Technological Research

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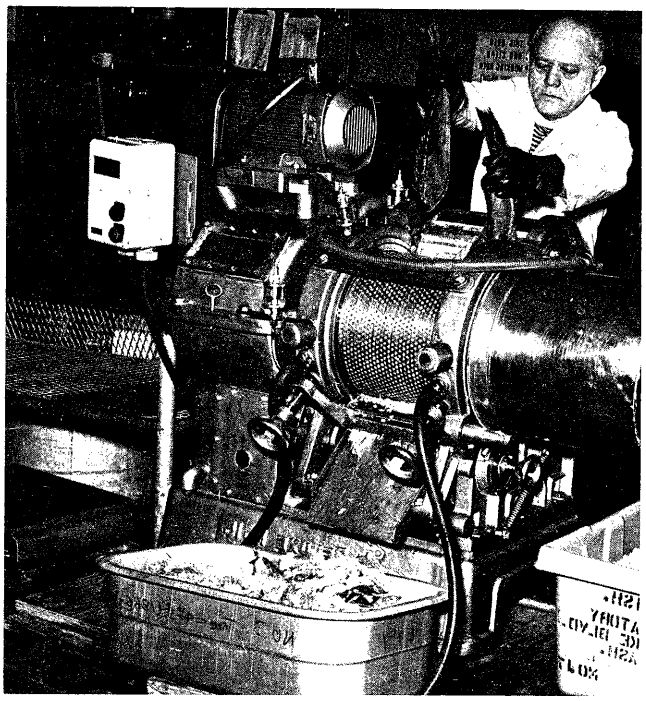

Top left
Dr. W.T. Roubal, chemist at the Pioneer Research Laboratory, explains the use of equipment for following oxidation of fish oils to an interested group of open house visitors in 1970.

Bottom left
Charles Butler, chemist at the Seattle Technological Laboratory, demonstrates in 1948 the use of the fish liver sampler devised by F. Bruce Sanford.

Right
Max Patashnik, chemical engineer, is shown operating a device that is separating the flesh of rockfish from the skin an bones. Photo taken at the Utilization Research Division in 1974.

PACIFIC COAST PRIOR TO 1933

Biological research on fisheries in the Pacific Northwest had an early beginning in the 1880s under the pioneering efforts of Gilbert and others. What was happening in fishery technology at these early stages? When the U.S. Commission on Fish and

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Fisheries was set up in 1871, its first Commissioner, Spencer Fullerton Baird, had an appreciation of the need for technological investigations. Under contract from the Commission, research was undertaken in New England to explore the nutritive value of fish. Baird also initiated efforts to adapt technological discoveries from Europe to fisheries in the United States. Unfortunately, Baird died before this type of work had been extended to the Pacific Coast. Baird's successors had no interest in fishery technology and decreed that all such work in the agency should cease. It was felt that if the U.S. Department of Agriculture was interested, it could carry out research on fish or fishery products along with its investigations on other foods. The Department of Agriculture was interested and began in a limited way some work on fishery products.

At first such work was limited to small field operations on the Atlantic coast, mostly from Washington, D.C. In 1913, the Bureau of Chemistry in the Department of Agriculture made fish studies an additional function of their egg and poultry laboratory at Philadelphia, which was under the direction of Mary Pennington. The task was assigned to Ernest D. Clark and L. H. Almy, who worked on fish in their Philadelphia laboratory while carrying out summer field studies, some in the Pacific Northwest. In 1916 Clark established a small laboratory in Seattle where research was conducted on storage of frozen and iced fish and on problems encountered in the transportation of fish. In 1921 the Philadelphia laboratory was closed and the Department of Agriculture's work on fish was discontinued.

Meanwhile, in 1917 Lewis Radcliffe became Chief of the Division of Statistics and Methods of the Bureau of Fisheries, succeeding Alvin Alexander, who had been in charge since 1903. Unlike Alexander, Radcliffe felt strongly that technological research should be conducted by the Bureau. As a result, in 1918 the first Bureau of Fisheries laboratory was established in temporary quarters in San Pedro, California, under the direction of Leslie Lingle. After Lingle resigned in 1921, Harry Beard became laboratory director, assisted by Arthur Wells and one or two temporary assistants. However, budgetary problems became acute, forcing closure of the laboratory in 1924.

Other technological activities were performed on the Atlantic coast by the Bureau of Fisheries, starting in 1919 when a temporary field station was opened in Gloucester, Massachusetts. Later a small permanent laboratory was opened in Washington, D.C., which operated during the 1920s but was closed about 1930. In the late 1920s, the principal technological station of the Bureau of Fisheries was in Reedville, Virginia, and the work there was concerned with menhaden fish meal and oil. In 1931, the personnel of this station, most of whom worked in Washington, D.C., were transferred to Gloucester, Massachusetts, and from 1931 to 1935 the Gloucester Laboratory was the principal technological laboratory of the Bureau of Fisheries. In 1935 it was closed, and all personnel transferred to a new laboratory at College Park, Maryland.

1933 THROUGH 1941

When plans were being formulated in the late 1920s for a new building in Seattle to house Pacific coast Bureau of Fisheries activities, space was

included for technological investigations. It was hoped that after completion of the building funds would be available to employ a staff for the technological operation in Seattle. Because the budget did not include special funds for such work, two employees, Roger Harrison and A. Anderson, were transferred in May 1933 from the Gloucester Laboratory to begin technological research at the new Montlake laboratory.

Harrison, who was in charge of the new Seattle Technological Laboratory, was a graduate of Washington State University and had worked as a chemical engineer at the U.S. Department of Agriculture in 1926-28 before transferring to the Bureau of Fisheries in 1928. He worked on improvements in the manufacture of fish meal in Washington and at the Bureau's field station in Reedville, Virginia, until 1931 when the laboratory was established at Gloucester. There he worked with Anderson on scientific experiments to investigate factors, such as drying temperature, in the manufacture of fish meal.

Anderson, a graduate of the College of Fisheries, University of Washington, was a fishery technologist, had worked in industry for a fish meal equipment manufacturer and had participated in the design and installation of fish reduction plants in California, Norway, Iceland, Hawaii, and British Columbia from 1922 to 1930. After a year in Washington, D.C., he went to Gloucester in 1931 to work with Harrison on the fish meal manufacturing project. He also worked on extraction procedures for obtaining oil from low-oil-content fish livers.

Upon their arrival in Seattle in 1933, it was not surprising that Harrison and Anderson gave first attention to problems connected with by-products of the fishing industry. Not only was there prior interest and experience in this field, but several urgent problems along these lines were awaiting solution in the Pacific Northwest and Alaska. Waste from salmon cannery operations was not being fully utilized, and there was growing interest in utilizing what had only then been recognized as a valuable source of vitamin A--low-fat-content fish livers, such as those from halibut.

One of the researchers' first projects concerned utilization of salmon trimmings; the result was the development of a method for extracting oil from edible portions of salmon, such as tail and collar trimmings, which could be added to subsequent lots of canned salmon when the oil content of the raw fish was below average. This practice soon became widespread and is still used today by the salmon canning industry.

Other projects conducted on by-products during the first few years of operation included: 1) working out, in collaboration with the Food and Drug Administration, standards of quality for halibut liver oil, 2) developing improved procedures for extracting oil from low-oil-content fish livers, 3) in collaboration with the Poultry Department of Washington State University, investigating the nutritional properties of dogfish shark meal for poultry, 4) designing a small-scale fish reduction unit for use at a Bureau of Fisheries salmon hatchery at Quilcene, Washington for rendering spent carcasses of salmon, 5) investigating the problem of overheating and oxidation of oil in stored fish meal and developing methods to reduce such changes.

In 1936 the first step was taken toward expanding the research into fields involving preservation of fish for human consumption. This consisted of initiation of an industry-supported fellowship for exploring the use of a product derived from oat flour (Avenex made by Musher Co.) to extend the cold storage life of frozen fish. This work continued for several years. Although the Avenex treatment failed to work successfully for fish, this study on preservation ultimately led to a broadening of the scope of research at the laboratory.

In 1937 the laboratory acquired the services of several Works Progress Administration (WPA) supported chemists on temporary assignments that continued for five years. Employed under this program at various times were: Jacob Ash, Charles Butler, Robert Carlson, William Clegg, and Louis Simonson. Several subprofessional positions, both full- and part-time, were also established under the WPA program. These temporary additions to the staff greatly increased the amount of productive work that was accomplished.

In 1937 Anderson was transferred to Washington, D.C., and in February 1938 the vacancy he left was filled by Maurice Stansby, a chemist transferred from the College Park laboratory to Seattle. During 1940 two additional full-time, permanent positions were acquired, one for a chemical engineer, filled by William Hamm, and one for a chemist, filled by Harris Magnuson. Stansby was transferred in 1940 to be laboratory director of the newly constructed Fishery Products Laboratory at Ketchikan, Alaska, and the vacancy he left was filled by F. Bruce Sanford, a chemist who had been employed at an oil company which processed fish and other oils. Stansby started several programs at the Seattle laboratory concerned with rancidity development in frozen fish, before his departure to Ketchikan. Sanford began studies on the chemistry and stability of vitamin A in fish liver oils, a project that continued for about 10 years.

In 1937-38 a pilot plant was constructed at the Seattle laboratory which permitted large-scale experiments, particularly in the by-products field. The cost of this facility was provided by the Public Works Administration (PWA), and it illustrates how, in the past, minimal funding could still result in significant accomplishments. Only $2,000 was granted for the pilot plant construction, but after the 25 x 40 ft wood frame building had been erected, it was found that remaining funds were sufficient to install plumbing, a steam boiler, and several other small pieces of equipment. Salaries of two full-time professional employees, one half-time typist, and one quarter-time scientific aide, plus all operational expenses in 1937, amounted to only about $9,000. During 1938 another $1,600 from PWA and WPA permitted further work and additions to the plant, including construction of a tunnel dryer and a brine freezer.

The fishery by-products program, which was continued by Harrison and Hamm, included work on spontaneous combustion of fish meal and on improvement of analytical methods for determining oil in fish meal. The WPA-sponsored employees worked on proximate composition determinations of Pacific Northwest fish (much of this was done over a 10-year period by William Clegg) and on development of freshness tests for salmon. Work was performed by Magnuson on solubility of fish protein.

A very large program, developing information needed for U.S. utilization

of Alaska king crab, was performed under Harrison in 1940 and 1941 (see discussion under Exploratory Fishing).

Considerable work was conducted to improve methods for the chemical analysis of fish and fishery products. Harrison was appointed referee by the Association of Official Agricultural Chemists to develop new analytical methods for the determination of the oil content of fish meal. Stansby developed new methods for both the determination of rancidity of the oil in fish and for the determination of volatile bases as a freshness test for fish.

Personnel.--During this initial period of technological investigations at the Montlake laboratory from 1933 to 1941, it is interesting to note how many individuals worked on the program in some capacity and later went on to long and productive careers in fishery work, either within this agency or with other institutions.

Andrew W. Anderson progressed through positions in the Washington office, as founder and head of the Market News Service, Chief of the Branch of Commercial Fisheries (1943-56), and then as Assistant Director, Bureau of Commercial Fisheries (1956-61). After his retirement from the Bureau, he worked for a few years as fisheries attache in Copenhagen for the U.S. Foreign Service. He lived near Poulsbo, Washington. (Died in April 1982)

Lyle Anderson worked at the Technological Laboratory at Montlake as a Musher Foundation Fellowship Student from 1935 to 1936. He later worked at the Fishery Products Laboratory starting in 1940 and was Director of the Seattle laboratory from 1942 to 1945. He then became a fishery technologist in private industry, and for many years he has been in charge of technological work at Bioproducts Company in Warrenton, Oregon.

Charles Butler worked as a WPA chemist at the Seattle Technological Laboratory from 1937 to 1938 and then as Musher Foundation Fellow in 1938. From 1939 to 1943 he worked in the fishing industry (Columbia River Packers Association, Astoria, Oregon, and Alaska Fish Oil Extraction Company at Ketchikan). He was employed in the Bureau of Commercial Fisheries from 1943 to 1967, rising from chemist to Director of Technological work at Honolulu (1948) to Chief, Technological Section (1954-59); he served as Assistant Director of the Industrial Research Division in Washington from 1962 to 1966. He retired in 1967, living first in Florida, then in Hendersonville, North Carolina, and finally in Alexandria, Virginia, where he died in January 1979.

John Dassow worked at the Seattle Technological Laboratory as a WPA chemist in 1940. He then was employed at the Fishery Products Laboratory at Ketchikan, Alaska (1940-45) and as chemist at the Alaska Fish Oil Extraction Company at Ketchikan (1945-46). He returned to the Seattle laboratory as a part-time chemist in 1946 where he also pursued academic studies at the University of Washington. He was employed at the Seattle Technological Laboratory part-time as a NDGA Fellowship student. He was appointed chemist at the Seattle laboratory in 1948 and served as Laboratory Director at the Ketchikan laboratory from 1950 to 1955. He has been working since as Deputy Director of the Technological Laboratory (now called Utilization Research Division) of the Northwest and Alaska Fisheries Center in Seattle. He retired

in April 1982.

Lauren Donaldson worked on a part-time temporary appointment under Roger Harrison from 1934 to 1936. Dr. Donaldson has gone on in his field of fishery biology to become a world-famous authority on the biology of salmon. He recently retired as professor at the College of Fisheries, University of Washington, but continues to live in Seattle.

William Hamm worked as a chemical engineer at the Seattle Technology Laboratory from 1940 to 1944. He left to become Director of the Bureau's technological laboratory in Puerto Rico. He died in the early 1950s while working as a chemist at Van Camp Seafood Company at Terminal Island, California.

Roger Harrison served as the first director of the Seattle Technological Laboratory and then transferred to the Washington office as Chief of the Technological Section in 1942. He left the Bureau of Fisheries in 1944 and went on to a series of positions in industry and other governmental agencies as follows: in charge of research at Halibut Liver Oil Producers, Seattle 1944-58; Agency for International Development, Korea, 1958-62; and Chief Technologist for Fisheries Department, U.N. Food and Agriculture Organization of the United Nations, Rome, 1962-69. Since his retirement he resides in La Mesa, California.

Robert Rucker was a National Youth Administration student assistant at the Seattle Technological Laboratory in 1936. He was at Western Fish Disease Laboratory, Seattle, 1945-75, where he was Laboratory Director for part of this time. He retired in 1975 and resides in Seattle.

Bruce Sanford began work as a chemist at the Seattle Technological Laboratory in 1940. Beginning in 1952 he served as a scientific editor for Seattle scientific publications, eventually becoming editor for scientific papers for all of the technological laboratories. Sanford retired in 1971 and still lives in Seattle.

Maurice Stansby worked as a chemist at the Seattle Technological Laboratory from 1938 to 1940 and then was Laboratory Director at the Ketchikan Fishery Products Laboratory, 1940-42; at the Seattle Technological Laboratory, 1942-66; at the Food Science Pioneer Research Laboratory, 1966-72; and Director of Environmental Conservation Division, Northwest and Alaska Fisheries Center, 1972 to November 1974. Since November 1974 he has been working in the Center Director's Office, Northwest and Alaska Fisheries Center.

Summary of 1933-41 Accomplishments.--During this 9-year period, 1933-41, under Roger W. Harrison as laboratory director, much effort went into developing the laboratory, its facilities, and personnel to a point where efficient operations were possible. The construction and outfitting of the pilot plant building was a major accomplishment. Although the budget for regular funds during this period only permitted an expansion of two to three full-time permanent staff, Harrison overcame the problem of inadequate staffing by arranging for WPA temporary employees and cooperative and fellowship people. By the end of 1941 and counting such individuals, the staff numbered nine persons. The work conducted during this period resulted in 13 research papers. The principal fields of research and accomplishments

included the by-products work, in which salmon oils and halibut liver oils were characterized as to chemical composition and vitamin content; fish liver oil extraction methods were improved; properties of dogfish meal were determined and manufacturing methods improved; and methods of utilizing salmon trimmings to make oil for adding to canned salmon were devised. In food fish studies, knowledge of location and handling methods of king crab was developed so that a new industry was established; long-term studies on characterization of chemical composition of fishes of the Pacific Northwest were initiated; and new chemical methods were developed for analysis of fish and fishery products.

1942 THROUGH 1954

In 1942 Roger Harrison was transferred to Washington, D.C., to serve as chief technologist for the Bureau of Fisheries. Maurice Stansby returned from Ketchikan to replace Harrison as director of the Seattle Technological Laboratory. The work programming changed drastically to cover important wartime activities, and the budget and staff size increased considerably to accomplish the expanded objectives. Although the WPA project, which had provided a major part of the personnel, was phased out in 1942, by the end of that year the new programs had raised the number of full-time personnel to 14; by the end of 1943, when the wartime projects reached full implementation, there were 20 individuals on the staff and 16 of them were full-time professionals. New projects included the investigation of feasibility of substitute containers, including such aspects as whether using fiber cases instead of tin, for iced fillets, would substantially reduce cooling time in ice, and how much the thickness of tin plate on cans could be reduced without causing major corrosion problems with different species of canned fish. Areas where U.S. exports had been cut off by the war were especially critical. In addition to potential tin shortages, a shortage of agar, obtained from Japanese seaweed, was feared. Investigations on substitutes for agar from other seaweeds showed that a product considerably inferior to agar could be extracted from Gracilaria seaweed. Fortunately, the war ended before either the stock-piled tin or agar were exhausted. Another project was conducted to investigate preparation of dehydrated fish. A process was developed and the product test-marketed.

The Laboratory's vitamin A project was expanded. Meetings were held with representatives of the vitamin A industry and standardized analytical methods were adopted for stockpiling vitamin A from fish livers. To augment this process, Bruce Sanford developed a rapid, portable, fish liver sampler which was adopted by the fish liver industry.

As an offshoot of the earlier king crab investigations, some of the fishery engineers, notably Carl Carlson, worked with laboratory technologists, principally Charles Butler, and represented the government in design and operation of the Pacific Explorer. This vessel was a government-financed factory ship modified from a World War I 8,800-ton vessel, the Mormacrey. It was converted to a factory ship, capable of freezing fish or shellfish, cutting fillets, and reducing waste to fish meal and oil. Although the vessel performed satisfactorily, it was not

completed until after the end of World War II. At that time, however, there was no longer the urgent need for additional protein food that would justify operation of the vessel, especially when considering the adverse economic aspects which made a profitable venture impossible.

Several employees of the Seattle laboratory were detailed to other government agencies in connection with wartime activities. Frank Piskur spent a long detail and Maurice Stansby a much shorter one at the Chicago Quartermaster Corps Laboratory in connection with use of fish by the armed forces. R. Paul Elliott was detailed to work with the Army Veterinary Corp in New England in connection with development of specifications for fish.

In 1946 and 1947 an addition was made to the pilot plant, doubling its size. In the new addition, cold storage and quick freezing facilities were installed, increasing research on freezing and storage of fish. Expanded facilities for dressing and handling fresh fish were also provided.

Between 1947 and 1954, after phasing out the wartime activities, the programs changed again. In 1947, wartime budgets were eliminated, resulting in a 50% reduction in the staff at the Seattle Technological Laboratory. Fortunately, a $48,000 grant allowed the rehire of some displaced personnel to work on a project involving utilization of Alaskan cannery waste. Methods were developed whereby substantial portions of the waste, formerly discarded in Alaska, were frozen and shipped to hatcheries in the Pacific Northwest for use as fish feed. The laboratory also worked in collaboration with the Bureau of Fisheries' Hatchery Division to improve the nutritive value of fish feed.

A new program evaluated the composition, especially the vitamin content, of fish meal. This work, conducted by Neva Karrick and others, provided information that enabled poultry feeders to realize the full value of fish meals when applying newly introduced computerized formulation of feeds.

In 1948 with funds of the Fishery Education Section of the Bureau of Fisheries, a new periodical began publication, Commercial Fisheries Abstracts (CFA). Maurice Stansby was editor and the staff of the Seattle Technological Laboratory prepared abstracts on commercial fishery topics from important scientific journals. This publication continued to be prepared at Seattle and mailed to users throughout the world for more than 25 years.

Starting in 1951 the laboratory began conducting technological work on fishes from fresh water such as the Great Lakes. This work first involved evaluation of the cold storage life of freshwater species. Work also started on determining the chemical composition of freshwater species of fish.

In 1953 research was begun, in a small way, on chemical derivatives to be made from fish oils and on methods for fractionation of fish oils. This work was greatly expanded in 1955.

Personnel.--From 1942 to 1954 in addition to staff continuing from the preceding period (Butler; Dassow, for part of the period; Sanford; and Stansby), many new employees participated in the program. These included William Clegg, chemist, who had previously worked on temporary

appointments and who carried out much work on proximate composition of fish. Mabel Edwards, a laboratory aide, began a career assisting Neva Karrick on vitamin B complex assays. R. Paul Elliott worked both as a microbiologist and on Commercial Fisheries Abstracts. Martin Heerdt, employed as a fishery technologist, carried out research on fish preservation, but after spending considerable time in a sanitarium recovering from tuberculosis, Heerdt discontinued his active laboratory work and spent most of his working hours preparing abstracts. In 1954 he prepared 150 abstracts, over 50% more than any other staff member.

Dr. G. Ivor Jones, a chemist, worked on problems involving utilization of salmon cannery waste. Neva Karrick began a long career as chemist with the Laboratory in 1947. She worked first on utilizing salmon cannery waste, then on vitamin content of fish hatchery feed.

Lynne McKee, with long experience in the salmon canning industry, carried out work during World War II on lowering the tin content of cans used for fish. He later worked on other problems in canning fish. David Miyauchi, a chemist, was employed during this period and worked on many chemical aspects of preservation of fish. Katheryn Osterhaug, a home economist, was employed to develop new recipes for fish. George Pigott, a chemical engineer, worked on the problems of utilizing salmon cannery waste and on corrosion of cans containing fish. Frank Piskur, a chemist, was on the staff for a short time during this period but then went on to assignments elsewhere in the agency including Director of the Bureau's College Park Laboratory, and Associate Regional Director in Alaska.

Bruce Sanford continued his chemical investigations on vitamin A, which he had begun in 1940. With chemical synthesis of vitamin A achieved in the late 1940s, however, the production of this vitamin from fish livers ceased. Sanford then turned to other endeavors, becoming increasingly active in editing scientific papers, which occupied most of his time for the remainder of his career. In 1954 he published his first paper in this field, "Planning Your Fishery Research Paper." He also founded and edited a new government journal, Fisheries Industrial Research.

In 1942 Victor Scheffer, on loan from the Alaska Fur Seal Investigation (suspended because of the war) began a 2-year project on American sources of agar. He was assisted by Vincent Senn, a newly appointed chemist. The field work was conducted at Scripps Institute of Oceanography at La Jolla, California.

Roy Stevens was employed to carry out many of the duties connected with the publishing of Commercial Fisheries Abstracts, and he served as assistant editor during this period.

David Wieg was employed in 1949 as a laboratory aide, and since that time he has assisted with a wide variety of laboratory investigations. He continues in this capacity.

In 1954 the staff of the Technological Laboratory included the following full-time employees: Maurice Stansby, chemist and Laboratory Director; Bruce Sanford, chemist; Neva Karrick, chemist; William Sumerwell, biochemist; David Miyauchi, fishery products technologist; Kathryn Osterhaug, home economist; Roy Stevens, fishery products technologist; Patricia Terao, chief clerk; David Wieg and Mabel Edwards, laboratory aides; Mildred

Martin, procurement clerk; Margaret Brown, secretary; Marjorie Zachow and Marjorie Pearse, clerk typists.

Part-time employees included: Martin Heerdt, William Clegg, Robert Doll, Edward Gruger, and Murray Andrews, all chemists; Rosemary Schairer, clerk-stenographer; Lois Elgin, home economist; and Harriet Starr and Marian MacFarlane, laboratory aides.

In 1942, the budget for the Laboratory was about $29,000, with five full-time employees. By 1945, when wartime activities had peaked the budget had reached about $64,000. Seventeen full-time employees were on the staff. In 1947 massive reductions of wartime positions and budgets took place, and the Seattle laboratory lost one-half of its personnel. This resulted in an annual budget of $34,000 and eight full-time staff members. The impact of the sudden drop in the budget and personnel was softened by the previously mentioned grant of $47,600 for a 2- to 3-year research project on utilization of salmon cannery waste. Although quite a few staff members had to be terminated, several were retained for the special projects. In the meantime, other contributed funds were obtained from the Refrigeration Research Foundation, from the fish hatchery section of the Bureau of Fisheries, and from the Continental Can Company. By 1954 the annual budget had risen to about $61,000 and there were 14 full-time staff members.

Summary of 1942-54 Accomplishments.--Under Maurice Stansby as Director, the Laboratory spent about 5 years with major emphasis on special wartime projects and 8 years on peacetime projects. This was a period of great expansion in the size and scope of the work. It also resulted in a tremendously increased output of research and other publications. During this period, 140 papers were published, an average of more than 10 per year. Facilities were improved by expanding the size of the pilot plant building and providing freezer and cold storage equipment. Accomplishments related to wartime activities included providing information, services, and in some cases personnel details, to numerous wartime agencies such as the War Production Board, the Office of Price Administration, and the Army Quartermaster Corp; developing a successful method of producing dehydrated fish; and developing equipment for sampling fish livers.

During peacetime, the laboratory staff devised a method for getting current literature to the fishing industry by publishing the monthly Commercial Fisheries Abstracts; devised a successful means for utilizing Alaskan salmon cannery waste which was adopted by industry; established the vitamin B content of fish meals; conducted research on cold storage properties and chemical composition of fresh water species of fish in the absence of facilities in the Great Lakes area; and conducted the first research on fractionization of fish oils and preparation of chemical derivatives from them.

1955 THROUGH 1965

Beginning in 1955 the Seattle Technological Laboratory received supplementary funding from import revenues under the Saltonstall-Kennedy (SK) Act. This provided up to $200,000 per year in addition to regular funding. After 1960, as the value of the research from the special SK funding became apparent, a portion of

the SK funds were replaced each year by additional regular funding so that by 1965 the SK funds were reduced to $70,000, but regular funding had increased to $316,000, making a total budget of nearly $400,000. A considerable portion of the supplementary SK funds was used for contract research at universities. This brought new ideas into the overall research programs and provided additional research findings.

The principal research areas covered by the new funding were in fish meal; in fish oil research, especially at Seattle; and in developing standards of quality for using the newly inaugurated inspection of fishery products program.

Much of the work carried out on contract at universities was carried out at the universities of Minnesota and California. The University of Minnesota was chosen for a major part of the fish oil research because the largest and best qualified oil research laboratory in the country was Hormel Institute, a part of the University of Minnesota located at Austin, Minnesota. Additionally, since the most immediate new use for fish oil was apt to be for iron ore concentration and 60% of all iron ore was mined in Minnesota, the School of Mines and Metallurgy of the University of Minnesota was the most experienced in this field.

The University of California was selected for another major portion of the work because the Institute of Marine Resources and the Department of Food Science and Technology, parts of the University, were best qualified for work on research on oil in fish meal and oil in fish flesh. Major aspects of the program required experienced laboratory work which the University of California was able to provide. Other universities and research laboratories where smaller portions of the work were carried out included the University of Washington's College of Fisheries; Oregon State University's Department of Food Technology; the Phillip R. Park Research Foundation at Terminal Island, California; the University of Wisconsin's Department of Poultry Science and Wisconsin Alumni Research Foundation; and the Mayo Clinic.

Fish Oil Research.--A major research thrust during the decade beginning in 1955 was to obtain background information on the chemistry of fish oils and to develop new uses for them. Fish oil work proceeded along industrial and nutritional lines. In the industrial area many new uses were investigated, including use of fish oil derivatives for ore flotation, for insecticides, for chemical intermediates to be used in making a variety of other products, and for other purposes. A considerable part of the industrial oil application program concerned the use of fish oil compounds for concentrating low grade iron ore. Work was conducted cooperatively with the University of Minnesota College of Mines and Metallurgy. A practical procedure was developed and has been used in some foreign countries. This procedure will be available for future use in this country after the higher-grade taconite ores, which use the cheaper magnetic process, have been depleted.

A number of chemical firms used the program's findings to produce new industrial products from chemically synthesized fish oil derivatives. Most of these uses are proprietary applications for which no information is available.

The nutritional investigations primarily examined the potential of polyunsaturated fish oils and fish oil

fatty acids for use as cholesterol depressants. Based upon rat feeding tests performed under contract by the University of Minnesota's Hormel Institute, it was found that fish oils and fish oil fatty acids are several times more effective, weight for weight, than vegetable oils, such as corn oil, in lowering serum cholesterol. Furthermore, in a 15- to 20-year study by a Seattle heart physician, Dr. Averly Nelson (1972), the animal tests were confirmed as applying to human subjects. Of those patients who followed the prescribed diet high in seafoods, nearly three times as many survived longer than heart patients on the ordinary (control) diet.

Other tests in the Seattle program on medical applications of fish oils suggested that they are valueless in curing wounds and burns. This study was performed at the Mayo Clinic to determine whether the use of fish oil in ointments facilitated healing, as had been believed for many years.

Perhaps the main benefit of the fish oil program was the accumulation of basic information on the chemistry and nutritive value of fish oils, about which very little was known before these studies were made. Much of the general information has been summarized in a book by Stansby (1967), and much of the nutritional and pharmaceutical information is given in a review by Stansby (1969).

Standards Program.--Under the standards program, detailed specifications were established for most of the commercially important species of fish which are handled in the fresh or frozen state in the Pacific Northwest. These standards provided the means for inauguration of a federal voluntary inspection service in the Pacific Northwest. Research on the quality of fresh and frozen fish, and on the development of standards was coordinated by John Dassow and included freezing and preservation studies by Richard Nelson and development of quality criteria and methodology for grade standards by Max Patashnik, Wayne Tretsven, and others.

Other Programs.--Studies on the chemistry and microbiology of fresh, chilled fish were expanded in 1961 with the initiation of a major research project on the feasibility of extending the storage life of chilled fish by low-dosage irradiation. This study was supported by the Atomic Energy Commission under its national food irradiation research program. Ten papers and several contract reports by the program leader, David Miyauchi, and co-workers John Spinelli and Dr. Melvin Eklund were published on the irradiation pasteurization studies. Other contributions included 12 papers on fresh fish quality determination and frozen fish inspection methodology, and six papers by George Pigott summarizing his comprehensive study of iron sulfide discoloration in canned tuna.

A program on the proximate composition, and sodium and potassium content, of saltwater fish of the Pacific Northwest and of the Great Lakes and other freshwater species was completed during the 1955-65 period. Much of this work was conducted by Claude Thurston at the Seattle Technological Laboratory. He published 15 scientific papers on this work.

Personnel.--During the decade ending in 1965, a considerable number of new personnel were added to the staff in connection with the SK and irradiation programs.

Harold Barnett carried out research on

preservation and processing, working particularly with hake.

John Dassow, in his capacity as supervisory fishery products technologist, was in charge of the work on the development of grade standards as well as all the work on the preservation of fish. The latter included the fish irradiation project which was being expanded. It also included the various programs on the preservation of fresh and frozen fish, and working with the fishing industry to assist them in problems in handling and processing fish.

John Dyer, a chemical engineer, worked to develop practical methods for fish oil fatty acid fractionization.

Dr. Melvin Eklund carried out microbiological research, especially studies of Clostridium botulinum problems in irradiation preservation of fish.

Erich Gauglitz, Jr., headed the project on preparation of chemical derivatives from fish oils.

Dr. Edward Gruger, until 1 July 1965, headed the organic chemistry program which dealt with fish oils. He then was detailed to the cooperative program with the Food Science and Technology Department, University of California at Davis, where he began thesis research on antioxidant mechanisms in fish oils.

Dr. Herman Groninger was project leader for biochemical research investigations concerned with spoilage of fish.

Alice Hall, a chemist, worked on characteristics and utilization of dogfish and other shark species of the Pacific and Atlantic coasts.

Patrick Hunter, an engineering technician, assisted in the refining of fish oil, especially in connection with molecular distillation to produce palatable fish oil.

Clifford Houle worked on fatty acid derivatives from fish oils.

Barbara Kemp worked on the fish irradiation project, particularly on chemical, and corresponding flavor changes that occurred in irradiation-pasteurized fresh fish. She also did research on the chemistry of shark and Pacific whiting (hake) proteins.

Neva Karrick, in her capacity as supervisory chemist, was in charge of the programs on fish oils and other chemical aspects classified as basic research.

George Kudo carried out research on sharks. He also was detailed to the biological laboratory to act as an observer on Japanese fishing vessels.

Lawrence Lehman, organic chemist, worked on the project to develop chemical derivatives of fish oil fatty acids.

Lynne McKee carried out work to assist the fishing industry with problems of freezing and canning crab. With John Dassow, she carried out the first technological work on the processing problems in the mechanized shrimp industry, following the introduction of the first mechanical peeler on the Pacific coast in 1956 in Westport, Washington. On several occasions, McKee was also detailed to assist with problems in east coast and Gulf of Mexico fisheries.

Dr. Donald Malins was detailed to Aberdeen, Scotland, where he worked at the University of Aberdeen and at Torrey Research Station, to carry out

work on biopathways in lipids.

David Miyauchi was the project leader for the expanding program on irradiation of fish being financed by the Atomic Energy Commission. He personally carried out research on the radiation process while supervising subprojects dealing with food chemistry, food microbiology, and Clostridium botulinum problems.

Richard Nelson, a chemical engineer, supervised several projects on food preservation and processing, including icing and refrigeration of fish at sea, objective measurement of quality changes in iced halibut, and development of quality standards for frozen fish.

Max Patashnik, a chemical engineer, carried out research on the measurement of quality changes in halibut, salmon, and bottomfish; and the application of this research to development of quality standards. Patashnik did the initial, and later, detailed research on the problems of mushy texture in Pacific whiting, the relationship to the protozoan parasites, and the effect of handling and icing practices aboard the vessels.

Gretchen Pelroy headed the subproject on food microbiology under the irradiation program.

Paul Robisch, a chemist, carried out miscellaneous chemical analyses for different programs. He also assisted Stansby in a program on odor and flavor.

Dr. William (Ted) Roubal returned from a 2-year detail at the University of California at Davis where he had been carrying out research on oxidation of fish oils. He received his doctorate while at Davis. After his return to Seattle he began research on fish oil oxidation employing the new technique that involved the use of an Electron Paramagnetic Radiation (EPR) instrument.

Dr. Virgina Stout, a chemist, carried out research on synthesis of organophosphorous fish oil derivatives as products which might be useful in a number of ways, such as fire-retardants, pesticides, and lubricants.

John Spinelli, a chemist, worked on the food chemistry portion of the irradiation project. This involved research on storage changes in iced fish which occur very early before actual spoilage has taken place. An important phase of this study was on the chemistry of the autolytic processes, the relation of early quality and flavor losses to nucleotide degradation, the decrease of inosine monophosphate, and the accumulation of hypoxanthine.

Patricia Terao continued her position as administrative officer for the laboratory. This involved such duties as budget planning and personnel appointments. Because of her long association with the laboratory, she took on other duties such as preparing many of the in-house annual reports. She also was in charge of answering general technological inquiries which did not require a detailed scientific reply.

Dr. Claude Thurston worked at the laboratory as a chemist from 1955 to 1961. He had been a professor of chemistry at Walla Walla University at College Place, Washington, and left to become the director of food research at Loma Linda University. During his 6 years with the Technological Laboratory at Seattle, he carried out a tremendous

amount of work on the proximate composition, and sodium and potassium content of fishes of the Pacific coast and also some work on freshwater species. He was assisted by several laboratory aides and organized the work to obtain a maximum amount of results. There is little that is not known about proximate composition of most Pacific Coast species as a result of the vast amount of data and published papers which were obtained during Thurston's relatively short tenure.

Wayne Tretsven conducted research on quality changes in fish with emphasis on the effects of handling, bleeding, icing, and washing fish aboard the vessel and in the plant. His early microbiological studies included problems of fillet contamination in the plant. Later work on halibut quality emphasized handling problems aboard the fishing vessel.

Dr. John Wekell, a chemist, worked on the chemistry and separation of glyceryl ethers from the flesh and livers of fish.

Dave Wieg, physical science aide, assisted John Spinelli in his food chemistry research.

Until 1961 Bruce Sanford worked as part of the Technological Laboratory staff. During this time he did editorial work almost exclusively, initially for the Seattle Technological Laboratory but later for all Bureau Technological Laboratories throughout the country. In 1961 this work was set up as a separate function from the Seattle Technological Laboratory, and it was designated as the Special Scientific Unit (SSU). It included both editoral activities and the preparation of the monthly publication, Commercial Fisheries Abstracts.

Summary of 1955-65 Accomplishments.--Under Maurice Stansby as Director, the Technological Laboratory activity expanded in budget and staff. The scope for the work was widened with a considerable portion of time spent on a crash program on chemistry and utilization of fish oils. During this period, 201 scientific papers and 23 books were published. In addition, a total of 80 papers resulting from contract and cooperative work financed by the Seattle laboratory were also published.

A major contribution from the research of this period was the compilation of information on the chemistry and nutritive value of fish oils. Much additional information was obtained on the proximate composition and mineral content of fish. The first research on irradiation as a means for preserving Pacific Northwest species of fish was conducted. Considerable research was also performed to obtain information required to establish standards for fish.

1966 THROUGH 1981

Organization and Objectives.--During 1966 the Technological Laboratory was reorganized. Under Maurice Stansby, formation of the Food Science Pioneer Research Laboratory became a separate research unit. The personnel and resources of the Technological Laboratory were assigned to either the Pioneer Research or the Technological Laboratory with a revised research program. Dr. Maynard A. Steinberg, formerly with the Gloucester Technological Laboratory, was appointed Director of the Seattle Technological Laboratory in August 1966.

At this time, it was obvious that factors other than reorganization made a complete review of the laboratory program essential. As the new Director, Dr. Steinberg had strong ideas about the importance of continuity in research objectives in relation to the scientific interests of the staff. The reorganized laboratory had retained, of course, the responsibility for applied research on the practical problems of preserving, processing, and utilizing fishery resources. The comprehensive research on the chemistry of fish oil from an analytical and industrial perspective was completed. New problems appeared: contaminants in fishery products, and the need to expand the horizons of fishery preservation. These problems included more than radiation preservation (supported by the Atomic Energy Commission) and emphasized the potential for research on other techniques for extending the keeping quality of traditional fresh fish species. Ideas for using fish species that were previously rejected by the Pacific coast trawl fishery needed more development to follow up the early work by Dassow and Patashnik with Pacific whiting. In 1968 the new objectives of the laboratory were defined at a program review as follows: (1) to develop scientific knowledge to improve the preservation, processing, and utilization of fishery resources; and (2) to apply and demonstrate to industry the improved process methods and concepts for efficient utilization of the total resource, with a primary emphasis on food production.

The laboratory was organized into six sections including four research programs, inspection, and administration: 1) Chemistry of Fishery Products--Erich Gauglitz, Jr., program leader, with Dr. Virginia Stout, Dr. Herman Groninger, John Dyer, Lawrence Lehman, Clifford Houle, Dr. John Wekell, and Barbara Kemp (later Koury) as research staff; 2) Preservation and Engineering--Richard Nelson, program leader, with Max Patashnik, Dr. Wayne Tretsven, Alice Hall, George Kudo, Harold Bennett, and Pat Hunter as research staff; 3) Radiation Preservation of Fishery Products--David Miyauchi, program leader, with John Spinelli, Gretchen Pelroy, Fuad Teeny, John Seman, Dave Wieg, and Laura Lewis as research staff; 4) Radiation Preservation Microbiology--Dr. Melvin Eklund, program leader, with Frank Poysky ; 5) Inspection--Morris Rafn, supervisor, and inspector George Berkompas, at Bellingham; 6) Administration--Laboratory Director Dr. Maynard Steinberg, Assistant Laboratory Director John Dassow, Administrative Officer Patricia Terao, and four secretaries--Margaret Hodgins, Gretchen Lindberg, Isabell Diamant, and Dolores DeWitt. Total staff was 33 and the budget was about $380,000, not including contract research funds for the radiation preservation research (funded by the Atomic Energy Commission from 1961 to 1969).

During the 1970s, the laboratory was designated the Pacific Utilization Research Center (PURC) with Dr. Steinberg as director. The technological research in Alaska, under Jefferson Collins, was relocated to Kodiak in 1971 and assigned to PURC after a somewhat confusing period of separate regional responsibility. Administratively this unification was very important in re-establishing Alaskan field research tackling problems of technological concern to the Northwest and Alaska fisheries. The budget increased to more than $900,000 by 1976; however, the staff remained at 35, including a scientific staff of three at the Kodiak Utilization Research Laboratory. In

October 1976, PURC became the Utilization Research (UR) Division of the Northwest and Alaska Fisheries Center, with continuing emphasis on increasing the utilization of fishery products. In August 1979 Dr. Steinberg retired and John Dassow was Acting Division Director until the new Director, John Spinelli, was appointed in February 1980. By early 1981, the total staff had decreased (with retirements in recent years of Dr. Tretsven, Dyer, Miyauchi, and Patashnik) to 29, including three at the Kodiak Utilization Research Unit--Jefferson Collins, Dr. Kermit Reppond, and Dennis Markey. In addition, two NOAA Corps officers, Lt. Jim Conrad and Lt. Cdr. Allan Kissam, were on detail to the Division's Preservation Research Program.

Chemistry of Fishery Products.--Increasing emphasis was devoted to the factors affecting the recovery, modification, and utilization of fish oils for food purposes. The recovery of oil derived from the isopropanol process for fish protein concentrate (FPC) production was studied as part of the national research program on FPC and, in 1971-72, in relation to the pilot production problems of FPC and oil at the experimental FPC plant in Aberdeen, Washington. Both species and process variables were examined; however, major emphasis was on the potential recovery of high-grade oil from menhaden and anchovy.

It turned out that the recovery and separation of isopropanol, oil, water, and soluble proteins was a much more difficult problem at the pilot production plant than at the laboratory. John Dyer was detailed to study this problem with fatty fish species at the Aberdeen plant, but because of related problems in the extraction of the oil from fatty fish as compared to the Pacific whiting, the engineering task became far too complex. For example, a major problem was eliminating the intractable and seemingly immovable emulsions that formed in the lines and heat exchangers, but this was essential to keep the process operating. Obviously a new engineering approach was needed to solve oil recovery problem with fatty species. The national FPC program and the Aberdeen FPC plant were terminated during 1972-73, ending the research on improved methods of extracting and refining the oil from menhaden and anchovy in the isopropanol FPC process.

The cooperative research and liaison of the Seattle staff with the FPC plant was remarkably unproductive in terms of finished results in relation to our plans and expectations. The effort and experience led to new directions and productive research in the 1970s on other processes for fish proteins, modified proteins, and protein derivatives. In addition, the process difficulties and lower yields that were encountered provided a broader technological understanding of the limitations of the FPC process.

Research on levels of organic contaminants in fish oil was initiated in 1966 with major emphasis on analyses for DDT in menhaden and other industrial fish oils and meals. The effort was broadened within a few years to include fish species of both the Atlantic and the northeast Pacific. Other chlorinated pesticides such as dieldrin were determined. The developing concern over polychlorinated biphenyls (PCBs) in the environment necessitated studies on its level in fish and shellfish of both the Atlantic and Pacific. With the continued cooperation of the menhaden industry,

the laboratory obtained seasonal samples of raw fish, meal, and oil for several years.

The long-range studies with the Atlantic menhaden industry presented numerous problems in obtaining the needed samples. The analyst, Dr. Virginia Stout, and the project supervisor, Erich Gauglitz, were concerned with the problem of obtaining cooperation with an industry which was sensitive both to the need for unbiased sampling and analysis of a most undesirable contaminant, and to the implications of the findings. When the results of the survey were finally published in 1981 they formed an historical note on the problem of environmental contaminants and the changing impact on a specific fishery. The decline in DDT usage was reflected in lower DDT levels in menhaden oil; however, data on PCB levels through 1976 showed a continuing moderate level in menhaden from most areas. Pacific species showed no problems with organic contaminant levels with the exception of fish from areas affected by agricultural runoff such as southern California coastal waters.

A major study of mercury levels in food fish was initiated following the 1970 reports of high mercury levels in tuna, swordfish, and freshwater fish from industrially contaminated waters. Major surveys were conducted on problem species such as halibut and sablefish in which high mercury levels (above the 0.5 ppm U.S. Food and Drug Administration guideline) appeared to be related primarily to age and size of the fish, and to a lesser extent, to the area.

In the history of the technological laboratory, it should be pointed out that this detailed study of mercury levels in fish and the accompanying health and economic implications represented an unprecedented high degree of industry and government cooperation. Fishermen, buyers, and processors were eager for the truth on mercury levels in the problem species but were concerned that premature release or confusing information could have dire effects in the marketplace. Looking back, the program worked quite well. An interesting sidelight is that in later years after the detailed analytical work was done, legal considerations dictated an increase in the FDA mercury guideline to 1.0 ppm, a level that would have ameliorated much of the short-term economic effects on industry in the few years of great concern. The work has gradually broadened in scope to include other trace metals of public health concern, e.g., lead, cadmium, and chromium.

Preservation and Engineering.--With the decreasing effort in development of product quality standards, a greater emphasis was given to the effects of handling, chilling, and preserving techniques on the quality of fish and shellfish.

The field studies on preserving and handling halibut at sea by Wayne Tretsven and Richard Nelson in the early 1960s and the detailed laboratory analyses on quality criteria by Max Patashnik had shown the real need for closely related vessel and laboratory experiments. A better understanding of the physical-chemical changes in the fish flesh during chilling and freezing was the result, and this affected the continuing preservation research on other species.

Studies were concerned with 1) live holding and shipping of Dungeness crab, 2) factors affecting water-holding capacity of fish tissue and methods of measurement, 3) quality of chilled and

frozen Dungeness and king crab meat, 4) quality of iced halibut and methods of determining and measuring quality differences for marketing, and 5) improved methods of chilling and holding fresh whole and dressed fish by use of modified atmosphere and modified refrigerated seawater (RSW) with carbon dioxide. The RSW research included several species of fish--salmon, rockfish, cod--in the early studies. In 1968, work on increasing the utilization of rockfish and Pacific whiting was initiated with new studies on the techniques and applications of mechanical flesh separation from skin and bone.

In 1968 Minoru Okada, a visiting biochemist with the Tokai Fisheries Regional Laboratory, Tokyo, Japan, arrived for a 10-month cooperative study of Japanese minced fish technology on Pacific coast species. Okada's pioneering research on minced fish, ("surimi") and fish cake ("kamaboko") had helped to increase the production of these processed products in Japan to astonishing levels--more than a billion pounds a year. His visit and the Seattle laboratory's interest in this new technology initially resulted from a brief visit by John Dassow to the Tokai Laboratory in 1966. The need to evaluate new processes for utilizing species like Pacific whiting and rockfish and, in later years, walleye pollock was the real incentive. From that year to the present, minced fish, and numerous ramifications of the concept of mechanically separated fish flesh, began to dominate much research at the Seattle laboratory and several other technological laboratories in the United States. Research on the properties and utilization of minced flesh in fishery products and processed meat products by David Miyauchi and George Kudo continued to the present, but with emphasis changing to species problems. A total of 89 papers and three patents were published on various preservation and engineering projects during 1966-76, a period of many new ideas for utilization as well as preservation.

With the passage of environmental protection and clean water legislation in 1969-72, a major study of the characterization, measurement, and treatment of fish and shellfish processing effluents was conducted during the early 1970s. A primary goal of this research was to provide objective data on the characteristics and physical-chemical treatment of the effluents. The efforts included cooperative industry studies at a number of processing plants in the Northwest and Alaska and provided a base for liaison with the Environmental Protection Agency, as well as advisory services with industry, and local and state officials in environmental control. Active field research in effluent treatment was terminated in 1976.

Inevitably, the cooperative field studies on effluent characteristics, analysis, and treatment by Richard Nelson and Harold Barnett of Seattle and Jefferson Collins in Kodiak established a new field of expertise in the laboratory that has been in continual demand.

Resource Development of Fish Protein Derivatives.--The research on problems of FPC production in 1971-72 led to continuing protein studies under John Spinelli, culminating in the development of and a public patent to Spinelli for the aqueous phosphate process for fish proteins. Work on improving the functional characteristics of purified muscle proteins resulted in a series of

studies by Dr. Herman Groninger and Ruth Miller on the preparation and properties of chemically modified (acylated) fish proteins. The extension of this field to modified forms of protein by Spinelli and Koury also suggested the preparation of drum-dried proteins with optional pretreatment of the fish or use of cereals for co-drying with fish mixture. A major objective in this research, which continues to the present, is the development of aqueous pretreatments of minced flesh and drying techniques that minimize costs and eliminate solvent processes for protein production from lean species.

One aspect of these studies on the purified proteins was the recognition of the importance of the functional characteristics, such as the gel-forming and emulsification properties, not only to protein isolates but to the quality changes of fresh and frozen fish. This work in the 1970s on functional proteins, resulted in two additional patents and 18 scientific papers, and remains an active area in the laboratory.

Radiation Preservation of Fishery Products.--This major research program was supported by the Atomic Energy Commission's (AEC) Division of Isotopes Development from 1961 through 1969 and included a comprehensive study of the feasibility of radiation preservation of fresh fish and shellfish. With his background on the research in measuring quality changes in fresh and chilled fish, David Miyauchi, the project leader, established a strong emphasis on the relationship of the sensory changes in the irradiated fish to the early chemical changes, as shown in Spinelli's research on correlation of flavor loss to the decrease in level of inosine monophosphate. Research included chemistry and microbiology of the early and late changes related to the freshness and spoilage of fresh fish, the measurements of acceptability by both subjective and objective criteria, the effects of prehandling and radiation at sea, the importance of packaging and quality control in extended storage and shipment tests, and the determination of preference at the consumption level. One of the final studies was the testing and experimental installation of a shipboard irradiator aboard the fisheries research vessel Miller Freeman. This research was conducted by Fuad Teeny, who irradiated five species at sea in various stages of rigor. Teeny and Miyauchi demonstrated in the later quality and storage tests that the shelf life of irradiated pasteurized fish was significantly longer for the pre-rigor fish than for the post-rigor fish. In addition to accomplishing the contract objectives, the studies provided numerous spinoff benefits for other research in basic quality determination, flavor changes, effects of additives, control of drip and water-binding characteristics, and variables of preference determination.

The data and reports proved to be particularly valuable because of the excellent documentation on changes in the control of untreated fish and shellfish along with the irradiated products. At the time the contract study was terminated, the approval of the radiation pasteurization process for fresh fish and shellfish by the Food and Drug Administration was in abeyance. It is useful to record that it now appears, in 1981, that FDA approval is imminent--almost 10 years later. A total of 29 reports and scientific papers were published on the specific phases of the contract research up to 1972.

Radiation Preservation Microbiology.--Early studies on the radiation pasteurization of fresh fish and shellfish and the profound effect on the survival and subsequent growth of the microflora led to a major investigation, supported initially by the AEC and currently by the U.S. Army Research Office, under Dr. Melvin Eklund, on the survival, outgrowth, toxigenesis, and possible control of Clostridium botulinum in radiation pasteurized fishery products. Following completion of the technological and chemical studies on radiation pasteurization, the research on C. botulinum was expanded to include any perishable fishery product, such as heat-pasteurized and smoked products.

The definitive research by Dr. Eklund and his small project staff on C. botulinum in relation to radiation pasteurization was applied in a most practical way to the problems of the hot-smoked fish industry. Of greatest importance was the need to show the specific limitations of temperature, moisture, salt, and sodium nitrite in establishing safe processing guidelines for hot-smoked fish. Active support by the smoked fish industry of this phase of Eklund's research has assured the continuation of this project, complementing the continuing support by the Army Research Office on the basic factors in growth and toxigenicity of the various types of C. botulinum. The research staff for these various projects in 1981 included: Dr. Melvin Eklund, program leader; microbiologists, Gretchen Pelroy and Mark Peterson; food technologist, Frank Poysky; and scientific aides, Lamia Mseitif, Rohinee Paranjpye, and Eric Rolseth.

The research on toxigenicity of C. botulinum includes the various forms of botulism of concern to public health, and effects of the environmental factors in the products and processes such as time-temperature, moisture content, salt level, and chemical additives. The continuing objective of the research is to understand the factors controlling C. botulinum outgrowth and toxin formation. This information should provide a firm basis for prevention of botulism by physical-chemical control of the organism whenever it is present in food. Through 1980, 35 reports and scientific papers were published on the microbiology of radiated pasteurized fish and the continuing studies of C. botulinum outgrowth in other partially processed and preserved fishery products, especially smoked and fresh fish stored in a CO_2-modified atmosphere.

The irradiation project offered a convenient means of studying autolytic changes in fish that occured in the absence of microbial growth. Under the direction of John Spinelli, it was shown that these changes produced a marked effect on the organoleptic characteristics of the fish. The rates of these changes and methodology for their detection were determined on several species of commercially important fish during the course of the irradiation research.

Fish Nutrition (Aquaculture).--The shortage and high price of fish meal during 1972-73 suggested the importance of technological research on alternative sources of feed proteins for use in developing aquaculture. To date, this study under John Spinelli has emphasized two aspects: 1) the problems and the potential of utilizing underutilized species (e.g., dogfish) and the unconventional protein sources (e.g., single-cell protein from petroleum), and 2) the improvement of the dietary components of salmonids in

relation to the nutritional requirements of the species and the desired qualities of the fish to be marketed. The utilization of pelagic red crab and krill as sources of carotenoid pigments for salmonids (rainbow trout and pen-reared salmon) and the effects on growth and quality of the harvested fish established a new research area in salmonid nutrition. Continuing carotenoid research in 1980-81 included evaluation of crayfish waste from Louisiana, a valuable carotenoid resource, and simple methods of extraction and concentration for feed using soy oil. Dr. John Wekell was named project leader in 1980 and with Karl Shearer, fish nutritionist, and Dave Wieg has continued research on problems of essential trace elements, particularly zinc, available in relation to alternative feed proteins (soy and cottonseed meal) in which natural chelators occur. Ten scientific papers have been published on these studies since 1975.

FOOD SCIENCE PIONEER RESEARCH LABORATORY 1966-81

Organization and Programs.--In 1965 Maurice Stansby, who had been director of the Seattle Technological Laboratory since 1942, received a PL 313 appointment. A group of scientists was transferred from the Technological Laboratory to work under Stansby in a new laboratory for long-term, fundamental research. These other scientists included: Neva Karrick, Dr. Edward Gruger, Dr. W. T. Roubal, Dr. Donald Malins, Anthony Barone, and Paul Robisch. The major field of research of the new Food Science Pioneer Research Laboratory was the mechanism of oxidative deterioration in fish oils, especially while fish oils were present within the flesh of fish. A secondary project was concerned with the role of unusual lipids in sharks and porpoises, the latter in connection with sonar reception and transmission. The sonar work under Dr. Malins was conducted primarily by Dr. Usha Varanasi, who was funded by the Office of Naval Research. A third project, undertaken several years later, was concerned with nitrosamines and smoked fish.

The Food Science Pioneer Research Laboratory was located on the same floor of the research buildings as the Technological Laboratory and had about five laboratories and several offices for its exclusive use. Instruments and certain o}her facilities were shared by the two laboratories.

Much of fiscal year 1966, the first year of the new laboratory's operation, was spent in completing research tasks that were underway before the Pioneer Research Laboratory was established. The laboratory started with its new programs in full operation by the summer of 1966 and terminated operations in 1971 when the Northwest Fisheries Center was established. At that time, the Pioneer Research Laboratory and its personnel became the first unit of the Division of Environmental Conservation of the Northwest Fisheries Center with Maurice Stansby as division director.

Research on Lipid Oxidation.--The research on oxidation of fish lipids within fish tissue was conducted partly at Seattle and partly by two of the Pioneer Research Laboratory personnel (Drs. Roubal and Gruger) stationed at the University of California at Davis' Food Science Department. In the latter investigations, Dr. Roubal determined the effects of oxidizing lipids in fish on proteins and established that

polymerization of protein occurred. Dr. Gruger investigated the role of natural biological antioxidants, principally alpha-tocopherol, and reduced co-enzymes on the oxidation of fish oil polyunsaturated fatty acids in model systems. At Seattle, Dr. Roubal applied electron paramagnetic resonance spectrometry to study effects of trapped radicals in dry products such as fish meal, fish protein concentrate, and freeze-dried fish. It was shown that the free radicals, rather than oxidation products of the oil such as aldehydes, are primary agents responsible for deterioration of protein quality. Such oxidative activity was shown to take place slowly over extended periods of time when the dry products were stored.

Also at Seattle, Karrick studied the effect of microbial action on oxidative deterioration of lipids in fish. Evidence was obtained to indicate that, when bacterial action occurred, the extent of lipid oxidation declined. Another phase of the work compared cold storage life of frozen coho salmon based upon lipid oxidation and flavor change. Comparisons were made between samples frozen in hermetically sealed tins and samples protected by other packaging means. The flavor of the samples stored in tin remained at an acceptable level for at least 10 times longer than for any other packaging method.

Research on Other Projects.--The work by Drs. Malins and Varanasi on unusual lipids concerned two quite different aspects. The nature and function of alkoxydiglycerides in dogfish and several other sharks was one aspect that was investigated. It was shown that in these species there is a varying ratio of such compounds to triglycerides. When this ratio changes, the buoyancy of the fish is altered and it is possible that lipid transformations between the two types of glycerides are employed by the sharks to assist in maintaining desired buoyancy levels when the fish move to different water depths.

In other aspects of the work, which was supported by the Office of Naval Research, the sonar communication sense organ of porpoises was investigated from a biochemical standpoint. The types of lipids present in the portions of the porpoise head through which the sonar waves are propagated and through which the reflected portions are received were found to vary. A hypothesis was investigated, namely, that the structure of these tissues is comprised of layers of lipids having different physical properties with respect to speed of transmission of sonar waves. Some evidence was found to suggest that the layers of lipids may be arranged in the form of a sort of lens which can focus the sonar waves and function as a sensing organ.

Because of published articles in the food science literature which suggested that nitrosamines having carcinogenic properties may form during processing smoked foods including fish, the U.S. Food and Drug Administration proposed limiting severely the amount of nitrates and nitrites that could be employed by the food industry. In the case of fish, the presence of considerable quantities of amines occurring naturally or as a result of early traces of spoilage indicated that on a theoretical basis fish might be more vulnerable to nitrosamine formation than other foods. Research conducted at the Food Science Pioneer Research Laboratory by Malins et al. (1970) showed that at the storage temperatures used for smoked fish and at nitrate and nitrite levels and other conditions used by fish processors, no

nitrosamines could form. In addition, Gruger showed that potential precursors for nitrosamine formation in fish flesh stored for long periods of time were either present at parts per million levels or were absent from the flesh. This work was also extended to possibilities that Alaskan salmon roe, which was preserved by nitrite and exported to Japan, might develop carcinogenic nitrosamines. The Japanese government had already tentatively banned importation of U.S. salmon roe preserved with nitrates for the subsequent season. Work performed by Dr. Roubal in the Washington, D.C., laboratories of the U.S. Food and Drug Administration showed decisively that nitrosamine formation did not occur. This work saved the multimillion dollar Alaskan salmon roe industry.

Accomplishments.--During the 5 years of active work of the Food Science Pioneer Laboratory in the field of food science, 74 scientific papers were published by its staff. Much of the work, which had been planned as a long-term basic research attack on the acute problems caused by lipid oxidation in fish, had concerned mechanisms of oxidation of fish lipids. Considerable basic information along these lines was accumulated. The Laboratory also became involved with the urgent practical problem concerning the possibility of carcinogenic compounds being formed in preserved fish, both from the Great Lakes area and from Alaska. The resulting crash program brought forth the needed information which prevented regulatory action that would have closed down the large and valuable Alaska salmon roe industry. It also bolstered the case against drastically and adversely requiring complete alteration in methods of manufacture for smoked Great Lakes chub which could have wiped out this industry.

It had been intended to follow up the initial basic findings concerning mechanism of fish lipid oxidation with work to suggest how oxidation in frozen salmon might be minimized. Because of reorganization and termination of the work of the Laboratory, this follow-up work had to be abandoned.

Finally, some basic research on the role of unusual lipids in both sharks and porpoises showed how these lipids are involved with functions of these species.

ALASKA, 1940-81

The Fishery Products Laboratory--later called Ketchikan Technological Laboratory--was built in 1940 and began operation in November of that year. When it opened, it had a staff and budget similar in size to the Seattle Technological Laboratory, including five full-time permanent professional employees. It did not change much in size over the years and is today, in fact, relocated at Kodiak, Alaska, somewhat smaller than it was in 1940.

Research in Alaska, 1940-65.--The Alaska laboratory, funded initially by both the Federal Government and the Territory of Alaska, was established primarily for the purpose of helping the Alaskan fishing industry utilize more species than were then being caught and processed. In 1940 salmon, halibut, and herring comprised 99.8% of the Alaskan fish catch. For all these species, stocks were either dwindling or were inadequate to supply a constant catch.

Initial research sought to develop crabs and clams as major new fisheries

in Alaska. The early efforts to develop king crab, which were directed from Seattle, have already been discussed. Today the Alaskan crab fishery comprises about 25% of the total fish harvest in Alaska. Efforts at the Ketchikan Laboratory in 1940 included as one of the major projects investigating the possibility of harvesting butter clams for marketing on the Pacific coast. At that time, supplies of clams harvested in Washington were diminishing. Preliminary work in 1941 and 1942 showed that there were abundant supplies of butter clams in southeastern Alaska which could be harvested. Later work, however, revealed that the presence of Gonyaulax at seasonal intervals made the clams toxic and inedible. Several years' work was spent trying to overcome this handicap to marketing these clams, such as by instituting a quality control inspection procedure to eliminate toxic clams, but without success.

Later work was conducted over a period of years on investigating preservation and handling procedures for Alaskan shrimp. These investigations have contributed to the success in building up a large Alaskan shrimp industry which currently amounts to more than 20% of the Alaskan fishery harvest.

By the mid-1950s, it was fairly obvious that the best possibilities for expansion of Alaska fisheries lay in developing shellfish resources. More and more of the effort of the laboratory went into work concerning such species. By the early 1960s practically the entire program of the laboratory was centered around aspects of shellfish utilization.

In 1962, when Dr. Murray Hayes became laboratory Director at Ketchikan, he continued to emphasize work on shellfish, particularly king crab and shrimp. He held annual meetings with industry representatives; the laboratory, working closely with the king crab industry, developed standardized criteria for king crab which helped to stabilize this still quite new industry.

From 1940 to 1965, 75 publications were issued resulting from the research and other activities of the Ketchikan Laboratory. Up to 1959, when Alaska became a state, the territory of Alaska supported the Ketchikan laboratory through the Fisheries Experimental Commission and employed individuals on the research staff who in several instances were later employed by the federal government in technological research at Seattle or elsewhere. These staff members included: Howard Craven, John Dassow, John Iverson, and Frank Piskur. At various intervals to 1971, when the Ketchikan laboratory was relocated at Kodiak, the research staff of four to six people included: Alfred Baker, Russel Brown, Clarence Carlson, John Chambers, Donna Galerman, William Hagevig, Robert Kyte, Raymond Landgraf, Carolyn Kelley, Richard Krzeczkowski, Phillip Sautier, Roy Porter, Frederick Stone, Richard Tenney, and Stanley Waskiewicz. Considering that this list does not include temporaries, it is obvious that turnover was a problem in the 31 years of the Ketchikan Technology Laboratory.

Research in Alaska, 1966-81.--The major program change during the period was the closing of the Ketchikan laboratory and the August 1971 relocation of personnel and facilities to the NMFS laboratory in Kodiak. The change reflected the decreasing importance of fisheries in the southeastern Alaska area and the continuing expansion of the shrimp and crab fisheries in central and western

Alaska. During the latter part of this period, the Alaska industry began plans for the development of a large bottomfish potential--pollock, rockfish, flounder, and cod.

During the last 5 years of the Ketchikan Laboratory, under Dr. Hayes and later Jefferson Collins, the staff initiated a major study of pink shrimp processing, including the conditions for precooking and canning in relation to yield and product acceptability. The growing problem of shrimp and crab waste in Alaska was studied in contractual research on potential utilization of crustacean waste for chiotina and chissam production. Studies of the chemistry of king crab and pink shrimp included quality and moisture retentivity factors, composition, and nucleotide studies. Eleven scientific publications resulted from these research activities.

Initial research at the relocated Kodiak laboratory, under supervision of Jefferson Collins, emphasized the physical-chemical characterization of fishery waste effluents with special attention to problems of sampling and analytical methodology. With the completion and publication of reports of this work in 1976, a major research project was initiated on development of bottomfish processing and the specific problem of handling and preserving walleye pollock and other trawl species.

The Technology Laboratory facilites at the Kodiak Laboratory were inadequate for wet fish preservation studies and pilot plant research; therefore, Collins developed separate research facilities in a building constructed by NMFS for storage and enforcement activities at Gibson Cove. One study was also completed on the use of the modified refrigerated seawater system as a method of improving the keeping quality of pink shrimp aboard vessel. In recent years, systematic studies were conducted on quality changes of walleye pollock, black rockfish, and Pacific cod in the refrigerated seawater and ice systems. To date, 10 publications and several industry information reports have been issued on the Kodiak technological research. The current staff of the Kodiak Utilization Unit is Jefferson Collins, program leader; and Kermit Reppond and Dennis Markey, chemists.

Ketchikan Laboratory Directors, 1940-81.

Name	Years
Maurice Stansby	1940-42
Lyle Anderson	1942-45
Harris Magnusson	1945-50
John Dassow	1950-55
Clarence Carlson	1955-57
Eyestein Einset	1957-60
Jefferson Collins (Acting)	1960-62
Murray Hayes	1962-70
Jefferson Collins	1970-71
Jefferson Collins	1971-present*

*After August 1971 the laboratory was relocated to Kodiak, Alaska