

New Zealand Fisheries
Assessment Report
2006/47
November 2006
ISSN 1175-1584

A summary of biological information on the
New Zealand fisheries for orange roughy
(*Hoplostethus atlanticus*) for the 2004–05 fishing year

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**Published by Ministry of Fisheries
Wellington
2006**

ISSN 1175-1584

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**Ministry of Fisheries
2006**

Citation:

Anderson, O.F. (2006).

A summary of biological information on the New Zealand fisheries for orange roughy (*Hoplostethus atlanticus*) for the 2004–05 fishing year.
New Zealand Fisheries Assessment Report 2006/47. 25 p.

This series continues the informal
New Zealand Fisheries Assessment Research Document series
which ceased at the end of 1999.

EXECUTIVE SUMMARY

Anderson, O.F. (2006). A summary of biological information on the New Zealand fisheries for orange roughy (*Hoplostethus atlanticus*) for the 2004–05 fishing year.

New Zealand Fisheries Assessment Report 2006/47. 25 p.

1. Size and reproductive data on orange roughy, collected by observers of the Ministry of Fisheries Observer Programme (OP) and from NIWA research surveys, were examined and summarised by fishery. Data were available from 447 OP tows during the 2004–05 fishing year, almost exclusively from within the New Zealand Exclusive Economic Zone (EEZ). Biological data collected by NIWA staff during research surveys on the Northwest Chatham Rise and Challenger Plateau were also summarised.

2. The level of OP sampling was more than 50% greater than that of the previous year, and represented a relatively average coverage in comparison with recent years. Coverage was patchy, with the Quota Management Area (QMA) ORH 1 receiving three times the sampling effort scheduled and a record 300 samples collected from the Chatham Rise, but only 7 of the 120 samples scheduled for fisheries outside the EEZ collected, and minimal coverage of the east coast fisheries in QMAs ORH 2A, ORH 2B, and ORH 3A. Coverage of the Spawning Box fishery in ORH 3B was particularly good, with 121 samples and over 15 000 fish measured during the spawning period. Several thousand fish were also measured in each of the East Rise, Southeast Rise, and Northwest Rise fisheries.

3. Sufficient length samples were obtained to determine size frequencies for 12 fishery/season combinations. These distributions were unimodal in shape in all areas, although there was variation between areas in the range of fish sizes and the calculated mean lengths. The smallest fish were from the Northwest Rise and Spawning Box pre-spawning, and Puysegur spawning fisheries (mean lengths 32.2–32.4 cm for males and 32.8–33.6 cm for females) and the largest from the West Norfolk Ridge fishery (mean lengths 38.4 cm (males) and 39.9 cm (females)). A large amount of length data was collected from research surveys on the Northwest Chatham Rise and Challenger Plateau and size distribution were produced for these also.

4. In most areas, sex ratios calculated from scaled observer size frequency data did not indicate a strong dominance of one sex, with 8 of the 12 calculated ratios falling within 5 percentage points of 50%. The most biased sex ratios were from the Northwest Rise spawning fishery (72.0% male) and the SE Rise pre-spawning fishery (35.9% male).

5. Sampling during the spawning period was sufficient in several fisheries to allow an estimate of the temporal progression of spawning to be made. The timing of spawning, as determined from combinations of observer and research survey data, was slightly earlier than usual for the Northwest Rise fishery, and close to typical, or slightly early, for the Challenger Plateau and Spawning box fisheries.

1. INTRODUCTION

This report documents the results of objective 3 of the Ministry of Fisheries project ORH2005/02 “Orange roughy stock assessment”, and objective 2 of Ministry of Fisheries project ORH2005/03 “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 Observer Programme and from other sources during the 2004–05 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 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 survey data. 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 incorporated into stock assessments for the Lord Howe Rise, Challenger, Northwest and Northeast Chatham Rise, East Cape hills, and Mid-East Coast (MEC) fisheries (Clark & Tilzey 1996, Hilborn et al. 2000a, 2000b, Branch et al. 2002, Smith et al. 2002a, Ward & Hicks 2005, M. Dunn, NIWA, unpublished results, A. McKenzie, NIWA, unpublished results). The use of observer data in these assessments was summarised by Anderson (2006b). 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. 2002b). Changes in mean length over time identified from observer data have been used to identify areas of heavy exploitation and provide clues to recruitment patterns (Francis & Smith 1995). Sex ratio information from observer data has been used to identify 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 EEZ (project ORH2005/02), and from several fisheries outside the EEZ (referred to in this report as ET fisheries, project ORH2005/03), during the 2004–05 fishing year. These summaries are constructed and presented in a manner consistent with that used in previous analyses of orange roughy biological data (e.g., Anderson 2006a) to provide a means of quickly identifying and obtaining data for input into stock assessment models.

This report also presents summaries of orange roughy biological data collected by NIWA staff during research surveys for orange roughy in June-July on the Northwest Chatham Rise (Graveyard hills and flats, ORH 3B) and on the Challenger Plateau (ORH 7A), and provides the location of station positions where small amounts of orange roughy biological data were collected on other NIWA research surveys of middle depth species in 2004–05. Further, industry run, orange roughy research surveys were carried out in June and July on the Graveyard Hill and Spawning Plume (Chatham Rise, ORH 3B), and in the Puysegur fishery (southern ORH 3B). Biological data were collected on these surveys by OP observers and so are included in this report in the summaries of observer data.

2. DATA COLLECTION

Orange roughy biological data were collected by OP observers hosted aboard commercial fishing vessels. Observers took measurements from random samples of about 100 fish (range 1–399) per trawl, from up to six 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.

Biological data collected by NIWA staff are available from the orange roughy research surveys on the Northwest Chatham Rise (R.V. *Tangaroa* and F.V. *Amaltal Mariner*) and on the Challenger Plateau (F.V. *Thomas Harrison*). Some orange roughy biological data is also available from a survey of hoki on the Chatham Rise in December 2004 to January 2005 and from a multi-species survey in the sub-Antarctic in November–December 2004. These data are held at NIWA, Greta Point, on the Empress *trawl* database.

3. METHODS

The OP 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 (e.g., Anderson 2006a).

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 mis-recording of position, and length and catch data were checked for unlikely values.

Catch and effort data from the orange roughy commercial fisheries were summarised to determine the level of OP observer coverage achieved in each of the main fisheries in 2004–05. Coverage was determined based on the proportion of the total catch observed in each fishery. These data came from extracts from Ministry of Fisheries databases held on the Empress database *dw_cdb* at NIWA, Greta Point. The level of OP observer coverage, in number of samples, was also compared to the level of coverage scheduled for the year for each fishery by the Ministry of Fisheries.

3.1 Size structure

Length frequency distributions were determined from the OP sampling data for each fishery and season where at least five tows were sampled and more than 400 fish measured. Samples were combined when they were entirely preceding, entirely within, or entirely subsequent to the period 1 June to 31 August, to approximate pre-spawning, spawning, and post-spawning sampling respectively. Size frequencies were scaled according to the fraction of the catch sampled for that tow, so as to be representative of the total catch sampled. For each length frequency prepared, sex ratios (percentage male) and the mean length of male and female fish (with normal standard deviations) were calculated from the combined length composition.

The research survey of the Northwest Chatham Rise (ORH 3B) orange roughy fishery comprised acoustic surveys of the hills and flats areas, combined with target trawling on hills and a stratified random trawl survey on the flats. A closer examination of size frequencies of orange roughy from the survey will form part of the survey analysis but, for the purposes of this summary, a single size frequency was prepared for the flats and another for the hills. There were insufficient fish measured (less than 400) in both the Chatham Rise hoki and sub-Antarctic middle-depth species surveys to produce meaningful size frequencies.

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 five (macroscopic) categories (Table 1). Note that these categories are different from those currently used for orange roughy by NIWA research staff, which more completely separate immature fish from mature fish and allow for partially spent and resting stages.

Gonad staging data from observers were aggregated by month and fishery area and the proportion of female fish in each gonad stage was determined to broadly summarise the observed timing and location of orange roughy spawning activity for the year.

The reproductive states of female fish (and male fish from research survey data) were also examined at a daily level. Where time series of appropriate data through the spawning period were available, plots were created to examine the progression of spawning. These plots were constructed by fitting a curve (a cubic “smoothing spline”, see Venables & Ripley (2000) for details) to daily values of the fraction of fish in each of the mature reproductive states (F2, F3/F4 combined, and F5) shown above. Sufficient data were available from the Northwest Chatham Rise survey (using *Amaltal Mariner* hill tows only), from the Challenger Plateau survey (all tows), and from OP data from two Chatham Rise fisheries.

4. RESULTS

4.1 Distribution of samples

Ministry of Fisheries OP observers sampled 447 catches of orange roughy collected during 18 voyages with the number of samples per voyage ranging between 2 and 75 (median 15). Of the six areas with sampling scheduled for 2004–05, three were over-sampled and three under-sampled (Table 2). By far the greatest number of samples was taken in QMA ORH 3B, where 300 samples were collected on the Chatham Rise (more than ever before) and 79 in “exploratory” areas of ORH 3B (second only to the 82 collected in 2000–01 (Anderson & Langley 2002)). Biological sampling in ORH 1 was at almost three times the scheduled level, due in part to the requirements of the Adaptive Management Programme (AMP) in place for this fishery. The number of samples was considerably less than scheduled in ORH 2A South, as has been the case in this fishery since 1999–2000 when 35 samples were collected (Anderson 2001). Sampling was also minimal in the fisheries outside the EEZ with scheduled observer coverage, with only seven samples taken from one fishery (Louisville Ridge).

Overall, the total number of OP observer samples collected during the 2004–05 fishing year exceeded the expected total by seven and was an increase of more than 50% over the previous year (Table 2).

Monthly totals arranged by OP area, ORH 3B fisheries, ORH 1 fisheries, and other fisheries are shown in Table 3. More than two-thirds of the samples came from the SOE (Chatham Rise) with the remainder mostly split between the SOU/SUB (Southland/Sub-Antarctic) and AKE/AKW (ORH 1) regions. On the Chatham Rise, between about 35 and 55 samples were collected from the Northwest, Southeast, and East Rise, and 159 samples representing over 18 000 fish were collected in the Spawning Box. There was also a scattering of samples spread over several of the smaller “exploratory” fisheries, Puysegur in particular, as a result of the industry survey there in July. Sampling was spread among six fisheries in ORH 1, with the highest level of sampling on the West Norfolk Ridge in October. This fishery also had a high level of sampling in 2003–04 (Anderson 2006a). Several samples were also available from the Aldermen, Mercury-Colville Box, White Island, and Tauroa Knoll fisheries. The three central east coast QMAs (ORH 2A, ORH 2B,

ORH 3A) were represented by only five samples, restricted to the East Cape (3) and Ritchie Banks (2) fisheries. Observer effort was only moderately well spread out over the fishing year, with 10 or more samples collected in 8 of the months but no samples at all collected in December, August, or September.

Outside the EEZ, sampling was at the lowest level since 1990–91 (see Anderson 2006b). Only the Louisville Ridge fishery received any coverage at all, and that amounted to only seven samples, the lowest in that area for five years.

The positions of all tows from which OP samples were collected are shown in Figures 2 and 3, which also show the positions of all tows that caught orange roughy in the 2004–05 fishing year, according to TCEPR returns. Of the northern fisheries, the northwest Challenger grounds received considerable fishing effort, over a wide area, but no observer sampling. Sampling covered the western and eastern extent of the ORH 1 fishery, but not the more central fisheries at Manukau and East Northland. It is possible, given the likelihood of small discrepancies between observer and vessel records of estimated catch, that all commercial catch of orange roughy was observed in the Mercury-Colville box (Table 4). Sampling at Aldermen Knoll, Tauroa Knoll, and West Norfolk Ridge also represented a significant fraction of the total commercial catch. Coverage of each of the Chatham Rise fisheries was also high in relation to commercial catch, with close to 3000 t of catch sampled overall, and almost half of the 3800 t catch in the Spawning Box sampled. Sampling was well spread out over the Spawning Box and the hill areas of the East and Southeast Rise, but was more restricted in the Northwest fishery to the main hills area centred around 180°. In the southern area of ORH 3B (south of 46° S), where fishing effort is spread over a wide area, samples were collected from several locations within the Pukaki and Puysegur fisheries, collectively accounting for over 300 t of orange roughy catch in 2004–05 (Table 4). Coverage levels in these southern fisheries tended to match well to the fishery catch, with the highest level of coverage (47 samples) taken from the productive Pukaki fishery, and moderate coverage in the next two largest fisheries in 2004–05, Bounty and Puysegur.

Observer coverage outside of the EEZ was restricted to a small area in the centre of the Louisville Ridge fishery (see Clark (1998a, 1998b) for definitions of these areas) from which an estimated 1500 t of orange roughy was caught in 2004–05 (Table 4).

The locations of trawl stations in the three research surveys in which orange roughy were measured by NIWA are shown in Figure 4. The data collected from the Northwest Chatham Rise survey complement those collected by observers from commercial fishing in the survey area at the same time. The Challenger Plateau survey covered the main fishing grounds in the vicinity of the Pinnacles, Central Flat, and Westpac Bank features (see, e.g., Clark & Tracey (1994) for the locations of these fishing grounds) and was the only fishing for orange roughy in this closed QMA in 2004–05. Few orange roughy data were collected from the other two surveys, in middle-depth fishing grounds on the Chatham Rise and sub-Antarctic, which overlapped only the shallowest part of the orange roughy depth range.

About 11 500 orange roughy were measured from a total (two vessel) catch of 53 t in the Northwest Chatham Rise survey, about 10 300 orange roughy were measured from a catch of 160 t in the Challenger Plateau survey, 142 orange roughy were measured from a catch of about 120 kg in the sub-Antarctic survey, and 23 orange roughy were measured from a catch of less than 20 kg in the Chatham Rise hoki survey.

4.2 Size structure and sex ratios

Length frequency distributions by sex from OP samples are given in Figure 5. Strong unimodal distributions with generally even sex ratios and larger female fish, typical for orange roughy size structures, were found in most areas, e.g., the Spawning Box (Figure 5c, d). The main differences in the size distributions between areas were in the range of fish lengths measured and in the position of the mode. The smallest fish were found in the Northwest Rise, Spawning Box, and Puysegur fisheries (Figure 5a, c, h) and the largest in the northern Mercury-Colville Box and West Norfolk Ridge fisheries (Figure 5j, l). In the Northwest Rise and Spawning Box fisheries, fish sampled during the spawning months were larger than fish sampled earlier in the year, particularly female fish in the Northwest Rise (Figures 5a–d).

Small fish, less than 25 cm, were uncommon in most areas, and are noticeable only in the size distribution for the Northwest Rise pre-spawning fishery (Figure 5a). In the fisheries from the Chatham Rise southwards few fish were measured at over 40 cm, but in the northern fisheries in the Mercury-Colville Box and West Norfolk Ridge, fish greater than this size were common (Figure 5j,l). The largest fish observed were in the West Norfolk Ridge fishery where 42% of fish (sexes combined) were over 40 cm, mean lengths were 38.4 cm (male) and 39.9 cm (female), and fish of up to 50 cm were recorded.

Sex ratios, based on scaled size frequency data, ranged from 35.9% male (Southeast Rise, pre-spawning) to 72.0% male (Northwest Rise, spawning) and tended to diverge more from a 50:50 ratio in spawning month samples (Table 5). Overall, there was no clear bias in the sex ratios in favour of one sex. Although 9 of the 12 fishery/area combinations showed a higher percentage of male fish, most of the sex ratios were close to 50:50, with 8 being within 5 percentage points of 50% male, and the strongest bias being 72% male in the Northwest Rise spawning fishery and 36% in the SE Rise pre-spawning fishery.

Scaled length frequency distributions were produced from the Northwest Chatham Rise orange roughy research survey to compare size structure on the flat areas with that on the Graveyard Hills (Figure 6). The size structure for the hills was similar to that measured by observers in the same general area at about the same time, with similar mean lengths and a similar strong bias in the sex ratio in favour of male fish. The size structure on the broad flat area to the west and east of the hills indicates a much higher fraction of small fish (mean size under 30 cm for both sexes) and an even sex ratio, although this contrast may be influenced by the effect of the fine-meshed “rat-catcher” net used by *Tangaroa* during these trawls. Half the orange roughy measured on the flats (scaled data) were under 30 cm and several fish under 10 cm were measured.

Small fish were also seen by research staff on the Challenger Plateau survey, with mean lengths of 29.3 cm (male) and 31.1 cm (female) for all areas combined (Figure 6). About 44% of all fish (scaled data) were less than 30 cm and a few fish under 10 cm were also caught.

4.3 Reproduction

Female fish were sampled for reproductive state by OP observers during spawning months (nominally June, July, and August) in several areas in 2005 and, for a few of these, an indication of the timing and location of spawning can be derived (Table 6).

Much of the sampling in the ORH 3B fisheries on the Northwest Rise and Spawning Box coincided with the winter spawning fishery, with many fish in the ripe, running ripe, and spent stages. Sampling in the East and Southeast Rise was outside the spawning season and in the Southwest Rise the small sample in July included only immature fish. Further south, in ORH 3B, the observer data from the

industry survey in Puysegur showed that spawning was taking place in July, and some spent fish were seen by observers in Pukaki in October.

Spawning fisheries in several parts of ORH 1 were covered by observers in 2005, with 100–200 fish staged in July in Aldermen Knoll, Mercury-Colville Box, and White Island. At White Island, fish moved from about 80% ripe/running and 15% spent on 1 July to about 35% ripe/running and 55% spent on 8 July. Although there were few days with data, spawning appears to have been about a week later than in 2000, the only other year in which sufficient data were collected (Anderson 2006b). Some spawning activity was also witnessed in the East Cape hills (17 June, mostly ripe and running ripe fish) and from a few fish staged in the Louisville Ridge fishery in June.

There were sufficient reproductive data collected by observers through the spawning period to make plots of the progression of spawning in the Northwest Rise and Spawning Box fisheries (Figure 7). In the Northwest Rise fishery, the fraction of maturing female fish decreased from about 70% to less than 5% between 11 June and 4 July, replaced by an increasing fraction of ripe/running ripe fish, which was at about 80% by early July, and a slow increase in spent fish to about 10% by 4 July. Spawning in this fishery was slightly later than encountered in research surveys in 2002 and 1999, when female fish were 20% spent at about 4 July and 30 June, respectively (Anderson 2000, 2003). The pattern was similar in the Spawning Box, except that the spawning progression appears to have moved more quickly, and taken place slightly later than in the Northwest Rise. The peak of spawning, and the reference point of 20% spent, probably occurred a few days after observer sampling ceased in the Spawning Box, about 13 or 14 July. This is slightly earlier than usual for this fishery but still more than a week later than in 2004, when spawning was exceptionally early (Anderson 2006a).

Research survey data from the Northwest Rise fishery (*Amaltal Mariner* hill tows only) show a snapshot of spawning in the central portion of the period covered by observers in the same area (Figure 8). These data agree well with those from observers, showing similar timing in the increasing fraction of spawning female fish and decreasing fraction of maturing fish. Spawning condition data from male fish also show very similar timing to the female fish from both sources. Research data from the Challenger Plateau indicate a slowly increasing fraction of ripe and running ripe fish of both sexes during the period of the survey, 26 June to 5 July, and a declining fraction of maturing fish (Figure 9). The fraction of spent fish, of both sexes, increased at a similar rate to ripe fish, reaching 20% spent at about 29–30 June. This is similar to the timing of spawning in this area in the 1997 to 1999 period, but far earlier than in any of the 10 years between 1984 and 1995 when timing was determined (Anderson 2006b).

5. SUMMARY AND DISCUSSION

Observer coverage. The number of samples collected by OP observers in 2004–05 was a considerable increase over the previous year, but represents only an average number when compared to the past 5 or 6 years. The number of samples was slightly above the number scheduled overall, but several individual area allocations were not met and other areas received more sampling than allocated. In particular, only 2 of the 40 scheduled samples were taken from the ORH 2A South fishery (continuing the pattern of low to no coverage in this area), and only 7 of the 120 scheduled samples from outside the EEZ were taken. In contrast, 119 samples over and above the 260 scheduled for ORH 3B, and almost three times the scheduled number for ORH 1, were taken. Eighty-five percent of the samples for 2004–05 were taken from ORH 3B, and a further 13% were taken from ORH 1. Sampling levels in ORH 1 were high due to the apparent priority given to this fishery in recent years because of the requirements of the Adaptive Management Programme currently operating. Sampling levels in the ET fisheries were the lowest for 15 years, with only seven samples taken from the Louisville Ridge. There was no sampling in the Wairarapa, Kaikoura, Challenger, Cook Canyon, Fiordland, or Macquarie fisheries and very low sampling levels in several other

southern (ORH 3B) fisheries. The OP programme continues to be unable to compensate for the drop in sampling levels in exploratory areas of ORH 3B brought about by the demise of the Orange Roughy Management Company observer programme, which has concentrated on this area in the past.

The level of sampling coverage was sufficient to determine length frequency distributions of orange roughy in 10 separate areas, and in two areas (Northwest Chatham Rise and Spawning Box) plots were prepared separately for pre-spawning and spawning periods.

Research coverage. The amount of biological data available from research surveys was relatively high, as there were several surveys for orange roughy in 2004–05. The two-vessel survey of the Northwest Rise measured over 11 000 orange roughy, and the survey of the Challenger Plateau measured over 10 000 orange roughy. Biological data were also collected from industry surveys of orange roughy on the Graveyard Hill, Spawning Box, and Puysegur Banks, but these were taken by observers and were summarised as observer data in this report. Very few fish were caught in the other two (middle depths) surveys (165 fish in total).

Size structure. Size structure was examined in 12 fishery/period combinations available from OP data, compared with the same number in 2003–04, 13 in 2002–03, 14 in 2001–02, 12 in 2000–01, and 20 in 1999–2000. Size distributions were typical of orange roughy in all areas, showing a single strong mode, but differed among areas in the sample mean lengths and observed size ranges. Fish in samples from around the spawning period tended to be larger than fish from samples taken beforehand in both fisheries where there were comparable observer data, i.e., the Northwest Rise and Spawning Box. Intensive sampling was carried out in some areas, particularly in ORH 3B. Over 15 000 fish were measured from 121 samples in the Spawning Box spawning fishery, 3000–4500 fish were measured in the Spawning Box, East Rise, and Southeast Rise pre-spawning, and the Northwest Rise spawning fisheries. Mean lengths, calculated from scaled size frequencies, varied among areas, ranging from about 32 cm to 38 cm (male) and from about 33 cm to 40 cm (female), and tended to be greater in the ORH 1 fisheries. Sex ratios were close to 50:50 in most fisheries, with the most extreme sex ratios observed in the Southeast Rise pre-spawning (36% male) and Northwest Rise spawning (72% male) fisheries.

Reproduction. Gonad stage data sufficient for tracking the progress of spawning in the winter of 2005 were available from observer sampling in the Northwest Rise and Spawning Box fisheries, and from research sampling in the Northwest Rise and Challenger Plateau fisheries. The quantity of data available to create the plots was sufficient in each area to show clear patterns of change in the relative fractions of reproductive stages over time, and to approximately determine the extent and timing of the spawning season. The timing of the onset of spawning determined for the Northwest Rise fishery was slightly later than that measured from research survey data in 1999 and 2002, and research and observer data were in good agreement. Spawning in the Spawning Box fishery occurred a week or two later than in 2004, and near to the usual time for this fishery. The timing of spawning in the Challenger fishery was typical for recent years, but later than observed in the 1984–1995 period.

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. For this reason it is important that the OP programme continues to collect data from these fisheries, with an emphasis on attaining, over time, coverage of all fisheries, and more consistent coverage of fisheries for which regular stock assessments are carried out.

6. ACKNOWLEDGMENTS

I thank the OP observers of the Ministry of Fisheries for their continued efforts. The Ministry of Fisheries (projects ORH2005/02 and ORH2005/03) funded this work.

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Table 1: Macroscopic orange roughy gonad stage codes and definitions used by MFish observers and NIWA research staff.

NIWA				Observer	
M1	Immature	F1	Immature	F1	Immature to early maturation
M2	Maturing	F2	Maturing	F2	Maturing
M3	Spermiated	F3	Mature	F3	Ripe
M4	Spermiated, running	F4	Ripe	F4	Running ripe
M5	Spent	F5	Running Ripe	F5	Spent
M8	Partially spent	F6	Spent		
M9	Resting adult	F7	Atretic		
		F8	Partially spent		
		F9	Resting adult		

Table 2: Comparison of expected and actual number of OP orange roughy biological samples processed in 2004–05, and the actual number of OP samples processed in the previous two fishing years.

Area	Number of samples			
	Expected* 2004–05	Actual 2004–05	Actual 2003–04	Actual 2002–03
ORH 3B				
Chatham Rise	220	300	113	279
South of 46° S/Arrow Plateau	40	79	29	26
ORH 2A				
North	0	3	0	0
South	40	2	0	8
ORH 2B	0	0	0	2
ORH 3A	0	0	0	0
ORH 7A	0	0	0	0
ORH 1	20	56	90	116
ORH 10	0	0	0	0
ORH 7B	0	0	0	0
ET				
Lord Howe/NW Challenger	60	0	14	7
Louisville Ridge	60	7	39	155
South Tasman Rise	0	0	0	0
West Norfolk Ridge	0	0	5	12
Total	440	447	290	605

* Ministry of Fisheries research summary tender document figures

Table 3: Number of OP orange roughy biological samples by area and month for 2004–05, with the total number of samples and voyages in each area (see Figures 1 to 3 for area boundaries).

Summary by OP area

Area	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	Voyages
AKE	–	–	–	–	–	–	–	–	4	19	–	–	23	1
AKW	33	–	–	–	–	–	–	–	–	–	–	–	33	1
CEE	–	–	–	–	–	–	2	–	3	–	–	–	5	2
LOUR	–	–	–	–	–	–	–	–	7	–	–	–	7	1
SEC	1	–	–	–	–	–	–	–	–	–	–	–	1	1
SOE	3	39	–	15	19	8	13	67	116	25	–	–	305	10
SOI	–	–	–	–	–	–	–	–	–	3	–	–	3	1
SOU	–	–	–	–	–	–	–	–	–	16	–	–	16	1
SUB	47	–	–	–	–	–	–	5	1	1	–	–	54	7
ALL	84	39	–	15	19	8	15	72	131	64	–	–	447	18

Summary by fishery area

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	Voyages	No. fish measured
ORH 3B fisheries															
Arrow Plateau	–	–	–	–	3	–	2	–	–	–	–	–	5	2	381
Auckland Is.	–	–	–	–	–	–	–	–	–	3	–	–	3	1	128
Bounty Is.	2	–	–	–	–	–	–	4	–	1	–	–	7	3	181
East Rise	3	11	–	9	4	2	6	22	–	–	–	–	57	5	4 462
NW Rise	–	7	–	–	1	–	1	7	11	8	–	–	35	6	4 363
Pukaki	45	–	–	–	–	–	–	1	1	–	–	–	47	6	2 105
Puysegur	–	–	–	–	–	–	–	–	–	15	–	–	15	1	2 565
SE Rise	–	12	–	5	8	6	–	17	–	–	–	–	48	3	3 305
Snares	–	–	–	–	–	–	–	–	–	1	–	–	1	1	13
Spawning Box	–	9	–	1	3	–	4	21	105	16	–	–	159	7	18 655
Southland	1	–	–	–	–	–	–	–	–	–	–	–	1	1	10
SW Rise	–	–	–	–	–	–	–	–	–	1	–	–	1	1	97
ORH 1 fisheries															
Aldermen Knoll	–	–	–	–	–	–	–	–	–	6	–	–	6	1	415
Mercury-Colville Box	–	–	–	–	–	–	–	–	2	6	–	–	8	1	424
Mokohinau Knoll	–	–	–	–	–	–	–	–	2	–	–	–	2	1	210
Tauroa Knoll	8	–	–	–	–	–	–	–	–	–	–	–	8	1	825
White Island	–	–	–	–	–	–	–	–	–	7	–	–	7	1	310
West Norfolk Ridge	25	–	–	–	–	–	–	–	–	–	–	–	25	1	937
Other fisheries															
East Cape (ORH 2AN)	–	–	–	–	–	–	–	–	3	–	–	–	3	1	303
Ritchie Banks (ORH 2AS)	–	–	–	–	–	–	2	–	–	–	–	–	2	1	138
Louisville Ridge (ET)	–	–	–	–	–	–	–	–	7	–	–	–	7	1	77
ALL	84	39	0	15	19	8	15	72	131	64	0	0	447	18	39 904

Table 4: Summary of number and weight of samples taken by OP observers relative to the observed catch and estimated total catch in the fishery, 2004–05; 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 1					
Aldermen Knoll	6	655	3	4	80
Mercury-Colville Box	8	971	34	36	93
Mokohinau Knoll	2	263	0.3	12	2
Tauroa Knoll	8	1 096	65	123	53
White Island	7	571	7	144	5
West Norfolk Ridge	25	1 843	37	267	14
ORH 3B					
Chatham Rise					
East Rise	57	5 881	289	2 730	11
NW Rise	35	5 602	397	1 461	27
SE Rise	48	4 477	336	1 539	22
Spawning Box	159	24 234	1 817	3 801	48
SW Rise	1	104	3	11	31
Southern/Arrow Plateau					
Arrow Plateau	5	703	26	63	41
Auckland Is.	3	189	5	5	100
Bounty Is.	7	218	3	112	2
Pukaki	47	3 104	212	1 452	15
Puysegur	15	3 215	98	117	84
Snares	1	27	1	1	100
Southland	1	6	0.01	0.3	4
OTHER AREAS					
East Cape (ORH 2AN)	3	400	61	241	25
Ritchie Banks (ORH 2AS)	2	185	1	718	0.1
Louisville Ridge (ET)	7	135	2	1 503	0.1

Table 5: Summary of numbers of fish measured, mean lengths, sex ratios (% male), and total catch sampled (t) for each fishery and reproductive period for which length distributions were prepared, from OP 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	538	579	1 120	50.6	40	32.4 (2.8)	32.8 (3.7)
NW Rise	spawning	2 158	1 082	3 243	72.0	356	33.8 (2.6)	35.3 (3.0)
Spawning Box	pre-spawning	1 737	1 440	3 177	54.4	299	32.2 (2.4)	33.5 (2.4)
Spawning Box	spawning	7 628	7 846	15 478	51.6	1 517	32.8 (2.8)	34.7 (2.8)
East Rise	pre-spawning	2 160	2 302	4 462	45.8	289	33.2 (2.4)	34.7 (2.6)
SE Rise	pre-spawning	1 343	1 961	3 305	35.9	335	33.8 (2.6)	35.6 (2.5)
Pukaki	pre-spawning	1 099	1 005	2 104	54.8	212	34.3 (2.3)	36.6 (2.6)
Puysegur	spawning	1 424	1 141	2 565	53.3	98	32.3 (3.1)	33.6 (3.4)
Alderman Knoll	spawning	200	215	415	38.0	3	34.2 (2.1)	35.3 (2.6)
Mercury-Colville Box	spawning	230	194	424	62.6	33	36.9 (2.7)	39.6 (2.6)
Tauroa Knoll	pre-spawning	426	399	825	51.5	64	34.3 (2.7)	35.5 (2.8)
West Norfolk R.	pre-spawning	496	441	937	51.9	37	38.4 (2.8)	39.9 (3.5)

Table 6: Percentage of female orange roughy at each gonad stage in each subarea and month, from OP 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	
NW Rise	Feb	20	78	3	0	0	40
	May	11	89	0	0	0	201
	Jun	9	38	32	20	1	678
	Jul	1	3	10	76	9	404
	Nov	59	35	1	0	5	330
Spawning Box	Feb	7	38	52	3	0	71
	Apr	29	71	0	0	0	133
	May	12	88	0	0	0	902
	Jun	4	84	10	1	0	5 725
	Jul	2	25	32	30	11	2 121
East Rise	Nov	52	48	0	0	0	309
	Jan	2	21	71	5	1	296
	Feb	19	40	38	4	0	124
	Mar	26	34	40	0	0	93
	Apr	35	65	0	0	0	282
SE Rise	May	24	75	0	0	0	962
	Oct	4	96	0	0	0	136
	Nov	61	38	0	0	0	409
	Jan	7	17	69	4	2	81
	Feb	5	32	62	0	0	215
SW Rise	Mar	20	62	18	0	0	152
	May	28	72	0	0	0	844
	Nov	55	45	0	0	0	669
	Jul	100	0	0	0	0	51
	Feb	7	69	23	1	0	137
Arrow Plateau	Apr	4	89	7	0	0	102
	Jul	35	45	15	3	3	40
Auckland Is.	Jul	35	45	15	3	3	40
Pukaki	Oct	53	21	3	2	21	989
Puysegur	Jul	61	1	6	18	14	1 141
Alderman Knoll	Jul	7	2	1	61	29	215
Mercury-Colville Box	Jul	1	3	9	85	3	176
Mokohinau Knoll	Jun	22	4	8	35	31	142
Tauroa Knoll	Oct	9	90	0	1	0	399
White Is.	Jul	3	6	13	51	26	211
West Norfolk Ridge	Oct	1	98	0	0	0	441
East Cape	Jun	0	16	40	44	0	50
Ritchie Banks	Apr	17	83	0	0	0	87
Louisville Ridge (ET)	Jun	6	66	16	13	0	32

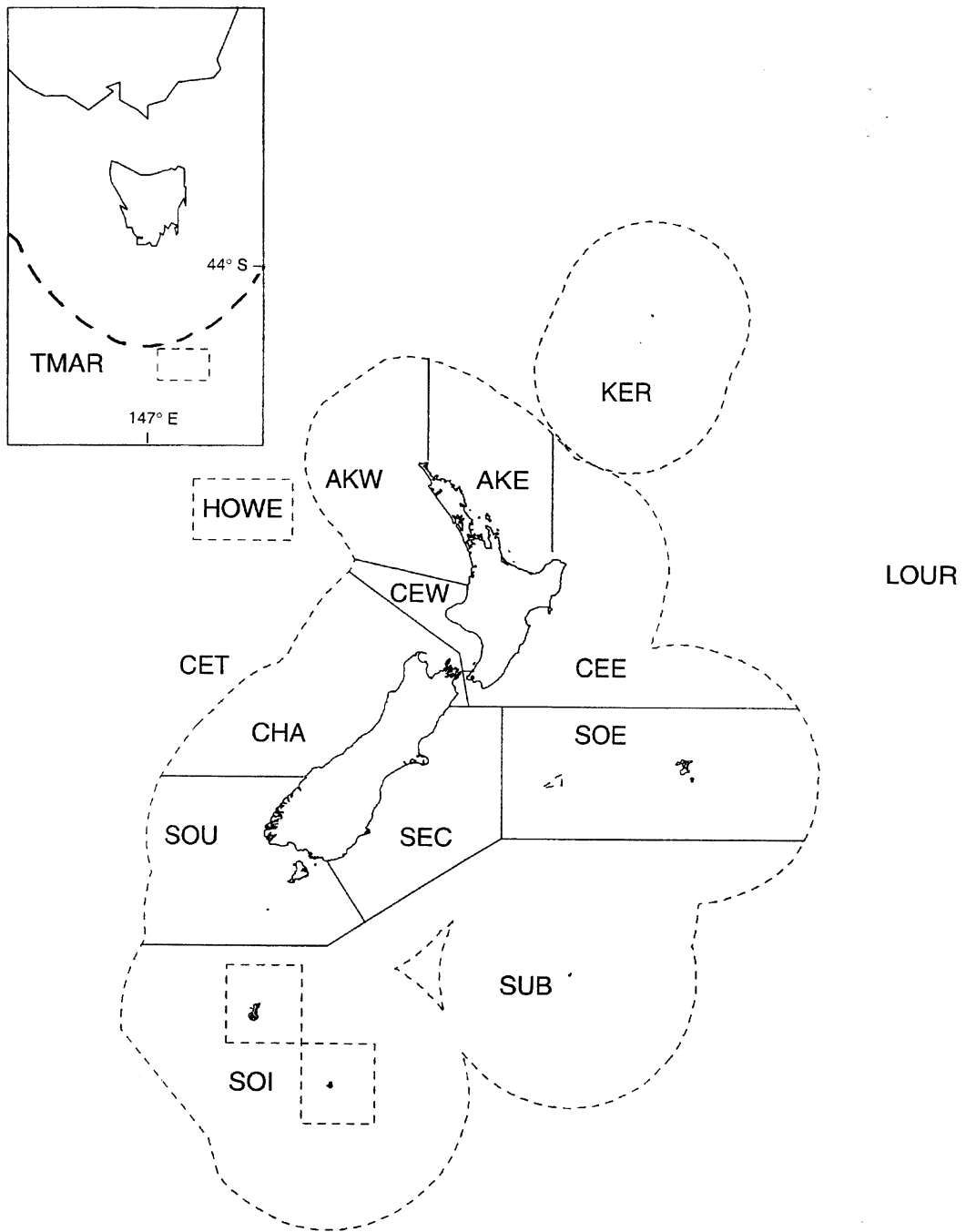


Figure 1: Ministry of Fisheries Observer Programme management areas.

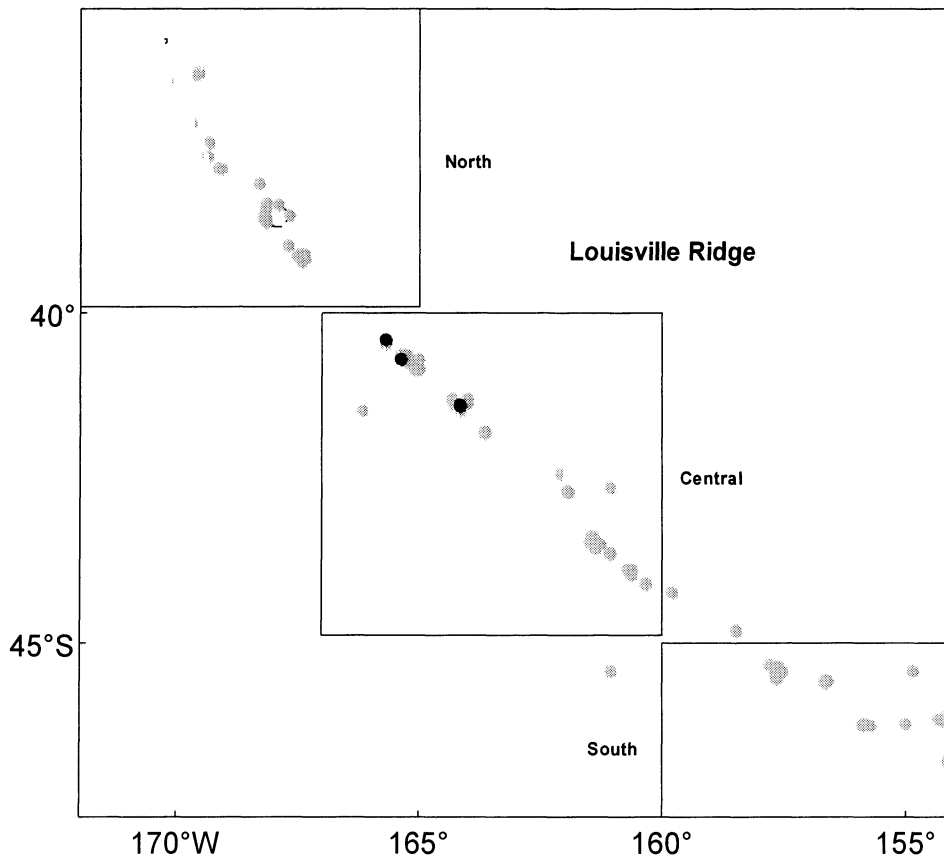
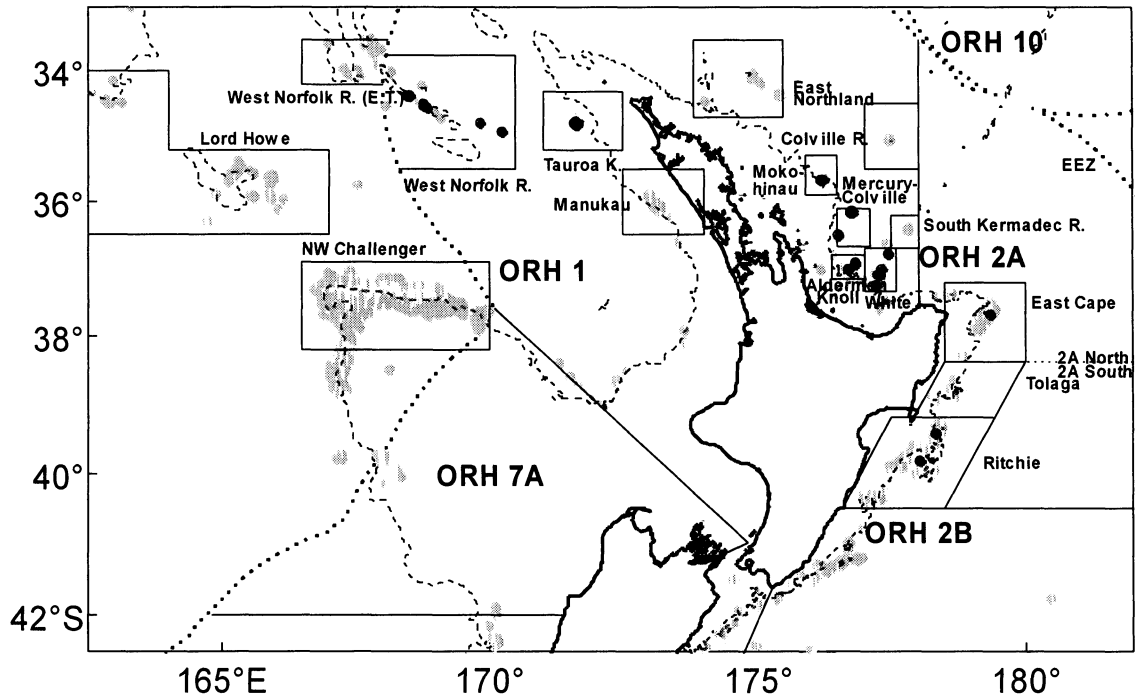


Figure 2: Location of fisheries used for analysis of biological data, position of trawls in the commercial fishery (grey dots), and location of samples of orange roughy taken by OP observers (black dots), during the 2004–05 fishing year. The dotted line shows the 1000 m depth contour.

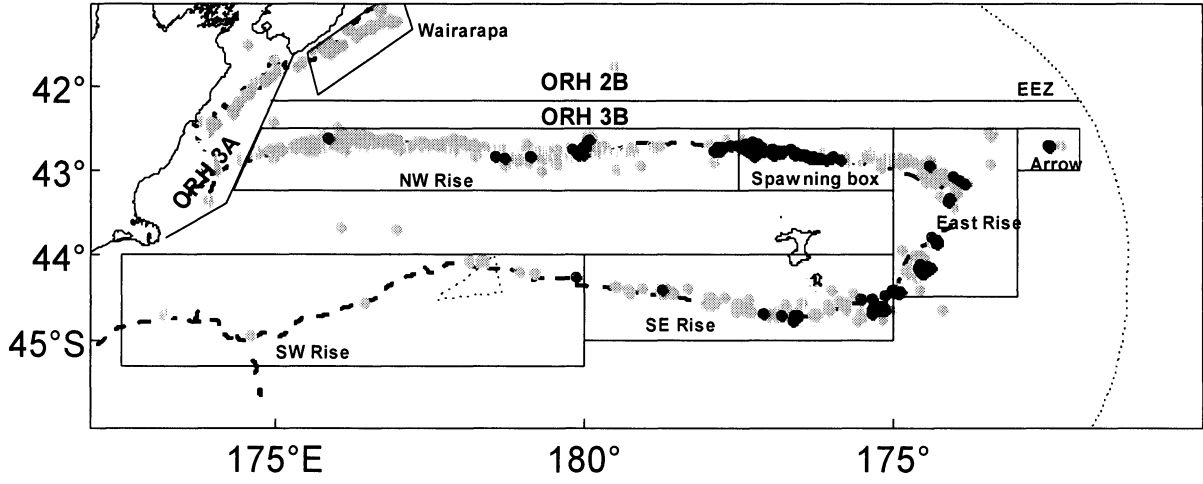
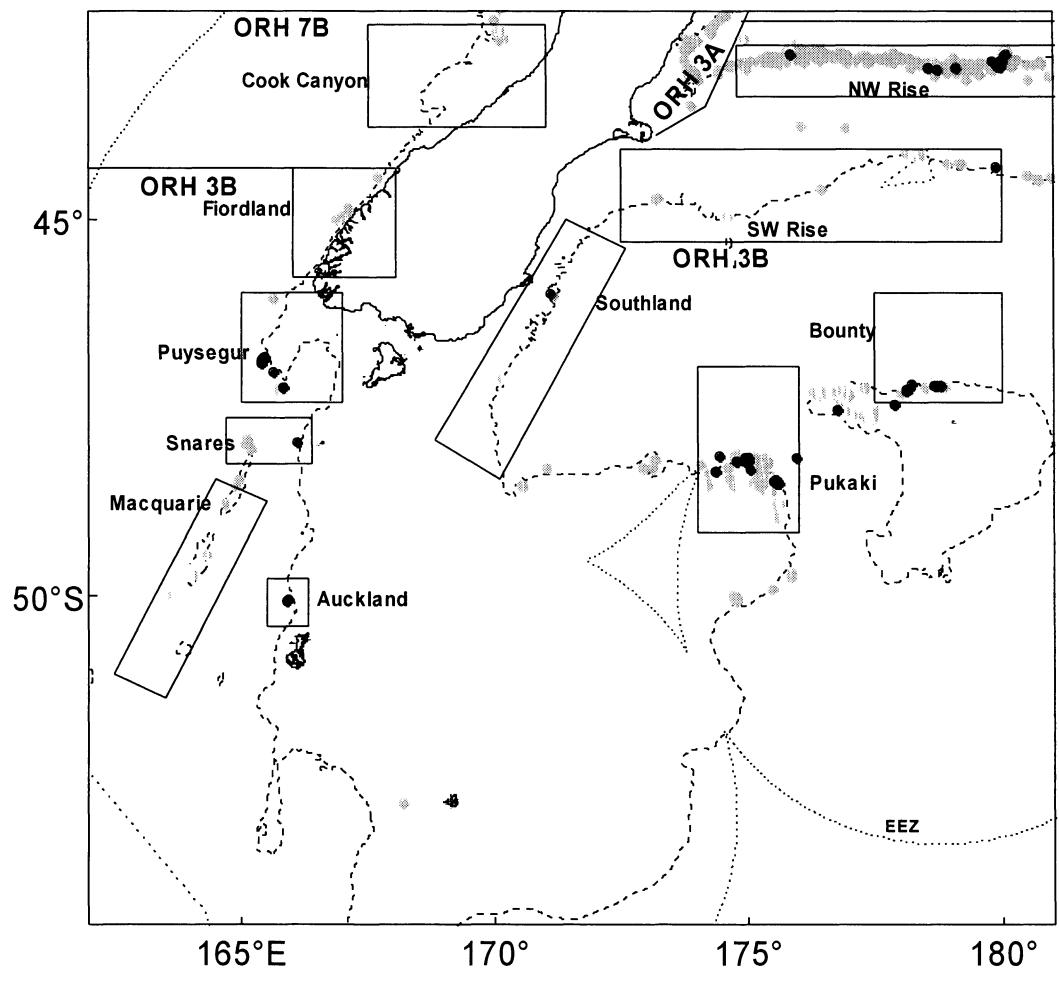


Figure 3: Location of fisheries used for analysis of biological data, position of trawls in the commercial fishery (grey dots), and location of samples of orange roughy taken by OP observers (black dots), during the 2004–05 fishing year. The dotted line shows the 1000 m depth contour.

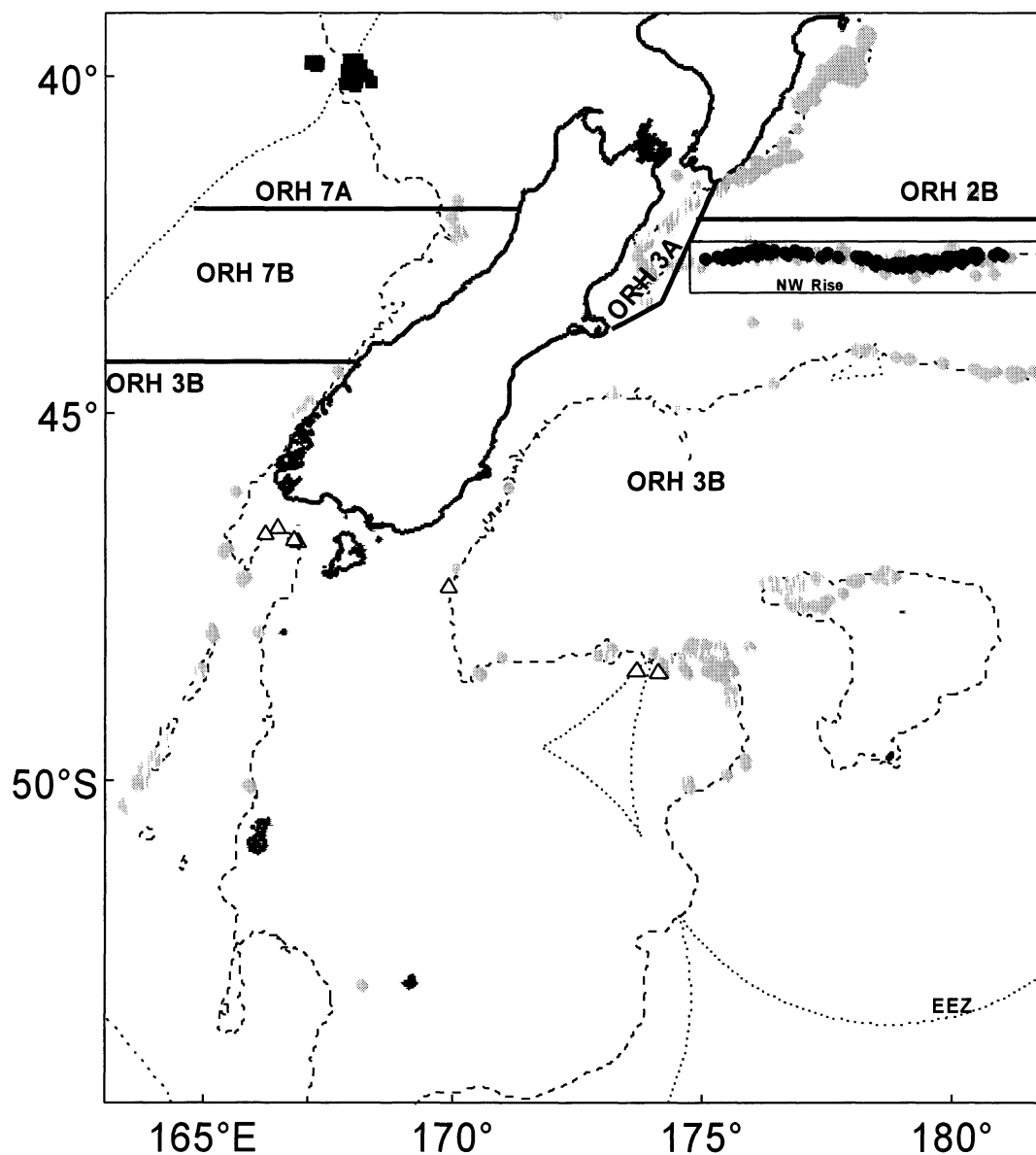


Figure 4: Location of fisheries and NIWA research trawls where orange roughy length data were recorded, and position of trawls in the commercial fishery (grey dots); closed circles, Northwest Chatham Rise orange roughy survey June–July 2005 (R.V. *Tangaroa*, F.V. *Amaltal Mariner*); open triangles, sub-Antarctic trawl survey November–December 2004 (R.V. *Tangaroa*); closed squares, Challenger Plateau orange roughy survey June–July 2005 (F.V. *Thomas Harrison*). The dashed line shows the 1000 m depth contour.

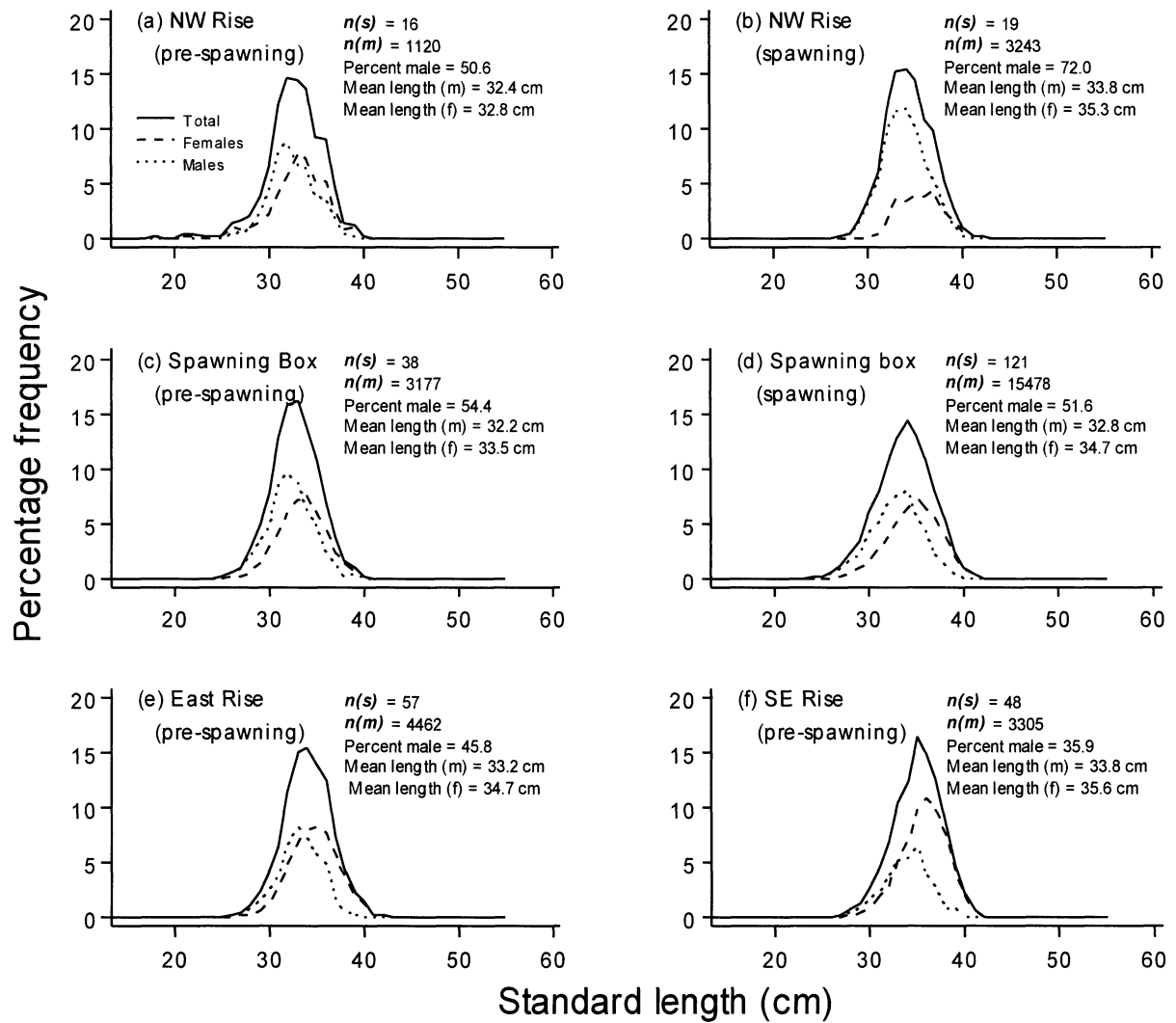


Figure 5: OP length frequency distributions (scaled by catch) of orange roughy by area and period, $n(s)$, number of samples; $n(m)$, number of fish measured.

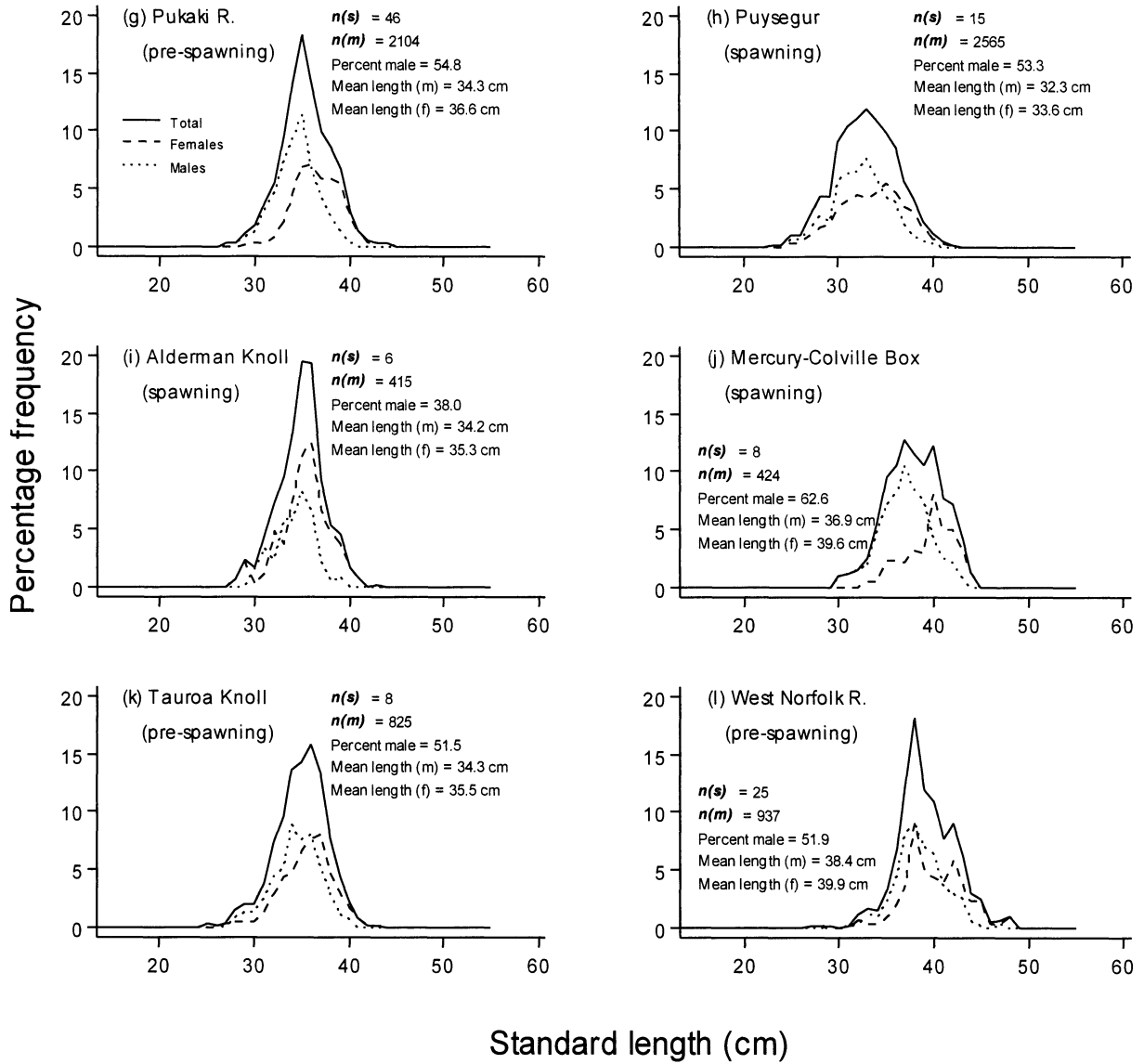


Figure 5 — continued.

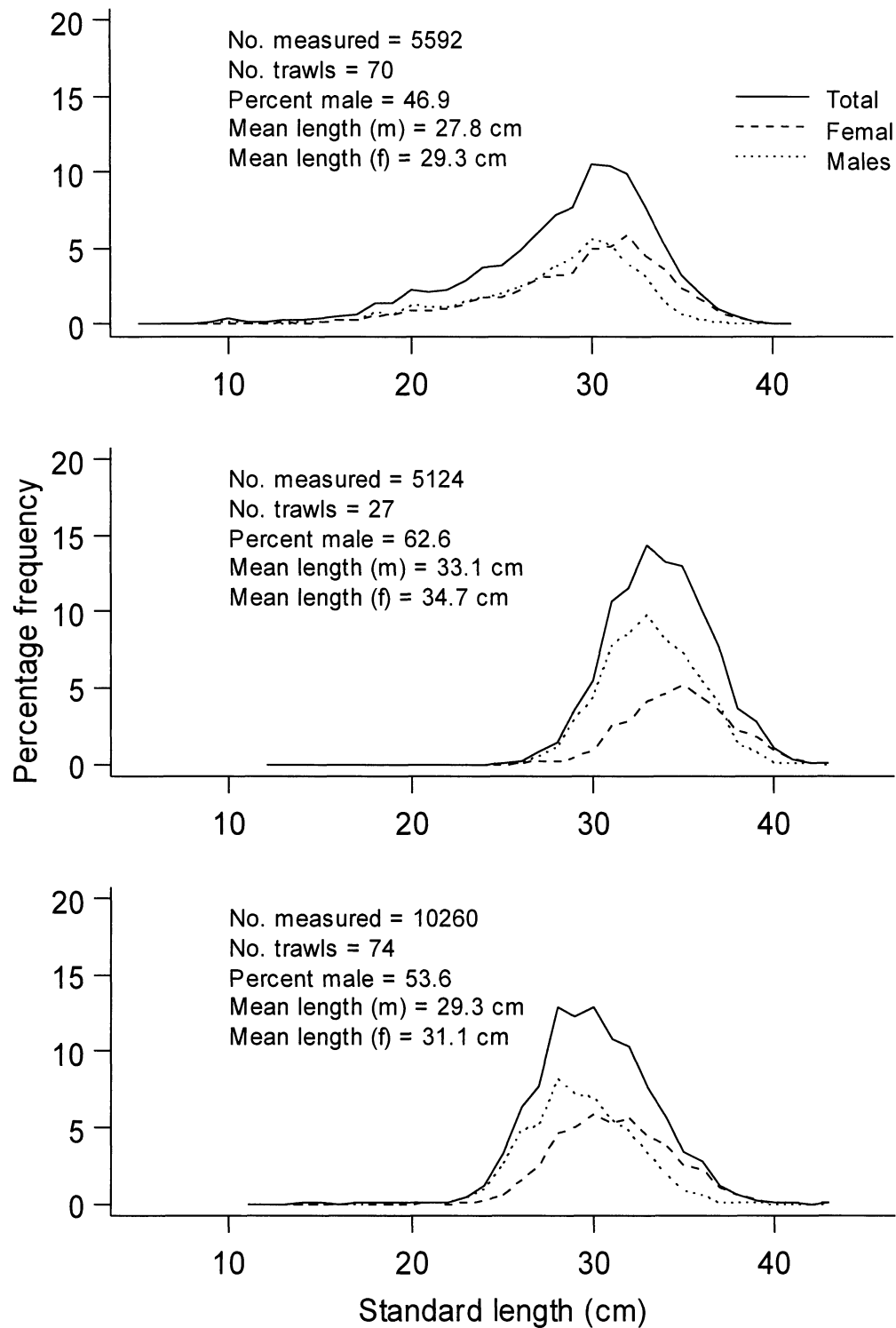


Figure 6: Orange roughy length frequency distribution (scaled by catch) from the Northwest Chatham Rise orange roughy research survey June–July 2005 (F.V. *Amaltal Mariner*, R.V. *Tangaroa*), top; flat area tows; centre, hill tows, and (bottom) from the Challenger Plateau orange roughy survey June/July 2005 (F.V. *Thomas Harrison*).

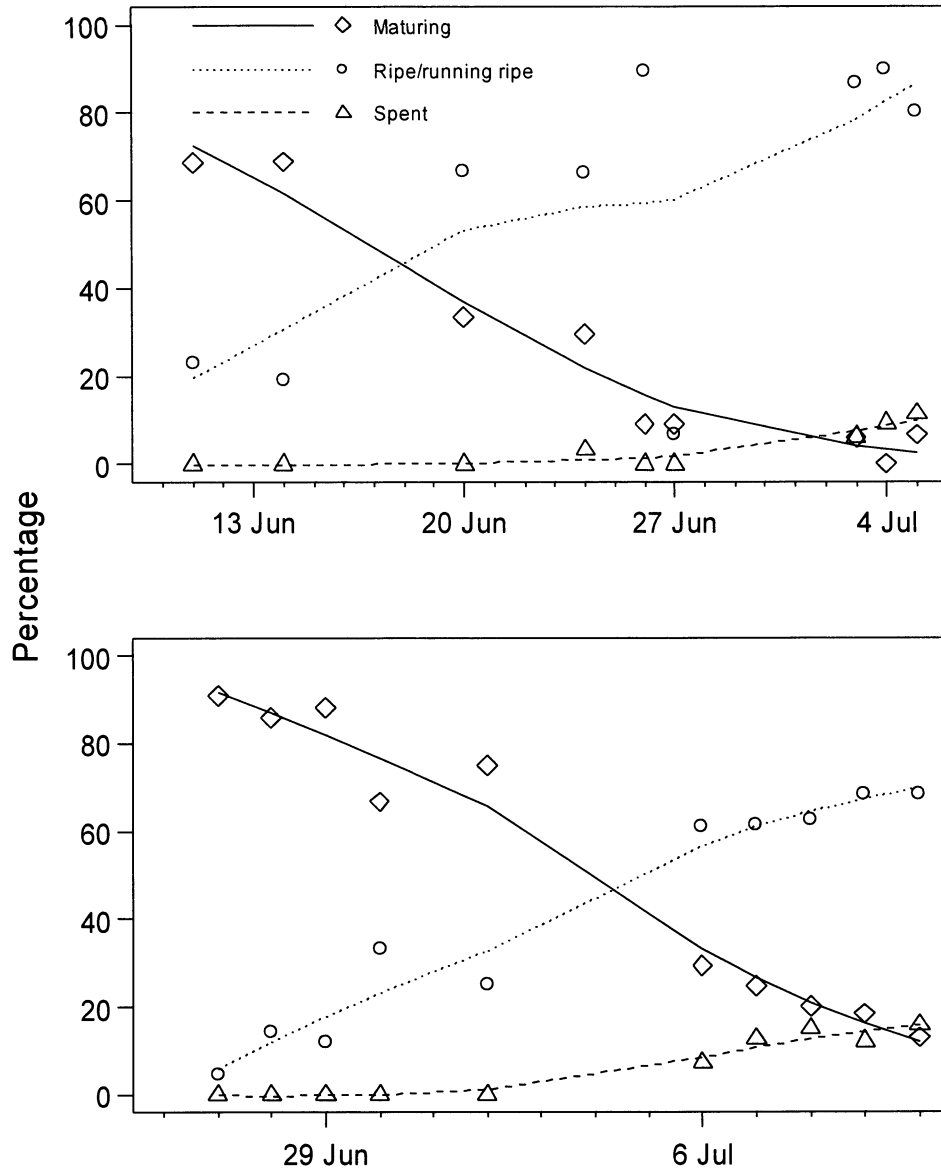


Figure 7: Daily changes in female orange roughy gonad stage proportions during the spawning season in two fisheries, from OP data; top, NW Rise (ORH 3B); bottom, Spawning Box (ORH 3B). Each point indicates the fraction of all fish examined (aggregated by day (top) and tow (bottom)) which were in the reproductive state indicated by the symbol.

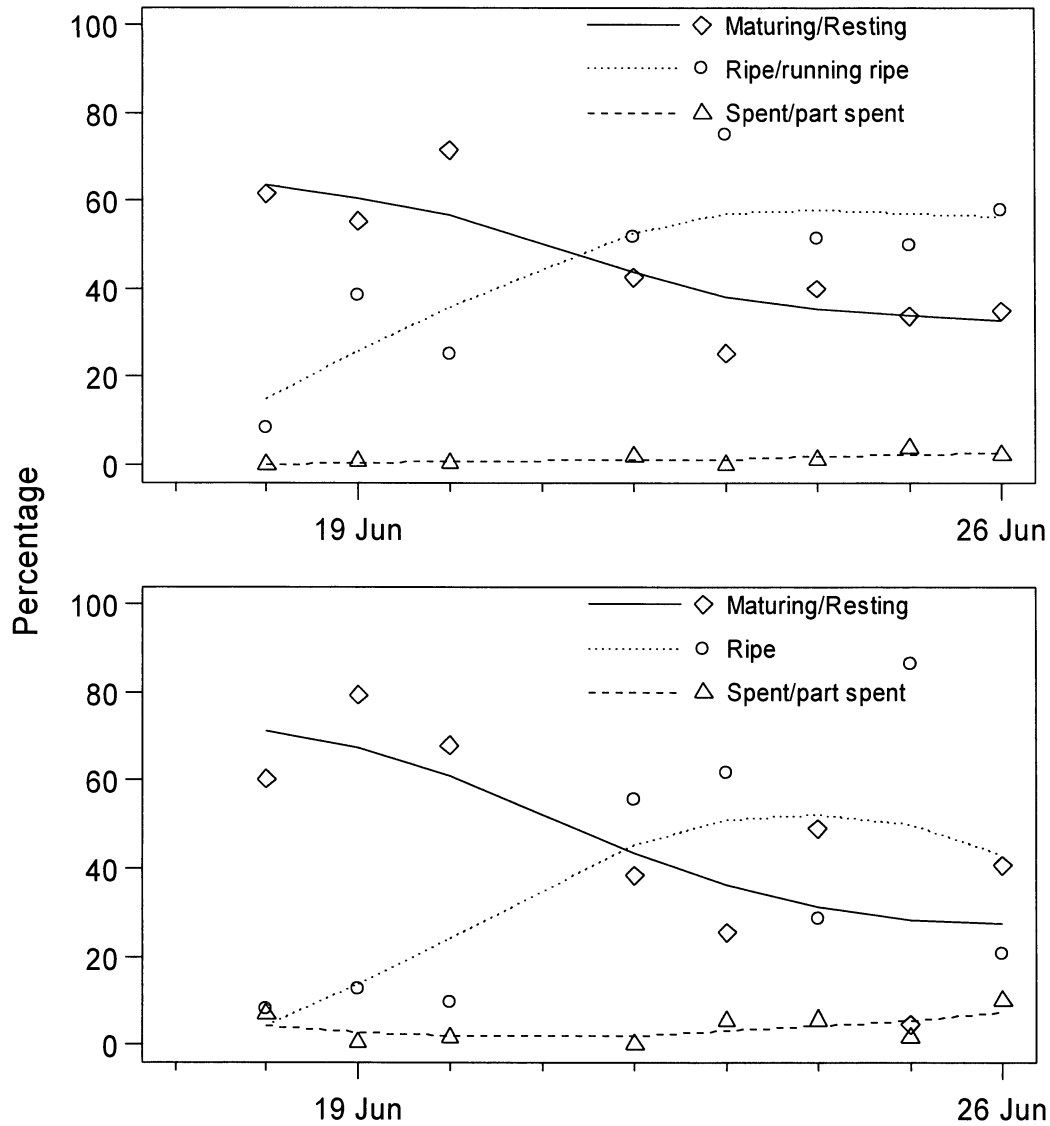


Figure 8: Daily changes in orange roughy gonad stage proportions during the spawning season in the NW Rise (ORH 3B), from research survey data (F.V. *Amaltal Mariner* hill tows only). Top, female fish; bottom, male fish. Each point indicates the fraction of all fish examined (in all samples taken on that day) which were in the reproductive state indicated by the symbol.

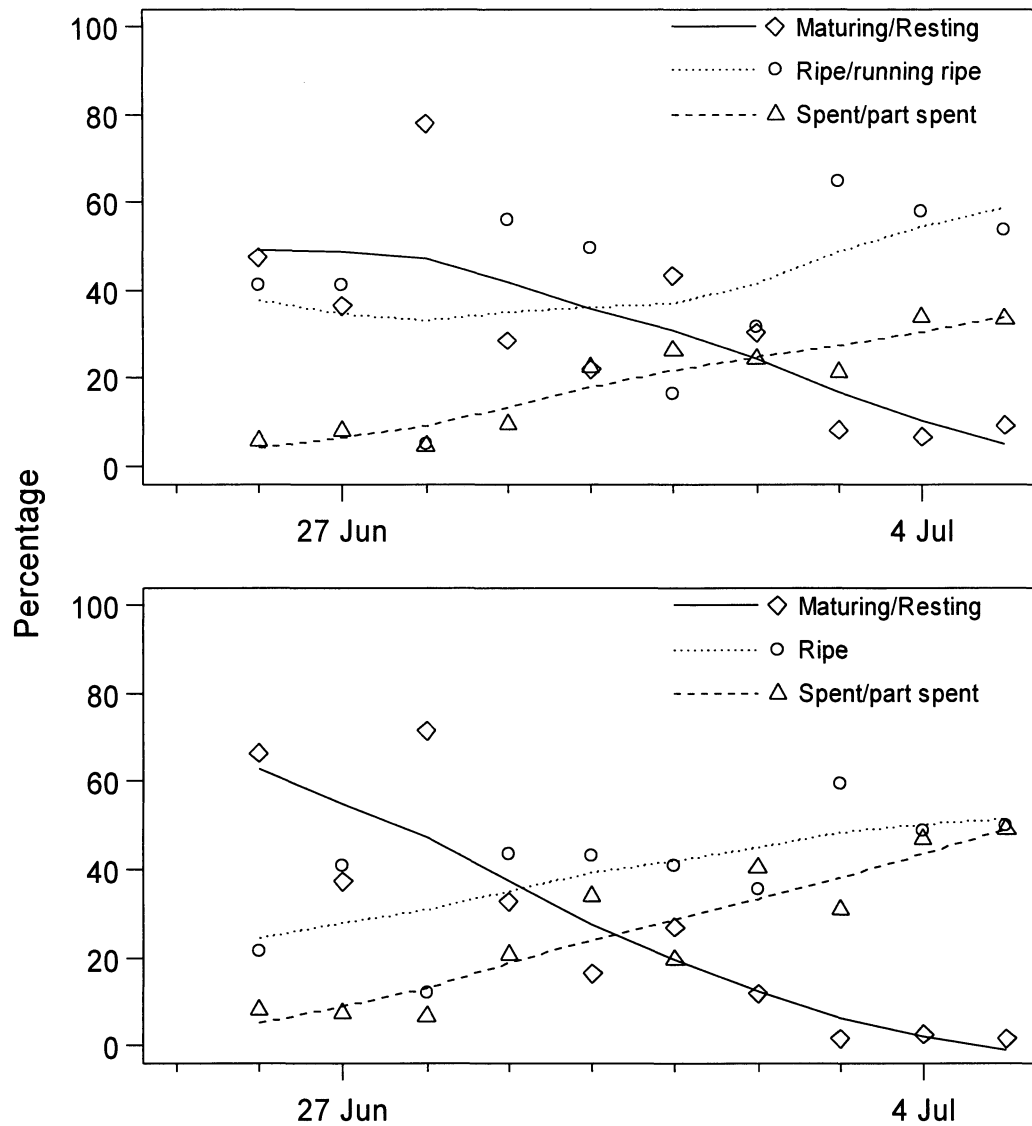


Figure 9: Daily changes in orange roughy gonad stage proportions during the spawning season in the Challenger Plateau (ORH 7A), from research survey data (F.V. Thomas Harrison). Top, female fish; bottom, male fish. Each point indicates the fraction of all fish examined (in all samples taken on that day) which were in the reproductive state indicated by the symbol.