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RECOMMENDATIONS FOR FRESHWATER FISHERIES RESEARCH AND MANAGEMENT FROM THE STOCK CONCEPT SYMPOSIUM (STOCS)

Alfred H. Berst, Co-chairman, STOCS Steering Committee

George R. Spangler, Co-convener, STOCS Synthesis

Great Lakes Fishery Commission

1451 Green Road
Ann Arbor, Michigan 48105

January 1982

The Great Lakes Fishery Commission was established by the Convention on Great Lakes Fisheries between Canada and the United States, which was ratified on October 11, 1955. It was organized in April 1956 and assumed its duties as set forth in the Convention on July 1, 1956. The Commission has two major responsibilities: first, develop coordinated programs of research in the Great Lakes and, on the basis of the findings, recommend measures which will permit the maximum sustained productivity of stocks of fish of common concern; second, formulate and implement a program to eradicate or minimize sea lamprey populations in the Great Lakes.

The Commission is also required to publish or authorize the publication of scientific or other information obtained in the performance of its duties. In fulfillment of this requirement the Commission publishes the Technical Report Series, intended for peer-reviewed scientific literature, and Special Publications, designed primarily for dissemination of reports produced by working committees of the Commission. Technical Reports are most suitable for either interdisciplinary review and synthesis papers of general interest to Great Lakes fisheries researchers, managers, and administrators or more narrowly focused material with special relevance to a single but important aspect of the Commission's program. Special Publications, being working documents, may evolve with the findings of and charges to a particular committee. Sponsorship of Technical Reports or Special Publications does not necessarily imply that the findings or conclusions contained therein are endorsed by the Commission.

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[1] Address: 30 Fashion Roseway, Suite 203E
Willowdale, Ontario, Canada M2N 6B4

[2] Address: University of Minnesota
Department of Zoology, Fisheries and Wildlife
219 Hodson Hall, 1980 Folwell Avenue
St. Paul, Minnesota, USA, 58108

TABLE OF CONTENTS

FOREWORD

The 1955 Convention on Great Lakes Fisheries charges, in part, the Great Lakes Fishery Commission to determine what measures are best adapted to make possible the maximum* sustained productivity of any stock of fish in the convention area which is of common concern to the fisheries of Canada and the United States. The commission views development and maintenance of balanced fish communities supported by natural reproduction as the ultimate goal of this charge. In determining measures to reach this goal the commission has come to believe that consideration and application of the stock concept in Great Lakes fishery research, in fish cultural activities, and in the management of fishery resources toward this goal may be advantageous to further rehabilitation of Great Lakes fish stocks.

To provide an opportunity for fishery scientists to explore the possibilities, the commission sponsored the Stock Concept Symposium (STOCS). During the concluding sessions, at the direction of the STOCS Steering Committee and Synthesis Coordinators, the attendees produced recommendations for research and management on the basis of their background plus their STOCS experience. Al Berst (STOCS Co-chairman) and George Spangler (STOCS Synthesis Co-convener) then organized the draft recommendations into this report which the commission is very pleased to make available to fishery workers in the hopes that fishery science may be advanced.

The commission, which has no fishery management authority beyond sea lamprey management, was unsure how to encourage consideration of these recommendations by culturists, researchers, managers, and administrators beyond the normal process of publication and distribution. The STOCS Implementation Working Group led by Peter Ihssen and George Spangler requested in November 1981 that the recommendations be sent to each lake committee for information and comment, seeking especially their ideas for implementation of those recommendations appropriate to their programs. The commission is pleased to comply with this request and has suggested such an item for each 1982 lake committee meeting plus consideration by the Council of Lake Committees. It is hoped that recommendations for consideration by both the commission and its cooperators will be forthcoming from the committee and council members.

The commission wishes to thank its Scientific Advisory Committee (since renamed Board of Technical Experts) for developmental ideas and efforts to assess the feasibility of holding STOCS, and Dr. Henry E. Booke for organizing a session on Fish Genetics - Fundamentals and Implications to Fish Management at the 1977 Annual Meeting of the International Association for Great Lakes Research. The proceedings and supporting materials were reproduced by the commission to provide an information package for the STOCS Steering Committee and a general resource for the STOCS participants.

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*In line with current philosophy and practice among fishery managers, when the commission discusses sustained productivity it substitutes "optimum" for "maximum" in its thinking.

The commission congratulates the STOCS Steering Committee for its planning and execution, the attendees for their written contributions to the STOCS Proceedings and for their diligence and effort in producing synthesis papers and recommendations, and Al Berst and George Spangler for putting the essence into a useable package.

As for the future, the commission looks forward to further consideration of the stock concept through interaction with the lake committees, the STOCS Implementation Working Group, the Board of Technical Experts, and the fish culturists, researchers, managers, and administrators who have responsibility for the welfare of Great Lakes fishery resources.

Carlos M. Fetterolf, Jr.
Executive Secretary
Great Lakes Fishery Commission
19 January 1982

INTRODUCTION

The Stock Concept Symposium (STOCS) was held at the Nottawasaga Inn, Alliston, Ontario, from September 29 to October 9, 1980. The symposium, supported by the Great Lakes Fishery Commission, was an initiative to synthesize knowledge of the stock concept, its present and potential applications in fisheries, and needs for research, especially as applied to the rehabilitation of freshwater fish stocks.

The 88 delegates to the symposium included biologists and fisheries experts from Europe, the east and west coasts of North America, and a substantial representation from the Great Lakes region. The subject matter of the conference, although generally related to the stock concept in fisheries, was diversified deliberately to permit accommodation of differing points of view.

A major product of the symposum is the proceedings, published as a special issue (number 12) of volume 38 of the Canadian Journal of Fisheries and Aquatic Sciences. The proceedings include 37 introductory, keynote, and technical papers. A special effort was made during the symposium to synthesize the technical information in a context facilitating access to ideas and concepts that might be applied to fisheries research and management. The results of these syntheses comprise a set of eight additional papers included in the proceedings.

In the final days of STOCS, delegates were asked to draft recommendations for research and management activities consistent with the findings of the symposium. No effort was made to document the origins of these recommendations, since they arose as part of the total communications experience at the conference. The draft recommendations were subsequently reviewed by a majority of the participants, and presented in a final report to the Great Lakes Fishery Commission Annual Meeting at Ottawa, June 1981. These recommendations reflected the broadest levels of concern of the STOCS participants. Many more recommendations of varying degrees of detail are to be found within the STOCS Proceedings.

This special report makes the general recommendations accessible as an aid to planning research and management activities for fisheries where stock considerations may be relevant. Responsibility for these recommendations rests collectively with all the STOCS participants. To expedite the accessibility of the information in the published Proceedings of the STOCS, the table of contents and list of participants have been included in this report.

The organization of the recommendations in this report is not intended to convey any order of priority. We have attempted to present the ideas with a minimum of editorial changes, although any errors of fact or interpretation are our responsibility.

The contributions of all the delegates making the original recommendations and those who commented on the first draft are much appreciated. Special thanks are due to Jim Clayton, David Evans, Brian Henderson and Joe Koonce, who worked with us on the final stages of assimilating the post-symposium critiques.

STOCS RECOMMENDATIONS

RESEARCH

I. Fish

A. Stock Discreteness

We anticipate many questions of fish stock discrimination which cannot be resolved by molecular (electrophoretic) data along. In such investigations it will probably be necessary to combine the molecular data with morphological, ecological and behavioral data in order to address the biological significance of the fish stocks in question. In the interpretation of the combined molecular and organismal data, the use of the molecular data as a time base seems to have a great deal of merit.

If molecular data are considered in terms of a time base it seems to clarify the use of different kinds of molecular data for different degrees of stock divergence. Thus, although the enzymes that are often assessed electrophoretically represent a class of relatively slowly evolving proteins, gene frequency measures among these enzymes are probably the best data we have for estimating very recent divergences among populations. For slightly greater evolutionary distances between closely related species, the Sarich (1977) electrophoretic band counting method would seem to have some application in fishery studies and it probably deserves more attention than it has received. For moderate evolutionary distances the microcomplement fixation procedure clearly seems to be the method of choice. Probably many of the higher orders of fish taxonomics could be very profitably investigated by this method. If electrophoretic gene frequencies continue to be the main biochemical input into fish stock investigations, then these data should be made as reliable as possible, first paying close attention to the actual genetics of the systems utilized and secondly using the very best electrophoretic methods that can be devised in order to come as close as possible to extracting all of the genetic information from the proteins,

The following specific recommendations are offered to add to information on the subdivisions of populations, especially when the locale of stock management includes several demes.

1. Compare allelic frequency initially to help delineate stocks.

2. Determine the amount or exchange of individuals between the neighboring demes in several different species by electrophoretic and morphological analyses, tagging studies, etc.

3. Investigate the "information flow" between generations as it is influenced by stock structure.

4. Describe population structures of species of interest in unperturbed ecosystems. These data should be valuable for the development of rehabilitation strategies and for comparison with newly established populations.

B. Heritability and Fitness

Fitness is the relative ability of an organism to survive and transmit its genes to the next generation (King 1974). Fitness is influenced by characters having a genetic basis. The degree to which these characteristics are influenced by genetic variation is described by the traits' heritability. Heritability indicates the proportion of the total variance in metric characterisics that is caused by the average effect of genes (Falconer 1960). It is important to understand which characteristics affect fitness and how these characteristics are inherited.

Some possible areas of research are:

1. Heritability of growth, life expectancy, and reproductive traits.

2. Genetic selection caused by commercial fishing and angling practices.

3. Systematic changes in genetic composition caused by various hatchery practices.

4. Determination of the appropriate parameters one must measure to describe stock fitness by literature search, field studies, statistical analysis, etc. These parameters could be used to evaluate fitness of hatchery stocks in relation to wild stocks, e.g. growth, survival, fecundity.

C. Imprinting and Homing

Imprinting, translated from the German *praegung,* was used by Lorenz to describe the irreversible learning that occurred during a brief "sensitive period" after hatching. Imprinting affects a bird's choice of its mother and future mates, and in the case of fish, possibly its spawning shoal.

Many species home to their natal ground with precision, even though they may conduct migrations of great length and complexity (Ricker 1.972, Horral 1981). In the case of lake trout, natal homing has not been demonstrated. However, several authors have suggested this hypothesis (Martin 1960, Martin and Olver 1980, Swanson 1974, Swanson and Sedberg 1980, Loftus 1958) while others report findings which argue against it (McCrimmon 1958, DeRoche MS 1962). Other possible isolating mechanisms are discussed by MacLean et al. (1981).

Reproductive isolation can result in local adaptation and development of discrete stocks. However, knowledge is meager on most aspects of behavioral stock-isolating mechanisms in fishes. Knowledge of such mechanisms may be important in rehabilitation of depleted fishery resources of the Great Lakes.

The following research is recommended:

1. New attempts to follow movements and document homing of lake trout in large lakes.

2. Laboratory investigations of the capability of freshwater species to become imprinted to odors, pressures, temperatures, and other environmental factors.

3. Laboratory and field investigations to determine the specific life history state(s) when imprinting of lake trout to spawning shoals may occur.

4. Field research should be conducted to test the hypothesis of natal homing in lake trout. This might involve "seeding" of former lake trout spawning shoals with genetically marked early stages (fertilized eggs, fry, or alevins) and the subsequent use of the same shoal for spawning by these marked fish.

5. Studies of the homing behavior of male and female fish to ascertain their fidelity to certain spawning shoals.

6. Laboratory and field investigations of the physical/chemical requirements for successful lake trout reproduction.

D. Conservation of Genetic Resources

1. Research is needed on the preservation of gametes. Genetic monitoring should be conducted across the ranges of individual taxa. Management. policies for genetic conservation require additional application of current technology and the development of new technologies.

2. Research is needed on a practical plan for the conservation of genetic variation in different stocks maintained for the purpose of stock rehabilitation. Further, it is important to know what genetic variation exists within various species so that tentative attempts can be made to delineate the stocks present in hatchery systems as well as in the Great Lakes.

II. Sea Lamprey

The success of many of the rehabilitative programs in the Great Lakes is contingent upon the management of sea lamprey. Sea lamprey control using selective toxicants has been accomplished since 1958 on Lake Superior, 1960 on Lake Michigan, 1966 on Lake Huron, and 1971 on Lake Ontario. Application of lampricides may have resulted in insidious

selection favoring ammocetes which migrate from streams to lentic areas in the vicinity of stream mouths and offshore gravel or sand shoals, Similarly, the control program may favor spawning populations in connecting waters such as the St. Marys River, where lampricides are relatively ineffective.

The following research projects are recommended:

A. Test (bioassay) potential sea lamprey resistance to both TFM and Bayer 73, and simulate lamprey control results attendant with various degrees of resistance.

B. Accelerate the development of alternate control methods that relate to anticipated or observed stock differences.

C. Modify stream treatment schedules to minimize the possibility of the development of resistance to treatment.

D. Determine the genetic effects of maleness/femaleness in controlled populations (see: Senner 1980, Soule 1980).

E. Conduct detailed population studies over extended periods to describe and explain variations in population size, cohort size, growth, maturation, mortality factors, and movement.

In addition, an understanding of how the selective predation by sea lamprey may alter the characteristics of the prey fish and its natural history may be useful.

MANAGEMENT

Effective management of the Great Lakes fishery can be achieved only if the managers are aware of and can use the available information. Research done on problems specific to the Great Lakes and work done elsewhere on similar problems should provide the necessary information for informed management. Fish culture, stock rehabilitation, and harvest management should all be considered in terms of the stock concept.

I. Fish Culture Strategies and Policies for Stock Rehabilitation Programs

Attempts at rehabilitation with plantings of hatchery reared stocks are based on the assumption that environmental conditions in the lake will exert selection pressure on the planted fish such that the survivors will be most fit for production of succeeding generations.

Diversity in the genetic and geographical background of the stocks used in hatchery programs should be maintained, because natural selection in the planted stock should operate on a broad spectrum of genetic diversity.

Fishery biologists and managers should recognize that hatchery operations and aquaculture development are not necessarily synonymous with conservation of genetic diversity. These operations, in fact, have

traditionally had the opposite effect. Through selection for production traits genetic diversity has been reduced.

The following recommendations are designed to conserve genetic diversity in fish culture systems. For background information and related references, consult the STOCS synthesis report by Hynes et al. (1981).

A. Policies

1. Re-examine traditional goals of hatchery operations (i.e. maximizing pounds and numbers) with the intention of creating new rationales and goals based on stock rehabilitation and management.

2. Develop a greater understanding of the role of hatcheries in a rehabilitation context. Closer administrative relationships and improved communication between professional and technical staff may facilitate a more rapid implementation of a scientific understanding into the fish production programs.

3. Emphasize the adaptive or experimental management approach in fish culture operations dedicated to new goals. Individual hatcheries and hatchery systems should be directly involved in and partly responsible for carrying out experimental management projects in which fish with carefully defined phenotypes and fitness attributes are monitored for performance in the wild. This should include, for example, the various lake trout strains previously planted in the Great Lakes.

   a. The different stocks of salmonids should be identified phenotypically and mapped both genetically and ecologically.

   b. Valuable stocks should be preserved, preferably by protecting their natural environments or by short-term rearing in hatcheries and subsequent release in suitable bodies of water, or, as a last resort, by freezing of sperm (a gene bank in a restricted sense). For sperm and ova preservation see Erdahl and Graham 1980, Erdahl and Graham 1978, Ott and Horton 1971, Zell 1978.

   c. The introduction of non-indigenous stocks of native species or exotic species should be viewed with caution. Where they are part of a clearly argued management plan, the recommendations related to the origin and genetic characteristics of such fish should be followed. In addition, it should be clear that the removal of stock does not prejudice the population from which it was originally taken.

   d. In addition to field evaluation capability, hatchery operations will require significant increases in expertise and information storage and analysis for planning and evaluation. A mechanism should be established by which current information on the reproductive performance of planted fish

(see also under Operational Procedures! can be made available to cooperating agencies for use in the development of hatchery programs.

4. Devote more attention to planning, monitoring, and control to eliminate or reduce the occurrence of serious fish diseases in hatcheries. Outbreaks of serious diseases may be one means by which strong insidious selection pressures are manifested in hatcheries. Survivors of epizootics in hatcheries may be resistant to the pathogenic agent but may not necessarily reflect the full spectrum of genetic diversity initially present in the stock.

   Many elements of a comprehensive program are well known (e.g., Policy and Model Programs of the Fish Disease Control Committee of the Great Lakes Fishery Commission, or the administrative and regulatory program associated with the Fish Health Protection Regulation under the Fisheries Act, Canada).

   Guidelines and techniques include:

   a. Phase out facilities dependent on surface water supplies which harbor pathogens.

   b. Follow disease classification and monitoring systems for hatchery and wild brood stocks.

   c. Adhere to guidelines on fish transfers.

   d. Create specific pathogen-free domestic broodstocks.

   e. For wild stocks, follow monitoring and quarantine procedures for eggs and use of ground water supply, especially for incubation and early rearing, until fish develop immunological response capabilities.

B. Operational Procedures

   For background information and related references please consult the STOCS synthesis report by Hynes et al. (1981).

   The following specific recommendations are offered.

   1. Sources of fish

      a. Seek broodstock sources from a broad base where possible, rather than retaining single (or few) stocks among available hatcheries.

      b. Bring gametes from self-sustaining stocks into hatcheries to modify certain hatchery stocks (especially those in captivity for many years). Collect eggs and sperm (to establish or augment a broodstock) over the broadest range of adults available (i.e. maturation dates and body sizes).

c. Identify distinctive stocks from which hatchery broodstocks may be established with due regard for the preservation of the original stock.

d. Consider maintenance of distinctive stocks in surrogate lakes for later use.

e. Consider how large a population of any stock is needed to maintain genetic diversity and if surrogate lakes *are* suitable for this purpose.

f. Evaluate the fitness (reproductive ability) of stock crosses relative to "pure stock" by comparing results of simultaneous releases.

2. Avoidance of overt selection in hatchery

a. It may be wise to avoid selecting the "best" fish for broodstocks, and to refrain from practices which deliberately produce products which, at the time of stocking, have characters such as condition factor, fat content, and vertebra number markedly different from wild phenotypes. Such practices include the use of heated water during incubation and early rearing. Identification of relevant parameters for monitoring should be a major area of research.

b. Examine the wisdom of hatchery practices including size grading of fish and elimination of 'runts' or other fish intuitively judged by hatchery staff to be unusual or abnormal.

c. Characterize and monitor genetic diversity of hatchery and wild stocks by methods such as electrophoresis.

3. Control of effective brood stock numbers

a. Question the appropriateness of establishing or maintaining a hatchery for low-fecundity species such as salmonids if the hatchery cannot sustain a brood stock of adequate numbers of each sex up to spawning time. For information on numbers of brood fish see Gregorius (1980) and Ryman and Stahl (1981).

b. Maintain brood stock and perform hatchery spawnings such that equality of male and female number is closely approx; mated.

c. Maintain' records identifying numbers of males and females that establish or augment a broodstock during every brood year.

4. Hatchery design

a. Consideration should be given to managing environmental conditions in hatcheries, a *priori,* to approximate natural

conditions and cycles. Certain parameters which have been well studied, e.g. temperature, oxygen, ammonia, pH, light and photoperiod, ought to be monitored along with fish quality. Serious efforts should be made to look for cause and effect or correlative relationships between these parameters (and others) and success or failure of rehabilitative projects.

b. More serious commitment is required to implement a general strategy to establish smaller, local facilities which are self-sufficient in terms of wild genetic material. Suggestions or examples include elimination of facilities requiring permanent masonry units, shifting to major emphasis on simulated natural spawning, incubation and nursery areas, and use of mobile facilities designed for intensive operation at local sites for a few years at a time.

c. A conclusion drawn from the STOCS results and other recent major science reviews e.g. the 1979 B&Engineering Symposium for Fish Culture, Allen and Kenney 1981, is that many facets of hatchery design have no basis in modern scientific understanding. Therefore an important general and widespread need exists for research which will directly or indirectly focus on hatchery design. An example of one recent, apparently positive concept, is design of new incubation units based on simulation of natural substrate composition. This concept was pioneered in the culture of Pacific slamon (for details, see Barns 1970, 1972, 1974, 1976, 1979).

5. Planting strategy

Careful consideration must be given to the origin of stocks, the numbers to be planted, the planting locations, and the objectives of the program.

II. Commercial and Sports Fisheries Management

A. Stock Dynamics

When stocks are mixed, intimate knowledge of the space/time trajectories of stocks through the year and between years offers the best prospect for harvesting individual stocks selectively. Acquisition of this information should be pursued by all available methods.

B. Harvest Strategy

1. Within identified stocks, managers should be aware of the potential selective effect of harvesting for size with selective gear (e.g. Ricker 1981) and for catch at specific times of the year (e.g. Biette et al. 1981). The potential yield may be reduced in comparison to circumstances where size is not highly heritable.

2. In addition to monitoring the catch for the characterisitics of each stock, the genetic variation should also be assessed. Harvest policies may be adjusted to compensate for changes in population and genetic structure.

3. Encourage imaginative approaches to regulation of fishing in situations where management by sub-stock is now impractical due to costs of monitoring and/or local implementation of restrictive measures.

COMMUNICATION AND APPLICATION OF THE STOCK CONCEPT

I. It is recommended that the following conception of a stock be adopted:

"A stock is a recognizable group of randomly mating individuals of a species that may mix with other groups during certain times of its life cycle, but is more or less reproductively isolated from other such groups through behavioral, spatial or temporal means."

II. The Great Lakes Fishery Commission should publish, possibly in its Technical Report Series, an up-dated version of the bibliography of scientific papers related to the stock concept. This bibliography of some 800 references was assembled during the early planning stages for STOCS to assist authors in literature searches. The bibliography received considerable use, and should continue to be useful to research and management agencies.

III. It is recommended that the Great Lakes Fishery Commission offer its services to cooperating agencies to facilitate communication of the technical ramifications of the stock concept to fisheries managers in the context of current management problems. This might be accomplished through regional workshops convened by cooperating agencies to examine specific problems such as broodstock development and maintenance, environmental control including disease control and water quality in hatcheries, or genetic typing and marking of stocks.

IV. The Great Lakes Fishery Commission should continue to encourage the dissemination and application of information inherent in the stock concept by offering the technical expertise necessary to simulate the genetic consequences of alternative management strategies applied to Great Lakes fishery rehabilitation. Workshops could be convened at the request of cooperating agencies to further develop genetic models similar to those initiated at the STOCS.

V. The Great Lakes Fishery Commission should initiate, sponsor and publish in its Technical Report Series, a document detailing the characteristics and subsequent performance of the various lake trout strains and mixtures of strains previously planted in the Great Lakes.

Upwards of 27 strains of lake trout have been planted in the Great Lakes. Original strains and combinations produced by cooperating agencies should

be described, and relative performance documented in a quantitative, well-referenced manner.

As the years pass, many of these stocks are becoming less available by reason of reproductive failure. Strategies for their preservation should be developed if they are to be retained. Many persons who participated in the early years of the lake trout rehabilitation program are now retired or nearing retirement and should be enlisted in this project.

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TABLE OF CONTENTS - STOCS PROCEEDINGS*

*Duplicated from the Canadian Journal of Fisheries and Aquatic Sciiences. 38(12).

STOCK CONCEPT INTERNATIONAL SYMPOSIUM

STEERING COMMITTEE

Alfred H. Berst, Co-chairman
John M. Byrne
W. John Christie
Peter E. Ihssen
Peter A. Larkin
Raymond C. Simon, Co-chairman
Henry E. Booke
Edward H. Brown, Jr.
Randy L. Eshenroder
Ron J. Poff

George R. Spangler and Joseph F. Koonce - STOCS Synthesis Coordinators

L. Winston Billingsley - STOCS Scientific Editor

Margaret A. Ross - Liaison between STOCS Steering Committee and Great Lakes Fishery Commission

ADVISORY COMMITTEE

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James E. Wright

STOCS SECRETARIAL STAFF

Margaret A. Hamilton
Rita E. Mitchill
Betty J. McEachern
Ruth E. Koerber

LIST OF STOCS PARTICIPANTS*

Dr. F. W. Allendorf
University of Montana
Missoula, Montana 598 I2
USA

Dr. Y. P. Altukhov
Population Genetics Laboratory
USSR Academy of Science, 117809
Moscow. GSP-I, B-33
Gubkin St., 3
USSR

Dr. R. M. Bailey
University of Michigan
Museum of Zoology
Ann Arbor, Michigan 48109
USA

Mr. B. A. Barton
Fisheries Branch
Ontario Ministry of Natural Resources
Parliament Buildings
Toronto, Ontario
CANADA

Mr. A. H. Berst
30 Fashion Roseway. Suite 203E
Willowdale, Ontario M2N 6B4
CANADA

Dr. R. M. Biette
Fisheries Branch
Ontario Ministry of Natural Resources
Parliament Buildings
Toronto. Ontario
CANADA

Dr. L. W. Billingsley
95 Renfrew Ave.
Ottawa. Ontario KIS 1Z6
CANADA

Dr. H. E. Booke
Massachusetts Cooperative Fishery
Research Unit
204 Holdsworth Hall
University of Massachusetts
Amherst. Massachusetts 0 1003
USA

Dr. D. P. Borgeson
Fisheries Division
Michigan Department of Natural Resources
Box 30028
Lansing, Michigan 48909
USA

Miss A. F. Brown
420 South Walnut St.
Apt. 223
Lansing. Michigan 48933
USA

Mr. E. H. Brown Jr.
United States Department of the Interior
Fish and Wildlife Service
Great Lakes Fishery Laboratory
1451 Green Road
Ann Arbor. Michigan 48105
USA

Dr. P. F. Brussard
Division of Biological Science
Langmuir Laboratory
Cornell University
Ithaca, New York 14853
USA

Mr. J. M. Byrne
Fisheries Branch
Ontario Ministry of Natural Resources
Parliament Buildings
Toronto. Ontario
CANADA

Dr. J. M. Casselman
Fisheries Branch
Ontario Ministry of Natural Resources
Box 50 -
Maple, Ontario L0J 1E0
CANADA

Mr. W. J. Christie
Ontario Ministry of Natural Resources
Glenora Fisheries Research Station
R. R. #4
Picton. Ontario K0K 2T0
CANADA

Dr. J. W. Clayton
Department of Fisheries and Oceans
501 University Crescent
Winnipeg, Manitoba R3T 2N6
CANADA

Dr. P. J. Colby
Fisheries Branch
Ontario Ministry of Natural Resources
Thunder Bay. Ontario P7C 5G6
CANADA

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Mr. J. J. Collins
Ontario Ministry of Natural Resources
Fisheries Research Station
R.R. #I
Tehkummah. Ontario POP 2CO
CANADA

Dr. E. J. Crossman
Royal Ontario Museum
100 Queen's Park
Toronto. Ontario M5S 2C6
CANADA

Mr. F. H. Dahl
U.S. Fish and Wildlife Service
P.O. Box 758
Marquette, Michigan 49855
USA

Mr. T. R. Dehring
420 South Walnut St.
Apt. 223
Lansing, Michigan 48933
USA

Mr. R. L. Desjardine
Central Region
Ontario Ministry of Natural Resources
10670 Yonge Street
Richmond Hill, Ontario L4C 3C9
CANADA

Dr. D. P. Dodge
Fisheries Branch
Ontario Ministry of Natural Resources
Parliament Buildings
Toronto. Ontario
CANADA

Mr. R. L. Eshenroder
Great Lakes Fishery Commission
1451 Green Road
Ann Arbor. Michigan 48105
USA

Dr. D. 0. Evans
Fisheries Branch
Ontario Ministry of Natural Resources
Box 50
Maple. Ontario LOJ IEO
CANADA

Mr. C. M. Fetterolf Jr.
Great Lakes Fishery Commission
1451 Green Road
Ann Arbor. Michigan 48105
USA

Mr. J. M. Fraser
Fisheries Branch
Ontario Ministry of Natural Resources
Box 50
Maple. Ontario LOJ IM
CANADA

Dr. A. J. Gharrett
University of Alaska
Juneau, Alaska 99803
USA

Dr. D. B. Goldthwaite
U.S. Fish and Wildlife Service
Suite 700. 1 Gateway Center
Newton Comer
Massachusetts 02158
USA

Mr. J. L. Goodier
Institute of Environmental Studies
University of Toronto
Toronto, Ontario M5S IA4
CANADA

Mrs. M. A. Hamilton
95 Yorkview Drive
Willowdale, Ontario M2R 1J9
CANADA

Dr. J. R. Harlan
Crop Evolution Laboratory
Agronomy Department
University of Illinois
Urbana, Illinois 61801
USA

Mr. R. C. Haas
Lake St. Clair Great Lakes Station
Mt. Clemens. Michigan 48045
USA

Mr. R. Hassinger
Department of Natural Resources
Regional Headquarters
424 Front Street
Brainerd, Minnesota 56401
USA

Dr. J. H. Helle
National Marine Fisheries Service
Auke Bay. Alaska 99803
USA

Dr. B. A. Henderson
Ontario Ministry of Natural Resources
Fisheries Research Station
R.R. #1
Tehkummah, Ontario POP 2C0
CANADA

Dr. R. M. Horrall
Marine Studies Center
Meteorology and Space Sciences Building
University of Wisconsin-Madison
1225 West Dayton Street
Madison, Wisconsin 53706
USA

Mr. J. D. Hynes
Fisheries Branch
Ontario Ministry of Natural Resources
Parliament Buildings
Toronto. Ontario
CANADA

Dr. P. E. Ihssen
Fisheries Branch
Ontario Ministry of Natural Resources
Box 50.
Maple. Ontario L0J 1E0
CANADA

Dr. M. G. Johnson
Great Lakes Biolimnology Laboratory
P.O. Box 969
Owen Sound, Ontario N4K 6H6
CANADA

Dr. S. R. Kerr
Bedford Institute of Oceanography
Marine Ecology Laboratory
Dartmouth, Nova Scotia B2Y 4A2
CANADA

Mr. G. R. King
Wisconsin Department of Natural Resources
Box 589
Bayfteld, Wisconsin 54814
USA

Mrs. R. E. Koerber
Great Lakes Fishery Commission
1451 Green Road
Ann Arbor, Michigan 48105
USA

Dr. J. F. Koonce
Department of Biology
Case Western Reserve University
Cleveland, Ohio, 44 106
USA

Dr. C. C. Krueger
Wisconsin Department of Natural Resources
101 South Webster Street
GEF 11
Box 7921
Madison. Wisconsin 53707
USA

Dr. J. H. Kutkuhn
Great Lakes Fishery Laboratory
1451 Green Road
Ann Arbor, Michigan 48105
USA

Mr. A. K. Lamsa
Great Lakes Fishery Commission
1451 Green Road
Ann Arbor, Michigan 48105
USA

Dr. P. A. Larkin
Institute of Animal Resource Ecology
University of British Columbia
2075 Wesbrook Mall
Vancouver, British Columbia V6T 1W5
CANADA

Mr. A. H. Lawrie
Fisheries Branch
Ontario Ministry of Natural Resources
Box 50
Maple. Ontario LOJ IEO
CANADA

Dr. C. C. Lindsey
University of British Columbia
2354-6270 University Blvd.
University Campus
Vancouver, British Columbia V6T 2A9
CANADA

Mr. K. H. Loftus
Fisheries Branch
Ontario Ministry of Natural Resources
Parliament Buildings
Toronto, Ontario
CANADA

Dr. J. A. MacLean
Fisheries Branch
Ontario Ministry of Natural Resources
Box 50
Maple, Ontario LOJ IEO
CANADA

Dr. P. S. Maitland
institute of Terrestrial Ecology
78 Craighill Road
Edinburgh EH6 4RQ
SCOTLAND

Mr. N. V. Martin
R.R. #4
Meaford, Ontario NOH 1Y0
CANADA

Dr. J. McDonald
Pacific Biological Station
Nanaimo, British Columbia V9R SK6
CANADA

Mrs. B. McEachern
U.S. Fish and Wildlife Service
P.O. Box 758
Marquette, Michigan 49855
USA

Dr. J. McGlade
Bedford Institute of Oceanography
Marine Ecology Laboratory
Danmouth. Nova Scotia B2Y 4A2
CANADA

Mrs. R. E. Mitchell
Fisheries Branch
Ontario Ministry of Natural Resources
Box 50
Maple, Ontario L0J 1E0
CANADA

Mr. S. J. Nepszy
Fisheries Research Station
Ontario Ministry of Natural Resources
R.R. #2
Wheatley. Ontario N0P 2P0
CANADA

Dr. N.-A. Nilsson
institute of Freshwater Research
S-1170 I I Drottningholm
SWEDEN

Mr. C. Olver
Fisheries Branch
Ontario Ministry of Natural Resources
Parliament Buildings
Toronto, Ontario
CANADA

Mr. N. R. Payne
Lake Huron Assessment Unit
Ontario Ministry of Natural Resources
Owen Sound. Ontario N4K 6H6
CANADA

Mr. J. Peck
Anadromous Fish Research
Marquette. Michigan 48955
USA

Dr. D. P. Philipp
Illinois Natural History Survey
172 Natural Resources Building
Room 133 Annex
Urbana, Illinois 61801
USA

Mr. R. J. Poff
Department of Natural Resources
Box 7921
Madison, Wisconsin 53707
USA

Dr. G. Power
Department of Biology
University of Waterloo
Waterloo. Ontario N2L 3G1
CANADA

Mr. J. A. Reckahn
Ontario Ministry of Natural Resources
Fisheries Research Station
R.R. #1
Tehkummah. Ontario POP 2C0
CANADA

Dr. H. A. Regier
Institute of Environmental Studies
University of Toronto
Toronto, Ontario M5S1A4
CANADA

Dr. W. E. Ricker
Pacific Biological Station
Nanaimo. British Columbia V9R 5K6
CANADA

Miss M. A. Ross
Great Lakes Fishery Commission
1451 Green Road
Ann Arbor, Michigan 48105
USA

Mr. R. A. Ryder
Fisheries Branch
Ontario Ministry of Natural Resources
Thunder Bay. Ontario P7C 5G6
CANADA

Dr. N. Ryman
Institute of Genetics
University of Stockholm
Box 6801
S-113 86 Stockholm
SWEDEN

Dr. R. L. Saunders
Fisheries and Environmental Sciences
Fisheries and Oceans Canada
Biological Station
St. Andrews, New Brunswick E0G 2X0
CANADA

Dr. B. Shuter
Fisheries Branch
Ontario Ministry of Natural Resources
Box 50
Maple. Ontario L0J 1E0
CANADA

Dr. R. C. Simon
National Fisheries Center
U.S. Fish and Wildlife Service
Kearneysville. West Virginia 25430
USA

Dr. P. G. Sly
c/o Glenora Fisheries Research Station
R.R. #4
Picton. Ontario K0K 2T0
CANADA

Dr. G. R. Smith
University of Michigan
Museum of Zoology
Ann Arbor. Michigan 48109
USA

Dr. M. H. Smith
Savannah River Ecology Laboratory
Alken, South Carolina 49801
USA

Dr. G. R. Spangler
University of Minnesota
Depatrment of Entomology
Fisheries and Wildlife
219 Hodson Hall, 1980 Folwell Avenue
St. Paul. Minnesota 55108
USA

Dr. G. Stahl
Institute of Genetics
University of Stockholm
Box 6801
S-113 86 Stockholm
SWEDEN

Dr. Wm. W. Taylor
Depanment of Fisheries and Wildlife
Michigan State University
East Lansing, Michigan 48824
USA

Dr. J. E. Thorpe
Department of Agriculture and Fisheries
Freshwater Fisheries Laboratory
Faskally Pitlochry
Perthshire PH15 4LB
SCOTLAND

Mr. T. H. Todd
U.S. Department of the Interior
Fish and Wildlife Service
Great Lakes Fishery Laboratory
1451 Green Road
Ann Arbor, Michigan 48105
USA

Dr. F. M. Utter
Northwest and Alaska Fisheries Center
Coastal Zone and Estuaries Studies Division
2725 Montlake Boulevard East
Seattle. Washington 98112
USA

Mr. A. Wainio
Fisheries Branch
Ontario Ministry of Natural Resources
Parliament Buildings
Toronto. Ontario
CANADA

Dr. C. Walters
Institute of Animal Resource Ecology
University of British Columbia
2075 Wesbrook Mall
Vancouver, British Columbia V6T 1W5
CANADA

Dr. D. A. Webster
N.Y. State College of Agriculture and Life Sciences
Cornell University
Department of Natural Resources
Fernow Hall
Ithaca, New York 14853
USA