A Synthesis of the Joint Meeting

Causes of Marine Mortality of Salmon in the North Pacific and North Atlantic Oceans and in the Baltic Sea

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INTRODUCTION

The increased marine mortality of some salmon stocks in recent years is a pressing concern in both the North Pacific and North Atlantic Oceans as well as in the Baltic Sea. In response to this situation a joint meeting, co-sponsored by IBSFC, ICES, NASCO, NPAFC and PICES, was held in Vancouver, Canada during 14–15 March, 2002 to review and exchange information on the causes of recent changes in marine mortality of salmon. The objectives of the meeting were to: (1) improve understanding of the mechanisms resulting in the increased mortality, (2) to identify research priorities, and (3) to stimulate enhanced cooperation and information exchange in the future. The meeting, which was the first of its kind to bring together five inter-governmental organizations to review information on salmon in the three areas, was attended by 142 delegates. Sessions were held on the status of salmon stocks and fisheries, and the possible factors associated with increased marine mortality of salmon, which were considered under three groupings - climate and oceanography, human-induced effects, and ecological factors. In addition there was a synthesis and general discussion session. A total of 21 oral and 16 poster papers was presented. In this synthesis we have summarised the main points that emerged from these presentations and the subsequent discussions, and have drawn some conclusions.

STATUS OF SALMON STOCKS AND FISHERIES

Baltic Sea

- more than half of the rivers historically known to support Atlantic salmon have been lost to production as a result of habitat loss in fresh water (mainly through hydro-electric developments);
- compensatory releases of hatchery smolts led to high exploitation of the remaining wild stocks, particularly in sea fisheries;
- in 1997, a Salmon Action Plan was adopted by the IBSFC, with the objective of achieving 50% of the estimated historical production of wild salmon by 2010 through reduced TACs and more focussed targeted harvesting of reared salmon;
- following the introduction of recent management measures, ICES had advised that most, but not all, wild salmon stocks are improving but there are concerns about the impacts of a neurological disorder, known as M74 syndrome, and seal predation.

North Atlantic

- there have been major reductions in salmon fisheries at sea but the abundance of salmon stocks has not responded;
- both European (particularly the southern component) and North American stocks, particularly multi-sea-winter stocks, have declined, with North American returns currently at the lowest recorded levels in history;
- for some monitored stocks marine mortality is currently double the level of the 1970s;
- it has been suggested on the basis of reconstructed climate cycles that the present abundance of North American Atlantic salmon is the lowest it has been for 300 years and that there is an increasing anthropogenic influence on these stocks.

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Pacific Ocean

- stock status varies regionally from favourable to endangered, and low marine survival is a problem for some stocks;
- US West Coast stocks are at very low levels and while Alaskan stocks are generally at high levels there is serious concern about Bering Sea stocks of chinook and chum salmon, probably due to reduced marine survival;
- in Canada, greatest concern is centered on several coho stocks that are at critically low levels of abundance; the other species of Pacific salmon are generally at low levels of abundance, but certain stocks of sockeye, chinook, and steelhead present serious conservation concerns; in most cases those stocks with the most serious conservation concerns are known to have reduced marine survival;
- stock status in the Far East is mixed but Russian coho and chinook salmon stocks have declined; the survival of Japanese hatchery chum salmon is high but declining.

On the basis of the information presented on status of stocks and fisheries, it is clear that there is concern about the low marine survival of some stocks in all three areas, that in response to these concerns there have been major reductions in marine fisheries, and that for some stocks these restrictive measures have not yet resulted in improvements in status. Particular concern was expressed about the status of stocks at the southern limits of the species' range, inevitably raising concerns about the effects of global warming. Some US stocks of both Pacific and Atlantic salmon have been designated under the Endangered Species Act.

FACTORS AFFEECTING SURVIVAL OF SALMON AT SEA

Research on salmon at sea has, until recently, been given relatively low priority rather than being considered fundamental to rational management. As a result the factors affecting survival of salmon at sea are poorly understood; new evidence, however, suggests that these factors may be driving abundance and need to be better incorporated into stock assessments. If the key to good management is knowledge, then it is important to develop a clearer understanding of this phase of the salmon's life-cycle. The joint meeting provided an opportunity to review new information on the factors affecting survival of salmon at sea.

Climate and oceanography

- marine survival of salmon stocks shows spatial coherence on scales related to regional ocean conditions. For example, in the North Pacific survival rates among stocks are positively correlated across local or regional spatial scales of several hundred kilometres but not at scales nearer to a thousand kilometres;
- environmental variability (e.g. sea surface temperature, upwelling) is correlated to salmon survival, and may provide a basis for forecasts useful to management;
- decadal-scale climate regimes lead to major changes in marine ecosystems, affect salmon production, and can have a profound effect on the population structure and diversity of salmon;
- links between the North Pacific and North Atlantic climatic regimes have resulted in common responses in salmon stocks. This was particularly marked for the climate regime shift in 1989, which resulted in low marine survival of Atlantic salmon and some stocks of Pacific salmon;
- while the precise factors affecting mortality at sea remain unclear, and may differ within and between ecosystems, changes in early marine growth of post-smolt salmon appear to be important;
- the effects of even small shifts in climate (on the timescale of a few years) can exceed the effect of long-term management actions on salmon population dynamics.

Human-induced effects

- exposure to sub-lethal concentrations of contaminants (e.g. pesticides and endocrine-disrupting chemicals) in fresh water or estuaries may delay or inhibit smolt migration, affect adaptation to marine conditions or lead to poor growth;
- other factors in fresh water (e.g. acidification, water temperature, factors affecting size and condition of smolts) may subsequently affect survival at sea. Appropriate targeting of management actions will require better identification of the relevance of these factors;
- there is concern about the impacts of aquaculture and hatchery practices in all three areas. In the North Pacific and Baltic, large-scale hatchery releases have led to concerns about the genetic impact of cultured salmon inter-

breeding with wild salmon and over-exploitation of wild salmon in fisheries. In the North Atlantic and in British Columbia, escapes of farm Atlantic salmon are a concern;

- diseases and parasites from aquaculture may cause problems for wild salmon:
  - in Norway it has been estimated that sea lice from salmon farms may result in up to 95% mortality of wild Atlantic salmon in some areas, despite target lice levels in farms conforming to regulatory requirements;
  - in the Baltic there are concerns about the spread of diseases, e.g. furunculosis, from coastal fish farms to wild salmon;
- high concentrations of persistent pollutants are a concern in the Baltic Sea and could have significant implications for the future of the salmon fishery. Eutrophication in the Baltic Sea is also a concern;
- human-induced changes in genetic diversity may reduce the resilience of salmon to environmental changes in both freshwater and marine environments. It is vital that in all three areas maintenance of biodiversity (life-history and genetic diversity) must be one of the key goals of salmon management.

Ecological factors

- the impact of predation on salmon stocks in all three areas is poorly understood but thought to be significant;
- in recent years the populations of many salmon predators, including species protected by legislation, have increased while salmon abundance has declined;
- there is little quantitative information on the impact of predators on salmon fisheries and stocks. However, the impact of some species is thought to be significant, e.g. salmon sharks in the North Pacific and pinnipeds in all three areas;
- much of the available information concerns predation in rivers and estuaries rather than at sea;
- the intensity of predation is variable and may be related to climate change and availability of other prey. For example, a significant cold-water event in the early 1990s led to a shift in diet of gannets off Newfoundland and an increase by an order of magnitude in the proportion of salmon post-smolts in the diet;
- in the Baltic, M74 syndrome, caused by thiamine deficiency, possibly related to pollution of the Baltic or changes in the prey species of salmon, has led to very high mortality of salmon fry and is a severe threat to the survival of the remaining wild populations of salmon;
- there is an urgent need to develop a basis for predicting the severity of M74 so that its impact can be taken into account in management decisions concerning the wild stocks of salmon.

DISSCUSSION

During the discussions a number of points emerged, including the following:

- the meeting had produced a valuable exchange of information. Efforts should be made to continue the dialogue, to enhance coordination of the work being undertaken in the three areas, and to improve cooperation in the development of new technologies for studying salmon at sea;
- it is likely that a variety of factors are influencing mortality of salmon at sea and that a clearer understanding of these will require a multi-disciplinary research effort, that there may be synergistic effects and that freshwater factors which may subsequently affect survival at sea should not be ignored;
- a priority area for research is to improve understanding of salmon migration patterns, distribution, and habitat utilization at sea, which may be stock-specific;
- a serious problem in understanding the marine phase of salmon is related to the scale, and therefore the cost, of research. There is a need to build on the progress being made. A number of suggestions as to the way forward were made, including:
  - the use of long-term cooperative studies in experimental marine areas;
  - analysis of historical scale collections;
  - use of electronic tags;
  - international cooperative research focusing on specific areas of the migratory range;
- salmon are highly prestigious species, in which there is much public interest. There is a need for effective communication so as to gain public support for scientific research on salmon at sea. NASCO has established an International Cooperative Salmon Research Board to identify research gaps and priorities and to seek funding from private sources to augment public spending.

CONCLUSIONS

The joint meeting demonstrated that progress is being made in understanding the factors affecting salmon at sea through ongoing research programmes in the three areas. Newly developed expertise and tools (such as electronic tags and live-capture trawls) will facilitate better and more cost-effective research on salmon at sea. The challenge will be to deploy these technologies effectively in the future. A priority for research is to increase understanding of distribution and migration at sea and there are likely to be cost savings and other benefits from internationally coordinated research. In order to assess trends in marine survival there is a need to maintain and critically appraise monitoring programmes. In particular, it should be recognised that information from hatchery salmon may not be representative of survival trends for wild salmon and that changes in hatchery practices can influence trends in marine survival of hatchery stocks.

The joint meeting demonstrated the benefits of, and the need to maintain and enhance, cooperation and information exchange within and between the North Pacific and North Atlantic Oceans and the Baltic Sea. There was strong agreement from those attending the workshop that there is substantial marine research on salmon now underway, the results from which would form the basis for an expanded international symposium on the marine survival of salmon. The development of such a symposium in the near future would provide a focus for international cooperation and exchange of information between scientists in the three areas on the problems facing salmon stocks in the marine environment, and provide an opportunity to communicate findings and ideas to the public so as to enhance support for research on salmon at sea.