Leibniz Institute For Baltic Sea Research Warnemünde

Effects of aquaculture effluents on nitrogen characteristics in two Chinese estuaries

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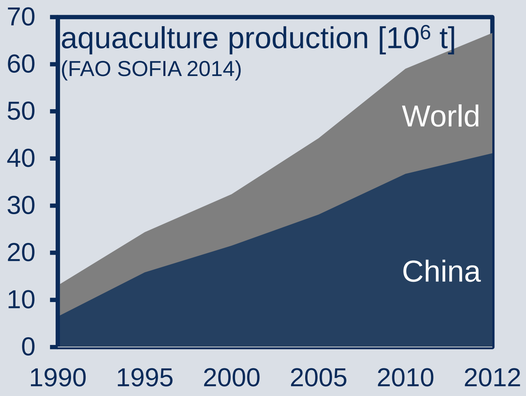
Introduction



Growing aquaculture production raises environmental concerns, particularly in China. The creation of brackish-water ponds in coastal areas has lead to large-scale destruction of mangrove forests, drastically reducing their capacity to filter anthropogenic pollution. At the same time, pond effluents, loaded with nutrients from feed and animal excretions, cause eutrophication in near-shore waters. This can have negative effects on adjacent seagrass and coral ecosystems. The effects of aquaculture depend on its spatial extend, climatic setting, and cultivation practice, which vary between regions.[1]

The Nanliu (**NL**) and Wenchang/Wenjiao (**WW**) Rivers are both situated in southern China, but the aquaculture in their estuaries is characterized by different management and hydrological influence, resulting in different ecological impacts.

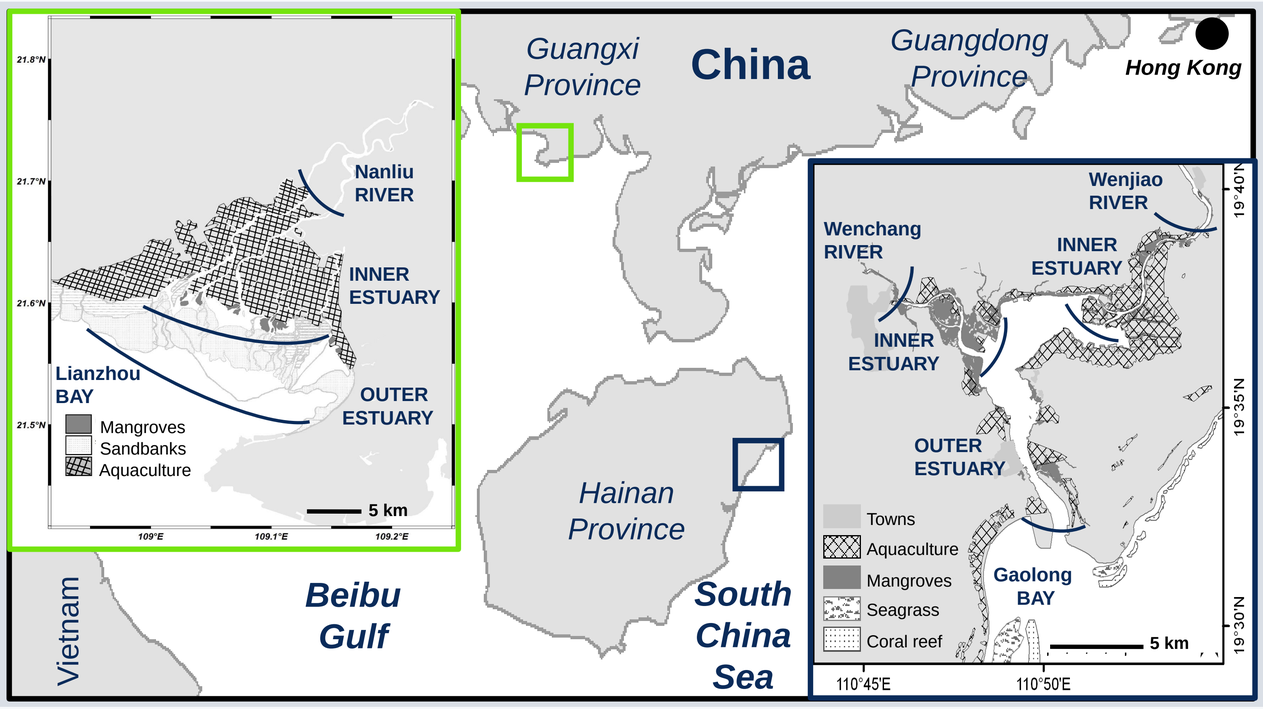
Study site

Nanliu Estuary

runoff:	166 $m^3 s^{-1}$
drainage basin:	9704 km^2
river length:	287 km
macrotidal:	>5m range
residence time:	1.4-6 days[2]

Aquaculture
>6500 ha ponds
mostly shrimp
2-3 harvest yr^{-1}
feeding: fertilizer for phytoplankton production

Mangrove reduction: 71%
1790 to 515 ha since 1990s[4]



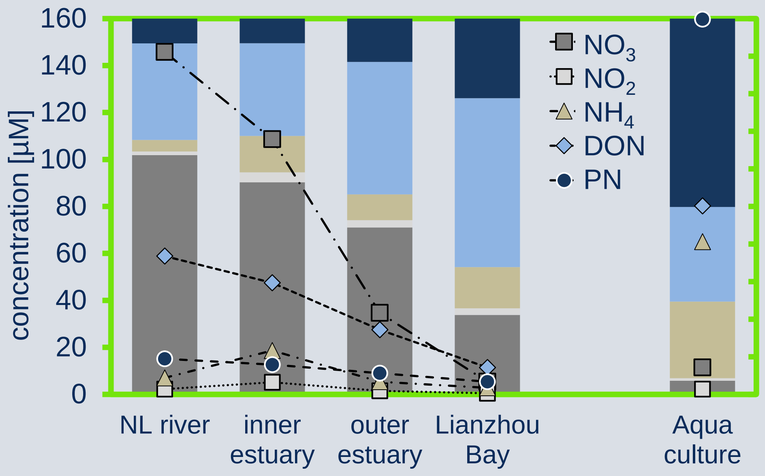
Wenchang/Wenjiao Estuary

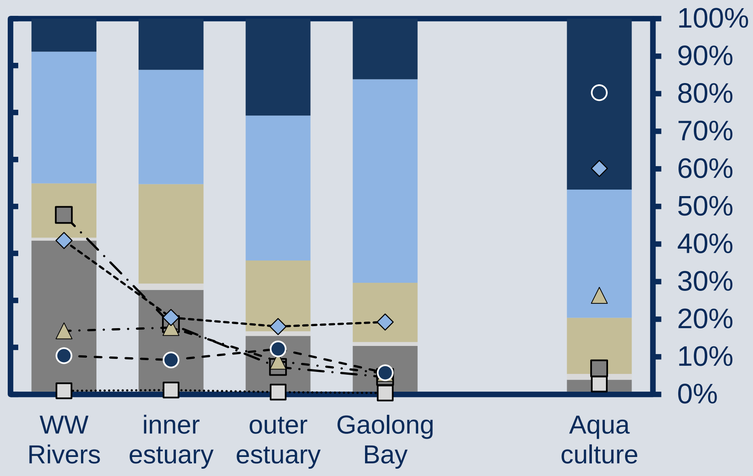
runoff:	20.7 $m^3 s^{-1}$
drainage basin:	903 km^2
river length:	<60 km
microtidal:	<2m range
residence time:	5.6 days[3]

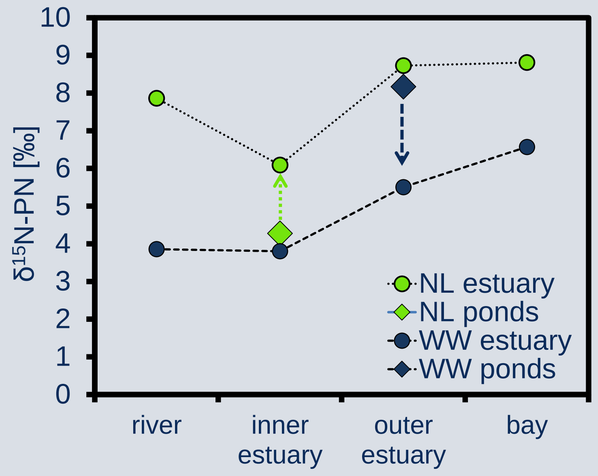
Aquaculture
2156 ha ponds
shrimp & fish
3-4 harvest yr^{-1}
feeding: fertilizer & artificial solid feed

Mangrove reduction: 73%
2970 to 812 ha since 1960s[3]

Nitrogen concentrations and composition

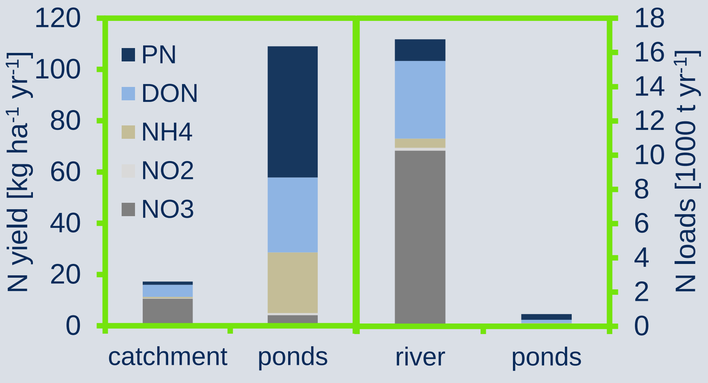


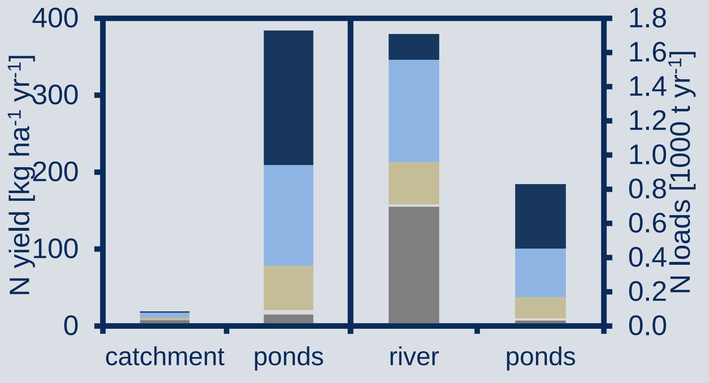




- NO_3 dominance in rivers reflects agricultural fertilizer influence[5,6], especially in NL, where NO_3 is the largest fraction throughout the estuary. NO_3 is conservatively mixed in both estuaries, confirming rivers as the main source.
- Pond water N is dominated by PN from feed and *in situ* primary production, and DON and NH_4 from feed leaching and animal excretions.[1,6]
- Low $\delta^{15}N$ in NL ponds result from direct fertilizer uptake by phytoplankton[7], high $\delta^{15}N$ in WW ponds from use of additional animal feed.[1]
- Changing N composition shows pond influence in the inner estuary of NL ($\delta^{15}N\downarrow$ DON↑ $NH_4\uparrow$) and entire estuary of WW ($\delta^{15}N\uparrow$ PN↑ $\%NH_4\uparrow$).

Nitrogen mass supply





- Pond export is dominated by PN and DON, while rivers export more NO_3.
- Pond yields exceed catchment yields, but N mass export is dominated by river loads.
- River N loads are higher in NL due to a larger catchment and higher concentrations.
- Pond loads are higher in WW due to more water exchange, not higher concentrations.

Ecological consequences

- In WW, pond effluents have been shown to cause eutrophication[1,8], increasing coastal sedimentary H_2S as well as enhance microalgal growth, and diminishing seagrass performance.[9]
- In NL, pond water impact is outweighed by river loads causing eutrophic conditions.[4] Due to tidal export they have no apparent negative near-shore effect[5] but disperse to remote coastal systems.[7]
- Aquaculture impact depends on a combination of pond management, background riverine pollution, and hydrology. These factors favor high impact of effluents in WW compared to NL.

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References

[1] Herbeck et al. 2013 – Continental Shelf Research, 57, 92-104; doi:10.1016/j.csr.2012.05.006
[2] Sun et al. 2014 – Journal of the Ocean University of China, 13, 13-22; doi:10.1007/s11802-014-1963-4
[3] Krumme et al. 2012 – Marine Environmental Research 82, 28-39; doi:10.1016/j.marenvres.2012.09.002
[4] Kaiser 2014 – Dissertation, University Bremen, 177pp; http://nbn-resolving.de/urn:nbn:de:gbv:46-00103622-11
[5] Kaiser et al. 2013 – Science of the Total Environment, 450–451, 92-107; doi: 10.1016/j.scitotenv.2013.01.096
[6] Herbeck et al. 2011 – Estuarine, Coastal and Shelf Science, 93, 375-388, doi:10.1016/j.ecss.2011.05.004
[7] Kaiser et al. 2014 – Continental Shelf Research, 82, 99-118; doi:10.1016/j.csr.2014.04.006
[8] Liu et al. 2011 – Marine Chemistry, 125, 49-68; doi:10.1016/j.marchem.2011.02.003
[9] Herbeck et al. 2014 – Marine Pollution Bulletin, 85, 190-203; doi:10.1016/j.marpolbul.2014.05.050

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