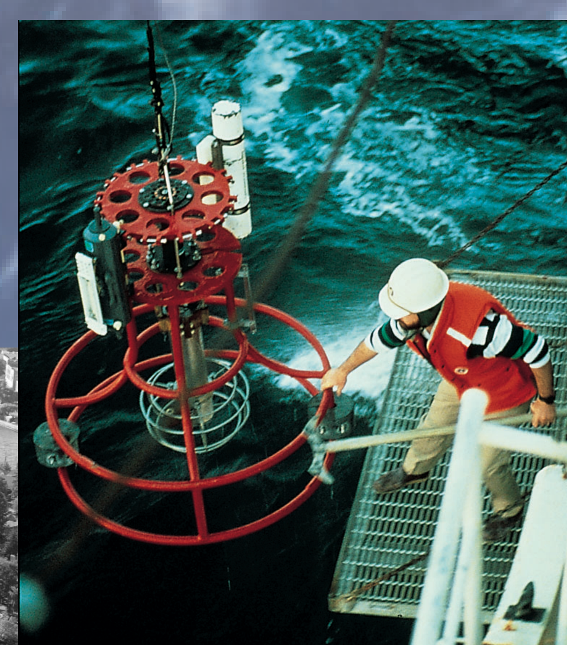
The Northwest Fisheries Science Center

Celebrating **70 YEARS** of cutting edge fisheries research

The Northwest Fisheries



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Science Center

FROM THE SCIENCE DIRECTOR

Thank you for joining us in our celebration of 70 years of science at the Montlake science complex. Because we are a government agency, our scientific accomplishments over the years have been to better serve you, the public, ensuring that you and the next generations can wisely use and enjoy anadromous and marine resources well into the future.

Seventy years is a long time and it is not possible to cover everything that has happened in one event or document, but I hope that you will leave this celebration with a better understanding of who we are today and how we got here.

The scientists and staff at the Center are the heart of our programs and accomplishments. If it weren't for them, we wouldn't have much to share with you. It is their hard work and dedication, spanning seven decades, that have brought us to where we are today, and I would like to take this opportunity to thank all Center employees, both past and present.

This publication introduces just a few of the scientists who have worked at the Center to increase our understanding of the biology and ecology of the Pacific Northwest's rich waters. This is a sampling of the range of scientists who work at the Center—behind each one, please remember that there are at least 20 or 30 more.

The Center has a wide range of programs, and I hope that this publication and the anniversary celebration will pique your interest in finding out more about the science that we conduct. In another 70 years, the Center will be a very different place than it is today, but its evolution will be forever rooted in the people and programs of the present.

Usha Varanasi

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Celebrating 70 years of Science

THE MONTLAKE FACILITY & THE NORTHWEST FISHERIES SCIENCE CENTER

From mussels and clams to chinook salmon, from microscopic plankton to Orca whales, the chilled seas of the Pacific Northwest teem with marine life. This corner of the North Pacific Ocean is truly a cornucopia of extraordinary resources.

Pacific Northwest is also home port to one of the world's largest concentrations of fishers and fishing vessels, ranging from plywood skiffs to ocean-going trawlers equipped with massive nets and seafood processing plants. Seafood harvesting is a $1 billion-a-year-business here, not including tribal fisheries and countless numbers of recreational anglers.

Marine resources are finite and rationalizing the myriad users to ensure that fish stocks are sustainable well into the future has become an increasing challenge for marine science and management. And for 70 years, this challenge has been met by a cadre of seasoned scientists at the Montlake facility, a quiet complex tucked away in its lakefront niche on Seattle's Portage Bay.

The Northwest Fisheries Science Center (NWFSC), a part of the National Oceanic and Atmospheric Administration's National Marine Fisheries Service, operates its Montlake laboratories next to the Seattle Yacht Club and just across the water from the University of Washington. The Center's task is to peer beneath the monochromatic gray surface waters of the oceans, streams, and rivers and unravel the mysteries of Northwest salmon and marine life.

Over the past seven decades, this science complex has gone through several name changes. More importantly, its very mission has shifted—from helping fishermen harvest and process valuable seafood to an emerging role as guardian of these exhaustible resources and the environments they depend on.

The Center conducts the science that the government needs in order to help conserve and manage living marine resources in the Pacific Northwest.

As evident by its name, the Northwest Fisheries Science Center is about science. The Center conducts the science that the government needs in order to help conserve and manage living marine resources in the Pacific Northwest. The research that Center scientists conduct is directly applied to both current and future anadromous and marine resource issues. This is in contrast to much of the research that is conducted at universities around the area, where the focus is on more basic research, which, while equally important, may or may not be directly applied to the management of our fishery resources.

All of the NWFSC's research is driven largely by an important set of laws—especially the Magnuson Fishery

VOICES OF THE CENTER: PAST AND PRESENT

This publication provides a brief glimpse at a few of the Center's scientists. Each has taken a moment out of their busy schedule to share with us how they found their way into science, the nature of their work, and its importance to the region and to the nation as a whole.

These snapshots are just a sampling of the diversity of people who work at the Center, but they provide an excellent glimpse into the Center's core—its scientists and staff.

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Conservation and Management Act, the Marine Mammal Protection Act, and the Endangered Species Act. Each of these laws, enacted in the 1970s, provides mandates for the NWFSC and the four other NMFS regional fisheries science centers around the country. As these legal mandates have changed over the years, through a number of amendments, so has the mission of the NWFSC.

Center scientists try to answer questions that come up in the management process: How many fish of a certain species can be safely harvested without overfishing the resource? How can we improve the quality of fisheries data used in making decisions? What causes toxic shellfish poisoning, and how can the risks to human health be minimized? Which salmon populations require protection as endangered species, and what factors have contributed to their decline?

NWFSC scientists spend their days—and sometimes even nights—trying to answer these questions, but as hard as they try, they know the answer is never final because that is the nature of science.

Science is a constantly developing endeavor. Even as one question is answered, new questions arise and new techniques must be developed for addressing them. Many factors contribute to the scientific process, including available technology and the ingenuity of the scientists.

Today's NWFSC is a meeting place of many disciplines. As recently as a generation ago, the Center was made up mostly of fisheries biologists who worked in relative isolation from other researchers. But modern science requires an interdisciplinary approach that involves biologists, chemists, geneticists, toxicologists, and many more.

The Center's approach to science is to ask the right questions in the right order. Just as some ecosystems have "key" species that may be indicators of ecological health, there are key questions that help unravel the unknowns in fisheries science that are most relevant to management decisions. Once these questions have been addressed, scientists communicate what they have learned to decision-makers, constituent groups, other agencies, industry, and academia. These are the Center's partners with whom they have open discussions and conduct cooperative research.

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Every corner of the Pacific Northwest is touched by the Center's science. You can find scientists conducting research in just about every type of habitat, from the coastal oceans of Oregon to the inland reaches of the Snake River in Idaho. These scientists are answering important questions that benefit everyone who lives and works in the Pacific Northwest.

GROWTH AND DEVELOPMENT

In order to understand what the NWFSC does today, it is important to understand where it came from. The institutional genealogy of the Science Center can be traced back to more than a century ago, when fisheries scientist David Starr Jordan persuaded the government to locate a Bureau of Fisheries research laboratory at Stanford University, where he was president.

The Bureau was interested in salmon, especially the huge salmon populations of the Northwest and Alaska. Early researchers knew little about the anadromous nature of salmon, but by the end of the World War I, they were beginning to understand the complex life history of the well-traveled fish that moved from fresh water to estuarine to marine waters and then retraced its path several years later.

Every corner of the Pacific Northwest is touched by the Center's science.

However, at that time, the government also had another interest in the geography of the Pacific Northwest—the untapped potential for hydro-electric power from the mighty Columbia River. In the 1920s, the U.S. Army Corps of Engineers began sketching plans for a series of dams. Aware of the potential impact on migrating salmon, Congress, in 1928, appropriated funds to the Stanford laboratory to study ways to get fish around the dams.

In May 1931, the government moved the Stanford laboratory to Montlake, the current location of the NWFSC. Led by Willis Rich, scientists began to study the natural history of Northwest salmon, learning more about its complex life cycle, which would create the foundation for later genetic studies. At the same time, the Montlake laboratory started researching hatcheries to enhance regional fish stocks, including those stocks that suffered from the new dams.

Year by year, the Center expanded its research, especially with the acquisition of a modern research vessel, the John N. Cobb, in 1949. The Cobb became the primary research platform for a new program whose mission was to survey the North Pacific Ocean for under-utilized fish resources.

We had no idea what was out there," recalls Dayton Lee Alverson, who joined the exploratory team in the 1950s and later served as the Center's science director. "Our job was to find out."

Those exploratory cruises detailed vast fisheries—enormous concentrations of cod, pollock, flatfish, and other species that were being harvested by foreign factory ships—or not at all.

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Walter Pereyra, then a young researcher on the crew, recalls the atmosphere onboard the Cobb. 'It was unbelievably fertile ground for research, for open and honest inquiry. It also exposed me to groundfish, the culture and romance of the fishery. We really had the feeling that we were discovering something new and important." And they were.

This work eventually opened the largest and richest fishery in the world. A 1964 report by Montlake scientists predicted that "expansion of these fisheries … appears to be just a matter of time and economics."

But the authors also warned that expanded fisheries "will complicate the problems of conserving and managing groundfish resources."

With the building of the Columbia River dams, science at the Center had largely focused on the upstream

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DR. VERA TRAINER

Dr. Trainer is manager of the NWFSC Marine Biotoxin program that works with harmful algal blooms, commonly known as shellfish poisoning or "red tides."

I have flexibility and choice and, most important, the ability to make a difference.

I've always liked the natural world, and the outdoors. So I decided that marine science sounded like an interesting thing to do. My professor at the University of Miami gave a lecture on harmful algal blooms, red tides, and I thought: Now that is interesting. How does this work? One thing led to another, and I've been working with harmful algae ever since.

I was hired here in 1996. I had the opportunity to work with Jack Wekell, building on his knowledge, bringing in some new insights. On paper, I'm the manager. But each of us in the Biotoxin group has a specialty and we depend very much on each other. One of us identifies the algae that cause the harmful blooms. Another does most of the fieldwork. Another analyzes seawater samples for toxins. And I try to keep it together.

There's a lot of bad information out there about harmful algal blooms. There's the myth that shellfish are safe from toxins only in months with Rs in them. Or that a silver spoon will turn dark if there are toxins. Or there's even the taste test. Actually, some people have used their pets to test for toxins. They would throw a shellfish gut to a cat. And there have been several cases of pets dying from PSP.

But this is serious stuff. Lately we've had people hospitalized with shellfish poisoning. I've talked to people down at the beach, and they'll tell me: "We've been eating these clams for years. There's a story being made up by government."

Some of our work is reactive—emergency response to algal blooms. There are outbreaks now and then, and we are set up to respond on a moment's notice to California or the Washington coast or wherever.

But some of our work is proactive. A big word in government these days is "forecasting." Although algae are not as hot as salmon, what we have in common is the desire to predict what will happen in the ocean. We're not out there to stop harmful algal blooms from happening, but to learn how to live better with the situation. That may mean opening a fishery a little earlier or a little later.

Without the Olympic Region Harmful Algal Bloom Project, we would never have enough information to make that call. It's a collaboration among the tribes, state and federal agencies. The tribes consume a lot of shellfish, but they also have commercial shellfish harvests, and now they're looking at things like mussel aquaculture. The Makahs, for example are used to gathering shellfish in the winter, and they want to continue to do that. They run the risk of being poisoned by harmful blooms. So we're trying to work with them to make shellfish safe to eat.

It started with the Quilleute Tribe. There had been an outbreak of domoic acid in California. We spoke with the tribe, and we were able to get a little money to continue a rigorous program that they had started several years ago, monitoring seawater and toxins in razor clams. It turned into a terrific program that set a precedent. They took samples once or twice a week, and this provided baseline data to put a story together. And it turned out to be a really big year for algal blooms.

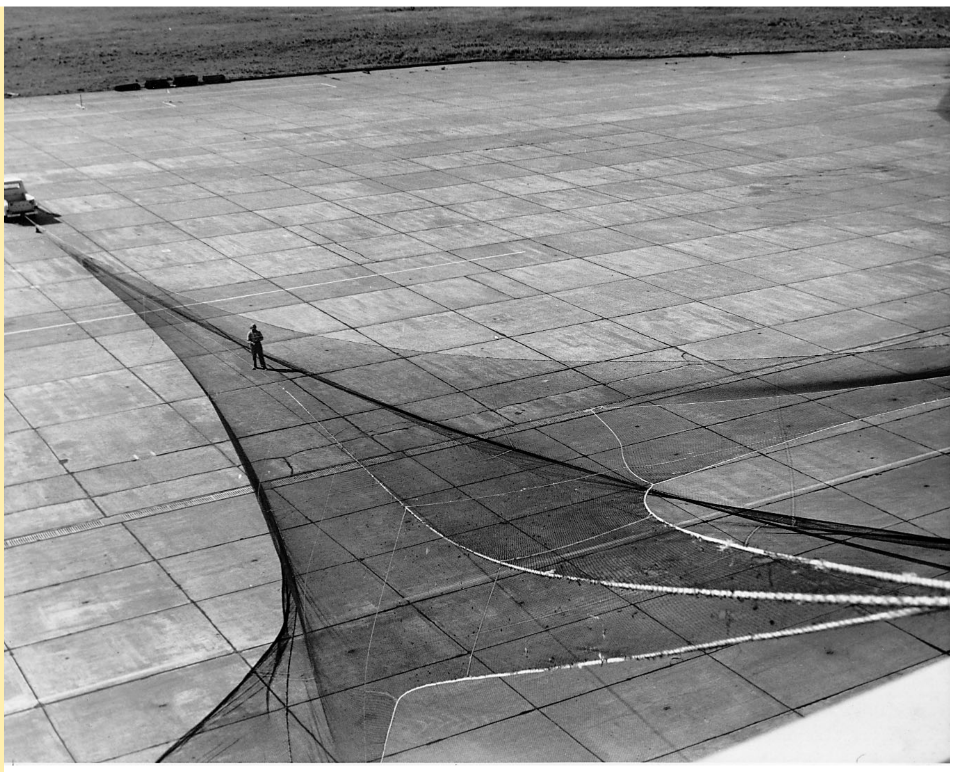
Now that program is being used by NOAA as a template for other regions, to establish monitoring programs for harmful algal blooms around the nation. Each area has its unique problems, unique organisms. But our partnership is so strong.

This is just one example of the changes that we're seeing in the fishery sciences. We're studying algae, but it's all inter-connected. Monitoring algae also applies to fish and whales, and ultimately to ourselves.

We're out there in the world. People see the results of our work. All the politics can be frustrating, but there are opportunities here to publish research papers, forge collaborations with other groups, print newsletters on harmful algae blooms. We can have a real impact on our field of science.

Now there's the possibility of a test kit, like a pregnancy test, that could be used in the field to determine if there are toxins out there. Or a monitoring device that could be placed on moorings. We're only a couple years away from this. We don't develop the technology. We assist companies out there that want to do that. But it's going to happen.

I try to look for what my unique role could be in the field. As an academic, I would get a grant and do my own little project. Working for the government has changed my sense of mission. Rather than thinking about what I can do for my career, I think about how I can impact the community, how I can help people work together to solve a problem. *There's great power in that.*



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migration of spawning fish. Later, researchers began to pay more attention to the downstream hazards faced by juvenile salmon. The problem: how to prevent the massive loss of migrating juveniles that were sucked into hydroelectric turbines or died from exposure to supersaturated water below the dams. Eventually Montlake scientists came up with a solution: collect the young fish and transport them downstream in trucks or barges—an innovative strategy that continues today.

In the mid-1960s, Montlake scientists developed a bold, new quantitative approach to studying fish populations, enabling them to assess the health of a population based on careful analysis of its age structure (i.e., the distribution of juvenile and adult fish). Fish stocks could then be predicted and management policies could be determined based not solely on past catches, like they had been previously, but on statistical projections of future stocks.

The 1960s also saw Montlake's first venture into aquaculture. A new research station in Manchester, WA began to cultivate salmon—a development that was to prove crucial to conservation efforts three decades later. The pioneering work of Conrad Mahnken and colleagues at Manchester made a significant contribution to the emergence of salmon farms, which have now spread around the globe to the extent that farmed salmon now dominate the world market.

As research at the Center continued to expand, the Center added a new research wing (the East building) in 1964 that tripled the size of the Montlake facility.

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GRETCHEN PELROY

Gretchen Pelroy has worked at the NWFSC since 19 . Presently she is the division coordinator or the Resource Enhancement and Utilization Technologies division.

Originally, I wanted to be an artist, but I decided I would never be able to make a living in art, so I paged through the University catalogue, and "bacteriology" came right after "art," so that was that.

I graduated in microbiology, and came across a bulletin board notice of a job here. It said: "HE will do this and HE will do that." So I called and asked: Would you consider a woman? And they said: Sure.

So I was hired, and I've been here all these years.

They had a contract to look at radiation pasteurizing—irradiation. It was about processing and product quality —not so much about safety to begin with. We were looking at chemical changes in the fish, how many and what kinds of bacteria were destroyed by irradiation.

Then I went to work on a project dealing with fish protein concentrate. They cooked up fish, extracted and dried it and you ended up with a protein-rich powder. It was a national program, and it was good stuff. You could add it to donuts, and one donut would have the protein of an egg and two slices of bacon. The only problem was: There was no market. The countries that needed it couldn't afford it.

Somewhere that program is still sitting on a shelf. That's too bad.

About that time there were outbreaks of botulism linked to smoked fish products. The products were vacuum packed, but didn't have enough salt and were abused by sitting in an unrefrigerated truck over a very hot weekend. Botulism is dangerous because it doesn't always have a bad odor to give warning and some people don't even taste anything wrong. The key to preventing it in these products is proper packaging, preservatives like salt, and refrigeration. We developed safety guidelines that are still used.

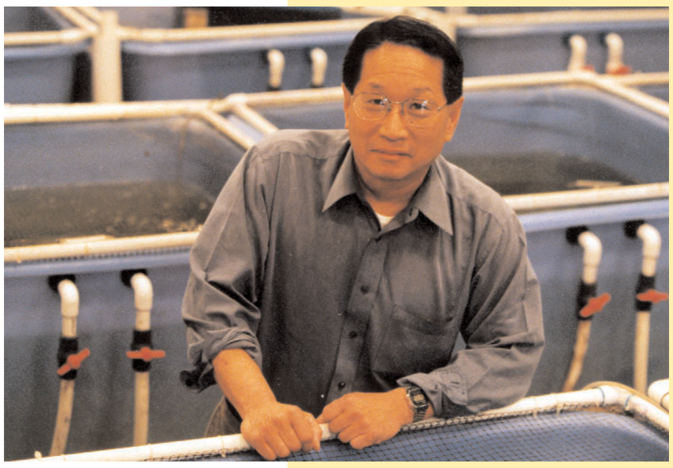
In the 1990s, we worked with listeria. There had been a big outbreak linked to cheese, and some 150 people got sick and about 40 of them died. Most people just get diarrhea and that's it, but people with weakened immune systems are highly susceptible. The organism is destroyed by cooking, so it is mostly a concern with ready-to-eat foods. The problem is, it can grow at low temperatures—even in the refrigerator.

Food poisoning is a difficult problem. The FDA was faced with shutting down a lot of fish-processing plants because they were finding listeria everywhere. We worked with the FDA

I worked in the lab for many years. Now I'm in administration, and I work mostly on budgets. I miss the lab work, but I do get exposed to what other people do at this center. Many people don't understand that most of the people who work in government science are truly dedicated to their work. They're smart, well-educated, and very passionate about what they're doing.

DR. ROBERT IWAMOTO

Dr. Iwamoto came to the NWFSC in 1992. He directs the Resource Enhancement and Utilization Technologies division and the Center's Operations, Management and Information program.



I'm a geneticist by training. Early on, as an undergrad and graduate student, I studied the genetics of fruit flies. But eventually I decided to focus on fish genetics, which had the added benefit of being able to eat what I studied, so I came to the University of Washington. There I specialized in fish breeding programs and, when I received my PhD, I spent several years in the commercial aquaculture sector, both as a researcher as well as learning how to run businesses.

When I came to the NWFSC, I worked with Earl Prentice on PIT tags. He brought me on to help develop an acoustic tag that would have a longer range. You have to be very close to the PIT tag to read it. We wanted something equally small that could be interrogated from 20 feet away. Eventually, it was not feasible, given the technology of those days.

Later I helped with implementing salmon survival studies on the Snake River. We would purse seine juvenile fish from the river and implant PIT tags to get survival estimates of juveniles as they passed through the dams. Until then, we were relying on old data, so these new estimates were a big part in getting a better idea of how improvements to the hydropower system affected survival. That project continues today.

Over the years, we've added interrogation systems to more of the dams—all the way down to Bonneville Dam, so we have more reliable estimates from the headwaters to Bonneville. That gives us a much better handle on the survival and mortality of juvenile fish in the freshwater phase. And if we know the survival of adults returning to Bonneville Dam, by simple subtraction, we also have a better handle on saltwater survival.

The center has changed even in the time I've been here. The big change was in 1997, when it was real obvious we had to be reorganized to meet new needs. We needed more mathematical modeling, greater ability to measure cumulative risk to listed salmon runs. And we needed expertise in groundfish. Those changes were hard on some people, but it needed to be done.

We've learned that we have to be more flexible, because we have no way of predicting things like the Exxon Valdez. These days, with some of the changes that have taken place recently, we have the capability to adjust to events like that.

The next big issue might be something like homeland security. We could find ourselves dealing with pathogens like botulism or listeria. We used to do a lot of that kind of seafood safety research and we still have some of the staff and the infrastructure to switch gears. The key is to maintain flexibility and core expertise.

And there are likely to be big changes in hatchery programs. There's much criticism of hatcheries because they haven't helped salmon recovery, but that's not what they were initially designed to do. We have to continue to help hatcheries contribute to harvest, and at the same time we need to develop new techniques and mindsets for using hatcheries to help with salmon recovery. Some of the hatchery improvements like substrate on the bottom, cover over raceways and structure in the water appear to work well in fresh water. But will they translate to overall survival including the saltwater phase? We're making headway in that area, and I think a lot of the same principles that we've learned from salmon research can be applied to depressed groundfish stocks. What we don't want to do is to make the same mistakes we made with salmon, but to learn from those experiences.

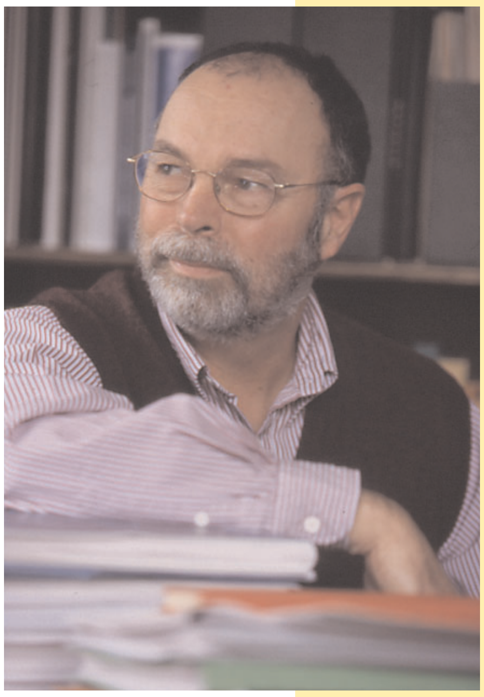
DR. MICHAEL SCHIEWE

Dr. Schiewe has been at the center for 30 years and directs the Fish Ecology division.

We occupy that niche between the ivory tower and the constituency groups. Our constituency used to be fishermen, but today it's far broader than that. We have legislation that drives us. The Magnuson Act defines our role in commercial fisheries, so that's why we do stock assessments, and we work for better management of salmon.

And now we're driven more and more by the Endangered Species Act.

I had a fisheries degree from Humbolt State, and I took a summer job pulling net for the Bureau of Commercial Fisheries down at Astoria. It was an interesting summer. We were trying to index the outmigration of juvenile salmon, so we could get an early estimate of abundance. We sampled all over. Along the way, I learned a lot about fishermen, all these tough Finns who were still gillnetting on the river.



I stayed in touch with people at the Astoria Field Station, and was able to get back on as a temporary biological technician in 1971. We looked at problems with gas-bubble disease, the nitrogen narcosis created by the dams.

I went back to school, got a masters in 1976 and PhD in 1980. And I became a division director in 1991, just as the ESA petitions started coming in. That really changed this institution. We found ourselves with a lot of general salmon ecology and biology experience, but little quantitative science, population dynamics, that kind of thing.

Fisheries have changed in recent years, mostly in that direction. It's no longer the country biologist testing which way the wind's blowing. You need to measure things, analyze things.

So we started getting these petitions, and it was clear we were going to be buried by that. In 1994, we launched this systematic review of all West Coast salmon populations. That led to listing of 29 different salmon populations.

That change was difficult, but necessary. In the old days, we practiced fish management from the harvest side. We needed to move toward conservation science, preventing species from going extinct. So we added some people and created a conservation biology program.

We were interested in cumulative risk. Salmon were dying from a thousand cuts. If you continue to try to Band-aid each of those cuts, you'll never make it. So we created a team that could bring the risks together and deal with them in a holistic way. That was pretty successful.

Of course, all this has a political dimension. Fish agencies frequently don't do a good job of separating their science from the politics. But we're fortunate that the structure of NMFS is such that each center is independent, which allows us to keep the science separate.

Take Snake River dams, for example. We take no laboratory position, per se. We basically collect information, which can be used to support other people's positions. There's not much question that those four dams are very hard on the fish populations. But the way they're operated now is far less hard on the fish. Are those operations a silver bullet? No. Would the fish be better without those dams? Of course they would be. But that's a societal question.

We're moving in the right direction. It's slow, but we're becoming more quantitative and more diverse. At one time, virtually everyone here had some connection with the University of Washington. Now we have people from Harvard, Stanford, North Carolina. And they're not all fisheries biologists anymore; they are ecologists, zoologists, mathematicians, geneticists. That helps.

We're also getting away from single-species management and moving toward ecosystem management. That's the way the world works. Will we ever understand it well enough to manage it? No, because these things are incredibly complex. It's hard to push on one side and predict what's going to come out the other. But it argues for being a bit more precautionary instead of trying to push things to the edge.

This center has had profound influence in a variety of ways. In those earlier years, my predecessors worked the political system and opened up a new fishery, wrested it away from the Russians. They were way out in front, facing all sorts of scientific challenges. Our colleagues at Manchester conducted the pioneering research that laid the foundation for salmon aquaculture that is now flourishing around the world. Then we played a role in responding to the Exxon Valdez oil spill. And now we are trying to make the ESA work.

People ask: What should we do? What does the science say? And we respond: Well, the science says there used to be that many fish, and now there are this many… And people ask: But what should we do?

Scientists don't make those decisions. We elect public officials to do that. But we do have opinions. As Congressman Joel Pritchard once told me: The most dangerous person is the one who has a lot of facts, and no judgment.

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In 1970, federal fisheries was reorganized and the Montlake Center became part of the National Marine Fisheries Service (NMFS) under the National Oceanic and Atmospheric Administration (NOAA), an agency of the Department of Commerce. The Montlake laboratory became the Northwest and Alaska Fisheries Science Center.

During the 1970s, the Science Center shifted more from the exploration of new fisheries, which occurred primarily in the 1950s and 1960s, to the management and protection of existing marine resources. Congress had passed a new wave of environmental legislation, including the Magnuson Fishery Conservation and Management Act of 1976, which extended federal control of coastal waters from the historic three to 200 miles, and gave the federal government sweeping new powers and more money to study and protect these areas.

Although exciting, these new laws meant more work for the Center's scientists. The new 200-mile zone teemed with unfamiliar species, such as pollock and whiting, which became new targets of opportunity. However, as many fishermen found out, the flesh of these species degrades quickly after being caught, making them unattractive to potential buyers. Center scientists isolated the enzyme responsible for the fishes' fast degradation and devised a process for making surimi, a fish byproduct originally developed by the Japanese, which is now a valuable worldwide commodity.

During the 1970s, the Science Center shifted more from the exploration of new fisheries, which occurred primarily in the 1950s and 1960s, to the management and protection of existing marine resources.

As the fish food industry continued to develop, a new hazard became apparent—the food-borne pathogen Listeria monocytogenes, which affected ready-to-eat products, including cold-smoked fish and cooked crab and shrimp. Center scientists, led by Mel Eklund, studied the sources of this contamination and various methods for controlling this pathogen. The results were transferred to industry, which prevented serious human illness and saved many companies from going out of business.

Scientists also continued to improve their methods for estimating fish populations, using age and growth studies of fish to predict future management needs. Trained observers on fishing boats provided the precise harvest data that the scientists needed to monitor the success of their computer models and refine them as necessary.

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DR TRACY COLLIER

Dr. Collier is a fisheries scientist who has been researching the effects of marine contamination on fish for nearly 30 years.

I was an otherwise-normal kid who wanted to become a zookeeper, and then a paleontologist, and finally decided I wanted to do something with fish and marine sciences. I guess I always saw myself going out on big boats and doing high seas stock surveys. And I knew there was a fishery center next door to the University of Washington, so I thought I would try to get a job.

I applied when I was 16 years old, and they just kept saying “we’re not going to let you take the exam.” I wrote letters off to my congressmen, and Sen. Warren Magnuson called them and told them, “I want that kid to take the exam.”

They set up a special exam for me. I didn’t even drive, so my mom had to drive me to downtown Seattle. I was the only person in this huge room. So I took this exam and then I got passing scores and they said I could be hired—except you’re still not 18 years old.

When I was 18 and I started at the UW School of Fisheries, I came back and I said, “Now can I get a job?” Well, things had changed and there were no jobs. So Sen. Magnuson wrote another letter to Lee Alverson, and found me a job.

I think I was about the only person under 40 in the group. I worked with a terrific scientist, researching membrane fluidity and contaminants. I didn’t have a clue what I was working on. I wanted to go out and work on the big boats, but they stuck me where I couldn’t cause any trouble. So I was working with these guys doing all this weird biochemistry and biophysics. It didn’t make any sense to me and it wasn’t what I wanted to do. But it grew on me. And 29 years later I’m still doing it, working on contaminants and how they affect fish.

I received my PhD in 1988. We had been working on methodologies for assessing oil exposure in fish, which until then was very hard to measure. Then came the Exxon Valdez oil spill in 1989, and we were ready. We had been researching oil and fish, and brought a lot of real professional expertise to bear.

But I think people have a misguided fear of oil spills. We give all this attention to an oil spill while ignoring the stuff that’s flowing down the Duwamish River into Elliott Bay every day.

More recently, we’ve been working on the issues of endocrine disruption in marine fish. We’ve known for some time that sewage and other discharges from human activity and industry in fresh water can cause male fish to take on some characteristics of female fish. And studies in Eastern Canada show that xeno-estrogens in fresh water can have a serious impact on salmon populations.

But not much is known about marine or saltwater systems. The assumption has been that ocean systems are well-flushed, so that you’re not likely to see much evidence of disruption. But now we’re seeing evidence of these same effects in Puget Sound.

Sewage is one of the first places you look. Right now we’re seeing contamination in Elliott Bay, with lesser indications in other parts of the Sound. The King County folks have been really great about working with us so we can see whether sewage effluent is a factor. Sewage treatment doesn’t remove these chemicals. It’s not designed to take out those sorts of things. We were actually surprised to learn that. Those guys that were running the sewage treatment plants are doing the best they can to deal with the stuff that we flush down our toilets every day—its not their problem, its really *our* problem. So far, most of our work has been with rockfish and flatfish, but now we’re going to be looking at whether that is an issue with salmon.

The main issue with a lot of chemicals is that they get accumulated in tissues, where they get biomagnified. We’ve worked out some good methods for detecting those kinds of chemicals, and figuring out how much risk they pose for fish and the people who eat fish. But there is a long list of things—pesticides, herbicides, pharmaceuticals, things that are highly water soluble—that are difficult to detect.

But are they biologically significant? Only in the last few years have we had tools to even ask some of these questions. We've wondered about it but we just haven't had the tools to find out. Now we're doing some really neat work on pesticides and behavior. We know that you can have dozens of pesticides in the water column at the same time, and we have no idea what that combination of chemicals might be doing to fish, or to people who eat those fish.

It's not very sexy, I guess, but it's pretty important science. And this kind of real world research isn't going to get done unless you have a government research institution willing to do it. People here are not in it for the money. They want to do science that actually affects the environment out there.

That's what I've been trying to do all these years. And while I got out on some pretty big boats, I never did get out on the really big boats that spend months at sea—which turns out to be a good thing—I get seasick.

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As environmental concerns swept the country in the mid-to-late 1970s, Center scientists began to focus on chemical pollution and its impacts on marine resources in the Pacific Northwest. Especially noteworthy was the work of Donald Malins and Usha Varanasi, the present science center director. Their work on the effects of oil on fish, along with the work of their colleagues, proved to be an important tool for assessing damage from the 1989 Exxon Valdez oil spill in Alaska.

The growth of the Alaska fishery, and the political clout of Alaska's congressional delegation, led in 1988 to the splitting of the Northwest and Alaska Fisheries Science Center. All of the Center's Alaska programs, which had gradually moved in the mid 1980s to NOAA's Sand Point labs in north Seattle, formed the Alaska Fisheries Science Center. The Pacific Northwest programs that remained at Montlake, become the Northwest Fisheries Science Center (NWFSC).

With this change, NWFSC scientists began to refocus their attention on salmon, hatcheries, aquaculture, pollution, and the environmental concerns that were beginning to dominate the science of modern fisheries. Under its new name, the NWFSC entered its biggest watershed—literally and figuratively.

The year was 1991, when the federal government received its first petitions to list Pacific Northwest salmon runs under the Endangered Species Act (ESA). The Center was designated to investigate those runs and determine which ones should be listed.

NWFSC scientists were well aware that they were about to be inundated with petitions, recalls Michael Schiewe, a fisheries biologist who directs the Center's fish ecology work. Scientists and policy-makers needed a comprehensive strategy, rooted in science, for addressing the petitions.

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DR. MICHELLE MCCLURE

Dr. McClure is a Poulsbo native who has been at the NWFSC since 1999. She is co-chair of the Interior Columbia Basin Technical Recovery Team.

I really like salmon. They're a beautiful fish and they live in neat places and they have such a cool life cycle. They really matter to people. And that means there is momentum to do something about their decline.

I decided at the age of 11 that I was going to be a biologist. I always had a strong interest in conservation issues and when I got my degree, I was looking for a job in salmon conservation. This job has lots of science, but definitely informs public policy. We are responsible for setting recovery goals for Columbia Basin salmon. We have to define the populations and then determine the recovery goals and eventually work as technical advisors to policy makers who are trying to put together a plan of action to actually achieve those goals. I've also been involved in the effort to establish a standardized risk assessment for all the stocks for which we can get data.

So this is your tax dollars at work right here.

All of this has the potential to be very controversial, of course. It hasn't been a minefield yet, but I expect it will be. Somebody won't like it. If we have done our job right, maybe nobody will like it. But as long as other biologists are satisfied, I'll be happy.

I spend a lot of time trying to make sure that I am presenting the results in the most unbiased manner possible. You want to be true to the results and true to the uncertainty inherent in those results. That's a really big challenge, because people either want your results to be absolutely true or absolutely uncertain. You have to be true to the evidence, not to what you want to happen.

I don't have a particularly hard time removing myself as a conservationist. This agency's legal mandate is to recover listed fish, so there's nothing wrong with having a conservation ethic. But if you have as your goal a particular action, that's where it gets tricky.

Science can get distorted by advocacy on either side of the issue. It can get bent or ignored, or it can get expanded beyond what the science actually says. The Columbia River dams are an example. There are people who want to remove them and people who want to keep them in place. And each side is willing to squish or inflate studies that support their views.

Climate change is another example. Sometimes policy makers hear more than perhaps what scientists have actually said. The fishing industry says salmon are declining because of changing climate and ocean conditions over the last 20 years. But these fish have been declining since the 1870s, so it's clearly more than ocean conditions. Still, ocean conditions are really important. It's a balancing act.

Government has an important role in science. Scientists here are not worried about their jobs and they are not being paid by industry or by anyone with a particular agenda.

But some of the questions are difficult to answer—basic questions such as how habitat affects fish survival. Or steelhead and rainbow trout, which are the same species, but we really don't know why some become rainbow and others go out to sea and become steelhead. That's pretty critical to know if you're going to come up with a recovery plan.

Or take salmon migrations. When a spawning salmon ends up in the wrong place, is it choosing or is it a mistake? Does it like the way it smells over there?

These are the questions that keep me going. There are times when I don't want to think about salmon, but I have no choice. I sit next to people on airplanes and end up drawing pictures of the Columbia River and the dams to explain the problem.

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That strategy was to launch a sweeping, systematic review of all West Coast salmon runs—from California to the Canadian border. These reviews were a major scientific accomplishment because of the complex issues that surround salmon. "The law tells us to protect distinct populations, but it does not tell us how to decide whether something is a distinct population," says Robin Waples, a widely respected fish geneticist at the Center. "We decided that a salmon population must show substantial reproductive isolation, and there must be something about that population that is important to the species as a whole, if it is to be considered a distinct population."

A team of top geneticists at the Center had been developing ways to use genetic markers to acquire even more detailed information about the status of salmon populations. This research grew out of the early work of Fred Utter, a leading geneticist at the Center in the 1970s. Using ecological, genetic, and life history information, Center scientists determined what populations (or groups of populations) should be considered "species" under the ESA and whether these "species" were at risk of extinction. Eventually, 26 distinct salmon populations were listed in Washington, Oregon, Idaho, and California.

After years of operating under the Magnuson Act, the Center was now driven increasingly by a different law—the ESA. In order to begin to recover listed salmon populations, scientists had to understand the complex life history of the salmon better. Years of salmon tagging revealed parts, but not all, of the their life history. Scientists at the Center, led by Earl Prentice, developed new technologies, including the passive integrated transponder or PIT tag, a marker the size of a grain of rice that is inserted into the body cavity of juvenile fish, allowing scientists to track fish during their migrations and determine their mortality rates, the impacts of predators, and the effectiveness of transporting salmon around dams.

Center scientists also developed captive broodstock programs to assist in the salmon recovery effort. In these programs, fish are raised in captivity throughout their life cycle to improve their survival. They are then released as adults or offspring to supplement wild populations.

The Center first developed a captive broodstock program in the early 1990s to prevent extinction of the most endangered salmon stock in the Pacific Northwest—Redfish Lake sockeye salmon from Idaho. Under this program, Center scientists, in cooperation with the Idaho Department of Fish and Game, developed methods to safely rear this fragile species to adulthood. Progeny from these captively reared adults were then transferred back to Redfish Lake. As a result of these enhancement activities, 257 sockeye salmon returned to Redfish Lake in 2000—almost 16 times the number of fish that returned to the Lake in the entire decade of the 1990s.

Armed with new tools, the Center is approaching salmon recovery from many angles. "With endangered salmon runs, we are undertaking one of the greatest and toughest ecological challenges of the century, " says Usha Varanasi. "The Center has scientists who look at everything from DNA to population dynamics. The challenge is pulling all the science together to make meaningful contributions to salmon recovery."

Despite its emphasis on salmon, the Center is not completely immersed in salmon recovery.

Despite its emphasis on salmon, the Center is not completely immersed in salmon recovery. NWFSC scientists remain involved in a broad range of issues from West Coast groundfish to harmful algal blooms and more. But all of the current issues the Science Center is addressing have emerged out of its rich history.

In the area of salmon, scientists are currently evaluating the interaction between salmon and estuarine and ocean environments. "Evaluation of the freshwater phase of the salmon life cycle has yielded important information about some of the primary factors influencing salmon production. However, a comparable understanding in the marine environment is not yet available and we are working on that," says Dr. Schiewe. "Over the years, we have

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DR. ELIZABETH CLARKE

Dr. Clarke is director of Fisheries Resource Analysis and Monitoring.

I despair about a nation that believes science will somehow bail them out of all their problems, *or* that scientists are a bunch of irrelevant nerds. Science is neither of these things.

I've worked with English scientists, and in England scientists are practically deified. Here we have the opposite extreme. Somewhere there has to be a status between being deified and being a nerd. And I think that is what we are doing at this institution.

I grew up in Southern California, where the ocean is very much integrated with everyday life. I was the classic surfer girl. I got my master's degree from the University of Alaska and then my doctorate from Scripps Institution of Oceanography and research for both degrees on pollock. I taught and did research for 10 years at the University of Miami, and a lot of scientists would say I had the perfect job. I had an impact on students' lives and careers. But I really wanted to get back to where I could see science used immediately, and that's why I took this job.

I've always been interested in how science is used in decision-making, and I needed to get out so I could see for myself. Some scientists like having their science used at a distance. But here science has immediate applicability. It is used by real people every day. You never have to go home and ask yourself: Is my work having any impact on the real world? It is.

But that impact also ups the ante. Sometimes we can have a negative effect on individual lives even though overall our work should always have a positive impact on the resource and on the nation as a whole. Our fish-stock assessments have direct effects on the livelihoods of fishermen. I have a lot of respect for fishermen. They're very much like Wyoming cowboys—the physicality, the independent lifestyle… But they are suspicious of us.

Our challenge is to maintain our credibility, which means we have to spend time being scientists, not just managers.

Everybody has the same goal—sustainability. It has to be sustainable. To sustain these fisheries from year to year we need better science, better stock assessments, more specific surveys, better biological data, a better understanding of habitat.

That's our job. And it makes a difference.

DR. DAYTON LEE ALVERSON

Dr. Alverson worked at the science center from the '50s to the'70s, serving as director during the 1970s. In 1979, he left to launch Marine Resources Consultants, a highly respected private consulting firm based in Seattle.

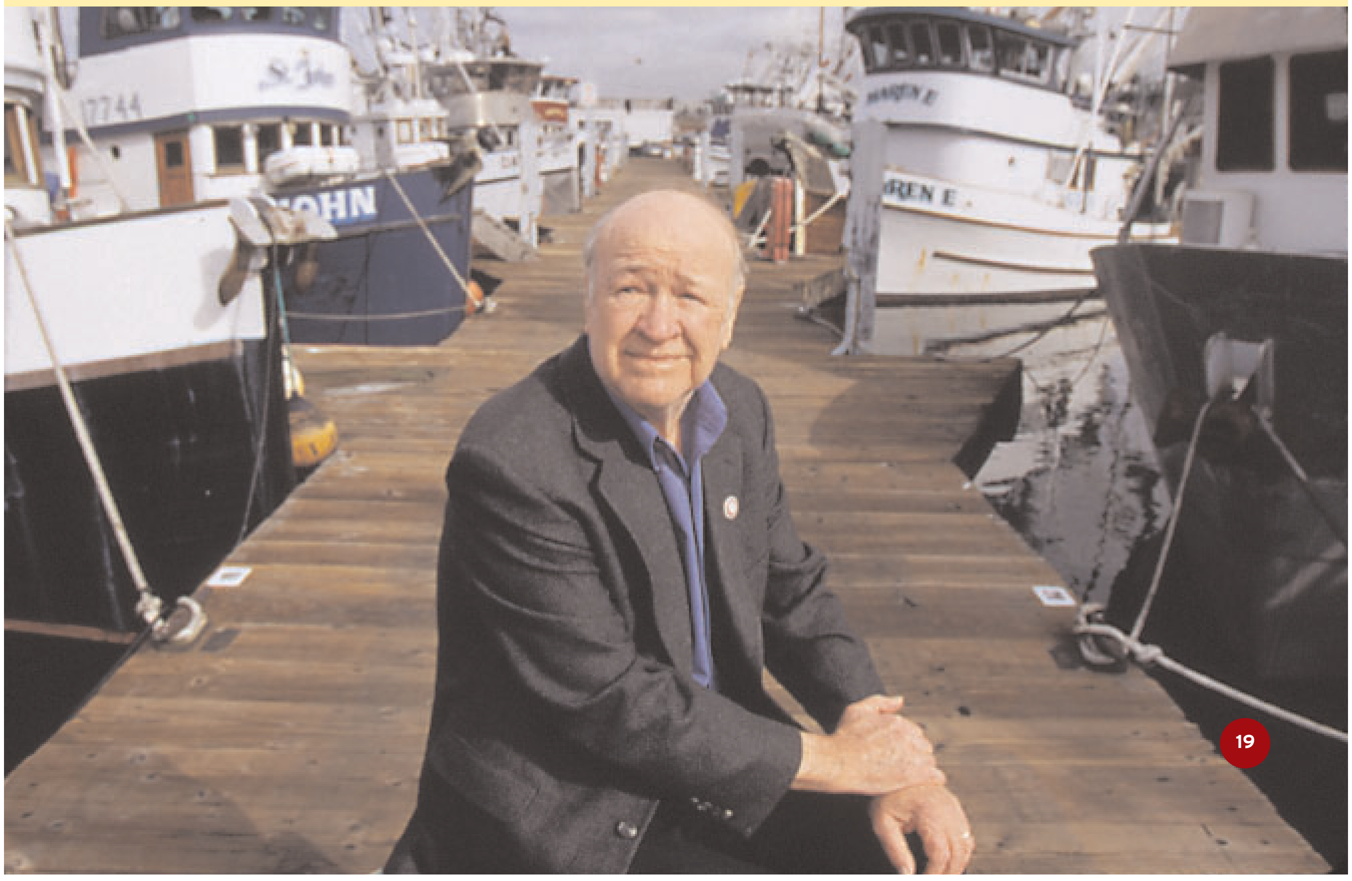
I went to work in the 1950s on the Exploratory Fishing Group, which was trying to find out what was on the continental shelf between here and Alaska.

I became director of that group in 1959, and did that for a decade. Our mission was to define the latent resources in the marine environment. We had no idea what was out there, the species or their magnitude.

We were not just looking for new fisheries for fishermen to catch. We were trying to increase this nation's understanding of what resources existed right off our coast, particularly because of the increasing intrusions of foreign fleets. It was important that we knew what was living off our own coast. But it also helped to develop our own fishing industry.

With passage of the Magnuson Act in 1976, our role began to change. Fisheries management became a federal responsibility. To manage fisheries, we needed to move into the environmental sciences, so we hired scientists such as Usha Varanasi. They were researching the effects of oil on fisheries long before the Valdez oil spill.

We had a strong heritage of conservation in the Pacific Northwest, and that meant that science played a crucial role in developing these new fisheries and in setting quotas. The industry has lived within very conservative quotas, and the fisheries center was largely responsible for that.



DR. JACK WEKELL

Dr. Wekell has worked at the NWFSC more than 40 years, and has become an authority on harmful algal blooms, or "red tides."

My feeling has always been that if God wanted me to go to sea he would have given me gills and fins. Besides, I tend to get seasick and I was never crazy about salmon fishing because of it. The salmon I liked, but the fishing part I could do without. So you have to wonder how I ended up in fisheries research all these years.

I try to tell young people who are starting their careers not to look down their noses at projects that appear to be trivial or boring. You could be really surprised how interesting things are when you get into it and start digging. You don't really have to do the most spectacular things.

I spent most of those years studying toxins in shellfish that I don't eat. Clams and mussels and I just don't get along. I guess I'm as close to a disinterested observer as you can get because I don't have a vested interest in the outcome. I do make exceptions for shrimp and lobster, though.

When I first came here in the 1960s, there were two major areas of work. There was the exploratory fishing, looking for new fishery resources out there, and of course they did a fantastic job. Until then, the US really knew little about groundfish, other than that there was a lot of groundfish.

In the early 60s, we had a very significant effort in seafood technology at what was known as the Seattle Technological Laboratory. We were looking for ways to utilize huge resources like hake and pollock, making them into useful food products.

The Japanese were already doing the surimi work, and we thought that surimi had tremendous potential. Our lab worked on adopting and adapting existing Japanese technologies to our groundfish. At first, American processors didn't see any future for that. But when they saw what the Japanese were doing, making various analog products such as imitation crab meat, then it caught on and went like gangbusters. That work dovetailed nicely with the new groundfish fisheries.

Over the past 10 years or so, the center has moved away from what have historically been called the hard sciences—chemistry, physics, and biology. We're becoming more of a management agency, managing the marine resources. We have a little broader mandate now. Some of this is certainly due to changes in the fishing industry itself with resources declining or at least under heavy fishing pressure, so I can understand why we are not putting as much effort into seafood products. Nevertheless, we are still doing some exciting basic research in areas such as harmful algal blooms, marine biotoxins and ecotoxicology.

Another reason for this change is that everyone in the world is hitting very heavily on the worldwide marine resources. Countries that never had fisheries or only limited coastal operations now have fishing fleets that range beyond their coastal waters and into international waters.

Because capital seeks the lowest costs, much of the processing has moved to cheaper labor markets. Go down to your local Costco or Safeway, and you see salmon completely headed, gutted, skinned and filleted, selling for $2.99 a pound. Those high-quality fillets are selling at prices lower than beef.

I see the future in culturing fish, or aquaculture. It's inevitable. Our lesson comes from human history, where you see the change from hunting and gathering to a society that cultivates its food. We human beings started out as hunters and gatherers and then we got a brilliant idea: Why are we traipsing all over the countryside when we can plant our fruits and berries and wheat and we don't have to walk as far to harvest it?

Of course, there are some problems with aquaculture. But, like anything, these problems are fixable once they are identified. I think the potential for aquaculture at this point is enormous.

DR. LINDA JONES

Still to come

DR. RICHARD METHOT

Dr. Methot specializes in population dynamics in the Fishery Resource Analysis and Monitoring division.

I spend most of my time working with population dynamics—what's going on with fish populations. I once spent significant time at sea trying to collect new data on anchovy, but I soon realized that my questions were beyond my budget. Since then, I've spent my time in the office extracting clues from available data.

Basically, we try to answer three questions:

How many fish are out there?

How many can be safely caught by fishermen without endangering the future of the species?

How can we consider climate and ecosystem factors in determining sustainable fish harvest levels?

Some people may wonder if it makes sense to spend all those tax dollars helping a few fishermen make a living. But we do more than that. Our dual mandate as stewards of the nation's marine resources is to facilitate sustainable, economically viable fisheries while protecting the habitat and ecosystems that these fish inhabit. A decades-long traditional part of this role is to advise management on how to set fishing quotas. We are GS12s who make multi-million-dollar calculations.

We're buffeted from both sides. One side of the equation wants to raise quotas, to push the envelope and maximize their profits. The other side says: You can't possibly know enough about the resource to say with confidence that this is a safe level of harvest. That puts us at the center of the storm.

As we get better at it, we take more factors into account—changes in the ecosystem, predators, long-term climate shifts. But whatever we do, we're still in the middle of that argument.

As we get more sophisticated, we develop mathematical models for assessing stocks. I developed a model that still is used in some areas. It's not a pure science, it's more like being a detective, collecting clues. Models are attempts to create a mathematical representation of what's going on in the ocean. Today we pay more attention to the biology of the fish population—especially their long lifespans. West Coast rockfish, for instance, may live 50 to 100 years, yet we've only been collecting data for one lifetime. That makes it more difficult to get a handle on the status of the population.

And we are developing more methods—direct observations, advanced technologies and better statistical models. When we make an observation, it should take into account the specific habitat. Is it taken from a rocky sea floor or muddy? Deep water or shallow? The idea is to get a better mix of information. The picture we get is more complex, but hopefully more reliable.

Most people don't understand that ecosystems are constantly changing. The public has a sense that the environment is a constant and knowable, and that sense spills over into law. We need to do a better job getting information on the right time-and-space scale.

I guess that's why we are becoming more and more ecosystem-based. We need to move that way, to improve our ability to monitor ecosystems. I don't see ecosystem science replacing single-species assessments. But detailed information from each species feeds into the ecosystem science and ecosystem science provides a background and framework for looking at each species.

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realized that systems are truly integrated, and that if we are to conserve or recover one part, we have to look at and understand many others."

Center research is focused on better understanding the complexity of ecosystems in the Pacific Northwest. Scientists are looking at the larger watershed processes that affect salmon habitat and the way in which fish use this habitat. "Habitat is critical to fish health and survival," states John Stein, a chemist who directs the Center's environmental conservation work.

The pollution work that began at the Center in the 1970s continues today. While the focus was once on point source pollution, such as oil spills and hazardous waste

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sites, research is now more focused on non-point source pollutants, such as agricultural and storm water runoff. Recent research by Center scientists has found that common pesticides can impact the ability of salmon to find their home spawning grounds. This has important implications for salmon recovery.

Research on hatcheries, captive broodstocks, and aquaculture continues at the Center. But where the focus was once on supplementing wild stocks for increased harvest, new technologies are now being developed with conservation goals in mind as well. For example, hatchery fish tend to behave differently than wild fish because they are raised in very sterile environments. Scientists have developed a semi-natural raceway that better mimics salmon's natural environment. It is hoped that rearing hatchery fish in more natural environments will not only increase their survival once they are released, but will also minimize differences, both genetic and behavioral, between wild and hatchery fish.

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And groundfish are still a very big part of the Center. Research cruises in the 1950s and 1960s documented vast groundfish resources in the North Pacific Ocean, and during the last decade, NWFSC scientists have been assessing groundfish complexes all along the West Coast. Through their investigations, Center scientists have come to better understand some of these species— they have found that West Coast groundfish are very long-lived, living upwards of 70 or 80 years—but there are still a number of West Coast groundfish species whose status is unknown. A new observer program to measure total catch and bycatch (discards), as well as an effort to conduct more comprehensive stock assessments, should help Center scientists provide some of the critical understanding that is necessary to preserve the West Coast's valuable groundfish resources.

The Center has come a long way in 70 years, but there is still much more to learn. "We will always strive to be at the leading edge of fisheries science that is directly applicable to current and future issues facing the Pacific Northwest," says Dr.Varanasi.

So where will the Center be in another 70 years? Only time will tell, but it is sure to be an exciting journey.

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DR. RICHARD BERRY

Dr. Berry was a researcher and then director of the Southeast Fisheries Center in Miami before moving to the NWFSC in 1988.He directed the Seattle center until he retired in 1995.

I came to Seattle in 1988, when the Alaska center was split off from Seattle. That made things a bit complicated for a while, but we worked things out. In an agency like this, a scientist learns to be an administrator on the job. You manage a project, and then a bigger project, and then a division and so forth.

Years ago, the center was involved in opening up new fisheries. Everything was wide open and you didn't have so many conflicts among user groups. By the time I arrived, those days were drawing to a close. Now it's much more about solving problems—whether it's pollution or endangered species or over-exploitation, or fishing groups at each other's throats.

But wherever you are, there's always a lot of uncertainty in the oceans. We saw the Northeast fisheries completely changed by over-exploitation, to the extent that the ecosystem has been changed. Then you saw the same thing happen in the Southeast. And now people are worried that the Northwest is going the same way.

DR. WILLIAM ARON

Dr. Aron was director of the Northwest and Alaska Fisheries Science Center from 1980 to 1988, and director of the Alaska Center until his retirement in 1996.

What distinguishes the National Marine Fisheries Service is that people are part of the equation. In academia, scientists study fish because they're fish, and they do a wonderful job of it. At NMFS, scientists study fish because they interact with people. Whether it is understanding pollutants, or establishing harvest quotas, humans are part of the equation.

Take, for example, the work of Maurice Stansby. He worked for years in the area of fish utilization, and was awarded a Presidential Citation for that work. He was always extremely modest, but he deserves much of the credit for recognizing the health benefits of fish oils. And as we move toward diets rich in Omega 3, we owe much of what we know to his work.

In the future, I would hope to see greater cooperation in the fishing community. The environmental community is coalescing around the concept of "ecosystem research." What are the consequences of taking large numbers of any given species out of the ecosystem? That's a legitimate question.

And we need greater cooperation in the scientific community as well. There was an expectation that NOAA would become the federal oceans agency. But that hasn't happened to the degree that we had hoped. There is an aloofness in many of these agencies. Fisheries agencies have their constituency groups, and marine mammals have their constituency groups, and there's not enough cooperation and communication between them.

DR. MARY RUCKELSHAUS

Dr. Ruckelshaus earned her PhD in zoology and botany from the University of Washington. She works on Puget Sound salmon recovery in the Conservation Biology division.

My family moved here in the mid-70's, so I was in high school when I had my first experience with nature in the Northwest, as opposed to Washington D. C. Spending a lot of time in the San Juan Islands gave me an appreciation for marine habitats.

I am a population biologist, and those principles can be applied to pretty much anything. I work on the risk evaluations for listed salmon, trying to identify the factors that affect the decline of the fish and what might limit their recovery. The recovery team includes scientists from various agencies and disciplines.

When I left academics to come here my mentors thought I was crazy, because academics are plum jobs. I think they're wrong. Here my research has to be relevant to the mission of the National Marine Fisheries Service. But that has not been confining. We have a lot of autonomy to argue why we think our research is relevant. We set our own research agenda as long as we can justify why it is relevant.

The center is involved in a very interesting experiment in conservation. It's challenging because it is so politically loaded, and because we scientists have to talk to the policy people. There's a lot of mistrust and we have decided we have to talk to the policy people from the beginning, because if we don't our science might not be relevant to the ultimate decisions. Our fear is that we will spend two years coming up with a big fat report that no one will pay any attention to.

It's frustrating because the policy makers don't speak the same language. We have to work at overcoming the mistrust between groups.

It's all complicated by misinformation and uncertainty. Each group wants to blame somebody else for the decline in salmon runs.

Take, for example, hatcheries. To some people, a fish is a fish, and it doesn't matter if it came from a hatchery or the wild. So why should we care and keep track of the difference between them? And there is definitely a difference of opinion over how to use hatcheries—to recover a wild stock or to produce extra fish for harvest. Some people say they should be used in perpetuity and some say we shouldn't use them at all. And I don't think the answer is simple. We need hard evidence to come in and be published and get credible scientific studies showing the risks and benefits.

Our biggest challenge is to figure out quantitative or analytical approaches to evaluating the sum of risk to salmon populations. How do you look at cumulative effects? And how do we reduce the uncertainties? Maybe we don't know what the ocean is going to look like or what the population growth is going to look like. But we can project a minimum and maximum. Instead of giving one answer, scientists have a much better chance of influencing policy if we anticipate the consequences of given decisions.

DR. JEFF HARD

Dr. Hard is acting director of conservation biology at the center.

Here in Conservation Biology, as part of the ESA process we took the lead on the status reviews for all seven species of Pacific salmon that have been the foundation of the agency's recovery efforts. As part of that change, we've had to learn how to do risk assessments for salmon over big chunks of real estate, which has required some new approaches. Salmon are hard animals to study, because they spend so much of their life cycle in places where they're difficult to observe. And the salmon-ocean relationship is still a huge mystery.

I grew up in Juneau, Alaska. My dad was a scientist with the Forest Service and my uncle was a teacher and commercial fisherman. I spent time on boats and in the woods. I went into biology and worked at a remote salmon station on Baranof Island, and it was there that I learned the value of hatcheries as research tools, an opportunity that is really unappreciated in this business.

When I went back to school, I became interested in genetics and worked on the evolution of mosquitoes. Salmon live too long to answer many evolutionary questions if you want to finish your PhD in 10 years.

The kind of genetics I do is quantitative, the branch of genetics that plant and animal breeders have been using for over a century, long before we knew what the structure of DNA was. Instead of eye color or a particular protein, we're interested in characteristics like body size and shape, run timing. The mechanism of inheritance is the same, but quantitative geneticists usually can't identify the individual genes, so we use statistical approaches to estimate in a composite sense how important genes are relative to environment.

One of the more controversial issues we're studying is the genetics of hatchery fish and wild fish. I still hear people argue we can maintain salmon runs by building hatcheries. It's a form of techno-arrogance, an attitude that's pervasive in our culture. You get seduced by technology and sweep the real problem under the rug. A hatchery essentially allows you to decouple a fish from its freshwater habitat. So you can trash that habitat and still have fish, but what kind of fish? Is hatchery fish and poor habitat really where we want to go?

I think there are over 5 billion fish being released into the North Pacific every year. And there is some evidence that we may be approaching the ocean's ability to support these numbers for at least some species.

On the other side, we hear environmentalists argue that every fish population is distinctive and important. On its face, that's true. But when you are in applied conservation, as we are, you often have to establish priorities. Each population is different, but how critical it is to the long-term species survival is a question we have to try to answer. That's something we've tried to do in the status reviews and are now doing in recovery planning.

The ESA process has been a steep learning curve for us. On the up side, we've learned a great deal about salmon. The scientists who conducted the status reviews and are now leading recovery efforts are some of the most talented and dedicated people I've ever worked with. The process has also forced us to collaborate more with our colleagues in the state agencies, the tribes and the private sector. That has been a great experience. They're the people who have the local knowledge about fish and their habitat. There are some really good people working for those groups, and we learn a lot from them. They may not agree with everything we're doing, but they still work with us because they care about the fish, too.

DR. ROBIN WAPLES

Dr. Waples earned his PhD from Scripps Institution of Oceanography and works in salmon genetics, focusing on the effort to craft a strategy for recovering Northwest salmon runs.

For a long time, I avoided science. I majored in American Studies and taught English in Hawaii for awhile. Then I bummed around for several years—body surfing and diving and underwater photography. When I went back to grad school, I was assigned an advisor in fish genetics.

I've been here at the center for 15 years, mostly working with salmon genetics. With genetics, you look at a collection of fish that appear to be one species. Genetic markers make it possible to unambiguously assign individuals to different species, and then it's possible to find morphological or other characteristics that distinguish the species. These differences might be difficult to discern if all you had was a big mixture of species.

There's no problem distinguishing one salmon species from another, but there are big problems within species.

We had the problem of mixed-stock fisheries—US fish mixing with Canadian fish, treaty and nontreaty fish, wild fish and hatchery fish. The question was: How can we harvest the abundant hatchery-bred fish stocks and not the overharvest the weak, wild populations?

Hatchery fish populations may be able to withstand harvest rates of 80 or 90 percent, but that's too high for most wild populations. But they swim together, which leads to enormous management problems. Mixed-stock fisheries are not the only cause of declining salmon stocks. Freshwater habitat is still the biggest issue. But harvesting these mixed stocks at sea is another big one.

So the idea is to use natural marking to figure out where harvested fish come from. We have these genetic markers that show up in all fish, but in different frequencies. If you detect enough of those markers, then you have something useable.

We began looking in earnest at ESA listings about 10 years ago. We started with some basic questions: What is a species under the ESA? Which of these species should be listed? The ESA definition of "species" includes taxonomic species, officially named "subspecies," and distinct population segments. The law tells us to protect distinct population segments, but it does not tell us how to decide when a population is "distinct." If you ask 10 salmon biologists what constitutes a distinct population, you are likely to get 10 different answers.

So the Center decided to formulate a policy. In 1991, we decided we will consider a group of salmon populations to be a distinct population segment if it is an "evolutionarily significant unit," or ESU. We established two criteria: The population must show substantial reproductive isolation. And there must be something about that population that is important to the species as a whole.

This was important because there was a fear that we would list hundreds of salmon stocks, whether they were significant or not. That's not the goal of the ESA. The idea is to avoid extinctions, which are permanent and irreversible. So our goal has been to identify major chunks of genetic diversity, the building blocks that make a species.

There really is broad public support for salmon conservation. And there is even a professed willingness to pay higher taxes to accomplish that.

But scientists need to come up with more specific answers about what is really necessary for salmon recovery. When we do that, it will be interesting to see if the public is really willing to do what is necessary. That's an open question.

DR. EARL PRENTICE

A fisheries research biologist at NWFSC's Manchester Field Station for 30 years, Dr. Prentice was primarily responsible for developing the Passive Integrated Transponder or PIT tag for tracking salmon and other marine life.

So how did we get into this tagging technology? I was interested in tagging and marking of fish. It's important because you need tools to evaluate the effectiveness of any recovery program or field study. The tools available—coded wire tags, freeze branding, external tags—didn't totally satisfy our needs, because you had to handle the fish, and you could not retrieve the tag information without sacrificing the animal. So we started to develop our own tag.

Driving to work one day, I heard about a new tag that could be placed under the skin of people. I traced the story to Denver, where this gentleman was working on a miniature radio-frequency tag—not for people, but for horses. He'd had some horses stolen, and he was working on this very small internal tag that could be used to identify horses—the same tag they implant in pets these days.

I immediately saw applications to fisheries. I've always been interested in the marriage of technology and biology. So I wrote a proposal to the Bonneville Power Administration, where folks had the foresight to support me.

I believe I received the first functional tag about 1983. The tags were about the size of a grain of rice—12mm long and 2.1mm diameter and very light. We tested it extensively, because when you apply a tag to a fish the animal must represent a larger population. If you've modified a fish's behavior or health, your data can be misinterpreted. We found the tagging process did not appear to have a significant effect. And we determined that the minimum size fish that could be tagged was about 60 mm long.

The tag is called a Passive Integrated Transponder, or PIT tag, basically consisting of a computer chip and a coil, all encapsulated in glass. There's an electronic switch that turns on and off, modulates the magnetic field that energizes the tag. The modulated field is interpreted as a specific code.

Each tag is uniquely coded—like a credit card. It provides an identification number for the animal. It's inserted into the body cavity with a needle attached to a modified syringe.

Now they're used throughout the world. Virtually any animal can be tagged and tracked—livestock, companion animals, laboratory animals. The same technology is being used in higher-priced automobiles; when you insert your key in the ignition it adjusts the seats.

These days, we tag up to a million fish every year in the Columbia River Basin. They can be tagged at hatcheries, in streams or at dams or fish traps. When the animal migrates downstream, the tag can be detected and interrogated at various points during its migration—for example, at specific locations within hydroelectric facilities. All that data is sent to a central database in Portland, and is available to anyone in the world via the Internet. I can sit in New Zealand and check in on my fish.

Now you see the PIT tag becoming the tool of choice for fisheries research. We can interrogate 100 percent of the fish without ever touching them at interrogation sites. We're in the high 90 percent range in reading efficiency and accuracy. So the quality of information has improved drastically over past tagging and marking systems, and the tag itself has minimal, if any, effect on the fish.

We still have improvements to make. We need to improve tag retention because, in the very late spawning stage, we see some tag loss. And we hope to reduce the size of the tag, so fish in the 40mm range can be tagged. A future step will be to incorporate micro-sensors which could provide information on the physiological state of the fish. That information might be used to determine if fish are being stressed at specific locations during their migration.

So what's the future role of technology in restoration of these runs? I think we'll need a whole suite of tools to help us obtain information on the animals—not only in fresh water but in the marine environment.

DR. USHA VARANASI

Dr. Usha Varanasi has been a researcher at the NWFSC's Montlake facility since 1975 and has been its director since 1994. She is an organic chemist, trained in both India and the United States.

Many people aren't exactly sure what science is, what scientists actually do, and what can and can't reasonably be expected of science. A key part of my job is to create a better public understanding of these questions.

Science is a critical part of our lives; it is behind the energy we use to light our homes, the fish we harvest from streams, estuaries and oceans.

Science is the heart of this Center.

I first fell in love with science when I discovered that it was a lot like being a detective in a mystery novel. You have to ask the right questions at the right time and in the right order. You also have to be thorough, accurate, and prepared for the unexpected.

My love for mystery and adventure brought me to the U.S. almost on a dare because I heard that a few boys from my high school class were going to America. When I asked if I could go too, my father and grandmother agreed that I could study in the U.S. if I got a scholarship. I wrote several universities and ended up going to the California Institute of Technology for my Master's degree. I then moved up the coast, where I continued my graduate studies at the University of Washington. I received my Ph.D in organic chemistry in 1968.

Organic chemistry has always fascinated me, but it was applying the study of chemistry to living systems that really excited me. My first research project that integrated chemistry and biology took place at the National Marine Fisheries Service's Montlake facility.

It was 1968, and I had just received my Ph.D. from the University of Washington. |At this time, a fellowship became available to analyze the very unusual kind of oil that porpoises have in their head cavities. What was its chemical structure, and what was it for?

Even though I had no idea what a porpoise was, from a chemist's point of view this analytical problem was very interesting. After several years of research, we found that this unusual oil is composed mostly of short-chain fatty acids, very unlike the fat you find in most aquatic creatures. We realized—after a lot of hard work analyzing the fat, and measuring its acoustic properties, in collaboration with physicists -- that the fat reservoir is a kind of acoustic lens. Porpoises can't see very well, but their ability to echolocate is extremely sophisticated and it seems this 'lens' made of specialized fat plays a critical role in echolocation.

This was a wonderful research experience for me because I was able to work in an environment where we could share and learn from scientists in other disciplines.

I have carried this experience with me throughout my career and have always tried to foster similar cross-disciplinary research approaches at the Center.

I started out at Montlake in a temporary position and quickly became interested in questions facing the newly formed National Marine Fisheries Service, such as, "what are the effects of oil pollution from petroleum projects on fisheries?" One of the great mysteries that I helped solve was where hydrocarbons, like petroleum, go in fish. We knew that there were hydrocarbons in the environment, but for some reason they weren't showing up in the tissues of fish, even after an oil spill. Some of the questions we asked ourselves, included, "Can fish process hydrocarbons into something harmless? Or are they somehow able to avoid oil and other hydrocarbons in

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the water altogether?" After many years of research using radio tracers, we came up with an unexpected answer. We found that fish are able to process hydrocarbons in their liver and remove these contaminants into their gall bladder. The liver is a primary site where the toxic effects of hydrocarbons are seen in fish; fish do not accumulate hydrocarbons in the tissues that we typically consume.

The results of our hydrocarbon research were very exciting and were directly applicable to problems occurring in the environment. For example, in 1989 the Exxon Valdez grounded on Bligh reef, spilling more than 11 million gallons of oil into the biologically rich waters of Prince William Sound, Alaska. Responding agencies, fishermen, and Alaska natives wanted to know what impact this oil spill was having on salmon and other fish that were harvested in the area. Because of our research, we were able to provide some answers, which increased understanding about what was happening to the fish and whether or not it was safe to harvest and eat them. This information allowed the agency to make critical decisions about opening or closing of important fisheries in Alaska.

Despite its plain outward appearance, the Center is a place of exciting challenges, critical thinking, and intense discussions.

Despite its plain outward appearance, the Center is a place of exciting challenges, critical thinking, and intense discussions. After many years of serving as a scientist in the Center, I moved into management positions, becoming an enabler of original science rather than an active practitioner, and since 1994 I have served as director. I still use science everyday, but instead of focusing on one particular problem, I look at many problems and the interactions among issues. For example, one of our current areas of research is salmon recovery. This is a hugely complex issue and we are working on teasing out all the important details, including finding out which life stage(s) of salmon is most susceptible to human and environmental influences, which habitats are most critical to salmon survival, and what criteria should be used for taking salmon off the endangered species list.

Science has changed a lot over the years. Here at the Center, I try to create an atmosphere in which interchange across disciplines is encouraged. One of our newest programs at the Center is the Cumulative Risk Initiative, which has at its foundation a team of scientists from half a dozen disciplines, that have all come together to work on and answer critical questions about salmon recovery, and communicate their results to a variety of audiences. These types of teams are critical to solving some of the complex environmental issues we are faced with today.

The Pacific Northwest is a beautiful place that I am proud to call home, but it is faced with many biological and environmental challenges. We and our colleagues in the 1970s and 80s helped define the impact of point source pollutants, such as heavy metals, DDTs and pollution from hazardous waste sites, on marine life, and this research led to better control of these toxic discharges from Industrial sources. Now the current generation of scientists is faced with the less obvious, but even more pervasive problems, such as non-point source pollution, where each one of us is responsible for how we use our resources and protect our environment. With increasing populations in coastal regions, more complex problems, such as declining stocks of salmon and marine species, and the increasing impact of invasive species are facing us. But this is the nature of science: the more we know the more we need to learn!

Each of us has an important role to play in the future of the Pacific Northwest. The Science Center's role is to provide unbiased scientific information to address marine resource issues. In these efforts we partner with scientists from universities and other agencies, but when it comes time for the Secretary of Commerce to set fishing quotas or implement ESA, it is our science and scientists who are on the frontline. It is therefore

criticalthat we stay the course of solid science. I believe there is a role for advocacy but for me it is important that we are known for our objectivity.

The Science Center has a rich history that I am proud to be a part of. In the future, I hope that we can be even more innovative, continuing to provide the best scientific information to help solve the marine and environmental resource challenges that we face as a region and nation. I want the future generation of scientists, with a diversity of talents and backgrounds, to find the Northwest Fisheries Science Center to be an exciting and challenging place where they can do meaningful work. I am committed to mentoring young students and scientists, and providing them with the kind of opportunities and encouragement that I received from many mentors throughout my career.

The Northwest Fisheries Science Center