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WG 10 Fukuoka Workshop

PICES WG 10 held an informal workshop in Fukuoka, Japan on Jan. 31 to Feb. 2, 1997, following the Second International CREAMS (Circulation of Regional East Asian Marginal Seas) Symposium. (The courtesy of the local hosts, Prof. Masaki Takematsu and Prof. Jong-Hwan Yoon, RIAM, Kyushu University, was highly appreciated.) The aim of the workshop was to advance the development of the WG 10 report, which is focused on the Circulation and Ventilation of the Japan/East Sea (JES) and its Adjacent Area. The outline of the report, writing assignments, and timetable for developing the report were updated. Most importantly, some of the summary material was developed in the plenary-mode, and a portion of which is summarized below. When established, WG 10 was asked to try to complete its work within two years. Hence, an attempt is being made to complete the report in advance of the PICES VI Annual Meeting in Pusan, Korea (Oct.14-26, 1997) if possible. Success in this regard depends upon the cooperation of a total of 15 members (and others) from all six PICES member countries. Thus, communications are non-trivial, and an attempt is being made to create the report dynamically and on-line through utilization of the Worldwide Web. If successful, the report will be immediately ready for electronic printing as soon as completed, reviewed, edited, and approved; obviously, it could also be kept available on the PICES Web Site.

As presently outlined, the WG 10 report will consist of the following elements: Executive Summary; Introduction; Summary of Present Knowledge; Summary of Ongoing and Planned Scientific Programs; Summary of Related Chemical, Biological, Geological, Geophysical, and Atmospheric Processes and the Potential for Interactive Multidisciplinary Studies; Scientific and Logistical Opportunities and Challenges for Research in the Japan Sea (East Sea); Possible Future Process Studies and Their Design; Status of Numerical Modeling for Japan/East Sea; and Findings & Recommendations, plus a Bibliography which emphasizes the recent literature. The Bibliography per se is expected to be maintained indefinitely on the PICES Web Home Page for periodic updating.

The preliminary Findings and Recommendations are paired (one against the other) and are listed below:

Findings

• F1. A high-level of scientific background information exists (especially due to CREAMS), but a comprehensive understanding of the general circulation and ventilation that is sufficient to support fully the needs of future studies regarding climate variability and change, pollution, fisheries, ecosystems, and biogeochemical fluxes has not yet been achieved.

(cont. on page 35)

Pacific salmon: climate-linked long-term stock fluctuations

Leonid Klyashtorin
Russian Federal Research Institute
of Fisheries and Oceanography (VNIRO),
Moscow 107140, RUSSIA
E-mail: frol@vniro.msk.su

Dr. Leonid Klyashtorin is Leading Scientist at the Russian Federal Research Institute of Fisheries and Oceanography (VNIRO, Moscow, Russia). For 15 years he studied primary productivity of the Southern Pacific (1958-1964) and marine and freshwater fish respiration and fish swimming energetics (1965-1980). Since 1980, Dr. Klyashtorin has been working on problems of salmon ranching and wild salmon stock fluctuations in the Pacific and Atlantic Oceans. His recent research interests include the impact of global (long-term) climate changes on the populations of the main commercial marine pelagic species and inter-relation between ocean carrying capacity limitations and the dynamics of wild salmon populations.

INTRODUCTION

The impact of large-scale climate change on the salmon productivity of the North Pacific is an important scientific and economical problem. Commercial catching may not always be a good indicator of abundance, but for larger aggregations of stocks we suppose that catches represent the abundance trends of the total aggregate (Beamish and Bouillon, 1993).

Reliable information on the trends of commercial catch is necessary to estimate the carrying capacity of the North Pacific for salmon. The commercial catches have been collected for more than 70 years, but the statistics of salmon catches in the 20-40s needs to be substantially corrected. (Klyashtorin and Smirnov, 1992, 1995; Chigirinsky, 1994). The dependence of the long-term fluctuations of Pacific salmon abundance on climate changes was demonstrated recently by a number of papers (Beamish and Bouillon, 1993, Klyashtorin, and Smirnov, 1995). Nevertheless, reliable predictive climatic indices for salmon dynamics still have not been determined. The main purposes of this paper are the following.

- To refine the long-term dynamics of total salmon catch and evaluate the carrying capacity of the Pacific for salmon stocks
- To determine if the climatic characteristics are correlated with salmon stock dynamics
- To outline new approaches to the forecast of the long term dynamics of Pacific salmon stocks

SOURCES AND APPROACHES

Basic data on catch statistics were obtained from the following sources: FAO Yearbook Fishery Statistics (1957-1996); Pacific Salmon Catch 1900-1986 (1989), Kazarnovsky (1987), Chigirinsky (1994), Current Fishery Statistics (1991), and Hilborn and Vinton (1993).

Time series on Global and Hemispheric anomalies of surface temperature (dT) were taken from Halpert et al, 1994. The Aleutian Low Pressure Index (ALPI) expressed as the area (millions square kilometers) bordered by 100.5 kPa isobar is recognized to be an important factor affecting the climate in the North Pacific. The time series on ALPI are published in the paper by Beamish and Bouillon, 1993.

The Atmospheric Circulation Index (ACI or the so-called Vangengeim-Girs' Index) is the generalized data on the atmospheric activities in the Atlantic-European region for the period of more than 100 years (Girs, 1971). According to Vangengeim-Girs' approach, all visible variations of atmospheric circulation can be combined into three basic types by the direction of the air transfer: Meridional (C); Western (W), and Eastern (E).

The dominant forms of atmospheric circulation were estimated using the data from daily charts of atmospheric pressure in the North Atlantic-Eurasian region. The recurrence of each circulation form (W, E, or C) taken place during the year was expressed as "days". Annual total sum of "days" with different circulation forms is equal to 365. It was shown that the recurrence of the "days" with a dominant form of the atmospheric circulation is more conveniently expressed as "anomalies" (relative to the long-term average). Even more convenient is to use the consequent summation of the anomalies and to use the so-called "integral curve" of atmospheric circulation. Annual sums of the anomaly recurrences of all circulation forms are equal to zero:

$$SC + SW + SE = 0$$

For the last 100 years, long-term periods have been observed when some forms of atmospheric circulation dominated over the other. These periods were named "Circulation Epochs". The so-called epochs of Meridional (C) and Combined (W+E) are specified:

$$S(W + E) = -SC$$

The epoch of meridional circulation (C) dominated for the periods of 1890-1920 and 1950-1980. The epoch of the combined circulation (W+E) dominated for 1920-1950 and 1980-1990. Current (W+E) epoch is not completed yet, and will likely finish during the first decade of the next century. In this paper, the index (W+E) used as a basic characteristic of global atmospheric circulation is labeled by the abbreviation ACI (Atmospheric Circulation Index). The generalized time series on the atmospheric circulation forms for 1891-1995 (according to Vangengeim-Girs) were kindly placed at our disposal by the Federal Arctic and Antarctic Institute in St. Petersburg, Russia.

Time series on the Earth Rotation Velocity Index (ERVI) were calculated from the data of International Time Bureau (Sidorenkov and Svirenko, 1991; Klyashtorin and Sidorenkov, 1996).

RESULTS AND DISCUSSION

Reliable statistic on Pacific salmon catches started in 1920. The statistical reports do not completely cover the Asian catch dynamics for the first part of the century. For example, for 1920-40s, up to 380 Japanese fishing concessions operated in the coastal regions of Kamchatka, Sakhalin, and South Far East of Russia (Primorie). Japanese drifter catch in the 50-mile coastal zone was also highly developed. It was shown that the average Japanese catch (primarily of chum and pink salmon) in the Soviet Far East in 1920-1943 was about 200 thousand tons, and in some years it reached 370 thousand tons (Kazarnovsky, 1987; Chigirinsky, 1994).

Refined data on the Pacific salmon catches for 1929-1994[*)] are presented in *Figure 1a*. A specific "Saw-like" shape of the curve displays interannual fluctuations of the pink salmon abundance. The contribution of the latter to the total salmon catch in the North Pacific is 35-40%. The 5-year average (*Figure 1b*) gives a visual indication of the long-term periodicity in the salmon catches. The catches increased in the 1920-1940s. From 1936 to 1942, the average catch was more than 900 thousand tons (and about 1000 thousand tons. in 1937 and 1941). In 1944, the salmon catch decreased sharply, due to the destruction of the Japanese fishery caused by the Second World War. In 1948, the catch dropped to 1 thousand tons (!), and the average catch for 1946-1953 was as low as 8 thousand tons. We tried to restore the catch trend taking into account the collapse of Japanese salmon fishery in this period. Figure 1b illustrates the probable total catch dynamics (dashed line). In the 1950-60s (the period of salmon stocks depression), the total salmon catches dropped to 400 thousand tons.

Beginning in the 1970s, the salmon catch started to rise again. It increased most sharply in the 1980s, but slowed down in the 1990s. In 1991, 1993, and 1994, the total catch was somewhat higher than 900 thousand tons, and in 1996 (according to preliminary data) it will likely exceed 1000 thousand tons for the first time since the 1930s.

The rough long-term dynamics of the total salmon catch in the North Pacific for the 20th century is the following: the period of growth in the 20-40s, depression in the 50-60s, and recent rise in the 80-90s.

[*)] *Data on catches used in the paper are available from PICES Secretariat based on personal request.*

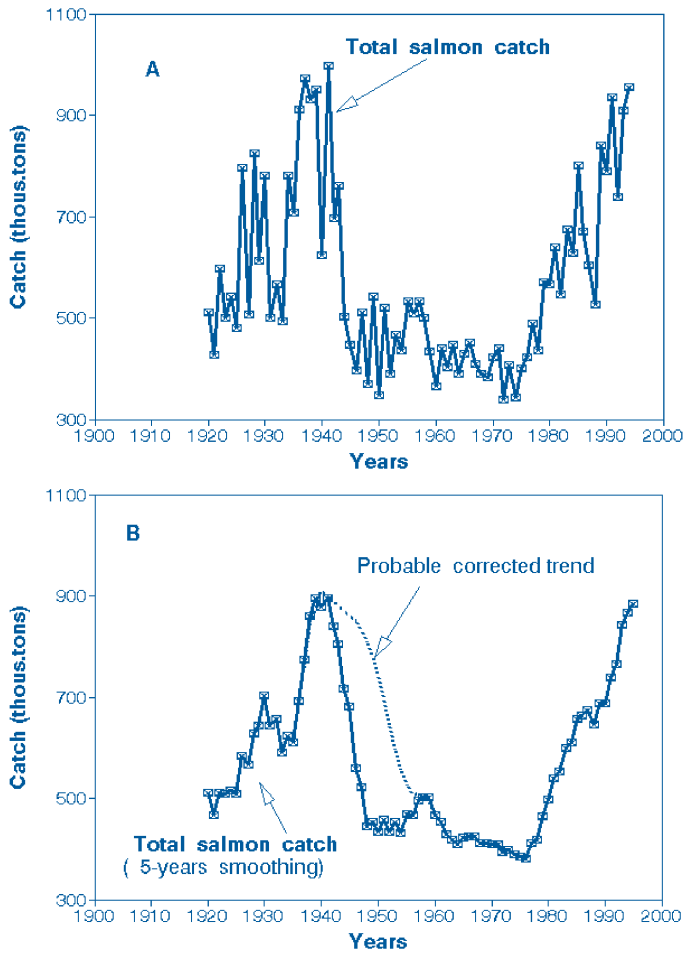


Fig. 1 *Total Pacific salmon catch according statistics data (A) and smoothed catch trend with corrections for suspension of Japanese salmon fishery in 1942-52 (B).*

Dynamics of Asian and American Salmon Catches

The dynamics of salmon catch from each continent is generally similar but there are individual specifics (*Figure 2*). In the late 30s, the Asian salmon catch was 550 thousand tons and exceeded the American salmon catch by almost 200 thousand tons. During the depression in the 50-60s, the American and Asian salmon catches have dropped to an equal level of about 200 thousand tons. The catch of "American" and "Asian" salmon started to rise simultaneously in the middle of the 70s.

American salmon catch increased rapidly, and to the 90s it exceeded the level of the 30s by 150 thousand tons on average. The Asian salmon stock increased slower than the American stocks, and in the 90s the Asian catch was 160 thousand tons lower than the corresponding figure in the 30s. This difference is due to the special reproduction characteristics of American and Asian salmons for the last 60 years.

Dynamics of Ranched Salmon Catches

In the 30s, artificial reproduction of Pacific salmon was of no particular importance. Period of "salmon stock depression" in the 50-60s has stimulated the development of salmon ranching. In Japan, the catches of ranched chum have increased by almost 200 thousand tons since the early 60s, and have stayed stable at this level for the recent decade (Shirahata, 1985; NPAFC, 1994, 1996). In Canada, the program development of salmon ranching started in the early 70s. Annual catches of ranched chum, pink, and red salmon are now approximately 12 thousand tons (Hilborn and Winton, 1993). In the USA, the catches of ranched salmon (primarily pink and chum salmon in Alaska) reached 30-35 thousand tons in the late 80s, and fluctuated around this level in recent years (Meacham and Clarck, 1994; NPAFC, 1994, 1996; FRED, 1989, 1990, 1992). The production of ranched salmon in Russia is approximately 15-20 thousand tons, primarily pink salmon.

The total catch of the ranched Pacific salmon is now around 240-280 thousand tons, which is more than a quarter of the total salmon catch in the North Pacific region. The proportion of ranched salmons in the Asian catch is about 50% (45-50%), and the corresponding figure for American salmon is about 10% (8-12%).

The geographic distribution of salmon reproduction has significantly changed since the 30s. In the 30s, the chum salmon reproduced in Japan provided no more than 3% of the regional catch. In the last decade, up to 85-90% of Asian chum was reproduced in the hatcheries of Hokkaido and Honshu. The catches of ranched chum exceed historical total catches of Japan-originated salmon by a factor of 5-7.

Dynamics of Wild Salmon Catch

The total catch of wild Pacific salmon in the 90s decreased by approximately 250 thousand tons compared to the 30s. This "deficit" is not uniformly distributed throughout the Asian and American continents, first noticed by Jackson and Royce (1986). The catch of Asian-originated wild salmons in the 90s decreased by approximately 350 thousand tons compared to the 30s. Correspondingly, the catch of American-originated wild salmons increased

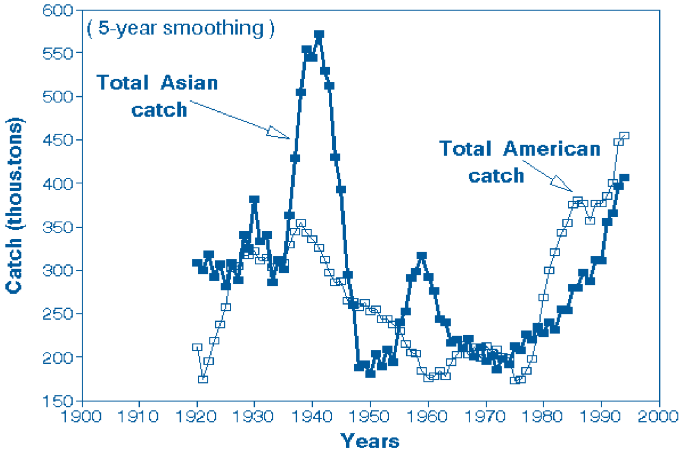


Fig. 2 *Asian and American salmon catch 1920-1994.*

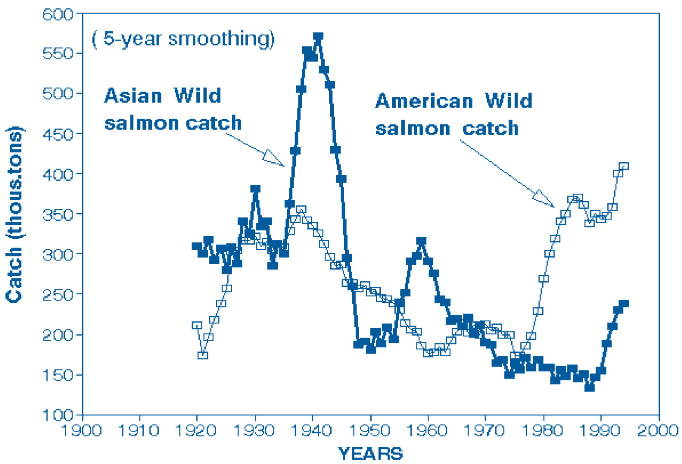


Fig. 3 *Asian and American wild salmon catch 1920-1994.*

100-110 thousand tons (*Figure 3*). The increase in the production of wild American salmons observed in the 70-90s has resulted from a significant rise in the reproduction of natural stocks of red and pink salmons in Alaska.

In the late 30s, annual catch of pink and chum salmon in the coastal regions of Northern and Southern Kuril Islands was 90 and 60 thousand tons, respectively. In the 80-90s salmon catch in this region did not exceed 40 thousand tons, i.e. was reduced by about 100 thousand tons compared to the 30s. In the late 30s - early 40s, average salmon catch in the Russian South Far East (Primorie) was about 10 thousand tons, and now it does not exceed 1 thousand tons. The main reason of this tenfold decrease is the degradation of spawning area in local rivers caused by mining and industrial wastes, removal of the coastal forests, and poaching. The salmon catches in the Amur river dropped since the 30s by 25-30 thousand tons for the same reasons.

The number of fishing industry installations in the West Kamchatka has decreased tenfold since the 30s. In the period of rapid elevation of salmon populations in the 70-80s, commercial salmon stocks of the West Kamchatka were underutilized, which resulted in the spawning area being overcrowded by highly-abundant generation of pink salmon, followed by a decrease in the salmon abundance according to the well-known mechanism (Ricker, 1954).

Estimates suggest that underutilization of commercial pink salmon stock in the years of highly productive generations reaches 100-150 thousand tons (Personal communication of professor V.P. Shuntov, Pacific Institute of Fisheries and Oceanography, TINRO, Vladivostok, Russia). Thus, since the 1930s, wild salmon catches in the North Pacific have decreased by about 250 thousand tons, and the ranched salmon catches correspondingly increased by 250-280 thousand tons. Therefore, it can be suggested that "disappeared" wild salmons were "substituted" in the oceanic feeding area by ranched salmons, and total catch in the North Pacific in the 90s returned to the historical maximum (about 1000 thousand tons) of the 30s.

Estimation of the North Pacific Carrying Capacity for Salmon

Carrying capacity of the North Pacific for the salmon can be roughly estimated from the assumption that the salmon fishery catches about 70% of the spawning population. Total annual production of salmons in the North Pacific feeding area can by assessed as about 1400 thousand tons. It can be conceived that the population of wild salmon now is at the level of the 30s, however with the same amount of ranched juveniles. Then, the total population of young salmons (wild and ranched) in the feeding area would be significantly greater than the present. In this case, an overpopulation of the feeding area is quite possible, accompanied by intense competition for food resources and retardation of fish growth.

Decrease in mean individual weight of salmons from high-abundant generations is a well-known

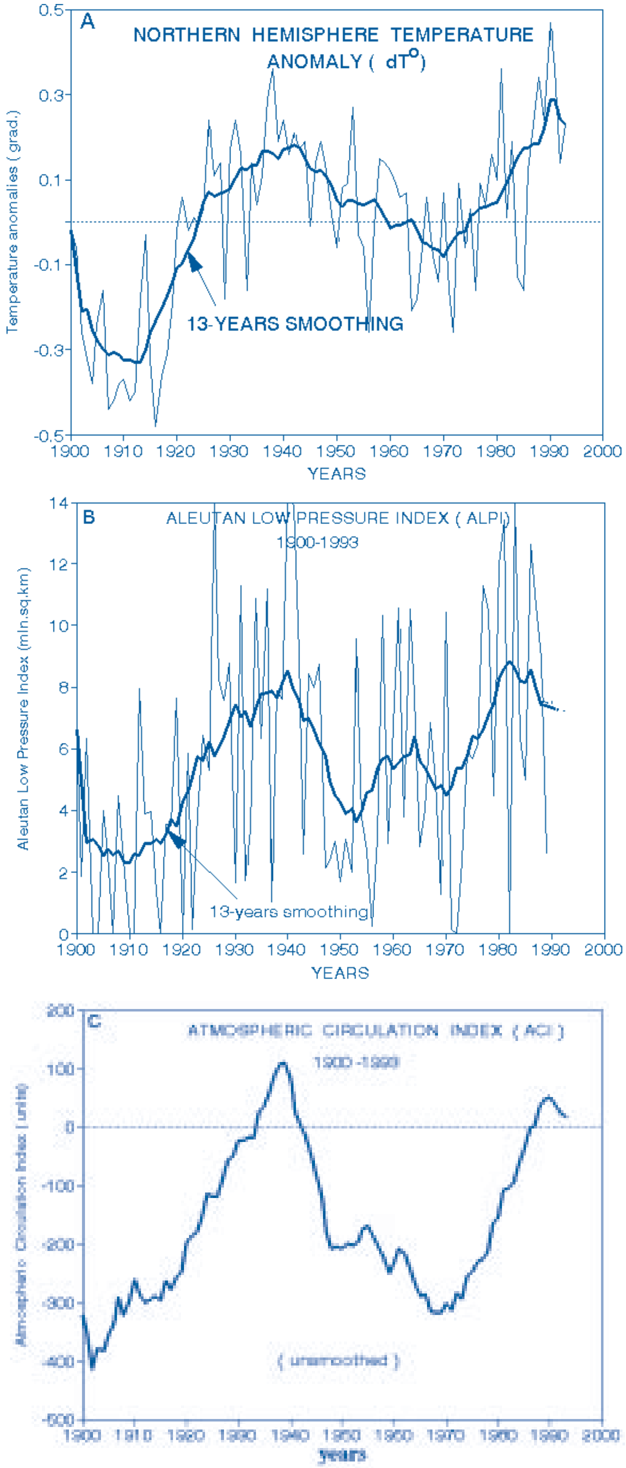


Fig.4 *Trends of the Northern Hemisphere air surface Temperature Anomalies (A), Aleutian Low Pressure Index (B) and Atmospheric Circulation Index (C) 1900-1993.*

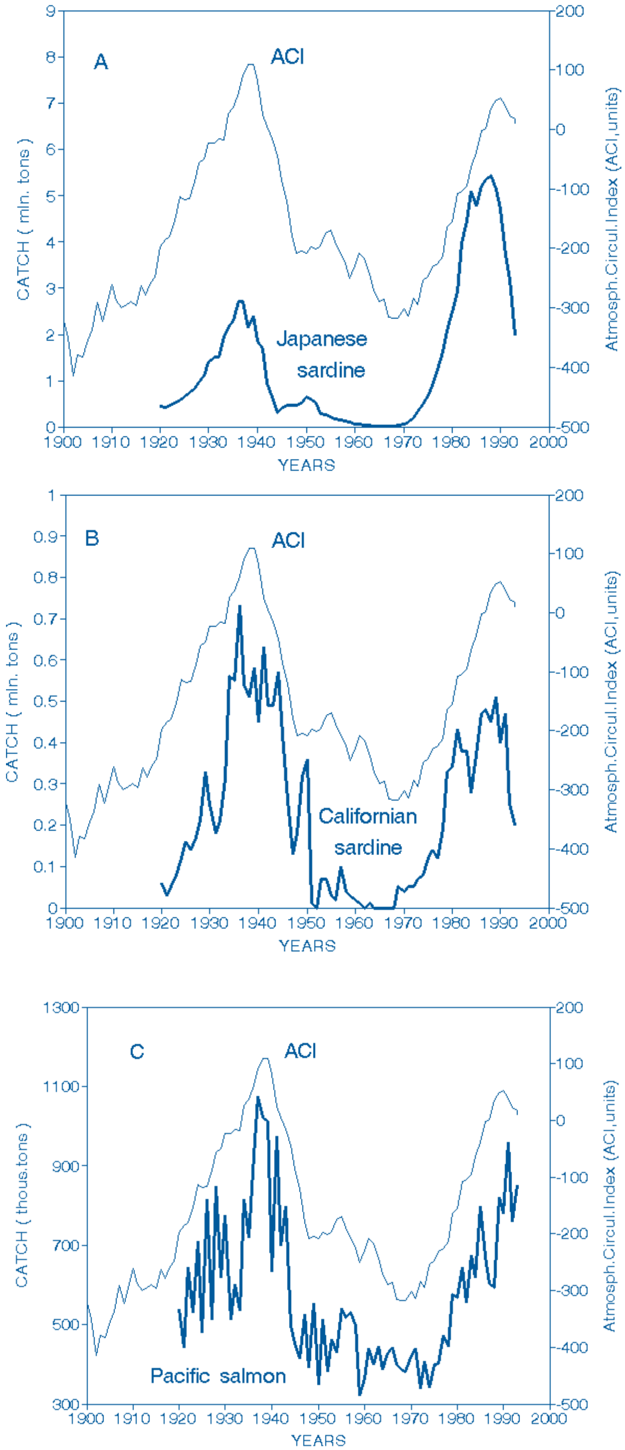


Fig.5 *Salmon and sardine commercial catch in the Northern Pacific and Atmospheric Circulation Index (ACI) trend 1900-1993.*
A - Japanese sardine; B - Californian sardine; C - Pacific salmon (All series are unsmoothed).

phenomenon (Pravdin, 1940, Anonimous, 1992; Heard, 1993; Bigler et al.,1995). This is particularly well defined for pink salmon: the differences between the mean weight of the individuals from low- and high-abundant generations can be as large as 30-40% (Ishida, 1966). Despite the decrease in the individual weight, the total catch increases manifold in the years of a highly-abundant generation return. This is evidence of the existence of a high biomass of food resources in the salmon feeding area, and on the other hand, it is a sign of the individual competition for food resources.

It appears that the annual release of more than 2 billion chum juveniles from Japanese hatcheries should increase the density of young salmons in the feeding area, aggravate food competition, and decrease commercial returns. However, the amount of adult chum returning to the Japanese coast is roughly proportional to the amount of juveniles that has been released to the ocean (Kaeriyama, 1989). A decrease in the mean individual size was registered in the case of more than 1 billion juveniles released. The release of each extra 250 thousand chum juveniles (after 1 billion) diminishes the mean weight of individual adults by 3-4%. Therefore, the potential decrease in the total ranched chum salmon production in response to the release of 2 billion juveniles should be about 10% (i.e. about 20 thousand tons of total commercial chum catch from 200 thousand tons expected). Even maximal (or close to maximal) increase in the juveniles abundance in the feeding area does not bring about lowering of the salmon survival, but somewhat retards salmon growth in the ocean. It may be suggested that total salmon production from the Pacific can be increased by 10-20% above the present level.

It must be emphasized that the carrying capacity of the oceanic feeding area for Pacific salmon undergo significant long-term fluctuations. Based on the catch statistics and above-mentioned suggestions, the level of carrying capacity of North Pacific for salmon can be approximately evaluated as 1400-1700 thousand tons in the period of maximal oceanic production to 600-800 thousand tons in the minimum. These variations correspond to the long-term fluctuations of feeding conditions in the ocean. The evidence was found in a large-scale doubling of summer zooplankton biomass in the Pacific between the 50-60s and 80s and estimated salmon biomass was nearly twice as high during the 1980s as it was in the late 1950s (Brodeur and Ware 1992,1995).

Salmons do not represent the most abundant pelagic species feeding in the North Pacific. The commercial catches of Japanese sardine and Californian sardine together exceed 6000 thousand tons, and the corresponding figure for Alaska pollock is more than 7000 thousand tons. Long-term fluctuations of salmon commercial catches coincide with the fluctuations of sardines and other pelagic species in the Pacific (Klyashtorin and Smirnov 1995, Klyashtorin and Sidorenkov 1996). The large-scale synchronous fluctuations of pelagic species abundance are believed to be caused by climate fluctuations of global or hemispheric scale (Shuntov and Vasilkov, 1982; Lluch-Belda, Crawford et al.,1989; Kawasaki, 1993).

Looking for Reliable Climatic Index

Time series of dT and ALPI (*Figure 4*) demonstrate high variability, and statistically reliable trends of their dynamics can only be obtained by using 13-year averages. Contrarily, the curve of ACI is low-variable, and do not need to be smoothed. The curves of ACI, the smoothed curves of ALPI and dT exhibit similar long-term dynamics: maximum in the 30s, minimum in the 50-60s, and the recent maximum in the 90s. The smoothed curves of dT and ALPI correspond basically to the dynamics of sardine and salmon catches, but the quantitative correlation is not very high. Long-term fluctuations of sardine (Japanese and Californian) and salmon catches coincide in phase (Klyashtorin, Smirnov, 1995), and ACI dynamics also corresponds to the dynamics of these species (*Figure 5*).

The total commercial catch in the beginning of the century differs significantly from the present one because of technology progress, modernization of the fishing fleet, and development of oceanic fishing. For example in the 1930s, the catch of Japanese sardine was 2700 thousand tons, and in 1989 the catch was 5200 thousand tons, which was caused by the fast development of commercial fishing in the second half of the century (Kawasaki, 1992a). Therefore, the relationship between climate changes and catch dynamics should be expressed as relative units or considered separately for each period.

(cont. on page 30)

The state of the eastern North Pacific in the second half of 1996

Howard Freeland
Ocean Science & Productivity Division,
Institute of Ocean Sciences,
P.O. Box 6000, Sidney, B.C.
CANADA V8L 4B2
E-mail: hjfree@ios.bc.ca

Dr. Howard Freeland is Head of the Ocean Science and Productivity Division at the Institute of Ocean Sciences (Department Fisheries and Ocean, Canada) and a memeber 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 & 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 PR6). Last year he was the winner of the Applied Oceanography Prize awarded annually by the Canadian Meteorological and Oceanographic Society.

The General Features:

The diagram opposite (*Figure 1*) shows the major circulation features of the N.E. Pacific Ocean. This is highly schematic, and one should bear in mind that the amount of water entering this region along the subarctic boundary itself must vary, and further, the fraction of that water that splits into the southbound California Current and the northbound Alaska Current also must vary. Hence the volume fluxes associated with these currents are highly uncertain. Nevertheless, the dominant patterns are remarkably robust. Both surface and subsurface drifters placed anywhere between 35˚N and 45˚N between 140˚W and the dateline will eventually migrate towards the Americas. More southerly floats will always end up in the California Current system, and more northerly floats will always end up in the Alaska Current system. The latitude of the bifurcation in the eastward drift is not really known, though it is widely assumed to vary both seasonally and inter-annually. The dominance, and persistence, of the general eastward drift has a direct impact on the temperature field. In the more northerly regions of the Pacific Ocean the density of seawater is largely determined by the salinity with temperature having only a rather weak influence. Thus temperature fluctuations tend to be carried by the large scale background currents.

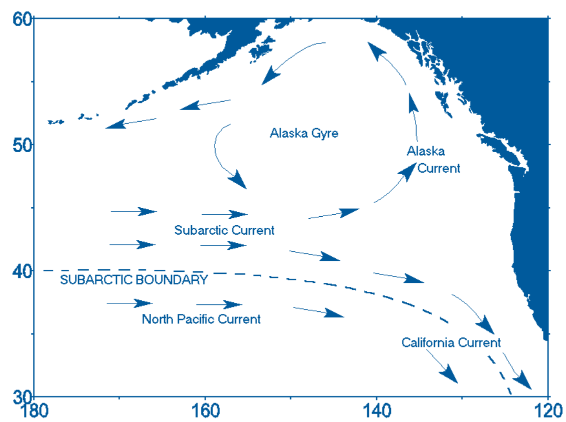


Fig. 1 *Cartoon of the general circulation of the N.E. Pacific Ocean showing the principal large-scale features.*

Sea Surface Temperature in 1996

Figure 2 shows plots of the temperature anomaly month-by-month through the second half of 1996. In all plots the contour interval is 0.5(C, the zero contour is indicated by a bold line, and negative contours (water colder than normal) are indicated by dashed lines. The maps are computed by taking a 1x1 degree grid of sea-surface

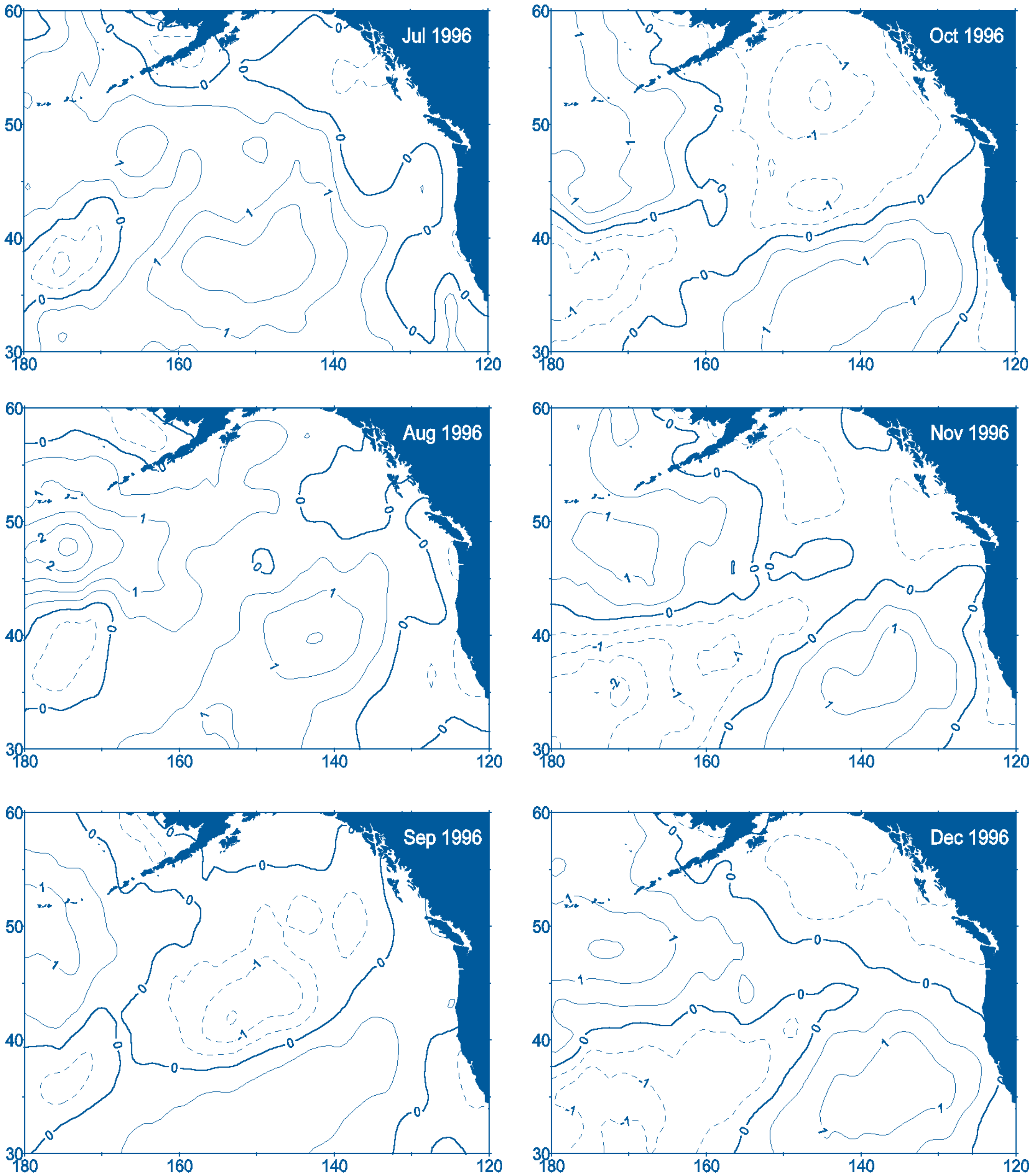


Fig. 2 Monthly mean temperature anomalies (deviations from normal) in the N.E. Pacific for July through December 1996. The contour interval is 0.5°C and negative anomalies are indicated by dashed lines

temperature for each month of 1996 and subtracting the average of grids computed for each month averaged over the years 1981 through 1996.

The maps indicate a remarkable general similarity. For every month of the year the ocean is cooler than normal in the Gulf of Alaska and in the bottom left of the maps. The ocean is warmer than normal off the Aleutians (top left corner) and in the California current system (bottom right corner). Thus, 1996 represents a significant departure from earlier years of the 1990s decade which were dominated by the direct influence of a series of El Niño events that were remarkable in their persistence, and then the long period necessary for the ocean to return to normal after this abnormal heating.

Though these four pools of warm and cold water were present in all months, the strength of the anomalies varied enormously. During March 1996, for example, anomalies were extremely weak over the entire N.E. Pacific. The negative anomalies appeared to be particularly weak during July and August 1996, but this may be more due to the absence of observations. (Objective mapping systems have a strong tendency to estimate the mean value, in this case, zero, when observations are sparse).

Off the coast of British Columbia we are fortunate to have an extensive network of buoys reporting data every hour onto the Global Telecommunications System. Also, for most of 1996 data from two profiling ALACE floats reported ocean conditions once every 5 days. Thus the data coverage of the region extending about 500 to 1000 km seaward of BC was well covered. The anomalies in this region rarely exceeded _ degree in either direction. This was not an artifact of the mapping procedures, rather it was real.

Near Surface Conditions

A recent paper by Freeland et al. (H. Freeland, K. Denman, C.S. Wong, F. Whitney & R. Jacques. 1997. Evidence of Secular Change in the Northeast Pacific Ocean. Deep-Sea Research, *sub judice)* reports that over the history of the Line P/Station P observation program we have seen a steady decline in the thickness of the winter upper mixed layer. This is important because it is the deep mixing during the winter that ensures a substantial supply of nutrients in the ocean in early spring. Thus, we also see a decline in the nutrient concentrations of the upper 100 metres of the ocean at the end of winter.

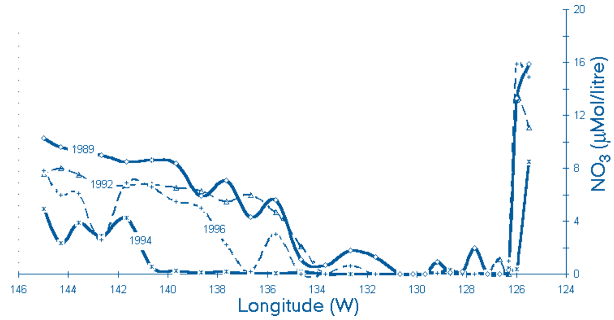


Fig. 3 Nitrate concentrations in late summer along Line-P for several recent years which show the extensive regions of zero-nitrate.

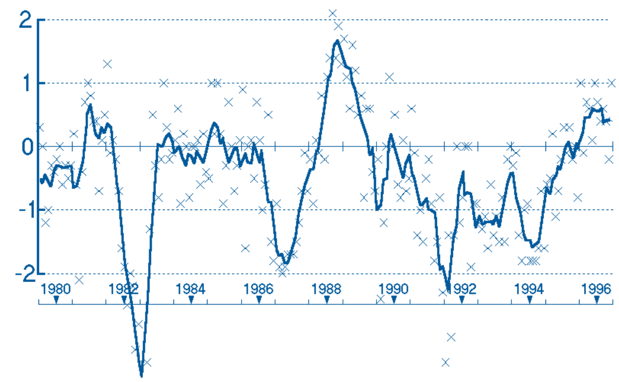


Fig. 4 The Southern Oscillation Index plotted against time from 1980 to Dec 1996. The X marks indicate actual observed monthly value, the solid line a 5-month running mean.

The problem here is that biological activity consumes dissolved nutrients at the same time (spring and summer) when mixing is weakest and so the re-supply rate is also least. The result is that, as shown in *Figure 3*, we have in recent years seen patches of water along Line P with zero dissolved nitrate. During the three most recent summers (1996 included) the nutrient depleted water has occupied most of the distance along Line-P from the continental slope to Station Papa. We do not know how far north or south of Line-P this nutrient depletion extends, but this is a high priority for future research.

The Large Scale

It is well known that large temperature variations do occur in the northern N. Pacific in response to events

(cont. on page 29)

The state of the western North Pacific in the second half of 1996

Teruko Manabe
Oceanographical Division
Climate and Marine Department
Japan Meteorological Agency
1-3-4 Otemachi, Chiyoda-ku
Tokyo 100, JAPAN
E-mail: t_manabe@umi.hq.kishou.go.jp

Ms. Teruko Manabe is Senior Scientific Officer of the Oceanologica Division of the Climate and Marine Department at the Japan Meteorological Agency (JMA). She is working as a member of a group in charge of monitoring and forecasting sea surface temperature, subsurface temperature and sea surface current. Based on in situ and satellite data, this group makes different products and the JMA disseminates them by meteorological radio facsimile broadcast and by publishing the "Monthly Ocean Report". Ms. Manabe's recent activities also include the development of a new analysis system of subsurface temperature in the North Pacific to improve sea surface temperature forecasts in the western North Pacific.

Sea Surface Temperature

Based on objective analysis for 1x1 degree grid points (Oceanographical Division, Marine Department, JMA, 1990. An objective analysis of ten-day mean sea surface temperature. Weather Service Bulletin, 57 (6): 283-291), the Japan Meteorological Agency operationally makes ten-day mean SSTs (Sea Surface Temperature) and SST anomalies in the western N. Pacific and disseminates them by meteorological radio facsimile (JMH) and through the Monthly Ocean Report. Monthly mean SSTs are arithmetic averages of the three ten-day mean analyzed SSTs of the relevant month. Anomalies are computed with respect to the JMA 1961-1990 climatology (Marine Department, JMA, 1991. Climate charts of sea surface temperatures of the western North Pacific and the Global Ocean, 77 pp.).

Figure 1 shows monthly mean SST anomalies in the western N. Pacific from July to December 1996. One of the most remarkable features in the second half of 1996 was that SSTs continued to be above normal north of 45˚N, in the Sea of Okhotsk and in the Bering Sea. In particular, in December, SSTs were more than 1˚C above normal in a very large area north of 45˚N.

Time series of regional ten-day mean SST anomalies in the western N. Pacific (*Figure 2*) show that SST of 1996 was the highest in the past nine years in region A (45˚-53˚N, 150˚-180˚E). In region B (35˚-45˚N, 150˚-180˚E), SSTs were rather near normal in the second half of 1996 as compared with quite negative anomalies observed throughout the first half of 1996.

As shown in *Figure 1*, in the mid-latitude area of the western N. Pacific, SSTs continued to be generally below normal between 30˚N and 45˚N in the second half of 1996. However, positive anomalies were observed in the seas adjacent to Japan in November and December, in particular, SSTs of more than 1˚C above normal were found off the east coast of Japan.

Kuroshio

The Kuroshio current has continued to take a non-large-meander path along the south coast of Japan since the summer of 1991.

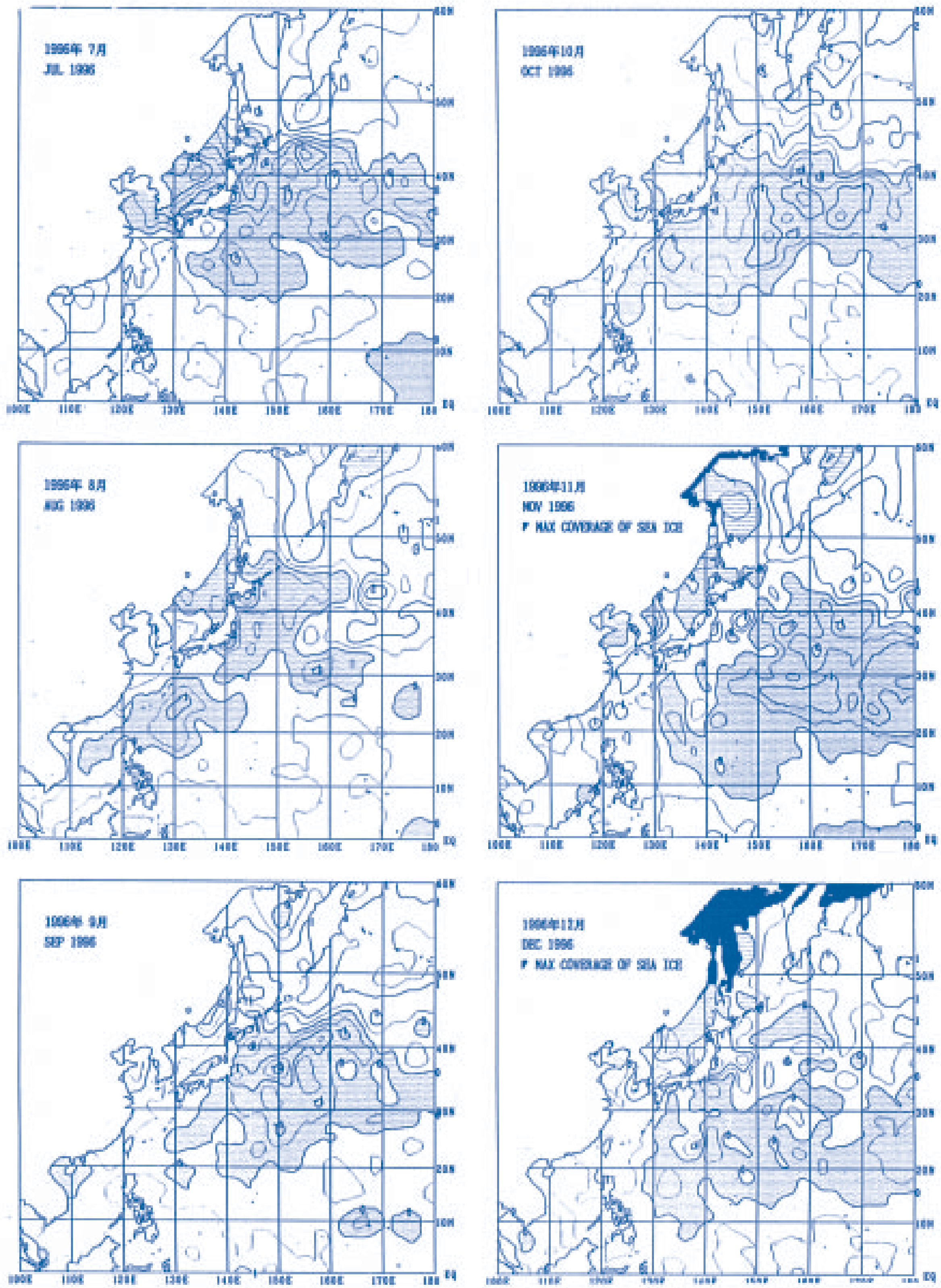
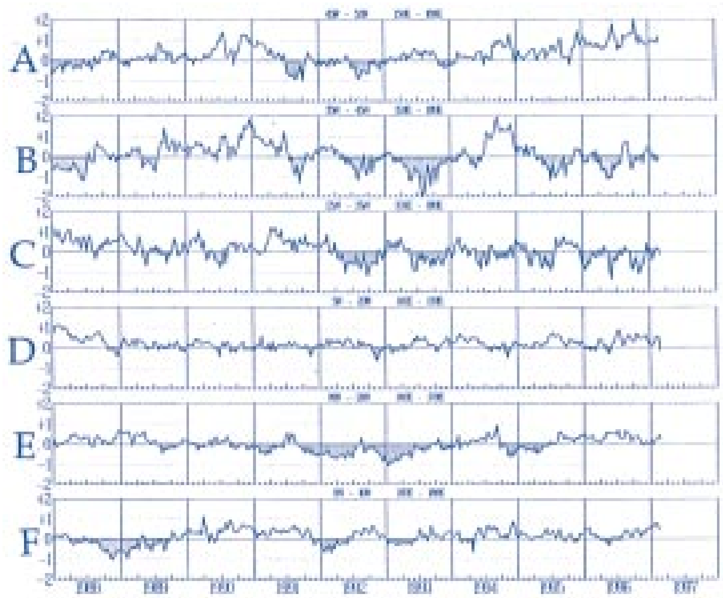


Fig. 1 Monthly mean sea surface temperature anomalies. Anomalies are depatures from the JMA Climatology (1961-1990). Contour interval is 1˚C and additional contours of 0.5˚C are shown as broken lines. Negative anomalies are shaded.



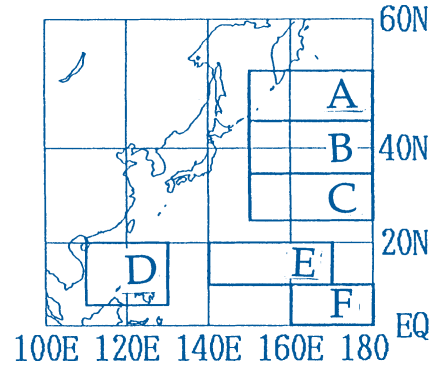


Fig. 2 *Time series of the ten-day mean sea surface temperature anomalies (˚C) in the western N.Pacific for the areas shown in the right figure. Negative anomalies, computed from the JMA climatology (1961-1990), are shaded.*

Sea ice

Sea ice first appeared in November 1996. Sea ice extent in the Sea of Okhotsk was below normal until the end of 1996.

Carbon Dioxide

JMA has been making measurements of oceanic and atmospheric CO_2 along 137˚E and in the equatorial Pacific since 1981. These surveys revealed that, in the mid-latitude between 10˚N and 30˚N of the western N. Pacific, the ocean fluctuates between being a sink for atmospheric CO_2 in the winter and being a source in the summer. It was also shown that the surface CO_2 concentration has been increasing in the past decade. In addition to the observations along 137˚E, in 1996 JMA commenced making observations along 165(E, and carried them out twice, in April-June and in October-December. According to the survey in May, the ocean was emitting CO_2 in high latitudes of the N. Pacific, while the mid-latitude area acted as a sink for atmospheric CO_2 (*Figure 3a*). In November, the ocean served as a sink for atmospheric CO_2 north of 30˚N along 165˚E, while it played as a source south of 30˚N. The CO_2 measurement in the equatorial Pacific in November indicated that it was a strong source area for atmospheric CO_2, which extended to as far west as 145˚E (*Figure 3b*).

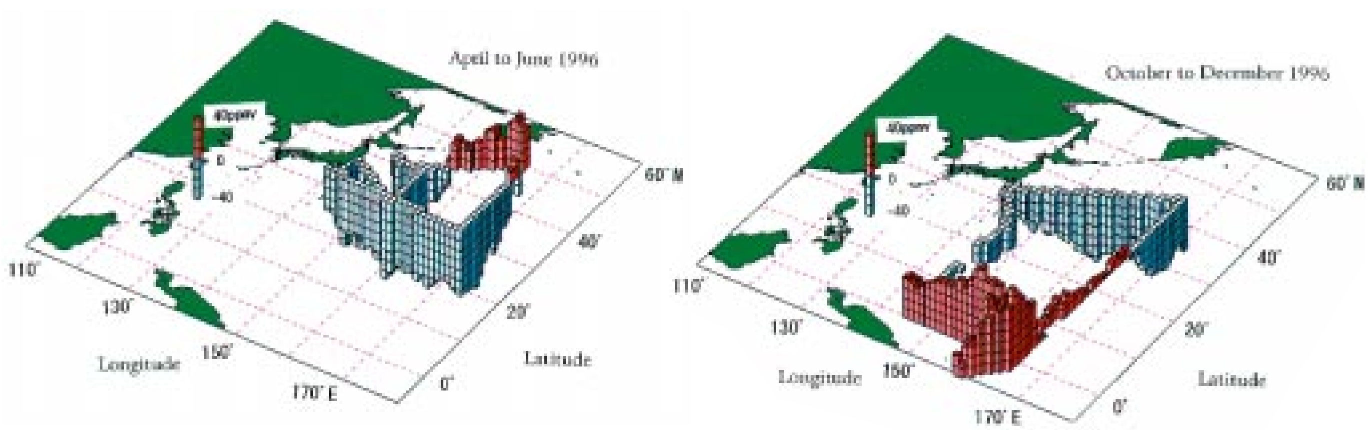


Fig. 3 *Difference of CO_2 concentration between sea surface water and air in April-June 1996 (a) and in October-December 1996 (b). Red upward bars indicate that the ocean was emmiting CO_2 ; blue downward bars indicate absorbtion of atmospheric CO_2 by the ocean.*

The status of the Bering Sea in the second half of 1996

Phyllis J. Stabeno
Pacific Marine Environmental Laboratory
National Oceanic and Atmospheric Administration
7600 Sand Point Way NE
Seattle, WA 98115, USA
E-mail: stabeno@pmel.noaa.gov

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 her knowledge of physical processes to fisheries oceanography, Dr. Stabeno plays a vital role in the success of NOAA's Fishery Oceanography Coordinated Investigations (FOCI) program. FOCI research focuses on building sustainable fishery resources in the Gulf of Alaska and Bering Sea while maintaining a healthy ecosystem. 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.

Wind speed and air temperature during the final quarter of the year determine winter oceanic temperature and sea ice conditions. Ice formation and extent over the eastern and western Bering Sea shelf is closely related to winds. Historically, when storms travel along, or south, of the Aleutian Island Chain, as opposed to moving northward into the Bering Sea, ice production is enhanced and the ice edge is south of its climatological position. The atmospheric conditions responsible for the ice phenomenon also can perturb the mean northward transport through Bering Strait; strong winds toward the south reduce the mean transport and generate reversals that extend over substantial periods. Early sea ice extent does not necessarily determine the maximum extent, however, since the maximum extent occurs in March or April.

Atmospheric conditions over the Bering Sea exhibited anomalous behavior during the last half of 1996. Monthly mean sea level pressure (SLP) was from 4 to 16 hPa higher than usual over the Bering Sea from July through December (as illustrated by the SLP maps for September and December; *Figure 1*). This pattern resulted from storms tracking primarily south of the Aleutian Island Chain. The transient atmospheric disturbances over the Bering Sea included greater anticyclonic activity than usual. These anticyclones are generally of Siberian or Arctic origin and are associated locally with anomalously large equatorward fluxes of cold air. Owing to the coupled nature of the atmospheric-oceanic-sea ice system, the sea level pressure distributions therefore suggest relatively extensive early sea ice formation with higher than normal spatial extent. Data from the Joint Navy/ NOAA Ice Center and the National Weather Service in Anchorage, Alaska support this. By January 3, the sea ice extent along 170˚W longitude was ~59˚N, or almost 200 km further south than the climatological position (determined from satellite data obtained between 1972-1995).

The Bering Slope Current (BSC), the dominant circulation feature in the eastern Bering Sea, provides another index of the status of the Bering Sea. Studies of the BSC suggest that two significantly different modes exist. Many hydrographic surveys reveal an ill defined, highly variable flow interspersed with eddies, meanders and instabilities. Other surveys, however, reveal a more regular northwestward flowing current. The trajectories from the more than 50 satellite tracked drifters deployed in the southeast Bering Sea support this dichotomy in the structure of the BSC. They reveal the strong variability in the flow patterns that occur along the shelf break. In some trajectories, the BSC appears as a well behaved current flowing northwestward along the shelf break.

During summer of 1996, a well defined BSC was not evident in satellite-tracked drifter trajectories. Along the shelf-break the flow was weak from July through September, with some evidence of stronger flows occurring in October. The structure of the BSC directly influences both the advection and dynamics along the slope, and also the occurrence of across shelf fluxes, which provide nutrients for the rich productivity of the Bering Sea shelf.

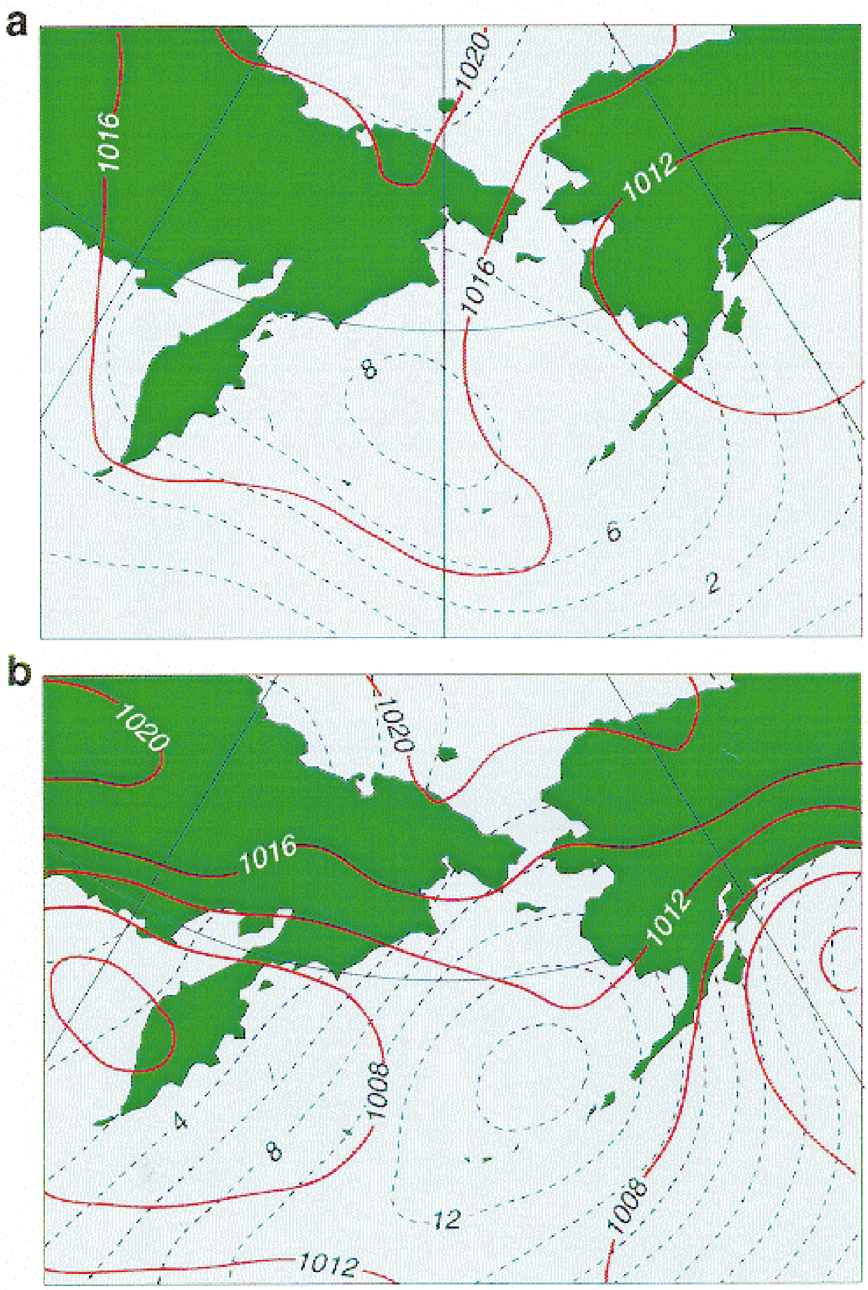


Fig. 1 The northern hemisphere mean and anomalous sea level pressure (hPa) for: (a) September 1996 and (b) December 1996. Solid red lines show the mean (calculated from 1979-1995) and the dashed lines show the anomalies from the mean (Climate Diagnostics Bulletin, Climate Prediction Center NOAA/NWS/NCEP).

Yutaka Nagata Eulogy

Key note speech at Fourth PICES Annual Meeting, Nemuro, Oct. 1994.

Yutaka Nagata is a major figure in marine science. His research interests span a wide range of topics in physical oceanography. He has served as major advisor for a large number of graduate students who now are important contributors to oceanographic science in Japan. One of the major themes of his work has been to foster international cooperation in marine science. In PICES we are familiar with his many contributions to the success of the program through the leadership he provided as the first Chairman of the PICES Physical Oceanography and Climate Committee.

I (Bruce Taft) first met Nagata in 1966 at the Geophysical Institute of the University of Tokyo. I had gone to Japan, as a participant in the US-Japan Cooperative Science Program, to work with Prof. Kozo Yoshida on the description of the variability of the Kuroshio Current. Prof. Yoshida assigned me a space in Nagata's office and we began a long and very friendly association. Nagata was a lecturer at the Institute at the time. Even though we were working in very different aspects of oceanography, he was working on the physics of generation of wind waves and I on the large-scale meander of the Kuroshio, he was remarkably generous with his time in helping me to do my research.

Because Nagata was a young faculty member and had a lively and welcoming personality, his office was a natural gathering place for the graduate students at the University. As a result it was easy for me to socialize with the students and I made many friends in this group of young oceanographers. Today they occupy a prominent role in marine science in Japan.

He also undertook the role of being my cultural tutor. I had much to learn! My family and I are indebted to him and his wife Fumie for many memorable times in Tokyo. We were fortunate to be able to reciprocate when Nagata and his family came to La Jolla, California for a three-year stay at the Scripps Institution of Oceanography. At Scripps he worked with Charles Cox on techniques of measurement of oceanic thermohaline microstructure (1 cm vertical scale) - a field of study which he pursued vigorously on his return to Japan in 1969.

Nagata is a sea-going oceanographer who has impressive analysis skills. He has made fundamental contributions to our understanding of ocean waves, the significance of shallow-water temperature inversions, the dynamical role of microstructure in the ocean and the processes of formation and circulation of North Pacific Intermediate Water.

His DSc (1964) thesis was on the role of waves in determining nearshore sediment transport. In order to do this research he designed an electromagnetic current meter which could be used in the harsh environment of the breaker zone. By obtaining accurate measurements of the deformation of the wave velocity field he was able to demonstrate many aspects of the physical mechanism of sediment transport. In this work he also proposed methods of obtaining the directional wave spectrum from time series of horizontal components of wave velocity field.

Just one year old, Nov. 1934.

Graduate student (with hand-made electromagnetic current meters to measure deformation of orbital velocity of waves on shoaling beach), Faculty of Science, University of Tokyo, Aug. 1959.

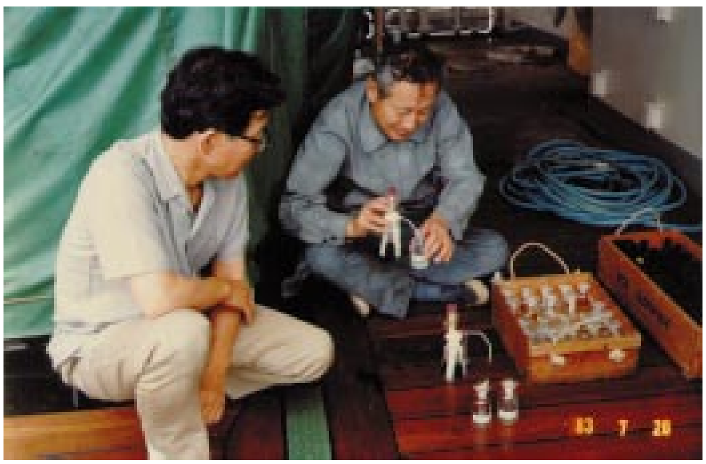
He was the first Japanese oceanographer to undertake studies of ocean microstructure and this area of research probably encompasses his most notable achievements. This research included both laboratory modeling and field studies. Under his leadership a series of research cruises were carried out in the Kuroshio Front beginning in the East China Sea, extending to the region south of Honshu Island, and concluding in the Kuroshio Extension east of the Izu Ridge. These studies on mixing processes led to his consideration of the effects of mixing on the modification of Intermediate Water in the Kuroshio and subsequently in the southward intrusion of the Oyashio Current. These various studies culminated in 1994 with the publication by Nagata and seven Japanese and US colleagues of an influential paper on the formation of North Pacific Intermediate Water.

Nagata spent 43 years at the Geophysical Institute of the University of Tokyo. A volume of the Kaiyo Monthly was dedicated to Nagata at the time of his retirement (1994) from the University of Tokyo, listed 104 scientific publications, 14 books and a literary essay entitled Poet of Ocean and Mermaid. In this publication there are 34 contributed review papers; many of these papers were authored by students of Nagata. Many of these students now occupy prominent positions in oceanography in Japan and other Asian countries.

After retirement from his Professorship at the University of Tokyo in 1994, Nagata moved to the Mie University. where he was Professor in the Faculty of Bioresources. At Mie he did research on the biology of the spiny lobster. Starting in April 1997 Nagata assumed the position of Director of the Marine Information Center of the Japan Hydrographic Association. His work, in cooperation with the Japan Oceanographic Data Center, (JODC) will focus on marine data and information management in Japan.

Nagata was a leader in promoting the study of the global ocean circulation. In the mid-1980s a small group of oceanographers began work on the formulation of a global study of the large-scale, low-frequency variability of the full-depth ocean circulation. This study was termed the World Ocean Circulation Experiment (WOCE) and was conceived of as an internationally coordinated observational and modeling program. During the period of time when the World Ocean Circulation Experiment (WOCE) was being proposed to the world oceanographic community, Nagata worked tirelessly (seven years on the WOCE Scientific Steering Group) to convince the Japanese oceanography community that Japan should be a major participant in the program. In large measure as a result of his creative advocacy Japan became a major partner in WOCE and contributed significant resources to its observational and modeling programs in the Pacific Ocean.

In the office of Geophysical Institute; Associate Professor at University of Tokyo, 1970.



Aboard the R/V Tansei-maru, University of Tokyo, Sept. 1983.

At International WOCE Scientific Meeting, Paris, Nov. 1988.

Nagata was deeply involved in PICES from the beginning. In fact, since he took part in the 1991 Scientific Workshop held in Seattle, his participation predated the formal establishment of the program. At the first meeting of PICES in October 1992, he was elected Chairman of the Physical Oceanography and Climate (POC) Committee and he initiated a sequence of activities which became the POC agenda.

First, a Working Group on the Okhotsk Sea and Oyashio Region was established and reported its findings at the second PICES meeting (October 1993). The lengthy and authoritative report of this working group, edited by Lynne Talley and Nagata, was published in 1995. Its publication preceded the POC sponsored workshop on the Okhotsk Sea and Adjacent Regions held in Vladivostok in June 1995. The report of the Vladvistok meeting, edited by Nagata, Vyacheslav Lobanov and Lynne Talley, was published in 1996. These reports synthesized for the first time an enormous amount of information about this key region in the PICES area. At the 1992 POC meeting, a second Working Group on Modeling of the Subarctic Region was established and produced a report which was published in March 1996. At the conclusion of the work of the Modelling Working Group, a third Working Group on Circulation and Ventilation of the Japan/East Sea was established and is now working. Of course, this steady sequence of successful activities was the product of POC as a whole, but no one doubts that it was the inspiration and leadership of Nagata that brought it to pass.

From the beginning Nagata felt that it was essential that Russian scientists from the far east region be included in PICES and worked effectively to include them - even before Russia was officially a PICES member country. His ability to read Russian was of great help in communicating with the scientists working on PICES problems. He perceived that it would be advantageous to have a PICES meeting in Russia to develop good working relationships with Russian scientists with interests close to those of PICES. He proposed that a workshop be held in Vladvistok to complete the work of Working Group 1 on the Okhotsk Sea and Oyashio area. The workshop was attended by 144 people and was judged by many to be the most important symposium on physical oceanography and fisheries held in Vladivostok over the last decade.

Playing soft-ball game, 1984.

Helicopter tour to Kamchatka with Dr. Makoto Kashiwai after PICES Okhotsk Sea Workshop in Vladivostok, June 1995.

With wife Fumie, Pt. Rome, San-Diego, 1993.

The chairmanship of POC has passed to Paul LeBlond but Nagata is still very active in other aspects of PICES. He is co-chairman of the Implementation Panel of the Climate Change and Carrying Capacity project and with Vyacheslav Lobanov is preparing a multilingual glossary of place names in the Okhotsk Sea and adjacent regions.

Within Japan Nagata has been very successful in establishing close ties between scientists and the public-at-large. Of particular note is his active membership on the Nemuro Science Board which made it possible for PICES to hold a series of meetings in this friendly and attractive city. A number of his books were written to communicate the results of scientific research to the reading public.

In the Kaiyo Monthly honorary volume there are nine essays on friendships with Nagata. They express (unfortunately in Japanese for some of us) very well many of the characteristics that we in PICES have come to recognize in Nagata. His warm personality is photogenic as can be recognized in the accompanying photographs. His sense of humor and frankness make it possible for people on first meeting to feel at ease with him. Even though he is capable of telling a poor joke, his delivery is so colorful and engaging that everyone ends up smiling and laughing. He is unfailing in his consideration of the feelings of others and seemingly incapable of gratuitous critical remarks of others. Most of his colleagues are not aware that he is also a skilled athlete. He is an accomplished baseball pitcher and for many years was a manager of a successful sandlot team in Chiba Prefecture.

PICES has benefited greatly from his commitment to the program; we look forward to his continuing contributions in substance and style to the program.

This article is written by Dr. Bruce Taft (School of Oceanography, University of Washington, USA) with special input from Drs. Makoto Kashiwai (Hokkaido National Fisheries University, Japan), Vyacheslav Lobanov (Pacific Oceanological Institute, Russia) and Warren Wooster (School of Marine Affairs, University of Washington, USA) in appreciation and recognition of Dr. Yutaka Nagata's outstanding service to PICES over many years.

A brief look at mechanisms for support of oceanographic research in the United States

Vera Alexander
School of Fisheries and Ocean Sciences
University of Alaska
245 O'Neil Bldg.,
Fairbanks, AK 99775-7220, USA
E-mail: vera@ims.alaska.edu

Dr. Vera Alexander is Professor of Marine Science at the University of Alaska Fairbanks (UAF). She serves as Dean of the School of Fisheries and Ocean Sciences and Director of the Coastal Marine Institute at UAF. Since 1992 Dr. Alexander is the U.S. academic delegate to the North Pacific Marine Science Organization. She is also a University of Alaska marine representative to the National Association of Land and Sea Grant Colleges, United States Marine Mammal Commissioner, Treasurer on the Board of Directors of the Arctic Research Consortium of the U.S., and a member of the Board of Governors of the Consortium for Oceanographic Research and Education and the Committee on Geophysical and Environmental Data of National Research Council. Vera received her B.Sc. (1955) and M.Sc. (1962) from the University of Wisconsin and her Ph.D. (1965) from the University of Alaska. Her fields of research are biological oceanography of high-latitude sea-ice impacted areas, with emphasis on ice biology, primary production and nitrogen dynamics, and high-latitude limnology.

Introduction

The primary source of financial support for ocean sciences in the United States is the federal government. Three agencies provide the major part - the National Science Foundation (NSF), the United States Navy's Office of Naval Research (ONR), and the National Oceanic and Atmospheric Administration (NOAA). Each of these plays a distinct role, given that their missions differ. The National Science Foundation is responsible for basic research, whereas ONR has defense-related obligations. Nevertheless, ONR supports much basic research, since oceanographic knowledge clearly has strategic value. NOAA supports research which contributes to its mission, and also has some specialized programs for research support. It is not possible to address all the many and varied programs which are included within the federal agencies. The aim of this discussion is to provide an idea of how the system works in the United States, from the perspective of a scientist independent of agency affiliation.

Primary Funding Agencies

The mechanisms for financial support of marine sciences in the United States are diverse and complex. However, the commonly accepted assumption among academic oceanographers is that the system used by NSF is effective and fair, and on the whole, results in support for the highest quality research. The process involves open competition based on research proposals, which may be submitted in response to a Program Announcement or may be unsolicited. Proposals are submitted according to an advertised schedule for each Program, and each is sent to a number of carefully selected scientists knowledgeable in the research area for peer review. The process also may include convening either a standing or an *ad hoc* panel to assist in ranking the proposals. The final scientific/technical decision lies with the Program Manager, within the constraints of the available funds. Although the Ocean Science Division of NSF is the primary source of marine science funds, other disciplinary Divisions also provide funds for marine research. The Office of Polar Programs supports most of the Southern Ocean research and a large proportion of the arctic oceanographic research.

The National Science Foundation maintains a balance between "big science" and small individual-investigator projects. This has been the case since the International Decade of Ocean Exploration launched the tradition of large, planned, multi-disciplinary, multi-investigator research. Following the end of the Decade, the Ocean Sciences Division of NSF developed a long-range plan which provided for global-scale ocean studies, recognizing the timeliness of and need for such approaches. The technological capabilities for conducting such work, in the form of satellite remote sensing, drifting buoys and moored instrumentation, had become available. There was, however, concern that such programs not overshadow and squeeze out the smaller projects. The Ocean Sciences Division of NSF has continued its periodic update of the plan, and remains the primary source for marine science support for academic institutions in the United States, with a budget exceeding $200 million. Today, some major large programs are in their final stages the World Circulation Experiment (WOCE) is one such. The competition for NSF funds is extremely rigorous, and many excellent proposals must be declined for lack of funds. Although the funds available have increased over the years, the number of scientists competing for them has increased at a higher rate.

The National Science Foundation coordinates and supports the United States academic fleet through the University National Oceanographic Laboratory System (UNOLS). Some of the university-based vessels are owned by the Navy, some by NSF, and some by the academic institutions themselves. Support for time at sea is requested in the scientific proposals, and the operational survival of a vessel ultimately depends on the number of successful proposals requiring its use.

The Office of Naval Research has a strong oceanography program and also an arctic program. Most of the support until recently was dedicated to deep water oceanography, with little attention to the coastal areas. With a new emphasis on "littoral oceanography", broadly defined as continental shelf areas, ONR is supporting additional work in near shore areas. Several large international projects supported in the past focused on physical oceanography and marine geology and geophysics. Some academic oceanographic institutions receive major funding through this agency. A new expansion of the Navy/Academic relationship has emerged as a result of the passage of the National Oceanographic Partnership Program in 1997. Although this is to be a multi-agency program, at present only the Navy is initiating support for projects under the act. A Broad Agency Announcement requested pre-proposals this spring, and those that fit the criteria for funding were developed into full proposals for further consideration. The guidelines are clearly designated, and require partnerships among federal, academic, and private entities. Here again, a peer review process is used to evaluate proposals.

The National Oceanographic and Atmospheric Administration has a complex mission, since it has the mandate to provide meteorological services, geodetic mapping services, as well as fisheries assessment and management. A strong in-house program in marine sciences exists through the NOAA Environmental Research Laboratories. For example, the Pacific Marine Environmental Laboratory in Seattle is a major player in oceanographic research in the North Pacific. The National Marine Fisheries Service conducts fisheries research and assessment, and also work on marine mammals; much of this is in response to federal legal mandates. Some external work is supported in conjunction with these programs. However, the major part of the funds currently provided to the academic marine sciences comes through two programs within NOAA - the Sea Grant College Program and the Coastal Ocean Program. NOAA's extramural funding appears to be increasing, primarily through partnerships with Academia through cooperative institutes.

Large programs benefit from multiple funding sources, since all agencies have severe budget constraints. NOAA was a major supporter of the Tropical Oceans and Global Atmosphere (TOGA) program, a ten-year international effort to study short-term climate change. From its inception in 1985, the program included studies of the atmosphere, the oceans, and their interactions, leading to a greatly-improved understanding of the El Nino and Southern Oscillation phenomena. This project is a good example of interdisciplinary work with university and

(cont. on page 36)

Research interests and the funding system for the new Ministry of Maritime Affairs and Fisheries of the Republic of Korea

Suam Kim
Korea Ocean Research and Development Institute
Ansan, P.O. Box 29
Seoul 425-600, REPUBLIC of KOREA
E-mail: suamkim@sari.kordi.re.kr

Dr. Suam Kim received his B.Sc (1976) and M.Sc. (1979) in oceanography from the Seoul National University and got his Ph.D. in fisheries oceanography from the University of Washington in 1987. Currently Dr. Kim is Principal Research Scientist at the Polar Research Center of the Korea Ocean Research & Development Institute (KORDI). His fields of interest include (1) the environmental factors causing the recruitment variability of fishery resources in the North Pacific and the Southern Ocean; (2) fisheries ecology, especially early life history of fish in relation to climate change; and (3) fish stock assessment, particularly by egg production method. Dr. Kim is the author of two books in assessment of fishery resources (1991) and fisheries ecology (1994) and co-editor of a few special publications on ecosystem structure and fisheries oceanography. He represents Korea on committees of international organizations such as: CCAMLR (Commission for the Concervation of Antarctic Marine Living Resources), SCAR (Scientific Committee of Antarctic Research), SO-GLOBEC (Southern Ocean-GLOBEC), and PICES (member of Fishery Science Committee and Implementation Panel on CCCC Program).

In Korea, marine-related affairs were handled by more than 10 government ministries. The growing needs for the formation of a more efficient organization have been suggested to deal with all marine-related affairs under one authority. Therefore, President Kim Young-Sam established a new cabinet-level ministry, the Ministry of Maritime Affairs and Fisheries (MOMAF), on August 8, 1996. The Korea Maritime and Port Authority, the Fisheries Administration of Korea, the National Maritime Police Agency, and the Hydrographic Office of Korea were consolidated, and their functions and budgets were transferred into the Ministry of Maritime Affairs and Fisheries.

To cope with the rapidly changing international relationships and the oceanic environment in the coming 21st century, the new ministry has highlighted the goals with several policy directions such as:

- constructing a nation that will lead the new marine order in the 21st century
- building the nation as a logistics center of northeast Asia with the aim of becoming the fifth strongest maritime power in the world
- stabilizing the supply of fishery products and construction of a prosperous fishery community
- building an advanced nation where both human and marine ecosystems can enjoy amicable coexistence
- developing the administrative expertise to meet the demand of the maritime industry, and enhancing its competitive edge in the international maritime arena

This ambitious plan of MOMAF will require a very high level of staff education as well as massive inputs on marine research. To carry out the objectives efficiently, long-term science planning and well-organized supporting systems are essential. MOMAF is considering how to construct research and development (R&D) systems in the fields of ocean and fishery sciences. Briefly speaking, the research that is of interest to PICES, will be the rational exploitation of resources and conservation of marine environments.

With government support, two governmental institutes, the National Fisheries Research and Development Institute (NFRDI) and the National Oceanographic Research Institute (NORI), will mainly undertake routine and basic scientific studies. Especially, hydrographic survey data will provide the fundamental information on tides, waves, currents, and other properties of seawater, and this information will be used for elaboration in forecasting techniques for finding fishing grounds or the occurrence of red tide, etc. The Korea Ocean Research and Development Institute (KORDI) and the Korea Institute of Maritime Affairs and Fisheries (KIMAF), which are government-sponsored institutes, will conduct pioneering scientific investigations, and take a role as a think tank to guide the direction of ocean research and to advise on ways to improve the strategic policy of government. MOMAF is a major funding agency supporting their activities through research contracts. Relatively small scale but process-oriented research will be conducted by universities (*Figure 1*).

In the early stages, MOMAF decided to undertake several plans over 10 years. Among them, the Marine Development Basic Plan (MDBP) and the Intensive Marine Environment Protection Plan (IMEPP) are related to PICES' interests. By putting a total of about 37 billion US dollars into a 10-year MDBP (1996-2005), which was enacted by the Marine Development Basic Act in 1987, the Korean government will:

- establish an ocean management system
- maximize the social and economic values of marine resources
- enhance the marine environmental quality
- reinforce the ocean technologies, oceanographic survey and research, and ocean services

A 5-year IMEPP (1996-2000) aims for the creation of cleaner marine environment. About 5.7 billion US dollars will be invested in the program, more than 90% of which will be used for the prevention of the influx of land-based pollutants, and the remainder for disaster prevention and protection of the marine ecosystem. The IMEPP will be carried out by joint efforts of several related ministries.

Korea is in a challenging position to advance both ocean and fishery sciences for its waters, though details in the direction of research and funding systems for marine sciences of the MOMAF are not yet clearly defined. Many scholars and advisory groups, therefore, have suggested to the government ways to enhance knowledge of the oceans. One of the opinions, which is very persuasive and agreeable to everyone, is to change the traditional paradigm. The key point of a new paradigm is to sustain living marine resources for the benefit of Korea through **science-based** conservation, enhancement, and management, and to promote the health of the Korean Exclusive Economic Zone. The new ministry might listen to this valuable advice and reflect it in this research direction when it designs an R&D funding system for marine sciences in Korea.

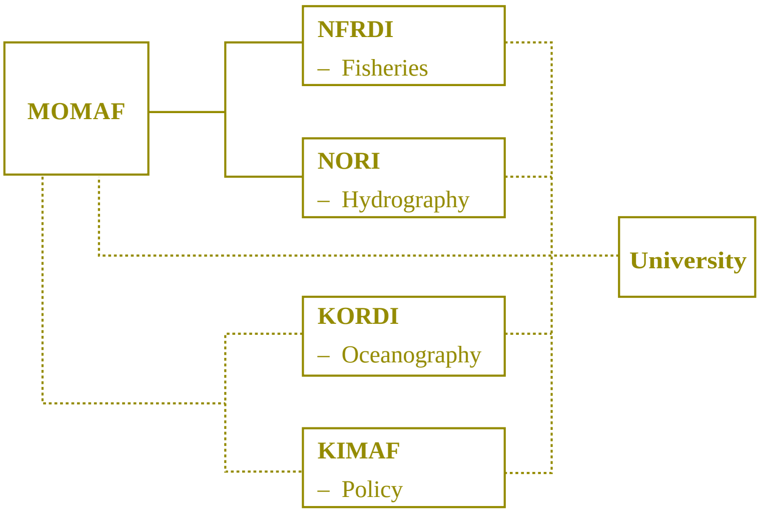


Fig. 1 The structure of marine research system funded by the Ministry of Maritime Affairs and Fisheries of the Republic of Korea (MOMAF).

The National Fisheries Research and Development Institute (NERDI) and the National Oceanographic Research Institute (NORI) are the governmental institutes, and the Korean Ocean Research and Development Institute (KORDI) and the Korean Institute of Maritime Affairs and Fisheries (KIMAF) are government-sponsored institutes.

PICES and Electronic Communication

Robin Brown
Ocean Science and Productivity Division
Institute of Ocean Sciences
P.O. Box 6000, Sidney, B.C.
CANADA V8L 4B2
E-mail:rmbrown @ios.bc.ca

Mr. Robin Brown is Oceanographic Data Manager at the Institute of Ocean Sciences (Department of Fisheries and Oceans) in Sidney, B.C., Canada. He graduated from the University of British Columbia in 1976 with a B.Sc. in Marine Biology and has participated in many physical, chemical and biological oceanographic programs in the North Pacific and Arctic Oceans, including the application of remote sensing techniques to oceanography. Presently Mr. Brown is the Chairman of the PICES Technical Committee on Data Exchange (TCODE).

During the PICES V meeting in Nanaimo, B.C., the PICES Secretariat conducted a survey of the state of electronic communications for PICES participants. The results were assembled by the PICES Secretariat and are an important information source for the Communications Study Group, which will report to the Science Board during PICES VI in Korea. The results of the survey are summarized below:

Participation

The response rate was only fair. We had 53 respondents from PICES nations, with a further 3 responses from other countries (one each from UK, Mexico and Australia). We originally received no responses from Chinese delegates, so the PICES Secretariat conducted a follow-up survey by e-mail, which was quite successful.

Email Access

All respondents have e-mail access, either through personal e-mail accounts (46/53) or through institutional email addresses (7/53). Most respondents check their e-mail frequently (once a day or better), but only in Canada, China and the U.S. it is common for people to be able to check their e-mail when they are out of the office. There are few organizations that use automated response systems, so it is possible that messages will not be responded to in a timely manner, especially by scientists who spend extended periods traveling or in the field. In general, there will be no indication if the recipient is unavailable to respond to e-mail for an extended period. Many respondents report that they are not able to receive binary attachments to e-mail messages reliably. We intend to review the responses in more detail, in order to present examples of hardware and software that do allow for reliable exchange of binary attachments.

World Wide Web Access

Most respondents have access to WWW (43/53). This number will increase, as a further 5 respondents suggested they would have access soon ("soon" was not defined). Access "speed" or bandwidth (and cost) is still an issue, although 31/53 respondents classify their web access as "fast" or "fast enough". WWW access has improved dramatically in China in the last year, but WWW access is still largely unavailable at institutions in the far east of Russia.

Most institutions in Canada, Japan and USA have web sites established, but personal web sites are not common. The PICES web site is well known to the respondents in most PICES countries, but further efforts are required to make Chinese scientists aware of the PICES Home Page.

There is modest support for the Bulletin Board function (30/53) but the number of respondents willing to contribute to such a BBS is smaller (25/53). We will need to carefully assess the demand for this, in view of the limited support for "contributions".

Question	Response	CANADA	CHINA	JAPAN	KOREA	RUSSIA	USA
1. E-MAIL Access:							
1.1 Do you have Personal e-mail access?	YES	8	2	11	3		22
	NO		4			3	
	No ans.						
1.2 Do you have institutional e-mail address?	YES	2	5	1		3	1
	NO	5	1	10	3		21
	No answer	1					
1.3 How often do you check your e-mail?	Continuously	2		2		1	10
	Once a day	6	5	5	3	1	12
	Several times a week		1	3			
	Several times a month			1		1	
1.4 Are you able to check your e-mail when you are out of the office for an extended period?	YES	6	5	1	1		13
	NO	2	1	9	2	3	9
	No answer			1			
1.5 Do you or your Institution/Agency use an immediate automatic reply system?	YES		3	3			4
	NO	6	3	6	1	3	17
	No answer	2		2	2		1
1.6 What mailing (communication) software are you using?	DEC (A1mail, Teamlinks,	6		1			1
	VAXMail)						5
	cc:mail			1			
	ELM						7
	PINE	1			2		3
	Eudora (various platforms)	1	3				
	Microsoft MAIL			1			
	Microsoft Exchange						2
	VINES			1			
	SUN Open Windows Mailer						1
	Groupwise						1
	WP Office			5	1	3	
	No specified		3				
1.7 Can you read Binary attachments to your e-mail messages?	YES	6	2	4	2	2	15
	NO	1	3	4	1		6
	Sometimes	1					
	No answer		1	3		1	1
	Total number of responses:	8	6*	11	3	3	22
	Total number of attendees :	72	8	43	15	16	76
	Response Rate (%):	11	0*	26	20	19	29
2. World Wide Web (WWW) Access:							
2.1 Do you have access to WWW?	YES	8	6	6	1		22
	NO			2		1	
	Soon			2	2	1	
	No answer			1		1	
2.2 Which web browser are you using?	Microsoft Internet Explorer	1	1				2
	Mosaic	2					
	Netscape	4	3	6	1		13
	Magellan						1
	No answer	1	2	5	2	3	6

2.3 How would you rate your WWW access?	So slow that it bothers me				2		7
	Fast enough for most purposes	7		6			13
	Very fast	1					2
	No answer			5	1	3	
2.4 Does your Institute have a WWW site?	YES	8		6			21
	NO		6	2		2	
	No answer			3	3	1	1
2.5 Do you have a personal WWW page?	YES	1					3
	NO	3	6	7		2	14
	No answer	4		4	3	1	5
2.6 Are you aware of the PICES WWW home page? (http://pices.ios.bc.ca)	YES	8	2	8	2	3	20
	NO		4	2	1		2
	No answer			1			
2.7 Do you think it would be useful to have a link between your Institution or Agency home page and the PICES home page?	YES	6	1	4	1	3	11
	NO	2	2	4			5
	No answer		3	3	2		6
2.8 Useful links							
2.9 Would you support a Bulletin Board on the PICES Home Page?	YES	8	3	3	2	1	13
	NO		2	4		1	4
	No answer		1	4	1	1	5
2.10 Are you willing to put information on such a Bulletin Board?	YES	8	3	2	2	1	9
	NO		1	2			
	No answer		2	7	1	2	7
3. FTP ACCESS							
3.1 Does your Institution of Agency have access to ftp? (file Transfer protocol)	YES	7	5	3	1		9
	NO	1	1	3		3	6
	No answer			4	2		7
3.2 Would it be helpful if the PICES Server will provide and FTP area for data exchange?	YES	6	6	4	2	3	13
	NO	1		1			3
	No answer	1		6	1		6
	Total number of responses:	8	6*	11	3	3	22
	Total number of attendees :	72	8	43	15	16	76
	Response Rate (%):	11	0*	26	20	19	29

* - Responses for China came from a follow-up survey conducted by e-mail after PICES V.

FTP Access

There does seem to be support for a PICES ftp area for exchange of documents and data. This may be an acceptable mechanism for exchanging binary document files, given that the support for binary attachments to e-mail is weak.

Comments on the PICES Web Page

There were few suggestions here. There were two suggestions that the pages need to be kept up to date, with fresh information whenever possible. The example used was that information on the PICES V meeting was not available on the web server (e.g. detailed program). There was a suggestion for more "useful lists" (data inventories, bibliographies, etc.). These issues are being addressed by TCODE and the Secretariat. A final suggestion was to provide links to on-line, real-time data (TOGA/COARE, OTIS and others). This is also in the TCODE workplan for 1997.

Comments on Improving Communications

More comments were received in response to this question. The main comment was that PICES should help improve access to e-mail and WWW in China and Russia, to allow fuller participation of the scientists in these countries. In particular, it was suggested that it was important to extend "low end" Internet capability (e-mail and ftp services) to the scientists in these two countries.

Japan Meteorological Agency: oceanographic activities

by Teruko Manabe *(see page 11)*

Outline of JMA

The Japan Meteorological Agency (JMA) is responsible for monitoring atmospheric, oceanic, seismic and volcanic phenomena as well as issuing and announcing related information including forecasts and warnings. In 1875, the forerunner of the Agency started national meteorological services and JMA was established in 1956 under the Ministry of Transport. JMA has been contributing to the improvements of public welfare including natural disaster prevention and mitigation, safety of transportation, prosperity of industries and international cooperative activities. Since the reorganization of the JMA Headquarters in July 1996, there are five Departments: Administration, Forecast, Observations, Climate and Marine, and Seismology and Volcanology. The budget of JMA is about 75 billion JPY for FY1996 and the total number of staff members is about 6,200.

Oceanographic Activities

JMA makes oceanographic observations and provides oceanographic information services. For better observations and information services, JMA also makes efforts in oceanographic research. These oceanographic activities are carried out in the Climate and Marine Department of JMA Headquarters in Tokyo, at four Marine Observatories in Hakodate, Kobe, Nagasaki and Maizuru and at the Meteorological Research Institute (MRI) in Tsukuba. The Climate and Marine Department is composed of four Divisions: Administration Division, Climate Prediction Division, Oceanographical Division and Maritime Meteorological Division. Oceanographic activities described below are mainly performed by the Oceanographical Division.

Observations

To monitor the state of the ocean and understand the mechanisms responsible for oceanic variability on various time scales, JMA has been making a variety of observations from hourly at the tidal stations to seasonal and annual on board research vessels. The Agency operates research vessels, ocean data buoys, tidal stations, and a Geostationary Meteorological Satellite (GMS) in order to obtain these observations.

JMA has six research vessels (two at the Headquarters and one at each Marine Observatory) which are used to collect *in situ* oceanographic data, including sea water temperature, salinity, ocean currents, chemical components (dissolved oxygen and nutrients), plankton and greenhouse gases, as well as marine meteorological data in the seas adjacent to Japan and in the western N. Pacific and equatorial regions (*Figure 1*). Observations are normally made from the sea surface to a depth of 2000 m (and only sometimes to the ocean bottom).

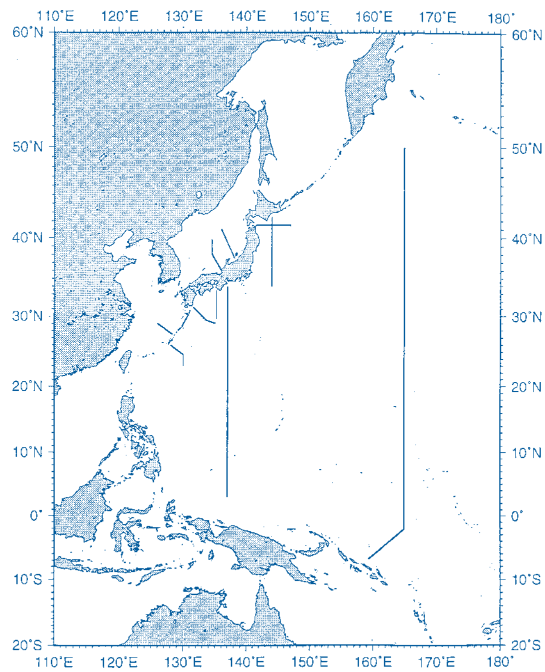


Fig. 1 Main observation sections of JMA.

The major interest of JMA for these observations are:

- ocean variability on decadal/interdecadal scales in the western North Pacific,
- seasonal/annual ocean variations in the areas adjacent to Japan such as the Kuroshio and the Oyashio,
- relationship between ENSO and warm water pool,
- monitoring of CO_2 flux between the ocean and the atmosphere.

In particular, meteorological and oceanographic observations have been made from south of Japan to the equator along 137˚E for about thirty years and have contributed to the understanding of the roles of the western N. Pacific in the climate system. In 1994, R/V Ryofu Maru, one of JMA's vessels, made a highly precise oceanographic survey as a part of the WOCE Hydrographic Program (WHP): one-time line P9 along 137˚E. A new R/V Ryofu Maru built in July 1995 is equipped with a greenhouse gases (CO_2, CH_4, CFCs, N_2O) measuring system and she commenced making observations along 165˚E from 50˚N to 7˚S in addition to the observations along 137˚E. JMA publishes "Data Reports of Oceanographic Observations" (available also on CD-ROM) to make the obtained data available to the public.

In the Oceanographical Division, the Pollutants Chemical Analysis Center was established in 1974. Its main task is to monitor the background level of heavy metals (such as cadmium and mercury) and petroleum pollution. The obtained data are published once a year in the "Report of Observation for Monitoring Background Marine Pollution".

Monitoring of greenhouse gases is a new important task of the research vessels. In 1989, JMA initiated operational monitoring of CO_2 and it has been determined that, in the western North Pacific, the ocean fluctuates between being a sink of atmospheric CO_2 in winter to being a source in summer.

In addition to the observations by its own research vessels, JMA is making an effort to promote subsurface temperature observations by ships-of-opportunity along routes: Japan - Persian Gulf and Hong Kong - New Zealand - Japan and in the TRANSPAC region.

As for coastal observations, there are 84 tidal stations along the coasts of Japan (*Figure 2*), which contribute to the protection of life of the citizens and coastal facilities from tsunami, storm surges and unusual tides. In addition, the observation apparatus for huge tsunamis are installed at 76 sites. Moreover, JMA began to observe the sea level at Minamitorishima (24(18'N, 153(58'E), which not only contributes to detecting tsunamis from the South Pacific well in advance but is expected to monitor the long-term variation of sea level related to climate change.

JMA also has three ocean data buoys in the Japan Sea, East China Sea and south of Japan. These moored buoys automatically make marine meteorological and oceanographic observations and send reports to JMA via GMS. These data are distributed to the world community through the Global Telecommunication System (GTS).

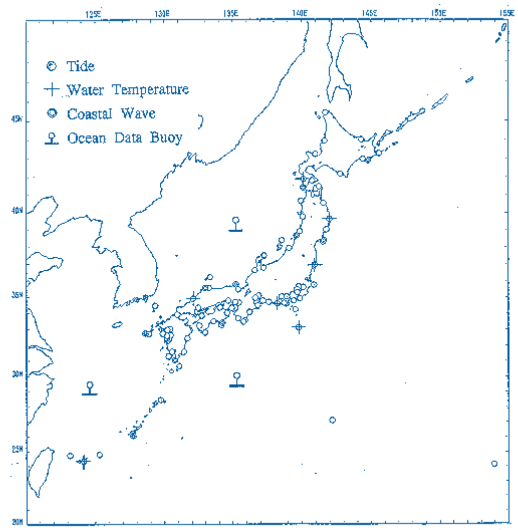


Fig. 2 Location of oceanographic and marine meteorological observation stations.

Oceanographic information services

JMA has been providing oceanographic information services for more than fifty years. The Agency collects *in situ* data from ships and buoys and remote-sensing data from satellites, as well as the observations made by JMA. Based on these data, the Agency has been making a variety of oceanographic products, including analyses and forecasts of 10-day and/or monthly mean sea surface temperature, subsurface temperature and sea surface currents. JMA has been making every effort to improve data analysis methods. For the purpose of ocean climate monitoring, especially ocean variability related to ENSO, JMA has developed an ocean data assimilation system and started to use it operationally and provide results for the equatorial Pacific in February 1995.

Some of these products are broadcast through meteorological radio facsimile to ships on an operational basis and JMA also publishes the Monthly Ocean Report which is distributed to interested domestic and international institutes and agencies. JMA also disseminates information on the latest states of El Niño events to the domestic public.

JMA has been in charge of a Specialized Oceanographic Center of the Integrated Global Ocean Services System (IGOSS) Data Processing and Services System (IDPSS) for the Pacific Ocean since 1984.

Research and development

To support the above operational tasks, JMA has been conducting various oceanographic research activities, mainly through the Meteorological Research Institute (MRI). To investigate oceanic variations and to study the mechanism of the interaction between the ocean and the atmosphere which makes it possible to predict climate change, basic research is conducted on the development of numerical models of ocean general circulation and ocean ice model for the simulation and/or prediction of the path of major currents (such as the Kuroshio), distribution of sea ice and sea surface temperature. A new ocean data assimilation system for the mid- and high-latitude regions is under development. Aiming at an operational forecast of ENSO, JMA is developing a coupled ocean-atmosphere general circulation model.

Furthermore, in the MRI, efforts are being made for developing methods for remote-sensing data analysis and for the application of the results to JMA's operational tasks. Recently, JMA has developed a method to derive sea surface dynamic heights from the TOPEX/POSEIDON altimetery data. JMA has also developed a method to determine sea surface current vectors from the obtained sea surface dynamic heights and sub-surface temperature distribution assuming the geostrophic balance (*Figure 3*).

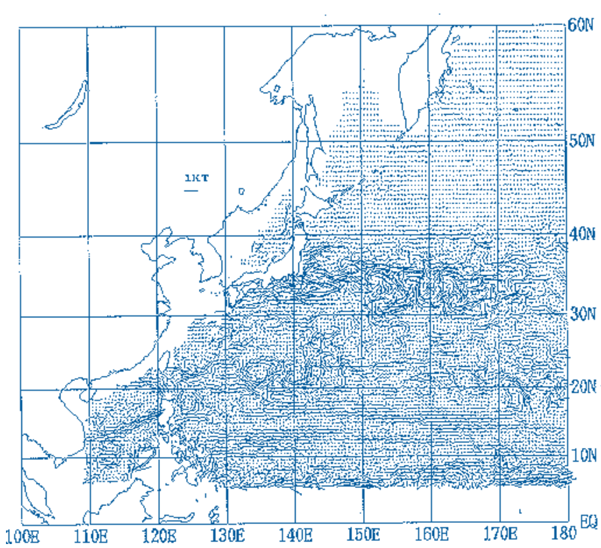


Fig. 3 Sea surface current vectors in the western N. Pacific (January 3, 1997). Vectors are derived from the sea surface dynamics heights from TOPEX/POSEIDON and sub-surface temperature distribution assuming the geostrophic relation.

(cont. from page 10)

occurring in the equatorial Pacific. Large scale pressure fluctuations originate on the equator, produce El Niño or its opposite the La Niña events, and these produce large responses in the extratropic regions. The early years of this decade were dominated (climatologically speaking) by a sequence of El Niño events without respite. The tendency towards or away from an El Niño is measured by the Southern Oscillation Index (hereinafter SOI) and this index is plotted in *Figure 4*. The SOI varied during 1996 between 0 and +0.8. This is on the La Niña side of normal, but the deviations from normal are weak. The SOI is usually reported in non-dimensional units, usually a normalized pressure difference divided by the standard deviation. Thus the peak value for 1996 is +1.0, or only one standard deviation above the long-term normal. The equatorial Pacific was close to the long-term climatic normal in 1996.

The Prospects for 1997 and 1998

In December of 1996 the SOI had the value +0.8. Also, other indicators were consistent with this value and indicated very cold conditions on the equator. Since El Niño and La Niña events, when they occur, usually start in the late fall of the year before (i.e., the 1983 El Niño started in Nov-Dec 1982) we can say with a very high level of certainty that there will be NO major climatic anomaly affecting the N. Pacific Ocean in 1997. Sea surface temperatures should not depart significantly from the climatic normals during 1997.

There are now about 15 computer models, each running on different principles, that attempt to predict the future of the equatorial Pacific and report their results monthly in the Experimental Log-Lead Forecast Bulletin published by the National Weather Service (National Centers for Environmental Prediction, and the Climate Prediction Center, NOAA, US Dept. of Commerce). Methods vary widely, some of the models are dynamical simulations, others are exclusively statistical. However, all agree that there will be no significant climate anomaly in the Pacific Ocean during 1997. Many of the models have been run for a long time and have developed an impressive track record, and the result is that it is believed that they have useful skill for forecasts 12 months in advance. So for the longer view, all of the dynamical models and most of the statistical models indicate that mild warming in the Niño-3 region should be evident by the end of 1997. In particular, the output of the new Scripps/MPI hybrid coupled atmosphere-ocean model suggests warming in the winter of 1997/98 sufficient to be called a moderate El Niño.

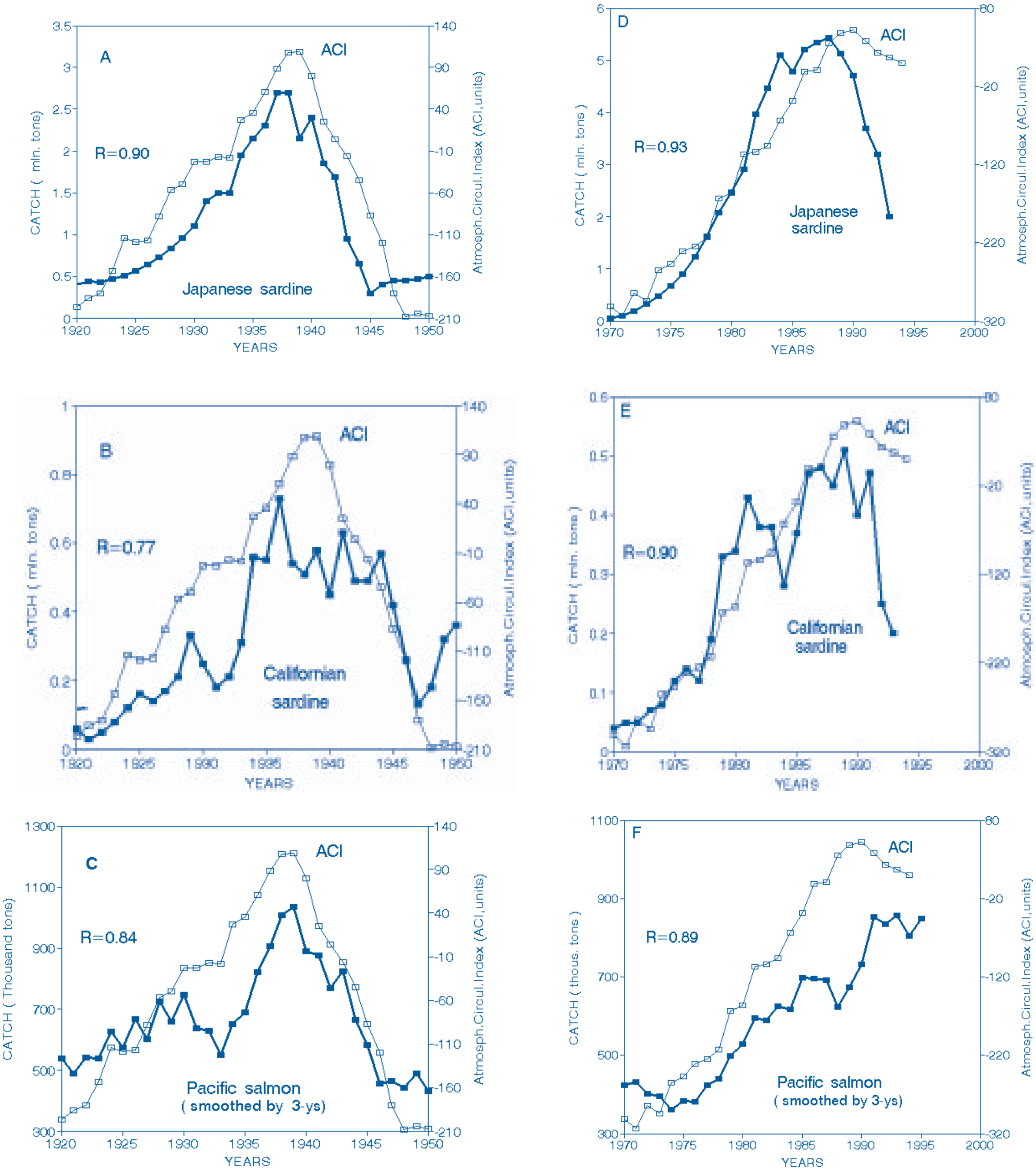


Fig. 6 *Relationship between salmon and sardine catch and Atmospheric Circulation Index (ACI) trend in the Northern Pacific for the periods of 1920-1950 (A, B, C) and 1970-1993 (D, E, F).*
A-Japanese sardine. B-Californian sardine. C-Pacific salmon.
D-Japanese sardine. E-Californian sardine. F-Pacific salmon.

(cont. from page 7)

The correspondence between ACI and sardine (salmon) catches for 1920-1950 and 1970-1994 is illustrated in *Figure 6*. The correlation coefficients between ACI and of Japanese sardine catch are 0.90-0.95. The corresponding figures for Californian sardine and Pacific salmon catches are 0.77-0.92 and 0.71-0.84, respectively. The curve of Pacific salmon catch has characteristic "saw-like" shape caused by the alternation of low and high-abundance (even and odd) generations of pink salmon. 3-year smoothing of this curve results in significantly higher correlation between ACI and salmon catches (0.84-0.89). A tight correlation is also found between ACI dynamics and catch fluctuations of most abundant Pacific species: Alaska pollock, Anchovy, Chilean jack mackerel and some others (Klyashtorin and Sidorenkov, 1996).

The Atmospheric Circulation Index (ACI) is calculated from the data obtained in the Atlantic-European region, but ACI trend corresponds to the long-term climate changes at a global scale (Girs, 1971). ACI fluctuations are synchronous with the fluctuations of the global and hemispheric temperature anomaly (dT), and corresponds to the dynamics of ALPI that is an important climate-governing index of the North Pacific.

ACI dynamics also correlates tightly (correlation coefficient equals 0.8) with the Earth Rotation Velocity Index (ERVI) that is a global geophysical parameter, digitally opposite to the Length of Day Index (Sidorenkov, 1980) (*Figure 7*).

The following hypothesis can be suggested to explain the above-considered phenomena. Some proportion of water evaporated from the ocean surface is carried to the polar regions and deposited in the ice sheets of Greenland and the Antarctic. Ice flows to the oceans do not vary much in time, and the increase in the ice mass is close to the dynamics of atmospheric precipitation and snow deposition. The latter is determined by dominant wind directions, and depends on the general direction of the air transportation during different climatic epochs (long-term changes in ACI). The water mass transfer from the ocean to the polar regions causes changes to the inertial moments and Earth rotation velocity (Sidorenkov, 1980). Changes in ERVI correspond to the fluctuations of some characteristics of global water exchange (Klige, 1985). Independently on a real mechanism of the above-considered phenomenon, tight correlation between ACI and ERVI makes it possible to accept the latter as a reliable global index of large-scale climate changes (Sidorenkov and Svirenko,1991).

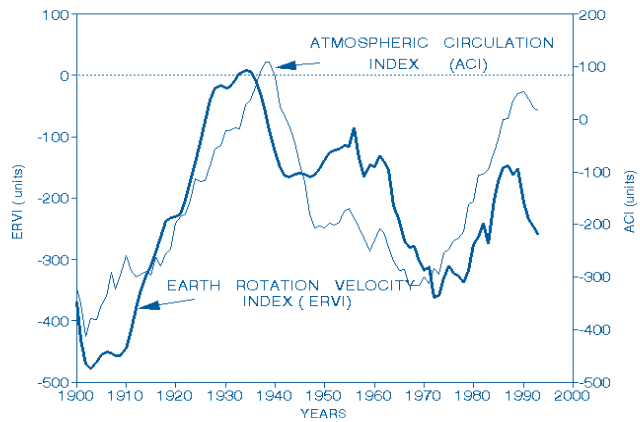


Fig. 7 *Trends of Atmospheric Circulation (ACI) and Earth Rotation Velocity (ERVI).*

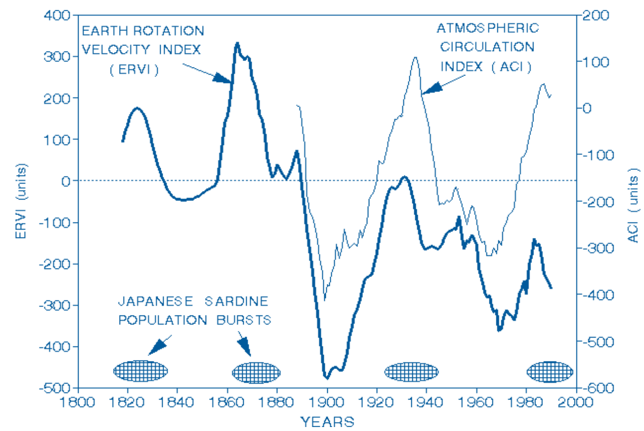


Fig. 8 *Trends of Atmospheric Circulation Index (ACI), Earth Rotation Velocity Index (ERVI) and Japanese sardine stock bursts for the period of 1800-1993.*

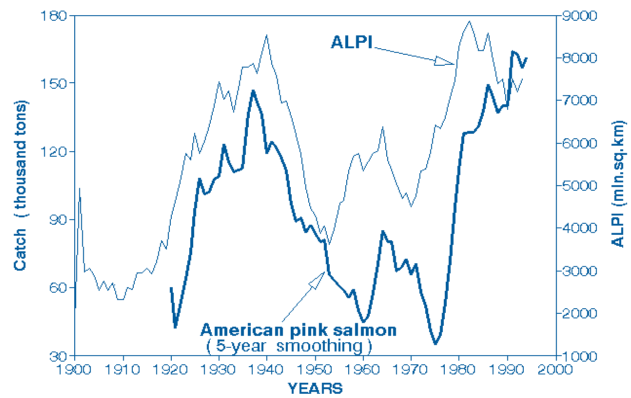


Fig. 9 *A comparison between trends of ALPI and American pink salmon catch.*

Periodicity in the Fish Production Fluctuations

Regular fishing statistics exist only for 70 years, however, the periods of high abundance of Japanese sardine have been registered in the Japanese chronicles since the 16th century (Kawasaki, 1992a,b, 1994).

Seven bursts of sardines have been registered over the past 400 years, (Kawasaki 1992a,1994) with average periodicity of about 60 years (from 50 to 70). Reliable time series on ERVI is 180 years old, and time series of ACI is about 100 years old. A good correspondence in ACI and ERVI dynamics (maximums), and outbursts of Japanese sardine are illustrated in *Figure 8*. The dynamics of Californian sardine and anchovy abundance was reconstructed recently by the method of detailed analysis of bottom deposition columns (Baumgartner, et al., 1992). The sardine outbursts have repeated regularly for almost 2000 years, with approximately 60-year periods. The bursts of anchovy took place with similar periodicity, but roughly opposite in phase to the sardine fluctuations.

Pacific salmon stocks also exhibit approximately 60-year periodicity, with maxima in the 1870s, 1930s, and 1990s (Beamish and Bouillon, 1993; Klyashtorin and Smirnov, 1992, 1995). Despite relatively high variability, the important climate-forming factor of the Northern Pacific - ALPI, agrees with the catch dynamics of American pink salmon (*Figure 9*).

CONCLUSIONS

Long-term fluctuations of pelagic fish production in the Pacific region in this century probably can be conceived as a result of two climate-related "waves". The first wave, with the maximum in the late 30s, was observed in the 20-50s. The second one started in the 70s and apparently reached its maximum in the late 80s-early 90s (*Figure 10*).

The development of the first climate-related wave of the 20-50s was manifested by synchronous change in the trends of basic climatic indices (dT, ALPI, ACI, ERVI) and stock dynamics of basic commercial species (salmons and sardines). After reaching a maximum in the late 30s, the catch trends and climatic indices decreased, and followed through the 40s to the "depressive" phase of the 50s (*Figure 10a*). The trends of climatic indices and catch dynamics follow in the

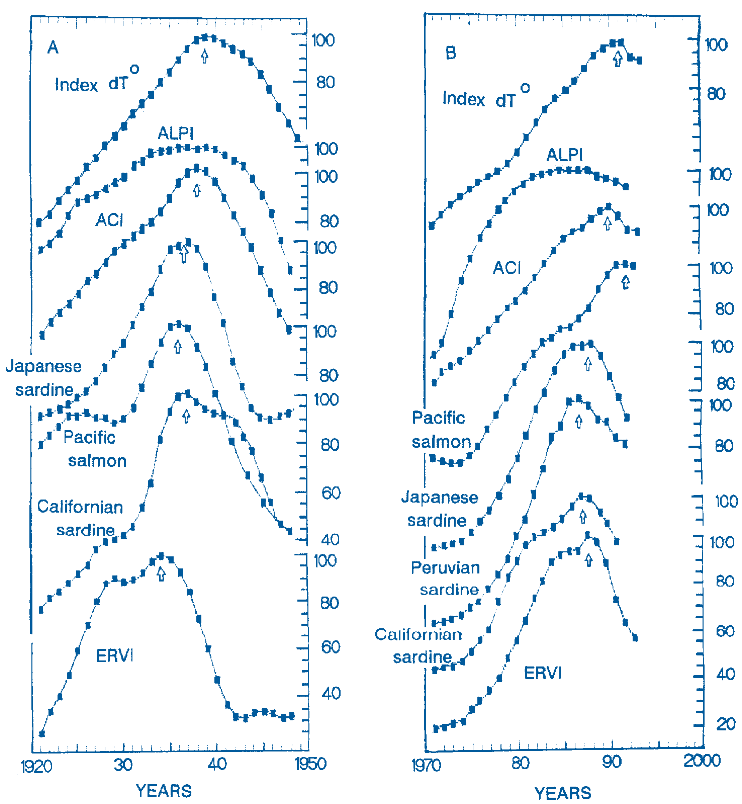


Fig. 10 The scheme of the general trend of climatic indices and commercial catches in the Pacific for the periods of 1920-1950 (A) and 1970-1993 (B). All curves are presented in per-unit form relative to a specific maximum taken as 100 percent and marked by arrows. All catches are smoothed by 5-years averaging.

dT - Annual air surface temperature anomalies (13-year smoothing); ALPI - Aleutan Low Pressure Index (13-year smoothing); ACI - Atmospheric Circulation Index (5-year smoothing); ERVI - Earth Rotation Velocity Index (5-year smoothing).

same manner during the development of the second wave of the 70-90s (*Figure 10b*). They reached their extreme points almost simultaneously (in the late 80s-early 90s), and now apparently come to their final phase analogous to the one of the 40s. The second climate-produced wave will likely be in a final phase in the beginning of the next century.

The dynamics of total salmon catches in the Pacific region is similar to that of main commercial pelagic species, and correlates with the above-considered global and hemispheric climatic indices. Based on the latter, one can conclude that the phase of fast catch increase (observed in the 80s) is already finished. In the near future, the catch trend will pass its extreme point, and gradual decline of the salmon abundance (and catches) will start in the beginning of the next century like it was in the 40s. It may also be assumed that by analogy with the period in the 40s, in the late 90s the trend of temperature anomaly (dT) will begin a gradual decline in line with ACI, ERVI, ALPI, and pelagic commercial catch. This contradicts the conventional belief in "global warming", but corresponds to the latest data on the dynamics of global and hemispheric temperature anomaly (Halpert et al., 1995). It is reasonable to expect that in the beginning of the next century, the oncoming new climatic phase will affect not only the oceanic but terrestrial ecosystems of all the Pacific region as well.

The large-scale changes in the Pacific fish production illustrate the response of oceanic system to long-term climatic changes. "In many instances biological organisms are integrators of environmental variables and may be more sensitive to low frequency climate events than physical time series" (Polvina et al., 1994). High correlation between ACI, ERVI, and catch trends allow us to consider these indices as predictors of long-term changes in salmon and other pelagic species abundance in the Pacific. Together with the concept of the approximately 60-year climate-production cycle, the application of these indices makes it possible to predict the dynamics of Pacific pelagic commercial species for 5-10 years ahead.

The existing forecasts of all scales may also be corrected in advance, as soon as new data on ACI and ERVI come to our disposal. Unlike many other meteorological indices, ERVI can be measured with high precision by astronomical methods, and the data on its actual dynamics can be obtained anytime. As soon as the mechanism of its high correlation with global water exchange processes is found, ERVI can be used as a basic indicator of global climate trends (Klyashtorin, 1996; Klyashtorin and Sidorenkov, 1996). The mechanism of the effect of climate changes on the fish production is not clear yet. The main reason is apparently the changes in total productivity of oceanic system in response to the long-term change in atmospheric circulation, heat transfer and oceanic surface turbulence (Bakun, 1990; Hsien and Boer, 1992; Brodeur and Ware, 1992, 1995).

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(cont. from page 1)

- F2. The level of regional scientific communication and cooperation is excellent.
- F3. Major scientific issues in ocean dynamics, in general, and marginal semi-enclosed seas, in particular, can be addressed in JES, especially with NEAR-GOOS in prospect.
- F4. Free access to EEZ-92s is the greatest limitation to international studies of the entire basin.
- F5. Access to Russian, North Korean, Japanese (NAVY), and American (NAVY) databases is a limiting factor.
- F6. JES circulation, chemistry, and biology are linked to adjacent seas and their river discharges, spawning grounds, etc.
- F7. Simulation and nowcast/forecast modeling JES circulation and ventilation to a broadly useful level of accuracy is a challenging but probably feasible task over the next decade.

Recommendations

- R1. Proceed to achieve the necessary level of understanding and encourage the coordination of PICES-GLOBEC, PICES-JGOFS, etc. activities with PAMS/JECSS, CREAMS II, NEAR-GOOS, and their follow-ones.
- R2. Future international studies should build upon recent CREAMS and fisheries science experience, expertise, and infrastructure.
- R3. Encourage development of such studies (e.g., CREAMS II) on an international basis.
- R4. PICES should endorse the general plan of research discussed in this report and use UNOLS to assure EEZ access. [Research vessels should possibly fly the PICES or UN (IOC) flag.]
- R5. PICES should work to improve the data exchange situation, e.g., through funding for Russian scientists.
- R6. Future multidisciplinary JES studies need to include links to adjacent seas, etc.
- R7. JES modeling activities should be evolved to interact well with observational studies and monitoring for mutual benefit; e.g., design of observational networks, hypothesis development, model evaluation, etc. An organized model-observations and model-model comparison activity should be considered to facilitate rapid progress.

Comments on the preliminary Findings and Recommendations will be welcomed, and suggestions for additional ones will be appreciated, as well. However, WG 10 will need to achieve a consensus on the final Findings and Recommendations.

For the PICES VI Annual Meeting, WG 10 is organizing the Physical Oceanography and Climate (POC) session on the Circulation and Ventilation of North Pacific Marginal and Semi-Enclosed Seas. In addition to presenting some of the highlights of the WG 10 report, this session will allow placing the Japan Sea/East Sea studies in the perspective of similar studies in the North Pacific region.

The summary report of PICES WG 10 workshop in Fukuoka was provided by the co-chairmen of WG 10, Drs. Sang-Kyung Byun and Christopher N. K. Mooers

Dr. Byun is Senior Research Scientist at the Korea Ocean Research and Development Institute (KORDI) and Manager of one of the biggest research projects at KORDI: "Study on Oceanographic Atlas in the Adjacent Seas to Korea - Southwest of the East Sea". His fields of interest include (1) hydrography, circulation and meso-scale eddies in the Japan/East Sea; (2) current measurements in the Korea Strait; and (3) ocean acoustic tomography. He received his B.Sc (1972) and Ph.D. (1980) in physical oceanography from the Seoul National University and the Universite de Bretagne Occidentale, France. Dr. Byun is a member of PICES' Physical Oceanography & Climate Committee.

Dr. Mooers is Professor of Applied Marine Physics (with secondary appointments in Meteorology and Physical Oceanography and in Marine Affairs and Policy) at the Rosenstiel School of Marine and Atmospheric Science (RSMAS) of the University of Miami (UM). He serves as Director of the UM Ocean Pollution Research Center and of the RSMAS Ocean Prediction Experimental Laboratory (OPEL: his own research group), and as the Coordinator of the Coastal Ocean Sciences Program at RSMAS. Most of his research has been focused on coastal ocean circulation dynamics. In recent years, OPEL has been developed to focus on circulation modeling of marginal and semi-enclosed seas and to engage in setting up experimental, real-time nowcast/forecast systems. Chris received his B.S. (1957) from the U.S. Naval Academy, M.S. (1964) from the University of Connecticut, and PhD (1969) in physical oceanography from the Oregon State University

(cont. from page 21)

government scientists working together. The research was coordinated by an external advisory panel, and in addition to NOAA support, NSF, the National Aeronautics and Space Administration (NASA), and ONR supported components of the work.

The National Oceanographic and Atmospheric Administration's Coastal Ocean Program is supporting a series of focused, ecologically-based regional studies to improve predictive ability for fisheries management. The same Program supports the U.S. GLOBEC program, in consort with NSF. Initiated in the Georges Bank area, the work has moved into the Antarctic regions and now GLOBEC is planning a Pacific Ocean program. GLOBEC involves a national steering committee. These programs also involve scientists from several sectors and disciplines, and funding is based on competitive proposals and peer review. Such cooperative efforts among agencies are likely to be the mechanism for U.S. participation in much of the international research evolving from the PICES planning project.

Other Agencies

The Department of Energy has a small marine research program primarily dealing with shelf-basin interactions and with carbon dioxide. The Environmental Protection Agency likewise has a small, but decreasing marine effort, and the Department of State has, at times, had funds to support specific areas of research. However, in developing PICES research programs, it is likely that the three major agencies, NSF, NOAA and ONR, will be the primary funding sources for any United States component. Given the process involved in developing programs, it is important to initiate planning well in advance so that either a national steering committee can be established through the appropriate channels, or the program can be attached to an existing initiative which has a steering mechanism in place.

PICES Sixth Annual Meeting

October 14 - 26, 1997
Pusan, Korea

- Bass Symposium (SB): Ecosystem dynamics in the eastern and western gyres of the subarctic Pacific
- Circulation and ventilation of North Pacific marginal and semi-enclosed seas (POC)
- Micronekton of the North Pacific: Distributions, biology and trophic linkages (BIO & FIS)
- Models for linking climate and fish (FIS & BIO)
- Processes of Contaminant Cycling (MEQ)
- Harmful algal blooms: Causes and consequences (BIO & MEQ)

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Sidney, B.C.,
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Tel.: (1-250) 363-6366
Fax: (1-250) 363-6827
E-mail: pices@ios.bc.ca
http://pices.ios.bc.ca

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