Canadian Atlantic Fisheries
Scientific Advisory Committee

Comité scientifique consultatif des
pêches canadiennes dans l'Atlantique

CAFSAC Research Document 84/10

CSCPCA Document de recherche 84/10

Comparison of two harvesting strategies for the Georges Bank scallop stock

by

R.K. Mohn and G. Robert
Invertebrates and Marine Plants Division
Fisheries Research Branch
Department of Fisheries and Oceans
P.O. Box 550
Halifax, N.S. B3J 2S7

ABSTRACT

Stock projections of Georges Bank scallops are performed in order to compare two proposed management strategies. One stragegy is to constrain the average size of meats landed to be no less than 30 meats per pound (blending). The other is to constrain the smallest meat landed to be no less than 11.3 g (equivalent to 40 per pound). The projections and accompanying yield per recruit analysis show a general similarity between the strategies. However the blending stragegy tends to conserve more stock and as it forces effort over more age classes, tends to stabilize fluctuations in the catch. Neither option is near optimality in terms of yield per recruit nor is either seen to be sufficient to significantly aid stock reconstruction at current effort levels.

RESUME

On a effectué des projections sur le stock de pétoncles du banc Georges afin de comparer deux stratégies de gestion. Une première stragégie stipule que la taille moyenne des chairs débarquées corresponde à pas moins de 30 chair à la livre (mélange) alors que l'autre stratégie exige que chaque chair débarquée pèse un minimum de 11,3 g (équivalent à 40 chairs à livre). Les projections et les analyses de rendements par recrue présentent une certaine ressemblance entre les stratégies. Cependant, la stratégie qui permet le mélange des chairs tend à conserver une plus grande portion du stock et, comme elle distribue l'effort de pêche sur plusieurs classes d'age tend à stabiliser les fluctuations dans les prises. Aucune des options considérées s'approche du rendement par recrue optimal; de plus, aucune n'est établi comme suffisante pour contribuer de façon significative à la reconstruction du stock aux niveaux d'effort encourus actuellement.

INTRODUCTION

Because of its sessile nature and the behavior of the commercial gear it is impossible to analyse Georges Bank scallops using traditional finfish yield per recruit or stock projections. As the stock is sedentary and is aggregated to a decreasing degree with age, it is possible to direct effort at animals of a given size. Therefore a selectivity vector that describes the gear alone will not successfully relate the catch and the standing stock.

The two harvesting strategies to be compared are harvesting with a minimum weight and with a minimum average weight (blended meat count). Under the former strategy the objective is to protect all animals under a given size. While under the latter the average size of the catch is specified but is naturally composed of animals above and below the target average. These two objectives will be compared by yield per recruit and stock projections with special emphasis given to a minimum meat weight (11.3g) of 40 per pound (40MMW) and an average meat weight, or meat count, of 30 per pound (30MC). These specific strategies have been chosen because 40MMW has been proposed by the U.S. for Georges Bank and 30MC is being considered by Canada for implementation. Also, as a basis of comparison, a projection was carried out using a managemnt objective of 24MC. This corresponds to setting the average at the mean size of a scallop as it begins its fifth year.

METHODS

A prerequisite to either yield per recruit or stock projections is data on growth and mortality (fishing and natural). The stock projections have the additional requirement of an estimate of the initial standing stock and assumptions about future recruitment. The natural mortality is set at .1 over all ages (Merrill & Posgay, 1964).

The fishing mortality is decomposed into an age dependent vector called partial recruitment or selectivity and a coefficient which is generally denoted by F and is assumed to be proportional to effort. Traditionally the selectivity vector is normalized such that its largest component is unity. There are a number of options that one may choose for partial recruitment. The so called knife-edge which is zero beneath a certain age and unity above it was chosen as we believe it was the vector chosen by the Americans in the New England Fishery Management Council manuscript in which the 40MMW strategy is presented. Another potential choice is the selectivity of the gear. Caddy (1968, 1971 and 1972) reported the results of gear selectivity and efficiency. The gear with 75 mm rings had a 50% retention at 70 to 80 mm animals and all animals above approximately 110 mm were retained. The ring size however is not a good escapement mechanism for small animals as the dredge fills with larger animals, bryozoans and other materials. Because the scallops, especially younger animals, are contagiously distributed the fishermen to a large degree can affect the size composition of the catch. For this reason we will base the selectivity patterns on the results of a cohort analysis reported in Mohn, Robert and Roddick (1984). Table 1 contains various partial recruiment patterns. The columns labeled S-SVPA, S-1983 and S-1981 are the selectivities from the separable virtual population analysis and the 1983 and 1981 fishing mortality respectively. The S-SVPA pattern is the best fit to all the data used in the analysis which covers the period from 1972 to 1983. The pattern denoted

by S-1983 is the result of tuning the analysis for the most recent year and is used in this document as the basis for all projections using blending. S-SVPA and S-1983 are seen to be quite similar. The pattern S-1981 is included as an indication of the behavior of the fleet when the enforcement of regulations was relaxed. This is used as a basis to formulate a probable fishing pattern if a MMW were instituted, S-MMW. It is assumed that the fleet will direct effort on the recruiting year class as it becomes available as 4 year olds. Therefore, the selectivity at age four is augmented relative to S-1981 and the rest of the pattern is unchanged.

The starting population is derived from the 1983 research survey abundance estimate reported in Mohn, Robert and Roddick (1984). Because of the rapid growth of young animals and the seasonal nature of the fishery the stock projection is done on a quarterly basis. The annual growth is divided into four quarterly components of 10, 35, 35 and 20% of the annual increment. Similarly the annual effort is partitioned into quarters at rates of 15, 40, 30 and 15%. The oldest age class in the projection is treated as a plus group or completed age class. The selectivity vectors must also be broken into quarterly components. For animals above age four the selectivity is the same for all quarters as they are fully recruited to the gear. For animals of age three the selectivity follows the selectivity of the gear and is shown in the result tables for each projection. The growth rates are derived from the meat weights at age reported in Mohn, Robert and Roddick (1984). Appendix A is an annotated listing of the computer program which does these projections.

The MMW and MC options are projected for two recruitment scenarios. The first is that recruitment remain at the present low level for the duration of the projection, 6 years. The second scenario is that a modest recruitment three times larger than the current level occurs in 1985 and the subsequent recruitments return to the low level. This is considered to be a modest recruitment because variability in year class strength is greater that an order of magnitude as based on estimates from cohort analysis (Mohn, Robert and Roddick 1984).

The yield per recruit analyses were carried out on animals aged 3 to 11 with the oldest age treated as a complete year class. The method of Thompson and Bell was used with weights at age as above. Three patterns of selectivity are used, S-1983, S-MMW and a knife-edge pattern.

RESULTS

The detailed outputs of the projections are contained in Tables 2 - 6 and these results are summarized in Tables 7 - 11. The order of presentation is 30MC and 40MMW without a recruitment pulse, then 30MC and 40MMW with the recruitment pulse then finally the 24MC corresponding to a five year old scallop. The

summary tables are presented in the same order. Each detailed table begins with the partial recruitment vector. The numbers and weights at age of the catch by quarter follow. Population numbers at age and biomass distribution in percent over age are the next two sub-tables. The bottom row in the biomass distribution sub-table is the total biomass. The final sub-table for each projection is entitled fishing summary and contains seven entries for each quarter. The first number is the oldest age that would be beneath the blending target size and the second entry is the intensity of the fishing mortality on those animals beneath the blending limit. For example if there were so few larger animals that only 60% of the small animals could be landed and maintain the target average meat count this number would be 0.6. The third row is the mean weight of the catch. The next three rows are the catch in millions and metric tons per quarter and the cumulative catch in tons over a year respectively. The last row is the biomass at the end of each quarter.

The catch in numbers for the 30MC regime in the absence of a recruitment pulse (Table 2) shows the catch of three year olds increasing from the first quarter in each year to the last. This is consistant with the patterns displayed by the fleet. The corresponding portion of Table 3 , no blending, shows no catch of three year olds or four year olds in the first quarter of a year. In order to have a basis for comparison between MC and MMW the exploitation rates for the first year were balanced by multiplying the effort vector for 40MMW by 1.45. The total catch for the first year for 30MC is 1869 t and for 40MMW it is 1878. Such a multiplication does not represent a 45% increase in effort as it would in a finfish projection. This point will be dealt with in detail in the discussion. The 40MMW catches slightly higher catch in 1985, approximately 8%, then the difference declines monotonically until 1989 when the 30MC becomes incrementally larger. The reduced catch over the second to fifth years is reflected by a slightly larger terminal biomass (approximately 9%). On the basis of these projections it is seen that in terms of catch and standing stock the two regimes are very similar, with 30MC being more conservative. The main discriminating characteristic is the variability of mean weight of the catch which is more stable under 30MC than 40MMW.

In the presence of a modest recruitment pulse the difference in performance between 30MC and 40MMW is more apparent (Tables 4, 5, 9 and 10). 600 million animals, three times larger than other years, appear as 3 year olds in the first quarter of 1985. The catch numbers of three year olds in that year are as expected much larger than for other years under 30MC and the year class can be followed throughout the projection. There are not sufficient numbers of large animals to blend with this year class and as is seen in the last quarter of 1985 and first quarter of 1986 only 82 and 88% of the small animals may be landed. The recruitment pulse is as expected much sharper under 40MMW and is depleted more quickly as a result of the directed fishing. In terms of a conservation measure 30MC leaves just over 9% more standing stock at the cost of significantly smaller catches in

1986 and higher catches in the other years.

The relative similarity in results for 30MC and 40MMW is contrasted by the projection when the blending meat weight is that of a five year old, 19g. This corresponds to a meat count of approximately 24 and will thus be denoted by 24MC. The modest recruitment pulse used in Tables 4 and 5 is also assumed for 24MC (Tables 6 and 11). Because of the low meat count animals beneath the target size can only be partially harvested until 1987 when there are enough larger animals to blend with the 3 and 4 year olds. The catch as expected under 24MC is lower for the first three years of the projection but thereafter 24MC supports 20 to 40% greater annual catch.

Yield per recruit analysis results are given in Table 12 for three patterns of partial recruitment. S-1983 and S-MMW (Tables 12A and 12B) show that for low fishing mortalities and young age of recruitment S-1983 gives higher yields. These analyses are for stable age distributions and do not take into account the reduction in mortality that may be required to reach the target meat count. They are included for completeness and do NOT form the basis of comparison between MC and MMW regimes. Table 12c shows the results of the analysis for knife-edge, or more accurately step function, recruitment. The patterns show maximum and hence 0.1 levels at much lower F's than do the other partial recruitment patterns. Also with the knife-edge recruitment the maximum yield occurs at much younger ages of recruitment. Using such a pattern is seen to seriously bias results.

DISCUSSION

In terms of catch and standing stock there is not a great deal of difference between 30MC and 40MMW on the basis of the projections reported in this study. The 30MC would seem to have an advantage in terms of conservation and stability of catch. The occurrence of a modest recruitment pulse emphasizes this advantage. As is demonstrated by the 24MC projections and yield per recruit analysis both in this document and previously reported (Brown et al. 1972 and Serchuk et al. 1979) harvesting large numbers of age 3 and 4 animals constitutes growth overfishing.

The methodology of the standard analytical model and stock projections needs to be carefully applied to sessile stocks of size-aggregated animals. Typically when comparing bottom trawl selectivity for different mesh sizes the larger mesh will catch fewer fish and require more effort to produce the same yield. For this reason when comparing projections the selectivity pattern is normalized such that its largest component is of unit magnitude. The inappropriateness of this approach when applied to an aggregated stock that is well recruited to the gear can be seen if the following example is considered. Imagine a stock comprised of two year classes say of 4 and 5 year olds in separate beds of equal size, $N_4 = N_5$. Further assume that both

ages are fully recruited to the gear which gives a selectivity vector of 1,1. If fishing fleet A spends half their effort in each bed their annual catch would be

$$C_A = qE(\bar{N}_4 + \bar{N}_5) = 2qE\bar{N}_4$$

where E is the annual effort and q the catchability coefficient. If fleet B fishes with the same amount of effort but only in the bed of 4 year olds their selectivity will be 1,0 and their annual catch is

$$C_B = qE\bar{N}_4 = .5C_A.$$

Thus the same effort with the same gear on a stock of the same density appears to give half the catch. Conversely, twice the effort would appear to be necessary to balance the catches. Clearly an error is introduced by normalizing the selectivity in the standard manner for size discrete stocks. In this simple example the problem can be resolved by normalizing the areas under the selectivity curves instead of the maximum element of the curves. Alternatively, instead of a different renormalization, the catchability could be redefined to reflect the different patterns of the fleets, $q_A = .5q_B$.

In order to have an objective basis for comparison of 30MC and 40MMW the catch rates for the first year were balanced. As the starting populations are the same for each projection this is equivalent to balancing the exploitation rates. The fact that the fishing intensity vector was multiplied by 1.45 to balance the catches is no indication that 45% more effort would be required from the fleet and to an undeterminable degree is an artifact of the selectivity normalization.

A second consideration related to the partial recruitment is the assignment of values to S-MMW. Such a pattern is necessarily somewhat conjectural as an MMW has never been applied to a scallop stock for which we have data. The closest situation we have is the relaxation of enforcement that took place on Georges Bank in 1981. S-MMW was formed by setting the selectivity of the 4 year olds 50% higher than that of the 5's from S-1981 and the other values were unchanged. How a fleet operating under a MMW would respond to a recruitment pulse cannot be anticipated in detail. In the event of such a pulse our estimate of the effort directed at age 4 animals may be too small. Similarly as the strong year class ages it is reasonable to expect that the effort would 'follow' it and $S\text{-}MMW_4$ may be too large in subsequent years of the projection. No model known to the authors is sufficiently sophisticated to allow an assessment of these effects and even if one were to exist the large number of assumptions needed to describe the interactions would seriously degrade the usefulness of the model's results.

The yield per recruit analysis shows the dependence of the yield to the partial recruitment vector. S-MMW and S-1983 are fairly similar while the knife-edge pattern diverges signifi-

cantly. The selectivity of the gear would produce similar results to the knife-edge except for the age 3 recruitment age yields. It is therefore important to consider the behavior of the fleet before drawing conclusions from yield per recruit analyses when applied to an aggregated stock. However it is apparent from both yield per recruit and stock projections that the two limits being proposed are still inadequate to prevent growth overfishing.

We have considered projected catches, their magnitude and stability, and the resulting standing stock as a biological basis for discriminating among harvesting strategies for Georges Bank scallops. When a stock is seriously growth overfished, as is the present case, any reduction of effort on younger animals should be beneficial. Thus we see that a 30MC is inferior to a 24MC and would expect that a 40MMW would be inferior to 30MMW. This is consistant with yield per recruit results. Also for each MC there would exist a MMW which gives approximately the same overall catch and stock conservation. The MMW represents a hard or abrupt limit while the MC poses a soft or gradual limitation. As blending will tend to force the effort over a number of ages it will result in greater catch stability. The two specific limits under consideration, 30MC and 40MMW are fairly closely matched for total catch with 30MC being the more conservative.

Although different aspects of incidental fishing mortality have been studied, applicable information does not exist to assess the relative performance of the two strategies under consideration. Nonetheless, incidental fishing mortality, both by the gear and culling practices, should be considered in the overall evaluation of any harvesting strategy.

REFERENCES

Brown,B.E., M. Parrack & D.D. Flescher. 1972. Review of the current status of the scallop fishery in ICNAF Division 5Z. ICNAF Res.Doc. 72/113, 13p.

Caddy,J.F. 1968. Underwater observations on scallops (Placopecten magellanicus) behavior and drag efficiency. J.Fish. Res. Bd Can. 25:2123-2141.

Caddy,J.F. 1971. Efficiency and selectivity of the Canadian offshore scallop dredge. ICES CM 1971/K:25.

Caddy,J.F. 1972. Size selectivity of the Georges Bank offshore dredge and mortality estimates for scallops from the northern edge of Georges Bank in the period June 1970 to 1971. ICNAF Res. Doc. 72/5.

Merrill,A.S. & J.A. Posgay. 1964. Estimating the natural mortality of the sea scallop. ICNAF Res. Bull. 1:88-106.

Mohn,R.K., G. Robert & D.L. Roddick. 1984. Georges Bank scallop stock assessment - 1983. CAFSAC Res. Doc. 84/12.

Serchuk,F.M., P.W. Wood, J.A. Posgay & B.E. Brown. 1979. Assessment and status of sea scallop populations off the Northeast coast of the United States. Proc. Natl. Shellfish. Assoc. 69:161-190.

TABLE 1. PARTIAL RECRUITMENT VECTORS

AGE	S-SVPA	S-1983	S-1981	S-MMW
3	0.013	0.019	0.035	0.000
4	0.620	0.761	0.907	1.000
5	1.000	1.000	1.000	0.667
6	0.581	0.582	0.510	0.340
7	0.336	0.371	0.275	0.180
8	0.198	0.262	0.213	0.140
9	0.141	0.140	0.173	0.113
10	0.100	0.116	0.139	0.093
11	-	0.109	0.073	0.049

Table 2.- Projection 30MC, S83, low recruitment pulses.

SCAP4
STARTING NUMBERS NR
WEIGHTS AT AGE WR
SELECTIVITY AT AGE S83
RECRUITMENT TO YOUNGEST AGE 24ρRR
FISHING INTENSITY 24ρER
BLENDING (Y OR N)
Y
MIN. MEAT WT.15
0.02 0.05 0.1 0.39 0.77 0.77 0.77 0.77 1 1 1 1 0.58 0.58 0.58 0.58 0.37 0.37 0.37 0.37

CATCH (NUMBERS 10*6) 17/ 4/84

Age	1984	1984	1984	1984	1985	1985	1985	1985	1986	1986	1986	1986	1987	1987	1987	1987	1988	1988	1988
3	0	3	6	12	0	3	6	13	0	3	6	13	0	3	6	13	0	3	6
4	6	17	13	6	11	31	23	10	12	33	25	11	12	33	25	11	12	33	25
5	6	15	11	4	3	9	6	3	6	16	11	5	6	17	12	5	6	17	12
6	1	2	2	1	1	3	3	1	1	2	2	1	1	3	3	1	1	4	3
7	0	1	1	3	2	4	3	6	4	7	6	9	7	9	8	8	6	9	8
Σ	13	39	32	26	18	50	41	33	23	61	49	38	26	66	53	39	26	67	54

Age	1988	1989	1989	1989	1989
3	13	0	3	6	13
4	11	12	33	25	11
5	5	6	17	12	5
6	1	1	4	3	1
7	11	8	11	10	12
Σ	41	28	69	56	43

Table 2 continued.

YIELD (MT) 17/ 4/84

Age	1984	1984	1984	1984	1985	1985	1985	1985	1986	1986	1986	1986	1987	1987	1987	1987	1988	1988
3	1	11	22	46	1	12	23	49	1	12	23	49	1	12	23	49	1	12
4	66	189	141	63	117	336	251	113	126	364	271	122	126	364	271	122	126	364
5	107	292	201	85	62	170	117	49	111	303	208	88	120	328	226	95	120	328
6	22	66	52	25	30	89	70	33	17	52	41	19	31	92	73	35	33	99
7	7	21	18	98	80	122	104	188	147	216	185	287	214	296	253	278	213	304
Σ	202	580	434	317	290	729	566	433	403	947	730	566	492	1092	847	580	494	1108

Age	1988	1988	1989	1989	1989	1989
3	23	49	1	12	23	49
4	271	122	126	364	271	122
5	226	95	120	328	226	95
6	79	38	33	99	79	38
7	261	350	266	376	322	410
Σ	860	654	547	1180	922	714

POPULATION (NUMBERS 10*6) 17/ 4/84

Age	1984	1984	1984	1984	1985	1985	1985	1985	1986	1986	1986	1986	1987	1987	1987	1987	1988	1988	1988
3	185	180	172	163	200	195	187	176	200	195	187	176	200	195	187	176	200	195	187
4	82	74	56	41	147	133	99	74	159	143	107	80	159	143	107	80	159	143	107
5	59	52	36	25	35	31	21	14	62	54	37	26	67	59	40	28	67	59	40
6	15	14	11	9	20	18	14	12	12	11	8	7	21	19	15	12	22	20	16
7	6	5	5	4	11	10	9	8	17	16	14	12	16	15	13	11	21	19	17
Σ	347	326	279	241	412	386	330	283	449	419	353	300	462	431	362	307	468	437	367

Age	1988	1989	1989	1989	1989	1990
3	176	200	195	187	176	200
4	80	159	143	107	80	159
5	28	67	59	40	28	67
6	13	22	20	16	13	22
7	14	24	23	19	17	26
Σ	311	472	440	370	313	474

Table 2 continued.

BIOMASS DISTRIBUTION (%/%) 17/ 4/84

Age	1984	1984	1984	1984	1985	1985	1985	1985	1986	1986	1986	1986
3	21.2	22.5	27.4	32.5	19.4	20.6	24.7	29.0	16.8	17.8	21.7	25.8
4	27.1	26.7	25.3	23.7	40.9	40.2	37.6	34.8	38.2	37.7	35.7	33.5
5	34.2	33.0	28.8	24.9	16.9	16.2	14.0	12.0	26.0	25.1	21.9	18.9
6	11.8	11.9	12.0	12.0	13.5	13.5	13.5	13.3	6.8	6.8	6.9	6.9
7	5.8	5.9	6.4	6.9	9.3	9.5	10.2	10.9	12.3	12.6	13.7	14.8
	3318.0	3037.0	2390.0	1902.0	3913.0	3596.0	2867.0	2306.0	4533.0	4149.0	3263.0	2593.0

Age	1987	1987	1987	1987	1988	1988	1988	1988	1989	1989	1989	1989
3	15.7	16.7	20.4	24.2	15.1	16.0	19.5	23.2	14.7	15.7	19.1	22.6
4	35.7	35.2	33.5	31.5	34.4	33.9	32.1	30.2	33.6	33.1	31.3	29.3
5	26.3	25.3	22.2	19.2	25.3	24.4	21.3	18.4	24.7	23.8	20.8	17.9
6	11.3	11.4	11.5	11.6	11.8	11.8	12.0	12.0	11.5	11.6	11.7	11.7
7	11.1	11.4	12.5	13.5	13.5	13.8	15.1	16.3	15.4	15.8	17.2	18.5
	4853.0	4440.0	3484.0	2761.0	5038.0	4612.0	3630.0	2884.0	5153.0	4721.0	3722.0	2963.0

Age	1990
3	14.5
4	33.1
5	24.4
6	11.4
7	16.6
	5225.0

Table 2 continued.

FISHING SUMMARY 17/ 4/84

	1984	1984	1984	1984	1985	1985	1985	1985	1986	1986
1	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25
2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3	15.59	16.94	17.54	17.40	16.66	16.67	17.62	18.40	18.28	17.69
4	12.98	38.73	31.64	26.17	17.87	50.00	41.09	32.89	22.89	61.00
5	202.26	656.11	555.05	455.48	297.69	833.57	723.77	605.22	418.31	1078.89
6	202.26	858.37	1413.42	1868.90	297.69	1131.26	1855.03	2460.25	418.31	1497.20
7	3036.60	2389.60	1902.20	3912.60	3596.00	2867.40	2306.30	4532.90	4149.10	3263.30

	1986	1986	1987	1987	1987	1987	1988	1988	1988	1988
1	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25
2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3	18.72	19.98	19.92	18.70	19.75	20.08	19.90	18.80	19.85	20.98
4	49.13	38.25	25.90	66.23	53.30	38.94	25.97	66.78	53.75	41.23
5	919.73	764.12	515.83	1238.83	1052.73	781.94	516.80	1255.25	1067.20	865.20
6	2416.93	3181.05	515.83	1754.66	2807.39	3589.33	516.80	1772.05	2839.25	3704.45
7	2592.60	4853.50	4440.00	3484.50	2761.30	5037.80	4612.30	3629.60	2883.80	5153.00

	1989	1989	1989	1989
1	4.25	4.25	4.25	4.25
2	1.00	1.00	1.00	1.00
3	20.87	19.36	20.42	21.64
4	27.58	68.96	55.62	43.04
5	575.57	1334.85	1135.52	931.30
6	575.57	1910.42	3045.94	3977.24
7	4720.60	3722.40	2963.40	5225.10

1: maximum blending age
2: rate on smalls
3: mean weight meat (g)
4: catch (mill.)
5: catch (t)
6: cumulative catch (t)
7: biomass (t)

MORE RUNS WITH THIS DATA

Table 3.- Projection MMW, SMMW, low recruitment pulses, and effort adjusted by a factor of 1.45.

```
      SCAP4
 STARTING NUMBERS NR
 WEIGHTS AT AGE WR
 SELECTIVITY AT AGE SMMW
 RECRUITMENT TO YOUNGEST AGE 24ρRR
 FISHING INTENSITY 24ρER×1.45
 BLENDING (Y OR N)
N
MIN. MEAT WT.11.3
0 0 0 0 0 1 1 1 0.67 0.67 0.67 0.67 0.34 0.34 0.34 0.34 0.18 0.18 0.18 0.18
```

CATCH (NUMBERS 10*6) 17/ 4/84

Age	1984	1984	1984	1984	1985	1985	1985	1985	1986	1986	1986	1986	1987	1987	1987	1987	1988	1988	1988
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	32	19	7	0	64	38	14	0	69	41	15	0	69	41	15	0	69	41
5	5	15	10	4	2	5	4	2	4	10	7	3	4	11	8	3	4	11	8
6	1	2	2	1	1	3	2	1	0	1	1	0	1	2	2	1	1	2	2
7	0	0	0	3	2	4	3	6	5	7	6	10	7	11	9	9	6	10	9
Σ	6	49	31	15	5	76	47	23	9	88	55	29	12	93	60	28	11	93	59

Age	1988	1989	1989	1989	1989
3	0	0	0	0	0
4	15	0	69	41	15
5	3	4	11	8	3
6	1	1	2	2	1
7	10	7	11	10	11
Σ	30	12	94	60	31

Table 3 continued.

YIELD (MT) 17/ 4/84

Age	1984	1984	1984	1984	1985	1985	1985	1985	1986	1986	1986	1986	1987	1987	1987	1987	1988	1988
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	345	202	75	0	699	411	152	0	757	444	165	0	757	444	165	0	757
5	103	285	198	84	35	97	67	29	71	197	137	58	77	213	148	63	77	213
6	19	57	47	23	26	79	65	32	9	27	22	11	18	55	45	22	19	59
7	5	16	14	97	75	121	108	204	152	239	212	331	235	349	310	295	213	323
Σ	127	702	461	279	136	997	651	417	232	1219	816	565	330	1374	948	545	310	1352

Age	1988	1988	1989	1989	1989	1989
3	0	0	0	0	0	0
4	444	165	0	757	444	165
5	148	63	77	213	148	63
6	49	24	19	59	49	24
7	287	337	242	366	326	376
Σ	928	588	339	1396	967	628

POPULATION (NUMBERS 10*6) 17/ 4/84

Age	1984	1984	1984	1984	1985	1985	1985	1985	1986	1986	1986	1986	1987	1987	1987	1987	1988	1988	1988
3	185	180	176	171	200	195	190	186	200	195	190	186	200	195	190	186	200	195	190
4	82	80	47	28	167	163	96	56	181	176	104	61	181	176	104	61	181	176	104
5	59	53	37	25	20	18	12	9	41	36	25	18	44	39	27	19	44	39	27
6	15	14	11	9	20	19	16	13	7	6	5	4	14	13	11	9	15	14	12
7	6	6	5	4	12	12	10	9	20	19	17	15	18	17	15	13	20	19	17
Σ	347	332	276	238	420	407	324	272	449	433	341	283	457	441	347	288	461	444	350

Age	1988	1989	1989	1989	1989	1990
3	186	200	195	190	186	200
4	61	181	176	104	61	181
5	19	44	39	27	19	44
6	10	15	14	12	10	15
7	15	22	21	19	17	24
Σ	290	463	446	352	292	465

Table 3 continued.

BIOMASS DISTRIBUTION (%/%) 17/ 4/84

Age	1984	1984	1984	1984	1985	1985	1985	1985	1986	1986	1986	1986
3	21.2	22.0	28.5	35.6	19.4	19.8	26.2	33.2	17.5	17.9	23.9	30.5
4	27.1	28.2	22.0	16.5	46.6	47.4	37.8	28.8	45.3	46.4	37.3	28.7
5	34.2	32.3	29.8	26.6	9.9	9.1	8.6	7.8	18.0	16.7	15.9	14.5
6	11.8	11.7	12.8	13.4	13.9	13.5	15.1	16.1	4.3	4.2	4.7	5.0
7	5.8	5.8	6.9	7.9	10.2	10.1	12.3	14.2	14.9	14.9	18.2	21.2
	3318.0	3111.0	2341.0	1828.0	3915.0	3748.0	2759.0	2126.0	4353.0	4150.0	3027.0	2310.0

Age	1987	1987	1987	1987	1988	1988	1988	1988	1989	1989	1989	1989
3	16.7	17.2	22.9	29.3	16.3	16.8	22.3	28.4	16.1	16.5	21.8	27.7
4	43.5	44.6	35.8	27.6	42.4	43.5	34.8	26.7	41.7	42.8	34.1	26.1
5	18.7	17.4	16.6	15.1	18.2	17.0	16.1	14.6	17.9	16.7	15.8	14.3
6	8.3	8.1	9.1	9.8	8.8	8.6	9.6	10.3	8.6	8.4	9.4	10.0
7	12.8	12.8	15.6	18.2	14.2	14.2	17.2	20.0	15.6	15.6	18.9	21.9
	4538.0	4317.0	3153.0	2404.0	4650.0	4423.0	3245.0	2484.0	4727.0	4497.0	3310.0	2543.0

Age	1990
3	15.9
4	41.3
5	17.7
6	8.5
7	16.6
	4781.0

Table 3 continued.

FISHING SUMMARY 17/ 4/84

	1984	1984	1984	1984	1985	1985	1985	1985	1986	1986
1	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3	20.27	16.33	18.82	24.00	28.22	15.27	17.88	23.64	28.57	16.04
4	6.25	49.15	31.12	15.11	5.08	75.90	46.92	22.87	8.68	88.02
5	126.77	802.85	585.75	362.76	143.45	1158.92	839.13	540.64	248.13	1412.22
6	126.77	929.62	1515.37	1878.13	143.45	1302.37	2141.50	2682.14	248.13	1660.35
7	3111.20	2341.30	1828.40	3914.90	3747.70	2758.90	2125.90	4352.70	4149.70	3027.00

	1986	1986	1987	1987	1987	1987	1988	1988	1988	1988
1	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3	18.78	24.98	30.04	16.98	19.89	24.63	29.60	16.83	19.71	25.15
4	55.23	28.66	11.85	93.25	59.65	28.23	11.24	92.63	59.08	29.55
5	1037.36	716.03	356.02	1583.63	1186.31	695.34	332.82	1558.65	1164.31	743.33
6	2697.71	3413.74	356.02	1939.65	3125.96	3821.30	332.82	1891.47	3055.78	3799.11
7	2309.90	4537.60	4317.00	3152.60	2403.90	4649.60	4422.80	3244.70	2484.30	4727.20

	1989	1989	1989	1989
1	4.00	4.00	4.00	4.00
2	1.00	1.00	1.00	1.00
3	30.11	17.11	20.04	25.60
4	12.13	93.96	60.27	30.75
5	365.43	1607.29	1207.66	787.26
6	365.43	1972.72	3180.38	3967.64
7	4496.50	3310.30	2542.70	4781.20

1: maximum blending age
2: rate on smalls
3: mean weight meat (g)
4: catch (mill.)
5: catch (t)
6: cumulative catch (t)
7: biomass (t)

MORE RUNS WITH THIS DATA

Table 4.- Projection 30MC, S83, recruitment pulse in 1985.

```
      SCAP4
 STARTING NUMBERS NR
 WEIGHTS AT AGE WR
 SELECTIVITY AT AGE S83
 RECRUITMENT TO YOUNGEST AGE RR6
 FISHING INTENSITY ER6
 BLENDING (Y OR N)
Y
MIN. MEAT WT.15
0.02 0.05 0.1 0.39 0.77 0.77 0.77 0.77 1 1 1 1 0.58 0.58 0.58 0.58 0.37 0.37 0.37 0.37
```

CATCH (NUMBERS 10*6) 17/ 4/84

Age	1984	1984	1984	1984	1985	1985	1985	1985	1986	1986	1986	1986	1987	1987	1987	1987	1988	1988	1988
3	0	3	6	12	1	10	18	32	0	3	6	13	0	3	6	13	0	3	6
4	6	17	13	6	11	31	23	10	31	102	76	34	12	33	25	11	12	33	25
5	6	15	11	4	3	9	6	3	6	16	11	5	19	53	36	15	6	17	12
6	1	2	2	1	1	3	3	1	1	2	2	1	1	3	3	1	4	11	9
7	0	1	1	3	2	4	3	6	4	7	6	9	7	9	8	8	6	9	8
Σ	13	39	32	26	19	56	53	52	42	130	101	61	39	102	78	49	29	74	60

Age	1988	1989	1989	1989	1989
3	13	0	3	6	13
4	11	12	33	25	11
5	5	6	17	12	5
6	4	1	4	3	1
7	11	9	14	12	24
Σ	44	28	72	58	55

Table 4 continued.

YIELD (MT) 17/ 4/84

Age	1984	1984	1984	1984	1985	1985	1985	1985	1986	1986	1986	1986	1987	1987	1987	1987	1988	1988
3	1	11	22	46	4	37	70	123	1	12	23	49	1	12	23	49	1	12
4	66	189	141	63	117	336	251	113	339	1117	833	375	126	364	271	122	126	364
5	107	292	201	85	62	170	117	49	111	303	208	88	368	1008	693	292	120	328
6	22	66	52	25	30	89	70	33	17	52	41	19	31	92	73	35	102	305
7	7	21	18	98	80	122	104	188	147	216	185	287	214	296	253	278	213	304
Σ	202	580	434	317	293	753	613	506	616	1700	1291	819	740	1772	1314	777	563	1314

Age	1988	1988	1989	1989	1989	1989
3	23	49	1	12	23	49
4	271	122	126	364	271	122
5	226	95	120	328	226	95
6	243	115	33	99	79	38
7	261	350	294	462	396	804
Σ	1024	732	574	1266	996	1108

POPULATION (NUMBERS 10*6) 17/ 4/84

Age	1984	1984	1984	1984	1985	1985	1985	1985	1986	1986	1986	1986	1987	1987	1987	1987	1988	1988	1988
3	185	180	172	163	600	584	560	528	200	195	187	176	200	195	187	176	200	195	187
4	82	74	56	41	147	133	99	74	483	440	328	245	159	143	107	80	159	143	107
5	59	52	36	25	35	31	21	14	62	54	37	26	205	181	124	85	67	59	40
6	15	14	11	9	20	18	14	12	12	11	8	7	21	19	15	12	68	63	50
7	6	5	5	4	11	10	9	8	17	16	14	12	16	15	13	11	21	19	17
Σ	347	326	279	241	812	776	703	635	773	716	575	465	601	553	446	364	514	479	401

Age	1988	1989	1989	1989	1989	1990
3	176	200	195	187	176	200
4	80	159	143	107	80	159
5	28	67	59	40	28	67
6	40	22	20	16	13	22
7	14	47	45	38	33	41
Σ	338	495	462	389	329	489

Table 4 continued.

BIOMASS DISTRIBUTION (%/%) 17/ 4/84

Age	1984	1984	1984	1984	1985	1985	1985	1985	1986	1986	1986	1986
3	21.2	22.5	27.4	32.5	42.0	43.7	49.7	55.1	9.4	10.0	12.5	15.2
4	27.1	26.7	25.3	23.7	29.4	28.5	25.1	22.0	65.3	65.0	63.1	60.8
5	34.2	33.0	28.8	24.9	12.2	11.5	9.4	7.6	14.6	14.1	12.6	11.2
6	11.8	11.9	12.0	12.0	9.7	9.6	9.0	8.4	3.8	3.8	4.0	4.1
7	5.8	5.9	6.4	6.9	6.7	6.7	6.8	6.9	6.9	7.1	7.9	8.7
	3318.0	3037.0	2390.0	1902.0	5433.0	5076.0	4286.0	3644.0	8067.0	7385.0	5676.0	4392.0

Age	1987	1987	1987	1987	1988	1988	1988	1988	1989	1989	1989	1989
3	10.1	10.9	14.0	17.3	12.1	12.9	15.7	18.6	12.8	13.6	16.4	19.2
4	23.1	23.1	22.9	22.5	27.6	27.2	25.8	24.2	29.3	28.7	26.9	24.9
5	52.2	51.0	46.7	42.2	20.3	19.6	17.1	14.8	21.5	20.7	17.8	15.2
6	7.3	7.5	7.9	8.3	29.1	29.2	29.4	29.5	10.0	10.0	10.0	9.9
7	7.2	7.5	8.6	9.7	10.8	11.1	12.1	13.0	26.3	26.9	28.9	30.8
	7492.0	6768.0	5085.0	3861.0	6266.0	5742.0	4528.0	3598.0	5917.0	5439.0	4338.0	3491.0

Age	1990
3	13.3
4	30.4
5	22.3
6	10.4
7	23.6
	5703.0

Table 4 continued.

FISHING SUMMARY 17/ 4/84

	1984	1984	1984	1984	1985	1985	1985	1985	1986	1986
1	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25
2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.82	0.88	1.00
3	15.59	16.94	17.54	17.40	16.13	15.37	15.17	14.89	14.89	15.20
4	12.98	38.73	31.64	26.17	18.64	56.48	53.41	52.21	42.40	130.07
5	202.26	656.11	555.05	455.48	300.61	867.91	810.01	777.18	631.34	1976.79
6	202.26	858.37	1413.42	1868.90	300.61	1168.52	1978.53	2755.71	631.34	2608.13
7	3036.60	2389.60	1902.20	5432.60	5075.60	4286.10	3643.80	8066.70	7385.30	5676.50

	1986	1986	1987	1987	1987	1987	1988	1988	1988	1988
1	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25
2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3	16.82	18.89	19.64	19.54	20.80	21.09	20.51	19.79	20.89	21.68
4	100.64	61.45	38.89	101.81	77.76	49.25	28.54	74.49	59.89	44.14
5	1692.30	1160.75	763.83	1989.52	1617.58	1038.73	585.44	1474.26	1251.21	956.81
6	4300.43	5461.18	763.83	2753.35	4370.93	5409.66	585.44	2059.70	3310.91	4267.72
7	4392.20	7491.80	6768.20	5084.80	3861.10	6265.60	5742.00	4528.20	3598.50	5917.60

	1989	1989	1989	1989
1	4.25	4.25	4.25	4.25
2	1.00	1.00	1.00	1.00
3	21.22	19.90	21.00	24.90
4	28.41	71.57	57.86	55.02
5	602.92	1424.25	1214.84	1369.93
6	602.92	2027.17	3242.01	4611.94
7	5439.20	4338.40	3491.30	5703.40

1: maximum blending age
2: rate on smalls
3: mean weight meat (g)
4: catch (mill.)
5: catch (t)
6: cumulative catch (t)
7: biomass (t)

MORE RUNS WITH THIS DATA

Table 5.- Projection MMW, SMMW, recruitment pulse in 1985 and effort adjusted by a factor of 1.45.

SCAP4
STARTING NUMBERS NR
WEIGHTS AT AGE WR

SELECTIVITY AT AGE SMMW
RECRUITMENT TO YOUNGEST AGE RR6
FISHING INTENSITY ER6×1.45
BLENDING (Y OR N)
N
MIN. MEAT WT.11.3
0 0 0 0 0 1 1 1 0.67 0.67 0.67 0.67 0.34 0.34 0.34 0.34 0.18 0.18 0.18 0.18

CATCH (NUMBERS 10*6) 17/ 4/84

Age	1984	1984	1984	1984	1985	1985	1985	1985	1986	1986	1986	1986	1987	1987	1987	1987	1988	1988	1988
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	32	19	7	0	64	38	14	0	208	122	45	0	69	41	15	0	69	41
5	5	15	10	4	2	5	4	2	4	10	7	3	12	33	23	10	4	11	8
6	1	2	2	1	1	3	2	1	0	1	1	0	1	2	2	1	2	7	5
7	0	0	0	3	2	4	3	6	5	7	6	10	7	11	9	9	6	10	9
Σ	6	49	31	15	5	76	47	23	9	227	137	59	20	116	75	35	13	97	63

Age	1988	1989	1989	1989	1989
3	0	0	0	0	0
4	15	0	69	41	15
5	3	4	11	8	3
6	3	1	2	2	1
7	10	8	13	11	20
Σ	31	13	95	62	39

Table 5 continued.

YIELD (MT) 17/ 4/84

Age	1984	1984	1984	1984	1985	1985	1985	1985	1986	1986	1986	1986	1987	1987	1987	1987	1988	1988
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	345	202	75	0	699	411	152	0	2271	1333	495	0	757	444	165	0	757
5	103	285	198	84	35	97	67	29	71	197	137	58	232	639	444	189	77	213
6	19	57	47	23	26	79	65	32	9	27	22	11	18	55	45	22	58	178
7	5	16	14	97	75	121	108	204	152	239	212	331	235	349	310	295	213	323
Σ	127	702	461	279	136	997	651	417	232	2733	1705	895	484	1800	1244	671	348	1471

Age	1988	1988	1989	1989	1989	1989
3	0	0	0	0	0	0
4	444	165	0	757	444	165
5	148	63	77	213	148	63
6	146	71	19	59	49	24
7	287	337	257	412	367	659
Σ	1026	636	353	1441	1008	911

POPULATION (NUMBERS 10*6) 17/ 4/84

Age	1984	1984	1984	1984	1985	1985	1985	1985	1986	1986	1986	1986	1987	1987	1987	1987	1988	1988	1988
3	185	180	176	171	600	585	571	557	200	195	190	186	200	195	190	186	200	195	190
4	82	80	47	28	167	163	96	56	543	529	311	183	181	176	104	61	181	176	104
5	59	53	37	25	20	18	12	9	41	36	25	18	133	118	82	57	44	39	27
6	15	14	11	9	20	19	16	13	7	6	5	4	14	13	11	9	46	43	35
7	6	6	5	4	12	12	10	9	20	19	17	15	18	17	15	13	20	19	17
Σ	347	332	276	238	820	797	705	643	811	786	548	405	546	519	402	326	491	473	373

Age	1988	1989	1989	1989	1989	1990
3	186	200	195	190	186	200
4	61	181	176	104	61	181
5	19	44	39	27	19	44
6	29	15	14	12	10	15
7	15	39	37	33	30	36
Σ	309	480	462	366	305	477

Table 5 continued.

BIOMASS DISTRIBUTION (°/°) 17/ 4/84

Age	1984	1984	1984	1984	1985	1985	1985	1985	1986	1986	1986	1986
3	21.2	22.0	28.5	35.6	42.0	42.5	51.6	59.8	9.2	9.3	13.7	19.4
4	27.1	28.2	22.0	16.5	33.5	34.0	24.8	17.3	71.3	72.2	64.1	54.7
5	34.2	32.3	29.8	26.6	7.1	6.5	5.7	4.7	9.4	8.7	9.1	9.2
6	11.8	11.7	12.8	13.4	10.0	9.7	9.9	9.7	2.2	2.2	2.7	3.2
7	5.8	5.8	6.9	7.9	7.4	7.3	8.1	8.5	7.8	7.7	10.4	13.5
	3318.0	3111.0	2341.0	1828.0	5435.0	5230.0	4205.0	3536.0	8298.0	7997.0	5286.0	3636.0

Age	1987	1987	1987	1987	1988	1988	1988	1988	1989	1989	1989	1989
3	12.2	12.7	17.2	22.5	13.9	14.3	18.7	23.5	14.4	14.8	19.1	23.8
4	31.6	33.1	26.9	21.2	36.1	37.1	29.2	22.1	37.3	38.3	29.9	22.4
5	40.8	38.7	37.3	34.8	15.5	14.5	13.5	12.1	16.1	14.9	13.8	12.3
6	6.0	6.0	6.8	7.5	22.4	21.9	24.1	25.6	7.7	7.5	8.2	8.6
7	9.3	9.5	11.7	14.0	12.1	12.1	14.5	16.6	24.5	24.5	29.0	32.9
	6234.0	5819.0	4197.0	3130.0	5466.0	5181.0	3866.0	2995.0	5283.0	5025.0	3780.0	2961.0

Age	1990
3	14.7
4	38.2
5	16.4
6	7.9
7	22.8
	5169.0

Table 5 continued.

FISHING SUMMARY 17/ 4/84

	1984	1984	1984	1984	1985	1985	1985	1985	1986	1986
1	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3	20.27	16.33	18.82	24.00	28.22	15.27	17.88	23.64	28.57	14.18
4	6.25	49.15	31.12	15.11	5.08	75.90	46.92	22.87	8.68	226.92
5	126.77	802.85	585.75	362.76	143.45	1158.92	839.13	540.64	248.13	3217.90
6	126.77	929.62	1515.37	1878.13	143.45	1302.37	2141.50	2682.14	248.13	3466.03
7	3111.20	2341.30	1828.40	5434.90	5230.20	4204.80	3536.10	8297.80	7997.40	5286.10

	1986	1986	1987	1987	1987	1987	1988	1988	1988	1988
1	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3	16.53	20.93	25.60	17.78	20.55	24.68	29.27	17.36	20.30	25.51
4	136.78	58.93	19.93	115.56	75.16	34.84	12.69	97.07	62.73	31.33
5	2260.65	1233.68	510.40	2054.31	1544.62	859.77	371.59	1684.83	1273.70	799.17
6	5726.68	6960.36	510.40	2564.71	4109.33	4969.10	371.59	2056.42	3330.12	4129.29
7	3636.30	6233.80	5818.90	4196.90	3130.10	5465.70	5180.40	3866.50	2994.60	5282.90

	1989	1989	1989	1989
1	4.00	4.00	4.00	4.00
2	1.00	1.00	1.00	1.00
3	30.21	17.35	20.35	28.00
4	12.56	95.35	61.50	39.35
5	379.57	1654.63	1251.27	1101.99
6	379.57	2034.20	3285.47	4387.46
7	5024.50	3780.30	2961.10	5168.60

1: maximum blending age
2: rate on smalls
3: mean weight meat (g)
4: catch (mill.)
5: catch (t)
6: cumulative catch (t)
7: biomass (t)

MORE RUNS WITH THIS DATA

Table 6.- Projection 24 MC, S83, recruitment pulse in 1985.

```
      SCAP4
 STARTING NUMBERS NR
 WEIGHTS AT AGE WR
 SELECTIVITY AT AGE S83
 RECRUITMENT TO YOUNGEST AGE RR6
 FISHING INTENSITY ER6
 BLENDING (Y OR N)
Y
MIN. MEAT WT.19
0.02 0.05 0.1 0.39 0.77 0.77 0.77 0.77 1 1 1 1 0.58 0.58 0.58 0.58 0.37 0.37 0.37 0.37
```

CATCH (NUMBERS 10*6) 17/ 4/84

Age	1984	1984	1984	1984	1985	1985	1985	1985	1986	1986	1986	1986	1987	1987	1987	1987	1988	1988	1988
3	0	1	3	8	1	4	7	13	0	1	3	13	0	3	6	13	0	3	6
4	1	9	10	5	5	13	11	5	11	33	45	53	12	35	26	12	12	33	25
5	6	15	11	4	5	13	9	4	10	27	19	8	31	86	59	25	7	18	12
6	1	2	2	1	1	3	3	1	1	3	2	1	2	6	5	2	6	19	15
7	0	1	1	3	2	4	3	6	4	7	6	9	7	9	8	10	8	11	10
Σ	8	28	26	22	14	37	33	29	27	70	75	83	52	139	104	62	32	85	68

Age	1988	1989	1989	1989	1989
3	13	0	3	6	13
4	11	12	33	25	11
5	5	6	17	12	5
6	7	1	4	3	1
7	15	13	21	18	39
Σ	52	33	79	64	69

Table 6 continued.

YIELD (MT) 17/ 4/84

Age	1984	1984	1984	1984	1985	1985	1985	1985	1986	1986	1986	1986	1987	1987	1987	1987	1988
3	0	5	12	31	2	13	25	49	0	3	10	48	1	12	23	49	1
4	16	94	104	59	60	144	124	58	120	358	494	574	131	378	282	127	126
5	107	292	201	85	91	249	171	72	191	523	359	152	600	1643	1129	476	125
6	22	66	52	25	30	89	70	33	25	75	60	28	53	158	126	60	166
7	7	21	18	98	80	122	104	188	147	216	185	287	218	306	262	324	255
Σ	152	478	388	298	262	616	495	400	484	1176	1108	1089	1003	2497	1822	1036	673

Age	1988	1988	1988	1989	1989	1989	1989
3	12	23	49	1	12	23	49
4	364	271	122	126	364	271	122
5	341	235	99	120	328	226	95
6	498	396	188	34	103	82	39
7	376	322	506	432	691	593	1270
Σ	1591	1247	964	714	1499	1195	1576

POPULATION (NUMBERS 10*6) 17/ 4/84

Age	1984	1984	1984	1984	1985	1985	1985	1985	1986	1986	1986	1986	1987	1987	1987	1987	1988	1988	1988
3	185	180	174	167	600	585	567	546	200	195	189	182	200	195	187	176	200	195	187
4	82	79	68	57	155	145	129	114	520	496	452	396	165	149	111	83	159	143	107
5	59	52	36	25	51	45	31	21	106	94	64	44	334	295	203	139	69	61	42
6	15	14	11	9	20	18	14	12	17	16	12	10	35	33	26	21	111	102	81
7	6	5	5	4	11	10	9	8	17	16	14	12	19	18	15	13	30	28	24
Σ	347	330	294	262	836	803	750	701	860	816	731	644	754	689	542	432	569	530	441

Age	1988	1989	1989	1989	1989	1990
3	176	200	195	187	176	200
4	80	159	143	107	80	159
5	29	67	59	40	28	67
6	65	23	21	17	13	22
7	21	75	70	60	52	58
Σ	370	523	489	411	349	506

Table 6 continued.

BIOMASS DISTRIBUTION (%) 17/ 4/84

Age	1984	1984	1984	1984	1985	1985	1985	1985	1986	1986	1986	1986
3	21.2	22.2	26.1	30.3	39.1	40.5	44.7	48.5	8.0	8.3	9.4	10.7
4	27.1	27.9	29.4	29.9	28.9	28.9	29.1	29.1	59.9	60.9	64.3	66.4
5	34.2	32.4	27.1	22.6	16.6	15.5	12.2	9.4	21.5	20.2	16.1	13.0
6	11.8	11.7	11.3	10.9	9.1	8.9	8.0	7.2	4.8	4.7	4.3	4.0
7	5.8	5.8	6.1	6.3	6.2	6.2	6.1	5.9	5.9	5.9	5.9	5.9
	3318.0	3087.0	2538.0	2093.0	5824.0	5488.0	4823.0	4284.0	9464.0	8878.0	7650.0	6497.0

Age	1987	1987	1987	1987	1988	1988	1988	1988	1989	1989	1989
3	7.2	7.8	10.2	12.8	9.8	10.4	12.6	14.9	11.1	11.7	14.0
4	17.1	17.2	17.3	17.3	22.3	21.9	20.7	19.3	25.3	24.8	22.9
5	60.7	59.5	55.4	51.0	17.1	16.4	14.2	12.3	18.6	17.8	15.2
6	9.0	9.2	9.9	10.5	38.2	38.3	38.5	38.4	9.0	9.0	8.9
7	6.0	6.2	7.2	8.3	12.6	12.9	14.0	15.1	36.0	36.7	39.0
	10511.0	9454.0	6988.0	5215.0	7765.0	7126.0	5642.0	4496.0	6844.0	6310.0	5084.0

Age	1989	1990
3	16.2	12.1
4	21.1	27.6
5	12.9	20.3
6	8.7	9.4
7	41.2	30.6
	4129.0	6283.0

Table 6 continued.

FISHING SUMMARY 17/ 4/84

	1984	1984	1984	1984	1985	1985	1985	1985	1986	1986
1	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75
2	0.23	0.43	0.57	0.66	0.48	0.36	0.35	0.31	0.28	0.26
3	18.59	18.85	18.86	18.89	18.86	18.84	18.87	18.90	18.82	18.83
4	8.16	28.31	25.86	21.96	14.33	36.77	32.76	29.02	26.51	70.47
5	151.68	533.71	487.64	414.78	270.20	692.80	618.16	548.47	498.84	1327.36
6	151.68	685.39	1173.03	1587.81	270.20	963.00	1581.16	2129.63	498.84	1826.20
7	3086.50	2538.50	2092.80	5824.30	5487.60	4823.20	4283.70	9463.60	8878.40	7650.20

	1986	1986	1987	1987	1987	1987	1988	1988	1988	1988
1	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75
2	0.40	0.94	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3	18.84	18.82	19.58	20.04	21.47	22.16	21.56	20.94	22.09	23.57
4	74.53	83.05	52.40	139.17	103.83	61.66	32.46	84.54	67.94	51.79
5	1404.49	1563.29	1025.91	2789.27	2228.79	1366.62	699.83	1770.55	1501.08	1220.84
6	3230.69	4793.98	1025.91	3815.18	6043.97	7410.59	699.83	2470.38	3971.46	5192.30
7	6497.30	10510.80	9454.00	6987.70	5215.30	7765.50	7126.20	5642.00	4496.10	6844.40

	1989	1989	1989	1989
1	4.75	4.75	4.75	4.75
2	1.00	1.00	1.00	1.00
3	23.12	21.32	22.43	27.30
4	32.66	78.69	63.95	69.24
5	755.25	1677.70	1434.53	1890.22
6	755.25	2432.95	3867.48	5757.70
7	6310.10	5083.50	4129.00	6283.30

1: maximum blending age
2: rate on smalls
3: mean weight meat (g)
4: catch (mill.)
5: catch (t)
6: cumulative catch (t)
7: biomass (t)

MORE RUNS WITH THIS DATA

Table 7.- Summary 30MC, S83, low recruitment pulses.

	Biomass distribution (%) at the end of the year					
Age	1984	1985	1986	1987	1988	1989
3	32.5	29.0	25.8	24.2	23.2	22.6
4	23.7	34.8	33.5	31.5	30.2	29.3
5	24.9	12.0	18.9	19.2	18.4	17.9
6	12.0	13.3	6.9	11.6	12.0	11.7
7	6.9	10.9	14.8	13.5	16.3	18.5

Fishing summary

(1) Range of MC during year (2) Catch (t) (3) Biomass (t) (end of year)

	1984	1985	1986	1987	1988	1989
(1)	26-29	25-27	23-26	21-24	22-24	21-23
(2)	1869	2460	3181	3589	3704	3977
(3)	3913	4533	4854	5038	5153	5225

Table 8.- Summary MMW, SMMW, low recruitment pulses, effort adjusted 1.45X.

	Biomass distribution (%) at the end of the year					
Age	1984	1985	1986	1987	1988	1989
3	35.6	33.2	30.5	29.3	28.4	27.7
4	16.5	28.8	28.7	27.6	26.7	26.1
5	26.6	7.8	14.5	15.1	14.6	14.3
6	13.4	16.1	5.0	9.8	10.3	10.0
7	7.9	14.2	21.2	18.2	20.0	21.9

Fishing summary

(1) Range of MC during year (2) Catch (t) (3) Biomass (t) (end of year)

	1984	1985	1986	1987	1988	1989
(1)	19-28	16-30	16-28	15-27	15-27	15-27
(2)	1878	2682	3414	3821	3799	3968
(3)	3915	4353	4538	4650	4727	4781

Table 9.- Summary 30MC, S83, recruitment pulse in 1985.

	Biomass distribution (%) at the end of the year					
Age	1984	1985	1986	1987	1988	1989
3	32.5	55.1	15.2	17.3	18.6	19.2
4	23.7	22.0	60.8	22.5	24.2	24.9
5	24.9	7.6	11.2	42.2	14.8	15.2
6	12.0	8.4	4.1	8.3	29.5	9.9
7	6.9	6.9	8.7	9.7	13.0	30.8

Fishing summary

(1) Range of MC during year (2) Catch (t) (3) Biomass (t) (end of year)

	1984	1985	1986	1987	1988	1989
(1)	26-29	28-30	24-30	22-23	21-23	18-23
(2)	1869	2756	5461	5410	4268	4612
(3)	5433	8067	7492	6266	5918	5703

Table 10.- Summary MMW, SMMW, recruitment pulse in 1985, effort adjusted by a factor of 1.45.

	Biomass distribution (%) at the end of the year					
Age	1984	1985	1986	1987	1988	1989
3	35.6	59.8	19.4	22.5	23.5	23.8
4	16.5	17.3	54.7	21.2	22.1	22.4
5	26.6	4.7	9.2	34.8	12.1	12.3
6	13.4	9.7	3.2	7.5	25.6	8.6
7	7.9	8.5	13.5	14.0	16.6	32.9

Fishing summary

(1) Range of MC during year (2) Catch (t) (3) Biomass (t) (end of year)

	1984	1985	1986	1987	1988	1989
(1)	19-28	16-30	16-32	18-26	15-26	15-26
(2)	1878	2682	6960	4969	4129	4387
(3)	5435	8298	6234	5466	5283	5169

Table 11 - Summary 24MC, S83, recruitment pulse in 1985.

	Biomass distribution (%) at the end of the year					
Age	1984	1985	1986	1987	1988	1989
3	30.3	48.5	10.7	12.8	14.9	16.2
4	29.9	29.1	66.4	17.3	19.3	21.1
5	22.6	9.4	13.0	51.0	12.3	12.9
6	10.9	7.2	4.0	10.5	38.4	8.7
7	6.3	5.9	5.9	8.3	15.1	41.2

Fishing summary

(1) Range of MC during year (2) Catch (t) (3) Biomass (t) (end of year)

	1984	1985	1986	1987	1988	1989
(1)	24	24	24	20-33	19-22	17-21
(2)	1588	2130	4794	7411	5192	5758
(3)	5824	9464	10511	7766	6844	6283

TABLE 12 YIELD PER RECRUIT RESULTS
(Grams Per Individual)

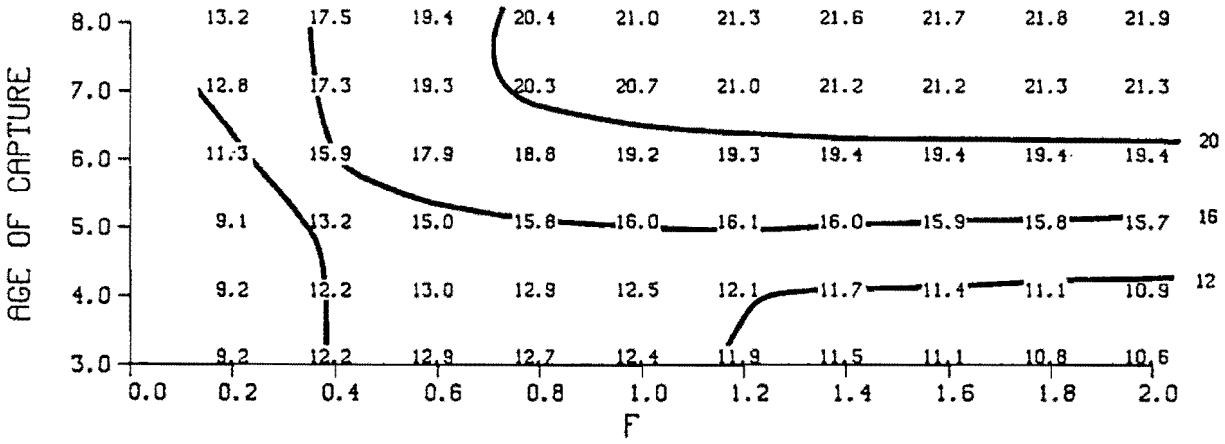

TABLE 12A PARTIAL RECRUITMENT S-1983

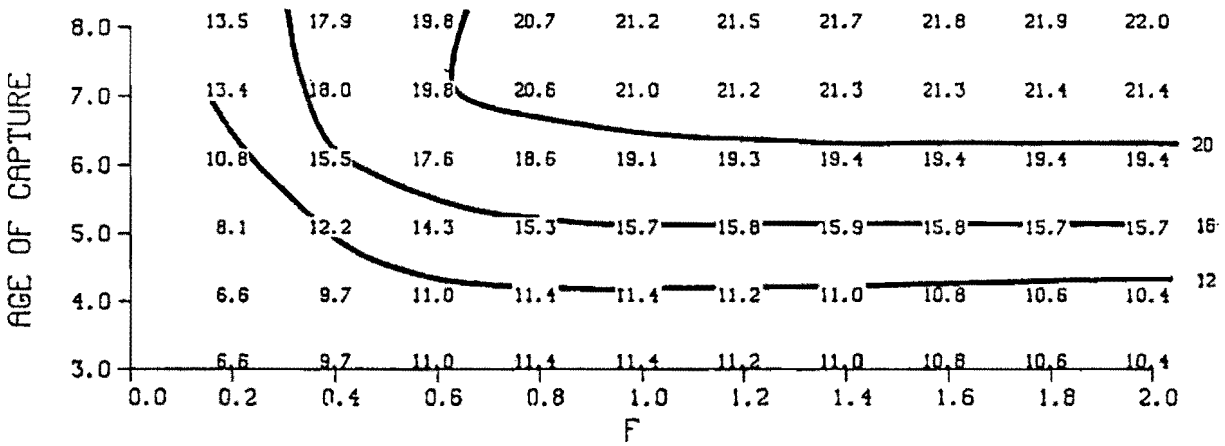

TABLE 12B PARTIAL RECRUITMENT S-MMW

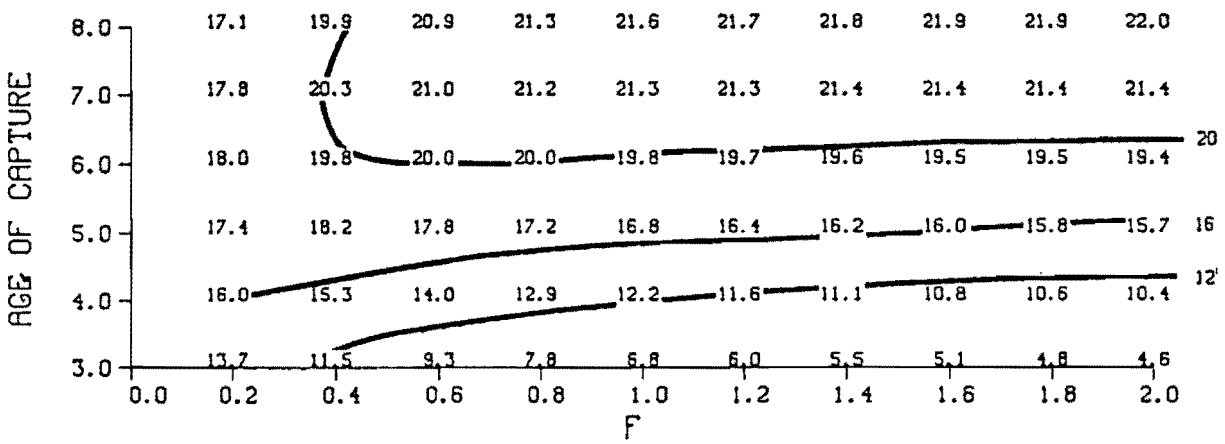

TABLE 12C KNIFE-EDGE RECRUITMENT

Appendix A. Annotated listing of projection program.

```
      VSCAP5
[1]    NX←,INPUT' STARTING NUMBERS '
[2]    WX←INPUT' WEIGHTS AT AGE '
[3]    SX←INPUT' SELECTIVITY AT AGE '
[4]    R←,INPUT' RECRUITMENT TO YOUNGEST AGE '
[5]   NEWF:F←,INPUT' FISHING INTENSITY '
[6]    ' BLENDING (Y OR N) '
[7]    W←WX
[8]    S←SX
[9]    BO←'Y'=1↑,⎕ ⍝ FLAG FOR BLENDING
[10]   N←((⍴NX),1)⍴NX
[11]   M←0.025 ⍝ QUARTERLY NATURAL MORTALITY
[12]   FH←(5,⍴F)⍴T←0
[13]   AVE←INPUT'MIN. MEAT WT.'
[14]   →BO/SK1
[15]   S[(AVE>WX)/⍳⍴S]←0
[16]  SK1:S←S÷⌈/S ⍝ NORMALIZE SELECTIVITY
[17]   2 ROUND S
[18]   AG←2+⌈0.25×⍳⍴S ⍝ AGE VECTOR FOR QUARTERLY OUTPUT
[19]   C←((⍴S),0)⍴0
[20]  LP:→((⍴F)<T←T+1)/OP ⍝ LOOP OVER PERIODS WITH COUNTER T
[21]   CO←(⍴S)⍴1
[22]   KT←0
[23]  AGN:Z←M+F[T]×S×CO ⍝ ITERATIVE LOOP TO FIND BLENDING RATE
[24]   CT←(F[T]×S×CO×N[;T])×((¯1↓(1-*-Z)),1)÷Z
[25]   AW←(+/CT×W)÷+/CT ⍝ AVERAGE WEIGHT OF CATCH
[26]   L←(W<AVE)/⍳⍴W ⍝ AGES BENEATH TARGET WEIGHT (AVERAGE)
[27]   →(~BO)/SK
[28]   →(0.01>|(AVE-AW)÷AVE)/SK ⍝ IS AVERAGE WEIGHT WITHIN .01 OF TARGET
[29]   CO[L]←CO[L]×(AW÷AVE)*2 ⍝ NO  -  ADJUST FISHING INTENSITY
[30]   →((CO[1]<1)∧10>KT←KT+1)/AGN ⍝  TRY TEN TIMES IF NECESSARY
[31]  SK:C←C,CT
[32]   NE←(*-Z)×N[;T]
[33]   FH[;T]←2 ROUND(2.75+0.25×¯1↑L),(1⌊CO[1]),AW,(+⌿CT),AW×+⌿CT
[34]   NE[¯1+⍴S]←+/NE[0 ¯1+⍴S] ⍝ ACCUMULATE COMPLETE AGE CLASS
[35]   N←N,0,¯1↓NE
[36]   QR←1+4|T
[37]   N[QR;T+1]←N[QR;T+1]+R[T] ⍝ ADD IN RECRUITMENT
[38]   →LP
[39]  OP:YR←1984+⌊0.25×¯1+⍳1+4×⍴F
[40]   →(~SQZON)/SK2 ⍝ SQUEEZE FLAG TO CONDENSE OUTPUT
[41]   C←4 SQZ C
[42]   N←4 SQZ N
[43]   W←((⍴W)⍴1 0 0 0)/W
[44]   AG←2+⍳⍴W
[45]  SK2:TTT←'CATCH (NUMBERS 10*6) ' ⍝ BEGIN DETAILED OUTPUT
[46]   →(FASTON)/FAST
[47]   0 OUT4 C⍕+⌿C
[48]   TTT←'YIELD (MT)'
[49]   NE←C×⍉(⌽⍴C)⍴W
[50]   0 OUT4 NE⍕+⌿NE
[51]   TTT←'POPULATION (NUMBERS 10*6) '
[52]   0 OUT N⍕+⌿N
[53]   TTT←'BIOMASS DISTRIBUTION (∘/∘) '
[54]   B←N×⍉(⌽⍴N)⍴W
[55]   1 OUT(100×B÷(⍴B)⍴+⌿B)⍕0 ROUND+⌿B
[56]  FAST:AG←⍳6
[57]   B←1 ROUND N×⍉(⌽⍴N)⍴W
[58]   TTT←' FISHING SUMMARY '
[59]   FORGIN,0 2↓2 OUT(FH⍕,+\((((1↓⍴FH)÷4),4)⍴FH[5;]))⍕1↓++⌿B
[60]   'MORE RUNS WITH THIS DATA'
[61]   →('Y'=1↑Y←,⎕)/NEWF
      ∇
```