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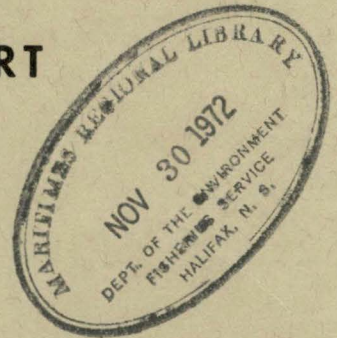


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MEDWAY RIVER, NOVA SCOTIA, FLOW CONTROL -

A FEASIBILITY STUDY

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by

L.J. Andre Ducharme

November 1972

**Fisheries Service
Halifax, N.S.**

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A FEASIBILITY STUDY

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L.J. Andre Ducharme
Resource Development Branch
Fisheries Service
Department of the Environment
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INTRODUCTION

Flow control on the Medway River has been a subject of concern for the Medway River for several decades. Most early requests for flow control on the river related to the prevention of floods. Since 1965, however, the residents have repeatedly indicated their interest in flow control as a means to prolong and increase angling success on the Medway.

The purpose of this paper is to consolidate pertinent information on the subject to date, and to examine proposals for flow control in the Medway River. In estimating benefit/cost ratios, only benefits which can be attributed to increased angling have been considered. Consideration was also given to other alternative methods for providing increased salmon runs to the Medway River which would increase angling potential.

Medway River Salmon Angling Status:

Angling catches in the Medway have decreased since 1965. Angling records indicate that at least part of this decrease is province wide as shown in the table below.

| <u>River</u> | <u>Average annual angling catch</u> | | |
|---------------------------|-------------------------------------|------------------|-------------------|
| | <u>1958-1964</u> | <u>1965-1971</u> | <u>% Decrease</u> |
| Medway River | 741 | 366 | 50% |
| LaHave River | 501 | 347 | 31% |
| West River Sheet Harbour | 302 | 222 | 26% |
| St. Mary's River | 625 | 467 | 25% |
| Nova Scotia (all streams) | 4170 | 3653 | 12% |

From the period of 1958-1964 to the period 1965-1971 the decrease in Medway River angling catch was nearly twice that in the St. Mary's, LaHave and West Rivers. The decrease in these three rivers is partly attributed to recent (1960) development in the commercial fisheries off the west coasts of Greenland, and driftnet fishing off Newfoundland. The extensive harvest of large salmon by these far off fisheries compounded with the local fisheries (also harvesting large salmon) has caused a change in the run composition, as reflected by the reduced weight of fish caught by anglers and the increasing number of grilse in the Medway River (Fig. 1). The additional decrease in Medway River angling

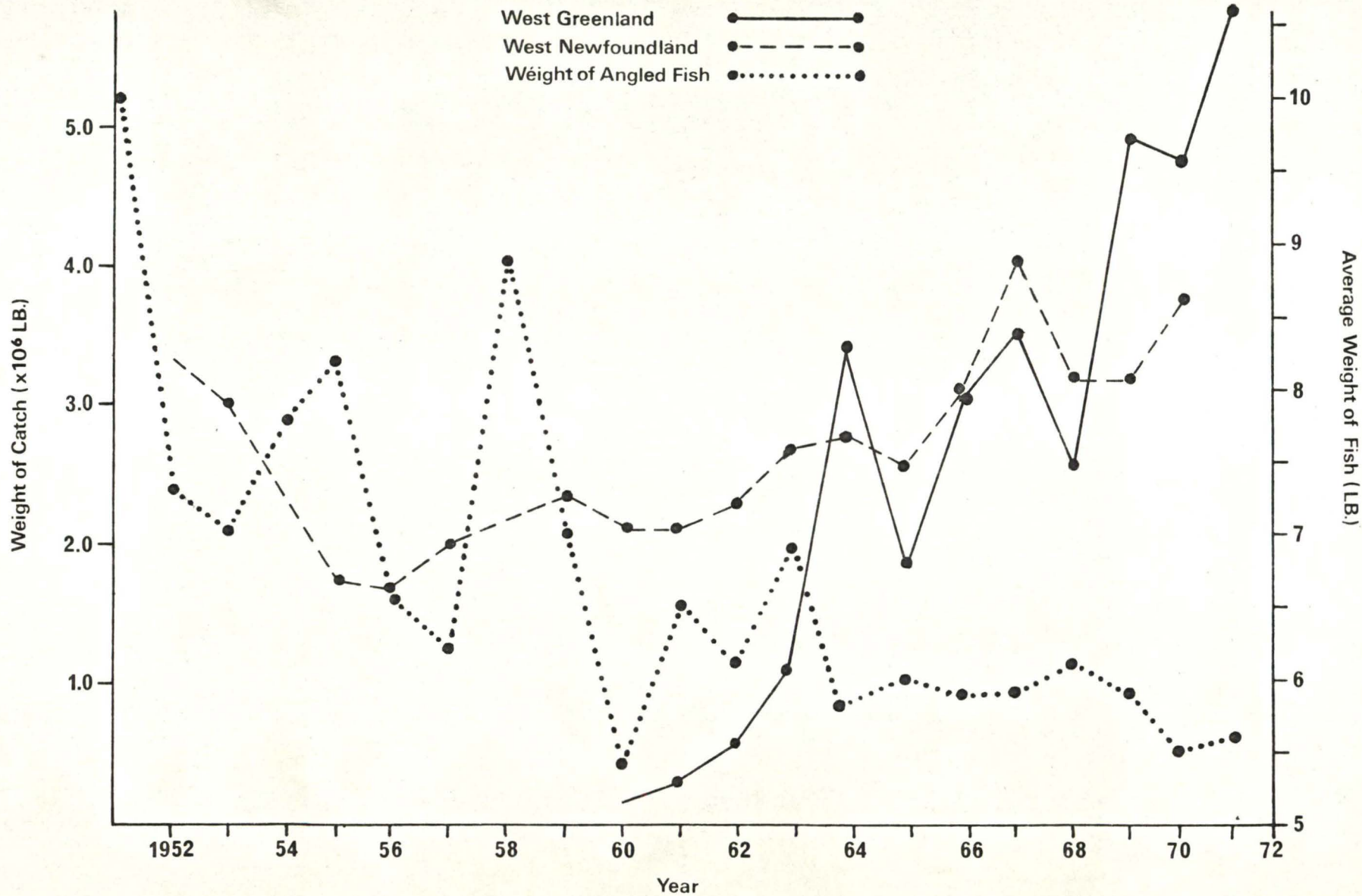


Fig. 1. Relationship between West Greenland and West Newfoundland commercial Atlantic salmon fisheries and the average weight of fish angled in Medway River, Nova Scotia.

catch based on the angling level for the period 1958-1964 represents approximately 170 fish per annum.

Medway River General Description

Detailed physical descriptions of the Medway River are contained in previous manuscript reports (Jefferson, 1966; Dominy, 1966; and Wykes, 1967). The Medway River flows southeasterly into Medway Harbour on Nova Scotia's South Shore approximately 100 miles west of Halifax. The river is formed by the confluence of two large streams, the Medway and Pleasant Rivers, adjoining 18 miles from salt water. From headwaters to head of tide the length of the river is approximately 58 miles (Fig. 2).

Two most important features of the Medway River system relating to flow regulations are the relatively steep gradient of the streams and the numerous lakes found throughout the watershed. The largest lakes in the system are Molega (8050 acres) and Ponhook (7950 acres) approximately 16 miles from salt water. Molega Lake is part of the Pleasant River system. It drains into Ponhook Lake from two separate outlets (Fig. 2). An important tributary stream of the Medway River is the Westfield River on which Tupper Lake is situated. This stream was assessed as 10% of the Medway River flow at Charleston (Beaulieu, MS 1967), and at 25% and 5% of the Medway River spawning and rearing area respectively (Dominy, MS 1966).

The main Medway River trunk below Ponhook Lake is wide, steep sloped (2.4 yards per 100 yards), and unobstructed. The Medway tributary between Ponhook and McGowan Lake is also unobstructed. The Harmony Mills dam and power plant at the outlet of McGowan Lake constitutes the most serious obstruction in the entire system. A fishway was incorporated in the dam but its operation has been erratic due to conflicting hydro operation requirements. Reports that the Pleasant River tributary contains two impassable falls approximately 10 miles above Molega Lake are erroneous; only moderately fast rapids are found at these locations. Several old timber dams (formerly used in log driving operations) also remain in the headwaters of both the Medway and Pleasant Rivers. Their usefulness as water control structures as well as potential effect on migratory salmon is minimal. The best salmon waters for rearing and angling in the Medway River lie between McGowan Lake and the Mouth of the River, and in the Westfield River below Tupper Lake (spawning).

Medway River Watershed Deforestation

It has been suggested by departmental engineers that reduced water levels of the Medway have been caused by extensive

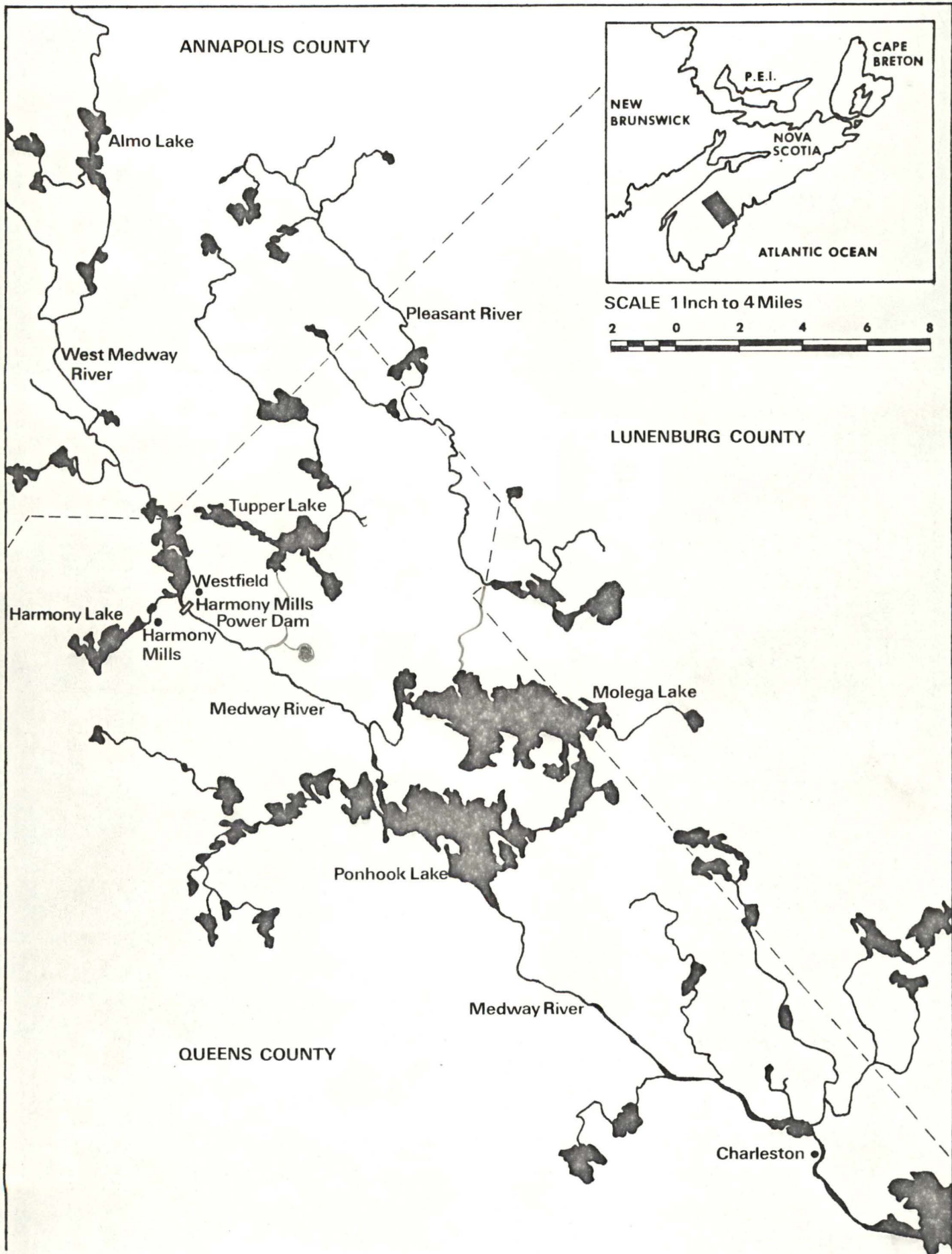


Fig. 2. Map of the Medway River watershed.

deforestation. The Bowaters Mersey Paper Company has been engaged in wood cutting in the Medway area since the early 1940's. Much of the cutover area lies in close proximity to the lakes and streams where it more directly affects the run-off characteristics of the streams. The extent of wooded area cleared or partially cleared during the period 1952¹ to 1972 is as follows:

| <u>County</u> | <u>Watershed Area (acres)</u> | <u>Cutover Area (acres)</u> | <u>% Cutover</u> |
|---------------|-------------------------------|-----------------------------|------------------|
| Annapolis | 150,786 | 7,851 | 5.2 |
| Lunenburg | 92,660 | 1,070 | 1.15 |
| Queens | 190,001 | 6,489 | 3.41 |
| Totals | 433,447 | 15,410 | 3.55 |

The effect of such low degree of deforestation on surface run-off is very difficult to quantify. In this instance, storage dams (for log drives), which may have reduced the effect of deforestation, were built concurrently to wood cutting. For the dry months of June and July, 24 years of data (Fig. 3) show great variability in river discharge and a gradual decline to 1968. In recent years, logging dams have become obsolete or fallen into disrepair. Many were either washed away or actively removed. This has resulted in intensified flood and drought conditions in the past 10 years.

Review of Flow Control Request for Medway River

Reiterated demands have been made by local residents for the Department to implement flow control on Medway River. These requests pointed out the need to improve angling and spawning conditions by: (1) repairing or rebuilding two dams at Molega Lake outlets [2] [Petition, May 1967] namely the Tait's Run and the Black Rattle dams. These dams were originally built by the Department in 1950 for the purpose of "Stabilizing summer water levels", and were abandoned in 1959. (2) Construction of flow control structure on Westfield River [Petition, January 1967] to "better the spawning conditions for fish"; and (3) By any other form of management or control such as: gravel removal control or repair of damages done in the past by gravel removal [1964], and minimum flow requirements through the fishway at Harmony Mills hydro station [N.S. Sal. Ass., 1971].

¹ Forest information from aerial photographs taken in 1967. Cutover areas remain identifiable for approximately 15 years. No information is available prior to 1952.

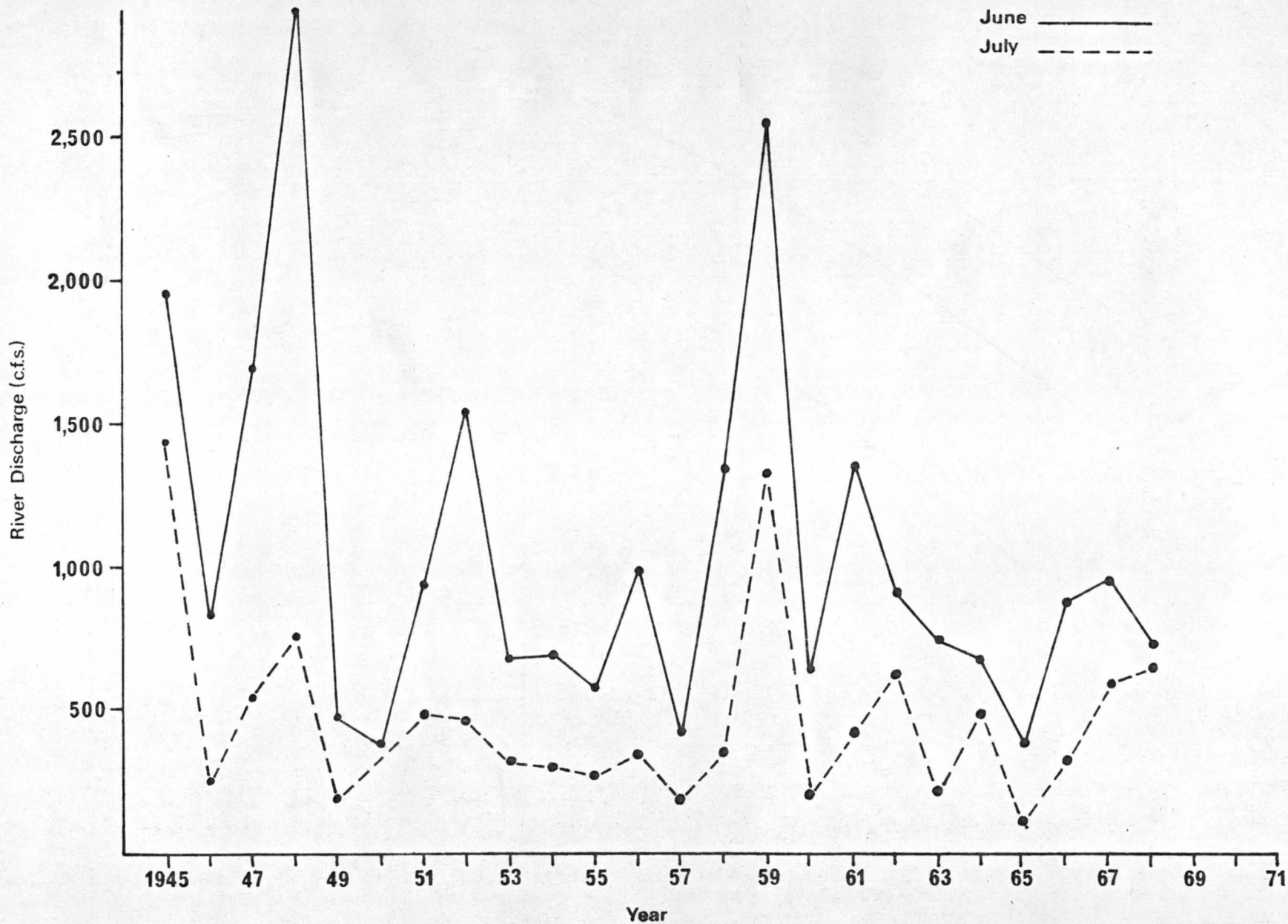


Fig. 3. Diagram of Medway River discharge measured at Charleston.

In 1969, three small dams in the headwaters of the Medway River (Medway, Alma and Crooker Lake dams) were extensively repaired by the cooperative efforts of the Nova Scotia Power Commission, the Nova Scotia Anglers' Association, Bowaters Mersey Paper Company and the Department of Fisheries and Forestry. By this work 75% of the Medway's headwater flow was re-harnessed. District Protection Officer C.D. Morrison (Oct. 1969) urged that similar renovation work be carried out on the Tait's Run dam at Molega Lake. His estimate of cost was a range from 5,000 to 10,000 dollars depending on materials used. Mr. Morrison estimated the life of the proposed structure would be 15 to 25 years.

In preparation for future flow control projects, extensive engineering and biological surveys were carried out by Departmental staff. Jefferson (MS 1966) suggested that flow control in the headwaters was impractical as too many widespread control installations would be required. The results of his investigation showed that a minimum discharge level of 100 c.f.s. (residual flow) could be obtained with only a 4 foot storage on the 8050 acres Molega Lake. This flow could be maintained for a period of 5 to 6 months and would benefit the 15 miles of river below the lake (principal angling area in the river). Concurrent with the engineering survey work of 1966, a biological investigation was carried out (Dominy, MS 1966). The purpose of this study was to map out and estimate Atlantic salmon spawning and rearing areas and provide information on the physical conditions in the Medway River watershed and its angling history. Mr. Dominy recommended the construction of a dam at Tupper Lake to maintain reasonable flows in the Westfield River (prime spawning area), the renovation of two flow control dams at Molega Lake, and the biological assessment of salmon juveniles (resident and migratory) and adult spawners ascending the river.

Further biological investigations were undertaken in 1967 to provide additional information on the life history of the Medway River salmon, and further prepare for a possible flow control program (Wykes, MS 1967). The conclusions drawn from this study were that: (1) there is no shortage of water in the Medway River at the time of upstream migration nor is there a shortage of water at spawning time; (2) in late summer [July, August, September] the ill effect of extreme low water levels may be mitigated by the presence of abundant pools and stillwater areas where adults and possibly juvenile fish may find refuge; (3) the angling catch in Medway River is relatively stable; (4) flow control should not be implemented on Medway River until its effect on salmon populations have been studied under more favourable experimental conditions.

Flow Control Proposals

Flow control was implemented at Molega Lake in 1950 by the construction of dams on the outlets (2) of the lake. The operation of these flow control structures was erratic for the period 1950-1959. The dams were abandoned in 1959 without being removed. The angling level from 1950-1959 was 628 fish/annum compared to the level of 626 fish for the 5 years (1960-1964) following the abandonment of "flow control" and the coming into effect of certain strong factors which will be discussed further in this report.

A proposal for the maintenance of summer flows (not flood control!) for the benefit of juvenile Atlantic salmon rearing naturally in the Medway system, as well as for the benefit of anglers was formulated by Millen (MS 1968). The Millen report was based on previous engineering and biological reports. He proposed structures of concrete and steel (50 year life) with a design minimum flow of 180 c.f.s. or that flow required to cover most of the river bed in the lower Medway. Two complementary control structures were proposed - these were the Molega Lake dams (2) and the Tupper Lake dam on the Westfield River. In this scheme, Molega Lake is used to supply bulk water (150 c.f.s.) for a 60-day drought period and Tupper Lake to provide a minimum of 30 c.f.s. for 60 days in the Westfield River, which was described as the best spawning and rearing area in the Medway system (Dominy, MS 1966). Millen's estimated costs in 1968 were as follows:

| | |
|---|------------------|
| Molega Lake Storage Dams (2) (including \$10,000. access road) | \$ 87,000 |
| Tupper Lake Dam | 26,000 |
| Total cost in 1968 | <u>\$113,000</u> |

Field work on these sites is complete, design work is also complete for the proposed concrete structures. Any modifications to the original proposal could be completed within one or two months (Jenkins, personal communication).

An alternative proposal involving the construction of several small dams in the headwaters of the Medway above McGowan Lake was deemed impractical because of: (1) the high cost of manpower required to regulate spread out and inaccessible dams [3]; (2) the small storage potential involved [approximately 1288 acres]; and (3) the loss of water control at Harmony Mills hydro-dam.

It is worth noting that while flow control may restore the volume of flow to its original level, in at least part of the Medway River course, the impoundment of water will probably increase the water temperature.

Estimate of Flow-Control-Related Angling Benefits

The Medway River salmon population has early-run characteristics and at migration time (May-June) there is no shortage of water nor is there a shortage of water at spawning time (Wykes, MS 1967). In July, August and September, river discharge decreases often drastically (see table below). The many lakes and pools in the system may have a dampening effect in providing juvenile populations of salmon a refuge during

Average Flows Period 1955-1968

| <u>Month</u> | <u>c.f.s.</u> |
|--------------|---------------|
| May | 1597 |
| June | 924 |
| July | 434 |
| August | 318 |
| September | 397 |
| October | 791 |

extended drought periods. This benefit is uncertain as this area of the Atlantic salmon biology is poorly documented.

The angling season on the Medway River takes place between April 1st and July 30th. This one month earlier than in the St. Mary's River, an equally good salmon angling stream in Nova Scotia. Figure 4 below shows that the bulk of salmon angled in the Medway River are caught during the month of June while the St. Mary's River has two good angling months (July, August).

A comparative biostatistical study of angling catch and hydrographic conditions between Medway and St. Mary's Rivers was carried out by Ezzat (1971). The study endeavoured to answer the question of usefulness of flow control in Medway River. The most significant conclusion drawn from this study was that flow control would benefit angling in the Medway River during the month of July only.

The examination of 24 years of annual angling and monthly flow data by Ezzat (1971) showed that the correlation between flow and annual angling catch is much stronger in July than in June (June $r = 0.614$, July $r = 0.932$). Also,

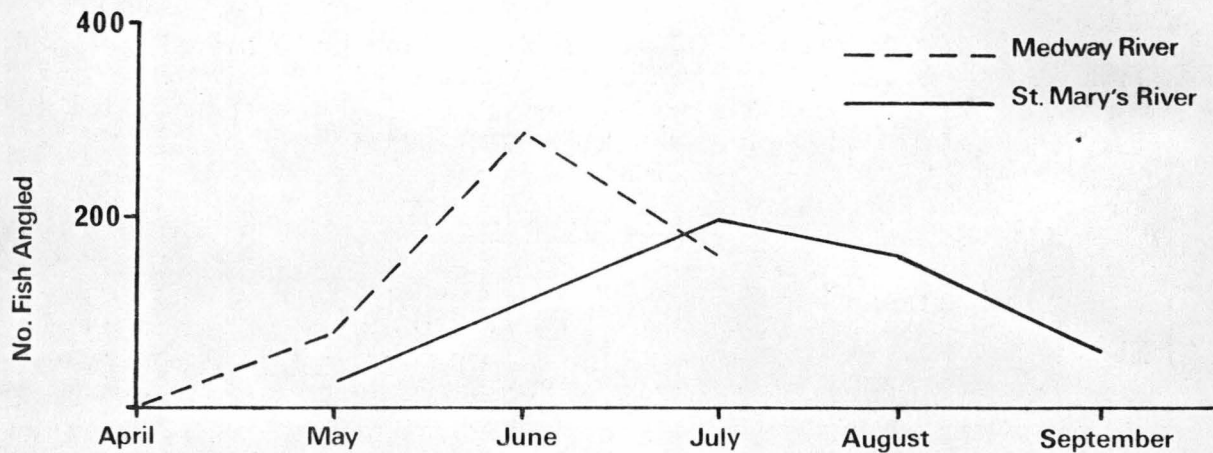


Fig. 4. Comparing mean monthly angling catch between Medway River (10 year average) and St. Mary's River (16 year average), Nova Scotia.

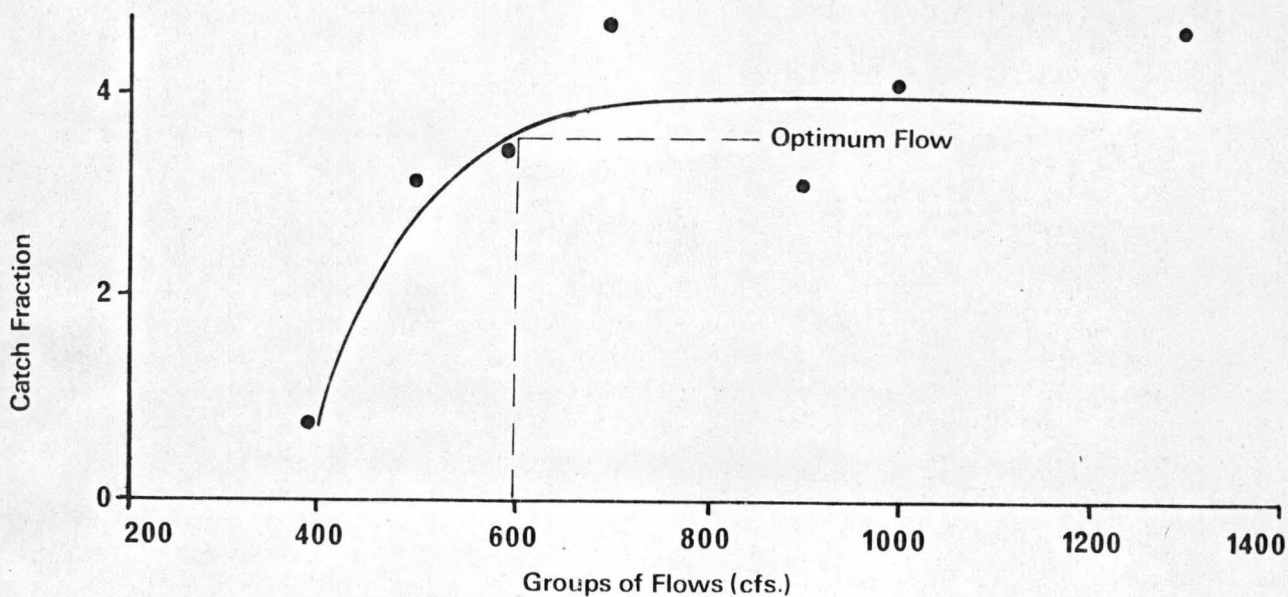


Fig. 5. Diagram showing the relationship between river flow and salmon angling catch in Medway River, Nova Scotia. Note the point of optimum flow at approximately 600 (cfs).

no significant correlation exists in June between fishing effort and flow but in July a significant positive correlation ($r = 0.7248$) exists between these two parameters.

Assuming that flow is the major factor influencing both fishing effort and catch, Ezzat (unpublished data, 1971) endeavoured to determine the optimum flow for good angling in Medway River, using June flow and catch data (month of highest yield). In Figure 5, angling catch expressed as a fraction of the highest monthly catch experienced during 16 years of data $\left(\frac{\text{mean catch per group of flow}}{\text{(max. recorded catch for the month (700 fish))} \times 10} \right)$ is plotted against flow groupings of 100 c.f.s. (flow measured at Charleston). The resulting sigmoidal curve shows the optimum flow to be approximately 600 c.f.s.

Determination of Angling Benefits

Substituting the optimum flow value in the mathematical equation which expresses the correlation between flow and angling catch in June (Ezzat, 1971), we find:

$$\begin{aligned} \text{June angling catch} &= 0.1542 F + 167.5251 \\ &= 0.1542 \times 600 + 167.5251 \\ &= 260 \text{ fish.} \end{aligned}$$

In June an actual average of 293 fish are caught (Table 1) and the mean river discharge was over 600 c.f.s. in 18 out of 24 years from 1945 to 1968 (Table 2). The lowest mean June flow on record for that period was 371 c.f.s. It follows that flow control in June would be virtually meaningless in terms of angling benefit.

Table 1. Summary of monthly salmon angling statistics for the period of 1952-1967.

| Month | (Mean) No. Fish Angled | (Mean) Rod Days | (Mean) Rod Days/Fish |
|-------|---------------------------|--------------------|-------------------------|
| April | 8 | 285 | 35.6 |
| May | 79 | 1186 | 15.0 |
| June | 293 | 2697 | 9.2 |
| July | 162 | 1293 | 7.9 |

Substituting the guaranteed flow of 180 c.f.s. (Millen 1968) in the equation expressing the catch/flow correlation in July, we find:

$$\begin{aligned} \text{July angling catch} &= 0.3543 F + 17.5557 \\ &= 0.3543 \times 180 + 17.5557 \\ &= 81 \text{ fish} \end{aligned}$$

In July an average of 162 fish are caught by anglers (Table 1). The addition of 180 c.f.s. to the mean monthly flow means that in 15 years out of 25 the July flow would be near or above the optimum flow calculated for June (Table 2). Theoretically, the proposed level of flow control would result in an approximate 50% increase in angling success for the month of July.

Table 2. Average monthly flows for June and July in Medway River, 1945-1968.

| Year | June Flow c.f.s. | July Flow | July Flow Corrected + 180 c.f.s. |
|------|---------------------|-----------|--|
| 1945 | 1950 | 1430 | 1610 |
| 1946 | 833 | 259 | 439 |
| 1947 | 1690 | 540 | 720 |
| 1948 | 2960 | 768 | 948 |
| 1949 | 477 | 187 | 367 |
| 1950 | 371 | 336 | 516 |
| 1951 | 934 | 486 | 666 |
| 1952 | 1550 | 457 | 637 |
| 1953 | 676 | 317 | 497 |
| 1954 | 696 | 297 | 477 |
| 1955 | 575 | 261 | 441 |
| 1956 | 990 | 348 | 528 |
| 1957 | 421 | 180 | 360 |
| 1958 | 1340 | 347 | 527 |
| 1959 | 2550 | 1320 | 1500 |
| 1960 | 633 | 202 | 382 |
| 1961 | 1350 | 424 | 604 |
| 1962 | 912 | 625 | 805 |
| 1963 | 740 | 207 | 387 |
| 1964 | 474 | 491 | 671 |
| 1965 | 392 | 106 | 286 |
| 1966 | 875 | 327 | 507 |
| 1967 | 962 | 598 | 778 |
| 1968 | 730 | 645 | 825 |

The estimated 81 additional fish in the July angling catch would provide an additional number of rod days equal to $81 \times 7.9 \text{ rod/days} = 640 \text{ rod days}$, assuming the catch efficiency for July in Medway River remained constant. Catch effort, however, is positively correlated to river discharge and thus substituting the additional flow value of 180 c.f.s. in the equation expressing the catch effort/flow relationship, (Ezzat, unpublished 1971), we find the increased number of rod days would be:

$$\begin{aligned} \text{Fishing effort in July} &= 2.2947 F + 259.9050 \\ &= 2.2947 \times 180 + 259.9050 \\ &= 673 \text{ rod days (additional)}. \end{aligned}$$

Effect of Water Temperature on Angling Catch

In South Shore Nova Scotia rivers, water temperatures in July are consistently in the 68-74 degree range as shown in the table below:

| Year | La Have (Morgan Falls) | | Medway (Charleston) | | Mersey (Mill Falls) | |
|------|---------------------------|-------|------------------------|-------|------------------------|-------|
| | 1-15 | 16-31 | 1-15 | 16-31 | 1-15 | 16-31 |
| 1967 | N/A | N/A | 69.7 | 72.2 | N/A | N/A |
| 1968 | " | " | N/A | N/A | 72.2 | 73.3 |
| 1969 | " | " | " | " | 72.4 | 74.2 |
| 1970 | " | " | " | " | 67.4 | 74.8 |
| 1971 | " | " | " | " | 73.8 | 71.9 |
| 1972 | 72.7 | 73.7 | " | " | | |

The effect of water temperature on angling success was investigated using daily water temperature and angling catch data from the lower Medway River for 1967 (Wykes and Morrison, unpublished). In 1967, a statistically significant ($P < 0.001$) negative correlation existed between daily angling catches and water temperatures in July (no correlation in June). Monthly flow rates in July 1967 were high (598 c.f.s.), well above the last fifteen years average of 434 c.f.s., and very close to the mathematically derived optimum angling flow of 600 c.f.s., (Ezzat, MS 1971). Due to the unfavorable effect of water temperature, angling catch declined from 7 fish per day at 63°F to 0 fish per day at temperatures above 73°F (Fig. 6). Angling catch for July 1967 was only 163 fish in spite of the near optimum flow conditions. Thus, in July high water temperature would have a mitigating effect on angling benefits accrued from increased flow. The angling catch increase of 81 fish is therefore considered maximal.

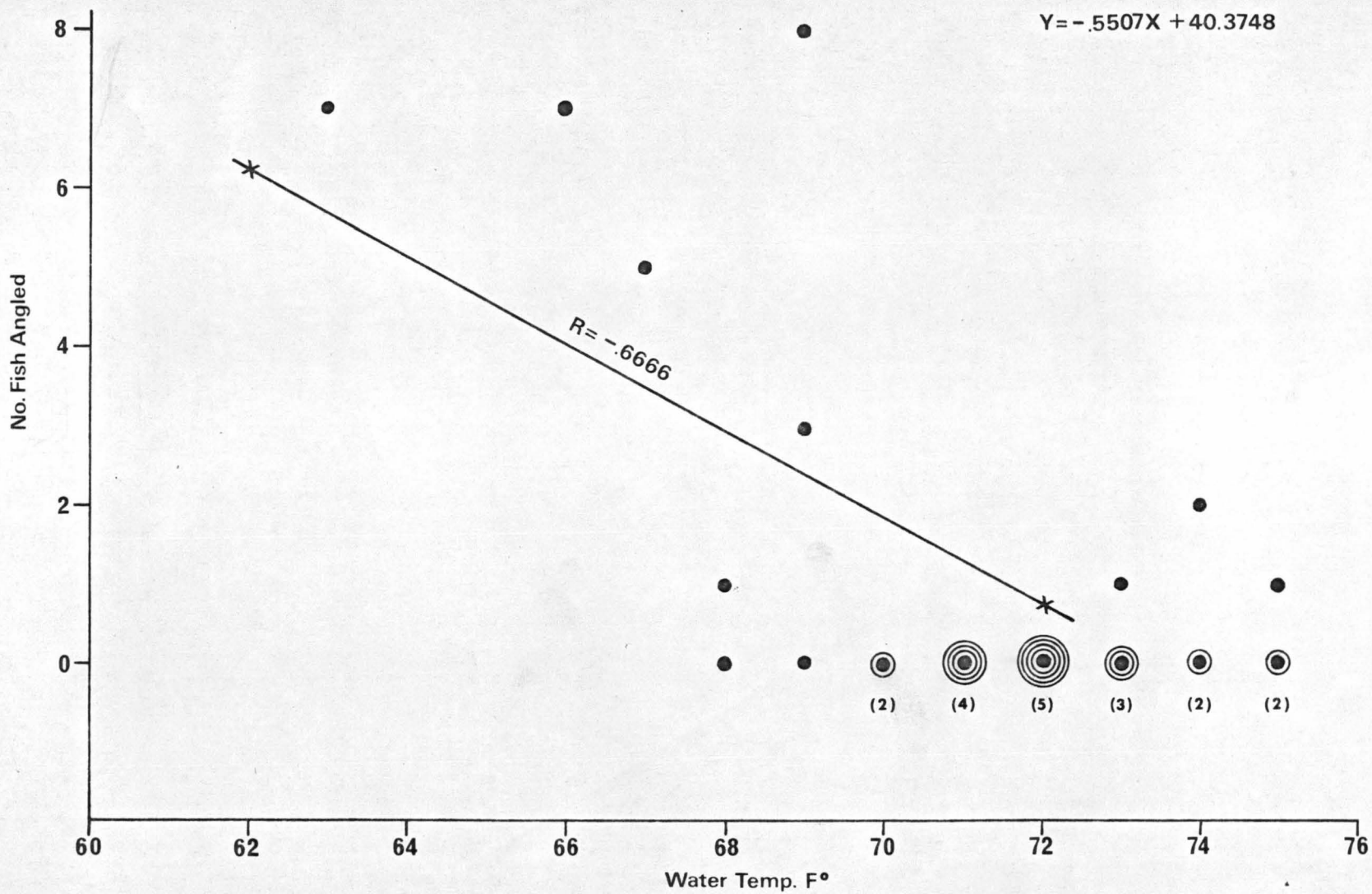


Fig. 6. Water temperatures and daily number of fish angled, Medway River, 1967.

To obviate the warm water temperature effect, colder water drawn from the depth of Molega Lake was suggested. The cost of the necessary structures (gravity fed pipe line) has been estimated at \$15,000. It is probable, however, that Ponhook Lake, into which Molega Lake empties, would either cause the cold water released from Molega Lake to warm up as it passed through or to sink deep into Ponhook, having little effect on the temperature of the surface water discharge in the lower Medway River. Ponhook Lake (Fig. 1) was deemed impractical as a reservoir site because of the legalities involved with land owners on the perimeter.

High water temperature in August (August 1-15, 1967 = 74.3°F, August 16-30, 1967 = 70.7°F) would negate benefits from increased flows. Thus the benefit cost ratio of flow control in Medway River must rely on benefits accrued in the month of July.

Cost Benefit Analysis

The cost benefit ratio of flow control is calculated on the basis of the additional rod days provided. It is assumed that we would select the proposal to construct 3 dams-on Molega Lake outlets (2), and Tupper Lake outlet-and that construction would be carried out in 1974, and the first benefits accrued in 1975. All calculations have been based on a 5% rate of interest (Millen & Ducharme, 1971).

Capital Cost Details

Alternate (1): Concrete and steel structures with access roads provided.

| (a) | <u>Year</u> | <u>Item</u> | <u>Expenditure</u> | <u>Compound Interest Factor to 1975</u> | <u>Compound Amount to 1975</u> |
|-----|-------------|---------------------------|--------------------|---|--------------------------------|
| | 1966-68 | Biological (Dominy) | 2,500 | | |
| | | " (Wykes) | 5,000 | | |
| | | Engineering (Jefferson) | 10,000 | | |
| | | " (Beaulieu) | 2,500 | | |
| | | " (Millen) | 500 | | |
| | | | <u>20,500</u> | x 1.551 | = 31,877 |
| | 1971 | Biology (Ezzat, Ducharme) | 2,500 | x 1,216 | = 3,040 |
| | 1972 | Biology (pre-assessment) | 2,500 | x 1,158 | = 2,895 |
| | 1973 | Biology (pre-assessment) | 3,000 | | |
| | | Engineering | <u>2,000</u> | | |
| | | | 5,000 | | |

| <u>Year</u> | <u>Item</u> | <u>Expenditure</u> | | <u>Compound Interest Factor to 1975</u> | <u>Compound Amount to 1975</u> |
|-------------|--|--------------------|----|---|--------------------------------|
| 1974 | Construction ¹ | 108,700 | | | |
| | " | 31,500 | | | |
| | Engineering | 2,000 | | | |
| | | 142,200 | x | 1.050 | = 149,310 |
| 1975 | Assessment | 3,000 | x | 1,000 | = 3,000 |
| 1976 | Assessment | 3,000 | x | 0.9524 | = 2,857 |
| 1977 | Assessment | 3,000 | x | 0.9070 | = 2,721 |
| 1978 | Assessment | 3,000 | x | 0.8638 | = 2,591 |
| | | Up to 1978 | .. | Capital= | 203,806 |
| | Mechanical Equipment (gates, etc.) renewal (1995) discounted to 1975 | 20,000 | x | 0.3769 | = 7,538 |
| | Road repairs (2000) every 5 years 10% of initial cost discounted to 1975 | 10,000 | x | 0.2953 | = 2,953 |
| | | | | Total Capital = | 214,297 |

¹Detail of construction given in Millen, MS (1968) Cost Estimates to 1968 were conservatively adjusted 25% to 1974.

Calculation of Annual Cost

| | | |
|---|---|------------|
| Total Capital Expenditure compounded at 5% interest to 1975 | = | \$ 203,806 |
| Future Expenditure discounted to 1975 | = | 10,491 |
| Total Capital | = | 214,297 |
| Remaining life of facilities in 1975 | = | 49 years |
| Capital recovery over 49 years at 5% = 0.05507 x 214,297 | = | 11,801 |
| Annual Operating Cost estimated | = | 3,000 |
| Total Annual Cost | = | \$ 14,801 |

Calculation of Annual Benefit

It has already been determined that the theoretical benefits derived from a guaranteed flow of 180 c.f.s. through the month of July is 81 additional salmon for the creel. Based on the rod days/fish characteristics of the Medway River for that month and taking account of the flow and catch effort relationship, the 81 additional fish angled will require 673 rod days to catch. Assuming a per rod day value of \$15.00 (Millen and Ducharme, MS 1971) the expected benefit is therefore 673 x \$15.00 = \$10,095 per year.

Calculation of Benefit/Cost Ratio

(a) Waiving all benefits of the flow control to juvenile production and also intangible experimental benefits (for future reference), the Benefit/Cost Ratio for the proposed Medway flow control scheme is:

$$\frac{\text{Annual Benefit}}{\text{Annual Cost}} = \frac{10,095}{14,801} = 0.682$$

(b) Same as (a) except that cost of biological and engineering assessment (31,877 or 14%) is not included because it has already been incurred (1966-1968).

| | | |
|--|---|--------------------------------|
| Total Capital Cost and Expenditures | = | 170,970 |
| 214,297 - 43,327 | | |
| Capital Recovery over 49 years at 5% | = | 9,450 per (a) |
| Annual Operating Cost | = | $\frac{3,000}{12,450}$ per (a) |
| Benefit/Cost Ratio = $\frac{10,095}{12,450}$ | = | 0.81 |

Alternate (2)

To limit capital investment, flow control structures could be built from round logs and untreated lumber with a life expectancy reduced to 15 years. No access roads would need be provided.

The estimated cost of flow control structure built from "on the site round logs" and untreated lumber (spill sections and fishway) is \$35,000 divided as follows: Tait Dam \$15,000, Black Rattle \$10,000, and Tupper Lake \$10,000, plus \$2,500 estimated for land acquisitions.

A new cost benefit ratio was calculated ignoring that part of the costs which has already been incurred and using the construction estimate cost of \$37,000; the results are as follows:

| | | |
|--|----------------------|------------------|
| Total Capital Investment to 1978 | = | \$ 61,994 |
| Replacement of Equipment (gates, etc.) in 1980 discounted to 1975 | = 3,000 x 0.7835= | 2,350 |
| Total Capital | = | <u>\$ 64,344</u> |

Calculation of Annual Cost

| | | |
|--|---|--------------|
| Total Capital expenditure compounded at 5% interest to 1975 | = | \$ 61,994 |
| Future Expenditures discounted to 1975 | = | <u>2,350</u> |
| Total Capital | = | \$ 64,344 |
| Remaining life of Facilities in 1975 | = | 14 years |
| Capital Recovery over 14 years at 5% = 0.10102 x 64,344 | = | \$ 6,500 |
| Annual Operating Cost estimated | = | <u>3,000</u> |
| Total Annual Cost | = | \$ 9,500 |

Calculation of Benefit/Cost Ratio:

$$\frac{\text{Annual Benefit}}{\text{Annual Cost}} = \frac{10,095}{9,500} = 1.07$$

Development and Expansion Alternatives

An alternative to flow control in Medway River is the development of salmon runs in the Pleasant River tributary and the Medway River above Harmony Mills power station. These areas presently have very small salmon populations and represent approximately 40-45 percent of the total rearing area available in the Medway River. The potential development area is divided as follows:

| <u>Stream</u> | <u>Miles</u> | <u>Width (Yards)</u> |
|--------------------------------------|--------------|--------------------------|
| Main Medway River: | | |
| McGowan Lake to Medway Lake | 13 | 15 |
| Medway Lake to Headwaters | 11 | 10 |
| West Medway Tributary | 12 | 5 |
| Pleasant River: | | |
| Molega Lake to Big Tumbling (Rapids) | 8 | 20 |
| Big Tumbling to Skull Bog Lake | 18 | 10 |
| | — | |
| | 62 | |

Assuming a production level of one smolt per hundred square yards, and a smolt-to-grilse survival of 8%, approximately 12,408 smolts could be produced, resulting in a return from the sea of 990 grilse. The potential angling yield, for an estimated 25% exploitation rate, would be 248 fish.

Development work in the upper Medway would comprise extensive modifications to the Harmony Mills Fishway at McGowan Lake. The fishway to be effective, must operate through a wider range of headpond levels (approx. 10'). A louver section leading to, and utilizing the fishway for a bypass would be required to prevent smolt migrants from entering the turbine intakes where mortalities would occur. This construction would also be complemented by adequate stocking.

Development work in the Pleasant River tributary would consist only in stocking with appropriate numbers of early run Atlantic salmon juveniles.

Cost Benefit Analysis

Assuming that the first planting of smolts and the construction work took place in 1974, the first benefit would start in 1975 but would not reach their maximum level until 1980. For the purpose of this study, the chosen starting year for benefits is 1977. As for flow control, the cost benefit ratio of development work is based on the number of additional rod days provided. It has been determined that an average of 10 rod/days is expended to capture a salmon during the months of May, June and July in Medway River. The per rod day value used is 15 dollars. The theoretical benefit is therefore:
248 fish x 10 rod days x 15 dollars = \$37,200.

Capital Cost Details

Concrete and steel structures for upstream and downstream migrants:

| <u>Year</u> | <u>Item</u> | <u>Expenditure</u> | <u>Compound Interest Factor to 1977</u> | <u>Compound Amount to 1977</u> |
|-------------|---|--------------------|---|--------------------------------|
| 1974 | Construction (fishway) | 30,000 | | |
| | Construction (louvers-skimmers) | 10,000 | | |
| | Engineering | 5,000 | | |
| | Biology | 3,000 | | |
| | Stocking (Upper Medway) 10,000 Smolts (30¢) & Distribution Cost | 3,500 | | |
| | Stocking (Pleasant River) 10,000 Smolts (30¢) & Distribution Cost | 3,500 | | |
| | | <u>55,000</u> | x 1.158 | = 63,690. |
| | | | | |
| 1975 | Stocking (Upper Medway) | 3,500 | | |
| | Stocking (Pleasant R.) | 3,500 | | |
| | Biology (Assessment & Operation) | 3,000 | | |
| | | <u>10,000</u> | x 1.103 | = 11,030 |
| 1976 | Stocking (Upper Medway) | 3,500 | | |
| | Stocking (Pleasant R.) | 3,500 | | |
| | Biology (Assessment & Operation) | 3,000 | | |
| | | <u>10,000</u> | x 1.050 | = 10,500 |
| 1977 | Stocking (Upper Medway) | 3,500 | | |
| | Stocking (Pleasant R.) | 3,500 | | |
| | Biology (Assessment & Operation) | 3,000 | | |
| | | <u>10,000</u> | x 1.000 | = 10,000 |
| 1978 | Stocking (Upper Medway) | 3,500 | | |
| | Stocking (Pleasant R.) | 3,500 | | |
| | Biology (Assessment & Operation) | 3,000 | | |
| | | <u>10,000</u> | x 0.9524 | = 9,524 |

Up to 1978Total Capital =\$104,744

Calculation of Annual Cost

| | | |
|--|---|--------------------|
| Total Capital Expenditures compounded at 5% interest to 1977 | = | 104,744.00 |
| Remaining life of facilities in 1977 | = | 47 years |
| Capital Recovery over 47 years at 5% = 104,744 x 0.05682 | = | 5,951.00 |
| Annual Operating Cost estimated | = | 2,000.00 |
| Total Annual Cost | = | <u>\$ 7,951.00</u> |

Calculation of Benefit/Cost Ratio

The benefit cost ratio for the combined rehabilitation of the Upper Medway River and the Pleasant River tributary is as follows:

$$\frac{\text{Annual Benefit}}{\text{Annual Cost}} = \frac{37,200}{7,951} = 4.68$$

CONCLUDING REMARKS AND RECOMMENDATIONS

The reduction in the Medway River salmon run, as reflected by angling catch, cannot be attributed to low summer flows alone. Undoubtedly, flow control would increase angling success in July but the theoretical benefits calculated are uncertain because of the effect temperature has on angling. Prejudice could also play a part in the success of flow control. Historically, poorer angling success in July has caused a decrease in fishing effort and this trend may not be readily reversible. The effect of prejudice on angling success is not ponderable, and therefore was not considered in this study.

Based on the facts presented above, we cannot recommend flow control for the Medway not only because the pecuniary benefits are low and uncertain, but also because to permit a greater harvest of the Medway River salmon escapement without first ensuring an equivalent increase in production could lead to depletion. The information presented above also shows how salmon runs in the Medway River can be developed to produce an additional 990 fish with a corresponding angling yield of 248 fish without further endangering the salmon population of this stream. The adoption of this alternative is recommended.

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