New Zealand Fisheries Assessment Research Document 88/31

Hake

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This series documents the scientific basis for stock assessments and fisheries management advice in New Zealand. It addresses the issues of the day in the current legislative context and in the time frames required. The documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Hake (*Merluccius australis*)

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I. Introduction

(a) Abstract

This paper reviews the catch and effort data available on hake in the New Zealand EEZ, the available literature relevant to stock assessment, and research carried out to date on hake in the EEZ. Estimates of biomass are derived for three separate areas, and recommendations given for Total Allowable Catches.

(b) The Fishery

Hake are widely distributed through the middle depths (200 to 800 metres depth) of the New Zealand Exclusive Economic Zone (EEZ) south of latitude 40°S. They are generally taken as bycatch in fisheries targeting on other species such as hoki and southern blue whiting. Only off the west coast of the South Island, where a target fishery for hake developed in 1976 and 1977, and to a lesser extent on the Chatham Rise in the early 1980's, has target fishing for hake taken place successfully.

Because hake are widespread and frequently form a significant part of the bycatch of middle-depth trawling operations a large part of company hake allocations are set aside to allow for such bycatch. Hake quotas are small in comparison to those for, for example, hoki and are generally too small to allow the establishment of target fisheries for hake except on a small scale.

For the 1987-88 fishing year the TAC for hake was 6500 tonnes, with 3000 t available off the west coast of the South Island (Challenger-Central (Plateau) FMAs), 1000 t available within the South-East (Chatham Rise) FMA, and the remaining 2500 t available throughout the rest of the EEZ.

(c) Review of Literature

There has been little recent work on the biology of the New Zealand hake. Inada (1981) established i's taxonomic status as the same species as one of the hakes found off South America. Patchell (1981) gave an account of the Westland hake stock and the fishery on it up to 1979, and Patchell (1985) summarised the main features of the biology of the New Zealand hake, though without citing all of his sources of data, some of which were unpublished data held at the Fisheries Research Centre in Wellington. Kerstan and Sahrhage (1980) summarised the data available from the 1979 *Wesermünde* surveys, and Colman and Livingston (1988) gave a brief review of existing biological information and an assessment of Total Allowable Catches for 1987-88.

Smith *et al.* (1979) were unable to find genetic evidence for multiple stocks of hake, though the distribution of spawning adults and juveniles (Patchell 1981) suggests that there may be several more or less separate stocks within the New Zealand EEZ.

Biomass surveys carried out in the New Zealand EEZ between 1980 and 1984 were summarised by Hurst and Fenaughty (1985). This summary was included by Patchell (1985) in his assessment of hake for the 1985 TAC recommendations. In June and November 1986 two further biomass surveys were carried out on the Stewart-Snares shelf (Hurst 1987) but these did not cover the full depth range occupied by hake, and few hake were caught. A survey on the Chatham Rise in July 1986 provided an assessment of hake biomass on the Chatham Rise (Livingston 1987).

II. Review of the Fishery

(a) Catch and Effort

Hake catches since 1975 are shown in Table 1. Only in area G (West coast of the South Island) have catches been consistently above 500 tonnes per year, reaching a maximum of 17,806 in 1977 (Patchell 1981), but occasionally catches have exceeded 500 tonnes in a year in areas D (Chatham Rise) and E(C) (Campbell Plateau). In no other areas except F(E) and F(W), and then only once in each area, have annual catches ever exceeded 250 tonnes (see Table 2).

Only in area G, and to a lesser extent in area D, have target fisheries for hake ever been developed. Even in these areas these fisheries have been severely constrained by the catch limits that have been imposed, and hake are now taken in all areas almost entirely as by-catch in fisheries targeting on other species such as hoki (areas F(W), G, for example) or southern blue whiting (area E). Seasonal variations in hake catches in most areas are therefore caused largely by changes in fishing effort targeted at other species. Because of this, and because of the constraints imposed by the catch limits on hake, interpretation of catch per unit effort data on hake is difficult.

Where catches have been significant, however, there are clear seasonal trends. Monthly hake catches since 1978 are shown in Table 3 for areas D, E(C) and G, and clear peaks in hake catches are apparent in December-January in area D, September in E(C), and in July-August in area G.

Hake are taken mainly by large trawlers, especially foreign chartered trawlers fishing in area G during the winter. The catch by small domestic vessels is generally only about 200 to 250 tonnes per year, also mainly in area G during the winter.

(b) Patchell (1981) presented data on the size distribution, sex ratio and stages of maturity of hake caught in the west coast hake fishery in 1979. These fish were virtually all large, mature hake over 70 cm in length. Patchell also presented data on the size distribution and sex of hake taken during the 1976 season on the west coast fishery and showed that there was little difference in size between 1976 and 1979. Kerstan and Sahrhage (1980) presented size frequency and sex data on hake from the Campbell Plateau, western and central Chatham Rise, and from the west coast of the South Island, taken by the *Wesermünde* during 1979. Except for the samples collected on the western Chatham Rise, which were composed mainly of small hake between 30 and 50 cm in length, the hake taken by the *Wesermünde* were mainly mature fish over 70 cm in length.

(c) There is no significant Maori or recreational involvement in the New Zealand hake fisheries.

III. Research

(a) Stock Structure

The taxonomic status of the New Zealand hake was established by Inada (1981) but he did not investigate whether the New Zealand hake consisted of one, or more than one, stock. Smith *et al.* (1979) were unable to find genetic evidence for more than one stock of hake, but the distribution of spawning adults and of juveniles suggests that there may be several more or less separate stocks: one off the west coast of the South Island; one on the Chatham Rise; and one on the Campbell Plateau (Patchell 1981).

(b) Resource Surveys

Patchell (1981) used data from the commercial fleet to derive an estimate of the standing stock of hake off the west coast of the South Island in 1979. Biomass surveys carried out in the New Zealand EEZ between 1980 and 1984 were summarised by Hurst and Fenaughty (1985). In June and November 1986 two further biomass surveys were carried out on the Stewart-Snares shelf (Hurst 1987), though these did not cover the full depth range occupied by hake and few hake were caught. Another survey was carried out on the Chatham Rise in July 1986 (Livingston 1987). Data from all of these surveys, except from those on the Stewart-Snares shelf in 1986, have been used in preparing this paper, and these data are summarised in Table 4.

(c) Other Studies

Little other information has been published on the New Zealand hake. Some unpublished data are held at the Fisheries Research Centre, such as some age determinations, but the data are scanty and not well documented.

(d) and (e) Estimate of Biomass and Analysis of Yields

Colman and Livingston (1988) analysed data available to 1987 in order to derive estimates of biomass for hake. They considered the stocks separately in three areas:

1. West Coast (Challenger, Central (Egmont and Plateau) and Auckland (West) FMAs: equivalent roughly to EEZ areas G and H.
2. Eastern (South-East, Central (East) and Auckland (East) FMAs: equivalent to EEZ areas B, C and D).
3. Southern (Southland and Subantarctic FMAs: equivalent to EEZ areas E and F).

The analysis presented by Colman and Livingston (1988) is repeated here, with some minor changes.

This stock assessment depends heavily on the results of the trawl surveys mentioned. In recent years the practice at FRC has been to use the average of two estimates to provide a basis for stock assessment (Hurst 1985). One of these estimates is made under the assumption that the area swept by a trawl is the area between the wingtips of the net.

The other estimate assumes that the swept area is the area between the trawl doors.

The results given by Hurst and Fenaughty (1985) assumed that the area swept was the area between the wingtips, and these have been adjusted to the average of the wingtip and door estimates. The results of other surveys have been treated similarly. In adopting this approach the assumptions are:

1. The area between the doors is the area of influence of the trawl.
2. By taking the average of the two estimates, some allowance is made for fish avoiding capture by swimming over the sweeps and bridles.

Patchell (1981) incorporated a catchability coefficient of 0.46 into his assessment of standing stocks of hake off the west coast of the South Island. This has been eliminated in order to make Patchell's estimate comparable with those from other areas, which has the effect of reducing Patchell's estimate to 46% of its original value. Taking the average of this adjusted wingtip estimate and a doorspread estimate reduces it further still. Table 4 summarises the estimates from the various surveys, and two figures are given for the west coast; one assumes a doorspread to wingtip spread ratio of 4.0, the other assumes a ratio of 3.0. The higher of these two biomass figures was used in assessing the west coast hake stocks.

Although there may be several more or less separate stocks of hake in the EEZ, it would be safest to set separate TACs for the three main areas (west coast, east coast and Chatham Rise, and Southland + Sub-Antarctic) and manage these as separate stocks.

For the purpose of deriving TAC recommendations from the standing stock assessments, the instantaneous natural mortality (*M*) is taken to be 0.2. This is a reasonable figure given that only a small proportion appear to survive to over 20 years old (FRC unpublished data). However, this value of *M* depends on aging methods which are not yet validated, and if subsequent research establishes that a different figure would be more appropriate, this will have an effect on future recommendations.

(i) West coast stocks (Challenger, Central (West), and Auckland (West))

The 1979 spawning stock off the west coast of the South Island, reassessed from Patchell's (1981) data, was about 11 200 to 12 000 t (Table 4). It was assumed, for the purposes of the estimation procedure that follows, that the stock was 12 000 t and represented the entire adult stock in the region. The following assumptions were also made:

1. Because reported catches before 1976 were very small it was assumed that the standing stock before the 1976 season was effectively unexploited and equal to the virgin stock biomass (B_0).
2. Reported landings of hake from the region in 1976, 1977, and 1978, a total of 23 309 t, accounted for all hake caught in the region during these seasons.
3. In the unexploited stock, annual natural mortality was balanced by growth (G) and recruitment (R); i.e., $G + R = B_0 \; (1 - e^{-M})$.
4. Growth plus recruitment has remained the same, with increases in growth rate of individual fish compensating for a reduced population, and recruitment being unaffected by fishing. The natural mortality rate has remained constant for all recruited ages.

5. Mean population size for 1976-79 is estimated by $0.5(S_{76} + S_{79})$, where S_{76} and S_{79} are the standing stocks before the 1976 and 1979 seasons respectively. Total natural mortality (Mortality, 1976-79) for the intervening 3 years is estimated at:

(1) $$\text{Mortality, 1976-79} = 0.5(S_{76} + S_{79}) \times 3 \times \frac{M}{F + M}(1 - e^{-(F + M)})$$

and total fishing mortality (Catch, 1976-79), amounting to 23 309 t, is estimated by:

(2) $$\text{Catch. 1976-79 } (= 23\ 309) = 0.5\ (S_{76} + S_{79}) \times 3 \times \frac{F}{F + M}(1 - e^{-(F + M)})$$

The 1976 standing stock (S_{76}) is estimated from:

(3) $$S_{76} = S_{79} - (G + R\text{, 1976-79}) + (\text{Catch, 1976-79}) + (\text{Mortality, 1976-79})$$

Assuming that $G + R = B_o(1 - e^{-M})$ (see assumption 3 above), and substituting from equations (1) and (2) in equation (3), gives:

(4) $$S_{76} = S_{79} - 3B_o(1 - e^{-M}) + 23\ 309 + 1.5(S_{76} + S_{79}) \times \frac{M}{F + M}(1 - e^{-(F + M)})$$

Rearranging and substituting B_o for S_{76}, and 12 000 t for S_{79} gives:

(5) $$B_o + 3B_o(1 - e^{-M}) = 35\ 309 + 1.5(B_o + 12\ 000) \times \frac{M}{F + M}(1 - e^{-(F + M)})$$

With only one equation and three unknowns (B_o, F, M), this equation (5) has no unique solution. However, if M is assumed to be 0.2 as suggested above, and equation (2) is solved simultaneously with (5), a solution is found whereby B_o is about 28 400 t and F (for the 1976, 1977, and 1978 seasons combined) is about 0.54. For higher values of M, F increases and B_o decreases and vice versa, though not greatly so.

For the purposes of this paper, M is assumed to be 0.2, which results in B_0 being estimated at 28 400 t and F at 0.54 over the seasons 1976, 1977, and 1978 combined. However, though estimates of B_0 from the above equations are not particularly sensitive to changes in M, it should be noted that they are highly dependent on the accuracy of the reported catches in 1976, 1977, and 1978 and on the accuracy and precision of S_{79}, the 1979 standing stock. The reported catches are likely to be an underestimate of the real mortality due to fishing, and the actual 1979 standing stock is unlikely to be significantly lower than the 12 000 t estimated, for the following reasons.

The reported catches would not have included fish which were killed as a result of fishing activity, but not actually landed. Such fish would include those damaged through encountering fishing gear and escaping and fish lost through nets bursting or similar causes. It is also possible that catches could have been wrongly estimated by those on board. Because no quota system was in operation during 1976, 1977, and 1978 there was no incentive to underreport catches deliberately but in 1976, and particularly in 1977, there was some incentive to overreport catches to build up a catch history in anticipation of quotas being set after New Zealand declared her 200 mile EEZ.

The estimate of S_{79} depended on the results from only one fishing season and was subject to confidence limits of about ±50% (see Patchell 1981) because of variability in the catch rates of vessels whose data contributed to the estimate and because of possible variation in catchability. Thus, S_{79} could have been between about 6 000 and 18 000 t.

In practice, it is unlikely that S_{79} was as low as 12 000 t. A level as low as this would indicate that a very high proportion (about 70%) of the population had been caught during the 1977 season. A higher figure seems more reasonable; if S_{79} was 18 000 t this would indicate an unexploited biomass of about 35 000 t, of which about 50% would have been taken during the 1977 season. However, until some of the uncertainties surrounding all the parameters contributing to the estimate of B_0 are resolved, it would be safer to adopt the estimate of 28 400 derived above as a basis for yield estimation.

Reported catches since 1979 have been fairly small. If the west coast catch for 1980 (area breakdown is not available for that year) is assumed to be 1500 t, the total catch for the 9 seasons from 1979 to 1987 inclusive was about 17 200 t, an average of about 1900 t per year. With a standing stock of 12 000 t and a value of M of 0.2, this catch level indicates a value of F of about 0.2 and total mortality of about 4000 t per year.

Growth and recruitment in the unexploited stock was estimated by $G + R = B_0(1 - e^{-M})$. For B_0 = 28 400 and M = 0.2, this gives a value of 5150 t per year. Thus, it is possible that the low catch levels from 1979 to 1986 would have allowed some recovery of the stocks. However, the growth and recruitment levels in a heavily exploited stock may be quite different from those in an unexploited stock, and there is also some evidence from observers' records that catches of hake may have been underreported recently. Therefore, it would be unwise to assume that there has been any significant recovery, and it is not unreasonable to conclude that present stock levels are similar to those in 1979; i.e., about 12 000 t, though they may have recovered slightly.

If the exploitation rate is set at MCY (Maximum Constant Yield) = 0.25 MB_0 (where MCY is the highest level of catch that is estimated to be sustainable at all probable levels of biomass), the TAC should be about 1420 t per year. If recruitment has not been affected, this should allow a gradual rebuild of the west coast hake stocks, provided that the estimate of $M = 0.2$ is realistic.

(ii) Eastern Stocks

The surveys in 1983 indicated a biomass of about 33 300 tonnes on the Chatham Rise, with about 20 000 tonnes on the eastern parts of the Rise in November-December. The 1986 survey indicated a biomass of about 17 800 tonnes on the Chatham Rise, somewhat less than the biomass indicated by the results of the 1983 surveys. The average of the 1983 and 1986 surveys over the whole Chatham Rise was taken to be the best estimate of biomass, and this figure was 25 550 tonnes.

Stocks in these areas appear to have been exploited at only moderate levels. Average annual catches in areas C(M), C(-) and D combined, between 1978 and 1986, were less than 500 tonnes, and recent stock levels are probably only a little less than they would have been if the stock had been unexploited. An unexploited biomass of about 26 000 tonnes seems reasonable. If M is assumed to be 0.2, and MCY = 0.25 MB_0 a long term *yield of at least 1300 tonnes should be sustainable. In the short term* the TAC could be set above this level but, until better data on M and on current biomass are available it would be wise to limit any permanent allocation of quota to the 1300 tonnes suggested for the long term yield.

(iii) Southern Stocks

The two surveys in 1982 and 1983 which covered the whole area gave estimates of biomass of 15 900 and 28 600 tonnes respectively. Taking other, less complete, surveys into account a stock size of 22 250 tonnes (the average of the two surveys) seems reasonable.

These southern stocks also appear to have been relatively lightly exploited. Annual reported catches for the last decade have averaged about 300 tonnes. Even allowing for the probability that actual catches would have exceeded those reported, the fishing pressure on these southern stocks will not have reduced the stock greatly from what it would have been if it had been unexploited. It is assumed here that the unexploited biomass would have been about 23 000 tonnes and, if M is assumed to be 0.2 and MCY = 0.25 MB_0 a long term yield of about 1150 tonnes should be sustainable and, in the short term, the TAC could be set somewhat above this level. However, until better and more recent data on M and on current biomass are available it would be unwise to allow permanent quota allocations to exceed the suggested long term yield figure of 1150 tonnes per year.

Current Annual Yield (CAY)

There are no data on which to base an assessment of CAY.

IV. Management Implications

From the foregoing analysis it is concluded that the MCY for hake stocks is 1420 tonnes per year off the west coast of the South Island, 1300 tonnes per year on the Chatham Rise and other eastern waters, and 1150 tonnes per year in southern waters.

These estimates are believed to be conservative, because they embody the assumption that all hake herded into the path of a trawlnet used in a trawl survey are in fact caught. Hake are large, active fish and there is some evidence (see Patchell 1981) that not all hake in the path of a net are caught. It is likely, therefore, that the MCYs of hake, in each of the areas considered in the EEZ, are larger than indicated above.

For the southern and eastern stocks the rate of exploitation has been low, and the stocks could stand a higher rate of exploitation while they are close to the unexploited level. Thus in the short term catches exceeding the indicated MCY could be taken from these two stocks. For the west coast stocks, however, the exploitation rate has been higher and the current stock size is likely to be well below the unexploited size. There is therefore less potential for short term increases of catch above the indicated MCY, and the current 3000 tonne TAC may not be sustainable.

Until the various assumptions surrounding the estimates of MCY can be verified it would be sensible not to allocate as permanent ITQ any quantities greater than the MCY. This would reduce the risk of having to buy back quota at a later stage if stocks were found either to be smaller than estimated, or more variable than expected. However, it is likely that present stocks could sustain higher catches than the indicated MCYs, for reasons outlined above, and short term TACs of up to 2000 t for each area could be considered.

For all stocks better information is required to estimate *M* more accurately, to determine stock variability with time, and to assess the current biomass. Until this additional information is available it would be sound policy not to allocate as permanent ITQ any hake above the indicated MCY levels, i.e. 1420 tonnes for the western stock, 1300 tonnes for the eastern, and 1150 tonnes for the southern stock. In the short term it is probable that stocks will sustain higher catch levels than this, however, and quantities of annual quota could be considered, to raise area TACs to 2000 tonnes for each of the three stocks.

These figures differ slightly from those recommended by Colman and Livingston (1988). The recommended TAC for the west coast is 2000 t compared with 2500 t for 1987-88, and recommended levels of permanent ITQ are slightly lower for all areas. The extra degree of conservatism is largely the result of increasing levels of uncertainty concerning the current biomass with increasing time since the most recent estimates of biomass.

<u>Recommendations</u>

For 1988-89 TACs and allocations should not exceed the following levels:

	TAC	Permanent Allocation	Annual Quota	1987-88 TAC
Western Stocks (Challenger, Central (Egmont and Plateau) Auckland (West))	2000	1420	580	3000
Eastern Stocks (South-East Coast Chatham Rise Central (East) Auckland (East)	2000	1300	700	1000
Southern Stocks (Southland, Subantarctic)	2000	1150	850	2500
Kermadec	10	0	10	10
TOTAL	6010	3870	2140	6510

These recommended TACs represent reductions of 1000 tonnes for the western and 500 tonnes for the southern stock, and an increase of 1000 tonnes for the eastern stock. The western stock TAC was raised to 3000 tonnes for 1986-87, from 1000 tonnes previously, and the level of 2000 tonnes recommended here is still well above levels of TAC set before the 1986-87 year. For the other areas the TACs are well above current catch levels.

Because of uncertainties previously referred to in the discussion above, it is recommended that not all of the TAC should be allocated permanently as ITQ or otherwise. Permanent allocations should not exceed the levels indicated in the table.

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Table 1. Hake catches: 1975 to 1985/86

Fishing Year	New Zealand			Foreign Licensed				Grand Total
	Domestic	Chartered	Total	Japan	Korea	USSR	Total	
1975*	0	0	0	382	0	0	382	382
1976*	0	0	0	5 474	0	300	5 774	5 774
1977*	0	0	0	12 482	5 784	1 200	19 466	19 466
1978-79**	0	3	3	398	308	585	1 291	1 294
1979-80**	0	5 283	5 283	293	0	134	427	5 710
1980-81			No data available					
1981-82**	0	3 513	3 513	268	9	44	321	3 834
1982-83**	38	2 107	2 145	203	53	0	255	2 400
1983#	2	1 006	1 008	382	67	2	451	1 459
1983-84§	196	1 212	1 408	522	76	5	603	2 011
1984-85§	265	1 318	1 583	400	35	16	451	2 034
1985-86§	241	2 104	2 345	465	52	13	530	2 875
1986-87 (provisional)								4 238

* Calendar year.
** April 1-March 31.
\# April 1-Sept 30.
§ Oct 1-Sept 30.

Sources: 1975-1977: Elder and Taylor 1979.
1978 onwards: Fisheries Statistics Unit.

Table 2. Hake catches (tonnes) by area: large vessels only (FSU data)

EEZ Area	B	C(M)	C(-)	D	E(A)	E(B)	E(C)	E(P)	F(E)	F(W)	G	H	Total
Fishing year													
1978-79	3	8	17	6	94	0	543	2	119	6	498	0	1 295
1979-80	0	35	14	560	108	1	165	1	38	51	4 737	0	5 714
1980-81	-	-	-	-	-	-	-	-	-	-	-	-	-
1981-82	0	20	1	976	57	0	68	7	120	21	2 565	0	3 834
1982-83	0	237	2	357	81	0	49	1	36	50	1 587	0	2 401
1983	0	94	6	202	52	0	170	2	78	97	743	7	1 459
1983-84	0	113	20	174	102	1	240	22	104	252	756	2	1 817
1984-85	0	100	21	396	115	0	152	31	142	85	633	34	1 771
1985-86	0	165	42	131	38	0	331	4	329	116	1 482	0	2 635
1986-87 (provisional)		*		198				1 060			2 981	*	4 238

* Included in catches for areas E and F.

Table 3. Hake catches (tonne) by month in areas D, E(C) and G (large vessels only)

Year	J	F	M	A	M	J	J	A	S	O	N	D
Area D												
1978	-	-	-	0	0	0	0	0	0	0	0	5
1979	0	0	1	3	33	6	0	5	11	19	17	209
1980	237	6	14	-	-	-	-	-	-	-	-	-
1981	-	-	-	147	37	10	0	0	0	12	15	597
1982	154	0	4	26	5	14	2	4	7	21	7	236
1983	33	0	4	44	51	21	11	15	60	4	2	27
1984	9	3	5	6	1	18	20	32	50	10	7	207
1985	40	1	70	2	0	12	2	25	24	1	19	18
1986	4	0	1	16	14	16	2	0	40	-	-	-
Area E(C)												
1978	-	-	-	0	0	0	0	81	443	4	6	1
1979	5	3	0	5	5	0	9	68	49	16	4	2
1980	9	0	0	-	-	-	-	-	-	-	-	-
1981	-	-	-	0	0	2	2	26	37	0	0	0
1982	2	0	0	0	0	10	10	23	6	0	0	0
1983	0	0	0	0	0	0	10	50	110	0	0	0
1984	0	0	0	0	1	1	24	70	145	1	0	0
1985	0	0	0	0	0	0	2	41	107	15	0	0
1986	0	0	0	0	0	0	0	84	232	-	-	-
Area G												
1978	-	-	-	0	0	4	159	45	0	0	290	0
1979	0	0	0	0	5	34	449	4 226	23	0	0	1
1980	0	0	0	-	-	-	-	-	-	-	-	-
1981	-	-	-	0	0	351	1 177	1 037	0	0	0	0
1982	0	0	0	0	0	197	1 352	18	20	0	0	0
1983	0	0	0	0	0	3	424	312	5	20	0	0
1984	0	0	0	0	0	0	292	389	55	0	0	0
1985	0	0	0	0	0	0	290	304	39	0	0	0
1986	0	0	0	0	0	59	852	543	27	-	-	-

Table 4: Summary of estimates of hake standing stock (t) made from results of trawl surveys

Area	Date of survey	Source	Estimates using spread of: Wingtips	Doors	Mean estimate	c.v. (%)
West coast South Island (area G)	Jul-Aug 1979	Patchell (1981)	17 900	4 500[1]	11 200	18
			17 900	6 000[2]	12 000	18
Chatham Rise (areas C and D)	Mar 1983	Hurst and Fenaughty (1985)	54 500	12 100	33 300	13
Chatham Rise (area D only)	Nov-Dec 1983	Hurst and Fenaughty (1985)	29 700	9 700	19 700	12
Chatham Rise (areas C and D)	Jul 1986	Livingston (1987)	29 300	6 300	17 800	12
Snares and Auckland Islands (areas EA and F)	Feb 1981	Hurst and Fenaughty (1985)	26 900	6 300	16 600	38
Snares and Auckland Islands (areas EA and F)	Apr 1983	Hurst and Fenaughty (1985)	19 100	4 500[3]	11 800	59
Campbell Plateau (areas E and F)	Mar-Apr 1982	Hurst and Fenaughty (1985)	25 700	6 100	15 900	15
Campbell Plateau (areas E and F)	Oct-Nov 1983	Hurst and Fenaughty (1985)	42 300	14 800[4]	28 600	23

[1] Doorspread taken to be wingtip spread x 4.
[2] Doorspread taken to be wingtip spread x 3.
[3] Doorspread estimated at 120 m.
[4] Doorspread estimated at 102 m.