Technology in Fisheries Development

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TECHNOLOGY IN THE NATIONAL MARINE FISHERIES SERVICE

Technology may be defined as the application of science and engineering principles and innovations to the solution of practical problems, usually in industrial applications and usually with highly rewarding results (Jones, 1976). The National Marine Fisheries Service (NMFS) of the National Oceanic and Atmospheric Administration, U.S. Department of Commerce, operates three technological facilities that service the country's needs related to the utilization of fish and shellfish, mainly for human food.

For the purpose of this discussion, the application of technology related to the utilization of fish and shellfish may be conveniently divided into two categories, even though they are both concerned with the welfare of the U.S. consumer. The first and most important of these is the role that recognizes the need for an assured supply of fish and shellfish to the U.S. public (Ronsivalli, 1976). The second category of technology activities is in support of fisheries development and it is this category of activities that is the object of this discussion.

FISHERY DEVELOPMENT

The incentive to develop new fisheries is generated by a variety of factors. Many of the conventional species are being overfished. The catch per unit of effort is steadily decreasing and the proportion of unusable species brought aboard the vessel is increasing. Species like the red crab and the Jonah crab, readily available to fishermen, have gone virtually untouched while the pressure on lobster stocks has created a reduction in the catch per unit of effort in the latter species. The potential for creating an acceptance for little used species in the United States has excellent precedence. Some of the species which are now highly valued (e.g., haddock and halibut) were once considered to be trash fish by American fishermen. Now they are in such high demand that their stocks are badly depleted. Thus, the development of new fisheries is both practical and feasible and serves two purposes. It results in an overall increased domestic catch and it helps to relieve the fishing pressure on conventional species by redistributing some of it among underutilized species.

Increasing the Domestic Catch

The successful development of a fishery translates into increased domestic landings. This is especially desirable in order to try to reverse a trend of increasing imports which now reportedly accounts for about two-thirds of the U.S. consumption. While a heavy reliance on imports may be tolerable for the present, it must remain a cause for considerable concern because of the growing probability of food supply crises in the normal international food trade.

Redistribution of Fishing Pressure

Figure 1 attempts to illustrate how fish and shellfish play an important part in contributing to the total U.S. food needs. It also attempts to show the source of this class of foods and some of the factors that affect their availability. The list is by no means complete. For this purpose, the diagram, originally designed to form the basis for a proposed computer program for a national seafood policy, omits all elements except those that affect commercial fishing, and even this list is not complete. However, there is enough information supplied to illustrate a point.

Factor number seven indicates that the domestic supply derived from commercial fishing is affected by the need to know that stocks are in sufficient supply. This information, for any given species, represents a complicated problem which NMFS biologists attempt to solve by stock assessment, environmental studies, etc., and it represents a management control problem. When a species is in danger of being overfished, it is at that point that the development of an alternate fishery becomes an expedient endeavor which takes the fishing pressure off the conventional species while at the same time maintains the fishing effort and the productivity. Thus, we can see that the establishment of a new fishery has the potential for resolving several crises simultaneously: 1) those concerned with relieving the fishing pressure on species that are in danger of depletion welcome any activity that

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Figure 1.—Some factors that affect U.S. food needs.

provides a reduction in the harvest effort; 2) fishermen engaged in fishing for species that are in danger of becoming depleted, who are being restricted by regulations, welcome the opportunity to stay in business by fishing for a more plentiful species; 3) fishermen presently wasting significant amounts of effort to harvest proportionally large amounts of unusable fish and to cull them out and to dispose of them at sea would welcome the opportunity to be able to sell all of their catch, regardless of the species; and 4) the consumer who must settle for fewer of the conventional species and at higher prices welcomes the opportunity to purchase alternative food species at relatively moderate prices.

TECHNOLOGY IN FISHERY DEVELOPMENT

The role of technology in fishery development covers a broad area that starts with the harvesting of the fish, continues throughout the processing, handling, and distribution of the product, and ends at the point where it is consumed as food. The extent of the technological input may vary from fishery to fishery depending on the needs.

The development of a new fishery may require the modification of presently available harvesting gear or it may require the development of new gear. The criteria for suitable gear such as ease of handling, effect on quality of catch, size of openings, and the nature of the material of which it is made apply to all species, and the available gear has to be evaluated and sometimes tested to determine its suitability for a new fishery. The bulk of the activities in gear research is in engineering.

Once the fish die or are killed, the technologist handles them as food, and here he employs all of the skills of the food technologist, which include microbiology, toxicology, chemistry, physics, nutrition, mathematics, engineering, and others. He studies the effects of processing on the organoleptic quality of the product and he monitors microbiological changes. He studies problems in off-flavor development like rancidity and discoloration such as the Maillard reaction. He investigates texture changes such as those resulting in toughening from the denaturation of protein and those resulting in softening such as from autolysis. He explores the environmental and processing effects on the product for possible toxicity when either the environment or the process has the potential for either adulterating the product or introducing reactants for the formation of toxic substances.

The technologist is, futhermore, constantly challenged by processing or handling techniques that tend to deteriorate the quality of the product and he is concerned with the design of packaging since the proper package can prevent quality deterioration through oxidative reactions and dehydration and, in some cases, light catalyzed reactions. The technologist is concerned with formulating standards of quality and devising physical and chemical tests for determining the various grades of quality. The technologist is also concerned with problems of human handling such as sanitation, inefficiency, variable yields, poor economics, and he is concerned with problems of mechanical processing such as adulteration from lubricants and metal chips. He is concerned about the need and use of additives and about the nutritive composition of seafoods. He studies the parameters of freezing, dehydration, canning, and other processes for their effects on quality, yields, and economics, and he assists the industry in the technological activities that it cannot do for itself. This area of assistance may involve the technologist deeply when unexpected variables in the parameters of a new process produce undesirable results. Thus, the role of the technologist to help solve the chemical, microbiological, and engineering problems of a new process may be crucial to its successful industrial implementation.

The successful conduct of technological research in fishery development depends on many things, but paramount among these is the need to keep the commitment to constituents. For example, the obligation to assure a continuing seafood supply to the general public must be met. In addition, there are obligations in communicating and working with industry, upon whose performance and welfare the effectiveness of our conduct on the public's behalf depends. This is an important duty that the technologist cannot afford to ignore. To quote a British article from the Fisheries Research and Development Board (Anonymous, 1975) "Fishermen regard the work of scientists as something abstract which has no real meaning for them" and "The basic problem is that as far as gear research and development is concerned, the industry does not know what is going on (they mean in research) and the laboratories do not know what the industry needs." In the United States this problem is recognized, and the New England Fishery Development Program (a government-industry collaborative effort) represents one attempt to resolve it.

When a conventional species such as the surf clam is in danger of becoming depleted, it would be desirable if conservationists would merely give a signal that would divert fishing pressure to a relatively underutilized species like ocean quahogs. It is then essential that processors would buy the quahogs from the fishermen and process them into various products for consumers. However, the conversion is not simple to implement. The meats of the ocean quahog are darker than those of the surf clams and they are stronger tasting (sometimes objectionably). Ocean quahogs are generally shucked by hand, making the meats more costly to produce than surf clam meats which are removed from their shells mechanically. Even if we do not consider the economics, it should be obvious that to introduce the quahog to markets accustomed to the surf clam requires that it either be made into an acceptable substitute by minimizing or eliminating the differences between the two or that it be used to make new products with an acceptance of their own. In either case there are problems requiring technological input. (While marketing and economics are necessary and related activities, these will be considered later.) Physical, chemical, and engineering principles can be applied to reduce the strong taste of the quahog meats and to automate the removal of meats from the shells and lighten their color. Some of the problems associated with ocean quahogs have been solved by NMFS technologists (Mendelsohn[1], pers. commun.).

A consideration of the federal expenditure to support this work is in order. It would have been better if taxpayers' money had not been used to do this work and if fish processors did their own technological research. After all, they are the ones that stand to realize a profit from the research. This line of thought can be carried even further. It might also be argued that fishermen should do their own stock assessment and stock management. In this way they could determine for themselves why they cannot harvest as many surf clams per unit effort as they did in the past and which species could be considered as substitutes for the surf clams and whether the stock of substitute species is of sufficient size. After all, the fishermen are the ones who benefit from this activity. Part of the answer is that neither the fishermen nor the processors have the economic capability to afford the research to determine the need for a new fishery and then to develop it. Even if a member of either group could afford any of the required research, this approach would imply a great duplication of effort, the costs of which would have to be borne by the consumer. The other part of the answer is that the fishermen and processors are only intermediate beneficiaries of the federally funded effort and that the ultimate and long-term beneficiaries are the American taxpayers, because these activities assure them of the availability of seafood protein of the widest variety and of the highest quality. In a way, government and the industry become partners in providing an assured supply of an important food commodity to the American consumer. It is not simply a case of federal support to industry.

One may or may not agree with the above observations, and one may choose to even ignore the situation, but the facts are not altered by opinion or by lack of attention. For example, industry will not on its own initiative develop a new fishery. While most of us believe that it cannot (has neither the capability nor the desire), there are those who believe that it can do it but chooses not to. Regardless of which explanation is correct, obviously there will be no pattern of fishery development if we expect industry to do it. Even if we do all of the necessary biological investigation and provide all of the required technology, the record shows that industry will not carry the ball simply because we think they should. When an action is necessary in the interest of the public, then its undertaking cannot be left to chance. It is, therefore, the role of government to take the necessary steps to maintain for the U.S. taxpayer the opportunity to have for the present, and for the future, a viable resource of fish and shellfish, primarily for food, but also for recreational or sport fishing and to employ any suitable strategy to effect its conservation policy without sacrificing jobs and without reducing the domestic production of seafoods.

National Marine Fisheries Service technologists have had a reasonable record of accomplishments when their efforts were integrated with machine manufacturers in a collaborative effort or when the proper set of coincidences set the stage for success. To illustrate, the following examples are given.

Success by Collaborative Effort

When NMFS technologists collaborated with equipment manufacturers, they successfully promoted the use of microwave ovens for thawing and tempering operations. (Several millions of dollars worth of these ovens have been put into operation, with distinct advantages to processors, as a result of that effort.) The technologists were able to demonstrate the many advantages of microwave thawing and these included comparisons of processing rates, sanitation, yields, organoleptic quality, and shelf life of the product, space requirements, etc. between conventionally thawed products and microwave-thawed products. The same kind of collaboration led to other successes which include the introduction of special centrifuges for separating

[1]Mendelsohn, J. M. 1976. Personal communication. Research Food Technologist at the Northeast Utilization Research Center, National Marine Fisheries Service, Emerson Avenue, Gloucester, MA 01930.

shell from meats of crabs and of deboning machinery for finfish. In all of these cases, certain essential elements were present. First there was a clear definition of the problem by the fish processors. Then there was the collaboration between machine producers who provided the marketing and economics capability and NMFS technologists who tested the processing effectiveness of the machines and who assisted processors in setting up and operating the processing lines. Experience shows that the processors would not have bought the machines if they had any doubt regarding the economics or the effectiveness of using them.

Success by Coincidence

When the availability of a popular commercial species declines significantly, fishermen who normally harvest it begin to feel the adverse economics of the reduced catch per unit effort and the pressure from the market demand. Such a situation exists in the lobster and crab fisheries. The red crab, *Geryon quinquedens*, was not fished commercially as recently as 3 years ago even though NMFS technologists had ascertained the feasibility of establishing the red crab fishery, albeit a small one according to fishery biologists. However, a combination of partly idle boats, a strong market demand, similarity between the edible characteristics of the product and those of lobsters and other crabs, and apparently reasonable economics stimulated industry to the point that the commercial landings of this species is currently about 2 million pounds per year. In another instance a visit to Europe by an eastern U.S. processor educated him to a guaranteed market for dogfish, the proper skinning procedure (important in processing dogfish), and a favorable economic analysis. As a consequence, he expects to begin processing dogfish soon.

The situations described above led to successful innovations by circumstances partly or completely beyond the control of NMFS. It is as though there exists a formula that leads to successful implementation but is, as yet, not defined. It appears that too often the formula we use excludes vital terms that make it incomplete. For example, too often we have expected technological research by itself to accomplish a mission such as the development of a fishery. Other times, we employed a high-powered marketing thrust to virtually develop a fishery, but the accomplishments have been shallow. The establishment of the New England Fishery Development Program added two vital terms to the formula. It added industry's input and it integrated biology and technology. Industry assisted in defining the problems, in setting priorities, in evaluating the approaches to the problem, and in monitoring the research progress. But it seems that the formula is still incomplete.

The attempt at industrial implementation of NMFS technology research and development has often been frustrated. In recent years especially, numerous potentially economically important fishery products developed at NMFS utilization laboratories have yet to be assimilated in commerce. The technologists believe that the reason for this undesirable situation is due to a lack of marketing effort. However, marketing personnel attribute the impasse to the resistance of potential buyers who will not buy unless they can be assured of two bits of information: 1) cost of product and 2) an identified source of supply. When they approach a potential processor he resists because he too needs two bits of information: 1) production cost and 2) market potential. Thus, we cannot generate a market because there is no processor for the product, and we cannot get a processor interested in producing the product because there is no market for it. The foregoing represents a circle without a point of entry and the situation is analagous to trying to establish as to whether the first egg came before the first chicken or vice versa. It seems that the only way to break into the circle is to do it via an integrated approach which includes inputs by fishery biologists, fishermen, processors, technologists, marketing specialists, and economists. It appears that all of these elements are vital and that there should be complete collaboration from beginning to end—from definition of the problems, assignment of priorities, evaluation of research proposals, and monitoring of research progress to the final step where the results of the research efforts are finally put into commercial practice. Input by fishery biologists is vital because we have to have an estimate of the size of the resources, the sustainable annual yield, etc. Input by fishermen and processors is essential because we need their help to keep the progress relevant and we need to be assured of their interest and commitment in the project. We need the technological input to solve problems in harvesting, handling, processing, quality control, etc., and we need help from marketing experts to maintain an assurance of the market potential. Finally, and perhaps most important, there needs to be a constant testing of economic feasibility because the economics of the proposed innovation is the critical consideration that determines whether a project should be permitted to proceed or to be terminated.

In summary then, the role of technology in fishery development is changing from one based on the assumption that:

Technology = Fishery Development (1)

(a formula that too often has resulted in frustration) to one that is based on the idea that:

Technology + Biology + Industry Input = Fishery Development. (2)

Equation (2) has demonstrated a greater potential for success than Equation (1). However, it appears that a more promising equation is:

Technology + Biology + Industry Input + Marketing + Economics = Fishery Development.

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