NORTHWEST FISHERIES CENTER
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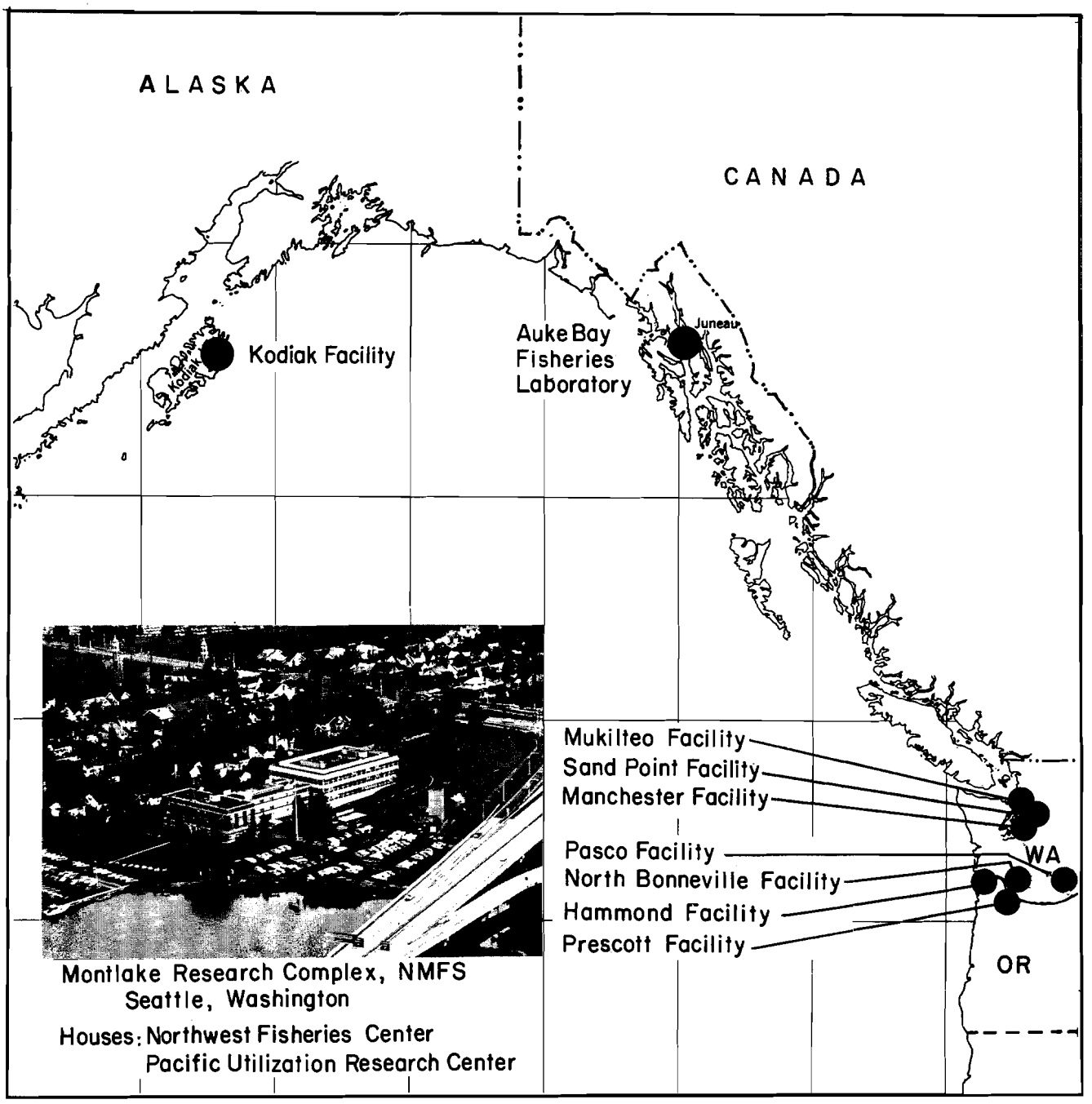
FISHERY RESEARCH AND DEVELOPMENT OF TECHNOLOGY AT THE NORTHWEST FISHERIES CENTER

(ROLE, PURPOSE, AND CONTRIBUTION)

by

George K. Tanonaka

Prepared by:
Northwest Fisheries Center
National Marine Fisheries Service
2725 Montlake Boulevard East
Seattle, Washington 98112



LABORATORY AND FACILITIES OF THE NORTHWEST FISHERIES CENTER
NATIONAL MARINE FISHERIES SERVICE

ABSTRACT

There is little understanding or appreciation of federal fishery research and its benefits in the United States. Neither the products of our research nor their values are well known. This report examines the causes underlying this deficient condition and outlines some of the steps being taken at the Northwest Fisheries Center, National Marine Fisheries Service to correct this deficiency. The presentation of some selected examples on practical benefits from our research as well as contributions we have made to the advancement of science is a small step in the direction of evaluating research and benefits and informing people of its values.

Some examples of practical benefits are: (1) development of commercial fisheries on king crab and shrimp in the northeast Pacific Ocean and enhanced angling success by sport fishermen on Lake Washington sockeye salmon from our resource surveys, (2) commercial application of fishing technology developed at the Center such as midwater trawl, universal trawl, deepwater trawl, sablefish pot, etc., (3) protection of North American salmon and southeastern Bering Sea king crab through stock assessment studies, (4) development of an industry around salmon aquaculture, (5) substantial savings by water resource development agencies in fishway construction costs based on our information on improved fishway designs, and (6) protection of salmonids from thermal pollution in the Columbia River. Unfortunately, information on such benefits have been retained to date by researchers primarily in the form of non-documented experiences. This is largely a result of our inability to evaluate and translate them into social, or practical terms.

A hypothesis developed in this report is consumers of fishery products and the general public seldom benefit directly from fishery research. Our information must first be accepted and applied by others such as fishermen, processors, management agencies, etc., before benefits such as stable product prices, a broader range and supply of fishery products, product quality, etc., can eventually accrue to these clients (consumers and the general public). Therefore, most people are not aware of what fishery research is about or its resulting practical benefits.

A basic cause underlying our deficiency in properly planning for and evaluating, documenting, and effectively communicating our research and benefits in practical terms is the narrow technical perspective maintained by federal fishery research groups. Simply put, we can say that application of our research findings may lead to an increased availability of "X" numbers of pounds of fish to a fishery but showing what it means in terms of, say, potential employment, increased earnings, consumer welfare, etc. and seeing if these were indeed accomplished, is beyond your current perspective and capability. In reality, these practical terms are those by which our processes in problem identification and definition, and research planning should also be framed but that which we have not carried out effectively.

The development and maintenance of our narrow technical perspective is a result of academic training, organizational norms, tradition, and professionalism. Background and capabilities in the social sciences (in economics, sociology, political science, communication, etc.) needed to broaden our perspectives and thus, help in part to correct the deficient condition evident today have not been formally developed at research centers and laboratories.

It is recommended that capabilities in the social sciences be developed at the technical (field) level of the National Marine Fisheries Service where program planning and program impacts take place. The training of people in the social sciences is an investment which should be undertaken by each research center or major laboratory. Development of capabilities as such is not a panacea. However, it should be a start in strenghtening our role and responsibility as scientists in a public organization of taking the abstractions of science and other bodies of knowledge and effectively applying them to the practical problems and affairs of our society.

CONTENT

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INTRODUCTION

There is little understanding or appreciation of federal fishery research and its benefits in the United States, even after decades of activity. Neither our products nor their values are well known. This is a deficient condition which should be recognized and acted upon.

This report by the Northwest Fisheries Center 1/, National Marine Fisheries Service 2/, NOAA (National Oceanic and Atmospheric Administration) examines the causes underlying this condition and outlines some of the needed steps being taken at the Center to correct it. A small step in this direction is found in the introduction to this report which includes examples of some past and projected contributions from our research. These examples will show that the benefits from our research are of magnitudes greater than most people realize.

Materials in this report have been arranged into four parts. The first part (Organization and Purpose) describes the structure, functions and responsibilities of the Center as a scientific organization and as a public research organization.

The second part (Research, Clients, and Practical Contributions) describes the type of applied (or programmed) research carried out by the Center and its clients; it presents documented examples of past and projected practical contributions (or benefits) from our research activities.

The third part (Contributions to the Scientific Community) gives documented examples of the Center's contributions to the scientific community in the form of scientific expertise and development of research tools.

The fourth part (Organizational Rationale -- Problems and Change) although somewhat abstract, identifies the causes underlying our current problems and consequent inability to properly identify and evaluate fishery research in practical terms (and, hence effectively communicate results to bring about better understanding and appreciation for federal fishery research), the changes needed to correct this condition, and recommendations on implementing these changes.

Although this report touches upon organization and administrative matters, it is not intended to replace or change National Marine Fisheries Service policies, directives, or practices but rather to augment them. It is essentially a perspective of the problem from the field.

ORGANIZATION AND PURPOSE OF THE NORTHWEST FISHERIES CENTER

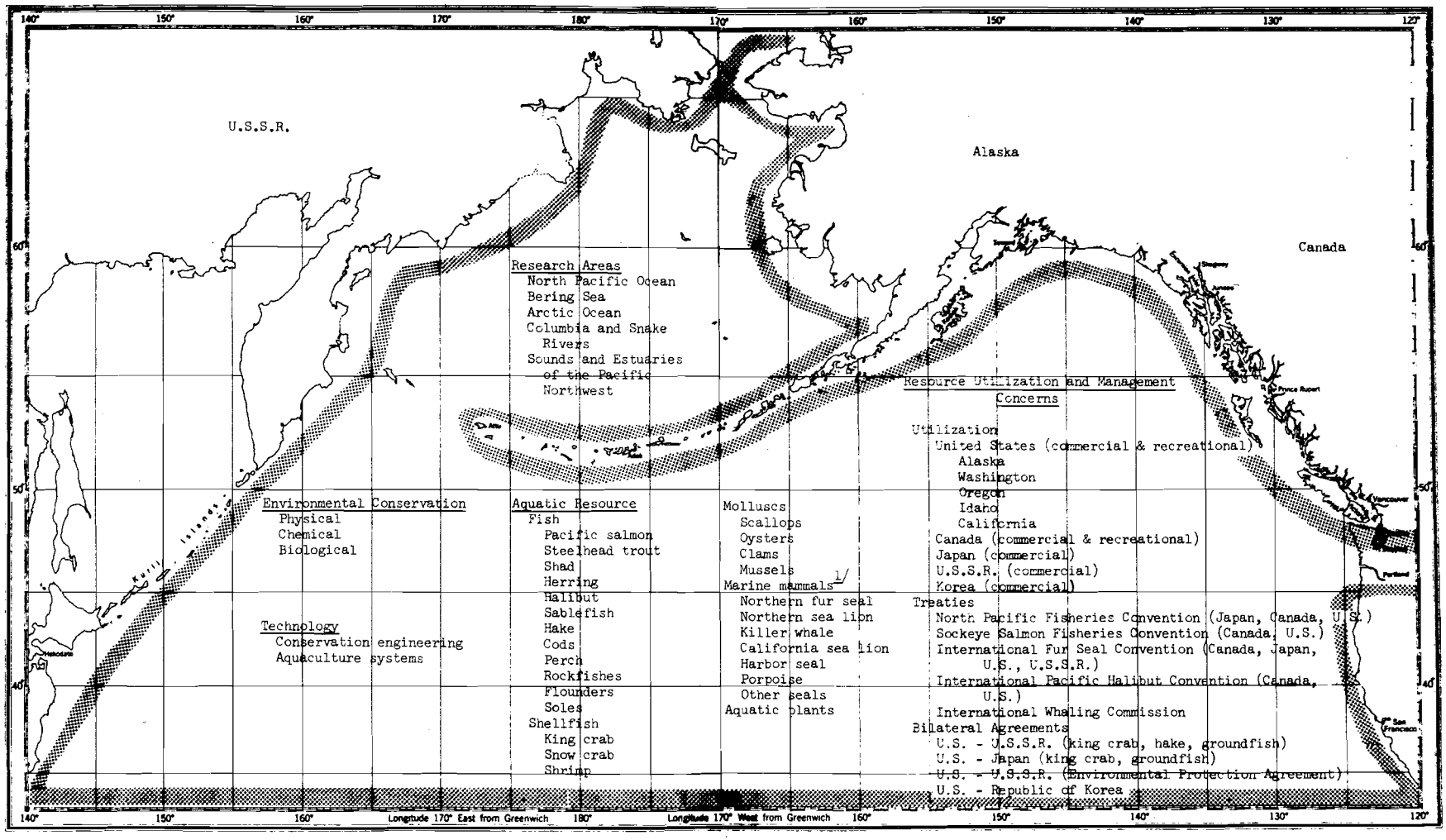
The Northwest Fisheries Center is a professional organization staffed by personnel with training in the fields of fishery biology, marine mammal biology and medicine, oceanography, chemistry, physiology, biometrics, electronics, and engineering. Managerial and operational personnel are primarily from these technical fields. Traditional administrative support activities are handled by personnel with training in accounting, procurement, and personnel matters. Personnel with training and experience in the areas of planning, programming and budgeting, economics, and public affairs contribute to overall management of the Center.

The Northwest Fisheries Center, as a fishery-related research organization, conducts research under statutory authorities; the Center also fulfills commitments resulting from international fishery treaties and agreements. A generalized areal representation of fishery resources and advisory areas under the Center's purview is presented in Figure 1. All are not the independent responsibility or concern of the Center. Many federal, state, and foreign agencies and groups, as well as fishery commissions are actively involved.

As indicated earlier, the core personnel at the Northwest Fisheries Center are scientists primarily from the biological and physical sciences. As a scientific organization, the Center has the role and responsibility of expanding man's knowledge on natural phenomena. As a public research organization, however, the function and purpose of the Center is (along lines of Price, 1965) to take the abstractions of science (or other systematic knowledge) and apply them to the concrete and practical affairs of men. Price further states, "Science can insist on ignoring questions of purpose in order to be objective and precise; the professions cannot". The Northwest Fisheries Center is, in that sense, a profession. This dual role and responsibility (scientific inquiry to expand man's knowledge and the taking of the abstractions of science and applying them to the practical affairs of men) underlie public, scientific-research organizations, such as the Northwest Fisheries Center. A conceptual framework on this duality is presented in Figure 2.

For ongoing research at the Center it will be assumed that the social and technical problems already have been identified and defined and that these led to the planning, programming, budgeting, and operation of the research. For new or emerging problems, the action flow at the Center generally begins by identifying and defining the social and technical problems. These problems may be of national origin or out of situations at the regional or local levels.

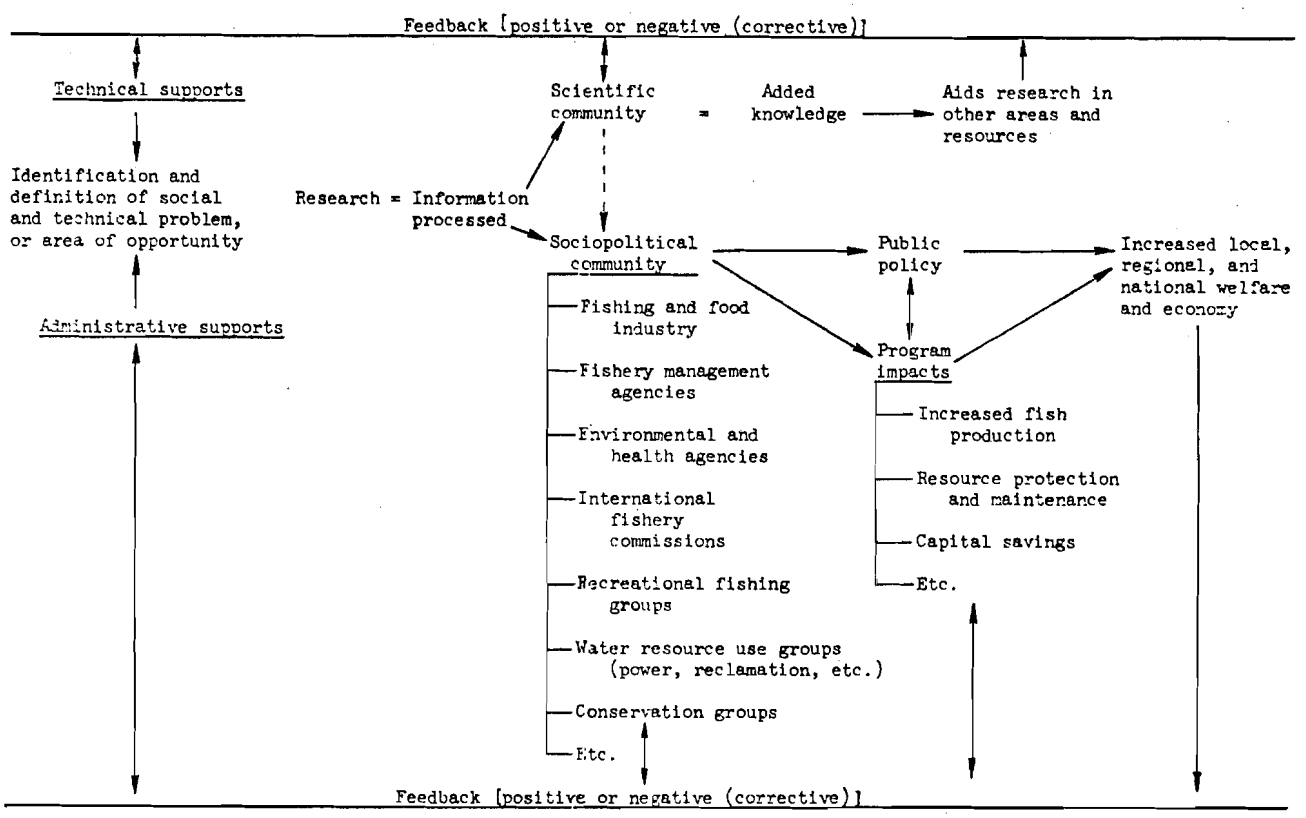
Figure 1.--Research and advisory areas of concern, Northwest Fisheries Center, NMFS, Seattle, Washington



1/ Marine mammal is, in part, worldwide; e.g., International Whaling Commission studies.

The problem may originate within the sociopolitical community as a result of information such as reports of foreign fishing activities on a stock of fish "traditionally" fished by the United States. One of the needs of the community is the need for technical information on the effects that such foreign activities have on the present and future condition of the fish stock. The problem is now both social and technical, even though it may have been social (foreign fishing) in origin. On the other hand, the problem may have been technical in origin. For example, during the course of research activities on the Columbia River salmon resources researchers observe that many juvenile salmon moving downriver are beginning to exhibit symptoms of "gas bubble" disease. Over time it is discovered that extensive mortalities of juvenile salmon are occurring from this disease. This is a technical problem. Such losses, however, will greatly affect the important commercial and recreational fisheries that depend on the salmon of the Columbia River. The problem is now both technical and social.

Figure 2.--General nature and impact of federal fishery research at the Northwest Fisheries Center.



For simplicity, the "research" stage in Figure 2 is assumed to cover the process of program planning and operation towards specific courses of action based on technical supports (e.g., technical operating standards and methods) and administrative supports (e.g., planning and programming method of the Planning and Management System (PAMS), cost-accounting method of NOAA, and NMFS and Center policies and objectives). A feedback or evaluation process is also assumed to operate in this stage.

As illustrated in the figure, information is relayed to the scientific community through formal (publications) and informal communication channels. Information here is technical and its general "value" is in contribution to knowledge. Application or incorporation of this information by others in their research generally constitutes the benefits of that research. Technical criteria (scientific norms and standards) largely determine the "value" of the information in the scientific community.

Information is simultaneously relayed to the complex sociopolitical community through formal and informal communication channels (Figure 2). Information here is primarily in social terms as the purpose and objective of the Northwest Fisheries Center is to cause an impact on the social environment (via clients) through this information. Government agencies (federal, state, and local), legislative bodies (federal and state), international fishery commissions, the fishing industry, interest groups, consumers, and similar groups make up this community. Information, when accepted, is applied by this community to formulate public policies, undertake capital projects to maintain or improve the condition of the resources, cause desired changes in resource management practices, counteract foreign fishery plans, increase domestic fish production, protect fishery resources habitats, etc. These resulting actions are then primarily quantifiable in social terms. Here, sociopolitical values and standards largely determine the "value" of the information. (Appendix A further examines the research process and also presents a classification method to aid in determining what types of research and consequent information fall into the categories of information directed to the scientific community and information directed to the sociopolitical community).

Finally, feedback mechanisms are included in Figure 2 to emphasize the fact that research objectives and goals undergo shifts in emphasis or other modifications due to internal and external technical, administrative, and social forces acting upon the organization and action flow (for example, budget cuts).

The "scientist to scientist" linkage and process of Figure 2 is well established. The assumption here is that scientific values, norms, and standards are fairly universal. The "scientist to sociopolitical community" linkage and process, however, is more complex and not as well established. A difficulty here is that exchange and acceptance of information is influenced by the social dynamics of brokerage politics, interest group values, professionalism, tradition, and cultural variables that permeate this community within the environment (domestic and international). This spectrum of social dynamics, varying in quality and quantity, has been faced by most personnel at the Northwest Fisheries Center but, unfortunately, has been primarily retained as nondocumented experiences. (The social sciences offer much in this regard. The area of diffusion of innovation is presented in Appendix B as an example of contributions from the social sciences being considered and used by the Center in the area of communication).

Using the framework developed in Figure 2 on the dual role and responsibility of the Center, an evaluation of the research, clients, and contributions (practical benefits) to the sociopolitical community is made in the next part of this report followed by research contributions to the scientific community.

RESEARCH, CLIENTS, AND PRACTICAL CONTRIBUTIONS OF THE NORTHWEST FISHERIES CENTER

Applied (or programmed) research-clientele relationships of the Center as discussed here are based largely on the concept of differences in system levels in organization found in the last part of this report on Organizational Rationale -- Problems and Change. The basic essentials are that clients of the Service at its institutional level (or central office) are primarily national in character while clients of the Service at its technical level (e.g., Northwest Fisheries Center) are primarily regional or local in character. Furthermore, a client of the Center (and also of the Service) is defined here in the "systems" sense as that person or group to which action flows (or energy) of the Center are directed. The actual impact may benefit the client directly, counter his attack on the agency, or dissipate his attempts to reduce support for the Center. Direct benefits to the clients are of prime interest.

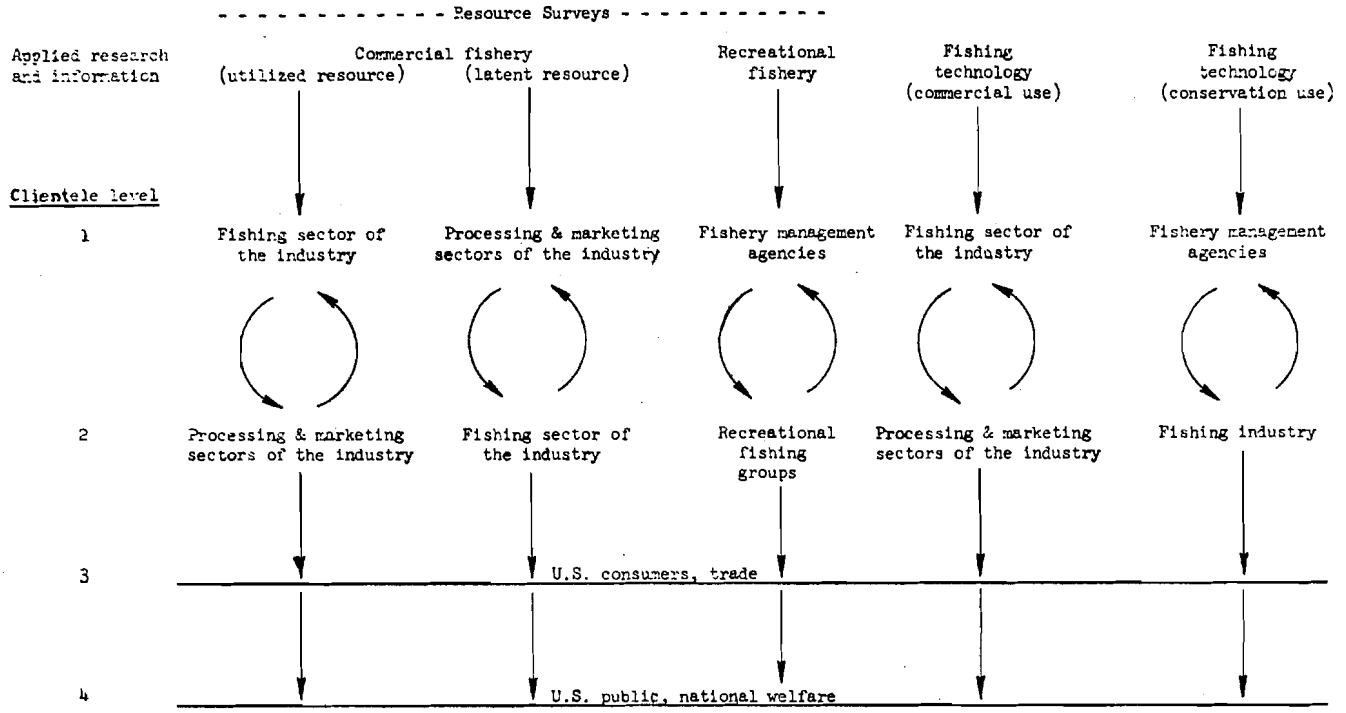
At the Center, differences in clients and their levels appear to exist in relation to programmed research activities (Figure 3). In the figure, clientele level is structured by the immediate user or beneficiary of Northwest Fisheries Center fishery and technology (Level 1), by the Level 2 clients believed to benefit from (or be affected by) acceptance and application of the information at Level 1, etc. This classification must be viewed in context of our existing institutional norms; that is, the limitations on Center activities to research, the "common property" nature of most fishery resources, the current role of the marketplace and its mechanisms in fishing, processing, and marketing of fishery products, the management role of state agencies in most domestic fisheries, and the role of state and other federal agencies in management of the environment (see Figure 2). Also, research and technology may be the result of a cooperative effort on the part of federal, state, and academic institutions. For purposes of a simplified discussion, however, the information labeled in Figure 3 is assumed to be primarily that of the Northwest Fisheries Center.

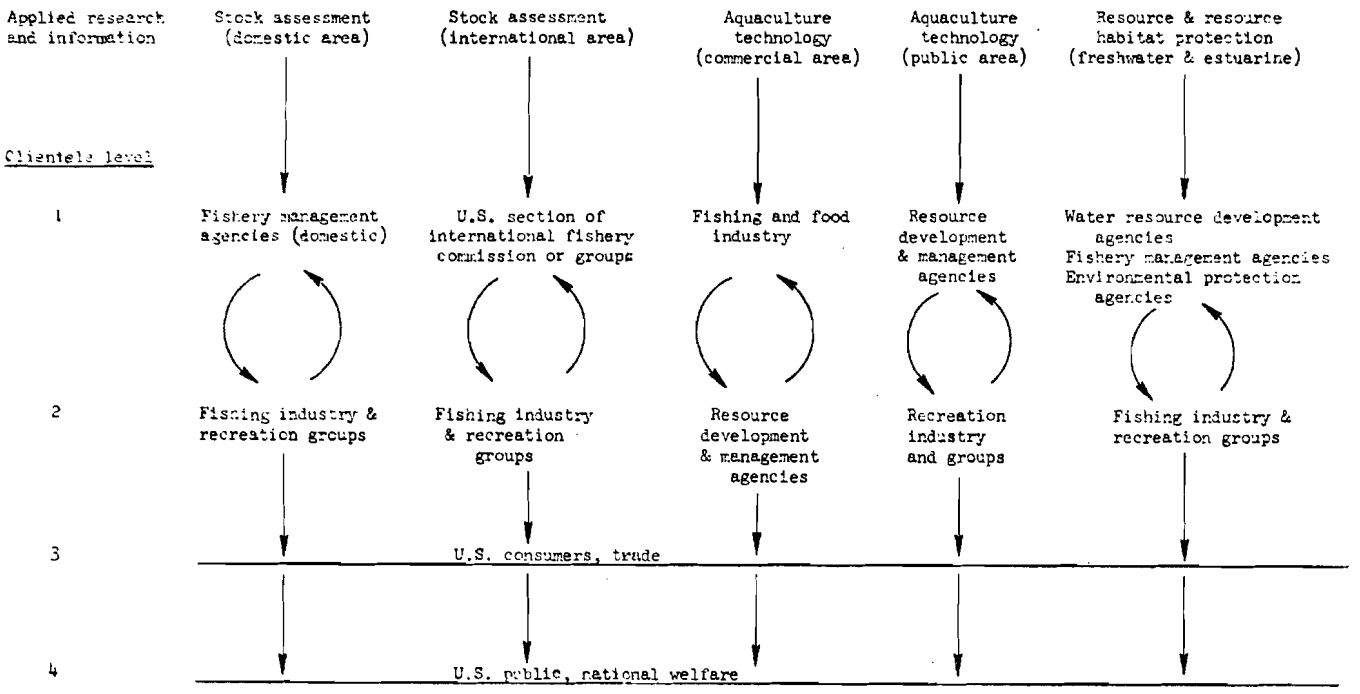
Center Research and Clients

Resource Survey Information and Clients

Resource surveys lead to information on the distribution, abundance, and availability of fishery resources (Figure 3). In the commercial fisheries area on resources currently utilized with a market demand, the immediate client (Level 1) of the information is primarily the fishing sector (fishermen) of the commercial fishing industry. The development of a fishery on a new stock or in an area results in additional supplies of the resource becoming available to processors and distributors (Level 2) to meet consumer (market) demand (Level 3). Implied here is that benefits are consequently experienced by all sectors of the fishing industry in the form, say, of increased earnings and to the consumers in the form, say, of increased availability of products at stable or lower prices.

Figure 3.--Generalized representation of the research information-client relation at the Northwest Fisheries Center, NMFS.





In contrast to the above, the immediate client (Level 1) of survey information on latent fish resources is primarily the processing and marketing sectors of the industry. If a real or potential market demand exists in the estimation of these sectors, fishing on the latent resource commences through the mechanism of the market (fishery) system. Economic benefits are assumed to flow through the sectors of the industry with benefits to the consumers (Level 3) in the form of increased availability of "desirable" fish products. As a reminder that research activities at the Northwest Fisheries Center are not mutually exclusive, the Pacific Utilization Research Center, NMFS, for example, has input here if the problem is not market demand for the latent resource but one of an adequate processing technology to prepare the resource for an existing market.

Research on anadromous and marine recreational fisheries was assigned to the Service following its recent reorganization in 1970. In cooperation with state agencies, the Center now carries out resource surveys directed to enhancing recreational fishing activities. In contrast to the commercial fishery area, the immediate client of the information here is the recreational fisherman who is not only the harvester but also the consumer in this case (Figure 3). Furthermore, the information is also used by the state agency, in a near simultaneous process, for management purposes.

Fishing Technology Information and Clients

Research on fishing technology is directed at: (1) increasing the efficiency of commercial harvesting methods; (2) reducing mortality of incidentally caught animals; and (3) developing improved sampling gear for stock assessment needs. Fundamental research activities underlying these are studies on animal behavior, on fishing and sampling system designs, and on performance evaluation.

The immediate client (Level 1) of information on efficient commercial harvesting methods is the fishing (fishermen) sector of the industry. For example, information from "fundamental" research on shrimp behavior at the Northwest Fisheries Center leads to "applied" research and the development of a new technology -- the selective shrimp trawl -- which is cheaper, more efficient, and improves the quality of raw shrimp landed. Market demand for shrimp is high. Assuming no institutional constraints, the acceptance and application by fishermen results in lower harvesting costs, or increased earnings, to them. The quality increase and lower cost is transferred to the processing and marketing sectors (Level 2) of the industry which, in turn, transfers these benefits to the consumers (Level 3). Tested application of this technology may lead to use by fishermen throughout the United States, whereever applicable.

The immediate client of information on effective harvesting methods to reduce mortality of incidentally caught animals are the fishing (fishermen) sector as well as management agencies. This is a near simultaneous communication process. For example, the development of a modified tuna seine which permits escapement of the "socially" important porpoise yet enable efficient capture and retention of tuna will benefit the fishermen as well as society -- the latter (society) via application of proper conservation measures by management agencies based on the fishing technology information.

Stock Assessment Information and Clients

Stock assessment studies provide the fundamental technical information base for resource management decisions by domestic agencies and for the development of U.S. policies or preferential positions in international fisheries. This is perhaps the most difficult research acitivty-information area to be evaluated at this time (see the later section on benefits).

In general, the immediate client (Level 1) of information on stock condition of domestic fish resources would be state management agencies or interstate fishery commissions (Figure 3). Within the limits of their authority and organizational procedures the "harvestable surplus" and their allocation are determined. Where applicable, regulatory activities are carried out by these agencies. The fishing industry and recreational fishing groups (Level 2) use this management information to make their investment and operational decisions.

Extensive stock assessment studies are also carried out by the Center on marine mammals as required under the Marine Mammal Protection Act and the Endangered Species Act recently passed by the U.S. Congress. Here, the immediate client is the Service itself who has the management authority on domestic issues related to utilization or protection of marine mammals.

The immediate client (Level 1) of information on stock conditions of multinationally exploited fish resources would be the U.S. section of international fishery commissions or groups. Decisions or actions taken at this level affect our domestic fisheries and management activities (Level 2). An aspect of stock assessment -- forecast of salmon runs — will be used to illustrate the above research information-clientele structure and process for both domestic and international areas.

In the domestic area, the immediate client of information on forecasts of salmon runs, for example, would be the management agencies and the processing and marketing sectors (salmon canners) of the industry. This information helps management agencies to approximate the harvestable surplus and to arrive at plans for management operations. The salmon canners use the forecast (and consequent information on "harvestable surplus" and the allocation of available fishing time, which is determined by management agencies) to make investment and operational decisions for the coming season. The Level 2 clients (primarily fishermen) use the above information to make their own investment and operational decisions. A successful season based on proper decisions at Levels 1 and 2 is assumed to benefit the consumer (Level 3) in the form of stable or lower prices for the end-products.

In the international area the immediate client of information on forecast of salmon runs is the U.S. Section of the International North Pacific Fisheries Commission (INPFC). Through the mechanism of the commission structure this information is used for a variety of national purposes — as information required under the treaty, to strengthen our position in negotiations, to deter a resolution, to minimize the adverse effects of foreign activities on "our" stocks of salmon, etc. Accomplishment of purposes are then assumed to benefit the U.S. fishing industry (Level 2) and, consequently, the consumer (Level 3).

Aquaculture Technology Information and Clients

The growing demand for seafood and recreational fishing emphasizes the need for aquacultural technology appropriate to the further development and better management of the fishery resources of the coastal zone. Research on aquaculture at the Northwest Fisheries Center is addressed to that need with principal focus on salmon aquaculture at this time (Figure 3).

On information directed to the private enterprise area, the immediate client (Level 1) is the fishing or food industries. Within the authorization and encouragement given by Level 2 agencies, the acceptance and successful application of the information is assumed, eventually, to result in consumer benefits (Level 3) in the form of increased supplies and a broader range of desirable fishery products at stable or lower prices.

The immediate clients of information on aquaculture technology appropriate to the "public" area are resource development and management agencies. The acceptance and application of the information in concert with Level 2 clientele needs (recreation industry and groups) is assumed, eventually, to result in sport fishery benefits at Level 3 (consumers).

Resource and Resource Habitat Protection Information and Clients

Research here is directed at providing information on the damaging effects of man-induced environmental changes on living aquatic resources and for recommendations to prevent or correct damages. Examples of "damaging" activities of man are: (1) effects of dams and other water resource developments on fish migration and survival in relation to changing ecology of rivers; (2) discharge of harmful effluents which may reach waters containing aquatic resources; (3) thermal changes resulting, for example, from operations of thermonuclear electric generating plants; and (4) dredging operations which disturb the bottom of waters containing aquatic life and resources.

In both freshwater and estuarine habitat areas (Figure 3) the immediate client (Level 1) of information is, singularly or in cooperative arrangements, the public agencies and private firms concerned with water resource development, fishery development and management, or environmental protection activities. Their acceptance and application of the information, within the social, economic, and political realities they face, lead to hoped-for beneficial impacts at Level 2 (fishing industry and recreation groups) and consequently at Level 3 (consumers).

Spin-off Information and Summary

Although not categorized in Figure 3, "spin-off" type information results from federal fishery research -- the benefits from which are not necessarily closely linked with the original field of investigation. Several examples are presented later.

In summary, Figure 3 shows there is a qualitative difference in the immediate clients of information processed at the Northwest Fisheries Center. An obvious implication is that benefits seldom accrue directly to the general public (Clientele Level 4) from the type of information (service) provided by the Center. Therefore, to the general public most federal fishery research activities would not be comprehensible, or only vaguely so. Furthermore, under existing institutional arrangements the consumers (Clientele Level 3) also do not appear to benefit directly from Northwest Fisheries Center's research information. (A possible exception is sport fishermen who may benefit directly from resource survey information). Benefits to be realized at Levels 3 and 4 depend upon the acceptance and application of research information at Levels 1 and 2.

A qualification is necessary. The Center does frequently respond directly or indirectly via our central or regional offices on requests for information from executive departments, legislators, and the general public such as students, an interested citizen, news media, etc. Information here, however, is mostly of non-programmed type in contrast to those outlined in Figure 3. In this regard the public would benefit directly from this type of service provided by the Center.

Finally, this qualitative difference in clients and information dictate to a large degree the social terms (economic, social-psychological, or political), by which research and contributions of the Northwest Fisheries Center are to be evaluated, and their degree of difficulty.

Applied Research Benefits

Examples of practical benefits, past and potential, follow. Some of these have been reported by Alverson (1973). Furthermore, some of the benefits were a result of cooperative research efforts (Northwest Fisheries Center and others), but since primary responsibility and initiatives were largely those of the Center, the benefits, with stated qualifications, are assumed under it.

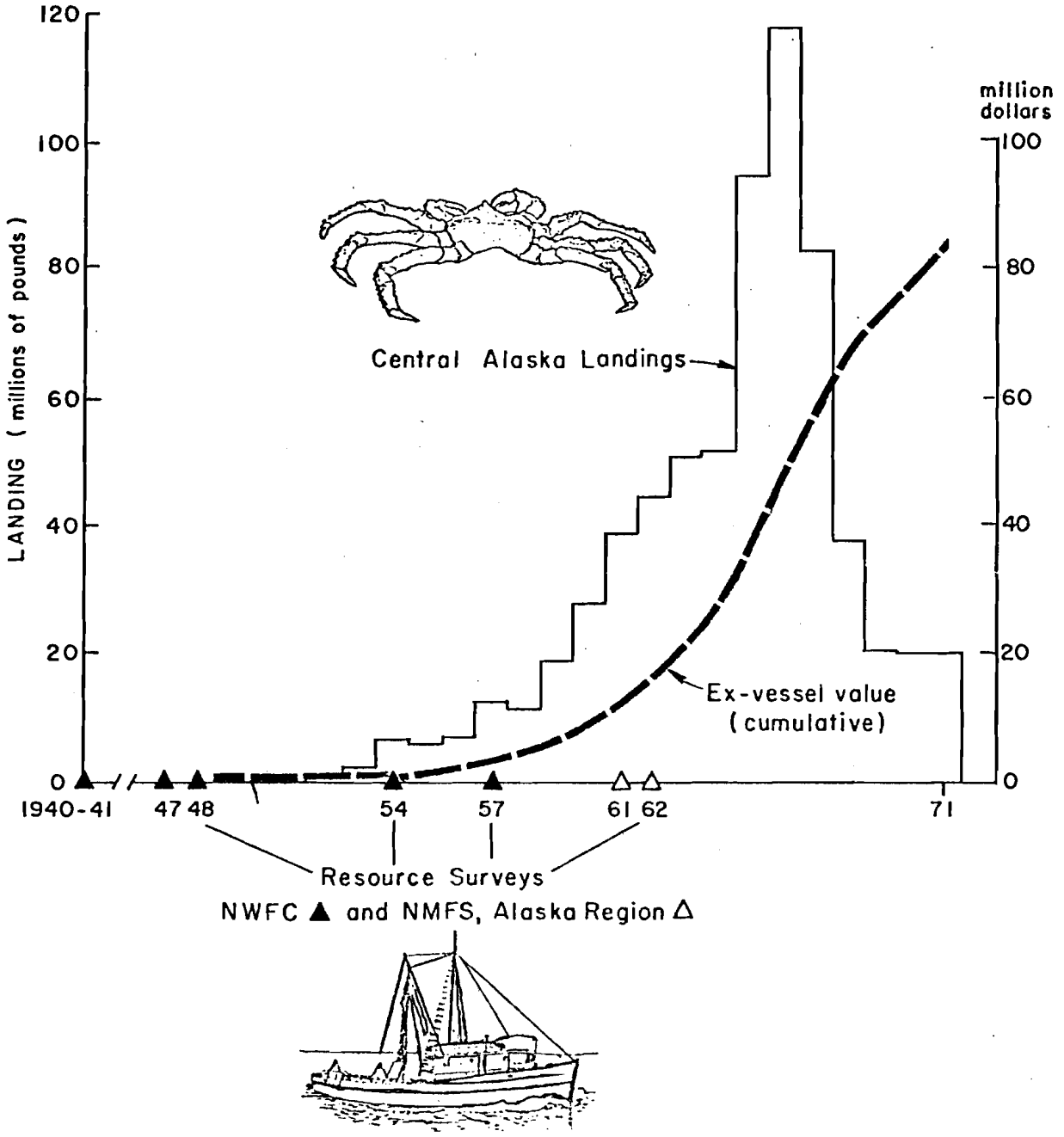
Resource Survey Benefits

Many important Pacific coast fisheries were started or were enhanced as a result of resource surveys by the Northwest Fisheries Center, its predecessor organization, or sister agencies. The king crab, Pacific ocean perch, and shrimp fisheries were selected to illustrate the general benefits to the United States from such government surveys. The rationale underlying "benefit" here are two-fold: (1) the resource survey was instrumental in starting a new fishery or (2) the resource survey made possible the subsequent efficient development of a fishery as new processing technology was developed (e.g., shrimp peeling machine) or as the market and demand for its products began to grow. As indicated earlier in Figure 3, the immediate client of information from resource surveys are members of the fishing industry.

King crab.--Initial government surveys on king crab resources off Alaska were conducted in 1940-41 and continued again in the late 1940's after World War II. According to Alverson (1973) "If one examines the scientific reports concerning the distribution and abundance features of these economically important invertebrates in light of recent commercial operations, it is apparent that the early investigations effectively described the areas where fisheries were likely to succeed. In fact, there is little doubt that the king crab operations, which were initiated in Alaska shortly following World War II, sprang up as direct results of the 1940-41 surveys. The entire growth of the Alaska king crab fisheries has been credited by Lowell Wakefield (1966), a major king-crab operator in the Alaska area, to have been stimulated by government resource surveys".

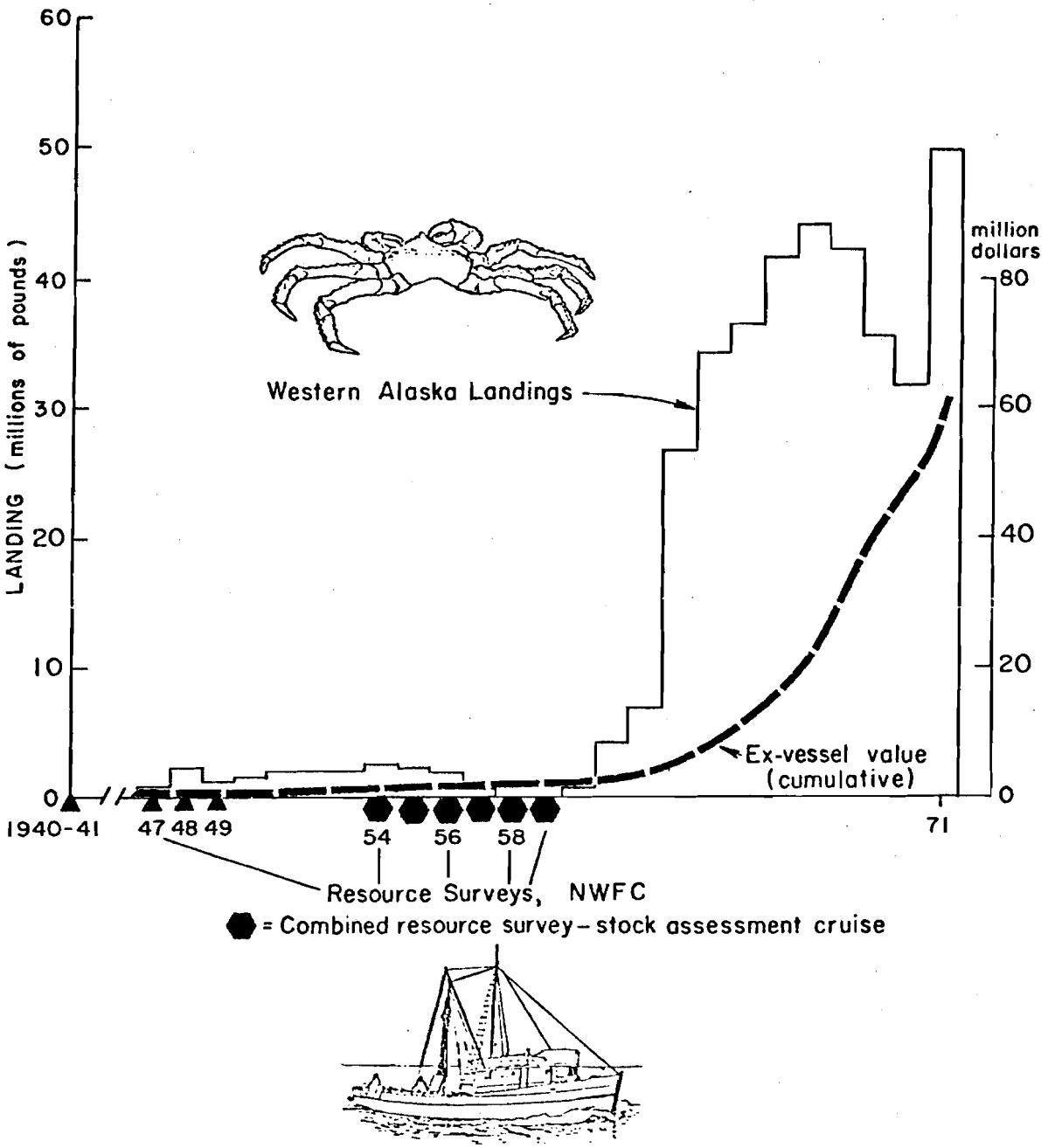
The general relationship between government surveys and the dramatic development of the king crab fishery off central Alaska is presented in Figure 4. The total cost of these surveys was approximately $108,000 (excluding administrative or support costs). The cumulative ex-vessel (or landed) value reached $84 million by 1971. The equally dramatic decline of the fishery since 1967 is a feature related to stock condition and management.

Figure 4.--Benefits to economic activity from resource surveys on king crab along the central Alaska area.



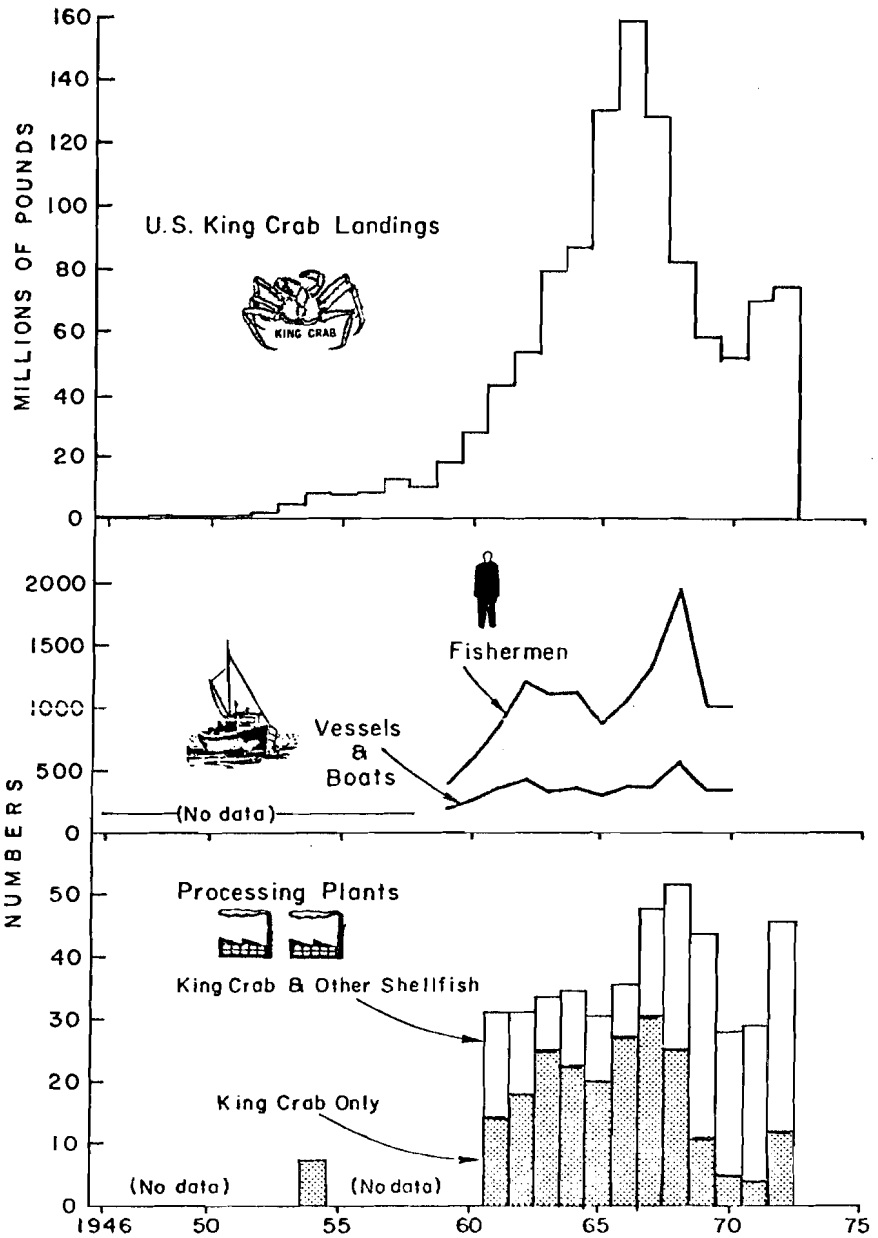
King crab surveys off western Alaska have resulted in the development of a large fishery since 1961 (Figure 5). The time-lag between survey and fishery development is much greater in this case. The cumulative ex-vessel value of this fishery reached $62 million by 1971. The cost of surveys during the 1940's was approximately $110,000 (excluding administrative or support costs).

Figure 5.--Benefits to economic activity from resource surveys on king crab along the western Alaska area.



The development of the United States king crab fishery and its implied impact on economic activities is presented in Figure 6. Currently, there are approximately 1,000 king crab fishermen and between 300 and 400 king crab vessels and boats. The number of processing units (shore plants and floaters) has ranged between 28 and 52 units since 1961. These units vary considerably in processing capacity. In contrast to the earlier years (1961-67), the number of units processing king crab and other shellfish (Dungeness crab, snow crab, shrimp, and clam) has increased while the number processing king crab only has declined. This generally coincides with the partial decline in king crab catch and development of other fisheries such as on shrimp and snow crab.

Figure 6.--United States king crab fishery: landings, fishermen, vessels and boats, and processing plants.

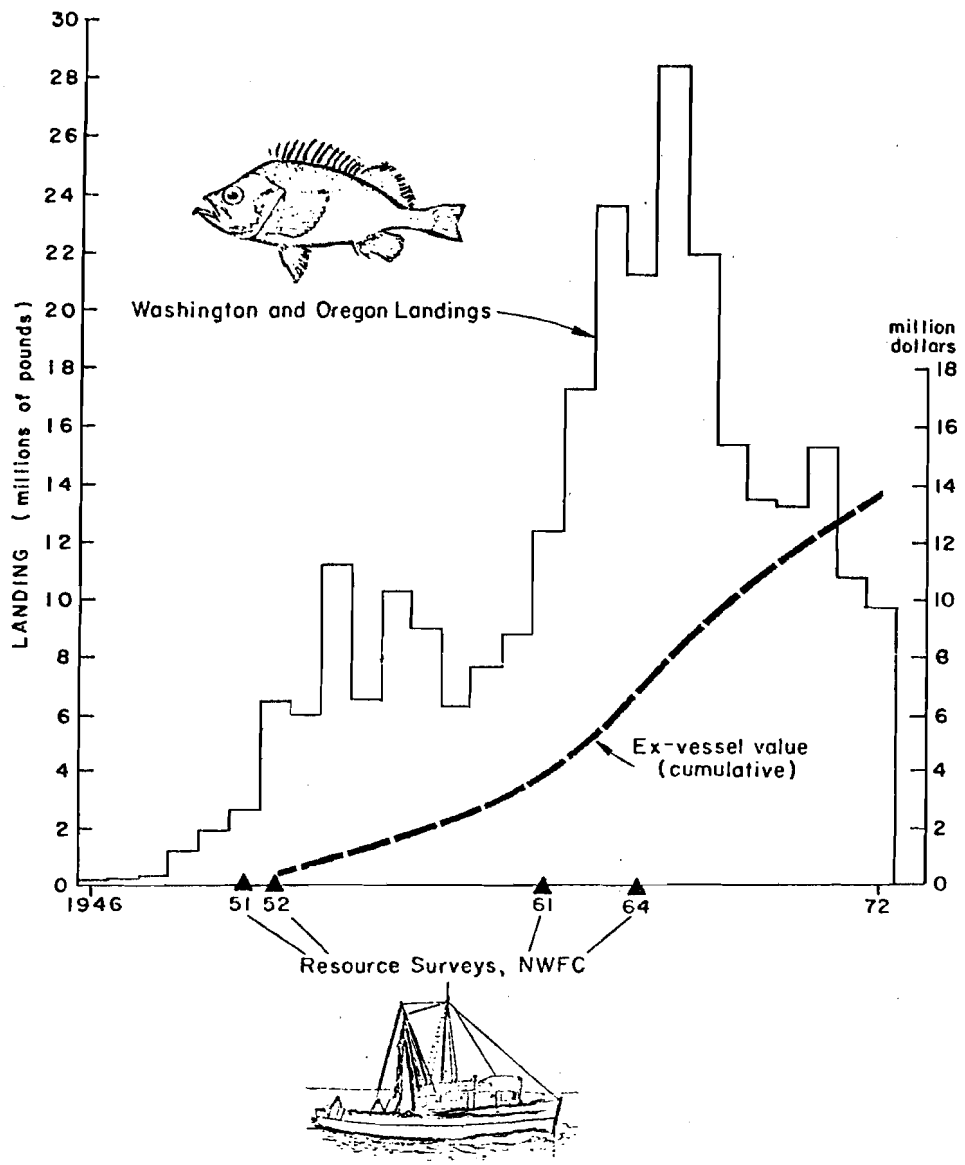


Pacific ocean perch.--The development of the Pacific ocean perch fishery off Washington and Oregon shows a similar response to government resource survey activities.

Prior to 1950, the species was still reported as "rare" with commercial operations conducted on a relatively small scale. Starting in 1951 a series of groundfish surveys were conducted from off southern Oregon to Unimak Pass in Alaska. These surveys demonstrated the presence of large concentrations of Pacific ocean perch at depths between 100 and 300 fathoms throughout the survey area in the North Pacific Ocean.

The 1951 and 1952, and subsequent 1961 and 1964 surveys off Washington and Oregon have resulted in an important trawl fishery (Figure 7). The cost of the surveys was approximately $90,000 (excluding administrative or support costs) while the cumulative ex-vessel value of Pacific ocean perch taken in the survey areas since 1951 has reached nearly $14 million.

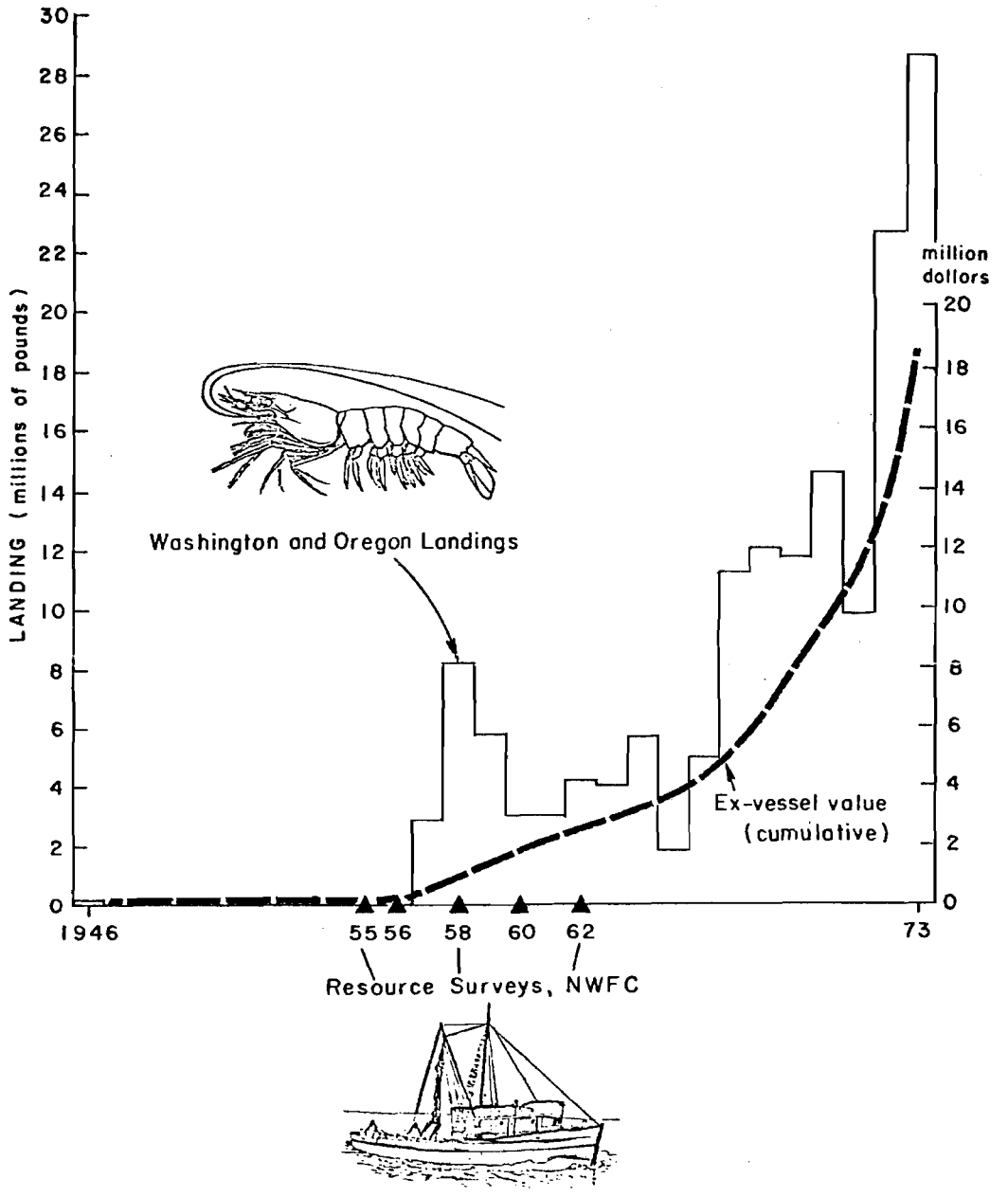
Figure 7.--Benefits to economic activity from resource surveys on Pacific ocean perch along Washington and Oregon.



Shrimp.--The pattern is similar for shrimp survey activities and consequent growth of ocean shrimp fisheries off Oregon, Washington, and central Alaska.

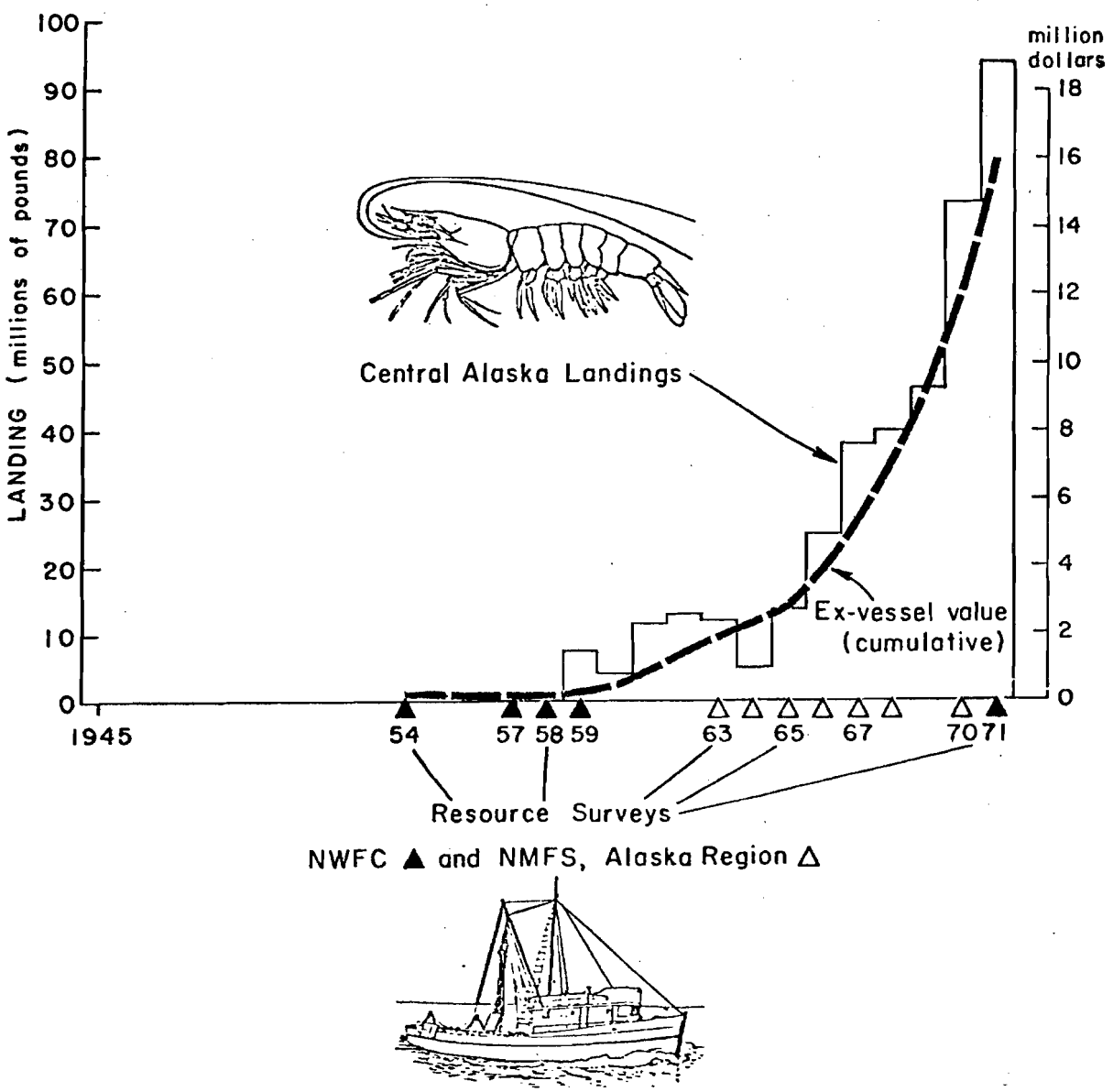
Surveys off Washington and Oregon during 1955 through 1962 showed commercial concentrations of pink shrimp on certain grounds at depths between approximately 30-90 fathoms. Commercial fishermen began to exploit these stocks in 1956 and the fishery has developed dramatically, especially since 1967 (Figure 8). Major grounds and depths actively fished closely correspond to those described in the published reports of the earlier government surveys. The cost of surveys was approximately $120,000 (excluding administrative orsupport costs) while the cumulative ex-vessel value of shrimp harvested since 1956 is nearly $19 million.

Figure 8.--Benefits to economic activity from resource surveys on shrimp along Washington and Oregon.



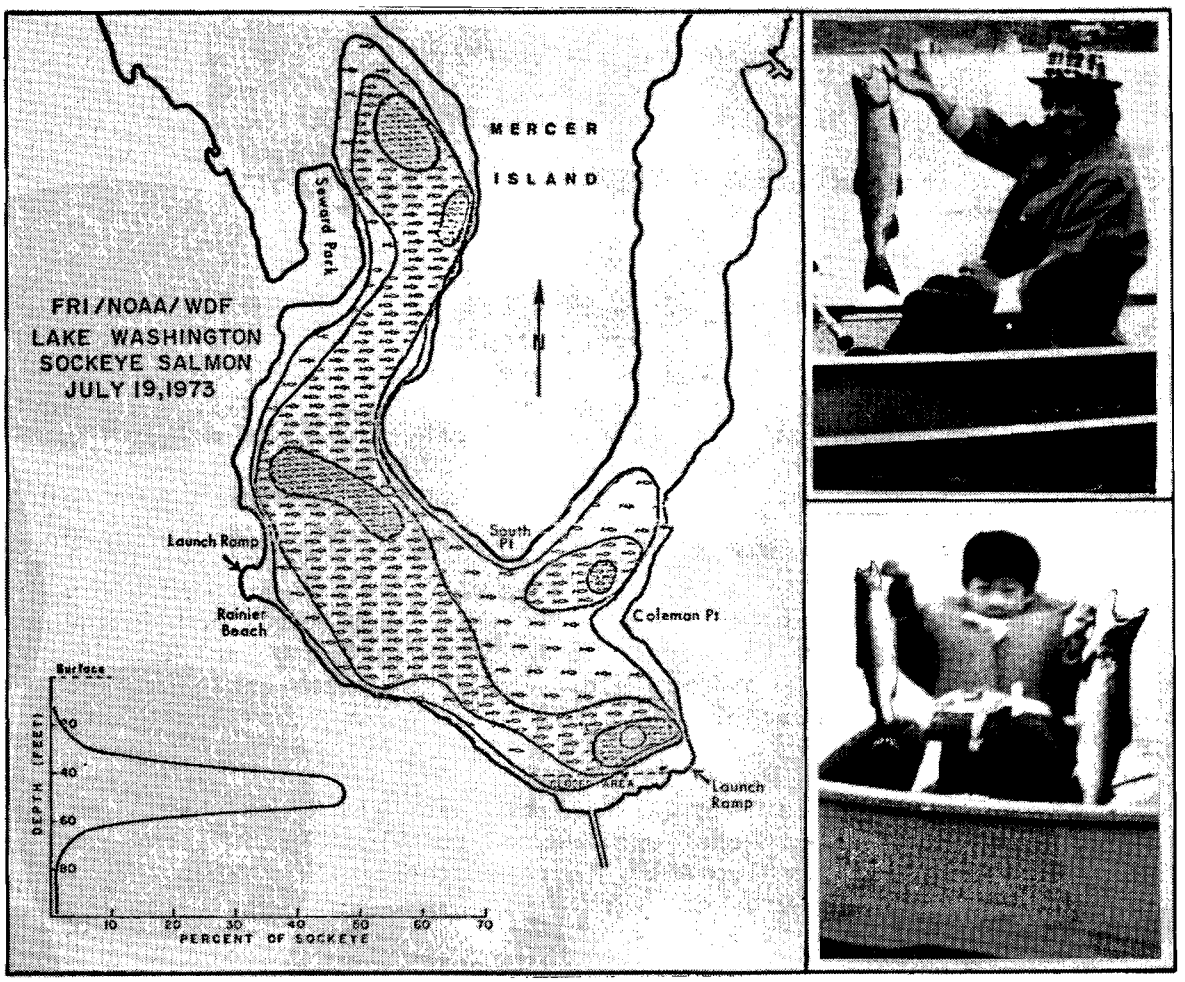
Equally dramatic is the result from government surveys on shrimp in the central Alaska area. When the surveys began in 1954, shrimp production from offshore grounds were almost nonexistent. Shortly after the survey results of the 1950's were made available to the fishing industry, a rapid growth in the fishery took place; especially near Kodiak Island (Figure 9). The central Alaska-Kodiak Island area has become the leading shrimp producing region on the West Coast of the United States. The cumulative ex-vessel value of shrimp taken reached nearly $16 million by 1971.

Figure 9.--Benefits to economic activity from resource surveys on shrimp along the central Alaska area.



Practical benefits from resource surveys in the recreational fishery area are also beginning to emerge. An example is the joint Washington Department of Fisheries-University of Washington-Northwest Fisheries Center surveys on sockeye salmon in Lake Washington. Acoustical surveys are carried out during the period when sockeye salmon are migrating through the lake. The resulting information on location and abundance of sockeye salmon is used by management and is also made available to the fishing public. The local newspapers carry this information during the run and there is general concensus that these survey information has helped greatly to enhance the angling success of sport fishermen (Figure 10).

Figure 10.--Recreational fishery benefits from resource surveys on Lake Washington sockeye salmon.



News release on location and abundance of sockeye salmon

Fishing Technology Benefits

Research related to fishing technology at the Northwest Fisheries Center had its formal inception in 1950 with the creation of the Exploratory Fishing and Gear Development Base, Bureau of Commerical Fisheries 3/, U.S. Fish and Wildlife Service, Department of the Interior. Since then, numerous harvesting systems and gear have been developed leading to new and more efficient commercial harvesting methods, reduced mortality in incidentally caught animals, and improved sampling gear for research purposes.

The following is a partial list of some of the systems and gear developed to date by the Center singly, or in coordination with other groups (e.g., state agencies, fishermen, net fabricators, etc.). Along with their commercial application, the technologies have served as effective research sampling gear, as well. Illustration of some of them are presented in Figure 11.

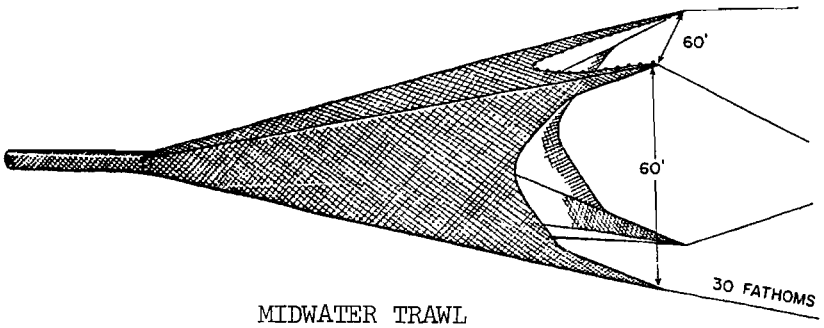
Deepwater trawl system and gear.--Together with the Center's resource survey information, this technology (a modified application of standard trawl techniques to deep area resources) has, since the 1950's, resulted in extensive commercial application leading to the development or enhancement of important groundfish fisheries, e.g., on Dover sole, petrale sole, Pacific ocean perch, etc. (Pacific Fisherman, 1952).

Midwater trawl system and gear.--This system and gear was directed at some of the pelagic-type fishery resources (e.g., Pacific hake), which up to the 1960's were not subject to efficient capture by existing methods and gear. New net design and materials, special otterboards, a depth telemetry system, and other innovative features underlie this technology (McNeeley, 1963; Johnson and High, 1970). Commercial application (with variations to the basic design) has taken place since 1966.

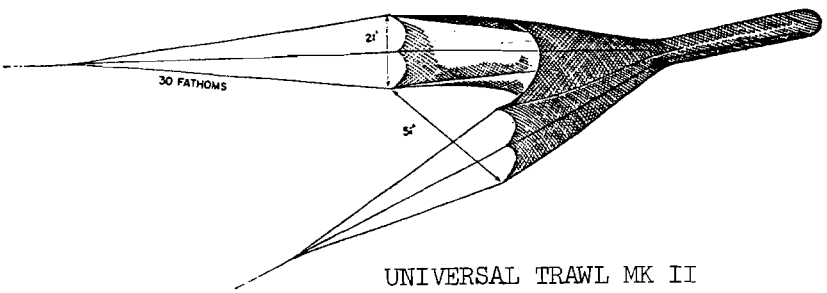
Universal trawl.--In the mid-1960's a new concept was pursued by the Center -- a single trawl to fish effectively in midwater and on the bottom. The result was the Universal Trawl combining the principles and characteristics of bottom and midwater trawling systems and equipment (Jurkovich, 1968). Commercial application has taken place since late 1960's.

Sablefish trap.--Sablefish (also known as black cod) have long been an important species in the longline and trawl fisheries along the Pacific Coast. Joint development of this trap by the Center and by fishermen was an outgrowth of fish trapping experiments initially directed at other species. The species-specific (sablefish) nature of the trap, the quality of fish captured, and other advantages not found in existing fishing methods have led to increasing commercial applications since 1969 (Hipkins and Beardsley 4/; Hughes, Worlund, and Hipkins, 1970; High, 1971; Parks, 1973).

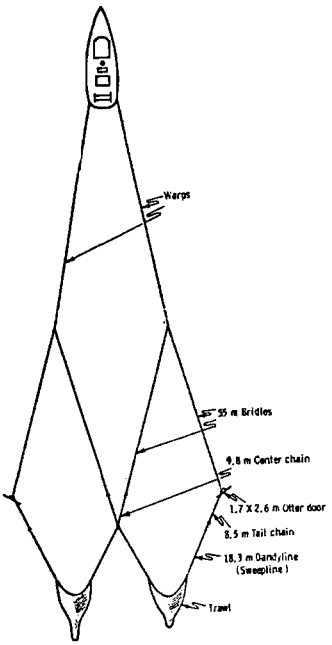
Figure 11.--Some fishing technology developed at the Northwest Fisheries Center.



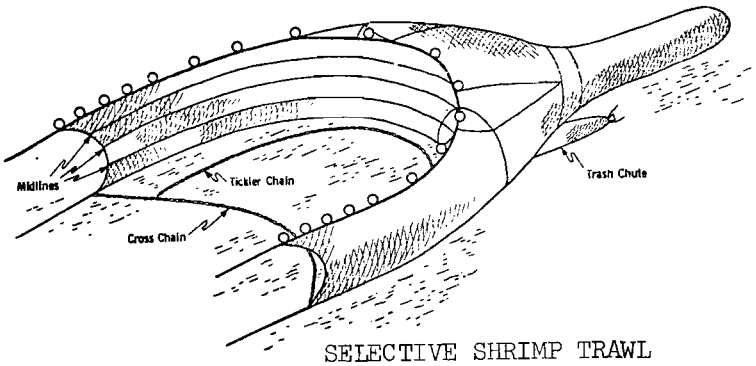
MIDWATER TRAWL



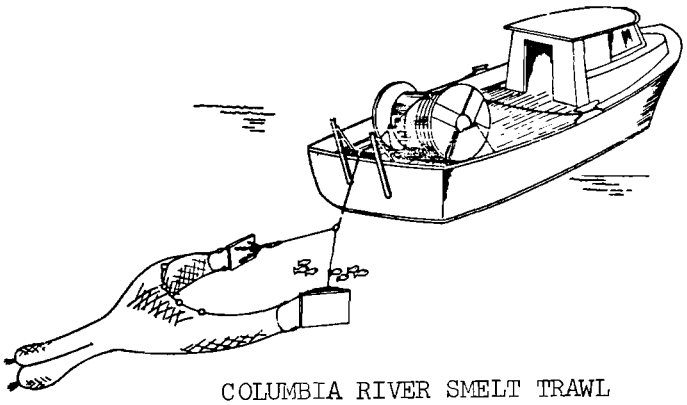
UNIVERSAL TRAWL MK II



DOUBLE TRAWLING SYSTEM



SELECTIVE SHRIMP TRAWL



COLUMBIA RIVER SMELT TRAWL

SABLEFISH TRAP

Columbia River smelt trawl.--Gillnets and dip nets have been the traditional harvesting gear for smelt in the Columbia River. A joint effort by the Northwest Fisheries Center and the Washington Department of Fisheries (WDF) has resulted in the development of a smelt trawl for this fishery. In commercial trials the trawl captured three times as many smelt than with gillnet. (The effectiveness of the trawl, however, depends upon the distribution of smelt in the river.) Higher catch-per--effort, lower gear cost, and higher quality fish have led to increasing commercial applications since 1969 (Ellis and Stockley, 1970a; 1970b).

High-opening shrimp trawl.--This is a modification to standard shrimp trawling method and equipment and has had extensive commercial application since 1969. It is estimated by the Center that every shrimp trawl vessel operating out of Kodiak, Alaska, employs this technology. The implications of this benefit can be brought into better focus by referring to Figure 9 (central Alaska shrimp).

Double trawling system.--The Center recently developed this technique which allows the towing of two trawls simultaneously from a standard, single rigged vessel. Operational and economic advantages are in less drag compared to a single large trawl with the same opening leading therefore, to broader bottom coverage and reduced power and fuel consumption (Ellis, no date) 5/. Commercial application has taken place in the groundfish and shrimp fisheries along the Pacific coast.

King crab bait trawl.--The U.S. king crab fishery is a pot fishery employing bait to attract the crabs. The Center recently developed a trawl specifically for the capture of king crab bait. Commercial application is in evidence.

Tuna seine and technique.--The tremendous success of the U.S. tuna seine fishery is a matter of record. Public opinion and pressure, however, has emerged in relation to the high incidence of mortality caused by the fishery on an aesthetically valuable marine mammal -- the porpoise. The Northwest Fisheries Center and the Southwest Fisheries Center (SWFC) of NMFS are in the process of field testing a tuna seine and technique designed to permit escapement of the socially valuable porpoise while maintaining a capability for effective capture of tuna.

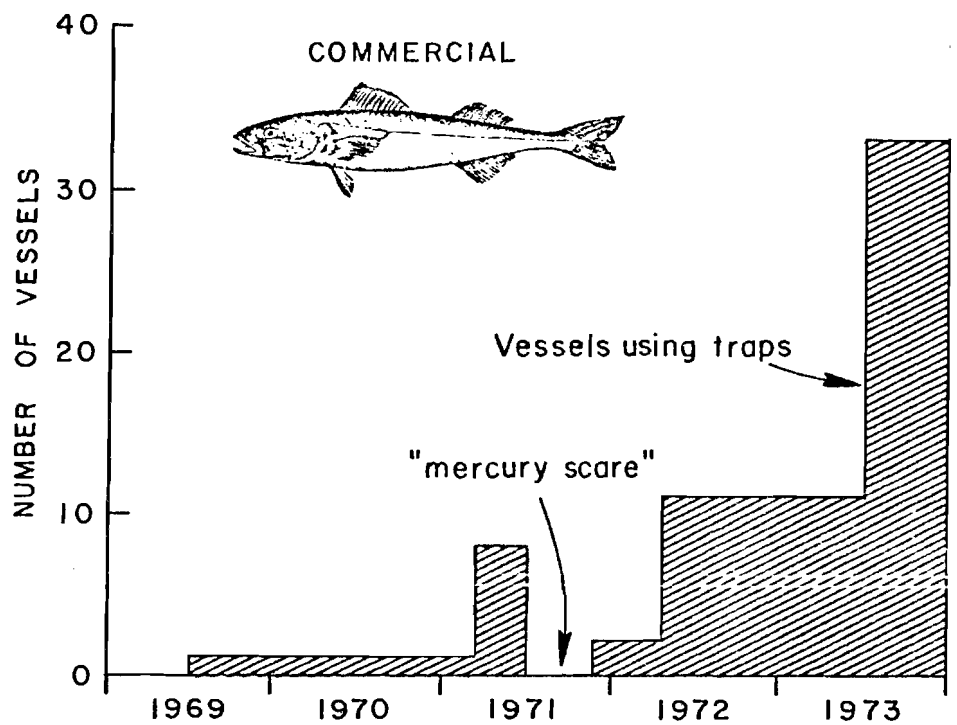
Selective shrimp trawl.--Vast potentials are implied from this technology under development by the Center which is directed at separating shrimp from unwanted fish and debris during a tow (Ellis, 1973). Research was initiated in 1968 and the trawl is undergoing commercial trials and design modifications. Implied potential benefits are in its efficiency, reduced manpower requirements on vessels (needed to sort out the unwanted debris and animals from the catch), enhancement of the quality of shrimp taken, and equally important, the reduction of mortality to young fish by preventing their incidental capture in a tow.

The previously described sablefish trap and the selective shrimp trawl will be used to further illustrate the general benefits from research on fishing technology.

Sablefish trap.--Commercial fishing activities and fishery research have both benefited from this technology (Figure 12). By 1973 there were 33 commercial fishing vessels (from California northward to Alaska) using the sablefish traps. A higher rate of use may have been made if it were not for the "mercury scare" (mercury level in sablefish) which essentially caused all sablefish fishing to stop for 5 months (May-September) during 1971.

The sablefish trap also proved to be a valuable research tool; more than 15,000 viable sablefish taken by this type of gear have been tagged for research. It primary advantage over other sampling methods is with the availability of viable, noninjured fish for tagging and release.

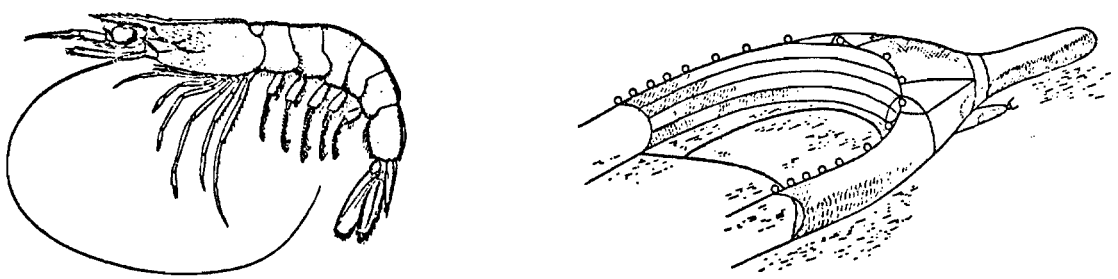
Figure 12.--General benefits from development of the sablefish trap at NWFC.



Selective shrimp trawl.--The implied, potential benefits of this technology were described earlier--high efficiency, quality of shrimp taken, etc. A preliminary analysis by Pereyra (no date) 6/ shows, in economic terms, the potential benefits to the U.S. shrimp fisheries from its application for a period of 15 years (Figure 13). The estimated net benefits are discounted at alternative rates of 6% and 12%.

For the period under consideration, a total, discounted net benefit of $59.4 million is estimated at the 6% rate and $40.2 million at the 12% rate.

Figure 13.--Implied, potential net benefits from application of the selective shrimp trawl under development at NWFC.



Present value of net benefits

Category	At 6% discount rate: Pacific coast	New England	Gulf & So. Atlantic	Total	At 12% discount rate: Pacific coast	New England	Gulf & So. Atlantic	Total
	(million dollars)							
Labor savings	7.6	0.6	36.0	44.2	4.0	0.4	25.0	29.4
Landing increases	11.9	-	-	11.9	8.7	-	-	8.7
Quality enhancement	1.2	0.8	-	2.0	0.7	0.6	-	1.3
Reduction of mortality to young fish	1.0	0.3	-	1.3	0.6	0.2	-	0.8
Total	21.7	1.7	36.0	59.4	14.0	1.2	25.0	40.2

Stock Assessment Benefits

Information from studies on stock condition provides one of the fundamental basis for resource management decisions and negotiations. As indicated in Figure 3, the immediate clients of this information are state or interstate fishery agencies in domestic fisheries and U.S. delegations or groups in multinationally exploited fisheries. This area, perhaps, is the most difficult in fishery research as far as determining benefits are concerned.

Three examples are given to illustrate the types of benefits realized or implied by the application of information from stock assessment studies. The examples were derived primarily from materials developed by Fredin (1970 7/, 1971-73 8/).

Southeastern Bering Sea king crab resource.--The valuable king crab resource in the southeastern Bering Sea is exploited by Japan, U.S.S.R., and the United States. Research on stock condition was intensified in 1960. Principal research agencies were the Northwest Fisheries Center, the National Marine Fisheries Service group in Alaska (NMFS-Juneau), and the Alaska Department of Fish and Game (ADF&G) as indicated in Figure 14. Since then, many significant events have taken place resulting in a predominantly U.S. fishery on this stock by 1972. The following is a summary of events (Fredin, Footnote 8):

Period I. (1960-64). Research studies show a serious deterioration in stock condition. The Convention on Creatures of the Continental Shelf is ratified by the U.S. in 1964. First bilaterals are held in late 1964.

II. (1965-66). Catch quotas for Japan and U.S.S.R. are imposed by the U.S. Research studies indicate some continuing deterioration in stock condition and that fisheries are catching suboptimal size crabs. Second round of bilaterals is held between 1966 and 1967 seasons.

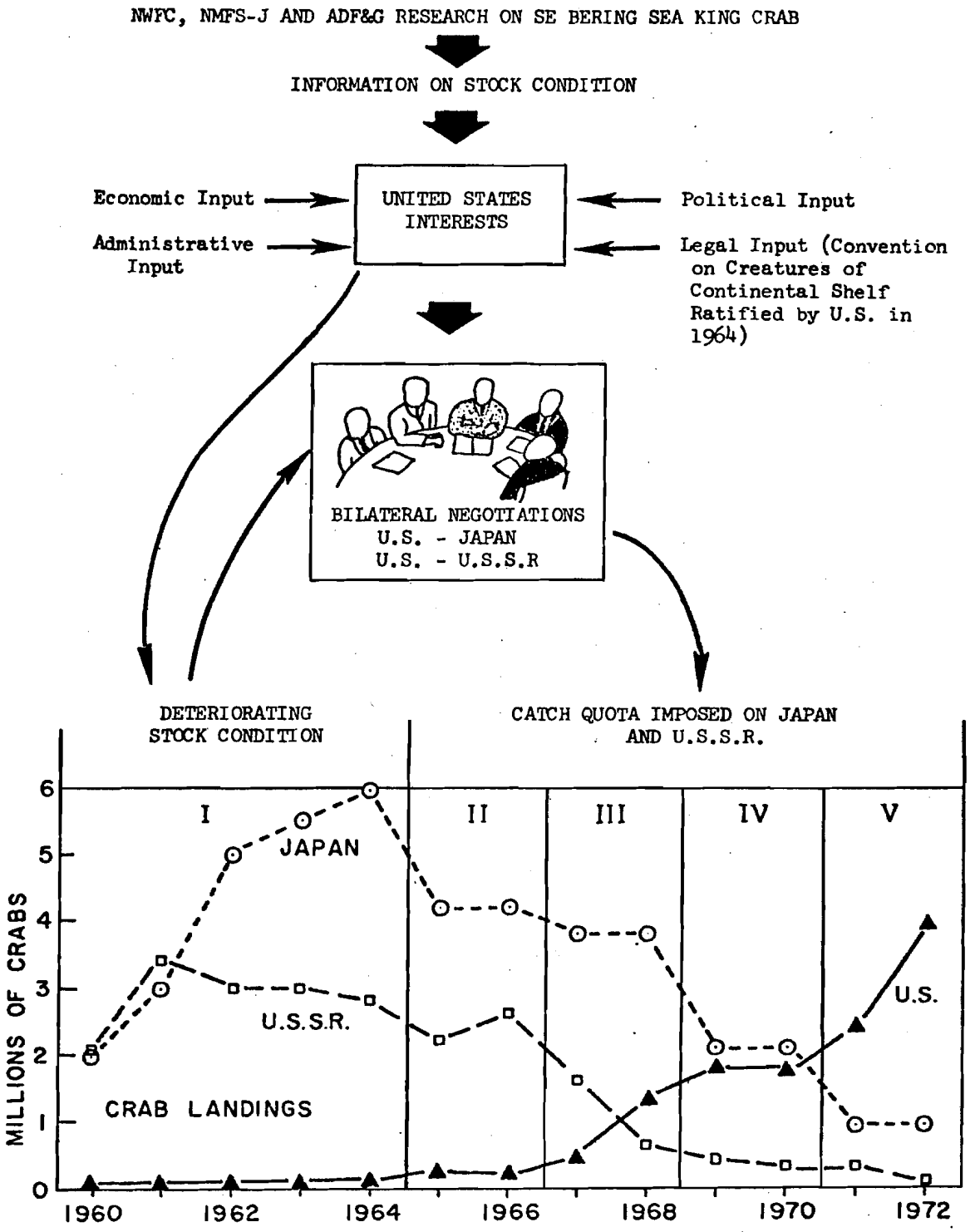
III. (1967-68). Further reductions are made in Japanese and U.S.S.R. catch quotas. U..S. share of total catch approaches 15%, compared to negligible fraction during 1960-67. Stock condition continues to deteriorate, as documented in research reports. Third round of bilaterals is held between 1968 and 1969 seasons.

IV. (1969-70). Sharp reductions are made in Japanese and U.S.S.R. catch quotas. Catch by U.S. fishery (1.7 million crabs average) reaches the level of 40% of the total catch. Some continuing deterioration in stock condition is shown by analysis of data. Serious questions as to wastage caused by tanglenet gear and trawling are raised by U.S. scientists. Fourth round of bilaterals is held between 1970 and 1971 seasons.

V. (1971-72). Further sharp reductions are made in Japanese and U.S.S.R. catch quotas. The phasing out of tanglenet gear is scheduled. Research indicates allowable annual yield to be approximately 4 million crabs under existing recruitment levels. The fishery is now predominantly U.S. Research, however, shows need for adequate enforcement of Japanese catch quota and additional information on incidental catch of crabs by groundfish trawlers.

A list of U.S. research and management documents on this fishery is in Appendix C.

Figure 14.--Benefits to the United States from research on stock assessment; southeastern Bering Sea king crab resource example.



Case for salmon abstention.--Under the provisions of the North Pacific Fisheries Convention (Canada-Japan-U.S.), entered into force in June 1953, Japan is required to abstain from fishing for salmon east of 175°W longitude. Qualifying conditions are that the United States (and Canada) demonstrate that their salmon stocks are fully utilized, managed for maximum average yield on a continuing basis, and under scientific study. Since the inception of the Convention, NMFS and state fishery agencies have had the responsibility of demonstrating that U.S. salmon stocks satisfy the above conditions for abstention. Center scientists have played a major role in this regard.

Abstention cases for U.S. salmon stocks by State and Federal agencies have been documented in 40 reports submitted to the International North Pacific Fisheries Commission (INPFC) since 1956 (see Appendix D for a list of these reports).

This subject matter and the decision-making process involved is extremely complex. A simplified diagram is presented in Figure 15. What has occurred to date is that Japan has abstained from fishing for salmon east of the provisional line since the Convention entered into force in 1953.

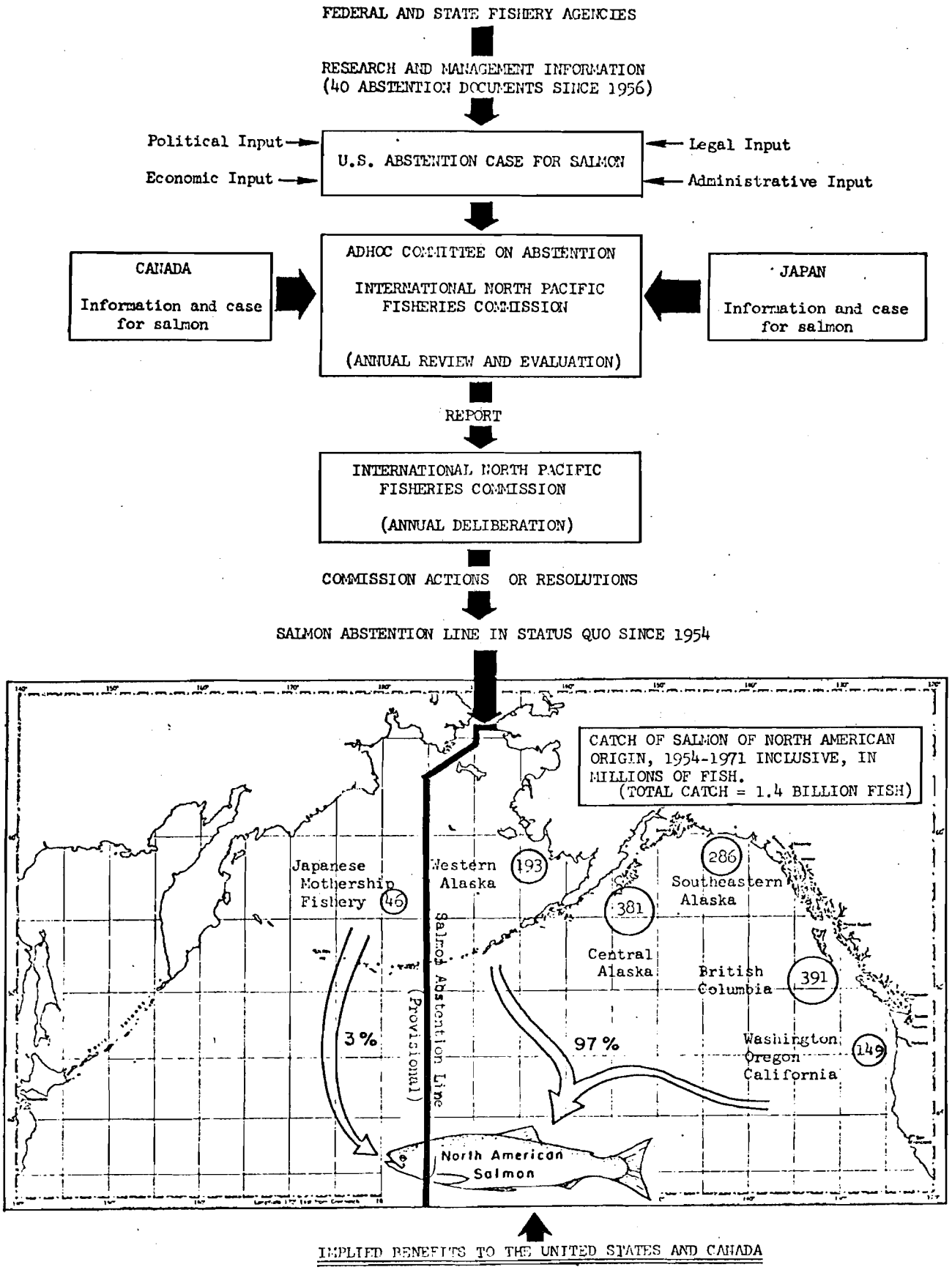
The implied benefits to the U.S. and Canada from this abstention was reported by Fredin (Footnote 7). Practically all North American salmon stocks originating in areas other than Western Alaska, plus an unknown percentage of Bristol Bay sockeye salmon, are protected from the Japanese mothership fishery by the salmon abstention line. Generally, the line has protected, in part, North American salmon worth a total of $1.4 billion to U.S. and Canadian fishermen during 1954-68; or an average annual value of $94 million. At the wholesale level the worth of the salmon during the same period was estimated at a total of $3.1 billion, or an average annual wholesale value of $203.5 million to U.S. and Canada.

Fredin (Footnote 8) also estimated that during the period 1954-71, nearly 97% of salmon of North American origin was taken by U.S. and Canadian fisheries east of the line, and 3% by the Japanese mothership fishery west of this line (Figure 15).

United States 200-mile fishery jurisdiction.--An emerging public policy issue is a U.S. 200-mile fishery jurisdiction zone. As in any policy issue, many types of information are needed for policy formulation. Technical information is one of these -- and analysis on the salmon resource by the Center serves as an example.

According to Fredin (Footnote 8), in the early 1970's, extension of U.S. fisheries jurisdiction to 200-mile offshore was advocated by many with the underlying view that such an extension by itself would protect all fisheries resources of concern to the U.S. It appeared, however, that the vulnerability of North American salmon stocks to foreign fishing outside a 200-mile zone had received little attention.

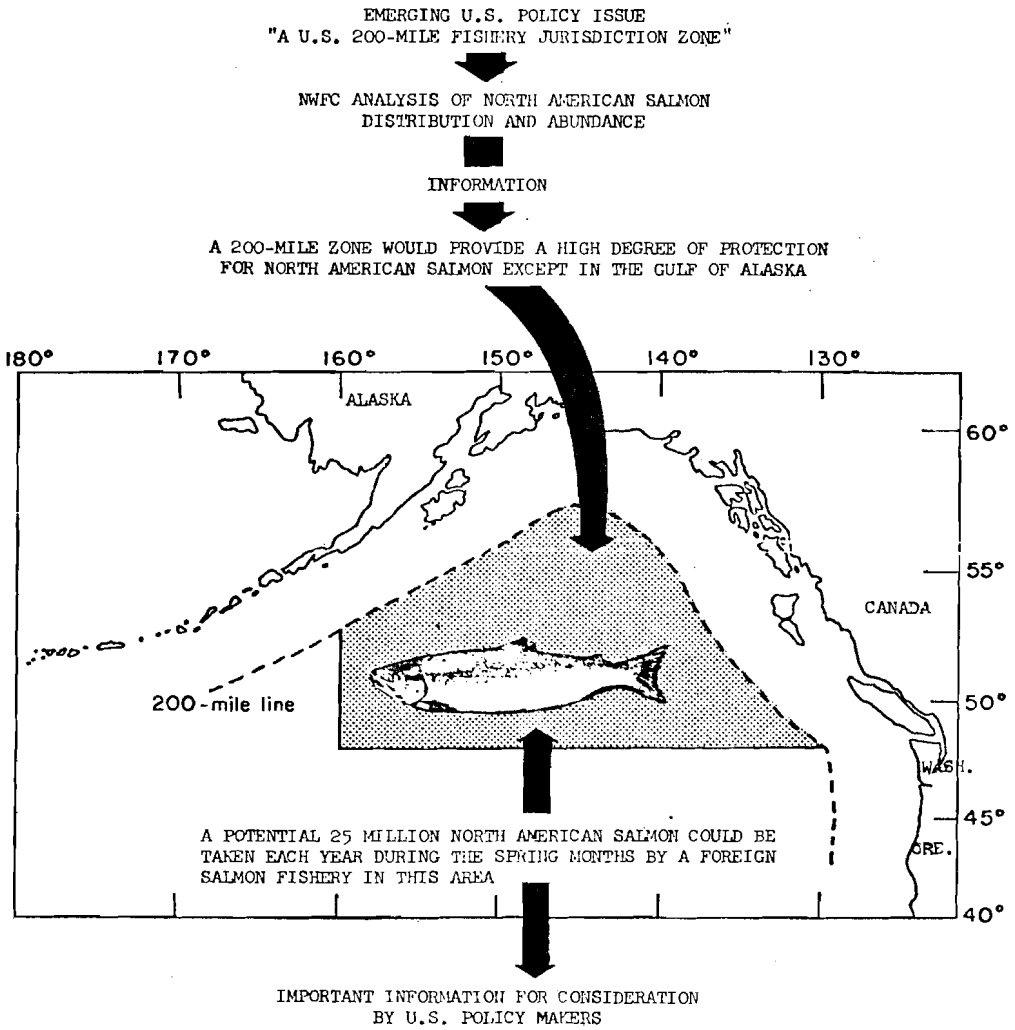
Figure 15.--Implied benefits to the United States from research on stock assessment; Salmon abstention case.



In this context, Center scientists analyzed a substantial body of data (gathered by Canadian, Japanese, and U.S. scientists over 15 years under the auspices of the INPFC) and found that the zone would indeed provide a high degree of protection to North American salmon in the Bering Sea and central North Pacific Ocean. In the Gulf of Alaska, however, a large portion of every major stock of North American salmon would be vulnerable to a high seas salmon fishery outside the zone at least during the spring months (Figure 16). Furthermore, it was estimated that a high-seas fishery comparable in size to the Japanese mothership salmon fleet could catch nearly 25 million salmon each spring outside the zone. Such a catch would represent about one-third of the total catch of North American salmon.

The implied, preliminary benefit of this research and information is recognized by negotiators in international fisheries conferences and advocates of extended fisheries jurisdiction -- that (1) a 200-mile line by itself would not be adequate to protect the valuable North American salmon from foreign exploitation and (2) that special arrangements for their protection, in addition, would be required. A follow-up on the final U.S. policy and on activities on international fisheries would assist in determining whether any practical benefits were indeed realized as a result of this and other information.

Figure 16.--Implied benefits to the United States from research on stock assessment; North American salmon example.

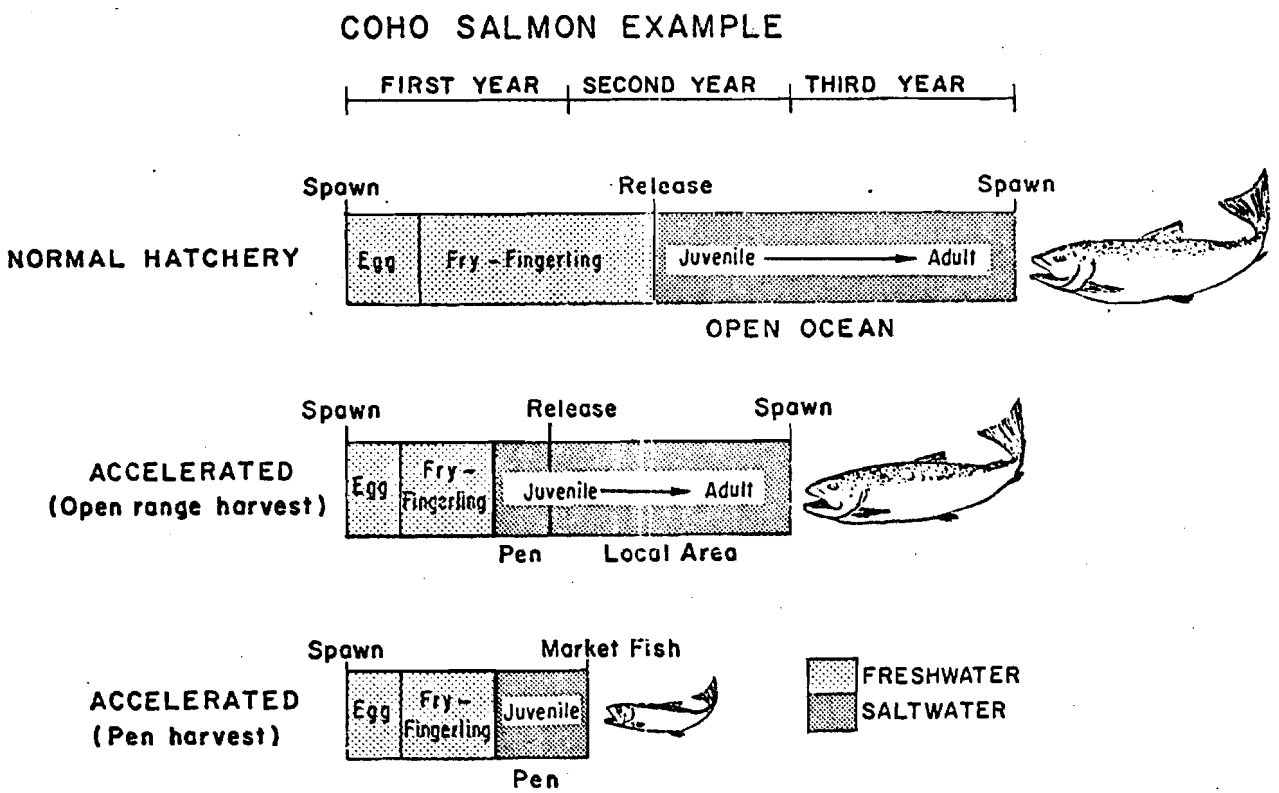


Aquaculture Technology Benefits

Research on aquaculture at the Northwest Fisheries Center had its inception in 1969. Principal focus has been on coho and chinook salmon aquaculture. The technology developed by researchers--accelerated open range harvest and accelerated pen harvest--has brought about new dimensions in salmon production and utilization appropriate to both private and public areas (Figure 17). Facilities development and research cost to date (FY 74) has been $1.1 million.

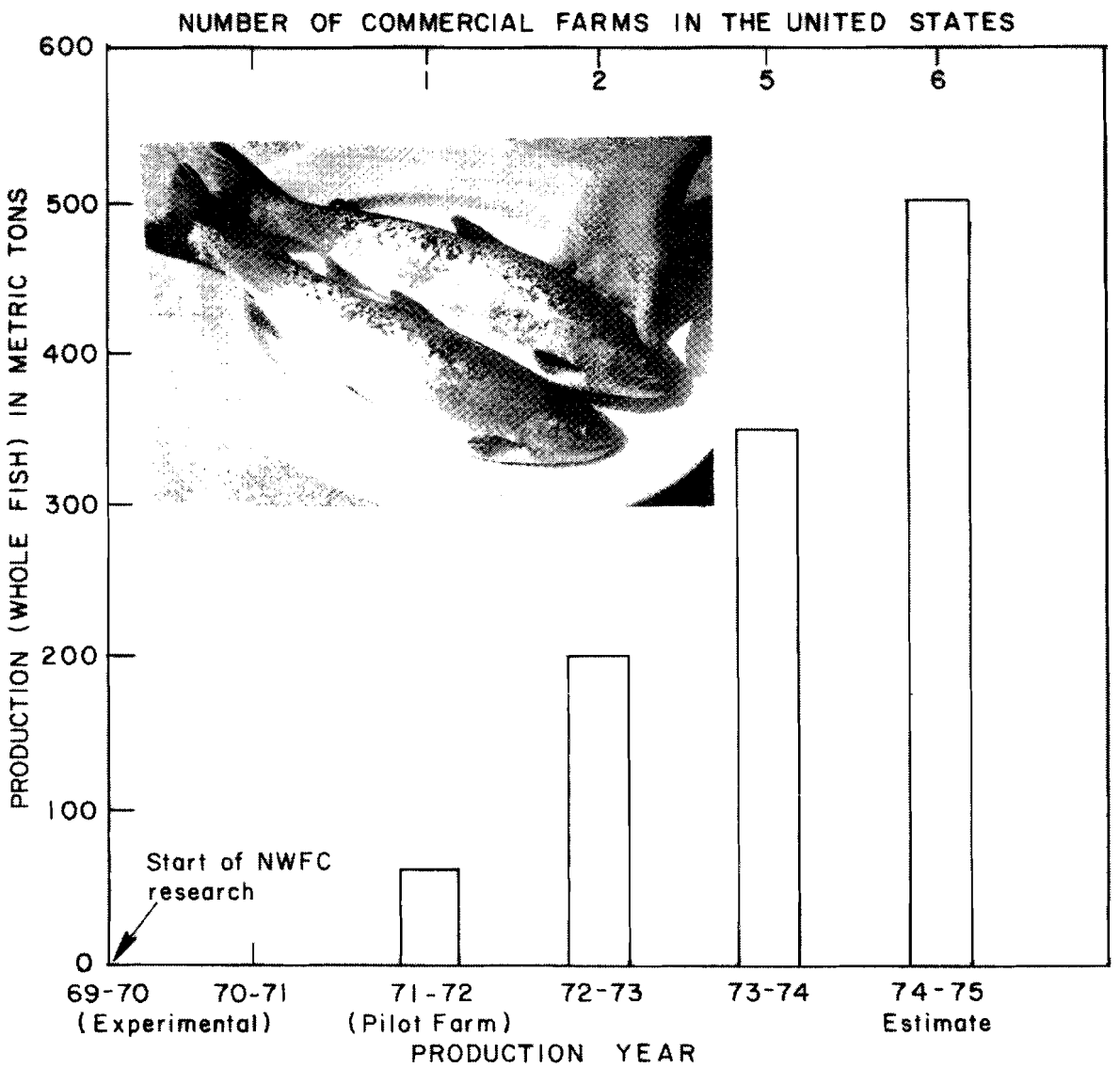
The accelerated rearing technique reduces by nearly half the normal freshwater rearing time (egg to fingerling stages) of 17 months for coho salmon, as an example. Furthermore, under the accelerated open range method the rearing of juvenile coho salmon in saltwater pens additionally for 3 months results in adult coho salmon becoming available a whole year ahead of normal (traditional) rearing methods (Figure 17). To date, the most interest and investment by private enterprise has been on the accelerated pen harvest technology where coho salmon are reared for 14 months (egg to 3/4-ounce juvenile) to a marketed product--pan size salmon.

Figure 17.--New rearing methods to enhance the production of Pacific salmon.



Although still in its formative stages, there are already six private firms in the United States (4 firms in the Puget Sound area of Washington and 2 firms in Maine) actively applying the pen harvest technology (pan-size salmon) developed by the Center (Figure 18). Capital investment by these firms reached a total of nearly $5.0 million by 1975. Pan-size salmon production has risen from the 60 metric tons in 1971-72 to a projected 500 metric tons (whole weight) for 1974-75 with an approximate wholesale value of $1.3 million. Total employment at the producer's level in 1974-75 was 50 plus full- and part-time personnel. 9/

Figure 18.--Private enterprise activities in salmon aquaculture -- pen harvest technology.



A seventh firm is in the commercial pilot stage but information was not available on their investment and production capabilities. In addition, six more firms are reported as seriously considering investment in salmon aquaculture. The level of growth and viability of the industry, however, is still a matter of speculation at this time.

Since the financial status of operating firms is proprietary, their profit or net income positions were not available for estimating net benefits. Research benefits, therefore, will be implied from the more gross characteristics of investment, gross revenue, and employment at this time.

First, the salmon aquaculture technology has resulted in a broader range of consumer products from the highly prized Pacific salmon. The employment opportunities which have developed (50 plus jobs by 1975) is a benefit. The nearly $5.0 million investment up to 1975 represents a beneficial impact on economic activities. The estimated $1.1 million value (wholesale) of the 1974-75 production from the four Washington State growers, for example, approximates a potential $990 thousand ($1.1 million times the factor, 90) in net inflow of money payments to Washington State residents. (See Crutchfield and MacFarlane (1968), and Joyner, Richards, and Tanonaka (1971) 10/ for rationale underlying the above method and benefit).

A large benefit potential is also indicated from application of the accelerated open range method by public agencies. According to Mahnken and Joyner (1973), Northwest Fisheries Center and Washington Department of Fisheries research showed that delaying the release of young salmon leads to the following advantages over normal (traditional) hatchery procedures:

1. They tend to remain in the immediate locality and stay available to local fishermen.

2. When they are held in salt water before being released, they do not return to the hatchery stream to spawn but move instead to a suitable stream near their point of release.

3. Survival to maturity is increased, with improved escapement and returns to sport and commercial fisheries.

These advantages along with adult coho salmon becoming available a year earlier than normal when reared in salt water for a short period imply vast public benefit potentials for Pacific Coast and New England areas from this technology.

Resource and Resource Habitat Protection Benefits

In the freshwater area the principal focus of research by the Northwest Fisheries Center has been on the Columbia and Snake Rivers -- the effects of water resource development projects and other industrial activities on the highly valuable anadromous resources (salmon, sea-going trout, sturgeon, smelt, etc.). In the estuarine and coastal areas the principal focus has been on the effects of effluent discharge (e.g., oil and chlorinated hydrocarbons), dredging activities, and thermonuclear power plant operations on aquatic resources and their habitat.

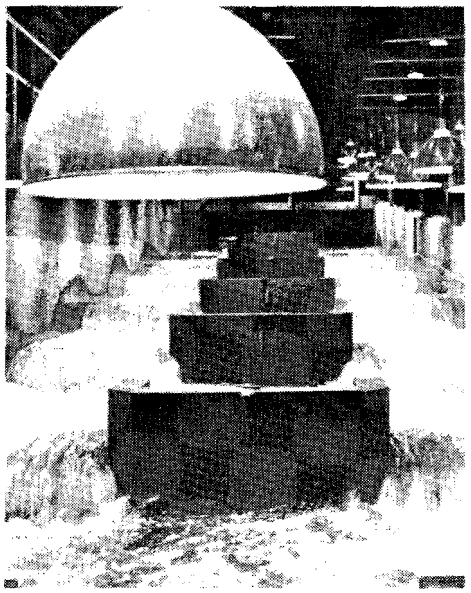
Research information here is directed to a variety of clients with benefits ranging from savings in capital construction costs by public and private groups engaged in water resource development to water quality standards information for environmental protection agencies. Selected examples of benefits from Northwest Fisheries Center research follow. The first two reported -- adult fish passage facility benefits and juvenile fish bypass-transportation benefits--represent results from the two most comprehensive benefit-cost analyses carried out at the Center to date 11/. The former is on benefits already realized while the latter is on implied, potential benefits.

Adult fish passage facility benefits (Columbia and Snake Rivers). -- Accomplishments at the Bonneville Laboratory are presented to illustrate the kinds of benefits that have resulted from fish-passage research at this unique facility (see Footnote 11). Investigations began in 1956 and were completed in 1972. Since their inception, studies have been carried out by the Northwest Fisheries Center under contract to the U.S. Army Corps of Engineers. Most of the funding has been by the Corps.

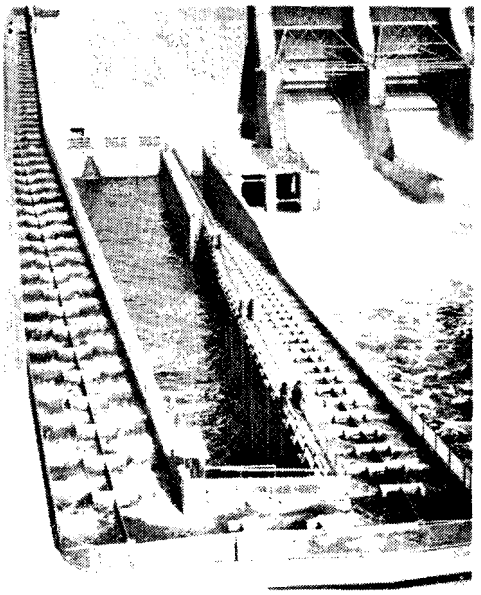
Initial studies centered on fishway slope, fishway capacity, and fishway entrance requirements. Research on slope and capacity offered substantial evidence that length and width (hence, cost) of fishways could be reduced. By reducing size of fishways, less water is needed, which makes it available for generating power (another benefit). Preferred entrance conditions were established. Results were applied to ensuing fishway construction within one year following aquisition of data.

Substantial savings in construction costs of new fishways have resulted from application of the steeper slope and modification in diffusion chamber design (Figure 19). Tangible benefits to date total $11.4 million. Projected savings from future construction or modification of fishway facilities can be expected to raise total net benefits to $15.7 million. Benefit-cost ratios greater than unity are indicated for the alternative discount rates presented in Figure 19. The 4-7/8% rate is reported as the appropriate discount rate for this analysis (see Footnote 11).

Figure 19.--Fishway research benefits.

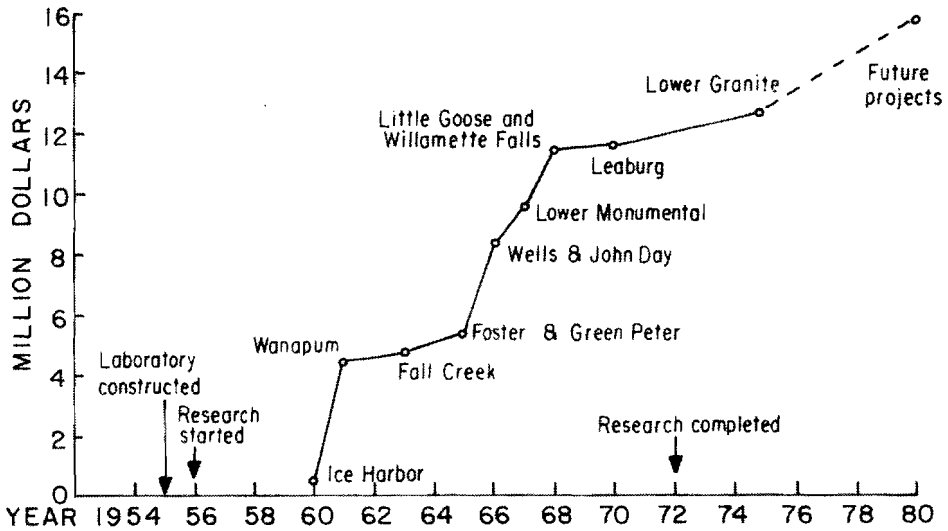


Bonneville Lab fishway testing



Application of new fishway

CUMULATIVE SAVINGS IN FISH PASSAGE CONSTRUCTION COSTS



INVESTMENT ANALYSIS

Research Cost (1955 - 72)	$1.8 million
Research Benefits (1960 - 80)	15.7 million

Discount rate	B-C ratio
4 7/8	6.8
6	6.5
12	5.0
20	3.6

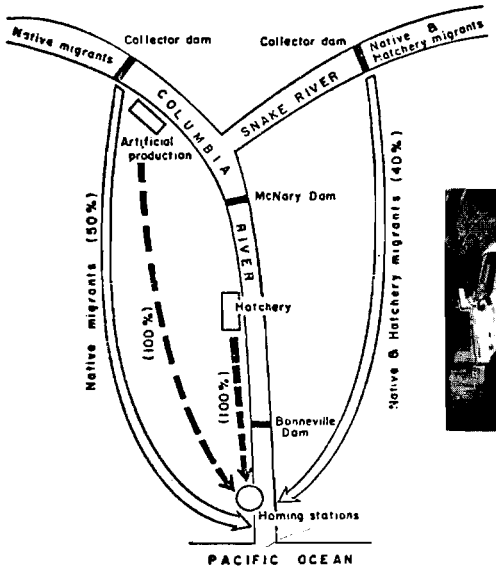
Juvenile fish transportation benefit (Columbia and Snake Rivers).--In the course of the development of water resources in the Columbia Basin, fishways at dams and propagation facilities such as hatcheries and spawning channels have been provided to maintain populations of salmon and steelhead trout affected by environmental changes. The concept followed in this development has been to provide for the passage of fish (primarily adults) wherever possible and to mitigate loss of spawning and rearing areas by means of the hatcheries and spawning channels. Nearly $250 million has been expended by the federal government and the private utility sector for fish preservation facilities in conjunction with dams completed and under construction.

On the surface of the foregoing actions, one might assume that an effective production of salmon and steelhead trout is assured. Such was probably true early in the development of the basin when only a few dams were involved and small losses during migration could be absorbed without severe effects on the fish runs. Now with a series of dams along the river, production of some populations is not assured. Water temperature and flow regimes have been adversely modified, lethal concentrations of dissolved nitrogen gas occur in large areas of the river in the spring due to heavy spilling of water at dams, and the passage of juvenile fish through a series of turbines and predator-laden impoundments can reduce the size of the original migrating population by 95% or more. High losses (up to 70%) also have been observed in the lower river where passage at dams is not a factor. Clearly, if the past expenditures for fishways and propagation facilities are to result in the most effective production of fish, the means of increasing their survival during downstream migration must be developed and put into practice. Furthermore, the success of projected fish production facilities in the lower, middle, and upper reaches of the basin will assuredly hinge on the development of passage systems affording far greater protection than exists today.

Northwest Fisheries Center research has been addressed to this major problem (see Footnote 11). Fundamental research has culminated in a design of a bypass-transportation plan to enhance the survival of migrating juvenile salmon and trout in the Columbia Basin (Figure 20). Pilot projects on this plan are being conducted by Center researchers. Although the feasibility (technical and economic) of this plan awaits project results, the implied potential of the plan is also presented in Figure 20.

The transportation plan, when put into full operation, is expected to result in a incremental increase in downstream survival of juvenile fish of 24 to 100% for some stocks. In terms of incremental numbers of fish eventually becoming available to our commercial and recreational fisheries, this represents a net economic gain of about $19 to $20 million per year. For the planning period selected, 1962-2000, total net economic benefits of $441.4 million are expected at a research cost (past and projected) of $22.5 million 12/. Cost to carry out the plan (capital project cost) is estimated at $5.1 million. At the alternative discount rates indicated, the benefit-cost ratios (the ratio of net benefit less capital project cost to research cost) are greater than unity except at the 20% discount rate (.8 ratio). The 12% rate is reported as the appropriate discount rate for this analysis -- or 2.4 B-C ratio (see Footnote 11).

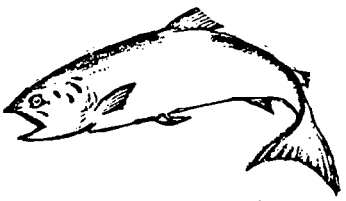
Figure 20.--Implied, potential benefits of the juvenile fish bypass-transportation plan.



PER TRANSPORT-YEAR

ADDITIONAL SURVIVAL OF 55 MILLION JUVENILES

ADDITIONAL 2.3 MILLION ADULTS



NET ECONOMIC VALUE OF $19.8 MILLION

INVESTMENT ANALYSIS

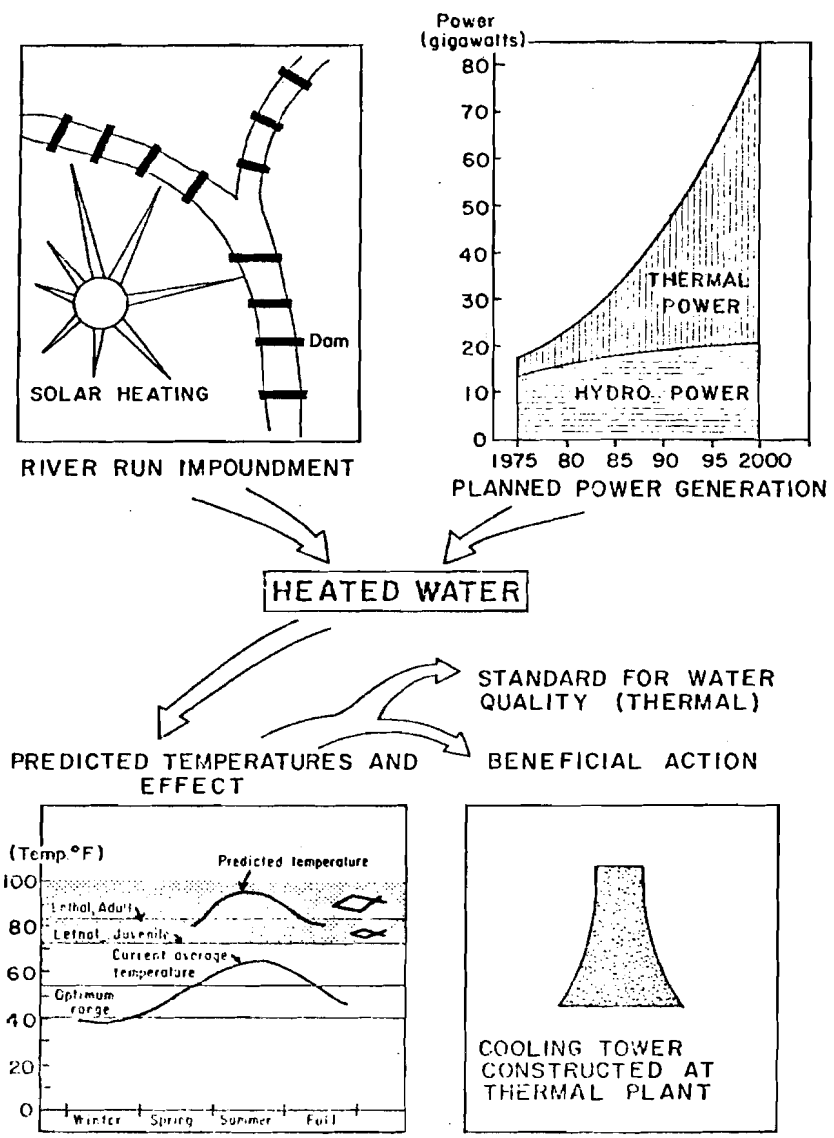
RESEARCH COST (1962-1980).....$ 22.5 MILLION
CAPITAL PROJECT COST (1969-2000).....$ 5.1 MILLION
RESEARCH BENEFIT (1971-2000).....$441.4 MILLION

Discount rate	B-C ratio
4-7/8	7.9
6	6.5
12	2.4
20	.8

Thermal effluent research benefits.--An emerging area of concern to the Northwest Fisheries Center in the early sixties was thermal effluents and their potential effect on aquatic resources. Principal focus was on the Columbia River Basin -- the source of much of the electrical power for the Pacific Northwest. Of concern was the additive and cumulative effect of solar heating of water in the many river-run impoundments plus waste heat discharge from thermal electric power plants proposed for construction in the Columbia Basin (Figure 21).

Research results indicated that the anticipated thermal regimes would be lethal to the valuable anadromous resources of the Basin. Based on this and other results and recommendations of the Center, the following beneficial actions have taken place: (1) the use of the information by environmental protection or ecology agencies to set up preliminary water quality standards relating to the thermal regime of water bodies and (2) the construction of a cooling tower by a thermal electric power plant operator with announced similar intentions by other anticipating construction of thermal electric power plants in the Basin (Figure 21).

Figure 21.--Benefits from research on thermal effluence.



Chemical pollutant research benefit.--This is the final example (of but many more) in the area of resource and resource habitat protection benefits. Research here was concerned with the effect of chemical fire retardants on survival of juvenile salmonids.

According to Blahm and Snyder (1973) 13/, "the use of chemical fire retardants to help control forest fires has become a widespread practice. Some 10 to 16 million gallons are used annually in the United States. The principal users are the U.S. Forest Service, Bureau of Land Management and State forestry agencies. The users realized that streams and lakes in the vicinity of a fire might be affected by the application of retardant directly into the water, or by run-off from the watershed on which the fire occurred. They also realized the possibility that the compounds might be harmful to fish and other aquatic organisms. In 1971 the Bureau of Land Management proposed a cooperative study with the National Marine Fisheries Service. The Bureau agreed to partially fund a two year study to determine the toxic effects of four of the most commonly used retardants on two species of salmonid fishes." The conduct of the study was enhanced considerably by the cooperation of the fire retardant manufacturers.

Research was completed in 1973. Results indicated that ammonical fire retardants are toxic to fish and that accidental misuse of the retardants could cause fish "kills". The retardants could enter a body of water either at the field mixing site or by an inadvertant application. However, careful use would virtually eliminate, or at least minimize, the possibility of causing deleterious effects on fish.

Based on our research findings and recommendations, the following beneficial actions are reported in progress:

1. New formulations on chemical fire retardants are being proposed by chemical companies.
2. Application quantities are being reviewed by user groups and new standards (for minimum application) are being recommended for existing retardants to prevent supersaturation of an area.
3. Research review board has been formed to ascertain the effects of direct application and seepage of retardants in watersheds.
4. Studies are underway to determine which retardant is "best" or least destructive to aquatic organisms.

Spin-off Benefits

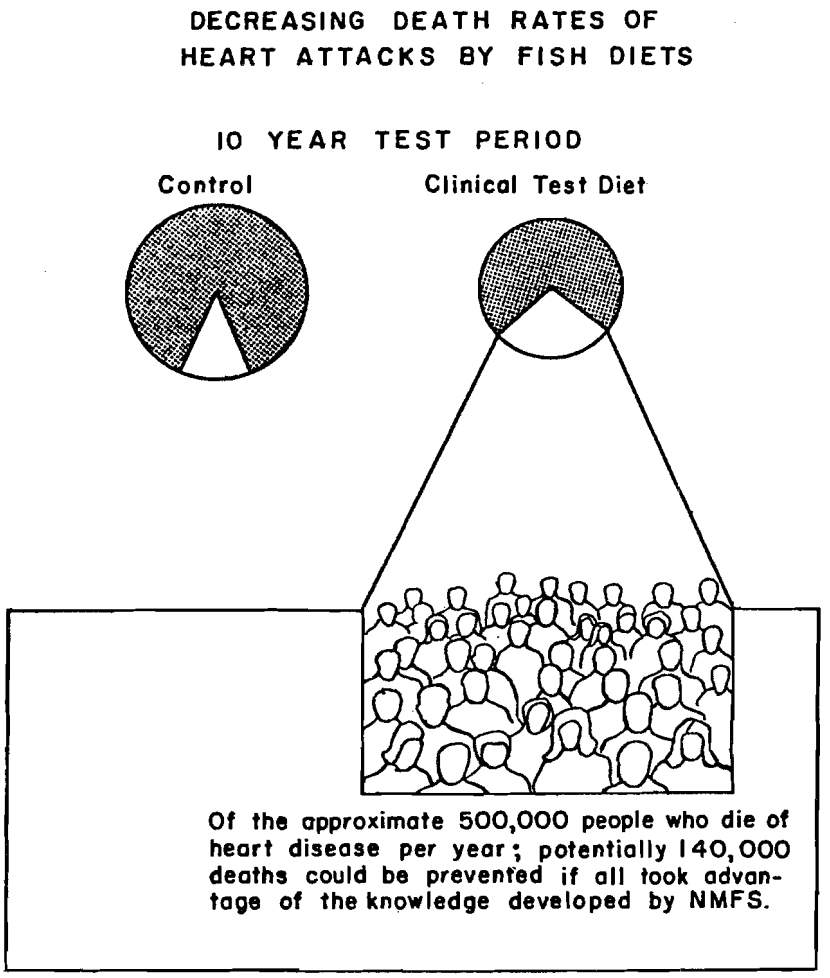
Spin-off type benefits are those which are not necessarily closely linked with the original field of investigation. Several examples which are still in the implied, potential stages follow.

Investigations of fish lipids.--Alverson (1973) reported that for a number of years scientists at the Center were involved in investigating the character and quantity of lipids in fish as related to their biological condition, age, size, etc. These investigations were instrumental in demostrating that fish oil are characteristically high in unsaturated fats.

Subsequent studies, conducted in Seattle in collaboration with the University of Minnesota's Hormel Institute, demonstrated that small amounts of fish oil, either as oil itself or oil in fish fed to rats, drastically lowered serum cholesterol levels. These findings led to cooperative studies with a Seattle heart specialist, in a 10-year clinical test of heart patients to see if the results obtained with animals applied to humans. Patients were fed salmon as a major item in their diets. Results of the test (Nelson, 1972) showed that 81% of 206 patients in the control group died of heart disease. Of those on special diets, only 64% subsequently died of heart disease. The results also showed a significant reduction in heart problems following an initial heart attack and in patient survival.

Nation-wide, the implied, potential benefit to public health is about 140,000 people per year could be prevented from dying of heart disease if they took advantage of this information (Figure 22).

Figure 22.--Implied, potential benefit to public health from investigations on fish lipids (source: Alverson, 1973).



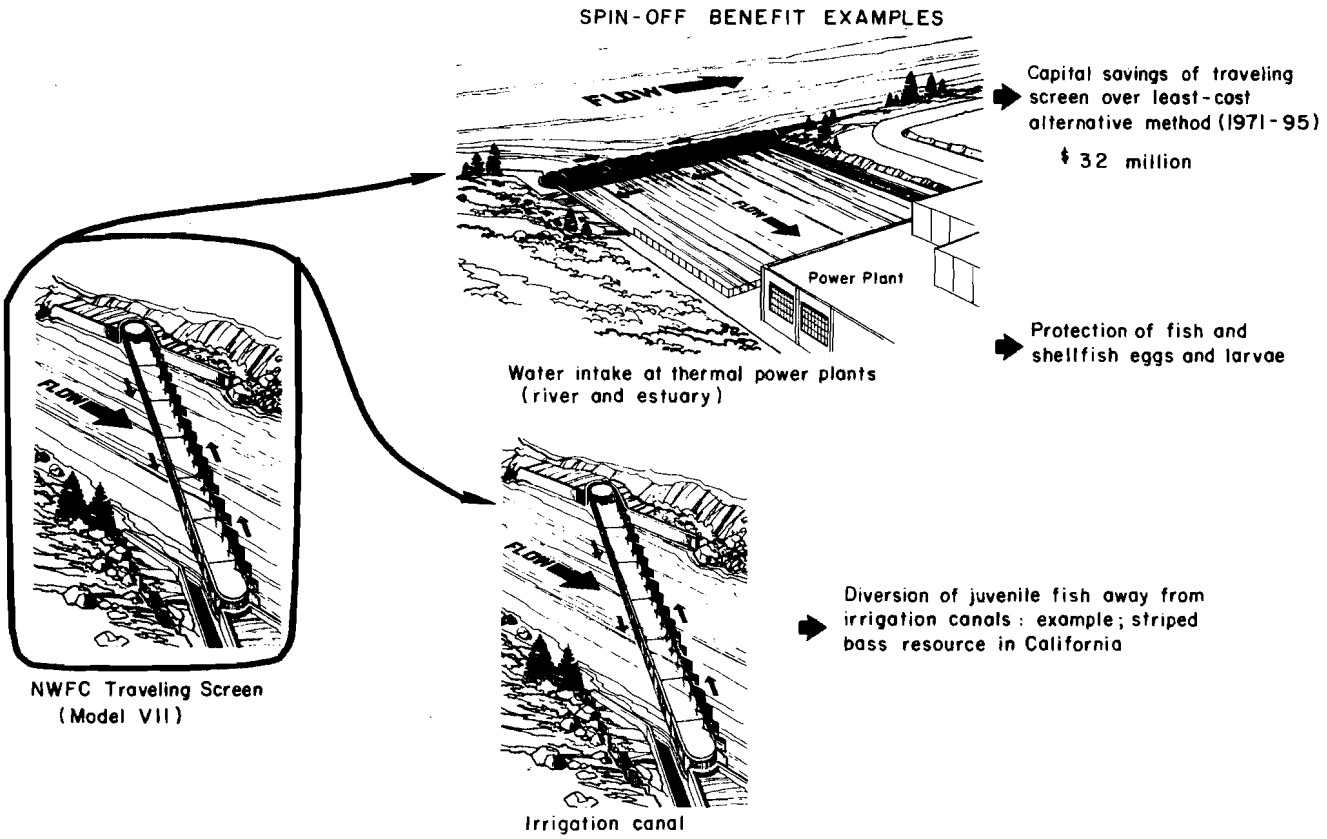
Traveling screens (fish deflection-diversion mechanisms).--The effects of water-use projects on aquatic resources have been of great concern in the United States. Many larval and juvenile fish, for example, are lost because they are drawn into irrigation canals, hydroelectric turbine intakes, cooling water intakes, etc. For many years biologists and engineers have studied the problem. The development of the drum screen has helped immeasureably to safeguard aquatic resources, especially juvenile salmonids, at the smaller water transfer systems such as irrigation ditches and canals. However, safeguards against larger water transfer systems such as turbine intakes, cooling water intakes, wide channels, high water velocity systems, etc., still remained underveloped. Numerous methods of deflecting fish have been examined, such as bands of rising bubbles, curtains of hanging chains, electrical stimuli, lights, louvers, sound, and water jets. These methods functioned satisfactorily under certain conditions but were never completely reliable.

Problems of this nature in the Columbia River Basin provided the impetus for the original field of investigation by the Center. In 1965 a new approach was conceived by Center personnel which showed promises of overcoming the many disadvantages of other deflecting methods. Development of the traveling screen provided many practical solutions to problems of fish diversion in large water transfer systems (Bates, 1970). Some of the advantages are: (1) reduced capital and maintenance costs compared to other alternative methods; (2) impingement of fish on screens are far less serious; (3) nonswimming forms, such as fish eggs, can be collected on the screen and safely carried for release into a bypass; (4) efficiency of operation remains high irrespective of fluctuations in water surface elevation; (5) and others. Northwest Fisheries Center research was terminated in 1972 with the design and test of the Model VII traveling screen.

The traveling screen concept has already made its contribution to the original field of investigation. Vertical traveling screens are now installed at turbine intakes of several dams in the Columbia River with planned installation at others. Many juvenile fish migrants are now diverted into bypasses away from a source of their mortality, the turbines.

The various traveling screen models developed by researchers at the Center have generated great interest among public and private groups throughout the United States (Bureau of Reclamation, public and private power utilities, fishery resource management agencies, etc.). Several applications of the traveling screen (with design modifications to meet individual problems and requirements) are reported in developmental or test stages. The implied potentials (as spin-off benefits) are indicated in Figure 23. An earlier analysis (see Footnote 11) indicated potential net benefits (as capital cost savings) of $32 million from its application alone by thermonuclear power plants.

Figure 23.--Implied, potential benefits from the traveling screen technology developed at NWFC.



The benefits are but part of a larger array of practical contributions attributable to the Northwest Fisheries Center. The desired quantification and quality in estimates, however, are generally lacking. For example, the benefit from the development of the sablefish trap was implied and based on a causal relationship -- i.e., the number of vessels using the trap. It would have been desirable to show how the quality of fish landed was improved (and, therefore, was of benefit to the consumer), how the efficiency of the trap lowered fishing costs, and the like. Capabilities for in-depth evaluation are currently not available at the Center. Why they are not available, what steps are needed, and what the Center is doing about them are discussed in the part on Organizational Rationale -- Problems and Change, of this report.

As a final note, the practical contribution of a research project, in a sense, represents only the tip of the iceberg. An enormous amount of manpower, funds, and time is expended by state and federal fishery agencies on necessary scientific investigations leading to such fishery benefits. The list of research and management documents presented in Appendix C (southeastern Bering Sea king crab resource) and Appendix D (U.S. Salmon Abstention case) give an indication of this. The lists, in turn, represent only the "tip" of the enormous amount of work that has gone into the preparation of each document by state and federal fishery agencies -- i.e., administrative matters, field operations, cooperative working arrangements, exchange of information, intense planning of research and evaluation of results, etc. This "proportion" may be overlooked or not be appreciated by those whose perspective is oriented towards practical results only.

In addition to these practical contributions from research, the Center has also contributed much to the scientific community. Selected examples are given in the following section to illustrate the magnitude of these scientific contributions. These are also greater than many people may realize.

CONTRIBUTIONS TO THE SCIENTIFIC COMMUNITY

A comprehensive list of published research of the Center would show the contributions made to knowledge (theoretical and applied) in fishery biology, mammal biology, oceanography, chemistry, physiology, engineering, etc. This would, however, be quite an undertaking. In the interim and for purposes of this report, the "content analysis of correspondence" approach is used as a technique to illustrate the technical contributions of the Center. A brief discussion on the selection of this approach from various alternatives follows.

Most of the attention in the scientist to scientific community link (see the earlier Figure 2) has centered on the communication process itself and less on measures of the values or impacts of the contributions. There are apparently five general approaches to evaluation of technical contributions: number of publications, number of request for reprints, literature citation counting, "TRACES", and "content analysis of correspondence".

Number of Publications

Counting the number of published papers gives a simple measure of the activity of a research group or an individual. Comparing the number of publications with the resources used (man-years for example) provides an estimate of productivity. Here, quantity is assumed to measure the "value" of the technical contributions. There are many objections to this approach, but it does offer a gross measure that is useful for some evaluation purposes, as in the administrative dictum of "publish or perish" (Meltzer, 1956) and that proposed by Hodge (1963) as a method of rating the productivity of research units in industrial companies.

Reprint Requests

Counting requests for reprints is another possible approach but one that does not appear to be mentioned in the literature. Some researchers may view "research notes" as being of little significance compared with research reports that deal with theories, principles, applied findings, and the like. What is the value of a "note"? A recent experience at the Northwest Fisheries Center serves to sharpen this question. A short note by Hunter (1969) on the confirmation of a symbiotic relation between Liparid fishes and male king crabs has resulted in nine requests for reprints up to 1971 with the following breakdown: by institution; universities - four; academies and museums - three; and government agencies - two; by country; U.S. - five; and one each from Canada, Puerto Rico, Queensland, and U.S.S.R. Any attempt to interpret these figures illustrates the basic difficulty of this method. What were the reasons for these requests? Why do researchers request reprints on any form of published research?

Literature Citation Counting

According to Westbrook (1960), comparisons of the number of literature citations should, in principle, make it possible to identify laboratories or individuals doing the most significant work in a definable subject field. His underlying assumption is that "...repeated citation of a particular source by independent research workers whose own contributions have met some standard of publishability is very probably indicative of the worth of the scientific output of the source". Westbrook's study centered on laboratories and on the field of ceramic engineering. Some of the conclusions were: (1) 6 of the more than 40 laboratories are responsible for especially significant work in ceramics and (2) universities are responsible for more significant work in ceramic science than industry or government agencies.

In fishery science, the only known attempt to measure research performance by citation counts is that of Fredin (1964) 14/ who attempted to evaluate fishery research conducted by each of the 64 members of a district of the American Institute of Fishery Research Biologists. Unlike the study by Westbrook, Fredin also discusses the need for scoring or weighing the citations (i.e., the reason for the citation). He found that the most often quoted 6 of the 64 biologists received 50% of the document citations in the selected fishery journals and books.

Of the three approaches examined thus far, the literature citation approach comes closest to measuring the impact of the published research. However, not knowing the reasons for the citation means that the impact or usefulness of the published research is not known.

TRACES

TRACES is an acronym for "Technology in Retrospect and Critical Events in Science: (Illinois Institute of Technology Research Institute, 1968), an approach to a systematic study of the process and components (nonmission or basic research, mission-oriented research, and development) which led to a number of major technological innovations (e.g., magnetic ferrites, video tape recorder, the oral contraceptive pill, etc.). The retrospective tracing of key events may be useful in fishery science as a means of identifying and according credit to key events (information-researcher-institution) that contributed to improved fishery technology or major event in fisheries. This approach comes closer than any of the earlier methods to being a true measure of the impact or value of past research.

Content Analysis of Correspondence

This was an alternative approach at a quantitative assessment of the impact of research and the "value" of five of nine major research programs of the Division of Coastal Zone and Estuarine Studies, Northwest Fisheries Center (see Footnote 11). Based on the assumption that correspondence is a legitimate channel for communication and one containing some "value" symbols, the contents of the correspondence files of the five research programs from 1965 through 1970 was classified and quantified along two major areas: (1) technical developments (primarily research tools) and their usefulness (or application) to other research and (2) apparent demand for "expertise" (knowledge and experience) of the program personnel. Expertise included such things as specific requests for information (excluding repring requests) or assistance, requests for presentations at seminars, symposiums, hearings, and at academic institutions, and requests for participation in task forces and committees. Using this approach, we find the Center has made significant and numerous contributions to the scientific community.

Technical Developments.--Of the numerous technical developments of the Center, two have made, and will continue to make, world-wide contributions to fishery research and related fields: (1) electronic (sonic and radio) fish-tracking device, and (2) thermal and nitrogen (N_2) fishmarking devices (see Footnote 11). These contributions are in addition to their application to the original field of investigations -- the Columbia River fishery resource problems. Their world- and nation-wide contributions ar, of course, primarily a function of their being developments in research tools basic to studies of animal populations. The combined frequency of past, present, and known planned uses of these devices by the international scientific community is shown in Figure 24, while national uses are shown in Figure 25. For the electronic fish-tracking device and technique, 40 past and present uses are known with 56 more planned uses known up to 1971. For the thermal and N_2 fish-marking devices and techniques, there are 19 known past and present uses with four more planned uses indicated to 1971. These uses are considered minimal since other scientists may have applied the devices and techniques without our knowledge. The wide application of these devices in terms of animal populations is shown in Figure 26. They cover the entire range of marine organisms from invertebrates to birds. In many cases, our researchers have been asked to travel to the source of the request to advise on use of the device and assist in the development of techniques applicable to the organism under study.

Figure 24.--International application of selected technical developments of NWFC (1965-70).

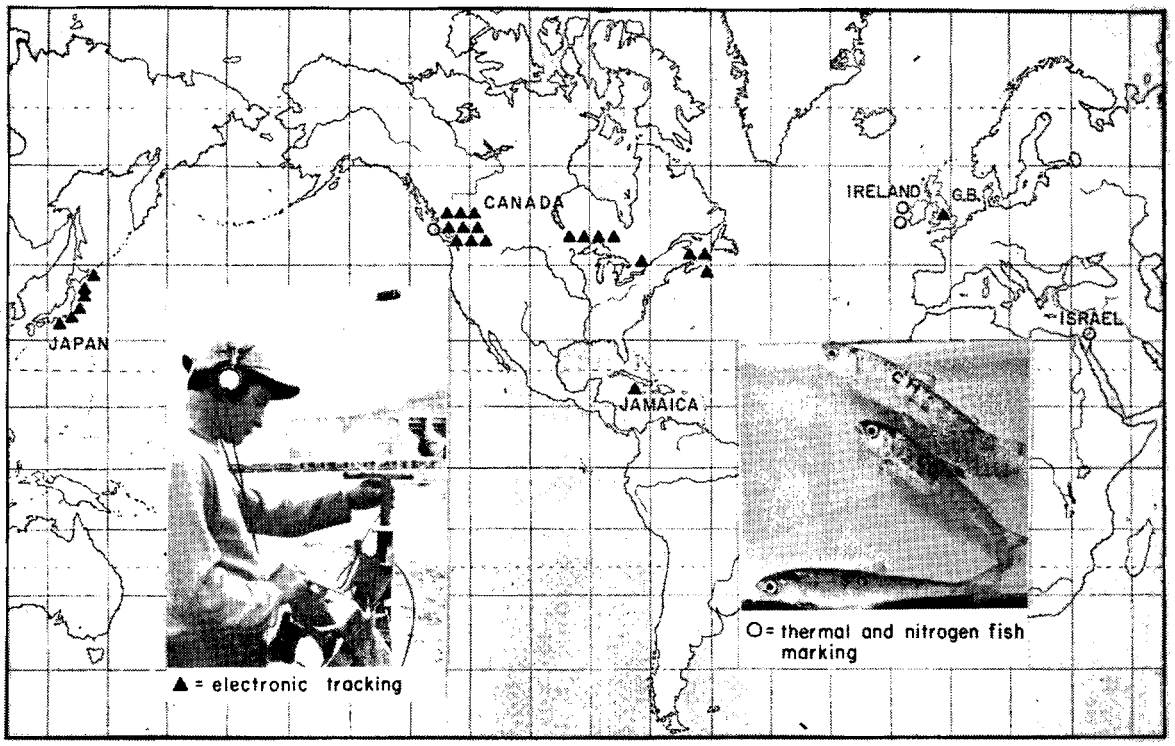


Figure 25.--National application of selected technical developments of NWFC (1965-70).

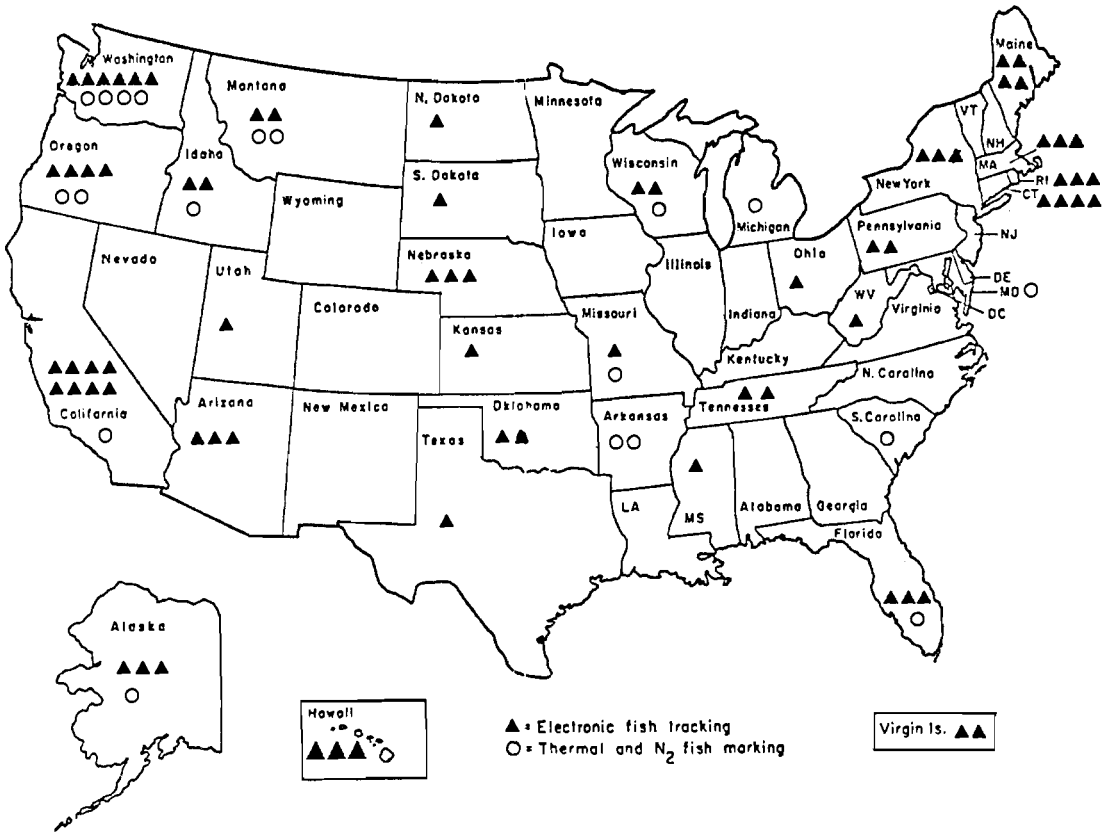
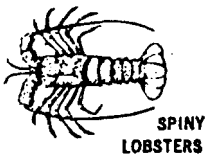


Figure 26.--Fauna that have been tracked and worked with using devices and techniques developed at NWFC.

Electronic tracking devices and techniques



Invertebrates

King crab, lobster, octopus

Vertebrates

Fish

Tuna:	yellowfin, albacore, skipjack, bluefin
Salmon:	sockeye, chinook, coho, chum, Atlantic
Trout:	steelhead, rainbow, lake, cutthroat
Bass:	striped, largemouth black, white
Others:	American shad, yellowtail, barracuda, black crappie, marlin, sailfish, sturgeon, paddlefish, flathead catfish, walleye pike, "totoaba" (Cynoscion), channel catfish, tilapia, shark, eel, alewife, shovelnose sturgeon, herring, cod

Reptiles and mammals

Porpoise, sea otter, aquatic salamander, humpback whale, turtle, harp seal, killer whale, manatee

Birds

Diving aquatic birds

Thermal and N_2 marking devices and techniques

Salmon:	Atlantic salmon, coho salmon, sockeye salmon
Trout:	eastern, rainbow, brown, steelhead
Others:	catfish, fundulus, carangids, cablefish, bass, whitefish, squawfish, carp, suckers

In addition to these documented technical developments many more are in evidence. Although not recorded as to users and number of uses at this time, the following partial list, nevertheless, provides additional insight into this area.

- A mechanical fish sorting and collection device for use at dams and hatcheries.
- A trawl for sampling juvenile tuna.
- A single warp trawling system for greater depth sampling.
- A vertical distribution sampler for shrimp.
- A saury seining system.
- A trawl for sampling fish at spillways of dams.

Expertise.--Another measure of the value of a research group is the apparent demand for their "expertise" - knowledge and experience (see earlier definition in this section). As an example, the source and frequency of requests for our expertise, during 1965 through mid-1970 on anadromous fish problems in rivers, are shown in Figure 27 (international) and Figure 28 (national). These are but a sample of five of the nine major areas of research and competence of that particular group (see Footnote 11). The frequency of requests for expertise on electronic fish-tracking and thermal and N_2 fish-marking programs are exclusive of those of the earlier Figures 24 and 25. In the area of environmental problems, half of the large number of requests documented for Washington (25 requests) and Oregon (18 requests) were for our expertise in a specific river basin -- that of the Columbia River. The source of documented requests for our expertise represent government agencies, academic institutions, and private industry.

Figure 27.--International request for selected NWFC expertise (1965-70).

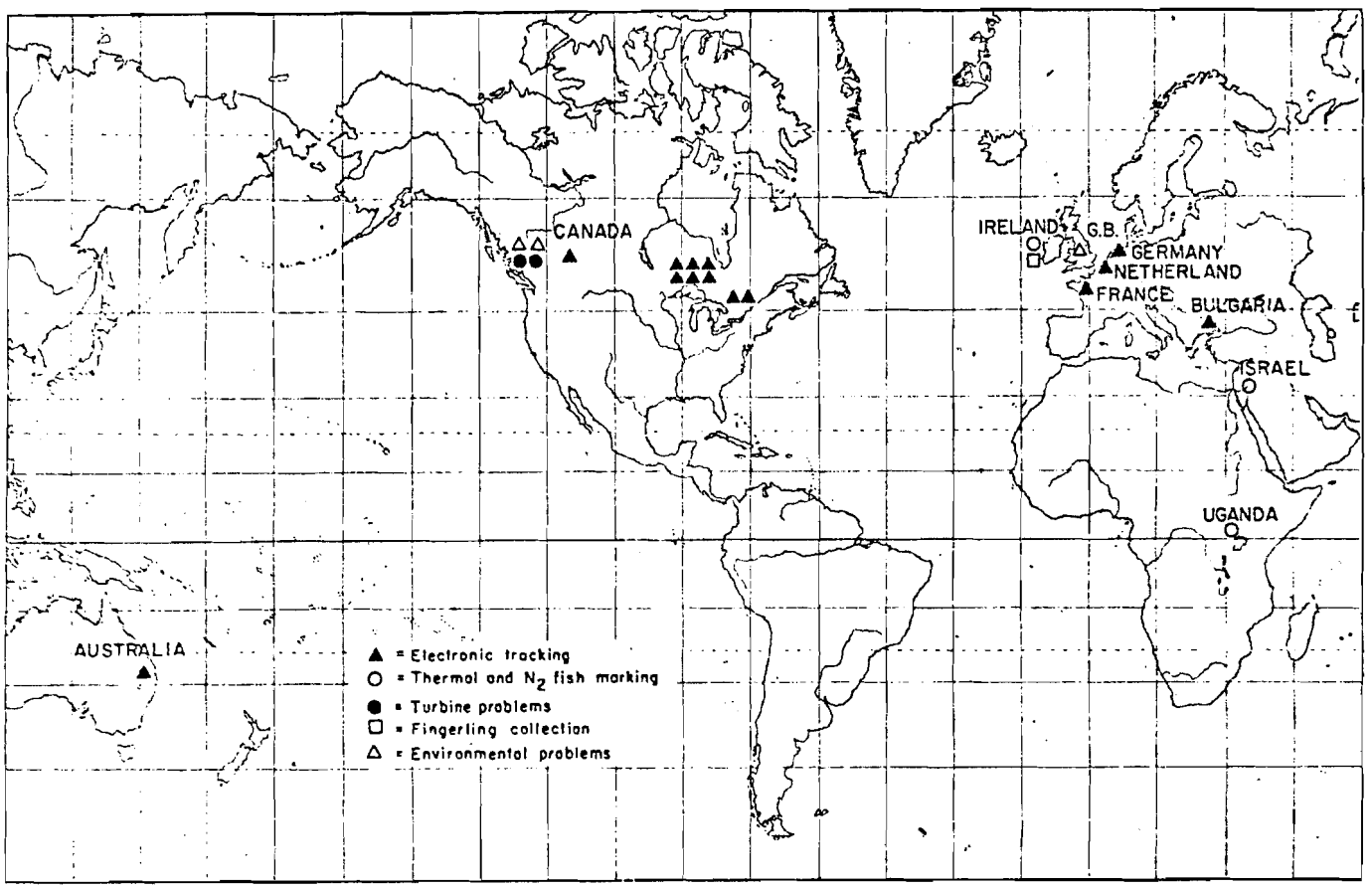


Figure 28.--National request for selected NWFC expertise (1965-70).

If the other areas of the Center's expertise (e.g., fishery biology and population dynamics, oceanography, biometrics, chemistry, mammal biology, engineering, etc.) were to be similarly documented, the result would indeed be impressive. As an indicator of this in the global sense, during 1973 alone Center scientists were requested to work on fisheries development or scientific programs in Africa, Asia, South America, and Europe (Figure 29).

Figure 29.--Location of nations that received Northwest Fisheries Center expertise during 1973.

Clearly, the benefits from our research, as measured by application of our technical developments and demand for our expertise, world and nation-wide, show that our contributions to the scientific community are also of significance and of much greater value than most people may realize.

Having identified as well as quantified some of the practical and technical benefits from our research there remains a need for better evaluation and communication especially as to our contributions (past and potential) to the socio-political community. Why this evaluative capability is largely lacking in the research arm of the Service, such as the Northwest Fisheries Center, why it is needed at the Center or field level of the Service, and what steps are needed to bring it about are aspects related to organization and management. These are discussed next.

ORGANIZATIONAL RATIONALE -- PROBLEMS AND CHANGE

Even after decades of federal fishery research activities our products are not well known nor are their values. Furthermore, even after a decade of administrative systems of national origin such as,

Planning, Programming, Budgeting (PPB)
Management Information System (MIS)
Planning and Management System (PAMS)
Management by Objectives (MBO),

the desired capabilities in identifying the fishery problem and evaluating the plans and results of the Center's research programs especially in social (practical)terms are, in general, still below the levels sought by these administrative systems.

This is a deficient condition which should be recognized and acted upon. Fundamental impediments relate to two areas in organizational rationality: (1) differences in perspectives; and (2) the organization's capacity and capabilities in social sciences.

Perspectives in Organizational Rationality

The Northwest Fisheries Center is one of many fishery research centers and laboratories of National Marine Fisheries Service which are concerned with the studious inquiry or examination of the complexity of interaction between the aquatic population, its physical environment, and the social values (patterns of belief) underlying the harvesting systems with purposes both of seeking solutions to social problems (applied research) and the asking of questions (fundamental research). Since fishery research is but the organized processing of information and one that does not take place in an environmental or social vaccum, organizational rationality is needed; that is, a systematic approach to the efficient and effective processing of information and the effective communication and application of the product (information) to produce the desired impacts.

In its broadest context, organizational rationality is an abstraction found in all forms of organized human activity from a society down to say, a small but formally organized golf club. As such, differences in perspective as to organizational rationality is inherent because of the differences in activity and purpose of organizations. Many studies have been carried out to bring about a common perspective on this abstraction. Some examples are: Weber (1947), March and Simon (1958), Parsons (1960), Katz and Kahn (1966), Buckley (1967), and Thompson (1967). The most publicized of organizational rationality in the Federal Government during the past decade took place with the implementation of PPB. The PPB system which was administrated by the Office of Management and Budget (OMB) was heavily framed in economic terms of reference with the objective of promoting and bringing about a common national perspective on organizational rationality. It is generally observed that PPB was not accepted by Congress because budgeting decisions of the Congress are greatly influenced by political bargaining. A study on its implementation and use at higher levels of 16 federal agencies indicates that PPB had limited success principally because of differences in perspective as to purpose (internal use of agency versus OMB uses; Harper, Kramer, and Rouse, 1969). PPB in the Federal Government became an "unthing", or was discarded, in 1971 (Schick, 1973). Some of PPB's elements, however, have lived on in subsequent management systems as evidenced by the need to state program benefits in economic terms, whenever applicable.

Under any management system the ultimate constrains to managerial perogatives in any federal entity lies with the Office of Management and Budget (OMB) and with Congress. Within the limits of these constraints and the priorities established by these bodies, the Center must have organizational rationality, a legitimate function and responsibility met by our Center, but here, again, it is in a different perspective from those of OMB, Congress, and our NMFS central office. Our perspective is generally much narrower and it is more technically (or scientifically) oriented rather than socially oriented, and in terms primarily of managing a process in scientific inquiry. For example, in relation to PPB the problem faced by our Center was the difference in our perspective to those of Congress, OMB, and our NMFS central office. Some of the symptoms of this problem at the Center at that time were frustration, anxiety, and resentment as found in remarks such as "you can't quantify results of research in dollar terms", or "we will not sacrifice our scientific integrity", to "let's go along with this game until it dies". Reactions ranged from reluctance and indifference up to tenuous estimates of benefits to accommodate the new terms of reference called for by OMB and our central office under PPB. As viewed by Center personnel, real costs (loss of research manpower and time) were experienced as a result of complying to directives associated with PPB (Tanonaka, 1971) 15/.

Administrative systems such as PPB, MIS, PAMS, and MBO bring new terms of reference outside of our traditional and normal perspective. These are realities which we must face, however. An emerging public policy issue which will add further to our problems in perspective is the expressed need for systems of "technology assessment" where evaluation is asked to be carried out on the beneficial as well as the undesirable, or secondary, consequences of current and impending technology from research. In other words, these are systems all directed toward accountability in research which require NMFS research centers and laboratories to broaden their perspectives in fishery research and development of technology. But why has this not generally taken place; and, also, why the differences in perspectives to begin with?

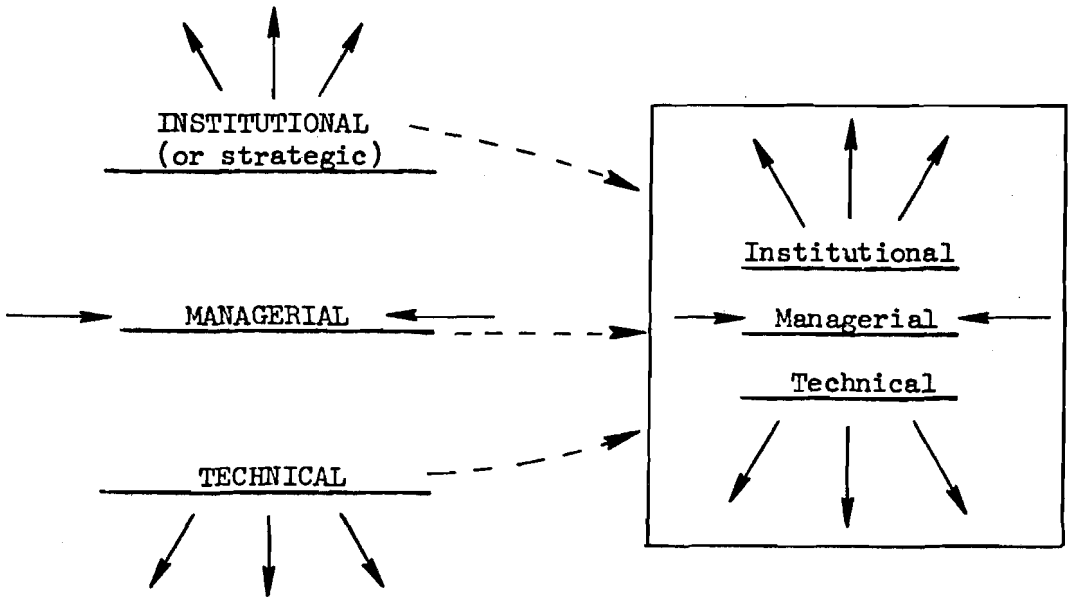
A basic factor underlying the difference in perspectives is the difference in values, interests, and needs of individuals and groups in our society. In fisheries, there are differences among and between resources (species and their distribution, abundance, and life history), differences in the harvesting, processing, and marketing method, differences in the culture and tradition of the men in the fishing industry, and regional as well as international differences in the political, economic, and social forces operating on the fisheries. All of these variables influence and condition the perspectives of NMFS research centers and laboratories. To begin with, major factors which appear to influence and condition differences in perspective within NMFS and also the Northwest Fisheries Center as to organizational rationality are identified and examined next.

Difference in System Levels and Clients

A major organizational factor underlying the differences in perspective is the difference in "system levels" in NMFS. From the standpoint of geography alone great distances separate the central office activities from those of regional offices, and individual research centers and laboratories of NMFS. Distance, per se however, does not contribute to differences in perspective as much as the composition of different ethnic groups, cultural norms, traditions, political forces, and economic factors that are indigenous to each geographic area. These are all different sources of constraint or support to the planning and conduct of fishery research activities. Although a complex area, a better understanding of this setting is possible by the examination first of the "system levels" concept -- an operational hypothesis for the purpose of studying organizations -- developed by Parsons (1960) and expanded upon for government organizations in a report prepared at the Graduate School of Public Affairs, University of Washington 16/.

According to this concept, formal organizations exhibit three distinct levels of responsibility and control -- institutional, managerial, and technical. These are suborganizations in a structural sense, or from the systems approach (dynamic flows of action) are differences in system levels. The basic scheme of this concept is given in Figure 30. Solid arrows indicate the major flow of action (or energy) at each level. A subset of the same three distinct levels is also found within each level, as indicated by the dashed arrows.

Figure 30.--System levels and major flows of action in formal organizations.



The institutional (or strategic) level links the organization with the environment which is the source of its legitimation and in which it functions. This linkage is primarily the generation of support, power, and influence needed to keep the organization viable and to carry out its function. Support flows from a variety of sources but originates basically from the body politic. Concern at this level is to link the organization with its supporting environment to balance potential threats by vigorous supports. For National Marine Fisheries Service, this would be the level of the Director and staff at Washington, D.C. Actions are directed primarily to this "national" environment (the solid, upward-directed arrows of the institutional level in Figure 30).

Action flows at the managerial level run across and within the organization. Most outside contacts for support are incidental. The purpose of action at this level is to contribute coherence, balance, and a degree of unity to the organization. The impact, or effect, of this action is upon the organization and thus, it is internal rather than external (Figure 30). The managerial level is concerned with the "traditional" administrative matters of allocation and control of funds, employment and purchasing policies, development of effective administrative procedures, etc., as well as concern for the broad technical tasks to be performed, resources for these tasks, and their appraisal. For National Marine Fisheries Service, this would be the level of the offices of administration, plans and policy development, and the like at Washington, D.C.

Action flows at the technical level channel the organization's program efforts to the external world (Figure 30). Program objectives are realized through the effective performance at this level: the development of a new, more economical shrimp trawl and consequent use by the industry, as an example. For National Marine Fisheries Service, this would be the level of the field research centers, marketing service offices, etc.

The internal subset of the three levels in Figure 30 requires clarification. At the technical level of National Marine Fisheries Service on a Center basis, the Center Director functions at the institutional level (but faces an environment different from the institutional level of the Regional Office and of the Service); the Deputy Center Director and Administrative Officer function at the managerial level; and the research Divisions function at the technical level. Similarly, a research Division itself consists of these three levels; the Division Director is at the institutional level (and faces an environment different from those of the Center Director, the Regional Director, or NMFS Director), the Assistant Division Director (and any Administrative Officer) at the managerial level, and the program (task) leaders and staff at the technical level.

This brief examination of the concept is an oversimplification of a complex pattern. The essential point, however, is that activities operating at one level tend to have quite different characteristics from those at another level; that is, the functions at each level are qualitatively different. As such, there is a qualitative break in the simple continuity of "line" authority and what links them together is a two-way interaction primarily through exchanges of information. In other words, these are conditions that lead to differences in perspective. Failure to understand these three distinct levels and their qualitative differences in formal organizations may generate some of the difficulties (lack of communication, misinterpretation of information or action, credibility problems, etc.) experienced between the public and NMFS, central office and field personnel, research center and regional office, and even within a research center.

These differences in levels and flow of action provide a guide to the identification of NMFS clients and areas of impact of our activities as called for in administrative systems (PAMS, MBO). (The identification and development of the applied research-clientele relationship of the Northwest Fisheries Center of the earlier Figure 3 of this report was based on this system levels concept and framework).

A client of the National Marine Fisheries Service is defined here in the "systems" sense: that person or group to which action flows (or energy) of the Service are directed. The actual impact may benefit the client directly, counter his attack on the agency, or dissipate his attempts to reduce support for the Service. Direct benefits to the clients are of prime interest herein.

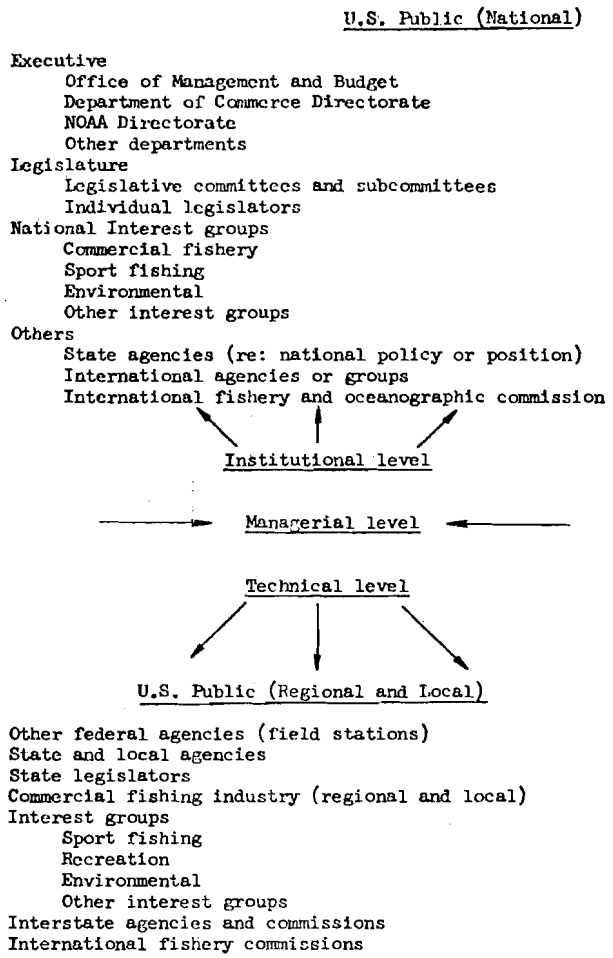
A simple definition of the client of the National Marine Fisheries Service is the United States public. What the Service really faces in our pluralistic society, however, is a phalanx of differing "interest" groups: public or private in character, formal or informal in organization, at times in conflict with one another. My identification of clients at the institutional level is based on the personnel observations of scientists at the Northwest Fisheries Center who experienced training or assignment at our central office (Washington, D.C.) In turn, the clients of the Northwest Fisheries Center are used as examples of the clients of the Service at the technical level.

A summary of National Marine Fisheries Service's clients at the institutional and technical levels is in Figure 31 (These are not all-inclusive). Clients at the institutional level are primarily "national" in character. What the Service faces at this level are primarily the uncertainties of the United States body politic. Activities at this level are primarily short-term -- coping with one "crisis" after another.

Clients at the technical level of the Service are qualitatively different from those at the institutional level (Figure 31). Representation is primarily "regional" and "local" in character. The uncertainties faced at this level are technical (fish populations and their habitat) as well as sociopolitical (other federal agencies, state and local agencies, fishing industry, international fishery commissions or groups, interest groups, etc.). Activities here are both short-term and long-term.

These differences in "system levels" and thus, clientele groups (areas of impact), have served to condition differences in perspectives and, thus, the somewhat provincial and technical perspective of field stations such as the Northwest Fisheries Center.

Figure 31.--Preliminary classification of the clients of the National Marine Fisheries Service.



Limitation on Northwest Fisheries Center's Activity

Another organizational factor underlying our technical perspective is in the nature of our activity. Statutory authorities determine the functions and responsibilities of the National Marine Fisheries Service and of the Northwest Fisheries Center. Currently, the National Marine Fisheries Service is limited mostly (in public affairs terminology) to "non-coercive" types of governmental activity in the form of service (e.g., research) and assistance (e.g., grants, subsidies, and loans). The Northwest Fisheries Center, in turn, is limited to research activity. The "coercive" types of activity implicit with control or regulatory functions (prior restraint, e.g., licenses and permits; corrective intervention, e.g., cease or desist powers; and law enforcement) are not normally exercised by the Center, the National Marine Fisheries Service, or its parent agency, National Oceanic and Atmospheric Administration (NOAA). Exceptions are management over marine mammals and the few fisheries specifically authorized by U.S. statute. Examples of government agencies which jointly exercise non-coercive and coercive types are state fishery agencies (e.g., research, issuing of fishing licenses, opening and closing a fishing season or area, fishery law enforcement, etc.) and outside of fisheries, the Food and Drug Administration, the Environmental Protection Agency, and the like.

In this regard, the following conditions emerge:

(1) The acceptance and application of management-oriented research results from the Center are primarily in the hands of other federal and stage agencies, or of the body politic.

(2) Information on technology and resource availability is used primarily by the fishing, processing, and marketing sectors of the commercial fishing industry, or by resource development and management agencies for marine and anadromous game fishes.

(3) In the area of international fishery affairs the acceptance and application of information is by the Department of State, or fishery commissions or groups otherwise authorized to negotiate for the United States.

This limitation on the ability of the Northwest Fisheries Center to formally apply or follow through on the information processed becomes a constraint to active and proper planning and evaluation of research contributions in social terms and, therefore, undoubtedly reinforces the Center's technical perspective. However, this constraint may be a blessing in disguise to NMFS. The exercise of coercive government activity is largely a regulation on, or intervention into, the behavior of people. Many complex problems are associated with this type of activity; the credibility problem for one where needed information for research may be withheld by, say, people in the fishing industry because of the possibility that it may be used to regulate their activities by the management section of the agency requesting the information. A perceptive study of the problems experienced by a research and management agency is the "A Wildlife Agency and Its Possessive Public" by Owens (1965). The California Department of Fish and Game, unfortunately, was the only visible target of social conflicts arising out of heterogeneity in human perceptions and expectations as to fish and wildlife resource utilization and management.

Research Capacity and Capabilities at Northwest Fisheries Center

Another organizational factor related to the problem of perspectives is in the "natural" process and capacity of the Northwest Fisheries Center -- natural, that is, in the sense of disciplines built into the organization, as well as being the appropriate way of life for the people involved because of accumulated experience, styles of operation, and doctrines or tradition of the Service and Center. Few of the scientists, even in higher administrative posts, are formally trained in economics, sociology, psychology, or political science. Traditionally, it has not been natural for the Center's staff to actively consider the social impacts of their research -- much less be able to evaluate it in social terms. A related example here was the implementation of PPB during the mid-sixties. Emphasis was on use of principles and analytical tools from economics. A study at the Northwest Fisheries Center (see Footnote 15) showed that economic capabilities were simply not available at the Center. Staff members who did have formal course-work in economics received their indoctrination ten to thirty years prior. Therefore, it was not rational or reasonable to expect Center scientists to evaluate fishery benefits in economic terms, much less be able to define them properly. Therefore, the "natural" process and capacity of the Center could permit only a technical perspective on fishery problems of the U.S.

Motivation and Satisfaction of Center Personnel

Interrelated with the previously mentioned "natural" process and capacity of the Center and formal limitations on activities in relation to our technical perspective is the motivation-satisfaction aspect of Center scientists. Academic training, tradition, professionalism, and organizational norms have evolved a general pattern of behavior where (aside from "administrative" abilities) tangible and intangible rewards have been determined mainly by contributions to the scientific community. Publication in scientific journals is a necessary and legitimate function and it is only when the degree of emphasis on publishing becomes distorted that we have concern -- e.g., when the number of publications becomes the primary criterion for evaluating performances. This organizational aspect has undoubtedly served to reinforce technical perspectives.

Scientific Integrity and Competence

Finally, our technical perspective is also reinforced by the role and responsibility of fishery scientists in the decision making process of fishery treaties, agreements, and compacts. Many people may not be aware that technical information serves as the base for numerous fishery policies, positions, or programs (national and international) 17/. That is, the validity of the technical information must first be established, and in this regard, fishery scientists have an active role and responsibility in vigorously examining and evaluating the research and information of all parties concerned. The highest of scientific competence and knowledge is required here as our scientists, serving on various technical committees, face the most competent of world fishery scientists -- Canadian and Japanese scientists in the International North Pacific Fisheries Commission (INPFC), Soviet scientists in U.S.-U.S.S.R. bilaterals, etc. Thus, the need to maintain or strengthen our scientific competence undoubtedly tends to reinforce our technical perspective.

The discussion thus far is not intended to imply that Center scientists are totally unfamiliar or unconcerned with the practical aspects of U.S. fishery problems. It is far from it. We are cognizent and do carry out research under these terms of reference but because we do not have the training and capabilities to properly quantify or define fishery problems and the contributions from research in practical terms, we have had to retain them as nondocumented experiences. The examples on practical problems and contributions contained in this report is a start in documenting these experiences and in bringing them to public attention.

These then, are some of the factors which have led to or tended to reinforce the somewhat narrow and technically oriented perspective of research groups such as the Northwest Fisheries Center. Many of the new terms of reference associated with administrative systems of the past decade are on the fringe or outside of this perspective — for example, evaluation of research plans and results in economic terms.

This problem in perspective is recognized at the Center. In turn, this should also be recognized by those at the higher levels of the federal government who are responsible for the development and administration of broad-based management systems.

Social Science Capabilities

Social science capabilities are in the process of development at the Northwest Fisheries Center (see the later section on recommendations). This should assist in broadening perspectives and in complying with some of the social science oriented terms of reference associated with administrative systems. The expected net result is more and better evaluation of research plans and results in practical terms leading to better communication with our clients and with the central office where such information is needed, in part, for budget justifications, gathering support for NMFS, and the like. In other words, to help keep the Service and the Center viable and in a position to continually serve our society most effectively.

Although still in a developmental stage, the framework followed by the Center in evaluating research in social terms is shown in Figure 32. It is a normative framework calling for evaluation of social impacts by general societal levels (clientele levels) and represents an outgrowth of the earlier discussed system levels (Figure 30) and research information-client relationship (Figure 3) frameworks. Generally, economic impacts cover those that are quantifiable primarily in terms of dollars or employment. Social-psychological impacts cover those quantifiable expressions of the community based on cultural or aesthetic values. Political impacts cover those quantifiable political or administrative actions (decisions) that result from legislative, council, or commission proceedings. The framework suggests that social impacts be evaluated and presented by the three societal areas at each level or class. A difficulty, however, is that these are not mutually exclusive. For example, sport fishing may involve both economic and social-psychological factors that are quantificable in their respective terms. The "state of art" of social sciences in relation to fishery problems as well as current organizational capabilities at the Center do not permit a comprehensive evaluation along all the levels at this time. Aquaculture research at the Center will be used as an example to illustrate the general use of the framework in Figure 32.

Figure 32.--Conceptual framework for evaluation of the social impacts from fishery research and technology.

	Social impacts 1/		
Impact level	Economic	Social-Psychological	Political
National	X (Y)	X (Y)	X (Y)
Regional	X (Y)	X (Y)	X (Y)
State	X (Y)	X (Y)	X (Y)
Local	X (Y)	X (Y)	X (Y)
Specific interest groups 2/	X (Y)	X (Y)	X (Y)

1/ X represents benefits and (Y) the undesirable consequences or dysfunctional effects. Depending on the type of information and its intended use, one type of social impact may be dominant over the others.

2/ The basic evaluation level ; e.g., fishermen, processors, recreation group, a management agency, a fishery commission, etc.

Economic area.--Assuming that the immediate client of information on salmon aquaculture technology (private enterprise area) is the industry, the economic information needed by them is primarily the cost associated with the technology. This was provided by Center researchers and Regional Economist to interested entreprenuers along with the information on physical production possibilities (Richards, Mahnken, and Tanonaka, 1972) 18/. In context of market and revenues the projected net earnings of the enterprise would serve as a measure of the economic impact of the technology at this level. At the local level (say, a county) the type of economic information to be developed as well as impact changes (Figure 32). The interest to be generated, or the interest of the county, would primarily be on information and impact in terms of net income and employment to the county. As we move up the impact levels the processing and measuring of economic information and impact become more complex and difficult. Evaluation at the state level would be primarily in terms of employment and net income accruing to residents of the state from the aquaculture activities. An evaluation on aquaculture of this nature was prepared in response to a request from Washington State legislators (see Footnote 10). At the regional level it would be in terms of regional welfare and economy with increasing considerations for consumer welfare. Finally, at the national level evaluation would be in terms of national welfare and economy (e.g., consumer welfare, employment, foreign trade, etc.)

An important implication here is that there are qualitative differences in the type of economic information and impact (benefits), and thus differences in analytical methods to be employed; that is, it all depends on who is asking the question, or to whom the information is to be directed. Also, although we are a federal agency, if one of our concerns is to generate interest in aquaculture at the state level, for example, effective accomplishment would probably not be possible if we were to present them with information couched in national terms. The direct concern of state officials and legislators, and interest groups is mainly with state welfare and economy. In contrast, the viability and survival of aquaculture research at the Center (and of the Service) depend in large part on support from our task environment (the body politic). Thus, the Northwest Fisheries Center would also need to develop or assist in developing information on aquaculture benefits (actual or potential) in terms of national welfare and economy for this purpose.

The (Y) impacts in Figure 32 are the identification and definition, and measure of any negative effects from aquaculture technology. A hypothetical example at the state or regional level would be a measure of any economic loss or unemployment experienced by traditional salmon fishermen and processors from the effects of pen-reared salmon on their market.

As indicated earlier, comprehensive economic evaluation as such is not within the Center's capabilities at this time but we are in the process of development assisted immeasureably by our Regional Economist, by information (especially the Working Papers or Manuscript Series) developed by the Economic Research Division, NMFS, and by analytical tools such as by Bell (no date) 19/.

Social-psychology area.--This area and the next, political, is beyond the current capabilities of the Northwest Fisheries Center. Only a brief and general discussion will be presented. Let us assume that one of the major, felt needs of the public in Washington State and of the counties around Puget Sound is environmental quality (that which is held in greater "value" than economic needs), and more specifically the present and potential impact of industrial and oil pollution in Puget Sound. Let us also assume that aquaculture represents a nonpolluting, alternative industrial use of some of the areas in Puget Sound. Various interest groups in the state concerned with environmental quality hear about the aquaculture program being carried out at the Center in cooperation with state agencies and request further information from our Regional Office, Center, or program personnel. A greater understanding or appreciation for aquaculture by these groups develops and is promoted by them as a desirable alternative use of Puget Sound, as well as to serve as the base for public expression which serves to halt indiscriminate practices or to make the "polluting" industries more closely examine their practices and plans. The aquaculture program has helped to effect a social impact -- the satisfying of this need of the people of Washington State and of the counties around Puget Sound. This impact may be overlooked if aquaculture is viewed purely in the context of commercial benefits. An evaluation of the aquaculture program would contain a statement to this fact along with the economic and political impacts.

An example of the (Y) impact would be the effect of aquaculture activities on the aesthetic values of interest groups that may have been in the minority; such as upland home owners who desire a "natural" scene in the waters of Puget Sound below them and do not want this visual quality spoiled by floating pens.

Political area.--In view of the current concern over the problems associated with the "common property" aspects of most domestic fisheries in the U.S., aquaculture -- with proper tenure arrangements -- would serve to effect a function of "ownership" with attending economic efficiency sought be advocates of "limited entry" in fisheries. A recent political impact in the State of Washington resulting from the influences of the Center's aquaculture program is discussed briefly.

It is generally observed that the private entreprenuer who was the first to become interested in pen-rearing of salmon was able to generate enough interest and support in the Washington State Legislature to effect an amendment to a state law and code authorizing the Director of Fisheries to permit fish farming. Although under administrative control and discretion of the Washington State Department of Fisheries and other agencies concerned, the pen-rearing of salmon by private enterprise has become possible. The change agent of this political impact was the private entrepreneur. Although of secondary nature, we may view this political impact as attributable in part to the aquaculture research and development activities at the Northwest Fisheries Center.

In summary, as the framework of Figure 32 indicates there are also qualitative differences in social analysis (levels and types). In other words, these also represent differences in perspectives, and just as the Northwest Fisheries Center recognizes the need for evaluation of our programs in national terms, so should those at the national level recognize the need for evaluation along other levels -- e.g., regional, state, local, and down to the basic interest group level.

Development of social science capabilities along such a comprehensive framework will be a gradual process for the Center. It is hoped that in time these will be developed up to the level of those capabilities we already have in the biological and physical sciences. With such a balance in capabilities, the Center will be in a position to respond to most perspectives in organizational rationality and, furthermore, be able to withstand the test of the most rigorous of program reviews and evaluations. (See Appendix E for the Northwest Fisheries Center's perspective and approach to program review and evaluation).

The recommended approach discussed next on broadening of perspectives, via development of social science capabilities, is the personal opinion of the author. It is, however, generally patterned along a practice already in existence at the Northwest Fisheries Center.

Generalist Approach to a Broadening of Perspectives at NMFS Research Stations

The impediments to evaluation of the social impacts of federal fishery research and technology were identified as the narrow (technically oriented) perspective at NMFS research stations (centers and laboratories) and the difference in perspectives as to organizational rationality between Congress, OMB, and NMFS central office and field stations. The proposed solution to this problem is the development at the technical level of NMFS of capabilities, or the arrangement for assistance, in the social sciences and administrative systems area. In other words, the perspective at research stations must be broadened and social science capabilities "designed" into the organized research processes of research centers and major laboratories of NMFS so that in time it will become a "natural" organizational capacity and process.

The Foundation of Alternative Solutions

Development of capabilities and of an acceptable system of organizational rationality at NMFS research stations will be a gradual process. Central to this is the development first of a "generalist" staff member from the scientist rank in each major research group. It is recommended that people with the necessary interest and motivation be formally trained for at least 2 academic years or more in economics, sociology, political science, and administrative systems as in a flexible graduate study program of schools of public affairs at universities. This was a general recommendation also of McHugh (1968). In addition, this essentially follows the recommendation of Wildavsky (1969) regarding the development of personnel in policy analysis at the higher levels of government:

> "One way of increasing the supply of policy analysis would be to improve the training of people who work directly in the various areas of policy. Instead of taking people trained in policy analysis and having them learn about a particular policy area, the people in that area would be capable of doing policy analysis. Three-day or three-month courses will not do for that purpose -- a year, and possibly two years, would be required. Since it is unlikely that the best people can be made available for so long a period, it is necessary to think in terms of education at an earlier period in their lives. There is a great need for schools of public policy in which technical training is combined with broader views of the social context of public policy. Although no one knows how to teach "creativity", it is possible to expose students to the range of subjects out of which a creative approach to public policy could come".

This "generalist" approach also relates to an aspect in the problem in education of fishery scientists studied by Royce (1972). He reports that no single curriculum is ideal for training in fishery science as the field has become much too broad and includes too many specialties, each requiring a higher level of training. In this sense, the generalist approach represents a specialization in the social sciences by fishery scientists. The specialization (in the form of graduate training) would take place not in a college or school of fisheries but in a school of public affairs. Furthermore, this training should take place for the intended generalist after a period of exposure at public research organizations such as the Northwest Fisheries Center.

The scientist turned generalist would provide the research group with minimum but basic capabilities in economics, sociology, political science, and organization-administrative concepts -- a basic start in the broadening of perspectives. This background would assist in identifying the clients and their needs, determine how the information is to be used by the clients, help to develop a forum for the communication of the information to the clients, and carry out analyses to measure the impacts (economic, social, and political) for purposes of program planning and evaluation. When necessary he would seek out guidelines or assistance in the social science area as they relate to the fishery research activities of his organization. He would also be in a position to assist research administrators with the conceptual and operational aspects of "administrative" systems. His background in the natural sciences will help him to understand the technical problems faced by his colleagues and thereby provide better working relations. In turn, he can serve as the needed "interpreter" of the languages and concepts of the social sciences to his colleagues.

The support given to development of this generalist by the center or laboratory directorate and general acceptance of a generalist staff member as such by center personnel are, of course, necessary requisites to effective development of this pivotal base which, in this report, is viewed as the key to the long-range and interim solutions to the problem.

Central Office Leadership

Using the generalist at the center or laboratory as a base, an alternative solution is the development of capabilities in the social sciences and development of "proper" administrative systems at the institutional level of NMFS. Economic capabilities are already well developed at the central office level. Assuming that sociology, political science, and other areas are also developed at that level, the generalist would service his organization under guidelines and instructions from the central office staff.

This solution, however, is rejected here because the qualitative differences in "systems levels" in NMFS would tend to influence the central office staff in the direction of the abstractions of national affairs which would be of little assistance to the generalist in the field who faces an entirely different environment. Even with an increased staff at the central office level it is doubtful that individual attention and assistance on economic and social analyses of the numerous fisheries and problems in the United States would be possible. In context of the long-range solution, however, some capabilities at the central office and their support will be a necessary condition for the final and desired solution at the field level.

Regional Office Leadership

A regional perspective would probably be the most functional from the standpoint of the Service and field stations, and the long-range solution sought. The staffing of each region with an economist (several regions have them), sociologist, political scientist, and perhaps even a jurist would be desirable. That these people would have to be concerned primarily with regional problems is recognized. However, their proximity, familiarity with regional and local characteristics, and their availability in terms of time would result in more assistance to the generalist and attention to the individual research programs of the various centers and laboratories. Full development of a regional perspective would also benefit the central office. They would be spared the necessity, as experienced under PPB, of having to rush in and fill the social science vacuum between them and the research groups.

Funding limitations, personnel ceilings, and need for central office support are realities which preclude full regional staffing at this time. In the interim the alternative is for the generalist, whenever it becomes necessary or desirable, to seek out "expert" assistance (guidelines and studies) via the consultant route in the areas of sociology, political science, law, etc. (economics is already available at several regions) as they relate to specific areas and problems of his center or laboratory.

Research Center or Laboratory Leadership

The long-range solution sought (regional leadership) will be a gradual process. In the interim and as a starting base for a research group, the solution is the development of a generalist, or generalists, under the graduate study programs in public affairs. The NMFS field stations should provide the leadership and investment in this regard. A generalist base as such would provide the broader perspective needed and put the center or laboratory in a better position to meet new or modified forms of administrative systems. From a staff position the generalist would generate information and also provide analytical assistance to laboratory personnel in the social areas of fishery problems. Day to day contact between the generalist and research personnel would, hopefully, lead to a gradual broadening of the perspectives held by the latter.

SUMMARY AND OUTLOOK

There is little understanding or appreciation of federal fishery research and development of technology, and their benefits, in the United States even after decades of activity. This report (based on the activities of the Northwest Fisheries Center, National Marine Fisheries Service, NOAA), examines the causes underlying this condition, the capabilities needed and being developed at the Center in taking corrective actions, and, as an introduction, some selected examples of benefits from past and ongoing research.

The Northwest Fisheries Center carries out research, which is the processing of information. We face two responsibilities and clients in this regard. As a scientific organization, we have the responsibility of expanding man's knowledge of natural phenomena. The client of that information is the scientific community. As a public research organization, we have the responsibility of taking the abstractions of science and applying them to the practical affairs of our nation and society. The client of that information is the sociopolitical community.

Research information-clientele relations at the Northwest Fisheries Center have been tentatively identified as follows:

-- Resource survey information. In the commercial fishery area, the immediate client is the fishing sector of the industry on utilized resources while the client is the processing and marketing sectors of the industry on latent resources. On anadromous and marine recreational fisheries, the immediate clients are sport fishermen and management agencies.

-- Fishing technology information. The immediate client of information on commercial fishing systems and gears is the fishing sector of the industry. The clients on conservation-purpose systems or gears are primarily the management agencies.

-- Stock assessment information. The immediate clients of information related to the domestic fisheries are domestic management agencies. In the international fisheries area the immediate clients are U.S. commissions or groups otherwise authorized to represent the U.S.

-- Aquaculture technology information. The immediate clients of information related to private enterprise potentials would be members of the fishing or food industries. In the public area, the clients are resource development and management agencies.

-- Resource and resource habitat protection information. The immediate clients are the various water and fishery resource development and management agencies, and environmental protection and ecology agencies.

Practical benefits to be realized depend on the initial acceptance and application of the information by the clients mentioned above.

Through retrospect and projection we have shown some examples of practical benefits from research at the Northwest Fisheries Center. These are of magnitudes far greater than most people realize.

-- The development of king crab, shrimp, and Pacific ocean perch fisheries from resource surveys.

-- Enhanced angling success of the sport fishermen from surveys on sockeye salmon in Lake Washington.

-- Commercial application of fishing systems and gears such as the deepwater trawl, midwater trawl, universal trawl, sablefish trap, Columbia River smelt trawl, selective shrimp trawl, and others.

-- The protection of valuable U.S. fishery resources (such as salmon and king crab of the southeastern Bering Sea) through information on stock assessment.

-- The development of an industry based on salmon aquaculture technology information.

-- The protection and enhancement of anadromous fish resources in the Columbia River Basin through research on resource-environmental change relationships. Some selected examples were: (1) savings in construction costs through improved fishway designs; (2) a fish transportation plan to increase survival of juvenile salmon and steelhead migrating downriver, and (3) the construction of cooling towers to prevent thermal pollution of rivers.

-- Potential, spin-off type benefits from research on fish lipids and devices (traveling screen) to protect fish in water transfer systems.

A wide variation was evident in the identification and measurement of practical benefits from research. With the exception of the fishway research benefits (adult fish passage) and the potential benefits of the juvenile fish transportation plan, the others were generally implied from causal relationships such as number of vessels using the new fishing gear developed by the Center, number of firms engaged in salmon aquaculture, etc. This is perhaps reflective of the state of art at field stations of the National Marine Fisheries Service.

The significance of our contributions to the scientific community was shown by the more than 119 documented past, present, and planned uses by international and national research agencies and academic institutions of but two of our technical developments -- electronic tracking device and technique and thermal and nitrogen fish marking devices and techniques. These along with numerous documented international and national requests for our "expertise" clearly show that the value of our research to the scientific community is far greater than most people realize.

It is fair to assume that field (or technical) level organizations such as the Northwest Fisheries Center have generally placed greater emphasis and attention to research and the communication of information to the scientific community, and less to the sociopolitical community. This is a deficient condition which should be recognized and acted upon. Several organizational characteristics were identified as leading to this condition.

Academic training, tradition, professionalism, organizational norms, and the like have led to the somewhat narrow (technically oriented) perspective evident at research organizations in the field. The scientific competence or value of the scientific information processed is not being questioned by the description--narrow perspective. It refers rather, to the inadequacies in training and capabilities in the social sciences which would aid in broadening perspectives as well as assist in proper evaluation and communication of research results in practical terms. Simply put, we can state that Event "A" will result in an increased availability of "X" numbers of fish to a fishery but what this means in terms of, say, potential employment, increased earnings, consumer welfare, etc. is beyond our current perspective and capability.

Another characteristic is related to the areas of communication and decision-making process. Without exception, information from the Center must be accepted and used by others (fishing industry, management agencies, fisheries negotiators, etc.) before practical benefits can be realized. Thus, since we are not able to follow-through on our information, in the sense of using the fishing gear we developed to fish it commercially ourselves, to manage a fishery based on our research, etc., the evaluation of their performance or worth has tended to be left out of our activities, if not responsibility.

A fundamental characteristic is in the difference in levels (or substructure) in social organizations. According to a hypothesis from organization theory, the Northwest Fisheries Center would be at the technical level of the National Marine Fisheries Service. It is at this level that program impacts of the Service take place. Clients at this level were shown to be qualitatively different from those at the institutional (or central office) level of the Service. Furthermore, it was shown that there are also differences in the clients of the Northwest Fisheries Center depending on the type of research information, as well as differences in the levels of the clients. The U.S. public or consumer seldom receives or benefits directly from our information, and, therefore, is not immediately aware of our products and their value. Even a fisherman who uses and benefits from a fishing gear we develop may not, in turn, be aware or appreciate the value of research such as on stock assessment which is directed primarily at management groups.

Although general theories, methods, and analytical techniques are available to serve as guidelines for evaluating the practical aspects of public programs, few precedents or guidelines are available in their application to fisheries research and development of technology. Even with the widely accepted and used analytical technique of benefit-cost analysis, the Northwest Fisheries Center must still identify and determine which costs and benefits should be included and how they are to be quantified. Capabilities leading to some competence in this regard (via the "Generalist" approach to broadening of perspectives) are in the process of development at the Center. This, we hope, will bring about the desired balance we seek in meeting our responsibilities to both the scientific and sociopolitical communities.

Finally, through this balance (in meeting our responsibilities) the anticipated result of effecting better communication between the Center (technical level) and the managerial and institutional levels of the Service will be accomplished. This should lead to better and more timely information for use by NMFS Directorate in meeting clientele needs at the institutional level and, consequently, the generation of support to keep the Service viable and in a position to continue to serve our society efficiently and effectively.

ACKNOWLEDGMENT

Fishery research and development of technology covers a broad, if not complex, range of activities. Any thorough examination into the specifics of these activities would be beyond the scope of a single individual. Hence, the contribution and assistance of personnel at the Northwest Fisheries Center, National Marine Fisheries Service, in preparing this introductory report is gratefully acknowledged. Further acknowledgement is made to personnel of the Marine Fish and Shellfish Division for their assistance and information on benefits related to fishing technology and resource survey.

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FOOTNOTES

1/ Hereafter, also referred to as the Center.

2/ Hereafter, also referred to as the Service.

3/ In 1956, the agency now known as NMFS was known as the Bureau of Commercial Fisheries (BCF). In 1970. when the National Oceanic and Atmospheric Administration was formed, BCF was included in the new organization and renamed NMFS.

4/ HIPKINS, F.W. and A.J. BEARDSLEY. 1970. Development of a pot system for harvesting blackcod (Anoplopoma fibria), A Progress Report. U.S. Dept. Commer., Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv., Northwest Fish. Center, Mar. Fish. Conserv. Eng. Base, Seattle, WA. 32 pp. (Processed).

5/ ELLIS, IAN E. No date. National Marine Fisheries Service double trawling system. Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv., Northwest Fish. Center, Seattle, WA. 7 pp. (Processed).

6/ PEREYRA, WALTER T. No date. Benefit cost analysis: Development of shrimp separator trawl. Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv., Northwest Fish. Center, Seattle, WA. 11 pp. (Processed).

7/ FREDIN, R.A. 1970. The salmon abstention line and the North American salmon fisheries. U.S. Bur. Commer. Fish., Biometric Inst., Seattle, WA. (now Natl. Mar. Fish. Serv., Northwest Fish. Center, NMFS), Administrative-use report. 48 pp. (Processed).

8/ FREDIN, REYNOLD A. 1971-73. Unpublished, Administrative-use materials and reports. Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv., Northwest Fish. Center, Seattle, WA.

9/ Personal Communication. Conrad V.W. Mahnken. Northwest Fisheries Center, Natl. Mar. Fish. Serv., Seattle, WA.

10/ JOYNER, TIMOTHY, JACK A. RICHARDS, AND GEORGE K. TANONAKA. 1971. Improving productivity of Washington's water resources through aquaculture. Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv., Northwest Fish. Center, Seattle, WA. APR. 1971, 27 pp. (Processed).

11/ STAFF, FRESH WATER AND ESTUARINE RESEARCH. 1971. Evaluation of research relating to migration of anadromous fish past dams. Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv., Biol. Lab. (now Northwest Fish. Center), Seattle, WA. Feb. 129 pp. (Processed).

12/ This is an inflated research cost as far as benefit-cost analysis of the transportation plan is concerned. Included are many common costs which could not be isolated and removed; i.e., the costs of research that provided information basic not only to juvenile fish problems but also to adult fish problems, environmental parameters, etc. An analogy here is benefit-cost analysis of a multipurpose dam. The specific cost (of the dam) related to specific purpose (and thus, benefit) such as for flood control, or for navigation, or for irrigation, or for power generation cannot be adequately isolated. This commonality problem occurs frequently in research.

13/ BLAHM, THEODORE H., AND GEORGE R. SNYDER. 1973. Effect of chemical fire retardents on the survival of juvenile salmonids. U.S. Dept. Commer., Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv., Environ. Facility, Prescott, Oreg., Dec. 43 pp. (Processed).

14/ FREDIN, R.A. 1964. Evaluation of fishery research. Bur. Commer. Fish., Biol. Lab., Seattle, WA. (Unpublished speech).

15/ TANONAKA, GEORGE K. 1971. A problem faced by a federal fishery research laboratory on planning, programming, budgeting (PPB). Action Rept., Grad. School Public Affairs, Univ. Washington, Seattle, WA. 53 pp. (Processed).

16/ GRADUATE SCHOOL OF PUBLIC AFFAIRS, UNIVERSITY OF WASHINGTON. No date. Administrative action systems in a complex organization. Grad. School Public Affairs, Univ. Washington, Seattle, WA. 20 pp. (Processed).

17/ On this point, see for example the materials developed by Fredin (see text, Footnotes #7 and #8) in Part II of this report on the Southeastern Bering Sea king crab problem, the salmon abstention case, and the problem of North American salmon and the 200-mile limit.

18/ RICHARDS, JACK A., CONRAD V.W. MAHNKEN, AND GEORGE K. TANONAKA. 1972. Evaluation of the commercial feasibility of salmon aquaculture in Puget Sound. Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv., Northwest Fish. Center, Seattle, WA. Feb. 3, 1972. 35 pp. (Processed).

19/ BELL, FREDERICK W. No date. A guide to benefit-cost analysis for Bureau of Commercial Fisheries programs. U.S. Fish & Wildl. Serv., Bur. Commer. Fish., Div. Econ. Res., Working Paper No. 35, 39 pp. (Processed).

20/ BUREAU OF COMMERCIAL FISHERIES. 1969. Joint master plan for the Calico scallop fishery. (U.S. Fish. Wildl. Serv., Washington, D.C., sample only). 96 pp. (Processed).

21/ A critical, but subtle, point overlooked in PPB or advocates of efficiency is that of organizational effectiveness (reliability and adaptability); perhaps a more important criterion than efficiency for research organizations. A popular and extreme example of effectiveness in this sense is "fail safe". In fishery research an example would be where a research program may have at its disposal several known, possible alternative approaches to solution of a problem from the start (planning stage). In the face of technical uncertainties, however, the normal process in organized research here, within budgetary and manpower limitations, is the simultaneous conduct of several or more of the alternative approaches. Effectiveness in the internal process of research is achieved by the availability of ongoing "backup" approaches in the event one or more projects are dropped because of technical difficulties, unanticipated costs, etc., or inversely, effectiveness is achieved when others are dropped because one of the approaches eventually proves or shows higher probabilities of success and is thereby selected and pursued. In contrast, the benefit-cost analytical tool under PPB implies that an *a priori* selection be made from these alternative approaches and pursued disregarding any need for "backup". Efficiency is overriding and thus effectiveness is assumed, incorrectly, to result from it, as under the PPB concept. Finally, some may view the simultaneous conduct of alternative approaches between or within organizations, or even within a research program, as a practice in "redundancy" (duplication and overlap). From the strict efficiency standpoint this may be so but not necessarily from the standpoint of effectiveness in organized research. Also, science is inherently redundant for knowledge proceeds by superceding of hypotheses which tacitly implies at least duplicate and more ofter replicate trials in testing existing hypotheses. An example from the illuminating article by Landau (1969) may illustrate this point. A commercial aircraft with its various backup systems and controls is a very redundant system, a fact which accounts for its reliability of performance and adaptability. The organization and management of fishery research, therefore, should be based on a balance in the notions of efficiency and effectiveness as much as possible.

APPENDIX A

INTERNAL ASPECTS OF THE RESEARCH PROCESS

Distinction between basic and applied science, and of research, is made on the basis of "purpose"; the asking of questions in the former (basic) and the seeking of solutions to practical problems in the latter (applied). As a public organization concerned with the practical affairs of men, research activities of the Northwest Fisheries Center are the applied type. The asking of questions, however, is also an integral part of the process in applied research. As such, those stages in the research process that ask questions will be identified as "fundamental" research here to maintain its distinction from the "basic" or "pure" research and terminology normally associated with, say, academic institutions.

An example of a research process with suggested classifications as to fundamental and applied, the intended user of the information, and the terms of evaluation are given in Appendix Figure A. The general problem faced by management and industry is the need for forecast on the sockeye salmon run to Bristol Bay, Alaska. The desired precision in forecasts is limited, however, and the problem faced by the research group at the Center in this situation is the lack of information on the ratio of returning 2-year-in-ocean sockeye (maturing) and those remaining at sea (immature). The applied research objective, or solution sought to this problem is to develop the technical ability to predict the maturation process in 2-ocean sockeye while at sea within defined limits of precision. The limits of precision are assumed to account for a desired precision in the prediction itself (statistically) as well as precision within the general limits of operational flexibility (economically) that can be tolerated by the industry.

The stages in research process (A, B, etc.) indicate the sequential steps taken over time in this particular example. Each essentially asks a question and, therefore, research here is of the fundamental type. The inherent consequence of a question (organizationally speaking) is the planning, budgeting, and operation of research at each stage. Normally, the initial stage of a scientific inquiry (as in "A") is a question on the simple or gross aspects of a phenomenon under investigation. In the example, the difference found in general characteristics were not sufficient for the precision required. This led to the question (or research) as indicated by stage "B". If differences (in stage "A") were sufficient for the precision required, however, then the information would have been applied to the solution (develop the ability to predict) of the problem. Inherent to all stages are technical, administrative, and economic considerations.

The example in Appendix Figure A should not be construed as scientific inquiry going off into an uncontrolled race away from the solution to a social problem. Internal (scientific and organizational) and external checks normally guide or limit the research process in public organizations. For example, if the projected cost of further inquiry along the direction taken appears to far exceed the estimated "value" to management and industry, then the inquiry may be terminated.

Assuming this approach and classification method to be valid, an implication here is most people may not understand or appreciate public research activities because of the subtlety in the internal aspects of the research process.

Appendix Figure A.--Generalized example of a research process and the classification of research and information. 1/

		Research		Information		
		Purpose	Type	User	Evaluation	Result
General problem and situation	Forecast is needed on the sockeye salmon run (maturing fish) to Bristol Bay, Alaska. Information is used by management to determine "harvestable surplus" and escapement, and by salmon canners to plan for their operations (capital and labor).	-	-	-	-	-
Subproblem and situation	Desired precision in forecasting is limited by lack of information especially on the ratio of returning 2-year-in-ocean sockeye (maturing) and those remaining at sea (immature).	-	-	-	-	-
Research objective	Develop the ability to predict the maturation process in 2-ocean sockeye while at sea within defined limits of precision.	Solution	Applied	Socio-political	Social terms	None as yet
"A"	Do differences exist in gross body characteristics of 2-ocean sockeye at sea which reflect maturation? (Body weight, length, gonad weight, and their ratios, etc.)	Question	Fundamental	Scientific	Technical	2/
	↓ No, for the precision required					
"B"	Are there obvious biochemical differences in 2-ocean sockeye at sea which reflect maturation?	Question	Fundamental	Scientific	Technical	2/
	↓ Yes in the case of S-M antigen but in terms of application to solution of the problem it is incomplete					
"C"	Would an assay of pituitary hormones provide an improved biochemical method (over S-M antigen)?	Question	Fundamental	Scientific	Technical	2/
	↓ No essentially. Some technical and economic problems encountered (e.g., high cost of assays).					
"D"	Do other biochemical events examined singly and in combination provide a basis for an improved criteria?	Question	Fundamental	Scientific	Technical	
	↓ Ongoing research					

1/ The assistance of Dr. Harold Hodgins of the Division of Environmental Conservation, NWFC in definition of the problem and outline of the research process is gratefully acknowledged.

2/ Some technical information of value to the scientific community have been published in scientific journals.

APPENDIX B

DIFFUSION OF INNOVATION

The social sciences have much to offer in federal fishery research activities. The selected example here is on the general area of communication.

Many theoretical as well as applied studies are already available that can contribute much to a better understanding on our part of information and communication. Two studies (of the many) in the area of diffusion of innovation will be discussed here as examples which may be of use to the Center since a large part of the information that are directed to the fishing industry are of the innovative type (e.g., new fishing gear, aquaculture technology, etc.)

The first study "Information, Decision, and Action" by Emery and Oeser (1958) is on the diffusion of farming innovations in a small community in Australia. This study apparently represents one of the earliest analysis on extension services. Some of the conclusions of this study are:

1. For the dairy farmer's sample, in contrast to the grazier's sample, mass media played a negligible part in the processes which led to the adoption of advanced practices. The printed word index was not associated with the adoption indices.

2. It became apparent that the change agent (the Dairy Supervisor) was not an important factor in the adoption process. It is suggested that his terms of reference have been too narrow (too technically oriented) and that he would be more effective with a more general outlook.

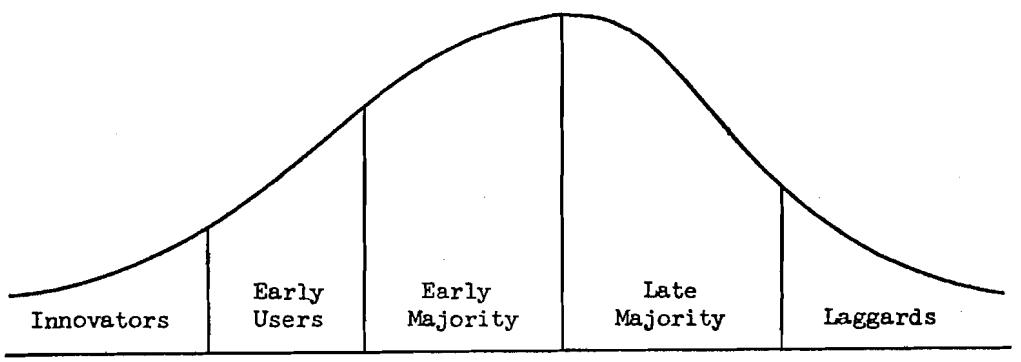
3. The farmers look to the early users and innovators rather than the change agents for new practices. The progressive farmers absorb the new information, translate it into practice, and pass it on.

The study by Rogers (1962) on "Diffusion of Innovation" had for its purpose the organizing into a coherent body of facts for meaningful comparison and evaluation all of the work done in the field of diffusion of innovation. Included was the Emery and Oeser study discussed earlier. This study by Rogers is rich in potential applications to federal fishery research activities -- definitions, conceptual framework, categorizations, and strategies. Only a few of the many salient features from this study will be presented.

Rogers defines innovation as an idea or invention perceived as new by an individual in a particular social system. It makes no difference how old the idea or invention is in other social systems. A fishery example perhaps, would be the "traditional" oyster-bed fishermen in the United States. The raft-culture method for oyster harvest has been in use for a long time in Japan but to the "traditional" oyster-bed fishermen this would be "new" to them according to the definition above.

Rogers divides the adoption process into five phases: awareness, interest, evaluation (decision making period), trial, and adoption. The adoption period is the length of time required for an individual to pass through the complete adoption process.

"Innovativeness" is divided into five categories along a continuum generally fitting a normal curve (Appendix Figure B).



Appendix Figure B.--Continuum and categories in "innovativeness" (after Rogers).

If the time variable were available, this curve and categorization would provide valuable assistance to quantification of a stream of benefits in analysis of fishery programs or technology.

Rogers feels that the norm and culture of a social system are the two most significant factors which must be taken into consideration before a determination about the innovativeness of that social system can be established. A traditional system is one which clings stubbornly to the past. A modern system, on the other hand, is one which is progressive, open to new ideas, and which accepts new innovation readily. Undoubtedly, many fishery researchers and administrators can recognize the existence of one or both of these types of systems (in fisheries) in their respective areas.

Rogers has other timely information to offer but this subject will be concluded by giving a general and hypothetical example of potential application of the principles discussed above to an emerging situation at the Northwest Fisheries Center.

A modified shrimp trawl with clear physical and economic advantages over existing gear is developed at the Center. The production data, gear specifications, and photographs of the nearly pure catches of shrimp and of the gear is communicated to the fishermen in printed form (publications and handouts). Even with inclusion of information on rather modest estimated cost and potentials or increased net earnings, there is no obvious clamor to adopt this innovation. The research group then decides to loan one of the modified gear to a fisherman perceived to be an "innovator" in the shrimp fleet on a trial basis with the understanding that biological information from this trial is needed for research purposes. A successful trial takes place and the gear is adopted by the "innovator". As others (fishermen) become aware of the competitive advantage in increased harvest and earnings accruing to the first user they also will adopt this gear. In this example (hypothetical), the experience gained by the research group on diffusion of innovation may be of great use to them in the future. Although hypothetical, a parallel would be indicated between this example and the earlier indicated third conclusion of Emery and Oeser:

3. The farmers (fishermen) look to the early users and innovators rather than the change agents (NWFC researchers or perhaps even extension service personnel) for new practices. The progressive farmers (fishermen) absorb the new information, translate it into practice, and pass it on.

APPENDIX C

UNITED STATES RESEARCH AND MANAGEMENT DOCUMENTS RELATED TO EASTERN BERING SEA KING CRAB RESOURCE

Year	Document
1957.....	King crab investigations. In: Report on the investigations by the United States for the International North Pacific Fisheries Commission - 1957. October 1957. INPFC Document No. 131.
1957.....	Progress report on king crab investigations. September 1957. INPFC Document No. 138.
1958.....	Progress report on king crab investigations. September 1958. INPFC Docuemtn No. 210.
1958.....	Observations of molting female king crab. December 15, 1958. INPFC Document No. 271.
1959.....	Stomach contents of the Bering Sea king crab. August 18, 1959. INPFC Document No. 280.
1959.....	Progress report on king crab investigations. October 12, 1959. INPFC Document No. 316.
1959.....	Estimated growth of the southeastern Bering Sea adult male king crab population. October 14, 1959. INPFC Document No. 318.
1960.....	King crab investigations. In: Progress report of investigations by the United States during 1960. October 12, 1960. INPFC Document No. 420.
1961.....	King crab investigations. In: Progress report of investigations by the United States during 1961. October 20, 1961. INPFC Document No. 482.
1962.....	King crab investigations. In: Report of the investigations by the United States for the International North Pacific Fisheries Commission 1962. October 29, 1962. INPFC Document No. 568.
1963.....	King crab investigations. In: Report on the investigations by the United States for the International North Pacific Fisheries Commission 1963. October 25, 1963. INPFC Document No. 649.
1964.....	King crab investigations. In: Report on the investigations by the United States for the International North Pacific Fisheries Commission 1964. October 23, 1964. INPFC Document No. 749.

Appendix C (Cont'd)

Year	Document
1965.....	King crab investigations. In: Report on the investigations by the United States for the International North Pacific Fisheries Commission 1965. October 15, 1965. INPFC Document No. 818.
1966.....	Growth of the immature king crab, Paralithodes camtschatica (Tilesius). October 28, 1965. INPFC Document No. 860.
1966.....	Movement and recovery of tagged king crabs in the eastern Bering Sea, 1955-63. INPFC Document No. 871.
1966.....	King crab investigations. In: Investigations by the United States for the International North Pacific Fisheries Commission - 1966. September 21, 1966. INPFC Document No. 876.
1966.....	Variations in biomass of eastern Bering Sea king crabs, based on tagging estimates of growth and mortality. September 1966. INPFC Document No. 909.
1967.....	King crab investigations. In: Investigations by the United States for the International North Pacific Fisheries Commission - 1967. September 29, 1967. INPFC Document No. 973.
1968.....	United States king crab catch in the eastern Bering Sea west of longitude 160°00' west and seaward of the United States territorial sea by degree of longitude and month, for 1967. INPFC Document No. 1035.
1968.....	Length-frequency data for king crab captured during International Pacific Halibut Commission trawl surveys in 1966 and 1967. INPFC Document No. 1036.
1968.....	Bering Sea tag recoveries received between January 1962 and October 1967 (king crab tagging by the U.S.). INPFC Document No. 1037.
1968.....	Agreement of November 25, 1964, between the United States of America and Japan - king crab fisheries (Treaties and Other International Acts Series 6155). INPFC Document No. 1041.
1968.....	Agreement of February 5, 1965, between the United States of America and the Union of Soviet Socialist Republics - king crab fisheries (Treaties and Other International Acts Series 5752). INPFC Document No. 1042.
1968.....	Agreement of February 13, 1967, between the United States of America and the Union of Soviet Socialist Republics - king crab fisheries (Treaties and Other International Acts Series 6217). INPFC Document No. 1043.

Appendix C (Cont'd)

Year	Document
1968.....	King crab investigations. In: Investigations by the United States for the International North Pacific Fisheries Commission - 1968. INPFC Document No. 1083.
1968.....	U.S. king crab research progress report - 1968. October 17, 1968. INPFC Document No. 1131.
1968.....	Data requirements of U.S. southeastern Bering Sea king crab program. September 24, 1968. INPFC Document No. 1132.
1969.....	Release and recovery information for thirteen Japanese king crab tags recovered by the United States in 1968. INPFC Document No. 1144.
1969.....	Trawl sampling station positions - 1968. U.S. Bureau of Commercial Fisheries Bering Sea king crab study (USBCF research vessels John R. Manning and Miller Freeman). INPFC Document No. 1145.
1969.....	Oceanographic data, spring and fall, 1968: U.S. Bureau of Commercial Fisheries Bering Sea king crab study (USBCF research vessels John R. Manning and Miller Freeman). INPFC Document No. 1146.
1969.....	Length frequency data for male king crabs: U.S. Bureau of Commercial Fisheries Bering Sea king crab study, spring and fall 1968. INPFC Document No. 1147.
1969.....	Length frequency data for female king crabs: U.S. Bureau of Commercial Fisheries Bering Sea king crab study, spring and fall 1968. INPFC Document No. 1148.
1969.....	Relation of fecundity and egg length to carapace length in the king crab, Paralithodes camtschatica. INPFC Document No. 1149.
1969.....	Fate of unfertilized eggs in king crabs Paralithodes camtschatica (Tilesius). January 1969. INPFC Document No. 1151.
1969.....	United States commercial king crab catch in the eastern Bering Sea west of longitude 160°00' west and seaward of the United States territorial sea by degree of longitude and month, for 1968.
1969.....	Agreement between the United States of America and the Union of Soviet Socialist Republics - amending and extending the agreement of February 5, 1965, as amended and extended. (King crab) (Treaties and Other International Acts Series 6635). INPFC Document No. 1159.

Appendix C (Cont'd)

Year	Document
1969.....	Agreement between the United States of America and Japan, amending and extending the agreement of November 26, 1964, as amended and extended (King crab) (Treaties and Other International Acts Series 6601). INPFC Document No. 1160.
1969.....	Release and recovery information for United States king crab tags recovered by the Japanese in 1968. INPFC Document No. 1171.
1969.....	King and tanner crab research. INPFC Document No. 1218.
1970.....	Trends in the eastern Bering Sea king crab fishery (1953-1969). INPFC Document No. 1320.
1970.....	Status of Bering Sea king and tanner crab stocks (1969-1970). INPFC Document No. 1321.
1970.....	Effect of trawling on Bering Sea crab stocks. INPFC Document No. 1322.
1970.....	The United States Bering Sea king and tanner crab fisheries, 1966-70. INPFC Document No. 1344.
1971.....	Agreement between the United States of America and Japan effected by exchange of notes signed at Tokyo December 11, 1970, with agreed minutes (King and Tanner Crab) (Treaties and Other International Acts Series 7019). INPFC Document No. 1382.
1971.....	Agreement between the United States of America and the Union of Soviet Socialist Republics signed at Washington February 12, 1971, with exchange of letters. (King and Tanner Crab) (Treaties and Other International Acts Series 7044). INPFC Document No. 1383.
1971.....	Longevity and growth of tagged king crabs in the eastern Bering Sea. INPFC Document No. 1449.
1971.....	United States king and tanner crab fishery in the eastern Bering Sea. INPFC Document No. 1449.
1971.....	United States king and tanner crab fishery in the eastern Bering Sea, 1971 (Addendum). October 26, 1971. INPFC Document No. 1451.
1972.....	U.S. king and tanner crab fishery in the eastern Bering Sea, 1972. INPFC Document No. 1507.

Appendix C (Cont'd)

Year	Document
1972.....	Equilibrium sustained yield model for the southeastern Bering Sea king crab fishery. INPFC Document No. 1509.
1972.....	King and snow (Tanner) crab research - 1971. INPFC Document No. 1510.
1972.....	King and tanner crab research by the U.S. in the eastern Bering Sea - 1972. INPFC Document No. 1511.
1972.....	Standardization of CPUE in the king and tanner crab fisheries of the eastern Bering Sea. INPFC Document No. 1514.
1972.....	Estimated incidental crab catch in the Japanese Bering Sea groundfish fishery. INPFC Document No. 1516.
1972.....	Observations on the incidental catch of halibut and crab aboard the Shikishima-maru. INPFC Document No. 1519.
1973.....	Agreement between the United States of America and Japan effected by exchange of notes signed at Washington December 20, 1972 with agreed minutes and Japanese note (king and tanner crab). (Treaties and Other International Acts Series 7527). INPFC Document No. 1554.
1973.....	Agreement between the United States of America and the Union of Soviet Socialist Republics signed at Moscow February 21, 1973. (Treaties and Other International Acts Series 7571). INPFC Document No. 1555.
1973.....	King and tanner crab research in the eastern Bering Sea, 1973. October 1973. INPFC Document No. 1611.
1973.....	Observations aboard Japanese crab motherships in 1973. October 1973. INPFC Document No. 1612.
1973.....	Data from the U.S. trawl survey for king and tanner crabs collected in the eastern Bering Sea in 1973. October 1973. INPFC Document No. 1619.
1973.....	United States fishery for king and tanner crabs in the eastern Bering Sea, 1973. INPFC Document No. 1626.

APPENDIX D

RESEARCH AND MANAGEMENT DOCUMENTS RELATED TO THE UNITED STATES CASE ON SALMON ABSTENTION

Year	Document
1956.....	Report of the United States of America concerning the management of certain North Pacific salmon stocks with reference to Article III (1) (a) of the International Convention for the High Seas Fisheries of the North Pacific Ocean of 1952 (Received November 15, 1956, Source-United States, INPFC Document No. None).
1957.....	Supplementary information on salmon stocks of the United States: (A) The statistics on salmon as to each species separately for each area. (b) The basis on which a standard unit of effort was developed, by areas. (c) The intensity of salmon fishing. (Received August 16, 1957, Source - United States, INPFC Document No. 7).
1957.....	Supplementary information on salmon stocks of the United States: Salmon fisheries in areas adjacent to the Aleutian Islands. (Received November 5, 1957, Source - United States, INPFC Document No. 159).
1957.....	Supplementary information on salmon stocks of the United States: Age composition of Pacific salmon, 1934-1955. (Received November 5, 1957, Source - United States, INPFC Document No. 160).
1958.....	Supplementary information on salmon stocks of the United States: Salmon stocks by species in the area north of Bristol Bay, including catch and effort statistics with regard to the United States fishery. (Received April 22, 1958, Source - United States, INPFC Document No. 170).
1958.....	Supplementary information on salmon stocks of the United States: Return-escapement relationships: salmon. (Received April 24, 1958, Source - United States, INPFC Document No. 171).
1958.....	Supplementary information on salmon stocks of the United States: The separate status of the stocks of salmon defined in Sections 1(c) and 2 of the Annex to the Convention. (Received April 24, 1958, Source - United States, INPFC Document No. 172).
1958.....	Supplementary information on salmon stocks of the United States: Relationships between numbers of salmon spawners and resulting seaward migrants. (Received May 3, 1958, Source - United States, INPFC Document No. 173).

Appendix D (Cont'd)

Year	Document
1958.....	Additional information regarding the United States report on salmon, halibut and herring stocks. Requested by the Ad Hoc Committee for Study of Reports Submitted under Article III (1)(a) of the International Convention for the High Seas Fisheries of the North Pacific Ocean of 1952. (August 13, 1958, Source - United States, INPFC Document No. 188).
1958.....	Supplementary information on salmon stocks of the United States: Rate of exploitation. (Received August 8, 1958, Source - United States, INPFC Document No. 189).
1958.....	A further discussion of the United States case for abstention as related to salmon stocks of North American origin. (Received October 20, 1958, Source - United States, INPFC Document No. 224).
1958.....	Supplementary information on salmon stocks of the United States: Information on the fishing intensity for each type of gear. (Received October 27, 1958, Source - United States, INPFC Document No. 236).
1959.....	Comments on the views of the Japanese National Section (Paper No. 12) on Document 224 (Paper No. 10) prepared by the United States Section for the International North Pacific Fisheries Commissions Ad Hoc Committee for Abstention. (Received October 12, 1959, Source - United States, INPFC Document No. 300).
1959.....	Supplementary information on salmon stocks of the United States: Age composition of red and chum salmon, Southeastern Alaska. (Received October 12, 1959, Source - United States, INPFC Document No. 336).
1959.....	Supplementary information on salmon stocks of the United States: Numbers of spawning salmon and resulting downstream migrants. Received October 29, 1959, Source - United States, INPFC Document No. 337).
1960.....	Additional information regarding the United States salmon and halibut stocks - Statistical Summary, (October 13, 1960, Source - United States, INPFC Document No. 414).
1961.....	Comments by the United States on INPFC Document 486 (Japan) entitled "On the question of abstention for North American salmon". (November 3, 1961, Source - United States, INPFC Document No. 498).

Appendix D (Cont'd)

Year	Document
1961.....	Additional information regarding the United States salmon and halibut stocks - Statistical Summary. (November 7, 1961, Source - United States, INPFC Document No. 499).
1962.....	Additional information regarding the United States salmon and halibut stocks - Statistical Summary. (October 26, 1962, Source - United States, INPFC Document No. 576).
1963.....	Additional information on Alaskan salmon. (April 16, 1963, Source - United States, INPFC Document No. 602).
1963.....	Additional information regarding the United States salmon and halibut stocks - Statistical Summary. (October 19, 1963, Source - United States, INPFC Document No. 654).
1964.....	Additional statistics for certain Alaskan salmon fisheries, 1959-1961. (October 1964, Source - United States, INPFC Document No. 716).
1964.....	Additional information regarding the United States salmon and halibut stocks. (November 3, 1964, Source - United States, INPFC Document No. 763).
1965.....	Additional information regarding the United States salmon and halibut stocks - Statistical Summary. (Received October 25, 1965, Source - United States, INPFC Document No. 826).
1966.....	Additional information regarding the United States salmon and halibut stocks - Statistical Summary. (Received October 24, 1966, Source - United States, INPFC Document No. 908).
1967.....	Additional information regarding the United States salmon and halibut stocks - Statistical Summary. (Received October 23, 1967, Source - United States, INPFC Document No. 1011).
1967.....	Northern Alaska salmon data. (Received November 7, 1967, Source - United States, INPFC Document No. 1031).
1968.....	Additional information regarding the United States salmon and halibut stocks - Statistical Summary. (Received October 21, 1968, Source - United States, INPFC Document No. 1115).
1968.....	Information on recent changes in the salmon fisheries of Alaska and the condition of the stocks. (Received October 31, 1968, Source - United States, INPFC Document No. 1134).

Appendix D (Cont'd)

Year	Document
1968.....	Status of commercial and subsistence salmon fisheries in the western Alaska region from Cape Newenham to Cape Prince of Wales (addendum to INPFC Document No. 1031). (Received October 31, 1968, Source - United States, INPFC Document No. 1135).
1970.....	Comments on INPFC Documents 1252 and 1253 (Japan). (Received October 26, 1970, Source - United States, INPFC Document No. 1346).
1970.....	Additional information on Alaska salmon fisheries and stocks: extension time-series data in INPFC Documents 1134 and 1135 through 1969. (Received October 26, 1970, Source - United States, INPFC Document No. 1347).
1970.....	Additional information regarding the United States salmon and halibut stocks - Statistical Summary. (Received October 27, 1970, Source - United States, INPFC Document No. 1348).
1971.....	Statistics for the Puget Sound pink salmon fishery, 1959-69 (odd-numbered years), (Received August 3, 1971, Source - United States, INPFC Document No. 1384).
1971.....	Comments on INPFC Document No. 1350 (Japan, 1970). (Received October 24, 1971, Source - United States, INPFC Document No. 1446).
1971.....	Information on Columbia River salmon runs and fisheries. (Received October 24, 1971, Source - United States, INPFC Document No. 1447).
1972.....	Information on California salmon fisheries and stocks. (Received October 25, 1972, Source - United States, INPFC Document No. 1537).
1972.....	Additional information on Alaska and Columbia River salmon fisheries and stocks: Extension of time-series data in INPFC Documents No. 1134, 1135, 1347 and 1447 through 1971. (Received October 25, 1972, Source - United States, INPFC Document No. 1538).
1973.....	Information on coho and chinook salmon stocks originating in Puget Sound and Washington coastal streams north of the Columbia River. (Received October 22, 1973, Source - United States, INPFC Document No. 1603).
1973.....	Additional information regarding United States salmon and halibut fisheries. (Received October 22, 1973, Source - United States, INPFC Document No. 1609).

APPENDIX E

PROGRAM EVALUATION

Emphasis in this report has been on the measurement of technical and social impacts of federal fishery research and technology. Evaluation of these impacts (or benefits) against the resources needed to achieve them is a concern of the managerial levels of NMFS and its suborganization (e.g., Northwest Fisheries Center).

Benefit-cost analysis, which has a long history, especially in the field of water resources development, has become a popular analytical tool in many government agencies, including NMFS (Bell, see Footnote 19), as a technique of project or program evaluation. Benefit-cost analysis may be generally defined as the systematic approach to the evaluation of a project or program by comparing the relevant benefits against the costs involved. In most cases in benefit-cost analysis, evaluation is related to the optimizing of strategic decisions on future courses of action. An example in NMFS would be the "sample" benefit-cost analysis carried out on the calico scallop fishery (Bureau of Commercial Fisheries, 1969) 20/.

Where benefits are intangible and not subject to quantitative measures in monetary terms the alternative approaches suggested are: (1) achievement of a specified task at minimum cost or (2) achievement of the most gains at a given cost (McKean, 1958, p. 46-49). Similar treatment along lines of these alternative approaches is found in the design and analysis of samping in statistical methods; for example, see Cochran (1956). Alternative (1) is generally identified as cost-effectiveness. The principles and mechanics of this approach were applied to an economic study of fish protein concentrate (Massachusetts Institute of Technology, 1970).

These analytical approaches offer an array of useful tools to the decision-making process in research organizations but there appears to be many conceptual and operational difficulties yet to be resolved (e.g., treatment of intangibles, secondary benefits, discount rates, etc.)

Perhaps of most concern and difficulty to research groups is the interpretation of the organizational objective to which these analytical approaches are used. It is generally stated that the purpose of benefit-cost analysis and of the alternative approaches mentioned is to provide information to meet the objectives of determining the most economically efficient use of the available resources. If interpretation of efficiency means the selection, through the decision-making process, of the single most economically efficient way in each research task, then this leaves no room for accommodation of effectiveness (reliability and adaptability). If "men were angels" this would be no problem but considering the vast technical and social uncertainties faced by personnel at the technical level of NMFS, however, it is suggested that interpretation of efficiency be such as to allow for costs associated with aspects of duplication and overlap and for the asking of questions which is inherent in scientific inquiry 21/.

If interpretation of efficiency also means "will the benefits exceed the costs" then this becomes an academic question as benefits quantifiable in monetary terms and benefits not quantifiable in monetary terms are incommensurables. This difficulty appears to have led to some current practices which depart from the general definition of "comparing the relevant benefits against the cost involved" to a definition of "comparing the relevant economic benefits against the costs involved" with resulting practices which either totally ignore the "intangibles" or, where considered, these "intangibles" are relegated to near or implied obscurity by reference to as "other benefits".

As to evaluation of federal fishery research and technology along the benefit-cost formula this paper suggests that in view of its "state of art", and in consideration of the differences in "systems levels" in NMFS, evaluation of research be carried out primarily at the technical level and that emphasis be placed only on the general comparison of benefits against costs at this time without any attempt at economic efficiency measurements (e.g., benefit-cost ratio). The benefits would consist of independent estimates of the technical contributions, the economic impacts, the social impacts, and the political impacts of a research program, laboratory, or region. Normatively speaking, the problem should also be identified and defined, and reported along its technical, economic, social and political aspects at the planning stage. Of course, in cases where economic factors are dominant and efficiency measurements are needed or are highly desirable, then benefit-cost analysis in economic terms may be possible and justified.

Some may view the above suggestion as not being practical since such a normative approach for the technical level of NMFS may not fit the realities of program evluation and budget justification faced by our personnel at the institutional level (Washington, D.C.). Even then, the contention here is that be developing capabilities, or by actively seeking assistance in the social sciences at the technical (field station) level, we can increase our understanding and abilities in the evaluation of social impacts from our research and technology. An "additive" measure of the various impacts of all the centers, laboratories, or the regions, would in essense serve as an expression of national accomplishments by NMFS.

Thus far in this section program evaluation has been treated in a very narrow framework reflective of the state-of-art and emphasis on the use of evaluative tools and criteria primarily from the field of economics (e.g., benefit-cost analysis and ratio). Furthermore, as common in most public program and policy areas, the development of criteria and standards for evaluation has long been in neglect and more so as to methodology; for example, "Evaluation" has been left out of the supposedly comprehensive managerial system of Planning, Programming, Budgeting (PPB). Also, a benefit-cost ratio is but only one form of criteria in program evaluation. The remainder of this appendix will be devoted to a preliminary and suggested approach to program evaluation and development of criteria and standards in federal fishery research and technology at the technical level of NMFS (e.g., at the Northwest Fisheries Center).

Assumptions underlying the approach to be presented are essentially a reiteration of earlier themes presented in this paper:

1. Research is the processing of information. Therefore, the product or output of a research organization such as, say, the Northwest Fisheries Center, NMFS, is information.

2. The Northwest Fisheries Center carries out both fundamental and applied research.

   a. Fundamental research is the seeking of knowledge by asking questions. It is an inquiry into and the understanding of natural phenomena.

   b. Applied research is the seeking of solutions to practical (social) problems. It is the process of taking the abstractions of science and applying them to the practical affairs of man.

3. Information is directed (or communicated) to the scientific community and the sociopolitical community. Information of the fundamental research nature is directed to the former while information of applied research nature is directed to the latter community (see earlier text Figure 2).

In organized research there are three phases in the research process (Appendix Figure E-1). These phases are, of course, interdependent with feedback processes.

1. Pre-Research Phase. Concern here is with program planning and budgeting. Evaluation, therefore, is on planning, or of plan(s).

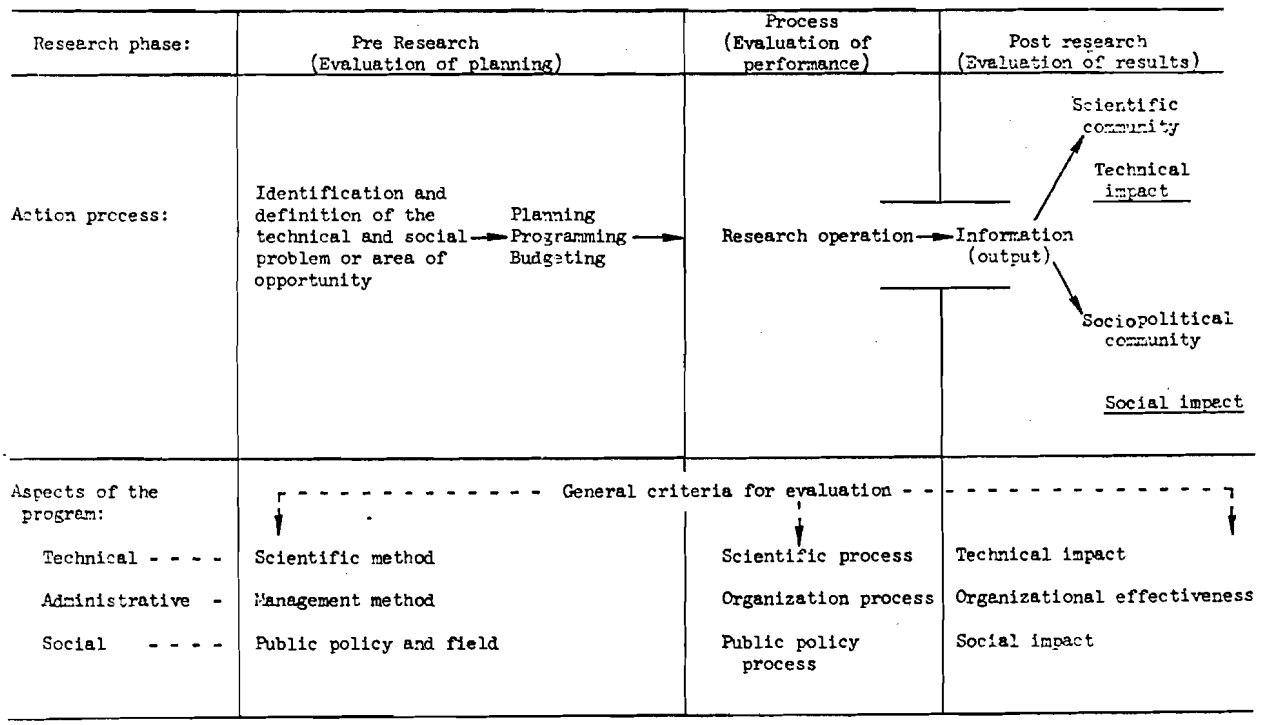
2. Process Phase. Concern here is with program operation. Evaluation, therefore, is on ongoing performance.

3. Post-Research Phase. Concern here is with program results. Evaluation, therefore, is on the impact of the information on the environment (scientific and sociopolitical communities) and on the effectiveness of the organization in achieving those results.

Under each research phase there are three interdependent aspects (or components) of a program to be evaluated: technical, administrative, and social aspect. These research phase-program aspect combinations provide the framework for the development of criteria and standards in evaluating research programs. As indicated in Appendix Figure E-1, the general criterion for evaluating the technical aspect of the program during the pre-research phase is Scientific Method; during the process phase it is Scientific Process; and during the post research phase it is Technical Impact. The above criteria are to be based primarily on scientific principles and methods, and practices.

Similarly, the general criteria for evaluating the administrative aspect of the program are Management Method, Organization Process, and Organizational Effectiveness respectively for the pre, process, and post research phases. These administrative criteria are to be based on management principles and methods, and practices. Finally, the general criteria for evaluating the social aspect of the program are Public Policy and Field, Public Policy Process, and Social Impact respectively for the pre, process, and post research phases. These social criteria are to be based on economic, social, and political principles and methods, and practices. In summary, the pre-research phase is concerned with method criteria, the process phase with process criteria, and the post research phase with net output criteria.

Appendix Figure E-1.--Suggested framework for program evaluation--federal fishery research and development of technology.



An expansion of the above generalized research phase -program aspect criteria framework is presented in Appendix Figure E-2. This matrix is offered as an initial and suggested approach to program evaluation. Here, each research phase-program aspect cell with its general criterion is broken down into suggested components which are to be evaluated against some appropriate or specific standards. Taking Cell 1, Scientific Method Criterion as an example, an evaluation would be made of procedure (identification and definition of the technical problem, etc.), the technical objectives, and experimental design (hypothesis, assumptions, etc.), each against selected standards. Assuming the existence of standards and the evaluation as having been carried out, and, say, a summary of "below standard", this would mean that as far as the technical (scientific) aspects of the program plan(s) or planning is concerned it is inadequate, or poor, or incomplete, or a rating of 2 (out of 5), or whatever value symbol and scale the evaluator(s) decides to use as related to the criterion "Scientific Method".

Appendix Figure E-2.-- Expanded framework for program evaluation--federal fishery research and development of technology.

Program aspect \ Phase	Pre research phase (Evaluation of planning)	Process phase (Evaluation of performance)	Post research phase (Evaluation of results)
Technical	Scientific method (Cell 1) Procedural Identification and definition of the technical problem Literature review Technical constraint and support Technical objectives Experimental design Hypothesis Assumption Sampling method Experimental scale	Scientific process (Cell 2) (Logic in technical means-ends) Input: Sampling & data collection Throughput: Analytical method Output: Research information; fundamental & applied	Technical impact (Cell 3) Scientific knowledge and advancement - quality - quantity
Administrative	Management method (Cell 4) Procedural Alternative Scheduling Resource allocation Organization objectives and goals Cost-effectiveness	Organization process (Cell 5) (Management of organizational means-ends) Input: Resource allocation (personnel, funds, equipment, etc.) Throughput: Schedule Deviation (planned, unplanned) Output: Program documents (reports, manuscripts, etc.)	Organizational effectiveness (Cell 6) Cost-efficiency Cost-effectiveness
Social	Policy and Field (Cell 7) Procedural Identification and definition of the social problem or area of opportunity Clientele; identification and participation Social constraint and support Social objectives and goals Cost-benefit	Public Policy Process (Cell 8) (Mediation of social means-ends) Input: Interface groups Throughput: Communication and participation Output: Support and sanction Acceptance of information	Social impact (Cell 9) Cost-benefit Economic Social Political

A general observation would be that NMFS field stations have the capabilities for evaluating the technical rationality of programs especially as to Cells 1 (Scientific Method) and 2 (Scientific Process). Capabilities in evaluating administrative rationality also exists as to Cells 4 (Management Method) and 5 (Organization Process), but the latter (Cell 5) is oriented primarily to the technical aspects (Cell 2) of the program. Capabilities in evaluating the social aspects of a program, however, are probably available only as to Cell 7 (Policy and Field), but one which is still in a developmental stage.

Before going on to standards for evaluation, the administrative aspect requires further clarification. The approach and framework developed is directed primarily at evaluating the formal or rational aspects of administration of the program. Thus, the rational aspect of the program plan, operation or result, may be judged as excellent, or good, or poor, etc., based on the evaluator's standards. From an organizational standpoint however, why it was good, or poor, etc., may require further inquiry into the formal and informal aspects of the organizational unit that produced the plan or is carrying out the operation. For example, a "poor" program plan may be the result not of lack of capabilities in technical and social analyses and administrative rationality on the part of the research group but one of overriding informal aspects such as intense interpersonal conflicts, weak leadership, lack of motivation, etc.,) or, put it another way, largely the nonrational aspects of human behavior in social organizations.

Thus far, the standards for evaluation have been assumed to exist. This is however, probably the most difficult area in program evaluation and also an unfinished aspect in program management. For simplicity and as an initial approach in this area the following two, primary standards are suggested: (1) a dichotomous standard and (2) a quantitative or qualitative standard.

The dichotomous standard is used first to determine the obvious on definable output or action; i.e., whether an output is there or not, or whether an action was carried out or not. The qualitative or quantitative aspect of the output or action is then measured against respective standards. It is from this point and on, however, that presents the most difficulty as far as standards for evaluation are concerned. In view of the state-of-art, subjective standards would be the rule rather than exception at this time. Furthermore, these subjective standards would likely be based on intervening standards in the form of individual experiences in a field, the qualifications of the evaluator himself, the qualifications of the program planners and operators, and the like.

The following is a hypothetical example using a component in Appendix Figure E-2. Example: Literature Review in Cell 1.

1. Dichotomous standard: Was a literature review carried out?

   Standard = yes or no. If yes,

2. Quantitative - qualitative standard:
   a. Quantitative standard on the comprehensiveness of the literature review. Ranking = comprehensive - sufficient - incomplete.

      Assumption: An "ideal" type situation where the evaluator is a qualified personnel on the technical aspects or area of the program. Some possible subjective standards for comprehensiveness would be:
      (1) The program planner reviewed the materials considered to be the major contributions on the subject matter or field, or
      (2) The program planner communicated with or reviewed the materials of recognized researchers in the field.

      Assumption: The evaluator is not familiar with the technical aspects of the program. Standards for comprehensiveness may be based on causal relationships.
      (1) The program planner is a recognized authority in that field; therefore, it will be assumed that the literature review was comprehensive.
      (2) The program planner reviewed the materials appearing in journals X and Y (which are recognized as <u>the</u> journals of the profession) and, therefore, the literature review was comprehensive.

   b. Qualitative standard on the assessment of the status of knowledge in the field based on the literature review. Ranking = good - adequate - poor.

      Assumption: An "ideal" type situation where the evaluator is a qualified personnel on the technical aspects of the program. A possible subjective standard for a "good" assessment would be:
      (1) It meets the program evaluators personal assessment of the status of knowledge in that field.

      Assumption: The evaluator is not familiar with the technical aspects of the program. Standards for a "good" assessment may be based on causal relationships.
      (1) The program planner is a recognized authority in that field; therefore, it will be assumed that the assessment was good, or
      (2) The program planner is not "qualified" but he consulted with recognized "experts" in the field on the assessment; therefore, it will be assumed that the assessment was good.

The above example with subjective, if not crude, standards serves to emphasize the low state-of-art in standards for program evaluation. It is hoped that this will stimulate further thought and discussion among NMFS personnel on this difficult area.

A final note on program evaluation. As indicated earlier, the content of Appendix Figure E-2 and discussions on criteria and standards are related to program evaluation at the field, or technical level of the Service. It would not be practical nor possible to carry out program evaluation of this depth and detail at the central office. Besides, program evaluation at the central office would be addressing different needs and thus, involve different levels and sets of criteria and standards. Nevertheless, the underlying concept of evaluating research programs as to its technical, administrative, and social aspects, and along the appropriate phase of the research (pre-research, process, and post research) is broad and flexible enough to be useful as a framework at any level of the Service.