Introduction

The Need for Interdisciplinary Research in Fisheries and Oceans Sciences

R. J. Beamish, G. A. McFarlane, and W. S. Wooster

Attempts to manage marine fish populations on a scientific basis are very recent. It was really not until the 1960's that scientists and managers developed and applied theories of population dynamics to management of exploited marine fish populations. To put this in perspective, consider the length of time and the number of doctors that have studied just one species — humans. Despite this enormous effort, numerous problems affecting the well-being of our species continue to elude attempts to solve them. Accepting that fisheries science is in its infancy, what direction should fisheries research take to give us an understanding of the factors that control the abundance, distribution and behaviour of fishes?

The organizers of this symposium believed that a better understanding of the population dynamics process required more interdisciplinary research among fisheries scientists and oceanographers. Many in the scientific community now believe this cooperation is not only essential, but there are limits on the time we have to understand the relationship between ocean conditions and fish abundance.

Fisheries scientists spend little time studying environmental effects and relatively few oceanographers seem interested in how their findings might relate to fishery problems. The sponsorship of this symposium was intended to stimulate research in this area. Sponsors hope that the results of this symposium will encourage scientists as well as the many patrons of fisheries and oceans science to recognize the need to understand the relationship among oceans, climate and fish populations.

The North Pacific Ocean and Bering Sea have some of the largest fisheries in the world. Walleye pollock (*Theragra chalcogramma*) have been exploited since the turn of the century, however, it was not until the late 1960's and early 1970's that the resource was fully utilized by the fleets of Japan, the USSR, and North and South Korea. Catches ranged from 5.7 to 6.0 million t in 1973–76 but declined slightly after this period as a result of fishery restrictions imposed by the U.S. and USSR, reflecting concern over reduced abundance of pollock. However, even with these restrictions, the walleye pollock fishery in the North Pacific Ocean has been the largest fishery in the world. Since the mid-1980's pollock catches have increased dramatically and averaged between 10 and 11 million tons annually. More recently, the expansion of this fishery into international waters of the Bering Sea has caused international concern that overfishing may be occurring.

The flying squid (*Ommastrephes bartrami*) fishery is the second largest fishery in the North Pacific Ocean. Squid are captured using surface gillnets that are set throughout the central North Pacific. This fishery has expanded dramatically since its inception in 1978. By 1986, Japan alone accounted for approximately 150 thousand tonnes; and it has been estimated that Korean and Taiwanese vessels catch a similar amount. Japanese, Korean, and Taiwanese vessels set an estimated 30 000 km of driftnet each night. This amount of net would stretch back and forth from Vancouver to Tokyo approximately four times each night. Clearly, this is a massive fishery that impacts not only on squid but also inadvertently on other species such as salmon, other fishes, and marine mammals.

The area is also the feeding grounds for steelhead (*Salmo gardneri*) and 6 species of salmon that originate from the U.S.A., Canada, Japan, and the USSR. Estimates of the size of salmon stocks in the North Pacific are generally unavailable. However, recent work indicates that the salmon biomass in the Gulf of Alaska alone (E 170° W) was 1 million t in the early 1980's (Ware and McFarlane, this volume), supporting an average catch of over 200 thousand t by North American fisheries annually. The landed value of North American salmon fisheries (in 1987 U.S. dollars) would be in excess of 3 billion dollars. Other major fisheries include Pacific hake (*Merluccius productus*), Pacific halibut (*Hippoglossus stenolepis*), sablefish (*Anopolopoma fimbria*), rockfishes, Pacific herring (*Clupea harengus pallasi*), Japanese sardine (*Sardinops melanosticta*). In addition, there is a large biomass of pomfret (*Brama japonica*), Pacific saury (*Cololabis saira*) and tuna which utilize the area intermittently.

It is obvious that the health of these and other fisheries is very important to the countries that surround the North Pacific Ocean. Because of the complexity of the fish-ocean interactions, there is a need to study the region as an integrated unit. This can be accomplished most effectively through a program that promotes interdisciplinary and multinational scientific collaboration.

IRIS (International Recruitment Investigations in the Subarctic) was formed to encourage research on ocean-fish interactions to understand better the affects of ocean variability on the abundance and distribution of fish stocks. IRIS was initiated in 1982 as a collaborative effort among university and government oceanographic and fishery institutions on the west coast of North America in British Columbia, Alaska, Oregon and Washington. This organization encouraged cooperative research among fisheries scientists and oceanographers by providing a communication network among senior scientists and administrators.

In support of these goals, IRIS jointly sponsored this symposium and has endorsed a proposal to establish a new international scientific organization in the northern North Pacific Ocean.

This proposed new organization is supported by IRIS because oceanic and atmospheric processes span the entire width of the North Pacific, and even the ecosystems usually extend over regions much larger than those containing the commercial fisheries. To be successful the study of such large regions and systems requires widely distributed research, monitoring and effective international cooperation. The information needs go well beyond the usual fisheries data, requiring the contributions of ocean and atmospheric scientists in addition to those of fisheries scientists.

The needs and benefits of a broader scientific forum for the North Pacific have been recognized by some scientists over the past 15 years. The need for this forum is particularly urgent now that biologists and oceanographers are aware of the importance of ocean conditions in determining global climate and local oceanographic conditions. A new North Pacific fisheries and oceans scientific organization would promote the systematic collection and exchange of scientific information, encourage multinational programs of benefit to the countries bordering the North Pacific Ocean, and generally promote a regular and timely exchange of ideas. IRIS proposed to co-host this symposium with the International North Pacific Fisheries Commission (INPFC) so that countries considering formation of a new North Pacific organization could meet in a manner similar in format and content to that proposed. INPFC was interested in co-hosting the symposium because it had previously sponsored international symposia on non-anadromous fisheries in the North Pacific, and its commissioners were interested in the establishment of a new organization that would accept INPFC's responsibility for non-anadromous species.

One of the topics of this symposium proposed by IRIS, the effects of ocean variability on recruitment, is timely in view of the advances that have been made in oceanography in recent years. There are well developed techniques for describing current regimes and upwelling events and for monitoring salinity, temperature, and production. Fisheries biologists stress the importance of conducting oceanographic studies on the continental shelves. The studies that have been carried out demonstrate the complex nature of the current systems. Despite this complexity, there are now sufficient oceanographic data to design studies to test hypotheses relating to the variability of recruitment. Papers of the symposium have paid particular attention to variations in ocean circulation as measured directly or suggested by surrogates such as sea surface temperature and related year-class strengths. Not content with just describing the relationships, most authors have sought possible explanatory mechanisms.

The INPFC was established in 1952 to ensure that fisheries of joint interest to Canada, United States, and Japan were maintained and conserved. The INPFC promotes and coordinates scientific studies necessary to determine conservation measures that need to be taken by the contracting parties. A major function of the Commission has been to regulate the catch of salmon of North American origin on the high seas. The convention was amended in 1978 when it was agreed that the contracting parties would work towards the establishment of an international organization with broader membership that would deal with species other than salmonids. It was also agreed that it would be useful to have scientific symposia that dealt with the biology and stock assessment issues of non-anadromous fishes. In an attempt to implement both of these initiatives, the INPFC commissioners agreed to hold a joint symposium with IRIS on the condition that topics be restricted to non-anadromous species. Thus, studies on salmon were not emphasized at this symposium. The topic suggested by INPFC members was the evaluation of the accuracy of parameters used in stock assessment of non-anadromous species.

The importance of error is commonly evaluated in most sciences. However, in fisheries science, in general, and in stock assessment models, in particular, there are very few practical evaluations of the consequences of errors in parameters. Errors can result from incorrect assumptions such as constant natural mortality, or from measurement errors in the accuracy of parameters such as incorrect age determinations or biases in sampling. Many models assume parameter values are constant, yet we know that variability is inherent in biological processes. When models are tested with each other, those that best reduce variance are usually accepted as representative of the particular data set. The agreement with data sets in such cases is given more emphasis than the accuracy of parameters used. Some models in fisheries science minimize the number of parameters used because of their uncertainty. For example, the original stock production model was developed because there was no method for ageing tuna (Schaefer 1954). Thus there was no doubt that uncertainty exists in the parameters, and assessing the accuracy of these parameters was an important topic.

Several papers indicated that the assumption of constant parameters, in particular that environmental conditions are invariant, restricts our ability to develop theories to explain the fundamental principles, especially in terms of the scales of climate change. In fisheries management, we know that in extreme cases a fishery can have major effects on the abundance of fish stocks. However, the development of good predictive models has proven difficult. Models predicting the abundance of fish populations are often based on catch information. Unfortunately, the various processes controlling abundance simply cannot be determined by the study of catch. Fisheries experimentation by intentionally altering catch is important but does not preclude the necessity to study other factors that control abundance. Undoubtedly better quality data, longer time series, and improved analytical techniques will help. But there also is no doubt that an understanding of the underlying relationships between the environment and the life history strategies of the important species is needed.

The vastness of the ocean, the difficulty of sampling large areas in sufficient time, combined with the need for extensive information on fish and fisheries present major obstacles to the understanding of the principles that govern stock size. In spite of these difficulties we should not avoid the challenge of unravelling the population dynamics process. We are certain that this barrier of complexity separates us from something fundamentally simple. Eventually we will uncover some underlying principles that govern the choice of life history types, migratory behaviour, reproductive strategy, longevity, and perhaps speciation. We will understand the importance of species interactions throughout the life of fishes and we will use this knowledge to regulate harvest to ensure future productivity of marine animals. Interdisciplinary research, particularly between fisheries and oceans scientists, is the key to establishing the framework to develop this understanding.

We expect in the future to be able to predict stock size or, in the case of salmon, run timing and migration routes. There are other benefits, in the longer term, potentially very useful for the resource-based economies of countries around the North Pacific Ocean. For example, we believe that significant changes in climate will occur in the next few decades. Many scientists are taking the predictions of global warming seriously. The effects on fisheries are relatively unstudied but observations for some fisheries show a strong relationship between temperature and commercial landings (Cushing 1982). We are also aware that the presence and absence of currents or upwelling can result in the production of strong or weak year-classes. Thus many scientists believe that global warming will change the nature of our fisheries. The time in which these changes could occur appears to be quite short. In fact, we may already be receiving signals indicating that important changes are occurring. Those of us who organized this symposium believe that we must move forward quickly. IRIS members expect to have another symposium in 1991 that will address the issue of climate change and its effect on the distribution and abundance of fishes in the North Pacific and North Atlantic. We hope that by this time a new North Pacific Science organization will be in place, and that countries will be more actively investigating the problem of understanding the relationships between ocean variability and recruitment.

Some participants felt that the topics and the format that combined papers on population dynamics, on physical and chemical oceanography, and on some old-fashioned biology, would not encourage interdisciplinary communication. Participants came to this symposium with labels such as biologist, oceanographer, physicist, or chemist. But during the conference there was a marriage of these interests. At the end of the 3 days, people thought a little differently about issues in their own field. A unity was developing between disciplines and the scientists of the participating countries. There was not indifference or frustration but rather acceptance of the need for fish-ocean science and of the problems and complexities of one another's fields. This change in attitude was surprising. The interest, even enthusiasm, indicates that under the right circumstance, an interdisciplinary approach in fisheries and oceans science can be made to work.

As scientists we know there are limits to production, to distribution, and to survival. We know that the oceans and marine animals can be overexploited. We have seen minor and major examples in the last few decades of man's ability to alter processes that regulate population size in fishes. It concerns many of us that our lack of understanding may mean that present and future exploitation of the oceans and marine animals may adversely affect our general quality of life. The role of science in preserving our quality of life is recognized but is more or less taken for granted. Unfortunately, there is a tendency to provide new resources and direction only when extreme examples of environmental damage occur. Despite the difficulty in obtaining resources, it is important that we not wait for a major crisis to occur before we improve our understanding of the factors regulating marine populations. We require innovative thinking, new approaches in our research, and some risk taking if we are to ensure that irrepairable changes do not occur as a consequence of world population increases.

The next decade will be a most exciting and stimulating period for fisheries biologists and oceanographers. It is possible that biology and oceanography will be more important in the planning and development of national economies. To meet these challenges in our science we must coordinate and integrate our understanding of fisheries and oceanography in the North Pacific. It is our hope that this symposium was a step toward the achievement of this aim and that it will be followed by many more, similar steps.

References

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