FISHERIES RESEARCH BOARD OF CANADA

MANUSCRIPT REPORT SERIES

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INTRODUCTION

The impounding of Sylvia Grinnell Lake near its outlet and the damming of the Sylvia Grinnel River 30 miles downstream from its source have been proposed for the purpose of supplying hydroelectric power to the community of Frobisher Bay.

The Sylvia Grinnell River system contains a large population of anadromous arctic char and conditions for their harvesting which are unique.

Inasmuch as char and hydroelectric developments of the type proposed are mutually exclusive,the following has been prepared to assist in the decision process for the priority use of the river.

GENERAL LIFE HISTORY OF ARCTIC CHAR

Briefly, the life history and habits of the anadromous char are as follows. Spawning occurs during the months of September and October on areas of lake bottom or river bed where suitable gravel or substrate occurs and where winter ice does not become a problem. Spawning females prepare shallow nests in the gravel and, depending upon their size, deposit from 3000 to 5000 eggs. These hatch in late April but the young fish remain in the gravel and continue to develop until they emerge as free swimming fry in July when planktonic food normally becomes abundant. In addition to using the lake habitat, young char invade the small tributary streams where they feed on plankton and insects.

Anadromous type char migrate to sea for the first time when they reach a length of 6 to 8 inches (15 to 20 cm), which in the Sylvia Grinnell system is usually when they are 5 to 8 years old. Migration

begins as soon as the river ice permits and normally occurs from early June to mid July. Overwintering in the sea is unknown and the char return to freshwater from mid August to late September. While in the sea char feed voraciously particularly on abundant small crustacea but also on other small invertebrates and fish that may be present. Migration to sea once started is annual until sexual maturity is reached and thereafter every other year when the fish is in the non spawning phase. Maturation occurs when the fish are about 18 inches long and 12 to 14 years of age. The average maximum size of char is reached when the fish are 20 years old and about 28 inches long (71 cm). The oldest specimen found in the Sylvia Grinnel River was 33 years old but specimens of 40 years have been reported from elsewhere.

While char which will spawn in a current year do not migrate to sea some specimens may penetrate into the estuarine waters in or near river mouths. However even the migrants of the year generally do not travel far from their parent stream and in the Sylvia Grinnell system may remain close to the river mouth. Elsewhere distances of over 100 miles (160 km) are known. Returning tagged char indicate, as with returning marked salmon, that a high degree of homing to the river of origin occurs. However, unlike salmon, the return from the sea in late August and September is not a spawning migration. Also, unlike salmon and trout, char are not prone to jumping major obstacles or migrating up steep gradients. Falls of 5 to 6 feet (1.5 to 1.8 m) are usually sufficiently high to block upstream movement.

DESCRIPTION OF THE AREA

A map of the Sylvia Grinnell River system taken from 1956 topographical survey maps is shown in Figure 1. The physical features of the area are taken from the same source and have been interpreted with the aid of aerial photographs from the National Air Photo Library and from personal observations.

Sylvia Grinnell Lake is located at an elevation of 450 feet above sea level and drains by way of the Sylvia Grinnell River into Frobisher Bay. The river is approximately 55 miles long and throughout much of its length is a long narrow lake and only in the lower 20 miles does it narrow and shallow into a river proper. Rapids are common throughout this lower stretch where rock and gravelly bottom is evident. The river first enters tidal water over falls ranging between 0 and 12 feet depending upon the height of the tide. The falls and mouth of the river are situated in a narrow inlet which is about one and one half miles from Frobisher Bay proper. At periods of extremely low tide the channel becomes an extension of the river.

Sylvia Grinnell Lake has an area of 24.6 square miles and is fed from adjacent lakes with an area of 10.7 square miles of which 5.9 square miles are passable to char. The area of Sylvia Grinnell Lake watershed is 460 square miles and the total area of the Sylvia Grinnell River drainage is 1150 square miles. Mean annual precipitation for the region is 15 inches per year and computes to a mean flow from Sylvia Grinnell Lake of 508 cfs and from the Sylvia Grinnell River of 1270 cfs.

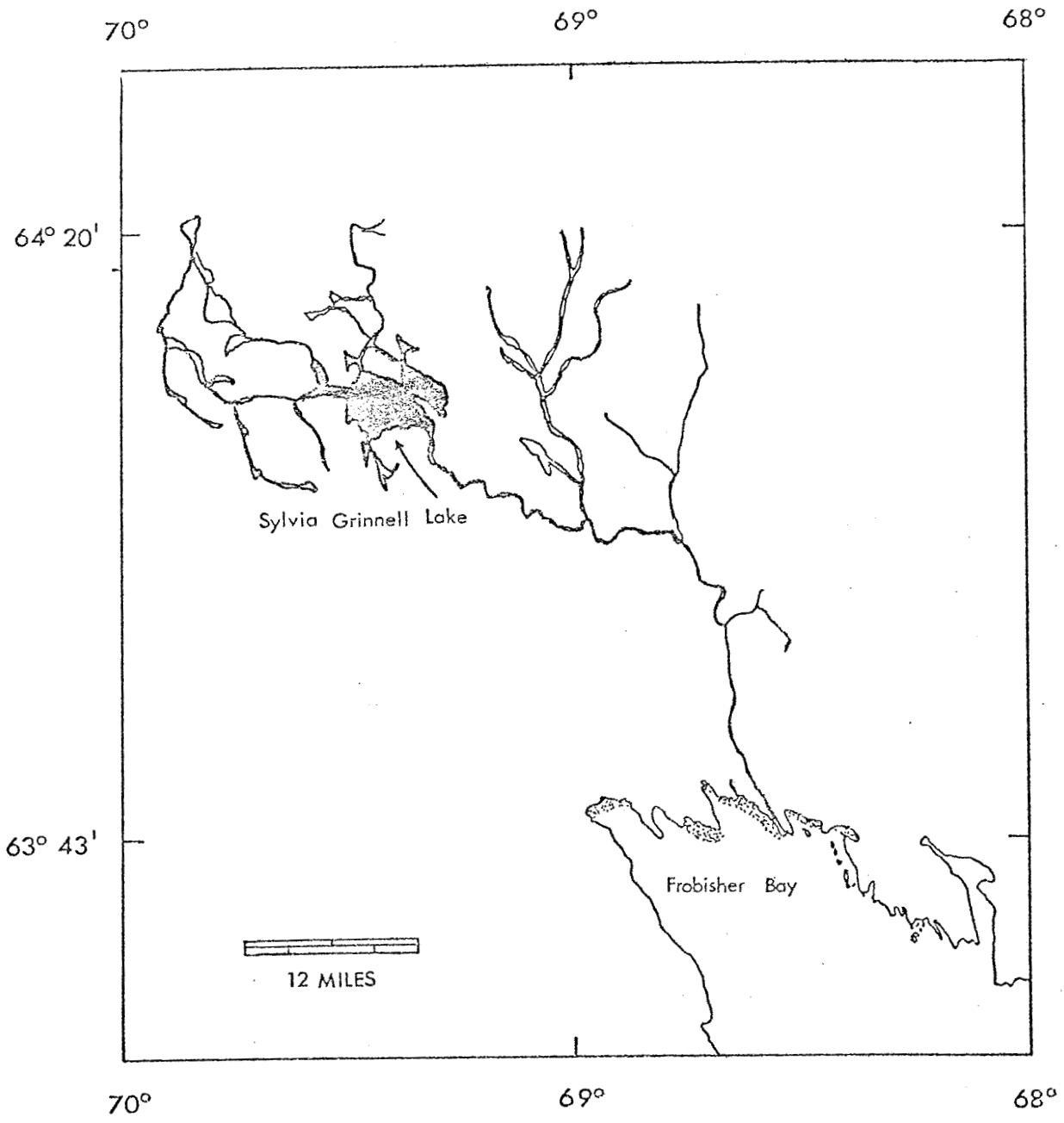

Figure 1. Map of Sylvia Grinnell watershed.

Throughout the winter the lake, river and bay are frozen over. River discharge drops to a low level at freeze up in the fall and eventually ceases until the following spring thaw (Figure 2). In 1951 the ice at the mouth of the river was broken by June 10 and went out on June 25 (Grainger, 1953)[1]. In 1958 the ice went out of the river on June 23.

THE FISHERY

Artifacts from near the outlet indicate that the lower reaches of the Sylvia Grinnell River have been a traditional Inuit summer fishing site. Following the development of the community of Frobisher Bay, the river supplied the needs of both the local subsistance fishery and a recreational fishery which was started by the personnel from the newly constructed airbase. In the years 1947, 1948 and 1950 the Shaw Steamship Company conducted a commercial gill net fishery in the mouth of the river. This was followed by a subsistance and recreational fishery until 1958 when commercial exploitation was carried out again by the Department of Northern Affairs. A 10,000 lb (4536 kg) commercial catch objective was set but it was recognized that the increased catch would be at the expense of capital stock and that the fishery would have to be discontinued within a few years. Declining catch per unit of effort (Figure 3) and small fish size resulted in the cessation of commercial fishing in 1967. Present status of the fishery is not known but observations

[1]Grainger, E.H. 1953. On the age growth, migration, reproductive potential and feeding habits of the arctic char (Salvelinus alpinus) of Frobisher Bay, Baffin Island. J. Fish. Res. Board Can., 11(6): 904-932.

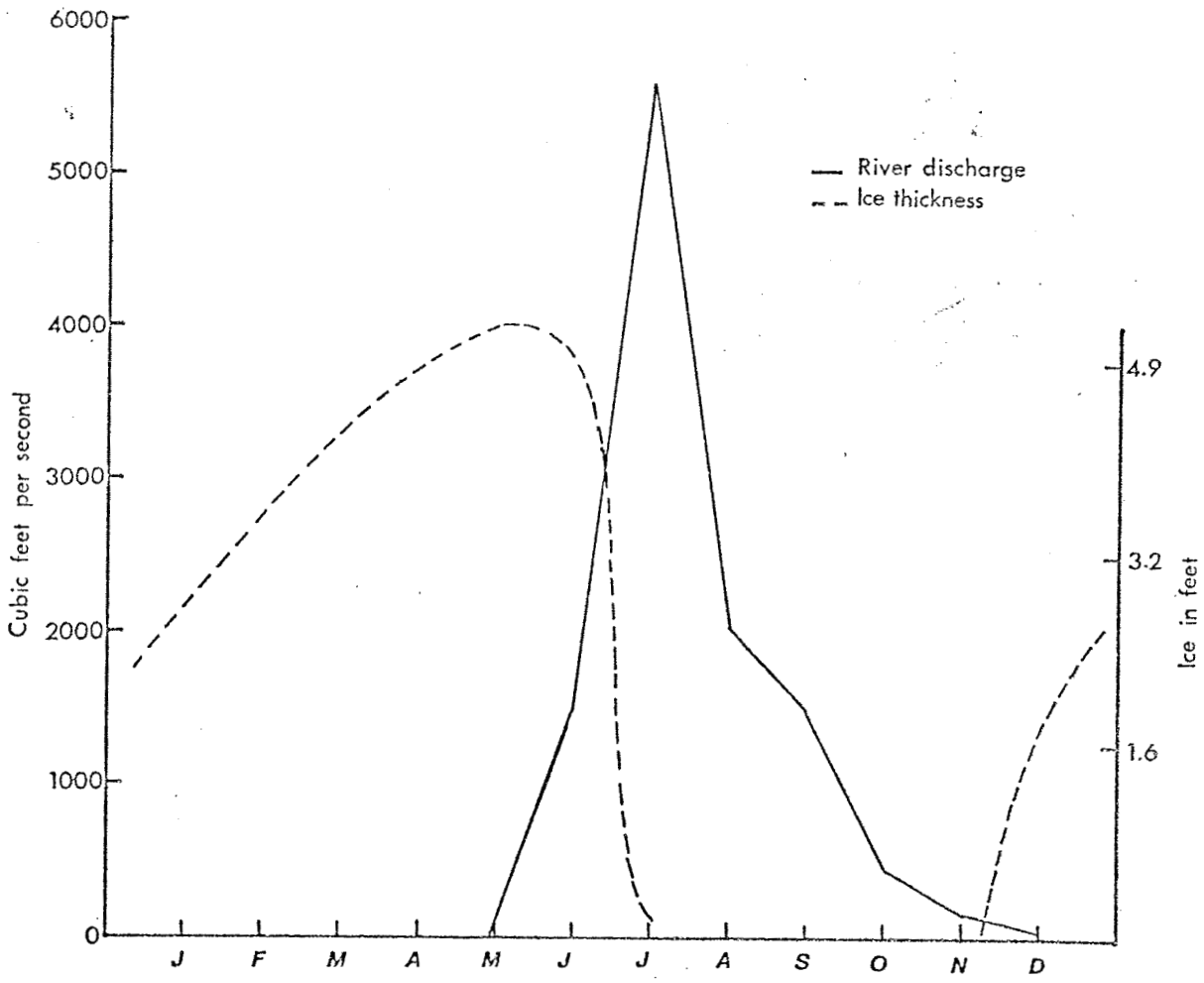

Figure 2. Sylvia Grinnel River discharge (Water Survey of Canada) and ice thickness (Courtesy Grainger 1968)

of the small char being caught are indicative of a high rate of exploitation and a low return per unit of fishing effort.

FISHERIES INVESTIGATION

The arctic char of the Sylvia Grinnell River were examined in detail in 1951. Age, size, fecundity, food and migration were of principal consideration in this initial study and in subsequent stock examinations in 1958 and 1959. The mortality rate estimated from 1951 data was compared to the mortality estimate obtained from the 1958 study (Figure 4) and the two rates were combined to provide an estimate of the ratio of the fishing intensities between the two periods and of the natural mortality rate. From the derived natural mortality rate, the component fishing mortality rate, assumed to be consistent between the two periods, was calculated and related to the total catch producing it to provide an estimate of the population. Recruitment size and age were obtained from samples caught in $4\frac{1}{2}$ inch mesh gill nets (Fig. 5, 6 and 7; Table 1). Yield, stock and mean weight estimates based upon these parameters are shown in Fig. 8 and 9 for different levels of fishing intensity.

Annual natural mortality was calculated to be 14.2% and fishing mortality to vary from 9.4% for char from 14 to 20 years of age to 24.2% for char 21 years and older. The total fishery, consisting of a domestic and sport fishery, had an annual catch of about 28,000 lb (12,700 kg) and the stock of catchable sized fish, at this level of fishing, was 300,000 lb (136,000 kg).

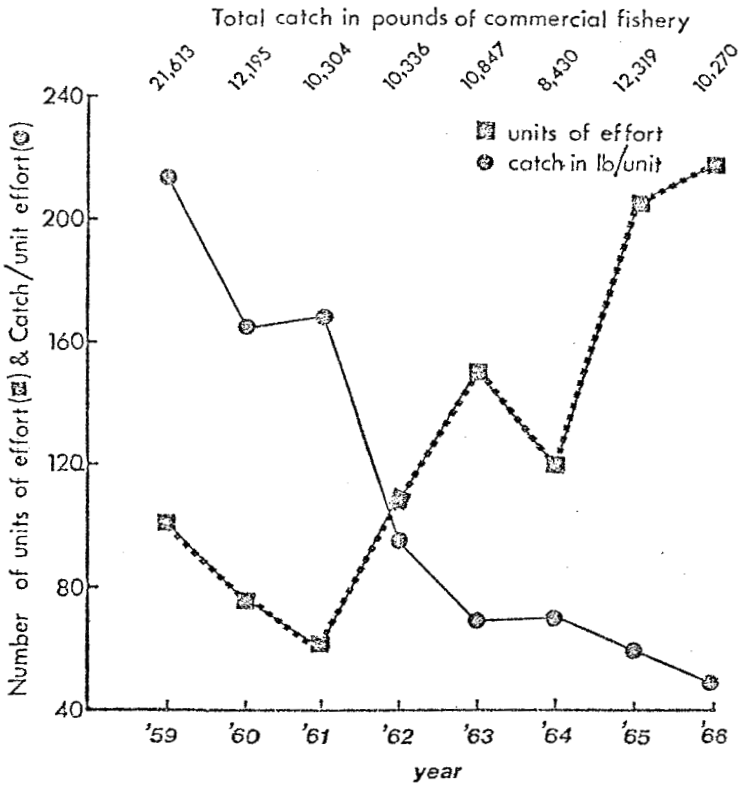

Figure 3. Catch, catch/unit effort and effort for arctic char from the Sylvia Grinnell River.

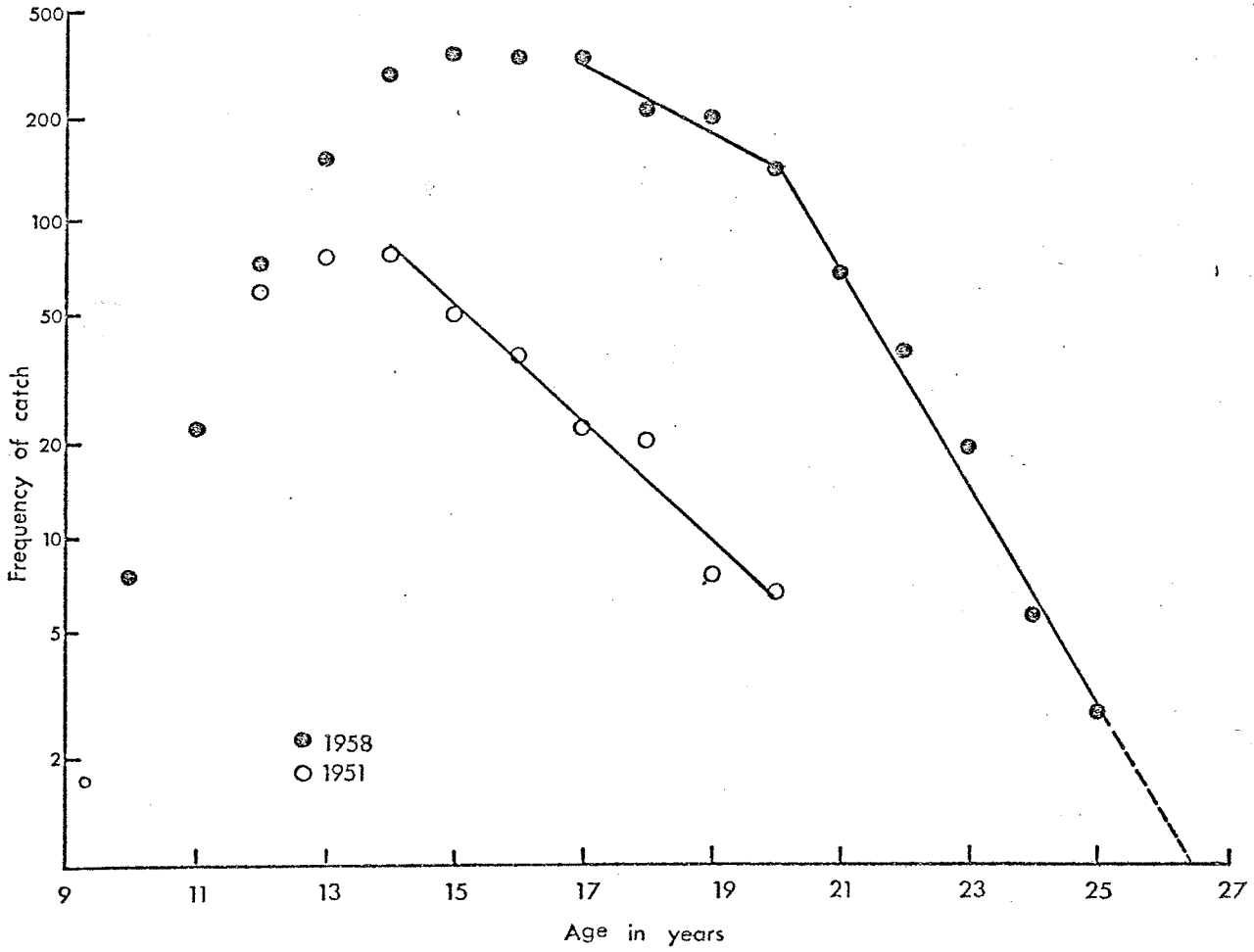

Figure 4. Catch curves of Sylvia Grinnell River char by gill nets in 1951 and 1958.

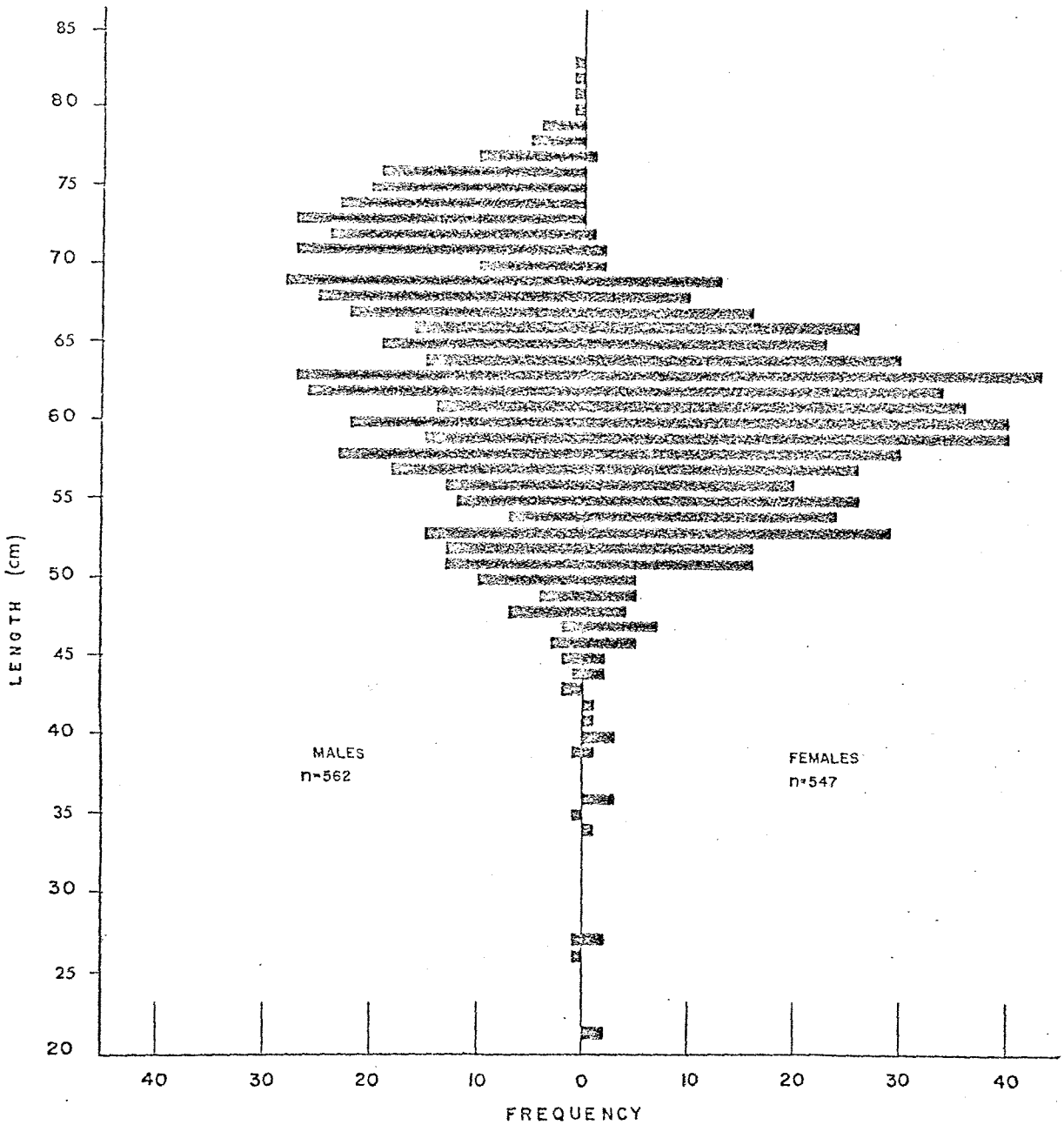

Figure 6. Length frequency distributions of arctic char caught by gill nets of different mesh size.

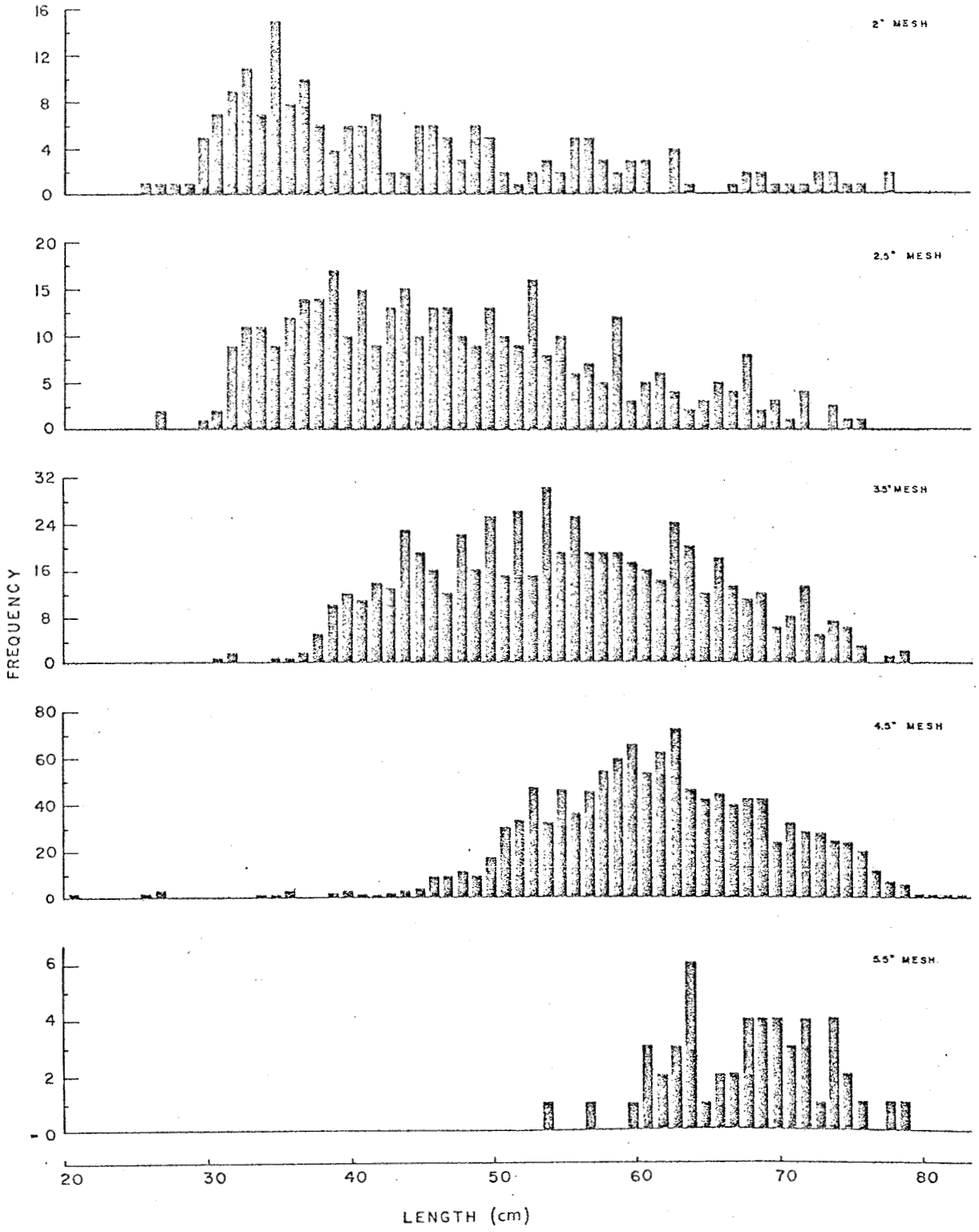

Figure 5. Length frequency distribution of male and female char caught in 4½" mesh gill nets.

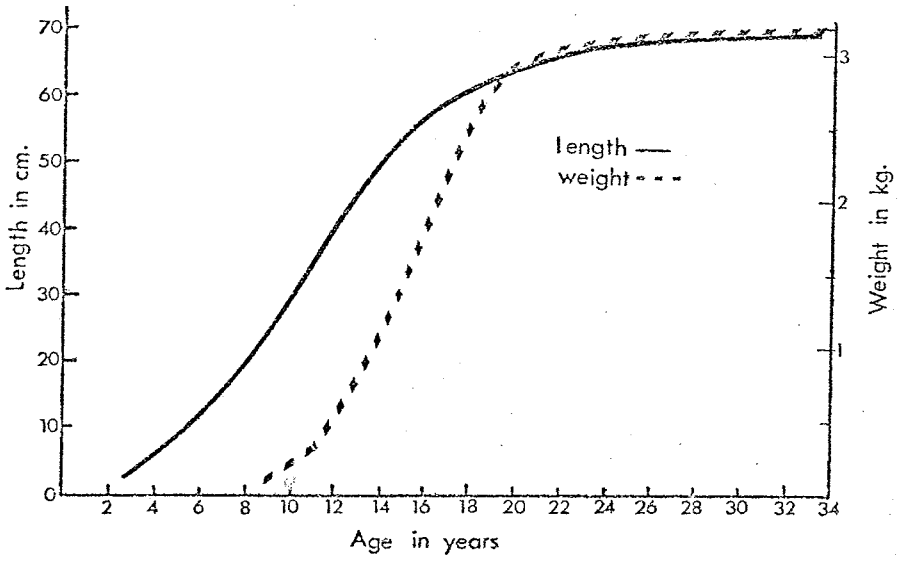

Figure 7. Length, weight and age relationship of arctic char from Sylvia Grinnell River.

Table 1. Number, mean fork length (cm) and sex ratio of arctic char caught in the Sylvia Grinnell River in 1958 and 1959.

	Year	1958								1959
	Gear	Snagged	Dip net	Gill nets						Gill nets
	Mesh			1½"	2"	2½"	3½"	4½"	5½"	Total	4½"
Male	Number	30	150	7	93	170	304	562	39	1,175	1,836
	Mean length	10.2	4.9	18.9	18.6	19.0	22.6	25.3	27.4	23.1	25.2
	SD	2.8	1.1	10.5	5.6	4.7	4.3	3.7	1.9	5.1	3.2
Female	Number	32	106	12	98	199	296	547	12	1,164	1,659
	Mean length	10.1	5.1	18.0	16.7	18.5	20.9	23.1	24.6	21.2	23.3
	SD	2.7	1.2	2.6	4.0	3.9	3.0	2.9	1.3	3.8	2.2
Male, Female, Unsexed	Number	63	253	19	192	369	600	1,172	51	2,403	3,504
	Mean length	10.2	4.6	18.3	17.6	18.8	21.8	24.2	26.7	5.9	24.3
	SD	2.7	1.5	6.4	4.9	4.3	3.8	3.6	2.1	4.8	3.0
	% male	48.4	49.8	36.8	48.4	46.1	50.7	50.7	76.5	50.2	52.5

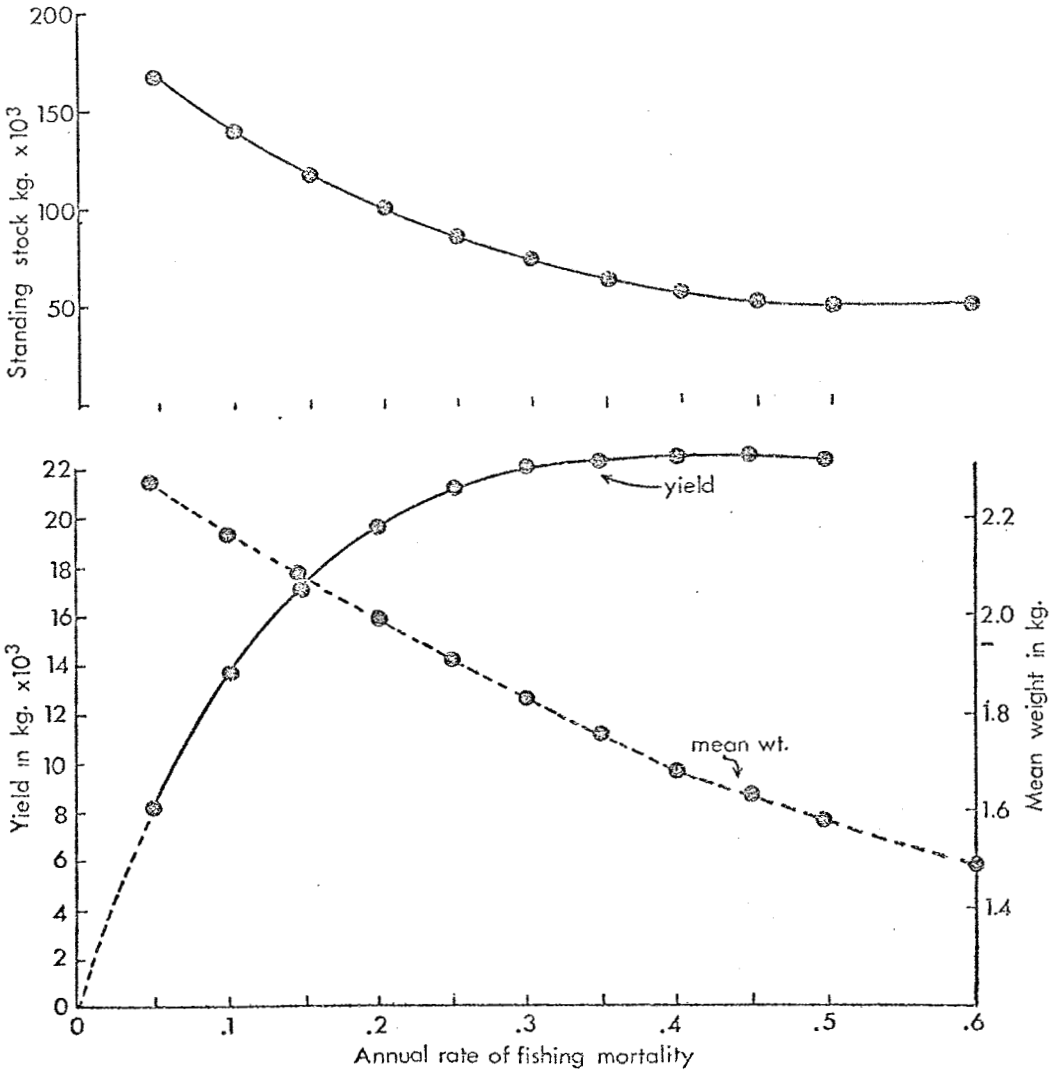

Figure 8. Standing stock, yield and mean weight of arctic char in Sylvia Grinnell River under different rates of fishing mortality.

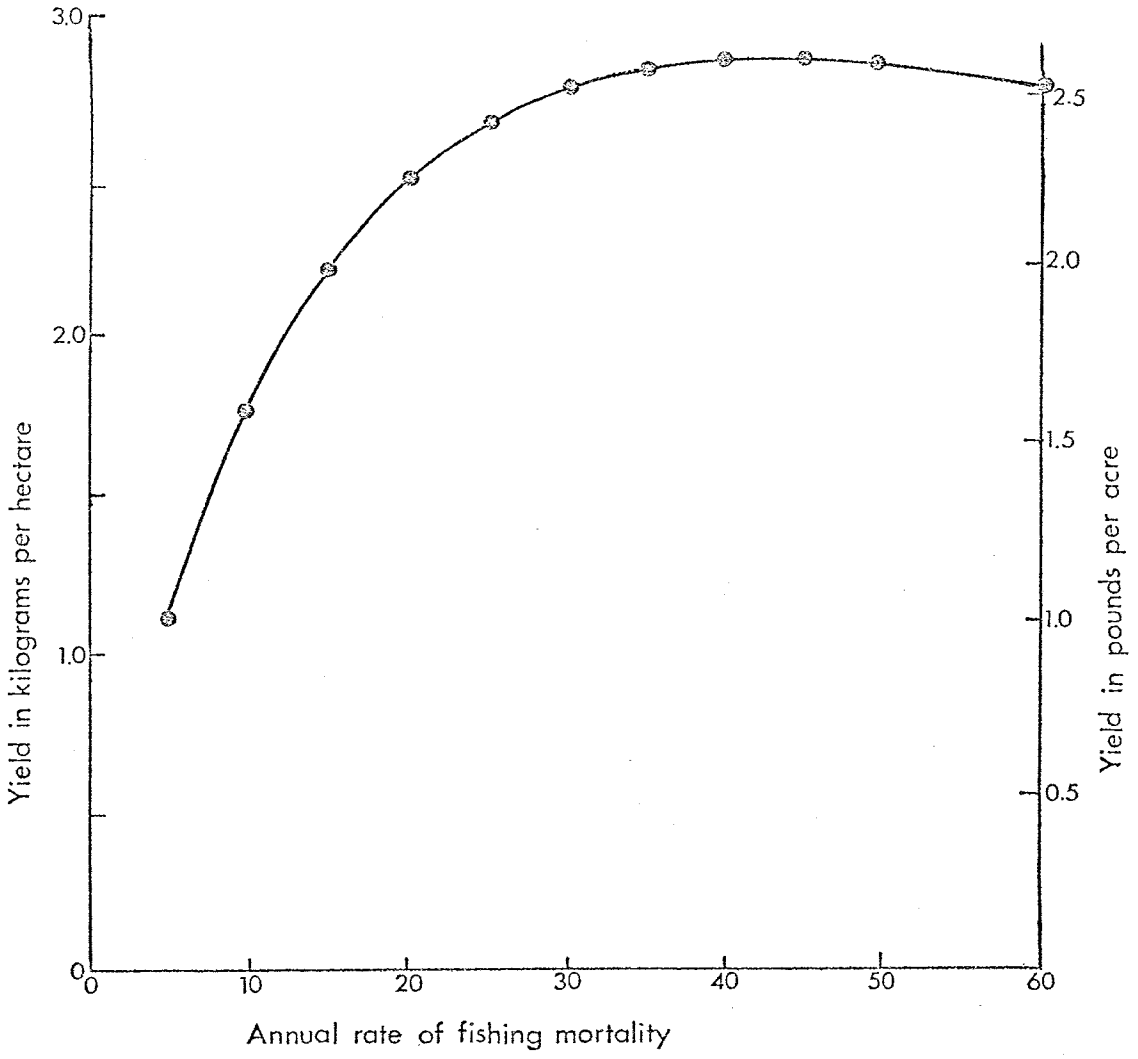

Figure 9. Yield of arctic char per acre of Sylvia Grinnell Lake surface under different rates of fishing mortality.

Results of the increased catch from the commercial fishery (Fig. 3) indicated the stock was possibly approaching stability but at a very low return per unit of fishing effort. Catch records of the local fishing have not been continued since the commercial fishery was discontinued but casual observations of numerous "small" fish with few large fish in the domestic catch suggests that the large effort, previously directed through the organized fishery, continues to operate through the domestic and recreational fisheries of an expanding community.

The factors which control char production are more complex than the relation of their numbers or weight to the surface area of their fresh-water habitat. However, this area-production index is frequently used to compare productive capacities of different water bodies and different fishing regimes. In this case the yield of char from the Sylvia Grinnell system under different fishing mortality rates (Fig. 9) has a maximum sustainable yield of 2.6 lbs/acre (2.91 kg/h). Prior to the commercial fishery starting in 1958, the combined subsistance and sport fishing catch of 28,000 lb (12,700 kg) was at the rate of 1.4 lbs/acre. (1.57 kg/h) while the return per unit area under the heavy exploitation rate after 1958 was 2.0 lbs (2.24 kg).

Sylvia Grinnell Lake also supports a population of land-locked char but these are not utilized directly by man and their productivity in this system is unknown.

ARCTIC CHAR EXPLOITATION

Sea run salmon (Salmo and Oncorhynchus) are traditionally fished on their upstream migration and the principal criteria of the fishery,

particularly for the Pacific form (Oncorhynchus) which dies after spawning, is to catch all but sufficient spawners to reproduce the stock. The char run observed migrating upstream in the fall is composed principally of the immature and non spawning fish and represents about half the total exploitable stock in the population. They are not lost production, as are Pacific salmon, if they are not caught in the course of a single migration. Many of the commercial fisheries (Novaya Zemlya, West Greenland, northern Labrador and central Canada) that have been attempted have failed because the migratory behaviour and low yield potential of the char have not been recognized. On the other hand, domestic fisheries have used this migratory feature to advantage and have fished a stock heavily for a few years and then left it for several years to recover before fishing it again. This form of management is also used in lakes for land-locked char where the annual sustainable yield level is too low for economic exploitation.

Char are slow growing and as a result the prerecruitment stock to the fishery is composed of many year classes of fish. The numerical strength of the early year classes is believed to be density dependent and that even heavy exploitation of the fishable stock does not effect recruitment numbers. It follows therefore that recovery of the capital stock from over-fishing can be fairly rapid and will be largely dependent upon the rate of fishing during the recovery period.

Documentation of the recovery of most char stocks that have been fished heavily is lacking but stocks of the Tree River, after over-fishing in 1964 and 1965, recovered on the basis of recruitment strength remaining high.

EFFECTS OF HYDROELECTRIC DAMS ON ARCTIC CHAR

The effects of hydroelectric developments on the behaviour, survival and productivity of anadromous arctic char are not known, but features common to northern lakes and known char behaviour suggest some probable changes.

The initial impact of the annual regulation of the lake from a new higher to lower water level would be to decrease the stability of the littoral zone with a probable lowering of the productivity of important food items associated with the water-bottom interface.

Lake regulation would be expected to reduce the spawning and habitat areas which could result in a smaller population of char in the lake. River habitats have been found to have a higher char productivity than lake locations. Change of a river - pool situation such as the upper 30 miles of Sylvia Grinnell River to a lake situation would be expected to reduce its char productivity greatly.

The fact that char, except for spawning individuals of the year, migrate to and from the sea annually from the time they are 5 to 8 years of age until they are 20 or more years old, exposes them through the frequency of ordeal of up and down river by-passes to almost impossible odds of normal survival.

Efforts to keep the many different sizes of downstream migrating char from being damaged by turbines or turbine by-passes, would have to be most successful not to annihilate the run. Even a small mortality factor could result in the loss of the fishery.

Char are not usually found in rivers with excessive gradients,

numerous small falls or even falls of heights that are compatible with trout and salmon survival and it is improbable that returning migrants would negotiate a fish ladder showing similar gradient characteristics. Traps and lift elevators may be an alternative to a ladder but any additional mortality factor compounded through multiple migrations would not benefit the fishery.

It is considered very probable that the anadromous char run will not survive if the Sylvia Grinnell River is developed for hydroelectric purposes.

If the anadromous stock of char were removed the lake could probably produce a yield of dwarf land-locked char equal in weight to that of the anadromous form. Such yields have been found in other arctic areas and are not inconsistent with char production rates from European lakes. However, the dwarf char of Sylvia Grinnell Lake are heavily parasitized with pleurocercoid cysts of the tapeworm Diphyllobothrium and would not be acceptable as a food item. Also since these fish are distributed throughout the lake, the catch rate would be expected to be considerably less than that for anadromous char, which are caught under near ideal conditions when they are congregated on a migration. The cost and inconvenience of harvesting dwarf fish would be much greater, the desirability of the catch would be low and the recreational aspect of harvesting would disappear completely.

VALUE OF THE CHAR

The system presently supports a stock of anadromous arctic char capable of maintaining an estimated annual yield of 48,000 pounds but with

a probable optimum economic yield close to 30,000 lb (13,600 kg) in which the average fish size exceeds 4 3/4 lb (2.15 kg).

The conditions for harvesting throughout the char's circumpolar range are unique in the Sylvia Grinnell River and lend themselves extremely well to the development of exceptional recreational fisheries.

Some of the spawning fish of the year pass over the falls and are restricted from returning upriver until the next spring tide. They are thus held available to fishermen for a relatively long time in the short distance between the sea and the falls. Equally important, since food is abundantly available in the sea at the mouth of the river, many sea run fish remain close to or within the same area. These too are held below the falls and are conveniently available to the fishing and at a moderate level of fishing contribute to a high catch per unit of effort.

The value of the char resource depends in part on the fish themselves and in part on the method of harvesting them. If used only as a local protein supply they have a market value easily assessed. If used as a base for a sports fishery, particularly for itinerant fishermen, their monetary value can be 10 to 20 times greater than if caught for protein only and would have an annual valus in excess of $1,000,000. If fished with some mix of subsistance and recreational fishing they contribute both to the economy and to the quality of life. Their loss would be seriously felt.

Overfishing and recovery of char stocks is historical fact and the stock abundance in the Syliva Grinnell River can be adjusted to any

level within the productivity of the system by adjusting the present rate of exploitation.