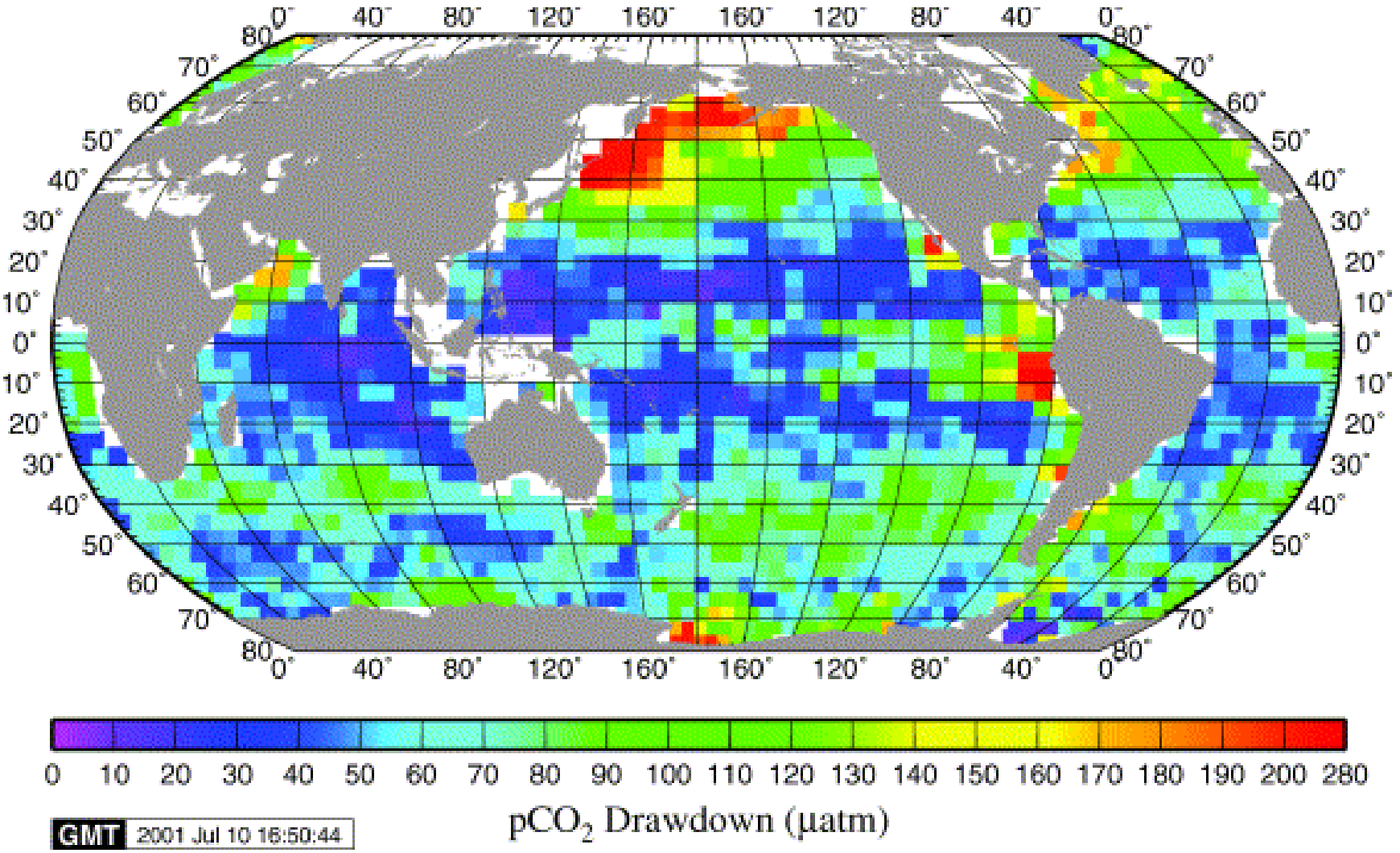
PICES 2011 Session 7
Khabarovsk, Russia 20 Sept. 2011

"*Giant fish-breeding forest*": a new environmental system linking continental watershed with open water

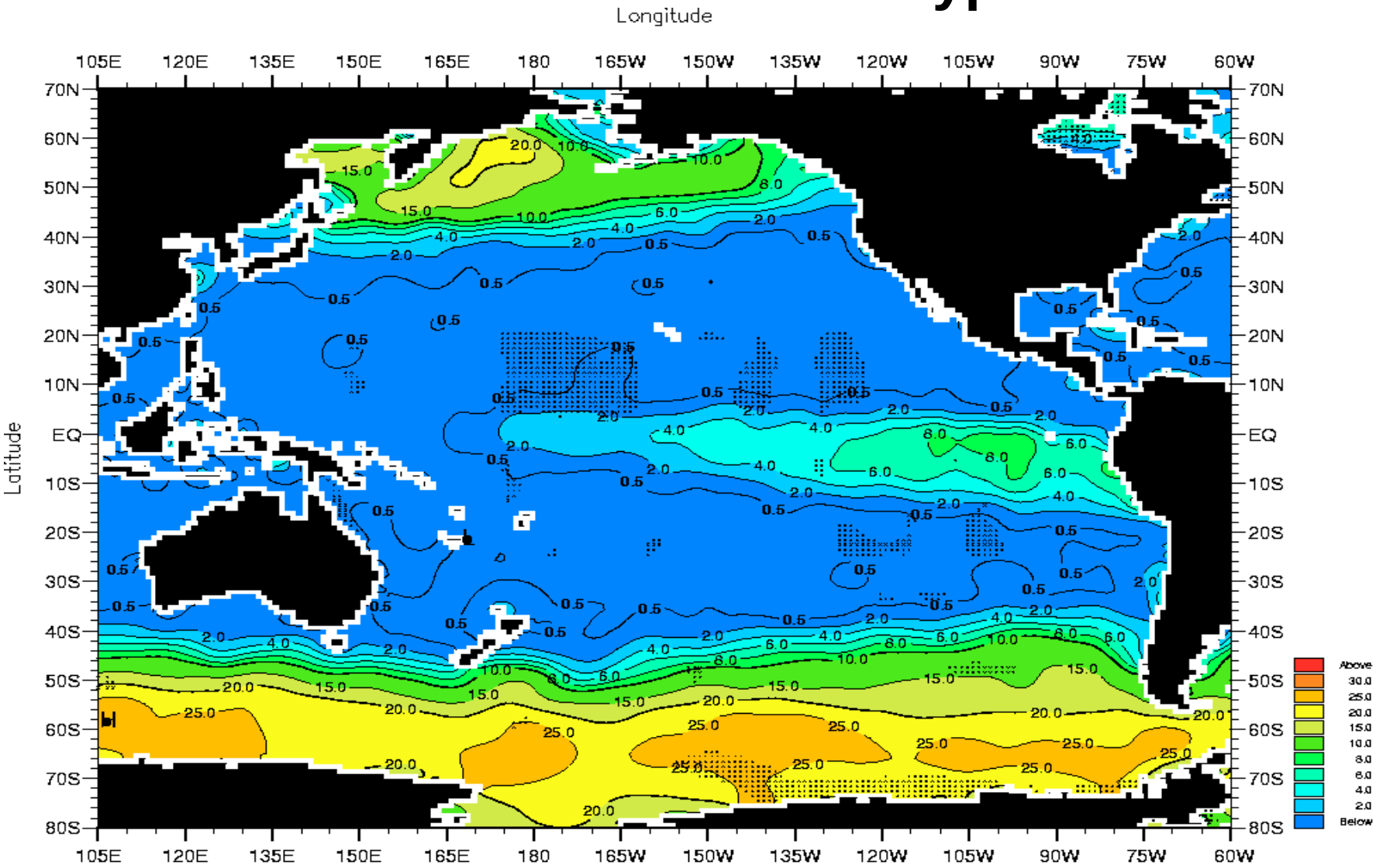
Takayuki Shiraiwa
Institute of Low Temperature Science, Hokkaido University
&
The members of the Amur Okhotsk Project 2005-2009

The world richest ocean



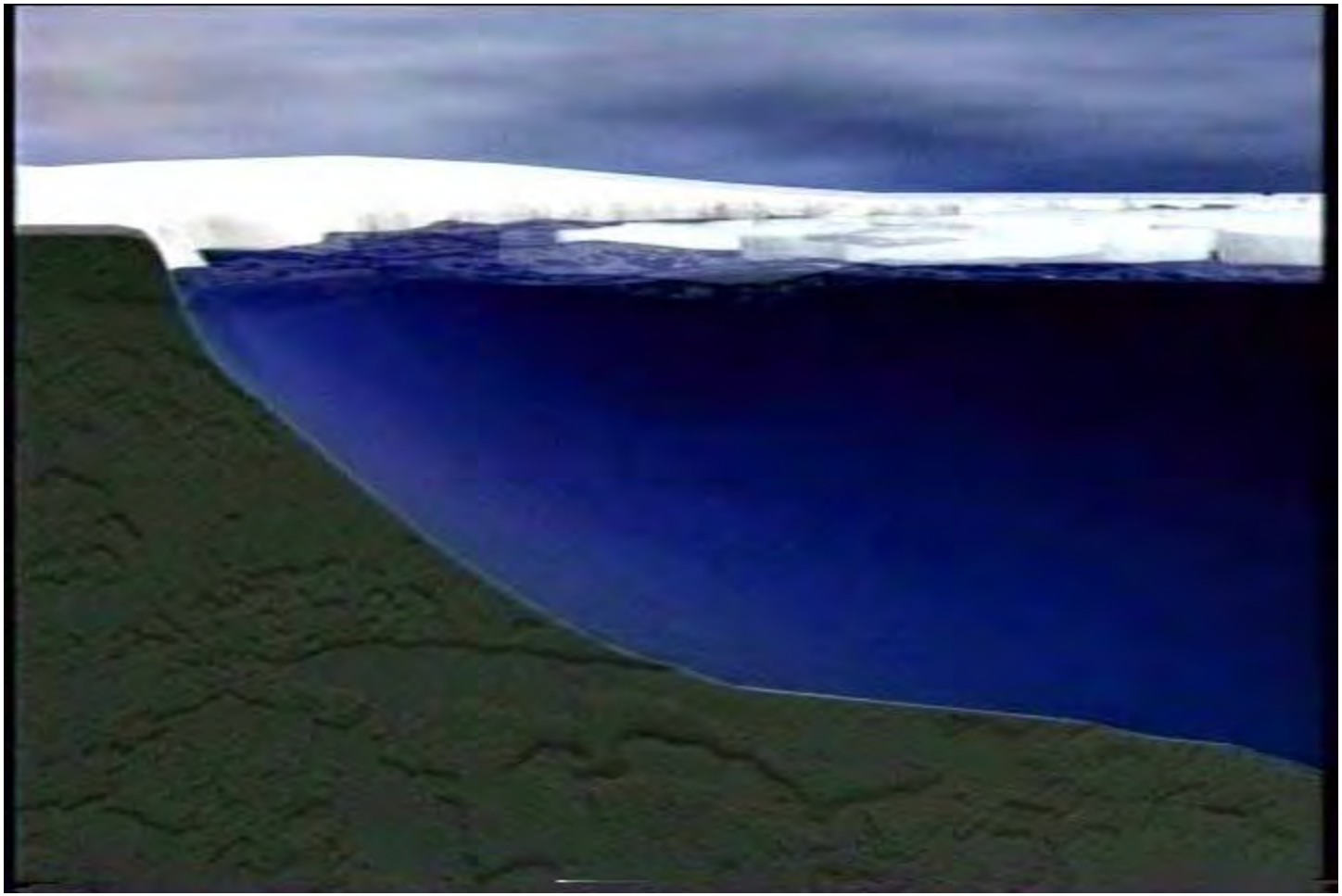
Takahashi et al., 2002

HNLC and iron limitation hypothesis



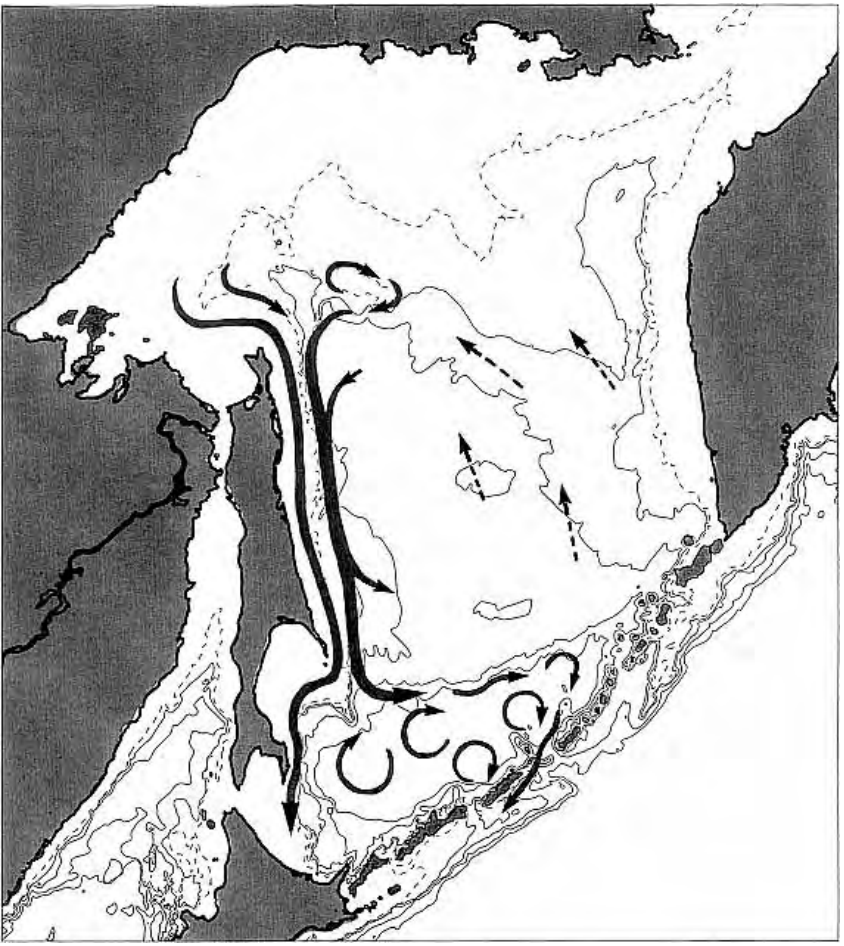
NO_3Concentration

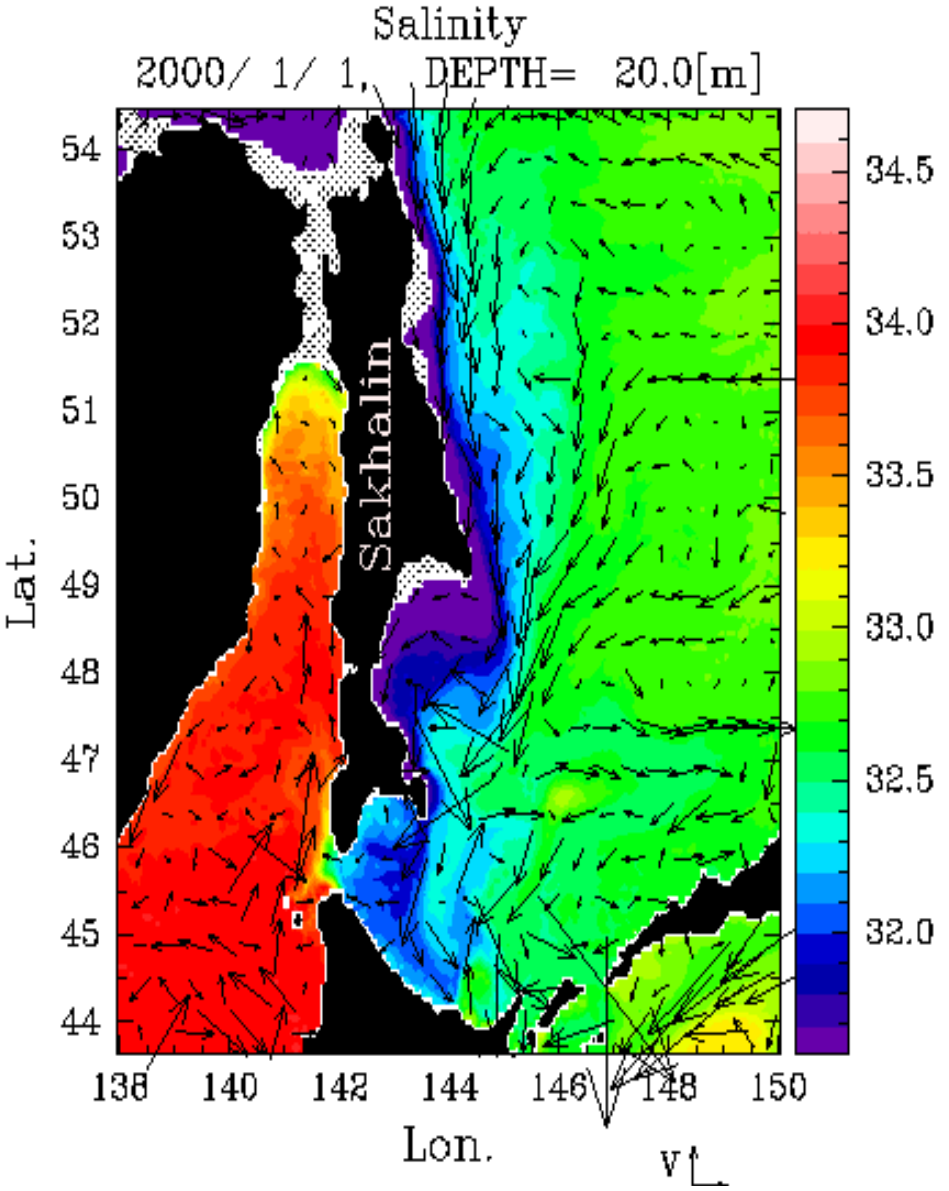
WOA (1998)



Courtesy of JST

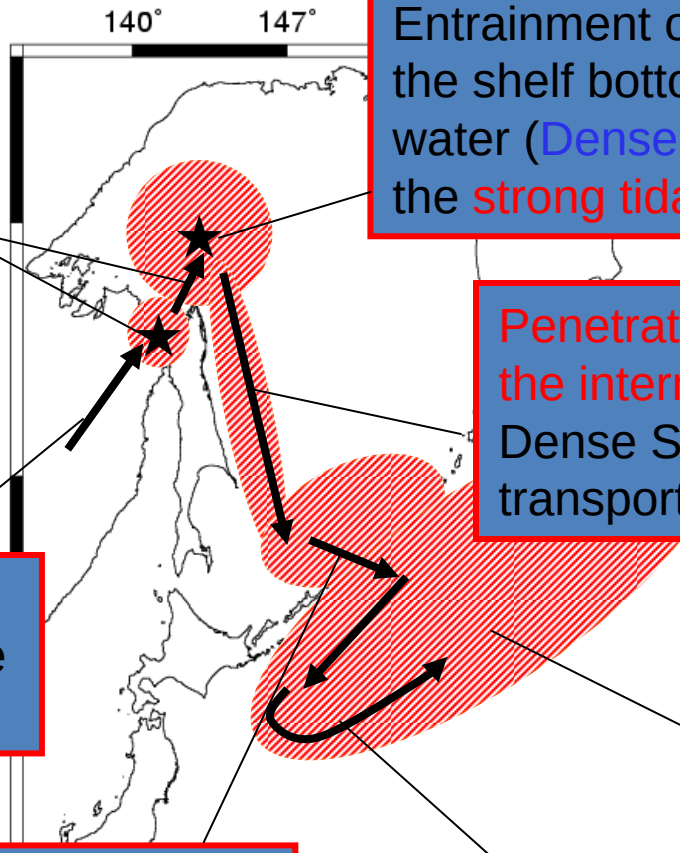
Ocean current in the Sea of Okhotsk





Ohshima et al. (2002)

Hypothesis: Amur River supplies sufficient amount of iron to these ocean



Most of the dissolved iron precipitates in the estuary area and it is transported to the continental shelf area

(2)

Supply of large amount of dissolved and particulate iron from Amur River

(1)

Entrainment of particulate iron from the shelf bottom to sea-ice brine water (Dense Shelf Water) due to the strong tidal mixing there

(3)

(4)

Penetration of particulate iron into the intermediate layer together with Dense Shelf Water and southward transport by East Sakhalin Current

Dissolution of particulate iron and its supply into surface layer by winter vertical mixing
= Uptake by organisms

(7)

Redistribution of iron into a wide range of intermediate depth by tidal mixing through straits

(5)

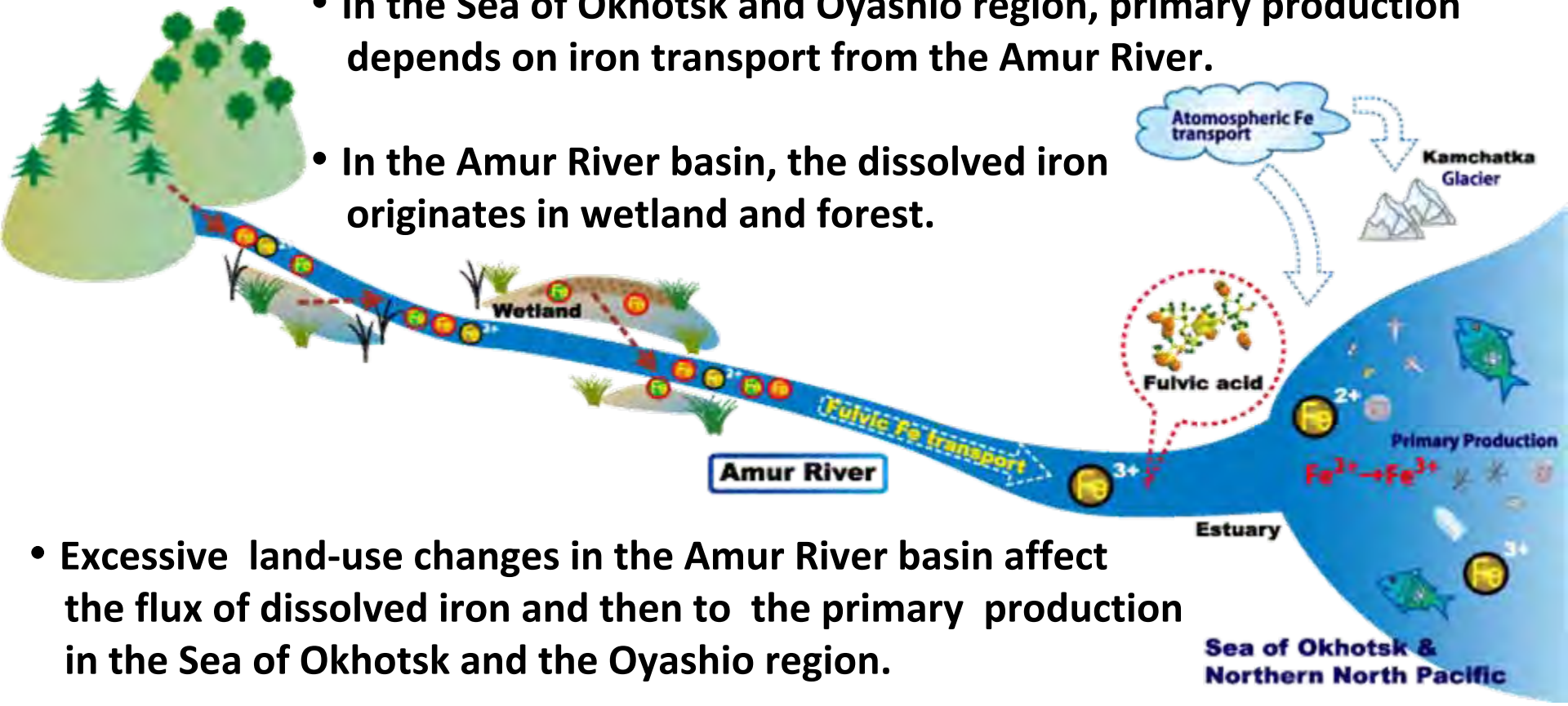
Horizontal transport of iron via intermediate layers in the region of Oyashio and Western North Pacific

(6)

Giant **F**ish-**B**reeding **F**orest hypothesis

-Ecological linkage between the continent and open waters-

- **In the Sea of Okhotsk and Oyashio region, primary production depends on iron transport from the Amur River.**
- **In the Amur River basin, the dissolved iron originates in wetland and forest.**



- **Excessive land-use changes in the Amur River basin affect the flux of dissolved iron and then to the primary production in the Sea of Okhotsk and the Oyashio region.**
- **International cooperative effort on conservation on the GFBF is necessary for the sustainability of marine ecosystem in the Sea of Okhotsk and Oyashio open water.**

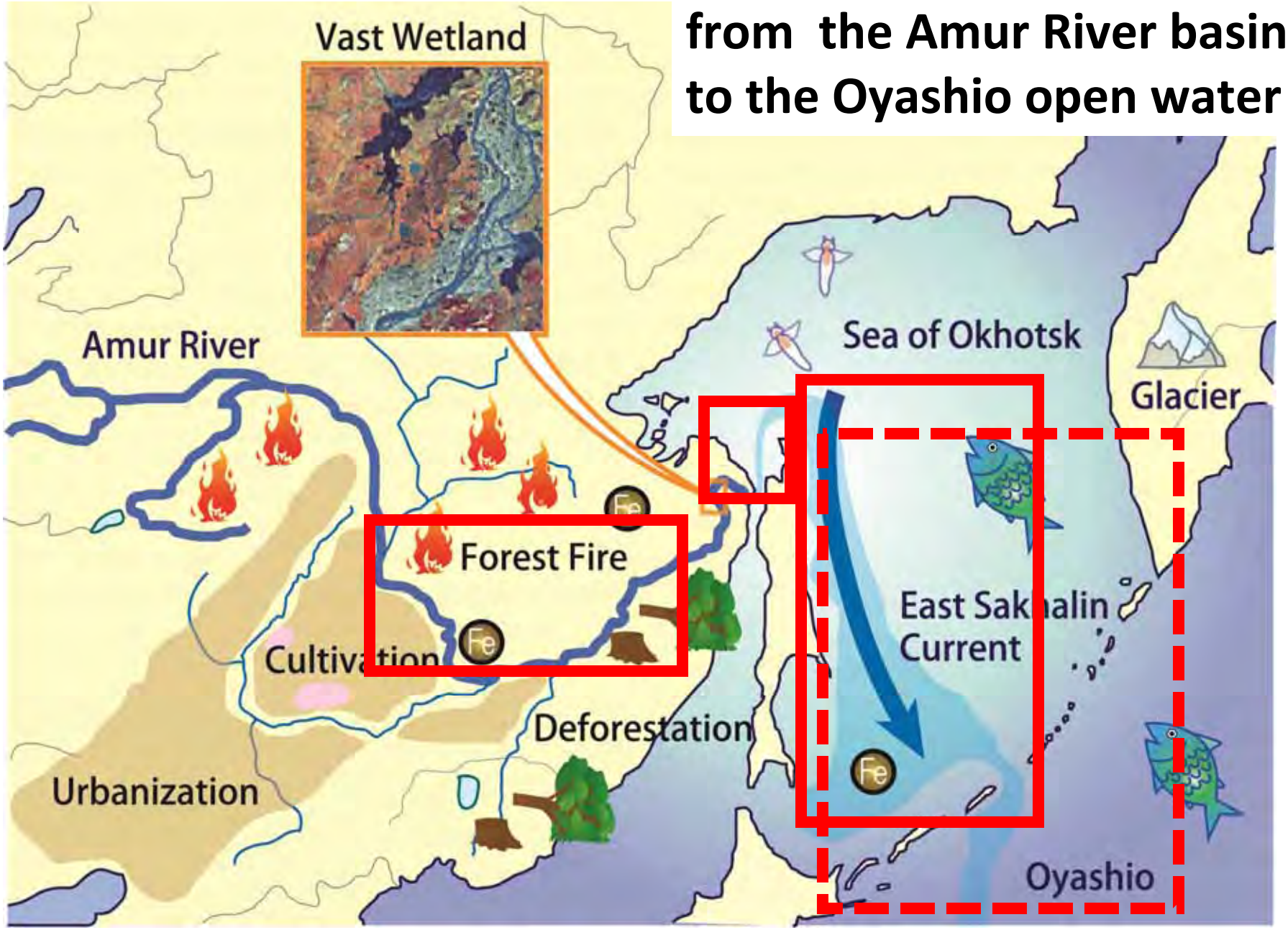
Contents

1. Does dissolved iron from the Amur River basin support the primary productivity in the Sea of Okhotsk and Oyashio region ?

2. Was (Is) there any influence of human activities in the Amur River basin on the flux of dissolved iron ?

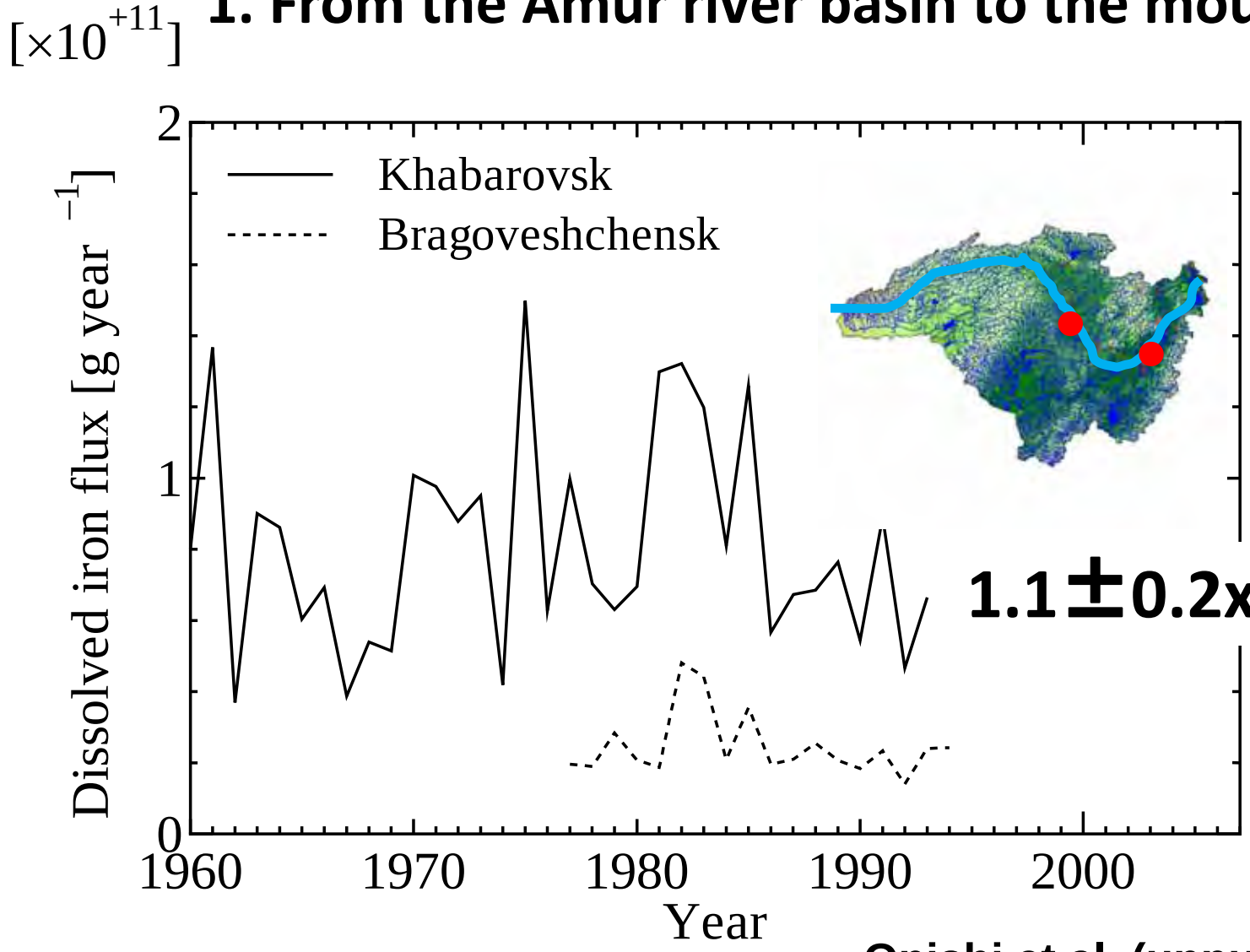
3. Proposed strategy for the conservation of GFBF and the ecosystem in the open waters.

Transport of dissolved iron from the Amur River basin to the Oyashio open water



Transport of the dissolved iron

1. From the Amur river basin to the mouth



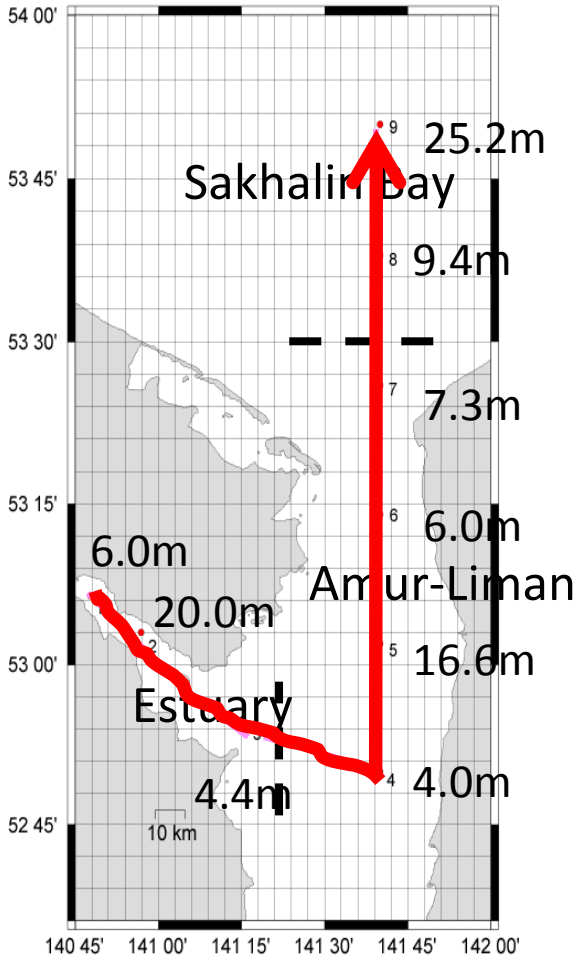
1.1±0.2x10^{11} g/yr

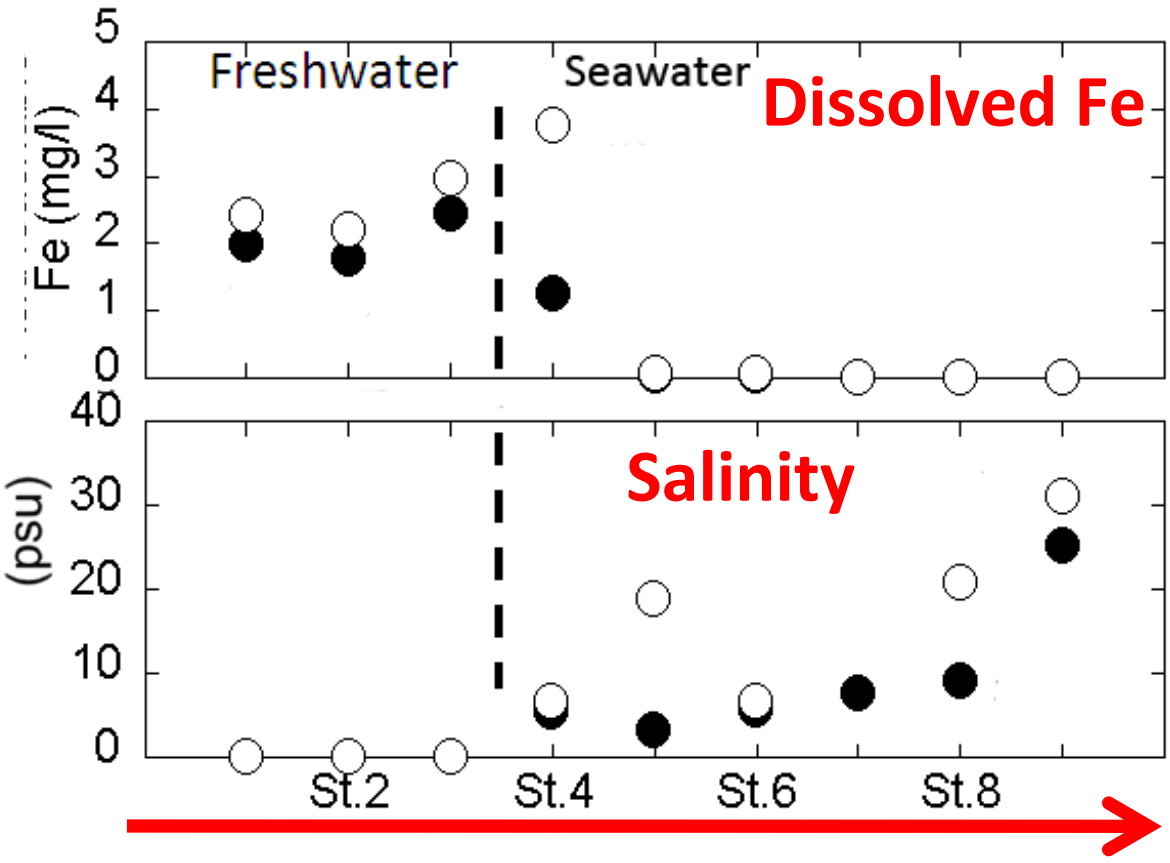
Onishi et al. (unpublished)

Data source: ROSHYDROMET

Transport of the dissolved iron

2. From Amur river mouth to the Sakhalin Bay

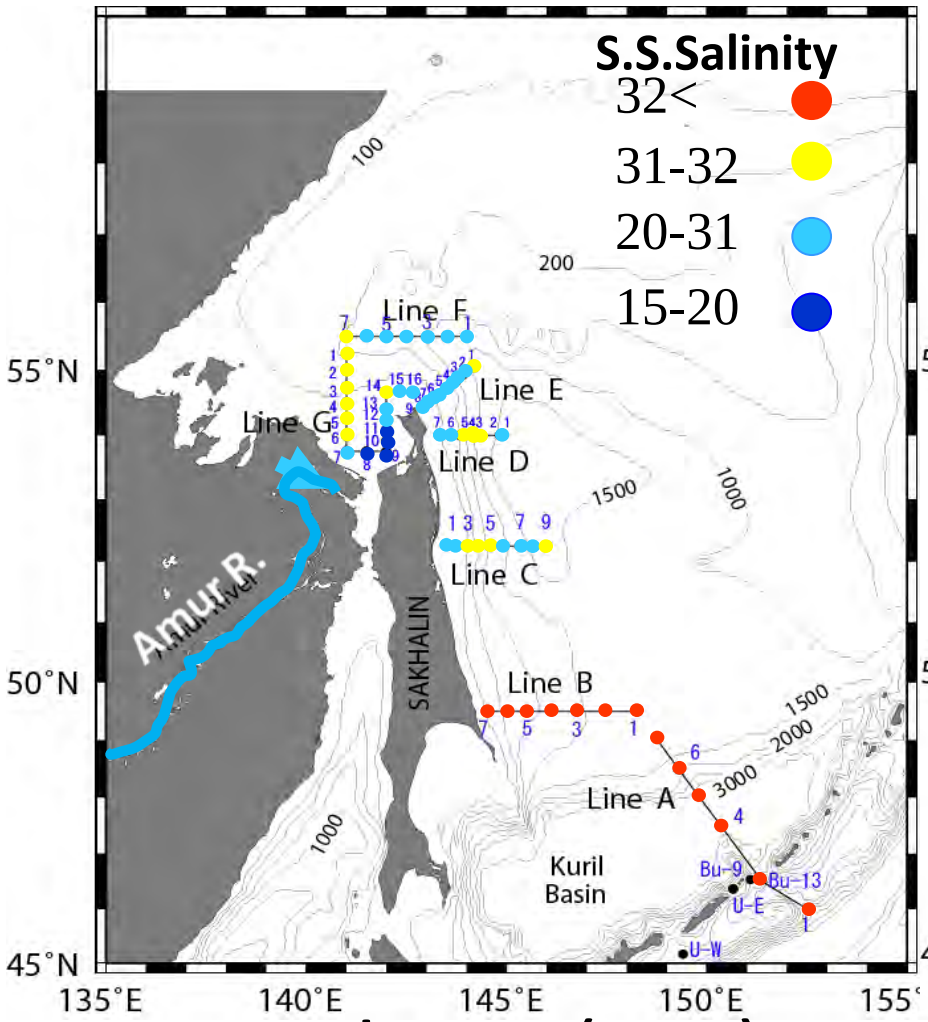




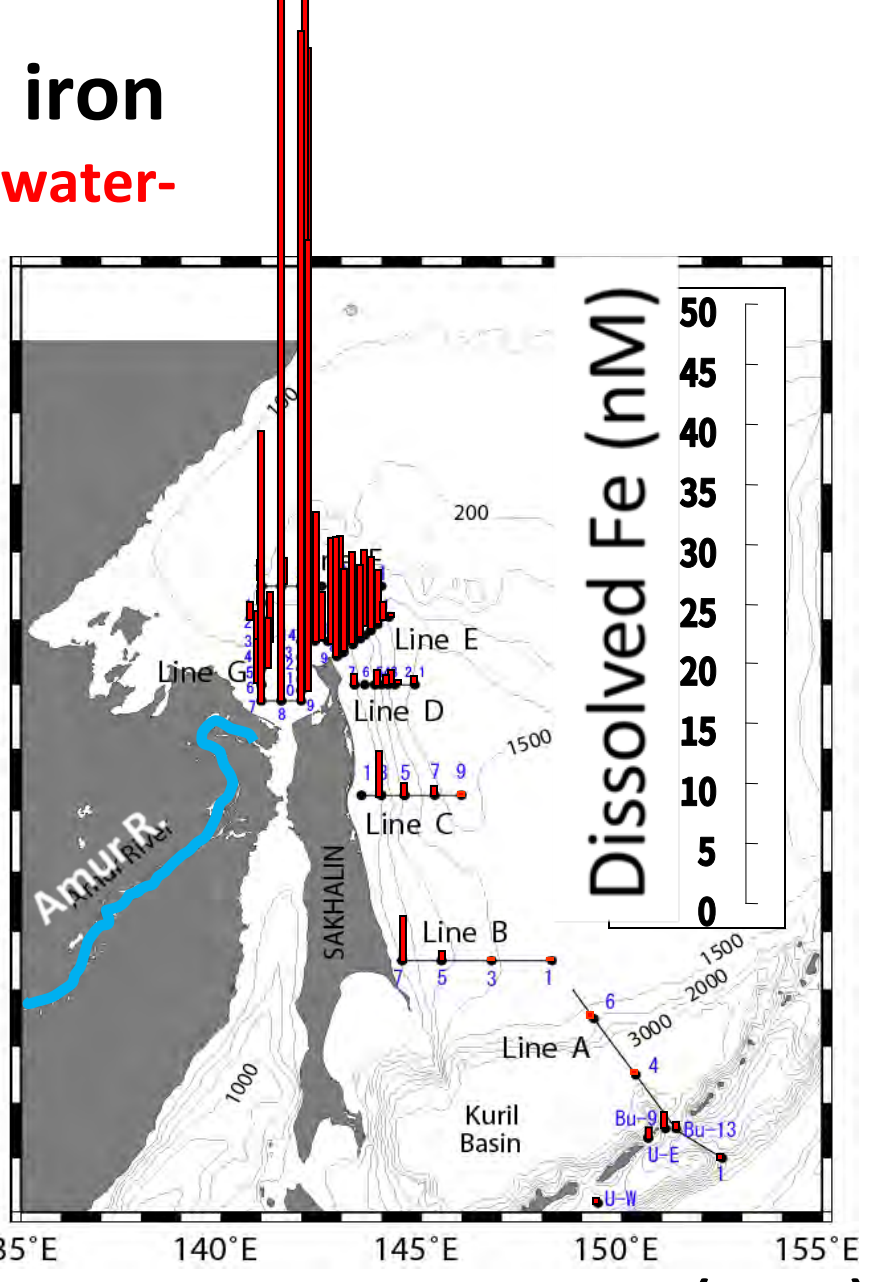
Nagao et al. (2008)

Transport of the dissolved iron

3. The Sea of Okhotsk –the surface water-



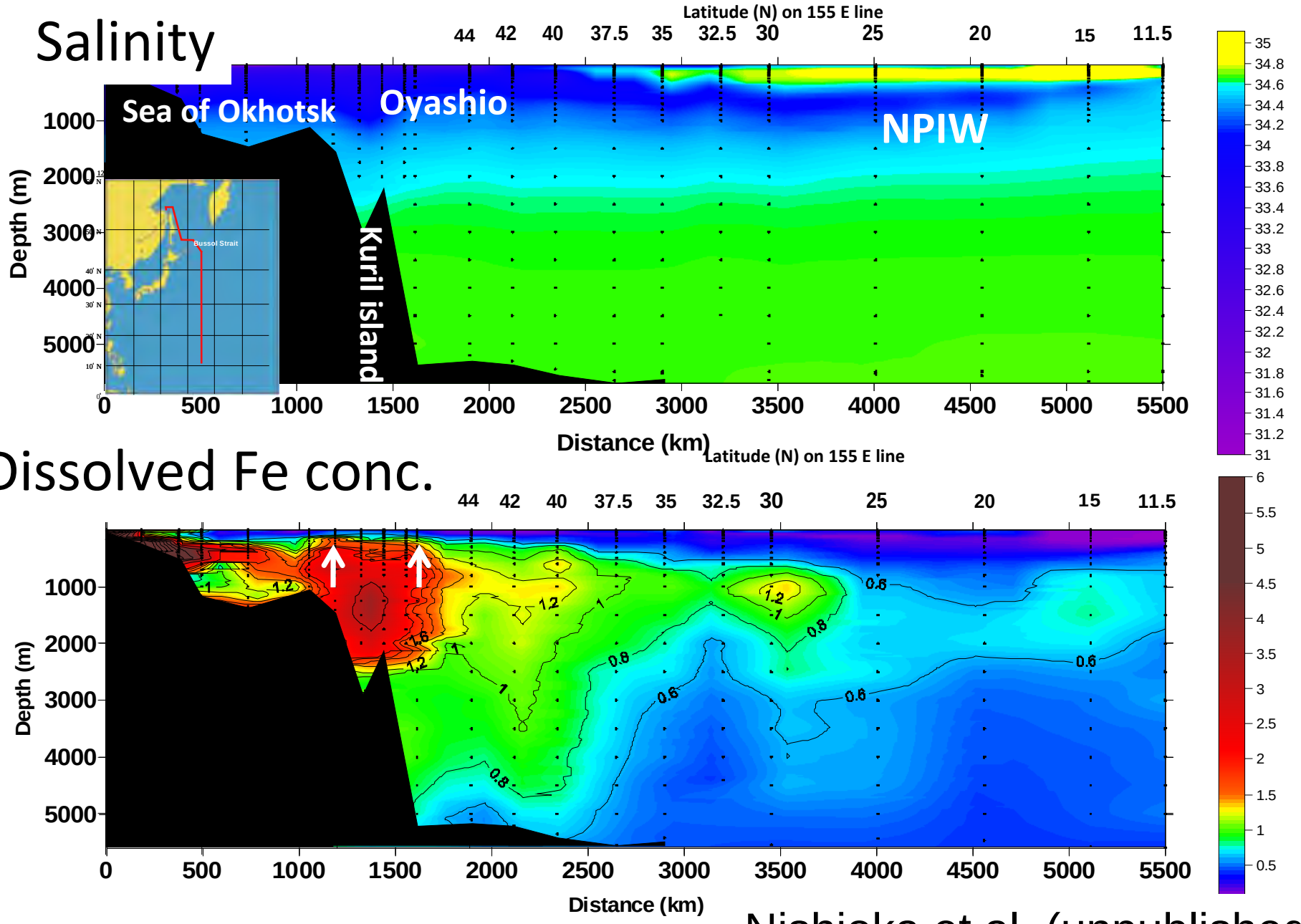
Salinity (psu)



Iron concentration (nM)

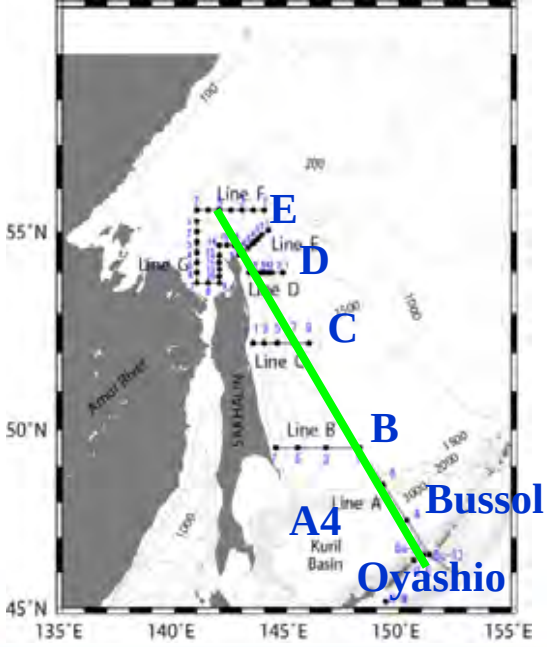
Nishioka et al. (unpublished)

Transport of the dissolved iron 3. the Sea of Okhotsk - Intermediate depth water



Nishioka et al. (unpublished)

Summary of total iron (g/yr) transport



Amur R.

1.1×10^{11}

2.2×10^{9}

2.0×10^{7}

Atmospheric

1.2×10^{8}

NPIW

4.7×10^{11}

1.9×10^{10}

6.0×10^{9}

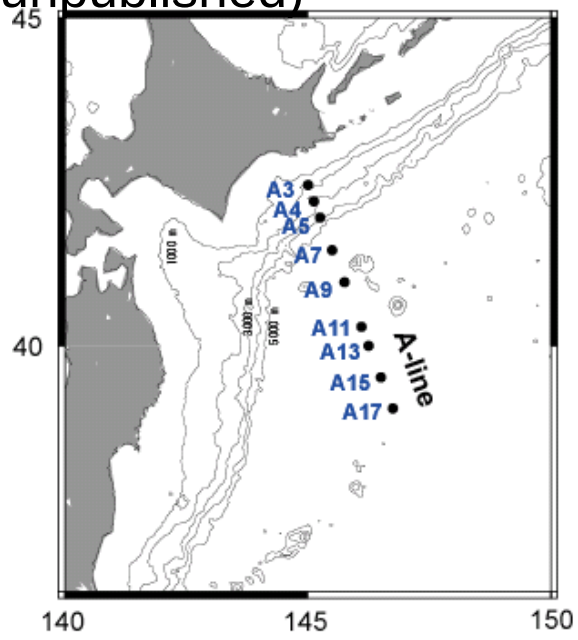
1.5×10^{8}

Sea of Okhotsk

Oyashio

Kuril Islands

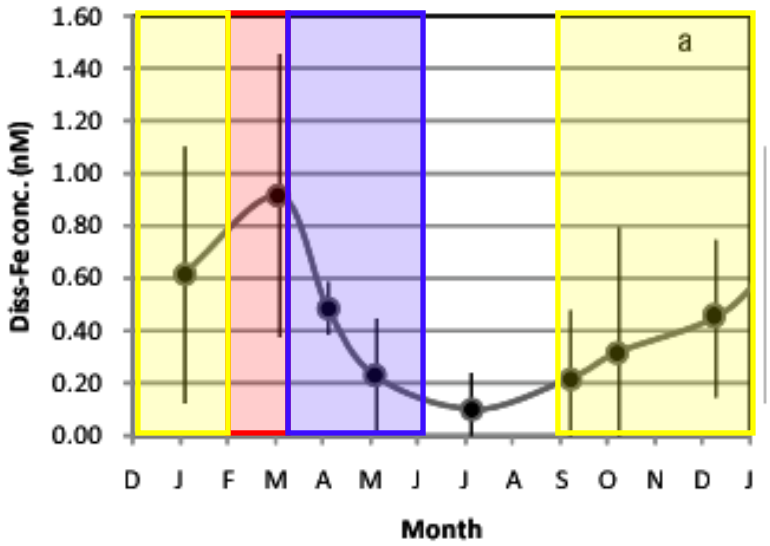
To what extent does the supply of (riverine) dissolved iron regulate primary production in the open waters ? (Nishioka, unpublished)



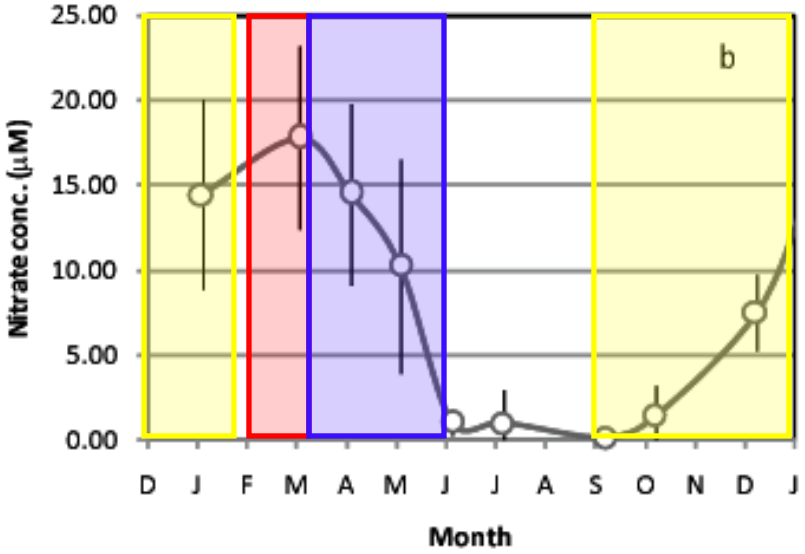
Sources of dissolved iron utilized for the spring bloom

40 %: from GFBF system
60%: from microbial loop

D. Iron



Nitrate



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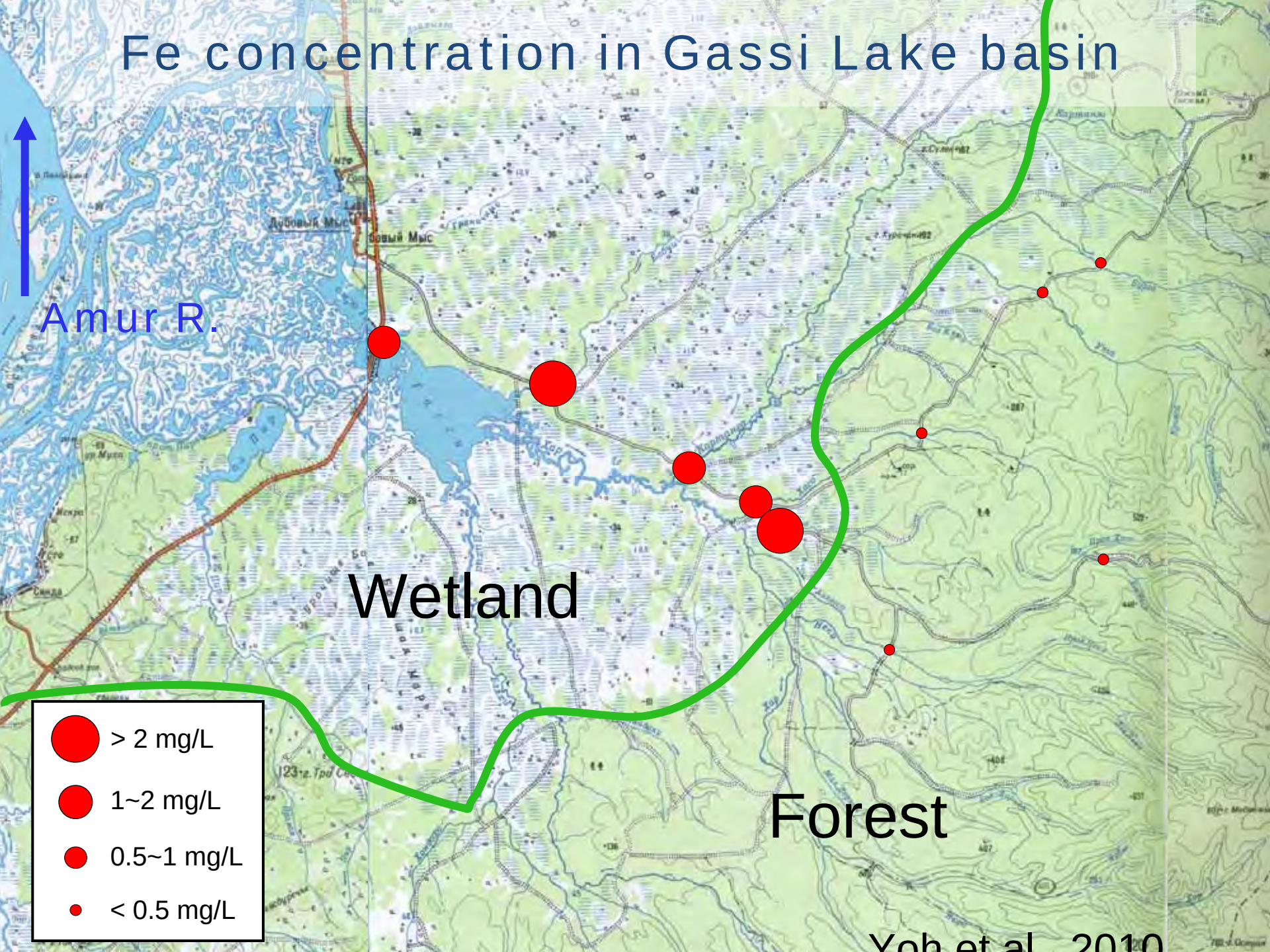
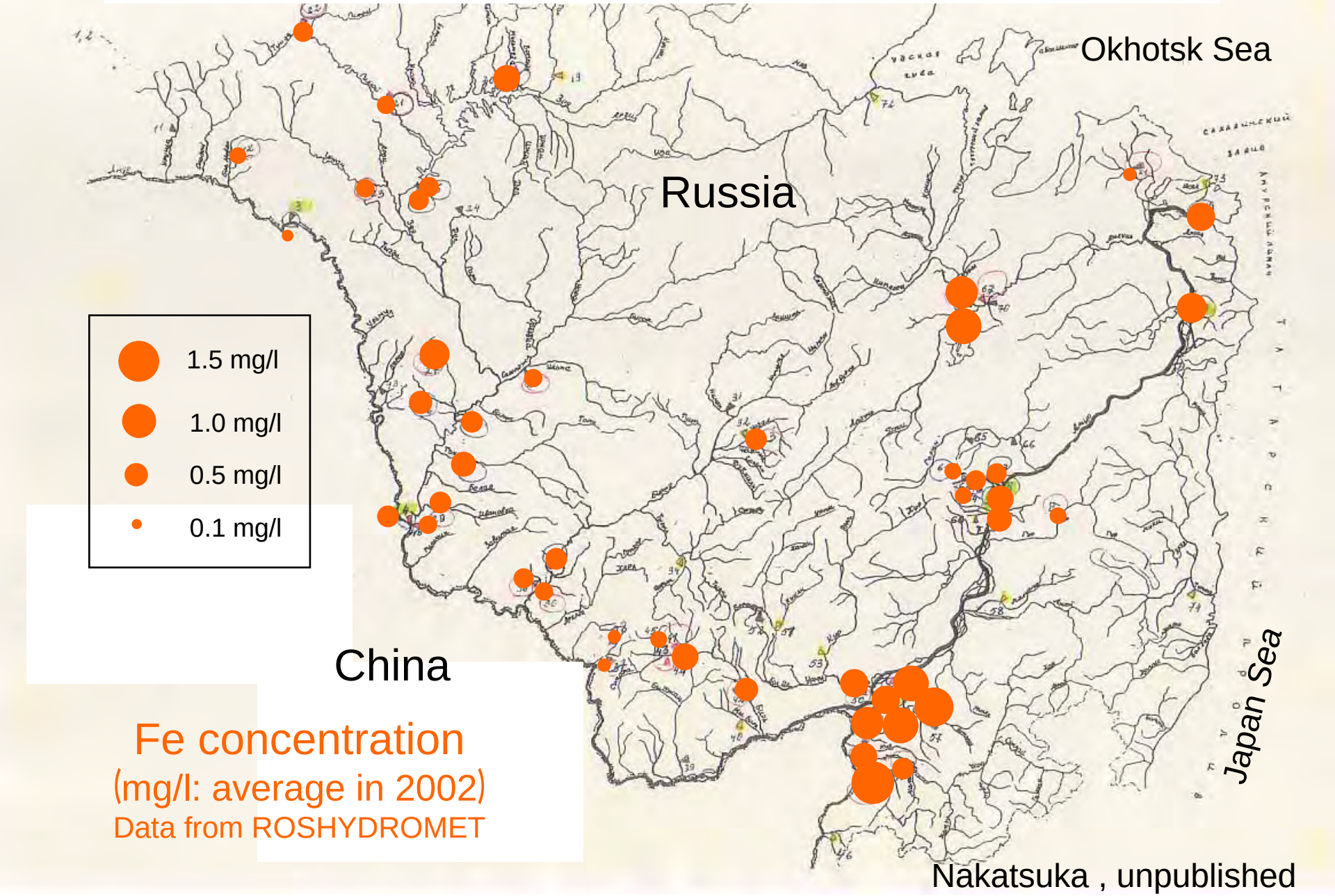
Fe concentration in Gassi Lake basin



Yoh et al., 2010

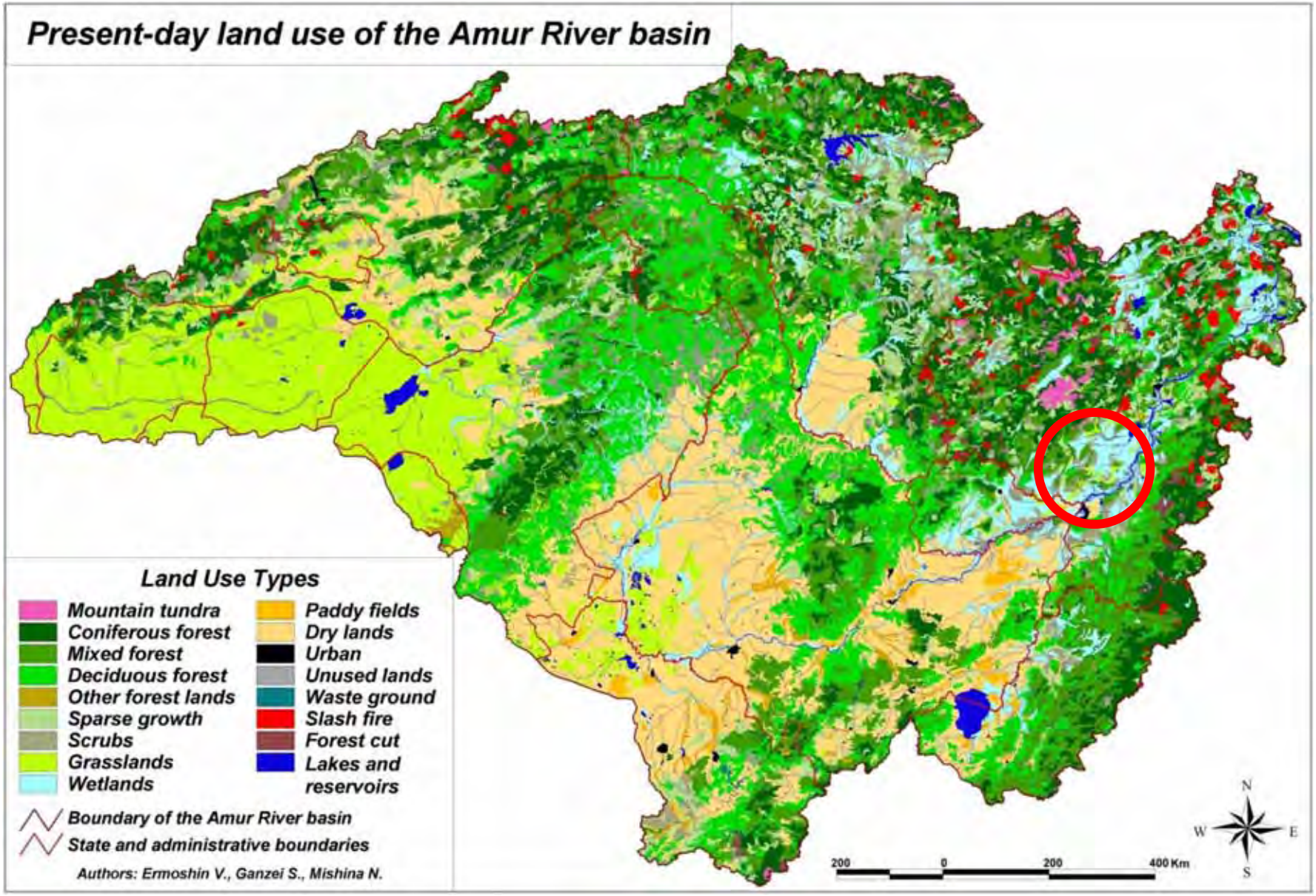
Dissolved iron concentration in the Amur River system (mg/L)



Fe concentration
(mg/l: average in 2002)
Data from ROSHYDROMET

Nakatsuka , unpublished

Land use of the Amur River basin in 2000

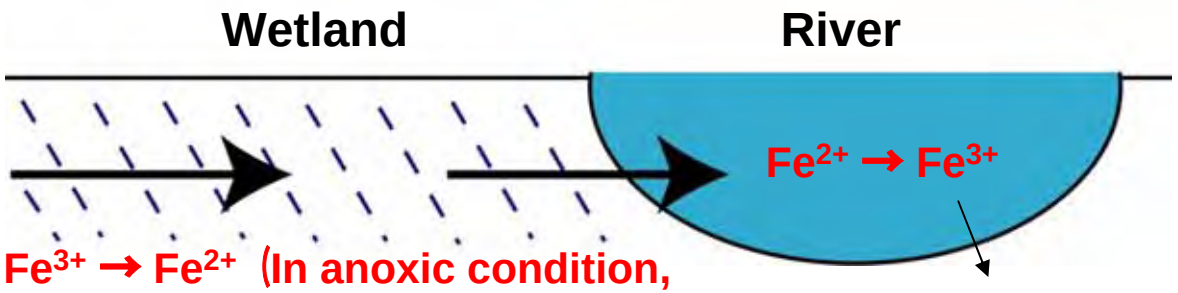


Compiled by Pacific Inst. Geography

Conditions to dissolve iron (Fe) into river (Amur)

In oxic environment, iron is Fe^{3+}. It cannot be dissolved in water.

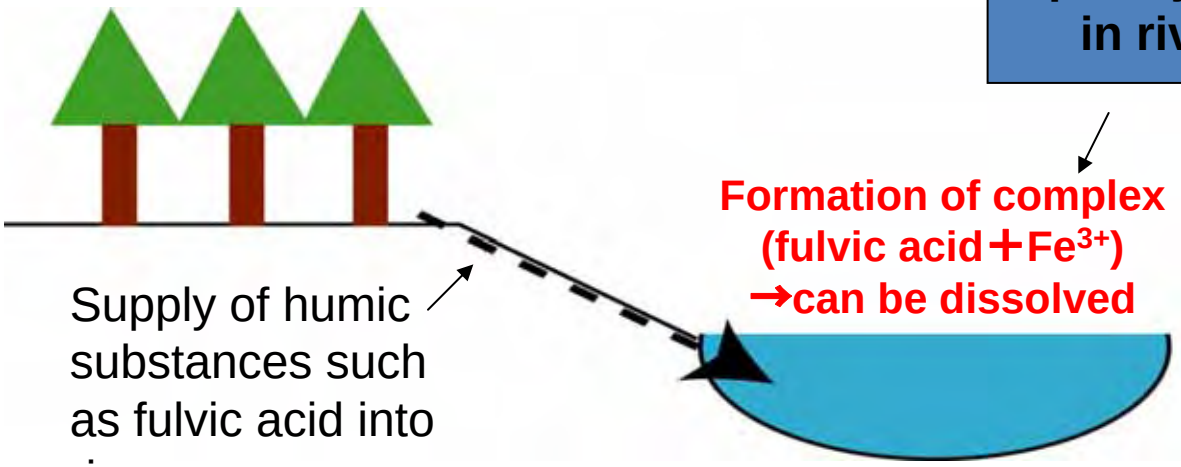
(1) "Water" – environment such as Wetland



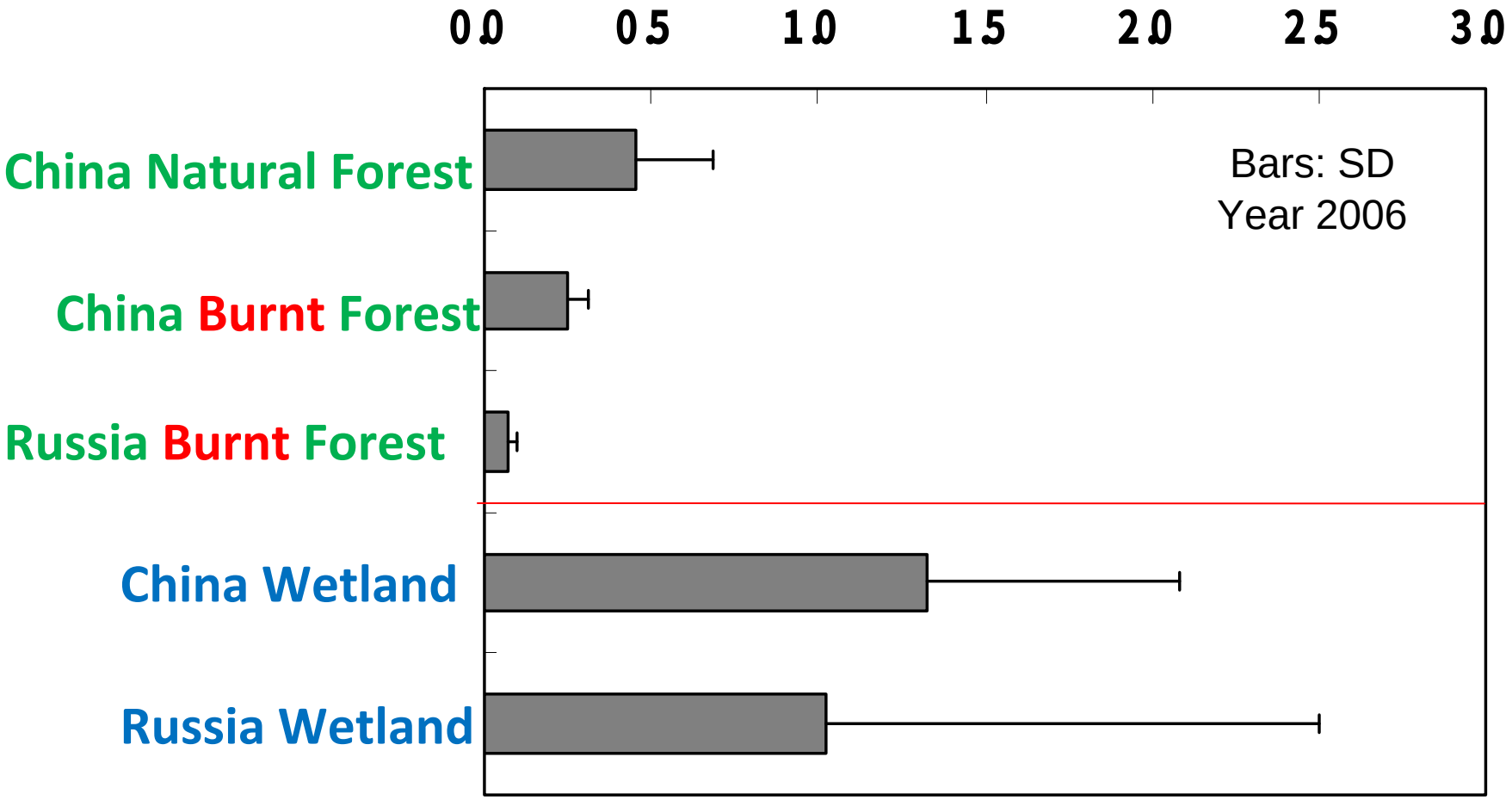
$Fe^{3+} \rightarrow Fe^{2+}$ (In anoxic condition, Fe^{3+} is reduced to Fe^{2+}, dissolved into groundwater and finally discharged to river.

Fe^{2+} is easily oxidized and sinks down quickly again in river…

(2) "Forest" – supply of humic substances



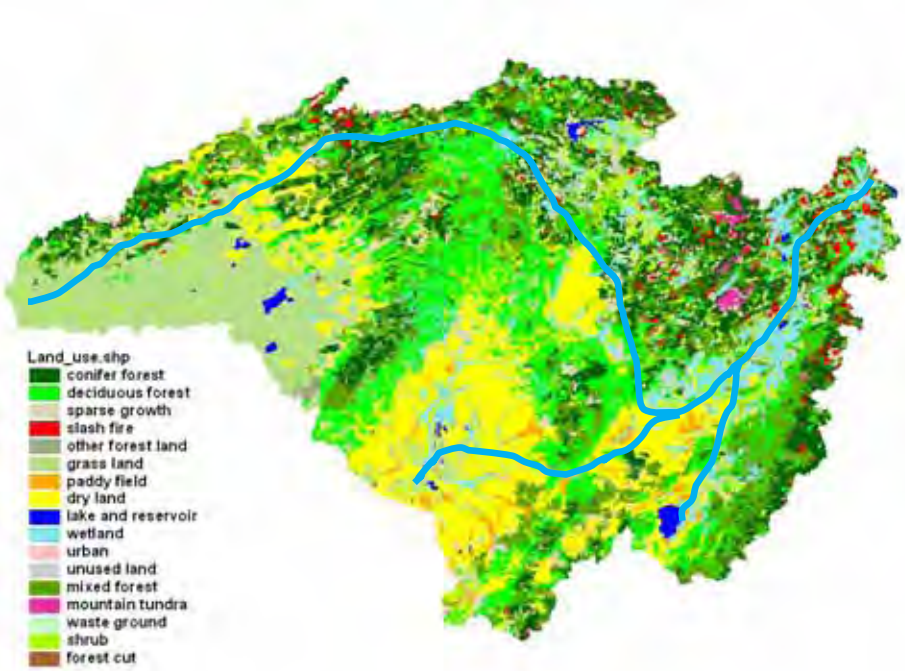
Dissolved iron concentrations (mg L^{-1}) measured at basins having various land-covers



Shibata et al. (unpublished)

Land cover/Land use changes in the Amur River basin between 1930s and 2000

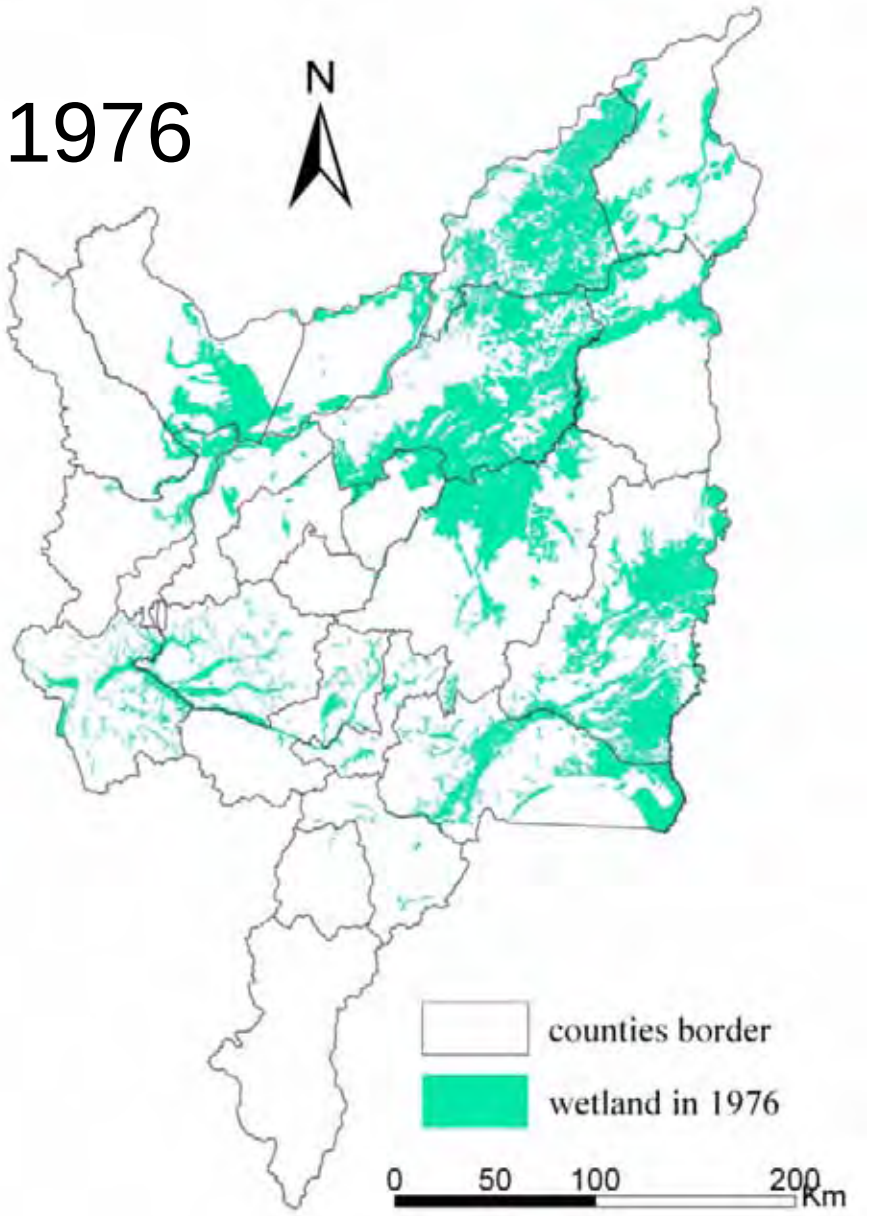
1930s



2000

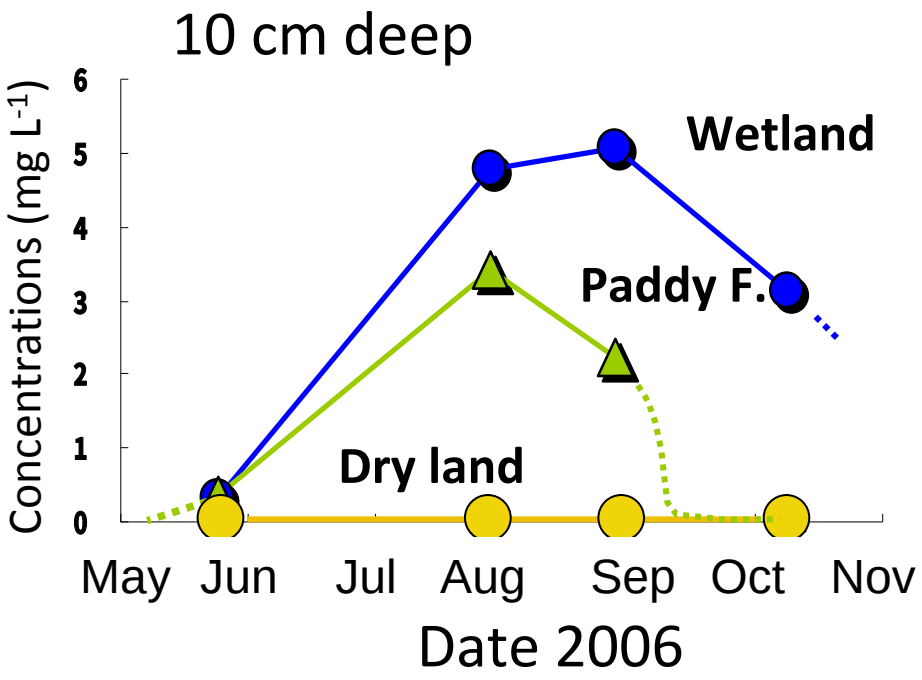
Ermoshin and Ganzey (2008)

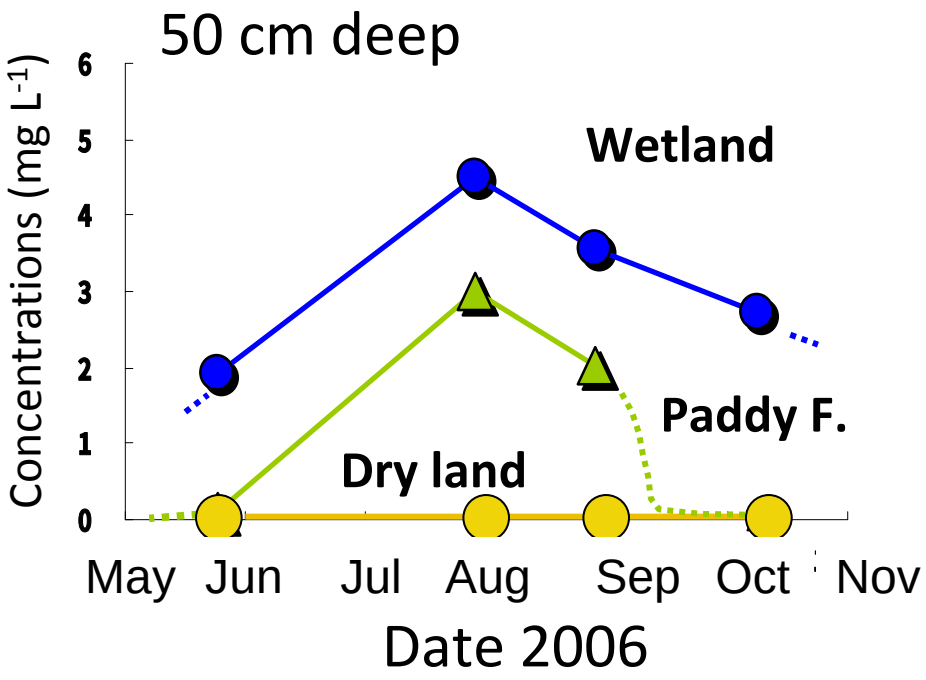
The area of wetlands in the Sanjiang plain in 1976 and 2005



(Song et al., 2007)

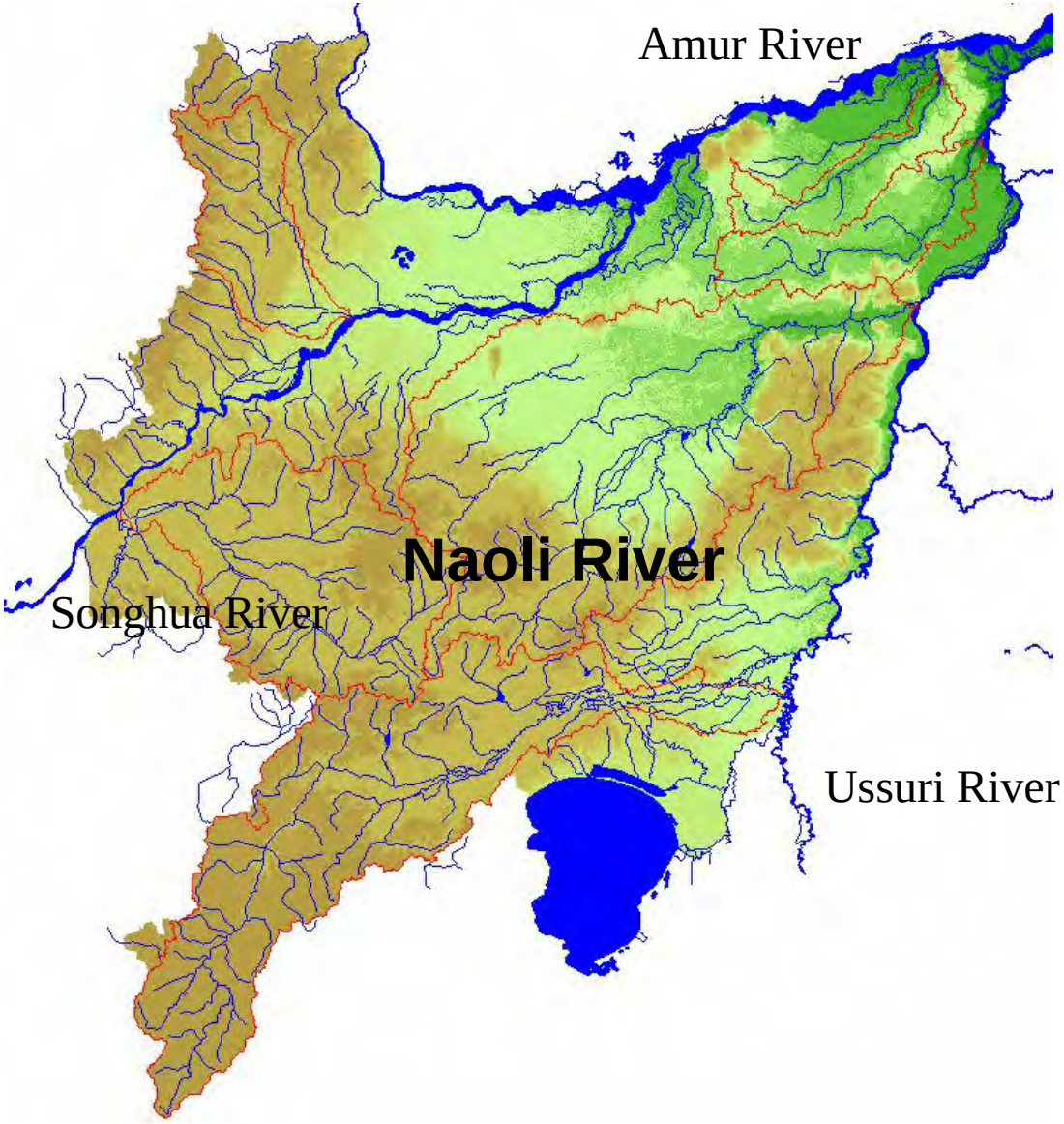
Seasonal changes in dissolved iron concentrations in the interstitial soil water at various land-cover in the Sanjiang Plain 2006





Yoh et al. (unpublished)

Total iron conc. in Naoli River, Sanjiang plain, China (mgL^{-1})



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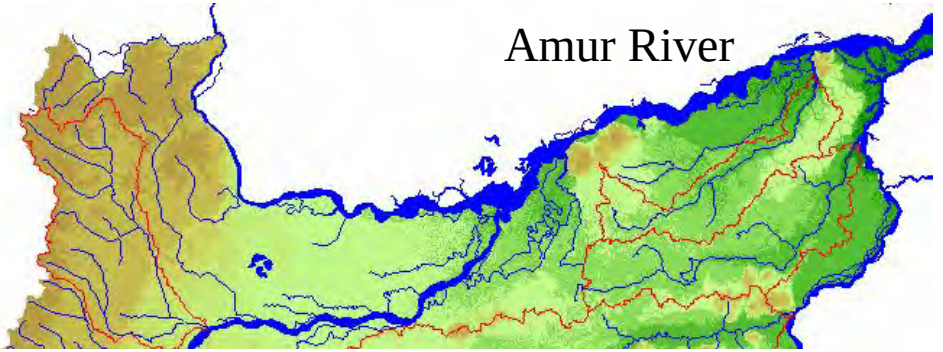

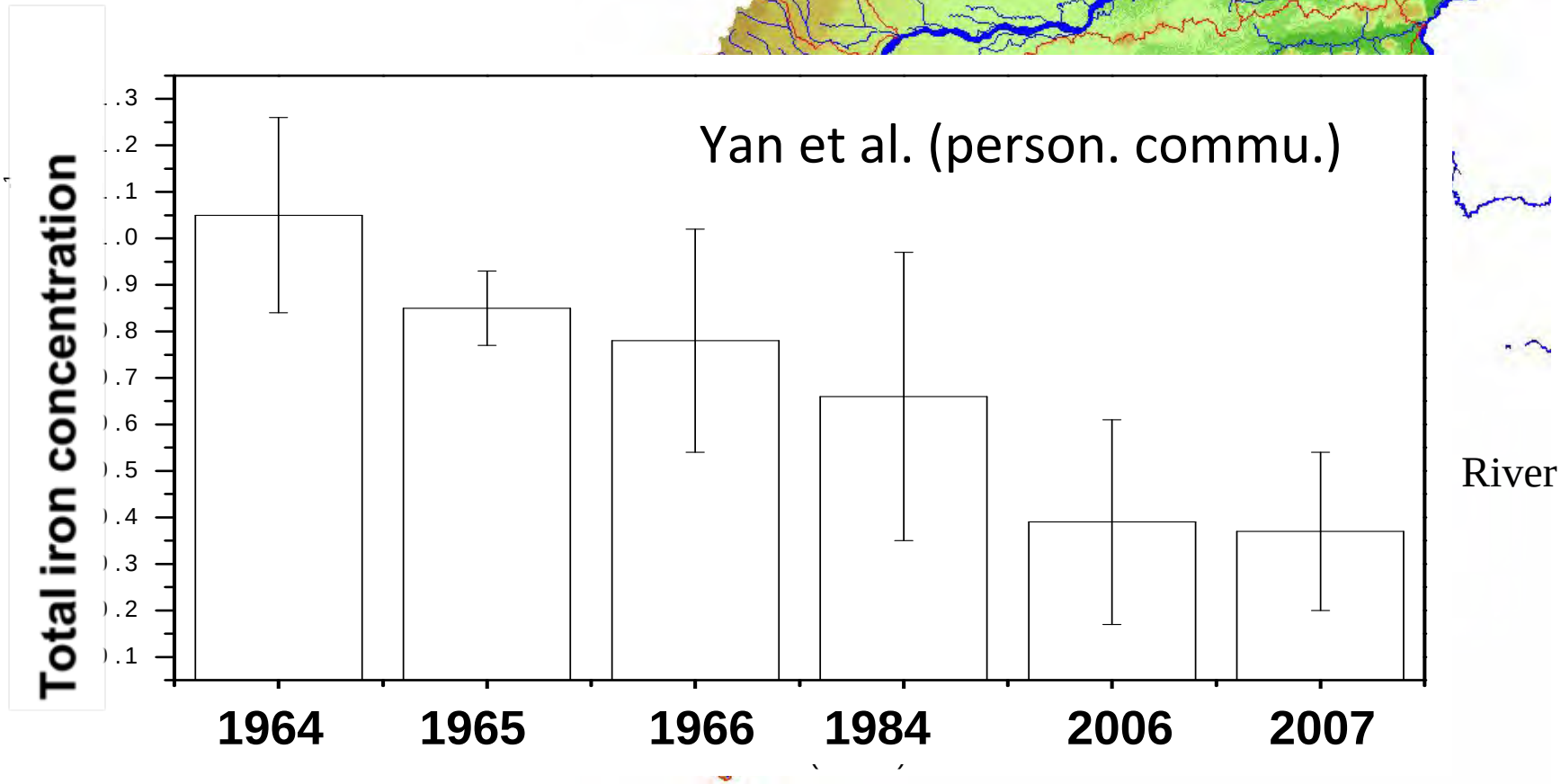

Result of land-cover/land-use change impact experiments
-Scenario based approach-

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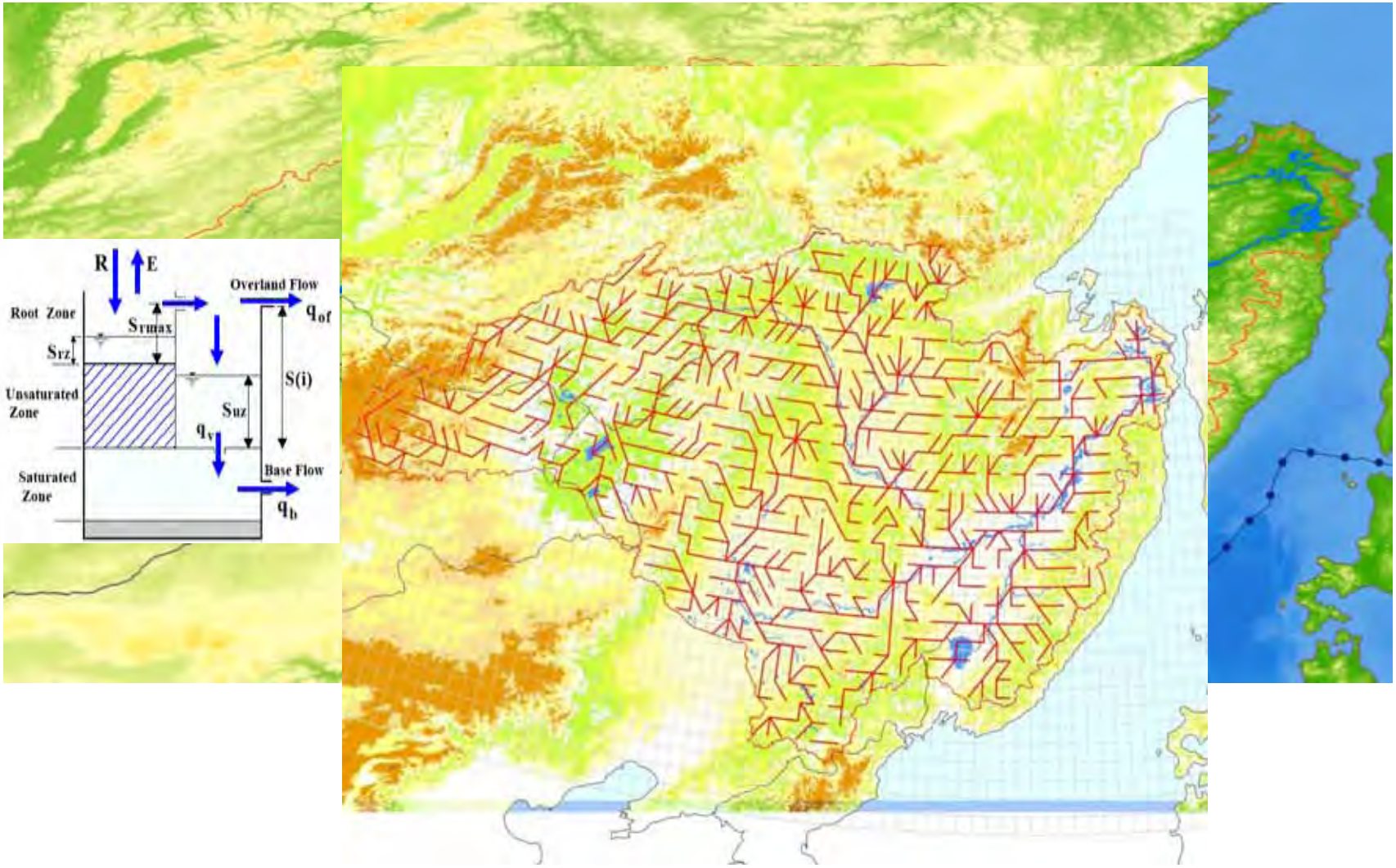
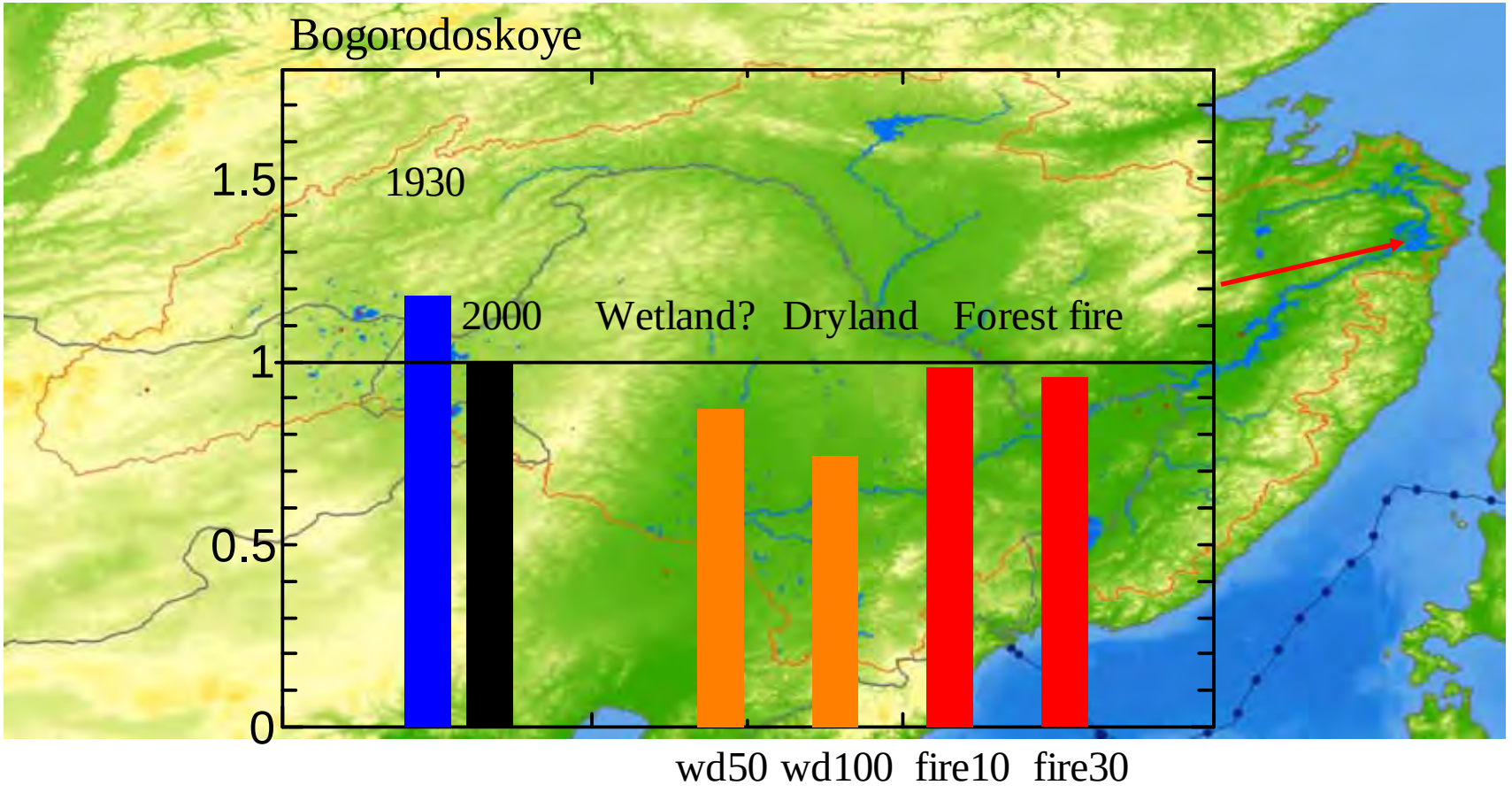


Result of land-cover/land-use change impact experiments
-Scenario based approach-



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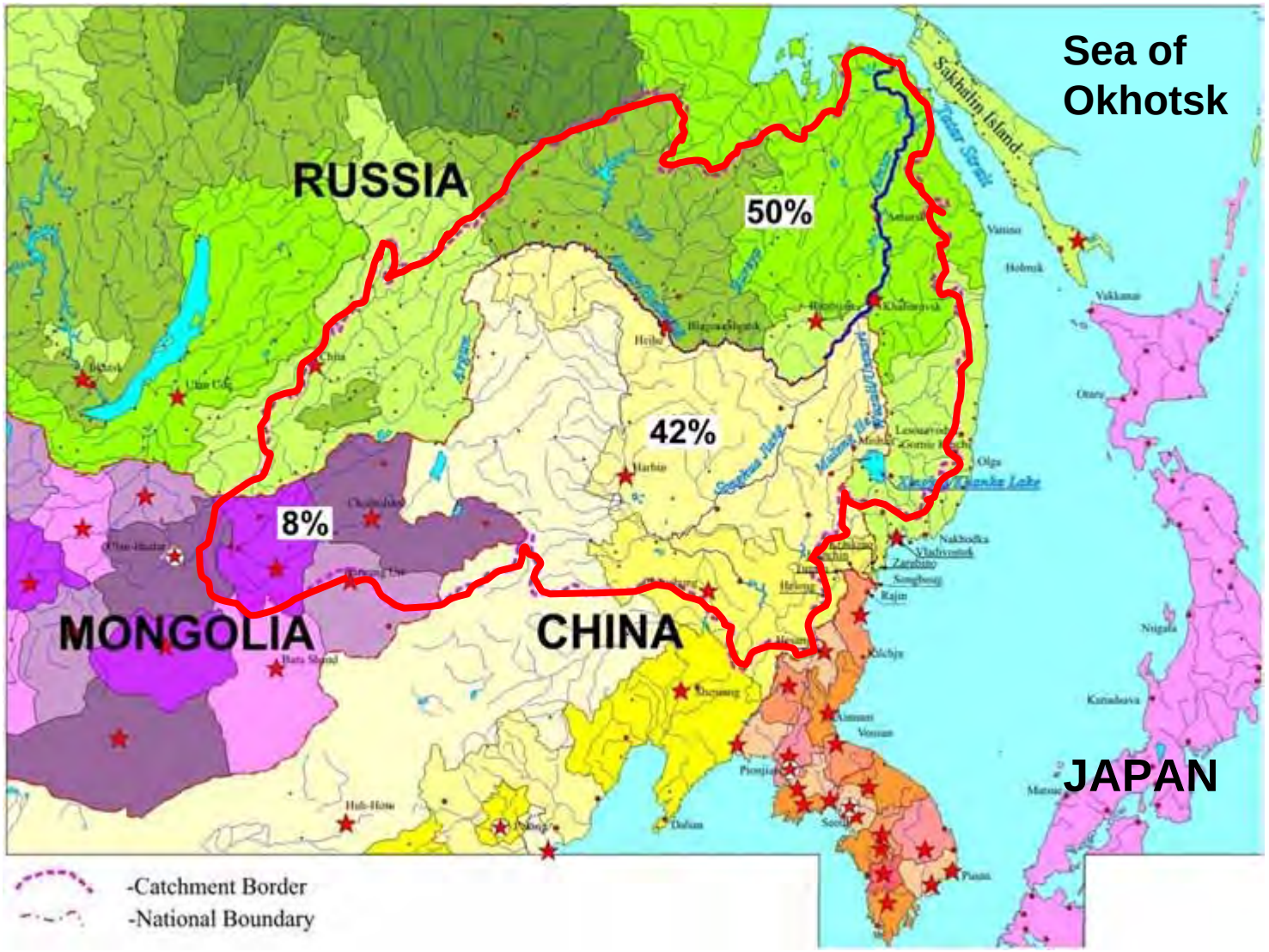
Explosion of a petrochemical plant in China and the nitrobenzene spill to the Songhua/Amur river system

Amur River basin and the Sea of Okhotsk



The Amur-Okhotsk Consortium (established in Nov 8 2009)

1.is multinational academic network to discuss the conservation and the sustainable use of the Amur-Okhotsk ecosystem;
2.shares and exchanges information and opinion on a regular basis concerning what is necessary and what must be done for the conservation of our nature;
3.make the best effort toward a cooperative environmental joint monitoring;

Consortium members are from;
Research Institutes;
University;
Governmental organizations;
Private companies;

from Japan, China, Russia (from 2009)

The 2nd Int. Meeting

November 5-6, Sapporo Japan

Purposes
Sharing of environmental data across national boundaries
Discussion for the future joint monitoring

S1 Environment of Amur River basin

S2 Changes in the Sea of Okhotsk

S3 Impact of Fukushima on marine environment

S4 Socio-economy of the Amur-Okhotsk region

S5 Multilateral effort for the conservation of Pan-Okhotsk region

Discussion How we can share the data ?

Conclusions

1. The Giant fish-breeding forest hypothesis was proposed and validated;

2. 1) Land-use change impact was clear in tributary scale;
   2) Land-use change impact is still controversial in basin scale;

3. 1) Launch of the international network named “Amur-Okhotsk Consortium” for the conservation of the Sea of Okhotsk and the Amur River basin