# 日本東方の亜熱帯―亜寒帯混合域におけるアルカリ度の季節変動

# Seasonal variation in total alkalinity in subtropical-subpolar transition area off eastern Japan

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アルカリ度の季節変動は二酸化炭素分圧や全炭酸濃度のそれと比較して小さく、これまであまり研究されていなかった。今回、北海道から関東東方の太平洋で2011–2015年に、気象庁の観測船や白鳳丸で測定されたアルカリ度のデータを使用してアルカリ度の季節変動について解析を行った。このデータは1月2月を除く全ての月で観測値があり、季節変動を捉えることが可能である。
アルカリ度の変動のうち、降水や蒸発に伴う塩分の変動によるものを取り除くため、塩分35に規格化した$nTA_{35}$ = TA * 35/*S*を計算した。表層の$nTA_{35}$は黒潮続流以南の亜熱帯域では季節を問わず2290–2300 μmol $kg^{-1}$で一定であった。また、北緯46度以北の亜寒帯域における5月から6月の観測では、表層(5–6°C)と冬季混合層の名残である亜表層の水温極小層(< 2°C)でともに$nTA_{35}$が2355–2370 μmol $kg^{-1}$であり、両者の$nTA_{35}$に有意な差はなかった。よって、この２海域では$nTA_{35}$に大きな季節変動がないとみられる。一方、この２海域に挟まれた亜熱帯―亜寒帯混合域では、$nTA_{35}$が夏に低く冬に高い季節変動を示した。これは黒潮を起源とする亜熱帯系水が夏季に高緯度まで移流してくることを裏付けるものである。
この亜熱帯亜寒帯混合域で観測されたアルカリ度を、水温・塩分と経度からアルカリ度を回帰・推定する*Lee et al.* [2006]の式と比較した。両者は7月8月についてはよく一致していたが、3月や12月にはLeeらの式が観測値に対して20–30 μmol $kg^{-1}$の過大評価になっており、季節変動を正しく再現できなかった。これはLeeらが回帰に用いたGLODAPデータベースに所蔵されているデータが夏季のものに偏っていることが原因と考えられ、この海域でアルカリ度の正確な分布を把握するには、夏季以外のデータも活用する必要があると示された。発表では、もうひとつのアルカリ度推定式である*Takatani et al.* [2014]との比較も行う。

キーワード：炭素循環、海洋酸性化
Keywords: carbon cycle, ocean acidification

 

# 親潮域における溶存酸素の長期変動と周期変動とその西部北太平洋への広がり

# Trends of oxygen with bidecadal oscillations in the Oyashio region and its propagation to the western North Pacific

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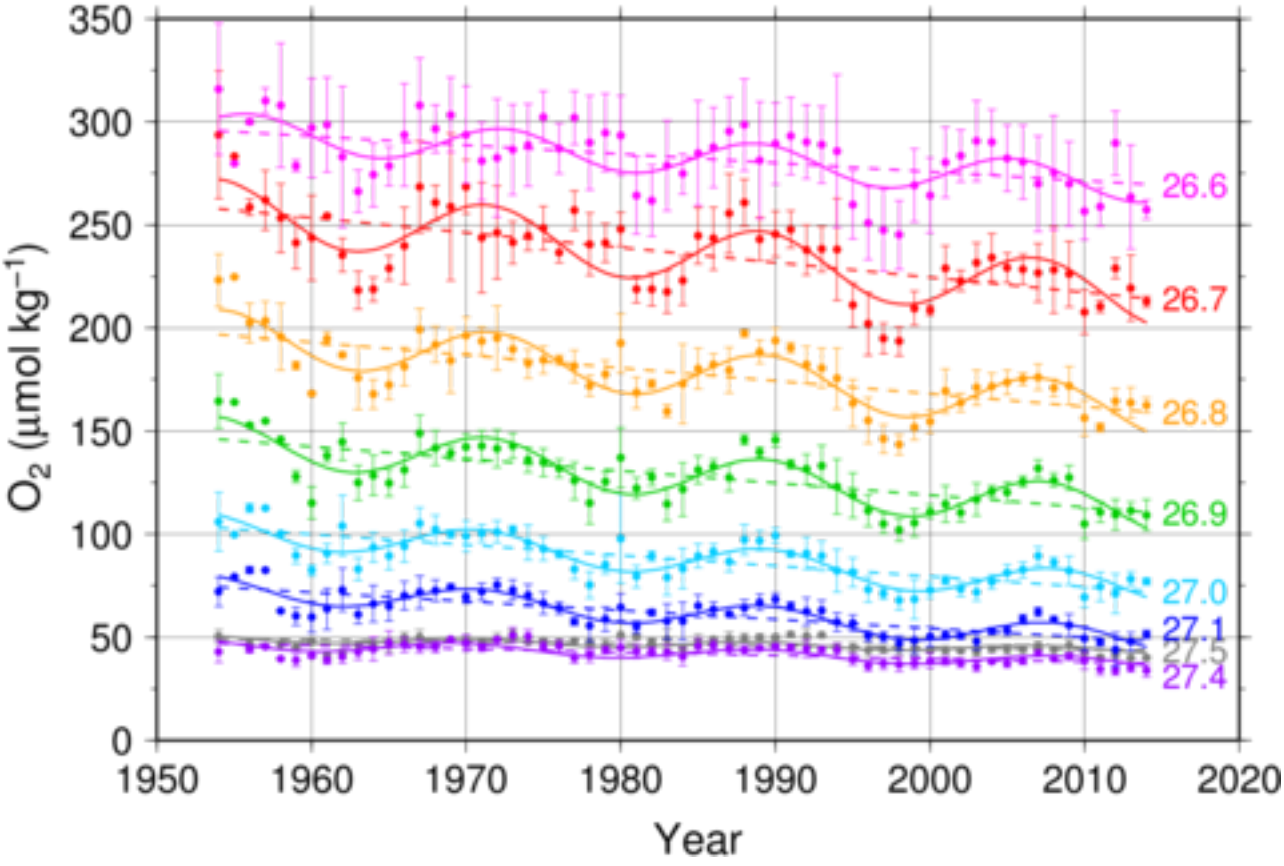
Over the past decades, secular trends toward decrease in dissolved $O_2$ have been observed in a variety of regions and depths in the North Pacific [Keeling et al., 2010, and references therein]. In the western North Pacific, $O_2$ decrease has been markedly found around 26.8$\sigma_\theta$ that corresponds to the core of North Pacific Intermediate Water (NPIW) along the 137°E section [Takatani et al., 2012] and the 165°E section [Sasano et al., 2015]. NPIW is formed in the subsurface of the Kuroshio-Oyashio Interfrontal Zone in the region offshore of northern Japan, and the Oyashio water is considered as one of the source of NPIW. In the Oyashio region, Ono et al. [2001] have found the trends toward increase in AOU and its bidecadal oscillations between 26.7$\sigma_\theta$ and 27.2$\sigma_\theta$ using time series data for the period of 1968–1998 in winter. They speculated that the reduction of ventilation caused the decreases in $O_2$. However, because the depth of isopycnal horizon of 27.2$\sigma_\theta$ is much deeper than that of 26.7$\sigma_\theta$ and does not outcrop in the western North Pacific, it is necessary to improve our understanding of these controlling factors. In this study, the controlling factors of secular trends in dissolved $O_2$ in the Oyashio region was investigated based on long-term hydrographic and biogeochemical measurements made over 1954–2014. We also evaluated the bidecadal oscillations in dissolved $O_2$ in the Oyashio region. Through the comparison of secular trends and bidecadal oscillations with those along the 165°E section, their propagation from the Oyashio region to the wide range of the western North Pacific was evaluated.
Significant linear trends toward decreasing $O_2$ were detected between 26.6$\sigma_\theta$ and 27.5$\sigma_\theta$ in the Oyashio region. The contribution of the decrease in the saturation concentration of $O_2$ due to warming was small (<10%). The largest decreasing rate in $O_2$ was found on 26.7$\sigma_\theta$ (-0.72 ±0.11 μmol $kg^{-1}$ $yr^{-1}$) while it was attributed to a deepening effect of isopycnal horizons by approximately 33%. Because this density corresponds to temperature minimum layer formed in winter convection in the subarctic zone and surface density in winter has been decreasing, the decreasing $O_2$ around 26.7$\sigma_\theta$ would be predominantly attributed to the reduction of ventilation. At 27.0$\sigma_\theta$, $O_2$ decline would be attributed to that in the Sea of Okhotsk where $O_2$ has been decreasing in this density due to the decrease in the formation of dense shelf water (DSW) in association with the decrease in sea ice forming. In deeper layers with densities up to 27.5$\sigma_\theta$, $O_2$ decreases would also be explained by the reduction of DSW that propagates through diapycnal mixing in the Bussol' Strait. Furthermore, the $O_2$ reduction in deep layer might be attributed to the increasing contribution of Western Subarctic water through strengthening of the Aleutian Low. In the Oyashio region, bidecadal oscillations of $O_2$ have been observed in 26.6$\sigma_\theta$–27.5$\sigma_\theta$. The periodicities were almost constant at 16.4–19.6 years, and were vertically synchronized within 1 year. Along the 165°E section, the bidecadal oscillations were also found horizontally in 30°N–42.5°N on 26.8$\sigma_\theta$ with a time lag of 1–3 years from the Oyashio region, and vertically in 40°N up to the subtropical OML at 27.5$\sigma_\theta$. It suggests that the bidecadal oscillations extended horizontally and vertically to the regions where the subarctic water influences. These results demonstrate that the western subarctic North Pacific is playing an important role as an origin for secular trends and natural variability in dissolved $O_2$.

キーワード：貧酸素化、20年規模周期変動、西部北太平洋
Keywords: deoxygenation, bidecadal oscillation, western North Pacific



# 地球温暖化に伴う溶存酸素の長期変動
# Millennial-scale changes in dissolved oxygen due to global warming

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地球温暖化による海水温上昇と成層化，深層循環の弱化は海洋中の溶存酸素を全球的に減少させると考えられており，海洋生態系や物質循環への影響が懸念されている．中程度の複雑さを持つ気候モデルを用いた先行研究では，今世紀中に人為起源CO2 の放出が止まったとしても，深層水の遅いturnover の為に酸素濃度は1000年以上減少し続け，全球平均濃度は30%程度減少すると予想されている(Shaffer et al., 2009)．このような長期的な酸素濃度の変動は深層循環の応答に大きく依存するが，先行研究では積分期間が長い為に簡略化モデルを用いているため，深層循環の応答と溶存酸素濃度の変化について不確実性が大きいと考えられる．
本研究では，より現実的な海洋循環を表現するGCMを用いて温暖化実験を2000年積分した．また溶存酸素濃度の変化は，3次元offline 海洋物質循環モデルに上記のGCMで計算された海洋物理場を与えて計算した．これらの手法は，長期的な溶存酸素の変化について先行研究より信頼度の高い結果を提供すると期待される．
最初の500 年では，海水温上昇と成層化により全球平均の酸素濃度は20μmol/L 減少し，CMIP5 などの先行研究や一般的な予測と同じ結果になった.しかしその後，表層の酸素減少と大西洋子午面循環の弱化は続いているにも関わらず，中深層の酸素濃度は全球的に回復し，最終的に全球平均の酸素濃度は産業革命前の濃度よりも12μmol/L高くなった．この回復はウェッデル海の外洋で形成される深層対流が一時的に停止した後に回復し，深層に酸素が送り込まれた為に引き起こされることが分かった．GCM を長期積分することで，南大洋の海洋循環の応答が，百年スケールの酸素減少とは異なる千年スケールの酸素回復を引き起こす可能性が示された．ただし，現在の粗い解像度のGCM では南大洋の外洋域において対流を過大評価する傾向があるため(Heuzé et al., 2013)，不確実性が大きいことに留意する必要がある．
発表ではウェッデル海における深層対流の応答メカニズムについても議論する予定である．

キーワード：地球温暖化、溶存酸素、深層循環、海洋物質循環モデル
Keywords: Global warming, Dissolved oxygen, Deep ocean circulation, Ocean biogeochemical model

 

# Measurement and mapping of dissolved methane distribution in the Sea of Japan: Influence of shallow gas hydrate deposits.

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Active methane seeps and shallow methane hydrate deposits are found in along the margins of the Sea of Japan. In this study, we installed several types of methane sensors on an ROV to determine dissolved gas concentrations in the water column as well as to map the distribution of concentrations near the seafloor. We first compare the performance of sensors from different manufacturers, then compare the results to actual water samples collected in vacuum bottles and in Niskin bottles. The recorded sensor data is then calibrated and compared with seafloor features recorded using the SeaXerocks mapping system developed at the University of Tokyo. The results show that high methane concentrations near the seafloor correspond to observed areas of microbial mats and exposed gas hydrate. The authors wish to acknowledge the crew and scientific staff of JAMSTEC that provided technical support during the 2014-2015 research seasons. This study was conducted as a part of the 2013-2015 shallow methane hydrate exploration project of the Ministry of Economy, Trade and Industry.

Keywords: methane hydrate, ROV, methane sensor

 

# Diffusive benthic nutrient flux in the central of East China Sea

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To evaluate the importance of nutrient supply from sediment, phosphate, silicate, nitrate and nitrite in the porewater, overlying water, and entire water column were measured in the central of East China Sea. A measurement of multi-size particulate characterizing contour (LIIST) was carried out together with CTD casts also to quantify the influence of suspended particle. All nutrient concentrations in the porewater were greater than overlying water at stations B1 (32.9N, 126.0E) and C1 (32.7N, 124.8E), suggesting sediment was one of nutrient sources to the water column. Nutrient diffusion fluxes were calculated from the corresponding concentration gradients at these two stations, accounting for 20-60% of primary productivity. In contrast, at station C4 (31.2N, 126.0E), sediment was a nutrient sink. Bottom water at station C4 had low dissolved oxygen (DO, 1.8 ml/l), high weighted nutrients, and finest suspended particle relative to stations B1 and C1. Thereby, opposite nutrient diffusion at station C4 is most likely caused by organic matter remineralization at bottom water. However, phosphate concentrations at the bottom seawater were greater than the overlying water at all three stations. It might be affected by lateral transport near bottom or phosphate was absorbed by high concentration of particles at the seafloor. This study infers that nutrient flux from sediment to the overlying water, and further diffusion to the water column depends on the sediment property (e.g. grain size), in situ biogeochemical process and may associated with water transport.

Keywords: Porewater, Nutrient, Benthic flux, East China Sea

 

# 希土類元素による東シナ海陸棚水の水塊構造解析ー黒潮中層水の寄与

# Water mass analysis using rare earth elements of shelf water in the East China Sea: contribution of Kuroshio Intermediate Water.

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To understand the origins and mixing of complicated water masses, as well as the contributions and nutrient supply via these various water masses in the East China Sea (ECS), a research cruise was conducted in the summer 2004. Water mass sources are defined by multiple tracers, including salinity and Rare Earth Elements (REE), etc. These sources include mixed shelf water (MSW, highest heavy REE concentration), Kuroshio surface water (KSW, highest temperature), Kuroshio tropical water (KTW, highest salinity), and Kuroshio intermediate water (KIW, highest nutrient content). High-nutrient water was identified in the middle shelf (bottom 100-130 m) and considered a mixture of MSW, KTW and KIW. The mixing ratios of three water sources are calculated using both conventional tracers (salinity and potential temperature) and four HREEs with the least squares method. Comparable results were obtained using these two datasets, suggesting HREEs, like temperature and salinity, are conservative comparing with water mass residence time and act as useful tracers to characterize the various water masses. The estimated KIW accounts for 26–55% of the middle shelf bottom water in the northernmost research area, while the proportion of $NO_3$+$NO_2$ from KIW is 55–81% and that of phosphate is 58–90%. This indicates that KIW is the major nutrient source in the bottom water of the middle ECS shelf.

キーワード：水塊構造解析、希土類元素、東シナ海
Keywords: water mass analysis, rare earth elements, East China Sea

 

# 海底鉱床掘削による重金属およびヒ素汚染リスクと海洋一次生産への影響評価
# Risk of heavy metal and arsenic contaminations and its effect on marine phytoplankton during seafloor mining

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[Introduction]
Hydrothermal ore deposits are important as a metallic mineral sources. Many sulfide deposits containing Cu, As, Ag, Pb and Zn were found in the Exclusive Economic Zone of Japan. Recently, development of seafloor mining technology is advanced to use commercially those minerals. Environmental impact assessment is required because the seafloor mining could lead to marine environmental problems. For example, heavy metals and arsenic might be released from waste ore minerals during transfer of those from seafloor to vessel.
Here, we discuss about the possibility of heavy metal and arsenic contaminations and its effect on the primary production of marine phytoplankton during seafloor mining.
[Experimental]
Five types of chimney samples (G03, G04, G05, G06, and R04) which collected from hydrothermal fields of Iheya North Knoll and Izena Hole during the NT11-15 (Aug. 2011, R/V Natsushima) and NT12-06 (Mar. 2016) cruises with provided from JAMSSTEC. In the laboratory, the chimneys were powdered manually and sieved with a 1/16 mm mesh. Approximately 3.0 g of the powdered chimney was stirred into 30 mL of ultrapure water or artificial seawater (Daigo SP) in a Teflon centrifuge tube (50 $cm^3$), and then the tube was shaken at room temperature for 6 h. The solid phase was separated by centrifugation and filtration (0.2 μm). The metals dissolving in the solution were quantified by ICP-AES and ICP-MS.
Marine phytoplankton was incubated to evaluate the toxicity of the metals released from the chimney to the phytoplankton. Seawater was collected from subsurface chlorophyll maximum layer at hydrothermal fields of Iheya North Knoll and Bayonnaise Knoll during the KR15-17 (Nov. 2015, R/V Kairei) and KR15-20 (Dec. 2015), respectively. The solution reacted with the chimney G06 was added to the seawater and incubated for 18 h on the board. The chlorophyll fluorescence (F0) of the sample solution was determined by a pulse amplitude modulated (PAM) fluorometer.
[Results and Discussion]
Heavy metals such as Zn, Pb, Mn, Cd, and Cu and As were released from the chimney into the solution after the shaking with ultrapure water. The concentrations of Zn dissolving in the solution were between 41.7–1026.0 ppm. Arsenic (43.1 ppm) was the most abundant in the solution reacted with the chimney G05. Copper (61.6 ppm) was highly released from the chimney G06, whereas it was undetected from the other samples. The compositions of metals dissolving in the solutions were different from those of the chimneys. When the chimney was reacted with artificial seawater, the concentrations of heavy metals and arsenic dissolving in the solution were similar to ultrapure water. These results suggest that heavy metals and arsenic could be released from ore minerals to ocean during seafloor mining.
The chlorophyll fluorescence of seawater gradually decreased with time without addition of the solution reacted with the chimney G06. Marine phytoplankton living in the seawater collected from

 

the subsurface chlorophyll maximum layers would be unvigorous. When the solution reacted with the chimney G06 was added to the seawater (0.2 %), the chlorophyll fluorescence rapidly decreased with time. Therefore, the primary production of marine phytoplankton would be limited by heavy metals and arsenic released from ore minerals.

キーワード：海底鉱床掘削、植物プランンクトン、重金属汚染
Keywords: seafloor mining, marine phytoplankton, heavy metal contamination

 

# 数値シミュレーションを用いた播磨灘における冬季赤潮の消長機構の解明

# Numerical simulation of the winter red tide of *Eucampia zodiacus* in the Harima-Nada

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沿岸域は、海洋の中でも人為起源の影響を大きく受ける領域であり、人間社会とのかかわりも密接な海域である。
特に、冬季の瀬戸内海（播磨灘など）では、最近数10年スケールで、海域の栄養塩が枯渇する「貧栄養化」という視点の問題が生じており、ノリの色落ち問題など、人間活動に直接影響を与える問題にまで発展している。
この数10年スケールの海域の栄養塩の変遷は、同じ時間スケールで生じている植物プランクトンの種の変遷と連動しているという仮説が考えられているが、これらの仮説は未だ解き明かされておらず、将来の環境変化（どのような種の変遷と水質の変化が起こるのか）も予測できていない状況である。
ここでは、冬季の播磨灘を対象にして、植物プランクトンを、小型の珪藻と大型の珪藻の2種類に分類した低次生態系モデルを用いた、栄養塩と植物プランクトンのブルームの時空間構造の再現計算を行った。
沿岸域の特徴としては、「水深が浅い」という特徴があるが、最近数10年で冬季のブルームが顕著となった大型珪藻は、海底到達後も光環境によっては死滅せず、巻き上げに伴って回帰する取り扱いを行うことで、パッチ状のブルームの規模とタイミングをよく再現できることが明らかとなった。
また、種の異なるパッチ状のブルームに対応して、栄養塩水質の時空間的な構造も捉えられている。
この結果は、仮説を基に構築したモデルを用いた現場データとの検証を行うことで、植物プランクトンの沿岸域スケールの競合の具体的な機構を解き明かしつつある事例でもあり、観測のみでは得られない情報をモデルを用いた数値実験により補間できた事例でもある。

キーワード：生態系モデル、珪藻、ユーカンピア、赤潮、播磨灘
Keywords: ecosystem model, diatom, Eucampia, red tide, Harima-Nada

 

# 黒潮域における植物プランクトン群集別基礎生産と動物プランクトン個体数密度との関係
# Phytoplankton Community Structure and Zooplankton Abundance around The Kuroshio Western Boundary Current

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The Kuroshio is one of the largest western boundary currents in the world. In spite of the recognition of its importance on coastal fisheries in the Kuroshio waters, ecological mechanisms supporting fisheries production are poorly known. Recent marine ecosystem models made significant advancement in representing interactions among physical, biogeochemical and biological processes, yet interactions among different organisms within the biological processes is not necessarily well represented, mainly due to a lack of sufficient observation data required for modeling. Here we extended in situ observation of multiple phytoplankton groups into satellite observation and investigated their interactions with zooplankton such as copepods, using Artificial Neural Network. We found that phytoplankton (especially diatoms) played an important role in explaining zooplankton variability but only so in summer time in some waters. In winter-time, however, zooplankton abundance was rather independent of phytoplankton (chlorophyll) biomass (regardless of phytoplankton groups) and was largely explained by environmental factors such as a velocity of the Kuroshio. These results did not contradict the dilution-recoupling hypothesis, although a further investigation remains necessary to support the hypothesis.

キーワード：植物プランクトン、動物プランクトン、黒潮
Keywords: Phytoplankton , Zooplankton, Kuroshio

 

# 超貧栄養亜熱帯太平洋における生元素地理： どの存在形態が重要なのか？
# Geography of biogenic elements in the super oligotrophic subtropical Pacific Ocean: What form is most important?

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Supply and dynamics of biogenic elements such as N, P, Si are essential marine processes to consider ocean domain since they are main control factors of biological productivity, ecosystem structure and biological pump. In marine ecosystems, most nutrients are supplied from deep water and the biological productivity is high in subarctic and upwelling regions. On the other hand, most part of subtropical waters are recognized as oligotrophic ecosystem with lower nutrient concentration than “detection limit” of conventional method of the analysis, e.g., <100 nM for $NO_3$ . In the oligotrophic subtropical waters, it has been suggested DOM contribute significant part of the supply of N and P supply and production, but the contribution of particulate matter is rarely studies. Recently, high-sensitive methods for nutrient measurement was developed (e.g., Hashihama et al., 2009) and found that the variations in nitrate and phosphate concentration were more than 3-order of magnitude in the western subtropical North Pacific. We developed the method of LWCC (Liquid Waveguide Capillary Cell) for nutrients into particulate forms of P and Si and also for DOP, and compared the inventory of each form in the Pacific Ocean. We found that variations in the concentrations of particulate N and P were within 2-order of magnitude and less variable than nutrients (5-order of magnitude). Our study suggests that particulate forms of P and N, including zooplankton, play important role as a source of biogenic elements in super-oligotrophic western subtropical gyre of the North Pacific. We will discuss contrastive biogenic elemental dynamics between subtropical and subarctic/upwelling ecosystems.

キーワード：亜熱帯太平洋、生元素、プランクトン
Keywords: subtropical Norht Pacific, biogenic elements, plankton

 

# Optimality based models of phytoplankton size structure in the North Pacific

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Phytoplankton size structure is an important factor determining trophic transferand export production in the ocean. To model phytoplankton size structure,conventional ocean models usually discretize the phytoplankton community intoa number of size classes, which is usually computing extensive. In addition, theflexible behaviors of phytoplankton physiology such as flexible intracellularnitrogen-to-carbon ratios and chlorophyll-to-carbon ratios should be alsoconsidered. Here we present a new ecosystem model which combines theflexible behavior of phytoplankton physiology and an innovative approach ofmodeling the mean and variance of a continuously distributed phytoplanktonsize. The key features of the new type of ecosystem model include: 1) A tradeoffexists phytoplankton photosynthesis and nitrogen uptake. Phytoplankton cellsare assumed to optimize the energy allocation between light harvesting andnitrogen uptake. 2) By assuming a continuous lognormal distribution ofphytoplankton size, key phytoplankton physiological parameters such asnutrient uptake rate, photosynthesis rate, minimal nutrient quota, etc. followvalidated size-scaling laws. Then the net growth rate of the bulk phytoplanktoncommunity can be expressed as a function of the net growth rate at mean log sizeand the second derivative of net growth rate evaluated at the mean log sizebased on moment closure approximations. 3) A killing-the-winner strategy isadopted to maintain phytoplankton size diversity. This model is coupled with a3D regional ocean circulation model (ROMS) in the North Pacific and canreproduce the large-scale patterns of oceanic circulation, temperature, andsalinity, nitrate and chlorophyll fields. As expected, nutrient concentration is themajor factor controlling distributions of phytoplankton mean size and sizevariance. Sensitivity analysis suggests that the ecosystem model is very sensitiveto the type of grazing functions and zooplankton mortality closure terms.

Keywords: Phytoplankton, Size, Modeling

 

# 東シナ海の夏の植物プランクトン群集の経年変化

# Internannual Variability of Summer Phytoplankton Community in the East China Sea

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Interannual variability of summer phytoplankton community was examined with HPLC pigments in 2009, 2010, 2011 and 2013. On 2009 and 2013, diatom was dominated in high chlorophyll-a water, while on 2010 and 2011 smaller phytoplankton was dominated. It is expected that influence of high nitrate Changjiang river water was stronger on 2010 and 2011, while phosphate amount was higher in 2009 and 2013 and coastal upelling may stronger. The sourse of nutrients may be the cause of the dominance of different phytoplankton groups.

キーワード：植物プランクトン、河川水、栄養塩
Keywords: phytoplankton, river water, nutrients

 

# 低次海洋生態系モデル(3-D NSI-MEM)と遺伝的アルゴリズム(μGA)を用いたデータ同化
# Data assimilated state variables of a lower trophic level marine ecosystem model (3-D NSI-MEM) by a micro-genetic algorithm in North Pacific

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Lower trophic level marine ecosystem models have become increasingly important for understanding marine ecological systems, but there are two main difficulties for improving simulation results of marine ecosystem models. Firstly, lower trophic level ecosystem models have recently had many parameters with state variables increasing. The difficulty of estimating adequate parameters have also increased. Unbalanced parameter sets often lead to numerical divergence. Secondly, it is difficult for ecosystem models with one kind of ecological parameter set to reproduce realistic situations (*e.g.*, distribution patterns of phytoplankton, timing of spring phytoplankton bloom and so on), especially when coupled to physical three-dimensional models. Because the characteristics of local species are different with various provinces in the ocean. To estimate optimal parameter sets and approximate model results to a realistic situation, we used data assimilative approach by a genetic algorithm with a three-dimensional lower trophic level marine ecosystem model.
The marine ecosystem model 'NSI-MEM' based on NEMURO has been developed in Japanese communities. The ecosystem model has 14 compartments including two phytoplankton functional groups (non-diatom small phytoplankton (PS) and diatoms (PL)). The model was extended three-dimensionally and worked offline with the environmental physical field obtained from another realistic physical 3-D model (MRI.COM) experiment. One of the focuses of this study is to approximate the PS and PL concentrations to the values estimated from satellite data in the North Pacific region in 1998. We divided the region (15~65°N, 120~160°E) into three provinces based on dominant species and nutrients limitation, and set different ecosystem parameters for each province. The optimal parameters were estimated by the similar method to that in Shigemitsu et al. (2012) that used one-dimensional NSI-MEM with a micro genetic algorithm.
The correlation of phytoplankton concentration between the model result and satellite data is totally larger than that in the result without the estimated optimal parameters. For seasonal analysis in 1998, the correlation becomes relatively larger especially in winter (January to March) and smaller in spring (April to May), compared to that without the parameter estimation. This is because the timing of phytoplankton spring bloom in the model domain is shifted to the early period, due to the data assimilation process. As a result, roughly speaking, the satellite data-based assimilation by the genetic algorithm can help the model results to improve. For future works, we should investigate the values of the estimated ecosystem parameters (*i.e.*, the consistency between the ecosystem parameters and the real ecology of phytoplankton).

キーワード：三次元低次生態系モデル、遺伝的アルゴリズムを用いたデータ同化、北太平洋域
Keywords: 3-D lower trophic level marine ecosystem model, Data assimilation by a micro-genetic algorithm, North Pacific

 

 

# 水産生物の環境履歴と水産資源変動
# Environmental history of living marine resources and fluctuation of fisheries resources

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潮汐の18.6 年振動と同期した海水中の栄養塩や酸素濃度の約20 年周期変動が、亜寒帯海域や亜熱帯海域で観測されている一方、日本周辺の水産資源にも約20 年周期変動やその約3 倍の50-70 年周期変動（マイワシ・マサバ・マアジ等）が卓越し、潮汐振動に起因する気候、水塊や餌料の変動が水産資源の変動と連動している可能性が高い。西部北太平洋海域で確認されている潮汐振動に起因する事象のつながりを明らかすることは、栄養塩循環，生態系，水産資源の長期変動過程の理解や予測可能性を高めることにつながる。2015年度より、文部科学省科学研究費補助金・新学術領域研究「海洋混合学の創設：物質循環・気候・生態系の維持と長周期変動の解明」の計画研究として、「水産生物の環境履歴と水産資源変動」に関する研究を開始したので、その内容を報告する。潮汐振動などに起因する海洋鉛直混合の長期変動が、直接・間接的に水産資源変動に与える影響を、耳石日輪の高解像度同位体分析による稚仔魚の環境履歴復元と生態系魚類モデルを用いた解析により明らかにすることを目的としている。

キーワード：海洋混合、長周期変動、海洋生態系モデル、魚類成長－回遊モデル
Keywords: ocean mixing, long term fluctuation, ecosystem model, fish growth-migration model

 

# 東シナ海におけるカタクチイワシの温暖化影響評価の試みII

# A challenge to evaluate effect of climate change on Japanese anchovy (*Engraulis japonicus*) in the East China Sea II

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海洋大循環モデルC-HOPE（Max-Planck-Institute Ocean Model）と海洋低次栄養段階生態系モデルNEMURO（North Pacific Ecosystem Model for Understanding Regional Oceanography）の拡張版であるeNEMUROを結合させた、CHOPE-eNEMUROを現在気候外力と将来気候外力を用いて駆動し、現在と将来の水温、流向・流速、餌料プランクトン場を得、その場を用いてカタクチイワシの成長－回遊モデル（eNEMURO.FISH）を積分することで、地球温暖化が東シナ海のカタクチイワシに与える影響を評価している。これまでは、初期産卵場を、深度1000 m以浅で且つ水温15.6～27.8℃の海域に形成されると仮定し推定していたが、東シナ海のカタクチイワシの産卵場水温を再解析した結果、好適水温が14.1～20.1℃及び27.2～27.8℃の範囲にあるとの結果を得た。この新しい好適水温を仮定して初期産卵場を求め、産卵から1年間の計算を行った。また、これまでは3月生まれのカタクチイワシを対象としていたが、4および5月生まれのカタクチイワシについても同様の計算を行い、生まれ月による影響の違いも検討した。現在気候下では、九州西岸域に加入するシラスは、九州北部では4月生まれが、南部では3月生まれが主体となったが、将来気候下では、北部、南部とも3月生まれが主体となり、北部で1ヶ月シラス最盛期が早まる結果となった。また、体長に注目すると、現在気候下では、九州西岸域に加入するシラスは、北部では5月生まれ、南部では4月生まれがモード体長最大となるが、将来気候下では、北部では4月生まれ、南部では3月生まれがモード体長最大となり、モード体長が最大となる時期が1ヶ月早期化する結果となった。将来気候下では、4月の南部および5月の北部および南部に加入するシラスが激減したが、これは20.2～27.1℃の間に産卵場が形成されないという仮定のために、将来気候下では東シナ海の産卵場が消失したためである。今後は、東シナ海で20.2～27.1℃が好適水温帯にならない理由を精査する必要がある。

キーワード：海洋生態系モデル、魚類成長－回遊モデル、カタクチイワシ、地球温暖化
Keywords: ecosystem model, fish growth-migration model, Japanese anchovy, climate change

 