NIMD Forum 2010
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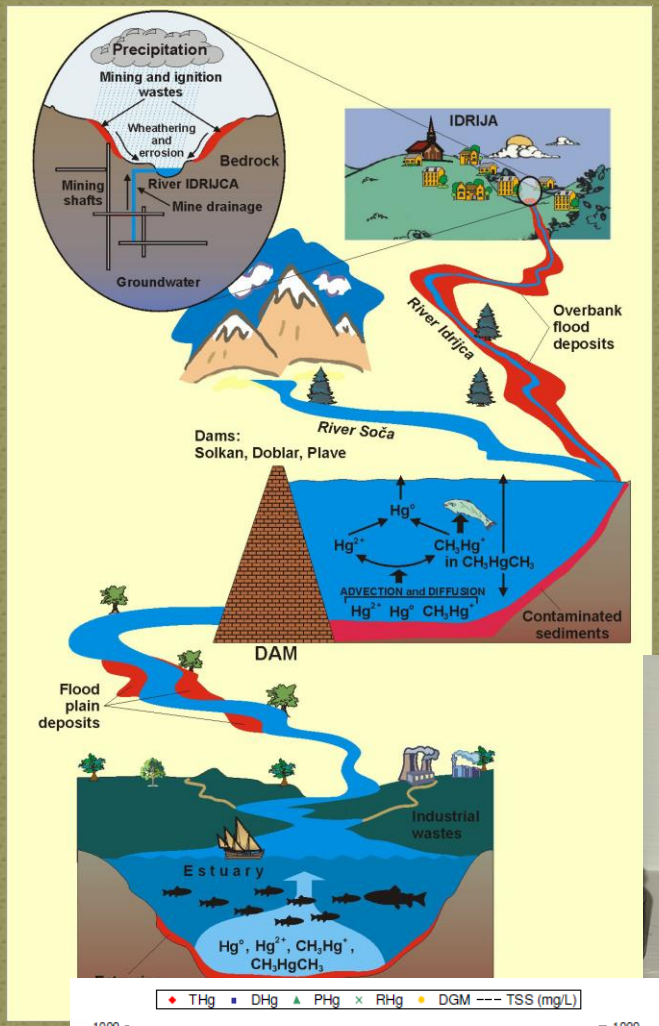
NIMD Forum 2010: A summary presentation

Steven J. Balogh
Metropolitan Council Environmental Services
St. Paul, Minnesota, USA

Broad themes and focus areas:

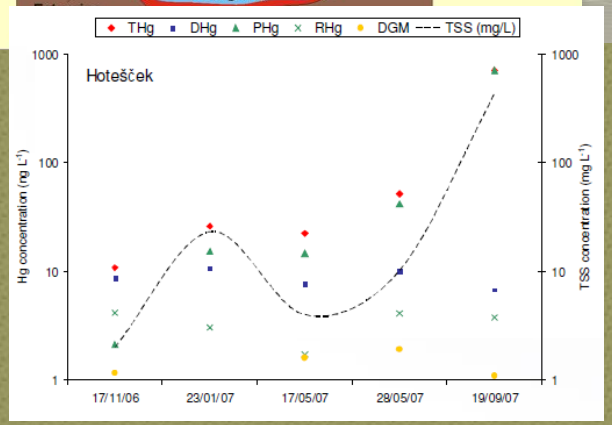
- *the consequences of Hg pollution for affected human communities and individuals*
- *the complexity of remediating Hg contaminated sites*
- *sources and cycling of methylmercury (MeHg) in coastal marine systems*

Minamata



- *a comprehensive, whole-watershed approach to understanding Hg pollution in Idrija and its dispersal in the watershed*

- *important identification of "hot spots," those areas that are contributing Hg to the Idrijca River and to the atmosphere at rates far beyond the mean*

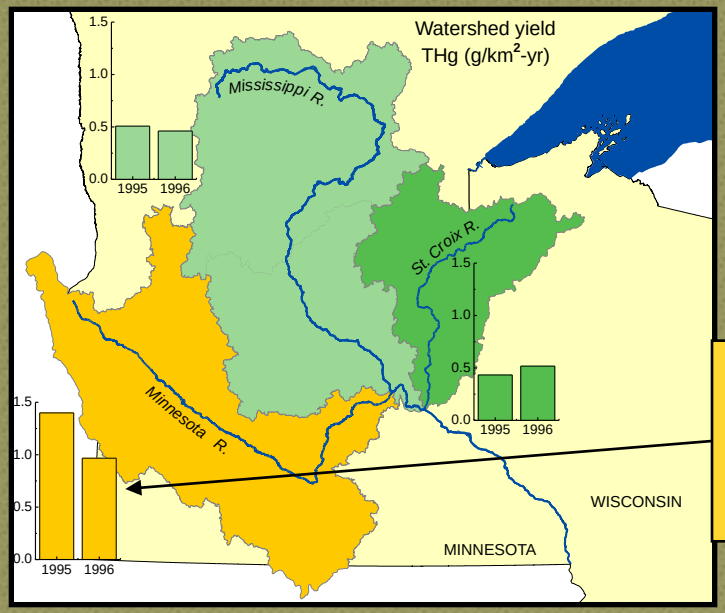


Storm events:

- THg concentrations up to 700 ng L^{-1}, > 99% bound to particulates
- suspended sediment from 10 up to 3000 mg L^{-1}
- riverbed erosion and transport of Hg enriched particles

- Important environmental controls on THg (and MeHg) in streams and rivers are: land use/cover, soils (wet vs. dry; organic vs. inorganic; fine grained vs. coarse), hydrology (flow paths, connectivity, drainage), climate (precipitation volume, intensity; temperature), topography.

Example of land use influence on THg export from watersheds: Much higher THg yield from areas of intensive row-crop agriculture

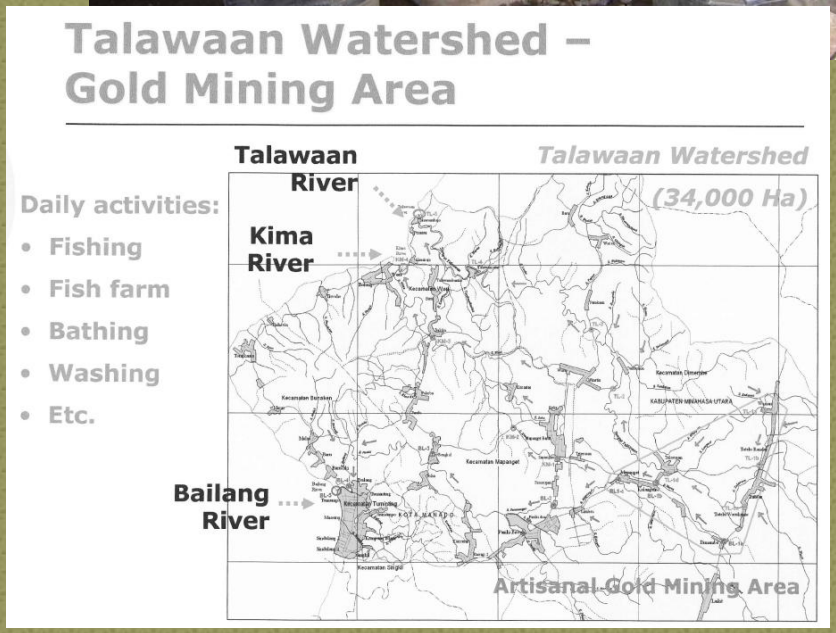


Soil enters streams from upland or bank erosion, carrying Hg with it

Characteristics of the watershed are important factors in determining Hg inputs to rivers and streams, and soil inputs from disturbed, contaminated landscapes during runoff events can deliver substantial amounts of Hg into streams, as was seen also in the Idrijca River.

from CETEM (2004)

- there is an economic incentive for local people to enter the gold mining trade

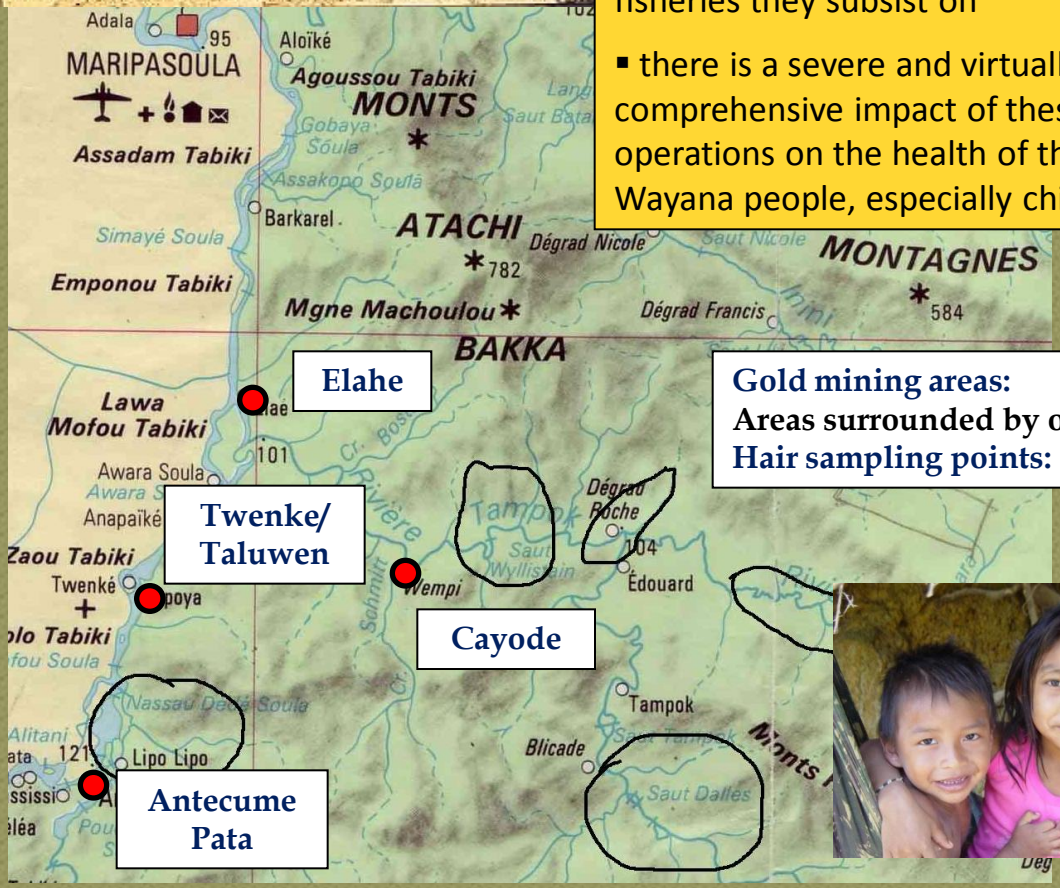


- but, in the process of making a living, the rivers and streams are contaminated, as are the fish the people eat

- *very high concentrations of total Hg and MeHg were observed in river sediments in the gold mining area, and widespread contamination was seen throughout the Talawaan watershed*

from Solidarité Guyane

- artisanal gold mining operations on the upper Maroni River follow a familiar pattern for these types of enterprises in Amazonia: severe soil displacement, heavily silted streams and rivers, Hg releases, and contamination of fisheries
- native Amerindians are being poisoned by Hg contamination of the fisheries they subsist on
- there is a severe and virtually comprehensive impact of these operations on the health of the local Wayana people, especially children



Gold mining areas:
Areas surrounded by open circle
Hair sampling points:

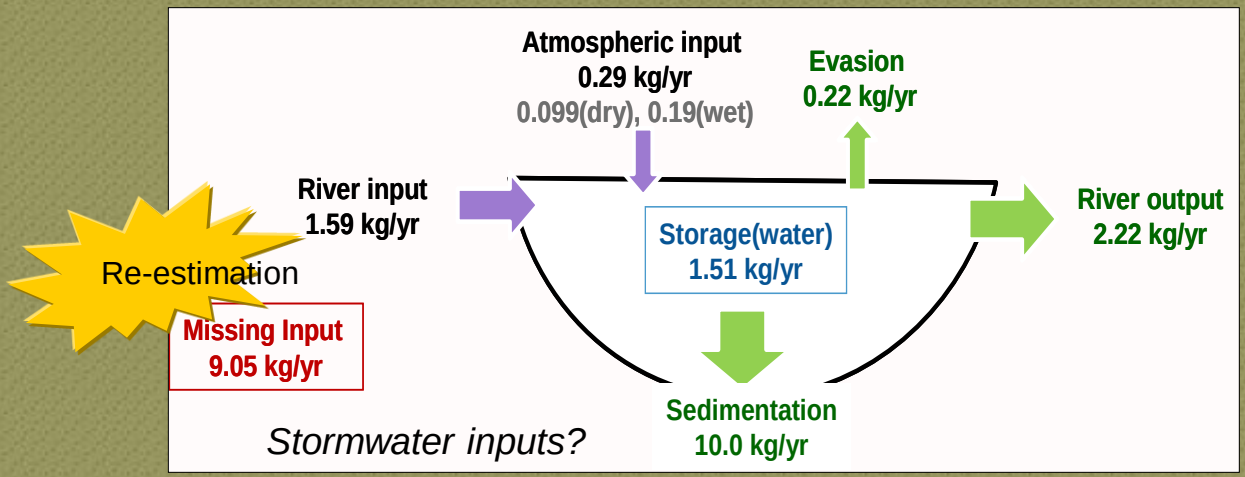
from Solidarité Guyane

Samples			Blood T-Hg (ng/g)	Percentiles			
				50 th	75 th		
Adult	Total (n=2,000)		4.34	4.65	6.89		
	Age	20-29	3.98	4.21	[illegible]	[illegible]	[illegible]
		30-39	4.18	[illegible]	6.68	6.21	10.69
		40-49	4.79	5.23	7.6	9.91	12.75
		50-59	4.52	4.82	7.22	9.73	12.52
		> 60	4.06	4.38	6.39	9.05	12.07
	sex	Male	5.01	5.33	7.98	10.16	12.75
		Female	3.76	4.03	5.98	8.03	9.77
Children	Total (n=2,000)		2.42	2.28	2.92	3.75	4.20

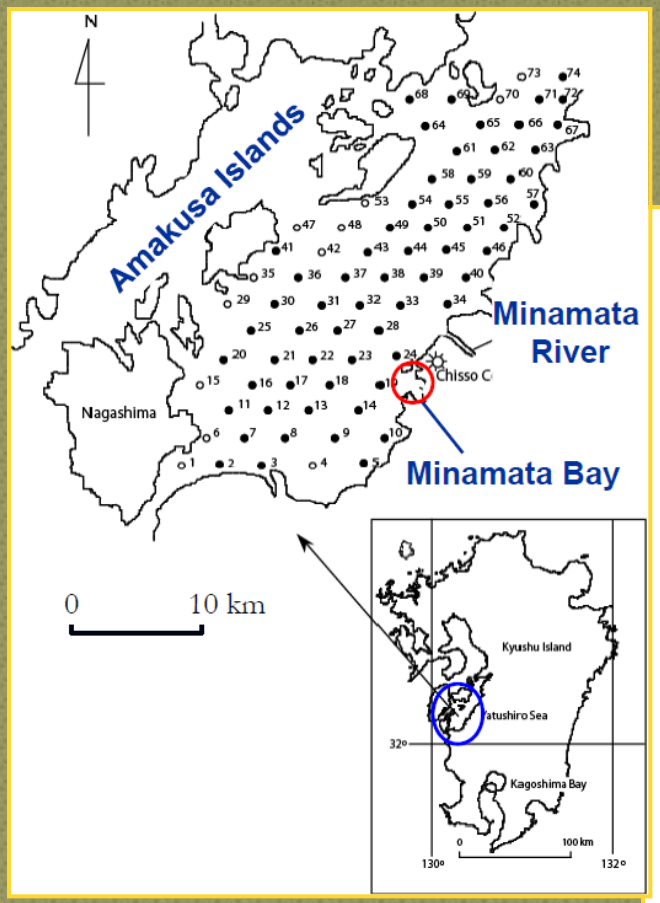
- ***high blood Hg levels***

- emission levels of Hg are relatively high, but concentrations of Hg in various environmental compartments don't appear to be remarkably elevated
- no "hot spots" can be immediately identified

Hg Mass balance of Lake An-dong



- *Intensive & long-term Hg & MeHg monitoring are needed to assess current status and to evaluate the effectiveness of Hg reduction policies.*



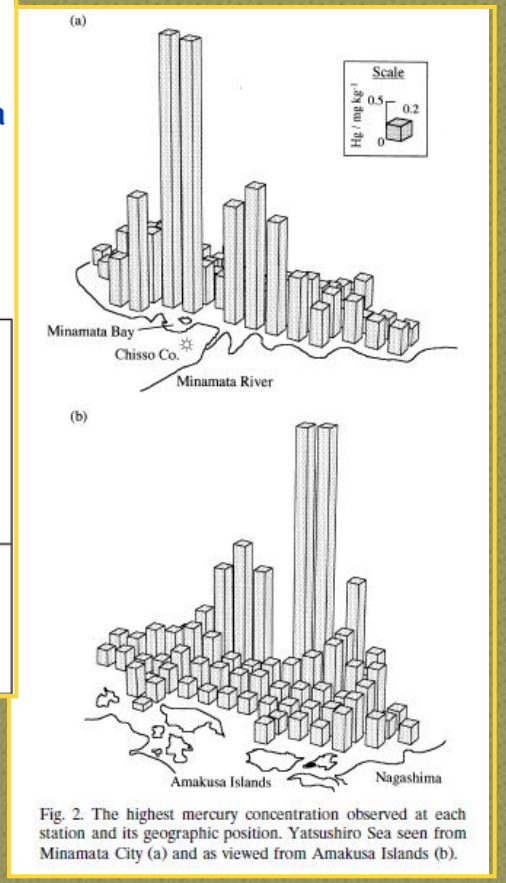
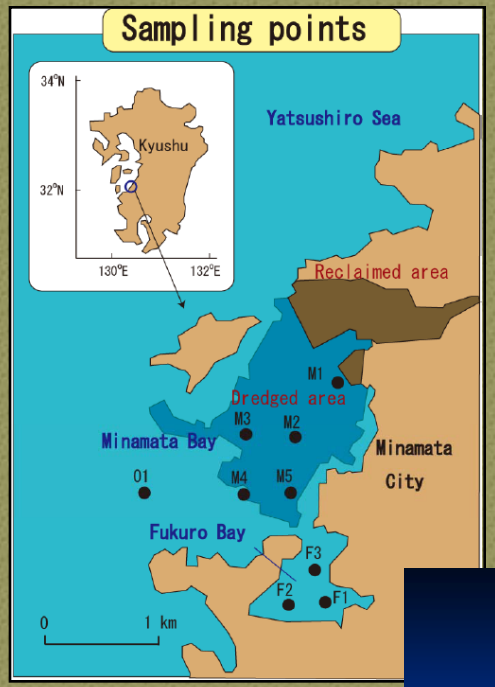


Fig. 2. The highest mercury concentration observed at each station and its geographic position. Yatsushiro Sea seen from Minamata City (a) and as viewed from Amakusa Islands (b).

- in the Yatsushiro Sea, the Hg-enriched sediment near Minamata Bay is still being redistributed (Tomiyasu et al., 2000)



Hg concentrations in sediment and ss

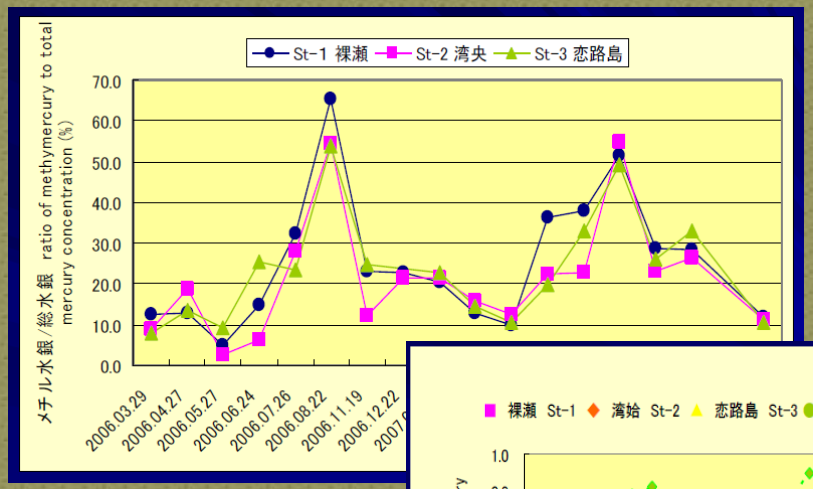
area	sediment T-Hg /mg kg^{-1}	sediment MeHg /ug kg^{-1}	sediment Me/T (%)
Minamata Bay	3.2±2.2	4.2±2.1	0.19±0.13
Fukuro Bay	4.5±1.1	16.6±16.6	0.39±0.41
Whole data	3.7±1.9	9.2±11.9	0.27±0.28

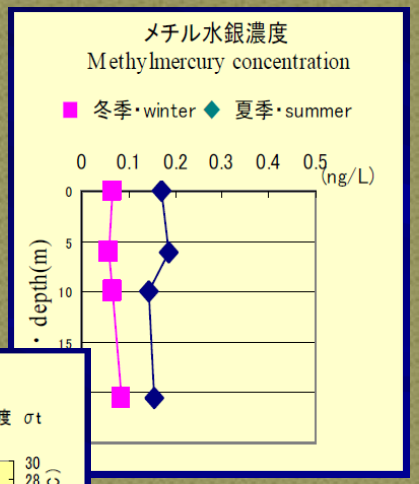
area	suspended particles T-Hg /mg kg^{-1}	suspended particles MeHg /ug kg^{-1}	suspended particles Me/T (%)
Minamata Bay	3.3±1.0	4.1±1.9	0.12±0.05
Fukuro Bay	6.0±1.4	14.1±12.8	0.26±0.24
Whole data	4.4±1.8	8.1±9.3	0.18±0.17

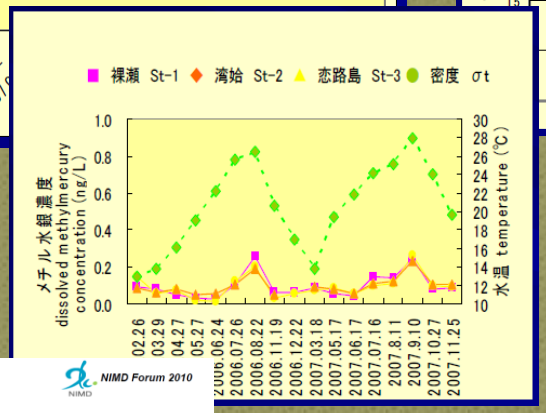
Hg concentrations in bottom water samples

	Oct. 2002						April 2005		
	clear layer			turbid layer			clear layer		
St.	T-Hg	MeHg	MeHg	T-Hg	MeHg	MeHg	T-Hg	MeHg	MeHg
	(ng L^{-1})		(%)	(ng L^{-1})		(%)	(ng L^{-1})		(%)
M1	1.7	1.0	62	9.8	2.9	30	0.9	0.6	62
M2	1.3	1.1	80	7.8	4.1	53	0.8	0.7	88
M3	3.3	0.3	10	9.3	1.2	13	-	-	-
M4	1.4	0.8	59	7.1	1.5	22	1.0	0.3	35
M5	4.3	0.5	12	22.3	5.2	23	-	-	-
F1	2.6	0.7	29	8.0	1.0	12	0.9	0.5	51
F2	1.5	0.9	60	7.4	0.8	10	1.6	0.3	17
F3	2.0	1.2	59	5.6	2.1	36	1.0	0.8	74
O1	2.6	1.7	64	7.1	1.3	18	-	-	-
ave	2.3	0.9	48	9.4	2.2	24	1.1	0.5	54
stdev	1.0	0.4	25	5.0	1.6	14	0.3	0.2	26

- *MeHg is produced in the sediments of Minamata Bay*
- *MeHg is preferentially released ("eluted") from sediment particles mobilized into the water column*

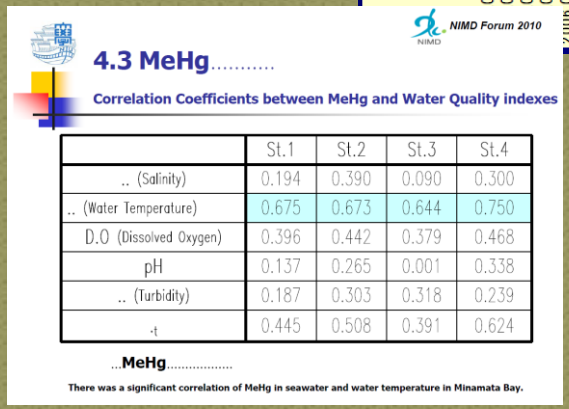


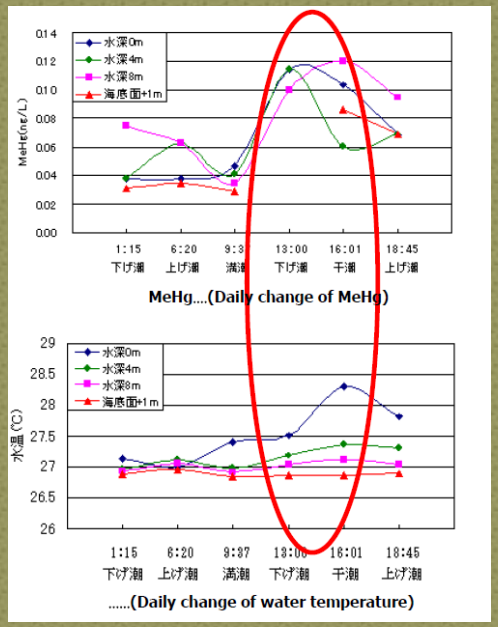




- *MeHg concentrations in Minamata Bay vary seasonally*

- *higher MeHg concentrations and %MeHg are observed in the summer*





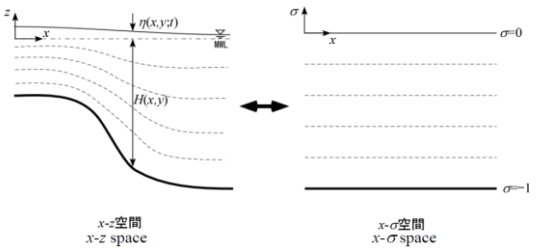
- MeHg concentrations in the water column are strongly correlated with water temperature

DELFT3D:

- σ-grid in the vertical.σ-....
- highly resolved horizontal grid.....
  (0.1° x 0.1° app.Δx=250m)
- sub-grid scale model: horizontal.....
- k-ε turbulence model: vertical .k-ε.....
- tidal flat: dry-wet process.....
- hydrostatic approximation .....
- f-plain approximation.f .....
- forcing with 40 tidal constituents.40.....

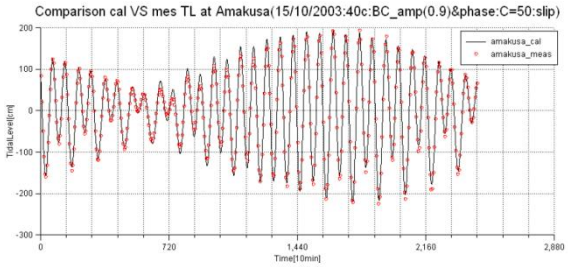
Development of a numerical model for mercury fate in the coastal environment

σ-grid system: σ-.....



$$x^* = x,\ y^* = y,\ t^* = t,\ \sigma = \frac{z-\eta(x,y,t)}{H(x,y)+\eta(x,y,t)} = \frac{z-\eta}{D}$$

- *new 3D model accurately predicts tidal levels*



- further datasets.....

-bottom sediment features (ex. grain size distribution, critical shear stress, etc.)
:.....

-discharge of B-class rivers around MB
:.....

-relation between mercury concentration and grain size of sediment
:.....

-precise bathymetry in MB
:.....

-measured current data in YS
:..... etc.

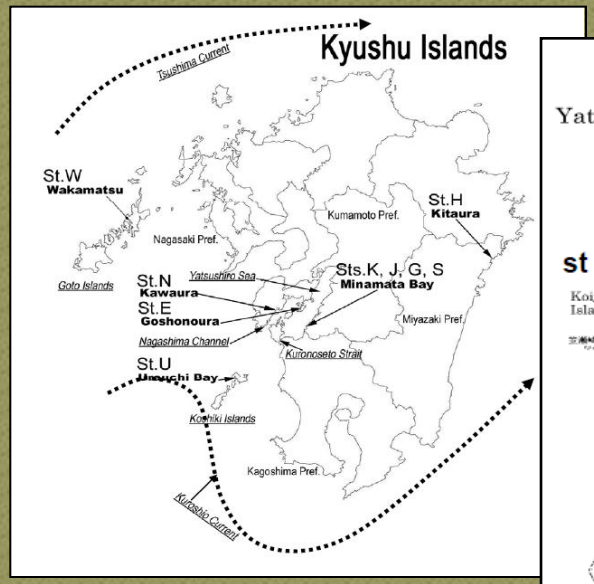
- *more data is needed, both as inputs to the model and as test-sets for model evaluations*

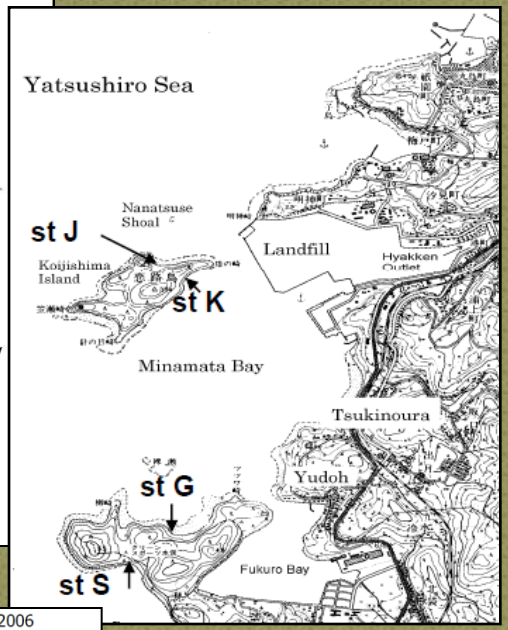
- further knowledge.....

- governing methylation/de-methylation process in MB
- effects of salinity, temperature, SS, light condition, etc?
  :.....
  .....
- exchange rate of mercury between sea and air
  :..-.....
- mercury process in pore water in bottom sediment
  :.....

etc.

Interdisciplinary collaborations: .....

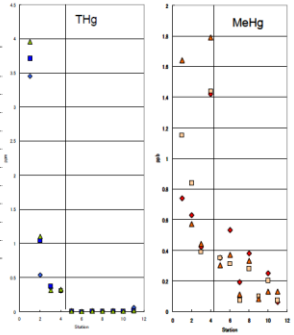




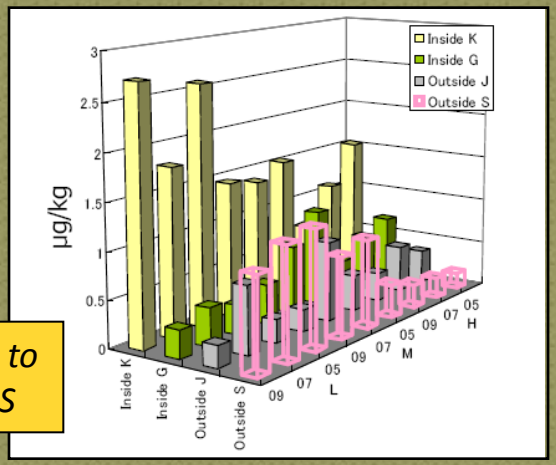
Difference of mercury concentration levels among stations in 2003 - 2006

	THg ng/g			MeHg ng/g		
'1. st K''	3452.2	3708.3	3953.3	0.74	1.15	1.64
2. st G	540.6	1039	1101.6	0.63	0.84	0.57
3. st J	344.4	374.4	314.3	0.42	0.39	0.44
4. st S	307.8	305.7	327.6	1.42	1.44	1.79
5. st E''	11.1	7.8	9.9	0.35	0.35	0.3
6. st N''	2.1	2.4	2.3	0.53'	0.31'	0.37'
7. st H''	10	9.1	8.2	0.19	0.07	0.11
8. st U''	4.8	5.6	5.2	0.38	0.28	0.33
9. st Wa''	13.7	5.4	4.8		0.1	0.08
10. st Wb''	5.9	5	4.4	0.25	0.2	0.13

Difference between values in Minamata Bay and control stations are significant ($p<0.01$**) for THg.
As an exception, MeHg in st N indicated $p < 0.05$*.

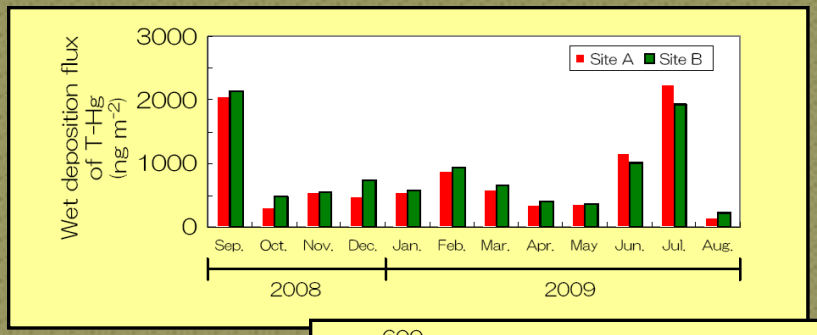


- *Hg-contaminated sediments of Minamata Bay are migrating out of the bay and being stranded in the inter-tidal zones on shores outside the bay*

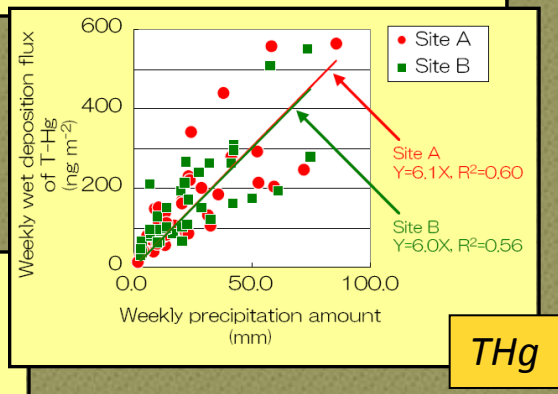


- *MeHg production is higher in low- to mid- inter-tidal areas at sites K and S*

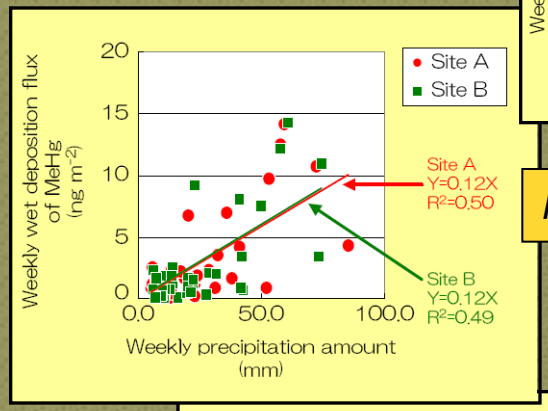
- *wet deposition flux of total Hg to Minamata Bay increased during the rainy season*



- *wet deposition fluxes of total Hg and MeHg are dominated by precipitation scavenging of atmospheric gaseous species*

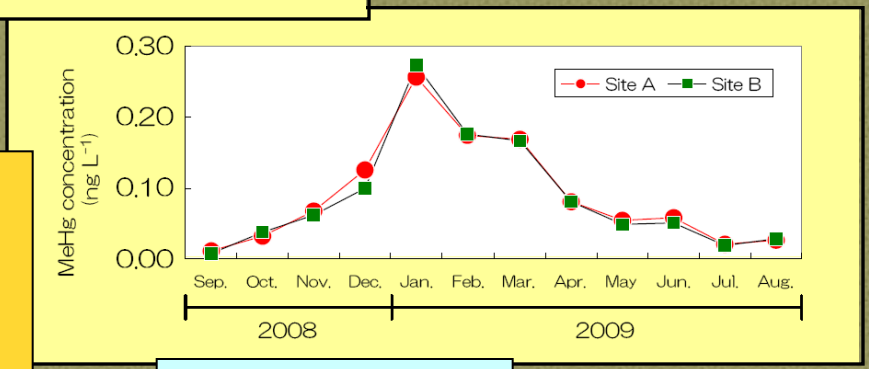


THg



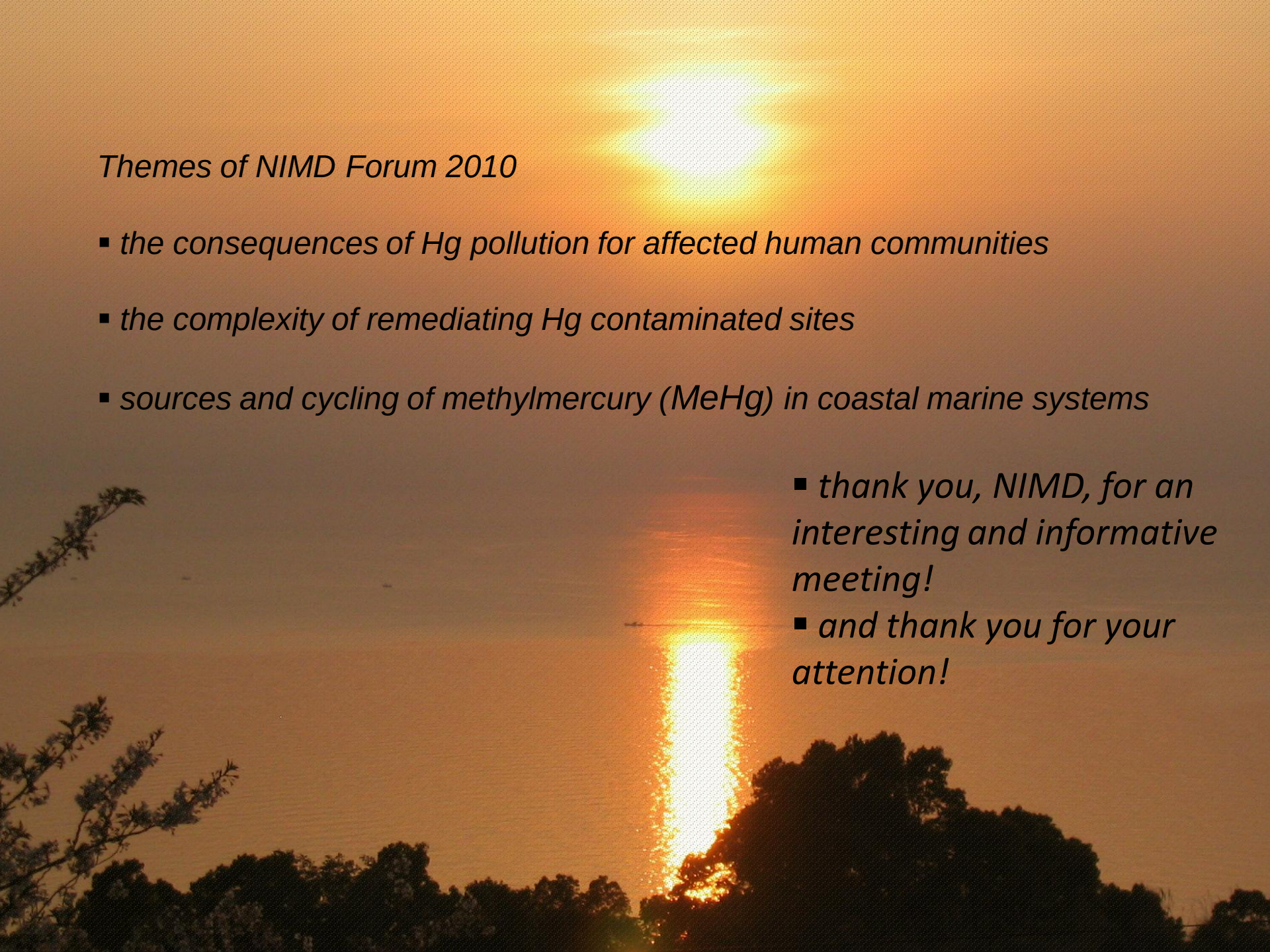
MeHg

- *first data in Japan for wet deposition of MeHg*



- concentrations and wet deposition fluxes of MeHg were higher in winter than in summer

- role of DOC?



Themes of NIMD Forum 2010

- *the consequences of Hg pollution for affected human communities*
- *the complexity of remediating Hg contaminated sites*
- *sources and cycling of methylmercury (MeHg) in coastal marine systems*

- *thank you, NIMD, for an interesting and informative meeting!*
- *and thank you for your attention!*