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Migratory Birds Methylmercury Exposure in Eastern China：Risk and Challenge

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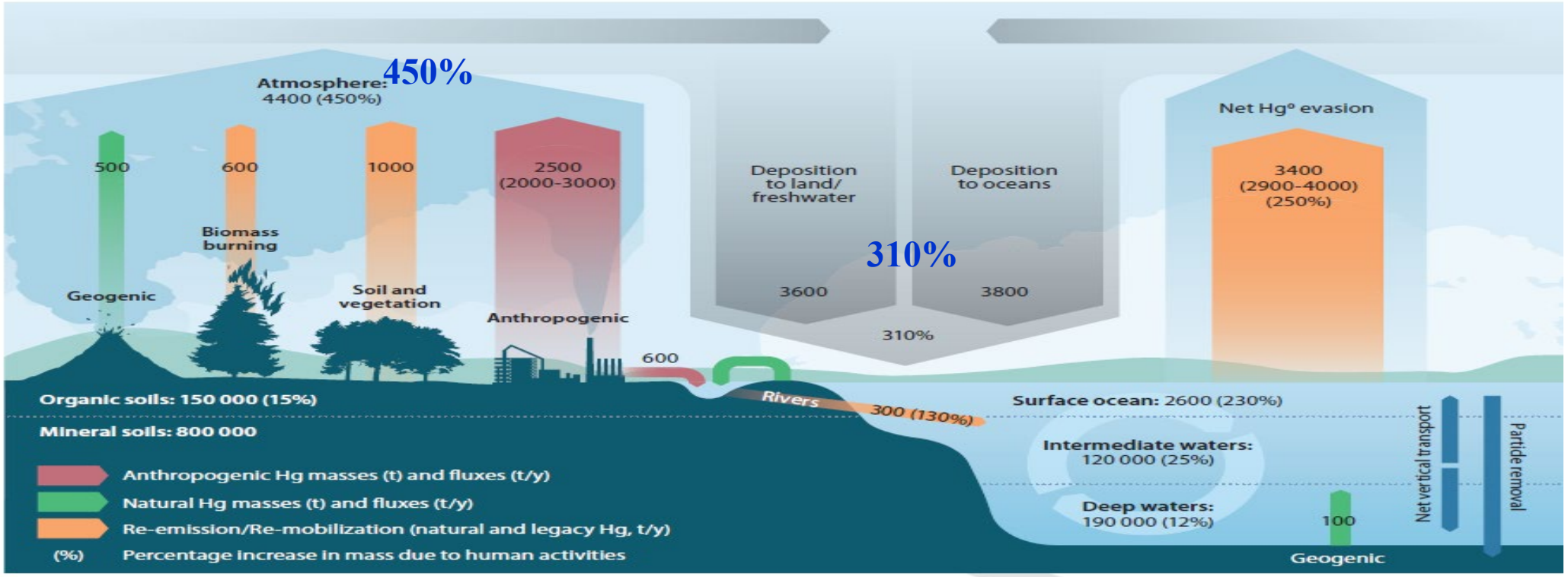
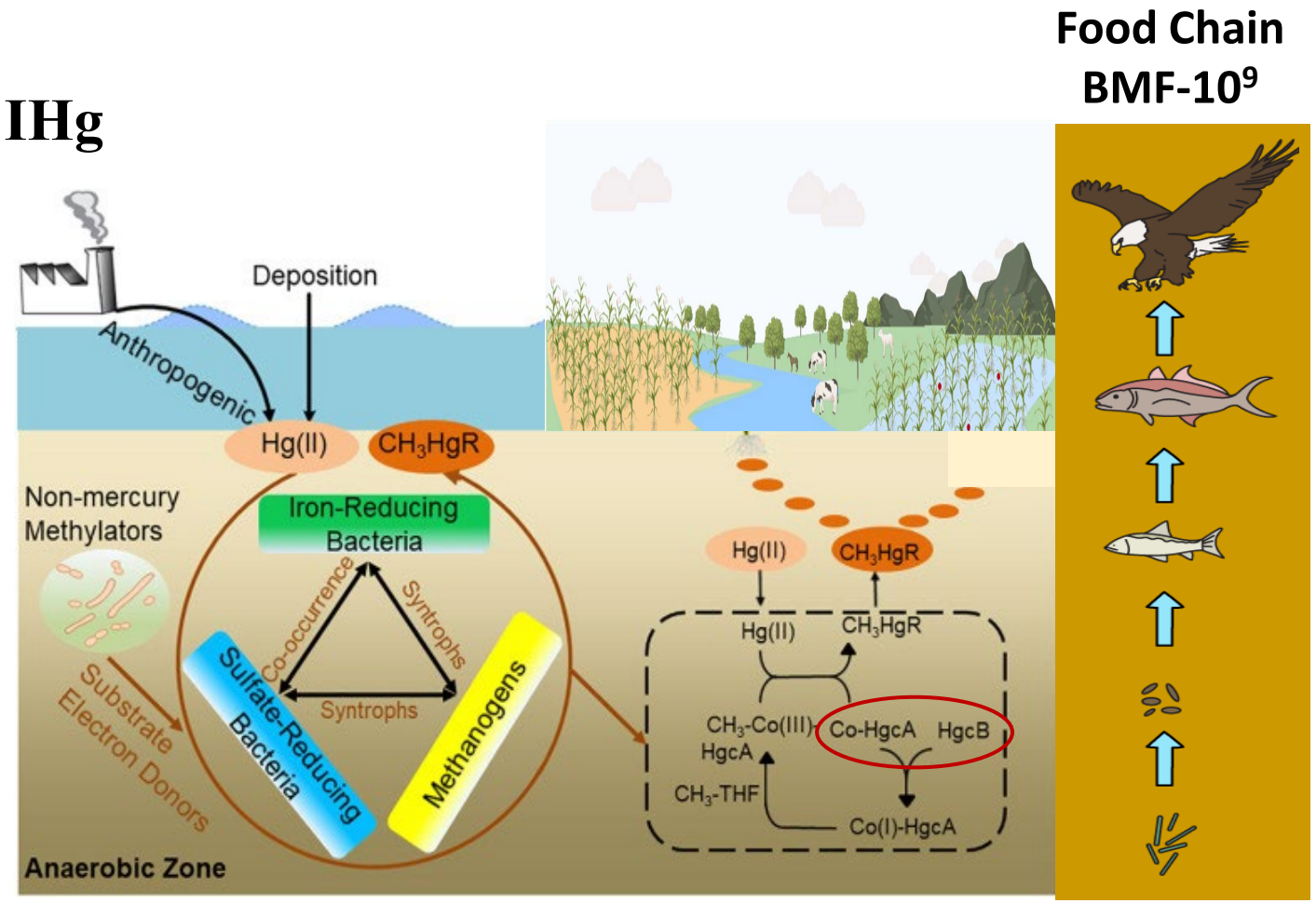
Human emissions increased mercury in the atmosphere

Mercury is Local-Regional-Global Pollutant, and can transport across multi-spheres on global scale.



- UNEP, 2018

Aquatic sediments are hotspots for MeHg production



- IHg can easily be converted into MeHg under anaerobic conditions
- Methylation potential: microbial processes, Hg availability, sulfate, pH, DOM, Cl^{-1}…
- MeHg is easy bioaccumulation with the food chains, and high levels of MeHg in biota raises global great concern.

Birds are Particularly Sensitive to MeHg toxicity

Reproduction completely fails

- Decrease eggs number & hatching success
- Increase ectopic embryos & incubation period
- Chicks less responsive to fright stimulus

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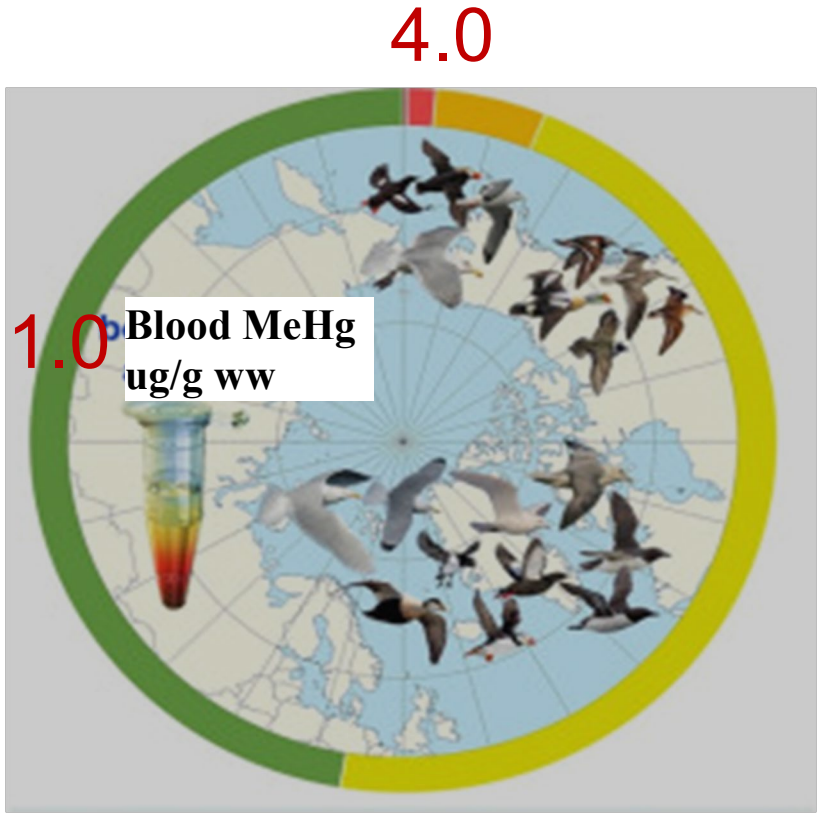


- AMAP, 2019

High MeHg exposure:

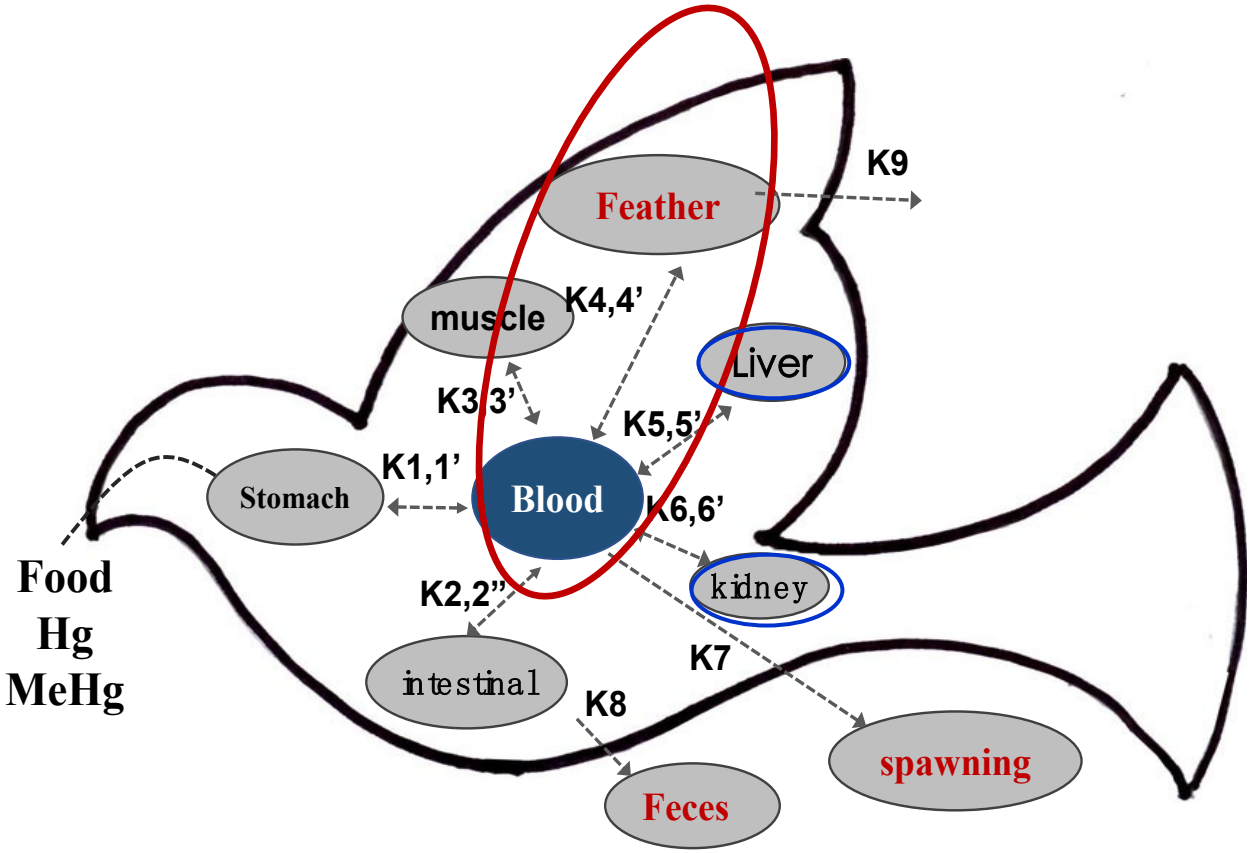
- alter the **migration behavior**

  (speed/time/vector orientation)

- decline in the number of migratory birds worldwide and endangered species.

Chad L. Seewagen et al.,2019,2020,2022

MeHg Metabolism in Bird



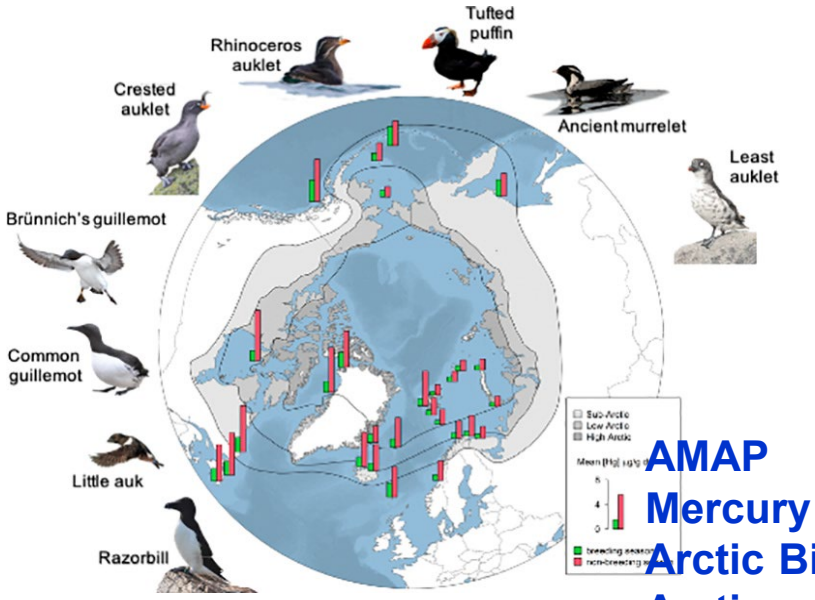
- Birds assimilated mainly MeHg(80%)
- Excretion routes :
  Feathers(63-95%), Egg (female) ~24%, Faeces and other
  Carcass(5.8-30%)
- Feather bound MeHg to keratin and accurately reflect blood mercury with time of feather growth.

Feather as indicator of MeHg exposure in birds

Threats of environmental mercury to birds

ARCTOX

A PAN-ARCTIC NETWORK TO TRACK MERCURY CONTAMINATION ACROSS ARCTIC MARINE FOOD WEBS, 2014

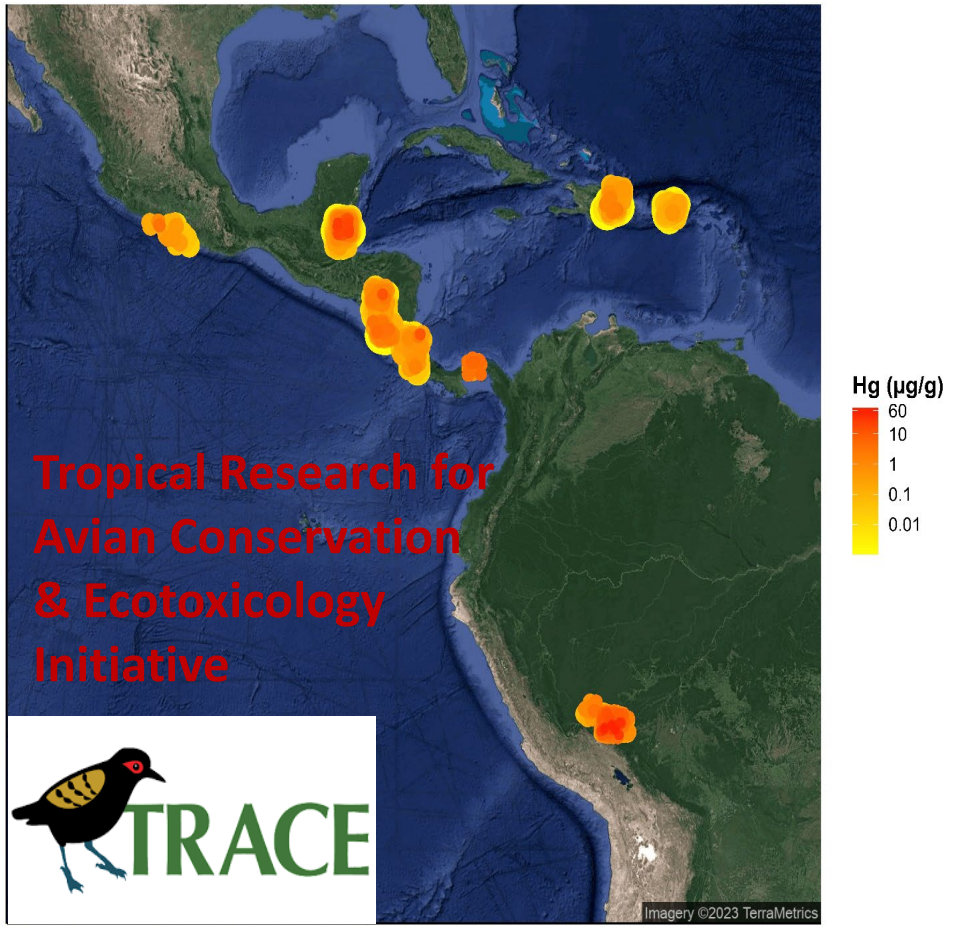


AMAP Mercury in Arctic Biota

Arctic Coucile

ASDN (Arctic Shorebird Demographics Network

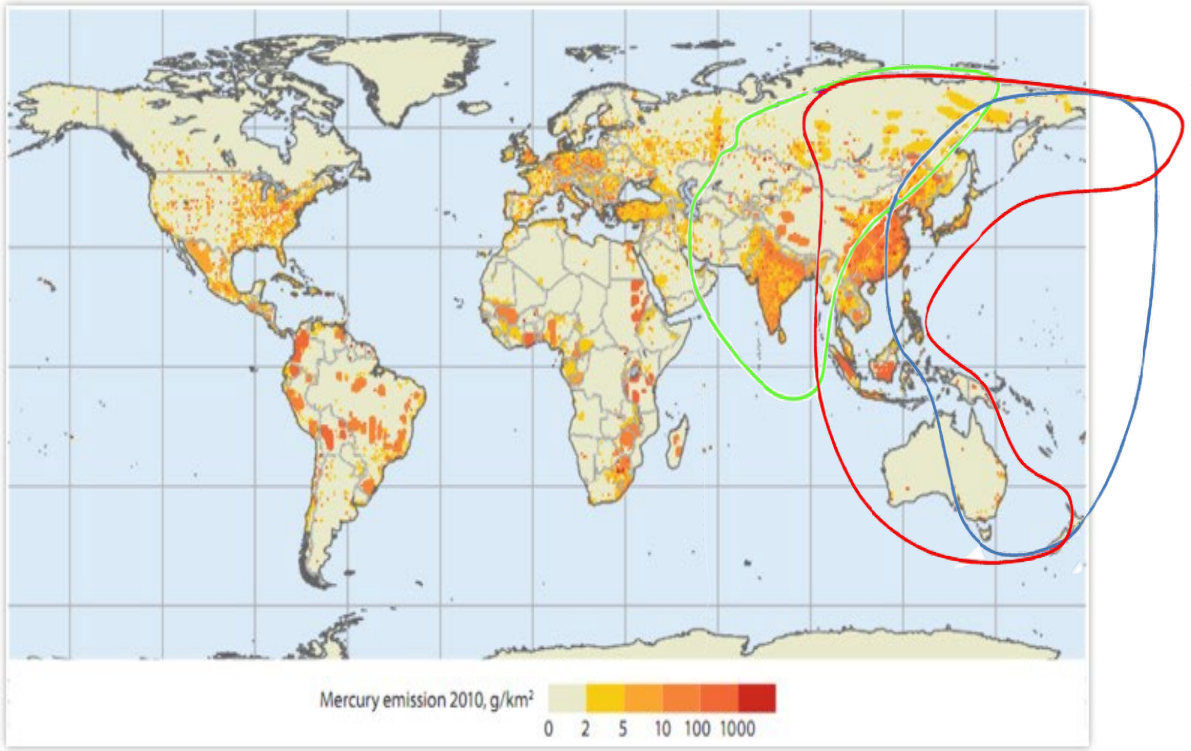
U.S. Fish & Wildlife Service



Arctic seabirds and shorebirds:

Knowledge gap

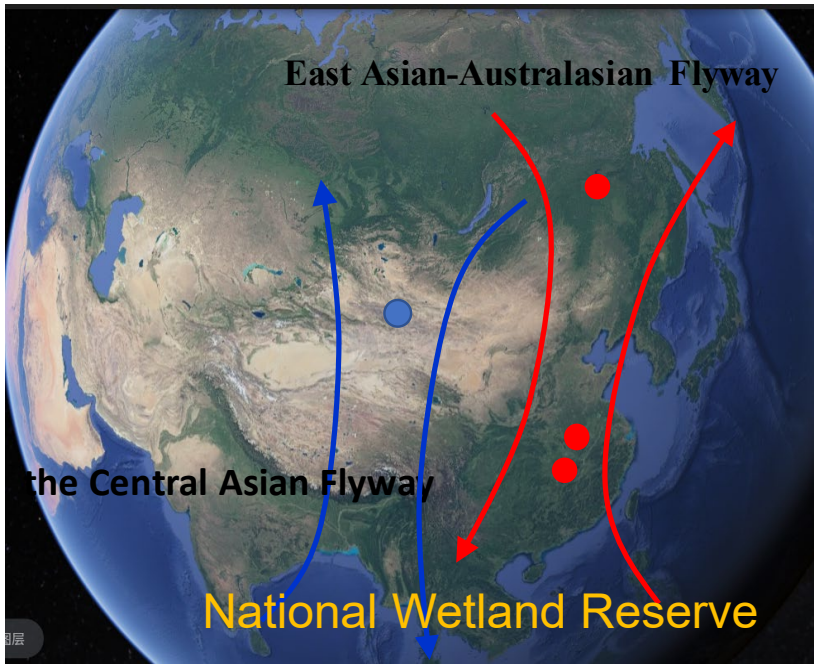
High Mercury deposition in East Asia/China



East Asian-Australasian Flyway (EAAF),
Central Asian Flyway (CAF)
West Asia/East Africa Flyways(WAEAF)

- MeHg load in bird habitats？
- MeHg accumulation in migratory birds?
- What risks arise? Does it affect reproduction, survival and population of birds?

The investigations of MeHg in birds and habitats



Sampling:

- **Environments: Soil/Sediment**
- **Aquatic biota : Insects, Snails, fish**
- **Birds (Feather, Organs&Carcass)**

Nanji Dec 2020 ~ Mar 2021	Nanfengmian Oct 2021	Zhalong Aug ~ Sep 2021
9 orders 15 families 32 species 232 individuals	7 orders 10 families 26 species 231 individuals	2 orders 3 families 4 species 46individuals

NSFC
National Natural Science Foundation of China

Sample Measurement

Total mercury (pyrolysis)

KOH-methanol digestion

CH_2Cl_2 extraction-ethylation derivation

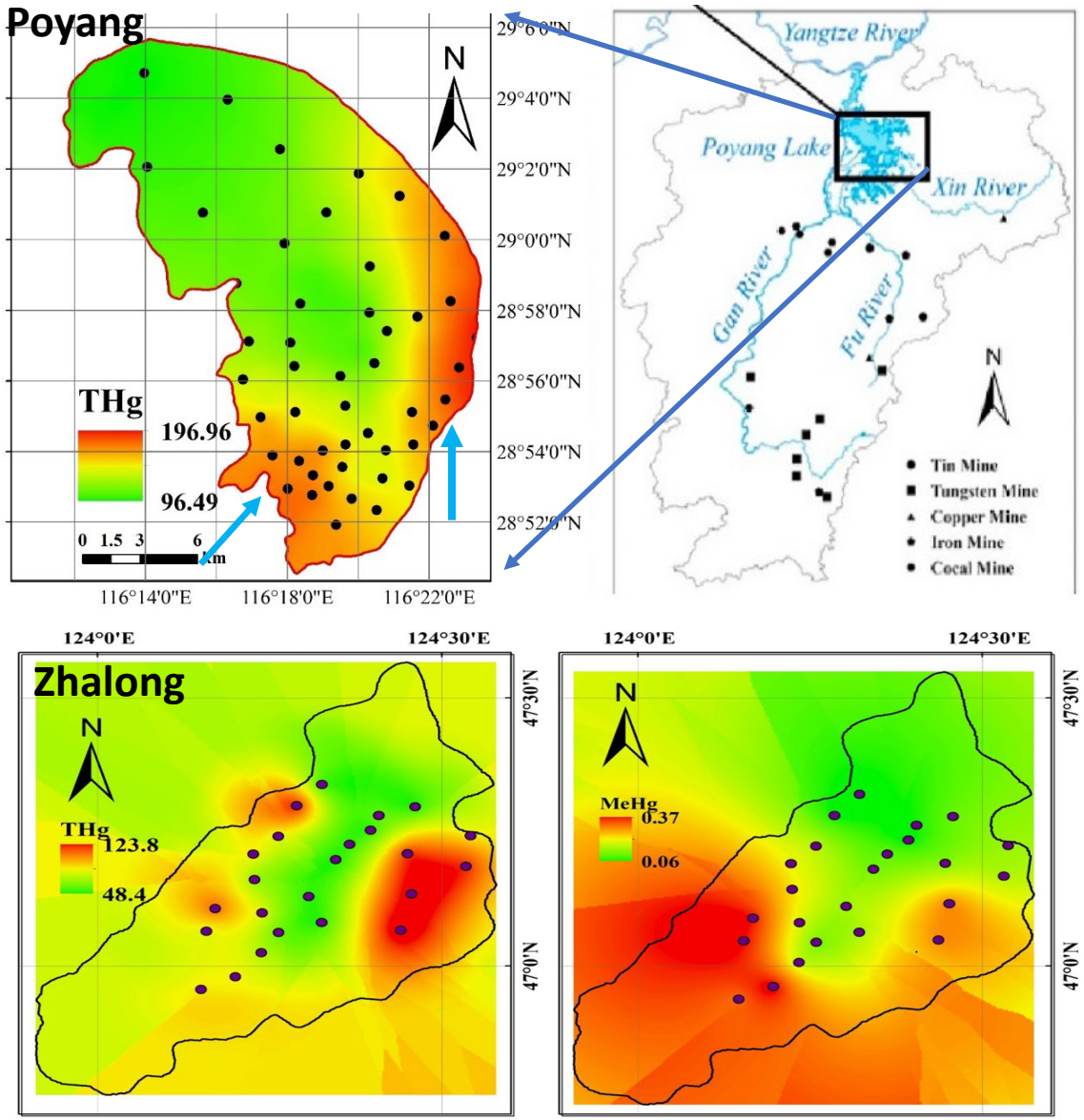
GC-CVAFS

Methylmercury

Data standardization（bird）

Original data (present study and references)	Standardization to blood equivalent THg µg/g wet weight	
Egg Blood Liver Kidney Muscle Body feather (back/ breast/others)	$(R^2=0.90)$:ln $\left(Blood\ THg_{\frac{\mu g}{g}ww}\right)=1.080\times\ln\left(Bird\ Muscle\ THg_{\frac{\mu g}{g}dw}\right)-1.024$ $(R^2=0.88)$:ln $\left(Blood\ THg_{\frac{\mu g}{g}ww}\right)=0.970\times\ln\left(Bird\ Liver\ THg_{\frac{\mu g}{g}dw}\right)-1.929$ $(R^2=0.87)$:ln $\left(Blood\ THg_{\frac{\mu g}{g}ww}\right)=1.003\times\ln\left(Bird\ Kidney\ THg_{\frac{\mu g}{g}dw}\right)-2.008$ $(R^2=0.32)$:ln $\left(Blood\ THg_{\frac{\mu g}{g}ww}\right)=0.673\times\ln\left(Bird\ Feather\ THg_{\frac{\mu g}{g}dw}\right)-1.673$ $(R^2=0.95)$:ln $\left(Female\ Bird\ Blood\ THg_{\frac{\mu g}{g}ww}\right)=1.0734\times\ln\left(Egg\ THg_{\frac{\mu g}{g}fww}\right)+0.8149$	Ackerman et al. 2016 Eagles-Smith et al. 2008 Custer et al. 2007
Age: only adult and post-fledgling		
Wet weight to dry weight: Moisture content: Blood 79% Liver 67% Kidney 74% Muscle 70% Egg 75% Feather : Grebe 47.3% Gull 63.9% Heron 76.3%	(Species have been excluded when n < 5)	

1 Catchment-scale: Hg load of sediment



- Pattern : **High level at the river entrance, the mining effects from upstream area.**
- **Poyang: the Igeo index shows 81.6% of sediment were contaminated, among which 8.2% were at the moderately polluted level. 16.3% exceeded the benchmark concentration for freshwater sediments;**
- **Zhalong : 70.8% of the main lake sediment were contaminated, among which 20.8% were at the moderately polluted level.**

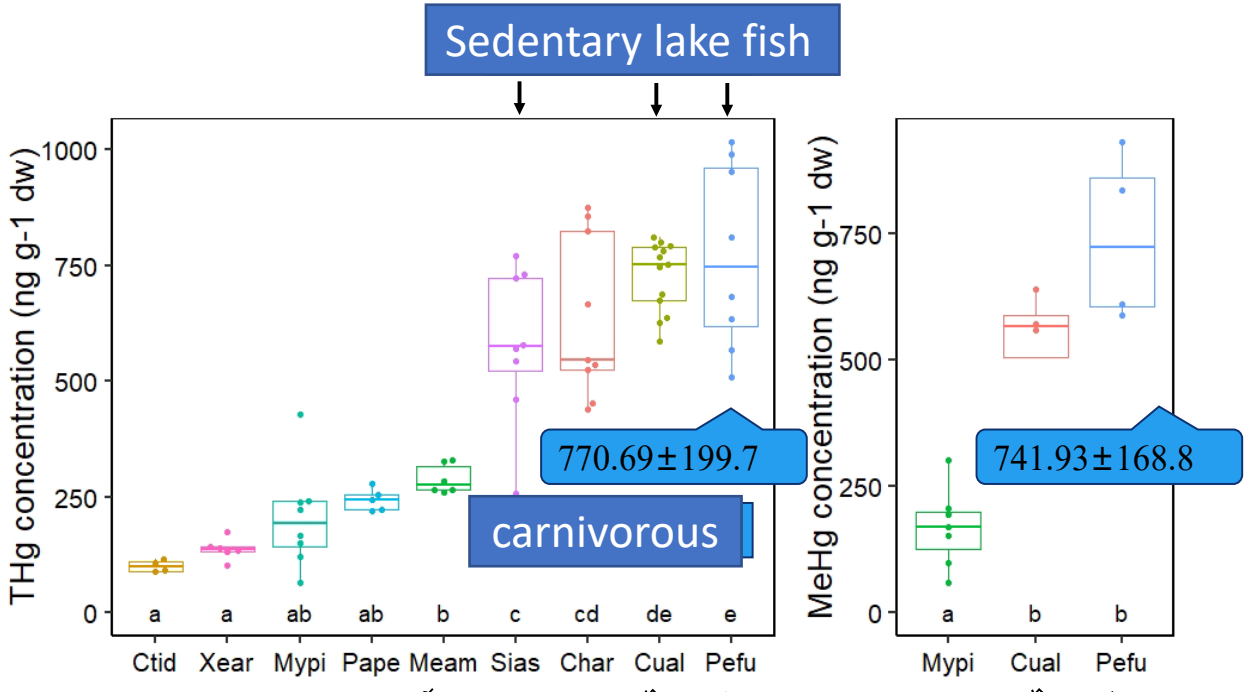
--- Liu and Wang et al., 2023

2 High Con. of MeHg in some wild carnivorous fish

ng g^{-1} ww

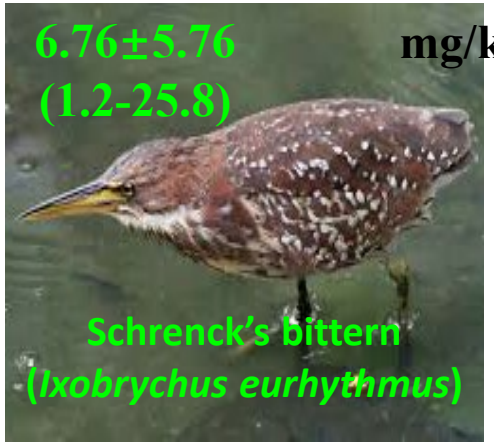
Sedentary lake fish

51%(>100ng g-1) carnivorous fish were adversely affected to Piscivores, but all fish did not exceed the human food safety standards recommend by China and the WHO.

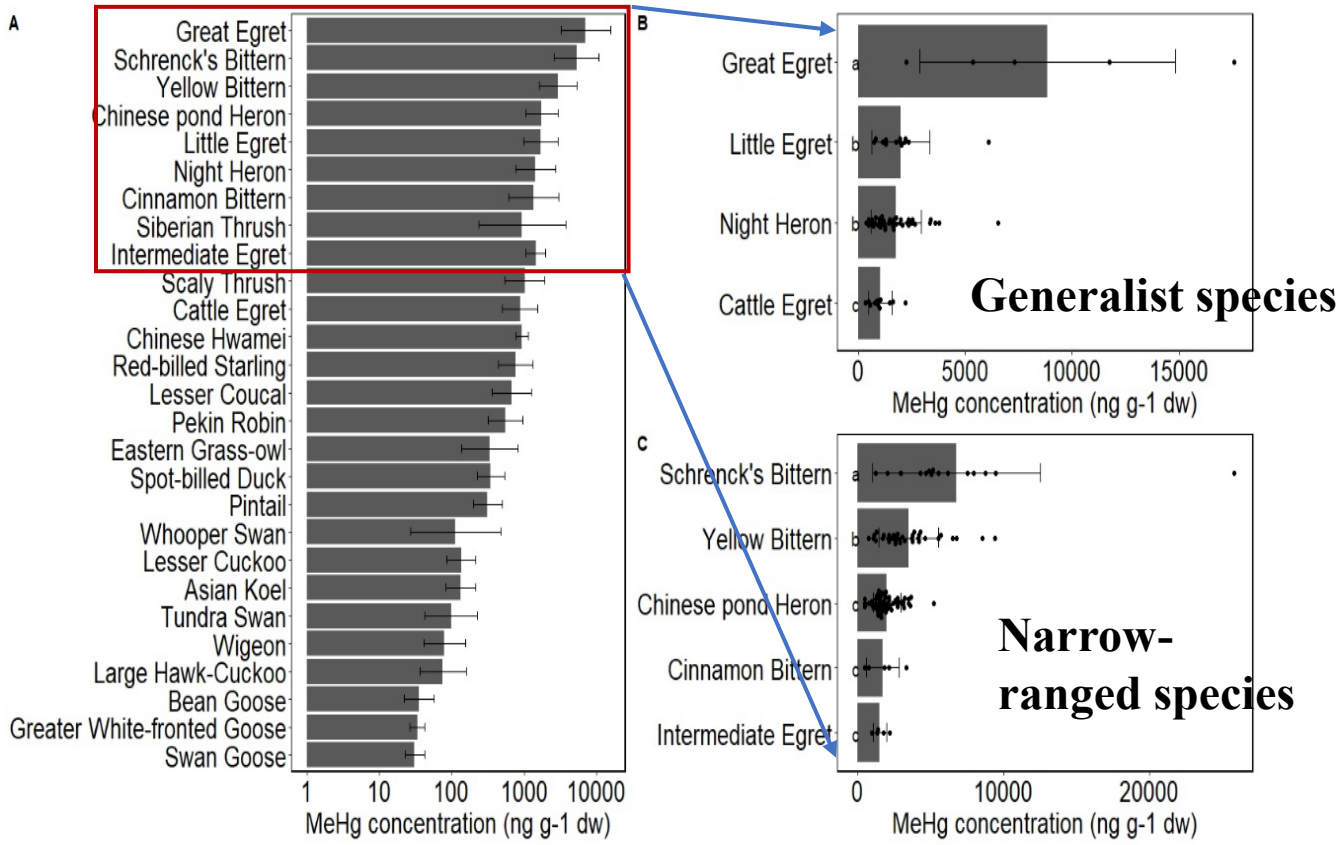


--- Liu and Wang et al., 2023

2 High levels of MeHg in some fish-eating birds



High MeHg accumulation in feathers of Ardeidae



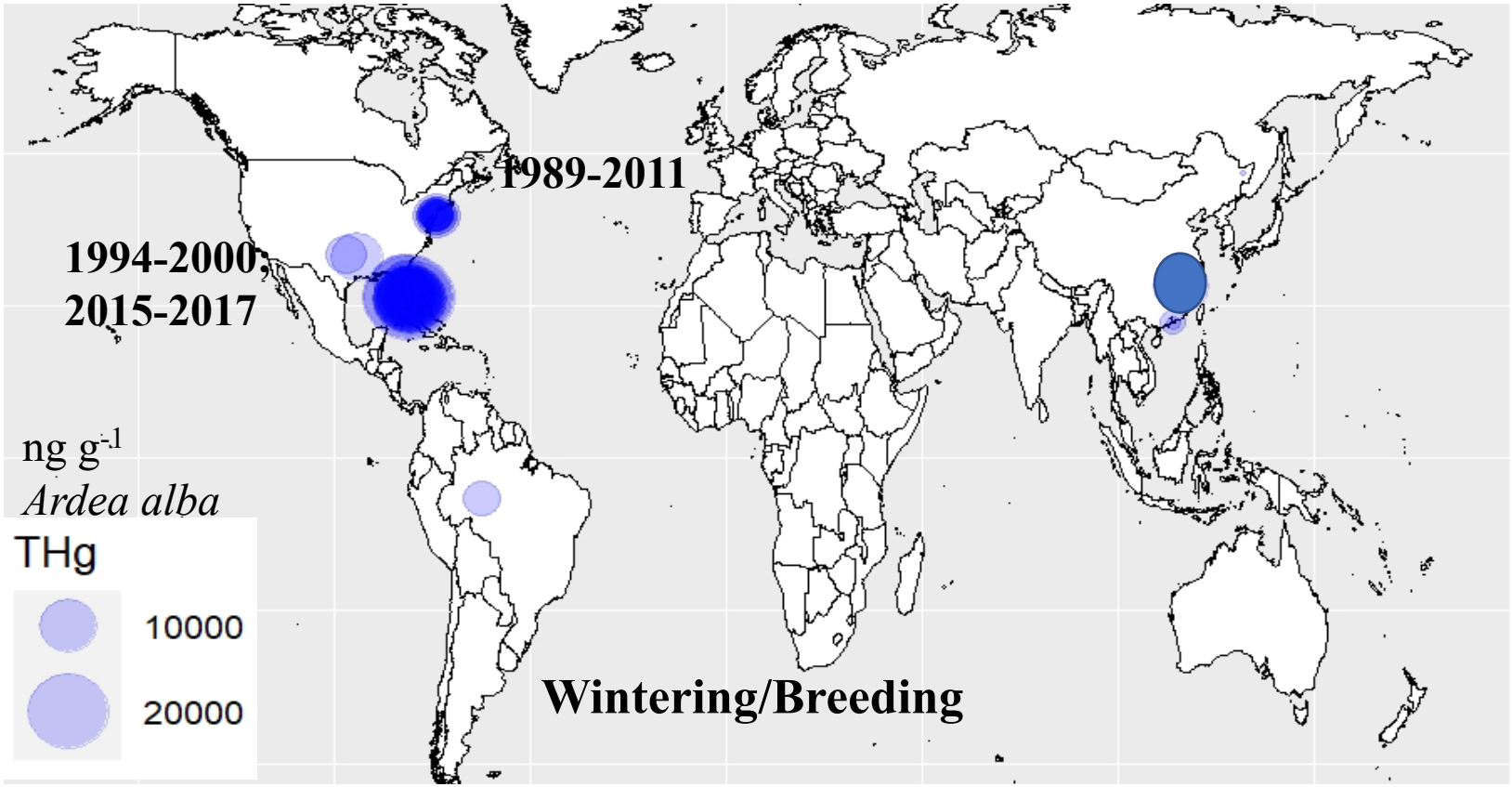
Feather MeHg varied greatly by species, foraging guilds and taxonomic orders, 3-4 orders of magnitude difference.

Generalist species:

Great egret : 8.85±5.97 ug g^{-1} dw

Min: 2.25 ug g^{-1} dw

Max:17.59 ug g^{-1} dw



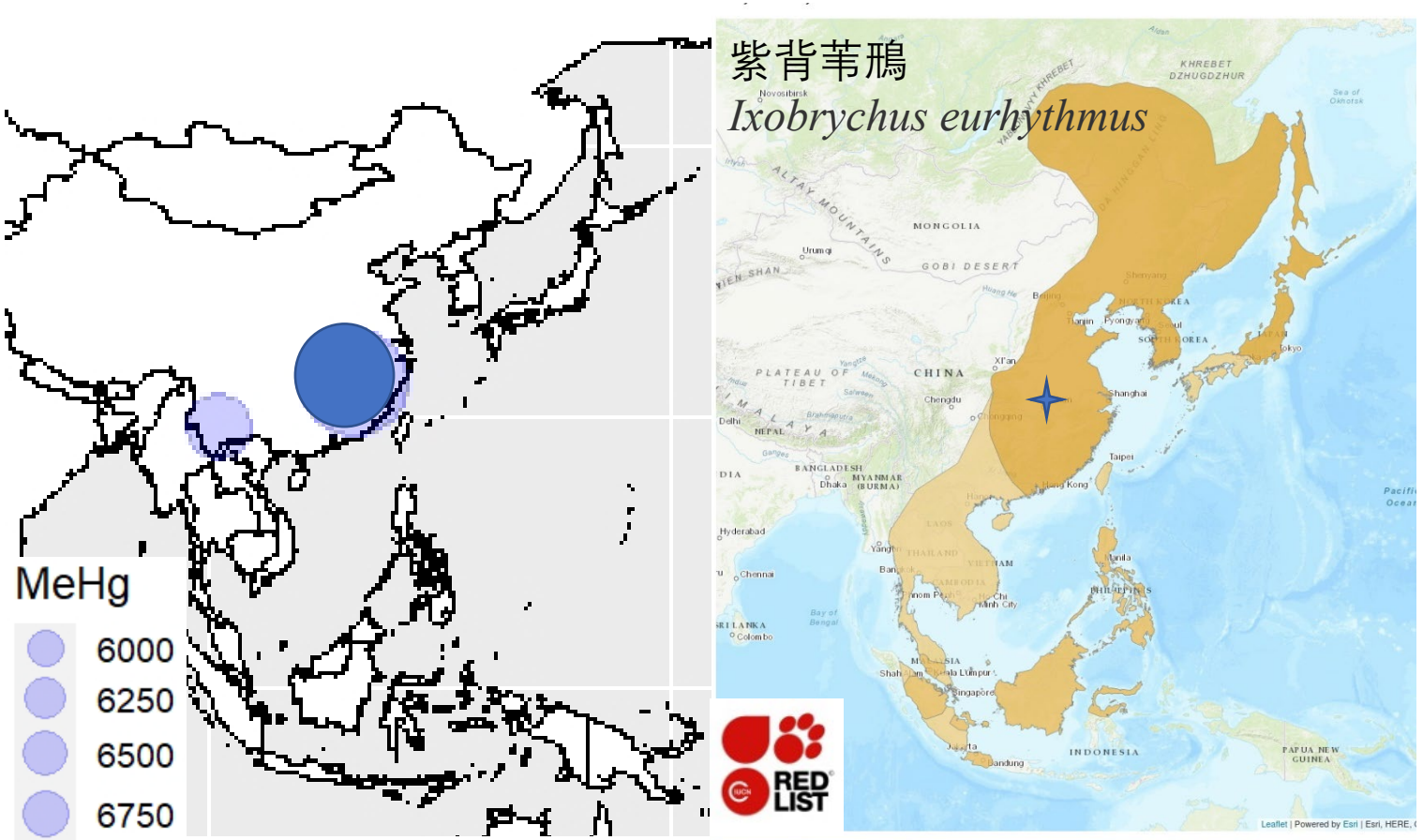
➢ *Narrow range species in Breeding:*

***Schrenck`s bittern*：**

➢ （6.75±5.76 ug g^{-1} dw）

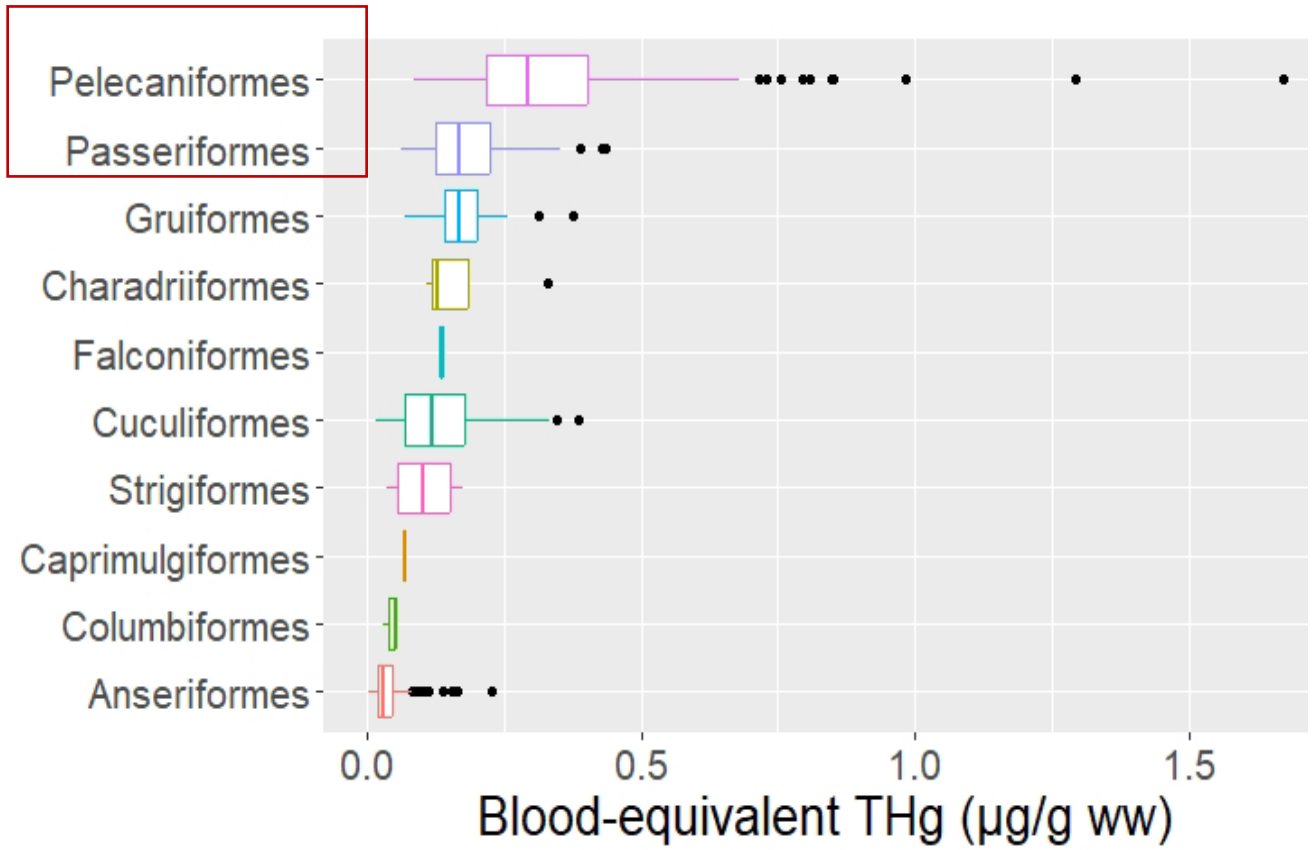
Min：1.20 ug g^{-1} dw

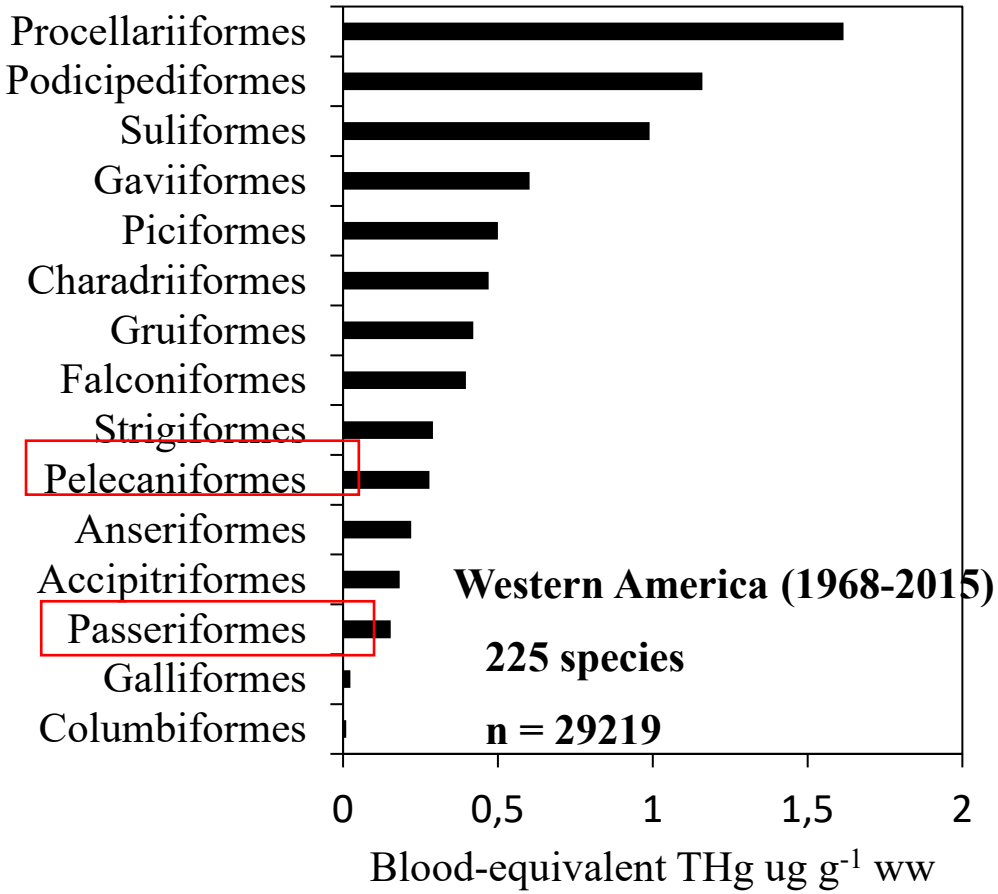
Max: 25.80 ug g^{-1} dw



2 Pelecaniformes and Passeriforme have the highest MeHg levels

MeHg concentrations of birds by taxonomic orders





(Ackerman et al. 2016)

3 The optimization for Hg exposure risk assessment

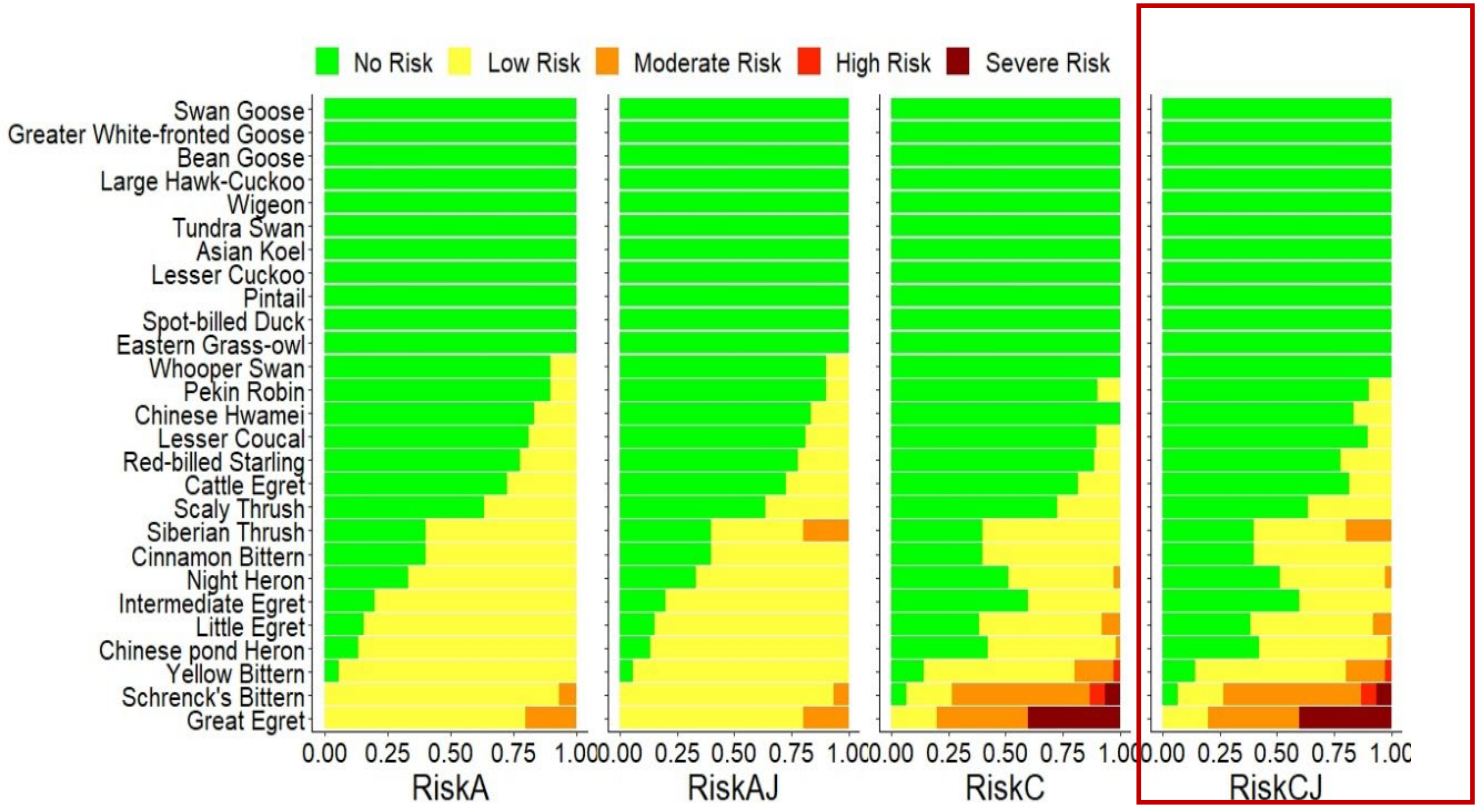
Transformation of blood-equivalent concentrations, and three equation:

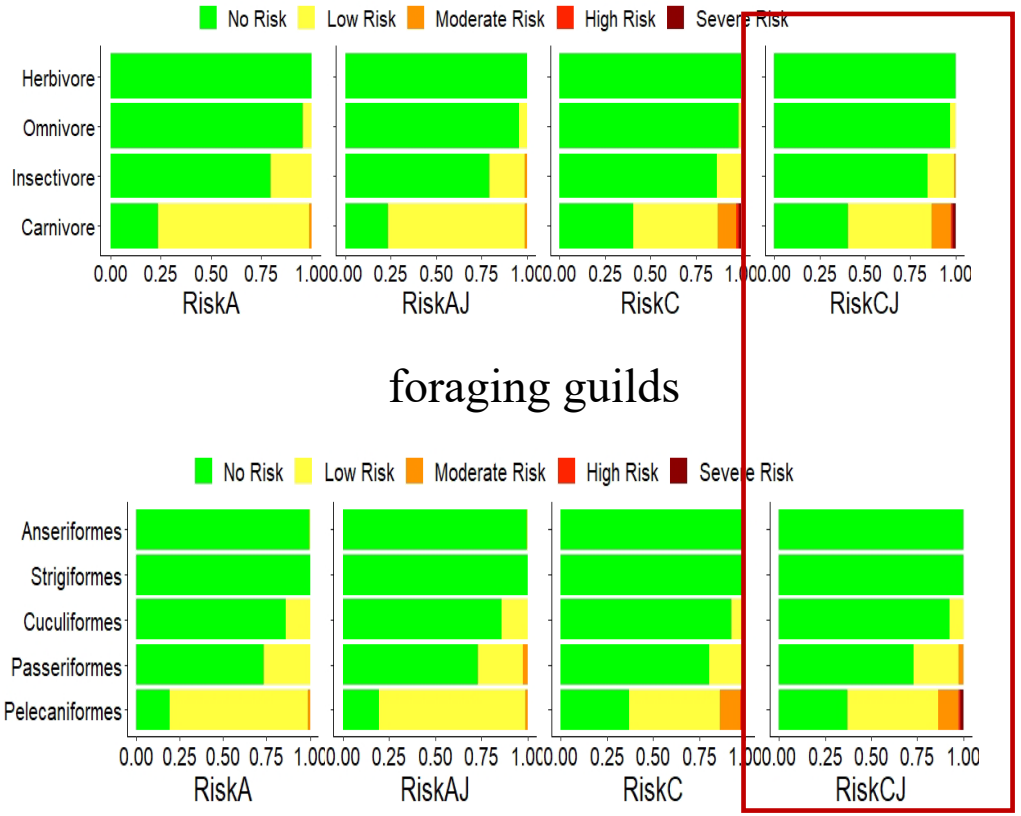
Equations	Species		Refer
Eq.A $\ln\left(Bird\ feather\ THg\ \frac{\text{mg}}{\text{kg}}\ \text{ww}\right) = 1.486 \times \ln\left(Blood\ THg\ \frac{\text{mg}}{\text{kg}}\ \text{dw}\right) + 2.486$	Charadriiformes n=601 R2 = 0.32	American avocet,black-necked stilt, caspian tern forster's tern	**Eagles-Smith et al. 2008**
Eq.C $\ln\left(Body\ feather\ Hg\ \frac{mg}{kg}\ dw\right) = 0.64 \times \ln\left(Blood\ Hg\ \frac{mg}{kg}\ ww\right) + 1.51$	seabirds and shorebirds	2077 individuals, 16 species, 2015-2017	**Chastel et al. 2022**
Eq.J $(Body\ feather\ Hg\ \frac{mg}{kg}\ ww) = 2.14 \times (Blood\ Hg\ \frac{mg}{kg}\ ww) + 0.85$	Passerines n = 21 R2 = 0.88	Carolina wren *Thryothorus ludovicianus*	**Jackson et al. 2011**

Four schemes: Eq.A， Eq.C， Eq.A + Eq.C , Eq.A + Eq.J

3 The optimization for Hg exposure risk assessment

We posed the combining Chastel et al. 2022 and Jackson et al. 2011 is the optimal for our dataset.

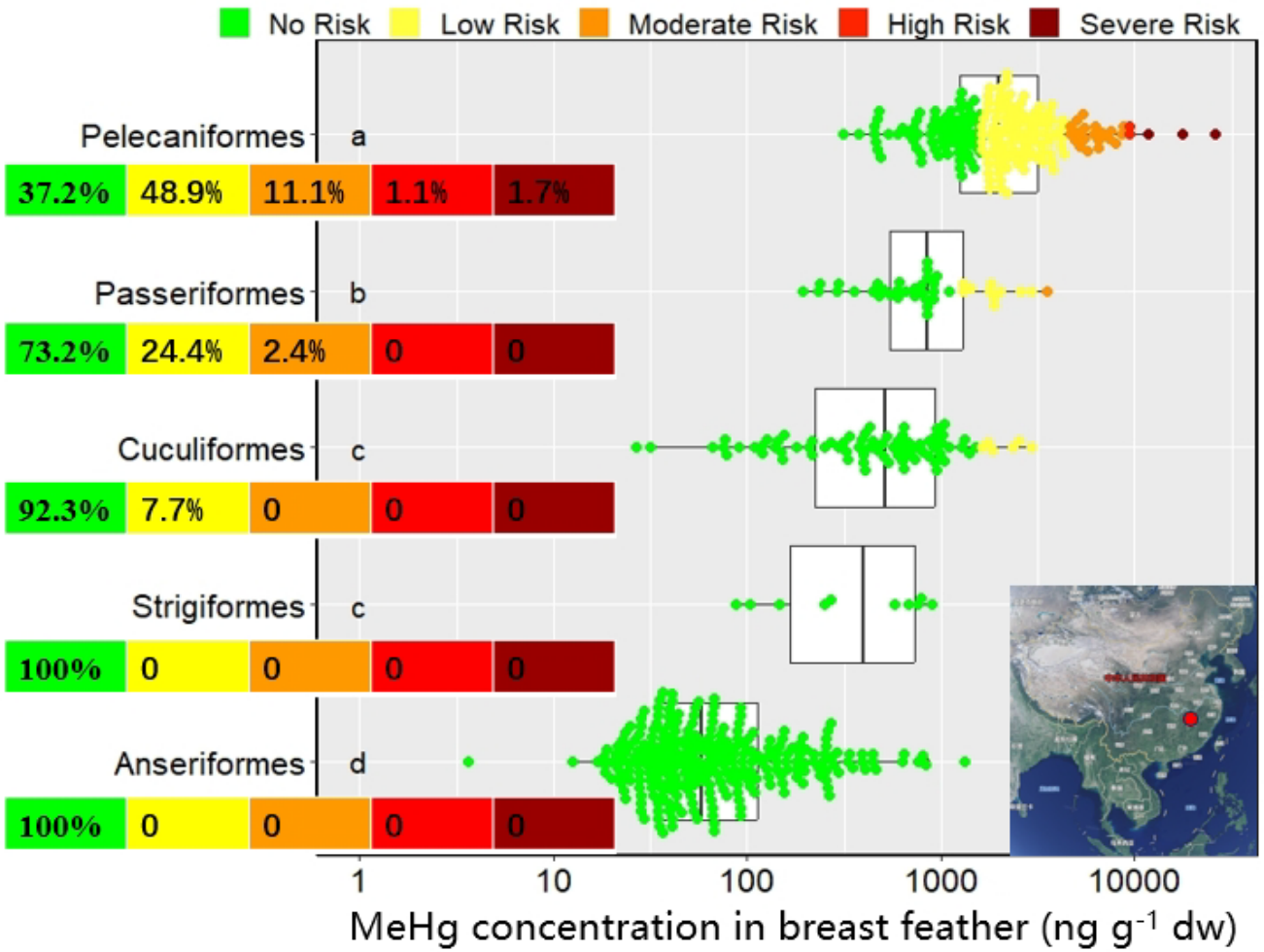




foraging guilds

orders

3 MeHg risks of wintering migratory birds in Poyang Lake basin



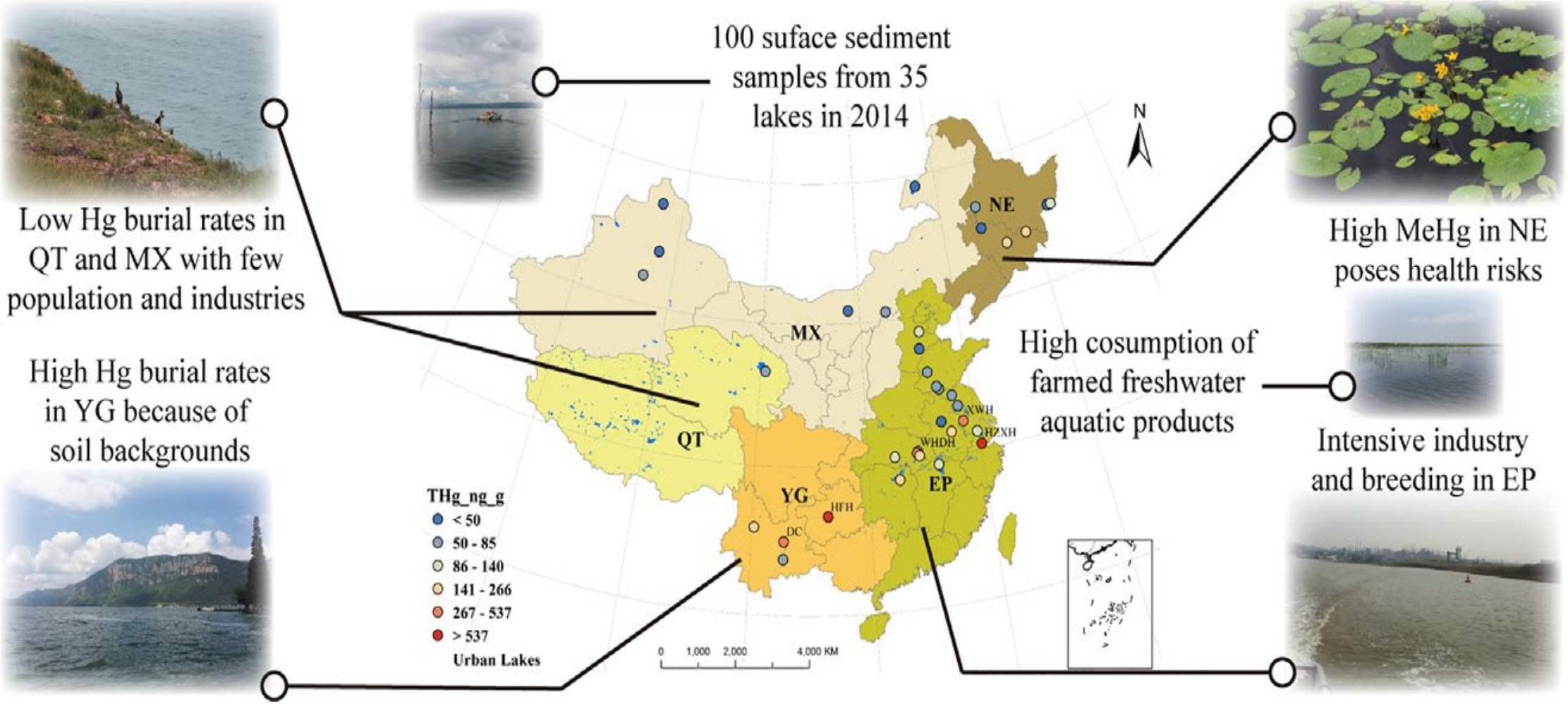
- **23.1%** of birds from Poyang Lake were at risk of Hg exposure.
- Carnivorous birds from **Pelecaniformes had the highest risk levels,** with **11.1%** as moderate risk (1000~3000 ng g^{-1} ww), **1.1% as high risk** (3000~4000 ng g^{-1} ww), and **1.7% as severe risk** (> 4000 ng g-1 ww).

MeHg risks of migratory birds

Risk rank	Poyang			Zhalong		West North U.S (Ackerman et al. 2016)		North Atlantic (Pollet et al. 2022)	Arctic Region (Chastel et al. 2022)	
	All species	Carnivorous	Pelecaniformes	All species	Carnivorous	All species	Carnivorous	Seabird	Seabird	Shorebird
No	76.9%	37.2%	35.3%	48.1%	18.2%	34%	23.7%	0	50%	45%
Low	18.5%	48.9%	47.1%	27.8%	42.4%	38%	39.7%	44%	43%	47%
Median	3.7%	11.1%	14.0%	24.0%	39.4%	20%	26.6%	30%	6%	5.5%
High	0.4%	1.1%	1.5%	0	0	4%	4.5%	21%	0.5%	2.5%
Extremely high	0.5%	1.7%	2.1%	0	0	4%	5.5%	5%	0.5%	0
		62.8%			81.8%		76.3%	56%	50.0%	55.0%

4 Migratory Birds MeHg Exposure challenge in the future

High flux of mercury emission and deposition in east china

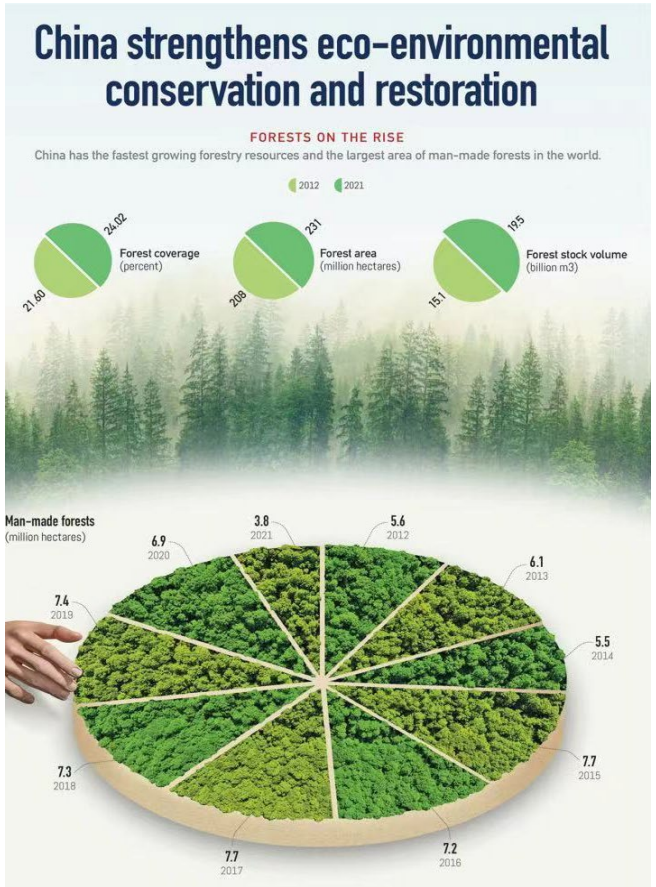


Mercury load enhanced in lake sediments of East China

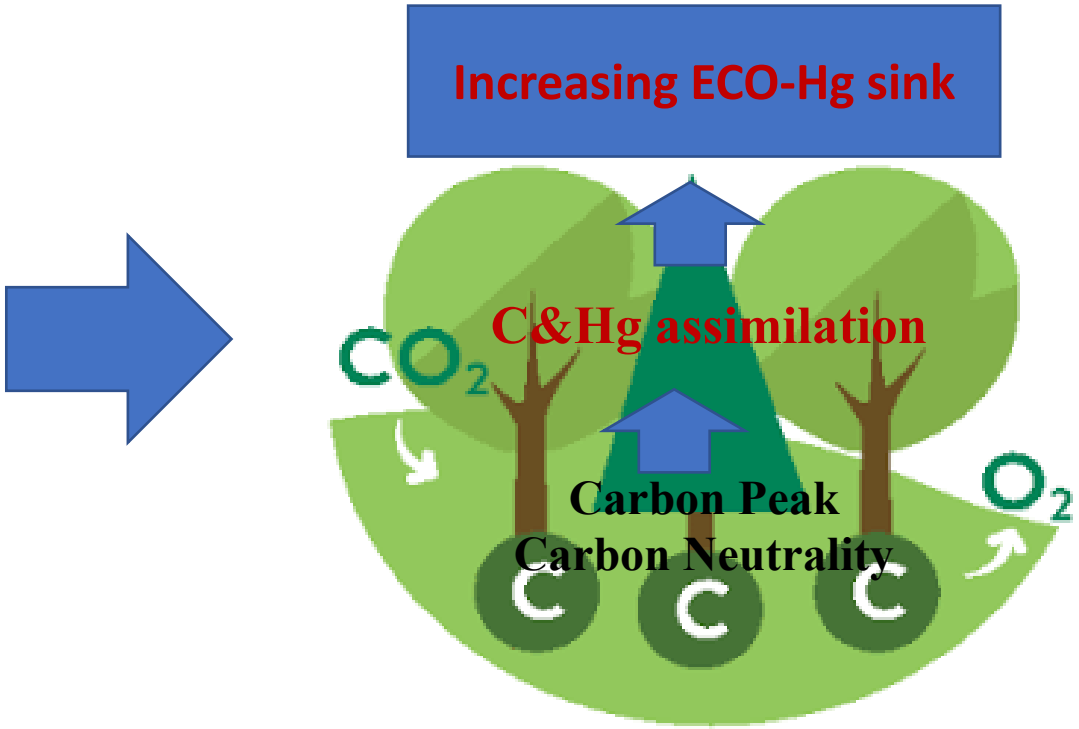
Yu et al.,2021

4 Challenge in the future: increasing ECO-Hg sink

➢ **The implementation of ecological protection and restoration polices are performing in China.**



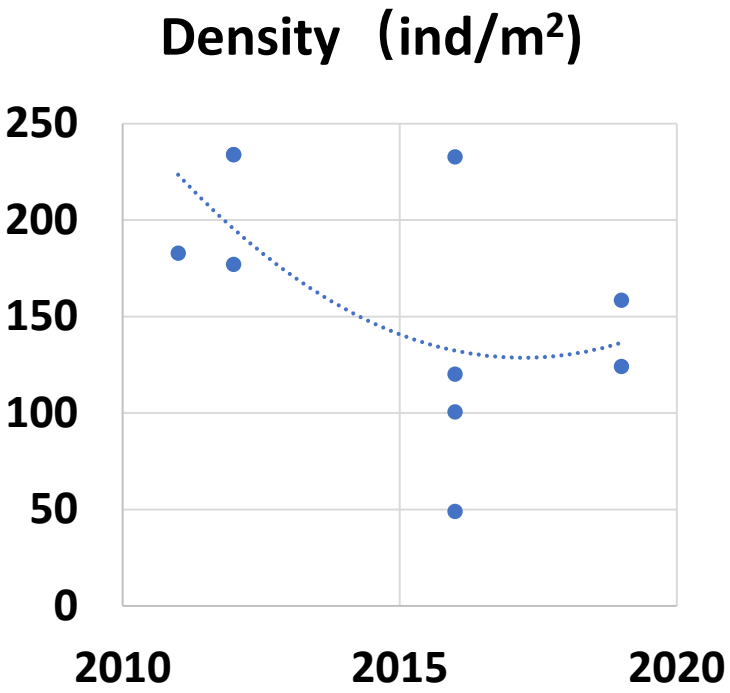
a synergistic effect of C&Hg assimilation

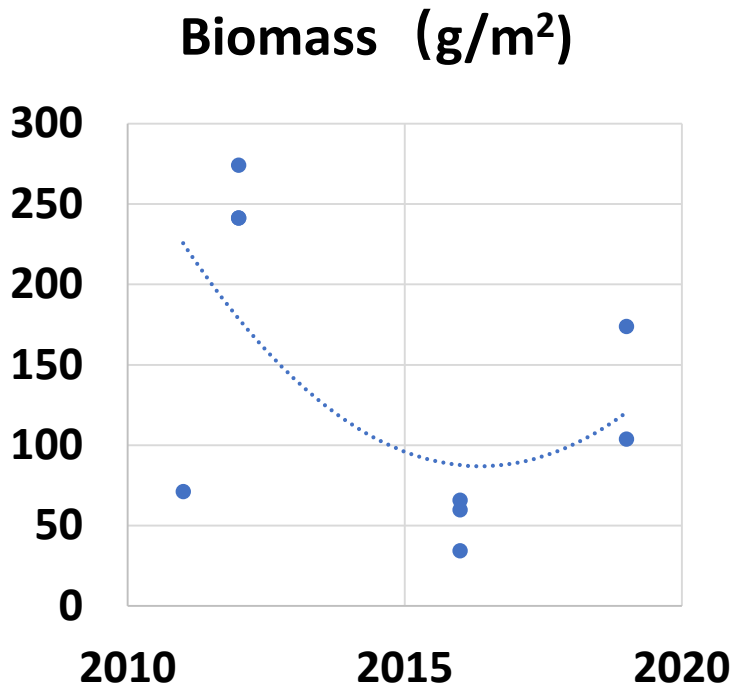


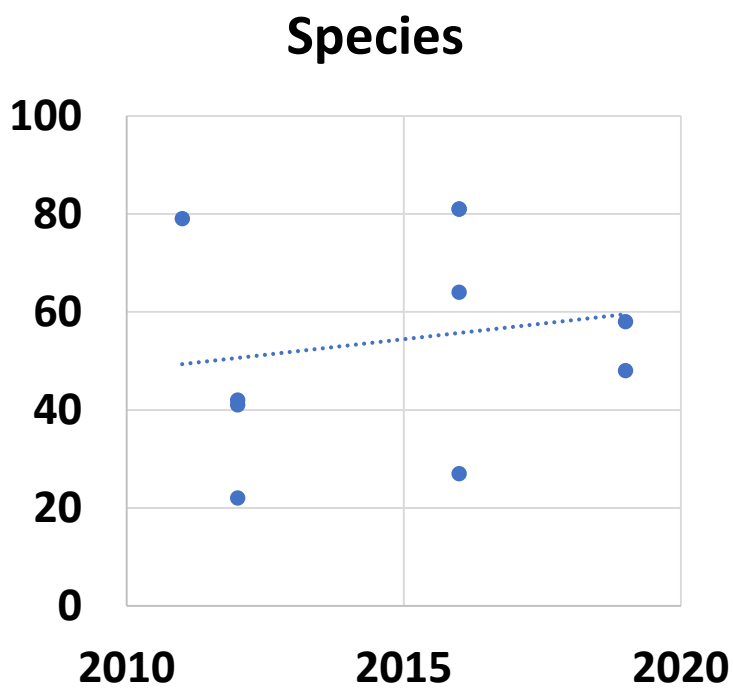
4

Challenge in the future: food web change

Zoo-benthos in Poyang Lake changes the food web



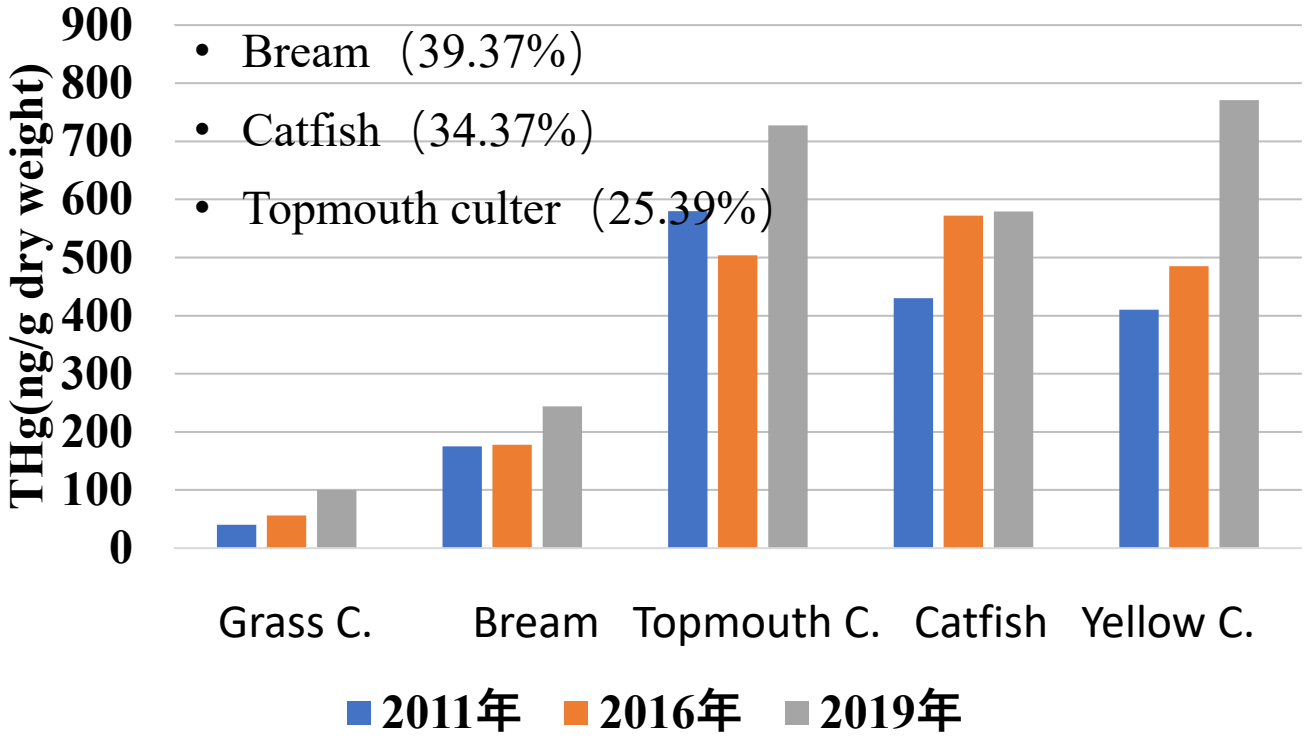




4 Challenge in the future: food web change

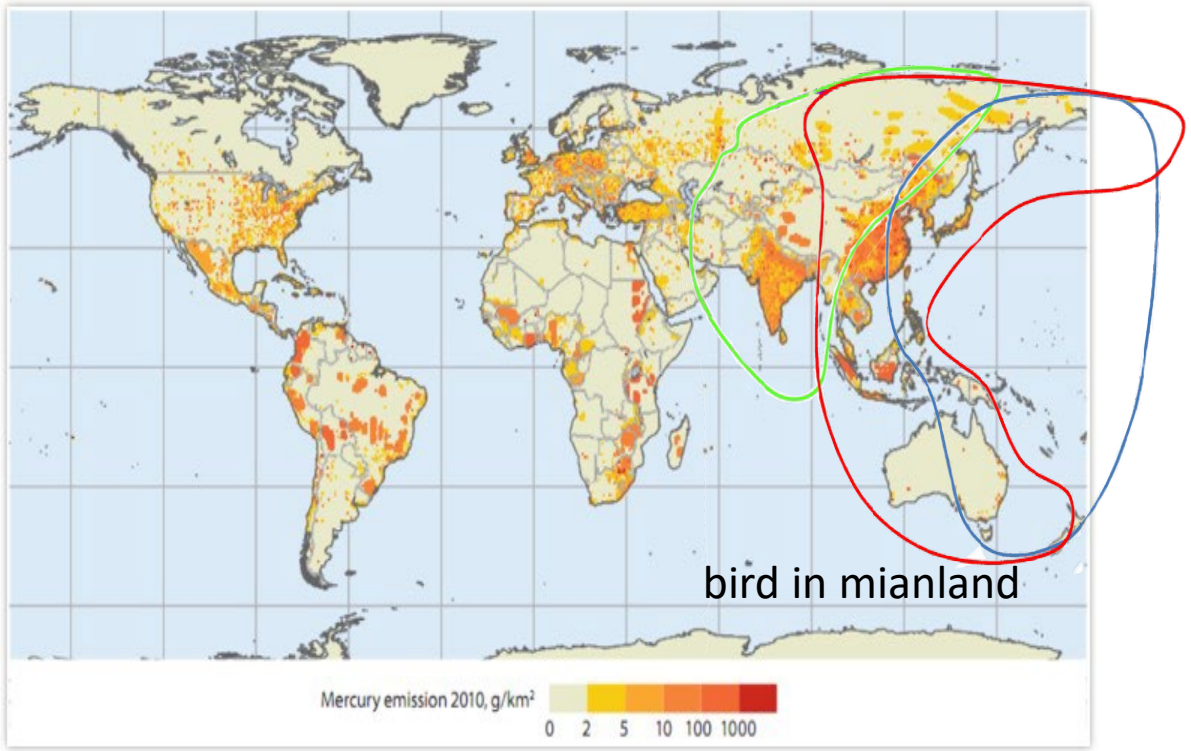
THg concentration in fish from PoYang Lake are increasing (25%-150%) (2011-2020)

- Grass carp (150.08%)
- Yellow Catfish (87.97%)
- Bream (39.37%)
- Catfish (34.37%)
- Topmouth culter (25.39%)



10 years fishing-ban in Yangtza River

4 Long-term monitoring network is necessary



- More species shorebirds/songbirds/waterfowls
- More sample types (Blood/Eggs)
- Exposure risk/effects

- **MeHg load in bird habitats？**
- **MeHg accumulation in migratory birds?**
- **What risks arise? Does it affect reproduction, survival and population of birds?**

Summary

- On catchment scale, significant Hg contamination were revealed and Some exceeded the benchmark concentration for freshwater sediments.
- Pelecaniformes and Passeriformes showed the highest MeHg exposure risk, especially for the egrets.
- With the increasing ECO-Hg sink and food web changes, the Migratory Birds MeHg Exposure is big challenge in the future.

Future: Long-term monitoring network is necessary

- More species （shorebirds/songbirds/waterfowls）
- More sample types (Blood/Eggs)
- Exposure risk/effects

Thanks…

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