

**A summary of biological information on the New Zealand fisheries
for orange roughy (*Hoplostethus atlanticus*)
for the 2007–08 and 2008–09 fishing years**

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EXECUTIVE SUMMARY

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1. Size and reproductive data on orange roughy, collected by observers of the Ministry of Fisheries Observer Programme (OP), the fishing industry Offshore Trawl Sampling programme (OTS), and from MFish/NIWA and industry research surveys, were examined and summarised by fishery. Data were available from 564 OP trawls and 60 OTS trawls during 2007–08, and from 625 OP trawls and 54 OTS trawls during 2008–09. These trawls were from fisheries both within and outside of the New Zealand Exclusive Economic Zone (EEZ). Biological data collected from 64 research trawls by NIWA staff on the Challenger Plateau in June–July 2009, and from 33 and 52 research trawls on the Chatham Rise in winter 2008 and 2009 respectively, by industry scientists, were also summarised.

2. The annual level of OP sampling for these two years was greater than for recent years, the highest since 2002–03, and was close to the anticipated level of coverage in most areas. Sampling effort increased considerably in the east coast fisheries in QMAs ORH 2A, ORH 2B, and ORH 3A, to levels not seen since the late 1990s. Sampling effort also increased in areas outside the EEZ, especially in the Lord Howe Rise, Northwest Challenger, and West Norfolk Ridge fisheries, where sampling has been intermittent in recent years. However, the Louisville Ridge fishery was not sampled at all, and has not been sampled since 2005–06. Coverage of the north Chatham Rise fisheries in ORH 3B was high in both years, with biological data collected during industry surveys from the Graveyard, Spawning Box, East Rise fisheries, as well as from both observer sampling programmes. In 2007–08, over 17 000 fish from 121 trawls were measured in the East Chatham Rise fishery, and more than 15 000 fish were measured from 111 trawls in the Spawning Box fishery. In 2008–09, more than 30 000 fish from 189 trawls were measured in the Spawning Box fishery. Several thousand fish were also measured in each of the east Chatham Rise, northwest Chatham Rise, southeast Chatham Rise, and Pukaki (ORH 3B); West Norfolk Ridge, and East Northland (ORH 1); and West Norfolk Ridge and Lord Howe Rise (ET) fisheries. The level of OTS sampling in 2007–08 and 2008–09 was relatively low compared with the two previous years, with sampling focussed on the east coast fisheries in ORH 2A, ORH 2B, ORH 3A, and on the ORH 3B fisheries, both around the Chatham Rise and on the southern plateau.

3. Sufficient length samples were obtained by OP observers to determine size frequencies for 17 and 16 fishery/season combinations, and by OTS observers for 6 and 2 fishery/season combinations, in 2007–08 and 2008–09 respectively. These distributions tended to be broadly unimodal in shape in most areas, but with considerable variation between areas in the range of fish sizes and the calculated mean lengths. The smallest fish tended to be from the east coast and Chatham Rise pre-spawning fisheries (mean lengths 31–33 cm for males and 33–35 cm for females) and the largest from the ORH 1 fisheries, especially the West Norfolk Ridge fishery in which mean lengths were about 40 cm (males) and 42 cm (females) in both years. A large amount of length data was collected from the industry/NIWA orange roughy research survey on the Challenger Plateau and from the industry survey of the orange roughy Spawning Box fishery, and size distributions were produced for these also.

4. Overall, sex ratios calculated from scaled observer size frequency data indicated a slight dominance of male fish, with 26 of the 41 fishery/area combinations (both years combined) showing a higher percentage of male fish, although this dominance tended to be slight in most areas, with 25 of the 41 calculated ratios falling within 10 percentage points of 50%. The most skewed sex ratios

were from the 2008–09 SE Chatham Rise pre-spawning fishery (35.0% male) and the 2007–08 East Northland spawning fishery (73.4% male).

5. OP observer sampling in several ET, ORH 1, and Chatham Rise fisheries, and research sampling in the Challenger Plateau fishery during the spawning period was sufficient to describe the temporal progression of spawning in those areas. The timing of spawning in the West Norfolk Ridge (ET) fishery was determined for the first time, from data collected in 2008, with the peak shown to occur at about 29 June. In 2009, peak spawning occurred later than usual in the NW Challenger Plateau, and earlier than usual in the East Northland fishery. In all other fisheries examined, the timing of spawning was typical.

1. INTRODUCTION

This report documents the results of objective 3 of the Ministry of Fisheries project ORH2008/02 “Orange roughy stock assessment”, which states:

“To analyse length frequency, sex ratio, and reproductive data for orange roughy collected by the Observer Programme and from other sources during the 2007/08 and 2008/09 fishing years 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, Dunn 2007, A. McKenzie, NIWA, unpublished results). The use of observer data in orange roughy stock assessments was summarised by Anderson (2006a). 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 the Chatham Rise Spawning Box fishery (Francis 1996).

This report presents summaries of orange roughy size and reproductive state data collected by observers of the MFish observer programme (OP) and by commercial vessels participating in the Offshore Trawl Sampling (OTS) programme during the 2007–08 and 2008–09 fishing years. These summaries are constructed and presented in a manner consistent with that used in previous analyses of orange roughy biological data (e.g., Anderson 2008b) to provide a means of quickly identifying and obtaining data for input into stock assessment models.

In addition to the analysis of observer data, this report also presents summaries of orange roughy biological data collected by NIWA staff during an industry-funded survey of orange roughy on the Challenger Plateau (ORH 7A) in June–July 2009, by scientists during industry-run surveys of the Spawning Box plume in July 2008 and July 2009, and provides station positions for where any amount of orange roughy biological data were collected on NIWA-run research surveys of middle depth species in 2007–08 and 2008–09.

2. DATA COLLECTION

Orange roughy biological data were collected by OP observers hosted aboard commercial fishing vessels. Observers took measurements from random samples of, usually, 80–100 fish (full range over both years, 2–400) per trawl, from an average of 1.7 (but up to five) 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 PostgreSQL *cod* database.

Further orange roughy biological data are also available from the OTS programme, which has operated off and on since 1996–97. On participating vessels, the sampling programme collects

biological data from the orange roughy catch from a randomly selected commercial trawl for each day of fishing, and generally follows the procedures used by OP observers (but see Langley (2001) for a detailed description of the sampling protocols). A revival of this sampling programme has resulted in a large amount of data being available since 2005–06.

Independent observers associated with Fisheries Audit Services (New Zealand) Limited (FAS) also collected some orange roughy biological data in recent years, from commercial vessels operating in ORH 1. For the 2007–08 and 2008–09 period, however, only one length frequency sample was taken by this programme.

Biological data collected by NIWA staff are available from the June–July 2009 orange roughy research survey on the Challenger Plateau (R.V. *Thomas Harrison*). In addition, a small amount of orange roughy biological data is also available from NIWA surveys of hoki on the Chatham Rise in January 2008 and January 2009, and from multi-species surveys in the sub-Antarctic in November–December 2007 and November–December 2008. On these surveys a random sample of up to 200 fish is taken from each catch (with multiple samples taken from large catches) and the length and reproductive condition of fish of both sexes recorded. These data are held at NIWA, Greta Point, on the Empress *trawl* database.

The industry-run surveys of the Spawning Box plume and other Chatham Rise fisheries typically have an observer on board, as well as industry scientists, and both take samples of orange roughy for measurement of length and female reproductive stage. Therefore often two sets of samples may be taken from the same catch, and in some cases these are the same set of fish. Like NIWA, the industry scientists take samples consisting of up to 200 fish, and multiple samples from larger catches but, like observers, record reproductive data only from female fish. These data are kept in files maintained by Rob Tilney (Clement & Associates Ltd).

3. METHODS

The OP records and manages data according to broad areas based on Fishery Management Areas (Figure 1). For this summary, however, data from both the OP and OTS programmes 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 to 6). These fishery areas are comparable to those used in previous analyses (e.g., Anderson 2008b).

All data were error checked before being added to the databases, and further checks were made 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 unlikely values.

Catch and effort data from the orange roughy commercial fisheries were summarised to determine the level of OP and OTS observer coverage achieved in each of the main fisheries in 2007–08 and 2008–09. Coverage was determined based on the proportion of the total catch observed and sampled in each fishery. These data came from an extract from the Ministry of Fisheries *Warehou* database (Rep Log 7720A). The level of OP observer coverage in each fishery, in number of samples, was also compared to the level of coverage scheduled, in number of days, by the Ministry of Fisheries. This comparison is possible because of the general requirement that observers collect one sample per day.

3.1 Size structure

Length frequency distributions were determined from the OP and OTS 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. The OP 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.

Length data collected by NIWA staff and by industry scientists were treated in the same manner as those collected by observers. There were insufficient fish measured (fewer than 400) in either of the two Chatham Rise hoki or the two sub-Antarctic middle-depth species surveys to produce meaningful size frequencies, but distributions were prepared based on measurements of several thousand fish on the 2009 Challenger Plateau and 2008 and 2009 Chatham Rise orange roughy surveys.

3.2 Reproduction

Due to difficulties with the consistent interpretation of the macroscopic stages of male orange roughy, observers and industry scientists examined gonads from only female fish. These were checked for reproductive state and assigned to one of five (macroscopic) categories (Table 1). Note that these are different from the categories currently used for orange roughy by NIWA research staff, which provide for a more complete separation of immature fish from mature fish and allow for partially spent and resting stages.

Gonad staging data from both OP and OTS 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 over time. These plots were constructed by fitting a curve to daily values of the fraction of fish in each of the mature reproductive states (observer, F2, F3/F4 combined, F5; research female, F3/F9, F4/F5, F6/F8; research male, M3/M9, M4, M5/M8) shown in Table 1. Sufficient data for this purpose were available from OP data in 2007–08 for Dargaville, East Northland, West Norfolk Ridge, Lord Howe, NW Chatham Rise, and the Spawning Box; and in 2008–09 for Lord Howe, NW Challenger Plateau, NW Chatham Rise, the Spawning Box, and East Northland. Reproductive condition data collected by the OTS programme were mainly from outside of the spawning period and hence not useful for building such plots.

4. RESULTS

OP samples of orange roughy ranged from 1.3 kg to 413 kg (2007–08) and 1.0 kg to 530 kg (2008–09) from catches of between 2 kg and 96 t (2007–08) and 3 kg and 85 t (2008–09). OTS samples were not weighed, although most consisted of 100 fish, and catch weight data were also not available. NIWA research samples from the 2009 Challenger Plateau survey ranged from 2.3 kg to 669 kg and were taken from catches of between 2.3 kg and 38 t. Samples taken on the 2008 Plume/East Rise hills survey were mostly 200–300 kg and came from catches of up to 48 t. Samples were of a similar size on the 2009 Plume/Graveyard hills survey, from catches of up to 55 t.

4.1 Distribution of samples

2007–08

Ministry of Fisheries OP observers sampled 564 catches of orange roughy collected during 27 voyages with the number of samples per voyage ranging between 1 and 100 (median 10). Three areas were specifically targeted for observer sampling in the 2007–08 fishing year; ORH 1, ORH 3B, and ORH 2A (Table 2). A large fraction of the targeted sampling in ORH 1 was to be directly funded by industry, and all fishing for orange roughy outside of the EEZ (in the South Pacific Regional Fisheries Management Organisation (SPRFMO) area) was to have observer coverage, also funded by industry. The expected sampling levels in each area (Table 2) are approximate as they are based on the MFish financial year (June–July) and are in units of sampling days rather than numbers of samples (although observers usually take one sample per day).

OP observer coverage was, as usual, focussed strongly in ORH 3B, and the 339 samples taken in 2007–08 was slightly more than in the previous two years. Sample numbers were lower in ORH 1 than in the previous year (but similar to the 2005–06 coverage) and were much lower than anticipated. The 43 samples collected from the east coast fisheries (ORH 2A, ORH 2B, ORH 3A) represented a dramatic increase in coverage for these areas, which have typically had fewer than five samples per year for the preceding several years. Although coverage was less than anticipated for these areas, it was the highest sampling level seen since 1999–2000. Observer coverage of the ET fisheries was limited to the Lord Howe/NW Challenger and West Norfolk Ridge fisheries, with no sampling in the Louisville Ridge fishery.

Sampling effort arranged by month and OP area is shown in Table 3, and sampling effort by month, sampling programme, and fishery is shown in Table 4. Over 50% of the OP samples came from area SOE (Chatham Rise) with the remainder spread mostly amongst areas SUB (Sub-Antarctic), AKE/AKW (ORH 1), CEE (ORH 2A/ORH 2B), and the ET and HOWE regions outside of the EEZ. Samples were taken in all months, but with a focus on the May–July, and November–December periods.

The OTS programme sampled 60 catches of orange roughy on 20 voyages (half the number of 2006–07), with the number of samples per voyage ranging from one to nine (Table 4). Half of these samples were from fisheries within ORH 3B, especially the southeast Chatham Rise, northwest Chatham Rise, and Pukaki Rise, and the remainder were from the east coast fisheries in ORH 2A, ORH 2B, and ORH 3A.

Sampling of commercial fishing on the Chatham Rise was spread amongst several major fisheries; the Spawning Box (84 OP samples), East Rise (115 OP samples), SE Rise (34 OP, 15 OTS samples), and NW Rise (65 OP, 5 OTS samples). Between the two programmes over 23 000 fish were examined in these four areas during 2007–08 (Table 4). In the region of ORH 3B below 46° S, sampling was almost entirely limited to the Pukaki fishery, where there was a high level of sampling by both programmes, spread throughout the year and mainly in the vicinity of the “Priceless” feature.

Sampling was spread among eight recognised fisheries in ORH 1, with OP coverage ranging from three samples in July/August in Mokohinau to 40 samples (mostly from June/July) in East Northland. Coverage was also good from early in the fishing year in West Norfolk Ridge (35 samples). Elsewhere in ORH 1, the total number of samples for the year was less than ten.

The east coast ORH 2A, ORH 2B, and ORH 3A fisheries received moderate levels of OP and OTS sampling effort, mainly from early in the fishing year. This region has received little coverage in recent years despite regular scheduling of sampling effort by the OP programme, mainly due to the small size of the vessels operating in these fisheries. Therefore the sampling by both programmes this year in each of the five sub-areas examined is a considerable improvement over recent years.

With the combined efforts of the two programmes, observer effort was moderately well spread out over the fishing year and samples were collected in every month. Only in September, when typically there is little fishing anywhere for orange roughy, was the total number of samples collected fewer than 10, with between 10 (February) and 110 (June) samples per month collected during the rest of the year. Overall, sampling tended to reflect the spread of the commercial fishery, where there is an emphasis on the May–July period encompassing orange roughy spawning, and also the October–December period, the start of the fishing year.

Outside the EEZ, the improved level of sampling included over 30 samples taken from both the Lord Howe and West Norfolk Ridge (ET) fisheries, during winter.

The positions of all tows from which OP samples were collected are shown in Figures 2–4, which also show the positions of all tows that caught orange roughy in the 2007–08 fishing year, according to TCEPR returns. Sampling was well spread over virtually all of the recognised ORH 1 fishing grounds that were fished during the year, and also in each of the western ET fisheries, although with a limited spread in NW Challenger. A very high fraction of the commercial fishery was observed in several of the larger ORH 1 fisheries, especially Tauroa Knoll (72%) and East Northland (59%) (Table 5), reflecting the continuation of the high coverage in this fishery instigated by the requirements of the Adaptive Management Programme (AMP) which operated in this QMA up until 30 September 2006. Complete coverage of the commercial fishery was achieved in the largest ET fishery (West Norfolk Ridge), and very high levels also in NW Challenger (71%) and Lord Howe (93%). On the east coast, coverage was well spread over the Tolaga and Wairarapa fisheries, representing 20% of the commercial fishery in both areas, but was low in the East Cape, Ritchie, and Kaikoura fisheries (Figures 2 and 3). Sampling was generally well spread around the fished regions of the Chatham Rise, especially the Spawning Box, East Rise, and Southeast Rise. In the southern (south of 46° S) parts of ORH 3B, commercial fishing effort was light in most areas, with similarly light observer sampling, but the higher level of effort in the Pukaki fishery was well covered by observers (Figures 3 and 4). Coverage of some of the ORH 3B fisheries was also high in relation to commercial catch, especially in the Spawning Box (28%), NW Rise (34%), East Rise (22%), and Pukaki (35%).

The positions of all tows from which OTS samples were collected are shown in Figures 5 and 6, which also show the positions of all commercial tows that caught orange roughy in the 2007–08 fishing year, according to TCEPR returns. The 60 samples collected by this programme were spread throughout the east coast fisheries, including the East Cape hills, Tolaga Hill, and the Castlepoint hills, along the northwest Chatham Rise (including the Graveyard hills) and southeast Chatham Rise (including the Big Chief complex), and Pukaki fishery, including “Priceless”.

The locations of trawl stations in the two NIWA research surveys in which orange roughy were measured are shown in Figure 7. Orange roughy were caught in small amounts (up to about 115 kg) on nine stations during the Chatham Rise hoki survey in December 2007–January 2008 and in similarly small amounts (up to about 42 kg) on 20 stations during the sub-Antarctic middle-depths survey in November–December 2007.

Only 225 orange roughy were measured, from a total catch of 100 kg, on the sub-Antarctic survey, and 237 orange roughy were measured from a total catch of 182 kg on the Chatham Rise hoki survey.

The industry-run survey of the Spawning Box plume and East Rise hills in July 2008 collected biological data from 33 trawls, mostly comprising large catches of orange roughy (4–48 t). Industry scientists measured nearly 10 000 fish from these trawls, the location of which, within the context of the Chatham Rise and Spawning Box, are shown in Figure 8.

2008–09

Ministry of Fisheries OP observers sampled 625 catches of orange roughy collected during 25 voyages with the number of samples per voyage ranging between 1 and 84 (median 19). The same three areas as in 2007–08 were specifically targeted for observer sampling in 2008–09, i.e., ORH 1, ORH 3B, and ORH 2A, with the same arrangements for industry funding of sampling in ORH 1 and in the ET fisheries. Observer coverage in this year was even more strongly focussed on the ORH 3B fisheries, and the total of 403 samples taken was more than in any previous year. Sample numbers in ORH 1 were lower than in the past three years, and much lower than anticipated. Sampling in the east coast fisheries (ORH 2A, ORH 2B, ORH 3A) was lower than in 2007–08 but still relatively high for this area, and the 11 samples from Kaikoura (ORH 3A) represented the highest level of coverage for this area since 2000–01. Observer coverage of the ET fisheries included a large number of samples for Lord Howe/NW Challenger and West Norfolk Ridge fisheries, but again there was no sampling in the Louisville Ridge fishery.

Sampling effort arranged by month and OP area (Table 3) and by month, sampling programme, and fishery (Table 4) shows that nearly 60% of the OP samples came from area SOE (Chatham Rise), with the remainder spread mostly amongst areas AKE/AKW (ORH 1), and the ET and HOWE regions outside of the EEZ. Samples were taken in all months, but with a focus on the May–July, and October–November periods.

The OTS programme sampled 54 catches of orange roughy on 20 voyages (slightly less than in 2007–08), with the number of samples per voyage ranging from one to ten (Table 4). More than half of these samples were from the southeast Chatham Rise fishery in ORH 3B, with all but one of the remainder spread over the East Cape, Tolaga, Ritchie, Wairarapa, and Kaikoura fisheries in ORH 2A, ORH 2B, and ORH 3A. A single sample was taken from the northwest Chatham Rise (ORH 3B).

Sampling of commercial fishing on the Chatham Rise was spread amongst several major fisheries; the Spawning Box (150 OP samples), East Rise (116 OP samples), SE Rise (80 OP, 29 OTS samples), and NW Rise (21 OP, 1 OTS samples). Altogether, over 16 000 fish were examined in the Spawning Box, over 8000 fish in the East Rise, and over 7000 fish in the southeast Rise, spread throughout 2008–09 (Table 4). In southern regions of ORH 3B samples were relatively few, small, and limited to the OP programme, with only several hundred fish examined from the combined Bounty Is., Pukaki, and Pukaki South fisheries.

Sampling was spread among seven recognised fisheries in ORH 1, with OP coverage ranging from two samples in Aldermen Knoll, south Kermadec Ridge, and White Island to 29 samples in East Northland, 26 in west Norfolk Ridge, and 21 in Tauroa Knoll.

The east coast ORH 2A and ORH 2B fisheries received low to moderate levels of OP sampling effort, mainly from early in the fishing year, but these were complemented by a similar level of OTS sampling in each fishery. The efforts of both programmes in this year, as well as in 2007–08, have combined to achieve a reasonable level of sampling effort in a region that has proven difficult to access in recent years.

Considering the two programmes together, observer effort was moderately well spread out over the fishing year and samples were collected in every month. Only in April, August, and September were the total number of samples collected fewer than 20, with between 26 (March) and 143 (June) samples per month collected during the rest of the year. Overall, sampling tended to reflect the spread of the commercial fishery, where there is an emphasis on the May–July period encompassing orange roughy spawning, and also the first few months of the fishing year.

Outside the EEZ, over 50 OP samples were taken from the Lord Howe Rise fishery, mainly from May–July, and the high level of coverage (over 20 samples) in both the West Norfolk Ridge (ET) and NW Challenger fisheries was also from this period.

Sampling was well spread over most of the recognised ORH 1 fishing grounds, with the notable exception of Dargaville, and also in each of the western ET fisheries (Figure 2). A high fraction of the commercial fishery was again observed in some of the main ORH 1 fisheries, including Tauroa Knoll (64%), East Northland (70%), and West Norfolk Ridge (69%) (Table 5). Coverage was lower in the West Norfolk Ridge (ET) fishery than in 2007–08, although still representing half of the commercial catch, and was high again in NW Challenger (64%) and Lord Howe (94%). In the east coast fisheries, sampling covered both the East Cape hills and northern “Twin Peaks” features in ORH 2A North, as well as scattered sampling around Tolaga Hill and Ritchie Banks (ORH 2A South), the Wairarapa (including the Castlepoint hills) (ORH 2B), and Kaikoura (ORH 3A) (Figures 3&4). However the catches sampled were small in the central east Coast fisheries and only in East Cape and Kaikoura were more than 30 kg of fish sampled. Sampling was well spread around the Chatham Rise, especially the Spawning Box, East Rise, and Southeast Rise, but sampling was less intensive than the previous year on the NW Rise, especially around the Graveyard (180°) hills. In the southern (south of 46° S) parts of ORH 3B commercial fishing effort was light in most areas and observer sampling was also limited, although there was good coverage of the Pukaki and Pukaki South fisheries, and the Bounty fishery (Figure 4). Coverage of the ORH 3B fisheries was relatively high in relation to commercial catch, especially in the Spawning Box (75%), NW Rise (35%), and East Rise (35%).

The positions of all tows from which OTS samples were collected are shown in Figures 5 and 6, which also show the positions of all commercial tows that caught orange roughy in the 2008–09 fishing year, according to TCEPR returns. The 54 samples collected by this programme were spread mainly along the east coast fisheries (including the East Cape hills, Ritchie Banks, and Castlepoint hills), and along the southeast Chatham Rise (including the Big Chief complex).

The locations of trawl stations in the three research surveys in which orange roughy were measured by NIWA are shown in Figure 7. Orange roughy were caught in small amounts (less than 40 kg), and measured, on three stations during the Chatham Rise hoki survey in December 2008–January 2009 and 14 stations during the sub-Antarctic middle-depths survey in November–December 2008. On the Challenger Plateau orange roughy survey in June–July 2009, orange roughy were caught and measured on 76 stations, from catches of up to 38 t.

Only 232 orange roughy were measured, from a total catch of 160 kg, on the sub-Antarctic middle-depth and Chatham Rise hoki surveys combined. The Challenger orange roughy survey measured almost 13 000 fish from a total catch of 240 t.

The industry-run survey of the Spawning Box plume and Graveyard hills in July 2009 collected biological data from 52 trawls, mostly comprising large catches of orange roughy (up to 55 t). Industry scientists measured almost 15 000 fish from these trawls, the location of which, within the context of the Chatham Rise and Spawning Box, are shown in Figure 8. A few additional biological samples were also collected on this survey from three hills on the South Chatham Rise, Mt Kiso, Hegerville, and Big Chief, but length data were not sufficient to construct useful plots of size frequency.

4.2 Size structure and sex ratios

Observer length frequency distributions by sex are given in Figures 9 and 10 (OP data) and Figures 11 and 12 (OTS data). The OP distributions are based on numbers at length scaled to the catch weight for the trawl but due to an incomplete set of sample weight and catch weight data, the OTS distributions are unscaled. Research survey length frequency distributions by sex (scaled by catch for the Challenger Plateau survey but unscaled for the Chatham Rise surveys) are given in Figures 13–15.

2007–08

Strongly 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 9c, d). The main points of difference in the size distributions between areas were small variations in the range of fish lengths measured and in the position of the mode. The smallest mean lengths were in the Spawning Box (pre-spawning) and Wairarapa fisheries (Figure 9c, q) and the largest mean lengths were in the West Norfolk Ridge fisheries (Figure 9k, l) where mean fish lengths were about 40 cm (male) and 42 cm (female).

Where length data were available from the same area for each reproductive period, length distributions, mean lengths, and sex ratios in most cases differed only slightly, with little indication of larger fish in samples taken during the spawning months, which might be expected with a predominance of mature, older fish in spawning aggregations. For example, although mean lengths of both sexes were 1–1.5 cm greater in the Spawning Box during spawning, in the east Chatham Rise, Pukaki Rise, and northwest Chatham Rise either female fish were larger and male fish smaller (or vice versa) during spawning (Figure 9a–h).

Small fish, less than 25 cm, were rarely found in any of the ORH 3B fisheries, and were evident only as a small proportion of the fish measured in the Lord Howe and Dargaville spawning fisheries, and the Wairarapa pre-spawning fishery (Figure 9j, n, q). In most of the southern fisheries there were few fish measured at over 40 cm, the main exception being in the Pukaki fishery, where fish were generally larger than in the Chatham Rise fisheries. Data from both OP and OTS programmes showed a relatively large difference between the mean size of male and female fish in this area (about 2.5–3.5 cm), as was also shown in 2008–09, and a larger proportion of female fish greater than 40 cm compared to most other areas. Although OTS data showed the southeast Chatham Rise to also have a large proportion of fish greater than 40 cm, this was not backed up by data from OP observers. Fish were generally larger in the northern fisheries, particularly the West Norfolk Ridge, East Northland, and Tauroa Knoll. The largest fish observed were in the West Norfolk Ridge (ET) spawning fishery and the West Norfolk Ridge pre-spawning fishery where, respectively, 71% and 76% of all fish were equal to or longer than 40 cm and fish of up to 50 cm were measured.

Sex ratios, based on scaled size frequency data, ranged from 38.6% male (Tolaga, pre-spawning) to 73.4% male (east Northland, spawning) (Table 6). Overall, there was a bias in the sex ratios, with 16 of the 23 fishery/area combinations showing a higher percentage of male fish. The sex ratios were generally close to 50:50, however, with 15 of the 23 being within 10 percentage points of 50% male, and only 1 more than 20 percentage points from 50:50.

Unscaled length frequency distributions were produced from the northeast Chatham Rise industry orange roughy survey (F.V. *San Waitaki*) for the Spawning Box plume (including Mt Muck) and eastern hills (Camerons and Smiths) (Figure 13). These distributions show a strongly unimodal shape, especially for the Spawning Box plume where this shape, the mean lengths, and the sex ratio (favouring males) are similar to the OP plot for the same area and period (see Figure 9d).

2008–09

Strongly unimodal distributions, mostly even sex ratios, and larger female fish, were again common features in most areas in this year. Where distributions were more multi-modal or uneven (e.g., Figure 10f, i) the number of fish measured tended to be relatively low. The smallest mean lengths were in the Kaikoura (pre-spawning) and NW Challenger (spawning) fisheries (Figure 10g, o) and the largest mean lengths were again in the West Norfolk Ridge spawning fisheries (Figure 10n, p) where fish were of a similar size to the previous year.

Where length data were available from the same area and reproductive period from both OP and OTS programmes (southeast Chatham Rise), length distributions showed a similar shape and mean lengths and sex ratios were also similar.

There was about a 1 cm difference in sample mean lengths between the pre-spawning and spawning periods in both areas for which each of these periods was sufficiently sampled, the Spawning Box and Lord Howe Rise (Figure 10a, b, i, j), the fish tending to be larger during the spawning period. Sex ratios were very similar between periods, and close to 50% male, in each area.

Small fish, less than 25 cm, were rarely found in most of the fisheries examined, although they were comparatively common in the Kaikoura fishery (Figure 10g) where they made up almost 8% of the fish measured. In the southern fisheries, orange roughly over 40 cm were again mainly limited to the Pukaki and southeast Chatham Rise fisheries, where mean lengths were 2–3 cm larger than in any of the other southern fisheries examined. The largest fish measured were again found in the two West Norfolk Ridge fisheries where 68% of fish inside the EEZ, and 86% of fish outside the EEZ, were equal to or longer than 40 cm.

Sex ratios, based on scaled size frequency data, ranged from 35.0% male (southeast Chatham Rise, pre-spawning) to 67.7% male (Mercury-Colville Box, spawning) (Table 6). Overall, there was no consistent bias in the sex ratios in favour of one sex, with 10 of the 18 fishery/area combinations showing a higher percentage of male fish. The sex ratios were generally close to 50:50, with 10 out of 18 being within 10 percentage points of 50% male, and only 3 being more than 20 percentage points from 50:50.

Unscaled length frequency distributions were produced from the Chatham Rise industry orange roughly survey (F.V. *San Waitaki*) for the Spawning Box plume (including Mt Muck) and Graveyard Hill (Figure 15). Distributions for both areas were strongly unimodal, and mean lengths very similar between locations. The main difference in these plots is the sex ratio, with female fish predominating in the Spawning Box and male fish on the Graveyard Hill. The size frequency plot for the Spawning Box based on OP data (collected from the same vessel during this survey) shows a similar size structure but a more even sex ratio (see Figure 10b).

Length frequency distributions, scaled by catch, were produced for male and female orange roughly sampled during the Challenger Plateau trawl survey in June–July 2009 (F.V. *Thomas Harrison*) (Figure 13). The distributions were well defined, with over 10 000 fish measured from biomass trawl stations, and showed strongly unimodal distributions for both sexes, a slight predominance of male fish, and very small mean lengths—matched only by those sampled by OP observers in the Kaikoura fishery.

4.3 Reproduction

Female fish were sampled for reproductive state by OP observers and staff on research voyages during spawning months (nominally June, July, and August) in several areas in 2008 and 2009 (Table 7) and, for several of these, an indication of the timing and location of spawning can be derived.

2007–08

Significant numbers of fish in ORH 3B fisheries in the ripe, running ripe, and spent stages were found in the NW Rise in June, Pukaki Rise in August, and the Spawning Box in July (Table 7). A few, mostly ripe, fish were also found in the Auckland Islands and Macquarie Ridge fisheries in February and March. Elsewhere in ORH 3B, OBS sampling was mostly outside the spawning months. Spawning fish were also common in the winter months' samples in several northern (ORH 1) fisheries including Dargaville, East Northland, Mercury-Colville Box, and White Is. Orange roughy in the ET fisheries on the West Norfolk Ridge, Lord Howe, and NW Challenger (ET) also showed spawning activity in winter, as did those in the East Cape Hills fishery (ORH 2A North). A few fish in each of the spawning states were found also in September in the Cook Canyon fishery (ORH 7B).

The OTS programme recorded significant numbers of female fish in spawning condition (running ripe and spent) only in the Northwest Rise, in June. Sampling by this programme in other spawning fisheries was generally outside of the spawning season (Table 8).

There were sufficient reproductive data collected by OP observers through the spawning period to make plots of the progression of spawning in two ORH 1 fisheries, Dargaville and East Northland; two ET fisheries, West Norfolk Ridge (ET) and Lord Howe; and two Chatham Rise fisheries, NW Chatham Rise and the Spawning Box (Figures 16–18).

In the Dargaville fishery there were data available across a four-week period encompassing the pre-spawning to mid spawning period. These show the typical decline in the fraction of maturing fish alongside an increase in the fraction of ripe and then spent fish. Sampling ended at probably near the peak of spawning activity, at about 9 July, at which point about 60% of mature fish were ripe or running ripe, and about 30% were spent. This is similar timing to that measured for 2007 (Anderson 2008b).

In East Northland, continuous sampling throughout much of the spawning period provided a clear picture of the progression of spawning, with a high fraction of ripe and running ripe fish persisting for several weeks between the middle of June and the middle of July, a steadily decreasing fraction of maturing fish from about 50% in early June to close to zero in mid-July, and spent fish appearing in samples from about 25 June. The peak of spawning is not very clearly defined but, based on the date at which 20% of fish were spent, probably occurred at about 6 July. This is similar timing to that measured for 2003 and 2004 (Anderson 2006a), but earlier than for 2007 (Anderson 2008b).

Fish were mainly in the ripe and running ripe stage in the West Norfolk Ridge (ET) fishery between 13 June and 9 July when samples were being collected in this fishery, and spent fish rose steadily to account for over 30% of the mature fish by the end of this period, with peak spawning occurring at about 29 June. This is the first year that the timing of spawning in this fishery has been able to be determined. In the Lord Howe fishery the fraction of ripe and running ripe fish decreased steadily throughout July, with a matching increase in spent fish—the peak of spawning probably occurring at about the same time as in the east Northland fishery, 10 July. This is similar timing, or slightly earlier, than recorded for this fishery in several years in the early 1990s (Anderson 2006a).

In the NW Chatham Rise, the fraction of ripe and running ripe fish increased rapidly from the beginning of June and accounted for 85–100% of all mature fish for much of this month. When

sampling ended in this area spent fish were just beginning to appear in the samples, and the peak of spawning was probably close to the end of June. This is similar timing to that determined from research surveys, but about a week earlier than estimated from OP observer data in 2005 (Anderson 2006b).

Further east on the Rise, in the Spawning Box, sampling began on 21 July, several days after the likely peak of spawning.

2008–09

In the ORH 3B fisheries, significant numbers of fish in the ripe, running ripe, and spent stages were found in the NW Rise in June and July and the Spawning Box in July (Table 7). A few, mostly ripe, fish were also recorded from the SW Chatham Rise fishery in September. Elsewhere in this QMA OP sampling was mostly outside the spawning months. Fish in spawning condition were also common in the winter months' samples in some of the ORH 1 fisheries, including Aldermen, East Northland, South Kermadec Ridge, White Is., and West Norfolk Ridge. As in 2007–08, the ET fisheries on the West Norfolk Ridge, Lord Howe, and NW Challenger (ET) also showed spawning activity in winter.

The OTS programme recorded significant numbers of female fish in spawning condition (running ripe and spent) only in the Ritchie area in June. Sampling by this programme in other spawning fisheries was generally outside of the spawning season (Table 8).

There were sufficient reproductive data collected by OP observers through the spawning period to make plots of the progression of spawning in two ET fisheries, Lord Howe and NW Challenger; one ORH 1 fishery, East Northland; and two Chatham Rise fisheries, NW Chatham Rise and the Spawning Box (Figures 19–21).

In the Lord Howe Rise maturity data were available over an extended period, from late May to early August, with ripe and running ripe fish present in varying fractions for almost this entire period. These showed a clear peak in the fraction of ripe and running ripe fish and a level of 20% spent fish occurring at about the same time, around 10–13 July. By 6 August, the last day sampled, spawning had only just ceased, and all fish examined were in the spent state. This is similar timing to that estimated for 2008, and for several years in the early 1990s (Anderson 2006a).

A few samples were collected in early June in the NW Challenger Plateau fishery then sampling ceased until 25 June, just before the peak of spawning. The fraction of ripe and running ripe fish began to decrease shortly after this date but was still at about 50% in mid-July, with spent fish at about the same level. Spawning peaked probably at about 1 July, a week or so later than estimated from OP observer data collected 10–15 years ago (Anderson 2006a).

Only a few samples were collected during the spawning period in the NW Chatham Rise, but these were enough to indicate that the peak of spawning occurred at about the date that sampling began, 26 June. This is similar timing to 2008 and to most previous estimates.

In the Spawning Box, samples were collected regularly throughout most of the spawning period. The peak of spawning was relatively well defined by the data, both by the peak of the fraction of ripe and running ripe fish and by the point at which 20% of the fish were spent, occurring at about 6 July. Spawning is regularly monitored in this fishery and this timing is similar to that determined for several recent years, but 2–3 weeks earlier than recorded in the 1980s and 1990s (Anderson 2006a, 2006b, 2008a, 2008b).

Maturity data were collected throughout the spawning period in the East Northland fishery also, with ripe and running ripe fish present in samples between the beginning of June and the beginning of

July. Spent fish began to appear in samples from about 21 June and the peak of spawning occurred at about 25 June. This is about two weeks earlier than estimated for 2003, 2004, and 2008, and earlier still than estimated for 2007 (Anderson 2006a, 2008b).

Maturity data collected on the Challenger orange roughy survey during the spawning period in 2009 covered a relatively short period, 27 June to 6 July. During this time the fractions of mature fish in each reproductive state remained relatively constant (Figure 22). The fraction of ripe and running ripe fish of both sexes fluctuated between about 40% and 60%, while maturing/resting fish were slightly less common on most days. The fraction of spent fish of both sexes was low throughout this period, but appeared to be increasing towards the end of it. The survey timing probably matched the early stage of the spawning period, with the peak to come a few days after the survey was completed. This is similar timing to that recorded in this fishery in the mid-1980s to early 1990s, but a week or more later than recorded during other recent surveys and in several years in the late 1990s (Anderson 2006a, 2006b, 2008a).

5. SUMMARY AND DISCUSSION

Observer coverage. The 564 samples collected by OP observers in 2007–08 and 625 collected in 2008–09 was a significant increase over the previous several years, and for both years the highest level achieved since 2002–03. Despite this, the number of samples was low in comparison to the maximum anticipated number, which was set at a high level to allow for 100% coverage of deepwater trawling in the SPRFMO region, as well as for blanket coverage of the ORH 1 fishery—a requirement which has remained in place since the completion of the Adaptive Management Programme at the end of the 2005–06 fishing year. Even so, sampling levels of fisheries in the SPRFMO region were relatively high, with a large number of samples taken from Lord Howe, Northwest Challenger, and West Norfolk Ridge fisheries in these two years. Only in the Louisville Ridge fishery, where commercial fishing effort has declined in recent years (Ministry of Fisheries 2009), was there no observer coverage in either year (or in 2006–07). Observer coverage of fisheries in the east coast EC and MEC stocks was also significantly improved upon compared to previous years, with a total of 43 samples in 2007–08 and 26 samples in 2008–09, even though the target of 52 sampling days for ORH 2A was clearly far from met in either year. Sampling levels were relatively high also in ORH 3B, where well over 300 samples were taken in each year, but probably still fell short of the number of sampling days scheduled for this QMA. Mostly these samples were from the major Chatham Rise fisheries, with few samples from the now lightly fished southern regions of ORH 3B with the exception of Pukaki (the area including the “Priceless” fishery) where a third of the catch was covered by OP observers in 2007–08.

The 60 samples collected by the OTS programme in 2007–08 and 54 samples collected in 2008–09 was somewhat less than collected in the previous year but, importantly, continues to collect data from fisheries where OP observers have difficulty getting onto vessels. This is particularly the case for the east coast fisheries in the EC and MEC stocks, where sampling from both programmes in these two years could be combined to produce a useful resource of length data.

The level of OP sampling coverage was sufficient to determine length frequency distributions of orange roughy in 13 discrete fisheries in 2007–08 and 14 in 2008–09. In four of these fisheries in 2007–08, and in two fisheries in 2008–09, distribution plots were prepared separately for both pre-spawning and spawning periods. For OTS sampling, length frequency distributions were produced for six discrete fisheries in 2007–08 and two fisheries in 2008–09.

Research coverage. Aside from a few fish measured during surveys of middle depth species, most orange roughy biological data from research surveys in 2007–08 came from the industry-run survey

of the Northeast Hills and Spawning Box plume on the Chatham Rise in June 2008, during which in total nearly 10 000 fish were examined. In 2008–09 the plume survey was repeated but, instead of the Northeast Hills, the Graveyard hills on the northwest Chatham Rise, were also surveyed. Well over 12 000 fish were measured in the plume fishery alone during this survey, with an additional 2000 fish measured in the Graveyard hills.

Size structure. Orange roughy size structure based on OP data was examined in 17 fishery/period combinations in 2007–08 and 16 fishery/period combinations in 2008–09. This is a few more than could be examined in any of the previous seven years, due to the increased sampling effort in these two years. In addition, size structure was examined in six and two fishery/period combinations available from OTS data for 2007–08 and 2008–09 respectively, slightly less than in the previous few years. Size distributions were typical of orange roughy in all areas, showing generally 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 were larger overall than fish from samples taken beforehand in both years in the Spawning Box fishery and in 2008–09 in the Lord Howe Rise fishery, but there were no such differences in the three other fisheries (in 2007–08) where this comparison could be made. Intensive sampling was carried out in some areas, particularly in ORH 3B. In 2007–08, over 17 000 fish were measured by OP observers from 121 samples in the East Chatham Rise fishery, and a further 15 000 fish were measured from 111 trawls in the Spawning Box fishery. In 2008–09, more than 30 000 fish from 189 trawls were measured in the Spawning Box fishery alone. Mean lengths, calculated from scaled size frequencies, varied among areas, ranging from about 30 cm to 42 cm (male) and from about 31 cm to 43 cm (female), and tended to be greater in the ORH 1 fisheries. Sex ratios were generally close to 50:50 in most fisheries, with the most extreme sex ratios observed in the southeast Chatham Rise pre-spawning (35.0% male) and east Northland spawning (73.4% male) fisheries.

Reproduction. Gonad stage data sufficient for tracking the progress of spawning in the winter of 2007 were available from OP observer sampling in six fisheries in 2007–08, and from five fisheries in 2008–09. Data collected during the Challenger orange roughy survey in 2009 were also used to examine spawning progression. The timing of the onset of spawning in the West Norfolk Ridge (ET) fishery was determined for the first time, with the peak of spawning in 2008 estimated to be about 29 June. The timing of peak spawning estimated for the NW Challenger Plateau in 2009 was later than previously estimated for this fishery and, for the East Northland fishery in 2009, earlier than previously estimated. In all the other fisheries examined in these two years, the timing of spawning was not unusual.

The collection of these data complements a growing resource of biological information on orange roughy, which is increasingly being utilised in stock assessment modelling. It is therefore important that these data collection programmes continue to operate in orange roughy 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.

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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 sample/days processed in 2007–08 and 2008–09, and the actual number of OP samples processed in the previous two fishing years.

Area	Number of samples				
	Expected* (approx.)	Actual 2008–09	Actual 2007–08	Actual 2006–07	Actual 2005–06
ORH 3B	454	403	339	307	300
ORH 2A	52	13	27	2	0
ORH 2B	0	2	15	0	0
ORH 3A	0	11	1	0	0
ORH 7A	0	0	0	0	2
ORH 1	271**	87	109	182	108
ORH 10	0	0	0	0	0
ORH 7B	0	0	5	0	2
ET	510***				
Lord Howe/NW Challenger		86	35	0	34
Louisville Ridge		0	0	0	22
West Norfolk Ridge		23	33	5	12
Total	1287	625	564	496	480

* Ministry of Fisheries observer programme schedule for the 2008–09 MFish June–July financial year. The schedule is specified in terms of numbers of sampling days, whereas the actual sampling level achieved is calculated as the number of samples. The comparison made here relies on the assumption that on average one sample was collected per day, as prescribed in the instructions to observers.

** 250 of these samples are directly funded by industry.

*** Predicted maximum based on 100% observer coverage for all ET bottom trawling in the SPRFMO region.

Table 3: Number of OP orange roughy biological samples by OP area and month for 2007–08 and 2008–09, with the total number of samples and voyages in each area (see Figure 1 for area boundaries).

2007–08

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	Voyages
AKE	7	2	–	–	–	–	–	–	27	21	1	–	58	3
AKW	14	28	–	–	–	–	–	–	6	3	–	–	51	3
CEE	–	31	8	–	–	–	–	–	–	3	–	–	42	5
CHA	–	–	–	–	–	–	–	–	–	–	–	5	5	2
ET	–	–	–	–	–	–	–	–	29	7	–	–	36	3
HOWE	–	–	–	–	–	–	–	–	4	17	11	–	32	4
SEC	–	1	2	–	–	–	1	1	–	–	–	–	5	4
SOE	–	23	50	14	4	3	35	80	41	29	18	–	297	8
SOI	–	–	–	–	2	1	–	–	–	–	–	–	3	1
SUB	7	–	–	–	1	5	10	4	–	1	7	–	35	4
ALL	28	85	60	14	7	9	46	85	107	81	37	5	564	27

2008–09

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	Voyages
AKE	–	1	–	–	–	–	–	–	27	12	–	–	40	2
AKW	25	–	–	–	–	–	–	–	11	7	–	4	47	4
CEE	–	15	–	–	–	–	–	–	–	–	–	–	15	2
CHA	–	2	–	–	–	–	–	–	–	–	–	–	2	1
ET	–	1	–	–	–	–	–	7	34	14	1	–	57	10
HOWE	–	–	–	–	–	–	–	8	7	36	1	–	52	7
SEC	–	–	–	–	–	4	5	–	–	–	–	7	16	2
SOE	42	29	15	46	36	19	4	50	59	57	11	–	368	8
SOI	–	–	–	–	–	–	–	–	–	–	–	–	0	–
SUB	–	10	12	–	–	–	–	–	–	–	–	6	28	2
ALL	67	58	27	46	36	23	9	65	138	126	13	17	625	25

Table 4: Number of OP/OTS orange roughy biological samples by area and month for 2007–08 and 2008–09, with the total number of samples and voyages in each programme and area (see Figures 2 to 6 for area boundaries), and the total number of fish measured (both programmes combined). Cells with single values show counts of OP samples only, no OTS samples having been collected.

2007–08

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	Voyages	N. fish meas.
ORH 1 fisheries															
Dargaville	–	–	–	–	–	–	–	–	6	3	–	–	9	1	573
East Northland	1	–	–	–	–	–	–	–	23	16	–	–	40	3	3895
Mercury-Colville Box	2	–	–	–	–	–	–	–	2	1	–	–	5	3	323
Mokohinau	–	–	–	–	–	–	–	–	–	2	1	–	3	1	270
South Kermadec R.	3	2	–	–	–	–	–	–	–	–	–	–	5	1	282
Tauroa Knoll	7	–	–	–	–	–	–	–	–	–	–	–	7	2	672
West Norfolk R.	7	28	–	–	–	–	–	–	–	–	–	–	35	1	2155
White I.	1	–	–	–	–	–	–	–	2	2	–	–	5	2	466
ORH 3B fisheries															
Auckland Is.	–	–	–	–	2	1	–	–	–	–	–	–	3	1	245
Macquarie	–	–	–	–	–	1	–	–	–	–	–	–	1	1	50
East Rise	–	8	36	13	–	–	20	32	–	–	6	–	115	4	7942
NW Rise	–/3	6	1	–	–	–	–	5	41	–/2	12	–	65/5	3/4	4989
Pukaki South	–	–	–	–	–	–	–	1	–	–	–	–	1	1	10
Pukaki	7	–/5	–/4	–/1	1	4	10	3	–	1	7	–	33/10	4/2	3656
SE Rise	–/4	9/1	1/3	1	4	3/3	1/1	13	–	2/3	–	–	34/15	7/8	3461
Spawning Box	–	–	13	–	–	–	14	30	–	27	–	–	84	3	7253
SW Rise	–	1	1	–	–	–	–	1	–	–	–	–	3	3	167
Other fisheries															
East Cape	–	5	–	–	–	–/2	–	–/3	–/2	3	–	–	8/7	2/4	1237
Tolaga	–	13	2	–	–/2	–/1	–	–	–/1	–	–	–	15/4	4/3	1034
Ritchie	–/3	3	1	–	–	–/1	–	–/1	–	–	–	–	4/5	2/5	700
Wairarapa	–/4	10	5	–	–	–/2	–	–/1	–	–	–	–	15/7	4/6	1451
Kaikoura	–/3	–	–	–	–/1	–/1	1/2	–	–	–	–	–	1/7	1/5	797
Cook Canyon	–	–	–	–	–	–	–	–	–	–	–	5	5	2	70
West Norfolk R (ET)	–	–	–	–	–	–	–	–	29	4	–	–	33	3	2568
NW Challenger (ET)	–	–	–	–	–	–	–	–	–	3	–	–	3	2	180
Lord Howe (ET)	–	–	–	–	–	–	–	–	4	17	11	–	32	4	2890
ALL	28/17	85/6	60/7	14/1	7/3	9/10	46/3	85/5	107/3	81/5	37/0	5/0	564/60	27/20	47336

Table 4:—Continued

2008–09

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total Voyages	N. fish meas.	
ORH 1 fisheries															
Aldermen Knoll	–	–	–	–	–	–	–	–	1	1	–	–	2	1 200	
East Northland	–	–	–	–	–	–	–	–	21	8	–	–	29	1 2683	
Mercury-Colville Box	–	–	–	–	–	–	–	–	5	–	–	–	5	1 500	
South Kermadec R.	–	1	–	–	–	–	–	–	–	1	–	–	2	2 200	
Tauroa Knoll	21	–	–	–	–	–	–	–	–	–	–	–	21	2 1370	
West Norfolk R.	4	–	–	–	–	–	–	–	11	7	–	4	26	3 1958	
White I.	–	–	–	–	–	–	–	–	–	2	–	–	2	1 124	
ORH 3B fisheries															
Bounty Is.	–	1	4	–	–	–	–	–	–	–	–	2	7	2 73	
East Rise	21	–	14	32	20	11	–	14	4	–	–	–	116	4 8336	
NW Rise	–	2	–	–	–	–	–/1	–	4	4	11	–	21/1	3/1 2082	
Pukaki South	–	5	4	–	–	–	–	–	–	–	–	2	11	2 218	
Pukaki	–	4	4	–	–	–	–	–	–	–	–	2	10	2 532	
SE Rise	13/7	27/11	1/3	9/4	3/1	4/1	4/2	16	–	3	–	–	80/29	6/9 7181	
Spawning Box	8	–	–	5	13	4	–	19	51	50	–	–	150	6 16253	
SW Rise	–	–	–	–	–	–	–	1	–	–	–	7	8	2 326	
Other fisheries															
East Cape	–	7	–	–	–/1	–	–	–/2	–/2	–	–	–	7/5	2/3 909	
Tolaga	–	2	–	–/1	–/1	–	–	–	–	–	–	–	2/2	1/2 223	
Ritchie	–	4	–	–	–/1	–/1	–	–/4	–/3	–	–	–	4/9	1/6 911	
Wairarapa	–	2	–	–/2	–/1	–	–/1	–	–	–	–	–	2/4	1/4 436	
Kaikoura	–	2	–	–/2	–/1	4/1	5	–	–	–	–	–	11/4	2/3 1283	
West Norfolk R (ET)	–	1	–	–	–	–	–	2	20	–	–	–	23	5 1562	
NW Challenger (ET)	–	–	–	–	–	–	–	5	14	14	1	–	34	9 2406	
Lord Howe (ET)	–	–	–	–	–	–	–	8	7	36	1	–	52	7 3315	
ALL	67/7	58/11	27/3	46/9	36/6	23/3	9/4	65/6	138/5	97/0	13/0	17/0	625/54	66/20	53081

Table 5: Summary of number and weight of orange roughy samples taken by OP observers relative to the observed catch and estimated total catch in the fishery, for 2007–08 and 2008–09; observed catch totals are based on the areas defined in Figures 2 to 6, fishery catch totals are derived from estimated catches recorded on TCEPR forms and are approximate only.

2007–08

Area	No. tows sampled	Weight of samples (kg)	Catch (t)		Percentage of fishery observed
			observed	fishery	
ORH 1					
Dargaville	9	622	52	237	22
East Northland	40	6 848	183	313	59
Mercury-Colville Box	5	561	13	13	99
Mokohinau	3	351	1.4	1	100
South Kermadec R.	5	729	7.9	7	100
Tauroa Knoll	7	927	101	141	72
West Norfolk R.	35	4 709	59	222	27
White I.	5	699	10	63	16
ORH 3B					
Chatham Rise					
East Rise	115	10 163	512	2 325	22
NW Rise	65	6 111	264	767	34
SE Rise	34	2 805	65	1 215	5.4
Spawning Box	84	8 835	935	3 297	28
SW Rise	3	234	11	6	100
Southern					
Auckland Is.	3	390	62	174	36
Macquarie Ridge	1	102	0.6	5	12
Pukaki South	1	20	0.2	7	2.3
Pukaki	33	4 147	460	1 296	35
OTHER AREAS					
East Cape	8	693	15	197	7.5
Tolaga	15	1 289	48	242	20
Ritchie	4	310	4.8	614	0.8
Wairarapa	15	1 019	39	197	20
Kaikoura	1	100	3.1	556	0.6
Cook Canyon	5	62	1.3	2	63
West Norfolk R (ET)	33	6 271	430	423	100
NW Challenger (ET)	3	183	28	40	71
Lord Howe (ET)	32	3 866	353	380	93

Table 5:—Continued**2008–09**

Area	No. tows sampled	Weight of samples (kg)	Catch (t)		Percentage of fishery observed
			observed	fishery	
ORH 1					
Aldermen Knoll	2	279	4.5	5	90
East Northland	29	4 397	122	175	70
Mercury-Colville Box	5	969	11	32	34
South Kermadec R.	2	476	18	41	43
Tauroa Knoll	21	1 768	90	141	64
West Norfolk R.	26	4 553	107	155	69
White I.	2	199	1.0	8	13
ORH 3B					
Chatham Rise					
East Rise	116	11 061	667	1 913	35
NW Rise	19	2 477	220	626	35
SE Rise	80	5 930	192	1 067	18
Spawning Box	123	21 899	2 269	3 012	75
SW Rise	8	434	11	5	100
Southern					
Bounty Is.	7	82	0.2	2	7.8
Pukaki South	11	360	0.5	8	5.7
Pukaki	10	806	42	826	5.0
OTHER AREAS					
East Cape	7	556	23	217	10
Tolaga	2	18	0.02	185	0.010
Ritchie	4	20	0.02	649	0.003
Wairarapa	2	26	0.03	176	0.015
Kaikoura	11	810	41	578	7.1
West Norfolk R (ET)	23	3 925	116	236	49
NW Challenger (ET)	34	2 464	167	260	64
Lord Howe (ET)	52	4 410	379	403	94

Table 6: 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 and OTS samples, for 2007–08 and 2008–09.

2007–08

Area	Period	Number measured			*Sex ratio (%male) (scaled)	Total Catch (t)	*Scaled Mean length (s.d.)	
		Male	Female	**Total			Male	Female
OP data								
NW Rise	pre-spawning	247	213	460	61.0	24	33.1(2.7)	34.0(2.8)
NW Rise	spawning	1 832	2 211	4 043	41.6	240	32.9(2.9)	34.8(3.2)
Spawning Box	pre-spawning	2 059	1 962	4 021	51.5	176	31.3(2.8)	33.2(2.9)
Spawning Box	spawning	2 098	1 134	3 232	64.2	759	32.5(2.4)	34.7(2.5)
East Rise	pre-spawning	3 504	4 022	7 528	45.3	497	32.2(2.6)	33.8(2.7)
East Rise	spawning	144	270	414	39.2	15	33.3(2.4)	33.7(2.5)
Pukaki R.	pre-spawning	927	748	1 676	59.9	171	34.3(2.1)	36.7(2.8)
Pukaki R.	spawning	512	468	980	54.8	289	33.7(2.2)	37.1(2.4)
SE Rise	pre-spawning	773	1 100	1 875	45.3	61	33.4(2.6)	35.0(2.8)
Lord Howe R.	spawning	1 433	1 454	2 890	53.4	353	33.6(3.6)	35.2(3.8)
West Norfolk R. (ET)	spawning	1 293	1 272	2 568	51.3	430	40.0(2.4)	42.5(2.3)
West Norfolk R.	pre-spawning	1 295	860	2 155	58.4	59	40.5(2.6)	42.0(2.8)
Tauroa Knoll	pre-spawning	411	261	672	59.6	101	35.2(2.7)	35.9(3.0)
Dargaville	spawning	279	278	573	55.1	52	32.1(3.3)	34.4(3.8)
East Northland	spawning	2 473	1 327	3 800	73.4	182	35.0(2.7)	37.1(3.0)
Tolaga	pre-spawning	234	394	634	38.6	48	33.2(2.5)	35.2(2.7)
Wairarapa	pre-spawning	276	458	751	40.2	39	30.7(2.9)	32.5(3.8)
OTS data								
East Cape	pre-spawning	242	257	500	51.5	–	32.0(3.2)	35.0(3.3)
Ritchie	pre-spawning	228	271	500	54.3	–	30.8(2.7)	33.4(3.4)
Wairarapa	pre-spawning	262	436	700	62.5	–	31.1(3.6)	32.8(3.9)
Kaikoura	pre-spawning	275	418	696	60.3	–	31.0(3.0)	32.7(3.4)
SE Rise	pre-spawning	702	448	1 177	39.0	–	33.4(4.3)	35.5(4.2)
Pukaki R.	pre-spawning	402	598	1 000	59.8	–	33.7(2.4)	36.0(2.5)

* OTS sex ratio and mean length data are unscaled

** Totals include some unsexed fish

Table 6:—Continued

2008–09

Area	Period	Number measured			*Sex ratio (%male) (scaled)	Total catch (t)	*Scaled Mean length (s.d.)	
		Male	Female	**Total			Male	Female
OP data								
Spawning Box	pre-spawning	1 866	1 985	3 855	49.7	260	32.4(2.5)	33.9(2.8)
Spawning Box	spawning	5 575	6 821	12 398	48.8	2 010	33.3(2.5)	35.1(2.5)
SE Rise	pre-spawning	1 538	2 459	4 007	35.0	186	32.7(3.1)	35.2(3.3)
East Rise	pre-spawning	3 743	4 238	7 988	46.1	649	33.0(2.4)	34.6(2.7)
NW Rise	spawning	1 128	692	1 822	67.2	2	33.0(2.7)	34.2(3.2)
East Cape	pre-spawning	217	192	409	54.2	23	32.5(2.1)	34.6(2.9)
Kaikoura	pre-spawning	411	472	883	44.5	41	30.6(2.8)	31.2(3.5)
Pukaki R.	pre-spawning	328	184	512	62.4	42	35.3(2.3)	37.7(2.2)
Lord Howe R.	pre-spawning	238	253	491	48.3	90	32.9(3.7)	34.3(4.1)
Lord Howe R.	spawning	1 447	1 466	2 917	52.9	371	33.6(3.4)	35.4(3.9)
Tauroa Knoll	pre-spawning	786	584	1 370	56.5	8	33.6(2.9)	34.4(3.0)
Mercury-Colville Box	spawning	322	178	500	67.7	219	34.9(2.6)	38.1(3.0)
East Northland	spawning	1 433	1 250	2 683	67.0	122	34.3(2.4)	37.0(2.5)
West Norfolk R.	spawning	551	784	1 335	37.0	42	39.7(2.4)	41.5(2.5)
NW Challenger	spawning	1 567	695	2 262	64.8	6	31.5(2.7)	33.5(2.7)
West Norfolk R. (ET)	spawning	1 036	1 214	2 250	58.9	159	41.6(2.5)	42.9(2.6)
OTS data								
Ritchie	pre-spawning	354	246	600	59.0	–	30.6(3.8)	34.4(3.8)
SE Rise	pre-spawning	1 062	1 793	2 889	37.2	–	34.4(3.8)	35.7(3.6)

* OTS sex ratio and mean length data are unscaled

** Totals include some unsexed fish

Table 7: Percentage of female orange roughy at each gonad stage in each subarea and month, from OP data, for 2007–08 and 2008–09. Only months in which at least 30 fish were staged are reported (see Section 3.2 for a description of the stage categories).

2007–08

Area	Month	Percentage at stage					Number staged
		F1	F2	F3	F4	F5	
Auckland Islands	Feb	0	46	54	0	0	61
	Mar	10	80	7	3	0	30
Cook Canyon	Sep	13	3	46	31	8	39
Dargaville	Jun	32	68	1	0	0	198
	Jul	1	29	34	23	14	80
East Cape	Jul	6	0	2	6	87	106
	Nov	34	65	0	1	0	86
East Chatham Rise	Jan	30	65	5	0	0	677
	Apr	24	72	3	0	0	586
	May	17	80	3	0	0	1 213
	Aug	90	7	0	0	3	270
	Nov	89	4	0	0	7	84
East Northland	Dec	21	78	1	0	0	1 462
	Jun	6	22	58	11	2	846
	Jul	2	3	30	38	26	481
	Oct	0	100	0	0	0	31
Kaikoura	Apr	36	62	2	0	0	53
Lord Howe	Jun	0	18	48	30	3	179
	Jul	38	6	11	25	20	781
	Aug	49	1	0	0	49	494
Macquarie Ridge	Mar	0	0	100	0	0	32
Mercury-Colville Box	Jun	2	3	33	44	19	101
	Jul	16	0	0	5	78	37
Mokohinau	Jul	45	0	0	1	54	83
	Aug	39	3	0	0	58	38
NW Challenger	Jul	7	7	0	51	36	45
NW Chatham R.	May	18	73	8	1	0	157
	Jun	8	12	51	27	2	1 639
	Aug	87	3	1	1	7	572
	Nov	37	60	2	2	0	52
Pukaki Rise	Mar	0	53	47	0	0	168
	Apr	3	90	7	0	0	313
	May	1	99	0	0	0	80
	Jul	0	97	3	0	0	30
	Aug	0	2	26	40	32	438
Ritchie Banks	Oct	88	0	0	1	11	163
	Nov	0	98	1	0	1	88
SE Chatham Rise	Feb	24	76	0	0	0	99
	Mar	16	84	0	0	0	146
	May	38	61	0	0	0	485
	Jul	64	13	6	0	17	110
	Nov	94	3	0	0	2	330
South Kermadec Ridge	Oct	0	100	0	0	0	90
	Nov	0	100	0	0	0	37
Spawning Box	Apr	17	80	3	0	0	499
	May	12	78	10	0	0	1 146
	Jul	7	1	1	37	55	1 134
	Dec	24	76	0	0	0	317
SW Chatham Rise	May	44	56	0	0	0	45
	Nov	89	8	0	0	3	38
Tauroa Knoll	Oct	11	82	6	0	1	261
Tolaga	Nov	48	52	0	0	0	326
	Dec	7	60	32	0	0	68
Wairarapa	Nov	73	20	0	0	7	274
	Dec	32	47	22	0	0	184
West Norfolk Ridge	Oct	0	92	7	0	0	252
	Nov	0	100	0	0	0	608
West Norfolk Ridge (ET)	Jun	0	14	37	40	9	1 133
	Jul	0	0	1	76	23	139
White Island	Jul	14	2	2	6	76	49
	Oct	0	100	0	0	0	40

Table 7—Continued

2008–09

Area	Month	Percentage at stage					Number staged
		F1	F2	F3	F4	F5	
Aldermen Islands	Jun	2	48	50	0	0	44
East Cape	Nov	69	28	0	0	4	192
East Northland	Jun	4	30	55	8	2	915
	Jul	4	1	9	39	48	335
East Chatham Rise	Jan	22	56	22	0	0	1 203
	Feb	7	93	0	0	0	693
	Mar	9	91	0	0	0	453
	May	21	78	0	0	0	656
	Jun	12	88	1	0	0	189
	Oct	3	86	11	0	0	815
	Dec	16	64	19	0	0	418
Lord Howe Rise	May	53	46	0	0	0	253
	Jun	44	39	10	6	0	343
	Jul	43	6	13	26	13	1 074
	Aug	69	0	0	0	31	49
Kaikoura	Mar	90	10	0	0	0	163
	Apr	90	10	0	0	0	214
	Nov	99	1	0	0	0	95
Mercury-Colville Box	Jun	4	15	38	41	1	178
NW Challenger	May	46	54	0	1	0	123
	Jun	12	24	34	25	5	456
	Jul	12	2	15	37	34	207
	Aug	81	0	0	0	19	32
NW Chatham R.	Jun	11	17	34	22	17	125
	Jul	7	1	2	23	67	162
	Aug	16	0	0	0	83	405
	Nov	18	62	21	0	0	91
Pukaki Rise	Nov	0	100	0	0	0	93
	Dec	0	99	1	0	0	91
Pukaki Rise South	Nov	1	98	1	0	0	96
SE Chatham Rise	Jan	17	49	35	0	0	113
	Feb	4	96	0	0	0	72
	Mar	6	94	0	0	0	162
	Apr	25	74	1	0	0	179
	May	44	56	0	0	0	659
	Jul	98	1	0	1	1	197
	Oct	33	65	2	0	0	344
	Nov	23	63	14	0	0	922
South Kermadec Ridge	Jul	0	0	0	0	100	50
	Nov	7	23	0	0	70	43
Spawning Box	Jan	18	58	23	0	0	213
	Feb	7	73	18	2	0	493
	Mar	25	74	1	0	0	129
	May	10	89	0	0	0	828
	Jun	5	80	13	1	0	2 564
	Jul	0	9	28	24	39	4 257
	Oct	1	80	19	0	0	322
SW Chatham Rise	Sep	3	71	24	2	0	148
Tauroa Knoll	Oct	46	4	0	0	50	584
White Island	Jul	5	9	0	2	84	58
West Norfolk Ridge	Jun	3	90	7	0	0	472
	Jul	1	2	1	7	90	312
	Sep	4	28	0	1	68	109
	Oct	1	0	0	1	98	182
West Norfolk Ridge (ET)	May	0	98	0	2	0	50
	Jun	1	39	51	9	1	1 214
	Nov	0	3	0	0	97	33

Table 8: Percentage of female orange roughy at each gonad stage in each subarea and month, from OTS data, for 2007–08 and 2008–09. Only months in which at least 30 fish were staged are reported (see Section 3.2 for a description of the stage categories).

2007–08

Area	Month	Percentage at stage					Number staged
		F1	F2	F3	F4	F5	
East Cape	Mar	11	89	0	0	0	85
	May	14	86	0	0	0	155
	Jun	7	85	8	0	0	59
Tolaga	Feb	17	83	0	0	0	98
	Mar	35	65	0	0	0	62
Ritchie	Mar	4	95	2	0	0	56
	May	10	90	0	0	0	40
Wairarapa	Oct	80	20	0	0	0	130
	Mar	26	74	0	0	0	95
	Oct	94	6	0	0	0	161
Kaikoura	Feb	50	50	0	0	0	34
	Mar	52	46	2	0	0	52
	Apr	35	65	0	0	0	69
	Oct	80	18	3	0	0	118
NW Chatham R.	Jul	8	21	22	43	7	101
	Oct	16	76	8	0	0	182
SE Chatham Rise	Mar	25	75	0	0	0	168
	Apr	7	93	0	0	0	60
	Jul	33	32	34	1	0	174
	Oct	27	70	2	0	0	244
	Dec	22	70	7	0	0	188
Pukaki	Jan	0	100	0	0	0	40
	Nov	0	84	13	3	0	152
	Dec	0	100	0	0	0	207

2008–09

Area	Month	Percentage at stage					Number staged
		F1	F2	F3	F4	F5	
East Cape	May	0	100	0	0	0	63
	Jun	0	51	49	0	0	37
Tolaga	Jan	5	95	0	0	0	66
Ritchie	Feb	19	71	10	0	0	31
	Mar	9	60	31	0	0	65
	May	16	84	0	0	0	148
Wairarapa	Jun	0	0	16	84	0	95
	Jan	78	22	0	0	0	64
	Feb	4	96	0	0	0	52
Kaikoura	Apr	18	80	2	0	0	44
	Jan	27	59	14	0	0	37
NW Chatham R.	Mar	38	33	29	0	0	55
	Apr	19	81	0	0	0	48
SE Chatham Rise	Jan	17	76	8	0	0	200
	Feb	0	99	1	0	0	69
	Mar	14	86	0	0	0	37
	Apr	39	61	0	0	0	109
	Oct	22	58	15	0	5	437
	Nov	21	51	26	1	1	740
	Dec	11	18	68	3	0	122

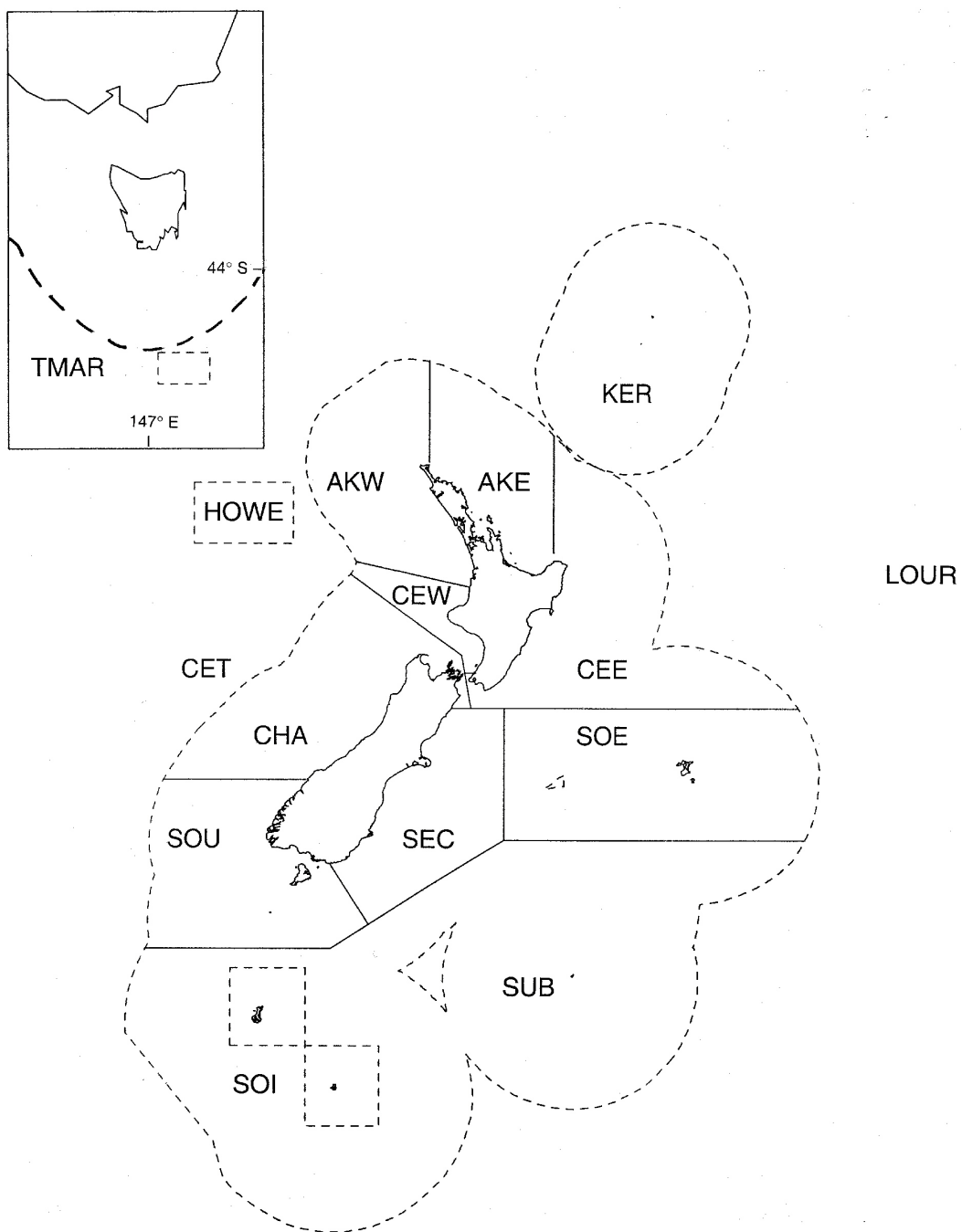


Figure 1: Ministry of Fisheries Observer Programme management areas.

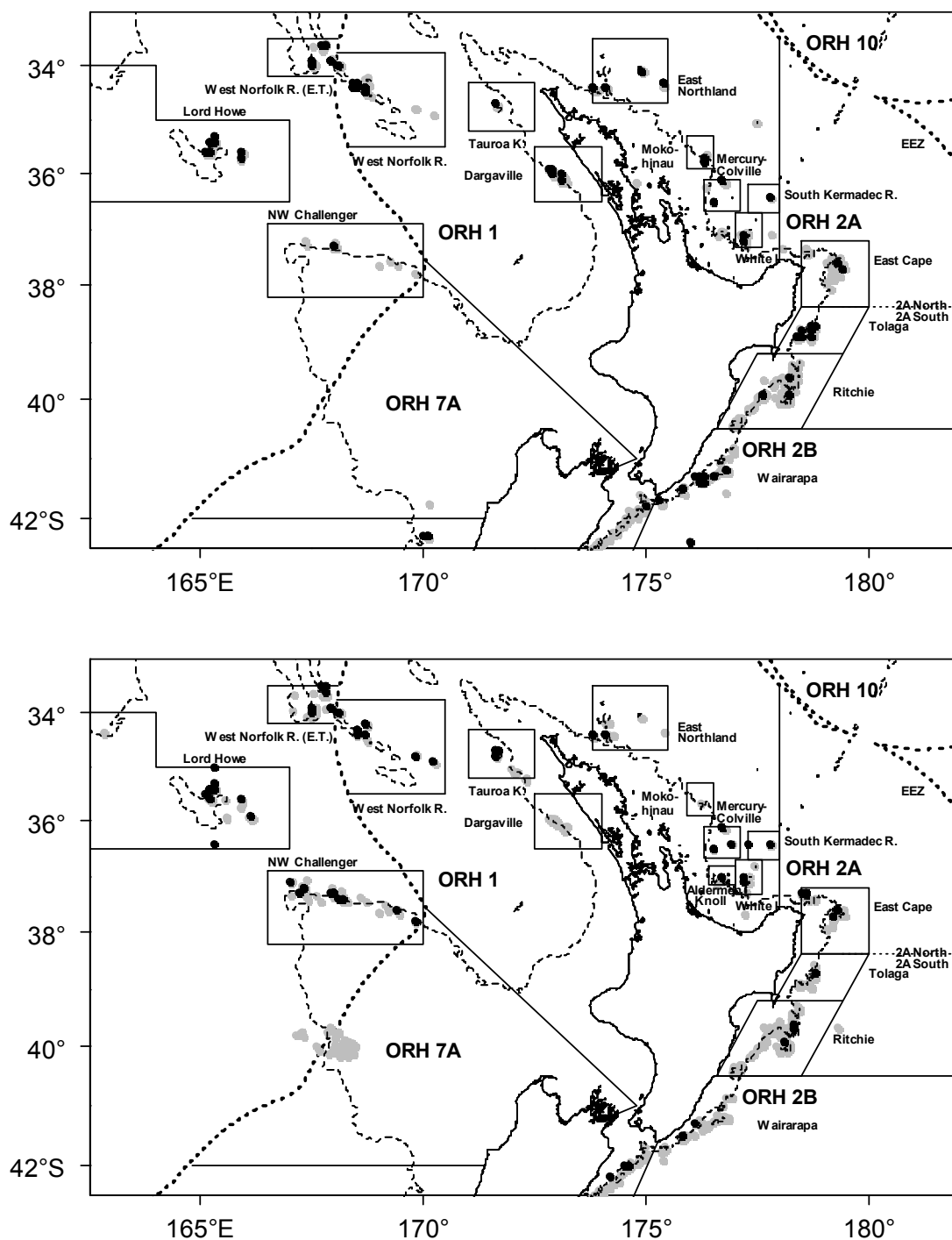


Figure 2: Location of fisheries used for analysis of biological data, position of trawls in the commercial fishery (grey dots), and location of samples of orange roughy taken by OP observers (black dots), during 2007–08 (top) and 2008–09 (bottom). The dotted line shows the 1000 m depth contour.

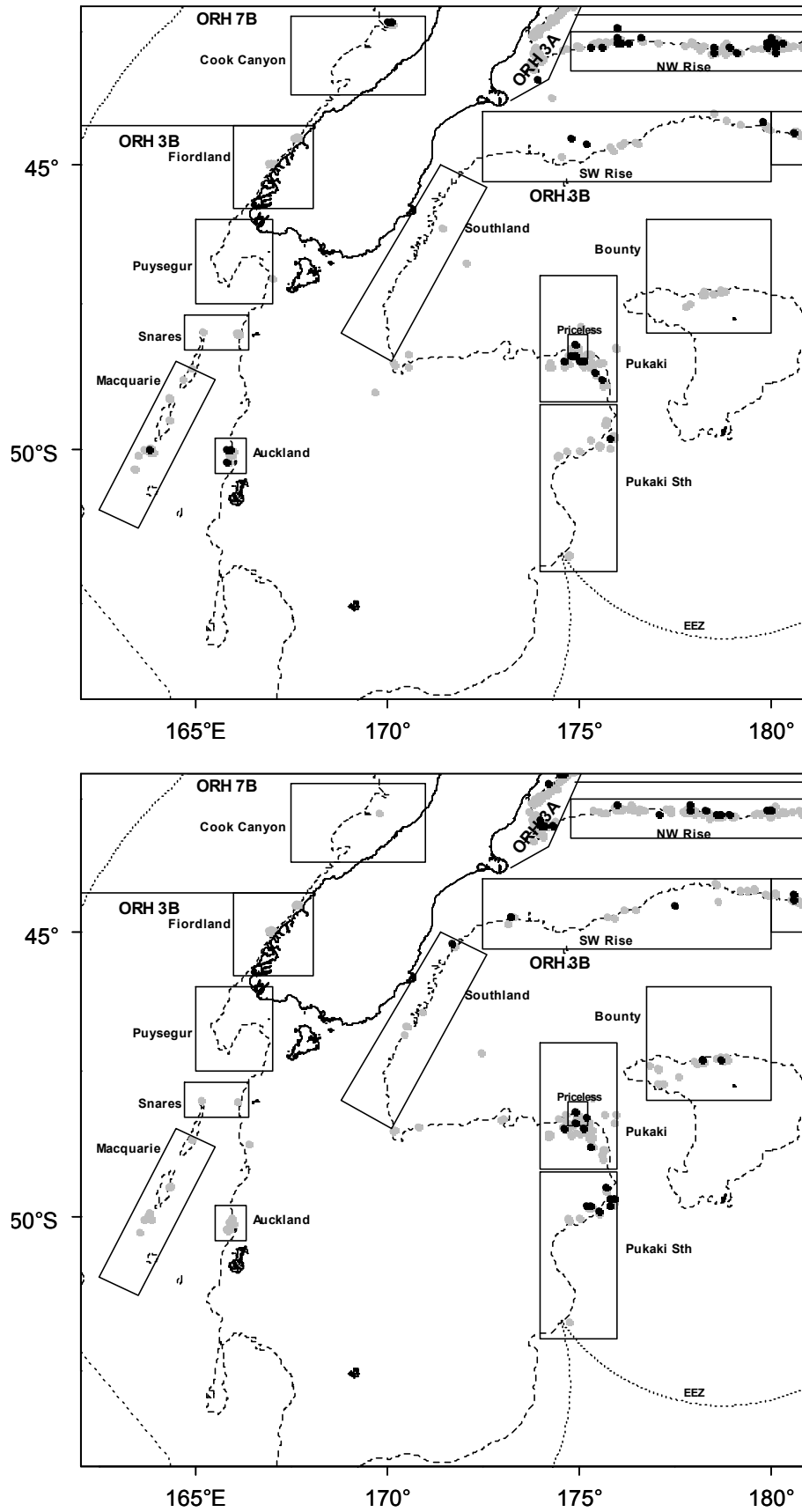


Figure 3: Location of fisheries used for analysis of biological data, position of trawls in the commercial fishery (grey dots), and location of samples of orange roughy taken by OP observers (black dots), during 2007–08 (top) and 2008–09 (bottom). The dashed line shows the 1000 m depth contour.

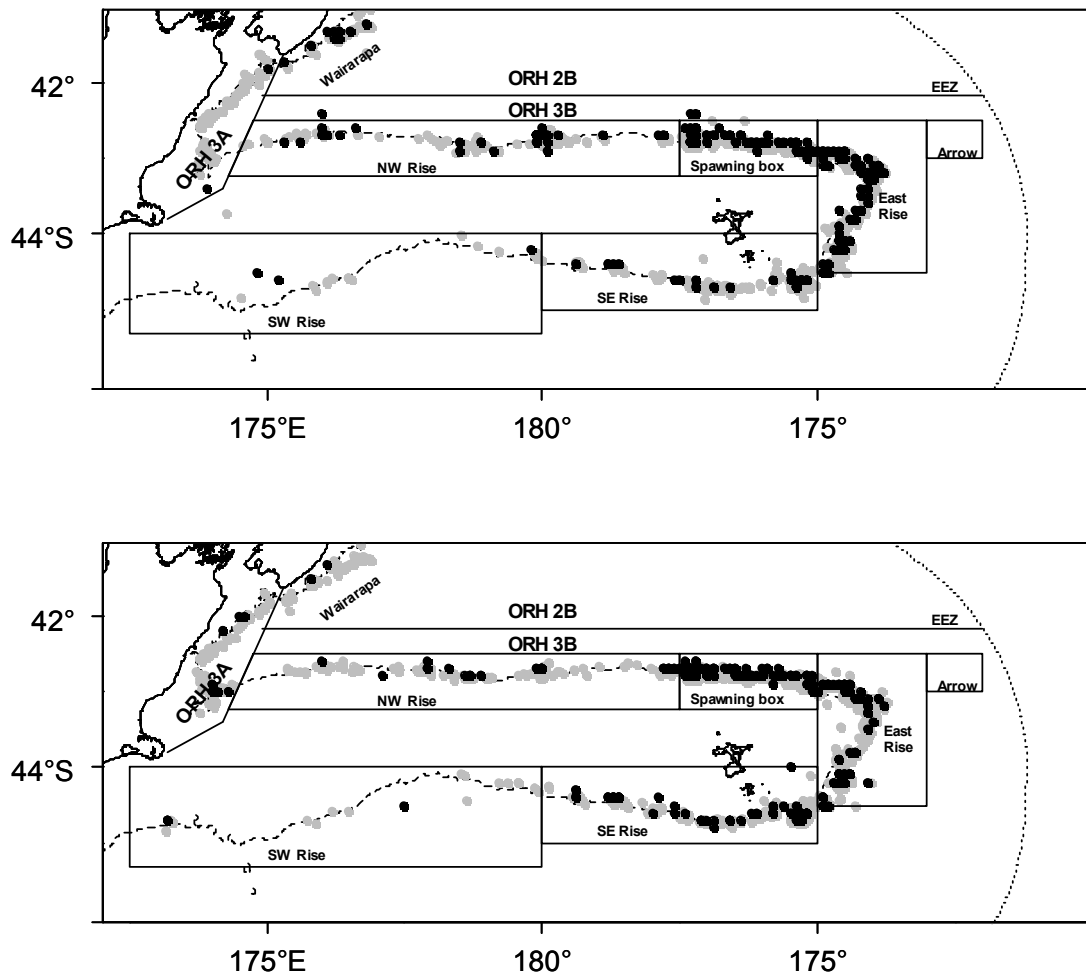


Figure 4: Location of fisheries used for analysis of biological data, position of trawls in the commercial fishery (grey dots), and location of samples of orange roughy taken by OP observers (black dots), during 2007–08 (top) and 2008–09 (bottom). The dashed line shows the 1000 m depth contour.

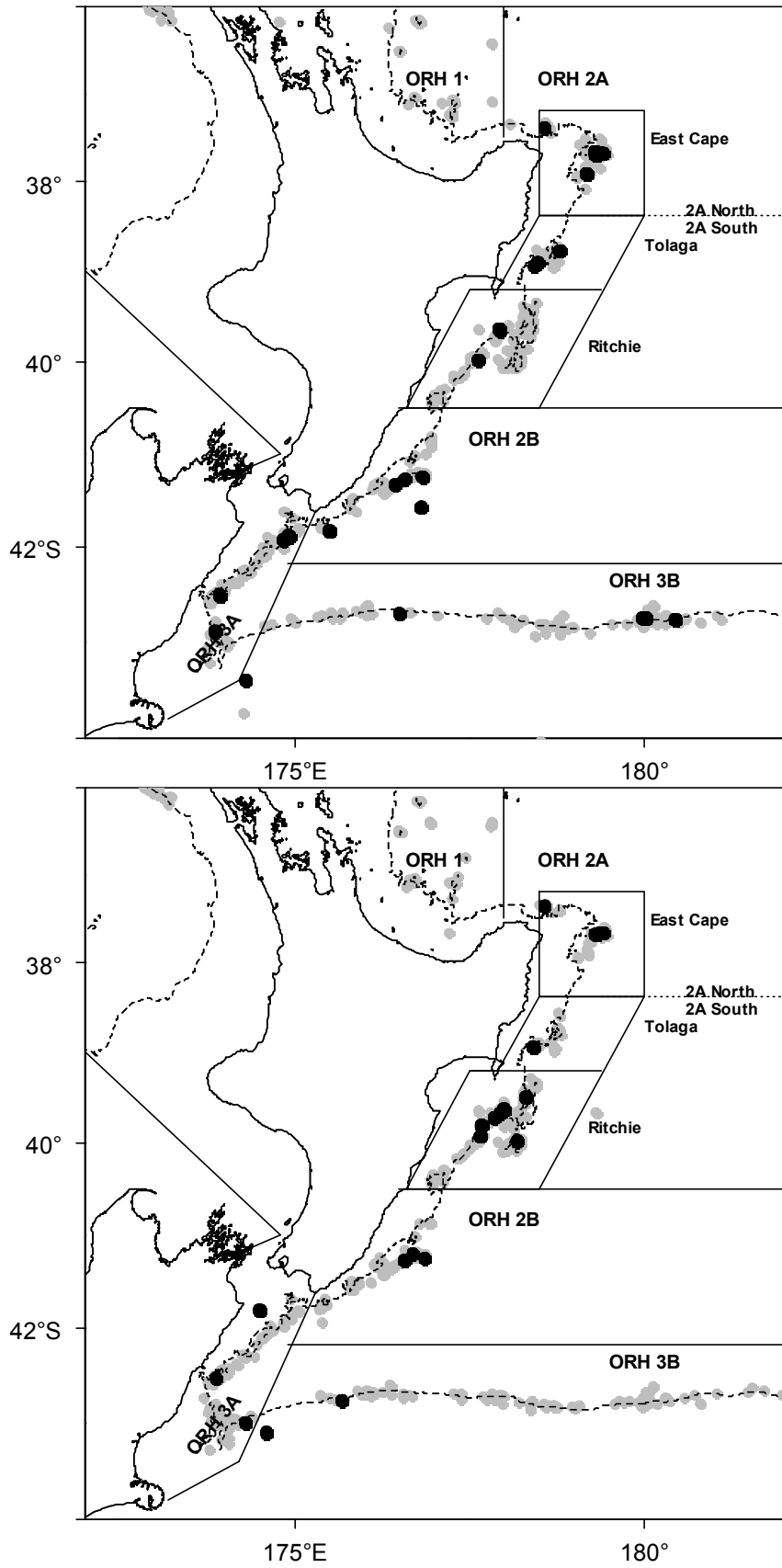


Figure 5: Location of fisheries used for analysis of biological data, position of trawls in the commercial fishery (grey dots), and location of samples of orange roughy taken by the industry OTS programme (black dots), during 2007–08 (top) and 2008–09 (bottom). The dashed line shows the 1000 m depth contour.

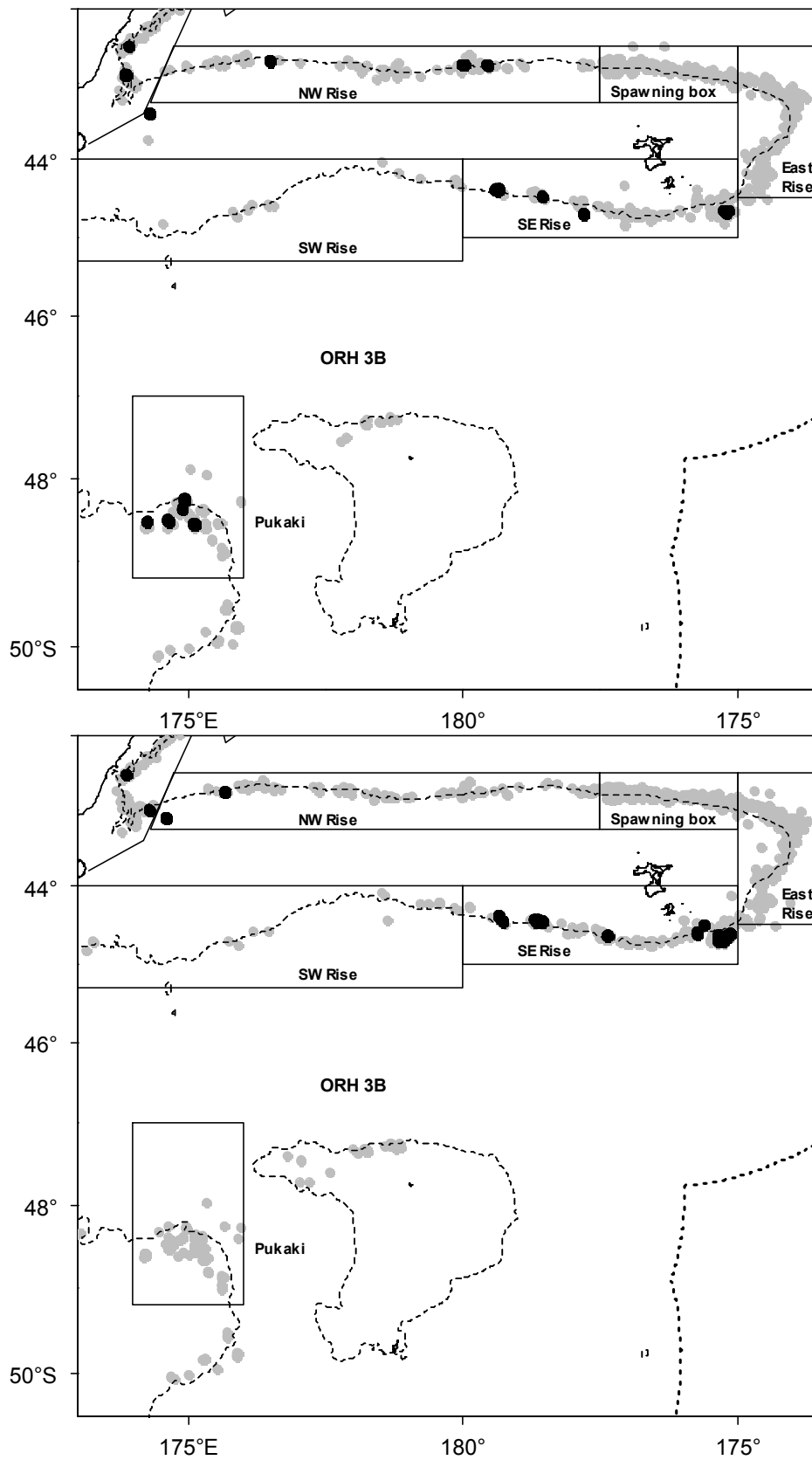


Figure 6: Location of fisheries used for analysis of biological data, position of trawls in the commercial fishery (grey dots), and location of samples of orange roughly taken by the industry OTS programme (black dots), during 2007–08 (top) and 2008–09 (bottom). The dashed line shows the 1000 m depth contour.

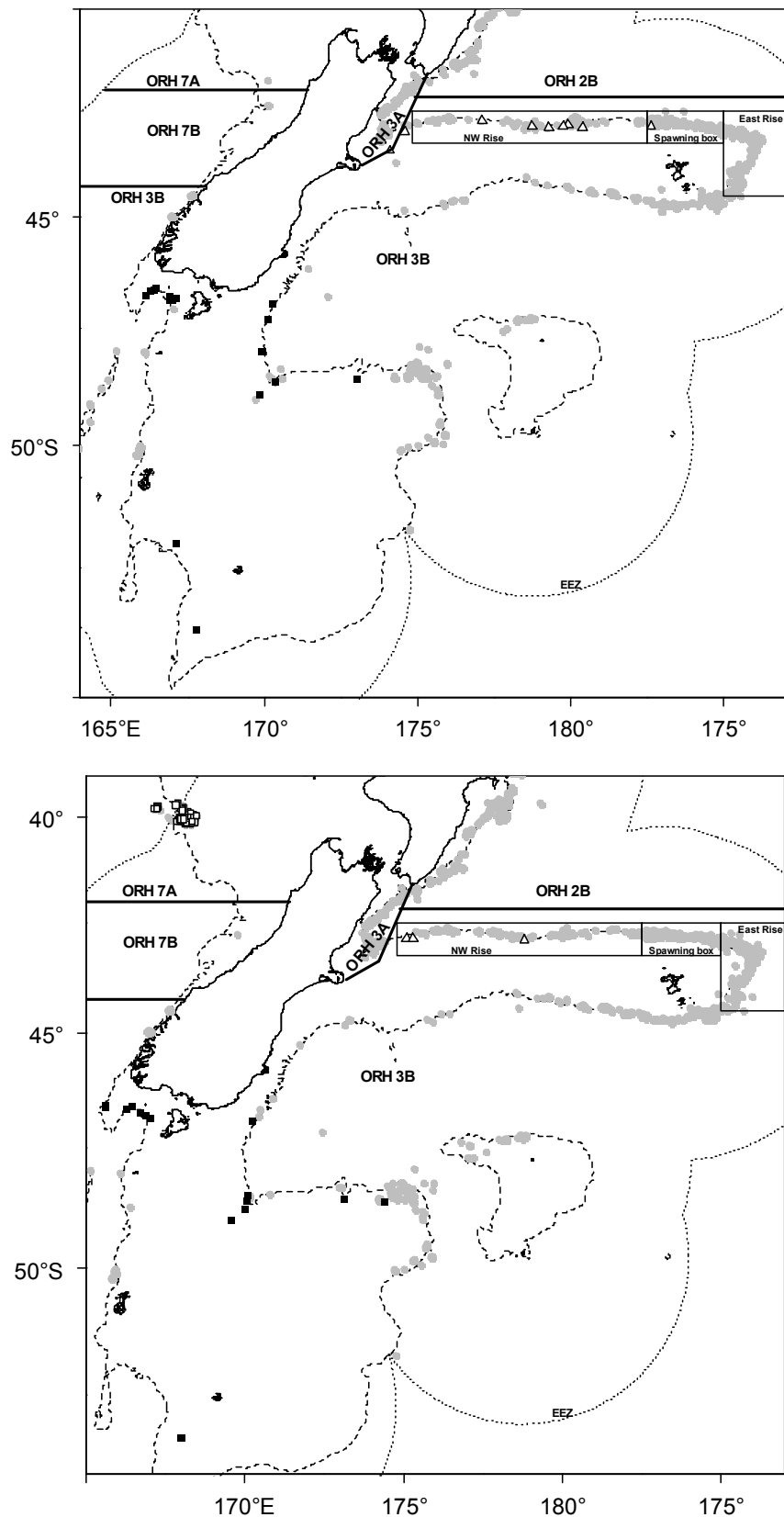


Figure 7: Location of fisheries and NIWA research trawls where orange roughy length data were recorded, and position of trawls in the commercial fishery (grey dots) for 2007–08 (top) and 2008–09 (bottom); black squares, sub-Antarctic trawl survey November–December (2007 & 2008) (R.V. *Tangaroa*); open triangles, Chatham Rise hoki survey January (2008 and 2009) (R.V. *Tangaroa*); open squares, Challenger orange roughy survey June–July 2009 (F.V. *Thomas Harrison*). The dashed line shows the 1000 m depth contour.

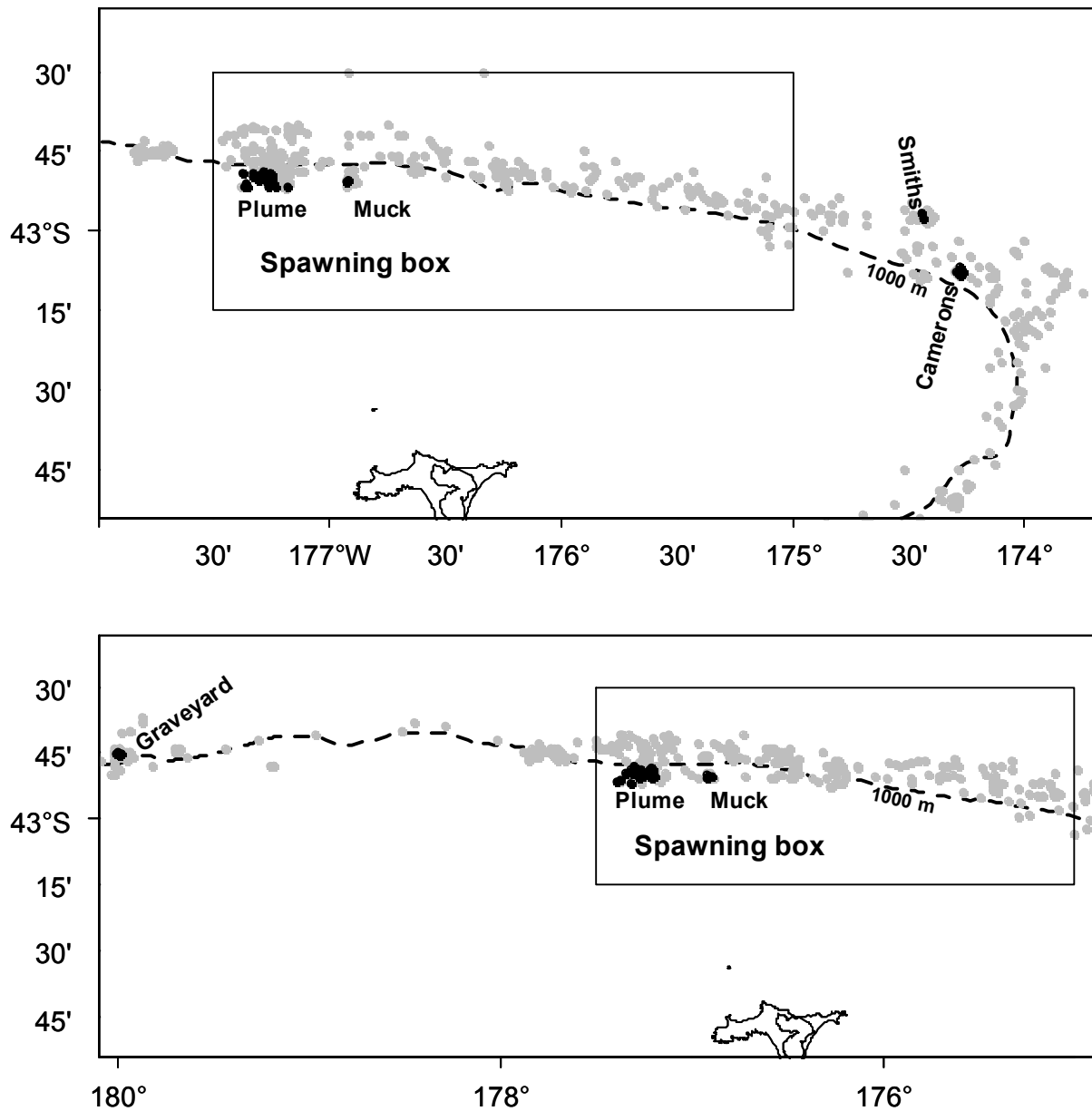


Figure 8: Position of trawl locations in the industry surveys of the Spawning Box plume and eastern hills in July 2008 (top), and Spawning Box and Graveyard seamount in July 2009 (bottom) (F.V. *San Waitaki*). Black dots indicate the survey trawl positions and the grey dots indicate the position of trawls in the commercial fishery.

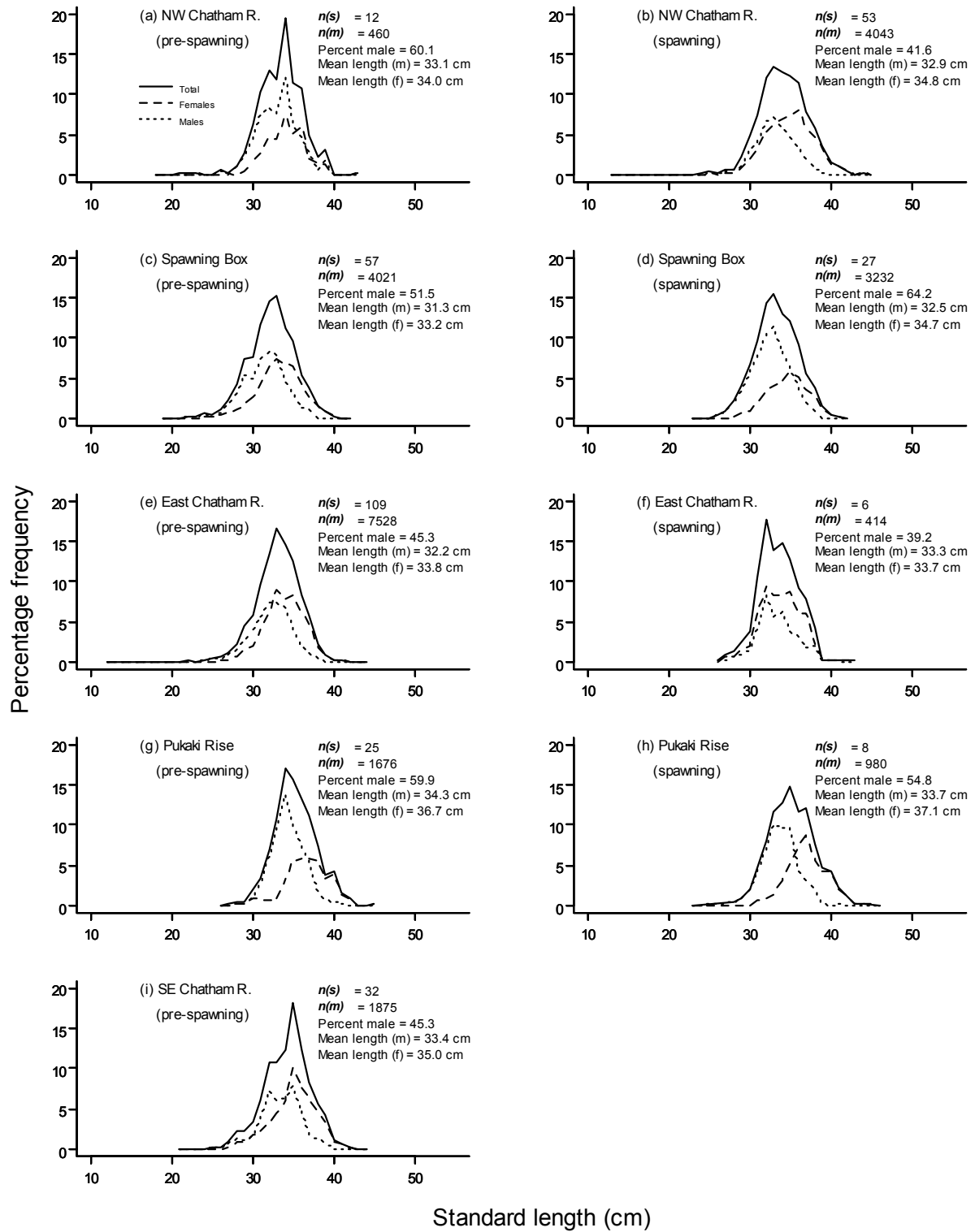


Figure 9: 2007–08 OP length frequency distributions (scaled by catch) of orange roughly by area and period, $n(s)$, number of samples; $n(m)$, number of fish measured.

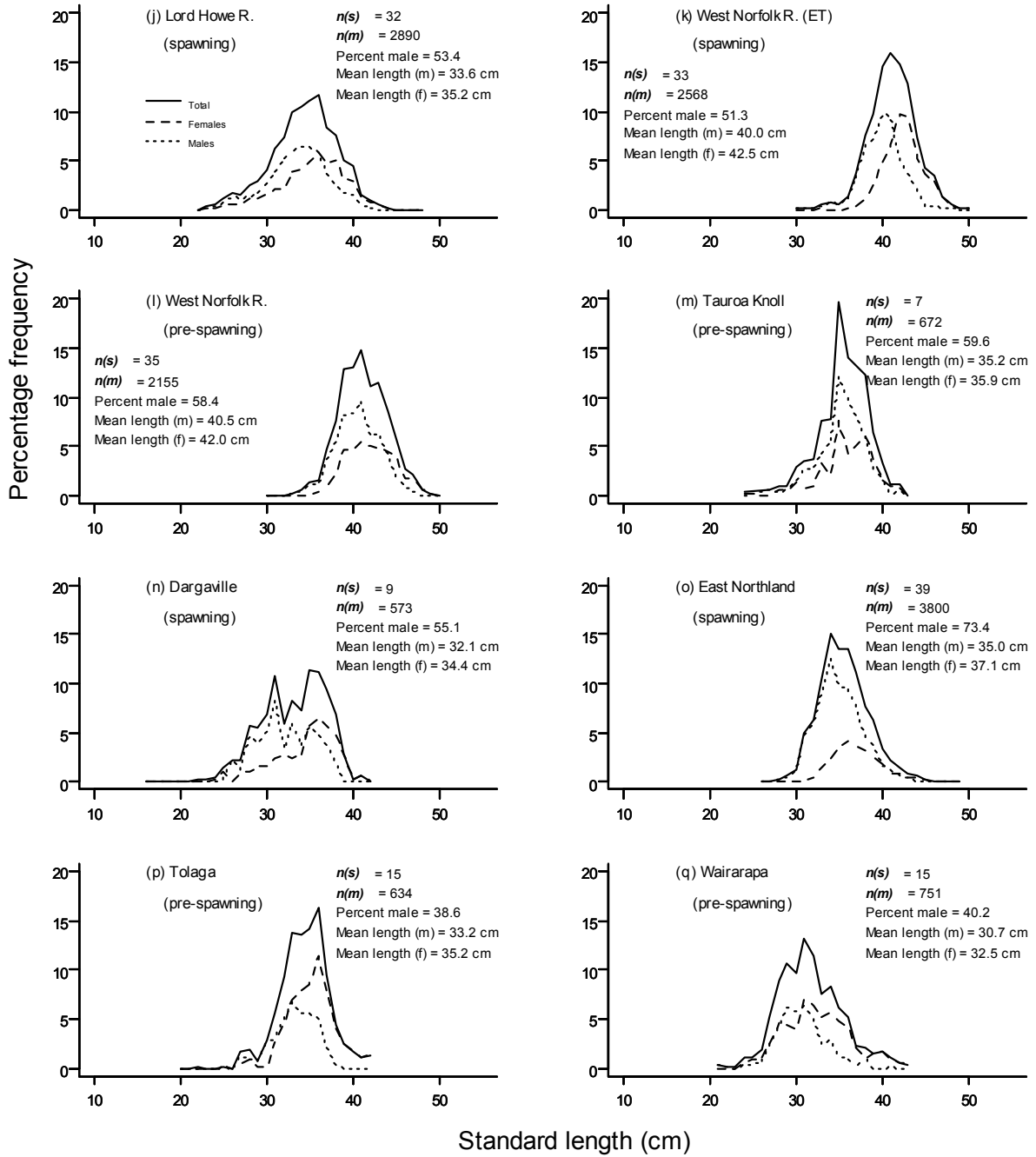


Figure 9: 2007–08 OP length frequency distributions — *continued*.

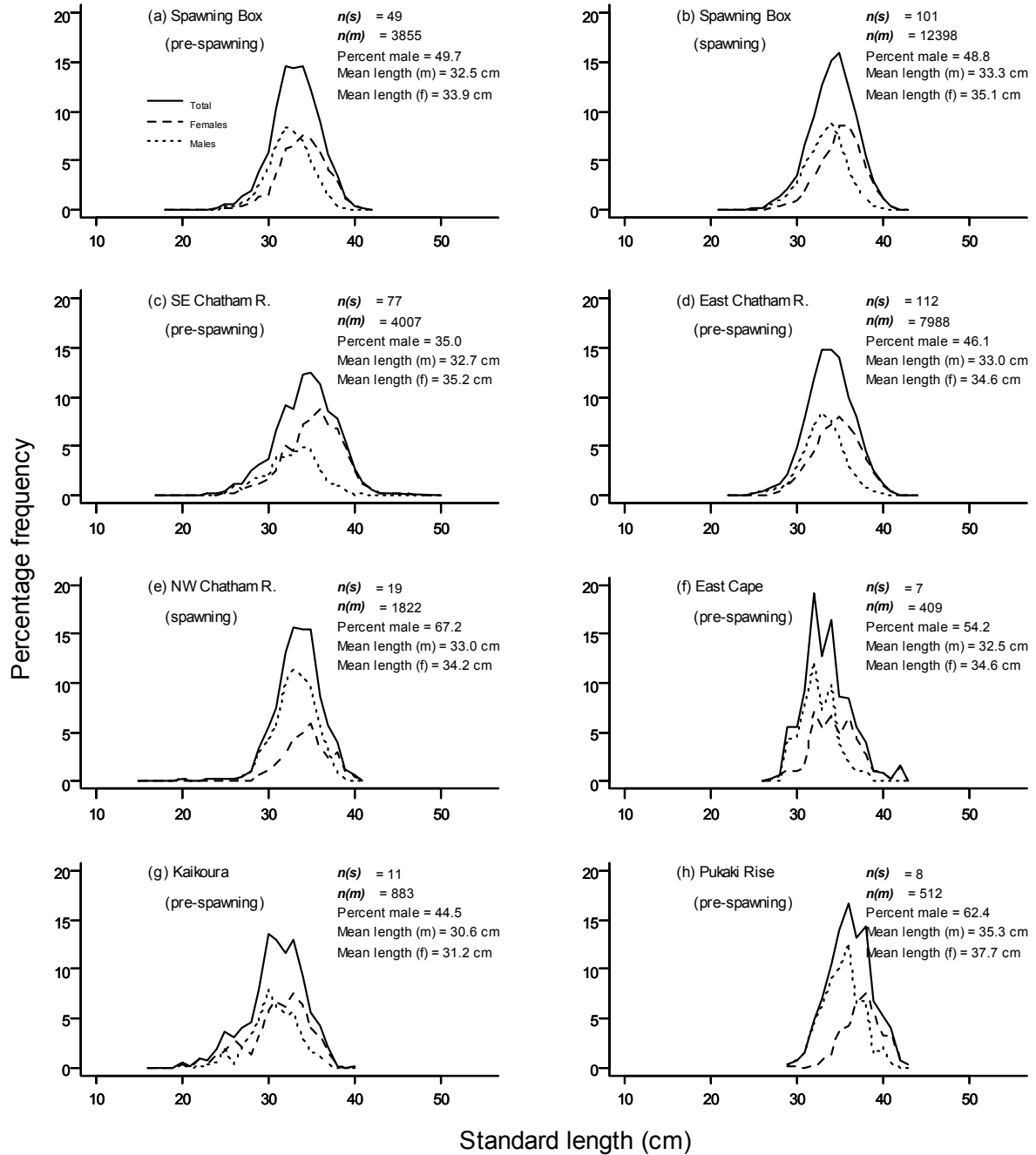


Figure 10: 2008–09 OP length frequency distributions (scaled by catch) of orange roughy by area and period, $n(s)$, number of samples; $n(m)$, number of fish measured.

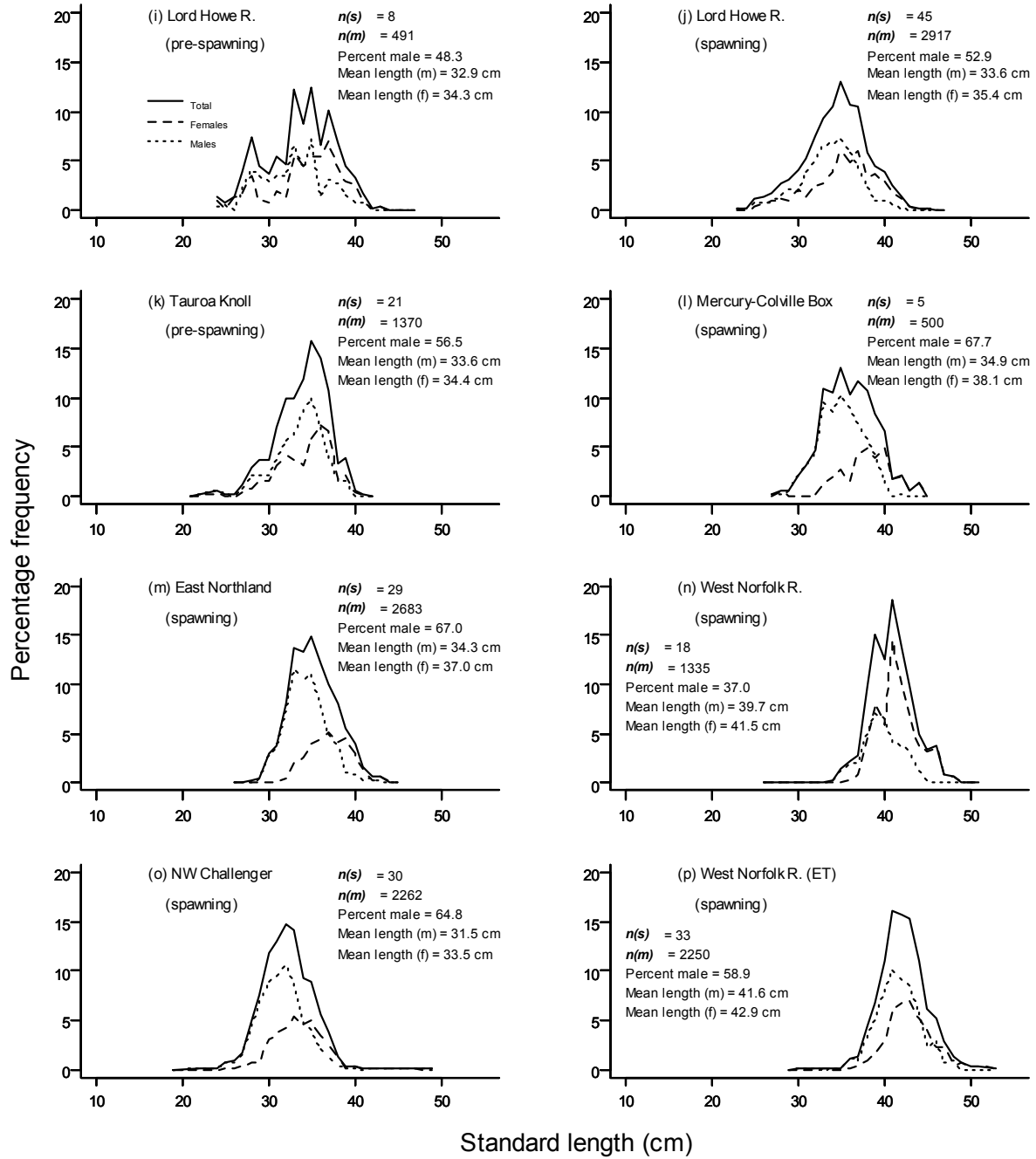


Figure 10: 2008–09 OP length frequency distributions — *continued*.

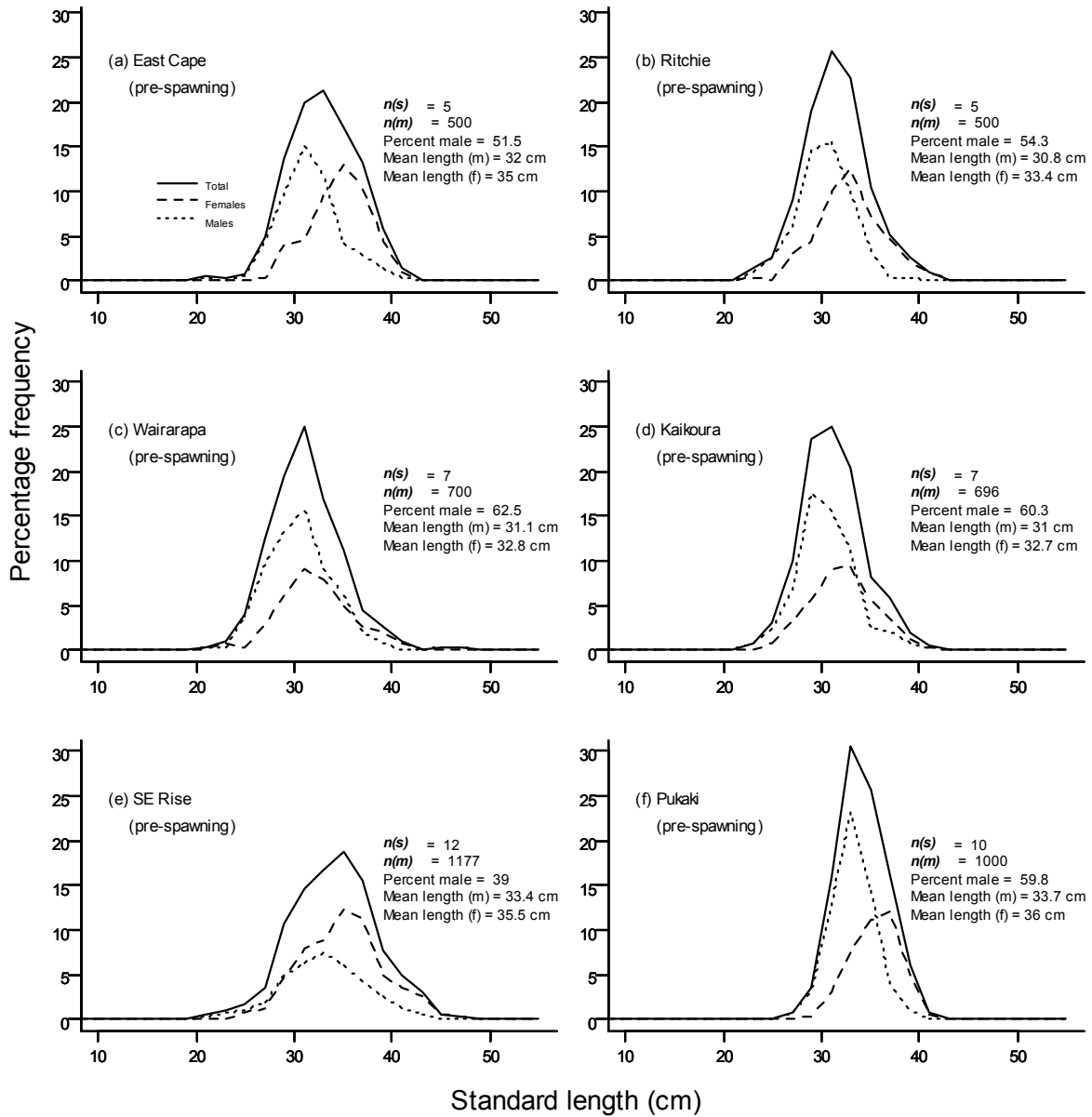


Figure 11: 2007–08 Industry OTS Programme length frequency distributions (unscaled) of orange roughy by area and period, $n(s)$, number of samples; $n(m)$, number of fish measured.

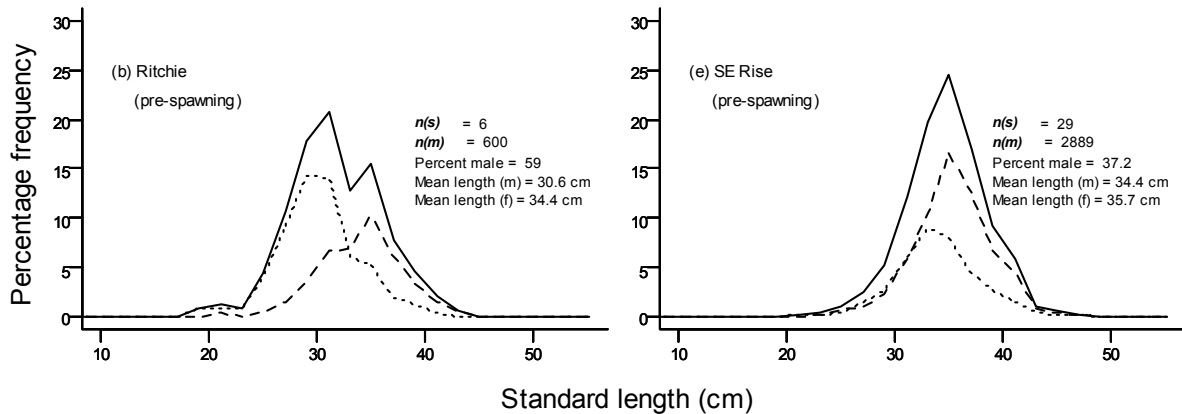


Figure 12: 2008–09 Industry OTS Programme length frequency distributions (unscaled) of orange roughy by area and period, $n(s)$, number of samples; $n(m)$, number of fish measured.

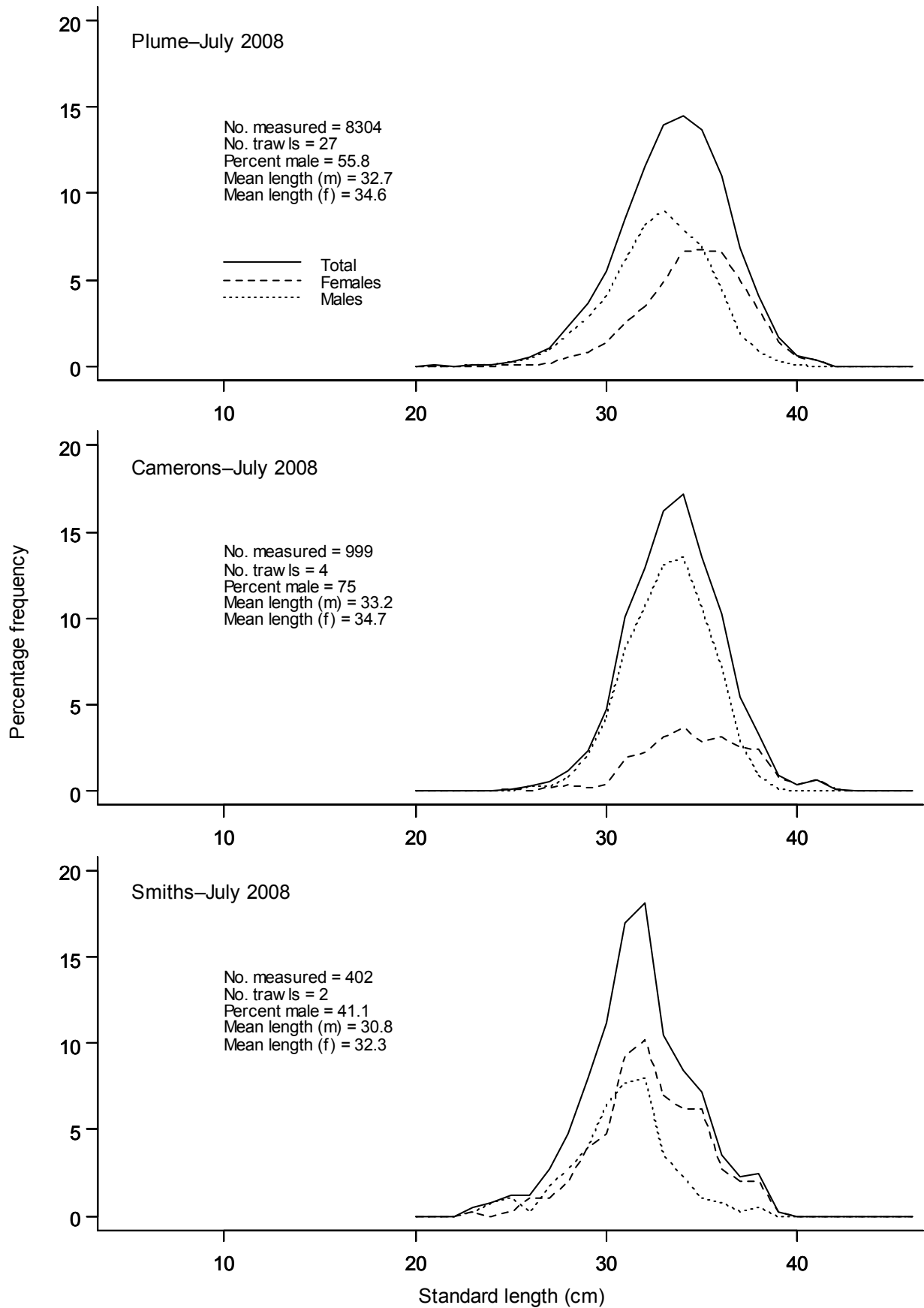


Figure 13: Orange roughy length frequency distribution (unscaled) from the industry survey of the Spawning Box plume and East Rise hills in July 2008 (F.V. *San Waitaki*).

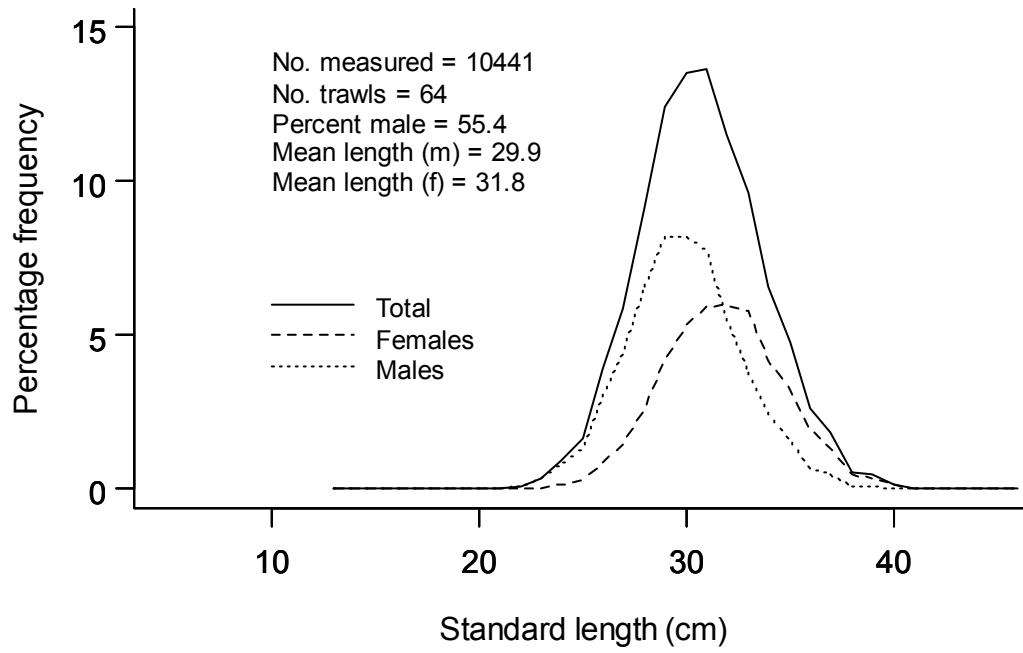


Figure 14: Orange roughy length frequency distribution (scaled by catch) from the Challenger Plateau orange roughy research survey June–July 2009 (F.V. Thomas Harrison). All biomass trawls.

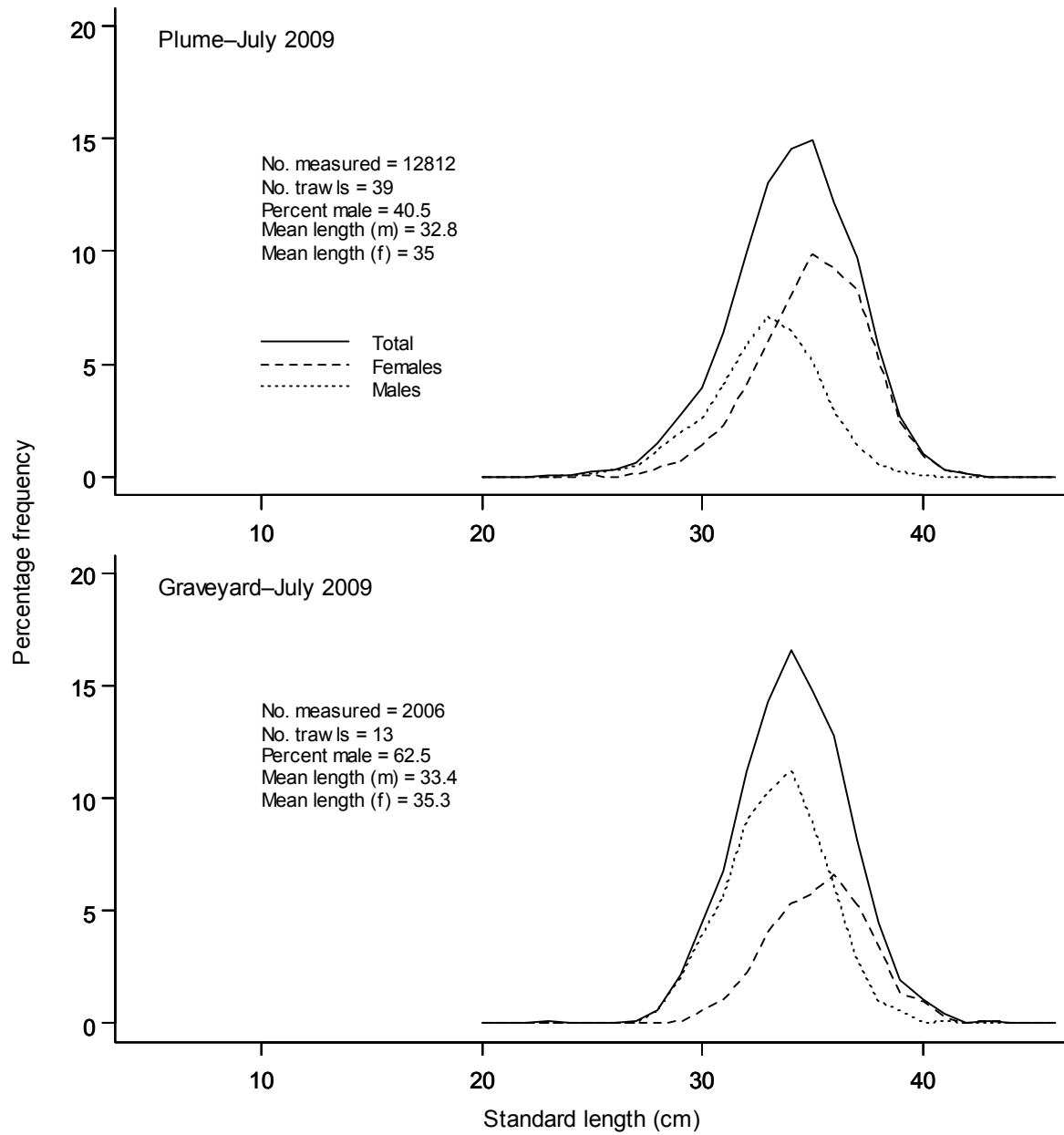


Figure 15: Orange roughy length frequency distribution (unscaled) from the industry survey of the Spawning Box plume and Graveyard hill in July 2009 (F.V. *San Waitaki*).

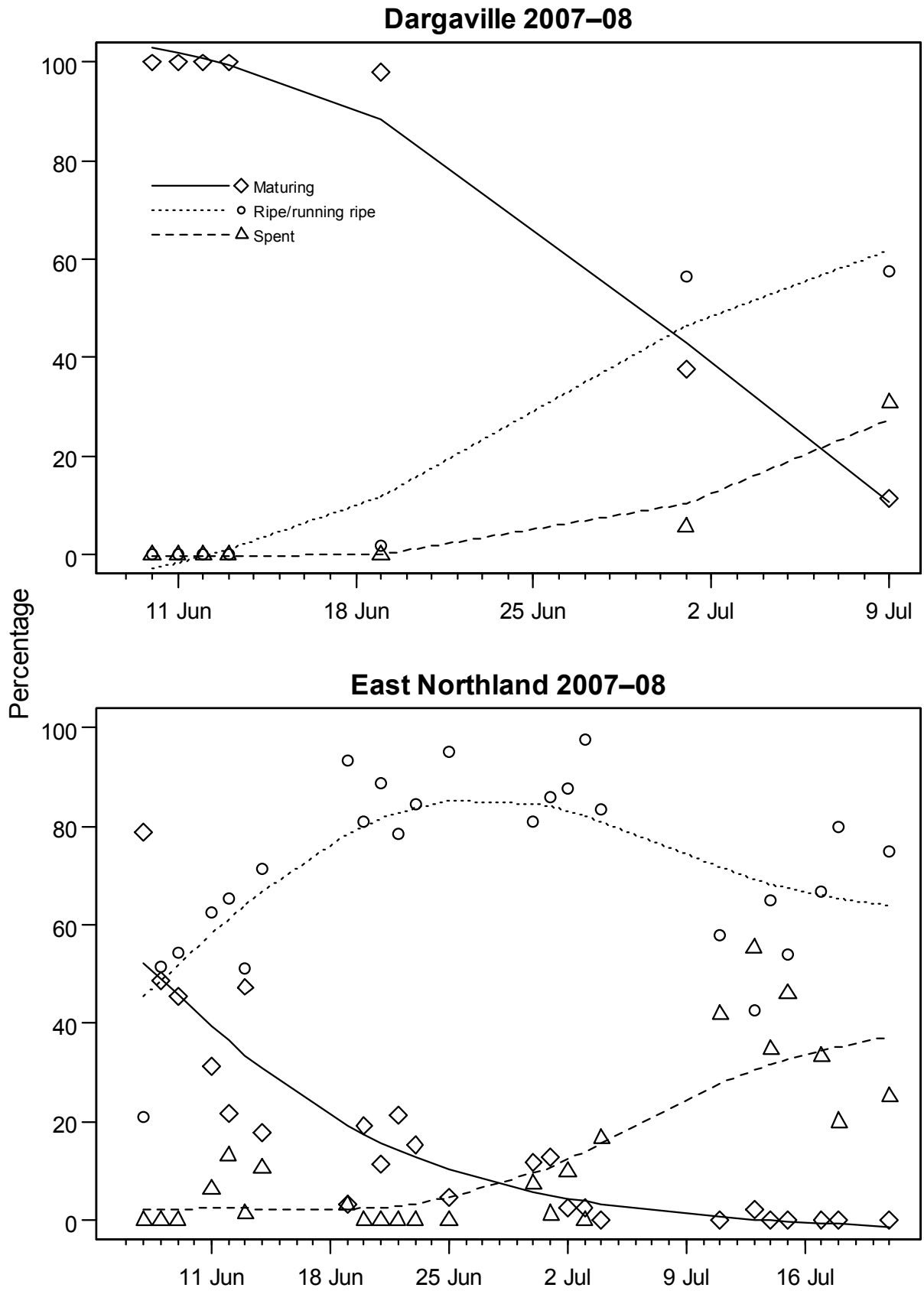


Figure 16: Daily changes in female orange roughy gonad stage proportions during the spawning season in the Dargaville and East Northland fisheries (ORH 1), from OP data from 2007-08. Each point indicates the fraction of all mature fish examined (aggregated by day) that were in the reproductive state indicated by the symbol.

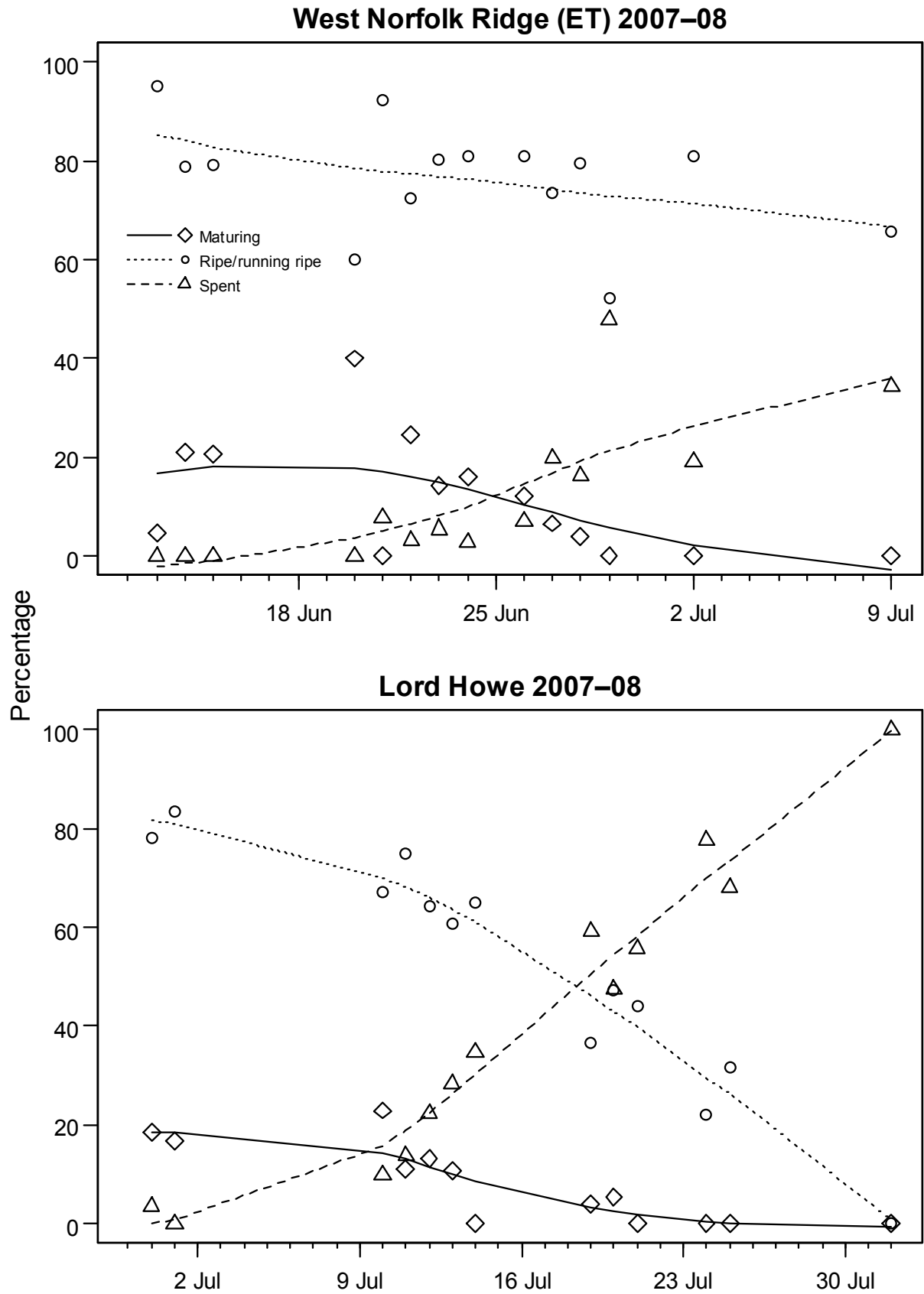


Figure 17: Daily changes in female orange roughy gonad stage proportions during the spawning season in the West Norfolk Ridge and Lord Howe fisheries (ET), from OP data from 2007-08. Each point indicates the fraction of all mature fish examined (aggregated by day) that were in the reproductive state indicated by the symbol.

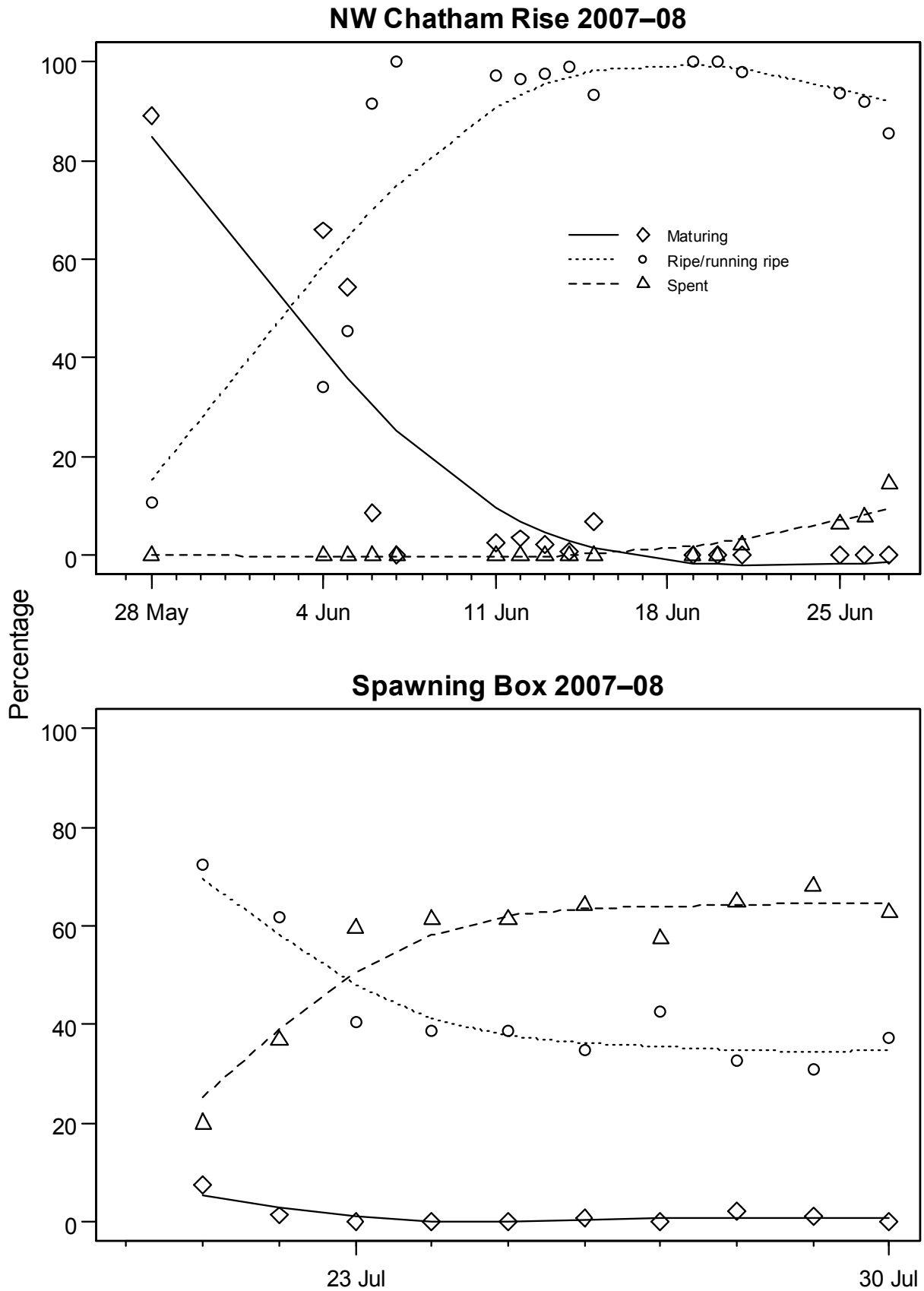


Figure 18: Daily changes in female orange roughy gonad stage proportions during the spawning season in the NW Chatham Rise and Spawning Box fisheries (ORH 3B), from OP data from 2007-08. Each point indicates the fraction of all mature fish examined (aggregated by day) that were in the reproductive state indicated by the symbol.

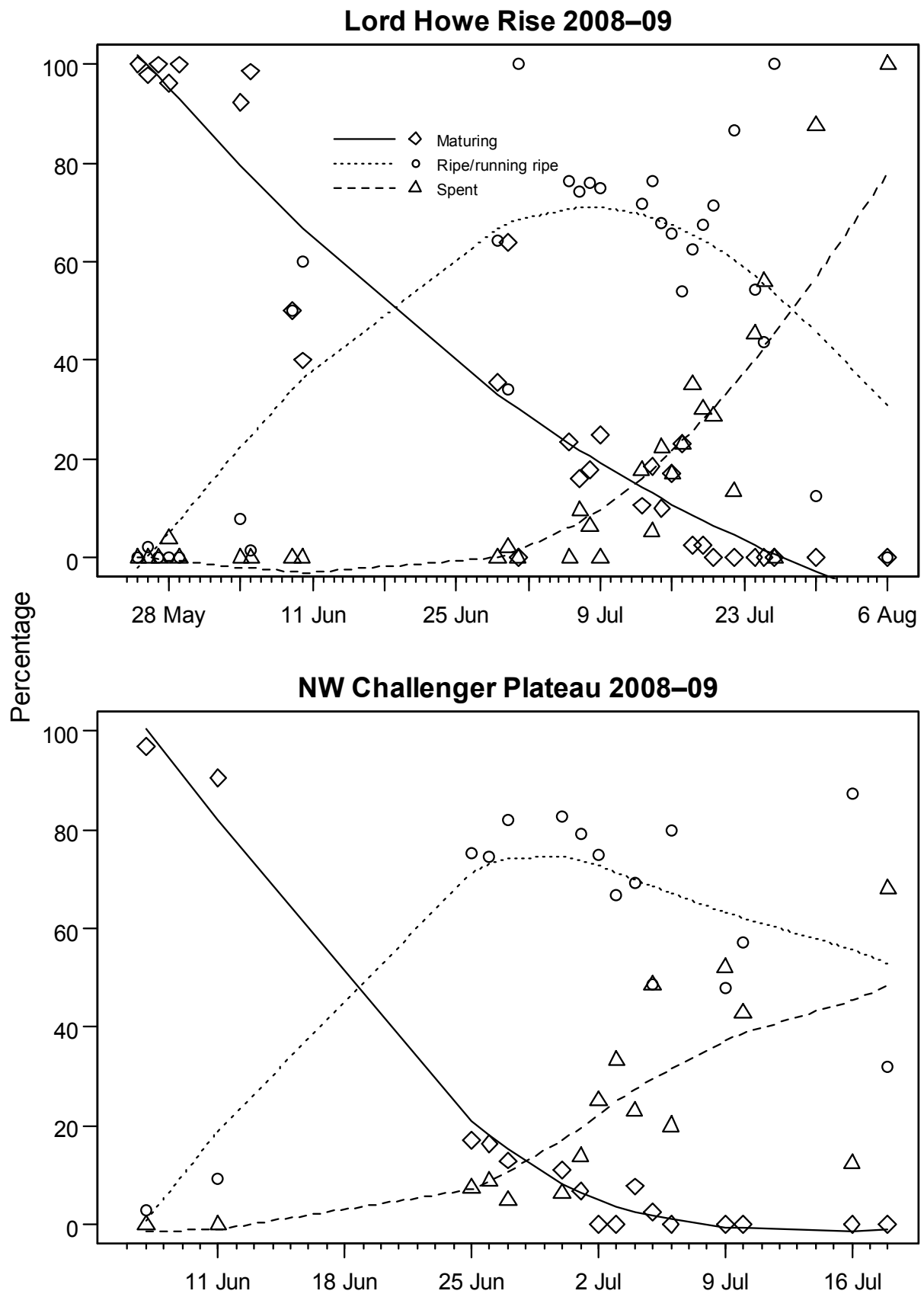


Figure 19: Daily changes in female orange roughy gonad stage proportions during the spawning season in the Lord Howe Rise and NW Challenger Plateau fisheries (ET), from OP data from 2008-09. Each point indicates the fraction of all mature fish examined (aggregated by day) that were in the reproductive state indicated by the symbol.

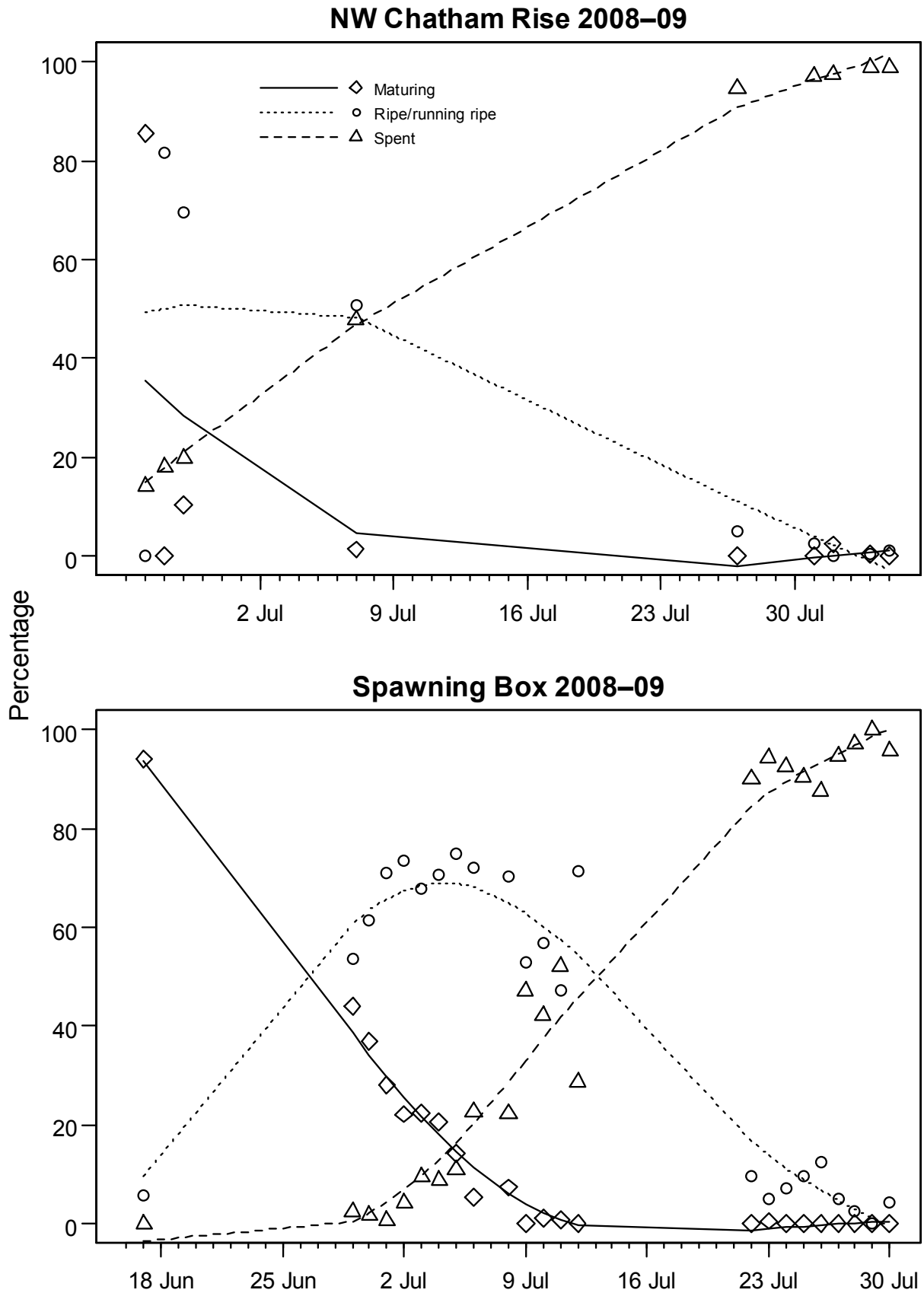


Figure 20: Daily changes in female orange roughy gonad stage proportions during the spawning season in the NW Chatham Rise and Spawning Box fisheries (ORH 3B), from OP data from 2008-09. Each point indicates the fraction of all mature fish examined (aggregated by day) that were in the reproductive state indicated by the symbol.

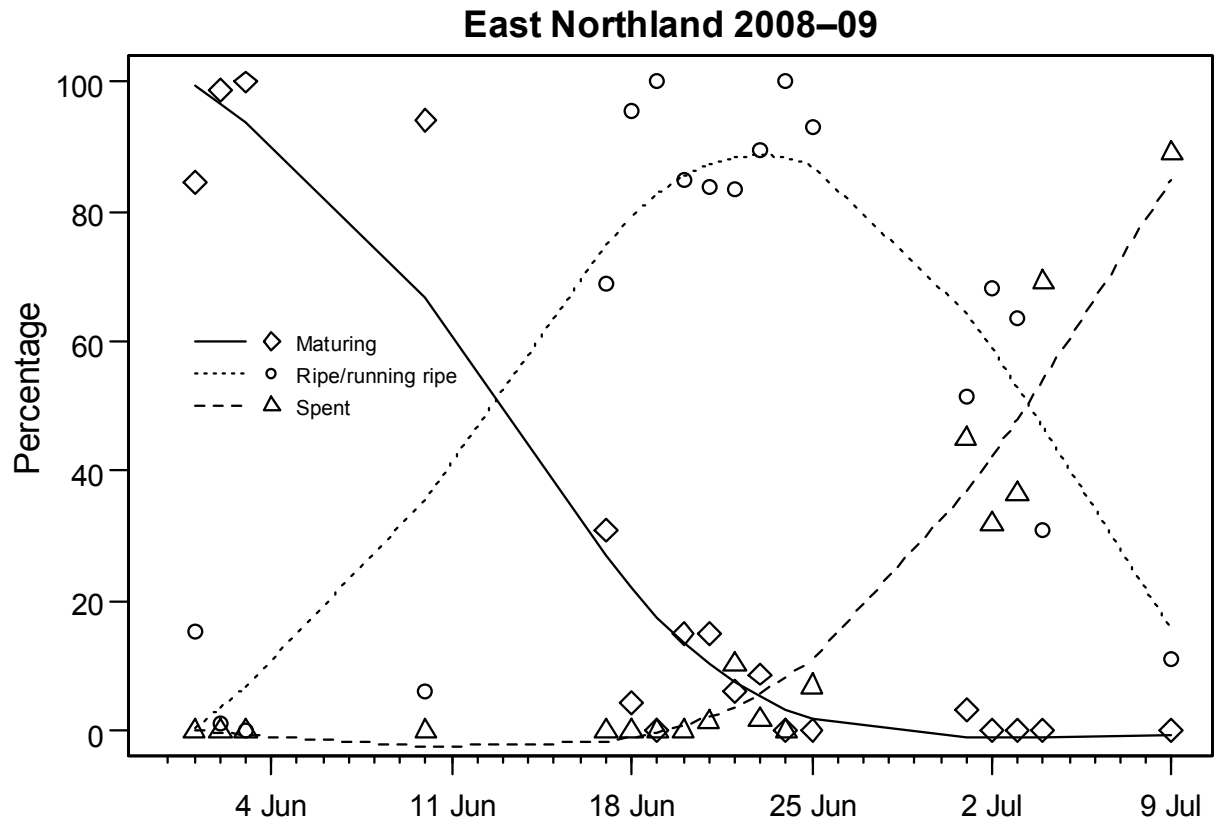


Figure 21: Daily changes in female orange roughy gonad stage proportions during the spawning season in the East Northland fishery (ORH 1), from OP data from 2008–09. Each point indicates the fraction of all mature fish examined (aggregated by day) that were in the reproductive state indicated by the symbol.

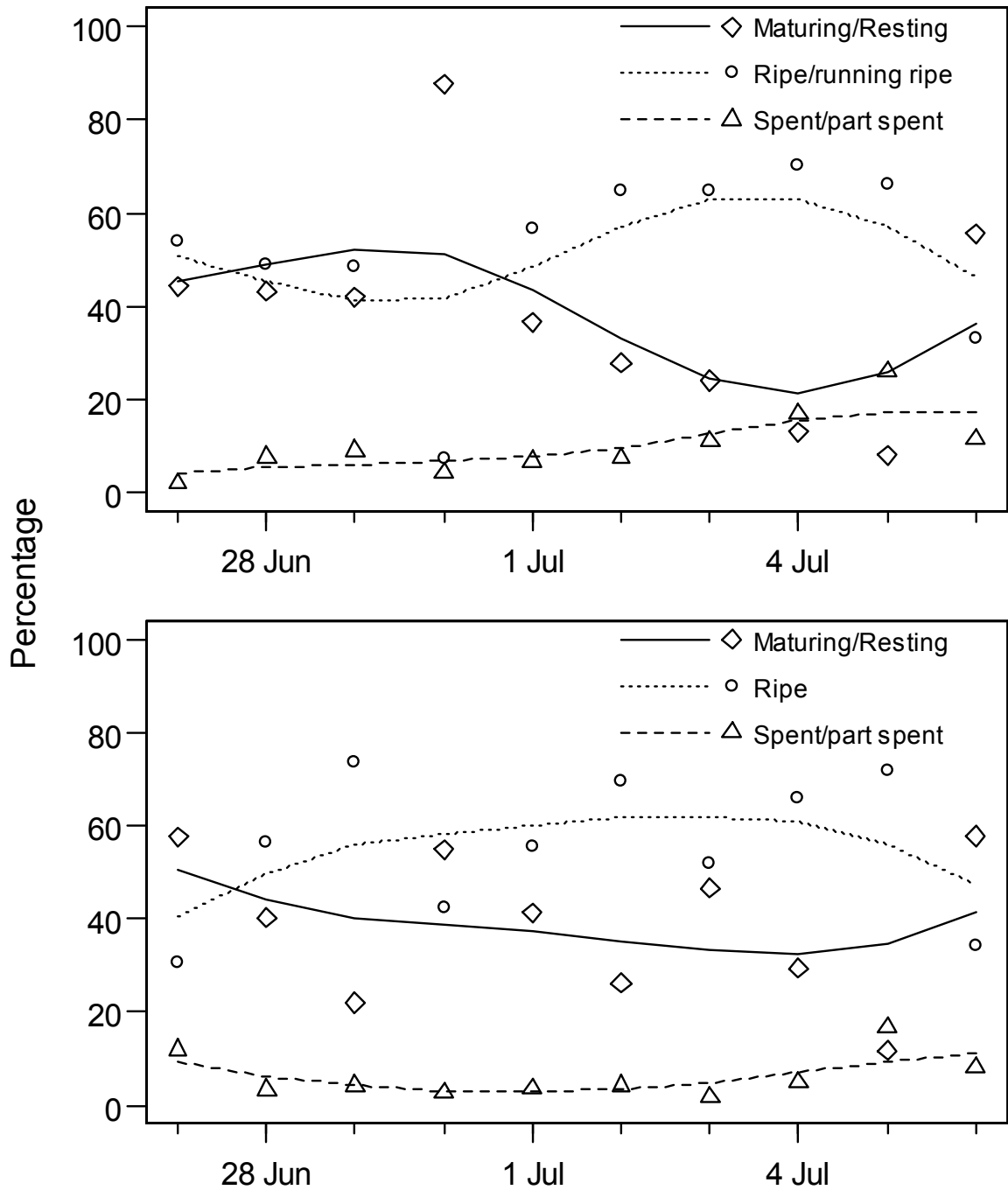


Figure 22: Daily changes in orange roughy gonad stage proportions during the 2008–09 spawning season in the Challenger Plateau fishery (ORH 7A), from research survey data (F.V. *Thomas Harrison*). Top, female fish; bottom, male fish. Each point indicates the fraction of all mature fish examined (aggregated by day) that were in the reproductive state indicated by the symbol.