

PICES Press



Newsletter of the North Pacific Marine Science Organization (Published semi-annually)



Highlights of PICES VI

The North Pacific Marine Science Organization (PICES) held its Sixth Annual Meeting on October 14 to 26, 1997, next to a beautiful beach in Pusan, Korea. 307 scientists from member (Canada, China, Japan, Korea, Russia and U.S.A.), and non-member (China-Taipei, New Zealand, and Philippines) countries participated in the meeting and enjoyed face-to-face communication during coffee breaks, which is the basis of scientific collaborations and which resulted in consumption of a large amount of coffee. One of the most important achievements of this Annual Meeting was that 139 Korean scientists joined PICES activities, many for the first time, and who now hopefully will contribute to the expansion of the PICES scientific community. This is one of the reasons why the Annual Meeting is held in a different member country each year.

Another potential but important achievement was the proposed initiation of a new research program under PICES on East Asian Marginal Seas. At the opening session, Dr. Kuh Kim gave a keynote lecture on Hydrography and Circulation in Asian Marginal Seas. He proposed a collaboration between PICES and the Circulation Research of the East Asian Marginal Seas Program (CREAMS) and an extension of the program to involve biological and ecosystem studies. The

Physical Oceanography and Climate Committee and the Science Board recognized the scientific value of the second phase of CREAMS (CREAMS-II) as a valuable component of research to be conducted within the PICES framework. The PICES Governing Council accepted Science Board's proposal to hold a CREAMS workshop in conjunction with PICES VII. These actions were due to WG 10 (Circulation and Ventilation in the Japan Sea/East Sea and its Adjacent Areas) discussions, and the attention and interest the program has drawn.

The scientific program of the meeting was composed of a Science Board Symposium on Ecosystem Dynamics in the Eastern and Western Gyres of the Subarctic Pacific, organized by the BASS Task Team of the PICES-GLOBEC Climate Change and Carrying Capacity (CCCC) Program; and five topic sessions: Circulation and Ventilation of North Pacific Marginal and Semi-Enclosed Seas (Physical Oceanography and Climate Committee); Micronekton of the North Pacific: Distribution, Biology and Trophic Linkages (Biological Oceanography and Fishery Science Committees); Models for Linking Climate and Fish (Fishery Science and Biological

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The state of the eastern North Pacific in the first half of 1997

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Dr. Howard Freeland is Head of the Ocean Science and Productivity Division at the Institute of Ocean Sciences (Department Fisheries and Oceans, Canada) and a member of PICES' Physical Oceanography and Climate Committee. His research interests include the climatic state of the ocean and low frequency variability. Dr. Freeland was the scientist primarily responsible for Canadian contribution to the WOCE lines P15 and P1. Presently he is accountable for maintenance of Line P, a line of CTD stations that has been monitored for over 40 years between the mouth of the Juan de Fuca Strait and Ocean Station Papa at 50°N and 145°W (also known as WOCE Repeat Hydrography Line P6). At the present time Howard is coordinating Canadian projects to monitor the 1997/98 El Niño and its impact on the west coast of British Columbia.

Figure 1 shows the monthly mean sea-surface temperature (SST) anomalies in the eastern North Pacific from January through June 1997. The year so far has been dominated overwhelmingly by the surprising events developing in the equatorial Pacific. The development of the 1997/98 El Niño was a surprise by itself, but the development so very early in the year was nothing short of astonishing.

Within the SST anomaly pictures of *Figure 1*, we see that conditions were close to normal at the beginning of the year. In the Gulf of Alaska SSTs were even marginally below normal from January through April. In March the first indications of an incipient El Niño became apparent to anyone who was watching sea level evolving on the equator. The event developed with great rapidity, and by May 1997, as we can see in *Figure 1*, extreme warm anomalies appearing in the map off California, meanwhile SSTs remained near normal in the Gulf of Alaska. By June the anomalies have penetrated through the entire northeastern Pacific and are heading towards the dateline along the Aleutian Islands. The pattern of anomalies displayed in June 1997, positive SST anomalies around the coast of N. America, and negative anomalies in the central Pacific, is the classic pattern of response of the eastern North Pacific to El

Niño forcing. This pattern is observed in response to all El Niño events.

If this El Niño continued to develop according to the book, then we would expect the largest SST anomalies to appear during the period January through March 1998. However, the rapid and very early rise of this event does make it unique in our experience and any attempt to forecast the future evolution of a unique event is probably a fool's game. I make no attempt to forecast the evolution. One thing is certain, by summer 1997 a large amount of extra heat had been injected into the surface layers of the eastern North Pacific. There is no easy way for the ocean to dispose of this extra heat, and so we must expect the entire region to be dominated by positive SST anomalies for the rest of the year.

As it became evident that a large El Niño was developing, the Canadian oceanographic community launched a substantial effort to monitor the development and evolution of oceanographic conditions off the west coast of Canada. It is our hope that we will thereby develop a thorough picture of the effects that this event has on the Pacific Coast of Canada. The writer encourages all oceanographers in the countries that make up the PICES family to

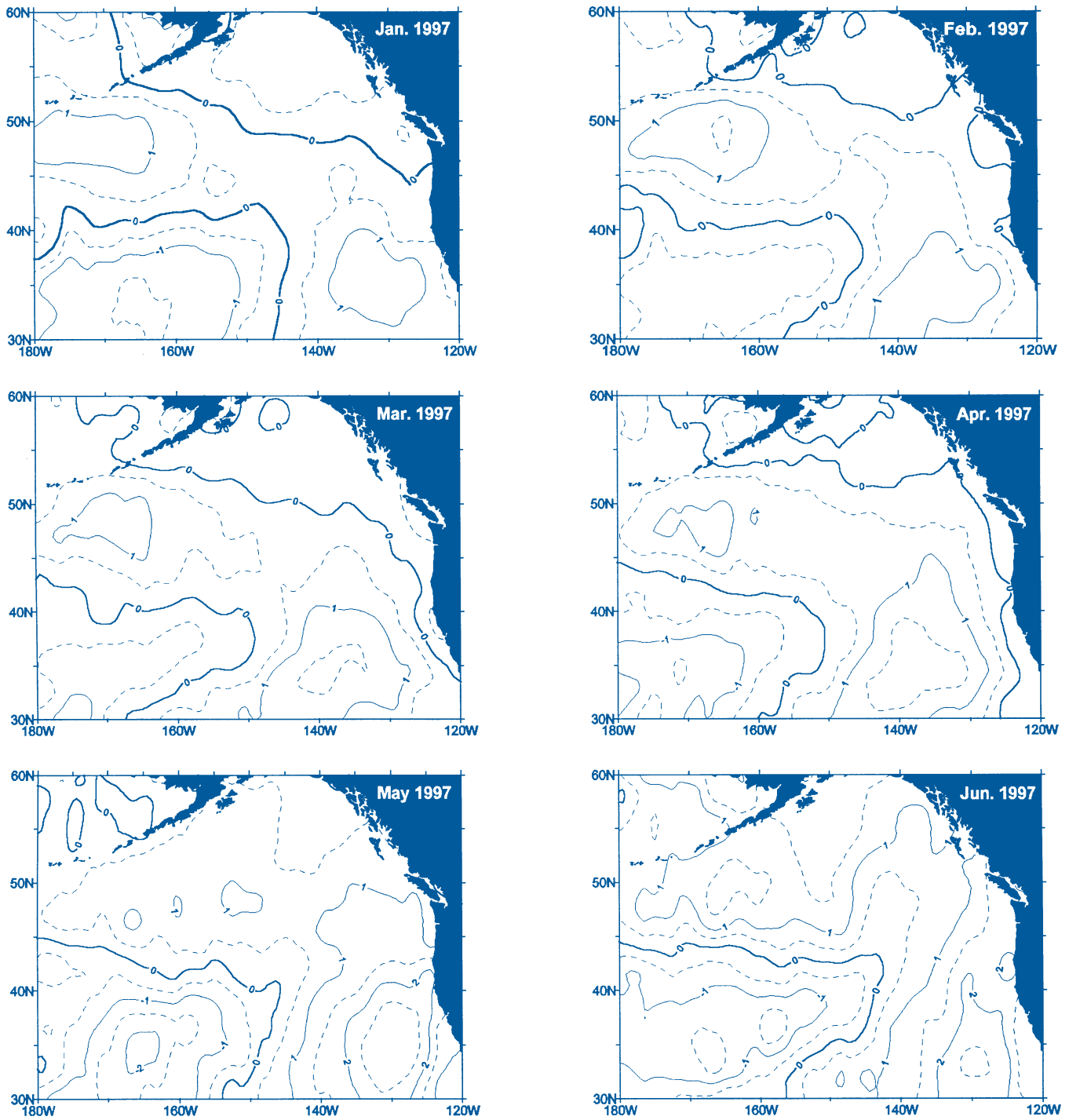


Fig. 1 Monthly mean sea-surface temperature anomalies for the eastern North Pacific Ocean, from January through June 1997. The solid contours are at intervals of 1°C, and dashed contours at intervals of 0.5°C. The bold contour indicates 0 anomaly.

develop similar monitoring programs. Even at this late date the evolution of the 1997/98 El Niño is not over and with co-operation we can develop a detailed description of the event.

Through the late summer of 1997, sea-surface temperatures continued to rise in the Gulf of Alaska.

This is shown clearly in the diagrams in Figure 2. However, by October 1997, evidence suggests that sea-surface temperatures are beginning to decline. The highest temperatures were observed off the coast of British Columbia in September and were quite remarkably high. We have been sampling ocean

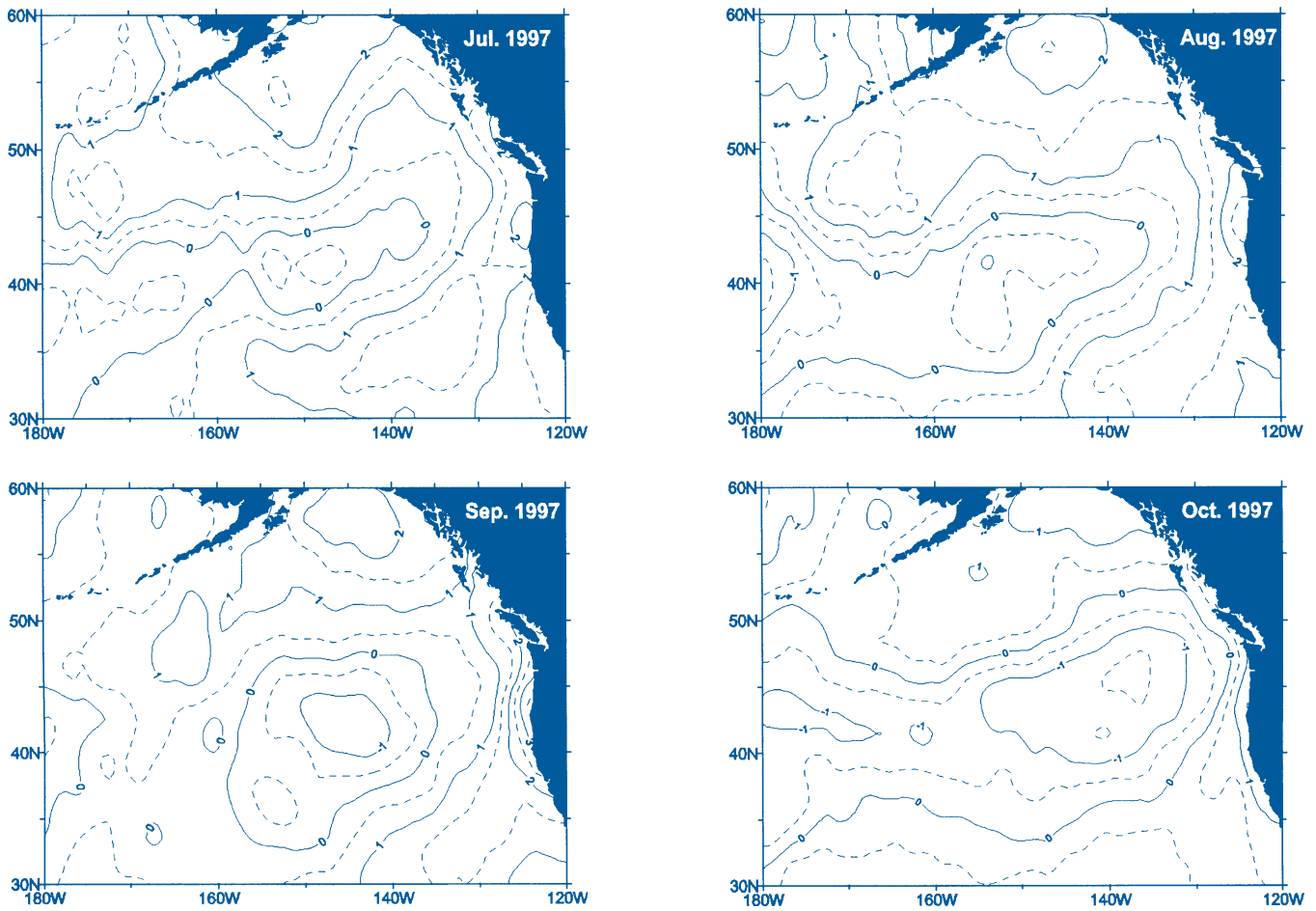


Fig. 2 Monthly mean sea-surface temperature anomalies for the eastern North Pacific Ocean, from July through October 1997. The solid contours are at intervals of 1°C, and dashed contours at intervals of 0.5°C. The bold contour indicates 0 anomaly.

temperatures daily at lighthouse stations around the coast of British Columbia since 1935, and saw the highest temperatures ever recorded in September 1997. For example, the monthly averaged temperature at Kains Island (northwestern coast of Vancouver Island) in September 1997 beat the previous record by 1.2°C, a very large margin. Other records were less impressive, but records were set from Amphitrite Point on the southwest coast of Vancouver Island to Langara Island on the northwest tip of the Queen Charlotte Islands.

The El Niño develops on the equator, as we all know, and affects higher latitudes. So to look at the future evolution we must look south. During September and early October the southern oscillation index showed a steady decline towards more normal conditions. Then towards the end of October a new westerly wind burst developed. This can be seen and followed quite easily on an Australian web site that lists the southern

oscillation index daily, and computes and displays 30-day running means. This site can be found at: <http://www.dnr.qld.gov.au/longpdk/>. Anyone who accesses this site should note that Australians define the southern oscillation index in the same way that the rest of the world does, except that they multiply the result by 10, thus during the Oct./Nov. burst peak values of the SOI were reported near -60. The burst appeared to have lasted for several weeks and now (November 10th 1997) appears to have subsided.

It is possible that the El Niño forcing on the equator is now over and the ocean is steadily returning to normal. However, the Oct./Nov. burst must serve as a warning that we do not really know what the tropical Pacific has in store for us. El Niño events are supposed to develop during the period November to December, forecasting models appear to have failed, so all we can do is wait and watch.

The state of the western North Pacific in the first half of 1997

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Mr. Takashi Yoshida is a Scientific Officer of the Oceanographical Division of the Climate and Marine Department at the Japan Meteorological Agency (JMA). He is working as a member of a group in charge of monitoring and forecasting sea surface temperature and sea surface current in the western North Pacific. Based on *in situ* and satellite data, this group makes various oceanographical products. One of the main products is the “Monthly Ocean Report”, which is published and distributed by JMA every month. Mr. Yoshida is now involved in developing a new analysis system of sea surface and subsurface temperature to improve sea surface temperature forecasts in the western North Pacific. His recent research interest centers on water masses distribution and its variation in seas east of Japan and the Okhotsk Sea.

Sea Surface Temperature

Figure 1 shows monthly mean Sea Surface Temperature (SST) anomalies in the western North Pacific from January to June 1997. These charts are based on the JMA’s objective SST analysis for 1x1 degree grid points over the western North Pacific using *in situ* observations reported from ships and buoys. The anomalies are computed from the JMA 1961-90 climatology. One of the most remarkable features in the first half of 1997 is that notable positive SST anomalies, which have been observed since the end of 1995, continued in the region north of 45°N. Time series of regional mean SST anomaly for region A (45-53°N, 150-180°E) shows that the SST anomaly has kept exceeding +0.5°C during the first half of 1997, though the anomaly has gradually reduced since it reached +2°C at its peak in October 1996 (Figure 2). Along 40°N from the Japanese coast eastward to the date line, negative SST anomalies have developed in May and June 1997 and those exceeding -1°C widely covered the area in June 1997.

Oyashio and Kuroshio

Figure 3 shows temperature distributions at the depth of 100m east of Japan for February and June 1997. These charts are based on the JMA’s objective 100m water temperature analysis for 0.25x0.25 degree grid

points in seas adjacent to Japan using *in situ* observations reported from ships and buoys. In the figure, temperatures colder than 5°C are recognized as the Oyashio cold water. The Oyashio cold water displayed typical seasonal variations during the first half of 1997. In February 1997, the Oyashio cold water occupied the area southeast of Hokkaido and its major part didn’t extend southward over 40°N except for the small patches of the cold water around 39°N, 147°E. After February, the Oyashio cold water has bifurcately penetrated into the area east of Honshu along the western and eastern side of the warm core ring centered at 41°N, 144°E. The penetrations are called the coastal and off-coastal branches of the Oyashio cold water or the first and second Oyashio Intrusions. The penetrations have formed a cold water pool east of Honshu and the southernmost part of the pool reached 38°N, 142°E in June 1997. The Kuroshio has kept taking a non-large-meander path south of Japan since the summer of 1991.

Sea Ice in the Okhotsk Sea

In the 1996/97 winter, drift ice came in sight at meteorological observatories along the Okhotsk Sea coast of Hokkaido from late January to early February and came on shore at the coast from mid- to late February. The first date of drift ice on shore was

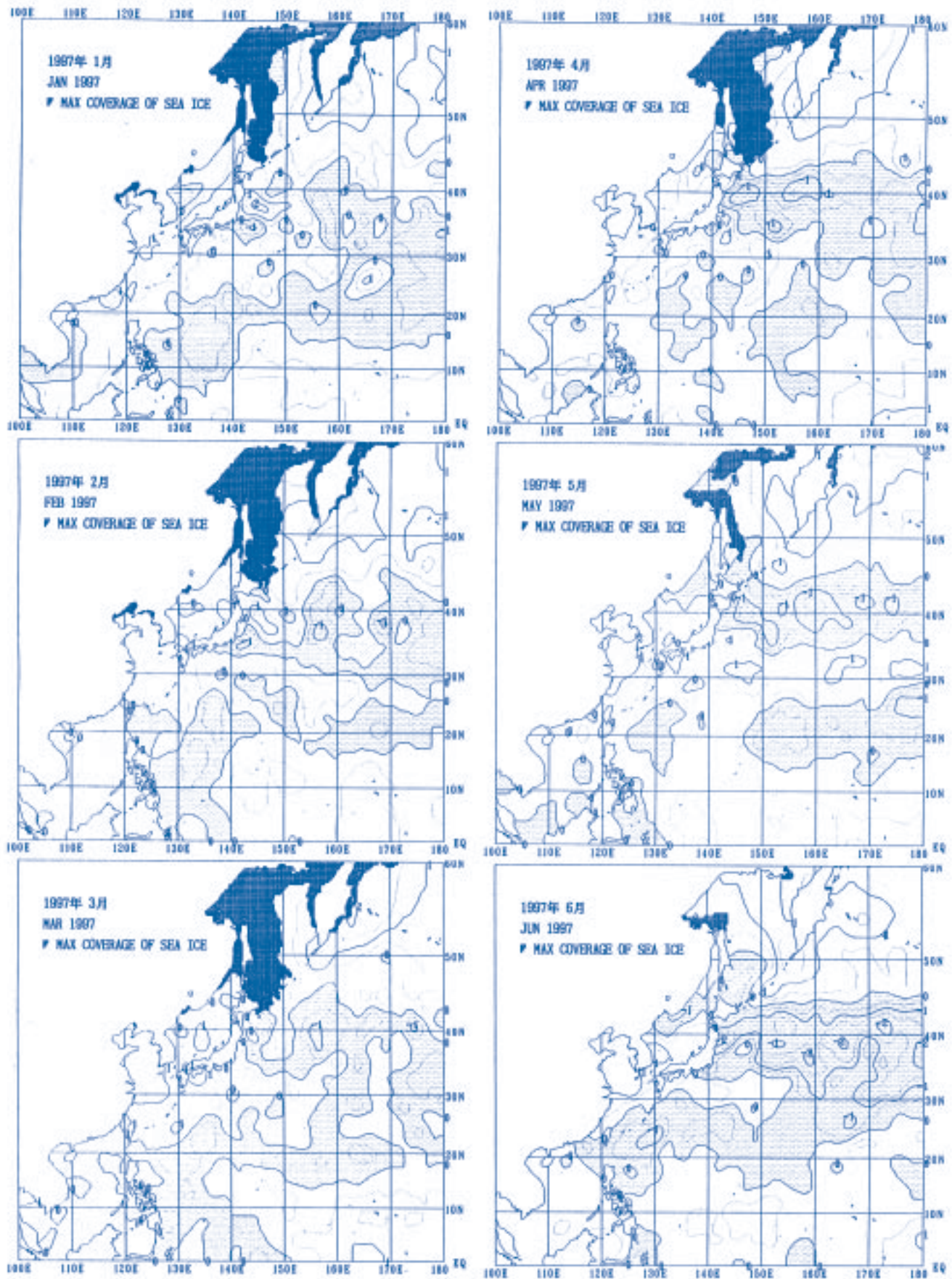


Fig. 1 Monthly mean sea surface temperature anomalies ($^{\circ}\text{C}$). Anomalies are departures from the JMA 1961-90 climatology. Contour interval is 1°C and additional contours of 0.5°C are shown by broken lines. Negative anomalies are shaded.

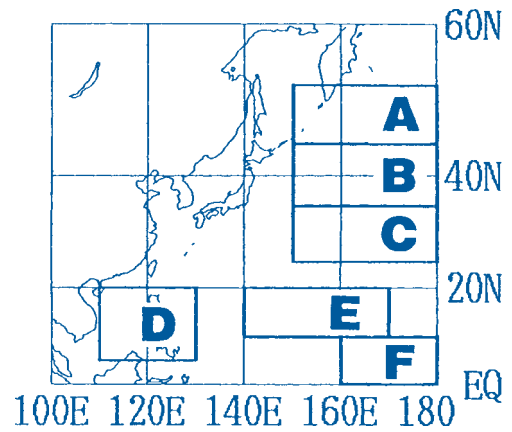
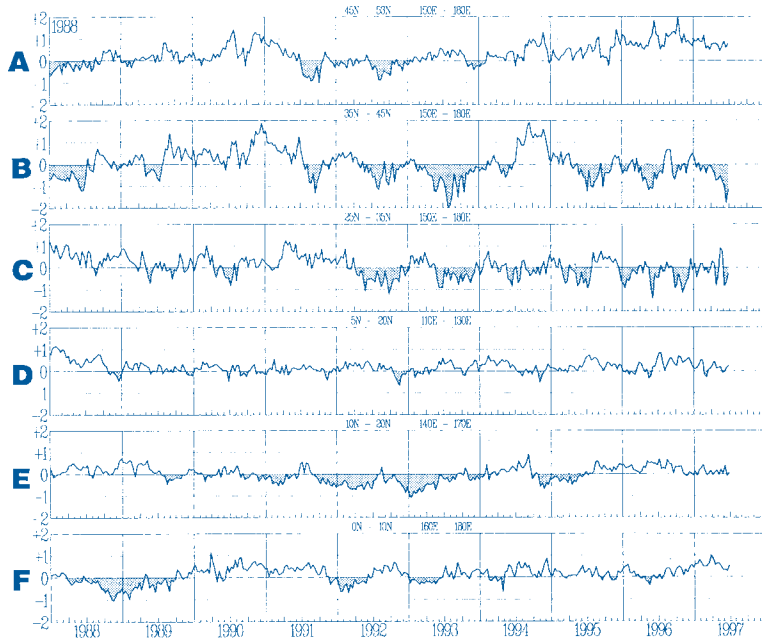


Fig. 2 Time series of the ten-day mean sea surface temperature anomalies ($^{\circ}\text{C}$), computed from the JMA 1961-90 climatology for the areas shown in the right panel. Negative anomalies are shaded.

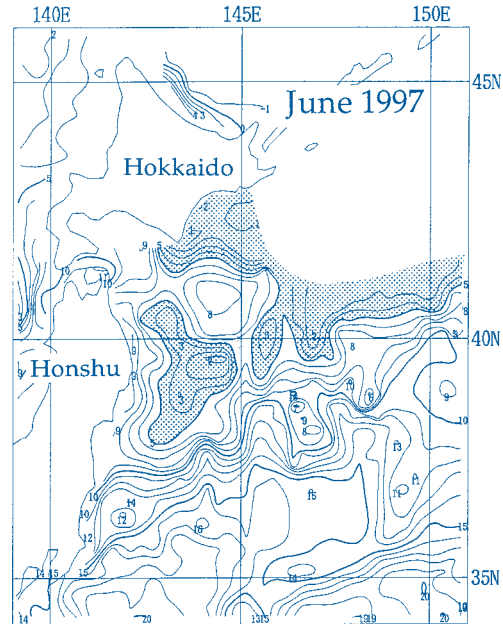
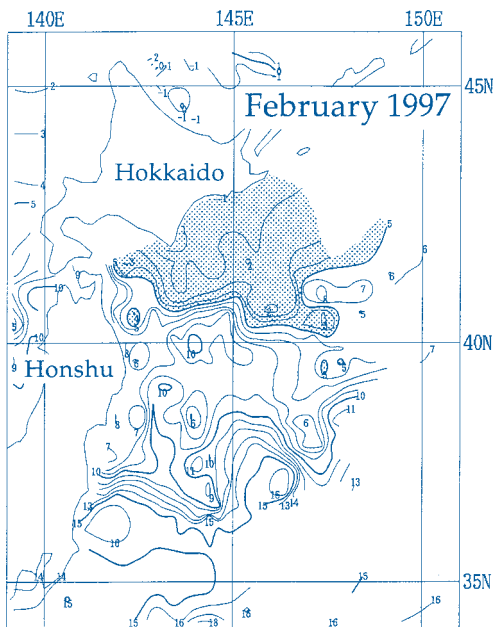


Fig. 3 Temperature ($^{\circ}\text{C}$) at the depth of 100 m east of Japan for February 1997 (left) and June 1997 (right). Contour interval is 1°C . Areas colder than 5°C are shaded.

about 10 days later than the 30 years (1961-90) average at almost every station and the date of ice breakup was earlier than the average at every station. Hence, the length of the ice season in the 1996/97 winter was shorter than the average at every station. Sea ice extent in the Okhotsk Sea was nearly equal to the 20 years (1971-90) average in December and smaller than the average from January to the end of the ice season. The sea ice extent was the smallest among the past 26 years at the end of January and from late April to late May. The outflow of drift ice

into the Pacific Ocean was significant from mid- to late March.

Carbon Dioxide

JMA made observations of carbon dioxide (CO_2) in the western North Pacific on her cruises in January-February and June-July in 1997. The concentration (partial pressure) of CO_2 in surface water was lower than that in the overlying atmosphere in January-

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The status of the Bering Sea in the first eight months of 1997

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Dr. Phyllis Stabeno, a physical oceanographer at the Pacific Marine Environmental Laboratory of the NOAA, conducts research focused on understanding the dynamics of circulation of the N. Pacific, Bering Sea and their adjoining shelves. By applying knowledge of physical processes to fisheries oceanography, Dr. Stabeno plays a vital role in the success of NOAA's FOCI (Fishery Oceanography Coordinated Investigations) program. Phyllis is also a Principal Investigator on several research elements for other programs, including: Southeast Bering Sea Carrying Capacity (Coastal Ocean Program), the Bering sea Green Belt: processes and ecosystem production (Arctic Research Initiative) and Prolonged Production and trophic Transfer to Predators: processes at the inner front of the southeast Bering Sea (National Science Foundation). This research seeks to improve our understanding of ecosystems through the integration of physical and biological phenomena.

During late spring and summer of 1997, a variety of anomalous conditions existed in the Bering Sea including a major coccolithophorid bloom, large die-off of marine birds (shearwaters), salmon returns far below predicted, calm sunny days and unusually warm sea surface temperatures. These events were likely related, in part, to the atmospheric perturbations associated with the strong equatorial El Niño. To present these in a timely manner this article has been expanded to include July and August of 1997. Because the southeast Bering Sea is one of the most productive ecosystems of the world, with commercially valuable fishing grounds, it is the focus of several research projects. These projects collected data throughout 1997 and future analysis will provide insight into the causes of the anomalous conditions and their impact on the ecosystem. The programs include National Science Foundation (NSF) funded research on prolonged production along the structure front (~50m isobath) and a group of programs funded by National Oceanic Atmospheric Administration (annual trawl surveys conducted by Alaska Fisheries Science Center/National Marine Fisheries Service; monitoring from biophysical platforms and

hydrographic sections by Southeast Bering Sea Carrying Capacity and Coastal Ocean Program; biophysical measurements of the green belt by the Arctic Research Initiative; and research by Fisheries Oceanography Coordinated Investigations). The scientists (N. A. Bond, R. D. Brodeur, K. O. Coyle, M. B. Decker, G. L. Hunt Jr., J. M. Napp, J. D. Schumacher, P. J. Stabeno, D. Stockwell, C. T. Tynan, T. C. Vance, T. E. Whitlege, T. Wyllie Echeverraind and S. Zeeman) from these programs provided much of the information that is reported in this article.

The seasonal variation of sea ice over the southeast Bering Sea is one of the striking characteristics of this shelf. The extent of sea ice is largely determined by the strength and direction of the winds. Strong, frigid winds out of the north blow the ice southward over the shelf. Typically sea ice reaches the Pribilof Islands (*Figure 1*) in March or April and then retreats within the month. The ice field at the end of December 1996 was more extensive than usual, but it did not advance significantly during January since the winds were particularly weak (*Figure 2a*). February-April winds were typical (*Figure 2b,c*), resulting in

an average ice coverage by early April. Melt back, however, appeared to be unusually rapid and ice was gone from the region by late April.

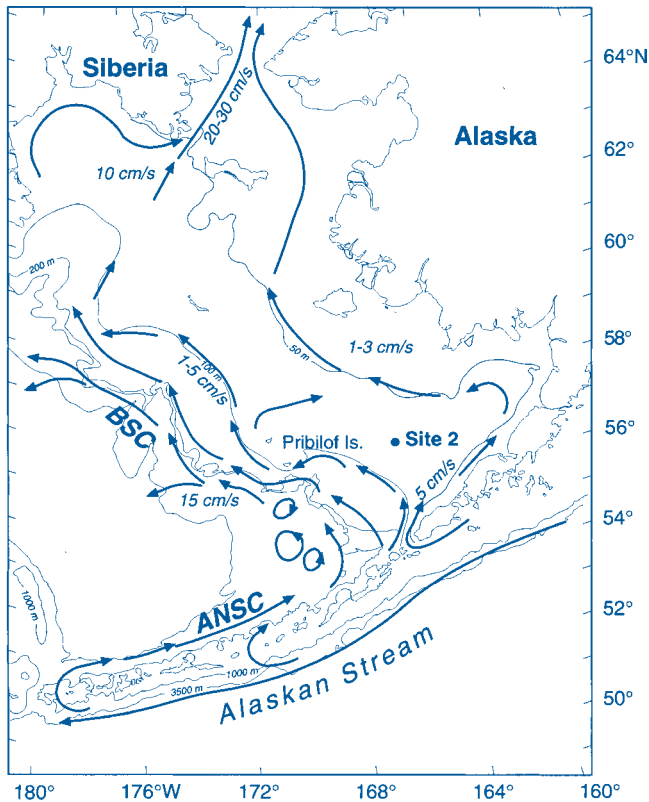


Fig. 1 A schematic of the mean circulation in the eastern Bering Sea. The Bering Slope Current (BSC) and Aleutian North Slope Current (ANSC) are shown. Site 2, the location of the time series measurements, is indicated.

Ice melt provides an input of fresh water, that is the major contributor to stratification of the water column early in the year, while in late spring and summer solar heating becomes the primary source of buoyancy. Water properties and water column structure separate this shelf into domains. Coastal waters ($z < 50$ m) are typically mixed (or weakly stratified) by a combination of tidal and wind stirring. During spring and summer, water over the middle shelf ($50 < z < 100$ m) is two layered with the upper layer wind mixed and lower tidally mixed. The depth of upper mixed layer usually varies from 15 to 30m depending upon wind strength and duration in a given year. Separating these two domains is a structure front (the inner front). Seabirds (Shearwaters-Puffinuss tenuirostris) return here each year, attracted by high food concentrations (euphausiids). In a “normal” year their prey thrive on prolonged and/or enhanced production from the base of the food web (phytoplankton) as a result of the persistent flux of nutrients into the sunlit waters.

Through April, both oceanographic and atmospheric conditions were not markedly atypical. In May, weather patterns changed, the winds weakened, so that by June and July winds were significantly weaker than usual (Figure 2e,f). In addition, the weather patterns resulted in more cloud free days than usual and thus an increase of solar radiation to the sea surface.

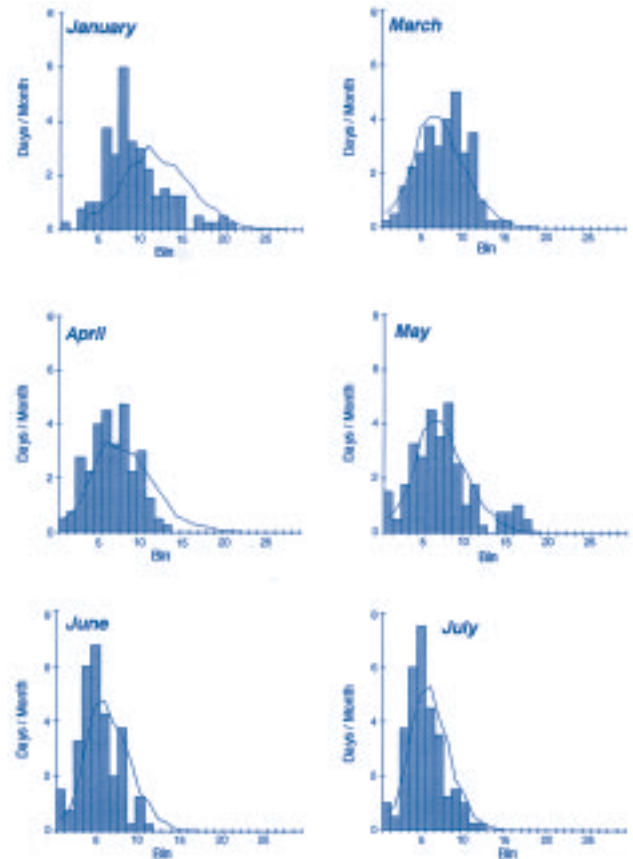


Fig.2 Histogram of wind speed at the Pribilof Islands for January, March, April, May, June and July 1997. Superimposed (line) is the histogram of mean (1950–1997) wind speed for same months. Each represents 2 discrete values of knots. (i.e. bin 1 is the number of days that had winds of 0 or 1 knot; bin 2 is the number of days that had winds of 2 or 3 knots, etc.)

One consequence of these unusual atmospheric conditions was that the coastal domain was strongly stratified even in water depths of 30m. The middle shelf domain usually characterized by two layers, with a sharp thermocline between them, was markedly different this year. Beneath the shallow mixed layer (< 10 m for much of June and July) was a transition zone (~ 20 m) to the lower tidally mixed layer. This weaker stratification permitted greater transfer of heat into the lower layer. Thus, the bottom temperatures warmed by 4°C over the summer.

The changes observed in the water column of both the middle shelf and coastal domains resulted in a structure front that was not as well developed as previously reported. The shallow mixed layer, together with the enhanced radiation resulted in warmer sea surface temperature. A time series of sea-surface temperature on the shelf (*Site 2 in Figure 1*) exists for April of the last three years. This summer temperatures were significantly warmer than usual (*Figure 3*).

Satellite remote sensing supports the warm sea surface temperatures observed at site 2 and provides the following sequence of sea surface temperature conditions throughout the region: in early May temperatures were slightly below normal (~ 0.0 to -1.0°C) but by mid-June the anomaly was strongly positive (2.0 - 2.5°C above normal). A positive anomaly persisted through September. The anomalous physical conditions likely supported a coccolithophorid bloom that was first observed during early July over the southeastern Bering Sea shelf. By this time, the normal summertime plant community had probably been replaced by coccolithophores. Reflectance of light off their calcium carbonate plates (coccoliths) gave the water its anomalous color which was clearly visible from space (*Figure 4*). Light penetration into the water column, essential for primary production, was markedly reduced. This potentially had detrimental effects throughout the food chain.

In June, the shearwaters were found to be eating their normal diet of adult euphausiids and exhibited normal body weights. As the summer progressed, however, massive die-offs of seabirds were observed. During late summer, both dead and living shearwaters had significantly reduced body mass when compared with birds collected during June. The diets of shearwaters in late summer were notably more diverse than in June with fish and squid being ingested. During late summer, birds ingesting euphausiids were preying upon juveniles, not adults. The juvenile euphausiids are much smaller than adults, and are likely to have a lower energy density. These observations suggested that starvation was the prime cause of the shearwater die-off. Additionally, foraging shearwaters appeared

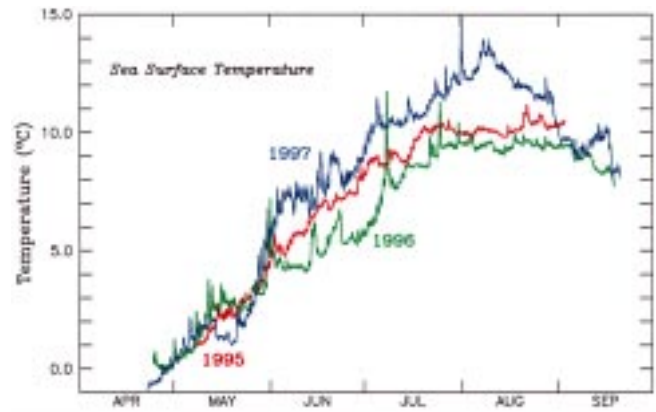


Fig. 3 Time series of sea surface temperature at Site 2 during spring and summer 1995, 1996 and 1997



Fig. 4 SeaWiFS composite true color image (Sept. 18–25, 1997) showing the extent of the aquamarine water indicating a coccolithophorid bloom (proved by SeaWiFS Project, NASA/Goddard Space Flight Center courtesy of Gene Feldman)

to avoid areas with aqua marine water, where they may have had difficulty in detecting and capturing euphausiid prey under the existing low underwater light conditions.

In addition to die-off of birds, the number of salmon returning to Bristol Bay was far below expected. This resulted in a catch of ~ 12 million sockeye, instead of the forecasted 25 million. Candidates for this decrease that are not related to conditions found in the Bering Sea this year exist, however, evidence from test fishing at Point Moller suggests that the fish are dying on their way to Bristol Bay, not earlier in their lives.

Just as water properties, particularly temperature,

were anomalous, the currents over the basin and shelf were unusual. Typically there is a moderate flow (5–10 cm s⁻¹) northwestward along the 100m isobath (*Figure 1*). This year, however, trajectories of satellite-tracked drifters revealed no net flow from May through August. In addition, stronger volume transports were observed in the Bering Slope Current (BSC) and the Aleutian North Slope Current (ANSC). The flow in the deep basin is cyclonic gyre, with a strong, steady ANSC flowing northeastward along the Aleutian Islands turning northwestward into BSC, an eastern boundary current (*Figure 1*). Typically transports in these flows range from 2–4x10⁶ m³ s⁻¹. This year, baroclinic transports from March through

July were greater than 6x10⁶ m³ s⁻¹. The transport through Amchitka Pass, the primary source of flow in the ANSC, was 5x10⁶ m³ s⁻¹, also larger than earlier measurements

The long-term effects of this summer on the Bering Sea ecosystem are not known and likely will remain a mystery until the year class strength of a variety of fish can be determined. The percentage of birds which died and the influence of this on the ecosystem is also unknown and must be evaluated. Hopefully, enough observations were made this year to elucidate the mechanisms that resulted in the coccolithophorid bloom and attended changes in the biota.

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-February south of Japan, implying that atmospheric CO₂ was being absorbed into the ocean (*Fig. 4a*). This is a typical feature of the carbon dioxide distribution in the western North Pacific in winter. On the other hand, CO₂ concentration in surface water was higher than that in the atmosphere in June-July south of Japan. In the seas east of Japan, CO₂ concentration in the sea surface water was much lower than that in the atmosphere in June-July. The CO₂ concentration difference was particularly large from 30°N to 45°N east of Japan, and the difference of 120 ppm observed at 43°N, 153°E in the June-July cruise was the largest difference observed since 1989 by Ryofu Maru in the western North Pacific (*Fig. 4b*). Similar pattern of the distribution of CO₂ difference in the seas east of Japan was observed during the Ryofu Maru cruise in April-June 1996 (PICES Press Vol.5 No.2).

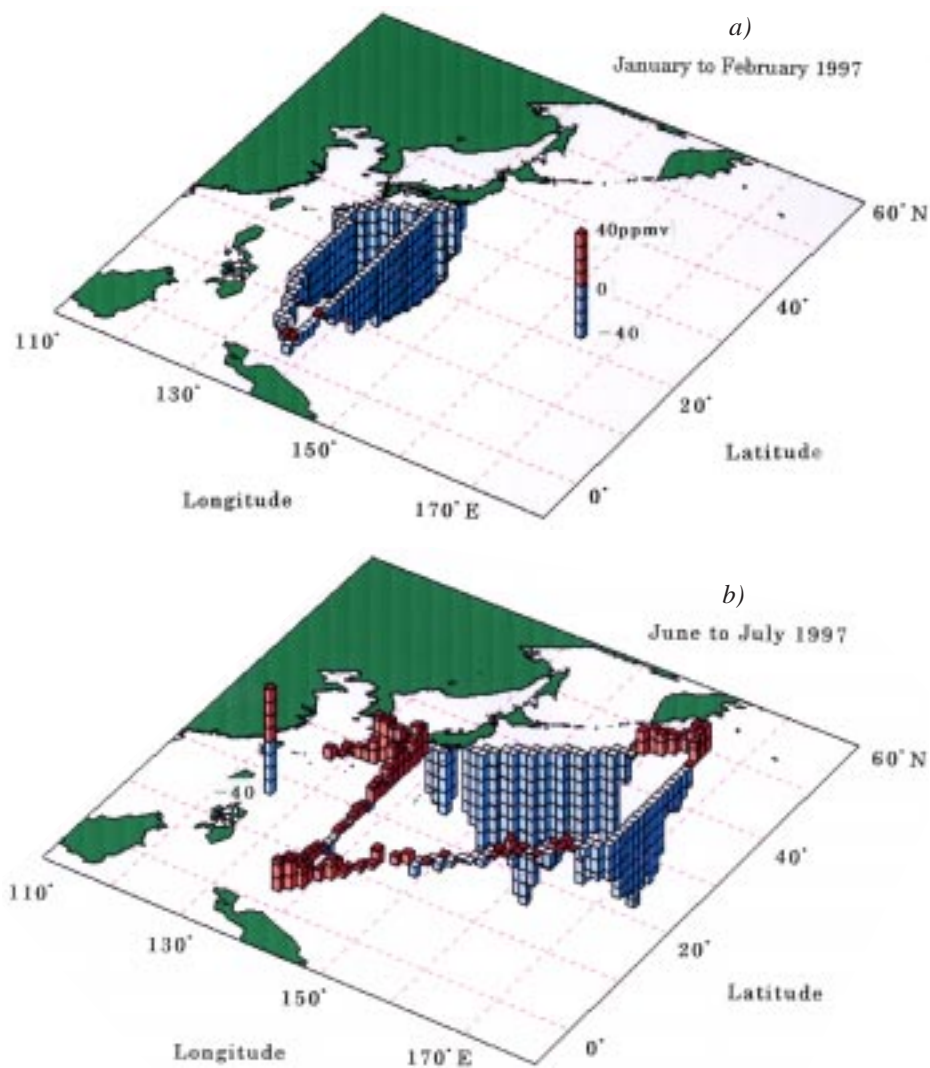


Fig 4. Difference in CO₂ concentration between sea surface water and air in January-February, 1997 (a) and June-July, 1997 (b). Red upward bars indicate that the ocean was emitting CO₂; blue downward bars indicate absorption of CO₂ by the ocean.

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Oceanography Committees); Processes of Contaminant Cycling (Marine Environmental Quality Committee); and Harmful Algal Blooms: Causes and Consequences (Biological Oceanography and Marine Environmental Quality Committees). Three of these sessions were joint sessions co-organized by various Scientific Committees. This is a natural reflection of the achievements of PICES as a multi-disciplinary international marine science forum.

The Best Presentation Awards, first introduced at PICES V to encourage speakers to make an effort to overcome language barriers by providing a clear presentation, were given to the following winners this year with congratulations; the FIS Award to Dr. Jin-Yeong Kim (Korea) for her paper entitled “Spawner-recruit relationship of anchovy, *engraulis japonica*, and environmental factors in the southern waters of Korea”; the POC Award to Dr. Young Jae Ro (Korea) for his paper entitled “Recent investigation of the polar fronts of the East Sea by CTD profiling and ADCP tracking”; the BIO Award to Dr. Atsushi Tsuda for his paper on “Life cycles of *Neocalanus flemingeri* and *N. plumchrus (calanoida, copepoda)* in the western Subarctic Pacific”; the MEQ Award to Dr. Dmitry L. Aminin (Russia) for his paper entitled “Use of fluorescent probes for biochemical monitoring of environmental contamination”; and the Science Board Award to Dr. Paul J. Harrison for his presentation on “Phytoplankton dynamics in the northeast Subarctic Pacific Ocean: bottom-up and top-down control”.

The CCCC Implementation Panel, recognizing that the Program is entering a new implementation phase, revised the statement of purpose for the Program, the terms of reference, and modified the structure of the Implementation Panel. Distinct new aspects of the Implementation Panel structure are a Task Team-based Executive Committee and the formation of a new MONITOR Task Team. The terms of reference of MONITOR include: suggesting improvements in the monitoring of the Subarctic Pacific by extending the activities of the disbanded WG 9 on Monitoring of Subarctic Pacific by addressing questions of standardization and intercalibration of measurements, particularly in the area of biological collections; assisting in development of a coordinated monitoring program to detect and describe events, such as the effects of El Niño in the Subarctic Pacific; and reporting on the PICES activities to be implemented in conjunction with the international Global Ocean Observing System (GOOS) Program.

Another important decision of PICES VI was the establishment of two new Working Groups: WG 13 on CO₂ in the North Pacific (POC) and WG 14 on Effective Sampling of Micronekton to Estimate Ecosystem Carrying Capacity (BIO). WG 13 is expected to propose a plan for cooperation with the North Pacific Task Team of the Joint Global Ocean Flux Study Program (JGOFS/NPTT). These Working Groups are expected to contribute in evaluating the relative importance of components missing in PICES activities. The existing Working Groups, WG 8 on Practical Assessment Methodology, WG 11 on Marine Mammal and Sea Birds and WG 12 on Crabs and Shrimps, will continue their activities.

The Communication Study Group, established at PICES V, recommended improvement in PICES communication to Science Board and was then disbanded. Recognizing the fact that the publication of good scientific papers is of critical importance to an organization like PICES, a new Publication Study Group was established to review the publication and translation policy, the desirability of establishing a peer reviewed publication series and a PICES editorial board, and other matters concerning PICES publications. Members of this Study Group are Drs. Warren Wooster (Chairman), William Doubleday, Makoto Kashiwai, and Paul LeBlond.

Any organization and its substructures need a medium and/or long-term strategic workplan, especially if chairmen have a definite term of office. Science Board decided to discuss and prepare a strategic workplan for the Scientific Committees and Science Board at the PICES VII. The chairmen of Science Board and three Scientific Committees (BIO, MEQ and POC) will be replaced at the end of the next Annual Meeting. They were instructed by Science Board to develop such plans by that time. The discussion of a strategic workplan will give committee members an opportunity to understand the views of the candidates in time of election.

Support provided by Mr. Seong-Ho Song (MOMAF), Prof. Chang-Ik Zhang (FIS Chairman), Dr. Jang-Uk Lee (NERDI), Mr. Won-Seok Yang, students and others helped PICES VI be a very enjoyable and successful meeting.

See you at PICES VII, Fairbanks, Alaska, in October 1998!

Makoto Kashiwai, PICES Science Board Chairman

Organization of fisheries, environmental and ocean science in Canada

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Dr. John Davis is the Regional Director of Science, Pacific Region, for Canada's Department of Fisheries and Oceans. He is responsible for biological, oceanographic, environmental, aquaculture and hydrographic programs run by the Department on the west coast of Canada and in the western Arctic. This work is delivered through three major research centers – the Institute of Ocean Sciences (Sidney, B.C.), the Pacific Biological Station (Nanaimo, B.C.) and the West Vancouver Laboratory. Since 1992 Dr. Davis has been Canadian delegate to PICES. He also serves as Chairman of the Asia Pacific Economic Cooperation (APEC) Working Group on Marine Resources Conservation, Co-chairman of the Canada-Japan Environmental Panel on the North Pacific and Canadian negotiator or delegate for bilateral and multi-lateral fisheries issues in the Pacific. Dr. Davis received his B.Sc. (1966) in biology from the University of Victoria, and M.Sc. (1969) and Ph.D. (1971) in zoology from the University of British Columbia

In Canada, under constitutional arrangements, responsibility for the sea coast and inland fisheries rests with the Federal Government, centered in Ottawa, Ontario, the nation's capital. In practice, most of the administrative responsibility for the inland freshwater fisheries of the country have been delegated to the Provinces who manage those resources on behalf of the federal government. Therefore, the federal government is responsible for management of the marine fisheries and also retains direct responsibility for anadromous species such as salmon which migrate from freshwater to the sea and return to freshwater rivers and lakes to reproduce.

Canadian legislation important to management of fisheries, habitats and the oceans includes the Fisheries Act, the Canada Oceans Act and other related legislation and regulations under the Acts to provide for an enforcement function. Both the Fisheries Act and the Canada Oceans Act are the responsibility of the Minister of Fisheries and Oceans. The Fisheries Act provides for the direct management and protection of fisheries with appropriate regulations and includes provisions to protect fish and fish habitat against damage and loss. A fish habitat policy of the Department provides for no net loss of productive fish habitat in the case of man-made developments. The Canada Oceans Act extends Canada's jurisdiction to the full 200 mile limit, describes the ocean science and Coast Guard

responsibilities of the Department and sets out an ocean strategy on behalf of the Minister of Fisheries and Oceans. Under this provision, the Minister is accountable for coordinating the responsibilities of other parties involved in the ocean, for provision of marine protected areas and for integrated coastal resource planning. The Oceans Act is somewhat unique, in that it provides for an ecosystem approach to ocean management.

The Department of Fisheries and Oceans, since its recent merger with the Canadian Coast Guard, is now one of Canada's larger federal departments with headquarters in Ottawa and a five regional divisions across the country- Pacific Region, Central and Arctic Region, Maritimes Region, Laurentian Region and Newfoundland Region. The Department has approximately 12,000 staff, mostly located in decentralized regional locations where services are needed, and a budget in excess of \$CDN 1.0 billion. Functions of the Department include conservation, protection and management of fisheries resources and their habitats, science, hydrography, provision of vessel harbor support to the fishing industry, navigational aides and vessel traffic control, search and rescue and maritime safety, pollution response to marine spills, and a variety of related programs. In Canada, the Department of Environment, another federal department, also has a major role to play in the setting of environmental standards and guidelines

and regulation of industrial and other forms of pollution.

In Canada provincial governments also have responsibilities for natural resource management and environmental protection through their delegated responsibilities as described above but also due to their regulatory powers over industry and commerce in their respective jurisdictions. Thus the provinces have regulations with respect to pollution control, aquaculture licensing, water and land use activities, and the shoreline and shoreline resources.

With respect to fisheries, habitat and ocean science in Canada, many of the universities have major programs in these areas, particularly those in coastal provinces. Technical institutions and colleges offer courses in applied environmental and resource management and some also provide training in aquaculture techniques. The Department of Fisheries and Oceans has the largest scientific infrastructure in the country with major laboratories in all of its regions. These laboratories have significant programs in fish and invertebrate stock assessment in support of the management function, habitat and environmental science including contaminants studies, aquaculture and resource enhancement science, ocean science and hydrography, including the production of navigational charts and tide and current study and prediction. Provincial governments have wildlife resource management expertise and the federal departments of Environment and Natural Resources have expertise in environmental science and geoscience respectively, the latter including undersea geoscience.

Research expenditures in Canada on fisheries, habitat and ocean related work are largely by the federal government through the programs of departments such as Fisheries and Oceans, Environment, and to a smaller extent, Natural Resources. Much of the spending supports the programs conducted directly by the departments themselves through their own research institutions and projects, and through support of infrastructure such as laboratories and vessels. From time to time, special federal programs become available, such as the Program on Energy Research and Development (PERD) which provides special funding for directed research which meets the objectives of the PERD Program.

The National Research Council of Canada and a system of grants administered by the federal government also supports research in the country, much of it through applications for research grant funding submitted by university faculty members for

direct research grant support or for infrastructure grants to equip and operate facilities. In British Columbia, the five western Canadian universities operate a marine station, the Bamfield Marine Station, on a cooperative basis with a combination of university funding support and federal grants. The provincial governments also support some aspects of research and development, particularly applied research. For example in British Columbia, the Provincial Government has provided considerable support for research and development expenditures related to the aquaculture industry, and is currently developing a new program for fisheries-related expenditures to address problems in the industry affecting coastal communities and habitat restoration.

The Canadian private sector is strong in a number of aspects of marine science and engineering and in many cases, is a world leader in certain types of technology. Canada has strength in submersible design and construction, innovative manned, remote and autonomous undersea vehicles, propulsion systems, diving equipment, acoustics, remote sensing technologies, survey and hydrographic systems, fuel cells and battery designs, deep sea mooring technology, ocean buoy technology, satellite and space equipment with relevance to marine applications, electronic charts and navigation systems, vessel traffic control systems, specialty solvents, contaminant ultra-trace analysis, and environmental consulting and marine engineering services. In addition, the biotechnology industry is well developed in Canada and has a number of innovative technologies for ocean-related applications. Programs are available through federal sources such as Western Economic Diversification to support R&D development involving private sector companies and partnership building is encouraged through those funding programs.

Several new developments in British Columbia are of potential interest to the PICES community as possible opportunities for partnership development or networking in the Asia-Pacific region. First, the Federal Department of Fisheries and Oceans, Pacific Region, is actively developing a new way of operating a marine laboratory, the Pacific Institute for Aquatic Biosciences (PIAB) located in West Vancouver, B.C., in partnership with the private sector, university and other partners, including international partners, such as Pukyong National University in Pusan, Korea. This laboratory, which

(cont. on page 19)

Richard James Beamish



Dick Beamish is a major international figure in fisheries science. The vitality he brings to an organization and energy he devotes to ensuring its success is boundless. Many organizations have benefited from his participation. His contributions to PICES are known to us all, but he has worked with and influenced the direction of many international organizations, including the International North Pacific Fisheries Commission (INPFC), the North Pacific Anadromous Fisheries Commission (NPAFC), and the International Pacific Halibut Commission (IPHC) to name a few. To describe Dick in a capsule form one can call him an intellectual maverick. It is his propensity for independent thinking and his readiness to question and challenge the established “authorities” that has catapulted him from the files of pedestrian researchers into the unique position he now occupies in the world of fisheries research. He displayed his capacity for original thinking early as a postgraduate student, when he became one of the first pioneers who discovered and studied the phenomenon of acid rain.

After completing his PhD in Zoology at the University of Toronto (1969), Dick headed to Woods Hole Oceanographic Institute as a postdoctoral fellow. He conducted investigations on myctophids and other mesopelagic fishes of the Atlantic, then as now, a little-studied component of the ocean ecosystem. While there he was a part of the scientific team aboard the C.S.S. Hudson, the first vessel to circumnavigate the America’s, and participated in deep-diving submarine experiments aboard the DSV Alvin. It was during these cruises that Dick developed his love of the ocean and his belief that “to understand how it worked you had to go out and study it”.

In 1971, Dick accepted a position as Research Scientist with the Canadian Department of the Environment at the brand new Freshwater Institute in Winnipeg (a city he still considers his second home). Over the next few years he investigated the effects of various pollutants from point-source emissions (mines) on fish populations in the natural environment. At this time he completed his work on “Acid Rain”, started in his last year at the University of Toronto. In 1972, he co-authored the initial scientific observations linking acidification of Canadian lakes to decreasing fish populations. This research set the stage for the general recognition of this major pollution problem and promoted international co-operation and research in this field.

While in Winnipeg he came to the attention of Dr. W. (Wally) Johnson, Director of the Freshwater Institute and, when Dr. Johnson accepted the position of Director of the Pacific Biological Station, he soon recruited Dick to the west coast. Placed in the ranks of the Groundfish Program scientists, Dick almost immediately became recognized for the originality of his approach to the field, no less than for his capacity for ruffling feathers of the more orthodox practitioners of the subject. It was obvious that he did not fit the role imposed on him by his “job description”. After a less-than-decent interval of time, he was asked to take over the leadership of the program. Characteristically, Dick balked at the proposal at first, protesting that he was not ready to become a supervisor. His reluctance overcome, he took over the Program and in no time at all made of it a unit all to itself, run by him like that other famous seafarer - Captain Bligh - in the best possible sense. The Program was welded into a team with many features that distinguish a family. The team spirit extended beyond the official duties of its members. The “groundfishers” had their own common bank account, which they used to finance their social activities. The climax of these activities was an annual yachting excursion during which Dick was ceremoniously tossed over the side - fully clothed. It became obvious that he was able not only to demand a lot from his subordinates but also to command their respect and slightly amused affection.

In Nanaimo, Dick continued his rigorous research activities, initially studying the biology of fishes in the Strait of Georgia, and groundfish biology and stock assessment of west coast stocks. In particular, his contributions to age determination methodology,



Checking the catch (early 70's)



First day on the job as Director, PBS (1980)

validation of techniques and sources of bias are fundamental to our concept of fish life histories and population dynamics. This work led to the re-evaluation of fisheries management strategies both in North America and abroad. At this time Dick developed an interest in lampreys and, through his interest in systematics, has significantly advanced the understanding of the evolution of primitive fishes.

While continuing his own research, the time had come for Dick to take a more active role in the activities of others. In 1980 he was appointed Director of the Pacific Biological Station. Over the next 12 years (except for a 6-month stint as a Director General in Ottawa) Dick provided dynamic scientific leadership. He initiated new programs, which now enjoy an international reputation for excellence, and increased the scientific productivity of the Station. He increased scientific services provided to the management sector and to industry and stimulated attention to developments for the future, including aquaculture and bioengineering projects. He was especially effective in fostering links with universities and colleges, throughout British Columbia and elsewhere in Canada.

During his years as Director his skills as an administrator were surpassed only by his skill at getting the most out of people. During those years it was not unusual to find staff at the Station evenings and weekends, working on some special "Beamish" project. All for free of course. As most in PICES know, he has brought these same skills to this organization.

Although Dick has been involved in international activities for most of his career through INPFC, the Canada-U.S. Groundfish Committee, and other organizations, it was in the mid-1980's that he increased his efforts to stimulate international co-operation. This he has done in the Pacific Rim. In 1985, he initiated and became the chairman of the International Recruitment Investigation in the Sub-Arctic (IRIS) project. This initiative eventually led to an international symposium in 1988 on the effects of ocean variability on recruitment, which was co-sponsored by INPFC.

In 1990, Dick was appointed as a Commissioner of the International Pacific Halibut Commission. This was one of the first times a scientist has been asked to fill this role. Dick carried the same skills he shows in science into the activities of meeting with fishermen, managers, and the Commission staff. He encouraged the Commission staff to broaden its consideration of environmental events as driving forces in halibut population dynamics. Because of his concerns for careful stewardship of the halibut resource, Dick has acted to reduce bycatch mortality of halibut in non-directed fisheries in both the U.S. and Canada. Dick's relationship with the halibut industry has grown over his years as a Commissioner. Industry respects his commitment to resource management and his scientific initiatives concerning halibut. Beyond that, harvesters and processors have come to realize that Dick is approachable and responsive to their concerns. His appointment to a third term as a Commissioner clearly emphasizes the wide recognition of his skills in this international arena.



Dick in charge – executive meeting (1986)



Helicopter ride to Kuril Lake (Kamchatka) with Dr. W.E. Ricker (1992)



With Drs. Leo Margolis (centre) and Don Noakes (left) on board the research ship W. E. Ricker (1996)

He was also instrumental in the formative meetings leading to the development of a North Pacific Marine

Science Organization, which became known as PICES. Since its inception Dick has been an active member of PICES, striving to ensure that the multidisciplinary goals of this organization are reached. The first formal meeting of PICES was held in conjunction with a symposium that Dick organized on climate change and northern fish populations. He has promoted the fisheries component of PICES through his membership on the Fisheries Science (FIS) committee and has worked to ensure close ties between member nations in the study of fish and fisheries related issues. Most recently, as co-chairman of Basin Studies Task Team (BASS) of the PICES-GLOBEC Climate Change and Carrying Capacity Program (CCCC), he is leading discussions on all aspects of meteorological and physical forcing and the resulting ecosystem dynamics of the important “basins” in the North Pacific. He took a lead role in organizing the Science Board Symposium (PICES 1997 meeting) on “Ecosystem Dynamics in the Eastern and Western Gyres of the Subarctic Pacific”, and was willing to return to his post-doc interests in myctophid fishes when unable to find anyone else to speak on the topic. This symposium brought together, for the first time, experts in many disciplines to examine available information on the dynamics of these two gyres specifically to examine differences in responses of these two areas. The resulting proceedings will become the textbook for future studies.

In addition to his work within international organizations, Dick has promoted trans-Pacific understanding by means of personal contacts between research workers. He has organized several meetings in Canada, and over the years has led several “groups” to Japan and Russia. Most notably, he organized and led several scientists and industry representatives on the first fisheries “expedition” to Vladivostok and Petropavlovsk-Kamchatki, after those ports were opened to Westerners.

Dick is just as active at regional and local levels. He is a member of the Georgia Basin Marine Science Panel and co-author of their report “The Shared Marine Waters of British Columbia and Washington”, which reviewed the current conditions of, and trends in, the marine waters of the Strait of Georgia, Strait of Juan de Fuca, and Puget Sound. This report identified areas that required immediate and joint action and provided recommendations, which will form the basis for



PICES Sixth Annual Meeting (1997)



With Sandy McFarlane looking for “research funds” in Vladivostok (1995)



Holidays with daughter Heather – electrofishing for lamprey (1984)

development of this sensitive area. He is chairman of the B.C./Washington panel on protection of marine

animals and plants in the shared waters of the Georgia Basin. He co-authored “Shared Waters: the Vulnerable Inland Sea of British Columbia and Washington” which provides recommendations to both governments on actions to halt or reduce the deterioration of these waters. He is an Affiliate Professor in Fisheries and Aquaculture at Malaspina University College (University of Victoria) and teaches a course on Fisheries Management which has become one of the most popular with students over the last few years. He is a member of the Board of the Morrell Sanctuary where goals are to preserve the unique ecosystems of this site for the enjoyment and education of the public.

He is founder and president of the Fisheries Science Documentary Society, which produces videos portraying biographies of some better known researchers in various aspects of fisheries science. He was executive producer for an award winning video on the life of one of Canada’s more famous fisheries scientist, Dr. W. E. (Bill) Ricker. This was especially gratifying, as Dr. Ricker has been both friend and mentor to Dick since they met in the early 1970’s. Bill and Dick share the same passion for science. One recent December 31st, Bill remarked to Dick that it was the last day of the year to discover “something new”. Dick shares the same enthusiasm for scientific discovery and this has been a trademark of his career.

Through all this he has maintained his strong record of research activity. His papers ranged from biochemical and cytological studies of marine and freshwater fishes to acidification of freshwater lakes and resulting effects on fish populations. He has published on fishing gear design and the systematics and evolution of lamprey. His papers on age determination methodology and biology of marine fishes led to major changes throughout the world on how we study, and manage fish populations. For the last decade, his major interest has been the relationship between climate, ocean productivity and fish dynamics. He has published numerous papers linking climate change to salmon and marine fish production. Currently he is studying the mechanisms underlying this relationship. In all he has published more than 150 peer-reviewed scientific papers. He has also served as editor of two books on climate change and fish populations. Quite some achievements, especially considering he started out his university career in



In the garden (1995)

medicine. Luckily, a few summers at St. Andrews Biological Station working on Atlantic fishes changed his direction. Some of us wonder what he might have accomplished had he chosen a career in medical research.

Although it doesn't seem possible, Dick does have moments of leisure. In true fashion he fills them. He is an avid gardener and he spends hours (or his wife Ann does) tending his 100's of Rhododendrons, Dahlias and just about every other plant or tree which fill his property in Nanaimo. His knowledge on rhododendrons is renowned and even professional gardeners seek his advice. He is a gourmet chef (long-time member of *Chine de rotisseur*), and chocolate maker, which he makes for every occasion. He collects stamps, specializing in Canadian and Japanese; and art. He is a member of the Nanaimo Hornets "over-forty" rugby team and enjoys travelling with the team to tournaments to have various bones broken; most recently during a tour of Japan (April 97). Fortunately for fisheries science, Dick's energy is unabated and we can look forward to many more years of leadership both at the international level and as part of research teams "going out to see how it works".



This paper is written by Dr. Gordon McFarlane in appreciation and recognition of Dr. Richard Beamish's outstanding service to fishery science and PICES over many years.

Gordon (Sandy) McFarlane is head of the Marine Fish Population Dynamics Section at the Pacific Biological Station, Nanaimo. He has been a member and advisor to many International commissions (INPFC, PICES, Canada/U.S. Groundfish Committee) and participated in several international research programs. His personal research centers on determining and refining biological parameters used in stock assessments; examining climatic and oceanographic factors influencing the dynamics of marine fish, and the physical, biological and fisheries oceanographic linkages of large marine ecosystems. Dick and Sandy have collaborated on numerous projects over the last 3 decades.

(cont. from page 14)

offers excellent water systems and live holding facilities as well as top quality research space and equipment, will be a center for collaborative work among the partners with those involved sharing the operating costs for the facility. Also affiliated with PIAB are two other initiatives, COFRI- Canada's Offshore Frontiers Initiative and ORNEP, a concept of an ocean science network linking Pacific Rim research centers. COFRI is a partnership between private sector, university and government ocean research interests on Canada's West Coast and seeks to develop innovative programs in ocean science through partnerships with the backing of loan funding from the Government of Canada. Further information

on any of these initiatives can be obtained from the author.

From the perspective of PICES and development of collaboration with the PICES community, from the above, it is clear that opportunities to work with Canadian scientists can be found by developing contracts with federal organizations, private sector companies or university faculty members engaged in fisheries, habitat or ocean science and ocean engineering or biotechnology. Those contracts provide the necessary connection into the Canadian marine science community and the funding and laboratory infrastructure that is present in Canada.

Highlights of the Six



Governing Council meeting: M. Kashiwai, W.S. Wooster, Q.F. Liu, A. Bychkov, H.D. Guo, Y. Li, S. Matsumura, K. Hagino, W.D. McKone, W.G. Doubleday, J.W. Balsiger, V. Alexander, M. Wildman, L.N. Bocharov, H.T. Huh, S.H. Song, C.I. Zhang, I. Shevchenko



Mr. Jung-Jay Joh, Minister of Maritime Affairs and Fisheries, giving the welcoming address at the Opening Session



Opening Ceremony



Front row: Drs. K.J. Ahn, S. Matsumura, W.D. McKone, W.G. Doubleday; Drs. C.I. Zhang and H.T. Huh behind Drs. McKone and Doubleday, at the Opening Session



Russian scientists, Drs. Y.I. Zuenko, A.K. Tkalin, Mrs. Tkalin, Drs. M.A. Danchenkov and L. Gramm-Osipov at the Welcoming Reception



Korean dance performance at the Opening Dinner



Drs. K. Nagasawa, M. Terazaki, Y. Nagata and W.S. Wooster at the Implementation Panel meeting



Discussion at the Science Board CCCC/BASS Symposium

10th Annual Meeting



Dr. A. Bychkov desperately looking for his Secretariat colleagues at the Pusan airport



Student volunteers help prepare registration packages



PICES meets CREAMS: Drs. M. Takematsu, K. Kim and M. Kashiwai, after Dr. Kim's keynote lecture at Opening Session



Session convenors and chairmen of PICES committees and groups: Drs. M. Kishi, Y. Nagata, R.D. Brodeur, P. Livingston, R.J. Beamish, M. Kashiwai, M. Terazaki and B.A. Taft



Secretariat staff with Grand Hotel contact person Mr. B.G. Kim and Local Organizing Committee Chairman Mr. S.H. Song and assistant Ms. H.W. Kwon



Dr. M.A. Danchenkov compares fish size with Secretariat's Ms. C. McAlister at a Pusan fishmarket



MEQ vs. WG 8 noodle eating contest



Dr. J.Y. Kim of Korea received the Best Presentation Award from FIS Committee Chairman Dr. C.I. Zhang at the Closing Session



PICES-GLOBEC Climate Change and Carrying Capacity Program



The PICES-GLOBEC Climate Change and Carrying Capacity Program (co-chairmen: Yutaka Nagata and Patricia Livingston) is on the verge of entering a new phase in the program, a phase where we are moving away from planning and beginning to undertake cooperative research activities. All our Task Teams (BASS, MODEL, and REX) have held workshops or symposia to outline the current state of knowledge in their area of interest and to identify areas for cooperative research experiments in support of the CCCC Program. The cooperative projects that have been identified are in various stages of implementation and we have a new task team, MONITOR, formed at the last annual meeting that will be just beginning to define its program of work in the coming year. In this newsletter we hope to bring you up to date with the activities of the CCCC Program by giving you a historical perspective on how the program was formed and an idea of where we are headed. We will also report on the REX Workshop and the BASS Symposium held in conjunction with the PICES Sixth Annual Meeting in Pusan, Korea, and summarize task team plans for 1998.

A Historical Perspective on the CCCC Program

In a workshop held in Seattle in December 1991, the year before PICES was formally established, scientists agreed that an underlying scientific question of concern to the new organization was:

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?

Recognition of that focus was reflected in two working groups established in October 1992 by PICES in its first Annual Meeting. One, WG 3, was concerned with the dynamics of small pelagics in coastal ecosystems, the other, WG 6, on the subarctic gyre, was explicitly charged to determine the relationship between PICES interests and those of GLOBEC, the Global Ecosystem Dynamics Program under development by the Scientific Committee on Oceanic Research and other international

organizations. It was WG 6 that raised three questions that led to the development of the new PICES scientific program:

How do the various scales of physical variability affect biological processes and productivity of the subarctic North Pacific ecosystem?

What is the structure of the food web in subarctic waters and what controls its spatial, seasonal, and interannual variability?

What physical and biological oceanographic processes affect the production and carrying capacity of salmon and other nekton in the subarctic North Pacific?

The question of limitations to carrying capacity arose because of the decreasing size-at-age of returns in some salmon stocks suggesting that a finite carrying capacity was being exceeded. In light of this suggestion, a decision was reached at PICES II to organize a workshop to develop a PICES-GLOBEC program on Climate Change and Carrying Capacity (CCCC). Workshop participants were charged to:

- Develop a strategy for determining the carrying capacity of the subarctic Pacific for salmon and other high-trophic level, pelagic carnivores and its changes in response to climate variations;
- Develop a plan for a cooperative study of how changes in oceanic conditions affect the productivity of key fish species such as salmonids in the subarctic Pacific and clupeoids and scombrids in the coastal zones of the Pacific Rim.

The workshop was held in October 1994, just before PICES III, and was the culmination of an interactive process whereby a Science Plan, published in the report of PICES III, was developed. A committee structure was established by which an Implementation Plan was to be developed. That plan was adopted during PICES IV, in October 1995, and is published together with the Science Plan in PICES Scientific Report No. 4. Given that the ultimate goal of the CCCC Program is to forecast the consequences of climate variability on the ecosystems of the subarctic Pacific the following Central Scientific Issues or questions were identified in the Implementation Plan:

What are the characteristics of climate variability, can interdecadal patterns be identified, how and when do they arise?

How do primary and secondary producers respond in productivity, and in species and size composition, to climate variability in different ecosystems of the subarctic Pacific?

How do life history patterns, distributions, vital rates, and population dynamics of higher trophic level species respond directly and indirectly to climate variability?

How are subarctic Pacific ecosystems structured? Do higher trophic levels respond to climate variability solely as a consequence of bottom up forcing? Are there significant intra-trophic level and top down effects on lower trophic level production and on energy transfer efficiencies?

It was recognized that the comparative approach would be a key ingredient to the study of these Central Scientific Issues, particularly, comparative studies of the ecosystems along the continental margins of the subarctic Pacific and east/west comparisons of the subarctic gyres. The first two task teams of the program were formed to provide that key ingredient: REX, to consider regional experiments to compare findings of coastal GLOBEC and GLOBEC-like programs, and BASS, to consider development of comparative research studies in the open ocean subarctic gyres. Subsequently, two more task teams were established; MODEL, to consider modeling requirements; and most recently, at PICES VI, MONITOR to review monitoring requirements of the program. The Implementation Panel of the program (which consists of two co-chairmen, four task teams, and an executive committee) oversees and performs the work of the program. The CCC Program's goal is to integrate and stimulate national activities on the effects of climate variations on the marine ecosystems of the subarctic North Pacific through the oversight of its coordinated implementation plan. As can be seen from the recent activities of the task teams, we have many activities underway or planned for the near future designed to achieve this goal.

Recent Task Team Activities

MODEL Task Team (co-chairmen: Ian Perry and Sinjae Yoo) held a workshop in Nemuro, Japan, in June 1996, to review the roles and limitations of modeling for the CCC Program, propose the level of modeling required, and provide a plan for how to

promote these modeling activities. The results and recommendations of this workshop have previously been reported (PICES Press, vol. 4 No 2; PICES Scientific Report No. 7, 1997). Since the workshop, MODEL has been refining its role in the CCC Program and has developed the following approach. The task team recognized that many modeling activities are already taking place regarding North Pacific physics and biology. But what seems to be lacking is the awareness and communication among these activities, and the possible linkages among physical and biological modelers, and the awareness and communication with field programs. Therefore, the primary role of MODEL has been identified as:

- Facilitate communication among modeling studies, and with field programs;
- Identify and stimulate areas of modeling that are significant to the CCC Program but which are not presently addressed; and
- Assist field programs of CCC's (e.g. REX, BASS) with model-related needs.

MODEL has recently completed several activities related to these goals. In the past year, an opportunity to explore simple mass-balance models was presented and a topic session on "Models for Linking Climate and Fish" was convened at PICES VI. In addition, North Pacific circulation modelers were contacted to explore possibilities of making model results widely available to the PICES community. An inventory and description of these North Pacific circulation models have been prepared, which includes contacts for access to results. This information will soon be available on a page within the PICES web site or by request to the Secretariat. In 1998, it is planned that this web page will be expanded to include biological models and modeling activities in the PICES areas, to serve as an information exchange for North Pacific modeling activities. Another hoped-for addition to the web page is an inventory of important but often missing components of models, such as parameterization of vertical mixing and diffusion and representations of vertical migration by zooplankton.

MODEL will be convening a small workshop in 1998 to compare lower trophic level physiological models. The purpose of this workshop is to facilitate standardization or intercalibration of these process models in order to aid comparison of ecosystem responses. It is also hoped that a nutrient database will be assembled at this workshop for modeling new production in PICES regions.

REX (Regional EXperiment) Task Team (co-chairmen: Anne Hollowed, Vladimir Radchenko, and Tokio Wada) convened a workshop October 17-18, 1997, just prior to PICES VI in Pusan, Korea. The purpose of the workshop was to review the status of national research programs and to identify areas for cooperative research experiments in support of the CCCC Program. Over 50 scientists participated in the workshop, representing approximately 40 research institutions. The focus of the workshop was to examine the possibility of applying the comparative approach to address the Central Scientific Issues identified by the Program. The workshop began with a review of the GLOBEC and GLOBEC-like research programs planned or on-going in each of the six PICES member nations. Subsequently, participants discussed coastal research programs in breakout sessions targeting forcing, lower trophic level response, higher trophic level response, and ecosystem response. The higher trophic level response sessions were further divided into four major species groups: salmon, mid-water and demersal fish, pelagic fish, and crustaceans. In each breakout session, participants were asked to review the Central Scientific Issues that pertained to the focus of the particular breakout group and to develop specific hypotheses related to these issues. Participants were also asked to discuss existing or potential research approaches to test these hypotheses and to identify barriers to implementation. A complete summary of the workshop proceedings and all of its recommendations will be prepared and published later this year in the PICES Scientific Report Series. Workshop recommendations that the team has adopted for the near future include:

- PICES member nations should compile a catalogue of historical samples and data sets which are not yet analyzed or readily available;
- Issues of standardization of sampling and analysis methods for comparative studies should be addressed;
- A two-day symposium and workshop on climate effects on small pelagic species should be convened prior to the PICES Seventh Annual Meeting in Fairbanks, Alaska; and
- A scientific session that highlights research findings of GLOBEC and GLOBEC-like programs in the North Pacific should be convened as part of the PICES Seventh Annual Meeting.

The first recommendation is a facet of the Planning and Data Assimilation Phase of the CCCC's

Implementation Plan wherein compiling a complete set of historic data for some species may need to be completed before a comparative study can begin. The second recommendation with regard to standardization or intercalibration of sampling is also an important requisite to performing certain comparative studies and the new MONITOR task team will be addressing this issue as part of its terms of reference. The last two recommendations are actions that reflect the increasing maturity, not only of the CCCC Program but also the national GLOBEC and GLOBEC-like programs operating in the regions of the North Pacific. Now that the national GLOBEC and GLOBEC-like programs have been operating for a while, researchers in these programs are ready to present some of their findings. Providing a forum for these researchers to discuss and compare research findings is a very important piece of the CCCC Program and an indication that we are entering the second phase of our Implementation Plan where observing, process studies, and modeling are being performed.

The two-day workshop and symposium on small pelagic species to be held just prior to PICES VII marks the beginning of what may become an ongoing comparative research project of the CCCC Program. It builds on the scope of the GLOBEC International Small Pelagic Fishes and Climate Change (SPACC) group, which is examining retrospective and process studies for sardines and anchovies, by including herrings, mackerels, squids, and others in its study objectives. Small pelagics are an ideal group for comparative ecosystem studies because of their wide distribution in the Pacific Rim, large fluctuations in abundance and habitat, short plankton-based food chains, and possible teleconnections between different ecosystems. Holding the workshop / symposium in cooperation with GLOBEC-SPACC forges a new link between the PICES CCCC Program and GLOBEC International, which sponsors SPACC

BASS (Basin Scale Studies) Task Team (co-chairmen: Dick Beamish, Makoto Terazaki) took a large step forward this year to meet the challenge of identifying comparative research projects in the North Pacific subarctic gyres. In order to develop plans for intensifying research in the subarctic gyres of the northern North Pacific, BASS considered it desirable to review present scientific knowledge of these features, with particular attention being given to comparisons of the eastern and western sides of the ocean basin. For this purpose, a symposium was

organized for PICES VI in Pusan on “Ecosystem dynamics in the eastern and western gyres of the subarctic Pacific.” Nine invited papers were scheduled, to start with climate and oceanic forcing of these systems and to include the several trophic levels from phytoplankton and nutrient dynamics to marine birds and mammals. Conveners were R. Beamish (Canada), M. Terazaki (Japan), S. Kim (Korea), and W. S. Wooster (USA). The presentations were followed by a discussion session in which speakers set forth their views on desirable future research. There were several recommendations on modeling and physical oceanographic research that involved mixed layer dynamics. Particularly, the importance of more small scale examination of the mixed layer, models which consider day-to-day variability in the mixed layer, and information on regional, seasonal, and interannual variation in mixed layer depth were cited as important research issues. Ocean chemistry and primary production research speakers emphasized the importance of understanding the role of iron in influencing productivity and of understanding mechanisms of nutrient transport into the area. There were a number of research recommendations involving zooplankton but one that has the most potential for comparative study was the suggestion of expanding the comparisons between eastern and western gyres to include zooplankton species composition, seasonal timing and study of life history strategies. Monitoring zooplankton species composition and examining macrocrustacea with single annual breeding seasons were also suggested areas of research. Areas that needed further study with regard to upper trophic level animals, including fish, seabirds and marine mammals, included obtaining seasonal distribution and abundance of fish inhabiting surface waters, standardization (or intercalibration) of methods for studying and sampling midwater fish, and updating data bases of seabird distribution in the North Pacific.

The BASS Task Team will be considering these research recommendations this year and deciding how they can be implemented in the near future. A discussion paper will be prepared by the symposium organizers and will be the basis for the development of a long-term work plan for BASS. Some of the

recommendations are already being implemented, such as the methods for studying and sampling midwater fish, which will be addressed by a new PICES Working Group 14 on “Effective Sampling of Micronekton to Estimate Ecosystem Carrying Capacity.” Also, some of the issues on modeling lower trophic level dynamics that were brought up at the symposium will be partly addressed by the upcoming MODEL workshop this spring.

BASS Task team also initiated some activities regarding study of the 1997/1998 El Niño. They proposed a symposium to be held in 1998 at PICES VII in Fairbanks, Alaska, to provide opportunities for researchers to present initial research findings of impacts from this event. After this preliminary opportunity to present research, it is hoped that there will be another symposium to be held sometime in 1999, to provide opportunities for more complete reporting of impacts.

The formation of a new MONITOR Task Team was approved at PICES VI in Pusan, Korea. The terms of reference for the new task team are:

- Review existing activities of PICES member nations and to suggest improvements in the monitoring of the Subarctic Pacific to further the goals of the CCCC Program.
- Consult with REX, BASS and MODEL Task Teams and TCODE on the scientific basis for designing the PICES monitoring system. Questions of standardization and intercalibration of measurements, particularly in the area of biological collections, should be addressed.
- Assist in the development of a coordinated monitoring program to detect and describe events, such as El Niño, that strongly affect the Subarctic.
- Report to CCCC IP/EC on the monitoring in the Subarctic to be implemented in the international Global Ocean Observing System (GOOS) or other related activities.

The co-chairmen of MONITOR will be Drs. Yasunori Sakurai and Bruce Taft. The rest of the Task Team members will be selected early this year and plans for implementing their terms of reference will begin.

Summarized by Pat Livingston (Alaska Fisheries Science Center, NOAA/National Marine Fisheries Service, 7600 Sand Point Way NE, Seattle, WA 98115, USA, e-mail: Pat.Livingston@noaa.gov) from contributions by: Dick Beamish, John Davis, Anne Hollowed, Pat Livingston, Yutaka Nagata, Ian Perry, Vladimir Radchenko, Makoto Terazaki, Tokio Wada, Warren Wooster and Sinjae Yoo)

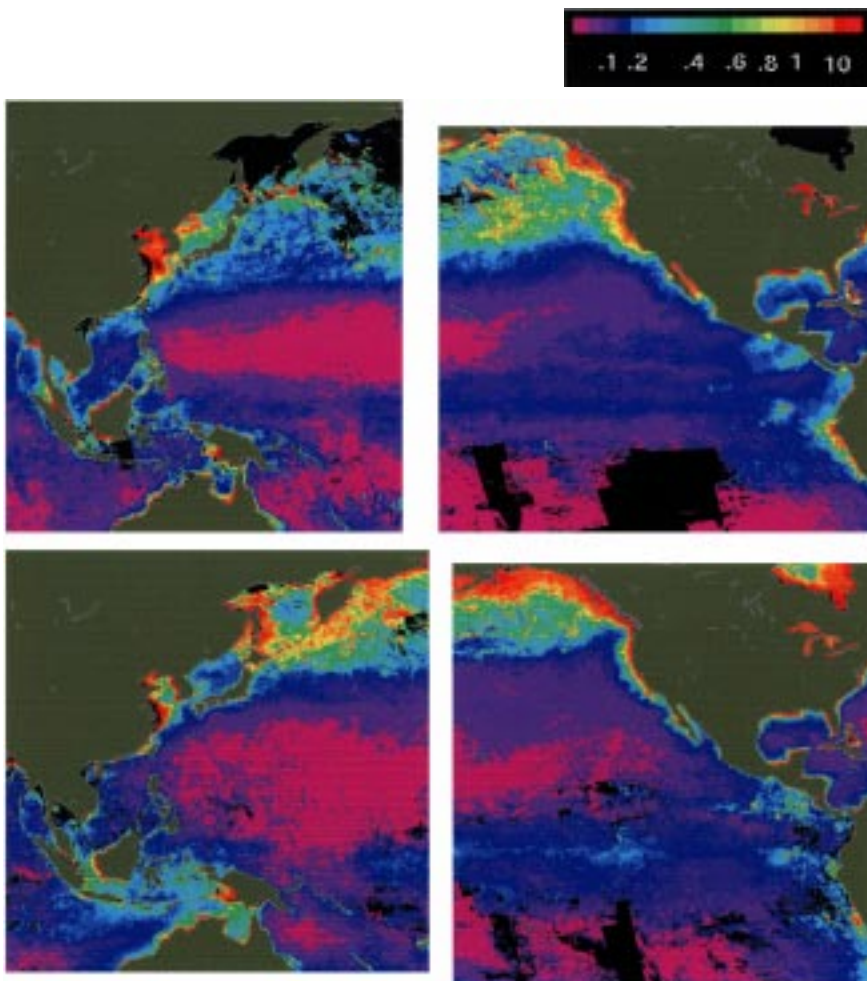
Epipelagic fish production in the open Subarctic Pacific: bottom up or self-regulating control?

R. Ian Perry, David W. Welch, Paul J. Harrison, David L. Mackas, and Kenneth L. Denman

We discuss the processes regulating the production of epipelagic fishes in the northern North Pacific, especially (but not limited to) salmonids, and whether this regulation is likely to be exerted predominately by plankton production processes or self-regulated by the influence of fish on their prey. This question is at the core of the PICES CCCC program, i.e. *Carrying Capacity* and *Climate Change*.

How is the carrying capacity regulated - by physical and resulting food-web processes (“bottom-up”), or by the effects of variable fish abundance and predation on their prey? If it is from the bottom-up, then one would expect direct linkages with climate variability. If it is regulated by fish abundance (in effect “top-down” control, or perhaps better described as “self-regulating” control), linkages with climate variability may be less direct and anthropogenic effects, e.g. fishing, changes to habitat and rearing conditions, etc., may be more important.

Fig. 1. CZCS satellite images of North Pacific chlorophyll climatology (1978-1986): Winter (top panel), Summer (bottom panel). Chlorophyll colour bar to the right (mg/m^3). Images courtesy of Gene Feldman (NASA).



“Bottom-up” Control

Studies of plankton in the North Pacific suggest that production processes may differ between the western and eastern regions, but that the temporal trends have generally been similar from the 1950’s at least to the late 1980’s. Winter chlorophyll is a particularly good indicator of these regional differences, being low in the western North Pacific and higher in the eastern side, especially in the southern Subarctic and Transition zones (Fig. 1). Phytoplankton in the western Subarctic Pacific (in particular the Oyashio Current region) have “traditional” spring bloom dynamics (e.g. Kasai *et al.* 1997) leading to the typical large phytoplankton - macrozooplankton - fish food web. In the early 1980s, phytoplankton biomass in the eastern Subarctic Pacific was considered to be kept low and constant year-round by a shallow mixed layer (in winter) and macrozooplankton grazing in spring, summer and fall (e.g. Parsons and Lalli 1988). The rapid increase in spring grazing pressure by macrozooplankton necessary to prevent a spring phytoplankton bloom was believed to be related in part to large calanoid copepods, whose arrival in surface waters after overwintering at depth was timed to take advantage of the spring increase in primary production.

However, recent studies at Station P in the eastern North Pacific by Project SUPER and the Canadian JGOFS and GLOBEC programs (Booth 1988; Booth *et al.* 1988;

Miller 1993; Boyd *et al.* 1995a,b) have determined that small phytoplankton (<5 μm) are the largest contributor to phytoplankton biomass in the eastern Subarctic region. One regulator of the biomass of this small phytoplankton is microzooplankton, whose grazing rates appear directly coupled to phytoplankton growth rates thereby preventing phytoplankton blooms. The microzooplankton are eaten by macrozooplankton, which are then eaten by fish; however, the abundance of the dominant macrozooplankton (large calanoid copepods such as *Neocalanus* spp.) varies seasonally due to the existence of a deep overwintering phase, which reduces grazing pressure on the microzooplankton during winter. Therefore, the view of phytoplankton biomass variations at Station P (representing the eastern Subarctic Pacific) must be modified to involve small phytoplankton and microzooplankton, as well as macrozooplankton and fish, thereby lengthening the food web and reducing its potential productive capacity for fish. The negative effects of this longer food web may be offset by the recent recognition that primary production in the eastern Subarctic Pacific may have been underestimated by 50% possibly due to the employment of trace metal clean techniques to measure primary productivity (Wong *et al.* 1995).

Concurrent with recognition of the importance of small phytoplankton and microzooplankton has been the recognition of the role of iron in stimulating the production of large phytoplankton such as diatoms in the eastern Subarctic Pacific (e.g. Martin *et al.* 1989; Boyd *et al.* 1996). Large diatoms have higher iron requirements than small phytoplankton (Muggli *et al.* 1996, Muggli and Harrison 1996). Consequently, the growth of large phytoplankton is iron-limited (except for winter), whereas small phytoplankton are not iron-limited and are growing at their maximum rates. However, their biomass is controlled by microzooplankton and hence nitrate is not completely consumed as one would expect in the spring and summer. Therefore, increases in large phytoplankton at Station P may be induced by inputs of iron; possible sources for iron include atmospheric transport and deposition (Duce and Tindale 1991), and vertical and horizontal advection. In addition, modeling studies are showing that both sinking of particulate matter out of the photic zone and input of iron into the photic zone are necessary to reproduce the annual phytoplankton and nutrient cycles (Fig. 2).

Plankton production in the eastern Subarctic Pacific therefore appears to be controlled by some combination

of iron limitation and grazing. Micro zooplankton biomass appears to be regulated by the growth rate of small-celled phytoplankton and the water temperature

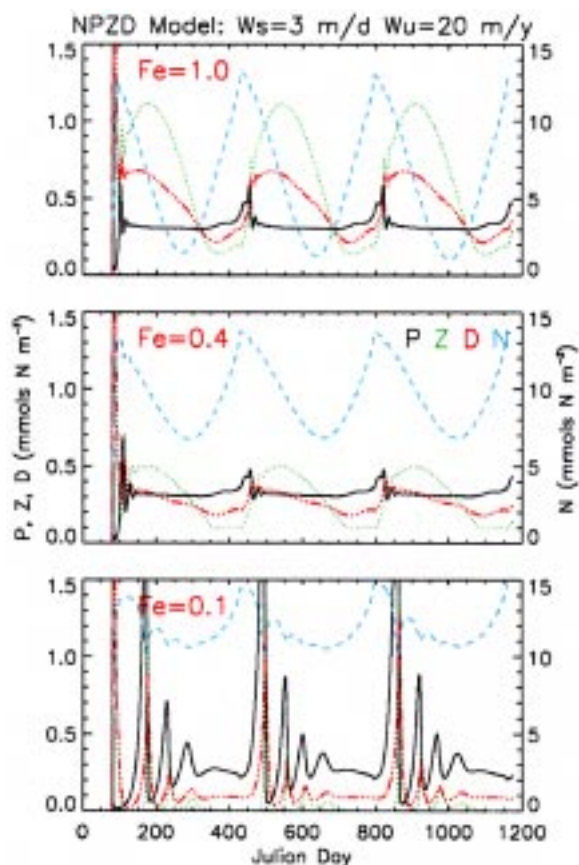


Fig. 2 Upper mixed layer time series (3 years) from a coupled ecosystem (Nitrogen-Phytoplankton-Zooplankton-Detritus)/mixed layer model for the eastern subarctic Pacific. In all three panels the detrital particles are sinking with a speed of 3 m/day and ‘remineralizing’ (redissolving back to the nutrient pool) with a time scale of 10 days. The nitrogen lost as sinking particles that exit the model (at 120m depth) is replenished by Ekman upwelling of 20 m/year at the bottom of the model. In the top panel there is no iron limitation and the summer mixed layer nitrate (dashed blue line) drops to nearly 1 mmol N m⁻³, far below the value of about 7 to 8 observed at Station Papa. In the middle panel, low iron limits primary production to 0.4 of its maximum value, even in full sunlight - yielding a realistic annual cycle in nitrate. In the bottom panel, low iron limits primary production to 0.1 of its maximum rate - the summer nitrate concentration is too high, and the phytoplankton biomass (solid black line) undergoes wild oscillations (unlike at Station Papa), probably because iron limits primary production even in winter, causing zooplankton (dotted green line) to drop so low in winter that they cannot graze down the spring bloom of phytoplankton as it develops. (Figure from Denman and Peña 1998)

in winter, and by the increasing biomass of macrozooplankton (their predators) in spring and summer. However, the mixed layer at Station P (and by inference over much of the NE Pacific) has been shallowing with a trend of about 60 m per century, but also with large multi-year variations about this trend (Freeland *et al.* in press). Gradual shallowing of the mixed layer could lead to an increase in diatoms for two reasons: an increase in iron since (assuming a constant supply rate) it will be dissolving in a smaller volume, and an increase in the amount of time that phytoplankton spend above the compensation depth. Increases in diatoms would shift the food web towards the large phytoplankton-macrozooplankton-fish linkages and, since it is a shorter link, to higher production of epipelagic fishes. It also suggests that production processes in the western and eastern North Pacific may converge towards similar plankton dynamics.

Shallowing of the mixed layer at Station P may also lead to warming of the upper layer as the solar heating becomes distributed over a smaller volume. Warmer temperatures have been associated with earlier average timing of development in copepod populations in the Subarctic North Pacific, with the result that the date of peak biomass has moved almost two months earlier since the 1970's (Fig. 3). If warmer temperatures in winter also increase microzooplankton growth and abundance, then the earlier spring peak in copepod biomass might also translate into better copepod survival. A relationship between increased zooplankton biomass and increased sea temperatures on the temporal scale of the quasi-biennial oscillation (average 28 months) has recently been identified by Conversi and Hameed (1997) using data from Station P for the period 1957-1980.

These processes suggest a trend towards increased macrozooplankton abundance, and therefore towards an increased potential for production of fish in at least the eastern Subarctic Pacific. Studies by Brodeur and Ware (1992, 1995) and Sugimoto and Tadokoro (1997) suggest that zooplankton and epipelagic fish production has indeed increased throughout most of the northern North Pacific between the 1950's and the 1980's. Wong *et al.* (1995) noted that estimates of primary production in the eastern Subarctic Pacific in the period 1984-90 were double the estimates made during 1960-76. However, it was unclear whether such a change was due to climatological effects, such as increased atmospheric circulation and increased inputs of wind-borne iron, or whether it was due

mostly to improved methodologies for estimating production. The higher zooplankton biomass through the 1980's has been suggested by a number of studies (e.g. Beamish and Bouillon 1993; Hare and Francis 1995) to have supported the higher abundance of salmonids that have occurred throughout the North Pacific during the 1980's. The question then arises as to whether such high abundance of epipelagic fishes are likely to limit the abundance of their prey, and in turn their own abundance.

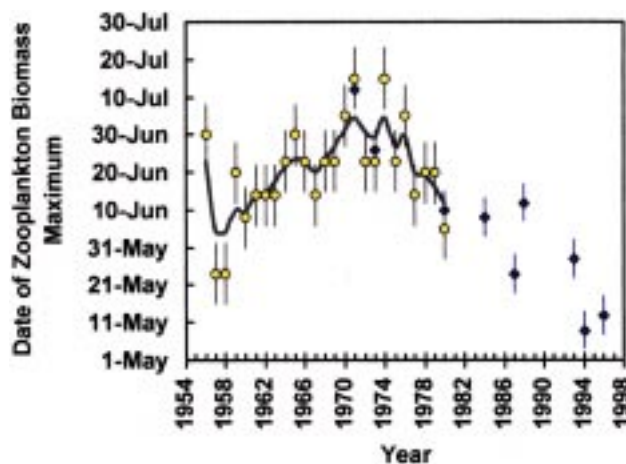


Fig. 3 Interdecadal change in timing of the spring-summer zooplankton maximum at Ocean Station P. Seasonal development of the zooplankton population was very late in the early 1970s, but by the mid 1990s had shifted about 60 days earlier. Circles show annual timing based on biomass measurements from the 1956-1980 Canadian weather ship time series. Diamonds show timing estimates based on copepodite stage composition (from Mackas, Goldblatt and Lewis, in review). Line is smoothed fit to the weather ship time series estimates.

Self-Regulating" Control

A variety of species dominate the epipelagic fish fauna of the Subarctic and Transition zones in the Northern Pacific (Brodeur 1988; Table 1). Salmonids are an important component of this fauna, making up 90% or more of surface net catches in the Subarctic Pacific. Unfortunately, modern sampling gear still does not allow an accurate comparison of the biomass of vertically migrating myctophids, or the biomass of the much faster moving squids, so the relative impact of these species groups on controlling macrozooplankton abundance is difficult to assess. There is some evidence that large abundance of epipelagic fishes can influence the biomass of their macrozooplankton prey in the North Pacific. Cooney (1988) identified a weak but significant correlation between Station P zooplankton biomass (1955 to

Table 1. Dominant epipelagic fishes in the Subarctic and Transition zones of the North Pacific Ocean. Modified from Brodeur (1988).

Scientific Name	Common Name	Subarctic or Transitional
<i>Lamna ditropis</i>	salmon shark	both
<i>Prionace glauca</i>	blue shark	both
<i>Oncorhynchus keta</i>	chum salmon	Subarctic
<i>O. gorbuscha</i>	pink salmon	Subarctic
<i>O. nerka</i>	sockeye salmon	Subarctic
<i>O. kisutch</i>	coho salmon	Subarctic
<i>O. tshawytscha</i>	chinook salmon	Subarctic
<i>Salmo gairdneri</i>	steelhead trout	Subarctic
<i>Cololabris saira</i>	Pacific saury	both
<i>Trachurus symmetricus</i>	jack mackerel	Transition
<i>Scomber japonicus</i>	Pacific mackerel	Transition
<i>Brama japonica</i>	Pacific pomfret	both
<i>Thunnus alalunga</i>	albacore tuna	Transition

1980) and North American pink salmon abundance, with lower zooplankton abundance occurring one year after high pink salmon abundance. He did not find, however, a significant relationship between Station P zooplankton abundance and the growth of pink salmon. Shiimoto *et al.* (1997) described an alternating cycle of high zooplankton biomass in the western North Pacific concurrent with low phytoplankton biomass in one year, followed by low zooplankton biomass and high phytoplankton biomass the next year, which they suggested was driven by predation of pink salmon on zooplankton, forced by the 2-year variation in strong and weak Asian pink salmon abundance. Odate (1994) also observed inverse spatial variations in the abundance of large phytoplankton and macro-zooplankton in the central North Pacific, and speculated that feeding by Pacific saury on macrozooplankton reduced zooplankton biomass resulting in higher abundance of large phytoplankton.

All of these studies address the potential effect of high epipelagic fish abundance on their macrozooplankton prey (a true “top-down” effect), so that phytoplankton abundance appears to vary in phase with the fish. But do these variations in plankton biomass affect the growth and survival of fish? There are some indications that the amount of food in the stomachs of chum, pink, and sockeye salmon varies inversely with the abundance of pink salmon, particularly in the western North Pacific (Sano 1963, Heard 1991, and Burgner 1991, respectively). Retrospective studies also suggest that

the terminal size of some species of salmon is lower in years when the abundance of pink salmon is high (e.g. Ogura 1991, Bugaev *et al.* (submitted)).

Ito (1964) suggested this type of variation was due to changes in diet, from squids in years of low pink salmon abundance, to zooplankton in years with high pink abundance. Perhaps the best example of the “self-regulating” effect of high pink salmon abundance on other salmon is the study of Tadokoro *et al.* (1996), which observed clear changes in the diet of chum salmon in the central Subarctic Pacific from predominately gelatinous zooplankton when Asian pink salmon were abundant to predominately crustacean zooplankton when pinks were not abundant. They argued this switch was forced by severe depletion of crustacean zooplankton by the abundant pink salmon. It is noteworthy that most of these observations relate to the effect of Asian pink salmon, which may be a result of their very large relative abundance in alternate years, which makes an effect easier to detect.

The observations of salmon grazing affecting zooplankton abundance, and potentially influencing salmon feeding, is rather surprising at first inspection. Calculation of zooplankton abundance in the North Pacific suggests that there is much more plankton available than can possibly be used by the salmon biomass (Sanger 1972). If salmon are broad spectrum and relatively unselective feeders, why should they show growth responses to their own abundances? In the North Pacific, maturing salmon appear to be opportunistic feeders, with the major prey items being (first) squid and fish, followed by euphausiids and amphipods, and only later by copepods (e.g. Percy *et al.* 1988; Heard 1991). However, at younger ages the diet may contain primarily macrozooplankton, and different species of salmon show evidence of trophic partitioning, suggesting that significant competition may occur in at least some areas and times. The latter observations are especially true for chum salmon, which do appear to specialize in feeding on gelatinous zooplankton and associated crustaceans (e.g. Welch and Parsons 1994). If the abundance of plankton is not affected by salmon abundance, there seems little reason that evolutionary pressure would have selected for some of the marked anatomical specialization seen in chum that help in feeding on gelatinous zooplankton (e.g. Welch 1997).

Concluding Comments

At some point, the ability of the open Subarctic Pacific to produce epipelagic fishes must be limited.

The question we have considered is whether this limitation is most likely to be due to constraints on the basic production of food (from phytoplankton to fish) or to the possibility that high abundance of fish “self-regulate” their production by over-grazing their prey. Observations of strong and concurrent increases in zooplankton and fish biomass on decadal scales (e.g. Brodeur and Ware 1992, 1995) argue for the direct food web effect (bottom-up control), but the picture is complicated by the differences in food web dynamics between the western and eastern Subarctic Pacific.

There is some evidence for top-down control of zooplankton biomass, mostly in the western North Pacific in relation to very large abundance of Asian pink salmon. The principal effect of this on salmon themselves appears to be a shift in the major dietary items, which in turn can cause lower weights of stomach contents. However, it is not clear that this is reflected in lower survival rates. The opportunistic nature of salmon feeding may serve to buffer them from major fluctuations in the availability of particular prey, but here again large interannual variation in size suggests that growth must be coupled with food abundance. The high importance of squid in the diets of all salmon (except chum) suggests more attention should be paid to this trophic level in the high seas; this attention appears to be lacking within the PICES CCC program at present.

Distinguishing bottom-up or self-regulating control of epipelagic fish production in the open North Pacific is not simple. One difficulty is determining what fraction of secondary production is consumed by other species, in particular the vertically migrating mid-water fishes such as myctophids. Seasonal migrants that move between the Transition and Subarctic zones will also cause a net loss of secondary production from the Subarctic region. Another difficulty is identifying when control on fish production has been exerted by food web processes, or by the fish themselves. For example, if fish production were limited by bottom-up processes, the responses in fish should be independent of fish density, although these responses may be more severe when fish density is higher.

If fish production were limited by fish density (e.g. by reducing prey abundance), then the effect should be most apparent at very high fish densities. Therefore, observations of *consistently* declining size-at-age or ocean survival may be indicative of bottom-up limitation. We are not suggesting that density-dependent effects of salmon (i.e. influences on salmon

growth and survival that occur as a function of fish density or abundance) do not occur, but that it may be a question of where and when during the life history such effects may be most important. For example, on-going work within the Canadian GLOBEC program (Fig. 4) suggests that growth of salmon (at least for some species and stocks) may be regulated more during their out-going and in-coming migrations along the continental shelf than by their time in the open Subarctic Pacific.

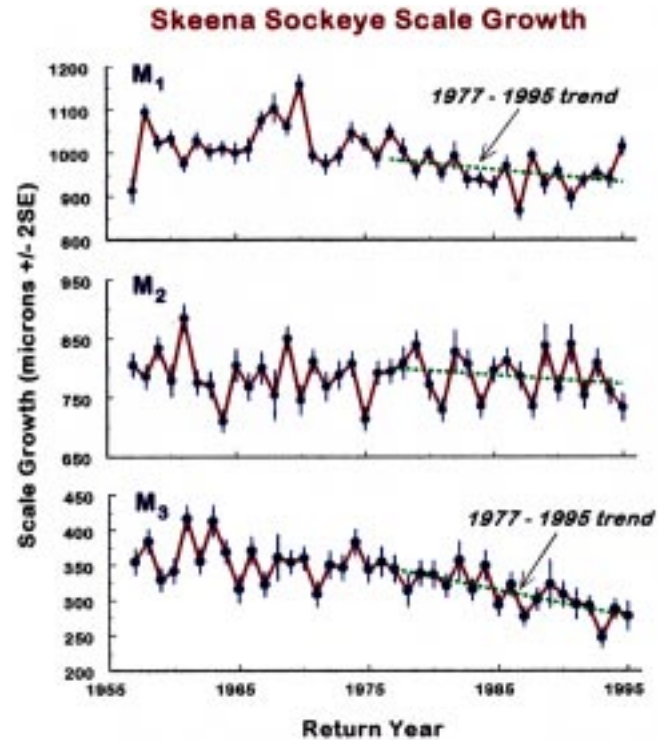


Fig. 4 Changes in salmon growth, measured as width of the annual rings on scales for Skeena River (B.C.) salmon. Note that a long-term trend towards lower growth rate is evident for the first (M_1) and last (M_3) years of life in the ocean, but not the second (M_2) year. This suggests that growth conditions in the coastal environment may be uncoupled from those in the offshore, and that the “carrying capacity” concept may need to incorporate the possibility of different carrying capacities in different regions of the Pacific, rather than a single homogenous whole.

Summary

We conclude that the production of epipelagic fishes in the Eastern Subarctic Pacific, especially (but not limited to) salmonids, is likely to be controlled by bottom-up (food web) processes rather than self-regulated by the effects of fish abundance on their zooplankton prey (e.g. “self-regulating” control), at

least when considered over the entire life history and entire North Pacific Ocean. While there are indications that exceptionally high abundances of salmon can affect the abundance of (local) zooplankton resources, this seems unlikely to be a dominant influence controlling the structure and functioning of epipelagic fish production in the Subarctic Pacific ecosystem. We agree with the comment by Sugimoto and Tadokoro (1997) that bottom-up control may be most influential on decadal and longer time scales. Although these authors also suggest that top-down predator control may be the dominant source of short (biennial) fluctuations in zooplankton and phytoplankton biomass in the Northern North Pacific, we believe that broad scale plankton dynamics, such as those associated with inputs of iron and microzooplankton grazing in the eastern Subarctic Pacific, are likely to dominate generally. However, an important issue that still remains to be resolved is the possibility of area-specific “bottlenecks” to production, such as shelf vs open-ocean, particularly when considered in the context of possible differences in spatial distribution and trophic overlap.

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Activity report of SCOR Working Group 105



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Currently about 80×10^6 tons of fish are removed from the world's oceans every year. An unknown but large amount of additional biomass is destroyed as unreported catch and as catch discarded at sea. Studies of freshwater systems have demonstrated that the removal of predators alters the biodiversity and stability of the ecosystem ("top-down control", cascade models). Alterations of intermediate trophic levels have consequences both higher and lower in lacustrine and riparian trophic systems. Despite continued expansion of fisheries on top predators and into lower trophic levels, only limited ecosystem-level examinations of the impacts of fisheries harvests on marine ecosystem dynamics have been carried out.

Many examples of changes in ocean ecology, including so-called regime shifts, have been documented; for example, the upsurge in Antarctic crab-eater seal; declines in Bering Sea seal and seabird populations; and changes in relative abundance of sardine and anchovies within eastern boundary currents. These changes may be the direct consequence of environmental influences. For example, the declines in Bering seal and seabird populations may be the result of mortality in drift-nets; while subtle changes in circulation and mixing of eastern boundary currents may have favored sardine growth over anchovies. However, these changes may also be the consequence of responses of the whole ecosystem to fishery harvests.

Given the magnitude of fishery removals in the world's oceans, it is urgent that scientists document not just the changes in ecosystems that have occurred, but also the contribution of the fisheries to causing the change. Moreover, as fisheries expand into lower trophic levels as well as different production regimes, it is important to understand and document how marine ecosystems respond to harvesting at different trophic levels.

In 1996 SCOR initiated a Working Group on the Impact of World Fisheries Harvests on the Stability and Diversity of Marine Ecosystems. Their activities compliment parallel work being carried out in the

North Atlantic under the auspices of the International Council for the Exploration of the Sea (ICES) by the Working Group on the Ecosystem Effects of Fishing, which has been active since 1990. While the ICES study concluded that the underlying reasons for the spatial and temporal differences in the patterns observed remain unclear, it is considered that a SCOR Working Group focusing on species regime shifts in all geographic region is appropriate at this time. At the PICES Fifth Annual Meeting in Nanaimo, Canada (1996), the Governing Council named me, then the Chairman-elect of the Fishery Science Committee, to represent PICES on the SCOR WG 105.

The first meeting of the new WG was held in Halifax, Nova Scotia, Canada, on November 5-7, 1996. In essence the terms of reference of the SCOR WG 105 are to provide a global synthesis of what is known about the impacts of fishing on the marine ecosystem, report on new methods for quantifying the impacts at the ecosystem level, and to provide a forum for discussions on how these methods can provide the basis for formulations of management strategies and tactics. The goal of the first meeting was to develop a work plan to meet the spirit of the terms of reference. It was decided that a number of teams should be established to provide peer-reviewed syntheses of the impacts of fishing on diverse ecosystems. To facilitate the synthesis and a forum for discussion, ICES and SCOR are planning to hold a symposium on "The ecosystem Effects of Fishing", the results of which are to be published in the primary literature (Co-conveners Dr. M. Sinclair and Mr. H. Gislason). The framework of symposium was discussed and it was decided to aim for a four-day meeting on March 16-19, 1999, in Montpellier, France; Presentations will be restricted to invited keynote papers that should all be subject to peer-review before the symposium.

I am encouraging all interested PICES members to attend the ICES/SCOR symposium. Any person who is interested in more details of SCOR WG 105 activities, feel free to contact me for more information.

Establishment of Marine Information Research Center: new strategy on oceanographic data management in Japan

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Dr. Yutaka Nagata is the first Director of the Marine Information Research Center at the Japan Hydrographic Association, which was established in April 1997. Dr. Nagata spent 43 years at the Geophysical Institute of the University of Tokyo, where he received his B.Sc. (1956), M.Sc. (1958) and Ph.D. (1964), and where he worked as Research Associate (1961-1965) and Professor (1980-1994). After retirement from the University of Tokyo, Dr. Nagata was Professor at the Mie University (1994-1997). He was a member of the WOCE Scientific Steering Committee for seven years, and then he was the first Chairman of PICES' Physical Oceanography and Climate Committee (1992-1995). He continues to be deeply involved in PICES and serves as Co-Chairman of the Implementation Panel on PICES-GLOBEC CCCC Program. Details of Dr. Nagata's research and personal interests can be found in "Yutaka Nagata Eulogy" (PICES Press, Vol.5, No. 2, 1997).

Data and information are essential for any research and exploitation business in various fields. Recently, human activities have expanded to oceanic spaces, and the need for high-quality data and information on oceans is continuously increasing. Especially because oceans play an important role in the world climate system, dense and accurate global data sets on oceans are needed to conduct predictions of climate changes. Oceanographic observations are not easy to collect, and they require huge expenses and labor. So, an effective data management system is required in oceanographic works, and the International Oceanographic Data and Information Exchange (IODE) was developed by the Intergovernmental Oceanographic Commission (IOC) to meet the needs. PICES is also aware of the importance of oceanic data management, and one of its two objectives is "to promote the collection and exchange of information related to marine scientific research in the area concerned" (Convention for PICES: Article III, Purpose of the Organization). PICES organized a Working Group on Data collection and quality control (WG 4) at the First Annual Meeting in Victoria, Canada (1992). This Working Group became the permanent Technical Committee of Data

Exchange (TCODE) at the Fourth Annual Meeting in Qingdao, China, (1995).

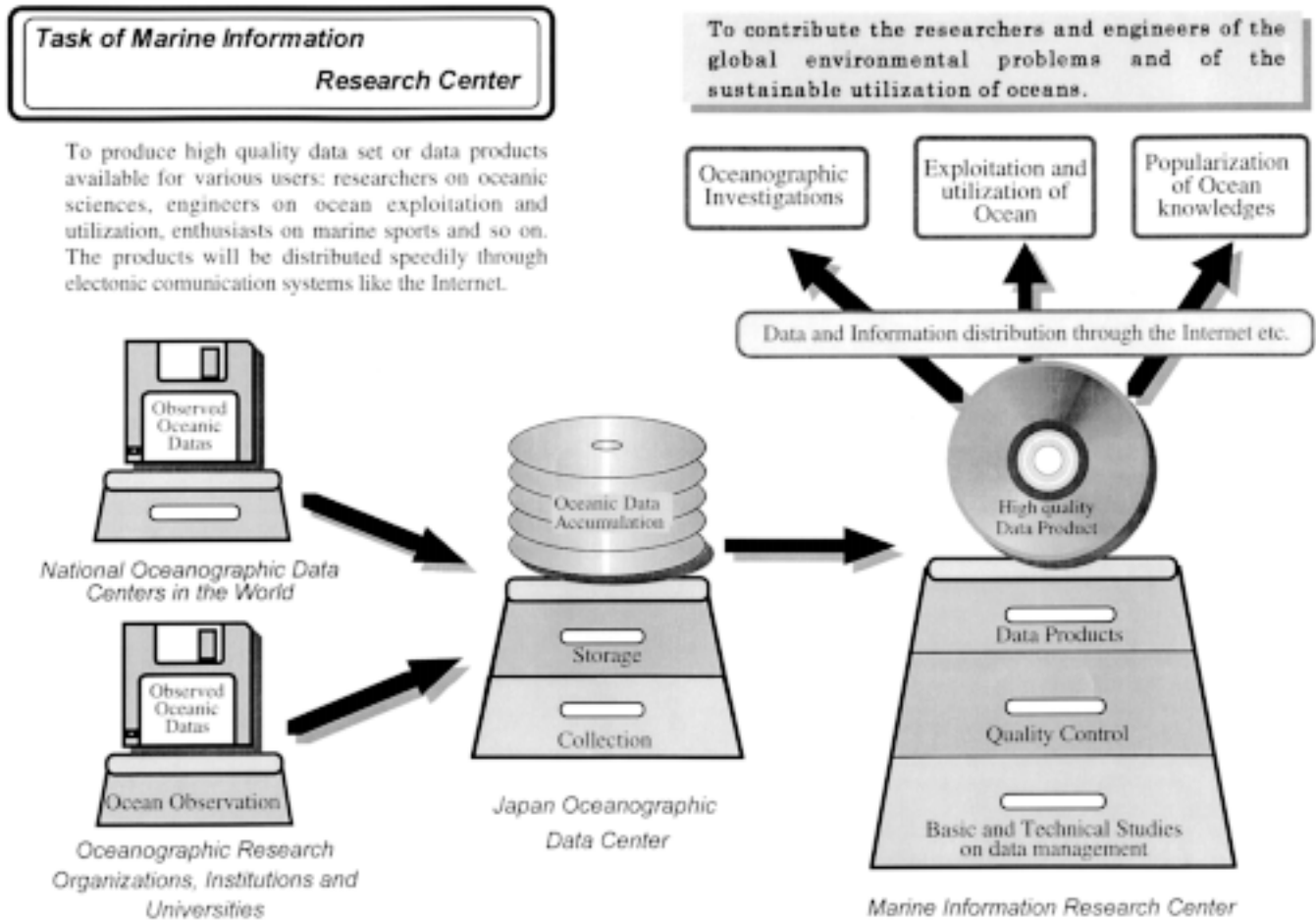
In Japan, there are three organizations handling oceanographic data and information: *Japan Meteorological Agency* (mainly for collection and exchange of real-time data relating to weather forecasting); *Japan Oceanographic Data Center (JODC)* in the Hydrographic Department, Maritime Safety Agency (for delayed-mode or historical data), and *Japan Fisheries Information Center* (to arrange the oceanic data especially for fishermen).

JODC has served as a synthetic data bank for the oceanographic community in Japan since its establishment in 1965. We believe that JODC is one of the most active and responsible data centers in the world. Thus, one of the Japanese delegates for TCODE/PICES is usually selected from the staff of JODC.

The field of oceanic research has tremendously expanded, especially that relating to the global environmental problems, and many large research programs had been conducted or are in progress. Besides, by reason of the Law of the Seas, the social interests on oceans increased and intensified. Due to

the rapid data accumulation and the increasing requirements for high quality data products, it became difficult for JODC to respond to all the needs of its users. As a governmental organization, JODC focuses its efforts on basic data management such as collection, arrangement, storage and distribution, thus another organization will be needed to effectively produce data products and respond to individual user's demands in various fields. Under this circumstance, the Marine Information Research Center (MIRC) was established in the Japan Hydrographic Association with the financial support of the Nippon Foundation on April 1, 1997. MIRC conducts high-grade quality control of the oceanic data compiled by JODC, and produces useful data products for users. Speedily distribution of necessary data sets and data products is also the task of MIRC. MIRC has experts and technical staff and computer and communication

facilities to conduct this business. To serve the studies on the global environment and the climate prediction researches, MIRC joins in international data exchange systems to produce the necessary global data sets of high quality. However, MIRC has no intention of overlapping any activities of JODC. MIRC will help JODC by designing higher quality control schemes and producing the various data products. The former users of JODC will benefit from MIRC by receiving data products that are much more suitable for their special needs. The staff of MIRC and JODC will be conducting various joint-studies on data management problems. For this purpose, a special task team has already been established in JODC. MIRC will work to enlightening and popularize knowledge of the ocean for the general publics use of some of its data products. The task of MIRC is illustrated in *Figure*



MIRC is made up of the following three sections: the Planning Division, which is responsible for general management, planning, and accounting and is also the window of international affairs; the Research Division for investigation and development of data

sets and data management systems; and the Service Office, which acts as a consultant and distributes data sets and data products to general users, and issues various publications, etc.

The Service Office shares the same room with the Marine Information Service Office of JODC on the first floor of the Hydrographic Department Building, whereas MIRC has its main office in the Ginza district, one of the most famous places in Japan. This site was chosen simply because it is very close to JODC (only 4 minutes walk). Powerful communication cables to the JODC database computer is under construction and MIRC's high-potency computer system will be in operation from October 1, 1997. Limited on-line service will also start in October. Please visit our MIRC office when you are in Tokyo!

We have no data-products available at the present stage of development. So, I shall introduce the strategy of MIRC (including the director's personal opinion) below:

Due to the huge accumulation of data and the increased variety of data items, individual researchers hardly ever arrange the data sets (raw data sets are supplied directly) by themselves into an applicable form to meet their own interest. For example, for world ocean simulation studies for climate prediction, time series of the oceanic data distributed to three dimensional lattice points would be most desirable. But usually, researchers in this field use the data products arranged by other investigators or other organizations. Namely, they do not use the most suitable data set for their study, but rather arrange their simulation scheme so as to fit the available data set. In this circumstance, accuracy, variability, and representativeness of the data set are almost in a black box for the individual users. Thus, the data products should be of high quality, and the investigators or the organizations producing such data products should have a high responsibility. Also, a mutual understanding between the product producers and scientific users is essential for future investigations.

To produce the high quality data products, high-level quality control of the data is required. It would be one of the study items to clarify the definition of "high-level" quality control. Usually, the first step of quality control is to exclude data that have extreme deviation and unbelievable values from a data set by eye inspection. Next step is to make a statistical calculation, and obtain a "mean value and standard deviation" for some sub-domains and for some given period or given season. These values are often used to judge reliability of the data and to improve quality. The skewness and/or bimodal nature of the data distribution are usually not considered. "Extreme

values" are always studied in case studies, but never investigated statistically. Namely, it is hard to discuss and find the "extreme values having physical significance" in a statistical sense. I do not recommend developing any special technique to handle such special data distribution and "extreme values" in a routine data management system. However, if we clarify their nature, we can get some precise meaning of the basic quantities such as "mean" and "standard deviation". We have lots of research items relating to the data management business and this is the reason why the term "research" is included in the name of MIRC.

It should be noted that "quality control" does not simply mean putting a quality flag on each data item or each data set. We need to improve the quality of the data flowing into JODC and MIRC. Enlightening or popularization of marine knowledge is one of the main tasks of MIRC, by using various data products not only for the general public but also for scientists and operation engineers. We need to establish the consulting and educating systems on the management of the oceanic instruments, observation and data handling techniques, and quality control tactics, in order to improve data quality flowing into our system.

International cooperation is essential to manage the data, as our targets are huge oceans. High quality data sets of world oceans are required for climate change investigations. We need to set the standard techniques for the quality control and related formats in order to improve data flows in the world, but these systems should be renewed according to the development of science and technology and to the changes of demands of the various users. MIRC should join and contribute to these international games. Enlightening or popularization business should be done also in an international sense. MIRC hopes to contribute to the education and training programs of the oceanographically developing countries.

In the present stage, there is a huge volume of valuable oceanographic data which have not been collected by JODC, so we should be involved in the data rescue business too. The present data management business is rather limited to physical quantities. We need to expand our activity to also include biological and chemical fields. MIRC will work as hard as possible in cooperation with JODC. However, the size of the MIRC's staff is limited in comparison with our tasks. We hope to receive the help and advice from domestic and overseas oceanographers and users in order to pursue our tasks efficiently.

Bering Sea Ecosystem Biophysical Metadatabase: A Collaborative Research Tool for Fisheries Oceanography and Ecosystem Investigations

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The U.S. National Oceanic and Atmospheric Administration (NOAA) is beginning a project to assemble a biophysical metadatabase on the Bering Sea ecosystem. The goal of this project is to facilitate research, education, and general knowledge of the Bering Sea by locating and assembling an inventory of the biological and physical data that have been collected on the Bering Sea ecosystem.

The three-year project is funded by NOAA's Environmental Services Data Information Management (ESDIM) Program. The project is managed by the Fisheries-Oceanography Coordinated Investigations Program through the Alaska Fisheries Science Center (AFSC) and Pacific Marine Environmental Laboratory (PMEL). Bernard Megrey and Allen Macklin serve as the project's co-leaders. The inventory of physical and biological data will help PICES and other researchers, managers, students, fishermen, and the general public investigate and understand the complex ecosystem of the Bering Sea. The inventory will be presented in an indexed, annotated catalogue (metadatabase) available through various mechanisms, including the World Wide Web (WWW). Those seeking more information or having knowledge of data that would enhance the metadatabase are urged to register through the WWW at URL <http://www.pmel.noaa.gov/bering/mdb/>, or contact Dr. Bernard Megrey, NOAA/AFSC, 7600 Sand Point Way N.E., Seattle, WA 98115, U.S.A., 01-206-526-4147 (phone), 01-206-526-6723 (fax), or at bmegrey@afsc.noaa.gov.

What are metadata? They are brief summaries and references to the actual scientific data. For example, if the data were vertical profiles of ocean properties obtained from CTD casts, the metadata would describe the locations and times of the casts, the inclusive depths, the variables measured, the location of the data, and the name of the person to contact to request access to the data. The data themselves are not part of the metadatabase and continue to reside with their owner. Metadata will be described in a

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common set of terminology and definitions using the recently established Federal Geographic Data Committee (FGDC) metadata standards.

When completed, the metadatabase will address a serious deficiency identified in 1996 by the National Research Council. In their report on the Bering Sea ecosystem, the council concluded that a directory of data and information sources relevant to the Bering Sea, catalogued in one place, was critically needed. Furthermore, they flagged the lack of such a database as the one major impediment to studying the Bering Sea. Although there is no accessible database at present, the project has identified many different types of physical and biological data that have been collected. For example, single-point and gridded time series, repetitive observations from earth orbiting satellites, ocean surveys of physical and biological oceanographic significance, specimen collections, and historical records of animal population changes have been assembled. Unfortunately, there is no easy way to know what institution has what research data holding because the data reside in the custody of various investigators or their institutions. Data are available from at least the last century, and in the last two decades the Bering Sea has been the subject of close scrutiny by such major research programs as the Outer Continental Shelf Environmental Assessment Program (OCSEAP) and Processes and Resources of the Bering Sea Shelf (PROBES). What is needed, and what NOAA's ESDIM Program has funded through this project, is a single, stand-alone resource that will reference as much historical data as can be located.

Recently the Bering Sea's economic and biological significance has provided impetus for the proliferation of a number of developing and active, regional (PICES/GLOBEC CCCC, Bering Sea Impacts Study, Bering Sea Ecosystem Project), national (Bering Sea FOCI, Southeast Bering Sea Carrying Capacity, Bering Sea Ecosystem Study), and international (PICES/GLOBEC, Japanese and Russian programs) research

efforts aimed at understanding dynamics of the Bering Sea ecosystem. All of these current programs have active and/or planned field and data collection components associated with them and are in a position to contribute to, and benefit from, the metadatabase.

Presently, the project is intent on identifying those researchers and institutions with data holdings that pertain to the Bering Sea ecosystem. Generally, data from the eastern Bering Sea is better known, so the project is focusing on cooperating with Asian scientists and their institutions. Toward that end, PICES has been an important and willing partner. The project mailed an information letter and metadata entry form to all scientists on the PICES general mailing list. Oral presentations were made to each of the PICES Committees during the Sixth Annual Meeting in Pusan, South Korea, during October 1997, a close working relationship with the PICES Technical Committee on Data Exchange was established, and a poster describing the project was centrally located in the meeting area. As a result of these activities, important contacts were established and information on the whereabouts and accessibility of data was obtained.

Besides its outreach through PICES, the project has also published its call for data in over twenty scientific newsletters worldwide, and made an appeal for data references to the subscribers of news from the North Pacific Fishery Management Council and the Fisheries-Oceanography Coordinated Investigations community.

You can participate and contribute to this project by identifying sources of physical and biological data on both the eastern and western parts of the Bering Sea ecosystem you are familiar with, submitting a form describing your data, remain available to answer questions we may have about your metadata, and submit updates as new data become available. We seek data products related to the Bering Sea ecosystem that span all biological and physical scientific disciplines, including historical as well as current information and information products on all Bering Sea ecosystem components, ranging from open ocean to intertidal areas. Types of information that are of interest include, but are not limited to, CTD; XBT or other water property and water chemistry information sources;

ocean currents and velocities; bathymetry; all satellite images, including maps of atmospheric circulation, ocean color, ocean SST, or ocean chlorophyll concentrations; abundance and distribution of all biological organisms from all trophic levels of the ecosystem, from microbacteria and small benthic organisms to whales; sea bird data; sea ice physics; geological information; bottom composition; information on atmospheric circulation; properties of the atmosphere and ocean-atmosphere interface; sources of anthropogenic contamination; and harvest of exploited marine populations.

*Please bear in mind that we are **NOT** interested in the actual data.* Rather, we plan to report the existence of the data with a metadata description. Metadata succinctly describe the content, quality, condition, spatial and temporal characteristics of data. A database of metadata is not a database of scientific data observations; rather it serves as a tool, which simply references the existence of data and information products. Reporting your information as metadata will keep your data under your control while assisting other scientists in locating and understanding your data.

Benefits from this project will accrue both immediately and with time. Although the call for data only was published in the middle of the summer of 1997, response has been good. By fall there were already appreciable returns of forms and an obvious excitement for the project. Nearly 70 forms from five countries have provided references to data representing all facets of the ecosystem – from chemistry to ice physics to microbiology to fish, birds, and mammals (*Fig. 1*). As well, the project has compiled addresses of nearly 70 WWW home pages that contain data relevant to the Bering Sea ecosystem. The project home page has been queried nearly 4,000 times since June from a wide variety of international locations, with most queries following outreach activities by mail or meeting (*Fig. 2*). In the coming year, metadata will be compiled and made available through the project's home page and through the NOAA Data Server. The historical metadatabase should be completed by the end of 1999. Updates on project status will appear regularly on the metadatabase home page on the WWW at <http://www.pmel.noaa.gov/bering/mdb/>.



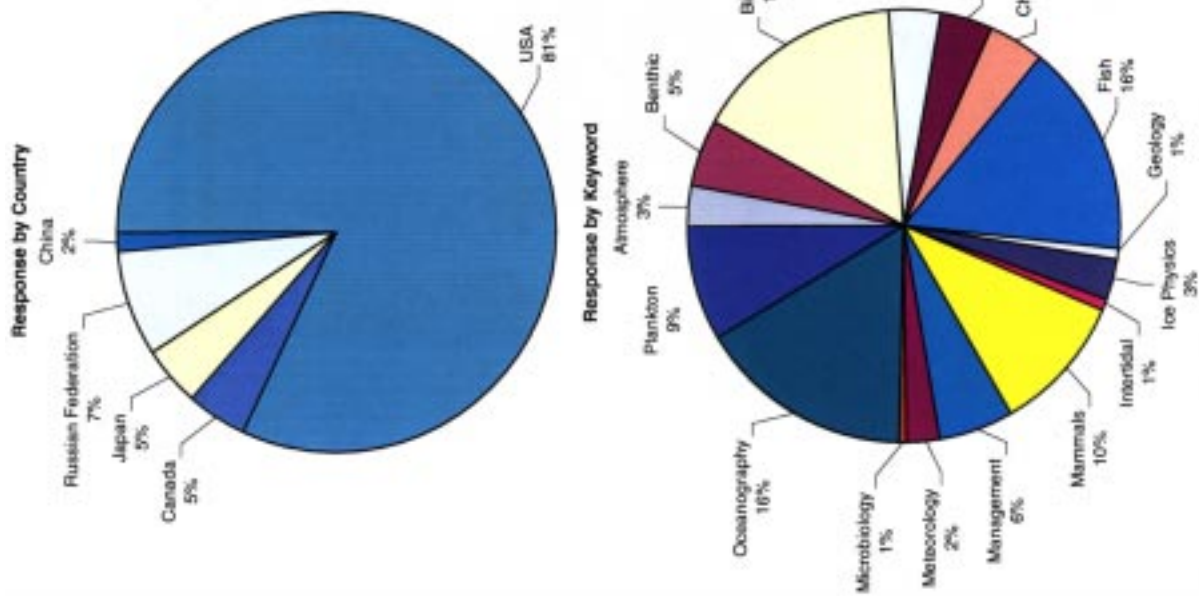


Fig. 1 Responses of 65 returned Bering Sea Ecosystem metadata entry forms tabulated according to country of response (top) and ecosystem component keyword response (bottom).

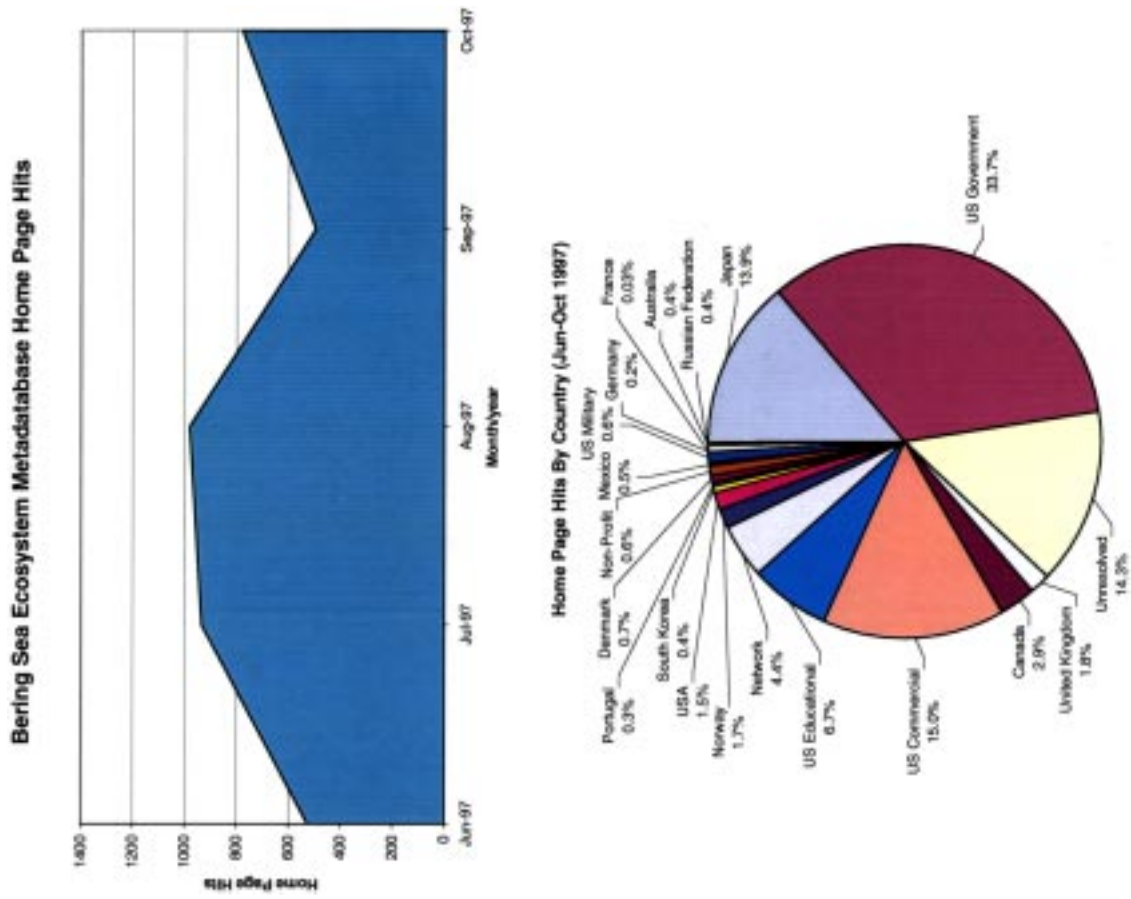


Fig. 2 Summary of Bering Sea Ecosystem Home activity from June 1997 to October 1997 (top) and a distribution of the hits by country (bottom).

Dr. Bernard Megrey is a research fisheries biologist with NOAA's Alaska Fisheries Science Center in Seattle, Washington, U.S.A., where he has worked since 1982. Presently serving as lead investigator for recruitment modeling studies for Fisheries-Oceanography Coordinated Investigations (FOCI), he has over 15 years experience studying the dynamics of exploited North Pacific fish populations, the relationships of the biophysical environment to recruitment variability, and the application of computer technology to fisheries research and natural resource management.



Mr. Allen Macklin is a meteorologist with NOAA's Pacific Marine Environmental Laboratory in Seattle, Washington, U.S.A. Presently he is the coordinator for Fisheries-Oceanography Coordinated Investigations (FOCI), a NOAA research program focused on building sustainable fishery resources in the Gulf of Alaska and Bering Sea while maintaining a healthy ecosystem. Allen received his B.Sc. (1970) and M.Sc (1975) from the University of Washington. Since then he has acquired over 20 years of experience studying Alaskan coastal meteorology and its relationship to the physical and biological oceanography of the region. His research encompasses wind drag on Bering Sea seasonal pack ice; katabatic, gap, and other ageostrophic winds in coastal areas; and relationships between measured attributes of the physical environment and the recruitment of marine fish.



PICES Seventh Annual Meeting
 October 14 - 25, 1998
 Fairbanks, Alaska, U.S.A.

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Climate change and carrying capacity of the North Pacific: recent findings of GLOBEC and GLOBEC-like programs in the North Pacific

More information available at the PICES Secretariat

A Note of Thanks

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