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*Summary of
paper on*

WORKING GROUP ON GENETICS

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INTRODUCTION

The new Working Group on Genetics met for 3 days in Copenhagen this past May with Gunnar Naevdal as Chairman. As specified in its approved terms of reference, considerations were restricted to genetics in mariculture and did not touch upon genetics of natural populations. It was decided to restrict discussions at this first meeting to oysters and salmonids. This was only because they have been the longest cultured and studied, and should not be taken to mean genetic improvement of other aquacultured groups was discounted. It was agreed to consider genetics and breeding of certain freshwater species insofar as it provided examples for the marine fish.

Eight (8) persons were present at the meeting (one an observer) from 7 ICES-member countries - Norway, England, Ireland, FRG, France, Canada, and the U.S. A second Working Group member from Canada could not attend, as well as two from France. Two appointed members from Sweden had to be in the U.S. at the time, and unfortunately not all Working Group members could change their schedules to accommodate a change in the meeting date.

REPORTED ACTIVITIES IN THE SEVERAL COUNTRIES

Prior to seriously considering the present status of oyster and salmonid breeding and genetics, members from the various countries represented at the meeting presented summary reports of ongoing or planned aquaculture genetics and breeding or related activities in their respective countries. In the case of those countries not appointing Working Group members this information was requested of their Delegates. At the time the Study Group Report was prepared our Chairman had received replies from all ICES countries except Belgium, Poland and the USSR. All these reported activities are listed by country as an appendix

to the Working Group Report. This is the first such summary to my knowledge, and should so be of some general interest. Significant activities were reported by 11 countries - Canada, Denmark, Finland, France, FRG, Ireland, Netherlands, Norway, Sweden, U.K., and U.S. I will briefly run through these reported activities which appear to me to be a substantial beginning although there is no way of knowing from such reports what the financial or manpower commitment to such projects is.

Canada

In Canada activities on marine species are underway at 3 institutions:

- 1) Dalhousie University - on oysters - and you have heard reports on this before at Mariculture Committee meetings - and on amphipods as a model organism for studying the genetics of domestication.
- 2) Bedford Institute of Oceanography - quantitative and biochemical genetics of the blue mussel.
- 3) North American Salmon Research Center - where a rather extensive program of salmon breeding is underway. Initially concerned with sea ranching this program has more recently also concerned itself with cage rearing.
- 4) At Nanaimo, B.C., the Department of Fisheries and Oceans is initiating breeding experiments with coho, and studying changes in the frequencies of biochemical genes in the domestication process.
- 5) At the West Vancouver Laboratory of the same department sex reversal is being induced in several Pacific salmon and efforts are being made to produce sterile fish. Gynogenesis and cryopreservation are being researched.
- 6) The Ontario Ministry of Natural Resources is studying genetic markers in rainbow trout in collaboration with geneticists at the Agricultural University of Guelph.

7) Strains of rainbow trout and arctic char are being developed at the Freshwater Institute, Department of Fisheries and Oceans in Winnipeg.

Denmark

A project concerned with the cryopreservation of fertilized eggs of trout, herring, turbot, and sole is under consideration. This would be conducted jointly by the Danish Institute for Fisheries and Marine Research and the Royal Veterinary and Agricultural University.

Finland

The Finnish Game and Fisheries Research Institute is conducting studies on the selective breeding, hybridization and sex control of rainbow trout with interest in growth and disease resistance. Eventually other salmonids will be included in the breeding programs. Plans are being drawn up for a new fish breeding station in central Finland.

Cryopreservation studies on salmonid sperm are being conducted at the University of Joensuu.

In cooperation with the Genetics Department, University of Helsinki, the biochemical genetic variation of Atlantic salmon is being analyzed. An application of this research will be in efforts at restocking and managing what Atlantic salmon resources remain of the natural river populations.

France

A variety of genetic research on both salmonids and oysters is underway in France at the Laboratoire d'Ecologie des Poissons et d'Aménagement des Pêches, INRA. In the salmonids this encompasses heritability studies, analysis of inbreeding, cytogenetics, Mendelian genetics and biochemical genetics. More recent work on oysters concerns disease resistance, inter- and intra-species variation and hybridization.

Federal Republic of Germany

Present research concerns improvement of husbandry techniques of the oyster and this would provide a better basis for more controlled breeding.

Ireland

At the Department of Zoology, University College, Galway, the Japanese and European oysters, and also Mytilus edulis, are the subjects of quantitative genetics, cytogenetic and biochemical genetic studies. The college has use of a pilot-scale hatchery and laboratory complex about 50 miles away. Work is done in cooperation with various fish farms.

Netherlands

Netherlands is conducting genetic studies on carp and other freshwater fish.

Norway

As this committee is aware, rather extensive salmonid breeding and genetic studies are underway, some in conjunction with commercial fish farms, at both the Department of Animal Genetics and Breeding of the Agricultural University of Norway and at the Institute of Marine Research. For those experts not usually meeting with the Mariculture Committee these studies concern projection of selection advances and inbreeding effects for a number of commercially important characters, and also the induction of polyploidy and genetic sterilization of fish.

Sweden

In 1980 Sweden organized a Steering Committee on Aquaculture with the aim of coordinating future developments within the entire aquaculture field. There are 7 working groups and one of these is concerned with genetics. Recommendations are to be made regarding a national policy for breeding compatible with both genetic (I presume conservation of natural genetic variability) and economic

prerequisites. Concerns are over both restocking and preservation of endangered stocks for a limited number of salmonid species. Scientists concerned with this work are at Department of Genetics, University of Stockholm, and at the Institute of Freshwater Research at Drottningholm.

United Kingdom

Principal genetic studies are conducted by the University of Agriculture, Fisheries and Food at the Lowestoft and Conwy Laboratories.

Fish genetic studies were begun in 1966 with limited facilities, but an experimental farm is now under construction which will allow expansion of special breeding.

For rainbow trout the long-term aim is to develop strains which will satisfy all UK needs. Strains are now being evaluated for heterozygosity. Gynogenesis is being employed to develop inbreds. The advantages of an intense inbreeding-hybridization program over more conventional selection programs are being evaluated.

Physiological control of sex is now being employed in some commercial production, and it is anticipated that genetic sterility will be accomplished in the future through use of triploids.

Recently, genetic research on both the European and Japanese oysters was begun. Hybridization studies are underway with both. The Japanese oyster is being inbred for hybridization trials of the inbred lines.

Some genetic research is underway on sex control in salmon.

United States

Mariculture Committee members heard a few years ago about U.S. programs. Ones being funded in '81 were summarized for Working Group members from new information I obtained through the Sea Grant Program, National Marine Fisheries Service, and the U.S. Departments of Interior and Agriculture.

The oyster is being bred and studied at the University of Washington, Seattle; at the Milford, Conn., Laboratory of the NEFC; and at Rutgers University where emphasis is on resistance to the MSX disease.

Natural clam populations are being studied at three southern universities. At the University of California hybridization and fertilization of abalone are being studied. Crustaceans are being studied at Davis and also at two other universities.

Genetics of the seaweed, Chondrus crispus, is being studied at the University of Maine and University of New Hampshire.

Projects are funded at the University of Oregon, Washington and Alaska for development of salmon stocks for pen culture. The genetic interactions of natural and hatchery stocks of pink salmon are being researched in Alaska.

The Department of the Interior has a genetics and breeding program for rainbow trout broodstock. We have here a paper from Dr. Kincaid of this department. Strain hybridization is being conducted, and inbred lines are being developed for hybridization. A trout strain registry is being developed, and strains are being characterized electrophoretically.

At Cornell University an effort is being made to develop strains of brook trout able to survive in acid water. At 3 other universities genetic studies are also underway on brook trout. At the University of Pennsylvania basic genetic studies concern the evolution of trout gene and chromosome complexes.

Catfish breeding and genetic studies are underway at no less than 7 midwestern and southern universities and one state experiment station. Studies encompass strain evaluation and crossbreeding, heritability estimates, 2-way selection experiments, inbreeding and diet strain interactions. Dr. Smitherman will tell of some of the work being conducted at Auburn State University, Alabama.

Other freshwater species under serious study are Tilapia, striped bass and yellow perch.

Cryopreservation studies are being pursued on yellow perch at the University of Wisconsin; striped bass at North Carolina State University; and on pike, trout, salmon, and muskellege sperm, eggs and zygotes at the University of Minnesota.

DELIBERATIONS ON SALMONID GENETICS

Published and ongoing salmon research and breeding impressed on Working Group members how few controlled generations salmonid researchers have to deal with relative to what agricultural geneticists concern themselves with. Yet, and perhaps because of this, a common feature of all salmonid populations so far examined has been the presence of considerable genetic variability. Dr. Saunders from Canada and Dr. Naevdal brought to the meeting some of their most recent results and deliberations. What is known of several selection goals and production traits was discussed and recommendations made on particular research needs: These were the relative importance of growth rate, and factors influencing it (food conversion rates and social hierarchy influencing food consumption); age at maturation; smolting factors; egg size, season of spawning; resistance to disease. In ranched salmon, selection for return rate which must be greatly influenced by fishing mortality and natural selection may be of minor importance. It was emphasized that selection goals be precisely defined and kept simple to maximize their effectiveness. Note was made of the importance of improved husbandry in the short term, and of genetic gain in the long term.

Hybridization of salmonids was also touched on (with reference to disease resistance). The use of intense inbreeding followed by hybridization of inbreds as an alternative to more standard selection programs was brought up several times. It was not possible to advise on the relative merits of the two approaches.

The importance of controls was stressed and there were discussions as to just what can constitute a good control in long-term, large-scale breeding of other than small or experimental species. See page 9 of the report.

These points are all taken up in the Working Group Report which concludes that salmon production could probably be increased significantly following genetic research and its application.

DELIBERATIONS ON OYSTER GENETICS

Also discussed was the breeding and genetics of oysters using my '76 review, the '79 review by Dr. Newkirk at Dalhousie, and a '78 Japanese review translated to English. I prepared a bibliography of papers on oyster genetics and breeding for distribution. This numbers only 140 papers, including abstracts and reviews, far less than a 24-year (1948-1972) general bibliography of oysters with over 4000 references.

Relative advantages and difficulties of genetic studies on oysters and salmonids were dealt with. In some regards one appears a better marine model organism than the other and vice versa. Certainly, genetic studies on the oyster are fewer and more recent.

With the aid of information from the published literature and contract reports to my agency I was able to provide some information on the current status of salmon and oyster culture in the U.S. relative to any perceived need for genetic improvement of stock.

The application of genetic principles to hatchery production of oysters was advised insofar as this is practical. Poor breeding practices could contribute further to current hatchery difficulties. At the same time the Working Group noted a need for a wider and stronger base of general genetic information on shellfish, and also the necessity for better husbandry practices. Likely success of selection for growth and genetics of larval viability was treated.

The same guidelines as given for salmonid rearing pertain generally to oysters as well. Particular points made on oysters (pages 11-13) concerned interest in, and need for disease resistance; necessity to assess strain and ecotype differences; importance of remnants of remaining populations of European oysters; and lack of much data on species hybrids.

SEPARATE DISCUSSIONS ON CYTOGENETICS AND CRYOPRESERVATION

Cytogenetics and cryopreservation were discussed as special topics. Both were concluded to be areas which deserve more recognition. Cytogenetics, aside from its basic aspects, is of importance in manipulations aimed at producing inbreds through gynogenesis, genetic sterility and in polyploidy, the subject of one U.S. paper at this meeting and touched on in another. The Working Group calls the attention of the Anadromous and Catadromous Fish Committee and the Working Group on Introduction/Transfer of Marine Organisms to the significance of single sex broods and sterile fish production techniques.

The Working Group agreed upon the likelihood that successful long-term cryopreservation of fish gametes and/or zygotes would greatly facilitate mariculture breeding even making possible controls otherwise impossible in breeding experiments, as well as stimulate aquaculture generally.

RECOMMENDATIONS MADE WITHOUT ANY PRIORITY

1) That ICES-member countries recognize that pilot-scale selection programs are essential to genetic improvement and that selection programs need be continued over several breeding generations to exploit potential improvements and evaluate fully the results.

2) Limited control over the species life cycle limits genetic progress; husbandry improvements must go hand-in-hand with breeding efforts.

3) Sources of experimental stock should be identified as completely as possible in initiating or reporting on programs.

4) Somewhat standard protocol should be followed in designing, conducting, and reporting breeding programs so results can be fully evaluated; for example, controls must be appropriate.

5) Recognition is sought for the importance of developing special strains for cage rearing of salmonids and/or intense rearing of oyster stock.

6) Recognition is sought for the importance of developing suitable salmonid stocks for sea ranching and/or restocking of oyster beds.

7) Encouragement is sought for further development in the special areas of cytogenetics, biochemical genetics and cryopreservation as they in important ways relate to mariculture.

8) That the Working Group and Council exchange information with other genetic groups with parallel interests, and that observers from these other groups and non-ICES countries with significant aquaculture genetic endeavors be invited to future Working Group meetings.

9) Finally, it was recommended that the '82 COST Symposium on Mariculture Genetics be endorsed by ICES,

10) and that the ICES Working Group continue, and meet in May of '83 at Lowestoft.