Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)


ACG35-01 Room:421 Time:April 28 14:15-14:30

# Effects of water and dissolved material exchanges between land and ocean on coastal ecosystem and fishery resources

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There are two pathways of water and dissolved materials from land to the ocean. The first one is river discharge and another is invisible submarine groundwater discharge (SGD). Many studies show the importance of SGD on coastal ecosystem and fishery resources. SGD is evaluated by using seepage meters and piezometers at local point scale, radon and strontium isotopes as tracers in bay scale to identify the origin of the fresh water, which is river water or groundwater. Another method is resistivity measurement which can tell us the salinity of the pore water in the sea bed near the coastal zone.

SGD observed by seepage meter and Rn concentration of the coastal seawater has a positive relationship over the world with different geology, geomorphology, and hydro-meteorological conditions. All SGD studies show that there are two components in SGD, one is fresh SGD and another is recirculated SGD. It is important for understanding coastal ecosystem and fishery resources to evaluate the ratios and processes of fresh SGD which is driven by hydrological condition in land, and recirculated SGD which is driven by oceanographic conditions in the sea.

In this study, SGD studies by using seepage meter and radon measurements over the world are reviewed to evaluate the physical and chemical factors which drive SGD and material transports by SGD, and the effects of SGD on the distribution of the fishery resources such as shell distributions in the coastal zone. River discharge is a main linkage between land and ocean through water and dissolved material transports, however it has huge temporal changes. On the other hands, the amount of SGD itself is not much but continuous contribution by SGD with constant temperature and nutrient discharges make stable physical, chemical, then biological conditions such as sea grass (Zostera bed).

Keywords: submarine groundwater discharge, coastal ecosystem, coastal fishery resources, nutrients, seepage, radon

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ACG35-02 Room:421 Time:April 28 14:30-14:50

# The effect of freshwater input from rivers on the ecosystem in coastal waters

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High production in coastal areas is supposed to be supported by large organic and inorganic inputs from rivers. Therefore, excessive reduction of nutrient loads from rivers would decrease nutrient concentrations in coastal areas. This manifests in poor growth of seaweeds, which has been observed in Seto Inland Sea in recent years. However, primary production in coastal areas is not only supported by terrestrial nutrients, but also external nutrients derived from ocean and regenerated nutrients formed in hypoxic water at the bottom. Evaluation of the contribution of each source of dissolved inorganic nitrogen (DIN) to phytoplankton production in Ise Bay revealed that DIN consumption by phytoplankton exceeds the DIN supply from rivers and ocean. This indicates that a large amount of primary production depends on regenerated DIN within the bay rather than on newly supplied DIN, although the ratio of consumption to external supply differs seasonally. We have to pay more attention to the behavior of each source of nutrients for future managements of coastal waters.

The effect of the freshwater input from rivers on coastal areas is not only the nutrient supply, but also the formation of estuarine circulation, which plays an important role in coastal ecosystems. Since the flux of water by the estuarine circulation is considerably larger than the river discharge, it has large effects on the material transport and biological production in estuaries and bays. For example, larvae of temperate seabass do not distribute in the surface, but in the middle layer, and thus the landward flow effectively transports larvae to coastal areas from the spawning grounds in the offshore. Therefore, the year-to-year variation in the amount of juveniles in the coastal area shows that the survival of juveniles improves in the years when the river discharge increases.

Keywords: coastal ecosystem, estuarine circulation, freshwater, nutrients

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ACG35-03 Room:421 Time:April 28 14:50-15:10

# Possible effects of submarine groundwater on biodiversity and fishery production in coastal ecosystems

SHOJI, Jun[1*] ; SUGIMOTO, Ryo[2] ; TOMINAGA, Osamu[2] ; KOBYASHI, Shiho[3] ; YAMADA, Makoto[4] ; TANIGUCHI, Makoto[4]

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Economic values of the ecosystem services of coastal ecosystems have been evaluated as among the highest of those the world's ecosystems. Recently more attentions have been paid on the mechanisms how the freshwater contribute to the high productivity and species diversity of the coastal ecosystems. In the present paper, previous researches that focused on effects of freshwater input from the land on productivity and species diversity of fishery resources in the coastal ecosystems are reviewed. In addition, results from recent surveys conducted in order to examine the possible effects of river water and submarine groundwater on productivity and species diversity of fishery resources are introduced.

Relationship between river discharge and recruitment of several estuarine-dependent fish species (flatfish, seabass and clupeid) have been reported in the world. Among these fish species, the mechanisms how river discharge promotes survival during the early life stages and recruitment of Morone fishes (striped bass and white perch) have been well studied. Larval survival rate is high and recruitment of 1-year-old fish is successful in years with high precipitation in these species. High freshwater discharge has been reported to increase availability of prey for the larvae, decrease predation through affecting predator species composition and biomass, then increase the growth and survival during the larval stage.

In a previous paper, on the other hand, low salinity zone has been reported to be one of the ecosystems where biodiversity is the lowest among the world's aquatic ecosystems. High fluctuation in salinity and tidal level within a relatively small spatial and temporal scale could be stressful for a variety of animal species. Recently high abundance of juveniles of several flatfish species were observed in low salinity zones nearby an estuary in the coastal waters of Japan. Species diversity of fishes was higher in a seagrass bed where freshwater supply from the land through submarine groundwater was expected compared to the surrounding areas. These observations suggest that low salinity condition does not always decrease diversity of fish species in coastal ecosystems. Future research plan to investigate the mechanism how the freshwater input from the land contributes to the high productivity and species diversity in the coastal ecosystems will be introduced.

Keywords: water-food NEXUS, fishery production, species diversity, submarine groundwater

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ACG35-04 Room:421 Time:April 28 15:10-15:25

# Evaluation of nitrogen dynamics in the Yodo River estuary using stable isotopes

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The increase in human population in coastal watersheds has increased the delivery of nitrogen from the land to coastal environments. Accelerated nitrogen cycles in coastal environments have led to an increase in hypoxic waters and instances of harmful algal blooms. Physical and biogeochemical processes within estuaries generally regulate nitrogen fluxes from land to sea. The estuaries of major rivers on the continents are thought to be sites of massive nitrogen losses. However, function of estuaries to nitrogen transfer must vary according to each estuarine hydrology and biogeochemistry. A large amount of terrestrial nitrogen empties into Osaka Bay head from the Yodo River. Although the estuary would have a crucial role in modifying nitrogen fluxes, its function to nitrogen transfer is still unclear. In this presentation, we will report the seasonal difference of nitrogen dynamics along the longitudinal section from the estuary to the head of Osaka Bay.

Keywords: nitrogen, stable isotopes, estuarine circulation, eutrophication, regeneration

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ACG35-05 Room:421 Time:April 28 15:25-15:40

# Factors of the temporal variation of marine phytoplankton at Yodo River estuary

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Red tides of *Alexandrium tamarense* have occurred in the estuary of the Yodo River in Japan in 2007, 2011 and 2013. *A. tamarense* is marine phytoplankton and causes shellfish poisoning. We have made in-situ observation in April 2-3 2012, and analyzed the temporal variation of marine phytoplankton by using the numerical ecosystem model. CTD and ADCP observation and water sampling ware carried out linked to the tidal change. Nutrient and chl.a concentration and cell density of *A. tamarense* were analyzed. *A. tamarense* was a few in this year. Typical estuary circulation which seawater run up to upstream in the surface layer and fresh water go down to the sea in the bottom layer. Therefore the estuary which have 2800m length was divided to three layers, 0-0.5m, 0.5-1.5m and 1.5m-bottom. The thickness of the bottom layer is changed with the tidal change. Nutrient, phytoplankton, the dissolved organic matter and the particulate mutter are in each layer, and the bio-chemical process between the forms, photosynthesis, mortality, decomposition and so on, are formulated. Then the temporal variations of each morphology and *A. tamarense*. Diurnal migration, salt limitation and utilization of organic matter for the photosynthesis and mortality by low salinity were considered in the bio-chemical process of *A. tamarense*. The temporal variations of phytoplankton in each layer were almost reproduced. Marine phytoplankton in the Yodo River estuary were not produced hardly and were supplied from the ocen. Phytoplankton which cannot swim by oneself is almost floated by the horizontal advection, it is the estuary circulation. But only 27% of *A. tamarense* transported from the ocean in the bottom layer go through upstream. 36% of it returned to the ocean in the middle and surface layers, and other 36% die in the surface layer. Weak estuary circulation is effective to limit the transport upstream of *A. tamarense* in Yodo River estuary.

Keywords: Yodo River, Estuary, Numerical ecosystem model, Phytoplankton, Alexandrium tamarense

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ACG35-06 Room:421 Time:April 28 15:40-15:55

# Utilization of terrestrial organic matter by marine benthic polychaetes in estuarine eosystem

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In semi-enclosed bays, terrestrial plants transported by river have become a major constituent of estuary sediment. Since it is difficult for marine organisms to digest the terrestrial plants which mainly contains the non-living refractory cellulosic matrics, few studies have been taken into account the role played by the terrestrial particulate organic matter(tPOM) in enhancing the productivity of the coastal biotic community. However, the important role of tPOM as the food source for marine benthic organisms has been recognized in estuarine environments. In the present study, we examined the $\delta^{13}$C, $\delta^{15}$N values and cellulase activity of the several species of polychaetes to elucidate the contribution of terrestrial plants to benthic biological production in small semi-enclosed Bay. Polychaete annelids were collected at estuary of the Kita and Minami River in semi-enclosed Obama Bay, the Sea of Japan from August 2007 to June 2010. The carbon and nitrogen stable isotope ratios of polychaetes were analyzed. Cellulase activity analyses were assayed by using carboxymethyl cellulose (CMC) plate assay. The $\delta^{13}$C values of deposit or suspension feeding polychaetes were lower than the $\delta^{13}$C value of POM but higher than the terrestrial plants. The $\delta^{13}$C and $\delta^{15}$N values of carnivores-feeding polychaetes were higher than those polychaetes. Cellulase activities was found in many deposit or suspension feeding polychaetes but also carnivorous feeding polychaetes. On the other hand, the polychaete species with lower isotope signature did not show cellulase activities. The polychaetes which showed cellulase activity were abundant through the four seasons in estuary. These results suggest that many polychaetes can decomposition and assimilation the terrestrial plants.

Keywords: terrestrial plants, cellulase,, semi-enclosed bay, polychaetes

Japan Geoscience Union Meeting 2014
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ACG35-07 Room:421 Time:April 28 16:15-16:30

# The origin of submarine groundwater discharge in the coastal zone of Hiji, Oita prefecture

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It is said that groundwater discharge from the seabed of the coastal zone of Hiji, Oita prefecture. The marbled sole which lives around this submarine groundwater discharge is called a " Shirosita Karei " , and is loved by the local people. From ancient times, the local people have believed that this Shirosita Karei grows because of submarine groundwater discharge. However, regarding the relevance of the ecology of a marbled sole and submarine groundwater discharge, it is not clear that this is the case. Moreover, although it is clear that there is submarine groundwater discharge, there is almost no information about the origin and dissolved component. Kono and Tagawa (1996) conducted an analysis of the major dissolved components of groundwater of this land area, and a vertical distribution investigation of the electric conductivity of the ocean. As a result, it has suggested the possibility that submarine groundwater discharge is the confined groundwater recharged in the mountain area. However, in that report, they said that they were not able to identify a recharge area clearly by this research. Because of that, we sampled the spring water of the land area, the spring water of a salt water mixture discharged in a seashore area, and a sea water sample, in order to conduct hydrological research using the stable isotope of water in this area and to clarify the flow process of submarine groundwater discharge. The recharge elevation of the spring water of this land area was assumed using the recharge-water line (Ohsawa et al., 2009) made using the data of the Beppu area of the southwest part of this research region. As a result, it became clear that the recharge area of most spring water is at an elevation of 200 m or more. Regarding fresh water and salt water mixture, the mixed rate of sea water and fresh water was calculated using electric conductivity, and the isotopic ratio of the original fresh water was computed using the mixed rate. As a result, it became clear that the recharge elevation of the fresh water mixed in sea water is near 300 m. Moreover, as a result of extracting the terrestrial environment of this area, the area with an elevation of 200 m or more is mainly forest, and there was a boundary between the forest area and plains near an elevation of 200 m. It became clear from these results that the origin of the submarine groundwater discharge in the coastal zone of Hiji is the water recharged in the forest area of the mountain slope, and that the water moves under the plain and is discharged at the sea bed.

Keywords: Submarine groundwater discharge, Stable isotope, recharge area, Hiji

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ACG35-08 Room:421 Time:April 28 16:30-16:45

# Location estimation of submarine groundwater discharge from Mt. Fuji in Suruga Bay

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Around the foot of Mt. Fuji, the main flow passages of groundwater are thought to be in the Younger Fuji volcano, which consists of the pervious basaltic lavas in new volcanic stage. Especially, the Fujikawa-kako fault zone, which stretches south to north in the southwestern side of Mt. Fuji, has a potentially effect on the local groundwater flow system into Suruga Bay. Therefore, precipitation at Mt. Fuji have been considered to be discharging partly from seabed in Suruga Bay and making a great impact on the biological production at the coastal sea area.

For the purpose of contribution to make sense of the rich coastal ecosystem in Suruga Bay, we conducted a survey for submarine groundwater discharge (SGD) in Oku-Suruga Bay: from the mouth of the Fuji River, at which the fault is found, to Tagonoura, where the lavas of the Younger Fuji volcano are distributed from 100 to 200 m below sea level. We are trying to estimate some locations of SGD from the condition of seabed and geological structure by using the side scan sonar and the sub-bottom profiler. We also use a remotely operated vehicle (ROV) for photographing for the image of the extrapolated spring points. In this presentation, we introduce our works noted above.

Keywords: submarine groundwater discharge (SGD), Mt. Fuji, Suruga Bay, side scan sonar, remotely operated vehicle (ROV)

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ACG35-09 Room:421 Time:April 28 16:45-17:00

# Evaluation of submarine groundwater discharge in Suruga Bay by using radon 222

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Submarine groundwater discharge (SGD) in coastal area has been recognized as an important pathway for material transport from land to ocean. SGD has been widely studied throughout the world and it is expected as ubiquitous phenomenon in coastal zone.

Suruga Bay is adjacent to the southern foot of Mt. Fuji where the permeable lava flow deposits and the active groundwater flow system exist. Therefore, large amount of groundwater input is expected at the coastal area in Suruga Bay. It is also expected that SGD has a significant effect for marine products in this area.

To evaluate submarine groundwater discharge in this area, we applied continuous radon measurement and sampled coastal water for chemical analysis. We will introduce these results in this presentation.

Keywords: Rn-222, Submarine groundwater discharge, Suruga Bay

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ACG35-10 Room:421 Time:April 28 17:00-17:15

# Estimating submarine groundwater discharge in Obama Bay, Japan, using 222Rn mass balance model

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Recently, a number of studies have shown that submarine groundwater discharge (SGD) is even more important than surface runoffs in terms of nutrient transport and can drive primary production in coastal seas. Obama Bay is semi-enclosed bay in central Japan. In spring, phytoplankton blooms in the bottom layer around 2 km offshore from the river mouth. Aquifer distribution in the Obama plain and our previous observation of low salinity water around the bottom layer suggests that unconfined groundwater discharges induce this phytoplankton bloom. However, quantitative contribution of groundwater discharge to the coastal ecosystem has not been well evaluated in Obama Bay. In this study, we estimated the input of freshwater and nutrients via SGD into Obama Bay using mass balance model of radon ($^{222}$Rn) and salinity. As a result, the volume of SGD into the bay was estimated to be 0.05-0.80$\times 10^6$ $m^3$ $d^{-1}$ during February 2013 to November 2013. Especially, the fraction of SGD in total freshwater flux in summer reached to 44%, because river water discharge decreased drastically. The nutrient fluxes from SGD were approximately 84%, 210% and 28% of riverine fluxes dissolved inorganic nitrogen (DIN), dissolved inorganic phosphorous (DIP) and dissolved inorganic silicate (DSi), respectively.

Keywords: Submarine groundwater discharge, 222Rn mass balance, Obama Bay

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# A study of primary production in plankton blooms driven by riverine inputs

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Rivers transport nutrients and suspended sediment matter (SSM) as well as fresh water from land to coastal regions, where the biological productivity is high. In the coastal area, the buoyancy of fresh water leads to the formation of horizontal anticyclonic gyres and vertical circulations, which affect the variation of biological production such as plankton blooms. However, the primary production caused by the three-dimensional dynamics have not been quantitatively discussed, and observations can hardly capture the daily temporal variations of phytoplankton blooms. We developed an ocean general circulation model (OGCM) including a simple ecosystem model, to investigate the three-dimensional and temporal changes in phytoplankton blooms caused by riverine input such as flooding.

We first conducted ideal setting-simulations. The distribution patterns of nutrients and phytoplankton differ significantly from that of fresh water. The phytoplankton maxima shift from the downstream (right-hand side of the river mouth) to the upstream regions (left-hand side of the river mouth). The shift from the downstream to the upstream region (D-U Shift) is categorized by the different nitrate origins: (1) river-originated nitrate (RO-nitrate) is dominant in the downstream region; (2) subsurface-originated nitrate (SO-nitrate) is dominant in the upstream region, and is transported by upwelling associated with vertical circulation and horizontal anticyclonic gyre; and (3) regenerated nitrate (R-nitrate) is dominant in the upstream region. The total primary production in phytoplankton blooms is maintained not only by RO-nitrate but also by SO-nitrate that is larger than the river-originated.

Next, we conducted a realistic simulation and a few ideal setting-simulations. The phytoplankton maxima shift toward the left-hand side of the river mouth during the early time, but the shift does not keep going to the left-hand side all the time. This is because much SO-nitrate does not come from the subsurface to the surface layer after the middle simulated time, due to weak upwelling forced by vertical circulation in the left-hand side. The gentle angle of bottom slope weaken the vertical circulation and SO-nitrate supply from the subsurface, and the NPP is small.

It is natural that D-U Shift of phytoplankton maxima often occurs in the real situation like Ishikari Bay when high riverine input such as flooding. The conclusion that the shift is categorized into three stages by the different nitrate origins, RO-, SO- and R- nitrates in turn depends on the bottom slope angle and the way of inputs and the amounts of fresh water and nutrients. Bottom slope angle and the way of fresh water input change the behaviour of plumes, nutrient supply from the subsurface with the change of vertical circulation, and the rate of regeneration.

Keywords: coastal ocean, biogeochemical cycles, 3-D modeling, riverine input, phytoplankton bloom, nutrient supply

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ACG35-12 Room:421 Time:April 28 17:30-17:45

# Clarification of relationship between nutrient loading and biological productivity in coastal area by ecosystem model

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Recently, the total volume control of COD loading from continental areas to coastal areas that is generally regarded as a barometer of eutrophication produce an effect for water quality improvement. On the other hands, the reduction in biological productivity caused by concentration reduction of nutrient was pointed out. We face the limit of control policies due to build the suitable interaction between continental areas and coastal areas.

Due to understand the interaction between nutrients loading and biological productivity, the investigation how nutrients provide any biological populations and fish catch is effective. The circulation pathway of nutrients is complex web of interactions, for example, relationship between among biological populations (prey-predator relationship, competitive relationship et. al.) or indirect interaction web (extinction of predator caused by anoxic water, et. al.). The ecosystem response to decrease or increase in nutrient loading is complex.

In this report, we apply ecosystem-model which include fishery product (laver culture, clam) to around Kako-river (*Harima-nada*, *Seto-Inland-Sea*, *Japan*). We quantified responses of material circulation to decrease or increase in continental loading by using this model. The biological productivity is responding to decrease or increase in nutrient loading is varying with the structure of material circulation networks.

Keywords: ecosystem model, nutrient loading, material circulation, productivity, Harima-Nada

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ACG35-13 Room:421 Time:April 28 17:45-18:00

# Construction of the comprehensive aquatic model of the Ise Bay watershed

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Though Integrated Water Resource Management (IWRM) is recognized as an important philosophy for consistent management through terrestrial area to oceans in 1990s', lack of scientific prove and grounds is one of the essential obstacles to implement the philosophy into actual policy making processes. To enhance and enrich scientific basis of IWRM, objective evaluation of change of terrestrial area impacts on oceanic environment is essential. Thus, we are conducting to construct a comprehensive aquatic model which combines water, material, and ecosystem models throughout terrestrial area, rivers, and ocean. The study site is the Ise Bay and its catchment area. Our model is targeting at carbon, nitrogen, and phosphorous for material, and low trophic levels for ecosystems. In addition, model development is based on the philosophy that promotes a model to be opened for public.

The model structure is that combination of hydrological model, river model, oceanic model, and ecosystem model. For about hydrological model, PnET-BGC is used for natural vegetation, SWAT model for agricultural lands, and the tank model for domestic water outflow from urban area. For about river model flow model, one-dimensional open channel model using kinematic wave method is utilized. For ecosystem model, NPZD model was implemented into aquatic systems. And, for ocean model, ROMS was used. In addition, dam operational rules were included to consider the impacts of dams on river discharge regimes. Calibration and validation period was from 2000 to 2010. Simulation time step was 1 day, and spatial resolution of driving force (weather data) of the model was 2km. ASTER-GDEM is utilized for DEM, National Land Numerical Information for vegetation, and Basic Land Classification Survey for soil and geological data. The result showed that while river discharge was relatively good, the level of water quality was not acceptable. One of the possible reasons of this discrepancy was the incomplete implementation of agricultural water use. Moreover, since coupling with ocean model is not yet realized, thus, improvement of terrestrial model, coupling of terrestrial and ocean model, and sensitivity analysis is further required.

Keywords: Integrated Water Resource Management, Landuse change, Eutrophication, Hypoxia, Ise Bay