CANADA'S TEN YEARS OF ACCOMPLISHMENTS WITHIN NPAFC

AN ERA OF DRAMATIC CHANGE IN CANADA'S PACIFIC SALMON FISHERY

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NPAFC - SUMMARY

The first decade of the North Pacific Anadromous Fish Commission (NPAFC) may turn out to be the most challenging period for Pacific salmon stewardship in the history of Canada's Pacific salmon fishery. Beginning in the mid-1990s, Canada's Pacific salmon catch declined from the highest levels in history in the mid-1980s to what would become the lowest levels in history in the late 1990s (Figure 1). At the same time, the understanding of the mechanisms that regulated the abundance of Pacific Salmon was undergoing what some might consider to be equally dramatic changes. The establishment of NPAFC provided a forum for scientific discussion on the mechanisms responsible for these changes. In particular, communication with Russian fisheries scientists was facilitated; an association started by W.E. Ricker in 1936.

There are tens of thousands of Pacific salmon stocks around the rim of the sub-Arctic Pacific. Studies of the detailed responses of these individual stocks have been necessary for responsible stewardship. Studies of the responses of larger aggregates have shown that there is remarkable synchrony in their population dynamics. The causes for this synchrony are believed to be in the ocean. NPAFC has facilitated the rapid exchange of data and ideas on both the detail of stocks and the dynamics of populations in the ocean. The sharing of this information represents a collective saving of millions of dollars to the research budgets of the contracting parties.

In parallel to the new activities within NPAFC, there was a new North Pacific Science Organization with the puzzling "nickname" of "PICES". PICES provided a focus for the physical and biological sciences that assisted in the interpretation of the responses of Pacific salmon. NPAFC continued to be the focus for Canadian studies on Pacific salmon and the science in PICES was centered around ocean impacts, including the interactions of Pacific salmon with higher and lower trophic levels.

This was the stage for Pacific salmon research of Pacific salmon in Canada from 1993 to 2002. There were dramatic fluctuations in abundances along with equally variable interpretations. There were new, iconoclastic theories about the influences of climate and oceans. There were unprecedented scientific opportunities that were the dreams of researchers only a few decades earlier. There were some intriguing politics within the Canadian Science organization that added a seasoning of reality to the normal boiled and poached routine of scientists. This summary is of the contributions made by Canadian participants to the various functions of the Committee for Scientific Research and Statistics (CSRS). It was an impressive decade that established the science and the processes needed to adapt to the certainties of the future impacts of a highly variable Pacific salmon habitat.

Contributions to Meetings

Early contributions by Canada were a result of the establishment of a high seas salmon program. High seas research in the 1960s was also closely associated with the International North Pacific Fisheries Commission. The renewed efforts in the 1990s provided a focus for studies of how oceanographic factors controlled the distribution and production of Pacific salmon. A major discovery facilitated by NPAFC, by Welch and colleagues from Russia and Japan was that salmon exhibited strong species - specific threshold responses to temperature over a very narrow, even sharp values. Critical temperatures were identified for pink, chum, coho, and sockeye. Temperatures lower than these critical values had no measurable influence on distributions. Several of the cruises reported results that identified temperatures of 10.5°C as an upper thermal limit for pink and chum salmon in the late winter.

Another early contribution was a report by Welch and staff, that followed up on initial observations by W.E. Ricker that the average individual size of some Pacific salmon was declining. The declines were most apparent for pink and coho salmon. Significant declines in the size of sockeye occurred in the 1990s. There was no trend for chum salmon and Chinook, in the 1990s, had sizes similar to the early sizes recorded in the 1950s. The reasons for the changes in size remain to be explained. Welch proposed in document 97 that the explanation of genetic selection favoured by W.E. Ricker for pink salmon, probably was not the cause of the long-term declines in size that started in 1951. Welch was leaning toward an explanation that related to density-dependent effects in the ocean, but at what age and where? More detailed studies of growth patterns in the ocean using scales were carried out, but consistent patterns were not found.

McKinnell showed that there was a negative correlation of sockeye growth with the magnitude of Western Alaska sockeye catches. The effects were age specific which he interpreted to suggest that aggregations of sockeye may be more structured than previously reported.

Beamish and colleagues concentrated their research in the Strait of Georgia, located between Vancouver Island and the British Columbia Mainland. Approximately 70% of British Columbians live around the shores and the Strait was an important nursery area for Pacific salmon that accounted for up to 40% of the total Canadian Pacific salmon catch. Early studies found that chum salmon remained in abundance much later than previously thought, indicating that something had changed in this important nursery area. A method developed and reported in 1994 using otolith microstructure was used to identify hatchery and wild salmon. Identification of rearing types was needed because large numbers of hatchery-reared Pacific salmon were being added to this ecosystem and the impact on wild juvenile salmon was unknown.

In the early 1990s, Beacham and associates were developing stock identification methods using microsatellite DNA. Analyses were found to provide accurate and precise estimates of stock composition for Chinook and coho.

In 1995, it was first reported at NPAFC that farmed Atlantic salmon caught in fisheries totalled 85,429 individuals. Although there was no evidence that Atlantic salmon were reproducing in freshwater, the rapidly developing industry that started in 1985 was recognized as competing for market share with the commercial fishery for wild and hatchery reared Pacific salmon.

At the 1995 meeting, Beamish and colleagues reported that in 1976/77 there was a major shift in the ocean/atmospheric systems in the North Pacific. There was an intensification of the Aleutian Low, a drop in sea surface temperatures in the central North Pacific and an increase in sea surface temperatures along the Pacific coast of Canada and the United States. At the same time there were dramatic changes in salmon abundance. They reported that "as the studies continue, it is expected that the mechanisms responsible for this carrying capacity shift will become clearer".

At the next annual meeting, Beamish submitted a series of papers that expanded on the regime concept. The papers showed that changes in the productivity of the aggregate of Fraser River sockeye salmon stocks could be separated into productivity regimes that corresponded to changes in the trends in climate. Another paper reported on the synchrony of abundance trends of Chinook and coho populations off Oregon, was higher and in the Strait of Georgia. The abundance trends were linked to trends of species farther north, but opposite in phase. The implications of these decadal scale shifts in mean productivity were proposed to have major impacts on the management of salmon stocks.

The study of the impacts of hatchery salmon on wild salmon continued with an emphasis on Chinook salmon. Otolith microanalysis showed that hatchery fish were released into the Strait of Georgia earlier than wild, ocean-type entered. However, by the end of the year, these wild ocean-type juveniles were the least abundant with hatchery fish, and wild, stream-type fish being more abundant. It was apparent that changes in the population structure had occurred since the studies of Healey in the 1970s, but the impacts remained to be determined. Again, this was evidence that the rearing habitat in the Strait of Georgia had changed.

In 1997, there was a major El Nino occurring in the Pacific Oceans. Sockeye salmon returning to the Fraser River selected a route from the north in unprecedented high numbers. There was more straying than ever recorded with sockeye salmon thought to be from Fraser River stocks occurring in many smaller rivers around Vancouver Island. Returning sockeye were also the smallest since 1951, and perhaps since 1917. Clearly, the ocean environment changes had profound impacts on the growth and behaviour of sockeye salmon. It is worth noting that these changes are indications of the sensitivity of salmon to the expected impacts of greenhouse induced climate change.

Surveys in the Gulf of Alaska in October 1996, and March 1997, added to the evidence accumulated by Welch that most juvenile salmon are confined to the continental shelf when migrating north. The reasons for migrating north along the shelf and then moving offshore after their first ocean winter continued to puzzle the investigators.

Russian investigators have used an index of atmospheric processes called the Atmospheric Circulation Index (ACI). This index is a simplification of the dominant directions of atmospheric winds. Beamish compared ACI to his index of the Aleutian Low (ALPI) and found that there was a striking similarity. What was remarkable was that ACI is an index of atmospheric processes over western Europe. Both the ACI and ALPI match the trends in total Pacific salmon catch quite well. The synchrony suggested that processes affecting Pacific abundance trends are even larger scale than just the Pacific. In the next year, a team of Canadian and Russian researchers used 100 years of Russian data to produce a Pacific equivalent of the ACI which they labelled the Pacific Circulation Index, or PCI. As might be expected, the PCI matched the ALPI quite well. The PCI and ALPI are indicators of regimes and regime shifts. In Document 321, Beamish and colleagues reported that in 1998 there was an intense Aleutian Low. If the intense low persists, they speculated that the productivity of Pacific salmon stocks in the sub-Arctic Pacific many improve. However, they confessed that they did not understand enough about the new regime to be forecasting abundance trends. This turned out to be good advice as the new regime may have started in 1998, rather than in 1996, and appears to be more favourable for salmon in British Columbia than in the Bering Sea. But time will tell. Regime impacts were also reported for steelhead (Oncorhynchus mykiss). The change in abundance trends was particularly pronounced after 1977. A possible change in 1990 was also reported by Welch.

In document 319, Beamish and Mahnken described a new hypothesis for the natural regulation of coho and other species of Pacific salmon. They proposed that there are two major sources of mortality. The first mortality is predation-based and occurs shortly after salmon enter the ocean. The second mortality is growth-based. They suggested that juvenile salmon must grow to a minimum size, a critical size by the late summer, in order to survive the harsh ocean conditions in the winter. This critical size, critical period hypothesis linked climate to marine survival through growth. Also, competition during periods of reduced ocean carrying capacity could increase mortality.

The work in the Strait of Georgia continued and a method was described for estimating abundances. These abundance estimates were used to show that the mortality of coho over the winter was large and an important determinant in the final, adult abundance.

In 1998, Canada first reported that it was thermally marking juvenile salmon. The program started in 1992. The major hatcheries marking fish with thermal marks in the otolith were Robertson Creek and Nitinat hatchery. In 2001, it as agreed that all thermal marking would be co-ordinated through NPAFC.

By 2000, the genetics laboratory at the Pacific Biological Station had developed genetic tools and baseline information for Pacific salmon and other species to address stock identification problems and other issues. To date, 22,000 coho salmon representing 140 stocks from British Columbia, Washington, and Alaska had been evaluated at 8 microsatellite and 2 Mhc (major histocompatibility complex) loci. Twenty-three thousand (23,000) Chinook salmon from 140 stocks from British Columbia, California, Washington, and Oregon have been analyzed using 13 microsatellite loci. In addition, 16,000 sockeye salmon for 90 British Columbia stocks had been analyzed at 14 microsatellite loci, and variation at two Mhc loci is currently being surveyed. Genetic markers and baseline information were also developed for four other species of salmon and trout, eight species of marine fish, and three species of marine invertebrates. Simulation studies had demonstrated that high levels of accuracy and precision were possible in the analysis of samples obtained from mixed-stock fisheries. Other applications of this technology included the definition of evolutionary significant units and the selection and improvement of brood stock for enhancement or aquaculture ventures.

The year 2000 marked a significant increase in the productivity of chinook and coho in the Strait of Georgia. By chance, Beamish and his colleagues had collected extensive data on the factors affecting juvenile salmon, before, during and hopefully after a major regime shift.

The abundance of ocean age-0 coho, chinook, and chum salmon estimated from surveys conducted in the Strait of Georgia in June and July indicated a substantial increase in 2000 compared to the previous three years. Pink salmon catch per unit effort (CPUE) increased from 1998 to 2000, however sockeye CPUE was the lowest in 2000 among the four years. The increases in coho abundance occurred despite a slight reduction in hatchery releases. An increase in wild coho abundance in 2000 may be related to a reduction in fishing mortality in 1998 or an improved freshwater survival or both. The synchrony of increased abundances among species, except sockeye salmon, indicates that a common factor is involved. These increases were also associated with good growth relative to previous years. This indicates that the productivity of the marine habitat may have increased in 2000.

The studies in 12001 indicated that the improved productivity has continued. In 2001, the abundance of ocean age-0 coho, chinook, and chum salmon remained high relative to the period from 1997 to 1999, but slightly lower than in 2000. Individual size and fitness also remained high. The increased growth for coho salmon in 2000 appeared to be related to improved marine survival in 2001. The composition of the diets of coho, chinook, and chum in 2001 changed only slightly from 2000. In both 2000 and 2001, there was a decrease in the number of empty stomachs compared to the earlier years and the average volume of daily gut contents in 2000 and 2001 was substantially larger than the average volume in 1997, 1998, and 1999. The increased growth and early marine survival in 2000 and 2001 appears to be directly related to the increases in gut volume rather than changes in diet composition. The persistence of the changes observed in 2000 through to 2001 indicated that the Strait of Georgia ecosystem probably is in a new, more productive regime that should continue on a decadal scale. In 2001, Beamish was able to provide direct evidence of the critical size and critical period hypothesis.

The critical size and critical period hypothesis identifies two distinct periods of mortality in the first ocean year of Pacific salmon. The first period is immediately after salmon enter the ocean and is believed to be primarily the result of predation. The second period occurs in the late fall and winter and is related to the ability of juvenile salmon to grow during the summer to a size that will allow them to survive in the ocean after the fall equinox. In 2001, coho salmon moved into the Strait of Georgia in the spring of their second year for the first time in 6 years. The scales from these coho salmon had an average circuli width in the area corresponding to the early marine period in the previous summer (2000) that was significantly wider than observed on the scales of coho from the same brood year sampled in September and November 2000. This indicated that mortality in the fall and winter of 2000/2001 was size related with more of the larger fish surviving the winter. The survival of larger coho supports the hypothesis that growth of coho during the first marine summer is an important component of the natural processes that regulate brood-year strength.

Workshops and Technical Reports

Workshops provided a formal setting for the timely exchange of new scientific information. Material presented at these events was quickly published, although most articles were not peer reviewed. Workshops provided encouragement for greater synthesis. Presentations were solicited which attracted participation from scientists that did not normally attend the annual meetings. The symposium format with formal and informal discussion is the standard method for stimulating the development of new ideas. NPAFC provided the central focus for researchers on Pacific salmon to meet and develop new hypotheses and partnerships. The first technical report in March 1998 contained 5 Canadian papers. Beamish and colleagues reported in the general concept of regimes and how regimes influenced the dynamics on Pacific salmon. A number of climate indices were used separately and in combination as a regime index to demonstrate that climate indices in the Northern Hemisphere were closely linked and changed trends in synchrony. It was proposed that a regime shift occurred in1989 - 1990 that resulted in a synchronous decline in the marine survival of coho salmon. Welch and co-authors provided convincing evidence that a significant decline in marine survival occurred for steelhead from a key river on Vancouver Island. This decrease occurred after a period of improved productivity beginning with the 1977 regime shift. Peterman and his collaborators looked at the impacts of climate and ocean factors on sockeye salmon. They identified an increase in the productivity of Alaskan stocks that was associated with the 1977 regime shift. They suggested that the impacts of the 1977 regime shift were greater for Alaskan stocks than for Fraser River stocks. An interesting synchrony in response was the coast-wide decline in size. A major mystery in the management of Pacific salmon off Canada's West Coast has been the collapse of the sockeye stocks that migrate into Rivers Inlet. The reason for the collapse remains to be explained, but McKinnell and others showed that it was unlikely that the cause of the collapse had a freshwater origin. These papers and a state of the N.E. Pacific Ocean report by Howard Freeland represented some of the strongest evidence that the dynamics of Pacific salmon is affected by trends in climate and ocean conditions. In the past, the impacts of the ocean environment were considered to be minor relative to fishing effects and changes to freshwater habitat.

The second workshop on factors affecting the production of juvenile salmon in October 2000, attempted to encourage collaboration between the Pacific Science organizations (PICES) and NPAFC. The emphasis was on the early marine phase of Pacific salmon. The only published Canadian paper was by Beamish and Neville. They proposed that the brood year strength of salmon is mostly determined in the first marine year, as a result of predation-based and growth-based mortalities. Growth-based mortality was identified as carrying capacity mortality and was related to the energy stored by an individual fish during the summer. Smaller fish would not survive periods of metabolic energy deficits as well as larger fish. The concept of mortality resulting from insufficient growth in the first marine summer links climate change directly to marine survival.

This second workshop also included papers on the history of all the studies of the early marine period of Pacific salmon. The publication of these papers will appear in Bulletin number three and will be the first published summary of Canada's studies on the early marine life of Pacific salmon.

The third workshop in March 2001, provided a timely focus for studies in salmonid otolith marking. The mass marking of otoliths is being coordinated through NPAFC and this workshop allowed investigators to review what is known and plan future studies. Canada presented two papers. A paper by Luedke and Gao proposed that stable isotopes could be used to identify the origin and life history pattern of sockeye salmon. Stable isotopes of oxygen provide a measure of the temperature history of a fish, while stable isotopes of carbon can provide an indication of the feeding history. Hargreaves and co-authors started the thermal marking of otoliths on Canada's West Coast and they reported on the development of their program. Their paper provides the first summary of the program. All participants were encouraged by the initiative by NPAFC for the international coordinator of otolith thermal marking patterns and the sharing of data.

The fourth technical report contained the proceedings of a joint meeting of five agencies on the causes of marine mortality of salmon in the North Pacific and North Atlantic Oceans and in the Baltic Sea. The meeting was held in March 2002, and the publication appeared in record-breaking time by September 2002. This joint effort may be the first attempt to identify the common factors that regulate the abundances of Atlantic and Pacific salmon.

Canada provided four papers. Beamish and colleagues continued to test their hypothesis that climate affected marine survival through growth in the first marine summer. Juvenile salmon must grow to a minimal size before fall in order to survive periods of energy deficits in the late fall and winter. Evidence was provided that showed that the slower growing fish had a significantly higher mortality over the first marine winter, than faster growing fish. Welch and staff presented two papers that reported on the bio-energetic response of coho to climate change and the potential interrelationships between patterns of migration and marine survival of Pacific salmon. In the study of how growth rates were influenced by oceanographic and climate conditions, the authors used stable isotope of caesium to measure food consumption rates. They concluded that the changing temperature affected growth by changing the prey type rather than the abundance of prey as was found in the study of the Strait of Georgia by Beamish et. al., in the same report. The second study by the Welch group concluded that juvenile salmon undertake rapid, long-distance migrations that are highly directed to maintain them over the continental shelf. A final paper by

Tanasichuk and Luedke reported a relationship between euphausiid availability in an area on the west coast of Vancouver Island and the subsequent return of coho and sockeye salmon.

Bulletins

In the first ten years, NPAFC will publish three bulletins. These are formal publications, which contain peer-reviewed papers on topics of international interest. The symposia and subsequent publications are organized by the scientists within NPAFC and their colleagues in other organizations. It is sometimes forgotten that the time taken to organize, write papers, edit proceedings is all volunteer time that must be found outside the normal responsibilities of participants. The resulting publications are the permanent records that support scientific discovery. Investigations can only become science when they are communicated to others. Those of us who struggle to improve our understanding of the processes which regulated Pacific salmon abundance recognize and greatly appreciate the importance of the organizations an individuals who allow these symposiums to occur and are our patrons.

In Bulletin No. 1, Canadian scientists contributed 8 papers. The history and status of Pacific salmon in British Columbia was reported by Henderson and Graham. Margolis summarized the biological characteristics of naturally acquired parasites that serve as "tags" for anadromous salmon stocks. He showed that when stock identification is based on the unique presence of heteroxecous helminth parasites, the use of these parasites provides a stable basis for stock identification. However, baseline data may have to be re-established at periods of one to ten years depending on the stocks to be distinguished. Unfortunately Dr. Leo Margolis died before this first bulletin was published. Leo Margolis, more than any other Canadian, provided a personal commitment to ensure the success of NPAFC and it's earlier organization, the International North Pacific Fisheries Commission. Beacham teamed up with Margolis and Nelson to compare the methods used for the stock identification of sockeye salmon in Barkley Sound, British Columbia. The most accurate and precise estimates of stock compositions were observed using parasitic identification. However, changes in the prevalence of parasites occurred in 1993-1995, substantially reducing precision. The use of variation at four microsatellite loci restored the previous level of accuracy of precision. Protein electrophoresis provided the least reliable estimates of stock identification. Ryall used a number of models to test the accuracy of their estimates of the abundance of chum salmon returning to the Fraser River. The different models were evaluated using the criteria of minimising the residual mean square. Pooled model results provided the best results, but estimates tended to underestimate run size early in the season and over estimate the run size at the end of the season. Welch and colleagues reported in their observation of thermal limits for steelhead trout. They reported that sharp thermal limits restricted the distribution of steelhead trout to only a small area of the North

Pacific. Both upper and lower thermal thresholds existed, but differences of less than 2° C existed, but differences of less than 2° C existed between regions and less than 0.5° C between decades. They proposed that by mid-2000, global warming impacts could result in the distribution moving north of the current distribution.

Noakes, Beamish, Klyashtorin and McFarlane joined forces to look at the relationship between salmon abundance and climate. They showed that salmon catches in the subarctic Pacific had a high degree of consistency. The pattern occurred over wide spatial and temporal scales suggesting a significant impact by climate and ocean conditions. Time series models were used to remove the trend component of the data as well as any autocorrelation. Significant relationships were observed between the all-nation salmon catch and each of the climate indices. The declining trend in the atmospheric circulation index was interpreted to indicate that all-nation salmon catch could decline.

Beamish and Folkes identified a new tendency for juvenile salmon chum salmon to remain the Strait of Georgia. The reason why large numbers of chum remained was not determined although it was shown that the Strait of Georgia was warming consistent with trends in climate. One issue is that large increases in the abundance of juvenile chum may have impacts on other species of juvenile Pacific salmon.

A final paper by Reinhardt and Healey reported on laboratory studies of predation risk. The full paper was not published, but the abstract contained speculation that in the ocean, the presence of predators may serve to depress growth rates in a population through risk-avoidance behaviour. However, according to this idea, the growth rates of the smaller fish would be reduced while the larger fish would be less wary of predators and thus would have higher growth rates.

The second bulletin contained three Canadian papers. King and Beamish followed up on the study of increased chum abundance in the Strait of Georgia, by examining the impacts on coho salmon. Stomachs of 2230 coho and 1558 chum ocean age-0 salmon were analysed. A large hatchery marking program was conducted for coho but no for chum salmon allowing a comparison of hatchery-marked and unmarked coho. There was almost complete diet overlap between hatchery-marked and unmarked coho throughout the summers of 1997 and 1998. The seasonal patterns in diet composition illustrated that in early summer chum are potential competitors of coho in the Strait of Georgia. By late summer, chum are still competitors but they begin to feed upon gelatinous zooplankton. The implications of all diet comparisons are that chum and hatchery-reared coho are competitors of non-hatchery coho during their first marine summer. In the Strait of Georgia, the catch per unit effort indicates that chum salmon is tow to four times more abundant than coho. If coho final brood year strength is determined via first summer growth and winter mortality (according to the critical-size-and-critical-period hypothesis), then the high abundance of chum and the overlap in chum and coho diets could explain, at least in part, the recent increase in natural marine mortality of coho.

Noakes, Beamish, Sweeting and King looked at the general relationship between hatchery and wild salmon as concern was developing about the replacement of wild fish by hatchery fish. They proposed that the interaction between hatchery and wild salmon is a function of trends in productivity in the ocean that are linked to trends in climate. Shifts to lower productivity regimes such as occurred in 1989/1990 may amplify the negative interactions. According to these views, releases from hatcheries should be reduced, not increased when the ocean carrying capacity is reduced through natural decadal-scale variation.

The final paper combined the experiences of Beacham, Wood, Withler, Le and Miller to determine the stock composition of sockeye salmon returning to the Skeena River. Variation at six microsatellite loci was surveyed from approximately 1,700 sockeye salmon from 17 populations in the Skeena River drainage in northern British Columbia as well as from 1,400 fish in test fisheries conducted in the lower river during 1996-1999. Stimulated mixed-stock samples suggested that the six microsatellite DNA loci should enable relatively accurate and precise estimates of stock composition when utilised for fishery management applications within the river. Analysis of the test fishery samples indicated that sockeye salmon from Babine Lake comprised a substantial portion of the returning fish. They also compared population structure of sockeye salmon from both the Skeena and Nass rivers. Stimulated and actual mixed-stock samples suggested that accurate estimates of stock composition of sockeye salmon from these two these two major production areas in northern British Columbia should be obtained in analysis of samples from mixed-stock marine fisheries.

The third bulletin will be published in 2003 and will summarize the early marine studies of juvenile salmon conducted throughout the distribution of Pacific salmon. This ambitious project will provide a standard reference of studies of the factors that affect salmon in their first marine year. The summary for Canada is being written by Beamish with considerable assistance by colleagues.

Summary

Pacific salmon are the focus for fisheries management on Canada's Pacific coast. The anadromous behaviour of salmon requires that there is international co-operation to protect salmon in the shared feeding areas outside of the 200-mile limits of the salmon producing countries. The health of Pacific salmon is a measure of the health of our environment and of our ability to be stewards of our ecosystems. Protecting salmon and preserving the environment is a responsibility the general public takes very seriously because they realize that the health of salmon reflects the general health of our ecosystems.

Governments recognised their responsibility when they agreed to NPAFC. It is timely to take some time after ten years and see how we are doing.

In Canada, it is clear that we have benefited immensely from the establishment of NPAFC. We have total protection on the high seas for our salmon stocks. We also received scientific information collected by our colleagues that we use to improve our management of our own stocks. Equally important, we have established partnerships that facilitate discussion and interpretation of data. Over ten year, a relationship has developed that can honestly be compared to a family. Science is the understanding of nature. It is difficult and expensive to understand how to ensure that Pacific salmon will not be harmed by our interventions into their natural processes of population regulation. The progress we have made over the past ten years helps minimise the risk of making major mistakes as have occurred recently for some other major fisheries. The contributions made by Canadian scientists in the past ten years have changed how we think about the management and population dynamics of Pacific salmon. Not all of Canada's Pacific salmon research is carried out within NPAFC, but NPAFC remains as the focus for the marine program. Canadian researchers contributed to this focus with advances in our understanding of how to identify stocks; affects of climate on the ocean distribution and survival of salmon; studies of the interactions between hatchery and wild salmon; identification of the new hypotheses on what determines brood-year strength, and how climate and ocean impacts compare to the impacts of fishing. The next 10 years may be the most exciting and challenging in our history. It is reassuring to know that there is a strong international commitment through NPAFC to work together to ensure that Pacific salmon are protected.

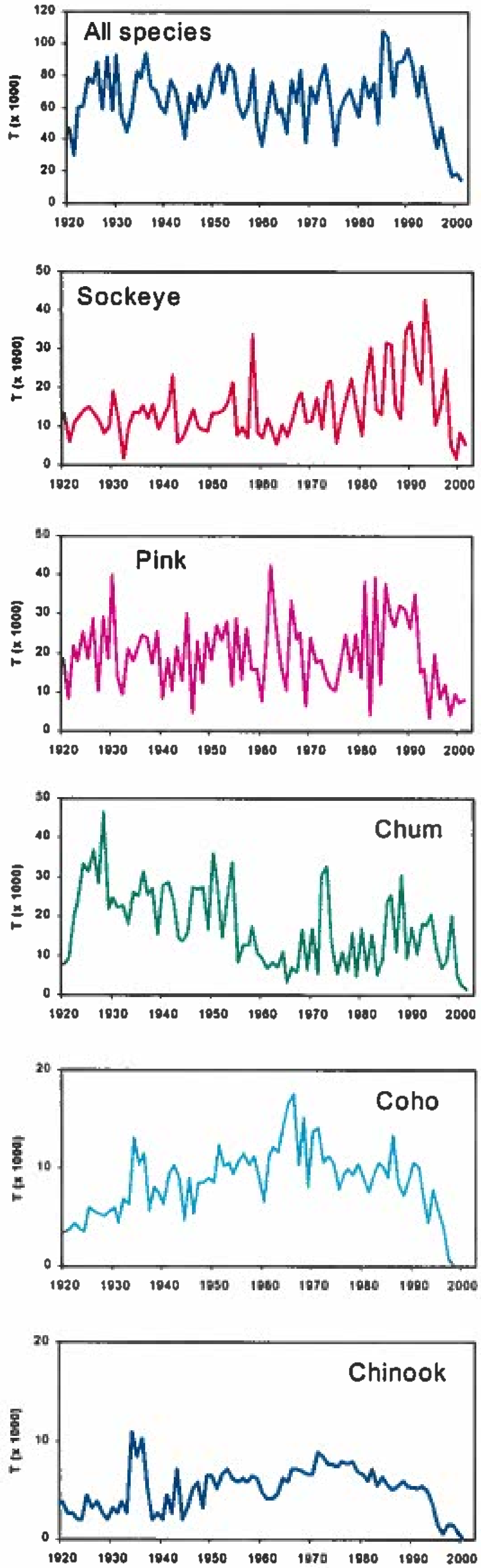

Figure 1. Catches of Pacific Salmon