

New Zealand Fisheries  
Assessment Report  
2006/56  
December 2006  
ISSN 1175-1584

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in the New Zealand region outside the EEZ:  
Lord Howe Rise, Northwest Challenger Plateau,  
West Norfolk Ridge, South Tasman Rise, and  
Louisville Ridge to the end of the 2004–05 fishing year

M. R. Clark

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Lord Howe Rise, Northwest Challenger Plateau, West Norfolk  
Ridge, South Tasman Rise, and Louisville Ridge  
to the end of the 2004–05 fishing year**

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**Published by Ministry of Fisheries  
Wellington  
2006**

**ISSN 1175-1584**

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**Ministry of Fisheries  
2006**

**Citation:**

**Clark, M.R. (2006).**

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*New Zealand Fisheries Assessment Report 2006/56.* 38 p.**

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

## EXECUTIVE SUMMARY

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Commercial catch and effort data for New Zealand vessels were obtained from the Ministry of Fisheries for the fishing years 2002–03 to 2004–05, and data from Australian vessels fishing the five areas were provided by the Bureau of Resource Sciences in Canberra to the end of the 2005 calendar year. The distribution of trawls confirmed the Lord Howe Rise, Northwest Challenger Plateau, and West Norfolk Ridge were the main areas of orange roughy catch in the Tasman Sea outside the New Zealand EEZ. The Louisville Ridge fishery continued to the east of New Zealand. The South Tasman Rise has not been fished by New Zealand in the last three years.

Descriptive analyses of these fisheries were carried out for the period 2002–03 to 2004–05. Total catch and levels of effort were summarised by month and by sub-area. The total catch by New Zealand vessels has remained relatively consistent over the three years between 2000 and 2500 t. The Northwest Challenger Plateau catch has declined substantially, while that of the Louisville Ridge has increased. The Louisville Ridge fishery has been the largest for the last three years, at 1300–1500 t. Catches from the Norfolk Ridge increased substantially in 2004–05 over the preceding two years. Catch rates on the Lord Howe Rise have shown an increasing trend in the last 3 years. Tow duration has increased consistently in the Northwest Challenger fishery, and, although catch rates overall have remained relatively constant, those in the winter hill fishery have decreased to very low levels. Catch rates on the Louisville Ridge have been variable in recent years, and trends have differed between individual seamounts, with some showing increases, others strong declines, in catch and catch rates. Catch rates of orange roughy on the West Norfolk Ridge were higher in 2004–05 than in 2002–03 and 2003–04.

## 1. INTRODUCTION

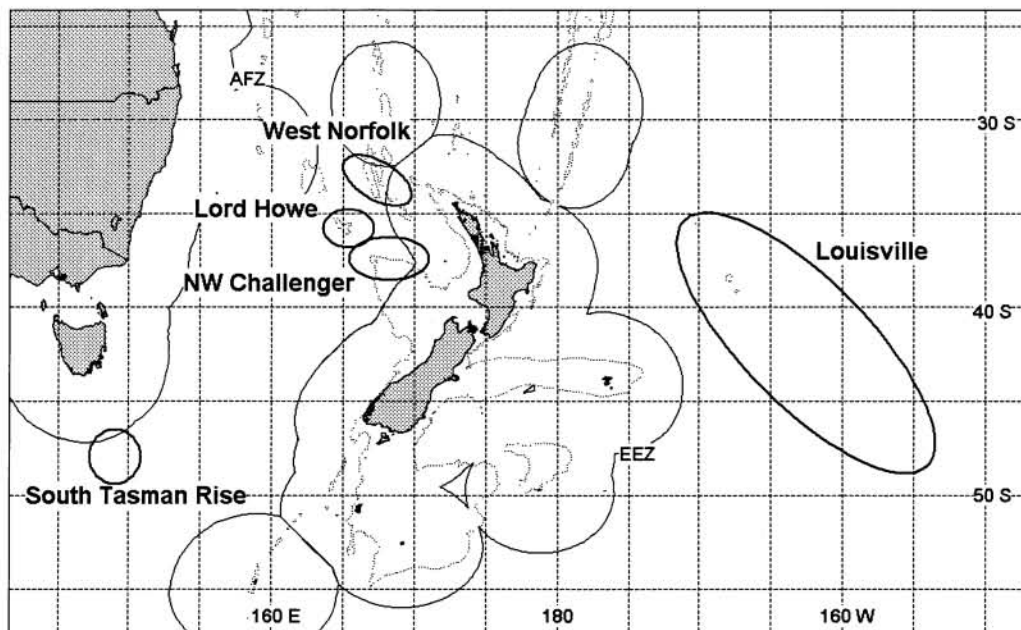
### 1.1 Overview

This report summarises commercial catch and effort information from New Zealand vessels for orange roughy fisheries outside the New Zealand EEZ. These areas include the Lord Howe Rise, Northwest Challenger Plateau, South Tasman Rise, Louisville Ridge, and West Norfolk Ridge. Overall results are given for all years of the fisheries, but the most recent three fishing years to 2004–05 are covered in more detail.

The work was carried out by NIWA in collaboration with the Bureau of Rural Sciences (BRS) as part of the Ministry of Fisheries research project ORH2005/03 (“Orange roughy fisheries outside the EEZ”). The specific objective (objective 1) was “To update descriptive analyses of commercial catch and effort data from orange roughy fisheries in the mid Tasman Sea (Lord Howe Rise), Louisville Ridge, and South Tasman Rise with the inclusion of data up to the end of the 2004/05 fishing year”.

### 1.2 Description of the fishing grounds

The Lord Howe Rise extends from the northwestern margin of the Challenger Plateau, off the west coast of New Zealand, out to Lord Howe Island in the western Tasman Sea. The ridge is mostly in international waters, although it does extend into both the Australian and New Zealand EEZs. A major fishery for orange roughy developed on the Lord Howe Rise in 1988, and has progressively shifted to the Northwest Challenger Plateau (Figure 1). A number of countries fished the area in the late 1980s, but during the 1990s it has been fished mainly by New Zealand and Australian vessels.



**Figure 1: The New Zealand region, showing location of major fisheries for orange roughy outside New Zealand and Australian EEZs (1000 m depth contour shown around New Zealand).**

New fishing grounds have recently developed on the West Norfolk Ridge, which runs northwest from the North Island towards New Caledonia. This comprises a chain of ridge peaks and seamount features both within (QMA ORH 1) and beyond the New Zealand EEZ.

The Louisville Ridge is a chain of seamount and guyot features extending southeast for over 4000 km from the Kermadec Ridge. It is a “hotspot” chain of more than 60 volcanoes, most of which rise to peaks of 200–500 m from the surrounding seafloor at depths about 4000 m. The Ridge is outside the New Zealand EEZ in international waters. The fishery dates from 1994.

The South Tasman Rise is a prominent ridge extending south from Tasmania into the Southern Ocean. It has a series of small peaks near its main summit at about 900 m just outside the Australian 200 mile Fishing Zone. A fishery developed for orange roughy in 1997, and it has since been fished mainly by Australian and New Zealand vessels. Since early 1998, the fishery has been regulated by a Memorandum of Understanding between Australia and New Zealand which has limited the catches by vessels from the two countries.

### **1.3 Literature review**

The Lord Howe Rise/Northwest Challenger fishery has been described in various assessment documents by Clark (1990, 1993, 1998a, 1998b), Clark & Tilzey (1996), Field (2000), O’Driscoll (2001, 2003), and Clark & O’Driscoll (2002). These previous reports include summaries of commercial catch and effort data from New Zealand vessels, together with biological data on size structure and reproduction. A stock reduction analysis using CPUE indices to estimate biomass and indicate yields was carried out by Clark & Tilzey (1996). Field (2000) and O’Driscoll (2001, 2003) attempted similar stock reduction modelling including more recent data, but did not update estimates of virgin biomass. CPUE indices were not thought to be an appropriate estimate of abundance for Lord Howe, and CPUE indices from the Northwest Challenger showed no decreasing trend over time.

The Louisville Ridge fishery has been described by Clark (1998c, 1998d, 1999, 2000, 2003b) and Clark & Anderson (2001, 2003). Standardised analyses of CPUE were carried out, but even when considered on an individual seamount basis, were not felt to be successful in tracking abundance of orange roughy. A “seamounts meta-analysis” by Clark (2003c) included estimates of virgin biomass based on the physical features of the fishing grounds.

Descriptive analyses of catch and effort data for the South Tasman Rise fishery were given by Tilzey (2000), Clark & Tilzey (2001), and Clark & O’Driscoll (2002). A standardised analysis by Wayte et al. (2001, 2003) showed a decline in catch rate over time. Echo-sounder surveys and biological sampling of the spawning grounds have been carried out in 2000 and 2001 (Prince & Diver 2001a, 2001b).

Clark (2004, 2006) updated and summarised catch and effort data for all these fisheries to the end of the 2002–03 and 2003–04 fishing years respectively.

## **2. METHODS**

### **2.1 Data sources**

Data on catch and effort are recorded by all New Zealand registered deepwater fishing vessels (and charter vessels) on Trawl-Catch-Effort-Processing>Returns (TCEPR) and High-Seas Trawl-Catch-Effort>Returns (HS-CER). Australian vessels involved in the South East Fishery (SEF) report their catches in SEF logbooks. These returns give tow-by-tow information, with specific location, duration, and estimated catch for each trawl. New Zealand data were obtained from the Ministry of Fisheries. Australian data were provided by the Australian Fisheries Management Authority (AFMA) to the Bureau of Rural Sciences (BRS) in Canberra, who in turn provided selected information for NIWA to combine with the New Zealand data. Available data where orange roughy or oreos were either caught or targeted were extracted from the Ministry of Fisheries catch-effort database and loaded into a relational (Empress) database at NIWA in December 2005.

Data were error-checked. Obvious mistakes in position (e.g., large differences in start and finish coordinates) were corrected, as were positions well outside any other fished area where typing or recording mistakes could be resolved (by examining that vessel's tows in sequence). Data for the 2004–05 fishing year may be incomplete due to forms not yet supplied by fishing vessels and records not yet entered into the Ministry database. Records containing errors that couldn't be resolved or corrected were excluded from further analyses.

The fishery on the South Tasman Rise has been managed on the basis of quotas set from 1 March to 28 February. Therefore, where fishing year is referred to *for the South Tasman Rise fishery only*, it covers that period, and hence is not comparable with the New Zealand fishing year of October–September which is used for all the other fisheries.

## 2.2 Fishing area boundaries

The following coordinates were used to define fishing areas.

### a) Lord Howe Rise

The main region of the fishery is 35°00' S – 36°45' S and 164°00' E – 167°00' E

In recent years there has been activity to the north of this, and so data were also extracted for a northern area, 32°30' S – 35°00' S, 162°00' E – 166°00' E.

### b) Northwest Challenger Plateau

In this report there are two regions used for the Northwest Challenger fishery. The total area is between 36°50' S – 39°30' S (north of the Westpac Bank area) and 166°00' E – 170°00' E, but excluding tows that fell within the New Zealand EEZ. Secondly, the area of the main target fishery (referred to as the “Core Area”), which is on the northern slopes of the Plateau, between 36°50' S – 38°00' S, and 166°00' E – 170°00' E (excluding tows within the EEZ).

### c) West Norfolk Ridge

32°30' S – 34°30' S, 166°30' E – 168°10' E, excluding tows within the New Zealand EEZ.

### d) South Tasman Rise

The area covered by this analysis is bordered by 46°00' S and 50°00' S and 145°00' E to 150°00' E.

### e) Louisville Ridge

Trawls on the Louisville Ridge have been clustered in three general areas for a number of analyses in this report (following the division by Clark (1998c, 1998d), although note the Central boundary has been shifted to the east):

- North: 35° S to 39.9° S, 165° W to 172° W.
- Central: 40° S to 44.9° S, 157° W to 167° W.
- South: 45° S to 50° S, 148° W to 159° W.

## 2.3 CPUE input data

Unstandardised CPUE analyses have been carried out for Lord Howe, Northwest Challenger, and Louisville fisheries as an update of previous work. Not all groomed data were included in these analyses. For Lord Howe and Northwest Challenger fisheries, CPUE indices were calculated using a subset of data from a group of core vessels in each fishery which had carried out 10 or more tows targeting orange roughy in each of at least two years to reduce the effect of novice vessels on the catch rate (after O'Driscoll 2003). In addition, the first four years (1988–89 to 1991–92) of fishing at Northwest Challenger (when effort was low) were excluded from the analysis. Because catches

showed a distinct seasonal pattern, a second set of CPUE indices for Northwest Challenger was calculated from a cropped data set of only tows less than 1 h conducted during June (peak spawning).

### 3. RESULTS

#### 3.1 Location of the fisheries

In the late 1990s and early 2000s there was activity by New Zealand vessels beyond the general New Zealand region, in the Southwest Indian Ocean, and in the Atlantic. However, since 2001–02 there has been nothing beyond the Tasman Sea and Louisville areas.

In the New Zealand region, there are clearly defined fishing grounds on the Lord Howe Rise, Northwest Challenger Plateau, West Norfolk Ridge, Louisville Ridge and, up until 2000–01, on the South Tasman Rise. Over the last three years there have been only minor changes in the distribution of fishing (Figure 2). The West Norfolk Ridge developed as a significant fishery in 2000–01, and this has continued in the same area to 2003–04. The distribution of effort on the Northwest Challenger Plateau has become more widespread, including extending southwards down the western flanks of the Plateau. There was some fishing further northwest on the Lord Howe Rise in 2003–04.

#### 3.2 Overall catch and effort in the fisheries

The total reported New Zealand orange roughy catch outside the EEZ in 2004–05 was about 2500 t. This was 300 t more than in 2003–04, and about the same as 2002–03. The quantity of catch reported in the QMS is low for 2004–05, for reasons which are unknown, although there is a discrepancy in the oreo figures the other way (Table 1). The catch (and effort) in the Northwest Challenger fishery has decreased, that on the Lord Howe Rise has been fairly constant, the Louisville catch has increased slightly to 1500 t, and the West Norfolk Ridge has increased substantially from less than 100 t in 2002–03 and 2003–04 to 250 t.

**Table 1: Reported catch (t) of orange roughy and level of effort (Ntows, number of vessels in parentheses) by fishing area for fishing years 2002–03, 2003–04, and 2004–05 for New Zealand vessels (note South Tasman Rise catch is for a 1 March to 28 February fishing year, totals include CELR data).**

Area	2002–03			2003–04			2004–05		
	Ntows	Catch (t)		Ntows	Catch (t)		Ntows	Catch (t)	
		ORH	OEO		ORH	OEO		ORH	OEO
Lord Howe Rise	286 (10)	210	11	207 (9)	180	1	219	255	2
Northwest Challenger	1 982 (22)	948	8	869 (16)	495	7	1 010	452	2
West Norfolk	91 (5)	35	0	90 (2)	88	0	248	274	0
Louisville	737 (11)	1 296	85	1 336 (12)	1 419	215	742	1 503	324
South Tasman Rise	0			0			0		
Reported total	3 056	2 479	104	2 502	2 182	223	2 219	2 484	328
QMS		2 410	112		1 967	305		1 696	747



Australian vessels are the only other nationality known to regularly fish these grounds (Table 2).

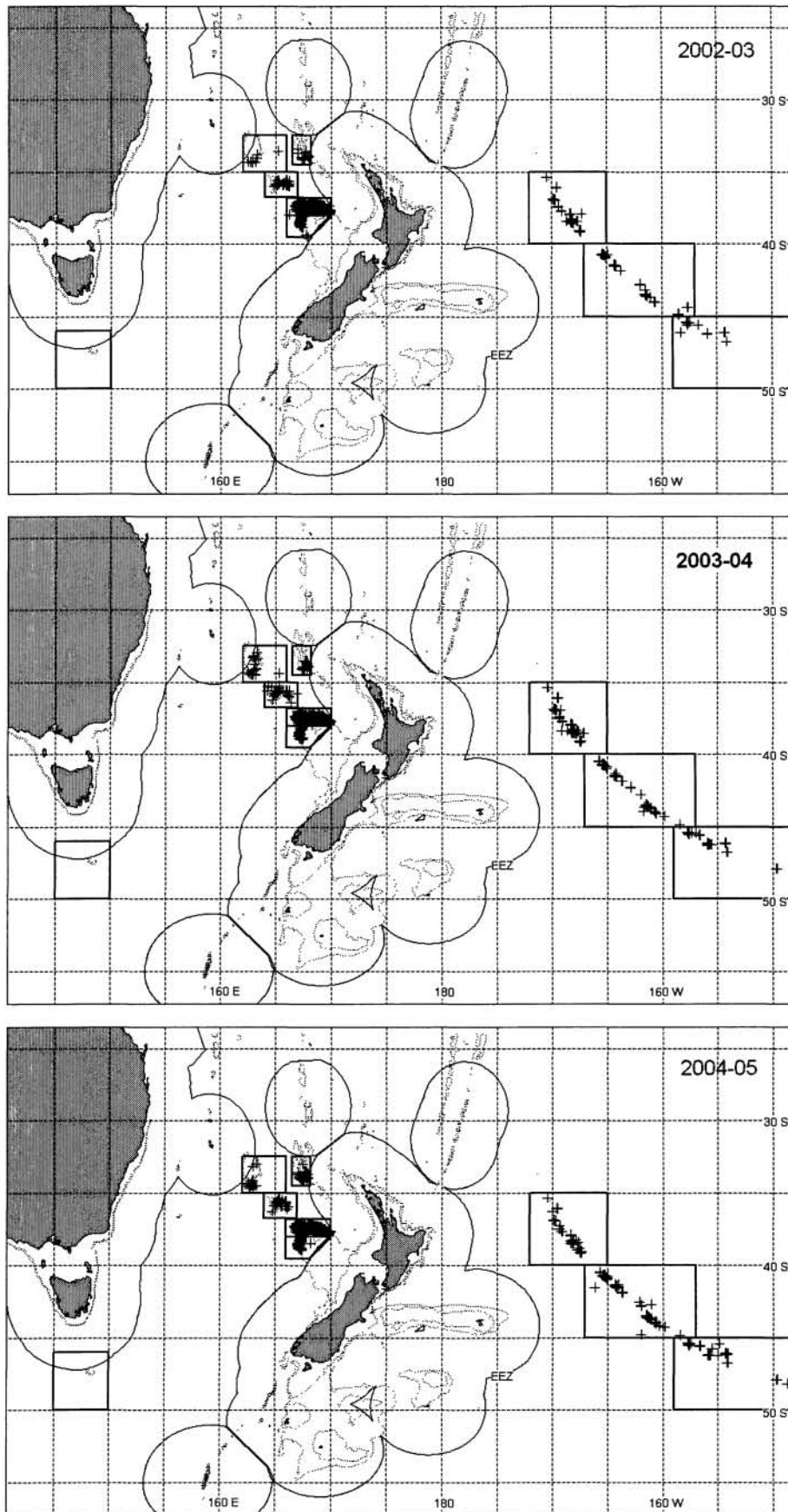
**Table 2: Reported catch (t) of orange roughy and level of effort (Ntows) by fishing area for fishing years 2001–02, 2002–03, and 2003–04 for Australian vessels (note South Tasman Rise catch is for a 1 March to 28 February fishing year).**

Area	2002–03			2003–04			2004–05		
	Ntows	Catch (t)		Ntows	Catch (t)		Ntows	Catch (t)	
		ORH	OEO		ORH	OEO		ORH	OEO
Lord Howe Rise	26 (4)	64	1	21 (2)	144	0	21 (2)	175	0
Northwest Challenger	86 (2)	62	0	72 (2)	159	1	5 (1)	19	0
West Norfolk	61 (4)	3	0	0		0			
Louisville	0			0			0		
South Tasman Rise	164 (6)	110	70	67 (6)	3	162	23 (3)	55	40
Reported total	337	239	71	160	306	163	49	249	40

The fisheries outside the EEZ continue to be a significant proportion of the total New Zealand and Australian orange roughy fisheries (Table 3).

**Table 3: Reported catch (t) of orange roughy in fisheries outside (ET) and inside (EEZ) the EEZs by New Zealand and Australian vessels in the southwest Pacific. Values in parentheses are the proportions of the EEZ catch taken ET).**

Fishery	2000–01	2001–02	2002–03	2003–04	2004–05
New Zealand ET	3 340	3 563	2 499	2 180	2 484
Australia ET	1 371	454	239	306	249
Total ET	4 711 (0.30)	4 017 (0.23)	2 739 (0.16)	2 486 (0.19)	2 733 (0.15)
New Zealand EEZ	11 903	13 459	14 432	13 226	15 368
Australia EEZ	3 858	3 817	3 091	2 736	2 617
Total EEZ	15 761	17 276	17 523	15 962	17 985



**Figure 2: Distribution of New Zealand fishing for orange roughy in the New Zealand region during 2002–03 (upper panel), 2003–04 (middle panel), and 2004–05 (lower panel). 1000 m depth contour is shown around New Zealand**

### **3.3 The Lord Howe Rise fishery**

#### **3.3.1 Catch effort data**

The Lord Howe Rise fishery has historically included 54 vessels. The fishery has been dominated by New Zealand registered vessels, although there was some effort in earlier years by vessels registered in Norway, Korea, Russia, Japan, Belize, and Panama. In the last three years almost all effort has been by domestic registered vessels (90%), with a few tows from vessels registered in Australia and the Cook Islands. Almost all tows (99%) have targeted orange roughy, although in 2003–04 and 2004–05 small numbers targeted alfonsino or cardinalfish in the northern part of the Rise.

Tows were relatively long (3 h) in the early years (1988–91) of the Lord Howe fishery when most fishing effort was on the flat ground of the broad platforms (Table 4). There was then a trend towards shorter tows (less than 1 h) from 1991 to 1998 associated with a shift to fishing on rough ground in the area, and short tows still dominate with mean tow duration in the last three fishing years of 0.5–0.7 h.

Unstandardised catch rates for all groomed data combined were expressed as tonnes per tow, tonnes per hour, and tonnes per nautical mile (Table 4). Catch rates decreased from relatively high levels in the first four years of the fishery to low levels in the late 1990s (mean of 0.2–0.3 t/tow) but have been at higher levels since 2000–01. Catch rates have increased over the last four years.

#### **3.3.2 Seasonal and spatial distribution of catch and effort**

Catch and effort in Lord Howe (Tables 5, 6, 7) were historically concentrated during the winter spawning period (May–July), although the seasonal distribution of effort has at times been patchy since 1994–95 (Table 5). In 2000–01, there was significant effort in July for the first time since 1993–94, and 89% of the catch was taken in this month (Table 6). Fishing in 2001–02 was also concentrated in July with 65% of the effort and 80% of the catch taken in this month, although the catch rate of 0.7 t/tow was much lower than in July 2001. Effort in July was reduced in 2002–03, but the mean catch rate was higher than in the previous year (Table 7). During 2003–04 fishing occurred in most months, especially July (32% of tows) which accounted for about 50% of the catch. In 2004–05 July was still the dominant month, although catch and effort levels increased in May and June.

The distribution of the fishery has expanded in recent years (Figure 3). In 2002–03 some exploratory fishing occurred in the northern region of the Rise, and although catch in this year was small, there was further fishing in the area by New Zealand vessels in 2003–04 and 2004–05. One locality provided several large catches of orange roughy.

The distribution of catch rates in the historical southern region has been consistent in recent years (Figure 4). In the past there have been two regions of good catch rates, but in the last few years only the more northern area produced high catch rates, with a more scattered distribution of catches in areas to the east.

Note that the scales used in the catch rate figure for Lord Howe are not comparable with other fishing ground figures. The maximum catch rate and the scale of the plots differ. They are consistent within an area, but are not intended for inter-area comparison.

**Table 4: Summary of groomed tow-by-tow data from TCEPR/HS-CER forms for the Lord Howe Rise.**

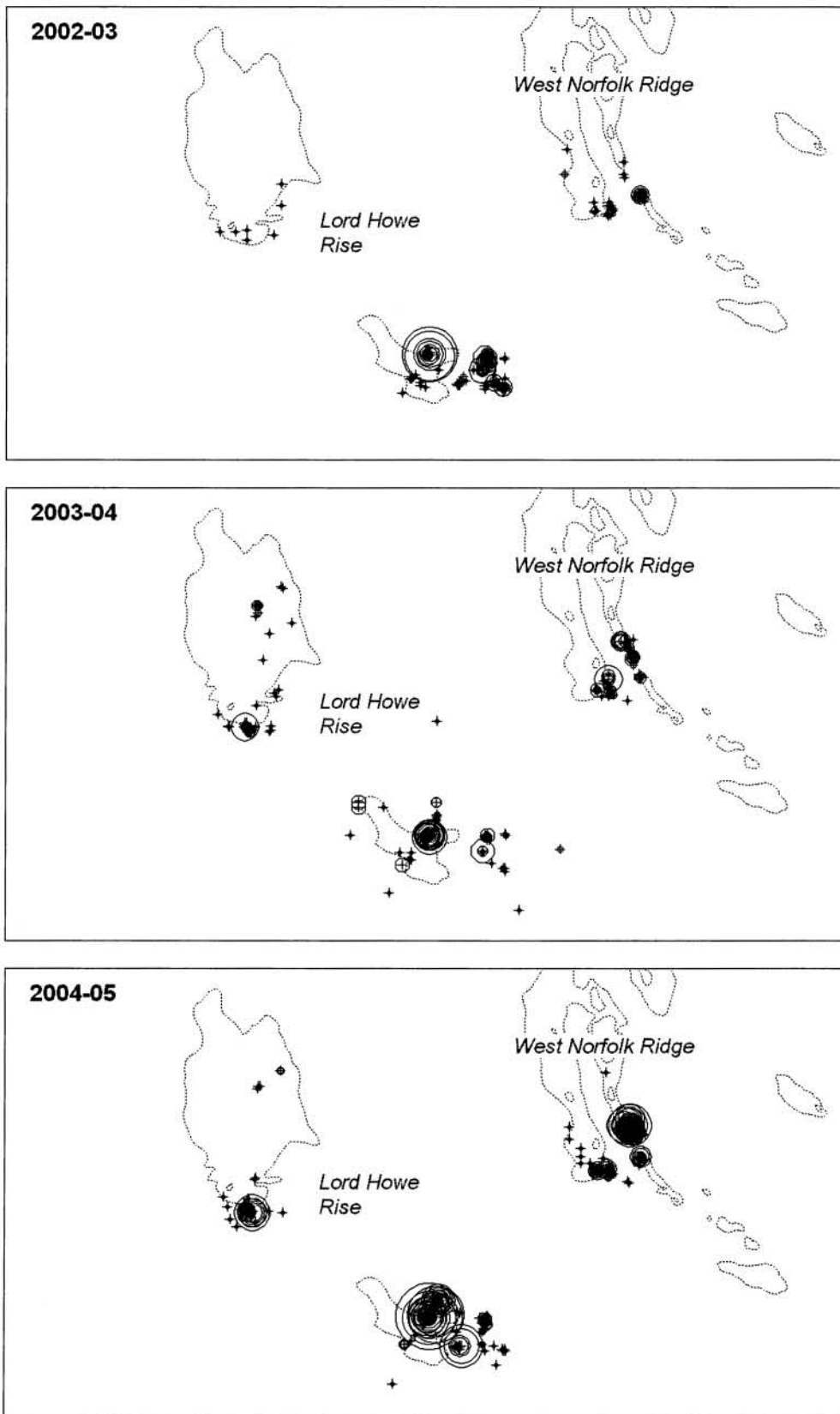
Fishing year	Number of vessels	Number of tows	Total recorded catch (t)	Mean tow speed (kt)	Mean tow length (h)	Mean tow length (n.mile)	Mean catch rate (t/tow)	Mean catch rate (t/h)	Mean catch rate (t/n.mile)
1988-89	6	181	766	3.3	3.0	9.9	4.2	5.2	1.5
1989-90	4	63	127	2.9	2.9	8.6	2.0	1.0	0.3
1990-91	3	14	52	3.0	2.9	8.7	3.7	2.0	0.7
1991-92	4	70	479	3.2	1.7	5.2	6.8	7.6	2.5
1992-93	18	825	1 363	3.0	1.3	3.9	1.7	3.6	1.2
1993-94	19	1 263	777	2.8	0.9	2.5	0.6	1.9	0.8
1994-95	8	110	61	2.9	1.2	3.6	0.6	0.5	0.2
1995-96	3	26	5	2.9	0.7	1.9	0.2	0.5	0.2
1996-97	5	179	44	3.0	0.8	2.5	0.2	0.8	0.3
1997-98	4	57	15	3.2	0.3	1.1	0.3	1.8	0.5
1998-99	16	138	48	3.1	1.0	3.3	0.3	0.5	0.2
1999-2000	8	121	34	2.9	1.1	3.4	0.3	1.3	0.5
2000-01	6	136	145	3.0	0.7	1.9	1.1	2.9	1.0
2001-02	10	191	110	3.1	0.7	2.3	0.6	2.3	0.7
2002-03	10	280	208	3.4	0.5	1.8	0.7	4.3	1.3
2003-04	9	207	180	3.1	0.7	2.1	0.9	4.5	1.5
2004-05	12	219	255	3.1	0.6	1.9	1.2	5.5	1.8

**Table 5: Monthly distribution of effort (number of tows) in the Lord Howe orange roughy fishery from New Zealand TCEPR/HS-CER returns.**

Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1988-89	0	0	0	0	0	0	0	0	8	99	64	10
1989-90	0	0	8	0	3	2	0	0	1	30	19	0
1990-91	0	0	0	0	0	0	0	1	1	12	0	0
1991-92	0	0	0	0	0	0	0	0	35	35	0	0
1992-93	0	0	0	4	0	0	0	121	209	479	12	0
1993-94	20	83	12	95	215	200	74	111	255	140	58	0
1994-95	6	9	12	10	12	0	11	22	16	8	3	1
1995-96	1	0	1	3	18	1	0	0	2	0	0	0
1996-97	55	3	17	6	13	0	26	42	17	0	0	0
1997-98	2	0	0	13	0	0	31	8	0	0	0	3
1998-99	2	0	2	2	0	13	1	36	72	0	0	10
1999-2000	12	1	0	21	0	0	0	51	33	3	0	0
2000-01	0	5	2	20	0	34	0	22	1	48	4	0
2001-02	6	6	9	4	3	3	16	11	12	121	0	0
2002-03	0	0	0	5	40	9	7	102	69	47	0	1
2003-04	14	8	3	8	18	24	5	22	38	66	1	0
2004-05	5	3		2	7	20	4	98	49	31		

**Table 6: Monthly distribution of catch (t) in the Lord Howe orange roughy fishery from New Zealand TCEPR/HS-CER returns. Blanks indicate months when there was no effort (see Table 5).**

Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1988-89									38	483	106	139
1989-90			2		0	0			0	119	5	
1990-91								0	0	52		
1991-92									269	211		
1992-93				0				165	313	876	9	
1993-94	137	57	8	53	153	87	7	49	158	53	16	
1994-95	1	0	1	2	15		0	1	39	3	0	0
1995-96	0		0	0	4	0			0			
1996-97	14	0	2	0	10		4	12	2			
1997-98	0			3			11	1				0
1998-99	0		0	0		0	0	4	42			1
1999-2000	11	0		3				5	14	1		
2000-01		1	0	4		5		5	0	129	0	
2001-02	2	2	8	2	1	2	3	3	1	86		
2002-03				0	43	3	1	49	16	97		0
2003-04	11	1	0	2	4	15	1	19	28	96	3	
2004-05	0	0		1	0	1	1	80	64	108		



**Figure 3: Distribution of catch rates of orange roughy (catch per trawl) in the Lord Howe Rise area during the 2002–03, 2003–04, and 2004–05 fishing years (+, trawl position, circle area proportional to catch, max = 45 t).**

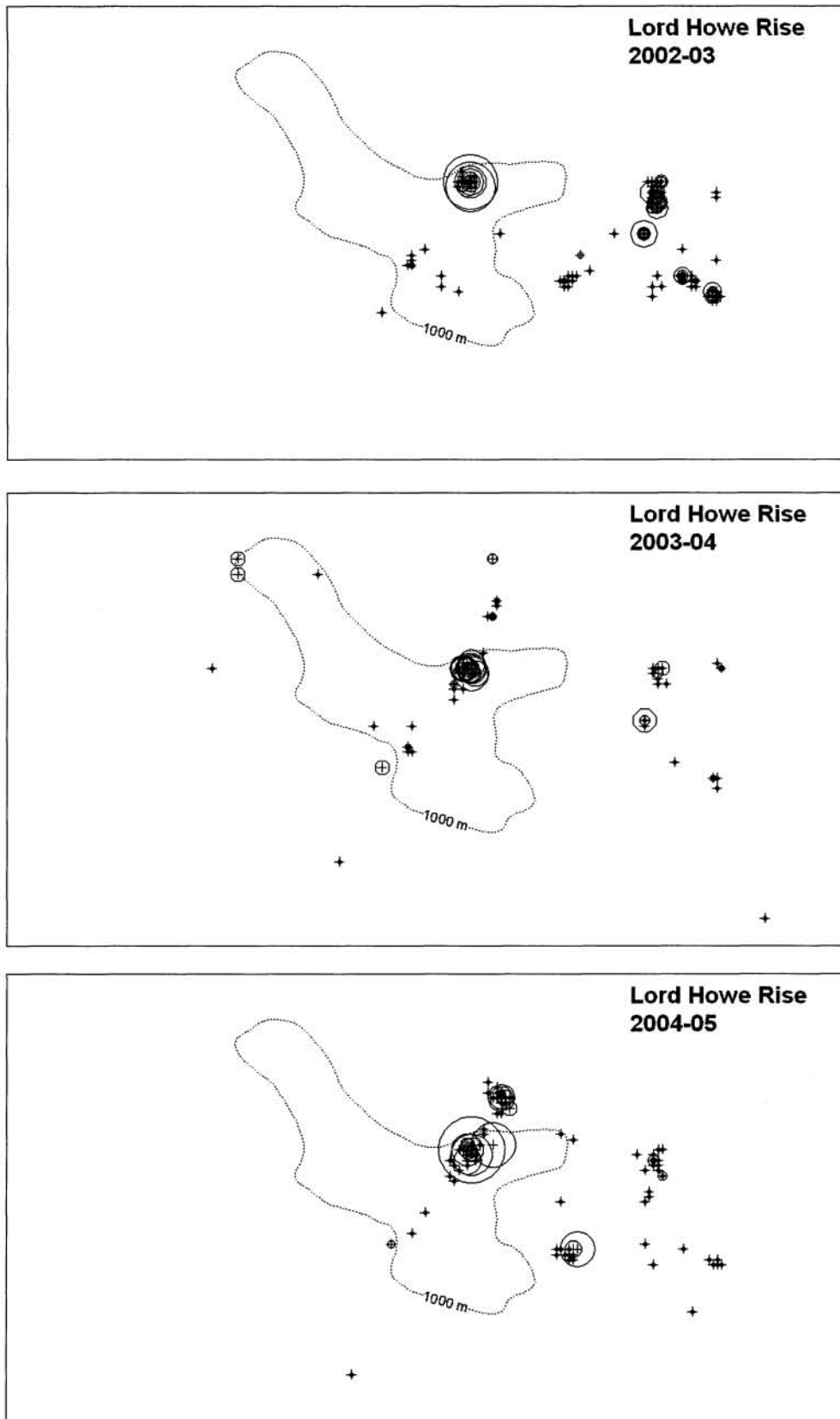


Figure 4: Distribution of catch rates of orange roughy (catch per trawl) on the Lord Howe Rise during the 2002–03, 2003–04, and 2004–05 fishing years (+, trawl position, circle area proportional to catch, max = 45 t).

**Table 7: Monthly distribution of catch rates (t/tow) in the Lord Howe orange roughy fishery from New Zealand TCEPR/HS-CER returns. Blanks indicate months when there was no effort (see Table 5).**

Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1988–89									4.8	4.9	1.7	13.9
1989–90			0.3		0.0	0.0			0.3	4.0	0.3	
1990–91								0.0	0.0	4.3		
1991–92									7.7	6.0		
1992–93				0.0				1.4	1.5	1.8	0.8	
1993–94	6.8	0.7	0.7	0.6	0.7	0.4	0.1	0.4	0.6	0.4	0.3	
1994–95	0.2	0.0	0.0	0.2	1.3		0.0	0.0	2.4	0.3	0.0	0.0
1995–96	0.0		0.0	0.1	0.2	0.0			0.1			
1996–97	0.3	0.0	0.1	0.0	0.7		0.2	0.3	0.1			
1997–98	0.0			0.2			0.3	0.1				0.1
1998–99	0.2		0.0	0.0		0.0	0.1	0.1	0.6			0.1
1999–2000	0.9	0.0		0.1				0.1	0.4	0.2		
2000–01		0.2	0.1	0.2		0.1		0.2	0.0	2.7	0.0	
2001–02	0.4	0.4	0.9	0.6	0.2	0.7	0.2	0.3	0	0.7		
2002–03			0.5	0.4	1.1	0.3	0.2	0.5	0.2	2.1	0	
2003–04	0.8	0.1	0.1	0.3	0.2	0.6	0.1	0.9	0.7	1.5	3.0	
2004–05	0	0.1		0.3	0.1	0.1	0.3	0.8	1.3	3.5		

### 3.3.3 Unstandardised CPUE analysis

The reduced input data set for CPUE analyses consisted of 2614 tows by 19 vessels for the Lord Howe fishery (Table 8). The distribution of effort between vessels over time was highly variable (Figure 5), and few vessels currently fishing were involved in the early years.

**Table 8: Unstandardised CPUE indices for core vessels from Lord Howe Rise.**

Fishing year	Number of tows	Catch (t)	t/tow	t/n.mile	% 0 catch
1988–89	65	268	4.1	0.4	9
1989–90	59	126	2.1	0.4	22
1990–91	13	52	4.0	0.7	8
1991–92	70	479	6.8	2.5	17
1992–93	473	994	2.1	1.2	27
1993–94	783	539	0.7	0.8	44
1994–95	98	58	0.6	0.2	59
1995–96	26	5	0.2	0.2	69
1996–97	173	44	0.3	0.3	64
1997–98	57	15	0.3	0.5	44
1998–99	30	2	0.1	0.0	41
1999–2000	45	24	0.5	1.1	36
2000–01	99	90	0.9	1.2	45
2001–02	157	104	0.7	0.8	26
2002–03	264	205	0.8	1.4	35
2003–04	127	114	0.9	1.5	20
2004–05	75	104	1.4	2.4	25

Catch rate was measured as both catch per tow and catch per nautical mile. Both unstandardised CPUE indices showed similar trends (Figure 6, Table 8). CPUE peaked in 1991–92, declined rapidly to low levels from 1994–95 to 1998–99, and has increased over the last 4 years.

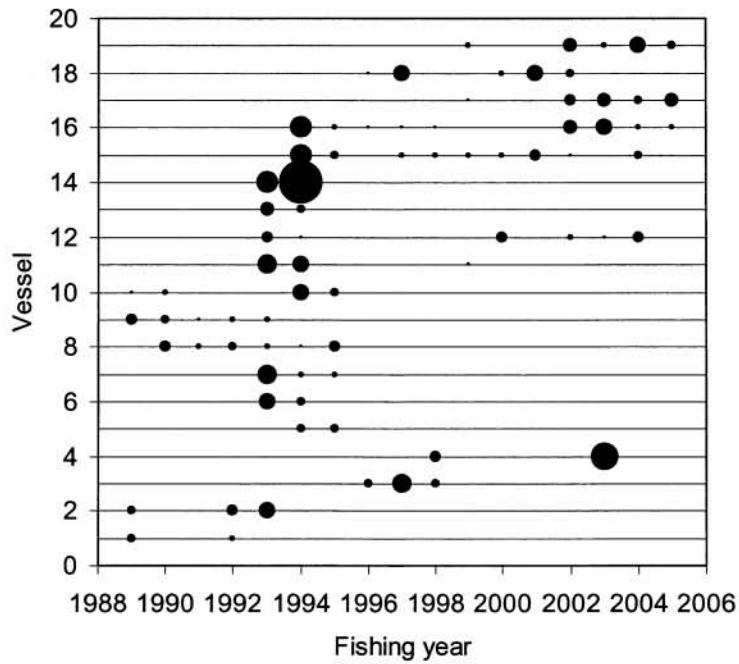


Figure 5: Annual distribution of tows by the 19 core vessels included in the CPUE analysis of the Lord Howe Rise orange roughy fishery. Circle area is proportional to the number of tows in each year. 1990 on x-axis refers to the 1989–90 fishing year.

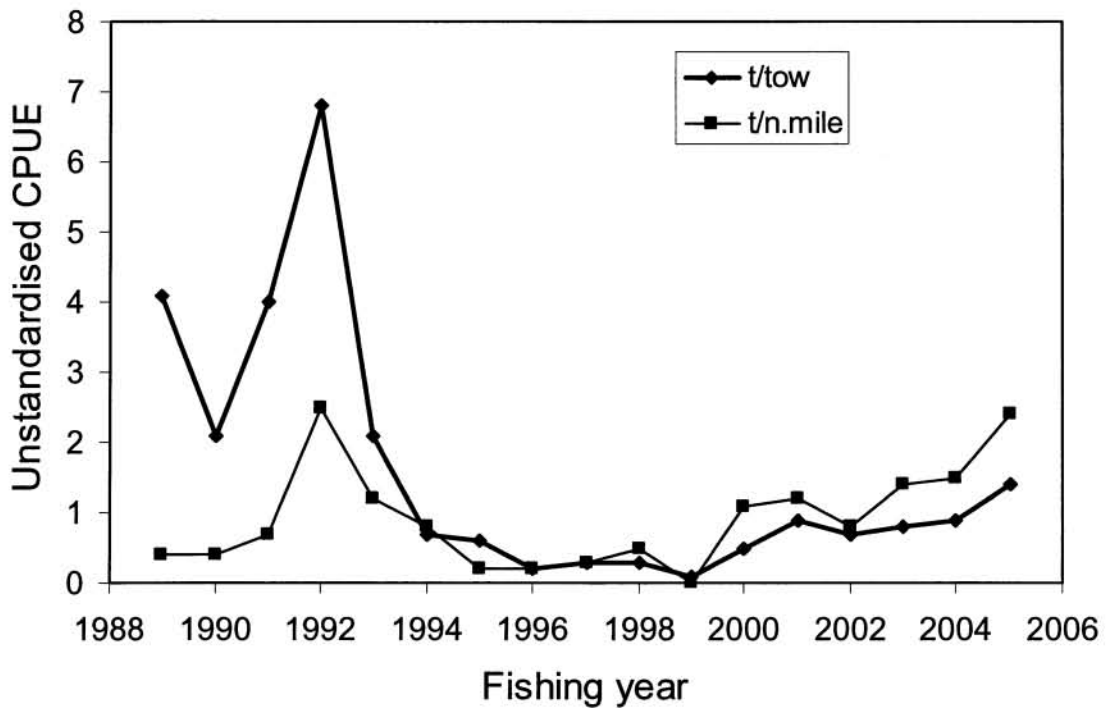


Figure 6: Unstandardised CPUE indices from the Lord Howe Rise orange roughy fishery 1988–89 to 2004–05 (data in Table 8). 1990 on x axis refers to the 1989–90 fishing year.



## **3.4 Northwest Challenger Plateau fishery**

### **3.4.1 Catch effort data**

There were over 12 000 tows by 65 vessels in the groomed (error-checked) TCEPR/HS-CER and CELR data from the Northwest Challenger region (Table 9). Note that the values in this table are for the entire Northwest Challenger area, and not the “core region”; hence, numbers differ slightly from the data reported by O’Driscoll (2003) but are comparable with those in Clark (2004, 2006). The fishery overall has been dominated by New Zealand registered vessels, and in the last three years this level has been over 90%. Almost all tows (99%) in recent years have targeted orange roughy.

Tow duration and distance on Northwest Challenger were long in the first two years of the fishery, but decreased as fishing shifted to hill features (Table 9). From 1992–93 to 1999–2000 mean tow duration was relatively constant at between 0.7 and 1.1 h. There was a major increase in tow duration in 2000–01, and this has remained high. The increase in tow length was associated with changes in the spatial pattern of the fishery (see below), with some effort moving away from the hills on to flat areas to the east.

The mean catch per tow overall (Table 9) has generally been highly variable, at between 1 and 2 t/tow, although it reached 4 t/tow in 1988–89. The catch rates in recent years are among the lowest for the entire time series. Catch rates have generally been greater than on the neighbouring Lord Howe Rise grounds, but in the last three years they have been lower, whether t/tow, t/h, or t/n.mile is considered.

### **3.4.2 Seasonal and spatial distribution of catch and effort**

Catch and effort in the core region of the Northwest Challenger fishery (Tables 10, 11, 12) were historically concentrated during the winter spawning period (May–July), although some years have seen substantial effort in October, March, April, and August.

In 2001–02, there was significant effort in July for the first time since 1994–95, and this has continued (Table 10). The amount of fishing has also been high at times in April. May and June have been the months of most fishing, although catches in both these months have tended to decrease (Table 11).

The relative distribution of catch rates by month has been similar in recent years (Table 12). Highest catch rates (t/tow) were generally in June and July, and were higher than in May. June and July catch rates dropped in 2001–02, and further in 2002–03, increased slightly in 2003–04, and decreased again in 2004–05. Monthly overall catch rates are now all at or below 1 t/tow.

The distribution of catch rates has been similar in recent years (Figure 7). Fishing occurs across the entire northern flank, although in 2003–04 and 2004–05 effort has been less intensive. Highest catch rates are generally on the northwestern corner. Fishing continues to extend down the western margin of the Plateau, but catches are small.

**Table 9: Summary of groomed tow-by-tow data from TCEPR/HS-CER forms for Northwest Challenger. Additional data from CELR forms in 2001–02 and 2002–03 are given below in parentheses.**

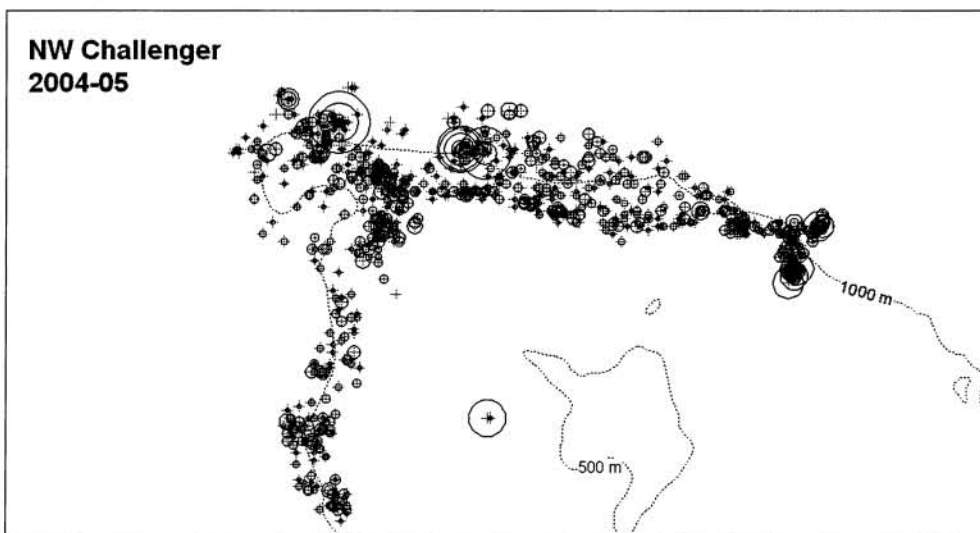
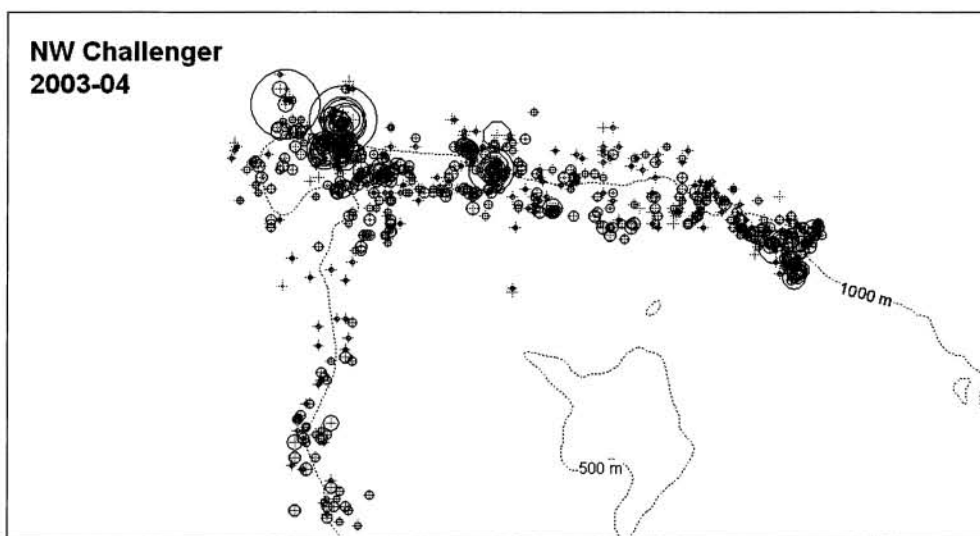
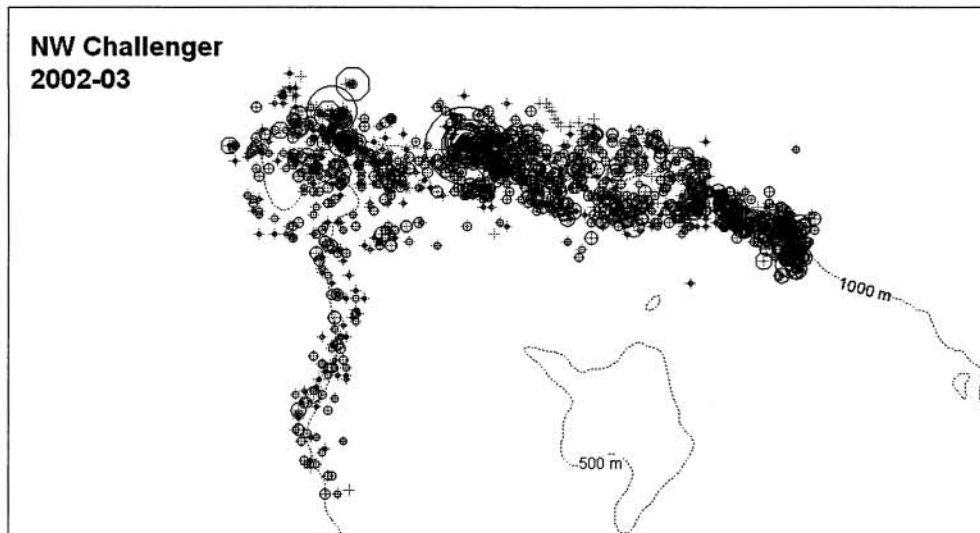
Fishing year	Number of tows	Number of vessels	Total recorded catch (t)	Mean tow speed (kt)	Mean tow length (h)	Mean tow length (n.mile)	Mean catch rate (t/tow)	Mean catch rate (t/h)	Mean catch rate (t/n.mile)
1988–89	33	3	107	2.8	3.2	9.2	3.3	1.5	0.5
1989–90	40	4	25	2.8	2.4	6.8	0.6	0.6	0.2
1990–91	4	1	1	3.5	0.2	0.6	0.3	1.5	0.4
1991–92	56	2	230	3.5	0.5	1.8	4.1	12.8	3.7
1992–93	1 370	19	2 250	3.2	0.8	2.5	1.6	3.9	1.2
1993–94	1 499	19	1 394	2.8	1.1	3.2	0.9	1.4	0.5
1994–95	877	11	1 138	2.9	0.8	2.2	1.3	5.7	2.0
1995–96	270	7	500	2.9	1.0	3.1	1.9	10.0	3.4
1996–97	385	7	332	3.0	0.8	2.5	0.9	3.5	1.2
1997–98	215	8	228	3.1	0.7	2.2	1.1	6.0	2.0
1998–99	707	21	838	3.0	0.8	2.3	1.2	4.2	1.4
1999–2000	598	11	335	3.0	1.0	3.2	0.6	2.6	0.9
2000–01	1 002	13	944	3.0	2.6	7.5	0.9	1.5	0.5
2001–02	2 154 (277)	20 (2)	1 656 (207)	2.9	3.9	11.2	0.8	1.4	0.5
2002–03	1 939 (40)	22 (1)	938 (10)	2.9	3.8	10.8	0.5	0.9	0.3
2003–04	869	16	495	2.9	3.5	10.0	0.6	0.9	0.3
2004–05	1 010	18	452	2.8	4.6	12.6	0.5	0.7	0.3

**Table 10: Monthly distribution of effort (number of tows). From the “Core region”.**

Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1988–89	0	0	0	0	0	0	0	0	17	5	1	10
1989–90	0	0	0	0	13	11	0	0	0	12	4	0
1990–91	0	0	0	0	0	0	0	0	3	1	0	0
1991–92	0	0	0	0	0	0	0	0	0	56	0	0
1992–93	0	0	0	2	0	0	23	338	762	219	24	2
1993–94	40	22	51	24	70	11	103	259	491	199	228	1
1994–95	126	81	71	36	2	0	32	43	179	168	74	65
1995–96	9	16	7	3	24	9	1	39	134	28	0	0
1996–97	24	8	32	8	11	0	58	79	165	0	0	0
1997–98	4	29	0	1	0	0	19	39	104	13	0	6
1998–99	1	0	5	23	3	24	3	113	487	23	0	25
1999–2000	59	56	28	49	28	34	11	100	216	6	0	11
2000–01	0	44	66	86	25	76	40	152	422	26	21	44
2001–02	71	54	25	41	48	103	356	535	843	200	91	31
2002–03	3	38	6	32	19	72	287	447	712	208	68	16
2003–04	16	36	2	2	6	20	47	192	414	75	0	0
2004–05	7	2	0	1	21	20	126	244	244	216	0	0

**Table 11: Monthly distribution of catch (t) from the “Core region”.**

Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1988–89									20	3	0	84
1989–90					9	13				3	0	
1990–91									1	0		
1991–92										230		
1992–93				0			3	473	1 473	298	3	0
1993–94	50	25	43	3	18	0	10	185	560	252	247	0
1994–95	141	73	21	3	0		20	12	653	158	29	28
1995–96	2	1	0	0	7	2	0	5	468	13		
1996–97	4	1	10	0	0		13	26	278			
1997–98	0	43		0			2	43	131	8		1
1998–99	0		0	7	0	3	1	92	726	4		5
1999–2000	40	27	5	12	9	2	0	54	178	1		7
2000–01		41	34	44	6	25	15	115	565	37	41	21
2001–02	45	34	9	27	65	92	227	417	724	166	36	8
2002–03	1	14	2	12	12	41	136	175	370	133	22	5
2003–04	3	9	0	0	2	15	23	68	274	76		
2004–05	1	1		0	1	3	44	88	107	149		



**Figure 7: Distribution of catch rates of orange roughy (catch per trawl) on the Northwest Challenger Plateau (total area) during the 2002–03, 2003–04, and 2004–05 fishing years (+, trawl position; circle area proportional to catch, max = 25 t).**

**Table 12: Monthly distribution of catch rates (t/tow) from New Zealand TCEPR/HS-CER and CELR returns. Blanks indicate months when there was no effort (see Table 10). “Core region”.**

Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1988–89									1.2	0.7	0.4	8.4
1989–90					0.7	1.1				0.3	0.0	
1990–91									0.3	0.0		
1991–92										4.1		
1992–93				0.0			0.1	1.4	1.9	1.4	0.1	0.1
1993–94	1.2	1.1	0.8	0.1	0.3	0.0	0.1	0.7	1.1	1.3	1.1	0.0
1994–95	1.1	0.9	0.3	0.1	0.0		0.6	0.3	3.6	0.9	0.4	0.4
1995–96	0.3	0.1	0.1	0.0	0.3	0.2	0.0	0.1	3.5	0.5		
1996–97	0.2	0.1	0.3	0.0	0.0		0.2	0.3	1.7			
1997–98	0.1	1.5		0.0			0.1	1.1	1.3	0.6		0.2
1998–99	0.1		0.1	0.3	0.0	0.1	0.2	0.8	1.5	0.2		0.2
1999–2000	0.7	0.5	0.2	0.2	0.3	0.1	0.0	0.5	0.8	0.1		0.6
2000–01		0.9	0.5	0.5	0.2	0.3	0.4	0.8	1.3	1.4	2.0	0.5
2001–02	0.6	0.6	0.4	0.7	1.4	0.9	0.6	0.8	0.9	0.8	0.4	0.3
2002–03	0.3	0.4	0.3	0.4	0.6	0.6	0.5	0.4	0.5	0.6	0.3	0.3
2003–04	0.2	0.2	0.2	0.1	0.3	0.8	0.5	0.4	0.7	1.0		
2004–05	0.1	0.2		0.0	0.1	0.3	0.3	0.4	0.4	0.7		

### 3.4.3 Unstandardised CPUE analysis

The reduced input data set for CPUE analyses consisted of over 10 000 tows by 30 vessels for the core Northwest Challenger fishery (Table 13). These vessels accounted for 80% of the total effort and catch in the fishery. The number of unsuccessful tows (where no orange roughy catch was recorded) has decreased substantially in the last three fishing years, but in spite of this, catch rates have declined, and for the last five years have been below 1 t/tow or 1 t/n.mile (Table 13).

The cropped data set, using short tows in June only, gave slightly different results (Table 14). This set was relatively small, involving 16 vessels, which accounted for 13% of the total effort and 24% of the total catch. Catch rates in recent years have been variable, with an increase in 2001–02 from 2000–01, but a substantial decrease in 2002–03, and again in 2004–05.

Trends in CPUE for both data sets are graphed in Figure 8.

**Table 13: CPUE indices for core vessels from all seasons.**

Fishing year	Number of tows	Catch (t)	Unstandardised CPUE		
			t/tow	t/n.mile	% 0 catch
1992–93	474	819	1.7	0.9	20
1993–94	1 115	1 343	1.2	0.6	42
1994–95	869	1 136	1.3	2.0	39
1995–96	266	499	1.9	3.5	36
1996–97	379	330	0.9	1.2	41
1997–98	211	227	1.1	2.0	35
1998–99	463	622	1.3	1.3	25
1999–2000	430	190	0.4	0.6	29
2000–01	997	940	0.9	0.5	15
2001–02	2 098	1 633	0.6	0.5	10
2002–03	1 822	896	0.5	0.3	12
2003–04	786	464	0.6	0.3	9
2004–05	828	385	0.5	0.3	7

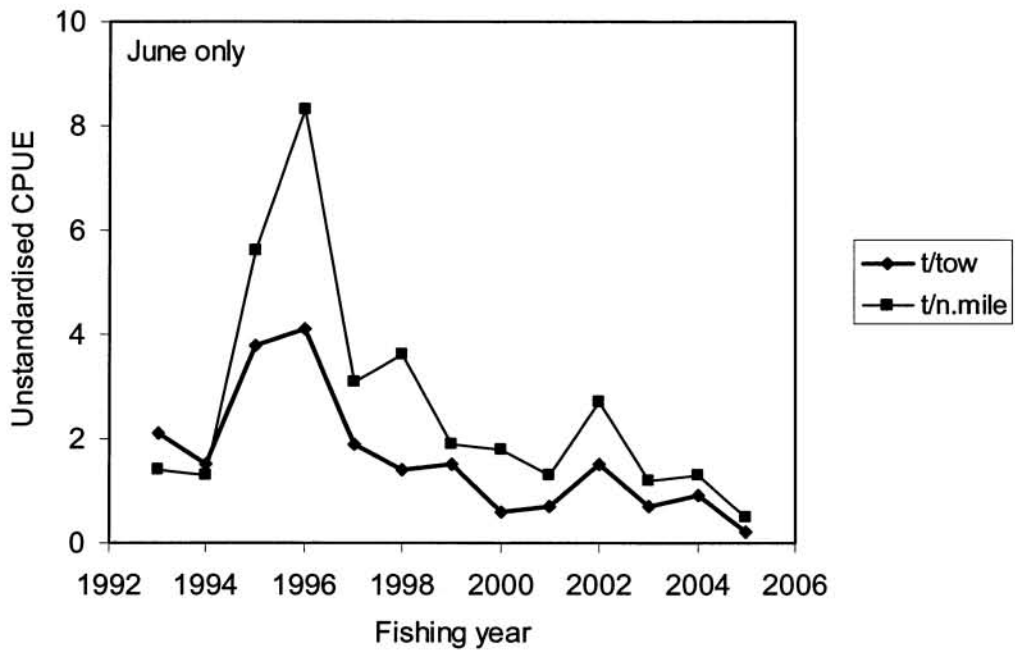
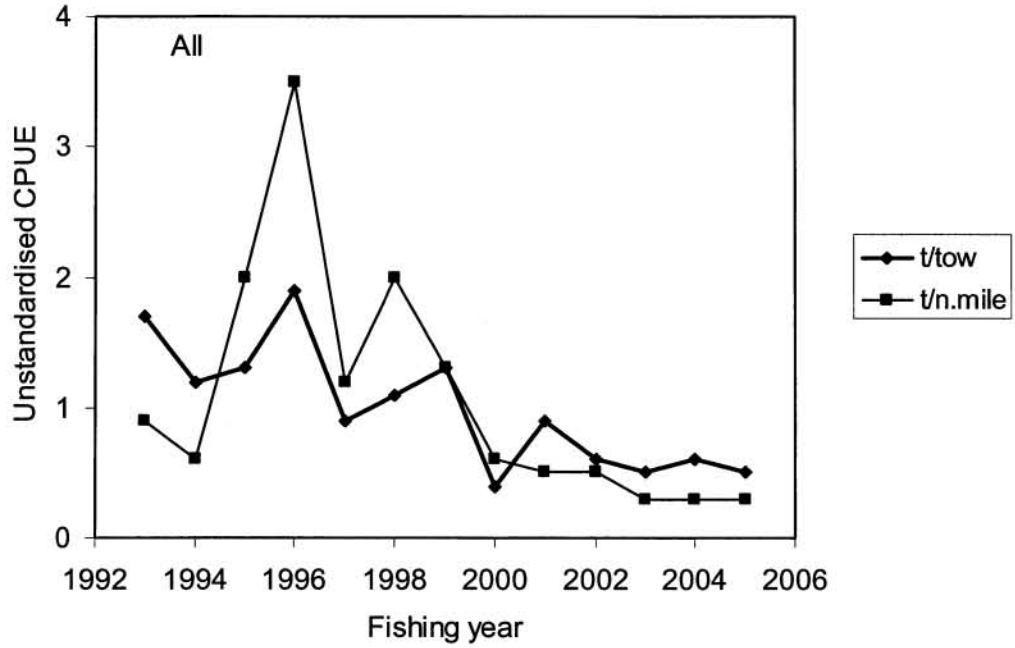
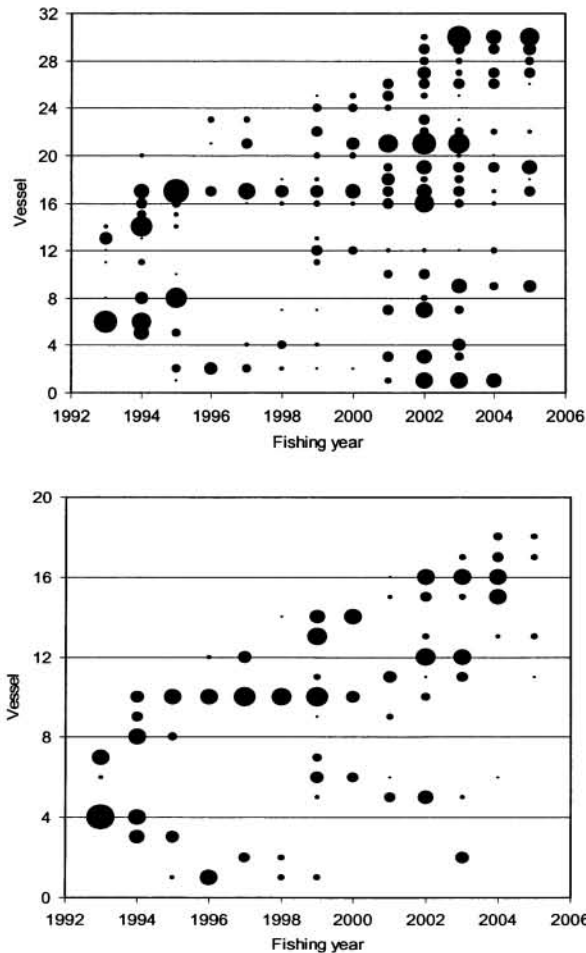


Figure 8: Unstandardised CPUE indices from the Northwest Challenger orange roughy fishery 1992–93 to 2004–05 (data in Tables 13–14). “All seasons” refers to the full data set. “June” refers to that comprising tows less than 1 h by the core vessels in June (peak spawning). 1992 on x axis refers to the 1991–92 fishing year.

**Table 14: CPUE indices for cropped data from June only.**

Fishing year	Number of tows	Catch (t)	Unstandardised CPUE		
			t/tow	t/n.mile	% 0 catch
1992-93	182	385	2.1	1.4	15
1993-94	187	283	1.5	1.3	28
1994-95	105	399	3.8	5.6	32
1995-96	103	426	4.1	8.3	33
1996-97	131	244	1.9	3.1	31
1997-98	80	108	1.4	3.6	26
1998-99	251	367	1.5	1.9	26
1999-2000	101	64	0.6	1.8	33
2000-01	65	49	0.7	1.3	32
2001-02	203	301	1.5	2.7	20
2002-03	174	127	0.7	1.2	26
2003-04	143	123	0.9	1.3	24
2004-05	38	7	0.2	0.5	16

The distribution of effort between vessels over time was highly variable in both the CPUE data sets (Figure 9). The composition of the fleet fishing outside the EEZ was inconsistent and variable, as in the Lord Howe fishery, and few vessels currently fishing were involved in the early years.



**Figure 9: Annual distribution of tows by the core vessels included in the CPUE analysis from all seasons (upper panel) and from the June hill fishery (lower panel). Circle area is proportional to the number of tows in each year. 1992 on x-axis refers to the 1991-92 fishing year.**

## **3.5 West Norfolk Ridge fishery**

### **3.5.1 Catch effort data**

There were 727 tows from 7 vessels in the groomed TCEPR/HS-CER data from the West Norfolk Ridge to the end of 2004–05 (Table 15). The fishery was developed in 2000–01 by several Australian vessels, but New Zealand registered vessels quickly entered the fishery. The New Zealand data set consists of five domestic and one Australian-registered vessel. The former account for 99% of New Zealand tows. All trawls were reported as targeting orange roughy.

Tows have been very similar in duration and distance over the period of the fishery, with a mean tow duration of 0.3–0.5 h, and a mean distance of 0.9–1.5 n.mile. The fishery takes place largely on small seamount-like features and peaks along the West Norfolk Ridge. There is limited ground for longer flat-bottom trawling.

Unstandardised catch rates for all groomed data combined were expressed as tonnes per tow, tonnes per hour, and tonnes per nautical mile (Table 15). These three measures all decreased from 2001–02 to 2003–04, and then increased in 2004–05

### **3.5.2 Seasonal and spatial distribution of catch and effort**

With only four years of data, there is little one can say about seasonal trends in catch and effort. However, effort in the fishery has been spread over much of the year (Table 16). In 2001–02, most effort was in March and July, with more than 50 trawls in each. January, February, and August all recorded 30 or more trawls. There were fewer trawls in 2002–03, and no month had more than 20 tows, while fishing in 2003–04 was primarily in October and September. In 2004–05 most effort occurred in May and June. The catch was also spread throughout the year in 2001–02 (Table 17), with November, December, March, and July all featuring with more than 50 t of catch. Trawling in most months yielded relatively good catches. In 2002–03, there were no monthly catches over 11 t. In 2003–04 catches in July totalled 28 t. Most catch was taken in 2004–05 between April and June.

Catch rates in 2001–02 were high in November and December (6–7 t/tow), and over 2 t/tow were taken in May and June (Table 18). By contrast, the maximum monthly average catch rate in 2002–03 was less than 1 t/tow. In 2003–04 catch rates in June and July were 1.5 and 2.8 t/tow respectively. April was the most successful month for fishing in 2004–05, with catch rates of 2 t/tow.

The distribution of catch rates has changed between years (Figure 10). In 2001–02, most effort, and high catch rates, occurred on the northern end of an elongated seamount, with moderate effort and good catches in an area to the west. The distribution of tows was similar in 2002–03, but catch rates were clearly greatly reduced. In 2003–04 highest catch rates were from the ridge to the west, and fishing had extended to the north with some success. Largest catches in 2004–05 were on the southern end of the northern ridge, with a spread of effort to the west.

**Table 15: Summary of groomed tow-by-tow data from TCEPR/HS-CER forms for the West Norfolk Ridge orange roughy fishery.**

Fishing year	Number of vessels	Number of tows	Total recorded catch (t)	Mean tow speed (kt)	Mean tow length (h)	Mean tow length (n.mile)	Mean catch rate (t/tow)	Mean catch rate (t/h)	Mean catch rate (t/n.mile)
2000-01	1	1	0.2						
2001-02	3	297	586	3.0	0.3	0.9	2.0	9.0	3.0
2002-03	5	91	35	3.0	0.3	0.9	0.4	2.4	0.8
2003-04	2	90	88	3.0	0.5	1.5	1.0	2.3	0.8
2004-05	6	248	274	3.0	0.4	1.3	1.1	4.4	1.5

**Table 16: Monthly distribution of effort (number of tows) in the West Norfolk Ridge orange roughy fishery from New Zealand TCEPR/HS-CER returns.**

Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2000-01	0	0	0	1	0	0	0	0	0	0	0	0
2001-02	12	16	11	31	31	55	25	14	15	57	30	0
2002-03	13	17	3	10	0	0	17	11	1	19	0	0
2003-04	20	0	4	0	0	0	2	15	12	10	0	27
2004-05	16	24	0	11	0	31	38	54	53	21		

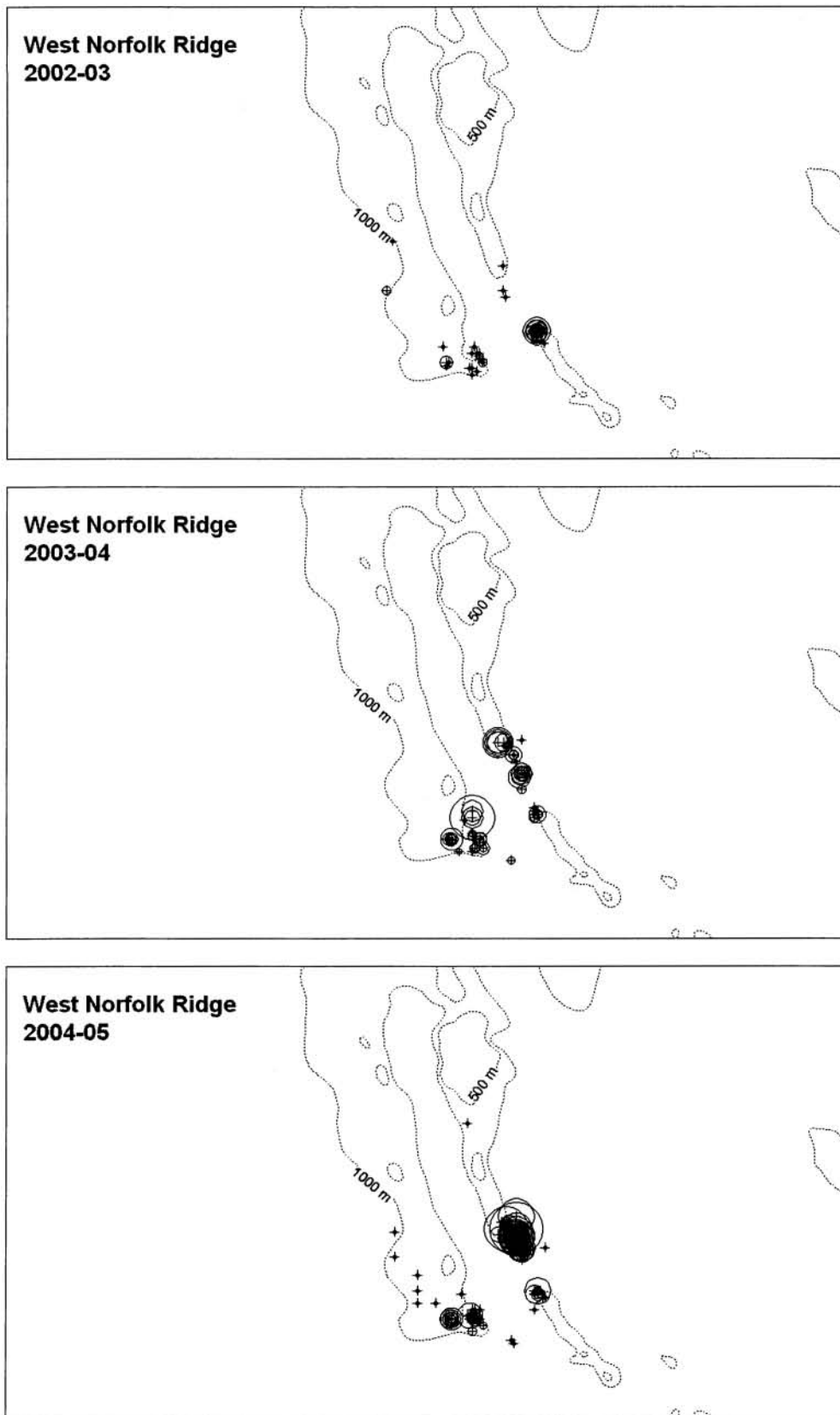
**Table 17: Monthly distribution of catch (t) in the West Norfolk Ridge orange roughy fishery from New Zealand TCEPR/HS-CER returns. Blanks indicate months when there was no effort (Table 16).**

Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2000-01				0.2								
2001-02	1	97	79	50	42	82	28	49	37	111	11	
2002-03	11	8	2	1			3	7	0.1	2		
2003-04	11		2				1	11	17	28		19
2004-05	17	14		2		18	75	42	80	24		

**Table 18: Monthly distribution of catch rates (t/tow) in the West Norfolk Ridge orange roughy fishery from New Zealand TCEPR/HS-CER returns. Blanks indicate months when there was no effort.**

Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2000-01				0.2								
2001-02	0.1	6.0	7.1	1.6	1.4	1.5	1.1	3.5	2.5	1.9	0.4	
2002-03	0.9	0.5	0.8	0.1			0.2	0.7	0.1	0.1		
2003-04	0.5		0.4				0.2	0.7	1.4	2.8		0.7
2004-05	1.0	0.6		0.2		0.6	2.0	0.8	1.5	1.1		





**Figure 10: Distribution of catch rates of orange roughy (catch per trawl) on the West Norfolk Ridge during the 2002–03, 2003–04, and 2004–05 fishing years (+, trawl position; circle area proportional to catch, max = 20 t).**

## **3.6 Louisville Ridge fishery**

### **3.6.1 Catch effort data**

There were about 17 500 tows from 54 vessels in the groomed TCEPR/HS-CER data from the Louisville Ridge (Table 19). The New Zealand data set consists primarily of New Zealand registered vessels (80% of tows), although other nationalities include USSR, Ukraine (since 1999), Korea, Norway, Japan, Belize, and the Cook Islands. The fishery is almost exclusively directed at orange roughy, with a very small number of tows with alfonsino or oreos as the declared target species.

New Zealand vessels first fished the Louisville Ridge in the 1993–94 fishing year. Reported catches rose from about 200 t in that year to over 11 000 t the following year (Table 19). Catches subsequently dropped for the next three years, before an increase in 1998–99. Since then catches have been relatively constant at 1000–1500 t per year. The Australian catch is believed to have been moderate in 1993–94 (primarily August–September 1994, over 500 t) when the fishery first developed. This increased to about 2000 t in 1994–95, decreased to 50 t in 1995–96, and the only other year Australian vessels are known to have been active was 1998–99 (140 t). There are no data available on the catch of other countries, but it is not thought to have ever been very substantial.

Tows have been similar in duration and distance in the last few years of the fishery, with a mean tow duration of 0.4–0.6 h, and a mean distance of 1–2 n.mile (Table 19). These tows are relatively long for a fishery that takes place mainly on seamount features, but the Louisville seamounts are much larger than those in most New Zealand fishing grounds.

Unstandardised catch rates for all groomed data combined were expressed as tonnes per tow, tonnes per hour, and tonnes per nautical mile (Table 19). These three measures have varied substantially in recent years, from high levels in 2000–01, a drop, then an increase in 2002–03, lower levels in 2003–04, and an increase in 2004–05.

### **3.6.2 Seasonal and spatial distribution of catch and effort**

There have been strong seasonal trends between years in catch and effort. Initially effort in the fishery was spread over much of the year (Table 20), but this began to contract in 1997–98, and from 1998–99 onwards, effort has been heavily concentrated in June, July, and August, with some limited trawling in February and May. The distribution of catch by month reflects the effort, with combined catches in June-July-August accounting for over 95% of the total New Zealand catch over the period 2000–01 to 2004–05 (Table 21).

Catch rates by month have been variable in recent years (Table 22). Through the late 1980s, the average catch per tow in June was between 2 and 3 t/tow, but this has decreased to about 1 t/tow in 2001–02 and 2002–03. In contrast to this, catch rates have tended to increase in July in the last few years. Catch rates during August have been variable, with no obvious trend.

The distribution of New Zealand catches has varied between years. The fishery initially developed in the central region in 1994–95, with other grounds quickly developing in the northern region of the Ridge, and southern seamounts also yielding good catch rates from 1995–96. Over the last three years (Figure 11), effort has decreased in the central region, and good catch rates have occurred on fewer seamounts. Fishing has expanded to more features in the southern area.

**Table 19: Summary of groomed tow-by-tow data from TCEPR/HS-CER forms for the Louisville Ridge.**

Fishing year	Number of vessels	Number of tows	Total recorded catch (t)	Mean tow speed (kt)	Mean tow length (h)	Mean tow length (n.mile)	Mean catch rate (t/tow)	Mean catch rate (t/h)	Mean catch rate (t/n.mile)
1993-94	7	134	189	2.5	1.4	3.5	1.4	1.5	0.6
1994-95	31	4 294	11 340	2.5	0.7	1.7	2.6	10.6	4.2
1995-96	26	4 024	8 764	2.5	0.7	1.7	2.2	7.4	3.0
1996-97	16	1 849	3 209	2.5	0.8	1.9	1.7	5.3	2.1
1997-98	13	787	1 404	2.9	0.5	1.5	1.8	14.2	4.8
1998-99	17	1 093	3 025	2.9	0.5	1.5	2.7	14.2	5.2
1999-2000	12	918	1 369	3.0	0.5	1.5	1.5	11.4	3.8
2000-01	11	749	1 598	3.0	0.5	1.7	2.1	18.0	2.3
2001-02	15	889	1 004	3.1	0.6	2.0	1.1	7.4	2.4
2002-03	11	736	1 296	3.0	0.4	1.1	1.8	13.8	4.6
2003-04	12	1336	1419	3.1	0.4	1.1	1.1	8.7	2.8
2004-05	8	742	1 503	3.1	0.4	1.1	2.0	13.1	4.3

**Table 20: Monthly distribution of effort (number of tows) in the Louisville Ridge orange roughy fishery from New Zealand TCEPR/HS-CER returns.**

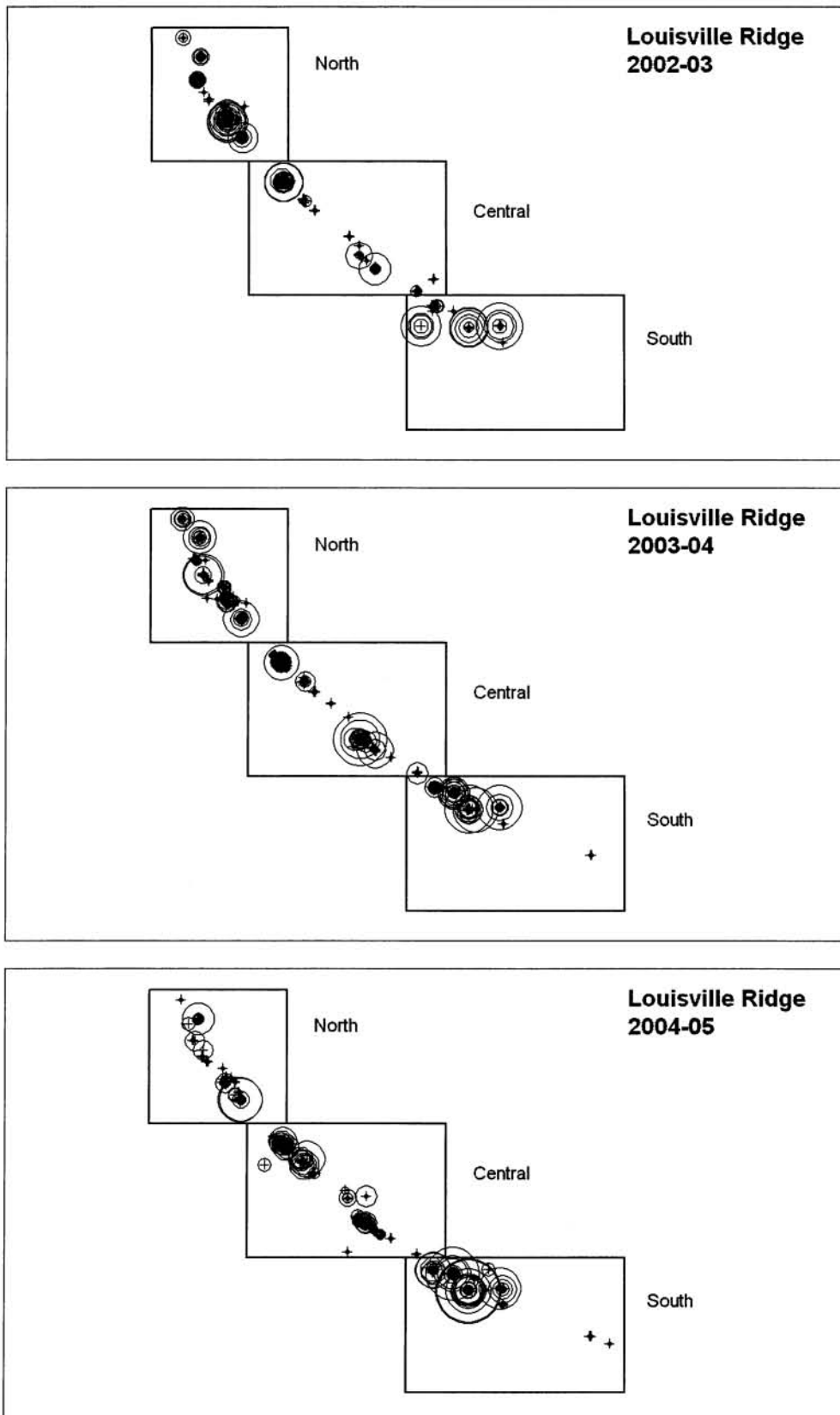
Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1993-94	0	0	0	2	0	0	2	2	0	52	6	70
1994-95	13	102	142	307	304	742	327	474	516	769	295	303
1995-96	222	255	230	479	267	271	222	260	969	477	369	3
1996-97	29	123	112	12	78	39	142	108	603	304	299	0
1997-98	2	0	0	94	40	35	84	3	162	206	161	0
1998-99	0	0	0	0	13	0	9	0	140	511	414	5
1999-2000	0	52	0	9	8	14	0	110	227	370	114	0
2000-01	0	0	0	0	67	0	0	11	307	221	141	0
2001-02	0	0	0	32	21	0	0	121	474	166	74	0
2002-03	0	0	0	0	0	31	2	32	319	234	119	0
2003-04	0	4	27	15	2	46	0	6	536	404	269	27
2004-05	0	0	0	30	0	0	0	3	191	338	177	3

**Table 21: Monthly distribution of catch (t) in the Louisville Ridge orange roughy fishery from New Zealand TCEPR/HS-CER returns. Blanks indicate months when there was no effort (see Table 20).**

Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1993-94				7			0	0		108	1	73
1994-95	25	144	339	763	1530	1882	981	995	2108	1662	535	377
1995-96	173	155	186	568	450	376	115	238	2408	2812	1233	1
1996-97	6	122	35	34	85	23	303	61	857	945	738	
1997-98	1			247	31	12	10	50	360	403	290	
1998-99					42		0		346	1339	1212	85
1999-2000		7		2	5	43		34	499	414	365	
2000-01					81			9	830	244	436	
2001-02				3	12			34	365	286	304	
2002-03						18	0	25	392	478	381	
2003-04		0	7	8	0	39		3	540	358	457	6
2004-05				17				10	367	423	687	1

**Table 22: Monthly distribution of catch rates (t/tow) in the Louisville Ridge orange roughy fishery from New Zealand TCEPR/HS-CER returns. Blanks indicate months when there was no effort (see Table 20).**

Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1993-94				3.5			0	0		2.1	0	1.0
1994-95	1.9	1.4	2.4	2.5	5.0	2.5	3.0	2.1	4.1	2.2	1.8	1.2
1995-96	0.8	0.6	0.8	1.2	1.7	1.4	0.5	0.9	2.5	5.9	3.3	0.3
1996-97	0.2	1.0	0.3	2.8	1.1	0.6	2.1	0.6	1.4	3.1	2.5	
1997-98	0.5			2.6	0.8	0.3	0.1	16.7	2.2	2.0	1.8	
1998-99					3.2		0		2.5	2.6	2.9	17.0
1999-2000		0.1		0.2	0.6	3.1		0.3	2.2	1.1	3.2	
2000-01					1.2			0.8	2.7	1.1	3.1	
2001-02				0.1	0.6			0.3	0.8	1.7	4.1	
2002-03						0.6	0.2	0.8	1.2	2.0	3.2	
2003-04		0	0.3	0.5	0	0.8		0.6	1.0	0.9	1.7	0.2
2004-05				0.6				3.3	1.9	1.3	3.9	0



**Figure 11: Distribution of catch rates of orange roughy (catch per trawl) on the Louisville Ridge during the 2002–03, 2003–04, and 2004–05 fishing years (+, trawl position; circle area proportional to catch, max = 90 t).**

### 3.6.3 Unstandardised CPUE

Unstandardised CPUE has been examined previously based on mean catch per trawl for the total Louisville Ridge area and the three main regions separately. This is updated in Table 23. The progressive contraction in distribution of effort and catch towards the winter months has suggested that unstandardised CPUE should also be presented for the June to August period which has been fished consistently each year.

Most fishing grounds showed reductions in CPUE from peak values in the first few years to relatively low values in 1997–98. CPUE increased in all areas in 1998–99, and declined in north and central regions in 1999–2000. Over the last few years CPUE has fluctuated, with overall unstandardised catch rates dropping in 2001–02, increasing in 2002–03, decreasing in 2003–04, and increasing in 2004–05. There is a similar pattern in the winter, which is to be expected as the bulk of the fishery occurs then. The patterns in catch rate differ slightly between regions, but the temporal trends are similar. Changes in the Central region have been less than in the North and South. The increases in 2004–05 were especially strong in North and South areas.

**Table 23: Average catch rate (t per tow) of orange roughy by New Zealand vessels from the Louisville Ridge, 1993–94 to 2004–05, and by sub-area. The winter column is for June–August.**

	Full Area		North		Central		South	
	All year	Winter	All year	Winter	All year	Winter	All year	Winter
1993–94	1.4	1.9			1.5	1.9		
1994–95	2.6	2.7	1.7	3.9	2.7	2.6	2.3	11.0
1995–96	2.2	3.6	3.0	6.0	1.4	2.1	2.8	3.9
1996–97	1.7	2.1	1.2	1.4	1.8	2.0	3.3	3.5
1997–98	1.8	2.0	1.7	1.9	2.0	2.4	0.7	0.7
1998–99	2.7	2.7	2.0	2.1	3.0	2.9	1.8	1.7
1999–2000	1.5	1.8	1.4	2.1	1.5	1.6	2.3	2.8
2000–01	2.1	2.3	2.4	2.6	1.9	2.0	1.9	1.9
2001–02	1.1	1.3	0.8	0.9	1.9	2.3	2.8	3.9
2002–03	1.7	1.9	1.6	1.7	1.2	1.2	5.3	5.3
2003–04	1.1	1.1	0.7	0.7	1.4	1.4	1.6	1.8
2004–05	2.0	2.1	1.6	1.8	1.6	1.6	2.8	2.9

The trends over the entire period of the fishery are clearly seen in Figure 12.

Vessel composition in the fishery has changed markedly over time (Figure 13). The number of vessels has decreased in recent years, and several of the current vessels were not involved in the early years of the fishery. However, most vessels have fished for several years, with a reasonable number of tows, and hence the data set was not reduced for the unstandardised CPUE analysis as it was for the Lord Howe Rise and Northwest Challenger fisheries.

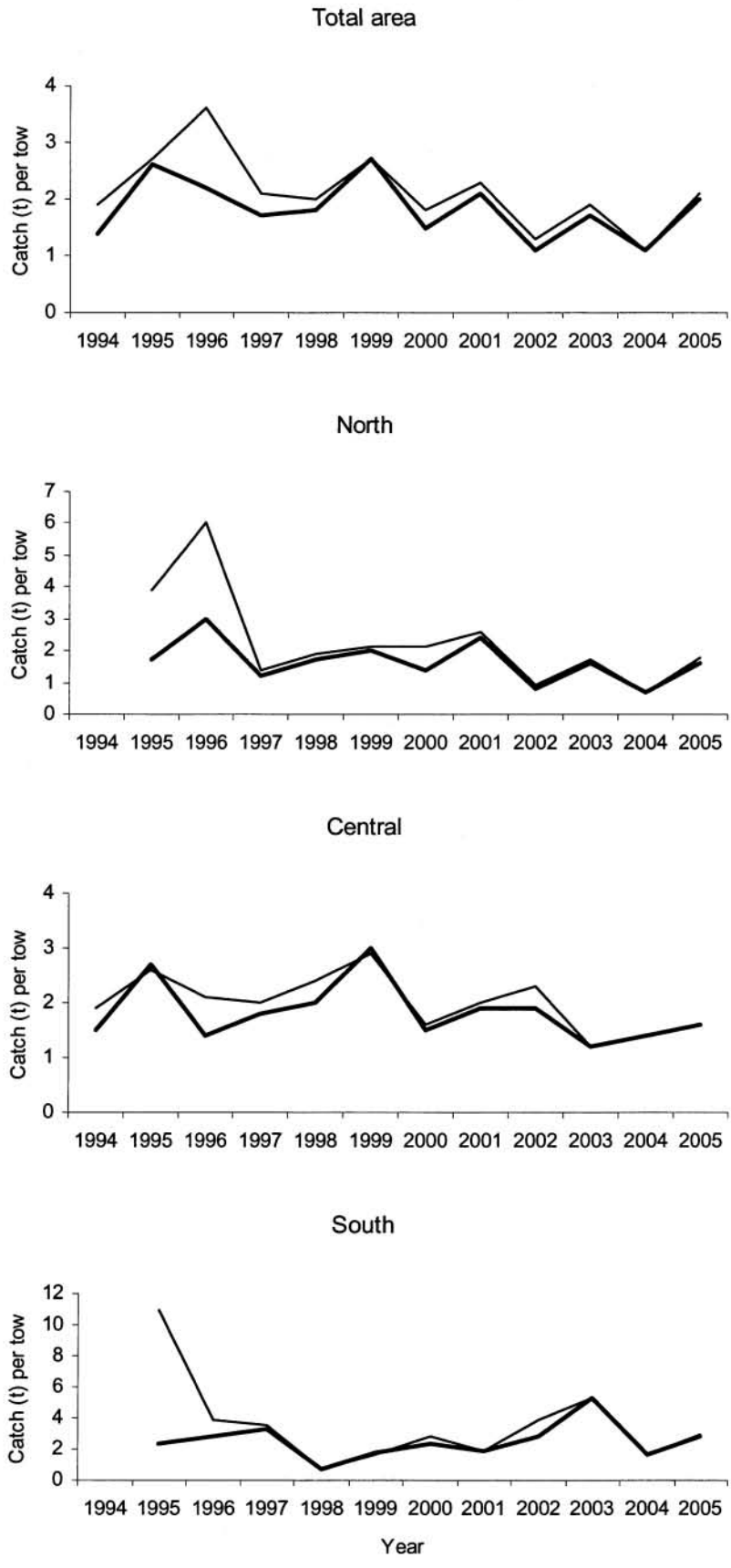
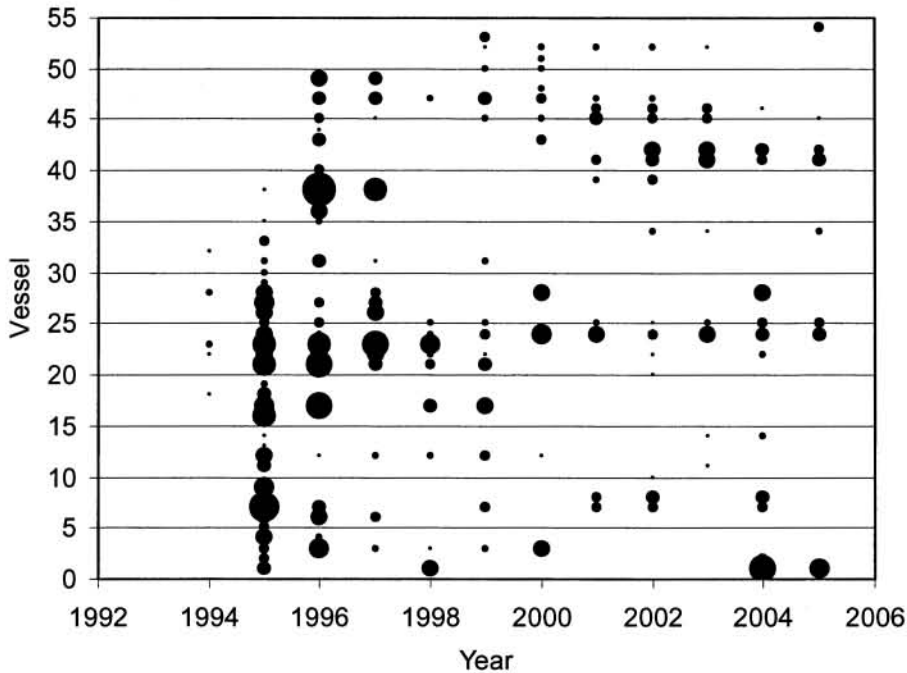


Figure 12: Unstandardised CPUE (t/tow) by area by year for all months (heavy line) and for the winter (thin line).

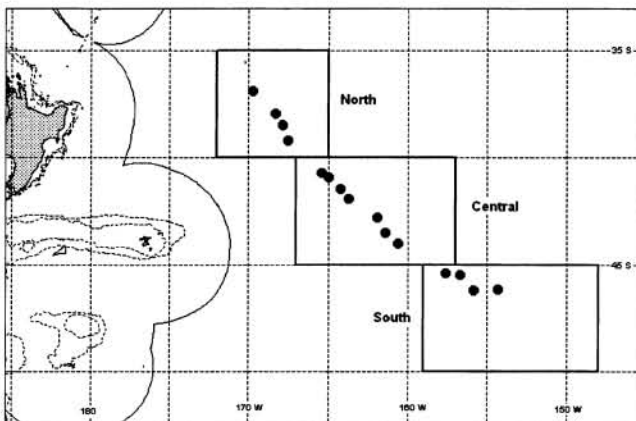


**Figure 13: Annual distribution of tows by vessels included in the CPUE analysis from the Louisville Ridge. Circle area is proportional to the number of tows in each year. 1992 on x-axis refers to the 1991–92 fishing year.**

### 3.6.3.1 Individual seamounts CPUE

The Louisville Ridge consists of an extensive chain of seamounts. The distribution of fishing has varied over time between seamounts, and this is thought to have been a confounding factor in previous CPUE analyses (Clark 2000) where broad regions have been considered. Up to 11 seamounts were chosen by Clark & Anderson (2001, 2003) and Clark (2003) to examine changes in catch and effort on the scale of an individual seamount. Over the duration of the fishery, these 11 features have accounted for 82% of the tows by New Zealand vessels, and 84% of the orange roughy catch. A further 4 seamounts were added to the analysis this year to include the extension of the fishery to the southeast (Figure 14).

Most of the seamounts have experienced a general decrease in catch rates over time (Figure 15), with broadly similar patterns in winter and the rest of the year. However, the extent of the decrease has varied between seamounts, indicating that the level of depletion is unlikely to have been consistent over the large area covered by the fishery. Northern and western seamounts have seen large fluctuations in catch rates, and the major central seamounts of Mts Ghost and Whales a more gradual and consistent decline to 2000–01 and 2001–02 when high catch rates occurred on Mt Ghost. Catch rates decreased again on Mt Ghost to 2004–05, but the last year saw an increase in fishing success on Mt Whales. Catch rates on those seamounts further east (East 1 to 4, FarEast and South 1 to 4) are more variable, with different patterns on various seamounts.



**Figure 14: Location of the 15 seamounts (closed circles) on the Louisville Ridge.**

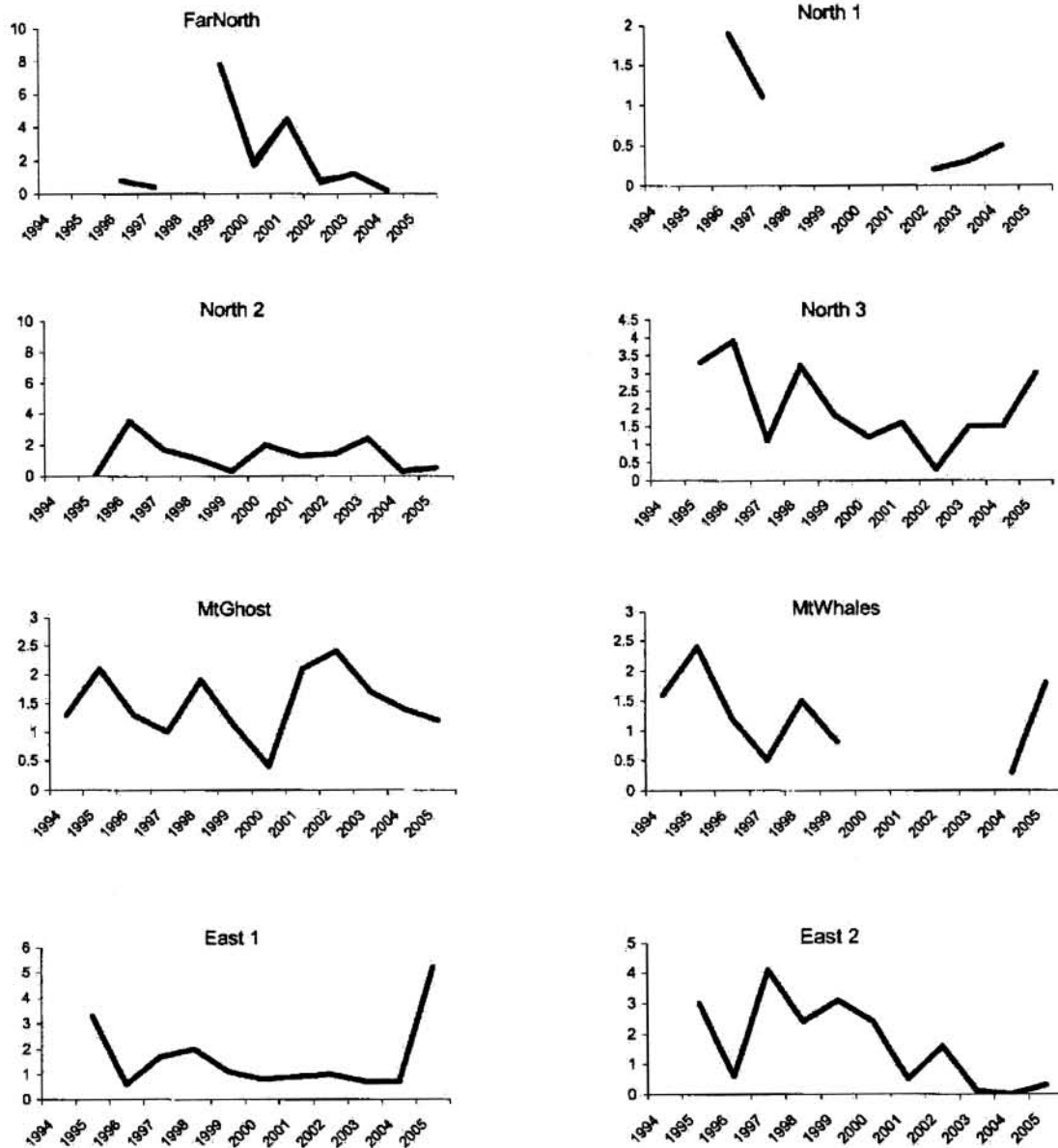


Figure 15: Unstandardised CPUE (t/tow, y-axis) on selected seamount groups by fishing year (1999 on x.axis = 1998–99 fishing year).



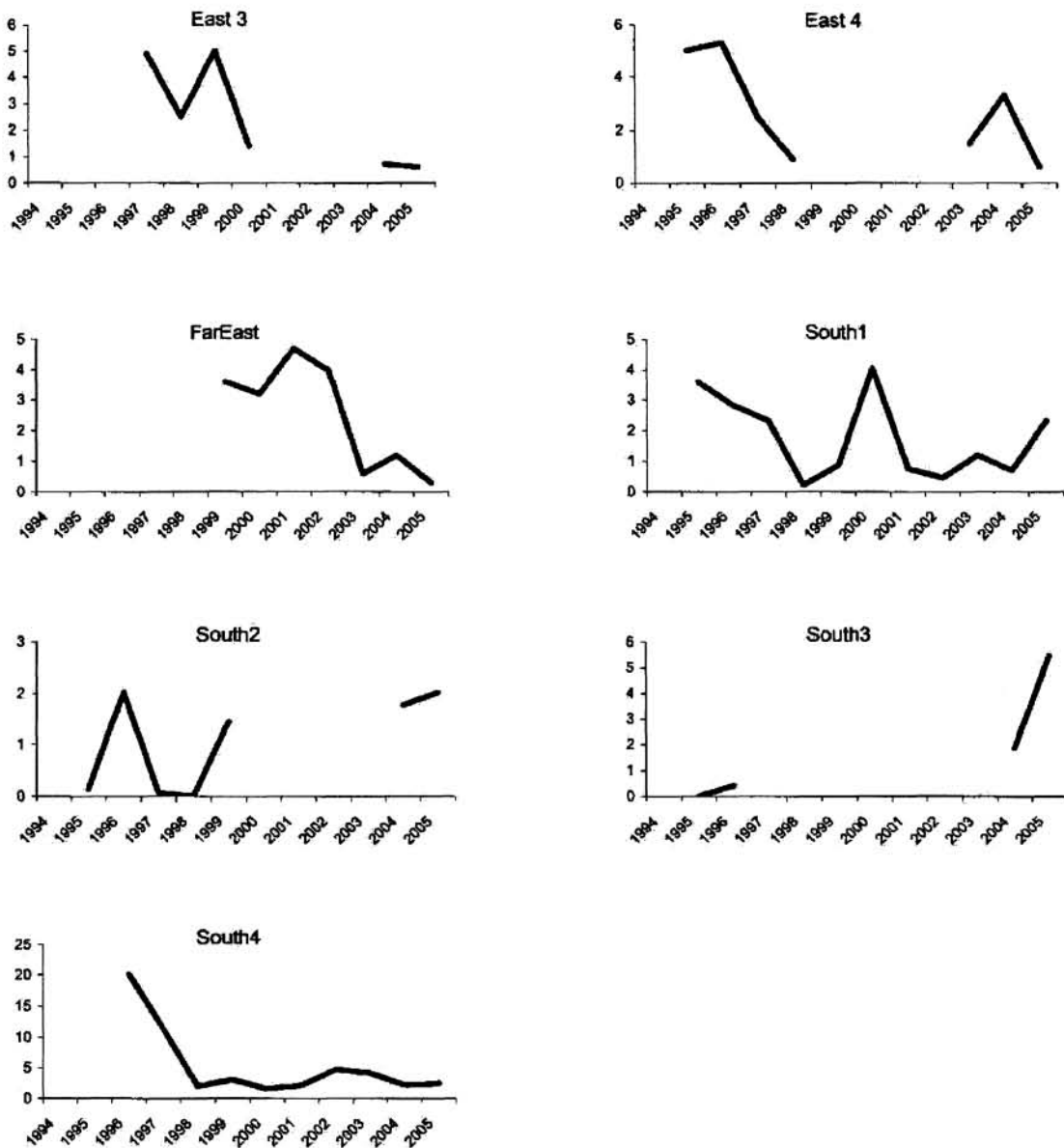


Figure 15 (cont): Unstandardised CPUE (t/tow, y-axis) on selected seamount groups by fishing year (1999 on x.axis = 1998–99 fishing year).

## 3.7 South Tasman Rise fishery

### 3.7.1 Catch effort data

The fishery started in September 1997, and expanded rapidly. An estimated 3900 t was caught in the 1997–98 fishing year (Table 24). Reported catches were 1700 t the following year, and increased to over 4000 t in 1999–2000. One Belizean and three South African vessels fished for a period during the 1999 winter, but no other non-Australasian vessels are known to have fished the region. Oreos were previously taken as bycatch in the fishery, with over 1000 t in both 1997–98 and 1998–99. Catches have dropped markedly since then, to less than 100 t during the last three fishing years.

**Table 24: Catch (t, rounded to nearest 5 t) of orange roughy (ORH) and oreos (OEO) by fishing year (Mar–Feb), 1996–97 to 2004–05. (Aus, Australia; NZ, New Zealand; catch figures for 2005–06 are incomplete).**

	ORH				OEO			
	Aus	NZ	Other	TOT	Aus	NZ	Other	TOT
1996–97	5	0	0	5	45	0	0	45
1997–98	3 520	410	0	3 930	1 085	120	0	1 205
1998–99	1 190	515	0	1 705	1 290	300	0	1 590
1999–2000	1 720	1 640	>750	>4 110	190	25	30	245
2000–01	790	40	0	830	190	80	0	270
2001–02	170	0	0	170	120	0	0	120
2002–03	110	0	0	110	70	0	0	70
2003–04	5	0	0	5	160	0	0	160
2004–05	55	0	0	55	40	0	0	40
2005–06	12	0	0	12	150	0	0	150

The fishery was formally regulated by a Memorandum of Understanding (MoU) between Australia and New Zealand in December 1998, and a precautionary TAC of 2100 t was agreed on for 1 March 1998 to 28 February 1999, with an additional 300 t being made available for research surveys by commercial vessels during the winter spawning season. The TAC was increased to 2400 t for the 2000–01 fishing season, before being reduced in 2002–03 to 1800 t, and subsequently to 800 t and 600 t for 2003–04 and 2004–05 respectively.

Detailed catch-effort data are available from a total of 33 Australian and New Zealand vessels, which have carried out over 5000 trawls (Table 25). Overall, catch rates have been variable, whether measured by tonnes per tow or tonnes per hour (catch rates per distance are not given for this fishery, as Australian vessels do not report towing speed (which is used with tow duration to estimate distance)). Mean catch rates dropped from peak levels in 1997–98 and 1999–2000 to about one-third for 2000–01 to 2002–03. Catch rates in 2003–04 to the end of December 2004 were extremely low, and improved in 2004–05. Only one vessel fished in 2005–06, and so no effort data are presented.

### 3.7.2 Seasonal and spatial distribution of catch and effort

Data on levels of effort and catch by month are presented in Tables 26 and 27. Catch and effort levels have been affected by the MoU, which had limitations on the amount of catch in 6 month blocks per year, and this tended to force effort into March and April as fishers competed for the available quota. Since 2000–01, effort has focused more on the winter months, as catches and catch rates (Table 28) outside July and August have decreased. However, even in the peak

spawning months, catches have not generally been large despite intensive effort, and catch rates have been relatively low.

**Table 25: Summary of groomed tow-by-tow data from the South Tasman Rise (combined Australian and New Zealand data).**

Fishing year	Number of vessels	Number of tows	Total recorded catch (t)	Mean tow length (h)	Mean catch rate (t/tow)	Mean catch rate (t/h)
1996-97	2	61	4	0.6	0.1	0.5
1997-98	20	1 132	3 930	0.7	3.5	17.4
1998-99	18	1 332	1 705	0.6	1.3	10.4
1999-2000	16	1 086	3 360	0.5	3.1	21.1
2000-01	15	1 155	830	0.4	0.7	6.7
2001-02	5	201	170	0.8	1.0	3.5
2002-03	6	164	110	0.5	0.9	7.9
2003-04	5	67	2	0.3	0.1	0.4
2004-05	6	47	55	0.3	1.2	14.7
2005-06	1		12			

**Table 26: Monthly distribution of effort (number of tows) of New Zealand and Australian vessels.**

Fishing year	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
1996-97	0	0	0	0	0	0	0	0	0	0	0	0
1997-98	6	0	6	13	0	1	57	239	316	0	87	339
1998-99	415	8	0	0	15	36	318	198	58	63	11	210
1999-2000	374	452	186	12	2	0	13	6	0	10	0	31
2000-01	145	200	62	57	441	165	37	0	25	7	10	6
2001-02	6	6	33	22	32	61	10	0	24	0	6	0
2002-03	4	0	2	0	56	90	0	0	0	0	9	3
2003-04	1	0	0	5	4	12	0	11	26	8	0	0
2004-05	0	14	2	0	4	9	9	0	0	9	0	3
2005-06												

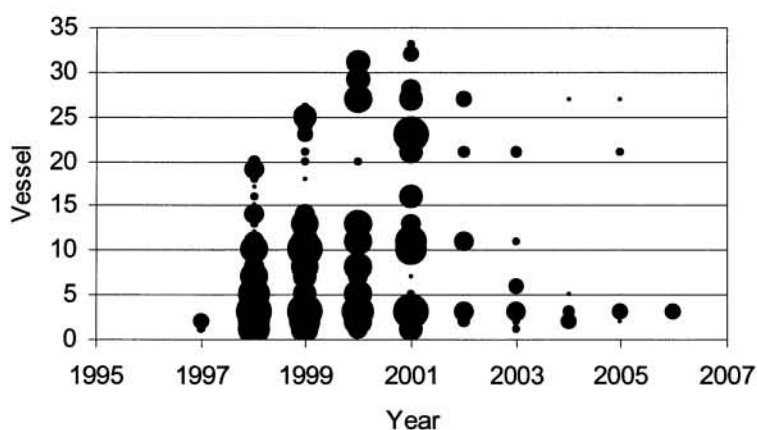
**Table 27: Monthly distribution of catch (t) of New Zealand and Australian vessels. Blanks indicate months when there was no effort (see Table 26).**

Fishing year	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
1996-97												
1997-98	0		0	0		0	106	1319	431		314	1748
1998-99	1042	0			0	238	13	37	8	1	0	269
1999-2000	445	1687	956	118	0		0	0		0		2
2000-01	31	20	13	96	620	48	0		0	0	0	0
2001-02	0	0	2	1	87	68	0		12		0	0
2002-03	0		0		62	41					9	0
2003-04	0			0	0	1		0	2	0		
2004-05		16	2		7	1	8			22		0
2005-06						1	1	4	2	4		

**Table 28: Monthly distribution of catch rates (t/tow) in the South Tasman Rise orange roughy fishery (combined NZ and Australian data). Blanks indicate months when there was no effort (see Table 26).**

Fishing year	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
1996–97												
1997–98	0		0	0		0	1.9	5.5	1.4		3.6	5.1
1998–99	2.5	0			0	6.6	0	0.2	0.1	0	0	1.3
1999–2000	1.2	3.7	5.1	9.8	0		0	0		0		0
2000–01	0.2	0.1	0.2	1.7	1.4	0.3	0		0	0	0	0
2001–02	0	0	0.1	0	2.7	1.1	0		0.5		0	
2002–03	0		0		1.1	0.4					1.0	0
2003–04	0			0	0	0		0	0.1	0		
2004–05		1.1	1		1.8	0.1	0.9			2.4		0
2005–06												

Vessel composition has varied between years: many vessels have fished in only one or two years (Figure 16). Since 2001–02, the number of vessels has decreased, with New Zealand boats leaving the fishery completely. The number of tows carried out by individual vessels has also declined markedly.



**Figure 16: Annual distribution of tows by vessels on the South Tasman Rise. Circle area is proportional to the number of tows in each year. 1998 on x-axis refers to the 1997–98 fishing year.**

The distribution of deepwater trawl shots (target/catch of orange roughy) is not plotted for this fishery (unlike the others) because, for the last three years, only Australian vessels have been involved in the fishery, and there is a need to preserve the confidentiality of their positional data.

#### 4. DISCUSSION

Most fisheries outside the New Zealand EEZ continue to have variable levels of catch and effort between years. Catch levels have decreased for all fisheries since they began, but in recent years the total catch by New Zealand vessels has been consistent at 2000–2500 t. Trends in catch and effort have been difficult to interpret, given changes in the vessel composition over time and the areas fished between years. Standardised CPUE analyses have not been carried out for several years, but unstandardised CPUE has been updated to continue monitoring general trends in the fisheries.

Mean catch rates for the Lord Howe Rise have increased in recent years, and the fishery appears more stable now following a period of low catch and effort in the mid 1990s. The orange roughy catch in the Northwest Challenger Plateau fishery has declined substantially in the last few years. Unstandardised CPUE has been at relatively low levels since 2000–01, and associated with a shift towards long tows on the flat, the winter fishery on the hills declined considerably in 2004–05. The Louisville Ridge fishery has been the largest of those in the New Zealand region, and catch and effort levels are broadly similar to those in recent years, although the patterns on individual seamounts differ, with some appearing stable, while others have declined. The fishery on the South Tasman Rise has decreased to very low levels, and New Zealand vessels have not fished the Rise since 2001. The West Norfolk Ridge fishery developed rapidly in 2001–02, and after an initial decrease in catch and effort, these increased in 2004–05 as new sites were fished.

Apart from the South Tasman Rise, none of these fisheries is formally managed, and levels of catch and effort are unpredictable between years. Typical catch rates are low, and none of the fisheries appear to represent substantial exploitable stocks. Strong declines seen in catch rates on some seamounts suggest that serial depletion can occur, and this is a difficult aspect to manage. Individual feature limits occur in some New Zealand orange roughy fisheries, and this may warrant consideration as the South Pacific RFMO develops.

#### 5. ACKNOWLEDGMENTS

This work was funded as part of the N.Z. Ministry of Fisheries research project ORH2005/03. Thanks to the Bureau of Resource Sciences (in particular Richard Tilzey and Phil Sahlqvist) for supplying Australian catch data.

#### 6. REFERENCES

- Clark, M.R. (1990). Orange roughy fisheries in the mid-Tasman Sea. In Abel, K.; Williams, M.; Smith, P (eds): Australian and New Zealand southern trawl fisheries conference. *Bureau of Rural Resources Proceedings 10*: 223–229.
- Clark, M.R. (1993). Orange roughy fisheries in international waters of the Lord Howe Rise: a summary of available commercial and research data. MAF Fisheries Greta Point Internal Report 217. 18 p. (Unpublished report held in NIWA library, Wellington.)
- Clark, M. (1998a). A summary of information on the fisheries for orange roughy (*Hoplostethus atlanticus*) on the Lord Howe Rise and northwestern Challenger Plateau, and update for the 1994–95 and 1995–96 fishing years. New Zealand Fisheries Assessment Research Document 98/4. 16 p. (Unpublished report held in NIWA library, Wellington.)
- Clark, M. (1998b). A summary of commercial catch and effort information for orange roughy (*Hoplostethus atlanticus*) fisheries on the Lord Howe Rise and northwest Challenger

- Plateau for the 1995–96 and 1996–97 fishing years. New Zealand Fisheries Assessment Research Document 98/21. 10 p. (Unpublished report held in NIWA library, Wellington.)
- Clark, M.R. (1998c). A summary of information on the New Zealand fishery for orange roughy (*Hoplostethus atlanticus*) on the Louisville Ridge for the 1993–94 to 1995–96 fishing years. New Zealand Fisheries Assessment Research Document 98/6. 18 p. (Unpublished report held in NIWA library, Wellington.)
- Clark, M.R. (1998d). An update of commercial catch and effort information on the orange roughy (*Hoplostethus atlanticus*) fishery on the Louisville Ridge for the 1995–96 and 1996–97 fishing years. New Zealand Fisheries Assessment Research Document 98/26. 14 p. (Unpublished report held in NIWA library, Wellington.)
- Clark, M.R. (1999). An update and standardised analysis of New Zealand commercial catch and effort information for the orange roughy (*Hoplostethus atlanticus*) fishery on the Louisville Ridge. New Zealand Fisheries Assessment Research Document 99/47. 17 p. (Unpublished report held in NIWA library, Wellington.)
- Clark, M.R. (2000). An update of New Zealand commercial catch and effort information, and stock assessment, of the orange roughy (*Hoplostethus atlanticus*) fishery on the Louisville Ridge. *New Zealand Fisheries Assessment Report 2000/31*. 31 p.
- Clark, M.R. (2003a). General summary of New Zealand fisheries for orange roughy outside the EEZ during the 2000/01 and 2001/02 fishing years. Final Research Report to the Ministry of Fisheries for ORH2002/03. (Unpublished report held by MFish, Wellington.)
- Clark, M.R. (2003b). Descriptive analyses of New Zealand commercial catch and effort data for the orange roughy fishery on the Louisville Ridge to the end of the 2001/02 fishing year. Final Research Report to the Ministry of Fisheries for project ORH2002/03. (Unpublished report held by MFish, Wellington.)
- Clark, M.R. (2003c). Estimation of orange roughy biomass on the Louisville Ridge: application of “Seamount Meta-analysis” results. Final Research Report to the Ministry of Fisheries for ORH2002/03. (Unpublished report held by MFish, Wellington.)
- Clark, M.R. (2004). Descriptive analysis of orange roughy fisheries in the New Zealand region outside the EEZ: Lord Howe Rise, Northwest Challenger Plateau, West Norfolk Ridge, South Tasman Rise, and Louisville Ridge to the end of the 2002–03 fishing year. *New Zealand Fisheries Assessment Report 2004/51*. 36 p.
- Clark, M.R. (2006). Descriptive analysis of orange roughy fisheries in the New Zealand region outside the EEZ: Lord Howe Rise, Northwest Challenger Plateau, West Norfolk Ridge, South Tasman Rise, and Louisville Ridge to the end of the 2003–04 fishing year. *New Zealand Fisheries Assessment Report 2006/25*. 37 p.
- Clark, M.R.; Anderson, O.F. (2001). The Louisville Ridge orange roughy fishery: an update of commercial catch-effort data and CPUE analysis of the fishery to the end of the 1999–2000 fishing year. *New Zealand Fisheries Assessment Report 2001/74*. 31 p.
- Clark, M.R.; Anderson, O.F. (2003). The Louisville Ridge orange roughy fishery: an analysis of commercial catch-effort data and stock assessment of the fishery to the end of the 2000–01 fishing year. *New Zealand Fisheries Assessment Report 2003/3*. 26 p.
- Clark, M.R.; O’Driscoll, R.L. (2002). Descriptive analysis of orange roughy fisheries in the Tasman Sea outside the New Zealand EEZ: Lord Howe Rise, Northwest Challenger Plateau, and South Tasman Rise from 1986–87 to the end of the 2000–01 fishing year. *New Zealand Fisheries Assessment Report 2002/59*. 26 p.
- Clark, M.; Tilzey, R. (1996). A summary of stock assessment information for orange roughy fisheries on the Lord Howe Rise: 1996. Bureau of Resource Sciences, Canberra. 23 p. (Available from BRS, P.O. Box E11, Canberra, Australia.)
- Clark, M.; Tilzey, R. (2001). A summary of commercial catch and effort information for the orange roughy (*Hoplostethus atlanticus*) fishery on the South Tasman Rise from 1987 to 1999. *New Zealand Fisheries Assessment Report 2001/3*. 16 p.

- Field, K. (2000). CPUE analysis of orange roughy fisheries outside the New Zealand EEZ: Lord Howe Rise and Northwest Challenger Plateau. *In* Clark, M.: Stock assessment of orange roughy outside the EEZ. Final Research Report for Ministry of Fisheries Research Project ORH1999/03 Objectives 1, 2, & 4. 18 p. (Unpublished report held by MFish, Wellington.)
- O'Driscoll, R.L. (2001). CPUE analysis of orange roughy fisheries outside the New Zealand EEZ: Lord Howe Rise and Northwest Challenger Plateau, to the end of the 1999–2000 fishing year. *New Zealand Fisheries Assessment Report 2001/36*. 26 p.
- O'Driscoll, R.L. (2003). Catch-per-unit-effort analysis of orange roughy fisheries outside the New Zealand EEZ: Lord Howe Rise and Northwest Challenger Plateau to the end of the 2001–02 fishing year. *New Zealand Fisheries Assessment Report 2003/36*. 38 p.
- Prince, J.; Diver, G. (2001a). Survey of the orange roughy spawning South Tasman Rise, 2000. Final unpublished report provided to AFMA. (Unpublished report held by CSIRO, Hobart.)
- Prince, J.; Diver, G. (2001b). Industry survey of the 2001 orange roughy spawning aggregation on the South Tasman Rise fishery. (Unpublished report held by CSIRO, Hobart.)
- Tilzey, R. (2000). South Tasman Rise trawl fishery. *In*: Caton, A.; McLoughlin, K. (eds) Fishery status reports 1999: resource assessments of Australian Commonwealth fisheries. BRS, Canberra.
- Wayte, S.; Bax, N.; Clark, M.; Tilzey, R. (2001). Analysis of orange roughy catches on the South Tasman Rise, 1997–2000. Report provided to the Orange Roughy Assessment Group. (Unpublished report held by CSIRO, Hobart.)
- Wayte, S.; Bax, N.; Clark, M.; Tilzey, R. (2003). Analysis of orange roughy catches on the South Tasman Rise, 1997–2002. Report provided to the Orange Roughy Assessment Group. 14 p. (Unpublished report held by CSIRO, Hobart.)