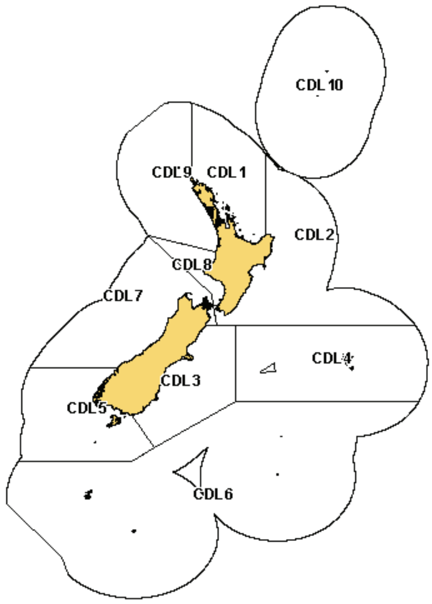
BLACK CARDINALFISH (CDL)

(*Epigonus telescopus*)
Akiwa



1. FISHERY SUMMARY

1.1 Commercial fisheries

Several species of *Epigonus* are widely distributed in New Zealand waters, but only black cardinalfish (*E. telescopus*) reaches a marketable size and is found in commercial concentrations. It occurs throughout the New Zealand EEZ at depths of 300–1100 m, mostly in very mobile schools up to 150 m off the bottom over hills and rough ground. Black cardinalfish have been caught since 1981 by research and commercial vessels, initially as a bycatch of target trawling for other high value species. The preferred depth range of schools (600–900 m) overlaps the upper end of the depth range of orange roughy and the lower end of alfonsino and bluenose. The exploitation of these species from 1986 resulted in the development of the major cardinalfish fishery in QMA 2.

It is primarily sold domestically due to the short freezer life of fillets. The species has a section of dark flesh under the lateral line that has caused problems with overseas marketing. The fillets can be tainted if this flesh is not removed quickly.

Landings for 1998–99 to 2007–08 are from QMR totals following introduction of the species into the QMS for 1998–99. For the 1982–83 to 1985–86 fishing years, the best estimate of landings was the sum of the FSU Inshore and FSU Deepwater, (i.e., FSU Total) catch returns. For 1986–87 to 1988–89 the best estimate was taken as the greater value of either the FSU Total or the LFRR. From the 1989–90 fishing year, the best estimate was taken as the higher of either the LFRR or the sum of the CLR and CELR Landed data.

The best estimate of total landings was split between the nine QMAs and ET (outside the EEZ) based on FSU and QMS data (Table 1). For FSU data (1982–83 to 1987–88 fishing years), catch where area was unknown was pro-rated to QMAs according to the catch level where area was reported. For QMS data (1988–89 to 1994–95 fishing years), catch by area in CELR Landed and CLR reports were scaled to equal the best estimate of the total catch. Commercial landings of black cardinalfish have been made in QMAs 1–9 and outside the EEZ (ET).

In most years since 1982 more than 65% of black cardinalfish landings were from the east coast of the North Island (QMA 2). The large increase in landings from this area in 1986–87 was associated with the development of the orange roughy fishery around the Ritchie Banks and Tuaheni High, and an increase in targeted fishing to establish a catch history when it was anticipated to become a quota species. Landings from the Bay of Plenty (QMA 1) have fluctuated since 1988. The relatively large landings in 1990–91 were a combination of bycatch of the orange roughy fishery and target fishing for black cardinalfish. Between 1991–92 and 2005–06 occasional large catches were taken from outside the EEZ on the northern Challenger Plateau and the Lord Howe Rise.

Black cardinalfish was introduced into the QMS on 1 October 1998 and quotas were set for QMAs 2–8. Quotas for QMAs 1 and 9 were subsequently set for 1999–00. TACCs were increased from 1 October 2006 in CDL 4 to 66 t and in CDL 5 to 22 t. In these stocks landings were above the TACC for a number of years and the TACCs have been increased to the average of the previous 8 years plus an additional 10%. A shortfall in catches achieved for CDL 2 in 2007–08 was associated with a vessel leaving the fishery. Figure 1 shows the historical landings and TACC values for the main CDL stocks.

Table 1: Reported landings (t) of black cardinalfish by QMA and fishing year (1 October to 30 September) from 1982–83 to 2007–08. The data in this table has been updated from that published in previous Plenary Reports by using the data through 1996–97 in table 32 on p. 262 of the "Review of Sustainability Measures and Other Management Controls for the 1998–99 Fishing Year – Final Advice Paper" dated 6 August 1998. Data for 1997–98 based on catch and effort returns, since 1998–99 on QMR records. –, no data.

	QMA											
	1		2		3		4		5		6	
Year	Catch	TACC	Catch	TACC	Catch	TACC	Catch	TACC	Catch	TACC	Catch	TACC
1982–83	–	–	76	–	<1	–	<1	–	–	–	–	–
1983–84	–	–	212	–	7	–	<1	–	–	–	–	–
1984–85	<1	–	189	–	341	–	<1	–	–	–	–	–
1985–86	<1	–	238	–	50	–	3	–	2	–	–	–
1986–87	1	–	1 738	–	72	–	2	–	<1	–	<1	–
1987–88	3	–	1 556	–	28	–	1	–	3	–	–	–
1988–89	305	–	1 434	–	57	–	4	–	–	–	–	–
1989–90	613	–	1 718	–	20	–	18	–	–	–	–	–
1990–91	233	–	3 473	–	598	–	1	–	4	–	–	–
1991–92	7	–	1 652	–	146	–	3	–	<1	–	2	–
1992–93	23	–	1 550	–	519	–	2	–	<1	–	–	–
1993–94	364	–	2 310	–	277	–	10	–	5	–	–	–
1994–95	1 162	–	2 207	–	51	–	7	–	1	–	<1	–
1995–96	1 418	–	2 621	–	57	–	4	–	10	–	–	–
1996–97	2 001	–	1 910	–	100	–	7	–	–	–	–	–
1997–98	995	–	1 176	–	40	–	351	–	–	–	–	–
1998–99	24	1 200	1 268	2 223	181	196	41	5	–	2	<1	1
1999–00	980	1 200	2 158	2 223	215	196	36	5	<1	2	<1	1
2000–01	294	1 200	1 135	2 223	99	196	35	5	74	2	<1	1
2001–02	455	1 200	1 693	2 223	146	196	29	5	18	2	<1	1
2002–03	583	1 200	1 845	2 223	172	196	80	5	9	2	<1	1
2003–04	481	1 200	966	2 223	96	196	148	5	27	2	<1	1
2004–05	267	1 200	1 102	2 223	43	196	49	5	15	2	<1	1
2005–06	643	1 200	2 153	2 223	50	196	53	5	<1	2	<1	1
2006–07	415	1 200	1 692	2 223	66	196	31	66	10	22	<1	1
2007–08	202	1 200	861	2 223	7	196	23	66	20	22	< 1	1

	QMA									
	7		8		9			Total (EEZ)	ET	Total
Year	Catch	TACC	Catch	TACC	Catch	TACC	Catch	TACC	Catch	Catch
1982–83	<1	–	–	–	–	–	78	–	–	78
1983–84	<1	–	–	–	–	–	220	–	–	220
1984–85	1	–	–	–	–	–	532	–	–	532
1985–86	<1	–	–	–	45	–	292	–	–	292
1986–87	<1	–	–	–	–	–	1 814	–	–	1 814
1987–88	2	–	<1	–	<1	–	1 638	–	–	1 638
1988–89	2	–	–	–	–	–	1 798	–	2	1 800
1989–90	15	–	–	–	–	–	2 385	–	<1	2 385
1990–91	1	–	<1	–	–	–	4 311	–	–	4 311
1991–92	11	–	–	–	–	–	1 821	–	17	1 838
1992–93	2	–	–	–	–	–	2 096	–	270	2 366
1993–94	6	–	–	–	–	–	2 972	–	829	3 801
1994–95	51	–	–	–	<1	–	3 479	–	231	3 710
1995–96	26	–	–	–	–	–	4 150	–	340	4 490
1996–97	27	–	–	–	–	–	4 045	–	522	4 567
1997–98	76	–	–	–	108	–	2 338	–	405	2 743
1998–99	16	39	<1	0	<1	4	1 531	3 670	390	1 921
1999–00	27	39	0	0	<1	4	3 415	3 670	962	4 377
2000–01	2	39	0	0	3	4	1 642	3 670	571	2 213
2001–02	3	39	0	0	5	4	2 349	3 670	490	2 839
2002–03	27	39	0	0	5	4	2 721	3 670	275	2 996
2003–04	2	39	0	0	6	4	1 727	3 670	58	1 785
2004–05	2	39	0	0	1	4	1 479	3 670	204	1 683
2005–06	<1	39	0	0	2	4	2 901	3 670	44	2 945
2006–07	1	39	0	0	1	4	2 216	3 751	2	2 218
2007–08	2	39	< 1	0	19	4	1 134	3 751	1	1 135

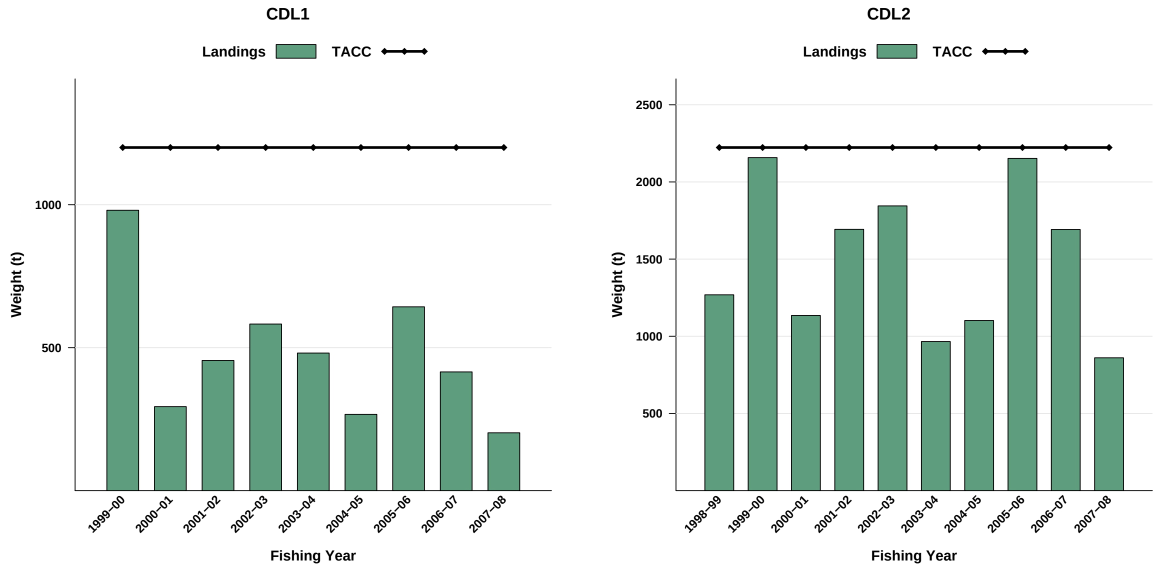


Figure 1: Historical landings and TACC for the two main CDL stocks. Left to right: CDL1 (Auckland East) and CDL2 (Central East). Note that these figures do not show data prior to entry into the QMS.

1.2 Recreational fisheries
Recreational fishing for black cardinalfish is negligible.

1.3 Customary non-commercial fisheries
The level of this fishery is believed to be negligible.

1.4 Illegal catch
No information is available about illegal catch.

1.5 Other sources of mortality
There has been a history of catch overruns (unreported catch) from loss of fish through burst nets, and the discarding at sea of this species while target fishing for higher value species. In the assessment presented here, the total removals were assumed to exceed reported catches by the overrun percentages in Table 2 (Dunn 2009). All yield estimates make an allowance for the current estimated level of overrun of 10%.

Table 2: Catch overruns (%) for CDL 2 by year.

Year	Over-run	Year	Over-run
1982-83	100	1991-92	30
1983-84	100	1992-93	30
1984-85	100	1993-94	30
1985-86	100	1994-95	20
1986-87	50	1995-96	20
1987-88	50	1996-97	20
1988-89	50	1997-98	20
1989-90	50	1998-99 and	10
1990-01	50	subsequently	

2. BIOLOGY

The average size of black cardinalfish landed by the commercial fishery is about 50–60 cm fork length (FL). Length frequency distributions from research surveys are unimodal with a peak at 55–65 cm FL. They reach a maximum length of about 75 cm FL. Otolith readings from 722 fish from QMA 2 have been validated using radiometric and bomb radiocarbon methods, and indicated that this species is relatively slow-growing and long lived (Andrews & Tracey 2007, Neil et al. 2008). Maximum ages of over 100 years were reported, with the bulk of the commercial catch being between

35 and 55 years of age. The validation indicated fish aged over 60 years tended to be under-aged, by up to 30%. This bias would be likely to have little impact on the estimated growth parameters, but would influence the estimate of natural mortality (*M*). Life history parameters are given below in Table 3.

Table 3: Life history parameters for black cardinalfish. All estimates are for CDL 2, except the length-weight parameters which are for CDL 2–4.

Fishstock	Estimate	Source
1. Natural mortality (*M*)	0.034*	(Tracey *et al*. 2000)
Age at recruitment (A_r)	unknown	
Gradual recruitment (A_m)	unknown	
Age at full recruitment	45	(Tracey *et al*. 2000)
Age at maturity (A_s)	35	(Field & Clark 2001)
Gradual maturity (S_m)	13	(Field & Clark 2001)

2. Weight = a(length)^b (weight in g, fork length in cm).

Both sexes		
a	b	
0.113	2.528	Dunn (2009)

3. Von Bertalanffy growth parameters (Tracey *et al*. 2000)

Both sexes			Female			Male		
L_∞	k	t_0	L_∞	k	t_0	L_∞	K	t_0
70.8	0.034	-6.32	70.9	0.038	-4.62	67.8	0.034	-8.39

* Because of uncertainties in ageing and *M*, the Deepwater Fisheries Assessment Working Group used a range of *M*’s in the assessments.

The reproductive biology of black cardinalfish is not well known (Dunn 2009). Indications from research survey and Observer Programme data are that spawning may occur between November and July. Spawning locations have been identified in CDL 1, CDL 2, CDL 7, CDL 9, and outside the EEZ on the northern Challenger Plateau, Lord Howe Rise, and West Norfolk Ridge. A probit analysis of maturity at length indicated fish became sexually mature at around 50 cm length, at an age of approximately 35 years (Field & Clark 2001). Maturity was also inferred to be between ages 26 and 44 years (mean 33 years) from changes in δ13C in otoliths (Neil et al. 2008).

Juveniles are thought to be mesopelagic until they reach a length of about 12 cm (5 years of age), after which they become primarily demersal (Neil et al. 2008). Larger juveniles have been caught in bottom trawls at depths of 400–700 m, extending into deeper water as they grow, with adult fish caught primarily at 800–1000 m (Dunn 2009). Prey items from research trawl samples include mesopelagic fish, natant decapod prawns and octopus.

Elevated levels of mercury (Hg) have been recorded in a sample of black cardinalfish from the Bay of Plenty (Tracey 1993).

3. STOCKS AND AREAS

The stock boundaries and number of black cardinalfish stocks in New Zealand are unknown. There are no data on genetics, or known movements of black cardinalfish which indicate possible stock boundaries.

There is evidence that spawning occurs in CDL 1, CDL 2, CDL 7 and CDL 9 and outside the EEZ (e.g. North Challenger, Lord Howe and West Norfolk Ridge). In CDL 2, three geographically close spawning locations have been identified: Tuaheni High, Ritchie Bank, and Rockgarden (Dunn 2009). Juveniles of less than 30 cm have been infrequently identified in CDL 2, and more frequently found on the northern flanks of the Chatham Rise, which is south of the spawning grounds in CDL 2. No spawning grounds have been identified on the Chatham Rise, where adult fish are relatively rare.

4. STOCK ASSESSMENT

A stock assessment for CDL 2–4 was completed in 2009. No assessments have been made for stocks in other areas. For the purposes of stock assessment, it has been assumed that black cardinalfish on the east coast North Island (CDL 2) are from the same stock as fish on the north Chatham Rise (CDL 3 and CDL 4).

4.1 Assessment inputs

The assessment inputs for CDL 2–4 were catches adjusted by overruns (Table 4), two CPUE indices (Table 5), and length frequency and maturity at length samples (Dunn 2009). The CPUE indices were derived from catch and effort data for fisheries focused on and around specific hill features in CDL 2 (Dunn & Bian 2009) with no overrun included. Whilst the CPUE indices accounted for a substantial proportion of the total catch (65–77%), the spatial extent of the fisheries was small compared with the overall area believed to be occupied by the stock. As a result, the indices may reflect local abundance, but it is less certain that they reflect overall stock biomass. The CPUE was split into two indices, before and after 1 October 1998, because of a change in reported fishing patterns in the late 1990s. This may have been caused, at least in part, by the introduction of the black cardinalfish TACC. The growth parameters used in the assessment are presented in Table 3. Length frequency samples were available for 8 years between 1989–90 and 2007–08 from at-sea and market sampling. Maturity was input as the proportions mature at length from samples collected during research trawl surveys of the east coast North Island in 2001 and 2003.

Table 4: Estimated catches calculated by summing the CDL2–4 catches from Table 1 (column 2), and increasing them by the overrun values in Table 2 (column 3), with the combined TACC for CDL2-4 (column 4).

Year	Reported catch	Catch including overruns	TACC
1982–83	76	152	–
1983–84	219	438	–
1984–85	530	1 060	–
1985–86	291	582	–
1986–87	1 812	2 718	–
1987–88	1 585	2 378	–
1988–89	1 495	2 243	–
1989–90	1 756	2 634	–
1990–91	4 072	6 108	–
1991–92	1 801	2 341	–
1992–93	2 071	2 692	–
1993–94	2 597	3 376	–
1994–95	2 265	2 718	–
1995–96	2 682	3 218	–
1996–97	2 017	2 420	–
1997–98	1 567	1 880	–
1998–99	1 490	1 639	2 424
1999–00	2 409	2 650	2 424
2000–01	1 269	1 396	2 424
2001–02	1 868	2 055	2 424
2002–03	2 097	2 307	2 424
2003–04	1 210	1 331	2 424
2004–05	1 194	1 313	2 424
2005–06	2 256	2 482	2 424
2006–07	1 789	1 968	2 485
2007–08	891	980	2 485

Table 5: Standardised CPUE indices, and their calculated c.v.s, as used in the stock assessment. –, no data.

Fishing year	Index a	c.v. (%)	Index b	c.v. (%)
1990-91	1.00	46	–	–
1991-92	0.73	43	–	–
1992-93	0.87	42	–	–
1993-94	0.58	46	–	–
1994-95	0.41	45	–	–
1995-96	0.26	39	–	–
1996-97	0.51	42	–	–
1997-98	0.29	47	–	–
1998-99	–	–	1.00	37
1999-00	–	–	0.57	32
2000-01	–	–	0.39	36
2001-02	–	–	0.50	35
2002-03	–	–	0.30	33
2003-04	–	–	0.26	38
2004-05	–	–	0.23	35
2005-06	–	–	0.34	34
2006-07	–	–	0.27	35
2007-08	–	–	0.17	37

4.2 Model structure and runs

Stock assessments were performed using the stock assessment program, CASAL (Bull et al. 2002) to estimate virgin and current biomass (Dunn 2009). Preliminary model runs were completed using all of the observational data. The key assumptions of the final model runs were**:**

- The biomass information in the data are primarily contained in the CPUE indices. Therefore, a two-step approach was used to produce the final model runs. In the final runs, selectivity and maturity were fixed at estimates from the preliminary runs and the length frequency and maturity data were not fitted. This ensured that any biomass signal from the length frequency data, potentially caused by errors in estimated growth and selectivity, did not dominate the signal from the CPUE trends.

- Runs where maturity and selectivity were estimated separately resulted in selectivity curves displaced to the right of the maturity ogive for *M*= 0.04 and *M*=0.06, resulting in a proportion of the spawning stock not being available to the fishery (called "cryptic biomass" for shorthand). The Deepwater Fisheries Assessment Working Group considered that it was unlikely that there existed mature biomass that was not vulnerable to the fishery, and agreed that the age of vulnerability should be fixed to the age at maturity for the base case and for the case with *M*=0.06. The WG agreed to present a sensitivity model run using M=0.04 and with separately estimated maturity and selectivity to explore the implications of this scenario.

- For runs assuming an *M* of 0.027, the selectivity and maturity estimates were similar; therefore the two were estimated separately in final runs.

- The base case with *M* set at 0.04 and vulnerability set equal to the MCMC median of maturity was considered to be the most credible.

Four model runs are therefore presented, two with selectivity assumed to be the same as maturity and *M* assumed to be either 0.06 or 0.04, and two with selectivity and maturity fitted as separate ogives and *M* assumed to be 0.04 or 0.027 (Table 6).

Table 6: Four alternative assumptions to the stock assessment.

Model	*M*	Selectivity
Base	0.04	Equal to MCMC median maturity
Mat&sel	0.04	Estimated separately
M0.027	0.027	Estimated separately
M0.06	0.06	Equal to MCMC median maturity

The model was fitted using Bayesian estimation, and partitioned the population by age (age-groups used were 1–90, 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 have a single maturation episode, with maturation modelled by a logistic ogive which was estimated in preliminary model runs. Selectivity of the fishery was assumed to be equal to maturity, or modelled by a logistic ogive estimated in preliminary model runs. 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. 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) c.v.s were assumed for the CPUE. In preliminary model runs, an additional process error was estimated and added to the length frequency distributions. Binomial errors were assumed for the proportions mature at length. The final model runs estimated virgin biomass, B_0, and two catchabilities. Confidence intervals were calculated from a posterior distribution of the model parameters, which was estimated using a Markov Chain Monte Carlo technique.

4.3 Biomass estimates

Biomass estimates depended on the assumed *M*, with the M0.027 run resulting in a larger and less productive stock, and the M0.06 run in a smaller and more productive stock (Table 7, Figure 2). Estimates of current biomass were lowest in the base case.

The mat&sel run estimated cryptic spawning stock biomass, where vulnerability to the fishery took place after maturity, such that a median of 86% and 62% of the mature biomass was vulnerable to the fishery at virgin and 2009 biomass levels, respectively. It is unclear whether cryptic biomass could occur for black cardinalfish, and it is possible that this result is an artefact generated from the model assumptions. Cryptic biomass was not estimated when maturity and selectivity were estimated separately and *M* was assumed to be 0.027, and in sensitivity runs the level of cryptic biomass was found to increase as *M* increased. The wide confidence intervals reflect the uncertainty in the model, which was fitted to only relative biomass indices having relatively high c.v.s (Table 5).

Table 7: Biomass estimates (medians rounded to the nearest 100 t, with 95% confidence intervals in parentheses) for the four model runs. Bcurrent is the mid-year biomass in 2009. p(B2009 < 0.1 B0) is the probability of the mature biomass in 2009 being less than 10% of the virgin mature biomass (B0). p(B2009 < 0.2 B0) is the probability of the mature biomass in 2009 being less than 20% of the virgin mature biomass (B0).

Run	B_0 (t)	$B_{current}$ (t)	$\%B_0$	$p(B_{2009} < 0.1\ B_0)$	$p(B_{2009} < 0.2\ B_0)$
Base	36 800 (32 800 – 95 400)	4 400 (1 900 – 60 400)	11.9 (5.9 – 63.3)	0.41	0.70
Mat&sel	40 800 (35 600 – 96 700)	7 300 (3 500 – 61 300)	17.8 (9.9 – 63.5)	0.13	0.56
M0.027	45 100 (39 500 – 93 500)	6 100 (2 000 – 53 000)	13.6 (5.0 – 56.6)	0.32	0.69
M0.06	33 800 (25 500 – 110 700)	8 200 (2 400 – 82 800)	24.2 (9.6 – 74.9)	0.16	0.43

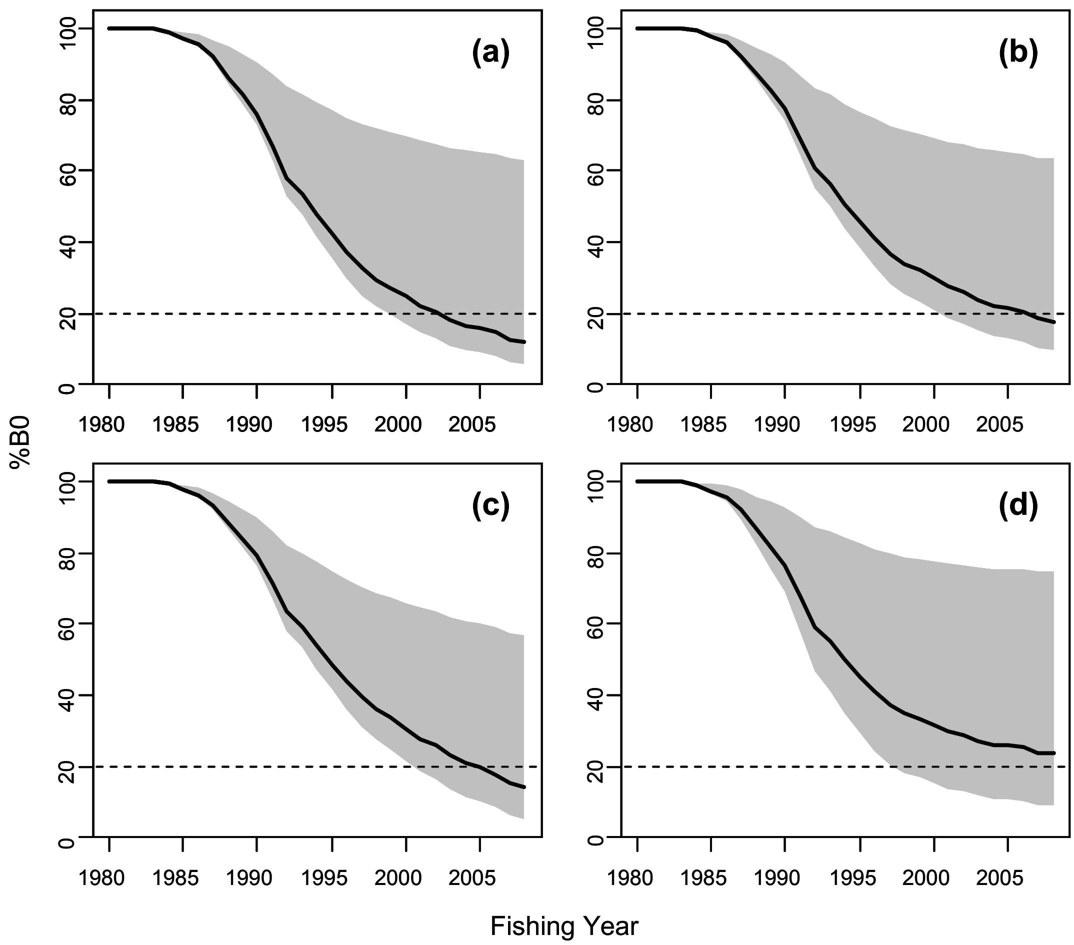


Figure 2: Estimated biomass trajectories (solid line) and 95% confidence intervals (shaded area) for the model runs (a) Base, (b) mat&sel, (c) M0.027, (d) M0.06. The horizontal broken line indicates 20% B0.

4.4 Sensitivity analyses

Several sensitivity analyses were conducted (reported in more detail in Dunn 2009). The assessment was found to be relatively insensitive to the assumed catch over-runs. When over-runs were either assumed to be zero, or were doubled for the period before 1998–99 (before the TACC was introduced), the mature stock in 2009 was estimated to be slightly less depleted compared to the Base case, at 13.5% (5.9 – 67.0%) B_0, and 12.2% (5.5 – 58.3%) B_0 respectively.

4.5 5-year projection results

Forward projections were carried out over a 5 year period using a range of constant catch options. A catch level of 180 t is approximately the level associated with $F=M$, a catch of 890 t is approximately the current (2007-08) catch and a catch of 2 490 t is approximately the current (2007-08) TACC. In all projections overrun of 10% was assumed for future catches. For each catch option, three measures of fishery performance were calculated. The first one, $\%B_0$, is the median biomass in 2009 as a percentage of B_0. The second one, $P_{0.1}$, is the probability that the biomass at the end of the 5-year period is less than 10% B_0. The third, $P_{0.2}$, is the probability that the biomass at the end of the 5-year period is less than 20% B_0. At high future catches the biomass may be reduced to such a low level that the catch is unlikely to be able to be taken (assumed to occur when the exploitation rate exceeds 0.9). This is indicated as P(no catch).

All projections indicate that the biomass would increase for all catch levels near or below the 2008–09 catch (890 t), and would continue to decline at catch levels of 1 200 t in all runs except M=0.06, where it would remain about the same (Table 8). In all runs the biomass would decline at catch levels equal to the current TACC (2 490 t), and there was a 38–71% probability the biomass would decline to a level where the catch could not be taken.

Table 8: Results from forward projections to 2013 for the model runs. $P_{0.1}$ is the probability of the mature biomass in 2013 being less than 10% of the virgin mature biomass (B_0). $P_{0.2}$ is the probability of the mature biomass in 2013 being less than 20% of the virgin mature biomass (B_0). P(no catch) is the probability that the catch could not be taken, which is assumed to occur if the exploitation rate exceeds 90%). Current (2007-08) values of $\%B_0$ are shown for each run in parenthesis next to the measure. 95% confidence intervals are shown for the $\%B_0$ estimates in 2013. A catch of 180 t is approximately *M* times the current biomass, 890 t is the current catch and 2 490 t is the current TACC.

							Future catch (t)
Run	Measure	0	180	530	890	1200	2490
Base	$\%B_0$ (11.9)	17.6 (8.5 – 67.4)	16.5 (7.01 – 66.0)	14.3 (5.3 – 63.9)	12.6 (3.6 – 62.7)	10.2 (2.9 – 62.6)	5.2 (2.7 – 56.2)
	$P_{0.1}$	0.11	0.19	0.30	0.40	0.49	0.70
	$P_{0.2}$	0.57	0.60	0.65	0.71	0.74	0.83
	P(no catch)	0	0	0	0	0	0.38
mat&sel	$\%B_0$ (17.8)	24.5 (14.0 – 68.8)	23.6 (12.9 – 67.8)	20.4 (10.2 – 65.5)	18.6 (8.0 – 63.4)	16.2 (6.5 – 61.7)	9.5 (5.5 – 57.8)
	$P_{0.1}$	0.00	0.00	0.06	0.14	0.22	0.53
	$P_{0.2}$	0.35	0.38	0.49	0.55	0.61	0.75
	P(no catch)	0	0	0	0	0	0.42
M0.027	$\%B_0$ (13.6)	17.9 (7.1 – 59.4)	16.7 (6.2 – 59.1)	14.3 (4.5 – 56.7)	12.0 (2.9 – 56.5)	10.0 (2.2 – 55.0)	4.3 (2.0 – 50.1)
	$P_{0.1}$	0.14	0.19	0.28	0.40	0.49	0.71
	$P_{0.2}$	0.57	0.60	0.67	0.71	0.75	0.84
	P(no catch)	0	0	0	0	0	0.41
M0.06	$\%B_0$ (24.2)	33.6 (13.0 – 80.2)	31.4 (12.5 – 79.2)	29.8 (10.6 – 77.5)	26.3 (8.3 – 77.2)	24.6 (6.7 – 75.7)	17.4 (4.8 – 71.2)
	$P_{0.1}$	0.02	0.33	0.07	0.15	0.17	0.35
	$P_{0.2}$	0.27	0.29	0.35	0.40	0.42	0.54
	P(no catch)	0	0	0	0	0	0.71

5. STATUS OF THE STOCKS

Stock Structure Assumptions

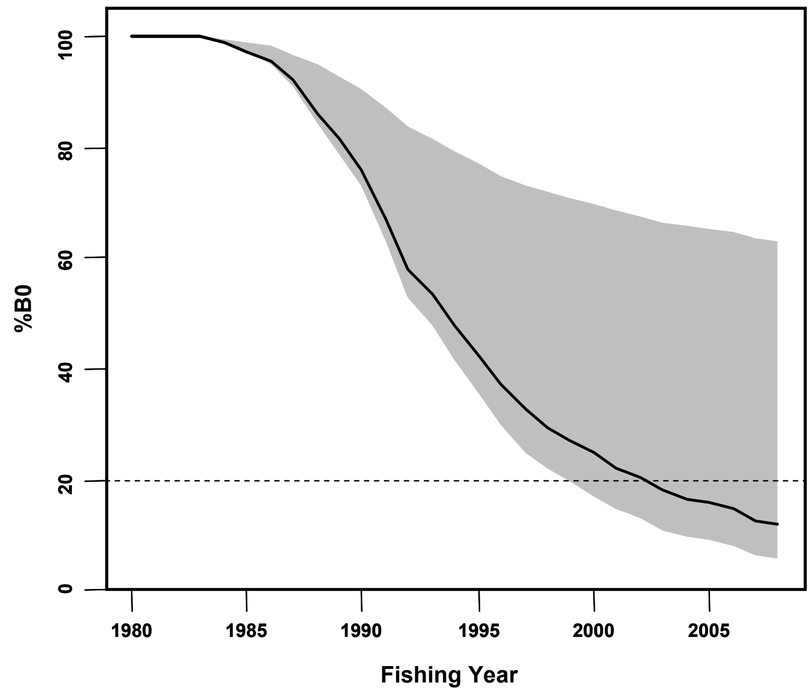
The stock boundaries and number of black cardinalfish stocks in New Zealand is unknown. There are no data on genetics, or known movements of black cardinalfish which indicate possible stock boundaries.

There is evidence that a spawning stock exists in CDL 2, with three geographically close spawning locations identified, on Tuaheni High, Ritchie Bank, and Rockgarden (Dunn 2009). Juveniles of less than 30 cm have been infrequently identified in CDL 2, and more frequently found on the northern flanks of the Chatham Rise, which is south of the spawning grounds in CDL 2. No spawning grounds have been identified on the Chatham Rise, where adult fish are relatively rare.

For the purposes of stock assessment, it has been assumed that black cardinalfish on the east coast North Island (CDL 2) are from the same stock as fish on the north Chatham Rise (CDL 3 and CDL 4).

- **CDL 2, 3 & 4**

Stock Status	
Year of Most Recent Assessment	2009
Assessment Runs Presented	One base case and three sensitivity runs. Base case: *M*=0.04; selectivity equal to maturity Sensitivity runs: various combinations of *M* and assumptions about the relationship between maturity and selectivity, considered to be less reliable than the base case
Reference Points	Management Target: Not yet specified Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	-
Status in relation to Limits	<u>Base case:</u> B_{2009} was estimated to be 12% B_0; About as Likely as Not to be below the Hard Limit and Likely to be below the Soft Limit. <u>Other model runs:</u> The range of B_{2009} was estimated to be 14-24% B_0; Unlikely to be below the Hard Limit but About as Likely as Not or Likely to be below the Soft Limit.
Historical Stock Status Trajectory and Current Status	



Estimated biomass trajectories (solid line) and 95% confidence intervals (shaded area) for the base case. The horizontal broken line indicates 20% B_0.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	All Models Runs: Biomass has exhibited a continuous decline since the 1980s when the orange roughy fishery developed in QMA 2.
Recent Trend in Fishing Mortality or Proxy	Unknown
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	-

Projections and Prognosis	
Stock Projections or Prognosis	Model projections indicate that the biomass will increase at catch levels near or below the 2007-08 level but will decline sharply at catch levels equal to the TACC
Probability of Current Catch causing decline below Limits	Soft Limit: Likely Hard Limit: About as Likely as Not
Probability of Current TACC causing decline below Limits	Soft Limit: Likely Hard Limit: Likely

Assessment Methodology		
Assessment Type	Level 1 – Quantitative stock assessment	
Assessment Method	Age-structured CASAL model with Bayesian estimation of posterior distributions.	
Main data inputs	- Two commercial catch-per-unit-effort (CPUE) series from the trawl fishery. - Estimates of biological parameters. New information since the previous assessment included more years of CPUE and updated catch information.	
Period of Assessment	Latest assessment: 2009	Next assessment: undecided
Changes to Model Structure and Assumptions	First accepted assessment for these stocks.	
Major Sources of Uncertainty	Major sources of uncertainty include the representativeness of the CPUE data, the relationship between CPUE and abundance, the assumption that recruitment has been constant throughout the history of the fishery, estimates of growth and natural mortality and the catch history.	

Qualifying Comments
None

Fishery Interactions
Main associated species are orange roughy, alfonsino and, to a lesser extent, hoki.

Other QMAs
There is no information on the status of cardinalfish stocks in other QMAs.

TACCs and reported landings for the 2007–08 fishing year are summarized in Table 9.

Table 9: Summary of TACCs (t) and reported landings (t) for black cardinalfish for the most recent (2007-08) fishing year.

Fishstock		QMA	FMA	2007–08 Actual TACC	2007–08 Reported landings
CDL 1	Auckland (East)		1	1 200	202
CDL 2	Central (East)		2	2 223	861
CDL 3	South-east (Coast)		3	196	7
CDL 4	South-east (Chatham)	4	5	66	23
CDL 5	Southland		5	22	20
CDL 6	Sub-Antarctic		6	1	<1
CDL 7	Challenger		7	39	2
CDL 8	Central (West)		8	0	< 1
CDL 9	Auckland (West)		9	4	19
CDL 10	Kermadec		10	0	0
Total				3 751	1 134

6. FOR FURTHER INFORMATION

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