ORANGE ROUGHY, CAPE RUNAWAY TO BANKS PENINSULA (ORH 2A, 2B, 3A)

1. FISHERY SUMMARY

(a) Commercial fisheries

The first reported landings of orange roughy between Cape Runaway and Banks Peninsula were in 1981–82 with the development of the Wairarapa fishery. Total reported landings and TACs grouped into orange roughy Fishstocks for 1981–82 to 2005–06 are shown in Table 1.

Table 1: Reported landings (t) and TACs (t) from 1981–82 to 2004–05.

Fishing year	QMA 2A (Ritchie + E.Cape)		QMA 2B (Wairarapa)		QMA 3A (Kaikoura)		All areas combined	
(1 Oct–30 Sep)	Landings	TAC	Landings	TAC	Landings	TAC	Landings	TAC
1981–82*	–	–	554	–	–	–	554	–
1982–83*	–	–	3510	–	253	–	3763	–
1983–84†	162	–	6685	–	554	–	7401	–
1984–85†	1862	–	3310	3500	3266	§	8438	–
1985–86†	2819	4576	867	1053	4326	2689	8012	8318
1986–87‡	5187	5500	963	1053	2555	2689	8705	9242
1987–88‡	6239	5500	982	1053	2510	2689	9731	9242
1988–89‡	5853	6060	1236	1367	2431	2839	9520	10 266
1989–90‡	6259	6106	1400	1367	2878	2879	10 537	10 352
1990–91‡	6064	6106	1384	1367	2553	2879	10 001	10 352
1991–92‡	6347	6286	1327	1367	2443	2879	10 117	10 532
1992–93‡	5837	6386	1080	1367	2135	2879	9052	10 632
1993–94‡	6610	6666	1259	1367	2131	2300	10 000	10 333
1994–95‡	6202	7000	754	820	1686	1840	8642	9660
1995–96‡	4268	4261	245	259	612	580	5125	5100
1996–97‡	3761	4261	272	259	580	580	4613	5100
1997–98‡	3827	4261	254	259	570	580	4651	5100
1998–99‡	3335	3761	257	259	582	580	4174	4600
1999–00‡	3120	3761	234	259	617	580	3971	4600
2000–01‡	1385	1100	190	185	479	415	2054	1700
2001–02‡	1087	1100	180	185	400	415	1667	1700
2002–03‡	782	680	105	99	235	221	1122	1000
2003–04‡	703	680	103	99	250	221	1056	1000
2004–05‡	1120	1100	206	185	416	415	1742	1700
2005–06‡	1076	1100	172	185	415	415	1663	1700

* MAF data † FSU data. ‡ QMS data. § Included in QMA 3B TAC.

There was a major change in the ORH 2A fishery in 1993–94 with a shift of effort from the main spawning hill on Ritchie Bank to hills off East Cape. Although these hills had apparently only been lightly fished in the past, during 1993–94 52% of the total catch from ORH 2A was taken from the East Cape area (Table 2). This led to an agreement between industry and the Minister of Fisheries that from 1994–95 the traditionally fished areas within ORH 2A (south of 38°23', hereafter referred to as "2A South") would be managed separately from the new East Cape fishery (north of 38°23', "2A North"). ORH 2A South was combined with ORH 2B and ORH 3A to form the Mid-East Coast (MEC) stock for management purposes.

The catch limits for these two areas changed three times in the following four years, including a subdivision of 2A North (Table 3). Catches in the exploratory sub-area of 2A North never approached the catch limit, with only 37 t being caught in 1996–97 and less in subsequent years.

For the 2000–01 fishing year the TACC for ORH 2A was reduced to 1100 t, for ORH 2B to 185 t, and for ORH 3A to 415 t. Within the TACC for ORH 2A, the catch limit for all of 2A North was reduced to 200 t, with no separate catch limits for the East Cape Hills and exploratory area, and the catch limit for 2A South was reduced to 900 t. This gave a catch limit for the MEC stock of 1500 t. The catch limit for MEC was reduced to 800 t (and ORH 2A South to 480 t) for the 2002–03 and 2003-04 fishing years. The combined catch limit for the MEC stock was raised to 1 500 t from 1 October 2004, while 2A North retained a separate TACC of 200 t.

Table 2: Ritchie + East Cape (ORH 2A) catches by area, in tonnes and by percentage of the total ORH 2A catch. (Percentages up to 1993–94 calculated from Ministry of Fisheries data; 1994–95 to 1996–97 from NZFIB data, and subsequently from Orange Roughy Management Co.) Mid-East Coast (MEC) stock (ORH 2A South, ORH 2B, and ORH 3A combined) catches in tonnes.

Fishing year	2A North		2A South		MEC (t)
	t	%	t	%	
1983–84	0	0	162	100	7401
1984–85	4	<1	1858	99	8434
1985–86	41	1	2778	99	7971
1986–87	253	5	4934	95	8452
1987–88	36	<1	6203	99	9695
1988–89	143	2	5710	98	9477
1989–90	20	<1	6239	99	10 517
1990–91	13	<1	6051	99	9988
1991–92	18	<1	6329	99	10 099
1992–93	30	<1	5807	99	9022
1993–94	3437	52	3173	48	6563
1994–95	2921	47	3281	53	5721
1995–96	3235	76	1033	24	1890
1996–97	2491	66	1270	34	2122
1997–98	2411	63	1416	37	2240
1998–99	1901	57	1434	43	2273
1999–00	1456	47	1666	53	2515
2000–01	302	22	1083	78	1752
2001–02	186	17	901	83	1480
2002–03	173	24	546	76	886
2003–04	170	24	533	76	886
2004–05	271	24	849	76	1471
2005–06	217	20	859	80	1446

Table 3: Catch limits (t) by sub-area within ORH 2A, as agreed between the industry and Minister of Fisheries since 1994–95 and the catch limit for the Mid-East Coast (MEC) stock (ORH 2A South, ORH 2B, ORH 3A combined). (Note that 2A North was split, for the years 1996–97 to 1999–2000, into the area round the East Cape Hills and the remaining area, which is called the exploratory area).

Fishing year	2A North		2A South	MEC
1994–95	3000		4000	6660
1995–96	3000		1261	2100
	East Cape Hills	**Exploratory**		
1996–97	2500	500	1261	2100
1997–98	2500	500	1261	2100
1998–99	2000	500	1261	2100
1999–00	2000	500	1261	2100
	2A North			
2000–01	200		900	1500
2001–02	200		900	1500
2002–03	200		480	800
2003–04	200		480	800
2004–05	200		900	1500
2005–06	200		900	1500

(b) Non–commercial fisheries

Non–commercial fishing for orange roughy is not known in this area.

(c) Maori customary fisheries

No information on Maori customary fishing for orange roughy is available for this area.

(d) Illegal catch

No information is available about illegal catch in this area.

(e) Other sources of mortality

There has been a history of catch overruns in this area because of lost fish and discards. In the assessments presented here total removals were assumed to exceed reported catches by the overrun percentages in Table 4.

All yield estimates and forward projections presented make an allowance for the current estimated level of overrun of 5%.

Table 4: Catch overruns (%) by QMA and year. –, no catches reported.

Year	2A (North and South)	2B	3A
1981–82	–	30	–
1982–83	–	30	30
1983–84	50	30	30
1984–85	50	30	30
1985–86	50	30	30
1986–87	40	30	30
1987–88	30	30	30
1988–89	25	25	25
1989–90	20	20	20
1990–91	15	15	15
1991–92	10	10	10
1992–93	10	10	10
1993–94	10	10	10
1994–95 and subsequently	5	5	5

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

Two major spawning locations have been identified in ORH 2A, one at the East Cape hills in "2A North" and the other on the Ritchie Bank in "2A South". Spawning orange roughy were located in Wairarapa (ORH 2B) in winter 2001, but no large concentrations were found, and the significance of this spawning event is not known. Spawning orange roughy have not been located in Kaikoura (ORH 3A). The major spawning area in ORH 2A South, ORH 2B, and ORH 3A is still believed to be the Ritchie Bank.

Results from allozyme studies show that orange roughy from the three areas, "2A South", Wairarapa, and Kaikoura cannot be separated, but are distinct from fish on the eastern Chatham Rise. Earlier data suggesting a genetic stock boundary between East Cape and Ritchie Bank were not supported by a recent replicate sample from East Cape. For these reasons, orange roughy in this region are currently treated as two stocks: the mid–East Coast (MEC) stock (2A South, Wairarapa, and Kaikoura) and the East Cape (EC) stock (2A North).

4. STOCK ASSESSMENT

Stock assessments are reported below for East Cape from 2006 and for Mid East Coast (MEC) from 2004 and 2005. An updated assessment was attempted for the MEC stock in 2007 with the addition of catch data up to 2005-06 and new standardised CPUE indices (Table 8). The work is still in progress but preliminary results are discussed in section 4.2 (f) below.

4.1 East Cape stock (2A North)

The stock assessment for the East Cape was last updated in 2003 and is summarised here (Anderson, 2003). An attempt to update the assessment with a new set of CPUE indices was made in 2006, but was rejected by the Working Group because of recent changes in the fishery which essentially invalidated the utility of the CPUE series as an index of abundance. With no other abundance estimates available, an updated stock assessment was not possible.

(a) Assessment Inputs

A CPUE analysis was performed in 2006, but was considered unreliable because of a change in fishing patterns and fleet size corresponding to the reduction of the catch limit to 200 t in 2000–01.

The Working Group noted that the last three years were dominated by a single vessel. Concern was raised about the utility of CPUE analyses in fisheries where substantial catch limit reductions have caused major changes in fishing patterns. The WG concluded that the large increase and subsequent decline in the CPUE index in recent years was not representative of biomass trends and was linked more to the change in fleet composition.

The model inputs for the 2003 stock assessment were catches, an egg survey, and CPUE indices (Table 5). The biological parameters used are presented in the Biology section at the beginning of the Orange Roughy section.

Table 5: Standardised CPUE and egg survey indices, and CVs, as used in the assessment for the EC stock. –, no data.

	CPUE	CV(%)	Egg survey	CV(%)
1993–94	1.00	12	–	–
1994–95	0.69	8	29000	69
1995–96	0.60	8	–	–
1996–97	0.41	8	–	–
1997–98	0.25	7	–	–
1998–99	0.25	7	–	–
1999–00	0.22	9	–	–
2000–01	0.21	15	–	–
2001–02	0.22	16	–	–

(b) Stock assessment

A stock assessment analysis for the East Cape stock was performed by NIWA in 2003 using the stock assessment program, CASAL (Bull et al., 2002) to estimate virgin and current biomass.

- The model was fitted using Bayesian estimation and partitioned the EC stock population by sex, maturity (the fishery was assumed to act on mature fish only) and age (age-groups used were 1–70, with a plus group).
- The model estimated virgin biomass, B_0, and the process error for the CPUE indices. Catchability, q, was treated as a nuisance parameter by the model.
- The stock was considered to reside in a single area, and to have a single maturation episode modelled by a logistic-producing ogive where 50% of fish of both sexes were mature at age 26 and 95% at age 29.
- The catch equation used was the instantaneous mortality equation from Bull et al. (2002) whereby half the natural mortality was applied, followed by the fishing mortality, then the remaining natural mortality.
- The size at age model used was the von Bertalanffy.
- No stock recruitment relationship was assumed.
- 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.
- Lognormal errors, with known (sampling error) CVs were assumed for the CPUE and egg survey indices. Additionally, process error variance was estimated by the model and added to the CVs from the CPUE indices.
- Confidence intervals were calculated from the posterior profile distribution of B_0 estimates, where the process error parameter was fixed at the value previously estimated.

(c) Biomass estimates

Biomass estimates for this stock are given in Table 6 and the biomass trajectories, plotted against the scaled indices, are shown in Figure 1. The base case assessment of the EC stock included only the CPUE indices. An alternative assessment was carried out including the point estimate of biomass from the 1995 egg survey along with the CPUE indices. The CPUE indices agree well with the biomass estimates, with only the 1993–94 and 1997–98 indices departing from the biomass 95% confidence intervals. The egg survey biomass estimate, with the large associated CV, has little effect on the biomass trajectory.

Table 6: Estimates of virgin biomass (B_0), B_{MSY} (calculated as B_{MAY}, the mean biomass under a CAY policy), and $B_{current}$, for the EC stock (with 95% confidence intervals in parentheses).

Assessment	Index	B_0 (t)		B_{MSY} (t)	$B_{current}$ (t)	% B_0	
Base case	CPUE	21 100	(19 650–23 350)	6300	5100	24	(20–32)
Alternative	CPUE + Egg survey	21 200	(19 700–23 550)	6380	5200	25	(20–33)

The base case estimate of $B_{current}$ (the mid–year biomass in 2002–03) is 5100 t (24% B_0) with a 95% confidence interval of 3800 to 7550 t. This is almost twice the value of $B_{current}$ estimated for mid-year 1999–2000 in the previous assessment (Anderson 2000). The alternative assessment gives a very similar estimate of $B_{current}$.

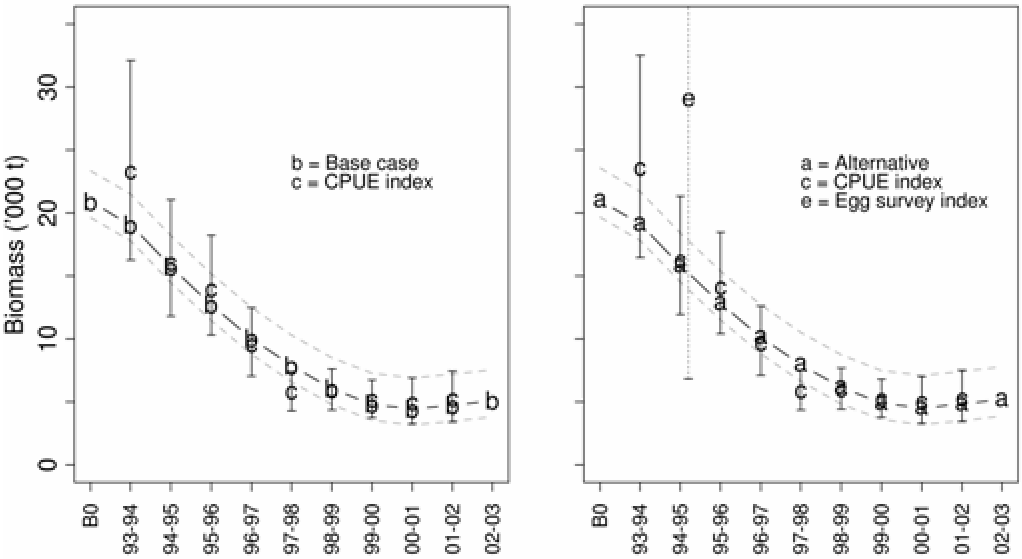

Figure 1: Estimated biomass trajectories for the base case and alternative model runs for the EC stock. Annual biomass estimates are mean posterior density (MPD) values and 95% confidence intervals (grey dashed lines) are calculated from the posterior profile distribution of B_0 estimates. The CPUE index CVs (sampling error plus process error) are shown, as is the CV calculated for the egg survey biomass estimate.

(d) Estimation of Yields

Estimates of MCY and CAY for the EC stock were calculated from large numbers of simulation runs using posterior profile sampling of B_0 and a series of trial harvest levels. These estimates, together with MAY (the mean catch with a CAY harvesting strategy) and CSP (current surplus production) are given in Table 7. CSP is driven by recruitment of fish spawned before the fishery began.

Table 7: Estimates of MCY, CAY, MAY, and CSP for the EC stock, with 95% confidence intervals in parentheses (all corrected for an assumed overrun of 5%).

Assessment	MCY (t)	CAY (t)	MAY (t)	CSP (t)
Base case	350	370	410	550
Alternative	350	370	410	550

4.2 Mid–East Coast stock (2A South, 2B, 3A)

The previous assessments for this stock were carried out in 2004 and 2005 and are summarised below. Biomass was estimated to be 17 – 18% B_0 (95% confidence interval 14-23%) when CPUE was assumed directly proportional to abundance (beta = 1) or about 30% B_0 when beta was estimated. The Working Group now prefers to drop the initial 3 CPUE data points from the assessment rather than to estimate the beta parameter within the model.

An assessment was carried out for the Mid-East Coast stock in 2004 by NIWA (National Institute of Water and Atmospheric Research), contracted by the Ministry of Fisheries, and in 2005 by UW/SeaFIC (a cooperation between the University of Washington School of Aquatic and Fishery Sciences, and the Seafood Industry Council) under contract to the Orange Roughy Management Company. Both assessments are reported here.

(a) Assessment inputs

The 2004 assessment inputs were updated catches, a revised CPUE index, an acoustic biomass estimate for 2003 (Table 8), and age frequency samples from commercial landings in 1989, 1990, 1991, and 2002 (Table 9). The acoustic survey in 2003 did not survey the background strata (Doonan et al., 2004), thus data from the previous survey (2001) were used to expand the 2003 survey to an area-wide absolute estimate (Hicks, 2004). Age frequency samples from 1989, 1990, and 1991 were aggregated and treated as a single observation for 1990. As in previous assessments, trawl survey length frequencies were fitted, the CPUE and trawl survey series were treated as relative, and the acoustic and egg survey biomass estimates were treated as absolute.

The 2005 assessment by UW/SeaFIC included the same data as the 2004 assessment, with the addition of an extra year of catch for 2004–05, a new ageing error matrix with larger error terms, and new growth parameters.

The biological parameters used in the assessments are presented in the Biology section at the beginning of the orange roughy section. The parameters describing maturity and growth were derived from the new age frequency samples, although the new maturity ogive was not used because the maturity ogive was set equal to the estimated commercial selectivity. A new analysis of the growth parameters in 2005 resulted in nearly the same estimates as in 2004, but the variation of length at age was larger in the 2005 assessment and modelled as a function of length. The length-weight and natural mortality parameters were the same as used in the previous assessments (Anderson et al., 2002).

The catches used were calculated by taking the ORH 2B and ORH 3A catches from Table 1 and the 2A South catches in Table 2, increasing them by the overrun values in Table 4, and then summing by year.

Table 8: Standardised CPUE, trawl survey biomass estimates, egg survey, and acoustic survey indices, and their calculated CVs, as used in the stock assessments for the MEC stock. The calculated CVs for the CPUE and trawl survey indices were inflated by a process error of 0.2 for use in the stock assessments. –, no data.

Fishing year	CPUE 2004	CV (%)	CPUE 2007 (early)*	CV (%)	CPUE 2007 (late)*	CV (%)	Trawl survey	CV (%)	Egg survey	CV (%)	Acoustic survey	CV (%)
1983–84	1.177	19	2.72	5	–	–	–	–				
1984–85	0.863	21	1.37	5	–	–	–	–				
1985–86	1.100	21	1.48	5	–	–	–	–				
1986–87	0.646	23	1.28	5	–	–	–	–				
1987–88	0.803	22	1.90	5	–	–	–	–				
1988–89	–	–	–	–	–	–	–	–				
1989–90	0.759	18	1.45	5	–	–	–	–				
1990–91	0.755	16	1.13	5	–	–	–	–				
1991–92	0.403	16	0.80	5	–	–	7073	28				
1992–93	0.329	17	0.37	5	–	–	4823	15	20 000	49	-	-
1993–94	0.199	17	0.52	5	–	–	5129	18				
1994–95	0.103	18	0.35	5	–	–	–	–				
1995–96	0.088	21	0.33	5	–	–	–	–				
1996–97	0.174	22	0.56	5	0.43	5	–	–				
1997–98	0.121	20	–	–	0.23	4	–	–				
1998–99	0.078	19	–	–	0.17	3	–	–				
1999–00	0.069	19	–	–	0.18	4	–	–				
2000–01	0.097	20	–	–	0.23	5	–	–	-	-	26 700	38
2001–02	0.16	25	–	–	0.45	7	–	–				
2002–03	0.194	28	–	–	0.37	7	–	–	-	-	18 486	76
2003–04	–	–	–	–	0.44	7	–	–				
2004–05	–	–	–	–	0.32	6	–	–				

* Not used in 2004 and 2005 assessments

Table 9: Details of age samples as used for the stock assessment for the MEC stock, indicating the number of trips sampled, the number of age samples (N age) and accompanying length samples (N length), and the median, minimum and maximum age range.

Year	Number of trips	N age	N length	Median Age	Age range
1989	3	150	1538	65	26 – 164
1990	4	200	2053	60	24 – 174
1991	5	249	2529	53	17 – 192
2002	7	795	1437	44	21 – 145

(b) Stock assessment

The stock assessments carried out by NIWA and UW/SeaFIC in 2004 were very similar in terms of inputs and runs. The 2005 assessment by UW/SeaFIC was slightly different in terms of inputs, as mentioned above. There are three general assumptions for the runs for both 2004 and 2005: 1) fixing β at 1, indicating a linear proportional relationship between CPUE and abundance; 2) estimating β, as described in the Introduction to Orange Roughy section; and 3) omitting the CPUE data altogether. Catch at age data were used in all the runs. Table 10 summarises these runs.

Table 10: Three alternative assumptions to the stock assessment.

Model	CPUE	β
Beta1	used	1
EstBeta	used	estimated
No CPUE	not used	not used

In the assessments, recruitment was assumed to be constant. Runs estimating recruitment from the age frequency data were explored, but they did not improve fits to the age frequency data, and therefore no results are presented.

2004 NIWA assessment

Stock assessments were performed by NIWA in 2004 using the stock assessment program CASAL (Bull et al., 2002) to estimate virgin and current biomass.

- The model was fitted using Bayesian estimation and partitioned the MEC stock population by age (age-groups used were 1–80, with a plus group).
- The model assumed a single sex, with growth modelled using the von Bertalanffy growth formula.
- The stock was considered to reside in a single area, and to have a single maturation episode, with maturation modelled by a logistic ogive fixed to equal the fishery selectivity ogive.
- Selectivity of the fishery was modelled by a logistic ogive fitted to the age frequency data.
- The catch equation used was the instantaneous mortality equation from Bull et al. (2002), whereby half the natural mortality was applied, followed by the fishing mortality, then the remaining natural mortality.
- Deterministic recruitment was assumed.
- The model estimated virgin biomass, B_0, and one catchability and two selectivity parameters each for the fishery and the trawl survey (therefore a total of seven parameters). This is increased to eight parameters when β is estimated for the relationship between CPUE and abundance.
- 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.
- Lognormal errors, with known (sampling error) CVs were assumed for the CPUE, trawl survey, and egg and acoustic survey indices. An additional, process error, variance of 0.2 was added to the CVs from the CPUE indices (to give an overall CV of around 30%, following Anderson et al., 2002), and to the trawl survey estimates.
- An ageing error misclassification matrix was applied, derived from an analysis of all orange roughy ageing data available to the working group.
- Confidence intervals were calculated from a posterior distribution of the model parameters, which was estimated using a Markov Chain Monte Carlo technique.

2005 UW/SeaFIC assessment

The 2005 UW/SeaFIC model used the Coleraine software to estimate the free and derived parameters (Hilborn et al., 2003). The UW/SeaFIC model uses the same assumptions outlined above for the NIWA model, except that a normal-log likelihood is used instead of a lognormal likelihood. Hicks and Francis (2005) outlined the known differences between models developed by Coleraine and CASAL for an assessment of Northeast Chatham Rise orange roughy in 2005. Most of the differences they found also apply to these assessments of the Mid-East Coast orange roughy stock.

For the 2005 assessment, the actual 2004 catch and estimated 2005 catch (assumed to be 1500 t) were incorporated. A new ageing error matrix, based on differences in ages between readers at NIWA and readers at the Central Ageing Facility in Australia, was also added. Lastly, new growth parameters were estimated and a different variation of length at age was used in the model. The coefficient of variation for the mean length at age was modelled as a function of length in the UW/SeaFIC model,

with the CV declining linearly from a value of 0.142 for the length at age 1 and finishing with a value of 0.057 for the length at age 80. This decline was determined within a growth model using the observations from the catch-at-age data that had length recorded. In contrast, the NIWA model kept the CV of the length at age at a constant value of 0.085. However this accounted for only a small part of the difference between the two models.
In the Coleraine model biomass is estimated as start of the year biomass, but the values reported here are mid-season biomasses, calculated by adding half of the start of the year biomass and half of the end of the year biomass.

Markov Chain Monte Carlo (MCMC) techniques were used to draw samples from the posterior distributions of the estimated parameters. One million draws were taken after a burn-in of 100 000, and every 1000th draw was used to create the posterior. Convergence was checked by plotting the usual MCMC traces, and no runs suggested non-convergence.

(c) Biomass estimates

The two models produced similar biomass estimates (Table 11, Figure 2). B_0 was estimated to be around 100 000 t. Estimates of current biomass depended on the treatment of the CPUE data, with lower estimates (17–18% B_0) when β=1. Estimates were higher (25–30% B_0) when β was estimated, and similar to those obtained when the CPUE data were dropped (29–32% B_0).

Table 11: Biomass estimates (medians, with 95% confidence intervals in parentheses) for the three runs from each model. B_{2004} is the mid-year biomass in 2004 for the NIWA and UW/SeaFIC runs and B_{2005} is the mid-year biomass in 2005 for the UW/SeaFIC runs.

Model (year assessed)	Run	B_0 (t)	B_{2004} (t)	% B_{2004}/B_0	B_{2005} (t)	% B_{2005}/B_0
NIWA	Beta1	93 600	17 300	18	—	—
(2003-04)		(91 300–104 200)	(13 300–23 000)	(15–23)		
	EstBeta	105 200	31 400	30	—	—
		(88 700–125 600)	(21 700–47 200)	(23–38)		
	NoCPUE	103 700	33 200	32	—	—
		(83 200–128 300)	(21 800–51 500)	(25–41)		
UW/SeaFIC	Beta1	99 400	17 000	17	18 500	18
(2004-05)		(87 300–107 600)	(12 400–22 300)	(14–21)	(13 500–24 300)	(15–23)
	EstBeta	106 100	25 000	24	26 700	25
		(92 000–118 700)	(16 300–34 700)	(24–30)	(17 500–36 500)	(19–31)
	NoCPUE	111 900	30 900	28	32 400	29
		(92 300–135 100)	(17 600–50 500)	(19–38)	(18 600–52 400)	(20–39)

Other parameter estimates were not significantly different for the two assessments (Table 12). Estimates of the mean age of selectivity (a_{50}) were higher when β was estimated and when CPUE was dropped, but the ogive was shallower.

Table 12: Assessment estimates (medians, with 95% confidence intervals in parentheses) of all non-biomass parameters. β is a parameter describing the curvature of the relationship between CPUE and biomass (if β = 1 there is no curvature); a_{50} (or a_{95}) is the age at which 50% (or 95%) of fish are available to either the commercial fishery or the trawl surveys.

			Commercial		Trawl Survey	
Model	Run	β	a_{50}	a_{95}	a_{50}	a_{95}
NIWA	Beta1	1.0	41 (37–47)	53 (45–64)	14 (10–42)	24 (12–74)
	EstBeta	1.9 (1.4–2.5)	43 (37–52)	58 (48–73)	13 (10–26)	19 (11–54)
	NoCPUE	–	47 (37–54)	64 (49–78)	13 (10–21)	18 (11–41)
UW/SeaFIC	Beta1	1.0	42 (37–47)	48 (39–58)	12 (10–17)	16 (11–27)
	EstBeta	1.5 (1.1–1.7)	43 (37–48)	51 (40–62)	13 (10–17)	16 (11–26)
	NoCPUE	–	42 (36–49)	52 (37–63)	12 (10–16)	16 (11–26)

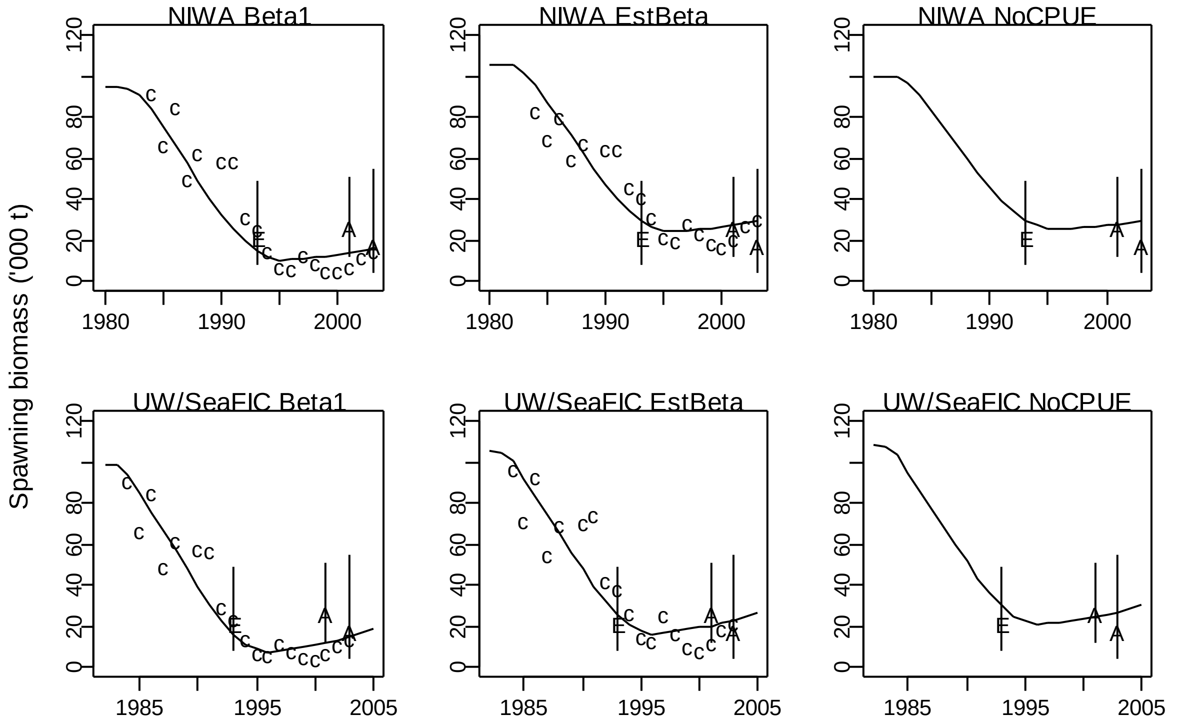

Figure 2: Estimated biomass trajectories (lines) and fitted data (points) from all model runs. Data are identified by plotting symbol ('c' = CPUE, 'A' = acoustic, 'E' = egg survey). CPUE data are scaled up to the biomass. Vertical bars for absolute indices show 95% confidence intervals. Plots are from the modes of the posterior distribution. The UW/SeaFIC assessment estimates biomass up to 2004–05 NIWA up to 2003–04).

(d) Sensitivity analyses

Several sensitivity analyses were conducted (reported in more detail in Fishery Assessment Reports). Four of the more consequential analyses are briefly summarized here. Dunn (2005) reported additional sensitivities for the 2004 NIWA assessment.

Independently estimating maturity ogives (from otolith transition zone data, outside the stock assessment model) and selectivity ogives (from catch at age and other information, within the model) resulted in selectivity curves displaced well to the right of the maturity ogive (age at 50% selectivity in the range 38.8-40.7 years, compared with an estimated age at 50% maturity of 31.3 years), although this did not lead to substantially better or worse fits of the model overall. Estimates of current mature biomass, mature virgin biomass, and the ratio of the two were invariably substantially higher for this sensitivity analysis than for the corresponding runs in Table 11. The results imply that a substantial proportion of the biomass of mature fish (about a half of current levels) is not available to the fishery. However, given that this fishery has mainly been conducted on the spawning grounds there is no biological rationale for this.

The assessments were also found to be highly sensitive to the weight (expressed as an effective sample size, N) given to the proportions-at-age data. Higher values of N give more weight to the age samples, and result in increased estimates of B_0 and the mean age of selectivity. The Working Group agreed to use N=30, which is approximately half the number of observed ages between recruitment and the plus group. N was set equal to the number of tows for proportions-at-length from trawl surveys (N=14 or 18); the assessments were not sensitive to the choice of N for the trawl survey data.

To determine the effects of the catch-at-age data on the model estimates, sensitivities were conducted by removing these data from the 2005 UW/SeaFIC Beta1 and EstBeta runs. The commercial selectivity and maturity ogives for these sensitivity runs were fixed at the MPD estimates of commercial selectivity from the corresponding Beta1 or EstBeta run with the catch-at-age data. Fits to the CPUE improved slightly and fits to the absolute acoustic estimates were slightly worse in the runs without catch-at-age data. The ratio of current biomass to virgin biomass decreased by less than 0.5% in the Beta1 runs, and by just under 2% in the EstBeta runs. Variability in the biomass estimates was smaller without the catch-at-age data, which is partly due to fixed selectivity parameters.

A further sensitivity was conducted using the 2005 EstBeta run to determine the effect of the prior on the estimate of β. The prior on β was shifted to the left so that it was centred on zero in log space, meaning the median of the prior on β was a linear relationship between CPUE and abundance. The estimate of β decreased from 1.47 to 1.44 using the shifted prior, and the lower 5% bound of the confidence interval on the estimated β decreased to 1.04. The parameter and biomass estimates were nearly the same as for the EstBeta run, and the 2005 biomass as a percentage of virgin biomass decreased 0.5% to 24.6% B_0. This result shows that, although the prior has some effect on the estimate of β, the data support a non-linear relationship between CPUE and abundance.

(e) Five year projection results

Forward projections were carried out over a 5-year period using a range of constant-catch options. This means that the NIWA assessment projected to 2008–09 and the UW/SeaFIC assessment projected to 2009–10. For each catch option, three measures of fishery performance were calculated. The first one, B_{med}, is the median biomass in five years time, expressed as a percentage of B_0. The second one, $P_{0.2}$, is the probability that the biomass at the end of the 5-year period is greater than 20% B_0 (biomass levels below 20% B_0 are considered risky to the stock). The third, P_{MSY}, is similar to the $P_{0.2}$, except that the reference biomass level is the Maximum Sustainable Yield (interpreted for orange roughy as 30% B_0).

All projections predict that the biomass will increase for all catch levels under about 3000 t (Table 13). These projections are uncertain because the magnitude and rates of future increases in stock size are driven by the assumption that future recruitment will be constant at the virgin level. However, this assumption is not currently supported by any direct observations or data.

Table 13: Probability of the mid-year spawning biomass in 5 years (2008–09 for the NIWA runs and 2009–10 for the UW/SeaFIC runs) exceeding 20% B_0 ($P_{0.2}$) and 30% B_0 (P_{MSY}), and the median biomass in 5 years as a percentage of B_0 (B_{med}) for the Mid-East Coast stock for each of three assessments and eight constant catch options. The current biomass, $B_{current}/B_0$ (%), is given in parentheses next to the assessment name for B_{med} (see Table 11).

			Annual catch (t, over five–year period)							
Performance measure	**Model (year assessed)**	**Run**	**0**	**400**	**800**	**1200**	**1500**	**2100**	**3000**	**4000**
$P_{0.2}$	NIWA	Beta1	1	0.99	0.98	0.95	0.94	0.84	0.54	0.19
	(2003–04)	EstBeta	1	1	1	1	1	1	0.99	0.97
		NoCPUE	1	1	1	1	1	1	0.99	0.98
	UW/SeaFIC	Beta1	1	1	1	1	1	0.94	0.44	0.02
	(2004–05)	EstBeta	1	1	1	1	1	1	0.97	0.76
		NoCPUE	1	1	1	1	1	1	0.98	0.91
P_{MSY}	NIWA	Beta1	0.40	0.28	0.15	0.09	0.06	0.02	0	0
	(2003–04)	EstBeta	0.94	0.91	0.88	0.85	0.82	0.74	0.59	0
		NoCPUE	0.93	0.91	0.89	0.86	0.84	0.80	0.69	0
	UW/SeaFIC	Beta1	0.85	0.65	0.37	0.13	0.04	0	0	0
	(2004–05)	EstBeta	0.99	0.97	0.92	0.82	0.72	0.46	0.11	0.01
		NoCPUE	0.99	0.98	0.96	0.93	0.89	0.76	0.49	0.23
Bmed (%)	NIWA	Beta1 (18)	29	28	27	25	25	23	20	18
	(2003–04)	EstBeta (30)	39	38	37	36	35	34	31	29
		NoCPUE (32)	41	40	39	38	37	36	33	31
	UW/SeaFIC	Beta1 (18)	33	31	29	27	26	24	20	16
	(2004–05)	EstBeta (25)	38	36	35	33	32	30	26	22
		NoCPUE (28)	41	40	38	37	36	33	30	26

(f) 2007 stock assessment

An updated assessment was attempted in 2007 with the addition of catch data up to 2005-06 and new standardised CPUE indices (Table 8), split into an early CPUE series using combined CELR and TCEPR data (1984-97) and a late CPUE series using only TCEPR data (1997-2006). These data were incorporated in a Bayesian stock assessment with deterministic recruitment. The Working Group noted that the model was insensitive to the late CPUE series and predicted a rebuild (driven by the recruitment assumptions), however, the rate of rebuild was less than the increase seen in CPUE since 1999.

No estimates of current biomass are available. The WG considered that the stock was likely to be increasing under recent catch levels but was unable to determine whether the current TACC (1500 t) would result in a continued rebuild of the stock.

5. STATUS OF THE STOCKS

For these stocks, B_{MSY} is assumed to be equal to 30% B_0, which, in previous assessments has been estimated to be the average biomass under a CAY management policy.

(i) EC stock (2A North)

The stock assessment for the East Cape was last updated in 2003. That assessment indicated that the stock was then about 24% of B_0 (range: 20-32% B_0). The current surplus production (CSP) in the year 2003 (550 t) was greater than both the current catch limit of 200 t and the catches in the two most recent years included in the assessment (2000-01: 302 t and 2001-02: 186 t). The best estimates of CAY and MAY (370 and 410 t) were also greater than both the catch limit and catches for the two most recent years in the assessment. This suggests that the current catch limit should allow the stock to rebuild.

(ii) MEC stock (2A South, Wairarapa 2B, and Kaikoura 3A)

No estimates of current biomass are available. Based on the 2004 and 2005 assessments, biomass was estimated to have reached a minimum in the mid 1990s and to have been slowly increasing since. The late CPUE series (Table 8) support the likelihood of an increase in stock size with catch rates increasing since 1999. The WG considered that the stock was likely to be increasing under recent catch levels but was unable to determine whether the current TACC (1500 t) would result in a continued rebuild of the stock.

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