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

1. FISHERY SUMMARY

1.1 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 2006–07 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‡	12 370	12 700
2005–06‡	12 554	12 700
2006–07‡	11 271	11 500
2007–08		10 500

† 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 Chatham Rise, where new fishing grounds developed on and around knolls and hill 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
2005–06	1 400	11	1 300	10	3 900	31	3 900	31	2 100	16
2006–07	700	7	1 200	11	4 200	37	3 700	32	1 500	16

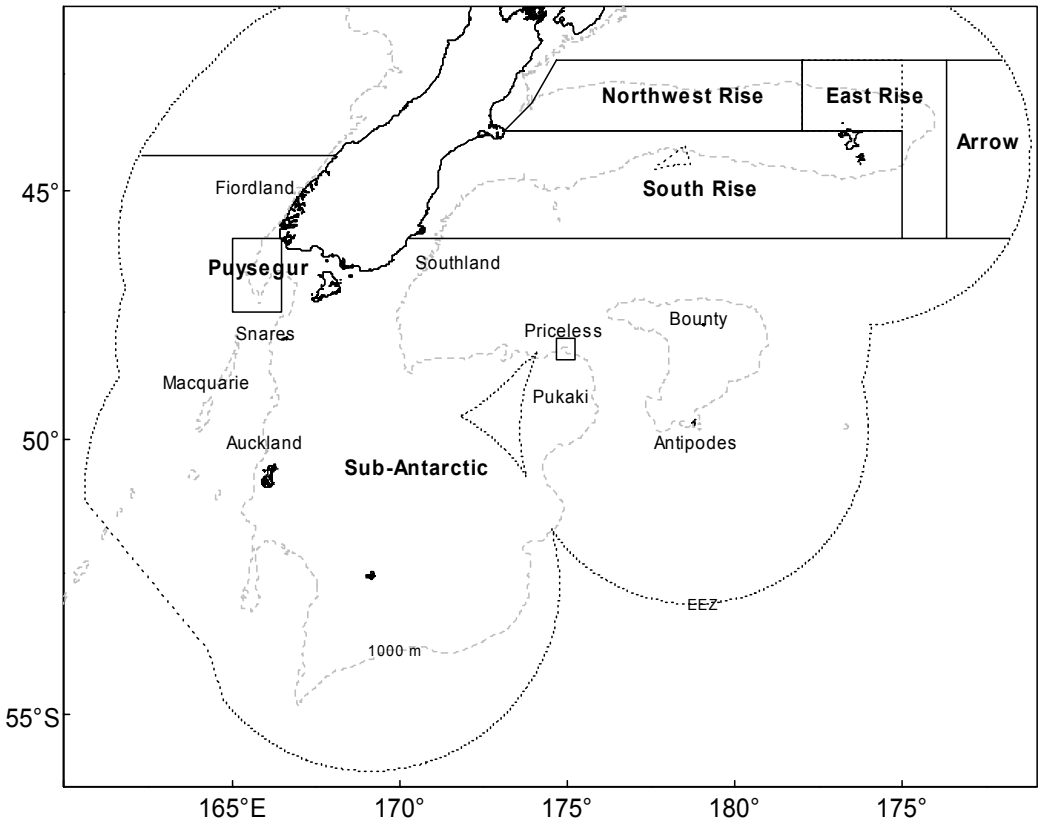

Figure 1: ORH3B designated sub-area boundaries (drawn and labelled in bold font), and the approximate position of other named fisheries outside of the Chatham Rise (labelled in normal font). The Spawning Box is the western part of the area East Rise (to the west of the vertical broken line at 175 W). 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 sub-areas to which they apply, have changed from year to year. The TACC has dropped to 10 500 t in 2007–08 (Tables 1, 3). The agreed catch limit for the Chatham Rise is currently 8400 t. Within the Chatham Rise, catches have generally been about the same as these agreed catch limits (Tables 2 and 3), however, the east Rise sub-area catch limit was exceeded by 550 t in 2005–06 and 650 t in 2006–07. In some years they have been exceeded by catches taken by commercial vessels in support of research surveys. Since 2004–05, 250 t of the TACC has been set aside for industry research surveys, but not allocated to any of the designated sub-areas (surveys of Puysegur were completed in 2004–05 and 2005–06, and Priceless in 2006–07).

Table 3: Catch limits (t) by designated sub-area 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. Sub-area 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
2006–07†	750	8 650‡	*	0	0	1 850
2007–08†	750	7 650#	*	0	0	1 850

† 250 t set aside for industry research surveys.

‡ 8 650 t allocated to the East and South Chatham Rise combined, with no more than 2 000 t from the South Rise, and no more than 7 250 t from the East Rise.

Combined East and South Rise catch not to exceed 7650 t; East Rise (Spawning Box, NE Rise and SE Rise) not to exceed 6500 t; South Rise catch not to exceed 1750t. A catch limit of 1650 t applies to each of the NE Rise and SE Rise; a catch limit of 3200 t applies to the Spawning Box from 1 June – 31 August. Outside of June-August, this subarea component is part of the NE Rise sub-area and subject to the 1650 t catch limit.

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. Flat areas of the northwest Rise and several major hills on the South Rise were important in the late 1980s, but do not support their previous levels of catch, now accounting for less than 5% of the estimated catch (Table 4). 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: the Andes, Smith City and neighbours, Graveyard, and Big Chief and neighbours (Table 4). All of these have shown a decline in unstandardised catch rate since the early years of the fishery, but in recent years unstandardised 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 37% in 2006–07). In addition, large catches have been made in recent years outside of the spawning season, in recently developed areas of the southeast Rise. Catches from the Spawning Box taken during the spawning season (which peaks in July) have been relatively high since 2001–02, although unstandardised catch rates have been variable.

Table 4: Estimated orange roughy catches (to nearest 10 t) and unstandardised median catch rates (to nearest 0.1 t/tow) for four important hill complexes and the Spawning Box In season (the "hotspot" area in June-August) and Out season (i.e., not 'In season') on the Chatham Rise (letters indicating sub-areas, 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: Andes, 44.2 S, 174.6 W; Smiths City and near-neighbours, 43.1 S, 174.2 W; Graveyard, 42.8 S, 180 W; Hegerville, 44.7 S, 177.1 W; Big Chief, 44.7 S, 175.2 W). –, catch < 10 t (2006–07 data are provisional, and catch totals may be incomplete).

	Andes (E)			Smith's City (E)			Spawning Box In (E)			Spawning Box Out (E)			Rest of East (E)		
Year	Catch	Tows	t/tow	Catch	Tows	t/tow	Catch	Tows	t/tow	Catch	Tows	t/tow	Catch	Tows	t/tow
1979–80	–	–	–	–	–	–	10 070	883	11.3	8 130	935	5.6	560	206	2.7
1980–81	–	–	–	–	–	–	10 570	822	11.5	6 600	516	10.9	30	10	3.0
1981–82	–	–	–	–	–	–	3 940	297	9.6	4 940	752	3.8	360	77	4.7
1982–83	–	–	–	–	–	–	3 920	215	15.1	3 800	382	8.1	1 030	63	16.3
1983–84	–	–	–	–	–	–	6 360	341	15.4	8 680	864	7.5	1 190	139	8.6
1984–85	–	–	–	–	–	–	8 900	651	10.4	7 490	522	10.6	990	80	12.4
1985–86	–	–	–	200	16	12.5	8 320	637	10.0	7 670	874	5.9	3 030	306	9.9
1986–87	–	–	–	110	16	6.9	7 900	566	9.5	11 910	1040	6.0	1 950	296	6.6
1987–88	–	–	–	270	38	6.0	7 780	607	8.4	5 730	697	4.9	2 100	324	6.5
1988–89	20	17	1.3	240	28	5.8	7 040	589	9.6	6 590	813	5.0	2 120	303	7.0
1989–90	90	13	6.5	10	4	2.5	6 830	403	12.5	5 030	607	5.3	360	86	4.2
1990–91	80	13	5.8	4 850	624	3.5	2 810	237	8.0	2 840	210	8.0	520	89	5.8
1991–92	7 170	739	9.7	2 470	384	2.0	650	85	6.0	310	57	5.5	3 050	366	8.3
1992–93	3 100	355	8.7	1 050	134	2.0	50	2	–	–	–	–	600	77	7.8
1993–94	3 350	614	5.5	1 010	195	2.5	–	–	–	–	–	–	510	122	4.2
1994–95	1 660	583	2.8	1 410	456	1.0	490	86	0.3	10	25	0.1	440	195	2.3
1995–96	1 120	419	2.7	690	226	1.0	1 260	107	6.0	250	47	1.5	500	122	4.1
1996–97	750	265	2.8	890	223	1.0	790	73	4.0	760	161	2.0	370	117	3.2
1997–98	1 140	478	2.4	540	239	0.4	1 550	103	10.0	660	165	1.0	440	259	1.7
1998–99	1 270	456	2.8	960	359	0.7	380	38	5.0	610	175	1.5	350	215	1.6
1999–00	2 010	536	3.7	860	260	0.7	890	33	25.0	510	111	2.0	390	162	2.4
2000–01	980	358	2.7	790	239	1.0	740	42	10.0	510	141	2.0	580	156	3.7
2001–02	2 040	546	3.7	930	256	1.0	2 060	135	6.0	1 030	245	2.0	900	240	3.8
2002–03	2 230	875	2.6	810	266	0.7	2 020	116	22.0	1 130	264	1.8	1 280	397	3.2
2003–04	1 180	685	1.7	540	242	0.7	1 770	125	12.0	2 190	469	2.5	840	394	2.1
2004–05	1 100	533	2.1	470	182	0.8	1 870	203	4.5	1 930	442	2.6	1 330	405	3.3
2005–06	1 340	730	1.8	480	186	0.7	1 620	101	14.0	1 910	339	2.7	1 810	533	3.4
2006–07	1 160	586	2.0	690	280	0.5	1 970	118	11.6	1 800	401	2.5	1 530	573	2.7

	Graveyard (NW)			Rest of northwest (NW)			Hegerville (S)			Big Chief (S)			Rest of South (E)		
Year	Catch	Tows	t/tow	Catch	Tows	t/tow	Catch	Tows	t/tow	Catch	Tows	t/tow	Catch	Tows	t/tow
1979–80	–	–	–	840	82	10.3	20	3	5.4	–	–	–	20	109	0.2
1980–81	50	7	7.0	8 320	2148	3.9	980	236	4.2	–	–	–	120	219	0.5
1981–82	90	12	4.8	3 830	611	6.3	40	10	4.2	–	–	–	30	28	1.1
1982–83	90	11	6.6	8 130	1418	5.7	7 530	866	8.7	–	–	–	180	35	5.1
1983–84	–	–	–	2 790	664	4.2	3 380	506	6.7	–	–	–	120	179	0.7
1984–85	–	–	–	1 620	316	5.1	5 660	824	6.9	–	–	–	870	292	3.0
1985–86	30	11	3.9	3 500	551	6.3	3 670	845	4.3	–	–	–	530	205	2.6
1986–87	30	11	2.2	2 650	600	4.4	2 470	601	4.1	–	–	–	1 440	433	3.3
1987–88	130	19	5.3	1 250	358	3.5	2 030	680	3.0	–	–	–	3 890	1 003	3.9
1988–89	130	25	5.0	2 410	661	3.6	1 170	568	2.1	1 010	199	5.1	4 660	1 771	2.6
1989–90	160	28	5.3	1 530	484	3.2	470	238	2.0	2 830	532	5.3	4 090	1 121	3.6
1990–91	10	2	4.3	910	224	4.1	170	74	2.2	3 150	453	7	1 650	503	3.3
1991–92	70	25	2.7	180	60	2.9	30	52	0.6	820	138	5.9	820	309	2.6
1992–93	3 300	298	11.1	130	56	2.4	320	84	3.8	3 310	704	4.7	1 200	466	2.6
1993–94	2 280	363	6.0	1 040	188	5.5	230	130	1.8	2 350	702	3.4	2 080	1 135	1.8
1994–95	1 510	364	4.1	670	244	2.7	100	95	1.0	510	242	2.1	880	937	0.9
1995–96	1 790	355	5.0	390	191	2.0	80	106	0.7	580	151	3.8	480	560	0.9
1996–97	870	242	3.5	1 100	365	3.0	170	77	2.2	560	195	2.8	440	311	1.4
1997–98	830	306	2.7	1 240	449	2.8	60	54	1.2	950	290	3.3	410	512	0.8
1998–99	930	186	5.0	1 310	501	2.6	50	17	2.7	560	215	2.6	390	259	1.5
1999–00	630	239	2.6	1 280	340	3.8	50	10	5.2	380	123	3.1	430	173	2.5
2000–01	1 010	301	3.4	1 220	587	2.1	100	21	5.0	1 020	213	4.8	400	203	2.0
2001–02	730	207	3.5	1 130	621	1.8	30	18	1.5	660	234	2.8	280	186	1.5
2002–03	1 080	253	4.3	1 000	569	1.8	150	42	3.5	660	276	2.4	480	204	2.4
2003–04	740	126	5.8	840	557	1.5	100	48	2.1	570	300	1.9	460	267	1.7
2004–05	920	170	5.4	430	296	1.5	100	23	4.2	790	308	2.6	490	231	2.1
2005–06	960	188	5.1	270	212	1.3	90	53	1.7	500	303	1.7	400	281	1.4
2006–07	590	78	7.6	40	24	1.8	160	38	4.2	510	282	1.8	200	188	1.0

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

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 under-caught. 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 and 2005–06 were taken during industry surveys).

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 5 years. In 2006–07, the fishery in the sub-Antarctic was limited to the northeast Pukaki Rise.

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).

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 estimated 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 (2005–06 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
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	3.0	880	4.9	–	–	–	–	–	–	1 260	7.9	20	0.4
1995–96	170	3.4	380	1.5	–	–	–	–	3 060	10	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	210	1.7	370	1.9	240	2.1	10	1.1	130	0.7	–	–	100	0.8
1998–99	580	3.7	440	2	150	0.9	–	–	120	1.6	–	–	90	1.2
1999–00	240	1.9	150	1.1	170	2.4	–	–	–	–	–	–	–	–
2000–01	180	2.4	60	0.9	150	2.7	–	–	20	0.8	–	–	860	1.8
2001–02	55	1.2	130	2.3	40	1.2	550	30.5	–	–	–	–	280	1.8
2002–03	220	2.8	–	–	120	3.4	480	13.0	–	–	–	–	90	1.2
2003–04	130	1.7	–	–	90	1.8	450	4.6	–	–	–	–	150	2.3
2004–05	60	0.9	–	–	100	2.6	540	3.1	520	12.0	100	5.6	90	2.9
2005–06	60	1.7	–	–	40	1.0	540	8.6	740	8.2	190	2.6	30	3.9
2006–07	–	–	–	–	–	–	470	5.1	810	6.2	–	–	–	–

1.2 Recreational fisheries

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

1.3 Customary non-commercial fisheries

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

1.4 Illegal catch

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

1.5 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

For the purposes of this report the term "stock" refers to a biological unit with a single major spawning ground, in contrast to a "Fishstock" which refers to a management unit.

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

Genetic data has been applied to define 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 those on the Ritchie Bank (ORH 2A). These data also suggest multiple stocks within the Chatham Rise, but do not indicate clear stock boundaries. Although there is significant heterogeneity amongst allozyme frequencies from different areas of the Rise, these frequencies varied as much in time (samples from the same location at different times) as in space (samples from different locations at the same time).

Chatham Rise

In 2008 the stock structure of orange roughy on the Chatham Rise was comprehensively reviewed (Dunn 2008). The approach evaluated all available data as no single dataset seems to provide definitive information about likely stock boundaries. The data analysed included: catch distribution and CPUE patterns; location of spawning and nursery grounds; inferred migrations; size, maturity and condition data; genetic studies, and habitat and natural boundaries.

There is evidence that a separate stock exists on the northwest Rise. The northwest Rise contains a substantive spawning ground on the Graveyard Hills, and also nursery grounds around, and primarily to the west of, the Graveyard Hills. There is a gap in the distribution of early juveniles (< 15 cm SL) between the Graveyard area and the Spawning Box at approximately 178°W. A research trawl survey found post-spawning adult fish to the west, but not to the east, of the Graveyard Hills, and a westerly post-spawning migration was inferred. Analyses of median length from commercial and research trawls found orange roughy on the northwest Chatham Rise and Graveyard Hills were smaller than those on the East Rise. A substantial decline in the size of 50% maturity after 1992 was found for both the Graveyard Hills and the northwest Rise, but not for other areas. The only information that does not support the northwest Rise being a separate stock is an indication from patterns in commercial catch rates that some fish arriving to spawn in the Spawning Box may come from the west (Doonan & Coburn 1994, 1997). Catch data and genetic studies do not shed any further light on stock structure. Oceanographic models suggest that a gyre to the east of the Graveyard may provide a mechanism for a separation between the northwest Chatham Rise and the east Rise. Based on the available data the northwest Chatham Rise is considered to be a separate stock.

The previous separation of the Northeast Hills and Andes as separate stocks from the Spawning Box and Eastern Flats was based on simultaneous spawning aggregations occurring on these hills, and because stock assessment models indicated a mismatch between the standardised CPUE trends. However, the scale of spawning on these hills is not known. The information that suggests all of these areas are a single stock includes: the occurrence of a continuous nursery ground throughout the area; similar trends in size of 50% maturity in each area; essentially continuous habitat with similar environmental conditions; inferred post-spawning migrations from the Spawning Box towards the east Rise. Analyses of median lengths from commercial catches showed no obvious differences between areas. In addition, the spawning aggregations found on the Northeast Hills and Andes appear to have been minor compared to that in the Spawning Box. The spawning aggregation on the Northeast Hills is also associated with an increase in mean length and catch rates, suggesting fish spawning on these hills are not resident, and thus are not separate from the surrounding area. Based on the available data the Northeast Hills and Andes are therefore considered to be the same stock as the Spawning Box and Eastern Flats.

The only evidence to separate the eastern area of the South Rise (Big Chief and surrounds) from the east Rise is the lack of spawning migrations inferred from an absence of a seasonal effect in standardised CPUE analyses. The evidence that the Big Chief area is the same stock as the east Rise includes: the nursery grounds and habitat are continuous; there were no splits between the areas identified from analyses of median length; and the fisheries are similar. The reports of spawning fish around Big Chief have been infrequent, and so are considered equivocal on stock structure. The Big Chief area is therefore considered part of the east Rise stock.

There is weak evidence that the area of the south Rise west of and including Hegerville is a separate stock. This includes: median length analyses indicated a split in this area; and there is an oceanographic front at 177°W. However, very few catches of spawning orange roughy have been reported in this area, and there appears to be no substantial nursery ground. Both of these factors support the idea that this area does not have a separate stock. In the area to the west of the suggested split the fish are relatively small during spawning, and relatively large during non-spawning. Combined with a standardised CPUE which shows a decline in abundance around July (peak spawning), and a somatic condition factor which declines during September-November (post-spawning). This supports a hypothesis of adult fish leaving the area to spawn elsewhere.

The south Rise could provide feeding habitat for the stock, which is estimated to have had an initial biomass of over 300 000 t, an amount that was probably too large to inhabit only the east Rise. There is more evidence to support orange roughy in this area being part of the east Rise stock than there is to the contrary. The current hypothesis is that the area to the west of the current convergence may be relatively marginal habitat, where larger juvenile, maturing and adult orange roughy were once predominant, and there is little spawning and few juveniles because the water is relatively cold.

Based on these analyses, the Chatham Rise has been divided into two areas: the Northwest, and the East and South Rise combined (Figure 1). The centre of the Northwest stock is the Graveyard hills.

The centre of the East and South Rise stock is the Spawning Box during spawning, and the southeast corner of the Rise during non-spawning.

4. STOCK ASSESSMENT

No new assessments were completed in 2008, however, the Plenary reviewed the status of the East and South Rise orange roughy stock using available information sources. Because the conclusions of the 2008 analyses of stock structure (section 3 above) indicated that the East and South Rise were likely to be a single stock, the earlier stock assessments for these areas are no longer considered to be reliable and are not reported here. The 2006 assessment for the northwest Chatham Rise, and the 1998 assessment for Puysegur are reported as previously. There are no assessments for any other areas of ORH 3B.

4.1 Northwest Chatham Rise

4.1.1 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 CVs for the series.

Table 7: Estimates of standardized catch per unit effort (and CVs) 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 CVs.

Fishing year	CPUE (All months)	(CV%)
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 CVs) for the northwest Chatham Rise stock.

Source	Date	Biomass (t)	CV	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	9100	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 CV 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, 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 2006). 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 1989–97 were collected into a single length-frequency that was centred on the 1993 fishing year. Eight years of length-frequency data from the period 1998–05 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)

4.1.2 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.

4.1.3 Biomass estimates

For the Alldata run, B_0 was estimated to be 55 000 t (95% confidence interval 51 400-59 500 t; Table 10), the 2006 biomass was 6000 t (4200-9300 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)	6000 (4200-9300)	11 (8-16)
Nobiomass	52 500 (48 300-56 400)	4400 (3200-6900)	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 CV).

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 CVs, 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.

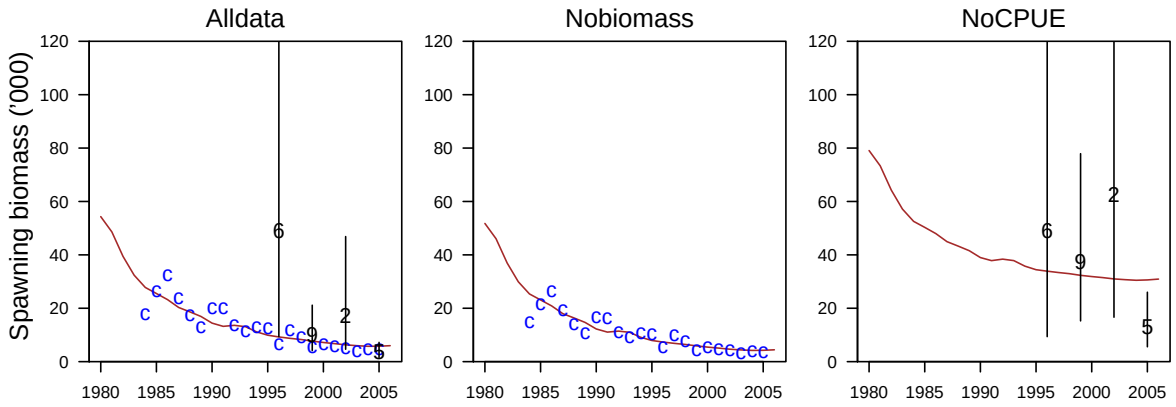

Figure 2: **Estimated biomass trajectories (lines) and fitted data (points) from all model runs. The data are identified by the plotting symbol ('c' = CPUE, '6' = 1996, '9' = 1999, '2' = 2002, '5' = 2005). CPUE data are scaled up to the biomass. Vertical bars (for biomass indices only) show 95% confidence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

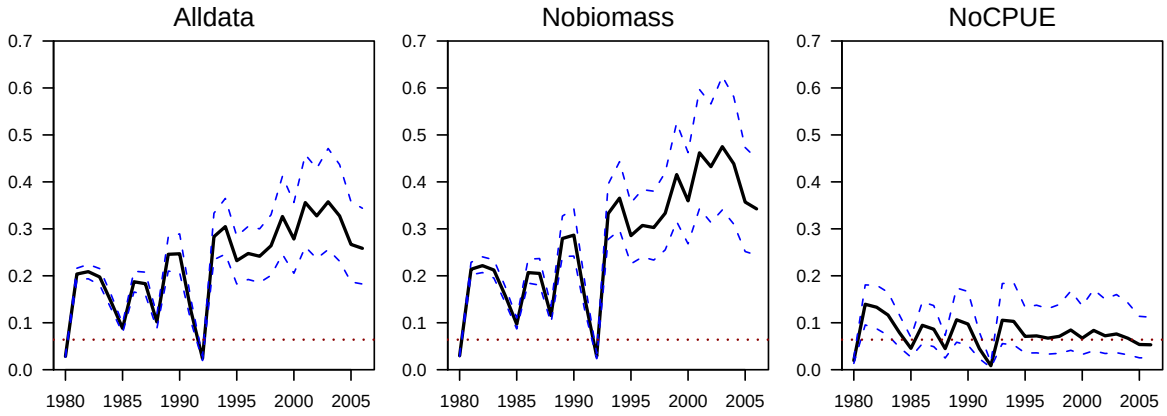

Figure 3: **Estimated exploitation rates (solid line) with 95% CI (dashed line) for all model runs. The horizontal dotted line shows the exploitation rate under a CAY policy, E_{CAY} (0.064).**

4.1.4 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 Plenary 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.

4.1.5 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) B_{MED}: 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 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 B_{MED}. A 5% overrun was assumed for all years (i.e., the actual catches were assumed to be 5% higher than the values shown).

		Annual catch (t, over five–year period)				
Performance measure	Run	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

4.1.6 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 a catch of 1500 t is 3.7-4.8 times the estimated CAY, and 1.4-1.5 times the associated long-term average yield (MAY) (Table 12).

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)

4.2 East and South Chatham Rise

Based on the conclusions of the 2008 analyses of stock structure (section 3 above) this evaluation of stock status assumes the East and South Rise to be a single stock. The previous stock assessment split the area into 4 sub-areas: the Spawning Box and Eastern Flats, the Northeast Hills, the Andes, and the South Rise.

The Northeast Hills, Andes, and the combined Spawning Box and Eastern Flats were last assessed in 2006. The Northeast Hills and Andes were treated separately from the Spawning Box and Eastern Flats because of a mismatch between declining CPUE trajectories in the hill areas, and a model estimated biomass rebuild for the combined Spawning Box and Eastern Flats. All the model runs for the Spawning Box and Eastern Flats predicted that the stock biomass had been rebuilding since the catches were substantially reduced in the early 1990s. However, this rebuild was insensitive to the recent observational data: when all of the data after 1994 were excluded the model gave an almost

identical result to when they were included. From this result, it became clear that the rebuild was largely being driven by model assumptions about incoming recruitment, rather than actual data.

The South Chatham Rise was last assessed in 2004. The stock assessment model did not provide a good fit to the biomass indices (standardised CPUE), and predicted a biomass rebuild which was not seen in the CPUE indices. The rebuild was also driven by model assumptions concerning recruitment.

Analyses of the main observational data are reviewed to draw conclusions on likely stock status. The data considered include (a) research trawl surveys, (b) acoustic surveys of the spawning plume and background areas, (c) catch, and (d) standardised CPUE. In addition the size of the virgin biomass is discussed.

4.2.1 Research trawl surveys

(i) Spawning Box surveys 1984 to 1994

Research trawl surveys of the Spawning Box during July were completed from 1984 to 1994, using three different vessels: *FV Otago Buccaneer*, *FV Cordella*, and *RV Tangaroa* (Figure 4). A consistent area was surveyed using fixed station positions (with some random second phase stations each year).

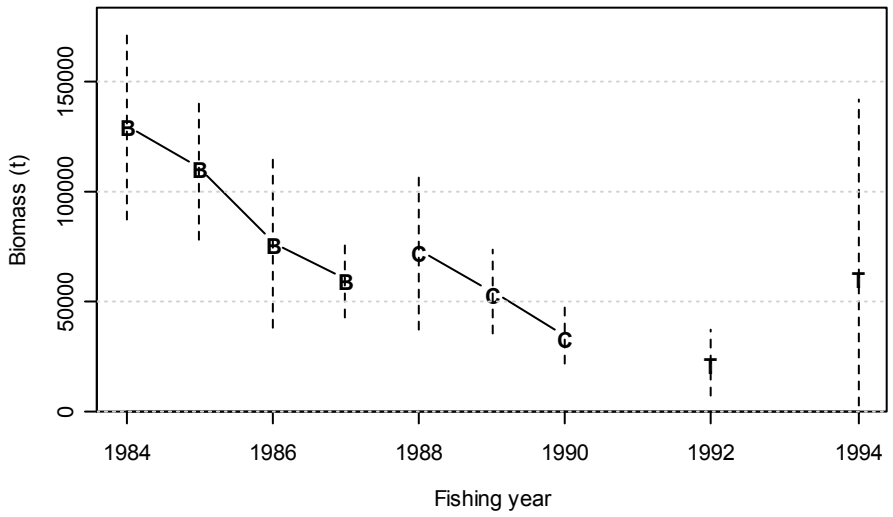

Figure 4: The Spawning Box trawl survey biomass index (assuming a catchability of 1 for each vessel), with 95% confidence intervals shown as vertical bars. Vessels indicated as B, *FV Otago Buccaneer*; C, *FV Cordella*; T, *RV Tangaroa*.

Whether the survey estimates of biomass are comparable within each series depends on whether the trawl surveys were consistently indexing the full spawning biomass. None of the fixed stations are located in the area where the plume is currently found and few if any of the survey stations fished on a "genuine spawning plume" (i.e., aggregations with a large vertical extent). This is of no consequence if in each year the spawning plume(s) contained a constant proportion of the spawning biomass. However, if there was an increasing (or decreasing) proportion of biomass within the plume(s) then the trawl indices would tend to over-estimate (or under-estimate) the decline in spawning biomass.

Under the assumption that the proportion of spawning fish in the plume was constant over time, each series gives a relative index of abundance over time. Four alternative abundance series were considered:

(a) *Otago Buccaneer*

Over 4 years the relative biomass estimates declined steadily from 130 000 t in 1984 to 60 000 t in 1987. The biomass in 1987 was 46.1% of the 1984 level.

(b) *Cordella*
Over 3 years the relative biomass estimates from the series declined from 73 000 t to 34 000 t. The biomass in 1990 was 46.6% of the 1988 level. There were some differences in the timing of the three *Cordella* surveys which means that the three estimates in this series may not be as comparable as the earlier *Otago Buccaneer* series.

(c) *Tangaroa*
The biomass estimate increased from 22 000 t to 61 000 t, a roughly 2.8-fold increase; however, the 1994 survey has wide confidence bounds due to the influence of a single large tow (Figure 4).

(d) 1984–90 time series
If the *Otago Buccaneer* and the *Cordella* are both assumed to have had the same catchability then the point estimate of spawning biomass in 1990 would be 26% of the 1984 spawning biomass. However, it is likely that the vessels had different relative catchabilities.

It is highly likely that the biomass was less than 50% B_0 by 1987 as the *Otago Buccaneer* series alone shows a decline of over 50% and the cumulative catch from the stock was about 130 000 t (including estimated catch overruns from Table 6) before the first *Otago Buccaneer* survey in July 1984. The subsequent *Cordella* series then shows a continuing decline in abundance consistent with the continuing high level of catches over the years 1988–90. The exact level of the decline remains uncertain because of the poorly known relative catchabilities of the different vessels and the possible impact of the timing of the surveys, but the Plenary agreed that by 1990 the stock was likely to be of the order of 30% B_0.

4.3 Wide-area surveys 2004 and 2007

The 2004 and 2007 surveys by *Tangaroa* covered the area which extends from the western edge of the Spawning Box around to the northern edge of the Andes. The area surveyed did not include the spawning plume, the northeast Hills, or the Andes. The survey used a random design over sixteen strata grouped into five sub-areas, and was a combined acoustic and trawl survey in 2004, and a trawl survey in 2007. The trawl net used was the full-wing and relatively fine mesh 'ratcatcher' net. The surveys covered the same survey area as the Spawning Box trawl surveys from 1984 to 1994 as well as additional strata to the east. The depth range surveyed was 825 m to 1250 m, except in subarea 2, where the limits were 800 m to 1350 m. The total area surveyed was 13 147 km^2. In 2007, the survey ran from 4-27 July and 62 trawl tows were completed. In 2004, the survey ran from 7-29 July and 57 trawl tows were completed.

The relative abundance of orange roughy estimated from the trawl surveys did not change significantly between 2004 and 2007 (Table 14). The size distribution of the fish did change, however, with an increase of about 2 cm in the left hand limb (see Figure 5).

Table 14: Relative estimates of orange roughy mature biomass and number of fish (CV. in parentheses) from the 2004 and 2007 trawl surveys, assuming a catchability of 1 between the wingtips (25.4 m).

Year	Biomass (t)		Numbers ('000,000)
	Total	Mature (> = 33cm)	Total
2004	17 000 (10%)	7 000 (12%)	19.1 (13%)
2007	17 000 (13%)	7 100 (17%)	18.8 (12%)

It is not known whether the difference in the size distribution between the last two wide area surveys reflects a real change in the population size structure. However, the surveyed areas were similar and the data appear to be comparable. The length distribution suggests recruitment has been poor or absent at the bottom end of the length range. Using assumed orange roughy growth rates, this recruitment failure, if real, would reach the spawning stock and the fishery in about 11 years. Further surveys would be required to determine whether the drop in recruitment is real.

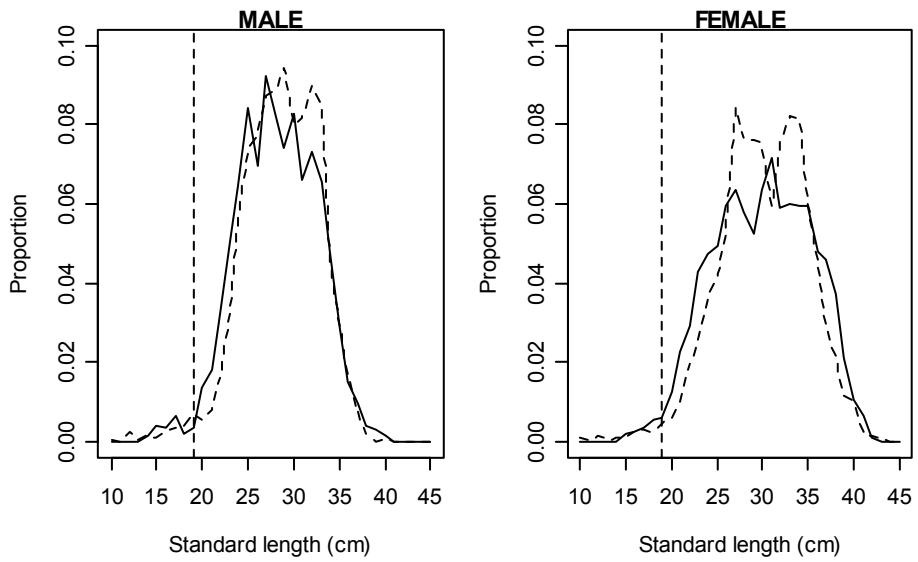

Figure 5: Orange roughy proportion at length estimated from the *RV Tangaroa* wide-area trawl survey of the Spawning Box and Eastern Flats in July 2004 (solid line) and July 2007 (dashed line). The vertical broken lines indicate a length of 19 cm, equivalent to the length of 50% vulnerability to the trawl net.

4.3.1 Acoustic surveys

In the following section, all of the acoustic biomass estimates have been converted to the arithmetic mean of the alternative biomass estimates obtained using the NIWA and the Kloser & Horne (2003) target strength relationships. This method was used in the previous stock assessments because of uncertainty in the true target strength for orange roughy.

i) Plume surveys

Eight acoustic surveys of the biomass in spawning aggregations (plumes) in the Spawning Box during July have been completed (Figure 6). The 1998 and 2000 surveys are not directly comparable to the later series but are important, and work is underway to put all surveys on a comparable basis.

The confidence intervals in Figure 6 include potential bias associated with the assumed mean orange roughy target strength. When considered as a relative time series, the confidence intervals should exclude the potential target strength bias and will therefore be much tighter. For the target strength assumed, the mean biomass in the plume during the last six surveys is 53 000 t.

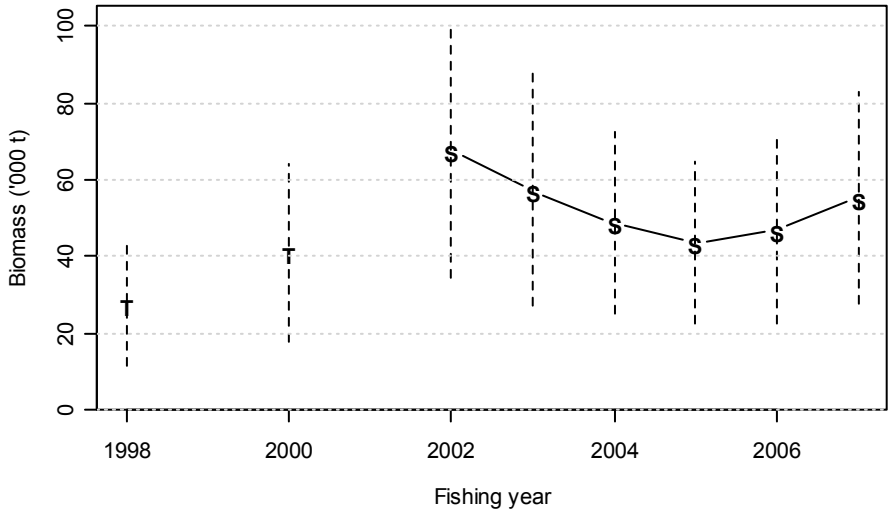

Figure 6: Acoustic biomass estimates for the spawning aggregations in the Spawning Box during July, completed by MFish/NIWA using RV Tangaroa (T), or by the Deepwater Group/FRS using *FV*

***San Waitaki* (S), with 95% confidence intervals of the absolute biomass estimates shown as vertical bars. The biomass estimates plotted are the arithmetic mean of the biomass estimates obtained from the NIWA and Kloser & Horne (2003) target strength relationships.**

(ii) Wide area acoustic surveys

In addition to the acoustic biomass series for the Plume a wide-area survey of the Plume, Spawning Box background areas, and Northeast Flats combined was completed by *Tangaroa* in 2004. The wide-area survey was 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 sub-area. These surveys show that there is mature fish outside the spawning plume and allowance needs to be made for this biomass in determining current stock size.

It is difficult to regard the wide area estimates as estimates of absolute biomass because they include fish from mixed-species marks. The low target strength of orange roughy relative to other species in the mixed-species marks means that there is much greater potential for bias in determining estimates outside the aggregations. Although there is obviously some mature biomass outside the plume, the proportion is difficult to determine.

iii) Acoustic surveys on hills

Acoustic surveys of the Northeast Hills (Smith's City & Camerons) have been completed by industry vessels and more recently by *RV Tangaroa* in 2004 and 2007. Because the species mix is not known it is difficult to determine the biomass of orange roughy in this area. Estimates of total acoustic backscatter from the *Tangaroa* surveys showed a low abundance of orange roughy, with no change between 2004 and 2007. Earlier surveys suggested that larger quantities of roughy may have been present.

4.3.2 Catch patterns

The extent and timing of the commercial fishery for orange roughy on the Chatham Rise has changed over time. The fishery started in the Spawning Box during the spawning season (centred on July), and the south Rise west of Hegerville outside of spawning. During the period around the Spawning Box closure (1992–93 to 1994–95) large catches were taken during the spawning season on the Northeast Hills, Andes, and Big Chief and neighbouring hills. Spawning season catches continued on Smith's City in subsequent years, but were negligible from 2001–02, leaving the Spawning Box as the only substantial spawning season fishery. The non-spawning fishery operated in the Spawning Box in 1979–80 and 1981–82, but otherwise was focused on the south and east Rise.

On the south Rise, catches progressed eastwards during the mid to late 1980s, an effect which was described as a serial depletion of orange roughy from the hills (Clark 1997). Since the early 1990s, the focus of the non-spawning fishery has been on the Northeast Hills, the Andes, and Big Chief and neighbouring hills. Little catch has come from the south Rise west of Big Chief and neighbours, and the only notable catches on the north Rise west of the Northeast Hills have been at the western end of the Spawning Box in 2003–04 and 2004–05, and at the eastern end of the Spawning Box pre-spawning (peaking in May) during 2005–06 and 2006–07. The non-spawning fishery has therefore largely contracted to the hill complexes on the southeast corner of the Rise, where in recent years some new fishing locations have been developed between the Andes and Big Chief ('Middleground'), and just north of the Andes ('Harrisville').

Overall, there has been a spatial contraction of the fishery during the spawning period to the Spawning Box, and a spatial contraction of the fishery during the non-spawning phase towards the southeast corner of the Rise. If we assume that the fishery focuses effort on the areas where catch rates are consistently highest, we can infer these areas are the centre of the distribution for this orange roughy stock. It is also unlikely that there are now many areas where high densities of recruited orange roughy can be found that have not already been fished.

4.3.3 Standardised CPUE

Eight standardised CPUE indices were developed for the east and south Rise, five of which have been updated to the end of the 2006–07 fishing year (Figure 7). The catch and effort data used in the analyses included all target species on the south Rise, where there is a substantial and overlapping oreo fishery, but were restricted to tows which caught or targeted orange roughy on the north and east Rise, where orange roughy was the dominant target species. Vessels were only included in the analyses if they had completed 20 or more tows in 3 or more years, and fine-scale sub-areas (2' squares) were only included if they had been fished 3 or more times for 8 or more years. The latter criterion was intended to restrict the analyses to areas which had been consistently fished. Tows which were believed to have come fast, and data for 1988–89, were also excluded. The estimation of indices took no account of potential technology creep.

Standardised CPUE indices for the spawning-box fishery show different trends pre and post closure of the spawning box. Post closure there is little trend, but pre closure there is a reduction by the early 1990s to about 35% of the 1980 level (Figure 7). The fishery on the eastern flats (which targeted orange roughy migrating out of the spawning box) also showed a marked decline in catch rates to about 35% of the initial level, but over the period 1983 to 1988 (Figure 7). The remaining CPUE indices (hill fisheries and the South Rise flat fishery) show initial very steep declines, followed by little trend (Hegerville and Neighbours and South Rise flats) or a continuing decline (Northeast Hills, Andes Complex, Big Chief and Neighbours). Since 1995, all of the hill indices, except Hegerville and Neighbours, have shown an overall decline of more than 50% (Figure 8).

Due to the targeted nature of fishing, and other factors, CPUE indices may not be proportional to stock abundance, and must be interpreted with care. Also, the orange roughy CPUE indices presented here cannot be considered equally reliable. In particular, the indices from the spawning-box fishery, which targets predictable spawning aggregations, are unreliable as indices of abundance and are only presented for completeness (Coburn & Doonan 1997, Dunn 2007).

It is likely that the hill CPUE indices reflect trends in "local abundance" (i.e., orange roughy associated with the hills during the non-spawning season). They suggest that total local abundance of the Northeast Hills, Andes Compaex, and Big Chief and Neighbours is about 5% of that in the early 1990s. On Hegerville and Neighbours it is perhaps 20% of the early 1980s level. The local abundance on the South Rise Flats has also likely declined to very low levels.

It is less certain that the hill CPUE indices (or the South Rise Flats index) reflect trends in total stock biomass. Certainly, the initial steep declines are too rapid to be indexing total abundance (e.g., if the biomass in the early 1990s was 30-50% B_0 then three of the hill CPUE time series suggest current biomass in the range of 1.5-2.5% B_0 – which is the level of current annual catches). However, although the initial declines are not proportional to total stock abundance, the CPUE indices for the main non-spawning fisheries have all declined at a similar overall rate since the mid-1990s, which suggest that vulnerable biomass may be continuing to decline at current catch levels.

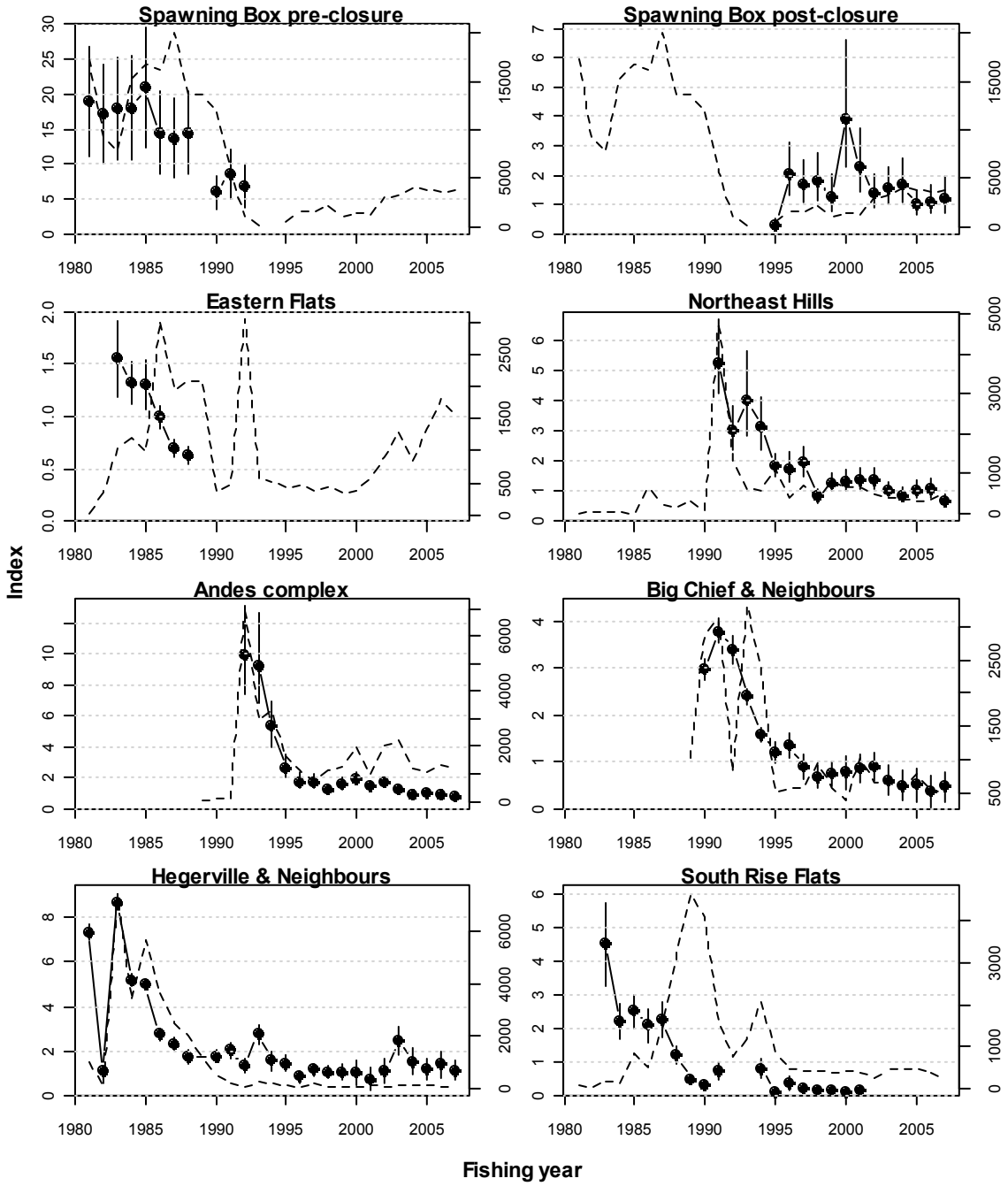

Figure 7: Orange roughy standardised CPUE indices (black circles with bars showing 95% confidence intervals) and annual catches (broken lines) from the commercial fisheries on the East and South Chatham Rise.

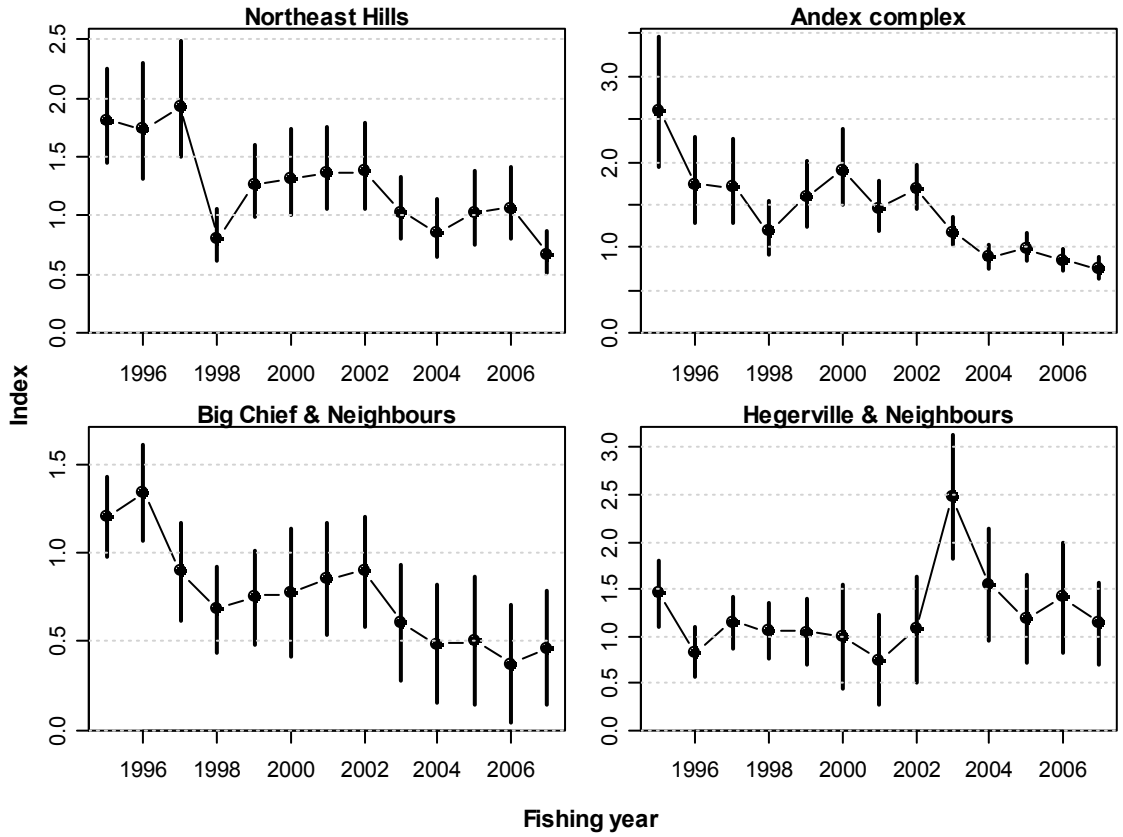

Figure 8: Orange roughy standardised CPUE indices (with 95% confidence intervals) for the main hill complexes in the commercial fishery on the East and South Chatham Rise between 1994–95 and 2006–07.

4.3.5 Estimates of virgin biomass

By the time the 1990 trawl survey was completed, about 325 000 t had been caught from the East and South Rise` stock, 70% of which came from the Spawning Box. The fishery has since been extended to the hills on the East and South Rise and the total cumulative catch (including over-runs) from the stock up to 2006–07 was 499 000 t.

Although recent models used to assess Chatham Rise orange roughy stocks are not thought to be useful in determining recent stock status (see section 4.2 above), earlier models are believed to provide ball-park estimates of the initial stock size before fishing began. Model outputs from the assessments in the early 1990s gave B_0 estimates of between 300 000 and 450 000 tonnes. Simple stock reduction models with the catch data give similar ranges. Based on the cumulative catch and the previous stock assessments for Chatham Rise orange roughy the Plenary considered that B_0 was likely to fall in the range 300 000 to 450 000 t.

4.3.6 Estimates of current biomass

The results from acoustic surveys, reported in section 4.2.(b), are summarised in Table 15. The low and the high estimates for the Plume are based on the two alternative target strength relationships. The low estimate is the mean of the biomass estimates for 2002-2007, using the NIWA target strength relationship (Coombs & Barr 2007). The high estimate is the mean of the biomass estimates using the Kloser & Horne (2003) target strength relationship. These are point estimates and do not include measurement error.

No data are available to estimate biomass for the South Chatham Rise. The assumed range is 0 to 4800 t. The figure of 2400 t assumes the spawning biomass on the South Chatham Rise is equal to the estimate of that on Andes. A figure of 0 t assumes there are no spawning fish on the South Chatham Rise, while the figure of 4800 t assumes twice the biomass estimated for the Andes.

Table 15: Estimates for the Plume, NE Flats, NE Hills and Mt Muck are all derived from data collected from 2002–2007;the estimate for the Andes was derived from 2000 as more recent data are not available. Plume survey estimates were derived from Table 7 of Soule *et al.* (2007). Estimates for the Northeast (NE) Hills refer to total orange roughy (almost entirely spawning); estimates for the Andes and Mt. Muck refer to spawning orange roughy; all were derived from Doonan *et al.* (2001, 2006, in prep.), All biomass estimates have been rounded to the nearest 100 t.

	Spawning biomass estimates		
Area	Mean	Low*	High*
Plume	53 000	33 300	72 800
NE Flats	5 700	5 700	5 700
NE Hills	700	700	700
Mt Muck	1 500	1 500	1 500
Andes	2 400	2 400	2 400
South	2 400	0	4 800
Total	65 700	43 600	87 900

* The low estimate of the Plume is based on the NIWA target strength relationship and the high estimate is based on that of Kloser & Horne (2003)

Based on these estimates, the Plenary considers that the current spawning biomass on the East and South Chatham Rise is between 43 600 and 87 900 t, with a mean of 65 700 t.

Estimates of the proportion of the total mature biomass that was likely to be spawning was considered by the Plenary. A review of available literature found that the multiplier of the spawning biomass to obtain an estimate of mature biomass ranged from 1.01 to 1.91 (Dunn & Dunn 2008). The Plenary considered those estimates that were more reliable and concluded that a maximum credible range was 1.1 to 1.91, with a mean of 1.49.

The estimate of current mature biomass was bounded at the lower end by applying the low multiplier to the low estimate of spawning biomass, and resulted in 48 000 t. The upper bound was derived from applying the high multiplier to the high estimate of spawning biomass, and resulted in 168 000 t. Applying the mean multiplier to the mean spawning biomass resulted in 98 000 t.

4.4 Summary

Catch data from the East and South Chatham Rise indicate that the stock was fished down from an initial biomass of about 300 000 to 450 000 t at a rate of nearly 30 000 t per year from 1980 to 1989-90. Catches from the stock were then cut back and new fisheries were developed in the southern parts of ORH 3B. Initial catches and the trawl surveys of the Spawning Box suggest a reduction in stock size by 1987 to less than 50% B_0 with further declines through to the end of the *Cordella* survey series in 1990. Given the level of catches from 1987 to 1990 (an additional 130 000 t) the Plenary agreed that the stock was likely to have been of the order of 30% B_0 by 1990.

It is likely that the hill CPUE indices reflect real trends in "local abundance". It is less certain that the hill CPUE indices (or the South Rise Flats indices) reflect trends in total stock abundance. However, the CPUE indices for the main non-spawning fisheries have all declined at a similar overall rate since the mid-1990s, which suggests that vulnerable biomass may be continuing to decline at current catch levels.

Acoustic surveys of the spawning plume from 2002 to 2007 have shown no trend in relative spawning stock biomass (53 000 t; range 43 400 to 67 400 t). These acoustic estimates of Plume biomass were used as a basis for estimating the current biomass, by first adding on an allowance for spawning fish in other areas and then scaling up the total spawning biomass by multiplying by 1.49 to obtain an estimate of current mature biomass. This gave a mean estimate of total mature biomass of 98 000 t.

A low estimate of total mature biomass (48 000 t) was calculated by taking the low estimate of spawning biomass from Table 15 (43 600 t) and multiplying it by the low end of the scalar (1.1).

Similarly a high estimate (168 000 t) was calculated using the value of 87 900 t and multiplying by 1.91.
Combining $B_{CURRENT}$ and B_0 estimates gives a current status of 11–56% B_0 (Table 16). However, estimates of stock status greater than 30% B_0 are not considered likely given the reduction in stock size to about 30% B_0 by 1990 and continuing declines in most CPUE indices. It is likely that the East and South Chatham Rise stock is in the range 15-30% B_0.

Table 16: Current biomass as a percentage of the initial biomass (B_0) using the range of estimates for B_0 and current biomass.

	Current biomass (%B_0)	
B_0 (tonnes)	High $B_{current}$ (168 000 t)	Low $B_{current}$ (48 000 t)
300 000	56.0%	16.0%
450 000	37.3%	10.7%

5. STATUS OF THE STOCKS

For orange roughy stocks, B_{MSY} is interpreted as the mean biomass under a CAY policy, which has been estimated to be 30% B_0 (Francis 1992)

5.1 Chatham Rise

Northwest Chatham Rise

The following results are based on the assessment conducted in 2006. The catch limit for the Northwest Chatham Rise was reduced to 750 t from I October 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 was likely to increase slowly if catches remained at the previous 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 was close to zero. The previous catch limit was 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.

East and South Chatham Rise

No new assessments were completed in 2008; rather the Plenary evaluated the status of the East and South Rise orange roughy stock using available information sources. Instead of using stock assessment models, the results from analyses of the main observational data were reviewed to draw conclusions on likely stock status. The data considered included (a) research trawl surveys, (b) acoustic surveys of the spawning plume and background areas, (c) catch, and (d) standardised CPUE.

Stock status was considered by the Plenary to be near to 30% B_0 in 1990. However, in the absence of a stock assessment, it is difficult to extend that estimate of stock status to the present. There are two

conflicting sources of recent abundance information: a series of non-spawning CPUE indices extending from 1992–93 to 2006–07 that suggest a continuing decline and another series of relative acoustic abundance indices spanning the period 2002 to 2007 targeted on the main spawning plume that indicate that there has been no trend.

Combining $B_{CURRENt}$ and B_0 estimates gives a current status of 11–56% B_0. However, estimates of stock status greater than 30% B_0 are not considered to be likely given the reduction in stock size to about 30% B_0 by 1990 and continuing declines in CPUE indices. It is more probable that the stock is in the range 15-30% B_0.

The status of the east and south Chatham Rise orange roughy stock presented here is much lower than the separate model based assessments completed in 2006 and 2004 respectively. However, these earler assessments were based on recruitment assumptions that lead to a biomass rebuild that is not supported by observations.

5.2 Southern ORH 3B fisheries

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 was 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 was uncertain. Estimates of MCY and CAY were 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}.

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 had been relatively little fishing activity in this area in the previous few 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.

Other fisheries

In 2006 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}.

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