# BROOK TROUT STUDIES IN THE ICEWATER CREEK 

WATERSHED
1983-1984

## File Report 62 January 1985

# A summary of study findings prepared for the Sault Ste. Marie District Office of the Ontario Ministry of Natural Resources 

D.P. KREUTZWEISER, P.D. KINGSBURY and S.B. HOLMES

```
            Government of Canada
            Forestry Service
                Forest Pest Management Institute
            P.O. Box 490
                Sault Ste. Marie, Ontario
            P6A 5M7
```

This report may not be copied and/or distributed without express consent of:

Director
Forest Pest Management Institute Canadian Forestry Service P.O. Box 490

Sault Ste. Marie, Ontario P6A 5M7

## Introduction

In 1980, the Environmental Impact Section of the Forest Pest Management Institute (FPMI), through the cooperation of the Sault Ste. Marie District Office of the Ontario Ministry of Natural Resources, set up an ongoing research program in the Icewater Creek watershed about 50 km north of Sault Ste. Marie, Ontario (Fig. 1). The objective of this programme is: to examine in-depth a number of aquatic and terrestrial habitats and microhabitats and their resident animal populations to determine: (1) the nature and degree of inherent risk, (2) the level of actual exposure, and (3) actual response to forest pest management strategies involving aerial applications of pest control agents.

The program will have three distinct phases designed to generate information on three aspects of the effects of forest pest control activities on the environment: (1) potential risk, (2) actual exposure, and (3) actual response. In general, the actual impact on each part of the environment is primarily a factor of the susceptibility of that portion of the ecosystem to the particular pest control procedure and its level of exposure to the pest control agent used, i.e., Risk + Exposure $=$ Response. To this extent, part of the objective of the first two portions of the program will be to help predict potential hazards of any suggested pest control action. The third portion of the program will test actual responses and elucidate the nature of and ecosystem responses to actual impacts. This will involve relating impacts at lower trophic levels or among specific groups of organisms to secondary impacts on higher trophic levels and changes within the ecosystem (e.g., altered food supply, changes in basic processes such as predation or pollination, etc.).


Fig. 1. The Icewater Creek Watershed

This report briefly highlites findings of studies on brook trout populations conducted in 1983 and 1984 as part of the overall Icewater Creek research program

1983 Studies
Following three years of intensive benthic invertebrate collection, aquatic studies at Icewater Creek in 1983 concentrated on an assessment of brook trout populations within the watershed. Attempts in previous years at studying resident brook trout in small sections of the creek yielded low numbers of trout and consequently insufficient data for providing information on density, growth, or population structure. The 1983 field program was designed to provide some of this information, incorporating the following general objectives:

1. Fish a large portion of the accessible watershed to determine relative brook trout densities.
2. Identify specific sections of the watershed suitable for future localized impact studies, based on both trout densities (determined by Objective 1) and workability of the section.
3. Field test hot branding technique for marking and individually recognizing fish
4. Determine frequency and extent of brook trout movement within the watershed.
5. Initiate a data base on growth, production and population structure of resident brook trout in various sections of Icewater Creek.

Brook trout were collected using a Smith-Root, Type VII electroshocker and dip nets. All fish were anaesthetized, weighed, measured, and adipose fin-clipped, and those greater than 100 mm in length were branded with various combinations of symbols. The brands, constructed of copper and brass shaped into letter symbols and mounted on wooden handles, were heated to the boiling point of water and applied lightly to the surface of
the fish in the caudal peduncle area. Scales were taken from a number of the branded fish to assist in age determination. Using the marked distance reference system in the creek, a record of the location of capture (within $30 \mathrm{~m})$ for each fish, as well as the morphological data and brand symbols, either applied or recaptured, was kept. Each fish was subsequently released in the stream as close as possible to the point of capture.

A total of $6,780 \mathrm{~m}$ of stream was fished a number of times over the season. To assist in delineating between stream sections and habitat types, the watershed was divided into five physically segregated fishing areas. The Downstream Area comprised the first $4,600 \mathrm{~m}$ upstream from the mouth of the creek. East Tributary, one of two major headwater tributaries of Icewater Creek, was fished from the confluence to a major waterfall 630 m upstream. The other major headwater tributary, West Tributary, was further divided into three separate sections with West Tributary proper extending 970 m from the confluence of East and West upstream to a point at which the tributary splits into two branches. The East Branch continued for 250 m to a large waterfall, while the West Branch was fished for a distance of 330 m to a several channel split and small waterfall. In order to more clearly determine habitat changes, localized trout densities, fish movement, population structure and production, each of these five fishing areas was arbitrarily subdivided into sections designated by recognizable physical features such as heads of pools, log jams, small accessible waterfalls, etc.

In total, 1,186 brook trout were captured, "processed," and released in Icewater Creek over the 1983 field season. The data collected from these fish have been summarized for each fishing area and the separate
sections. Tables 1-3 have been included to illustrate some of the information pertaining to brook trout distribution and relative densities, catch and recapture analysis, and fish movement, obtained from West Tributary. The data obtained from the 1983 brook trout survey provide a number of summarizations or conclusions:

1. The hot branding technique for marking fish worked well. Almost all of the brands found on recaptured trout were easily recognized throughout the field season (May to November), and most of the obscure ones were decipherable in light of the location and size of the fish. Using various combinations and positioning of three symbols, well over 2,000 different brands were possible. The ability to recognize individual fish provided an opportunity to measure movement and growth of those that were recaptured.
2. Relative densities of brook trout varied to a large extent throughout the watershed, with some sections containing up to seven times higher numbers than adjoining sections of approximately the same length. Density has been expressed as the number of fish per limear distance, usually obtained in two electroshocker passes through an area, and is not a statistically valid density estimate. The scope of the 1983 program (to fish as much of the watershed as possible) did not permit the type of systematic sampling required for obtaining statistically derived estimates of trout density.
3. Certain areas of the watershed, especially in the Downstream portion of the creek contained sections of up to 300 m with few or no brook trout captured. The relative densities in these sections usually ranged from 0 to 0.3 trout per 20 m of stream. Although several factors may be con-
tributing to the extremely low trout density in these areas the most apparent is the lack of instream or shoreline cover.
4. The numbers of brook trout in the upper portion of the watershed appeared to be less variable than those in the lower end indicating a more stable resident trout population in the upper watershed. The proximity of Goulais River to the lower watershed may influence the density of the trout in that area by allowing movement between the two water courses in response to changes in water temperature, water level, or other factors.
5. Based on the dispersion patterns of 174 recaptured branded individuals, it was apparent that brook trout in Icewater Creek show little tendency to move substantial distances within the watershed from June to November. From 56 to $84 \%$ of the trout in various sections remained within 50 m of the point of initial capture, while another 10 to $33 \%$ moved less than 200 m . For those that did show some dispersion, including a few trout that moved 1 km or more, net upstream movement was slightly greater than downstream movement.
6. Changes in weight and length over time of recaptured trout indicate that most growth occurs from May to July and has virtually ceased by early September. Less than $6 \%$ of the yearling and older fish caught and recaptured between July and November demonstrated an increase in length of greater than 5 mm. As with length, the most substantial weight gains were found in trout recaptured in the May to early July period. These data indicate that any comprehensive trout growth assessment must include extensive early season sampling, unfortunately coinciding with the seasonal worst sampling conditions in Icewater Creek.
7. The small size of scales on most brook trout caught in Icewater Creek has made age determination of the various size classes difficult. Pending the modificiation of a scale projection system, the age structure of the trout population sampled from the watershed has been simply divided into young of the year $(0+$ ) and yearling or older ( $1++$ ) fish. Figure 2, drawn from data collected in the Downstream Area, illustrates the distinct division in the size class between these two age groupings. The length frequencies suggest that approximately one-third of the population may be $0+$, with most of the remaining ones comprising $1+$ and $2+$ trout. Probably few trout survive to their third year.
8. Young of the year, or $0+$, brook trout were encountered in almost all sections of both upper and lower reaches of the creek indicating that successful spawning occurs throughout most of the accessible watershed. The west branch of West Tributary consistently contained higher numbers of $0+$ trout than any other fishing section (up to $79 \%$ of the total catch) and may represent a preferred nursery or production area in Icewater Creek.
9. By frequently fishing large portions of the creek through various water level conditions a number of areas have been identified as having potential for use as fish population study areas. These sections are reasonably accessible, contain viable numbers of brook trout and are workable under all but extreme water level conditions.

The above information obtained from the 1983 field program provides a basis for designing specific impact related brook trout studies. Since most current and proposed forest pest control strategies do not directly threaten survival of resident fish in streams, an assessment of impact on
brook trout must include an evaluation of secondary effects such as changes in migration patterns, production, growth, feeding activity, and reproductive success induced by an alteration in food availability. All of these require a rigorous and systematic approach and forthcoming brook trout impact assessments at Icewater Creek will incorporate a sampling design consistent with producing statistically corroborative data.


Fig. 2. Size (mm) class distribution of brook trout caught in downstream portions of Icewater Creek, August 1983.

Table 1. Brook trout catch in seven sections of Icewater Creek West Tributary, July--November 1983

| Section | Date | Total catch | No. per 20 m of stream | $\begin{aligned} & \text { New } \\ & \mathrm{H}_{+} \end{aligned}$ | $\begin{array}{r} \text { fish } \\ 1++ \end{array}$ | Recaptures |  | \% new $0+$ | $\begin{aligned} & \text { fish } \\ & \text { l++ } \end{aligned}$ | \% recaptures $0+1+$ |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\begin{gathered} 1 \\ (0-180) \end{gathered}$ | 26 July | 6 | 0.7 | 0 | 6 | 0 | 0 | 0 | 100 | 0 | 0 |
|  | 18 August | 4 | 0.4 | 0 | 3 | 0 | 1 | 0 | 75 | 0 | 25 |
|  | 22 September | 4 | 0.4 | 1 | 1 | 0 | 2 | 25 | 25 | 0 | 50 |
|  | 8 November | 2 | 0.2 | 1 | 1 | 0 | 0 | 50 | 50 | 0 | 0 |
| 2 | 26 July | 19 | 2.6 | 2 | 17 | 0 | 0 | 10 | 89 | 0 | 0 |
| (180-325) | 18 August | 17 | 2.3 | 5 | 9 | 0 | 3 | 29 | 53 | 0 | 18 |
|  | 22 September | 7 | 1.0 | 1 | 1 | 1 | 4 | 14 | 14 | 14 | 57 |
|  | 8 November | 13 | 1.8 | 3 | 6 | 1 | 3 | 23 | 46 | 7 | 23 |
|  | 26 July | 1 | 0.3 | 0 | 1 | 0 | 0 | 0 | 100 | 0 | 0 |
| (325-490) | 4 August | 7 | 1.6 | 2 | 5 | 0 | 0 | 28 | 71 | 0 | 0 |
|  | 18-22 August | 18 | 2.2 | 9 | 8 | 1 | 0 | 50 | 44 | 6 | 0 |
|  | 22 September | 8 | 1.0 | 0 | 5 | 0 | 3 | 0 | 62 | 0 | 38 |
|  | 8 November | 0 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 4 August | 8 | 1.3 | 2 | 6 | 0 | 0 | 25 | 75 | 0 | 0 |
| (490-610) | 22 August | 14 | 2.3 | 0 | 13 | 0 | 1 | 0 | 93 | 0 | 7 |
|  | 29 September | 6 | 1.0 | 2 | 1 | 1 | 2 | 33 | 17 | 17 | 33 |
|  | 4 August | 8 | 0.9 | 2 | 6 | 0 | 0 | 25 | 75 | 0 | 0 |
| (610-780) | 11 August | 6 | 1.5 | 0 | 5 | 0 | 1 | 0 | 83 | 0 | 17 |
|  | 23 August | 27 | 3.2 | 5 | 15 | 0 | 7 | 18 | 56 | 0 | 26 |
|  | 29 September | 6 | 0.7 | 0 | 2 | 0 | 4 | 0 | 33 | 0 | 67 |
|  | 4 August | 10 | 2.0 | 1 | 9 14 | 0 | 0 | 10 | 90 | 0 | 0 |
| (780-880) | 11 August | 20 | 4.0 | 4 | 14 | 0 | 2 | 20 | 70 | 0 | 10 |
|  | 23 August | 28 | 5.6 | 8 | 8 | 1 | 11 | 29 | 29 | 4 | 39 |
|  | 29 September | 10 | 2.0 | 1 | 3 | 2 | 4 | 10 | 30 | 20 | 40 |
|  | 11 August | 15 | 3.3 | 3 | 12 | 0 | 0 | 20 | 80 | 0 | 0 |
| $(880-970)$ | 23 August | 8 | 1.8 | 3 | 2 | 0 | 3 | 38 | 25 | 0 | 37 |
|  | 29 September | 9 | 2.0 | 1 | 4 | 0 | 4 | 12 | 44 | 0 | 44 |

0+ "young of the year" trout
$1++$ yearling and older trout

Table 2. Combined brook trout catch, Icewater Creek, West Tributary, 26 July to 8 November 1983

|  | Number | Percentage <br> of catch |
| :--- | :---: | :---: |
| Individual fish caught | 222 |  |
| Recaptures | 62 | 28 |
| Individual fish by age class |  |  |
| $0+$ | 164 | 26 |
| $1+$ |  | 74 |
| Numbers of each age class |  |  |
| marked subsequently recaptured | $7 / 59$ |  |
| $0+$ | $55 / 164$ | 12 |
| $1++$ |  | 34 |
| $0+$ "young of the year" trout |  |  |

Table 3. Movement of recaptured brook trout, August to November 1983, Icewater Creek

|  | East trib | West trib | East branch | West branch |
| :--- | :---: | :---: | :---: | :---: |
| Total marked recaptures | 28 | 55 | 32 |  |
| Stationary (within 50 m ) | $61 \%$ | $60 \%$ | $84 \%$ | $56 \%$ |
|  |  |  |  |  |
| Total upstream movement | $29 \%$ | $18 \%$ | $16 \%$ | $44 \%$ |
| Less than 200 m | $18 \%$ | $11 \%$ | $16 \%$ | $33 \%$ |
| Greater than 200 m | $11 \%$ | $7 \%$ | 0 | $11 \%$ |
| Total downstream movement | $14 \%$ | $22 \%$ | 0 | 0 |
| Less than 200 m | $3 \%$ | $11 \%$ | 0 | 0 |
| Greater than 200 m | $11 \%$ | $11 \%$ | 0 | 0 |

A base line assessment of resident brook trout in Icewater Creek was continued in 1984. Based on results from the 1983 fish survey, specific brook trout study sections were designated in five portions of the upper watershed (Fig. 2). Trout populations within these sections were sampled monthly from early May to October with an electroshocker and dip nets. All brook trout captured were tallied, weighed, measured, and fin clipped. Those measuring greater than 70 mm were hot branded with a combination of letter symbols to allow for individual recognition of recaptured fish.

The 1984 field season initiated a systematic trout sampling routine which will be continued for establishing a pretreatment data base and, subsequently, for assessing effects on resident brook trout populations of a forest pesticide applied to portions of the upper watershed. Density estimates of brook trout in each of the study sections, calculated with a maximum weighted likelihood estimation model, varied throughout the sampling season (May to October) with spatial differences more apparent than seasonal trends (Table 4). Capture fractions were determined for each sample date (Table 5) and indicated that percent recaptures ranged from 10 to 76 , with an overall recapture rate of approximately $30 \%$. Trout in the current year cohort appeared in the fish collections by late May, increased in percent composition of the total catch throughout the season, and represented 50 to $85 \%$ of the trout present in the study areas by October.

The recapture of marked fish allowed for direct measurement of growth of individual brook trout from different times of the year. Fish recaptured within specific time segments were pooled and instantaneous
rates of growth were calculated for different seasons. These values, presented in Table 6, provide an indication of temporally relative growth rates and suggest that most growth of brook trout in Icewater Creek occurs in early summer. Length-weight regressions were determined and plotted for trout collected at the end of their first year of growth to facilitate annual comparison of growth of trout in the current year cohort. Regressions plotted for $0+$ trout in October 1983 and 1984 (Figures 4 and 5) illustrate good length-weight correlation and a strong similarity in slope for both groups of fish.

Annual trout production and standing stock estimates were computed for each of the study sections using a modified size-frequency method. The values presented in Table 7 indicate that trout production in Icewater Creek is substantially lower than most previously documented production rates cited by other researchers studying brook trout populations in various other areas of North America. These estimates, however, are probably indicative of trout populations found in physically similar cold water streams, and provide viable base line data against which to evaluate secondary effects of a forest pesticide on the resident brook trout population.

The computer program used for determining the annual production and biomass has consistently underestimated the variance for both parameters, and is currently being reworked to provide more rellable estimates of variance. The intended revision will revise the production and standing stock estimates downwards but not change the relative differences between sites.


Fig. 3. Brook trout study sections in the upper watershed of Icewater Creek where 1984 studies were concentrated.

Table.4. Brook trout density estimates in Icewater Creek Fish population assessment areas, 1984

| Location | Date | $\hat{N}$ | $v(\hat{N})$ | $\begin{aligned} & 95 \% \\ & \text { C.I. } \end{aligned}$ | $\hat{p}$ | $V(\hat{p})$ | Number/ hectare |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| East trib | 29 May | 33 | 0.60 | 33-35 | 0.767 | 0.006 | 306.2 |
|  | 07 Aug. | 21 | 0.72 | 21-23 | 0.724 | 0.011 | 194.9 |
|  | 12 Oct. | 72 | 65.38 | 61-88 | 0.455 | 0.009 | 668.2 |
| West trib | 28 May | 28 | 0.80 | 28-30 | 0.737 | 0.008 | 306.3 |
|  | 04 July | 34 | 7.06 | 32-40 | 0.582 | 0.012 | 372.0 |
|  | 01 Aug. | 34 | 3.21 | 33-38 | 0.647 | 0.009 | 372.0 |
|  | 10 Oct. | 38 | 3.03 | 37-42 | 0.661 | 0.008 | 415.7 |
| East branch | 08 May | 32 | 8.03 | 30-38 | 0.462 | 0.011 | 746.9 |
|  | 06 June | 35 | 14.90 | 32-43 | 0.681 | 0.018 | 816.9 |
|  | 09 July | 46 | 9.64 | 43-53 | 0.581 | 0.009 | 1073.6 |
|  | 16 Aug. | 37 | 3.19 | 36-41 | 0.655 | 0.008 | 863.6 |
|  | 15 Oct. | 54 | 27.35 | 48-65 | 0.505 | 0.010 | 1260.4 |
| West branch | 04 May | 23 | 133.91 | 16-46 | 0.308 | 0.050 | 393.5 |
|  | 31 May | 21 | 0.32 | 21-23 | 0.778 | 0.009 | 359.3 |
|  | 05 July | 36 | 19.38 | 32-45 | 0.500 | 0.015 | 616.0 |
|  | 10 Aug. | 17 | 0.15 | 17-18 | 0.810 | 0.009 | 290.9 |
|  | 03 Oct. | 23 | 0.61 | 23-25 | 0.742 | 0.010 | 393.5 |
| Crossover | 03 May | 23 | 10.75 | 21-30 | 0.512 | 0.022 | 677.3 |
|  | 30 May | 19 | 1.12 | 19-22 | 0.576 | 0.013 | 559.5 |
|  | 03 July | 20 | 0.79 | 20-22 | 0.714 | 0.012 | 589.0 |
|  | 31 July | 15 | 5.17 | 14-20 | 0.538 | 0.031 | 441.7 |
|  | 02 Oct. | 18 | 0.95 | 18-20 | 0.692 | 0.015 | 530.1 |

[^0]Table 5. Summary of brook trout capture data from Icewater Creek fish population assessment areas, 1984

| Location | Date | Actual catch | \% O+ trout | \% recapture of total catch | \% recapture excluding $0+$ |
| :---: | :---: | :---: | :---: | :---: | :---: |
| East trib | 29 May | 33 | 0 | 30 | 30 |
|  | 07 Aug. | 21 | 81 | 10 | 50 |
|  | 12 Oct. | 61 | 81 | 11 | 45 |
| West trib | 28 May | 29 | 3 | 48 | 50 |
|  | 04 July | 32 | 28 | 28 | 39 |
|  | 01 Aug. | 33 | 54 | 42 | 80 |
|  | 10 Oct. | 37 | 49 | 57 | 63 |
| East branch | 08 May | 30 | 0 | 67 | 67 |
|  | 06 June | 35 | 8 | 51 | 56 |
|  | 09 July | 43 | 35 | 44 | 68 |
|  | 16 Aug. | 36 | 67 | 42 | 67 |
|  | 05 Oct. | 48 | 70 | 33 | 67 |
| West branch | 04 May | 16 | 0 | 50 | 50 |
|  | 31 May | 37 | 43 | 51 | 90 |
|  | 05 July | 32 | 44 | 44 | 78 |
|  | 10 Aug. | 17 | 53 | 76 | 100 |
|  | 03 Oct. | 23 | 43 | 52 | 77 |
| Crossover | 03 May | 21 | 0 | 43 | 43 |
|  | 30 May | 22 | 14 | 64 | 74 |
|  | 03 July | 20 | 85 | 20 | 100 |
|  | 31 July | 14 | 86 | 29 | 100 |
|  | 02 Oct. | 18 | 67 | 17 | 50 |


Fig. 4. Weight-1ength regression of $0+$ brook trout, October 1983, Icewater Creek.


Fig. 5. Weight-1ength regression of $0+$ brook trout, October 1984, Icewater Creek.

Table 6. Seasonal growth of individually marked brook trout in Icewater Creek subsequently recaptured at a later date, October 1983 to October 1984

|  | $\begin{gathered} \text { Aug. to Oct. } \\ 1983 \end{gathered}$ | $\begin{gathered} \text { Sept. '83 to } \\ \text { May '84 } \end{gathered}$ | June to Aug. $1984$ | $\begin{aligned} & \text { Aug, to Oct. } \\ & 1984 \end{aligned}$ |
| :---: | :---: | :---: | :---: | :---: |
| N | 14 | 22 | 15 | 11 |
| Mean initial FL (mm) | 147.6 | 136.2 | 103.5 | 113.0 |
| SD | 22.8 | 27.2 | 29.9 | 25.8 |
| Range | 108-183 | 89-198 | 74-174 | 82-162 |
| Mean initial Wt (g) | 34.0 | 27.3 | 13.5 | 16.8 |
| SD | 15.6 | 18.4 | 14.6 | 11.6 |
| Range | 11.5-61.0 | 6.8-80.0 | 4.1-57.0 | 5.4-45.0 |
| Mean increase in length (mm) | 1.36 | 11.91 | 23.9 | 10.8 |
| SD | 1.78 | 7.36 | 8.19 | 10.18 |
| Range | 0-6 | 1-27 | 12-43 | 2-30 |
| Instantaneous rate of increase | 0.004 | 0.037 | 0.093 | 0.045 |
| SD | 0.005 | 0.022 | 0.032 | 0.046 |
| Range | 0-0.016 | 0.004-0.760 | 0.049-0.152 | 0.006-0.135 |
| Mean increase in weight (g) | 0.32 | 6.49 | 11.00 | 2.55 |
| SD | 0.95 | 6.71 | 9.17 | 2.53 |
| Range | 0-3.5 | 0-24.5 | 3.1-35.5 | 0-7.7 |
| Instantaneous rate of increase | 0.003 | 0.101 | 0.278 | 0.089 |
| SD | 0.010 | 0.075 | 0.089 | 0.111 |
| Range | 0-0.038 | 0-0.222 | 0.144-0.424 | 0-0.329 |

Table 7. Annual production and standing stock estimates of brook trout in Icewater Creek computed from 1984 fish population sampling data

| Location | $\begin{gathered} \hat{\mathrm{P}} \\ \mathrm{~kg} / \mathrm{area} \end{gathered}$ | $V(\hat{P})$ | $\begin{aligned} & \text { 95\% C.I. } \\ & \text { half-1ength } \end{aligned}$ | $\begin{gathered} \hat{\mathrm{P}} \\ \mathrm{~kg} / \mathrm{ha} \end{gathered}$ | $\bar{B}$ kg/area | $\mathrm{V}(\overline{\mathrm{B}})$ | $\begin{gathered} \bar{B} \\ \mathrm{~kg} / \mathrm{ha} \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| East trib | 0.5896 | $1.381 \times 10^{-2}$ | $2.122 \times 10^{-2}$ | 5.471 | 0.4267 | $5.115 \times 10^{-2}$ | 3.960 |
| West trib | 0.6971 | $2.551 \times 10^{-3}$ | $4.259 \times 10^{-3}$ | 7.626 | 0.5292 | $2.346 \times 10^{-3}$ | 5.789 |
| East branch | 0.8129 | $4.041 \times 10^{-3}$ | $7.288 \times 10^{-3}$ | 18.973 | 0.5481 | $7.602 \times 10^{-3}$ | 12.792 |
| West branch | 0.5096 | $2.006 \times 10^{-2}$ | $2.864 \times 10^{-2}$ | 8.719 | 0.4558 | $2.578 \times 10^{-2}$ | 7.799 |
| Crossover | 0.175 | $4.945 \times 10^{-4}$ | $4.131 \times 10^{-3}$ | 5.139 | 0.1157 | $1.989 \times 10^{-4}$ | 3.407 |
| $\begin{array}{ll} \overline{\hat{P}} & =\text { estimated production } \\ V(\hat{P}) & =\text { variance of estimated production } \\ & =\text { mean annual standing stock } \\ V(\bar{B}) & =\text { variance of annual standing stock } \end{array}$ |  |  |  |  |  |  |  |


[^0]:    Note: $0+$ trout not included in density estimate until July. $\hat{\mathrm{N}} \hat{\text { D }}$ Density estimate.
    $\mathrm{V}(\hat{N}) \quad$ Variance of density estimate.
    $\hat{p}$ Estimated probability of capture.
    $\mathrm{V}(\hat{\mathrm{p}})$ Variance of probability of capture.

