

# **PICES Scientific Workshop Seattle, 10-13 December 1991**

## **Summary Report**

### **1. Introduction**

At the Plenary Session in Ottawa on 12 December 1990 during which the final report encompassing the Convention to establish the North Pacific Marine Science Organization, PICES, was approved, the representative of the United States advanced her government's offer to host a meeting of North Pacific scientists in Seattle during 1991. This meeting, the PICES Scientific Workshop, was held one year later, on 10-13 December 1991.

Financial support for local meeting expenses was provided by the Marine Mammal Commission, the National Science Foundation, the National Oceanic and Atmospheric Administration, and the Scientific Committee on Oceanic Research.

The purpose of the workshop was to review the state of knowledge in selected fields, to list relevant ongoing research, to identify research gaps and priorities, and to consider joint action that might be developed through PICES. The region of concern to PICES is the subarctic Pacific and adjacent seas. The topics selected were (1) Climate Change, (2) Bering Sea, (3) Environmental Quality, and (4) Fishery Oceanography. Review papers on each of these topics were prepared as indicated below.

A list of participants is attached (Attachment A). The workshop was chaired by Professor Warren S. Wooster. Officers of the topic sessions were as follows:

- I. Climate Change: Chairman, Professor Minyu Zhou; Reviewers Drs. K. Denman and KGroot; Rapporteur, Dr. B. A. Taft.
- II. Bering Sea: Chairman, Professor K. Ohtani; Reviewer, Dr. V. I. Radchenko; Rapporteur, Dr. R. Methot.
- III Environmental Quality: Chairman, Dr. J.C. Davis; Reviewer, Professor Qingli Lin; Rapportuer, Mr. J.M. Coe.
- IV. Fishery Oceanography: Chairman, Dr. M. A. Stepanenko; Reviewer, Dr. K. Kitani; Rapporteur, Dr. A. B. Hollowed.

Format of the workshop was as follows: During a reception on the evening of 10 December, there was a general discussion of the goals and format of the workshop. During the next two days, half a day was spent on each of the topics, with all participants taking part. The review papers were summarized and the opportunities for further research were discussed. On the morning of 13 December, groups on each of the topics met simultaneously and addressed a common set of questions. In the afternoon of 13 December, recommendations of the groups were reviewed in a plenary session.

It was agreed that the Rapporteurs in consultation with the Chairman of the Workshop would revise the individual group reports and that the Chairman would prepare an overview. These would be circulated to participants as drafts and after a relatively brief period for comment would be prepared in final form and promulgated. This report consists of:

- Part A. 1. Introduction
- 2. Chairman's overview
- 3. Group reports
- 4. List of participants
- Part B. 1. Review papers
- 2. National reports.

## 2. Chairman's Overview

While it is commonplace for scientists to organize by disciplines and for agencies to focus on specific tasks, most of the scientific problems in the subarctic Pacific (and elsewhere in the world ocean) are interdisciplinary in nature and may require the attention of a variety of agencies. Accordingly this first PICES workshop was organized around several specific problem areas each of which was first addressed by all participants, regardless of country, discipline, or agency.

Scientific research is normally conducted by individuals or groups of scientists working in national laboratories at national expense. The role foreseen for PICES (e.g., in Article V of the PICES Convention) would be one of data and information exchange, collective assessment, cooperation and coordination, and joint planning. Furthermore, this role would be in concert with ongoing international programs, usually in order to strengthen the regional component of global endeavors. Thus in considering a possible scientific agenda for PICES, an important constraint was to identify the useful actions that might appropriately be taken by PICES out of the totality of possible actions with respect to one or another of the topic areas.

With this in mind, the views of the several topic groups can be summarized as follows:

What are the principal scientific questions that should be addressed by PICES and with what priority?

While each group identified specific questions of importance, these questions are to some extent different facets of a common problem. Thus the Climate Change group speaks of obtaining a description of the changing climate in such a way that the processes involved can be understood and the evolution of the physical and biological system predicted. The Bering Sea group proposed studies of the relationships and variability among components of the physical and biological environment, especially with regard to circulation, productivity, and biological interactions. The Fishery Oceanography group asked what governs fish resources, species, composition, and biomass in the North Pacific and Bering Sea and emphasized the importance of interactions among organisms and between them and the physical environment. The Environmental Quality group, while assigning highest priority to questions of nutrient loading and eutrophication, the fate of chronic and persistent chemical pollutants, and the role of the North Pacific in waste disposal, discussed these and other questions in terms of environmental changes and ecosystem responses.

The common problem that emerges from these differing perspectives might be stated as follows:

*What is the nature of the subarctic Pacific ecosystem (or ecosystems) and how is it affected over periods of months to centuries by changes in the physical environment, by interactions among components of the ecosystem, and by human activities?*

This question suggests that PICES should foster a basin-scale and interdisciplinary approach to thinking about the subarctic Pacific, thereby not only addressing the central scientific issues of the region but also those related to weather and climate prediction, to fisheries, and to maintenance of environmental quality.

To what extent is the study of these questions impeded by the lack of data that already exist but are not widely available? What steps might be taken by PICES to improve the availability of such data?

It was generally agreed by all topic groups that physical, chemical, biological and fishery data exist that are not widely available, that present mechanisms for exchange and distribution of such data are inadequate, and that PICES could contribute to strengthening the exchange of such data within the region. PICES should identify the location of data sets, disseminate that information, and facilitate data exchange but should not attempt to establish its own data archive and processing facility.

To what extent is the present exchange of ideas and information, including data analysis and interpretation, satisfactory? How might it be improved through action of PICES?

Information exchange was widely felt to be inadequate. The personal contacts made possible by the present workshop were considered to have been important in this respect. PICES could: (1) serve as a clearing house for information on research plans and findings, (2) organize workshops and other scientific meetings, (3) compile bibliographies and facilitate translations, (4) promulgate information by means of publications, and (5) explore other approaches such as electronic correspondence and networking. It was generally accepted that the PICES secretariat should play an active role in these matters.

Are there existing international programs or arrangements for cooperation that are applied to these questions? How might PICES strengthen these efforts?

There are important global programs related to studies of climate change, for example, the World Ocean Circulation Experiment, WOCE, and the Joint Global Ocean Flux Study, JGOFS, that bear directly on the important scientific questions noted earlier. A Global Ocean Observing System, GOOS, is also under development. PICES could focus attention on elements of particular regional interest such as those affecting the subarctic Pacific ecosystem, and could strengthen participation of its members in the programs.

Active participation of PICES members in programs specifically directed to fishery oceanography - e.g., Global Ocean Ecosystem Dynamics, GLOBEC, International Recruitment Program, IREP, Sardine Anchovy Recruitment Program, SARP - could accelerate the availability of findings applicable to outstanding fishery questions in the region.

There are also international organizations, both regional (e.g., the International North Pacific Fishery Commission, INPFC, and its successor and the International Pacific Halibut Commission, IPHC) and global (e.g., the Intergovernmental Oceanographic Commission, IOC, the United Nations Environmental Program, UNEP, and the International Maritime Organization, IMO) whose programs could contribute to solution of regional questions and thus merit the support of PICES and its members.

There appear to be few multilateral investigations or arrangements directly related to the Bering Sea ecosystem, and PICES could play an important role in promoting and coordinating such research and as well as facilitating the assessment of natural resources.

Are there joint investigations by scientists from PICES countries that would contribute significantly to solution of the scientific problems? How might PICES assist in the planning and coordination of such investigations.

While examples of desirable joint investigations were offered by some of the groups, no clear set of desired studies emerged. The examples included studies of varved sediment to reconstruct the history of recent climate changes, determination of the distribution of salinity and fresh water in the region, reconstruction of the history of contamination through analysis

of deep sea sediments, establishment of tissue banks for evaluation trends in concentrations of toxic chemicals in marine organisms, and coordinated research using satellites, long-term buoys, and synoptic surveys.

A detailed agenda of joint investigations will eventually emerge from discussion among scientists actively engaged in research on specific problems in contrast to the general review attempted by the workshop. A role for PICES in the development of such studies could be to (1) focus attention on the problem, (2) organize joint thinking, for example in workshops, (3) encourage joint planning and, as appropriate, coordination, and (4) disseminate information among those concerned.

### **3. Group reports**

#### **I. REPORT OF CLIMATE CHANGE WORKING GROUP**

The Climate Change working group met on December 13, 1991. Participants included: M. Zhou (Chair), P. LeBlond, D. Hu, K. Denman, R. Beamish, Y. Nagata, K. Groot, and B. Taft (Rapporteur). The following matters were discussed:

##### 1.) Principal scientific question.

The principal question that should be addressed in the subarctic Pacific is how to obtain the description of the climate change in such a way that the processes involved in climate change can be understood. In this way the basis for prediction of the evolution of the physical and biological system can be laid.

In order to do this a parallel development of physical and biological models and the implementation of an adequate long-term observational program to provide data for model assimilation and validation must be undertaken. The collection of time series data with sampling frequencies adequate to resolve the important intra-seasonal signals as well as the longer period fluctuations is crucial to the success of the climate observing system. The most pressing need is for biological data to guide model development and posing of hypotheses about climate change. One program which can be undertaken now is broad-scale sediment-trap measurements in key areas of the North Pacific. Technology in the area of measurement of biological and chemical variables, which is presently under development, should be incorporated into the ocean observing system as soon as it has reached a mature state.

##### 2.) Is lack of data impeding study of the principal scientific questions?

There were identified several types of data whose unavailability was impeding scientific analysis. There is a significant amount of catch data on both commercial and non-commercial species that is not reported. The unavailability of this data is hampering the analysis of the variability of the abundance of these species on climate time scales. Also, surface drifter velocity data for the study of the basin-scale surface circulation and long period dispersal patterns of surface layer materials has not been easily available to North Pacific investigators. Historical ocean data, especially from the northwest subarctic Pacific are needed to permit reconstruction of changes in ocean climate over as long a period as possible.

The PICES Secretariat staff should include an aggressive data management expert who will be able to address data exchange practices. An up-to-date catalogue of data collected in the PICES area of interest should be published at least at yearly intervals. PICES should not create a data archiving and dissemination system which would be redundant with the

international data exchange programs.

### 3.) Is the present exchange of ideas and information adequate?

The present exchange of ideas is not adequate. Lack of joint analysis of basin-wide data is a particular shortcoming. PICES can help in this regard by encouraging and organizing scientific workshops on particular subjects that are ripe for collaboration. An example of a meeting of great potential interest to PICES is the "Climate Change and Northern Fish Populations" meeting to be held in the fall of 1992. A suggested topic for this meeting is how to relate sediment-trap measurements to those of other components of the biological system.

The PICES Secretariat should compile a yearly bibliography of papers published and manuscripts completed on climate variations in the subarctic Pacific. Because a number of papers of interest will be published in languages not accessible to all members of the PICES community, consideration should be given to creating the means to translate landmark papers.

### 4.) Relation to existing international programs

The World Ocean Circulation Experiment (WOCE) and the Joint Global Ocean Flux Study (JGOFS) are existing programs which address climate change problems. WOCE is a global program to measure the ocean circulation over a seven year period and includes extensive measurements in the subarctic Pacific. Planned for the PICES region are several one-time top-to-bottom high-horizontal-resolution CTD sections with a full complement of ocean tracer measurements. In addition variability of the circulation is to be measured by relatively short repeat hydrographic sections, surface velocity drifters and intermediate depth (about 1000 m) floats. The WOCE program will provide the background information for interpreting the circulation models in the subarctic; it is important that the countries in PICES that have planned WOCE provide the resources to complete it.

The JGOFS program (a component of the International Geosphere-Biosphere Program (IGBP)) is a series of process studies in various regions; the subarctic Pacific is not at present one of the chosen sites. For this reason JGOFS will not provide direct insights into processes governing biological production which are peculiar to the PICES region. PICES can strengthen the JGOFS efforts in the area of global modeling by promoting the collection of chemical and biological data that can be used for model assimilation and model validation.

There are a number of international committees (Ocean Observing System Development Panel (OOSDP), Joint Scientific and Technical Committee for the Global Climate Observing System (GCOS), etc.) that are considering the design of a global ocean observing system. Predominantly these committees are considering the measurement of the physical variables. PICES should keep in touch with the planning which emerges from these committees and consider in particular whether the variables of most interest to biological modeling are properly included in the plans. Communication to the parent committees of these panels, e.g. World Climate Research Program, Committee on Climate Changes and the Ocean, Joint Scientific Committee, would be appropriate if proper attention is not being given to biological variables in the planning. The IGBP is the oversight committee for JGOFS and other programs of potential importance for PICES.

### 5.) Joint investigations needed to contribute to the solution of climate problems in the North Pacific

The working group felt that at this stage it would be premature to recommend a list of joint

investigations. It does recommend that for the next 2-3 years a series of program design workshops be held on specific topics that are ready for consideration. Each workshop, rather than focus on the review of existing programs and the state of present knowledge, would develop a rationale for a specific joint program and the essential elements of the program.

Two particular programs are suggested as ready for consideration.

#### a. Paleoceanography

Although there is a natural interest in the greenhouse gas climate change problem, there is a broad range of climate fluctuations that should be of interest to PICES. A potentially important source of information on climate fluctuations of time scales of centuries is the record preserved in the varved sediments contained in various basins of the North Pacific. Studies of these records (similar to those done in the Santa Barbara Basin) should provide insight into the long time-scale climate variability and the associated changes in species abundance and composition.

#### b. Salinity observing system

Planning could commence immediately on a program to increase our knowledge of the salinity/fresh water distribution in the subarctic Pacific and the adjacent Okhotsk and Bering Seas. Elements of the program would be (a) measurement of the vertical profile of salinity by the deployment of expendable CTD probes from ships-of-opportunity traveling through areas of interest; and (D) the outfitting of thermosalinographs on research ships and ships of opportunity to obtain continuous records of surface temperature and salinity. Reliable technology now exists for both modes of operation. In the implementation of (b) consideration should be given to augment the sampling by selective discrete sampling of biological and chemical variables, e.g., pigments and nutrients.

## II. REPORT OF BERING SEA WORKING GROUP

The Bering Sea working group met on December 13, 1991. Participants included: K. Ohtani (Chair), H. Hatanaka, V. Alexander, D. Eggers, R. Methot (Rapporteur), J. Schumacher, W. McCaughran, A. Alekseev, O. Gritsenko, V. Ilyichev, and V. Radchenko. The group considered the following questions:

1.) What are the principal scientific questions that should be addressed by PICES and with what priority?

The Bering Sea is characterized by a wide, shallow shelf and large biomasses of diverse species. Better knowledge of this system is necessary for effective husbandry. PICES can contribute to the understanding of this system through fostering studies of the relationships, and variability, among components of the physical and biological environment. The consensus of the group was that the highest priority should be on research in the following major areas of investigation:

A. Circulation - Understanding patterns of circulation, with emphasis on volume exchange with adjacent bodies of water and material fluxes between the basin and the eastern continental shelf. In particular, the mean and variation of volume exchange with the North Pacific Ocean (primarily transport of Alaskan Stream water into the basin through the deeper passes and outflow from the basin into the Kamchatka Current) needs to be defined and understood.

B. Production - At these high latitudes, extreme seasonality in primary production

can result either in highly efficient transfer of energy between pelagic trophic levels if highly pulsed events are synchronized, or high rates of benthic input if events are not synchronized. The variability in temperature, ice extent, and cross shelf transport can affect the availability of food on the Bering Sea shelf, perhaps by causing changes in the timing, intensity, duration and fate of the spring bloom. Alternatively, effective cross shelf transport enhanced by topographic features could allow sustained primary production in specific areas during the summer. Extensive studies that may be coordinated by PICES should focus on describing the seasonality of physical dynamics and of production in the lower trophic levels.

C. Species Interactions - These studies should focus on biological interactions of species in higher trophic levels, particularly to understand the ecological impact of resource exploitation. PICES should encourage exchange of information on food habits and distribution patterns for all life stages of exploited species and their important predators and competitors. Historical changes in the abundance and composition of the fish in the Bering Sea should be documented to provide a context for interpretation of anthropogenic effects.

2.) To what extent is the study of these questions impeded by the lack of data that already exist but are not widely available? What steps might be taken by PICES to improve the availability of such data?

Some studies contemplated for the Bering Sea require information from throughout this area. This is particularly true for estimates of mass transport and total production by a trophic level. Questions of this sort could benefit from knowledge of other studies and access to other data. All nations should have access to time series of catch data for each exploited species, and access to archived biological data that may provide insight regarding historical changes in the Bering Sea fish community. PICES could establish a committee to begin a compilation of existing data sources and to explore the need for and feasibility of a comprehensive data base.

3.) To what extent is the present exchange of ideas and information, including data analysis and interpretation, satisfactory? How might it be improved through action of PICES?

The present level of exchange is not entirely satisfactory as evidenced by examples of new exchange of ideas and information occurring at the first PICES workshop. Clearly, it would be beneficial for PICES to encourage further opportunities for personal contact and exchange of ideas. Computer networks, scientific workshops, and joint expeditions are examples of such opportunities. PICES may wish to consider convening a symposium to assemble the oceanographic data available in the Bering Sea.

4.) Are there existing international programs or arrangements for cooperation that are applied to these questions? How might PICES strengthen these efforts?

Natural resources of the Bering Sea currently are assessed and managed largely through bilateral and multilateral arrangements, including joint resource assessment surveys. PICES could provide a more comprehensive framework for coordination of research activities undertaken in these programs. In addition, PICES could encourage existing global oceanographic programs to focus a greater share of their efforts on the North Pacific Ocean, particularly the Bering Sea. Cooperation through PICES should provide opportunities for nations to conduct research throughout the North Pacific.

5.) Are there joint investigations by scientists from PICES countries that would contribute significantly to solution of the scientific problems? How might PICES assist in the planning and coordination of such investigations?

Data from satellites, long-term buoys, and synoptic surveys are useful to researchers from all nations, yet are too expensive for each to pursue comprehensively. PICES could provide a forum for development of coordinated research proposals. Each proposal would be tailored to a nation's individual needs and capabilities, while\* the collective projects would provide the needed comprehensive data. Monitoring circulation throughout the Bering Sea is a reasonable project that would benefit from this multi-national approach. In addition, personal contacts in future PICES workshops should result in new opportunities for joint investigations.

#### REPORT OF ENVIRONMENTAL QUALITY WORKING GROUP

The Environmental Quality working group met on December 13,1991. Participants included: J. Davis (Chair), C. Davis, K. Xu, Q. tin, V. Anikiev, E. Goldberg, U. Varanasi, Y. Sugimori, C. Wong and J. Coe (Rapporteur).

The working group identified the research issues of primary importance in the PICES as follows:

- A. Nutrient Loading and Eutrophication;
- B. Chronic and Persistent Chemical Pollutants;
- C. The Role of the North Pacific in Waste Disposal;
- D. Large-Scale Environmental Impacts;
- E. Biological Community Impacts due to Exploitation.

The group chose to prioritize these research areas for consideration by PICES into two categories. The high priority research areas include the nutrient loading and eutrophication work, the chronic and persistent chemical pollutants and the role of the North Pacific in waste disposal. The secondary priority includes research on large-scale environmental impacts and on biological community impacts due to exploitation.

The working group listed elements of each of the principal research areas that deserve consideration and the known data and information limitations.

#### A. Nutrient Loading and Eutrophication

##### 1. Research considerations

- The phenomena of algal blooms, red tides and toxic blooms;
- Identification of indicator organisms, and monitoring and trend detector schemes
- The effects of land and water use practices;
- Evaluate natural and man-induced fluxes in nutrients, e.g., N, P, Si ratios in river run-off;
- Evaluate estuarine ecodynamics (including bio-geochemical factors, use of closed systems/microcosms);
- Develop techniques to identify pathogens in water and seafood;
- Investigate causative mechanisms for red tide and develop predictors of their intensity

##### 2. Data and Information limitations

- Causative mechanisms for red tides are unknown;
- Trends in red tide occurrence need to be elucidated;
- The ecosystem dynamics of red tides are unknown (physics, chemistry, biology and

synergistic effects);

- Natural and human induced fluxes in nutrients are unknown.

## B. Chronic and Persistent Chemical Pollutants

### 1. Research Considerations

- Evaluate toxicity, bioaccumulation mechanisms and chemistry;
- Consider seafood quality and human health impacts/implications;
- Consider effects on marketability of seafood products;
- Establish a list of priority chemicals for evaluation/assessment;
- Consider the utility of monitoring indicator organisms for early detection of impacts.

### 2. Data and Information Limitations

- Limited knowledge on the risks and effects on species and on ecosystems from exposure to specific toxic and persistent chemicals;
- Information on short and long-term effects of exposure is limited;
- Limited information on synergistic effects of combined exposure;
- Limited information on the sub-lethal effects of exposure.

## C. The Role of the North Pacific in Waste Disposal

### 1. Research Considerations

- What are the PICES nations doing regarding use of the ocean to dispose of wastes of all types?
- What are the real and potential impacts by waste type and location?
- What waste management practices are being, or might be used for at-sea disposal?
- What are the indicators of environmental quality related to ocean disposal of various types of wastes?
- What is the assimilative capacity of the North Pacific for specific pollutants or combination of pollutants?
- What specific considerations are important regarding the release/disposal of radioactive wastes?

### 2. Data and Information Limitations

- Information on current disposal practices is not collated or accessible;
- Current levels of discharge and their impacts on ocean ecosystems are unknown;
- Reliable indicators of the impacts of ocean disposal on environmental quality are lacking;
- Current data on the population levels of affected species is needed from the coastal areas of all Pacific Rim nations;
- Limited information on the mechanisms and processes of assimilation, degradation and persistence of various disposed materials.

## D. Large-Scale Environmental Impacts

### 1. Research Considerations

- Study of the long-range transport and dispersal of substances by the atmosphere, and ocean currents;
- Model the oceanic and atmospheric processes of dispersion, dilution and concentration (including oil, toxics, debris, etc.).

### 2. Data and Information Limitations

- Improved models of ocean atmosphere interaction are needed;
- Three dimensional ocean models are needed;
- Coordinated monitoring of marine debris density distribution and composition is needed;

- "Ground truth" data are needed to validate ocean physics models.

## E. Biological Community Impacts Due to Exploitation

### 1. Research Considerations

- Consider exploitation rates and their potential ecosystem effects;
- Consider fishing gear selectivity, bycatch rates and their impacts;
- Aquaculture (mariculture) activities and their impacts on environmental quality;
- Consider the impacts of fish processing wastes on ecosystem health.

### 2. Data and Information Limitations

- Not Considered.

The group was asked to consider actions that might be taken by PICES to improve availability and utility of data and information. It made the following suggestions for PICES action in this area:

1. Identify gaps in knowledge on environmental quality and its assessment.
2. Promote and conduct data collection as appropriate.
3. Facilitate the exchange of data, information, and personnel (clearinghouse function).
4. Promote research cooperation between nations, laboratories, programs, etc.
5. Develop working relationships with other organizations, agencies, programs and governments.
6. Establish a publication series to disseminate research results as well as workshop and symposia proceedings.
7. Develop and nurture multi-disciplinary linkages.
8. Provide translation services.
9. Organize the sharing of equipment, resources and cooperative data analyses.
10. Investigate the need for and establish systems of indicator species for environmental quality monitoring.
11. Recognize and recommend new research technologies as they come into use in the community.

In addition to these general recommendations for PICES actions which apply to each of the research areas identified (A-E), the working group had some suggestions specific to the research on chronic and persistent chemical pollutants. It was recommended that a history of contaminants be constructed by sampling of the sediments in the deep North Pacific. Establishment of tissue banks for the evaluation of trends in concentration and impacts of toxic chemicals on specific species or species groups was also recommended.

The working group considered what organizations and programs might be expected to cooperate with PICES in addressing the environmental quality research questions in the North Pacific and listed the following:

#### ICES

- East-West Center, Hawaii
- Asia-Pacific Economic Cooperation (APEC)
- Universities in member countries
- UN Organizations (IOC, FAO, UNEP, IMO)
- UN University
- Professional and scientific societies
- Government agencies in member countries

Regarding steps that may be taken by PICES to strengthen the cooperative relationships with

these organizations, the working group referred to those actions listed above.

#### IV. REPORT ON FISHERY OCEANOGRAPHY WORKING GROUP

The Fishery Oceanography working group met on December 13, 1991. Participants included: M. Stepanenko (Chair), J. Garrett, J. McInerney, D. McKone, T. Parsons, J. Rice, D. Ware, H. Shen, Q. Tang, K. Kitani, J. Yoshida, A. Bakun, J. Hunter, G. Stauffer, R. Hofman, R. Tuttle, B. Kotenev, and A. Hollowed (Rapporteur).

##### General Statement

Evidence is accumulating that changes in ocean circulation and mixing affect not only the distribution but also the abundance of fish and shellfish stocks. These changes and effects occur on a spectrum of time scales including interannual, decadal, and longer periods. Neither the patterns of change nor the mechanisms of the interactions are well known.

Understanding of the environmental influence is valuable because knowledge of this type may enable scientists to predict abundance changes and to evaluate the consequences of climate change.

Members of the Fisheries Oceanography attempted to answer five questions.

##### 1). What are the principal scientific questions that should be addressed by PICES and with what priority?

The members of the fisheries oceanography group discussed several important research questions pertaining to fisheries oceanography. Six major questions were proposed:

- a. What is the carrying capacity of certain regions of the North Pacific?
- b. What are the linkages between the atmosphere and productivity?
- c. What is the cause of major shifts in the abundance of marine organisms in the North Pacific? Are they predictable?
- d. What strategies do fish use to survive in the ocean? Can these strategies be generalized for specific types of physical conditions?
- e. What physical factors lead to concentrations of important prey?
- f. How can environmental variables be incorporated into stock-recruitment theory and optimal harvest strategies?

These questions differ substantially; the first four represent large scale ecosystem issues, whereas the last three are smaller scale stock-specific questions. The group agreed that all six would be encompassed by one general question:

*What governs fish resources, species composition, and biomass in the North Pacific and Bering Sea?*

##### 2). To what extent is the study of these questions impeded by the lack of data that already exist but are not widely available?

With the exception of the Pacific sardine and walleye pollock, detailed information on rates of growth, reproduction, or mortality for species that occupy several locations in the North Pacific is seldom exchanged. Knowledge of life history parameters would allow for a comparison of the adaptations fish make to existing environmental conditions. Quantification of the influence of physical factors on survival of fish is also impeded by the lack of detailed information on long term and interannual variability in large scale circulation patterns, eddies, fronts, and upwelling zones in the North Pacific.

It was generally agreed that PICES could improve the availability of physical and biological data through the following steps:

- a. Facilitate an exchange of existing time series of recruitment, spatial distribution (catch locations and survey data), and abundance of fish stocks.
- b. Assist in the collection of data from ships of opportunity.
- c. Collect and distribute existing information on current systems of the North Pacific including detailed information on the location of major frontal systems.

3.) To what extent is the present exchange of ideas and information, including data analysis and interpretation, satisfactory?

The group agreed that existing mechanisms for exchange of information were unsatisfactory. How might it be improved through action of PICES?

- a. Advise members of upcoming cruise plans, or research activities with sufficient time for making adjustments for cooperative research.
- b. Develop a computer bulletin board to improve communication between scientific organizations,
- c. Assist scientists from member nations in their efforts to obtain travel approval to visit laboratories or to participate in survey activities,
- d. Facilitate cooperative cruise planning,
- e. Convene symposiums or workshops.

4.) Are there existing international programs or arrangements for cooperation that applied to these questions.

There are several existing programs and organizations that could provide information that may pertain to fisheries oceanography, including:

Arctic Data Center (ADC), Committee on Climate Change in the Ocean (CCCO1 Convention for Conservation of Anadromous Species in the North Pacific (CCASNP), Food and Agriculture Organization of the United Nations (FAO), Global Ocean Ecosystem Dynamics (GLOBEC), Intergovernmental Oceanographic Commission (IOC), International Arctic Science Committee (IASC), International Pacific Halibut Commission (IPHC), International Recruitment Experiment (IREP), Joint Global Ocean Flux Study (JGOFS), Ocean Science in Relation to Living Resources (OSLR), North Pacific Albacore Symposia (NPA), Pacific Science Association (PSA), Sardine Anchovy Recruitment Project (SARP), United Nations Environment Program (UNEP), World Ocean Circulation Experiment (WOCE).

How might PICES strengthen these efforts?

- a. Improve communication through news letters, computers, or annual reports. This information should include: dates of upcoming meetings and symposiums and plans for cruises to be conducted by other organizations,
- b. Promote participation of scientists from other member nations in meetings, workshops and planning sessions,
- c. Promote PICES research goals to gain interest among other existing organizations in our projects.
- d. Assist scientists from member nations in their efforts to obtain travel approval to attend workshops or symposia, or cruise participation.

5.) Are there joint investigations by scientists from PICES countries that could contribute to the solution of questions in fisheries oceanography.

There are several joint investigations by scientists from PICES countries that could contribute to the solution of questions in fisheries oceanography.

- a. Japan Canada Science and Technology organization for the study of high seas salmon and squid.
- b. Cooperative USSR, Canada and U.S. International North Pacific Ocean Climate Study. Designed to investigate physical and chemical variations in the sub-arctic North Pacific.
- c. Science and technology of marine ocean science agreement between the U.S. and China.
- d. Existing bilateral agreements.
- e. WOCE, JGOFS, and GLOBEC.

How might PICES assist in planning and coordination of such investigations?

- a. Facilitate joint cruise planning.
- b. Inform PICES nations of research plans and encourage participation from other nations.

#### **4. List of Participants**

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