水俣湾における水銀濃度変化と水質動態に関する現地観測

Field Observations on Mercury Behaviors and Water Quality Dynamics in Minamata Bay

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１．本研究の背景(Background of This Study)

- 水俣湾では、環境修復事業より安全宣言が出されています。
- In Minamata Bay, the remediation works on water and bottom sediment environment have been carried out since 1977. As a result, the Governor of Kumamoto declared that the fish were safe in July, 1997.

- しかし、未だ底質には微量残留水銀が存在し、微量残留水銀が水俣湾から八代海東岸沿いに拡がっていることが報告されている(Tomiyasuら、2000)。
- However, the recent measurement result has shown that mercury is spreading along the eastern coast of Yatsushiro Sea from Minamata Bay (Tomiyasu et al., 2000).

水俣湾の概要(Map of Minamata Bay)

2．本研究の目的(Purpose of This Study)

最終目標：微量残留水銀の輸送機構の解明

Final Target: Realization on a transport mechanism of low level mercury (<10 ppm) which contains in bottom sediment in Minamata Bay

■本研究の内容(The matters of this study)

- 季節変化に伴う、水質動態および残留水銀の変化を把握する。
- **To realize seasonal changes of mercury in seawater and water quality for about 3 year**
- 夏季における、水銀濃度変化の特性を正確に把握する。
- **To reveal weekly changes of mercury in seawater and water quality during summer season for two months**
- 一潮汐間における、水質動態と水銀濃度の日変化の把握する。
- **To realize daily changes of mercury in seawater and water quality on the 1st of September, 2008.**

3. 現地観測の概要①（Outline of Field Observation）

- **定期観測**： St.1～St.3、1ヶ月毎、下げ潮最強時 (観測期間：2006/2～2009/2)

・Regular Observation; St.1-St.3, every month for three years, from Feb. 2006 to Feb. 2009, at the maximum current velocity of ebb tide

- **夏季集中観測**： 観測櫓、1週間毎

(観測期間：2008/7/25～9/21)

・Intensive Observation during summer season; An observational tower, every week for two months, from July 25 to September 21, 2008

- **一潮汐間連続観測**： 観測櫓、3時間毎

(観 測 日 ：2008/9/01 ～9/02)

・Continuous Observation for the one cycle of tide; An observational tower, every three hours, from the 1st to the 2nd of September, 2008

水俣湾の概略図(Locations of Observational Point)

3. 現地観測の概要 ②(Outline of Field Observation)

■観測内容:

①多項目水質計(塩分、水温、溶存酸素、濁度＆Chl-a等)による水質観測

①water temperature, salinity, Dissolved Oxygen (DO), turbidity, pH and so on were measured by using water quality measurement sensors (JFE ALEC Co. Ltd., Model-AAQ1183)

②海水サンプリング(採水調査)

②Water sampling was performed by a water sampler with water pressure meter.

■水銀濃度分析: T-Hg, MeHg, SS, SS中のT-Hg

国立水俣病総合研究センター(N.I.M.D.)

・Chemical analysis of mercury in seawater has been carried out by the National Institute of Minamata Disease.

Total Hg in seawater, Total Hg in SS, MeHg in seawater, SS

●: Observational Tower

水俣湾の概略図(Locations of Observational Point)

3. 現地観測の概要③（Outline of Field Observation）

裸瀬南側に新設された観測櫓

An observational tower in Minamata Bay

多目的水質計〔JFEアレック(株)製　Model-AAQ1183〕

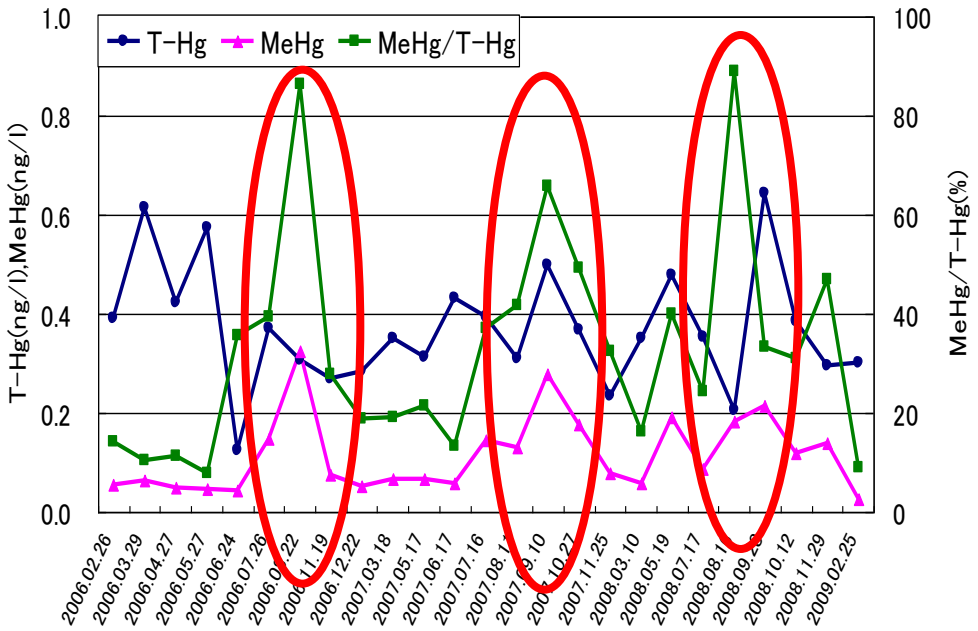
A water quality measurement sensors
(JFE ALEC Co. Ltd., Model-AAQ1183)

4. 観測結果(Results of Felid Observations)

4.1 T-Hg、MeHg、MeHg/T-Hgの季節変化(St.1)

Seasonal Changes of T-Hg, MeHg & MeHg/T-Hg at St.1

- 夏季において、MeHgがピークになっている。
- The maximum of MeHg has occurred in every summer.
- MeHg/T-Hg の比率が顕著に上昇していることが認められる。
- It was confirmed that a ratio of MeHg/T-Hg has risen significantly at the same time.
- 2008年度は、夏季後半にMeHgの増大傾向を確認。
- In the latter half of summer season in 2008, MeHg was increasing qualitatively.



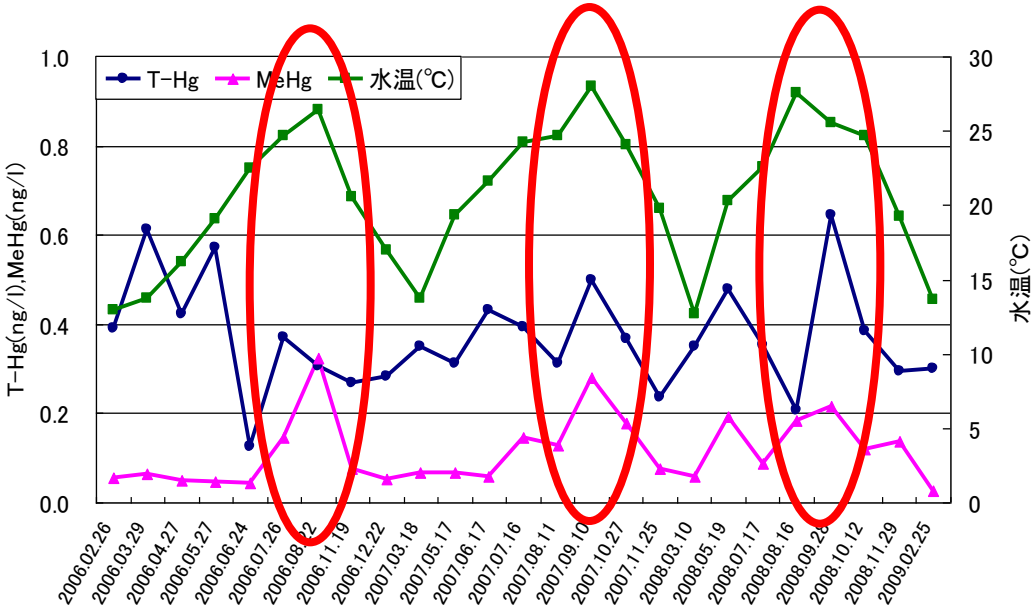
Seasonal Changes of T-Hg, MeHg & MeHg/T-Hg at St.1

4.2 T-Hg、MeHg、水温の季節変化（St.1)

Seasonal Changes of T-Hg, MeHg & Water Temperature at St.1

- **MeHgと水温が、夏季に共通して最大値になることが確認される。**
- **It is found out that the highest concentration of MeHg in seawater occurred at water temperature's peak.**

- **水温の上昇とMeHgの増大には関連性があると考えれる。**
- **It is guessed that the increases of MeHg are related with the rises of water temperature in Minamata Bay.**



Seasonal Changes of T-Hg, MeHg &Water Temperature at St.1

4.3-1 MeHgと各水質指標の相関係数

Correlation Coefficients between MeHg and Water Quality indexes

	St.1	St.2	St.3
塩分 (Salinity)	0.194	0.390	0.090
水温 (Water Temperature)	0.675	0.673	0.644
D.O (Dissolved Oxygen)	0.396	0.442	0.379
pH	0.137	0.265	0.001
濁度 (Turbidity)	0.187	0.303	0.318
σ_t	0.445	0.508	0.391

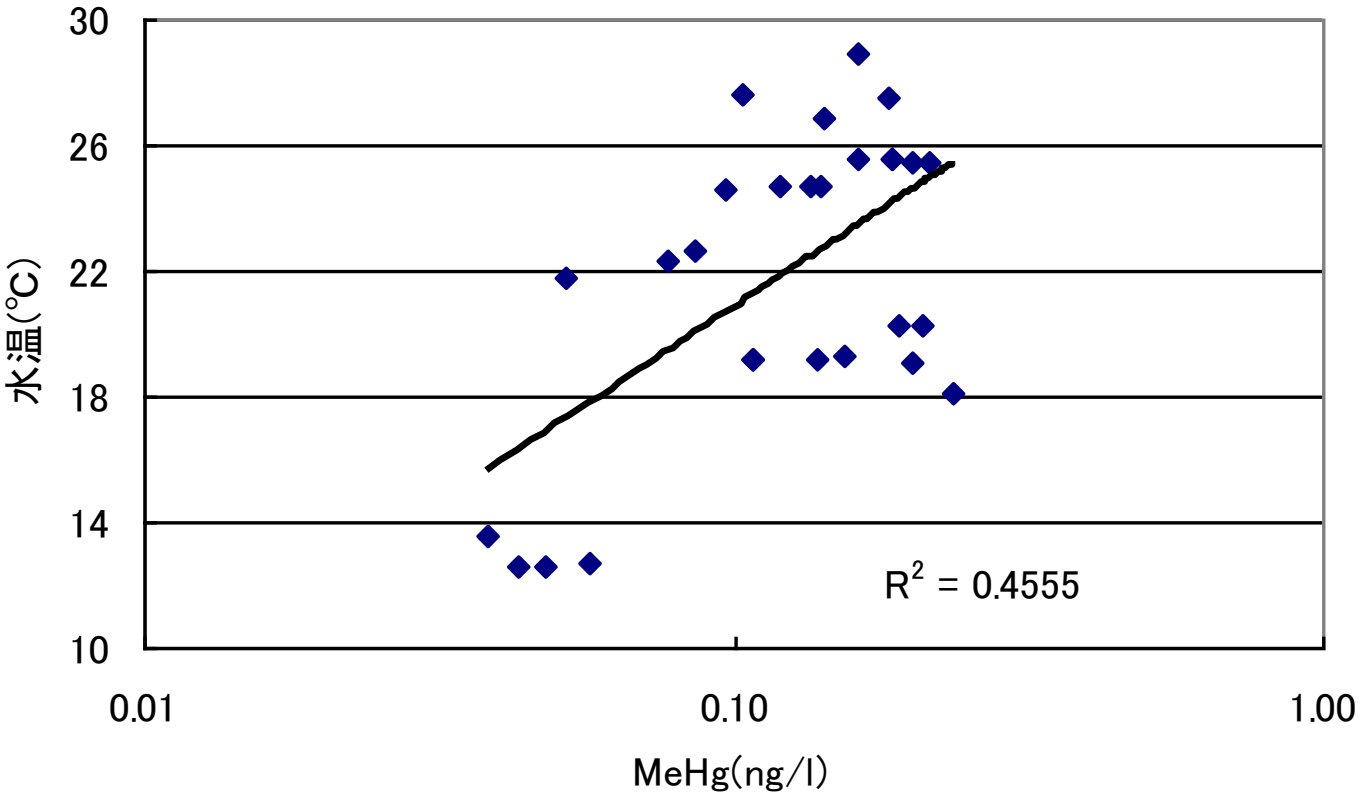
水温とMeHgとの間には、高い相関度が読み取れる。

There was a significant correlation of MeHg in seawater and water temperature in Minamata Bay.

4.3-2 MeHgと水温の相関係数

Correlation Coefficients between MeHg and Water Temperature

一例として (For example)



4.4 観測櫓での夏季集中観測の結果

Results of Intensive Observation during summer season at the observational tower

・夏季における水銀濃度の変化特性を正確に把握することは重要！

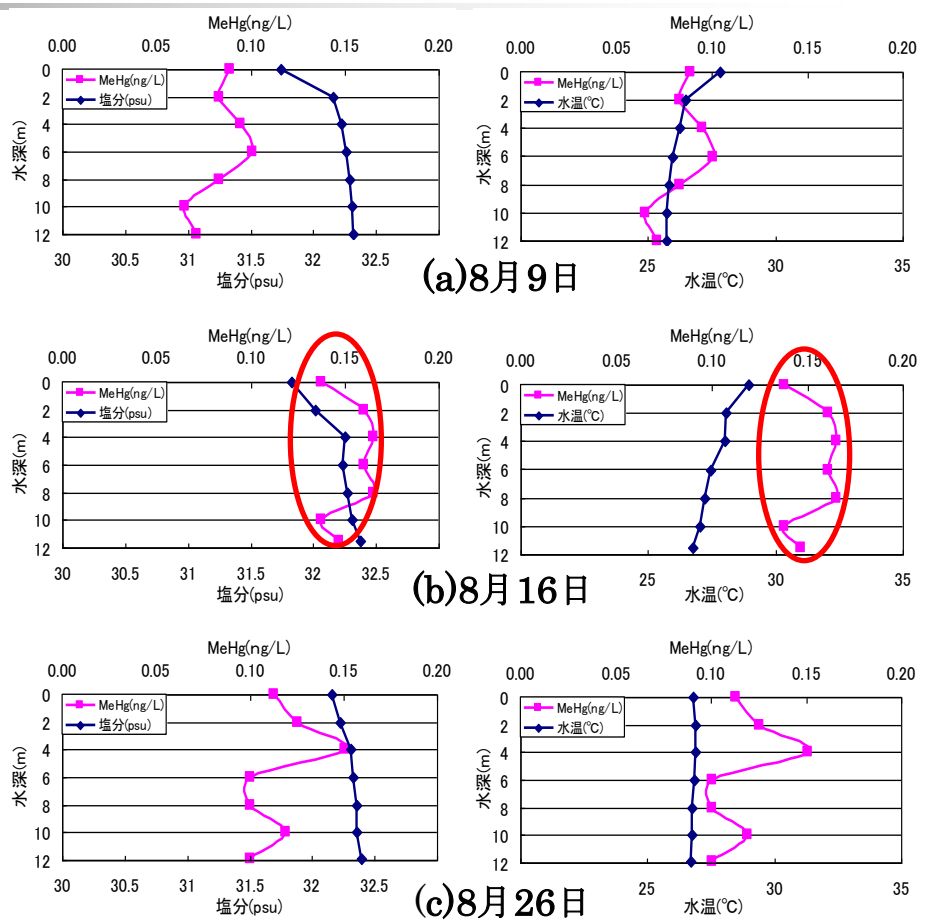
- It is important to reveal weekly changes of mercury in seawater during summer season with high accuracy.

・8月16日には、MeHg濃度が最も高くなっている。

- On the 16th of August in 2008, the concentration of MeHg in seawater became the maximum.

・全ての観測日において水深6mから8m付近でMeHgが最大となる。

- It was realized that the concentration of MeHg have gotten the maximum between a water depth of 6 m and the one of 8 m for whole data.



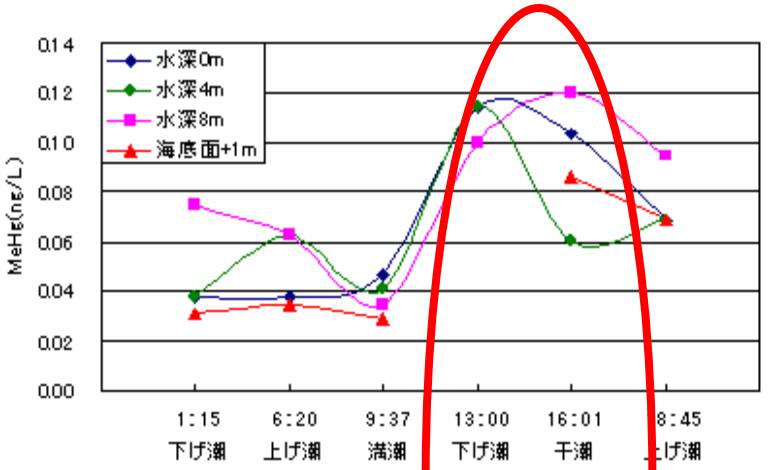
塩分およびMeHg
Salinity and MeHg

水温およびMeHg
Water Temperature and MeHg

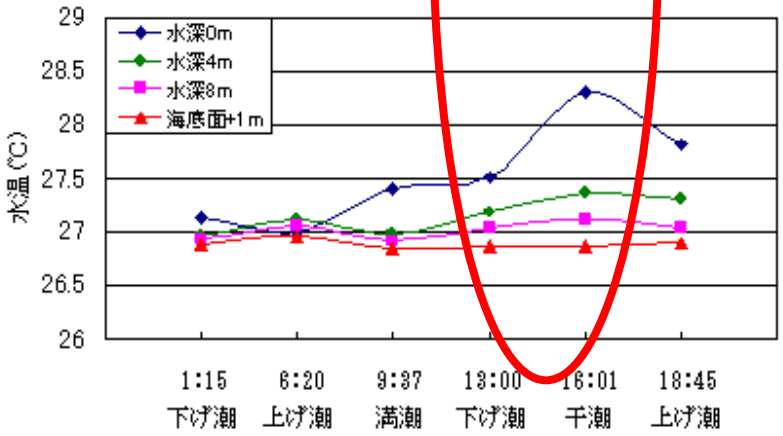
4.5 一潮汐間連続観測①;MeHgの日変化
Daily changes of MeHg at the observational tower

- 一潮汐間における水質動態と水銀濃度の日変化の把握
- **Moreover, it is essential to realize daily changes of mercury in seawater and water quality during the one cycle of tide.**

- 日射の影響を受け、水温が高くなる時間で、MeHgが最大に達している。
- **MeHg became the biggest values in the afternoon when water temperature has risen up due to the influence of sunshine.**
- 水温およびMeHgが、比例して上昇する傾向が推測できる。
- **It is obvious that the concentration of MeHg increases almost linearly with the increase of water temperature.**



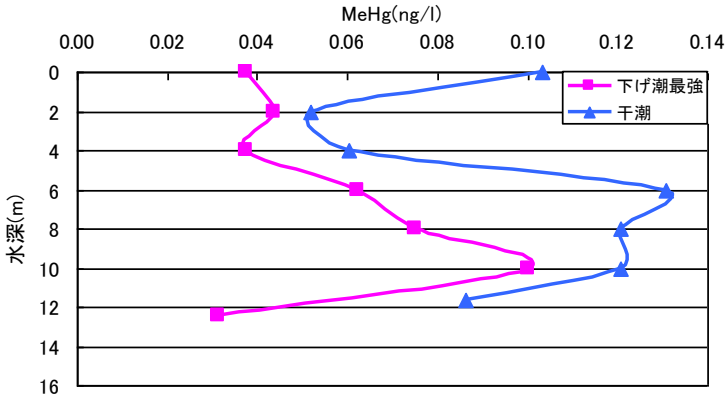
MeHgの日変化(Daily change of MeHg)



水温の日変化(Daily change of water temperature)

4.5一潮汐間連続観測②;MeHgの鉛直分布の日変化 Daily Changes of MeHg's Vertical Distribution

- 下げ潮最強時および干潮時;
- At the maximum current velocity of ebb tide & at the low tide;
- 上げ潮最強時および満潮時;
- At the maximum current velocity of flood tide & at the high tide;

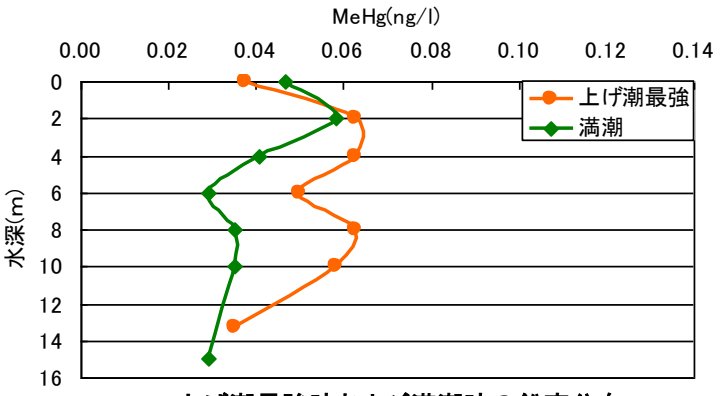


下げ潮最強時および干潮時の鉛直分布

MeHgの鉛直分布がほぼ類似している。

The former of MeHg's vertical distribution is almost similar to the latter of the one.

- 潮汐流が、MeHgの鉛直分布に及ぼす影響が推測される.
- It is suggested that tidal currents have an influence upon the vertical distribution of MeHg.



上げ潮最強時および満潮時の鉛直分布

- 一潮汐間の流動特性とMeHgの日変動を詳細に計測する 。
- It is necessary to compare vertical distributions of MeHg with the dynamic behaviors of tidal currents during the one cycle of tide.

5. 結論①(Conclusions)

■現地観測より、以下のことが明らかとなった。

According to felid observations, the obtained results are summarized as follows;

- 定期観測から、水俣湾内のMeHgと水温には高い相関関係を有する可能性があることが考えられる。
- The regular field observations suggest that there was a significant correlation of MeHg in seawater and water temperature in Minamata Bay.

- 夏季集中観測より、水温のピーク時にMeHgが最大になることが分かった。その深度は、温度躍層が認められる水深6mから水深8mの位置である。
- It was found out that the highest concentration of MeHg in seawater occurred at water temperature's peak between a water depth of 6 m and the one of 8 m, where there was a thermocline.

5. 結論②(Conclusions)

■今後の課題(Further Assignments)

水俣湾内の微量残留水銀の輸送機構を解明していく上では、流動特性および躍層近傍のメチル水銀の挙動を詳細に把握する必要がある。

・It is necessary for us to investigate a chemical reaction of MeHg (Methylation) near a thermocline in Minamata Bay.

・It is necessary for us to compare vertical distributions of MeHg with the dynamic behaviors of tidal currents during the summer season.

ご静聴有り難うございました！

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Thank you for your kind attention!

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Field Observations on Mercury Behaviors and Water Quality Dynamics in Minamata Bay

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3) Senior Researcher, National Institute for Minamata Disease

In Minamata Bay, the remediation works on water and bottom sediment environment have been carried out since 1977 by removing about 0.8 million m^3 of bottom sediment contaminated by mercury. As a result, the Governor of Kumamoto declared that the fish were safe in July 1997, and fishermen resumed fishing operations in Minamata Bay. However, the recent measurement result has shown that mercury is spreading along the eastern coast of Yatsushiro Sea from Minamata Bay (Tomiyasu et al., 2000). Although the measured concentration of mercury in bottom sediment is a trace of amount (< 3 ppm), prediction on mercury dynamics is necessary.

In order to elucidate the dynamic behavior of mercury in a coastal area, it is important to measure mercury transport in an actual sea accurately. Thus, we have been attempting to carry out the following field observations for water quality and mercury in Minamata Bay since 2006.

(1) Seasonal changes of mercury concentration in seawater and water quality were investigated at three stations in Minama Bay every month.
(2) Weekly changes of mercury in seawater and water quality were examined at an observational tower during the summer season in 2008.
(3) Daily change of mercury in seawater and water quality was measured at the tower every three hours on the 1st of September in 2008.

In other words, the vertical distributions of water temperature, salinity, Dissolved Oxygen (DO), turbidity, pH and so on were measured at not only three stations but also the observational tower in Minamata Bay by using water quality measurement sensors (JFE ALEC Co. Ltd., Model-AAQ1183) at the maximum current velocity of ebb tide. Moreover, water sampling was performed by a water sampler with water pressure meter (Diver 30 m, Eijkelkamp Co., accuracy: FS 0.1 %), which can monitor a sampling depth.

The obtained results are summarized as follows;

(1) There was a significant correlation of MeHg in seawater and water temperature in Minamata Bay..
(2) According to data measured in the observational tower, the highest concentration of MeHg in seawater occurred at water temperature’s peak.
(3) It was confirmed that the concentration of MeHg in seawater have gotten maximum value between a water depth of 6 m and the one of 8 m, where there was a thermocline, for whole observed data.

(Reference)

1)Tomiyasu et al.(2000):Mercury contaminant in the Yatsushiro Sea, south-western Japan : spatial variations of mercury in sediment, Sci. Total Environ. Vol. 257, pp.121-132.