Anthropogenic impacts on the carbon cycle and related biogeochemical processes of western North Pacific continental margins

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Acknowledgment:
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PICES: FUTURE Research them 3. How do human activities affect coastal ecosystems and how are societies affected by changes in these ecosystems?

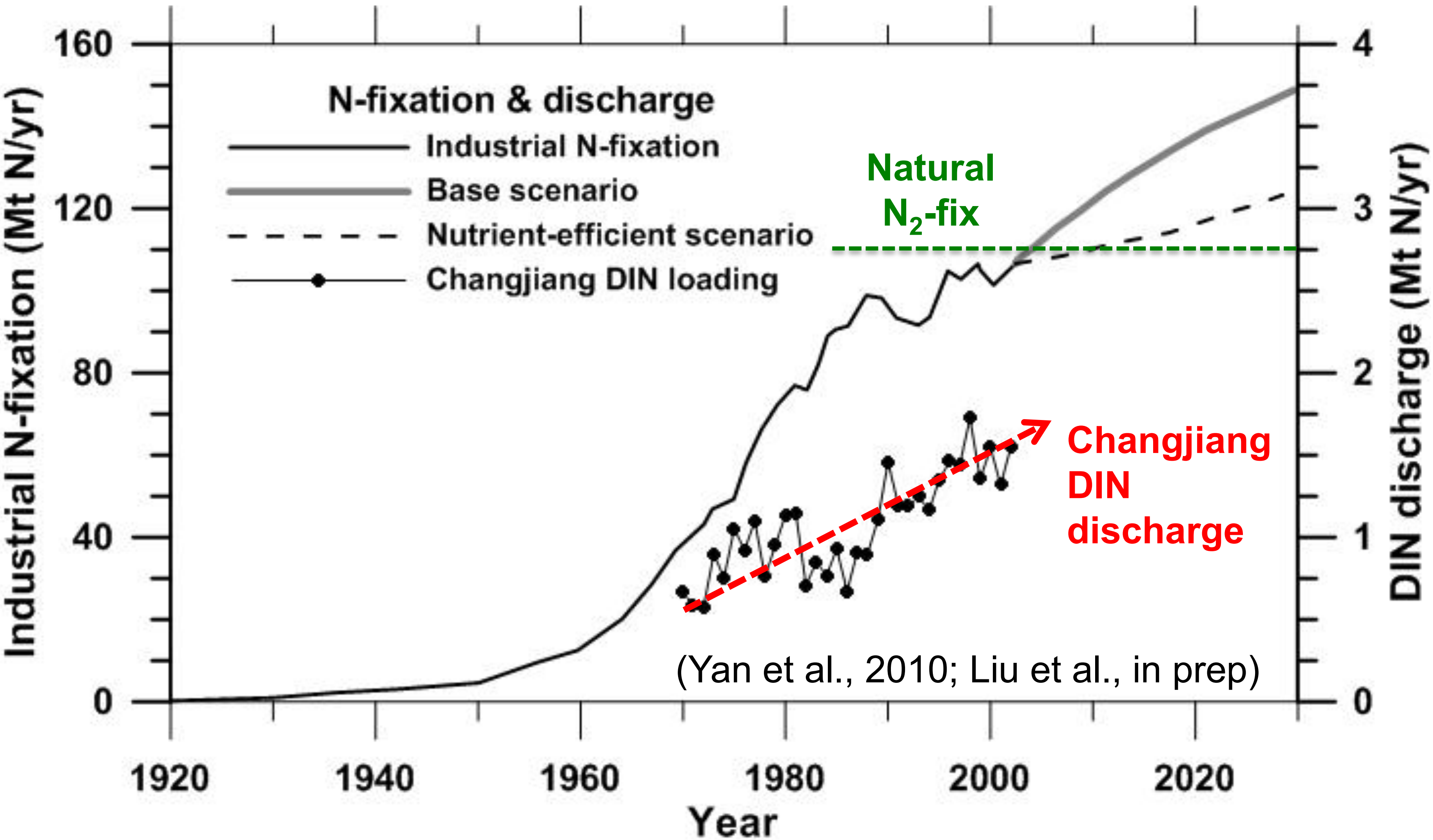
- 3.1. What are the dominant anthropogenic pressures in coastal marine ecosystems and how are they changing?
- 3.2. How are these anthropogenic pressures and climate forcings, including sea level rise, affecting nearshore and coastal ecosystems and their interactions with offshore and terrestrial systems?
- 3.5. How can we effectively use our understanding of coastal ecosystem processes and mechanisms to identify the nature and causes of ecosystem changes and to develop strategies for sustainable use?

Main points

- Drivers:
  - Anthropogenic nutrients
  - Human-perturbed geochemical cycle
  - eutrophication-enhanced acidification,
  - human altered/accelerated water cycle
  - Ocean exploration-resources extraction

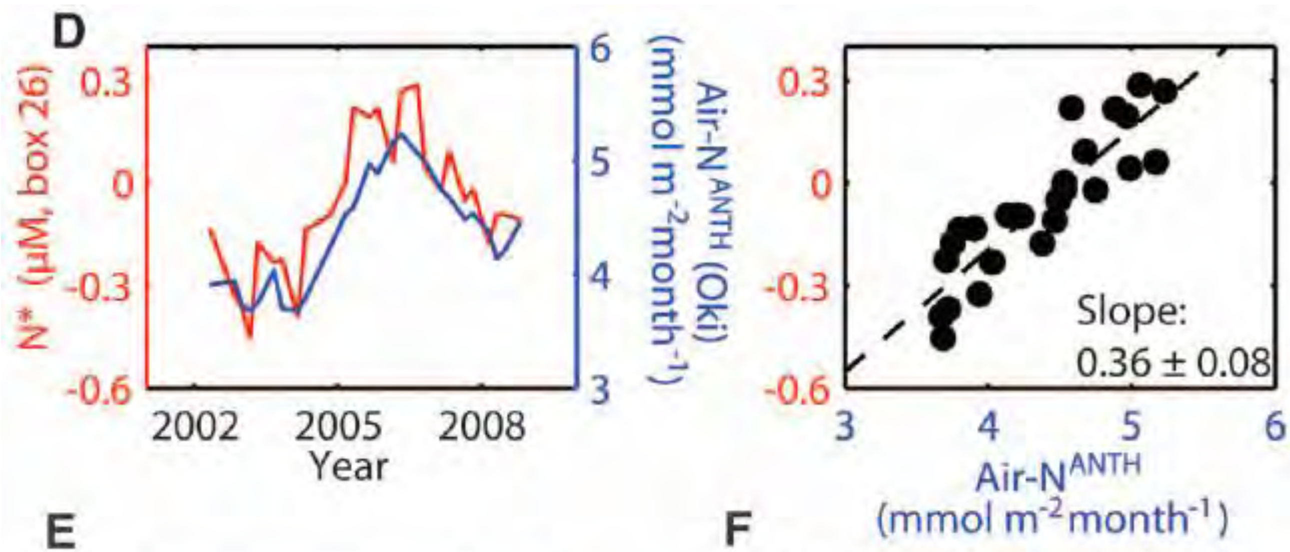
- Responses:
  - Shelf productivity
  - Biogeochemical conditions
  - Ecosystem structure
  - Continental shelf pump
  - Microbial carbon pump
- What can we do about it?
  - Mitigation: Blue carbon, Microbial carbon pump
  - Adaptation: Better management

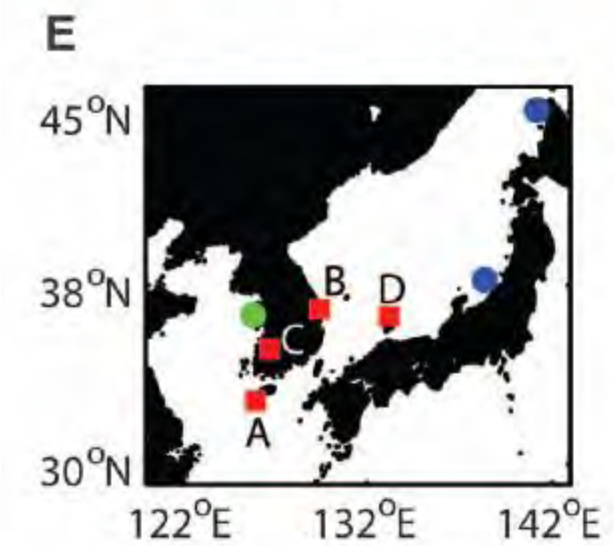
Anthropogenic N_2 fixation



Input of air-borne DIN in Japan/East Sea

$N^* = DIN - DIP^* R_{N/P}$

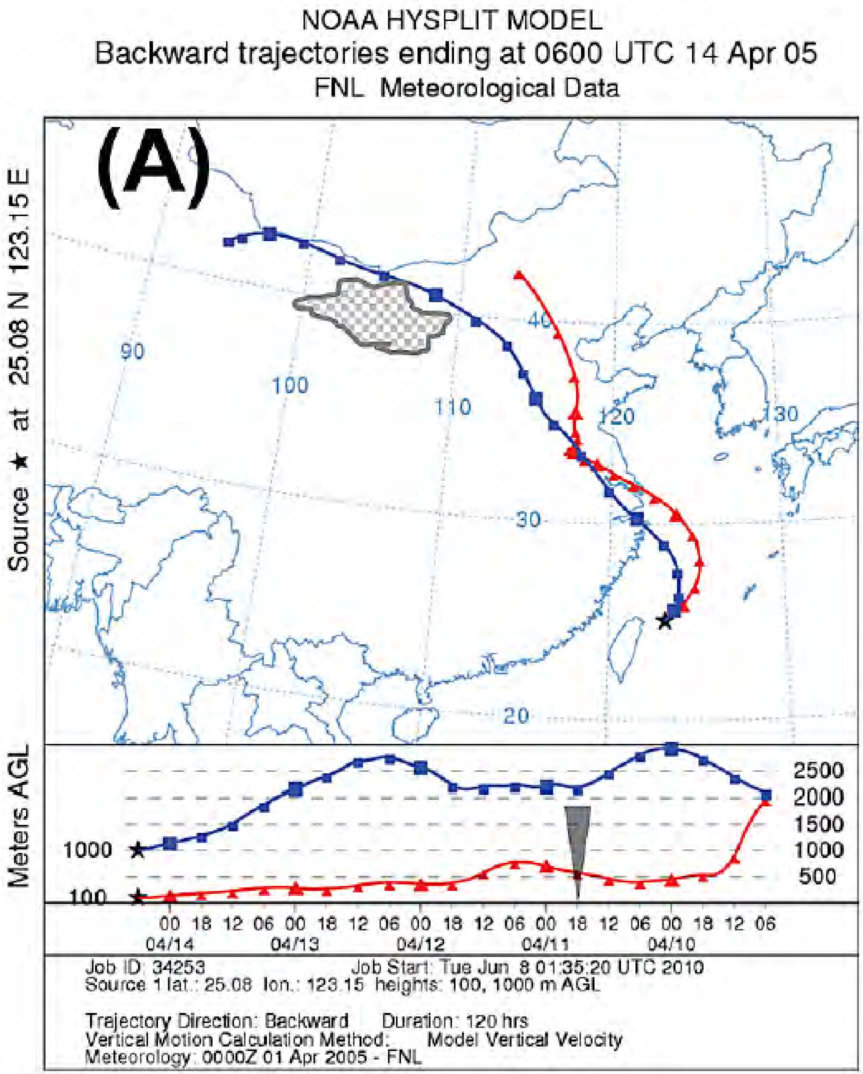




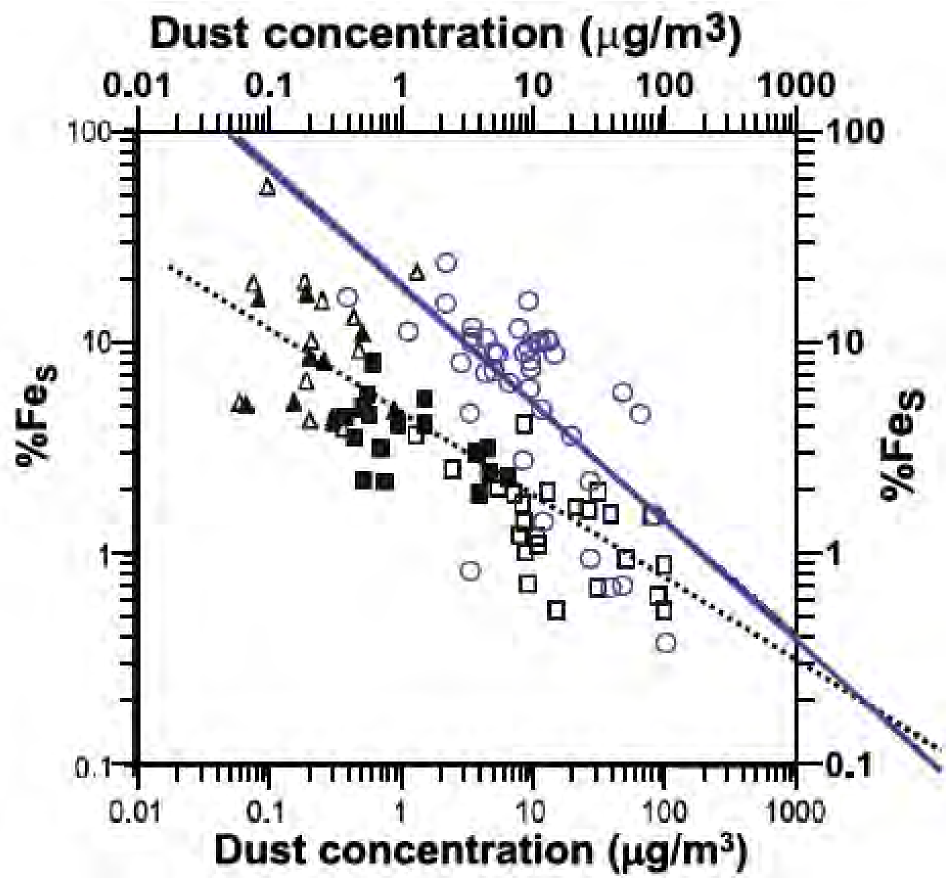
Excess DIN in the top 50 m in the western N. Pac marginal seas is strongly correlated with deposition of air-borne DIN.

Kim et al., 2011, Science)

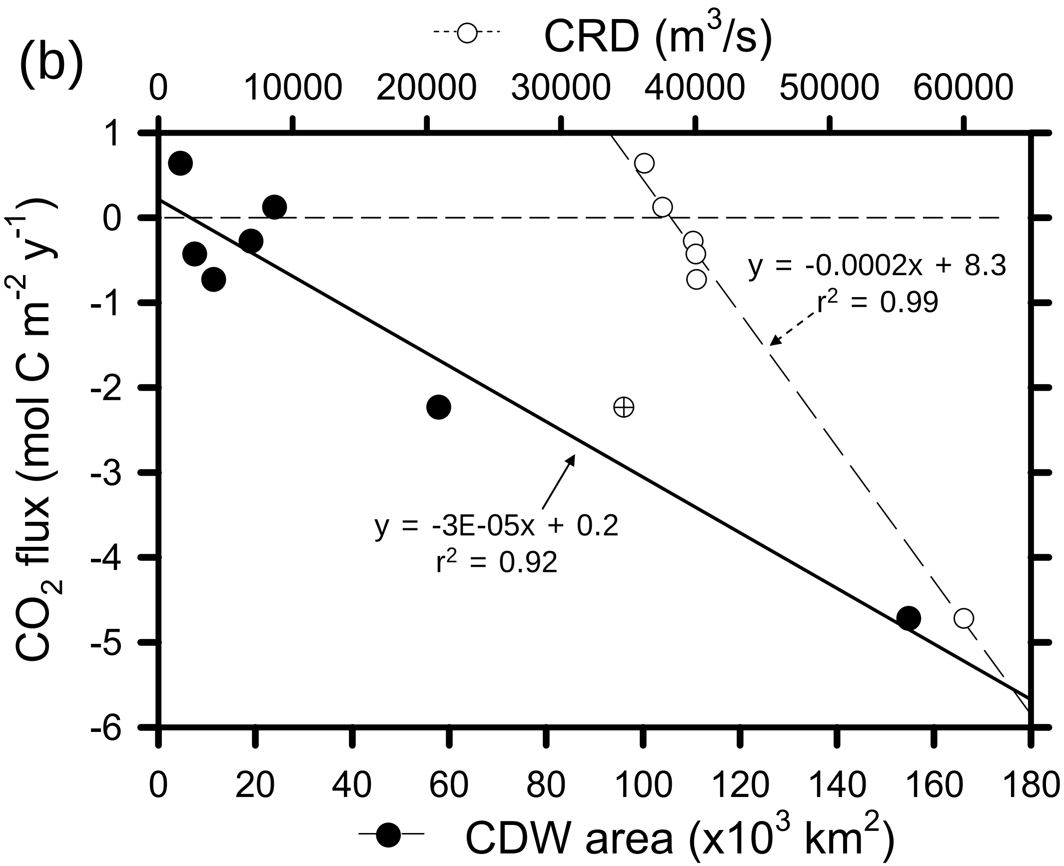
Soluble Fe fraction in aerosol enhanced by air pollutants
(Hsu et al., 2010, JGR)



Higher Fe solubility in ECS dusts than global average (Baker and Jickells, 2006) due to mobilization by atm. SO_x and NO_x.



CO_2 uptake in the ECS correlated with Changjiang discharge

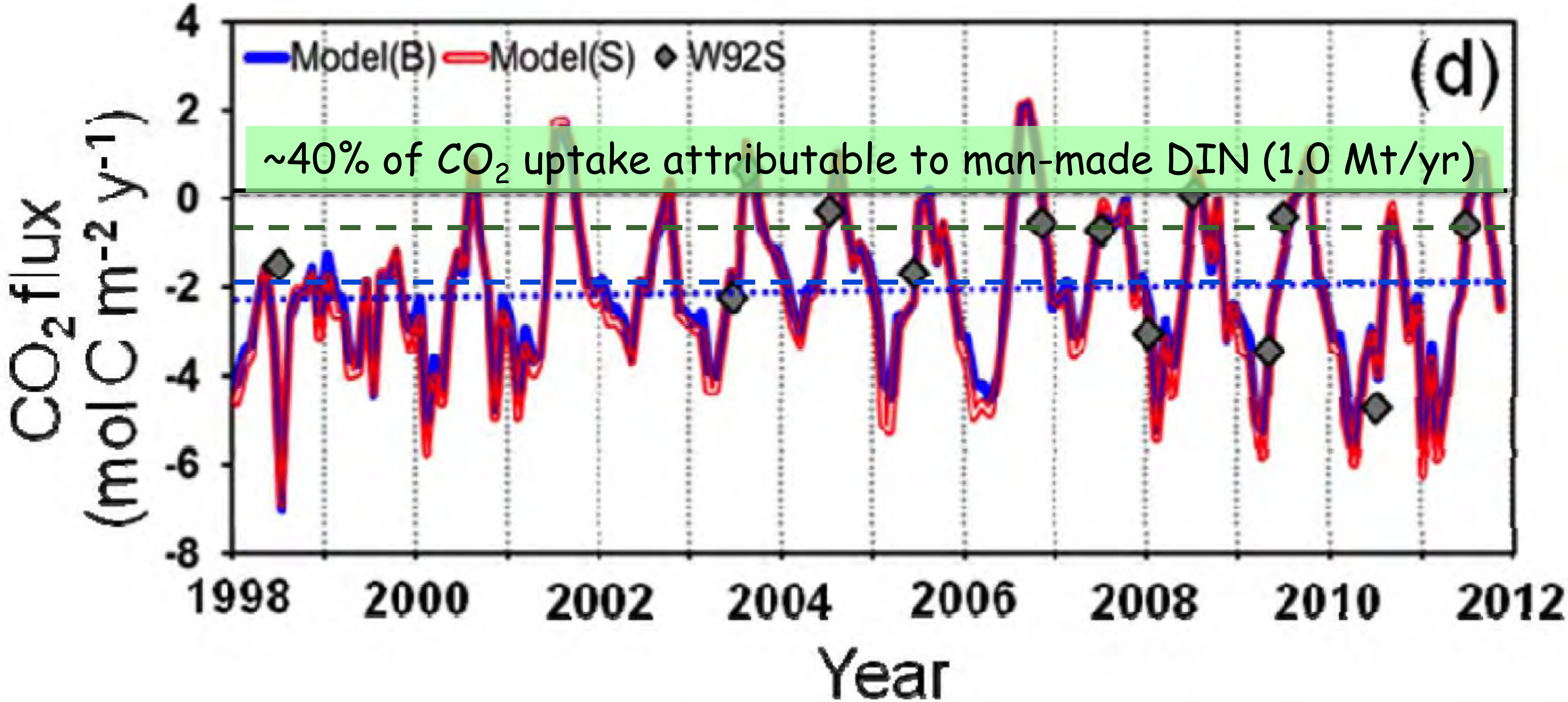


(Tseng et al., 2011, GRL.)

CO_2 uptake was proportional to Changjiang discharge indicating the riverine nutrient load fueling the biological pump that takes up CO_2.

Sea-air CO_2 flux in the East China Sea

- Latest estimate = -22 gC m^{-2} yr^{-1}



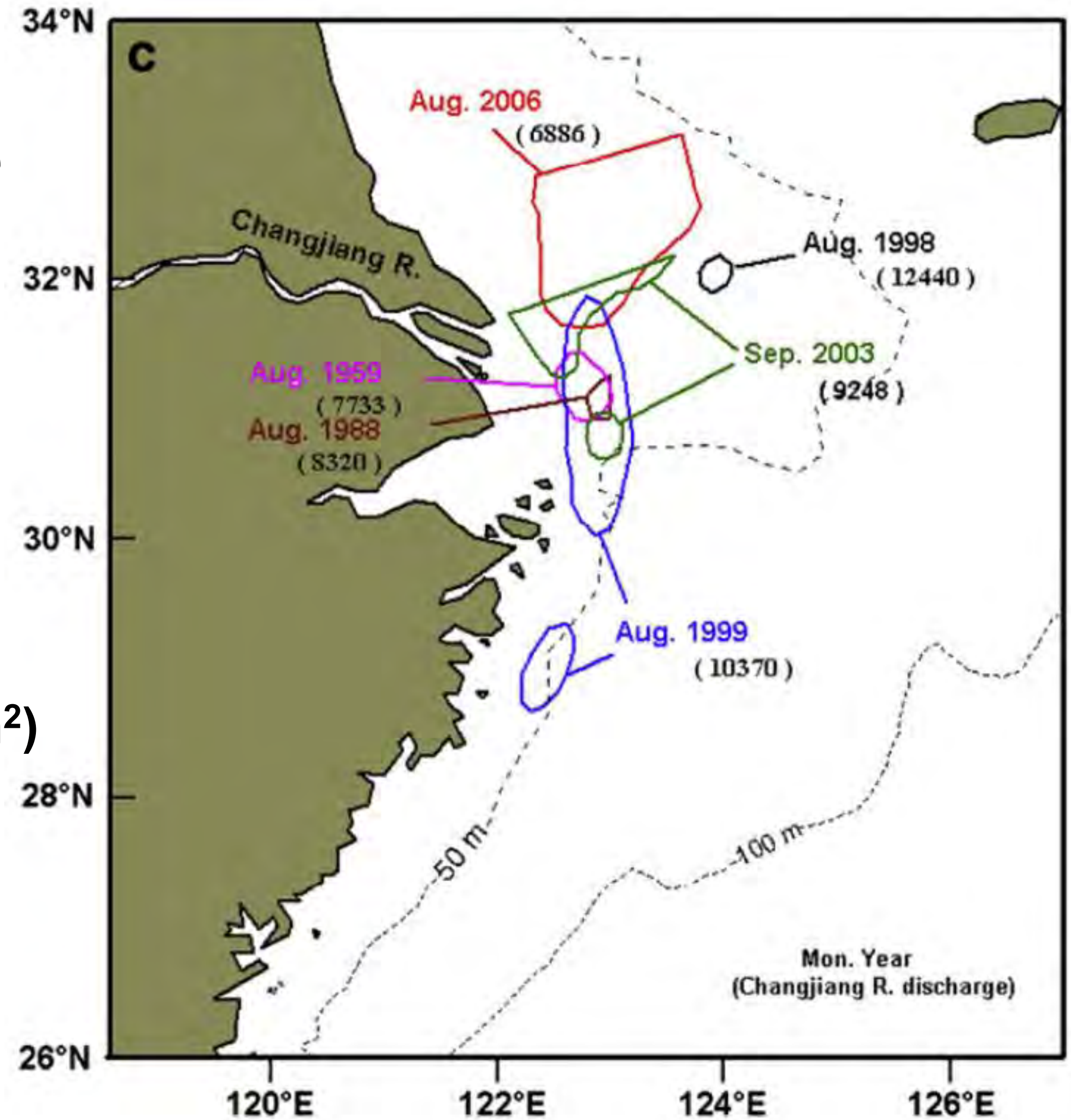
(Tseng et al., 2013, BGD)

Occurrences of hypoxia in the ECS: 1959-2006

(Zhu et al., 2011, Mar. Chem.)

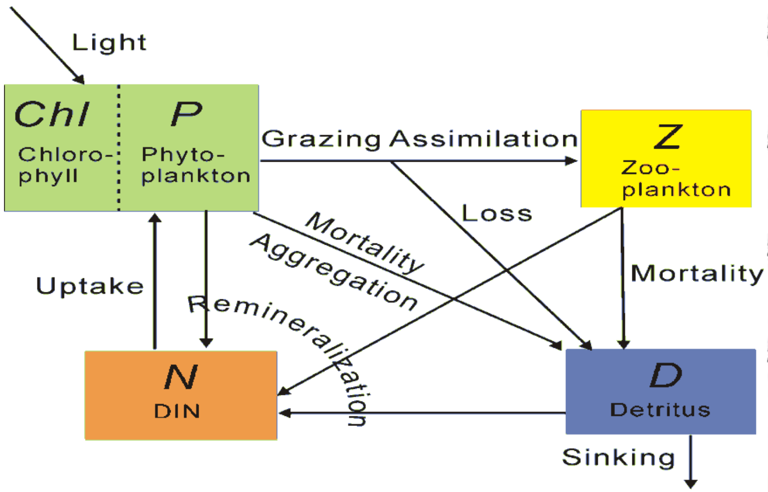
(Area of $[O_2]$ < 2 ppm in km^2)

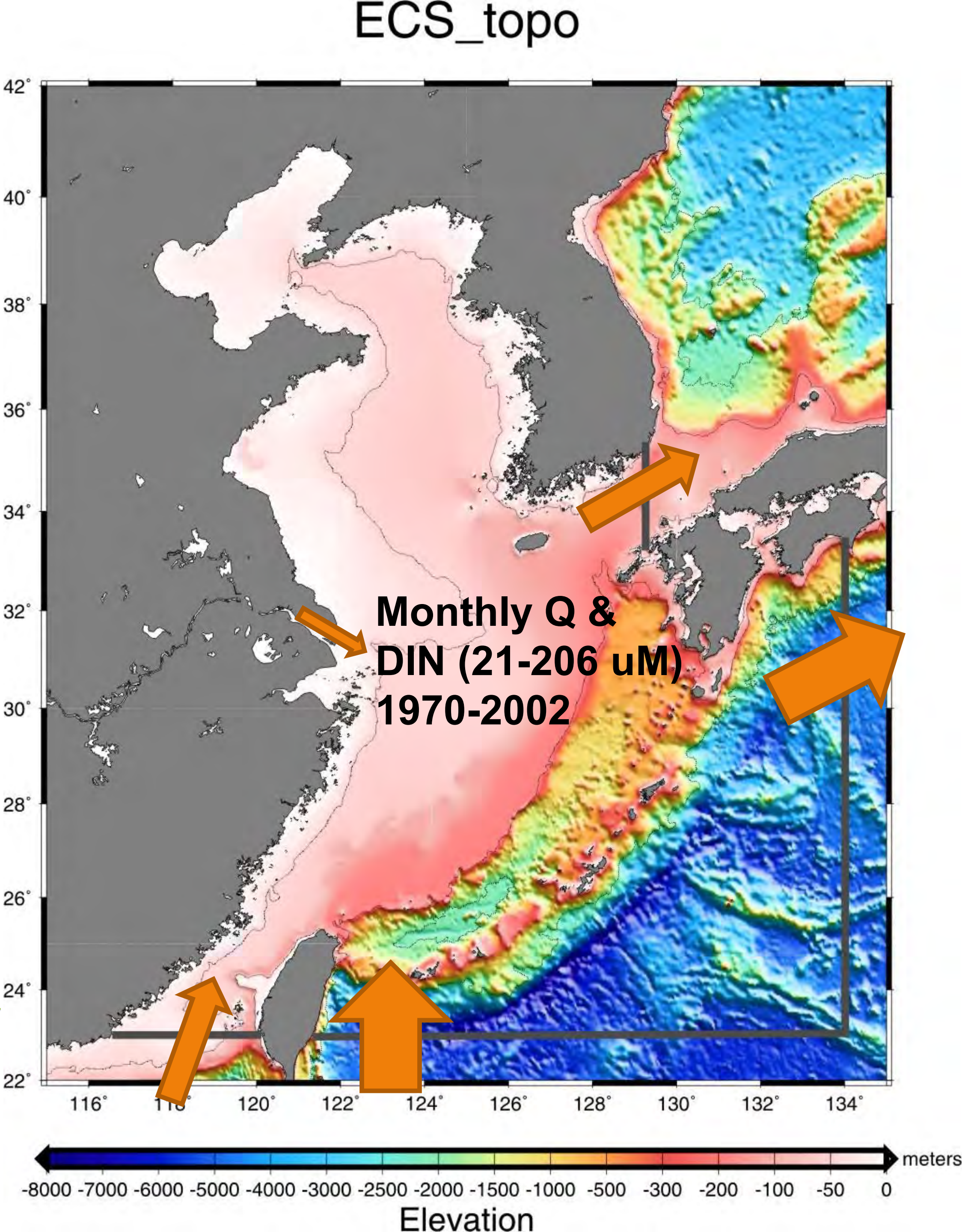
Was hypoxia in the ECS caused by anthropogenic nutrients?



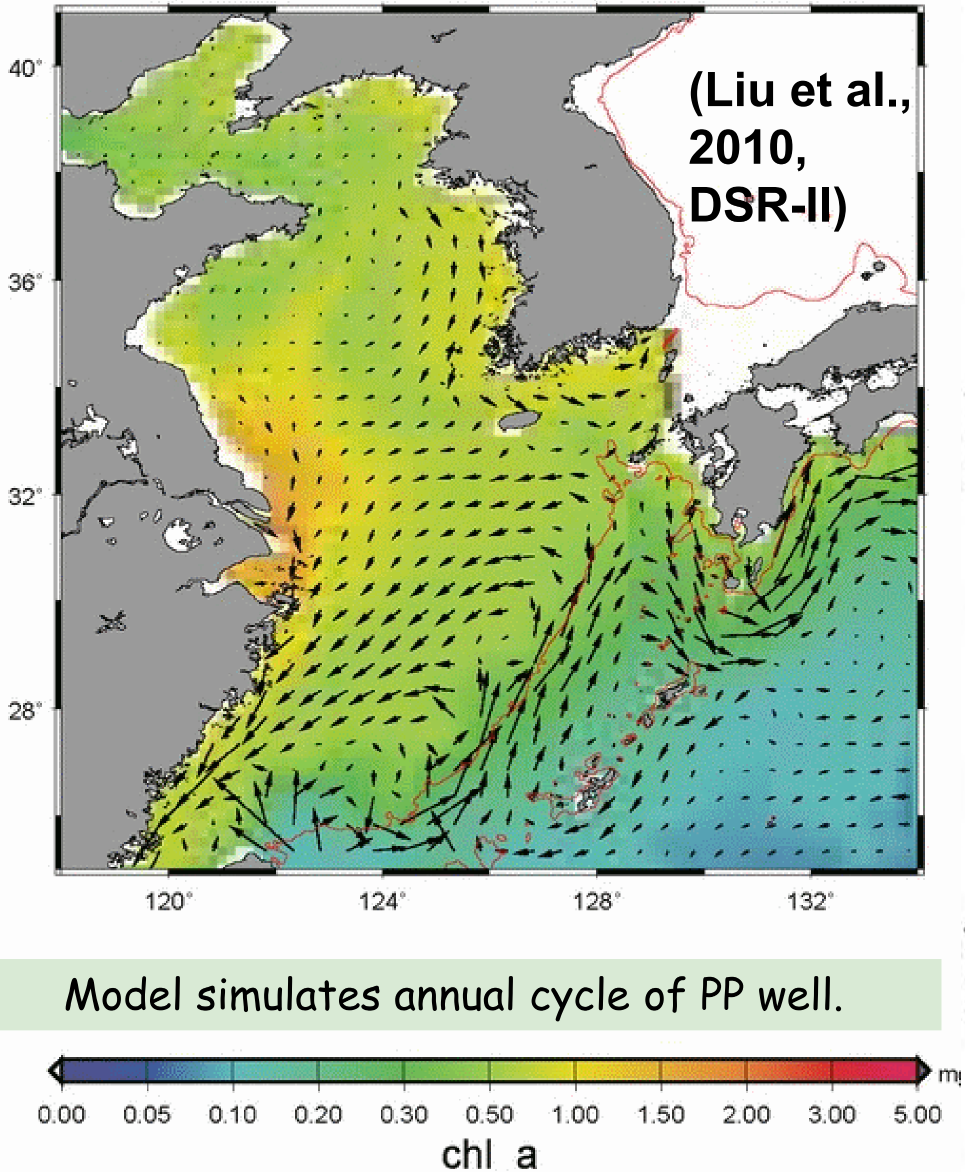
Coupled physical-biogeochem model

- Lateral resolution: 1/6°
- Vertical resolution: 33 levels – 5 m, up 17.65% per level deeper
- Prescribed climatology monthly transport for the Kuroshio and Taiwan Strait throughflow.
- Observed monthly discharges and DIN concentrations for Changjiang.
- Driven by monthly mean wind from NCEP R1 (1970-1978) and NCEP R2 (1979-2002) and 6 hourly SW radiation from R1.
- The tide-induced sea level contains 6 tidal constituents (P1, O1, K1, N2, M2 and S2).
- Under linearity assumption, corresponding tidal currents on the open boundaries are calculated for each of the 6 tidal constituents.

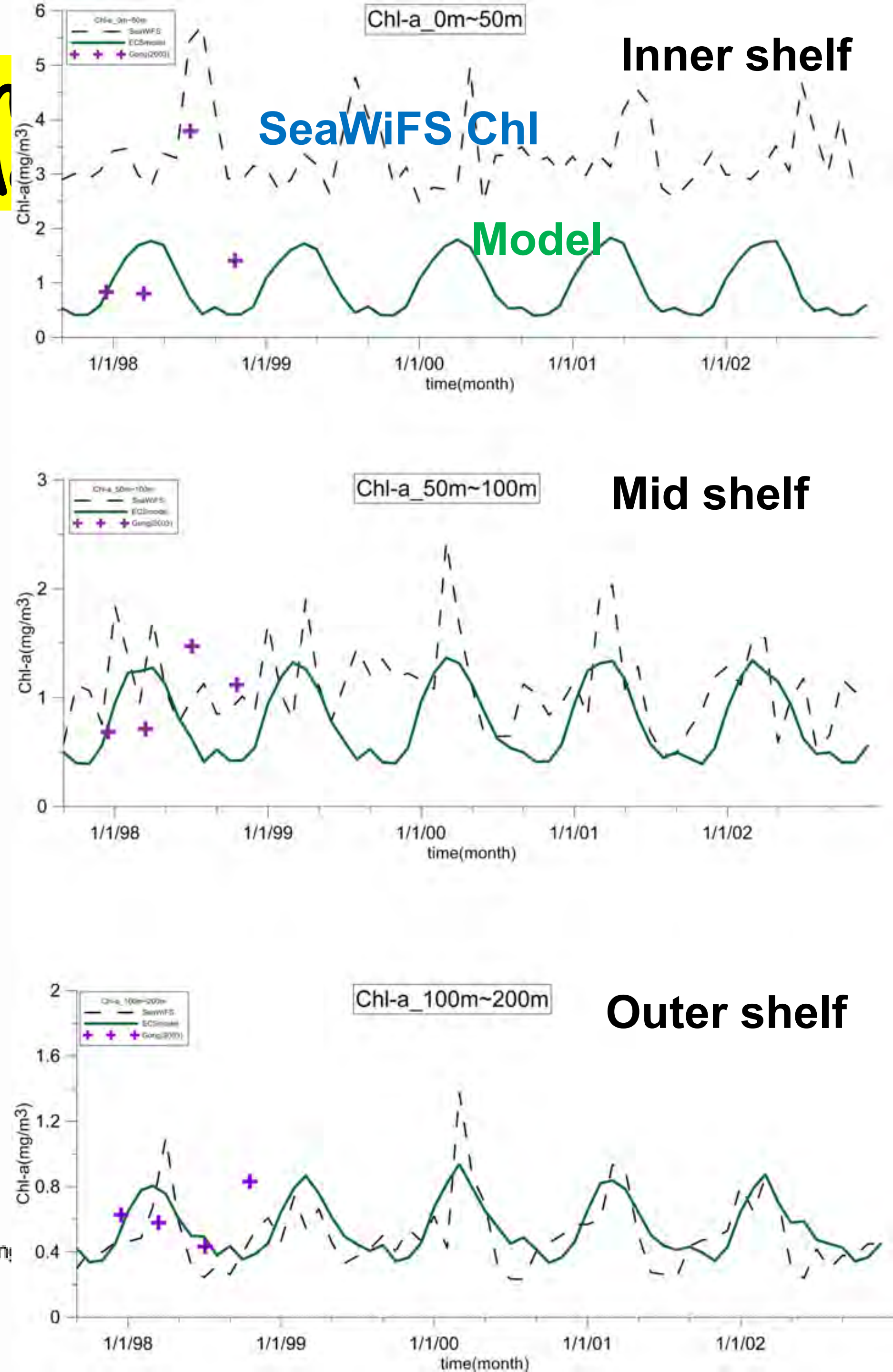




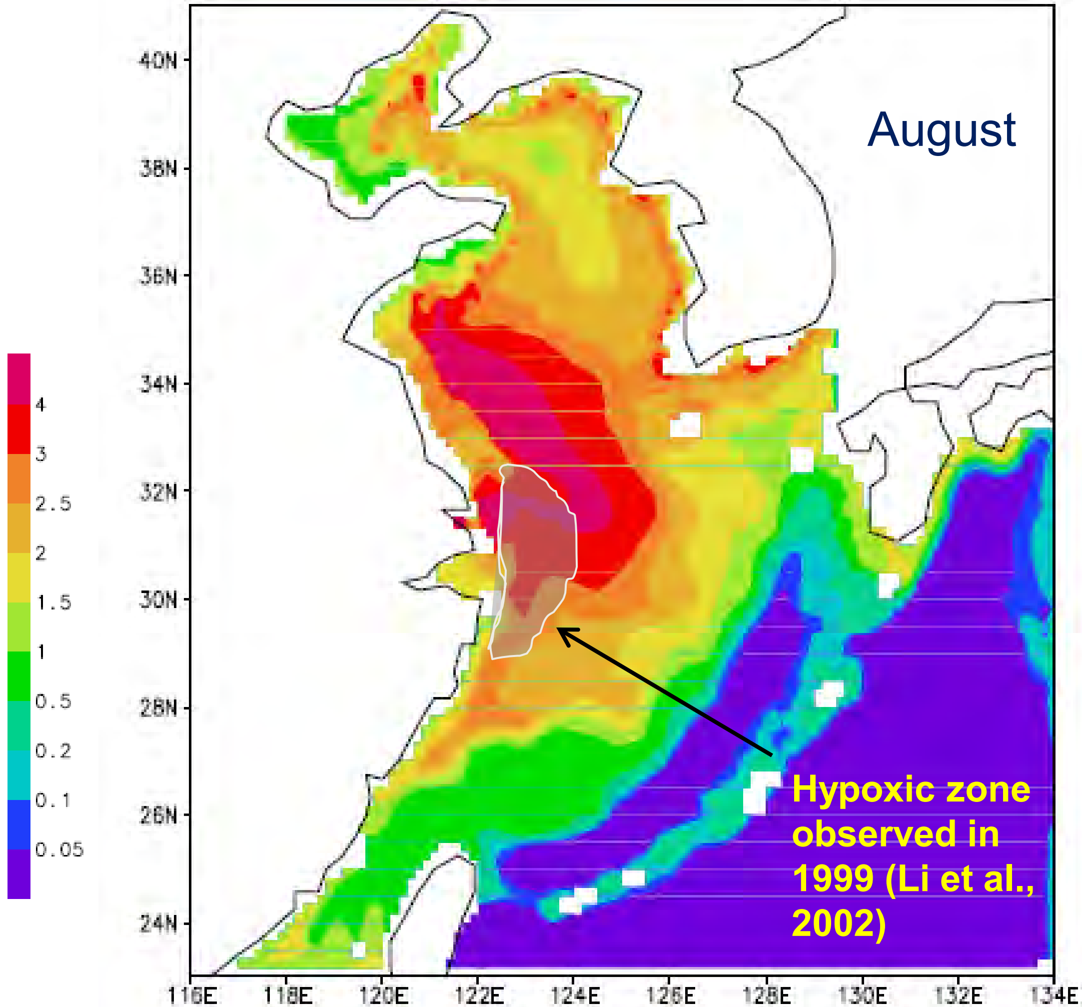
East Chin…
Chl distribution: M…



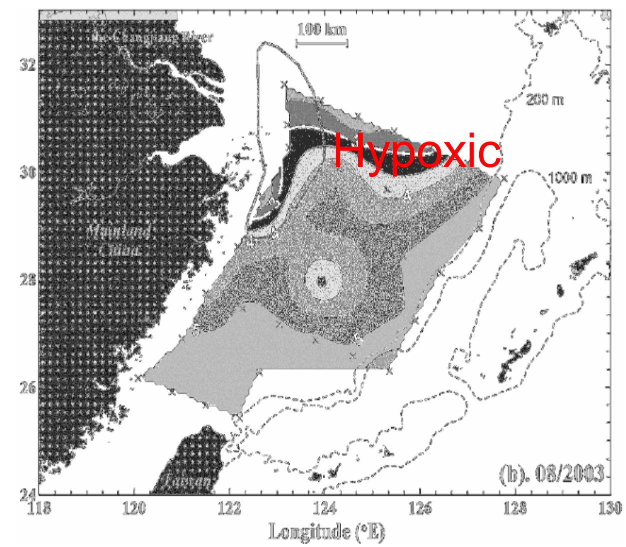
Model simulates annual cycle of PP well.

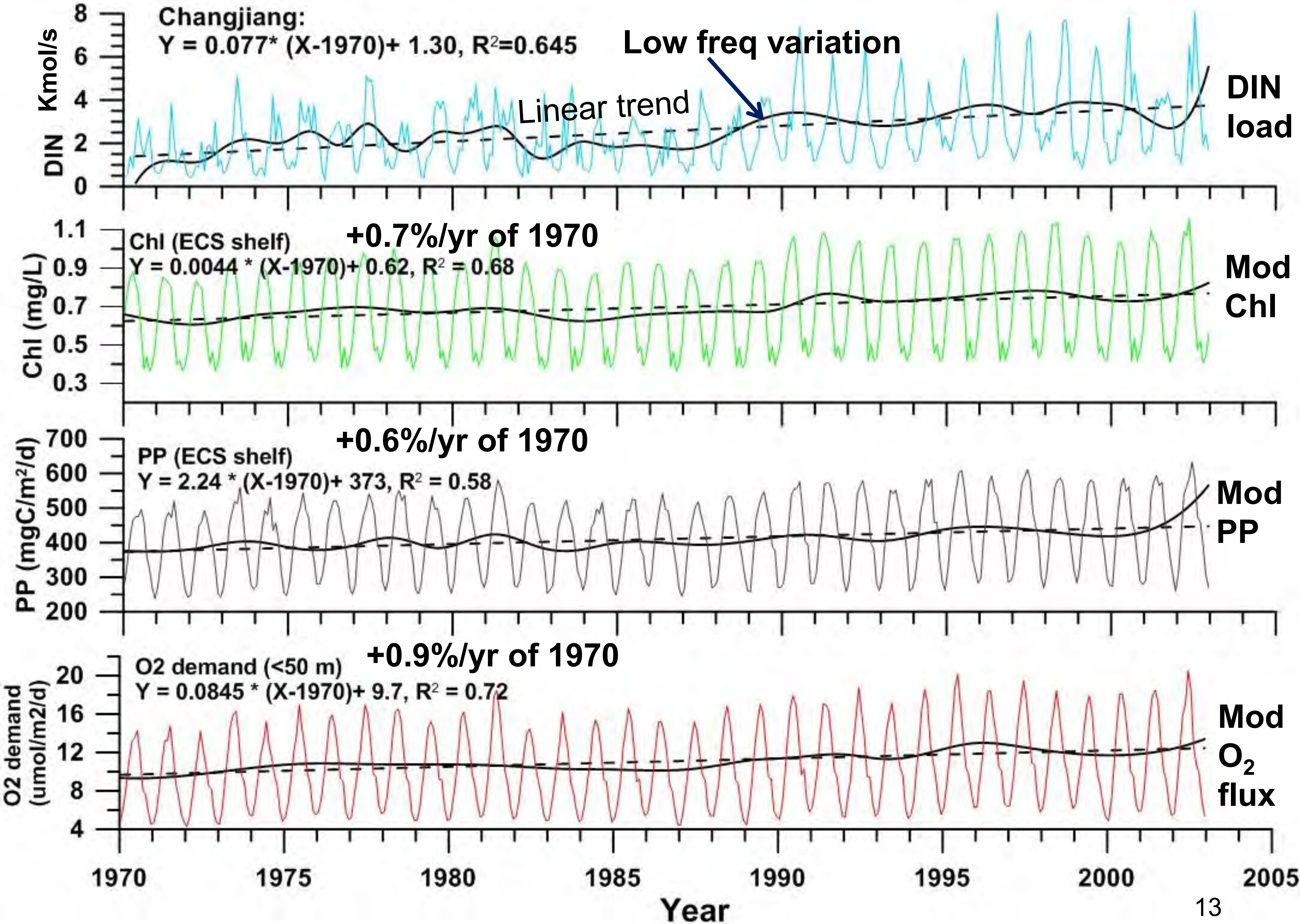


Modeled benthic oxygen demand ($mol\ O_2\ m^{-2}\ yr^{-1}$)

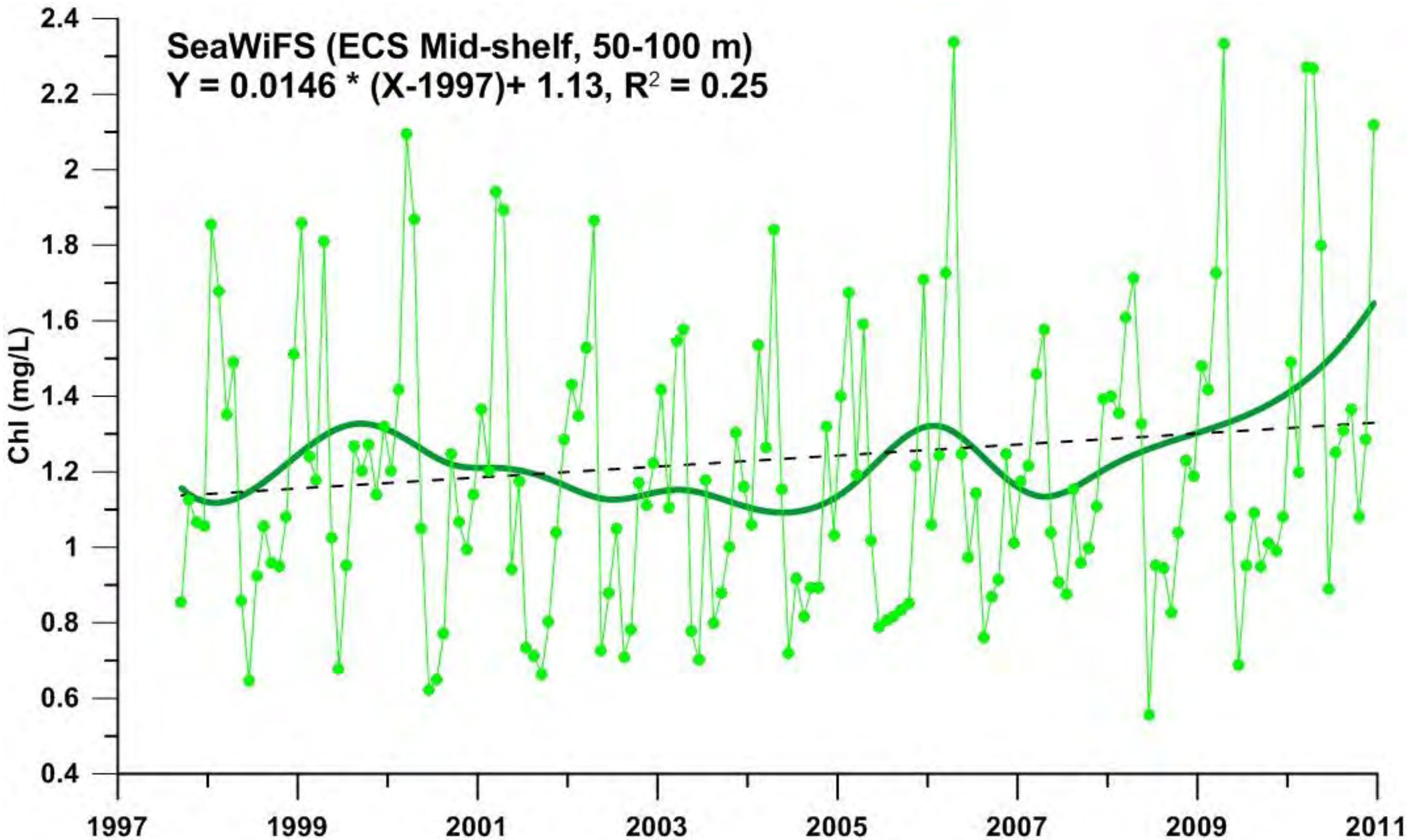


Observed bottom water $[O_2]$ (ppm) Aug. 2003 (Chen et al., 2007, Mar. Env. Res.)

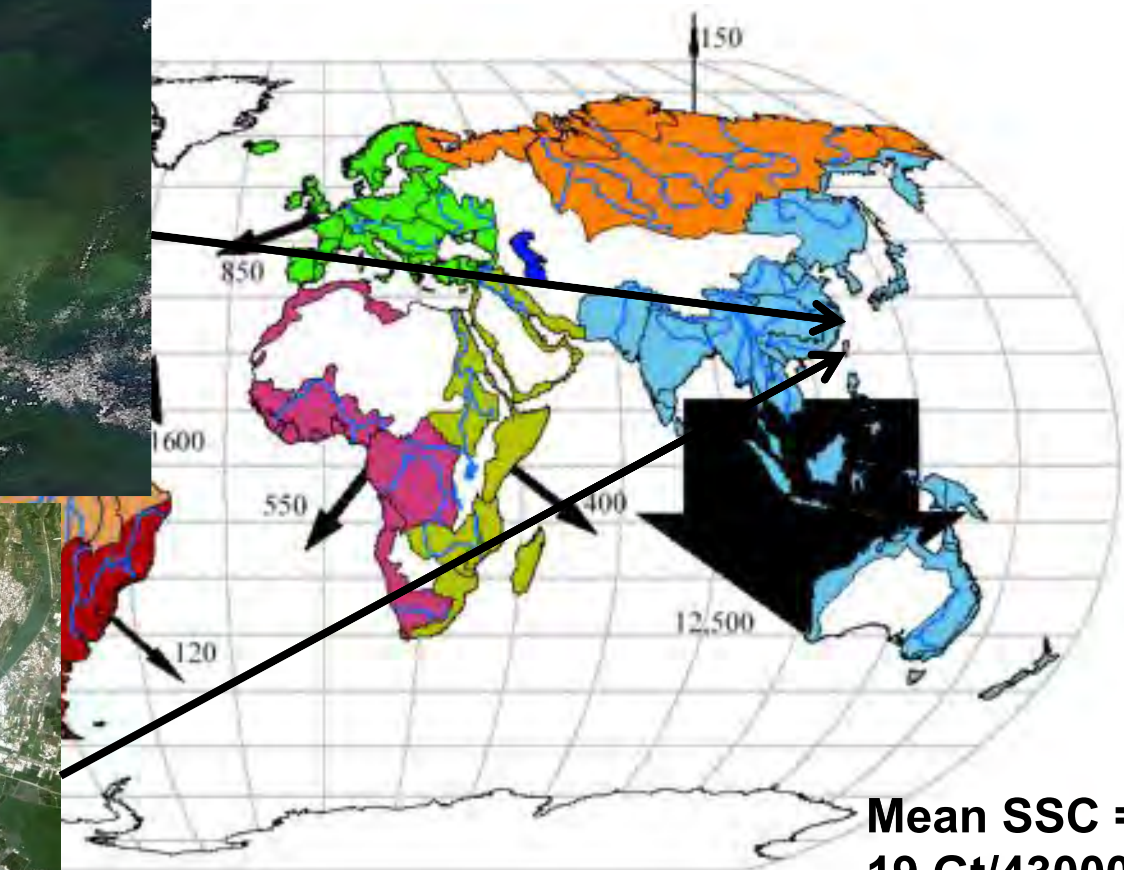



Changjiang:
Y = 0.077* (X-1970)+ 1.30, R2=0.645
Low freq variation
Linear trend
DIN load
Kmol/s
DIN
Chl (ECS shelf)
Y = 0.0044 * (X-1970)+ 0.62, R2 = 0.68
+0.7%/yr of 1970
Mod Chl
Chl (mg/L)
PP (ECS shelf)
Y = 2.24 * (X-1970)+ 373, R2 = 0.58
+0.6%/yr of 1970
Mod PP
PP (mgC/m2/d)
O2 demand (<50 m)
Y = 0.0845 * (X-1970)+ 9.7, R2 = 0.72
+0.9%/yr of 1970
Mod O2 flux
O2 demand (umol/m2/d)
Year

SeaWiFS Chl-a in ECS (mid shelf): show significant increasing trend
(+1.3%/yr of 1997 value)



Sediment discharge to continental margins



Pristine level ~ 1000 Mt/yr

Mean SSC = 19 Gt/43000Gt = 440 ppm

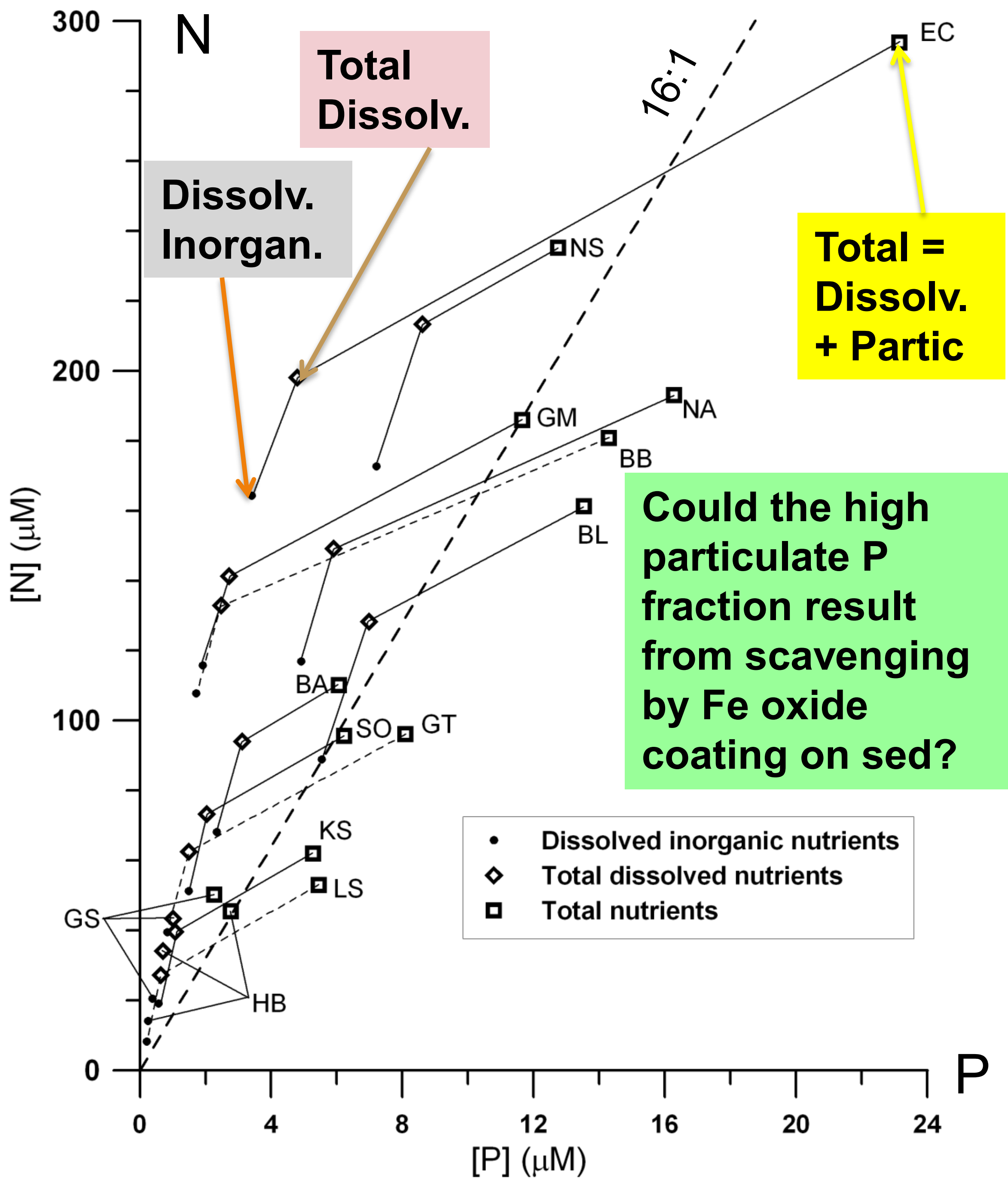
otal = 19,000 * 10^6 t/yr

(Milliman and Farnsworth, 2011)

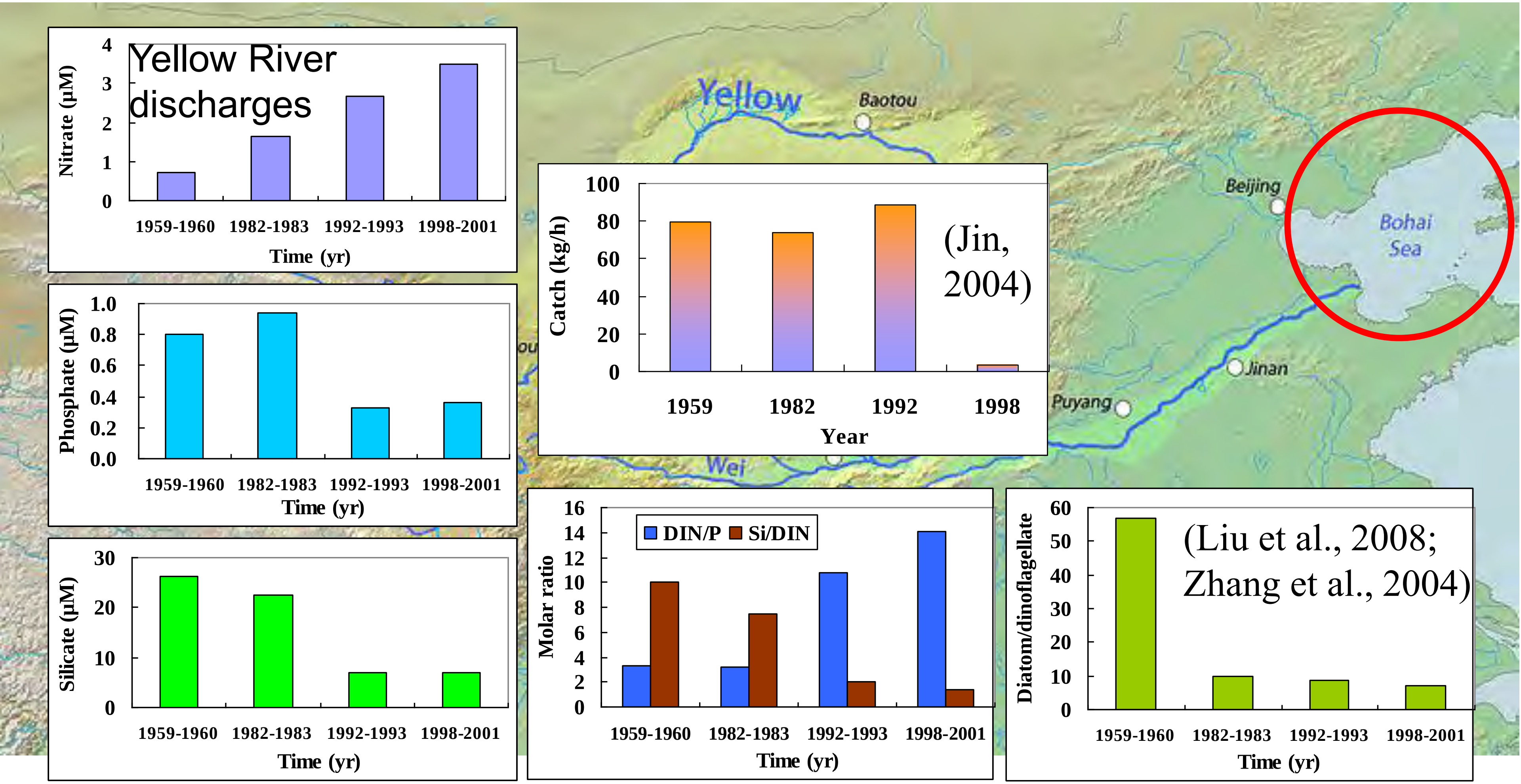
N vs P in river loads

BA	Baltic Sea
BB	Bay of Bengal
BL	Black Sea
EC	East China Sea
GM	Gulf of Mexico
GS	Gulf of St Lawrence
GT	Gulf of Thailand
HB	Hudson Bay
KA	Kara Sea
LS	Laptev Sea
NA	Northern Adriatic Sea
NS	North Sea
SO	Sea of Okhotsk

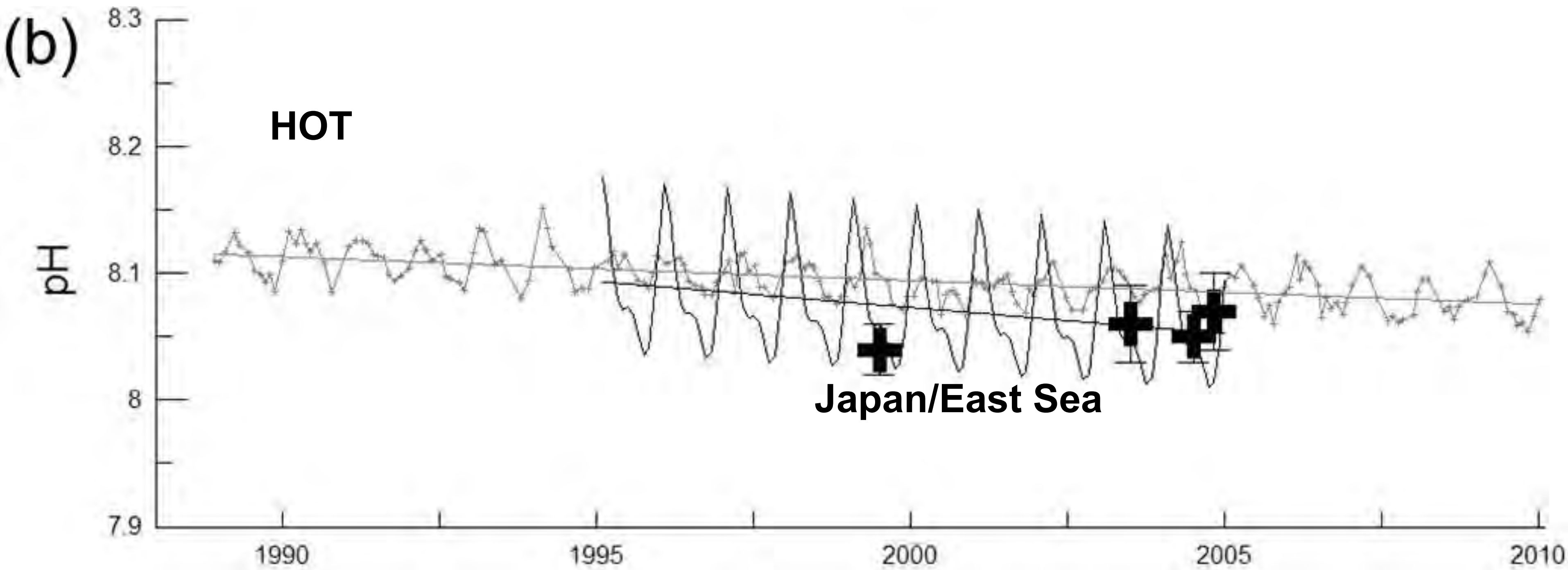
(Liu et al., 2008, SCOPE 70)



Dramatic ecosystem change in the Bohai Sea due to human induced nutrient regime shift

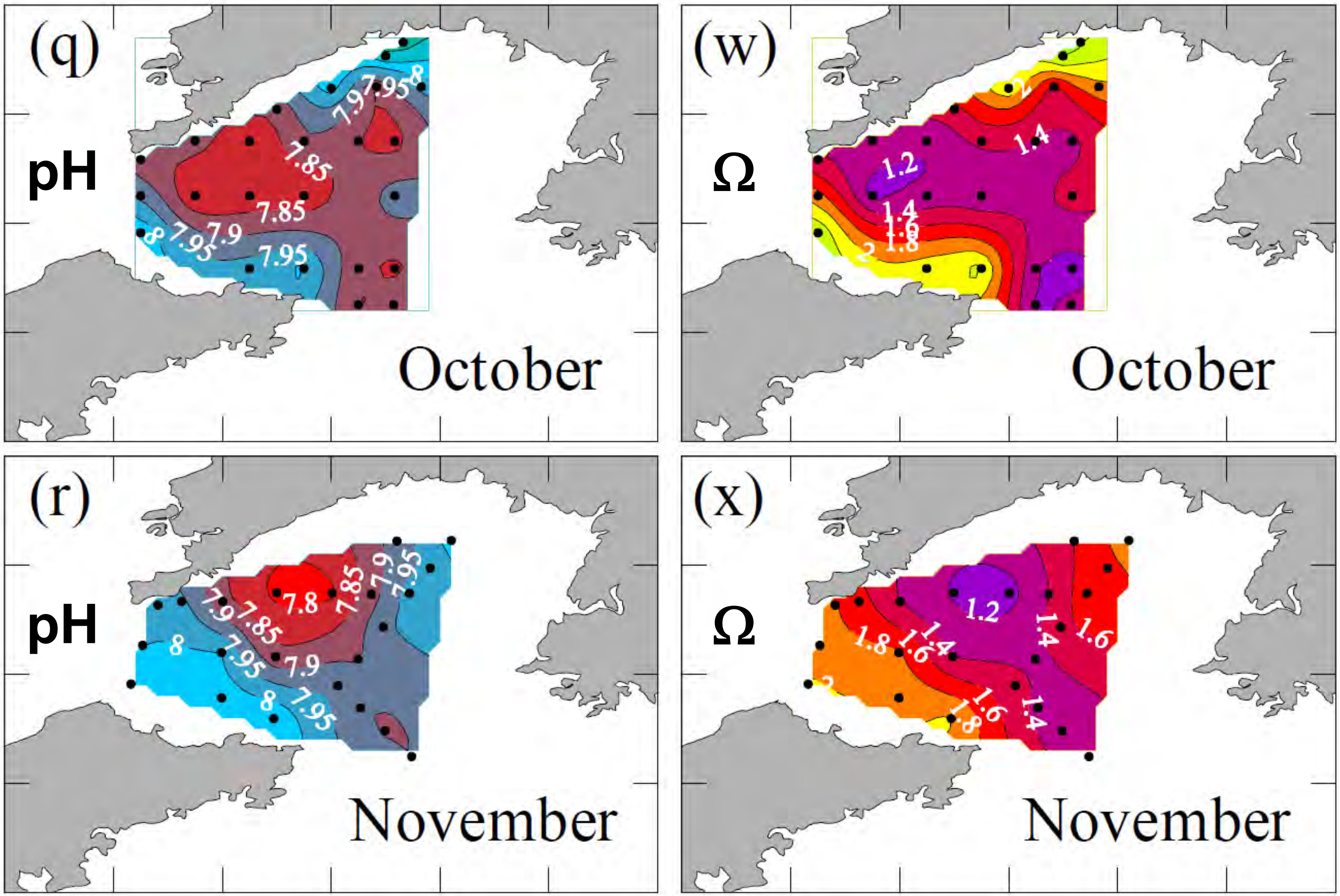


Ocean acidification: Rapid drop of pH in the Japan/East Sea



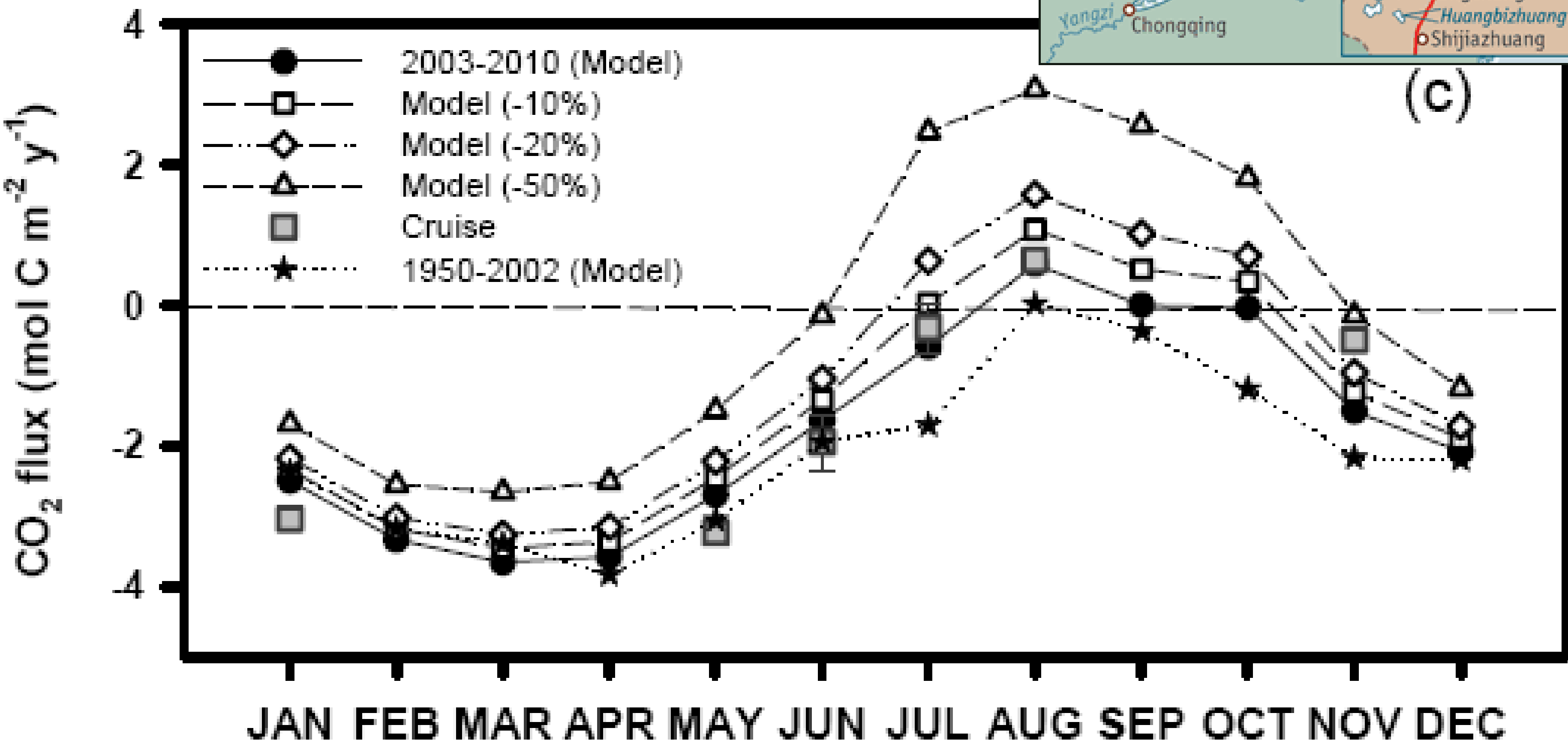
Kim et al. (2013) in: Liu et al. (Ed.) Biogeosciences Discussion special issue on: “Biogeochemistry and ecosystems in the western north Pacific continental margins under climate change and anthropogenic forcing”.

Very low pH and aragonite saturation in northern Yellow Sea bottom water in 2011



(Zhai et al., 2013, BGD, special issue)

Potential impact of "Water Projects" on the CO2 sink in the East China Sea (Tseng et al., 2011, GRL)

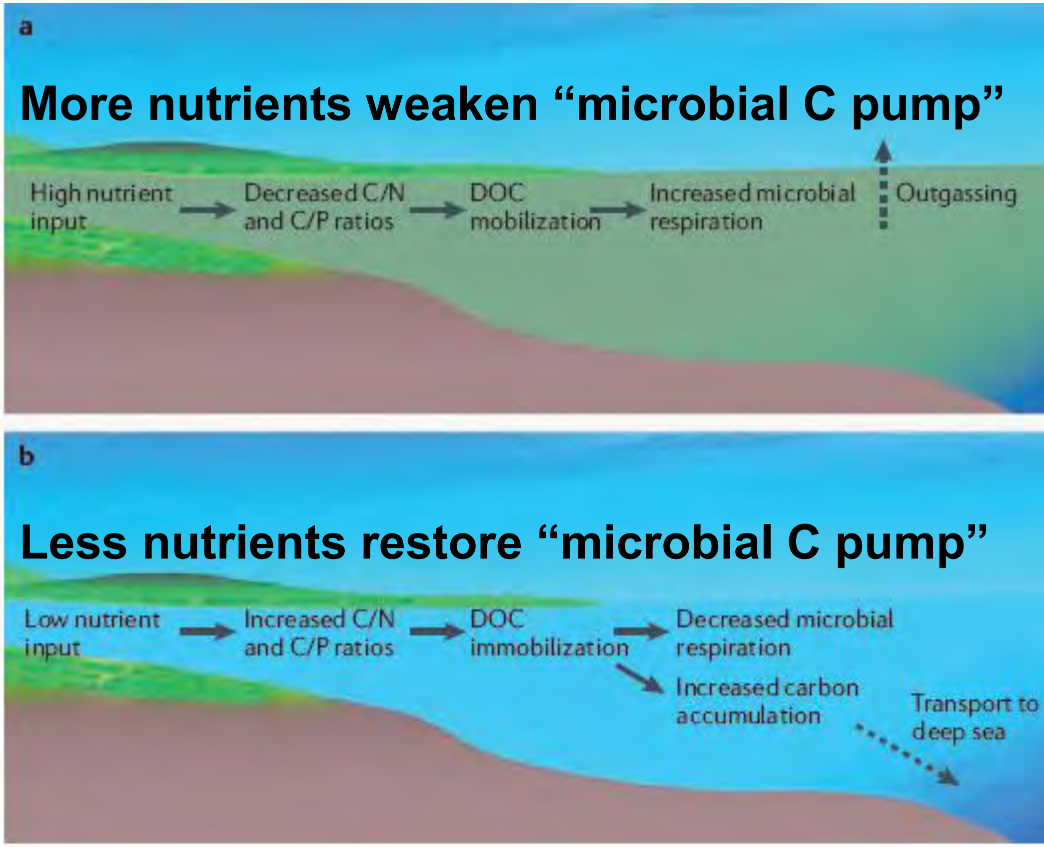


Blue Carbon:

an emerging approach for mitigation

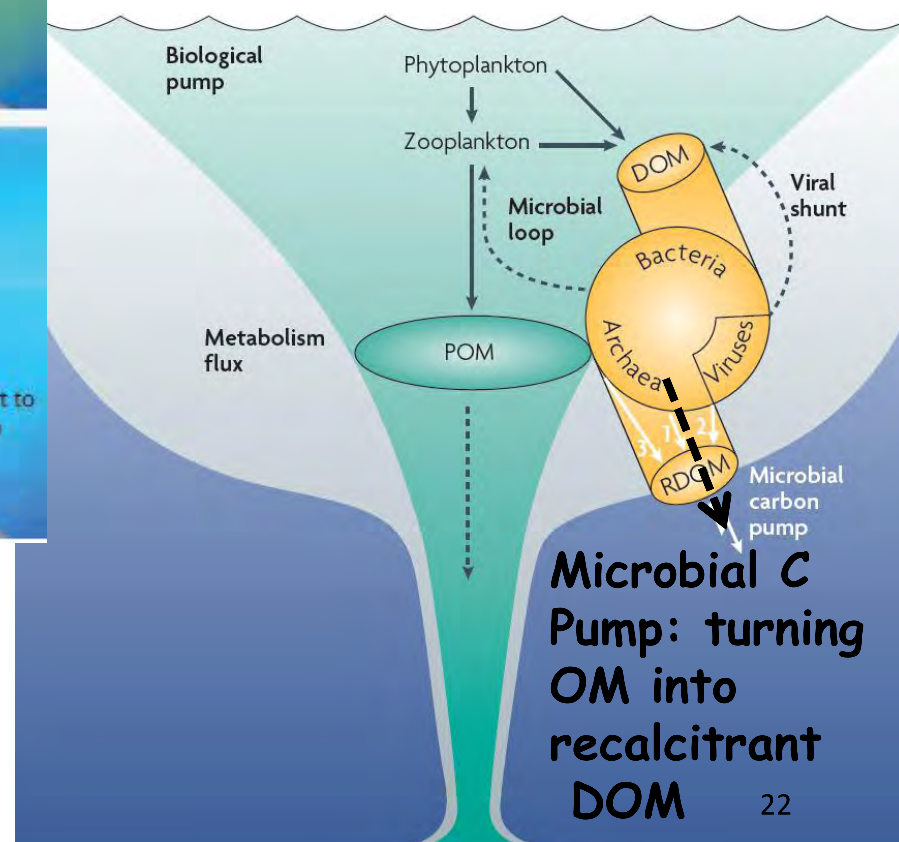
- **Focus: The ocean's vegetated habitats, in particular mangroves, salt marshes and seagrasses.**
- **Capacity: These habitats and estuaries capture and store between 235–450 Tg C every year.**
- **Emphasis: Preservation and restoration of coastal vegetated habitats.**

A potential benefit of reducing nutrient discharge



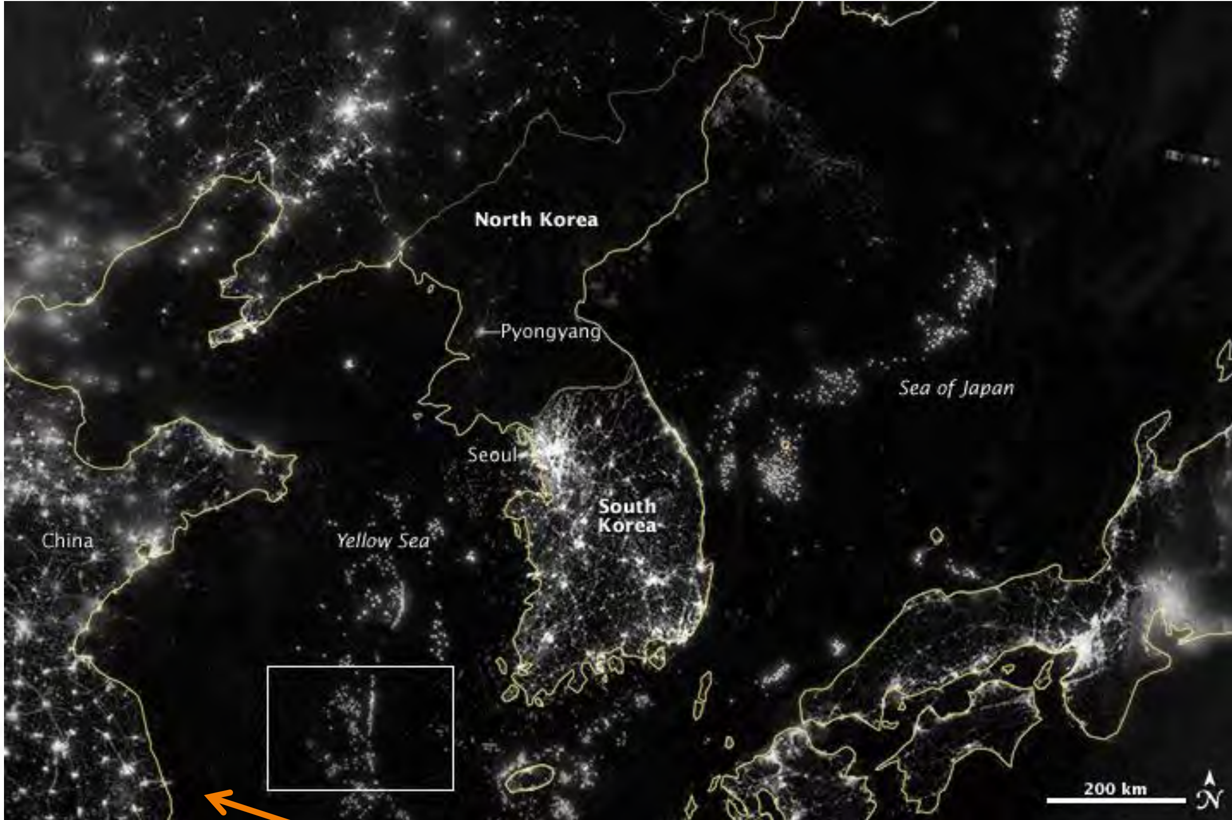
Jiao et al., Nature Microb. Rev. 2011

Jiao et al., Nature Microb. Rev. 2010

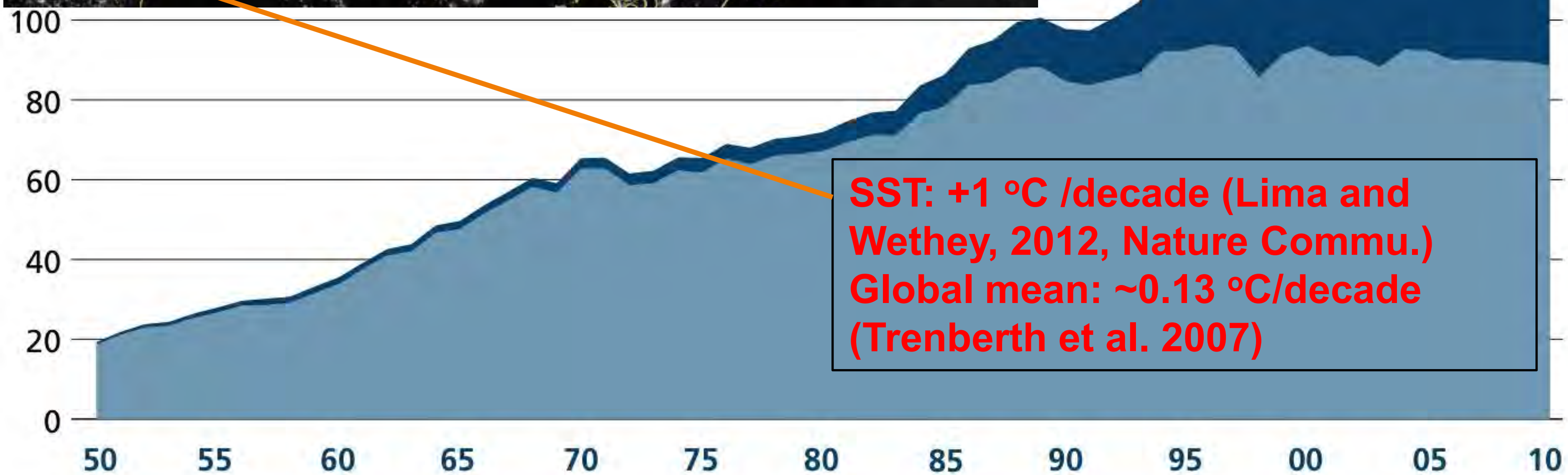


Mt/yr)

n USD



Better management based on ecosystem approach is necessary for adaptation to the decreasing fish stock and a sustainable fishery.



SST: +1 °C /decade (Lima and Wethey, 2012, Nature Commu.)
Global mean: ~0.13 °C/decade (Trenberth et al. 2007)

Special session F3:

Impacts of anthropogenic stressors and climate change on biogeochemistry-ecosystem in continental margins and feedbacks to earth system and society: challenges and solutions

Conveners:
Jing Zhang (East China Normal University)
Hiroaki Saito (Tohoku National Fisheries Research Institute, Japan)
Se-Jong Ju (KIOST, Korea)
Rosamma Stephen (National Institute of Oceanography Kochi, India)
Helmuth Thomas (Dalhousie Univ., Canada)
Kon-Kee Liu (National Central Univ., Taiwan)

Abstract deadline: 15 January 2014

Conclusions

- Western N. Pacific margins are experiencing **significant human-induced alteration of nutrient cycles** (Man-made N_2 fix > Natural, DIP scavenged by $Fe(OH)_3$ on sediments, Fe in dust solublized by SO_x, NO_x)
- **Ocean acidification appears especially intense** probably due to the relatively small water volume as well as man-made conditions, such as eutrophication.
- **The water cycle has been accelerated and often altered** by impoundments; influences on coastal biogeochemistry/ecosystem are expected but not well understood.
- **The anthopogenic impacts on ecosystem in continental margins could be serious but often unclear** so that more research is necessary to better understand the impacts, which need be properly assessed for adequate measures of mitigation and adaptation.

Professor Frank Fenner's warning

Eminent Australian scientist Professor Frank Fenner helped to wipe out smallpox.

- "Humans will probably be extinct within 100 years, because of overpopulation, environmental destruction and climate change." http://phys.org/news196489543.html#jCp