New Zealand Fisheries Assessment Research Document 88/29

Trevally

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December 1988

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TREVALLY

I. INTRODUCTION

(a) Overview

This paper summarises all the information available relevant to the assessment of the trevally fishery in New Zealand. This includes general fishery information, biological information and stock assessment analyses. Yield estimates consistent with current practice are obtained. They differ only slightly from previous estimates. Yields and Total Allowable Catches (TACs) are given in Table 1.

(b) Fishery

Trevally is caught around the North Island and the north of South Island. The main catches are generally from both the northern coasts of the North Island.

Before the late 1960s varying and often large quantities of trevally were dumped at sea by trawlers because there was little demand for the species. A significant proportion of the catch was used for bait, but by the late 1960s there was an increased demand for human consumption. Since the mid-1970s significant quantities of trevally have been exported to countries such as Japan where the species is highly regarded.

Trevally is taken in the northern coastal mixed trawl fishery, mostly in conjunction with snapper. This fishery has developed steadily over the years up until the early 1980s. The introduction of pair trawling in the early 1970s resulted in increased landings of trevally. Although trevally is taken by trawl throughout the year the best catches are taken in summer. The peak of the trevally season is usually a little later than that of snapper.

Since the mid-1970s trevally has been taken by purse seine in variable but often substantial quantities. The purse seine fishery for trevally is primarily in Bay of Plenty, but sometimes extends to other parts of the east coast of the North Island. Purse seine catches are usually taken in winter-spring. In summer purse seiners do not target trevally because the higher valued skipjack is available.

Modest quantities of trevally are taken by set net. During the late 1970s this method accounted for somewhat more of the catch than it does now.

Total New Zealand commercial landings of trevally grew to about 6000 t in the early 1970s and peaked in the late 1970s at about 6500 t. Since then they have fallen to be somewhat under 4000 t by the mid-1980s.

(c) Literature

Considerable work on trevally in New Zealand has been carried out by G.D.James including the definitive Fisheries Research Bulletin on trevally (James 1984). Other trevally papers have also been published by James. The bulletin establishes the main biological parameters and describes the trevally fishery. It includes a yield per recruit analysis but does not contain stock or yield assessments. An unpublished manuscript (James & Ryan 1979) does contain stock and yield assessments but doubt has subsequently been thrown on the validity of these analyses (see below). The assessment results given here are based on McKoy and Gilbert (1985) and Gilbert (1986).

II. REVIEW OF FISHERY

(a) Catch and Catch per unit effort (CPUE)

Trevally commercial landings for 1931 to 1987 are given in Tables 2 to 4. Until 1982 they are only available by port of landing (Table 2). From 1983 onwards landings are by statistical area fished (Tables 3 and 4). The commercial catch prior to the late 1960s included trevally that was dumped at sea or used for bait and not recorded in the landings. During 1975 problems with the fisheries statistics system led to a substantially incomplete record of landings. Trevally is an inshore species and catches by deepwater and foreign vessels have never been more than a few tonnes.

CPUE has been derived for trevally fisheries in particular cases. Table 5 gives CPUE between 1973 and 1984 for trawlers in Bay of Plenty. Figures 1 and 2 give CPUE for trawlers on the west coast of the North Island between 1974 and 1985.

(b) Catch composition

The composition of trevally catches taken by trawl and purse seine differ substantially. Purse seine catches are composed almost entirely of mature adult fish greater than 38cm in length which are at least of age 4 y. Trawl catches contain younger fish between 25 and 37cm which are of age 2 to 5 y, as well as the larger, older fish. A minimum size limit of 25cm exists for trevally so that few fish below this size are landed. Figure 3 gives typical length and age distributions of purse seine and trawl catches of trevally.

(c) Maori and recreational fishing

Trevally are caught by Maori and recreational fishers by set net, beach seine and line. Trevally are known to have been caught by Maori fishers in pre-European times. The only estimate of the size of the present day non-commercial catch was based on a tagging experiment in Bay of Plenty and Hauraki Gulf in 1973/4 by

James (1980). He found that 15% of recovered tags were taken by non-commercial fishers. He noted that this was not likely to be very accurate because of the uneven distribution of tags in the population. The estimate is smaller than, but not inconsistent with, those obtained for the non-commercial catch of snapper in more recent tagging experiments in the same areas.

III. RESEARCH

(a) Stock separation

Tagging of trevally in Bay of Plenty and Hauraki Gulf has provided evidence of some movement along the north-east coast of the North Island. Slight differences in growth rates suggest possible stock separation amongst the east and west coasts of the North Island and Tasman Bay. This evidence is not strong and not a sufficient reason for retaining stock boundaries. The primary reason for retaining any stock boundaries is that very high catches might otherwise be taken persistently in some areas causing local depletion. Existing stocks listed in Table 1 are therefore retained.

(b) General biology

Trevally (Caranx georgianus) is a member of the family Carangidae. The species also occurs in Australia. Other species in this family occurring in New Zealand waters are: pilotfish, samson fish, koheru, yellowtail kingfish and the 3 species of jack mackerel.

Trevally are both pelagic and demersal in behaviour. Juvenile fish up to age 2 y are found in shallow inshore areas including estuaries and harbours. Young fish enter a demersal phase from about age 2 y until they reach sexual maturity. At this stage adult fish move between demersal and pelagic phases. Schools occur at the surface, in mid-water and on the bottom. They are often associated with reefs and rough bottom. Schools are sometimes mixed with other species such as koheru and kahawai. The occurrence of trevally schools at the surface appears to correlate with settled weather conditions rather than with time of year.

Surface schooling trevally feed on planktonic organisms, particularly the euphausid Nyctiphanes australis. On the bottom trevally feed on a wide range of invertebrates.

Trevally is a long-lived species with individual fish having been aged at well in excess of 40 y. The largest fish are around 60cm in length and weigh about 4.5 kg. Trevally grow at a moderate rate during the first few years, but after sexual maturity (32 to 37cm) the growth rate becomes very slow (Fig. 4). Growth rates of males and females do not differ significantly.

Large numbers of eggs are not produced by females until they reach about 40cm in length. The fish appear to be partial spawners, releasing small batches of eggs over periods of several weeks or months during the summer. The eggs are planktonic.

Ageing of trevally is achieved by counting annual rings on the otolith (James 1984). The method is reasonably well validated although systematic error may exist in the ages of older fish estimated by this method. Large samples have been aged and used to give estimates of mean length at age and of the natural mortality rate.

(c) Stock dynamics parameters

Recruitment to the trawl fishery occurs at about 2 y (25cm) and to the purse seine fishery at 4 - 5 y of age (38cm). A mean length at age curve for Bay of Plenty fish is given in Fig. 4. Growth curves for other areas are similar but not identical.

James (1984) estimated instantaneous natural mortality for Bay of Plenty fish to be the extremely low value of 0.03 y^{-1}. Fish older than about 35 y appeared to suffer a much higher rate of natural mortality. A mean maximum age of 39 y would be appropriate for stock modelling purposes, even though some individuals grow older than this.

James (1984) estimated that fishing mortality in Bay of Plenty in the late 1960s and early 1970s was about 0.6 y^{-1}. It appears that between the ages of 2 to 6 y catchability by trawling decreases markedly with age. It is because of this that James' estimates of fishing mortality based on trawl catch curves are far too high. If his value were true the stock size in the early 1970s would have been so low that by the present day it would certainly have been exhausted. Values below 0.1 y^{-1} are far more likely.

A yield per recruit analysis was carried out by James (1984) assuming equal fishing mortality on all recruited age-classes. Analysis of this type has been repeated for east and west coast growth rates. F_{max} and $F_{0.1}$ have been calculated assuming various values for the age at recruitment and for the non-commercial fishing mortality (assumed to act like natural mortality). These are given in Table 6.

Purse seine fishing on the East coast means that recruitment is only partial at age 2 y. Some non-commercial fishing occurs on the East coast, although the corresponding fishing mortality is unknown. F_{max} is therefore probably about 0.2 y^{-1} and $F_{0.1}$ is probably about 0.08 y^{-1}. For the West coast the corresponding values are 0.1 y^{-1} and 0.06 y^{-1}. These values are higher than those assumed for productivity (0.02 to 0.06 y^{-1}) in the Stock Reduction Analysis (SRA) model of McKoy and Gilbert (1985) described below.

A result from the yield per recruit analysis is that increasing the age of recruitment would increase the maximum and the $F_{0.1}$ yields per recruit. The corresponding mortalities would be higher. Hence, if more of the trevally catch were taken by purse seine and the economics of this were not unfavourable, then a relatively larger TAC should be recommended.

(d) Stock assessments

Four types of data have been used for stock assessment of trevally, but all have major drawbacks. They are: aerial sighting, tag-recapture, trawl survey and catch per unit effort. Estimates of stock size are derived in various ways by combining these data with annual catch and biological parameters.

Aerial surveys conducted since June 1976 by MAF and commercially by spotter pilots give estimates of quantities of sighted surface schooling trevally. Data are summarised by Habib et al (1981, 1982) and Wood and Fisher (1983, 1984). McKoy and Gilbert (1985) give tables and figures of time series of maximum daily sightings of trevally. The value of these data is low. The precision of visual estimates is probably low. The proportion of the stock occurring in surface schools at any one time cannot be estimated, but is certainly highly variable. The extent of coverage of the potential surface schooling areas is variable over time.

Trends in the maximum daily sightings between 1976 and 1985 perhaps give a very general indication of stock size changes over the period. For the north-east coast of the North Island and for the Bay of Plenty these trends are generally downward. For the west coast of the North Island sightings are extremely erratic. For the south-east coast of the North Island the trend is upward.

Tagging experiments on trevally are discussed by James (1980) and James and Ryan (1979). These experiments were not designed for stock assessment but in one case the data have been used for this purpose. 3000 fish were tagged in the Motiti Island area and about 10% were recaptured by purse seine within 3 months. Total trevally purse seine catch in this area for this period was 1700 t. It was assumed that there was: no tag loss, no tag mortality, complete reporting of recaptured tags, complete mixing of tagged and untagged fish, no emigration and no catchability effects caused by the tags. This gives a crude estimate of stock size in the area of 17000 t. James and Ryan further assumed that this represented only a third of the Bay of Plenty stock and hence gave a stock estimate of 51000 t. This now appears unlikely when compared with other data, as described below.

Several trawl surveys of Bay of Plenty have been carried out. Biomass indices obtained from such surveys are appropriately weighted mean catch rates, which under certain assumptions are proportional to the stock biomass. Biomass indices obtained for recruited trevally were: FRV Ikatere, 1961, 3467; FRV Ikatere, 1980, 446; FRV *Kaharoa*, 1983, 37; FRV *Kaharoa*, 1985, 311; FRV *Kaharoa*, 1987, 84. The indices obtained by the two vessels are not quite comparable. It is probable that the catchability of trevally by FRV *Kaharoa* is *higher* than FRV *Ikatere*. Trevally is not a particularly suitable species to assess by single trawl survey because catchability by single trawl of the smaller fish is probably higher than that of the larger fish and because the overall catchability is probably influenced by the highly variable schooling behaviour of the species. The indices have fairly high coefficients of variation and are rather erratic. Nevertheless the time series of biomass indices suggests a substantial decline in biomass since 1961.

The length frequency of the catches in the 5 surveys is consistent with a substantial change in stock structure. Only in the 1961 survey was a significant proportion of the catch mature adult fish.

CPUE data have been derived for commercial trawling in 2 areas. Table 4 shows winter and summer mean CPUE for 5 trawlers (50 ft, 230 HP) in Bay of Plenty for 1973 to 1984. A substantial downward trend is apparent. Figures 1 and 2 show winter and summer CPUE for 3 categories of trawling on the west coast of North Island for 1973 to 1985. In this case the CPUE is quite erratic and no trend is apparent.

Because trevally is not the primary target species (snapper) in these trawl fisheries and because its schooling behaviour means it is caught erratically, CPUE by the commercial trawlers is not a particularly good indicator of changes in stock size.

(e) Maximum Constant Yield estimates

In this report new definitions have been introduced, Maximum Constant Yield (MCY) and Current Annual Yield (CAY) and formulae have been applied more consistently than previously to obtain yield estimates. Because they are applied to the same information as before the values do not differ greatly from those obtained previously. They are given above in Table 1.

Three different methods were used to determine MCY depending on the data available in each area. For the purposes of stock assessment the 3 sub-areas of TRE 1 were treated separately, as were the west coasts north and south of Cape Egmont for TRE 7.

For Bay of Plenty sufficient data were available for a simple SRA model McKoy and Gilbert (1985). The trawl surveys, commercial CPUE, aerial sightings and commercial catches were used to estimate the extent of stock reduction from 1973 to 1983. The stock was estimated to have fallen to between 0.3 and 0.7 of its initial size in the period. Conservative net stock productivity values (0.02 to 0.06 y^{-1}), comparable with natural mortality (0.03 y^{-1}) were assumed. The estimate of absolute stock size from the tagging experiment in 1977 proved too high to be consistent with the other model assumptions. It was necessary to modify the assumptions on which it was based to reduce it. The present sustainable yield (PSY, present surplus production) obtained (600 t) is conservative and can safely be taken to be the MCY.

It is not clear whether further work will show the productivity figures used in the SRA to be consistent with those obtained in the yield per recruit analysis. However, if the range of values for productivity used in the SRA were proved to be too low, this would increase the degree of inconsistency of the tagging experiment estimate of absolute stock size.

MCY for the other areas was calculate using the equation MCY = cY. Analysis of trawl CPUE for 1973 to 1985 in the region New Plymouth to North Cape revealed no systematic trends. Because the period analysed is short relative to the longevity of the species and because the CPUE may not be a good stock index for a less favoured species, a factor of c = 0.9 has been applied to the mean annual commercial landings for the period to obtain the MCY. For all other areas data has not been derived to indicate whether or not stock size has remained steady over recent years. Therefore a factor of c = 0.6 has been applied to the mean annual commercial landings over the decade 1977 to 1986 to obtain the MCY. The estimated MCYs by commercial fishing are given in Table 1.

(f) Current Annual Yield estimates

Sufficient data are not available to estimate CAYs.

(g) Economic analyses

A bioeconomic model described by Gilbert (1988) has been applied to trevally in two areas, east coast North Island and west coast North Island. The model is a single stock, age-structured and constant recruitment one in which cost per unit fishing mortality is constant and independent of stock size. Although a measure of inconsistency appears to exist in the parameters used for the west coast North Island, both cases give similar conclusions. These are that optimal economic management would involve reduced fishing mortality, increased long-run stock size and somewhat reduced long-run yield. These results apply even though present fishing mortality was assumed to be low (less than $0.1\ y^{-1}$). The optimal long-run annual surpluses (super-normal profits) estimated were in the order of 10-20% of the port price.

This bioeconomic analysis should not be given too much weight because of the by-catch nature of the trevally fisheries. Trevally is caught in fisheries where other species are the primary targets. It is therefore difficult to obtain proper economic parameter estimates for a single stock model. The optimal economic management of such fisheries will be largely influenced by the target species and it is probably not particularly useful to model the by-catch species separately. The conclusion that should be drawn from this is the general one that optimal economic management tends to involve lower fishing mortality and higher stock size, provided the cost per unit fishing mortality does not fall with falling stock size.

(h) Reliability

All the stock assessments described above depend heavily on reported catch and on CPUE. Good data on the biological parameters, natural mortality, lifespan, and weight at age are also available. It was implicitly assumed that the non-commercial catch would continue to be the same proportion of the total catch as it has been in the past. Because trevally is a less preferred species in the fisheries in which it occurs, it is targeted erratically or not at all. Catch and CPUE statistics are therefore likely to be very variable and not very good for stock assessment purposes. For the Bay of Plenty several other sources of data were used to make the assessment somewhat more reliable, but for all the other areas the reliability is only low to moderate.

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TABLE 1: Trevally estimated Maximum Constant Yields (MCY) and Total Allowable Catches (TAC) (tonnes).

Area	Stock code	Estimated MCY 1988/89	Gazetted TAC 1987/8
Auckland (East)	TRE 1	1160	1210
Central (East)	TRE 2	21	190
Southeast (Coast), Southland	TRE 3	1	20
Auckland (West), Central (West), Challenger	TRE 7	1800	1800
Kermadec	TRE10	0	10
New Zealand	TOTAL	3171	3230

TABLE 2: Trevally landings by port from Annual Reports, 1931-1982. 1931-1943 periods are year to following March. 1944-1982 periods are calendar years. 1940-1943 reported New Zealand totals exceed sum of port landings, otherwise totals are sums of rounded column entries. ' ' denotes nil catch, '0' denotes catch less than 0.5t and '-' denotes value unavailable.

	Stock	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940
Mangonui											
Whangaroa											
Russell											1
Whangarei								2	1	1	0
Auckland		3		30	29			20	43	14	7
Thames				0				0	4	0	0
Coromandel											
Mercury Bay											
Tauranga		7	6	3	1			0	9	3	4
Whakatane											
E NORTHLAND								2	1	1	1
HAURAKI GULF		3		30	29			20	47	14	7
BAY OF PLENTY		7	6	3	1			0	9	3	4
AUCKLAND EAST	TRE 1	10	6	33	30			22	57	18	12
Gisborne											
Napier										0	
Castlepoint											
Wellington								6	14	13	18
Makara											
CENTRAL EAST	TRE 2							6	14	13	18
Kaikoura											
Lyttelton									1	1	
Akaroa-Karitane											
Port Chalmers											
Taieri-Bluff											
SOUTHEAST	TRE 3								1	1	
Hokianga											
Kaipara								0		0	0
Manukau											
Raglan											
Kawhia					0						
New Plymouth											
Wanganui											
Manawatu											
Paraparaumu											
Paremata											
Blenheim											
Picton											
Pelorus											
Nelson											
Motueka											
Golden Bay											
Westport											
Greymouth											
WEST AUCKLAND					0			0		0	0
SW COASTS											
WEST COASTS	TRE 7				0			0		0	0
NZ TOTAL		10	6	33	30			28	72	32	42

TABLE 2, ctd: Trevally landings by port from Annual Reports, 1931-1982. 1931-1943 periods are year to following March. 1944-1982 periods are calendar years. 1940-1943 reported New Zealand totals exceed sum of port landings, otherwise totals are sums of rounded column entries. ' ' denotes nil catch, '0' denotes catch less than 0.5t and '-' denotes value unavailable.

	Stock	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950
Mangonui					10	31	64	113	31	9	3
Whangaroa							0		0		
Russell		0	0		2	3	27	0	0		
Whangarei		2	16	56	79	20	45	37	31	10	12
Auckland		8	6	2	148	167	102	116	235	274	354
Thames		3	11	39	49	34	27	20	30	7	27
Coromandel											
Mercury Bay										0	0
Tauranga		6	57	93	127	62	55	39	126	13	34
Whakatane					1	7		1	2	3	3
E NORTHLAND		2	16	56	91	54	136	150	62	19	15
HAURAKI GULF		11	17	41	197	201	129	136	265	281	381
BAY OF PLENTY		6	57	93	128	69	55	40	128	16	37
AUCKLAND EAST	TRE 1	19	90	190	416	324	320	326	455	316	433
Gisborne										2	0
Napier		1	0								15
Castlepoint											
Wellington		8	2	2	3	12	17	9	9	10	35
Makara							0	1	1	1	0
CENTRAL EAST	TRE 2	9	2	2	3	12	17	10	10	13	50
Kaikoura								1			
Lyttelton									0		
Akaroa-Karitane							0	0			
Port Chalmers								0		0	
Taieri-Bluff											
SOUTHEAST	TRE 3						0	1	0	0	
Hokianga							0		2		
Kaipara		0	0	0	0		1	0		0	0
Manukau					3	1	1	0	0	0	1
Raglan								0		0	
Kawhia							0	1	0	0	
New Plymouth										3	4
Wanganui											0
Manawatu											
Paraparaumu										0	
Paremata					0	2	1		0	0	
Blenheim											
Picton											
Pelorus											
Nelson								13	6	4	10
Motueka								0			
Golden Bay											
Westport								0			
Greymouth											
WEST AUCKLAND		0	0	0	3	1	2	1	2	3	5
SW COASTS					0	2	1	13	6	4	10
WEST COASTS	TRE 7	0	0	0	3	3	3	14	8	7	15
NZ TOTAL		56	146	230	422	339	340	351	473	336	498

TABLE 2, ctd: Trevally landings by port from Annual Reports, 1931-1982. 1931-1943 periods are year to following March. 1944-1982 periods are calendar years. 1940-1943 reported New Zealand totals exceed sum of port landings, otherwise totals are sums of rounded column entries. ' ' denotes nil catch, '0' denotes catch less than 0.5t and '-' denotes value unavailable.

	Stock	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
Mangonui		13	7	9	7	15	6	11	1	2	18
Whangaroa					0	0		0			
Russell		4	3	1	2	3	1	1	2	2	2
Whangarei		9	3	29	17	6	13	17	6	2	7
Auckland		403	271	272	355	446	419	607	640	765	878
Thames		25	6	26	34	23	28	34	127	87	126
Coromandel		0	3						4	0	
Mercury Bay		0	2	0	0	1	1	0	0	1	1
Tauranga		48	31	52	65	127	100	128	99	163	164
Whakatane		3	5	6	4	12	7	5	5	7	7
E NORTHLAND		26	13	39	26	24	20	29	9	6	27
HAURAKI GULF		428	280	298	389	469	447	641	771	852	1004
BAY OF PLENTY		51	38	58	69	140	108	133	104	171	172
AUCKLAND EAST	TRE 1	505	331	395	484	633	575	803	884	1029	1203
Gisborne			0		37	42	48	112	75	55	36
Napier		41	69	83	105	86	76	121	140	119	149
Castlepoint						0			0		
Wellington		24	14	21	16	19	29	66	20	36	35
Makara		0	0	0	0	3	0			0	0
CENTRAL EAST	TRE 2	65	83	104	158	150	153	299	235	210	220
Kaikoura											
Lyttelton									0		
Akaroa-Karitane					0				0		0
Port Chalmers								0	0		
Taieri-Bluff											
SOUTHEAST	TRE 3				0			0	0		0
Hokianga								0			
Kaipara		0	1	2	2	3	1	3	5	4	4
Manukau		2	9	84	60	116	86	187	224	195	427
Raglan		0	0	0	0	0	2	7	4	2	2
Kawhia			0	0	1	1	1	2	5	3	0
New Plymouth		9	9	4	9	12	10	11	15	16	16
Wanganui									1	12	14
Manawatu		0									
Paraparaumu			0	0	0	0	0	0	0		0
Paremata				1	2	3	11	17	29	27	16
Blenheim								1		0	1
Picton							4	46	23	50	40
Pelorus			0	1	1	1	1	2	0		0
Nelson		25	11	10	3	2	14	20	33	28	64
Motueka		0	1	1	0		0		4	14	10
Golden Bay										0	1
Westport											
Greymouth											
WEST AUCKLAND		11	19	90	72	132	100	210	253	220	449
SW COASTS		25	12	13	6	6	30	86	90	131	146
WEST COASTS	TRE 7	36	31	103	78	138	130	296	343	351	595
NZ TOTAL		606	445	602	720	921	858	1398	1462	1590	2018

TABLE 2, ctd: Trevally landings by port from Annual Reports, 1931-1982. 1931-1943 periods are year to following March. 1944-1982 periods are calendar years. 1940-1943 reported New Zealand totals exceed sum of port landings, otherwise totals are sums of rounded column entries. ' ' denotes nil catch, '0' denotes catch less than 0.5t and '-' denotes value unavailable.

	Stock	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Mangonui		14	17	9	15	37	37	17	6	26	31
Whangaroa				0			0	1	0		0
Russell		1	5	1	2	2	4	1	1	0	1
Whangarei		7	6	15		6	16	6	7	6	10
Auckland		888	1138	980	1007	1176	926	721	885	775	786
Thames		127	109	132	139	152	91	41	80	72	168
Coromandel		0	7	5	35	11	20	17	23	17	24
Mercury Bay		1	2	2	1	5	4	4	8	4	20
Tauranga		136	149	156	139	233	470	261	379	494	906
Whakatane		6	19	19	8	10	14	20	9	18	33
E NORTHLAND		22	28	25	17	45	57	25	14	32	42
HAURAKI GULF		1015	1254	1117	1181	1339	1037	779	988	864	978
BAY OF PLENTY		143	170	177	148	248	488	285	396	516	959
AUCKLAND EAST	TRE 1	1180	1452	1319	1346	1632	1582	1089	1398	1412	1979
Gisborne		85	150	128	169	152	177	279	291	201	274
Napier		291	327	243	289	214	248	214	255	327	282
Castlepoint		0					0		0		
Wellington		55	32	49	21	56	13	30	17	18	24
Makara		0	0	0	0	0	0				
CENTRAL EAST	TRE 2	431	509	420	479	422	438	523	563	546	580
Kaikoura											
Lyttelton			0	0	2	2	0	1	0	0	0
Akaroa-Karitane					0	0					
Port Chalmers				0		0			0		
Taieri-Bluff											
SOUTHEAST	TRE 3		0	0	2	2	0	1	0	0	0
Hokianga		0	0		0		0			0	
Kaipara		5	7	6	6	1	1	2	1	3	2
Manukau		338	391	520	425	338	613	598	664	877	989
Raglan		1	1	1	1	3	7	15	8	17	33
Kawhia		1	0	1	1	19	18	10	9	13	12
New Plymouth		25	30	26	29	64	24	68	77	59	139
Wanganui		1	16	45	39	38	128	103	114	65	203
Manawatu		0	1	1			0				
Paraparaumu			0	2	0	0	0	0	0		
Paremata		10	8		15	22	36	58	40	23	17
Blenheim			0					0	1	0	1
Picton		11	0		0	0	1	5	5	1	1
Pelorus		0	0		0	0	1	0	0	0	0
Nelson		68	75	54	16	47	235	609	530	215	244
Motueka		9	9	3	0	6	6	15	61	49	40
Golden Bay		2	5	3	2	6	10	9	0	0	
Westport								1		0	0
Greymouth			0						3	0	1
WEST AUCKLAND		370	429	554	462	425	663	693	759	969	1175
SW COASTS		101	114	108	72	119	417	800	754	353	507
WEST COASTS	TRE 7	471	543	662	534	544	1080	1493	1513	1322	1682
NZ TOTAL		2082	2504	2401	2361	2600	3100	3106	3474	3280	4241

TABLE 2, ctd: Trevally landings by port from Annual Reports, 1931-1982. 1931-1943 periods are year to following March. 1944-1982 periods are calendar years. 1940-1943 reported New Zealand totals exceed sum of port landings, otherwise totals are sums of rounded column entries. ' ' denotes nil catch, '0' denotes catch less than 0.5t and '-' denotes value unavailable.

	Stock	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Mangonui		27	41	20	27	41	52	55	184	179	148
Whangaroa		1	2	2	1	25	21	22	43	79	3
Russell		5	7	15	10	0	3	3	10	11	11
Whangarei		13	14	20	41	15	18	45	79	66	61
Auckland		963	996	729	633	613	689	703	737	638	297
Thames		89	113	273	241	180	164	177	164	91	35
Coromandel		13	6	18	26	22	37	71	70	14	8
Mercury Bay		60	40	31	103	24	67	128	168	87	76
Tauranga		1769	1292	758	1119	498	1316	2427	2076	1314	770
Whakatane		19	33	12	17	10	12	9	15	22	19
E NORTHLAND		46	64	57	79	81	94	125	316	335	223
HAURAKI GULF		1065	1115	1020	900	815	890	951	971	743	340
BAY OF PLENTY		1848	1365	801	1239	532	1395	2564	2259	1423	865
AUCKLAND EAST	TRE 1	2959	2544	1878	2218	1428	2379	3640	3546	2501	1428
Gisborne		525	891	360	633	307	1116	547	473	383	186
Napier		390	248	371	215	107	138	156	125	144	166
Castlepoint		2	9	2	0	0	0	1	6	3	2
Wellington		35	74	15	40	54	151	28	53	42	48
Makara				0	0	0	0		0	0	0
CENTRAL EAST	TRE 2	952	1222	748	888	468	1405	732	657	572	402
Kaikoura				0	0	0	0	0	1	1	0
Lyttelton		1	0	0	0			0	0	0	0
Akaroa-Karitane			0	0	0					0	
Port Chalmers			0	0	1	0	0	0		0	1
Taieri-Bluff					0	0		0			
SOUTHEAST	TRE 3	1	0	0	1	0	0	0	1	1	1
Hokianga				0	0	0	1	1	0	0	3
Kaipara		4	7	18	7	5	21	11	24	17	4
Manukau		1147	1230	1510	1370	916	1022	1298	1369	1743	1690
Raglan		41	74	123	46	60	143	149	140	133	118
Kawhia		10	12	25	30	9	15	11	5	3	5
New Plymouth		243	258	260	106	182	202	235	270	323	353
Wanganui		214	229	163	197	279	324	257	184	173	169
Manawatu			0	1	3	6	5	4	2	10	6
Paraparaumu						0	0	0	2	2	1
Paremata		27	30	42	40	20	10	3	3	1	1
Blenheim		0	1	1	0	0	0	4	1	1	0
Picton		0	0	2	0	0	1	0	0	0	0
Pelorus		0	0	0	0	0	0	0	0	0	0
Nelson		309	341	155	201	108	120	109	285	146	110
Motueka		40	42	17	18	11	24	28	14	42	31
Golden Bay		0	1		2	0	1	1	14	5	3
Westport		1	1	2	1	0	0	0	0	1	1
Greymouth		1	0	1	3	2	5	2	9	0	0
WEST AUCKLAND		1445	1581	1936	1559	1172	1404	1705	1808	2219	2173
SW COASTS		592	645	384	465	426	490	408	514	381	322
WEST COASTS	TRE 7	2037	2226	2320	2024	1598	1894	2113	2322	2600	2495
NZ TOTAL		5949	5992	4946	5131	3494	5678	6485	6526	5674	4326

TABLE 2, ctd: Trevally landings by port from Annual Reports, 1931-1982. 1931-1943 periods are year to following March. 1944-1982 periods are calendar years. 1940-1943 reported New Zealand totals exceed sum of port landings, otherwise totals are sums of rounded column entries. ' ' denotes nil catch, '0' denotes catch less than 0.5t and '-' denotes value unavailable.

	Stock	1981	1982
Mangonui		155	156
Whangaroa		10	11
Russell		8	12
Whangarei		150	67
Auckland		410	670
Thames		27	50
Coromandel		9	20
Mercury Bay		34	42
Tauranga		693	1078
Whakatane		17	28
E NORTHLAND		323	246
HAURAKI GULF		446	740
BAY OF PLENTY		744	1148
AUCKLAND EAST	TRE 1	1513	2134
Gisborne		152	101
Napier		62	50
Castlepoint		2	2
Wellington		48	4
Makara		1	0
CENTRAL EAST	TRE 2	265	157
Kaikoura		0	0
Lyttelton			0
Akaroa-Karitane			0
Port Chalmers			
Taieri-Bluff			0
SOUTHEAST	TRE 3	0	0
Hokianga		0	1
Kaipara		8	15
Manukau		2032	1854
Raglan		198	105
Kawhia		2	2
New Plymouth		152	162
Wanganui		133	195
Manawatu		0	0
Paraparaumu		0	10
Paremata		1	1
Blenheim		0	
Picton		0	0
Pelorus		0	0
Nelson		114	124
Motueka		193	19
Golden Bay		4	6
Westport		0	3
Greymouth		7	0
WEST AUCKLAND		2392	2139
SW COASTS		452	358
WEST COASTS	TRE 7	2844	2497
NZ TOTAL		4622	4788

TABLE 3: Trevally landings by area fished by month, from Fisheries Statistics, 1983-1987. Area '100' denotes catch by deepwater vessels.
' ' denotes nil catch, '0' denotes catch less than 0.5t and '-' denotes value unavailable.

	1982			1983									
AREA	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Tot
-1	-	-	-		83	12	5	3	3	3	1	4	218
1	-	-	-										
2	-	-	-	13	11	7	13	6	3	2	5	8	69
3	-	-	-	11	13	40	29	15	7	3	2	5	124
4	-	-	-	0					0	0			0
5	-	-	-	9	10	9	14	2	0	0	0	0	44
6	-	-	-	7	6	13	5	0		1	0	0	32
7	-	-	-	2	3	8	6	3	4	9	7	11	53
8	-	-	-	3	8	29	12	3	1	2	1	3	62
9	-	-	-	21	46	39	54	8	6	7	7	69	258
10	-	-	-	4	27	18	5	0	2	1	0	0	57
11	-	-	-	0		0	0	0	0	0	0	0	2
12	-	-	-	0	0	2	1	1	0		0	0	4
13	-	-	-	2	4	1	3	5	1	1	1	2	19
14	-	-	-	0	0	0	0	2	0	0	0	0	3
15	-	-	-	0	0	3	0	6	0		0	0	10
16	-	-	-	0	0	0	3	1	4	0	0	0	9
17	-	-	-	0	0	0	0	0	0	0		0	0
18	-	-	-		0	0	0		0				0
19	-	-	-										
20	-	-	-							0			0
21	-	-	-										
22	-	-	-	0					0				0
23	-	-	-										
24	-	-	-				0	0					0
25	-	-	-										
26	-	-	-	0									0
27-31	-	-	-										
32	-	-	-										
33	-	-	-			0	0	0	0			0	1
34	-	-	-	0	0	0	0	0	0	0	0		0
35	-	-	-	0	0	0	0	0	1		0	1	2
36	-	-	-	0	0	1							1
37	-	-	-	0	6	0	1	0		0	0	1	7
38	-	-	-	4	3	0	0	0	0				8
39	-	-	-	0	2	4	2	0	0	1	0	1	12
40	-	-	-	6	7	5	2	9	9	7	3	2	49
41	-	-	-	38	88	15	9	16	5	1	2	5	179
42	-	-	-	226	43	11	15	4	7	5	2	12	324
43	-	-	-	1	4	1	2	2	1	3	3	4	22
44	-	-	-	0	1	2	3	5	2	2	4	10	29
45	-	-	-	113	77	54	13	5	13	1	4	10	289
46	-	-	-	21	106	53	38	16	1	1	1	2	239
47	-	-	-	1	37	104	21	1	0	1	2	0	168
48	-	-	-					0	0				0
49-52	-	-	-										0
100	-	-	-	-	-	-	-	-	-	-	-	-	2
TOTAL	-	-	-	-	-	-	-	-	-	-	-	-	2297

TABLE 3, ctd: Trevally landings by area fished by month, from Fisheries Statistics, 1983-1987. Area '100' denotes catch by deepwater vessels. ' ' denotes nil catch, '0' denotes catch less than 0.5t and '-' denotes value unavailable.

	1983			1984									
AREA	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Tot
-1	6	2	25	5	14	18	8	8	4	5	3	6	105
1													
2	8	26	10	48	70	95	27	10	10	4	6	30	343
3	19	10	12	43	76	27	50	8	6	6	7	5	267
4	0						1	0		0			1
5	6	3	1	7	33	22	19	2	1	3	8	6	111
6	1	2	4	7	5	3	4	1	1	0	0	0	28
7	11	6	2	2	4	8	15	5	5	3	4	8	74
8	3	3	4	5	11	25	11	1	6	6	5	4	85
9	252	263	71	38	29	37	28	12	4	4	4	173	916
10	2	15	10	50	26	10	5	3	1	0	2	3	127
11		1		0	5	0	0	0	0	0	0	0	6
12	0	0	0	2	1	2	1	2	1	0	0	0	9
13	2	12	2	1	3	6	7	3	6	1	3	5	50
14	5	1	1	5	1	1	2	1	11	2	0	1	32
15	0	0		0	0	0	6	0	1	2	0		9
16	0	0	0	1	1	0	0	2	1	0	0	0	6
17	0	0	0	0	0	0	0	0				1	1
18		0	0	0	0	0	0		0		0		0
19													
20										0			0
21													
22												0	0
23													
24								0					0
25												0	0
26				0		0						0	0
27-31													
32		3											3
33					0			0					0
34		0		0		0	0	0	0	0	0	0	0
35	1	0		0	1	0	0	0	0	0	0	0	4
36	1						0	0	0	0	0	0	1
37	5	2	0	1	0	0	0	1	0	1	1	0	11
38	4	0	1	19	1	2	0	0	0	0	0	0	28
39	0	1	0	0	0	0	0	0	0	0	1		4
40	8	12	12	9	4	3	4	3	11	3	8	2	79
41	7	13	5	33	8	18	44	11	3	1	2	1	146
42	16	59	42	183	32	22	18	23	5	4	11	13	428
43	6	3	1	2	0	0	1	0	1	1	1	2	18
44	9	5	1	1	0	1	2	2	1	2	4	9	36
45	13	96	309	156	113	31	2	18	0	0	1	0	739
46	1	24	17	26	5	41	32	2	1	1	2	3	154
47	4	3	0	4	34	16	4	0	11	3	7	7	93
48								0	2				2
49-52													0
TOTAL	-	-	-	-	-	-	-	-	-	-	-	-	3919

TABLE 3, ctd: Trevally landings by area fished by month, from Fisheries Statistics, 1983-1987. Area '100' denotes catch by deepwater vessels. ' ' denotes nil catch, '0' denotes catch less than 0.5t and '-' denotes value unavailable.

	1984			1985									
AREA	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Tot
-1	8	18	4	46	4	7	7	3	3	1	2	4	107
1						0	0			0	0		0
2	123	203	25	62	87	82	33	8	5	2	2	22	655
3	16	11	6	51	57	45	11	6	9	2	4	6	225
4				1	0				0		0	0	1
5	3	4	4	22	58	17	5	1	1	0	0	0	116
6	1	2	2	8	8	19	3	1	0	0	1	1	46
7	15	17	4	1	2	9	15	7	5	5	8	10	99
8	1	2	2	17	60	13	4	4	6	45	86	19	258
9	54	23	19	61	29	52	40	10	6	4	44	12	353
10	1	1	8	71	33	2	4	2	0	0	0	1	123
11	0	1	0	2		1	0	0	0	0	0		4
12	0	0	0	1	7	1	0	1	0	0	0	1	13
13	8	6	183	7	6	4	9	1	3	1	0	4	231
14	2	1	3	21	0	1	3	14	0	0	0	0	45
15	0	0	2	0		0	0		0		0		3
16	0	0	0	0	0	0	0	1	0	0	0	0	1
17	0	0	0	0	0	1					0		1
18	0	0	0	0	0		0						0
19													
20					0		0						0
21													
22					0								0
23													
24				0				0					0
25													
26					0								0
27-31													
32													
33							0						0
34	0			0			0	0	0				0
35	1	0	0	1	0	0	0	0		0	0	0	3
36	0			0	2	0		0			0		3
37	12	3	1	7	1	3	0	2	0	0	0	0	30
38	0	2	2	1	4	6	0	0	0	0	0	1	18
39	0	0	0	0	0	1	1	1	0		2	1	5
40	3	2	2	2	12	15	1	2	2	3	4	4	53
41	12	45	31	121	57	34	26	16	7	1	3	4	356
42	3	55	161	65	83	11	7	5	0	2	2	3	397
43	3	1		0	0	1	1	0	1	0	0	1	8
44	6	1	0	0	0	0	0	2	1	1	3	5	20
45	6	126	131	117	5	24	19	31	0	0	1	2	461
46	2	2	0	45	5	4	2	3	0	0	1	3	67
47	11	5	1	15	5	6	2	0	12	2	2	0	62
48						0	0	0	0				0
49-52									0				0
100	-	-	-	-	-	-	-	-	-	-	-	-	9
TOTAL	-	-	-	-	-	-	-	-	-	-	-	-	3774

TABLE 3, ctd: Trevally landings by area fished by month, from Fisheries Statistics, 1983-1987. Area '100' denotes catch by deepwater vessels. ' ' denotes nil catch, '0' denotes catch less than 0.5t and '-' denotes value unavailable.

	1985			1986									
AREA	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Tot
-1	31	22	18	28	32	35	10	7	1	2	1	6	191
1		0					0						0
2	43	59	24	23	180	22	28	7	2	1	47	69	505
3	20	41	37	39	74	36	39	31	2	2	4	5	329
4		0	0	0	0	0	0	0	0		0		1
5	1	1	2	6	12	14	6	1	0	1	0	0	45
6	5	1	1	3	5	9	4	0	0	0	0	0	28
7	15	13	3	0	2	4	8	5	2	2	5	7	69
8	97	21	2	24	10	12	10	1	1	1	1	1	179
9	27	36	20	33	55	57	35	14	5	4	4	7	298
10	3	1	29	78	15	8	6	3	1	1	0	1	145
11	0			0	3	1		0		1	0	0	5
12	0	1	0	13	0	11	2	1	1	0	1	0	30
13	23	9	2	6	9	1	14	4	1	1	0	7	79
14	2	1	0	7	22	1	2	1	2	0		1	40
15	0		0	0	0		2	0	0			0	3
16	0	0	0	0	0	0	5	0	0	0	0	0	6
17		0		0	0		0	0		0	0		1
18					0			0				0	0
19													
20						3							3
21													
22						0							0
23													
24													
25													
26													
27-31													
32													
33	0										0		0
34	0	0	0			0	0	4	0				4
35	0	0	1	0	1	0	0	0			0	0	3
36	0	1		0			0	0	0	0			2
37	0	0	11	12	2	6	6	0	0	0	0	0	37
38	4	3	9	2	2	0	1	4	1	0	0	0	27
39	0	0	0	0	1	2	12	6	0	0	0	1	23
40	1	6	3	6	4	5	12	1	1	3	2	0	44
41	7	30	43	55	27	6	14	10	4	1	5	5	208
42	17	95	151	261	2	16	4	9	2	2	1	0	560
43	2	3	8	0	0	0	1	1	0	0		0	16
44	4	7	7	0	0	0	0	1	0	0	0	1	22
45	74	188	148	170	54	29	18	5		0	0	0	687
46	14	37	24	16	1	4	2	3	0	0	0	0	102
47	11	20	1	81	129	5	0	3	2	0	0	19	274
48		0				0					0		0
49-52													
100	-	-	-	-	-	-	-	-	-	-	-	-	3
TOTAL	-	-	-	-	-	-	-	-	-	-	-	-	3965

TABLE 3, ctd: Trevally landings by area fished by month, from Fisheries Statistics, 1983-1987. Area '100' denotes catch by deepwater vessels. ' ' denotes nil catch, '0' denotes catch less than 0.5t and '-' denotes value unavailable.

	1986			1987									
AREA	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Tot
-1		10	42	-	-	-	-	-	-	-	-	-	54
-1*	48	24		-	-	-	-	-	-	-	-	-	72
1		0		-	-	-	-	-	-	-	-	-	0
2	87	2	1	-	-	-	-	-	-	-	-	-	91
3	6	7	1	-	-	-	-	-	-	-	-	-	14
4				-	-	-	-	-	-	-	-	-	
5	0	1	2	-	-	-	-	-	-	-	-	-	3
6	1	0	0	-	-	-	-	-	-	-	-	-	1
7	4	2	1	-	-	-	-	-	-	-	-	-	6
8	1	0	0	-	-	-	-	-	-	-	-	-	2
9	10	16	13	-	-	-	-	-	-	-	-	-	39
10	0	1	9	-	-	-	-	-	-	-	-	-	10
11	1		1	-	-	-	-	-	-	-	-	-	2
12	0	0	1	-	-	-	-	-	-	-	-	-	1
13	4	2	11	-	-	-	-	-	-	-	-	-	17
14	0	0	2	-	-	-	-	-	-	-	-	-	2
15	0			-	-	-	-	-	-	-	-	-	0
16	0	0		-	-	-	-	-	-	-	-	-	0
17				-	-	-	-	-	-	-	-	-	
18			0	-	-	-	-	-	-	-	-	-	0
19				-	-	-	-	-	-	-	-	-	
20				-	-	-	-	-	-	-	-	-	
21				-	-	-	-	-	-	-	-	-	
22			0	-	-	-	-	-	-	-	-	-	0
23				-	-	-	-	-	-	-	-	-	
24				-	-	-	-	-	-	-	-	-	
25				-	-	-	-	-	-	-	-	-	
26				-	-	-	-	-	-	-	-	-	
27-31				-	-	-	-	-	-	-	-	-	
32				-	-	-	-	-	-	-	-	-	
33				-	-	-	-	-	-	-	-	-	
34	0			-	-	-	-	-	-	-	-	-	0
35	0		0	-	-	-	-	-	-	-	-	-	0
36			0	-	-	-	-	-	-	-	-	-	0
37		0	9	-	-	-	-	-	-	-	-	-	9
38	1	4	9	-	-	-	-	-	-	-	-	-	14
39	5	13	2	-	-	-	-	-	-	-	-	-	20
40	0	1	1	-	-	-	-	-	-	-	-	-	1
41	16	38	68	-	-	-	-	-	-	-	-	-	123
42	2	15	33	-	-	-	-	-	-	-	-	-	50
43	1	0	0	-	-	-	-	-	-	-	-	-	1
44	1	0	0	-	-	-	-	-	-	-	-	-	1
45	28	182	230	-	-	-	-	-	-	-	-	-	441
46	5	0	9	-	-	-	-	-	-	-	-	-	14
47	13	1	5	-	-	-	-	-	-	-	-	-	19
48				-	-	-	-	-	-	-	-	-	
49-52				-	-	-	-	-	-	-	-	-	
TOTAL	-	-	-	-	-	-	-	-	-	-	-	-	1007

* Catch not recorded on FSU database.

TABLE 4: Trevally landings by area from Fisheries Statistics 1983-86, and from Quota Management System for 1986/7.

Provisional

Area	Stock code	1983	1984	1985	1986	1986/87 Oct-Sep
E Northland		300	934	751	763	-
Hauraki Gulf		180	235	260	117	-
Bay of Plenty		1054	636	891	464	-
Auckland (East)	TRE 1	1534	1805	1902	1344	-
Central (East)	TRE 2	77	301	135	157	-
Southeast&South	TRE 3	3	0	0	0	-
Auckland (West)		2029	1628	1733	1772	-
SW Coasts		136	113	129	158	-
West Coasts	TRE 7	2165	1741	1862	1930	-
Kermadec	TRE10	0	0	0	0	-
NZ total		3779	3847	3899	3431	2928

TABLE 5: Mean CPUE ($kg.day^{-1}$) of trevally in Bay of Plenty, 5 single trawlers (50 ft, 230 HP).

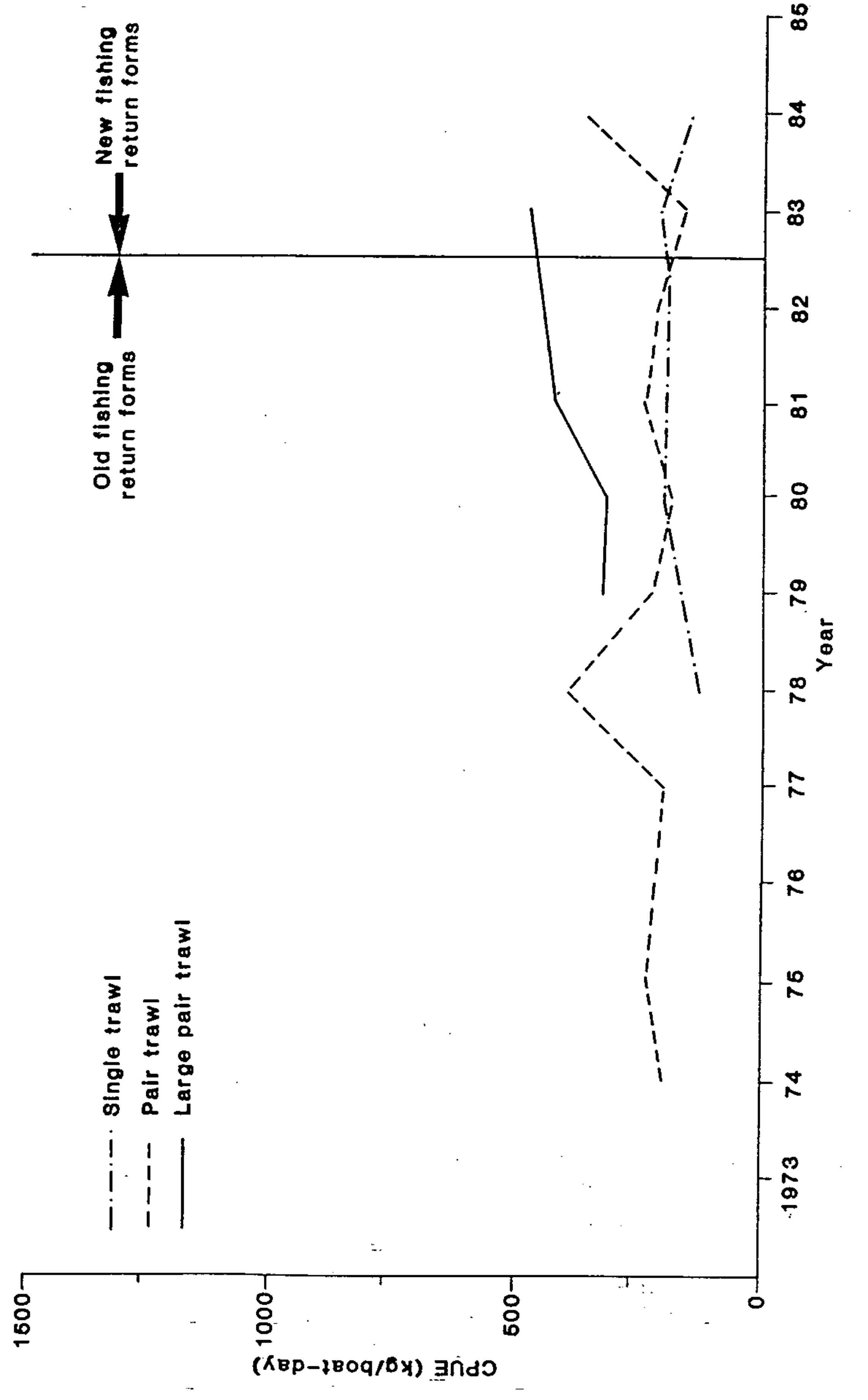
	Jun-Nov	Sep-Aug	
1973			
		386	
1974	305		
		531	
1975	302		
		201	
1976	119		
		158	
1977	65		
		44	
1978	29		
		96	
1979			
1983	72	)	3 boats only; based
		137)	on mean monthly
1984	30	)	kilogrammes per day fished off all boats combined.

TABLE 6: Yield per recruit estimates for trevally for east and west coast growth rates.

Parameters			Estimates			
Recruit age	Natural mortality	Amateur mortality	F_{max}	$F_{0.1}$	Y/R_{max}	$Y/R_{0.1}$
y	y^{-1}	y^{-1}	y^{-1}	y^{-1}	kg	kg
East coast growth rate						
2	0.03	0	0.115	0.060	0.921	0.851
2	0.03	0.02	0.155	0.075	0.793	0.723
5	0.03	0	0.210	0.075	1.148	1.033
5	0.03	0.02	0.415	0.095	1.073	0.922
West coast growth rate						
2	0.03	0	0.105	0.060	0.705	0.658
2	0.03	0.02	0.145	0.075	0.600	0.555

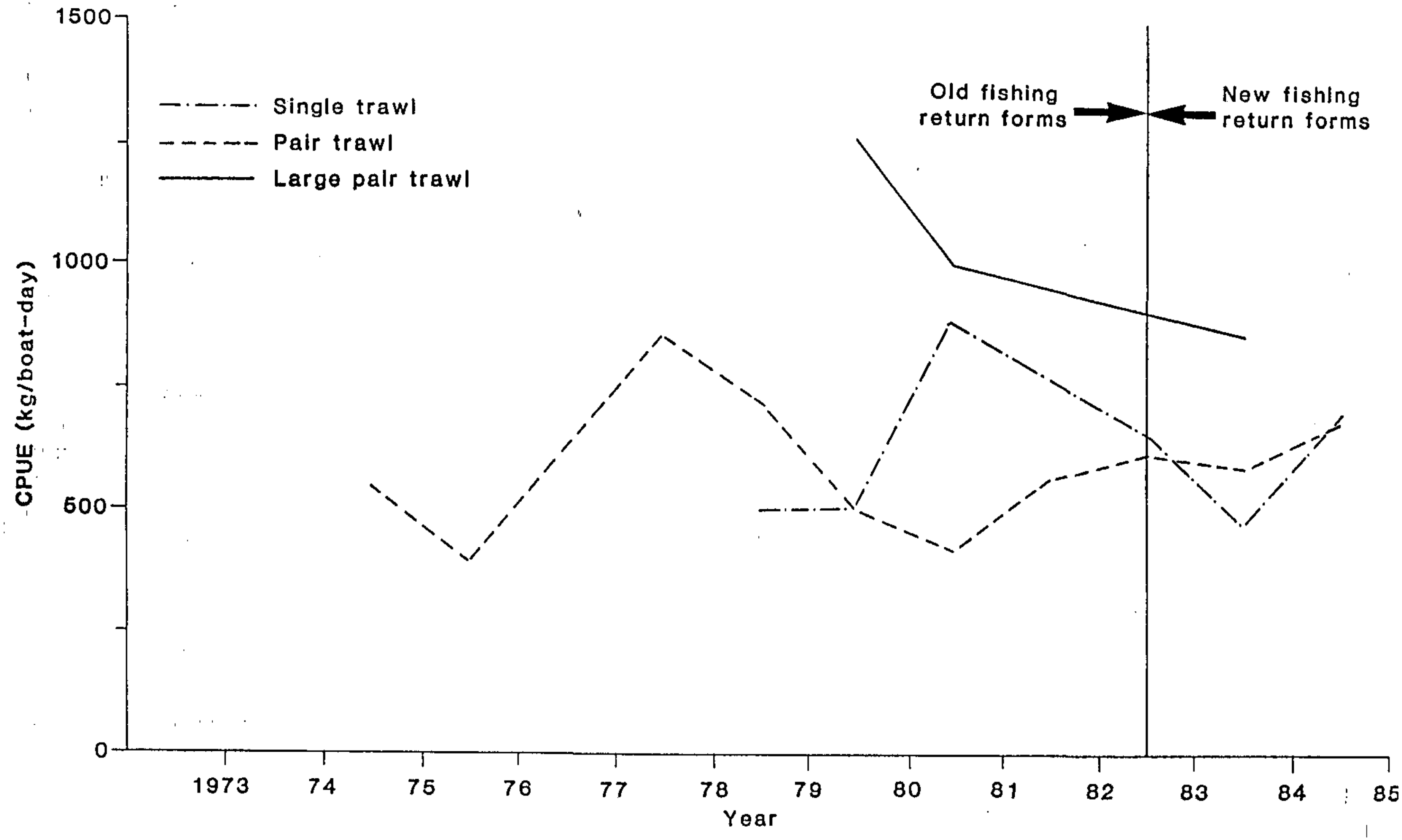
FIGURES

Figure 1



Old fishing return forms
New fishing return forms
Single trawl
Pair trawl
Large pair trawl
CPUE (kg/boat-day)
1500
1000
500
0
1973
74
75
76
77
78
79
80
81
82
83
84
85
Year

Figure 2



1500
1000
500
0
CPUE (kg/boat-day)
Single trawl
Pair trawl
Large pair trawl
Old fishing return forms
New fishing return forms
1973
74
75
76
77
78
79
80
81
82
83
84
85
Year

Figure 3

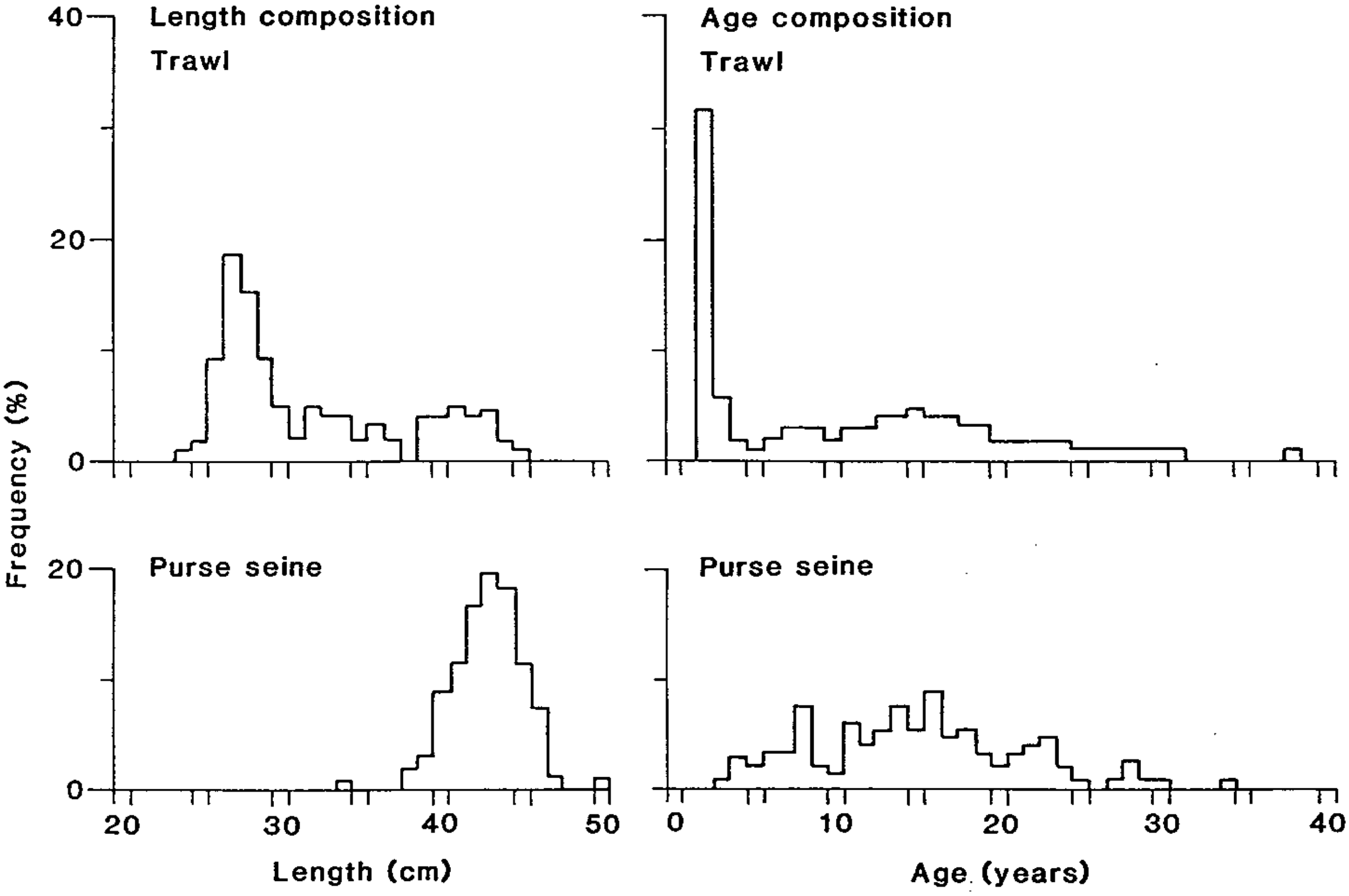

Length composition
Trawl
Age composition
Trawl
Purse seine
Purse seine
Frequency (%)
40
20
0
20
0
20
30
40
50
0
10
20
30
40
Length (cm)
Age (years)

Figure 4