Spatial variability of trace metals concentration in different mussel species from coastal areas of northwestern Pacific Ocean

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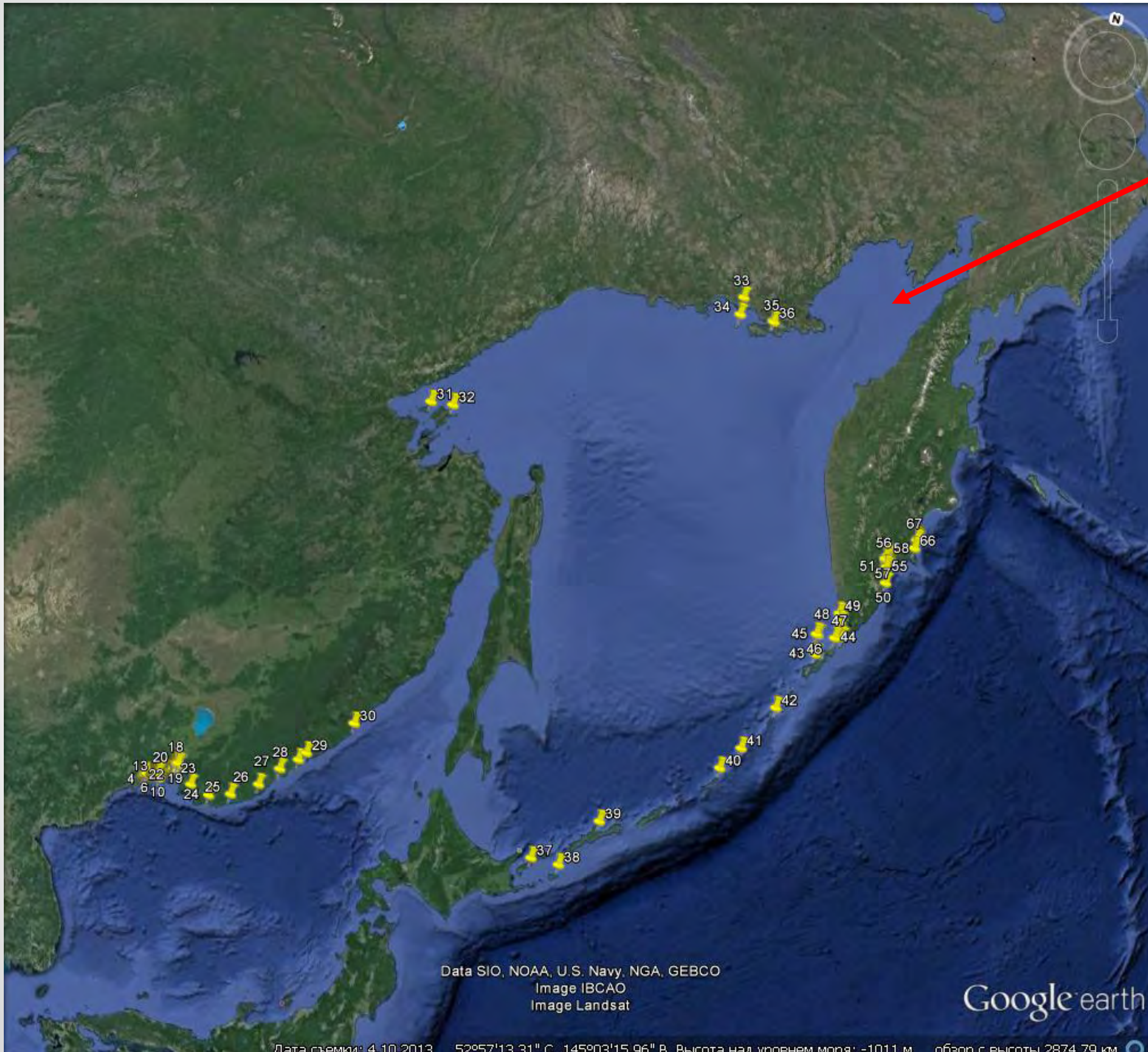
Outline

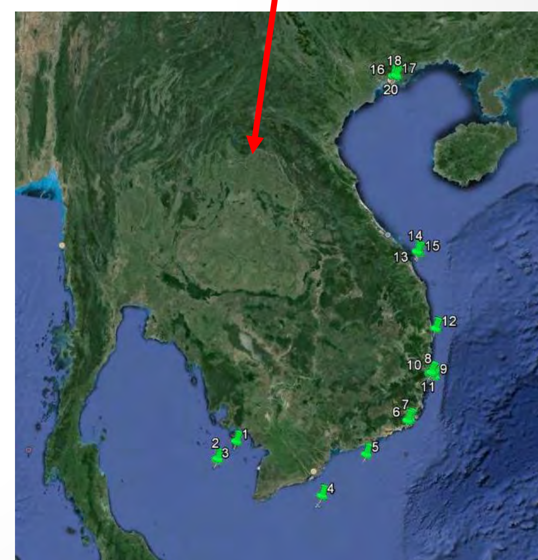
- **Introduction**
- **To analyze spatial variability of the trace metals concentration (Zn, Cu, Pb, Cd, Ni, Mn, Fe) in the soft tissues of *Mytilus trosulus* from the Sea of Japan, Sea of Okhotsk and east coast of Kamchatka;**
- **To examine spatial variability of the trace metals in the soft tissues of mussel *Septifera bilocularis* from the coastline of Vietnam;**
- **To compare, boreal, and tropical coastal areas by the features of trace metals concentration in mussel species and outline possible controlling factors;**

Introduction

- **Widespread distribution, sedentary nature, ability to concentrate pollutants and resistance to their action make Mytilidae suitable bioindicator of pollution.**
- **There are several large scale programs collecting data on the concentration of pollutants in bivalves.**
- **Last years shift in MWPs was occur to the study of flame retardants, pharmaceuticals, and pesticides, but trace metals (Cd, Cu, Pb, Ag, Hg) continue to be in the list of pollutants.**
- **Analysis of natural spatial variability of the trace elements concentration in mussels is a prerequisite of their usage for the monitoring.**
- **Another topic is study of interspecies variation of the trace metals concentration in respect to the use of new species of mussels as biomonitor.**

Study areas

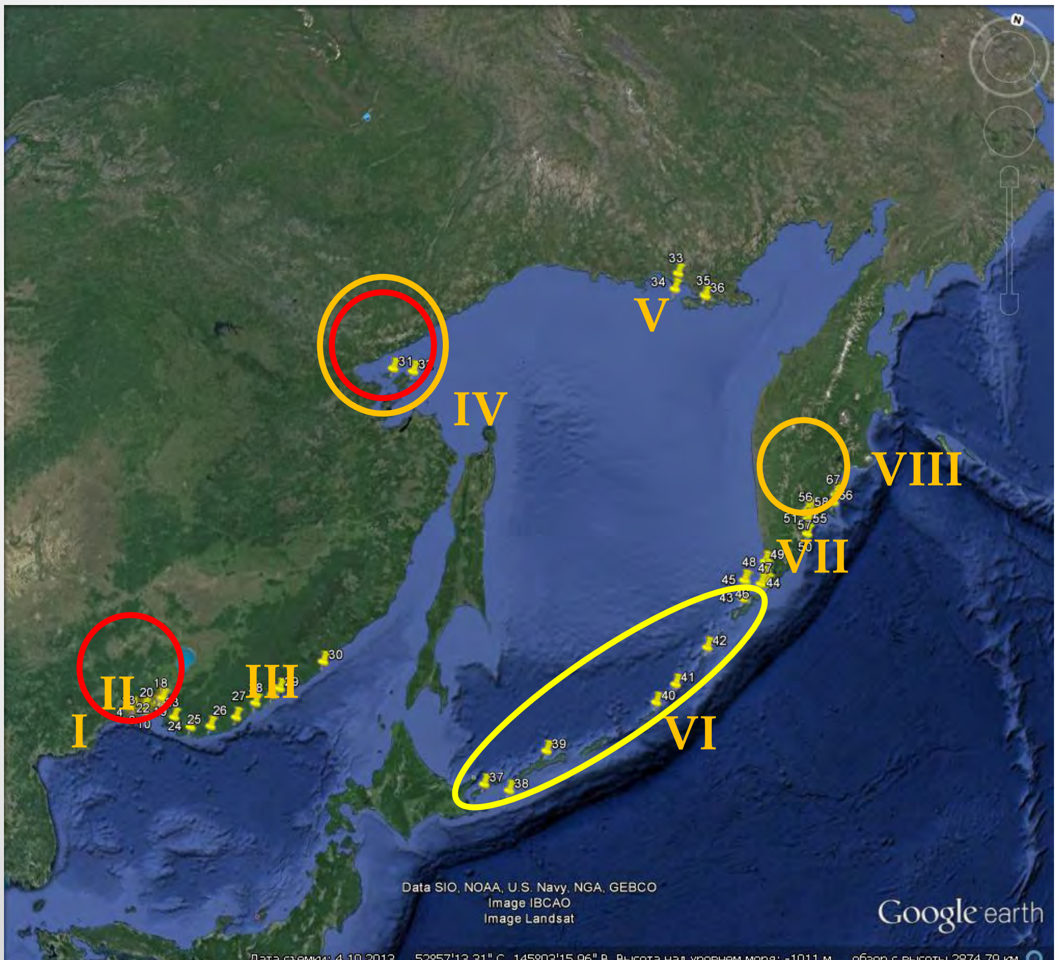

Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image IBCAO
Image Landsat
Google earth
Дата съемки: 4.10.2013 52°57'13.31" С 145°03'15.96" В Высота над уровнем моря: -1011 м обзор с высоты 2874.79 км

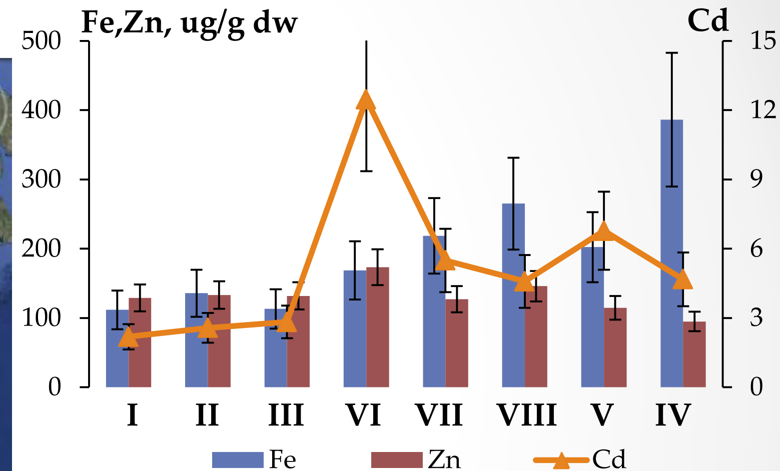


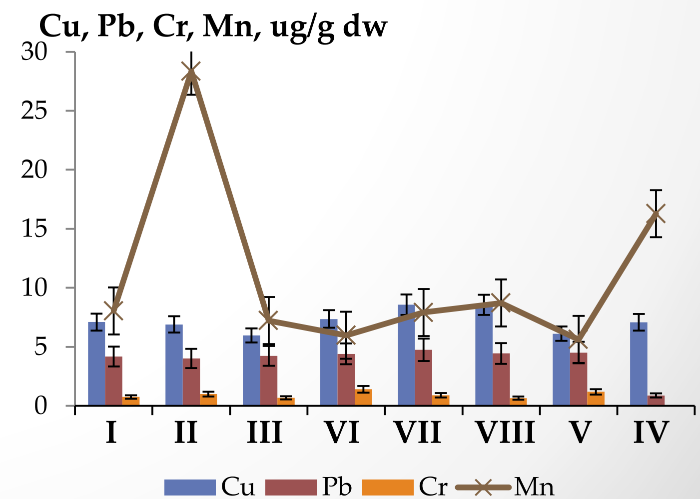
Materials and Methods

- **68 stations from 8 subregions along the coast of Sea of Japan, Sea of Okhotsk and east coast of Kamchatka were sampled in summer time of different years;**
- **21 stations along the coast of Vietnam from the Siam Bay to the Halong Bay were sampled in May 2013;**
- **At each station 5-10 mussels of the similar size and with similar condition index were sampled at 1-5 m depth and analyzed as separate subsamples after 2 days depuration in the ambient water and acid digestion of the soft tissues;**
- **AAS methods with flame and graphite furnace atomization was used for the determination of metal content in the mussel tissues with analysis of SRM 2976 (Mussel tissues) and NIST 1566 (Oyster tissues) for QA/QC;**

Spatial variability of metals concentration in *Mytilus trossulus* from the northwestern Pacific



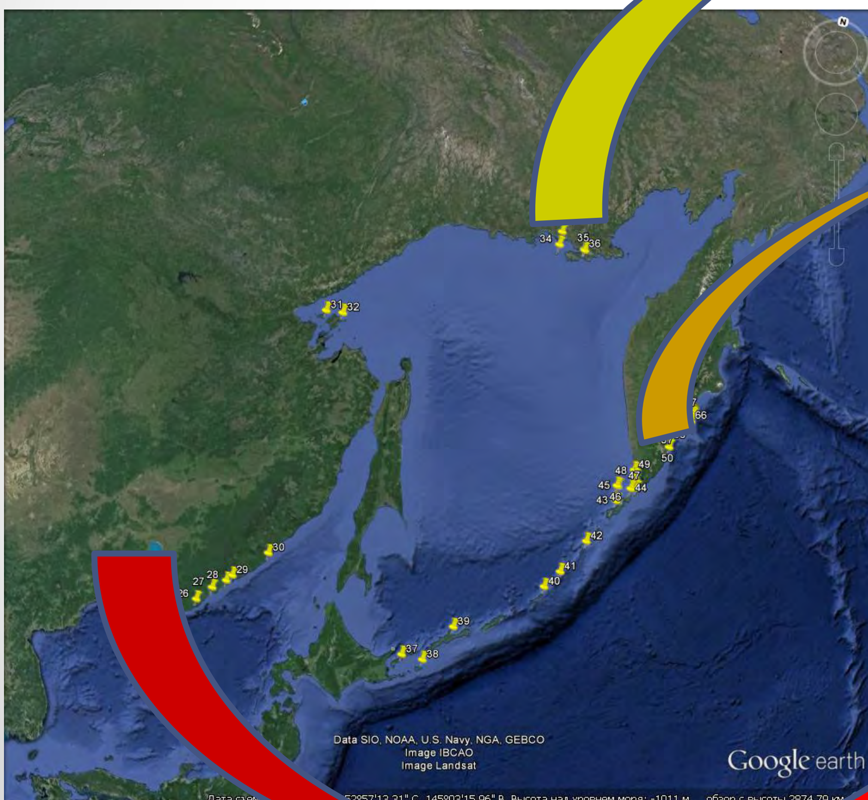




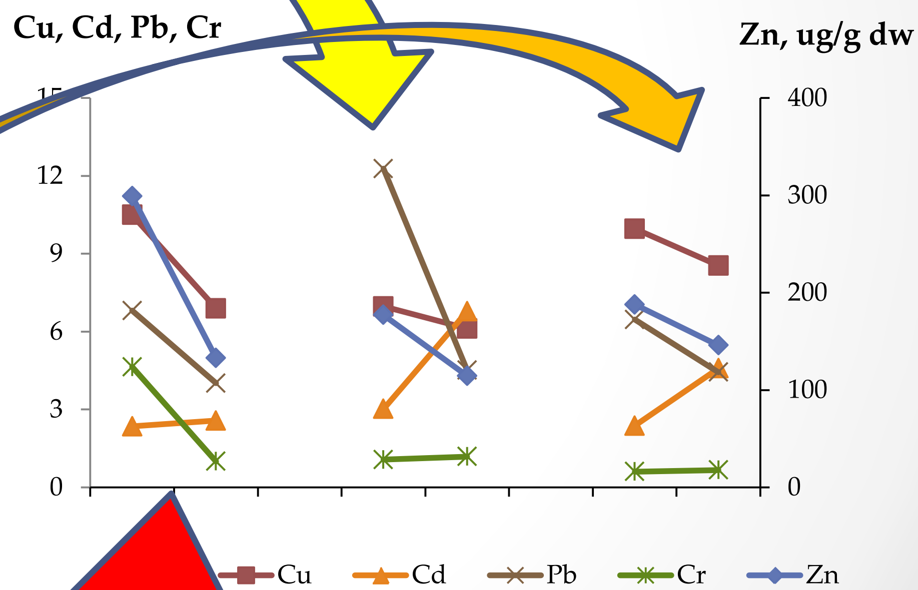
Anthropogenic influence on the metals concentration in *M.trossulus* from the northwestern Pacific

K_{Zn} = 1.3-2.2; K_{Pb}= 1.5-2.7;
K_{Cu}= 1.1-1.5; K_{Cr}= 0.9- 4.6
K_{Cd}=0.4-0.9

Magadan Port



Avacha (Seroglazka) Port



Vladivostok Port Area

M.trossulus: Anthropogenic influence vs Natural variability

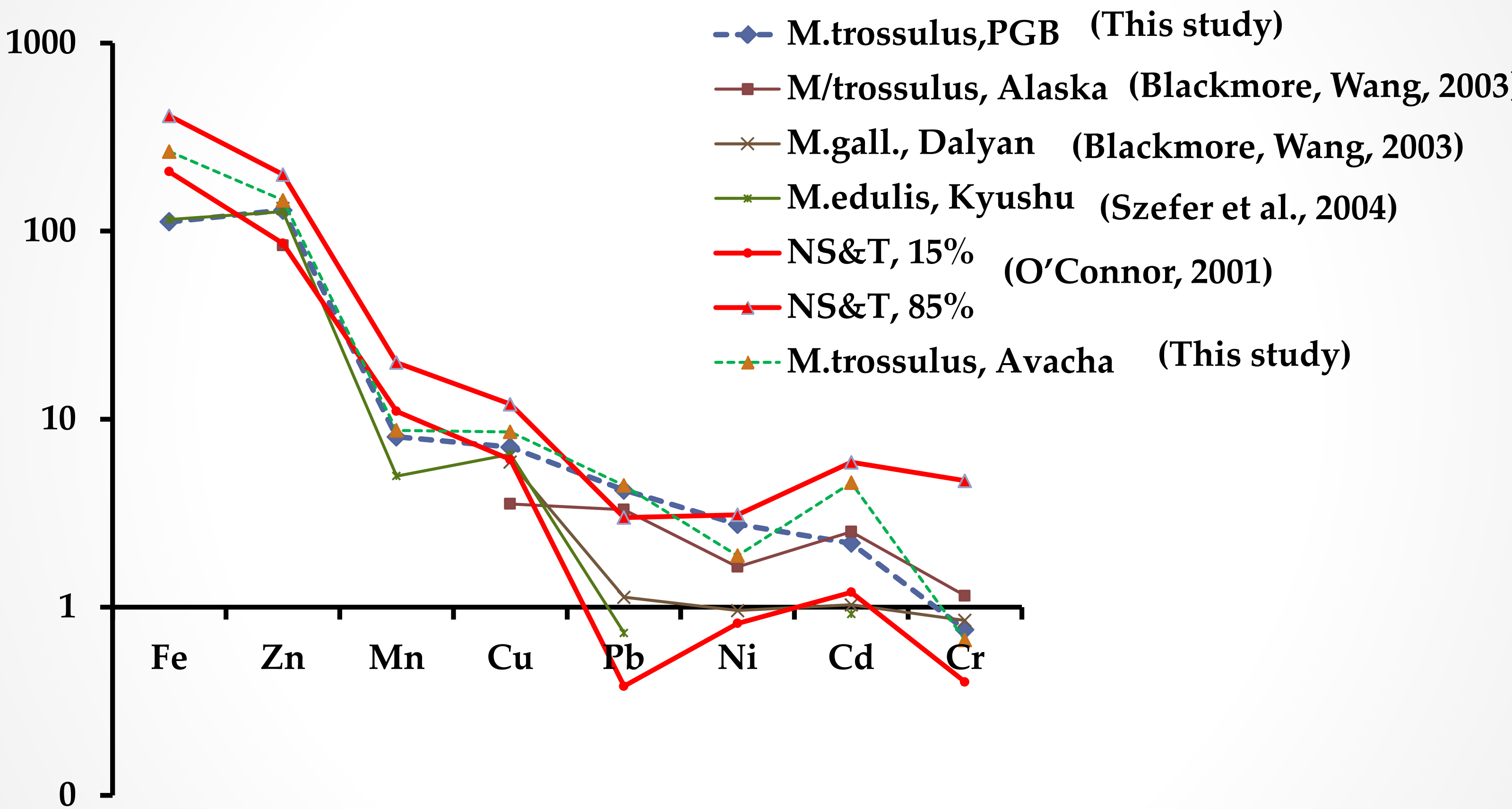
Natural reasons ?

- Cd enrichment of mussels from Kuril Is. with K_{Cd}= 5.7 in average, and from Okhotsk Sea - with K_{Cd}=2.1-3.6;
- Fe enrichment of mussels from the northern parts of the region with K_{Fe}=1.9-3.4;
- Mn enrichment with K_{Mn}= 2.0-3.5 of mussels from the areas with most probable river runoff influence (Amursky Bay and Shantar Is.)

Anthropogenic pressure?

- The absence of Cd accumulation;
- The accumulation of Zn and Pb with K= 2.2-2.7 in the mussels sampled in the areas of port facilities;
- The natural variability of the metals concentration in the soft tissues of M.trossulus exceed the influence of the human activities outside the “hot spots”

The interspecies features of metals concentration in soft tissues of *M.trossulus*



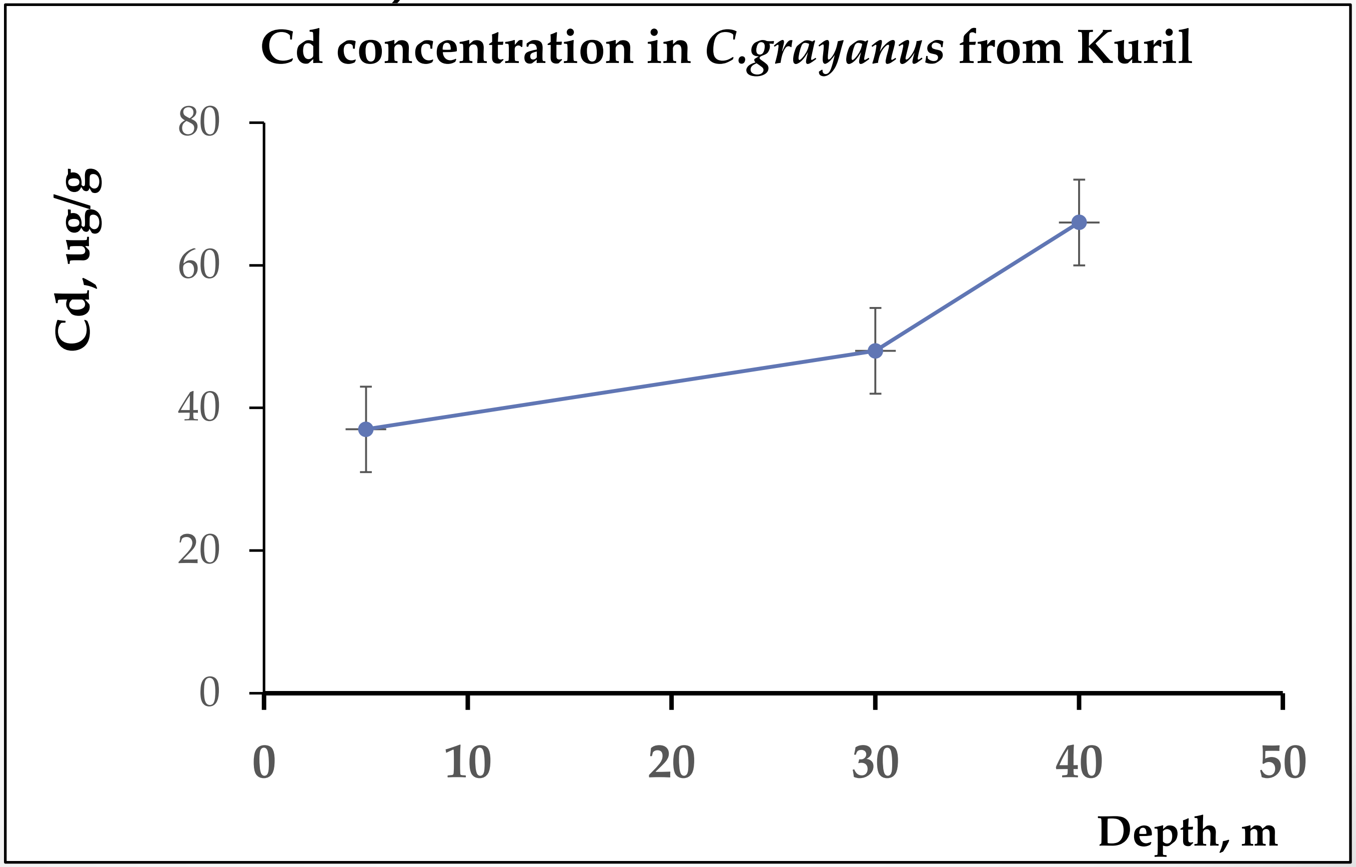
In western Pacific *M.trossulus* off the areas with elevated Cd and Fe concentrations is close to other mussels from the boreal waters around the World

Cd accumulation in *M.trossulus*

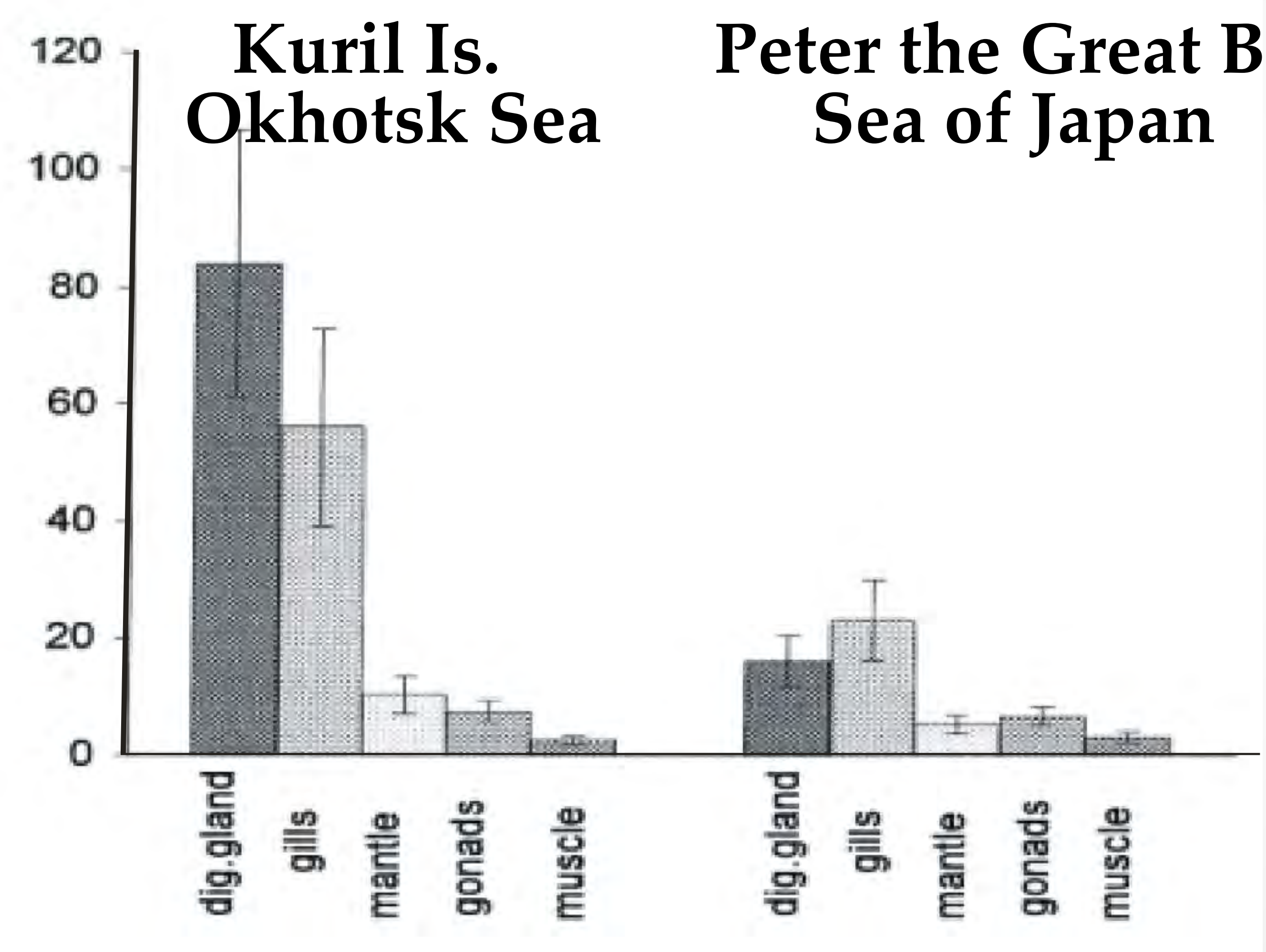
- MWP NS&T found Cd median in mussels around USA from **3.2** to **2.1** µg/g during 1986- 2003 (O'Connor, 2006);
- Anthropogenic press can lead to Cd increase in mussels up to **4-8** µg/g only above background 0.5-1.0 µg/g (Chiffoleau et al., 2001);
- Cd increase in *M.californianus* from **4-6** µg/g to **16-18** µg/g due to upwelling was registered along Pacific coast of Mexico (Lares et al., 2002).
- Cd in *M. galloprovincialis* from the west coast of Cape Town has mean **6.2** µg/g (Sparks et al., 2014) and upwelling influence can not be excluded;
- Kuril Is. – **12.5** ± 11.9 µg/g

The upwelling is a possible reason of the Cd accumulation in *M.trossulus*

- In tissues of long-lived mussel *C. grayanus* from the Kuril Is. Cd accumulates up to 37-66 µg/g and direct connection with sampling depth is observed (Kavun et al., 2002)

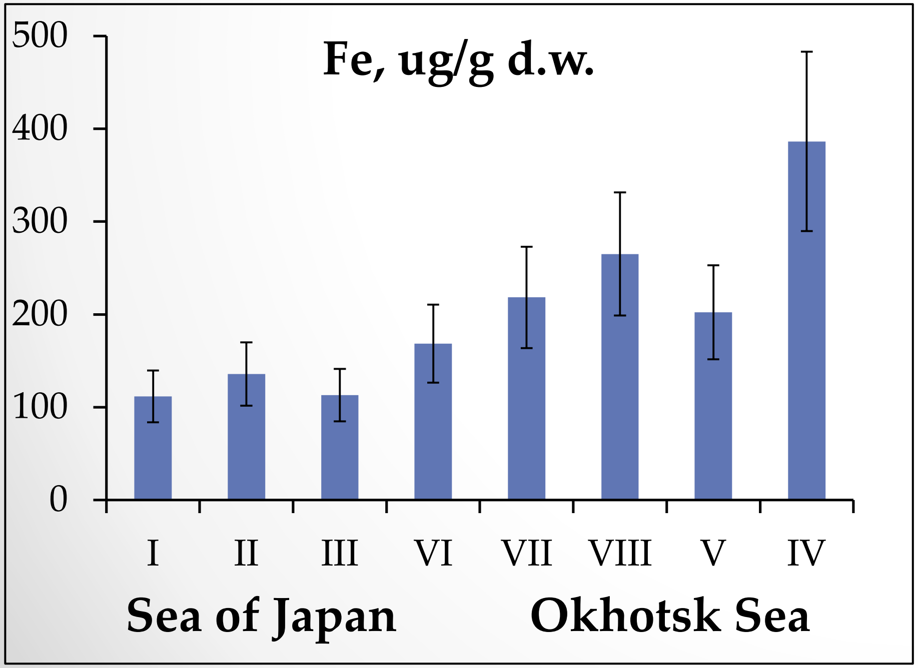


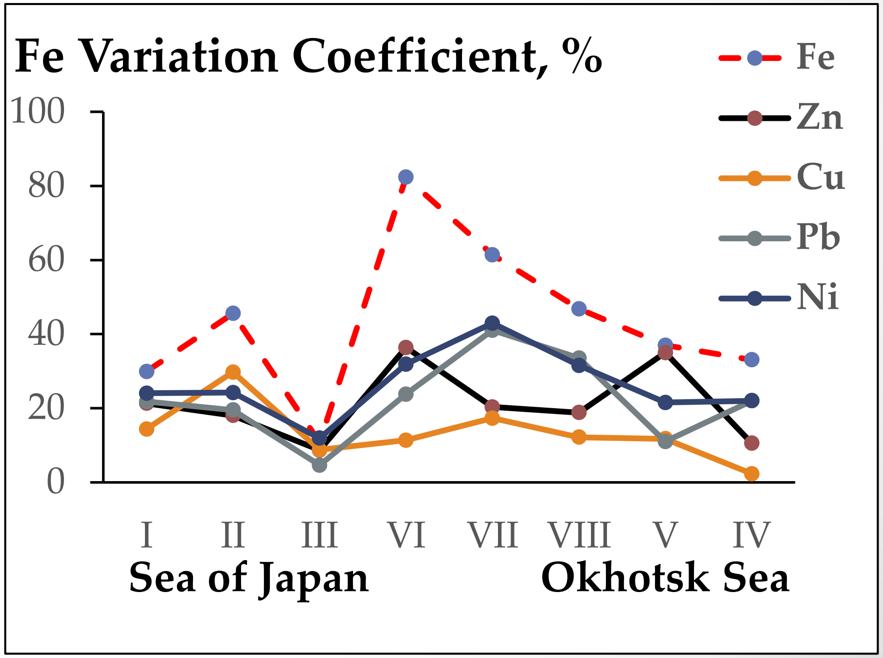
Cd distribution among organs of mussel C.*grayanus* from Kuril Is. and Peter the Great Bay (Sea of Japan) (Kavun et al., 2002)



The reasons of increase trend of Fe concentration northward

- **Increase trend of Fe concentrations in *M.trossulus* from the Sea of Japan to the Okhotsk Sea and Bering Sea coasts was accompanied by the increased variability of Fe compare with other metals;**

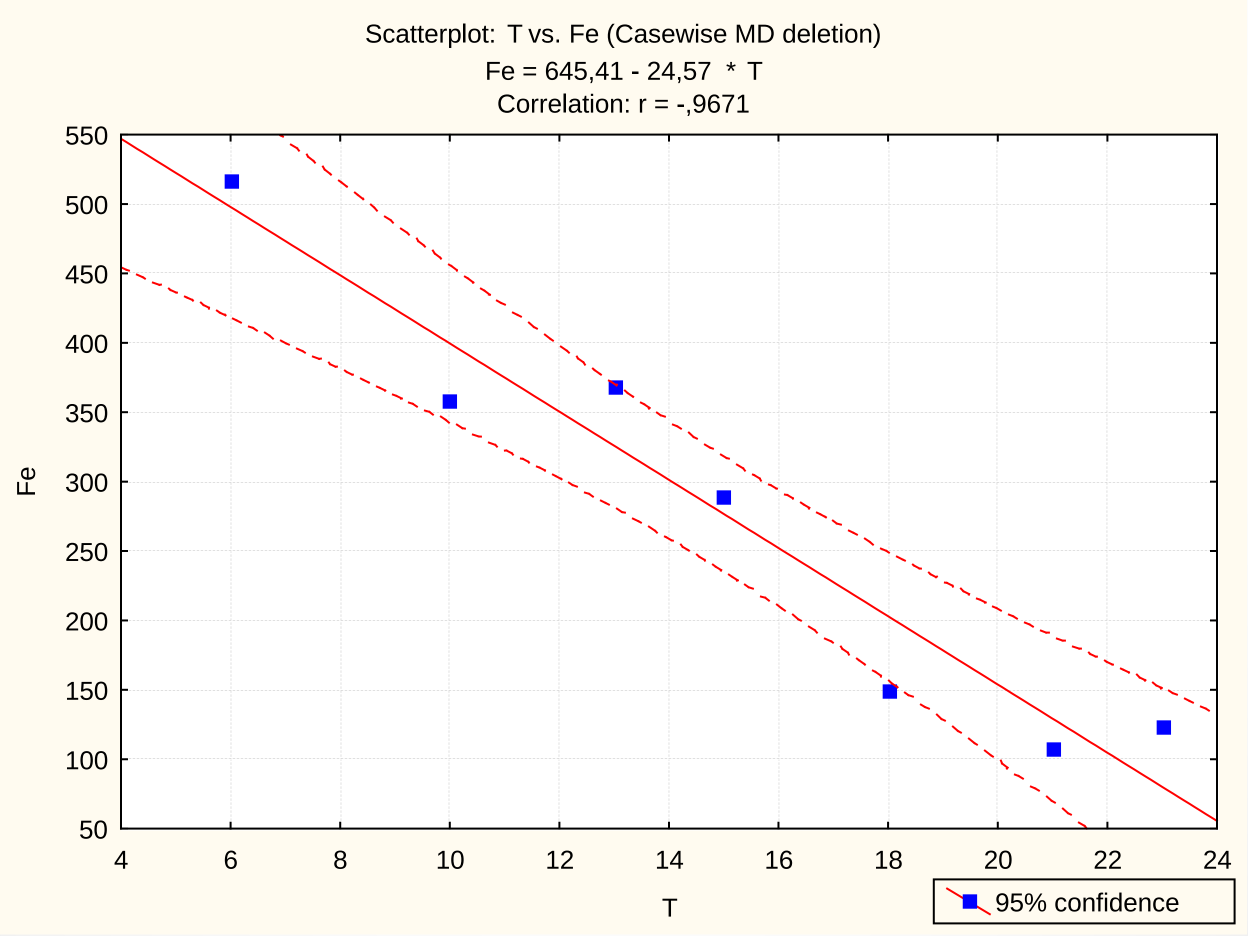




- **The diet and Fe content in the environment are the main factors controlling the Fe accumulation in mussels (Eisler, 2010);**

- **Diminished Fe concentrations in mussels from "clean" subareas I and III (outer part of Peter the Great Bay and open northwestern coast of the Sea of Japan) are in accordance with it;**
- **Enhanced and maximum variable Fe concentrations in mussel from Kuril Is (subareas VI) where some stations are under direct influence of volcanic activity, are also reasonable;**
- **But significant increase of Fe concentrations in mussels from the cold waters of Magadan, Shantar Is., and Kamchatka areas compare with mussels from Amursky Bay at the similar elevated level of Fe in the waters need explanation**

The negative correlation between Fe concentration in mussels and water temperature during sampling period



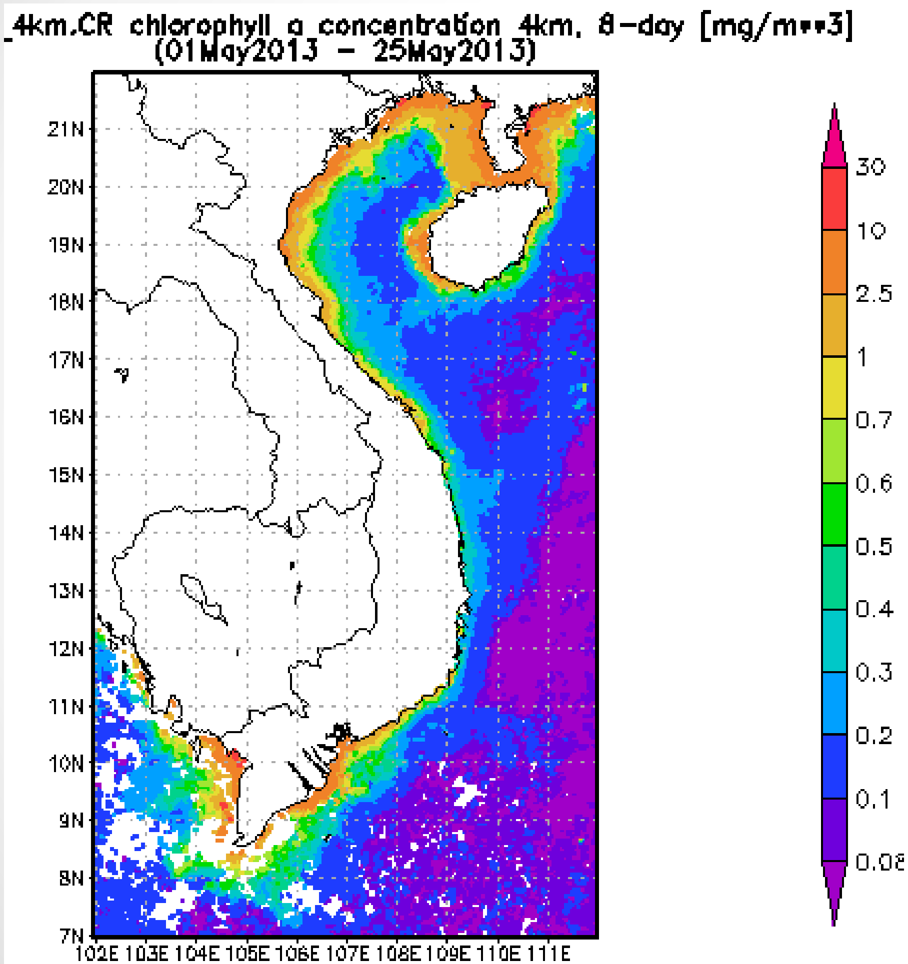
Summary on *M.trossulus*

- **Natural levels of Zn, Cu, Pb, Ni and Cr concentration in *M.trossulus* are rather equal along all coasts of NW Pacific and similar to other short-living mussels;**
- **Therefore *M.trossulus* can be used successfully as biomonitor for these trace metals in this region;**
- **Cd shows significant and logical natural spatial variability: in the areas under upwelling influence Cd in mussels is increased up to the level several times higher than in the severe polluted localities;**
- **Natural variability of Fe in the *M.trossulus* is also logical: there is clear increase trend from the Sea of Japan to the Okhotsk Sea and Kamchatka coast;**
- **More effective regulation of Fe uptake and release at the south of boreal zone could be one of the probable reason.**

Spatial variability of metals concentration in mussel *Septifera bilocularis* from the Vietnam coast

- **Mussel *Perna viridis* living in the muddy habitats is successfully used as biomonitor in the tropic coastal waters (e.g. Yap et al., 2002);**
- ***Septifera bilocularis* is a more common mussel for the coral reef habitats with solid substrates;**
- **Coral reefs are outstanding habitats and exist under increasing human press along the Vietnam coast;**
- **The monitoring of reefs is necessary and *S.bilocularis* could be one of the suitable biomonitor , but background information on the metal concentration in the mussel and environment is needed.**

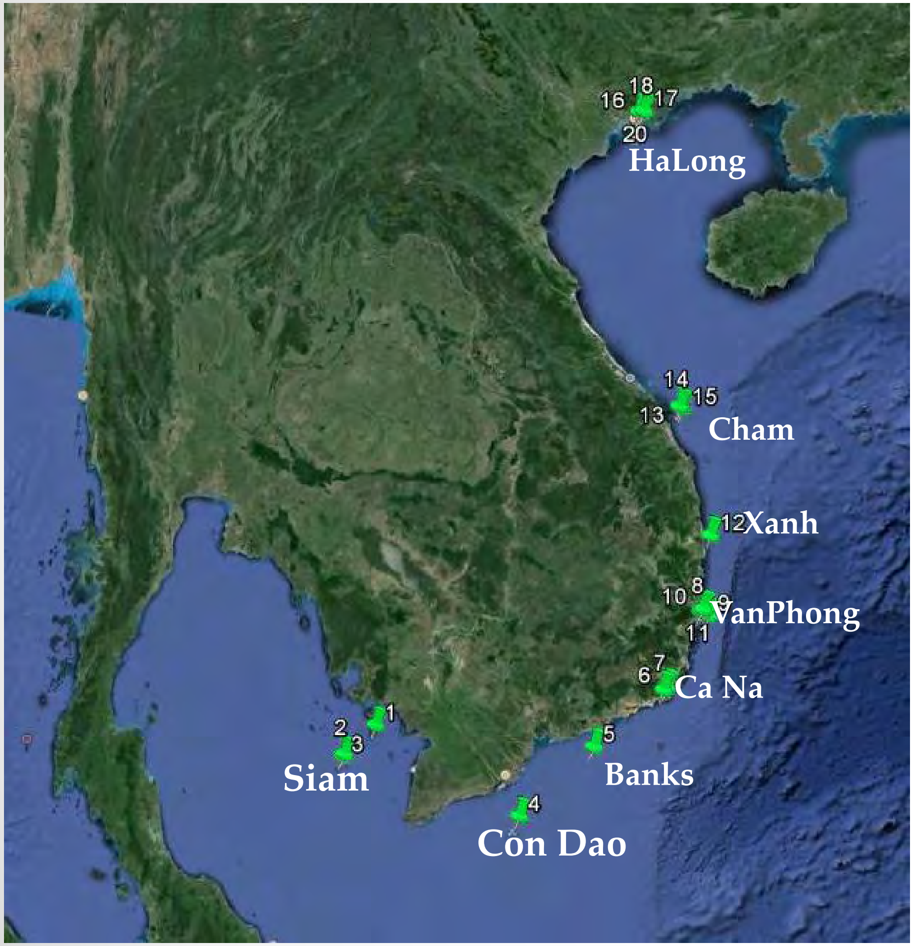
Oceanographic features of Vietnam coastal waters

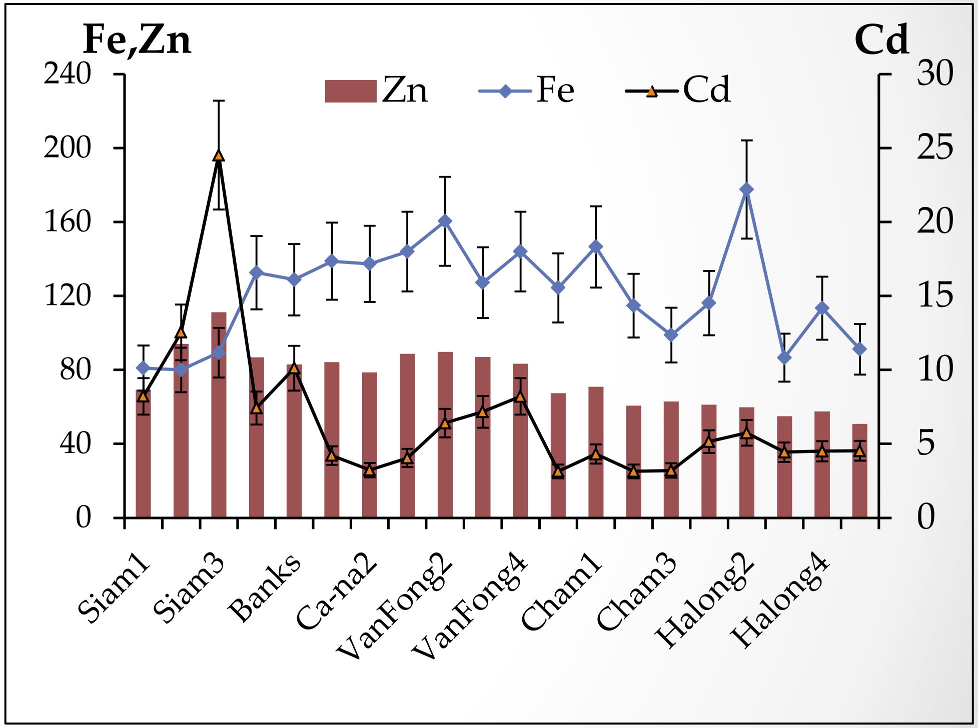


(Giovanni data system , NASA GES DISC)

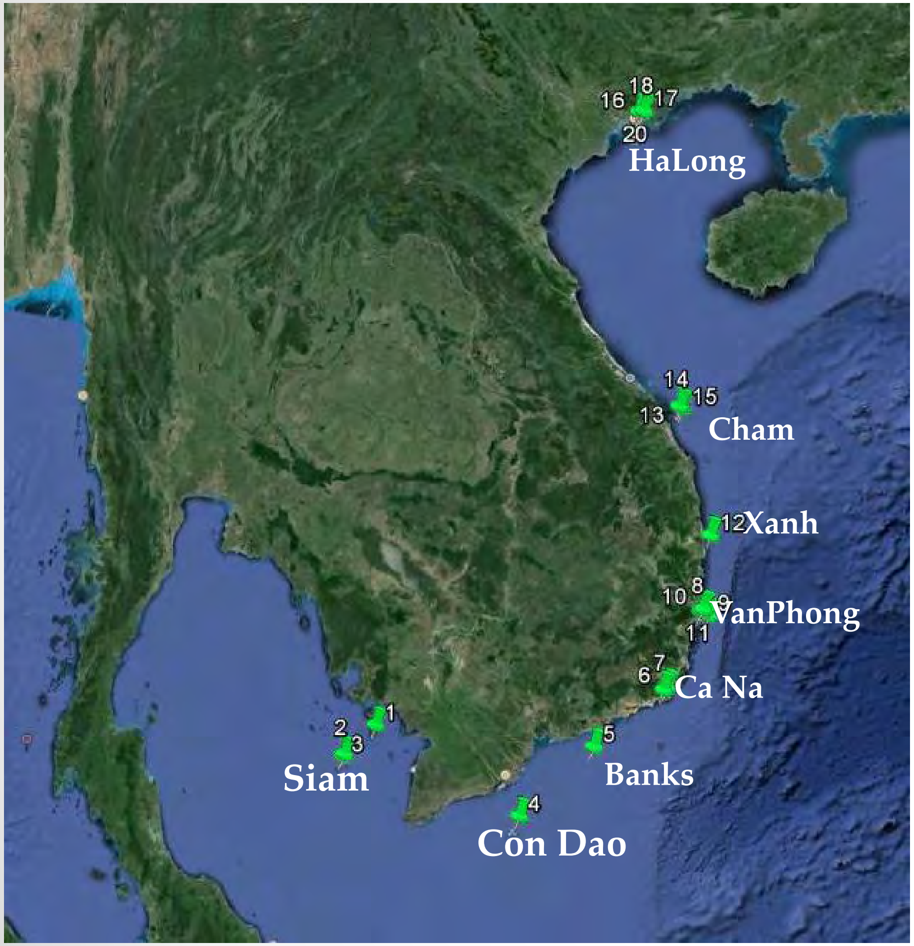
- **Coastal waters of central Vietnam are oligotrophic, but Mekong delta and Gulf of Siam has more plenty nutrients supply;**
- **Spatial distribution *of* remote sensing chlorophyll "a" data is rather stable with minimum along central Vietnam and increase northward and southward;**
- **Areas of most oligotrophic waters is maximal during March-June period and is decreased from September till February;**

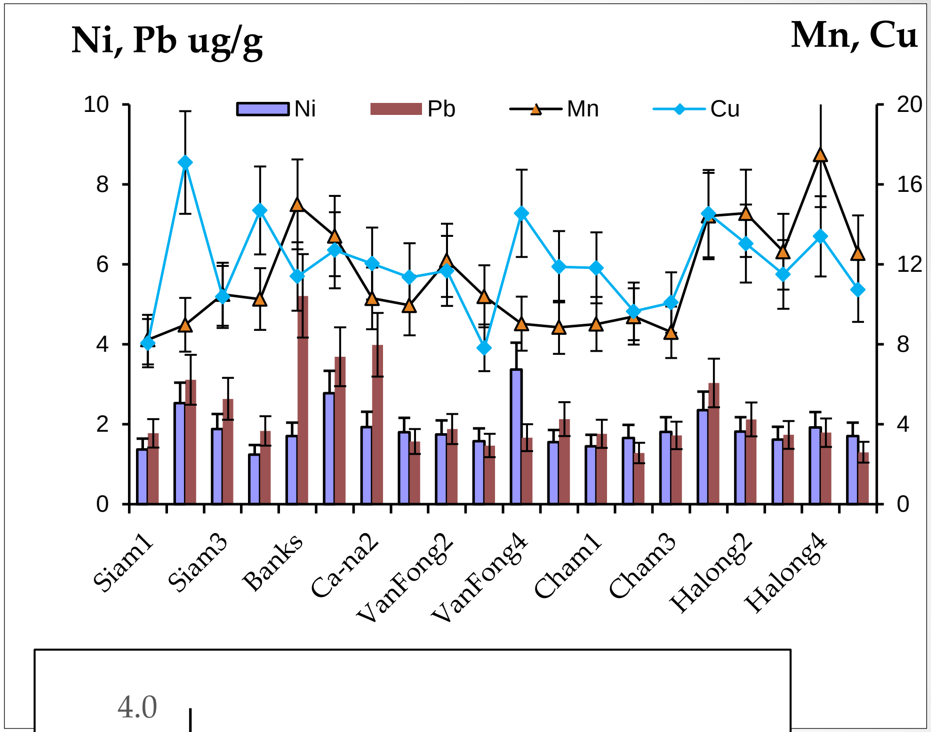
Spatial variability of metals concentration in *S.bilocularis* (I)

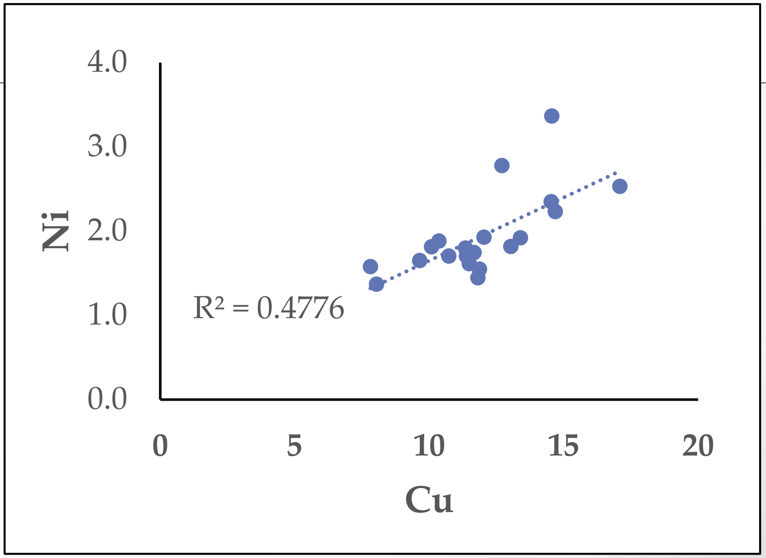




Spatial variability of metals concentration in *S.bilocularis* (II)



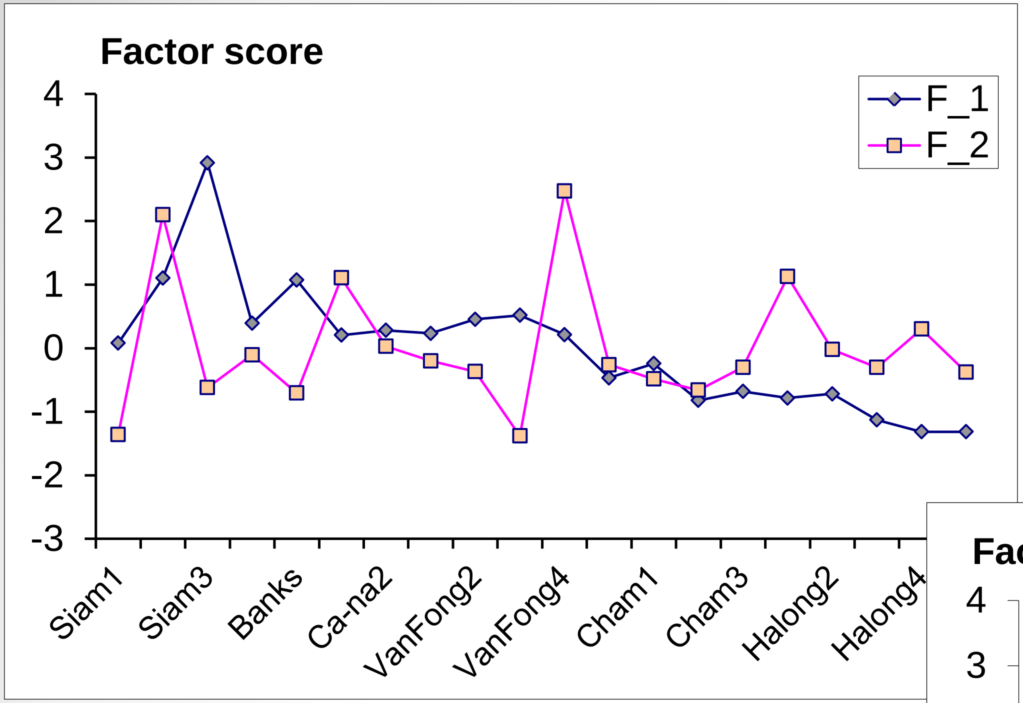




PCA (Factor analysis) of the metals concentration in *S.bilocularis, n=21*

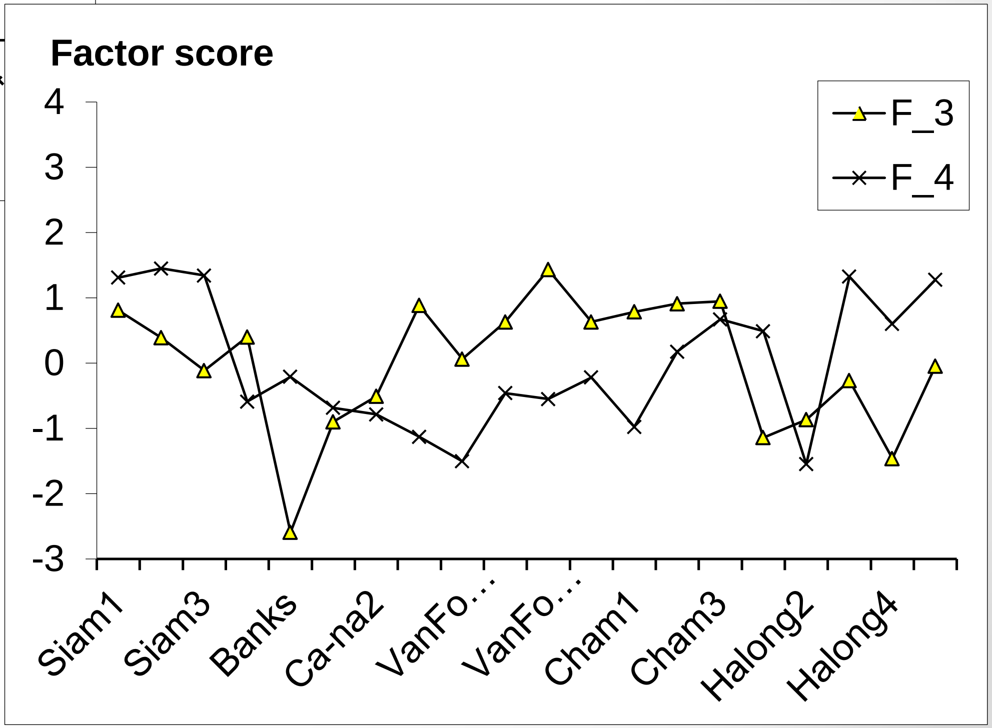
	Factor1	Factor2	Factor3	Factor4
Fe	-0,05	0,08	-0,10	**-0,98**
Zn	**0,94**	0,12	0,11	-0,18
Cu	0,01	**0,85**	-0,19	-0,08
Cd	**0,85**	0,02	-0,08	0,36
Mn	-0,27	0,07	**-0,87**	-0,07
Pb	0,42	0,21	**-0,71**	-0,06
Ni	0,12	**0,88**	-0,02	-0,02
% explained Variance	0,27	0,22	0,19	0,16

Factor scores at the different stations along Vietnam coast



Factor I (27%) = Zn $_{0.94}$ Cd $_{0.85}$

Factor II (22%) = Cu $_{0.82}$ Ni $_{0.88}$



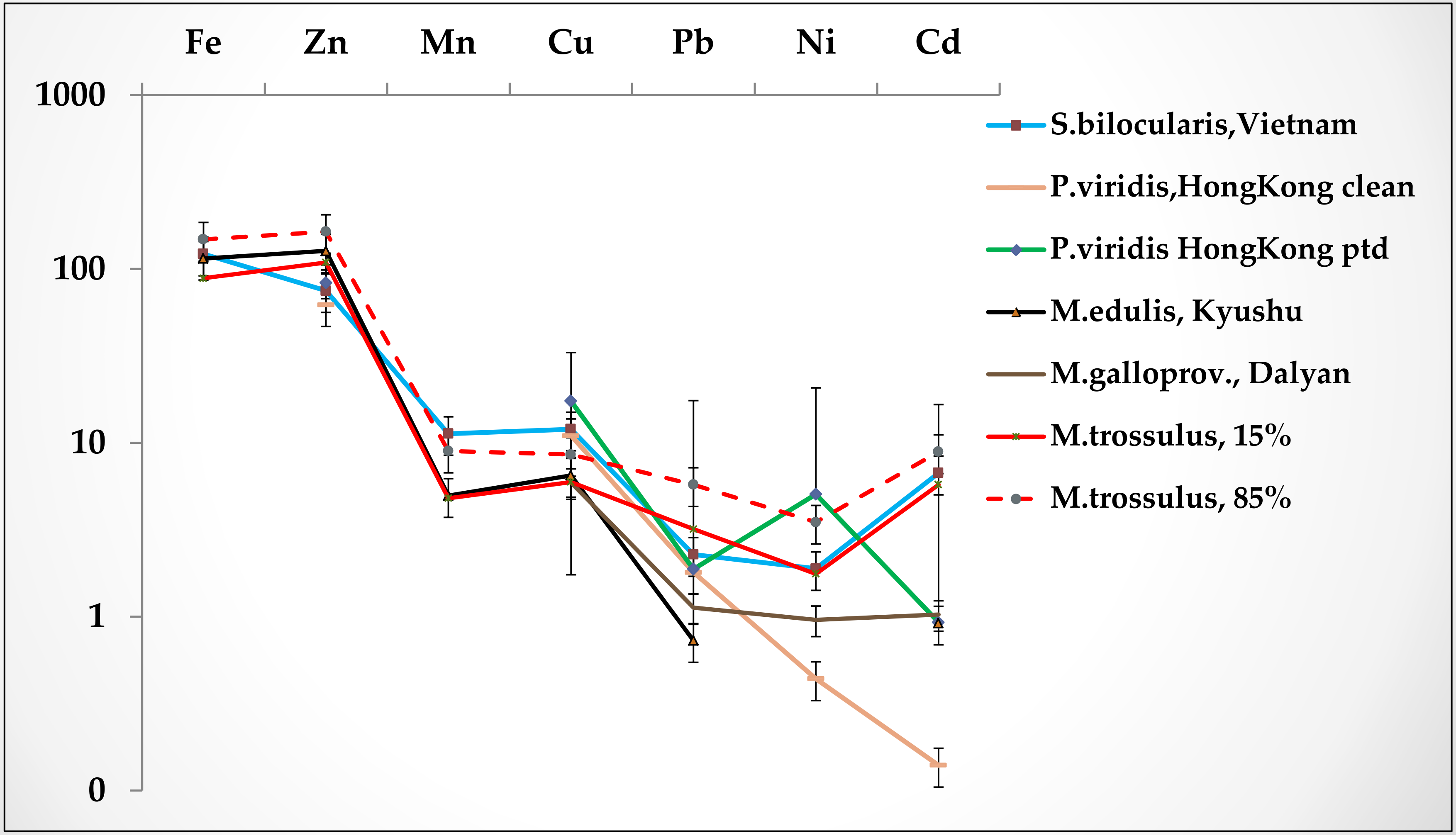
Factor III (19%) = Mn $_{0.87}$ Pb $_{0.71}$

Factor IV (16%) = Fe $_{0.98}$

Summary on *S.bilocularis*

- There is significant natural spatial variability of Cd and Zn concentration with clear (2-4 times) enrichment of mussels from the outer part of Siam Bay, near Mekong delta.
- Seasonal upwelling could be a reason, but additional study is necessary;
- Pb and Mn spatial variability is determined by the anthropogenic and river runoff influence;
- Fe concentrations in *S.bilocularis* are reasonably diminished in the highly productive Siam Bay, and accumulates more effectively in the mussels from oligotrophic waters of central Vietnam.

Metal concentrations in the mussels from the different climatic zones



Conclusions

- The natural spatial variability of Zn, Cu, Pb, Ni and Cr in the short-living mussels within all northwestern sector of Pacific allow to use successfully all studied species for the biomonitoring of pollution by these metals;
- The Cd concentration in the mussels has significant natural variability along the coasts with clear enrichment in the areas under upwelling influence;
- Significant and logical spatial variability is observed for the Fe in the mussels. The combined effect of Fe availability in some coastal areas and influence of temperature on the Fe uptake and release lead to the increase of Fe concentration in mussels northward of boreal zone. In the tropic zone the difference in the amount of the bioavailable Fe in the environment is a probable key factor.

Way forward

- **Despite the rather long history and obvious achievements the trace metals issues in the "Mussel Watch" programs still have some gaps;**

- **It is necessary to distinguish the influence of upwelling waters with elevated dissolved Cd concentration, and trophic status of coastal waters on the Cd accumulation in the mussels;**

- **It is necessary to highlight the ability of mussels to regulate the Fe accumulation at the elevated amount of Fe in the environment, and then to quantify this regulation capacity upon temperature.**


Thank you for attention