

The Montlake Laboratory of the Bureau of Commercial Fisheries and Its Biological Research, 1931-81

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In the Beginning

On 22 May 1931, the new laboratory of the U.S. Bureau of Fisheries opened on Montlake Boulevard in Seattle. An "Open House" was held just before the actual occupancy of the building. Those present included Henry O'Malley of the Bureau of Fisheries and the International Fisheries Commission; Miller Freeman, editor of the *Pacific Fisherman*; and U.S. Senator Wesley Jones, author of the Jones Act. No doubt others prominent in fisheries in the Pacific Northwest and Alaska were present also, along with the local staff members of both the Bureau and the International Fisheries Commission, commonly known as the Halibut Commission.

The report of the U.S. Commissioner of Fisheries for 1930 (1931) notes, "The completion of the new laboratory at Seattle provides the much needed facilities for the Pacific coast biological staff of the Bureau as well as for certain of its other personnel and the staff of the International Halibut Commission." In the report for 1931 (O'Malley, 1932), there is the succinct statement, "On May 22, 1931, the personnel and equipment of the Stanford field station were transferred to the new Fisheries Biological Laboratory at Seattle, including all

of the Bureau's Pacific biological investigations dealing with Pacific coast fishery problems, except shellfish and the cooperative work on California trout."

The actual move did not occur all at once; the period between May and June was the beginning of the summer's work on Pacific salmon, *Oncorhynchus* spp., in Alaska and on the Columbia River, so most of the staff had left or were in the process of leaving for the field. Ed Power, the newly appointed statistical agent for the Pacific Northwest and Alaska, was among the first to move into the building. George Rounsefell and Edwin Dahlgren of the Alaska Herring Investigations were early occupants. Joseph Craig, the new director of the Pacific coast laboratory, was there also, working out problems of space and operating expenses, as well as initiating the one new investigation for Montlake—the study of salmon fisheries on Puget Sound.

The Halibut Commission moved into the Montlake facility in July 1931. At the time, all of the junior staff members were in the field and two of the senior staff were at the University of Washington's Biological Station at Friday Harbor for the summer, leaving Heward Bell in charge of the Seattle office. While the others were away, Bell was given the task of moving the files and belongings of the staff into their new quarters at Montlake. It took months, so the story goes, before the absentees could locate and reorganize their records and personal effects.

The First Decade: The Depression Years

Even these first years, the Montlake Laboratory was the training ground for a number of future leaders in fisheries

research and management. Richard VanCleve, who eventually became Dean of the University of Washington's College of Fisheries, and John Kask, who has served as head of several fishery agencies in the United States and Canada, both attained their advanced degrees at the University of Washington while working for the International Pacific Halibut Commission at Montlake.

Lauren Donaldson, known throughout the world for his work in the selective breeding of trout, *Salmo* spp., and salmon, worked part time at Montlake reading salmon scales. He really did not find the job too interesting, but it provided a means of support during his first years at the College of Fisheries in the depths of the depression.

With one exception, the biological research program at Montlake remained the same as when the work was conducted from Stanford University. The one new program, initiated in 1931, concerned a study of the biology of Puget Sound runs of sockeye salmon under the direct supervision of the laboratory director, Joseph Craig. A small, short-term operation, tagging Rogue River steelhead trout, *Salmo gairdneri*, was started in the winter of 1930-31 and completed the same year.

Continuing programs at the new laboratory consisted of six programs on Alaskan fish: Four dealing with sockeye salmon, one with pink salmon, and one with herring. Specifically, these programs were: 1) Karluck sockeye salmon, *O. nerka*, under Thomas Barnaby, 2) Chignik sockeye salmon under Harlan Holmes assisted by George Kelez, 3) Copper River sockeye salmon under Seton Thompson assisted by Morris Rafn, 4) Bristol Bay sockeye salmon under T. L. Schulte; 5) Alaska pink

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salmon, *O. gorbuscha*, under Frederick Davidson assisted by S. J. Hutchinson; and 6) Alaska herring, *Clupea harengus pallasi*, under George Rounsefell assisted by Edwin Dahlgren.

Work also continued on a program to obtain information for the Bureau of Fisheries to help the U.S. Army Corps of Engineers design a new dam on the Columbia River that would offer minimal interference with salmon runs. This program dealt largely with fish-ladder and fish-screen design for various localities. It was under direction of U.B. Gilroy, a civil engineer, with guidance from Shirley Baker, a San Francisco consulting engineer, who had originally headed this program.

In 1933 Davidson was appointed laboratory director. He was particularly aware of the importance of statistical analysis in the interpretation of the results of fishery research. During his first months as director, he hired Elizabeth Vaughn as the laboratory's statistical analyst. About the same time, W. F. Thompson and the staff of the Halibut Commission began to apply Baranof's theory of fishing to the regulatory problems of the halibut fishery. These were firsts in fishery research. During this same period, Davidson and Eugene Shostrom also undertook a study of the physical and chemical changes that occur in salmon during migration upstream and spawning.

The pink salmon program soon evolved towards studies of freshwater survival of the eggs and young. In 1934, Samuel Hutchinson, the first permanent biologist to be employed at Montlake and later the Regional Director, was placed in charge of establishing a new field station for pink salmon survival studies on Sashin Creek near the Little Port Walter field station in southeastern Alaska. The U.S. Forest Service set aside 2,000 acres, covering the entire drainage of Sashin Creek, as a reserve. Building materials, Bureau supplies, and equipment were brought in on the *Heron* with the help of Edward Dahlgren and LeRoy Christey. The "little green shack" that was built on Sashin Creek in 1934 was used by biologists stationed there until larger and more permanent facilities were constructed in

the fall of 1940; also in 1934, Christey began his studies of the fluctuations in the catch of pink salmon in southeastern Alaska and in the movement of these fish within the commercial fisheries.

Much credit is due to Davidson and Hutchinson for their wisdom and labor in establishing the experimental station on Sashin Creek. Soon this station will also reach its 50-year mark. Over the years it has provided innumerable studies and experiments on salmon and other fish and has contributed much to our understanding.

Although the details are not well known, permanent quarters were also built on Kodiak Island at Karluk near the outlet of the lake. There were similar problems in getting materials and supplies to the building site. In this case, the means was a barge up the Karluk River which in itself is quite an accomplishment.

It was also during this period (1932) that a very extensive tagging program was begun on the herring in southeastern Alaska, using the new metal "belly" tag which can be recovered by a magnetic detection system on the conveyer belts at processing plants. The tagging of herring with internal magnetic tags was first undertaken during the summer of 1932 in Chatham Strait, southeastern Alaska, near Port Alexander. Using the motor vessel *Heron* and a floating herring pot as the tagging facility, George Rounsefell, Edwin Dahlgren, and Samuel Hutchinson tagged and released some 5,000 herring. Many of these tagged herring were caught in the commercial fishery and the tags recovered by electric magnets at the herring reduction plants. It was Ed Dahlgren's ingenuity and extraordinary inventive instincts that led to the development of the internal metal belly tag for tagging herring. He also devised and developed the electronic and magnetic systems for recovering the tagged herring or the tags as they passed through the reduction plant. This was an outstanding research development for determining the magnitude and distribution of the various herring populations in Alaska.

However, the most significant expansion of the fisheries programs in the early years of the Montlake laboratory

occurred on the Columbia River, related to the development of the system of dams proposed for that River. Since 1928, the Bureau of Fisheries had been studying problems and methods of fish passage at various water diversion projects along the Pacific coast, but the effort was not adequate to satisfy the needs of the proposed dams on the Columbia River; Rock Island Dam had already been built, Bonneville was under construction, and Grand Coulee was planned for construction beginning in 1934.

Because of some previous experience in fish counting and fish passage problems at Rock Island and Lewis River dams, Harlan Holmes became the Bureau's fish passage expert. He, along with representatives from Oregon and Washington and the Army Corps of Engineers, solved numerous problems arising from the construction of the Bonneville Dam. It is difficult to describe the character of Harlan Holmes. He was completely dedicated to his work, had a very inquisitive mind, and was continually setting up hypothetical situations which he, or members of his staff, would then try to solve. Milo Bell, who worked with the Washington Department of Fisheries and later became one of the top fishery engineers in the world, tells of the time that Holmes swam up the Rock Island fishways (and almost made it) just to prove that if a man can swim up a fishway, then a salmon should have no problem.

Holmes was transferred to Portland in 1933 or 1934, ostensibly to be close to his work and the offices of the Army Corps of Engineers, although the real reason was simply to get paid. In those days, it was impossible to transfer funds from the Corps to the Bureau; to solve the problem, Harlan simply transferred to the Corps. He remained in Portland until Bonneville Dam had been completed.

In 1939 Holmes returned to the Montlake Laboratory as Biologist-in-Charge of the new Hydraulic Engineering Section, working on the Bureau's growing fish-passage problems in the Columbia River system. The section was to review all Federal power permit applications and to develop, design, and restore fish-passage structures and devices including

fish screens throughout the Columbia River where needed, such as at dams and diversions.

Ole Lindgren was Holmes' design engineer for a short time, and he was succeeded by Scott Bair. Clifford Burner, a University of Washington graduate student hired by Craig and Suomela in early 1938 to do salmon spawning surveys, joined the staff as an engineering draftsman and troubleshooter. Holmes was delighted! When tests were needed, it was now Burner who swam through flumes, ladders, weirs—even the new Burkey electric fish screen—while Holmes took notes from the bank and signaled directions with eloquent whistles and arm-waving. Many of the Columbia River fish-screens were massive, rotary-drum types requiring a field maintenance crew. This crew was headed by Robert Holcomb working out of shops in Yakima, Wash. Russell Lambert, an engineer, was added to the Hydraulic Engineering Section at Montlake, and when Burner was called by the U.S. Navy, Ronald and Esther Barker joined the project as draftsmen.

Holmes and Bair, along with Milo Bell of the Washington Department of Fisheries, became recognized nationally and internationally as an expert team of consultants in the field of "fish hydro" problems. Bair later became design engineer for the Chelan Public Utility Department on Rocky Reach Dam near Wenatchee, Wash.

In 1941, Harlan Holmes succeeded Davidson as Laboratory Director, but typical of his interest and tireless energy, he retained direction of the Hydraulic Engineering Section. Principally for his research in this field, Holmes received the Department of Interior's Distinguished Service Award, its highest honor, with a gold medal, when he retired in 1958.

The first major increase in funds for the Bureau's work at Montlake came in 1934 with the initiation of the very extensive Columbia River Investigations, which were closely associated with the water-use development program for the Columbia River basin. Joe Craig was placed in charge of the new program and his position as Director of the Montlake laboratory was turned over to Fred

Davidson.

The Columbia River Program was sparked by the well known "308 Report" of the Army Corps of Engineers (1933) which outlined the basic plan for the development of a series of multi-purpose dams on the Columbia and Snake Rivers and their tributaries. Information was needed almost immediately to provide the basis for a complete program of maintenance and rehabilitation of the fisheries on the Columbia River. In addition to Joe Craig, who was in charge of the program, Willis Rich served as consultant in the various studies and Robert Hacker compiled the background history and other information on the development of the Columbia River fisheries.

A major part of the Columbia River Program during the first years was the comprehensive survey of all accessible salmon streams in the river system. This survey determined the present condition of the various tributaries and their availability and usefulness for the migration, spawning, and rearing of migratory fishes (i.e., salmon and steelhead). Arnie Suomela, who at his own request had returned to Montlake earlier in 1934, was named head of the Columbia River survey and was actively assisted in the work by Mitchell Hanavan and Zell Parkhurst. There were at least 15 other Bureau employees who, over the next several years, were associated with this program¹. This sudden increase in activity and staff brought with it a need for additional space at the laboratory and thoughts quite naturally turned to the "15 room units" occupied by the International Fisheries Commission (later to be named the International Pacific Halibut Commission).

¹The following were named by Willis Rich (1948) as having participated in the stream surveys at one time or another: Charles Baltzo, Floyd Bryant, Roger Burrows, LeRoy Christey, David Frey, Frank Jobs, Lawrence Kolloen, Ray Langton, Milton Lobell, William (Mark) Morton, Robert Peterson, Richard Shuman, Kingsley Weber, Richard Whiteleather, James Wilding, and Paul Zimmer. Later, Clifford Burner, Willard Brewington, Leonard Fulton, and Harold Gangmark also became a part of this program. The sudden increase in activity and staff brought with it an almost immediate need for additional space at the Montlake laboratory, and thoughts quite naturally turned to the "15-room units" occupied by the International Fisheries Commission (Halibut).

There were many factors associated with the termination of the joint occupancy of Montlake by the Bureau and the International Fisheries Commission. On 18 March 1936, William Thompson wrote the following letter to the U.S. Commissioner of Fisheries, Frank T. Bell:

"The removal of the International Fisheries Commission from the Bureau's laboratory at 2725 Montlake Boulevard is now virtually completed. May I express to yourself and Mr. Higgins our appreciation of the courtesy and friendliness with which we have been treated while guests of the Bureau. I am sure that there has been the utmost good feelings on both sides, something which we hope will persist in the years to come."

Thus ended the period of joint occupancy in the history of the Montlake laboratory.

Although Bonneville Dam was of major concern to the fishery agencies because it was the first dam to be encountered by anadromous fish in their ascent of the Columbia River, the real problem for the salmon fisheries of the Columbia occurred at Grand Coulee Dam located in the middle section of the Columbia River. The dam, claimed to be the largest man-made structure in the world, was some 320 feet high (forebay to tailrace) precluding any hope of either passing the adult salmon over the dam or the young migrants downstream. Thus more than 1,000 miles of spawning and rearing grounds for salmon above the dam were eliminated.

In 1939 a study was carried out by the Washington Department of Fisheries to determine the possible means of preserving the salmon runs that would be blocked by the dam. In due time a plan was developed, reviewed by a board of consultants, and finally approved by the various agencies. Since the U.S. government had jurisdiction over "navigable waters," the Bureau of Fisheries was given the responsibility for the salmon rehabilitation program—somewhat to the dismay of those who had developed the plan.

However, many of the state and Federal fishery biologists had gone to school

together, had worked together on a number of other projects, and helped organize the informal meetings of the Pacific Fishery Biologists at which they met at least once a year. Thus, throughout the project there was much personal cooperation between the staffs of the two agencies.

As an amusing example, one night Wilbert Chapman, always an energetic and capable biologist, was apprehended for murder in Leavenworth, Wash., the center of the Grand Coulee project. There had been a murder in the area and the alert local constabulary noted blood trickling from the trunk of Wib's car. The blood, of course, was salmon blood but Wib had little identification with him and the local police simply could not believe that anyone would be interested in collecting dead salmon. Arnie Suomela, who was in charge of the Grand Coulee project for the Bureau and who just happened to be in Leavenworth at the time, had to convince the local authorities that Wib was really a state employee and the salmon were a necessary part of his work.

The Grand Coulee fish maintenance project continued for 9 years (1939 to 1948) and was the first attempt at massive transplants of salmon runs from their native streams to new, quite distant spawning and rearing areas. There were numerous problems, especially in the early years. The salmon were trapped at Rock Island Dam and hauled by truck to the new "home" streams which appeared to be best suited to the particular species: Nason Creek (Wenatchee River) for spring-run steelhead and chinook salmon, Wenatchee and Entiat rivers for summer-run chinook salmon and fall-run steelhead, and Lakes Wenatchee and Osoyoos for sockeye salmon. Biologists often accompanied trucks and ran chemical analyses for pH, oxygen, carbon dioxide, and methyl orange alkalinity on the water in trucks, rivers, and lakes. As reflected in the counts at Rock Island Dam, salmon that have returned to the area of transplant have generally not only maintained their original levels of abundance but have increased from two- to threefold.

Although not really part of the biological program, the Division of Hatcher-

ies of the Bureau of Fisheries shared in the management of the Grand Coulee fish maintenance program. The Division was responsible for all fish culture operations at the hatcheries and for the physical trapping and transportation of adult fish at Rock Island Dam. Accordingly, in 1937 the Western Regional Office of the Division of Hatcheries was established at Montlake. Fred Foster served as the Regional Director, Clarence Lucas as the Assistant Regional Director, Al Kemmerich as Superintendent-at-large for hatcheries, Hanford Thayer as engineer, and Fred Fish as the fish pathologist. Lauren Donaldson of the University of Washington's College of Fisheries was once again at Montlake as a troubleshooter for the hatchery program, and Robert Rucker, who later became head of the Western Fish Disease Laboratory, began his career at Montlake under a fellowship program.

The center of the fish culture activities relating to the Grand Coulee projects was at Leavenworth, Wash., where there was a very large hatchery complex which included some 288 troughs, about 70 rearing ponds, and an elaborate system for the collection of fish. Fred Fish was in charge of the laboratory at the Leavenworth station to do research on holding adult salmon, artificial spawning, rearing eggs and fish, nutrition, and the control of diseases. In addition to Leavenworth, two substation hatcheries were located on the Entiat and Methow Rivers, where similar research was carried out by Fish's staff.

Other salmon fishery concerns began to surface during this period. For almost a half century, there had been recurring conflicts between the Canadian and U.S. fishermen in Puget Sound and the Gulf of Georgia, where they competed for sockeye salmon bound for the Fraser River in British Columbia, Canada. Finally, in May 1930 the Sockeye Salmon Fisheries Convention was signed, but questions about the role of the Commission in regulation of the fishery, the division of catch between the fishermen of the two countries, and the agency or agencies responsible for the investigations remained unresolved.

To provide background information needed by the U.S. government before

ratification, a new study was begun on the sockeye salmon fisheries of Puget Sound; as noted previously, Joe Craig was in charge of this project simultaneously with his appointment as head of the Montlake laboratory. After his transfer to the Columbia River program, George Rounsefell, who had been in charge of the Alaska herring studies for some 6 years, took over the Puget Sound sockeye salmon study. Shortly thereafter, on 16 June 1936, the convention was ratified by the U.S. Senate; documents of ratification were exchanged on 23 July 1937. The Commission was formally established in October 1937, with W. F. Thompson as Director of Investigations and an independent staff, similar to the organization of the Halibut Commission.

Results of the Puget Sound sockeye salmon study were eventually published by Rousefell and George Kelez (1938), coauthor, but unfortunately they became available 2 or 3 years after the Commission's own research program had been established.

A related program was also started in 1934-35 on the coho salmon fisheries of Puget Sound under the direction of George Kelez. This was one of the early studies by the Bureau on the relation between the release time of young from the hatcheries and the ultimate number of returns of adult coho salmon.

The first major expansion of the Alaskan fishery research program at the Montlake laboratory occurred in 1938 when funds were made available for the beginning of a large, comprehensive program of study on the salmon runs in the Bristol Bay area of the Bering Sea. The program which developed was divided into two major parts. One part of the study was on the freshwater life history of the Bristol Bay sockeye salmon and the environmental factors that would affect their survival.

A field station and experimental area was established on Brooks River, near the outlet of Brooks Lake. This was a beautiful site for study in the Bristol Bay area; it was accessible by float plane from King Salmon, and the lake and river were large enough to provide normal access and spawning and rearing conditions, yet the site was small enough

to allow studies of environmental conditions in some limnological detail. During the first year of study, an adult counting weir was installed in Brooks River, near the outlet of the lake, and the collection of samples of downstream young migrants was started, not only for Brooks Lake but in four other river systems of Bristol Bay as well. George Kelez was transferred from Chignik to take charge of this phase of the Bristol Bay studies.

The other part of the Bristol Bay program was in many ways more exciting because it was the first real study in the United States of the ocean life history of salmon. Tom Barnaby, a veteran of the Karluk studies, was placed in charge of the marine phase of the program. The oceanographic part of the work, an essential part of the study, was done in close cooperation with the U.S. Coast Guard and involved the use of the cutter *Redwing*. In the second and subsequent years, U.S. purse seiners were chartered to explore the availability of salmon on the ocean. These vessels fished with ocean-type salmon gill nets, similar to those used in the Japanese high-seas fisheries. This work was funded primarily by the U.S. Department of State, which sought additional information on the extent of Japanese operations in the eastern Bering Sea and the Aleutian Islands.

It is somewhat ironic that these studies had to be terminated in 1941 with the outbreak of World War II and the invasion of the Aleutian Islands by the Japanese. The general study plan was to begin work in Bristol Bay and each year to fish farther and farther offshore. At the time the work was cancelled, the distribution of salmon over the continental shelf of the eastern Bering Sea as well as around some of the Aleutian Islands had been established, but the more distant waters of the central Bering Sea and the North Pacific Ocean had not yet been explored. Had the work continued for another year or two, the United States would likely have had the information it needed for post-war negotiations at the International North Pacific Fisheries Convention with Japan and Canada in 1952.

The Second Decade, 1941-51: World War II and the Post-War Readjustment

The first 10 years of Montlake's history was marked by the very rapid expansion of the biological and related research programs and a comparable growth of a competent staff of young biologists, led by a group of the top fishery scientists of the time. The programs were new and there was the excitement of discovery and the momentum that would carry the various programs through periods of difficulties. The Montlake laboratory, in a very short period of time, had become well established among the fishery biological laboratories along the Pacific coast, and the staff had gained the respect of their colleagues in other agencies.

The next 10 years, however, saw the gradual disintegration of the research program and the dispersion of the staff. This change began even before the U.S. declared war in December 1941. In 1939, in accordance with the President's Reorganization Plan No. II, the Bureau of Fisheries was transferred from the Department of Commerce to the Department of the Interior, and in 1940 it was merged into the newly formed U.S. Fish and Wildlife Service.

At that time, the Western Regional Office of the Hatchery Division, with Fred Foster, Al Kemmerich, and others, was moved to Portland and became part of the Regional Office of the Fish and Wildlife Service. Then in 1941, Fred Davidson resigned as Director of the Montlake laboratory and from the Bureau. Harlan Holmes was appointed to succeed Davidson, but he soon developed a distaste for the job and asked to be replaced. Willis Rich then served as director (1943-44).

In 1943, Fred Foster, who had been transferred from Montlake to the Regional Office in Portland 2 or 3 years earlier, was appointed the Director of Fisheries for the State of Washington by the newly elected Governor, Arthur Langlie. He almost immediately persuaded two of his old friends and hunting companions at Montlake to join his staff, Joe Craig as Director of Research,

and Arnie Suomela as Managing Biologist. Foster served as director until early 1945. Later that year he received an appointment as Director of Fisheries for the Fish Commission of Oregon. He returned to Washington, D.C., in 1954 as Assistant and later Associate Director of the U.S. Fish and Wildlife Service.

These were war years—1941 to 1945. Following the attack on Pearl Harbor on 7 December 1941, George Kelez, who was in the Navy's Reserve Officer Training Corps (ROTC) Reserve, was called up immediately and Clifford Burner and others on the staff soon followed. Ralph Ferrandini, Victor Samson, Sam Hutchinson, and other members of the staff were assigned to the Office of the Coordination of Fisheries or similar wartime agencies. Funds were kept to a minimum, the use of vehicles was curtailed, and supplies and equipment became increasingly difficult to obtain.

Although many of the research programs were maintained at basically a "standby" level, there were exceptions. In 1942, Tom Barnaby, in George Kelez's absence, took over the Bristol Bay program to finish construction of the field station at Brooks Lake and continue the series of counts at the weir of Brooks River and the sampling throughout Brooks Lake. The Grand Coulee fish maintenance program continued to transplant salmon into new "home" streams through 1943, with 4 years of evaluation afterwards. However, the work in general was limited and there was not the excitement of the first decade.

In 1944 Tom Barnaby was named the new Director of the Montlake laboratory. In the following year, Lionel Walford replaced Elmer Higgins as Director of Research for the Bureau of Commercial Fisheries in Washington, D.C. Elmer Higgins had been head of biological research programs for the Bureau in Washington since 1927 and played a key role in the selection of the site and construction of the Montlake laboratory and in the development of the research program at Stanford and at Montlake. He was especially interested in the problems of the salmon fisheries of the Pacific Northwest and Alaska. He frequently visited these areas and devel-

oped a research program aimed directly at problems of management. Higgins' professional career was almost entirely in the administration of fishery research and he was a very good administrator.

Walford's background and experience were completely different from Higgins'; he was a graduate of Stanford University and had received his doctorate from Harvard. He was a scientist in every sense of the word and his primary interest was in the marine sciences and the marine fisheries. Walford was not happy with most of the research programs of the Bureau of Commercial Fisheries at the time he was appointed Director of Research; he deplored the lack of publications and set about to reorganize the entire research program. He was almost obsessed with the policy of creating "new and exciting" research programs and of bringing into the scientific staff new blood with new ideas. He encouraged transfers of scientific staff between laboratories and programs or into other Divisions of the Bureau.

Sam Hutchinson transferred to the Portland office in 1945 to become the Assistant Regional Director for Fisheries. As a result of Hutchinson's transfer, Mitchell Hanavan was placed in charge of all pink salmon research at Little Port Walter and southeastern Alaska. Eugene Maltzoff and Paul Zimmer also transferred to Portland in 1945, Bill Peck and Mark Morton in 1949, and finally Tom Barnaby, Harlan Holmes, and Zell Parkhurst in the early 1950's. Ed Dahlgren transferred to Washington, D.C., in 1950 to become Chief of the Marine Fisheries section in the Division of Research under Walford.

In the latter part of this period, new faces began to appear at the Montlake laboratory. Ralph Silliman transferred in 1945 from the California Sardine Investigations at Stanford University to be in charge of a study funded by the U.S. Army Corps of Engineers on the population dynamics of salmon spawning in the tributaries of the Columbia River with John Hodges, Harlan Johnson, and Mark Morton. The project ended in 1949 and Silliman moved back to Washington, D.C., to become Chief of the Anadromous Fisheries section in the

Division of Research.

Ken Mosher, who had a long experience with the determination of the age of fishes on the Pacific coast, transferred to Seattle in 1949 to read and analyze the large collection of salmon scales accumulated from previous Alaskan and Columbia River studies.

Gerald Collins was employed at Montlake in 1950 to begin his program on the passage of salmon at dams on the Columbia River.

In 1951, when Tom Barnaby transferred to the Regional Office of the Fish and Wildlife Service in Portland, Cliff Burner became the Director of the Columbia River program and Acting Director of Montlake, and Mitchell Hanavan became Director of Alaskan Investigations.

Some changes occurred in the research program at Montlake in 1950-51. Phillip Nelson began a study of the fertilization of Bare Lake, a small lake on Kodiak Island, in cooperation with Dr. Edmundson of the University of Washington, and new studies were started at Sashin Creek, in the vicinity of Little Port Walter, on the intertidal spawning of pink salmon. There was no change in the research in Bristol Bay or in the herring studies. The research program on the Columbia River was almost entirely oriented toward problems of fish passage at dams, especially in the diversion of downstream migrants away from the turbine intakes and in other sources of mortality.

During the latter half of that decade, the Alaskan research activities were further affected by the development of a highly competitive research organization on the University of Washington campus—the Fisheries Research Institute (FRI) of the College of Fisheries. In 1943 W. F. Thompson had resigned as Director of Investigations of the International Pacific Salmon Fisheries Commission. He was retained, however, by the Commission to complete his reports on the obstruction to salmon migration at Hell's Gate on the Fraser River, British Columbia, and to serve as a consultant to the Commission. The Alaska Salmon Industry Inc., an association of Alaskan salmon packers, approached

Thompson in 1944-45 to undertake a series of extensive investigations of the salmon fisheries of Alaska that was well financed by a self-imposed levy on their annual pack. The research was done by a group of well chosen graduate students from the University of Washington. Finally, in 1947, the FRI was accepted as a research unit of the University of Washington and formally established within the College of Fisheries.

There is no question that results from the research program of the Fisheries Research Institute were of high scientific quality and were well received among their colleagues in the Bureau of Fisheries and other agencies. Unpublished information from FRI's field studies, however, began to be injected by the Alaska salmon industry into the regulations proposed each year by the Alaska Management Division of the Fish and Wildlife Service and gradually became a source of embarrassment to the Bureau and at times a source of almost violent animosity towards the policies (but not the staff) of the FRI—perhaps a fitting end to the chaotic second decade of biological research at Montlake.

The Third Decade, 1951-60: Pacific Salmon Investigations and the North Pacific

In 1952, Walford, of the Bureau's Division of Research, began to reorganize the biological program at Montlake, and in February of that year, he selected Clinton Atkinson as Director of the laboratory. Atkinson was a graduate of the College of Fisheries at the University of Washington, had worked for a short time for W. F. Thompson at the International Pacific Halibut Commission, and then was employed by Thompson as a member of the scientific staff of the International Salmon Fisheries Commission in 1938. He left the Commission 10 years later, to join the Bureau of Commercial Fisheries as Chief of Middle and South Atlantic Investigations. He was involved at the time with a new research program on the shad fisheries along the Atlantic coast and in rehabilitating the Bureau's biological laboratory at Beaufort, N.C., and had little thought

of ever returning to the west coast or to salmon.

The instructions given to Atkinson by Walford were simple: Revitalize the research program at Montlake, create an environment for productive research by the staff, and enhance the prestige of the laboratory through cooperation with other fishery agencies and the industry.

In heading up the new salmon program at the laboratory, Atkinson was asked to develop a research program that would provide a better understanding of the biology and the environment of salmon. However, it was not to include any "management biology," which was the responsibility of the Bureau's Fishery Management Office in Juneau, nor was it to conflict with or duplicate work that was already being done by other fishery agencies along the Pacific coast. After considerable discussion, it was decided that the salmon research program of the Bureau should be combined into a single unit for better coordination of staff and funds. The new organization was to be called Pacific Salmon Investigations, and Clifford Burner was appointed Assistant Director for this program.

The major changes that occurred under the Pacific Salmon Investigations were 1) the establishment of an experimental chinook salmon study area on Mill Creek on the Sacramento River; 2) modification of the Columbia River program into a more comprehensive study of the relation of temperature and water quality to the migration and survival of salmon in the Columbia River, and the initiation of study of predation by squawfish on young salmon in the Columbia River—especially below dams; and 3) survey of the Cook Inlet area prior to establishment of a more permanent study area. The research program developed by Gerald Collins in 1951 for the study of fish passage at Columbia River dams remained unchanged, as did the existing research underway at Bare Lake, Karluk Lake, Brooks Lake, Sashin Creek, and the studies on Alaskan herring².

In 1951 the Army Corps of Engineers prepared a preliminary prospectus entitled "Columbia River Fisheries Engineering Investigations and Research Programs," a broad program designed

to provide design criteria for more economical and more efficient fish passage facilities at the Corps' projects on the Columbia River. Subsequently, a technical committee was formed consisting of the heads of the various research units within the several state fishery agencies and representatives from the Fisheries Research Institute of the University of Washington and the Pacific Salmon Investigations at Montlake.

There were many meetings of this committee over the next 3 years. The relative importance of the criteria was discussed at length in an attempt to determine the best experimental approach to obtain the needed results. There was considerable controversy at times within the committee since each agency and investigator had their pet projects and each was competing for a share of the funds available from the Corps.

Collins was convinced that most of the problems troubling the Corps on the upstream migration of salmon over the dams could only be solved by building a large experimental flume where full-scale fishways could be constructed. As envisioned, salmon, in their normal migration up a fishway, could be diverted into test fishways of various designs, and researchers could compare their speed and ease of passage. Finally, in 1955, Collins' proposal was approved by the committee and the Corps. A test facility was built for his research program adjacent to the north shore fishway of Bonnevile Dam.

²The staff working on the various freshwater studies of the Pacific Salmon Investigations (1952-60) were: Harold Gangmark (Mill Creek, Calif.) with R. Broad, H. Meyer, and later R. Bakkala; Kingsley Weber (Columbia River Environment) with C. Abegglen, D. Craddock, J. Gauley, B. Pullias, and later R. Major and R. French; R. Thompson and Galen Maxfield (Predator Studies and Control) with T. Duncan, B. Patten, K. Liscom, and G. Osterberg; Mitchell Hanavan (Pink Salmon Spawning, Southeast Alaska) with Bernard Skud, Willard Brewington, and Jerold Olson; Philip Nelson (Fertilization Studies, Bare Lake, Kodiak Island) with W. Edmondson, Carl Abegglen, Charles Hunter, and Clark Thompson; George Eicher (Brooks Lake, Bristol Bay) with C. Weaver; Carl Elling (Cook Inlet Studies) with C. Weaver and K. Liscom; and others. In addition to the environmental study program, Larry Kolloen was in charge of the Alaska Herring Studies with Carl Elling and Bernard Skud; Elizabeth Vaughan was the statistical analyst during the first year of investigations.

The results from this laboratory were truly amazing, contributing more to the understanding of the movement of salmon and steelhead in fishways and over dams than any previous research. The results were immediately applicable to the design of fish passage facilities in the mid-Columbia and lower Snake Rivers at a considerable savings in construction cost³.

Less successful were the attempts to develop means of guiding the young, downstream migrants away from the turbine intake and other areas of high loss. The use of sound over a wide range of frequencies had little effect on the movement of the young fish, nor did the use of a moving series of lights⁴.

The most promising method for guiding the downstream migrating salmon, and one with proven application, was the use of a pulsating electrical current to divert fish into areas of safe passage. The costs, however, were high and generally impractical for use in large areas of water with any appreciable flow⁵.

Another valuable development at the Montlake laboratory was the sonic tag—a small capsule with a battery-operated, sound-emitting device which is attached to a fish for continuous tracking in a stream or in the ocean⁶. Also significant was the development of the electronic fish counter which was found to be quite accurate in counting the numbers of salmon ascending the fishways at the Hiram M. Chittenden Locks in Seattle⁷.

There were a number of "fringe benefits" that came out of the electrical guiding/electronics laboratory at Montlake

³Assisting Collins in these studies were: Carl Elling, J. Gauley, C. Weaver, R. Holcomb, J. Johnson, C. Long, H. Raymond, and others.

⁴Sound studies were conducted by Clifford Burner and Harvey Moore; moving light studies were conducted by Leonard Fulton.

⁵Laboratory studies on electrical guiding were conducted under Gerald Collins with H. Newman, A. Groves, G. Monan, C. Long, and S. Dole; field studies were carried out under James Mason with H. Garrett, C. Hunter, G. Maxfield, K. Liscom, G. Esterberg, G. Monan, J. Hughes, J. Smith, and others.

⁶Fish tracking was under the direction of Parker Trefethen, J. Johnson, G. Monan, and K. Liscom with J. Hughes, C. Volz, G. Esterberg, D. Thorne, and C. Bartlett.

⁷Fish counting was under the direction of Julius Rockwell with R. Bergstrom and G. Lucich.

during this period. It is now remembered as a mildly unconventional unit, always coming up with some new device or idea. Many still recall Chuck Volz's demonstration of a headless fish swimming across the tank on a pulsating electrical current. But there was also the experimental application of electronic sensors for monitoring water quality at remote locations, in fresh water or at sea, and the little device that would indicate the freshness of fish. None of these developments reached the stage of practical application—they were regarded as 20 years too early, but they did open the eyes of the fishery biologists to the application of electronics to their work, and this was a valuable contribution⁸.

The other new phase of research at the Montlake laboratory was on the high seas of the North Pacific and was under review by the U.S. section of the International North Pacific Fisheries Commission. This treaty was negotiated in 1952 and ratified in 1953, but the Commission was not formally organized until February 1954. In January of that year the biological laboratory at Montlake received a call from Washington, D.C., requesting that it devise, almost overnight, a research program for the U.S. portion of the work, that is, a program to determine the areas and degree of intermixing of Asian and North American salmon in the North Pacific. The program which it proposed on such short notice was the obvious one, focusing on distribution, movement or migration, and identification of stocks of salmon and the oceanographic factors that affect all of these.

After considerable discussion at the first meetings of the U.S. section of the Commission, it was finally agreed that the research tasks would be divided between the biological research group at Montlake and the University of Washington as follows: Studies of movement and migration of salmon by the Fisheries Research Institute, studies of oceanography by the Department of Oceanography, both of the University of

Washington, and studies of distribution and identification of salmon by the staff at Montlake. This decision united the work and the staffs of the Bureau and the Fisheries Research Institute and closed the gap that had gradually developed between the two groups over the preceding years.

Preliminary explorations for salmon in the offshore waters of the Aleutian Islands were made in 1953 by the *John N. Cobb*, mainly to develop the techniques of fishing for salmon with gill nets on the high seas. The first survey to determine the distribution of salmon in the eastern North Pacific Ocean was made in the spring of 1955, again by the *John N. Cobb*, and was followed later that year by similar cruises of two chartered halibut schooners, the *Mitkof* and the *Paragon*. Wherever these vessels fished in the northern part of the Gulf of Alaska or along the Aleutians (north of about lat. 48°N and out to long. 175°E), salmon were taken. Studies of the distribution of salmon continued with the use of the *John N. Cobb* and various chartered halibut schooners, and by 1961 the general distribution of salmon in the North Pacific Ocean and the Bering Sea had been firmly established⁹.

The probability that the biologists at Montlake could identify and separate stocks of North American and Asian salmon was less certain. It was true that in previous studies, differences had been found between certain stocks of fish, but in general, these differences were lost when all the stocks in the fishery were mixed together. Fortunately, the major concern of the United States was protecting the sockeye salmon of Bristol Bay, and this species, because of its characteristic history of remaining in different freshwater environments or a year or more before going to sea, have the greatest probability of detectable differences. Therefore, the first studies at Montlake were on this species.

Although the 1955 results were preliminary, there were indications that the Japanese high seas mothership fleet was

taking significant numbers of Bristol Bay sockeye salmon. This was based on an analysis of growth patterns in scales examined by Kenneth Mosher, an expert in scale analysis who transferred from the Bureau's sardine studies at Stanford University in 1949. Although both the Japanese fishermen and the scientists had apparently been aware of the dominance of a different sockeye salmon in the mid-Aleutians, which was "probably North American in origin and probably from Bristol Bay," the findings by Mosher and the rapid progress being made in the other studies of the North Pacific came as a shock to the members of the Japanese section of the International North Pacific Fisheries Commission. Japan increased active participation in the Commission's research program almost immediately¹⁰.

Scales alone, however, were not adequate to separate North American and Asian stocks of sockeye salmon with any acceptable degree of accuracy. Accordingly, the research program for the identification of salmon stocks was built around a very comprehensive study of differences in the anatomical structures of salmon, e.g., number of fin rays, vertebrae, scales along the lateral line. A large number of these characteristics were examined and finally 7 were chosen that would provide the greatest degree of separation between North American and Asian sockeye salmon¹¹.

Because of the amount of data required and the complexity of the analysis itself, the only possible way to obtain the results was by use of a computer. Computer systems were not too common in those days and it required much discussion, correspondence, and justification before Montlake got its computer, probably the first fisheries biological laboratory to begin the regular use of automatic data processing equipment for

⁸C. Volz, H. Dale, R. VanHagen, D. Thorne, K. Compton, C. Gillespie, and others.

⁹The Ocean Salmon Studies were under the direction of Mitchell Hanavan with Richard Hajny, George Tanonaka, Douglas Weber, Richard Johnson, Eugene Hill, Robert Ting, and others.

¹⁰Kenneth Mosher was Project Leader with Ray Anas, Mabel Casterlin, and the part-time assistance of Ted Koo and Richard Hajny. James Mason joined this unit later.

¹¹The Sampling Unit for Racial Studies was under the direction of Alvin E. Peterson with R. Duncan, L. Nakatsu, W. Meyer, C. Fiscus, and others. The Analytical Unit for Racial Studies was under Francis Fukuhara, with Sueto Murai, Jack LaLanne, George Slusser, Roger Pearson, George Beam, and others.

storing and analyzing data¹².

Two other methods were used at the Montlake laboratory to support and confirm the identification and separation of the salmon stocks on the high seas. First, the development and use of serological techniques allowing researchers to identify stocks through the presence or absence of certain antibodies in the blood of the fish. Second, the then-new method of electrophoretic analyses allowing researchers to examine the protein composition of blood and tissue; a method commonly used in the genetic studies of fish and in implants of genetic tags¹³.

As noted earlier, a very important part of the North Pacific salmon studies was the tagging program carried out by the Fisheries Research Institute of the University of Washington (under a Bureau contract)¹⁴. The initial problem was how to capture salmon on the high seas leaving them uninjured and suitable for tagging. A method of purse seining for salmon on the high seas was developed which proved to be especially effective in this particular study. In 5 years, 1956 to 1960, the Institute tagged more than 60,000 salmon north and south of the Aleutian Islands and lesser numbers in the northern part of the Gulf of Alaska. The returns from both Asia and North America defined the patterns of intermixing for the various species of salmon across the North Pacific and in the Bering Sea¹⁵.

In the following years the results from the work carried out at Montlake and the FRI revealed the extent of the catch of Bristol Bay sockeye salmon by the Japanese high-seas salmon fisheries in the mid-Aleutian area. Understandably,

the Japanese section of the Commission was quite reluctant to accept the findings of U.S. scientists because of the impact on their fishery; in general, the Japanese maintained that definition of "areas of mixing" applied to all species combined. Finally in 1960, based on the results obtained by U.S. scientists and their counterparts in Canada and even Japan, the Commission agreed to consider the areas of mixing on a species by species basis, opening the way for recognition of the preponderance of Bristol Bay sockeye salmon subject to capture by the Japanese high-seas fisheries.

In 1956 the U.S. section of the Commission began to question the contribution being made towards the U.S. portion of the Commission's research on the North Pacific problems and decided to terminate the University's contract. The Montlake laboratory's scientists were left in somewhat of a dilemma. First, they recognized that there was a relationship between ocean conditions and the distribution of salmon on the high seas: A temperature barrier to salmon both to the north and to the south had already been detected and needed further study. Second, Japan, Canada, and the Commission were giving considerable attention to oceanography in their research programs, and it was essential that the United States participate in these studies. Thus, in a few months and with other funds, an oceanographer, Felix Favorite, was added to the staff and an oceanography program was underway at Montlake¹⁶.

Two other research projects were assigned to the Montlake biological staff by the U.S. section of the Commission. The first was to develop proof that the U.S. stocks of salmon, halibut, and herring were being managed properly and were fully utilized in order to qualify for abstention from fishing by Japan and Canada. The results of these studies were subject to endless arguments with the Japanese scientists over the adequacy and interpretation of the data. Finally, however, the staff was able to show that

while salmon and halibut did indeed fulfill all of the treaty requirements for abstention, herring, due to economic and other problems had not been fished commercially to any extent since World War II or before, and did not qualify¹⁷.

The second research project dealt with king crab, *Paralithodes camtschatica*, stocks in the eastern Bering Sea. This work was not an original part of the tripartite treaty between Japan, Canada, and the United States but was requested by the United States at the organizational meeting of the Commission in February 1954 and was limited to study only. The request for the study was the result of efforts by Lowell Wakefield, a member of a pioneering and well-known fishing family in Alaska who had acquired and outfitted a high-seas crab processing vessel, the *Deep Sea*, and was intent on developing a U.S. king crab fishery in the eastern Bering Sea. The Japanese had operated a king crab fishery in this area during the late 1930's and re-entered the fishery in 1952 after the signing of the peace treaty. Wakefield was anxious to develop a mechanism for exchange of information between the two countries and also to keep this fishery under the "umbrella" of the Commission, should problems arise.

Almost nothing was known of the biology and populations of king crab in the eastern Bering Sea or elsewhere in Alaska. But within an 8-year period (1956-64), the complete story (life history, rate of growth, migrations, survival, and numbers of crab in the area) was developed by the group at Montlake.

On one occasion during the research, the group was stymied in their efforts to determine the age and growth of the king crab. They had many samples of the very young and there was no problem in obtaining samples of the large crabs taken by the commercial fisheries. However, missing was a size group in between that eluded all conventional methods of sampling. Finally, early one spring, two scuba divers from the staff went to the area in the eastern Bering Sea where these crab were most likely to be found and were able to collect the

¹²The original Biometric Unit was under the direction of R. Fredin, with Robert Lander, Donald Worlund, and others. Later, Sueto Murai and Murray Amos were transferred into this group.

¹³George Ridgway was project leader with G. Klontz, L. Holmes, and others.

¹⁴The tagging program was under the direction of Allen Hart and Benjamin Jones with Albert Palmer and others.

¹⁵W. F. Royce, a former and long-time employee of the Bureau (Woods Hole, Honolulu, and Juneau), was appointed Director of the Institute upon the retirement of W. Thompson in 1958. Subsequently, Thompson served as Consultant to the Montlake laboratory's biological program until 1965.

¹⁶In the next several years, as the oceanographic program developed, J. Hebard, Timothy Joyner, Patsy McLaughlin, Betty Morris, and W. Ingraham were added to the staff.

¹⁷The cases for abstention were prepared by R. Fredin and others in the Biometrics Unit.

necessary samples, like butterflies, of the missing group. This was one of the very early applications of scuba in biological studies¹⁸.

As support for the staff of the expanded biological program at the laboratory (and especially for those working on international problems) grew, a literature research unit was established to assist the scientists in the search for and retrieval of literature needed in their studies. More importantly, the unit developed the capability for translating Japanese, Russian, and Chinese literature—a valuable aid in all of the studies on the North Pacific fisheries¹⁹.

In 1956 Congress enacted laws reorganizing the Fish and Wildlife Service into two divisions: 1) the Bureau of Commercial Fisheries and 2) the Bureau of Sport Fisheries and Wildlife. The plan also added a Commissioner of Fisheries and an Assistant Secretary for Fish and Wildlife. In 1957, Arnie Suomela, who had joined the Montlake laboratory's staff in 1934 and was a part of the early history of the laboratory, was nominated and confirmed as the first Commissioner of Fish and Wildlife and held this position until the change of administration in 1961 and his subsequent appointment as fishery attache in the American Embassy in Tokyo.

Under the new organization, the Alaskan operations were placed under the Administrator for Alaska Commercial Fisheries, Donald McKernan. As part of the reorganization plan, all biological research associated with the Alaskan fisheries (with the exception of the research being performed for the International North Pacific Fisheries Commission) was transferred to Juneau. Some of the staff also transferred to Juneau at that time, but project leaders and most of the staff requested reassignment elsewhere. Subsequently, the Alaska biological laboratory was established at Auke Bay, near Juneau (the establishment and

subsequent development of the Alaskan research program is given in another section of this review).

So ended the third decade—one of the most exciting decades in the 50-year history of the Montlake laboratory. The period was marked by very rapid expansion of research programs, by the rapid accumulation and development of the staff, by new ideas and the application of those ideas, by a continuing critical review by scientists in other agencies, both in the Pacific Northwest and Alaska and in Canada and Japan. The accomplishments by the staff are still classics in fisheries research today.

The Fourth Decade, 1961-70: Return to the Environment

By 1961 many of the major goals of the North Pacific and fish-passage research at the laboratory had been met, often under great pressure and urgency. The 1960's became a time to evaluate the application and the value of completed research and to plan for the future. The research climate at Montlake became noticeably more relaxed and a number of new research facilities were constructed.

In 1962-63 the *George B. Kelez*, a converted U.S. Navy surplus vessel, was acquired which allowed, for the first time, our oceanographic and high seas salmon studies to be extended into the winter season. Previously, schooners and seiners had been chartered for spring and summer work, but they were too small for safe winter operations far offshore and they lacked adequate space for laboratory studies and for gear storage and repair.

In 1964, work began on the new addition to Montlake—a fully modern laboratory, library, and conference room/auditorium of some 65,000 feet². In 1967, a new 215-foot ocean research vessel, the *Miller Freeman*, was launched: It was carefully designed to provide laboratory space and equipment for the North Pacific studies. In addition, several field stations were established on the Columbia River and Puget Sound.

This was also a period of further analysis and the publication of summary reports of research results from the past 10 years of work. For example, the In-

ternational North Pacific Fisheries Commission directed the scientists of the three countries to jointly prepare comprehensive reports on the accomplishments and interpretation of the results of the Commission's research programs since its first meeting in 1954. It was during the early part of this period that the Montlake laboratory initiated the massive compilation of all significant salmon research literature into a salmon compendium—probably the first attempt of its kind for a more efficient system of fishery literature search and retrieval²⁰.

In 1964 Ralph Silliman, who served as Chief of the Section of Anadromous Fisheries in Washington, D.C., from 1949 to 1961, was selected as one of six senior scientists by the Bureau of Commercial Fisheries, and in the next year he moved to the Montlake laboratory to continue his work on the population dynamics of fish—a series of basic studies on the relation between population size and the ultimate production or yield from a stock of fish. Silliman remained at Montlake until his retirement from the Bureau of Commercial Fisheries/National Marine Fisheries Service in 1973.

By the early 1960's the critical information required by the U.S. Army Corps of Engineers for the passage of adult salmon at dams had been obtained at the North Bonneville laboratory, and the attention of this unit shifted toward the more difficult problem of the downstream passage of the young, migrant salmon over the dams on the Columbia and Snake Rivers. The mortality of the young salmon passing through the turbines was evaluated, studies were started on the movement of the young fish in and through the large impoundments behind the dams, and the whole problem of diverting and/or collecting the young salmon at dams was reviewed. Perhaps most significant was the discovery of mass mortality caused by the supersaturation of gases, mainly nitrogen, in the tail waters below some of the dams. The unit also began exploring the feasibility of transporting the young fish by barge or truck around several of the

¹⁸The king crab research was under the direction of Fred Cleaver and Tak Miyahara with Henry Sakuda and others. In many respects, the use of the vessel *Deep Sea*, provided without cost, was an integral part of these studies along with other help and the assistance of Lowell Wakefield.

¹⁹Paul Macy was in charge of literature research with Elizabeth Keyser, Sherry Pearson, Art Priddy, and others.

²⁰The system was suggested by W. Thompson and compiled by Galen Maxfield.

dams in the Snake River²¹.

At the same time, the research being done for the International North Pacific Fisheries Commission also began to change from the primary concern for the sockeye salmon taken each year by the Japanese high-seas fisheries to the distribution and fate of the chinook and chum salmon from the Yukon River and other streams flowing into the eastern Bering Sea. Around 1964 the Commission's scientists began to examine the groundfish fisheries of foreign vessels operating in the Bering Sea off Alaska²².

In 1964-65, Atkinson served as Assistant Director for Research with the Bureau of Commercial Fisheries in Washington, D.C., and in 1966 he resigned as Director of the Montlake Biological Laboratory to become the fishery attache with the American Embassy in Tokyo, Japan. During this period, Clifford Burner was the Acting Laboratory Director at Montlake.

Shortly thereafter, Gerald Collins was appointed Director of the Laboratory and Francis Fukuhara, who had previously led the difficult research of identifying and separating North American and Asian sockeye salmon, was chosen to be the new Assistant Director. There was considerable reorganization within the program and staff to allow for a greater emphasis on research relating to the effect of the environment, both freshwater and marine, on the movements and survival of salmon and other fish.

With the new *Miller Freeman* and the *George B. Kelez* as a core, there was a marked expansion in the oceanographic programs at the laboratory.

A salmon aquaculture program was established at the Montlake laboratory in 1967 with a laboratory and field station at Manchester, Wash. The program of aquaculture research included all phases of rearing salmon in saltwater pens, e.g., nutrition, stock selection,

and temperature control. Within a short time, this laboratory was able to demonstrate the rapid growth of coho salmon, *Oncorhynchus kisutch*, in saltwater rearing pens from 0.3 ounces to marketable size (0.5 pounds) in about 6 months. Similar work has been done on other species²³.

Two new research units were established in 1968: Studies on the physiology and biochemistry of fish, and the effect of thermal and petroleum products (and other environmental contaminants) on fish. In addition to the Montlake laboratory, a total of six field stations operated during this period for research on fish passage and environmental problems: The Adult Fish-Passage Laboratory at North Bonneville, Wash.; the Juvenile Migrant Biological Field Station at Pasco, Wash.; the Environmental Field Laboratories at Prescott and Hammond, Oreg.; and the Environmental Pollutant Laboratory at Mukilteo, Wash.

Although the fourth decade did not have the rapid development of new research programs experienced in the previous 10 years and perhaps lacked much of the associated excitement of discovery, the biological research program was anything but dull. The completion of the large new addition to Montlake with greatly improved laboratory facilities and the availability of a modern research vessel for ocean studies alone must have been an inspiration for the staff. The total staff at the end of this decade was almost 200, nearly double the number employed in 1961²⁴.

However, of greater significance was the broadening and reorienting of the biological research programs at Montlake towards multispecies studies of the fisheries of the North Pacific and the

development of environmental criteria for fish found in both fresh water and in the ocean. The results of this work provided perhaps a 10-year advantage to the fishery regulatory agencies of the Pacific Northwest and Alaska in enforcing several acts that would become effective in the next decade.

The Fifth Decade, 1971-81: A Period of Change

The fifth decade is marked by major changes in the organization of the U.S. Fish and Wildlife Service and the Bureau of Commercial Fisheries, and in the direction and demands of the biological research program at the Montlake laboratory by important new legislation.

On 3 October 1970, all functions of the Bureau of Commercial Fisheries (excluding certain freshwater programs such as the Great Lakes, work involving the Alaska pipelines, and similar investigations) were transferred from the Department of the Interior to the Department of Commerce and placed under a newly created agency, the National Oceanic and Atmospheric Administration (NOAA)²⁵. The Bureau was recreated as the National Marine Fisheries Service (NMFS). One of the problems that arose during the early stages of reorganization concerned the structuring of the various research activities and laboratories within the NMFS. This was not a new problem. Although the biological and research laboratories had reported to Regional Offices since the reorganization in 1956, many of the programs carried out by these units were broad in scope, extending beyond regional jurisdiction and were even responsible, in some instances, to international organizations.

Shortly after the creation of the Na-

²¹Although incomplete, the staff associated with the fish-passage studies in 1963 included Gerald Collins, Carl Elling, Joseph Gauley, Leonard Fulton, Parker Trefethen, John Hughes, Daniel Bates, Clifford Long, and Alan Groves.

²²Although incomplete, the staff associated with the North Pacific research in 1963 included Francis Fukuhara, Robert French, H. Larkins, Charles Hunter, Jack LaLanne, Roger Pearson, Thomas Dark, George Ridgway, Fred Utter, Betty Landrum, Kenneth Mosher, and Raymond Anas.

²³The Aquaculture Station was under the direction of Conrad Mahnken, Anthony Novotny, Timothy Joyner, C. Hunter, and others.

²⁴The Marine Research Program was under the direction of Francis Fukuhara with Herbert Larkins (Groundfish), Richard Major (Identification of Fish Stocks), Richard Thompson (Marine Behavior), Robert French (Ocean Distribution/Abundance of Salmon), Felix Favorite (Oceanography), and Harold Hodgins (Physiology and Biochemistry). The Freshwater and Estuarine Research Program was under the direction of Carl Elling with Alan Groves (Behavior Laboratory), Daniel Bates (Fingerling Collection), Howard Raymond (Migration Rates and Timing), Clifford

Long (Turbine Studies), George Snyder (Prediction of Environment), Leonard Fulton (Production in Inaccessible Area), James Johnson (Sonic Fish Tracking), Wesley Ebel (Transportation of Migratory Fish), and others. The Service Units included Reynold Fredin (Biometrics Institute), Winston Farr (Engineering and Gear Development), Roger Pearson (Publication Unit), Gerald Monan (Staff Services), Ralph Sandvigen (Vessel Operations), and Beryl Mortensen (Administration). Roy Robeck and Harry Jacobsen were Masters of the *George Kelez* and the *Miller Freeman*, respectively.

²⁵Reorganization Plan No. 4 of 1970 (84 Stat 2094).

tional Marine Fisheries Service, Robert White, the Administrator of NOAA, addressed the issue of organizing research. He appointed an internal committee to study the problem and recommend action, and he employed an independent consulting firm to make a similar study and recommendations. Dayton (Lee) Alverson from the Montlake laboratory was a member of the internal committee.

The recommendations of the two study teams were basically the same. Two groups were established to conduct research. One group conducting primarily oceanic research would report to the appropriate Associate Director of the National Marine Fisheries Service in Washington, D.C., while another group conducting shore research, local in nature, would report to the Regional Director. Four fishery research centers concerned with marine studies were established, of which the Montlake laboratory was one; four inshore and estuarine laboratories were established, of which the Auke Bay Laboratory near Juneau was one.

The Pollution Laboratory at Mukilteo, the Environmental Laboratories associated with the Columbia River programs, and Fisheries Engineering (Fish-Passage) program, the Aquaculture Station at Manchester, and a field station at Kodiak, Alaska, all remained with the newly established Northwest Fisheries Center (NWFC) at Montlake²⁶.

As a result of the studies, all vessels under the NOAA programs were placed into a vessel pool, available to all but beyond the control of any single unit.

In 1976 the National Marine Fisheries Service realigned its organization and functions in order to administer the new and expanded responsibilities it assumed as a result of the 200-mile fisheries conservation zone legislated by the Magnuson Fishery Conservation and Management Act. The four regional fisheries centers were given full responsibility for both the biological/environmental and fisheries utilization research. The Auke Bay Laboratory had been a part of the NWFC since 1974 and continued under the administration of the newly named Northwest and Alaska

Fisheries Center²⁷.

At the time of the establishment of the Northwest Fisheries Center at Montlake in 1971, Alverson, who had been with the Exploratory Fishing and Gear Development Unit at Montlake since 1958, was appointed Center Director. Brian Rothschild served as the Deputy Center Director for the first year and was then replaced by A. T. Pruter, a former associate of Alverson's in the Exploratory Fishing Unit who was working at the time at NMFS headquarters in Washington, D.C. Alverson remained Director of the Center and the Montlake laboratory until his retirement in October 1979. Francis Fukuhara then served as Acting Director until his retirement in February 1980, followed by Murray Hayes. The new Center Director, William Aron, was appointed in July 1980²⁸.

The biological research program during this last decade was strongly influenced by the passage of several laws: The National Environmental Policy Act of 1969, the Federal Water Pollution Control Act of 1972, the Marine Mammal Protection Act of 1973, the Endangered Species Act of 1973, and the Magnuson Fishery Conservation and Management Act of 1976. In addition, the laboratories at Montlake, and later, Auke Bay also participated in a number of cooperative programs, including the Outer Continental Shelf Environmental Assessment Program (OCSEAP) of NOAA and the Bureau of Land Management; the Processes and Resources of the Bering Sea Shelf (PROBES) Program of the National Science Foundation; and the Marine Resources, Monitoring, Assessment, and Prediction (MARMAP) Program of the National Marine Fisheries Service.

As a result of the reorganization, the biological programs of the joint staffs of the former Montlake laboratory and the Exploratory Fishing and Gear Development Unit related to resource management were placed into three major divisions: Resource Assessment and Con-

servation Engineering (RACE) Division (formerly Fish, Shellfish and Oceanography Studies), Resource Ecology and Fisheries Management (REFM) Division, and Coastal Zone and Estuarine Studies (CZES) Division. The Environmental Conservation (EC) Division (in part) and the Fisheries Data and Management Systems (FDMS) Division are described elsewhere in this review²⁹.

The first 2 or 3 years as part of the new NOAA organization were difficult for the biological programs of the Northwest and Alaska Fisheries Center at Montlake and the other Centers. Funding was limited and staffs had to be markedly reduced. Because of the costs of vessel operation, the oceanographic studies, begun near the end of the previous decade, were among the hardest hit. The *Miller Freeman* could not be operated for the oceanographic studies in 1971, and the *George B. Kelez* was decommissioned and taken out of the fleet in 1974. The Center was unable to participate in the national multiagency MARMAP Program involving the basic collection of oceanographic data on ocean currents, water properties, and food patterns in the North Pacific. Most research was limited to addressing the original research requirements of the International North Pacific Fisheries Commission program and to finishing existing field studies.

The marine biological program at

²⁹When the Center was first established, there was no change in project leaders from the previous organization of the laboratory: Francis Fukuhara (Marine Fish, Shellfish and Oceanography), Gerald Collins (Coastal Zone and Estuarine), and Reynold Fredin (Fisheries Data and Management). Resource Assessment and Conservation Engineering (RACE) Division is under the direction of Murray Hayes with R. Wolotira (Shellfish Assessment and Ecology, Kodiak, (MARMAP)), Miles Alton (Multispecies Assessment (MARMAP II)) including R. Mintel (Survey Strategy) and W. High (Foreign Cooperative Research), B. F. Jones (Conservation Engineering), and M. Nelson (Hydroacoustic Assessment (MARMAP II)), and assistants. Resource Ecology and Fisheries Management Division (REFM) is under the direction of R. Marasco and includes L. Low (Division Data Management), J. Ingraham (Descriptive Oceanography), T. Laevastu (Ecosystem Model Development), A. Kendall (Ichthyoplankton Investigations), R. French (Foreign Observer Program), R. Marasco (Socio-economic Models), G. Hirschhorn and J. LaLanne (Age and Growth Studies), J. Balsiger, R. Francis, K. Henry, J. Reeves, R. Major and others mentioned above (Status of Stock Models and Evaluation), and assistants.

²⁷The history of the Auke Bay Laboratory is found in another section of this review.

²⁸At the present time, the Center's Administrative Unit consists of Center Director Dr. William Aron (vice D. Alverson), Deputy Director Hiro Heyamoto (vice A. Pruter), and Senior Scientist and Scientific Consultant Maurice Stansby, with G. Tanonaka, L. Low, C. Gill, A. Wilson, M. Barrett, E. Zweifel, and assistants.

²⁶Originally named the North Pacific Research Center but changed shortly afterwards to the Northwest Fisheries Center.

Montlake began to recover about 1975-76 with the new responsibilities and funding made available from OCSEAP and the enactment of the Magnuson Fishery Conservation and Management Act of 1976.

The Resource Ecology and Fisheries Management Division was given an especially important role in the development of the management plans and policies for the U.S. and foreign fisheries operating in the northeastern Pacific Ocean and the Bering Sea. The immediate demands were great: The scientists at the Seattle and Auke Bay laboratories had to assemble the available information on the life histories and fisheries of the various species of fish and to define the optimum harvesting schemes for each species for use by the Pacific and North Pacific Fishery Management Councils. Especially difficult were the Fishery Management Plans for the groundfish fisheries involving mixed catches of the various species. The preliminary plans were developed within a very short period, reviewed, and became a part of the Councils' management program in 1977.

In the years that followed, the direction of the program shifted toward the problems and information necessary for the prediction of the abundance of fish and the optimum level of harvest in the near future as a base for the management plans that must be prepared for each coming year.

The age and growth studies became an essential part of the forecast since results indicated the relative abundance of young fish entering the fishery in each successive year. It began as a modest program and a carryover from the early days at Montlake, but in 1980, ages were determined for some 92,000 wall-eye (Alaska) pollock, *Theragra chalcogramma*; Pacific whiting, *Merluccius productus*; Pacific cod, *Gadus macrocephalus*; rockfish, *Sebastes* spp.; sablefish, *Anoplopoma fimbria*; and yellowfin sole, *Limanda aspera*.

Of similar importance and use is the study of the abundance of eggs and larval fish collected by fine-mesh nets from the spawning-nursery areas in the North Pacific and the Bering Sea. The information gained from these studies provides a direct link to the effect of the ocean environment on the survival of

commercially important fish at the very young and critical stage of life.

During 1975-76, the oceanographic studies took on new meaning and purpose, and over the next several years, an eight-component ecosystem model (DYNUMES) and a prognostic (or predictive) bulk biomass model (PROBUB) were developed. These models have proven most useful in evaluating the complex interactions between the marine biological and oceanographic conditions. For example, by the use of these computer models, it is now possible to predict with some accuracy the size and fluctuations in abundance and distribution of the various species of fish, and the effect of varying intensities of fishing on the different stocks of fish as well as the environment. These analyses provide a most valuable tool for fishery management and rank as one of the outstanding accomplishments of the fifth decade at Montlake.

This unit is also responsible for placing observers aboard foreign fishing vessels to collect information on the size and composition of the catches and other information on the operation of the fisheries within the U.S. 200-mile fisheries conservation zone. This is a large program, involving about 90 observers in 1980, with volumes of narrative and data reports which are valuable not only for the management of the U.S. foreign fisheries but also for the fishermen in their efforts to develop fisheries in this offshore area.

The Resources Assessment and Conservation Engineering Division focuses on the other objective of the Magnuson Fishery Management and Conservation Act, that is, assisting in the development of U.S. fisheries both within the coastal area, and more important, in the 200-mile zone. In developing a fishery, the fisherman usually asks three questions: How many fish are there, where are the greatest concentrations of fish, and what is the most efficient gear for catching them? This very succinctly defines the work of this division.

At the present time, most of the effort is devoted to surveys of the important fishing areas to determine the relative abundance of the fish in the different areas. The studies continually involve new techniques that can be used to more accurately census the abundance of the

fish in the ocean. For example, a great deal of attention is being given to the use of very modern sonic or acoustical equipment that will detect and continuously identify major concentrations of fish as the vessel moves from one area to another. The unit is also developing new shrimp and herring "samplers."

In connection with ocean surveys, this unit conducts most of the basic biological studies on the populations of various fish. They have undertaken innumerable tagging studies on the North Pacific stocks of fish (rockfish, Pacific cod, sablefish) and many of these have been undertaken cooperatively with state and university research groups of several states and with the scientists and agencies of Canada, Japan, Republic of South Korea, and the Soviet Union.

The Division of Coastal Zone and Environmental Studies operates the fish-passage program developed by Gerald Collins in the early 1950's. Expanded considerably in scope during the 1960's, it has been under the direction of Wesley Ebel since the establishment of the Center in 1970. The Division has three major sections: Aquaculture, ecological effects of dams, and habitat investigations³⁰.

Since the beginning of the fish passage program, the results have provided important criteria for the design and preparation of the dams on the Columbia River. A substantial part of its present funding still comes from other agencies. The deleterious effect of dams on the runs of salmon and steelhead ascending the Columbia River has become even more pronounced in the past 2 or 3 years. Many of the runs of chinook and coho salmon ascending the rivers are now declining markedly, causing much concern to the fishery agencies of Washington, Oregon, and Idaho. One of the principal causes of this decline is the loss of migrants as they pass over or through the dams on the Columbia River or the lower Snake River.

In 1970, CZES estimated that the effect of the two dams on the lower Snake River at that time reduced the survival

³⁰Snyder and the personnel from the Oregon field stations were transferred in 1978 back to the Coastal Zone and Estuarine Studies (CZES) Division, where they had been until 1972, because their work on salmon in the Columbia River then was more closely associated with the program of CZES Division than with EC Division.

of migrants by 50 percent. The major causes of this loss are the passage of downstream migrants through the turbines, the heavy predation on the weakened fish just below the dams, and the association of the fish with the supersaturation of nitrogen or other gases in the water below the dams.

Methods have been devised to collect and transport young salmon and steelhead around these dams and avoid these sources of high mortality. CZES also conducts work on the survival of hatchery and wild fish in the estuarine areas, and studies the behavior of adult salmon near the dams by use of a radio tracking system, to determine the effect of dam operations on the migrating salmonids.

Studies have also been made of other causes of mortality in the lower Columbia River estuary. Three areas of work have now been completed: The effect of dredging in the lower Columbia River, the toxicity of the discharge from the cooling towers of the Trojan Nuclear Power Plant, and the effect of chemical fire retardants on salmonids. The results of these studies have had immediate impact on decisions made by a number of Federal and state agencies.

Fisheries enhancement studies conducted at Manchester, Wash., on Puget Sound demonstrated in the first years that rapid growth can be obtained by rearing coho salmon in salt water. Subsequent work has focused on ways in which the present methods used can be made more economical. A *Vibrio* disease has been identified and a method of mass vaccine developed. A number of studies have been made that will increase the returns from aquaculture, including the development of rearing strategies of salmon from freshwater through saltwater stages, broodstocks of salmon kept for their entire life in saltwater pens, and, perhaps most interesting, methods of rearing spot prawn successfully in pens with salmon at a more rapid growth than those found in natural conditions. For instance, harvestable shrimp (40/pound) can be grown in 12 months and "prawn-size" shrimp (16/pound) in 24 months.

In summary, the biological research program at Montlake over the fifth and last decade can best be characterized by

two words—change and success. There has been the vast reorganization of commercial fisheries within NOAA in the Department of Commerce followed by a period of austerity, reduced staffs and the elimination of a number of the programs and activities. There has been the centralization of all research activities into four major Centers and the introduction of multi-disciplinary approach to our fishery problems. There has been the effect of legislation which placed new and primary responsibilities upon Montlake and its research staff for criteria needed in the maintenance and management of the fisheries in the North Pacific and Bering Seas. The research programs that were aimed during the third and fourth decades toward the more basic research are now more applied and are considered by many to be "management biology." And, at last, use is being made of the vast amount of data that the Montlake laboratory has accumulated over the years.

It is perhaps a fitting conclusion that the end of this decade and the first 50 years of the Montlake laboratory, was marked by the retirement of D. L. Alverson and the appointment in 1980 of William Aron as the new Director. Aron is no stranger to Seattle nor to the Pacific Northwest. Although born on the east coast, he did his graduate work at the University of Washington, receiving his Master's Degree in 1956 and his Doctorate in 1960. He took part, indirectly, in the activities at Montlake at that time and often relates that it was the money received through a contract between the laboratory and the Department of Oceanography at the University of Washington that helped him survive during those lean student years. The work that Aron did under that contract provided him with material for his first publication.

We end the fifth decade and begin the next 50 years at Montlake with no great change in program nor organization but a heritage of accomplishment and dedication of the many scientists who worked at the laboratory over the years, setting standards for others to follow.

In addition, there are other assets characterizing the Montlake laboratory that Aron recognizes and is intent on following. There has been the spirit of

growing cooperation between the Northwest and Alaska Fisheries Center and the universities and other agencies, the industry, and the community as a whole; these ties will be strengthened even further to solve the fishery problems that each year are becoming more and more complex. Aron is also very much aware of the plans to retain as far as possible the depth of scientific expertise that has been characteristic of the Montlake laboratory over these 50 years, and the ability of the scientists to be able to respond to new challenges that will certainly arise in the future development and management of the fisheries and the maintenance of the resource. These are the thoughts that have been so well expressed in the theme of this 50th anniversary, "Fifty Years of Cooperation and Commitment," and this remains Aron's goal for the future.

Acknowledgments

This history of the biological programs and research would not have been possible without the help of a number of "old timers" who, individually and collectively, have recounted and documented the events that occurred at the Montlake laboratory during the first 10 years or so. We are especially grateful for the assistance given us by the following: Thomas J. Barnaby, Heward Bell, Clifford J. Burner, Lauren Donaldson, Samuel J. Hutchinson, Edward A. Power, Robert R. Rucker, and Arnie Suomela. We also wish to give special recognition to William Markham Morton, who until his recent death, had undertaken a compilation of the biographies of a number of his colleagues at the Montlake laboratory. The material, which he presented in the first two volumes, has provided innumerable references to dates and events reported in this text.

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