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# AN ASSESSMENT OF SCALLOP, PECTEN MAXIMUS (L.), STOCKS OFF SOUTH-WEST SCOTLAND

by

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## Abstract

The history of the scallop fishery west of Kintyre is reviewed. In recent years this has been the largest Scottish scallop fishery. This paper brings up to date the assessment of this fishery made in 1976. The results of virtual population analyses are presented. Yield per recruit and biomass per recruit are examined in relation to estimated levels of exploitation and conclusions are drawn referring to possible changes in fishing policy, in particular the introduction of a minimum legal landing size of 95 or 110 mm.

## Résumé

On examine l'histoire de la pêche aux coquilles St Jacques à l'ouest de Kintyre. Dans ces dernières années cette pêcherie a été la plus importante de l'Écosse à l'égard du pecten. Ce mémoire tient à jour l'évoluation de cette pêcherie faite en 1976. Les résultats des analyses virtuelles de la population sont présentés. On examine le rendement par recrue et la biomasse par recrue relativement aux nivaux estimatifs d'exploitation et on tire des conclusions à propos des modifications possibles de la conduite de la pêche, notamment l'introduction, selon les lois d'une taille minimum pour la sortie de l'eau de 95 ou 110 mm.

## Introduction

The population dynamics of recently-established and long established scallop fisheries off the south-west of Scotland were compared using data up to 1975 (Mason, Nicholson and Shanks, 1979). Exploitation of the stocks in the Clyde sea area has since been at a low level. The fishery west of Kintyre has, however, remained the most important in Scotland, and this paper brings up to date the earlier assessment. In view of the proposed introduction of protective legislation, yield per recruit and biomass per recruit are examined in relation to estimated levels of exploitation and conclusions drawn relating to possible changes in fishing policy.

## Material and Methods

The scallop stock west of Kintyre consists of discrete concentrations which, as in the earlier paper, are considered as one unit because of the practice by fishermen of moving from one concentration to another. Again, because the annual growth ring is laid down in the spring when growth recommences after the winter cessation, all material has been related to a "scallop year" 1 April-31 March.

Age and length composition data were obtained by sampling commercial landings. Virtually all scallops caught by commercial dredges are landed. Commercial statistics provide total landings and number of hours' fishing but take no account of the number of dredges used. Estimates of total effort taking this into account were therefore obtained by getting from selected vessels details of catch, number of dredges used and numbers of hours fished. Catch per unit effort (CPUE) is expressed as numbers of scallops per unit of fishing time per unit of dredge width.

## Catch per Unit Effort and Stock Composition

The scallop stock west of Kintyre was virtually unfished before 1966 but has since been heavily exploited. The total landings rose rapidly to a peak of 1918 t in 1968-69, fell to 317 t in 1972-73 as boats switched to queen fishing but had increased to 1153 t in 1974-75. Landings have since remained high in the late 1970s, ranging from 1087 t to 1517 t per year (Table I). CPUE was at first high, as might be expected in a new fishery, but it fell to half its original value by 1971-72. The increase in CPUE which followed in 1973-75 has been maintained subsequently (Table I), coincident with improved recruitment, 2-, 3- and 4-ring scallops having become much more abundant in the landings than older individuals (Table II).

## Population Assessments

The number of scallops of each age landed in each of the years 1975-76 to 1978-79 was estimated from total landings and age composition data obtained by sampling. These data, along with the data used in the previous (1976) analysis (Mason et al., 1979) are given in Table II. Estimates of fishing mortality and total number of scallops in the sea at each age were obtained from virtual population analyses (Gulland, 1965). Values for the instantaneous natural mortality coefficient, M, which is assumed to be constant, and the exploitation rate F/Z for the oldest animals in the catch are necessary to carry out the analyses. A range of values of M from 0.1 to 1.0 were used in conjunction with several input values of F/Z between 0.4 and 0.7. The resulting estimated fishing mortalities were averaged and plotted and it was found that the array derived using a value of M of 0.15 and of F/Z of 0.6 (Table III) gave values which closely followed a sigmoid curve with increasing age. The value of M agrees with the findings of the previous analysis. The value of F/Z, used in the previous analysis was, however, 0.7. The sigmoid curve of fishing mortalities which was constructed from the average fishing mortality at age for the years 1966-67 to 1977-78 was used to produce smoothed estimates of fishing mortality at age (Table IV).

The estimated numbers of scallops of each age present in the sea are shown in Table V. The most striking changes in number which have occurred during the period of the analysis are i) the decrease in numbers of the oldest age groups, ie 8+, 9+ and > 9+ ( the stock had been virtually unfished prior to 1966), ii) the large increase in the numbers of the 2+ to 4+ age groups and iii) the appearance of the very good 1973-74 year class.

From the fishing mortalities given in Table IV the two quantities, yield per recruit (YPR) and biomass per recruit (BPR) were calculated.

YPR and BPR are expressed in terms of muscle weight. Table VI gives the mean muscle weight at age of scallops from west of Kintyre. Very few 1+ scallops are caught and virtually all these are discarded. Since their adductor muscles are too small to provide a saleable yield these few scallops were omitted from the summations for YPR and BPR as in the previous analysis. BPR can therefore be interpreted as reflecting the biomass per recruit of the saleable stock and coincidentally of the breeding stock.

The effect of varying the array of fishing mortalities given in Table IV was investigated. In particular the effect on YPR and BPR of a) multiplying the complete age array of F values by a constant K, which if less than unity corresponds to a decrease in fishing effort and if greater than unity corresponds to an increase in fishing effort, and b) shifting the F array relative to the ages for which it was calculated, which corresponds to changing the age at first capture. Table VII shows the YPR and BPR values found by multiplying the array of fishing mortalities by a factor of K equal to $\frac{1}{3}$, $\frac{1}{2}$, 1, 2 and 3 and by shifting the array by -2, -1, 0, 1 and 2 years. The estimated present yield per recruit is 10.3 g muscle weight and the biomass per recruit is 90.5 g. The corresponding YPR and BPR values found in the previous assessment were 11.3 g and 76 g respectively.

## Results and Conclusions

During the period 1974 to 1979 the stock west of Kintyre appears to have been in a healthy state in terms of both total yield and total biomass and recruitment has been at a high level (Table VIII). Both are higher than at the times of the previous assessment and indeed have increased markedly from the period of poor recruitment (1967-1972) to the period of good recruitment (1974-1979). However, the effect on equilibrium yield of changes in fishing mortality rate or in age at first capture have been assessed and the results are summarised below.

Assuming no reduction in age at first capture, YPR increases with increasing fishing mortality rate over the range of values studied (Table VII). A reduction in fishing effort would not therefore result in an increase in YPR. Increasing fishing effort from its present level would increase YPR only slightly and would do so at the expense of a considerable decrease in biomass. Environmental factors as well as stock size are important in determining recruitment in lamellibranch molluscs. However, although no definite recruitment/stock relationship has been established it would be unwise to reduce biomass to such an extent that recruitment might be endangered.

Consideration is being given to the introduction of minimum legal landing sizes in the scallop fisheries of the United Kingdom. Two values being considered are 95 mm and 110 mm overall length. The introduction of a minimum legal landing size of 110 mm west of Kintyre (equivalent to a delay of one year in age at first capture) would slightly reduce the yield per recruit, but increase the biomass per recruit, and hence, if recruitment is maintained at its current level, total biomass also. However, owing to different growth rates in different stocks, 110 mm minimum would have the effect in some slow-growing stocks (eg off the south-west of England) of virtually closing the fishery, since few scallops would ever reach the minimum size.

The national minimum landing size decided on is 95 mm which, west of Kintyre, is equivalent to reducing the age at first capture by half a year, would have very little effect on yield per recruit but would slightly decrease biomass per recruit. However, few scallops smaller than 100 mm are caught and most of these are returned to the sea. Experiments have shown that scallops returned show a high degree of survival (Chapman, Mason and Kinnear, 1977). It is almost certain that fishermen would continue voluntarily to discard these small scallops owing to their low market value. Therefore the proposed legislation would have little or no effect on this stock.

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References

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Table I Total landings of scallops and total effort, together with catch per unit effort as calculated from samples of selected vessels from west of Kintyre

| Year | Landings (tonnes) | Effort (100 metre hours) | C.P.U.E. (kg/10 metre h) |
|---|---|---|---|
| 1966 - 67 | 451 | 217 | 208 |
| 1967 - 68 | 884 | 413 | 214 |
| 1968 - 69 | 1918 | 945 | 203 |
| 1969 - 70 | 1549 | 962 | 161 |
| 1970 - 71 | 556 | 415 | 134 |
| 1971 - 72 | 728 | 743 | 98 |
| 1972 - 73 | 317 | 273 | 116 |
| 1973 - 74 | 578 | 431 | 134 |
| 1974 - 75 | 1153 | 908 | 127 |
| 1975 - 76 | 1274 | 861 | 148 |
| 1976 - 77 | 1517 | 966 | 157 |
| 1977 - 78 | 1269 | 933 | 136 |
| 1978 - 79 | 1087 | 856 | 127 |

Table II Estimated numbers (00s) of scallops landed by age from west of Kintyre.

| Age | 1966-67 | 1967-68 | 1968-69 | 1969-70 | 1970-71 | 1971-72 | 1972-73 | 1973-74 | 1974-75 | 1975-76 | 1976-77 | 1977-78 | 1978-79 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2+ | - | 252 | 639 | 664 | 239 | 208 | 468 | 1 459 | 3 631 | 6 741 | 4 300 | 2 998 | 2 157 |
| 3+ | 687 | 1 052 | 1 918 | 3 908 | 1 088 | 1 109 | 483 | 2 505 | 11 608 | 12 880 | 14 907 | 6 115 | 7 446 |
| 4+ | 902 | 3 240 | 2 923 | 6 121 | 2 336 | 2 808 | 814 | 3 028 | 6 877 | 14 505 | 17 558 | 11 391 | 5 803 |
| 5+ | 2 061 | 3 198 | 5 024 | 7 006 | 2 150 | 4 402 | 1 870 | 2 477 | 4 181 | 6 982 | 11 968 | 13 345 | 9 911 |
| 6+ | 1 009 | 3 829 | 10 688 | 7 964 | 2 044 | 3 917 | 2 353 | 4 514 | 3 961 | 6 982 | 5 088 | 8 273 | 7 446 |
| 7+ | 1 653 | 3 703 | 9 958 | 10 914 | 1 805 | 4 645 | 2 262 | 4 046 | 5 336 | 2 829 | 3 153 | 5 455 | 4 673 |
| 8+ | 1 267 | 3 914 | 9 501 | 8 407 | 1 752 | 4 264 | 1 840 | 2 698 | 4 456 | 3 611 | 3 727 | 4 676 | 5 033 |
| 9+ | 1 374 | 3 661 | 7 948 | 6 121 | 2 283 | 2 531 | 1 026 | 1 349 | 3 246 | 1 745 | 2 365 | 2 878 | 3 543 |
| >9+ | 12 517 | 19 231 | 42 753 | 22 639 | 12 795 | 10 780 | 3 982 | 5 450 | 11 608 | 3 912 | 6 593 | 4 796 | 5 341 |

Table III Fishing mortality coefficients at each age derived by virtual population analysis for scallops west of Kintyre.

M = 0.15 F/Z = 0.60

| Age | 1966-67 | 1967-68 | 1968-69 | 1969-70 | 1970-71 | 1971-72 | 1972-73 | 1973-74 | 1974-75 | 1975-76 | 1976-77 | 1977-78 | 1978-79 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2+ | 0.000 | 0.004 | 0.008 | 0.010 | 0.004 | 0.002 | 0.004 | 0.012 | 0.022 | 0.027 | 0.025 | 0.014 | 0.011 |
| 3+ | 0.011 | 0.013 | 0.037 | 0.061 | 0.019 | 0.020 | 0.006 | 0.027 | 0.114 | 0.096 | 0.073 | 0.042 | 0.043 |
| 4+ | 0.015 | 0.063 | 0.042 | 0.149 | 0.044 | 0.059 | 0.018 | 0.045 | 0.092 | 0.193 | 0.173 | 0.070 | 0.048 |
| 5+ | 0.029 | 0.065 | 0.124 | 0.126 | 0.068 | 0.104 | 0.048 | 0.065 | 0.077 | 0.121 | 0.228 | 0.183 | 0.076 |
| 6+ | 0.016 | 0.065 | 0.303 | 0.278 | 0.047 | 0.161 | 0.071 | 0.148 | 0.133 | 0.170 | 0.115 | 0.230 | 0.139 |
| 7+ | 0.023 | 0.071 | 0.227 | 0.541 | 0.088 | 0.135 | 0.125 | 0.158 | 0.247 | 0.125 | 0.102 | 0.165 | 0.186 |
| 8+ | 0.013 | 0.067 | 0.247 | 0.287 | 0.145 | 0.291 | 0.069 | 0.203 | 0.248 | 0.249 | 0.228 | 0.205 | 0.213 |
| 9+ | 0.039 | 0.046 | 0.178 | 0.235 | 0.111 | 0.302 | 0.099 | 0.063 | 0.378 | 0.137 | 0.242 | 0.261 | 0.223 |
| >9+ | 0.225 | 0.225 | 0.225 | 0.225 | 0.225 | 0.225 | 0.225 | 0.225 | 0.225 | 0.225 | 0.225 | 0.225 | 0.225 |

Table IV Smoothed average fishing mortalities at age derived from virtual population analysis for scallops west of Kintyre.
M = 0.15 F/Z = 0.60

| Age | Average Fishing Mortality |
|---|---|
| 1+ | 0. |
| 2+ | 0.014 |
| 3+ | 0.038 |
| 4+ | 0.072 |
| 5+ | 0.108 |
| 6+ | 0.148 |
| 7+ | 0.184 |
| 8+ | 0.211 |
| 9+ | 0.222 |
| 9+ | 0.225 |

Table V Estimated number (000s) at each age in the sea and total biomass (tonnes) derived by virtual population analysis for scallops west of Kintyre.

M = 0.15 F/Z = 0.60

| Age | 1966-67 | 1967-68 | 1968-69 | 1969-70 | 1970-71 | 1971-72 | 1972-73 | 1973-74 | 1974-75 | 1975-76 | 1976-77 | 1977-78 | 1978-79 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2+ | 10 520 | 6 672 | 8 382 | 7 361 | 6 943 | 9 992 | 11 693 | 13 606 | 18 009 | 27 102 | 19 030 | 22 505 | 19 609 |
| 3+ | 6 738 | 9 055 | 5 719 | 7 155 | 6 274 | 5 954 | 8 581 | 10 021 | 11 576 | 15 164 | 22 702 | 15 981 | 19 092 |
| 4+ | 6 426 | 5 736 | 7 696 | 4 745 | 5 797 | 5 299 | 5 022 | 7 341 | 8 393 | 8 889 | 11 859 | 18 159 | 13 189 |
| 5+ | 7 810 | 5 447 | 4 637 | 6 354 | 3 517 | 4 773 | 4 301 | 4 247 | 6 038 | 6 587 | 6 310 | 8 583 | 14 575 |
| 6+ | 6 865 | 6 531 | 4 392 | 3 526 | 4 820 | 2 828 | 3 701 | 3 529 | 3 426 | 4 810 | 5 024 | 4 325 | 6 154 |
| 7+ | 7 738 | 5 815 | 5 267 | 2 794 | 2 299 | 3 960 | 2 072 | 2 967 | 2 620 | 2 582 | 3 494 | 3 853 | 2 958 |
| 8+ | 10 213 | 6 507 | 4 662 | 3 613 | 1 400 | 1 812 | 2 978 | 1 574 | 2 180 | 1 762 | 1 961 | 2 715 | 2 812 |
| 9+ | 3 872 | 8 673 | 5 238 | 3 135 | 2 333 | 1 043 | 1 166 | 2 393 | 1 105 | 1 464 | 1 183 | 1 343 | 1 905 |
| >9+ | 2 086 | 3 205 | 7 126 | 3 773 | 2 132 | 1 797 | 664 | 908 | 1 935 | 652 | 1 099 | 799 | 890 |
| Biomass (tonnes) | 13 181 | 12 201 | 11 244 | 8 987 | 7 518 | 7 929 | 8 505 | 9 861 | 11 702 | 14 608 | 15 381 | 16 566 | 17 185 |

Table VI Mean muscle weights at age for scallops from west of Kintyre

| Age | Mean Muscle Weights (g) |
|---|---|
| 2+ | 4.5 |
| 3+ | 15.0 |
| 4+ | 23.0 |
| 5+ | 29.0 |
| 6+ | 32.5 |
| 7+ | 34.5 |
| 8+ | 37.0 |
| 9+ | 39.5 |
| >9+ | 41.0 |

Table VII The estimated effects of varying fishing mortality rate and age at first capture on yield per recruit and biomass per recruit for scallops west of Kintyre.

| Yield per recruit | Fishing Mortality Factor (K) | | | | |
|---|---|---|---|---|---|
| Change in age | 0.33 | 0.50 | 1.0 | 2.0 | 3.0 |
| -2 | 6.46 | 8.21 | 10.65 | 11.45 | 11.06 |
| -1 | 6.16 | 7.93 | 10.61 | 11.97 | 12.01 |
| 0 | 5.74 | 7.48 | 10.32 | 12.19 | 12.67 |
| 1 | 5.21 | 6.87 | 9.75 | 11.98 | 12.82 |
| 2 | 4.62 | 6.15 | 8.91 | 11.22 | 12.22 |
| **Biomass per recruit** | | | | | |
| Change in age | | | | | |
| -2 | 114.4 | 99.6 | 71.8 | 46.3 | 34.6 |
| -1 | 119.6 | 106.3 | 80.6 | 55.9 | 43.9 |
| 0 | 125.2 | 113.6 | 90.5 | 67.4 | 55.7 |
| 1 | 130.8 | 121.0 | 101.0 | 80.3 | 69.4 |
| 2 | 135.8 | 127.6 | 110.6 | 92.3 | 82.5 |

Table VIII Total yield (tonnes) and total biomass (tonnes) estimated for periods of good and poor recruitment for scallops west of Kintyre

| Level of Recruitment | Recruits | Total Yield (tonnes) | Total Biomass (tonnes) |
|---|---|---|---|
| Poor (1967-68 to 1971-72) | $7.9 \times 10^6$ | 514 | 5319 |
| Previous analysis (1970-71 to 1974-75) | $8.8 \times 10^6$ | 667 | 4484 |
| Good (1974-75 to 1978-79) | $21.2 \times 10^6$ | 1378 | 14275 |