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Assessment of the Challenger Plateau (ORH 7A) orange roughy fishery for the 1998–99 fishing year

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1. EXECUTIVE SUMMARY

1. The ORH 7A fishery developed in the southwestern region of the Challenger Plateau in 1981. Catches are taken inside the EEZ and on the Westpac Bank about 25 n. miles outside the EEZ. Reported catches have varied from 1400 t to 12 200 t per year, following changes in the TACC as the fishery developed and became fully exploited. The current TACC is 1900 t for ORH 7A and the Westpac Bank, and has been undercaught since 1992–93.

2. This fishery assessment incorporates updated landings from 1996–97, analysis of commercial CPUE data from 1982–83 to 1996–97, revised biological parameters, and results of stock reduction analyses.

3. Unstandardised (average catch per tow in winter months) and standardised (year effects) CPUE indices both show substantial decreases over the period of the fishery. The indices in 1996–97 were 11% and 1.5% of peak levels for the respective analyses.

4. Virgin biomass was estimated from stock reduction analysis on the two sets of CPUE data at between 94 500 and 128 700 t. Current biomass, $B_{mid1997-98}$, was 15–38% of virgin levels, but is not considered well estimated. The model estimates that stock size is currently increasing slowly, but this is not reflected in the CPUE data.

5. Yield estimates have been calculated. MCY is estimated to be 940–1710 t, and CAY is 880–2250 t.

6. The continued decline of CPUE, and the TACC not being fully caught for 4 years, cause concern about the status of the stock. The stock assessment is regarded as uncertain, but it appears unlikely that the current TACC is sustainable.

2. INTRODUCTION

2.1 Overview

This document updates the stock assessment of the orange roughy fishstock on the Challenger Plateau (ORH 7A, Figure 1). The assessment incorporates a standardised analysis of commercial catch and effort data from the fishery between 1982–83 and 1996–97. Biomass and yield estimates are calculated using a deterministic stock reduction analysis, and updated estimates of the biological parameters A_m, A_r, and L_{inf}.

2.2 Description of the fishery

The fishery is centred in the southwestern region of the Challenger Plateau, about 200 n. miles west-north-west of Cape Farewell. The fishery developed in late 1981, and rapidly expanded as spawning concentrations of fish were located inside the EEZ. Between 1980–81 and 1983–84 there was some scattered fishing outside the EEZ and apparently widespread misreporting of catches taken inside the EEZ. Reported catches have varied from 1400 to 12 200 t per year, after several changes in the TACC (Table 1). From 1989–90 to 1991–92 the bulk of the landings were in the winter months when the fishery focused its efforts on aggregations of spawning fish. However since 1992–93 winter fishing has increasingly incorporated long tows ranging southeast of the traditional spawning grounds.

A major fishery developed outside the EEZ in 1987. Westpac Bank, the main area fished, is about 25 n. miles outside the EEZ boundary, and 40 n. miles from the centre of fishing inside the zone. Peak catches of 3500 t were taken in 1988–89 (*see* Table 1). Catches have declined since then, partly on account of an agreement between New Zealand and Australia to restrict fishing in the area, and because catches by New Zealand vessels count against ORH 7A quota inside the EEZ. The accuracy of reported catches outside the EEZ by foreign vessels is uncertain.

2.3 Literature Review

Most papers relevant to the Challenger orange roughy fishery were outlined in previous stock assessment reports (*see* Clark 1991, 1992, Field & Clark 1996). The stock assessment was substantially updated in 1995 with the use of a revised stock reduction model and the same life history parameters used for Chatham Rise orange roughy (Doonan 1994), and in 1996 with standardised CPUE indices (Field & Clark 1996).

3. REVIEW OF THE FISHERY

3.1 Total Allowable Catches and landings data

Total Allowable Catches (TACs), reported landings, and total estimated catches (adjusted by the estimated overrun, detailed discussions of overrun were given by Clark 1991 and Francis *et al.* 1993) for ORH7A from 1980–81 to 1996–97 fishing years are shown in Table 1. The TAC was considerably reduced in 1989–90 following evidence the stock had been overexploited and had declined to relatively low levels (Clark 1991). Since 1990–91 the TAC has been held at 1900 t, and since 1993–94 has not been fully caught.

3.2 Recreational fisheries

There is no known recreational catch of orange roughy.

3.3 Maori customary fisheries

There is no known Maori customary fishing for orange roughy in this area.

3.4 Illegal catch

There is no quantitative information available on illegal catch.

Table 1: Reported catches (t), estimated overrun, total estimated catch (t, i.e., adjusted for overrun) and TACs (t) from 1980–81 to 1996–1997

Fishing year	Inside EEZ	Outside EEZ	Total catch	% overrun	Total estimated catch	TAC
1980–81†	1	32	33	30	43	–
1981–82†	3 539	709	4 248	30	5 522	–
1982–83†	4 535	7 304	11 839	30	15 410	–
1983–84†	6 332	3 195	9 527	30	12 385	4 950
1984–85†	5 043	74	5 117	30	6 652	4 950
1985–86†	7 711	42	7 753	30	10 079	6 190
1986–87†	10 555	937	11 492	30	14 940	10 000
1987–88‡	10 086	2 095	12 181	30	15 835	12 000
1988–89‡	6 791	3 450	10 241	25	12 801	12 000
1989–90‡	3 709	600 *	4 309 *	20	5 171	2 500
1990–91‡	1 340	17	1 357	15	1 560	1 900
1991–92‡	1 894	17	1 911	10	2 102	1 900
1992–93‡	1 412	675	2 087	10	2 296	1 900
1993–94‡	1 594	138	1 732	5	1 819	1 900
1994–95‡	1 554	82	1 636	5	1 718	1 900
1995–96‡	1 206	463	1 669	5	1 752	1 900
1996–97‡	1 055	253	1 308	5	1 373	1 900

† FSU data
‡ QMS data
* Minimum value because of unreported catches by foreign vessels fishing outside the EEZ.

4. RESEARCH

4.1 Stock structure

There are no new data which would alter the stock boundaries given in previous assessment documents.

Orange roughy on the Challenger Plateau are regarded as a single separate stock. Size structure, parasite composition, flesh mercury levels, and mitochondrial DNA studies show differences to other major fisheries within the EEZ. Spawning occurs in July, at a similar time to fish on the Chatham Rise, Puysegur Bank, Ritchie Banks, Cook Canyon, and Lord Howe Rise (Clark 1990).

4.2 Resource surveys

Trawl surveys of orange roughy have not been carried out on the Challenger Plateau since 1990 and have not been used in stock assessments since 1992–93 (Clark 1992). Trawl surveys and voyages for collection of biological, plankton, and hydrographic data have been outlined in previous stock assessment reports (*see* Clark 1991, 1992, Field & Clark 1996).

4.3 Catch per unit effort

4.3.1 Unstandardised catch rates

For the CPUE analyses the Challenger fishery was defined as the area between latitudes 39° and 41°S, and longitudes 166.5° and 169°E (*see* Figure 1). Within the fishery, tows were assigned to five sub-areas: Westpac Bank; the Central Flat; the Pinnacles with tow lengths less than 2 n.miles (these tows were assumed to be "hill shots" on the Pinnacles, hereafter referred to as Pinnacles hill); the Pinnacles with tow lengths greater than or equal to 2 n.miles (these tows were assumed to be tows on the flat area around the pinnacles hereafter referred to as Pinnacles Flat); and, Other (included all tows not in these areas).

Unstandardised seasonal catch rates of tows (tonnes per nautical mile) for all areas combined are shown in Figure 2. The distribution of fishing effort during the year, amount of fishing effort, and catch rates have all changed markedly since the fishery began. In the early years of the fishery fishing took place throughout the year and catch rates were high, especially during the June-July spawning season when there were very few zero catches. By 1987–88 however, the number of tows had trebled (*see* Table 2) *and* were concentrated in the spawning season when fish were normally highly aggregated (Figure 2). Also at this time tow length on flat areas away from the Pinnacles increased to a new high of about 11 n.miles (Table 3).

Despite this greatly increased effort catch rates dropped to very low levels (Table 4). In 1988–89 there was a substantial reduction in the TACC from 12 000 to 2500 t. Currently almost all fishing takes place during the spawning season.

Along with the changes in timing of fishing effort, the geographical distribution of effort also changed (Figure 3). In the early years of the fishery over 80% of fishing effort was directed at flat areas (*see* Table 2). Then in the mid 1980s up to 40% of tows moved to the Pinnacles or Westpac Bank hills, a change prompted by the decline in catch rates on the Central Flat and made possible by increased fishing skill and new technologies (Field & Clark 1996). Since 1991–92, as catch rates on all the historical spawning aggregations decreased, vessels have ranged much further out onto the southeastern flats of the Challenger area (*see* Figure 3). In 1996–97 60 % of tows were carried out in this area (*see* Table 2) and average tow length had increased to 15 n.miles (*see* Table 3).

Table 2: Total number of tows and percentage of tows by sub-area in the Challenger fishery

Year	Total tows	Central Flat	Pinnacles hill	Pinnacles flat	Westpac Bank	Other
1982–83	747	22	2	8	0	68
1983–84	786	15	4	37	0	45
1984–85	678	31	12	33	0	23
1985–86	876	41	10	32	0	18
1986–87	1 379	34	13	25	5	19
1987–88	2 265	26	18	15	26	18
1988–89	1 872	22	21	9	24	24
1989–90	507	28	29	18	12	12
1990–91	302	42	17	10	4	28
1991–92	369	18	36	13	1	32
1992–93	649	13	18	6	25	38
1993–94	428	25	15	7	19	35
1994–95	431	20	16	13	8	43
1995–96	484	14	11	4	21	51
1996–97	613	6	8	5	21	60

Table 3: Mean tow length (n.miles) by sub-area (*see* Figure 2) in the Challenger fishery. -, not fished

Year	Central Flat	Pinnacles hill	Pinnacles flat	Westpac Bank	Other
1982–83	5.8	1.3	5.5	-	6.1
1983–84	4.7	1.2	5.0	-	6.7
1984–85	7.8	1.0	4.6	-	7.0
1985–86	4.6	1.0	5.0	-	7.5
1986–87	4.6	1.0	4.3	4.9	7.5
1987–88	9.4	0.6	6.9	3.2	9.8
1988–89	12.0	0.5	9.4	2.2	11.1
1989–90	11.1	0.8	5.0	1.6	10.3
1990–91	13.7	0.7	6.9	2.2	11.8
1991–92	11.1	0.7	8.3	2.8	11.5
1992–93	12.0	0.6	10.5	1.4	12.3
1993–94	11.1	0.6	5.5	1.0	11.8
1994–95	9.3	0.6	7.5	1.1	11.4
1995–96	11.1	0.6	10.6	1.6	10.6
1996–97	15.2	0.7	11.2	1.9	15.1

4.3.2 Unstandardised CPUE analysis

An estimate of unstandardised CPUE was calculated as the total catch for all vessels combined for the June-September period, divided by the total number of tows. Indices haved changed slightly from those reported by Field & Clark (1996) because they are now calculated from the error checked dataset. The resulting indices (*see* Table 4) show that unstandardised total CPUE in the winter months declined steadily during the mid 1980s, after which catch per tow appeared to stabilise until 1996–97 when it declined to a new low of 11% of catch rates in the first year of fishing. As discussed by Field & Clark (1996) unstandardised CPUE is not thought to be a reliable index of abundance due to a number of major changes in fishing effort.

Table 4: **CPUE indices from unstandardised data (mean catch (t/tow) in the June-September period, all NZ vessels combined)**

Year	Central Flat	Pinnacles hill	Pinnacles flat	Westpac Bank	All other	Total CPUE
1982–83	10.57	–	11.65	–	17.67	15.8
1983–84	16.45	–	1.86	–	11.94	15.3
1984–85	14.50	9.35	7.99	–	13.45	13.5
1985–86	12.15	18.48	10.05	–	6.09	10.8
1986–87	12.21	10.03	7.62	7.01	5.11	9.4
1987–88	6.13	7.67	4.88	3.79	4.51	5.3
1988–89	2.85	5.60	3.22	2.85	2.44	3.5
1989–90	5.61	9.02	5.87	2.31	2.84	5.8
1990–91	3.86	6.52	2.55	0.75	3.05	3.9
1991–92	3.62	5.48	3.66	0.50	3.61	4.3
1992–93	2.11	2.49	2.29	3.43	2.58	2.7
1993–94	2.88	2.02	1.70	2.21	4.71	3.2
1994–95	5.71	2.97	1.10	2.01	4.41	3.8
1995–96	3.51	1.84	2.39	3.03	3.82	3.7
1996–97	0.99	1.40	1.73	1.35	1.93	1.8

4.3.3 Standardised CPUE analysis

The proportion of the reported landings for ORH 7A which was also reported as estimated catch on TCEPRs from the Challenger fishery (as defined in Section 4.3.1) is given in Table 5.

Table 5: **Percentage of total reported landings (t, inside and outside the EEZ) in ORH 7A also reported as estimated catch for individual tows on the catch-effort database. FSU, Fisheries Statistics Unit; QMS, Quota Monitoring System**

Year	Data source	Reported landings	% on database
1982–83	FSU	11 839	101
1983–84	FSU	9 527	99
1984–85	FSU	5 117	99
1985–86	FSU	7 753	99
1986–87	FSU	11 492	96
1987–88	FSU	12 181	101
1988–89	FSU & QMS	10 241	61
1989–90	QMS	4 309	72
1990–91	QMS	1 357	93
1991–92	QMS	1 911	89
1992–93	QMS	2 087	84
1993–94	QMS	1 732	78
1994–95	QMS	1 636	101
1995–96	QMS	1 669	109
1996–97	QMS	1 308	84

A standardised CPUE analysis of commercial data for the orange roughy fishery in ORH 7A was carried out using the multiple regression technique described by Field (1992) and used previously by Field & Clark (1996). The analysis was run for the fishery from 1982–83 to 1996–97. Records of tows

by New Zealand (DOM), USSR (SOV), Japanese (JAP), Korean (KOR), Russian (RUS), and Norwegian (NOR) vessels that had targeted and/or caught orange roughy were included in the analysis. This resulted in a dataset of 12 411 records for 77 vessels.

Variables used in this analysis are described in Table 6. They were regressed against a CPUE of log(tonnes/n.mile + 0.001).

Table 6: Summary of variables in the standardised model. Variable types are: cont, continuous; cat, categorical with the given number of categories

Variable	Type	Description
Area	cat 5	sub-area that the tow occurred in
Year	cat 13	fishing year (1 October - 30 September) that the tow occurred in
Month	cat 12	month that the tow occurred in
Net depth	cont	depth in metres of groundrope at start of tow
Start time	cont	time in decimal hours at start of tow
End time	cont	time in decimal hours at end of tow
Speed	cont	speed of the vessel at start of tow
Nation	cat 6	country of origin of the vessel
Vessel power	cont	power of vessel engine in kilowatts
Vessel tonnage	cont	gross tonnage of the vessel

Results from this regression analysis which were used to choose the best predictor variable at each iteration are shown in Table 7. Variables were included in the model if they improved the R^2 by more than 0.1%. The analysis chose a model which included the variables area, year, month, nation, net depth, and gross tonnage of the vessel. Area, year, and month together explained 21% of the variability in CPUE. Inclusion of nation, net depth, and vessel tonnage explained a further 1.5% of the variability.

The relative year effects for each year included in the analysis are shown in Table 8 and Figure 4. The relative year effect showed a sharp decline between 1984–85 and 1987–88. Between 1992–93 and 1995–96 the index was stable at about 2% of its 1983–84 peak value. In 1996–97 it dropped to a new low of just 1.2% of its peak.

Table 7: Choice of variables in stepwise regression against log(tonnes/n.mile). Each entry shows the R^2 that would be achieved by including the given variable into that iteration

	R^2 at iteration						
Variable	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Area	8.23						
Fishing year	6.91	14.93					
Month	2.67	10.18	21.34				
Nation	3.22	11.23	15.39	22.02			
Net depth	4.66	8.74	15.80	21.75	22.49		
Vessel tonnage	0.22	8.30	15.15	21.69	22.32	22.79	
Vessel speed	0.12	8.35	15.54	21.58	22.15	22.63	22.89
Vessel power	1.03	9.32	15.67	21.83	22.33	22.78	22.86
Start time	0.12	8.32	15.01	21.39	22.07	22.53	22.84
Finish time	0.14	8.32	15.00	21.39	22.06	22.53	22.83
Improvement in R^2	8.2	6.7	6.4	0.7	0.5	0.3	0.1

Table 8: **Relative year effects for regression of log(tonnes/n.miles). *n*, number of tows; P(0), percentage of tows with zero catch**

Year	Number of vessels	*n*	P(0)	Relative year effect
1982–83	18	747	3	1.00
1983–84	19	786	9	1.30
1984–85	10	678	24	0.37
1985–86	15	876	15	0.58
1986–87	21	1 379	18	0.27
1987–88	24	2 265	19	0.083
1988–89	24	1 872	12	0.062
1989–90	18	532	10	0.088
1990–91	8	302	5	0.036
1991–92	11	369	10	0.036
1992–93	10	649	15	0.026
1993–94	9	428	14	0.025
1994–95	13	431	11	0.026
1995–96	14	484	20	0.024
1996–97	15	613	18	0.015

During the 1998 stock assessment process the ORH/OEO Working Group requested that interaction effects between predictor variables in this model be examined. The stepwise multiple regression model used here can look only at the interaction between variables for which there is data for **all** combinations of the two variables being interacted. For instance for the year*area interaction there must have been tows carried out in all areas for all years.

There were no combinations of the main predictor variables area, year, month, and nation in the original dataset for which this condition was met. The only months which had fishing in every year were the spawning months June and July. Restricting the model to these months would have been a significant change to the original model. New Zealand (DOM) was only nation which fished in all years. Clearly there can be no interaction for a single category of a variable.

The only area which did not have tows for every fishing year was Westpac Bank (the fishery began in this area in 1986–87. As an experiment I ran the original model without the Westpac data and included an interaction effect for year*area (i.e., 15 years by 4 areas). This model explained **28.63%** of variability in CPUE, compared to **25.39%** for the same model without the interaction of year*area, i.e., including the interaction improved the explanatory power of the model by **3.24 %.**

A plot of the relative year*area interaction effects is given in Figure 5a. The interaction effects are calculated relative to the area Pinnacle flat. There is essentially no trend in the effects for Central Flat and Other, while the year*area interaction for Pinnacle hill shows a slightly increasing effect in more recent years. A plot of the relative year effects with the year*area interaction effect added to them is shown in Figure 5b. This demonstrates that the interaction is of relatively little importance in early years when the year effect itself is so strong, and increases its importance as the year effect declines. This model that excludes the Westpac data and included an interaction of year*area was not used further in this assessment.

4.4 Estimation of biomass

A deterministic stock reduction analysis technique (*after* Francis 1990) was used to estimate virgin (B_o) and current (B_{1998}, mid-season 1997–98) biomass. Biological parameters for the Challenger Plateau were revised in 1998 (Table 9) in line with results from recent ageing work (Anderson *et al.* 1998, Annala & Sullivan 1998). Examination of the transition zone of otoliths from Challenger fish showed they had a younger age at maturity (A_m) and recruitment (A_r) than previously estimated for other stocks (Horn *et al.* in press). Considering this, and recognising that the size distribution is about 2 cm smaller than that of Chatham Rise fish, L_∞ was also reduced for both sexes. All other biological parameters remain the same as used for Chatham Rise (ORH 3B) orange roughy (*see* Doonan 1994, Francis *et al.* 1995). The catches used in the model were the "Total estimated catch" given in Table 1 (i.e., total catches including estimated overrun). Catches in 1997–98 were assumed to be equal to the TACC plus 5% overrun. In keeping with previous orange roughy assessments, the maximum exploitation rate (E_{max}) is assumed to be 0.60 (Francis *et al.* 1995).

Table 9: Biological parameters used in this assessment

Parameter	Symbol	Male	Female	Both sexes
Natural mortality	M	–	–	0.045 yr^{-1}
Age of recruitment	A_r	–	–	23 yr
Gradual recruitment	S_r	–	–	3 yr
Age at maturity	A_m	–	–	23 yr
Gradual maturity	S_m	–	–	3 yr
von Bertalanffy parameters	L_∞	33.4 cm	35.0 cm	–
	K	0.070 yr^{-1}	0.061 yr-1	–
	t_0	–0.4	–0.6	–
Length-weight parameters	a	–	–	0.0921
	b	–	–	2.71
Recruitment variability	σ_R	–	–	1.1
Recruitment steepness		–	–	0.75

The biomass indices used in the stock reduction analysis, and results of the runs, are given in Table 10. All indices were used as indices of relative abundance. They were assumed to have a *c.v.* of 30%, and this was constant across all years. Model structure considers both sexes separately, and assumes natural mortality occurring before fishing mortality. The latter is because most of the catch occurs in June-July, which is towards the end of the fishing year. Confidence intervals for B_o were derived from bootstrap analysis. Population trajectories for both cases and scaled index values are given in Figure 6.

Table 10: Summary of stock reduction results: indices used, and biomass estimates (t)

	Unstandardised CPUE	Standardised CPUE
Indices:		
1982–83	15.8	1.00
1983–84	15.3	1.30
1984–85	13.5	0.37
1985–86	10.5	0.58
1986–87	9.4	0.27
1987–88	5.3	0.083
1988–89	3.5	0.062
1989–90	5.8	0.088
1990–91	3.9	0.036
1991–92	4.3	0.036
1992–93	2.7	0.026
1993–94	3.2	0.025
1994–95	3.8	0.026
1995–96	3.7	0.024
1996–97	1.8	0.015
Estimates:		
B_0	109 200	94 500
B_{min} – $B_{upper\ 95\%\ CI}$	100 800 – 128 700	94 500 – 99 400
$B_{current}$	20 500 – 49 100	13 800 – 19 000
$B_{current}/B_0$ (%)	20 – 38	15 – 19
Exploitation rates:		
1994–5	0.06	0.15
1995–6	0.06	0.14
1996–7	0.05	0.10

The estimates of B_0 from the stock reduction analyses were 109 200 t for the unstandardised indices and 94 500 t for the standardised indices. In Table 10, a range is given for B_0 of B_{min}, the minimum biomass consistent with the catch history and an assumed maximum instantaneous fishing mortality of 1 yr^{-1} (this corresponds to a maximum exploitation rate of about 0.60), and an upper 95% confidence limit for B_0 (calculated using the bootstrap procedure of Cordue & Francis 1994). The current (mid-season 1997–98) biomass is estimated as 20–38% and 15–19% B_0 for the unstandardised and standardised indices, respectively.

4.5 Yield estimates

Yield estimates were calculated for the biomass range, B_{min}, to the upper 95% confidence limit for B_0 (Table 11). Maximum Constant Yield (MCY) and Current Annual Yield (CAY) were estimated using the simulation model of Francis (1992) with the biological parameters of Table 9. By this method the long-term MCY is 1.40% of B_0, and under continued fishing at this level the mean biomass is 50% B_0. Where the mid-season $B_{1997-98}$ was estimated to be less than 20% of B_0 the MCY was adjusted by MCY = $MCY*B_{1997-98}/(0.2B_0)$ (*after* Francis 1992).

The exploitation rate associated with CAY, E_{CAY}, is 0.06. This was applied to beginning of season biomass (less natural mortality) for 1996–97. The mean catch when fishing at E = 0.06 is 1.84% B_0, and the mean biomass is 30% B_0. All these estimates are sensitive to assumed values of natural

mortality and steepness (*see* page 223, tables 1 and 2 of Annala & Sullivan 1998).

Table 11: Biomass (t) and yield estimates (t, corrected for an assumed overrun of 5%). The lower value of the ranges given correspond to B_{min}, the upper value to the upper 95% confidence limit for B_0. The long-term MCY is the MCY when the biomass is greater then 20% B_0; the MAY is the long-term average CAY

Series	B_0	$B_{current}$	$MCY_{1997-98}$	$MCY_{long-term}$	$CAY_{1997-98}$	MAY
Unstandardised	100 800–128 700	20 500–49 100	1340–1710	1340–1710	1270–2900	1760–2250
Standardised	94 500–99 400	13 800–19 000	940–1260	1260–1320	880–1180	1650–1740

5. MANAGEMENT IMPLICATIONS

Commercial catch per unit effort and research trawl survey data clearly indicate that the orange roughy stock in the southwestern region of the Challenger Plateau (both inside and outside the EEZ) declined markedly during the 1980s. CPUE continues to decline in all areas except newly fished grounds southeast of the main spawning area. The estimates of B_0 calculated from the standardised CPUE indices is in the range 94 000–99 000 t, with current biomass for these results estimated to be between 15% and 19% of B_0. Contrary to the continued decline in CPUE the stock reduction analysis estimates that stock size is currently increasing slowly (Figure 6). These estimates of increasing stock size are considered unreliable due to inadequate information being available on historic or current recruitment. Recruitment variation has therefore not been taken into account, and the biomass and yield estimates are based on a deterministic model using constant recruitment.

The continued decline of CPUE, and the TACC not being fully caught since 1992–93, cause concern about the status of the stock. Estimates of MCY are less than the current TACC, although similar to the 1996–97 level of catch. The CAY estimate is less than the TACC. The stock assessment is regarded as uncertain, but it appears unlikely that the current TACC is sustainable, or will allow the stock to rebuild towards a size that will support the MSY. It is unknown if current catch levels, which are less than the TACC, are sustainable or will allow the stock to move towards B_{MSY}.

6. REFERENCES

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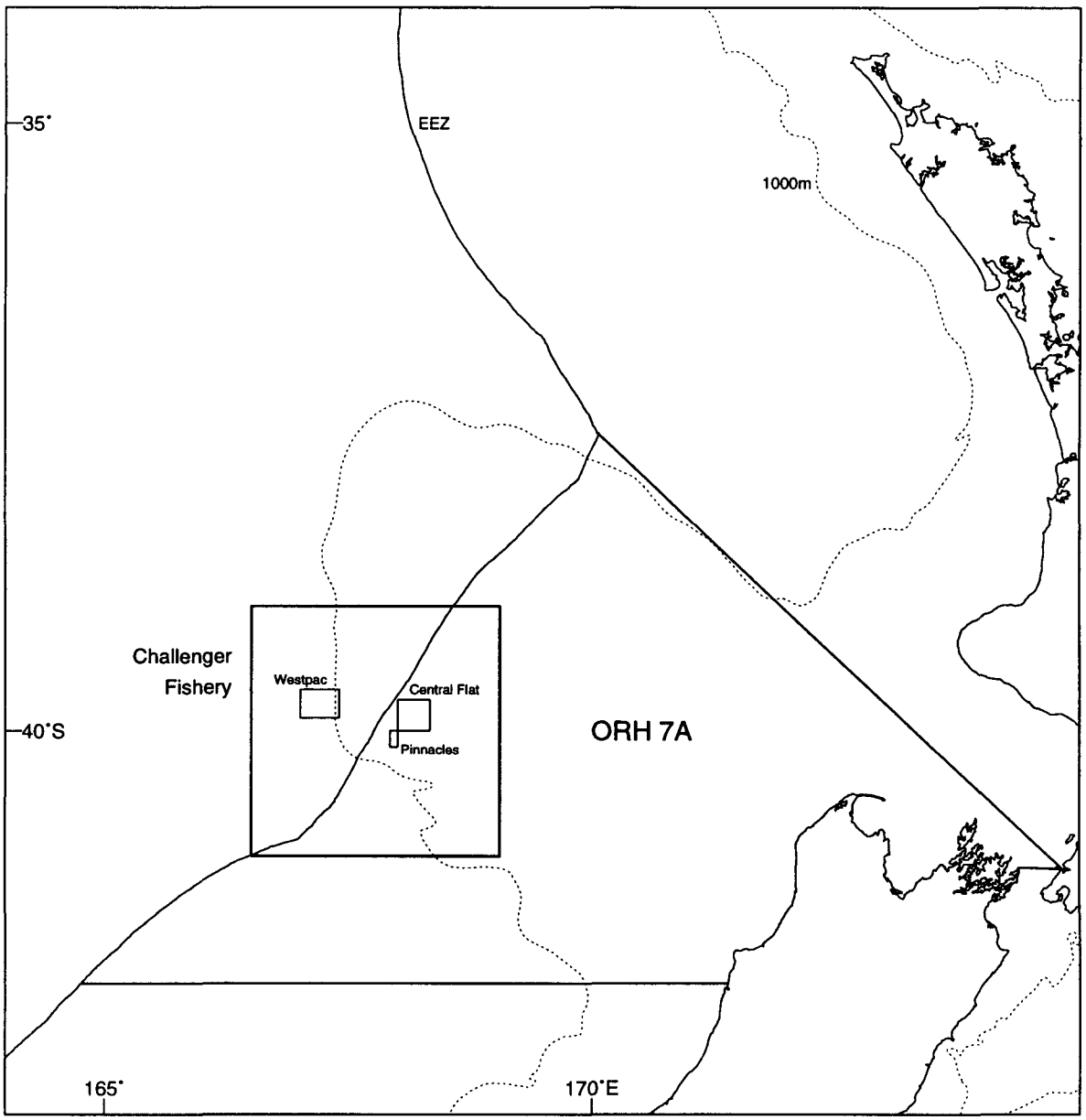

Figure 1: Location of the Challenger Plateau orange roughy fishery and sub-areas used in this analysis.

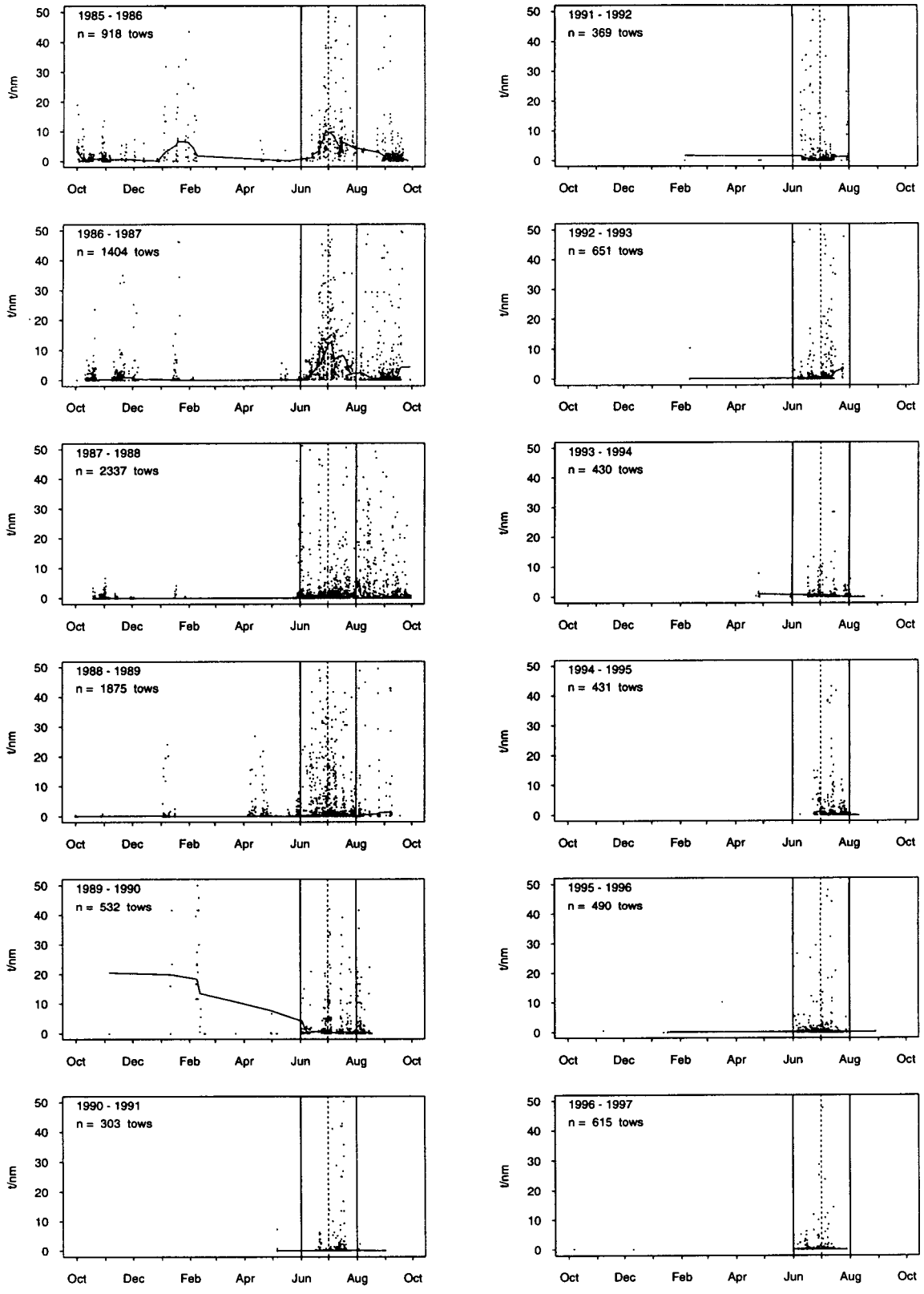

Figure 2: Unstandardised catch rates (t/n. mile) and smoothed medians (medians calculated for five consecutive data points) by fishing year for orange roughy caught in the Challenger fishery. (June-July is the spawning period)

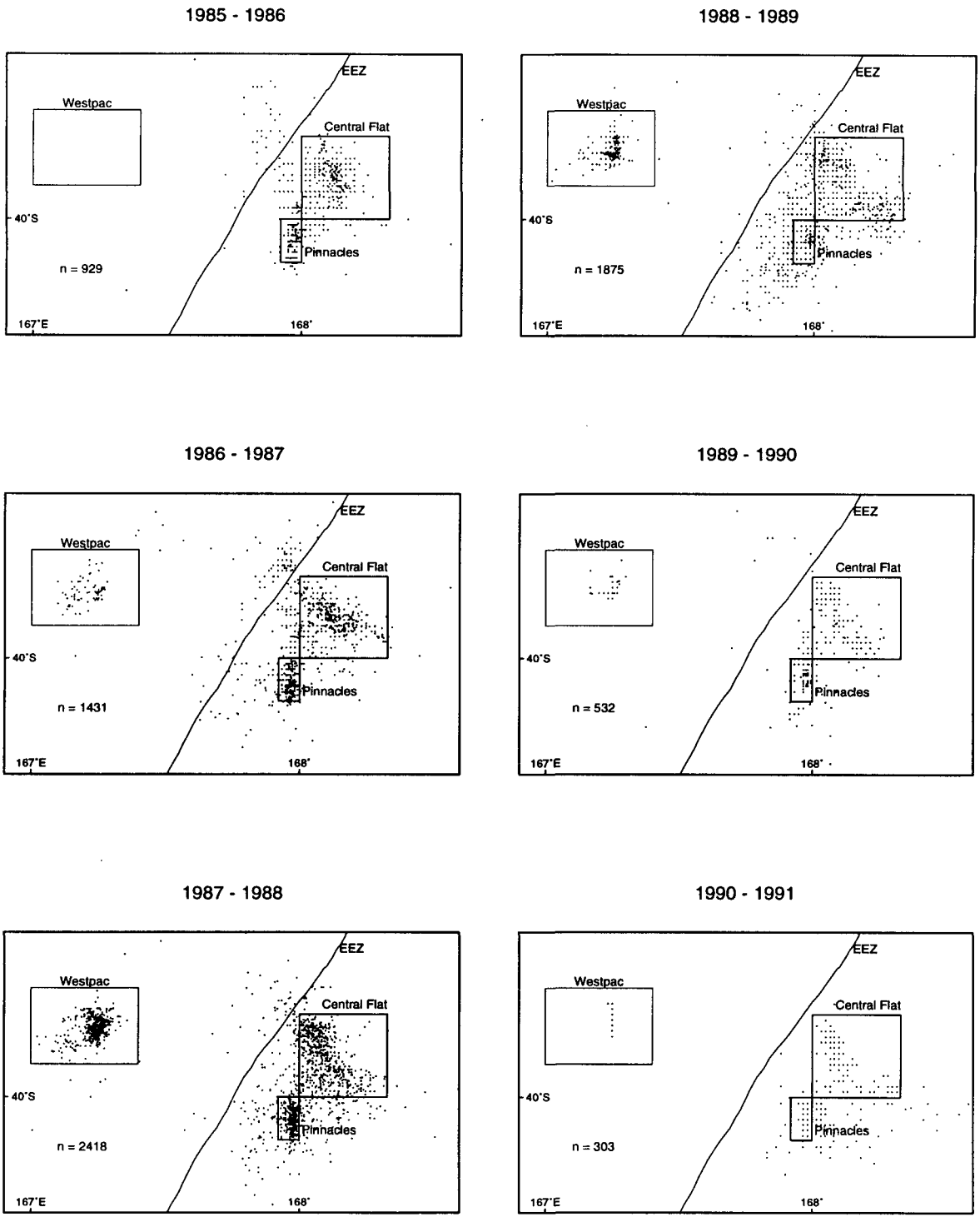

Figure 3: Position of tows which caught or targeted orange roughy in the Challenger Plateau fishery 1985–86 to 1990–91.

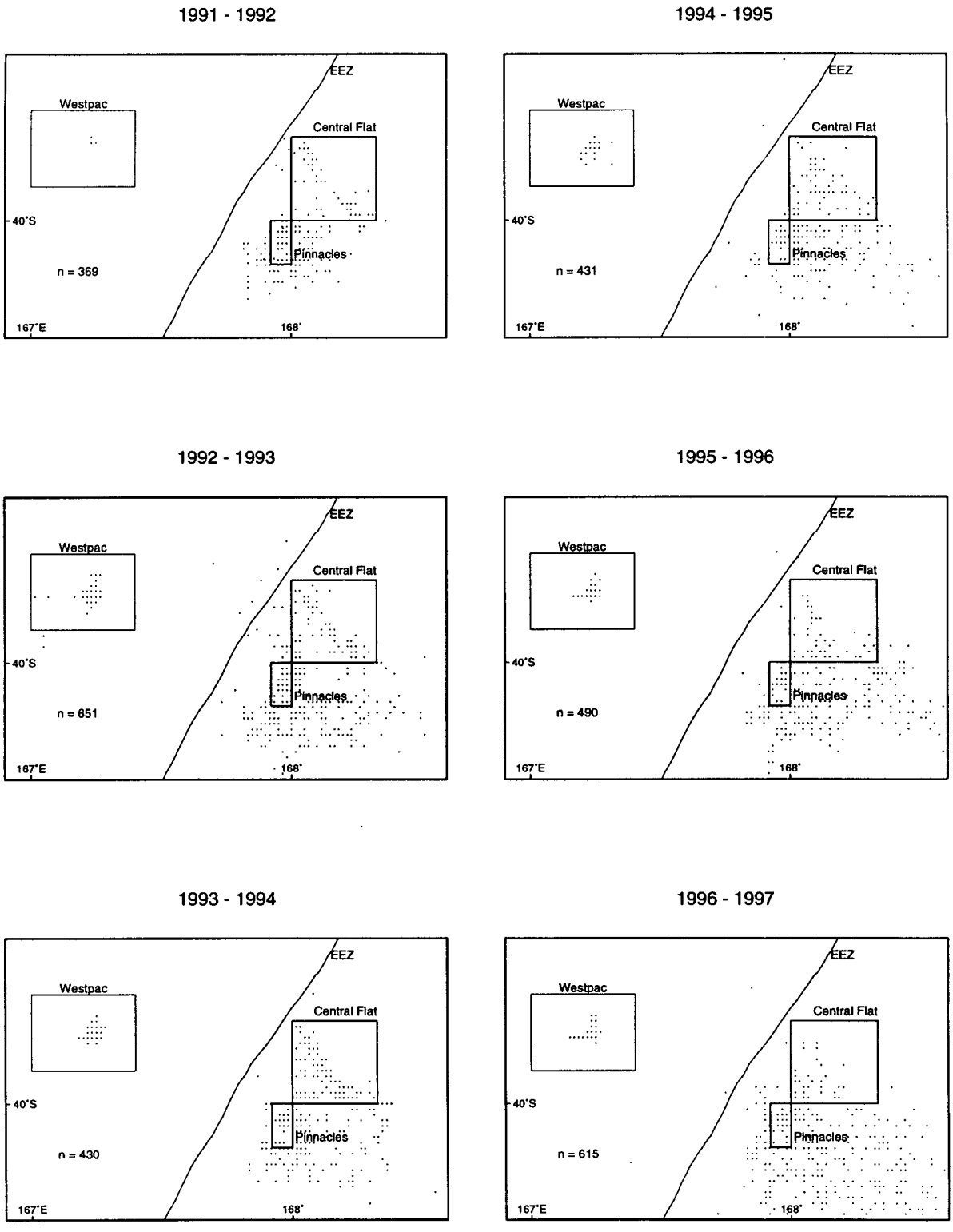

Figure 3 cont: Position of tows which caught or targeted orange roughy in the Challenger Plateau fishery 1991–92 to 1996–97.

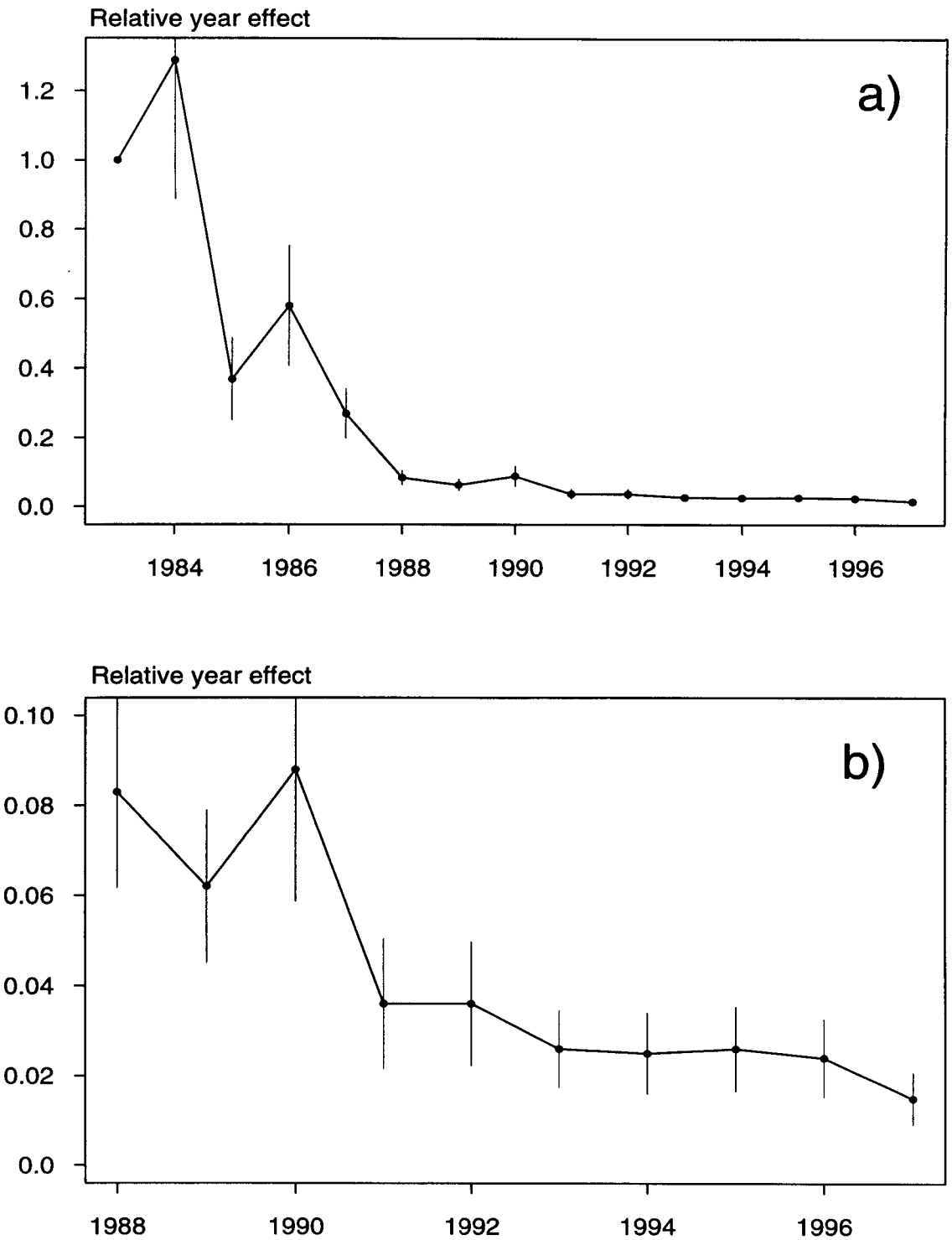

Figure 4: Relative year effects for the standardised regression of CPUE in the Challenger fishery with error bars representing two standard errors a) 1983–84 to 1996–97, b) 1987–88 to 1996–97.

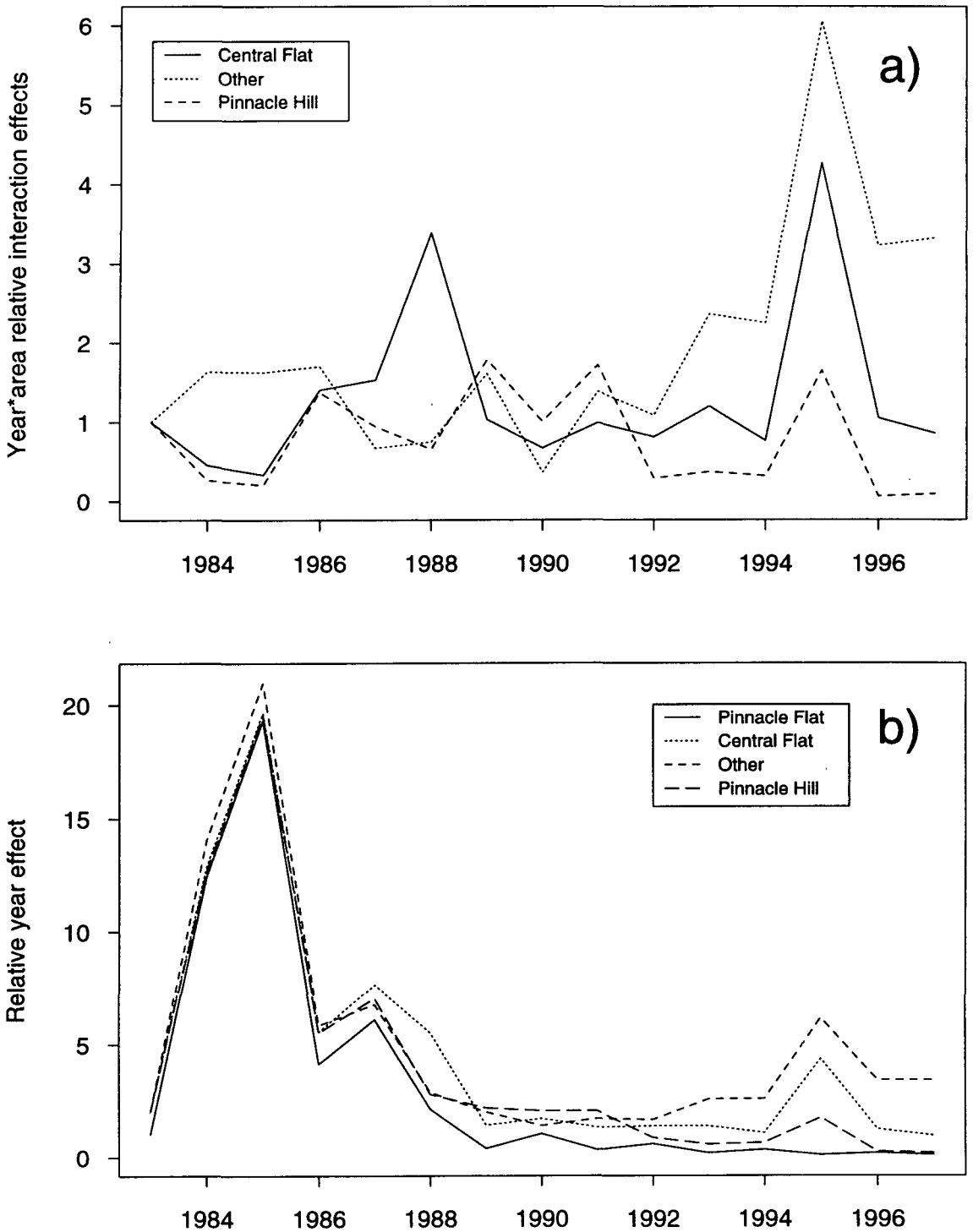

Figure 5: Year*area interaction effects for the standardised regression of CPUE in the Challenger Fishery, excluding Westpac Bank a) year*area interaction effects calculated relative to the area Pinnacles Flat, b) relative year effects with the year*area interaction effects added to them and Pinnacles Flat the base area.

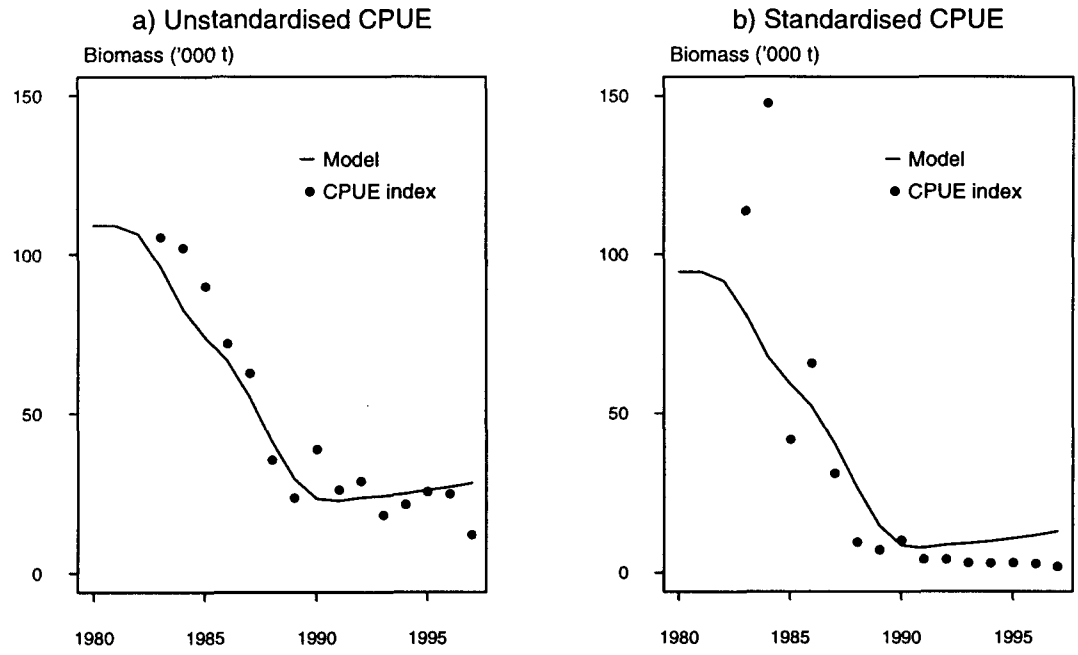

Figure 6: Biomass trajectory estimated from the deterministic stock reduction analysis using a) unstandardised and b) standardised CPUE indices.