

Introduction: the Physical, Biological, Chemical and Geological Processes in the Pacific Ocean and Asian Marginal Seas

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Since the first Japan and East China Sea Studies(JECSS) Workshop was convened on 1-4 June 1981 at Tsukuda University by joint convenership of Dr. Kenzo TAKANO (Prof. Emeritus of the University at present) and late Prof. Takashi ICHIYE of Texas A&M University, JECSS Workshop has been held once in every two years. Its purposes were initially to exchange knowledge on research activity and to discuss research results on the physical aspects of the Japan and East China Seas under the unfortunate political circumstances among countries around the Japan and East China Seas. For responding to increase in demand for better understanding of global change of marine environment, its scope was expanded to include the physical, biological, chemical and geological aspects of the Pacific Asian Marginal Seas, and the name of the workshop has been changed to PAMS/JECSS Workshop since 1993 at Qingdao, China. Succeeding the ninth PAMS/JECSS Workshop held on 22-24 September 1997 at Taipei, Taiwan, the tenth PAMS/JECSS Workshop was held on 7-9 October 1999 at the Inamori Auditorium, Kagoshima University, Kagoshima, Japan, as a part of the 5th International Marine Science Symposium on the Physical, Biological, Chemical and Geological Processes in the Pacific Ocean and Asian Marginal Seas of Japan Marine Science Foundation.

It is an urgent task to fix the plans for keeping the marine environment appropriate for whole future human beings. Materials dis-

charged locally into coastal seas, are spreading globally after passing through the marginal seas. In order to predict the global change of marine environment, it is crucial to estimate the amount of materials discharged into coastal seas and elucidate the physical, biological, chemical and geological processes in the marginal seas. The objectives of this workshop was to provide a forum to review the status of oceanographic research on the various processes in the Pacific Ocean and Asian marginal seas and their role in the global change of marine environment.

A total of one hundred and two persons participated in the workshop. Among them, 47 were from Japan, 29 from Korea, 8 from U.S.A, 7 from China (Beijing), 7 from China (Taipei), 2 from Indonesia, 1 from Malaysia, and 1 from Russia. The workshop consisted of 11 sessions for oral presentations together with 2 poster sessions. Number of papers on the Tushima Strait, South Sea of Korea, and Japan (East) Sea including oral and poster presentations was the maximum of twenty one, followed by 13 papers on the Kuroshio in the regions from near Taiwan to south of Japan, and 11 papers on the coastal ocean.

It is our pleasure that this workshop contributed largely to improvements of our understanding of spatial and temporal variation processes of marine environment in each of the Asian marginal seas as mentioned in the following summary reports.

Session 1. South China Sea

South China Sea (SCS) is the largest marginal sea in the world. Its water interacts with the Kuroshio and the surrounding seas,

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including the Philippines Sea, the East China Sea, the Sulu Sea and the Jawa Sea, etc. Recently there have been some studies on their interaction and the water exchange. In the 10th PAMS/JECSS workshop, the first session was devoted to the studies of the SCS with four oral presentations. (1) Y. HSUEH presented a model to calculate the topography-forced current bifurcation. The model explained dynamically the formation of the perennial South China Sea Warm Current (SCSWC). (2) T. YANAGI used the satellite altimetric data to estimate the horizontal distribution of sea surface dynamic topography and obtained the eddies and the seasonally averaged circulation patterns in the SCS. (3) Based on the water mass analysis, T. NAMBA discussed the circulation in the SCS in winter and summer. (4) A. K. LIU discussed the nonlinear internal waves in the SCS, based mainly on synthetic aperture radar observations and mooring measurements.

The following are some of the unsolved problems, which should be studied further in the future. (1) On the Kuroshio intruding into the SCS through Bashi Channel, there are different views. Some scientists consider that there is a branch of the Kuroshio intruding into the SCS, which is called to be as the South China Sea Branch of the Kuroshio. However, other scientists consider that the Kuroshio has no direct branch intruding into the SCS and there is a stronger southwestward flow near the Dongsha Islands, which is a part of the circulation in the north eastern part of the SCS. (2) There is a seasonal change in the circulation in the SCS. We must elucidate their dynamic mechanism. (3) There are a lot of warm and cold eddies with seasonal change in the SCS. We must show the dynamical causes of their change. (4) In contrast with the upper circulation in the SCS, there have been few studies on the deep circulation in the SCS which differs from that in the upper layer.

(reported by Y. YUAN, Second Institute of Oceanography, SOA)

Session 2. Kuroshio near Taiwan

C. T. LIU presented results from 11 hydrographic and acoustic Doppler current profiler (ADCP) surveys for measuring the volume

transport of the Kuroshio through the East Taiwan Channel. These results provide the first definitive estimations of Kuroshio transport in the area. The variability in the transport detected in the ADCP monitoring program across PCM-1 of WOCE suggests the influence of open ocean eddies. The eddy/Kuroshio interaction is invoked to explain the migration path of sea turtles. YUAN *et al.* perform inverse calculation on density sections from a number of hydrographic surveys in an expanded area east of Taiwan and west of the Ryukyu Islands. The Kuroshio transport estimates east of Taiwan are generally 10 Sv or more greater than that through the East Taiwan Channel. Those west of the Ryukyu Islands are similar to those reported by C. T. LIU, suggesting the diversion of part of the Kuroshio transport to east of the Ryukyu Islands. LIU and YUAN, in the fourth paper in the session, show that a northeastward flow of 12 Sv is indeed found east of the Ryukyu islands. Multiple current cores with alternating directions are also present. XINYU GUO uses a series of nested numerical (POM) models of the North Pacific Ocean to focus on the volume transport through the Taiwan Strait, a parameter of strategical importance in the oceanography of the marginal seas around Taiwan. The average for 1992-98 is 1.9 Sv northward with a root-mean-square value of 1 Sv. In view of a prolonged absence of any measurement due to the difficult political situations in the Taiwan Strait, this result can be considered as the best estimate to date and points to the value of numerical models.

Of the four poster papers, MANDA *et al.* describe upwelling of subsurface Kuroshio water onto the East China Sea shelf. The concentration of seeded (350-450 m) particles in the lower half of the shelf water column seems to suggest a general foreshortening of water column in the meander. Anticyclonic vorticity must be generated. ISOBE performs interesting numerical experiments to show that the branching of the Kuroshio southwest of Kyushu depends upon the amount of water allowed to leave the East China Sea through the Tokara Strait. NAKAMURA *et al.* provide evidence for a cyclonic circulation in the deep layers in the northern part of the Okinawa Trough, just

below the anticyclonic flow of the Kuroshio. YAMASHIRO *et al.* examine the flow and temperature distribution in the Tokara Strait and relate them to the path fluctuations of the Kuroshio.

All in all, except for the flow in the Luzon Strait, a paradigm of the Kuroshio flow around Taiwan appears to emerge. The diversion to the east of Ryukyu seems to make sense. Meanders of the Kuroshio allows the subsurface Kuroshio water to encroach onto the shelf. It is hopeful that, the next time around, a complete picture of the Kuroshio around Taiwan may be a possibility.

(reported by Y. HSUEH, Florida State Univ.)

Session 3. Kuroshio in the East China Sea

There are two oral and six poster presentations in this session. The oral presentations are on the spatial and temporal variation of Kuroshio in the East China Sea. From the data of surface drifter and hydrographic surveys, H. -J. LIE concluded that the eddies and Kuroshio frontal movements are closely related, and that the shoreward cyclonic movement is associated with the upwelling of the slope water. He also found that the downstream propagation speed is 20 km/day for meander of wavelength 100 km and amplitude 15 km. S. MIZUNO used two years long moored current meter data combined with hydrography and wind forcing analysis to conclude that the Ekman dynamics is the controlling mechanism on the shoaling of the mixed layer of Kuroshio in the Summer and Fall. Both above conclusions were also reached by Taiwanese oceanographers on the study of Kuroshio near Taiwan.

In the poster session, six more papers related to the above topics : (1) The upwelling associated with Kuroshio was verified with diagnostic models by A. MANDA *et al.* ; (2) A. ISOBE also used diagnostic models to discuss the generation mechanism on the branching of Kuroshio near Japan that started near Taiwan ; (3) H. NAKAMURA *et al.* studied the variation of the deep water in the Northern Okinawa Trough and found that its variation is strongly related to the variation of Kuroshio water near the surface layer ; (4) the Kuroshio variation influences the coastal water movement further

downstream in the Tokara Strait by T. YAMASHIRO *et al.*, southwest of Tokara Strait by H. ICHIKAWA *et al.*, and south of Shikoku by M. KASHIMA *et al.*

All of these papers demonstrated that the phenomena on the Kuroshio variation is similar from Taiwan to Japan and Korea, and the physics that governs the Kuroshio variation should be very similar. PAMS/JECSS provided an unique opportunity for the local oceanographers to exchange their findings and research ideas on oceanography of this region.

(reported by C. -T. LIU, National Taiwan Univ.)

Session 4: Yellow and East China Seas

The session composed of two oral presentations (one invited) and four posters, dealing with tide and tidal current, circulation and biogeochemical aspects in the continental shelf area of the Yellow and East China Seas: two papers for tide and tidal current, two for circulation, one for biogeochemical process.

Invited speaker, B. H. CHOI, has evaluated modification of the Yellow Sea tidal regime by tidal barrier construction in the western coastal area of Korea. Significant perturbations of the order of 20 cm in sea level and 10 cm/s in current were expected in the neighbourhood of the barrier and they affect not only the whole Yellow Sea tidal regime, but also the marine environmental system related to the tide such as sediment distribution and suspended matters. J. -J. HUNG presented recycling of organic matters using intensive data collected in the southwestern East China Sea.

In the poster session, new findings and methods were presented ; (1) M2 current of the Yellow Sea was estimated from Lagrangian drifter, (2) annual cycling motion of fresh coastal water in the southern Yellow Sea was clearly suggested based on intensive hydrographic data, (3) Stratified tidal current in summer was numerically investigated, (4) a 3-D circulation model was applied to simulate basic oceanographic features in the Yellow and East China Seas.

Number of presentation is limited, compared to previous PAMS/JECSS Workshops. However, scientific level and understanding are much improved, with many new findings.

(reported by H. J. LIE, KORDI)

Session 5: Tushima Strait and South Sea of Korea

Recent observations of CTD and direct currents in the sea between the Cheju Strait and the western channel of the Korea/Tsushima Strait indicate a large fluctuation of water properties and currents on various time scales. However, all observations show that the eastward transport through the Cheju Strait accounts for a significant portion of the transport in the western channel of the Korea/Tsushima Strait. A coastal current along the Korean coast is uncertain as observations do not agree in its direction. A continuous program is necessary in future to understand the variability of the current system in this system in this area, which determine the inflow condition for the Tushima Current.

(reported by K. KIM, Seoul National Univ.)

Session 6 and 7. Japan/East Sea I and II

The analysis of satellite and modern and historical field data and numerical simulations provided new insight into the variability of the JES circulation (flow and mass fields) on time scales ranging from the atmospheric mesoscale and synoptic scale to seasonal, interannual, and interdecadal. For example, K. -H. CHO simulated the interaction of the Korean seabreeze/landbreeze system with coastal topography and the coastal marine boundary layer, resulting in strong atmospheric forcing of coastal waters. C. N. MOOERS forced JES-POM with Siberian cold-air-outbreaks simulated by a mesoscale atmospheric model (MM5) to study synoptic scale, event-driven wintertime convection, and additionally found that basin-scale sea surface height and transport oscillations were generated. A. MORIMOTO used several years of satellite altimeter data to describe the space-time evolution of JES currents and mesoscale variability in several subdomains, finding a common spectral peak of 50 days and typical eddy lifetimes of 9 months. H. HASE examined 27 years of monthly hydrographic transects to describe the seasonal evolution of the thermal wind and, thus, map the pathway of the First and Second Branches of the TWC,

finding that the First(Nearshore) Branch flows inside the 200 m isobath from the eastern T/K Strait to Tsugaru Statit, the Second(Middle) Branch flows from the western T/K Strait seaward of the 200m isobath, presumably to Soya Strait, and the First Branch has a summer maximum that translates downstream at the rate of 7 km/d. Y. H. SEUNG simulated intrinsic interannual variability (due to dynamical instability of the subpolar jet sytem) on time scales of several years, finding, with steady throughflow-forcing plus no-wind-forcing versus wind-forcing cases, that wind-forcing drastically changed the character of the Subpolar Jet meanders and eddy-shedding and reduced the intensity of internnual variability.

K. KIM used high quality and high resolution CTD and DO data from CREAMS winter cruises off Vladivostok to demonstrate that low salinity, low temperature water was present in the outcrop zone in the western Japan Basin for low salinity Intermediate Water formation and sinking beneath the Subpolar Front to 200 to 400 m, while high salinity Intermediate Water was formed in the eastern Japan Basin. C.-W. SHIN analyzed MMO&KORDI historical hydrographic data to trace the wintertime formation off Vlaidvostok and North Korea, summertime spreading to Ulleung Basin, and autumnal dissipation of the salinity minimum of the low salinity Intermediate Water. H. KAWAMURA simulated the influence on JES of global atmospheric warming that began 50 years ago and found that JES swiched from Deep to Intermediate Water formation about 40 years ago, and that cyclonic wind stress curl off Vladivostok, together with low salinity, low temperature water from the Amur River, plays an important role in cyclonic circulation generation and Intermediate Water formation there. S. IKEDA simulated the JES marine ecosystem and biogeochemistry, taking into account organic carbon loading from land and regional economic development and global warming scenarios, and finding that the transport of organic carbon to the middle and deep layers may decrease, which would decrease the DO in the upper layer, but longer computations are needed for better confidence. Overall, new and old data, and complex and simple models,

are addressing overlapping questions in the JES, whose answers have major implications for the design of future monitoring and modeling systems, scientific research and societal policy agendas.

(reported by C. N. MOEERS, Univ. of Miami)

Session 8. Instruments

Five papers were presented in Section 8 on the applications of advanced technology in studying the Pacific Asian Marginal Sea. W. T. LIU presented an invited paper on using various combinations of spacebased sensors, including Quik SCAT, TRMM, Topex/Poseidon, SSMI, and AVHRR. These data were used to study the interplay between the dynamics and hydrologic parameters in typhoons Olga which landed on Korea, the monsoons in the South China Sea and their relation with ENSO, and El Niño modification of decadal anomalies in the North Pacific. He also used an image of the evolving typhoon Dan to introduce an information system, which processes, displays, and disseminates data in near real-time. Two papers on H. F. Radar were presented. S. FUJII developed a long-range instrument that can observe the Kuroshio from land. D. BARRICK presented a compact, low-cost, and easy-to-deploy radar, and S. RAMP discussed its scientific application at a number of locations around the world. There were also two papers on acoustic tomography. S. OH presented an experiment using explosive charge in deep water and a vertical line array as receiver to map the profile of temperature perturbation. H. YAMAOKA presented a system composed of five moored acoustic transceivers and a ship monitor, and the measurement of the tidal vortex. The result suggest powerful new technology in future scientific pursue in the PAMS/JECSS Program.

(reported by W. T. LIU, JPL)

Session 9. North Pacific Ocean and its Marginal Sea

Three papers by oral presentation relating to simulation of ocean circulation using GFDL Modular Codes were made in session 9. First invited paper by Y. MASUMOTO deals with the simulation of internnual variations of the Indonesian through flow using the dataset of ERS

scatterometer and NOAA/NESDIS for surface heat flux during 1992–1997 with model coverage of the Indian and Pacific Oceans. Despite a raised question regarding the suitability of a half-degree horizontal grid resolution of the model for resolving the complex geometry and narrow passages for flow through the Indonesian Archipelago, simulated interannual variations were consistent with observation. Author suggested further observations and additional modeling studies with fine grid resolution models of various kinds. Second paper by D. XU *et al.* deals with simulation of the seasonal change of the Kuroshio using climatological dataset of Hellerman and Levitus. Model simulations were performed prognostically as temperature and salinity restored for the surface boundary condition. Last paper by Z. WEI *et al.* deals with a diagnostic circulation study on the world ocean circulation. There were suggestions to carefully examine the restoring time scale for diagnostic experiments.

There were also seven poster presentations. M. KUBOTA and H. TOMITA: Satellite derived turbulent heat flux estimation over western North Pacific with satellite data, SSM/I and NCEP and also COADS and results had higher resolution on time and space. B. H. CHOI *et al.* indicated further necessity of establishing global tidal current dataset to improve regional and global dissipation of the M2 tide to complete the balancing of energy in the model. Paper by Z. YUAN *et al.* have dealt the ADCP measurement from VOS. C. -T. A. CHEN documents a 20-year seawater temperature at Nanwan, where there is heat-discharge from a coastal Power Plant. M. MATSUYAMA presented a result on direct ADCP measurement at Soya Strait, of which the summer transport is about 1.2 SV. K. ICHIKAWA's poster deals with T/P, ERS altimetry-derived SSH anomaly in the Bungo Channel, and correlated with mesoscale eddies east of Ryukyu Islands.

(reported by B. H. CHOI, Sungkyunkwan Univ.)

Session 10 and 11. Coastal Ocean

The research on Coastal Ocean in the early time of its development neglected the research on the Oceanography. A few measurements of coastal hydrography were carried out due to

engineering requirements. We in the oceanography community know the importance of the Kuroshio, the major current in the world ocean. But the most people outside the oceanography community, are not aware of the importance of the oceanography in relation to our daily lives. Coastal Oceanography, however, has its role related to people's daily lives, especially to the coastal area.

In the session of coastal oceanography, there are five oral presentations. Two of which by C. -T. A. CHEN and D. -L. TANG are related to nuclear power plant. The other two by A. ATMADIPOERA and I. MURIPTO discuss the coastal hydrography of Jakarta Bay and its fisheries. The last one by J. NA discusses tidal flat in the western coast of Korea. I believe the issue will play an important role for the land utilization of coastal area in future.

(reported H. -W. LI, National Taiwan Ocean Univ.)

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