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Assessment of the Challenger Plateau (QMA 7A) orange roughy fishery for the 1989–90 fishing year

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1. INTRODUCTION

1.1 Overview

This document updates the Challenger Plateau (QMA 7A) orange roughy stock assessment. Research and commercial data collected in 1988 are incorporated, together with recent information on age and growth of orange roughy from the Chatham Rise. Yields are estimated for the 1989–90 fishing year, and the management implications of the estimates are discussed.

1.2 Description of the fishery

The fishery developed from late 1981 and is currently the second largest for orange roughy in New Zealand waters. Orange roughy are caught throughout the year, but most fishing occurs in a relatively small area during winter and spring.

Initially, foreign chartered vessels dominated the fishery, but these have in recent years been progressively replaced by domestic vessels, in particular ice boats of 25–55 m.

Before 1983–84 there was no specific quota for the area, but catches were limited by a TAC for the rest of the EEZ apart from the Chatham Rise (old EEZ areas C and D) and Wairarapa coast. From 1983–84 a TAC of 4950 t was set for the Challenger Plateau and west coast of the South Island (Table 1). In 1985–86 a quota of 6190 t was set specifically for the Plateau. This was raised in 1986–87 to 10 000 t to assess the effects of heavier fishing on the population. A further increase in quota to 12 000 t occurred in 1987–88 as the result of a quota trade between Chatham Rise and Challenger Plateau fisheries. Part of this quota trade continued into 1988–89, together with some quota transferred from Wairarapa and Kaikoura fisheries. There is currently a total allocated quota of 9030 t, comprising 5626 t ITQ, and 3404 t ATQ. MAFFish holds 2970 t (as at March 1989).

A fishery has recently developed for orange roughy in the western region of the Challenger Plateau outside the 200 mile EEZ. Reported catches increased rapidly in 1987 and 1988 from low levels prior to 1986. Most fish are caught on the 'Westpac Bank', approximately 25 miles outside the EEZ boundary.

1.3 Literature review

Results of annual trawl surveys from 1984 to 1988 have been produced as FRD/FRC internal reports: Tracey (1984, 1985), Tracey *et al.* (1987), Clark and Tracey (1988, 1989). Unpublished cruise reports have been prepared for a number of research trips, particularly by GRV *James Cook*.

Literature relevant to this assessment additional to that outlined in the previous stock assessment report (Clark 1988) includes a report of a trawl survey in July 1988 (Clark and Tracey 1989), and a paper on age and growth of orange roughy from the Chatham Rise (Mace *et al.* in prep.).

2. REVIEW OF THE FISHERY

2.1 Catch, landings, and effort data

Reported catches of orange roughy from the Challenger Plateau inside the EEZ (old EEZ area H, corresponding to QMA 7A) and outside are given in Table 1. These reported catches are estimated to be 30% low due to an incorrect product conversion factor, and other fishing, processing, and reporting practices (Robertson 1986). Consequently, these values have been increased by 30%, and combined with total catches from research surveys (which are not included in FSU statistics) for analyses in this assessment.

Fishing effort data have been collected since 1983. Catch and effort information for orange roughy, however, is difficult to interpret. Fish can be aggregated at various times of the year; saturation fishing occurs; the catch can be taken in a very short time, or in a small proportion of the total time a trawl is on the bottom; gear damage with loss of catch can frequently occur; vessels have different gear and fishing power; target quantity of fish per tow may vary; fishing performance can improve with experience and advances in technology; and fishing logbooks often do not have accurate information on length of tow on the bottom. The last point in particular makes meaningful analysis of catch rate/unit time difficult in an area like the Challenger Plateau. Fishing occurs on flat bottom, in troughs, and on pinnacles, and in each case effective bottom fishing time differs greatly. Consequently, data have been analysed on the basis of catch per tow, although it is acknowledged that this gives only a general indication of catch rate trends.

Catch per tow values by month for domestic ice vessels (generally 25–40 m, up to 55 m) and domestic factory trawlers (65–95 m) are presented separately in Table 2. A trend of declining catch rates noted for non–winter months from 1983–86 by Clark (1988) continued with both classes of vessel in 1987 and early 1988. Catch rates in the winter months of June–August, when the fishery centres on aggregations associated with spawning, are high and relatively consistent from 1983 to 1987. However, there was a marked decrease in catch rates in winter 1988. This occurred with both ice vessels and factory trawlers. Because the fishery at this time centres on schooling fish, catch rates would be expected to remain high even when biomass was declining. In addition, there have been recent improvements in technology for fishing rough ground in the area, and the level of experience of most fishermen involved in the fishery is high. Because of these factors, this decline in catch rates indicates there have been major changes in abundance or availability of orange roughy.

2.2 Other information

Extensive data on length, sex, gonad stage, and otoliths from orange roughy on the Challenger Plateau have been collected from commercial vessels in 1988 during a pilot study for a stock monitoring programme. These data have not yet been analysed.

2.3 Recreational, traditional, and Maori fisheries

There are no known non-commercial fisheries for orange roughy.

3. RESEARCH

3.1 Stock structure

Orange roughy on the Challenger Plateau are regarded as a single, separate stock. Size structure of the population differs from other major fisheries, with orange roughy being smaller than elsewhere. Spawning occurs at a similar time to fish on the Cook Canyon, Ritchie Banks, and Chatham Rise. A study of parasite loads in fish from the Challenger Plateau, Cook Canyon,

and Chatham Rise in 1986 reported major differences between the areas. Flesh mercury levels differ between Challenger Plateau and Chatham Rise fish. Research at FRC on stock separation of orange roughy is currently being conducted involving mitochondrial DNA, electrophoretic analysis, and parasite composition and infestation rate comparisons.

In 1987 and 1988 aggregations of orange roughy were fished on the Westpac Bank, 25 miles outside the EEZ boundary, and about 40 miles from the main spawning area inside the EEZ. Data were collected during trawl surveys in July 1987 and 1988 from both the Westpac Bank and main fishing areas inside (see Clark and Tracey 1988, 1989). The size of orange roughy was similar in both areas, but gonad stages differed. On the Westpac Bank a higher incidence of immature and/or resting fish was observed in comparison with more advanced stages inside the EEZ. Running ripe fish have been recorded, but not in high proportions. From Scientific Observer Programme records in 1988, there are indications that levels of spent fish were very high on the Westpac Bank from August, with some ripe fish in September. Further analysis of biological and commercial catch data are continuing, but at present there is no evidence that orange roughy inside and outside the EEZ on the Challenger Plateau are separate stocks.

3.2 Resource surveys

Trawl surveys to measure the distribution and abundance of orange roughy on the Challenger Plateau have occurred annually since 1983 (Table 3). In addition there have been several cruises of GRV *James Cook* directed at collection of biological, plankton, and hydrographic data.

3.3 Other studies

Mace *et al.* (in prep.) have studied age and growth of orange roughy from the Chatham Rise. They compared annual ring counts on otoliths with length frequency modes of juvenile fish, and concluded that orange roughy grow very slowly and recruit to the fishery at ages of 18–20 years. Preliminary analysis of otoliths collected from juvenile orange roughy on the Challenger Plateau in 1983 and 1984 suggest that juvenile growth is similar to that of Chatham Rise fish.

Trawl position and catch data from all commercial vessels fishing on the Challenger Plateau between July and September 1987 have been examined for patterns of fish movement after spawning (see Figure 1). In July commercial activity centred on a flat area at depths of 850 m inside the EEZ, and then shifted in August to the northwest in 850–950 m across the EEZ boundary. Throughout September highest catch rates were recorded on the Westpac Bank and around 'the Pinnacles' inside the EEZ. These data indicate that some orange roughy may disperse after spawning to parts of the Plateau outside the EEZ.

3.4 Biomass estimates

Biomass estimates from stratified random trawl surveys carried out from 1983 to 1988 are presented in Table 3. The area surveyed, timing of the survey, and the vessel used have varied, and consequently all results are not directly comparable.

The survey in 1983 occurred after spawning when fish may have dispersed to an extent into deeper water beyond the survey area. In addition there was a low density of trawl stations in likely areas of fish aggregations. Sampling in 1984 centred on the main spawning area with a greater number of trawls. Very large catches occurred in a small area, with low catch rates elsewhere. Consequently, in 1985 and 1986 the survey area was considerably reduced, and emphasis placed on mapping the size of the schools. The number of trawls was low, and variance of the biomass estimates was high.

The 1987 survey covered a larger area with more trawls to ensure the main regions of the distribution of orange roughy were sampled. This survey was intended as the basis for a time series, and the same area was covered in 1988.

The distribution of orange roughy during the 1988 survey differed from that observed previously, with the absence of one of two concentrations regularly recorded (see Clark and Tracey 1989). Strata boundaries were consequently altered from those used in 1987. No heavy marks or plumes of fish were recorded on the echo–sounder (this was also noted by vessels commercially fishing at the time), and no trawls during the survey were shortened because of indications on the net monitor of possible large catches.

Catch rates in depth strata outside the main spawning area have been examined to determine if 'background' densities of fish that are not schooling differ between years. Identical strata outside the spawning area were surveyed in 1987 and 1988, and catch rates in general decreased between these two years (Table 4). Earlier data are difficult to compare directly with 1987-88 because of differences in strata boundaries, survey timing (1983), and vessel used.

The extent of the apparent decline in biomass from 1987 to 1988 cannot be attributed solely to catches in the fishery (about 15 000 t including 30% overruns) and cannot be reconciled at this stage. Both surveys are considered representative of the distribution and abundance of orange roughy in the area at the time. Therefore, results from each survey are used independently below as estimates of absolute abundance.

3.4 Yield estimates

3.4.1 Simulation model assumptions and inputs

Biomass estimates from research surveys in 1987 and 1988 were used in computer model simulations to estimate biomass in 1989–90 from which yields for the 1989–90 fishing year were calculated. The results of a stock reduction analysis on a time series of trawl survey biomass estimates of orange roughy from the Chatham Rise (Orange Roughy Working Group 1989) show reasonable agreement with the actual wingtip biomass estimates from these surveys. Therefore, the wingspread biomass estimates from the Challenger Plateau trawl surveys were assumed equal to estimates of absolute biomass. Stock reduction analyses were also investigated for the Challenger Plateau, but available data were considered inadequate to produce reliable results.

The first step for these analyses was selection of values of growth and mortality parameters (i.e. von Bertalanffy parameters, $L_{infinity}$, K, and t_0; the parameters of the length (L)–weight (W) relationship, $W = aL^b$; age at recruitment, A_r; and natural mortality, M). These parameters were estimated by Mace *et al.* (in prep.) for orange roughy from the Chatham Rise : $L_{infinity}$ = 42.5 cm, K = 0.059 year^{-1}, t_0 = -0.346, a = 0.0963, b = 2.68, A_r = 18–20 years at a length of 30 cm.

The value of M for orange roughy cannot be reliably estimated from available data. A value of M equal to 0.05 is regarded as consistent with the present interpretation of orange roughy growth (Orange Roughy Working Group 1989).

The size distribution of orange roughy on the Challenger Plateau differs from that of fish on the Chatham Rise. The modal peak of the length frequency distribution in research catches is characteristically at 32–33 cm (Figure 2a), compared with 35–36 cm on the Chatham Rise, and there are few fish larger than 38–39 cm. Therefore, a value of 39.5 cm has been used for $L_{infinity}$. This does not markedly alter the von Bertalanffy growth curve, and values of K and t_0 have not been changed.

Orange roughy smaller than 30 cm are regularly caught on the Challenger Plateau. Examination of research and commercial data (Figure 2) indicates a length of about 27 cm to be appropriate for length at recruitment. This corresponds to an age at recruitment of 19 years.

To summarise, values of growth and mortality used for the Challenger Plateau were:

$L_{infinity}$	=	39.5 cm
K	=	0.059 year^{-1}
t_0	=	-0.346
a	=	0.0963
b	=	2.68
A_r	=	19 years
M	=	0.05

These values were used in a deterministic simulation model (Mace and Doonan 1988). Recruitment was assumed to follow a Beverton–Holt function, with steepness of 0.95. Total catch figures from Table 1 were used in back–calculation of virgin biomass (B_0). The 1988–89 catch was assumed to equal the allocated quota, with a 30% overrun. No allowance was made for catches outside the EEZ in 1988–89.

3.4.2 Estimation of B_0 and biomass projections

Simulation 1: Computer model simulations were based on the biomass estimate from the trawl survey in 1987. This trawl survey took place in late June–July 1987, and covered an area of approximately 8270 km^2 (see Table 3, and Clark and Tracey 1988). Extensive trawling occurred over the area, and several aggregations were sampled. The biomass estimate based on wingtip area swept was 94 920 t, with a coefficient of variation of 26%. This value was set equal to mid–year biomass in 1986–87. The simulation results were:

B_0	= 144 500 t
$B_{1986–87}$	= 94 750 t
$B_{1989–90}$	= 64 900 t

Simulation 2: Computer model simulations were based on the biomass estimate from the trawl survey in 1988. This survey was conducted in July 1988, over the same area as that covered in 1987 (see Table 3, and Clark and Tracey 1989). It is the most recent trawl survey of orange roughy on the Challenger Plateau. It resulted in a biomass estimate of 31 070 t, with a coefficient of variation of 27%. This value was set equal to mid–year biomass in 1987–88. The simulation results were:

B_0	= 97 000 t
$B_{1987–88}$	= 30 900 t
$B_{1989–90}$	= 16 600 t

3.4.3 Yield per recruit analysis

Yield per recruit analysis was carried out over 81 year classes (19–100) to estimate the reference fishing mortality $F_{0.1}$. The model of Mace *et al.* (in prep.) was used, with the growth values specified above. The value of $F_{0.1}$ was calculated as 0.065.

3.4.4 Estimation of Maximum Constant Yield (MCY)

The fishery for orange roughy on the Challenger Plateau is relatively new, and it is likely that the population has not yet reached equilibrium and is still declining. Therefore, MCY was estimated using the equation $MCY = 0.25 * F_{0.1} * B_0$ (Method 2 of McKoy 1988).

Using the two values of B_0 from above:

(1) B_0 = 144 500 t
MCY = 0.25 * 0.065 * 144 500 t = 2 350 t

(2) B_0 = 97 000 t
MCY = 0.25 * 0.065 * 97 000 t = 1 600 t

3.4.5 Estimation of Current Annual Yield (CAY)

CAY was estimated using the catch equation (Method 3 of McKoy 1988). Values of CAY were determined from computer model simulations for the two options described above. Virgin biomass was back–calculated, and the model then run forward, with the value of $F_{0.1}$ equal to 0.065 used to define the rate of exploitation in projections for 1989–90 and 1990–91 (Table 5). The yield values in Table 5 should be divided by 1.3 to allow for 30% overrun of reported catch.

3.4.6 The effects of a constant catch policy

The effects of a constant catch policy were investigated using three options:

i) Constant catch of 12 000 t (the current TAC)
ii) Constant catch of 9000 t (the quota held by the industry at present — including annual quota).
iii) Constant catch of 5600 t (the amount of permanent quota).

Computer model simulations were run using the two values of virgin biomass (144 500 t and 97 000 t) and two levels of catch over–runs (0% and 30%) to project forward assuming the above catch levels from 1989–90 onwards. Results are given in Table 6, specifying the year at which biomass declines to a level less than 20% of B_0 (this is considered to be the minimum "safe" level of biomass). Under most conditions, this occurs within 10 years.

4. MANAGEMENT IMPLICATIONS

The available data on the Challenger Plateau orange roughy fishery do not at present permit a reliable estimate of yield. The two options presented here give very different estimates of biomass and yield. It is difficult to interpret the 1987 and 1988 trawl survey results. The difference in absolute biomass between the years is over 60 000 t, which cannot be attributed solely to catches in the fishery (about 15 000 t). Distribution of orange roughy differed appreciably between the surveys, and catch rates generally were much lower during 1988. The marked decline in commercial catch rates in winter 1988 supports the research survey findings. It is uncertain whether there has been a temporary or permanent change in distribution, abundance, or availability of fish. Nevertheless, indications are that the present fishing level is too high, and major changes may be occurring in the population. Constant catch levels of 5600 t, 9000 t, or 12 000 t are not sustainable, especially if the existing level of estimated catch overruns continues. Simulation model results indicate that the population may still be slightly above its equilibrium level under an $F_{0.1}$ fishing strategy.

A further trawl survey over the same area as that of 1987 and 1988 surveys is planned for July 1989. This work should help clarify our uncertainties. Commercial CPUE data are also providing very valuable information on trends in the Challenger Plateau fishery. The decline in catch/tow in winter 1988 highlights the importance of ensuring comparable data are available for 1989.

In recent years a fishery for orange roughy has developed on the Challenger Plateau outside the EEZ. In 1987–88 over 2000 t was caught, mainly on the 'Westpac Bank'. We regard the fish inside and outside the EEZ in the south–western region of the Plateau as one stock, and they should be managed as such. Efforts need to be made in the present season to reduce the potential TAC overrun by large catches outside the EEZ.

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Table 1: Reported catches (t) of orange roughy from the Challenger Plateau. Data from Fisheries Statistics Unit and Quota Management System (*). TAC (t) for 1983–84 and 1984–85 is combined Challenger Plateau and west coast South Island. Catches reported outside in 1982–83 to 1983–84 probably caught inside).

Fishing year (Oct-Sep)	Catch Inside EEZ	Catch Outside EEZ	Total reported catch	+ 30% overrun	Research catches	Total catch	TAC
1980/81	1	32	33	43	-	43	
1981/82	3 539	709	4 248	5 522	-	5 522	
1982/83	4 535	7 304	11 839	15 391	18	15 409	
1983/84	6 332	3 195	9 527	12 385	129	12 514	4 950
1984/85	5 043	74	5 117	6 652	55	6 707	4 950
1985/86	7 711	42	7 753	10 079	172	10 251	6 190
1986/87	10 555	937*	11 492	14 940	810	15 750	10 000
1987/88	10 086	2 095*	12 181	15 835	397	16 232	12 000

Table 2: Comparison of monthly catch rate (t/trawl) in Area H by domestic trawlers: (a) ice boats (specified trawlers); (b) factory trawlers (CR = catch rate; Nt = number of trawls; N/A = data not yet available; data from FSU).

(a)

Month	1983 CR	1983 Nt	1984 CR	1984 Nt	1985 CR	1985 Nt	1986 CR	1986 Nt	1987 CR	1987 Nt	1988 CR	1988 Nt
Jan	-		8.9	41	5.9	123	5.9	92	3.9	68	1.6	14
Feb	-		9.0	65	5.6	55	3.1	15	-		0.9	51
Mar	-		10.3	28	-		-		7.7	2	-	
Apr	-		-		2.3	18	9.3	6	-		-	
May	0.3	2	<0.1	11	8.0	21	1.2	15	1.1	19	-	
Jun	-		-		18.7	7	13.4	110	11.9	146	4.6	208
Jul	14.0	30	13.5	21	18.4	26	12.9	100	13.9	92	8.3	97
Aug	-		17.8	9	16.2	13	16.8	42	14.6	28	5.0	138
Sep	-		15.9	24	8.2	41	10.5	68	5.4	68	2.1	64
Oct	4.1	20	5.6	43	6.3	100	1.0	23	1.3	15	N/A	
Nov	8.7	112	3.4	123	2.4	34	3.1	42	0.7	26	N/A	
Dec	5.6	55	4.2	29	4.4	14	1.5	44	<0.1	10	N/A	

(b)

Month	1983 CR	1983 Nt	1984 CR	1984 Nt	1985 CR	1985 Nt	1986 CR	1986 Nt	1987 CR	1987 Nt	1988 CR	1988 Nt
Jan	-		-		3.4	12	-		-		<0.1	2
Feb	-		-		-		-		1.6	22	-	
Mar	-		-		-		-		-		-	
Apr	-		-		-		-		-		-	
May	-		-		-		-		-		6.9	29
Jun	-		-		-		-		14.8	83	5.9	388
Jul	21.4	37	-		-		-		14.1	35	9.1	208
Aug	13.4	107	-		-		8.0	6	5.9	72	5.5	113
Sep	19.9	48	-		-		6.2	186	6.5	157	1.9	53
Oct	13.9	70	4.4	121	3.1	89	4.5	95	1.3	52	N/A	
Nov	10.5	48	-		3.0	34	2.1	154	2.4	41	N/A	
Dec	-		2.4	54	0.4	30	-		-		N/A	

Table 3: Orange roughy trawl surveys on the Challenger Plateau from 1983 to 1988. Biomass index is the estimate using wingspread as the area swept. c.v. = coefficient of variation.

Date (month/year)	Area (km^2)	Vessel	Number of trawls	Biomass index (t)	c.v. (%)
8-10/1983	101 000	Arrow	180	103 657	38
7/1984	11 956	Arrow	118	185 366	60
7/1985	209	Arrow	16	103 903	85
7/1986	94	Arrow	10	184 893	83
6-7/1987	8 270	Amaltal Explorer	129	94 920	26
7/1988	8 270	Amaltal Explorer	85	31 067	27

Table 4: Comparison of mean catch rate (kg/km) of orange roughy in comparable survey strata outside the main spawning area

Depth Stratum (m)	1983	1984	1987	1988
800 - 899	7.2	23.0	48.1	13.4
900 - 999	17.6	9.3	20.9	15.7
1000 - 1099	7.6	4.3	28.7	2.8
1100 - 1199	12.8	-	1.3	2.3

Table 5: Estimated virgin biomass (B_0), mid-year biomass in 1989–90 ($B_{1989-90}$), and current annual yield (CAY) from the simulation model. Biomass and yields rounded to nearest 100 t.

B_0 (t)	$B_{1989-90}$ (t)	CAY (t) (1989-90)	CAY (t) (1990-91)
144 500	64 900	4 200	4 100
97 000	16 600	1 100	1 200

Table 6: Year in which biomass declines to less than 20% of virgin biomass under constant catch strategies and two levels of catch overrun.

Catch level from 1989-90	Overrun level	Virgin biomass	
		144 500 t	97 000 t
12 000 t	0%	1993	1990
	30%	1992	1990
9 000 t	0%	1996	1990
	30%	1993	1990
5 600 t	0%	2008	1990
	30%	1999	1990

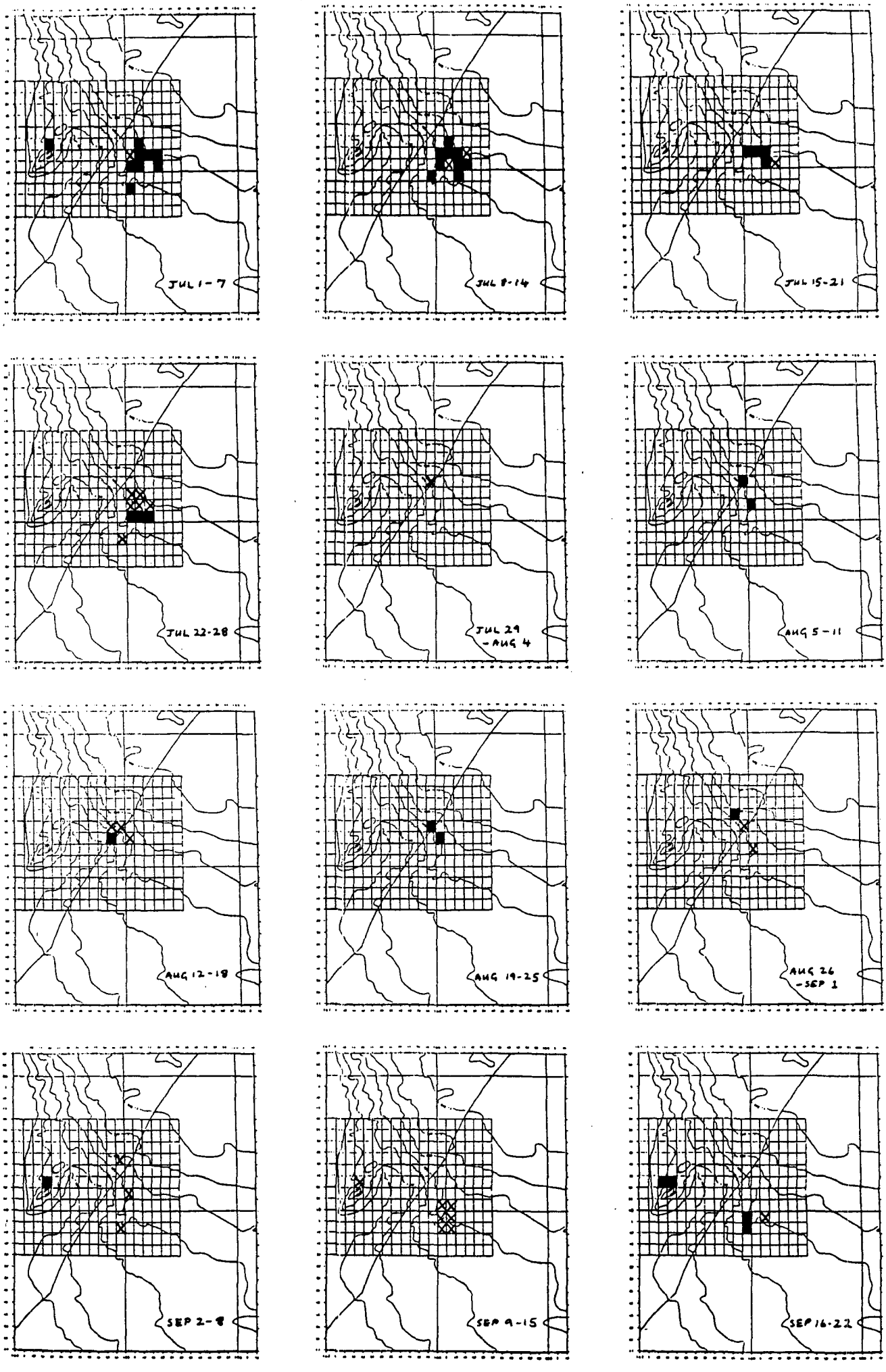
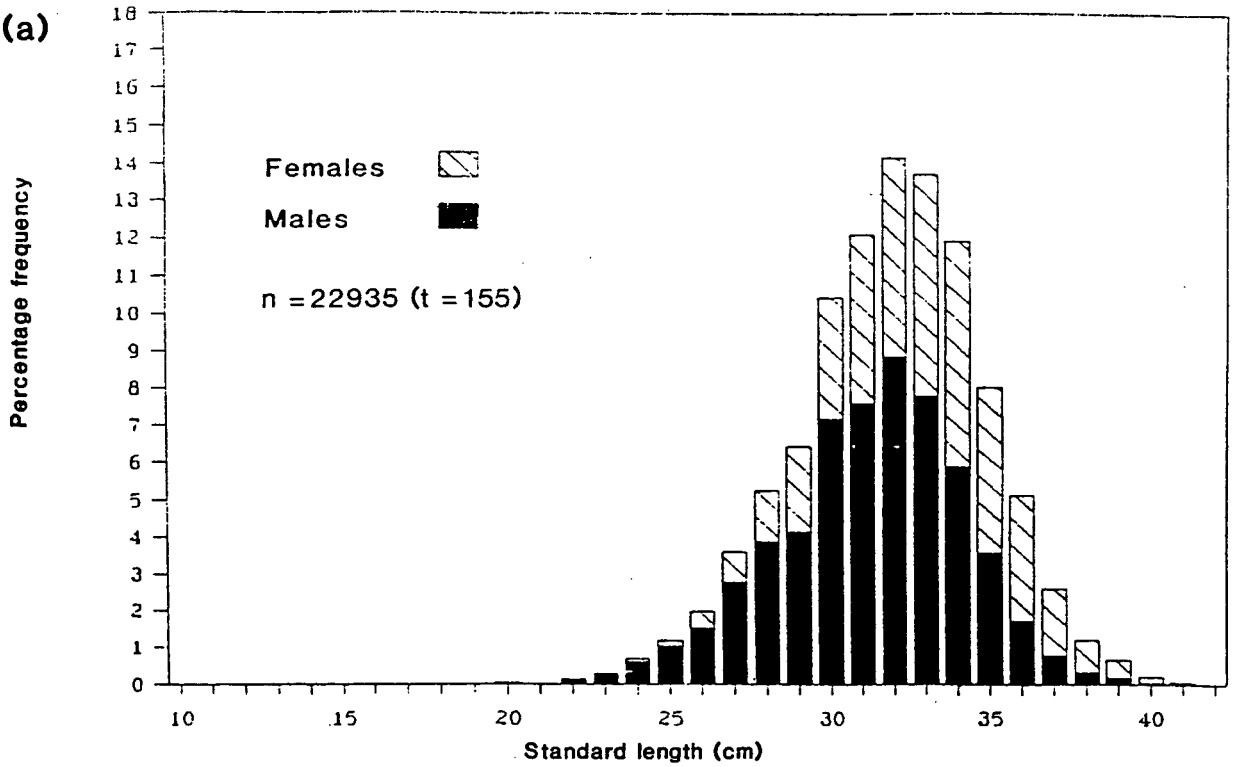


Figure 1:
Distribution of catch rates (mean t/trawl) of commercial vessels by week on the Challenger Plateau July 1 - September 22, 1987. (x = 5-10 t/trawl, ■ = >10 t/trawl.



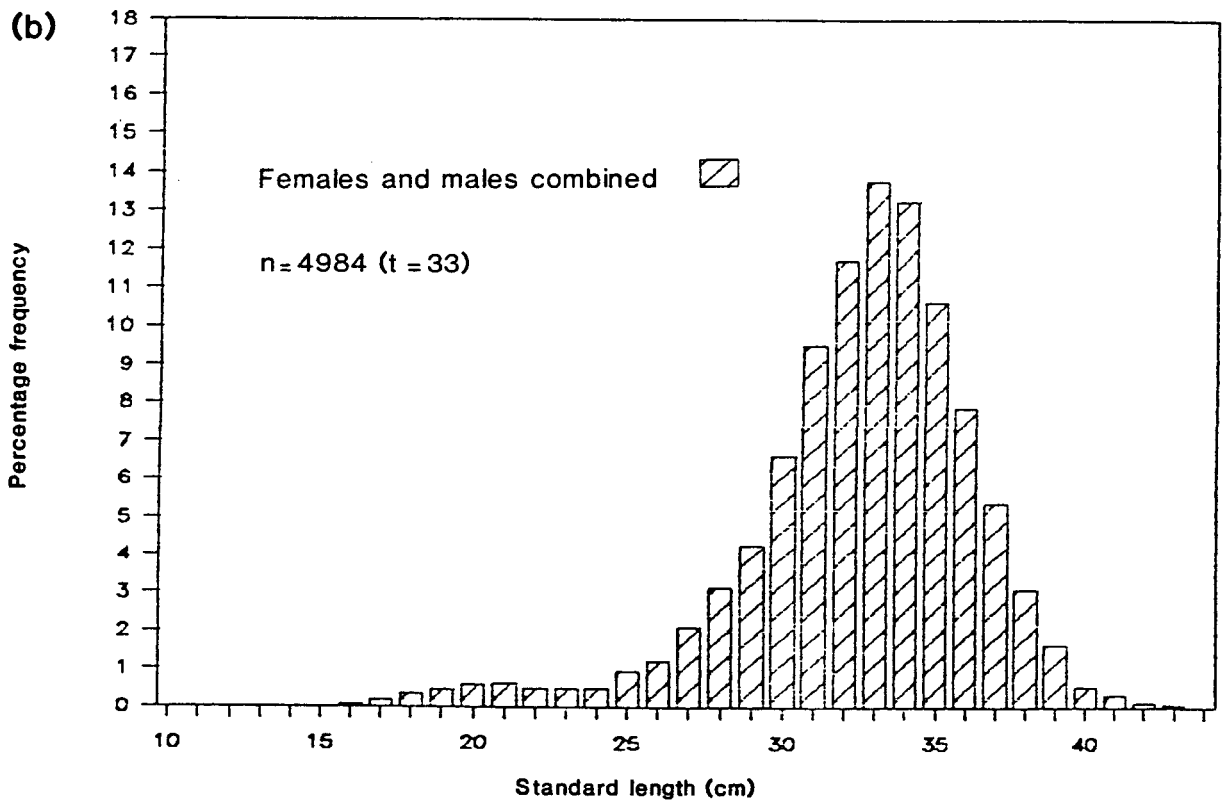


Figure 2:

Length frequency distributions of orange roughy from the Challenger Plateau in 1988 (a) research survey, July 1988; (b) commercial vessels, July-September 1988.
(n = number of fish measured, t = number of trawl samples were taken from; distribution in (a) is scaled to represent total catch, (b) is unscaled).