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Virtual population assessment of the cod stock in ICNAF Divisions 3NO¹

by

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Introduction

At previous mid-term and annual ICNAF meetings, virtual population assessments have been presented for cod stocks in ICNAF Divisions 2J + 3K + 3L and Subdivision 3Ps. The present paper presents a similar assessment for cod in Divisions 3NO.

Materials and Methods

The method of treating the Sampling Yearbook data on lengths and ages was similar to that of previous assessments and consisted of adjusting length frequencies by month and quarter to the numbers landed and applying quarterly age-length keys to these quarterly length frequencies to produce quarterly age-distributions of the numbers landed. These were then combined into annual numbers caught at each age. Because of lack of data on discards and of adequate length samples before discard, no attempt was made to adjust numbers landed to numbers caught. In addition to Sampling Yearbook data, age-length keys from Canada (Nfld.) research vessel surveys were used to supplement or even replace commercial age-length keys in some years.

Natural mortality of 0.20 and $E = 0.8$ and $E(1 - e^{-Z}) = 0.506$ was used for the oldest age-groups. Average weight-at-age data were derived from growth curves and length-weight curves for the most recent period available.

Estimates of Fishing Mortality

Numbers of cod caught per year and age-group are shown in Table 1 and Fig. 1. From the data in Table 1, estimates of instantaneous fishing mortalities (F) for each age were derived for the 1959-68 period (Table 2). F of fully recruited age-groups fluctuated between 0.3 and 0.6 during 1959-64 but increased to 0.72 and 0.77 in 1965 and 1966, respectively, and to 0.9 in 1967 and 1968.

During the 1959-66 period cod were fully recruited at age 6 and 50% recruited at 4.4 years, while very few 3-year-olds were taken. However, during 1967-68 cod were fully recruited at age 5 and were 50% recruited at age 3.8 while an average of 15% recruitment occurred at age 3. This represents a distinct shift in fishing pattern toward the earlier ages on this stock during 1967-68.

Yield per Recruit

Yield-per-recruit calculations incorporating the partial recruitment estimates shown in Table 2 produced a curve almost identical to that shown by Pinhorn and Wells (1970) with the point of maximum sustainable yield per recruit at $F = 0.2$ (Fig. 2). The level of F in fully recruited age-groups during 1959-64 fluctuated about a level of 1.5-3 times the level of F_{max} but in 1965-66 the F was about 3.5 times F_{max} and in 1967 and 1968 about 4.5 times F_{max} .

A reduction in fishing effort below the level of 1965-68 is necessary to approach the level of maximum yield per recruit. Estimates of F obtained from projected stock sizes and catches in 1969-71 indicate that F was lower than in 1967-68, probably being in the vicinity of 0.5-0.6, still 2.5 to 3 times F_{max} .

¹ Revision of Sp.Mtg.Res.Doc. 73/4 presented to Special Commission Meeting, FAO, Rome, January 1973.

Stock Size

Numbers present in the stock at the beginning of the year (Table 3) indicated that total stock size of fish age 4 and older decreased from about 156 million fish in 1959 to 120-125 million in 1961-62 and then increased to 185 million during 1964-65 and to 300 million in 1967. There was a subsequent decline to 180 million in 1969. The adult portion of the stock (age 7+) fluctuated around 20-30 million fish in 1959-66 and then decreased to 15 million in 1969. The adult proportion of the commercially-exploited stock decreased from 12-19% in 1959-66 to 6-8% in 1967-69.

Table 1. Numbers of cod caught per year and age-group, ICNAF Divisions 3NO, 1959-70 (X10⁻³).

| Age | Year | | | | | | | | | | | |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|--------|-------|-------|
| | 1959 | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 |
| 2 | 417 | 230 | - | 21 | 6 | - | 9 | - | 179 | 853 | 81 | 25 |
| 3 | 1711 | 1846 | 812 | 1026 | 313 | 6202 | 1013 | 753 | 20086 | 16359 | 8154 | 2105 |
| 4 | 13036 | 6503 | 4400 | 3882 | 5757 | 15555 | 7611 | 18413 | 62442 | 56775 | 12924 | 19703 |
| 5 | 5068 | 22050 | 11696 | 2206 | 11210 | 19496 | 7619 | 19681 | 50317 | 48608 | 26949 | 10799 |
| 6 | 6025 | 3095 | 15258 | 1581 | 4849 | 7919 | 13258 | 11795 | 18517 | 18485 | 11191 | 9481 |
| 7 | 3935 | 2377 | 2014 | 3594 | 1935 | 2273 | 9861 | 8486 | 4774 | 6337 | 2089 | 3646 |
| 8 | 1392 | 2504 | 1672 | 773 | 3840 | 1109 | 4827 | 4467 | 4651 | 1592 | 1393 | 1635 |
| 9 | 757 | 583 | 847 | 668 | 1165 | 788 | 1081 | 1829 | 236 | 505 | 518 | 541 |
| 10 | 926 | 387 | 196 | 433 | 608 | 328 | 1248 | 1694 | 180 | 178 | 292 | 149 |
| 11 | 1220 | 898 | 25 | 226 | 322 | 37 | 163 | 122 | 71 | 90 | 186 | 227 |
| 12 | 103 | 242 | 245 | 216 | 208 | 112 | 141 | 57 | 45 | 45 | 202 | 90 |
| 12+ | 1128 | 1409 | 392 | 746 | 473 | 56 | 276 | 183 | 335 | 35 | 574 | 1472 |
| Total | 35718 | 42124 | 37557 | 15372 | 30686 | 53875 | 47107 | 67480 | 161833 | 149862 | 64553 | 49873 |

Table 2. Estimates of instantaneous fishing mortality for cod in ICNAF Divisions 3NO, 1959-68.

| Age | Year | | | | | | | | | | Average F | | | % Recruited | | | | |
|----------------------|-------|-------|-------|-------|-------|-------|--------|--------|-------|-------|-----------|---------|---------|-------------|---------|---------|---------|--|
| | 1959 | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1959-66 | 1967-68 | 1959-68 | 1967-68 | 1959-68 | 1967-68 | 1959-68 | |
| 3 | 0.036 | 0.041 | 0.012 | 0.010 | 0.004 | 0.068 | 0.008 | 0.004 | 0.12 | 0.17 | 0.02 | 0.15 | 0.05 | 4 | 15 | 9 | | |
| 4 | 0.17 | 0.19 | 0.13 | 0.070 | 0.076 | 0.31 | 0.11 | 0.17 | 0.52 | 0.62 | 0.15 | 0.57 | 0.24 | 31 | 57 | 43 | | |
| 5 | 0.34 | 0.47 | 0.61 | 0.093 | 0.29 | 0.39 | 0.25 | 0.41 | 0.93 | 0.96 | 0.36 | 0.95 | 0.47 | 75 | 100 | 84 | | |
| 6 | 0.51 | 0.35 | 0.70 | 0.15 | 0.30 | 0.35 | 0.51 | 0.79 | 0.88 | 1.15 | 0.45 | 1.01 | 0.57 | 100 | 100 | 100 | | |
| 7 | 0.47 | 0.38 | 0.41 | 0.35 | 0.27 | 0.22 | 0.96 | 0.74 | 0.91 | 0.89 | 0.47 | 0.90 | 0.56 | 100 | 100 | 100 | | |
| 8 | 0.51 | 0.63 | 0.50 | 0.27 | 0.78 | 0.24 | 1.03 | (2.10) | 1.30 | 0.93 | 0.57 | 1.11 | 0.69 | 100 | 100 | 100 | | |
| 9 | 0.41 | 0.42 | 0.46 | 0.38 | 0.84 | 0.36 | 0.40 | (1.80) | 0.67 | 0.42 | 0.47 | 0.54 | 0.48 | 100 | 100 | 100 | | |
| 10 | 0.38 | 0.38 | 0.24 | 0.45 | 0.72 | 0.61 | (1.75) | (2.40) | 0.65 | † | 0.46 | 0.65 | 0.49 | 100 | 100 | 100 | | |
| Ages 3-10 | 0.35 | 0.36 | 0.38 | 0.22 | 0.41 | 0.32 | 0.47 | 0.43 | 0.75 | 0.73 | | | | | | | | |
| Fully recruited ages | 0.46 | 0.43 | 0.46 | 0.32 | 0.58 | 0.36 | 0.72 | 0.77 | 0.89 | 0.87 | | | | | | | | |
| Catch (*000 tons) | 62.4 | 77.7 | 71.5 | 34.4 | 67.7 | 62.0 | 95.6 | 105.9 | 220.1 | 158.9 | | | | | | | | |

Table 3. Numbers of cod present in the stock at the beginning of the year, ICNAF Divisions 3NO, 1959-69 (X10⁻³).

| Age | Year | | | | | | | | | | |
|---------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| | 1959 | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 |
| 3 | 53302 | 51854 | 75185 | 115280 | 86944 | 103367 | 140694 | 209167 | 195010 | 115204 | 153849 |
| 4 | 91803 | 41737 | 40199 | 62232 | 91030 | 67436 | 83633 | 121957 | 169389 | 137899 | 78967 |
| 5 | 19270 | 63861 | 28011 | 28392 | 48754 | 66656 | 37519 | 64843 | 89969 | 83772 | 59340 |
| 6 | 16507 | 11370 | 32970 | 12451 | 20851 | 29724 | 35937 | 23329 | 34614 | 29237 | 26780 |
| 7 | 11472 | 8187 | 6600 | 13402 | 8889 | 12550 | 17174 | 17338 | 8719 | 11697 | 7578 |
| 8 | 3814 | 5862 | 4633 | 3479 | 7718 | 5671 | 8219 | 5398 | 6912 | 2861 | 3932 |
| 9 | 2416 | 1870 | 2532 | 2314 | 2240 | 2876 | 3636 | 2406 | 507 | 1577 | 1140 |
| 10 | 3215 | 1342 | 1006 | 1304 | 1295 | 787 | 1646 | 1967 | 388 | 277 | 816 |
| 10+ | 7273 | 6776 | 3488 | 3208 | 3000 | 1199 | 1002 | 740 | 615 | 387 | 1371 |
| 4-10+ | 155770 | 141005 | 119439 | 126782 | 183777 | 186899 | 188766 | 237978 | 311113 | 267707 | 179924 |
| 7-10+ | 28190 | 24037 | 18259 | 23707 | 23142 | 23083 | 31677 | 27849 | 17141 | 16799 | 14837 |
| 7-10+ as % of 4-10+ | 18 | 17 | 15 | 19 | 13 | 12 | 17 | 12 | 6 | 6 | 8 |

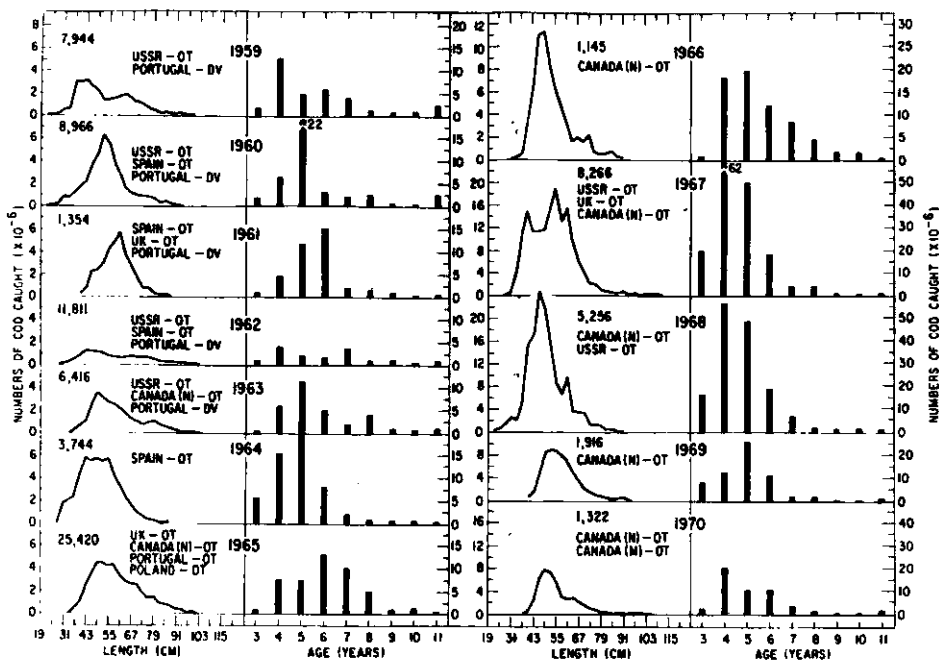


Fig. 1. Age and length distributions of cod catches used in assessment of Divisions 3NO cod stock, 1959-70. Numbers for each year are total numbers of length measurements. Countries for which measurements were available in each year are also shown.

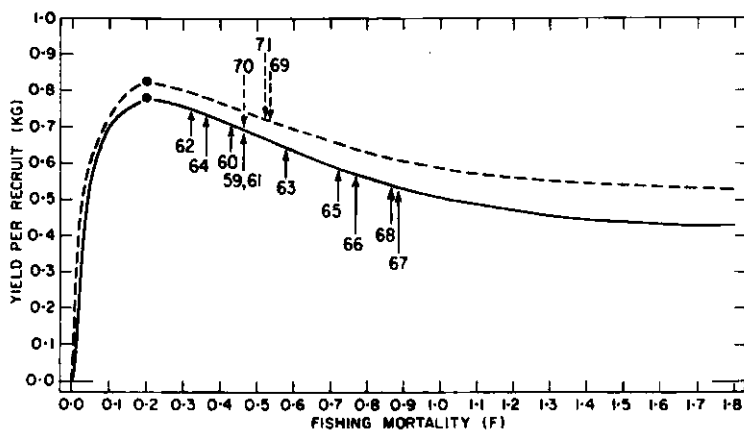


Fig. 2. Yield per recruit for Divisions 3NO cod stock. Solid line represents curve using 1967-68 recruitment pattern. Broken line represents curve using 1959-66 recruitment pattern.