ORANGE ROUGHY, CHATHAM RISE AND SOUTHERN NEW ZEALAND (ORH 3B)

1. FISHERY SUMMARY

(a) Commercial fisheries

Orange roughy are found in waters deeper than 750 m throughout Quota Management Area 3B. Historically, the main fishery has been concentrated on the Chatham Rise. Annual orange roughy catches in ORH 3B were mostly just over 30 000 t in the 1980s but progressively decreased since 1989–90 because of a series of TACC reductions (Table 1).

Table 1: Annual reported catches and TACs of orange roughy from ORH 3B. (Catches from 1978–79 to 1985–86 are from Robertson and Mace 1988) and from 1986–87 to 2004–05 from Fisheries Statistics Unit and Quota Monitoring System data).

Fishing year	Reported catch (t)	TAC (t)
1979–80†	11 800	–
1980–81†	31 100	–
1981–82†	28 200	23 000
1982–83*	32 605	23 000
1983–84*	32 535	30 000
1984–85‡	29 340	30 000
1985–86‡	30 075	29 865
1986–87‡	30 689	38 065
1987–88‡	24 214	38 065
1988–89‡	32 785	38 300
1989–90‡	31 669	32 787
1990–91‡	21 521	23 787
1991–92‡	23 269	23 787
1992–93‡	20 048	21 300
1993–94‡	16 960	21 300
1994–95‡	11 891	14 000
1995–96‡	12 501	12 700
1996–97‡	9 278	12 700
1997–98‡	9 638	12 700
1998–99‡	9 372	12 700
1999–00‡	8 663	12 700
2000–01‡	9 274	12 700
2001–02‡	11 325	12 700
2002–03‡	12 333	12 700
2003–04‡	11 254	12 700
2004–05‡	12 369	12 700

† Catches for 1979–80 to 1981–82 are for a April-March fishing year.
* Catches for 1982–83 and 1983–84 are 15 month totals to accommodate the change over from an April-March fishing year to an October-September fishing year. The TAC for the interim season, March to September 1983, was 16 125 t.
‡ Catches from 1984–85 onwards are for a 1 October – 30 September fishing year.

There have been major changes in the distribution of catch and effort over the history of this fishery (Table 2). Initially, it was confined to the Chatham Rise and, until 1982, most of the catch was taken from areas of relatively flat bottom on the northern slopes of the Rise (in the Spawning Box), between mid-June and mid-August, when the fish form large aggregations for spawning (Figure 1).

From 1983 to 1989 about one third of the catch was taken from the south and east rise, where new fishing grounds developed on and around small seamount features. Much of the catch from these areas was taken outside the spawning season as the fishery extended to most months of the year.

In the early 1990s, effort within the Chatham Rise further shifted from the Spawning Box to eastern and northwestern parts of the Rise. The Spawning Box was closed to fishing from 1992-93 to 1994-95. In recent years, the main fishing grounds on the Chatham Rise have yielded relatively constant catches.

The early 1990s also saw the Puysegur fishery develop, followed by other fishing grounds near the Auckland Islands and on the Pukaki Rise, which is now the focus for the fishery south of the Chatham Rise.

Table 2: ORH 3B catches by area, to the nearest 100 t, and by percentage (to the nearest percent) of the total ORH 3B reported catch. Catches are equivalent to those shown in Table 1, but allocated to area using the ratio of estimated catches, and revised such that all years are from 1 October-30 September. Note that catches for the East Rise are given by the sum of Spawning Box and Rest of East Rise.

Year	Northwest Rise		South Rise		Spawning box		Rest of East Rise		Non-Chatham	
	t	%	t	%	t	%	t	%	t	%
1978–79	0	0	0	0	11 500	98	300	2	0	0
1979–80	1 200	4	800	3	27 900	90	200	4	0	0
1980–81	8 400	30	3 700	13	16 000	57	100	0	0	0
1981–82	7 000	28	500	2	16 600	67	800	3	0	0
1982–83	5 400	35	4 800	31	4 600	30	600	4	0	0
1983–84	3 300	13	5 100	21	15 000	61	1 500	6	0	0
1984–85	1 800	6	7 900	27	18 400	63	1 100	4	0	0
1985–86	3 700	12	5 300	18	17 000	56	4 100	13	0	0
1986–87	3 200	10	4 900	16	20 200	66	2 400	8	0	0
1987–88	1 600	7	6 800	28	13 500	56	2 300	10	0	0
1988–89	3 800	12	9 200	28	16 700	51	3 100	9	0	0
1989–90	3 300	10	11 000	35	16 200	51	1 100	3	200	1
1990–91	1 500	7	6 900	32	6 100	28	6 100	29	900	4
1991–92	300	1	2 200	9	1 000	4	12 000	51	7 800	34
1992–93	3 800	19	5 400	27	100	0	4 700	23	6 100	30
1993–94	3 500	21	5 100	30	0	0	4 900	29	3 500	20
1994–95	2 400	20	1 600	13	500	5	3 500	30	3 800	32
1995–96	2 400	19	1 300	10	1 600	13	2 200	17	5 000	40
1996–97	2 200	24	1 400	15	1 700	19	1 900	21	1 900	21
1997–98	2 300	23	1 700	17	2 400	24	2 200	22	1 600	16
1998–99	2 700	28	1 200	13	1 100	11	2 500	27	1 900	21
1999–00	2 100	24	1 100	13	1 500	17	3 100	36	800	9
2000–01	2 600	27	1 700	18	1 200	13	2 300	24	1 500	17
2001–02	2 200	19	1 100	10	3 100	28	3 600	31	1 300	12
2002–03	2 200	19	1 500	13	3 200	27	3 900	33	1 500	7
2003-04	2 000	18	1 400	12	4 300	38	2 600	23	1 000	9
2004-05	1 600	13	1 700	14	4 100	33	3 000	24	2 000	16

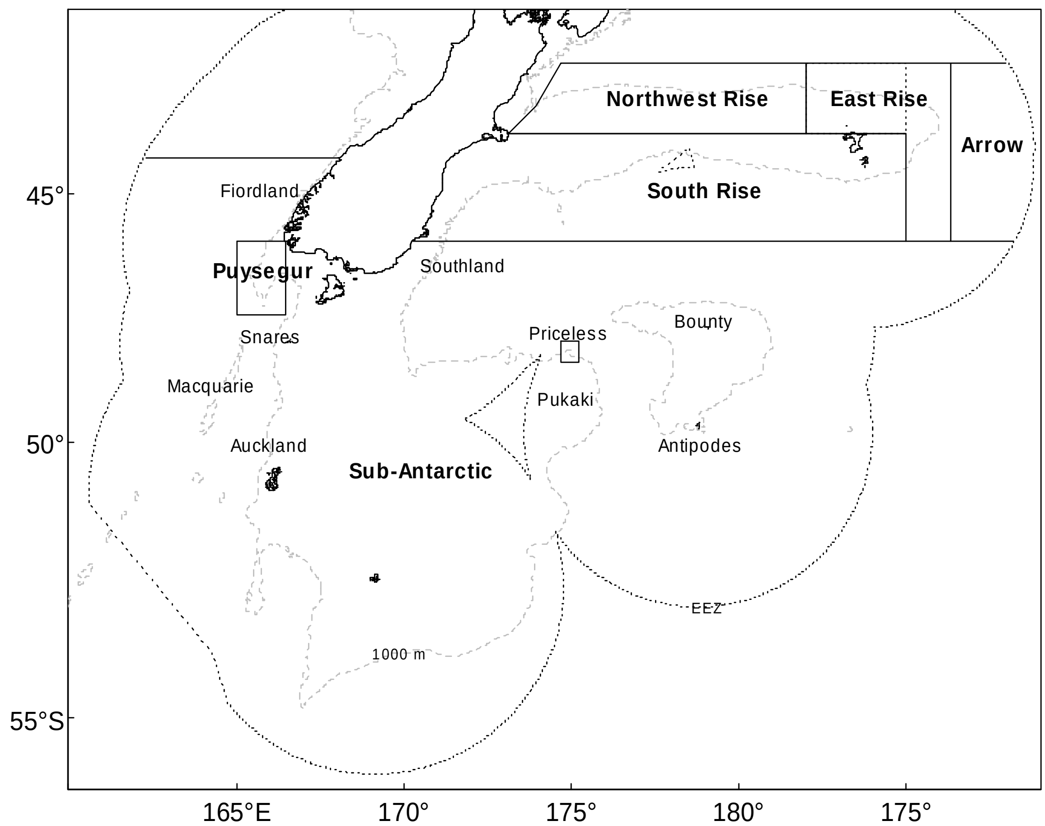

Figure 1: ORH3B designated subarea boundaries (drawn and labelled in bold font), and the approximate position of other named fisheries outside of the Chatham Rise (labelled in normal font). The Spawning Box is the western part of the area East Rise (to the west of the vertical broken line at 175 W). The Sub-Antarctic is all areas below 46°S on the east coast, and 44°16'S on the west coast, except Puysegur.

Since 1992–93, the distribution of the catch within ORH 3B has been affected by a series of catch-limit agreements between industry and the Minister of Fisheries. Initially, the agreement was that at least 5000 t be caught south of 46° S. Subsequently, the catch limits, and the designated subareas to which they apply, have changed from year to year and the TACC has dropped from 21 300 t to 12 700 t (Tables 1, 3). The agreed catch limit for the Chatham Rise is currently 10 150 t. Within the Chatham Rise, catches have generally been about the same as the agreed catch limits (Tables 2 and 3), although in some years they have been exceeded by catches taken by commercial vessels in support of research surveys. In 2004–05 and 2005–06, 250 t of the TACC was set aside for industry research surveys (e.g. Puysegur in 2004–05), but not allocated to any of the designated subareas.

Table 3: Catch limits (t) by designated subarea within ORH 3B, as agreed between the industry and Minister of Fisheries since 1992–93. Note that East Rise includes the Spawning Box, closed between 1992–93 and 1994–95; South Rise includes Waitaki. Subarea boundaries have varied somewhat between years. * South Rise included in East Rise catch limit. ** Arrow Plateau included in Sub-Antarctic.

Year	Northwest Rise	East Rise	South Rise	Puysegur	Arrow Plateau	Sub-Antarctic
1992–93	3 500	4 500	6 300	5 000	–	2 000
1993–94	3 500	4 500	6 300	5 000	–	2 000
1994–95	2 500	3 500	2 000	2 000	3 000	1 000
1995–96	2 250	4 950	*	1 000	**	4 500
1996–97	2 250	4 950	*	500	**	5 000
1997–98	2 250	4 950	*	0	1 500	4 000
1998–99	2 250	4 950	*	0	1 500	4 000
1999–00	2 250	4 950	*	0	1 500	4 000
2000–01	2 250	4 950	*	0	1 500	4 000
2001–02	2 000	7 000	1 400	0	1 000	1 300
2002–03	2 000	7 000	1 400	0	1 000	1 300
2003–04	2 000	7 000	1 400	0	1 000	1 300
2004–05†	1 500	7 250	1 400	0	1 000	1 300
2005–06†	1 500	7 250	1 400	0	1 000	1 300

† 250 t set aside for industry research surveys.

On the Chatham Rise, the overall catch rate (for target tows) fluctuated around 8 t/tow from 1979–80 to 1986–87, dropped to around 6 t/tow until 1992–93, and has since dropped further and remained at around 3–4 t/tow. However, outside the Spawning Box catches increased in the 1990s and catch rates have been highly variable, sustained largely by the discovery of new fishing areas. Several major hills on the South Rise that were important in the late 1980s do not support their previous levels of catch. High catch rates can still occur, but these are sporadic.

Between 1991–92 and 2000–01, more than half of the Chatham Rise catch came from four hill complexes (Table 4). All of these have shown a decline in catch rate since the early years of the fishery, but in recent years catch rates have been relatively stable. After 2000–01, the proportion of the catch from these hill complexes decreased, as a greater proportion of the catch came from the Spawning Box (about 40% in 2003–04 and 2004–05). In particular, large catches have been made in the last two years, outside of the spawning season, and close to the western end of the Spawning Box. Catches from the Spawning Box taken around the spawning season (which peaks in July) have been relatively high since 2001–02, although unstandardised catch rates have been declining since 1999–2000.

Table 4: Estimated orange roughy catches (to nearest 10 t) and unstandardised catch rates (to nearest 0.1 t/tow) for four important hill complexes and the Spawning Box In season (May-August) and Out season (September-April) on the Chatham Rise (letters indicating subareas, as in Table 3, in parentheses), using catch and effort data held by NIWA. Only tows targeted at orange roughy are included. (Approximate positions are: Big Chief, 44.7 S, 175.2 W; Smiths City and near-neighbours, 43.1 S, 174.2 W; Andes, 44.2 S, 174.6 W; Graveyard, 42.8 S, 180 W). –, catch < 10 t (2004–05 data are provisional, and catch totals may be incomplete). –, catch < 10 t.

	Andes (E)		Big Chief (S)		Graveyard (NW)		Smiths City (E)		Spawning Box In (E)		Spawning Box Out (E)	
Year	Catch	t/tow	Catch	t/tow	Catch	t/tow	Catch	t/tow	Catch	t/tow	Catch	t/tow
1979–80	–	–	–	–	100	11.5	–	–	17 080	10.1	210	2.3
1980–81	–	–	–	–	230	7.0	–	–	17 330	13.2	40	0.7
1981–82	–	–	–	–	120	4.8	–	–	9 220	8.6	–	–
1982–83	–	–	–	–	120	6.6	–	–	7 840	13.0	40	0.8
1993–84	–	–	–	–	60	10.9	30	16.7	15 200	12.7	30	1.3
1994–85	–	–	–	–	–	–	–	–	16 810	14.1	40	2.1
1995–86	–	–	–	–	70	3.9	200	13.4	16 140	10.9	100	2.0
1986–87	–	–	–	–	30	2.2	100	6.3	20 110	10.4	40	1.9
1987–88	–	–	–	–	190	5.3	100	6.2	13 690	10.5	10	0.5
1988–89	30	1.4	1 010	5.3	220	5.0	180	7.7	13 670	9.7	30	1.6
1989–90	90	6.5	1 650	5.9	290	5.3	–	–	11 750	11.8	120	6.1
1990–91	80	6.2	2 470	7.3	10	4.3	4 810	7.8	5 340	12.8	320	10.5
1991–92	7 370	9.8	520	6.1	70	2.7	1 270	5.8	960	7.0	–	–
1992–93	2 970	8.6	2 480	4.9	3 340	11.0	600	7.3	50	27.0	–	–
1993–94	3 340	5.4	1 930	3.8	3 040	6.5	560	5.2	–	–	–	–
1994–95	1 660	2.8	390	2.4	1 870	3.9	1 120	3.3	490	4.5	–	–
1995–96	1 180	2.7	460	4.9	1 880	4.5	400	2.8	1 440	10.4	70	4.2
1996–97	730	2.7	380	3.4	940	3.4	720	4.4	1 420	7.5	130	2.9
1997–98	1 310	2.4	760	3.5	1 080	2.7	390	2.8	1 850	11.1	360	3.5
1998–99	1 270	2.8	470	3.0	1 190	4.4	800	3.0	720	6.6	270	2.6
1999–00	2 040	3.6	290	3.6	1 500	3.8	670	3.3	960	20.0	470	4.8
2000–01	990	2.7	690	4.9	1 560	3.0	650	3.4	960	11.7	290	2.9
2001–02	2 070	3.7	390	3.1	950	2.6	480	2.9	2 770	11.5	330	2.3
2002–03	2 550	2.7	390	2.6	1 290	3.2	400	3.3	3 030	11.0	120	1.1
2003–04	1 270	1.7	460	2.2	800	4.0	360	2.3	2 490	9.6	1 460	4.4
2004–05	1 150	2.1	710	3.0	960	4.5	290	2.4	2 630	8.0	1 170	3.7

Since 1990, there has been considerable exploratory fishing throughout ORH 3B, and several fisheries have developed in areas outside the Chatham Rise (Table 5).

Table 5: Estimated ORH 3B catches (to the nearest 10 t) and unstandardised catch rates (to nearest 0.1 t/tow) for areas outside the Chatham Rise, using catch and effort data held by NIWA. Only tows targeted at orange roughy are included. For this table the areas were defined by the following rectangles: Arrow – 42.17–46°S, 173.67°W; Auckland - 49–52 °S, 165–167 °E; Bounty – 46–47.5°S, 177.5–180°E; Priceless – 48–48.44°S, 174.7–175.2°E; Other Pukaki – 47–50.4°S, 174–176.4°E (and not in Priceless); Puysegur - 46–47.5 °S, 165–166.5 °E. The area described as Antipodes in previous reports is now included in Other Pukaki. All years are from 1 October-30 September (2004–05 data are provisional and catch totals may be incomplete). –, catch <10 t.

	Arrow		Auckland		Bounty		Priceless		Other Pukaki		Puysegur		Other	
Year	Catch	t/tow	Catch	t/tow	Catch	t/tow	Catch	t/tow	Catch	t/tow	Catch	t/tow	Catch	t/tow
1985–86	120	13.8	–	–	–	–	–	–	–	–	–	–	–	–
1986–87	110	10.8	–	–	–	–	–	–	–	–	–	–	–	–
1987–88	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1988–89	–	–	–	–	–	–	–	–	–	–	–	–	30	3.4
1989–90	–	–	–	–	–	–	–	–	–	–	100	1.4	50	17.0
1990–91	150	9.3	–	–	–	–	–	–	–	–	600	4.6	20	0.5
1991–92	100	12.1	–	–	–	–	–	–	–	–	6 320	10.6	170	5.3
1992–93	10	6.5	30	1.5	–	–	–	–	–	–	4 280	6.7	330	1.6
1993–94	470	8.3	180	1.1	–	–	–	–	–	–	2 410	1.9	80	0.2
1994–95	750	2.9	880	4.9	–	–	–	–	–	–	1 260	7.9	20	0.4
1995–96	170	3.4	380	1.5	–	–	–	–	3 060	10.0	730	2.4	20	0.1
1996–97	280	1.8	120	1.1	20	1.5	–	–	670	1.1	490	2.6	90	0.5
1997–98	330	1.8	370	1.9	240	2.2	10	1.1	130	0.7	–	–	100	0.8
1998–99	730	2.6	440	2.0	130	0.8	–	–	120	1.6	–	–	90	1.2
1999–00	290	1.8	150	1.1	170	2.4	–	–	–	–	–	–	–	–
2000–01	190	2.3	60	0.9	150	2.7	–	–	20	0.8	–	–	860	1.8
2001–02	70	1.5	130	2.3	40	1.4	550	30.5	–	–	–	–	280	1.8
2002–03	220	2.7	–	–	220	4.1	480	13.0	–	–	–	–	90	1.2
2003–04	140	1.8	–	–	90	1.8	450	4.6	–	–	–	–	150	2.3
2004–05	60	0.7	–	–	100	2.6	540	3.1	520	11.7	100	5.6	90	2.9

The first fishery to be developed south of the Chatham Rise was on Puysegur Bank, where spawning aggregations of orange roughy were found during a joint Industry-MFish exploratory fishing survey in 1990–91. The fishery developed rapidly, but from 1993–94 catch limits were substantially undercaught. Catch limits were subsequently reduced from the initial level of 5000 t, and the industry implemented a catch limit of 0 t beginning in the 1997–98 fishing year (catches in 2004–05 were taken during an industry survey).

Exploratory fishing on the Macquarie Ridge south of Puysegur in 1993 saw a fishery develop off the Auckland Islands. Total catches rose to around 900 t in 1994–95, but then dropped to less than 200 t by 1999–00, and has been infrequent in recent years (Table 5).

In 1993–94, the first major catches were taken to the east of the Chatham Rise, on the 'Arrow Plateau'. A catch limit of 3000 t was put in place for 1994–95, with a limit of 500 t for any one hill. Only a few areas have been fished successfully, and the catch has never reached the catch limit (Table 5).

In 1995–96, large catches were reported on the southeast Pukaki Rise, with a catch total of over 3000 t (Table 5). However, the catches dropped rapidly, and within a few years the fishery had effectively ceased. In recent years, a fishery has developed on the northeast Pukaki Rise, and includes the area known as Priceless, where catches are mostly taken at the start of the fishing year, and have reached the feature limit of 500 t for each of the last 4 years.

Catches of orange roughy have also been taken off the Bounty Islands (around 200 t/yr since 1997–98, Table 5), off the Snares Islands (up to around 500 t, but infrequently in recent years), areas of the Macquarie Ridge (100–500 t per year since 2000–01), and off Fiordland (around 500 t in 2000–01, but catches then rapidly decreased).

(b) Non-commercial fisheries

No non–commercial fishing for orange roughy is known in this quota management area.

(c) Maori customary fisheries

No Maori customary fishing for orange roughy is known in this quota management area.

(d) Illegal catch

No information is available on illegal catch in this quota management area.

(e) Other sources of mortality

There has been a history of catch overruns on the Chatham Rise because of lost fish and discards, and discrepancies in tray weights and conversion factors. In assessments, total removals from each part of the Chatham Rise were assumed to exceed reported catches by the overrun percentages in Table 6.

Table 6: Catch overruns (%) by year.

Year	1978–79	1979–80	1980–81	1981–82	1982–83	1983–84	1984–85	1985–86	1986–87	1987–88
Overrun	30	30	30	30	30	30	30	28	26	24

Year	1988–89	1989–90	1990–91	1991–92	1992–93	1993–94	1994–95 & subsequently
Overrun	22	20	15	10	10	10	5

For Puysegur and other southern fisheries there is no reason to believe that, if there was an overrun in catches, this shows any trend over time. For this reason, it was assumed that there was no overrun for this area.

2. BIOLOGY

Biological parameters used in this assessment are presented in the Biology section at the beginning of the Orange Roughy section.

3. STOCKS AND AREAS

Genetically two main stocks are recognised within ORH 3B (Chatham Rise and Puysegur; Smith and Benson 1997) and these are considered to be distinct from stocks in adjacent areas (Cook Canyon and Wairarapa). However, it is likely, because of their geographical separation and discontinuities in the distribution of orange roughy, that recently discovered concentrations of spawning fish on the Arrow Plateau, near the Auckland Islands, and west of the Antipodes Islands form separate stocks.

Genetic data are useful in defining stock boundaries, both within ORH 3B, and between it and adjacent areas. Mitochondrial DNA shows that there are considerable differences between Puysegur fish and fish from the geographically adjacent areas Cook Canyon and Chatham Rise. Allozyme frequency studies suggest that Chatham Rise fish are distinct from the three east coast orange roughy management areas, ORH 2A, 2B and 3A. These data also suggest multiple stocks within the Chatham Rise. However, they do not indicate clear stock boundaries. Although there is significant heterogeneity amongst allozyme frequencies from different areas, these frequencies can vary as much in time (samples from the same location at different times) as in space (samples from different locations at the same time).

For this assessment, the Chatham Rise has been divided into three areas: the Northwest, the East and the South (Figure 1). There is some evidence of stock separation between the Northwest and the East. Spawning occurs simultaneously in the two areas and the post-spawning migration out of the Spawning Box (in the East) is away from the boundary between the two areas. However, there may be more than one spawning stock in the East and there is no clear boundary between this area and the South Chatham Rise, which may or may not contain a separate stock. The 2006 assessment of the East Chatham Rise was split into three subareas (see below).

4. STOCK ASSESSMENT

Assessments are available for four areas within ORH 3B: the Northwest, East and South Chatham Rise, and Puysegur (Figure 1). The assessments for South Chatham Rise and Puysegur remain unchanged from those given in the 2005 Plenary Report (Sullivan et al. 2005).

(i) <u>Northwest Chatham Rise</u>

(a) Assessment inputs

Fours sets of observational data are used in the assessment:

(1) A standardised CPUE series;
(2) An absolute mature biomass estimate (egg survey);
(3) Three relative mature biomass estimates (acoustic/trawl wide-area surveys); and
(4) A commercial fishery length-frequency data series.

The standardised CPUE series excluded short duration tows made in the Graveyard hills complex (McKenzie, 2006), and is shown in Table 7. The first three point of this series were excluded from the assessment (see Introduction), and a process error of 20% was added to the c.v.s for the series.

Table 7: Estimates of standardized catch per unit effort (and c.v.s) for the northwest Chatham Rise stock. The first three points were excluded from the assessment (1980-81 though to 1982-83). A 20% process error has been added to each of the c.v.s.

Fishing year	CPUE (All months)	(c.v.%)
1980-81	1.34	28
1981-82	1.61	25
1982-83	0.96	24
1983-84	0.60	24
1984-85	0.89	25
1985-86	1.09	25
1986-87	0.80	24
1987-88	0.58	24
1988-89	0.44	25
1989-90	0.68	24
1990-91	0.67	26
1991-92	0.46	33
1992-93	0.38	35
1993-94	0.43	34
1994-95	0.42	27
1995-96	0.22	34
1996-97	0.40	26
1997-98	0.31	26
1998-99	0.18	28
1999-00	0.22	30
2000-01	0.19	27
2001-02	0.17	27
2002-03	0.13	28
2003-04	0.16	28
2004-05	0.15	28

Biomass estimates from four resource-surveys were used in this assessment: a 1996 egg survey, and acoustic surveys in 1999, 2002, and 2005 (Table 8).

Table 8: Estimates of mature biomass (and their c.v.s) for the northwest Chatham Rise stock.

Source	Date	Biomass (t)	c.v.	Reference
Egg survey	June/July 1996	49 000	0.8	Francis et al. (1997)
Acoustic survey	June/July 1999	29 000	0.425	Bull et al. (2000), Francis & Bull (2000)
Acoustic survey	June/July 2002	42 000	0.63	Doonan & Hart (2003)
Acoustic survey	June/July 2005	9 100	0.40	Smith (2006)

The 1996 egg survey estimate was treated as absolute but very uncertain. Although the best estimate (which combines data from all four snapshots) is 49 000 t, estimates from individual snapshots varied widely (from 12 000 t in snapshot 2 to 1 000 000 t in snapshot 1), probably because the assumptions under which they were made (e.g., that daily egg production and mortality was constant throughout each snapshot) were violated. Thus, it was not possible to calculate a c.v. for this estimate, and an arbitrary high value of 0.8 was assigned.

The acoustic survey estimates were treated as relative estimates with informed priors. There is uncertainty about the expansion of the acoustic biomass estimates to the whole of the Northwest Chatham Rise. Two alternative approaches for 1999 gave a "low" and "high" estimate (Bull et al., 2000 and Francis & Bull, 2000) of which the "high" estimate was used. The 2002 estimate (Doonan & Hart, 2003) expanded the biomass by a spawning ratio of 1.35 to obtain a single value of 42 000 tonnes. Hicks (2004c) gives a brief overview of the 1999 and 2002 surveys. The 2005 estimate was from a wide-area survey that covered almost the entire northwest Chatham Rise. An informed prior was placed on the 2005 proportionality constant (q_{2005}). Informed priors were also developed for the ratios q_{1999}/q_{2005} and q_{2002}/q_{2005}. All priors on q were lognormal with the best estimate equated to the median of the prior distribution (Cordue, in prep.). These and other priors are summarised in Table 9.

Table 9: The prior distributions on the free parameters and ratio penalty quantities in the model. The parameters, μ and cv, defining the lognormal priors are in natural space. No explicit bounds were put on the ratios q_{1999}/q_{2005} or q_{2002}/q_{2005}, but are implicit from the bounds on q_{1999}, q_{2002}, q_{2005}.

Free parameters	Prior	[lower bound, upper bound]
B_0 (t)	uniform-log	[5000, 300 000]
relativity constant (q)	uniform-log	[1e-07, 0.01]
catchability 1999 (q_{1999})	uniform	[0.1, 4.0]
catchability 2002 (q_{2002})	uniform	[0.1, 4.0]
catchability 2005 (q_{2005})	lognormal (μ=1.113, cv=0.6069)	[0.1, 4.0]
commercial logistic selectivity a_{50}	uniform	[5, 50]
cv at age 1 for length-at-age	uniform	[0.001, 1]
cv at age 80^+ for length-at-age	uniform	[0.001, 1]
Ratio penalty quantities	**Prior**	**[lower bound, upper bound]**
q_{1999}/q_{2005}	lognormal (μ=1.027, cv=0.2330)	-
q_{2002}/q_{2005}	lognormal (μ=0.952, cv=0.03301)	-

Nine years of length-frequency data from the period 1989–1997 were collected into a single length-frequency that was centred on the 1993 fishing year. Eight years of length-frequency data from the period 1998–2005 were collected into a single length-frequency that was centred on the 2002 fishing year. The effective sample size was set at 1/6 of the number of tows for each period: 19 for the “1993” period and 35 for the “2002” period (A. Hicks pers. comm.).

Age frequency data (used in the 2004 assessment) were excluded from the 2006 assessment as intersessional work indicated that the ages assigned to orange roughy otoliths were both biased and imprecise (see Introduction). The use of age data was restricted to the estimation of basic biological parameters. Unfortunately, it was not possible to use otoliths from the Northwest Chatham Rise stock itself as only 69 suitable otoliths were available. Therefore, otolith data from the adjacent East Chatham rise were used to re-estimate the parameter values for the sexual maturity, length-at-age, and weight-at-length curves. The values for other biological parameters (i.e., natural mortality and maximum exploitation rate) were unchanged from the 2004 assessment (McKenzie, 2005)

(b) Stock assessment

The observational data were incorporated in a Bayesian stock assessment with deterministic recruitment to estimate stock size and do forward projections. The stock was considered to reside in a single area, with no partition by sex or maturity. Age groups were 1-80 years, with a plus group of 80+. Exploratory model fits demonstrated an apparent disparity between the age of sexual maturity as found from the otolith data (using counts to the transition zone) and the size of fish caught by the commercial fishery. Therefore, the maturity data were not used and the maturity ogive was set equal to the selectivity ogive, which was estimated within the model using the length-frequency data (see Introduction).

Three alternative model runs are reported: Alldata (in which both the CPUE and biomass survey data were incorporated), Nobiomass (in which the biomass survey data were omitted), and NoCPUE (in which the CPUE data were omitted). For each run, the uncertainty in the estimated parameters was evaluated using Monte Carlo Markov Chain (MCMC) techniques. For the MCMCs, 3000 samples were taken from a chain of length 3 million.

(c) Biomass estimates

For the Alldata run, B_0 was estimated to be 55 000 t (95% confidence interval 51 400-59500 t; Table 10), the current biomass was 6 000 t (4 200-9 300 t), or 11% (8–16%) $B_{0;}$. The Nobiomass run produced slightly lower estimates of all biomass metrics. The NoCPUE run produced higher estimates of B_0 (79 800 t; 59 600-128 600 t) and $B_{current}$ (30 900; 12 400-77 500 t) with the median estimate for the ratio of the two being 39% (21-61%) B_0.

Neither of the runs that included the survey estimates fit all four biomass indices well (Figure 2). For the Alldata run, the estimated biomass trajectories provided a reasonable fit to the acoustic biomass indices, but not the egg survey. The NoCPUE run provided a reasonable fit to the egg survey and the first two acoustic biomass indices, but was above the upper confidence interval of the most recent (2005) biomass index.

Table 10: Biomass estimates (medians, with 95% confidence intervals in parentheses) for three runs. $B_{current}$ is the mid-year biomass in 2006.

Run	B_0(t)	$B_{current}$(t)	$B_{current}$(% B_0)
Alldata	55 000 (51 400-59 500)	6 000 (4 200-9 300)	11 (8-16)
Nobiomass	52 500 (48 300-56 400)	4 400 (3 200-6 900)	9 (6-13)
NoCPUE	79 800 (59 600-128 600)	30 900 (12 400-77 500)	39 (21-61)

The large discrepancy between the NoCPUE run and the other two runs reflects the relative influence of biomass vs. CPUE indices. When CPUE data are included, they dominate the result (as in the Alldata and Nobiomass runs) because there are a large number of CPUE observations and they cover a period in the fishery when the biomass changed a lot. In contrast, there are only four fishery-independent indices of biomass and they occur in recent years when the biomass is not likely to have changed much. In addition, two of these indices have extremely high CVs. The egg survey, in particular, is deemed to be unreliable (thus its high c.v.).

The Plenary noted that the three runs presented should not be given equal weight. The NoCPUE run was not considered to give a reliable assessment of stock status because it relies on survey estimates that are few in number, have high c.v.s, and are restricted to the end of the time series when there is relatively little contrast in stock size. However, it should also be noted that there is uncertainty in the other two runs that include CPUE because the extent to which the CPUE (which is based only on flat tows) indexes the entire stock is unknown.

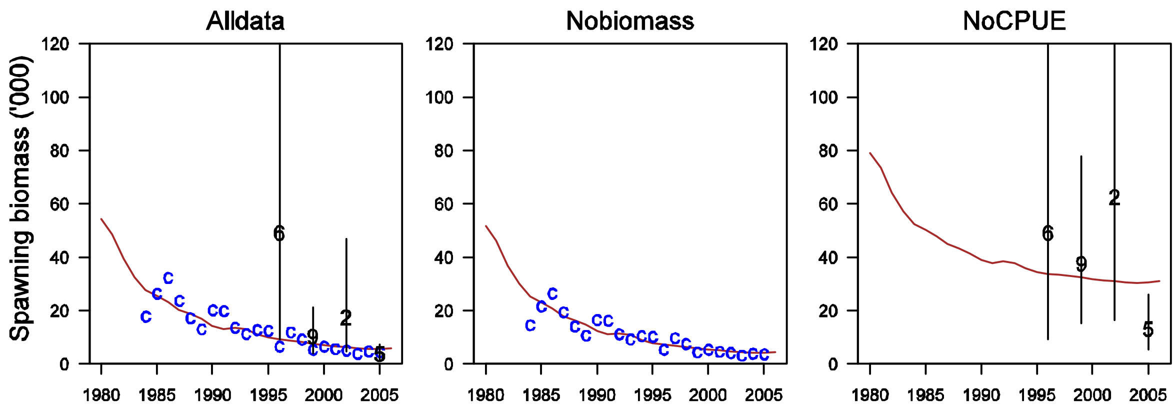

Figure 2: Estimated biomass trajectories (lines) and fitted data (points) from all model runs. The data are identified by the plotting symbol ('c' = CPUE, '6' = 1996, '9' = 1999, '2' = 2002, '5' = 2005). CPUE data are scaled up to the biomass. Vertical bars (for biomass indices only) show 95% confidence intervals. Plots are from the medians of the posterior distribution.

For the Alldata and Nobiomass runs, exploitation rates appear to have been higher than the exploitation rate associated with a CAY strategy, E_{CAY} (0.064) for most of the history of the fishery (Figure 3). This is to be expected since the fishery was purposely managed to have a fishing down phase. Estimated exploitation rates for 2004-05 were 0.26 and 0.34 for the Alldata and Nobiomass runs respectively, both of which were considerably higher than the estimate for the NoCPUE run (0.053).

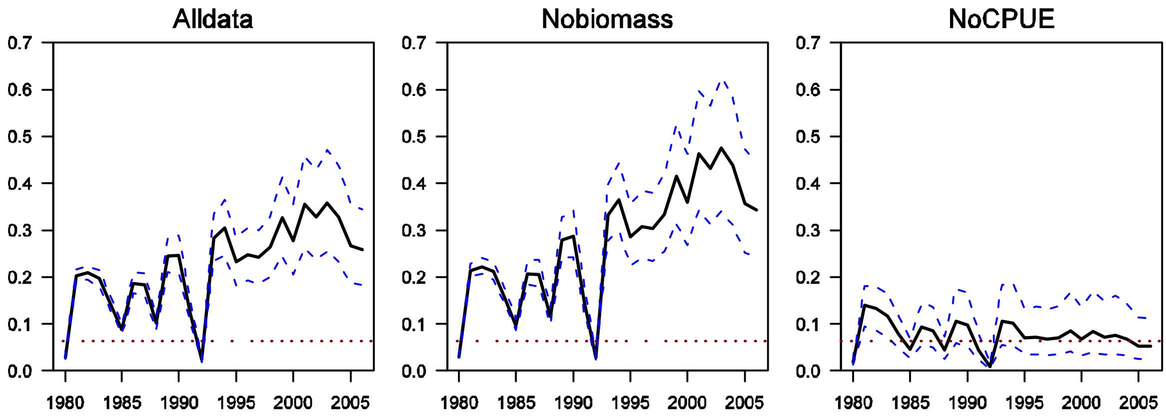

Figure 3: Estimated exploitation rates (solid line) with 95% CI (dashed line) for all model runs. The horizontal dotted line shows the exploitation rate under a CAY policy, E_{CAY} (0.064).

(d) Sensitivity analyses

Independently estimating maturity ogives (from otolith transition zone data, outside the stock assessment model) and selectivity ogives (from length-frequency and other information, within the model) gave similar results to previous assessments (selectivity curves estimated to be well to the right of maturity curves; see Introduction), an outcome believed by the Working Group to be untenable.

Halving the natural mortality gave moderately better fits to all the observational data, with a current $\%B_0$ that was slightly less than that from the Alldata model.

(e) Projections

Five-year projections based on deterministic recruitment were carried out using a range of constant catch options. For each catch option, three measures of fishery performance were calculated:

(1) $P_{0.2}$: the probability that the biomass in 2011 is greater than 20% B_0 [P(B_{2011} > 20%B_0)];
(2) P_{MSY}: the probability that the biomass in 2011 is greater than B_{MSY} [P(B_{2011} > B_{MSY})] (where 30% B_0 is used as a proxy for B_{MSY}, as is conventional for New Zealand orange roughy stocks – see Introduction); and
(3) Bmed: the median biomass in 2011 (expressed as a percentage of B_0).

For all runs the projections indicate that the biomass should slightly increase with a catch at the current catch limit of 1500 t (Table 11). However, for the Alldata and Nobiomass runs, maintaining the catch at 1500 t results in close to zero probability that the stock will have rebuilt to 20% B_0 or to B_{MSY} within 5 years. Zero catch results in a high probability of rebuilding to 20% B_0, but almost zero probability of rebuilding to B_{MSY} .

Table 11: Results from projections to 2011 for three runs from each model. $B_{current}$ (as % B_0) is given in parentheses next to the run name for Bmed. A 5% overrun was assumed for all years (i.e., the actual catches were assumed to be 5% higher than the values shown).

Performance measure	Run	Annual catch (t, over five–year period)				
		0	500	1000	1500	2000
$P_{0.20}$	Alldata	0.97	0.50	0.09	0.01	0.00
	Nobiomass	0.71	0.11	0.01	0.00	0.00
	NoCPUE	1.00	1.00	1.00	0.99	0.98
P_{MSY}	Alldata	0.00	0.00	0.00	0.00	0.00
	Nobiomass	0.00	0.00	0.00	0.00	0.00
	NoCPUE	0.99	0.97	0.94	0.88	0.81
B_{med} (10.6)	Alldata (10.9)	23.4	20.0	16.7	13.6	10.5
	Nobiomass (8.5)	20.9	17.5	14.3	11.2	8.3
	NoCPUE (38.8)	49.0	46.5	44.0	41.4	38.8

(f) Yield estimates

For Chatham rise orange roughy, the exploitation rate under a CAY policy is 0.064 and the associated long-term average yield (MAY) is 1.99% B_0 (see Introduction). The Alldata and Nobiomass results suggest that the current catch limit of 1500 t is 3.7-4.8 times than the estimated CAY, and 1.4-1.5 times the associated long-term average yield (MAY) (Table 12). In contrast, for the NoCPUE run, the current catch limit is similar to the long-term average yield and about three-quarters of the estimated CAY.

Table 12: Estimated yields: CAY for 2007 and long-term yield under a CAY policy (MAY). The median is shown with the 95% confidence interval in parentheses. All yields were adjusted to allow for an assumed over-run of 5% in future catches.

Run	CAY_{2007} (t)	MAY (t)
Alldata	410 (300-610)	1040 (970-1130)
Nobiomass	310 (230-470)	990 (910-1070)
NoCPUE	1950 (810-4790)	1510 (1130-2440)

(ii) East Chatham Rise

The results presented here are derived from two sets of assessments conducted in 2006. These assessments were a continuation of work done in 2005 and numerous recommendations were incorporated from two orange roughy workshops held in New Zealand in October 2005 and February 2006. One set of assessments was performed by NIWA scientists with the software CASAL (Bull et. al. 2003), and will be referred to as the CASAL runs. The other set of assessments was performed by the Seafood Industry Council (SeaFIC) and the University of Washington (UW) using the software called Awatea, which is a modification specific to orange roughy (Hicks pers. comm.) of previously used software called Coleraine, and will be called the Awatea runs. The two sets of assessments are similar in most assumptions. Software differences between CASAL and Awatea are discussed when appropriate. The two sets of assessments are not independent in that the modelling of this stock was a joint effort. Performing two sets of assessments using two software packages resulted in the clarification, agreement, and development of modelling and estimation methods, the sharing of ideas, and checks on the data and models for correctness. In some cases, when the two sets of assessment results were similar, only the CASAL runs are reported for conciseness.

Some of the common modelling assumptions are

- The model was fitted using Bayesian estimation and partitioned the population by age.
- Age-groups from 1–80 were used with a plus group at 80.
- The model assumed a single sex, with growth modelled using the von Bertalanffy growth formula.
- Deterministic recruitment was assumed, except where explicitly stated.
- Natural mortality, M, was assumed to be constant at 0.045, except in some runs where it was halved to act as a proxy for a lower productivity.
- The population was considered to have a single maturation episode, with maturation modelled by a logistic ogive fixed to equal the estimated fishery selectivity ogive (see Introduction).
- The catch equation used was the instantaneous mortality equation from Bull et al. (2006), whereby half the natural mortality was applied, followed by the fishing mortality, then the remaining natural mortality.
- A Bayesian estimation procedure was used with a penalty function included to discourage the model from allowing the stock biomass to drop below a level at which the historical catch could not have been taken.
- Selectivity of the fishery was modelled by a logistic ogive.
- Lognormal errors, with known (sampling error) c.v.s were assumed for the CPUE, trawl survey, and acoustic survey indices. An additional, process error, variance of 0.2 was added to the c.v.s from the CPUE indices and to the trawl survey estimates (Francis 2001).
- The model assumed a linear relationship between CPUE and abundance.
- Confidence intervals were calculated from a posterior distribution of the model parameters, which was estimated using a Markov Chain Monte Carlo (MCMC) technique.

The data used for the 2006 assessments were CPUE, catch-at-length, and trawl survey and acoustic survey biomass estimates when available. These are described in more detail later.

Some assumptions differ considerably from those used in the previous assessment in 2001 (Francis 2001, Smith et al. 2002). Specifically:

- The 2006 assessment splits the East Chatham Rise into three subareas, whereas the previous assessment assumed a single area. The assessments of these three subareas (presented below) therefore represent a new approach.
- The assessment in 2001 used age-frequency data, whereas they were not used in the 2006 assessment following concerns raised about the validity of these data and final recommendations of the orange roughy stock assessment workshop in February 2006. New growth and length-weight parameters were estimated outside of the model using only NIWA age data from surveys in 1984 and 1990.
- Acoustic biomass estimates were recalculated using the average (in linear space) of the NIWA and Kloser and Horne (2003) orange roughy target strengths.
- In the previous assessment, all acoustic estimates were assumed to be absolute ($q = 1$). However, in this assessment informed lognormal priors were developed for the acoustic q’s, which were then estimated in the model.
- This assessment incorporates a new wide-area acoustic biomass survey (2004), and new acoustic plume biomass surveys (2000–2005).
- In the previous assessment, the trawl survey was assumed to be a single consistent series. In the current assessment, this series was split into three, one for each vessel, with informed lognormal priors on the ratio of catchabilities between the vessels (Cordue in prep.).

Stock hypothesis and subarea components

The East Chatham Rise was divided into three subareas (Figure 4) for the 2006 assessment in order that all CPUE indices could be used. In the 2001 assessment, the indices for the Northeast Hills and Andes were omitted because they showed trends that were very different from that in the main spawning area (the Spawning Box). In 2005, catch-rates and fishing patterns were examined in greater detail and an unsuccessful attempt was made to construct a migration model that would move fish between the three subareas and allow use of all CPUE indices.

The three subareas in the 2006 assessment were defined on the basis of the chronological development of fishing within the East Chatham Rise. The subarea with the largest cumulative catch encompasses the Spawning Box and the flat area to the east and southeast of the Spawning Box (the Northeast Flats). These two areas were treated together because in the earlier years most of the catch on the Northeast Flats was taken by boats that appeared to follow a post-spawning migration of fish out of the Spawning Box (Coburn and Doonan 1997). Catches from the flat outside the Spawning Box have generally been relatively low since the closure of the Spawning Box (Table 13), although they have been increasing in recent years.

The second subarea is that on the Northeast Hills. This is presumed to target a population separate from that in the Spawning Box because spawning occurs simultaneously in the two subareas and historical trends in CPUE differ substantially. However, there is no distinct separation of the Northeast Hills from the Northeast Flats as the Northeast Hills subarea is composed of eight hill regions, each with a radius of three nautical miles centred on the top of known undersea features within the Northeast Flats (Figure 4).

The third subarea is that south of 44° S latitude, which includes the Andes complex of hills (Figure 4). The relationship between the fish caught in this subarea and those from the other two subareas is unclear, although the northernmost Andes Hill (Aloha) is within 30 kilometres of the three southernmost Northeast Hills. As with the South Chatham Rise, no major spawning aggregations have been found in this subarea. It is treated as a separate subarea in the stock assessment simply because the biomass trend in this subarea (inferred from the CPUE data) is different from that in the other two subareas.

Because of differences in catch-rates and fishing patterns, the Working Group agreed to analyse each subarea separately for the purposes of the 2006 assessments, even though there in no direct evidence that these three subareas are independent.

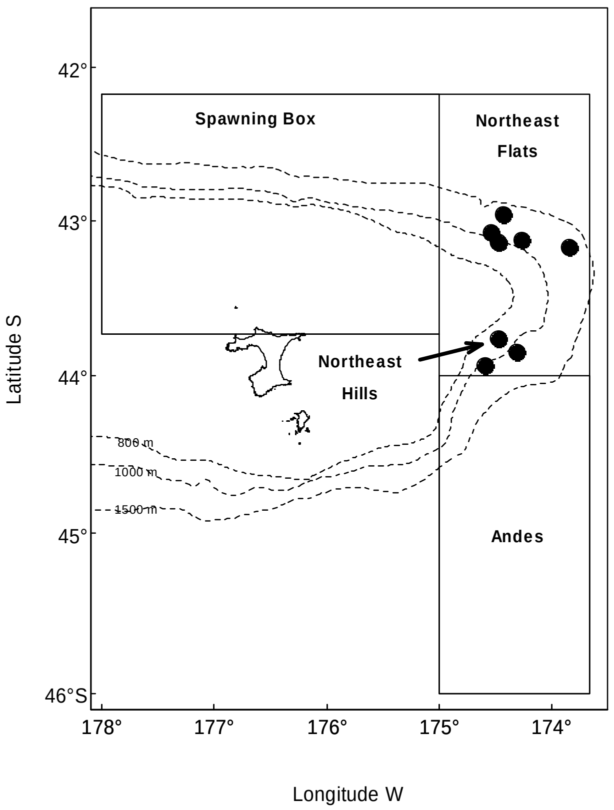

Figure 4: The three subareas of the East Chatham Rise for which assessments were done in 2006: Spawning Box nd Northeast Flats, Northeast Hills (indicated by filled circles), and Andes.

Table 13: Catches by subarea, rounded to the nearest 10 t. Overruns are added in as specified in Table 6. With the exception of the 2003-04 and 2004-05 catches, these are the numbers entered into the 2006 assessments. For 2003-04 and 2004-05, the numbers available at the time of the assessments were provisional: 510, 4 150, 4 660, 590 and 1 420 t were used in place of the 2003-04 row; and 1 030, 4 040, 5 070, 470, and 1 220 t were used in place of the 2004-05 row.

	Spawning Box and Northeast Flats				
Year	Northeast Flats	Spawning Box	Total	Northeast Hills	Andes
1978–79	0	15 338	15 338	0	0
1979–80	1 390	36 270	37 660	160	0
1980–81	110	20 800	20 910	20	0
1981–82	980	21 580	22 560	60	0
1982–83	780	5 980	6 760	0	0
1983–84	1 860	19 500	21 360	90	0
1984–85	1 430	23 920	25 350	0	0
1985–86	4 960	21 760	26 720	290	0
1986–87	2 820	25 450	28 270	200	0
1987–88	2 480	16 740	19 220	370	0
1988–890	3 340	20 370	23 710	400	50
1989–90	880	19 440	20 320	200	240
1990–91	550	7 020	7 570	6 370	100
1991–92	1 490	1 100	2 590	3 100	8 620
1992–93	80	110	190	1 280	3 820
1993–94	90	0	90	1 250	4 060
1994–95	40	530	570	1 740	1 900
1995–96	120	1 680	1 800	810	1 380
1996–97	10	1 790	1 800	1 170	820
1997–98	50	2 520	2 570	710	1 550
1998–99	120	1 160	1 280	1 120	1 390
1999–2000	60	1 580	1 640	930	2 270
2000–01	240	1 260	1 500	880	1 300
2001–02	200	3 260	3 460	1 040	2 540
2002–03	360	3 360	3 720	870	2 870
2003–04	550	4 510	5 060	640	1540
2004–05	1 190	4 300	5 490	540	1 410

SPAWNING BOX AND NORTHEAST FLATS SUBAREA

(a) Assessment inputs

Both fishery-dependent and fishery-independent data were used in the assessment of the Spawning Box and Northeast Flats subarea. The data consist of fishery abundance indices (CPUE), survey abundance indices, fishery catch-at-length, and survey catch-at-length. Differences in the treatment of these observations between the previous and current assessment were summarised at the start of the East Rise Section.

Three standardised CPUE series were used in the assessment; two for the flat areas of the Spawning Box (pre- and post-closure), and a third for the flat area of the Northeast Flats (Table 14). A process error term of 0.20 was added to the c.v.'s for these series.

Table 14: Estimates of standardised catch per unit effort (CPUE) (% c.v.s in parentheses) for the Spawning Box and Northeast Flats subarea.

Year	Spawning Box pre-closure	Spawning Box post-closure	Northeast Flats
1981	18.9 (21)	— —	— —
1982	17.1 (21)	— —	— —
1983	17.7 (21)	— —	1.6 (12)
1984	18.0 (21)	— —	1.3 (8)
1985	20.9 (21)	— —	1.3 (9)
1986	14.3 (21)	— —	1.0 (6)
1987	13.7 (21)	— —	0.7 (6)
1988	14.4 (21)	— —	0.6 (7)
1989	— —	— —	— —
1990	5.9 (21)	— —	— —
1991	8.6 (21)	— —	— —
1992	6.8 (23)	— —	— —
2000	— —	4.9 (27)	— —
2001	— —	3.2 (25)	— —
2002	— —	2.6 (25)	— —
2003	— —	2.2 (23)	— —
2004	— —	2.7 (22)	— —
2005	— —	2.2 (23)	— —

Three trawl survey series in the Spawning Box were done sequentially by three vessels: *FV Otago Buccaneer*, *FV Cordella*, and *RV Tangaroa*. Table 15 shows the estimated indices, the c.v.'s, and the vessel that performed the survey in that year. Each series was used as a relative abundance index with a separate catchability coefficient estimated for each vessel, but informed prior distributions were used to relate the catchability of the three vessels (see Cordue, in prep). A uniform prior was assigned to the catchability for *Tangaroa* and lognormal priors were given to the ratio of *Cordella* to *Tangaroa* catchabilities, and the ratio of *Buccaneer* to *Cordella* catchabilities. A process error of 20% was added to all c.v.s, as recommended by Francis (2001).

Two alternative acoustic biomass series were used: the first was for the Plume only (the area of high catch rates within the Spawning Box) in 1998-2005, and the second was two wide-area surveys of the Plume, Spawning Box background areas, and Northeast Flats combined. The wide-area surveys were used as the default series, because they were designed to survey the entire stock, unlike the Plume surveys, which were assumed to index a constant proportion of mature orange roughy in the Spawning Box and Northeast Flats subarea. In the previous assessment, acoustic surveys of the Plume and Spawning Box background in 1998 were combined with surveys of the Plume and Northeast Hills in 2000 to create a single biomass estimate for 1999. In the current assessment, these were revised and a single wide-area estimate was calculated for the year 1998, which was compatible with a wide-area survey conducted in 2004. The Plume survey for 2000 was then included with the Plume survey from 1998 and industry Plume surveys from 2002–2005 to create the Plume index. Unlike the 2001 assessment, the wide-area acoustic surveys were not used as absolute estimates, but treated as relative with an informed lognormal prior on the catchability coefficient (see Cordue, in prep). The Plume series was also used as relative with an informed lognormal prior. The difference in target strengths is not an issue when using the estimates as relative indices, and the harmonic mean of the estimates of the NIWA and Kloser and Horn (2003) target strengths was used.

Table 15: Survey biomass indices and c.v.s used as inputs for the assessments of the Northeast Chatham Rise. The c.v.s for the trawl survey were inflated with a 20% process error in the model. The vessel that performed the trawl survey is also listed (BUC, *Otago Buccaneer*; COR, *Cordella*; TAN, *Tangaroa*). Acoustic Plume biomass estimates for 1998 and 2000 were from NIWA surveys, and 2002–2005 from industry surveys.

	Trawl survey						
Year	Vessel	Biomass	(c.v.)	Plume acoustic survey		Wide-area acoustic survey	
1984	BUC	130 000	(17)	—	—	—	—
1985	BUC	111 000	(15)	—	—	—	—
1986	BUC	77 000	(16)	—	—	—	—
1987	BUC	60 000	(15)	—	—	—	—
1988	COR	73 000	(25)	—	—	—	—
1989	COR	54 000	(18)	—	—	—	—
1990	COR	34 000	(19)	—	—	—	—
1991	—	—	—	—	—	—	—
1992	TAN	22 000	(34)	—	—	—	—
1993	—	—	—	—	—	—	—
1994	TAN	61 000	(67)	—	—	—	—
1995	—	—	—	—	—	—	—
1996	—	—	—	—	—	—	—
1997	—	—	—	—	—	—	—
1998	—	—	—	23 677	(30)	60 800	(31)
1999	—	—	—	—	—	—	—
2000	—	—	—	35 344	(29)	—	—
2001	—	—	—	—	—	—	—
2002	—	—	—	58 042	(25)	—	—
2003	—	—	—	49 168	(27)	—	—
2004	—	—	—	41 815	(25)	49 200	(23)
2005	—	—	—	37 364	(25)	—	—

Trawl survey catch-at-length remains the same as used in the previous assessment and was input into the model to estimate selectivity curves. CASAL runs assumed that *Cordella* and *Tangaroa* selectivity curves were the same, thus a separate selectivity curve was estimated for *Otago Bucanneer*. Awatea runs assumed each vessel had a separate selectivity.

Commercial catch-at-length was estimated for pre-closure and post-closure time periods using observer data from 1989–1991 and 2002–05, respectively, and entered into the model as 1990 and 2003. Mean lengths were similar within each time period, but were smaller in the post-closure time period (Table 16). A single selectivity covering both time periods was estimated in the runs, although it is uncertain whether the decline in mean size is due to a change in the population, a change in selectivity, or a combination of both (Hicks 2006).

Table 16: Summary of length data used in the Spawning Box and Northeast Flats assessment. "Year" is the year the length frequency entered the model, "Years" is the block of years that the LF was estimated from, and "EffN" is the effective sample size used when fitting to the LF.

Year	Years	EffN	Mean Length
1990	1989–91	46	35.92
2003	2002–05	50	34.00

(b) Model runs and estimates

Three runs are presented for the Spawning Box and Northeast Flats subarea assessment and are described in Table 17. All three runs included wide-area acoustic and trawl survey biomass estimates as well as commercial fishery and research survey length data, but CPUE was omitted in one run, and another run halved natural mortality as a proxy for lower productivity. The median of the estimated posterior distribution and the variability in the estimates are reported for these runs.

Table 17: Alternative runs for the Spawning Box and Northeast Flats assessment of the East Chatham Rise (Y, used; N, not used).

Label	Trawl biomass	CPUE	Acoustics	M
All.W	Y	Y	Wide-area	0.045
NoCPUE	Y	N	Wide-area	0.045
HalfM	Y	Y	Wide-area	0.0225

Results from both software packages, CASAL and Awatea, are shown because there were some differences between the two that affect the outcome. The most important differences in the model assumptions were:

- It was assumed in CASAL runs that *Cordella* and *Tangaroa* selectivities were equal. Separate selectivity ogives were estimated for each of the three research vessels in the Awatea runs.
- A log-uniform prior was used when estimating virgin biomass in CASAL, while Awatea runs used a uniform prior on virgin age 1 recruitment.

Estimates of B_0 ranged from 292 800 to 366 200 and the current biomass ranged from 33% B_0 to 61% B_0 (Table 18). Awatea runs tended to estimate smaller biomasses and lower Bcurrent (%B_0). In all runs, biomass was estimated to have increased since either the 1990-91 or 1991–92 fishing year when it was at a minimum (*Bmin)*, just prior to the period when the Spawning Box was closed to fishing (Figure 5). Estimates of *Bmin* ranged from 25-44% B_0. Halving natural mortality (HalfM run) resulted in the smallest increase of the biomass in this subarea and the lowest %B_0. Recent years have seen a reduction in the biomass increase due to larger catches (Table 13), but the exploitation rate has remained below E_{CAY} since the closure of the Spawning Box in 1991–92 (Figure 5) for the runs with natural mortality equal to 0.045.

Table 18: Biomass estimates (medians from the posterior distribution, with 95% confidence intervals in parentheses) for the Spawning Box and Northeast Flats assessments. *Bmin* is the minimum estimated biomass in the time series (which occurred in either 1990-91 or 1991-92 depending on the run).

				CASAL
Run	B_0 (t)	*Bcurrent (t)*	*Bcurrent (%B_0)*	*Bmin (%B_0)*
All.W	323 800 (268 200–439 700)	181 000 (127 300-297 300)	56 (47-68)	37
No.cpue	366 200 (267 900-596 000)	223 100 (128 900-449 500)	61 (48-76)	44
Half.M	342 700 (304 300-418 600)	129 200 (93 000-203 700)	38 (30-48)	30

				Awatea
Run	B_0 (t)	*Bcurrent (t)*	*Bcurrent (%B_0)*	*Bmin (%B_0)*
All.W	292 800 (250 800–378 800)	148 500 (107 900-232 500)	51 (43-61)	30
No.cpue	317 500 (248 900–466 500)	172 000 (105 800–318 300)	54 (42–69)	35
Half.M	314 500 (281 300–384 600)	103 100 (72 100–170 500)	33 (26–44)	25

(c) Sensitivity analyses

Seven runs to study the effect of different datasets and model assumptions are described in Table 19. These runs included Plume or wide-area acoustic biomass estimates, omitting some datasets, estimating initial recruitment deviates, and halving M as a proxy for lower productivity.

Table 19: Sensitivity runs for the Spawning Box and Northeast Flats assessment of the East Chatham Rise (Y, used; N, not used).

Label	Trawl biomass	CPUE	Acoustics	M	Notes
All.P	Y	Y	Plume	0.045	
All.W	Y	Y	Wide-area	0.045	
NoPostClose	Y	Y*	N	0.045	No post closure CPUE
CPUE	N	Y	N	0.045	
NoCPUE	Y	N	Wide-area	0.045	
HalfM	Y	Y	Wide-area	0.0225	
All.R	Y	Y	Wide-area	0.045	Recruitment deviates estimated

*The post-closure Spawning Box CPUE was omitted

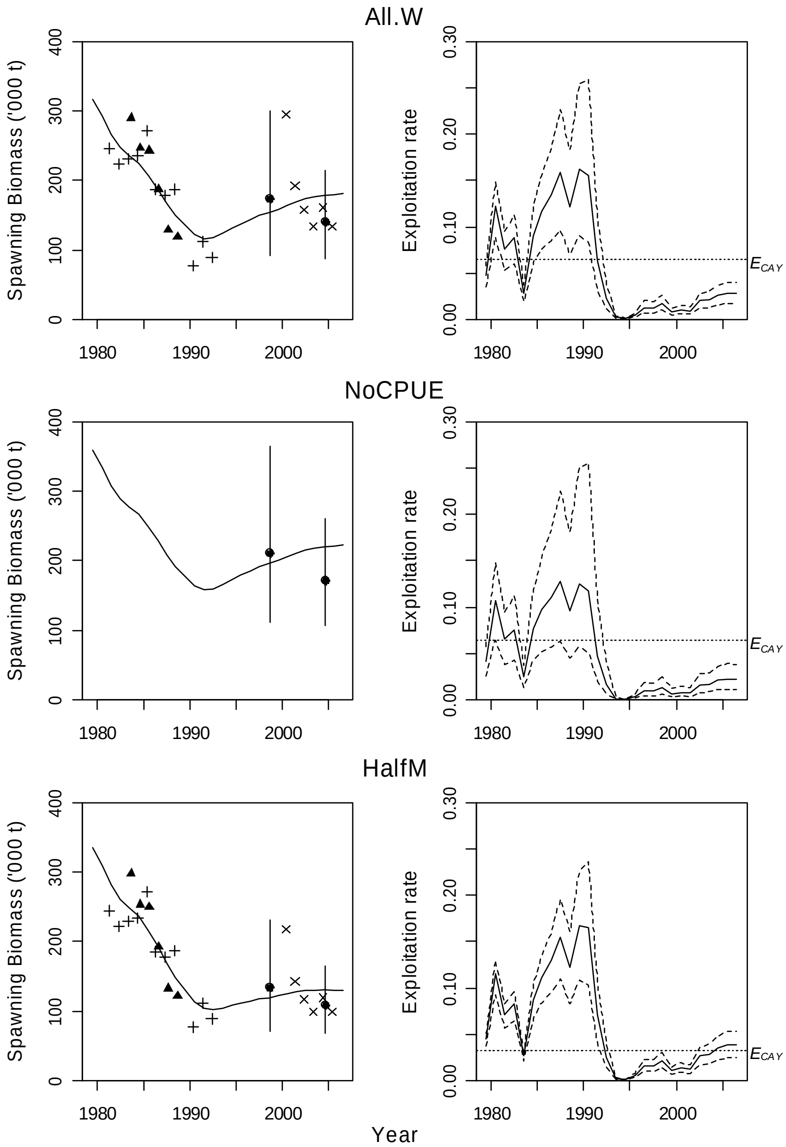

Figure 5: Estimated spawning biomass and exploitation rates for the Spawning Box and Northeast Flats subarea for the CASAL runs only. Patterns for the Awatea runs were qualitatively similar. The observed CPUE series are plotted without confidence bounds (+, Spawning Box pre-closure; Ï, Spawning Box post-closure; p, Northeast Flats) and the wide-area acoustic estimates are plotted with 95% confidence bounds. The 95% confidence interval from the estimated posterior distribution of the exploitation rates is also shown. The horizontal line on the right panel indicates E_{CAY} (0.064 for M=0.045, and 0.032 for HalfM).

All runs indicated that biomass decreased until 1990–91 or 1991–92 followed by an increase, except for the CASAL All.R run, which indicated a biomass decrease until 1997–98 followed by an increase (Table 20). The main differences between the runs were the starting point of the biomass trajectory and the extent to which the stock increased relative to its minimum, resulting in different current biomasses. The three runs that estimated substantially different patterns from the rest are the NoCPUE, HalfM, and All.R runs. The NoCPUE runs gave the highest $\%B_0$ because biomass did not decline as steeply in the pre-closure period. The HalfM runs resulted in relatively small increases in biomass since the year it was at a minimum, and gave the lowest estimates of Bcurrent. Estimating initial recruitment deviates (All.R run) produced a pattern of recruitment where a large pulse of recruitment coincides with the start of the fishery, followed by a large reduction in recruitment during the period of the fishery. This causes a starting biomass larger than average virgin biomass and little increase in biomass when catches are reduced. The NoPostClose run shows that the post-closure biomass increase indicated in the All.W run is not driven by the post-closure data. This suggests that this increase in biomass is simply a product of the pre-closure data and the productivity assumptions built into the model. The HalfM and All.R runs show that when these productivity assumptions are altered then so is the strength of the increase.

One measure of the extent of increase in biomass since the lowest point in the biomass trajectory (B_{curr}/B_{min}) is reported in Table 20. B_{curr}/B_{min} measures the proportional increase in biomass compared to minimum biomass. It ranged from 1.06-1.90.

Table 20: Measures of the amount of increase in biomass for the seven sensitivity runs for the Spawning Box and Northeast Flats subarea. Only MPD estimates are reported.

	CASAL		Awatea	
Run	B_{curr}/ B_{min}	**Year of** B_{min}	B_{curr}/ B_{min}	**Year of** B_{min}
All.P	1.61	1990–91	1.81	1990–91
All.W	1.62	1990–91	1.80	1990–91
NoPostClose	1.61	1990–91	1.75	1990–91
CPUE	1.77	1990–91	1.90	1990–91
NoCPUE	1.49	1990–91	1.63	1990–91
HalfM	1.29	1991–92	1.36	1991–92
All.R	1.06	1997–98	1.25	1991–92

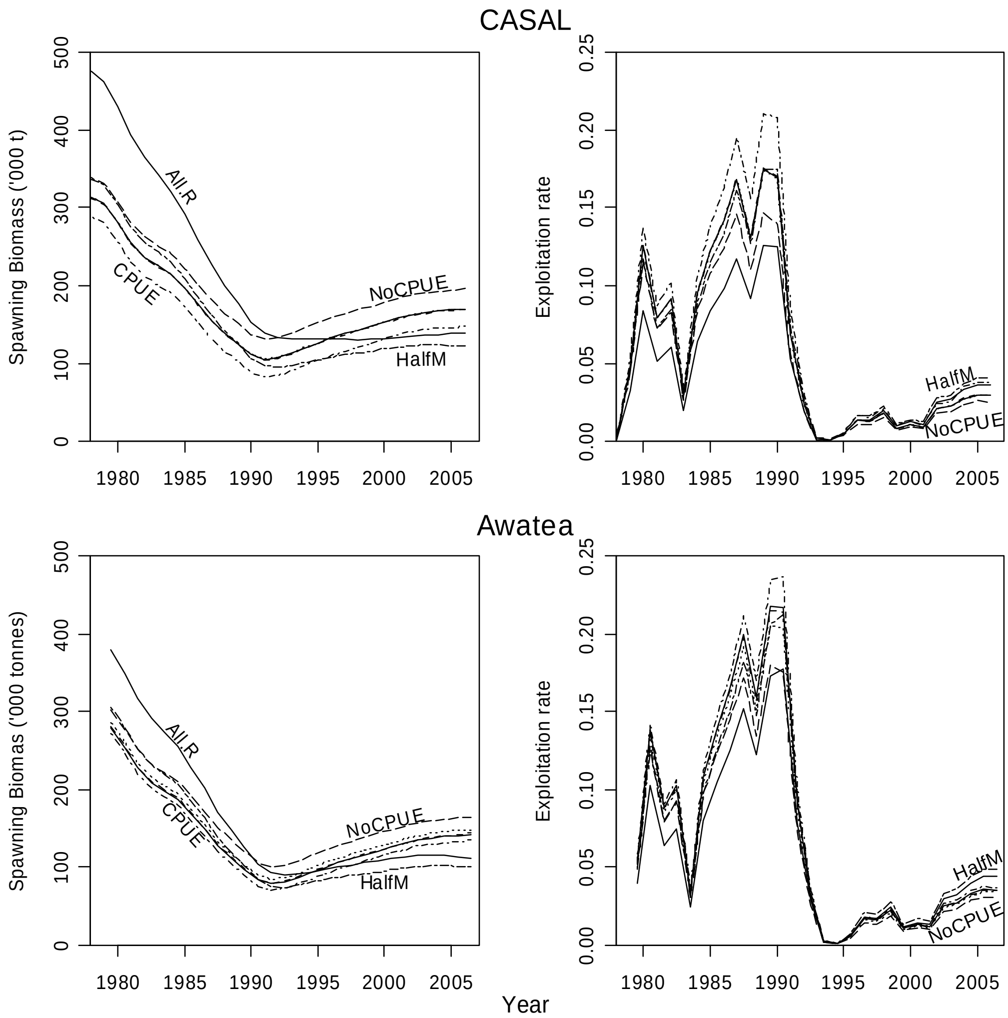

Figure 6: Estimated biomass trajectories (left panel) and exploitation rates (right panel) for the Spawning Box and Northeast Flats sensitivity runs. Only the most extreme runs are labelled. For both CASAL and Awatea, the order of runs, from top to bottom in the most recent year in the left (biomass) panels, are NoCPUE, NoPostClose, All.W, All.P, CPUE, All.R, and HalfM. For CASAL (top panels), the runs NoPostClose, All.W and All.P are very close together, for Awatea (bottom panels), the runs All.W and All.P are very close together.

(d) Catch projections

Five-year projections based on deterministic recruitment were carried out using a range of constant catch options. For each catch option, three measures of fishery performance were calculated:

(4) $P_{0.2}$: the probability that the biomass in 2011 is greater than 20% B_0 [P(B_{2011} > 20%B_0)];
(5) $P_{0.3}$: the probability that the biomass in 2011 is greater than 30% B_0 [P(B_{2011} > 30% B_0)] (where 30% B_0 is used as a proxy for B_{MSY}, as is conventional for New Zealand orange roughy stocks – see Introduction); and
(6) Bmed: the median biomass in 2011 (expressed as a percentage of B_0).

The projections indicated that the biomass would remain stable with a catch between 4 000 and 6 000 tonnes (Table 21). The estimated catch in 2004-05 was 5 200 t.

Table 21: Results from forward projections to 2011 for the Spawning Box and Northeast Flats CASAL and Awatea models. Bcurrent (%B_0) is given in parentheses next to the run names for Bmed. The estimated catch in 2004-05 was 5 200 t.

Performance			Annual catch (t, over five–year period)										
measure	Software	Run	0	2000	4000	5000	6000	7000	8000	9000	10 000	12 000	15 000
$P_{0.2}$	CASAL	All.W	1	1	1	1	1	1	1	1	1	1	1
		NoCPUE	1	1	1	1	1	1	1	1	1	1	1
		HalfM	1	1	1	1	1	0.99	0.99	0.98	0.97	0.89	0.71
	Awatea	All.W	1	1	1	1	1	1	1	1	1	1	1
		NoCPUE	1	1	1	1	1	1	1	1	1	1	1
		HalfM	1	1	1	1	1	0.99	0.96	0.92	0.85	0.65	0.36
$P_{0.3}$	CASAL	All.W	1	1	1	1	1	1	1	1	1	0.99	0.96
		NoCPUE	1	1	1	1	1	0.99	0.99	0.99	0.98	0.97	0.94
		HalfM	0.99	0.97	0.90	0.85	0.78	0.72	0.66	0.58	0.50	0.37	0.22
	Awatea	All.W	1	1	1	1	1	1	1	1	1	1	0.93
		NoCPUE	1	1	1	1	1	1	1	1	1	0.99	0.95
		HalfM	1	0.94	0.77	0.64	0.52	0.41	0.32	0.24	0.18	0.10	0.04
Bmed (%)	CASAL	All.W (56)	63	61	58	57	56	55	53	52	51	48	45
		NoCPUE (61)	68	65	63	62	61	60	59	58	56	54	51
		HalfM(37)	43	40	38	36	35	34	33	31	30	27	24
	Awatea	All.W (51)	59	56	53	52	51	49	48	46	45	42	38
		NoCPUE (54)	62	59	57	56	54	53	52	50	49	46	42
		HalfM (33)	39	36	33	32	30	29	27	26	25	22	18

(e) Yield estimates

For Chatham rise orange roughy, the exploitation rate under a CAY policy is 0.064 (or 0.032 when natural mortality is halved) and the associated long-term average yield (MAY) is 1.99% B_0, or 0.995% B_0 when natural mortality is halved (see Introduction). For the All.W and NoCPUE runs both the CAY for 2007 and the MAY are considerably greater than the 2004–05 catch of 5490 t. However, these yields are less than the 2004–05 catch for the HalfM run due to the lower implied productivity (Table 22).

Table 22: CAY catch and MAY for the Spawning Box and Northeast Flats subarea. The median is shown with 95% confidence intervals in parentheses. CAY and MAY are 6.4% and 1.99% of the 2007 mid-season vulnerable biomass, respectively, when M=0.045. For HalfM runs, CAY and MAY are 3.2% and 0.995% of the 2007 mid-season vulnerable biomass, respectively.

		CASAL
Run	CAY (t)	MAY (t)
All.W	11 200 (7 900-18 300)	6100 (5100-8300)
NoCPUE	13 800 (8 000-27 600)	6900 (5100-11 300)
HalfM	4000 (2880–6300)	3250 (2900– 4000)

		Awatea
Run	CAY (t)	MAY (t)
All.W	9300 (6800-14 400)	5500 (4800-7200)
NoCPUE	10 700 (6700-19 600)	6000 (4700-8800)
HalfM	3200 (2300-5200)	3000 (2700-3600)

NORTHEAST HILLS SUBAREA

(a) Assessment inputs

The data available for the Northeast Hills subarea are a CPUE series from 1991–2005 and two sets of commercial length frequencies created from clusters of years with good observer coverage.

The CPUE series is a standardised series based on tows from four of the main hill features (Table 23). A process error term of 0.20 was added to the c.v.s for the series. The first three years (1991-1993) of the CPUE index were excluded to eliminate possible biases at the start of the series.

Table 23: Estimates of standardised catch per unit effort (CPUE) and c.v.s for the Northeast Hills subarea.

Year	CPUE	c.v. (%)
1991	5.75	21
1992	2.92	21
1993	3.17	23
1994	2.48	22
1995	1.43	20
1996	1.33	21
1997	1.15	19
1998	0.52	18
1999	0.80	17
2000	0.86	14
2001	1.00	14
2002	0.75	12
2003	0.56	13
2004	0.52	14
2005	0.54	15

Length frequencies (LFs) were calculated from blocks of years 1991–97, and 2001–05, and entered as years 1994, and 2003, respectively. The effective sample sizes were calculated by dividing the number of tows by 6, a result found when calculating bootstrapped estimates of variance (Francis 2006). The length frequencies are summarised in Table 24.

Table 24: Summary of the length frequencies used in the Northeast Hills subarea assessment. Year refers to the year the LF was entered in the model, Years refers to the block of years used to create the LF, and EffN is the effective sample size used when fitting the LF.

Year	Years	EffN	Mean Length
1994	1991–97	24	34.51
2003	2001–05	8	34.08

(b) Model runs and estimates

The data were incorporated into a Bayesian stock assessment using both CASAL and Awatea with deterministic recruitment to estimate stock size and do forward projections. The two assessment models produced very similar results, thus only the CASAL results are reported here.

It was agreed that the only one run reported for the Northeast Hills subarea would be that using a shortened CPUE series (first three years eliminated) and both sets of length frequencies (Table 24).

B_0 was estimated to be 17 800 t (95% confidence interval 14 700–22 900 t) and the current biomass 14% B_0 (95% confidence interval 7–32%) (Table 25). Estimated biomass has declined rapidly, but after substantial reductions in catches in the last two years it has increased by approximately 4.5% per annum. Catch-rates over the last three years have also been relatively stable (Table 23). Estimated exploitation rates have declined in recent years but are still almost three times E_{CAY} (Figure 7).

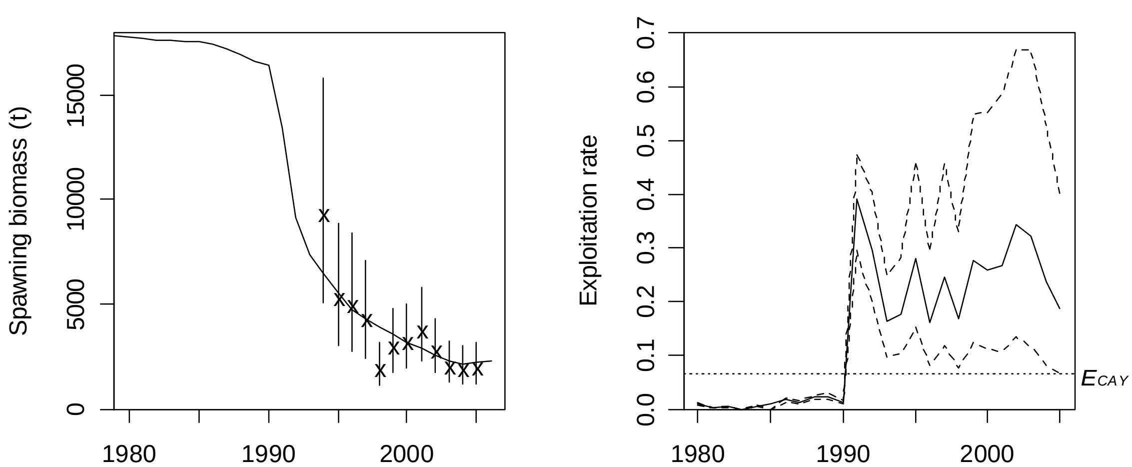

Figure 7: Estimated spawning biomass trajectory and exploitation rates for the Northeast Hills subarea. The observed CPUE with 95% confidence bounds is plotted with the spawning biomass trajectory. The 95% confidence interval from the estimated posterior distribution of the exploitation rates is also shown. The horizontal line on the right panel indicates E_{CAY} (0.064).

Table 25: Biomass estimates (medians, with 95% confidence intervals in parentheses) for the Northeast Hills CASAL assessment model.

B_0 (t)	Bcurrent (t)	Bcurrent (% B_0)
17 800 (14 700–22 900)	2 500 (1 100–7 200)	14 (7–32)

(c) Sensitivity analyses

Independently estimating maturity ogives and selectivity ogives resulted in selectivity curves displaced to the right of the maturity ogive, similar to results described in the Introduction. Thus the maturity was fixed equal to the estimated selectivity ogive.

Estimating a non-linear parameter for the long CPUE series resulted in a slightly better fit to both the CPUE and length frequencies, and a larger current stock status because of the estimated hyperdepletion. Halving natural mortality produced considerably worse fits to all data.

(d) Catch projections

Five-year projections based on deterministic recruitment were carried out using a range of constant catch options. For each catch option, three measures of fishery performance were calculated:

(7) $P_{0.2}$: the probability that the biomass in 2011 is greater than 20% B_0 [P(B_{2011} > 20%B_0)];
(8) $P_{0.3}$: the probability that the biomass in 2011 is greater than 30% B_0 [P(B_{2011} > 30% B_0)] (where 30% B_0 is used as a proxy for B_{MSY}, as is conventional for New Zealand orange roughy stocks – see Introduction); and
(9) Bmed: the median biomass in 2011 (expressed as a percentage of B_0).

The projections indicated that the biomass would remain stable at approximately 14% B_0 with a catch between 600 and 700 t (Table 26). The estimated catch in 2004-05 was 540 t.

Table 26: Results fromprojections to 2010–11 for the Northeast Hills subarea assessment. Bcurrent (%B_0) is given in parentheses after Bmed. Estimated catch for 2004–05 was 540 t.

	Annual catch (t, over a five-year period)								
Measure	**0**	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**
$P_{0.20}$	0.94	0.85	0.72	0.57	0.42	0.32	0.24	0.18	0.13
$P_{0.3}$	0.35	0.27	0.21	0.15	0.11	0.09	0.08	0.06	0.05
Bmed (14)	27	25	23	21	19	17	15	13	11

(e) Yield estimates

For Chatham Rise orange roughy, the exploitation rate under a CAY policy is 0.064 and the associated long-term average yield (MAY) is 1.99% B_0 (see Introduction). Both the CAY for 2007 (170 t) and the MAY (350 t) (Table 27) are less than recent catches (870, 640, and 540 t for the three most recent years;Table 13).

Table 27: CAY catch and MAY for the Northeast Hills subarea. The median is shown with 95% confidence intervals in parentheses.

CAY Catch (t)	MAY (t)
170 (80 – 460)	350 (290 – 460)

ANDES SUBAREA

(a) Assessment inputs

The data available for the Andes subarea are a CPUE series from 1992–2005 and three sets of commercial length frequencies created from clusters of years with good observer coverage.

The CPUE series is a standardised series based on tows on hill features (Table 28). A process error term of 0.20 was added to the c.v.s for the series. The first three years (1992-1994) of the CPUE index were excluded to eliminate possible biases at the start of the series.

Table 28: Estimates of standardised catch per unit effort (CPUE) and c.v.s for the Andes subarea.

Year	CPUE	c.v. (%)
1992	6.03	16
1993	4.81	17
1994	3.27	16
1995	1.40	16
1996	0.82	16
1997	0.88	16
1998	0.70	14
1999	0.89	15
2000	1.05	13
2001	0.63	12
2002	0.77	10
2003	0.60	9
2004	0.42	9
2005	0.50	10

The length frequencies (LFs) were calculated from the blocks of years 1992–95, 1997–99, and 2001–05, and entered as years 1993, 1998, and 2003, respectively. The effective sample sizes were calculated by dividing the number of tows by 6, a result found when calculating bootstrapped estimates of variance as in Francis (2006). The length frequencies are summarised in Table 29.

Table 29 Summary of the length frequencies used in the Andes subarea assessment. Year refers to the year the LF was entered in the model, Years refers to the block of years used to create the LF, and EffN is the effective sample size used when fitting the LF.

Year	Years	EffN	Mean Length
1993	1992–95	38	34.71
1998	1997–99	8	34.20
2003	2001–05	29	33.99

(b) Model runs and estimates

The data were incorporated into a Bayesian stock assessment using both CASAL and Awatea with deterministic recruitment to estimate stock size and do catch projections. The two assessment models produced very similar results, thus only the CASAL results are reported here.

It was agreed that the only run reported for the Andes subarea would be that using a shortened CPUE series (first three years eliminated) and all three sets of length frequencies (Table 29).

B_0 was estimated to be 35 700t (95% confidence interval 29 300–97 600t), and the current biomass 29% B_0 (95% confidence interval 14–74%) (Table 30). Biomass has continued to decline despite recent reductions in catches (Table 13). Exploitation rates have been variable but in recent years they have been above the exploitation rate under a CAY policy, E_{CAY} (0.064) (Figure 8).

Table 30: Biomass estimates (medians, with 95% confidence intervals in parentheses) for the Andes subarea assessment.

B_0 *(t)*	*Bcurrent (t)*	*Bcurrent (%B_0)*
35 700 (29 300–97 600)	10 300 (4 400–72 100)	29 (14–74)

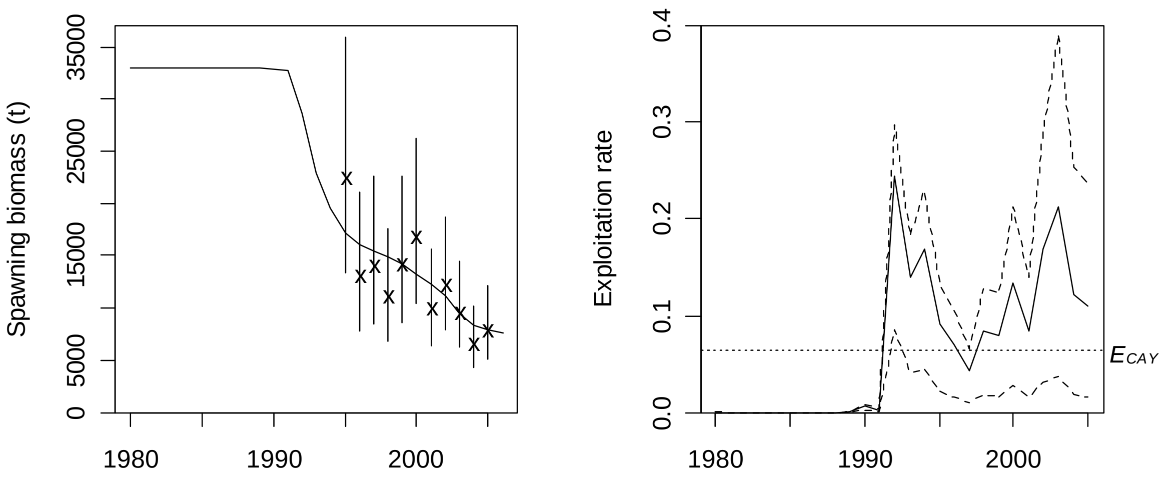

Figure 8: Estimated spawning biomass trajectory and exploitation rates for the Andes subarea assessment. The observed CPUE with 95% confidence bounds is plotted with the spawning biomass trajectory. The 95% confidence interval from the estimated posterior distribution of the exploitation rates is also shown. The horizontal line on the right panel indicates E_{CAY} (0.064)

(c) Sensitivity analyses

Independently estimating maturity ogives and selectivity ogives resulted in selectivity curves displaced to the right of the maturity ogive, similar to results described in the Introduction. Therefore, the maturity was fixed equal to the estimated selectivity ogive.

Runs using the longer CPUE series resulted in poor fits to the early part of the series, with a current biomass (%B_0) that was lower compared to the short CPUE series run. Allowing the model to estimate a non-linear relationship between CPUE and abundance improved the fit to the long CPUE series, although the run still did not adequately fit the steep early decline in CPUE, and the current biomass (%B_0) was estimated to be higher than that in the short CPUE series run. Halving the natural mortality gave a worse fit to all observational data, with an estimated current biomass (%B_0) that was slightly less than that estimated by the short CPUE series run.

(d) Catch projections

Five-year projections based on deterministic recruitment were carried out using a range of constant catch options. For each catch option, three measures of fishery performance were calculated:

(10) $P_{0.2}$: the probability that the biomass in 2011 is greater than 20% B_0 [P(B_{2011} > 20%B_0)];

(11) $P_{0.3}$: the probability that the biomass in 2011 is greater than 30% B_0 [P(B_{2011} > 30% B_0)] (where 30% B_0 is used as a proxy for B_{MSY}, as is conventional for New Zealand orange roughy stocks – see Introduction); and

(12) Bmed: the median biomass in 2011 (expressed as a percentage of B_0).

The projections indicated that the biomass would likely remain stable at approximately 29% B_0 with a catch between 800 and 1 000 t (Table 31). The estimated catch in 2004-05 was 1 410 t.

Table 31: Results from 5-yearyear projections to 2010–11 for the Andes subarea assessment. Bcurrent (%B_0) is given in parentheses after Bmed. The estimated catch for 2005–06 was 1 410 t.

	Annual catch (t, over a five-year period)							
Measure	**0**	**200**	**400**	**600**	**800**	**1000**	**1200**	**1400**
$P_{0.20}$	0.99	0.97	0.93	0.88	0.81	0.74	0.67	0.59
$P_{0.3}$	0.78	0.70	0.62	0.56	0.50	0.45	0.41	0.37
Bmed (29)	39	37	34	32	30	28	25	23

(e) Yield estimates

For Chatham Rise orange roughy, the exploitation rate under a CAY policy (E_{CAY}) is 0.064 and the associated long-term average yield (MAY) is 1.99% B_0 (see Introduction). Both the CAY for 2007 (650 t) and the MAY (710 t) (Table 32) are about quarter to half of the catches in recent years (2 870, 1 540, 1 410 t for the three most recent years; Table 13).

Table 32: CAY catch and MAY for the Andes subarea. The median is shown with 95% confidence intervals in parentheses.

CAY catch (t)	MAY (t)
650 (280 – 4 420)	710 (580 – 1 940)

5. STATUS OF THE STOCKS

For orange roughy stocks, B_{MSY} is interpreted as the mean biomass under a CAY policy, which is estimated to be 30% B_0.

(a) <u>Chatham Rise</u>

(i) Northwest Chatham Rise

The following results are based on a new assessment conducted in 2006.

When all data were included (Alldata run), the 2006 biomass was estimated to be below B_{MSY} at 11% (8-16%) B_0 and recent exploitation rates were estimated to be about four times that under a CAY policy. Projections based on deterministic recruitment indicated that the biomass is likely to increase slowly if catches remain at the current catch limit of 1500 t. However, with these catches the probability that the stock would rebuild to 30% B_0, or even 20% B_0, within 5 years is close to zero.. This catch limit is more than three times the estimated CAY for 2007 (410 t) and about 50% higher than the long-term yield under a CAY policy (1040 t; MAY).

When the survey biomass indices were excluded (Nobiomass run), the stock status (%B_0) and yield estimates were slightly lower than the estimates for the Alldata run.

When the CPUE data were excluded (NoCPUE run), the stock status and yield estimates were considerably more optimistic than the other two runs. However, this run was not considered to give a reliable assessment of stock status.

The assessment is uncertain because the estimated current status of the stock is strongly dependent on the CPUE data for the flat areas and the extent to which these data index the entire stock is unknown. Survey biomass indices provided only limited information on stock status because there are so few of them and they are restricted to the end of the time series when there is relatively little contrast in biomass. There is also conflict amongst the survey estimates in that no model run provided satisfactory fits to all of them.

(ii) East Chatham Rise

It was not possible to carry out an overall assessment for the whole East Chatham Rise area due to pronounced differences in CPUE trends for different subareas.

New assessments were carried out in 2006 for three separate subareas: 1) the Andes, 2) the Northeast Hills, and 3) the Spawning Box and Northeast Flats. Assessment results for each subarea are given below.

Spawning Box and Northeast Flats

Model runs indicate that the biomass declined to a low point of 25-44% B_0 in 1990-91 or 1991-92, but has subsequently increased. What is very uncertain is the extent of the increase, which appears to be driven by model assumptions about productivity, rather than recent data.

If the usual productivity assumptions are correct, then the increase has been substantial, the current biomass is high (between 51% and 61% B_0), and yield estimates (CAY and MAY) are higher than the 2004–05 catch of 5 490 t. Five-year projections suggest that continued fishing at this level will allow a small further increase. Recent exploitation rates are estimated to be less than that associated with a CAY policy, E_{CAY} (0.064 for Chatham Rise orange roughy).

If the actual productivity of orange roughy in this subarea is lower than is usually assumed, the increase in biomass will be less and the estimated yields will be lower. For example, if lower productivity is represented by halving M, the current biomass is estimated to be 33-37% $B_{0,}$ yield estimates (CAY and MAY) are less than the 2004–05 catch of 5 490 t, and five-year projections indicate that continued fishing at this level is likely to cause a slight fall in biomass (but with a greater than 50% chance that the biomass will still be above 30% B_0 in 2011). Recent exploitation rates are estimated to have exceeded E_{CAY}.

Northeast Hills

The assessment of the Northeast Hills indicates that the biomass has been fished down to a level of about 14% B_0 (range 7–32%), but has increased slightly in the last two years in response to reductions in catches. Five-year projections indicate that biomass is likely to increase further if the catch remains at its 2004–05 level of 540 t. However, the current exploitation rate is about three times E_{CAY}, and yield estimates (CAY and MAY) are both lower than the 2004–05 catch.

Andes

The assessment of the Andes indicates that the biomass has been fished down and is currently estimated to be about 29% B_0 (range 14–74%). Five-year projections indicate that the biomass is likely to decrease further if the catch remains at its 2004–05 level of 1410 t, and to remain stable up to catch levels between 800 and 1000 t. The current exploitation rate is about double E_{CAY} and yield estimates (both CAY and MAY) are both about half the 2004–05 catch.

(iii) South Chatham Rise

The status of this stock is uncertain because of the limited information available. Changes over the history of the fishery necessitated the production of separate CPUE indices for each of three sectors of the fishery (two hill areas and fishing on the flat), but no information is available about the movement of fish between these sectors. The simplest assumption, of no movement, produces estimates of virgin biomass (B_0) of around 100 000 t. Assessment results that indicate rebuilding over the past 15 years to levels of either 29% B_0 or 41% B_0 (depending on assumptions) are not supported by the CPUE data. This inconsistency also undermines confidence in the yield estimates and forward projections. Initial attempts to model migration between the sectors showed some promise but were not comprehensive enough to be conclusive.

(b) <u>Southern ORH 3B fisheries</u>

(i) Puysegur

Comments on the status of this stock are unchanged from those presented in the 1998 Plenary Report (Annala et al., 1998).

The assessment for this stock is uncertain because the three time series of biomass indices on which it is based are all very short. Further, the degree of uncertainty is greater than is suggested by the range of biomass and yield estimates presented above. However, all three series (two of trawl surveys and one of CPUE) suggest that the biomass has been reduced substantially. The point estimate of biomass from this assessment is probably below B_{MSY}, but it is uncertain. Estimates of MCY and CAY are 420 t or less. The fishery has been voluntarily closed since 1997–98 and zero catch should allow the stock to move towards B_{MSY}.

(ii) Auckland Islands (Pukaki South)

The Deepwater Working Group examined the data on orange roughy catch and effort from the Auckland Islands area in 2006, and found that there has been relatively little fishing activity in this area in recent years. There were insufficient data to conduct a standardised CPUE analysis, and it was believed that unstandardised CPUE did not provide a suitable index of relative abundance. Therefore, a stock assessment could not be carried out.

(iii) Other fisheries

The Deepwater Working Group examined the data on orange roughy catch and effort from other parts of ORH 3B – the Bounty Islands, Pukaki Rise, Snares Island and the Arrow Plateau – and agreed that there was insufficient data to carry out standardised CPUE analyse for any of these areas. The status of orange roughy in these areas is therefore unknown. It is also not known whether recent catch levels or the current catch limit are sustainable or whether they will allow the stock(s) to move towards B_{MSY}.

6. FOR FURTHER INFORMATION

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