Appendix A

A Proposal to Establish an International Year of the Salmon

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Abstract

The Long-term Research and Monitoring Plan developed by the North Pacific Anadromous Fish Commission concluded that a proposal should be developed for an International Year of the Salmon. An International Year of the Salmon will allow experts from all Pacific salmon producing countries to focus on identifying the mechanisms that regulate Pacific salmon abundance and to use this understanding to maximize economic opportunities in the future while ensuring responsible stewardship. This proposal identifies some of the major climate and ocean influences on Pacific salmon production to show that there will be major changes in abundance trends in the future. It is of benefit to everyone that these changes are anticipated and not come as surprises. I suggest that the NPAFC form a group that will look at the feasibility of funding an International Year of the Salmon.

Introduction

The Long-term Research and Monitoring Plan (LRMP; Beamish et al. 2009a) for Pacific salmon *Oncorhynchus* spp. that was produced and published by the North Pacific Anadromous Fish Commission concluded that a proposal for an International Year of the Salmon should be developed. Thus, this is a proposal to establish an International Year of the Salmon. The goal is to ensure that each Pacific salmon producing country has the information to make management decisions that optimize economic opportunities relating to Pacific salmon production while maintaining responsible stewardship. The trends in production and catches of Pacific salmon from around the North Pacific are a history of surprises. International fisheries science now has the ability and new technologies to reduce these surprises and minimize their economic impact. Furthermore, many researchers recognize that we are in a period of increasing variability in Pacific salmon production most likely because ocean and freshwater environments are changing. The following examples of major changes in climate and ocean environment probably will affect the abundance of Pacific salmon. An International Year of the Salmon is a practical way of using all available resources to anticipate future trends in the abundance of the various species of Pacific salmon. An International Year of the Salmon will bring experts from all countries into teams that will use existing knowledge and hopefully new information to understand the mechanisms that regulate Pacific salmon abundances and allow all countries to plan for the future.

Major Issues

The following are examples of major, natural changes that affected Pacific salmon production. It is likely that their impacts will continue. An improved understanding of the linkages between these changes and Pacific salmon production will help each country plan for the economic consequences of these changes.

The Resource

The total commercial catch of all Pacific salmon set historic high records in 1995, 2007 and 2009 (Figure A.1). The historic high catches resulted from improved marine survival and, to a lesser extent, from increases in hatchery production. However, the reasons for the improved marine survival remain to be explained in a way that can be used to manage Pacific salmon production. An International Year of the Salmon will attempt to identify the capacity of the ocean to produce Pacific salmon.

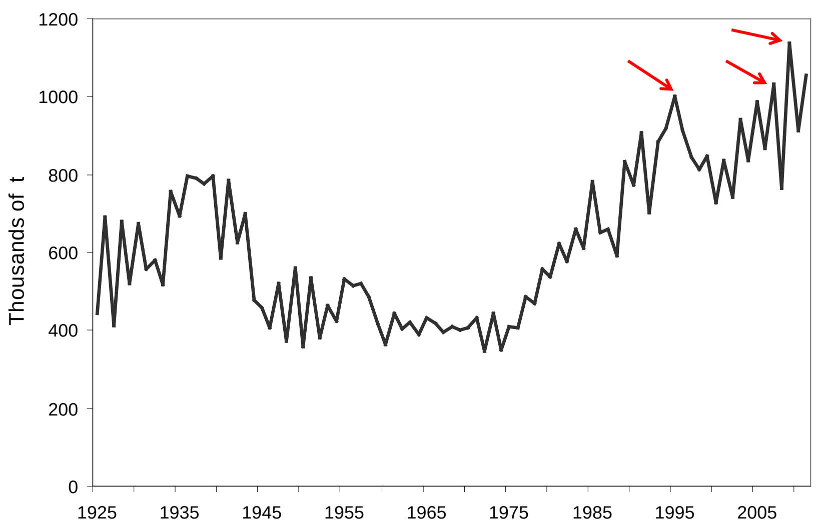

Figure A.1. Total commercial catch of Pacific salmon by all countries in the North Pacific from 1925 to 2011 in thousands of t (2011 catches are preliminary). Arrows indicate the record high catches.

Pink salmon

The increasing catches of Pacific salmon result from the increasing production of pink salmon *O. gorbuscha*. Numerically, pink salmon in recent years represent 64.6 % of the total catch of all Pacific salmon and 45.3 % of the total catch by weight (1998–2011). From the late 1970s to the early 1990s, the rate of increase of odd- and even-year pink salmon was about the same (Figure A.2). Beginning in the early 1990s and through to the present, the average catches of even-year pink salmon have not increased but the catches of odd-year pink salmon continue to increase. There is no explanation for the different behaviour of the two lines of pink salmon but it is apparent that it is most important to discover the reasons.

Chinook and coho salmon

Chinook *O. tshawytscha* and coho *O. kisutch* salmon catches collectively represent only about 4% of the total catch by weight of all Pacific salmon in the North Pacific over the past 20 years (1992–2011). However, catches of Chinook and coho salmon are particularly important in the Canadian and United States fisheries. The efforts of supplementing wild production with hatchery production have not rebuilt abundances and in some fisheries hatchery fish are virtually the only fish caught. The marine survival of both of these species has declined dramatically at the southern portion of their ranges over the past 25 years. In some populations of Chinook salmon, the marine survival is now less than 0.5%. The marine survivals are so low in some populations of Chinook and coho salmon that it is not an exaggeration to consider it a crisis. Perhaps surprisingly, the total catches of Chinook salmon in all major areas throughout the North Pacific have also declined over the past 50 years (Figure A.3(a)). Catches of coho salmon have also declined in all of the major areas except in Alaska (Figure A.3(b)). The reasons for the continuing decline in catch have to be more than reduced fishing opportunities and remain to be explained. It is particularly important to Canada and the United States to determine if the trends will continue.

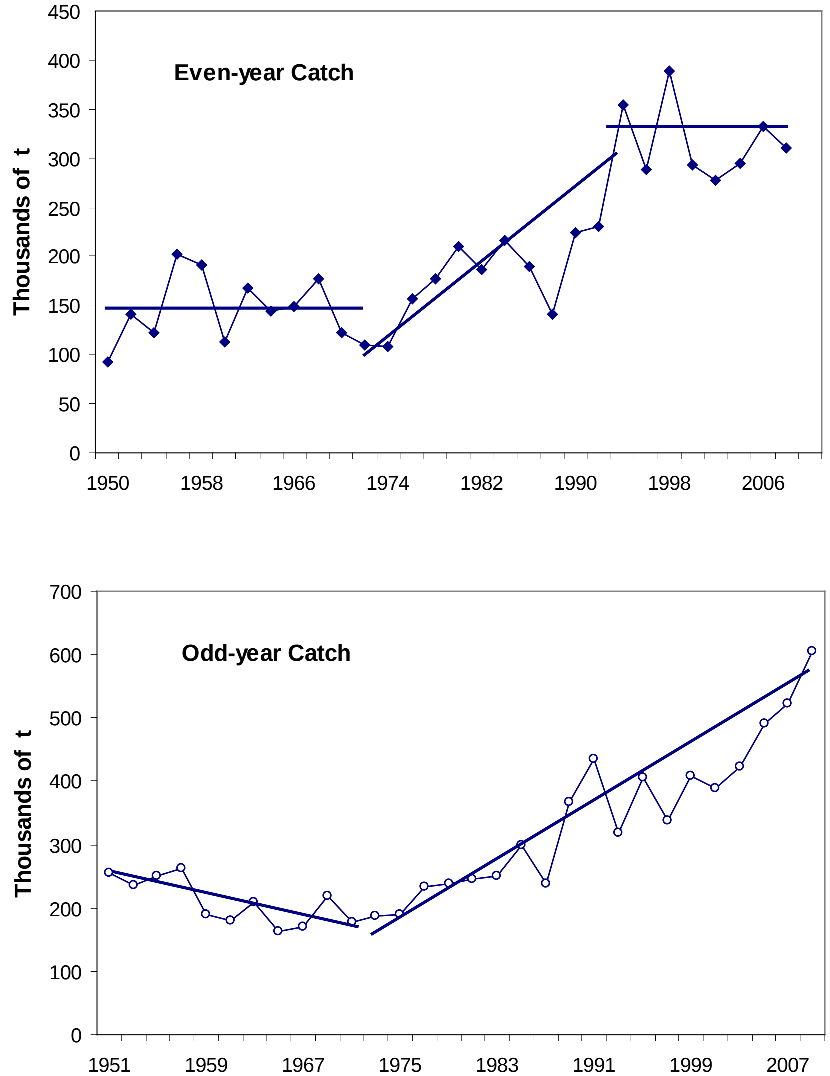

Figure A.2. Commercial catch of pink salmon in the North Pacific in even (upper panel) and odd years (lower panel) from 1950–2009. The odd-year catch continues to increase about 1990 after the average even-year catch levels off. Data from the North Pacific Anadromous Fish Commission.

Sockeye salmon

The Fraser River is a key producer of sockeye salmon *O. nerka* and the production is shared with the United States. Canada and the United States established the Pacific Salmon Commission to facilitate agreements on the catch and stewardship of Fraser River sockeye salmon as well as for other species that move in and out of the territorial waters of the two countries. There was an increasing trend of production of Fraser River sockeye salmon up to the early 1990s, followed by a decreasing trend. The decreasing trend was highlighted by an historic low return in 2009, followed by an historic high return in 2010 (Figure A.4). The extreme variability was unexpected and the extreme low resulted in Canada spending about $27 million CAD on a judicial inquiry to determine the reason for the surprise. Canada and the United States provide funds to operate the Pacific Salmon Commission and many people participate in the proceedings of the Commission. An understanding of the mechanisms responsible for the trends and the variation in sockeye salmon production would facilitate the work of the Commission, help the industry and assure a concerned public that sockeye salmon stewardship is in good hands.

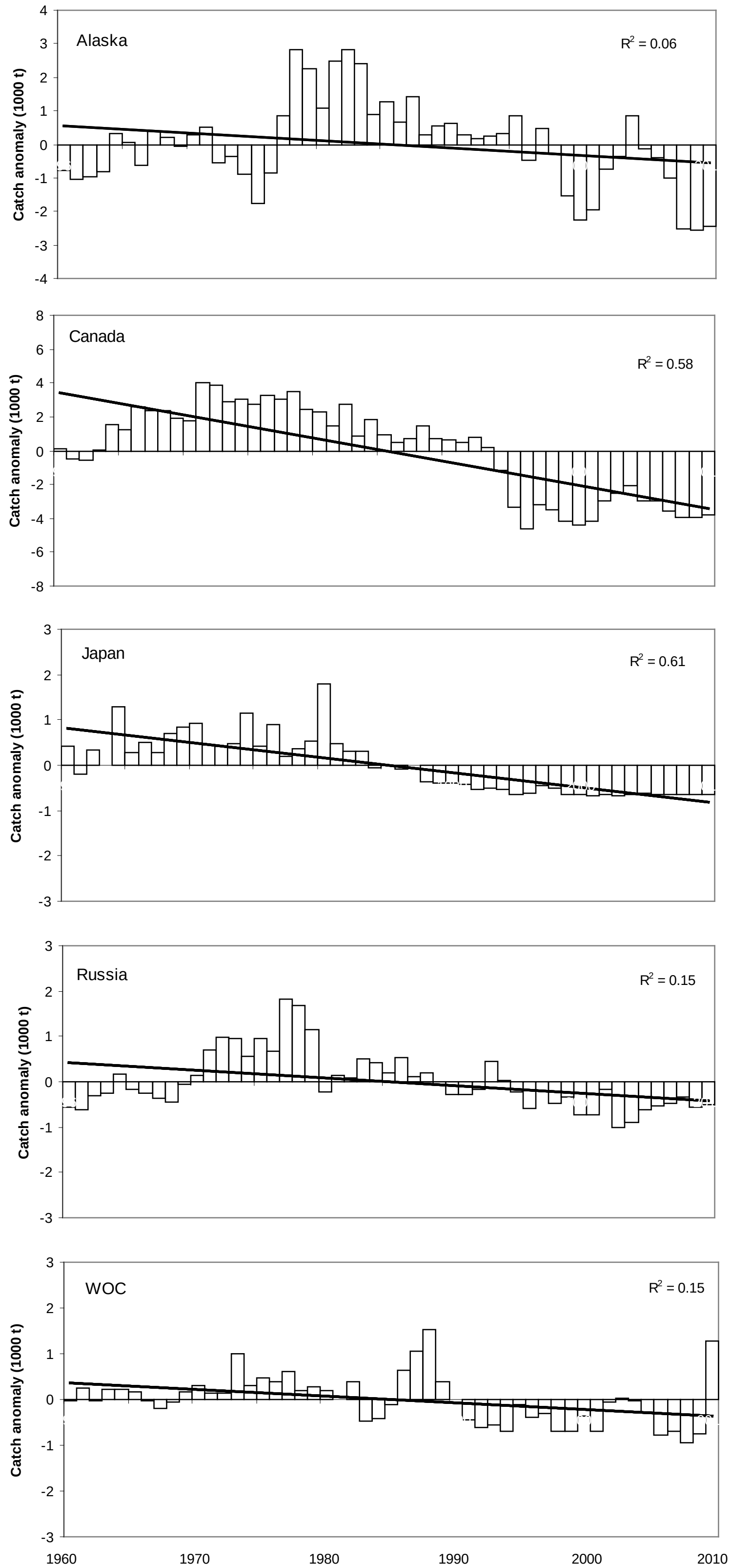

Figure A.3(a). Anomalies of catch of Chinook salmon by Alaska, Canada, Japan, Russia and Washington, Oregon and California (WOC) from 1960 to 2010 showing the declining trend in all countries beginning about 1990.

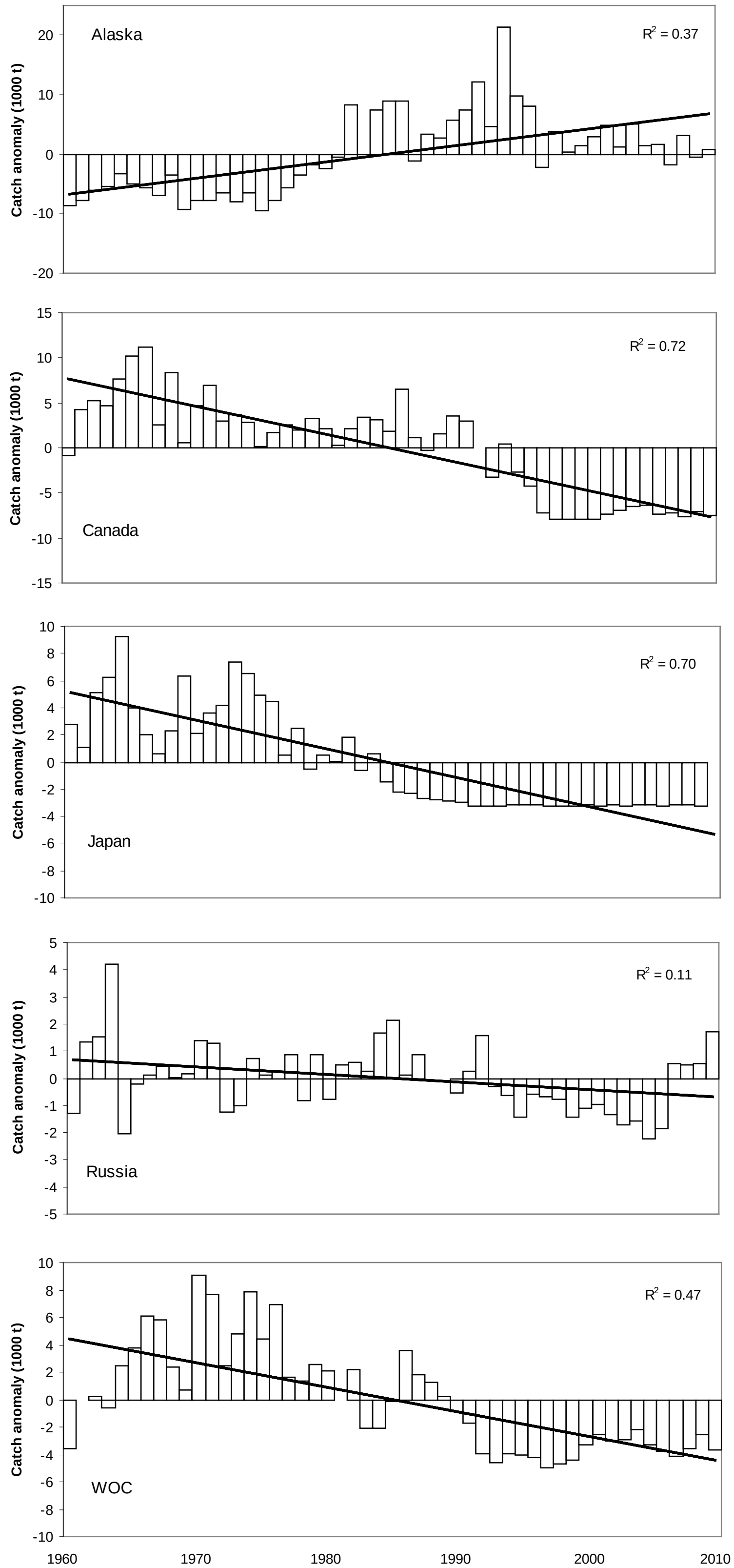

Figure A.3(b). Anomalies of catch of coho salmon by Alaska, Canada, Japan, Russia and Washington, Oregon and California (WOC) from 1960 to 2010 showing the declining trend in all countries beginning about 1990, except for Alaska.

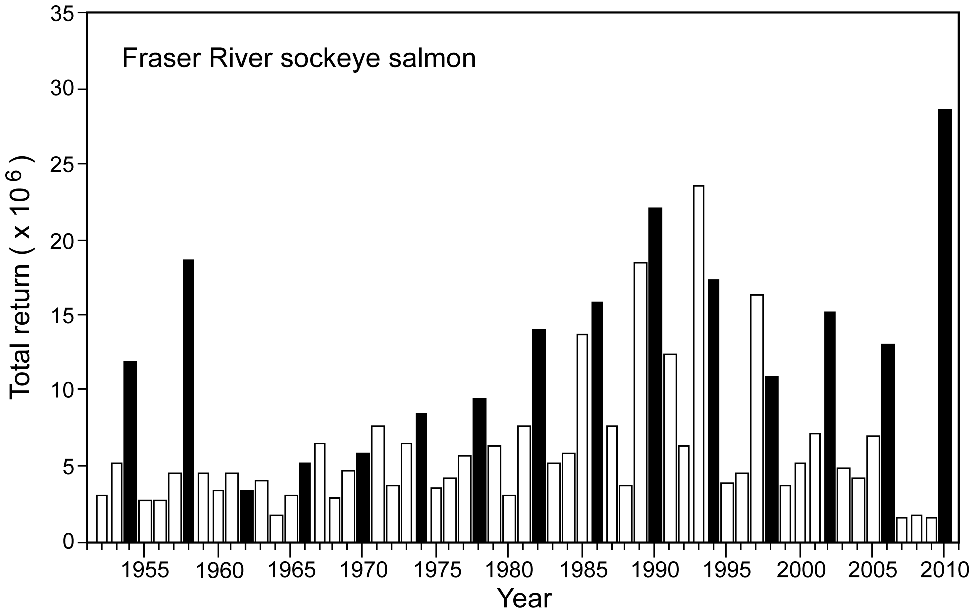

Figure A.4. Total returns of sockeye salmon to the Fraser River. Dark bars indicate those years when late-run Adams River stocks make a major contribution to the total salmon return. Return years 2007, 2008, and 2009 (brood years 2003, 2004, and 2005) were record low years. The highest recorded return was in 2010.

Chum salmon and Hatcheries

Chum salmon *O. keta* are produced in hatcheries by all countries in the North Pacific (Figure A.5). The marine survivals vary, apparently as a result of the conditions in the early marine coastal environment and as a consequence of the summer and winter rearing areas in the open ocean. It is important for all countries to understand how to optimize the early marine survival of chum salmon by designing cooperative research programmes throughout the distribution of juvenile chum salmon. It is also necessary to map the seasonal distributions of chum salmon from all countries in the open ocean to better understand the capacity of the ocean to produce chum salmon.

Pacific Decadal Oscillation

Large-scale trends in sea surface temperature in the subarctic Pacific were shown by Mantua et al. (1997) to be related to total Pacific salmon production. The major changes in the Pacific Decadal Oscillation that corresponded to major changes in Pacific salmon production trends occurred in the late 1940s, the late1970s and about 1998 (Figures A.6, A.7, A.8). Other studies showed that there has been a general warming in the ocean habitat of Pacific salmon (Figure A.9), but it is not known if the warming trend will continue or be affected by the factors that cause the oscillations in the Pacific Decadal Oscillation. Because temperature affects the prey production for Pacific salmon as well as the amount of energy that is available for growth and storage, it is important to determine the reasons for the large-scale changes in temperature and to determine how the cyclic trend of the Pacific Decadal Oscillation will affect Pacific salmon production in the future.

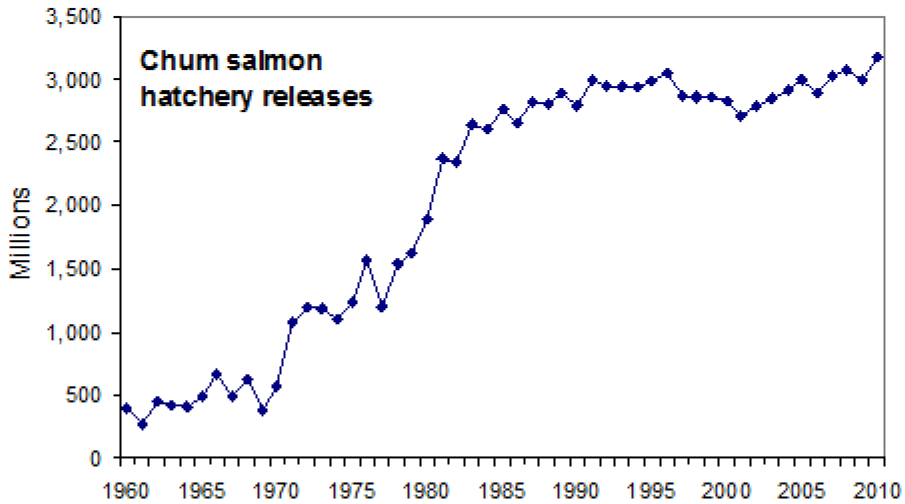

Figure A.5. Annual hatchery releases of chum salmon by all countries in the North Pacific in millions of fish.

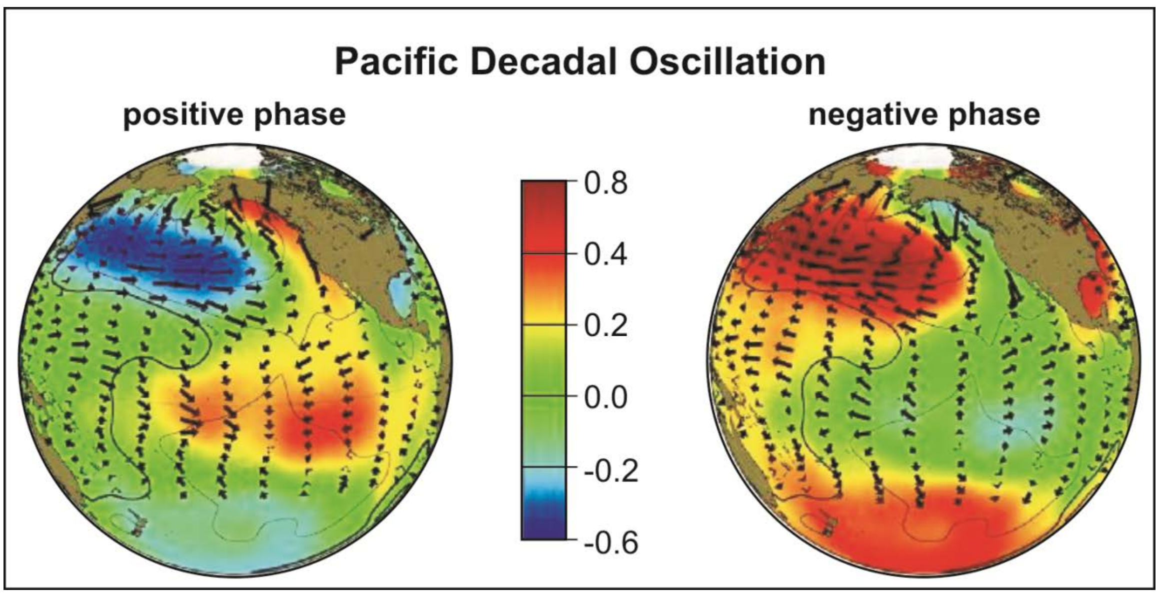

Figure A.6. Representation of the warm and cool phases of sea surface temperature anomaly in the Pacific Ocean and associated wind anomaly patterns.

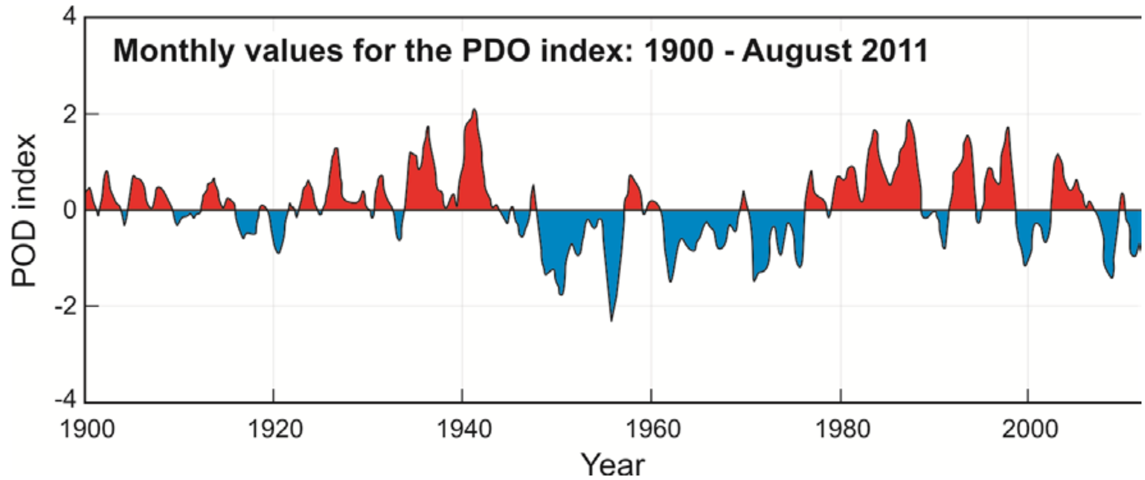

Figure A.7. Monthly values of the Pacific Decadal Oscillation (PDO) index from 1900–present. Red values are periods of warmer than normal water along the west coast of North America and correspond to the increased Pacific salmon catches in Figure A.8; blue periods correspond to periods of cooler than normal temperatures along the coast and correspond to periods of low total catch in Figure 7.

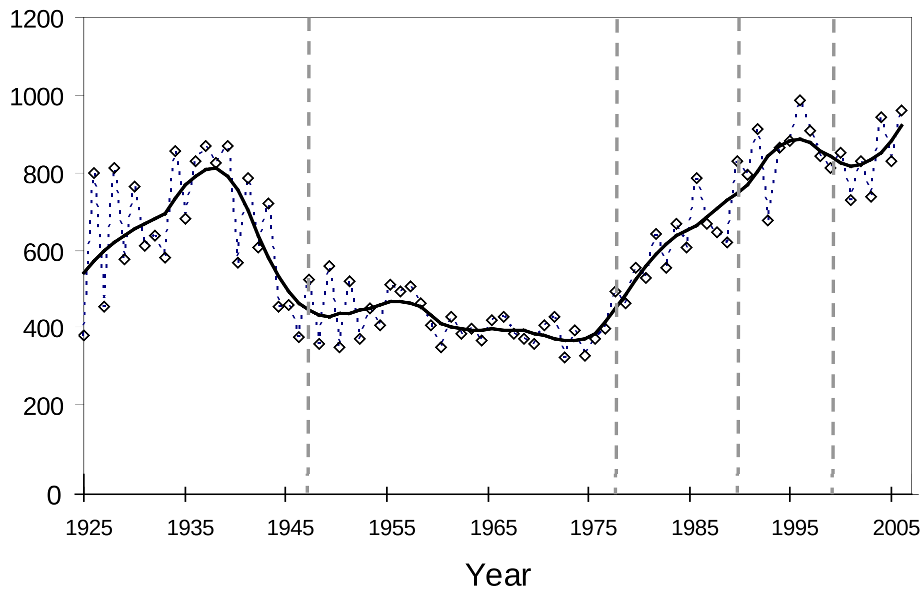

Figure A.8. Total Pacific salmon catch (dashed lines) smoothed using LOWESS (solid line) (band width, *f*, 0.2). Vertical dashed lines indicate regime shift years of 1947, 1977, 1989, 1998. (From Beamish et al. 2009b).

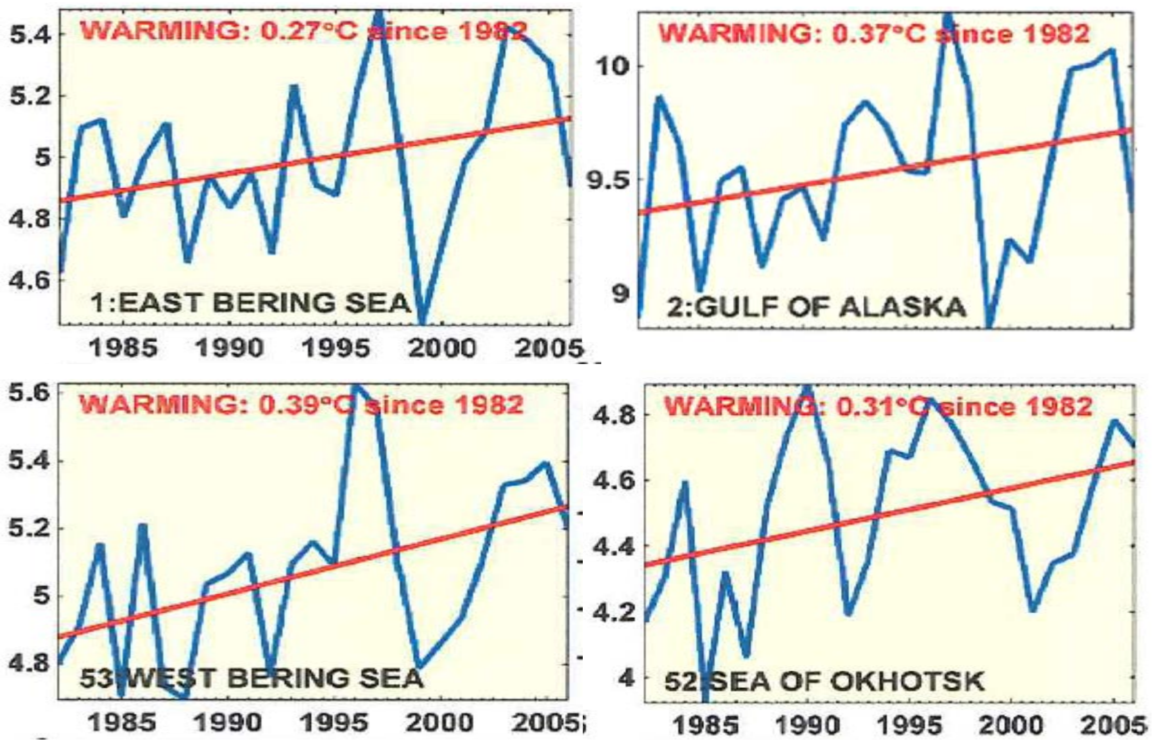

Figure A.9. Plots of sea surface temperature (°C) showing that the North Pacific Ocean has warmed from 1980 to 2005. From Sherman et al. (2009).

Indices of large-scale changes in winds

There are major cycles in the dominant direction and intensity of winds that blow across the subarctic Pacific. Indices of these winds include the Aleutian Low Pressure Index (ALPI; Beamish and Bouillon 1995) and the Pacific Circulation Index (PCI; King et al. 2006). The Aleutian Low Pressure Index is similar to the Pacific Decadal Oscillation (PDO; Figure 10), indicating that large-scale changed in winds as well as temperature affect trends in Pacific salmon production. The Pacific Circulation Index (King et al. 2006) is the Pacific counterpart of the Atmospheric Circulation Index (ACI; Klayshtorin 1998) and summarizes the annual dominant direction of the winds blowing across the subarctic Pacific (Figure A.11). The Aleutian Low Pressure Index categorizes the intensity of the winter low pressure in the area around the Aleutian Islands. The annual wind index (PCI) and the winter wind index (ALPI) are related to large-scale Pacific salmon production and both indices shift from one persistent state to another. The reasons for the shifts are not known, but it is most likely that there will be future shifts in annual wind direction (PCI) and winter wind intensity (ALPI) and these shifts will affect Pacific salmon production. An international effort to understand how the changes will affect the species-specific productivity of Pacific salmon would help explain and possibly forecast future changes to fishermen and the concerned public.

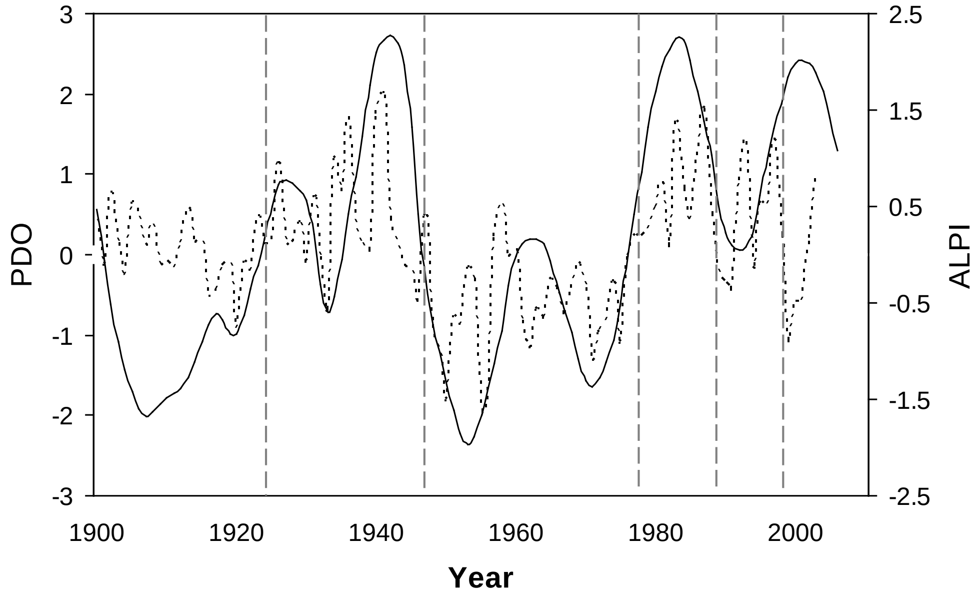

Figure A.10. The Pacific Decadal Oscillation (PDO) and Aleutian Low Pressure Index (ALPI) smoothed with LOWESS (**——)** (band width, *f*, 0.2). Vertical dashed lines indicate regime shift years. (From Beamish et al. 2009b).

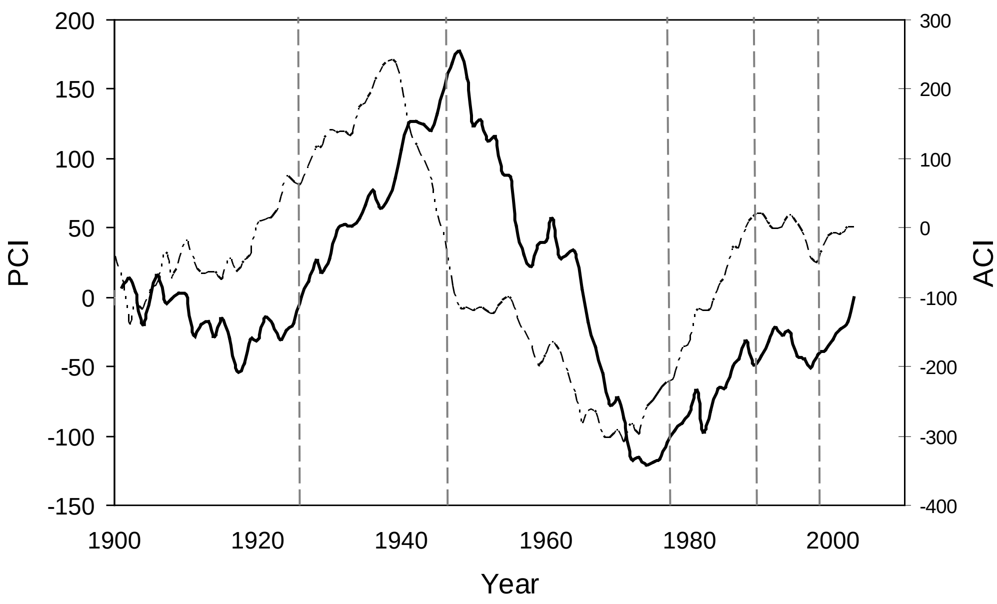

Figure A.11. The Atmospheric Circulation Index (ACI) and Pacific Circulation Index (PCI from 1900 to 2003. Vertical lines indicate regime shift years in Figure 7 (From Beamish et al. 2009b).

1977 Regime Shift

There have been abrupt changes in the composition of ecosystems. These regime shifts have occurred on scales of about 10 years. There also are longer term shifts of about 30 years and 70 years. Recent regime shift years were 1947, 1977, 1989 and 1998 but the shift that most researchers recognize is the 1977 regime shift (Figures A.8, A.9, A.11). Regime shift years in 1947, 1989 and 1998 are associated with changing trends in Pacific salmon production but the largest change occurred in 1977. There were profound changes in the Gulf of Alaska and the Bering Sea that changed the structure of the ecosystem (Figure 12). Pacific salmon as well as Pacific halibut and other fish species increased in abundance. The reasons for the abrupt shift are unknown but it is generally accepted that the 1977 shift was not a unique event and will occur again. A reversal of the change in 1977 would have major economic impacts. A better understanding of the mechanisms that affect Pacific salmon production in the ocean will help ensure that the consequences of another major regime shift will be understood in a timely manner, allowing fisheries and hatcheries to be well managed.

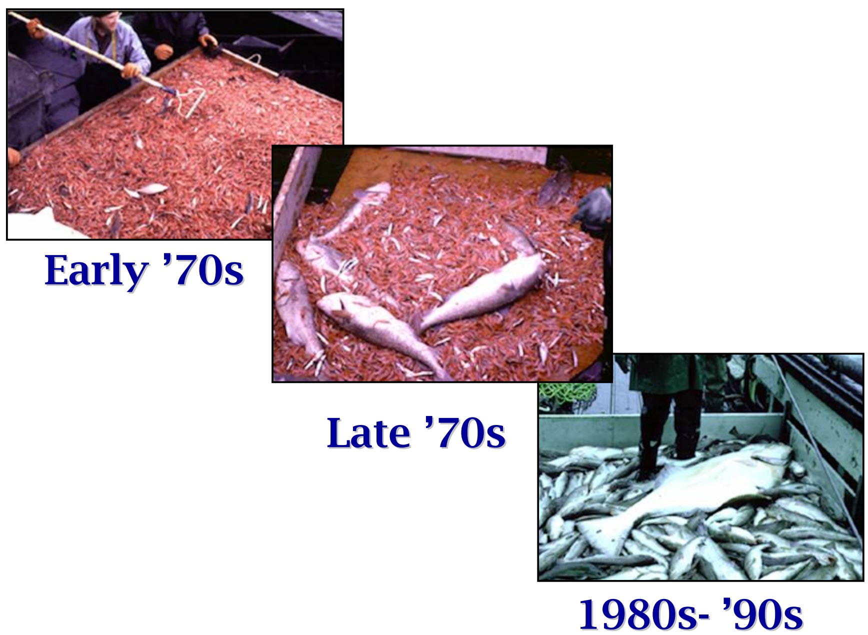

Figure A.12. Categorization of the changes that occurred around the 1977 regime shift in the Gulf of Alaska and the Bering Sea. (Credit: Phil Mundy and Paul Anderson, National Marine Fisheries Service)

Cost of Research

All Pacific salmon producing countries are experiencing reductions in the funding available for Pacific salmon research. There even is evidence that the number of biologists that are able and willing to study Pacific salmon on the open ocean is diminishing. A solution is to make efficient use of what is available by combining the resources available to all Pacific salmon producing countries as was done in the Bering-Aleutian Salmon International Survey (BASIS). The International Year of the Salmon could begin with a series of workshops that would focus on using existing science to determine the future abundance trends of the various species of Pacific salmon.

Benefits of an International Year of the Salmon

The major benefit of an International Year of the Salmon is the focus of resources on understanding mechanisms that regulate Pacific salmon production. The programme would include large-scale ocean studies, freshwater research and a team approach to analyzing and modelling the data. The goals would be for each Pacific salmon producing country to optimize their salmon production and improve forecasts. Each country would have specific interests, many of which were listed in the LRMP, with the common intent to be prepared for the future and optimize economic opportunities.

First Steps

I propose that the NPAFC establish a group that will consider the feasibility of an International Year of the Salmon. The feasibility group could consider three levels of activity. The simplest would be to host a series of workshops that would use existing information to forecast changes in the productivity of Pacific salmon and identify major information needs. These workshops could be jointly supported by other organizations such as PICES. A second level of involvement would add a year of marine research activities that would focus on identifying the country and population-specific rearing areas in the ocean, and improving the understanding of the mechanisms that regulate brood year strength. A third level would be to carry out the ocean studies for two years and include winter surveys.

Alaska has been a leader in supporting Pacific salmon stewardship and perhaps representatives from Alaska can agree to find the support for an initial feasibility meeting. The feasibility meeting could consider finding support from governments as well as from other groups and foundations that may be interested in a well-coordinated effort to identify the determinants of Pacific salmon production.

References

Beamish, R.J., and D.R. Bouillon. 1995. Marine fish production trends off the Pacific coast of Canada and the United States. Pages 585–591 *in* R.J. Beamish (ed.) Climate change and northern fish populations. Canadian Special Publication of Fisheries and Aquatic Sciences 121.

Beamish, R.J., B.E. Riddell, K.L. Lange, E. Farley Jr., S. Kang, T. Nagasawa, V. Radchenko, O. Temnykh, S. Urawa, T. Azumaya, R. Brodeur, R. Emmett, H. Imai, Y. Ishida, M. Kaeriyama, S. Kim, L. Klyashtorin, M. Koval, G. Kristianson, C.S. Lee, L-L. Low, I. Melnikov, J. Moss, P. Mundy, K. Myers, S. Naydenko, V. Nazarov, G. Ruggerone, J. Seeb, J. Seki, K.B. Seong, G. Smith, V. Sviridov, B. Templin, M. Trudel, V. Volobuev and S. Young. 2009a. A Long-term Research and Monitoring Plan (LRMP) for Pacific salmon (*Oncorhynchus* spp.) in the North Pacific Ocean. N. Pac. Anadr. Fish Comm. Sp. Pub. 32 pp.

Beamish, R.J., Sweeting, R.M., and Neville, C.M. 2009b. Planning the management of Pacific salmon in a changing climate. Pp. 155–173 *In*: Haro, A. J., K. L. Smith, R. A. Rulifson, C. M. Moffitt, R. J. Klauda, M. J. Dadswell, R. A. Cunjak, J. E. Cooper, K. L. Beal, and T. S. Avery, editors. *Challenges for Diadromous Fishes in a Dynamic Global Environment*. American Fisheries Society, Symposium 69, Bethesda, Maryland.

King, J.R., Ivanov, V.V., Kurashov, V., Beamish, R.J., and McFarlane, G.A. 2006. An index of general circulation of the atmosphere over the North Pacific. Izvestiya TINRO. Vol. 145, p. 220-227. (in Russian, English Abstract)

Klayshtorin, L. B. 1998. Long-term climate change and main commercial fish production in the Atlantic and Pacific. Fisheries Research 37:115–125.

Mantua, N. J., S. R. Hare, Y. Zhang, J. M. Wallace, and R. C. Francis. 1997. A Pacific interdecadal climate oscillation with impacts on salmon production. Bulletin of the American Meteorological Society 78:1069–1079.

Sherman, K., I.M. Belkin, K.D. Friedland, J. O'Reilly and J. Hyde. 2009. Accelerated warming and emergent trends in fisheries biomass yields of the world's large marine ecosystems. Ambio 38:215–224.