令和５年度　神戸大学大学院海事科学研究科国際交流基金援助金申請書
（３　国際学術交流のための教職員海外派遣事業）

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国際学術交流のための教職員海外派遣事業への援助をいただき有り難うございました。

下記の通りご報告申し上げます。

記

<table>
<tr><td colspan="2">渡　航　者</td><td colspan="2">氏名（所属・職名）林美鶴（海洋基礎科学領域・准教授）</td></tr>
<tr><td colspan="2">3. 開催地</td><td colspan="2">都市名：カーン　　国名：フランス</td></tr>
<tr><td rowspan="5">渡航目的</td><td rowspan="4">国際学術講演会等</td><td>1. 学会名<br>2. 開催日時</td><td>COAST CAEN 2023<br>10 月 24～27 日（公式行事 10 月 22～28 日）</td></tr>
<tr><td>講演題目</td><td>Distribution of $CO_2$ and $N_2O$ concentrations in surface seawater measured in the Seto Inland Sea and Shikoku southern offing</td></tr>
<tr><td>講演者</td><td>林美鶴</td></tr>
<tr><td>4. 規模</td><td>参加 300 名</td><td>8 セッション、120 講演、30 ポスター、</td></tr>
<tr><td>6. 関わり</td><td colspan="2">講演者</td></tr>
<tr><td colspan="2">渡航期間</td><td colspan="2">2023 年 10 月 20 日　～　2023 年 10 月 28 日　（　　9 日間）</td></tr>
</table>

5. 発表要旨

深江丸の瀬戸内海航海において、1990～2004 年に大気・海水中 CO2、N20 濃度を測定した。両者を同時に測定した 2008 年 3 月、9 月、2009 年 3 月、9 月、2010 年 3 月の 5 航海の結果を比較した。船底（水深 3m）から取水し、CO2 濃度は 15 分ごと、N20 濃度は 1 時間ごとに、バブリング法により測定した。3 月の CO2 濃度は 3 年間ほぼ同じであった。9 月の CO2 濃度は 2 年の濃度レベルが異なるが、空間変動の傾向は一致していた。3 月の N20 濃度は、海水密度が高い年ほど高くなる傾向があったが、9 月には有意な傾向は見られなかった。CO2 および N20 濃度と塩分、水温、溶存酸素濃度との相関は、CO2 については各年で異なる傾向を示し、CO2 濃度に生化学的な影響が大きいことが示唆された。N20 の相関は各年で類似の分布形状を示し、年によって全体がシフトした。このことは、N20 濃度に対する物理的影響が大きいことを示唆している。

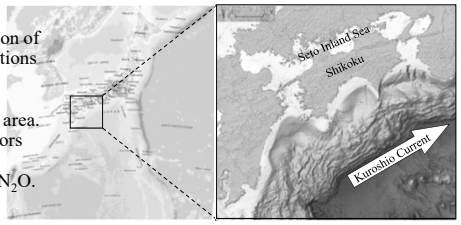
発表論文の写し：Springer Nature から書籍として出版する講演論文集の編纂中のため、プレゼンテーションファイルを添付する。

# Distribution of $CO_2$ and $N_2O$ concentrations in surface seawater measured in the Seto Inland Sea and Shikoku southern offing

HAYASHI Mitsuru (Kobe Univ.) & YAMASHITA Eiji (Okayama Univ.)

## Objective

# To crafty the distribution of $CO_2$ & $N_2O$ concentrations in the seawater in the Seto Inland Sea & around area.
# To understand the factors contributing to spatial distribution of $N_2O$.




## Background

# $CO_2$ & $N_2O$ (Nitrous Oxide) are the greenhouse effect gas.
# $N_2O$ has low concentration in the atmosphere of 1/1000 of $CO_2$, however a life time of over 100 years.

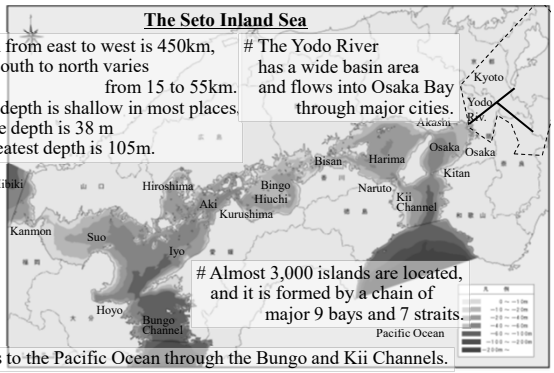
| Gas | Concentration (ppb) | Life Time (year) | Radiative Forcing ($W/m^2/ppb$) | GWP (100 year) |
|---|---|---|---|---|
| $CO_2$ | 379,000 | 5 | $1.4 \times 10^{-5}$ | 1 |
| $N_2O$ | 319 | 114 | $3.0 \times 10^{-3}$ | 310 |

(IPCC)

# The ocean is a large $N_2O$ source to the atmosphere accounting for 10–33% of the global source (Jiang et al., 2007), and coastal sea account for 35–60% of that (Bange et al., 1998).
# We measured seawater and atmospheric concentrations of $CO_2$ from 1994-2010 and $N_2O$ from 2008-2010.

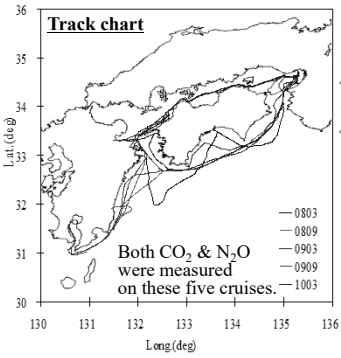
## The Seto Inland Sea

# The length from east to west is 450km, and from south to north varies from 15 to 55km.
# The water depth is shallow in most places. the average depth is 38 m and the greatest depth is 105m.
# The Yodo River has a wide basin area and flows into Osaka Bay through major cities.



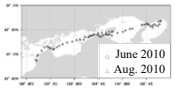

# Almost 3,000 islands are located, and it is formed by a chain of major 9 bays and 7 straits.
# It connects to the Pacific Ocean through the Bungo and Kii Channels.

## Track chart



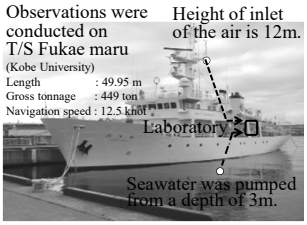

Both $CO_2$ & $N_2O$ were measured on these five cruises.

Additionally, $N_2O$ was measured on two cruises.

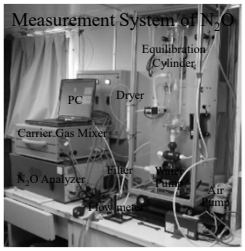


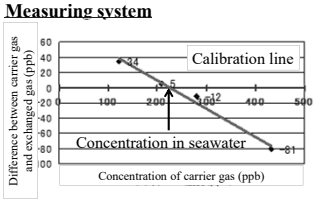

Observations were conducted on T/S Fukae maru
(Kobe University)
Length : 49.95 m
Gross tonnage : 449 ton
Navigation speed : 12.5 knot

Height of inlet of the air is 12m.




## Measuring system



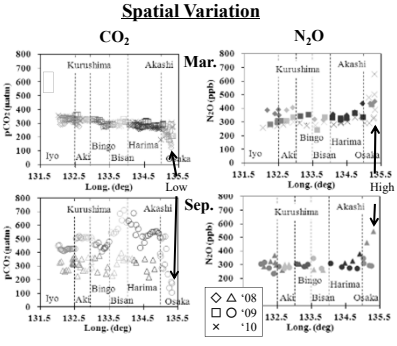




# The bubbling method was used for gas exchange.
# The gas concentration was measured using the principle of infrared absorption.
# The concentration in the seawater was quantified by calibration line.
# $CO_2$ was also measured by the same method.

$CO_2$: Yamashita et. al.(1993), $N_2O$: Sakamoto et.al. (2013)

# Water temperature
# Salinity
# Dissolved Oxygen
# pH
# Meteorology

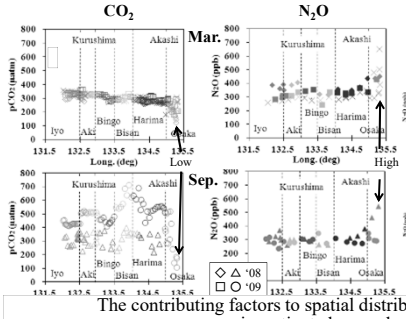
## Spatial Variation



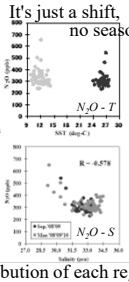

$CO_2$
# in Mar.
Nearly consistent for three years
# in Sep.
Concentration levels vary from year to year, however trends in spatial variability are generally consistent.

$N_2O$
# Characteristics of spatial variability are unclear, except for Osaka Bay,

## Spatial Variation



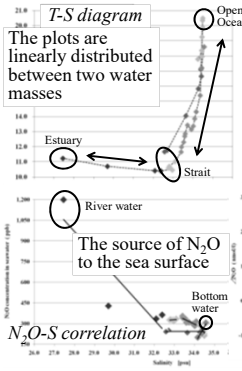

## Correlation between $N_2O$ and T, S, DO

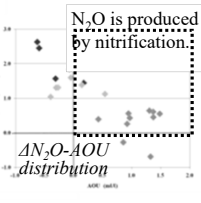



The correlations show similar trends in both seasons. It's just a shift, no seasonal differences.

The contributing factors to spatial distribution of each region were investigated on cruises.

## Method of investigation



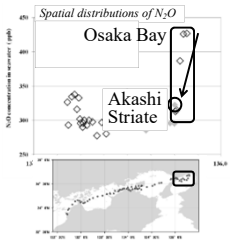



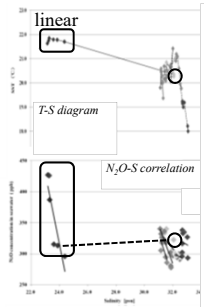

# In the T-S diagram the seawater is exchange horizontally between the water masses.
# The $N_2O$-S correlation was used to determine fluvial effects (low S & High $N_2O$) and vertical mixing (High S & High $N_2O$).

# $AOU_{(Apparent\ Oxygen\ Utilization)}$ = $O_2$ saturation - observed DO > 0 means $O_2$ consumption
# $\Delta N_2O$ = observed $N_2O$ - $N_2O$ solubility > 0 means $N_2O$ production

(T.Yoshinari,1976, Walter, 2006)

## Akashi Striate ~ Osaka Bay in June 2010

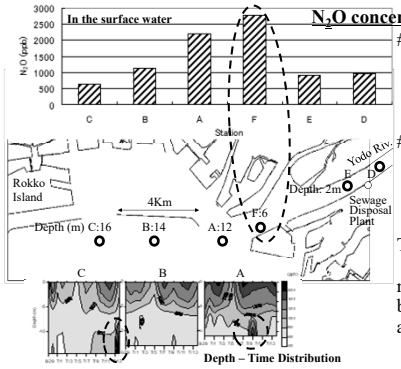



# $N_2O$ was highest in the inner part of Osaka Bay and decreased toward the west.
# Plots of T-S was linearly distributed in Osaka Bay.
# In the inner part Salinity is lower & $N_2O$ is higher compare to the west.
# Slightly higher $N_2O$ & Higher S, lower T in Akashi Strait compared to Osaka Bay.

$N_2O$ would have been supplied at the inner part and spread to the west, and from the bottom layer in Akashi Strait.

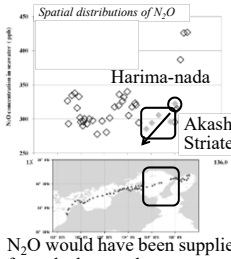
## $N_2O$ concentration in Yodo River Estuary

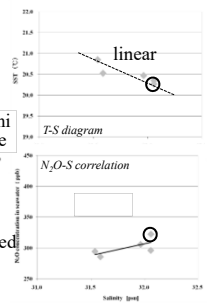


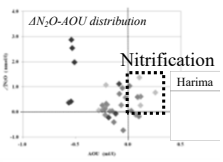

# $N_2O$ in the surface water, was highest at the river mouth. Based on the nitrogen budget, it was presumed to be produced by nitrification.
# High concentrations also appear in the bottom layer, which would be denitrification in the sediment.

The source of $N_2O$ at the inner part of Osaka Bay not only river water, but also nitrification and denitrification in the estuary.

## Harima-nada ~ Akashi Striate in June 2010



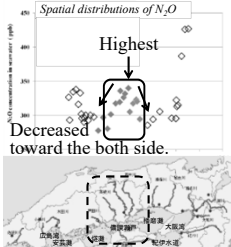



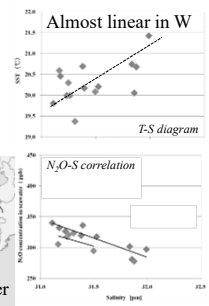

# $N_2O$ decreased toward Harima from Akashi.
# Plots of T-S was linearly.
# Slightly higher $N_2O$ & S in Akashi Strait.
# Nitrification was occurring.

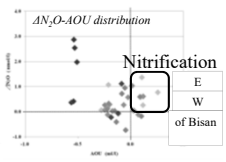
$N_2O$ would have been supplied from the bottom layer in Akashi Strait and spread to Harima-nada, and produced by nitrification in Harima-nada.

## Bisan-seto in June 2010



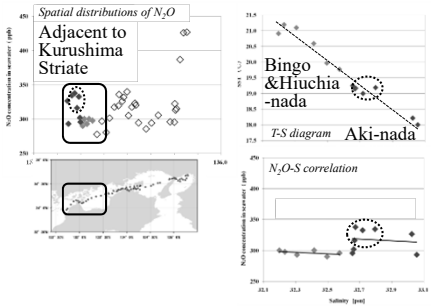





$N_2O$ would have been supplied from the rivers, and produced by nitrification mainly in the central part of Bisan-seto.

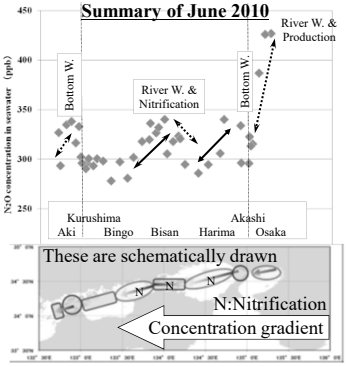
## Aki-nada ~ Kurushima Striate ~ Hiuchi&Bingo-nada in June 2010




# $N_2O$ was almost constant in Bingo&Hiuchi-nada & high in Aki-nada adjacent to Kurushima Striate.
# Plots of T-S was linearly.
# The salinity in Aki-nada was lower in the adjacent area to Kurushima Strait.

$N_2O$ may have been supplied from the bottom layer in the Kurushima Strait & spread to the Aki-nada side.

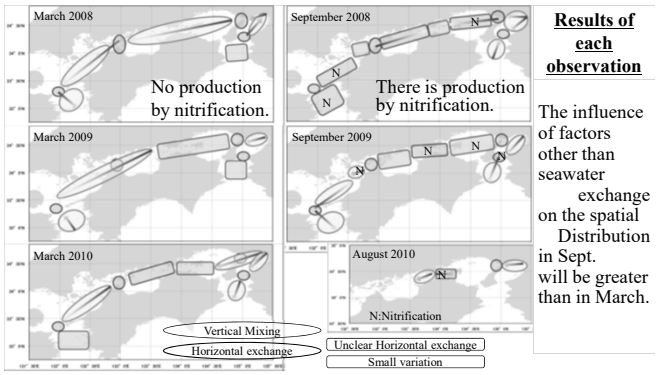
## Summary of June 2010




The source of $N_2O$ would be
# River water to Osaka Bay & Bisan-seto
# Nitrification & Denitrification in the estuary of the inner part of Osaka Bay
# Nitrification in Bisan-seto & Harima-nada
# Bottom water in Akashi & Kurushima Striate

Then, $N_2O$ spread from these sources by horizontal mixing.

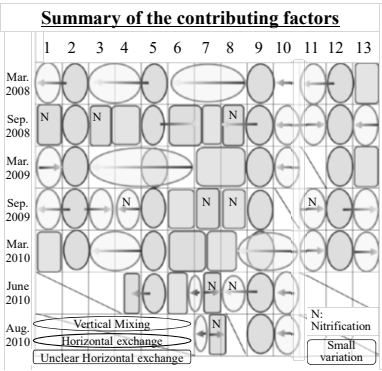
Vertical Mixing
Horizontal exchange
Unclear Horizontal exchange
Small variation

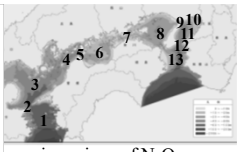



## Results of each observation

The influence of factors other than seawater exchange on the spatial Distribution in Sept. will be greater than in March.

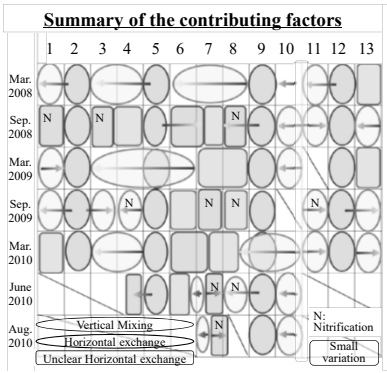
## Summary of the contributing factors

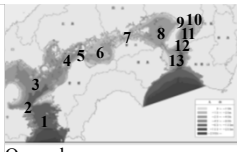



# The main regions of $N_2O$ source were the straits and the inner part of Osaka Bay in all observations.
# The contribution of horizontal seawater exchange to the spatial distribution of $N_2O$ is large form Kurushima and Akashi Strait to the open ocean.

## Summary of the contributing factors




# $N_2O$ supply from the bottom layer was not observed in Bisan Seto, a vertically mixed area.
# In the central par of the sea, $N_2O$ were produced by nitrification in summer, however, not enough to be a source to the around area, and it is difficult to explain the spatial distribution by horizontal seawater exchange.

## Conclusion

$CO_2$ and $N_2O$ concentrations in surface seawater were measured in the Seto Inland Sea and Shikoku southern offing.

# It was characteristic both $CO_2$ and $N_2O$ concentrations in Osaka Bay.
# The main regions of $N_2O$ source were the inner part of Osaka Bay & the straits.
# The contribution of horizontal seawater exchange to the spatial distribution of $N_2O$ is large expect the central par of the Seto Inland Sea.

To quantify & clarify the spatial distribution & it's variation of concentration of $N_2O$ in seawater in the Seto Inland Sea, it is necessary to correctly estimate the horizontal and vertical advection of seawater.