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ATLANTIC HERRING

U.S. RESEARCH AND SUGGESTIONS FOR FUTURE PROGRAMS

BY THE:

BUREAU OF COMMERCIAL FISHERIES

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ATLANTIC HERRING--BACKGROUND INFORMATION

DISTRIBUTION

HERRING OCCUR ALONG THE EAST COAST OF NORTH AMERICA FROM VIRGINIA TO LABRADOR, WITH CENTERS OF ABUNDANCE IN THE GULF OF MAINE AND THE GULF OF SAINT LAWRENCE. THEY ARE USUALLY CAUGHT WITHIN A FEW MILES OF SHORE, AND OFTEN VERY CLOSE TO SHORE. SPAWNING HERRING CONSTITUTE THE BASIS FOR THE FISHERY IN THE GULF OF SAINT LAWRENCE AND ON THE NOVA SCOTIA COAST, WHILE SARDINE-SIZE HERRING (FISH IN THEIR FIRST THREE YEARS OF LIFE) ARE CAUGHT IN THE GULF OF MAINE. A LARGE STOCK OF ADULTS ALSO EXISTS ON GEORGES BANK, BUT HAS BEEN UTILIZED ONLY RECENTLY.

ABUNDANCE

HERRING ARE SUBJECT TO SPORADIC FLUCTUATIONS IN ABUNDANCE. FOR EXAMPLE, LANDINGS IN THE GULF OF SAINT LAWRENCE FELL FROM A HIGH OF OVER 40,000 METRIC TONS IN 1952 TO A LOW OF 20,000 METRIC TONS IN 1958, DUE LARGELY TO EPIDEMIC DISEASE. LANDINGS OF SARDINE-HERRING IN THE GULF OF MAINE IN THE PAST DECADE HAVE FLUCTUATED BETWEEN 70 AND 170 MILLION POUNDS.

FLUCTUATIONS IN AVAILABILITY

THE FISHERY FOR ADULT HERRING IN THE GULF OF SAINT LAWRENCE AND ON THE NOVA SCOTIA COAST IS CONFINED TO THE SPAWNING SEASONS (SPRING AND AUTUMN), WHILE THE FISHERY FOR IMMATURE HERRING IN THE GULF OF MAINE IS CARRIED ON PRINCIPALLY FROM MAY TO DECEMBER. SINCE MOST HERRING ARE CAUGHT BY RELATIVELY IMMOBILE GEAR (ANCHORED GILL NETS FOR ADULTS; WEIRS AND STOP SEINES FOR IMMATURES), AVAILABILITY TO SUCH GEAR IS IMPORTANT. LITTLE IS KNOWN OF FACTORS THAT INFLUENCE AVAILABILITY--THIS IS PARTICULARLY TRUE FOR MOVEMENTS OF IMMATURE FISH IN INSHORE WATERS. IN RECENT YEARS PURSE SEINES HAVE BEGUN TO TAKE INCREASING QUANTITIES OF HERRING, PARTICULARLY IN THE COLDER MONTHS OF THE YEAR, AND PARTICULARLY IN THE EASTERN GULF OF MAINE.

CATCH

U. S. HERRING LANDINGS IN THE GULF OF MAINE HAVE AVERAGED 150 MILLION POUNDS DURING THE PAST DECADE. OVER 90% OF THIS CATCH IS PROCESSED AS SARDINES; THE REMAINDER IS USED FOR PET FOOD, PEARL ESSENCE, REDUCTION, SMOKING, ETC. CANADIAN ANNUAL LANDINGS (GULF OF SAINT LAWRENCE AND NOVA SCOTIA) WOULD APPROXIMATE THIS AMOUNT. BECAUSE OF THE RELATIVE INEFFICIENCY OF THE GEAR USED, AND THE SEASONAL NATURE OF THE FISHERY IN MOST AREAS, THE CATCH CAN NOT BE CONSIDERED AS A RELIABLE INDICATION OF ABUNDANCE OF HERRING IN ANY SINGLE YEAR.

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MAJOR U.S. RESEARCH ACCOMPLISHMENTS

THE HERRING BIOLOGICAL RESEARCH PROGRAM AT BOOTHBAY HARBOR BEGAN IN 1947, DURING AN EPIDEMIC OF FUNGUS DISEASE IN GULF OF MAINE HERRING. RESEARCH WAS CARRIED OUT UNDER A COOPERATIVE AGREEMENT WITH THE U. S. FISH AND WILDLIFE SERVICE, THE MAINE DEPARTMENT OF SEA AND SHORE FISHERIES, AND THE MAINE SARDINE PACKERS ASSOCIATION. THE DISEASE SUBSIDED BY 1949, AND FOR THE NEXT FEW YEARS HERRING RESEARCH WAS CONCERNED WITH SIZE OF FISH AT MATURITY AND WITH DEVELOPMENT OF A STATISTICAL SYSTEM FOR THE FISHERY, IN ADDITION TO CONTINUING STUDIES OF DISEASE. EXPANSION IN RESEARCH ACTIVITIES AND PERSONNEL WAS EFFECTED IN 1956. EFFORTS WERE CONCENTRATED ON UNDERSTANDING THE LIFE HISTORY AND BIOLOGY OF HERRING, AND THE ENTIRE GULF OF MAINE WAS CONSIDERED THE STUDY AREA. AN EXTENSIVE VESSEL PROGRAM PROVIDED KNOWLEDGE ABOUT THE DISTRIBUTION AND DRIFT OF HERRING LARVAE, AND DISCLOSED THE EXISTENCE OF A MAJOR HERRING SPAWNING AREA ON GEORGES BANK. IN 1957 A 3-YEAR STUDY OF PASSAMAQUODDY BAY WAS INSTITUTED, TO DETERMINE WHETHER A PROPOSED TIDAL POWER DAM WOULD AFFECT THE FISHERY. THIS STUDY PRODUCED VALUABLE FINDINGS ABOUT THE BEHAVIOR AND MOVEMENTS OF HERRING. AFTER THE COMPLETION OF THE PASSAMAQUODDY STUDY, MAJOR ATTENTION HAS BEEN FOCUSED ON THE FACTORS THAT INFLUENCE ABUNDANCE OF SARDINE-SIZE HERRING AND THEIR AVAILABILITY TO THE FISHERY. SPECIFIC AREAS OF RESEARCH INCLUDE STUDY OF DISEASES, SURVIVAL OF HERRING LARVAE, MOVEMENTS OF IMMATURE FISH, INSHORE ENVIRONMENT OF HERRING, AND POPULATIONS OF HERRING.

SIGNIFICANT ACCOMPLISHMENTS INCLUDE:

(1) ESTABLISHMENT OF A COMPREHENSIVE STATISTICAL SYSTEM FOR THE FISHERY. THIS IS VITAL TO ALMOST EVERY OTHER PHASE OF RESEARCH. THE SYSTEM HAS BEEN IN OPERATION SINCE 1947, AND PROVIDES DETAILED INFORMATION ABOUT EACH INDIVIDUAL HERRING CATCH MADE ON THE NORTHERN NEW ENGLAND COAST. SEASONAL AND ANNUAL VARIATIONS IN QUANTITIES, SIZES OF FISH, AND LOCATIONS OF CATCH CAN BE DETERMINED. INFORMATION HAS BEEN RECORDED ON KEYSORT CARDS, WITH THE COOPERATION OF SARDINE INSPECTORS OF THE MAINE DEPARTMENT OF AGRICULTURE. DATA ARE KEPT ON A CURRENT BASIS FROM MONTH TO MONTH.

(2) DETERMINATION OF THE SIZE AT MATURITY OF HERRING. THIS IS IMPORTANT TO AN UNDERSTANDING OF SPAWNING STOCKS OF HERRING AND THE PERIOD WHEN THEY ARE OF COMMERCIAL IMPORTANCE AS SARDINES. THE STUDY DISCLOSED THAT THE FISHERY FOR SARDINE-HERRING DEPENDED ENTIRELY ON IMMATURE FISH, AND THAT THE MINIMUM SPAWNING SIZE IN THE GULF OF MAINE WAS 20 CENTIMETERS.

(3) DETERMINATION OF LOCATION AND EXTENT OF HERRING SPAWNING AREAS IN THE GULF OF MAINE. IT IS IMPORTANT TO HAVE AS MUCH INFORMATION AS POSSIBLE ABOUT THE SOURCES OF SUPPLY OF IMMATURE HERRING. THE DISCOVERY OF A MAJOR SPAWNING AREA ON GEORGES BANK WAS THE MOST SIGNIFICANT OUTCOME OF THIS WORK. OTHER SPAWNING AREAS, ON OFFSHORE BANKS AND IN INSHORE AREAS, WERE LOCATED, PRINCIPALLY BY CAPTURE OF 5 TO 7 MM. LARVAE. THE GEORGES BANK SPAWNING AREA WAS SURVEYED FOR SEVERAL YEARS, TO DETERMINE THE EXTENT OF SPAWNING AND SUBSEQUENT DRIFT OF LARVAE. CRUISES DURING LATE AUTUMN AND WINTER INDICATED THAT PREDOMINANT DRIFT WAS SOUTHWARD AND WESTWARD, AWAY FROM THE GULF OF MAINE.

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(4) A BETTER UNDERSTANDING OF OCEAN CURRENT PATTERNS IN THE GULF OF MAINE. A CONTINUING PROGRAM OF DRIFT BOTTLE RELEASES ON ALL CRUISES HAS LED TO A BETTER SEASONAL PICTURE OF CIRCULATION ALONG THE NORTHERN NEW ENGLAND COAST. RESEARCH WAS CARRIED OUT THROUGH A CONTRACT WITH THE WOODS HOLE OCEANOGRAPHIC INSTITUTION. THE GENERAL COUNTER-CLOCKWISE EDDY, CHARACTERISTIC OF THE GULF OF MAINE IN SUMMER, WAS FOUND TO WEAKEN AND DISAPPEAR IN WINTER. FURTHERMORE, THE STRENGTH OF THE EDDY WAS FOUND TO FLUCTUATE ANNUALLY -- RELATED APPARENTLY TO VARIATIONS IN RIVER RUNOFF.

(5) KNOWLEDGE ABOUT THE EXTENT OF MOVEMENTS OF IMMATURE HERRING ALONG THE COAST. SARDINE-SIZE FISH HAVE BEEN TAGGED FOR SEVERAL YEARS, AND THE RESULTS SUGGEST VERY LIMITED MOVEMENTS OF SUCH FISH DURING THE FISHING SEASON. TWO TYPES OF TAGS HAVE BEEN USED: A PLASTIC DISC OPERCLE TAG, USED PRINCIPALLY WITH STUDIES IN PASSAMAQUODDY BAY, AND A SPAGHETTI TAG INSERTED THROUGH THE DORSAL MUSCULATURE, USED IN MORE RECENT STUDIES. SEVERAL OF THE LATTER TYPE HAVE BEEN RECOVERED AFTER OVERWINTERING. MAXIMUM MOVEMENT OF TAGGED FISH DID NOT EXCEED 50 MILES FROM TAGGING SITE.

INFORMATION FROM SO-CALLED "PARASITE TAGS" INDICATES THAT HERRING DO NOT UNDERTAKE EXTENSIVE MIGRATIONS DURING THE PERIOD WHEN THEY ARE OF COMMERCIAL IMPORTANCE AS SARDINES. A PROTOZOAN PARASITE HAS BEEN FOUND ONLY IN FISH FROM THE WESTERN MAINE COAST. SEASON TO SEASON EXAMINATION OF SEVERAL YEAR CLASSES HAS DISCLOSED THAT SUCH "TAGGED" FISH DO NOT MOVE EASTWARD TO ANY GREAT EXTENT DURING THE PERIOD WHEN THEY ARE IMPORTANT AS SARDINES.

(6) KNOWLEDGE ABOUT THE EXISTENCE OF GEOGRAPHIC GROUPS OF HERRING. USE OF BLOOD TYPING AND PARASITE DISTRIBUTION HAS INDICATED THAT THERE ARE AT LEAST TWO MAJOR GROUPS OF IMMATURE HERRING ALONG THE MAINE COAST, WITH A ZONE OF INTERMIXING IN THE PENOBSCOT BAY AREA. A BLOOD GROUP SYSTEM HAS BEEN DESCRIBED FOR HERRING, AND FREQUENCIES OF AN ERYTHROCYTE ANTIGEN WERE FOUND TO BE MARKEDLY DISSIMILAR IN EASTERN AND WESTERN GROUPS. ATTEMPTS TO RELATE IMMATURE STOCKS TO SPAWNING POPULATIONS HAVE INDICATED THAT THE EASTERN GROUP IS MORE SIMILAR TO NOVA SCOTIA SPAWNERS THAN TO GEORGES BANK SPAWNERS. PARASITE DISTRIBUTION STUDIES HAVE DEMONSTRATED THAT GEORGES BANK ADULTS CAN BE DISTINGUISHED FROM NOVA SCOTIA ADULTS BY DIFFERENT FREQUENCIES OF SEVERAL ENCYSTED WORMS.

(7) DEVELOPMENT OF METHODS OF AGEING HERRING. TO ASSESS AND UNDERSTAND FLUCTUATIONS IN ABUNDANCE, IT IS IMPORTANT TO KNOW THE AGES OF FISH. THIS HAS BEEN A DIFFICULT PROBLEM FOR IMMATURE HERRING SINCE THE SCALE-RING METHOD HAS NOT PROVED RELIABLE FOR THIS SPECIES IN THE GULF OF MAINE. STUDY OF OTOLITHS HAS INDICATED THAT THE GROWTH ZONES IN THESE STRUCTURES CAN BE USED TO AGE IMMATURE FISH. YEAR-ROUND SAMPLING AND AQUARIUM STUDIES HAVE DEMONSTRATED THAT ONE OPAQUE AND ONE HYALINE ZONE ARE LAID DOWN ANNUALLY. AGES HAVE BEEN ASSIGNED TO IMMATURE FISH FROM THE COMMERCIAL FISHERY, BEGINNING WITH THE 1960 SEASON.

(8) BETTER UNDERSTANDING OF THE IMPORTANCE OF DISEASE IN HERRING POPULATIONS. MANY ENVIRONMENTAL FACTORS CAN AFFECT THE SURVIVAL OF HERRING. A CONTINUING STUDY OF A FUNGUS DISEASE HAS DEMONSTRATED THAT THIS CAN BE A MAJOR FACTOR IN DETERMINING THE NUMBERS OF

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HERRING AVAILABLE TO THE FISHERY. SEVERAL EPIZOOTICS HAVE OCCURRED IN HERRING OF THE WESTERN NORTH ATLANTIC IN THIS CENTURY, AND THE TWO MOST RECENT ONES (1947 IN THE GULF OF MAINE, AND 1954-55 IN THE GULF OF SAINT LAWRENCE) WERE STUDIED IN SOME DETAIL. INFORMATION ABOUT INFECTIVITY, TRANSMISSION, LIFE CYCLE OF THE PATHOGEN, ALTERNATE HOSTS, AND PATHOGENECITY HAS BEEN GAINED. IT SHOULD BE POSSIBLE TO PREDICT FUTURE OUTBREAKS AT LEAST SEVERAL YEARS IN ADVANCE.

DISEASES OTHER THAN THE FUNGUS HAVE BEEN STUDIED, PARTICULARLY THOSE DUE TO PROTOZOAN AND WORM PARASITES.

(9) INFORMATION ABOUT THE BEHAVIOR OF HERRING. AS PART OF THE PASSAMAQUODDY STUDY, SWIMMING SPEEDS OF IMMATURE HERRING, TOLERANCE TO LOW SALINITIES, AND RESPONSES OF HERRING TO WATER CURRENTS WERE DETERMINED. WHEN COMBINED WITH ENVIRONMENTAL DATA, SUCH STUDIES HELP TO EXPLAIN THE DISTRIBUTION AND MOVEMENTS OF IMMATURE FISH.

PRESENT RESEARCH PROGRAM

THE ATLANTIC HERRING PROGRAM BASED AT THE BUREAU OF COMMERCIAL FISHERIES BIOLOGICAL LABORATORY, BOOTHBAY HARBOR, MAINE CARRIES ON RESEARCH TO PROVIDE INFORMATION PERTINENT TO THREE FUNDAMENTAL PROBLEMS:

WHAT IS THE ABUNDANCE OF HERRING?

HOW AND WHY DO HERRING VARY IN ABUNDANCE?

WHAT IS THE ORIGIN OF INSHORE IMMATURE STOCKS OF HERRING?

BIOLOGICAL INFORMATION ABOUT THE SPECIES HAS ACCUMULATED AT AN ACCELERATED RATE SINCE 1956. FURTHER EXPANSION OF THE PROGRAM IN 1963 WILL PERMIT QUANTITATIVE STUDIES ON A MUCH LARGER SCALE.

THERE ARE FIVE MAJOR PROJECT AREAS AT PRESENT.

(1) ABUNDANCE AND AVAILABILITY
(2) BIOSTATISTICS
(3) OFFSHORE POPULATIONS
(4) BEHAVIOR AND MIGRATION STUDIES
(5) RACIAL STUDIES

(1) ABUNDANCE AND AVAILABILITY STUDIES ARE DESIGNED TO DETERMINE ABUNDANCE AND CAUSES OF FLUCTUATIONS IN ABUNDANCE OF IMMATURE HERRING. SINCE THE PRESENT FISHERY IS COASTAL, THE FACTORS THAT INFLUENCE AVAILABILITY OF FISH TO THE FISHERY MUST ALSO BE STUDIED. EACH YEAR CLASS OF HERRING IS STUDIED, FROM LARVAL STAGES UNTIL RECRUITMENT, TO ASSESS RELATIVE ABUNDANCE AND DISTRIBUTION. INSHORE ENVIRONMENTAL FACTORS ARE ALSO EXAMINED, PARTICULARLY THOSE THAT MAY AFFECT THE DISTRIBUTION OF EARLY LIFE HISTORY STAGES. FACTORS THAT AFFECT HATCHING AND EARLY SURVIVAL OF HERRING EGGS AND LARVAE ARE STUDIED EXPERIMENTALLY.

(2) BIOSTATISTICS IS CONCERNED PRINCIPALLY WITH CATCH DATA AND SAMPLES FROM THE COMMERCIAL FISHERY. DETAILED STATISTICS ON EACH CATCH ARE AVAILABLE, AND SAMPLES FROM SUCH CATCHES ARE EXAMINED FOR AGES, GROWTH, AND RACIAL CHARACTERISTICS. DETERMINATIONS OF GROWTH RATES, MORTALITY RATES, RELATIVE ABUNDANCE, AND POPULATION MODELS ARE OBJECTIVES OF THE WORK.

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(3) Offshore Populations studies are designed to examine adult and spawning populations, particularly those that may contribute progeny to the coastal fishery for immature herring. Emphasis is placed on determinations of age structures, relative abundance, and racial characteristics of adult groups. Distribution and abundance of larvae resulting from offshore spawnings are studied, and compared with similar data from previous years.

(4) Behavior and Migration studies concentrate on immature herring of commercial sizes. Tagging studies provide information about movements during the fishing season and from one season to the next. Behavior studies are closely related, being concerned with reactions of commercial size fish to environmental factors and to changes in them.

(5) Racial studies are designed to determine the discreteness of spawning populations and to identify the source of coastal immature stocks. Traditional methods such as meristic studies, as well as the more recent approaches of immunogenetics and biochemistry are being used in this work.

FUTURE RESEARCH PROGRAM

Recent significant increase in U. S. herring research effort makes the following plans feasible:

(1) Abundance and Availability

Continue and expand the study of the inshore habitat of herring. Attempt to relate presence and movements of herring to environmental factors being examined.

Carry on coast-wide cruises to determine spawning areas as well as distribution and abundance of larvae and post-larvae. Obtain environmental data simultaneously on temperature, currents, salinity, etc.

Develop and carry out methods for annual quantitative sampling of early life history stages (larvae, post-larvae, brit) on a coast-wide basis, to get preliminary estimates of the abundance of each year class before it enters the fishery.

(2) Biostatistics

Continue and expand collection and analysis of catch and environmental data to provide a basis for abundance estimates. Convert data to machine handling of information.

Continue and expand sampling of the commercial catch, to provide information about contribution of various year classes, geographic patterns of the fishery, seasonal trends in the fishery, size composition, etc.

Utilizing data from all aspects of the herring program, past and present, construction population models, including such factors as absolute and relative abundance, mortality rates, and effect of the fishery on abundance.

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(3) Offshore populations

Obtain many samples of adult herring from known spawning areas, especially Georges Bank. Determine age structure and relative abundance of each year class in the samples. Examine all samples for characteristics that may be useful in relating adult herring to juveniles. Repeat this sampling as often as possible, concentrating on spawning aggregations. Compare age data with results of studies made in previous years, to see if the intensive 1961 fishery on Georges Bank has produced any discernible effect.

Assess success of spawning annually on Georges Bank, and, as far as possible, elsewhere in the Gulf of Maine, by larval survey cruises. Compare distribution and abundance of larvae with results of earlier studies.

(4) Migrations and Behavior

Beginning in July of '63, tag immature herring along the entire New England coast. Repeat taggings annually to determine whether variations in movement patterns occur.

Conduct laboratory experiments and field studies of responses of herring schools to environmental variables such as temperature, currents, light, food supply, and presence of predators. Relate experimental findings to field observations, and to availability of herring inshore. Study variations in responses of herring to environmental changes as the fish increase in age.

(5) Racial Studies

Attempt to recognize by traditional methods (age and growth, meristics, tagging) as well as new approaches (biochemical, physiological, serological) whatever geographic subgroups of adult and immature herring exist.

Determine by these methods what spawning groups contribute to coastal sardine stocks, the extent of this contribution, and the extent of intermixing of various groups. Continue the determination for several years to see whether the extent of contribution from each spawning area is variable from year to year.

In addition to U. S. herring research already in progress, or planned for the immediate future, there are several major research areas that would be desirable, but would require cooperative or joint efforts by several countries, to be carried out successfully. These proposals might best be considered in the framework of ICNAF:

(1) Continuous larval surveys

Clues to spawning areas and intensity, and subsequent drift of larvae can best be obtained by extensive surveys using high speed plankton collection equipment. Such surveys should be timed to collect and to trace movements of late summer-autumn spawned larvae, and also any spring-early summer spawned larvae. Standard cruise tracks and methods could provide a basis for comparison of each year's spawnings. Inshore as well as offshore waters should be surveyed. It might be possible to include a cooperative synoptic survey, possibly in October of each year, to cover the entire Gulf of Maine and adjacent waters.

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(2) STOCK IDENTIFICATION

SPAWNING AGGREGATIONS OCCUR ON MANY OFFSHORE BANKS AND NEAR OUTER ISLANDS ALONG THE NORTHERN NEW ENGLAND COAST. CONCENTRATIONS OF IMMATURE FISH OCCUR PRINCIPALLY IN COASTAL WATERS. INFORMATION IS NEEDED ABOUT THE DISCRETENESS OF SPAWNING STOCKS, AND THE SUBSEQUENT MOVEMENTS OF ADULT FISH. INFORMATION IS ALSO NEEDED ABOUT THE RELATIONSHIP OF JUVENILES TO SPAWNING STOCKS. MORPHOLOGICAL, MERISTIC, PARASITOLOGICAL, BIOCHEMICAL, AND OTHER CHARACTERISTICS OF EACH SPAWNING AGGREGATION MUST BE DETERMINED, AND AN ATTEMPT MADE TO RELATE JUVENILES TO ADULTS BY STUDY OF COMPARABLE CHARACTERISTICS. THIS MIGHT BEST BE ACCOMPLISHED BY A COOPERATIVE SAMPLING PROGRAM FOR ADULT AND HIGH SEAS STOCKS, AND MUST INCLUDE STANDARDIZATION OF SAMPLING AND MEASURING TECHNIQUES.

(3) ABUNDANCE STUDIES

AGE STRUCTURES AND GROWTH CHARACTERISTICS OF EACH SPAWNING AGGREGATION SHOULD BE DETERMINED ANNUALLY FOR A NUMBER OF YEARS, TO ASSESS SUCCESS OF YEAR CLASSES, TO DETERMINE MORTALITY RATES, AND TO ASSESS THE EFFECT OF FISHING ON POPULATIONS EXPLOITED AT DIFFERENT LEVELS OF INTENSITY. OTHER CRITERIA FOR DETERMINING RELATIVE ABUNDANCE, SUCH AS DISTRIBUTION AND INTENSITY OF SPAWNING, SHOULD BE EMPLOYED. CATCH-EFFORT INFORMATION FROM BOTH THE HIGH SEAS AND THE INSHORE FISHERIES MUST BE AVAILABLE. THE CONTRIBUTION OF EACH YEAR CLASS TO THE FISHERY SHOULD BE DETERMINED ANNUALLY.

(4) MIGRATIONS

FUNDAMENTAL TO THIS STUDY WOULD BE A LARGE SCALE TAGGING OF JUVENILES AND ADULTS OVER AT LEAST A FIVE-YEAR PERIOD WITH A SUITABLE LONG-TERM TAG. THIS STUDY WOULD PROVIDE INFORMATION ABOUT MOVEMENTS OF HERRING OF ALL AGES, GROWTH RATES IN VARIOUS AREAS, SOURCES OF CONTRIBUTIONS TO SPAWNING STOCKS, AND MORTALITY RATES. ASPECTS OF THE TAGGING MIGHT BY SYNOPTIC, WITH JOINT HIGH SEAS TAGGINGS BY THE VARIOUS COUNTRIES CONCERNED. TAGGING OF ADULTS SHOULD BE DONE WITH SPAWNING AGGREGATIONS, AND SHOULD INCLUDE ALL KNOWN SPAWNING AREAS.

A COOPERATIVE STUDY OF CERTAIN PARASITE TAGS COULD BE MADE, SIMILAR TO THE JOINT ICES STUDY OF THE COD PARASITE LERNAEOCERA. THIS STUDY SHOULD ALSO BEGIN BY WORKING WITH SAMPLES FROM SPAWNING AGGREGATIONS.