

ESTIMATION OF NORTH ATLANTIC ALBACORE CATCH-AT-AGE FOR THE PERIOD 1975-95

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1. INTRODUCTION

The First ICCAT Albacore Workshop (Anon., 1989) discussed about the question of estimating catch at age and recommended the investigation of the utility of stochastic methods for estimating the international albacore catch at age data. Santiago (1990) applied the method developed by Schnute & Fournier (1980) and demonstrated the utility of the stochastic methods, at least for the separation of the younger age groups. The Second ICCAT Albacore Workshop (Anon., 1990) recommended the use of this kind of methods to break down the 1975-1989 catch by size tables into age groups, working with the finest strata possible: month/gear for the surface fisheries and quarter for longline.

Santiago (1992) utilised the length frequency analysis package MULTIFAN (Otter Research Ltd.) that implements the model of Schnute & Fournier (1980) to analyse several length frequency data simultaneously. Preliminary results were presented at the Ad-hoc Meeting on Progress in the ICCAT Albacore Research Program (Anon., 1992) and final results were used during the Albacore Special Stock Assessment Session in 1992 (Anon., 1993) and the final meeting of the ICCAT Albacore Special Program in 1994 (Anon., 1995).

However, during the final meeting of the ICCAT Albacore Special Program (Anon., 1995) some inconsistencies in the analysis were noted mainly due to the inclusion in the analysis of the not fully recruited age 1 group and length sampling deficiencies. Therefore the actions proposed by the Group were: to eliminate the age 1 class from the analysis because it is probably a biased group and moreover it can be easily separated by a simply visual inspection; to consider in the analysis only those quarterly length distributions that are adequately sampled; and, to introduce constrains in the analysis such as bounds for mean length at age.

These recommendations were taken into account by the Group met during the last Albacore Stock Assessment Session in 1994 (Anon., 1995). The period analysed to estimate growth parameters was from 1988 to 1993, and the growth parameters obtained were applied to the complete quarterly data for the period 1975-1993.

And it was agreed that calculation of catch at age to the next two years should be based on the growth equation determined during the 1994 SCRS meeting.

This paper documents the analysis carried out with the 1975-1995 North Atlantic albacore length frequency data provided by the Secretariat (July 1996) in order to compute the catch-at-age table for the 1996 albacore assessment.

2. DATA AND METHODS

2.1. The data

Quarterly length frequency distributions of North Atlantic albacore catches for the period 1975-1995 (provided by ICCAT Secretariat). The following combinations of gear-country have been considered: All gears-All countries, Longline-Taiwan, Longline-Japan, Troll-France, Troll-Spain, Baitboat-Spain. Individual gear-country combinations have been considered to allow the estimation of partial selectivities for those abundance indices that cover more than one age class.

2.2. The MULTIFAN method

MULTIFAN is a computer package designed by D. Fournier and J. Sibert (Otter Research Ltd.) to analyse length frequency distributions in order to get estimates of growth parameters and age composition. It uses a likelihood-based method that extends the model of Schnute and Fournier (1980) to simultaneously analyse several length frequency data sets. A detailed description of the mathematical basis of this method is given in the User's Guide and Reference Manual and in Fournier and Sibert(1990).

The main assumptions of the basic model are: normality of the distributions of length at age; mean lengths at age follow a von Bertalanffy growth model; and length dependence of standard deviations at age.

2.3. Application of MULTIFAN to the albacore data

According to the recommendations of the last Albacore Stock Assessment Session in 1994 (Anon., 1995), growth parameters estimated in that Session (Table 1) have been used to derive numbers at age for the period considered in this document.

| | |
|----------------------|-----------|
| Period analysed | 1988-1993 |
| Number of age groups | 8 |
| von Bertalanffy K | 0.217 |
| L_{∞} | 122.8 |
| Average SD | 3.593 |
| Ratio SD | 1.391 |

Table 1. Growth parameters assumed for the 75-95 catch-at-age computation (Anon., 1995).

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In order to estimate numbers at age from the different sets of length distributions considered in the analysis, quarterly "length-age keys" were derived according to:

$$P_{ij} = N_j q_{ij} / \sum N_j q_{ij}$$

where p_{ij} = probability that a fish of length i has age j ;
 N_j = numbers of fish of age j ;
 q_{ij} = probability that a fish of age j lies in length interval i ; it is defined as the area under the normal distribution $N(m_j, s_j^2)$ in the i th interval

3. RESULTS

Catch-at-age tables estimated applying the above procedure are shown in Tables 2a-f.

| YEAR | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8+ | TOTAL |
|------|-------|-------|-------|-----|-----|-----|-----|-----|-------|
| 75 | 301 | 1,073 | 1,245 | 298 | 282 | 184 | 211 | 71 | 3,666 |
| 76 | 894 | 2,266 | 936 | 823 | 447 | 315 | 148 | 72 | 5,902 |
| 77 | 437 | 2,606 | 1,439 | 328 | 454 | 276 | 106 | 76 | 5,722 |
| 78 | 2,782 | 2,671 | 1,373 | 498 | 223 | 224 | 89 | 27 | 7,886 |
| 79 | 890 | 3,592 | 1,848 | 178 | 155 | 103 | 51 | 125 | 6,942 |
| 80 | 1,809 | 1,617 | 1,673 | 303 | 85 | 53 | 31 | 67 | 5,638 |
| 81 | 1,090 | 1,565 | 1,009 | 313 | 72 | 49 | 42 | 103 | 4,242 |
| 82 | 236 | 1,821 | 1,640 | 282 | 76 | 72 | 34 | 175 | 4,337 |
| 83 | 857 | 1,607 | 1,631 | 620 | 208 | 159 | 71 | 115 | 5,267 |
| 84 | 417 | 1,206 | 987 | 274 | 210 | 125 | 123 | 225 | 3,568 |
| 85 | 1,009 | 1,395 | 1,002 | 235 | 237 | 139 | 31 | 221 | 4,268 |
| 86 | 761 | 1,630 | 1,164 | 343 | 413 | 168 | 73 | 153 | 4,705 |
| 87 | 354 | 2,384 | 1,373 | 148 | 51 | 48 | 26 | 71 | 4,454 |
| 88 | 1,722 | 2,295 | 1,104 | 153 | 40 | 14 | 15 | 22 | 5,365 |
| 89 | 1,087 | 1,849 | 1,376 | 95 | 45 | 22 | 8 | 10 | 4,493 |
| 90 | 1,070 | 2,634 | 790 | 227 | 89 | 93 | 34 | 78 | 5,016 |
| 91 | 1,124 | 2,262 | 547 | 84 | 59 | 30 | 27 | 46 | 4,179 |
| 92 | 1,299 | 1,959 | 835 | 174 | 45 | 100 | 48 | 24 | 4,483 |
| 93 | 938 | 2,150 | 1,034 | 208 | 82 | 57 | 85 | 170 | 4,724 |
| 94 | 594 | 2,944 | 683 | 182 | 27 | 32 | 48 | 148 | 4,659 |
| 95 | 1,236 | 2,459 | 1,019 | 56 | 76 | 89 | 72 | 157 | 5,165 |

Table 2a. Catch at age (1,000 individuals): North Atlantic albacore total international catch

| YEAR | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8+ | TOTAL |
|------|----|-----|-----|-----|-----|-----|----|-----|-------|
| 75 | 1 | 8 | 118 | 136 | 81 | 45 | 52 | 30 | 471 |
| 76 | 4 | 21 | 111 | 267 | 207 | 128 | 62 | 30 | 829 |
| 77 | 2 | 25 | 131 | 123 | 227 | 141 | 59 | 41 | 749 |
| 78 | 1 | 2 | 59 | 112 | 121 | 127 | 52 | 13 | 488 |
| 79 | 2 | 33 | 72 | 48 | 71 | 48 | 30 | 64 | 368 |
| 80 | 11 | 13 | 120 | 112 | 56 | 35 | 21 | 48 | 417 |
| 81 | 10 | 30 | 62 | 97 | 38 | 25 | 27 | 72 | 360 |
| 82 | 11 | 67 | 153 | 119 | 58 | 56 | 23 | 117 | 603 |
| 83 | 7 | 51 | 162 | 239 | 119 | 102 | 46 | 88 | 815 |
| 84 | 18 | 60 | 129 | 167 | 152 | 80 | 63 | 137 | 805 |
| 85 | 4 | 32 | 106 | 134 | 178 | 103 | 23 | 170 | 751 |
| 86 | 8 | 33 | 93 | 205 | 350 | 144 | 62 | 128 | 1,022 |
| 87 | 48 | 105 | 103 | 61 | 27 | 30 | 17 | 63 | 453 |
| 88 | 0 | 4 | 71 | 43 | 6 | 2 | 4 | 13 | 144 |
| 89 | 1 | 0 | 26 | 19 | 22 | 11 | 1 | 0 | 80 |
| 90 | 0 | 0 | 9 | 26 | 37 | 12 | 1 | 5 | 90 |
| 91 | 0 | 0 | 51 | 16 | 48 | 14 | 4 | 6 | 140 |
| 92 | 0 | 0 | 21 | 27 | 25 | 53 | 16 | 6 | 149 |
| 93 | 2 | 20 | 84 | 66 | 71 | 22 | 34 | 57 | 356 |
| 94 | 2 | 25 | 38 | 31 | 8 | 14 | 28 | 113 | 260 |
| 95 | 1 | 15 | 27 | 9 | 9 | 12 | 19 | 65 | 157 |

Table 2b. Catch at age (1,000 individuals): North Atlantic albacore Taiwan-longline catch.

| YEAR | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8+ | TOTAL |
|------|---|---|----|----|----|----|---|----|-------|
| 75 | 0 | 3 | 28 | 22 | 16 | 8 | 6 | 3 | 87 |
| 76 | 1 | 2 | 13 | 30 | 22 | 12 | 4 | 2 | 86 |
| 77 | 0 | 3 | 15 | 11 | 15 | 5 | 1 | 0 | 51 |
| 78 | 0 | 2 | 9 | 8 | 7 | 4 | 2 | 1 | 33 |
| 79 | 0 | 4 | 26 | 22 | 16 | 7 | 2 | 4 | 80 |
| 80 | 0 | 3 | 29 | 22 | 5 | 5 | 2 | 2 | 68 |
| 81 | 0 | 9 | 30 | 37 | 17 | 9 | 5 | 4 | 112 |
| 82 | 0 | 1 | 11 | 15 | 7 | 6 | 2 | 6 | 48 |
| 83 | 2 | 3 | 25 | 23 | 11 | 5 | 2 | 2 | 73 |
| 84 | 2 | 7 | 7 | 6 | 6 | 3 | 2 | 3 | 36 |
| 85 | 0 | 1 | 9 | 13 | 17 | 6 | 1 | 5 | 52 |
| 86 | 0 | 1 | 6 | 7 | 10 | 3 | 2 | 3 | 31 |
| 87 | 0 | 1 | 6 | 5 | 6 | 5 | 3 | 3 | 30 |
| 88 | 0 | 2 | 14 | 9 | 12 | 4 | 4 | 2 | 46 |
| 89 | 0 | 0 | 18 | 9 | 2 | 1 | 0 | 0 | 30 |
| 90 | 0 | 2 | 8 | 14 | 15 | 4 | 1 | 3 | 48 |
| 91 | 2 | 4 | 15 | 17 | 2 | 4 | 4 | 3 | 49 |
| 92 | 4 | 5 | 5 | 11 | 2 | 3 | 2 | 1 | 32 |
| 93 | 0 | 0 | 13 | 15 | 1 | 2 | 1 | 1 | 33 |
| 94 | 0 | 2 | 14 | 11 | 1 | 2 | 1 | 1 | 32 |
| 95 | 0 | 1 | 6 | 2 | 0 | 1 | 1 | 0 | 12 |

Table 2c. Catch at age (1,000 individuals): North Atlantic albacore Japan-longline catch.

| YEAR | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8+ | TOTAL |
|------|-----|-----|-----|----|---|---|---|----|-------|
| 75 | 40 | 329 | 302 | 8 | 1 | 0 | 0 | 0 | 678 |
| 76 | 295 | 813 | 72 | 8 | 0 | 0 | 0 | 0 | 1,188 |
| 77 | 108 | 746 | 232 | 23 | 2 | 0 | 0 | 0 | 1,111 |
| 78 | 556 | 838 | 296 | 39 | 2 | 2 | 0 | 0 | 1,733 |
| 79 | 195 | 958 | 305 | 8 | 1 | 1 | 0 | 0 | 1,469 |
| 80 | 227 | 280 | 125 | 4 | 0 | 0 | 0 | 0 | 636 |
| 81 | 113 | 224 | 82 | 6 | 0 | 0 | 0 | 0 | 425 |
| 82 | 32 | 224 | 120 | 5 | 0 | 0 | 0 | 0 | 380 |
| 83 | 11 | 166 | 102 | 10 | 0 | 0 | 0 | 0 | 289 |
| 84 | 50 | 253 | 113 | 5 | 0 | 0 | 0 | 0 | 422 |
| 85 | 77 | 138 | 64 | 3 | 1 | 0 | 0 | 0 | 283 |
| 86 | 37 | 107 | 35 | 2 | 0 | 0 | 0 | 0 | 181 |
| 87 | 23 | 127 | 55 | 4 | 0 | 0 | 0 | 0 | 209 |
| 88 | | | | | | | | | |
| 89 | | | | | | | | | |
| 90 | | | | | | | | | |
| 91 | | | | | | | | | |
| 92 | | | | | | | | | |
| 93 | | | | | | | | | |
| 94 | | | | | | | | | |
| 95 | | | | | | | | | |

Table 2d. Catch at age (1,000 individuals): North Atlantic albacore France-troll catch.

| YEAR | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8+ | TOTAL |
|------|-----|-------|-----|----|----|---|---|----|-------|
| 75 | 100 | 281 | 221 | 21 | 4 | 1 | 0 | 0 | 628 |
| 76 | 303 | 885 | 171 | 56 | 3 | 1 | 0 | 0 | 1,419 |
| 77 | 179 | 1,235 | 383 | 38 | 4 | 0 | 0 | 0 | 1,838 |
| 78 | 927 | 1,396 | 492 | 66 | 4 | 3 | 0 | 0 | 2,887 |
| 79 | 356 | 1,749 | 558 | 15 | 3 | 1 | 1 | 1 | 2,683 |
| 80 | 692 | 855 | 381 | 13 | 1 | 0 | 0 | 0 | 1,943 |
| 81 | 383 | 757 | 277 | 21 | 0 | 0 | 0 | 0 | 1,438 |
| 82 | 120 | 844 | 454 | 18 | 0 | 0 | 0 | 0 | 1,436 |
| 83 | 51 | 808 | 495 | 47 | 2 | 0 | 0 | 0 | 1,403 |
| 84 | 144 | 728 | 325 | 13 | 1 | 0 | 0 | 0 | 1,213 |
| 85 | 378 | 676 | 313 | 14 | 4 | 1 | 0 | 0 | 1,386 |
| 86 | 331 | 945 | 306 | 14 | 3 | 1 | 0 | 0 | 1,601 |
| 87 | 156 | 869 | 373 | 29 | 2 | 0 | 0 | 0 | 1,430 |
| 88 | 517 | 963 | 419 | 64 | 10 | 3 | 2 | 2 | 1,978 |
| 89 | 349 | 804 | 478 | 14 | 1 | 0 | 0 | 0 | 1,647 |
| 90 | 265 | 1,091 | 268 | 34 | 2 | 2 | 1 | 1 | 1,664 |
| 91 | 449 | 1,089 | 192 | 8 | 1 | 0 | 0 | 0 | 1,739 |
| 92 | 417 | 668 | 241 | 13 | 1 | 1 | 0 | 0 | 1,341 |
| 93 | 298 | 603 | 199 | 8 | 0 | 0 | 0 | 0 | 1,109 |
| 94 | 193 | 724 | 138 | 8 | 0 | 0 | 0 | 0 | 1,065 |
| 95 | 706 | 1,074 | 259 | 8 | 2 | 0 | 0 | 0 | 2,049 |

Table 2e. Catch at age (1,000 individuals): North Atlantic albacore Spain-troll catch.

| YEAR | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8+ | TOTAL |
|------|-------|-------|-----|-----|-----|----|-----|----|-------|
| 75 | 150 | 419 | 527 | 81 | 138 | 84 | 105 | 17 | 1,521 |
| 76 | 272 | 507 | 518 | 361 | 118 | 82 | 22 | 11 | 1,890 |
| 77 | 142 | 571 | 629 | 77 | 90 | 54 | 18 | 5 | 1,585 |
| 78 | 1,246 | 415 | 485 | 221 | 36 | 24 | 8 | 1 | 2,435 |
| 79 | 331 | 827 | 851 | 60 | 20 | 14 | 2 | 6 | 2,112 |
| 80 | 861 | 454 | 988 | 133 | 13 | 3 | 2 | 2 | 2,456 |
| 81 | 563 | 521 | 518 | 123 | 10 | 8 | 2 | 1 | 1,745 |
| 82 | 72 | 675 | 876 | 113 | 6 | 1 | 1 | 2 | 1,746 |
| 83 | 777 | 571 | 821 | 241 | 38 | 13 | 2 | 1 | 2,464 |
| 84 | 201 | 150 | 385 | 64 | 26 | 4 | 1 | 1 | 833 |
| 85 | 544 | 538 | 493 | 55 | 20 | 11 | 1 | 2 | 1,663 |
| 86 | 379 | 531 | 710 | 108 | 32 | 5 | 1 | 1 | 1,766 |
| 87 | 114 | 1,241 | 812 | 44 | 5 | 3 | 1 | 1 | 2,220 |
| 88 | 1,112 | 1,063 | 511 | 25 | 3 | 1 | 1 | 1 | 2,717 |
| 89 | 666 | 648 | 740 | 47 | 10 | 2 | 1 | 1 | 2,115 |
| 90 | 766 | 983 | 397 | 116 | 11 | 11 | 2 | 1 | 2,286 |
| 91 | 646 | 701 | 146 | 27 | 1 | 1 | 1 | 0 | 1,523 |
| 92 | 662 | 546 | 378 | 81 | 5 | 5 | 3 | 2 | 1,683 |
| 93 | 591 | 571 | 410 | 73 | 1 | 4 | 6 | 24 | 1,681 |
| 94 | 335 | 842 | 346 | 98 | 4 | 3 | 4 | 17 | 1,648 |
| 95 | 505 | 659 | 364 | 11 | 2 | 2 | 3 | 9 | 1,555 |

Table 2f. Catch at age (1,000 individuals): North Atlantic albacore Spain-baitboat catch.

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