IONTU-AORI workshop 2018
Theme: Northwestern Pacific Ocean Dynamics
Place: NTU

Day 1, Dec. 12
Morning: NTU plenary section
Lunch
Afternoon: Research presentation 思亮館 (Moderator: Jen-Chieh Shiao)

Time	Speaker	Title
1400-1410	Sen Jan	Opening by director of IONTU
1410-1440	Eitarou Oka	Remotely forced decadal physical and biogeochemical variability of North Pacific Subtropical Mode Water over the last 40 years
1440-1510	Shih-Nan Chen	Effects of bottom drag on the baroclinic instability in shallow flows
1510-1540	Kyoko Okino	Two contrasting hydrothermal fields in the Southern Okinawa Trough
1540-1610	Emmy Chang	New insights into Marine Geosciences, the recent study of the sedimentary and seafloor seismology in the northern South China Sea
1610-1640	Group photo and Tea break	
1640-1710	Yoichi Miyake	Early life ecology of marine invertebrates and fishes
1710-1740	Vianney Denis	A re-evaluation of coral's adaptive strategies based on species plasticity to environmental changes
1740-1810	Chuya Shinzato	Application of genomics to coral biology

1840- Dinner (Buffet at Just Sleep 捷絲旅二樓的「義饗食堂 Just Italian」)

Day 2. Dec. 13
Morning: Research presentation 思亮館 (Moderator: Chih-hao Hsieh)

Time	Speaker	Title
0900-0930	Kotaro Shirai	Retrospective environmental monitoring using bivalve shell geochemistry: an case study for the tsunami following 2011 Tohoku Earthquake
0930-1000	Jen-Chieh Shiao	Fractionation and application of nitrogen stable isotopes in fish otoliths
1000-1020	Tatsuya Sakamoto*	Combining microvolume isotope analysis and numerical simulation to reproduce fish migration history
1020-1040	Kuan-Mei Hsiung*	Variances of Japanese eel larval and juvenile transport process affected by climatic changes
1040-1100	Tea break	
1100-1130	Huei-Ting Lin	Spatial and temporal distribution of dissolved organic nitrogen (DON) in the Western Pacific Margin
1130-1200	Hiroaki Saito	Recent progress and perspective of the Kuroshio study
1200-1220	Wan-Hsuan Cheng*	Vertical beta-diversity depending on water mixing in the Kuroshio region east of Taiwan

*Postdoc and student talk
1230-1400- Lunch

14:00-1630 Group discussion (R215 and R106 or PI's office)- tentatively, separate into:
1) Physical oceanography and climate;
2) Marine geophysics
3) Marine ecology and biodiversity
4) Biological oceanography and biogeochemistry and larval transport

1630-1730 Wrap-up section to decide research direction of cooperation

1830- Dinner (金色三麥誠品酒窖店(台北市信義區松高路 11 號 B1))

Remotely forced decadal physical and biogeochemical variability of North Pacific Subtropical Mode Water over the last 40 years

Eitarou Oka[1], Kodai Yamada[1], Daisuke Sasano[2,3], Kazutaka Enyo[2], Toshiya Nakano[2,3], and Masao Ishii[3,2]
([1]Atmosphere and Ocean Research Institute, The University of Tokyo, [2]Japan Meteorological Agency, [3]Meteorological Research Institute)

Abstract:
Subtropical mode water is a less stratified, voluminous water that ventilates the upper permanent pycnocline of the western subtropical gyre. Its long-term variability plays an important role in climate and material cycles, but is not well understood. By analyzing half-century-long shipboard observations at the 137ºE hydrographic section in the western North Pacific, here we demonstrate decadal physical and biogeochemical variability of subtropical mode water over the last 40 years. During unstable periods of the Kuroshio Extension that lagged the warm phase of the Pacific Decadal Oscillation by 3−4 years, high regional eddy activity reduced the formation rate and salinity of subtropical mode water in its main formation region south of the Kuroshio Extension. At the 137ºE section south of Japan, decreasing advection of subtropical mode water from the east resulted in decreases of dissolved oxygen and pH and increases of nutrients and dissolved inorganic carbon, accelerating acidification. Such changes reversed and acidification slowed down during stable periods of the Kuroshio Extension, especially in the current period since 2010 exhibiting a hiatus of acidification. These results indicate a new mechanism by which climate variability affects physical and biogeochemical structure in the ocean interior.

Effects of bottom drag on the baroclinic instability in shallow flows

Shih-Nan Chen and Chiou-Jiu Chen

(Institute of Oceanography, National Taiwan University.)

Abstract:
The influences of bottom drag on the structure and growth of baroclinic instability are studied using quasigeostrophic (QG) theory and a three-dimensional, primitive equation ocean model (ROMS). The basic flows represent bottom-attached, thermal-wind balanced boundary currents. Such currents have been observed to be unstable, but counterexamples also exist, highlighting a need of exploring parameter space. As in Williams and Robinson (1974), the linear QG theory assumes that bottom drag indirectly forces the inviscid interior by inducing Ekman pumping at the lower boundary. The interior instability can then grow when the disturbances manifested in boundary-intensified Rossby waves are phase-lock and mutually reinforcing, as described in the Classic Eady problem. The theory suggests that the growth rate continues to decrease as the bottom drag (characterized by the Ekman number Ek) increases. The Ekman pumping acts to slow the phase speed of near-bottom baroclinic wave, modifying the up-shear phase tilt and hence reducing the growth. The most unstable mode also shifts toward larger wavelength in order to maintain wave coupling. Fully nonlinear calculations generally support the validity of the linear theory, but only for a range of small Ek ($\sim O(0.1)$). For large-Ek flows, stratification near the top of Ekman layer supports significant vertical shear, which considerably weakens the near-bottom flows. The use of interior vorticity to infer Ekman pumping in the QG theory therefore breaks down.

Two contrasting hydrothermal fields in the Southern Okinawa Trough

Kyoko Okino
(Atmosphere and Ocean Research Institute, The University of Tokyo)

Abstract:
The Okinawa Trough is located at back arc area of the Ryukyu arc-trench system and is considered to be in transitional stage from continental rifting to oceanic crust formation. Many hydrothermal fields have been recently discovered in the area both in Japanese and Taiwanese sides. Hydrothermal systems play important role in heat and mass flux between solid earth and ocean, as well as supporting unique chemosynthetic ecosystem. The structure, fluid geochemistry and associated ecosystem of hydrothermal systems are highly diverse and the diversity is constrained by the surrounding geological setting. In the Okinawa Trough and its adjacent areas, both sporadic basaltic intrusion/extrusion along the back arc rift axis and arc (mainly rhyolitic) volcanism take in place and drive hydrothermal circulations.
We conducted the integrated exploration using AUV Urashima at Tarama and Irabu Knolls in the southern Okinawa Trough to reveal the origin and extent of these hydrothermal systems and their geological and geophysical background. The Tarama Knoll is rhyolitic arc volcano located just northwest of the Ryukyu Islands, whereas the the Irabu Knoll is basaltic knoll complex located just on the rift axis. Our survey objectives are 1) to conduct high-resolution, three dimensional mapping of two sites using multiple sensors equipped on the AUV, 2) to compare two sites of different host rocks and tectonic settings, and 3) to identify an unknown high-temperature vent site at the Tarama Knoll. The AUV was generally operated at constant altitude mode (alt.=100m). We succeeded to cover whole area of these two knolls, using multi beam echo-sounder, side-scan sonar, sub-bottom profiler, three-component magnetometer, CTD, ADCP, pH/ORP/turbidity sensors, and 24-channel water sampler. High resolution sonar mapping reveals the collapsed slope sediment on the northeastern flank of the Tarama Knoll, where water column acoustic anomaly was also detected. We predicted the existence of unreported hydrothermal vent there and the following submersible dive in 2017 discovered a new high-temperature vent. Both shipboard and AUV-based magnetic data show very low magnetic anomalies over the Tarama Knoll, that is consistent with its rhyolitic mother rocks. The Irabu Knoll is characterized by its high magnetization and the AUB-based high resolution magnetic survey reveals the distribution of positively magnetized newly erupted lava flow and reduced magnetization caused by hydrothermal alteration. Two hydrothermal sites clearly show that the geological and tectonic setting controls their contrasting features.
Another very interesting hydrothermal field is the Yonaguni IV area in the westernmost end of the Okinawa Trough. IONTU-AORI project team planned to survey this field in 2017, but, very unfortunately, we could not reach the survey area due to bad sea condition…

New insights into Marine Geosciences, the recent study of the sedimentary and seafloor seismology in the northern South China Sea

Emmy T.Y. Chang, Don C.C. Su, Ho-Han Hsu, and Char-Shine Liu

(Institute of Oceanography, National Taiwan University.)

Abstract:
The study of marine environments, both locally and globally, enables us to better understand many of the big challenges facing our planet today, including climate change, natural hazard and renewable energy. The IO MG&G marine team have devoted to exploring the underwater geological background in the offshore area since 1968, by means of active/passive seismic survey and sediment coring. Our work now takes us from two subduction zones, neighboring to Taiwan, to the South China Sea (SCS). Benefiting from various research projects and international cooperation, the sediment analyses reveal that the offshore southwestern Taiwan is relatively stable even though there exhibits a high sedimentation rates (~30 m kyr-1). In contrary, the fluid activities, existence of weak layers and earthquake triggering are potential factors which might induced seafloor failures in the offshore Taiwan. The following research will be extended to the biological and chemical processes that contribute to marine resources, such as gas hydrate in the northern SCS.

The ocean bottom seismometer (OBS) has been considered to be a useful tool to study the lithospheric structures in the past decades. The OBS arrays deployed across the continental slope and the abyssal basin in the northern SCS has indicated an abundance of gas hydrate deposit in the offshore southwestern Taiwan and the northern South China Sea. Beside the tectonic units detected along the OBS seismic profiles, we maximise the analysis with the OBS data. The results reveal the energy transforming at the interface of media (water and sediments). The major ambient noises emitting from the shallow water zone such as the continental shelf or the break, indicates the energy may be converted from the non-linear interaction of the ocean current with the underwater topographic slope. Whereas the ambient noise generators are also detected at deep-sea abyssal basin. We consider the submarine volcanism and hydrothermal activity at tectonic fracture zones should play the main role for the deep-sea ambient noise. The study of T-phase event can also approve this inference. These observations provide not only the seismic information but also the clues for the seafloor geology which may relate to the post process of the SCS opening.

Early Life Ecology of Marine Invertebrates and Fishes

Yoichi Miyake
(Atmosphere and Ocean Research Institute, The University of Tokyo)

Abstract:
Knowledge in early life ecology of marine invertebrates and fishes is critical in understanding their population dynamics. My research on the early life ecology employs both field work (physical and biological surveys) and modeling (hydrodynamic and larval transport simulations). I will discuss some of our studies related to the recruitment of commercially-important species.
Many abalone species are experiencing population decline worldwide. We investigated larval dispersal of Japanese abalone and evaluated marine protected areas (MPAs). The warm-water abalone (*Haliotis discus discus*, *H. gigantea*, and *H. madaka*) shared similar early life ecology with the cold-water abalone *H. d. hannai*. [i.e. spawning during rough oceanic conditions, and mixed larval dispersal mode (short- and long-distance)]. The protection measures (e.g. MPAs), assuming short-distance dispersal of larvae, may not always lead to an increase in local stocks.
Japanese spiny lobster *Panulirus japonicus* releases larvae (phyllosomas) in the coastal waters between northern Taiwan and mid Pacific coasts of Japan in summer, and postlarvae (pueruli) return to the coastal waters the following summer. The one-year larval migration and its routes had been previously hypothesized based on in-situ larval distributions and stages; however, it was unknown if the hypothesized migration was possible, especially with regard to the ocean circulation. We conducted simulations of larval migration using an individual based model, and water flow and temperature from the reanalysis data. The hypothesized migration was possible even when hydrodynamics and larval mortality were considered. The vertical behavior of larvae was revealed to function as a mechanism for successful migration.
The aquaculture of Japanese eel *Anguilla japonica* relies on the commercial catch of juveniles (glass eels) in the coastal waters. However, predation on glass eels for all three endangered freshwater eels (i.e. Japanese, European and American eels) is a knowledge gap in their early life history. In order to find predators of *A. japonica* glass eels, we collected fishes in the Tone River Estuary (major glass eel fishing ground), and analyzed the stomach contents. *A. japonica* glass eels were preyed upon by an immature blackfin seabass *Lateolabrax latus* and an invasive channel catfish *Ictalurus punctatus*. Only two percent of the collected fishes consumed glass eels, and therefore these juvenile eels may not be a common prey item of the predatory fishes.
We are currently working on the recruitment mechanisms of marine organisms from the western boundary currents (e.g. Kuroshio), and the effects of light pollution on aquatic organisms.

A re-evaluation of coral's adaptive strategies based on species plasticity to environmental changes

Denis V[1], Chen Q[1], Hsieh E[1], Sturaro N[1,#], Yang SH[2], Tang SL[2]

([1]Institute of Oceanography, National Taiwan University, [2]Biodiversity Research Center, Academia Sinica, [#]Current address: Laboratory of Oceanology, MARE Centre, University of Liège)

Abstract:
Environment filters individuals on the base of the traits they exhibit. For tropical corals, species' trait averages have been used to distinguish four contrasted life-history strategies to interpret how different coral species may respond to disturbances. However, aggregate response at species level occults individual trait variation, which represents a fundamental aspect in the mechanism of natural selection and in the survival of coral species in the face of environmental changes. In this study, we developed a research framework integrating intra-species variation into our re-evaluation of coral's adaptive strategies. Our multidisciplinary approach encompasses detailed descriptions of three major characteristics of the coral holobiont (their physiology, trophic ecology, and associated microbiome) which together help us to delineate coral species niches. In addition, it directly informs us on trade-off in energy sources and allocation in contrasted habitats. Generalist species adjust their traits to environmental variations and display various phenotypes across habitats. To contrast, specialists perform better in a narrow range of environmental conditions and are characterized by few inter-individual variations. A generalization of this framework in studies on coral physiology is critical for our understanding of coral response to environmental changes.

Application of genomics to coral biology

Chuya Shinzato
(Atmosphere and Ocean Research Institute, The University of Tokyo)

Abstract:
Coral reefs are estimated to harbor about one-third of the world's described marine species and are regarded as the most diverse marine ecosystems on Earth. The structure of coral reefs is formed by calcium deposition by anthozoan cnidarians known as scleractinian corals. Scleractinian corals form obligate endosymbioses with photosynthetic dinoflagellates of the genus *Symbiodinium*, which provide the clear majority of photosynthetic products to their host corals. Although coral reefs have been disappearing due to both natural and anthropogenic disturbances, the molecular mechanisms underlying much of coral biology remain unclear. To address the lack of molecular data for scleractinian corals, we decoded, for the first time, the coral genome in 2011 and the genome of a *Symbiodinium* in 2013. Using the genomic data, we have performed various studies on coral reef ecology and conservation biology. We have developed a novel DNA testing method for one of the most widespread coral genus *Acropora*, assessed genetic diversity of both natural and cultured *Acropora* corals, and revealed detailed coral population structures in Okinawa, Japan. In addition, we have recently developed a novel method for simultaneous monitoring of both *Acropora* corals and their symbionts using environmental DNA in seawater that ensures frequent, high-density monitoring, enabling an understanding of the changing coral reef ecosystems. In this talk, I would like to show how we have applied various genomics techniques to coral reef biology and introduce our ongoing coral genomics projects.

Retrospective environmental monitoring using bivalve shell geochemistry: an case study for the tsunami following 2011 Tohoku Earthquake

Kotaro Shirai
(Atmosphere and Ocean Research Institute, The University of Tokyo)

Abstract:
On 11 March 2011, the eastern coast of Japan was seriously inundated by a massive tsunami following the 2011 Tohoku Earthquake. The tsunami caused major disturbance to both the natural coastal and socio-economic environments. However, an understanding of the consequences of such an event is often hampered by a lack of knowledge of prior conditions. Furthermore, field observations during and immediately after the event are often particularly difficult. We demonstrated that environmental reconstruction by geochemical and growth pattern analyses of mussel shells successfully revealed transitional (daily) environmental changes caused by the Tohoku tsunami. A pronounced surge in shell Mn/Ca ratio observed immediately after the tsunami implied a drastic emission of pore water following sediment disturbance as well as a large input of terrestrial material through backwash. Subsequent decease of the high Mn/Ca peak indicated a prolonged tsunami disturbance effect over ca. 40 days, the stabilized shell Mn/Ca ratio observed thereafter (being higher than that prior to the tsunami) suggesting that the latter had altered the coastal environment, allowing greater susceptibility to terrestrial input following ground subsidence and loss of coastal levees. Shell Mn/Ca patterns provided evidence for tsunami-generated release of materials stored in sediments, such as organic, nutrient and pollutant materials, such being suspended in the water column for sufficient periods as to allow incorporation into geochemical cycles. Although the greatest environmental disturbance occurred immediately after the tsunami, the effects lasted for longer than several months thereafter.
I will also present about carbon isotopic analysis of mussel periostracum and its implications for the decipherment of coastal carbon source.

Fractionation and application of nitrogen stable isotopes in fish otoliths

Jen-Chieh Shiao[1], Li-Chi Cheng[1], Pei-Ling Wang[1], Kotaro Shirai[2], Kentaro Tanaka[2], Naoto Takahata[2], Yuji Sano[2], Sung-Yun Hsiao[3], Yung-Che Tseng[4]
([1]Institute of Oceanography, National Taiwan University, [2]Atmosphere and Ocean Research Institute, University of Tokyo, [3]Institute of Earth Science, Academia Sinica, [4]Institute of Cellular and Organismic Biology, Academia Sinica)

Abstract:
This study elucidates the nitrogen isotopic fractionation between diets and otolith organic materials via two kinds of feeding experiments. First, larval stage tilapias (*Oreochromis mossambicus*) were fed diets having different isotopic compositions for up to one and a half years. Then the otoliths were converted to N_2O gas by a peroxodisulphate oxidationbacterial method and nitrogen isotopic compositions ($\delta^{15}N_{oto}$) were measured by an isotopic ratio mass spectrometer (IRMS). This highly sensitive method reduced the minimal mass of otolith required for $\delta^{15}N_{oto}$ analysis to as low as 2 mg compared to conventional methods, which required approximately 100 mg of otolith. The tilapia otolith $\delta^{15}N_{oto}$ compositions did not significantly differ from the $\delta^{15}N$ values of each diet. This indicates that the $\delta^{15}N_{oto}$ might be randomly derived from dietary amino acids without any biochemical transamination. For the second feeding experiment, the unicellular green algae (*Tetraselmis chui*) were incubated with ^{15}N labeled potassium nitrate and fed to the tilapia juveniles for 18 days. The otoliths were extracted and measured for $\delta^{15}N_{oto}$ values deposited before and after the feeding experiments by the NanoSIMS. The $\delta^{15}N_{oto}$ values showed abrupt surge from the natural abundant level to 1500-2000‰ after the fish ate the spiked algae with $\delta^{15}N$ values of 2200‰, suggesting that the otolith organic nitrogen is derived from the food not the metabolic tissues of fish. Therefore, $\delta^{15}N_{oto}$ can be used as a proxy for nitrogen in the food sources of the fish. Analysis of $\delta^{15}N_{oto}$ especially by a manner of high temporal resolution may have new applications in ecological studies such as the detection of diet shift or migration at certain life stages, which are difficult to detect in the metabolic tissues due to the slow turnover rate of their isotopic compositions.

Combining microvolume isotope analysis and numerical simulation to reproduce fish migration history

Tatsuya Sakamoto[1], Kosei Komatsu[2,1], Shirai Kotaro[1]
([1]Atmosphere and Ocean Research Institute, The University of Tokyo, [2]Graduate School of Frontier Sciences, The University of Tokyo)

Abstract:
Tracking the movement of migratory fish are of great importance in fisheries science, although it has been technically difficult for small sized fish to which artificial tags cannot be attached. Oxygen stable isotope ratio ($\delta^{18}O$) in otolith is known to record the linear combination of temperature and salinity variation of ambient water, and thus considered to be a potential alternative for conventional techniques such as tagging and electronic loggers. However, the difficulty of separating the two factors have been limiting its application. In this study, we show that the migration history of small pelagic fish, the Japanese sardine, can be individually reproduced by the combination use isotopic analysis and numerical migration simulations. We found that the detailed and reasonable movements can be estimated by searching the routes that should be passed to reproduce the otolith $\delta^{18}O$ history, using a simple individual based migration model in a realistically simulated ocean. The scheme will enable researchers to estimate the environment that an individual fish experienced in the early life history for numerous species. Cooperative studies using the scheme to fishes that live in both Taiwanese and Japanese waters, such as horse mackerel or anchovy, may improve understandings of their stock structures.

Variances of Japanese eel larval and juvenile transport process affected by climatic changes

Hsiung Kuan-Mei
(Atmosphere and Ocean Research Institute, The University of Tokyo)

Abstract:
For Japanese eels (*Anguilla japonica*) distribute in the western Pacific Ocean, the position of the North Equatorial Current (NEC) salinity front, its bifurcation, and the velocity of the NEC and Kuroshio Current (KC) play critical roles in their spawning location, transport processes, recruitment dynamics, and distribution. Therefore, variations in oceanic environmental conditions might significantly influence larval transport.
El Niño Southern Oscillation (ENSO) events serve as the potentially important drivers of interannual variability across the equatorial Pacific. This study has conducted numerically modeling experiment and otolith daily increment analysis. The results showed that during El Niño years, the southward and northward movement of the NEC salinity front and the NEC bifurcation might prolong the time needed for the larvae to enter the KC from their spawning ground. On the other hand, this might cause more water to flow into the Mindanao Current (MC), leading to a decline in the rate at which larvae get entrained into the KC.
In addition, the influence of warming climate on the oceanic environment is becoming a more serious concern nowadays. An ocean model MIROC simulation under the Intergovernmental Panel on Climate Change A1B climate-warming scenario predicted that the NEC salinity front and bifurcation will move northward, the strong part of the NEC will move southward, and the KC velocity will increase in the future. Therefore, the combination of several mechanisms will affect the transport and recruitment of *A. japonica* larvae and juveniles. Particle modeling predicted a decline in particles recruited into the KC, and the drifting time from their spawning area to the KC might extend. Furthermore, the drifting time and distribution of the particles after entering the KC will be affected by intensify of the KC in the future.

Spatial and temporal distribution of dissolved organic nitrogen (DON) in the Western Pacific Margin

Huei-Ting Lin

(Institute of Oceanography, National Taiwan University.)

Abstract:
In the Western Pacific margin, it is paradoxical that the corals and seagrass flourishing in oligotrophic regions is able to obtain sufficient nitrogen to maintain highly productive and hosts a diverse community. In coral reefs and grass meadows, a large part of the organic matter is produced in dissolved forms. Efficient cycling of dissolved organic nitrogen (DON) may play an important role to sustain the nitrogen requirement. To evaluate the sustainability of a reef ecosystem and to elucidate details on nutrient cycling, we surveyed and obtain a spatial distribution of DON collected seawater samples around Taiwan's coral reef waters and background Kuroshio sites. To investigate the temporal distribution of DON, we deployed an autonomous underwater sampler to collect time-series seawater samples by a patch of corals on a seagrass meadow inside the Dongsha lagoon. In this talk, we will present the first time-series data of dissolved organic nitrogen (DON) in Taiwan's coastal waters. We will also compare our DON data with previously published work done around the Miyako Island (Suzuki et al., 2000) and the Ishigaki Island (Tanaka et al., 2011) by Japanese colleagues. The biogeochemical implications from the DON distributions will be discussed.

Suzuki, Y., Casareto, B. and Kurosawa, K. (2000) Import and export fluxes of HMW-DOC and LMW-DOC in coral reef at Miyako Island, Okinawa, Proc. 9th Inter. Coral Reef Symp. Citeseer, pp. 555-559.

Tanaka, Y., Miyajima, T., Watanabe, A., Nadaoka, K., Yamamoto, T. and Ogawa, H. (2011) Distribution of dissolved organic carbon and nitrogen in a coral reef. Coral Reefs 30, 533-541.

Recent progress and perspective of the Kuroshio study

Hiroaki Saito
(Atmosphere and Ocean Research Institute, The University of Tokyo)

Abstract:
The Kuroshio transports warm subtropical water and organisms to the north and influences climate and ecosystems of the region along the Kuroshio axis (Kuroshio region). The economy and culture of human society in the Kuroshio region are also influenced by the Kuroshio through the continuous supply of the marine ecosystem services. In Japan, various sea foods from sea weed, mollusca, fish and marine mammals have been used. This is based on high fisheries productivity in the Kuroshio region in spite of the oligotrophic condition. I named this inconsistency of high fisheries production in oligotrophic environment as *the Kuroshio Paradox*. To solve the paradox, an interdisciplinary approach encompassing physical oceanography to fisheries sciences is essential.
Recent studies focused on microscale physical processes along Kuroshio axis revealed that the presence of multiscale routes to supply nutrients, such as diapycnal turbulent mixing, wind- or tide-induced near-inertial internal waves, and double-diffusive convection. The importance of each mechanism differs owing to various factors such as current and wind direction, tidal cycle and intensity, and topography. It is suggested that the presence of topography-specific nutrient supply mechanisms along the Kuroshio, i.e., *hot spots of nutrient supply* which characterize the geographical variation in the Kuroshio ecosystem. In the presentation, I review the recent progress in nutrient supply mechanisms along the Kuroshio and show my perspective for future collaboration studies between UTokyo and NTU on the Kuroshio study.

Vertical Beta-diversity Depending on Water Mixing in the Kuroshio Region East of Taiwan

Wan-Hsuan Cheng[1,2], Hsiao-Pei Lu[3], Chung-Chi Chen[4], Sen Jan[3], and Chih-hao Hsieh[3]

([1]College of Earth Science, National Central University, [2]Taiwan International Graduate Program, Academia Sinica, [3]Institute of Oceanography, National Taiwan University, [4]Department of Life Science, National Taiwan Normal University)

Abstract:
Environmental dissimilarity and geographic distance are recognized as two major factors influencing beta diversity. However, whether and how beta diversity of marine bacteria in a vertical dimension would be influenced by water mixing and stratification remains unclear. Here, we collected 78 samples from surface and chlorophyll maximum (CM) layers along a transect of Kuroshio region east of Taiwan across seasons. We applied the variation portioning to disentangle the relative importance of environmental dissimilarity, vertical distance between sampling depths and the strength of stratification in determining the vertical beta diversity of the paired surface and CM bacteria communities in water mixing periods (e.g. spring and fall) versus stratification periods (e.g. summer). We tested the hypotheses: H1) during stratification periods, the strength of stratification determines environmental dissimilarity, which in turn drives vertical beta diversity. H2) During mixing periods, vertical beta diversity is determined only by vertical distance, assuming that the environment of water column is homogeneous due to mixing. Our results suggested that during stratification periods, the vertical beta diversity was significantly explained by environmental dissimilarity, which was determined by strength of stratification in combination of vertical distance; this, to some extent, supports H1. Whereas in mixing periods, environmental dissimilarity alone was the most important factor explaining vertical beta diversity. This finding is inconsistent with H2, and can be explained by the fact that mixing is not strong enough to completely homogenize the water column in fall and spring. Vertical beta diversity in the Kuroshio east of Taiwan was structured by different mechanisms, depending on the strength of mixing versus stratification of water column. Climate changes affecting on ocean mixing regime can have profound effects on vertical beta diversity of microbes, with potential impacts on their ecosystem functioning.