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Analysis of the Voisey Assessment Unit Arctic Charr Populations in 1986
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#### Abstract

The Voisey assessment unit, made up of Voisey Bay and the Antons subarea, was first assessed as a homogeneous unit at the end of the 1984 fishery. Annual landings have ranged from 4 to 41 t (mean $=22 \mathrm{t}$ ) and from 1977 to 1986 have represented $17 \%$ of the total commercial catch of Arctic charr from the Nain fishing region. Total allowable catch in 1986 was 20 t. Landings in 1986 were 17 t or $83 \%$ of the TAC. Effort increased by $44 \%$ and catch per unit effort decreased by $26 \%$ in comparison with 1985. A sequential population analysis was carried out on catch at age data from 1977 to 1986 and suggested a reference level catch of $17 t$ remain in effect for 1987.


## Résumé

L'unitē d'évaluation de Voisey, constituée de la baie de Voisey et de la sous-zone Antons, a été évaluée pour la première fois comme unité homogène à la fin de la saison de pêche de 1984. Les débarquements annuels ont varié de 4 à 41 t (moyenne $=22 \mathrm{t}$ ) et, de 1977 à 1986, ils ont constitué 17 \% de la pēche commerciale totale d'omble chevalier pour la zone de pêche de Nain. En 1986, le TPA ētait de 20 t et les débarquements ont ēté de 17 t , ou $83 \%$ du TPA. L'effort a augmenté de $44 \%$ et les prises par unité d'effort ont diminué de $26 \%$ comparativement à 1985. Une analyse séquentielle de population a ētē rēalisēe à partir des donnēes sur les prises par âge de 1977 à 1986 et cette analyse a indiqué un taux de prise de rēfērence de 17 t pour 1987.

## Introduction

Catch statistics for the Voisey assessment unit (Fig. 1) have been available since 1974. On the basis of tag recapture information these areas were considered as one unit and assessed as such beginning in 1985. The quota area catch column in Table 1 summarizes landings from this subarea only. Annual landings for the entire assessment unit have ranged from a low of $4 t$ in 1975 to 41 t in 1979 with an average of 22 t over the 13 -year period. Since 1977, landings from this assessment unit have represented $17 \%$ of the total commercial catch of Arctic charr from the Nain Fishing Region. The TAC recommended for 1986 was 20 t.

This paper examines the results of the 1986 fishery and provides a reference level catch for 1987 as derived from a sequential population analysis.

## Stock Assessment

Catch and effort data for the Voisey assessment unit are summarized in Table 1 for 1974-86. Landings in 1986 totaled 17 t ; an increase of $6 \%$ from 1985. This catch was $83 \%$ of the recommended TAC. Effort increased by $44 \%$ although catch per unit effort decreased by $26 \%$ to $203 \mathrm{~kg} / \mathrm{man}$-week. This was similar to the value recorded for 1984. The majority of the catch from this assessment unit was taken from the Antons subarea. The quota area catch in Table 1 summarizes landings from the subarea specifically under quota regulation only (Voisey Bay) prior to the formation of the assessment unit in 1985.

Numbers at age were available since 1977 and are summarized in Table 2. Data were derived from annual commercial sampling programs. Mean age of the catch has ranged from 8.2 to 9.1 years with no apparent increasing or decreasing trend (Table 2). From 1977 to $1986,58 \%$ of the catch has been made up of 8 and 9 year old fish. Eleven per cent of the fish were 11 years of age or older.

Weights at age were calculated from commercial samples obtained from 1977 to 1986. Gutted head-on weights were converted to whole weight using the conversion factor of 1.22 (Dempson 1984). For the yield per recruit analysis, mean weight at age from 1977 to 1979 was used. For stock projections, mean weight at age for the period 1984-86 was used (Table 3).

As observed in the Nain assessment unit, mean weight at age has decreased over time. For 7-10 year old Arctic charr the average percentage decrease in weight was $15 \%$ ( 0.33 kg ) (average 1977-79 to 1984-86), while the average decline for 11 to 14 year old fish was $23 \%(0.76 \mathrm{~kg})$. Both the Voisey Bay and Antons subareas have had declines in the proportion of large Arctic charr (charr greater than 2.3 kg gutted head-on weight) similar to that observed in subareas within the Nain assessment. This may suggest a selective removal of the larger fish from the population.

Total mortality $(Z)$ was calculated using the Paloheimo method (Ricker
1975) for all years (1977-78 to 1985-86) was 0.82. Assuming a natural mortality rate of 0.2 yields an estimate of fishing mortality of 0.6. As in past years, there was a considerable amount of variation in the estimates and a catch curve was also used to provide an alternative measure of $z$. The use of catch per unit of effort at age data from $1984-86$ resulted in a $z$ of 0.70 .

An initial cohort analysis was run using partial recruitment values and terminal fishing mortality $\left(F_{T}\right)$ from the 1985 assessment (Dempson and LeDrew 1986) $\left(F_{T}=0.45\right)$. An iterative procedure was used to obtain estimates of fishing mortality for the oldest age group ( $F_{B}$ ) (Rivard 1982). Following this the cohort analysis procedure was rerun using the newly derived values for $F_{B}$.

Partial recruitment rates were calculated using the historical averaging method from the matrix of fishing mortality rates generated from the last cohort run and are listed in Table 3.

Yield per recruit was calculated by the method of Thompson and Bell (Ricker 1975) using partial recruitment rates and mean weight at age. $F_{0.1}$ was 0.39 at a yield per recruit of 1.08 kg .

Cohort analyses were performed using a range of terminal fishing mortality ( $F_{T}$ ) rates from 0.2 to 0.7 using newly derived estimates of partial recruitment. In each cohort run, fishing mortality rates for the oldest age group ( $F_{B}$ ) were re-evaluated using the iterative procedure. Regressions of $F$ (weighted mean F for fully recruited fish) on fishing effort, and population biomass on catch per unit effort for fully recruited fish were used in tuning the analysis to identify an appropriate value for 1986. Regression were based on data from 1977 to 1985.

Regressions of $F$ on effort produced the highest correlation at $F_{T}=0.35$ (Table 4). The distance from the last point to the regression line was lowest when $F_{T}=0.6$. The sum of the residuals for the last three years (1984-86) and the sum of squares of the residuals for the last three years was the lowest when $\mathrm{F}_{\mathrm{T}}=0.55$ and $\mathrm{F}_{\mathrm{T}}=0.60$ respectively.

Regressions of biomass on CUE produced the highest correlation coefficient obtained when $F_{T}=0.4$. The residual of the last year to the regression line was lowest when $F_{T}=0.6$. Similarly, the sum of the squares of the residuals for the last three years were lowest when $\mathrm{F}_{\mathrm{T}}=0.5$ and 0.55 respectively.

In summary, on the basis of the best correlations $F_{T}$ for 1986 would be 0.35-0.4 while an analysis of the residuals would suggest $F_{T}$ is 0.5-0.6. On the basis of the analyses of the residuals and in consideration of the Paloheimo and catch curve estimates, $F_{T}$ in 1986 would appear to be 0.55-0.60.

Stock projections, however, were run with $F_{T}$ varying from 0.45 to 0.6. Recruitment for projections was estimated from the geometric mean of population numbers for age 6 and 7 year-old fish for years 1977-84. Weights at age were based on 1984-86 data. Table 5 summarizes the population numbers and fishing mortality matrix for the cohort analysis run with $\mathrm{F}_{\mathrm{T}}=0.50$.

Results of the projections are summarized in Table 6. With $F_{T}=0.55$ to 0.60 suggests a 'reference level' catch in 1987 of approximately 17 t .

## References

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Table 1. Summary of catch and effort statistics for the Voisey assessment unit, 1974-86. Quotas and landings are in kg-round weight, effort is expressed as man-weeks fished.

| Year | Quota | $\begin{aligned} & \text { Quota }{ }^{\text {a }} \\ & \text { area } \\ & \text { catch } \end{aligned}$ | Landings | Effort | CUE |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 1974 |  |  | 29,180 |  |  |
| 1975 |  |  | 3,727 |  |  |
| 1976 |  |  | 14,652 | 57 | 257 |
| 1977 |  |  | 24,108 | 75 | 321 |
| 1978 |  |  | 36,991 | 102 | 363 |
| 1979 | 22,500 | 21,880 | 40,590 | 116 | 350 |
| 1980 | 22,500 | 11,557 | 19,694 | 82 | 240 |
| 1981 | 16,100 | 16,325 | 23,810 | 90 | 265 |
| 1982 | 16,100 | 2,688 | 13,309 | 60 | 222 |
| 1983 | 16,100 | 2,953 | 25,593 | 80 | 320 |
| 1984 | 16,100 | 8,113 | 20,873 | 101 | 207 |
| 1985 | 23,400 |  | 15,648 | 57 | 275 |
| 1986 | 20,000 |  | 16,655 | 82 | 203 |

a Quota applied to the Voisey Bay subarea only from 1979 to 1984.

|  | TABLE 2 |  | ESTIMATED CATCH AT AGE FOR VOISEY STOCK UNIT,1977-86 |  |  |  |  | ARCTIC$1984$ | CHARR$1985$ | ROM |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 |  |  | 1986 |
| 61 | 318 | 619 | 475 | 132 | 75 | 255 | 1841 | 253 | 1 | 41 |
| 71 | 2085 | 4374 | 4914 | 666 | 983 | 770 | 2870 | 2306 | 2012 | 797 |
| 81 | 4030 | 5372 | 7928 | 3349 | 2607 | 1628 | 3100 | 3352 | 3213 | 3025 |
| 91 | 2086 | 2330 | 3382 | 4086 | 4780 | 2297 | 4125 | 2374 | 3396 | 3644 |
| 101 | 1237 | 1236 | 1163 | 1341 | 2350 | 1140 | 1790 | 1577 | 454 | 1313 |
| 11 I | 600 | 1141 | 634 | 521 | 941 | 595 | 1196 | 806 | 336 | 645 |
| 121 | 389 | 380 | 212 | 260 | 406 | 62 | 801 | 401 | 247 | 229 |
| 131 | 212 | 380 | 159 | 166 | 43 | 12 | 68 | 377 | 69 | 140 |
| 141 | 108 | 334 | 55 | 64 | 19 | 20 | 8 | 136 | 91 | 111 |
| TOTAL | 11065 | 16166 | 18922 | 10585 | 12204 | 6779 | 15799 | 11582 | 9819 | 9945 |
| MEAN |  |  |  |  |  |  |  |  |  |  |
| $A G E$ | 8.6 | 8.5 | 8.2 | 8.9 | 9.1 | 8.8 | 8.5 | 8.8 | 8.5 | 8.9 |

Table 3. Summary of weight (kg round) at age data, partial recruitment rates and calculated $\mathrm{F}_{0.1}$ for the Arctic charr population in the Voisey assessment unit.

| Age | Weight |  | Partial recruitment |
| :---: | :---: | :---: | :---: |
|  | 1977-79 | 1984-86 |  |
| 6 | 1.53 | 1.18 | 0.023 |
| 7 | 1.77 | 1.41 | 0.195 |
| 8 | 2.07 | 1.86 | 0.607 |
| 9 | 2.60 | 2.14 | 1.0 |
| 10 | 2.78 | 2.50 | 1.0 |
| 11 | 2.94 | 2.41 | 1.0 |
| 12 | 3.24 | 2.61 | 1.0 |
| 13 | 3.33 | 2.51 | 1.0 |
| 14 | 3.50 | 2.46 | 1.0 |
| 15 | 3.46 |  | 1.0 |
| 16 | 3.46 |  | 1.0 |
| $F_{0.1}=0.39$ at a $\mathrm{Y} / \mathrm{R}$ of 1.08 kg . |  |  |  |

Table 4. Results of regressions (1977-85) of $F$ on effort and population biomass on catch per unit effort for various terminal fishing mortality rates ( $F_{T}$ ) for the Voisey assessment unit.

| Regression | Parameter | Terminal F |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 0.2 | 0.25 | 0.3 | 0.35 | 0.4 | 0.45 | 0.5 | 0.55 | 0.6 | 0.7 |
| F (weighted mean for fully recruited fish) on effort |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | $r$ | 0.73 | 0.75 | 0.77 | 0.77 | 0.77 | 0.75 | 0.74 | 0.72 | 0.69 | 0.64 |
|  | residual-1986 | -0.33 | -0.30 | -0.26 | -0.23 | -0.19 | -0.15 | -0.11 | -0.06 | -0.02 | 0.07 |
|  | normalized | -0.60 | -0.53 | -0.45 | -0.38 | -0.31 | -0.24 | -0.17 | -0.10 | -0.03 | 0.28 |
|  | intercept | -0.01 | 0.03 | 0.06 | 0.09 | 0.11 | 0.14 | 0.16 | 0.18 | 0.20 | 0.24 |
|  | normalized | -0.02 | 0.04 | 0.10 | 0.15 | 0.19 | 0.23 | 0.26 | 0.29 | 0.32 | 0.37 |
|  | residuals $(1984-86)$ | -0.64 | -0.53 | -0.43 | -0.34 | -0.25 | -0.17 | -0.08 | -0.00 | -0.07 | -0.22 |
|  | $\begin{aligned} & (\text { residuals })^{2} \\ & (1984-86) \end{aligned}$ | 0.16 | 0.12 | 0.09 | 0.06 | 0.04 | 0.02 | 0.01 | 0.01 | 0.00 | 0.02 |

Population biomas
(fully recruited
fish) on CUE

| $r$ | 0.50 | 0.63 | 0.74 | 0.81 | 0.82 | 0.81 | 0.78 | 0.74 | 0.70 | 0.64 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| residual (t)-1986 | 641 | 26 | 21 | 15 | 11 | 7 | 4 | 2 | 0 | -2 |
| normalized | 1.52 | 1.13 | 0.84 | 0.62 | 0.45 | 0.31 | 0.20 | 0.10 | 0.02 | -0.11 |
| intercept (t) | 13 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| normalized | 0.47 | 0.49 | 0.50 | 0.51 | 0.51 | 0.52 | 0.52 | 0.53 | 0.53 | 0.54 |
| residuals <br> (1984-86) | 60 | 40 | 27 | 18 | 11 | 5 | , | -3 | -6 | -10 |
| $\begin{aligned} & (\text { residuals })^{2} \\ & (1984-86) \end{aligned}$ | 1882 | 906 | 454 | 228 | 112 | 53 | 26 | 17 | 18 | 37 |

Table 5. Summary of the population numbers and fishing mortality matrix for the cohort analysis run at $\mathrm{F}_{\mathrm{T}}=0.50$ on the catch at age data for the Voisey assessment unit Arctic charr population.

FOFULATIOR MUMEEFS

| 1 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 61 | 40390 | 31435 | 19657 | 19466 | 17007 | 24648 | 28910 | 21894 | 11488 | 3792 |
| 71 | 21293 | 32781 | 25178 | 15664 | 15818 | 13856 | 19949 | 22004 | 17695 | 9405 |
| 81 | 11634 | 15515 | 22881 | 1.6167 | 12222 | 12061 | 10648 | 13736 | 15929 | 12668 |
| 91 | 5732 | 5879 | 7867 | 11560 | 10206 | 7648 | 8402 | 5912 | 8213 | 10134 |
| 01 | 3645 | 2806 | 270. | 3381 | 5767 | 4031 | 4183 | 3146 | 2693 | 3651 |
| 11 | 1597 | 1865 | 1179 | 1162 | 1555 | 2595 | 2269 | 1805 | 1149 | 1794 |
| 21 | 1049 | 765 | 494 | 391 | 480 | 422 | 1587 | 776 | 749 | 637 |
| 3 | 756 | 507 | 282 | 213 | 85 | 26 | 289 | 574 | 272 | 389 |
| 41 | 152 | 427 | 71 | 87 | 24 | 31 | 10 | 175 | 129 | 160 |
| $6+1$ | 86248 | 92012 | 80315 | 68093 | 63165 | 55317 | 75246 | 70022 | 58317 | 42630 |
| $7+1$ | 45858 | 60576 | 60558 | 48626 | 46158 | 40670 | 47336 | 48129 | 46829 | 38838 |
| $8+1$ | 24566 | 27795 | 35480 | 32962 | 30340 | 26814 | 27387 | 26125 | 27133 | 29434 |
| $9+1$ | 12932 | 12249 | 12599 | 16795 | 18118 | 14752 | 16740 | 1.2389 | 13205 | 16766 |

FISHING MOF:TALITT

|  | 1 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 |
| ---: | ---: | ---: | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 6 | 1 | 0.009 | 0.022 | 0.027 | 0.008 | 0.005 | 0.011 | 0.073 | 0.013 | 0.000 | 0.012 |
| 7 | 1 | 0.115 | 0.160 | 0.213 | 0.048 | 0.071 | 0.063 | 0.173 | 0.123 | 0.134 | 0.098 |
| 8 | 1 | 0.483 | 0.481 | 0.483 | 0.260 | 0.269 | 0.162 | 0.383 | 0.314 | 0.252 | 0.304 |
| 9 | 1 | 0.514 | 0.576 | 0.615 | 0.795 | 0.729 | 0.403 | 0.782 | 0.587 | 0.611 | 0.500 |
| 10 | 1 | 0.470 | 0.667 | 0.645 | 0.577 | 0.598 | 0.375 | 0.640 | 0.807 | 0.206 | 0.500 |
| 11 | 1 | 0.536 | 1.128 | 0.902 | 0.684 | 1.105 | 0.292 | 0.874 | 0.680 | 0.390 | 0.500 |
| 12 | 1 | 0.527 | 0.796 | 0.642 | 1.325 | 2.730 | 0.177 | 0.816 | 0.847 | 0.454 | 0.500 |
| 13 | 1 | 0.371 | 1.761 | 0.973 | 1.976 | 0.816 | 0.728 | 0.301 | 1.293 | 0.329 | 0.500 |
| 14 | 1 | 0.496 | 0.716 | 0.673 | 0.548 | 0.735 | 0.369 | 0.719 | 0.695 | 0.479 | 0.500 |
| -+1 | 0.497 | 0.749 | 0.676 | 0.563 | 0.773 | 0.370 | 0.754 | 0.707 | 0.493 | 0.500 |  |

Table 6. Summary of projected available catch ( $t$ ) for 1987 and 1988 with $F_{T}$ in 1986 varying from 0.45 to 0.6 .

|  | $\mathrm{F}_{\mathrm{T}}$ in 1986 |  |  |  |  |
| :--- | :--- | :--- | :--- | :--- | :---: |
| Reference leve1 <br> catch | 0.45 | 0.50 | 0.55 | 0.60 |  |
| 1987 | 20.7 | 19.0 | 17.6 | 16.5 |  |
| 1988 | 21.8 | 20.6 | 19.6 | 18.8 |  |



