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LIST OF ABSTRACTS
(Oral Presentation)

Circulation in the South China Sea

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South China Sea (SCS), with a deep basin, is the largest marginal sea in the tropical Pacific. Its basin-scale circulation is forced by both the strong East Asia monsoon and the Kuroshio. The latter in fact represents the dynamics of the subtropical ocean gyre of the North Pacific. Because of low latitude location of the SCS, fast Rossby wave dynamics renders its circulation adjusting readily with the seasonal winds. On the other hand, in various ways the Kuroshio exerts significant influence on the circulation at the northern SCS. In addition, active meso-scale eddies is another prominent feature in the SCS. Statistics indicate that, in any dekad (10 days) there are 4~6 meso-eddies over the deep basin of the SCS. Orographic effects on the monsoon seems to be the dominant mechanism generating these eddies, as well as causing features of ocean upwelling in SCS. In this review, present understanding of the SCS circulation will be highlighted and their possible relevance to ecological interest will also be commented on.

A Coupled Circulation - Ecosystem Model over the Continental Shelf off Hong Kong during Upwelling

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Driven by the prevailing southwesterly monsoonal wind stress in summer, coastal upwelling occurs over the wide continental shelf off Hong Kong in the northern South China Sea (NSCS). Pearl River Estuary and waters around Hong Kong (PREHK) are under the influence of strong upwelling-induced across-shelf transport which advects cold and nitrate-rich deep waters onto the inner shelf region. A three dimensional coupled circulation/ecosystem is applied in the NSCS domain with a high resolution grid (3 km horizontal grid size and 30 vertical levels) to investigate three-dimensional upwelling circulation and the associated dynamics. The modeling will be conducted for process studies and direct simulation to determine the effects of the temporally and spatially variable flow field and the across-shelf transport processes on the magnitude and the distribution of primary production on the shelf. The model will also be used to investigate the relative roles of the circulation effects (advection and diffusion) compared with the biological processes.

Eutrophication Dynamics in Hong Kong - An Environmental Hydraulic Perspective

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Hong Kong, a mega-city with a population of 6.7 million, is situated at the mouth of the Pearl River Estuary in southern China. The marine resources in the 1800 km^2 of coastal waters are intensively utilized. The water quality has been deteriorating as a result of the high nutrient loads from the rapidly urbanised and industrialised Pearl River Delta (PRD) region, and significant sewage discharges into Victoria Harbour. Hong Kong waters are relatively unique because of the frequent occurrence of harmful algal blooms, and the complexity and richness in eutrophication dynamics within a relatively small area. Viewed against the increasing nutrient loads, it is surprising that the eutrophication impacts on Hong Kong waters are not worse than they are. This presentation gives an overview of the temporal and spatial dynamics of algal blooms. The tidal current and salinity structure in the partially-mixed estuary are elucidated using numerical results from a calibrated three-dimensional hydrodynamic model. Physical and biological interactions are discussed in relation to seasonal phytoplankton ecology as well as episodic events. In particular, a hypothesis will be put forward to explain the difference in observed frequency of red tides in Hong Kong's western and eastern waters.

Possible influence of coastal upwelling and meso-scale eddies on the bio-geochemical patterns in the northern South China Sea

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Hydrographic, tide-gauge and satellite observations are used to study coastal upwelling in the northeastern South China Sea off the coast of Fujian and Guangdong Provinces, China, in the summer of 2000, and meso-scale eddy in 2003/04 winter. Upwelling in this region is intermittent in time and occurs preferably when surface winds are southwesterly, inducing an offshore surface Ekman flow and a drop in coastal sea level. Cold and salty water rises along the sloping bottom in a hydrographic transect, with a thermohaline front separating the upwelling region from the open-sea water in the surface layer. Although upwelling-favorable winds cover a much larger area, significant surface cooling is observed along the coast only east of 116^{o}E. To the west a fresh-water tongue originating from the Pearl River forms a barrier layer, which appears to play a role in preventing the upslope intrusion of cold and salty water in the bottom boundary layer from reaching the surface. The expected decrease in Pearl River runoff in the coming decades may lead to an increase in upwelling off the coast of southern China, with profound effects on the coastal ecosystem. Finally, the coastal jet and its adjustment in the bottom boundary layer as well as alongshore variations in bottom topography may all modify the coastal upwelling. The results show that two anticyclonic eddies in shelf of the northern SCS have a strong influence on the bio-mass patterns. Surprisingly, those two eddies, which were supposed locally generated in the Luzon Strait, have high productivity partially.

MASNUM Marine Ecosystem Model

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By using the Prandtl mixing length principle and the results of real wave statistics, the waving and breaking stirring mixing coefficients are firstly derived. And then two kinds of mixing scheme for the upper and medium ocean layer were presented. The first includes waving and breaking stirring mixing as well as second order closure turbulence mixing. The second includes waving stirring mixing and second order closure turbulence mixing with surface input source function of breaking energy dissipation and surface mixing length of breaking entrainment depth. Using the MASNUM mixing scheme greatly improved the ability of the numerical model system for ocean dynamics and ecology.

Carbon Dynamics in the Oligotrophic South China Sea

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South China Sea (SCS) is a largest marginal sea located at low latitude. As a marginal sea, the main portion of SCS is characterized by low nutrients in the mixed layer and hence low primary productivity. As a consequence, carbon fluxes and dynamics in SCS behave differently in many aspects from those relatively eutrophic marginal seas located at mid and/or high latitude. Current available information tends to suggest that SCS is overall a weak source to atmospheric CO_2 with significant seasonal variation and very likely inter-annual variation. This presentation attempts to assess air-sea CO_2 fluxes at different time scales, including diurnal, intra-seasonal, seasonal and inter-annual time scales. Processes including primary and export productivity that potentially modulate the air-sea CO_2 exchange will be examined.

Responses of phytoplankton to circulation-nutrient coupling in the South China Sea

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In recent years the responses of phytoplankton communities to the physical-chemical oceanographic coupling in the South China Sea (SCS) have been studied. The results showed that phytoplankton stock, production and community structure were closely related to this coupled process. Coastal upwelling occurred along the west, northwest and north coasts induced by the Ekman transport, due to the summer southwesterly monsoon, resulted in high nutrient concentrations and high standing stock and production of phytoplankton dominated by diatoms. Several mesoscale cyclonic cold eddies and anticyclonic warm pools were identified in the SCS. During summer, upwelling regions with low temperature, high salinity, rich nutrients, low dissolved oxygen (DO), high chlorophyll *a* (Chl *a*) and primary production (PP) were found in the area off the coast of central Vietnam, southeast of Hainan Island and north of the Sunda shelf; while during winter, upwelling regions were mainly found in the basin area off Vietnam, northwest of Luzon, and the Sunda Shelf break. The warm pool regions with opposite features to those of the cold eddies were mainly found in basin area of the SCS, southeast of Vietnam, east of Hainan Island, southeast of HK and west of Luzon during summer, and a strong warm water jet from the Sulu Sea through the Mindoro Strait towards northwest with properties similar to the warm pools was encountered during winter. The phytoplankton stock and primary production were higher in winter than in summer due to nutrient depletion, particularly PO_4, in surface water during summer. This phosphorus depletion resulted in phytoplankton species succession from diatoms to dinoflagellates and cyanophytes. In the anticyclonic eddies of the east of Hainan Island and southeast of HK with extremely low nutrient conditions caused by frontal instability and modulated by topography, confirmed by both oceanographic surveys and satellite remote sensing, nutrient enrichment experiments illustrated that pronounced successions of phytoplankton community dominant group and dominant size class were found from dinoflagellates to diatoms, and from picoplankton to nano- and net-plankton, and increases in phytoplankton biomass occurred in multi-nutrient addition cases. It suggested that phytoplankton growth was limited by several nutrient in the anticyclonic eddies.

Phytoplankton dynamics in the northern South China Sea based on photosynthetic pigment analysis

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The Pearl River estuary and its adjacent northern South China Sea provide a significant nutrient gradient from the eutrophic estuary to the oligotrophic slope waters of the northern South China Sea, and hence it is an ideal site for studying the coupling of physical-chemical-biological processes. The phytoplankton community structure was investigated based on photosynthetic pigment analysis by high-performance liquid chromatography (HPLC) in the northern South China Sea during the cruises in winter (Feb) and summer (July) of 2004. Diagnostic pigment concentrations were interpreted using a matrix factorization program ‘‘CHEMTAX’’ (Mackey *et al*., 1996) to obtain the Chl *a* biomass of nine phytoplankton groups. There were distinct variations in Chl *a* biomass and phytoplankton composition from the Pearl River estuary to the slope waters. Similar geographical distribution patterns were observed in both seasons by cluster analysis. Two distinct phytoplankton community structure patterns were clustered. In the Pearl River estuary and coastal waters, the Chl *a* concentration was higher than that over the continental shelf of northern South China Sea, and Bacillariophyta dominated the phytoplankton community. From the estuary to the coastal waters, Prasinophyceae and Cryptophyta became more important and a supplement to the dominance of the Bacillariophyta. The other community structure patterns were characterized by the dominance of cyanobacteria, Prochlorophyta and Haptophyta in mid-shelf and off the shelf. In the upper layer, cyanobacteria and Prochlorophyta were important, while Haptophyta, Prochlorophyta dominated in the chlorophyll *a* maximum layer. The relationship between diagnostic pigments and hydrographical properties was not uniform with different water masses. In the Pearl River estuary, the significant negative correlation between phosphate and Chl *a* confirmed that phosphate played a key role in phytoplankton growth. In the shelf, two warm eddies were found during the cruise of Feb 2004, and the community was dominated by pico-sized phytoplankton such as Prochlorophyta and cyanobacteria in the center, possibly due to the source of warm core waters in the eddies from the Kuroshio current.

Revisiting the structure and functioning of planktonic food webs

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At the beginning of the 1980s, the "microbial loop" conceptual model assigned key roles to microbes in the planktonic food web. In our presentation, we introduce and develop the concept of "microbial hub" as an extension of the microbial loop, and build this concept into an operational model. Our steps are to define some of the key components of a generalized planktonic food-web model, to discuss how to assess the roles of food-web compartments in planktonic food webs, to develop and quantify a steady-state model of the planktonic food web, to re-formulate that model to combine heterotrophic bacteria and eucaryotic microbes into a functional microbial hub that contrasts metazoan heterotrophs, and ultimately to apply the microbial-hub model to assess food-web effects of changes in key climate variables.

Some key points of our approach are: there is a fundamental food-web difference between heterotrophic microbes and metazoans, which led us to structure the pelagic food web around the microbial hub (heterotrophic bacteria and protozoan microzooplankton) and metazoan heterotrophs (heterotrophic organisms larger than microbes); heterotrophic respiration is the only metric that can be used for comparing food-web compartments; both dissolved and particulate primary production (PP) must be considered when computing the fraction of PP respired by food-web compartments; increased food-web complexity and feedbacks largely explain the major role of heterotrophic bacteria in carbon cycling within pelagic ecosystems; in the microbial-hub model, much organic carbon is channeled toward the microbial hub, from which carbon is redirected towards both hub respiration and metazoan heterotrophs; the microbial hub has emergent and quantifiable properties; changing climate will increase microbial-hub (and decrease metazoan) respiration and channeling of PP toward community respiration; the microbial-hub model provides a new, powerful tool for exploring ecosystem metabolism.

Trophic linkages between the mesopelagic microbial loop (bacteria and protozoa) and zooplankton under phosphorus limitation in the NW Mediterranean Sea

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Ocean biogeochemistry aims at understanding the role of biological processes in the cycling of major elements, not only the euphotic, but also in the aphotic layer. In this context, the NW Mediterranean Sea may is a very interesting site because of: (1) DOC export to the aphotic layer, and nutrient supply to the euphotic layer leading to the spring phytoplankton bloom during the mixing period, and (2) low nutrient concentrations, P limitation for both heterotrophic bacteria and phytoplantkon and DOC accumulation in the surface mixed layer during the stratified period. We showed that: (1) surface waters become P-limited for both bacteria and phytoplankton during stratified periods, (2) orthophosphate uptake in this situation becomes close to diffusion limitation for both cyanobacteria and autotrophic nanoflagellates, with cyanobacteria as the superior competitors, (3) bacteria, heterotrophic nanoflagellates and ciliates are always distributed down to 2000 m, with a depth-dependent decrease of one, two and three orders of magnitude, respectively, (4) control of bacterial abundances in the mesopelagic layer not only by substrate, but also by predation, and (5) seasonal variability in the availability of dissolved organic matter for bacteria in the mesopelagic layer. By integrating these findings to previous studies, we present conceptual models of the microbial food web in the surface layer and the microbial loop in the aphotic layer.

Pelagic food webs under environmental stress

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Biological components of pelagic food web are permanently submitted to the natural and anthropogenic environmental stress. I distinguish these stresses into three categories: chemical, physical and biological. The responses of microbial food web to environmental modifications, based on the nature of stress, are different: 1) the enrichment chemical stress (*e.g.* nutriment load by rain, river, underground waters and upwelling current) produce a fast response of microbial web in the scale of week to months. These stresses favor the development of a herbivorous food web characterized by large phytoplankton rapidly assimilating inorganic nutrients and producing significant biomass (new production); 2) the physical, biological and pollutant chemical stresses (acid rain, hydrocarbon, etc.), in short and medium scales drives the system towards the microbial food web and finally the microbial loop with a low productivity based on regenerated production. In the first case, the system is largely autotrophic. In contrast, in the second case, the heterotrophic components especially bacteria and their activity conduct the system drive towards the heterotrophy. The future of pelagic food web would depend on the balance between two types of stresses.

Nutrient and predator control of diversity and ecosystem functions in bacterioplankton

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The effect of nutrient (bottom-up) and predator (top-down) control on the production of bacterioplankton has been well studied and during the last 17 years, the role of viruses as important mortality factors besides protists has been elucidated. It is also known that predators (protists and viruses) influence diversity, although details are lacking. Even less is known whether bottom-up and top-down control shape the link between diversity and functions of bacterioplankton. However, mathematical and conceptual models are available to test hypotheses. In a series of experiments to tests the effect of flagellates and viruses on bacterioplankton, it could be shown that viruses and flagellates can have variable effects, however, when both predators were present, diversity (as estimated by the number of detectable phylotypes in genetic fingerprints) was typically stimulated and production reduced compared to experiments with no predators present. These data indicate that predators modify the nutrient control of the link between diversity and ecosystem functions of bacterioplankton.

Spatial and Temporal Variations in the Marine Bacterioplankton Community in Victoria Harbor, Hong Kong

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The ubiquitous bacterioplankton are major components of food webs and thus they play key roles in biogeochemical cycles and energy flow in the marine ecosystem. The nitrogen cycle plays an essential role in the marine ecosystem by providing nitrogenous nutrients and controlling biological productivity. Nitrogen fixation is catalyzed by nitrogenase, a key enzyme in the N cycle. Nitrogenase iron protein gene, *nifH*, is one of the oldest functional genes and can be used for phylogenetic analysis.

A large sewage pollution reduction program has been implemented in Hong Kong with the aim to improve water quality in Victoria Harbor. Drastic changes in bacterioplankton composition are expected due to the anticipated changes in nutrient profiles in the harbor areas. The aim of our project is to investigate the interrelationships between bacterioplankton population dynamics and the availability of carbon, nitrogen, and other nutrients in the seawater. Bacterioplankton samples were collected bi-monthly at 5 selected stations along the harbor. The population dynamics of the total bacterioplankton and nitrogen-fixing bacteria were determined using the 16S rRNA gene and *nif*H gene, respectively. Complete 16S rRNA genes and partial *nif*H genes were amplified using PCR and subjected to Terminal-Restriction Fragment Length Polymorphism (T-RFLP) analysis, Denaturing Gradient Gel Electrophoresis (DGGE), and clone libraries construction, followed by phylogenetic analysis. Diversity data were then coupled with bio-oceanographical data to determine the interrelationship among physical environmental parameters, nutrient profiles and bacterial population dynamics. Results thus far indicated high bacterioplankton and *nif*H gene diversity in Victoria Harbor areas, including α-proteobacteria, Cytophaga-Flexibacter-Bacteroides, and low G+C Gram-positive bacteria. The abundance and diversity of bacterioplanktons and *nif*H gene varied spatially and temporally. Bacterial biomass was the highest (about 10^{6-7}cells/ml) in the central part of Victoria Harbor (Stn B2 and B3), possibly due to the high dissolved organics from the sewage discharge. Spatial and temporal variations of *nifH* gene diversity can be related to environmental parameters and the variations showed more seasonal than spatial variations.

Phytoplankton composition and nutrient co-limitation processes in aquatic ecosystems. Implications for the design of a modelling tool addressing climate change: Eco3M

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The dominance of diatoms in a phytoplankton assemblage is of major importance for the biological pump, since they tend to export C to depth and eventually to the seafloor more efficiently than non-siliceous (flagellates) species. In the last decade, several studies have reported an increasing dystrophy in coastal waters especially when submitted to the influence of riverine discharges. The consequential decrease in the Si:N ratio appears to be a general trend in various coastal areas including European Atlantic and North Sea coasts as well as Mediterranean systems like the Adriatic Sea. While a decrease in the Si:N ratio would lead to a predominance of non-siliceous and sometimes toxic species over diatoms, resulting in undesirable eutrophication effects such as anoxic conditions, fish and shellfish mortality, and harmful algal blooms, some studies also suggest that the effect of nutrient dystrophy could rather lead to a shift within the diatom community, favoring species with high affinity constants for $Si(OH)_4$ rather than a shift towards non-siliceous species, with potential implications on the food web structure. Studies on causes of diatom shifts have been limited hitherto by the inability to provide species-specific paramerizations of nutrient uptake within natural communities but new methodologies will soon be available to overcome this difficulty especially with regards to the silicon cycle and will probably increase our comprehension of the dynamics of phytoplankton changes. In the meantime, new coupled ecological/biogeoche-mical models are developed which are able to integrate some degree of ecosystem complexity. The Eco3M (Ecological Mechanistic and Modular Modelling) tool is able to represent species successions and correlated element (C, N, P, Si, etc.) fluxes in various ecosystems. Examples are presented for simulation experiments of phytoplankton growth and the seasonal succession in the coastal Gulf of Lion (Mediterranean Sea).

Dual niche of aerobic anoxygenic phototrophic bacteria in eutrophic and oligotrophic marine ecosystems

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With light energy as a supplement to organic carbon respiration, Aerobic Anoxygenic Phototrophic Bacteria (AAPB) are perceived to be relatively more dominant in oligotrophic oceans than in coastal waters. However, our large scale investigation along trophic gradients revealed that AAPB are actually more abundant than has been ever realized in eutrophic waters, but less abundant than previously reported in oligotrophic waters. The widespread geographic distribution of AAPB in various environments from tropical to arctic regions and the broad phylogenetic affiliation of AAPB to Alpha-, Beta- and Gamma-Proteobacterial groups suggested a possible path of niche-driven development of their photosynthetic genes. Associated with light and depending on labile dissolved organic carbon, more than other bacteria, AAPB occupy a unique niche between phototrophs and heterotrophs in the sea.

Linkage between coastal land loss and hypoxia: the role of appendicularians in transforming microbial loop to sinking particles

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Occurrences of hypoxic events and the 'dead zone' in coastal waters around the world have increased due to an increased input of anthropogenic nutrients. A good example is the northern Gulf of Mexico where a large (nearly 15,000 km^2) 'dead zone' with dissolved oxygen (DO) <2 mgL^{-1}, occurs every summer due to nutrients from the Mississippi River. Phytoplankton bloom on the shelf resulting from high inorganic nutrients in the Mississippi River discharge, and consequence sinking and decomposition of the POC into the deeper layer, together with the water column stratification, have been attributed as the causes of the formation of the hypoxia. However, recent modeling study suggests that sedimentation of river produced POC is not sufficient to fuel the entire hypoxic region. We hypothesize that, among a few other possible sources, the microbial loop fueled largely by the DOC exported from the deteriorating wetland of Louisiana coast is a very important contributor to the hypoxia in Louisiana shelf.

The microbial foodweb consists of small organisms that sink slowly has not been considered as a significant contributor to vertical flux and hypoxia. However, gelatinous zooplankton, especially pelagic appendicularians such as *Oikopleura dioica*, mediate the conversion of microbial web organisms to organic particles with high sinking rates. When pelagic appendicularians are abundant in coastal regions of the northern Gulf of Mexico, they stimulate the rapid vertical transfer of microbial web productivity in the surface layer to the sub-pycnocline layer that becomes hypoxic each summer. Based on data from two cruises in 2002 and 2004, discarded gelatinous houses and fecal pellets from the appendicularian populations often provided significant amount of organic carbon for the establishment and maintenance of hypoxia in the northern Gulf of Mexico. The wetland along the Louisiana shelf exports large amounts DOC that support the microbial food web. The DOC – bacteria – appendicularian – sinking particle pathway provides an important link between Louisiana's eroding wetlands and coastal hypoxia.

Roles of Solar UV Radiation in Photosynthetic C-fixation in Surface Seawater of South China Sea: The Double-edged Sword *

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Solar UV radiation (UVR, 280-400 nm) is a permanent environmental factor that is attenuated by seawater and causes a variety of biological effects within the euphotic zone. Increasing levels of atmospheric CO_2 and solar UV-B (280-315 nm) are viewed as the main factors resulting from global change. Although elevated CO_2 concentrations has been demonstrated to enhance marine primary productivity and hinder biological calcification in the sea, to date, such ecological interactive effects of CO_2 and UV radiation have not been investigated. Solar UVR might make our understanding of the ecological impacts of CO_2 and acidification more complicated than previously considered. Here we report the UVR-triggered activation and inhibition of photosynthetic C fixation by phytoplankton in the South China Sea.

We found that solar UVR, mainly UV-A (315-400 nm), was used for carbon fixation by a surface phytoplankton assemblage when PAR (400-700 nm) was filtered out, triggering about 10% PAR-saturated photosynthetic C-fixation, and resulted in inhibited C-fixation along with UV-B when PAR was present (full-spectrum of solar irradiance). Experiments with a ubiquitous diatom, *Skeletonema costatum*, showed significantly less photoinhibition of $^{14}CO_2$ incorporation compared with that of PSII caused by solar UVR. Such unbalanced inhibition was found to be associated with UVR-stimulated activity of extracellular carbonic anhydrase (facilitates the conversion of HCO_3^- to CO_2 at the plasma membrane) under CO_2-limited conditions.

UVR-induced inhibition (occurs when photosynthetic electron transport "Z" operative under PAR) and promotion of photosynthetic C-fixation (observed in the absence of PAR) could simultaneously take place under any solar conditions, but become only "visible" at reduced or negligible inhibition under low irradiance. We previously found that reduced levels of solar UV-A enhanced the photosynthetic C-fixation by phytoplankton, which is also shown by the UVR-induced negative inhibition of photosynthetic C-fixation on cloudy days. UV-A induced fluorescence has been recognized recently in the diatom *Pseudo-nitzschia multiseries*, indicating UV-A might also be transmitted via some unknown processes and activate the Calvin cycle. Short-wave solar irradiance may be utilized for C-fixation and play a significant role in the marine biological CO_2 pump, especially at low levels of solar irradiance (sunrise, sunset, deep water, cloudy days), though it is known to damage D1, D2 proteins of PSII, Rubisco and other cellular components.

Our results imply that impacts of increased CO_2 on the oceanic primary production could be significantly influenced by solar UVR depending on the level and spectrum of sunlight that the cells received at different locations or depths. There could to be an optimum level of UV-A irradiance for its positive role, above which inhibitory effects would overlap and make it invisible. Previous global oceanic primary production estimates could have been over estimated for the surface seawater and under estimated for deeper depths due to solar UVR.

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Satellite remote sensing and in situ observation of harmful algal blooms (HABs) and related coastal environments in the South China Sea

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Harmful algal blooms (HABs) occur frequently in the South China Sea (SCS), causing enormous economic losses in aquaculture in recent years. We have analyzed historical HAB records and satellite remote sensing data for the period from 1980 to 2003 in the northern, southern, western and eastern regions of SCS. We found that HAB affected areas have expanded and the frequency of HAB has increased during this time. The seasonal and annual variations, as well as causative algal species of HAB are different among the four regions. Areas with frequent HAB were the Pearl River estuary (China), the Manila Bay (Philippines), the Masinloc Bay (Philippines), and the western coast of Sabah (Malaysia). HABs occurred frequently during March-May in the northern region, May-July in the eastern region, July in the western region, and all the year round in the southern region. Among the species which cause HABs, *Noctiluca scintillans* dominated in the northern region, and *Pyrodinium bahamense* in the southern and eastern regions. Causative species also varied in different years for the entire SCS. Both *Pyrodinium bahamense* and *Noctiluca scintillans* were the dominant species during 1980 to 2003. Some new species formed blooms during 1991-2003, including *Phaeocystis globosa, Scrippsiella trochoidea, Heterosigma akashiwo*, *Mesodinium rubrum* and so on. The HAB variations are related to various regional conditions, such as reversed monsoon wind in the entire SCS, river discharges in the northern area, upwelling of Vietnam coastal waters during southwest winds in the western region, and eutrophication from coastal aquaculture in the Peal River estuary, Manila Bay and Masinloc Bay.

Constrasting ecosystems between the Pearl River estuarine coastal waters and the northern South China Sea

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The Pearl River coastal waters and South China Sea (SCS) are two contrasting marine ecosystems. The Pearl River discharge into the South China Sea creates a strong salinity gradient. The coastal waters are dominated by estuarine water masses and two layer estuarine circulation, whereas in the South China Sea, oceanic water masses and oceanic circulation are dominant. When the Pearl River discharges a large amount of anthropogenic nutrients into the oligotrophic SCS, it creates a strong eutrophic gradient. In the Pearl River estuarine waters, there are high nitrogen and low phosphorus concentrations and hence, N:P ratios are very high >64:1. In contrast, both nitrogen and phosphorus are very low, and N:P ratios are low <10:1 in the South China Sea. As a result, P tends to be potentially the most limiting nutrient to phytoplankton biomass production in the estuarine influenced waters, whereas N is the most limiting nutrient in the South China Sea. Phytoplankton biomass is dominated by the large size-fractionation in the eutrophic estuarine waters, while the small size-fractionation of phytoplankton was dominant in the SCS. Also, the biomass of microbes such as bacteria and viruses is higher in the coast than in the open SCS. Bacterial production is high in the estuarine coastal waters than in the open SCS. However, bacterial production appears to consume an increasing proportion of phytoplankton fixed carbon. Understanding these contrasts between these two ecosystems is important in understanding biogeochemical processes and in determining the effects of anthropogenic influences.

Understanding the Dynamics of Eutrophication Impacts in the Pearl River Estuary and Hong Kong Waters

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Estuaries are complex and dynamic and hence eutrophication processes are difficult to predict and manage. Eutrophication in the Pearl River Estuary is not as bad as one would expect from the nutrient (nitrogen) inputs from the Pearl River and from Hong Kong's sewage discharge. Physical processes such as river discharge, tidal dilution, vertical and horizontal transport, and estuarine flushing play an important role in controlling the production and accumulation of algal blooms and the potential for the occurrence of hypoxia. Superimposed on the physical processes of the estuary are the chemical and biological processes involved in the production of the bloom. While there are no long term occurrences of hypoxia in Hong Kong waters, episodic hypoxic events have been reported to occur during late summer due to factors such as low wind, high rainfall and river discharge which produces strong stratification that subsequently reduces vertical mixing processes. Continued monitoring in Hong Kong waters and the initiation of a monitoring program in the Pearl River Estuary are essential in order to evaluate episodic events such as rainfalls, a period of low winds, and short-lived climatic events such as El Nino and longer time scales involving climate-driven regime shifts. Nutrient loads are likely to change over the next several decades and monitoring programs are essential to detect the response of the ecosystem due to the future changes in nutrient loading.

Characteristics of Stream Water Quality Entering the Pearl River Delta

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An understanding of the characteristics of various nutrients, especially phosphorus or nitrogen entering coastal regions by streamflow is important for studying the response of the marine food web to these nutrient inputs. In this study, for exploring nutrient conditions in the Pearl River Estuary, the phosphorus and nitrogen concentrations of streamflow into the Pearl River Delta are studied using observations. The relationship between the nutrients and the streamflow discharges will be discussed.

Modelling the effects of N/P/Si loading ratio on diatom/ dinoflagellate/ prymnesiophyte balance in French eutrified coastal waters

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Eutrophication is of increasing concern in lakes, rivers and the coastal zone. Studies have determined which nutrients are limiting, or controlling in various eutrified water bodies. Whereas phosphorus has been recognized for a long time as the limiting factor in most polluted freshwater systems, a more contrasting situation arose in coastal marine environments. Phytoplankton massive blooms in the plumes of main rivers are often phosphorus- or silicon-limited near-shore, but nitrogen-limited offshore, especially in summer. The continuously changing N:P:Si ratios in enriched coastal waters may drastically change the conclusions about the controlling factor in a few years. Understanding and controlling, phytoplankton eutrophication is more complicated than the eutrophication caused by green macroalgae, which has been unanimously considered as being always nitrogen controlled and is typical of coastal, very shallow, areas which have been heavily enriched in inorganic nitrogen, mainly of land runoff origin (nitrate), but sometimes of urban sewage origin (ammonia or nitrate). When the limiting factor has been determined, the question often arises about the main source to be diminished: operational restoring plans need to identify the most important target, and to know to what extent the nutrient load has to be reduced. Direct field experiments with chemical tracers are unfeasible in many cases, because of the non-existence of enough isotopes of the element under study (a n-source problem requires at least n-1 isotopes), or the lack of sufficient discrepancy between the natural isotopic signatures of the various sources. Only numerical models can evaluate the effect of each source on the global system: up to now, they have been used to test modified situations, e.g., partial or total removal of a nutrient source, but recently, we developed a new numerical technique to track separately, in the whole, undisturbed, simulated food web the limiting element coming from a specific input in a multi-source context, and to assess the precise proportion of the different existing sources in the actual feeding of proliferating algae.

Significance of Si:N:P ratios to Harmful Algal Blooms

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While the significance of the N:P ratio and its relation to the outbreak of harmful algal blooms (HABs) was studied enthusiastically in recent years, limited attention has been given to the importance of silicate and variations in the Si:N ratio in triggering HABs. Since silicate (Si) is one of the limiting factors for diatom growth, and diatoms are the main competitor of dinoflagellates in marine ecosystems, the abundance of silicate should be considered an indirect influencing factor for HABs. Coupled with a review of water quality in the inner Tolo Harbour, the algal assay: bottle tests were conducted to validate results using *Skeletonema costatum*, *Nitzschia longissma*, *Ceratium furca* and *Prorocentrum triestinum* as tested organisms. Experimental results showed that the growth of diatom species was favored for Si:N (atomic) ratios <1 and N:P (atomic) ratio > 16. However, for the growth of *Ceratium furca* and *Prorocentrum triestinum*, two dinoflagellates which often cause HABs, Si:N < 1 and N:P <15 are the optimal conditions according to bioassay/ bottle tests. The significance of Si:N:P (atomic) ratios imply that, other than discharges of domestic sewage and agricultural wastes, a reduction in Si input due to urbanization, soil erosion and river diversion may also be the trigger for dinoflagellate-related HABs.

Accelerated eutrophication at the northern coastal waters of the South China Sea for the last 100 years: evidence from sedimentary records

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Deforestation, urbanization and anthropogenic discharge are known to result in eutrophication in many estuarine and coastal waters of the world. During the past 50 years, Pearl River estuarine system has experienced increasing pressure of anthropogenic pollution. Especially, it has received a high loading of nutrients during the past two decades due to increased activities in agriculture, marine fish farming and discharge of sewage. Nowadays, eutrophication and algal blooms or/ and red tides have frequently occurred in the northern coastal waters of the South China Sea, which has draw much public attention because of their potential harmfulness to human health and risk to the local mariculture and fishing industries.

To control the red tides, an investigation of eutrophication causes and mechanisms is essential. Much research have been done in the Pear River Delta estuary for this purpose, but we still lack historical data to assign eutrophication causes. Besides observational data, sedimentary records provide a very useful tool for evaluating and reconstructing the history of anthropogenic sewage discharge, eutrophication and their impacts on local ecosystem.

The sedimentary organic matter in coastal areas mainly originates from primary and secondary production within the ecosystem, terrestrial inputs and bacterial production in the water and sediments. The relative significance of these sources is determined by local environmental factors, such as climate, hydrodynamic conditions and nutrient supply. Changes in any of these factors will result in a change in sedimentary organic matter. Algal blooms or/and red tides caused by eutrophication occurred at some given environmental condition and may imprint markers in the sedimentary records.

A sediment core taken from the Southeast of Hong Kong was studied. The high-resolution sedimentary records of the bulk organic matter, lipids and biogenic silica (BSi) reflected the accelerated eutrophication for the last 100 yr in the northern coastal waters of the South China Sea. The primary production indicated by BSi and dinosterol concentration increased gradually after 1940. The primary production increased slowly and consistently from 1940 to 1965 and increased faster after 1965, especially during the last 20 yr, reflecting that algal blooms or/and red tides caused by eutrophication accelerated. In addition, the synchronous temporal changes in the domestic sewage marker—coprostanol, terrestrial markers and the primary production indicators in the sediments showed clearly that the accelerated eutrophication was related to the anthropogenic activities in the northern coastal waters of the SCS in recent decades.

Responses of benthic communities to hypoxia in a sub-tropical environment: Problems and hypotheses

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Hypoxia affecting thousands of km^2 all over the world, and has caused mass mortality of marine animals, benthic defaunation and decline in fisheries production in many places.

In Hong Kong, eutrophication has resulted in regular occurrence of hypoxia and defaunation in Tolo Harbor. The benthic community was, however, soon restored to its original state by rapid winter recolonization. The abundance and dominance of predatory gastropods show an increase along a gradient of hypoxia in the Harbor, reflecting changes in the trophic structure in relation to oxygen. No significant changes in percentage of deposit-feeders however, was found along the same gradient. We hypothesize that predators are more oxygen-demanding, and therefore would be more sensitive to hypoxia, while deposit feeders are more tolerant.

Field manipulation experiments and multivariate statistics were used to examine recolonization and succession of benthos in defaunated sediments, and the time for recovery. Again, rapid recolonization was found after defaunation. No significant difference in abundance or species richness was observed between defaunated sediment and natural benthic community after 15 months, suggesting that a stable community had been achieved within a short time.

Often, the occurrence of hypoxia in the natural environment is associated with elevated levels of ammonia, hydrogen sulphide and particulate organic materials. The interactions between hypoxia and these water quality parameters however, are poorly known. The inability to isolate effects from individual factors and their interactions makes it difficult to attribute the observed ecological effects to hypoxia.

Motility and autotoxicity in *Karenia mikimotoi* (Dinophyceae)

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Karenia mikimotoi is one of the most common red tide dinoflagellates proliferating in the Eastern North Atlantic and around China and Japan. Kills of marine fauna kills are associated with its blooms. In mixed water columns, it migrates vertically while in stratified water columns, the population remains confined within pycnocline layers. Wind events, increasing mixing and agitation, initiate declines in its populations. This contribution is focussed on the formulation of mortality rate relative to shear rate. Autotoxicity is demonstrated by the use of the synthetic toxin. Bioconvection observed in cultures allow the establishment of a trade-off between phototropism which leads to the local accumulation of cells and their autotoxicity which would prevent cell concentration. The combination of these processes allows diffusion of the toxin into the underlying water, where it subsequently degrades. Confinement of the population in the pycnocline results also from another trade-off between growth conditions and shear-rate-modulated mortality. A simplified encounter kernel was introduced into the population dynamics equation to account for a mortality factor. Under realistic forcing conditions with a small number of parameters, this model reproduced the confinement of the population in the pycnocline, the proper timing and the duration of the recurrent *K. mikimotoi* bloom on the Ushant Front (France).

Metal Uptake and Transfer in Marine Plankton

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Over the past decades, it is well known that the geochemical behavior of various trace metals is considerably affected by marine organisms, and vice versa. I will discuss the interactions between trace metals and marine plankton. Marine plankton can affect the residence time of trace metals in surface waters by actively participating geochemical cycling. Conversely, many trace metals are essential to marine plankton and may potentially limit biological productivity in the ocean. The interaction between plankton and trace metals presents an intriguing paradigm to marine biogeochemists.

Metal concentrations in Hong Kong waters tend to be high, especially in the sediments. Copper, zinc and silver are metals of concern since they exceed present acceptable concentrations. These metals can be taken up by phytoplankton and transferred to zooplankton and experiments documenting this transfer will be discussed.

LIST OF ABSTRACTS
(Poster Presentation)

Latent effects of larval feeding history on filtration rate, carbon assimilation and growth of juvenile gastropod *Crepidula onyx*

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In this study, we examined the possible latent effects of larval feeding history on juvenile performance in *Crepidula onyx* in both laboratory and field conditions. Larvae were exposed to either high or low larval food concentration before induced to metamorphose. Juvenile growth was followed as increase in shell length and total organic carbon content for another 3 to 17 days. We found that growth was hampered for the juveniles that were developed from larvae fed with limited food. In follow-up experiments, we examined if the juveniles developed from larvae fed with limited food have a reduced ability to obtain, digest or assimilate food. Our results showed that larval feeding history did not affect carbon assimilation efficiency. However, filtration rate of juveniles developed from the larvae fed with limited food was significantly reduced. Therefore, the poor food collecting performance of the juvenile gills has at least partially affected the juvenile growth in *C. onyx*. In conclusion, the effects of larval food are not erased after larval metamorphosis in this species.

Do biofilms drive barnacle larvae to their final destination?

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Our previous studies showed that cyprid larvae of the barnacle, *Balanus amphitrite*, can distinguish biofilms originating from different tidal height, but our knowledge of their ability to distinguish biofilms originating from different habitats remains poor. This study examined the attachment response of *Balanus amphitrite* larvae to bacteria-dominated biofilms originating from four sites of varying environmental conditions in the intertidal region of subtropical Hong Kong waters in both laboratory and field conditions. Two experiments were carried out in this project. In Expt 1, colonization pattern of barnacles in four field sites was monitored in winter and summer 2005. In both summer and winter, significantly higher barnacle recruitment was observed in one site (OA) than in others. The Expt 2 tested the hypothesis that barnacle larvae can distinguish biofilms originating from different habitats. Larval settlement response to biofilms originating from the above four sites was examined using both laboratory and field multiple-choice bioassay. Results showed the larval preference to biofilms developed from OA to other sites. We have also determined the abundance of bacteria and bacterial diversity in order to trace the larval settlement cues. The T-RFLP and DGGE analysis showed the differences in bacterial community composition of biofilms originated from different sites. Fluorescence in-situ hybridization (FISH) technique was also employed to distinguish biofilms developed at OA and UST. Biofilms from a more productive site (OA) had a significantly higher proportion of *Gamma-proteobacteria* (>50%) than that of oligotrophic site (HKUST). This study highlights the significance of site-specific variation in biofilms on larval recruitment and demonstrated the discriminative behavior of barnacle larvae to biofilms originated from contrasting environments in the intertidal region. This study also supported our previous conclusion that bacterial community structure in biofilms determines the attractiveness of biofilms to larvae**.**

Larval settlement pattern of Spionid *Pseudopolydora vexillosa* (Polychaeta: Spionidae): potential indicator of organic pollution in subtropical coastal waters

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Pseudopolydora spp. is one of the most conspicuous spioniform polychaetes in subtropical Hong Kong and is often abundant on surface sediments. There is no published information on the biology of spioniforms from Hong Kong waters. With the purpose of exploring the potential of developing this species as an indicator of sediment organic pollution and to support further ecological studies, the culture techniques of the species in the laboratory was standardized. Newly hatched (3-setigers stage) planktotrophic (trochophore) larvae of *Pseudopolydora vexillosa* were grown at optimal conditions (32 psu and 28 ^{o}C) to examine growth, survival to metamorphic competence, and substrate selection at competency. Our results showed that 3-setigers stage larvae (220 ± 20 μm long) can attain metamorphic competence at 13-15 setigers stage (730 ± 10 μm long) when fed *Chaetoceros gracilis* at a concentration of ~10^5 cells ml^{-1} for 6 days. The effect of sediment organic matter on larval substrate selection and settlement was examined based on a preliminary observation on the recruitment level of this species in 3 sites along a transect perpendicular to a sewage discharge site. Among the three sites, each 60 m apart, recruitment doubled in the site furthest away from the discharge ("Oceanic" site) when compare to the nearest site ("Sewage" site). Sediment organic content and nutritional quality of the 3 sites were determined, the C/N ratio being significantly lower in the "Oceanic" site compared with the "Sewage" site. Subsequent single-choice and multiple-choice bioassays were performed in the lab, competent larvae showed a preference to settle in "Oceanic" site when they were given a choice. The study demonstrated that organic sedimentary cues affected larval substrate selection in settlement.

The importance of surface sediment organic matter quality for colonization of an opportunistic polychaete (*Capitella* sp. I) in Hong Kong waters

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Among different benthos, *Capitella* sp. I, an opportunistic deposit feeding polychaete, often found in organically enriched sediments and also serve as a good pollution indicator. The aim of this study was to understand how larvae and juveniles of the opportunistic polychaete *Capitella* sp. I respond to natural sediments of varying biochemical properties. Muddy sediments of similar particle size spectrum from five sites along a pollution gradient of domestic sewage collected in four sampling occasions in both wet and dry seasons in Hong Kong were used to study the influence of organic matter quantity and composition (i.e. TOC, TN, chlorophyll *a*, biopolymeric carbon and enzymatically hydrolysable amino acid contents) on larval metamorphosis (i.e. habitat selection) and juvenile performance (i.e. growth and survivorship). The western site (PC) adjacent to Victoria Harbor is affected by the river runoff while the eastern site (TLC) is oceanic. The transition sites, VH, VHE and VHW located in Victoria Harbor, are polluted by domestic sewage. Organic matter quantity and composition varied with sampling date and site. According to still-water multiple-choice experiments, larval choice at settlement varied with spatial and temporal variations in sediment biochemical properties. For instance, larvae preferred sediments from the VH over other sites in December 2004 and June 2005 and there was no difference in larval metamorphosis among TLC, VHE, VH and VHW in August 2004. However, they preferred sediments from both VH and VHW in March 2005. Interestingly, larvae did not prefer sediments from the PC regardless of sampling dates. A series of experiments in this study showed that both the quantity and the composition of organic matter affect the attractiveness of substrates to larvae and appear to play a key role in determining larval behavior at the time of settlement. Further laboratory experiments showed that larvae did not choose to settle on sediments from the sites that supported poor juvenile growth and higher mortality. Our field data indicated that both larval metamorphosis and juvenile performance patterns observed in this laboratory study partially corroborate with the abundance of adult *Capitella* spp. in the field. Overall, this study suggests that the field distribution of *Capitella* sp. I and consequently species composition in a community could be determined by the habitat selection by larvae and early juvenile performance. This study also proved that the larvae can assess the quality and quantity of the organic matter necessary to support subsequent juvenile growth.

Bacterial diversity in the water column and on soft and hard substrate in contrasting coastal environments: Linkages and implications for ecosystem recovery

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A major scientific challenge is to evaluate the significance of the great diversity of bacterial life in sediments, water column and intertidal regions for ecosystem functioning. In this study, we systematically investigated the bacterial species diversity in water column, sediment and on intertidal rocks at five sites with contrasting water quality conditions (TLC-Tung Lung Chau; VHE-Victoria harbor east; VH-Victoria harbor; VHW-Victoria harbor west; PC-Peng Chau) in the vicinity of Victoria Harbor, Hong Kong, by DNA fingerprinting techniques. We have also monitored both water quality and sediment biochemical characteristics at each site in order to: 1) link bacterial species diversity pattern to environmental conditions, and 2) document the recovery of bacterial species diversity in response to sewage discharge in the vicinity of Victoria Harbor. Bacterial cells had the higher abundance (10^7 cells cm^{-3}) on sediment surface than on biofilms (10^5 cells cm^{-2}) and in the water column (10^5 cells ml^{-3}). Bacterial species richness, as determined by the number of genera in PAT (phylogenitic analysis tool) analysis, was the highest in water column (>80), followed by surface sediments (~20 to 40) and then in biofilms (<10), irrespective of sites. Some bacterial taxa were specific to distinct habitats and sites, while others had a ubiquitous distribution. According to PAT analysis, the total number of bacterial species recorded in the eastern part of the Harbor was higher than in the central and western side of the Harbor. To-date, this study has not detected any adverse changes in bacterial diversity among the study habitats and sites.

Comparison of unexpected bacterial diversity in surface sediments in Hong Kong by 16S ribosomal DNA derived clone libraries

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The phylogenetic composition of bacterial communities from the surface sediment in different regions of the Victoria Harbour (TLC, VH, VHW and PC) was analyzed by full-length sequencing cloned 16S rRNA genes. The four regions differed in contaminate nutrient load and geochemistry. Our results show that each location has its own distinct bacterial community. The regional variability of sediment bacterial community composition and diversity was studied by comparative analysis of four 16S rRNA clone libraries. Amplified rDNA restriction analyses of 354 clones from the libraries indicate that the rDNA richness and evenness was high. Phylogenetic analysis of 178 fully sequenced bacterial 16S rDNA sequences from the sediment libraries demonstrated that Gamma-proteobacteria, Delta-proteobacteria, Holophaga/Acidobacteria, and Planctomycetales were represented in all four libraries. A few clones also grouped with Cyanobacteria, Verrucomicrobia, Beta-proteobacteria, Aminobacterium, Chlorofiexi, and candidate division OP 1, OP 8 and only appeared at one site. Actinobacteria, Bacteroidetes, Thermomicrobia, Epsilon-proteobacteria, Alpha-proteobacteria, Firmicutes, and Nitrospirae were found at some of the sites. Some sequences in the four sediment libraries clustered with uncultured 16S rDNA phylotypes from marine habitats, such as hydrocarbon seeps, salt mash. LIBSHUFF statistics of 16S rDNA gene sequences from the four libraries revealed major differences, except that at VHW and PC, indicating either a high richness in the sediment bacterial communities or considerable variability in bacterial community composition among regions, or both.

Phylogenetic diversity and spatial heterogeneity of sulfate-reducing bacteria along a pollution gradient in surface sediments of Hong Kong waters

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The phylogenetic diversity of sulfate-reducing bacteria and their spatial heterogeneity in the surface sediments across a pronounced gradient of pollution in Victoria Harbour, Hong Kong was investigated by phylogenetic analysis of the sequences from the clone library constructed with the full-length dissimilatory sulfite reductase gene (dsrAB) and terminal restriction fragment length polymorphism analysis of dsrA. One major clade of dsrAB sequences distantly related to the uncultured sequences in the GenBank and two clades of dsrAB related with the fatty acid-oxidizing delta-proteobacterial family Desulfobacteraceae and Desulfobulbaceae. The other dsrAB clones were affiliated with propionate-degrading and thermophilic sulfate reducers in the family Syntrophobacteriaceae. Analysis of SRB spatial heterogeneity showed that the most diversified terminal restriction fragments (T-RFs) were found at central Harbour area which has been contaminated by urban surface runoff and domestic and industrial sewage whereas the least T-RFs were found in relatively clean western site of Harbour. Three common T-RFs retrieved at all four sites had found phylogenetic affiliations in a clone library of Victoria Harbour west, whereas 13 T-RFs with minor peak area found no matching affiliations. The correlations between the number of T-RFs and selected sediment biochemical parameters indicated the SRB communities might be promoted by sulfur-rich pollutants or be stimulated by high concentration of metals.

Diel growth and mortality rates of *Synechococcus* in Eastern Hong Kong Waters

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In July and August of 2006, we studied the daily growth and mortality of picoplankton in Port Shelter near UST using two approaches. We used the standard dilution method and size-fractionated method to measure the growth and grazing rate of picoplankton at 2~4 hour intervals. *Synechococcus* was the main component of picophytoplankton in this water and it grew mainly during daytime. There was a trend that grazing rate on *Synechococcus* was stronger during the day, although this difference was not significant statistically. Grazing did not have an impact on the size of the whole *Synechococcus* population as indicated by the relative size index (FS), which suggested that grazers did not selectively ingest larger or smaller *Synechococcus* prey. Results from size-fractionated experiments showed that nano- and microzooplankton with the size up to 60 μm could consume *Synechococcus* directly, while grazers larger than 60 μm might release the grazing pressure on *Synechococcus* by grazing on heterotrophic flagellates.

Alkaline Phosphatase Activities of Aureoumbra lagunensis in Phosphate-limited Cultures

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The brown tide-forming alga, *Aureoumbra lagunensis*, was reported to be able to out-compete other phytoplankton in P-limited environments. Previous study suggests that it has low cellular P requirement, but its ability to use forms of phosphorus other than phosphate under severe phosphate deficiency remain unclear. We have studied changes of alkaline phosphatase activity (APA) of *A. lagunensis* growing in P-sufficient (+P) and P-limited (-P) batch cultures and in a series P-limited continuous cultures over a range of growth rates. In the batch cultures, the growth rates and APA in the -P culture were higher than that in the +P culture, and the peak value of APA in -P culture occurred right after the peaking of cell density. The results from the continuous culture indicated that as growth rate increased the intracellular phosphorus cell quota increased, while the intracellular carbon and nitrogen cell quota remained relatively constant. The nitrogen to phosphorus ratio (N:P) decreased as the growth rate increased. At the same time, APA and growth rate were positively related. Specifically, APA varied from 63.8 at a growth rate of 0.1 d^{-1} to 603 at a growth rate of 0.6 d^{-1} (i.e., an almost 10-fold increase). Together, these results suggested that APA positively correlated with the growth rates of *A. lagunensis* in P-limited continuous cultures. More experiments are needed to explain this positive correlation.

Phytoplankton Cell Mortality and Environmental Stresses – Nutrient Limitation and Light Deprivation

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Phytoplankton play an important role in the marine food web, global climate change and biogeochemical cycles. Few studies have investigated the effects of environmental factors on phytoplankton cell death since most studies focus on phytoplankton growth. The goal of my research is to determine how various environmental stresses affect cell death of marine phytoplankton. The effects of nutrient limitation (nitrogen, phosphate and silicate) and irradiance on the growth and mortality of the marine diatom *Thalassiosira weissflogii* were investigated. Cultures were grown under nutrient sufficient and nutrient-limited conditions and then half of the cultures were put in the dark. Both light deprivation and nutrient limitation had effects on the mortality of algal cultures. P limitation had the largest effect on algal mortality with a significant reduction in final cell density to nearly 50% of the initial in P-limited cultures, while there was only a 21% reduction in N-limited cultures, but no obvious decrease in silicate-limited cultures. The mortality rate of P limitation was the largest, around -0.24 d^{-1}, while in other treatments it was <-0.1 d^{-1}. Fluorescence per cell decreased 60% in N-limited cultures and ~90% for P and Si limitations. Light deprivation induced mortality, but also prolonged the survival of algae to some extent. Mortality rates in the dark were smaller than in light with the same nutrient limitation even though darkness induced cell death initially. P-limited cultures had a death rate of -0.08 d^{-1} in the dark, which was still the largest decreasing rate compared with other treatments in the dark. We illustrate the cell lysis processes under nutrient stress and light deprivation.

Long Term Trends in Nutrients and Phytoplankton Biomass along an Eutrophic Gradient in Hong Kong Waters and Response to Recent Sewage Treatment

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To evaluate the cost-effectiveness of the sewage treatment process at SCI, the present study investigated the long term changes in water quality parameters at 12 stations in HK waters during the last two decades, and the response of VH and its vicinity to the sewage pollution abatement. A long term decrease in NH_4, TIN, PO_4 and chl *a* accompanied by an increase in bottom dissolved oxygen (DO) was observed in VH, especially after the implementation of HATS in December 2001. This indicates that the water quality in VH is improving. The bottom DO concentration in HK waters was generally >4 mg L^{-1} which reveals that eutrophication impacts in HK waters was not as severe as what we expected from the high nutrient loading. However, the long term increases in NO_3, TIN and chl *a* and the decrease in bottom DO, especially in western and southern waters may be an early sign of deterioration of water quality in these areas, which may be linked to the nutrient inputs from both the Pearl River Estuary and the sewage from Stonecutters Island.

Anthropogenic nutrient inputs from local sewage and the Pearl River Estuary have increased the nutrient loading in HK waters. To minimize the problems such as hypoxia and fish kills caused by the eutrophication, HKSAR implemented the Harbor Area Treatment Scheme (HATS) in 2001. Now 70% of the sewage is treated and the discharge site has been moved from Victoria Harbor (VH) to Stonecutters Island (SCI).

Microbial Response to Anthropogenic Inputs in Subtropical Hong Kong Waters

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Bacterial and phytoplankton activities, nutrients, dissolved inorganic carbon (DIC) and partial pressure of CO_2 (pCO_2) were investigated in Hong Kong waters in 2005 to 2006. Average pCO_2 and oxygen were about 570 μatm and 5 mg L^{-1} respectively, which indicated moderate heterotrophy in Hong Kong waters. The sewage discharge significantly increased nutrient concentrations and heterotrophic processes in the Victoria Harbour ($p < 0.05$), although the increase in the average percent oxygen saturation indicated an improving conditions after the abatement of sewage pollution in Victoria Harbour. Bacterial and phytoplankton production varied from 0.2 to 5 g m^{-2} d^{-1} and 1 to 15 g m^{-2} d^{-1} respectively, and showed dynamic variations along trophic gradients during different seasons. Microbial activities had higher uptake ratios of DIC/nutrients in summer than winter and spring, which was also affected by anthropogenic and estuarine inputs.

Spatial and Temporal Complexity in Potential Nutrient Limitation in Hong Kong Waters

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The concentration of the potential limiting nutrient in seawater determines the potential amount of algal biomass that can be produced. If a large amount of algal biomass is produced, these algae may eventually die and become decomposed by bacteria which use up oxygen in the bottom water and result in hypoxia. Therefore it is important to know which nutrient potentially limits algal biomass production and how this potential nutrient limitation varies spatially and seasonally.

To provide evidence of nutrient limitation, nutrient enrichment experiments were conducted in Victoria Harbor, southern waters, and eastern waters. Five nutrient treatments were conducted. The results show that N and P co-limitation occurred in eastern waters. Nitrogen was the first limiting nutrient, except in June when P was the first nutrient to limit growth because of the influence of the nitrogen-rich Pearl River discharge. Si limitation occurred in the southern waters and Victoria Harbor because the river discharge volume is low in November and the Pearl River is the main input of Si to surface waters in the western region. Also the sewage input into Victoria Harbor is high in N and P relative to Si. My results show clear temporal and spatial variations in nutrient limitation in HK waters. More nutrient enrichment experiments are on-going along with estimates of 33P uptake and turnover time.

Dynamics of dissolved oxygen (potential hypoxia) and benthic release of nutrients in the bottom layer: effects of light penetration and tidal shoaling in shallow vs deep areas in Hong Kong waters

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High nutrient loading (nitrate) and seasonal stratification have been regarded as the major essential drivers for persistent seasonal hypoxia in shallow coastal waters, for example, the famous "dead zone" in the northern Gulf of Mexico. However, not all nutrient enriched shallow coastal areas are susceptible to extensive and persistent hypoxia. Historical EPD data revealed that nutrient loading (nitrate concentration up to 120 μM) in Hong Kong waters was comparable to that in the Mississippi River and Chesapeake Bay which suffer from persistent hypoxia. However, bottom dissolved oxygen (DO) of < 2.5 mg/L was only occasionally observed in a small confined area in the Pearl River estuary and deeper southern waters in Hong Kong. Low bottom DO rarely occurs in areas with shallow water depth. It is suggested that the combined effect of site-specific physical and hydrometeorological factors such as bottom topography, irradiance attenuation, turbidity and tidal shoaling may provide a natural buffering capacity for suppressing the occurrence of hypoxia in Hong Kong waters.

In order to increase our understanding of DO and nutrient dynamics, *in situ* water sampling, and 24-hour Light and Dark bottle incubation experiments were conducted to investigate the effect of irradiance attenuation on the DO consumption and production at different water depths in the bottom water layer on 22 – 23 August 2006 (late summer). A 3.5 m long custom-made bottom water sampler was constructed to collect the overlying water few centimeters above the sediment. During 24-h time series, high-resolution vertical bottom water profiles (8-10 cm per layer) of DO, fluorescence, suspended particulate matter concentration and nutrients at two southern water stations, SM7 (shallow) and SM18 (deep) at different tidal status on the same day were taken.

DO incubation results show that bottom water at the SM7 station has higher photosynthetic DO production compared with SM18. With deployment of the bottom water sampler, microprofiles for parameters such as titrated DO, nutrients, *in vitro* chlorophyll *a*, suspended particulate matter (SPM) and Dissolved Organic Carbon (DOC) were measured at different tidal conditions.

Field studies of metal biomagnification in different marine food chains

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The trophic positions and food web structures of organisms collected from two Hong Kong rocky shore and epiepibenthic environments were investigated by using nitrogen stable isotopes. The metal body concentrations (Ag, Cd, Cu and Zn) were concurrently measured in order to investigate whether biomagnification occurred in these environments. Generally, metal concentrations were higher in the predatory gastropods compared with organisms from other classes. Cadmium was enriched along two marine rocky shore food chains; its concentration was biomagnified about 8 – 10 times within the food chains. Copper was also enriched along one of the marine rocky shore food chain; it was biomagnified about 100 times along the food chain. However, biomagnification of Cu was not as common as that of Cd. Metal concentrations in the invertebrates were higher than those in the fish. No observable biomagnification of metals was found in the epiepibenthic food web. This may be due to the difference in the biodynamics between the epiepibenthic animals and the rocky shore animals. The analysis of nitrogen stable isotopes coupled with measurements of metal concentrations in different organisms provides evidence of Cd and Cu biomagnification along specific food chain in the marine environment.

How contact time affects the bioavailability of sediment-bound heavy metals

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We employed the radiotracer technique to assess the bioavailability of sediment-bound Cd and Zn by quantifying the metal assimilation efficiency in two deposit-feeding invertebrates: the sipunculan *Sipunculus nudus* and the soldier crab *Mictyris longicarpus*, and the extraction of metals from sediment by the gut juice of sipunculans. The sediments were spiked with the radiotracers for different durations (3 days, 3 months, 0.5 year, and 2 years) and the bioavailability and speciation (determined by the sequential extraction method) were tested. Sediment contact time longer than 3 months did not significantly influence the assimilation efficiency and speciation of Cd, but it affected the distribution of Zn in different geochemical phases. We found a positive correlation between the gut juice extraction and the assimilation efficiency (AE) for both sipunculans and crabs, while a relatively weaker correlation between normal seawater extraction and AE was documented. There was a positive relationship between the Cd in the exchangeable and the carbonate fractions and the AE, and a negative relationship between the Cd in the reducible phase and the AE. Similar trends were also found between the Cd speciation and the gut juice extraction. Overall, it is possible to combine gut juice extraction, assimilation efficiency measurement, and sequential extraction to predict the bioavailability of Cd in deposit-feeding invertebrates. It is important to consider the sediment-metal contact time when using spike technique to assess the bioavailability and toxicity of sediment-bound metals, especially for Zn.

Spatial Distribution of Viral Abundance in the Northern South China Sea

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Viruses are now known to be an important component of the marine microbial loop because viruses affect all major members and thus, to play an important role in the biogeochemical cycling of carbon and nutrients in the ocean. A cruise was conducted to investigate the spatial distribution of virus abundance in the northern of South China Sea on the large scale during September 2005 and other variables such as bacterial abundance and chlorophyll *a* concentration. We found that viral abundances on average are high in the estuarine coastal plume (25.21±3.06×106 ml^{-1}), low in the open sea (11.61±5.26×106 ml^{-1}) with an intermediate concentration on the continental shelf (14.09±6.50×106 ml^{-1}). In general, viral abundance was greater in the surface layer than in the bottom layer. In the open sea, viral abundance declines rapidly below the euphotic zone (100 m) and remained to be relatively constant at low abundances of $<10^6$ ml^{-1}. Bacterial abundances followed the similar spatial distribution with 4.80±1.06×106 ml^{-1} in the estuarine coastal plume, and 1.76±0.95×106 ml^{-1} in the open sea with 2.84±1.72×106 ml^{-1} on the continental shelf. Ratios of viruses to bacterial abundance (VBR) were 5.34±0.65, 5.84±2.08 and 7.63±4.38, respectively, which show that the VBR increased as bacterial abundance decreased. Viral abundance was found to be positively significant ($p < 0.001$) correlation with bacterial abundance and not significantly correlated ($p > 0.001$) with chlorophyll *a* concentration, which suggests that bacteria are the major host members of marine viruses and control the viral abundance in the ocean.

There was a maximum in viral and bacterial abundance at the halocline layer. In the deepwater column, there was another maximum in viral abundance, coinciding with the minimum in bacterial abundance at 800-1000 m. Ratio of viruses to bacterial abundance was maximal (12.5), higher than the average VBR. It is interesting to note that there was the minimum in dissolved oxygen (2.91 mg l^{-1}), which was at the same depth as the maximal VBR ratio. The coincidence provides us an important piece of evidence that viruses might control bacterial abundance when bacterial abundance was slowed by the limitation of organic supply at deep sea and consequently, influenced biogeochemical processes such as oxygen consumption and nutrient regeneration.

Viruses and flagellates sustain richness and reduce biomass accumulation of bacterioplankton in coastal marine waters

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In order to gain a better understanding of the interaction among prokaryotes, viruses and protists (flagellates) in coastal marine ecosystems, we investigated the effect of viral lysis and protistan bacterivory on bacterial abundance, bacterial diversity (16S rRNA gene PCR and denaturing gradient gel electrophoresis [DGGE]), and bacterial production in six experiments at three coastal marine sites in Hong Kong, the anthropogenically nutrient-polluted Victoria Harbor (VH), the nutrient-rich Peng Chau (PC), and the nutrient-poor Clear Water Bay (CWB). This is the first systematic attempt to study the interactive effects of viruses and flagellates on prokaryotic populations in coastal marine ecosystems. Both viruses and flagellates had significant repressing effects on prokaryotic abundance and production. Bacterial species richness was often higher in the presence of viruses and flagellates than in the predator-free control. Cluster analysis of the DGGE pattern showed that the effect of viruses and flagellates on bacterial community structure was relatively stochastic, while co-effects of both predators changed the bacterial community substantially. Overall, we found strong evidence that viral lysis and protist bacterivory act additively to reduce bacterial production and sustain diversity in coastal waters. Our data also offer an explanation as to why bacterial phylotypes do not form blooms in coastal marine waters as phytoplankton do.

Diurnal variation of surface seawater pCO_2 in a suite of coastal environmental settings

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This study examines the diurnal variation of surface seawater pCO_2 and its potential implication on the estimate of air-sea CO_2 fluxes. Experiments were conducted in a variety of environmental settings such as at Xiamen Bay (Xiamen, China), Shacheng Harbor (Fuding, China), Taiwan Strait, Xisha Islands (Paracel Islands, a coral reef system in the South China Sea) as well as in the basin and shelf of the South China Sea. Experiments were conducted with an autonomous fiber optical chemical pCO_2 sensor and an infrared CO_2 analyzer equipped with a shower head equilibrator.

Through seawater pCO_2 time series observations, and along with the surface water column chemistry, we observed significant diurnal changes of surface pCO_2 ranging from 10 - 20 μatm in the oligotrophic South China Sea, up to as high as 400 μatm in the coral reef system at Xisha islands. Such a magnitude of seawater pCO_2 variation at a diurnal time scale will certainly impact on the estimate of the air-sea CO_2 fluxes at longer time scale. A first order analysis on the environmental conditions such as tides, currents, biological production and temperature that modulate the diurnal variation will be given in the presentation.

Offshore and nearshore phytoplankton increases are induced by a typhoon and typhoon rain

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The phytoplankton chlorophyll response to Typhoon Damrey in the South China Sea (SCS) in September 2005 was studied with remote sensing. Chlorophyll *a* (Chl *a*) concentration increased in 2 locations after the typhoon. (1) An offshore bloom along Damrey's track exhibited a Chl *a* peak (4 mg m^{-3}) 5 d after the typhoon's passage. It was preceded by sea surface cooling (-5˚C), mainly on the right side of the typhoon track, and sea level decrease (-25 cm) along the typhoon track 1 d post-typhoon. The offshore bloom was due to nutrients uplifted by mixing and upwelling. (2) A nearshore Chl *a* increase succeeded typhoon rain (>300 mm on 26 Sep) on Hainan Island in the northwest SCS. In the bloom region, the water was rich in suspended sediments, phytoplankton, and colored dissolved organic matter and was entrained by an eddy. This nearshore feature might have resulted from typhoon rainwater runoff discharge and seaward advection by a typhoon-induced current. Therefore these 2 mechanisms, both typhoon and typhoon rain can nourish marine phytoplankton.

Validation of Chl-*a* Derived from SeaWiFS and MODIS for the South China Sea Region

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The South China Sea (SCS) in the northwest Pacific Ocean is the second largest marginal sea in the world; this region is strongly influenced by the East Asia monsoon wind, and tropical storms and typhoons. The present study analyzed SeaWiFS and MODIS derived Chlorophyll a (Chl-a) products with in-situ data collected from three research cruises in May 1999, September in both 2004 and 2005 in the SCS region. By chance, 4 typhoons or tropical storms occurred during the 2005 cruise period, Generally, both SeaWiFS and MODIS provide comparable Chl-a concentration data with in situ measurements, especially for offshore ocean water, and somehow overestimate, particularly for the river mouth areas and coastal water. Usually, SeaWifS derived Chl-a values are higher than that of MODIS, and SeaWiFS data have a better spatial coverage than that of MODIS; but MODIS-retrieved Chl-a data have a better correlation coefficient with in situ measurements than that of SeaWiFS data. Soon after a typhoon or tropical storm, Chl-a concentrations increased, and satellite sensed Chl-a values were found to be lower than in situ data, particularly in the typhoon area.

Accelerated eutrophication at the northern coastal waters of the South China Sea for the last 100 years: evidence from sedimentary records

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Deforestation, urbanization and anthropogenic discharge are known to result in eutrophication in many estuarine and coastal waters of the world. During the past 50 years, Pearl River estuarine system has experienced increasing pressure of anthropogenic pollution. Especially, it has received a high loading of nutrients during the past two decades due to increased activities in agriculture, marine fish farming and discharge of sewage. Nowadays, eutrophication and algal blooms or/ and red tides have frequently occurred in the northern coastal waters of the South China Sea, which has draw much public attention because of their potential harmfulness to human health and risk to the local mariculture and fishing industries.

To control the red tides, an investigation of eutrophication causes and mechanisms is essential. Much research have been done in the Pear River Delta estuary for this purpose, but we still lack historical data to assign eutrophication causes. Besides observational data, sedimentary records provide a very useful tool for evaluating and reconstructing the history of anthropogenic sewage discharge, eutrophication and their impacts on local ecosystem.

The sedimentary organic matter in coastal areas mainly originates from primary and secondary production within the ecosystem, terrestrial inputs and bacterial production in the water and sediments. The relative significance of these sources is determined by local environmental factors, such as climate, hydrodynamic conditions and nutrient supply. Changes in any of these factors will result in a change in sedimentary organic matter. Algal blooms or/and red tides caused by eutrophication occurred at some given environmental condition and may imprint markers in the sedimentary records.

A sediment core taken from the Southeast of Hong Kong was studied. The high-resolution sedimentary records of the bulk organic matter, lipids and biogenic silica (BSi) reflected the accelerated eutrophication for the last 100 yr in the northern coastal waters of the South China Sea. The primary production indicated by BSi and dinosterol concentration increased gradually after 1940. The primary production increased slowly and consistently from 1940 to 1965 and increased faster after 1965, especially during the last 20 yr, reflecting that algal blooms or/and red tides caused by eutrophication accelerated. In addition, the synchronous temporal changes in the domestic sewage marker—coprostanol, terrestrial markers and the primary production indicators in the sediments showed clearly that the accelerated eutrophication was related to the anthropogenic activities in the northern coastal waters of the SCS in recent decades.

Numerical study of the barotropic tide and tidal dynamics in the South China Sea

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Semi-diurnal and diurnal tides and their dynamic processes in South China Sea (SCS) are studied by assimilating Topex/Poseidon altimetry data into a barotropic ocean tide model using a tidal data inversion scheme developed by Egbert, et al (1994, 2002). Results from the sensitivity studies reveal that the data assimilation scheme is necessary to overcome the errors caused by the complex topography and coastlines. High resolution (~10 km) and a large model domain are adopted to better resolve physical processes involved and to minimize the uncertainty from open boundary condition. Thus the final model results compare well with tidal gauge observations, and therefore, we were able to find some tidal features that have not been documented before: when the tidal waves propagate from the West Pacific into the SCS through Luzon Strait (LS), the amplitude of semi-diurnal tide M2 decreases, while the amplitude of diurnal tide K1 increases after entering SCS. This is also an indication of the M2 tidal energy conversion into internal tide in Luzon Strait, and the K1 tide amplification in the SCS caused by particular geometry. Energy studies show that LS is a place where both M2 and K1 tidal energy is dissipated most, and the work rate of tidal generating force in the SCS basin is negative for M2 and positive for K1. All these tidal features appear to be strongly controlled by the bottom topography, and the differences between M2 and K1 in SCS seem to be correlated to their propagating directions in the Pacific, their different frequency, wave length, and consequently different responses to the local geometry.