DEPARTMENT of the INTERIOR

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Using Fish as Experimental Animals in Basic Research Programs of the Bureau of Sport Fisheries and Wildlife

Thoreau once said, "In wildness lies the salvation of mankind." Each of us here could puzzle over that enigmatic phrase and arrive at quite a variety of interpretations.

Let me give you one interpretation.

Perhaps he meant that when man will take the time to be concerned that no harm should come to wild things from the projects he undertakes for his own benefit, when he shows this kind of concern for the defenseless, then he will have come of age.

The Bureau of Sport Fisheries and Wildlife is the focal point of the national effort to provide fish and wildlife-based recreation for our people today, and to insure that this heritage be passed on. In addition to providing recreation for coming generations, efforts to insure the perpetuity of our fish and wildlife heritage could be thought of as a means of buying time. To make sure that, when mankind does come of age, there will be fish and other wild things left to be concerned for.

To accomplish this goal--to assure the perpetuation of fish and wildlife in the face of an explosive population increase with its attendant pressures on fish and wildlife resources--will require an unprecedented amount of knowledge. These riddles of inner space, if you will, are quite as complex as are those of outer space. And to solve them in a reasonable period of time would require a comparable research effort.

The number of scientists engaged in fishery research is growing, but compared with the needs, and compared with the number of scientists engaged in agricultural research or in medical research or in most other research fields, the number is pitifully small.

So, the notion of a group of scientists from many fields gathered together to talk of how fish can be used as an experimental animal in basic research is both intriguing and important to me. The results of research using fish as the experimental vehicle is, of course, important. What intrigues me is that this symposium may stimulate interest in a widening circle of scientists to recognize the potentials of, and thus to come to use, fish in their research. As more and more scientists learn what they must to use fish effectively as a basic research tool, our knowledge base will be greatly expanded and our job of applying this knowledge to the problems of conservation will be made easier and quicker.

And so I salute you and your discussions of basic research on fish; and I am gratified to have the opportunity to tell you something of our programs and of our needs for a greater understanding of fish.

Sooner or later the bugaboo of how we define basic research and differentiate it from applied research will raise its head, so let me begin by saying "about" how I will use the term. I say "about" because, in the spectrum of activities ranging from pure research on the one end to technological development on the other, there are no sharp dividing lines. The time scale on which research is likely to find application is useful in deciding between the appliedness or the basicness of research. For the purpose of this discussion, I will consider research to be basic if it is concerned primarily with gaining a fuller knowledge or understanding of the subject under study and if the results are likely to require further application before useful products or methods can be developed. I realize that to some, basic research means simply the search for knowledge without regard for its applicability. I don't find this concept very useful, and if the definition of basic research were restricted to this, I'd have to admit that we do none, and this would probably be the shortest after-dinner speech on record!

To conform with the symposium topic, I will also limit my remarks to basic research with fish as an experimental animal. This will exclude much research that we do on fish ecosystems where we study fish and aquatic communities rather than individual fish. I personally find it regrettable not to talk about ecological research because, as a scientist-turned-administrator, this was my former interest and love. I would be much more at ease talking about fish communities and their external environment than about the inner workings of fish.

Research is done in three of the Bureau programs. These are:

(1) The grant-in-aid program, which returns certain revenues to State fish and game agencies for research or habitat improvement.

(2) Fishery Cooperative Units which are located on State universities and are jointly funded and administered by the Bureau, the State fish and game agency, and the host university.

(3) The in-house research program conducted in Bureau laboratories.

The grant-in-aid research projects are selected by the State fish and game agencies and traditionally are directed toward the solution of pressing fishery management problems within the State. For this reason they tend to be shaded more toward applied research and development than toward basic research. Also, the portion that tends more toward the basic end of the research spectrum is more likely to be concerned with field biology or ecology than it is toward research on fish as an experimental animal. As in any generalization, there are, of course, exceptions. However, I believe that the exceptions are too few to warrant further time in this discussion.

The Co-op Units were established primarily to encourage and to assist in the graduate training of fishery scientists. Speaking for the national program, one would have to say that research, although important, is incidental to this primary purpose. Having said that, we would also have to recognize that there are some Units where it is difficult to determine which objective is paramount. The program at each Unit is approved by a coordination committee which includes representatives of the three cosponsoring agencies. The program is influenced by the needs of the State fishery agency, by the interest and field of expertness of the Co-op Unit leader and assistant leader and by the number and kind of graduate students available. Due to the changing nature of the program, it is difficult to get a clear fix on the degree of appliedness or basicness of the total program and also on the mix between field biology or ecology and research on fish as experimental animals. If generalities may be permitted again, I would say that the research tends to be oriented slightly more toward basic than applied and that ecological and environmental problems predominate.

There are, however, many more exceptions to this generality than in the grants-in-aid program and I would like to draw some of these to your attention.

In 1967, 2 of the 23 Co-op Units had 8 research projects in genetics. Dr. Ray Simon, leader of the Unit at Oregon State University, is on the program tomorrow morning and will undoubtedly tell you something of this research. Eleven of the Units had 14 research

projects involving various aspects of physiological research; 5 Units had studies on nutrition and metabolism; 4 had toxicology studies and 1 had studies on embryological development. With the exception of the two Units which have substantial genetic studies, these programs involving fish as a research animal comprise a minor part of the total research being done at the Units.

I have reserved the bulk of my time to talk about research programs conducted in the Bureau by our Division of Fishery Research, for it is here that we have the greatest freedom to shape the content and balance of research programs best to fit fishery conservation needs as we see them.

The mission of sport fishery conservation is to provide for today's recreational fishing needs and to plan for the needs of the future. To meet today's needs the fishery manager seeks fullest use of the natural productivity of the aquatic environment and, where necessary, he supplements natural productivity with hatchery produced fish. Planning for growing future needs requires better ways of doing both these tasks and also, a better understanding of how to protect the environment and how to enhance its productivity for desirable species.

Our research program is grouped according to these three separate kinds of needs. We call the studies of natural productivity, fish ecosystems research; studies of production and use of hatchery fish, fish husbandry research; and studies of environmental protection and enhancement, pest control research.

The research program in each area is shaped by the kind and quantity of information available; the kind and quantity of research being done by others; the priorities for specific kinds of information; and the resources available. As you might guess, these factors differ in each program and consequently, the mix between basic research, applied research and methods development differs in each as does the kind of basic research being done.

Without going into great detail, let me try to give you a feel for the shape and scope of each program and to describe more fully our studies on fish as a research animal.

Our fish ecosystem research program is concerned with the factors governing the distribution and abundance of sport fishes in both marine and freshwater environments. Of major concern are such factors as: fecundity; time and place of spawning; food habits and environmental requirements for all life stages; food-chain

organisms and their requirements; competing and predaceous species; behavior, migratory patterns; temperature tolerance and preference; and others. I would classify most of our research in this area as basic, but the program does include applied research and methods development. With only minor exceptions, the basic research is concerned with fish populations rather than with isolated fish as a research animal.

The exceptions that come to mind include a study of immunological and biochemical methods for the racial identification of subpopulations of marine sport species and the physiological and biochemical responses of estuarine species to environmental pollutants. We recognize the need for knowledge of the fish itself and we plan to expand in this direction as funds and facilities permit.

The marine portion of this program is conducted in two laboratories on the Atlantic Coast, one on the Pacific, and two laboratories are under construction on the Gulf Coast. The freshwater part of the program is done on the larger cold water reservoirs of the Missouri River in South Dakota and on the large warm water reservoirs of the White River in Arkansas.

The fish husbandry research program includes studies in the traditional husbandry sciences: nutrition, pathology, genetics, environmental requirements and cultural methods. The distribution of the program between basic research, applied research and methods development is by no means constant between the 11 laboratories. For the program as a whole, however, applied research dominates and basic research and methods development are about equally stressed.

For this program nearly all of the basic research is concerned with fish as an experimental animal. The following kinds of studies are included: basic nutritional requirements; metabolic pathways; osmotic regulation; physiological changes in response to environmental change; endocrine function; disease pathogenesis; immune response in salmonids; identification and mode of transmission of infectious agents; carcinogenesis; physiological indicators of genetic differences in rainbow trout; physiological and biochemical indicators of fish quality; production and evaluation of catfish hybrids.

It would be necessary to do research in most of these fields if we were merely concerned with producing fish for food. But the principal concern of fishery managers is to provide recreational fishing. For this, fish must be able to meet and survive a host

of environmental stresses after they are released. The anadromous salmonids, for example, must be able to make a long and arduous journey to the sea, and when there they must be capable of making the physiological changes that are necessary to adapt to a hypertonic, salt water environment. Thus successfully rearing salmon is more like the care and feeding of Olympic athletes than it is like raising hogs for the market.

Applied research and the development of improved fish culture methods must both be supported by knowledge of the body processes of the fish we deal with--the importance of this basic research can scarcely be over-emphasized.

Our pest control research programs are concerned with developing an understanding of the consequences of pesticide exposure to sport fish and their environment and with developing the methods and techniques for controlling rough fish that limit the productivity of the environment for important sport species.

The two parts of the program remind me of Ogden Nash's little ditty:

> Even fleas have little fleas
> Upon their backs to bite 'em
> And little fleas have lesser fleas
> And so ad infinitum.

We are "bit" by the insecticides, herbicides, fungicides, larvacides, and all the other-cides, collectively called pesticides, that have become so important and widely used in agriculture, public health and land management programs. Fish and aquatic organisms are remarkably sensitive to most of these biocides--sometimes even more so than the treatment target. Since fish and wildlife are also important national resources, we are called on to provide safe usage guidelines. Would you believe this calls for research?

The other side of the fleas and lesser fleas coin is that we too have pests that we'd like to put the bite on. In our case, there are many, many waters that would be more productive for sport fishes if the predaceous or competing rough fish such as carp could be kept under control. The need here is for methods--chemical, biological, mechanical or others--that will effectively control the target fish with minimal harm to sport fish, or to the environment, or to other beneficial uses and users of the water. This too calls for research.

The pest control research program is about equally divided between basic research, applied research and methods development. The basic research portion of the program is also about equally divided between seeking an understanding of the effect of biocides (including piscicides) on the body processes of fish and in learning of the ecological effects of pest control measures.

Studies of the former kind include: rates of uptake, storage and excretion of biocides; metabolism and metabolic products; physiological significance of residues; effect of physiological stress on toxicity; effects on reproduction success; relation of chemical structure to toxic effect.

The fish-pesticide studies are conducted by our laboratory at Columbia, Missouri, and at field stations where needed specific facilities are available. The field stations are at Tiburon, California, where salt water problems can be studied; at Jackson, Wyoming, where long-term studies on trout are made; and at Marion, Alabama, and Stuttgart, Arkansas, where the specific problems and needs of pond fish culture can be considered. The fish-control studies are done at laboratories in La Crosse, Wisconsin, and Warm Springs, Georgia.

I would like now to go back to the programs we have discussed to get some feeling for where we have been and to try to anticipate what the future will bring. In trying to paint a picture of research sponsored or done by the Bureau, I had to resort to very broad strokes. Neither time nor, quite frankly, my own knowledge would permit a detailed presentation. The formal presentations and the discussion of papers at this symposium will go far toward filling that void. Also, I have brought copies of the latest annual reports for the grant-in-aid program, for the fishery co-op units programs and for the programs of our Division of Fishery Research. I will leave these here for you to look through--I invite you to write to us if you would like to have copies. Better still, if you see a study that interests you, write to the investigator.

I hope that I have not given the impression of slighting the importance of applied research and development programs. The State fishery research programs that are partially funded through the grant-in-aid program have resulted in significant improvements in management techniques. The knowledge gained also contributes to Bureau programs--both management and research. As funding for this program is relatively fixed, we can anticipate no great increase.

As I mentioned earlier, 23 States now have co-op units. More States have expressed an interest in establishing units and these will be accommodated as Congress authorizes funds for that purpose. We can be sure that the contribution from this program will increase.

Growth of the Bureau's fishery research program hinges on several factors. Prominent among these is the amount and kind of research being done by others. This is so because we view our responsibility more in supplying cohesiveness and in filling major research gaps than in trying to be all-inclusive. We do not propose to become a "National Institute of Fish" although admittedly, this would be one way to get the job done.

In the past few years we have seen a terrific growth in fishery research by other government agencies and by outside institutions. Much of the knowledge gained from these programs can be applied to the solution of our own problems. Some of these programs that influence our own decision of where and how to grow include: The recent establishment of sea-grant college programs; expansion of research by the Federal Water Pollution Control Administration; establishment of the Water Resources Research Institutes in each of the States; yes, and on the amount of research on fish being done by scientists from allied fields.

My crystal ball does not give as clear a picture of outside efforts as I could wish for, but our needs are clear. The coastal region and the major reservoirs are our greatest hope for maintaining traditional sport fishing opportunities--clearly much research of all kinds is needed for the development of imaginative management techniques. The application of genetic facts and principles has provided the most dramatic improvements in plants and animal species--we are years behind and should bend every effort to catch up. There is much need for knowledge of the body processes of fish--particularly those that will lead to methods of improving fish survival. Pollution and pesticides will, like the poor, be with us forever. We will have to run hard just to stay even with the influx of new toxicants. As the human population continues to grow, our need to make maximum use of every body of water will increase. To accomplish this requires accurate means of controlling and keeping fish populations in balance. To date we have emphasized chemical control methods--we need to expand our knowledge of other control techniques.

I would like to return briefly to my original thesis. The obstacles to effective conservation are formidable but not insurmountable. What is needed most is knowledge with which to devise better ways of doing things. But it will require a massive effort to meet this need.

It is our pledge that conservation will remain viable--that those who come after us will have the right to enjoy fish and wild things, and the opportunity to protect them too.

I started this talk with a quote from an eloquent voice for conservation in an earlier era. Let me close with a quote that seems appropriate to the urgencies of today's conservation. I quote from Robert Frost:

> The woods are lovely, dark and deep.
> But I have promises to keep,
> And miles to go before I sleep,
> And miles to go before I sleep.

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