Climate Actions

CCAMLR 2000(yes)-study

11.34 The Working Group on Physics and Chemistry of the Atmosphere is planning to establish a reference database of Antarctic climate observations over the last 50 years. This will allow correlation with changes in populations.

CCAMLR 2005(yes)-study

14.22 The Chair of the Scientific Committee, Dr Fanta, presented a report on her attendance at CEP-VIII (CCAMLR-XXIV/BG/20). The full report has been submitted to, and discussed by, the Scientific Committee (SC-CAMLR-XXIV, paragraphs 9.2 to 9.7). Dr Fanta focused, in addition to the report of the Executive Secretary, on the following points:

(v) the suggested incorporation of climate change, bioprospecting and outreach in the CEP agenda;

16.12 The Commission requested the Scientific Committee to include in its intercessional program of work and its agendas for next year's meetings consideration of:

(ii) 'understanding trends and responses to climate change including the consideration of establishing ecosystem reference areas'.

CCAMLR 2006(yes)-study

4.7 The Commission also noted that the Scientific Committee had requested Members to consider:

• what the potential effects of climate change on Antarctic marine ecosystems might be, and how this knowledge could be used to advise the Commission on management of the krill fishery;
• how the effects of fishing might be distinguished from the effects of climate change.

The Scientific Committee requested that Members provide submissions on this item to the next meeting of WG-EMM.

17.3 Australia continued by highlighting the need to address climate change effects and in monitoring such effects in relation to future potential changes in, and influences on, the species and area for which CCAMLR is responsible. It suggested that Members may wish to reflect on such advances and needs with a view to tabling ideas for further consideration at CCAMLR-XXVI.

CCAMLR 2007(yes)-study

Climate change on the agenda of CCAMLR

15.16 The Commission noted a joint Norwegian and UK proposal that climate change and its impact on physical and biological processes in the Antarctic marine ecosystem should be placed on the Commission's agenda (CCAMLR-XXVI/39). The proposal comprised three elements:

(i) the issue of climate change should be included in future agendas of both the Scientific Committee and the Commission;

(ii) a scientific assessment be undertaken to consider the impact of climate change on the Southern Ocean;

(iii) SCAR should be the 'organizational nexus' for the project and should appoint a steering committee for it. Updated information from the project should be reported annually to CCAMLR and the ATCM.

15.17 The UK, as co-sponsor of the proposal presented by Norway (CCAMLR-XXVI/39), noted that some changes in the climate have already become evident. In that regard, the Commission was referred to an ASOC paper (CCAMLR-XXVI/BG/28) which, in particular, provided a selection of abstracts from recent publications on climate change and marine ecosystems. Thirteen of these abstracts were from research conducted by British Antarctic Survey scientists. The UK recommended that special consideration should be given to the effects of climate change on the Antarctic ecosystem and that it was CCAMLR's duty to provide responsible policy action on the matter. The matter of climate change should therefore become an important agenda item for CCAMLR.

15.18 The European Community supported the Norwegian/UK proposal, noting that the issue of climate change is one of the European Community's political priorities. The European Community noted that it would be appropriate for this issue to be placed on the agendas of both the Commission and the Scientific Committee as these bodies are responsible for conservation of marine living resources in the Convention Area.

15.19 Italy noted that CCAMLR has a special role in monitoring climate change.

15.20 Australia noted that the ATCM had already commenced discussions on how to bring climate change issues to the attention of other elements of the Antarctic Treaty System. It advised that during early IPY surveys under CAML, scientific data had been collected highlighting the impacts of climate change. Australia expressed the view that the Scientific Committee should consider the scientific aspects of the issue and that the Commission is able to respond to the advice it receives.

15.21 China agreed with the importance of climate change for the Antarctic ecosystem. It recalled that climate change was not introduced as a separate item but as a subitem under the state of the environment monitoring at both the ATCM and CEP. It proposed that it may be appropriate for the Scientific Committee to discuss climate change as a subitem under the current agenda item 'Ecosystem monitoring and management'.

15.22 New Zealand agreed that early IPY voyages have already delivered important information on climate change and that it would be important for the Commission to find an appropriate place for such an item on its various agendas.

15.23 Japan agreed with the importance of climate change to CCAMLR but it also shared China's view, noting that CCAMLR should avoid any duplication of work being carried out by other fora.

15.24 South Africa supported the proposal and advised that climate change is a high priority on its national agenda.

15.25 In considering placement of a climate change item on the Commission and the Scientific Committee agenda, the USA suggested that it was for the Scientific Committee to consider whether and how to focus its work related to climate change. The Commission could then consider issues related to climate change as part of its discussions of the Scientific Committee report.

15.26 Russia supported the proposal to include a climate change item on the Scientific Committee agenda, as CCAMLR should continue to maintain its leading position in the application of an ecosystem approach to conservation and management of marine living resources. Russia also noted that the work on the issue should be coordinated between CCAMLR, CEP and SCAR to avoid duplication.

15.27 Brazil shared the views expressed by China and others on the need to find an appropriate place on CCAMLR's agenda for discussions of climate change issues. If the focus was on

monitoring, then climate change could be a separate agenda item. However, if discussions were only on a scientific assessment of climate change impacts, a permanent agenda item would not be required.

15.28 Belgium reminded the Commission of the need to avoid duplication of work and to strengthen cooperation with other Antarctic Treaty System elements.

15.29 Uruguay supported the proposal as contained in CCAMLR-XXVI/39.

15.30 The SCAR Observer, Dr G. Hosie, welcomed the proposal, noted that SCAR was proposed to act as a project coordinator as identified in CCAMLR-XXVI/39 and advised that SCAR would be willing to discuss establishment of a steering committee. He also noted that SCAR may need to find additional resources to undertake the project.

15.31 ASOC introduced CCAMLR-XXVI/BG/28 entitled 'Climate change and implementation of CCAMLR's objectives'. The paper suggested that CCAMLR could play an important role in monitoring the effects of climate change on marine ecosystems and species. This would entail regularly reporting on the likely effects and consequences that climate change may have on the Antarctic marine environment in the Convention Area. In this context, ASOC urged CCAMLR Members to take the following steps at CCAMLR-XXVI:

• adopt a resolution acknowledging that climate change is a major factor currently affecting the Southern Ocean and commit Members to deal with the issue;

• establish a Commission standing agenda subitem 'Consequences of climate change' under Agenda Item 17 'Implementation of the Objectives of the Convention';

• establish mechanisms whereby CCAMLR can identify and annually report on the likely effects and consequences that climate change may have on the Antarctic marine environment in the Convention Area.

15.32 The UK urged the Scientific Committee to consider the issue of climate change further by having a separate agenda item. By definition, consideration of a policy to deal with climate change would be the responsibility of the Commission based on advice received from the Scientific Committee.

15.33 Norway agreed with the UK and urged Members to cooperate with SCAR by making resources available and to proceed with any recommendations. Norway recommended that the issue of climate change remain open and asked the Scientific Committee to report back with advice on how to proceed so as to enable the matter to be placed on next year's Commission agenda.

15.34 The European Community suggested the issue of climate change should be placed on the Scientific Committee's agenda with the Committee's agreement. In its view, the Commission will therefore be able to analyze this issue together with other subjects included in the Scientific Committee report.

15.35 The Republic of Korea proposed that the Scientific Committee be requested to consider where the issue of climate change could be placed on its agenda and how it could be addressed and to report back to the Commission for further discussion next year.

15.36 The Commission agreed with the proposal made by the Republic of Korea and to ask the Scientific Committee how it will address the issue of climate change in relation to the conservation of Antarctic marine living resources within its agenda, and how it will formulate advice accordingly to the Commission.

CCAMLR 2008 (yes)-study

1.11 His Excellency welcomed delegates to Hobart and Tasmania. He said that 2008 had been a momentous year for CCAMLR. Noteworthy initiatives included an independent review of the institution's performance, a joint workshop with the IWC on developing scientific inputs for coherent models of Antarctic marine ecosystems and continuing work on defining vulnerable marine ecosystems (VMEs), as well as initiatives on facing the management challenges arising from global climate change. The issues to be addressed have become more complex, the available resources increasingly limited and the need for effective outcomes has greater urgency than ever before.
1.12 CCAMLR had responded to such challenges and His Excellency said that it was gratifying that consideration of climate change was now on the Commission's agenda, along with the subdivision of the precautionary krill catch limits in Area 48 and the development of spatial management in general. It was also pleasing to see that the CCAMLR Scientific Committee and the Antarctic Treaty's Committee for Environmental Protection (CEP) are scheduled to hold a joint workshop immediately prior to the Antarctic Treaty Consultative Party meeting in Baltimore, USA, next April. This particular workshop requires little promotion amongst CCAMLR Members, given its important role in enhancing cooperation between the two most important elements of the Antarctic Treaty System – the Treaty and the Convention.

Climate change
4.61 The Commission endorsed the three key areas of work proposed by the Scientific Committee (SC-CAMLR-XXVII, paragraphs 7.10 to 7.16) in relation to management responses arising from climate change. Taking account of the issues outlined in SC-CAMLRXXVII, paragraph 7.13, the Commission agreed that examining the following would contribute to meeting the objectives of the Convention:

(i) the robustness of the Scientific Committee's advice provided and the stock assessments prepared by its working groups in the face of increasing uncertainty accompanying climate change, particularly in relation to predictions of future population responses and recruitment levels;
(ii) the need for, and implement as appropriate, improvements to current monitoring programs of harvested species and dependent and related species so as to provide robust and timely indicators of climate change impacts;
(iii) whether CCAMLR's management objectives and performance indicators require modification to remain appropriate in the face of climate change uncertainty.

4.62 The Commission agreed that climate change is a very important issue and that it looked forward to continuing to receive reports from the Scientific Committee and its working groups in terms of accessing further information on progress and on the presentation of relevant advice.
4.63 Australia referred the Commission to SC-CAMLR-XXVII, paragraph 7.16, and encouraged CCAMLR Members to facilitate the attendance of scientists at a workshop to be held in Hobart, Australia (20 to 24 April 2009 at CCAMLR Headquarters), which will address important issues associated with measuring, assessing and providing early-warning detection of climate change impacts on Southern Ocean ecosystems and biodiversity (www.aad.gov.au/default.asp?casid=35088).

15.18 (iii) Prediction on Changes in the Physical and Biological Environment of the Antarctic – the terms of reference are listed in CCAMLR-XXVII/BG/42, paragraph 49. This Action Group

will be useful to CCAMLR in understanding the effects of global warming, as well as ocean acidification.

15.20 (iii) discussions among climate scientists working in the polar regions have consistently indicated that various scenarios predict climate impacts in the polar regions to be at the upper end of the range of scenarios provided in the fourth report of the Intergovernmental Panel on Climate Change (IPCC).
15.21 The UK that it was an advocate of the Commission examining climate change as part of its agenda (CCAMLR-XXVI recalled, paragraphs 15.16 and 15.17) and requested an update from SCAR on the Antarctic Climate Change and the Environment (ACCE) report (SC CIRC 08/41).

IOTC 2002**(yes)-study**
Research on tunas in relation with the environment and ecosystem
109. CLIOTOP, a new IGBP/GLOBEC project was presented in IOTC-SC-02-Inf5. CLIOTOP is a
research project devoted to the application of the comparative approach to elucidate the influence of climate
on key ecosystem processes involving tuna and other top predators. CLIOTOP will end its implementation
meeting late in 2003.

IOTC 2009**(yes)-adapt**
Challenges to manage tuna resources sustainably are becoming obvious in the past years. Sustainability of tuna resources in Indian Ocean were threatened by increase in world tuna demands which in turn driven raising fishing effort and capacity of fleet in this region. In addition, IUU fishing activity obviously pose significant uncertainty for sustainable management of tuna resources, while global phenomenon of climate change pose threat that concertedly need to be addressed. In this regard, legitimate conservation and management measure followed by non delay adoption should be achieved.

IPHC 1998**(yes)-study**
Climate change and its effects on fishery stocks is of concern to everyone, so the IPHC staff worked closely with other agencies and scientists to create a comprehensive set of information.
…
This marked the second year of an ongoing project to examine the influence of climate variability on Pacific halibut biology. Growth and recruitment are ofparticular interest to IPHC scientists since both strongly affect the stock assessment. In 1998, several research projects were conducted to study the link between atmospheric and oceanic changes and marine populations.

IPHC 1999**(yes)-study**
In 1997, the IPHC embarked upon a three year fisheries oceanography project to examine the influence of climate variability on Pacific halibut biology, particularly growth and recruitment. Beyond better understanding the factors that influence halibut population dynamics, the ultimate goal of the project is to integrate the fisheries oceanography research more closely with the stock

assessment, hoping to expand it beyond a single-species environment-free model. During the first two years of the project, a number of research activities were conducted, reaching varying levels of completion. A few of these are summarized below

PACIFIC BASIN CLIMATE VARIABILITY AND PATTERNS OF NORTHEAST PACIFIC MARINE FISH PRODUCTION

In collaboration with scientists from NOAA and the UW, two analyses were conducted on recruitment trends for the major salmon, pelagic and groundfish species and their relationship to the major climate signals in the northeast Pacific. The two climate signals we used were the Pacific Decadal Oscillation and "Nino North". Niño North was defined from an analysis of sea surface temperature data and yielded an index that differed from traditional El Niño indices in that it indexed events based on the strength of their northern (as opposed to equatorial) impacts. We found that recruitment in a large fraction of the northeast Pacific marine fish stocks appears to be related to either PDO or Niño North climate forcing (Table 1). Pacific salmon stocks appear to respond to both climate signals though more strongly to the PDO. The decadal-scale nature of variability in halibut recruitment (Fig. 5) and salmon productivity, and their similarity to the PDO index, are illustrated in Fig. 6. Understanding the mechanisms behind this long-term temporal variability is expected to improve our management of the halibut resource.

IPHC 2001**(yes)-study [weak action here, but this observation is dropped from the time series analysis anyhow due to lack of budget information]**

The recruitment of Pacific halibut is strongly influenced by climatic regime and weather in the year of spawning. Our analysis has shown that better fits to the pattern (and the computer model) can be made if the annual PDO index is included, and if there is allowance made for unexplained differences among the periods around and including the 1960s. [AR, p41]

In the Appendix, we summarize the current scientific understanding of North Pacific climate, regime status and recruitment predictions. [Bluebook, p52]

Appendix – North Pacific climate, regime status, and halibut recruitment predictions

In 1999, a set of halibut stock recruitment models were fit and recruitment forecasts made for the next several years. The intent was to establish a historical record of forecasts that could eventually be used to monitor the extent to which we had identified the factors controlling recruitment. Model fits from last year, as well as the updated model fits this year, overwhelmingly favored models that incorporated some environmental component. [Bluebook, p55]

IWC 2000**(yes)-study**

RECALLING that, at the 49th Annual Meeting, the Commission requested the Scientific Committee to develop appropriate research in the priority areas identified by the Standing Working Group on Environmental Concerns (SWGEC), namely climate/environmental change, ozone depletion and UV-B radiation, chemical pollution, impact of noise, physical and biological habitat degradation, effects of fisheries, Arctic issues, disease and mortality events;

IWC 2002**(yes)-study/adapt**

RECALLING FURTHER that since 1995, the IWC has recognised the need for a broader understanding of environmental changes and threats affecting whale stocks in the Antarctic marine ecosystem and recommended the application of precautionary principles in their discussions. On several occasions there was consistent support within the SC (2002) for the precautionary approach, specially when dealing with Arctic and Antarctic resource management. (SC/54/IA7, IA11, IA15, SC/54/E3, E11, E16, SC/54/IA7, IA11, IA18, SC/54/BRG4).

[note: recalling 1995, but clearly reiterating that stance]

RECOGNISING that if there is no consensus on specific issues within sanctuaries, the Precautionary Approach should limit the negative impacts of environmental uncertainty (e.g. effects of climate change over sea-ice dynamics and feeding habitat accessibility and unforeseen problems in the RMP to the other regions where it was applied). In such cases, currently established sanctuaries complement the provisions of paragraph 10 e) of the Schedule as an integral management strategy.

IWC 2003**(yes)-study**

The other main developments in the IWC's scientific agenda, include:

1. e) Range of threats addressed: Previously the IWC only considered the effects of whaling on whale populations, which was reasonable in the past when this was by far the greatest threat to whales. Over the years, the agenda has expanded to include: incidental catches; pollutants and contaminants; effects of exploitation of other species on which whales depend; effects of environmental change including climate change; habitat alteration and degradation; noise pollution;

IWC 2009**(yes)-study/adapt/mitigate [note Commission statement, but obviously allowed by members]**

NOTING that the Scientific Committee identified the priority issues for cetaceans of climate/environmental change, ozone depletion and UV-B radiation, chemical pollution, impact of noise, physical and biological habitat degradation, effects of fisheries, disease and mortality events;

APPRECIATIVE of the efforts to date of the Scientific Committee to understand the impact of environmental changes, starting with workshops on chemical pollution and climate change/ozone depletion in 1995 and 1996 resulting in the development of long-term, multi-disciplinary, multi-national research programmes;

AWARE that knowledge about climate change has advanced substantially since the first IWC workshop in 1996 and that since that time, unequivocal greenhouse-gas induced global warming has been demonstrated, often at rates exceeding some worst-case modelling scenarios;

NOTING work by other international fora on climate change and its impacts on wildlife, ecosystems, and human society;

WELCOMING the report of the Costa Rica Workshop on Cetaceans and Other Marine Biodiversity of the Eastern Tropical Pacific held in February 2009;

WELCOMING the Report of the February 2009 International Whaling Commission Scientific Committee (IWC SC) workshop on cetaceans and Climate Change (SC/61/Rep4);

CONCERNED that, as stated by the IWC SC workshop, "climate-related changes will impact negatively on at least some species and populations, especially those with small and/or restricted ranges, those already impacted by other human activities and those in environments subject to the most rapid change …. For these species there is a real potential for elevated risks of extinction."

The Commission therefore:

ENDORSES the outcome of the climate change workshop and associated recommendations of the Scientific Committee given in IWC/61/Rep1, including the need to expand the current international multi-disciplinary efforts and collaborative work with other relevant bodies;

REQUESTS Contracting Governments to incorporate climate change considerations into existing conservation and management plans;

DIRECTS the Scientific Committee to continue its work on studies of climate change and the impacts of other environmental changes on cetaceans, as appropriate;

CALLS on Contracting Governments, IGOs and NGOs to support the expansion of this important work;

REQUESTS the Secretariat to forward this resolution and the workshop report (SC/61/Rep 4) to relevant bodies and meetings including inter alia the World Climate Conference, the UNFCCC and the IPCC in time for upcoming meetings;

and APPEALS to all Contracting Governments to take urgent action to reduce the rate and extent of climate change.

NAFO 1999**(yes)-study**
Environmental Indices – Implementation in the Assessment Process (SCR Doc. 99/6, 7)
A review was given of recently published material on the relationship between fish productivity and environmental variables as well as between climate changes and the response of marine ecosystems. Strong evidence was provided for an environmental influence on distribution, recruitment and growth of a number of different stocks from a variety of geographical locations. The conclusion was drawn that despite the chaotic nature of the climate system, efforts should be

made to incorporate environment into the stock assessment process, especially since we may be able to predict the environment on at least decadal scales.
Univariate seasonal Autoregressive-Integrated-Moving-Average (ARIMA) and intervention models were used to forecast monthly mean air and bottom water temperatures from 3 sites in the
Northwest Atlantic, up to one year in advance (SCR Doc. 99/7). These models explained a reasonable amount of the total variability, with results showing a good agreement between the forecasts and observations. The structure of the random processes that generated the temperature time series was specified for most cases as ARIMA models with moving average terms.
These papers generated much discussion. More work on the predictions was required, especially using longer time series. One of the problems in fisheries is to determine what temperature fish actually experience. In the past, temperatures were usually taken from a fixed site, whereas we know that fish move and may traverse water masses of different temperatures. Temperature indices that take this movement into account are required. Finally, environmental information should be considered as part of the precautionary approach. For example, biological reference points may differ during different periods because of different environmental conditions. Thus reference points may need to be adjusted depending upon environmental conditions.

Discussions of a warming trend in the
Northwest Atlantic associated with the North Atlantic Oscillation, and an anticipated cooling trend
in the North Pacific perhaps delayed by recent unusual El Nino-Southern Oscillation (ENSO) events and their probable effect on shrimp stocks suggest a growing confidence in our ability to, if
not understand all the linkages between ocean climate and shrimp populations, at least formulate testable hypotheses involving such large scale events.

NAFO 2000**(yes)-study**

The meeting focused upon the possible effect of temperatures on catchability and whether this could explain the improved cod catches on the Grand Banks that were reported. Opinions were divided but it was noted that the number of cod collected was still very low. It was suggested that a
similar analysis comparing bottom-temperatures and distributions should be performed with yellowtail flounder since they have been very abundant in recent years. It was stated that when the
yellowtail flounder abundance was low, they were confined to the Southeast Shoal of the Grand Bank but have been spreading into the southern areas of Div. 3L. It was also noted that temperature might effect not only distribution or catchability, but also growth. This had been discussed in a previous NAFO meeting in regards to warming around Iceland. No specific recommendations were felt to be required at this time, however.
The joint Russian/German Project "Assessment of short-time climatic variations in the Labrador Sea" reported to the meeting on the relationship between physical variables (air temperatures, winds and SSTs-surface salinity and temperature) and cod recruitment off West Greenland and Iceland were analysed. Results included a significant relationship between wind and recruitment of West Greenland cod. During April, northerly winds off southern Greenland and easterly winds in the Denmark Strait favour higher recruitment. During summer, easterly winds west of Iceland

favour good recruitment.

NASCO 2005**(yes)-study**

5.4 With regard to support for SALSEA, the Group recognized that there has been a very significant increase in marine mortality of salmon since the 1970s and that returns to fresh water are now less than 50% of the levels in the 1970s and 1980s. The severity of the situation facing Atlantic salmon needs to be stressed to potential funders of the research. It was, however, recognized that if the increased mortality is related to climate change, there may be no opportunity to counteract it. This might make the programme less attractive to governments but the programme might still be attractive to private funders as an opportunity to contribute to a better understanding of the salmon's life at sea.

Paul Knight (Salmon and Trout Association, UK)…referred to the very high winds in Britain in the last two weeks and noted that such extreme events are predicted to become more frequent with climate change.

Hugh Becker…With regard to climate change and its impacts on the marine survival of salmon, it is important to recognize that there may be nothing that can be done about such macro events in the oceans…

Godfrey Williams (Environment Agency, UK) indicated that he supported NASCO's work in the marine environment, which should also consider the implications of climate change for salmon stocks. Further extreme events are predicted and these could affect aquaculture operations and consequently the wild stocks through, for example, escapes.

NGOs have already stressed the importance of ICES advice; over the past few years salmon stocks have been relatively stable at an historically low base, showing a slow decline. There is a clear risk, particularly from accelerating climate change, that a move to biennial reporting might allow significant changes in the salmon stock to escape scrutiny. We appreciate the motives, in terms of cost saving and freeing-up time during Council meetings, but believe a Precautionary Approach should be applied.

<u>The following additional focus areas were identified:…</u>

- <u>The implications of climate change for the wild Atlantic salmon…</u>

1.4 In the case of a new site, where a full Environmental Impact Statement is required, it shall, as a matter of course, assess wave climate, hydrography, prevailing weather conditions and any other factors which may cause stress to pens and nets.

2. Inshore – Death in the Early Migration Phase…

Research tasks:

…The impact of physical factors in fresh water (eg water flow and temperature) on marine mortality.

Abiotic parameters of the river, such as water flow and temperature, are believed to affect the phenotypic and genotypic characteristics of a salmon stock.

NPAFC 1997**(yes)-study**

Japan-

(xv) Has Climate Change Affected the Survival of Hokkaido Chum Salmon Population Since the 1970s?

The result of a multiple regression analysis of return rate of Hokkaido chum salmon in 1977-1991 brood years on mean body size and number of juveniles released, and the ACI showed that the return rate depends entirely on the mean body weight of released juveniles, and is independent of the fluctuation of the ACI and the number of juveniles released. Therefore, return rate of the Hokkaido chum salmon released from hatcheries may be closely associated with size-selective mortality in the early marine life period. The survival of hatchery juveniles, which was higher than that of wild fish, may depend on their body size and optimum period at release.

Not Japan-

There was agreement that the effects of oceanographic conditions on salmon runs should be discussed at a scientific meeting or as a special topic at the Annual Meeting in the near future. Other topics considered for such a discussion include…:

- Effect of weather and climate changes on the freshwater stage of salmon life…

NPAFC 2002**(yes)-study**

6.1 Cooperation with PICES

PICES proposed co-sponsorship of joint meetings as a form of cooperation between the two organizations. There was no disagreement on PICES co-sponsorship on a possible NPAFC symposium in 2004. Sponsorship will depend on choice of topic. The CSRS agreed to co-sponsor a PICES symposium or workshop on the Okhotsk Sea and adjacent areas to be held in Vladivostok in May-June 2003. At a later date NPAFC would nominate scientist(s) to give invited talk(s) on the status of salmon in the region. There was general support for the concept of two workshops proposed by PICES to consider the response of Pacific salmon to climate change. The workshops might be held in 2004 or 2005. Further discussions are

needed on the times of the meetings, locations, and possible conflict with other NPAFC workshops or symposia.

NPAFC 2005**(yes)-study**

NPAFC SCIENCE PLAN 2006-2010

1. Broad Scientific Questions

Overarching hypotheses that emerged from the results of scientific research under previous NPAFC science plans, as well as from research by other organizations and independent scientists, are that (1) anadromous stocks play an important role in North Pacific marine ecosystems, and (2) there is a close relation between climate and climate change and subsequent changes in marine productivity and survival of anadromous stocks in the ocean. The Science Sub-Committee (SSC) identified two broad scientific questions relevant to the program goals of NPAFC that would further an ecosystem-based approach to conservation of North Pacific anadromous stocks, as well as contribute substantial new scientific information to the marine ecosystem research, fishery management, and conservation activities planned by relevant organizations:

- What are the current status and trends in marine production of anadromous stocks; and how are these trends related to population structure (spatial and temporal) and diversity of anadromous stocks in marine ecosystems of the North Pacific?
- How will climate and climate change affect anadromous stocks, ecologically related species, and their North Pacific marine ecosystems?

Over the past decade, there have been significant variations in the marine production of Asian and North American anadromous stocks that appear to be linked to climate change. There is a strong need for new international cooperative research that provides better scientific information on the status and trends in marine production of anadromous stocks, identifies the roles of anadromous stocks in North Pacific marine ecosystems, and examines the extent to which anadromous stocks, since they return to coastal regions, can be used as indicators of conditions in North Pacific marine ecosystems.

Variation in the time, frequency, and amplitude of climate events that affect the ocean production of marine fish seems to be increasing. This has led many experts to conclude that precision monitoring of abundance and biomass in the ocean may be the only reliable method for predicting changes in production of anadromous stocks. That each species of salmon follows a life history strategy in the ocean is probable. Cooperative research that identifies the common mechanisms will improve regional forecasting. In addition, the conceptual framework for the management of fish populations has expanded from relatively simple assessments of abundance and productivity to broader needs for information on population structure (spatial and temporal) and diversity.

2. Conceptual Model

The SSC used a salmon ecosystem/life history conceptual framework to render a holistic understanding of the two broad questions. Under this framework, Asian and North American anadromous stocks migrating in the Convention Area can be viewed as one large population that has evolved to respond successfully to natural stressors and stressor regimes at the ecosystem level. Salmon life history provides natural organization to this framework because at each maturity stage there is substantial regional and local variation in distribution and migration patterns, stressors, and stressor regimes that affect survival and growth rates. These differences may provide a buffer against climate variability and optimize the survival of the larger population. Cooperative research within this conceptual framework will provide information on abundance, biomass, vital rates, and processes essential to filling gaps in scientific information to evaluate effects of climate and climate changes in ocean ecosystems.

3. Research Theme: Status and Trends in Production of Anadromous Stocks in Ocean Ecosystems

The influence of regional and local environmental stressors on the status of different salmon species and stocks at initial and subsequent life history stages is varied. These stressors may affect the quantity and biomass of juvenile salmon migrating to the sea, immature and maturing salmon migrating in the open ocean, and adult salmon returning to coastal and freshwater fisheries. Obtaining reliable abundance estimates is essential to understanding survival at each marine life history stage. For conservation of anadromous stocks, better scientific information is needed on the effects of climate and climate change on anadromous stocks, ecologically related species, and their North Pacific marine ecosystems.

Cooperative research activities will attempt to clarify the present status and trends in production of North Pacific anadromous stocks, to determine important stressors and stressor regimes that affect population structure and diversity, to evaluate subsequent effects of these mechanisms on the viability and performance of North Pacific anadromous stocks at critical marine life-history stages, and to evaluate effects of climate and climate changes on marine production of anadromous stocks.

3.1Component 1: Juvenile Anadromous Stocks in Ocean Ecosystems

In at least some species of anadromous stocks (e.g. pink and chum salmon), variation in adult returns may depend more on marine survival than on reproductive efficiency during the freshwater period. A common hypothesis is that the initial period of after migration to sea is the most critical phase with respect to ocean survival of anadromous stocks. Recent cooperative and national research on juvenile salmon suggests considerable interannual variation in abundance, growth, and survival rates of juvenile salmon in the ocean. These variations may be related to climate-induced changes in habitat environments that operate at

regional and local scales. To a greater or lesser extent, these processes are monitored annually in marine survey areas along the coasts of Asia and North America. A better understanding of these processes is needed for conservation and management of anadromous stocks.

Cooperative research may focus on the following issues:

- Seasonal distribution and migration route/timing of juvenile salmon
- Hydrological characteristics, primary production, and prey resources in the habitats
- Trophic linkages, growth rates and predation rates of juvenile salmon
- Population size, survival rate and survival mechanism of juvenile salmon

3.2Component 2: Anadromous Stocks in the Bering Sea Ecosystem (BASIS)

The centerpiece of NPAFC's marine ecosystem research to date is the Berign-Aleutian Salmon International Survey (BASIS). Under the Science Plan 2001-2005, BASIS research has progressed and evolved to more complex research issues, and has become an integral part of ecosystem research planned by other international, national, and regional conservation, management, and research organizations (e.g., PICES, North Pacific Research Board). In the face of global climate change, the Bering Sea may become the most important marine ecosystem for production of Asian and North American anadromous stocks. The results of cooperative BASIS ecosystem monitoring research in 2002-2004 indicated a very high density of Asian and North American anadromous stocks in the Bering Sea from summer to late fall. BASIS process studies have demonstrated the important influences that various physical and biological stressors and stressor regimes may have on production of anadromous stocks and ecologically related species in the Bering Sea ecosystem. While this recent research confirms the high productivity of the Bering Sea, carrying capacity, growth, and production of anadromous stocks has shown a high degree of variation. <u>These results confirm the necessity of continuing cooperative research in the Bering Sea to clarify the mechanisms of biological response of anadromous stocks to climate and climate change</u>.

Cooperative research may focus on the following critical issues:

- Distribution, migration route/timing, production, and health of anadromous stocks and ecologically related species
- Multi-year trends (regimes) in physical and biological factors that influence long-term changes in Bering Sea food production and fluctuations in salmon production and growth rates
- Hydrological characteristics, primary production, and prey resources in the habitats
- Trophic linkages, growth changes, and predation rate of anadromous stocks
- Interactions between species, between stocks, and between life-history stages
- Changes in carrying capacity of anadromous stocks

3.3Component 3: Anadromous Stocks in the Western Subarctic Gyre and Gulf of Alaska Ecosystems

Anadromous stocks play a very important role in the Western Subarctic Gyre and Gulf of Alaska ecosystems. Immature and maturing salmon originating from Asia and North America intermingle in both of these ecosystems. Recent research vessel surveys by Canada, Japan, Russia, and the USA have collected a considerable amount of new data on anadromous stocks, ecologically related species, and environmental conditions in the Western Subarctic Gyre and Gulf of Alaska ecosystems. In particular, three species – pink, chum, and sockeye salmon – occur in high abundance in Western Subarctic Gyre and Gulf of Alaska ecosystems during all seasons. Anadromous stocks consume a substantial quantity and biomass of prey organisms in these ecosystems, and play an important role as a higher trophic level predator. Changes in marine tropic relations in these ecosystems influence the productivity of salmon populations returning to different reproduction regions in Asia and North America.

Both ecosystems provide the major wintering habitats for various anadromous stocks. While previous research has identified this as a critical period that defines the biological characteristics and biomass of anadromous stocks, open ocean field research and monitoring programs have typically been carried out only during the late spring to early fall period. Better information on the status and trends in production and condition of Pacific salmon during the late fall to early spring period is needed for conservation and management of salmon resources.

Knowledge of variation in the characteristics of marine production in the Western Subarctic Gyre and Gulf of Alaska ecosystems is needed for conservation of anadromous stocks resources in Asia and North America. In addition, more accurate forecasts of adult salmon returns will benefit salmon industries around the Pacific Rim.

Cooperative research may focus on the following issues:

- Seasonal distribution, production, and health of anadromous stocks and ecologically related species
- Seasonal changes in feeding, growth, and habitat condition
- Winter survival strategies of anadromous stocks
- Effects of climate change on population size and survival rate
- Multi-year trends (regimes) in physical and biological factors that influence long-term changes in food production and fluctuations in salmon production and growth rates
- Interactions between species, between stocks, and between life-history stages
- Changes in carrying capacity of anadromous stocks

3.4Cooperative Research Approaches and Implementation of Science Plan

Relevant approaches to cooperative research under the Science Plan 2006-2010 will include collection and synthesis of existing data and metadata to generate and test specific

hypotheses, integrated ecological monitoring research (research vessels, remote sensing), conceptual and quantitative modeling, process-oriented field and laboratory studies, and retrospective analyses. Scientific results from cooperative studies using these approaches will progressively fill in major gaps in scientific knowledge with respect to the two research themes, components, and issues (sections 3.3), as well as contribute new scientific information to climate-change/ecosystem research being carried out by other relevant programs (e.g., PICES, North Pacific Research Board). NPAFC workshops and symposia serve an important purpose in the rapid exchange of significant new research results. The timely publication by NPAFC of research results presented at workshops and symposia is an important part of this process.

As in the case of the 2001-2006 BASIS research plan, specific proposals and approaches for new cooperative research under the NPAFC Science Plan will be developed at the CSRS working-group level, and will be subject to approval by the CSRS and the Commission. Implementation of cooperative research plans approved by the CSRS and the Commission under the Science Plan 2006-2010 will follow the same procedures that were approved by CSRS for the BASIS research program (Figure).

Specific policies for cooperation, identifying and addressing user needs, data quality, management and dissemination, logistics, outreach and education, and public involvement will be developed at the working-group or sub-group level, and will be subject to approval by the CSRS and the Commission.

Scientific Research

3.1 The most obvious area for enhanced cooperation between NASCO and NPAFC is on scientific aspects. The symposium described above would be a significant and symbolic step in enhancing this cooperation. Other scientific topics that might be explored in future might include information on stock assessment methodologies (e.g. genetic stock identification), hatchery practices and their impacts on the wild stocks, and the impacts of climate change.

(Appendix 13)

NPAFC 2008**(yes)-study**

(4) Coordination of Scientific Research Activities

4.1 Report of the Science Sub-Committee (SSC)

The chair of SSC R. Beamish summarized the progress on the development of the Long-Term Research and Monitoring Program. A draft plan was reviewed by representatives of all Parties in early October 2008. Comments by participants are

being incorporated into the plan. An annotated bibliography of approximately 450 papers will be produced. A summary of these papers were produced and are currently in review. These three documents will be finalized and reviewed by the Scientific Steering Committee in April or May, 2009. The final reports are due in August 2009. There has been an excellent cooperation and strong support for the project by all Parties.

NPAFC was invited to join PICES and ICES as a co-sponsor for the International Symposium on "Forecasting Climate Change Impacts on Fish and Shellfish" (tentative title) to be held in spring of 2010. The location of this symposium is not yet determined. It was agreed that NPAFC would participate, and it was also agreed that the chair of SSC, R. Beamish, would be the representative on the symposium steering committee.

d) ***Other Items***

Proposal: NPAFC is moving forward toward a long term monitoring research plan to examine how climate change effects salmon survival in the marine environment. This will be an extraordinary achievement for NPAFC and will provide the context for ocean research objectives on salmon for some time to come.

NPAFC has been very successful during the last 7 years monitoring ecosystem health of the Bering Sea under the BASIS Program. The Working Group identified a set of core measurements on fish and ocean characteristics that lend well to describing factors effecting salmon and other nekton health and survival. These core measurements are shared among Parties. This cooperative effort in research and sharing of fish samples and data is paramount to the success of this important international effort.

Therefore, the United States proposes expanding the BASIS Program to the North Pacific Ocean and Arctic. The expanded program with its core observations of fish and ocean characteristics lends well to be the "basis" for the survey effort and cooperative international spirit that will be needed to meet the goals and objectives of the LRMP.

This idea can be further discussed at the next RPCM, during 2009.

J-2-1 Bering Sea Salmon Ecology Studies

Current studies suggest that changes of salmon growth may occur in the Bering Sea, when many salmon migrate in the waters for their feeding and growth in summer. To clarify relations between the growth and mortality of salmon and the carrying capacity in the Bering Sea, the research will be focused on the following research items:

- Climate change and primary production
- Production of prey organisms
- Population size and distribution of major salmon stocks
- Feeding competition and growth change of salmon

- Homing migration and maturing mechanism

K-2 Climate Change Effects on Salmon

Climate change effects on salmon distribution, migration route, and abundance will be investigated. This research includes:

- Continuous monitoring activities on environmental conditions in the Korean waters and thewestern Pacific Ocean, and
- Climate change effects on the biological characteristics of chum salmon returned to the Koreanwaters.

7.5 United States Research Plan

U-1 Juvenile Salmon Studies in the Gulf of Alaska and Bering Sea (BASIS)

Research activities take place primarily in the coastal waters of the Gulf of Alaska from the southeast Alaska area to the western Kodiak Island area and in the eastern Bering Sea from Bristol Bay northward through Kotzebue Sound. Activities include: (1) repeated measurements of the habitat, and stock-specific life history characteristics of salmon from their early marine residence period to their later migration through coastal waters; (2) fine-scale field studies that focus on aggregations of salmonids to look for specific processes or factors that influence their distribution, behavior, and growth; (3) studies on diet overlap and prey selectivity among salmon and other fishes; (4) genetic stock-identification studies of juvenile, immature, and maturing salmon; (5) monitoring of thermally marked salmon; (6) studies of growth and size of juvenile and immature salmon; (7) modeling salmon production based on interannual variability in early marine salmon survival and growth; (8) describing the trophic dynamics of juvenile salmon and their predators in coastal waters; (9) bioenergetic models of juvenile salmon growth; and (10) archival tagging of immature and maturing salmonids. Research in the coastal area of the Gulf of Alaska was initiated in 1995. A coastal monitoring activity was initiated in 1997 in southeast Alaska. Particular focus of this research is placed on examining the extent of seasonal (May–October) interactions between hatchery and wild stocks of salmon, and their potential impact on marine carrying capacity, and to examine the use of juvenile catch data and associated biophysical parameters to forecast pink salmon run strength. This research was expanded in 2005 to include stations in southern as well as northern Southeast Alaska. The Bering Sea program in western Alaska began in 1999. Particular focus of the western Alaska research was placed on monitoring effects of climate on growth, migration, and distribution of juvenile Bristol Bay sockeye salmon as they migrate in the coastal waters of the eastern Bering Sea. In 2002 research activities expanded in the Bering Sea to participate in offshore as well as coastal studies within the BASIS operation plans. Research activities under BASIS are designed to address the following issues: (1) seasonal-specific migration patterns of salmon inhabiting the Bering Sea, particularly those stocks exhibiting recent declines in production, and their relation to the Bering Sea ecosystem; (2) key biological, climatic, and oceanographic factors affecting long-term changes in Bering Sea food production and salmon growth rates,

(3) similarities (or dissimilarities) in production or survival trends among salmon populations originating in rivers around the Bering Sea Rim, and (4) the limit or carrying capacity of the Bering Sea to produce salmon, and the effect of hatchery salmon on Bering Sea food supplies.

U-2 Retrospective Analyses

Retrospective studies characterize past variability in climate and salmonid population parameters over various time and space scales, and are a key component to understanding effects of climate change on the abundance and life-history of U.S. salmon populations. Current retrospective studies include: (1) analyses of scale growth patterns of Karluk Lake and Bristol Bay sockeye salmon, Yukon River chum salmon, and six pink and chum salmon populations from the northern and eastern Gulf of Alaska; (2) a summary of historical salmon research in the Karluk Lake area; (3) time-series analyses of North American salmon population and climate data; and (4) analyses of scale growth patterns of Auke Creek coho salmon to examine the relationship of marine growth to precise estimates of stock-specific marine survival.

U-5 Southeast Coastal Monitoring Research Plan

The Southeast Coastal Monitoring (SECM) program in 2009, following elements of NPAFC's science plan, will focus on biophysical factors and key stocks of juvenile salmon that will enable researchers to better understand how growth, abundance, and ecological interactions, both on an intra-and interannual basis, effect survival and year-class strength. Long- term monitoring of biophysical data will continue in primary marine migration corridors of juvenile Pacific salmon in southeast Alaska; in the northern part since 1997 and in the southern part since 2005. Data are periodically collected at up to 21 stations at four sampling intervals from May to August. Sampling stations include three habitat types: (1) inshore, (2) strait, and (3) coastal where fish, zooplankton, surface water samples, and physical profile data are collected using surface rope trawls, conical bongo nets, and a conductivity-temperature-depth profiler. These systematic surveys attempt to identify and understand biophysical parameters that influence habitat use, marine growth, predation, stock interactions, year-class strength, and carrying capacity of hatchery and wild juvenile salmon as they migrate through corridors into oceanic environments. In addition to providing baseline data sets for documenting potential effects of climate change on epipelagic ichthofauna and associated biota, these data have become a useful tool showing real promise for successfully forecasting regional abundance of pink salmon. Large regional hatchery programs that otolith mark all chum salmon juveniles released in southeast Alaska also enable this research to closely examine interactions between wild and hatchery juveniles during the early marine period including any potential impacts of hatchery fish on carrying capacity.

8.1 Cooperation with PICES

The Executive Secretary of PICES, A. Bychkov, pointed out that NPAFC's focus on the conservation of salmon stocks, combined with the broad scientific mandate of PICES provide the two organizations with great potential for cooperation. A. Bychkov invited

NPAFC to (1) participate in the development of the second PICES North Pacific Ecosystem Status Report, which will focus on status and trends in marine ecosystems of the North Pacific and its marginal seas for the period 2003–2008 (see Report of the WG on Stock Assessment for details); (2) contribute to the salmon research component of the new PICES integrative scientific program, called FUTURE (Forecasting and Understanding Trends, Uncertainty and Responses of North Pacific Marine Ecosystems); and (3) co-sponsor the international symposium on "Forecasting Climate Change Impacts on Fish and Shellfish" to be held in spring 2010 (see Appendix 7) and report of the Science Sub-Committee for details). A. Bychkov thanked the Contracting Parties for their willingness to collaborate with PICES and positive attitude towards PICES' proposals.

8.3 2010 International Symposium

NPAFC was invited to join PICES and ICES as a co-sponsor the International Symposium on Forecasting Climate Change Impacts on Fish and Shellfish (tentative title) to be held in Japan in the spring of 2010 (Appendix 7). The committee discussed and nominated the chairperson of the Science Sub-Committee, R. Beamish, as a member of the Steering Committee of the symposium.

Appendices:

Appendix 6: Goal of NPRB's GOA IERP

The North Pacific Research Board's (NPRB) Gulf of Alaska Integrated Ecosystem Research Program (GOA IERP) addresses the overarching question: "How do environmental and anthropogenic processes, including climate change, affect various trophic levels and dynamical linkages among trophic levels, with particular emphasis on fish and fisheries, marine mammals and seabirds within the Gulf of Alaska?" The overall GOA IERP is divided into four components: (1) upper trophic level, (2) forage base; (3) lower trophic level, and (4) a vertically-integrated modeling effort. This pre-proposal addresses the first, upper trophic level component, and NPRB's goal to "*determine and quantify the processes driving upper trophic level populations and to better understand observed and potential future variability therein as they affect key management issues in the North Pacific.*"

The goals of NPAFC's proposed investigation are:

(1) significantly enhance understanding of
the major ecosystem processes that regulate distribution and abundance of salmon andtrophic ally-linked species in the GOA in winter,
(2) quantify changes in
the processes under various environmental and anthropogenic forcing scenarios, and
(3) evaluate direct and indirect human-induced impacts
on salmon (climate change, ocean carrying capacity, management strategies
for endangered stocks, ocean acidification).

b. Elements and processes to be studied:

(4) Relevance to fisheries management: The proposed study will provide managers with direct measurements and parameters ofocean conditions and distribution, abundance, and biomass of epipelagic species at all trophic levels in the GOA in winter, as wellas tools that managers can use to evaluate and plan for future effects of human activities and climate change.

[study adaptation]

APPENDIX 7

SUGGESTED INTERNATIONAL SYMPOSIUM

Tentative Title: Forecasting Climate Change Impacts on Fish and Shellfish

Recommended Convenors: A. Hollowed (U.S. A.), Manuel Barange (United Kingdom), Suam Kim (Korea), Harald Loeng (Norway)

Tentative Steering Committee: members of the joint PICES/ICES Working Group on Forecasting Climate Impacts on Fish and Shellfish and representatives of co-sponsoring organizations

Tentative Date: May 2010

Tentative Venue: Japan

Rationale: Warming of the climate system is unequivocal, as is now evident from observations of increases in global average ocean temperatures. The 2007 IPCC (Intergovernmental Panel on Climate Change) Assessment reported most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gases concentrations. Continued greenhouse gasses emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would very likely be larger than those observed during the 20th century. Therefore, climate change is the most important threat to the ocean. Some direct effects of climate change in the marine environment are already visible, but others need to be defined by enhanced observations, analysis and modelling. The work of PICES and ICES on climate change and fisheries has been diverse and has included: a) guidance on methods for selection of IPCC scenarios for use in projections; b)techniques for downscaling IPCC scenarios to local regions, c) development of coupled ecosystem models for use in evaluating climate induced shifts in environmental conditions, d) literature documenting relationships between climate forcing and marine fish and shellfish distribution and production, and e) stock assessment techniques for evaluating management strategies to mitigate the impacts of change. This challenge calls for the necessity for experts from around the world to focus attention on the development of common and standardized frameworks for forecasting climate change impacts on marine ecosystems, with particular emphasis on the distribution, abundance and production of

commercially important fish (including salmon) and shellfish. ICES and PICES and other international organizations should act now to ensure that our research communities develop the capibilities to provide quantitative contributions to the next IPCC reports and to provide guidance for management under climate change scenarios. The proposed symposium in 2010 will provide an opportunity to present and discuss forecasts of climate change impacts on the world's commercial fish and shellfish resources, to review the methodological developments, and to compare marine species and community responses to climate forcing in different ecosystems. The results from the symposium are expected to be published in a major scientific journal by 2011. The timing for the publication is critical because the Fifth IPCC Assessment Report (IPCC AR5) is slated for release in 2013. The symposium organizers will seek involvement of relevant academic, governmental and intergovernmental organizations, such as the Intergovernmental Oceanographic Commission (IOC) of UNESCO, Food and Agriculture Organization (FAO), North Pacific Anadromous Fish Commission (NPAFC), in event (IOC and FAO has already indicated their willingness to participate).

Background:

Dramatic fluctuations in the ocean growth and survival of many Asian and North American salmon populations over the p astdecade have been attributed to changes in the Bering Sea and other marine ecosystems. The absence of scientific observations forsalmon, ecologically related species, and environmental conditions in the Bering Sea has limited our understanding of these changes and how they affect salmon populations and economies around the Pacific Rim. An international research effort to address theseissues was developed by the NPAFC, as part of their 2001-2005 Science Plan. The research plan, called BASIS (the Bering-AleutianSalmon International Survey), began in 2002 as a coordinated program of cooperative research on Pacific salmon in the Bering Sea. The goal of BASIS research was to clarify the mechanisms of biological response by salmon to the conditions caused by climatechange in the Bering Sea.

The purpose of the present symposium is to summarize BASIS research conducted during 2002 to 2006.

WCPFC 2006**(yes)-study**

3.46 Research recommendations with respect to ecological modelling included:

d) Ecosystem models should be used to explore management scenarios and the effects of climate variability and change; and

7.24 Research with respect to ecosystem and bycatch is described in the EB-SWG report (Annex X). This research is focused on the review of the impact on fishing on components of the ecosystem

not targeted by fisheries; the interactions between climate and environmental factors and the target and non-target species; and, the development of ecosystem-based models.

56. Recommendation:

f. Test first simulation with climate change scenario (1860-2100) and carry out; and

1 only adapt; 2 adapt/study

1 adapt/study/mitigate

18 study only