

駿河湾沿岸域における海底湧出地下水調査の総括

Summary of investigation for submarine groundwater discharge in Suruga Bay

*小野 昌彦¹、村中 康秀²、神谷 貴文²、大山 康一²、伊藤 彰²、丸井 敦尚¹

*Masahiko Ono¹, Yasuhide Muranaka², Takafumi Kamitani², Koichi Oyama², Akira Ito², Atsunao Marui¹

1.産業技術総合研究所、2.静岡県環境衛生科学研究所

1.National Institute of Advanced Industrial Science and Technology, 2.Shizuoka Institute of Environment and Hygiene

Submarine groundwater discharge (SGD) in coastal area has been recognized as an important pathway from land to ocean. Suruga Bay is adjacent to the foot of Mt. Fuji where active groundwater flow system exist, and it could be occurred that large amount of groundwater directly discharges into the bay.

To evaluate SGD and groundwater flow system in the coastal area of Suruga Bay, some geophysical and geochemical surveys have been conducted from 2013 to 2015. Side scan sonar and sub bottom profiler was used to detect an anomaly of sonic wave at the bottom of sea. Flow direction and velocity around the coast were observed by the Acoustic Doppler Current Profiler. Distribution of radon and salinity in surface water was investigated by towing survey. Bottom water of the bay was also collected by using the Niskin sampler and analyzed for radon. This study attempts to combine each survey result and summarize the investigation of submarine groundwater discharge in Suruga Bay.

キーワード：海底地下水湧出、駿河湾

Keywords: submarine groundwater discharge, Suruga Bay

水の安定同位体比から見たルソン島東方海域（黒潮源流域）の水塊構造の特徴

Spatial distribution of oxygen and hydrogen isotope ratios of seawater in the nascent Kuroshio of Lamon Bay

渡邊 敦¹、*宮島 利宏²、Villanoy Cesar³、San Diego-McGlone Maria Lourdes³、Gordon Arnold L.⁴Atsushi Watanabe¹、*Toshihiro Miyajima²、Cesar Villanoy³、Maria Lourdes San-Diego McGlone³、Arnold L. Gordon⁴

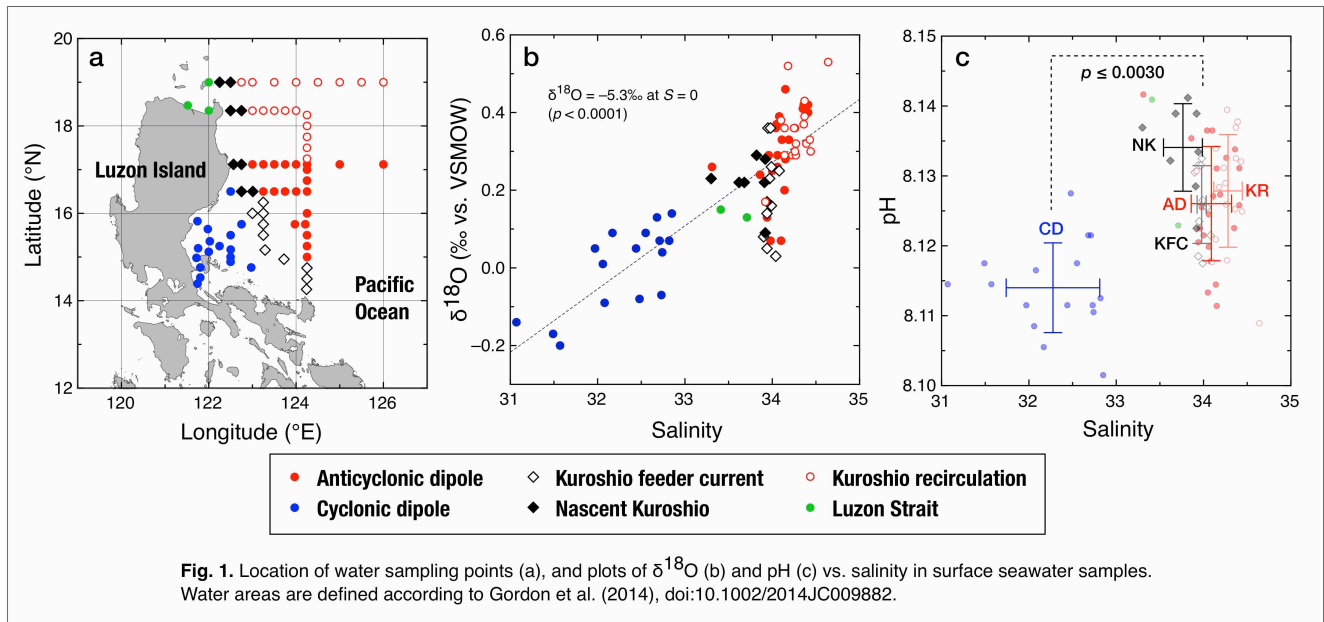
1.東京工業大学 環境・社会理工学院、2.東京大学 大気海洋研究所、3.Marine Science Institute, University of the Philippines、4.Lamont-Doherty Earth Observatory, Columbia University

1.School of Environment and Society, Tokyo Institute of Technology, 2.Atmosphere and Ocean Research Institute, The University of Tokyo, 3.Marine Science Institute, University of the Philippines, 4.Lamont-Doherty Earth Observatory, Columbia University

黒潮源流域に位置するフィリピン・ルソン島東岸のLamon湾とその外洋側海域（14°-19°N, 122°-126°E; Fig. 1a）において海水の酸素・水素安定同位体比（ $\delta^{18}\text{O}$ ・ $\delta^2\text{H}$ ）の鉛直分布と平面分布の観測を行った。観測は2012年4～5月に実施された調査船Roger Revelle号の航海において行われた。試料はガラスバイアルに密封して持ち帰り、CRDS式水同位体比分析計により $\delta^{18}\text{O}$ と $\delta^2\text{H}$ の測定を行った。鉛直分布では、表層から水深100～200 mに位置する回帰線水（NPTW）に由来する塩分極大に向けて $\delta^{18}\text{O}$ が上昇し、極大値1.5～2.0%を示した。その後、水深500 m付近に位置する北太平洋中層水（NPIW）に由来する塩分極小に向けて $\delta^{18}\text{O}$ が低下し、塩分極小以深では4000 mまで-1～0%の間のほぼ一定の値を示した。このように鉛直分布がほぼ海洋循環に基づく水塊構造に対応しているのに対し、表層水の $\delta^{18}\text{O}$ を見ると、陸域側（-0.3%）から外洋側（+0.6%）に向かって上昇する明瞭な勾配を示した。塩分との強い正の相関があり（ $p < 0.0001$; Fig. 1b）、表層水の平面分布が陸域からの淡水流入に強く支配されていることが示唆された。 $\delta^2\text{H}$ の鉛直・平面分布は $\delta^{18}\text{O}$ と同一のパターンを示したが、 $\delta^{18}\text{O}$ に対する $\delta^2\text{H}$ の相対変動を表すdeuterium excessを比較すると、陸域に近い表面水で微増する傾向が確認された。これはdeuterium excessの高い河川水の流入を反映したものと考えられる。Gordon et al. (2014)によって明らかにされたこの海域の海水流動パターンと比較すると、黒潮源流の流軸とルソン島とに挟まれた半定常的な低気圧渦の存在する海域において、表層水中の塩分と $\delta^{18}\text{O}$ が周辺海域より明瞭に低く、またpHが有意に低く、deuterium excessが有意に高くなっていた（ $p < 0.003$; Fig. 1c）。このことは、この海域において定常渦の存在により表層水の滞留時間が長くなるために淡水流入の影響が累積しやすいこととともに、黒潮の存在によって淡水の影響が及ぶ範囲が限定されていることをも示している。一方、黒潮はpHの低いこの海域の表層水を一部巻き込みながら形成されるにもかかわらず、黒潮源流部の表層pHは上流の海域に比べてわずかに高い傾向があった（8.134 vs. 8.126, $p = 0.0329$; Fig. 1c）。黒潮の形成過程において、表層水のpHを高く維持する何らかの生物地球化学的プロセスが作用している可能性がある。

キーワード：海水の酸素安定同位体比、鉛直構造、淡水流入、pH、ラモン湾

Keywords: oxygen isotope ratio of seawater, vertical structure, freshwater input, pH, Lamon Bay



夏季の大分県国東半島における河川水中の溶存無機態窒素・リンの動態

Dynamics of dissolved inorganic nitrogen and phosphorous of the river water in the Kunisaki Peninsula in summer

*理焔 隆人¹、杉本 亮¹、田村 勇司²、笠井 亮秀³、山下 洋⁴

*Takahito Rihei¹, Ryo Sugimoto¹, Yuji Tamura², Akihide Kasai³, Yoh Yamashita⁴

1.福井県立大学海洋生物資源学部、2.大分県農林水産研究指導センター水産研究部浅海・内水面グループ、3.北海道大学水産科学研究所、4.京都大学フィールド科学教育研究センター

1.Faculty of Marine Biosciences, Fukui Prefectural University, 2.Oita prefectural agriculture, forestry and fisheries research center, fisheries research division shallow/fresh group, 3.Graduate School of Fisheries Sciences, Hokkaido University, 4.Kyoto University Field Science Education and Research Center

2013年に世界農業遺産に認定された国東半島宇佐地域は、クヌギに代表される豊かな里山と小規模なため池を複数連結させた独特な水利用システムを持つ地域である。このような水利用システムは河川の水質形成だけでなく、河口・沿岸海域の生物生産過程にも大きな影響を及ぼしているものと考えられるが、その実態は明らかとなっていない。本研究では、国東半島の小河川群から沿岸海域へ輸送される栄養塩量を定量するとともに、河川ごとの違いを集水域の森・水利用の観点から評価した。

2015年7月末に計80地点で採水を行い溶存無機態窒素（DIN）、溶存無機態リン（DIP）および水の安定同位体比（ $\delta D \cdot \delta^{18}O$ ）を分析するとともに最下流地点の河川流量を測定した。

DIN濃度は6.3から153.4 μM 、DIP濃度は0.1から4.1 μM 、 d 値（ $=\delta D - 8 \times \delta^{18}O$ ）は8.9から15.5の範囲で変動していた。DIN濃度・ d 値は渓流域で高く、流下にともないその濃度が減少したのに対し、DIP濃度は渓流域で低く、流下にともないその濃度が増加した。海域への栄養塩輸送量は、DINで0.8から140 $kg d^{-1}$ 、DIPで0.2から22 $kg d^{-1}$ であり、主に河川流量に支配されていた。しかし、DIN/DIPは6から39と河川ごとに大きく異なり、 d 値が高いとDIN/DIPが高く、 d 値が低いとDIN/DIPが低い傾向が認められた。これらの結果は、流域内でのDINとDIPの動態に国東半島特有の水利用が大きく関係していることを示唆する。DINは主に森林域から供給されており、流下に伴って増加するため池や水田等で消費されているものと考えられる。一方、DIPは、農地や建物用地、ため池数が増加することでその濃度が増加していた。 d 値が高い河川群は、森林からの豊富なDINが流下過程でさほど減少することなく海にまで達しているためDIN/DIPが高いのに対し、 d 値が低い河川群では水の滞留時間の増大に伴うDINの損失と農地などからDIP流出の結果が強く反映されDIN/DIPが低くなったと考えられた。

キーワード：栄養塩、渓流水、農地、森林、世界農業遺産

Keywords: Nutrients, stream water, agricultural land, forest, GIAHS

日本沿岸海域における海底湧水インパクトの異なる場所での一次生産速度の比較

A comparative study of in situ primary productivity under different sites of submarine groundwater discharge impacts in Japanese coasts

*杉本 亮¹、北川 勝博¹、西 沙織¹、本田 尚美²、山田 誠²、小林 志保³、小路 淳⁴、大沢 信二⁵、谷口 真人²、富永 修¹

*Ryo Sugimoto¹, Katsuhiro Kitagawa¹, Saori Nishi¹, Hisami Honda², Makoto Yamada², Shiho Kobayashi³, Jun Shoji⁴, Shinji Ohsawa⁵, Makoto Taniguchi², Osamu Tominaga¹

1.福井県立大学海洋生物資源学部、2.総合地球環境学研究所、3.京都大学フィールド科学教育研究センター、4.広島大学大学院生物圏科学研究科、5.京都大学大学院理学研究科附属地球熱学研究施設

1.Faculty of Marine Biosciences, Fukui Prefectural University, 2.Research Institute for Humanity and Nature, 3.Field Science Education and Research Center, Kyoto University, 4.Hiroshima University, 5.Institute for Geothermal Sciences, Kyoto University

In recent years, a number of studies have shown that submarine groundwater discharge (SGD) is an alternative nutrient pathway and can drive primary production in coastal seas. However, very little is known about an exact relationship between input of groundwater and response of primary production. To clarify the relationship, we conducted in situ measurements of primary productivity using stable ^{13}C tracer method under different strength sites of SGD in the Japanese coasts (Site A: Obama Bay, Site B: Beppu Bay and Site C: the coastal area of Mt. Chokai) in summer from 2013 to 2015. Simultaneously, ^{222}Rn activity was measured as SGD index. ^{222}Rn activity in Site A, B and C varied from 0.8 to 6.0 dpm L^{-1} , 3.6 to 11.2 dpm L^{-1} and 0.4 to 444.5 dpm L^{-1} , respectively. In situ primary productivity in Site A, B and C ranged from 7.0 to 49.5 $\mu\text{g C L}^{-1} \text{h}^{-1}$, 10.7 to 38.4 $\mu\text{g C L}^{-1} \text{h}^{-1}$ and 0.8 to 11.8 $\mu\text{g C L}^{-1} \text{h}^{-1}$, respectively. In site A, there was significant relationship between in situ primary productivity and ^{222}Rn activity. Although light intensity and water temperature were different in each station and month, concentrations of nutrients limited primary productivity. In site B and C, concentrations of dissolved inorganic nitrogen and phosphorus showed significant increasing trends with an increase of ^{222}Rn activity, indicating nutrients in coastal regions were mainly derived from the SGD. However, there were no clear relationships between in situ primary productivity and ^{222}Rn activity, since primary production would be limited by light intensity as well as nutrients. Our experimental studies clearly showed that nutrients through the SGD affect crucial impact on primary production in coastal ecosystems.

キーワード：一次生産速度、ラドン222、海底湧水、沿岸海域

Keywords: Primary productivity, ^{222}Rn , Submarine groundwater discharge, Coastal seas

淀川潮間帯で発生する有毒植物プランクトンの数値生態系モデルによる解析

Analysis of harmful phytoplanktons in Yodo River mouth by the numerical ecosystem model

*林 美鶴¹*Mitsuru Hayashi¹

1.神戸大学自然科学系先端融合研究環内海域環境教育研究センター

1. Research Center for Inland Seas, Kobe University

Red tide of *Alexandrium tamarens* occurred in Yodo River estuary in Japan in 2007, 2011 and 2013. *A. tamarens* is marine phytoplankton and causes shellfish poisoning. We had made in-situ observation on 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 were carried out with the tidal change. Nutrient and Chl.a concentrations and the cell density of *A. tamarens* were analyzed. Seawater ran to upstream in the surface layer. And fresh water went to the sea in the bottom layer. It is the typical estuary circulation. The estuary which have 2800m in 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 matter are in each layer, and the bio-chemical process, photosynthesis, mortality, decomposition and so on, were formulated. 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. tamarens*. Then the temporal variations of each morphology and *A. tamarens* were calculated. The variation of phytoplankton in each layer was almost reproduced in-situ data. Marine phytoplankton was not hardly produced in Yodo River estuary and was supplied from the ocean. Phytoplankton which cannot swim by oneself almost floated by the horizontal advection, it is the estuary circulation. But only 27% of *A. tamarens* transported from the ocean to the bottom layer go through upstream. 36% of it returned to the ocean in the middle and the surface layer, and other 36% died in the surface layer. Weak estuary circulation is effective to the transport limitation to the upper stream of *tamarens* in Yodo River estuary.

キーワード：淀川、有毒植物プランクトン、数値生態系モデル

Keywords: Yodo River , harmful phytoplanktons , numerical ecosystem model

大分県別府地域の沿岸域への温泉熱の流入が河口域周辺の魚類群衆に与える影響

The inflow of hot spring heat impact on fish communities around estuaries in Beppu, Oita prefecture

*山田 誠¹、小路 淳²、大沢 信二³、三島 壮智³、宇都宮 達也²、本田 尚美¹

*Makoto Yamada¹, Jun Shoji², Shinji Ohsawa³, Taketoshi Mishima³, Tatsuya Utsunomiya², Hisami Honda¹

1.総合地球環境学研究所、2.広島大学大学院生物圏科学研究科、3.京都大学大学院理学研究科附属地球熱学研究施設

1.Research Institute for Humanity and Nature, 2.Center for Field Science of the Seto Inland Sea, Hiroshima University, 3.Institute for Geothermal Sciences, Graduate School of Science, Kyoto University

Hot spring drainage flows into a river and then flow into the coastal area in Beppu, Oita prefecture which is a region with many hot springs in Japan. In Hirata River where many hot spring drainage flow into, hot spring drainage creates a better habitat for *Oreochromis niloticus* (Nile tilapia), a foreign species, in terms of available food and water temperature. Hot spring drainage flow into the river except Hirata River in Beppu area. However, it is not clear that the influence of hot spring drainage on ecosystem of those rivers. In order to evaluate the impact of thermal energy from hot spring drainage on the fish communities near the estuary, we investigated water temperature, flow rate and fish communities near the estuaries of six rivers in Beppu area. We sampled the fish using a small seine net in January 2015. Although the number of fish collected in four rivers was very small, Nile Tilapia and *Opsariichthys platypus* was collected in Hirata River and Haruki River, respectively. Hot spring drainage flow into these two rivers, however, there is a big difference in the water temperature near the river mouth in these two rivers. These results suggest the possibility that the difference in inflow of the hot spring heat affects the dominant species of the fish community near the estuary. In this presentation, we will discuss the inflow of hot spring heat impact on fish communities near the estuary with the result of the summer investigation.

キーワード：温泉熱、魚類群衆、河口域周辺、温泉排水

Keywords: hot spring heat, fish community, around estuary, hot spring drainage

異なる海底湧水環境で育てたアサリの成長比較

Comparative study of growth in Manila clam under different environmental conditions of submarine groundwater discharge

*富永 修¹、杉本 亮¹、北川 勝博¹、山田 誠²、小路 淳³、本田 尚美²、小林 志保⁴、谷口 真人²

*Osamu Tominaga¹, Ryo Sugimoto¹, Katsuhiko Kitagawa¹, Makoto Yamada², Jun Shoji³, Hisami Honda², Shiho Kobayashi⁴, Makoto Taniguchi²

1.福井県立大学海洋生物資源学部、2.総合地球環境学研究所、3.広島大学、4.京都大学フィールド教育センター

1.Faculty of Marine Biosciences, Fukui Prefectural University, 2.Research institute for Humanity and Nature, 3.Hiroshima University, 4.Kyoto University

Submarine Groundwater Discharge (SGD) is often characterized by high concentration of nutrients and documented as an important pathway between land and sea contributing to the biological productivity in coastal waters. We investigated to what extent SGD contributed to the growth of primary consumer by the field rearing experiments of Manila clam at two sites (Mega and Torisaki) along the Mt. Chokai volcanic coast in northern Japan from June to August 2015. Average Radon 222 (^{222}Rn) concentration at surface layer of Mega and Torisaki for two months were 4037 Bqm^{-3} and 241 Bqm^{-3} , respectively. The $\delta^{13}\text{C}$ of shell of Manila clam ($\delta^{13}\text{C}_{\text{SHELL}}$) reflected the $\delta^{13}\text{C}_{\text{DIC}}$ of the ambient water, i.e. lower $\delta^{13}\text{C}_{\text{SHELL}}$ value at Mega than that at Torisaki. There was the positive correlation between ^{222}Rn activity and DIN concentration ($r=0.881$ $p<0.01$). Contrary to expectations, the average growth rate of Manila clam reared at Mega was slightly smaller than that at Torisaki. The concentration of chlorophyll-a was almost the same at two sites. However water temperature at Mega was about 2°C lower than Torisaki. Kobayashi and Toba (2005) reported that clear positive correlation between the growth rate of Manila clam and rearing water temperature. This suggested the negative effect of low temperature on the growth of Manila clam. This study showed the seepage area does not always have a favorable influence on fisheries resources. The larger-scale effects of SGD on biological production of primary consumer is necessary.

キーワード：海底湧水、アサリ、成長、炭素安定同位体比

Keywords: submarine groundwater discharge, Manila clam, growth, stable carbon isotope ratio