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A summary of biological information on the  
New Zealand fisheries for orange roughy  
(*Hoplostethus atlanticus*) for the 2006–07 fishing year

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for orange roughy (*Hoplostethus atlanticus*)  
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## EXECUTIVE SUMMARY

**Anderson, O.F. (2008). A summary of biological information on the New Zealand fisheries for orange roughy (*Hoplostethus atlanticus*) for the 2006–07 fishing year.**

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1. Size and reproductive data on orange roughy, collected by observers of the Ministry of Fisheries Observer Programme (OP), a 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 496 OP trawls and 126 OTS trawls during the 2006–07 fishing year, almost exclusively from fisheries within the New Zealand Exclusive Economic Zone (EEZ). Biological data collected from 62 research trawls by NIWA staff on the East Chatham Rise and from 16 research trawls on the Spawning Box plume by industry scientists were also summarised.

2. The level of OP sampling was slightly greater than in 2005–06 and, although representing a relatively high level of sampling in comparison with recent years, was well short of the 608 samples scheduled for the year (based on the standard of one sample per day). Coverage was at or above the expected level in the high profile ORH 1 and ORH 3B fisheries but, as in the last several years, there was almost no sampling in the east coast fisheries in QMAs ORH 2A, ORH 2B, and ORH 3A. Sampling in areas outside the EEZ, although at a similar level to that of two years previous, was the lowest recorded since 1990–91, when there was no sampling at all. Coverage of the Spawning Box and East Rise fisheries in ORH 3B was particularly good, with biological data collected in these fisheries by an MFish/NIWA survey, an industry survey, and both the OP and OTS sampling programmes. In total over 23 000 fish from 185 trawls were measured in the Spawning Box fishery and over 12 000 fish from 142 trawls were measured in the East Rise fishery in 2006–07. Several thousand fish were also measured in each of the Pukaki (ORH 3B), West Norfolk Ridge, and East Northland (ORH 1) fisheries. There was a relatively high level of OTS sampling compared to recent years, although less than achieved in 2005–06, focussing on the main ORH 3B fisheries on the Chatham Rise and Pukaki Rise, as well as the east coast fisheries in ORH 2A, ORH 2B, and ORH 3A.

3. Sufficient length samples were obtained by OP observers to determine size frequencies for 15 fishery/season combinations, and by OTS observers for 9 fishery/season combinations. These distributions were broadly 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 tended to be from the Chatham Rise pre-spawning fisheries (mean lengths 32–33 cm for males and 34–35 cm for females) and the largest from the ORH 1 fisheries, especially the West Norfolk Ridge pre-spawning fishery with mean lengths of 40.7 cm (males) and 42.0 cm (females). A large amount of length data was collected from the MFish/NIWA and industry orange roughy research surveys on the East Chatham Rise, and size distributions 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 11 of the 24 fishery/area combinations showing a higher percentage of male fish and 14 of the 24 calculated ratios falling within 10 percentage points of 50%. The most skewed sex ratios were from the West Norfolk Ridge spawning fishery (28.4% male) and the Mercury–Colville Box spawning fishery (84.1% male).

5. OP observer sampling in several ORH 1 fisheries and research sampling in the Spawning Box fishery during the spawning period was sufficient to describe the temporal progression of spawning in those areas. The timing of spawning in the Spawning Box fishery was similar to that in recent years (although earlier than the historical average), and was generally later than previously recorded in the ORH 1 fisheries.

## 1. INTRODUCTION

This report documents the results of objective 3 of the Ministry of Fisheries project ORH2007/02 “Stock assessment of orange roughy”, and objective 2 of Ministry of Fisheries project ORH2007/03 “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 2006/07 fishing year”, with the additional phrase in project ORH2007/02 “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 (2006). 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 2006–07 fishing year. Data from fisheries within the EEZ are covered by MFish project ORH2007/02, and data from fisheries outside the EEZ (referred to in this report as ET fisheries) by project ORH2007/03. These summaries are constructed and presented in a manner consistent with that used in previous analyses of orange roughy biological data (e.g., Anderson 2008) 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 MFish-funded survey of orange roughy on the East Chatham Rise (ORH 3B) in July 2007, by scientists during an industry-run survey of the Spawning Box plume in July 2007, and provides station positions where small amounts of orange roughy biological data were collected on NIWA-run research surveys of middle depth species in 2006–07.

## 2. DATA COLLECTION

Orange roughy biological data were collected by OP observers hosted aboard commercial fishing vessels. Observers took measurements from random samples of 80–100 fish (range 1–402) per trawl, from an average of one (but up to seven) 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.

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 for the last two fishing years.

Biological data collected by NIWA staff are available from the orange roughy research survey on the East Chatham Rise (R.V. *Tangaroa*). Some further orange roughy biological data are also available from a survey of hoki on the Chatham Rise in December 2006 to January 2007 and from a multi-species survey in the sub-Antarctic in November–December 2006. 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 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 4). These fishery areas are comparable to those used in previous analyses (e.g., Anderson 2008).

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 2006–07. 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 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 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 were treated in the same manner as those collected by observers. There were insufficient fish measured (fewer 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 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 for the Aldermen Knoll, Dargaville, East Northland, and Mercury-Colville Box fisheries (ORH 1), and for the Chatham Rise Spawning Box fishery.

## 4. RESULTS

OP samples of orange roughy ranged from 0.8 kg to 515 kg from catches of between 1 kg and 78 t. OTS samples were not weighed, although most consisted of 100 fish, and were from catches of between 4 kg and 50 t. NIWA research samples ranged from 0.6 kg to 665 kg and were taken from catches of between 0.6 kg and 7 t.

### 4.1 Distribution of samples

Ministry of Fisheries OP observers sampled 496 catches of orange roughy collected during 32 voyages with the number of samples per voyage ranging between 1 and 54 (median 11.5). Five areas had specific levels of scheduled sampling covering the 2006–07 fishing year; ORH 1, ORH 3B, ORH 2A, Lord Howe/NW Challenger, and Louisville Ridge (Table 2). In ORH 3B, the level of scheduled sampling was to increase from 260 days in the 2006–07 (June–July) MFish financial year to 470 days in the following year. The 307 samples achieved in the 2006–07 fishing year for this area was appropriately in between these two figures (assuming one sample per day), but only slightly up on the coverage achieved in the previous fishing year. The 182 samples from ORH 1 was more than twice the target (in days) for that area in the 2006–07 schedule and considerably greater also than expected from the 140 days scheduled for the 2007–08 financial year. The low coverage in ORH 2A in recent years continued into 2006–07, despite a constantly scheduled level of 40 days per year, with only 2 samples collected. Observer coverage of the ET fisheries was particularly poor in 2006–07, despite the schedule of between 60 and 120 days, with no samples taken from the Lord Howe/NW Challenger or Louisville Ridge fisheries, and only a few samples collected from the West Norfolk Ridge (ET) fishery. The 113 and 71 days assigned to “ORH general” were provided by the Conservation Services Programme of the Department of Conservation, for monitoring the adverse effects of commercial fishing for orange roughy on protected species. This allocation of observer days was not strictly assigned to specific areas so achieved coverage for this category cannot be determined. However, the total of 496 samples collected in 2006–07 was well below that expected from the schedule of 628 or 781 sampling days for the two relevant MFish financial years. Figures provided by MFish (Alan Martin, pers. comm.) show that the overall coverage for the 2006–07 MFish

financial year was also lower than scheduled for that year, with 597 sampling days achieved out of 628.

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. About 40% of the OP samples came from area SOE (Chatham Rise) with the remainder spread amongst areas SOU/SUB (Southland/Sub-Antarctic), AKE/AKW (ORH 1), CEE (ORH 2A/ORH 2B), and ET regions.

The OTS programme sampled 126 catches of orange roughy on 32 voyages (a similar number to 2005–06), with the number of samples per voyage ranging from 1 to 18 (Table 4). These samples were mainly from fisheries within ORH 3B, especially the East Chatham Rise, Spawning Box, and Pukaki Rise, but also included a few samples from east coast fisheries in ORH 2A, ORH 2B, and ORH 3A.

Overall, sampling of commercial fishing on the Chatham Rise was strongly focussed on the Spawning Box and East Rise where OP observers collected 108 and 70 samples respectively and the OTS programme collected a further 30 and 41 samples respectively. Between the two programmes over 14 000 fish were examined in the Spawning Box and over 10 000 fish in the East Rise, spread out over several months (Table 4). In the region of ORH 3B below 46° S, both programmes collected large amounts of orange roughy data from the Pukaki fishery, mainly in October/November and mainly in the vicinity of the “Priceless” feature which is now the focus of fishing in this large area. The few samples collected in southern ORH 3B outside of this fishery reflect the low level of fishing effort in 2006–07 in the other known fisheries in the region.

Sampling was spread among nine recognised fisheries in ORH 1, with OP coverage ranging from a single sample from December in South Kermadec Ridge to 79 samples covering several months in East Northland. Coverage was also good from the spawning period in East Northland, with a total of 40 samples from that fishery, and a relatively large sampling effort also in the Dargaville, Mercury-Collville Box, and Tauroa Knoll fisheries.

The three central east coast QMAs (ORH 2A, ORH 2B, ORH 3A) received low sampling effort overall, with all but 2 of the 29 samples from those fisheries taken by the OTS programme. This region has received little coverage in recent years despite the continuous allocation of samples to the OP programme, mainly due to the small size of the vessels operating in these fisheries, and will benefit from the continued efforts of the OTS programme.

With the combined efforts of the two programmes, observer effort was moderately well spread over the fishing year and samples were collected in every month. Only in September was the total number of samples collected fewer than 10, with between 22 (August) and 131 (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/June/July period encompassing orange roughy spawning. Over half of the samples were collected during these three months.

Outside the EEZ, the level of sampling was very low, with only five (OP) samples collected from a single voyage to the West Norfolk Ridge (ET) fishery, and no sampling of the other main ET fisheries on the Lord Howe Rise and Louisville Ridge.

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 2006–07 fishing year, according to TCEPR returns. Sampling was well spread over most of the ORH 1 fishing grounds, but coverage was noticeably missing from the western ET fisheries and very low in the east coast fisheries in ORH 2A/2B/3A (Figure 2). A very high fraction of the commercial fishery was observed in several of the ORH 1 fisheries, especially Colville Ridge (80%) and Tauroa Knoll (64%) (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. Sampling was generally well spread around the fished regions of the Chatham Rise, especially the Spawning Box, East Rise, and Southeast Rise. And, apart from Pukaki, sampling was also well spread around the mainly lightly fished regions of southern (south of 46° S) parts of ORH 3B (Figure 3). Coverage of some of the ORH 3B fisheries was also high in relation to commercial catch, with sampling representing 56% of the 3800 t catch in the Spawning Box, 73% of the Pukaki catch, and 40% of the NW Rise catch.

The five OP observer samples collected outside the EEZ in the West Norfolk Ridge fishery accounted for about 2% of the estimated 543 t of orange roughy caught there in 2006–07 (Table 5).

The positions of all tows from which OTS samples were collected are shown in Figure 4, which also shows the positions of all tows that caught orange roughy in the 2006–07 fishing year, according to TCEPR returns. The 126 samples collected by this programme were spread mainly around the north and east Chatham Rise, especially the Spawning Box, the East Rise, and the eastern end of the South Rise. Outside these areas, there was a moderate level of sampling well spread along the east coast fisheries from East Cape to Kaikoura, accounting for between 6% and 19% of the estimated catches in those fisheries (Table 6). Because of their size, the percentage of the total fishery catch observed was relatively low in the Chatham Rise fisheries, but high catches observed in the Pukaki fishery accounted for 25% of the estimated catch so that, together with the OP coverage, about 98% of the catch from this fishery was sampled (Table 6).

The locations of trawl stations in the three research surveys in which orange roughy were measured by NIWA are shown in Figure 5. Orange roughy were caught in small amounts (up to about 50 kg) on seven stations during the Chatham Rise hoki survey in December 2006–January 2007 and in similarly small amounts (up to about 75 kg) on 11 stations during the sub-Antarctic middle-depths survey in November–December 2006. The orange roughy survey on the northeast Chatham Rise in July 2007 caught (and measured) orange roughy at 75 stations comprising random tows over flat ground in the Spawning Box and East Rise, and target tows on marks in the spawning plume in the Spawning Box and on the hills Cameron's and Smith's.

About 7300 orange roughy were measured from a total catch of 23 t on the Chatham Rise survey, 391 orange roughy were measured from a catch of 185 kg on the sub-Antarctic survey, and 109 orange roughy were measured from a catch of 76 kg on the Chatham Rise hoki survey.

The industry-run survey of the Spawning Box plume in July collected data from 16 large catches (20–41 t) of spawning orange roughy. Industry scientists measured over 6400 fish from these trawls, the location of which, within the context of the Chatham Rise and Spawning Box, are shown in Figure 6.

## **4.2 Size structure and sex ratios**

Length frequency distributions by sex are given in Figure 7 (OBS data) and Figure 8 (OTS data). The OBS 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.

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 east Chatham Rise (Figure 7a, b). 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. Smaller fish were found in the East Chatham Rise, Spawning Box, and Wairarapa fisheries (Figure 7a–d, 8i) and larger fish in the East Northland, Mercury–Colville Box, and West Norfolk Ridge fisheries (Figure 7i, j, m, n). The fish in the West Norfolk Ridge fishery were particularly large, with mean lengths more than 4 cm greater than in any other area.

Where length data were available from the same area and reproductive period from both OBS and OTS programmes, length distributions showed a similar shape and mean lengths and sex ratios were in most cases very similar. For example, the extreme sex ratios seen from the OBS data for Pukaki Rise (predominance of males) and SE Rise (predominance of females) pre-spawning fish were confirmed by the OTS data for the same fisheries (see Table 7).

In the Spawning Box and East Rise fisheries, fish sampled during the spawning months were clearly larger than fish sampled earlier in the year according to OBS data, a pattern that might be expected with a predominance of mature, older fish in spawning aggregations. But the difference in fish size between the two periods was less clear-cut, or in the opposite direction, in the Pukaki Rise (both OBS and OTS data) and West Norfolk Ridge (OBS data) fisheries.

Small fish, less than 25 cm, were rarely found in most areas, but are evident as a small proportion of the fish measured in the East Rise, Spawning Box, and East Cape pre-spawning fisheries, and the Dargaville and White Island spawning fisheries (Figure 7c, l, o, 8a, e, g). In most of the southern fisheries there were few fish measured at over 40 cm, the exception being in the Pukaki fishery. Data from both OBS and OTS programmes showed a relatively large difference between the mean size of male and female fish (about 4 cm), and a larger proportion of female fish greater than 40 cm compared to adjacent areas. Fish were generally slightly larger in the northern fisheries, particularly the West Norfolk Ridge, East Northland, and Mercury-Colville Box. The largest fish observed were in the West Norfolk Ridge fishery where 63% of all pre-spawning period fish and 50% of all spawning period fish were longer than 40 cm. Several fish with standard lengths over 50 cm were measured in this fishery.

Sex ratios, based on scaled size frequency data, ranged from 28.4% male (West Norfolk Ridge, spawning) to 84.1% male (Mercury-Colville Box, spawning) (Table 7). Overall, there was no consistent bias in the sex ratios in favour of one sex, with 11 of the 24 fishery/area combinations showing a higher percentage of male fish. The sex ratios were generally close to 50:50, with 14 being within 10 percentage points of 50% male, and only 2 more than 20 percentage points from 50:50.

Scaled length frequency distributions were produced from the East Chatham Rise orange roughy survey (R.V. *Tangaroa*) (Figure 9) and orange roughy Spawning Box plume survey (F.V. *San Waitaki*) (Figure 10). Two separate size distributions were prepared from the East Chatham Rise survey data, collected using stratified random trawls and the “ratcatcher” net, which is designed to catch small fish. One distribution shows data from Spawning Box background (non-plume) trawls and the other from Northeast Flat background trawls.

These plots show relatively small fish in the areas adjacent to the Spawning Box plume during spawning, with scaled mean lengths of 30.6 cm (male) and 32.5 cm (female). Fish in the Northeast Flat background area were even smaller, with mean lengths of 27.1 cm (male) and 28.6 cm (female). Although the long left-hand tail of these distributions indicates that small fish were more commonly caught than in commercial trawls, the position of the modes shows that this was not the reason for the small mean lengths (Figure 9). Male fish were less common than female fish in the Spawning Box background samples (sex ratio 38.9% male) but were in relatively even proportion in the Northeast Flat.

Data from the Spawning Box plume survey, taken at about the same time as the background samples, show that fish in the plume were, on average, longer by about 2 cm than fish in the background areas. The sex ratio in the plume was close to 50:50 and fish smaller than 25 cm were rare.

### 4.3 Reproduction

Female fish were sampled for reproductive state by OBS observers during spawning months (nominally June, July, and August) in several areas in 2007 and, for a few of these, an indication of the timing and location of spawning can be derived (Table 8).

Fish in ORH 3B fisheries in the ripe, running ripe, and spent stages were found in the NW Rise in June, Pukaki in July and August, and the Spawning Box in June and July (Table 8). A few, mostly ripe fish, were also found in the East Rise in June. 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 Aldermen Is., Dargaville, East Northland, Mercury-Colville Box, White Is., and West Norfolk Ridge.

The OTS programme recorded female fish in spawning condition (running ripe and spent) in the Northwest Rise in June, and Pukaki in July and August. A few fish were also recorded in spawning condition outside the known spawning period in the East Rise (in November) and the Southeast Rise (in January) (Table 9).

There were sufficient reproductive data collected by OBS observers through the spawning period to make plots of the progression of spawning in four ORH 1 fisheries: Aldermen Knoll, Dargaville, East Northland, and the Mercury-Colville Box (Figures 11 & 12).

In the Aldermen fishery there were data available for only four individual days, but these were sufficiently spread over a 2-week period to show that there was a rapid increase in the proportion of spent fish from about 8% on 4 July to about 90% on 19 July, and indicate a peak in spawning sometime during the first week of July. This compares with a slightly earlier date of 21–22 June estimated for 2000 (Anderson 2001).

There were considerably more data available for the Dargaville fishery in June and July 2007, and the plot produced showed high levels of ripe and running-ripe fish over a 2-week period in late June and early July, with increasing numbers of spent fish, and suggested a similar spawning timing to Aldermen Knoll, about 5–6 July. This is the first time that the timing of spawning has been estimated for this fishery.

Coverage of the East Northland fishery during spawning was high, with regular sampling between 2 June and 28 July. The proportion of ripe and running-ripe fish increased steadily during this time and spent fish began to appear in the samples from about 14 July. The peak of spawning in this fishery was about two weeks later than in the more southern Aldermen and Dargaville fisheries, at about 18–20 July. This compares with estimates of 7–9 July in 2003 and 5–6 July in 2004 (Anderson 2006).

The timing of the peak of spawning in the Mercury–Colville Box was more difficult to determine as there were few data points and ripe and running-ripe fish were at high levels for a long period. Spent fish accounted for about 20% of the mature fish at about 8 July and so this date may represent the best estimate for peak spawning. This is about two weeks later than previously estimated for the 1997–2000 period (Anderson 2006).

In the Spawning Box maturity data were collected by OBS observers on most days between 1 June and 19 July, with a gap between 21 and 27 June (Figure 13). The proportion of ripe and running-ripe fish peaked at about 4 July, by which time spent fish were beginning to appear in the samples. Spent fish dominated the samples after about 17 July. The peak of spawning in this fishery was at about 4–5 July. This is a similar timing to that observed in several recent years, but 2–3 weeks earlier than recorded in the 1980s and 1990s (Anderson 2006, 2008).

## 5. SUMMARY AND DISCUSSION

**Observer coverage.** The 496 samples collected by OP observers in 2006–07 was a small increase over the previous year, and was the highest level achieved since 2002–03 (Anderson 2004). Despite this, the number of samples was low in comparison to the expected number based on current schedules, and sampling fell well short of the individual area allocations in three fisheries. Sampling levels of fisheries outside the EEZ were particularly low, with only a handful of samples taken from the West Norfolk Ridge fishery, and no samples from the Lord Howe and Louisville fisheries. There was only a single sample from each of the EC and MEC stocks—one from East Cape, the other from Tolaga hill. Sampling levels were typically high in ORH 3B where over 300 samples were taken, in line with the increase in the scheduled sampling in 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 over 70% of the catch was covered by OP observers. Sixty-two percent of the samples for 2006–07 were taken from ORH 3B, and a further 37% were taken from ORH 1, leaving only 1% (5 samples) taken from all other areas. The high level of sampling in ORH 1 in relation to the size of the fishery was due to the additional, industry-funded, observer coverage which has remained in place after the completion of the Adaptive Management Programme at the end of the 2005–06 fishing year..

The 126 samples collected by the OTS programme in 2006–07 was slightly less than collected in the previous year, but is still high relative to earlier years. Although most of the samples were from ORH 3B fisheries also covered by OP observers (providing, for example, virtually 100% coverage of the Pukaki fishery), there was also good coverage of areas not sampled by OP observers, especially the east coast fisheries in ORH 2A/2B/3A.

The level of OP sampling coverage was sufficient to determine length frequency distributions of orange roughy in 11 discrete fisheries, and in 4 of them (Pukaki, West Norfolk Ridge, Spawning Box, and East Rise) plots were prepared separately for pre-spawning and spawning periods. For OTS sampling, length frequency distributions were produced for 7 discrete fisheries, with separate pre-spawning and spawning plots produced for the Spawning Box and Pukaki fisheries.

**Research coverage.** Biological data for orange roughy from research surveys in 2006–07 came primarily from surveys in a single area, the East Chatham Rise. The Ministry of Fisheries contracted NIWA to run a survey of orange roughy on flat grounds of the Spawning Box and East Chatham Rise in July using *Tangaroa*, and there was an industry funded survey of the Spawning Box spawning plume also in July using *San Waitaki*. Over 5700 fish were examined on the *Tangaroa* survey, and over 6400 fish were examined on the *San Waitaki* survey. Small amounts of data were also collected from two other *Tangaroa* surveys for middle-depth species on the Chatham Rise and sub-Antarctic plateaus.

**Size structure.** Size structure was examined in 15 fishery/period combinations available from OP data, the same number as in 2005–06 and slightly more than in 2004–05 and 2003–04 (12). In addition, size structure was examined in 9 fishery/period combinations available from OTS data, two more than in 2005–06. 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 the East Chatham Rise, Spawning Box, and Pukaki fisheries, but this pattern was reversed in the West Norfolk Ridge fishery, where very large fish were found in all samples. Intensive sampling was carried out in some areas, particularly in ORH 3B. Over 11 000 fish were measured by OP observers from 108 samples, and a further 3000 fish by the OTS programme from 30 samples, in the Spawning Box fishery, and almost 10 000 fish were measured from the East Rise fishery (both programmes combined) from 110 samples. Mean lengths, calculated from scaled size frequencies, varied among areas, ranging from about 32 cm to 41 cm (male) and from about 33 cm to 42 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 West Norfolk Ridge spawning (28% male) and Mercury-Colville Box spawning (84% 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 four ORH 1 fisheries, and from research sampling in the Spawning Box fishery. The quantity and temporal spread of data were sufficient in these fisheries to follow changes in the relative fractions of reproductive stages over time, and so to approximately determine the extent and timing of the spawning season. The timing of the onset of spawning determined for the Spawning Box fishery was similar to that of recent years, but 2–3 weeks earlier than consistently recorded in the 1980s and 1990s. The timing of spawning in the East Northland and Mercury-Colville Box fisheries was also about two weeks later than measured previously, and was also slightly early in the Dargaville fishery.

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 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.

## 6. ACKNOWLEDGMENTS

I thank the OP observers of the Ministry of Fisheries for their continued efforts, and the fish-measuring crew on commercial vessels for whom this is an extra task on top of their regular duties. The Ministry of Fisheries (projects ORH2007/02 and ORH2007/03) 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 sample/days processed in 2006–07, and the actual number of OP samples processed in the previous two fishing years.**

Area	Number of samples			
	Expected*	Actual 2006–07	Actual 2005–06	Actual 2004–05
ORH 3B	260/470	307	300	379
ORH 2A	40/40	2	0	5
ORH 2B	0/0	0	0	0
ORH 3A	0/0	0	0	0
ORH 7A	0/0	0	2	0
ORH 1	95/140**	182	108	56
ORH 10	0/0	0	0	0
ORH 7B	0/0	0	2	0
ET				
Lord Howe/NW Challenger	60/60	0	34	0
Louisville Ridge	60/0	0	22	7
South Tasman Rise	0/0	0	0	0
West Norfolk Ridge	0/0	5	12	0
ORH general (DOC)	113/71	–	–	–
Total	628/781	496	480	447

\* Ministry of Fisheries observer programme figures for the 2006–07 and 2007–08 MFish June–July financial years. The schedule relates to these year definitions rather than the 2006–07 fishing year with which they overlap, and 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.

\*\* 75/120 of these samples are industry funded.

**Table 3: Number of OP orange roughy biological samples by area and month for 2006–07, 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	3	–	4	–	–	–	–	–	23	37	–	–	67	10
AKW	31	7	–	–	–	–	–	41	8	21	7	–	115	9
CEE	–	–	–	–	–	–	–	–	–	–	2	–	2	1
ET	4	1	–	–	–	–	–	–	–	–	–	–	5	1
SOE	–	–	9	22	26	4	–	26	90	29	2	–	208	10
SOU	2	–	–	–	–	–	–	–	–	–	–	–	2	2
SUB	33	34	10	–	–	–	1	3	–	3	8	5	97	7
ALL	73	42	23	22	26	4	1	70	121	90	19	5	496	32

**Table 4: Number of OP/OTS orange roughy biological samples by area and month for 2006–07, with the total number of samples and voyages in each programme and area (see Figures 1 to 3 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.**

**Summary by fishery**

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	Voyages	N. fish meas.
<b>ORH 1 fisheries</b>															
Aldermen Knoll	–	–	–	–	–	–	–	–	–	4	–	–	4	2	324
Colville Ridge	–	–	–	–	–	–	–	–	–	2	–	–	2	1	18
Dargaville	–	–	–	–	–	–	–	3	8	8	–	–	19	3	1 402
East Northland	3	–	–	–	–	–	–	–	17	20	–	–	40	7	2 138
Mercury-Colville Box	–	–	3	–	–	–	–	–	6	6	–	–	15	3	552
South Kermadec R.	–	–	1	–	–	–	–	–	–	–	–	–	1	1	70
Tauroa Knoll	13	4	–	–	–	–	–	–	–	–	–	–	17	2	945
West Norfolk R.	18	3	–	–	–	–	–	38	–	13	7	–	79	7	4 238
White I.	–	–	–	–	–	–	–	–	–	5	–	–	5	2	444
<b>ORH 3B fisheries</b>															
Antipodes	–	–	1	–	–	–	–	–	–	–	–	–	1	1	1
Bounty Is.	1	2	–	–	–	–	–	–	–	1	–	–	4	3	62
Macquarie	1	–	–	–	–	–	–	–	–	–	–	–	1	1	5
East Rise	–/1	–/3	8	14/7	12/6	1/7	–/8	15/8	20/1	–	–	–	70/41	5/16	10 006
NW Rise	–	–/1	–	–	–	–	–	1	9/1	–	–	–	10/2	3/2	1 054
Pukaki South	–	5	2	–	–	–	–	1	–	–	2	1	11	3	27
Pukaki	32/11	27/4	7	–	–	–	1	2	–	2/2	6/3	4	81/20	7/4	8 547
SE Rise	–/1	–	1	1	12/1	3/3	–/1	1	–	1	–	–	19/6	5/6	1 533
Spawning Box	–	–/2	–	7/2	2	–/6	–/10	8/5	61/5	28	2	–	108/30	7/8	14 022
SW Rise	–	–	–	–	–	–	–	1	–	–	–	–	1	1	1
Snares	1	–	–	–	–	–	–	–	–	–	–	–	1	1	80
<b>Other fisheries</b>															
East Cape	–/2	–	–	–	–	–	–	–/3	–/2	–	1	–	1/7	1/3	694
Tolaga	–	–	–	–	–	–	–/2	–/1	–	–	1	–	1/3	1/2	311
Ritchie	–	–	–	–	–	–/2	–/1	–/3	–/1	–/1	–	–	–/8	–/6	800
Wairarapa	–/1	–	–	–	–/1	–/2	–/1	–/1	–	–/1	–	–	–/7	–/6	697
Kaikoura	–/2	–	–	–	–	–	–	–	–	–	–	–	–/2	–/2	202
West Norfolk R (ET)	4	1	–	–	–	–	–	–	–	–	–	–	5	1	318
ALL	73/18	42/10	23/0	22/9	26/8	4/20	1/23	70/21	121/10	90/4	19/3	5/0	496/126	32/32	46 792



**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, 2006–07; observed catch totals are based on the areas defined in Figures 2 to 4, 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	
<b>ORH 1</b>					
Aldermen Knoll	4	513	8	15	54
Colville Ridge	2	51	0.05	0.06	80
Dargaville	19	1 617	44	199	22
East Northland	40	3 857	142	276	51
Mercury-Colville Box	15	874	7.8	25	31
South Kermadec R.	1	169	1.1	4	28
Tauroa Knoll	17	1 177	92	143	64
West Norfolk R.	79	9 240	156	266	59
White Island	5	612	2.2	23	9.3
<b>ORH 3B</b>					
Chatham Rise					
East Rise	70	8 033	602	3 269	18
NW Rise	10	1 176	266	665	40
SE Rise	19	1 194	104	1 068	10
Spawning Box	108	14 495	2109	3 798	56
SW Rise	1	1	0.001	36	0.003
Southern					
Antipodes	1	1	0.001	1	0.16
Bounty Plateau	4	69	0.3	3	13
Macquarie Ridge	1	10	0.16	1	30
Pukaki South	11	42	0.15	3	5.6
Pukaki	81	9 372	933	1 283	73
Snares	1	139	0.52	1.3	40
<b>OTHER AREAS</b>					
East Cape	1	20	0.3	204	0.15
Tolaga	1	16	0.06	426	0.014
West Norfolk Ridge (ET)	5	665	10	543	1.9

**Table 6: Summary of number of orange roughy samples taken by the OTS sampling programme, and the observed catch and estimated total catch in the fishery, 2006–07; observed catch totals are based on the areas defined in Figures 2 to 4, 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	
<b>ORH 3B</b>					
Chatham Rise					
East Rise	41		114	3 269	3.5
NW Rise	2		16	665	2.4
SE Rise	6		27	1 068	2.5
Spawning Box	30		115	3 798	3.0
Southern					
Pukaki	20		322	1 283	25.1
<b>OTHER AREAS</b>					
East Cape (ORH 2AN)	7		12	204	5.9
Tolaga (ORH 2AS)	3		58	426	13.6
Ritchie (ORH 2AS)	8		79	407	19.4
Wairarapa (ORH 2B)	7		21	141	14.9
Kaikoura (ORH 3A)	2		45	434	10.4

**Table 7: 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.**

Area	Period	Number measured			*Sex ratio (%male) (scaled)	Total catch (t)	*Scaled Mean length (s.d.)	
		Male	Female	Total			Male	Female
<b>OP data</b>								
East Rise	pre-spawning	1 991	2 261	4 254	43.8	408	32.6(2.5)	34.3(2.7)
East Rise	spawning	779	908	1 697	47.4	193	33.6(2.4)	35.7(2.9)
Spawning Box	pre-spawning	752	694	1 446	52.0	86	32.1(2.9)	33.9(3.1)
Spawning Box	spawning	4 675	4 898	9 577	50.2	2 021	32.9(2.8)	34.9(2.9)
SE Rise	pre-spawning	332	591	923	33.7	103	33.1(3.1)	34.7(3.1)
NW Rise	spawning	476	360	837	55.6	262	33.6(2.8)	35.5(3.1)
Pukaki R.	pre-spawning	3 583	1 911	5 494	66.0	804	33.9(2.4)	36.3(2.8)
Pukaki R.	spawning	390	331	721	59.7	121	33.7(2.2)	37.3(2.4)
West Norfolk R.	pre-spawning	1 575	1 213	2 807	61.5	89	40.7(2.8)	42.0(3.2)
West Norfolk R.	spawning	490	935	1 431	28.4	66	39.6(2.4)	40.8(2.7)
Tauroa Knoll	pre-spawning	608	337	945	63.6	91	34.4(2.8)	35.5(2.7)
Dargaville	spawning	505	646	1 188	43.4	42	33.5(2.8)	34.8(2.9)
East Northland	spawning	1 093	849	1 957	53.1	133	36.1(2.3)	37.2(3.2)
MC Box	spawning	317	123	440	84.1	7	36.2(3.4)	38.5(3.2)
White I.	spawning	308	136	444	65.3	2	34.6(2.8)	36.8(3.5)
<b>OTS data</b>								
Spawning Box	pre-spawning			2 499	48.1	89	32.7(3.1)	33.5(3.3)
Spawning Box	spawning			500	44.2	26	32.4(2.6)	34.2(3.0)
Pukaki R	pre-spawning			1 529	67.2	228	34.2(2.5)	35.6(2.9)
Pukaki R	spawning			500	46.8	94	33.8(2.3)	37.6(2.4)
East Rise	pre-spawning			3 955	46.5	112	33.5(4.0)	34.2(3.6)
SE Rise	pre-spawning			600	34.5	27	32.7(3.8)	34.8(3.7)
East Cape	pre-spawning			479	42.1	9	32.5(3.8)	34.8(3.5)
Ritchie	pre-spawning			600	44.7	64	32.4(2.9)	35.0(2.9)
Wairarapa	pre-spawning			597	39.5	18	32.8(3.3)	33.9(3.5)

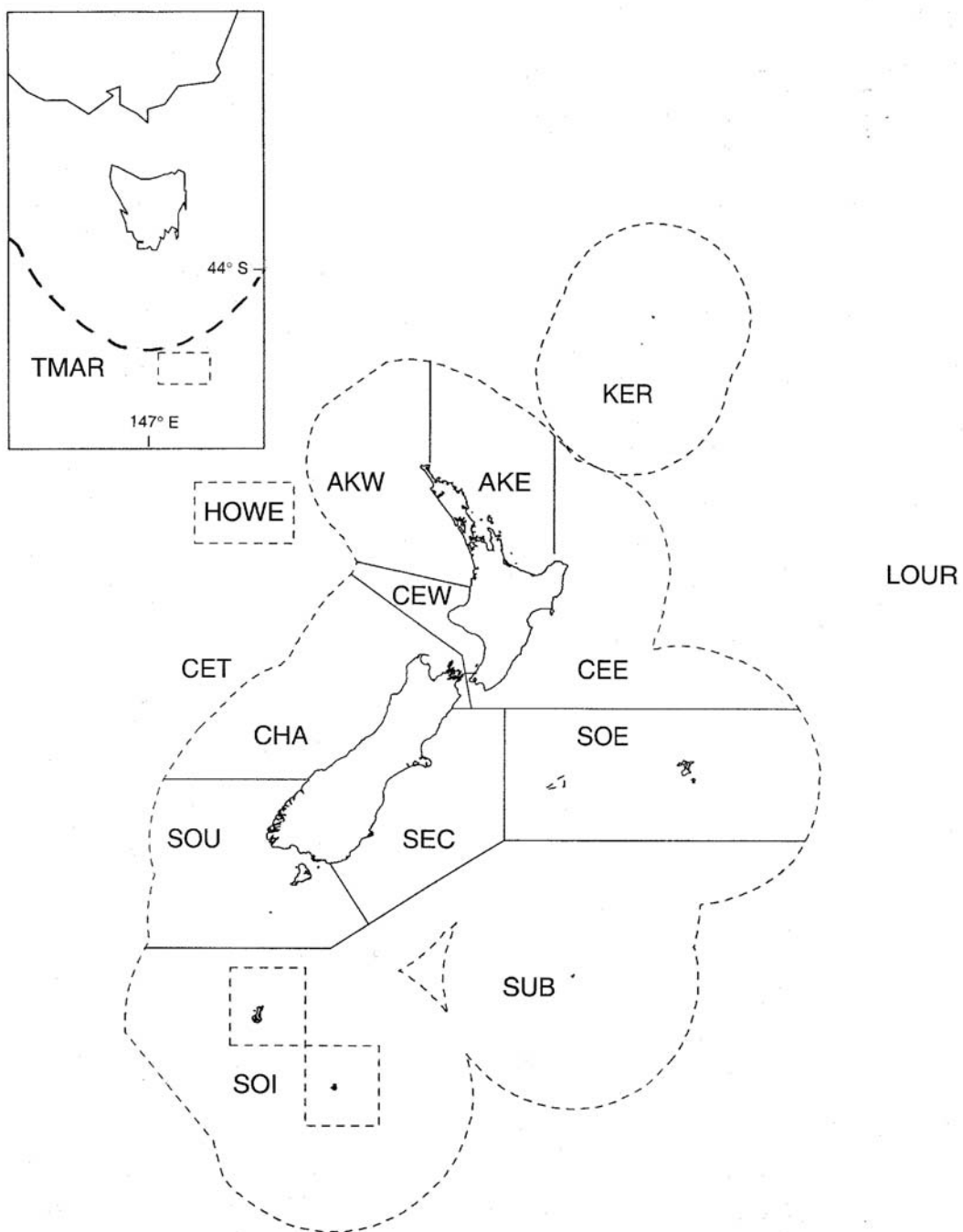
\* OTS sex ratio and mean length data are unscaled

**Table 8: 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	
Aldermen Is.	Jul	11	1	1	31	57	168
Dargaville	May	48	51	1	0	0	83
	Jun	33	48	17	2	1	307
East Northland	Jul	9	1	9	41	39	339
	Jun	2	71	21	4	2	285
	Jul	9	19	10	56	6	517
East Rise	Oct	19	8	0	0	73	77
	Jan	14	86	0	0	0	554
	Feb	7	93	0	0	0	647
	Mar	2	98	0	0	0	56
	May	15	76	9	0	0	605
	Jun	15	73	11	1	0	907
	Dec	41	58	1	0	0	358
Mercury–Colville Box	Jun	0	5	48	47	0	58
	Jul	14	0	8	18	60	65
	Dec	33	65	0	0	2	60
NW Rise	Jun	1	11	47	39	2	360
Pukaki	Apr	11	85	4	0	0	46
	Jul	0	66	30	4	0	77
	Aug	0	7	59	26	7	254
	Sep	92	1	0	1	7	118
	Oct	4	89	1	1	6	1013
	Nov	86	13	0	0	0	606
	Dec	59	41	0	0	0	234
	SE Rise	Feb	13	87	0	0	0
Snares	Mar	17	83	1	0	0	161
	Dec	57	39	2	0	2	46
Spawning Box	Oct	100	0	0	0	0	48
	Jan	9	90	0	0	0	265
	Feb	16	84	0	0	0	44
	May	8	89	3	0	0	346
	Jun	6	72	18	4	0	2759
	Jul	1	11	25	29	34	2109
Tauroa Knoll	Oct	18	72	0	0	9	276
	Nov	70	2	2	0	26	61
White I.	Jul	2	16	53	26	2	136
West Norfolk R.	May	9	90	1	0	0	734
	Jul	7	11	22	7	52	689
	Aug	11	0	0	1	87	245
	Oct	1	27	0	0	71	403
	Nov	29	1	0	0	70	76
West Norfolk R. (ET)	Oct	1	0	0	0	99	96

**Table 9: Percentage of female orange roughy at each gonad stage in each subarea and month, from OTS data. Only months in which at least 30 fish were staged are reported (see Section 3.2 for a description of the stage categories).**

Area	Month	Percentage at stage					Number staged
		F1	F2	F3	F4	F5	
East Cape	May	15	85	0	0	0	171
	Jun	13	45	42	0	0	88
	Oct	1	0	17	43	39	98
East Rise	Jan	28	72	0	0	0	490
	Feb	32	67	1	0	0	308
	Mar	30	69	0	0	0	358
	Apr	40	59	2	0	0	461
	May	14	85	1	0	0	433
	Jun	30	70	0	0	0	60
	Oct	100	0	0	0	0	45
	Nov	24	60	3	12	0	123
	Nov	28	70	0	0	2	128
Kaikoura	Oct	28	70	0	0	2	128
	Nov	42	56	2	0	0	43
NW Rise	Jun	1	7	39	53	0	76
	Nov	42	56	2	0	0	43
Pukaki	Mar	84	16	0	0	0	58
	Jul	1	73	23	3	0	92
	Aug	0	7	70	22	2	174
	Oct	55	34	0	0	10	1006
	Nov	51	49	0	0	0	235
Ritchie	Mar	16	77	6	0	0	111
	Apr	5	94	2	0	0	62
	May	3	97	0	0	0	154
	Jun	0	4	96	0	0	49
	Jul	42	58	0	0	0	69
SE Rise	Jan	20	57	14	2	7	44
	Feb	78	22	0	0	0	77
	Mar	28	70	3	0	0	257
	Apr	27	69	4	0	0	176
	Oct	43	55	1	0	0	76
Spawning Box	Jan	74	25	1	0	0	100
	Mar	9	91	0	0	0	286
	Apr	32	63	5	0	0	558
	May	10	83	7	0	0	252
	Jun	3	92	4	1	0	278
	Nov	8	92	0	0	0	84
Tolaga Knoll	Apr	16	82	1	0	1	128
	May	19	81	0	0	0	31
Wairarapa	Feb	59	38	2	0	2	64
	Mar	17	82	2	0	0	130
	Apr	82	14	4	0	0	49
	May	6	94	0	0	0	66
	Jul	6	94	0	0	0	70
	Oct	0	0	9	62	30	47



**Figure 1: Ministry of Fisheries Observer Programme management areas.**

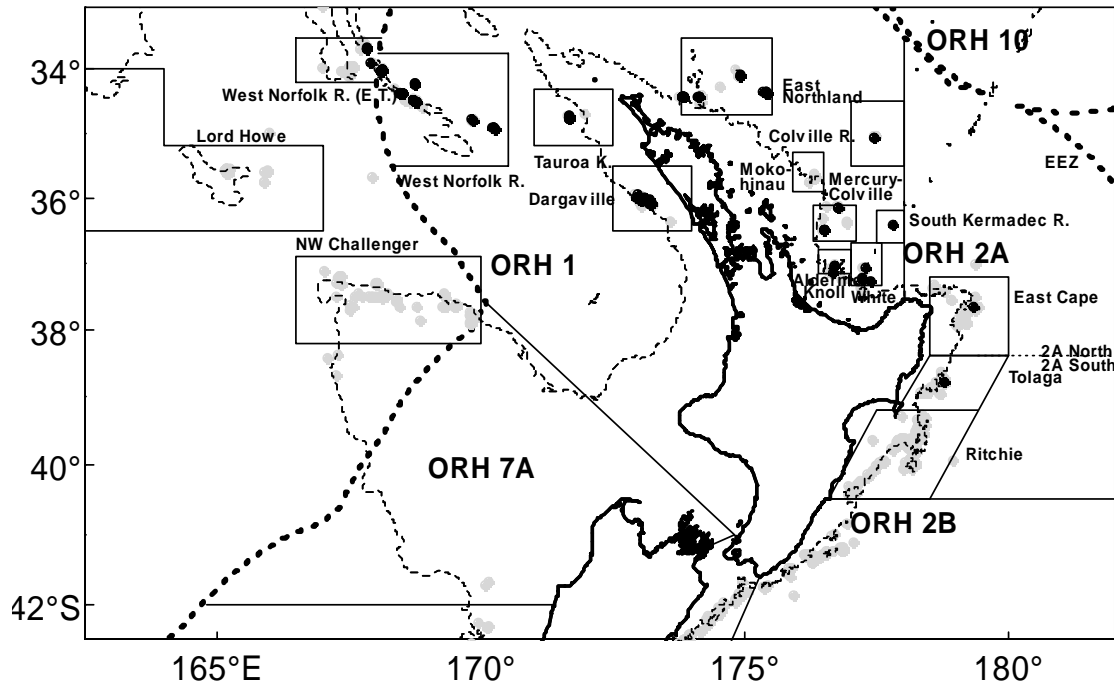


Figure 2: Location of fisheries used for analysis of biological data, position of trawls in the commercial fishery (grey dots), and location of samples of orange roughy taken by OP observers (black dots), during the 2006–07 fishing year. The dotted line shows the 1000 m depth contour.

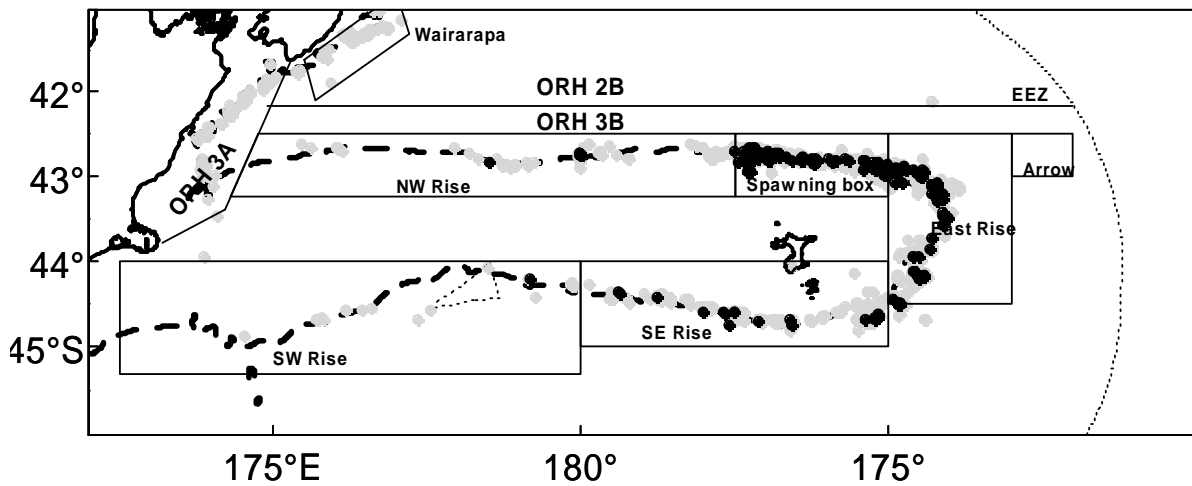
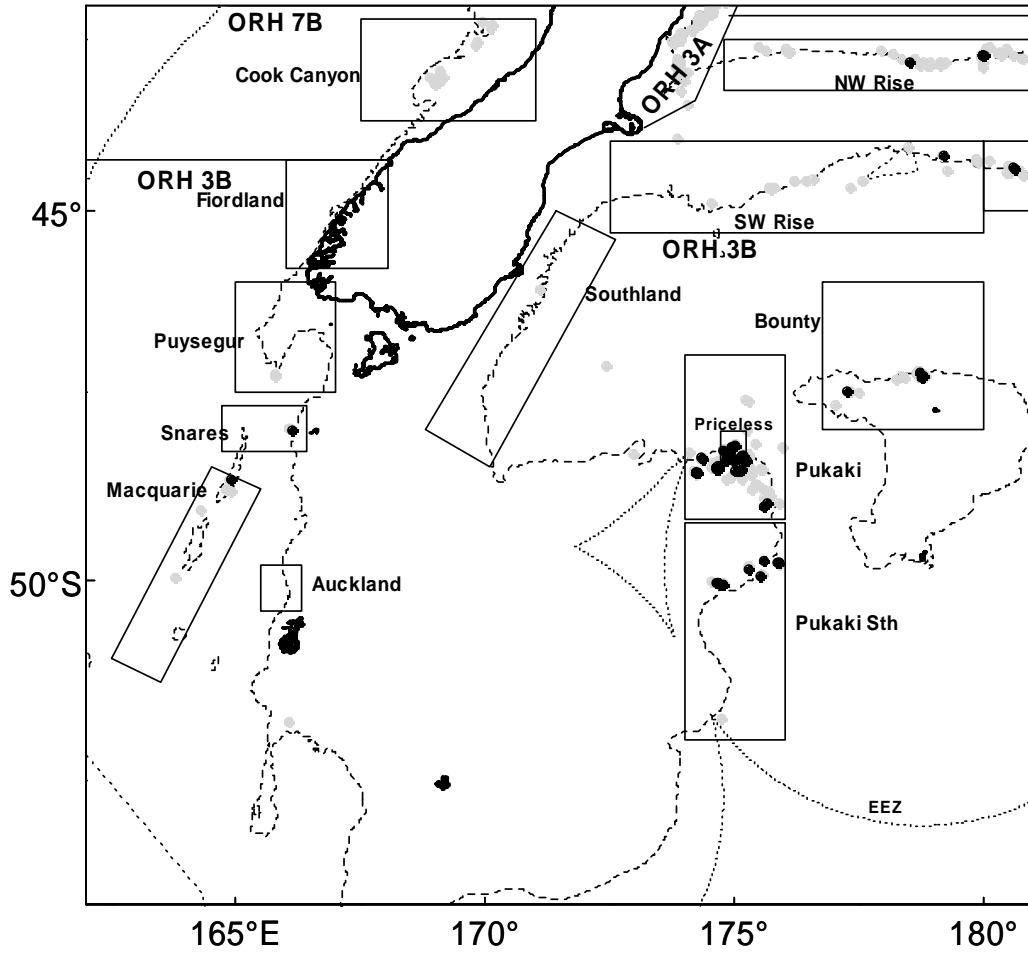
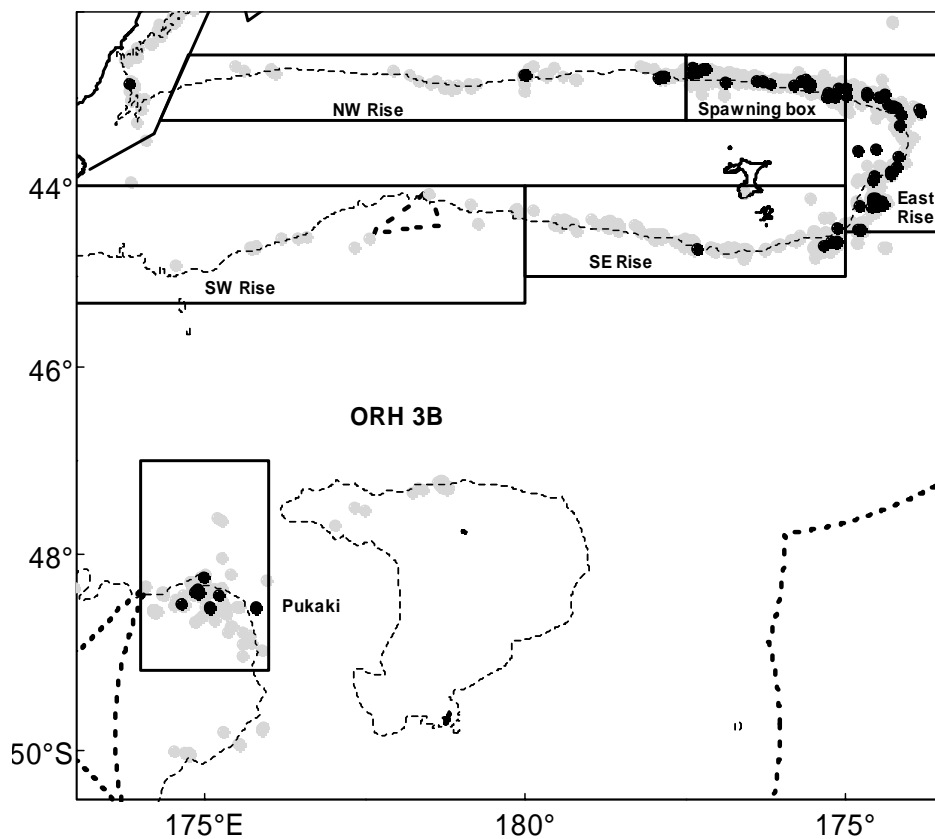
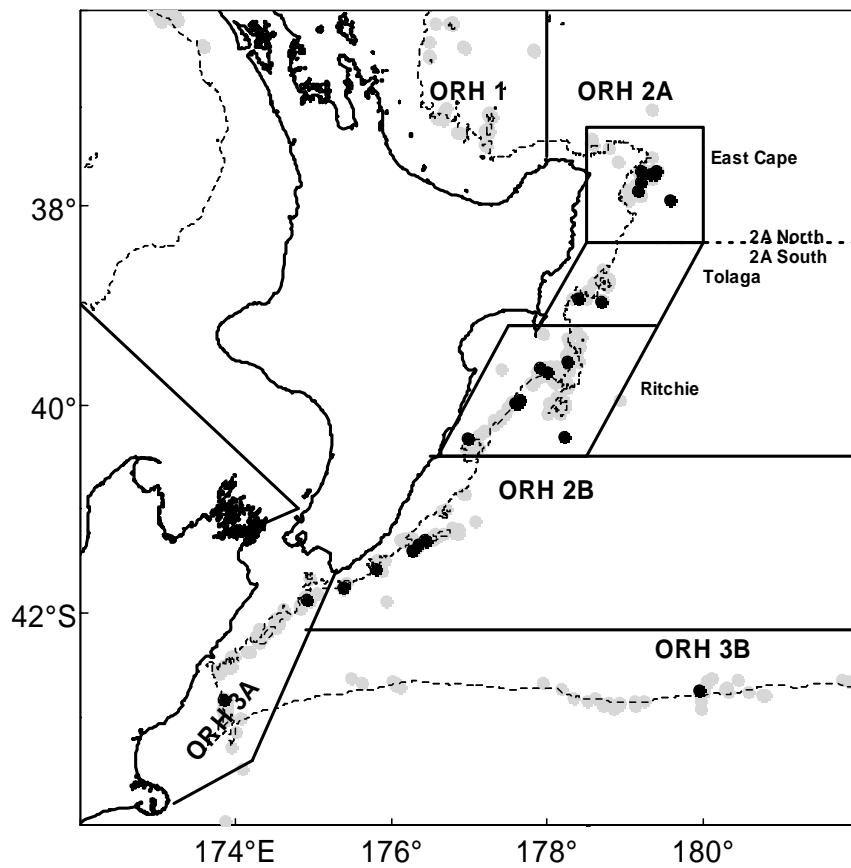


Figure 3: Location of fisheries used for analysis of biological data, position of trawls in the commercial fishery (grey dots), and location of samples of orange roughy taken by OP observers (black dots), during the 2006–07 fishing year. The dashed line shows the 1000 m depth contour.



**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 the industry OTS programme (black dots), during the 2006–07 fishing year. The dashed line shows the 1000 m depth contour.**



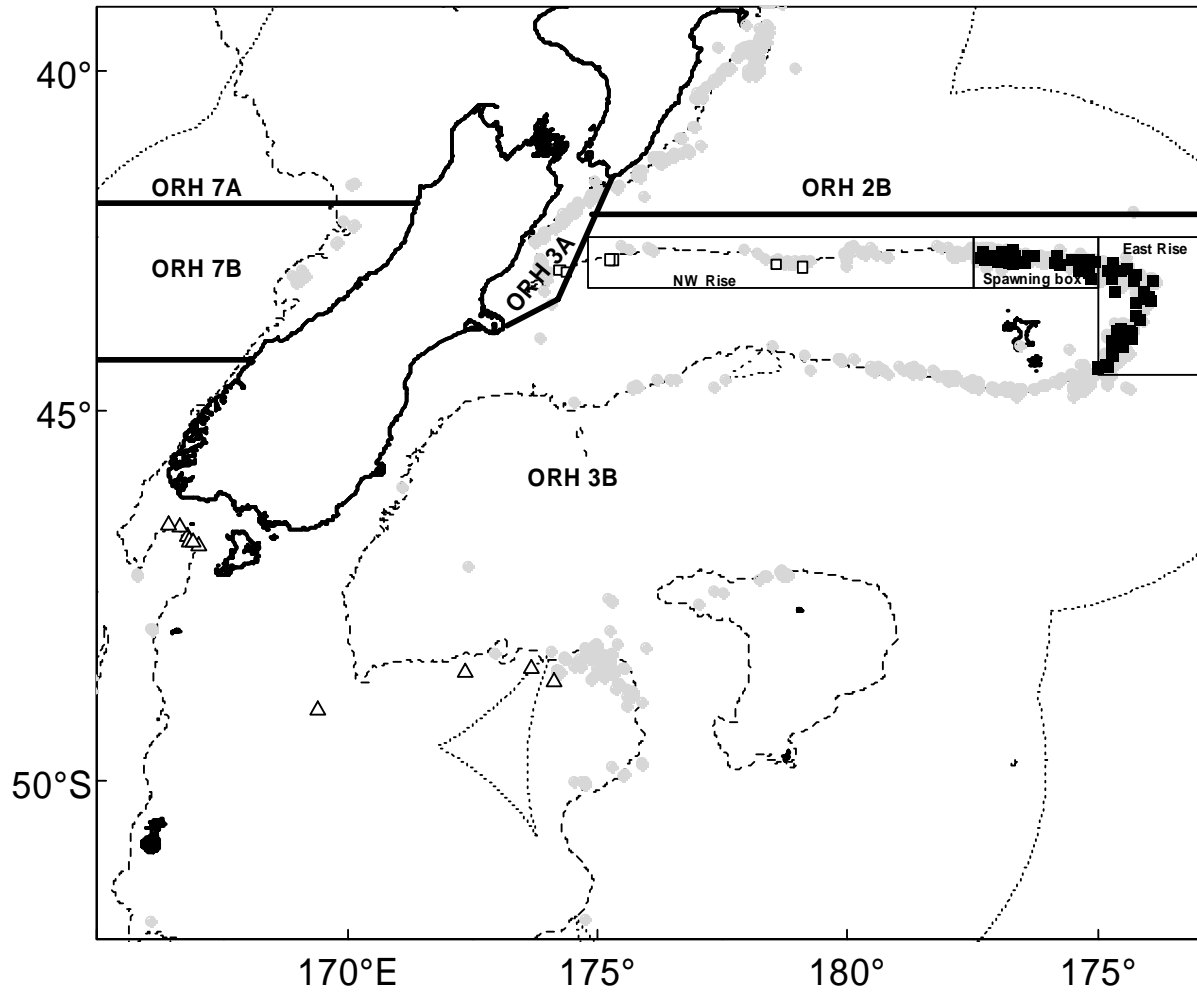


Figure 5: Location of fisheries and NIWA research trawls where orange roughy length data were recorded, and position of trawls in the commercial fishery (grey dots); closed squares, East Chatham Rise orange roughy survey July 2007 (R.V. *Tangaroa*); open triangles, sub-Antarctic trawl survey November–December 2006 (R.V. *Tangaroa*); open squares, Chatham Rise hoki survey January 2007 (R.V. *Tangaroa*). The dashed line shows the 1000 m depth contour.

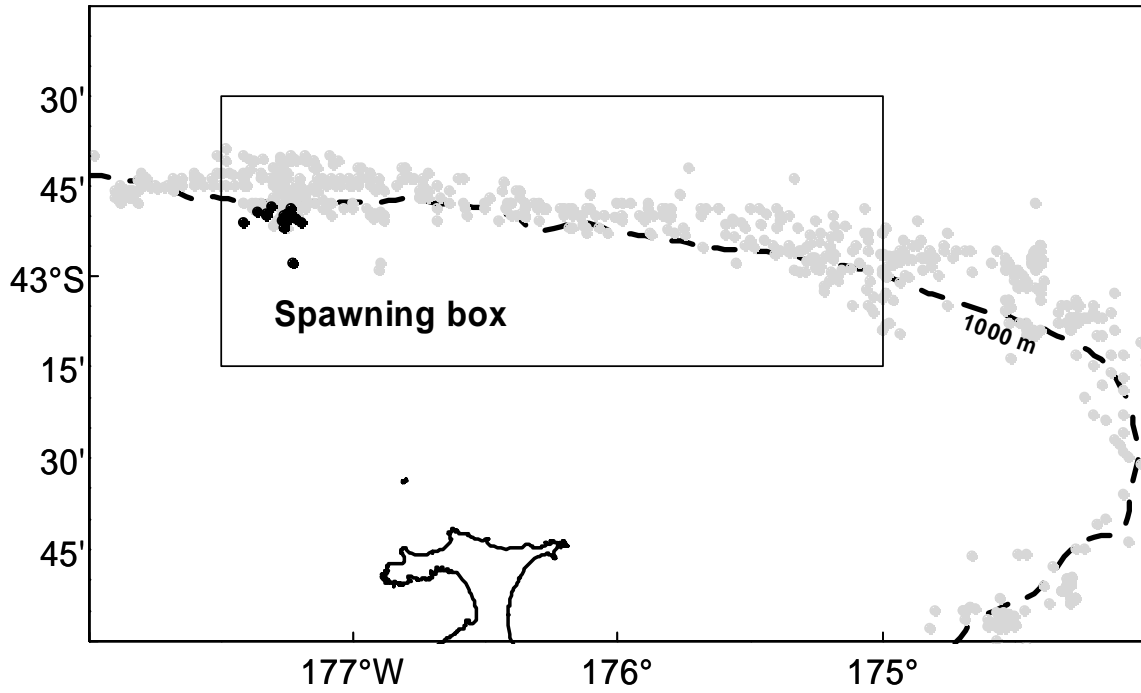


Figure 6: Position of trawl locations in the industry survey of the Spawning Box plume in July 2007 (F.V. *San Waitaki*) (black dots) and position of trawls in the commercial fishery (grey dots).

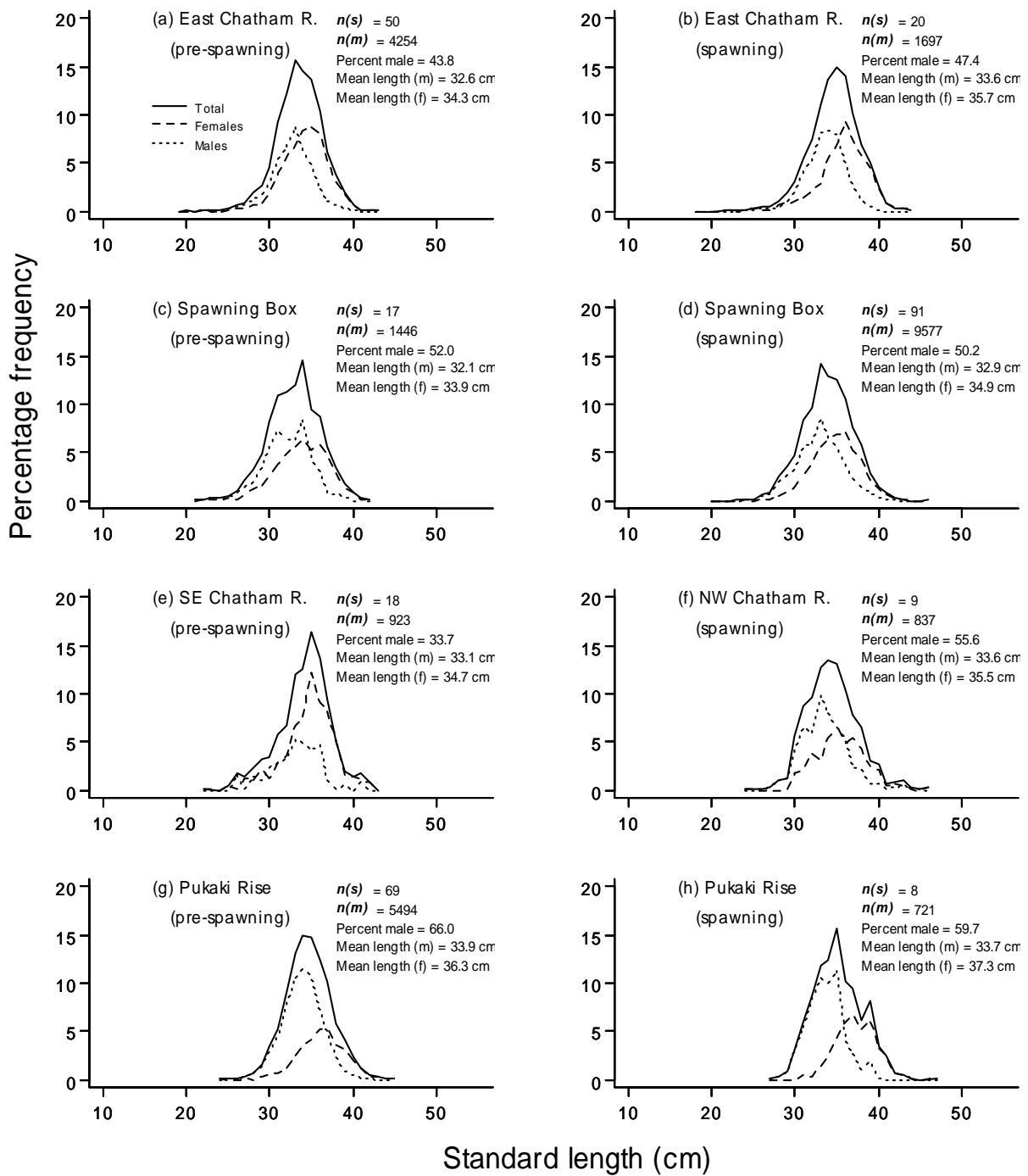


Figure 7: OP length frequency distributions (scaled by catch) of orange roughy by area and period,  $n(s)$ , number of samples;  $n(m)$ , number of fish measured.

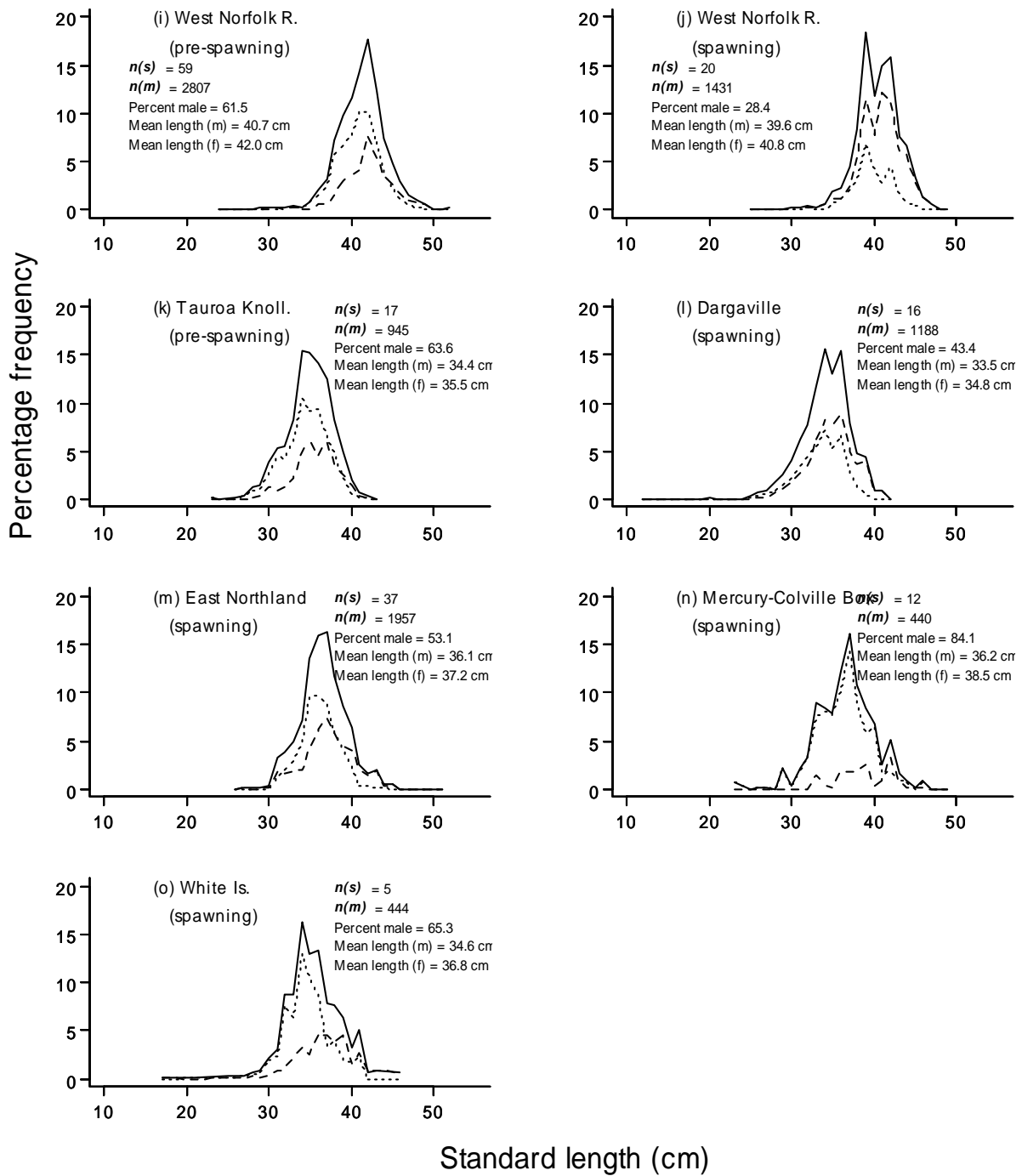
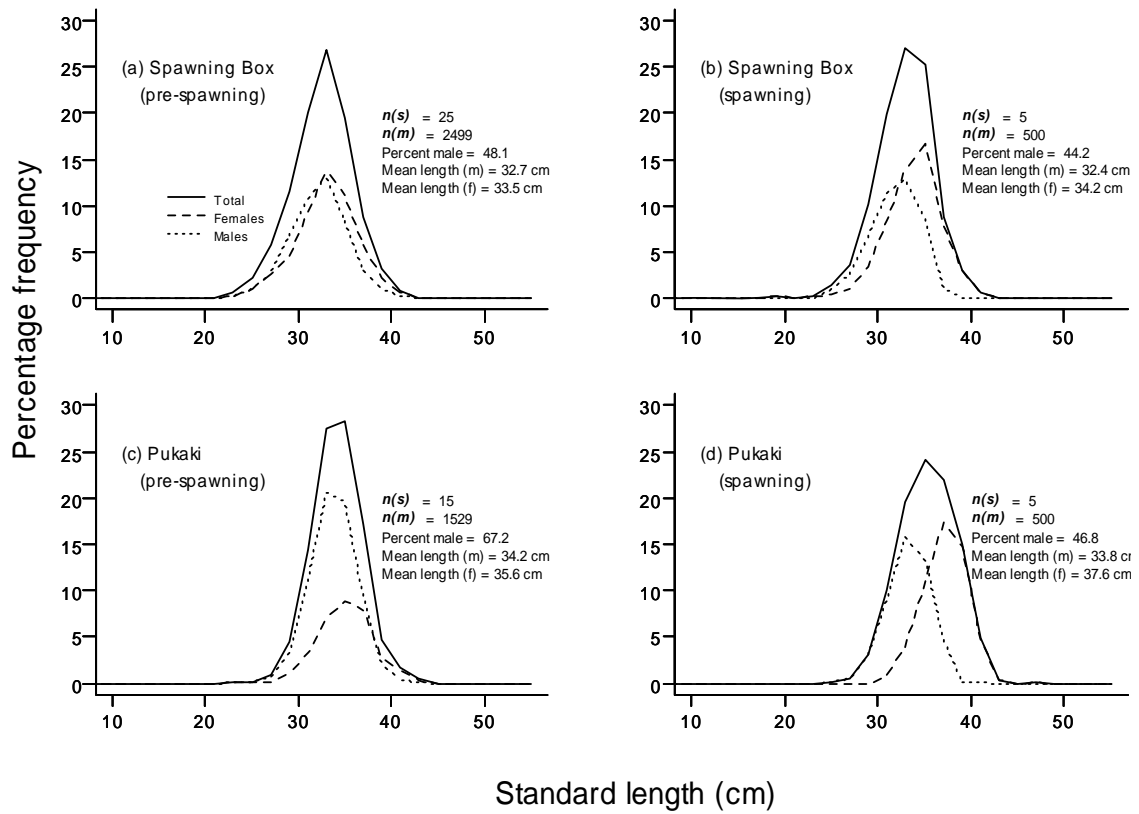


Figure 7 — continued.



**Figure 8: 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.**

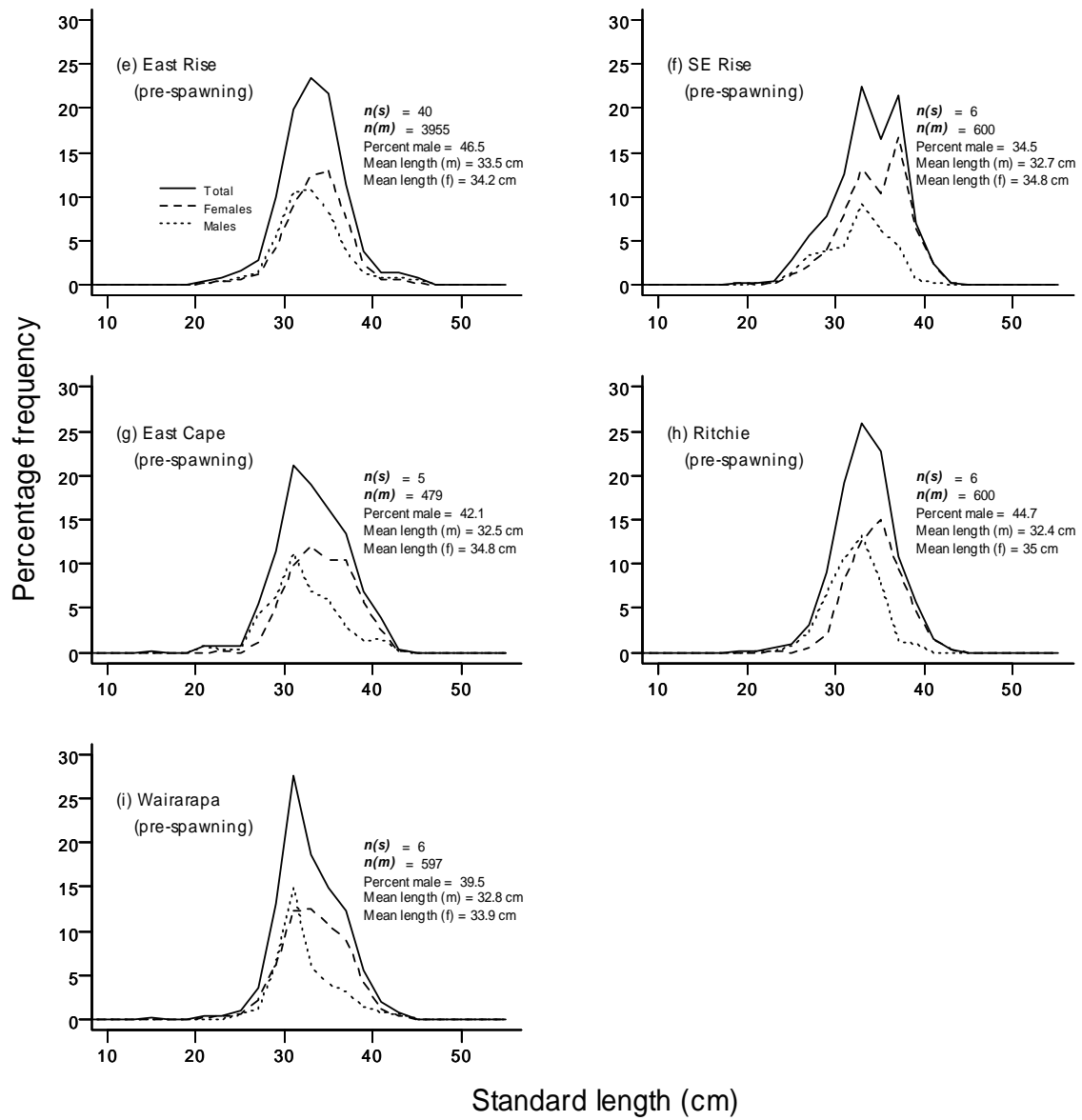
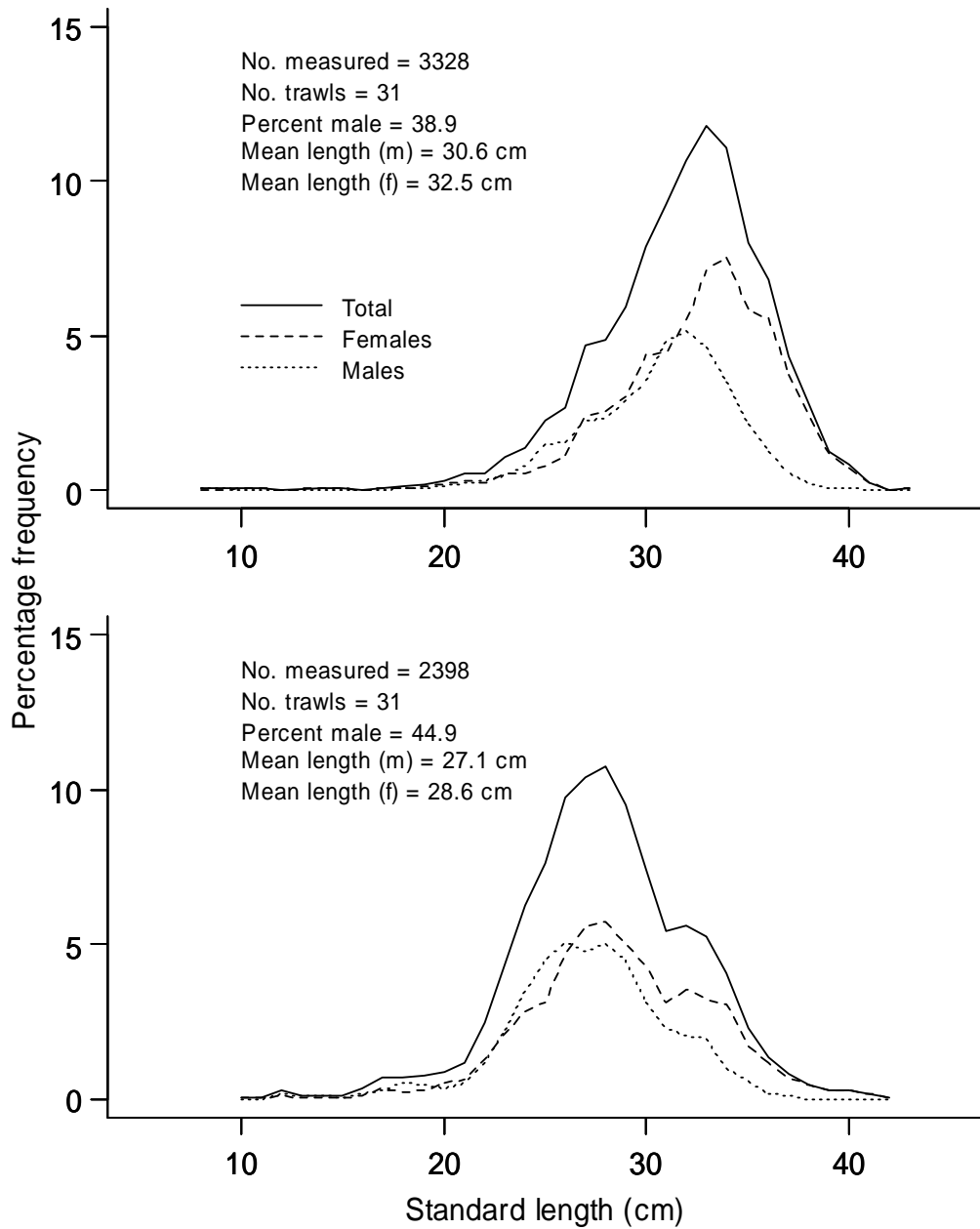
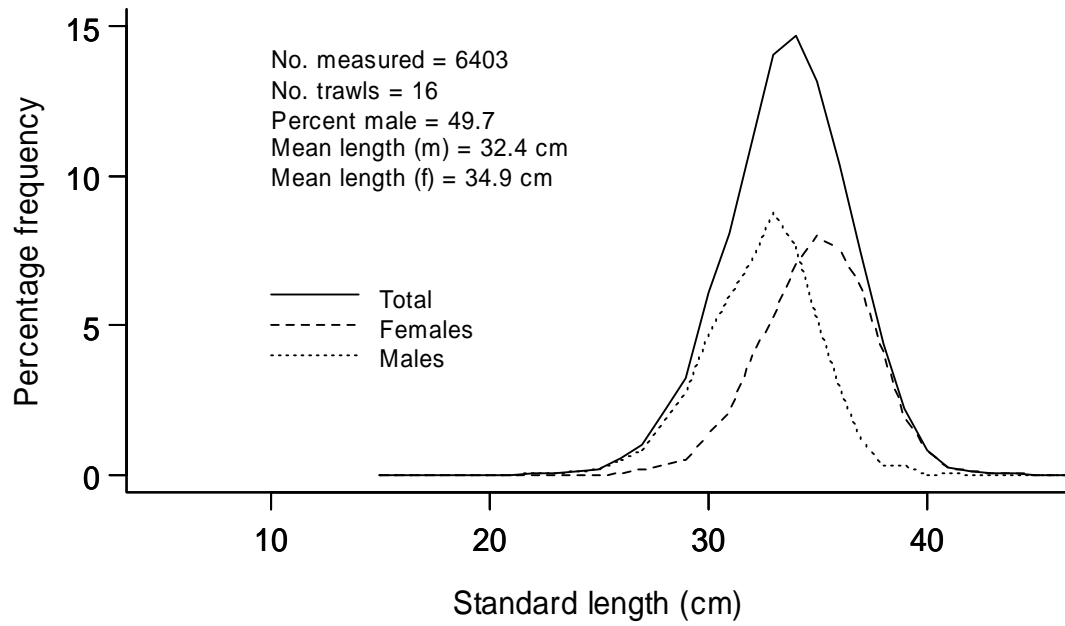


Figure 8 — continued.

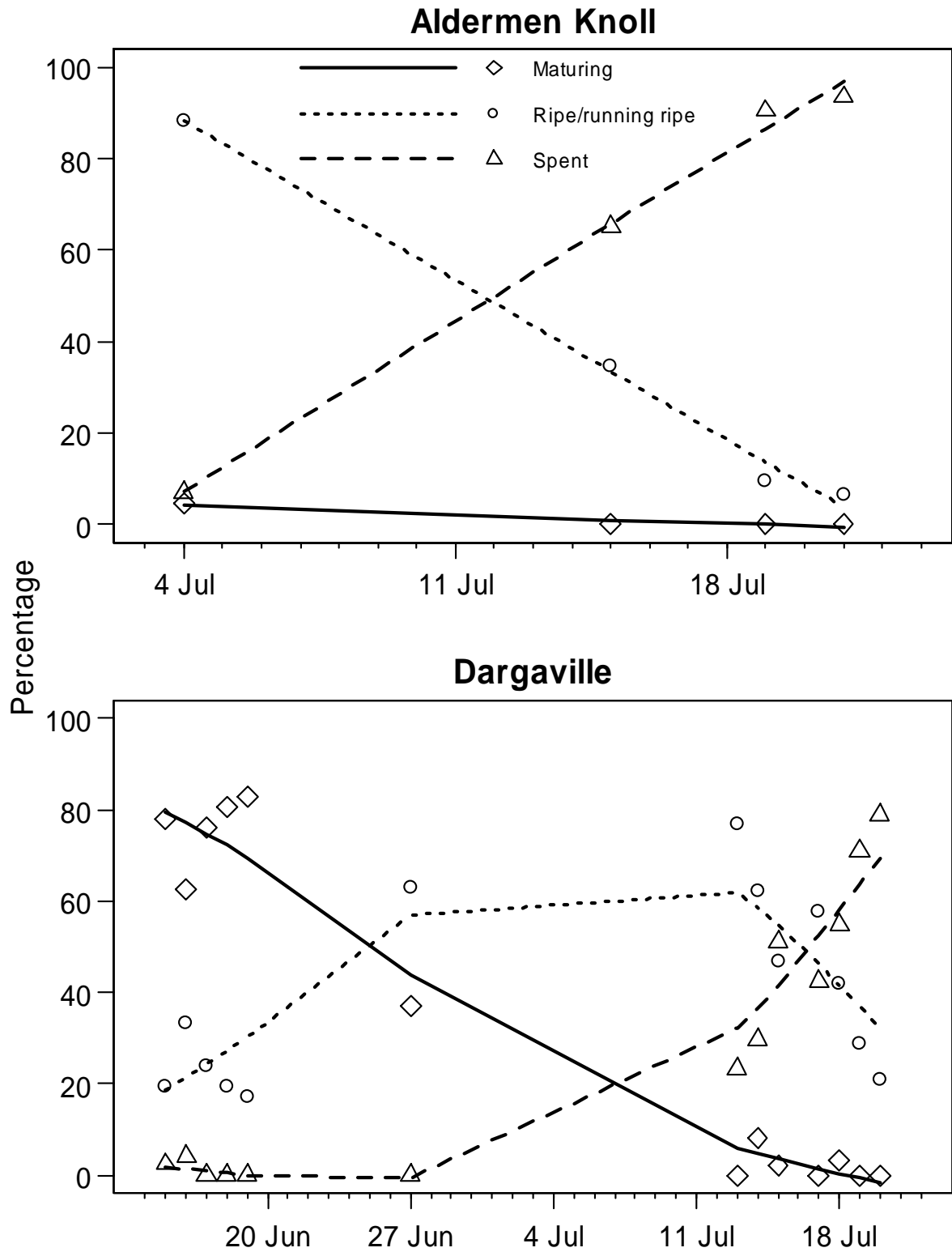


**Figure 9: Orange roughy length frequency distribution (scaled by catch) from the Northeast Chatham Rise orange roughy research survey July 2007 (R.V. *Tangaroa*). Top, Spawning Box background tows; bottom, Northeast flat background tows.**



**Figure 10: Orange roughy length frequency distribution (unscaled) from the industry survey of the Spawning Box plume in July 2007 (F.V. *San Waitaki*).**





**Figure 11: Daily changes in female orange roughy gonad stage proportions during the spawning season in the Aldermen Knoll and Dargaville fisheries (ORH 1), from OBS data. Each point indicates the fraction of all mature fish examined (aggregated by day) which were in the reproductive state indicated by the symbol.**

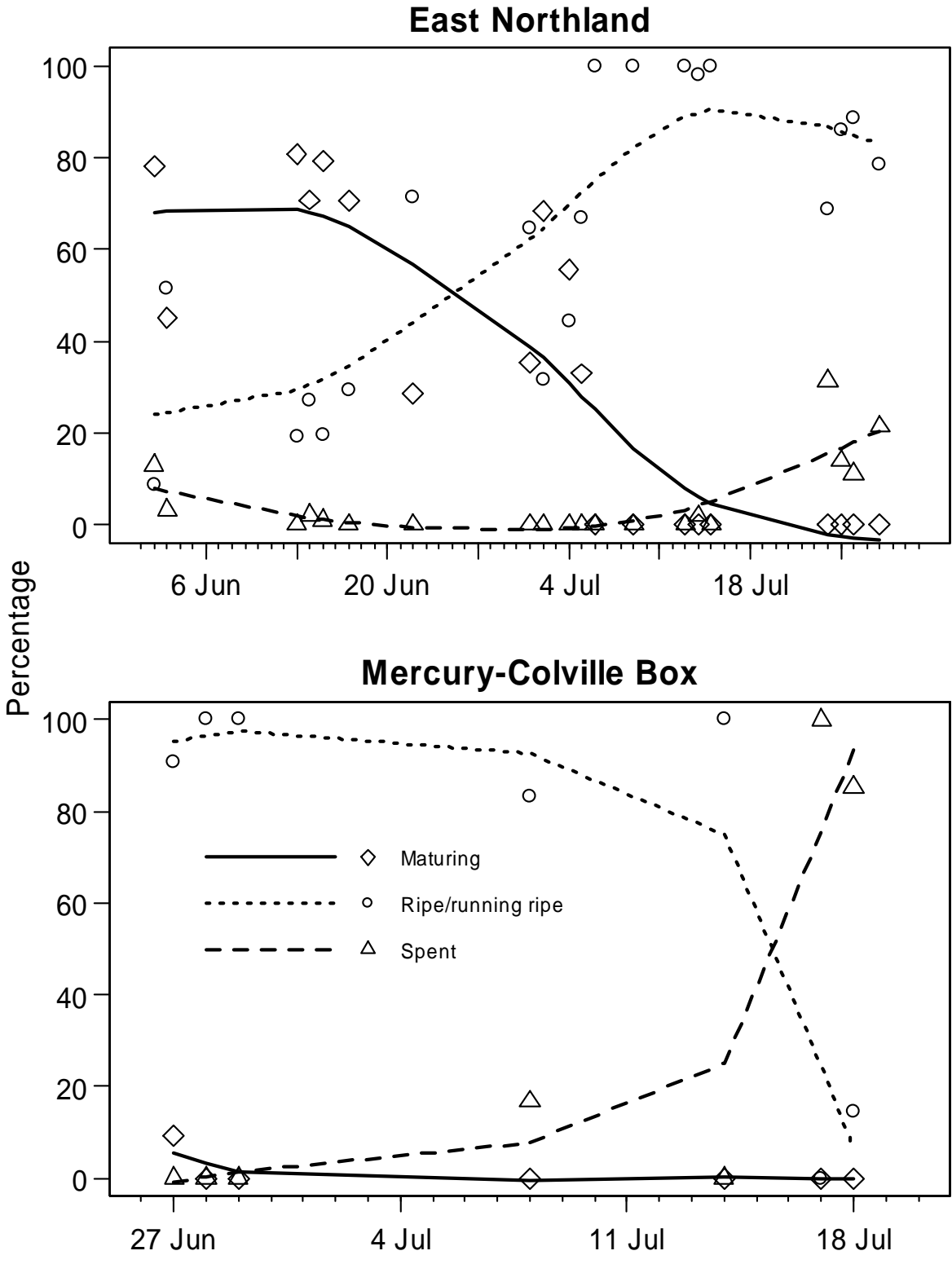
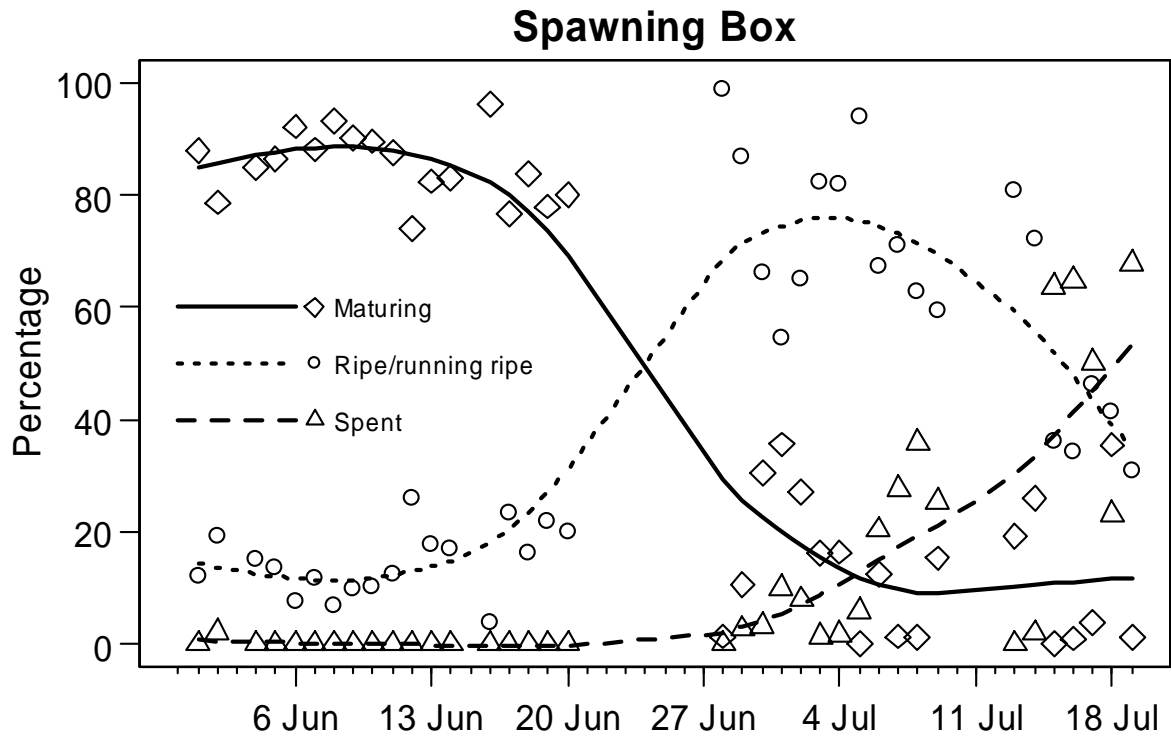


Figure 12: Daily changes in female orange roughy gonad stage proportions during the spawning season in the East Northland and Mercury-Colville Box fisheries (ORH 1), from OBS data. Each point indicates the fraction of all mature fish examined (aggregated by day) which were in the reproductive state indicated by the symbol.



**Figure 13: Daily changes in female orange roughy gonad stage proportions during the spawning season in the Spawning Box fishery (ORH 3B), from OBS data. Each point indicates the fraction of all mature fish examined (aggregated by day) which were in the reproductive state indicated by the symbol.**