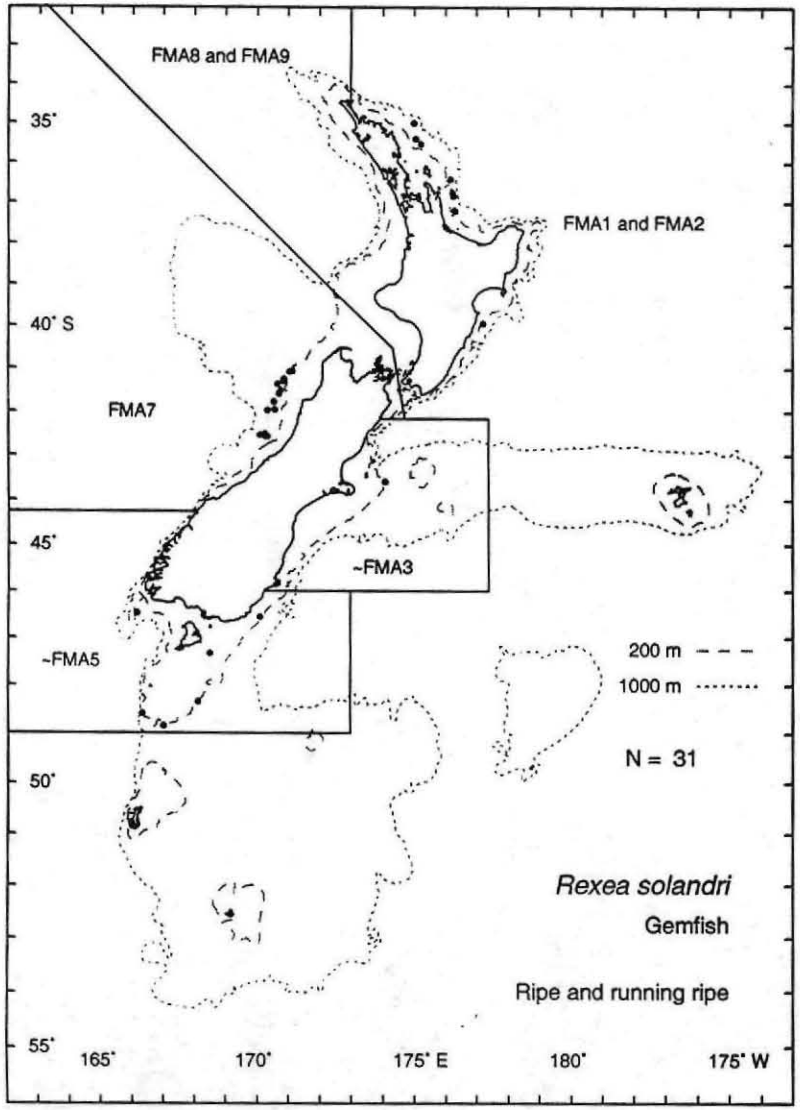
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
FMA7, FMA8, and FMA9
FMA1 and FMA2
FMA3 and FMA4
~FMA5
~FMA6
200 m
1000 m
N = 261
Pseudophycis bachus
Red cod
Ripe and running ripe

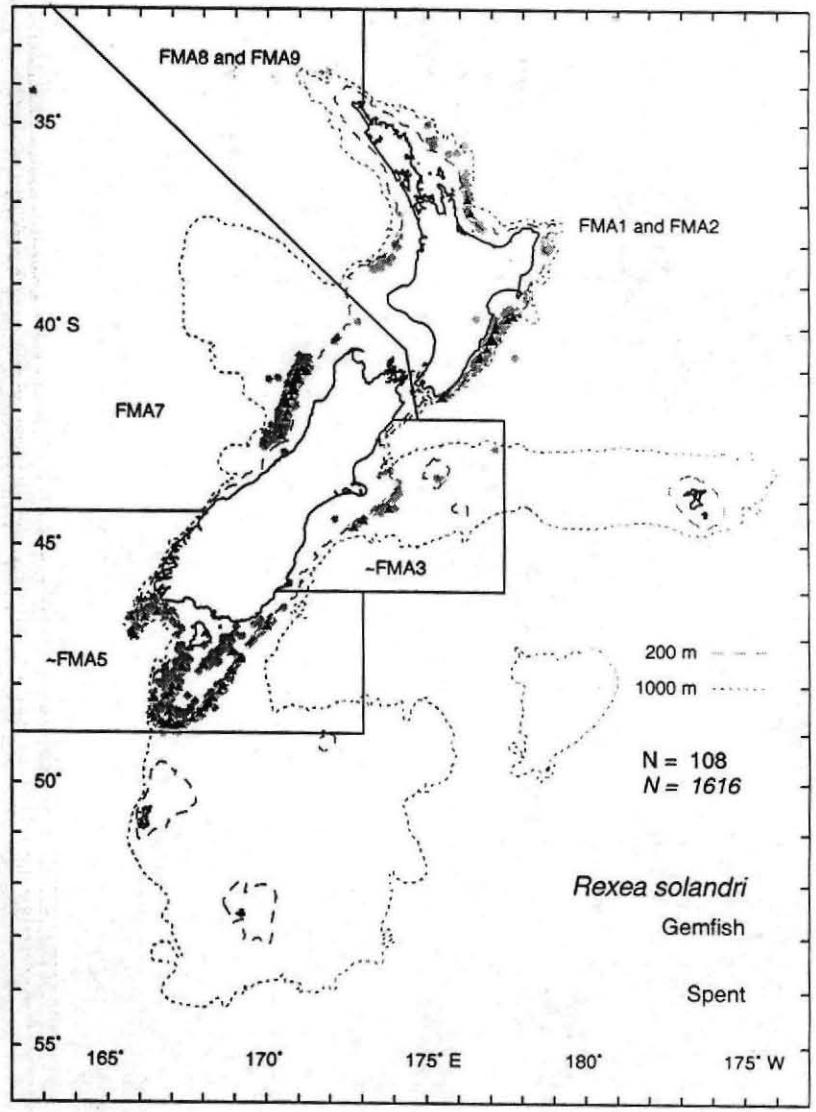


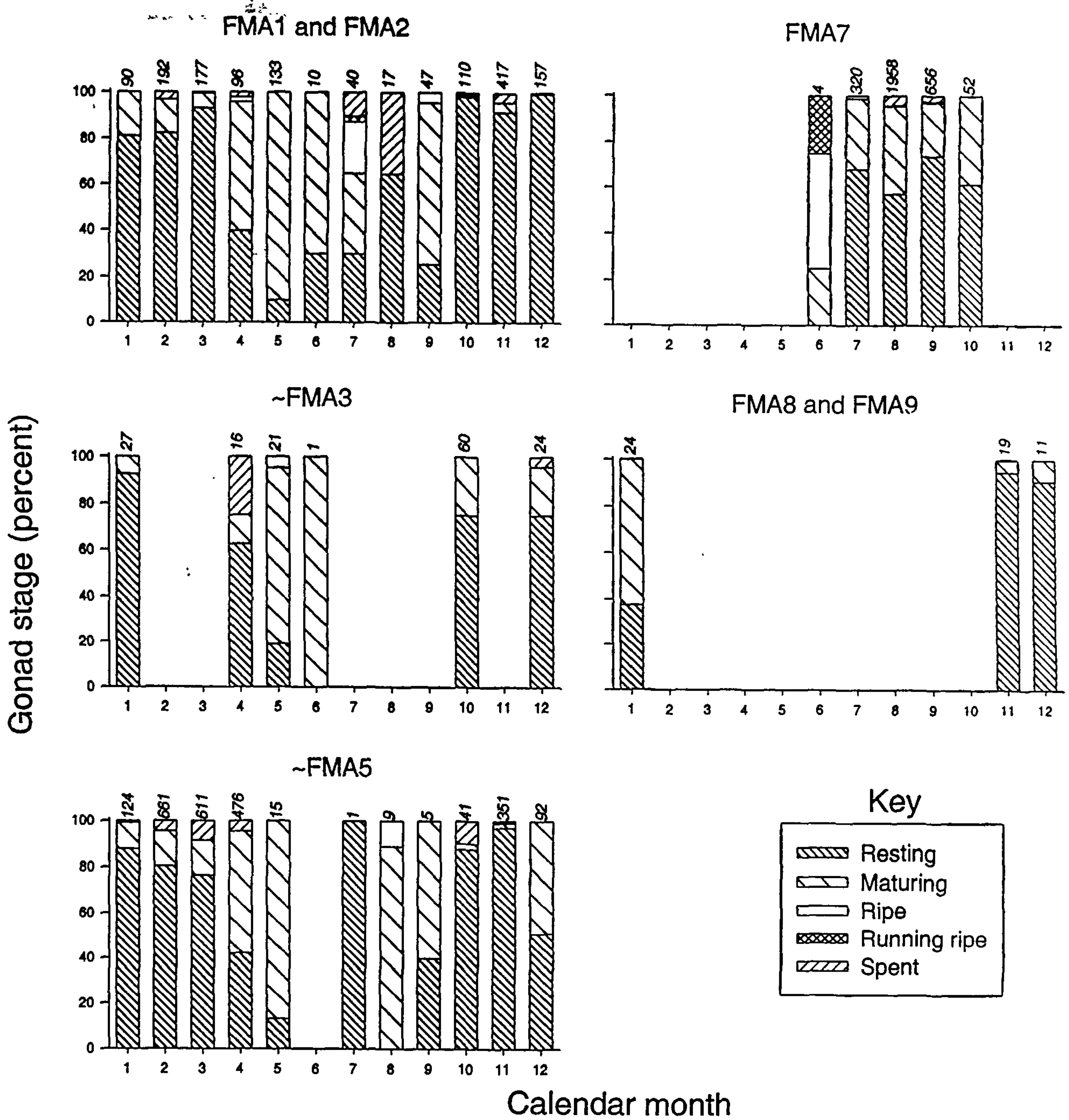
35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
FMA7, FMA8, and FMA9
FMA1 and FMA2
FMA3 and FMA4
~FMA5
~FMA6
200 m
1000 m
N = 53
N = 1413
Pseudophycis bachus
Red cod
Spent



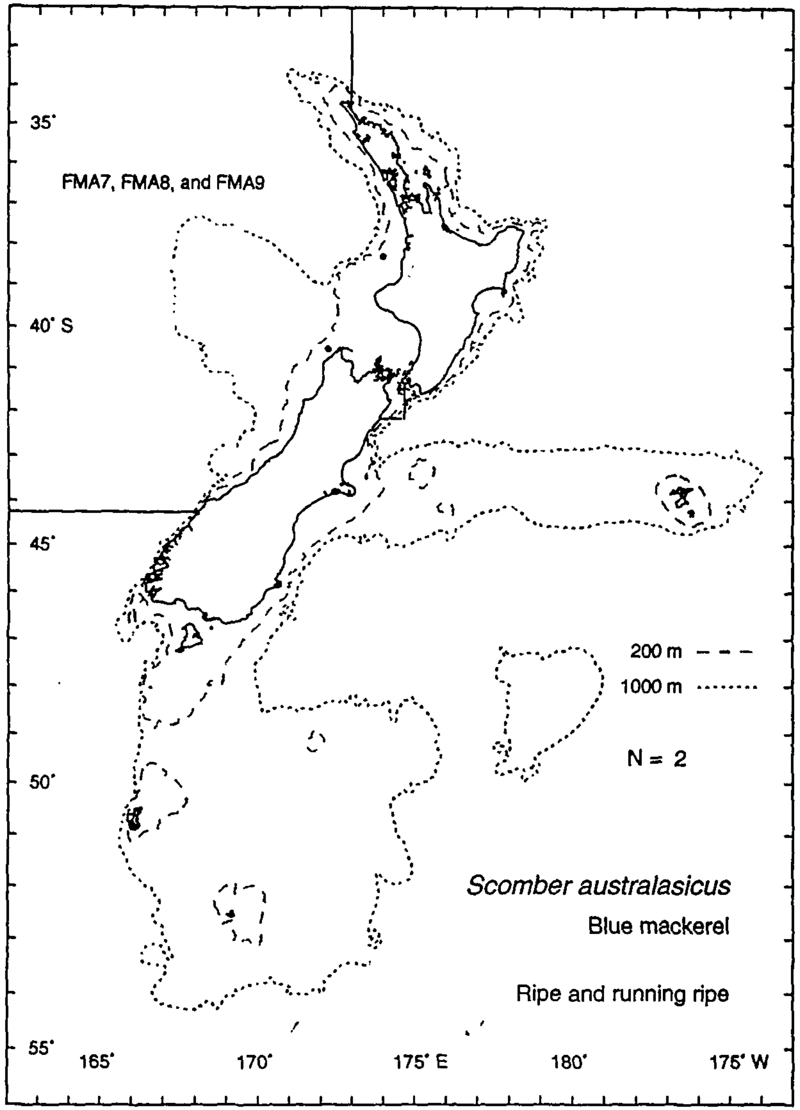
Red cod gonad stages by area by month. See distribution figure on page opposite for definition of areas. Numbers in italics are the numbers of mature sized fish staged per month.

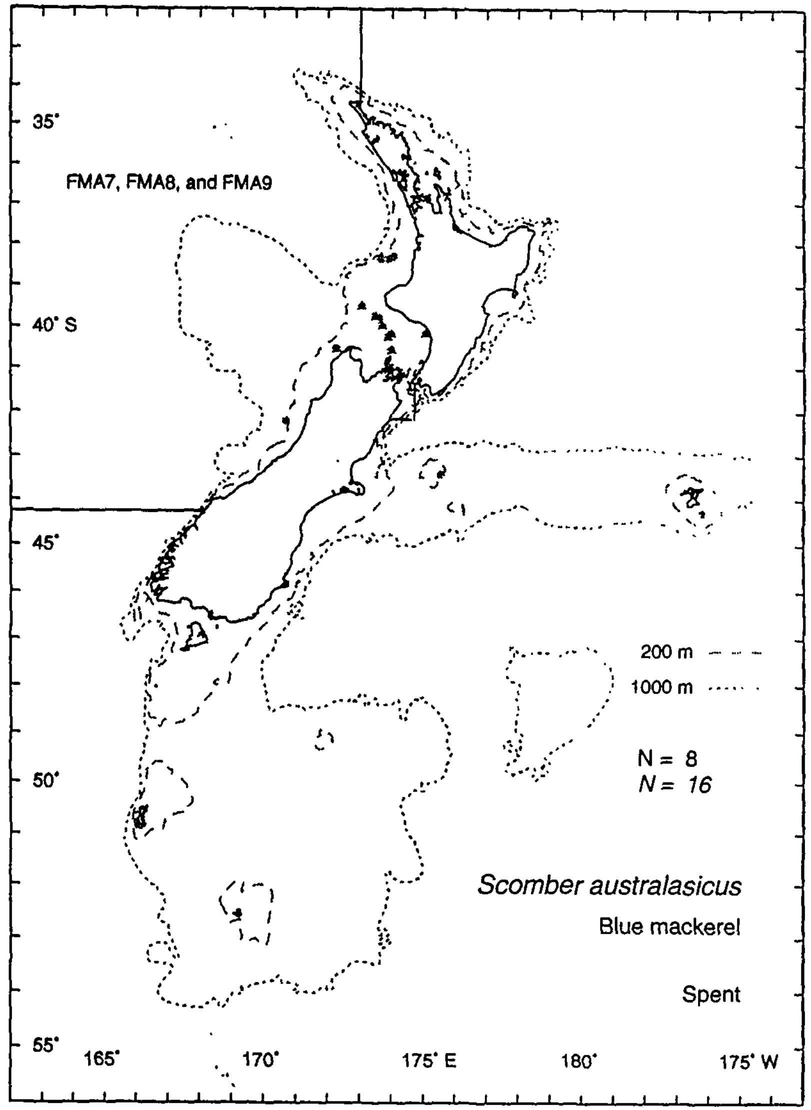

FMA8 and FMA9
35°
FMA1 and FMA2
40° S
FMA7
45°
~FMA3
~FMA5
200 m
1000 m
N = 31
50°
Rexea solandri
Gemfish
Ripe and running ripe
55°
165°
170°
175° E
180°
175° W

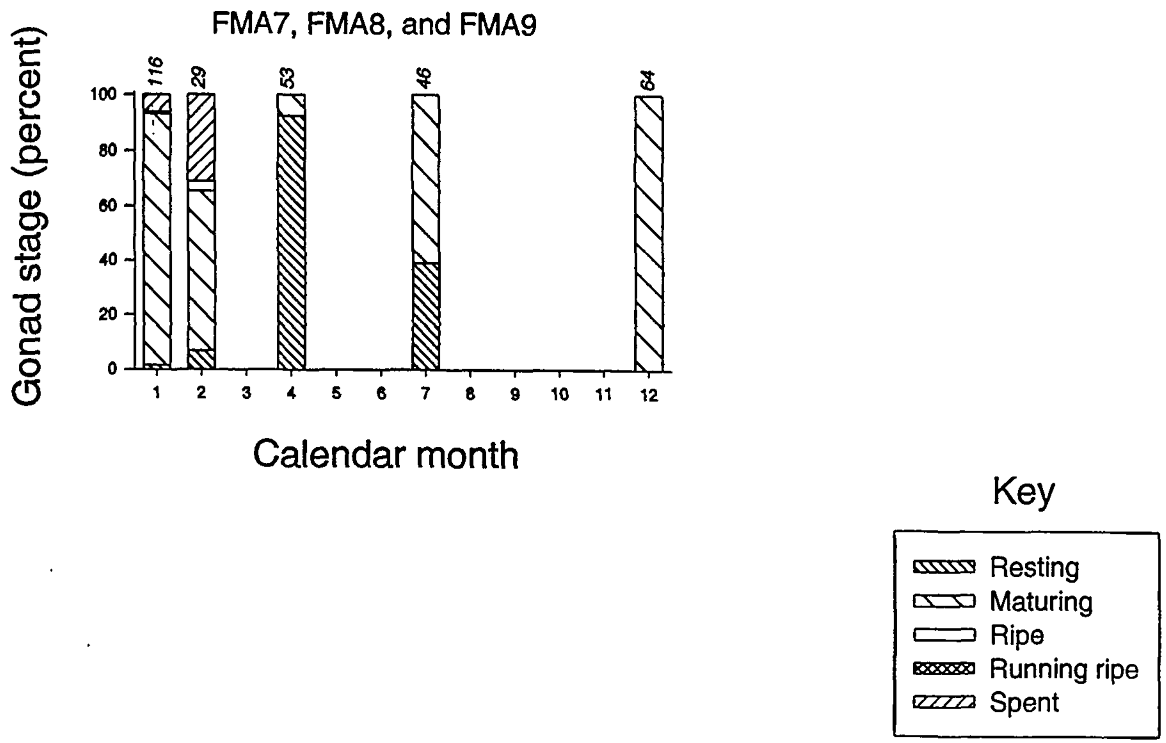

FMA8 and FMA9
35°
FMA1 and FMA2
40° S
FMA7
45°
~FMA3
~FMA5
200 m
1000 m
N = 108
N = 1616
50°
Rexea solandri
Gemfish
Spent
55°
165°
170°
175° E
180°
175° W



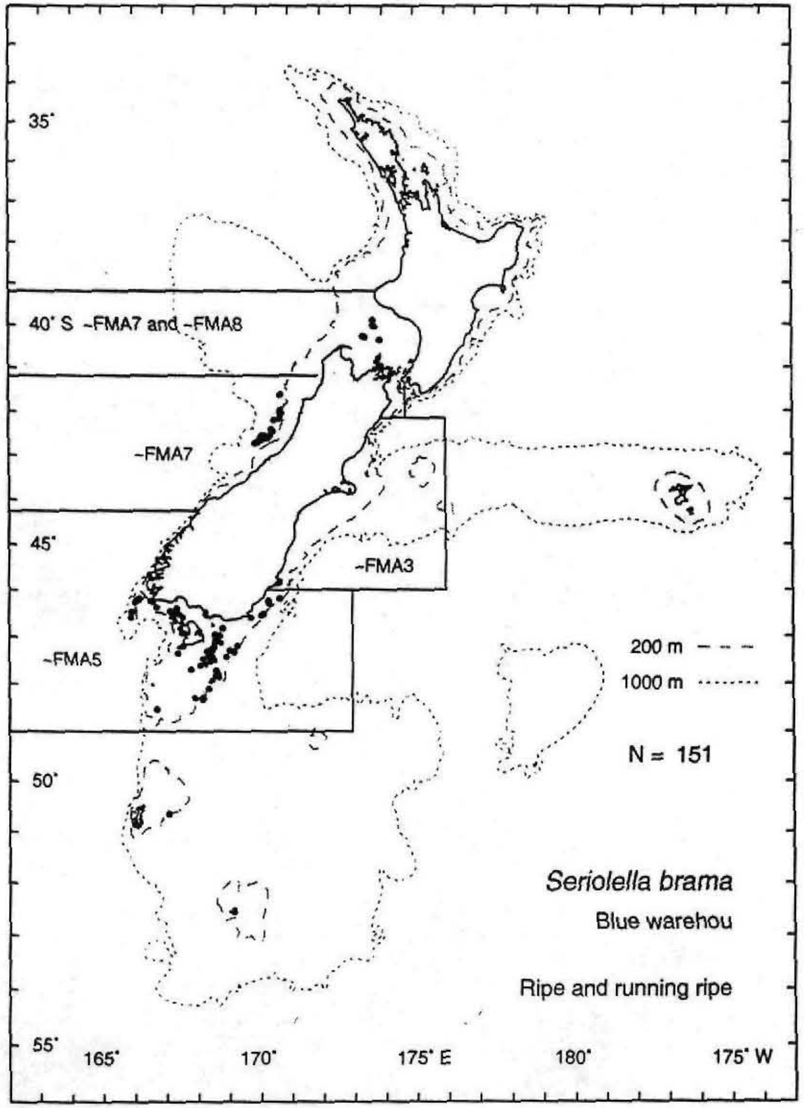
Gemfish gonad stages by area by month. See distribution figure on page opposite for definition of areas. Numbers in italics are the numbers of mature sized fish staged per month.

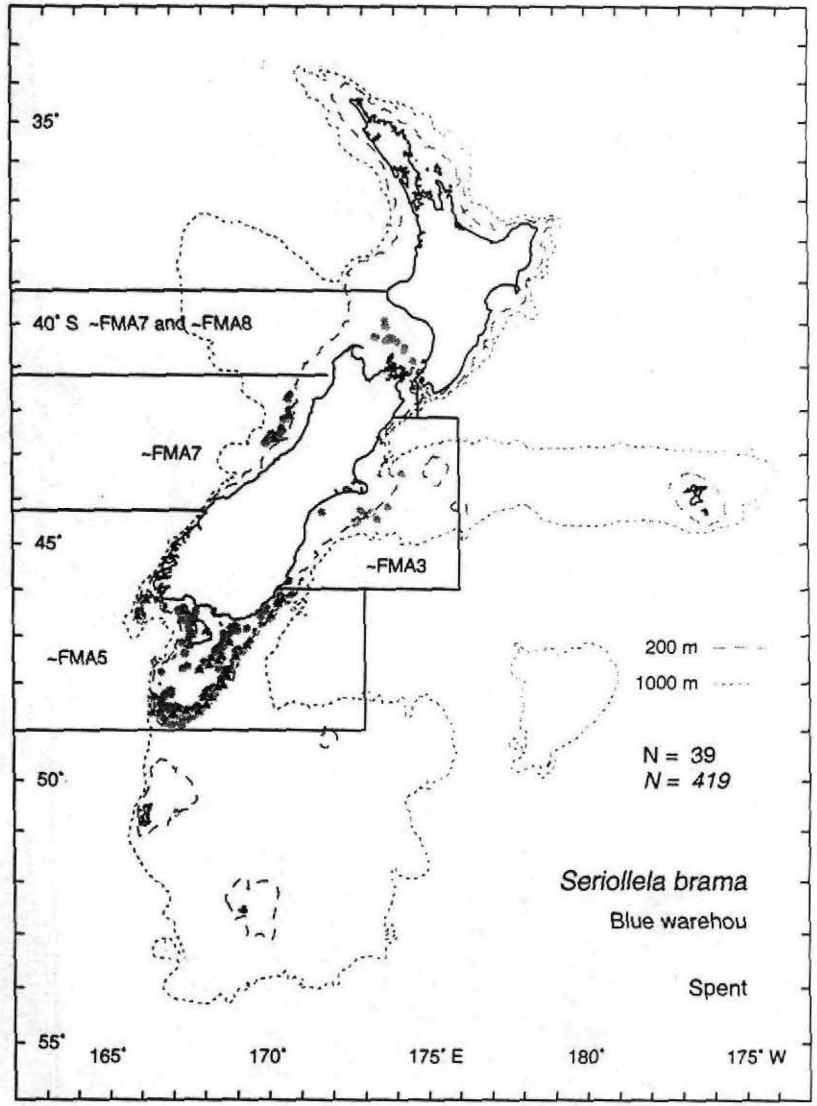

35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
FMA7, FMA8, and FMA9
200 m
1000 m
N = 2
Scomber australasicus
Blue mackerel
Ripe and running ripe

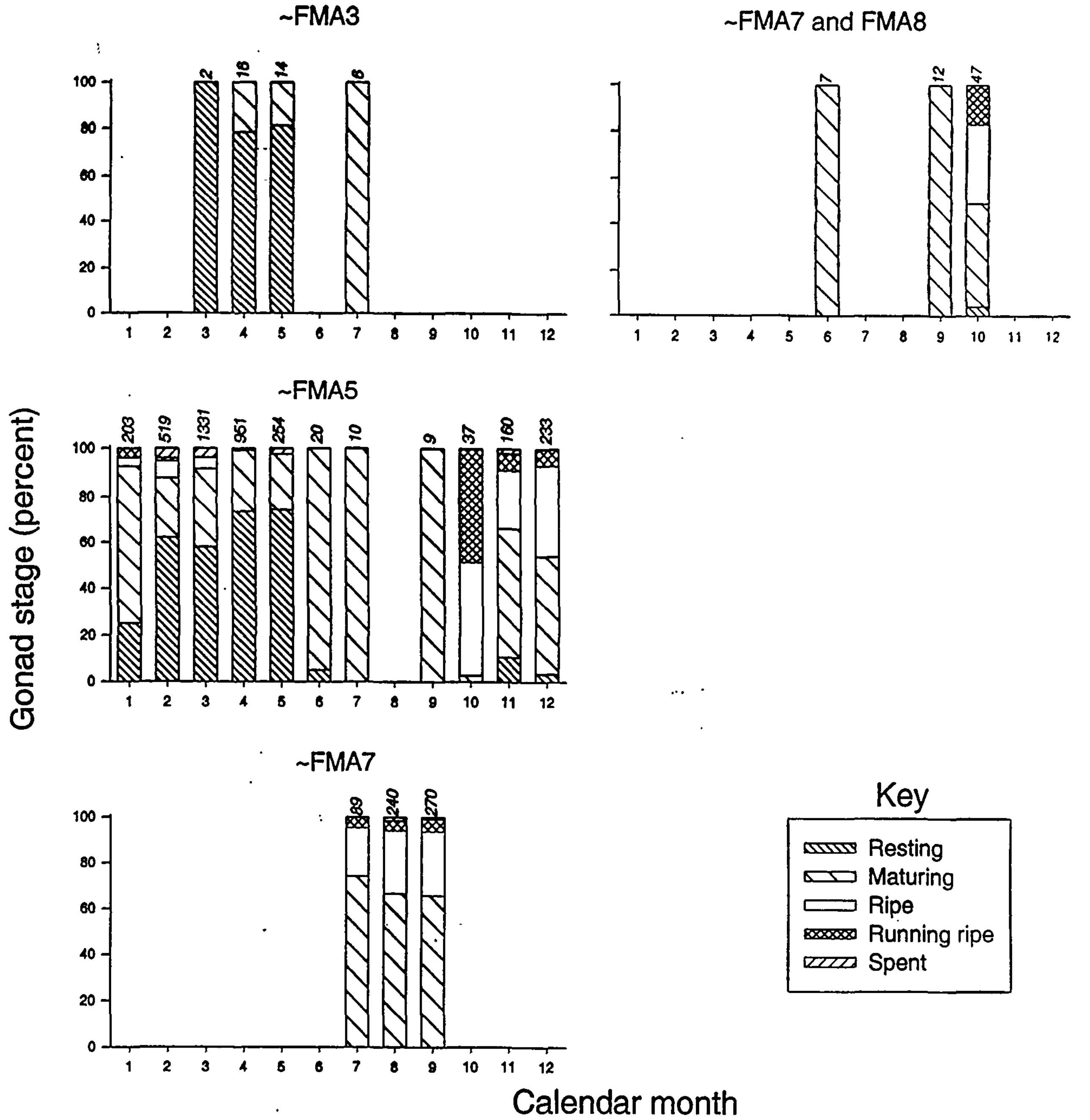

35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
FMA7, FMA8, and FMA9
200 m
1000 m
N = 8
N = 16
Scomber australasicus
Blue mackerel
Spent



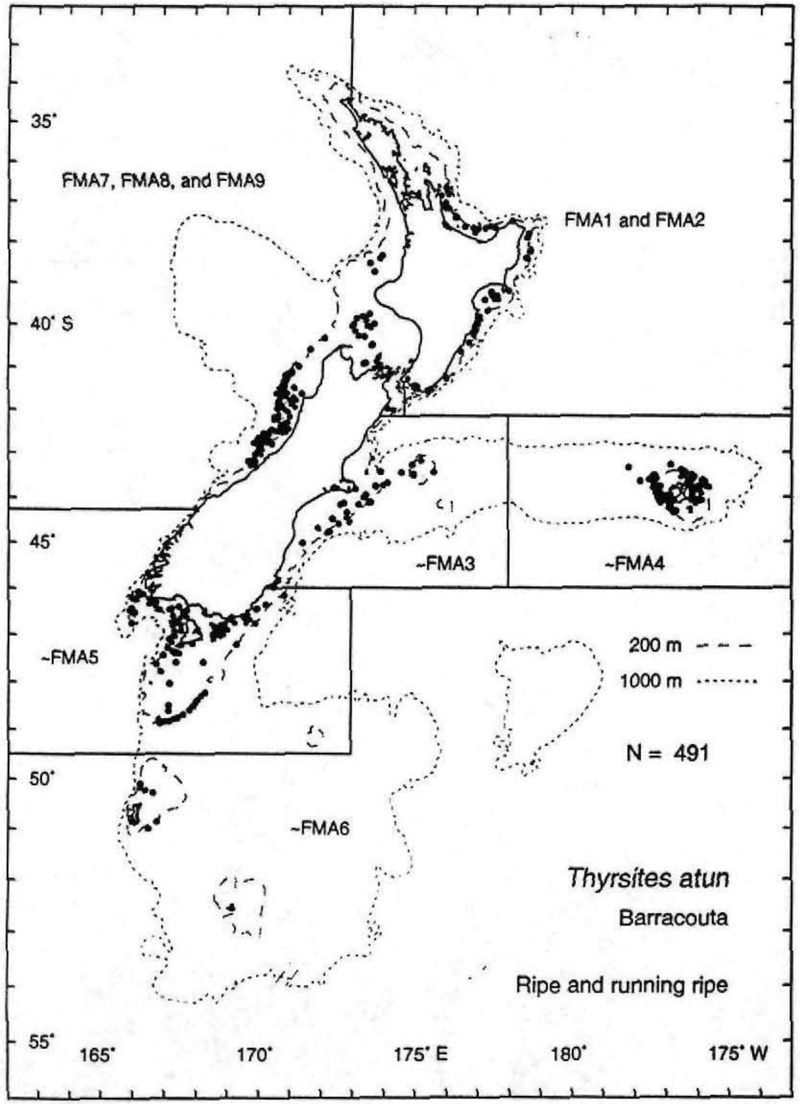
Blue mackerel female gonad stages by area by month. See distribution figure on page opposite for definition of areas. Numbers in italics are the numbers of mature sized female fish staged per month.

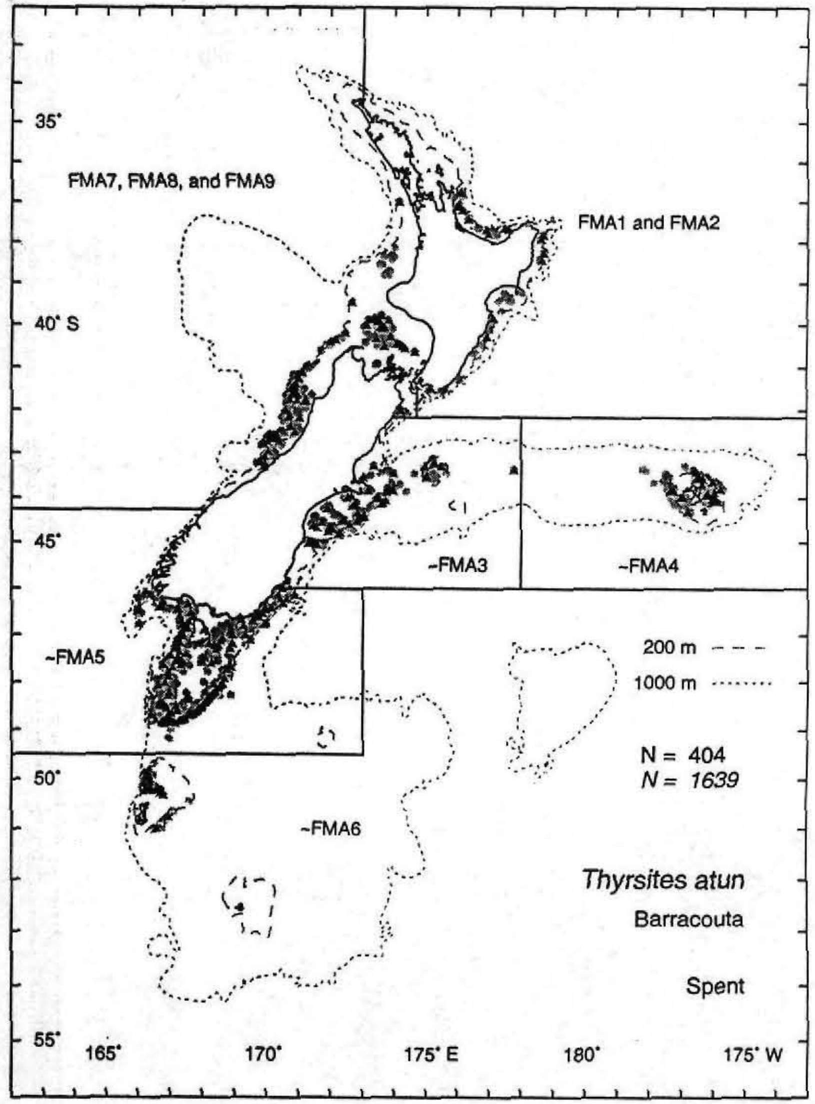

35°
40° S ~FMA7 and ~FMA8
~FMA7
45°
~FMA3
~FMA5
200 m
1000 m
N = 151
50°
Seriolella brama
Blue warehou
Ripe and running ripe
55°
165°
170°
175° E
180°
175° W

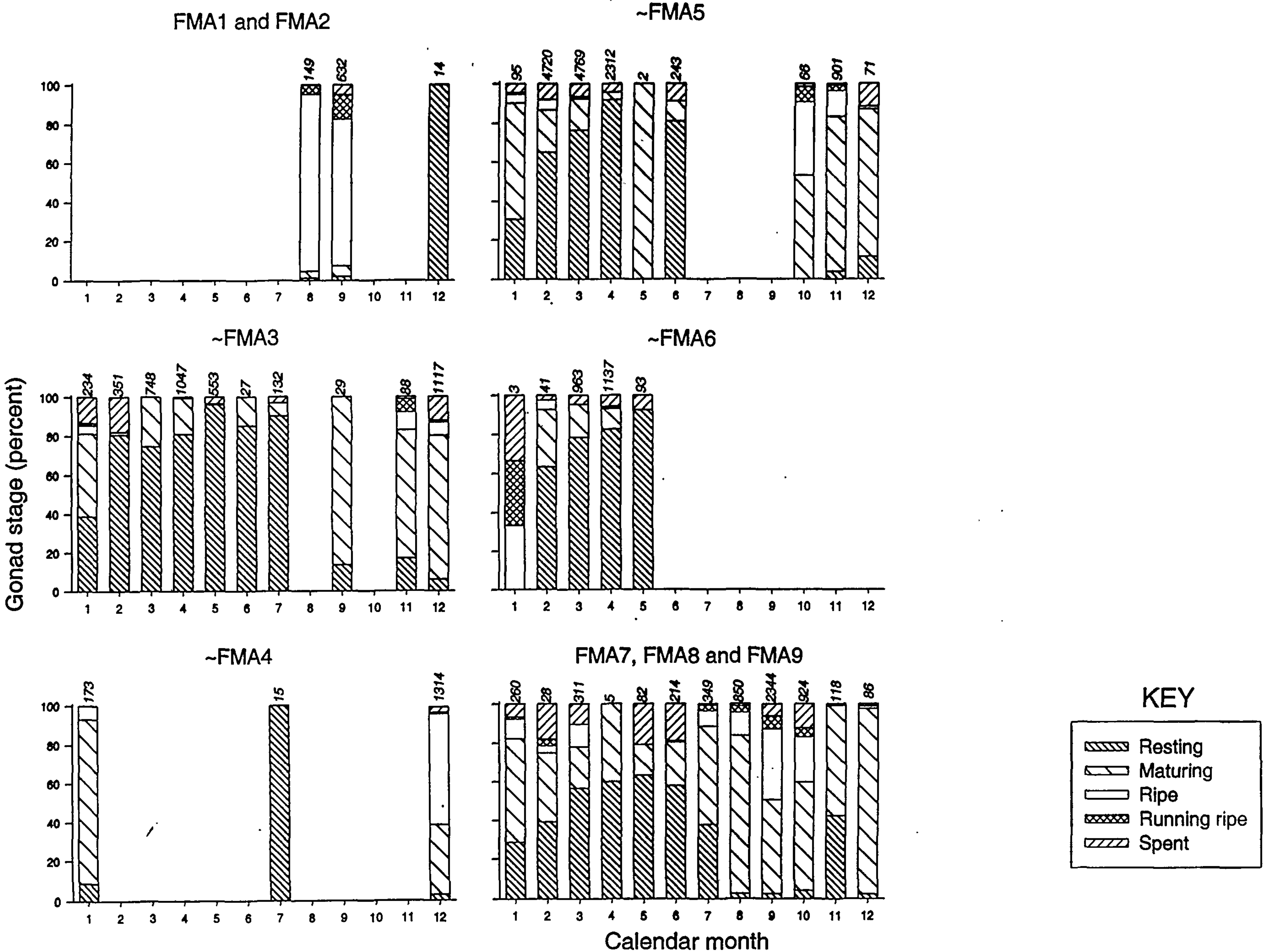

35°
40° S ~FMA7 and ~FMA8
~FMA7
45°
~FMA3
~FMA5
200 m
1000 m
N = 39
N = 419
50°
Seriollela brama
Blue warehou
Spent
55°
165°
170°
175° E
180°
175° W



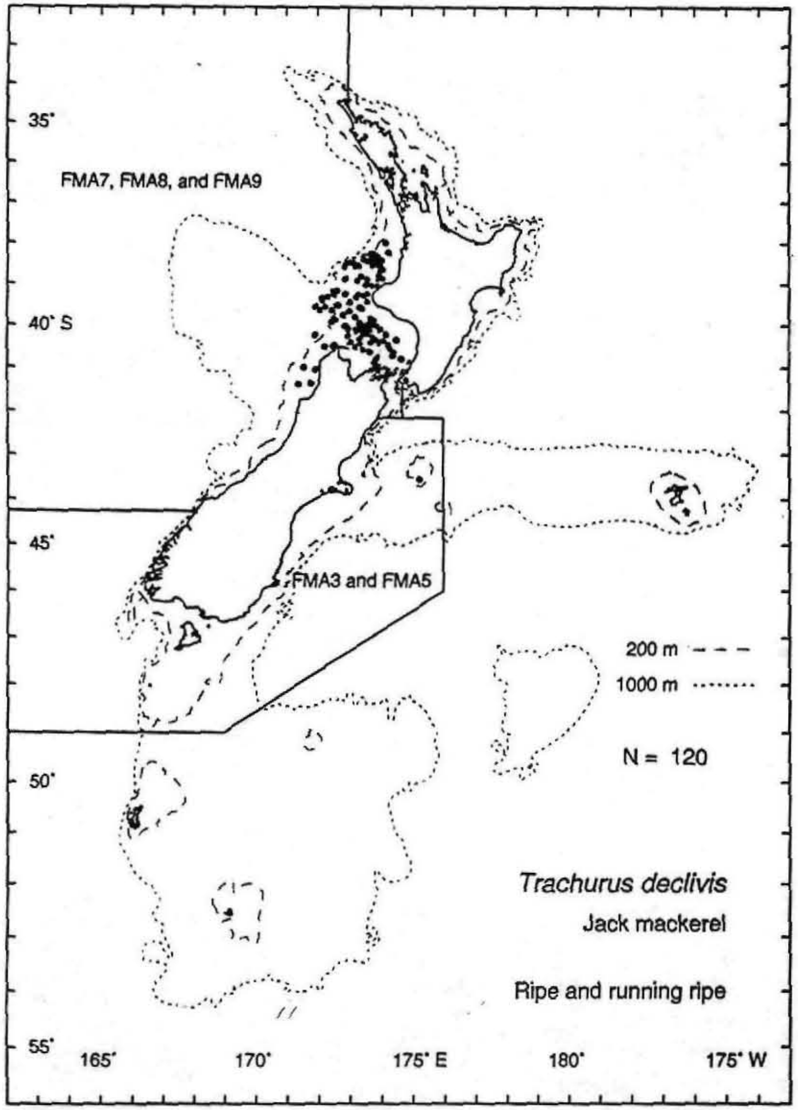
Blue warehou gonad stages by area by month. See distribution figure on page opposite for definition of areas. Numbers in italics are the numbers of mature sized fish staged per month.

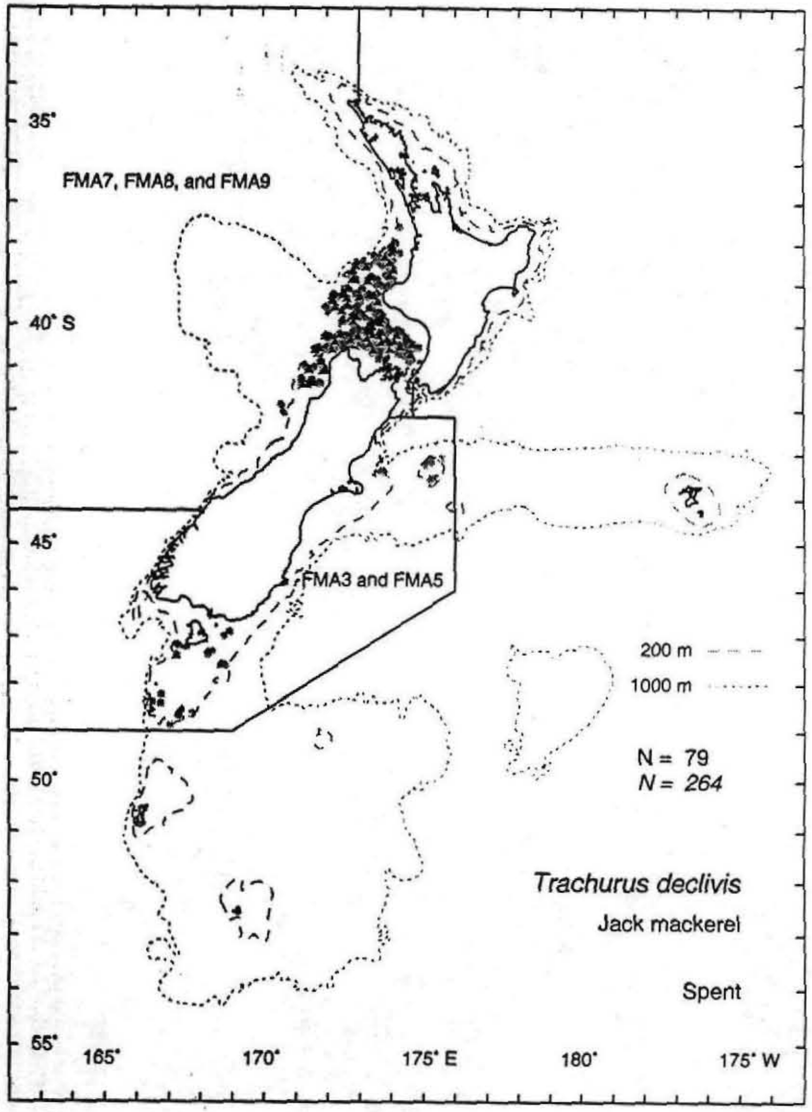

35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
FMA7, FMA8, and FMA9
FMA1 and FMA2
~FMA3
~FMA4
~FMA5
~FMA6
200 m
1000 m
N = 491
Thyrsites atun
Barracouta
Ripe and running ripe

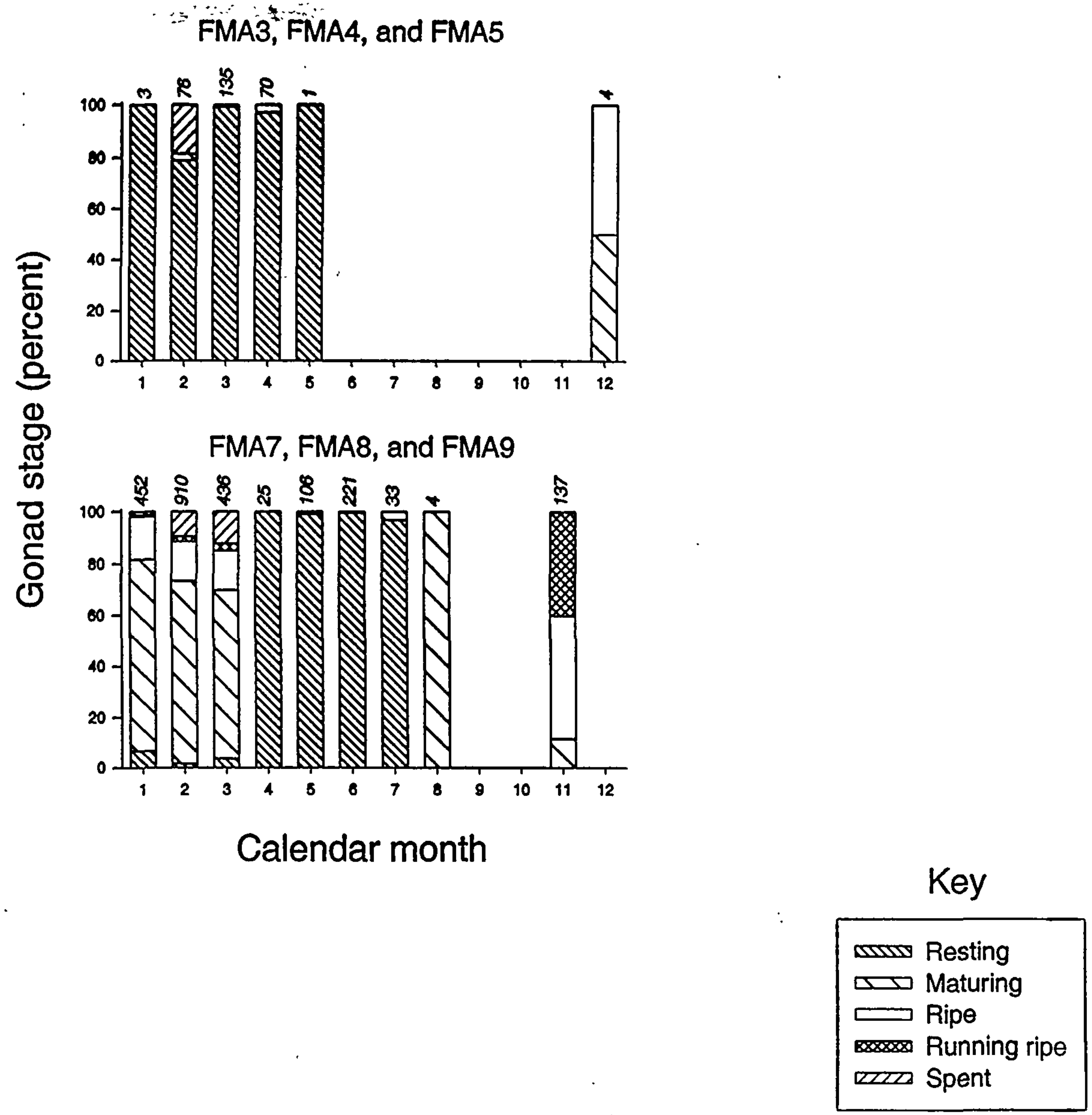

35°
40° S
45°
50°
55°
165°
170°
175° E
180°
175° W
FMA7, FMA8, and FMA9
FMA1 and FMA2
~FMA3
~FMA4
~FMA5
~FMA6
200 m
1000 m
N = 404
N = 1639
Thyrsites atun
Barracouta
Spent



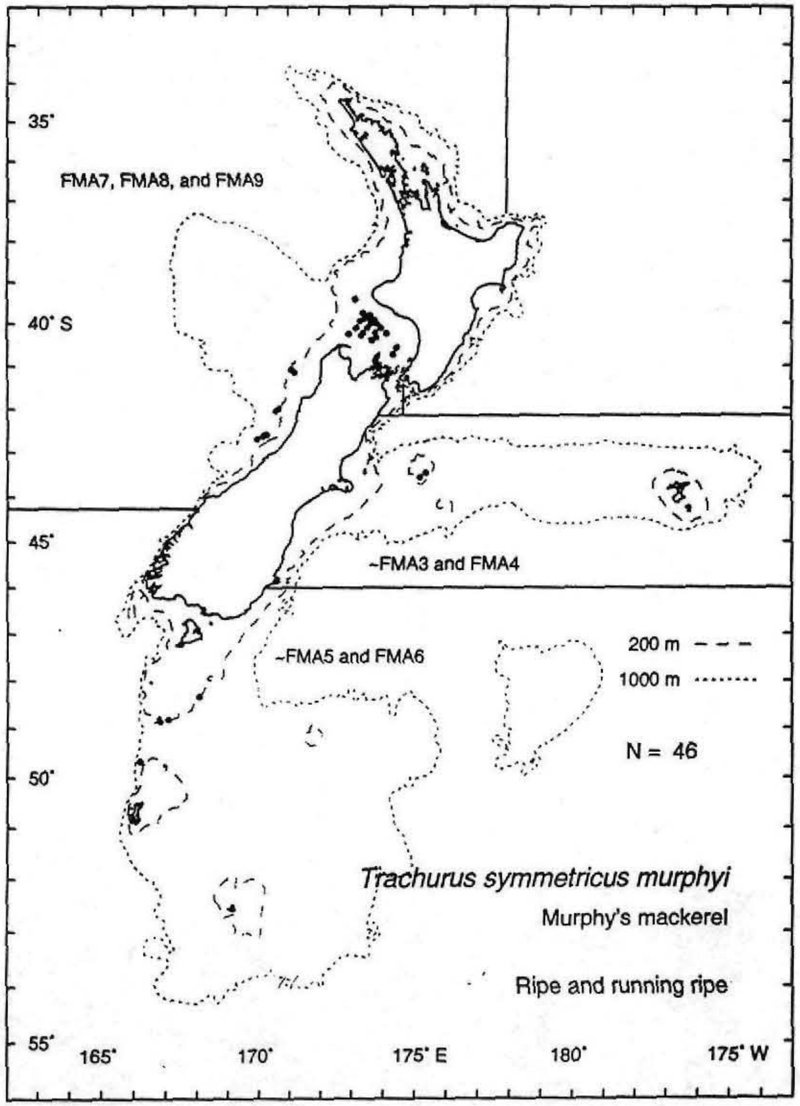
Barracouta gonad stages by area by month. See distribution figure on page opposite for definition of areas. Numbers in italics are the numbers of mature sized fish staged per month.

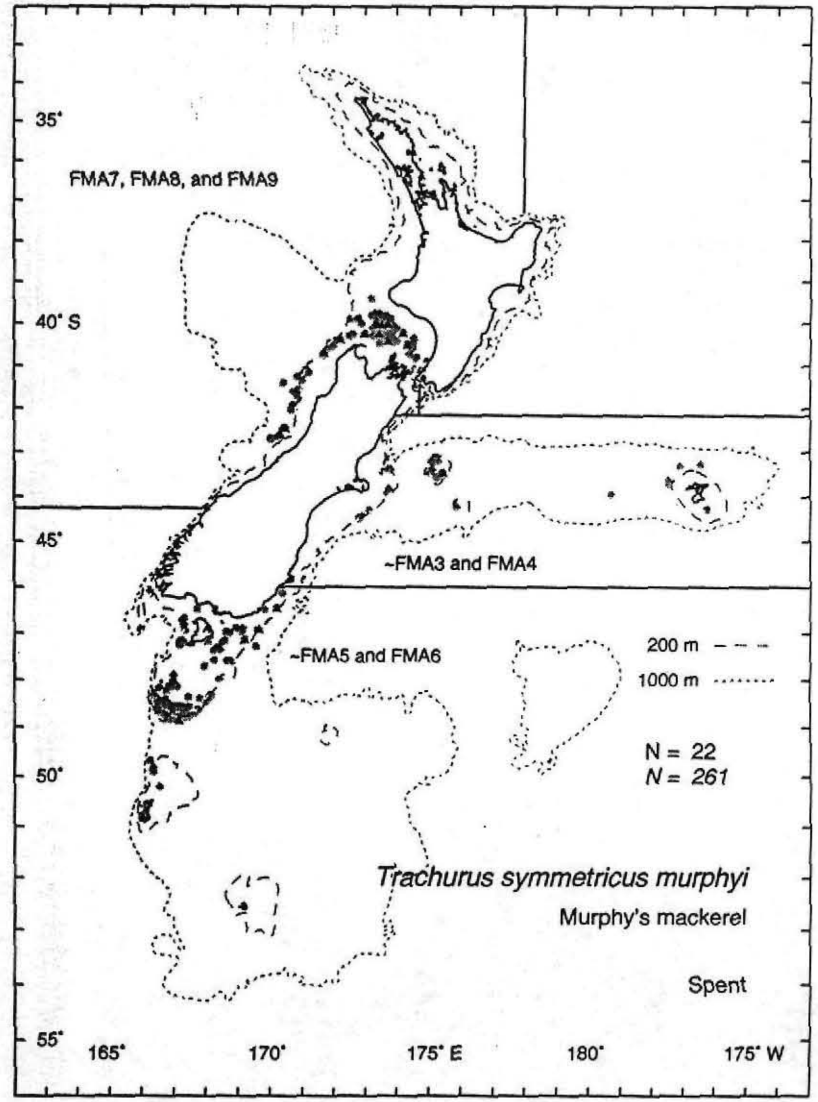

35°
FMA7, FMA8, and FMA9
40° S
45°
FMA3 and FMA5
200 m
1000 m
N = 120
50°
Trachurus declivis
Jack mackerel
Ripe and running ripe
55°
165°
170°
175° E
180°
175° W

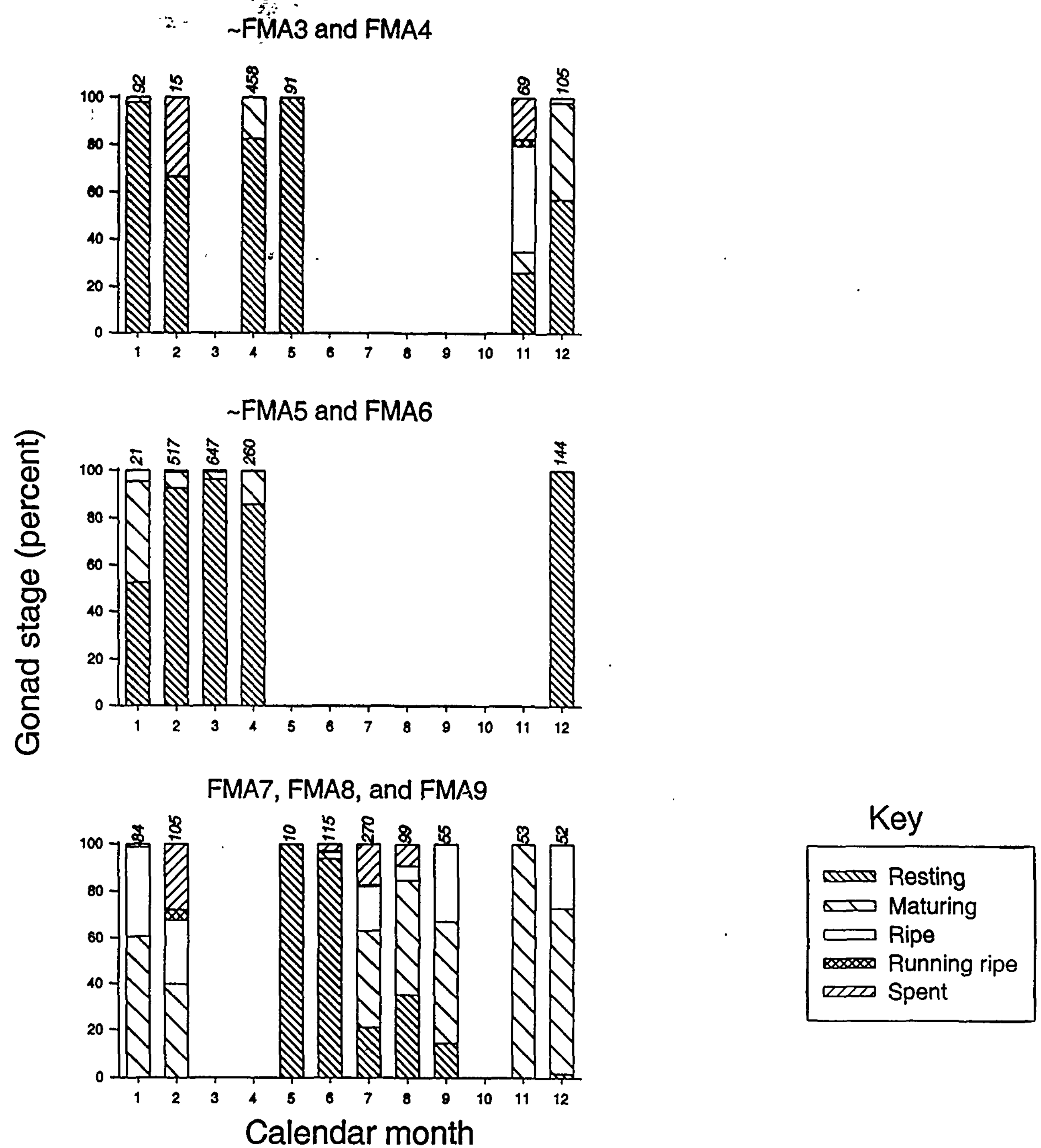

35°
FMA7, FMA8, and FMA9
40° S
45°
FMA3 and FMA5
200 m
1000 m
N = 79
N = 264
50°
Trachurus declivis
Jack mackerel
Spent
55°
165°
170°
175° E
180°
175° W



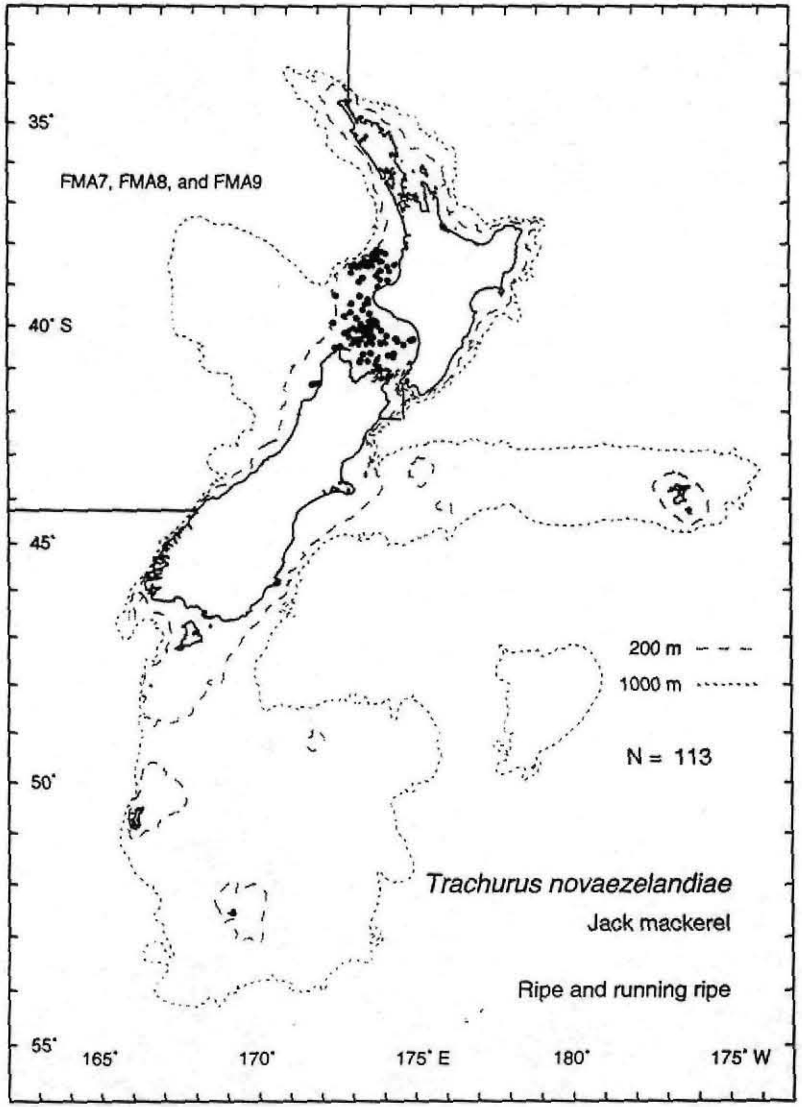
Jack mackerel (*Trachurus declivis*) female gonad stages by area by month. See distribution figure on page opposite for definition of areas. Numbers in italics are the numbers of mature sized female fish staged per month.

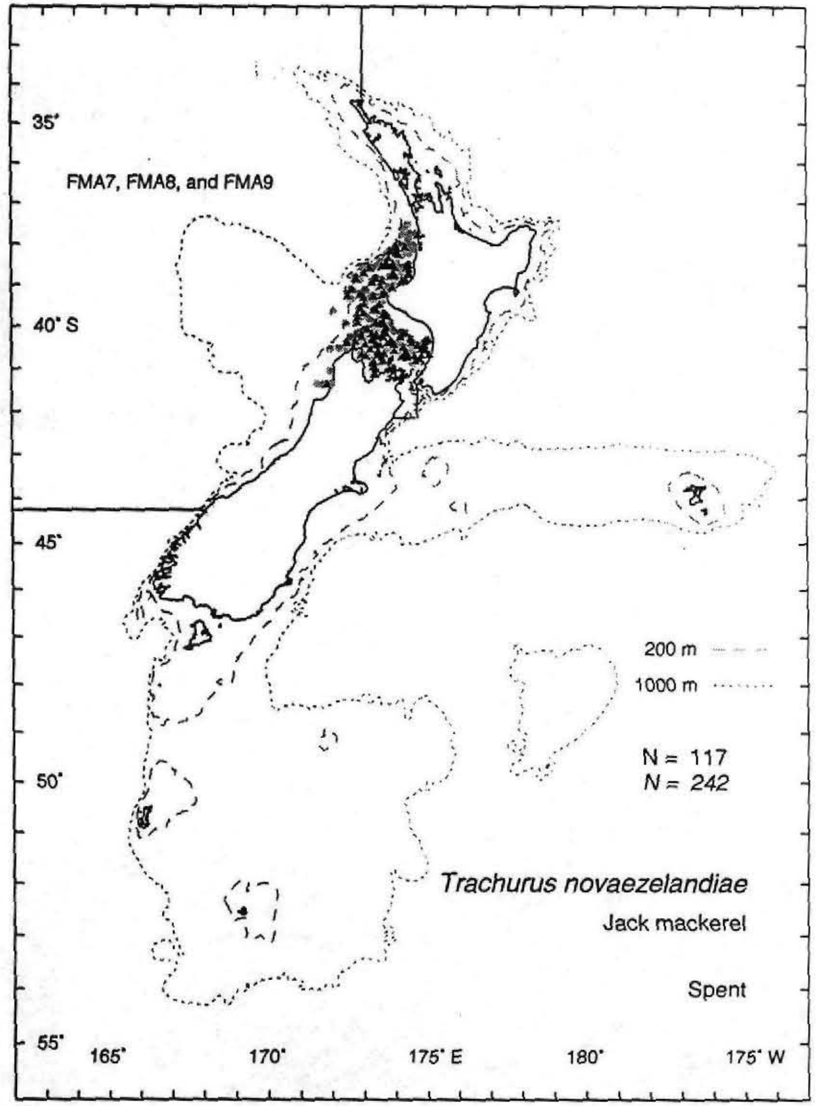

35°
FMA7, FMA8, and FMA9
40° S
~FMA3 and FMA4
45°
~FMA5 and FMA6
200 m
1000 m
N = 46
50°
Trachurus symmetricus murphyi
Murphy's mackerel
Ripe and running ripe
55°
165°
170°
175° E
180°
175° W

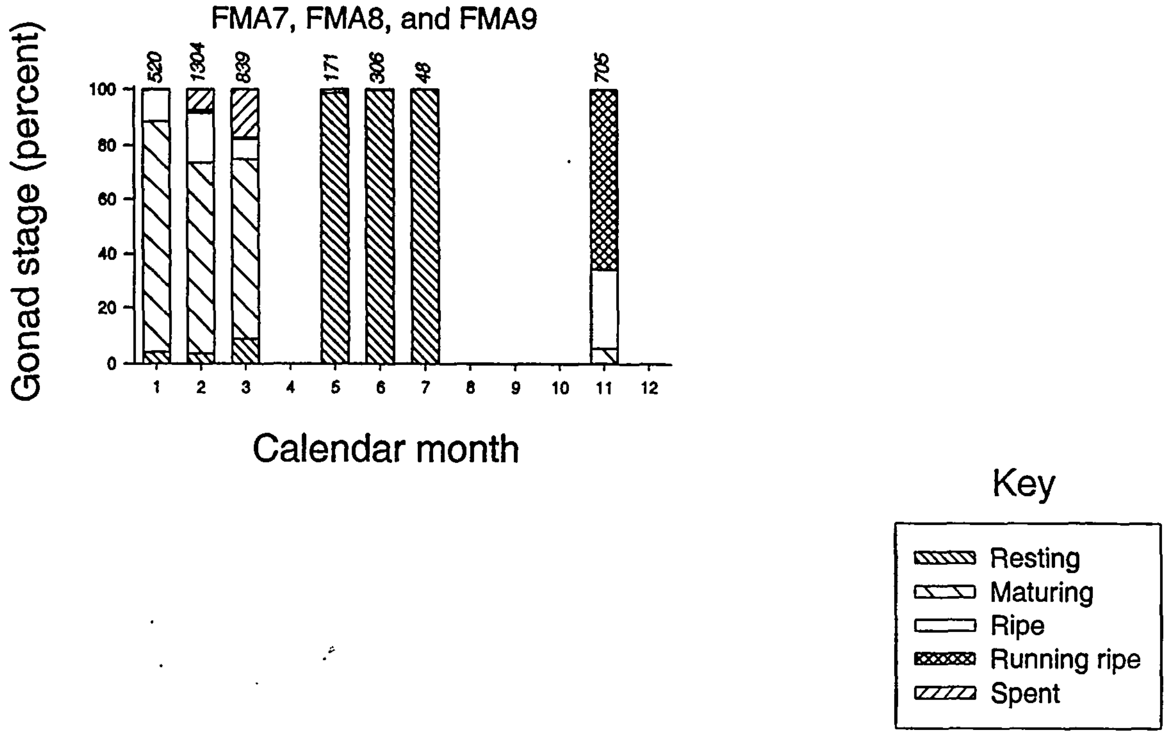

35°
FMA7, FMA8, and FMA9
40° S
~FMA3 and FMA4
45°
~FMA5 and FMA6
200 m
1000 m
N = 22
N = 261
50°
Trachurus symmetricus murphyi
Murphy's mackerel
Spent
55°
165°
170°
175° E
180°
175° W



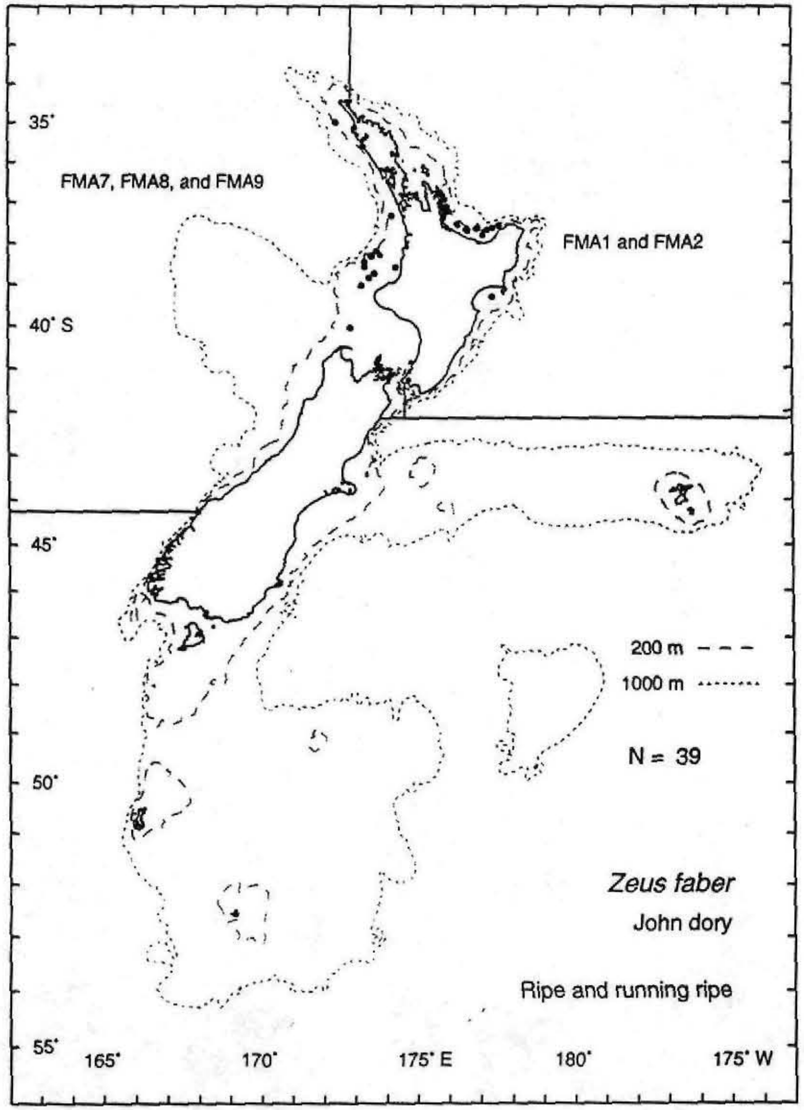
Murphy's mackerel female gonad stages by area by month. See distribution figure on page opposite for definition of areas. Numbers in italics are the numbers of mature sized female fish staged per month.


35°
40° S
45°
50°
55°
FMA7, FMA8, and FMA9
200 m
1000 m
N = 113
Trachurus novaezelandiae
Jack mackerel
Ripe and running ripe
165°
170°
175° E
180°
175° W

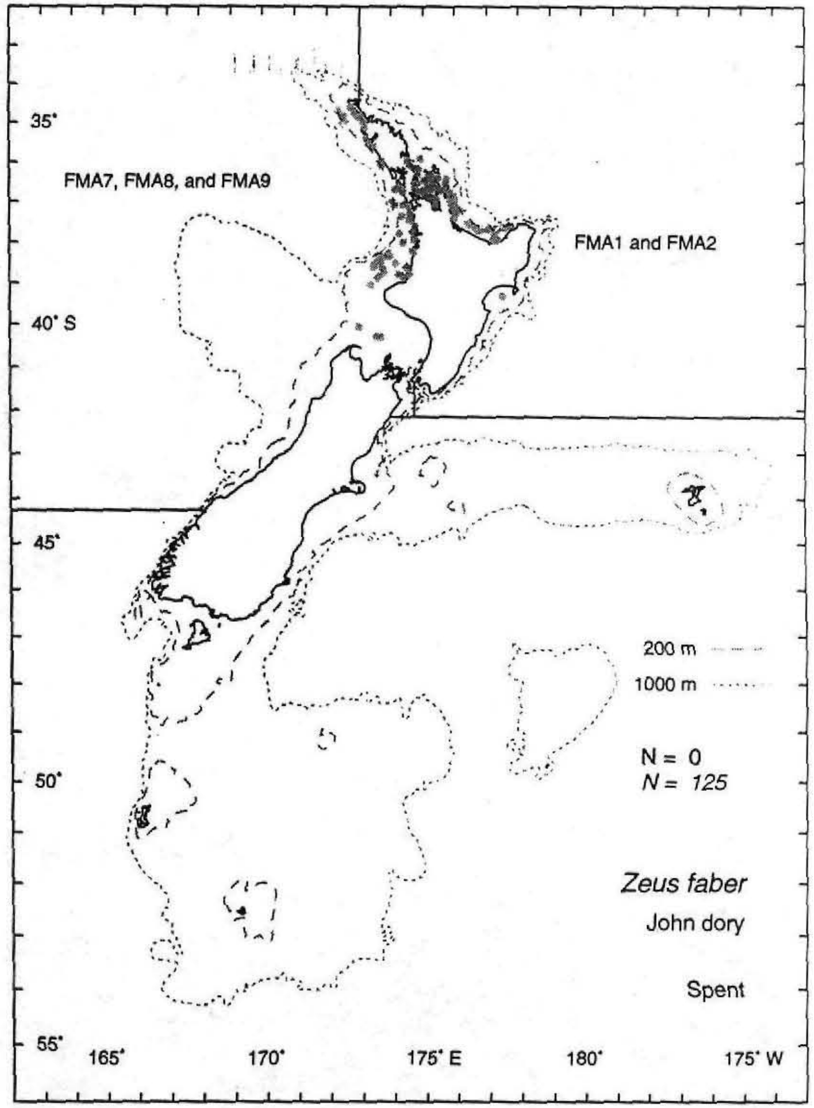

35°
40° S
45°
50°
55°
FMA7, FMA8, and FMA9
200 m
1000 m
N = 117
N = 242
Trachurus novaezelandiae
Jack mackerel
Spent
165°
170°
175° E
180°
175° W



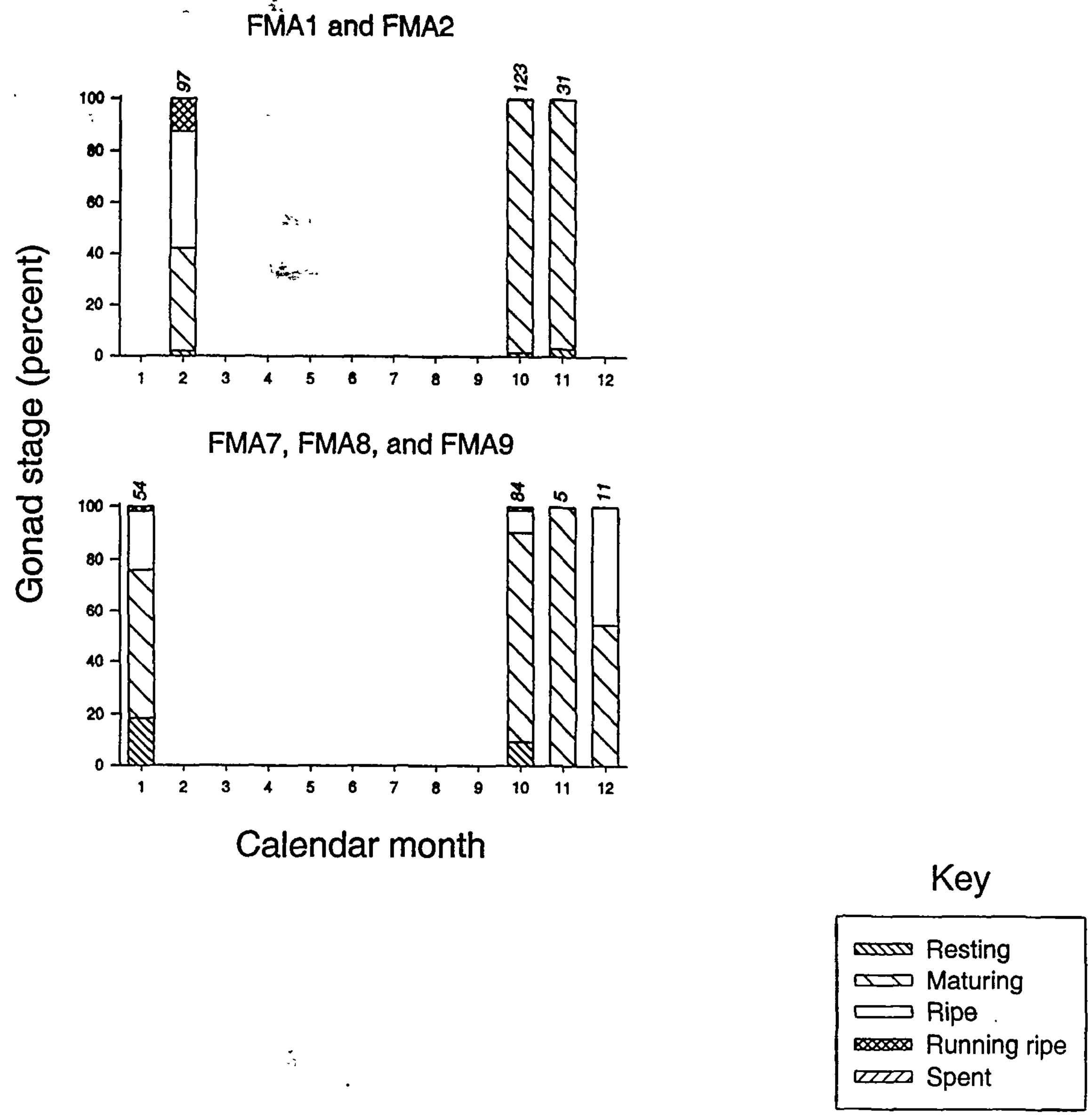
Jack mackerel (*Trachurus novaezelandiae*) female gonad stages by area by month. See distribution figure on page opposite for definition of areas. Numbers in italics are the numbers of mature sized female fish staged per month.



35°
FMA7, FMA8, and FMA9
FMA1 and FMA2
40° S
45°
200 m
1000 m
N = 39
50°
Zeus faber
John dory
Ripe and running ripe
55°
165°
170°
175° E
180°
175° W

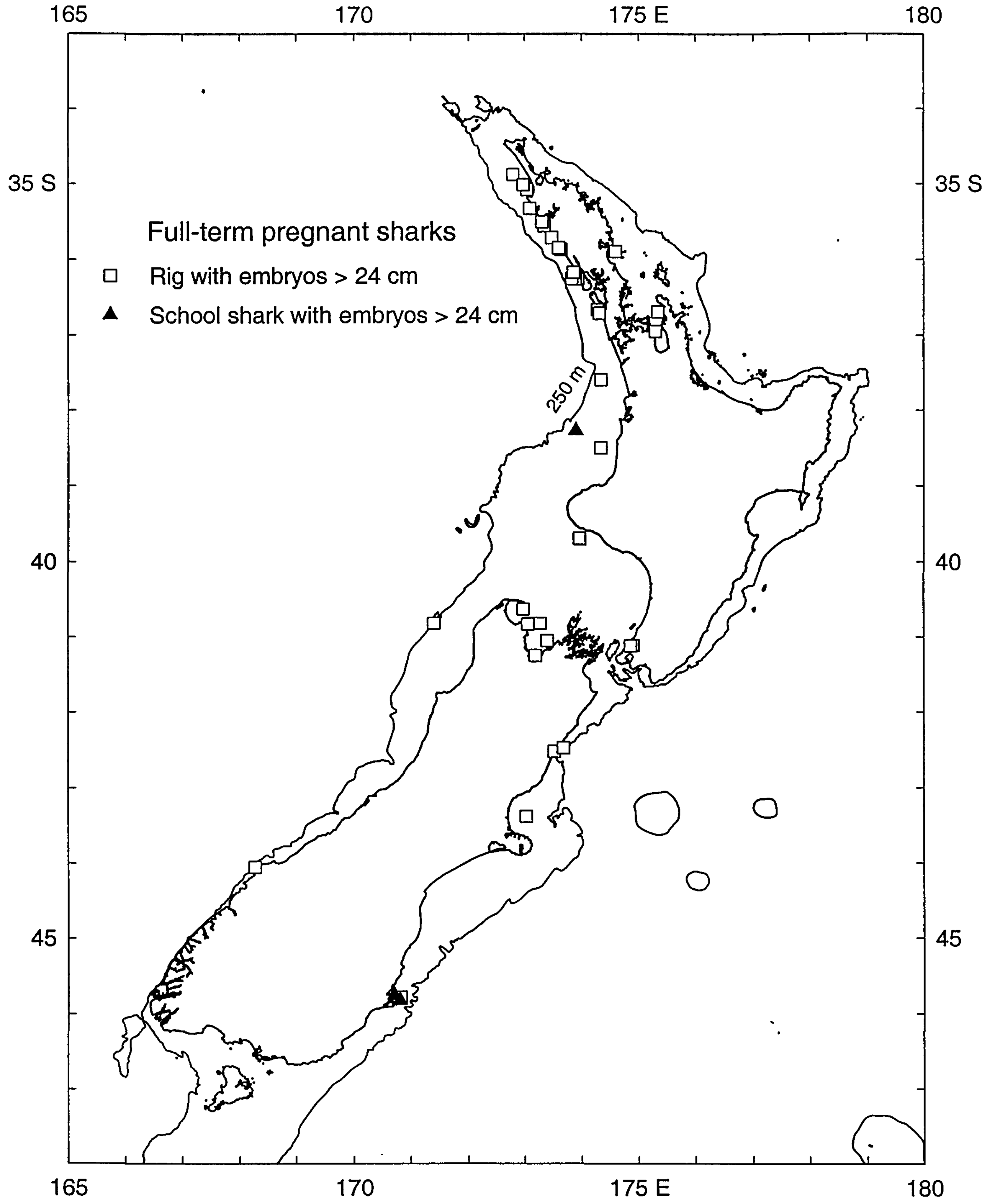


35°
FMA7, FMA8, and FMA9
FMA1 and FMA2
40° S
45°
200 m
1000 m
N = 0
N = 125
50°
Zeus faber
John dory
Spent
55°
165°
170°
175° E
180°
175° W

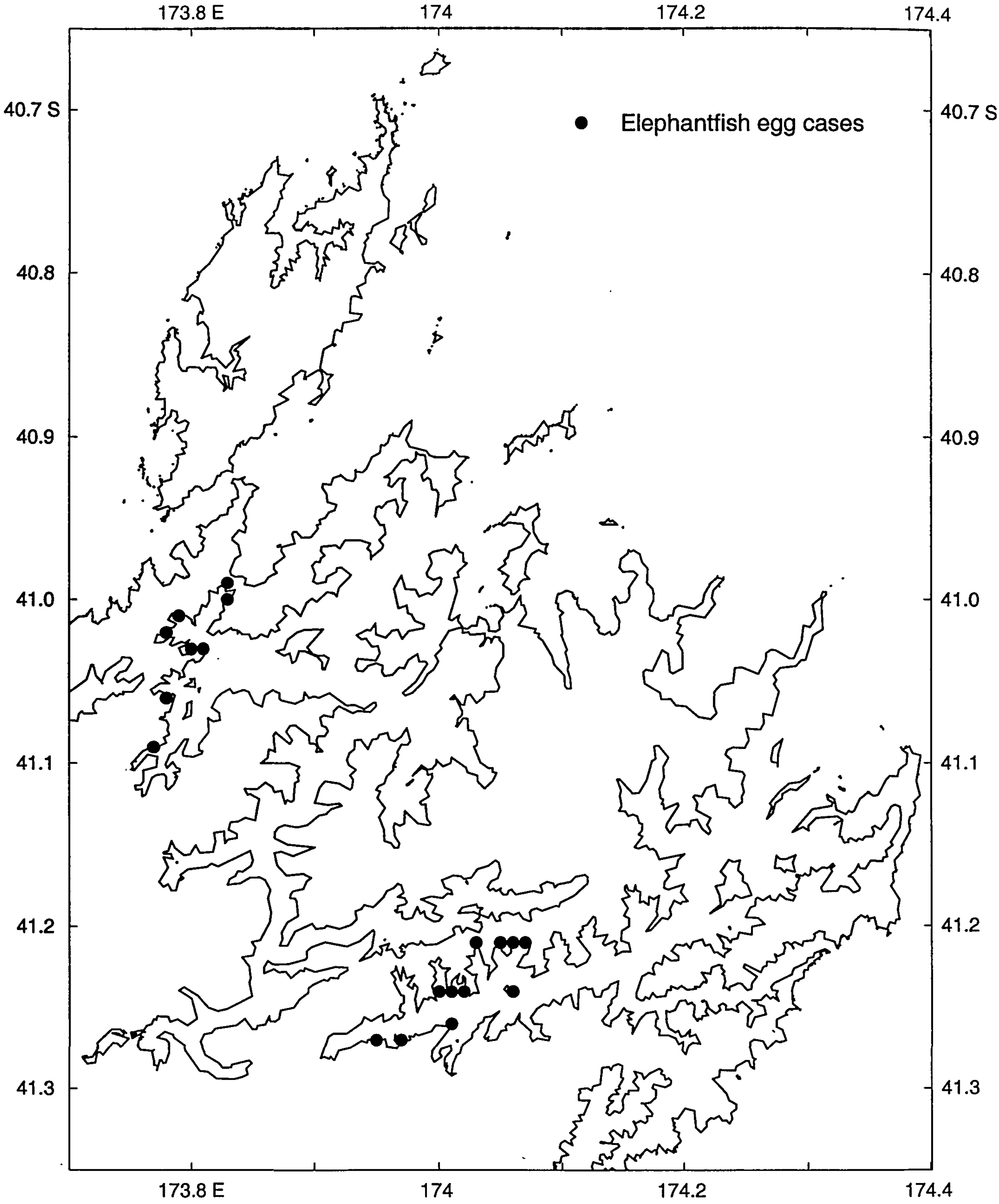


John dory female gonad stages by area by month. See distribution figure on page opposite for definition of areas. Numbers in italics are the numbers of mature sized female fish staged per month.

3 Pupping and egg-laying areas



165
170
175 E
180
35 S
40
45
Full-term pregnant sharks
Rig with embryos > 24 cm
School shark with embryos > 24 cm
250 m



173.8 E
174
174.2
174.4
40.7 S
40.8
40.9
41.0
41.1
41.2
41.3
Elephantfish egg cases

Elephant fish (*Callorhinchus milii*) spawning sites in the Marlborough Sounds, South Island, New Zealand.

Clinton A. J. Duffy

Science & Research Unit
Department of Conservation
P.O. Box 112
Hamilton
New Zealand.

INTRODUCTION

This report provides information collected by the Department of Conservation on *Callorhinchus milii* (Callorhynchidae) spawning sites in Marlborough Sounds for Ministry of Fisheries research project ENV1999/03. Most of this information was collected between 4 September 1989 and 1 June 1990 during a Department of Conservation dive survey of shallow subtidal habitats of Marlborough Sounds. This survey covered the area from Cape Soucis, Tasman Bay to Port Underwood, Cloudy Bay, including D'Urville, Stephens, Rangitoto, Trio and Titi Islands and Jag, Witts and Awash Rocks. A total of 363 sites were surveyed using SCUBA and snorkel (Appendix 1). Site descriptions recorded qualitative details of the substrate type, conspicuous benthos and the depths at which changes in substrate or species composition occurred. Since completion of the original survey Didier (1995a, 1995b) and I have surveyed other potential *C. milii* spawning sites, and made follow-up dives on known sites in Marlborough Sounds during June 1990, December 1992, April - May 1995, and January and November 1999. The spawning site descriptions that follow give:

- Latitudes and longitudes for all locations at which egg cases have been found.
- The number of egg cases seen at each site, or a qualitative assessment of relative abundance.
- Depth and habitat information for each site.
- Conspicuous benthos and fish species recorded at each site.

Sites dived during the 1989-1990 survey are identified by the prefix MSS.

SPAWNING SITE DESCRIPTIONS

1. Wedge Point to Iwirua Point, Grove Arm, Queen Charlotte Sound (S 41° 15.5' E 174° 0.5' to S 41° 15.5' E 173° 59.9')

This site extends from the small beach 200 m inside Grove Arm from Wedge Point to the jetty at Iwirua Point. A cable beacon is located above the beach at the start of the site. On 15 September 1989 two SCUBA divers surveyed a 150 m shore-normal transect located in the middle of this beach (MSS Site 33). Maximum depth was 27 m. Underwater visibility was 6-9m. A single *Callorhinchus* egg case containing a near term embryo was collected. No others were observed. On 25 April 1995 the area between the start of the beach and the 1989 transect was searched for *Callorhinchus* egg cases by two SCUBA divers. Maximum depth was 26 m. Depths at which *Callorhinchus* egg cases were observed or collected were:

- 15 m
- 17 m - two cases approximately 2 m apart
- 14.8 m
- 14.5 m
- 15 m - empty case
- 16.4 m
- 17 m - empty case
- 17.9 m
- 16.7 m - one empty and one recently laid case

- 17 m
- 13.9 m
- 13.3 m - 3 m from previous case
- 12.7 m - two cases about 2 m apart
- 6.7 m

Of the seven egg cases collected one had hatched, one had been drilled by a mollusc, one contained a decomposing egg and four contained embryos. Dive duration was 54 minutes and a linear distance of about 150 m was covered. Underwater visibility was 3.6-4.5 m. The area searched was about 540 m^2, giving a maximum density of "live" cases of 0.02 m^{-2} (this excludes the egg case seen at 6.7 m depth). The encounter rate of live cases was 0.18 per minute.

On 26 April 1995 I made three five minute counts at 15-18 m depth between the middle of the bay at the start of the site to the jetty at Iwirua Point using an Apollo dive scooter. Underwater visibility was 3-4 m. No egg cases were seen during the first count, 1 empty case was seen on the second and 1 empty case on the third. After that the scooter battery died and I swam about 300 m from the jetty towards the start of the site at 9-12 m depth. Only one empty egg case was seen.

Substrate:

The bottom shelves rapidly away from the shore. Off the beach marked by the cable beacon the substrate consisted of coarse silty shelly sand covered with small cobbles, granules and shell debris to 17 m depth. Below this fine silty sand predominated. The sand-mud transition occurred at about 24 m depth.

At MSS Site 33 there was a narrow band of cobbles at low water. The substrate was firm coarse shelly sand, grading into soft mud below 20m. Below 3m depth the cover of drift shell was high. This exceeded 50% between 12-18m depth. Between MSS Site 33 and the Iwirua Point jetty the bottom was predominantly course silty shelly sand covered by shattered rock (pebbles and small cobbles) and drift shell. Off points outcropping rock was exposed to about 12 m depth. Below 21 m depth the bottom consisted of mud with a thick cover of drift *Dosina*.

Conspicuous benthos:

Corallina officinalis, Hormosira banksii, Cystophora retroflexa and *Carpophyllum flexuosum* grew on the band of cobbles at low water. Between low water and 17m all hard substrates were heavily encrusted with crustose coralline algae. *Polysiphonia* sp. was common to 2 m depth. Off the beach at MSS Site 33 sabellid and terebellid tubes were commonly covered with epizootic *Rhodymenia linearis* and smaller amounts of *Lenormandia chauvini, Callothamnion consanguineum* and *Gelidium* n.sp. Macroalgae became uncommon towards Iwirua Point.

Above 10 m depth common epifaunal invertebrates were *Turbo smaragdus* (above 7.5 m), *Cryptoconchus porousus, Galeolaria hystrix* (occasionally forming small colonies), large terebellids, *Coscinasterias calamaria, Patiriella regularis, Stichopus mollis,* Pagurids, *Pecten novizelandiae* and large solitary ascidians. At MSS Site 33 an unidentified yellow sponge formed aggregates of cobbles, granules and dead shell between 6-10.6 m depth. The *Callorhinchus* egg case observed at 6.7 m was attached to one of these aggregates. An *Atrina zelandica* bed begun at about 10 m depth and extended to at least 27 m. In addition to *Atrina* large solitary ascidians, *Evechinus chloroticus, Pseudechinus albocinctus, Branchiomma* sp., *Protula bispiralis, Coscinasterias, Patiriella* and *Stichopus* dominated the epifauna below 17 m. *Neothyris lenticularis* was common below 21 m, reaching 7-12 m^{-2} at 27 m. Bivalve species dominant in the drift were *Gari stangeri* (3-6m), *Venerupis largillierti* (15m) and *Dosina zelandica* (below 20m).

Outcropping bed rock was devoid of macroalgae but heavily encrusted with coralline crusts, *Galeolaria* and *Cnemidocarpa bicornuata*. A large *Cancer novaezelandiae* and a large *Leptomithrax longimanus* were observed on small reefs. Mysids were present at all depths but were abundant in the upper 7.6 m.

Fish species:

The spotty (*Notolabrus celidotus*) was the most common larger fish species above 24 m depth. *Forsterygion lapillum* was abundant above 9 m. Below 12 m *F. flavonigrum* was common around rock outcrops, serpulid mounds and *Atrina*. *F. malcolmi, Nemadactylus macropterus,* and *Parika scaber* were observed around rock outcrops. *Congiopodus leucopaecilus, Genyagnus monopterygius* and *Parapercis colias* were recorded over sandy substrates. *Hemerocoetes monopterygius* occurred below 24 m. An empty skate (*Dipturus* sp.) egg case was collected at 17 m depth.

2. Iwirua Point, Grove Arm, Queen Charlotte Sound (MSS Site 34 - S 41^0 15.5' E 173^0 59.9')

This site was dived on the 11 September 1989, 18 October 1989, 29 March 1990 and 5 June 1990. Numerous *Callorhinchus millii* egg cases were observed between 12-18 m on the sloping bottom on the western side of the point. Those collected on 5 June 1990 contained embryos at stages of development varying from blastulae to near term. Most were found below a dense bed of *Lenormandia chauvini* at 15 m.

Substrate:

A shelf about 150 m wide extends directly offshore for a distance of about 360 m. A reef of exposed bed rock runs along its western edge. In most places the rock barely rises above the surrounding sediment. East of the reef the bottom above 18 m depth consists of coarse shelly sand with a cover of drift shell. Below 18 m the sand grades into soft mud. The western margin of the shelf slopes steeply to about 30 m depth. Silty sand extends down this slope to approximately 12 m depth. Below this soft mud predominates.

Conspicuous benthos:

Serpulid tubeworm (*Galeolaria hystrix*, *Pomatoceros terraenovae*) colonies up to 1 m high were a conspicuous feature of the reef. These were encrusted with a variety of compound and solitary ascidians, several species of encrusting sponge and two species of red algae (*Pugetia delicatissima*, unidentified finely branching sp.). Drift shell, tubeworm debris and rock was encrusted with crustose coralline algae. Between 11-14 m depth the reef fauna also included *Cryptoconchus porosus*, large numbers of *Turbo smaragdus*, *Cookia sulcata*, *Modiolarca impacta*, large *Perna canaliculus*, large Terebellids, *Notomithrax* sp., *Leptomithras longimanus*, *Stichopus mollis*, *Evechinus chloroticus*, *Patiriella regularis*, *Pentagonaster pulchellus*, *Allostichaster insignis*, *Coscinasterias calamaria*, and the solitary ascidian *Cnemidocarpa bicornuata*.

Conspicuous epifaunal invertebrates observed on the sand east of the reef at 12 m depth included *Pecten novaezelandiae*, *Evechinus*, *Stichopus*, *Patiriella*, *Coscinasterias*, large *Perna*, *Atrina zelandica*, and large numbers of *Cnemidocarpa* (attached to drift shell). *Atrina* were present below 12 m and increased in density with depth. Between 12-21 m depth their shells were encrusted with hydroids, sponges, *Galeolaria* and ascidians. Below 21 m depth they were relatively clean. *Neothyris lenticularis* occurred amongst *Atrina* below 18 m depth.

West of the reef a dense bed of *Lenormandia chauvini* occurred between 12-15 m depth. At about 12 m this covered a dense bed of *Chaetopterus* sp. Other infaunal polychaetes included *Branchiomma serratibranchis* and *Protula bispiralis*. A small sample of *Lenormandia* collected from mud at 15 m contained live *Trochus tiaratus*, *Corbula zelandica* and *Chirodata nigra*. *Pecten* and *Alcithoe arabica* were common.

Fish:

Parapercis colias, *Forsterygion varium*, *F. lapillum*, *F. malcolmi*, *F. flavonigrum*, *Helicolenus percoides*, *Congiopodus leucopaecilus*, *Upeneichthys lineatus*, and *Notolabrus celidotus* were observed on the reef. *Parapercis*, *Notolabrus*, *Congiopodus* and schools of *Nemadactylus macropterus*, *Caesioperca lepidoptera* and *Seriola lalandi* were seen over the sloping bottom west of the reef. A small number of skate egg cases were also observed there. One of these collected in June 1990 contained a full term *Dipturus nasutus* embryo.

2b. Long Beach, Grove Arm, Queen Charlotte Sound (MSS Site 35)

Long Beach is a local name for a small beach situated between Iwirua Point and the first rocky headland immediately west of it. This site was dived on the 12 September 1989, 10 October 1989, and 22 December 1989. No *Callorhinchus* egg cases were ever observed here.

Substrate:

The bottom slopes rapidly, reaching a depth of 30 m within 250 m of shore. Beach sediments consist of very coarse clean sand and granules. Subtidally the bottom consists of coarse shelly sand grading into silty shelly sand between 14-17 m depth, with shelly mud below 20 m. Thick drift shell covered the bottom in many places. Above 12 m *Venerupis largillierti* and *Gari stangeri* dominated the drift. *Dosina zelandica* dominated the drift in muddy areas.

Conspicuous benthos:

Above 15 m depth drift shell was heavily encrusted with crustose coralline algae. *Cnemidocarpa, Pyura carnea* and a large unidentified solitary ascidian were common. Above 10 m depth there were large patches of aggregates formed by an unidentified yellow sponge, drift shell and *Corallina officinalis.* The red alga *Griffithsia* sp. grew attached to shell fragments between 9.5-12 m. At the eastern end of the beach *Plocamium cartilagineum* covered more than 50% of the bottom at 12 m depth.

Coscinasterias calamaria was abundant above 12 m. *Venerupis* and *Gari* were also abundant at this depth and *Coscinasterias* was frequently observed predating them. *Dosina* was found in silty sediments below 12 m. *Pecten novaezelandiae, Patiriella regularis, Stichopus mollis* and hermit crabs were common at all depths. Hermit crabs were most abundant above 3 m. Large *Turbo smaragdus* were common to 6-7 m. Six *Archidoris wellingtonensis* (25-30 cm length when crawling) were observed between 6-10 m depth on 12 September 1989. Two of these were copulating next to a 24 cm diameter orange spawn mass. One was observed feeding on *Griffithsia.* On 18 October 1989 a total of six *Archidoris* spawn masses was observed at this site. *Atrina zelandica* occurred below 12 m depth, forming a dense bed below 18 m.

Fish:

Relatively low numbers of fish were observed at this site. The most abundant species were *Forsterygion lapillum, Parapercis colias* and *Notolabrus celidotus. Forsterygion flavonigrum* was common in dead *Atrina* at 21 m. Three species, *Grahamichthys radiata,* an unidentified tripterygiid (?*Grahamina* sp.) and two juvenile *Taumakoides* sp. were found beneath a sheet of corrugated iron at 11 m.

3. Mouth of Governor's Bay, Queen Charlotte Sound (S 41⁰ 15.9' E 173⁰ 58')

Didier (1995b) surveyed this site on 26 April 1995. Two divers searched an area at the mouth of the bay between 15 m depth and the shoreline of the headland separating it from Ngakuta Bay. Three egg cases were observed between 6-15 m depth. Above 9 m the substrate was silty gravelly sand. From 9-12 m depth the substrate was silty sand with gravel patches. Patches of unidentified red algae occurred throughout this depth zone. Below 13.6 m the substrate was firm shelly mud. There was a sparse epifauna dominated by *Atrina.*

4. The headland separating Governors and Ngakuta Bays, Grove Arm, Queen Charlotte Sound (MSS Site 38 - S 41⁰ 15.9' E 173⁰ 57.9')

On 14 September 1989 a 100 m transect line was run directly off the point. Six *Callorhinchus* egg cases were observed at 15 m depth. On 26 April 1995 at 9 fertile and a smaller number of hatched eggs were observed between 9-13.6 m depth on sand near patches of *Lenormandia chauvini.*

Substrate:

A shallow rock platform extends approximately 10-15m off the point. Depth at the edge of the platform is 2 m. From here the rock drops almost vertically to 6 m depth. Pockets of sediment and drift shell (mainly *Aulacomya, Mytilus* and *Venerupis*) are found on the platform but exposed rock predominates. Between 6-12 m depth the bottom consists of firm muddy shell gravel, with a significant large pebble (16-64 mm) fraction at the base of the rock scarp. A thick layer of coralline encrusted shell covered the surface of the sediment from 6-10 m depth. Below 12 m depth the sediment is firm shelly mud.

Conspicuous benthos:

Mytilus edulis aoteanus and *Aulacomya ater maoriana* form mixed aggregations in the intertidal. *Corallina officinalis* and *Cystophora torulosa* occur near low water. Subtidally a dense stand of *Carpophyllum flexuosum* extended from low water to the base of the scarp at 6 m depth. Between 10-12 m and 12-15 m depth the sediment was covered with discrete bands of *Griffithsia* sp. and *Lenormandia chauvini* respectively. The algae composing each band appeared to be unattached. Cover exceeded 50%.

Over the sediment unidentified sponges were common at all depths but were most abundant above 9 m. A single *Cerianthus* sp. was observed between 13-15 m on the 26 April 1995. The serpulid tubeworm *Galeolaria hystrix* was common on drift shell at all depths. Hermit crabs were common between 6-9 m. A single spider crab *Notomithrax* sp. was observed at 9 m. Common molluscs were *Trochus tiaratus, Turbo smaragdus, Maoricolpus roseus, Penion sulcatus, Perna canaliculus, Modiolarca impacta* and small *Pecten novaezelandiae. Atrina zelandica* was present in low numbers. The echinoderms *Patiriella regularis, Coscinasterias calamaria, Evechinus chloroticus, Pseudechinius albocinctus* and *Stichopus mollis* were common. The solitary ascidian *Cnemidocarpa bicornuata* was abundant on drift shell.

Fish:

Notolabrus celidotus was abundant at all depths. *Parapercis colias* occurred between 6-15 m. A single *Dipturus* egg case was observed at 12 m depth in 1989. An adult *Dipturus nasutus* was seen in 1995.

5. Takaputira Point to the first moorings towards Momorangi Point, Grove Arm, Queen Charlotte Sound (S 41° 16.1' E 173° 57.2')

An Apollo dive scooter was used to search for *Callorhinchus* egg cases on 26 April 1995. Depths egg cases were observed at were:

- 8 m
- 9.4 m - collected
- 10.9 m
- 10.9 m - about 3m from previous case, collected
- 14.5 m
- 9.7 m - collected

Total duration of the dive was 26 minutes. Maximum depth was 15.7m. Visibility was 3-4 m.

Substrate:

Between 8-14.5 m depth the bottom consisted of coarse silty shelly sand, covered with pebbles, granules and broken shell (all heavily encrusted with crustose coralline algae). There was a large amount of *Atrina* and *Perna* shell in the drift. Below 15 m depth the substrate was soft mud.

Conspicuous benthos:

Between 9-12 m the bottom was covered with large amounts of unattached *Hormosira banksii* and *Codium gracile*. Below 15 m the substrate was covered with dense *Lenormandia chauvini*.

Conspicuous invertebrates recorded between 8-14.5 m were *Turbo smaragdus, Maoricolpus roseus, Cnemidocarpa bicornuata, Patiriella regularis, Coscinasterias, Paguristes setosus, Pagurus* sp., *Cryptoconchus porosus, Trochus taiaratus, Pecten novaezelandiae, Atrina zelandica* and very large *Perna canaliculus*. Occasional *Evechinus chloroticus* and one very large *Aphelodoris lactuosa* were also seen.

Fish:

Spotties (*Notolabrus celidotus*) were common. The only other fish observed was a large triplefin (?*Grahamina sp.*). Single *Dipturus* egg cases were seen at 11.2 m and 11.8 m depth.

6. **First two embayments on the western side of Lochmara Bay, Queen Charlotte Sound (41•14'29"S 173•59'47"E)**

This site was surveyed using a dive scooter on 28 April 1995. Two hatched egg cases were observed at 14.2 m and 16.7 m depth in the first bay. The egg case at 16.7 m depth had recently hatched. In the second bay egg cases were observed at 15.4 m, 18 m, 18.5 m and 14.8 m depth. All had been deposited on *Lenormandia chauvini* and were recently laid. Dive duration was 40 minutes. Maximum depth was 24 m. Horizontal visibility was 4-5 m. Didier (1995b) subsequently collected seven egg cases containing embryos at early stages of development from this site.

Substrate:

The bottom of the first bay consisted of silty shelly sand covered with pebbles and a smaller amount of small cobbles and broken shell (all heavily encrusted with coralline crusts) to a depth of about 15 m. At this depth sand graded into firm shelly mud. In the second bay the substrate changed from gravel near shore, to shell rubble with clumps of tunicates and serpulid tube worms, to silty sand at 12 m depth. Rocky outcrops extended to at least 18 m depth between the bays. These outcrops were partially covered by coarse shelly sand.

Conspicuous benthos:

Relatively few epifaunal species were observed between 14.2 – 16.7 m depth in the first bay. Small patches of *Lenormandia chauvini* were common. Invertebrates included an *Atrina* bed commencing at about 13.6 m depth, mysids, *Pseudechinus albocincta, Coscinasterias calamaria,* terebellids, *Cnemidocarpa bicornuata, Maoricolpus roseus* and *Pecten novaezelandiae.* The exposed surfaces of the outcrops observed between the bays were devoid of algae but were encrusted with *Galeolaria hystrix, Monia zelandica,* hydroids and several species of unidentified sponge. In the second bay an extensive *Lenormandia* bed completely covered the bottom between 12 m and about 19.7 m depth. In places it extended below 21 m. Beneath the *Lenormandia* there was a dense bed of *Chaetopterus* sp. *Atrina* occurred below the *Lenormandia* bed.

Fish:

Spotties (*Notolabrus celidotus*) were seen at all depths. An unidentified Triptrerygiid (?*Grahamina* sp.) was very common amongst *Atrina* in the first bay. Also seen in the first bay were one southern pig fish (*Congiopodus leucopaecilus*) and one female *Dipturus nasutus* (13.9 m). Large numbers of spotties, *Forsterygion varium* and some juvenile tarakihi (*Nemadactylus macropterus*) were seen around the rock outcrops. Blue cod were expected around these but none were seen.

7. **Eastern side of the mouth of Lochmara Bay, Queen Charlotte Sound (41• 14.4' S 174• 0.45' E)**

Didier (1995b) surveyed this site on 28 April 1995. Four egg cases were observed between 15-19.7 m depth. All were empty. The substrate was mostly silty rock and shell rubble, with a few sand patches. Algae were uncommon. Solitary ascidians and *Atrina zelandica* were abundant.

8. **Double Cove, Queen Charlotte Sound (MSS Site 48 - 41• 14.1' S 174• 1.0' E)**

A single empty *Callorhinchus* egg case was observed at 21 m depth on 19 September 1989.

Substrate:

Shelly, sandy mud between 15-21 m.

Conspicuous benthos:

Dense *Atrina zelandica* bed with colonies of *Galeolaria hystrix. Cnemidocarpa bicornuata* was abundant. Other species recorded included large terebellids, *Trochus tairatus, Maoricolpus roseus, Pecten novaezelandiae,* hermit crabs, *Terebratella* sp., *Coscinasterias calamaria, Patiriella regularis* and *Evechinus chloroticus.*

Fish:

Notolabrus celidotus, Forsterygion varium, F. lapillum and *Notoclinops segmentatus.*

9. Torea Bay, Queen Charlotte Sound (MSS Site 51 - 41• 12.7' S 174• 1.9' E)

Three *Callorhinchus* egg cases were observed at 4m depth on 29 September 1989.

Substrate:

Fine sand overlying gravel immediately below low water. The silt fraction increases with depth and distance from the shore. At a distance of approximately 150 m from the head of the bay the bottom consisted of soft shelly mud with patches of cobbles and pebbles.

Conspicuous invertebrates:

Atrina common up to low water. *Pagurus novizelandiae, Patiriella regularis, Coscinasterias calamaria* and *Stichopus mollis* also abundant. Other species recorded were *Turbo smaragdus, Cominella adspersa, Chione stutchburyi, Pecten novaezelandiae, Tiostrea chilensis, Perna canaliculus, Venerupis largillerti* and *Gari stangeri.*

Fish species:

Aldrichetta fosteri, Notolabrus celidotus and *Genyagnus monopterygius.*

10. Kaipakirikiri Bay, Queen Charlotte Sound (MSS Site 53 - 41• 12.7' S 174• 2.9' E)

Eleven *Callorhinchus* egg cases were observed between 4.0-7.5 m depth at the head of the bay on 28 September 1989. All appeared to contain embryos. Six *Callorhinchus* egg cases were observed between 15-21 m on 30 December 1992 during a dive close to the point on the eastern side of bay.

Substrate:

Below low water at the head of the bay the bottom consists of fine silty sand and patches of cobbles to approximately 5 m. Below 5 m the substrate changed to muddy sand and shell, and patches of mud. In places the bottom was covered with numerous sticks and small branches of trees.

On the eastern side of the bay a steep rubble bank extends to between 6-9 m depth. Below this the bottom consists of coarse silty sand with a large amount of large pebbles and small cobbles to at least 21 m.

Conspicuous benthos:

At the head of the bay *Atrina zelandica* was common as shallow as 1 m below low water. Infaunal bivalves noted in fine sand above 5 m were *Tawera spissa, Venerupis largillerti, Dosinia subrosea, Mactra* sp. and *Bassina yatei.* Epifaunal species included *Ovalipes catharus, Pagurus spinulimanus, Notomithrax minor, Pecten novaezelandiae, Patiriella regularis, Coscinasterias calamaria* and *Stichopus mollis.*

Neothyris sp. and *Atrina zelandica* were abundant below 18 m. The *Neothyris* were attached to small shell fragments and pebbles. *Cnemidocarpa bicornuata* was abundant at all depths. *Protula bispiralis* and small *Pecten novaezelandiae* were common. Other species included *Stichopus mollis, Coscinasterias calamaria, Evechinus chloroticus, Pseudechinus albocincta, Patiriella regularis,* an orange-brown sponge with tubular oscula (?*Raspalia* sp.) and *Galeolaria hystrix* colonies.

Fish species:

Forsterygion lapillum, F. flavonigrum, Parapercis colias, Notolabrus celidotus and *Pelotretis flavilatus.*

11. Western arm of Kumutoto Bay, Queen Charlotte Sound (Site 54 - 41• 12.5' S 174• 3.7' E)

On 29 September 1989 two divers snorkelled the head of this arm. Two recorded *Callorhinchus* egg cases were observed on pebbles at about 6 m depth, and another six on sand below 9 m. On 5 June 1990 two SCUBA divers collected 12 egg cases between 6-9 m depth during a 20 minute dive. On 30 December 1992 I observed numerous egg cases between 9-12 m depth during a recreational SCUBA dive.

Substrate:

The intertidal at the head of the arm is paved with cobbles. Below low water the sediment is covered with pebbles to a depth of approximately 9 m. Below 9 m the pebbles give way to coarse silty sand which grades into sandy mud at approximately 12 m. The sides of the arm are covered by rubble to a depth of approximately 6.0-8.0 m, with coarse silty sand below this.

Conspicuous benthos:

Pecten novaezelandiae, Patiriella regularis and the solitary ascidian *Cnemidocarpa bicornuata* were common to abundant. *Turbo smaragdus* was common immediately below the rubble bank, and in areas where the sediment was covered with pebbles.

Fish species:

Dipturus nasutus, Myliobatis tenuicaudatus, Conger verreauxi, Caesioperca lepidoptera, Forsterygian vairum, F. lapillum and *Notolabrus celidotus.*

12. Eastern arm of Kumutoto Bay, Queen Charlotte Sound (MSS Site 55 - 41• 12.5' S 174• 4.2' E)

On 28 September 1989 eight *Callorhinchus* egg cases were observed between 7.5 - 9 m depth by two divers snorkelling the head of the arm. On 29 April 1995 I used a dive scooter to search haphazardly for egg cases during a 30 minute SCUBA dive at the head of the bay. My observations were as follows:

- 1 egg case at 7 m depth;
- 1 pair of egg cases at 7.3 m depth;
- 2 egg cases (not a pair) at 7.6 m depth;
- 7 egg cases within a 3 m radius at 7.9 m depth, not all containing embryos;
- 1 hatched and 1 live egg case at 8 m depth;
- 3 hatched egg cases at 8 m depth;
- 1 egg case at 8.5 m depth;
- 1 live and 1 empty egg case at 8.8 m depth;
- 2 empty egg cases at 9 m depth;
- 1 empty egg case at 10.6 m depth.

The average depth at which these egg cases were encountered was 8 m. In some places the egg cases appeared to have been disturbed. Several older egg cases were tipped on their sides or up-ended and partially buried. These did not contain embryos. On 22 November 1999 I counted egg cases in four haphazardly placed 50 x 4 m transects. The results are given in Table 1. Egg cases were located between 6.2 – 11 m depth. The deepest unhatched egg case was observed at 11 m. Egg cases were deposited on silty sand. Near the sides of the bay this was covered by a pebble and shell lag. In transect 3 a live near term embryo was found in a highly eroded egg case. This egg case consisted of little more than the central spindle and tail sheath. It was coloured dark brown and encrusted with small serpulid tubeworms. No recently deposited egg cases were observed.

Table 1. Elephant fish egg cases recorded in 50 x 4 m transects in Kumutoto Bay, Queen Charlotte Sound, November 1999.

Transect	Depth range (m)	Unhatched egg cases	Hatched egg cases	Hatched and eroded egg cases
1	6.8-7.5	3	12	-
2	6.8-11	5	2	1
3	5.4-10.7	2	12	4
4	3.8-8.1	-	1	-

Substrate:

The western side of the arm is steep, and ringed by an intertidal rock scarp. Below low water a rubble bank extends down to approximately 6.0-8.0 m. Patches of cobbles also occurred below this. The intertidal at the head of the arm is paved with cobbles and pebbles. A sandy beach is situated on the eastern side of the arm approximately two thirds of the way in. Fine clean sand extends to a depth of approximately 5.0-6.0 m (no *Callorhinchus* egg cases observed here in 1989). Either side of this there is an intertidal rock scarp. Boulders and cobbles extend to approximately 6.0 m. Towards the head of the arm these drop onto firm shelly mud.

At 8.2 m depth at the head of the arm the bottom consisted of firm shelly sand, with cobbles and boulders covering approximately 10% of the surface. Percentage cover of drift shell (including *Pecten*, *Maoricolpus* and *Zenatia*), was less than 10%. At 7.6 m depth on the eastern side of this cove the cover of gravel and broken shell exceeded 50%. Below 15 m depth the substrate was predominantly shelly mud and gravel.

Conspicuous benthos:

At the head of the arm the finely branched red alga *Ceramium apiculatum* was common between 7.6 – 9 m depth. Percentage cover was less than 10%. *Atrina zelandica* was the dominant invertebrate species. Its density increased with depth, and it formed a dense bed below 8.5 m. Other common species were *Pecten novaezelandiae*, *Patiriella regularis*, *Coscinasterias calamaria*, *Stichopus mollis* and *Cnemidocarpa bicornuata*. *Phyllochaetopterus socialis* was present at low densities. There were also occasional *Galeolaria hystrix* colonies between 9-15 m.

Fish species:

Notolabrus celidotus and *Forsterygion lapillum* were common. No other species were observed.

13. Allport's Island, Queen Charlotte Sound (MSS Sites 57 & 58 - 41• 14.5' S 174• 3.4' E; 41• 14.2' S 174• 3.4' E)

One *Callorhinchus* egg case was observed on the southern side of the island (MSS Site 57) on 22 November 1989 (note: three divers, duration 50 minutes, no more than half of this time was spent in potential *Callorhinchus* spawning habitat). On 22 November 1989 and 29 April 1995 two dives were conducted halfway along the northern side of the island (MSS Site 58). No *Callorhinchus* egg cases were seen on either of these dives. Maximum depth was 24 m.

MSS Site 57

Substrate:

Rock outcrops predominate to a depth of 9 m. These broken by gutters filled with coarse sand and cobbles. Below this muddy shelly sand extends to at least 18 m depth. Between 9-15 m percentage cover of pebbles and broken shell exceeds 50%.

Conspicuous benthos:

Pebbles and broken shell were heavily encrusted with coralline algae. No other species of algae were recorded between 9-18 m.

Pecten novaezelandiae, Maoricolpus roseus, hermit crabs and *Cnemidocarpa bicornuata* were abundant. Other common species were sponges, *Pseudechinus albocinctus, Branchioma serratibranchis, Galeolaria hystrix, Atrina zelandica, Coscinasterias calamaria, Patiriella regularis* and *Stichopus mollis.* Clumps of serpulids were common-abundant. Species present in low numbers were *Evechinus chloroticus, Aulacomya ater maorianus, Terebratella* sp. and *Pectinaria australis.*

Fish:

The only common species between 9-18 m depth was *Notolabrus celidotus. Forsterygion flavonigrum* was observed between 15-18 m, and *Notoclinops segmentatus* was common between 9-12 m. Single individuals of *Nemadactylus macropterus* and *Congiopodus leucopaecilus* were observed at 12 m and 15 m respectively. Two *Dipturus* sp. egg cases were seen.

MSS Site 58

Substrate:

The bottom shelves very steeply. Outcropping and broken rock is the predominant substrate above 9 m depth, and occurs to at least 15 m depth. Below 9 m coarse sand predominates. This becomes increasingly silty with depth and grades into muddy sand at 18 m. Sandy mud begins at 22.7-24 m depth.

Conspicuous benthos:

Rock encrusted with coralline crusts, spirorbids, *Galeolaria, Monia* and *Cnemidocarpa.* Almost no macroalgae, occasional *Carpophyllum flexuosum* plants the only exception. Between 12-21 m depth there are numerous *Galeolaria* colonies. A single *Ceriantfus* sp. was observed at 21 m. *Cnemidocarpa* and *Pecten* were common. Occasional *Atrina, Evechinus* and *Pseudechinus albocincta. Atrina* increases in abundance with depth. Single large *Perna* seen.

Fish:

Four live *Dipturus* egg cases were seen between 22 – 24 m. *Notolabrus celidotus* and *Forsterygion flavonigrum* were common.

14. Penzance Bay, Tennyson Inlet, Pelorus Sound (MSS Site 231 - 41• 5.2' S, 173• 46' E)

A small number of *Callorhinchus* egg cases were observed between 6-9 m depth at the head of the bay on 16 January 1990.

Substrate:

Broken rock was the predominant substrate on the sides of the bay. Below 3 m depth there were large patches of shelly sand amongst the rock. The floor of the bay was covered with silty gravel.

Conspicuous benthos:

The benthos was sparse. No algae were recorded over the floor of the bay. The epifauna consisted of occasional unidentified sponges, *Atrina zelandica, Turbo smaragdus, Coscinasterias calamaria, Evechinus chloroticus* and *Stichopus mollis.*

Fish species:

The only fish observed was a small *Parapercis colias* at a depth of 10-12 m.

15. Elaine Bay, Tennyson Inlet, Pelorus Sound (MSS 232 - 41• 3.4' S 173• 47' E; 41• 3' S 173• 46.8' E)

On 17 January 1990 a single *Callorhinchus* egg case was observed on the south side of the bay about 400 m inside Red Point (MSS Site 232). No depth was recorded. On 2 January 1999 I observed one hatched and one unhatched egg case between 9-12 m depth during a 30 minute SCUBA dive just inside the point on the northern side of the bay. I also snorkelled a small shelf located off the small cove 450 m inside the bay and observed two more unhatched egg cases at about 9 m depth.

Substrate:

At MSS 232 the substrate consisted of pebbles, cobbles and silty shelly sand to 7.6 m depth, pebbles and silty shelly sand between 7.6-11.5 m, muddy shelly sand and drift *Glycymeris laticostata* valves between 11.5-13.6 m and sandy mud and drift shell from 13.6-18 m. The bottom inside the point on the northern side of the bay shelves steeply away from the shore. Cobbles, boulders and outcropping rock predominate to between 9-10.6 m depth. Below this the substrate consisted of coarse silty sand to at least 12 m depth.

Conspicuous benthos:

At MSS 232 *Aaptos aaptos, Turbo smaragdus, Cominella adspersa* and the solitary ascidian *Cnemidocarpa bicornuata* were dominant between 7.6-11.5 m depth. Other species included *Trochus tiaratus, Maoricolpus roseus, Pecten novaezelandiae, Coscinasterias calamaria, Evechinus chloroticus, Stichopus mollis* and *Patiriella regularis.* The small brown alga *Asperococcus bullosus* occurred from 11.5-18 m depth but did not form an extensive cover. The dominant invertebrates below 11.5 m were *A. aaptos,* tubeworms (*Chaetopterus* sp.) and *Atrina zelandica.* Other species included unidentified sponges, *T. tiaratus, M. roseus, P. novaezelandiae, C. calamaria, E. chloroticus, S. mollis* and *Terebratella* sp. No macroalgae were observed on the northern side of the bay. No other observations of the benthos were made at this site.

Fish species:

Fish were uncommon at both sites. Those recorded were *Nemadactylus macropterus, Notolabrus celidotus* and *Parapercis colias.*

16. Camel Point, Tawhitinui Reach, Pelorus Sound (Site 237 - 41• 1.9' S 173• 48.6' E)

Two *Callorhinchus* egg cases were observed between 13.6-18 m depth on 13 January 1990.

Substrate:

Coarse, clean shelly sand to 13.6 m. Silt fraction and percentage cover of drift shell increasing with depth. Coarse muddy shelly sand at 18 m with high percentage cover of empty *Glycymeris laticostata* valves. Occasional cobbles and pebbles.

Conspicuous benthos:

Patches of *Caulerpa geminata* at 13.6 m. Microalgal film covering surface of sediment. *Atrina zelandica* was common at 18 m depth. Epifauna sparse otherwise. Occasional *Pecten novaezelandiae, Evechinus chloroticus, Coscinaterias calamaria, Stichopus mollis* and *Terebratella* sp. Single knobbed whelk (*Penion dilatatus*) observed at 18 m. Infaunal bivalves *Gari stangeri* and *Tawera spissa* common.

Fish species:

Occasional *Notolabrus celidotus* and a single *Hemerocoetes monopterygius.*

17. Canoe Bay, Pelorus Sound (41• 1.5' S 173• 47.8' E)

This site was dived by Didier (1995b). Three egg cases were observed at a site on the northern side of the bay on 27 April 1995.

18. Savill Bay, Pelorus Sound (41• 1.2' S 173• 46.7' E)

This site was dived by Didier (1995b). Egg cases were not as abundant as in Garne Bay. About 50 were observed between 6-12 m depth. About half of these had hatched. Four of the five egg cases collected contained decomposing eggs. The remaining one was empty. The substrate was predominantly gravel and fine sand. Patches of unidentified red algae were common.

19. Garne Bay, Pelorus Sound (MSS Site 239 - 41• 0.5' S 173• 47.1' E)

Large numbers of *Callorhinchus* egg cases were observed between 4.2-13.6 m depth during January and June 1990 and on 27 April 1995. On the southern side of the bay egg cases were most abundant between 10-11 m depth.

Substrate:

On the southern side of the bay cobbles are the predominant substrate to about 7.6 m depth. Below this pebbles cover coarse silty shelly sand to about 12 m depth. Between 12-16.6 m the bottom consists of shelly mud with small amounts of cobble and intact shell. Below 16.6 m the bottom is composed of soft mud. On the northern side of the bay the rubble bank drops abruptly onto a broad area of coarse clean sand at about 5-6 m depth. This grades into silty sand between 9-12 m. At the head of the bay there is an extensive area of fine clean sand immediately below low water.

Conspicuous benthos:

There was little macroalgal growth inside the bay. Pebbles and drift shell below 7.6 m were heavily encrusted with crustose coralline algae.

The dominant invertebrates between 7.6-12 m on the southern side of the bay were *Chaetopterus* sp., *Phyllochaetopterus socialis, Galeolaria hystrix, Turbo smaragdus, Trochus tiaratus, Maoricolpus roseus, Gari stangeri, Patiriella regularis, Coscinasterias calamaria, Evechinus chloroticus, Terebratella* sp., *Cnemidocarpa bicornuata* and *Pyura carnea.* Other species included occasional sponges (*Ancorina alata*), *Atrina zelandica, Pentagonaster pulchellus* and compound ascidians. Epibenthic invertebrates were sparse between 12-16.6 m. Small clusters of *Cnemidocarpa bicornuata* and *Maoricolpus roseus* were observed. Small compound ascidians were sometimes associated with these. A small pagurid, *Australeremus* sp. (?*kirkii*), was common. Below 16.6 m depth no epibenthic species were recorded due to the poor visibility.

Trochus tairatus, Cominella adspersa, Myadora striata, Chione stutchburyi and Pagurus novizelandiae dominate the shallow fine sand habitat at the head of the bay. Other species include *Atrina zelandica* and *Paguristes setosus.* The only epibenthic species recorded from coarse sand substrates on the northern side of the bay was a single *Archidoris wellingtonensis. Glycymeris laticostata* and *Gari stangeri* appeared to be the dominant infaunal species.

Fish species:

The only fish observed on the southern side of the bay were a large *Myliobatis tenuicaudatus,* and low numbers of *Notolabrus celidotus. Notolabrus, Parika scaber* and *Parapercis colias* occurred close to the base of the rubble bank on the northern side of the bay.

20. Cissy Bay, Hallam Cove, Pelorus Sound (MSS Site 241 - 40• 59.4' S 173• 49.5' E)

A single empty *Callorhinchus* egg case was observed at 10.6 m depth on 9 January 1990.

Substrate:

The bottom between 9-12 m consisted of coarse silty shelly sand with a cover of fragmented serpulid tubes, shells and small pebbles.

Conspicuous benthos:

No macroalgae were observed. The dominant invertebrates included *Chaetopterus* sp., *Branchiomma serratibranchis, Trochus tairatus, Paguristes setosus, Pagurus traversi, Patiriella regularis, Evechinus chloroticus* and *Cnemidocarpa bicornuata.* Other species included three unidentified sponges, small clumps of *Galeolaria hystrix, Pomatoceros terranovae* and *Modiolarca impacta, Buccinulum* sp., *Xymene ambiguus, "Pagurus" spinulimanus, Notomithrax minor, Terebratella* sp. and *Coscinasterias calamaria.*

Fish species:

No fish were seen below 6 m.

21. Te Towaka Bay, Hallam Cove, Pelorus Sound (MSS Site 242 - 40• 59.7' S 173• 50' E)

Two empty *Callorhinchus* egg cases were observed at 9-10.6 m depth on 9 January 1990.

Substrate:

Firm muddy sand between 9 – 15 m depth, with less than 10% cover of small cobbles, pebbles and drift shell.

Conspicuous benthos:

Algae covered about 20 % of the substrate. These were mainly finely branched red species with a small amount of *Codium gracile* and *Asperococcus bullosus.*

The dominant invertebrates were *Atrina zelandica, Trochus tairatus, Paguristes setosus* and *Cnemidocarpa bicornuata.* Other species included three unidentified species of sponge, small clumps of *Pomatoceros terranovae* and *Galeolaria hystrix, Branchiomma serratibranchis, Turbo smaragdus, Cookia sulcata, Cominella adspersa, Xymene ambiguus, Maoricolpus roseus, Pecten novaezelandiae, Australeremus kirkii, Notomithrax minor, Terebratella sanguinea, Patiriella regularis, Coscinasterias calamaria, Evechinus chloroticus,* and an unidentified apricot coloured compound ascidian.

Fish species:

Grahamichthys radiata, Grahamina sp. and *Parika scaber. Dipturus* egg cases were abundant below 12 m depth.

DISCUSSION

Callorhinchus milii egg cases were observed at 21 inner sound locations. In Queen Charlotte Sound spawning occurs discontinuously along the southern shoreline of Grove Arm between Wedge Point (S 41° 15.5' E 174° 0.5') and Momorangi Point (S 41° 16.1' E 173° 57.2'), at the mouth of Lochmara Bay, at the head of Torea Bay, in Kaipakirikiri Bay, Kumutoto Bay and occasionally at Allport's Island and in Double Cove. Along the southern shoreline of Grove Arm the most important spawning sites observed were located off the beach 200 m west of Wedge Point, along the western side of the reef extending off Iwirua Point and off the headlands either side of Ngakuta Bay. Anecdotal records of elephant fish being caught in set and drag nets in Ngakuta Bay suggest spawning may also occur there. Unfortunately no survey dives were conducted inside the bay itself. The most important *Callorhinchus* spawning sites identified in Queen Charlotte Sound to date are located in Kaipakirikiri and Kumutoto Bays. Both of these bays appear to have the highest egg case densities and largest areas of spawning habitat. However as only one shallow snorkel dive was conducted in Torea Bay this area may also contain important spawning sites. In Pelorus Sound spawning occurs along the western shoreline of Tennyson Inlet from Penzance Bay to Camel Point, and Canoe Bay, Savill Bay, Garne Bay and Hallam Cove. Egg case densities at the Tennyson Inlet sites were low but spawning appears to occur wherever there is suitable habitat. Garne and Savill Bays appear to have the highest egg case densities and largest area of spawning habitat found so far in Marlborough Sounds (Didier 1995b). Spawning appears to occur infrequently in Cissy and Te Towaka Bays, Hallam Cove.

Little is known of the spawning behaviour of *Callorhinchus milii*. Females probably deposit two eggs at a time and may spawn repeatedly through the breeding season (Didier 1994, 1995a, 1995b). In New Zealand egg cases are typically deposited on sand and mud substrates in water shallower than 30 m between November-March (Graham 1953; Gorman 1963; Coakley 1971; McClatchie & Lester 1994). The total number of eggs deposited by a female during the breeding season is unknown. In Marlborough Sounds elephant fish appear to migrate to well defined spawning areas. Repeat observations have shown these areas are used year after year. Substrate type appears to be more important than depth in determining the site of egg deposition. At 62% of the sites where substrate information was available (n = 20) egg cases were deposited on silty/muddy sand. Other spawning substrates included pebbles/gravel (20%), shelly mud (20%), soft mud (5%) and beds of *Lenormandia chauvini* (10%) (note: spawning usually occurred on more than one substrate type at a site). In Queen Charlotte Sound spawning depth ranged from 4 – 21m. In Pelorus Sound it ranged from 4.2 – 18 m. The lower limit of spawning was generally marked the transition from silty sand to soft mud. The exception being at Iwirua Point, Grove Arm where egg cases were most numerous on soft mud immediately below an extensive bed of *Lenormandia*. The upper limit of spawning generally marked the transition to coarser sediments and rock substrates.

Elephant fish spawning probably occurs in Marlborough Sounds from December into June with embryo's hatching from August to November (Didier 1995b). Throughout development small slits in the egg capsule allow circulation of oxygenated water to the embryo. As the embryo grows the beating of its tail and gradual enlargement of the slits aid circulation (Didier 1995a). Anything that causes these slits to become blocked, such as accumulation of excess silt on the egg case, burial of the egg case or encrusting growth will kill the embryo. Elephant fish spawning areas in Marlborough Sounds are therefore vulnerable to increased siltation caused by catchment development or marine farming, marine dumping, trawling, dredging or any other form of disturbance of the sea bed. Anchors, or recreational scallop dredging probably caused the disturbance and partial burial of egg cases noted in Kumutoto Bay. Causes of natural embryo mortality observed in Marlborough Sounds include predation by *Evechinus chloroticus* (consumption of egg cases observed directly), predation by molluscs (indicated by whelk or octopus drilling of egg capsules), and one possible instance of fish predation (indicated by a torn and punctured egg capsule). The cause of death of the decomposing eggs collected at Iwirua Point and Savill Bay is unknown. These eggs may have been unfertile, or they may have been smothered by silt or killed by a pathogen.

REFERENCES

Coakley, A. 1971: The biological and commercial aspects of the elephant fish: 1. The commercial fishery. *Fisheries Technical Report No. 76.* New Zealand Ministry of Agriculture and Fisheries, Wellington. 29 pp.

Didier, D. A. 1993: The Chimaeroid Fishes: A taxonomic review with notes on their general biology (Holocephali: Chimaeroidei). *Chondros 4(5)*: 1-6.

Didier, D. A. 1994: The Fishery Status of Chimaeroids (Chondrichthyes, Holocephali), Summary Report. *Shark News 1.* Newsletter of the IUCN Shark Specialist Group: pg 6.

Didier, D. A. 1995a: Phylogenetic Systematics of Extant Chimaeroid Fishes (Holocephali, Chimaeroidei). *American Museum Novitates No. 3119*, American Museum of Natural History, New York. 86 pp.

Didier, D. A. 1995b: Spawning of elephantfish (*Callorhinchus milii*) in the Marlborough Sounds. Unpublished report prepared for the Department of Conservation, Nelson Marlborough Conservancy. 5 pp.

Gorman, T. B. S. 1963: Biological and economic aspects of the elephant fish (*Callorhynchus milii*) Bory in Pegasus Bay and the Canterbury Bight. *Fisheries Technical Report No. 8*, New Zealand Ministry of Agriculture and Fisheries, Wellington. 54 pp.

Graham, D. H. 1953: A Treasury of New Zealand Fishes. A.H. & A.W. Reed, Wellington. 424 pp.

McClatchie, S.; Lester, P. 1994: Stock assessment of the elephant fish (*Callorhinchus milii*). *New Zealand Fisheries Assessment Research Document 94/6.* MAF Fisheries, New Zealand Ministry of Agriculture and Fisheries, Wellington. 17 pp.

APPENDIX 1:

Location of the sites dived during the Department of Conservation's 1989-1990 survey of subtidal habitats in Marlborough Sounds.

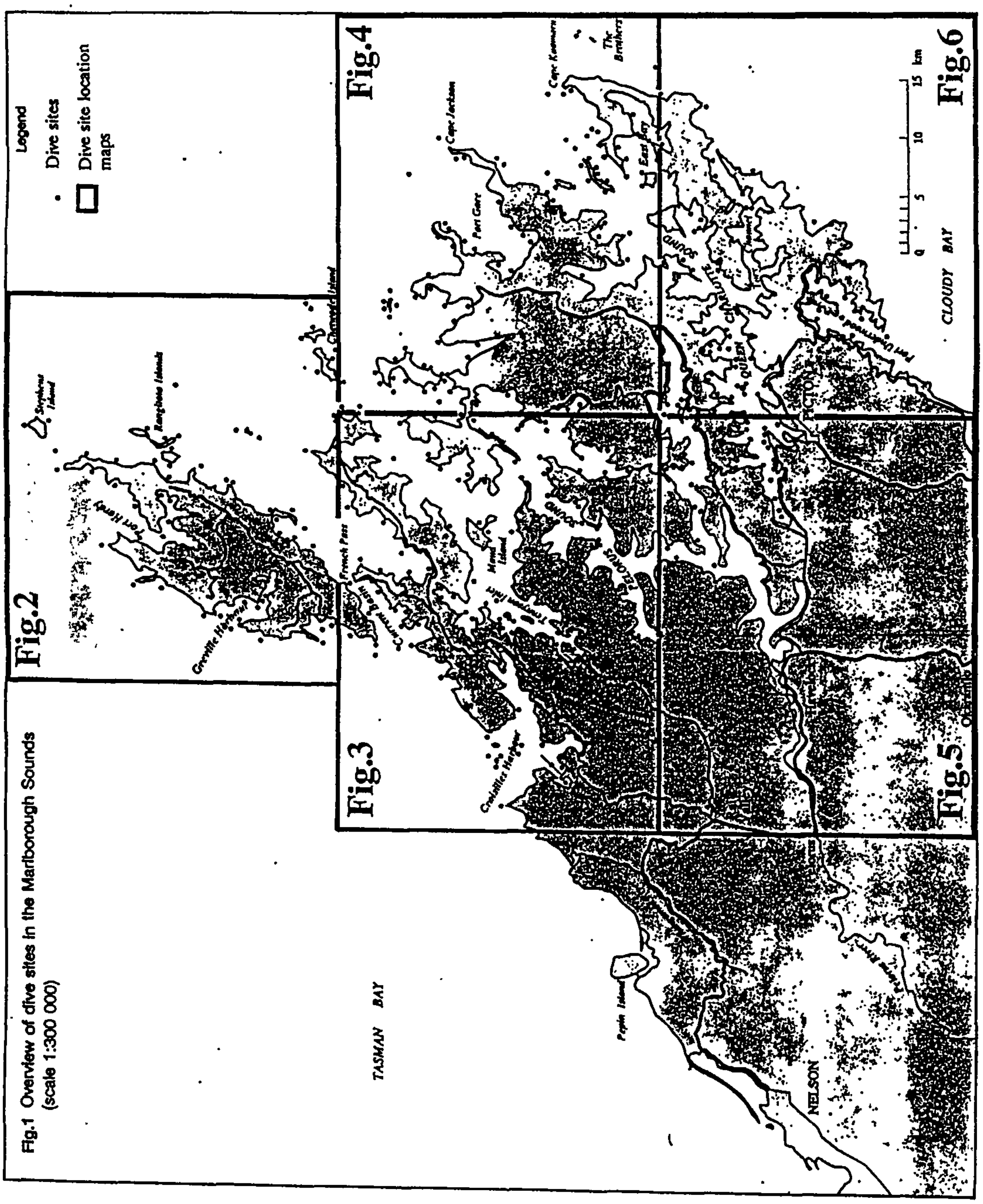


Fig.1 Overview of dive sites in the Marlborough Sounds (scale 1:300 000)

4 Area and species summaries

Figure 1: Summary of juvenile distributions from the North Island. SW, south west; NW, north west; Inner, inner shelf; Outer, outer shelf; Present, abundance not determined because of insufficient records

Species	SW		NW		Hauraki Gulf		Bay of Plenty	
	Inner	Outer	Inner	Outer	Inner	Outer	Inner	Outer
Arrow squid	Low	+	Low	Low	Low	Moderate	Moderate	Moderate
Banded stargazer								
Barracouta	Low	+	Low	Low	High	Low	Low	Low
Blue cod	+				+		+	
Blue mackerel		+	Low		Low	Moderate	Low	
Blue moki							+	
Blue warehou	Low	+	Low	+	Low	Low	Moderate	Low
Elephantfish								
Gemfish		+		+		+		Low
Giant stargazer	Low	+	Low	Low	Low	Low	Moderate	+
Grey mullet	+		+		+			
Hake			+					
Hapuku		+		Low		Low	Low	Low
Jack mack. *(T.d)*	+	+		Moderate	Low	High	Low	Moderate
Jack mack. *(T.nz)*	Low	+	Low	Low	High	Moderate	Moderate	Moderate
Jack mack. *(T.s.m.)*		+		+				
John dory	Low	+	Low	Low	Moderate	Low	Low	Low
Kahawai	Low		Moderate		High		Low	
Kingfish	Low		Low		Low	Low	Low	Low
Lemon sole			Low		Low	+	Low	+
Ling		+		+		+		Low
N.Z. sole	+		+		+		+	
Red cod	+	+	+		+	+	+	+
Red gurnard	Low	+	Moderate	Low	Moderate	Low	Moderate	Low
Rig	Low	+	Moderate	Low	High	+	Low	+
Sand flounder			Low		Low		Low	+
Sea perch	Low			Low		Low		Low
School shark	Low	+	Moderate	Low	Low	Low	Moderate	Low
Silver warehou	+	+	+	+	+		+	+
Snapper	Low		Low		High	Low	High	Low
Spiny dogfish	Low	+	Low	Low				
Tarakihi	Low	+	Low	Low		Low	Low	Moderate
Trevally	Low		High		Low		Moderate	
Yellowbelly founder	+		+		+		+	
Yelloweyed mullet	+		+		+		+	

Present (literature or trawl data) +

***Kaharoa* abundance:** **Low** **Moderate** **High**

Figure 2: Summary of juvenile distributions from the East coast North Island. Inner, inner shelf; Outer, outer shelf; Present, abundance not determined because of insufficient records

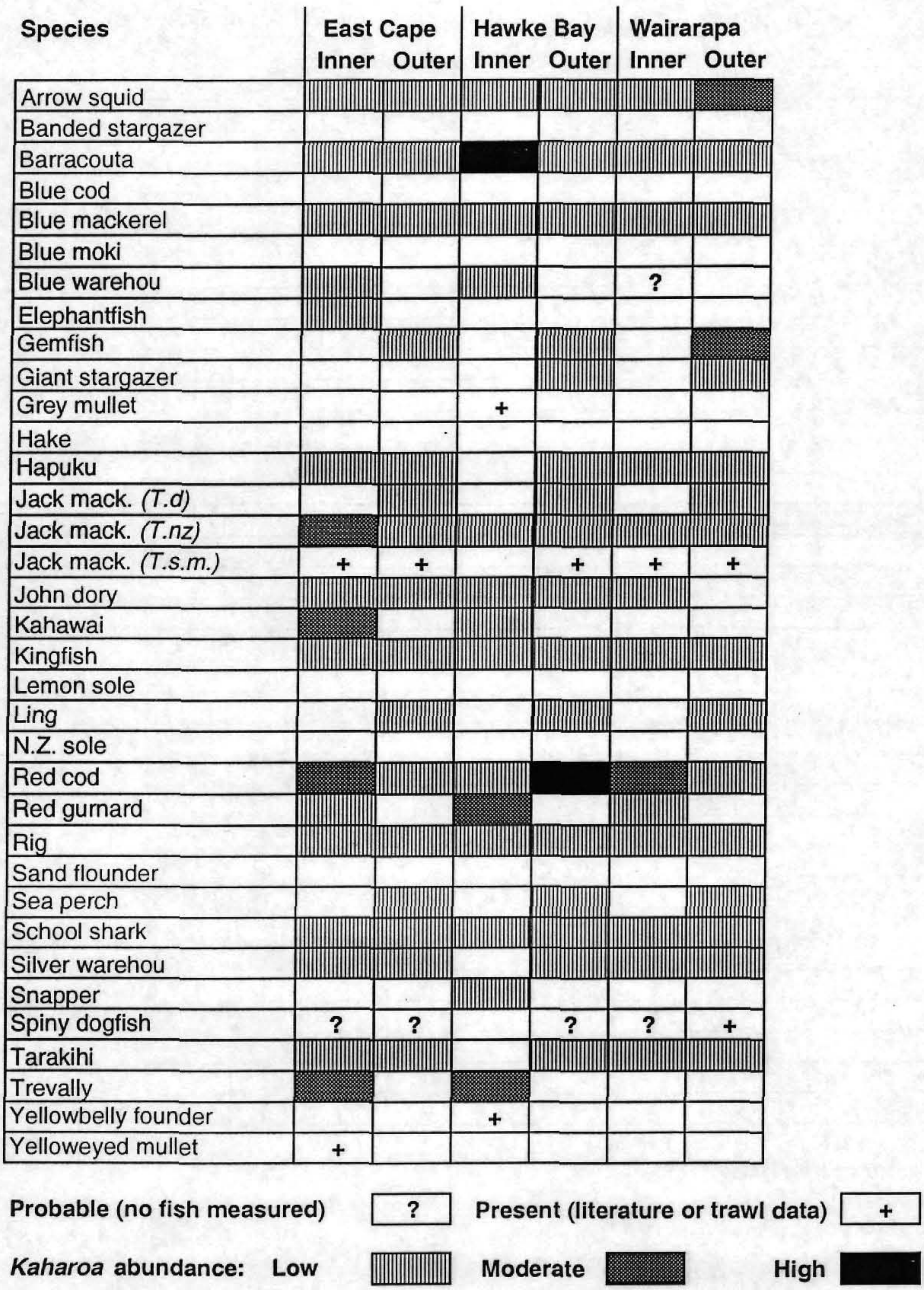


Figure 3: Summary of juvenile distributions from the South Island. WC, west coast South Island; Ts/Gd, Tasman/Golden; N. Banks, North of Banks Peninsula S. Banks, South of Banks Penisnsula; Inner, inner shelf; Outer, outer shelf; Present, abundance not determined because of insufficient records

Species	WC Inner	WC Outer	Ts/Gd Bay	N. Banks Inner	N. Banks Outer	S. Banks Inner	S. Banks Outer
Arrow squid	Low	Moderate	Low	Low	Low	High	High
Banded stargazer							
Barracouta	Low	Low	Moderate	Moderate	Low	High	Moderate
Blue cod			+	+		+	
Blue mackerel			+				
Blue moki						+	
Blue warehou	Low	Low	Low	Moderate	+	Moderate	
Elephantfish	Low			Low	Low	High	Low
Gemfish		Low			Low		Low
Giant stargazer	Low	Low	Low	Low	Low	Low	Moderate
Grey mullet							
Hake	High	Moderate	Low	Low	Moderate	Low	Low
Hapuku		Low		Low	Low	Low	Low
Jack mack. *(T.d)*	Low	Low	Low	Low	Low	Low	Low
Jack mack. *(T.nz)*	Low		Moderate	Low	Low	Low	+
Jack mack. (*T.s.m.*)	+	+		+			+
John dory	Low	Low	Low				
Kahawai			+				
Kingfish							
Lemon sole	Low		Low	Low	Low	Low	Low
Ling	Low	Low	Low	Low	Low	Low	High
N.Z. sole	+		+	+		+	
Red cod	Moderate	Moderate	Moderate	Moderate	Moderate	High	High
Red gurnard	Moderate	Low	Moderate	Low	Low	Low	Low
Rig	Low	Low	Low	Low	Low	Moderate	Low
Sand flounder	Low		Low	Low		Low	
Sea perch	+	Low	Low	+	High	+	High
School shark	Low	High	Low	Moderate	Low	High	Low
Silver warehou	Low	Low	Moderate	Low	Low	Moderate	Moderate
Snapper	Low		Low				
Spiny dogfish	Moderate	Moderate	Moderate	High	High	High	High
Tarakihi	Low	Low	Low	+	Moderate	High	High
Trevally			+	+			
Yellowbelly founder			+	+			
Yelloweyed mullet							

Present (literature or trawl data) +

***Kaharoa* abundance:** **Low** **Moderate** **High**

Figure 4: Summary of juvenile distributions from Southland and on the Chatham Rise. Inner, inner shelf; Outer, outer shelf; 3-600, upper slope, 6-800, mid-slope; Present, abundance not determined because of insufficient records; Survey, all by *Tangaroa* except for the *Akebono Maru* at the Chatham Is.

Species	Southland			Chatham Rise				Chatham Is.	
	Inner	Outer	3-600	Inner	Outer	3-600	6-800	Inner	Outer
Arrow squid	Low	High	+	+	Low	Low	Low	Low	High
Banded stargazer	Low	Low			Low				
Barracouta	Moderate	Low		+	Low			High	Moderate
Blue cod	+			+					
Blue mackerel									
Blue moki	+								
Blue warehou	Moderate								
Elephantfish	+								
Gemfish	Low	Low							
Giant stargazer	Low	Low	+	+	Low	Low	+	+	+
Grey mullet									
Hake			Low			Low	Low		
Hapuku	Moderate	Moderate		+	Low			Low	High
Jack mack. (*T.declivis*)	+								
Jack mack. (*T.nz*)	+								
Jack mack. (*T.s.m.*)	+	Low				Low			
John dory									
Kahawai									
Kingfish									
Lemon sole									
Ling		+	Low		Moderate	Low	Low	?	?
N.Z sole	+								
Red cod	Low	High			Low	Low		?	Moderate
Red gurnard	Low			?				?	?
Rig	+	+							
Sand flounder									
Sea perch	Low	Low		?	Low	Low	Low	?	?
School shark	Low	Low		+	Low			Low	Low
Silver warehou	Low	High		?	High	Low		Low	High
Snapper									
Spiny dogfish	High	Moderate	Low	+	High	Low	+	?	?
Tarakihi	Moderate	Low		+	+			Low	Low
Trevally									
Yellowbelly founder									
Yelloweyed mullet									

Probable (no fish measured) ? **Present (literature or trawl data)** +

Survey abundance: Low (vertical hatching) **Moderate** (stippled) **High** (solid black)

Figure 5: Summary of spawning, pupping or egg-laying distributions from the North Island. SW, south west; NW, north west; Inner, inner shelf; Outer, outer shelf; Possible, based on the distribution of young juveniles and adults and lack of gonad sampling; ND, not determined in this study

Species	SW		NW		Hauraki Gulf		Bay of Plenty	
	Inner	Outer	Inner	Outer	Inner	Outer	Inner	Outer
Arrow squid		+		+	?	?	?	?
Banded stargazer								
Barracouta		Common		Occasional				Common
Blue cod	?				?		?	
Blue mackerel	S	S		Occasional				
Blue moki								
Blue warehou		Occasional	?	?			?	?
Elephantfish								
Gemfish						Occasional		Occasional
Giant stargazer				Occasional	?		?	Occasional
Grey mullet					?			
Hapuku								
Hake	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*
Jack mack. *(T.declivis)*		Common		Common		+		?
Jack mack. *(T.nz)*	Common	Common	Common	Common	+	+	?	?
Jack mack. *(T.s.m.)*		Common		?		+		+
John dory	?	Occasional	Occasional	Common	?	?	Occasional	Common
Kahawai	?		?		?		?	
Kingfish	?		?		?		?	
Lemon sole	+		?		+		?	
Ling	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*
N.Z. sole	+		?		?		?	
Red cod		S						Occasional
Red gurnard		Occasional	Common	Common	Occasional		Common	Common
Rig	+		?		+		?	
Sand flounder	+		?		+		?	
Sea perch	?	?		?		?		?
School shark			?		?		?	
Silver warehou	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*
Snapper			Common		Common		Common	
Spiny dogfish								
Tarakihi				Occasional				Occasional
Trevally			?				?	
Yellowbelly flounder	+		+		+		?	
Yelloweyed mullet	+		?		?		?	

Possible ? **Literature** + **Spent** S

Ripe/Running ripe: **Occasional** (striped shading) **Common** (dark shading)

Figure 6: Summary of spawning, pupping or egg-laying distributions from the south east coast of the North Island. Inner, inner shelf; Outer, outer shelf; Possible, based on the distribution of young juveniles and adults and lack of gonad sampling; *ND*, not determined in this study

Species	East Cape		Hawke Bay		Wairarapa	
	Inner	Outer	Inner	Outer	Inner	Outer
Arrow squid	?	?		?	?	+
Banded stargazer						
Barracouta						
Blue cod						
Blue mackerel	?		?		?	
Blue moki	S		+S		S	
Blue warehou	?	?	+		+	+
Elephantfish	?					
Gemfish						S
Giant stargazer						
Grey mullet						
Hapuku						
Hake	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*
Jack mack. *(T.declivis)*		?		?		?
Jack mack. *(T.nz)*	?	?	?		?	
Jack mack. *(T.s.m.)*		?		?		?
John dory	?	?		?		
Kahawai	S		S			
Kingfish	?		?		?	
Lemon sole						
Ling	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*
N.Z. sole						
Red cod	S			S		S
Red gurnard						
Rig			?			
Sand flounder						
Sea perch		?		?		?
School shark	?		?			
Silver warehou	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*
Snapper						
Spiny dogfish						
Tarakihi						
Trevally						
Yellowbelly flounder						
Yelloweyed mullet	?					

Possible ? **Literature** + **Spent** S

Ripe/Running ripe: **Occasional** **Common**

Figure 7: Summary of spawning, pupping or egg-laying distributions from the South Island. WC, west coast; North, Tasman/Golden Bay and Marlborough Sounds N.Banks, Nth of Banks Peninsula; S.Banks, Canterbury/Otago; Inner, inner shelf; Outer, outer shelf; Possible, based on the distribution of young juveniles and adults and lack of gonad sampling; ***ND*****, not determined in this study**

Species	WC		Nth	N.Banks		S. Banks	
	Inner	Outer	Inner	Inner	Outer	Inner	Outer
Arrow squid		+			+		
Banded stargazer							
Barracouta	Common	Common	Occasional	S	Occasional	S	Common
Blue cod			+			Occasional	Occasional
Blue mackerel	Occasional						
Blue moki							
Blue warehou		Common	?	?	+	?	
Elephantfish			+			Common	
Gemfish		Common					Occasional
Giant stargazer		Common	?		Common		Common
Grey mullet							
Hapuku		Occasional					Occasional
Hake	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*
Jack mack. *(T.declivis)*		Occasional	+		?		?
Jack mack. *(T.nz)*	Occasional		Occasional	?		?	
Jack mack. *(T.s.m.)*		Occasional					
John dory			?				
Kahawai	Occasional		?				
Kingfish							
Lemon sole	?		?	?		?	
Ling	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*
N.Z. sole	?		?	?		?	
Red cod	Occasional	Common	S		Occasional		Common
Red gurnard	Common	Occasional	Common	Common	Occasional	Common	Common
Rig	?		+	+		?	
Sand flounder				+		+	
Sea perch		?	?		?		?
School shark	?		?	?		?	
Silver warehou	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*
Snapper			+				
Spiny dogfish	?	?			+		+
Tarakihi	Common	Common	?		Occasional		Occasional
Trevally			?				
Yellowbelly flounder			?	+			
Yelloweyed mullet				+			

Possible ? **Literature** + **Spent** S

Ripe/Running ripe: **Occasional** **Common**

Figure 8: Summary of spawning, pupping or egg-laying distributions from Southland, the Chatham (Chat.) Rise, the Chatham Islands, and the Auckland Islands (Auck). Inner, inner shelf; Outer, outer shelf; slope, 3-600m; Possible, based on the distribution of young juveniles and adults and lack of gonad sampling; *ND*, not determined in this study

Species	Southland			Chat. Rise		Chat.Is.		Auck
	Inner	Outer	Slope	Shelf	Slope	Inner	Outer	Shelf
Arrow squid	+			+			+	+
Banded stargazer		Common					?	
Barracouta	Common	Common		Occasional		Occasional	Common	Occasional
Blue cod	Occasional	Occasional		?		?		
Blue mackerel								
Blue moki	S							
Blue warehou	Common	Common						Occasional
Elephantfish	?							
Gemfish		Occasional						
Giant stargazer	Common	Common		Common	Common		?	Common
Grey mullet								
Hapuku		Occasional			Occasional		?	?
Hake	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*
Jack mack. *(T.declivis)*		S		Occasional				
Jack mack. *(T.nz)*								
Jack mack. *(T.s.m.)*		Occasional		Occasional				Occasional
John dory								
Kingfish								
Lemon sole	?							
Ling	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*
N.Z. sole	?							
Kahawai								
Red cod	Occasional	Common		Common			?	Common
Red gurnard	Common			?		?	?	
Rig	+							
Sand flounder								
Sea perch		?			?			?
School shark	+							
Silver warehou	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*
Snapper								
Spiny dogfish		+						
Tarakihi		Common				+	+S	
Trevally								
Yellowbelly founder								
Yelloweyed mullet								

Possible ? **Literature** + **Spent** S

Ripe/Running ripe: **Occasional** (light hatching) **Common** (dark shading)