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**A summary of biological information on the New Zealand fisheries
for orange roughy (*Hoplostethus atlanticus*) for the 2000–01 fishing year**

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EXECUTIVE SUMMARY

Anderson, O.F.; Langley, A.D. (2002). A summary of biological information on the New Zealand fisheries for orange roughy (*Hoplostethus atlanticus*) for the 2000–01 fishing year.

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1. Size and reproductive data on orange roughy, collected by observers of the Ministry of Fisheries Scientific Observer Programme (SOP) and of the Orange Roughy Management Company Limited (ORMC) on New Zealand fishing vessels from 470 tows both inside and outside the New Zealand Exclusive Economic Zone during the 2000–01 fishing year, were examined and summarised by fishery. Biological data collected during a research survey in the Ritchie Banks and Wairarapa fisheries were also summarised.
2. There was a 40% decrease in SOP sampling over the previous year, but total sampling effort fell only slightly short of the requested level. Although sampling effort was severely reduced in some areas, especially ORH 1 and some of the fisheries outside New Zealand's Exclusive Economic Zone (EEZ), in other areas, such as ORH 3A and ORH 3B, sampling effort was considerably improved. Some historically important fisheries, e.g., the Chatham Rise Spawning Box and ORH 2A (North and South), were not well sampled. The ORMC programme collected a similar number of samples to that achieved in 1999–2000, with intensive sampling carried out in the Macquarie Ridge and Fiordland areas.
3. Sufficient length samples were collected to determine size frequencies for 16 fishery/season/observer programme combinations, a considerably smaller number than the previous year. These distributions are typically unimodal in most areas, but mean lengths calculated from the samples were variable, ranging from 27.9 to 39.9 cm for males and 29.0 to 41.4 cm for females. Fish from the Louisville Ridge fishery were larger and fish from Kaikoura were smaller, on average, than those from other areas. The size distributions derived from trawl survey data indicated considerable differences in size structure of fish in large spawning aggregations compared with fish in background areas in the Ritchie Banks area.
4. Sex ratios calculated from scaled size frequency data did not indicate a strong dominance of one sex over the other in the observer samples as a whole, with most of the ratios calculated within 10 percentage points of 50%, although in the Macquarie Ridge pre-spawning fishery male fish accounted for an estimated 79% of the fish caught.
5. Sampling during the spawning period of orange roughy was limited, but what data were collected showed the expected seasonal patterns with spawning activity occurring mostly in June and July. In the Ritchie Banks fishery, the spawning season was well described by the research data collected, and indicated that the survey timing was well matched to the spawning activity of orange roughy in the area.

1. INTRODUCTION

This report documents the results of objective 3 of the Ministry of Fisheries (MFish) project ORH2001/02 "Orange roughy stock assessment", and objective 3 of MFish project ORH2001/03 "Stock assessment of orange roughy fisheries outside the New Zealand EEZ" which both state:

"To analyse length frequency, sex ratio, and reproductive data for orange roughy collected by the Scientific Observer Programme (SOP) and from other sources during the 2000–01 fishing year for input into stock assessment models."

Biological data collected by observers can be important inputs to stock assessment of orange roughy in New Zealand. This is especially true for areas where there are no independent estimates of biological parameters such as age at recruitment or age at maturity, or of changes in population size structure over time, available from research surveys. These parameters can be derived from observer-collected size and reproductive stage information where data meet certain requirements that minimise any bias associated with commercial fishing operations, such as non-random sample selection or lack of comparability (Francis & Tracey 2000). Such information from observer data has been used as stock assessment inputs in New Zealand fisheries on the Lord Howe Rise, the northeast Chatham Rise, and the East Cape hills (Clark & Tilzey 1996, Hilborn et al. 2000a, 2000b). Reproductive stage data collected by observers are also important for examining trends such as changes in timing and location of spawning activity (e.g., Smith et al. in press). Changes in mean length over time have been used to identify areas of heavy exploitation and provide clues to recruitment patterns (Francis & Smith 1995). Sex ratio information can be used to determine a selectivity bias in a fishery (Francis 1996).

This report presents summaries of orange roughy size and reproductive state data collected from fisheries throughout the New Zealand Exclusive Economic Zone (EEZ) (project ORH2001/02), and from several fisheries outside the EEZ (project ORH2001/03), during the 2000–01 fishing year. These summaries are constructed and presented in a manner consistent with that used in previous analyses of orange roughy biological data (Anderson et al. 1998, Anderson 1999, 2000, 2001, Langley 2001) to provide a means of quickly identifying and obtaining data for input into stock assessment models.

Summaries of biological data collected during a research trawl survey in the Ritchie Banks and Wairarapa fisheries are given here, but most length and gonad stage data presented come from observers, either those employed by the MFish SOP or industry observers collecting data under the direction of the Orange Roughy Management Company Limited (ORMC). In this document we use the abbreviations SOP and ORM to distinguish between data from the MFish and industry programmes, respectively. Through these two complementary programmes, observer data were available from most of the major orange roughy fisheries in the New Zealand region.

2. DATA SOURCES

Orange roughy biological data were collected by SOP observers hosted aboard commercial fishing vessels. Observers took measurements from random samples of about 100 fish per trawl, from up to eight trawls a day. The standard length (SL) and sex of these fish, and reproductive condition of female fish, were recorded along with the weight of the sample and of the entire orange roughy catch. These data are managed by staff at NIWA, Greta Point, and held on the Empress *obs_lfs* database (Sanders & Mackay 1999).

Since 1996–97, orange roughy biological data have also been collected through a second, industry managed, sampling programme which has focussed mainly on Exploratory Fishing Areas within

ORH 3B (Langley 2001). For each day of fishing, the sampling programme collects biological data from the orange roughy catch from a randomly selected commercial trawl¹, and generally follows the procedures used by SOP observers. In the past, the data collected by this programme have been summarised in a separate report (e.g., Langley 2001), but for this year all data have been amalgamated to provide a complete summary of the available data from 2000–01. A copy of the ORM data has been incorporated in the *obs_ifs* database and is therefore stored in the same place and format as the SOP data.

Australian observers were also present on Australian vessels during an industry survey of the orange roughy spawning aggregation on the South Tasman Rise during July and August 2001. These observers collected orange roughy length and maturity data from several trawls a day between 27 July and 7 August. Additional data were collected from shed sampling during a break in the survey between 31 July and 5 August. A brief summary of these data is included in this report.

Biological data from a two-vessel research survey of orange roughy in ORH 2A South and ORH 2B in June and July 2001 (NIWA surveys TAN0109 and TVI0101) are also presented. These data are held at NIWA, Greta Point, on the *Empress trawl* database (Mackay 2000).

3. METHODS

The SOP records and manages data according to broad areas based on Fishery Management Areas (Figure 1). For this summary, data were arranged by Quota Management Area (QMA) or by recognised fisheries within each QMA where there were sufficient data to produce meaningful size frequencies, and by recognised fisheries outside the EEZ (see Figures 2 and 3). These fishery areas are comparable to those used in previous analyses (Anderson et al. 1998, Anderson 1999, 2000, 2001, Langley 2001).

All data were error checked before being added to the databases, and again before any analyses were begun. Tow positions were plotted to identify any outliers or impossible tow sequences caused by misrecording of position, and length and catch data were checked for irregularities.

Catch and effort data from the orange roughy commercial fisheries were summarised to determine the level of observer coverage achieved in each of the main fisheries in 2000–01. Coverage was determined based on the proportion of the total catch observed in each fishery. These data came from extracts from MFish databases held on the *Empress* database *dw_cdb* at NIWA, Greta Point. The level of SOP coverage, in number of days, was also compared to the level of coverage scheduled for each fishery by the Ministry of Fisheries.

3.1 Size structure

Length frequency distributions were determined from the SOP and ORM sampling data for each fishery/season/sampling programme where at least five tows were sampled and more than 400 fish measured. Samples were combined when they were entirely outside, or entirely within, the period June–August inclusive, to approximate non-spawning season and spawning season sampling respectively. Size frequencies were scaled according to the fraction of the catch sampled for that tow to be representative of the total catch sampled. The sample weight was not recorded by ORM samplers and occasionally not recorded by SOP observers. For these samples, the sample weight was estimated by applying the standard orange roughy length-weight function (Annala et al. 2001) to the length frequency from the sample. For each length frequency prepared, sex ratios (percentage male)

¹ For a complete description of the sampling protocols used by industry observers collecting orange roughy biological data, see the report by Langley (2001).

and the mean length of male and female fish (with standard deviations) were calculated from the combined length composition.

In the research survey of the mid-east coast orange roughy fishery, three sub-surveys or "snapshots" were carried out over "main" and "background" areas within ORH 2A South (Ritchie Banks), and a few trawls were also carried out in ORH 2B (Wairarapa). Trawls for mark identification and species mix complemented acoustic transects in each area. Size frequency plots were prepared for each of the two areas ("main" and "background"), with size data from Wairarapa trawls plotted separately, combining data from all snapshots. Length data were scaled by the catch weight of orange roughy in each trawl.

3.2 Reproduction

Due to difficulties in interpretation of the macroscopic stages of male orange roughy, observers examined gonads only from female fish. These were checked for reproductive state and assigned to one of the following (macroscopic) categories.

- F1 Immature to early maturation
- F2 Maturing
- F3 Ripe
- F4 Running ripe
- F5 Spent

These categories are different from the eight categories used for orange roughy by NIWA research staff.

Gonad staging data were aggregated by month and fishery area and the proportion of female fish in each gonad stage was determined.

The reproductive states of female fish were examined to determine where and when spawning activity was occurring. Where time series data through the spawning period were available, plots can be created to examine the progression of spawning with a curve ("Lowess"; Cleveland 1985) fitted to the data points. Gonad stage data from the mid-east coast survey was collected during the spawning period and the gonad state progression over time was plotted for both sexes.

4. RESULTS

4.1 Distribution of samples

Scientific Observer Programme observers sampled 406 catches of orange roughy collected during 22 voyages with the number of samples per voyage ranging between 1 and 66 (median 11). The number of samples was less than scheduled in some areas, especially in ORH 1, ORH 2A South, and to a lesser extent the Louisville Ridge. In other areas the number of samples collected was greater than requested, especially ORH 3A, and southern areas of ORH 3B. Overall, the number of SOP observer samples was about one third less than in the previous year, and was at a similar level to that in the 1998–99 fishing year (Table 1).

ORM observers examined 64 samples of orange roughy from 13 voyages. The number of samples per voyage varied between 1 and 12 (median 3). This is similar to the level of sampling achieved by this programme in the previous fishing year when 57 samples were taken (Langley 2001).

Monthly totals arranged by SOP area, ORH 3B fisheries, and other fisheries are shown in Table 2. Nearly half the SOP samples (190) came from the SOE (Chatham Rise) area and a further 65 samples were from the SOU area (southern ORH 3B). SOP sampling on the Chatham Rise covered the northwest, east, and south Rise fisheries, but only three samples were collected from the Spawning Box fishery. In southern areas, most of the SOP samples came from off the coast of Fiordland, a new fishery from which samples have not previously been collected. Most SOP sampling was carried out before the spawning season and few samples were collected after June.

Outside the EEZ, a number of samples were collected from two voyages to the Louisville Ridge area, before and during the spawning period, and from two voyages to the northwest Challenger fishery in March and April. In the South Tasman Rise fishery Australian observers collected samples of orange roughy from 43 trawls, measuring up to 250 fish per trawl, on two vessels involved in an industry survey during the spawning period.

Sampling by ORM observers was confined to fisheries within ORH 3B, particularly the Sub-Antarctic area (south of 46° S), principally the Macquarie Ridge, and off Fiordland. A few samples were also collected from the east and southeast Chatham Rise.

The positions of all tows from which samples were collected (both SOP and ORM) are shown in Figures 2 and 3. These figures also show the positions of all tows that caught orange roughy in the 2000–01 fishing year, according to TCEPR returns. The number of samples collected within the EEZ north of the Chatham Rise was very low relative to the level of fishing effort, with only a few samples collected from the East Cape and ORH 2A South fisheries. In contrast, outside the EEZ there was a good spread of samples in the northwest Challenger, Lord Howe, and Louisville (not shown) fisheries. A few samples were collected from the Cook Canyon fishery, although these were restricted mostly to the northeast region of that area.

In Fiordland a large number of samples were collected from a relatively small area, by observers of both the SOP and ORM programmes. For reasons of confidentiality, the trawl positions and the locations of the samples taken from the Fiordland area are not presented. On the Chatham Rise all the main fisheries were well covered, except the Spawning Box, with samples spread out fairly evenly over the known grounds. On the southeast and east Chatham Rise there was a mixture of SOP and ORM sampling, and sampling coverage was concentrated around the Andes and Smiths City hill complexes (Figure 3). Samples were collected from the main area fished on the Arrow Plateau.

Good spatial coverage was also achieved over most of the extent of the ORH 3A (Kaikoura) fishery. In southern regions of ORH 3B, ORM observers collected a large number of samples from the Macquarie Ridge area and both ORM and SOP observers sampled the Southland and Bounty Platform fisheries moderately well. However, only a few samples were collected from each of the other recognised fisheries in the southern region although fishing effort and catch in these areas was relatively low.

Sample weight totals, observed catch totals, and total catch are summarised by fishery to provide a quantitative measure of the proportion of each fishery covered by SOP observers (Table 3) and ORM observers (Table 4). This confirms the good coverage of the fisheries on the Chatham Rise, where between 16 and 26% of the total catch was sampled in the east, southwest, and southeast fisheries. A relatively large fraction of the fishery catch was also sampled in Kaikoura, Fiordland, and the Louisville Ridge. ORM observers achieved very high coverage of the total fishing effort in the Arrow Plateau (58%) and Macquarie Ridge (33%) fisheries.

Only a small proportion of the total orange roughy catch from the other fishery areas was sampled. Only 10 t of catch was sampled from the ORH 2A (North and South) and ORH 2B fisheries

combined, less than 1% of the spawning box fishery was sampled, and no samples were collected from the ORH 1 fishery.

The locations of research trawl stations in the mid-east coast survey are shown in Figure 4. The biological data available from this survey complement the relatively small amount of observer data available from this area, where only six tows were sampled. More than 50 research tows were made in the ORH 2A South area, which was categorised into "main" spawning features and "background" areas. Seven tows were also carried out in the Wairarapa fishery (ORH 2B).

A summary of the number of trawls sampled, weight of samples, and weight of catch of orange roughy from the survey is presented in Table 5, along with sex ratios and mean lengths by area. Over 3300 fish were measured from a catch of 57 t of orange roughy in the "main" area, and about 1500 fish were measured in each of the other two areas. In the "background" area, because most of the catches were small, almost 90% of the orange roughy catch was measured.

4.2 Size structure and sex ratios

Length frequency distributions by sex from SOP samples are given in Figure 5. Strong unimodal distributions by sex, typical for orange roughy size structures, were found for most areas, e.g., east Chatham Rise (Figures 5b, c). A few areas, however, showed broader size distributions with a less well-defined peak, e.g., Fiordland (Figure 5f) and southwest Chatham Rise (Figure 5d). More spiky distributions are evident for areas where sample sizes were smaller, e.g., Ritchie (Figure 5g). On the east Chatham Rise and Louisville Ridge, fish sampled during the spawning months showed a generally similar size distribution to those sampled pre-spawning, with similar mean sizes and sex ratios (Figures 5b, c, k, l).

Length frequency distributions from ORM samples are presented for four area/periods (Figure 6). On the east Chatham Rise the distribution shows a similar shape to that shown for SOP data, with a strong unimodal shape and narrow size range, and similar mean lengths and sex ratios. Distributions are shown for both the pre-spawning and spawning periods for the Macquarie Ridge fishery and these show a similar general shape, with only slightly greater mean lengths during the spawning months, but the sex ratio strongly favoured male fish in the pre-spawning samples. Fish sampled in this area had generally a greater mean size than those from most other areas. The distribution of Fiordland fish sizes shows a strong spike at about 30 cm, particularly for males. Closer examination of the raw data shows this to be due to the effect of a combination of possible rounding of measured lengths and the influence of larger catches, causing the scaling process to magnify the size mode.

Few fish smaller than 20 cm were measured by either observer programme, but in some areas there was evidence of a proportion of the population in the 20–25 cm length range. These included Kaikoura (Figure 5h), Fiordland (Figures 5f & 6d), and the southwest Chatham Rise (Figure 5d).

Where size frequency data were collected from the same area and period by both SOP and ORM observers, they appeared comparable in terms of the shape of the distribution and the mean lengths and so some combined SOP/ORM data size distributions were prepared (Figure 7). The few additional ORM samples added to the plots for the northwest and southeast Chatham Rise (Figures 7a, c) make little difference to the shape of the distributions shown in the plots from SOP data only (see Figures 5a, e), but allow an increase in the sample size. All three east Rise figures (see Figures 5b, 6a, 7b) show a similar shape, and the sample size is increased to 87 samples and 6831 measured fish. The spike in the size distribution in the ORM figure for Fiordland fish (see Figure 6d) is absorbed into the combined SOP/ORM distribution and has little influence in the overall shape (Figure 7d).

Mean lengths of fish from the Kaikoura fishery were considerably shorter than from other areas. The mean lengths of male and female fish were 27.9 cm and 29.0 cm respectively, compared to a range of 30.6–39.9 cm (male) and 32.2–41.4 cm (female) elsewhere (Tables 6 and 7). The largest fish sampled were from the Louisville Ridge fishery. Samples taken from there during both the pre-spawning and spawning periods showed greater mean lengths of both sexes than the other fisheries examined here.

Sex ratios, based on scaled size frequency data, ranged from 36.9% male (southwest Chatham Rise pre-spawning) to 78.8% male (Macquarie Ridge pre-spawning). Overall there was a bias in the sex ratios in favour of females with 10 of the 16 fishery/area combinations showing a higher proportion of females. Most of the sex ratios were close to 50:50, however, with 8 of the 16 calculated being within 5 percentage points of 50% male, and only four of the ratios calculated more than 10 percentage points from 50% male.

Length frequency distributions (scaled to orange roughy catch) were prepared for each day of sampling in the South Tasman Rise survey (Prince & Diver 2002) between 27 July and 7 August 2001. These distributions provided no evidence of a change in size structure during this period, but the sex ratio varied somewhat with an even mix of male and female fish early in the survey becoming increasingly biased towards male fish after 29 July. Mean lengths were not presented by Prince & Diver (2002), but the figures generally show unimodal distributions with peaks at about 35–36 cm (males) and 38–39 cm (females). These lengths and also the male bias are in agreement with data collected by SOP observers in the 1999–2000 fishing year (Anderson 2001).

Additional scaled length frequency distributions are presented from the research survey of the mid-east coast fishery, prepared separately for the “main” survey areas, the “background” areas, and Wairarapa area (Figure 8). The main area comprised the main spawning features between Ritchie Hill and the Rock Garden, the background area comprised the remainder of the ORH 2A South fishery, and the Wairarapa area comprised all tows in ORH 2B. To provide an overall picture of the size structure in each area, data from each of the three snapshots carried out were combined. Trawls in the “main” area targeted fish marks, those in the “background” were at randomly chosen locations, and those in the Wairarapa were a combination of target and random trawls. Over 6000 fish were measured from 59 tows. In the “main” area the distributions were unimodal and were dominated by male fish (over 70%, see also Table 5). Fish of both sexes were of a moderate size with mean lengths consistent with those derived from previous research. There was a much wider distribution of fish lengths in the “background” area, male fish were less predominant (33%), and mean lengths of both sexes were considerably smaller. The mean lengths of the fish and the shape of the size structure in the Wairarapa area fell in between those of the other two areas, and male fish made up about 40% of the fish caught.

4.3 Reproduction

The spawning months (June and July) were not well covered by observers in most areas in 2001. Where samples were taken in these months, ripe, running ripe, and spent fish were usually present (Tables 8 & 9). Fish in spawning condition were observed in the Spawning Box, the east Chatham Rise, the southeast Rise, the Arrow Plateau, Fiordland, and the Louisville Ridge in June. In contrast, samples collected in Cook Canyon and on the Macquarie Ridge in June did not include any ripe fish. Despite this, numbers of spent fish were observed on the Macquarie Ridge (as well as the Auckland Islands) in September, and in northwest Challenger in October.

Observer coverage by the SOP and ORM programmes was insufficient during the spawning period in any area to determine with any precision the timing of the progression of spawning from changes in the relative proportions of gonad stages. However, gonad stage data collected from the South Tasman Rise (Australian) industry survey showed an increase in the proportion of running ripe female orange

roughly at the end of July and beginning of August, reaching a peak on 2–4 August (Prince & Diver 2001). The proportion of spent female fish increased after the beginning of August, to about 12% by 7 August. This timing is later than in other New Zealand fisheries, but is consistent with the known spawning period of orange roughy in that fishery, and with data collected in previous years by the SOP (see Anderson 1999, 2001).

The large amount of reproductive data gathered during the mid-east coast research survey indicated that the onset of spawning, the point at which 20% of fish were spent (after Pankhurst 1988), occurred near the start of the survey, about 24 June (Figure 9). This timing is a few days earlier than shown for the 1995 spawning from observer data (authors' unpublished data).

5. SUMMARY

Observer coverage. The trend in recent years of increasing numbers of samples collected by SOP observers ceased this year, with the number of samples 40% less than in the previous year and also falling short of the total requested number of samples for the year. The area most affected was ORH 1 where no samples were collected in 2000–01 compared to 224 in 1999–2000 (see Table 1 and Anderson 2001). Due to the absence of New Zealand vessels no samples were collected from the South Tasman Rise either (compared with 94 samples in 1999–2000), and the sample count in the Lord Howe and northwest Challenger fisheries was halved. Increases in sampling were seen on the Chatham Rise, in southern regions of ORH 3B, in ORH 3A, and on the Louisville Ridge. Sampling by ORM observers was restricted to ORH 3B, with most of the samples taken from trawls in the Macquarie Ridge, Fiordland, and East Chatham Rise fisheries.

The level of sampling coverage was sufficient to determine length frequency distributions of orange roughy in 11 separate areas. This included most of the main orange roughy fisheries, although insufficient data were available to determine the length composition of the catch from some important fisheries, notably the Chatham Rise Spawning Box, the East Cape hills, and ORH 1.

For most of the fisheries, the spatial coverage of the sampled trawls was broadly consistent with the distribution of the entire fishery. The effect of season on size structure was not investigated in detail. However, the stratification of samples into pre-spawning and spawning periods will minimise the effect of any strong seasonal change in length composition.

Research coverage. The amount of biological data available from research surveys was less than has been available in recent years (see Anderson 1999, 2000, 2001) with only one, acoustic based, survey carried out. However, data from this survey were valuable and were sufficient to allow a close examination of the size structure and spawning periodicity of orange roughy in an area poorly covered by observers in this fishing year.

Size structure. Size structure was examined in 12 fishery/period combinations available from SOP data, down from 20 in 1999–2000. Size structure in a further 4 fishery/area combinations was available from ORM data, some of which overlapped with SOP sampling. Intensive sampling was carried out in some areas, with 87 samples and 6831 (pre-spawning) fish measured on the east Chatham Rise fishery and 71 samples and 3714 (pre-spawning) fish measured on the newly developed Fiordland fishery. Mean lengths, calculated from scaled size frequencies, varied between areas. Mean lengths of fish in the Louisville Ridge fishery were about 9 cm more (both sexes) than those of fish in Kaikoura, during the same time period. An increase in mean length of fish of both sexes in samples collected during the spawning months, over those collected beforehand, was apparent in the Louisville Ridge and Macquarie Ridge fisheries, but only for female fish in the East Chatham Rise fishery. There were few extreme sex ratios observed, although 78.8% of fish sampled

in the pre-spawning Macquarie Ridge fishery were male. Overall, sex ratios more often showed a dominance of female fish in the samples.

Reproduction. Gonad stage data sufficient for tracking the progress of spawning in the winter of 2001 were not available from observer sampling in any area. Gonad stage data were available from the mid-east coast research survey, however, and this showed that orange roughy spawning was taking place throughout the survey with the onset of spawning on the Ritchie Banks estimated at about 24 June, a date similar to that identified for the 1995 spawning in this area. Gonad stage data were also available for female fish from the spawning period in the South Tasman Rise fishery. This indicated that running ripe fish were present in late August and early July.

The collection of these data adds to a growing resource of biological information on orange roughy, which is increasingly being incorporated into the stock assessment process. It is important that the SOP programme continues to collect data at the level of recent years, with an emphasis on attaining a more even spread of sampling throughout the main fisheries. The ORM programme plays a crucial role with collection of data from exploratory areas, but has the potential to expand considerably and it is vital that the momentum gained in this programme over the past few years is maintained.

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Table 1: Comparison of expected and actual number of SOP orange roughly biological samples processed in 2000-01, actual number of SOP samples processed in the previous two fishing years, and number of ORM samples processed in 2000-01.

Area	Number of samples				
	Expected*	Actual	Actual	SOP	ORM
	2000-01	2000-01	1999-2000	1998-99	2000-01
ORH 3B					
Chatham Rise	220	208	129	70	12
South of 46° S/Arrow Plateau	40	82	23	20	52
ORH 2A					
North	0	2	4	5	0
South	40	5	35	22	0
ORH 2B	0	1	7	4	0
ORH 3A	0	19	5	18	0
ORH 7A	0	0	2	103	0
ORH 1	20	0	224	60	0
ORH 10	0	0	0	0	0
ORH 7B	0	7	18	1	0
ET					
Lord Howe/NW Challenger	60	55	110	36	0
Louisville Ridge	60	27	0	0	0
South Tasman Rise	0	0	94	63	0
Total	440	406	651	402	64

*MFish research summary tender document figures

Table 2: Number of SOP/ORM orange roughy biological samples by area and month for 2000–01, with the total number of samples and voyages in each area (see Figures 1 to 3 for area boundaries).

Summary by SOP area

Area	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	Voyages
CEE	–	8	–	–	–	–	–	–	–	–	–	–	8/0	1/0
CET	–	–	–	–	–	23	19	–	–	–	–	–	42/0	2/0
CHA	–	–	–	–	–	–	–	1	–	6	–	–	7/0	3/0
HOWE	6	–	–	–	–	6	–	–	–	–	–	–	12/0	2/0
SEC	3	9	9	18	1	–	1	3/2	–	–	–	–	44/2	10/1
SOE	32	61	6/8	5/3	36/1	2/2	24	0/2	24	–	–	–	190/16	7/5
SOI	–	–	–	–	–	–	–	–	–	–	–	0/1	0/1	0/1
SOU	–	–	–	0/7	0/8	7/2	–	52/2	6/1	–	–	0/2	65/22	2/4
SUB	–	0/9	–	–	0/1	–	0/2	11/6	0/4	–	–	0/1	11/23	1/7
LOUR	–	–	–	–	14	–	–	–	13	–	–	–	27/0	2/0
ALL	41/0	78/9	15/8	23/10	51/10	38/4	44/2	67/12	43/5	6/0	–	0/4	406/64	22/13

Summary by sub-area of ORH 3B

Area	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	Voyages
Spawning Box	–	–	–	–	–	–	–	–	3	–	–	–	3/0	1/0
NW Rise	3	20	6	0/1	4	–	8	–	–	–	–	–	41/1	7/1
East Rise	21	40	0/5	2/2	16	0/1	–	–	12	–	–	–	91/8	4/3
SW Rise	3	–	3	8	1	2	13	–	–	–	–	–	30/0	7/0
SE Rise	7	6	1/3	3	16	–	3	–	7	–	–	–	43/3	5/1
Arrow Plateau	–	–	–	–	0/1	0/1	–	0/2	2	–	–	–	2/4	1/3
Southland	–	–	–	–	–	–	1	3/2	–	–	–	–	4/2	3/1
Snares	–	–	–	–	–	–	–	0/1	–	–	–	0/1	0/2	0/2
Antipodes	–	–	–	–	–	–	–	2	–	–	–	–	2/0	1/0
Auckland Is.	–	–	–	–	–	–	–	–	–	–	–	0/1	0/1	0/1
Bounty Is.	–	–	–	–	0/1	–	–	6	–	–	–	–	6/1	1/1
Macquarie	–	0/9	–	–	0/3	0/1	0/2	0/7	0/5	–	–	0/2	0/29	0/8
Pukaki	–	–	–	–	–	–	–	3	–	–	–	–	3/0	1/0
Puysegur	–	–	–	–	–	0/1	–	–	–	–	–	–	0/1	0/1
Fiordland	–	–	–	0/7	0/5	7	–	52	6	–	–	–	65/12	2/1
ALL	34/0	66/9	10/8	13/10	37/10	9/4	25/2	66/12	30/5	–	–	0/4	290/64	15/13

Summary for other areas

East Cape	–	2	–	–	–	–	–	–	–	–	–	–	2/0	1/0
Ritchie	–	5	–	–	–	–	–	–	–	–	–	–	5/0	1/0
Wairarapa	–	1	–	–	–	–	–	–	–	–	–	–	1/0	1/0
ORH 3A	–	4	5	10	–	–	–	–	–	–	–	–	19/0	4/0
Cook Canyon	–	–	–	–	–	–	–	1	–	6	–	–	7/0	4/0
Lord Howe (ET)	6	–	–	–	–	6	–	–	–	–	–	–	12/0	2/0
NW Challenger (ET)	1	–	–	–	–	23	19	–	–	–	–	–	43/0	2/0
Louisville Ridge (ET)	–	–	–	–	14	–	–	–	13	–	–	–	27/0	2/0
ALL	7/0	12/0	5/0	10/0	14/0	29/0	19/0	1/0	13/0	6/0	–	–	116/0	12/0

Table 3: Summary of number and weight of samples taken by SOP observers relative to the observed catch and estimated total catch in the fishery, 2000–01; observed catch totals are based on the areas defined in Figures 2 and 3, fishery catch totals are derived from estimated catches recorded on TCEPR forms and are approximate only.

Area	No. tows sampled	Weight of samples (kg)	Catch (t)		Percentage of fishery observed
			observed	fishery	
ORH 2A					
East Cape	2	119	2	291	1
Ritchie	5	472	4	727	1
ORH 2B (Wairarapa)	1	112	3	146	2
ORH 3A (Kaikoura)	19	1 035	60	376	16
ORH 3B					
Chatham Rise					
Spawning Box	3	177	6	1 205	<1
NW Rise	41	2 939	83	2 478	3
East Rise	91	8 137	362	2 203	16
SW Rise	30	810	8	44	18
SE Rise	43	3 756	422	1 614	26
Southern/Arrow Plateau					
Southland	4	76	<1	1	
Arrow Plateau	2	152	7	184	4
Antipodes	2	10	<1	<1	
Fiordland	65	2 830	150	484	31
Bounty	6	42	<1	150	<1
Pukaki	3	20	<1	45	<1
ORH 7B (Cook Canyon)	7	58	<1	40	<1
ORH ET					
Lord Howe	12	922	3	149	2
NW Challenger	43	3 234	29	946	3
Louisville Ridge	27	4 782	217	1 363	16

Table 4: Summary of number and weight of samples taken by ORM observers relative to the observed catch, and estimated total catch in the fishery, 2000–01; observed catch totals are based on the areas defined in Figures 2 and 3, fishery catch totals are derived from estimated catches recorded on TCEPR forms and are approximate only.

Area	No. tows sampled	Weight of samples ¹ (kg)	Catch (t)		Percentage of fishery observed
			Observed	fishery	
ORH 3B					
Chatham Rise					
NW Rise	1	120	<1	2 478	<1
East Rise	8	1 356	106	2 203	5
SE Rise	3	455	33	1 614	2
Southern/Arrow Plateau					
Southland	2	378	<1	1	
Arrow Plateau	4	961	107	184	58
Macquarie	29	5 864	171	511	33
Fiordland	12	2 537	17	484	4
Bounty	1	127	1	150	1
Auckland Is.	1	148	8	82	10
Puysegur	1	64	<1	34	1
Snares	2	493	3	24	13

¹Sample weights estimated from length frequency and L-W function

Table 5: Summary of number and weight of orange roughy samples, weight of orange roughy catch, number of fish measured, sex ratios, and mean lengths from the mid-east coast research survey in June and July 2001.

Area	No. tows sampled	Weight of samples (kg)	Weight of catch (kg)	No. fish measured	Sex ratio (%male)	Mean length (cm)	
						Male	Female
Main	35	4 274	57 584	3 306	70.4	33.8	35.8
Background	17	1 498	1 689	1 519	33.3	26.9	31.2
Wairarapa	7	1 462	7 366	1 420	39.8	29.9	32.6

Table 6: Summary of mean lengths and sex ratios (% male) by fishery and reproductive period, and total catch (t) from which length data were selected, from SOP samples.

Area	Period	Number measured			Sex ratio (%male) (scaled)	Total catch (t)	Scaled Mean length (s.d.)	
		Male	Female	Total			Male	Female
NW Rise	pre-spawning	1 404	1 003	2 407	62.6	83	32.7 (3.1)	34.3 (3.1)
East Rise	pre-spawning	2 944	3 083	6 027	48.7	303	34.3 (2.5)	35.4 (2.7)
East Rise	spawning	318	353	671	45.2	57	34.3 (2.7)	36.1 (3.1)
SW Rise	pre-spawning	248	376	625	36.9	7	33.5 (4.7)	35.6 (4.6)
SE Rise	pre-spawning	1 357	1 581	2 940	45.4	418	33.6 (3.0)	34.5 (3.6)
Fiordland	pre-spawning	1 283	1 157	2 444	49.1	129	31.2 (4.2)	32.8 (4.4)
Ritchie	pre-spawning	175	230	405	45.3	4	31.8 (3.7)	33.8 (4.3)
Kaikoura	pre-spawning	711	726	1 444	50.7	59	27.9 (3.2)	29.0 (4.0)
Lord Howe	pre-spawning	221	339	560	39.5	3	34.6 (4.4)	37.0 (4.7)
NW Challenger	pre-spawning	1 511	1 616	3 127	48.4	28	30.6 (2.9)	32.2 (3.1)
Louisville Ridge	pre-spawning	473	535	1 008	40.7	36	37.1 (3.6)	38.0 (4.0)
Louisville Ridge	spawning	790	569	1 359	59.3	179	39.9 (3.1)	41.4 (3.3)

Table 7: Summary of mean lengths and sex ratios (% male) by fishery and reproductive period, and total catch (t) from which length data were selected, from ORM samples.

Area	Period	Number measured			Sex ratio (%male) (scaled)	Total catch (t)	Scaled Mean length (s.d.)	
		Male	Female	Total			Male	Female
East Rise	pre-spawning	366	435	804	41.9	105	33.8 (2.4)	34.7 (2.6)
Macquarie	pre-spawning	1 314	710	2 024	78.8	130	36.6 (3.1)	38.8 (3.6)
Macquarie	spawning	247	253	500	53.1	40	37.1 (2.7)	39.1 (3.1)
Fiordland	pre-spawning	772	498	1 270	66.9	17	30.9 (4.2)	33.9 (3.9)

Table 8: Percentage of female orange roughy at each gonad stage in each sub-area and month, from SOP data. Only months in which at least 30 fish were staged are reported (see section 3.2 for a description of the stage categories).

Area	Month	Percentage at stage					Number staged
		F1	F2	F3	F4	F5	
East Cape	Nov	53	47	0	0	0	86
Ritchie Banks	Nov	40	58	0	2	0	230
Wairarapa	Nov	13	88	0	0	0	48
Kaikoura	Jan	76	24	0	0	0	418
	Nov	72	28	0	0	0	187
	Dec	61	38	0	0	0	121
Spawning box	Jun	2	93	5	0	0	60
NW Rise	Feb	2	98	0	0	0	119
	Apr	25	13	58	4	0	244
	Oct	29	69	3	0	0	108
	Nov	13	79	7	1	0	384
	Dec	18	82	0	0	0	148
East Rise	Jan	2	98	0	0	0	42
	Feb	13	87	0	0	0	725
	Jun	16	59	2	17	6	353
	Oct	14	86	0	0	0	758
	Nov	15	85	0	0	0	1 558
SW Rise	Mar	9	88	3	0	0	118
	Apr	18	43	33	5	0	213
	Dec	36	61	3	0	0	33
SE Rise	Jan	8	90	0	0	2	97
	Feb	8	92	0	0	0	733
	Apr	21	42	36	0	0	99
	Jun	66	27	2	0	5	83
	Oct	32	68	0	0	0	299
	Nov	27	72	0	1	0	301
	Dec	73	25	0	0	2	52
Arrow Plateau	Jun	2	85	13	0	0	55
Southland	Apr	63	20	12	4	0	49
Fiordland	Mar	56	42	2	0	0	145
	May	51	41	8	0	0	1 012
	Jun	36	54	8	1	1	153
Cook Canyon	Jul	98	2	0	0	0	92
Lord Howe	Mar	30	70	0	0	0	179
	Oct	23	74	2	0	2	160
NW Challenger	Mar	38	62	0	0	0	812
	Apr	35	65	0	0	0	762
	Oct	38	48	2	0	12	42
Louisville Ridge	Feb	2	98	0	0	0	535
	Jun	0	3	63	32	2	569

Table 9: Percentage of female orange roughy at each gonad stage in each sub-area and month, from ORM data. Only months in which at least 30 fish were staged are reported.

Area	Month	Percentage at stage					Number staged
		F1	F2	F3	F4	F5	
NW Rise	Jan	15	75	9	0	0	53
East Rise	Jan	35	65	0	0	0	118
	Mar	7	95	0	0	0	44
	Dec	19	80	1	0	0	273
SE Rise	Dec	22	76	2	0	0	168
Arrow Plateau	Feb	5	95	0	0	0	65
	Mar	0	86	8	0	0	49
	May	4	95	1	0	0	115
Auckland Is.	Sep	0	0	0	0	100	55
Bounty	Feb	25	75	0	0	0	57
Macquarie	Feb	0	100	0	0	0	121
	Mar	0	100	0	0	0	41
	Apr	0	100	0	0	0	69
	May	3	97	0	0	0	299
	Jun	0	100	0	0	0	253
	Sep	50	0	0	0	50	52
	Nov	7	87	6	0	0	180
Puysegur	Mar	55	45	0	0	0	58
Snares	May	1	99	0	0	0	76
	Sep	100	0	0	0	0	48
Fiordland	Jan	37	62	2	0	0	298
	Feb	37	63	1	0	0	200

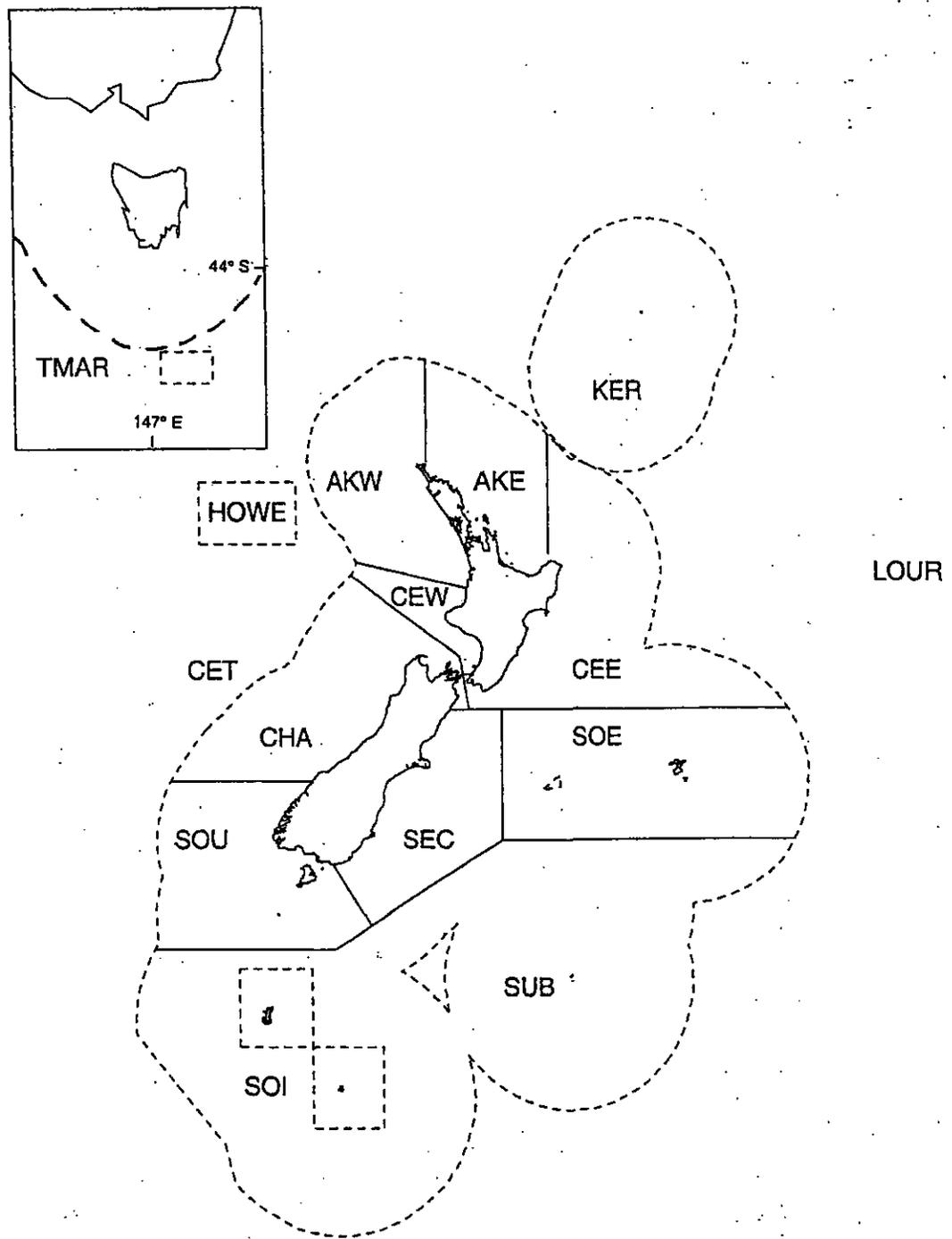


Figure 1: Scientific Observer Programme management areas.

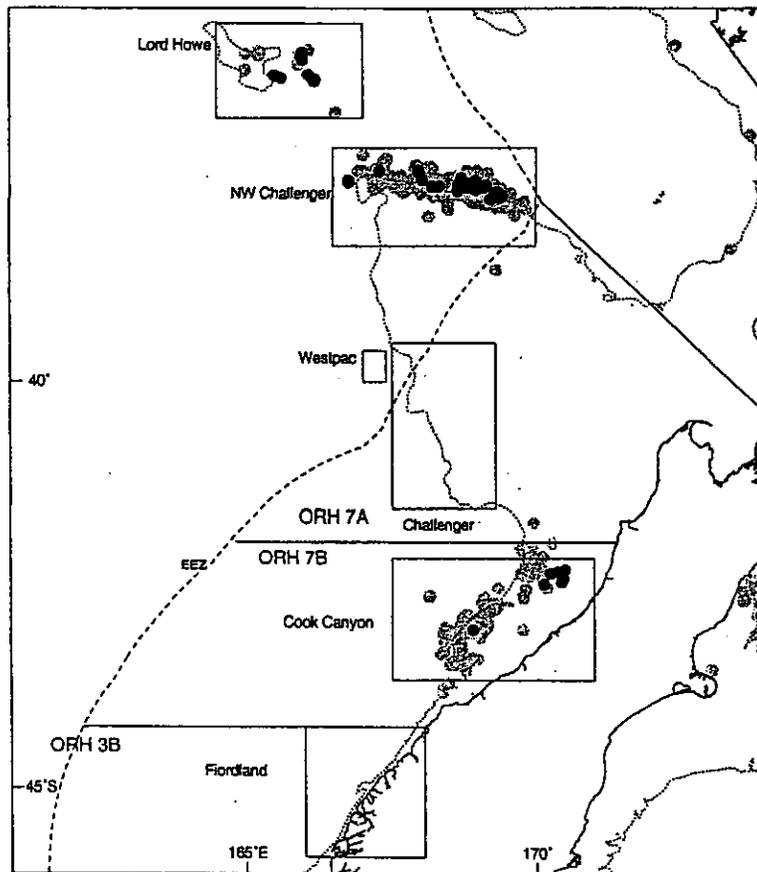
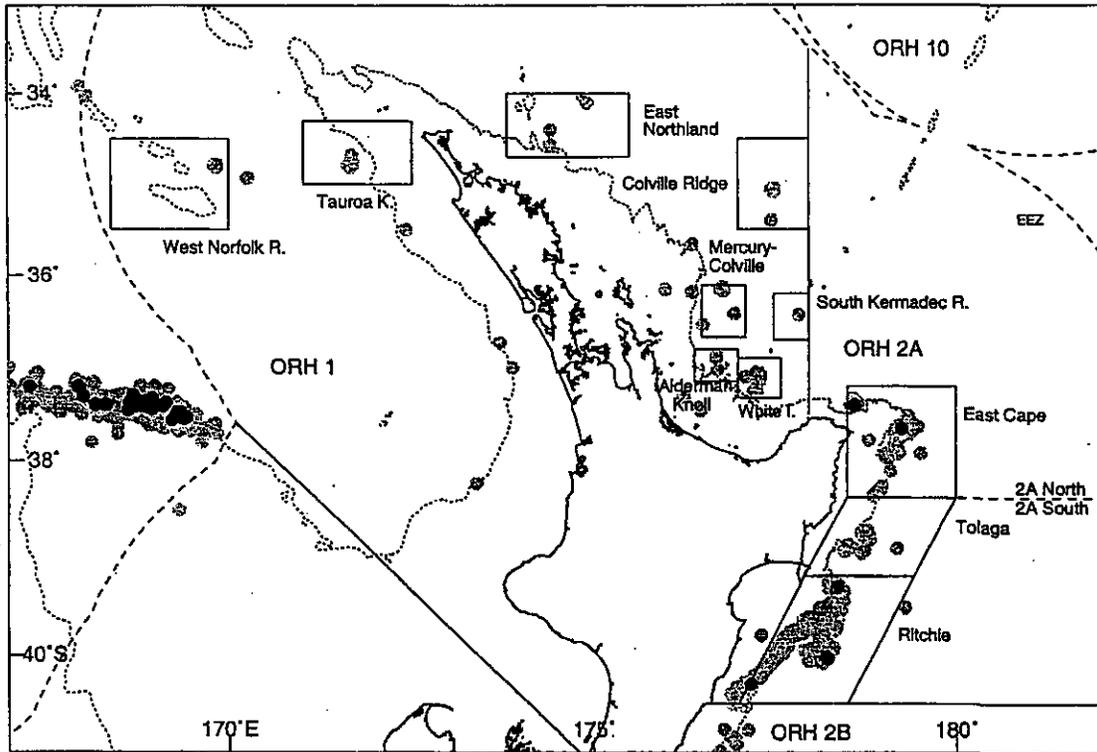


Figure 2: Location of fisheries used for analysis of biological data, position of trawls in the commercial fishery (grey dots), and location of samples of orange roughy taken by SOP observers (black dots), during the 2000–01 fishing year. For reasons of confidentiality, the positions of trawls sampled in the Fiordland area have been omitted from the lower figure.

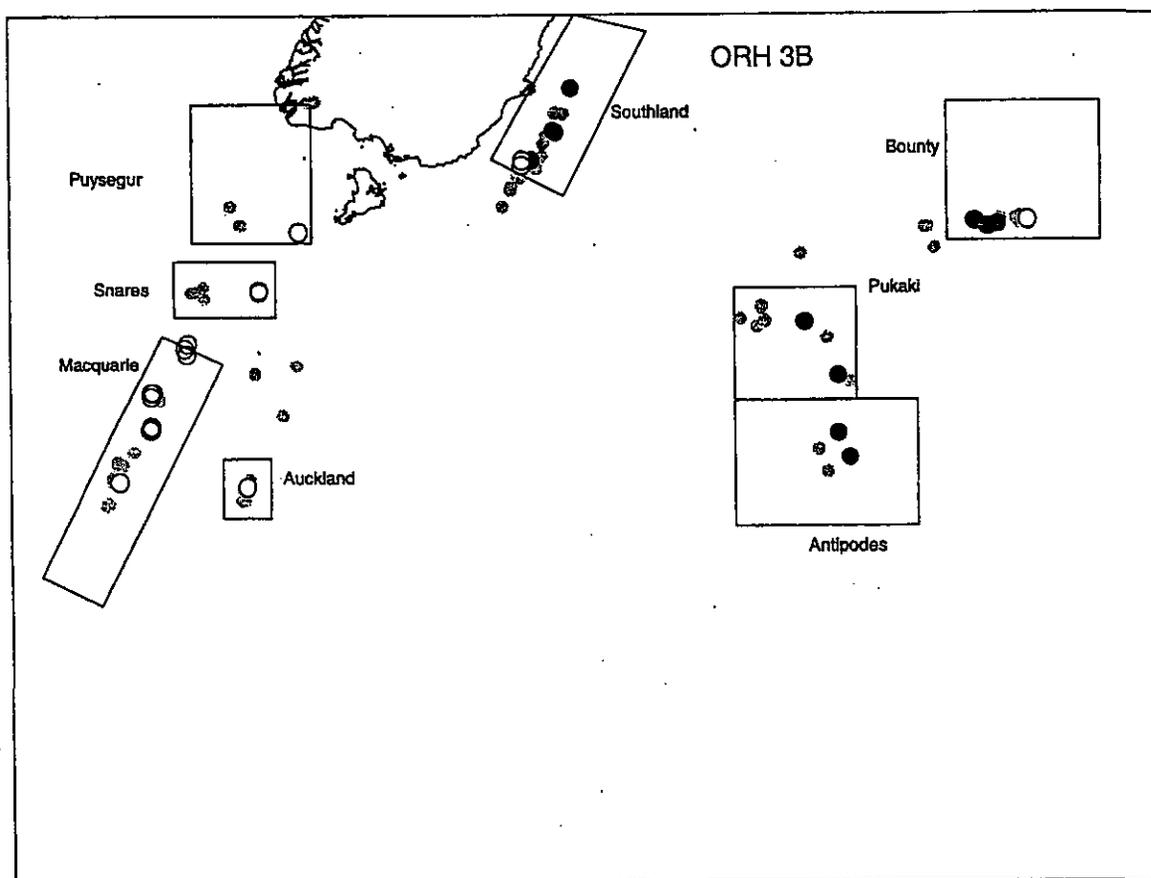
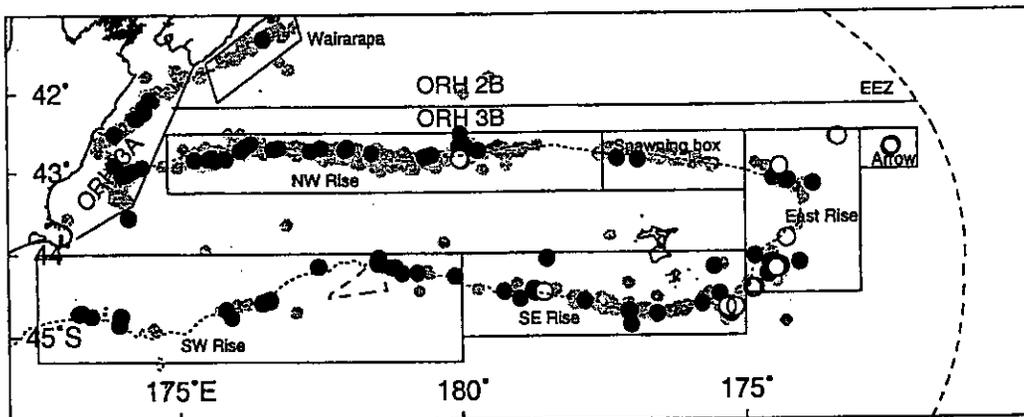


Figure 3: Location of fisheries used for analysis of biological data, position of trawls in the commercial fishery (grey dots), location of samples of orange roughy taken by SOP observers (black dots), and location of samples of orange roughy taken by ORM observers (white dots) during the 2000–01 fishing year. For reasons of confidentiality, the axis scales and details of bathymetry and geography have been omitted from the lower figure.

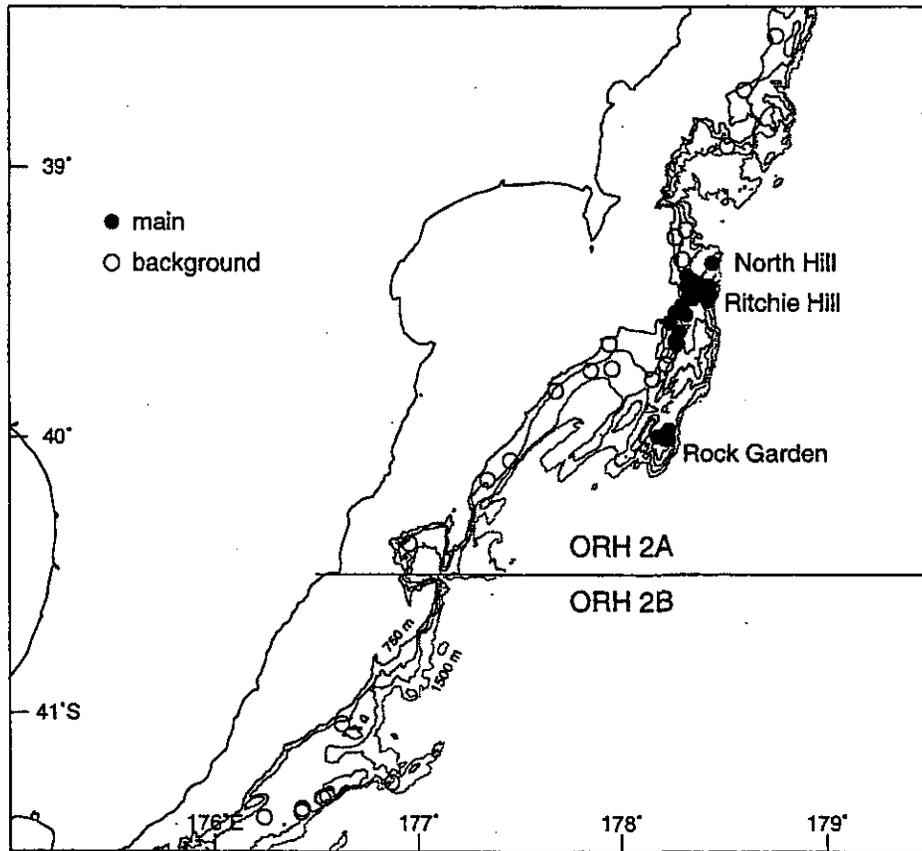


Figure 4: Location of research trawls, with orange roughy length data, in the mid-East Coast (ORH 2A South, ORH 2B) fishery in June/July 2001.

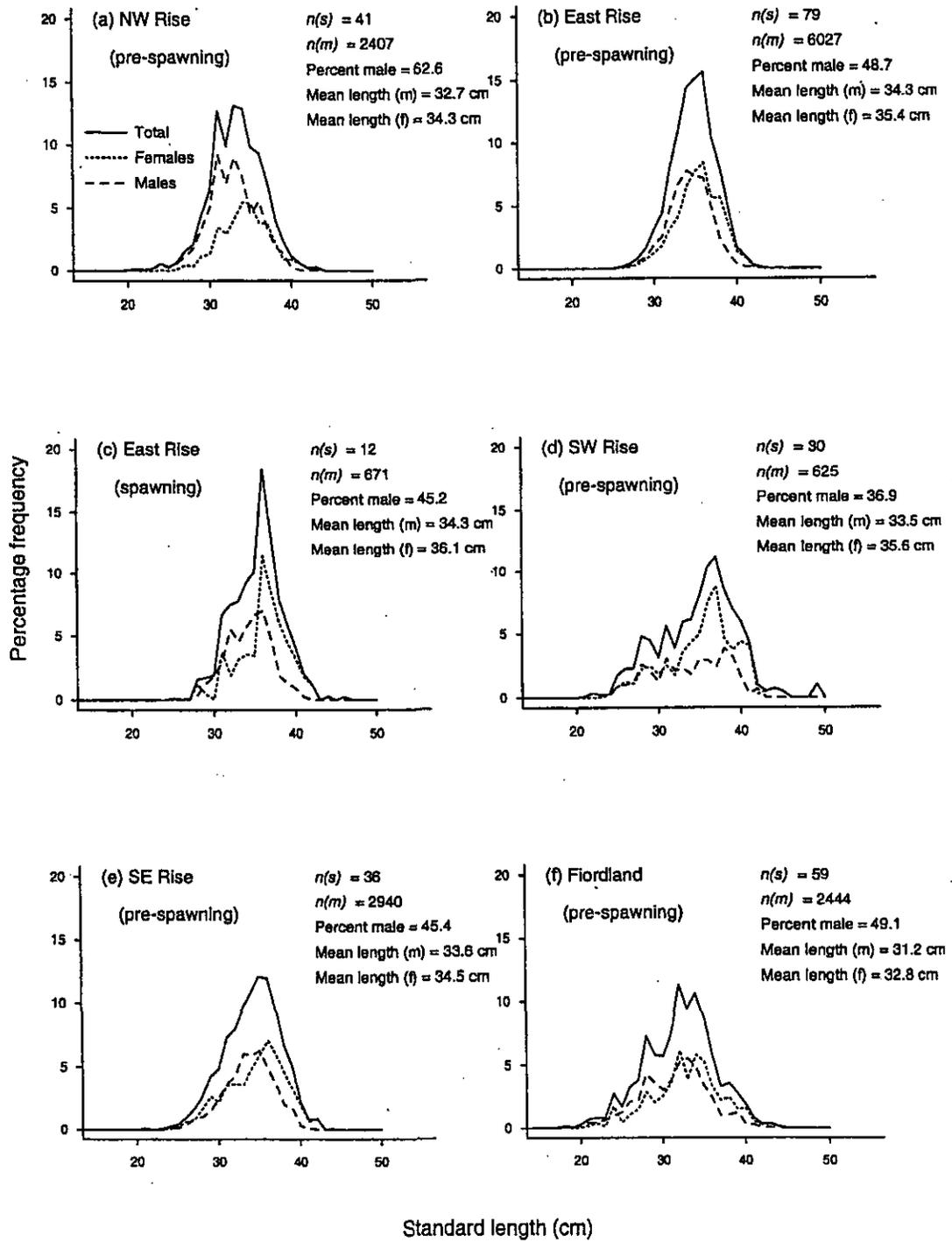


Figure 5: SOP length frequency distributions (scaled by catch) of orange roughy by area and period, $n(s)$, number of samples; $n(m)$, number of fish measured.

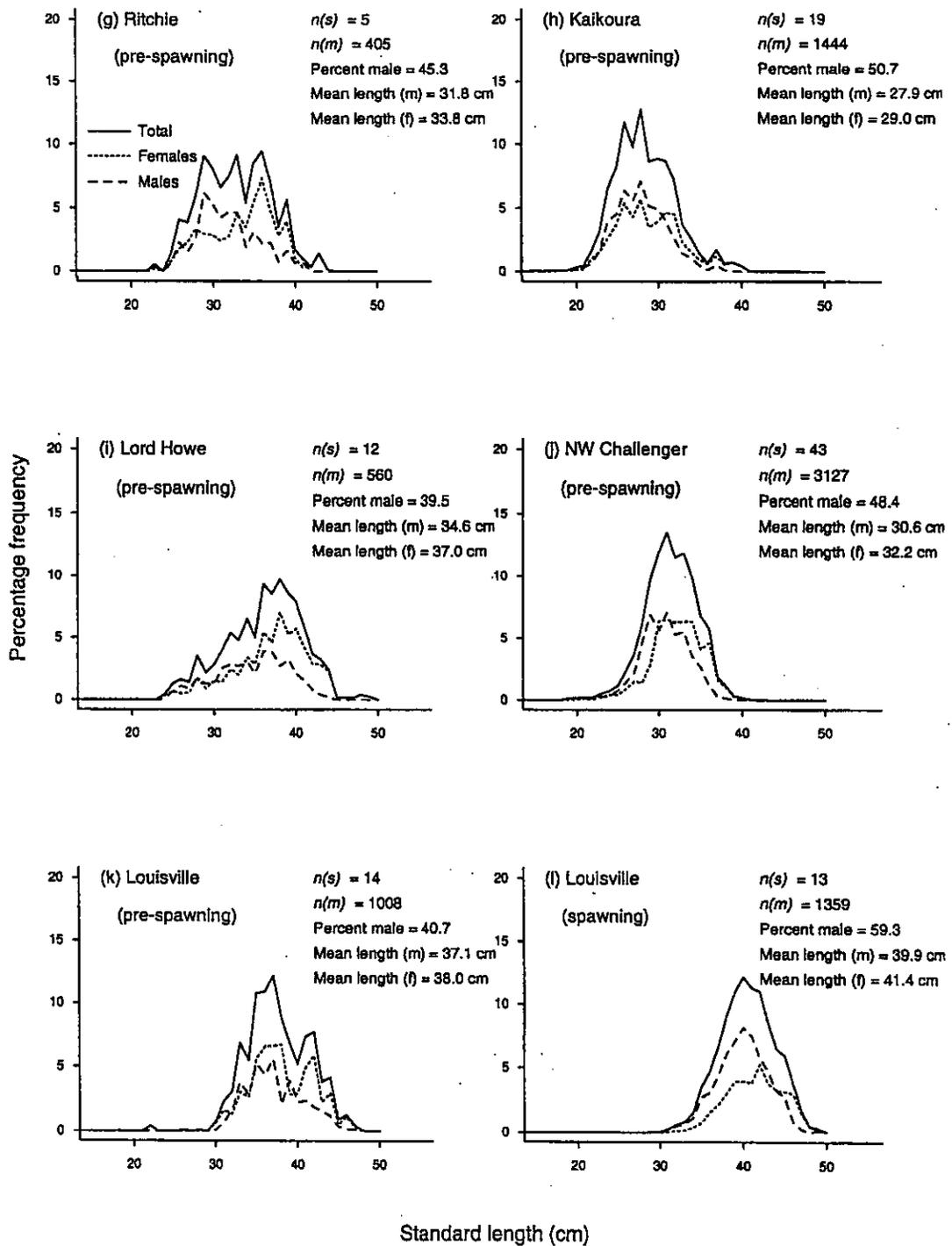


Figure 5 — continued.

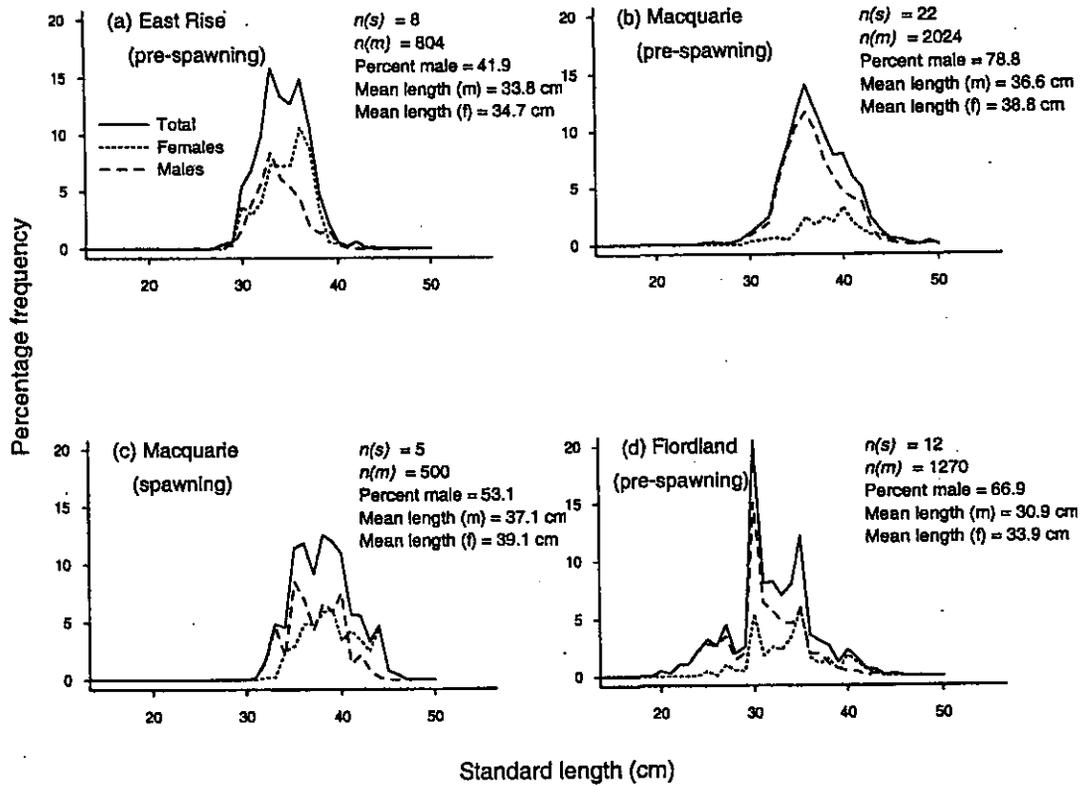


Figure 6: ORM length frequency distributions (scaled by catch) of orange roughy by area and period, $n(s)$, number of samples; $n(m)$, number of fish measured.

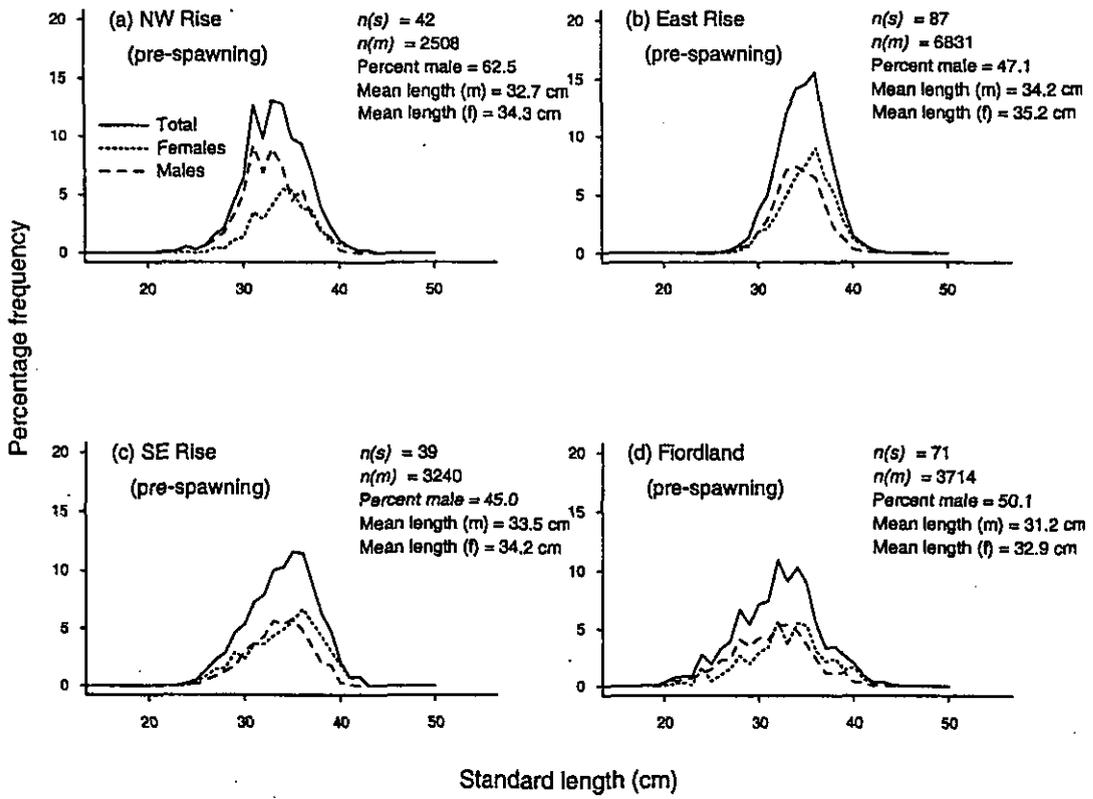


Figure 7: Combined SOP and ORM length frequency distributions (scaled by catch) of orange roughy by area, $n(s)$, number of samples; $n(m)$, number of fish measured.

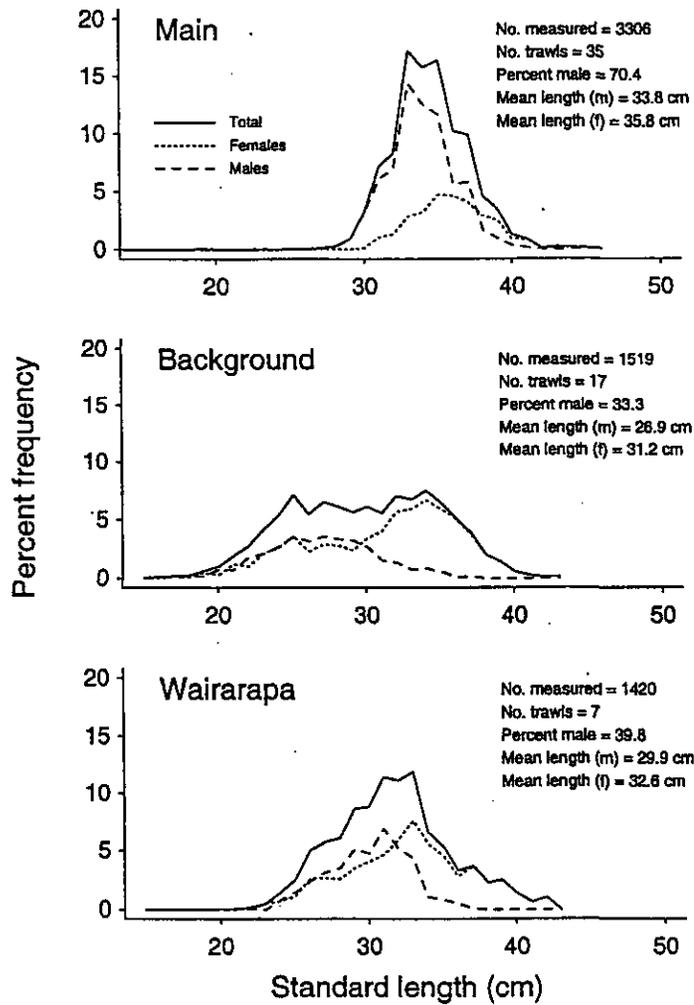


Figure 8: Research length frequency distributions (scaled by catch) of orange roughy from a survey carried out on the mid-East Coast fishery in June/July 2001. Top, "main" spawning hills; middle, "background" areas; bottom, "Wairarapa" tows.

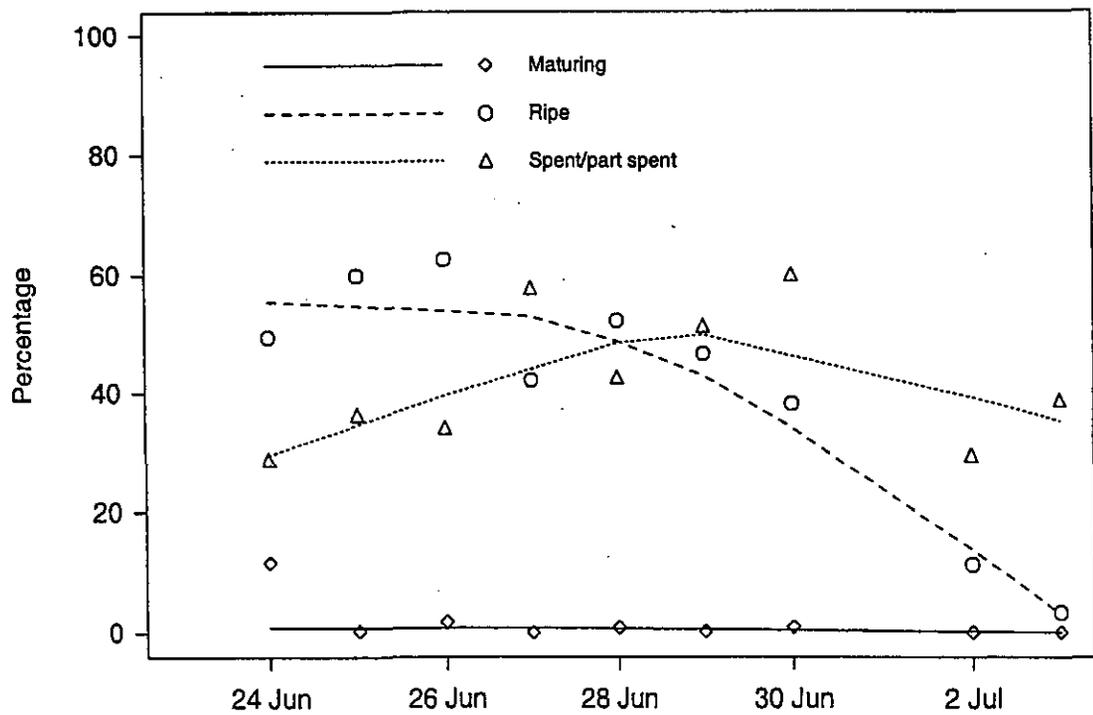
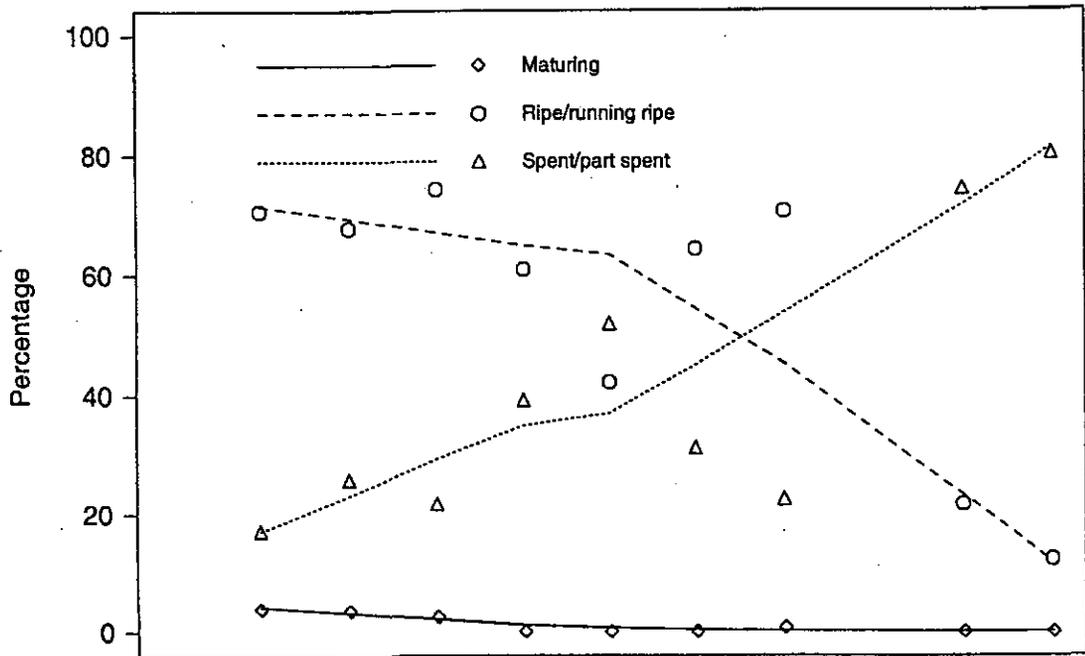


Figure 9: Daily changes in orange roughy gonad stage proportions during the spawning season in the ORH 2A South fishery, from research survey data. Top panel, female fish; bottom panel, male fish.