NORTH PACIFIC ANADROMOUS
FISH COMMISSION

北太平洋溯河性魚類委員会

КОМИССИЯ ПО АНАДРОМНЫМ РЫБАМ
СЕВЕРНОЙ ЧАСТИ ТИХОГО ОКЕАНА

Science Plan 1995-96

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The Commission

members....Canada, Japan, the Russian Federation, and the United States....

The North Pacific Anadromous Fish Commission was founded by the Convention for the Conservation of Anadromous Stocks in the North Pacific Ocean. The Parties of the Commission are Canada, Japan, the Russian Federation and the United States of America. The primary objective of the Commission is to promote the conservation of anadromous stocks in the Convention Area. Anadromous fish stocks are the six Pacific salmon species (chum, coho, pink, sockeye, chinook, cherry), and steelhead trout. The Convention Area is the waters of the North Pacific Ocean and its adjacent seas, north of 33 degrees North Latitude beyond 200 nautical miles from the baselines from which the breadth of the territorial sea is measured.

The scientific work of the Commission is carried out by the member Parties through coordination by the Commission's Committee on Scientific Research and Statistics (CSRS). The CSRS has established the following ad hoc groups to carry out its activities for 1995-96: a Science Sub-Committee to develop and implement the Commission's science plan, a steering committee to plan a 1996 Salmon Symposium, and four working groups on a) standardization of methodology, b) stock identification and growth, c) stock assessment , and d) format of the statistical yearbook.

The Science Plan

....two critical issues....

At the 1993 annual meeting of the Commission, the CSRS identified the following two critical issues for research by the Parties:1) factors affecting current trends in ocean productivity in the North Pacific Ocean and their impacts on salmonid carrying capacity, and 2) factors affecting changes in biological characteristics (growth, size and age at maturity, oceanic distribution, survival, and abundance) of Pacific salmon. A research planning and coordinating group reviewed each party's planned research activities that are related to these two issues and, based on these planned activities, developed a preliminary NPAFC Science Plan for 1995-96.

...three components....

The NPAFC Science Plan consists of three components of research:1) salmonid life history, 2) salmonid population dynamics, and 3) salmonid habitat and ecosystem. Each component has several items that identify questions relating to the two critical issues. The questions are to be clarified by coordinated research of the Parties. Each year, new questions will be raised, and the science plan will be revised accordingly. This process could lead to answers for the two critical Commission issues by the year 2000.

The plan was developed only for 1995-96 because of short term budget considerations of each Party. It is the intent of the Parties to conduct research over the next five years to address the following types of questions:

1. Life History of Salmonids

1.1 Spatial Distribution

- When and where do salmon concentrate in highest density?
- Does sea surface temperature regulate salmon distribution?
- Does interaction between different species and different stocks affect the distribution?
- Are juvenile salmon distributed in oceanographically protected waters?
- Is salmon distribution related to distribution of predators or competitors?
- Do oceanographic conditions and productivity of food organisms affect salmonid distribution, and is there a trend in this influence at various periods during their life history?

1.2 Growth and Maturity

- When and where does growth variation of salmon occur?
- Which life history stage is the most important for determining growth variation (juvenile, immature, maturing, or returning adult)?
- What factors (salmon density, sea temperature, food resources, competitors, predators) affect growth variation?
- How does growth variation affect maturation and reproduction?

1.3 Feeding Ecology (Diet)

- Is salmon diet species-specific?
- Is the composition of food specific to salmon species?
- Does salmon diet change by salmon density?
- Does salmon diet reflect the abundance of food items?
- Does salmon diet affect salmon growth, and survival?
- Does salmon diet relate to salmon distribution and population numbers?
- Does salmon abundance regulate food supply or does food supply regulate salmon abundance?

2. Population Dynamics

2.1 Abundance, monitoring, and Forecasting

- Does salmon abundance on the high seas provide a good estimate of adult returns? Where and when?
- What are the most important and effective monitoring items?
- How can carrying capacity be estimated?
- What determines changes in carrying capacity of salmon?
- How can a strategy of forecasting be determined for the commercial returns in various populations?
- What factors are related to changes in carrying capacity?
  a) Do changes in carrying capacity alter salmon abundance and production?
  b) What are the environmental variables that control carrying capacity?
  c) Does carrying capacity change with changing climate? If so, by what mechanism?
- Can the Ricker model be used to estimate the carrying capacity of salmon?

2.2 Mortality

- What factors are related to salmon survival (return rate)?
  a) Do predators and/or competitors affect salmon survival?
  b) What is the relationship among starvation, disease, temperature, and mortality?
  c) Does over-wintering affect mortality?
- Which period is critical for determining the abundance of the various species, populations, and age-groups?
- Does stock interaction affect growth, distribution, diet, and reproduction?

2.3 Stock Interaction

- Does stock interaction affect growth, distribution, diet, and reproduction?

2.4 Stock Indentification

- Are baseline data (genetic, parasite, etc.) stable?
- What salmon stocks are identifiable with each of the various techniques?
- How accurate and precise are the stock identification estimates?

3. Salmon Habitat and Ecosystem

3.1 Physical-biological Interaction and Productivity

- Does the Aleutian Low affect production?
- Does salmon abundance affect productivity?
- Is productivity in western, central, and eastern North Pacific different?

3.2 Climate Change Effects

- Does sea ice affect salmon production?
- What are the effects on southern distribution limits of salmon?
- What are the effects on food supply and predators of salmon?
- In what way do meteorological changes affect productivity? Is there a trend?

3.3 Regime Effects (Temporal and Spatial)

- How can regime shifts be detected?
- Are ancient salmon otoliths and scales available for retrospective analyses?
- Are regime shifts reflected in hard parts (scale, otoliths, etc.)?
- Are there other indicators (parameters) that permit tracking the changes?

Science Subcommittee

Members of the Science Subcommittee:

Canada - Richard Beamish
Japan - Kiyoshi Wakabayashi
Russia - Vladimir Karpenko
U.S.A. - Michael Dahlberg (Chairperson)

Cooperation

..with PICES-GLOBEC....

The Commission is cooperating with PICES to examine the two critical issues identified at the 1993 meeting. The Science Subcommittee of CSRS provides the technical laision to coordinate the Commission's salmon reasearch activities with the PICES-GLOBEC international program on "Climate Change and Carrying Capacity" of the North Pacific Ocean. PICES is the North Pacific Marine Science Organization and GLOBEC stands for Global Ocean Ecosystem Dynamics Studies.

..among the Parties...

The Parties of the Commission are also coordinating their respective research activities to address the issues identified in the Commission's Science Plan. Specific research activities for 1995-96 are described in the following sections.

Research by the Parties

NPAFC Science Plan for 1995-96
Research Activities of the Parties

Research Components	NPAFC Issue #1 Productivity, Carrying capacity				NPAFC Issue #2 Biology, Abundance, Distribution			
	Cdn	Jpn	Rus	US	Cdn	Jpn	Rus	US
1. Life History								
- Spatial Distribution	C-1	J-1			C-1	J-1	R-1	
- Growth & Maturity	C-1			U-1	C-1	J-1		U-1 U-3
- Feeding Ecology	C-1				C-1	J-1		U-1
2. Population Dynamics								
- Abundance, monitoring, forecasting		J-2				J-2 J-3		
- Mortality mechanisms						J-2	R-2	
- Stock Identification					C-4	J-3	R-3	U-4
- Stock Interactions	C-2				C-2	J-2		
3. Slamonid Habitat and Ecosystem								
- Physical-biological interaction & productivity	C-1	J-3	R-4	U-2	C-1			
- Climate change effects	C-1 C-3	J-2			C-3			
- Regime effects (temporal & spatial)	C-3	J-1			C-3			

Canadian Research Plan

C-1 Distribution, growth, and bioenergetics of salmon in the eastern North Pacific Ocean

Research will focus on obtaining a better understanding of the biological mechanisms underlying the sharp thermal limits on the distribution of Pacific salmon found in the Pacific Ocean. It is not clear why these thermal limits are as sharp as recent investigations have found, or what the implications are for oceanic influences on salmon productivity.

C-2 Stock and species interactions in the eastern North Pacific Ocean

One aspect of this research will focus on retrospective analysis of interannual variation and covariation in the size of fish in different salmon stocks, particularly sockeye salmon, in relation to abundance in the North Pacific. A second aspect of this work will be conducted using archival scale collections to identify annual rates of marine growth for different stocks, and to relate these rates of scale growth to changes in marine abundance of Pacific salmon and oceanographic conditions. In addition, comparative work on the relative trophic position and degree of trophic overlap of the different species will be conducted using stable isotopes as an index of feeding history.

C-3 Climate change vs. survival, Strait of Georgia, coho and chinook salmon

Canada (DFO) has funded a three-year multidisciplinary study of the biological and physical factors that affect the brood-year strength of Fraser River salmon stocks that pass through or reside in the Strait of Georgia. The emphasis of the study will be on chinook and coho, but there also appear to be impacts on chum, pink and sockeye. There is evidence that the shift in the ocean regime in 1976-77 that increased the productivity of salmon residing in the open Pacific Ocean had the opposite impact on the coastal area in the Strait of Georgia. Our hypothesis is that the carrying capacity for salmon that reside in the Strait of Georgia decreased because earlier spring plankton blooms improved the survival of species that spawned earlier in the year. These species would compete directly or indirectly with salmon for food. If our hypothesis turns out to be correct, there may be evidence of a trade-off between decreased coastal survival for salmon and improved high seas survival. In this study, the influence of hatchery-reared coho and chinook smolts on marine survival of wild smolts is also being investigated.

C-4 Stock identification (genetics, scales, etc.)

Current stock identification research is focussing on genetic techniques. In addition, baseline scale data continue to be collected for chum

salmon stock identification, and a study is being conducted on the use of parasites for stock identification among certain stocks of sockeye salmon. The genetic stock identification work is based on variability among stocks in nuclear DNA sequences. Microsatellite and minisatellite loci are being examined in chinook, coho, and sockeye salmon using the PCR (polymerase chain reaction). Variability in Class I and Class II genes of the Major Histocompatibility Complex (MHC) is also being examined using the PCR. MHC genes are involved in the immune response and are the most polymorphic coding genes of the vertebrate genome. Sequence variability in the exons (coding regions) and variable number tandem repeat (VNTR) variability in the introns (non-coding regions) of MHC genes are being examined for stock specificity in chinook and coho salmon.

Japanese Research Plan

J-1 Life history, distribution, growth, and feeding ecology

Investigate the distribution of salmonids, by ocean age and maturity, based on data accumulated by research vessels in the North Pacific Ocean. Identify factors affecting salmonid distributions, such as ocean temperature and interactions with other species. Investigate growth variations of salmonids, based on age and body size of adult salmonids returning to spawning rivers and biological data of salmonids collected by research vessels in the North Pacific Ocean. Examine formation of hard tissues, such as otolith and scales, in order to clarify the growth mechanisms. Conduct experiments in order to clarify external (water temperature and feeding conditions) and internal (fish density) factors which cause growth variations of salmonids. Investigate the feeding ecology of salmonids in the North Pacific Ocean. Establish methods to assess the nutritional condition of salmonids. Identify mechanisms of variations in feeding ecology and nutritional condition.

J-2 Population dynamics, mortality, carrying capacity, and ocean environment

Estimate the survival rates of salmonids from changes in salmonid abundance by age group and by year, based on data collected by research vessels. Investigate the occurrence of salmonids affected by diseases or predators, and distribution of predators. Investigate factors affecting the survival, such as predation, starvation, and diseases, by experimental methods. Establish methods to assess the carrying capacity of salmonid populations based on accumulated meteorological and oceanographic data (including plankton data) and biological data of salmonids, and examine the relationships between meteorological and oceanographic factors and salmonid carrying capacity. Investigate the salmonid ecology in winter using a large research vessel, clarify the southern limit of salmonid distribution in winter, examine the so called "reverse migration hypothesis" in that salmonids migrate northwards to minimize metabolic demands and maximize utilization of food in winter, and elucidate the relationship between wintering ecology and population dynamics of salmonids.

J-3 Stock assessment, biological monitoring, and stock identification

Develop methods for stock identification of salmonids including juveniles: (1) scale and otolith pattern analysis, (2) genetic analysis, and (3) artificial and biological tagging. Continue salmon research vessel surveys in summer, and establish methods to assess salmonid abundance and biological characters by species and stock. Establish methods of estimating abundance and survival of juvenile salmonids before wintering. Monitor genetic and reproductive characters, population structure of mature salmonids returning to their natal rivers. Improve biological monitoring methods for primary and secondary producers, competitors and predators of salmonids in the North Pacific Ocean.

Russian Research Plan

R-1 Distribution of pink and sockeye salmon in the western Bering Sea

Investigations concerning the dynamics of changes in distributional boundaries of pink and sockeye salmon in relation to different stock abundances will be pursued. To estimate fish distribution in the Western Bering Sea and North Pacific Ocean, retrospective analyses of abundance of the main pink and sockeye populations in the 1970s-1990s and data of tagging and scale examination are being used. Earlier data will be used for comparison with the new results.

R-2 Mortality of pink salmon in the western Bering Sea

The isolation of pink salmon populations in Northeast Kamchatka makes it possible to estimate the stock abundance of each generation at different stages of life. Based on the results of direct estimation of abundance of fry, smolts and juveniles in Karaginski Bay and stock abundance of adults returning to spawn, we hope to estimate pink salmon mortality during the 1980s-1990s. Habitat conditions associated with different brood years will be examined to identify the reasons for changes in mortality rates.

R-3 Stock identification

Stock identification will be conducted using genetic and scale markers. Basic data will be collected from the main sockeye, pink, and chum populations, and from sampling of other salmon species.

Genetics. Research will be developed on an expanded geographic range of native populations of pink, sockeye and chum salmon: the data on some populations from the Kuril Islands and Kamchatka River Basin will be involved in the database, characterizing genetic divergence of those species. The electrophoretic study of Asian chinook salmon will be initiated. Research on distribution of Pacific salmon in the ocean will be focused on stock indentification of pink, chum, sockeye and chinook

salmon in mixed sample collections from the Bering Sea and Pacific Ocean in the area to the east of Northern Kuril Straits.

Scales. Investigations concerning scale sampling and processing techniques will be aimed at their standardization. This will help with correct analysis of growth characteristics. The sampling and processing of other materials (otoliths, data on parasites, etc.) are also included in the program

R-4 Environmental impact

The main task of investigations is to estimate quantitatively the influence of environmental factors (temperature, hydrological conditions) on salmon mortality during the embryo - larval stage. The observations are being conducted in the basin of the Bolshaya River, West Kamchatka. For comparison, qualitative indexes of salmon reproducing in wild and regulated conditions were taken. The results could be used for the development of methods of forecasting salmon returns.

United States Research Plan

U-1 Juvenile salmon growth in the Eastern North Pacific

This set of studies is designed to address the following questions. Do salmonids distribute to maximize growth, minimize predation, or is there no active selection of habitat? What are the effects of temperature, water current structure, and predator/prey densities on growth of juvenile salmonids and ecologically-related fish species? Is the growth of salmonids in the Alaska Coastal Current (ACC) limited by food supply, or by competition? The juvenile salmonid growth studies comprised: (1) bioenergetic modeling of the effects of habitat quality and fish density on the growth rates of juvenile salmonids and ecologically related species; (2) studies on trophic dynamics, diet overlap, and prey selectivity among juvenile fishes in the ACC; and (3) prediction of year-class strength and adult size of southeast Alaska pink salmon based on first-year scale and otolith growth.

U-2 Alaska Coastal Current ecosystem

This research examines how the broad- and fine-scale spatial distributions of juvenile salmonids and ecologically related species are related to the biological and physical features of the ACC epipelagic ecosystem. Research activities include: (1) broad-scale field studies of juvenile salmonids that include a basic description of the physical and biological properties of the ACC using a combination of ship surveys and satellite observations; (2) fine-scale field studies that focus on aggregations of salmonids or other juvenile fish to look for specific processes or factors that influence their spatial patterns in the ACC; and (3) evaluation of the effectiveness of various gear types in catching juvenile salmonids.

U-3 Immature and maturing salmonid life history in the Eastern Pacific

There are three life-history studies planned in 1995. The first consists of a salmonid age-of-maturity study designed to examine annual changes in the age of maturity of salmonid stocks. The goal of this study is to identify the onset of maturity of salmonids in natural environments, develop measures of growth that are associated with that onset, and to relate habitat quality to salmonid growth rates. Methods for distinguishing "maturing" from "growing" salmon will be developed and used at sea to gather age of maturity data in conjunction with oceanographic data. The second study examines the broad and fine-scale distributions of maturing and immature salmonids and their relationship to hydrography and habitat quality. Emphasis will be given to identifying the spatial scales in secondary productivity of the Alaska Gyre, and in studying the foraging characteristics of salmonids in offshore waters. The third study consists of various retrospective examinations of long-term trends in growth and abundance of salmonids and ecologically related species based on scale or otolith measurements.

U-4 Stock identification

This research program is designed to develop biological markers capable of identifying stocks of salmon in the North Pacific Ocean. These biological markers include genetic characters developed from protein electrophoresis, and non-genetic characters derived from scale pattern analysis. These data will assist in identifying the origins of stocks harvested in mixed-stock fisheries, and to determine the oceanic distribution of stocks. The first task is to develop standardized methods of genetic analysis among parties, and to identify important stocks of salmon that should be included in the database. Contacts between investigators in each country with stocks of salmon are being developed and arrangements will be made for the exchange of samples for analysis. A pilot project on sharing collection of scale pattern data is being conducted, and will be expanded if successful. A workshop to develop standardized techniques of scale pattern analysis has been proposed to be held in conjunction with the 1996 Annual Meeting. Agencies should be encouraged to continue collaboration of scales of important stocks of salmon.

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