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Food for Thought

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I think that I will just sit here and wait

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Food for Thought articles are essays in which the author provides their perspective on a research area, topic, or issue. They are intended to provide contributors with a forum through which to air their own views and experiences, with few of the constraints that govern standard research articles. This Food for Thought article is one in a series solicited from leading figures in the fisheries and aquatic sciences community. The objective is to offer lessons and insights from their careers in an accessible and pedagogical form from which the community, and particularly early career scientists, will benefit.
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Fisheries research has always been an opportunity of discovery for me and never really a job. Finding a new species of fish, discovering that fish can outlive humans, or that atmospheric transport of chemicals can profoundly affect fish survival over vast distances kept each day exciting. So many people I worked with or met remain as wonderful memories. There are now much better opportunities for discoveries of mechanisms responsible for the dynamics of fish populations than in the past. There is also an urgency for these discoveries as our changing climate affects the capacity of habitats to support fish. We need young people in spirit who can work in teams that excel in pursuing these new opportunities.

Keywords: a passion for science, acid rain, Pacific salmon, Richard Beamish.

To write about my experiences that might have some advice for researchers beginning their careers was the email I received from the editor of *ICES Journal of Marine Science*, Dr Howard Browman. I am not sure if these selected experiences relate to the current, social-media-influenced environment of science, but that may depend on the reader. I end this paper by identifying what may be award-winning opportunities for younger or younger-in-spirit fisheries scientists. I also end with one sentence of advice.

The title relates to my beginning in science. I started at the University of Toronto in a new course designed to produce research medical doctors. The new course hybridized topics from two established departments, resulting in spillage onto Saturday mornings. It was not a friendly environment as a first-year professor made it clear that the third year could only accommodate about 75% of the people who started first year. Despite some ups and downs, I made it to the third year.

It was the beginning of the third year when a professor in the School of Medicine told the class survivors that we would be memorizing "Ham's Histology Book". I raised my hand to report that in the previous year, we all passed the histology course taught by the Zoology Department. You will now learn histology correctly was the response. Not this guy was my response as I walked out of the room. Memorizing and repeating histology was not my idea of the best way to train research medical doctors.

I was able to transfer to Honour Science after a brief concern that I had not dissected a spiny dogfish (*Squalus suckleyi*). It was agreed that my dissection of a human cadaver would be sufficient, but it all had to be approved by the University Senate, which seemed a little excessive. It was about 3 months into my new course and classes that I received a notice that for the second time the Senate had rejected my transfer. In a very short order, I arrived in the office of the Chairman of the Department of Zoology. I still remember Dr Langford's name. His very receptive secretary said he was busy, but if I left my name and contact information, then she would try to fit me in. I think that I will just sit here and wait was my response. There were some ins and outs by Dr Langford with quick glances in my direction before we met in his office. The short version of the story was that he would tell me the person who rejected my transfer if I agreed that he had not told me. The transfer was opposed by the chairman of the Botany Department. Back across campus, I found my way to the chairman's rather musty office where the secretary explained that a meeting would not be possible as he was very busy, but if I left my name and contact information, then they would try to fit me in. I think that I will just sit here and wait was my response. I also remember his name although the spelling is a complete guess. Professor Badenhuizen was not a happy camper when he found out that I knew he had opposed the transfer. Could you please tell me the problem, I said? I will shorten his answer to "you did not take first year botany". Okay, I will take it in the fourth year, I said, and he agreed. My career as a research scientist may have depended on not giving up, on a respectful confrontation with authority, and on trusting my instincts.

The discovery of acid rain

I finished my four undergraduate years and was allowed to go directly into a Ph.D. programme. There were some remarkable professors along the way who were beyond helpful. Dean Fisher and Bev Scott were two of them. I wanted to do a Ph.D. with Dr Scott as he had allowed me as an undergraduate to work on fish taxonomy projects at the Royal Ontario Museum, where he had an office and a collection. Dr Scott felt that it was important to find a project that would require being more involved in the student community and referred me

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to a younger, full of enthusiasm Dr Harold Harvey, who accepted me as his student. Dr Harvey's middle initial was H, so we just called him H^3. He was more of a colleague than a supervisor, always finding time to help in the field and coming up with what was needed. He saved money by putting carrots in spaghetti sauce instead of meat. He also taught all his students the importance of effective communications with the public who really are our patrons—a lesson that stayed with me.

The project involved determining why a population of a particular fish was stunted in one lake and not in a nearby lake. The project appealed to me because the concept of "stunting" had an ecosystem component that would allow an integration of differences in lake productivity with fish survival and growth. In reality, I probably did not have any idea what I was agreeing to. About 2 years into the study, just about everything was falling apart. The populations of fish I was studying along with other species of fish were disappearing with no obvious explanation. My research was going nowhere quickly. The chemical analysis of the lake water was done by a Provincial laboratory and did not show anything unusual. I decided to start there and do my own analysis. My study lakes were about a 5-hour drive mostly north of the University of Toronto. I took our university truck early in the morning in October 1969, drove to the lakes, collected the water samples, and came back to the university. My father was an analytical chemistry professor at the university and gave me the keys I needed to get into the building and his laboratory. All the water samples were unbelievably acidic. After repeating the measurements over and over again, I decided to call my father about 3 a.m. to ask if he was sure his pH meters were working fine. "Dick", he said, "I run an analytical chemistry laboratory" and then he went back to bed. This was the discovery of acid rain, although it was not called this at the time. The next day I told H^3. He was supportive but a little sceptical. I told a few other professors who were even more sceptical, and one even said it was not possible to acidify a lake. Dr Fred Fry was one of the world's most respected fish physiologists and just down the hall from where I sat. When I walked into his office and told him, he immediately dropped what he was doing and we walked quickly down the hall to the library. He searched around the shelves for a few minutes and pulled out a just published issue of a journal with a paper that was the first report of the acidification of some Swedish lakes. He said that he had just heard about this and it might be relevant to my results. At that moment, I knew I had discovered something important.

There is a lot more to this story as the source of the SO_2 that was acidifying the lakes was from a nickel mining operation in the nearby city of Sudbury Ontario that had just built the tallest smokestack in the world to disperse the gases over a greater area as had been advised by experts. Lakes in this greater area were very poorly buffered and easily acidified. As the word of the discovery spread, I received calls from many researchers, some with names that were quite famous. Dr Harvey and I published the first paper on acid rain in North America on the editorial page of a national newspaper in 1971 and in a scientific journal in 1972 (Beamish and Harvey, 1972).

There is a message in all of this for people starting their careers. First, there was no professor on the Departmental or University committees who reviewed my thesis that recognized this was the discovery of acid rain. Second, there was very little recognition that I had made the discovery. The recognition did come 30 years later when I was awarded the Order of Canada for the discovery. Public recognition of your science is much less important than your personal satisfaction in your research. One of the world's best fisheries scientists, Dr Bill Ricker, was relatively unknown to the public. Even most fisheries scientists did not know he was also a world authority on stone flies (Plecoptera).

Freshwater Institute, Winnipeg, Canada

I finished my Ph.D. in 1970 and received a scholarship, that would allow me to do postdoctoral research anywhere in the world. I followed Dr Scott's advice and was accepted as a postdoctoral student at Woods Hole Oceanographic Institute with Dr Dick Backus as a supervisor. This was a stunning place for science and discovery. Everyone seemed interested in everything. It is still the favourite place on earth for my wife and me. I was offered a job in the United States; however, we wanted to return to Canada. There were no jobs in the government fisheries research stations so I wrote to the Prime Minister of Canada to tell him how much money Canada had spent on my education only to be forced to accept job offers in the United States. I do not know if the Prime Minister read my letter, but it was sent to the Directors of all major fisheries stations, and I received interviews from three major fisheries research stations ending up at the Freshwater Institute in Winnipeg in the winter of 1971. I later learned that my handwritten letter to the Prime Minister was much appreciated by all the station Directors who were suffering from recent budget cuts.

I continued my research on acid rain at the Freshwater Institute. I was invited by another government department to help with a court case involving the loss of fish in an acidified lake on land owned by a First Nation. Lawyers in my department had decided it would not be possible to win the case, but I was given permission to work with the lawyers from the other department. A famous nickel mining company in Sudbury was being sued because of their release of SO_2. They argued that all the gas was not necessarily from their operation. I was able to show that in addition to the gas, there were large levels of nickel in the fallout entering the lake that could only come from their processing. We won the case in an out-of-court settlement with an agreement that there would be no publicity. Our lawyers accepted that I had not made this agreement, and I wrote a report about the whole case (Beamish *et al.*, 1975) that I think was mostly ignored.

Pacific Biological Station in Nanaimo, British Columbia, Canada

Shortly after I arrived at the Freshwater Institute, the Director, Dr Wally Johnson, whom I barely knew, accepted the position of Director of the Pacific Biological Station in Nanaimo, British Columbia, Canada. He passed by me in the hall one day and I introduced myself with an additional comment that if he ever needed a good researcher, give me a call as I always wanted to work at the famous Pacific Biological Station. He called me a year later, and 6 months after the call, in the spring of 1974, I was the youngest scientist on the staff of the Pacific Biological Station.

My job was to find ways to age some commercially important species and find out if a newly discovered large population of fish with very sharp teeth was eating the more favoured Pacific salmon (*Oncorhynchus* spp.). It was only a few years until I found myself head of the groundfish programme. This

was 1977 when Canada and other countries were extending their jurisdiction over coastal fisheries to 200 nautical miles from the earlier 12 nautical miles (22.2 km) established by Canada. As head of the programme, I organized annual meetings with fishermen in Vancouver followed the next day by meetings in the northern city of Prince Rupert. At these meetings, we talked about fishing issues, science issues, and how we needed to work together. Fishermen spent more time with fish than we ever could and wanted to give us information they considered important. We had a better ability to make associations and wanted fishermen to hear what we thought was affecting abundances. Meetings lasted into the night and language could be salty. But, at the end, we were in the pub with the person who had earlier called us names, now buying us beer.

I was fortunate that the administrative responsibilities did not take a lot of time away from research. The groundfish fishery was just developing on Canada's Pacific coast along with opportunistic amounts of new money for new research. One of my projects led to the discovery that rockfish (*Sebastes* spp.) were substantially older than everyone thought (Beamish, 1979a). Instead of being 10–15 years old, rockfish were now known to be up to and even older than 100. It quickly became apparent that many species of rockfish were being overfished. In a controversy over reviewer comments on another paper on age determination, the editor agreed to publish my paper despite the comments, if I agreed to write another paper defending my objection to the reviewer's comments. The paper I wrote with a colleague (Beamish and McFarlane, 1983) was titled "The forgotten requirement for age validation in fisheries biology", and became one of the most cited papers in the history of *Transactions of the American Fisheries Society*.

Becoming director of the Pacific Biological Station in Nanaimo, British Columbia, Canada

It was a Saturday morning in the summer of 1979 when the Director, Dr Johnson, knocked on the front door of our modest home in Nanaimo. I said a few meaningless sentences before he suggested that I invite him in for coffee, which I did. He explained that his boss, the Regional Director General, would be fired on Monday and he would take over as the head of all west coast of Canada fisheries activities. He wanted me to replace him as Director of the Pacific Biological Station. It was quite a discussion, but in the end I said I was much too young to be Director. For almost a year following the Saturday morning coffee, we had an acting Director with my activities not changing much, including the annual late-in-the-year meeting with fishermen. At this meeting in Vancouver, during the coffee break, a very well known fisherman with the biggest hands, I think, I had ever seen came up on the stage and literally with some tears in his eyes said I was wasting my time in groundfish and the industry wanted me to switch over to a focus on the much more important Pacific herring (*Clupea pallasii*) fishery. A few days later, I met with Dr Johnson to say that I would take over herring if he wanted. His response was to say that I should take over the whole (he had an expletive here) thing and become Director. I agreed. There was a competition and I was offered the position. I accepted. The representative from our headquarters in Ottawa on the selection committee started to tell me how I was to fit into their bureaucracy, and I said they had hired the wrong person for what he was talking about. For the next 14 years, I do not remember anyone from Ottawa telling me how to do the job. I was told that there was political interference in the scientific process in other regions while I was Director, but I did not experience any myself.

As Director of the Nanaimo Station, I was also Director at some other sites, making me a Branch Director. I reported to a Regional Director General who chaired a committee of Directors that headed up Branches. However, I was also part of a National Government Fisheries Research Organization that was located at department headquarters in Ottawa. It is little difficult to explain, but these reporting responsibilities never were a problem. In fact, I had an enjoyable working relationship with our headquarters team in Ottawa. There even was a 6 month period in the late 1980s when I was in Ottawa as the acting head of all fisheries research in Canada. That was over 30 years ago and I am told that things have changed. If this is true, it is unfortunate.

I was Director from 1980 to 1993. It is useful for a reader to know a little about the Pacific Biological Station in Nanaimo. The Reverend George Taylor started the Pacific Biological Station in 1908. He and his son actually built the first building. The station and the researchers developed a world famous reputation in fisheries science and in oceanography. In the early days, the research in Nanaimo and in the other stations across Canada was managed by an independent group of professionals called the "Fisheries Research Board". There was independence to the research with an emphasis on creativity, curiosity, and productivity. Importantly, there was separation from the political process. In the 1960s at the Pacific Biological Station, there were some of the best fisheries scientists and oceanographers in the world. Then, two things changed everything. Late in the 1960s, the oceanographers wanted their own establishment away from their fisheries colleagues. This was agreed to and they eventually moved away. This was a mistake. Ocean science is integral to fisheries science. The second change made more sense. Commercial fisheries were developing on Canada's east and west coasts, and the Government needed a scientific organization that would provide sustainable commercial fisheries for obvious reasons. The Fisheries Research Board was abolished and Federal Government Agencies were created, which were followed by a series of organizational and name changes. I took over as Director as these changes were working themselves out.

The 14 years from 1980 to 1993 was a period of tremendous change in fisheries and fisheries science on Canada's west coast. In 1980, there were ongoing programmes to identify the population-specific origins of salmon and to assess the impacts of pollutants mostly on salmon. Pacific herring populations were quickly recovering from a major collapse. New fisheries for shellfish were starting. In addition to the new activities associated with the extension of jurisdiction over fisheries to 200 nautical miles, we had also started the salmon enhancement programme. This was a hatchery programme based on the thinking that there was unused ocean capacity for salmon that if filled by adding hatchery fish would double the commercial catch by 2005. The programme has now spent over one billion Canadian dollars and the commercial salmon fisheries have collapsed (Figure 1a). If we accepted from the start that the programme was testing an hypothesis, we would now reject the hypothesis and come up with a new idea of how to increase salmon abundance.

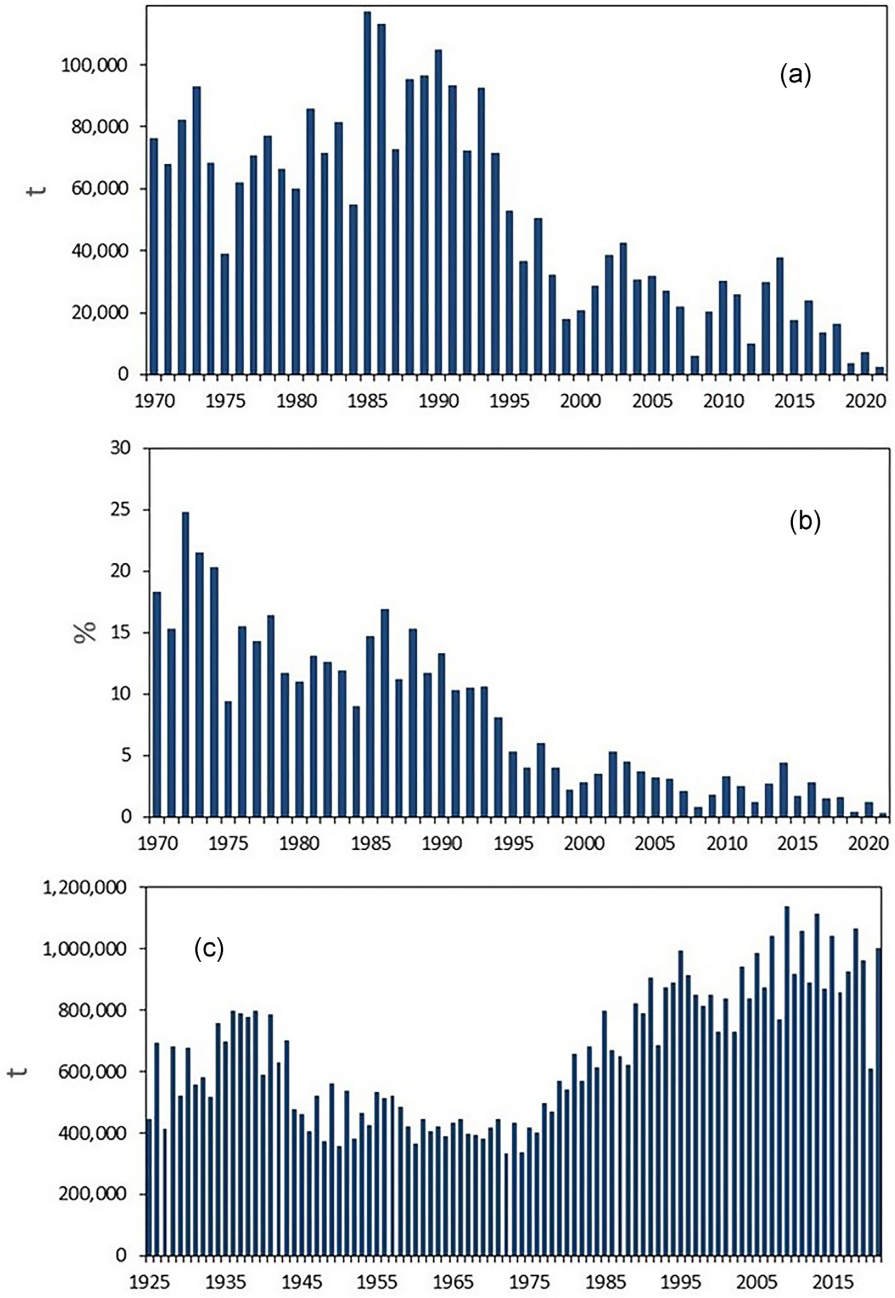

Figure 1. (a) The commercial catch (t) of all species of Pacific salmon from the west coast of Canada from 1970 to 2021. (b) The commercial catch in (a) as a % of the total commercial catch of all species of Pacific salmon by all Pacific salmon producing countries from 1970 to 2021. The commercial catch of all species of Pacific salmon from the west coast of Canada in 2021 was 0.2% of the catches by all countries. (c) The commercial catch of all species of Pacific salmon by all countries from 1925 to 2021. Data available from the North Pacific Anadromous Fish Commission (NPAFC). 2022. NPAFC Pacific salmonid catch statistics (updated June 2022). North Pacific Anadromous Fish Commission, Vancouver. Accessed November, 2022. Available at: https://npafc.org.

The Japanese were fishing using massive amounts of gillnets in the open ocean with an incidental catch, which upset environmentalists and just about everyone else. We had programmes to assess the impact of this high-seas fishing on a number of species. We began to recognize *El Niños*. My acid rain and Woods Hole Oceanographic Institute experiences had convinced me that climate and ocean changes had non-random impacts on fish production, but this was not a popular interpretation in the early 1980s. It took a while, but most researchers now recognize that climate change has an important influence on the productivity of commercially important species. Aquaculture and salmon farming started to become important. Salmon farming remains a controversial issue in British Columbia with a number of people thinking the declining Pacific salmon abundance (Figure 1a) is caused by salmon farms. This farming of Atlantic salmon (*Salmo salar*) is now the major agricultural export of the Province of British Columbia. Computers were appearing and typewriters were disappearing. The International Pacific Salmon Commission had heated discussions between Canada and the United States

over whose salmon each country was catching. The rights of First Nations were now being recognized in the management of fisheries. We started the six-country organization called "PICES" on the west coast, which was loosely modelled after ICES. The concept of a PICES was rejected by a group of international scientists meeting in Seattle in the late 1970s. Warren Wooster and I believed we needed an integrated oceans and fisheries approach to understanding stewardship so we started our own privately run organization called IRIS (International Recruitment Studies in the Subarctic). We even organized a large international conference to show governments why a PICES was needed (Beamish *et al.*, 1989). PICES is actually a nickname for the North Pacific Marine Science Organization, which was favoured by Warren Wooster. Activities and meetings associated with the International North Pacific Anadromous Fish Commission consumed considerable staff time. Russia and Korea were eventually added to Canada, Japan, and the United States as part of the Commission. The collapse of the east coast cod fishery in the late 1980s resulted in new approaches to reporting scientific assessments. Most importantly, in the late 1980s we all started to realize that our emissions of greenhouse gasses were changing the planet.

One major issue was the need for a new fisheries research ship. Our ship, the *G. B. Reed*, was the only side trawler fishing groundfish on the Pacific coast of North America as all ships now set and hauled their fishing nets over the stern. The Branch in Ottawa responsible for providing new ships was building two new vessels for the east coast, and we were well down the list for anything new. There was an economic crash in the early 1980s, which affected the commercial fishing industry in Prince Rupert. A company wanted to sell a commercial stern trawl fishing vessel at a cost that was a small fraction of the cost government needed to build a new ship. I was offered the opportunity to buy the ship, and I asked the best groundfish fisherman on our coast for advice. He travelled back east to see what was being built and returned to recommend that we buy the ship, which we did. The political party that was not in power objected to the purchase. It was hard to know why. This opposition party became government shortly after we received the ship, which was then tied to a dock for well over a year. As it rusted, there finally was a compromise that resulted in the ship being retrofitted with a new deck level for better accommodation of the ship's officers. As the final touches were being completed, there was the issue of a name. Government policy was never to name a vessel after a person who was still alive. However, as I talked to officials higher and higher in authority, I eventually found someone who agreed to the name W. E. Ricker. I think of all the recognition Dr Ricker received, this was close to being the one that he most appreciated.

As Director, I continued my recognition that fishermen and the general public were our patrons. We had a responsibility to inform them and listen to their concerns. We had an annual meeting with heads of the fishing industry. Company Presidents would fly over in float planes and land at our wharf. There was always a wind-up discussion in my office with a glass or two of cheer. Our patrons were also our colleagues in Ottawa and we informed them by developing what we called "awareness notes" that almost weekly reported relevant activities and discoveries. The Director of our oceans programmes and I did our best to integrate our research activities as we both believed strongly that the abundances of commercially fished species were regulated by influences other than fishing. The Director of the Salmon Enhancement Program and I also did our best to have staff working together. At one of our social events, I think I lost the Pacific Biological Station to him in a dart game. He gave it back to me after I bought him a glass of wine. Silos and siloing are both cultural and structural. As Directors, we tried to identify benefits of cooperative research to our staff. This worked only some of the time. I think this is still an issue in our west coast fisheries and oceans research and most likely throughout our profession. At least, some future research should be based on funding integrated teams. It is also important to always remember that research and publishing in peer-reviewed journals is not easy and does not need to be made more difficult with a never-ending requirement of bureaucratic housekeeping. In return for better protection, researchers need to recognize that it is not useful science until it is communicated in some way to others.

There is a social side to science that is historically important in fisheries science. We started running open houses for the public every few years. We had an annual staff and friends seafood barbeque that I had started in the 1970s along with other social functions, which I strongly supported. Our staff was passionate about their work, and we maintained the historically strong scientific reputation of the Pacific Biological Station as well as the respect of the general public.

Working off the corner of your desk

I continued some science on the corner of my desk as they say. My advice to anyone accepting management positions after being involved in research is to always continue your passion for science. Continuing some science was also a reminder of why there was a Pacific Biological Station. During the time as Director, I discovered a new species of freshwater fish in British Columbia and that the winter weather system in the Subarctic Pacific was related to trends in abundance of Pacific salmon populations. The new fish species was a freshwater parasitic lamprey that I named *Lampetra macrostoma* (Beamish, 1982b) and is now *Entosphenus macrostomus*. This new species occurs only in one large lake and one small lake that flowed into the larger lake. It is a closely related species to a widely distributed anadromous parasitic lamprey. The area had been glaciated up to about 12000 years ago, so the new species has recently evolved. The discovery that large-scale climate trends affect Pacific salmon production resulted from an encounter on a street in Khabarovsk, Russia. Years earlier, Bill Ricker had informed me that Russia had 10 times more scientists working on the same problems that we were working on. So we met regularly with Russian scientists. We met in Khabarovsk when in Russia as Vladivostok, the headquarters in the Russian Far East, was closed to foreigners. In 1989, at a meeting in Khabarovsk, the head of their delegation from Moscow declared that we all would get up from the table and go for a walk down their main street. As we walked, I was separated from the group by the head of the delegation and given a brown-covered binder that had all the Russian Pacific salmon catches. The handwritten comment on the first page indicated it was given to me personally. I was told that it contained the real salmon catch numbers and not the data submitted to an international organization. As far as I knew, I was the only foreigner to have the actual catches. Dan Bouillion and I compiled the annual total salmon catches for all countries using the real Russian catches, and there was a distinct pattern of trends. It reminded me of a recently published

data set for the winter, an Aleutian Low Pressure weather system in the Subarctic Pacific. We developed an index of average annual winter low pressures, and the pattern was a close match to the total Pacific salmon catch by all countries. Years of extreme low winter pressures were good for Pacific salmon production, presumably because of more intense mid-ocean upwelling. Vladivostok was opened up to foreigners in 1991 after the fall of the Soviet Union, and I was invited to present this analysis in an all-union conference on Pacific resource management in the early fall of 1991, which had 171 papers, all from Russians except for me and one American from Alaska. We called our index the Aleutian Low Pressure Index or ALPI and published it in 1993 (Beamish and Bouillion, 1993). As far as I know, this was the first demonstration that large-scale atmospheric processes are associated with major trends in abundances of Pacific salmon. I think my understanding that large-scale atmospheric transport of SO_2 could acidify lakes over vast distances and affect fish survival, plus the importance of seeing a bigger picture that I learned at the Woods Hole Oceanographic Institute helped to see the bigger picture of the factors affecting Pacific salmon abundance.

A passion for science

My term as Director ended in 1993 and I moved back to full-time research. I had always planned to return to research and my work as Director influenced my research. Discovering things was still important, but informing the public was a partnership that expanded the reach of the science beyond the practitioners and into a stewardship. Governments will make better decisions when the public are better informed, but governments do not do a good job of informing the public. This is a bottom-up responsibility. Too many senior officials worry that something may be offensive to current politics. It is not just telling people what we discovered, but it is an honest communication about what we know, do not know, and need to know. The need to know new things is now not something that would be nice to do; it is urgent as our changing climate changes our ocean ecosystems.

Documentaries of influential Canadian aquatic scientists

I started a society in the late 1980s to produce documentaries about the lives of well-known Canadian aquatic scientists whose careers could be inspirational to students thinking about a career in science. These videos would also provide public awareness of the lives and contributions of some of our best aquatic researchers. I could produce videos much cheaper than governments, who were in any case uninterested, and I did not need political approval. I needed a registered non-profit society so I could provide tax receipts for donations. In the late 1980s and for the next 20 or so years, my playwright friend and I met every weekend for breakfast to plan videos and go over scripts. My volunteer job was to choose the scientist, help with script and editing, and raise the money. Each documentary cost about 50000–70000 Canadian dollars with some of this paying my friend, Rod Langley, who produced each video. Many people helped with the videos as we moved around Canada to collect the needed material. One friend even produced an original musical score. Wendy Watson-Wright in the Department of Fisheries and Oceans was a big help. As you might expect, there are lots of stories associated with this initiative. The following are some of my favourites. As I raised the money for the Dr Bill Ricker video, which was titled "A Passion for Science", the head of all fisheries research in Japan asked all their fisheries scientists to donate $100 CAD each. Their names are all listed in the credits. During the filming of the Ricker video, which won a Shaw Cable award for a documentary, Bill talked about falling in love that was both analytical and passionate. If you fall in love and are thinking of getting married, he said on camera, I suggest you both go camping first. Another story is that after we finished the video about Reverend George Taylor, who founded the Pacific Biological Station, our production crew visited his unmarked grave in the Nanaimo cemetery, where we installed a marker and consumed a good bottle of Scotch. Our society owned the copyright for the videos, which many years ago I transferred to the Department of Fisheries and Oceans. I was in a meeting with the Deputy Minister and others many years ago in Ottawa when the head of communications reported that the videos were the most downloaded of all the videos on the Department's website.

Canada has English and French as official languages, which required that the videos have English and French sound tracks. We produced each video except for the Reverend Taylor video with a vacant sound track that could accommodate a French translation, which we could not afford. The Department of Fisheries and Oceans provided the French translation on the videos except for the Reverend George Taylor video. All videos, including Reverend Taylor, are available from the sites I list at the end of this paper (available documentaries). A reader would gain a very good understanding of the history of fisheries science in Canada if all were watched. I think young viewers will be inspired.

Coho salmon (*Oncorhynchus kisutch*)

Coho salmon are a sought-after species in the commercial and recreational fisheries in British Columbia and throughout their distribution (Sandercock, 1991; Beamish *et al.*, 2018). After returning to full-time research, I focussed on understanding why coho salmon abundances were declining beginning in the late 1980s. The accepted interpretation was that overfishing and freshwater habitat loss reduced the number of juveniles produced in fresh water. However, the addition of large numbers of hatchery-produced coho salmon had not restored abundances, so something else was happening. One of our studies showed that the decline in ocean survival had occurred synchronously in the Strait of Georgia, in Puget Sound, and off the coasts of the Washington and Oregon states as well as being linked to a large-scale climate event (Beamish *et al.*, 2000). The Strait of Georgia is a 6.5-km^2 body of water between the British Columbia mainland and Vancouver Island. Puget Sound is south of the Strait of Georgia in the Washington State. These two areas and the ocean off the west coast of the United States are very different ocean habitats that received juveniles (smolts) from a diversity of rivers. It was clear that there was increased ocean mortality that was mostly related to a climate-related change in ocean survival. It was also unlikely that there was a synchronous increase in the abundance of predators. About the same time as these observations were being published, I started working with Connie

Mahnken, who was studying the early ocean survival of coho salmon in ocean net pens. His studies and our ocean studies indicated that survival was linked to an initial rapid growth period that exceed a threshold level by a critical time. We called our hypothesis the critical size and period hypothesis (Beamish and Mahnken, 2001). Fish that exceeded the growth threshold by a critical period would experience a metabolic change to storing more lipids, whereas those not exceeding the threshold would continue to use most energy for growth. It is now about 20 years since the hypothesis was published and the idea is still widely cited. Support for the hypothesis comes from the freshwater life history of coho salmon. Coho salmon that do not grow sufficiently in their first year in fresh water do not become smolts and enter the ocean in the next year. Saltwater entry can be delayed for one or two more years, depending on growth. In general, almost all coho salmon from more northern rivers, where annual growth is slower, stay in rivers longer than in the south. This accepted behaviour in fresh water would require a growth threshold by a critical period, and our ocean growth and survival hypothesis has a similar mechanism. The consequence for coho salmon in the ocean is that fish that grow faster and quicker survive better or grow fast or die young. I think it is possible that this is a common mechanism for all Pacific salmon. In a recent paper, we used a 20-year study of the early ocean ecology of coho salmon to show that above a minimum threshold, the abundance of juveniles surviving in the ocean is related to ocean growth and carrying capacity and not the number of spawners (Beamish and Neville, 2021). In this study, a reduction in hatchery releases of about 50% did not affect the number of hatchery fish surviving to the fall of their first ocean year.

Sockeye salmon (*O. nerka*)

Sockeye salmon are an iconic fish species in British Columbia with fish returning to the Fraser River dominating the interest of biologists and the public. There was a gradual increasing trend in the total returns (catch plus number of spawners) from the early 1950s to a high of 22.7 million fish in 1993 and then a gradual declining trend. It was the historic lows in 2007 of 1.6 million, in 2008 of 1.7 million, and in 2009 of 1.6 million that alarmed the Canadian Government, resulting in a Commission of Enquiry to identify the reasons for the declining trend and the collapse in 2009. We were studying the early ocean ecology of Fraser River sockeye salmon in the Strait of Georgia. I testified to the Commission that ocean and climate conditions were extremely poor for growth and survival in the first weeks in the ocean for the juveniles that went to sea in 2007 and returned in 2009. The Judge agreed with our explanation and wrote: "I am also satisfied that marine conditions in both the Strait of Georgia and Queen Charlotte Sound in 2007 were likely to be the primary factors responsible for the poor returns in 2009" (volume 3, p. 59, Cohen, 2012). However, the Judge also wrote: "Some, I suspect, hoped that our work would find the 'smoking gun'—a single cause that explained the two-decade decline in productivity. The idea that a single event or stressor is responsible for the 1992–2009 decline in Fraser River sockeye is appealing but improbable" (volume 3, p. 88, Cohen, 2012). I think the "smoking gun" actually was identified and it was "marine conditions" as he wrote and as we reported later in Beamish *et al.* (2012) and Thomson *et al.* (2012). The difficulty was that at the time of the Commission, few would accept that climate could have major impacts on the ocean dynamics that would affect the ocean survival of sockeye salmon in particular and Pacific salmon in general. People were looking for a perpetrator that could be removed, allowing things to return to normal. I think in time it will be clear that climate-related changes to the ocean ecosystems during the early ocean residence reduced the availability of food for the juvenile sockeye salmon, which, in turn, reduced their ability to survive in the ocean.

The sea among us—the amazing Strait of Georgia

The Strait of Georgia is one of the most productive marine areas in the world. It is full of wildlife and is important for food, jobs, travel, and recreation. The seaport in Vancouver is the largest in Canada, and about 70% of the population of British Columbia live within about 10 km of the strait. My concern was that what people mostly knew about the Strait was that they floated on it, fished in it, and dumped into it. The residents of British Columbia are the best stewards, but they need a comprehensive and understandable account of what to protect. Along with a colleague, Sandy McFarlane, and with the support of the Pacific Salmon Foundation and encouragement of Harbour Publishing, I invited experts on essential components of the Strait of Georgia to volunteer their time to each write a chapter in a book that would help British Columbians understand the importance and complexity of its stewardship (Beamish and McFarlane, 2014). There are chapters on geology, physical and biological oceanography invertebrates, marine plants, fishes, marine mammals, birds, fisheries, and the First Nations' use of the Strait of Georgia before and after the arrival of settlers from Europe. Authors of each chapter were the leading authorities and were busy people, yet all agreed immediately to voluntarily write one of the chapters. We all also agreed that author royalties would go to the Pacific Salmon Foundation. The book was published in 2014 with two printings in hardcover and a recent softcover printing. It won a British Columbia Book award, and a local book store in Nanaimo reported that it was their best-selling book ever. I think the success of this book identifies a need for better "bottom-up" science communication with the public.

Another retirement activity, along with a colleague, Brian Riddell, has been to try to coordinate Pacific salmon research and monitoring among researchers in all Pacific salmon producing countries (Beamish *et al.*, 2009). In the 2009 report, we suggested that there should be an attempt by all countries to map out the ocean distributions of all Pacific salmon from all countries in one coordinated international winter survey that we called "The International Year of the Salmon (IYS)". Eventually, there was an agreement to have an IYS. However, after several international planning workshops made little progress, I decided to organize my own IYS. During a reception at one of the workshops in Vancouver, I asked a Russian colleague if the Russian Government would charter their famous research ship to me personally. Within 24 hours, it was agreed that for 1.2 million USD I could charter the *Professor Kaganovsky*. All I had to do was to find the money and a science crew. I was able to raise the money from wealthy individuals, businesses, and just about anyone who would listen to me for 15 min. Subsequently, I asked the Russian Fisheries Minister for a better price and he reduced the cost to 900000 CAD. We formed a small organizing committee and ended up with a volunteer

science crew of 21 international researchers. We (I was not on the ship as I was too old) completed the survey (Pakhomov *et al*., 2019) and started to understand how Pacific Salmon survive a critical part of their life history. Brian Riddell and I privately funded and organized similar surveys in 2020 and 2022 with the support of the Pacific salmon Foundation and many donors. Preliminary results are in NPAFC (2022). I am currently organizing the fourth expedition, which I hope will be carried out by members of First Nations in British Columbia and Tribes in the United States. It will be an "Inter-National" study of the winter ecology of Pacific salmon in the Gulf of Alaska.

We made some important discoveries in these winter surveys that have not made their way into the peer-reviewed literature, but papers are being written. For example, we have the first evidence, including photographs, that chum (*O. keta*) and coho salmon can school in the winter. Our DNA analysis shows that juveniles that entered the ocean over vast distances find their way into species-specific schools in the open ocean. My thinking from the results of these surveys is that Pacific salmon have evolved very specific metabolic and behavioural adaptions to survive the winter that might even be cued by day-length changes. If we are to model the effects of ocean and climate changes on Pacific salmon from British Columbia, we will need to use our DNA stock identification information to identify where British Columbia salmon spend the winter and specifically if some populations of the same species consistently are in different areas of the ocean.

A future for fisheries scientists

I started my career in the early 1970s with the Canadian government organizing their fisheries science with the expectation of having sustainable commercial fisheries on the east and west coasts. The Pacific salmon fishery on Canada's west coast has recently collapsed (Figure 1a and b). The average Canadian annual commercial catch of all Pacific salmon in the 1970s was 70280 t, and this was 16.3% of the total catch by all countries. In 2019 and 2020, the total catch was 3388 and 7031 t, respectively. In 2021, the Canadian commercial catch of all Pacific salmon was only 2289 t or 0.2% of the total commercial catch by all Pacific salmon producing countries (Figure 1b). Preliminary estimates for 2022 indicate another poor commercial catch. The expectation of the hatchery programme that started in the late 1970s was that the total Canadian commercial Pacific salmon catch would be 140000 t by 2005. After all the efforts to increase the commercial catch, the catch in 2021 was only 3.3% of the annual average catch in the 1970s.

This collapse of the commercial fishery for Pacific salmon in British Columbia is occurring at a time of historic high catches of Pacific salmon in all commercial fisheries (Figure 1c). Even at a time of historic high catches, there is an alarming anomaly. In 2020, the total commercial catch of Pacific salmon by all countries was 609000 t (Figure 1c). This 37% decrease from the previous year is the largest single yearly decline ever recorded. Preliminary catches for 2022 show that a second precipitous decline in total catches by all countries has occurred. I think the recent catch trends in all countries show that our changing climate is having a major effect on the population dynamics of Pacific salmon. Such large-scale effects will also affect other species of fishes in the North Pacific Ocean and probably in other oceans. Thus, I think that it is time to take a hard look at the mechanisms we thought regulated Pacific salmon abundances in particular and fish abundance in general. The magnitude and importance of the changes in population dynamics along with new research technologies make the next decade an exciting opportunity for fisheries science. There are award-winning opportunities here for young spirited researchers.

Social media has changed how science and science-related issues are communicated to the public and political suppliers of research funds. There needs to be an intermediary group between social media and the political process. In the Pacific, the Fisheries Resource Conservation Council was an independent body with members appointed by the Federal and Provincial Governments. The council provided advice to both governments and the public relating to the conservation of fish populations. I was on the Council from start to finish. We were free to look into any issue and there never was political interference. There could be a diversity of interpretations among council members on a topic, but we knew our responsibility was to achieve consensus. Our reports frequently informed the public about the complexities of particular issues. The teamwork of the volunteers on these councils uniquely integrated popular and professional interpretations of issues affecting fish, fisheries, and aquatic environments. My advice for governments in Canada is to restore the independent fisheries resource advisory process on the east and west coasts and perhaps create a third council for the Arctic.

My advice to researchers beginning their careers is to expect the unexpected, trust your instincts, and never give up your passion for science as your rewards are the personal satisfaction of discovering something new.

I am now in my 80s. My retirement in 2011 was only a reduction in pay and responsibility. There is just too much to be interested in to stop doing research.

Conflict of interest

None declared

Data availability

No new data were generated or analysed in support of this research.

Available documentaries

All videos except the Reverend Taylor, "Legacy of a gentle man", are available on the Department of Fisheries and Ocean (DFO) website: https://science.gc.ca/site/science/en/educational-resources/marine-and-freshwater-sciences/ocean-scientists/ricker-passion-science

All six videos are also available on YouTube.

Reverend Taylor, Legacy of a gentle man: https://www.youtube.com/watch?v=oorIk6x_gS0

Z. (Bob) Kabata, Evolution of a scientist: https://youtu.be/KqI2BwfTzW4

W. E. Ricker, A passion for science: https://youtu.be/6elhe4MsfdI

W. Templeman, A fisherman's son: https://youtu.be/l9pP-xRj1Sw

A. G. Huntsman, A fisherman's friend: https://youtu.be/R4YvZvUARPc

W. B. Scott and E. J. Crossman, The freshwater fishes of Canada: https://youtu.be/Ril58we1QRU

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