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CREAMS, PICES, and the Exploration of the Japan/East Sea

The Japan Sea, known as the East Sea in Korea, is the site of a large variety of oceanic phenomena. The Japan/East Sea (JES) appears to be unique in that nearly all of the physical processes that occur anywhere in any ocean also occur in the Japan/East Sea (JES). The southern portion of the JES is subtropical most of the year, and the northern sector of the JES is ice-covered in winter and behaves as a localized polar sea. Strong frontal mixing along a subtropical-subpolar frontal boundary and deep convection are two processes that generally do not take place in close proximity to each other in most of the world's oceans, but in the JES the two can sometimes be quite active at the same time within a few degrees of latitude and longitude. This large variety of physical processes occurring over a relatively small geographic region makes the JES an ideal laboratory for improving our general physical oceanographic knowledge.

Scientists from countries that border the JES have, of course, studied these phenomena for a number of years under the auspices of the CREAMS (Circulation Research of East Asian Marginal Seas) program (see Professor Kuh Kim's excellent discussion of CREAMS in PICES Press, Vol. 5, No. 1), and other efforts to understand the circulation of the JES go back over half a century. Last year, a new program in the United States was initiated that will support approximately 15 U.S. investigators to make detailed observations and develop models of the JES circulation during the period 1999-2003. The collaboration of the ongoing CREAMS research and this newly sponsored work in the U.S. suggests that the ability to observe the JES well enough to understand its physics and to develop a predictive modelling capability is within the reach of the JES oceanographic community within the next decade.

The development of future research programs in the JES and the collaboration between scientists in the countries studying the JES were the topics of two days of discussion at the recent 5th CREAMS Workshop, held in Seoul on April 28-29 of 1998. Nearly 50 scientific representatives from the Republic of Korea, Japan, Russia, and the United States attended the meeting, and a number of important discussions took place that were centered on the short-term and long-term plans for the exploration of the JES and how this exciting work could best be carried out. In addition, since all of these countries are also members of PICES, there were several important discussions of the relationship of PICES to this expanded research effort in the JES.

(cont. on page 34)

The state of the eastern North Pacific from September 1997 to February 1998

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

Figure 1 shows the monthly mean sea-surface temperature (SST) anomalies in the eastern North Pacific from September 1997 through February 1998. The North Pacific remains dominated by the 1997/98 El Niño and is likely to stay under that influence for several more seasons.

The anomalies vary somewhat in intensity, but the pattern of the anomalies is remarkably consistent through all of the elements of *Fig. 1*. Throughout the months shown, sea surface temperature is high along the coast of North America and lower than normal in the Central Pacific. This distribution is a typical response of the northern North Pacific to El Niño forcing. The most intense anomalies occurred in September, 1997. In support of that, we found that at the British Columbia lighthouses (where sea surface temperatures have been registrated daily for 65 years) the highest monthly mean surface temperatures ever recorded were observed at the west coast stations also in September. Though anomalies off western Canada remain high, the tongue of high SST that previously extended along the Aleutians past the dateline indicates evidence of its retreat to Kodiak Island.

Figure 2 below demonstrates a plot of the subsurface temperature anomaly field observed on the outbound trip along Line-P during February 1998. Line-P extends from the mouth of the Juan de Fuca Strait (southern Vancouver Island) to Ocean Station Papa at 50°N and 145°W and is marked by a bold line on the February 1998 panel on *Figure 1*.

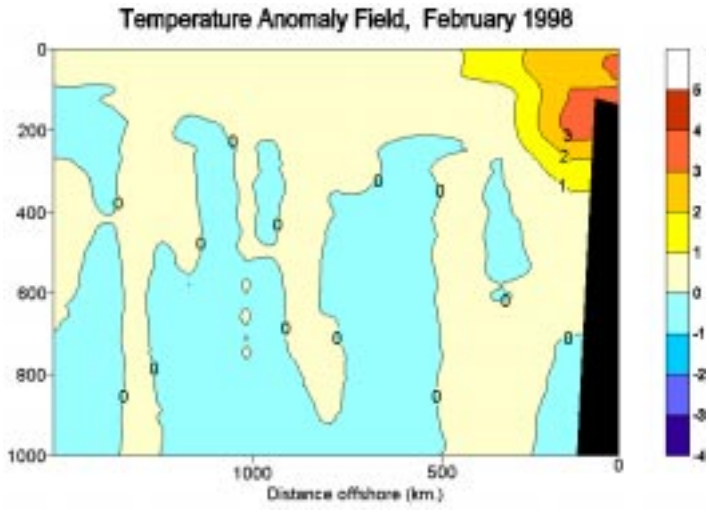

Fig. 2 Temperature anomaly field along Line-P, courtesy of Frank Whitney and Marie Robert.

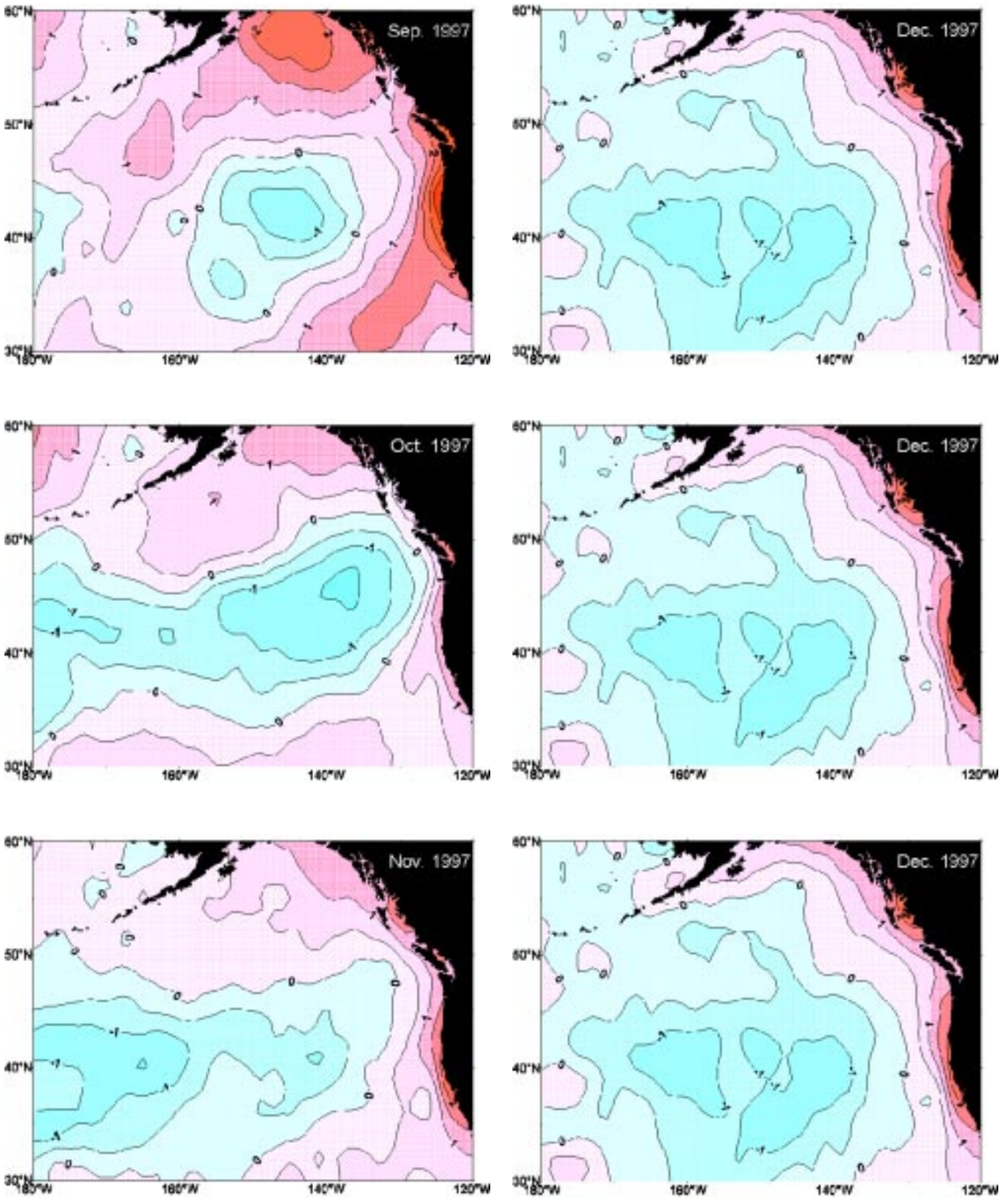

Fig. 1 Monthly mean sea-surface temperature anomalies for the eastern North Pacific Ocean, from September 1997 through February 1998. The labeled contours are at intervals of 1ºC with intermediate contours at intervals of 0.5ºC. Red tones indicate warm anomalies and blue tones cold anomalies.

The section is in general agreement with the sea surface temperature chart for February indicating near-normal conditions along most of Line-P. Also in agreement with the surface maps, we see the largest anomalies close to the coast of Vancouver Island. However, the surface chart is striking in that it shows the largest subsurface anomalies between depths of 100 m and 200 m. In this respect the anomaly pattern is very similar to the anomalies observed along Line-P in March 1983, during the largest El Niño event of the century.

Figure 3 demonstrates the variations in sea level at Prince Rupert. The purple line shows the variation in the long-term average sea level, and the blue line displays the 28-day averaged sea level from January 1997 to the present time. This illustrates the magnitude of the impact of the 1997/98 El Niño on the coast of British Columbia. Sea level is standing, as of early March 1998, about 35 cm above normal. This anomaly is larger than what occurred in 1983 and indeed has set new record anomalies around the coast of British Columbia.

Finally, no discussion of the state of the Pacific Ocean would be complete without some speculation about what the future holds. *Figure 4* shows a plot of the southern oscillation index (SOI) observed daily by Queensland Department of Natural Resources and the Department of Primary Industries in Australia. By mid December, 1997, the southern oscillation index had returned close to normal. However, through January there was a slow trend towards increasingly negative values culminating at the end of January and beginning of February in a large "westerly wind burst". This burst of El Niño-like activity on the equator was also clearly visible in the wind field observed on the equator by the TAO array. Since then the index has fluctuated but remained persistently negative.

Figure 5 presents monthly mean values of the SOI and the 5-month running mean. This demonstrates once again that the El Niño forcing on the equator remains substantial and we stay under the influence of a strong event.

Thus it is too early to claim that the 1997/98 El Niño is over, even on the equator. At higher latitudes we saw earlier that SSTs remain high over large regions of the North Pacific. Furthermore, the positive anomalies are distributed well down in the water column. The excess heat cannot be removed from the ocean in short order, thus the 1998 fishing seasons in the northeast Pacific will be influenced by the 1997/98 El Niño.

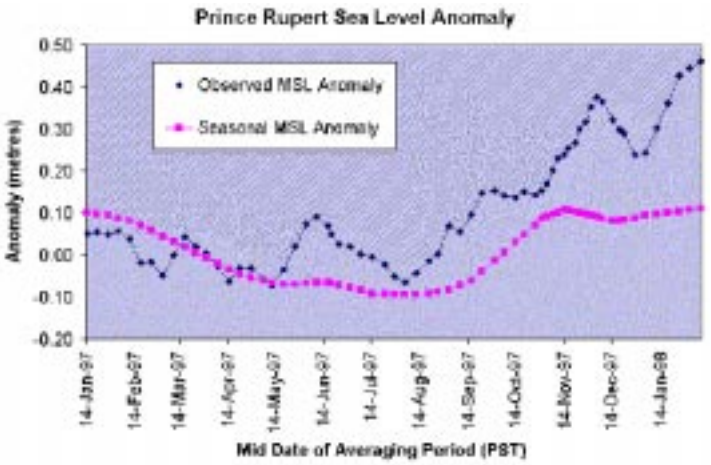

Fig. 3 Sea level anomalies at Prince Rupert, British Columbia, courtesy of Bill Crawford, Canadian Hydrographic Service.

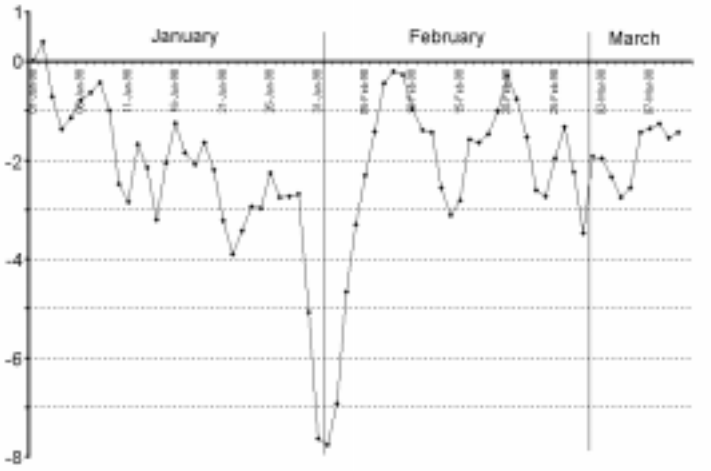

Fig. 4 Daily values of the southern oscillation index from January 1st to March 10th,1998.

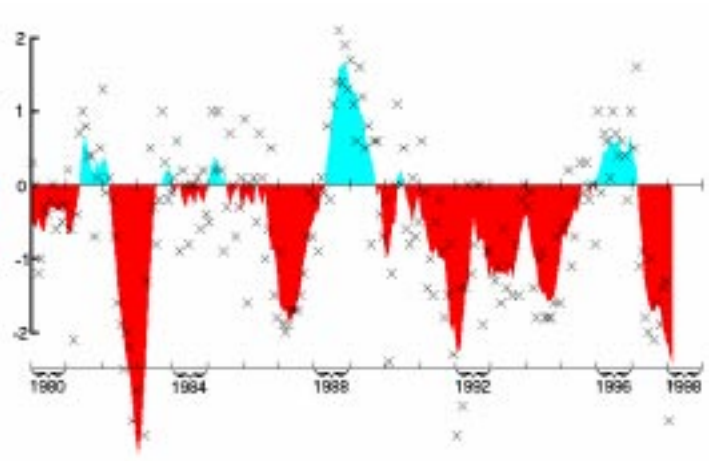

Fig. 5 Monthly values (X) of the southern oscillation index from 1980 to present. Colored fill areas show the 5-month running mean.

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

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

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

Sea Surface Temperature

Figure 1 shows monthly mean sea surface temperature (SST) anomalies in the western North Pacific from July to December 1997. These charts are based on monthly mean JMA's objective SST analysis for 1x1 degree grid points over the western North Pacific using *in situ* ship and buoy observations. The anomalies are computed from the JMA's 1961-90 climatology.

One of the most remarkable features in the second half of 1997 is that notable negative SST anomalies exceeding 1˚C were observed along 40˚N from May to October 1997. Anomalies were extremely negative in August exceeding -3˚C between 165˚E and 175˚E. These negative anomalies moved eastward in October, and SSTs were more than 1˚C below normal between 170˚W and 150˚W in December. Positive SST anomalies have persisted north of 50˚N during the same period.

Oyashio and Kuroshio

Figure 2 shows temperature distributions at the depth of 100 m east of Japan for July and October 1997. These charts are based on JMA's objective 100 m water temperature analysis for 0.25 x 0.25 degree grid points in seas adjacent to Japan using *in situ* observations from ships and buoys. In the figure, temperatures colder than 5˚C are recognized as the Oyashio cold water. The Oyashio cold water displayed typical seasonal variations during the second half of 1997 as in the first half of the year. In July 1997, the cold water pool, which was formed in June from the coastal penetration of the Oyashio cold water, extended southward reaching 37˚N. The pool gradually reduced in August and September, and no more Oyashio cold water has been observed south of 39˚N since October. The Kuroshio has maintained a non-large-meander path south of Japan since the summer in 1991.

Carbon Dioxide

JMA observed carbon dioxide (CO_2) in the western North Pacific on board the *R/V Ryofu Maru* in September-November 1997. The CO_2 concentration (partial pressure) in surface water was lower than that in the overlying atmosphere in the western subarctic Pacific, implying that atmospheric CO_2 was being absorbed by the ocean (*Figure 3*), but higher than that in the atmosphere in the subtropics. The CO_2 concentration in the equatorial surface water is usually higher than that in the atmosphere, meaning that the equatorial ocean emits CO_2 into the atmosphere. In October 1997, when very strong warm ENSO episode conditions continued, the difference in CO_2 concentration between the seawater and atmosphere no longer exceeded +30 µatm in the western equatorial Pacific. This is in great contrast to the CO_2 difference of +80 µatm observed in November 1996, when the tropical Pacific was undergoing slightly cooler-than-normal ENSO conditions.

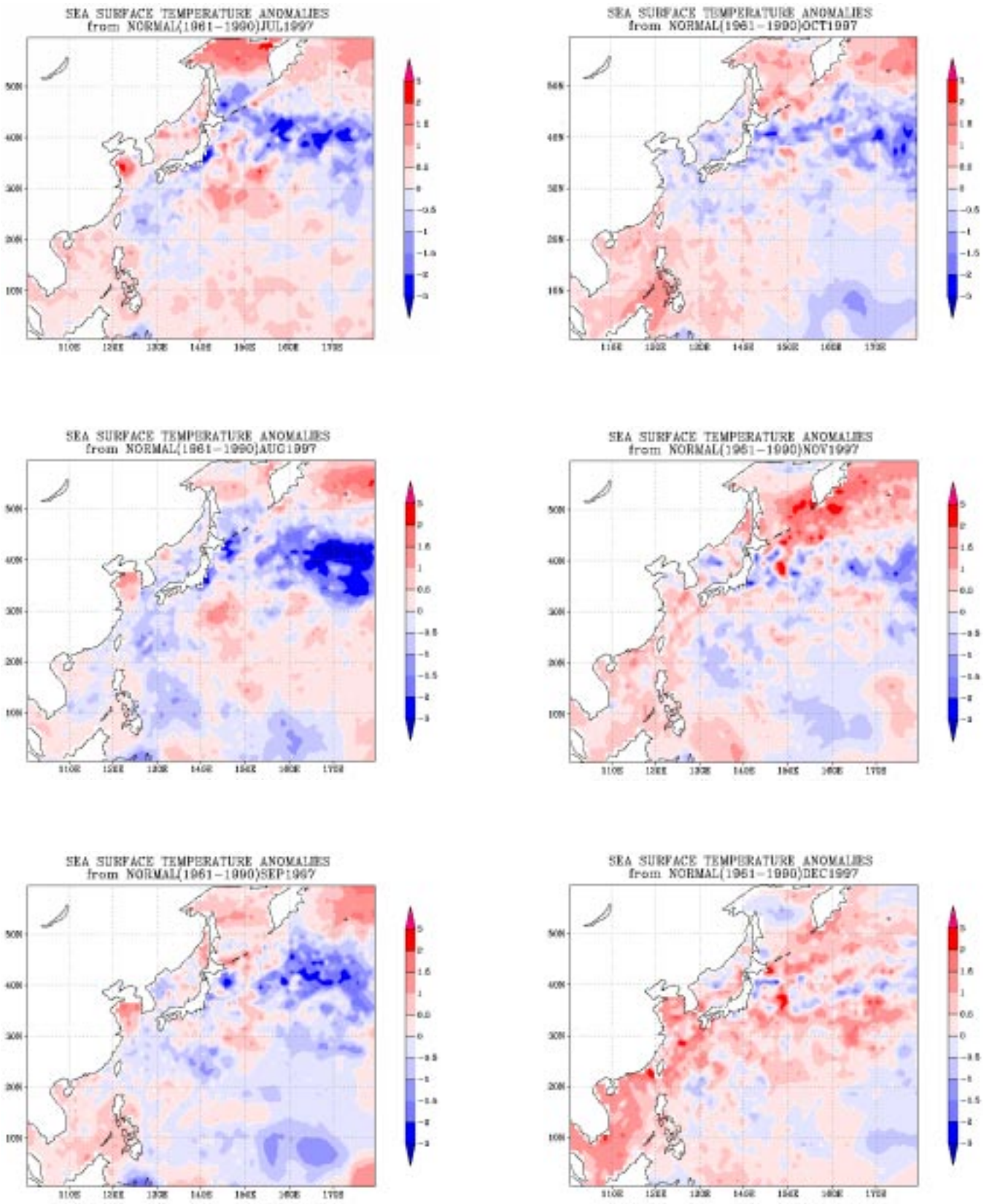

Fig. 1 Monthly mean sea surface temperature anomalies (˚C). Anomalies are departures from the JMA 1961-1990 climotology.

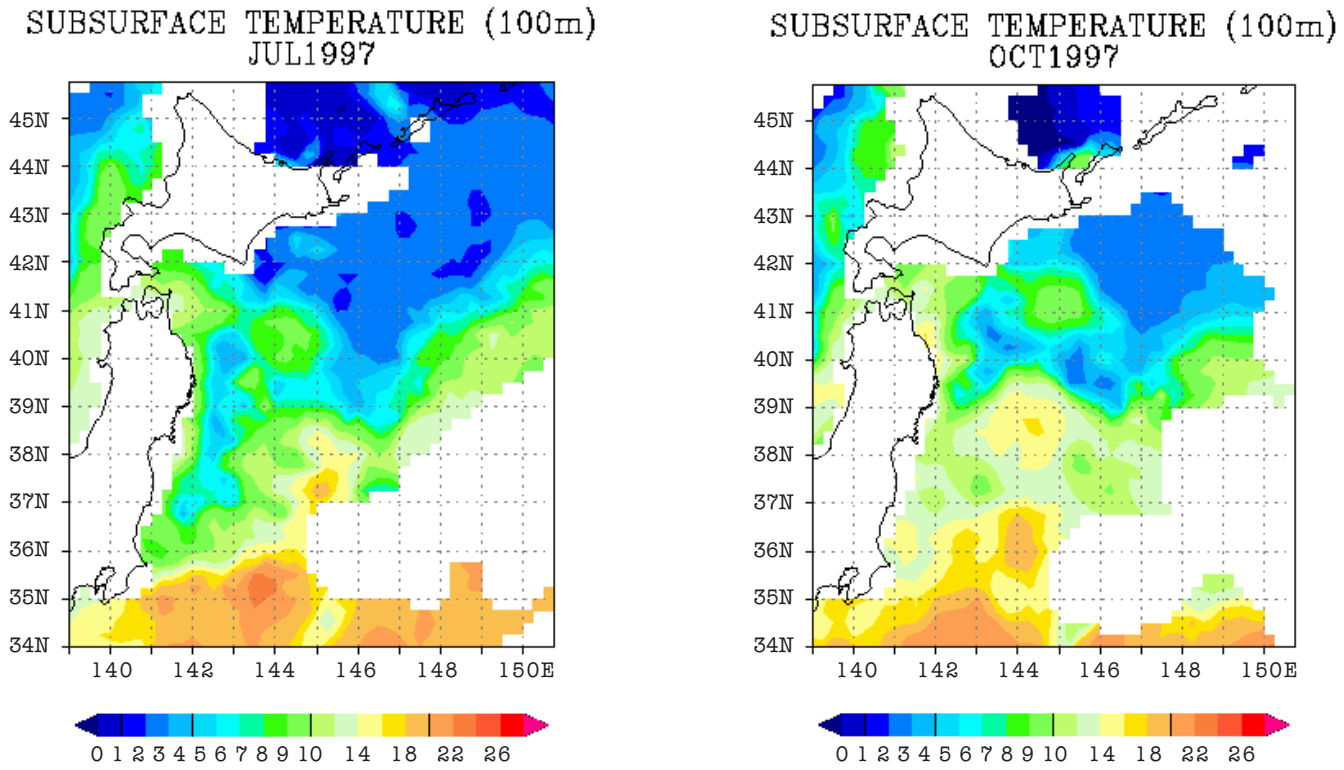

Fig. 2 Temperature (˚C) at the depth of 100 m east of Japan for July 1997 (left) and October 1997 (right).

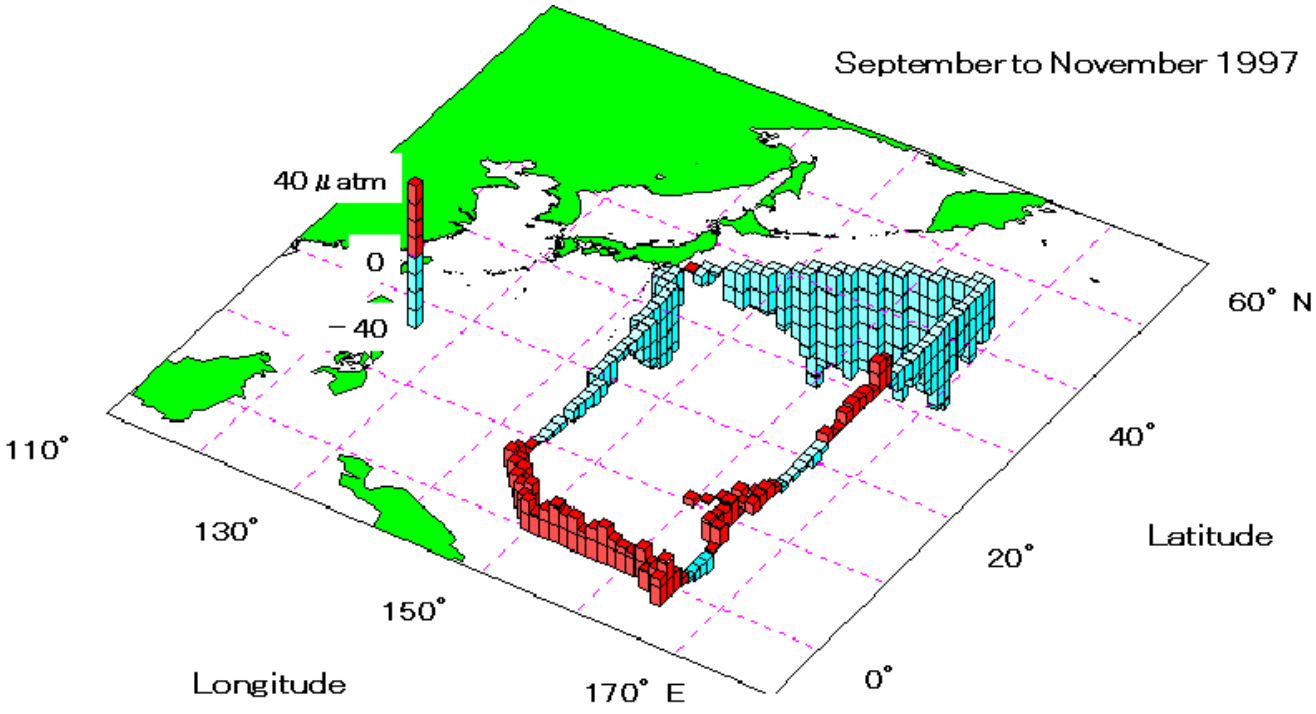

Fig. 3 CO_2 concentration difference between sea surface water and air in September-November 1997. Red upward bars indicate that the ocean emits CO_2 and blue downward bars indicate atmospheric CO_2 absorption by the ocean.

The status of the Bering Sea in the second half of 1997

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

Dr. Phyllis Stabeno, a physical oceanographer at the Pacific Marine Environmental Laboratory (PMEL) of NOAA, conducts research focused on understanding the dynamics of circulation of the North Pacific, Bering Sea and their adjoining shelves. She is the PMEL Director of NOAA Fishery Oceanography Coordinated Investigations (FOCI), and by applying her knowledge of physical processes to fisheries oceanography she plays a vital role in its success. 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 unmderstanding of ecosystems through the integration of physical and biological phenomena.

The Bering Sea, a northern extension of the North Pacific Ocean, is the world's third–largest semi–enclosed sea. It is divided into almost equal parts of a basin (maximum depth 4000 m) and a shallow, broad eastern shelf (*Figure 1*). Abundant fish and game in the Bering Sea have supported Asians and North Americans since prehistoric times. Presently, the sea is the most productive marine ecosystem for the United States and one of the most productive in the world. The U.S. fishery there provides about 40% of the U.S. fish and shellfish output.

The environment of the Bering Sea is highly variable. For instance, seasonal sea ice extent fluctuates over 1000 km. The Bering Sea is ice–free in the summer, but ice may extend over the shelf south to the Alaska Peninsula and eastern Bering Sea shelf break in winter. In addition, large interannual variations (100s of km) occur in maximal sea ice extent. The North Pacific (including the Bering Sea) displays considerable decadal variability; over one–third of the interannual variability of the winter Aleutian Low since 1900 is at decadal scales. This variability is influenced nearly equally by two larger atmospheric variability patterns, a tropical/temperate Pacific North American (PNA) pattern and an Arctic/NE Asia pattern, termed the Arctic

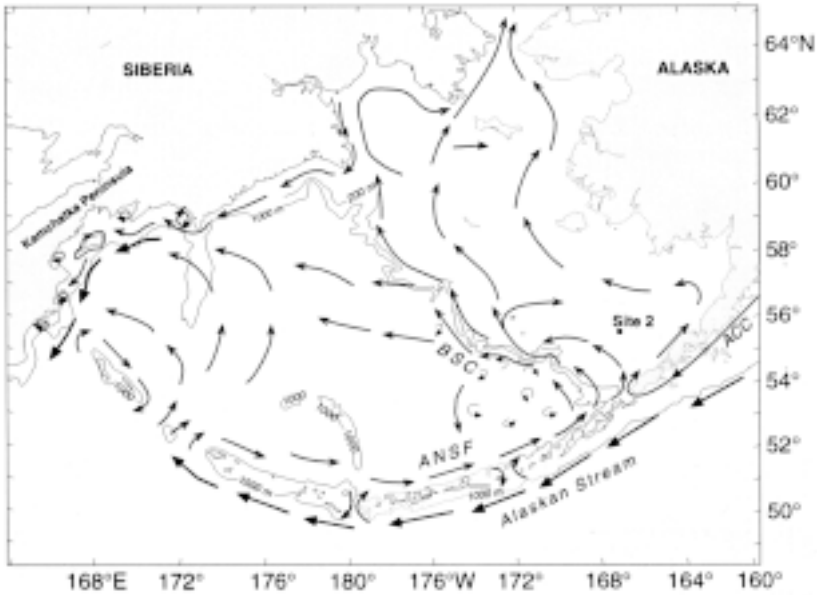

Fig. 1 A schematic of the mean circulation in the eastern Bering Sea. The Bering Slope Current (BSC) and Aleutian North Slope Current (ANSC) are shown. Site 2, the location of the temperature measurements, is indicated.

Oscillation (AO). There was a drift to deeper (lower sea level pressure) Aleutian Low around 1977, and there appears to be a return to pre–1977 conditions after 1989, driven primarily by changes in the AO.

Climate variability in turn affects the ecosystem. Alterations in storm tracks and storm intensity modify vertical mixing and the extent of sea ice, with greatest ice production occurring in years when the Aleutian Low is well developed and winds from the north are common. Changes in atmospheric forcing influence the exchange with adjacent oceans (North Pacific and Arctic Oceans) and the circulation on both the basin and shelf. The position and strength of the Bering Slope Current in turn influences the basin–shelf exchange of heat, salt, and nutrients for primary production.

The extremes in atmospheric forcing and its effect on the ecosystem were readily evident in 1997. Unusually weak winds during summer (*Figure 2*) and greater than usual solar insulation resulted in an anomalously shallow mixed layer and unusually warm sea surface temperature in the Bering Sea. These events were likely related, in part, to the atmospheric perturbations associated with the strong equatorial El Niño, as well as decadal variability. In addition, transport in the Bering Slope Current was approximately twice that previously observed (6–7 x 10^6 m^3 s^{-1}) and the flow along the 100 m isobath (*Figure 1*) was much reduced. There was a lack of on-shelf flow evident in the trajectories of satellite–tracked drifter. This lack of flux onto the shelf could have been a contributing factor in the reduced amounts of nutrients found on the shelf in 1997.

The weather patterns and the extreme oceanic conditions directly affected the ecosystem. The relatively warm and calm summer brought a rare bloom of coccolithophorid phytoplankton to the eastern Bering Sea. The bloom was evident in the first *SEAWIFS* imagery and was also noticed and photographed by astronauts on the high latitude flight in August. There were scattered reports of bloom continuing into at least October. In addition the largest die–off of short tail shear waters ever recorded in Bering Sea occurred. The commercial salmon fishery in Bristol Bay was declared a commercial failure. The calm pattern that dominated summer, ended with the arrival of four storms in September (*Figure 1*). This pattern of storms continued through January. A mooring, at site 2 (*Figure 1*) on the middle shelf, was maintained throughout the winter, and temperature (*Figure 3*) was measured throughout the water column. The two-layer structure characteristic of this shelf is clearly evident. Daily average upper layer temperature reached 14˚C during part of August, while temperatures

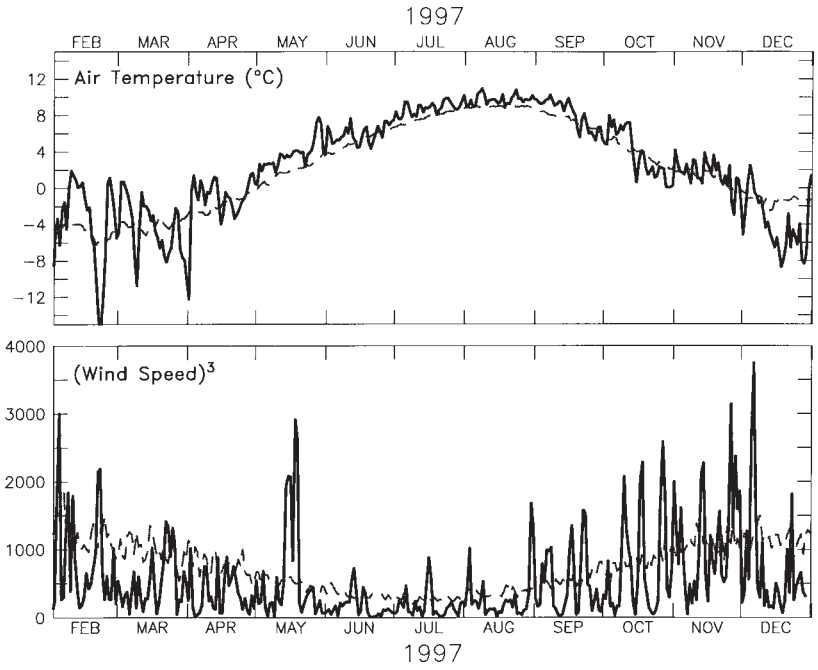

Fig. 2 A time series of air temperature and wind speed measured at St. Paul Island.

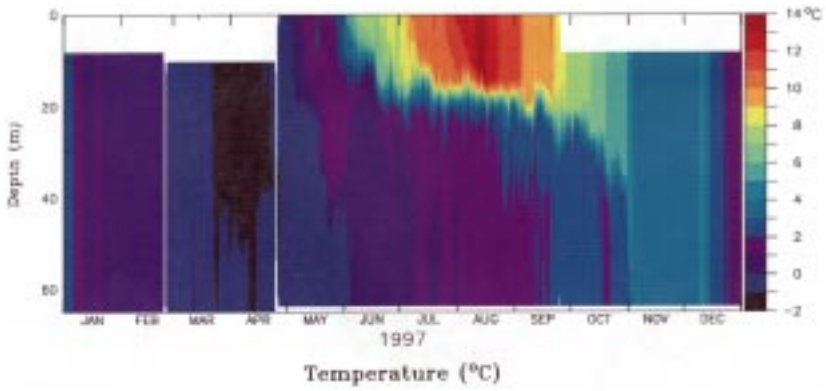

Fig. 3 Temperatures measured at Site 2. Temperature was measured ~3m½ in the upper 30 m and ~5 m below that. There were four separate mooring deployments. The very cold temperatures evident in April 1997, resulted from melting of sea ice. At this depth the water depth is 70 m.

(cont. on page 29)

Hyung Tack Huh

President of the Korean Society of Oceanography 1991-93.

No one has contributed more widely and intensively to the marine and fisheries sciences than Hyung Tack Huh, at least in Korea and to some extent in Asia. His contributions to marine and fisheries communities were highlighted when he has served as Director of the Korea Ocean Research and Development Institute (KORDI) from 1981-1988.

I (Chang Ik Zhang) first met Dr. Huh in 1982 at KORDI where he was young Director of the institute in his early 40s. At that time I was a young scientist at the National Fisheries Research and Development Agency in Pusan. I was impressed with his active and ambitious character as director of the organization, and I wished I could work with him at KORDI in the future. This dream was realized in 1988, when he called me early one morning in Seattle (because of the time difference between Seoul and Seattle) to offer me a senior scientist position at KORDI, when I just finished my Ph.D. program at the University of Washington. Since then I have joined KORDI and worked together with him on various fields of ocean research such as 'Cooperative Studies on Ocean Sciences among East Asian Nations', 'Yellow Sea Large Marine Ecosystem Research Project' and so on. He has managed the works with truly splendid skills during his years as Director at KORDI.

Prior to joining KORDI, Dr. Huh held several positions in the U.S. after finishing his graduate works at the University of Wisconsin in Madison. He was Head of the Plankton Section at the Nalco Environmental Sciences, Inc. in Chicago, Illinois and a Research Scientist for the Battelle Memorial Institute in Columbus, Ohio. He was elected as a fellow of the Ohio Academy of Sciences while he was in Ohio.

Dr. Huh has held domestically several positions in professional societies and activities. He has been the President of the Korean Society of Oceanography (KSO), and the Ichthyological Society of Korea, and President-elect for the Korean Society of Fisheries Resources. He was a founding member of the Korean Society of Oceanography and served as first Secretary-Treasurer for KSO. He has also been the Vice President for the Korean Fisheries Society and the Korean Aquaculture Society. He was the Editor-in-Chief for the Journal of the Korean National Commission for Antarctic Research in 1987 and served as Chairman for two terms during 1987-1991. Currently, Dr. Huh is Chairman of the Korean Oceanographic Commission which acts as National Committee for the Intergovernmental Oceanographic Commission (IOC).

Also, he has actively participated in the international marine science activities, especially with the IOC and PICES. He represented Korea in many intergovernmental and non-governmental conferences such as IOC, WESTPAC, SCAR, ATCM, IMO, UNEP, US-Korea Forum on Ocean Sciences and so on. He is the Vice-Chairman of WESTPAC, a Subcommission of IOC, concurrently serving as Vice-Chairman for PICES since 1995. He is also Vice President of the Pacific Congress on Marine Science and Technology (PACON).

Vice Chairman of WESTPAC (1996-99) with Dr. G. Kullenberg of IOC (center), Tokyo, 1996.

Chairmen of PACON 96 (from left, H.T. Huh, Dr. N. Saxena, Mr. Yan Hongmo, and Mr. J. Carey), Honolulu, 1996.

With Dr. Steeman-Nielsen in his laboratory in Copenhagen, Denmark, 1966.

Inspecting plankton samples, 1980.

His career as a marine biologist began as a junior scientist (planktologist) at the National Fisheries Research and Development Institute in Pusan, Korea in 1960. After working at the Korean National Commission for UNESCO as a program coordinator for marine science in early 1960s, he attended the UNESCO's Advanced Course in Marine Biology held in Denmark in 1966 where he studied under the supervision of well-known scientists such as Dr. Steeman-Nielsen and Dr. Gunnar Thorson. He went to Wisconsin from Denmark in 1967 where he obtained his degrees of M.S. in limnology and Ph.D. in biological oceanography from the University of Wisconsin-Madison.

With interests in the fields of marine biology/ biological oceanography (ecology, bioenergetics and behavior of fish, secondary productivity, thermal ecology and aquaculture), he has published over 100 scientific papers and over 200 articles and authored/ co-authored 7 books. Dr. Huh has contributed considerably in promoting Korea's marine science education at the high school and college levels by authoring two high school and two college text books in fish ecology and marine biology. Dr. Huh was also a lecturer at the Graduate School of Seoul National University and Kunkook University, and a guest professor at the Sungkyun-Kwan University in Seoul, Korea.

He pioneered aquaculture programs for the Pacific salmons, coho *Oncorhynchus, kisutch* and masu *O. mascu,* and rainbow trout *O. mykiss* in Korea. Experimental studies by Dr. Huh and his group have led the commercialization of salmon and trout culture using net-pens in the sea for the first time in Korea.

Touring mariculture farms on the southern coast of Korea with U.S. delegation including Drs. T. Smayda (URI), John Ryther (WHOI), and J. Mihursky (U. of Maryland), 1979.

Dr. Huh's achievements could also be recognized by many other contributions. Besides his leading role in founding the Korean Society of Oceanography, he contributed a great deal in bringing the Korea Ocean Research and Development Institute (KORDI) to the status of a major marine research institute by strengthening the facilities as well as supplementing man power.

Director of KORDI, 1981-1988.

During his tenure as Director of KORDI (1981-1988), he constructed the present campus in Ansan and tripled man power. He also engineered to build R/V Onnuri, one of Korea's first and most updated ocean going research vessels, and established an Antarctic Research Station (The King Sejong) on the King George Island in Antarctica. He initiated the Korea's deep seabed mining project (project leader) in the early 1980s which led Korea to join the Pioneer Investor Group (7 countries) for the Deep Seabed Mining in 1994 by acquiring a mining site (150,000 km^2 of seabed) in the Central Pacific Ocean authorized by the International Seabed Authority of the United Nations.

Dr. Huh has been actively involved in the governmental policy making activities in relation to fisheries, marine environmental protection, integrated coastal zone management, etc. He has been a member of the Advisory Committee for the several ministries of Korean Government such as the Ministries of Science and Technology, Maritime Affairs and Fisheries, Environment, Construction and Transportation, Education, Agriculture and Forestry, Internal Affairs, and many other public organizations such as Korea Electric & Power Co., Korean Association of Environmental Protection, Korean Federation of Fisheries, etc.

As a senior marine scientist, Dr. Huh has been playing a key role in promoting and coordinating regional and international cooperative programs in marine science. He has been the Korean project leader for the GEF's Yellow Sea Large Marine Ecosystems. He is responsible for the Korea-ASEAN Marine Biotechnology Program, and has been a national coordinator for the Canada-Korea Joint Workshops in Marine Science. In addition, he has played a key role in the development of scientific cooperation between Canada and Korea leading to signing of collaborative agreements between Canada's Department of Fisheries and Oceans and KORDI. He has served for many international conferences as honorary chairman/general co-chair for PACON 93-98, organizer/advisor for the Coastal Ocean Space Utilization (COSU), Oceanology International, International Congress on History of Oceanography, and chairman for the Scientific Organizing Committee for the WESTPAC Symposium.

Delivering opening remarks for the 1st Korean Antarctic Research Station (at the podium), 1988.

With Prof. Arthur D. Hasler of Univ. of Wisconsin visiting mariculture farms in the southern coast of Korea, 1989.

Dr. Huh has organized a series of international conferences, symposiums and workshops, notably "the International Conference on East Asian Seas." The Conference, jointly organized with the East-West Center of the University of Hawaii, has been held annually for five years from 1987 through 1991 covering most of the East Asian seas, the Yellow Sea, East China Sea, East Sea (Japan Sea), and the Okhotsk Sea. The conference was to seek cooperative solutions to transnational issues in the region, and eventually lend an impetus to the establishment of several international programs such as the Tumen River Development Project, NOWPAP (Northwest Pacific Action Plan), the Northeast Asia Economic Forum, etc.

Revisit to the University of Wisconsin campus with family, 1989.

He is also the Project Manager for the APEC Workshop on Persistent Organic Pollutants (POPs) in the Marine Environment which is an annual event held in Korea since 1997.

Dr. Huh has been involved in several EIS projects for the EPA and Commonwealth Edison Co. of U.S.A. as project manager or chief investigator while in the United States. His experience through the EIS studies in the U.S.A. led him to become one of the key personnel in establishing the Korea's Environmental Criteria for Nuclear Power Plants in the late 70s.

Dr. Huh has been awarded at home and abroad with such recognitions as the Moran-Jang (2nd highest national medal), Mokryun-Jang (4th class national medal), Wolhae Research Award in Fisheries (Wolhae Foundation), Excellent R & D Award (Ministry of Science & Technology), Excellent Paper Award (KORDI), Achievement Award (The Honor Society of Phi Kappa Phi), Ocean Service Award (PACON International). He has been the Fellow of the Korean Academy of Science and Technology (KAST) since 1994. Dr. Huh has been listed in the Marquis (U.S.A.) *Who's Who in the World*, and International Biographical Center's (U.K.) *Men of Achievement* since 1985 Editions.

Dr. Huh is fond of art and collects the works of locally known artists, especially abstract paintings. He is also a lover of music, particularly classical and impressionistics of Mozart, Beethoven, Debussy, Ravel, etc.

In Praha, Czecho with wife Yunghae, 1997.

With his knowledge of music he sometimes gives tips to his wife, a music professor at the Kyunghee University in Seoul. She is the only Asian referee among five international judges for the Missouri Southern International Piano Competition which was held in Joplin, MO, U.S.A. in April, 1998. His three sons, two in college and the last one in high school, play instruments, clarinet, violin, cello, and piano as a hobby. They sometimes play in an ensemble at home. Dr. Huh is a devout Christian and serves as an elder at the Nam-Seoul Presbyterian Church.

Dr. Huh is expected to contribute further in bridging Korean marine sciences into the regional and international cooperative works in the coming years.

Dr. Zhang received his B.Sc. (1976) and M.Sc. (1981) in fisheries biology from the Jeju National University and the National Fisheries University at Pusan respectively. He got his Ph.D. in fisheries ecology from the University of Washington in 1987. Dr. Zhang is Professor and Chairman (since March 1, 1998) of the Department of Marine Production Management of the Pukyung National University, Pusan, Korea. His fields of interest are fisheries ecology, fish population dynamics and stock assessment, and fishery management. Dr. Zhang is the author of two books (1991 and 1994) in fisheries ecology and the winner of the Most Significant Paper Award from the American Fisheries Society in 1991 and the Best Paper Award from the Korean Cooperation of Science and Technology in 1993 and from the Korean Fisheries Society in 1994. He is deeply involved in PICES activities, at first as a member and since 1996 as Chairman of PICES Fishery Science Committee. Dr. Zhang also serves as a member of SCOR Working Group 105 on The Impact of World fisheries Harvests on the Stability and Diversity of Marine Ecosystems.

Report on GOOS Living Marine Resource Panel Meeting

Warren S. Wooster
University of Washington
School of Marine Affairs
3707 Brooklyn Avenue,
Seattle, WA 98105-6715, U.S.A.
E-mail: wooster@u.washington.edu

Dr. Warren Wooster is an oceanographer who studies interactions between climate variations and marine ecosystems. He is a professor emeritus at the School of Marine Affairs, University of Washington in Seattle, and served as the first Chairman of PICES in 1992-1996. Previously he was President of the International Council for the Exploration of the Sea (1982-1985) and of the Scientific Committee on Oceanic Research (1968-1972), as well as Secretary of the Intergovernmental Oceanographic Commission (1961-1963). His earlier academic appointments were at the Scripps Institution of Oceanography (1947-1973) and the University of Miami, and he has been at the University of Washington since 1976. A detailed biography of Dr. Wooster can be found in PICES Press Vol.5, No.1 (January 1997).

The Global Ocean Observing System (GOOS) is sponsored by the Intergovernmental Oceanographic Commission (IOC), the World Meteorological Organization (WMO), the International Council of Scientific Unions (ICSU) and the United Nations Environmental Program (UNEP). Its mission is to use long term, multi-disciplinary, operational oceanographic monitoring for producing reliable assessments and predictions, including predictions of climate change, and to guide the direction of research and training to facilitate development of the system. Climate and health-of-the-ocean modules have been in preparation for several years, and most recently planning of coastal and living marine resource (LMR) modules has been initiated.

I had the opportunity to chair the first meeting of the LMR Panel, in Paris, on March 20-23, 1998. Other participants with PICES connections were Takashige Sugimoto and Chang Ik Zhang. The LMR panel had been preceded by workshops in Costa Rica (1993) and Dartmouth (1996), but agreement has yet to be reached on goals and objectives, as well as on an action plan for the future.

We agreed that the goal of LMR-GOOS is to provide operationally useful information on changes in the state of living marine resources and ecosystems. Its objectives are to obtain from various sources relevant oceanographic and climatic data, along with biological, fisheries, and other information on marine ecosystems, to compile and analyze these data, to describe the varying states, and to predict future states of the ecosystems, including exploited species, on useful time scales. Users of this information will include those concerned with the harvest, conservation, and scientific investigation of living marine resources.

Conceptually the requirements of scientists are easiest to satisfy in that most repeated measurements of ocean variables can be used in studying marine ecosystem variability. But what measurements will meet the needs of fisheries and their managers? Understanding of marine ecosystems is too limited to permit assessment and prediction of fish and other upper trophic level components from observations of physical conditions or of lower trophic level components. Perhaps direct observations of the abundance and distribution of fish will be essential to meet the needs of GOOS users.

While methods are available for monitoring many physical and chemical variables, measurement difficulties increase as one moves beyond the lower trophic levels. Distributions become more patchy in space and variable in time so that sampling as well as measurement becomes more problematic on anything more than the local scale. This argues that a goal should be to develop ways whereby the future abundance and distribution of upper level components can be predicted from variability at lower, more easily monitored, levels or preferably from physical variability.

Even if and when this capability materializes, predictions are likely to be on larger time and space scales than required by fisheries in their short term operations. While significant relations are appearing between physical variables and recruitment of some stocks, these seem to apply on relatively longer time scales, to some extent interannual, but more generally on decadal or longer, regime shift, scales. Thus one should soon be able to say that during a given physical regime in a given region, certain stocks might be expected to prosper while others would decline. The challenge will be to sharpen such predictions, perhaps through knowledge of variability

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PICES-GLOBEC Climate Change and Carrying Capacity Program
GLOBAL CONNECTIONS: A report of the GLOBEC International Open Science Meeting

Patricia A. Livingston
Alaska Fisheries Science Center
National Marine Fisheries Service, NOAA
7600 Sand Point Way NE,
Seattle, WA 98115, USA
E-mail: Pat.Livinston@noaa.gov

Patricia Livingston has been a fishery research biologist at the U.S. National Marine Fisheries Service (NMFS) - Alaska Fisheries Science Center in Seattle, WA, since 1977. She received her B.S. in Fisheries from the Michigan State University, M.Sc. in Quantitative Fisheries Management and M.P.A. in Natural Resource Administration and Policy from the University of Washington. Pat is presently serving as leader of the Resource Ecology and Ecosystem Modelling Task. At NMFS she has worked to parameterize, debug, and test various ecosystem and upper-trophic level models of the N. Pacific. Her research has focused on understanding groundfish trophic interactions relative to marine birds and mammals, particularly in the eastern Bering Sea. The work of her group over the last decade has been to build a database documenting groundfish food habits and to provide important information for understanding groundfish feeding ecology, marine food webs and parameterizing upper-trophic level models of predation and bioenergetics of groundfish populations. Pat is deeply involved in PICES activities, at first as a member of the WG 5 on Bering Sea and a member of Model Task Team for the PICES-GLOBEC Climate Change and Carrying Capacity (CCCC) Program and since 1996 as Co-chairman of the Implementation Panel of the CCCC Program.

As I was making the necessary connections from my hotel to the airport and from one airport to another to get home from this meeting, I began thinking about the other type of connections we need to make - those in the scientific world and the GLOBEC world, in particular.

The GLOBEC International Meeting that was held March 17-20, 1998, in Paris, was in a large way a meeting about connections: teleconnections, oceanic connections, trophic connections…, connections between scientists, national programs, regional programs and connections to other international programs. We were challenged to answer the following questions: How can we learn from each other? How can we create a greater understanding by putting the pieces together? HOW CAN WE CONNECT?

Scientific Program Connections

The meeting began with a keynote address by John Steele entitled “From Nutrient Flux to Regime Shifts”. This talk really set the stage for the meeting by summarizing work done by some previous large scale programs such as IRONX in the 1980’s and by providing a very enlightening synthesis of our knowledge about global ecosystem dynamics. We were challenged to think about the future of GLOBEC, how we can incorporate what has been learned from past programs, and how we can pass on our knowledge to emerging and future programs.

The rest of the program was designed to inform us about the various components of GLOBEC from the individual research project level, to the national and regional programs (including the PICES CCCC Program), and culminating at the GLOBEC International level. We learned about other programs presently being sponsored by the International Geosphere-Biosphere Program (IGBP) and the links between them.

A major focus of the meeting was to review and provide input to the GLOBEC International implementation plan. The CCCC Program was given the opportunity to discuss its plans, their role in relation to the draft implementation plan, and to consider suggestions for Framework and Integrating activities to be included in the final implementation plan.

CCCC - GLOBEC International Connections

The discussion started by comparing the GLOBEC International framework activities with the structure of the CCCC Program. There was a large degree of correspondence among four of the framework activities: comparative studies of ecosystem function; data management; measurement

standards, protocols, and methods comparison; and modelling and the CCCC's Task teams (REX, BASS, MONITOR, MODEL) and the PICES Technical Committee on Data Exchange.

The proposal of developing a GLOBEC regional ecosystem typology was discussed extensively. Although it was recognized that the process could become overly concerned with the fine details of such a typology, it was thought to be an essential step if the goal was to extrapolate from a well-studied ecosystem to similar but unstudied systems. Such a typology could also assist in choosing areas for conducting comparative ecosystem studies.

Although recommendations were made with respect to training, education, data sharing, and intercalibration of methods, the topic of comparative studies was one of the most interesting parts of the CCCC's discussion session. Many possible comparative studies were suggested from whole ecosystem comparisons of seasonally ice-covered seas (Bering, Barents, Okhotsk Seas) to comparisons of physical processes across systems, such as those with different primary forcing (wind versus buoyancy driven), and to comparisons of ecologically similar species (e.g., Neocalanus plumchrus/tonsus vs. Calanus finmarchicus; among gadids such as walleye pollock, cod, and haddock, or between euphausiids in the Southern Ocean vs. North Pacific).

The most compelling recommendation given to GLOBEC International was that much of the global synthesis that needs to take place within the program should be done through regional ecosystem comparisons. The comparative approach, of course, is the key ingredient of the CCCC. As we begin comparative work within our own area, we should be thinking of ways to include those outside the North Pacific.

Future Connections

Most importantly for me, the meeting provided me with general and specific ideas on how we can improve our connections. I hope to find ways that we can communicate more with scientists involved in the North Pacific Task Team of the Joint Global Ocean Flux Study (JGOFS) because their studies on processes involved in carbon flux are important to many of the questions being asked by the CCCC Program. We also need to find ways of including scientists involved in the newly forming Global Ocean Observing System (GOOS) activities into our program so that what we learn can be passed on to them. There are also many ways in which we can begin our comparative work in the CCCC's program, including starting up a series of backward-facing workshops such as those that have been done in the ICES region, that will prove useful to us and to the international scientific community as a whole. I hope to be connecting with many of the CCCC's scientists in the near future to develop some ideas for these types of activities.

(cont. from page 14)

of lower and intermediate trophic levels. For example, changes in ocean color, monitored by satellite sensors, might allow a better prediction of upper trophic level behavior than would the physical variables alone.

These thoughts suggest the potential links between LMR-GOOS and GLOBEC, and in the case of PICES, the CCCC Program. In our meeting, we tried to compile a list of desirable measurements whereby fish and other components of marine ecosystems, along with their forcing, could be monitored. We also noted that a variety of organizations, from national to global scale, have programs to monitor the status of marine ecosystems or selected biological or physical components thereof, and we asked IOC to compile and make available information on significant monitoring and assessment programs of its member states. Likewise we asked FAO to identify on a global scale the existing fishery analyses that could contribute to a meta assessment of population changes in the upper trophic levels of marine ecosystems, and to advise us on how such an assessment could best be organized and carried out.

The likelihood of a successful LMR-GOOS might be tested in retrospective "experiments" where available data on ocean conditions and fish stocks are evaluated for possible use in hindcasts. In the eastern North Pacific, for example, one could take data from before and after the regime shift, say from 1960 to 1990, and look for predictive relationships among variables. To what extent could the ecosystem changes have been predicted from the observed variables? Could predictability have been improved if additional or different variables had been monitored? If observed changes were not predicted, was this because of inadequate monitoring, inadequate analysis, or inadequate understanding?

Such experiments could be tried on both sides of the North Pacific and North Atlantic, in eastern boundary current upwelling ecosystems, and in other locations of important fisheries. These studies would throw light not only on the LMR-GOOS potential, but on the kinds of additional measurements that would be most valuable for the purpose of LMR predictions. Two such studies were proposed for the PICES area, one in the Japan Sea/East Sea and East China Sea, and one in the CalCOFI region.

The work of the LMR-GOOS panel has only begun, and members agree to submit short papers on lacunae and on future steps. A more extensive report should be available within the next few months. The next meeting will probably be in March 1999, in Montpellier, France on the occasion of the ICES/IOC Symposium on Ecosystem Effects of Fisheries.

Update on U.S. GLOBEC Research Projects and Coordination Activities in the Northeast Pacific

Harold P. Batchelder
Department of Integrative Biology
University of California
Berkeley, CA 94720-3140, U.S.A.
E-mail: halbatch@socrates.berkeley.edu

Dr. Hal Batchelder is an oceanographer at the University of California, Berkeley, CA, where for the past five years he has been the coordinator of the National U.S. GLOBEC Scientific Steering Coordinating Office, a position which he will soon relinquish as the national office moves from Berkeley to the Chesapeake Biological Laboratory at the University of Maryland. He will continue in his capacity as the coordinator of the U.S. GLOBEC NEP regional program. His field of research is biological oceanography, with particular focus on the dynamics of zooplankton populations and their interaction with physical environment. Dr. Batchelder received his B.Sc. (1977) in biology from the University of Maine, and M. Sc. (1980) and Ph.D. (1986) in oceanography from the Oregon State University.

Late last year, the NSF Ocean Sciences and NOAA Coastal Ocean Program selected thirteen projects to begin U.S. Global Ocean Ecosystems Dynamics' (U.S. GLOBEC) scientific research program in the ecosystems of the Northeast Pacific (NEP). Thus begins U.S. GLOBEC studies in two regions (California Current System [CCS] and the Coastal Gulf of Alaska [CGOA]) that represent important ecosystem types - eastern boundary currents and buoyancy-driven coastal currents (*Fig 1.*: Ware and McFarlane, 1989) - that were identified in the U.S. GLOBEC Initial Science Plan (U.S. GLOBEC Report No. 1, published in February 1991). On a wide range of time scales - from seasonal to interdecadal - there are strongly correlated signals in physical and biological variables in the CGOA and CCS (e.g., Roemmich and McGowan, 1995; Brodeur and Ware, 1992; Francis and Sibley, 1991), making these systems and the potential connections between them ideal sites/topics for U.S. GLOBEC studies. For additional background on the NEP program, see the U.S. GLOBEC Northeast Pacific Implementation Plan (U.S. GLOBEC Report No. 17, 1996). This first funding of studies in the NEP follows numerous workshops and the publication of several planning documents—all of them available electronically from the U.S. GLOBEC web site at http://www.usglobec.berkeley.edu/usglobec/globec.homepage.html.

The Announcement of Opportunity for initial studies in U.S. GLOBEC's NEP program requested proposals for modeling, pilot monitoring, and retrospective data analysis in both the CCS and CGOA, and was released jointly with the NSF Coastal Ocean Program (CoOP), which requested proposals for modeling in the CCS.

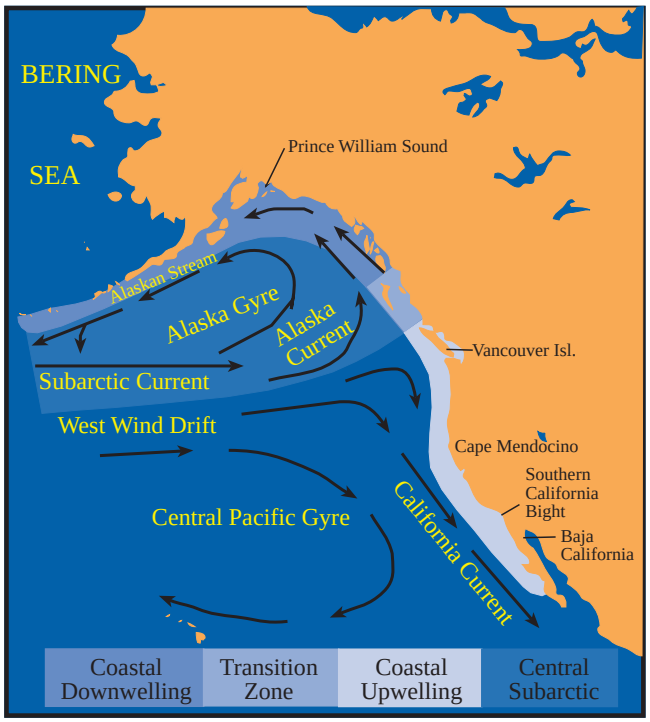

Fig. 1 Fisheries production domains and general large-scale circulation in the Northeast Pacific Ocean (from Ware and McFarlane 1989). Shaded regions are named at the bottom of the figure.

Table 1. Funded U.S. GLOBEC projects in the Northeast Pacific Regional Study

Project Title	**PI's/Institutions**
U.S. GLOBEC: Retrospective analysis of growth rate and recruitment for sablefish, *Anoplopoma fimbria,* from the Gulf of Alaska and California Current System	Steven Berkeley (Oregon State Univ. [OSU]) Dudley Chelton (OSU)
U.S. GLOBEC: Physical influences on populations in the California Current	Loo Botsford (U.C. Davis), Alan Hastings (U.C. Davis), John Largier (U.C. San Diego)
U.S. GLOBEC: Analysis of ichthyoplankton abundance, distribution, and species associations in the western Gulf of Alaska	Rick Brodeur (NOAA Alaska Fisheries Science Center [AFSC]), Kevin Bailey (AFSC), Miriam Doyle (Pacific Marine Environmental Laboratory [PMEL]), Ann Kiernan (AFSC)
U.S. GLOBEC: Northeast Pacific retrospective study, long term variability in salmon abundance in the Gulf of Alaska and California Current Systems	Bruce Finney (Univ. Alaska, Fairbanks [UAF])
U.S. GLOBEC: Coupled bio-physical models for the coastal Gulf of Alaska	Dale Haidvogel (Rutgers Univ.), Al Hermann, A. J. (PMEL), Phyllis Stabeno (PMEL), Sarah Hinckley (AFSC), M. Iskandarani (Rutgers), Hernan Arango (Rutgers)
A zooplankton population dynamics model in the California Current region	Mark Huntley (Scripps Institute of Oceanography [SIO]), Meng Zhou (SIO)
U.S. GLOBEC: A retrospective study of top predator trophic positions, productivity, and growth in the Gulf of Alaska for 1960-75 and 1975-90	Richard Merrick (AFSC), Keith Hobson (Canadian Wildlife Service), John Piatt (Biological Resources Division, USGS)
Long-term changes in California Current zooplankton: A retrospective analysis	Mark Ohman (SIO), David Checkley (SIO)
U.S. GLOBEC: Patterns, sources and mechanisms of decadal-scale environmental variability in the Northeast Pacific: A retrospective and modeling study	Franklin Schwing (NOAA Southwest Fisheries Science Center [SWFSC]), Grigory Monterey (SWFSC), Richard Parrish (SWFSC), Thomas Murphee (Naval Post-graduate School)
Pilot monitoring off Oregon for climate change studies in the eastern North Pacific	Robert Smith, Adriana Huyer, Patricia Wheeler, William Peterson, Michael Kosro, Jack Barth (All at OSU)
Retrospective analysis of northeast Pacific microzooplankton: a window on physical forcing of food web structure	Suzanne Strom (Western Washington Univ.)
U.S. GLOBEC: Remote sensing of the NE Pacific: Retrospective and concurrent time series analysis using multiple sensors on multiple scales	P. Ted Strub (OSU), Mark Abbott (OSU), Andrew Thomas (Univ. of Maine), Jan Svejkovsky (Ocean Imaging)
Physical-chemical structures, primary production and distribution of zooplankton and planktivorous fish on the Gulf of Alaska shelf: A GLOBEC monitoring proposal	Thomas Weingartner (UAF), Lew Haldorson (UAF), L., A. J. Paul (UAF), Ken Coyle (UAF), Thomas Royer (Old Dominion Univ.), Terry Whitledge (Univ. Texas)

CoOP funded a modeling project headed by John Allen of Oregon State University entitled "Circulation and Ecosystem Modeling for the Oregon Coast".

U.S. GLOBEC funded three modeling, two long-term observation programs, six retrospective data analyses, and two cross-activity projects. Of the three modeling projects, two are specifically directed to the CCS (Botsford et al.; Huntley et al.) and one to the CGOA (Haidvogel/Hermann et al). These projects complement a recently NSF funded modeling project of Powell and Haidvogel (Linked Biophysical Modeling in the California Current System: The Influence of Circulation and Behavior on Prominent Mesozooplankton Species). Three of the retrospective projects (Brodeur et al.; Merrick et al.; Strom) were specific to the CGOA; one (Ohman et al.) was specific to the CCS; and two (Berkeley et al.; Finney) consider both regions. Two pilot monitoring projects, one each in the CCS (Smith et al.) and the CGOA (Weingartner et al), were funded. One project (Schwing et al.) involves both retrospective data analysis and modeling, and one project (Strub et al.) involves both retrospective data analysis and monitoring. This last project, using remote sensing to characterize basin- and meso-scale variability of the NEP is funded partially by NASA in addition to U.S. GLOBEC. The titles, principal investigators, and institutional affiliations of the successful U.S. GLOBEC proposals are provided in *Table 1*. Abstracts of each funded research project are available in U.S. GLOBEC News No. 12 (available at http://www.usglobec.berkeley.edu/usglobec/news/news12/news12.nep.begins.html)

Unlike the U.S. GLOBEC Georges Bank program in the Northwest Atlantic, the PI's in the Northeast Pacific are not concentrated at only two institutions. In fact, the projects span a geographic range from the Southern California Bight to the Aleutians, and from lakes in Alaska and Washington to Station *Papa* and beyond in the open North Pacific ocean. Most of the PI's are associated with federal laboratories or academic institutions in Pacific coast states, and although there are no PI's located at the "University of Station *Papa*", there are PI's at institutions spanning from San Diego, CA, to Fairbanks, AK. From an ecosystem perspective, the funded projects encompass meteorological forcing, physical structure and dynamics, nutrient concentrations, and all trophic levels from phytoplankton to marine mammals and seabirds, with an expected heavy emphasis on zooplankton and fish.

Because of the diversity of tasks funded and PI institutions, coordination of the program at the programmatic and national levels are priorities. Toward that end, a first coordination meeting of the Northeast Pacific (NEP) investigators was held in Seattle on 18-19 August, 1997. The purpose of the meeting was to 1) provide the investigators with information about the various funded elements of the NEP program, 2) evaluate the program's strengths and weaknesses, and 3) provide recommendations about future needs/perceived gaps of the NEP program back to the U.S. GLOBEC Scientific Steering Committee (SSC) and funding agencies. A final goal was to determine appropriate mechanisms for organizing the NEP program, so that the discussions that occurred during the meeting could be continued in the future. Subsequently, the modelers met at a separate meeting in Seattle in December 1997, and most of the PI's got together for a Saturday meeting in San Diego following the AGU/ASLO Ocean Sciences Meeting in February. Aside from the task of building collaborations among the funded projects and between U.S. GLOBEC projects and other research programs in the NEP, the February meeting was used to brainstorm about themes/topics that needed to be addressed in a forthcoming Announcement of Opportunity (AO). That AO will solicit additional proposals for long-term observations, modeling and retrospective data analysis, as well as for the first NEP field studies in the Northern California Current. It is expected that this AO will be released by the funding agencies late this year, with funding decisions announced in mid-1999, so that the first process-oriented research can begin in the CCS in early 2000. An Interim Northeast Pacific Executive Committee (INEC) consisting of a mix of members of the National U.S. GLOBEC SSC and funded NEP PI's has been selected which will take the organizational lead of the NEP program. Thomas (Zack) Powell has agreed to serve as chair of the INEC. Moreover, a NEP Coordinating Office has been established. Presently that office is located at the University of California, Berkeley and is staffed by Hal Batchelder (halbatch@socrates.berkeley.edu). It is expected that following the next round of NEP project funding (e.g., the first funding of process-oriented field work), a more permanent home for the NEP Coordinating Office will be selected.

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Institutional Framework for Oceanographic Research in Japan

Satsuki Matsumura
National Research Institute of Far Seas Fisheries
Fisheries Agency of Japan
5-7-1, Shimizu-shi, 424-8633 JAPAN
E-mail: smatsu@enyo.affrc.go.jp

Dr. Satsuki Matsumura is presently Director of the Research Planning and Coordination Division at the National Research Institute of Far Seas Fisheries (NRIFSF) of Japan. Besides the Oceanographic Division, he is in charge of three fishery resources divisions in the institute that deal with oceanic fish resources such as tuna, salmon, pollock, squid and cetacean. Prior to the present position, he was the director of the Oceanographic Division of NRIFSF during 1992-96. His major is satellite oceanography and he has been leading Japanese satellite ocean color remote sensing activity, since the inception of the ADEOS/OCTS program in 1988. He established and led the ocean color research team in Japan till recently. After successfully bringing up the Japanese ocean color research team, he got involved in the practical use of remote sensing data in the development of fisheries and its management. He has been instrumental in establishing an inter-institutional collaborative research program between the National Space Development Agency (NASDA) and the Fisheries Agency (FA) of Japan, which aims at undertaking joint satellite and ship observations by fishery research fleets. This program is contemplated to go long way in gathering pertinent data both from satellite and ship and to be useful for scientific management and sustainable development of fisheries.

It may appear strange to mention that there are only two universities in Japan that have Oceanography as an independent faculty. Many universities have oceanography just as a course under the discipline of Fisheries Science or Earth Science in the Faculty of Science. The Ocean Research Institute (ORI) of University of Tokyo is the only institution in any Japanese national university to have a dedicated faculty for oceanographic research. Likewise the Tokai University is the only private university to have an exclusive name of the faculty, School of Marine Science and Technology, for education and research in the field of marine science and technology.

There are mainly one ministry and five agencies that deal with oceanographic research in Japan. Out of them the Ministry of Education (ME), the Science and Technology Agency (STA) and the Environmental Agency (EA) are the main funding agencies for oceanographic research. The other three agencies are the Fisheries Agency (FA), the Meteorological Agency (MA) and the Hydrographic Department in the Maritime Safety Agency (MSA). They are often referred to as the "Oceanic-Three Agencies".

Even though STA is the major funding agency for oceanographic research in Japan, it has no direct control over the national institutes it funds, except for the Japan Marine Science and Technology Center (JAMSTEC), that has a rather large infrastructure base to undertake research work on various fields of oceanography. This includes an operating submersible research boat *SHINKAI 6000* and a large research vessel *MIRAI (8600 GT and 130 m)*.

EA, apart from having its own institution, also acts as a funding agency to support research activities in other national institutions. On the other hand MA has a meteorological research institute of 142 scientists involved in research in diverse fields such as meteorology, volcanology and oceanography, and four marine observatories manned with many oceanographers. MSA has a hydrographic division with 35 scientific staff members and FA has nine research institutes all over Japan. The "Oceanographic-Three" agencies do not provide direct research funds, but they support funding for specific projects dealing with themes of their interest. For example, FA has an interest in knowing the mechanism leading to red tides, and information on harmful algae etc., concerning fishery related activities, hence they provide funding to the laboratories in the universities that have research programs dealing with such aspects. However, funding of this kind is not termed as research funding, rather, they are known as supplementary financial assistance.

Oceanographic research vessels

FA has 10 ocean-going research vessels altogether. The largest one is *KAIYO MARU*, of 2630 GT. There are also 56 local fishery research stations under the control of prefectural governments, each having one to three research vessels of 50 to 500 GT capacity. Those vessels usually operate within the Exclusive Economic Zone (EEZ), 200 nautical miles from the coastline. Some of them also operate beyond the EEZ. MA has six research vessels including the ones owned by its marine observatories. MSA has five research vessels

for undertaking the activities of their hydrographic division. The University of Tokyo has two oceanographic research vessels. Other universities/faculties of Fisheries have fifteen training vessels that are often being used as research vessels. JAMSTEC has altogether five research vessels including the mother ship of the submersible research boat *SHINKAI 6000*. It is interesting to note that the scientists who participate in research cruises on these vessels are not required to meet any expenses towards the vessel operation, because specific funds are allocated for the operation of these vessels by their respective organizations. Scientists can participate in a research cruise on any of these vessels simply by arranging their research materials.

The Self Defense Force of Japan also has oceanographic research programs in specific fields. However, sometimes the role of the Self Defense Force in oceanographic research is ignored as Japan has a declared national policy that science should be aimed at peace purposes alone. The Japan Maritime Self Defense Force (JMSDF) has been involved with Japan's Antarctic research program since 1965. Presently the icebreaker *SHIRASE* embarks helicopters that are in service for the transportation of observation personnel and other logistics between Japan and Japan's Showa base at Antarctica.

Budget for marine science and technology related research activities for 1998

According to the information provided by STA, the budget towards marine science and technology related research activities for 1998 has been estimated at about 598 million US dollars. STA has allocated 198 million dollars to oceanographic research programs such as the Kuroshio Exploitation and Utilization Research, KER Phase III (1993), the Japan-China cooperative research project on the subtropical gyre in the Pacific Ocean (1995-), the Japan Experiment on Asian Monsoon, JEXAM (1983-), the World Ocean Circulation Experiment (WOCE), the Joint Global Ocean Flux Study (JGOFS), the TOPEX/Poseidon Data Distribution Center, the Global Observation Information Network (GOIN), the Global Ocean Observing System (GOOS), the North-East Asian Region GOOS (NEAR-GOOS), and the North Pacific Marine Science Organization (PICES). Operational cost of the large research vessel *MIRAI* (16 million dollars) is also included under this allocation. FA has a budget of 108 million dollars for undertaking research that includes aquaculture, fish resource assessment, catch control system development, conservation of marine environment, etc. ME has a budget of 3.9 million dollars for special projects under NEAR-GOOS, IOC, but it excludes research assistance to the universities. MA and MSA have a budget of 74.7 million dollars. The Ministry of International Trade and Industry (MITI) has a budget of 199 million dollars towards ocean-related activities that include deep sea mine resource development, deep sea petroleum and natural gas survey, and development of sea water lift-up power plant system, etc. The Ministry of Construction has allocated 3.9 million dollars to coastal oceanography. Although the above figures are very rough estimates, it would help to have a cursory idea of the general allocation of funding by different government agencies of Japan for oceanographic research.

System of oceanographic research funding in Japan

It is rather difficult to provide a comprehensive framework of the process of research funding in Japan like the funding system presented earlier in this newsletter by Dr. Vera Alexander or Dr. John Davis in their respective countries. The allocation of annual funding, as presented above for the year 1998, is in fact decided taking into account the policy of the Japanese Government and that of the respective agencies. First, each agency circulates their policy guidelines to the concerned organizations to be pursued under its funding. The funding by STA and EA are restricted to the national research institutes, whereas, the universities are being funded by ME. Significantly, the system of research funding to the universities and national institutions is being pursued through different channels. However, cross-collaboration is possible by the association of the scientist with the appropriate channel. The difference between the two is difficult to explain through simplistic flow charts. The overall process of research funding followed by STA, is presented below based on the long association of the author with the system and his practical experience.

As it has been pointed out before, STA is the leading funding agency in the field of marine science and technology in Japan. The budget of STA is allocated under two categories. One is for the research program to be undertaken by its own organizations such as JAMSTEC, and the other is for the national research institutes coming under different ministries of the Government of Japan. In fact, the amount allocated for JAMSTEC includes the operational cost of the research vessel *MIRAI*. Let me give you a simplistic example about the procedure followed by STA for providing funds to the scientists from a national research institute.

The prospective scientist from a national institute has to submit a detailed project proposal to STA as the principal investigator, in consultation with the scientists (co-investigators) in their field of interest from the other institutes or organizations, and also with the concerned people from the administration. The proposal should explain the objectives of the research and its possible contribution to oceanography under the discipline of Earth Science, plus, the social relevance of the proposed output from the project. The proposed mode of execution of the project involving other organizations are also to be stated. The name of co-investigators and individual consent of their respective organizations are to be submitted with the project proposal. If the consent of any of the co-investigator is less than final at the time of the submission of the project proposed, it may delay its evaluation process. Hence the principal investigator

should obtain consent of all his co-investigators before submitting the proposal to avoid such delay. If the proposal is acceptable to STA, the principal investigator will be asked to give a presentation on the project proposal before an evaluation committee for Earth Science formed by STA. The evaluation committee consists of not only oceanographers, but also scientists from other fields under Earth Science, experts from industries, and journalists. The proposer is fortunate if there are three oceanographers on the fifteen-membered panel. The committee has to go through the research proposals received from a large number of prospective scientists on a wide spectrum of fields under Earth Science, therefore, usually each proposer is given only fifteen minutes for presentation of the proposal before the committee that includes the discussion with the committee members on various aspects of the proposal. Although all the members are provided with a copy of the proposal prior to the presentation of the proposed plan before the committee, it is hard for many of them to read and understand some one hundred pages of a proposal by themselves before coming to the evaluation committee meeting. Usually 20-30% of the proposals are approved through such an evaluation process. In the case that a proposal is not approved, it is always possible to resubmit the proposal after brushing up the contents. So it can again be considered for evaluation the next year. The prized project on "The sub-arctic circulation on North Pacific" for example, was ultimately approved in 1997 with an approximate budget of 2 million dollars per year, after three years of continuous efforts.

Once the prospective themes of research are approved by STA, an announcement is circulated to the national institute to which the principal investigator belongs, through the relevant ministry. On receipt of such an announcement the principal investigator has to submit the final proposal again to his institute to be forwarded to STA through the relevant ministry. An administrator at STA would check the final proposal and then communicate with all the prospective investigators associated with the project, for individual presentations of their research program before him. The investigators have to explain in person the detailed objectives, requirements and the logic behind the requirements and so on, under the general purview of the project. This presentation will usually last one hour. There is no peer review of the proposals in Japan for research funding. So this is the first time direct contact is established between individual investigators and STA. In fact, if scientists from a university or prefectural government have an interest in a project to be funded by STA, they have to join the project through the national institutes, not through their own organizations. Roughly 30-200 thousand dollars per year can be obtained by each investigator towards the operational expenses of their projects under STA funding, that excludes the salary of the investigators and of course the cruise-related expenses. Usually the duration of such projects ranges between three to five years. A symposium has to be organized after successful completion of the project for general appraisal of the scientists. STA will form a sub-committee for monitoring the operation of the project from time to time to ensure its smooth execution.

The funding system at EA is almost identical to that of STA. Other ministries and agencies also have the provision of research funding, but it is restricted to the organizations that are under the administrative control of the concerned ministry. However, cross collaboration is possible at the level of scientists, by joining the institutional project of any research institute different from their own, such as university or prefectural institutes. In case of universities, the process of obtaining research funding from ME is almost the same as that of STA system, except the fact that the principal investigator should be from a university instead of a national research institute. Scientists from national research institutes can also join projects funded by ME by associating themselves with a university project as a co-investigator.

In the context of research funding towards the operational cost of the research project, there are few points to take note of. As it has already been mentioned, scientists do not have to worry about research-cruise-related expenses, however, they have to bear the cost towards aircraft-related expenses under the operational cost of the project. Thus if any research program requires the use of an aircraft or aerial surveys, a large amount of funding has to be diverted towards such purposes under the operational cost. So there is a huge gap between the expenses to be borne on these two modes of logistics. We, around 180 oceanographers working at different research institutes under FA, are rather lucky to have access to 10 ocean-going research vessels belonging to the agency. Often scientists from FA can also use the fisheries training vessels of prefectural governments and even fishing boats as charted research vessels by mounting certain necessary oceanographic instruments.

This is the general scenario of oceanographic research activities with special reference to the funding aspect. There may be some more finer details involved with the funding system, as it is recommended that scientists, especially from PICES member countries who have further interest on the subject, contact the potential Japanese colleagues for more details in this regard. In fact the Japanese budget for oceanographic research includes some international projects and it is possible to collaborate with scientists from PICES member countries for joint research programs in the future.

This article is not officially endorsed by the Government of Japan. Hence it should be considered as a personal view of the author.

The Kuroshio Edge Exchange Processes (KEEP) Project

Ching-Ling Wei
Institute of Oceanography
National Taiwan University
PO Box 23-13
Taipei, China (Taipei)
E-mail: weic@ccms.ntu.edu.tw

Dr. Ching-Ling Wei is Professor at the Institute of Oceanography, and Chairman of the Kuroshio and Ocean Circulation Division at the Global Change Center, National Taiwan University, China (Taipei). He received his B.Sc. (1979) in Oceanography from the Provincial College of Marine Science and Technologies, and M.Sc (1985) and Ph.D. (1990) in Chemical Oceanography from the Oregon State University and the University of Washington respectively. Dr. Wei is especially interested in marine radiochemistry, and in 1994 he got the Outstanding Research Award from the National Science Council, China (Taipei). He also serves as a member of the National Committee for the International Geosphere Biosphere Program (IGBP) and Chairman of the National Committee for the Joint Global Ocean Flux Study Program (JGOFS). At the present time Dr. Wei is coordinating the Kuroshio Edge Exchange Processes (KEEP) Programme, the major contribution of China (Taipei) to JGOFS.

1. Introduction

Located at a unique position in the western North Pacific Ocean, Taiwan Island is ideally situated for studying the interactions between the Chinese marginal seas and the deep North Pacific Ocean. Since 1989, oceanographers in China (Taipei) have committed tremendous efforts to investigate material exchange processes in the East China Sea through the Kuroshio Edge Exchange Processes (KEEP) Project. This multidisciplinary study of the biogeochemical cycle of carbon and associated elements in the East China Sea has provided an extensive database for the area and discovered many important phenomena since its inception in 1989. The National Science Council, the major funding agency for marine research in China (Taipei), has allocated generous support to the program. The KEEP Project has completed two phases (KEEP-I and KEEP-II), which lasted for 5 and 3 years respectively, and is now in the second year of its third phase (KEEP-III). This article is aimed to describe the findings and activities of the KEEP Project.

2. Environmental settings

The study area of the KEEP Project shown in *Figure 1* covers the continental shelf of the East China Sea, the Taiwan Strait, and the Okinawa Trough. In the context of elemental budget, the East China Sea is dominated by its interactions with the Changjiang runoff to the west and the Kuroshio to the east.

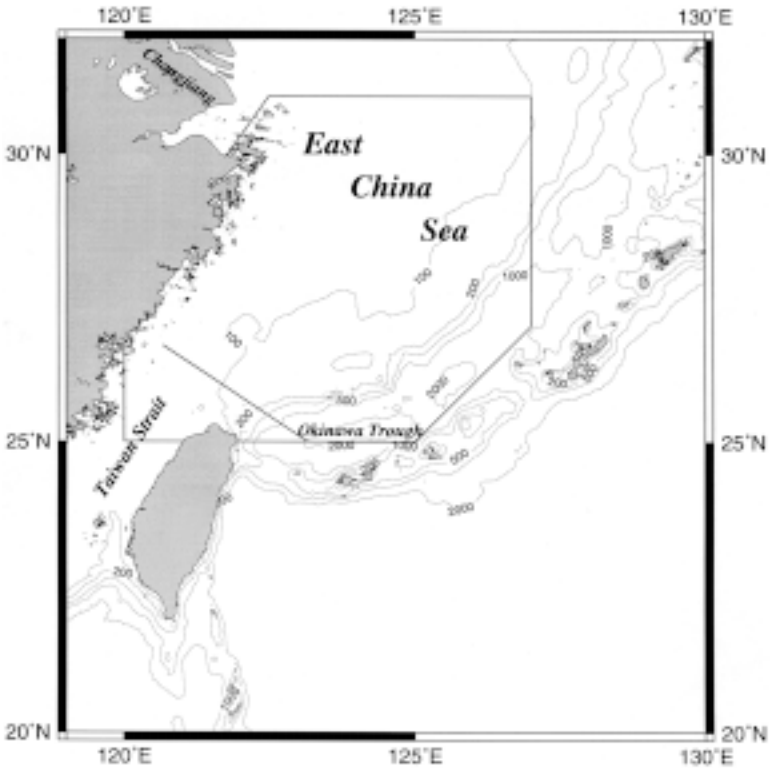

Fig. 1 Bathymetry of the East China Sea. Study area of the KEEP project is bracketed by solid line.

Typical distributions of hydrographic data (salinity, potential temperature, and potential density) in the upper 250 m along a transect (shown as the diagonal line in *Figure 1*) across the southern East China Sea in spring and winter are shown in *Figure 2*. Detailed description of the hydrography in the area was given by Liu et al. (1992). The major water masses in the East China Sea are: the Continent Coastal Water (CCW), the Taiwan Strait Warm Water, the Kuroshio Surface Water and the upwelling Kuroshio Subsurface Water. The core of the Kuroshio was represented by the subsurface salinity maximum (S >34.7 psu). A year-round upwelling phenomenon due to the Kuroshio intrusion onto the continental shelf/slope has been documented in the past few years (Liu et al., 1992, Gong et al., 1995). This topographically induced upwelling is depicted by dome-like structures of the hydrographic parameters and nutrients at the shelf break and results in a high concentrations of chlorophyll a, high primary productivity, high concentrations of particulate organic matter and abundant ichthyoplankton (Gong et al., 1996; Chiu, 1991). Between the two seasons, the cross-sectional structures of the hydrographic parameters generally resemble each other except that the water column at the shelf stations were more homogenized during the winter and the shelfward intrusion of the Kuroshio water extends farther into the shelf during the spring.

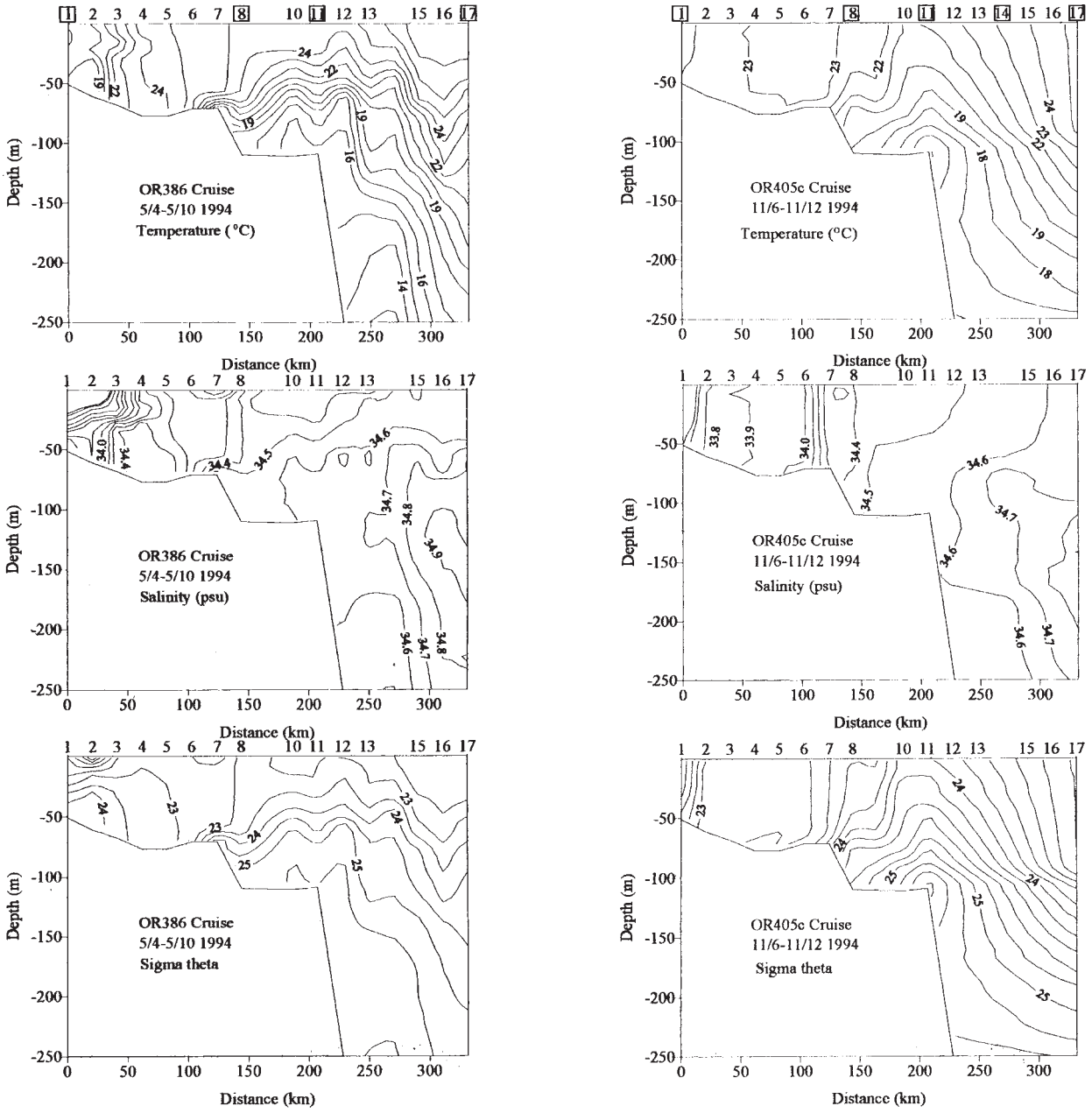

Fig. 2 Vertical distributions of temperature, salinity, and density in spring (left panel) and in winter (right panel) along the cross-section shown in Figure 1.

Table 1. Information of principle investigators of KEEP-III project

#	P.I.	Title of Proposal	Main Task
	Wei, Ching-Ling National Taiwan Univ. weic@ccms.ntu.edu.tw	Kuroshio Edge Exchange Processes (III)-the common project	Logistic support, service
1	Chen, S.-C. Taiwan Fishery Research Inst. scchen@mail.tfrin.gov.tw	Satellite remote sensing the sea surface interaction of the East China Sea and Kuroshio: A serviceable plan	Sea surface temperature, satellite data
2	Hung, J.-J. National Sun Yat-sen Univ. hungjj@mail.nsysu.edu.tw	Trace elements in the deep plumes and sinking materials of the Southern Okinawa Trough	Trace metals, POC, DOC
3	Wei, Ching-Ling, Tang, T.-Y. National Taiwan Univ. weic@ccms.ntu.edu.tw	Radionuclides as particle tracers in the Southern Okinawa Trough	Current meter mooring, U-Th radionuclides
4	Chung, Yu-Chia National Sun Yat-sen Univ. ycchung@mail.nsysu.edu.tw	Settling particulates and associated radiogeochemistry in the southern Okinawa Trough	Sediment trap, current meter, ^{226}Ra
5	Sheu, David D. National Sun Yat-sen Univ. ddsheu@mail.nsysu.edu.tw	$\delta^{13}C$ and $\delta^{18}O$ of the East China Seawater and organic $\delta^{13}C$ of particles collected from sediment traps	$\delta^{13}C$, $\delta^{18}O$
6	Gong, Guo-Chin National Taiwan Ocean Univ. gcgong@ntou66.ntou.edu.tw	Biological carbon cycling within the euphotic zone of the East China Sea: Chemical hydrography, chlorophyll and primary production	Nutrients, chlorophyll, primary productivity
7	Pai, Su-Cheng, Liu, K.-K. National Taiwan Univ. kkliu@ccms.ntu.edu.tw	Biogenic organic carbon cycling in the euphotic zone of the East China Sea: community respiration, bacterial production, standing stock, of organic carbon and biogeochemical modeling	POC, DOC, carbon flux, mesocosm
8	Lee, Y.-L. National Sun Yat-sen Univ. yllee@mail.nsysu.edu.tw	Biological carbon cycling within the euphotic zone of the East China Sea: the role of new production	New production, primary production
9	Chang Jeng National Taiwan Ocean Univ. b0176@ntou66.ntou.edu.tw	Biological carbon cycling within the euphotic zone of the East China Sea: growth and grazing mortality of ultraphytoplankton	Phytoplankton, grazing rate
10	Chiang, K.-P. National Taiwan Ocean Univ. b0173@ntou66.ntou.edu.tw	Biological carbon cycling within the euphotic zone of the East China Sea: The biomass and production of protozooplankton	Microbial loop, protozoan
11	Huh, Chih-An Academia Sinica huh@earth.sinica.edu.tw	Sedimentation dynamics in the East China Sea: A multitracer approach	Sedimentation rate, mixing rate
12	Lin, Saulwood National Taiwan Univ. swlin@ccms.ntu.edu.tw	Spatial and temporal variations of organic carbon oxidation through sulfate reduction and suboxic oxidation in the East China Sea continental margin sediments	Sulfate reduction rate, Fe/Mn in sediments
13	Jeng, Woei-Lih National Taiwan Univ.	Sedimentary environment of the East China Sea: Early diagenesis of lipids	Lipids, diagenesis

3. Organization

Participants of the KEEP-III are organized into three major groups: particulate plume transport, euphotic zone dynamics, and benthic dynamics (Table 1). The particulate plume group concentrates on the southern Okinawa Trough. The investigators will deploy sediment traps and collect large-volume seawater samples for the determination of trace metals and particle-reactive radionuclides. More accurate material transport through the southern Okinawa Trough may be estimated from these measurements together with direct measurements of current velocities. The euphotic zone group will design biogeochemical cruises to sample the diverse biological and chemical regimes in the shelf and slope region of the East China Sea. Inventories of and exchange rates among the different components of the lower food chain will be estimated in order to delineate the role of biological processes in the carbon cycle in the East China Sea. The benthic group will collect cores from the East China Sea

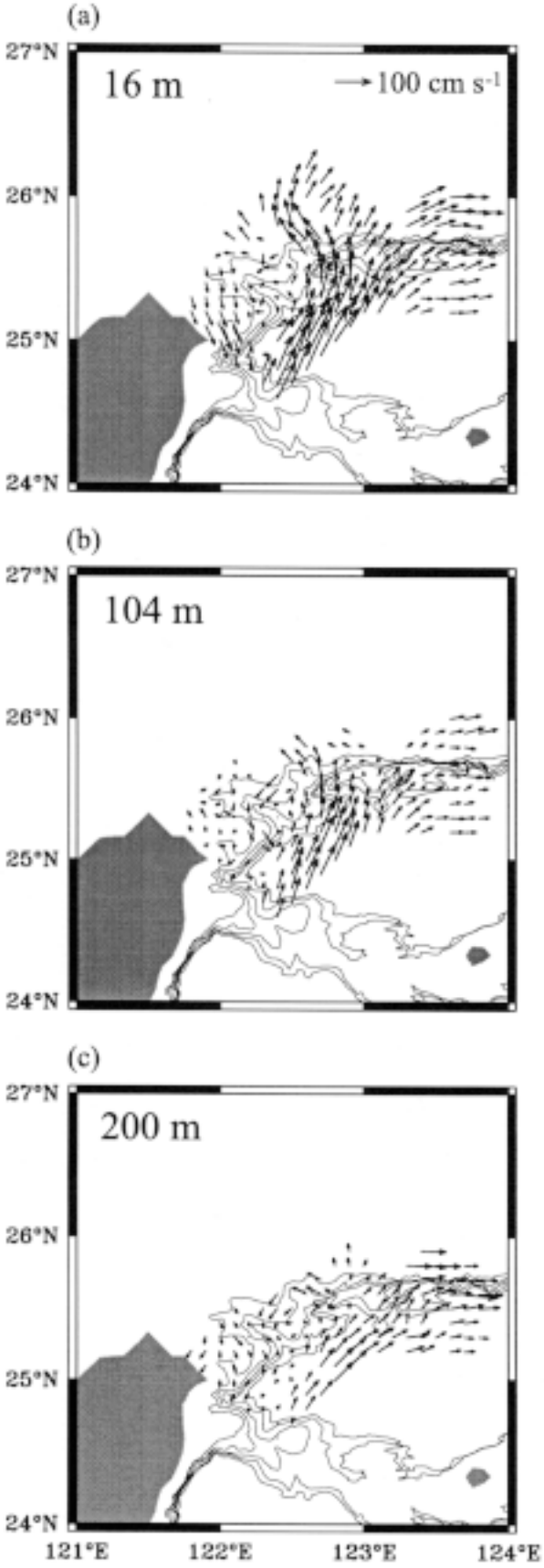

Fig. 3 Mean circulation pattern at three depths observed by Sb-ADCP in August, 1994 (Tang et al., in press).

and the Taiwan Strait. The sedimentation rates and sediment mixing rates in these areas will be determined from the distribution of multiple tracers (^{210}Pb, ^{239,240}Pu, ^{137}Cs etc.) in these cores. The information may then be used for estimating the removal of carbon by burial in the carbon budgets.

4. Findings

4.1 Kuroshio intrusion onto the continental shelf

To investigate the water exchange between the Kuroshio and the East China Sea shelf, the spatial distribution of current velocity along the shelf break off northeastern Taiwan was studied with Ship-board Acoustic Doppler Current Profiler (Sb-ADCP). A phase average technique carried out by two research vessels (*R/V Ocean Researcher 1* and *R/V Ocean Researcher 2*) was adopted by Dr. T.-Y. Tang to eliminate high-frequency noises caused by tidal current. The current velocity fields obtained at three different depths off northeast Taiwan in August 1994, are shown in *Figure 3.* The maximum speed of the Kuroshio reaches up to 80 cm/s. As the Kuroshio enters the Okinawa Trough from the Pacific Ocean, its northward progression was blocked by the sharply shoaling shelf edge of the East China Sea. As a result, it branches into two limbs. The main branch flows approximately along the shelf break and turns to the east while the other branch flows northwestward and intrudes onto the shelf. The intruding water forms a cyclonic eddy, with a diameter of ~70 km, centered at the Mien-Hwa Canyon. A detailed discussion of the branching behavior of the Kuroshio in the southern East China Sea can be found in Tang et al. (in press).

4.2 Euphotic zone dynamics

Much information on the temporal and spatial variation of biological and chemical parameters in the study area have been compiled in the past 10 years. The distributions of Chl a in the surface water in the East China Sea in May 1996 (data provided by Dr. G.-C. Gong) and the mean surface current velocities in the seas surrounding Taiwan in the spring (prepared by Dr. T.-Y. Tang) are shown in *Figure 4*. The Chl a distribution reveals two major sources of nutrients to the East China Sea shelf: the upwelling of the Kuroshio Subsurface Water and the Changjiang runoff. The zone of high Chl a near the mouth of the Changjiang is obviously induced by the nutrient-laden runoff. In the frontal region between the Changjiang Diluted Water and the intruding Kuroshio Water in the mid-shelf, Chl a is also enriched. The influence of Kuroshio upwelling on the biological activity is shown as a patch of high Chl a in the sea northeast of Taiwan. Nutrient budget estimated from a box model calculation indicates that the upwelling Kuroshio Subsurface Water contributes more than 5 times the riverine fluxes (Li, 1994; Chen, 1996).

Spatial variation of the primary productivity in the East China Sea was measured by both C-14 (Drs. G.-C. Gong and F.-K. Shiah) and C-13 (Dr. Y.-L. Chen) uptake methods.

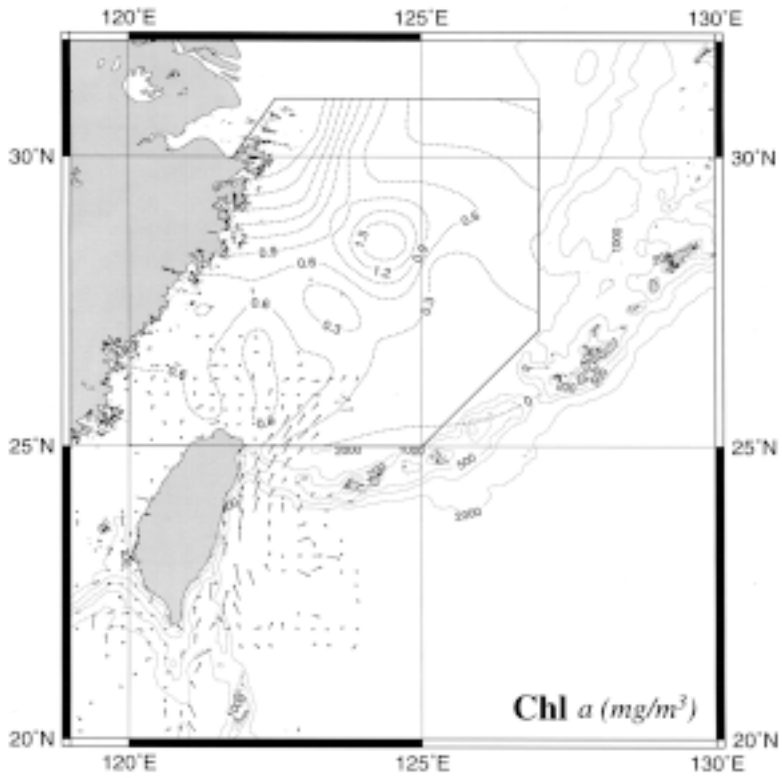

Fig. 4 Chlorophyll a distribution in the surface water observed in April 1996 (provided by Dr. G.-C. Gong). Arrows represent mean surface current velocity averaged from long term Sb-ADCP measurement in spring (provided by Dr. T.-Y. Tang).

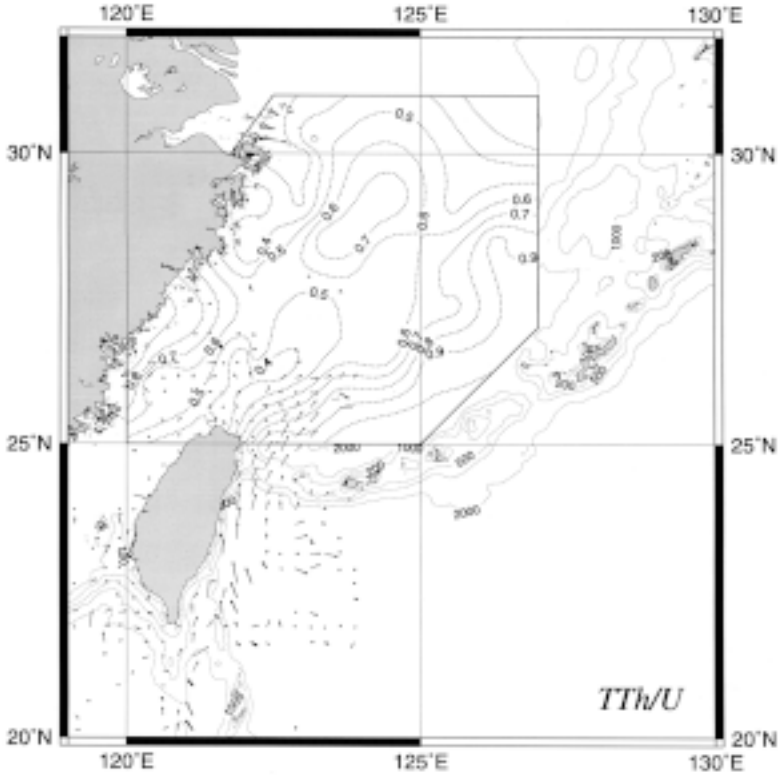

Fig. 5 Contours of $^{234}Th/^{238}U$ activity ratio observed in April 1996.

In southern East China Sea, the integrated primary production reached 1901 mgC/m^2/d in the coastal waters, and ranged between 418 and 1537 mgC/m^2/d in the upwelling region. In the continental shelf and Kuroshio region, substantially lower values, ranging between 110 and 425 mgC/m^2/d, were observed (Shiah et al., 1995; Chen, 1995). These values are significantly higher than previously reported results from the same general area and in the same seasons (Guo, 1991). The cause of this discrepancy merits further studies.

In order to construct a carbon budget of the East China Sea, biomasses and exchange rates of carbon between different trophic levels in the ecosystem have been investigated. For example, the bacterial production rate was measured by the ^{3}H-thymindine uptake method (Dr. F.-K. Shiah). The bacterial production rates range from 28 to 351 mgC/m^2/d and they correlate positively with primary productivity and particulate organic carbon concentration. Ratios of new production to primary production (f ratio), assuming that all the productivity of microphytoplankton is supported by new nitrogen supplied by the upwelling, were measured using the $^{15}NO_3$ uptake technique (Dr. Y.-L. Chen) and ranged from 0.64 to 0.76 in the southern East China Sea. Dr. J. Chang is investigating the abundance and grazing rate of protozoan zooplankton. Using the dilution culture method, it is found that microzooplankton consumed about 18 mg Chl a/m^2/d in the Kuroshio upwelling region.

Other than the aforementioned biological studies, spatial and temporal distribution of trace elements with different chemical properties was also investigated to study the fate of anthropogenic pollutants in the East China Sea. Suspended particles and sinking particles were collected by filtration and sediment traps, respectively, for the determination of trace elements and particle-reactive radionuclides. The disequilibrium between the short-lived ^{234}Th ($t_{1/2}$=24.1 days) and its parent ^{238}U is used for estimating the scavenging rate of particle reactive elements onto particle surfaces. The distribution of $^{234}Th/^{238}U$ activity ratio measured in May 1996, in the surface water of the East China Sea (*Figure. 5*) shows that the ratio increased progressively from 0.4 in the inner shelf to 0.9 in the Kuroshio, indicating an enhanced scavenging and removal of particle-reactive elements in the Changjiang plume. The deficiencies of ^{234}Th with respect to ^{238}U increased with increasing

Chl a concentration (*Figure 4*), indicating the importance of biological particles for elemental scavenging in the East China Sea.

4.3 Cross-shelf material transport

In the past few years, more than twelve deployments of deep sea mooring with time-series sediment traps (PPS 3/3) and current meters were carried out by Dr. Y.-C. Chung. The locations of the sediment trap deployments are shown in *Figure 6*. Various analyses were done on the settling particles collected by the traps. The results indicate that episodic slumping coupled with lateral transport of slope sediments may be the major mechanism for cross-shelf material transport from the southern East China Sea to the Okinawa Trough. The channels or canyons that cut across the continental slope are important conduits for funneling sediments into the Okinawa Trough. Along the axis of the Mien-Hwa Canyon, the total mass fluxes measured by the lower traps dramatically decreased toward the mouth of the canyon. The mass fluxes in the canyon averaged about 44 g/m^2/d while that at the mouth of the canyon averaged about 6.9 mg/m^2/d. The mass fluxes also decreased from the slope area toward the western Okinawa Trough. Organic carbon fluxes measured by Dr. J.-J. Hung from the sediment traps are shown in *Figure 7*. In accord with the total mass fluxes, the organic carbon fluxes at a given location increased towards the bottom. The higher fluxes were found in the canyons. The fluxes found in the Mien-Hwa Canyon are much higher than those observed in the northern Mid-Atlantic Bight and in the SEEP sites (Biscaye et al., 1988, 1994).

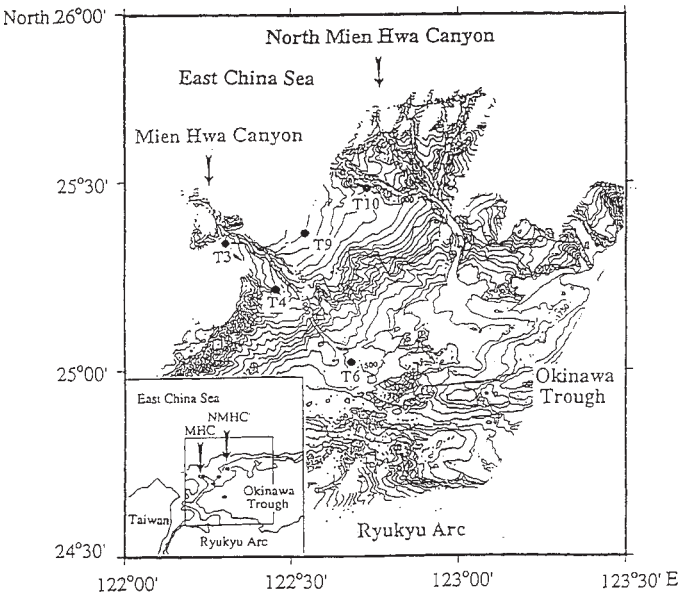

Fig. 6 Locations of sediment traps moorings off northeast Taiwan (provided by Dr. Y.-C. Chung).

4.4. Sediment biogeochemistry

Based on our understanding of the sediment dynamics and geochemistry in the East China Sea, sediment cores were collected from different depositional domains of the sea for various analyses. Sulfate reduction rates in the continental shelf sediments were measured by Dr. S. Lin using ^{35}S incubation technique. The sulfate reduction rates in the continental shelf sediments ranged from 1 to 4 mmol/m^2/yr, which were higher than most other shelf environments (Huang and Lin, 1995). The sulfate reduction of the concentration of organic carbon, indicating that organic carbon is the primary factor in controlling sulfate reduction in the study area. About half of the deposited organic carbon on the shelf is consumed by sulfate reduction.

Preliminary excess ^{210}Pb data obtained by Dr. C.-A. Huh indicate that the apparent sedimentation rates vary from ~0.1 to >1 cm/yr over the shelf, 0.06~0.09 cm/yr at the slope, and 0.02~0.05 cm/yr at the base of the slope. More accurate sedimentation rates will be estimated when other tracers like ^{239,240}Pu and ^{137}Cs are measured

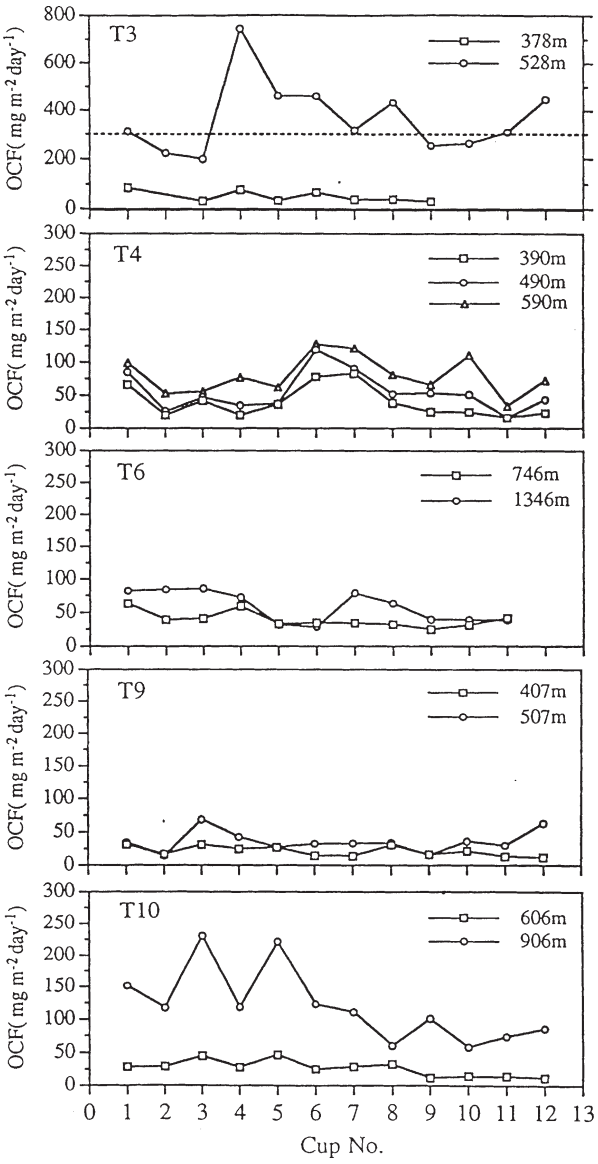

Fig. 7 Organic carbon fluxes measured by sediment traps deployed at various depths at the stations shown in Figure 6 (provided by Dr. J.-J. Hung).

to correct the sedimentation rates for the effects of sediment mixing. In contrast to the shelf region, extremely high apparent sedimentation rates (0.2~0.7 cm/yr) were found in the slope region of the Okinawa Trough with elevated concentration of organic carbon (Chung and Chang, 1995). Spatial variations of the sedimentation rate in the study area indicate that sediments from the East China Sea are transported from the shelf and buried in the slope region. The distributions of biomarkers in the sediments in the shelf and slope regions were investigated by Dr. W.-L. Jeng and they also indicate that the slope is a depocenter for materials from the shelf. The focusing phenomenon of East China Sea sediments in the southern Okinawa Trough will be investigated in the future.

5. Concluding remarks

Focusing in the southern East China Sea, the KEEP project has provided an excellent opportunity for a multidisciplinary collaboration among oceanographers in China (Taipei) and generated significant results to further the present appreciation of the processes operating in ocean margin systems. The participation of international collaborations in the project is welcomed. The publications and data originated from the KEEP project can be found at our web site (http://keep.oc.ntu.edu.tw) and in the forthcoming special issue of Continental Shelf Research.

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(cont. from page 9)

in the lower layer remained below 3˚C. The depth of the upper mixed layer remained less than 20 m through August. In September, with the occurrence of several storms, the mixed layer deepened and the lower layer began warming. By November, 1997 the water column had become well mixed and continued to cool reaching approximately 1.9˚C at the end of December. Similar timing and temperatures were observed in the fall and winter of 1996.

Continued measurements in the Bering Sea are planned this year by programs funded by the National Science Foundation (research on prolonged production along the structure front at ~50m isobath) and by the National Oceanic and Atmospheric Administration (annual trawl surveys conducted by the Alaska Fisheries Science Center/National Marine Fisheries Service; monitoring from biophysical platforms and hydrographic sections by the Southeast Bering Sea Carrying Capacity (Coastal Ocean Program); biophysical measurements of the green belt by the Arctic Research Initiative; and research by the Fisheries Oceanography Coordinated Investigations). These measurements will be of particular interest to see if there is a repetition of 1997.

Report on NPAFC Workshop on Climate Change and Salmon Production

Don Noakes.
Pacific Biological Station
3190 Hammond Bay Road
Nanaimo, B.C.
CANADA V9R 5K6
E-mail: noakesd@dfo-mpo.gc.ca

Dr. Don Noakes is the Director of the Pacific Biological Station and Head of its Aquaculture Division (Department of Fisheries and Oceans, Canada) as well as the Canadian Scientific Advisor for the North Pacific Anadromous Fish Commission (NPAFC) and the Canadian Scientific Advisor for the International Pacific Halibut Commission (IPHC). His research interests include the applying of time series analysis and forecasting methods as well as nonparametric and modern regression techniques to address resource management problems. Dr. Noakes has published in the fields of hydrology and water resources management as well as many areas of fisheries and oceans science including research on Pacific salmon, Pacific herring, and various species of molluscs and crustaceans. He has overall responsibility for the Department's aquaculture research, development, and coordination programs in the Pacific region. In addition to promoting the sustainable development and diversification of aquaculture in Canada, Dr. Noakes is continuing to study the impacts of climate change and regime shifts on fishery resources.

There is a growing body of scientific evidence supporting the significant direct and indirect impacts of environmental change on multi-species fish production. These impacts are often a consequence of complex changes to marine and freshwater ecosystems. While the causal mechanisms linking the various physical and biological processes are neither completely defined nor understood, there is general consensus that these links exist. These concepts are not new and indeed have been alluded to in the process of explaining away large discrepancies encountered with traditional fisheries models. What is new is the relative importance given to the environment and ecosystem changes to the point where the impacts of climate change on fish production are now being given equal consideration to the competing hypothesis that fish production is governed solely by an intrinsic stock-recruitment relationship and fishing. In reality, all of these factors are important and ways must be found to incorporate all of the relevant information when assessing and managing fish populations.

In recognition of the importance of these issues, the North Pacific Anadromous Fish Commission (NPAFC) held a workshop March 26-27, 1998, in Vancouver, B.C., to examine evidence from around the Pacific rim on the impacts of climate change and shifts in oceanographic conditions on the production of Pacific salmon. The workshop attracted more than 60 individuals from Canada, Japan, Russia, and the United States, and 20 papers were presented over the two days. Topics included discussions on the oceanographic conditions and trends in the North Pacific, particularly in 1997, changes in primary productivity both in terms of biomass and species composition, trends in regional and global indices of climate change, and the biological impacts of these factors on the production of various Asian and North American salmon stocks. While it was clear that El Niño resulted in anomalous conditions in 1997, there was also a recognition that longer term decadal scale trends in climate were also impacting salmon stocks.

Salmon catches in the North Pacific have undergone significant fluctuations in the past 70 years and have been at or near historic high levels (about 900,000 t) in the last few years (*Figure 1*). While some of this observed increase could be attributed to the significant salmon enhancement activities around the Pacific rim, evidence presented at this workshop and elsewhere suggests strong links to climate change and subsequent increases in marine productivity and survival. For instance, a strong correspondence between salmon catch and an index of atmospheric climate in the northern hemisphere (ACI) might lead one to conclude that salmon production would have increased naturally (perhaps not to the same extent or with regional differences) as a

result of a shift to a more productive regime in the late 1970s (*Figure 2*). A number of speakers at the workshop noted similar patterns (synchronous shifts) in other indices of climate change (such as the Aleutian Low Pressure Index, North Pacific Index, Southern Oscillation Index, and Pacific Decadal Oscillation Index) supporting the concept of decadal scale shifts between low and high productivity regimes. Evidence presented at the workshop suggests that there may have been a shift to a new productivity level (regime) in the late 1980s or early 1990s but this shift was not a return to the pre-1977 levels. If such a change is confirmed, then this shift would at least partially account for the observed changes in salmon catches in the 1990s.

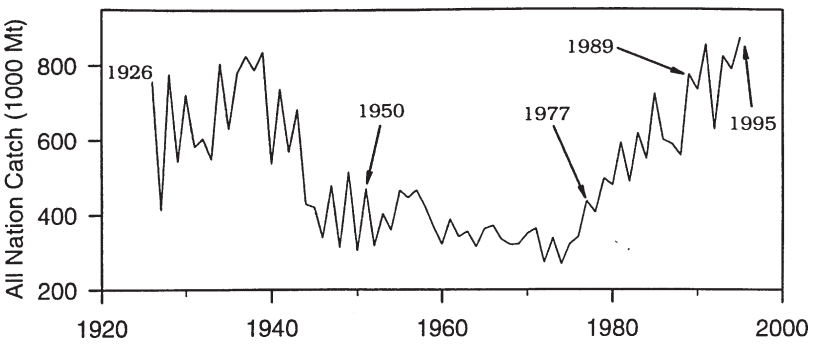

Fig. 1 All-nation catch of sockeye, pink, and chum salmon 1926-95.

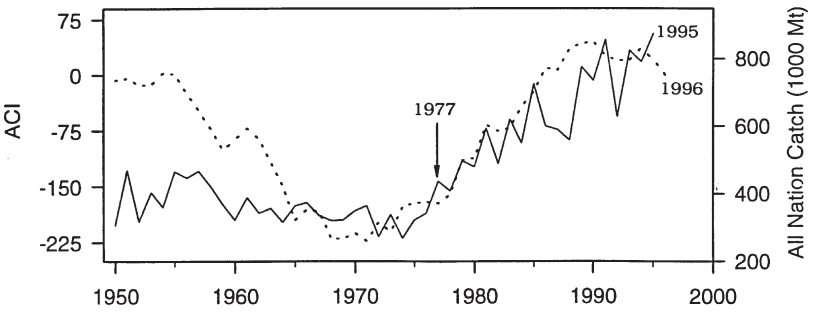

Fig. 2 Atmospheric circulation index (ACI) [dashed line] and all-nation catch of sockeye, pink, and chum salmon [solid line] 1950-1996.

The effects of the 1997 El Niño continue to influence oceanographic conditions, particularly along the North American coast, and are expected to persist for some time. There is still no clear pattern developing for 1998, and no bold predictions either for or against renewed El Niño conditions were ventured at the workshop. There was some recognition by participants that La Niña or the colder climate (reverse) equivalent of El Niño also had dramatic influences on our climate, ocean conditions, and fish stocks. However, the La Niña phenomenon has received considerably less attention than El Niño, and this should change. While both types of extreme events are likely to cause transient changes in coastal ecosystems, there was no strong evidence to link either El Niño or La Niña events to longer term shifts in productivity. These events may signal or perhaps even trigger longer term shifts in productivity but these isolated and random events do not account for the observed persistent trends in salmon productivity.

There was a recognition that environmental conditions need to be explicitly accounted for in our assessment and management of fish stocks. Traditionally, fisheries science and fisheries management have been based on the premise that fluctuations in fish populations were intrinsic functions of the reproductive capacity of the species and various anthropologic factors such as fishing pressure and habitat changes. These beliefs resulted in the development of concepts such as maximum sustainable yield and the faith that fish stocks could always be rebuilt to these maximal yields almost independent of the dynamics of other stocks (either predators or prey) and/or the environment.

The net result of this philosophy was a single species approach to assessment and management that merely uses the environment to explain away large discrepancies rather than incorporating the environment as an integral part of the process. During periods of stable or increasing fish production, the consequences of such an approach may be minimal particularly if conservative harvest strategies are adopted. However, during periods of decreasing or low fish production the consequences of assessing and managing single stocks or species in isolation can be dramatic if appropriate conservation measures are not taken promptly.

Such fundamental changes will require time and above all education both within and outside the scientific community. The NPAFC workshop on Climate Change and Salmon Production, PICES “CCCC” , and efforts in other related programs will help speed the process. However, much work remains to be done.

Those interested in additional information concerning the NPAFC workshop should contact Dr. Irina Shestakova, Executive Director, NPAFC (Suite 502, 889 West Pender Street, Vancouver, BC, V6C 3B2, Canada, Phone: 604-775-5550, Fax: 604-775-5577, Email: irina@unixg.ubc.ca).

A New Ocean Time Series Station in the Western Subarctic Pacific

Yukihiro Nojiri
Global Warming Research Laboratory
National Institute for Environmental Studies
16-2 Onogawa, Tsukuba,
Ibaraki 305-0053, JAPAN
e-mail: nojiri@nies.go.jp

Dr. Yukihiro Nojiri is the Head of the Global Warming Research Laboratory in the National Institute for Environmental Studies, Japan Environment Agency. He received his Ph.D from the University of Tokyo (Department of Chemistry) in 1986. His scientific background is marine geochemistry. Investigation of hydrothermal processes on seafloor, work on the trace metal chemistry in fresh water lakes and gaseous component studies were the important steps in his career. Since March 1995, he is the chief scientist in the Japan-Canada ship-of-opportunity monitoring program, in which CO_2 exchange over the North Pacific is measured with complete seasonal coverage. Currently, he is also the leader of the Japanese Ocean Time Series project in the western North Pacific. Recently Dr. Nojiri was appointed as co-chairman of the new PICES WG 13 on CO_2 in the North Pacific.

Ocean Time Series Stations

There are currently two active ocean time series stations in the North Pacific. One is station P in the central Gulf of Alaska, which started in 1956 and is maintained mainly by the Institute of Ocean Sciences (IOS), Canada. The other, which stated in 1988, is station ALOHA archived in the Hawaiian Ocean Time Series (HOT) from the subtropical central Pacific, mainly maintained by the University of Hawaii. These are JGOFS (Joint Global Ocean Flux Studies) time series stations aimed at understanding the biogeochemical processes in various time scales. The phytoplankton production in the oligotrophic station HOT is sustained by a relatively sporadic supply of nutrients owing to vertical circulation of seawater. The subarctic station P is characterized as the High Nutrient/Low Chlorophyll (HNLC) site, where high nutrient concentrations are maintained throughout the year. A new Japanese time series station under the international JGOFS scheme is being initiated to study the oceanic biogeochemical processes in the western subarctic gyre, the area of highest productivity in the pelagic North Pacific Ocean.

Goals of JGOFS Japan North Pacific Process Study

The main targets of the North Pacific Process Study by JGOFS Japan are (1) to quantify CO_2 that is drawn down by physical and biological pumps in the northern North Pacific, by identifying and studying the regional, seasonal to interannual variation of the key processes, and (2) to understand their regulating mechanisms. The JGOFS Japan activities are categorized into intensive studies by research vessel (R/V) programs, extensive studies by WOCE line occupation and ship-of-opportunity programs, satellite remote sensing, and modeling studies. There is a lack of observations from a time series station in the western part of the North Pacific. A large difference in productivity between western and eastern subarctic Pacific is well known. Plankton blooms occur in the western subarctic Pacific, however, not in the eastern subarctic Pacific. To have a new time series station in the western subarctic Pacific would be the best strategy to observe various time scale phenomena and to do comparative study between western and eastern Pacific. The biggest difficulty in survey works in the high latitude Pacific is the rough weather condition, especially in winter, but the world's largest R/V *Mirai* of JAMSTEC (Japan Marine Science and Technology Center), launched in 1997, has made winter survey possible in the western subarctic Pacific.

Location and Scientific Background

The new time series station is named KNOT (Kyodo North Pacific Ocean Time Series). As this station is run by several oceanographic institutes in Japan, the time series is cooperative ("Kyodo" in Japanese). The KNOT station is located at 44°N and 155°E (*Figure 1*). The western subarctic Pacific is the source region for NPIW (North Pacific Intermediate Water), forming a widely spread salinity minimum at mid depth over the North Pacific subtropical gyre. The physical oceanography of the area was recently reported by Yasuda (*J. Geophys. Res.*, **102**, 893-909, 1997), summarizing the extensive CTD surveys by the fisheries research institutes of Japan. The paper concluded that the NPIW formation is caused by mixing of low salinity Okhotsk

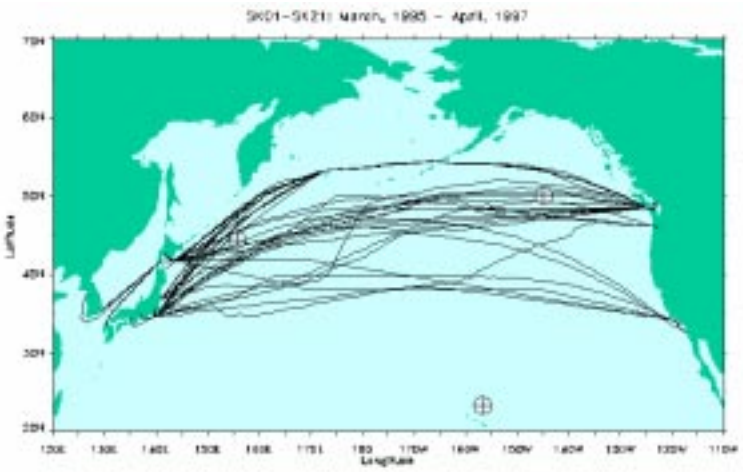

Fig. 1 Japan-Canada ship-of-opportunity CO_2 monitoring (M/S Skaugran) cruise tracks and the time series stations in the North Pacific.

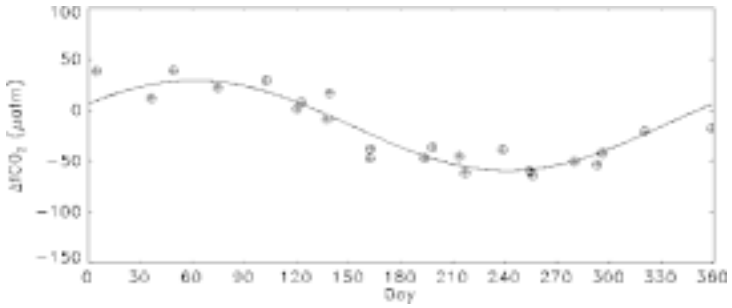

Fig. 2 Seasonal function of ΔfCO_2 around station KNOT observed by M/S Skaugran program.

Sea water and high salinity Kuroshio Extension water. However, there is a lack of winter observations. In March 1995, NIES (National Institute for Environmental Studies) and IOS started a Japan-Canada cooperative CO_2 monitoring project, using a ship-of-opportunity (M/S *Skaugran*) between North America and Japan. The ship route widely covers the North Pacific, including the western Subarctic Gyre (*Fig. 1*). The recent data analysis indicates a clear seasonality in the surface distribution of fCO_2 and nutrients. *Fig. 2* shows the seasonal variability in the delta fCO_2 (seawater – atmosphere) from 23 observations by the east and west bound legs of M/S *Skaugran*. It indicates the increase of fCO_2 by the deepening of the surface mixed layer with autumn-winter cooling and the decrease of it by dissolved inorganic carbon consumption with the spring-summer biological production. As a result, winter efflux and summer influx of CO_2 is observed around the KNOT station. Relating to the larger biological productivity, the fCO_2 seasonal amplitude is much bigger than that in the western subtropic and eastern subarctic Pacific. The nutrient seasonality is just the same as the delta fCO_2, as nutrients are supplied from the subsurface water by winter mixing and consumed during the spring-summer bloom. The summer depletion of the nutrients is usually not complete.

Station Occupation Schedule

The project is supported by the CREST (Core Research for Evolutional Science and Technology) program of the Japan Science and Technology

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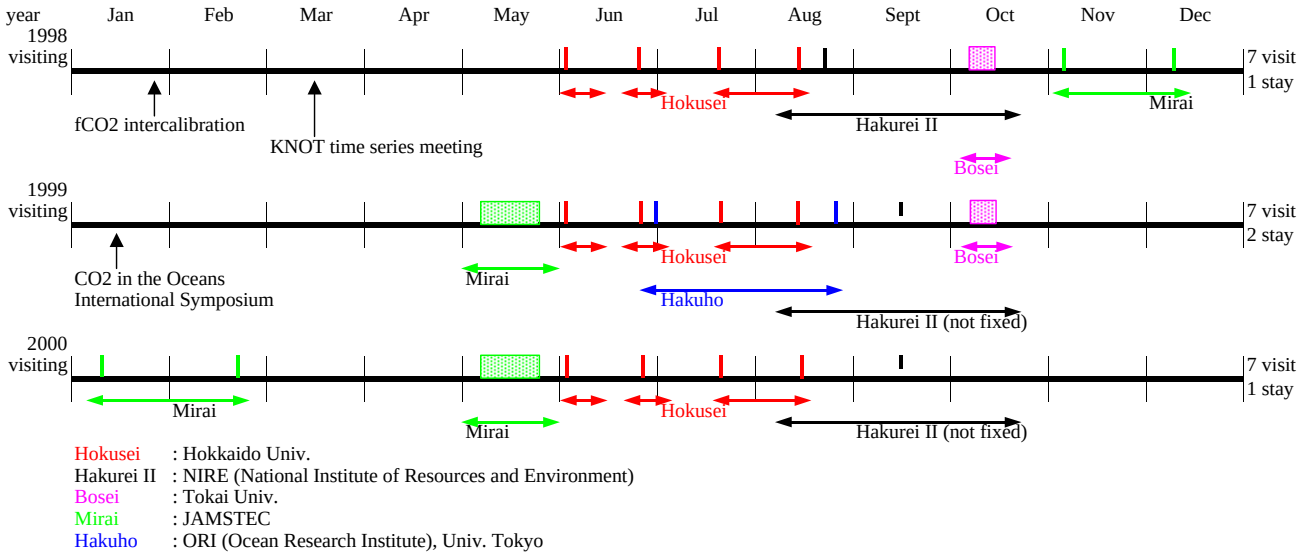

Fig. 3 Station KNOT Ocean Time Series research vessel visiting schedule.

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From Korea, hosts Profs. Kuh Kim and Kyung-Ryul Kim of Seoul National University spoke about their work of the past five years in CREAMS, centered on carrying out hydrographic and chemical tracer measurements on cooperative, international cruises in the JES. This work has yielded important new clues to the origin of JES deep water and the nature of long-term changes in the JES deep circulation. It is planned for this work and the international collaborations that it has fostered to continue into the future. In addition, a number of scientists from the Korean Ocean Research and Development Institute (KORDI) are planning to begin projects that examine the properties of mesoscale variability in the southern JES in the next few years.

From Japan, Professors Akira Masuda, Jong-Hwan Yoon, and Masaki Takematsu reviewed their results of the past several years, which have centered on making moored measurements of the deep JES circulation and developing numerical models of the flow. Prof. Takematsu's well-known current measurements, which show strong seasonal dependence on the flow in even the deepest portions of the JES, have revolutionized our picture of the JES circulation and have shown the necessity of having the ability to carry out high-resolution modeling. The participants in the workshop agreed that the continuation of this current measurement program was an important priority for the next phase of JES research. Professors Masuda and Yoon, from the Dynamics Simulation Research Center at Kyushu University, discussed their plans to continue the modeling efforts of the past several years and to build on their progress with a new program of observations and data assimilation. If data and models are to be used in an optimal way, then we must learn how to use the observations as constraints on the models as they are being run, and this topic is central to their goals in the coming years.

Drs. Yuri Volkov and Alexander Tkalin of the Far Eastern Regional Hydrometeorological Research Institute (FEHRHI) in Vladivostok, Russia, noted that most of the CREAMS observations of the past five years have been carried out from Russian research vessels. They expressed the hope that this kind of international collaboration will continue; it seemed clear at the meeting that most JES researchers are assuming that the use of Russian ships will continue to be indispensable for carrying out high-quality JES research in the future. Dr. Vyacheslav Lobanov of the Pacific Oceanological Institute in Vladivostok noted that scientists from his institute plan to carry out important measurements in the coming years in the region near the Russian coast of the JES where the densest water is formed in winter and deep convection is thought to occur, which should help to address one of the most pressing questions concerning the circulation of the JES. Additionally, both Russian institutes have a large quantity of JES observations dating from early in this century in their archives that they plan to process and examine in the near future.

The U.S. plans for JES research were introduced at the meeting; while these plans have been discussed in a general way for the past two years, this was the first occasion where the details of the U.S. projects were publicly presented to the JES community. All of the U.S.-sponsored projects have important collaborators in the nations bordering the JES. Several scientists in the United States have been developing numerical models of the JES for the past several years, and this work will be augmented by a substantial U.S. field program. A number of projects addressing questions ranging from mesoscale variability in the southern JES, variability

Dr. Stephen Riser is Professor at the School of Oceanography, University of Washington, Seattle, U.S.A. He received his B.Sc. (1971) in Physics from the Purdue University, and M.Sc. (1973) and Ph.D. (1981) in Physical Oceanography from the Massachusetts Institute of Technology and the University of Rhode Island respectively. Steve's research interests include circulation and mixing mechanisms in the North Pacific and North Atlantic, long-term changes in the deep circulation of the marginal seas, ocean models, and ocean instrumentation. Currently he leads the following projects: Ventilation and deep convection in the Japan/East Sea; The Okhotsk Sea as a source of North Pacific Intermediate Water; and Air-sea interaction and climate effects in the western North Atlantic. He is also the Chief Scientist of the U.S. Japan/East Sea Project Office. Since 1993, Dr. Riser has been deeply involved in PICES activities, as a member of Physical Oceanography and Climate Committee, Working Group 1 (The Okhotsk Sea and Oyashio Region) and 7 (Modelling of the Subarctic North Pacific Circulation). He also serves as a member of the U.S. WOCE Steering Committee, and a member of the JGOFS North Pacific Task Team.

in Tsushima Strait, mixing along the subpolar front, and wintertime convection in the western JES will begin in 1999 and continue for a two-year period. Several of these programs plan to apply technological developments made in research programs conducted elsewhere in the World Ocean to JES research projects for the first time. As with the Japanese plans, the assimilation of data from the observational programs into high-resolution numerical models will be an important goal of the U.S. work.

It is clear that the next five years will be an exciting time for oceanographic research in the JES. It also seems obvious that as the number of participants in this research and the extent of international collaboration increase, the type of organization necessary to coordinate these activities will probably have to evolve. In recent years the CREAMS efforts have had little in the way of structure, formal agreements, or committees; instead, the scientists in CREAMS were bound together simply by their mutual desire to carry out oceanographic research in the JES and to hold regular meetings to present their findings. With the addition of a large contingent of U.S. participants to JES research, as well as the proposed expansion of the efforts by countries that border the JES, it is not clear that such an informal structure will continue to be appropriate. Since the countries involved in JES research are all members of PICES, the possibility that PICES might be able to help in some aspects of coordinating research in the JES was discussed at some length at the Seoul meeting. It was generally agreed that PICES might be able to provide important help to JES research, especially in the area of obtaining permission for scientific work to be carried out across the various EEZ boundaries of the JES. As a result of discussions that took place at the PICES Sixth Annual Meeting in Pusan in October of 1997, the PICES Science Board formally recognized the scientific value of the work in CREAMS and approved the development of stronger ties between PICES and CREAMS. One of the first steps in nurturing these ties will be to hold a joint PICES/CREAMS Workshop at PICES VII in Fairbanks later this year. Taken together, the extensive new research programs planned for the JES plus the development of strong ties between the scientists involved in this work and PICES, imply that the JES has the potential to become one of the most active regions of international cooperation in oceanographic research in the world. Given the wide variety of physical processes that appear to be active in the JES, this suggests that the results of cooperative research in the JES might be of primary importance to research in other regions of the global ocean.

Stephen C. Riser
School of Oceanography
University of Washington
Seattle, WA 98195-7940, U.S.A.
E-mail: riser@ocean.washington.edu

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Cooperation under the Science and Technology Agency. *Fig. 3* shows the schedule of research vessel occupation of the station KNOT. The "highlight period" of the time series campaign is from June 1998 to August 2000. Research vessels of 5 institutions will join the project. R/V's *Mirai*, *Hakurei II* and *Hakuho* will visit KNOT during their survey in the western North Pacific. R/V *Hokusei* will visit KNOT on her regular fishery training cruises. R/V *Bosei*'s visit is supported through the CREST funding and the cooperation of the Tokai University. The extension of the time series work after 2000 would need other funding. The selected time series occupations cover the period of high productivity from May to October. The role of R/V *Mirai* is quite important, covering the winter season. It is expected that there will be volunteer occupations by other R/Vs during the highlight period.

Core Measurements

The core measurements following the JGOFS protocol, will include: underway fCO_2 measurements (equilibrator with NDIR); CTD and Rosette sampling to analyze salinity, dissolved oxygen (potentiometric or photometric titration); dissolved inorganic carbon (newly developed coulombetric analyzer); alkalinity (potentiometric titration); pH (glass electrode); nutrients (onboard auto analyzer); phytoplankton and pigments (HPLC); and primary production (^{13}C incubation with drifting sediment trap). Because the time series occupations are carried out with different R/V's, intercalibrations are still progressing for these core measurements. The target measurement of the time series campaign is to study carbon cycling and its controlling factors. Optional measurements, including carbon isotopes, dissolved gases, radionuclides, dissolved iron, organic carbon and nitrogen, etc., are planned to complete the process study. The major participants in the program are: Hokkaido University/Graduate School of Environmental Earth Sciences, Hokkaido University/Faculty of Fisheries, National Institute for Resource and Environment, Ocean Research Institute/University of Tokyo, Central Fishery Research Institute, JAMSTEC, Nagoya University/Institute for Hydrospheric-Atmospheric Sciences and Kinki University. The moored sediment traps at depths of 1000, 3000 and 5000 m have already been deployed by JAMSTEC in November 1997.

This encouraging new cooperative program by the Japanese chemical oceanographers is open to researchers from the other PICES countries.

PICES Seventh Annual Meeting

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Decadal variability of the North Pacific climate (POC)

Carbon cycle in the North Pacific Ocean (POC & BIO, and co-sponsored by JGOFS)

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Contaminants in high trophic level biota - linkages between individual and population responses (MEQ & BIO)

Climate change and carrying capacity of the North Pacific: recent findings of GLOBEC and GLOBEC-like programs in the North Pacific (FIS & CCCC)

Small pelagic species and climate change in the North Pacific Ocean (REX Workshop)

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Physical oceanography of the Okhotsk Sea
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Interannual variations and the regime shifts

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