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Mercury distribution in seawaters, planktons and fishes collected from the Kuroshio Current region of the East China Sea

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Introduction

Mercury (Hg) is widely recognized as a global pollutant because of its long-ranged atmospheric spreading. In addition, it is well known that methyl mercury (MeHg) is produced by the in-situ methylation of inorganic Hg in aquatic environments and highly biomagnified in fish through the food web. Humans are exposed to a significant level of MeHg due to the consumption of fishes which the majority are marine species. However, the MeHg production in the ocean and its intake into marine organisms are a process of particular concern.

To obtain the knowledge on the production and the decomposition of MeHg in seawater and MeHg intake into planktons and fishes, we investigated the distribution of total and methyl Hg in the seawater, planktons and fishes in the East China Sea, which is located between the Asian Continent and the Japanese islands. This is one of the noteworthy sea areas because the East Asian region has been recognized as the largest Hg emission source into the atmosphere.

Total Hg in seawater was measured by CVAFS according to the EPA method 1631 and total Hg in planktons and fishes was measured by acid digestion using the Mercury analysis manual of Ministry of the Environment, Japan (MOEJ method). MeHg in seawater and planktons were measured by a hybrid method combined the dithizone extraction using the another MOEJ method and the EPA method 1630 (draft version).

Acknowledgements

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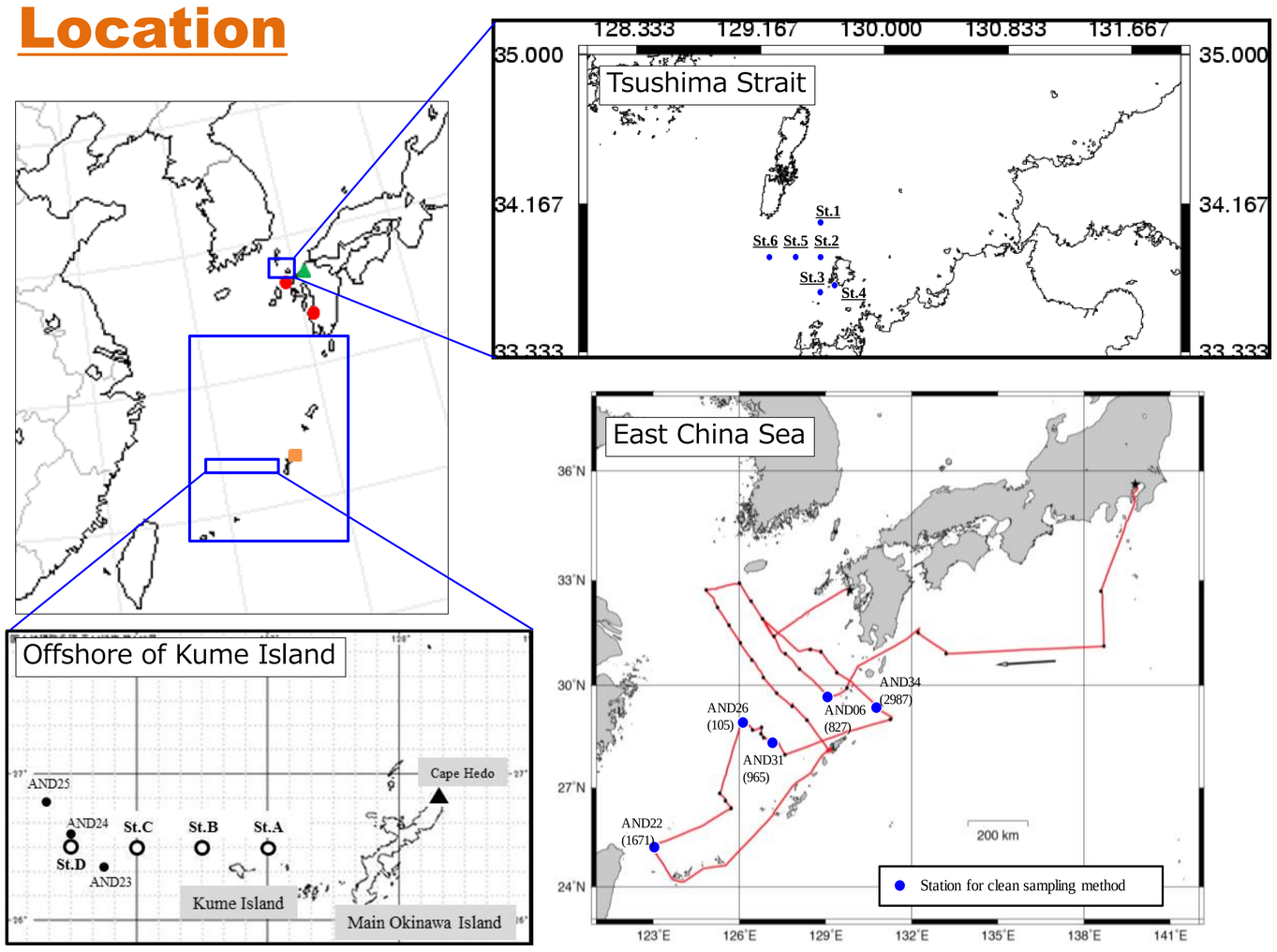
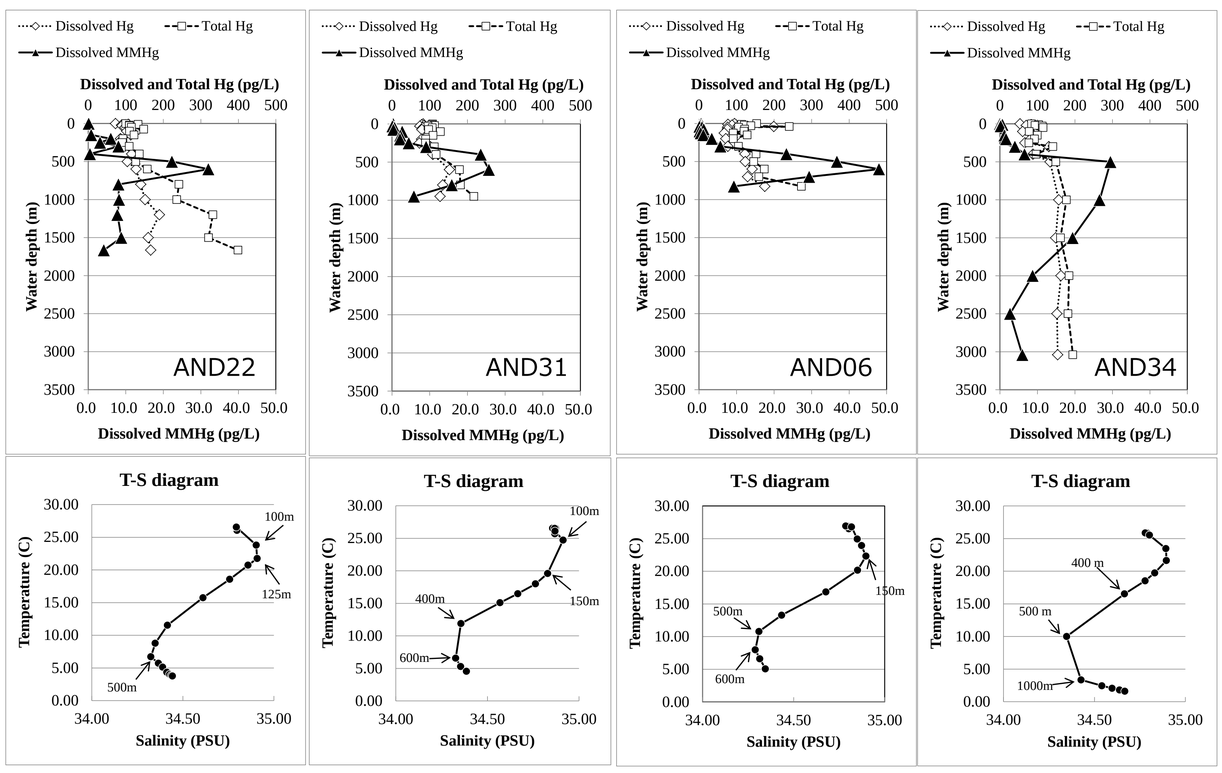
Location

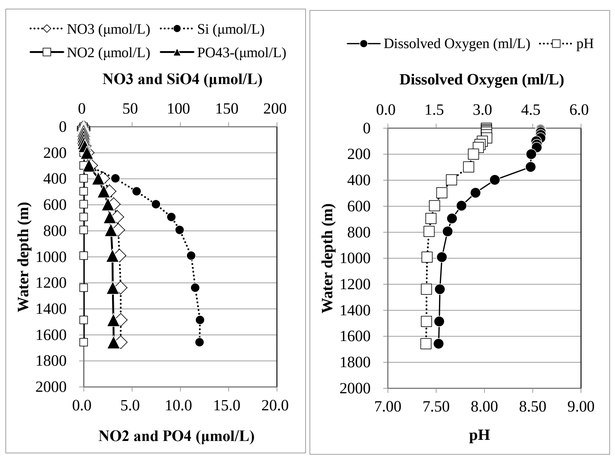


Results and Discussion

South ⟶ North



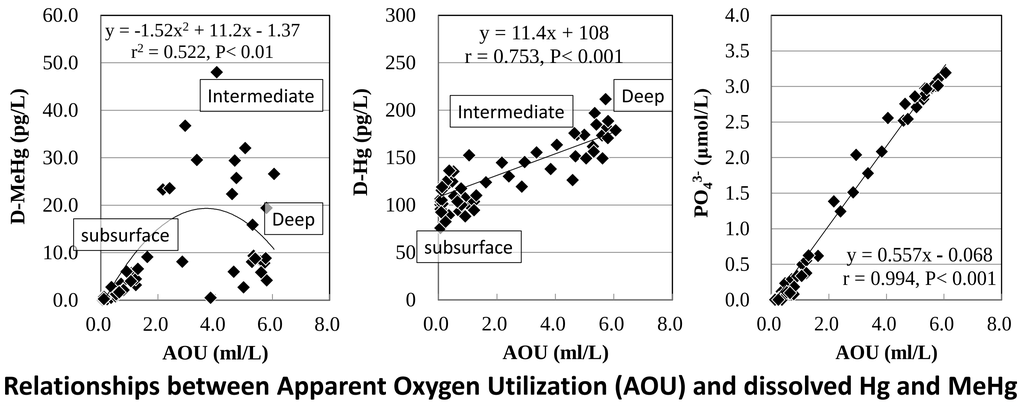
Vertical profile of seawater Hg and Temperature – Salinity diagram at each site of the East China Sea



Vertical profile of nutrients, pH and dissolved oxygen at AND22 (Offshore of Taiwan island)

The maximum layer of MeHg in seawater exists around the depth of 500m at all stations. At this layer, there is no oxygen minimum zone which the MeHg production is accelerated.

As shown in T-S diagram, it is indicated that the water mass at this depth is different from other layers and may be North Pacific Intermediate Water (NPIW) characterized by low-salinity and low-temperature. Some researchers suggested that NPIW has high MeHg concentration. Thus, advection of NPIW is related to MeHg maximum in this sea area. However, the reason why high MeHg is observed in NPIW is still unclear.



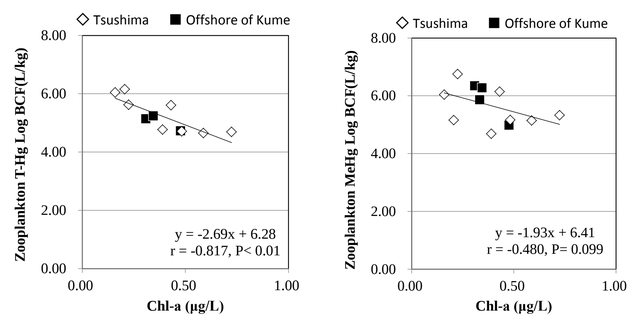
Relationships between Apparent Oxygen Utilization (AOU) and dissolved Hg and MeHg and Phosphate

Dissolved Hg concentrations were correlated with AOU like PO_4^{3-} in all layers except for the subsurface. On the other hand, at the only subsurface layer, MeHg and AOU were also correlated.

Total and methyl Hg concentrations in the seawater and zooplanktons, and their bio-concentration factors (BCFs) in our study area and other sea area

Location	Seawater		Zooplankton							Reference
	Diss. total Hg (pg/L)	Diss. MeHg (pg/L)	*N*	Size	Total Hg (µg/g ww)	Log BCF (HgT;L/kg)	MeHg (µg/g ww)	%MeHg	Log BCF (MeHg;L/kg)	
Tsushima Strait (October 2014)	100 ± 55	3.5 ± 2.0	*4*	>100µm	0.005 ± 0.001	4.71 ± 0.05	0.0004 ± 0.0003	8.3 ± 4.6	5.04 ± 0.27	This work
Tsushima Strait (August 2015)	73 ± 37	9.6 ± 1.5	*5*	>100µm	0.054 ± 0.021	5.86 ± 0.28	0.0061 ± 0.0089	12.4 ± 16.6	6.02 ± 0.66	This work
ECS Kuroshio Current region (August 2016)	101 ± 16	2.1 ± 3.9	*4*	>100µm	0.012 ± 0.005	5.03 ± 0.28	0.0011 ± 0.0002	10.2 ± 3.3	5.91 ± 0.54	This work
Long Island Sound, USA	1000	30		>200µm			0.0011 *a		4.6	(1)
Northwater Polynya, Baffin Bay			*3*	>520µm	0.025 ± 0.017		0.0024 ± 0.0013	7.5 ± 0.1		(2)
Gulf of St. Lawrence, Canada	886	116	*21*	>333µm	0.009	4.0	0.0008	12.6	3.9	(3)
Northwest Atlantic Ocean		3.0 -11.2	*25*	0.2 - 200µm			0.00014 ± 0.00006	6 ± 3	4.3 ± 0.3	(4)
			78	>200µm			0.00056 ± 0.00056	15 ± 12	Around 4.9	(4)
Central Tropical Pacific Ocean	58 ± 52 *b	14.6 ± 6.8 *b		>200µm	0.001 - 0.027	3.7 - 6.1	0.0002 - 0.0034		4.1 - 6.5	(5)

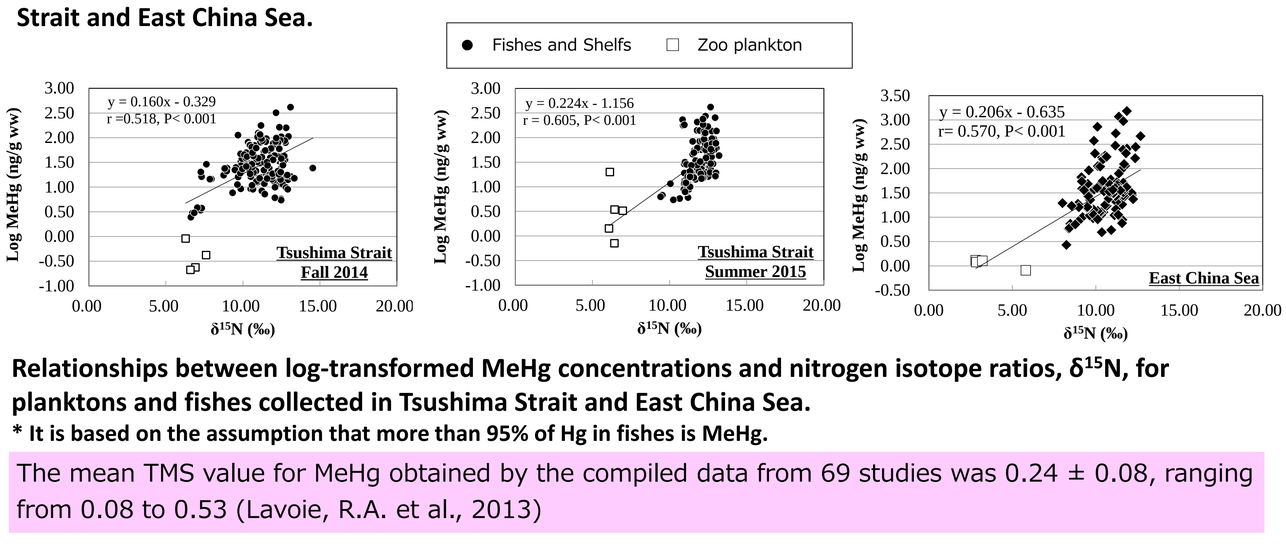
(1) Hammerschmidt, C.R. and Fitzgerald, W.F., 2006; (2) Campbell, L.M., 2005; (3) Lavoie, R.A., 2010; (4) Hammerschmidt et al., 2013; (5) Gosnell, K.J. and Mason, R.P., 2015;
*a Water content of zooplankton is assumed at 90%.
*b Munson et al., 2015 (Within thermocline in the seaarea of 4°N - 3.5°S)



Relationships between log-transformed BCFs in total and Methyl Hg and Chl-a concentrations in Tsushima Strait and East China Sea.

The percentage of MeHg for total Hg in the planktons obtained in this study was around 10%. The average BCF for MeHg is 3 fold higher than that for total Hg.

The log-transferred BCF for total Hg was negatively correlated with Chl-a conc., indicating that biomagnification of total Hg in zooplanktons is controlled by the dilution effect due to phytoplankton breeding. However, for MeHg, there is no correlation with Chl-a.



Relationships between log-transformed MeHg concentrations and nitrogen isotope ratios, $\delta^{15}N$, for planktons and fishes collected in Tsushima Strait and East China Sea.
*** It is based on the assumption that more than 95% of Hg in fishes is MeHg.**

The mean TMS value for MeHg obtained by the compiled data from 69 studies was 0.24 ± 0.08, ranging from 0.08 to 0.53 (Lavoie, R.A. et al., 2013)

Summary and Conclusion

- We obtained the first dataset on total and methyl Hg in seawaters, planktons and fishes collected from the Kuroshio Current region of the East China Sea for evaluating Hg distribution and bioaccumulation in these sea areas.
- MeHg in the seawater of the study area was higher at the depth of 500-600m, which the NPIW flows.
- Intake of MeHg in the subsurface seawater into the planktons is occurred like nutrients such as PO_4^{3-}.
- The bio-accumulations of total and methyl Hg between planktons and fishes in the study sea area were comparable with those in other areas. The East China Sea is the adjacent sea area of the Asian Continent which has the largest Hg emission source in the world. However, we cannot find the remarkable Hg pollution in this sea area.