Distribution characteristics of methylmercury and dissolved gaseous mercury in the Western Pacific Ocean

Seunghee Han[1]*, Hyunji Kim[2], Tae-Siek Rhee[3]

[1]Gwangju Institute of Science and Technology (GIST), Gwangju, Republic of Korea; [2]Korea Basic Science Institute, Seoul, Republic of Korea;

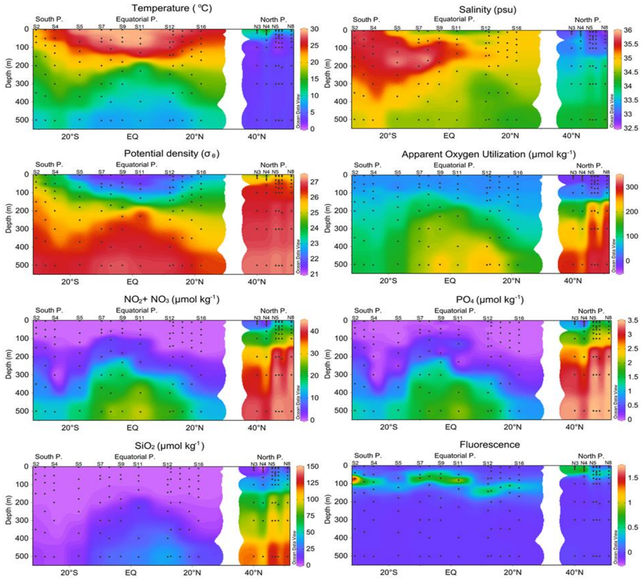
[3]Korea Polar Research Institute, Incheon 406-840, Republic of Korea

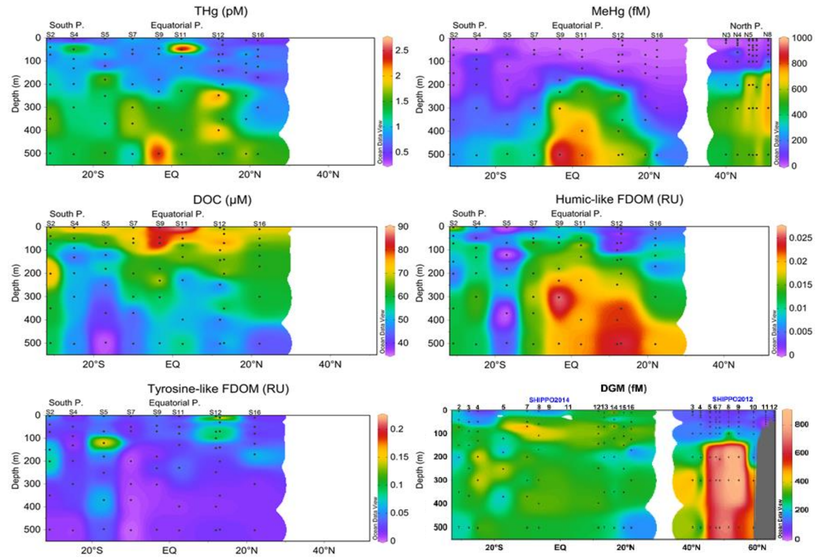
Abstract

Methylmercury (MeHg) accumulation in marine organisms poses serious ecosystem and human health risk, yet the sources of MeHg in the surface ocean remain uncertain. We present the first mass budget estimation and distribution characteristics of MeHg and dissolved gaseous Hg (DGM) in the Western Pacific Ocean, estimated based on cruise data (2012 and 2014 SHIPPO survey, 30° S-50° N). We found from the cruise data that the major net source of MeHg in surface water to be vertical diffusion from the subsurface layer (1.8 to 12 nmol m^{-2} yr^{-1}). A higher upward diffusion in the North Pacific (12 nmol m^{-2} yr^{-1}) than in the Equatorial Pacific (1.8–5.7 nmol m^{-2} yr^{-1}) agreed with elevated surface MeHg concentrations observed in the North Pacific (limit of detection-34 fM) as compared to the Equatorial Pacific (< LOD). On the contrary, surface water DGM concentration was found to be higher in the Equatorial Pacific (100-300 fM) than the North Pacific (50-100 fM). In particular, surface seawater DGM was higher in the low salinity water of the intertropical convergence zone (ITCZ), which agrees to the previous results. It was explained by increased wet deposition flux of Hg and shallow mixed layer depth in the ITCZ. Our results suggest that MeHg and DGM distribution in surface of the Western Pacific Ocean is mainly controlled by the upward diffusion from subsurface water and the in situ reduction of deposited Hg, respectively.

Results

Interpolated cross-sectional contours of the chemical properties

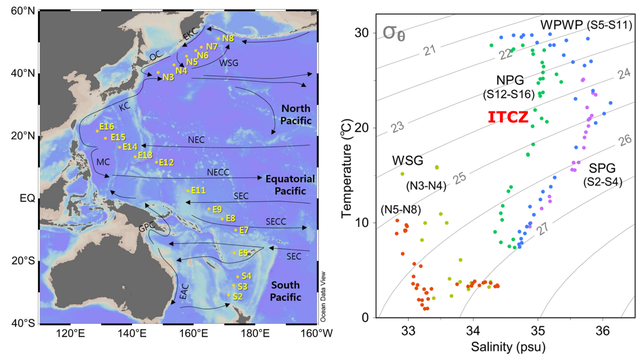




Materials and Methods

Sampling sites

- To constrain major sources and sinks of MeHg and DGM in the surface and subsurface ocean, we collected seawater samples during two cruises (2012 and 2014 SHIPPO) in the West Pacific Ocean.

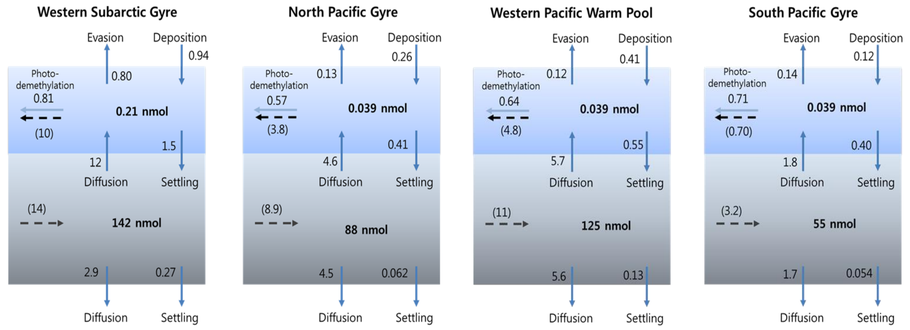


MeHg flux estimation

- **Deposition flux**
  Using precipitation data from NASA Earth Observations and MeHg concentrations (as1% of total Hg)
- **Air-Sea exchange of DMHg**
  $DMHg_{flux} = K_w ([DMHg] - [DMHg_{air}] / H_{DMHg})$
  $K_w = 0.25 \times u^2 \times (Sc_{DMHg}/600)^{-0.5}$
- **Photodemethylation flux**
  Using a rate constant of 1×10^{-3} m^2 E^{-1}
  PAR of each depth was obtained during the cruise
- **Diffusion flux**
  Using a uniform eddy diffusion coefficient of 1×10^{-4} m^2 s^{-1}
  $[MeHg_{min}]$ in surface water, $[MeHg_{max}]$ in subsurface water, $[MeHg_{min}]$ in deep water (>500m)
- **Settling flux**
  v_s (m s^{-1}) = $\frac{2}{9} \times [(d_p - d_{sw}) \times 1000) / \mu] \times g \times r_{pw}^2$
  $\mu = (1.88 \times 10^{-3}) - (0.04 \times 10^{-3} \times Temp)$

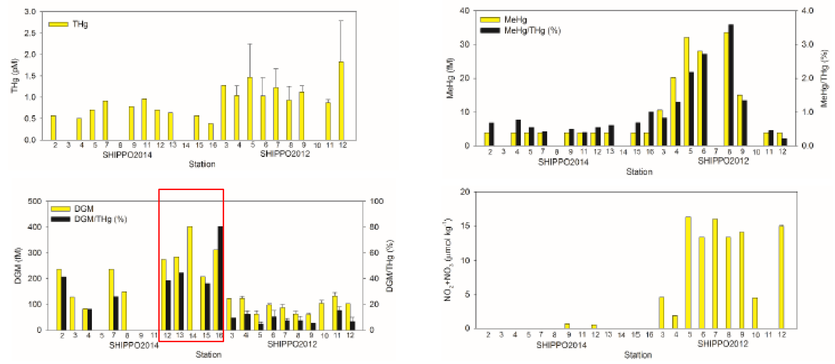
Discussion

MeHg Mass Budget



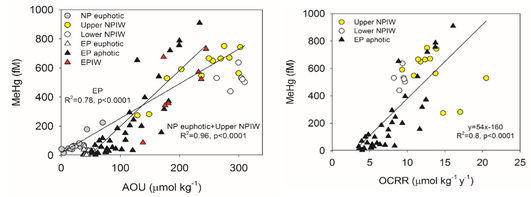
- We found the major source and sink of MeHg in surface water to be vertical diffusion and in situ demethylation, respectively. The major source of subsurface MeHg could be in situ methylation based on the mass budget results.

High DGM in the ITCZ



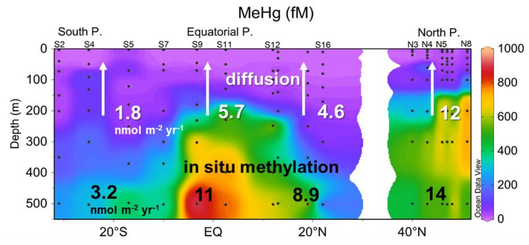
Higher DGM was found in the ITCZ than the surrounding water perhaps due to the enhanced wet deposition and low wind speed. A higher upward diffusion of MeHg in the North Pacific than in the Equatorial Pacific caused elevated surface MeHg concentrations in the North Pacific.

MeHg vs AOU



- The difference in the slope was attributable to the age of the water mass (Equatorial Pacific aphotic water is younger than North Pacific).

Conclusions



- ✓ Most MeHg in subsurface water seems to be produced by in situ reaction associated with organic carbon remineralization. MeHg in the surface water was transported from the subsurface layer.
- ✓ High DGM found in the ITCZ, attributable to high wet precipitation, slow wind speed as well as shallow mixed layer depth, indicates that rapid equilibrium is reached between DGM and Hg(II).

Acknowledgement

This study was supported by the National Research Foundation of Korea (NRF-2015R1A2A2A01003774), KOPRI grant (PM16050), and the Korea Polar Program (PE13410). A.L.S. acknowledges support from the Danish Council for Independent Research.