WHOI-79-49

Copy 2

Woods Hole Oceanographic Institution

MATAMEK ANNUAL REPORT FOR 1978

by

Frederick G. Whoriskey

May 1979

TECHNICAL REPORT

Supported by the Woods Hole Oceanographic Institution and the Department of Tourism, Fish and Game of the Province of Quebec.

WOODS HOLE, MASSACHUSETTS 02543

WHOI-79-49

MATAMEK ANNUAL REPORT FOR 1978

by

Frederick G. Whoriskey

WOODS HOLE OCEANOGRAPHIC INSTITUTION
Woods Hole, Massachusetts 02543

May 1979

TECHNICAL REPORT

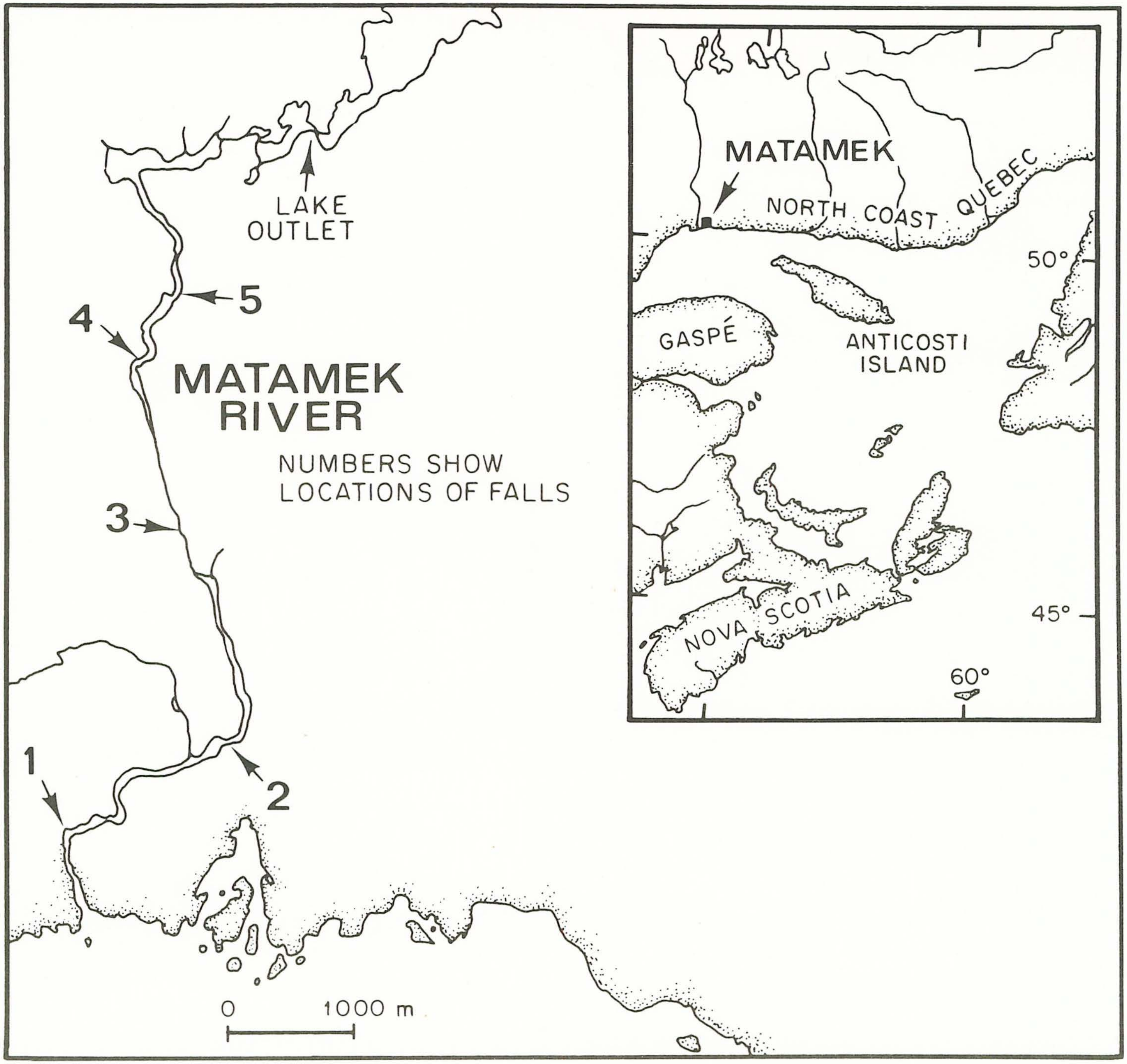
Supported by the Woods Hole Oceanographic Institution and the Department of Tourism, Fish and Game of the Province of Quebec.

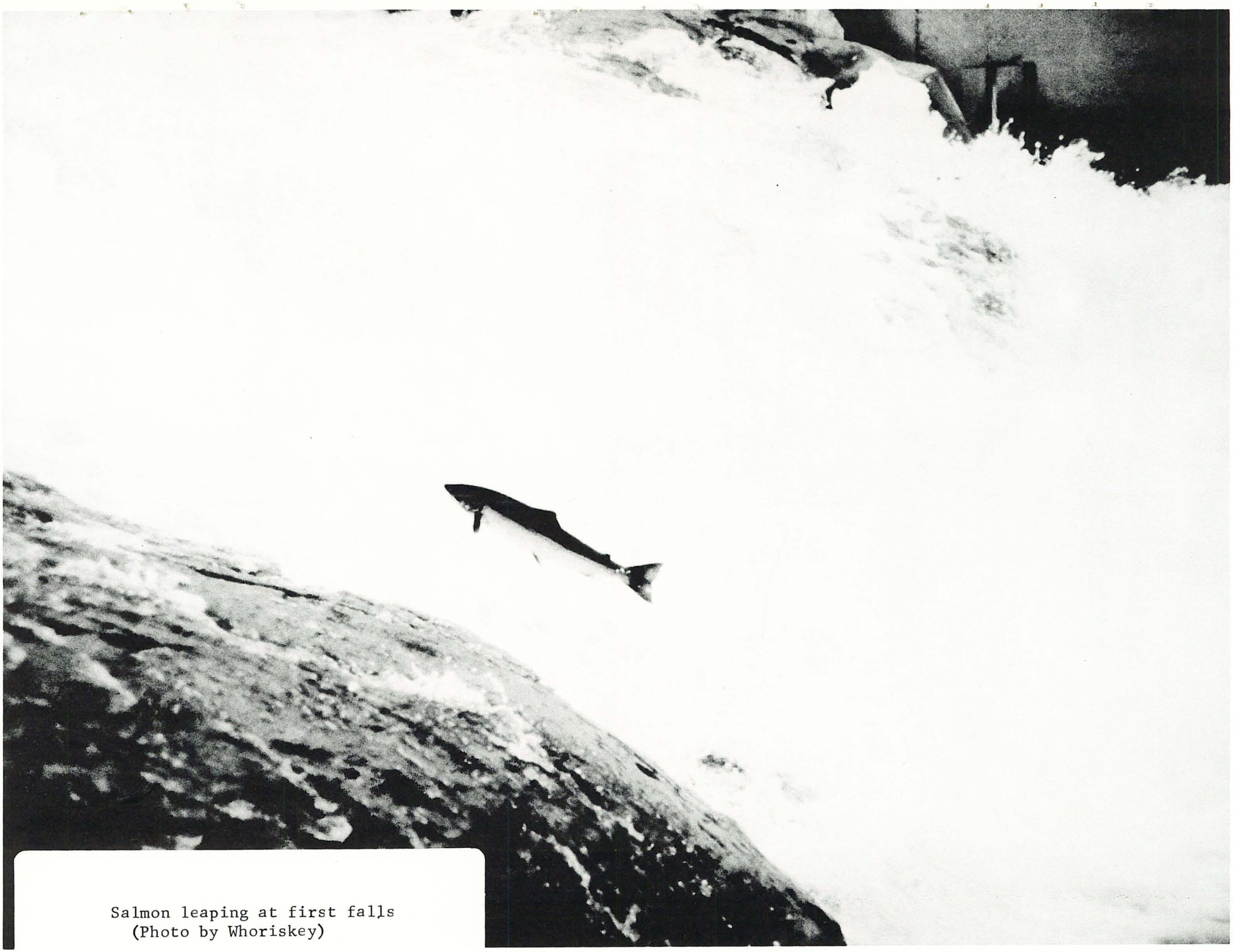
Approved for Distribution: George Grice

George D. Grice, Chairman
Department of Biology

ABSTRACT

This is a report describing activities associated with the Matamek program in 1978. Research was conducted on biological, chemical and physical factors related to salmonid production in Matamek River and Matamek Lake. Canadian universities, the Quebec government and Woods Hole Oceanographic Institution cooperated in this program.


LAKE
OUTLET
5
4
MATAMEK
RIVER
NUMBERS SHOW
LOCATIONS OF FALLS
3
1
2
0
1000 m
MATAMEK
NORTH COAST
QUEBEC
50°
GASPÉ
ANTICOSTI
ISLAND
NOVA SCOTIA
45°
60°



Salmon leaping at first falls
(Photo by Whoriskey)

List of Personnel

Woods Hole Oceanographic Institution

R. J. Gibson
F. G. Whoriskey, Jr.
Elaine M. Ellis

University of Waterloo

John Carter
Jean Yves Charette
Patricia Chou
James Critchley
Hamish Duthie
Arthur Harrison
Gary Kramer
Deborah Martin
Phil Ross

Universite du Quebec a Chicoutimi

Francois Garneau
Denis Larrivee
Jean-Luc Simard

Universite de Laval

Denis Blanchet
Mario Caron
Marcel Frenette
Marcel Roy

University of Guelph

Thomas Dickson
Hugh MacCrimmon
Jacqueline McGlade

INRS-EAU

H. G. Jones
Gervais Tremblay

Other Personnel

Fay Cotton
Johanne Guibault
Peter Heinerman
Lise Paquin
M. Evrade Boudreault

Matamek Canadian Awards - 1978
25/4.01

Principal Investigator	Affiliation	Title of Proposal	Award C$
John C. Carter	University of Waterloo	Nature and fate of the plankton in the Matamek River	C$ 3,818
Hamish Duthie	University of Waterloo	Trophic dynamic aspects of the ecology of the ultraplankton in Lake Matamek, a Canadian precambrian shield lake	15,000
Arthur D. Harrison	University of Waterloo	Qualitative and quantitative studies of the zoobenthos of Lake Matamek	7,000
Hugh MacCrimmon	University of Guelph	The effects of species interaction on the growth of *Salmo salar* and *Salvelinus fontinalis* in the Matamek River	7,416
Marcel Frenette	University of Laval	Critical flow requirements for maintenance of salmonids survival and productivity in the Matamek River	12,000
		Total Awards - Canadian dollars	$45,234

Table of Contents

Introduction

This season saw a changeover in the leadership of the Matamek Research Station. Dr. R. J. Gibson, Scientific Coordinator of the Matamek Program, left Woods Hole Oceanographic Institution at the end of the research season to join MacLaren Marex, Inc. in Newfoundland. Dr. Gibson was a veteran of many research seasons, originally starting his involvement in the Matamek Program as a graduate student. Much of his work forms the basis of future fisheries research directions at the Matamek Station, and we are grateful for his efforts. We hope he continues his interests in the Matamek Program.

Joining the Woods Hole Oceanographic Institution as the new Scientific Coordinator is Dr. Robert J. Naiman. His credentials include work on desert fishes, limnology in a variety of streams ranging from the Amazon River drainage basin to British Columbia, and on food web dynamics. His interest and enthusiasm should insure a bright future for the Matamek Station.

The research season went very well. Salmonid studies continued with smolt tagging and parr and trout population estimates being made. A new program for the sea ranching of brook trout was initiated, and preliminary results look most promising. Stocking of fishless and salmonless areas in the Matamek watershed with salmon was also continued. The adult run of salmon was monitored again this year, and a population estimate made. The fishway, after repairs this season, is now almost totally functional. This most certainly will make our adult estimates more accurate and simpler in the future. Final repairs shall be finished early this coming season, before the adult migration. Stream tank studies on competitive interactions of exotic and native salmonids were continued at the flume (stream tank) in Woods Hole.

In addition to the studies mentioned above, further salmonid studies were carried out by investigators from the U. of Guelph. Behavioral interaction observations of juveniles of brook trout and salmon were conducted in the stream tanks at the second falls, and at field sites in small tributaries of the Matamek River. Meristic, morphometric, and genetic studies of populations of trout from the Matamek and Moisie Rivers were also conducted. All of the above salmon studies are described in more detail in individual reports following the Introduction.

Dr. John Carter has finished his work on the zooplankton of the River. He is currently preparing it for publication, and a report is presented here.

The group from the University of Laval continued their excellent studies of the hydrology, hydraulics, and morphology, of the Matamek River. A number of very interesting correlations between river flow characteristics and salmonid dynamics in the river are emerging, and are discussed in Dr. Marcel Frenette's et al. report which follows.

At the lake, phytoplankton, zooplankton, and zoobenthos studies were continued. A sea curtain was set in lower Baie Phillippe and, after a few logistical problems were solved, a phosphorus fertilization experiment was carried out with good success. Results of these studies are presented in three reports in this volume.

A number of other investigators also used station facilities during their research programs this season, under independent funding. The Station was most happy to provide them with accommodations, meals, and logistical support where possible. These were: 1) a study on colonization of larval insects in stream basket samples by John Carter and J. Y. Charette from the U. of Waterloo in Ontario; 2) a limnological study of the Matamek River by H. G. Jones, G. Trembley, and B. Trembley from INRS-eau; 3) a marine study on larval colonization and marine natural products conducted by Drs. Denis Larivee, Francois Garneau, and Mr. Jean Luc Simard from the Universite of Quebec at Chicoutimi; 4) an estimation of the population of the harbor and grey seals of the north coast of the Gulf of St. Lawrence, by M. Jean Lavigne under the auspices of the Arctic Biological Unit (Environment Canada) in Ste. Anne de Bellevue. Unfortunately we have reports only from the Chicoutimi Group as we go to press.

Also notable this season was a visit to the Station by a number of French scientists, touring under the Joint French/Quebec scientific exchange program who came to inspect our facilities and exchange ideas.

More so than any other way, morale at the Station was kept high by our gourmet cooks Mlles. Johanne Guibault and Lise Paquin. We extend our grateful thanks to both.

M. Evrade Boudeault continued to guard the station during the winter and assist with support in the winter sampling periods. Our grateful thanks go out to the Biologists, Technicians, and Enforcement Personnel of the Ministry of Tourism, Fish, and Game. Their able support, efficient patrolling of the River, and apprehension of poachers was vital to the success of this year's programs. We look forward to equally productive seasons for the future.

F. G. Whoriskey, Jr.

Introduction

Cette année la direction de la Station de Recherches de la Matamek a été confiée à un nouveau directeur. L'ancien coordinateur scientifique, le Dr. R. J. Gibson, ayant quitté l'Institution Océanographique de Woods Hole à la fin de la saison dernière pour s'associer avec McLaren Marex, Inc., à Terre Neuve. Le Dr. Gibson qui dès le début pris part au programme de la Matamek en tant qu'étudiant gradué, y consacra ensuite de nombreuses années. La plupart de ses travaux serviront de base à différents projets de future recherche poursuivie à la Station. Nous lui sommes très reconnaissants pour la contribution scientifique qu'il a apportée à ce programme, et nous espérons qu'il continuera de s'intéresser à la Matamek.

L'Institution Océanographique de Woods Hole a nommé le Dr. Robert J. Naiman nouveau coordinateur scientifique de la Station. Parmi les titres de capacité du Dr. Naiman on remarque les études qu'il a faites sur les poissons du désert, sur la limnologie de diverses rivières, y compris les ruisseaux des bassins de drainage de l'Amazone et de la Colombie Britannique, et également des travaux sur la dynamique de la chaine alimentaire. L'intérêt et l'enthousiasme du Dr. Naiman devrait assurer à la Station de la Matamek un brillant avenir.

La saison de recherches s'est bien passée à la Matamek. L'étude sur les salmonidés a été poursuivie; on a ferré des saumoneaux et fait des estimées de population de tacons et de truites de rivière. Un nouveau programme, dont les résultats s'avèrent très prometteurs, fut initié. Il s'agit de l'élevage de truites de rivière en milieu marin. On a continué aussi l'empoissonnement de certains endroits du bassin de la Matamek dépourvus de poissons ou de salmonidés. A nouveau, on a surveillé la montée du saumon adulte et estimé sa population. Les réparations effectuées la saison dernière sur la passee migratoire rendent maintenant celle-ci presque totalement fonctionnelle. Ceci permettra à l'avenir de faire plus facilement et plus exactement les estimées du saumon adulte. Les réparations finales devraient être terminées à temps cette année, avant la montée du saumon adulte.

Dans le bassin expérimental de Woods Hole on a continué les observations sur les interactions compétitives entre les salmonidés indigènes et exotiques.

De plus, aux études mentionnées ci-dessus, d'autres travaux toujours relatifs aux salmonidés furent accomplis par des chercheurs de l'Université de Guelph. Dans les bassins expérimentaux installés aux deuxièmes chutes ainsi que dans certains endroits des rivières tributaires de la Matamek, on a observé les interactions de comportement des jeunes truites de rivière et des jeunes saumons. On a aussi réalisé des études méristiques, morphométriques et génétiques des populations de truites de la Rivière Matamek et de la Rivière Moisie. Toutes les études énumérées ci-dessus sont décrites en détail dans les rapports individuels qui suivent cette introduction.

Le Dr. John Carter a terminé ses travaux sur le zooplancton de la Rivière. Il en prépare actuellement la publication et en présente un rapport ci-joint.

Le groupe de chercheurs de l'Université Laval a continué son excellent travail sur l'hydrologie, l'hydrolyse et la morphologie de la Rivière Matamek. De nombreuses et très intéressantes corrélations entre les caractèristiques du débit de la Rivière et la dynamique des salmonidés, ressortent de ces études qui sont discutées dans le rapport du Dr. Marcel Frenette _et al_.

Au Lac Matamek on a poursuivi les études sur le phytoplancton, le zooplancton et le zoobenthos. On a installé un "rideau marin" en contrebas de la Baie Philippe, et après avoir résolu quelques problèmes d'ordre logistique, on a pu réaliser avec succès une expérience de fertilisation au phosphore. Le résultat de ces études est présenté dans trois rapports de ce volume.

Durant la saison dernière également, d'autres chercheurs, pourvus de fonds indépendants, purent utiliser la Station pour leur programme de recherches. L'hébergement, les repas et le support leur furent gracieusement fournis chaque fois que ce fut possible. Ces recherches furent les suivantes: 1) Une étude faite par le Dr. John Carter et J. Y. Charette de l'Université de Waterloo, Ontario, sur la colonisation des insectes larvaires, réalisée à l'aide de paniers d'échantillons placés dans les cours d'eau. 2) Une étude limnologique de la Rivière Matamek réalisée par H. G. Jones, G. Trembley et B. Trembley de INRS-eau. 3) Une étude marine sur la colonisation larvaire et les produits naturels marins dirigée par le Dr. Denis Larivée, le Dr. Francois Garneau et Mr. Jean-Luc Simard de l'Université de Québec à Chicoutimi. 4) Une estimée de population des phoques des ports et des phoques gris de la Côte Nord du St. Laurent, réalisée par Mr. Jean Lavigne sous les auspices de l'Unité de Biologie de l'Arctique (Environnement Canada) à Ste Anne de Bellevue. Malheureusement au moment d'imprimer ce compte-rendu nous ne disposons que du rapport du groupe de Chicoutimi.

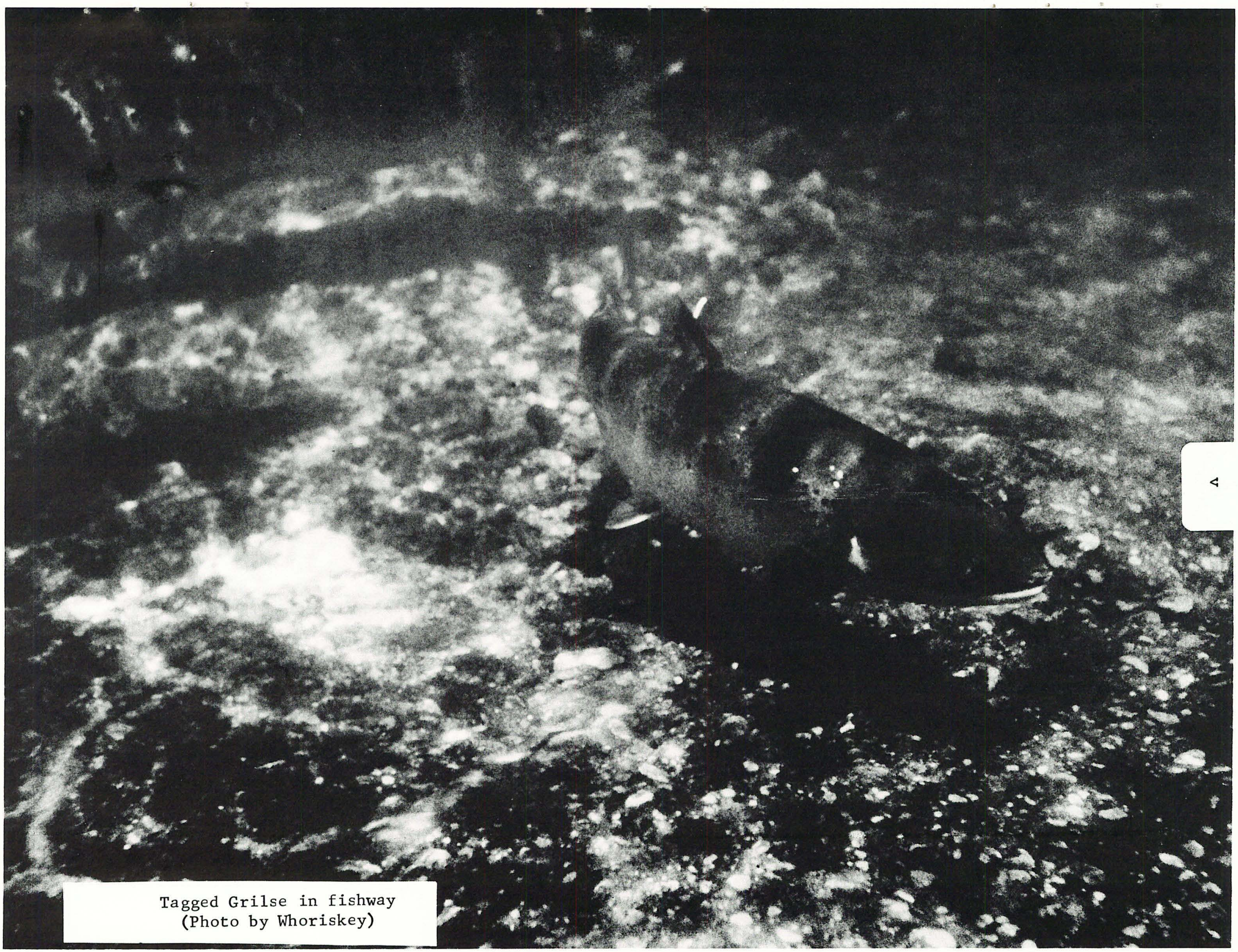
Mentionnons également parmi les activités de la saison passée, la visite à la Station de plusieurs scientifiques francais en tournée de programme d'échange scientifique conjoint franco-québecois.

Le bon moral de la Station fut toujours assuré grâce à nos cuisinières Mesdemoiselles Johanne Guibault et Lise Paquin que nous remercions cordialement.

Mr. Evrade Boudeault continue d'assurer la surveillance de la Station l'hiver et aide au ramassage des échantillons en période hivernale.

Nous remercions également très sincèrement les biologistes, les techniciens et le personnel du Ministère du Tourisme, de la Chasse et de la Pêche du Québec. Leur aide, la surveillance éfficace de la rivière et l'appréhension des braconniers contribuèrent énormément à assurer le succès des programmes de cette année. Nous espérons des saisons aussi productives dans l'avenir.

F. G. Whoriskey, Jr.
Pour R. J. Gibson
Coordinateur Scientifique



Tagged Grilse in fishway
(Photo by Whoriskey)

SALMONID STUDIES

The Fishway and Adult Salmon Run

Adult salmon normally arrive in the River in mid to late June. At this time the discharge level prevents them from jumping the first falls. When the fishway is operational the adults may use it, otherwise they wait until discharge drops enough to allow an ascent in the falls.

After the first falls the adult salmon will ascend one or two more falls before reaching either of the principal spawning areas located at the base of the third or fourth falls. The fourth falls forms an impassable barrier to further natural upstream migration. The first, second, third, and fourth falls are 0.7, 2.4, 4.4 and 5.9 km from the sea respectively.

Reparations on the non functional fishway were nearly completed this year. Unfortunately, repairs designed to make the fishway partially operational were completed well into the upstream adult migration. Previous to the opening of the fishway salmon and grilse were observed jumping in various places in the 1st falls. Due to decreasing discharge over the period in which repairs were made, a number of fish were successful in ascending the falls without the aid of the fishladder. Hence, only part of the migration could be sampled.

The remaining repair consists of installing a concrete floor in the one chamber which now does not have one. Lack of a proper floor will lead to further erosion of the supports of the main wall. This repair shall be made and the fishway should be operational for the upcoming season, providing there is no further damage during the spring runoff.

The fishway was opened for the season on July 16, 1978. Between then and August 1, 30 fish were taken in the fish ladder trap. Each fish was tagged, the fork length in centimeters taken, and about six scales removed for aging at a later date.

After this procedure the fish were transferred to the upstream side of the trap, and released to continue their migration. The water level during this period continued to drop and the falls became relatively easy for the salmon to ascend. We continued to observe fish ascending the falls successfully.

Of the 30 fish which ascended the 1st falls via the fishway, 28 were grilse and two were adult salmon. The mean fork length and standard deviation of the grilse was 51.7 ± 2.84 cm. Only two salmon passed by the fishway. They were 70.3 cm (passed on July 17th) and 78.8 cm (passed on July 22). It is not surprising that so few salmon (2 sea year run fish) passed by the fishway. The salmon are the first to arrive back in the Matamek River, sometime in mid June. The bulk of their run is finished by mid July, the point at which we opened the fishway.

As has been previously reported (Gibson, 1978b) 218 smolt were tagged in 1977. Of these fish, three were recaptured in the Matamek River as grilse, two of them passing through the fishway. This is a tag return of about 1.4% for the 1977 smolts, and implies an adult escapement of 1.4%. This estimate would be low however, as it does not take into account the returning two year fish which are still at sea. In addition at least one other tagged returned fish entered the fishway but backed out of the trap before it could be pulled and was not taken again. It seems certain that

Tourists at first falls fishway
(Photo by Whoriskey)

Table 1. Returns From Smolts Tagged in 1977

Tag Number	Place of Capture	Date of Capture	Date Tagged	F.L. of Smolt (cm)	F.L. of Adults (cm)
P.Q. 24772	Matamek River	78/07/19	77/06/17	14.1	50.7
P.Q. 24840	Matamek River	78/07/17	77/06/13	14.3	46.7
P.Q. 24842	Harbour Deep Newfoundland	78/07/??	77/06/13	16.3	-
P.Q. 24882	Snooks Head Newfoundland	78/07/25	77/06/15	15.3	-
P.Q. 24894	Matamek River	78/09/13	77/06/16	13.1	-
P.Q. 24898	Gooseberry Cove T. Bay, Newfoundland	78/07/10	77/06/16	14.3	-

escapement must be higher than 1.4%. The returns for 1977 are presented in Table 1. The last fish of the season passed through the ladder on August 1.

Again this year a trap net spanning the river above the 2nd falls was installed and a population estimate of the adults was made. The census estimates (95% confidence limits in brackets) for the returned fish are for grilse 68 (42-116) and for salmon 12 (4-23), giving a total of 80 adults (46-139). This is an increase over the 1976 estimate of 70 (50-110), (Gibson, 1977) but it still means the runs are dangerously low. Scheifer (1969, and personal communication) took a sample of 97 fish in 1967. He feels the run of fish was a maximum of 500 at this time. Since new regulations controlling the Gulf of St. Lawrence fishery for salmon are being considered it is hopeful the new regulations will decrease mortality of adult salmon once they are implemented.

Based on an estimated run in 1978 of 80 fish, it would appear that about 37% of the run used the fishladder.

In addition to its scientific function, the fishladder has become a tourist attraction. A guest book placed out at the fishway after its opening for the season collected over 500 signatures. Many other people visited the fishway before the guest book was present, and others did not sign the book. Brochures on the Atlantic salmon by M. Yvon Cote (Ministry of Tourism, Fish and Game (M.T.F.G.)) and a brief description of the station activities by M. Pierre Bertrand (M.T.F.G.) were distributed, and station personnel were on hand at the fishway to answer any questions.

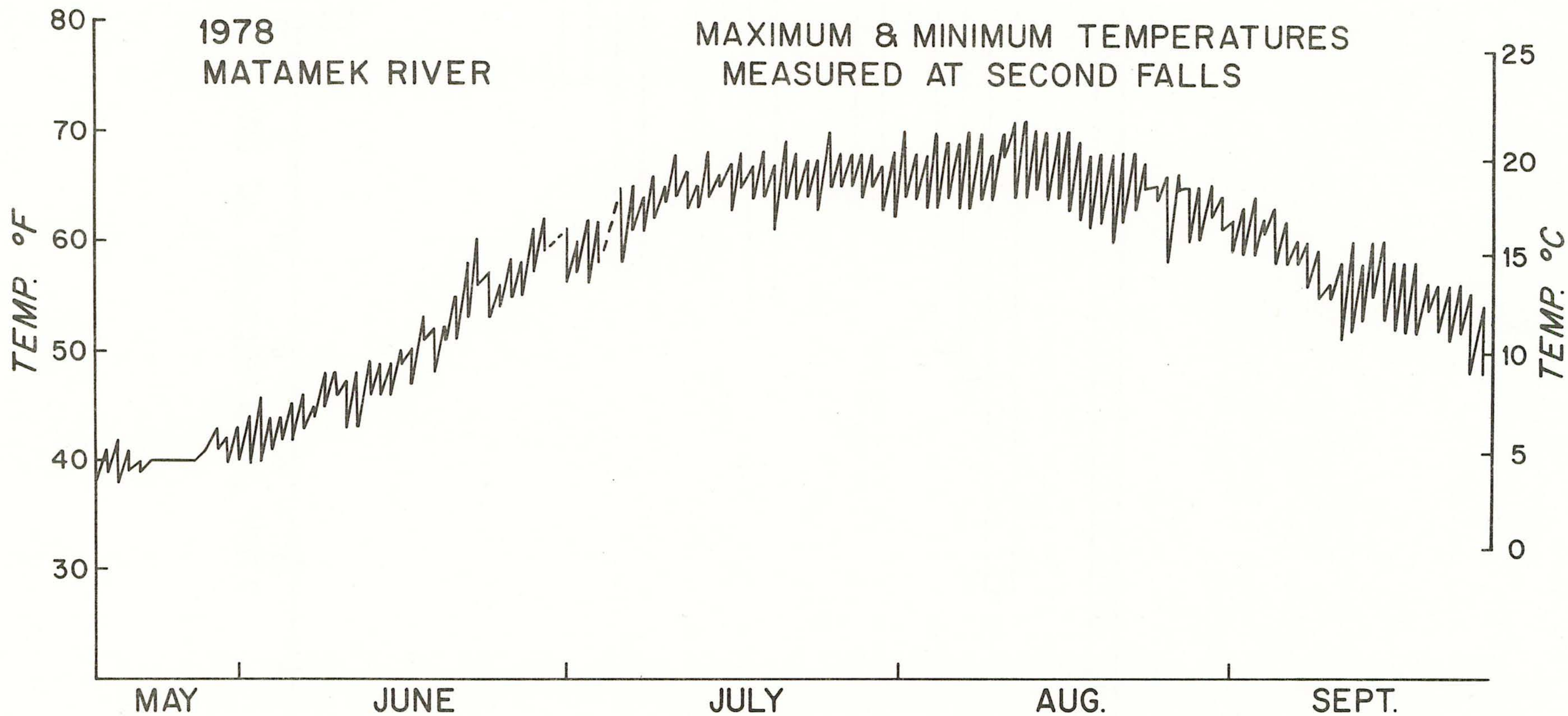
THE SMOLT RUN

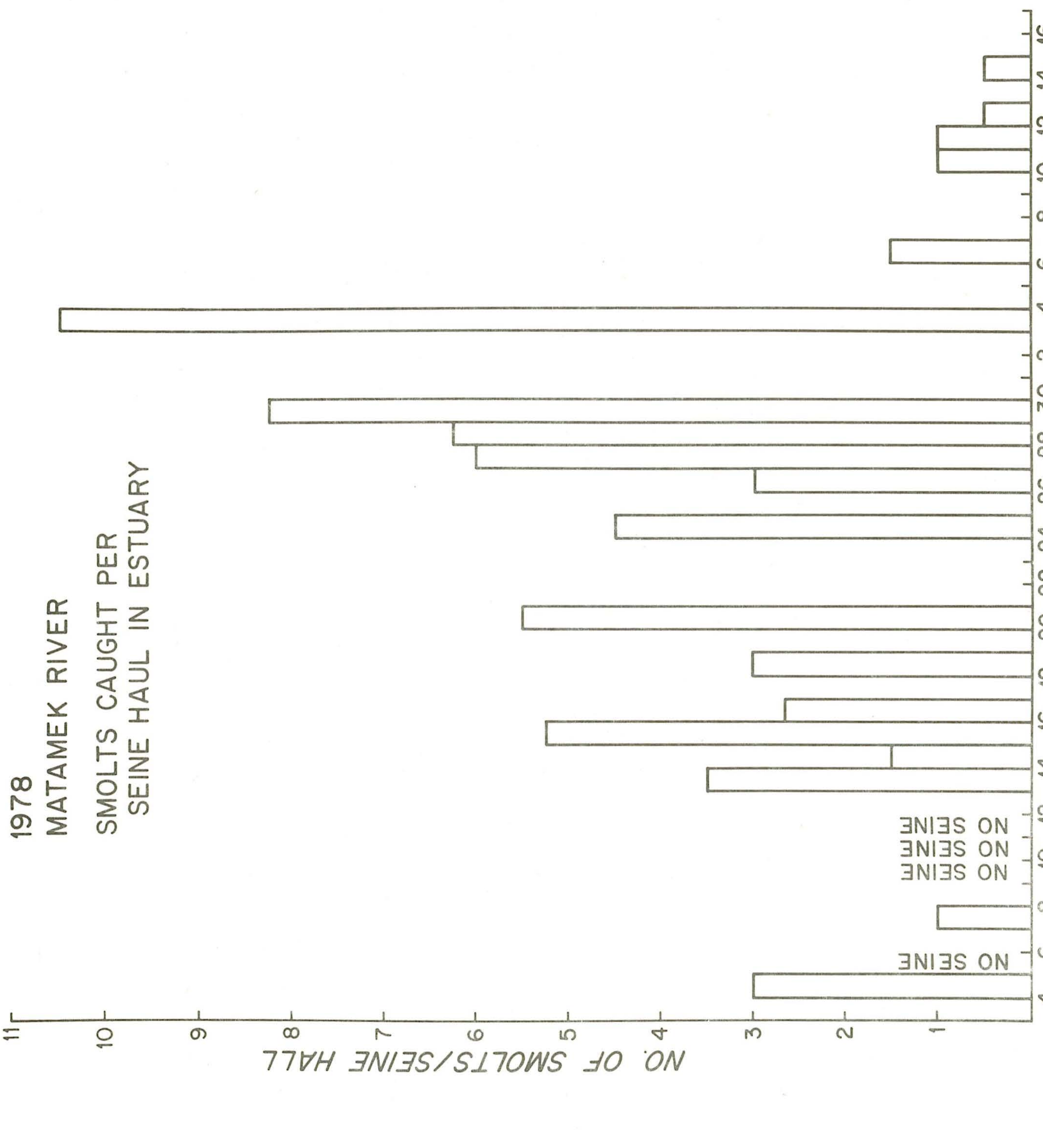
As in previous years, smolts were tagged at the base of the 2nd falls with the intention of making an estimate of the downstream migration. Unfortunately, only two recaptures of fish tagged at the 2nd falls were made in the estuary, which probably precludes a Petersen estimate of the smolt population size.

A total of 300 smolt were tagged this year; 103 at the 2nd falls and 197 in the estuary. This is up from the 1977 combined 2nd falls-estuary total of 218. The 1+ and 2+ parr population estimates for the 2nd falls study area in 1977 indicated a population rise over the 1976 totals. Consequently, it is not surprising to see an elevation in the number of smolts tagged. The mean fork length of the 2nd falls smolts was 13.8 cm (range 11.3-18.8 cm). In the estuary the mean fork length was 14.4 cm (range 11.0-19.0 cm). In addition, we also weighed 185 smolts captured in the estuary before they were tagged and released. The mean weight was 28.5 gm (range 11.8-60.8 gm). The 1977 smolts from the 2nd falls and estuary had fork lengths and ranges of 14.5 cm (11.2-20.5 cm) and 14.9 cm (10.7-19.7cm), respectively.

Previously, it had been suggested that in the Matamek River decreasing parr population size, possibly caused by decreased adult escapement had resulted in a relative abundance of food. The increased abundance of food allowed for accelerated growth rates and corresponding increase in the mean fork length and weight of each parr year class (Gibson, 1978a). It is possible the decrease in mean fork length of 2nd falls smolts is a reflection of increased competition for food due to the recent increases


1978
MATAMEK RIVER
WATER LEVELS,
MEASURED AT SECOND FALLS
WATER DEPTH, cm
260
250
240
230
200
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
MAY
JUNE
JULY
AUG.
SEPT.


1978
MATAMEK RIVER
MAXIMUM & MINIMUM TEMPERATURES
MEASURED AT SECOND FALLS
TEMP. °F
80
70
60
50
40
30
TEMP. °C
25
20
15
10
5
0
MAY
JUNE
JULY
AUG.
SEPT.


1978
MATAMEK RIVER
SMOLTS CAUGHT PER
SEINE HAUL IN ESTUARY
NO. OF SMOLTS/SEINE HALL
NO SEINE
NO SEINE
NO SEINE
NO SEINE
JUNE
JULY

in the size of the parr classes.

The first smolts appeared and were tagged at the 2nd falls during a high but falling river discharge at a temperature of 4.0°C. This was on May 27. The smolts did not really become active until June 9, when the numbers caught and tagged per day began to increase. This corresponded to a daily maximum water temperature of 9°C, during a continued decline of river discharge. In previous years we observed the same response of the smolts to the 9°C maximum daily water temperature. While a few smolts would become active in the 4-5°C temperature range, most did not become active and start moving until daily maximum temperatures were 9°C. Gibson (1975), in a stream tank study on the effect of temperature on parr activity, observed that below 9°C salmon parr would abandon feeding stations and disappear into rock rubble in the channel bed. Presumably the 9°C temperature point represents the lower physiological temperature limit at which the juvenile Matamek salmon remain active.

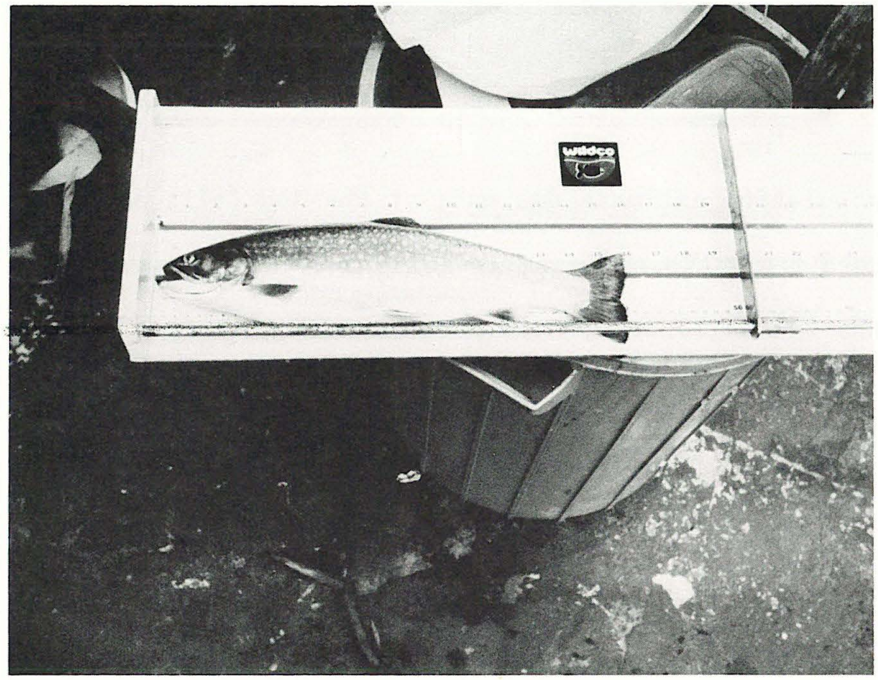
At the second falls 20 fish were recaptured near the location in which they had been tagged. The mean time between recaptures was six days (range 1-20). Six of the fish were multiple recaptures ranging from 2-7 captures in periods from 6-15 days.

Despite intensive fishing pressure which continued until the end of July, the last smolt tagged at the 2nd falls was on July 7th, and the last recapture taken in the same area was on July 8th. Presumably most smolts had migrated at least as far as the estuary at this point.

In addition to capturing smolts at the 2nd falls by fyke nets, seining, and angling, an attempt to use a purse seine was also employed this year. It met with limited success, accounting for 20% of the smolts caught at the 2nd falls.

The first appearance of smolts in the estuary was on June 4th. The run in the estuary appeared to peak on or about July 3, at a temperature of 15.9°C. Thirty five of the 197 fish originally tagged in the estuary were recaptured there. Multiple recaptures ranged from 1-5, with the period between recaptures ranging from 1-20 days. The mean time between recaptures was nine days. One fish was recaptured five times in seven days. Two others were recaptured once each after resting in the estuary for a period of 29 days. This may suggest that the smolts spend some time in the estuary adapting to sea water before finally migrating, although other explanations including food availability or wounds caused by the Carlin tag could account for this observation. The last smolt captured in the estuary was on July 14th.

Dr. Marcel Frenette has suggested that hydraulic conditions in the estuary may be biasing our sampling stations for smolts. Our seining locations in the estuary are determined by the bottom configuration of the estuary. They can only be seined on flood tide due to the number of large rocks in the area. Assuming that the salmon smolts have a preferred salinity dictated by their state of physiological adaptation to sea water, one could expect to find the smolts actively following a salinity gradient within the estuary as this gradient oscillates as a function of tides and river discharge. Both tides and especially the river discharge are variable in predictable and unpredictable manner. It is conceivable the sampling stations may be located outside these pre-



Matamek River Natural Sea Trout
(Photo by Whoriskey)

ferred gradients at any given time. However, further study is necessary to clarify this question.

2nd Falls Parr and Trout Population Estimates

A parr population estimate was made at the 2nd falls again this year. The data from this estimate is being analyzed now. This year most trout from the 2nd falls study area were removed to the estuary as part of a sea ranching program. The response of the parr population to the removal of interspecific competition with the brook trout should be most interesting.

The Sea Ranching of Brook Trout

A pilot program on the feasibility of sea ranching of brook trout was initiated this year. Sea ranching offers many advantages over conventional culture of trout. The fish, once released in the estuarine environment, are left free to forage for themselves. Economically this means that once the fish are planted in the ocean there are no costs for food and food supplements, for labor in feeding or tending of tanks, or for expensive water or air circulation apparatus. Vitamin deficiencies and disease sometimes associated with artificial culture of these animals are also avoided. The increased availability of food for the fish in the sea, when compared with the river system, results in a greatly accelerated growth rate. And brook trout, unlike salmon, do not undertake extensive migrations, eliminating susceptibility to high sea fisheries.

The Matamek River has a waterfall impassable for trout, the 1st falls, 0.7 km upstream from the sea. Once sufficient numbers of trout are planted in the river below the falls, feeding pressure forces them to use marine food resources. Sea trout must return to fresh water for spawning in the fall. The fishway located at the Matamek 1st falls provides an ideal sampling station as they migrate upstream.

A small natural sea trout run occurs in the Matamek River. Based on fin clips there is some evidence the natural sea run trout are probably derived from spillage over the 1st falls. On June 16, 1976 two exceptionally large natural sea trout (998.75 gms and 1038.66 gms) were taken in a smolt seine haul. One of these fish was fin clipped in earlier studies upstream of the 1st falls in the Matamek River. Scale readings indicated they were 4+ fish, with two sea years. A Matamek River dwelling trout at an age of 4+ could be expected to weigh 150-200 gm. The existance of this natural population indicates conditions in the estuary are suitable for supporting a population of sea trout, but the lack of a method for upstream migration previous to the construction of the fishway will have worked against genetic selection of a sea run stock. No suitable spawning grounds occur below the 1st falls.

The advantages of a sea ranching program lie in development of either a commercial or sport fishing potential in underdeveloped areas, in the excellent quality of the fish (1-5 lb, and generally pink flesh), and this type of program could minimize some of the effects of large scale hydroelectric dams on fishing resources of the North Coast, providing adequate spawning areas are preserved.

In this study 933 wild brook trout were trapped at the base of the 2nd falls and transported to the estuary of the Matamek River. Trapping started on May 29, 1978 and continued until July 29, 1978. Fish with greater than 10 cm fork length were marked with an Anchor tag, those less than 10 cm fork length were fin clipped as they were too small to accept the tags. In addition to trout removed from the 2nd falls a number of trout were taken while seining for smolts in the estuary. Of a total of 126 fish, 38 had obvious sea trout morphology (large fish, silver color, large body-head ratio), and 88 could not be readily distinguished from river dwelling trout. These fish were also tagged. A total of 1059 tagged fish were released.

Sampling of the sea trout was initiated in early September. Techniques included use of the fishway, seines, angling, gill, and trammel nets. Water temperatures were decreasing during the sampling period, and sampling was arrested in late September due to inactivity of the fish. We recovered about 25% of our released fish.

In late September, when fish were no longer moving into the sampling gear many would still rise to, but not take, flies. Most of these fish were tagged. We feel fairly certain a much larger percentage than the 25% we sampled stayed and survived within the Matamek estuary and lower river over the summer. It will be most interesting to follow over winter effects and a second season of growth of these fish.

Analysis of the 1st years results is just underway. Baseline data for trout growth over a number of years for Matamek River fish is available for a comparison. An analysis of the seasonal river diet of the trout has just been completed and shall be available for comparison shortly.

Preliminary results indicate that there were elevated growth rates for fish which moved into the estuary to feed on marine organisms. Not all of the transplanted trout were utilizing this marine feeding resource however. Some of the fish migrated upstream from the estuary release point and appeared to remain in the large freshwater pool at the base of the 1st falls for the entire summer. Stomach samples have tended to confirm these ideas. Fish with accelerated growth rate and developing sea trout morphology were feeding on a marine diet of sand launce (*Ammodytes americanus*) and marine crustaceans primarily mysid shrimps and amphipods. These fish generally had fuller stomachs than river trout, implying a greater abundance of food in the brackish water. The river dwelling fish fed primarily on insect larvae and adults.

There did not appear to be any major problems with parasites, either fresh water or marine, in the fish sampled.

Some straying of the tagged fish did occur. A trout (#884) released in the Matamek estuary on July 12 was taken by an angler in a tributary of the Moisie River, about 16 km from the Matamek, on August 11. Another fish (#436) released on June 20 was taken opposite the Moisie Salmon Club, 27 km upstream on the Moisie River about August 9. We were unable to recover either of these fish from the anglers.

On July 1 two poachers were seized on the river by officers from the enforcement division of the Ministry of Tourism, Fish and Game. They had in their possession 21 trout of which 18 were tagged. The fish were recovered by the station. We do not believe, however, many fish were lost to poachers due to efficient patroling of the river by Ministry of Tourism Fish and Game officers and station personnel.

SALMON FRY PLANTINGS

Salmon fry were stocked in two areas this year. The fry were progeny of Matamek River adults sent to the Quebec Governments fish culture facility at Tadoussac. About 12,000 fry were planted by helicopter, 6000 in the area at the base of the 5th falls, and 6000 just below the outlet of Tchinicaman Lake located at an elevation of 364 meters on the Precambrian Shield in the upper watershed of the Matamek River.

The area at the base of the 5th falls has a native population of brook trout. The objectives for stocking salmon in this area were two-fold, 1) to further study the interactions between Atlantic salmon and brook trout and 2) to open up previously unavailable habitat to exploitation by Matamek River salmon stock. The 4th falls 5.9 km from the sea, forms a barrier to upstream migration of salmon. The 5th falls 6.7 km from the sea is also impassable.

Objective #1 is described in more detail in the report which follows by Gibson and Dickson.

The area at the base of the 5th falls offers both good salmon parr habitat and some good potential spawning grounds. A natural channel around the 4th falls exists but has water in it only during the spring runoff. If the stockings are successful it may be passible in the future to blast an opening in this channel, allowing enough water through to permit an upstream migration of adult salmon.

The Tchinicaman area was not colonized by fishes after the last Glacial retreat. The watershed of the river, an alteration of rapids and small lakes, provides miles of suitable salmon parr habitat. Previous stocking of Shield areas (Rimmer and Power, 1978) have shown that growth rates in Shield lakes can be very good in the absence of interspecific competition and with an abundance of unexploited food present. Previously, yearling parr were placed in the lower watershed of the Tchinicaman River and 5th falls, but seemed to have been washed out.

By placing fry at the base of the Tchinicaman outlet in the shallows of a small lake it is hoped recovery from transport shock will take place, and that fry will be able to overwinter in the lakes and recolonize the rapids the following spring. If planting is successful and the fry survive, it is hoped to establish a lake run of Ouaniche, which could forage in Matamek Lake on a relict, lake locked population of smelt (Osmerus mordax).

We have sent eight fish to the provincial hatchery in Tadoussac for spawning. The progeny will once again be planted in the 5th falls and Tchinicaman areas in 1979. This will be the first time we will be able to sample the fish planted in the Tchniciman in 1978. Survival and growth at the 5th falls area appears to be good.

F. G. Whoriskey, Jr., R. J. Gibson, Fay Cotton, and Peter Heinermann.

REFERENCES

Gibson, R. J. 1975. Matamek Annual Report for 1975. 121 pp.

Gibson, R. J. 1977. Matamek Annual Report for 1976. 116 pp.

Gibson, R. J. 1978a. Recent changes in the population of juvenile Atlantic salmon in the Matamek River, Quebec, Canada. J. du Conseil 38(2): 1-7.

Gibson, R. J. 1978b. Matamek Annual Report for 1977. 154 pp.

Rimmer, D. and G. Power. 1978. Rearing Atlantic salmon (Salmo salar) in fishless lakes of the Matamek River system, Quebec. Can. Field Naturalist v. 92(1): 1-9.

Scheifer, K. 1969. Ecology of Atlantic salmon Salmo salar L. in the Matamek River. M.Sc. Thesis, University of Waterloo.

5th Falls Fry Planting

R. J. Gibson

Tom A. Dickson

5th Falls Fry Planting

To more fully understand interactions between Atlantic salmon (*Salmo salar*) and brook trout (*Salvelinus fontinalis*), it was decided to plant salmon fry below the 5th falls. The growth and distribution of the two species would then be followed over the summer. Both the 4th falls and 5th falls are insurmountable to both species, and brook trout are the only salmonid naturally present in the 0.8 km of river between the two falls. In 1976 adult salmon and parr were planted here late in August with the hope that the adults would spawn in that area. No juvenile salmon were found the next summer, it was concluded therefore that both the adults and the parr drifted over the 4th falls before spawning (Gibson *et al.*, 1977). In a previous attempt to introduce salmon here fry were released in 1969. No survival was found and it was concluded the fry had been preyed on by the brook trout or had left the area. They had been released in June about a month earlier than their normal time of emergence in the Matamek.

It was decided to plant salmon fry at the same time they would normally emerge in other sections of the river. Adults were captured in a trap net between the 2nd falls and 3rd falls and held in floating holding pens by the net. The fish were taken to the Quebec Government Hatchery at Tadoussac, where they were spawned and the Matamek progeny kept separate from other stocks. The fry were brought to Matamek on July 5/78 in good condition and taken by helicopter to the 5th falls. There the fish were put into a holding pen for 24 hrs to overcome travelling shock (Mathews *et al.*, 1974). The 6000 fry (less 5-10% estimated mortality) were released after a sample of 15 fry were taken. Samples were taken in August and September with a beach seine (3.2 mm mesh x 6 m long), and preserved in 5% formaldehyde (Table 1).

The planted fry surpassed the trout in size by August and were much larger by September. In a natural population with the two species cohabiting, below the 3rd falls, the trout remained larger than the salmon through the first season of growth (Table 1).

From previous data (Gibson, unpublished data), we find that the salmon emerge at the 3rd falls at the same time as at the 4th falls. Secondly, the salmon emerge at the same size as that of the trout at emergence, but one month later.

MacCrimmon and Dickson (1979), in Trappers Cabin Creek determined that the trout did not use the very fast current regions, regardless if in allopatric or sympatric populations. The salmon have adaptations, both morphological and behavioral, which allow them to exploit this region better than the trout (Gibson, 1973). With only a few salmon fry planted (less than 6000) they would be able to occupy this area unavailable to the trout. During the September sampling, salmon were caught in the fastest water. The seine hauls covered both the slower and faster current type of habitat, so that it was impossible to distinguish the type of water velocity in which fry might be caught close to the falls. Only trout were caught in the seine hauls downstream of the riffle areas, where the current was uniformly slow.

LITERATURE CITED

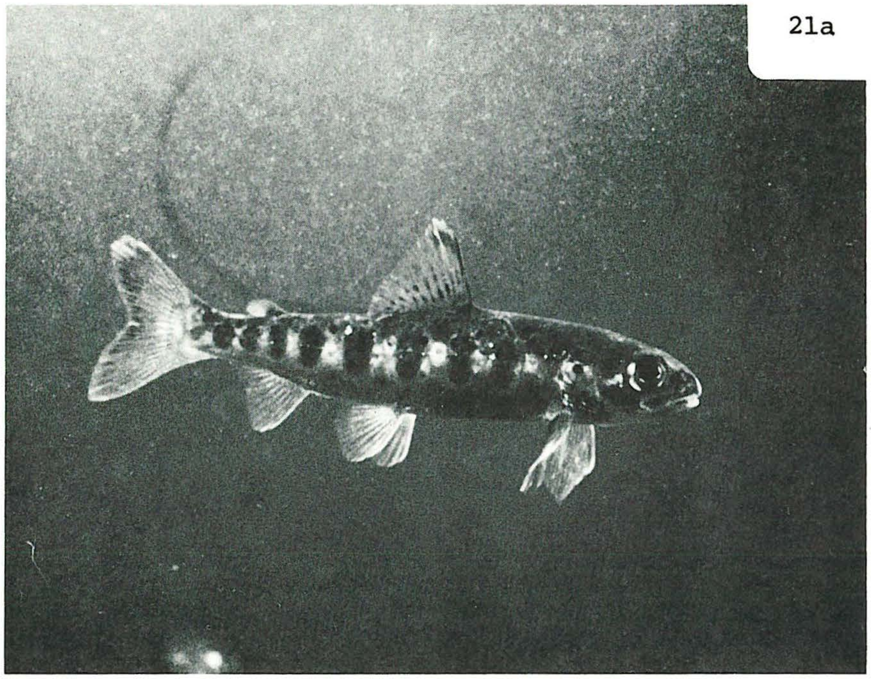
Gibson, R. J., P. Kerkhoven, T. Dickson, and R. Sears. 1977. Introductions of salmon within the basin beyond their normal distribution. Matamek Annual Report 1976, W.H.O.I.-77-28 32-34.

Matthews, A., D. Rimmer, and J. R. Matthews. Report on the Biological Studies Carried Out at Pisciculture Provinciale Tadoussac. University of Waterloo. 24 pp.

MacCrimmon, H. R. and T. A. Dickson. 1979. Comparative growth and behavior of Salvelinus fontinalis and juvenile Salmo salar in the Matamek River. Matamek Annual Report 1978 (in press).

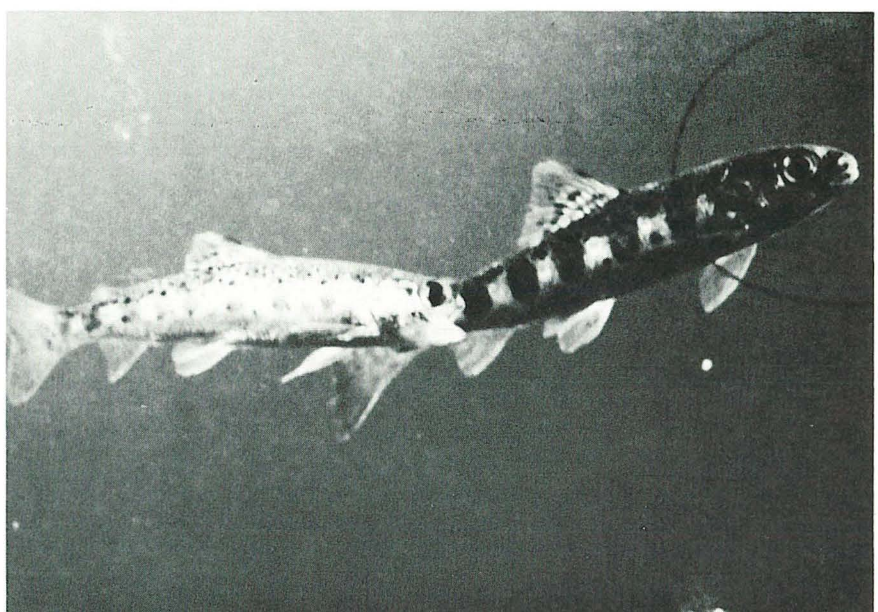
Table I. Salmon and trout fry samples from the Matamek River, 1978 (sample sizes in brackets).

		Weight (g.)		Fork Length (cm.)	
Date	Falls	Trout	Salmon	Trout	Salmon
6/6	5	0.26 (12)		2.86	
26/6	3	0.23 (19)		2.97	
8/7	5	0.53 (60)	0.47 (90)	3.58	3.55
3/8	5	1.04 (18)		4.22	
7/8	5		1.24 (14)		4.47
6/9	5	1.45 (42)	1.94 (21)	5.06	5.58
6/9	3	1.68 (19)	0.93 (25)	5.26	4.29



SALMON PARR: LATERAL DISPLAY

SALMON PARR: NIP



PHOTOS BY TOM DICKSON

COMPARATIVE GROWTH AND BEHAVIOR OF SALVELINUS FONTINALIS AND JUVENILE SALMO SALAR IN THE MATAMEK RIVER

Hugh R. MacCrimmon

and

Tom A. Dickson

The University of Guelph

Where Atlantic salmon (Salmo salar) and brook trout (Salvelinus fontinalis) cohabit areas in the Matamek River the biomass and the production of the two species are similar, but the salmon are smaller and more numerous then the trout (Gibson, 1973). In sympatric populations, both species are found in the riffle areas when food is plentiful (June) (Gibson and Galbraith, 1975), but trout are found in the pools when food is scarce (Gibson, 1973). This phenomenon is called interactive segregation as used for ant populations by Brian (1956) and has been documented in other coexisting salmonid species (Hartman, 1965; Kalleberg, 1958; Nilsson, 1967; Stein et al., 1972). A better term might be "character displacement", defined by Brown and Wilson (1956) as "two closely related species which are distinct where they occur together, but where one member of the pair is alone it converges toward the second.

In many of the interacting pairs of salmonids the interaction was found to affect the growth of one species more than the other (Frost, 1950; Gibson, 1973; Hartman, 1965; Nilsson, 1967; Stein et al., 1972). In most cases the species winning the preferred habitat exhibits the best growth. The juvenile Atlantic salmon are more aggressive and can outcompete the brook trout in medium and fast flows (Gibson, 1973). They hold feeding territories (Keenleyside, 1962), while the trout wander more (Gibson, 1973). Yet, the salmon have a slower growth rate, as can be seen from the year class size ranges. The first objective of this research is to examine behavioral interactions, and determine the effect, if any of the presence of the trout biomass on the growth of the salmon.

Dunbar (1960) proposed that interactive segregation was characteristic of young faunas. If so, one would expect to find other animals in north temperate streams interacting in a similar manner. The literature for freshwater environments is sparce and the only conclusive findings have come from a stream in Wales. The two species of triclads compete and the subordinate species has reduced growth in sympatric populations. While it seems to be a trend with sympatric salmonid populations, it has not been determined if this is a general trend in north temperate streams.

In fluvial salmonids it is common for density to be regulated by relative "space - food" requirements, but this relationship would seem to break down when food is abundant (Chapman, 1966). This is not so in the salmon like "Ayu" (Plecoglossus altivelis), where with the same amount of food, territories break down as more fish enter an area, and growth is better for all fish as opposed to only the dominant fish growing well (Kawanabe, 1968). The second objective of the research is to determine if the growth of the juvenile Atlantic salmon does change in the salmon when territories are broken down by high fish densities.

Dill (1977) followed the early development of behavior in Atlantic salmon from hatching to one week after emergence under laboratory conditions. He found that agonistic acts began just after emergence, and observed both charging and nipping. Parzefall (1969) observed more frequent agonistic acts in the fry then in the older fish. The third objective of the research is to determine if behavior patterns (qualitatively and quantitatively) change during the juvenile life stages and if so, to relate these to changes in natural habitat preferences and growth patterns by quantitative examination of fish in natural and artificial stream systems.

Matamek Stream Tank Studies

Experiments in the Matamek stream tank undertaken during the summer of 1978 were designed to interlock with work done at Matamek in 1977 (Dickson and Gibson, 1978). The main objective of the study is to determine the effect of the trout biomass on the growth of the juvenile salmon, by examining both growth and behavioral components. Earlier studies by Gibson (1978) have demonstrated in part, that both temperature and water velocity effect the types and intensity of interactions. The present study is monitoring these and other environmental factors in conjunction with the standard behavior observations. As in 1977, the populations were examined singly and in combination at two densities, to determine if salmon territoriality is broken down at higher density and if production in the juveniles increases. The experiments also provide novel quantitative data for comparing behavior patterns of the two species at different stages of juvenile development.

Materials and Methods

Each of three flumes with observation windows, in the stream tank at the second falls, were divided into two sections (2.46 x 1.5 m). Sand (approximately 8.0 cm), gravel, and some large rocks scattered throughout, covered the bottom of the flumes. One quarter of each section was darkened with a shade cover of black plastic or tar paper, on a wooden frame. The water temperature was recorded daily (Fig. 1) and a thermograph was kept. Water flow was kept uniform in all tanks, and the depth constant at 48.5 cm. The water was analysed (Table 6).

Six fish populations consisting of two different densities (4 or 5 and 10 or 11 fish/section) by three species mixtures (all trout, all salmon, and 50% mixtures, except exp. #2) were created (Table I). The low density populations were always in the front section of each flume (Table I).

Fish for the experiments came from seine hauls and fyke nets below the second and third falls on the Matamek River. Experiments started with the fish were transported to the station in buckets, anesthetized with "Alka-Selzer", weighed (on a Sartorius #3704, $\pm$ 0.01 g), measured to the nearest mm, and finally individually branded. The trout were branded with a heated Nichrome wire (Gibson, 1973), and the salmon by using a brass wire bent to form a shape and frozen with "Cryokwik", an aerosal freezing spray. The weighing and measuring was repeated at the end of each experiment. It commenced at 5:00 a.m. (or at first light, which ever was later), when the water was coldest to reduce mortalities. Fish were reused in consecutive experiments, until they surpassed the size limits set for this summers work. When the fish were returned to the flumes all were added at one time, or special note was made of replacement fish and the required adjustments made to the calculations.

Food consisted of freshly boiled shrimp ground up in a meat grinder. It was added each evening at the upstream end of each section by hand to drift through, except for the first four days of the experiment when food was also given in the morning. Ration level was approximately 4.5 g/fish/day, although not all of this food was consumed, i.e., the fish were fed to satiation.

Behavioral observations commenced when all fish had become acclimated to the flume section, usually after five days. Each experiment consisted of 10 observations (except exp. #7, only five observations) on the six sections (always in a set order; IA, IB, 3B, 3A, 2A, 2B, without regard to the order of the population types). An observation started with the position of each fish in the flume being mapped, then successful agonistic acts were then recorded on a tape recorder. All six sections were observed consecutively. A maximum of two observations a day were made, at well separated periods. The agonistic acts recorded are described by Gibson (1977). Along with the behavior observation on each section the following factors were recorded; water temperature ($\pm$ 0.01^{o}C), wind, air temperature, precipitation and water speed.

Results

The behavior of salmon was found not to differ at high or low density, but did so between mixed species or solely salmon. When mixed with trout there was a significant decrease in the use of lateral display and an increase in the use of approach (Table 3). The behavior exibited by the trout was similar at high density, both mixed and alone. There was slight differences in the low density populations but this is most likely the result of the small sample sizes (Table 3).

Trout use more "approach" (from use of the approach - nip combination, used very little by salmon), charge and chase and nip were used less by the trout than the salmon. The salmon use approximately double the amount of lateral display.

In the 1977 experiments (Dickson and Gibson, 1978), on larger fish (10.5-13.0 cm), the average behavior, when compared by species, was similar with this years data (Figure 5). The larger salmon (1977) tended to use more charge and chase, more lateral display and less nip (Tables 3 and 4) than smaller salmon. The trout exhibited a large difference between the low and high density populations (Table 3 and 4). The differences between the 1977 and the 1978 data is likely the result of experimental design and because only one replication was used in the 1977 experiments.

In the low density experiments the trout had a similar percentage of success in the interspecific interactions, but were involved in 48% less interactions than the salmon, which had a lower success rate. At high density the salmon had a higher success rate and were involved in 60% more successful interactions than the trout (Table 8). Generally the salmon are much more aggressive and as a result are more successful than the salmon.

The correlation coefficient (by observation) of the following factors; time of day, population type, cloud cover, precipitation, water temperature, water velocity, and interactions (intraspecific, interspecific, and total) will be calculated. Also to be calculated by population type the correlation between tank, experiment, date, average water velocity, average water temperature, photoperiod, growth (fork length and weight) and behavior (intraspecific, interspecific, and total) by experiment.

The trout grow at a similar rate when alone at either low or high density. Growth is best when at low density and a mixed population, the growth is poorest at high density mixed population. The salmon grow best when mixed, at a low density (Table 2). This might be expected as the salmon can displace similar sized trout by aggression (Table 8). The production would be greater at higher density as the fish would all grow well at a slightly slower rate, as opposed to a few fish growing well and the rest growing very little. This was observed in the experiments (1977) on the larger juveniles (Dickson and Gibson, 1978). The high density experiments this year did not completely break down the territoriality. One or two dominant fish per tank maintained large territories, while the rest of the fish schooled.

There is great differences in the growth recorded in 1977 in the stream tank compared with the 1978 data (Table 2). These could be accounted for in the poorer experimental design in 1977. The high and low density experiments were run consecutively instead of simultaneously as in 1978. Also, there was only one replication of each population type, therefore leading to large confidence limits.

Trappers Cabin Creek Experiments

Ohm (1958) states that the early emergence of one species gives an advantage to that species. The trout are first seen after emergence from the gravel in the Matamek river about the middle of June, while the salmon fry are not seen for another month in the middle of July (Schieffer, 1969). From this point on, the trout are larger than salmon of the same age (Gibson, 1973). In some British rivers a similar situation exists between the Atlantic salmon and brown trout (Salmo trutta). The brown trout emerge about a month before the salmon, secure the best feeding territories and defend them with an aggressive nature. The result is a faster growth rate for the trout and a larger size than the salmon at any older juvenile stage. Egglishaw and Schackley (1973) planted salmon eggs that were at an advanced stage in a fenced section of a trout creek. They emerged before the trout and had a faster growth rate. After one seasons growth the salmon were larger than the trout. However, this was not true in the rivers of British Columbia where the coho salmon (Oncorhynchus kisutch) emerge before the steelhead trout (Salmo gairdneri). The steelhead compensate for the late emergence with a faster growth rate than the coho (Fraser, 1968).

The observed emergence in the Matamek River of the trout one month before the salmon could be of important ecological significance. Hence, a series of experiments were designed to investigate the effect of the trout biomass on the growth and behavior of the salmon in a natural stream. An opportunity was provided also, to observe spacial distribution (environmental partitioning) by the two species and to observe the behavioral interactions.

Methods

Five areas were set up along the lower reaches of Trappers Cabin Creek which enters the Matamek River below the fifth falls. Each area was approximately 3.3 m (10 feet) long, enclosed up and downstream by two 3.2 mm (1/8") vexar screening (area #5 was enclosed using 3.2 mm knotless netting), and separated from the next by approximately 10 meters of stream (Table 7). Each enclosure was chosen to have a riffle section upstream of a pool area. Populations of 30 fish were set up with all salmon (2 areas), all trout (1 area), and 50/50 mixture of salmon and trout (2 areas), which were rotated to different areas in each experiment (Table 7). The density of fish for these experiments was chosen by visually estimating natural densities in the Creek and in the river.

The areas were first dip netted (night and day) to remove all resident fish. Then, individual fish were measured for fork length and each population weighed as a group (Dial-a-gram, ± 0.1 g), while anesthetized by "Alka-Selzer". All groups were then added simultaneously to the enclosures. The trout for the experiment came from below the fifth falls in seine hauls. The salmon came from Matamek adults spawned at the Tadoussac hatchery and the fry returned to us on July 5, 1978 and were flown to the fifth falls. Each experiment lasted 29 days and was ended by dip netting (day and night) the fish out of the areas and again weighing and measuring them.

During the experiment the screens were cleaned by hand every second day, and the water temperature (2 day max/min^{o}C) (Figure 3) and water depth (Figure 2) were recorded. A water sample was analysed (Table 6).

Observations were made on the fish behavior, noting species distribution and interactions. These data were analysed with reference to water depth, velocity and the environmental parameters previously plotted on detailed maps of the study area.

Results

The salmon grew best on their own, when the trout were present the growth was significantly reduced. This effect was observable only in the weight and not in fork length (Table 2). The trout grew best when the salmon were present, and significantly less when on their own. Again this was seen only in the weight and not in the fork length. The increase in fork length by the trout was greater than the salmon (Table 2). The growth of the salmon was reduced in experiment #2 compared with experiment #1 and also declined slightly in the trout. This is most likely the result of the decreasing average temperature in experiment #2 (Table 7).

The species were seen to interact aggressively, and charges and nips were noted in several of the areas. No lateral displays were seen due to the viewing angle of the observer. From the distribution maps the salmon were generally found in the fast and medium currents. The trout were usually found in the slow and medium flows. Salmon more frequently than trout were found in the fastest flow, whether in mixed or all salmon populations. This is a preliminary observation and must be substantiated with further experiments.

Towards the end of experiment #2 it became increasingly difficult to locate the fry before the water approached the high for the day. I presume they were under the rocks or larger pieces of gravel on the stream bottom. This agrees with the results of Gibson (1978) and Hartman (1963). The lower temperature would also account for the lower growth of both species in experiment #2. The trout having a colder preferred temperature range (Fisher and Elson, 1950; Fry, 1951) would get a growth advantage over the salmon at the end of the season.

The early emergence of the trout could be a major factor in the greater growth of this species. This not only allows them to grow over a period when food is abundant (Gibson and Galbraith, 1975) before the salmon emerge, but, allows them to acclimatize to the environment. Also the trout will be over the difficult period of first feeding when the salmon begin to interact. Lastly, Mason and Chapman (1965) concluded that early emergence in the coho underyearling populations gave "settler's rights" to the best territories. This suggests the trout can out-compete the salmon by virtue of their larger size or greater experience in the environment, which accounts for the poorer salmon growth when the trout are present.

According to the distribution maps the salmon occupy the fast current significantly more than the trout. Therefore, when both species are present they use the available environment more efficiently. In the all trout enclosures there is 30 fish which prefer to occupy the slow and medium current, while in the mixed areas (only 15 trout present) some of the salmon occupy the fast current. Which would account for the improved growth of the trout when in mixed populations. At the moment this is very speculative and needs more experiments to enlighten the situation.

Discussion

The following hypothesis has developed over the early stages of this research with regard to the salmon-trout interaction. It will need more experimentation over the next year to affirm it's validity.

The trout fry, because of their early emergence which results in greater experience in the environment and a longer growth period, can outcompete the salmon fry for the preferred habitat. They are larger than the salmon fry by the end of the first season of growth. By the next season this changes and the salmon are able to outcompete the trout by their more aggressive nature (Table 8) and adaptations for the faster currents (Gibson, 1973). The growth advantage from the first season is enough to give the trout the size superiority for the remainder of the time that the two species co-habit the river. This interaction is further illustrated by Gibson's (1973) estimates of salmonid populations in the Matamek River. There was an 80% drop in the number of 1+ trout in allopatric populations versus sympatric populations with the salmon. These 1+ trout are the same size as the 2+ salmon, salmon are able to outcompete the brook trout.

One variation on this theme was seen when salmon fry were planted below the fifth falls this year (Gibson and Dickson, 1979). The salmon were much larger than the trout, by the end of the first season, while at the third falls, where both species co-habit naturally, the salmon were much smaller than the trout. It is hypothesized that this relatively small number of salmon fry at the fifth falls occupied the very fast current unavailable to the trout (as was observed in Trappers Cabin Creek).

This program looks at the growth and relates it to the observed behavior, but, many other factors could influence the situation. Food is a limiting factor (Dickson and Gibson, 1978), as the main drift of insects in the river is June to mid-July (Gibson and Galbraith, 1975), this has been observed in other species by several authors (Benson, 1953; Gerking, 1962; Logan, 1963). Temperature has been identified as a significant seasonal effect in many species (Wingfield, 1940; Fisher and Elson, 1950; Fry, 1951; Swift, 1961). The observed seasonal growth in juvenile Atlantic salmon (Symons, 1976) maybe related to an annual rhythm in pituitary hormone. Rising temperature (Pickford and Atz, 1957) and increasing photoperiod (Gerking, 1966) have been postulated as stimuli to the pituitary hormone production. Photoperiod has been shown to effect growth, food consumption, and food conversion (Gross _et al_., 1965) and no doubt has an effect on the growth patterns of the Matamek salmon and trout through endocrine concentrations.

Whether both species are similar in their reaction physiologically to the above environmental factors is unknown at this time.

The research thus far includes stream tank observations (at Matamek) on fish 7.5-13.0 cm and creek experiments on the fry at the fifth falls. At the time of this writing, experiments are being conducted under controlled laboratory conditions at Woods Hole Oceanographic Institution on fish 7.6-11.0 cm. Further, this spring (1979), at the University of Guelph, experiments will be run on the fry of the two species in the laboratory.

It is hoped in the summer (1979) to return to Matamek and complete the work as follows. The stream tank will be modified to experiment with the fry in the same manner as was done on the larger fish previously and Trappers Cabin Creek will be used for growth and distribution studies on the fry.

In conjunction with Dr. Gibson's previous work, juvenile salmonids will be sampled in three areas of the river. Below the second falls, where the trout have been removed; below the third falls where both species are present; and below the fifth falls, where salmon fry will be planted.

The end result is a comprehensive study of growth and behavior of the juvenile stages of Atlantic salmon and brook trout under controlled laboratory conditions, semi-controlled field settings, and in the natural river habitat. This will provide much useful information on the ecology and interactions of these two species.

Acknowledgements

The authors wish to acknowledge the strong contribution which Dr. R. John Gibson has made to the initiation and progress of the present study. His continuing interest in the research and timely advise is most sincerely appreciated. Special thanks is extended to Fred Whoriskey, Peter Heinermann, Fay Cotton, and all others at the Matamek Station who assisted so greatly with various aspects of the field study. I would also like to thank the Ministere du Tourisme, de la Chasse et de la Peche of the Quebec Government for providing hatchery facilities for the Matamek salmon fry.

Bibliography

Benson, N. G. 1953. Seasonal fluctuations in feeding of brook trout in the Pidgeon River, Michigan. Trans. Am. Fish. Soc. 83: 76-83.

Brian, M. V. 1956. Segregation of species of the ant genus *Myrmica*. J. Anim. Ecol. 25: 319-337.

Brown, W. L. and E. O. Wilson. 1956. Character displacement. Syst. Zool. 5: 49-64.

Dickson, T. A. and R. J. Gibson. 1978. Comparative growth of *Salvelinus fontinalis* and juvenile *Salmo salar* in the Matamek River. Matamek Annual Report 1977 W.H.O.I. Technical Report #78-92.

Chapman, D. W. 1966. Food and space as regulators of salmonid populations in streams. Am. Nat. 100: 345-357.

Dill, P. A. 1977. Development of behavior in alevins of Atlantic salmon (*Salmo salar*) and rainbow trout (*S. gairdneri*). Anim. Behav. 25: 116-121.

Dunbar, M. J. 1960. The evolution of stability: natural selection at the level of the ecosystem. *IN*: Cameron, T. W. M. (Ed.) Evolution: its science and doctrine. University of Toronto, Toronto.

Egglishaw, H. J. and P. E. Shackley. 1972. An experiment on faster growth of salmon *Salmo salar* (L.) in a Scottish stream. J. Fish Biol. 5: 197-204.

Fisher, K. C. and P. F. Elson. 1950. The selected temperature of Atlantic salmon and speckled trout and the effect of temperature in the response to an electrical stimulus. Physiol. Zool. 23: 27-34.

Fraser, F. J. 1968. Population and density effects on survival and growth of juvenile coho salmon and steelhead trout in experimental stream-channels. Symposium salmon and trout streams. McMillan lecture series. University of British Columbia. p. 253-266.

Frost, W. E. 1950. The growth and food of young salmon (Salmo salar) and trout (Salmo trutta) in the River Forss, Caithness. J. Anim. Ecol. 19: 147-158.

Fry, F. E. J. 1951. Some environmental relations of the speckled trout (Salvelinus fontinalis). Proc. N. E. Atlantic Fisheries Conf. May 1952: 1-29.

Gerking, S. D. 1962. Production and food utilization in a population of bluegill sunfish. Ecol. Monographs. 32: 31-78.

Gerking, S. D. 1966. Annual growth cycle, growth potential, and growth compensation in bluegill sunfish in Northern Indiana Lakes. J. Fish. Res. Board Can. 23(12): 1923-1956.

Gibson, R. J. 1973. Interactions of juvenile Atlantic salmon (Salmo salar L.) and brook (Salvelinus fontinalis (Mitchell)). International Atlantic Salmon Symposium, 1972. Int. Atl. Salmon Found. Spec. Publ. Ser. 4(1): 181-202.

Gibson, R. J. 1977. Behavioral interactions between juvenile coho salmon (Oncorhynchus kisutch) and juvenile Atlantic salmon (Salmo salar) and brook trout (Salvelinus fontinalis). ICES CM 1977/M:23. 18 pp.

Gibson, R. J. 1978. The behavior of juvenile Atlantic salmon (Salmo salar) and brook trout (Salvelinus fontinalis) with regard to temperature and to water velocity. Trans. Am. Fish. Soc. 107: 703-712.

Gibson, R. J. and D. Galbraith. 1975. The invertebrate "drift" in the Matamek River, Quebec, compared at two stations downstream from a lake. Trans. Am. Fish. Soc. 104: 529-535.

Gibson, R. J. and T. A. Dickson. 1979. Planting of Atlantic salmon fry at the fifth falls of the Matamek River. Matamek Annual Report 1978 (pg. 17).

Gross, W. L., E. W. Roelofs, and P. O. Fromm. 1965. Influence of photoperiod on growth of green sunfish, Lepomis cyanellus. J. Fish. Res. Board Can. 22(6): 1379-1383.

Hartman, G. F. 1963. Observations on behavior of juvenile brown trout in a stream aquarium during winter and spring. J. Fish. Res. Board Can. 20: 769-787.

Hartman, G. F. 1965. The role of behavior in the ecology and interaction of underyearling coho salmon (Oncorhynchus kisutch) and steelhead trout (Salmo gairdneri). J. Fish. Res. Board Can. 22: 1035-1081.

Kalleberg, H. 1958. Observations in a stream tank of territoriality and competition in juvenile salmon and trout. Inst. Freshw. Res. Drottningholm. 39: 55-98.

Kawanabe, H. 1968. The significance of social structure in production of the "Ayu", Plecoglossus altivelis. Symposium salmon and trout streams. McMillan lecture series. University of British Columbia. p. 243-251.

Keenleyside, M. H. A. 1962. Skin diving observations of Atlantic salmon and brook trout in the Miramichi River, New Brunswick. J. Fish. Res. Board Can. 19: 625-634.

Logan, S. W. 1963. Winter observations on bottom organisms and trout in Badger Creek, Montana. Trans. Am. Fish. Soc. 92: 140-145.

Mason, J. C. and D. W. Chapman, 1965. Significance of early emergence, environmental rearing capacity, and behavioral ecology of juvenile coho salmon in stream channels. J. Fish. Res. Board Can. 22: 173-190.

Nilsson, N. A. 1967. Interactive segregation between fish species. IN: Gerking, S. (Ed.) Biological basis of freshwater fish production. J. Wiley and Sons, Inc., New York 495 pp.

Ohm, D. 1958. Die ontogentische Entwicklung des Kampfverhaltens bei *Aequidens portalegrensis* Hensel und *Ae. latifrons* Steindachner (Cichlidae). Verhandl. Deut. Zool. Ges. Frankfurt. p. 181-194. IN: Baerends, G. P. 1971. The ecological analysis of fish behavior. p. 279-370. IN: Hoar, W. S. and D. J. Randal (Eds.). Fish physiology, vol. 6, Environmental relations and behavior. Academic Press, New York, pp 559.

Parzefall, J. 1969. Zur vergleichende Ethologie verschiedener *Molliensia*-Arten einschliesslich einer Hoblenform von M. sphenops. Behavior 33: 1-37. IN: Baerends, G. P. 1971. The ethological analysis of fish behavior. p. 279-370. IN: Hoar, W. S. and D. J. Randall. Fish physiology, vol. 6, Environmental relations and behavior. Academic Press. New York, pp. 559.

Pickford, G. E., and J. W. Atz. 1957. The physiology of the pituitary gland of fishes. New York Zool. Soc. New York. 613 pp.

Schiefer, K. 1969. Ecology of Atlantic salmon, *Salmo salar* L., in the Matamek River system. M.Sc. University of Waterloo. 63 pp.

Stein, R. A., P. E. Reimers, and J. D. Hall. 1972. Social interactions between juvenile coho (Oncorhynchus kisutch) and fall chinook salmon (O. tshawytscha) in Sixes River, Oregon. J. Fish. Res. Board Can. 29: 1737-1748.

Swift, D. R. 1961. The annual growth cycle in brown trout (Salmo trutta Linn.) and its cause. J. Exp. Biol. 38: 595-604.

Symons, P. E. K. 1976. Behavior and growth of juvenile Atlantic salmon (Salmo salar) and three competitors at two stream velocities. J. Fish. Res. Board Can. 33: 2766-2773.

Wingfield, C. A. 1940. The effect of certain environmental factors on the growth of brown trout (Salmo trutta L.). J. Exp. Biol. 17: 435-448.

Table 1. Particulars of the stream tank experiments 1978, Matamek (standard deviation given in brackets).

Exp.#	Date of Experiment Start	Finish	# Days	Av. starting fork length (cm) Low density Salmon	Low density Trout	High Density Salmon	High Density Trout	Temperature (°F) High	Low	Photoperiod Hrs:Min	Flume #	Species/flume Front	Back
2	7/7	21/7	14	alone 8.7 [0.7]	8.3 [0.7]	8.5 [0.7]	8.6 [0.6]	66.3	62.9	16:02	1	(4)S*	(6)S(5)T*
											2	(5)T	(11)T
				mixed 8.6 [0.8]	9.1 [0.7]	9.1 [0.3]	8.4 [0.3]				3	(3)S(2)T	(11)S
3	21/7	4/8	14	alone 8.8 [0.9]	8.3 [0.3]	8.8 [0.9]	8.7 [0.7]	68.1	63.8	15:29	1	(2)S(2)T	(10)S
											2	(4)S	(5)S(5)T
				mixed 9.0 [0.1]	9.5 [0.6]	9.7 [0.2]	8.8 [0.3]				3	(4)T	(10)T
4	4/8	18/8	14	alone 8.3 [0.6]	8.8 [0.3]	8.1 [0.8]	8.9 [0.4]	69.7	64.0	14:47	1	(4)T	(10)T
											2	(2)S(2)T	(10)S
				mixed 9.4 [0]	9.5 [0.6]	8.1 [0.5]	9.1 0.3]				3	(4)S	(5)S(5)T
5	18/8	1/9	14	alone 8.5 [0.8]	9.1 [0.5]	8.2 [0.5]	9.3 [0.6]	66.6	61.7	13:58	1	(4)S	(5)S(5)T
											2	(4)T	(10)T
				mixed 8.6 [0.7]	8.4 [0.8]	8.3 [0.5]	8.7 [0.6]				3	(2)S(2)T	(10)S
6	1/9	15/9	14	alone 8.7 [0.5]	9.2 [0.6]	8.5 [0.6]	9.5 [0.6]	60.9	57.0	13:08	1	(2)S(2)T	(10)S
											2	(4)S	(5)S(5)T
				mixed 8.5 [0.2]	8.7 [0.9]	8.6 [0.5]	8.6 [0.5]				3	(4)T	(10)T
7	15/9	27/9	12	alone 9.2 [0.5]	9.2 [0.3]	8.8 [0.6]	9.5 [0.6]	52.9	51.8	12:19	1	(4)T	(10)T
											2	(2)S(2)T	(10)S
				9.0 [1.1]	9.3 [0.8]	9.2 [0.5]	9.0 0.5]				3	(4)S	(5)S(5)T

* - S = salmon

Table 2. Average % increase/day/fish.

	Weight (g)			Fork length (cm)		
	Stream tank Exp. '77	Stream tank Exp. '78	5th Falls Creek '78	Stream tank Exp. '77	Stream tank Exp. '78	5th Falls Creek '78
<u>SALMON</u>						
Low Density						
Alone	0.91	1.33	2.87	0.03	0.32	0.31
Mixed	-0.07	1.93	1.51	0.03	0.46	0.31
High Density						
Alone	2.29	1.16		0.03	0.29	
Mixed	1.95	1.56		0.01	0.40	
<u>TROUT</u>						
Low Density						
Alone	1.12	1.36	1.21	0.07	0.33	0.52
Mixed	1.64	1.83	2.96	0.09	0.44	0.53
High Density						
Alone	1.50	1.37		0.04	0.33	
Mixed	2.12	1.19		0.04	0.31	

Table 3. Percent use of behavioral displays by salmon and trout in the stream tank, 1978.

1978	CHARGE AND CHASE	APPROACH	DRIFT	NIP	LATERAL DISPLAY	FRONTAL DISPLAY	PRESENCE	SUPPLANT
SALMON								
Low Density								
Mix	46.20	12.09	0.0	39.28	1.21	0.06	0.46	0.0
Alone	45.83	5.63	0.0	37.78	7.41	0.0	2.91	0.44
High Density								
Mix	45.34	10.51	0.0	37.31	4.83	0.0	2.02	0.0
Alone	43.59	5.17	0.0	41.31	8.30	0.48	1.15	0.0
TROUT								
Low Density								
Mix	43.20	14.38	0.0	38.23	3.65	0.23	0.32	0.0
Alone	50.11	17.28	0.21	28.29	0.87	0.72	2.52	0.0
High Density								
Mix	38.96	18.68	0.14	37.29	1.25	1.15	2.30	0.23
Alone	38.62	19.45	0.0	34.97	2.99	1.53	2.32	0.12

Table 4. Percent use of behavioral displays by salmon and trout in the stream tank, 1977.

1977	CHARGE AND CHASE	APPROACH	DRIFT	NIP	LATERAL DISPLAY	FRONTAL DISPLAY	PRESENCE	SUPPLANT
SALMON								
Low Density								
Mix	38.90	18.36	2.28	20.53	11.8	1.04	4.89	2.28
Alone	50.75	1.49	0.0	29.85	14.93	0.0	2.99	0.0
High Density								
Mix	43.47	4.32	0.36	46.04	3.60	0.0	2.52	0.0
Alone	48.56	11.54	0.0	27.88	7.69	0.96	2.88	0.48
TROUT								
Low Density								
Mix	59.44	0.70	0.0	32.87	3.50	0.0	3.50	0.0
Alone	54.48	4.83	0.0	31.56	1.50	0.0	7.36	0.20
High Density								
Mix	30.00	27.60	0.79	32.50	2.49	0.27	6.01	0.39
Alone								

Table 5

Water Samples from the Stream Tank at the Second Falls 25/9/78

	Sample #1	Sample #2
pH	5.0	4.9
Oxygen (ppm)	9.7	9.3
Temperature (°C) of sample	13.0	12.5
% Dissolved Oxygen	91.51%	86.92%
Conductivity (µmµos)	10	10

Water Samples from the Trappers Cabin Creek, 10:30 14/9/78

	Sample #1	Sample #2
pH	5.8	6.1
Oxygen (ppm)	10	10
Temperature (°C) of sample	9	9
% dissolved Oxygen	86.21%	86.21%
Conductivity (µmµos)	40	50

Table 6. Particulars of the Trappers Cabin Creek experiments 1978, Matamek.

Exp. #	Start	Finish	Area	Species	Av. starting Fork Length (cm)	Av. starting Weight (g)	Temperature (°C) Max	Temperature (°C) Min	Length of each Area (M)	Distance to next Area (M)
1	8/7	6/8	1	S*	3.5	0.45	12.7	9.4	4.3	14.0
			2	S	3.7	0.48			3.4	
				T*	3.6	0.50				9.5
			3	S	3.6	0.50			3.7	30.5
			4	T	3.6	0.56			4.0	9.5
			5	S	3.4	0.46			4.0	
				T	3.5	0.50				
2	7/8	6/9	1	S	4.1	0.52	11.2	8.1		
				T	4.3	0.86				
			2	T	4.5	1.06				
			3	S	3.8	0.53				
			4	S	4.0	0.49				
				T	4.3	0.71				
			5	S	3.9	0.43				

* S = salmon

T = trout

Table 7. Stream tank experiments 1978, analysis of behavioral interactions of the salmon and trout.

	Low Density	High Density
Successful interactions against trout by salmon/ total # of successful salmon interactions	46.4%	44.9%
Total # of salmon interactions	328	727
Successful interactions against salmon by trout/ total # of successful trout interactions	60.2%	41.9%
Total # of trout interactions	173	450
Successful interactions against trout by salmon/ total # of successful interactions by both species	30.3%	26.5%
Successful interactions against salmon by trout/ total # of successful interactions by both species	11.8%	15.5%
Total # of interactions by both species	501	1177

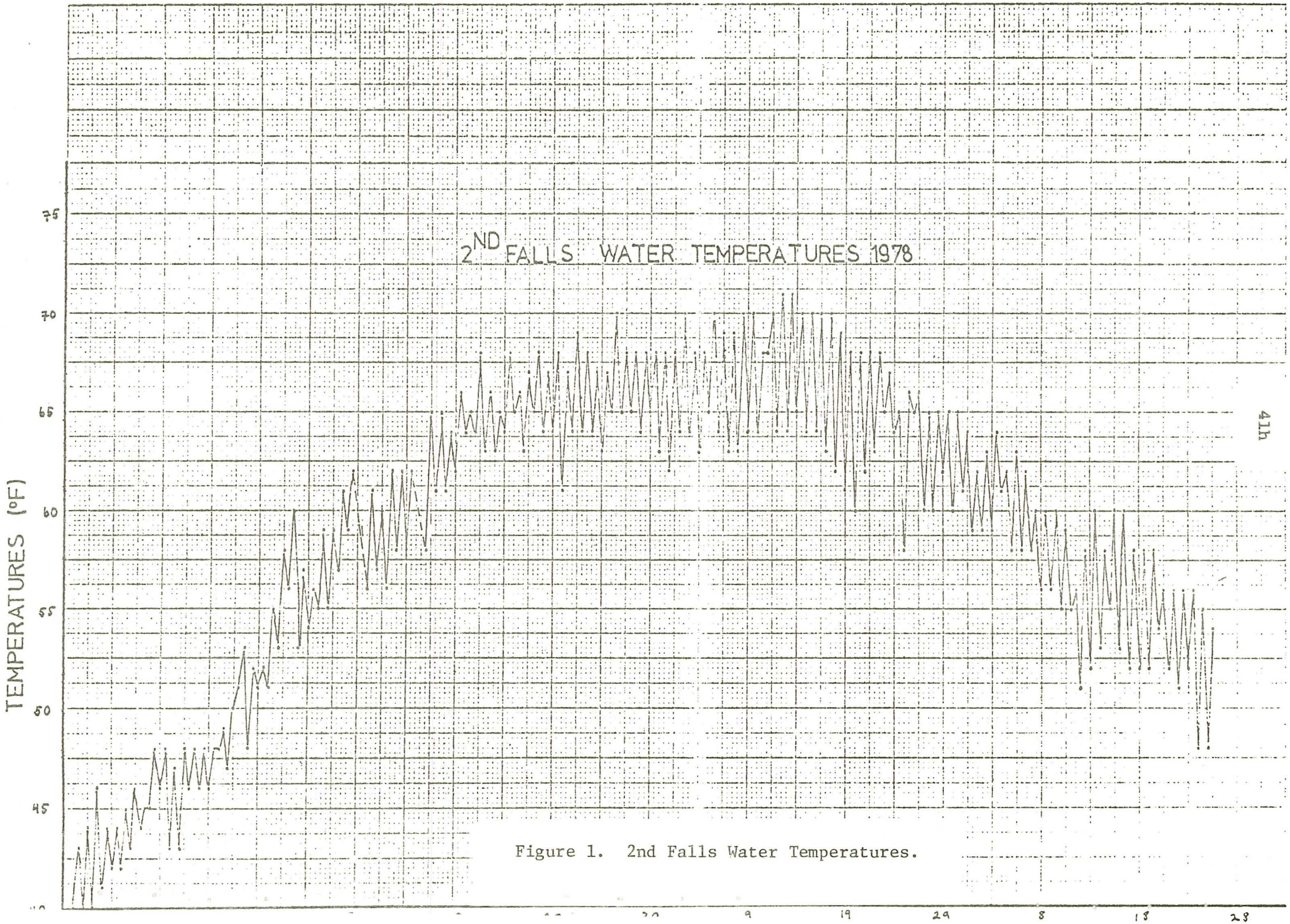


Figure 1. 2nd Falls Water Temperatures.

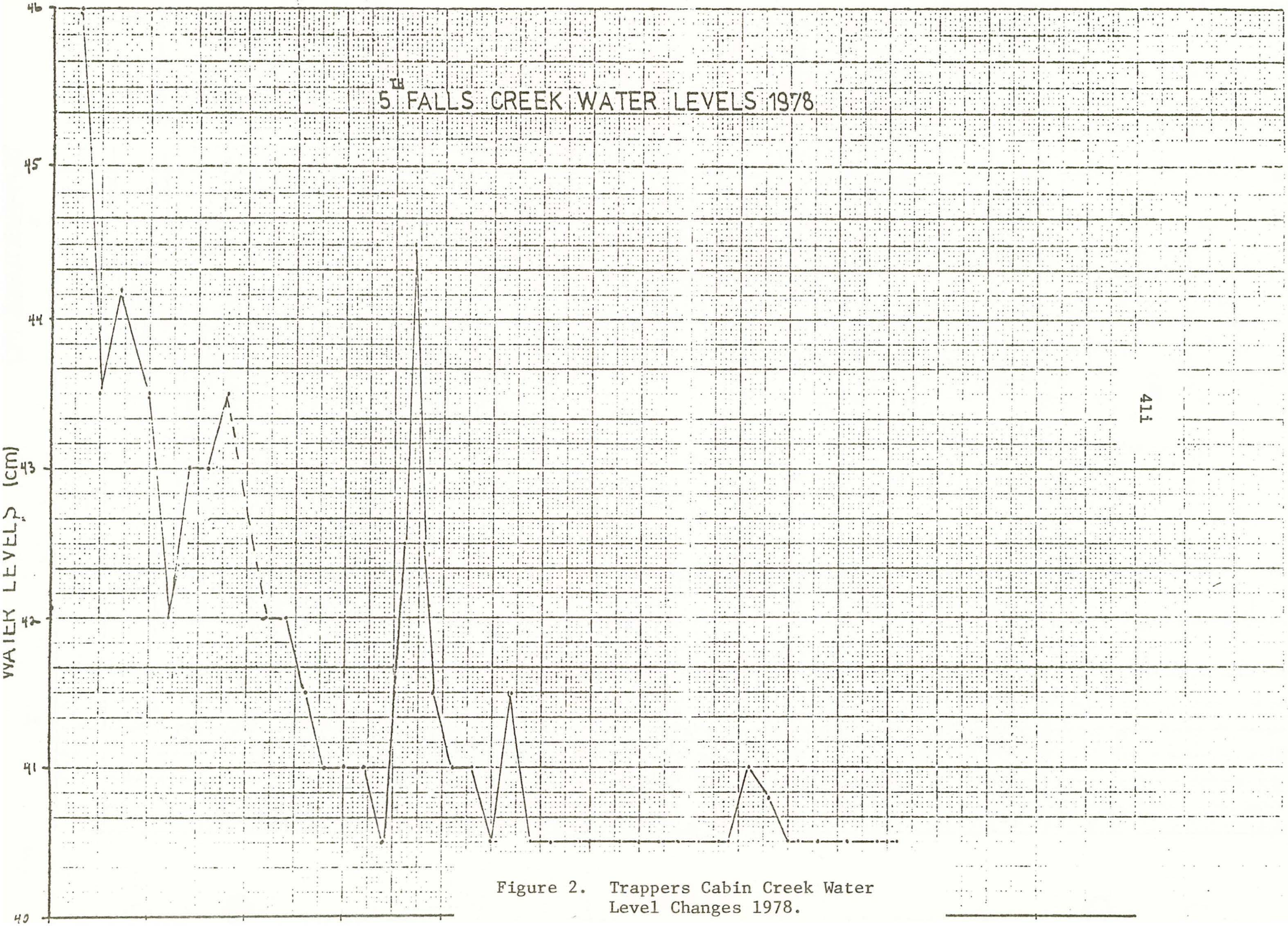


Figure 2. Trappers Cabin Creek Water Level Changes 1978.

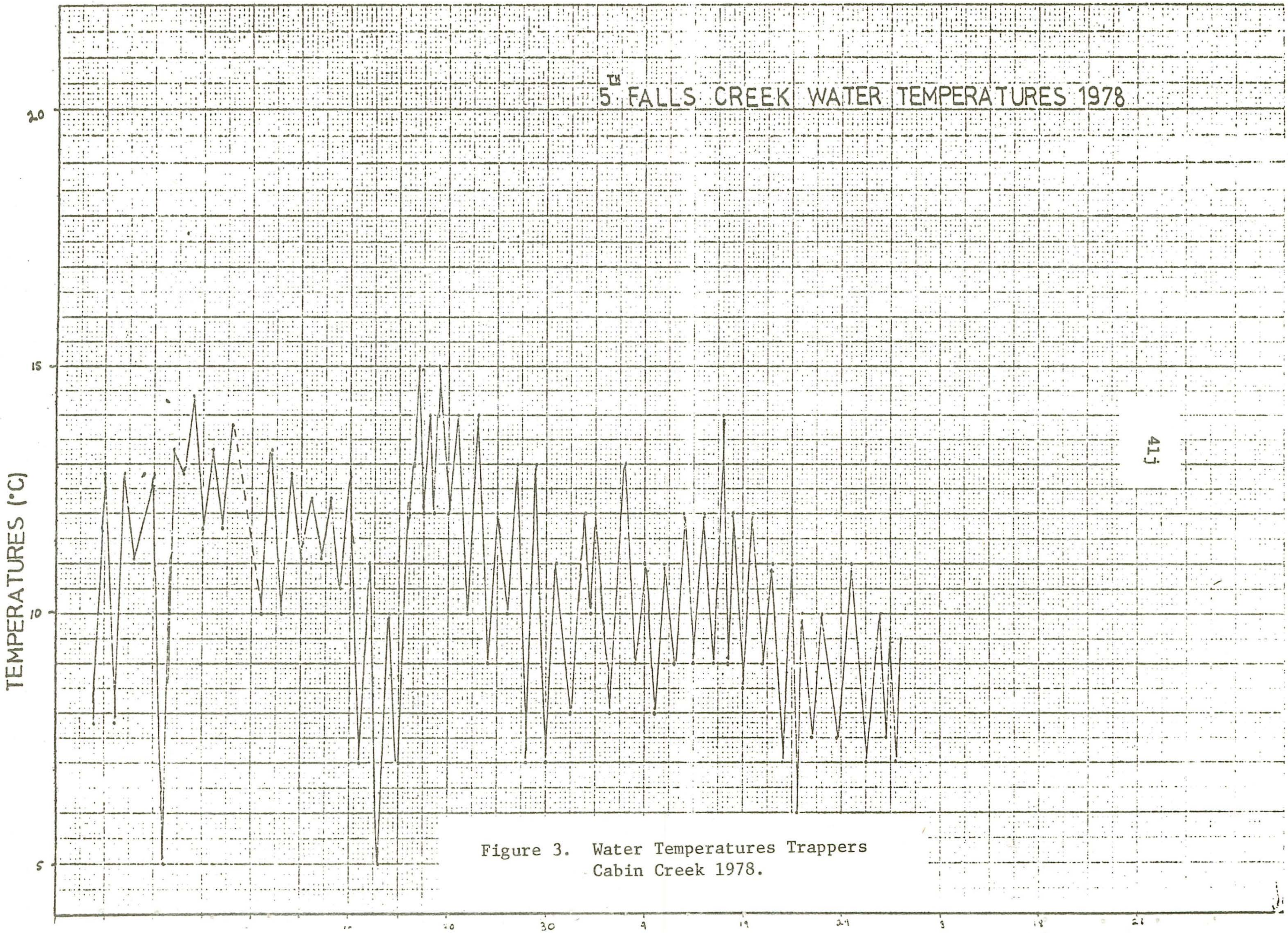


Figure 3. Water Temperatures Trappers Cabin Creek 1978.

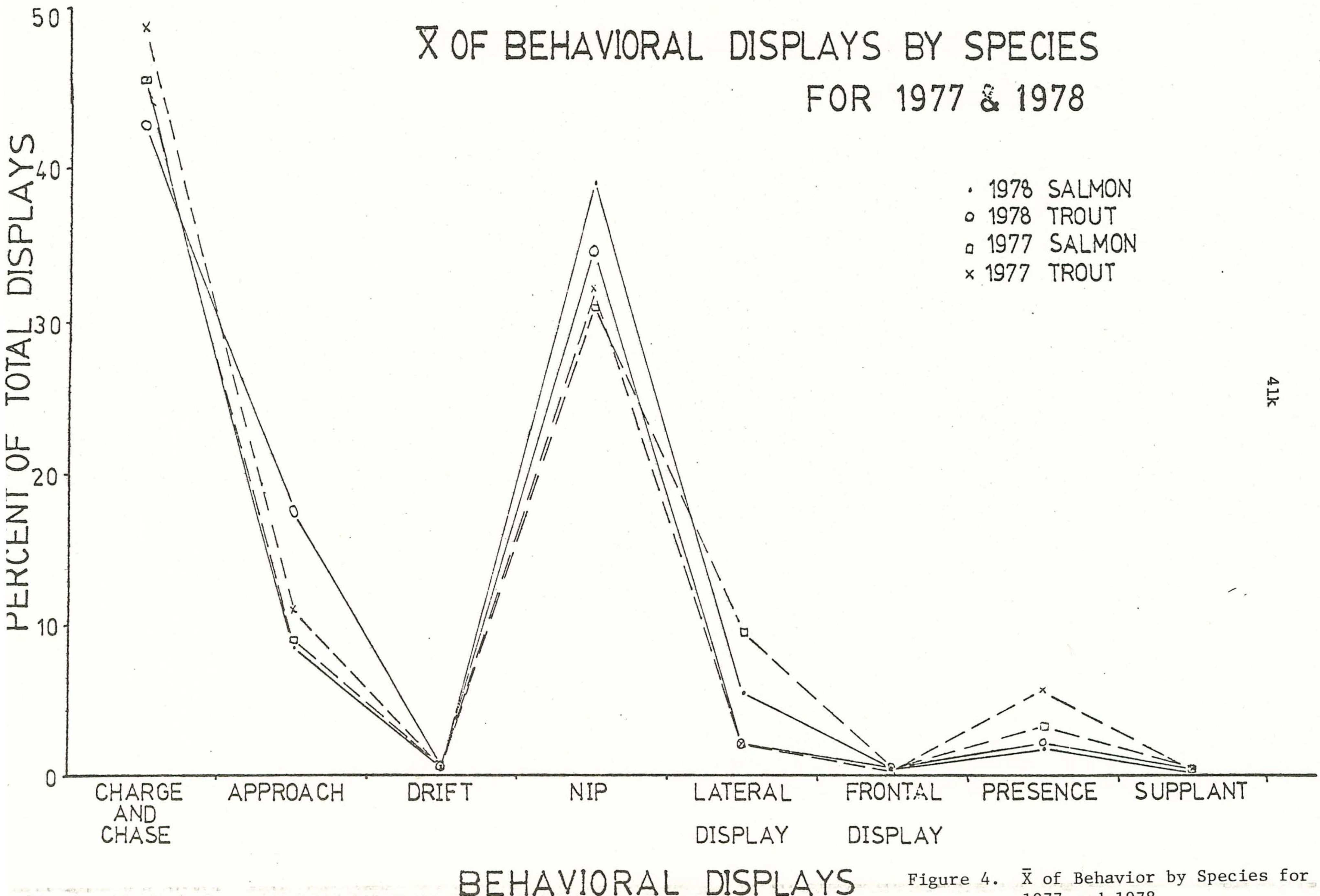


Figure 4. $\bar{X}$ of Behavior by Species for 1977 and 1978.

Taxonomic Variation in the Brook Trout, *Salvelinus fontinalis*, in the Matamek-Moisie Watersheds, Quebec

Hugh R. MacCrimmon
Professor

and

Jacqueline McGlade
Graduate Student

Department of Zoology
University of Guelph
Guelph, Canada N1G 2W1

PREAMBLE

The inadequacy of taxonomic information on the brook trout, *Salvelinus fontinalis*, an indigenous eastern North American species, seriously affects any attempts to assess genotypic and phenotypic variability occurring within its extensive native and naturalized range. Only by means of an intensive analysis of base-line information, using such criteria as morphometric, meristic and protein characteristics, will it be possible to derive ecological, genetic and behavioural profiles. This information is essential to a complete understanding of selection pressures on an organism, and its relationship to other organisms in a particular ecosystem.

INTRODUCTION

The brook trout, Salvelinus fontinalis, was first described in 1814 by Mitchill (1815), on the basis of the abdominal position of the ventral fins and colouration. By 1836, Richardson had placed it with the charrs, (Richardson, 1836). Finally in 1842, DeKay created a distinct subgenus Baione, of which S. fontinalis is the sole representative taxon, (DeKay 1842). Since then, few taxonomic studies have been undertaken beyond those of Vladykov (1954) and Behnke (1965), and specimens examined restricted largely to specimens from New York State, New Brunswick and western Quebec. However, the native range of the species extends from Ungava Bay, Quebec, to Georgia, U.S.A., covering a wide span of environmental conditions (MacCrimmon and Campbell 1969), indicating both phenotypic and genotypic plasticity.

This study demonstrates the phenotypic and genotypic variability within two adjacent watersheds, the Matamek and Moisie systems, which flow into the Gulf of St. Lawrence, (50°19'N, 60°47'W). The brook trout from this area are slow-growing, often attaining lengths of 40 cm, and ages of 7+, (O'Conner and Power 1976). Longevity is greater than that commonly occurring in more southern stocks, (Hunt 1966), and is probably the result not only of latitude and production within the watersheds, but also the lack of exploitation. Three locations, Matamek Lake at the inlet of Matamek River, below the fifth series of waterfalls, and the estuary of the Moisie, provided fish from three different situations; namely lacustrine, fluvial and anadromous. Brook trout from each sampling area were examined using morphometric, meristic and biochemical techniques in order to draw up ecological and genetic profiles.

MATERIALS AND METHODS

Fifty fish were taken from each of the three locations, Matamek Lake, below the 5th falls, and at the estuary of the Moisie, the area of sampling kept to a minimum. Forty-three morphometric measurements were taken on each fish to an accuracy of 0.1 mm, and five tissue samples removed and placed on ice; these included heart, liver, brains, eyes and muscle. The fish were then preserved and returned to Guelph for X-raying and meristic counts (Table 1).

The tissue samples were analysed electrophoretically using the methods of Allendorf (1975), whose initial studies concentrated on another salmonid, *Salmo gairdneri* (Richardson). Sixteen enzyme systems were examined, with a possible total of 27 loci.

STATISTICAL TREATMENT OF RESULTS

The raw data and subsequently reciprocal transformations of the morphometric and meristic analyses were used in three programmes; a multivariate analysis of variance, a principal components analysis and a stepwise discriminate analysis.

The electrophoretic data were used to calculate genotypic frequencies, and electrophoretic variant frequencies using the following equation:

$$p = \frac{2(AA) + (AA') + (AA'')}{2N}$$

where p = electrophoretic variant type A; A" and A' are alternate q and r variants, (Strickberger 1976). Finally, differentiation of samples was calculated using 95% confidence intervals.

RESULTS

Morphometric and Meristic Analysis

The results from all three programmes showed close correlation, those from the discriminate analysis giving the clearest classification. The jackknifed Mahalanobis D^2 (Table II), classified 100% correctly fish from the Moisie River in both sets of characters. Fish from the Matamek Lake show a tendency to be classified with those from the 5th falls on the basis of meristics, and with those from the Moisie River on the basis of morphometrics. However, the percentage correct classifications are high and represent good separation of samples, as shown in the plots of canonicalvariables I and II for both sets of data, (Tables I and II). A significant observation at this point is the presence in 35% of the Moisie River sample of four reduced branchiostegals in the region of the isthmus. A reduced set of 12 characters forms the basis of separation (Table III).

Electrophoretic Analysis

Seven of the 16 enzyme systems examined are polymorphic (Table IV): -glycerophosphate dehydrogenase, isocitrate dehydrogenase, lactate dehydrogenase, malic enzyme, phosphoglucoisomerase and tetrazolium oxidase (SOD). At the 95% confidence intervals the samples show differentiation on the basis of IDH-3, AGP-I, PGI-I, Me-I,2, and ADH.

DISCUSSION

An important problem in any numerical taxonomic study is to know what number of characters is required to obtain a stable classification. Sneat and Sokal (1975) recommend that 60 characters be used whenever possible. The total number of characters in this study is well in excess of this nominal figure, but the question still remains as to how applicable are these results to brook trout identification as a whole.

From the reduced set of characters there appears to be an emphasis on head proportions and fin dimensions, thus indicating some environmental pressures on feeding and swimming performance (Webb 1976). An examination of the relative proportions of head and jaw parts shows that fish from below the 5th falls have smaller mouth parts than fish from the other two locations. This is possibly a direct result of the concentrating effect of the waterfalls on organisms such as insects, found in the stomachs of these fish. Larger mouth parts in fish from the lake would seem to better accommodate the diet of planktonic copepods found in their stomach contents; and which act as intermediary hosts for the many parasites found in these fish (Hanek and Molnar 1974). Finally, larger mouth parts in fish from the Moisie River would seem appropriate for their piscivorous diet.

The fin characteristics of pectoral, dorsal and anal fins, show similarity in the Matamek Lake and River samples. However, each of these fins is larger in the Moisie sample, possible a pre-adaptation for their seaward migration. This difference is also shown in the meristic counts, the Moisie fish having higher values. This finding agrees with those of

Taning (1952), which show higher ray counts in fins of fish exposed to higher salinities.

On the basis of electrophoresis all three samples can be differentiated by the examination of five enzyme systems, all of which are regulatory according to the classification of Johnson (1974); a fact which tends to support the hypothesis that those enzymes which exert acute control over flow-through metabolic pathways should be most individually sensitive as sites of action of selective forces (Johnson 1971).

Finally, to relate the present findings to published details on brook trout taxonomy, a number of meristic values obtained in the study of these Quebec trout exceed the limits given by Scott and Crossman (1973). For example, the range of branchiostegals was 7-14 compared to a previous range of 9-12. With such extensions in ranges, many of the values overlap with other species of charr, and provides reason to question the accuracy of intraspecific meristic identification, as commonly used in definitive and comparative taxonomic descriptions. The study has also identified problems such as body colour, response to environmental inputs which increase as the base-lines for taxonomic studies are expanded.

REFERENCES

Allendorf, F. W. 1975. Genetic variability in a species possessing extensive gene duplication genetic interpretation of duplicate loci and examination of genetic variation in populations of rainbow trout. Ph.D. Thesis, Univ. of Washington.

Benhke, R. J. 1965. A systematic study of the family Salmonidae with special reference to the genus Salmo. Ph.D. Thesis. Univ. of California, Berkeley.

DeKay, J. E. 1842. Zoology of New York, or the New York Fauna: IV. Fishes. Albany, N.Y.

Hanek, G. and K. Molnar. 1974. Parasites of freshwater and anadromous fishes from Matamek River System, Quebec. J. Fish. Res. Board. Can. 31: 1135-39.

Hunt, R. 1966. Production and angler harvest of wild brook trout in Lawrence Creek, Wisconsin. Wisconsin Cons. Dept. Tech. Bull. 35:52.

Johnson, G. B. 1971. Enzyme polymorphisms. Nature (London) 232: 347.

Johnson, G. B. 1974. Enzyme polymorphisms and metabolism. Science 184: 28-37.

MacCrimmon, H. R. and J. S. Campbell. 1969. World distribution of brook trout, Salvelinus fontinalis. J. Fish. Res. Board Can. 26: 1699-1725.

Mitchill, S. L. 1815. The fishes of New York, described and arranged. Trans. Lit. Phil. Soc. New York, I: 355-492.

O'Connor, J. F. and G. Power. 1976. Production by brook trout (Salvelinus fontinalis) in four streams in the Matamek Watershed, Quebec. J. Fish. Res. Board Can. 33: 6-18.

Power, G. et al. 1973. Postglacial colonization of the Matamek River, Quebec, by fishes. J. Fish. Res. Board Can. 30: 1586-1589.

Richardson, J. 1836. Fauna Boreali Americana: III. Fishes. London, 328 pp.

Scott, W. B. and E. J. Crossman. 1973. Freshwater fishes of Canada. Bull. Fish. Res. Board Can. 184.

Sneath, P. H. and R. R. Sokal. 1973. Numerical Taxonomy. Freeman, San Francisco.

Strickberger, M. W. 1968. Genetics. MacMillan Co., New York.

Taning, A. V. 1951. Experimental study of meristic characters in Fishes. Biol. Reviews, 27: 169-193.

Vladykov, V. D. 1954. Taxonomic characters of the Eastern North American Charrs (Salvelinus and Cristivomer). J. Fish. Res. Board Can. II(6): 904-932.

Webb, P. W. 1976. The effect of size on the fast-start performance of Rainbow Trout. J. exp. Biol. 65: 157-177.

Table 1: Morphometric and meristic characters used in the analysis of brook trout from Matamek Lake, Matamek River and Moisie River.

MORPHOMETRIC MEASUREMENTS	MERISTIC COUNTS
TOTAL LENGTH	BRANCHIOSTEGAL LEFT
FORK LENGTH	BRANCHIOSTEGAL RIGHT
STANDARD LENGTH	GILL RAKERS ON FIRST ARCH LEFT
SNOUT TO END OF LATERAL LINE SCALES	GILL RAKERS ON FIRST ARCH RIGHT
OPERCLE TO END OF LATERAL LINE SCALES	VERTEBRAL NUMBER
HEAD LENGTH	PYLORIC CAECAE
PREDORSAL LENGTH	ANAL RAYS
DORSAL INSERTION TO FORK LENGTH	DORSAL RAYS
DORSAL INSERTION TO STANDARD LENGTH	PECTORAL RAYS LEFT
VENTRAL ORIGIN TO ANAL ORIGIN	PECTORAL RAYS RIGHT
ANAL INSERTION TO FORK LENGTH	VENTRAL RAYS LEFT
ANAL INSERTION TO STANDARD LENGTH	VENTRAL RAYS RIGHT
DORSAL INSERTION TO ADIPOSE ORIGIN	MANDIBULAR PORES
LOWER JAW TO VENTRAL INSERTION	SCALES ABOVE LATERAL LINE
MAXIMUM BODY DEPTH	SCALES BELOW LATERAL LINE
PELVIC ORIGIN TO VENTRAL ORIGIN	
EYE DIAMETER	
EYE EDGE TO PREOPERCLE	
INTER ORBITAL WIDTH	
POST ORBITAL LENGTH	
SNOUT LENGTH	
MAXILLA LENGTH	
PREMAXILLA LENGTH	
UPPER JAW LENGTH	
MAXILLA HEIGHT	
LOWER JAW LENGTH	
LOWER JAW TO PECTORAL ORIGIN	
CAUDAL PEDUNCLE HEIGHT	
DORSAL BASE LENGTH	
DORSAL ORIGIN HEIGHT	
DORSAL INSERTION HEIGHT	
ADIPOSE BASE LENGTH	
ADIPOSE HEIGHT	
ANAL ORIGIN HEIGHT	
ANAL INSERTION HEIGHT	
PECTORAL HEIGHT	
VENTRAL HEIGHT	
AXILLARY LENGTH	
AXILLARY HEIGHT	
ANAL BASE LENGTH	
ADIPOSE TO FORK LENGTH	

Table II: Jackknifed classifications for morphometric and meristic characteristics: Matamek Lake, 5th falls-below the 5th falls, Moisie-Estuary of River.

JACKKNIFED CLASSIFICATIONS

MORPHOMETRIC

GROUP	PERCENT CORRECT	MATAMEK	FIFTHFL	MOISIE
MATAMEK	84.0	42	0	8
FIFTHFL	97.8	0	44	1
MOISIE	100.0	0	0	50

MERISTIC

GROUP	PERCENT CORRECT	MATAMEK	FIFTHFL	MOISIE
MATAMEK	80.0	32	6	2
FIFTHFL	87.5	5	35	0
MOISIE	100.0	0	0	40

Table III: Reduced set of morphometric and meristic characters.

MORPHOMETRICS	MERISTICS
ADIPOSE HEIGHT	DORSAL RAYS
ANAL ORIGIN HEIGHT	ANAL RAYS
LOWER JAW - ORIGIN OF PECTORAL	MANDIBULAR PORES
MAXIMUM BODY DEPTH	PYLORIC CAECAE
POST-ORBITAL LENGTH	BRANCHIOSTEGALS
EYE - PREOPERCLE	
DORSAL INSERTION HEIGHT	

TABLE IV: Enzyme systems examined.

(Abbreviated according to Allendorf 1975).

AAT	DIA	ME*	PGM
ADH*	IDH*	PEP	PMI
AGP*	LDH*	PGI*	SDH
CPK	MDH	6PG	SOD*

(* Indicates polymorphic system.)

ACKNOWLEDGEMENTS

Sincere thanks is expressed to the Woods Hole Oceanograhic Institution for making available the facilities of the Matamek Research Station for the collection and preliminary examination of brook trout stocks in the laboratory. The provision of lodging and transportation, and the unstinting cooperation of field staff and researchers made the field research not only possible, but a rewarding experience.

This is an abstract from a report in preparation for submission to the Government of the Province of Quebec.

1. Abstract

Behavioural interactions between coho salmon (*Oncorhynchus kisutch*), Atlantic salmon (*Salmo salar*), brook trout (*Salvelinus fontinalis*) and steelhead trout (*Salmo gairdneri*), at the juvenile fluviatile stages.

R. John Gibson

Behavioural interactions were studied, in a stream tank, between coho salmon (*Oncorhynchus kisutch*), brook trout (*Salvelinus fontinalis*) and Atlantic salmon (*Salmo salar*) and between steelhead trout (*Salmo gairdneri*), Atlantic salmon and brook trout. Dominance was based to a large extent on size. However, steelhead trout were the most aggressive of the four species. Atlantic salmon parr were more aggressive than coho or brook trout. Morphological and behavioural characteristics probably favour Atlantic salmon parr over the other three species in the fast water habitats. Severe competition might be expected between Atlantic salmon parr and juvenile steelhed trout, both riffle dwellers, and between coho and small brook trout, both found in the pool environment. Introductions of these Pacific salmonids should be discouraged until adequate field studies have been undertaken.

Zooplankton of the Matamek River, Quebec

John C. H. Carter

Department of Biology

University of Waterloo

The object of this project is to determine, on both numerical and biomass bases, zooplankton of various groups passing down the lower Matamek River and originating in Lake Matamek or other sources.

Samples were collected in 1977 with drift monitors fashioned on the reverse funnel plan (Stocker 1972) and similar to those used previously in Gibson's (1975) study. Each comprised an aluminum hopper with an opening at the upstream end 2.5 cm wide and 20 cm high. The downstream opening, 20 cm x 20 cm, was fitted with a nylon plankton net 1.7 m long and with No. 25 mesh (apertures 64 μ). A plexiglass collecting bucket was attached to the tapered end of the net. Since some clogging of the fine mesh was suspected in the early stages of the project the opening at the upstream end of each hopper was reduced from 20 cm in height to 7 cm by taping off both the top and bottom. Subsequently no clogging of the nets was observed.

A single drift monitor was set at a station beneath each falls and the outflow rapids (Fig. 1) and the plankton sample was collected normally every 48 hours. Each monitor was moved as little as possible although changes in water levels made some adjustments necessary. The nets were removed and washed frequently and on the rare occasions when a net was torn it was changed and the sample discarded. Due to logistic difficulties and excessive velocity of the current in early June the sampling periods differed between stations: Station 1 from June 22 to October 1, Station 2 from June 2 to October 1, Station 3 from June 4 to October 7, Station 4 from June 2 to October 1, Station 5 from June 12 to October 1, Station R from June 24 to August 17.

Current velocities were recorded at the beginning and completion of each 48 hr sampling run at each station with an Ott C-2 current meter. The mean of the two values was used in calculating the volume of water filtered.

In addition to the river collections a station was established within the lake approximately 40 m from the outflow at a depth of 16 m. Single vertical hauls with a conical net of No. 25 mesh and mouth diameter of 0.5 m were taken from bottom to surface, 4 m to surface and 2 m to surface on eight occasions between June 24 and August 27.

Samples were preserved in 10% formalin. In the laboratory aliquots of 25 ml were extracted from the well-mixed samples which were often diluted several times because of accumulated sediment. Under a dissecting microscope at least 200 crustaceans and 200 rotifers were counted from each sample or the whole sample was analyzed when these numbers were not present.

Of the total copepods collected 71% were Diaptomus minutus, 26% Cyclops scutifer and the remaining 3% Diaptomus oregonensis, Epischura lacustris, Tropocyclops prasinus mexicanus and Mesocyclops edax. Bosmina longirostris comprised 97% of cladocerans with occasional Daphnia longiremis and some chydorids making up the remainder. Of the rotifers Keratella Cochlearis and K. taurocephala made up about 40% each with the rest consisting of Kellicotia longispina, Brachionus spp. and Asplanchna spp.

Crustacean plankton was most abundant in June at all stations except Station 1 where sampling started late (Fig. 2). In the copepod copepodites and Cladocera this spring pulse was more prolonged at the upstream stations, extending into July. In the copepod nauplii numbers dropped off at all stations after mid June, probably as a result of rapid development of copepodite stages in Lake Matamek. From early July through October 1 numbers were generally low in all three crustacean groups although brief pulses occurred at the upstream stations which were probably related to the periodic increases in discharge after mid July.

One might expect to find a pattern of steadily declining abundance progressing downstream from the rapids station but this is only partially apparent from Fig. 2. In the copepodites the highest June peaks occurred at the rapids with either lower or fewer peaks proceeding downstream. In the nauplii and the Cladocera there is no obvious trend although at Station 2, with the exception of a single peak on June 14, the numbers of Cladocera were much lower in June than at the four stations upstream. However, when numbers are averaged over the entire season an overall pattern emerges (Fig. 3). Copepodites decline from a high of $47/m^3$ at the rapids to about 0.2 at Station 1. Nauplii rise slightly between the rapids and Station 4 before declining steadily through Station 1. Cladocera are highest at Station 5 and then decline consistently through Station 1. Lower than expected numbers at the rapids can be explained by the absence of samples before late June. While the same argument should apply for Station 1 it is highly unlikely that crustacean plankton would have been very abundant even in June at this most distant station from Lake Matamek. The rotifers show a pattern different to all crustacean groups with highest numbers at Stations R, 4 and 1 and lowest at 5 and 2. Undoubtedly rotifers are fed into the main flow from a number of sources, most particularly from numerous backwaters between Stations 5 and 4 and from the Muskrat River.

Presently biomass values are being worked out and analysis of zooplankton samples from Lake Matamek is proceeding to determine vertical distribution in the lake and its possible influence on the facility with which zooplankters are caught in the outflow.

REFERENCES

Gibson, R. J. and D. Galbraith. 1975. The relationship between invertebrate drift and salmonid populations in the Matamek River, Quebec, below a lake. Trans. Am. Fish. Soc. 104: 529-535.

Stocker, Z. S. J. 1972. The ecology of the streams at Char Lake, Resolute Bay, N. W. Territories. M.Sc. Thesis. Univ. of Waterloo, Waterloo, Ontario 122 pp.

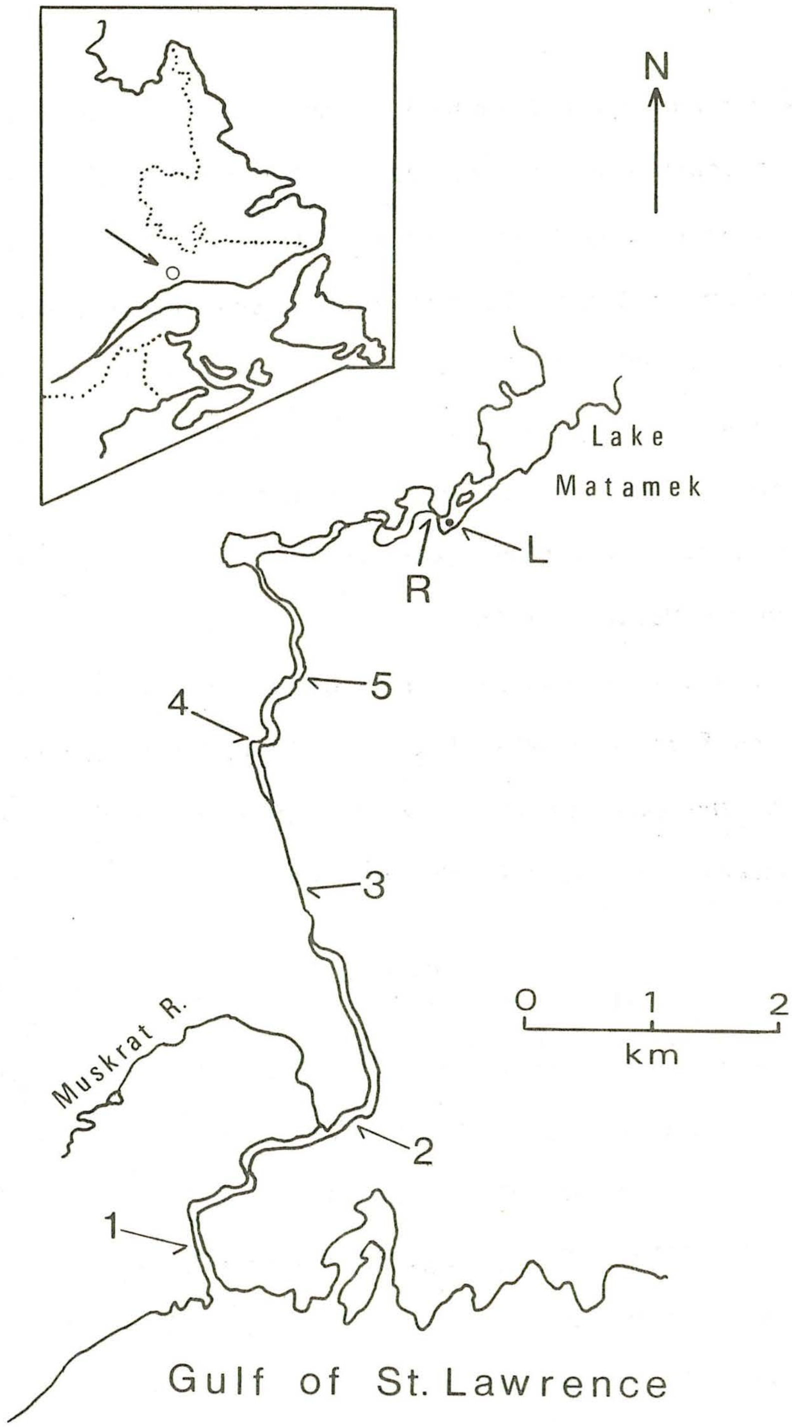


Figure 1. Map of lower Matamek River showing sampling stations. Stations 1-5 and R were directly below the first to fifth falls and outflow rapids respectively.

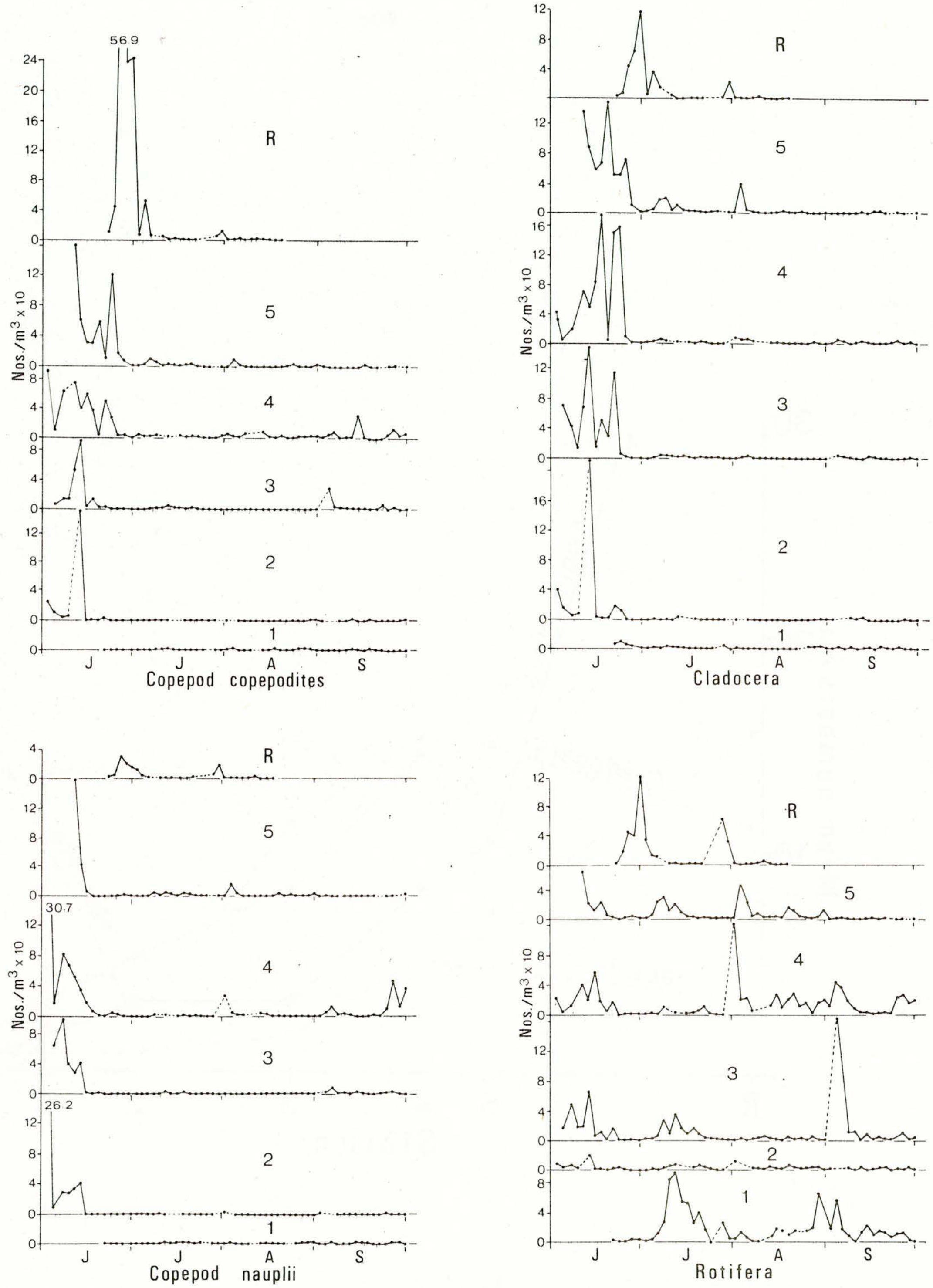


Figure 2. Numbers of the four major zooplankton groups collected at Stations 1-5 (first to fifth falls) and R (outflow rapids) during 1977.

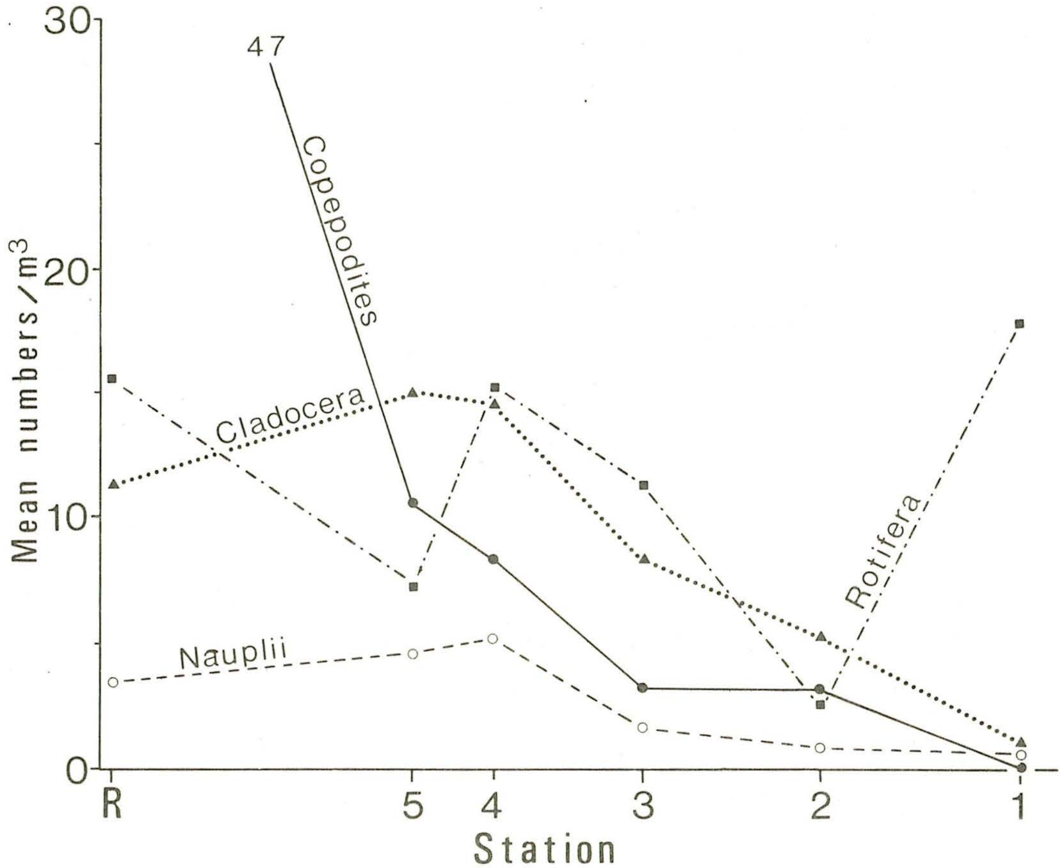


Figure 3. Mean numbers/m^3 of the four major zooplankton groups collected at each station from June 12, 1977.

EXPERIMENTS IN PHYTOPLANKTON-ZOOPLANKTON DYNAMICS AT LAC MATAMEC IN 1978

P. E. Ross and H. C. Duthie
University of Waterloo, Ontario, Canada

After winter sampling visits in February and in early April, the summer season began on 26 May, two days after the main break-up, although some bays were still inaccessible at that time. In both Upper Baie Philippe (UBP) and Lower Baie Philippe (LBP), primary production experiments were performed weekly, at which times samples for phytoplankton enumeration and for the analysis of chlorophyll, carbon, phosphorus and nitrogen were also collected. Zooplankton grazing experiments were also done regularly in both basins.

In mid-July, LBP was segregated from the body of the lake by a polypropylene curtain and fertilization began. 138 kg of phosphorus, as monoammonium phosphate, or about six times the calculated annual load (Martin, 1978) were added over the remaining seven weeks. The weekly experiments in both LBP and UBP (now a control station) were continued with a view towards evaluating the effects of fertilization in LBP. A comparison of the chlorophyll concentrations in the two basins in 1977 and 1978 (Fig. I) suggests that a sizeable increase in productivity was obtained after fertilization in LBP in 1978.

The production, phytoplankton enumeration, and grazing studies are now being analyzed. Benthic samples from LBP and UBP before and after the fertilization of LBP were collected and preserved for future analysis.

In the East Basin a full-day sequence (four experiments) of production runs was done three times as part of a continuing evaluation of an empirically derived model (Ross and Kalff, 1975) for the estimation of daily productivity from one four-hour experiment.

The upland lakes Gallienne and Randin were visited each fortnight for the collection of phytoplankton and chlorophyll samples.

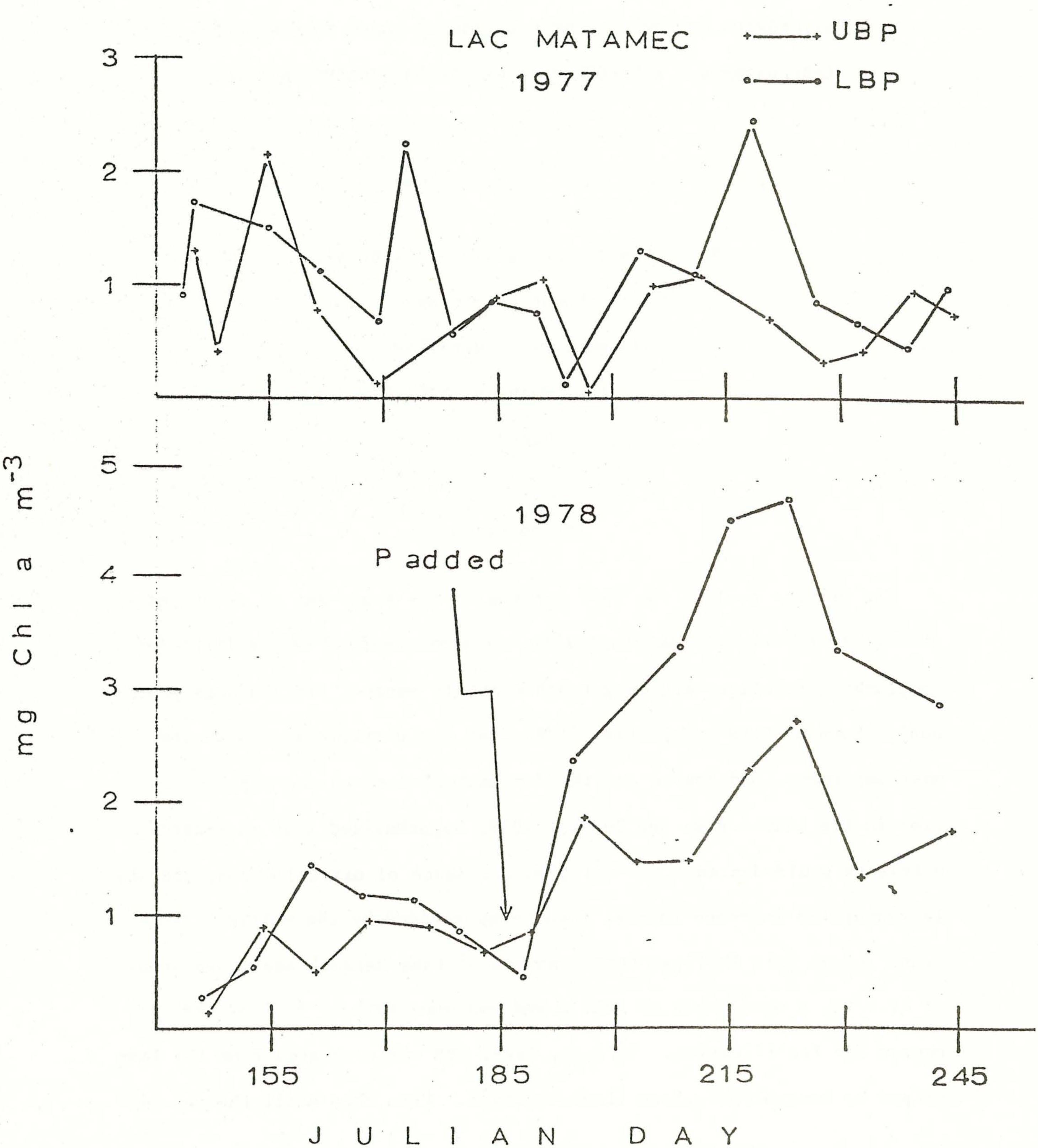
The field season ended on 5 September. Two visits are planned for the winter 1978-1979, when primary production, carbon and phosphorus will be measured in LBP and in UBP.

REFERENCES

Martin, D. K. 1978. A Phosphorus Budget for Baie Philippe, Lake Matamek, Quebec. Undergraduate honors thesis, University of Waterloo. 22 p.

Ross, P. E., and J. Kalff. 1975. Phytoplankton production in Lake Memphremagog, Quebec (Canada) - Vermont (U.S.A.). Verh. internat. Verein. Limnol. 19(2): 760-769.

FIGURE I


LAC MATAMEC
1977
UBP
LBP
3
2
1
5
4
3
2
1
mg Chl a m-3
1978
P added
155
185
215
245
J U L I A N D A Y

CHANGES IN PHYTOPLANKTON AND PHYTOPLANKTON-ZOOPLANKTON RELATIONSHIPS FOLLOWING FERTILIZATION OF LOWER BAIE PHILIPPE, LAKE MATAMEK. A PRELIMINARY REPORT ON STUDIES IN 1978.

by

P. E. Ross, P. Chow and H. C. Duthie
Department of Biology
University of Waterloo
Waterloo, Ontario N2L 3G1
Canada

Introduction

The primary goal of the 1978 portion of the study was to determine the result of moderate nutrient addition upon the food availability for zooplankton in oligotrophic-dystrophic shield waters. It had been previously shown by Ross and Duthie (1978) that the ultraplankton were the most important food source for the dominant cladoceran and copepod species in the lake. Ross and Duthie (1978) hypothesized that increased nutrients would decrease the relative abundance of ultraplankton, thereby lessening the increase in real food value yielded by the nutrient addition. Lower Baie Philippe (LPB), an arm of Lake Matamek having an area of 41.2 ha, a mean depth of 24.6 m and maximum depth of 63.1 m, was chosen for fertilization. In July, 1978, LBP was separated from the lake proper by two polypropylene limno-curtains. From then until the end of

August, LBP received equal weekly amounts of mono-ammonium phosphate (Nutrite, Genstar & Chemical, Ltd.) (Table I) dissolved in lake water and dispensed at a constant flow rate from a boat while cruising randomly around the bay. The total mass added was 500 kg, which meant that LBP received 61 kg of nitrate-nitrogen (0.15 g m^{-2}) and 135 kg of phosphorus (0.33 g m^{-2}). This P loading was chosen to closely approximate the "dangerous loading" level (0.31 g m^{-2}) which we interpolated from Table 4.6 in Vollenweider (1971). In the context of this fertilization, both LBP and Upper Baie Philippe (UBP) were sampled intensively each week to examine the effects on LBP and to monitor UBP as a control. The East Basin (EB) was visited once a month as a secondary control. The principal experiments performed, and results were available at this time, are summarized below.

Physical and Chemical Studies

After fertilization of LBP began, both light transmissivity and Secchi disc depth decreased in LBP relative to both LBP in 1977 and to UBP in 1977 and 1978. Phosphorus concentrations (total P) in LBP were much higher than in UBP (Fig. 1). N:P ratios did not differ significantly between the two basins, ranging from 33.0 at turnover to a mid-August low of 0.9 in LBP and from 26.2 to 0.8 on the same dates in UBP. Dissolved inorganic carbon (DIC) concentrations are extremely low in the Matamek region, ranging from 0.3 to 1.5 mg l^{-1} over the last three years. In 1978, DIC concentrations increased in late summer in both basins but no significant difference between basins was observed.

Table I. Regime of nutrient additions to Lower Baie Philippe, Lake Matamek, Quebec in 1978

DATE	JULIAN DAY	ADDITIONS AS Kg OF:		
		$NH_4H_2PO_4$	P	N
18/07	199	75	20.25	9.15
25/07	206	75	20.25	9.15
01/08	213	75	20.25	9.15
08/08	220	75	20.25	9.15
15/08	227	75	20.25	9.15
22/08	234	75	20.25	9.15
29/08	241	50	13.50	6.10
TOTAL		500	135.00	61.00

The pH changed very little, falling within the narrow range of 5.5 to 5.8 at all times in both basins. Thus, there is no evidence that LBP was any more carbon-limited than UBP. In response to the increased P concentration, the concentration of chlorophyll *a* also rose sharply in LBP (Fig. 2).

Phytoplankton

As shown in Fig. 3, total phytoplankton biomass increased dramatically in LBP after nutrient additions. Since the biomass data points are single values, confidence limits cannot be applied, but a Mann-Whitney analysis yielded a probability of less than 0.01 that the differences between the two basins could be a random occurrence. The largest gains were among the genera *Cryptomonas* and *Katablepharis* of the Cryptophyceae, *Rhizosolenia* and *Asterionella* of the Bacillariophyceae, and *Dinobryon* and *Mallomonas* of the Chrysophyceae, with the largest increase for any one species being that of *Rhizosolenia eriensis*.

For the analysis of size structure, we have divided the phytoplankton into three size classes: the ultraplankton, cells whose maximum dimension (XSIZE) is less than 15 m; the nannoplankton, where 15 μm < XSIZE 64 < m; and the net plankton, where XSIZE > 64 μm. In 1977, the relative proportions of each group in the total biomass varied dramatically over the season (Fig. 4) but no consistent difference between UBP and LBP was observed. In 1978 after fertilization began, the ultraplankton contributed less to the total biomass in LBP than in UBP on all but one sampling date (Fig. 5) and the nannoplankton made up a larger fraction of the total biomass in LBP than in UBP on all sampling dates, but these differences are not significant in any valid statistical tests. The net plankton were nearly always a minor constituent of the total biomass.

Primary production experiments were performed in LBP and UBP, but the data are not completely analyzed yet.

Phytoplankton-Zooplankton Relationships

In situ grazing experiments were performed in LBP and UBP with the phytoplankton food source labelled with three different isotopes according to size class, and the data, when analyzed, will examine possible shifts in the size classes of food selected by the zooplankton that may have been caused by the phytoplankton community after fertilization.

DISCUSSION

It is clear from both Fig. 2 and Fig. 3 that fertilization enhanced the standing crop of phytoplankton in LBP. The evidence from Fig. 1 suggests that the nannoplankton may have contributed the most of this increase and the ultraplankton relatively less. It follows that if this were the case, it would mean that although the food source to zooplankton was augmented by the increase in ultraplankton, it was not enhanced as much as the change in total biomass would suggest. This differential yield would support the hypothesis of Duthie and Ross (1978) and should be an important factor in calculations for future fertilization projects in shield waters. If increased zooplankton production is desired, then the project design should be based on predicted increases in ultraplankton biomass, rather than total phytoplankton biomass.

In 1979, we hope that, by taking all phytoplankton samples and enumerations in triplicate, by sampling more often and by doing bi-monthly depth profiles, we can obtain more definitive and quantitative measurements of the impact of fertilization upon the size structure of the phytoplankton community and thus upon the food availability to zooplankton.

LITERATURE CITED

Ross, P. E., and H. C. Duthie. 1978. Lake Matamek Primary Production and Phytoplankton-Zooplankton Dynamics. Woods Hole Oceanographic Institution. WHOI-78-92: 68-78.

List of Figures and Their Legends

Fig. 1) Total phosphorus concentrations, as mg m^{-3} from May to September, 1978, in Lower Baie Philippe (naughts) and in Upper Baie Philippe (crosses) of Lake Matamek.

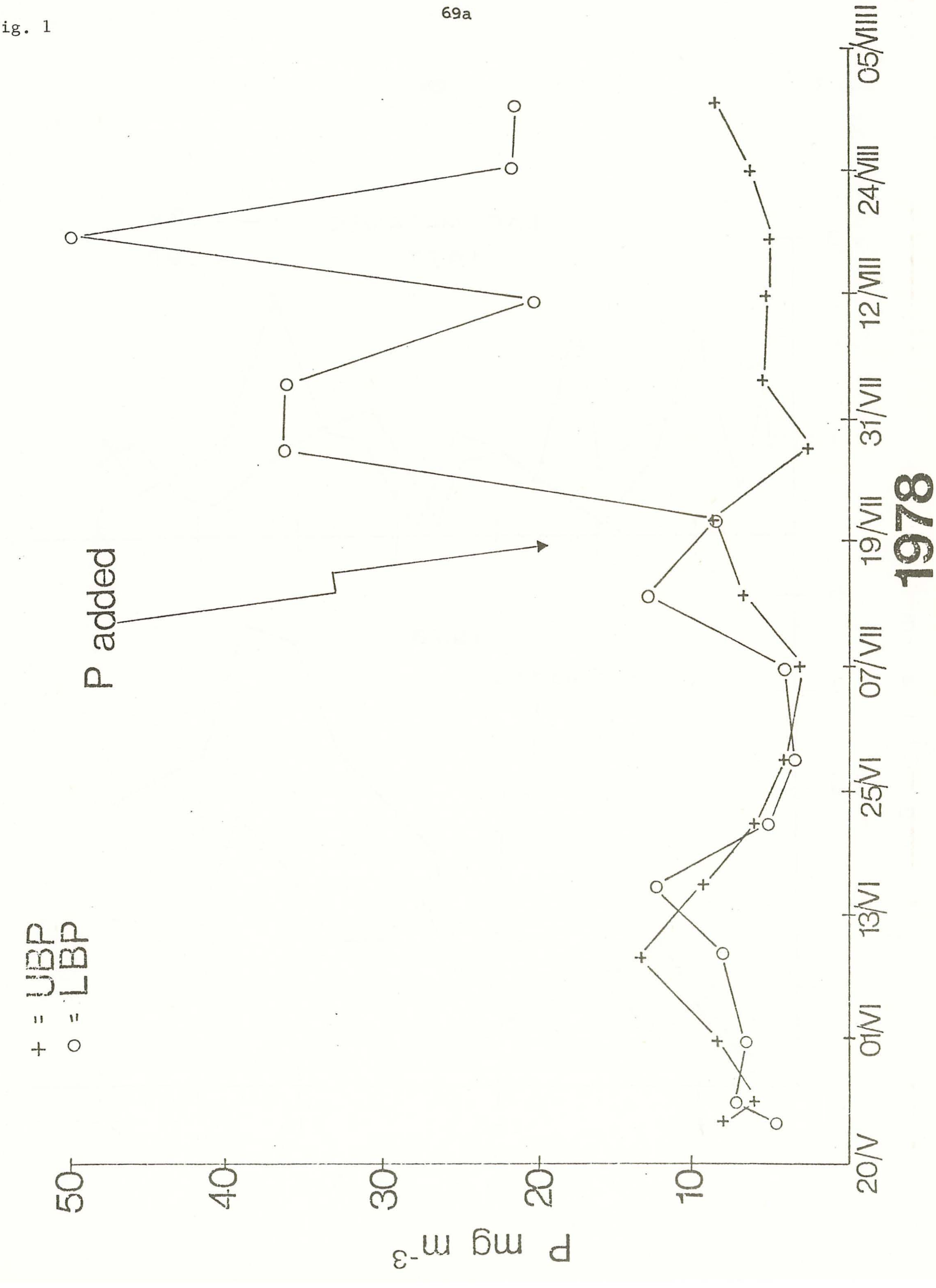
Fig. 2) Chlorophyll a concentrations, as mg m^{-3}, from May to September of 1977 and 1978 in Lower Baie Philippe (naughts) and in Upper Baie Philippe (crosses) of Lake Matamek, Quebec.

Fig. 3) Total phytoplankton biomass, as mg m^{-3}, from May to September of 1977 and 1978 in Lower Baie Philippe (naughts) and in Upper Baie Philippe (crosses) of Lake Matamek, Quebec.

Fig. 4) The proportion, as %, of the total phytoplankton biomass, contributed by each of three size classes of phytoplankton from May to September 1977, in Lower Baie Philippe (naughts) and in Upper Baie Philippe (crosses) of Lake Matamek, Quebec.

Fig. 5) The proportion, as %, of the total phytoplankton biomass contributed by each of three size classes of the phytoplankton from May to September, 1978, in Lower Baie Philippe (naughts) and in Upper Baie Philippe (crosses) of Lake Matamek, Quebec.

Fig. 1



+ = UBP
o = LBP
P added
1978
P mg m-3
50
40
30
20
10
20/V
01/VI
13/VI
25/VI
07/VII
19/VII
31/VII
12/VIII
24/VIII
05/VIIII

Fig. 2

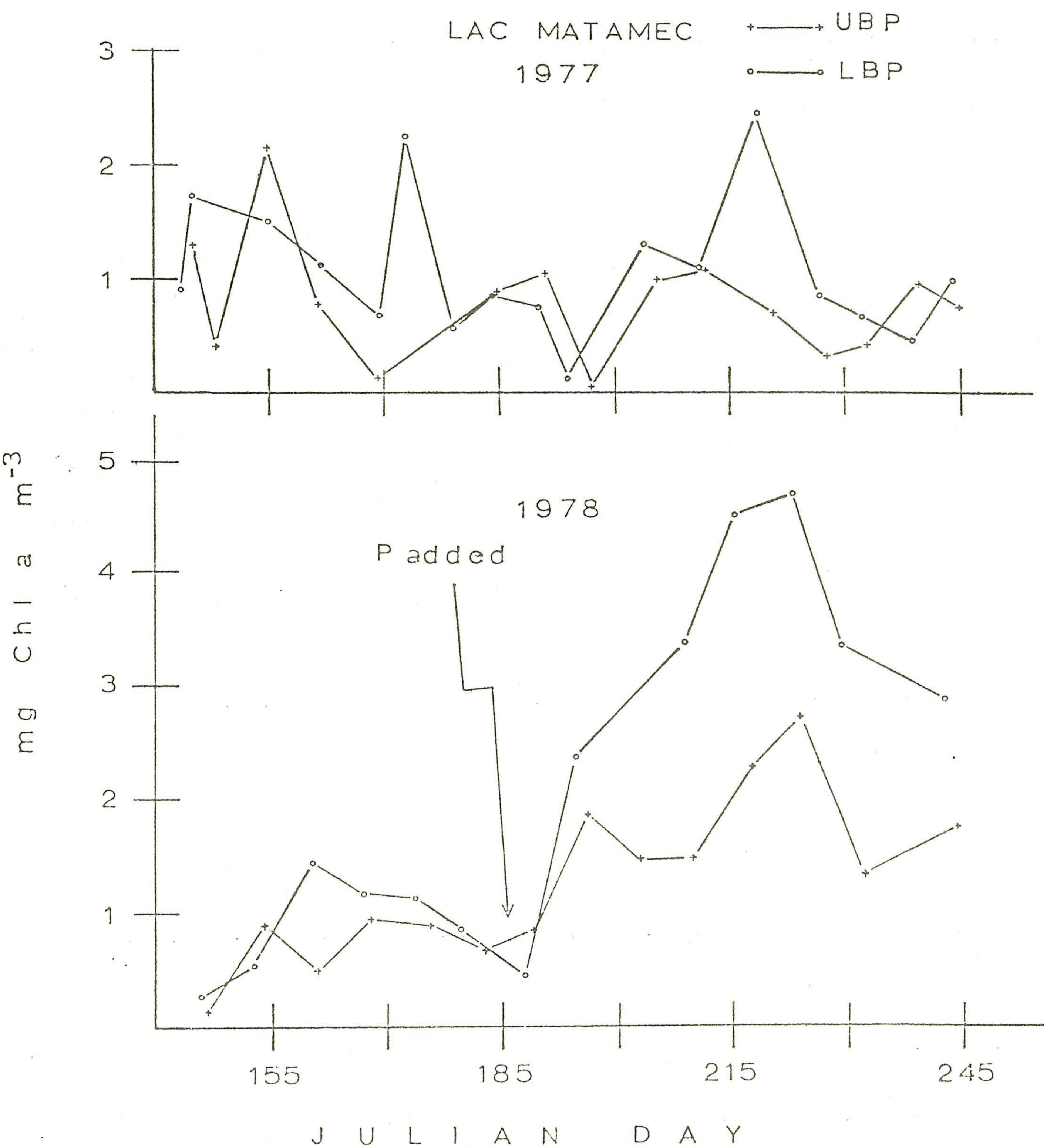

LAC MATAMEC
1977
UBP
LBP
3
2
1
1978
P added
5
4
3
2
1
mg Chl a m-3
155
185
215
245
JULIAN DAY

Fig. 3

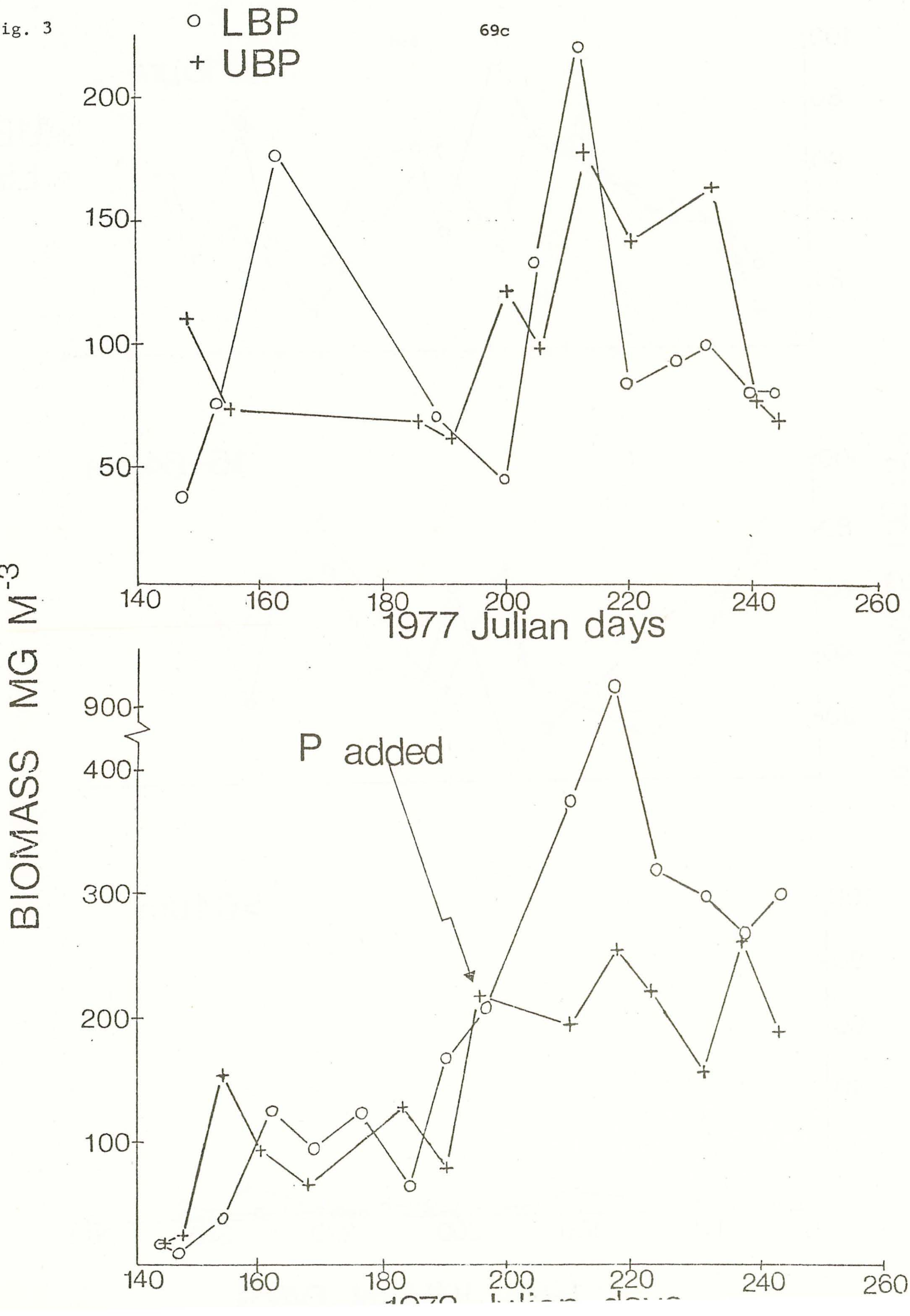
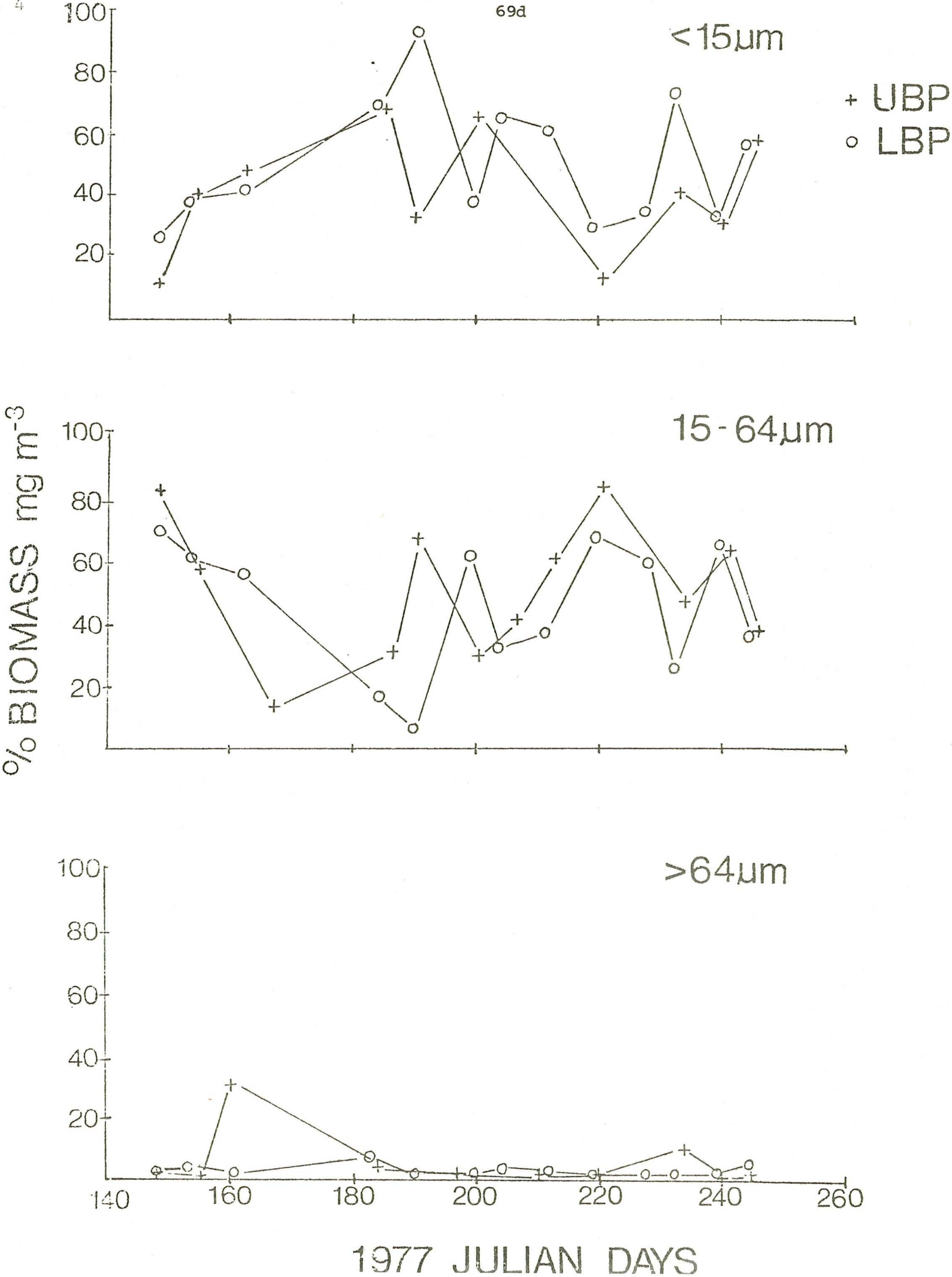

○ LBP
+ UBP
200
150
100
50
140
160
180
200
220
240
260
1977 Julian days
BIOMASS MG M-3
900
400
300
200
100
P added
140
160
180
200
220
240
260

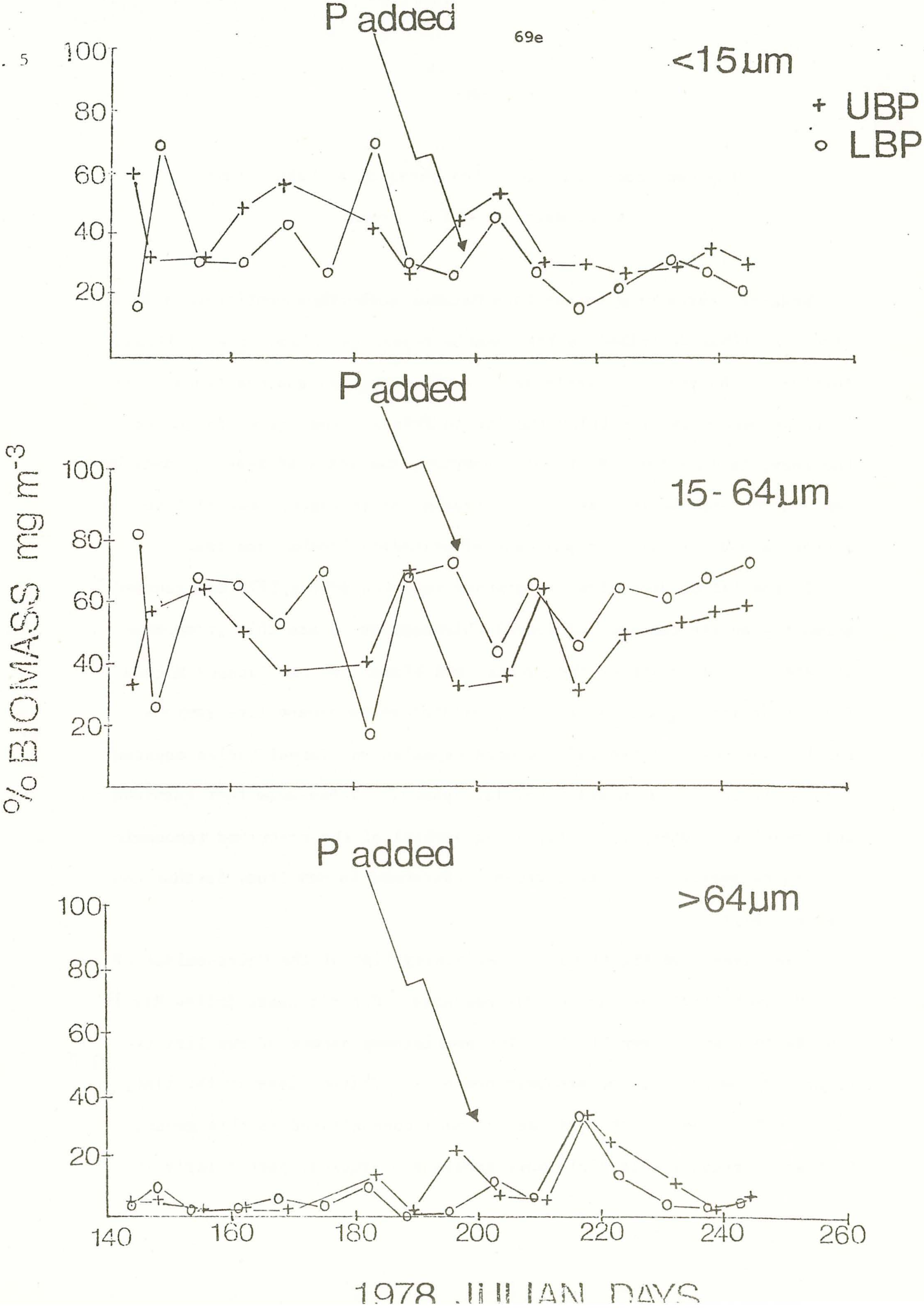
Fig. 4



% BIOMASS mg m-3
<15µm
+ UBP
o LBP
15-64µm
>64µm
100
80
60
40
20
140
160
180
200
220
240
260
1977 JULIAN DAYS

69e

Fig. 5


P added
<15µm
+ UBP
o LBP
P added
15-64µm
P added
>64µm
% BIOMASS mg m^-3
100
80
60
40
20
140
160
180
200
220
240
260
1978 JULIAN DAYS

Progress report on Zoobenthos research at Lake Matamek

A. D. Harrison and G. Kreamer

Research pertaining to the Lake Matamek zoobenthos continued in 1978, along the lines described in last year's report (Harrison _et al._, 1978). Sorting of the previous year's samples was completed and additional collections were made from below the ice in February and again, following the thaw, in late May. With these samples, two years of seasonal data on the Lake Matamek benthos are now available for assessing general life histories and distribution patterns of principal benthic species.

In the latter direction, laboratory research during 1978 was focused primarily on the taxonomy of larval Chironomidae, since this group constitutes a large share of the numbers and biomass of the Matamek bottom fauna (Harrison _et al._, 1978). Representative specimens from various samples were decapitated and the head capsules and larval bodies mounted separately on slides in polyvinyl lactophenol. These were then examined and identified, where possible, using several of the scattered taxonomic references available for this group (referenced in Hamilton, Saether and Oliver, 1969).

From these investigations, a preliminary list of the Chironomidae of Lake Matamek (included herein) was produced. Generic names follow Hamilton, Saether and Oliver (1969). The preliminary nature of the list is suggested somewhat by the predominance of the Chironominae in the list, since much of the effort thus far has been concentrated in this group. Further progress should yield more genera and species, particularly in the Orthocladiinae and Tannypodinae.

On the basis of the material thus far examined, an estimate of around 50 Chironomid species for Lake Matamek seems realistic. Although such diversity is not especially high for north-temperate oligotrophic lakes (Oliver, 1976), it does exceed our initial expectations, and is indicative of the success of the Chironomidae in habitating the acid, humic lake environment, where certain other benthic groups (e.g., higher crustaceans and molluscs) are generally poorly represented (Wiederholm, and Eriksson, 1977).

However, it is important to note that many of the chironomid genera found in the Lake Matamek samples were limited to the littoral and sublittoral habitats, and some may have enetered the lake via lotic environments (i.e., the Matamek River inlet). On the other hand, the typologically-more-important profundal fauna is relatively simple, being characterized primarily by the Chironomini genera - Chironomus (salinarius group) and Phaenopsectra (Sergentia). This is not unlike the situation described for the humic, oligotrophic lakes of Northern Europe (Brinkhurst, 1974).

Still other chironomid groups were also represented in the Lake Matamek profundal benthos, but these were most common in the upper (10-50 m) portions, including: Procladius (Tanypodinae), Protanypus (Diamesinae), Heterotrissocladius (Orthocladiinae) and Micropsectra (Tanytarsini). In the littoral and sublittoral, Heterotanytarsus, Trissocladius, Procladius, Cladotanytarsus and Polypedilum were typically abundant.

Ecologically, several of the above groups have been described as typical cold-stenothermic (C. salinarius-gr) and oligotrophic (e.g., Heterotanytarsus, Heterotrissocladius and Protanypus) inhabitants of Nearctic lakes (Saether, 1970 and 1975). Therefore it is not surprising that these same groups are common under the nearly subarctic, ultraoligotrophic conditions that characterize Lake Matamek.

Similarly, in view of Saether's typological scheme (1975), the high humic content of Lake Matamek should also be manifested in the specific Chironomidae associations therein. In this regard, the necessary species identifications are currently in progress and should be completed soon, at least for the taxonomically well-documented larval groups (e.g., Heterotrissocladius and Protanypus). Correlations of immatures with reared adults and those collected from light and emergence traps during previous summers should also clarify some identification problems, and furthermore, allow assessment of life cycles of the predominate chironomid species. Such information, along with numerous other, but less emphasized, aspects of the taxonomy and ecology of other Lake Matamek zoobenthic components will be elaborated on in the associate investigator's Masters Thesis, which is to be completed during 1979.

Literature Cited

Brinkhurst, R. O. 1974. The benthos of lakes. The Macmillan Press LTD: London. 190 pp.

Hamilton, A. L., O. A. Saether and D. R. Oliver. 1969. A classification of the Nearctic Chironomidae. Fish. Res. Bd. Can. Tech. Rpt. No. 124: 1-12.

Harrison, A. D. et al. 1978. Progress report on zoobenthic studies of Lake Matamek. In: Gibson, R. J. Matamek Annual Report. WHOI: Woods Hole, MA.

Oliver, D. R. 1976. Chironomidae (Diptera) of Char Lake, Cornwallis Island, N.W.T., with descriptions of two new species. Can. Ent. 108: 1053-1064.

Saether, O. A. 1970. A survey of the bottom fauna in lakes of the Okanagan Valley, B.C. Fish. Res. Bd. Can. Tech. Rpt. 196: 1-17.

Saether, O. A. 1975. Nearctic chironomids as indicators of lake typology. Verh. Internat. Verein. Limnol. 19: 3127-3133.

Wiederholm, T. and L. Eriksson. 1977. Benthos of an acid lake. Oikos 29: 261-267.

Preliminary List of the Chironomidae (Diptera) of Lake Matamek

TANYPODINAE

Macropelopiini

Procladius spp.

Pentaneurini

Ablabesmyia sp.
Natarsia sp.
Other spp.

DIAMESINAE

Protanypini

Protanypus sp.

ORTHOCLADIINAE

Heterotanytarsus sp.
Heterotrissocladius spp.
Psectrocladius spp.
Trissocladius sp.
Other spp.

CHIRONOMINAE

Chironomini

Chironomus anthracinus-gr sp.
C. salinarius-gr spp.
Cryptochironomus sp.
Dicrotendipes sp.
Endochironomus sp.
Lauterborniella sp.
Microtendipes sp.
Paracladopelma sp.
Phaenopsectra spp.
Polypedilum sp.
Pseudochironomus sp.
Stictochironomus sp.

TANYTARSINI

Cladotanytarsus sp.
Micropsectra spp.
Stempellina sp.
Tanytarsus spp.
Zavrelia sp.

Woods Hole Oceanographic Institution

Résumé des travaux effectués
à la station Matamek en 1978

Summary of the research done
at Matamek station in 1978

par/by

Marcel Frenette, D.Sc.Ing.
et son groupe
and his group

Mario Caron (chef d'équipe)
Denis Blanchet
Marcel Roy

Collaborateur/Collaboration
M. Yvon Côté (Biologiste au MTCP)

Date: December 1978 Centreau: Université Laval

Station Matamek

Résumé des travaux effectués en 1978

I - Introduction

De 1974 à 1977, les recherches à la station Matamek ont porté particulierement sur l'hydrologie, le morphologie et l'hydraulique de la rivière.

En 1978, deux buts étaient visés:

1) Finaliser les études hydrologiques, morphologiques et hydrauliques.
2) Entreprendre des etudes corrélatives entre les données biologiques et le comportement hydrologique de la rivière.

II - Hydrologie et hydraulique

La reconstitution du régime hydrologique de la rivière Matamek à partir de celui de la riviere des Rapides au moyen d'équations de corrélation est maintenant complètement terminée.

Les débits journaliers, depuis 1969, sont complètement connus, de meme que l'analyse statistique des débits moyens, minima et maxima.

Ces données sont essentielles afin d'effectuer des corrélations entre la biologie et l'hydrologie de la rivière.

Une courbe de débit-masse a aussi été reconstituée afin d'établir les minima requis pour la productivite et la survie des salmonidés dans la rivière.

Pour mieux comprendre le comportement hydraulique de la rivière

Matamek, plusieurs études ont été realisées à partir de relevés sur le terrain.

a) Etude de la variation des paramètres hydrauliques en fonction du débit.

Trent-quatre (34) transects furent étudiés et six (6) paramètres ont été reliés au débit: la profondeur moyenne, la largeur au miroir, la surface de section, la vitesse moyenne, le rayon hydraulique et le périmètre mouille.

b) Etude de la variation des paramètres hydrauliques moyens sur un tronçon en fonction du débit.

En plus des paramètres mentionnés en a), le volume d'eau global, la surface mouillée ont été reliés au debit.

A noter que s'il devient possible d'identifier les zones privilégiées du saumon dans ses différents stages de croissance, ces deux études permettront d'identifier immédiatement les conditions hydrauliques préférées du saumon.

c) Etude des forces tractrices.

Les forces tractrices permettent le calcul des conditions de debut d'entrainement des fonds, particulièrement au niveau des frayères et ainsi de definir la stabilite de celles-ci.

d) Etudes sur les frayeres.

Des relèves sedimentologiques en surface et en profondeur ont été realisés pour chaque frayère (actuelle et potentielle).

Les zones exondées et des cartes de courants sont tracées pour differents débits.

e) Etude du débit dominant ou débit formateur de la rivière.

Le calcul du débit dominant a mis en évidence la divergence entre les methodes mathematiques (2500 pcs) et la méthode morphologique basée sur des observations de la ligne de végétation (1000 pcs).

Quelques recherches supplementaires restent à faire sur cet aspect des études.

III - Physico-chimie

Une analyse de la concentration de plusieurs paramètres physico-chimiques en relation avec le débit a permis d'établir pour certains parametres une équation du type:

$$\text{concentration} = aQ^{-1} + b$$

alors que pour d'autres paramètres la concentration demeure à peu près constante.

Les paramètres étudiés sont: Ca, NO_3, PO_4, Mg, Na, Si, SO_4 et K (donnés obtenues auprès du Ministère des Richesses Naturelles du Québec).

IV - Hydrobiologie

Un calcul préliminaire par la méthode d'Elson a permis d'estimer à 90 geniteurs* la population optimale pour la partie présentement accessible de la rivière Matamek.

Une étude de la migration des saumoneaux (smolts) a aussi été effectué.

Il a été demontré que la température initiatrice du mouvement des saumoneaux (9°C)* correspond à un débit de 1165 pcs (80%: 1092-1237 pcs).

De plus, lors de la décrue du printemps, une relation linéaire a été trouvée entre le débit et la température.

Il semble en outre que les pointes de capture des saumoneaux dans l'estuaire peuvent être reliées à des parametres associés à l'amplitude relative des marées.

Un complément d'étude au niveau estuarien permettrait de confirmer cet énoncé, très important pour étudier le comportement des saumoneaux dans l'estuaire et pour l'estimation des populations.

De plus, les résultats démontrent que pour des conditions de mar identiques, le nombre de saumoneaux enregistré l'avant-midi est constamment inférieur a celui de l'aprés-midi.

Enfin, une étude des populations de tacons + 1 (parrs + 1) et tacon + 2 au pied de la deuxième chute a permis de définir des relations entre les populations et différents types de débits.

Par exemple, la population totale de tacons au pied de la deuxième chute (P) est fonction de trois types de débit:

Q_{min} printemps, enregistré 2 ans auparavant

Q_{moyen} août, enregistré 2 ans auparavant

Q_{min} printemps, enregistré 1 an auparavant.

Il est très intéressant de noter que ces types de débits correspondent à des périodes critiques dans les phases antérieures (1 ou

---

*A être confirmé par les biologistes.

2 ans avant) de croissance du saumon. Des coefficients de corrélation très élevés ont été atteint (R ≃ .98) pour le prédiction des populations.

V - Conclusion

Du point de vue hydraulique, hydrologique et morpho-sédimentologique la rivière Matamek est suffisamment connue pour permettre une multitude de prédictions à court, moyen et long terme sur le comportement dynamique propre à celleci. De plus, les études permettent d'entrevoir le comportement des rivières à saumon de la Côte Nord (et probablement de la Gaspésie) dans les conditions extrêmes. Ainsi il est possible d'obtenir les conditions critiques pour la productivité, la survie et la migration des saumons selon différentes hypothèses développement. Ces recherches seront de première importance pour les dévelopements hydroélectriques futurs de la Côte Nord.

Quelques dossiers hydrobiologiques ont été ouverts cette année. Les premières données analysées et corrélées aux conditions hydrologiques permettent déjà de prédire, avec assez d'exactitude la relation existante entre les populations de jeunes dans la rivière, à différents niveaux de croissance et différents débits caractéristiques observés antérieurement. En d'autre terme, on établit l'équilibre entre la population (variable) de jeunes et l'évolution de son milieu (également variable). Les résultats de cette recherche ont une portée importante sur le plan pratique eu égard aux ensemensements et au développement des cours d'eau.

Ce nouveau dossier apparaît très prometteur mais pour l'approfondir davantage et ouvrir d'autres horizons du même type, une meilleure intégration est nécessaire entre les objectifs et les différents groupes de recherches; d'ou la nécessité de suivre un plan d'orientation et un plan d'opération pré-établis.

Matamek Station

Summary of the research done in 1978

I - Introduction

Between 1974 and 1977, the research at Matamek Station were carried mainly on the hydrological, morphological and hydraulic aspects of the river.

In 1978, two objectives were considered:

1) To complete the hydrological, morphological and hydraulic behaviors of the river.
2) To undertake some correlated studies between biological data and hydrological behaviour of the river.

II - Hydrological and hydraulic aspects

The reconstitution of the hydrological regime of Matamek River from the rapid river is completed.

The daily flow since 1969 is completely known as well as the minimum average and maximum discharges.

Those data are essential in order to establish the correlation between the biology and the hydrology of the river.

Many observations on the hydraulic aspect have also been realized:

a) The variation of the hydraulic geometry in regard to the flow discharge

Thirty four (34) sections were studied and six (6) parameters were related to the discharge: mean depth, width, wet area, velocity, hydraulic radius and wet perimeter.

b) The variation of the hydraulic parameters over a reach in regard to the discharge

In addition of the parameters mentioned above in a) the total volume of water, total miror surface and total wet surface have been related to the discharge.

Let us note that if it become possible to identify the privilege zones of the salmon at different stages of growing these two studies will permit to identify immediately the hydraulic conditions requested by salmon.

c) Bed shear stress

The tractrices forces are used to define the bed movement and thus to establish the stability of a river. At Matamek this was applied to the spawning area.

d) Spawning area

Observations were also made on the sedimentological conditions of the spawning area (actual and potential) bed material at surface and below the surface have been analysed.

e) Dominant or formative discharge

The work done to establish the dominant discharge was not very successful, other research is needed to complete this aspect.

III - Physico-chemical study

The analysis of several physico-chemical parameters has permitted to relate those to the discharge by the equation:

$$x = a\,Q^{-1} + b$$

x = concentration of the parameters

a and b = constant

Q = discharge

Parameters considered: Ca, NO_3, PO_4, Mg, Na, Si, SO_4 and K. The data have been obtained from the department of Natural Resources of the Province of Quebec.

IV - Hydrobiology

First, it was established, by using the Elson method that the river can carry about 90 genitors*.

Then the study of the migration of the smolts has been realized. It has been shown that the temperature that initiate the movement of the smolts (9°C) correspond to a discharge of 1165 cfs, after the peak flow, (80%: 1092-1237 cps).

Also, during the spring flood (after the peak), a direct relation

---

*To be confirmed by the biologists.

have been found between the temperature and the discharge.

On the other hand, the peak of smolts caught in the estuary seems to be related to the relative amplitude of the tide. Some other research is needed to confirm this first ascertaining, very important for the estimation and behaviour of the smolts.

Finally, a study of the population of the parrs + 1 and parrs + 2, downstream the second fall has permitted to define the relation between the population and different kinds of discharges.

For example, the population of the total parrs in function of:

Q_{min} springtime, observed two (2) years before

$Q_{average}$ August, observed two (2) years before

Q_{min} springtime, observed one (1) year before.

Q = discharge (correlation coefficient: r: .98).

V - Conclusion

Many predictions can be made now in regard to the hydrological, hydraulic and morphological aspects of the Matamek River and other salmon rivers of the North Shore of the St. Lawrence River. The most important ones are the prediction in regard of the flow requirements for the productivity, survival and migration of salmons in river.

From the hydrobiological point of view, the first data analysed and correlated to the discharge, are very promoted. Results shall be very useful in regard to any development of salmon river. In order to complete this work however a good integration between the objectives of research is needed. This means that research must be well oriented and must follow a plan of operation pre-established.

Matamak Biological Station

Woods Hole Oceanographic Institution

Studies On Marine Organisms

Denis Larrivée

Francois-X. Garneau

1979

STUDIES ON MARINE ORGANISMS

We are pursuing studies in Amory Cove with the objective of characterizing some of the critical factors in shallow water marine productivity. Amory Cove is a small area of the North Shore, near the Matamek biological station (see Fig. 1), and showing a variety of bottom substratum types at various depths. We have focused our attention on the most sensitive stages within the life cycles of some of the benthic animals living there. These stages will normally be found during the breeding period and larval development. We have therefore concentrated our effort on the analysis of reproductive habits, growth and settling of larvae, and development events of selected organisms. Moreover we have developed studies on certain chemical aspects, and in particular, the structural elucidation of natural products and the determination of the role they play in these events. In relation to this we have elaborated a bioassay.

The shallow water communities are to a larger extent than other communities exposed to extreme changes in the physico-chemical conditions (temperature, salinity, wave action, chemicals from the land, etc.). The critical stages in the life cycle of shallow water organisms are bound to amplify the processes of survival by particular developmental adaptation such as reproductive fecundity, growth rate, settling distribution, metamorphic adaptation, etc., involving structural as well as chemical particularities.

We have tried here to survey the general conditions of productivity in Amory Cove in order to identify the most interesting characteristics. We offer here a brief exposure of the work. We should caution here that

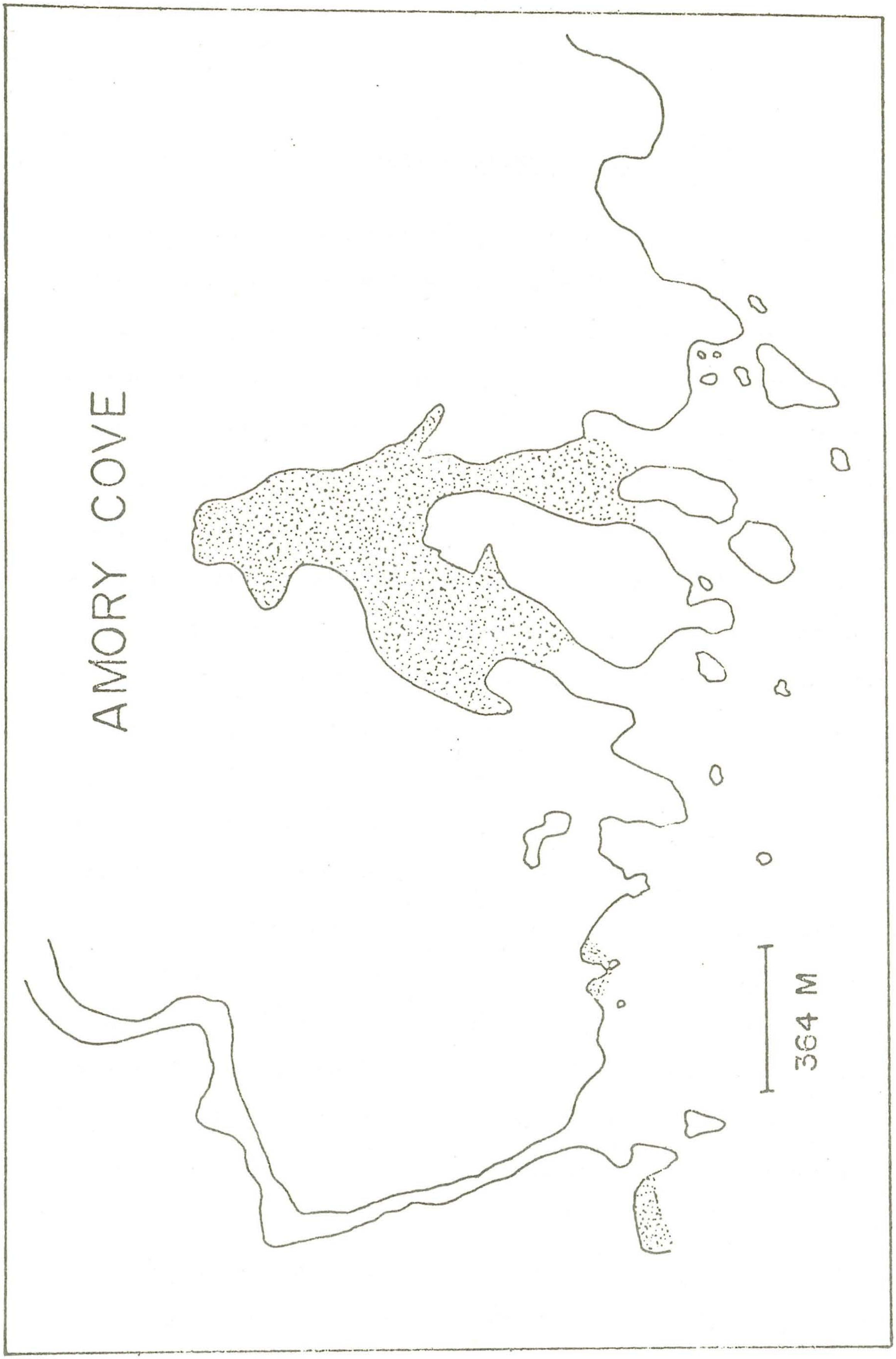


FIG. 1

the analysis is only partial and that when it has been completed, a full account of these studies will be submitted for publication.

In a preceding report (1975) we established a partial list of the benthic invertebrates that can be found in Amory Cove and made a description of the bottom communities and substratum. This is being completed and presented elsewhere. In this report, the following studies are presented:

I) Studies on reproduction

II) Studies on larval settling

III) The biology of Buccinum undatum

IV) Studies on natural products in holothuroidae

V) Development of a bioassay

I - Studies on reproduction

The problems of reproduction in northern areas is a complex one. Under conditions which usually do not permit repeated opportunities, the organisms have to adapt in order to reconcile short and variable periods of optimal conditions to slow growth. John Himmelman has shown how the spawning in Strongylocentrotus droebachiensis can be controlled and synchronized through specific algal products. It seems also that the whole process of gametogenesis is somehow synchronized with the appearance of these specific algae.

When we consider, on the other hand, the preferential feeding of these organisms (Vadas) we may realize that the optimization strategy touches at the control of gametogenesis. Thus, gametogenesis presents a

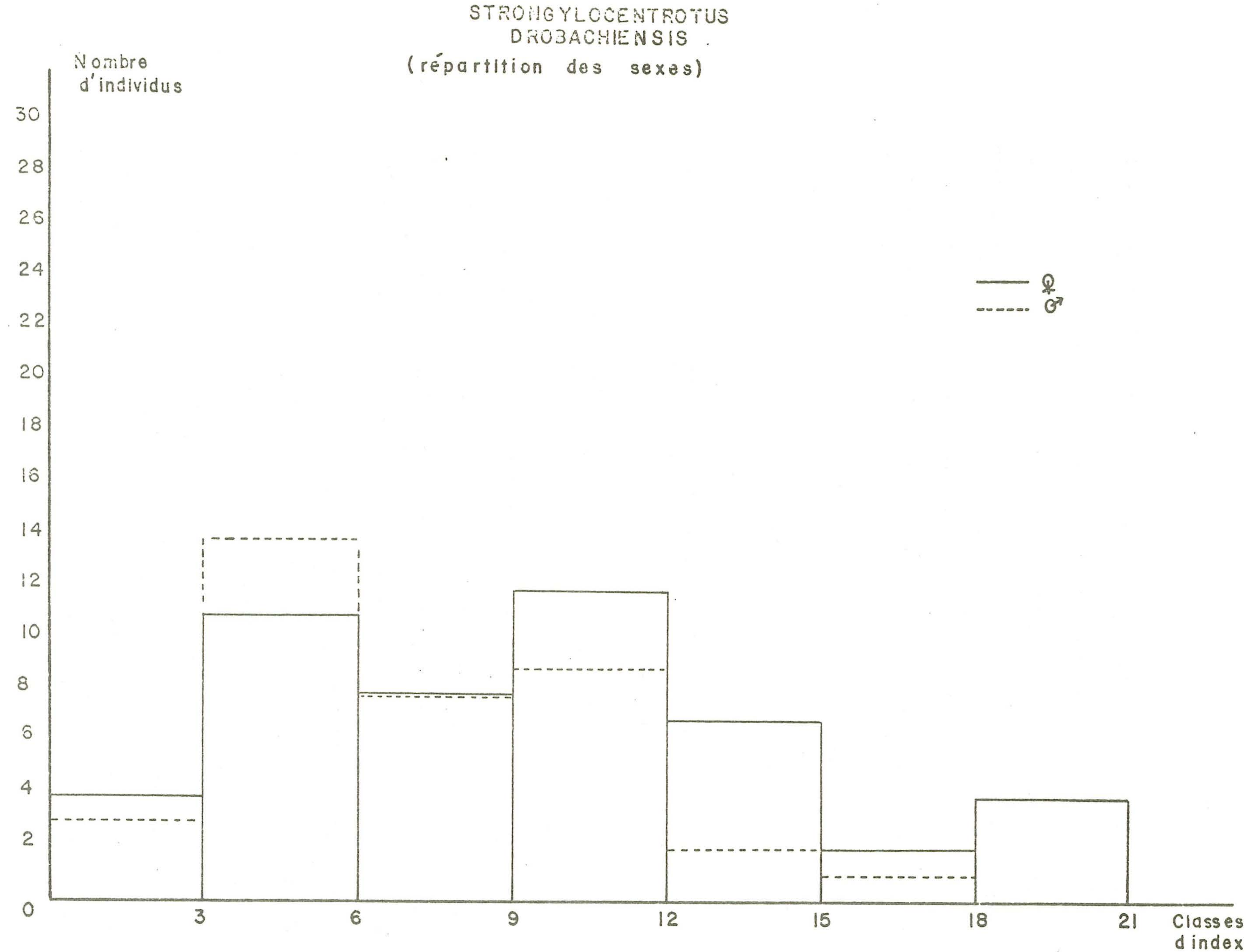

STRONGYLOCENTROTUS
DROBACHIENSIS
(répartition des sexes)
Nombre
d'individus
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
3
6
9
12
15
18
21
Classes
d index
♀
♂

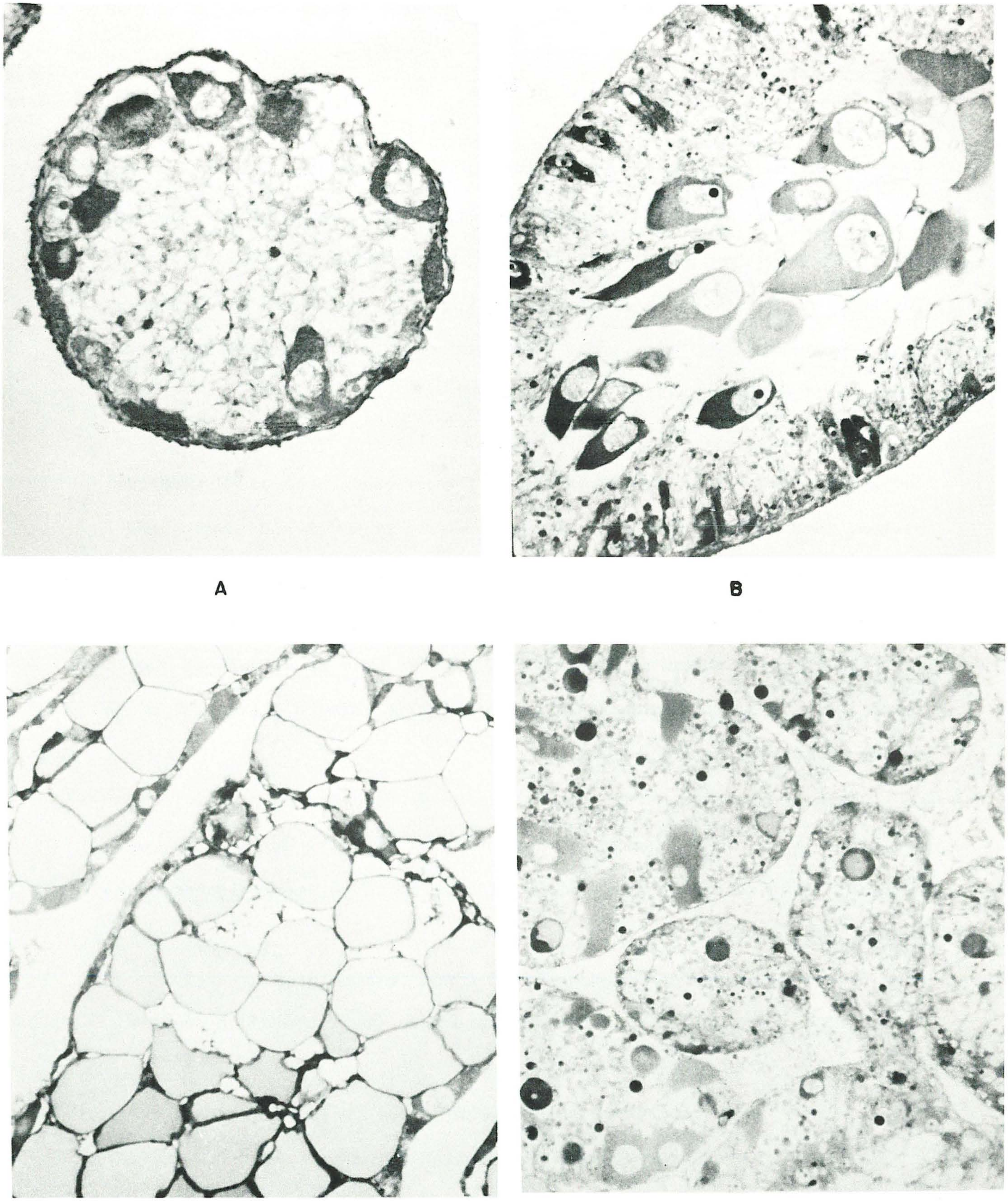
FIG. 2

good situation to study exogenous and endogenous interactive control. Gonor found that the gonadal index increase between July and November was due to the storage of nutrients in specialized cells, the nutritive phagocytes, and not to the accumulation of gametes. It is therefore imperative to study not only the gonad index but also to obtain a clear picture of the cell differentiation in the gonad.

Consequently, we have looked histologically and histochemically at the gradual changes in the formation of the gametes in selected invertebrates. For this we establish the gonad index of males and females and analyse sections of these gonads at regular times throughout the year. We have in this regard been comparing animals sampled in Amory Cove (the gulf) and at Les Escoumins (estuary). We offer here an example of the gonad index in *Strongylocentrotus droebachiensis* sampled during the month of May in Amory Cove (Fig. 2).

In the case of the estuary for the same period, the spread of individuals in each class seem to be more uniform. Looking at sections, we have been able to divide the periods of ovogenesis in *Strongylocentrotus droebachiensis* into:

1) A period of uncommitted gonad (reticulated aspect)
2) A period of ovocytic appearance (reticulated in center (Fig. 3A)
3) A period where eggs appear in the lumen (Fig. 3B) and ovocytes are present near the stroma
4) A period where mature eggs form the bulk of the gonad (Fig. 3C)



A B C D

FIG. 3

5) A period of egg degenerescence and gonad recuperation (Fig. 3D)

Due to the small number of gonads analysed in sections it is impossible at present to determine whether the process of gametogenesis is spread over two years for the whole population as Gonor suggested. The general degeneration observed in October indicates that this is not the case for *Strongylocentrotus* sampled in Amory Cove. This system offers interesting opportunities to study environmental effects at the cellular level. We know from earlier studies on hermaphrodites that once the gonad or part of the gonad is committed it will follow autonomous differentiation. This commitment occurs approximately in December in our regions.

Vadas has shown that urchins with well-developed preferences will on the whole grow faster, reproduce earlier, and contribute more offspring to future generations, than individuals with indiscriminate feeding behaviour. We are working here on the hypothesis that the cycle of growth and the cycle of gametogenesis in these animals are in some way asynchronized, not only in the sense of funneling energy sources into one utilization or the other but in the sense of commitment to growth or gametogenesis. It is the nature of this commitment that we would like to characterize. We have been working on a number of other systems with this in mind.

II - Studies on larval settling and development

Another objective of the research in Amory Cove was to determine developmental and growth characteristics of the benthic animals, many of which have a planktonic stage. In order to achieve this, we have developed some techniques to permit the settling and metamorphosis of the larvae. We are using a converted plastic chlorine distributor (see Fig. 4) filled with shells and suspended at different heights above the bottom and covering the entrance of the cove. These collectors permit a full recovery of the animals settling inside, and a rapid evaluation of the total surface occupied. The collectors are submerged for different lengths of time (minimum four months) and at different times of the year. This method follows essentially Gunar Thornson's, but special precautions have to be taken here because of storms and the formation of ice.

The species of invertebrates which actually have pelagic larvae in cold waters are preferentially summer breeders when illumination is intense. They are shallow water settlers for the same reason. Since in these waters, illumination will vary greatly during any particular season it should be interesting to observe the distribution of the settlers during the same period. Moreover, since different conditions along the coast (estuaries, ice formation, types of bottom deposits, etc.) will bring about differential illumination it would be interesting to compare these situations.

The problem of specific recognition in biology is a general one. Whether at the moleculur, cellular or organismal level the definition of specificity of receptor or activator and of their interactions is a difficult one. By choosing simpler receptor geometry, it might be possible to understand these specific interactions. For the settling of larvae, different substrates within the dispersal range of the larvae present heterogeneity which can be called habitat diversity. Marine larvae faced with this heterogeneity usually display habitat selection. Marine larvae can be remarkably restrictive in their choice of substrates. For example, we can refer here to the studies on Spirorbis by Gee and Williams or Knight-Jones.

One can also observe with time a decrease in substrate specificity. Whether it is chemical or morphological, the larvae must undergo changes defining this specificity. Scheltema's definition of the onset of delay phase for the settling of the larvae, involves both developmental criteria (cessation of growth and differentiation) and behavioral criteria (ability to settle on a suitable substrate). Is it possible to devise experiments to observe changes in these events? This is what we hoped to achieve in the collecting of settlers in Amory Cove. Before resuming the results, let us recall Doyle's relation to define attractiveness to the substrate:

$$\gamma = \frac{N_j}{P_j N}$$

which essentially states that the relative attractiveness is equal to the relative numbers of settled larvae in the experiment. There is in our experiment remarkable constancy, in a given time, for specific position in the relative number of larvae settling on our artificial islands. More than 85% of the settlers are made up by Mytilus and Balanus species. They occupy mostly the outer surfaces of the collectors but in

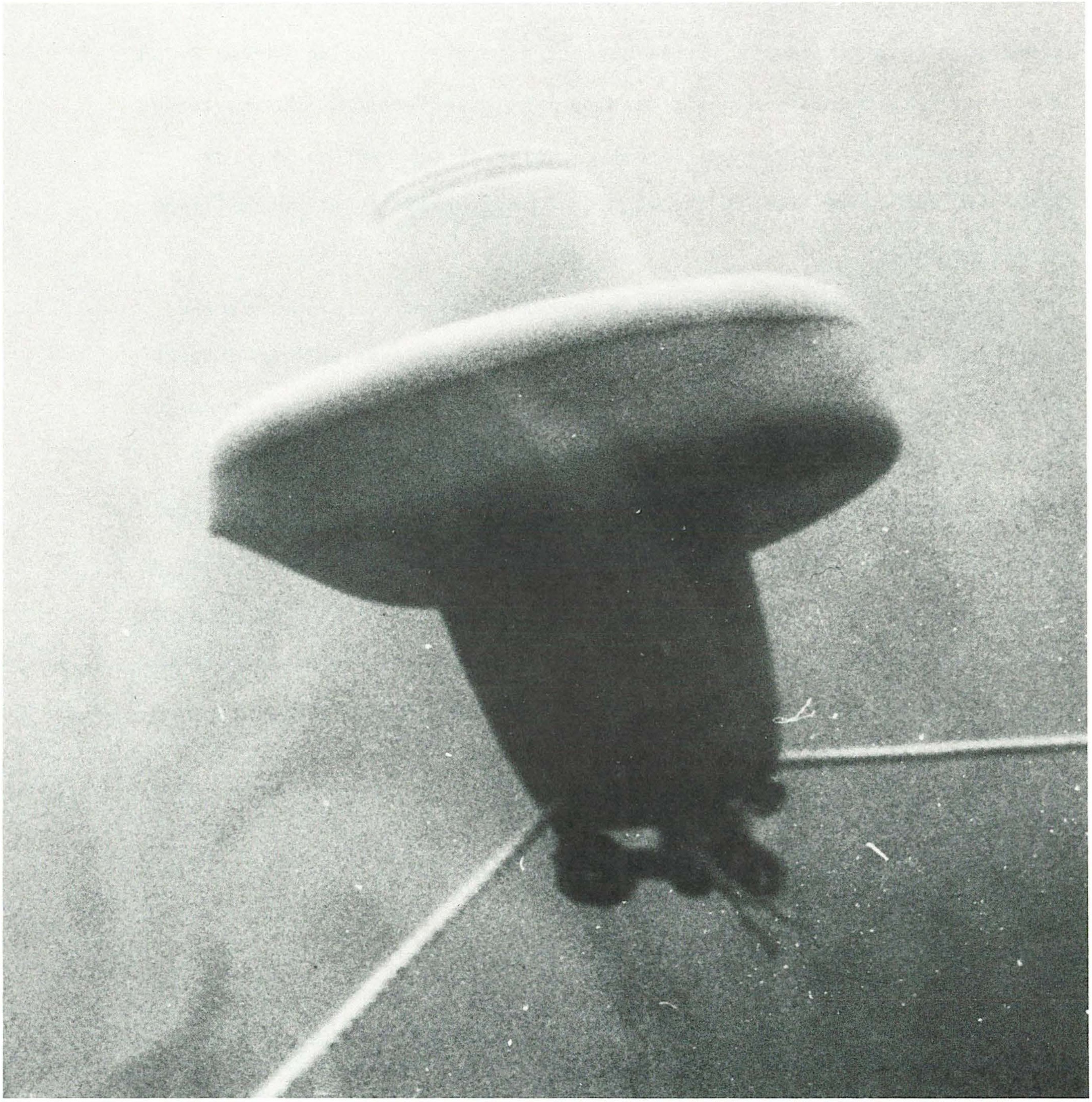


FIG. 4

these experiments Mytilus has definite settling preference for more illumination than Balanus. Balanus settling is therefore predominantly geotropic while Mytilus settles on top of the floats.

We could draw a correlation between the degree of maturity in the organs and tissues of the organism and its settling ability. Moreover, certain specific adaptations of attachment must manifest themselves to explain the situation. In our experiment we can easily qualify the characteristics of larval settling (time, growth rate, maturation, etc.) between two different species, Mytilus and Balanus. The situation is therefore simplified and since heterogeneity is quite definite, studies should lead us to an interpretation of this critical stage in the productivity of these animals.

Osman described five major factors to be important to both the development of the community and its distribution on rocks:

"1) The selectivity of the metamorphosing larvae
2) The seasonal fluctuation in larval abundance
3) The biological interactions within and between species
4) The size of rock substrata; and
5) The physical disturbance of substrata."

He concludes that physical disturbance is probably the most important factor in determining the diversity and species composition of sessile epifauna on rocks. Special attachment behaviour of the larvae together with their metamorphic and postmetamorphic growth is certainly determinant in this regard. We have presently obtained the settling conditions which permit us to follow more closely the evolution of two species. We can also observe a definite differentiation in the settling characteristics along the entrance of the Cove. A study of the plankton communities at different times of the year will have to be completed with the specificity and abundance of food and the specificity and abundance of settlers in mind. Moreover, since we believe, from other studies, that the coupling of growth-gametogenesis cycles determine ultimately the success of a species relative to the other we will have to look more carefully at the pattern of growth and gametogenesis of the two types most frequently found on the collectors, *Mytilus* and *Balanus*.

III - The biology of Buccinum undatum

The prosobranch *Buccinum undatum* offers interesting characteristics permitting the study of metamorphosis, growth and differentiation in relative independance of exogenous influence. The eggs, internally fertilized, are encapsulated (about 300 per capsule) and tied to a rock (several spawns on top of each other forming large grapes of egg capsules) from 20 feet down (low tide). Some of the eggs (10 to 15 out of 300) will develop, digesting in the process the remaining unsegmented eggs, and the animals will hatch from the capsule as a small snail having undergone metamorphosis entirely within the capsule. The eggs deposited in May will hatch around the end of September or the beginning of October.

Development:

We have followed the development of *Buccinum undatum* at 40°F. We have previously given a series of illustrations to show the different stages of this development. An interesting aspect of this development is the presentation of the early embryo with several nuclei unseparated by cytoplasmic membrane as is illustrated in the electron micrograph of Fig. 5A. At this stage, no nucleoli appear in the nucleus. Soon after, at the time when nucleoli appear (corresponding to the gastrula stage) cytoplasmic membranes, separating the nuclei, will be formed. This we can see in Fig. 5B.

Growth:

As has been shown previously there seem to be a linear relationship between shell size and the number of operculum growth lines. We also showed that the population studied in Amory Cove would range up to eight years of age assuming one operculum line equals one year. The growth studies have been continued in aquarium where we have been able to obtain spawning. We have here a direct, if slow technique, to study growth in *Buccinum undatum*.

The advantage here is the possibility of correlating biochemical aspects to macro and micro structural changes. For this, we have concentrated our studies on the shell formation. In *Buccinum undatum* at about six weeks of age one can observe the differentiation of a shell gland. This can be seen in Fig. 6A as a thickening of the outer layer near the gut area. A closer examination of this area (Fig. 6B) shows cells with extreme polarization, multiple mitochondria and vesiculisation where the calcium carbonate is deposited. The "isozymic adaptation" hypothesis which we developed for *Ylyanassa* has not yet been tested here for lack of

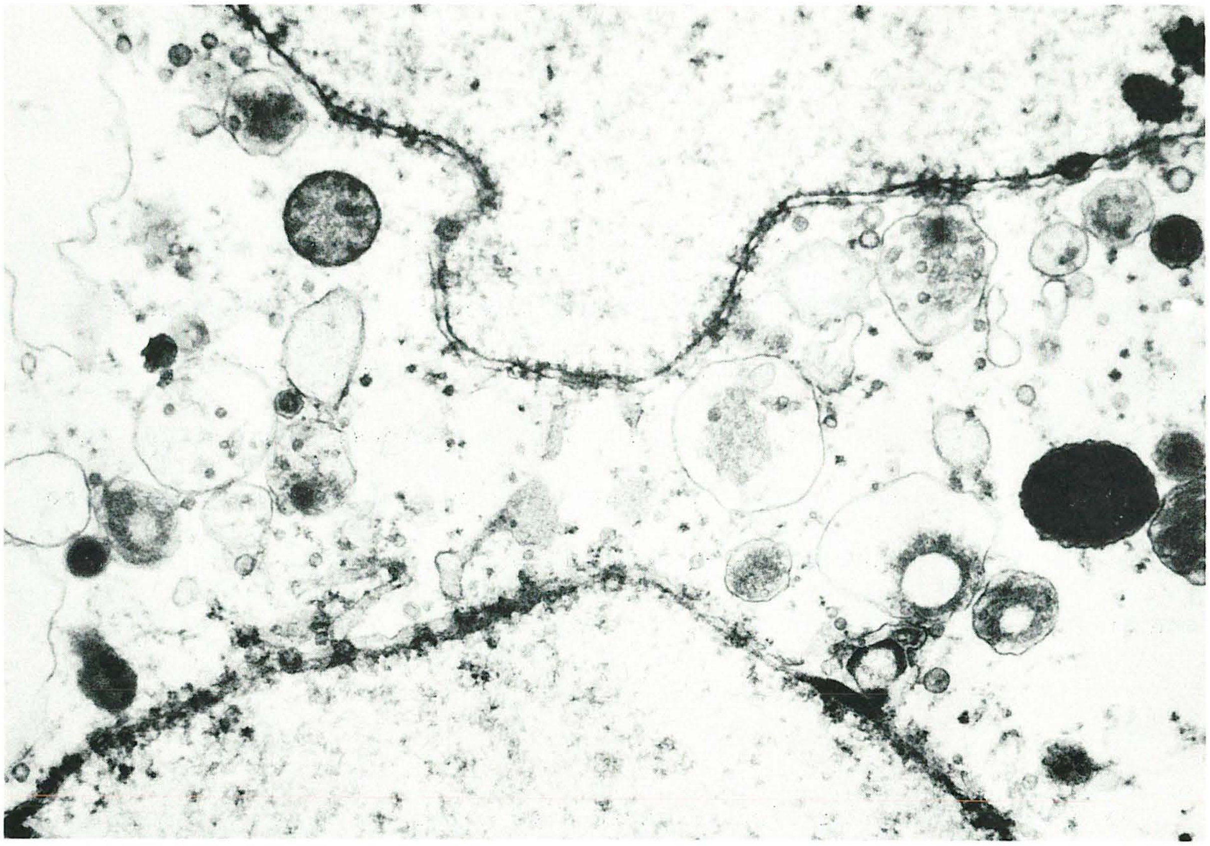


FIG. 5A

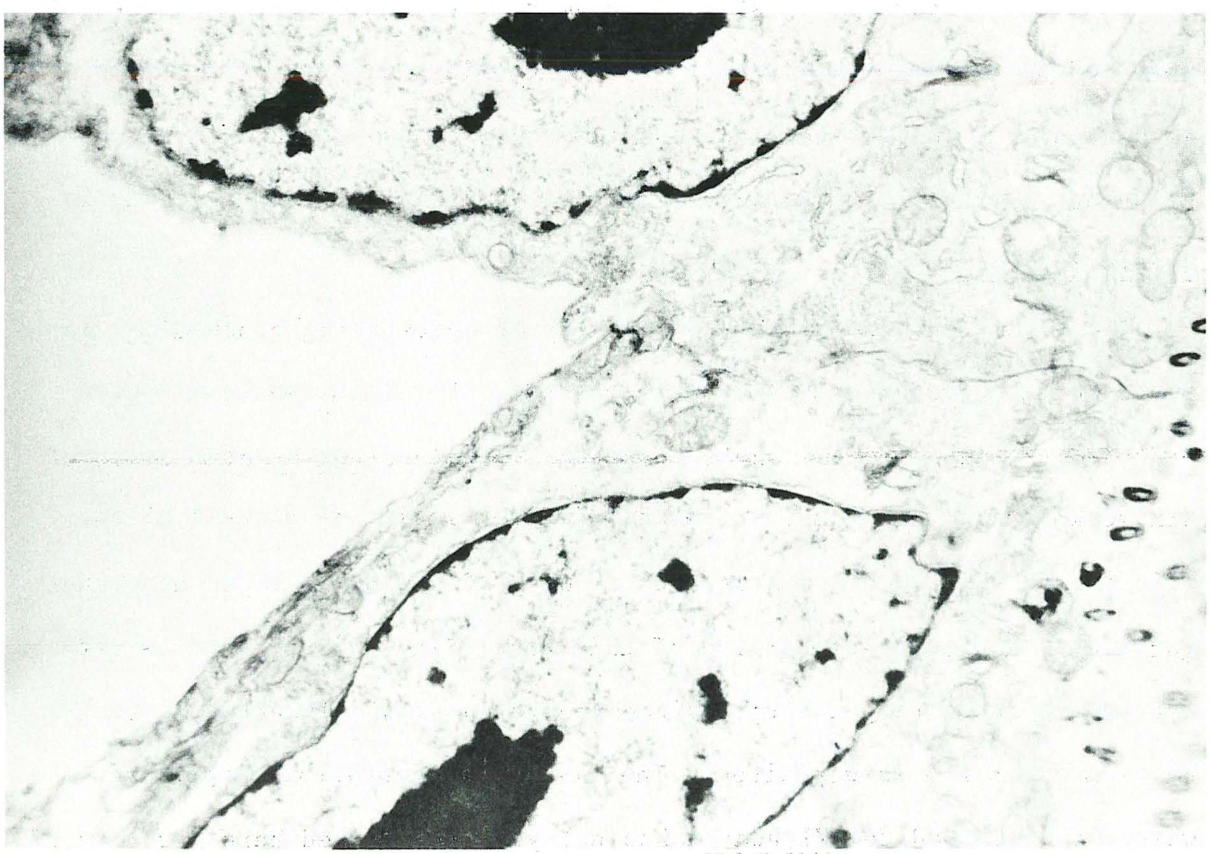


FIG. 5B

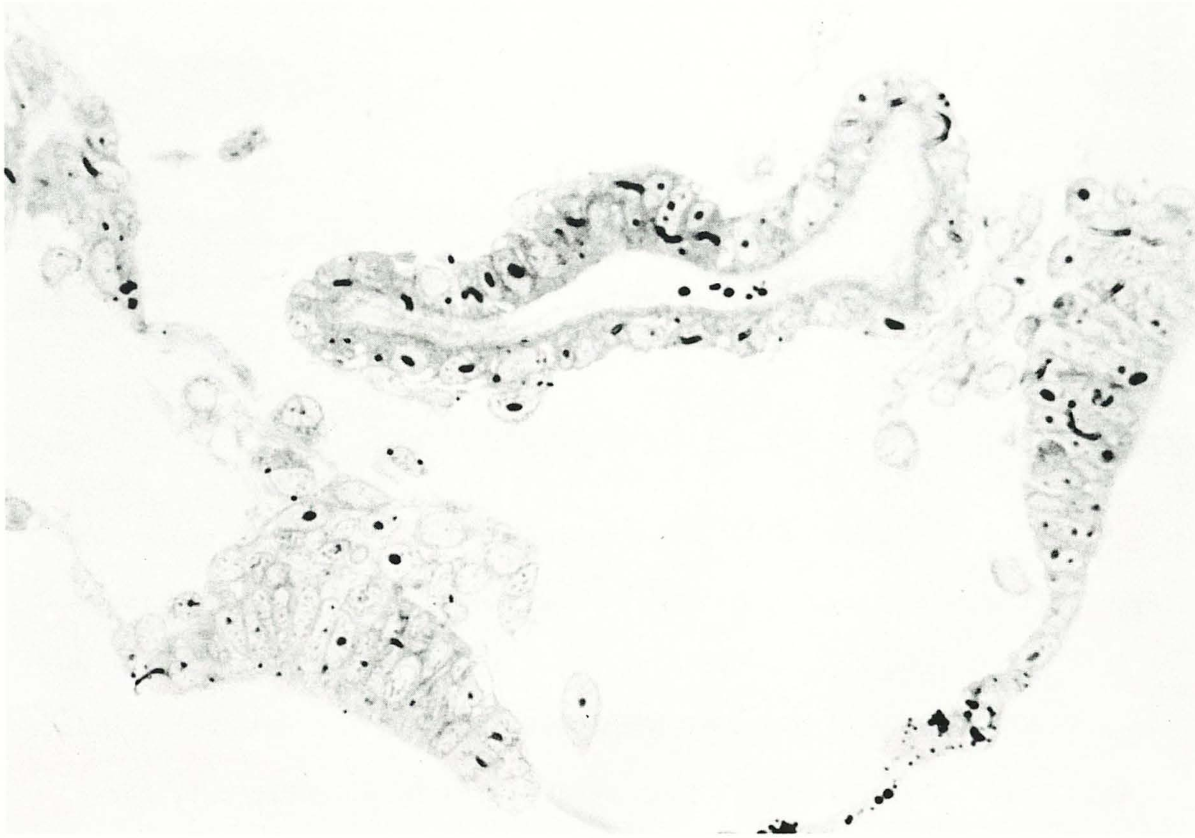


FIG. 6A

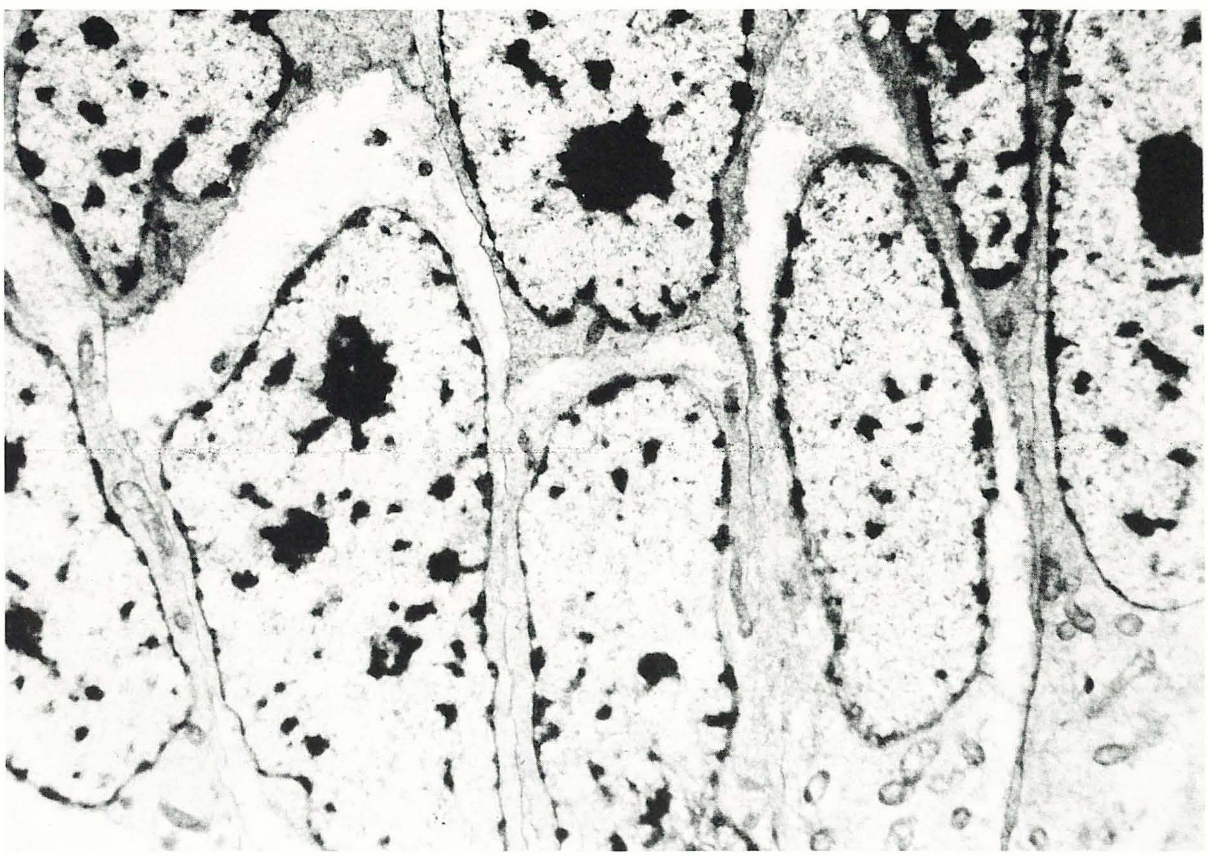


FIG 6B

material. We could recall that in *Buccinum undatum* we have determined that the carbonic anhydrase of embryos grown at 40°F reveals two bands and is manifest at two months of development.

Reproduction:

With the objective of determining interrelationships of growth and reproductive processes, we have examined the reproduction characteristics of *Buccinum undatum*. A comparative study of reproductive habits of *Buccinum* in shallow water and deep water (250 feet) has not been completed at this time. One may recall that we characterized tentatively three major periods of oogenesis in *Buccinum*. A more detailed study of these periods is underway.

IV - Studies on natural products in holothuroidae

Two years ago, we began our investigations into the natural products of marine organisms of the north west of the St. Lawrence estuary. Our initial work has been directed toward the search for saponins (triterpene glycosides) in the sea cucumbers *Psolus fabricii* and *Cucumaria frondosa*. Although research on the holothurins (holothurian saponins) has relatively long and active history, no studies on the genus *Psolus* have as yet been reported and *Cucumaria frondosa* was referred to only very briefly in a short note dealing with the species *Stichopus japonicus*. Specimens of *C. frondosa*, the subject of our initial studies, were obtained from Les Escoumins, the Ilets de Mai and Matamek. The residue obtained from an aqueous ethanol extract of the body wall was prepared into eight fractions by thin-layer chromatography. Four of these fractions has a toxic effect on the fish Brachidanio rerio causing their deaths within an hour when dissolved in very small quantities into the water of a beaker containing the fish. Certain physical properties of these substances resembled those previously reported for holothurians such as a foaming action when shaken in fresh water, a decomposition on melting and an absorption in the infrared spectrum characteristic of a lactone moiety.

Because these preliminary investigations consumed all our available (at that time) specimens of C. frondosa, we turned our attention to the bright red holothurian, Psolus fabricii, a specimen found in arctic and sub-arctic waters. Here again, an aqueous ethanol extract of the body wall (including a calciferous outer layer) contained saponin-like substances. The mixture of holothurians were purified by column and thin-layer chromatography on silica gel followed by recristallizations from 85% aqueous ethanol to give a white solid m.p.t. 195-198^{o} (dec.). An infrared spectrum of this solid displayed an absorption in the region of a saturated -lactone and also a strong and broad hydroxyl band.

Hydrolysis in aqueous acid resulted in a cleavage of the mixture of holothurians into sugars and aglycones. The sugars were identified by comparison with authentic compounds using paper and gas-phase chromatography. They were shown to be 3-O-methylglucose, quinovose, glucose and xylose. The structural elucidation of the aglycones is being carried out by a graduate student, Michel Girard, at Carleton University and is part of a joint research effort between John ApSimon of Carleton and Francois-X. Garneau of the Universite du Quebec a Chicoutimi.

Future plans are to examine as large a specturm as possible of marine fauna and flora in the Matamek area and at other points along the coast, for the presence of active substances by means of a bioassay technique (see below). In a long term project, studies on the influence of seasonal and geographical factors on the nature and abundance of there substances will be carried out and should provide at least in part an insight into the role of such compounds in the marine coastal ecosystem.

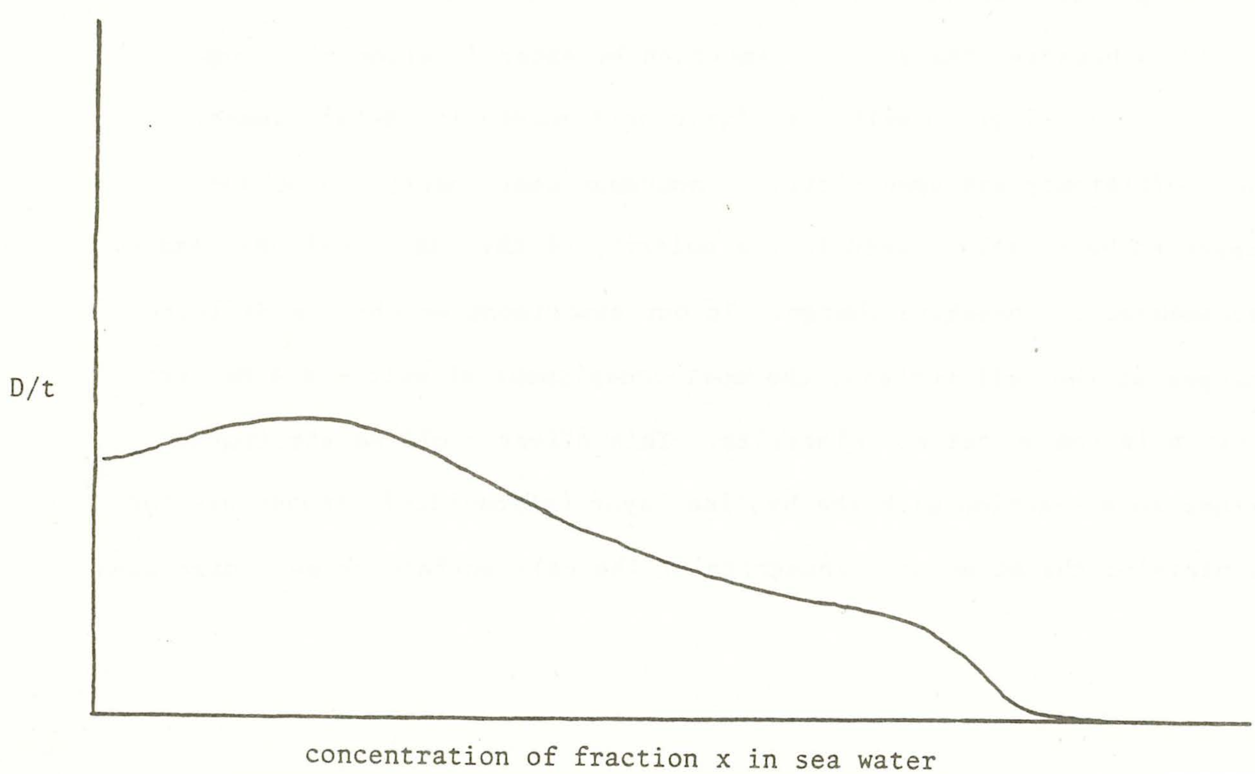
V - Development of a bioassay

For testing properties of bioactive compounds the bioassay offers essential advantages. If on one hand it is sometimes difficult to quantify the results, on the other hand it often opens up aspects for understanding function. If we were to try to define the characteristics of a good bioassay we should single out the following:

1) A good bioassay should offer the possibilities for quantification. Ideally it should affect linearly a process which is itself measurable quantitatively.
2) A good bioassay should offer the opportunities for understanding the mechanism by which the agent operates.

Considered along these lines, the sea urchin embryo offers unique properties for quantification and observation of interactions at the molecular and cellular level. By choosing some periodic event such as cell cleavage or DNA replication it may be possible to establish a correlation with the concentration of a bioactive compound. We thus worked up a procedure for testing one of the purified fractions (see section IV) of a holothurian. A series of concentrations were chosen and the same number of eggs were incubated in each of these concentrations and in pure sea water (control) immediately after fertilization. Observations were made at given intervals corresponding to cleavage periods. We consequently examined the developing embryos by photographing a population of about 50 individuals for each point in time and for each concentration.

We also took a few specimens for ultrastructural analysis. A full analytical account will be presented later but we would like to indicate here a few of the results. If we take for one point in time the ratio of divided cells per total embryos and we plot this ratio versus the concentration we obtain a graph as illustrated below.



Apart from the slight increase in the ratio at weak concentrations, an increase which could be explained in different ways, it is apparent that increased concentrations lead to an ever smaller number of cells able to divide. For a complex phenomena such as cell division we should not expect to find a linear relationship with concentration. We are dealing here with a phenomenon of the third or more order and therefore we should expect a curve of the sort we obtain. These curves will be investigated further but they all confirm already the possibility of using divisions of embryonic cells to reveal quantitatively the biodynamic effects of holothurians. Pushing further the analysis we have looked at the ultrastructural effects of these products looking especially at the cell surface. From the point of view of the products, we know from literature that the triterpenoidal saponins from echinoderms are characterized by:

1) a complex triterpenoid nucleus
2) a series of closely related sugars attached glycosidically to 3rd position of the triterpene
3) a negative charge locus imparted by esterification of a sugar hydroxyl group with a sulfuric acid moiety in certain cases.

Their efficiency and specificity in neuromuscular junction blockade appear to be closely linked to the polarity of the sugar residues, and to requirement for negative charge. In our experiment we observe definite changes at the cell surface, the most conspicuous of which is a net reduction in the number of velocities. This effect could be attributed either to a reaction with the hyaline layer (glycosidic) responsible for maintaining the structural integrity of the cell surface or more directly with the lipids of the cell membrane. In either case the velocities will be affected.

We come therefore to the conclusion that not only can we use this bioassay to quantify and demonstrate an effect due to the holothurian fraction but that we can also probe into the type of mechanism by which this holothurian operates at the cellular and molecular level.

BIBLIOGRAPHIC DATA SHEET	1. Report No. WHOI-79-49	2.	3. Recipient's Accession No.

4. Title and Subtitle MATAMEK ANNUAL REPORT FOR 1978	5. Report Date May 1979
	6.
7. Author(s) Frederick G. Whoriskey	8. Performing Organization Rept. No.
9. Performing Organization Name and Address Woods Hole Oceanographic Institution Woods Hole, MA 02543	10. Project/Task/Work Unit No.
	11. Contract/Grant No.
12. Sponsoring Organization Name and Address Department of Tourism, Fish and Game of the Province of Quebec	13. Type of Report & Period Covered Technical
	14.

15. Supplementary Notes

16. Abstracts

This is a report describing activities associated with the Matamek program in 1978. Research was conducted on biological, chemical and physical factors related to salmonid production in Matamek River and Matamek Lake. Canadian universities, the Quebec government and Woods Hole Oceanographic Institution cooperated in the program.

17. Key Words and Document Analysis. 17a. Descriptors

1. Salmonid ecology
2. Boreal limnology

17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report) UNCLASSIFIED	21. No. of Pages 120
	20. Security Class (This Page UNCLASSIFIED	22. Price

Woods Hole Oceanographic Institution
WHOI-79-49

MATAMEK ANNUAL REPORT FOR 1978 by Frederick G. Whoriskey. 120 pages. May 1979. Supported by the Woods Hole Oceanographic Institution and the Department of Tourism, Fish and Game of the Province of Quebec.

This is a report describing activities associated with the Matamek program in 1978. Research was conducted on biological, chemical and physical factors related to salmonid production in Matamek River and Matamek Lake. Canadian universities, the Quebec government and Woods Hole Oceanographic Institution cooperated in the program.

1. Salmonid ecology
2. Boreal limnology

I. Whoriskey, Frederick G.
II. Woods Hole Oceanographic Institution
III. Department of Tourism Fish and Game

This card is UNCLASSIFIED

Woods Hole Oceanographic Institution
WHOI-79-49

MATAMEK ANNUAL REPORT FOR 1978 by Frederick G. Whoriskey. 120 pages. May 1979. Supported by the Woods Hole Oceanographic Institution and the Department of Tourism, Fish and Game of the Province of Quebec.

This is a report describing activities associated with the Matamek program in 1978. Research was conducted on biological, chemical and physical factors related to salmonid production in Matamek River and Matamek Lake. Canadian universities, the Quebec government and Woods Hole Oceanographic Institution cooperated in the program.

1. Salmonid ecology
2. Boreal limnology

I. Whoriskey, Frederick G.
II. Woods Hole Oceanographic Institution
III. Department of Tourism Fish and Game

This card is UNCLASSIFIED

Woods Hole Oceanographic Institution
WHOI-79-49

MATAMEK ANNUAL REPORT FOR 1978 by Frederick G. Whoriskey. 120 pages. May 1979. Supported by the Woods Hole Oceanographic Institution and the Department of Tourism, Fish and Game of the Province of Quebec.

This is a report describing activities associated with the Matamek program in 1978. Research was conducted on biological, chemical and physical factors related to salmonid production in Matamek River and Matamek Lake. Canadian universities, the Quebec government and Woods Hole Oceanographic Institution cooperated in the program.

1. Salmonid ecology
2. Boreal limnology

I. Whoriskey, Frederick G.
II. Woods Hole Oceanographic Institution
III. Department of Tourism Fish and Game

This card is UNCLASSIFIED

Woods Hole Oceanographic Institution
WHOI-79-49

MATAMEK ANNUAL REPORT FOR 1978 by Frederick G. Whoriskey. 120 pages. May 1979. Supported by the Woods Hole Oceanographic Institution and the Department of Tourism, Fish and Game of the Province of Quebec.

This is a report describing activities associated with the Matamek program in 1978. Research was conducted on biological, chemical and physical factors related to salmonid production in Matamek River and Matamek Lake. Canadian universities, the Quebec government and Woods Hole Oceanographic Institution cooperated in the program.

1. Salmonid ecology
2. Boreal limnology

I. Whoriskey, Frederick G.
II. Woods Hole Oceanographic Institution
III. Department of Tourism Fish and Game

This card is UNCLASSIFIED