南京水利科学研究院
NANJING HYDRAULIC RESEARCH INSTITUTE

Ecohydrological effects of river damming and adaptive management

Qiuwen Chen, Jianyun Zhang, Wenqing Shi, et al.

CEER Nanjing Hydraulic Research Institute

Yangtze Institute for Conservation and Development

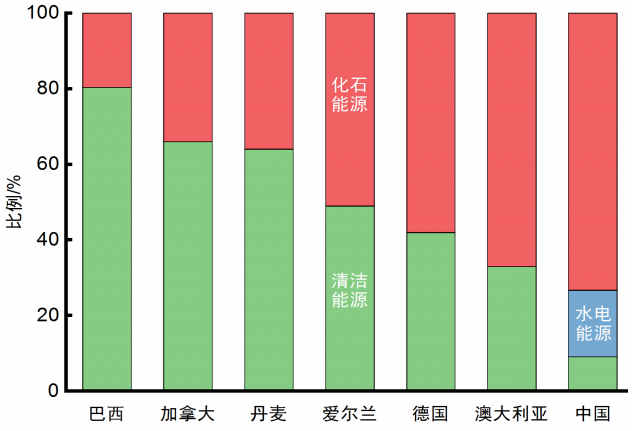
Outlines

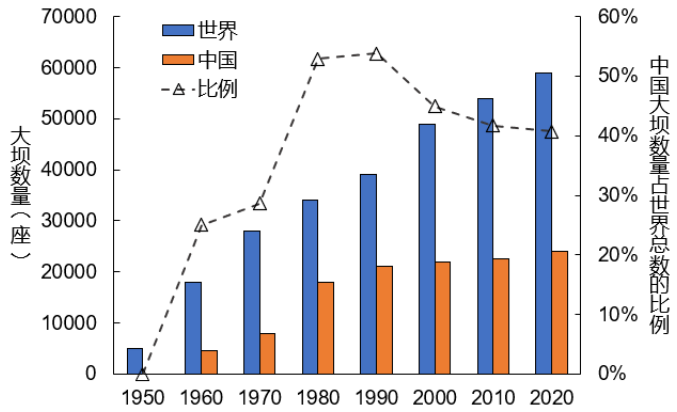
1. Research background
2. Impact on biogeochemical cycles
3. Impacts on fish and conservations
4. Remarks and perspectives

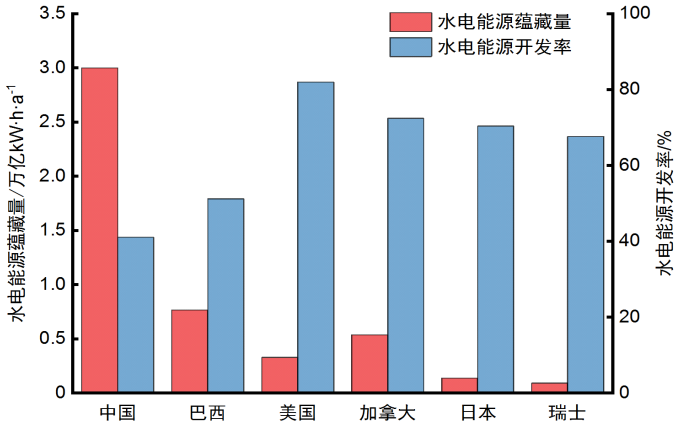
1. Research background

❑ National demands: energy security, carbon neutralization, poverty relief

- ✧ Carbon peaking and neutrality
- ✧ Hydropower improve energy structure
- ✧ Small hydropower & pumping storage



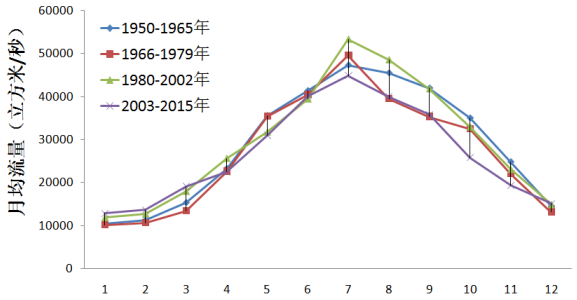




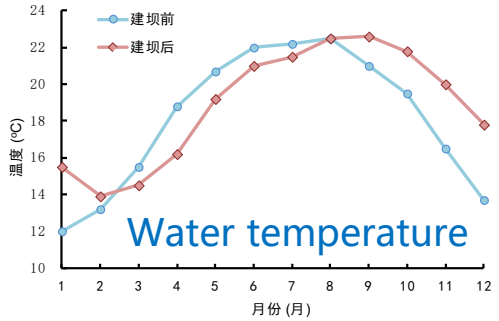
1. Research background

- National demands: energy security, carbon neutralization, poverty relief

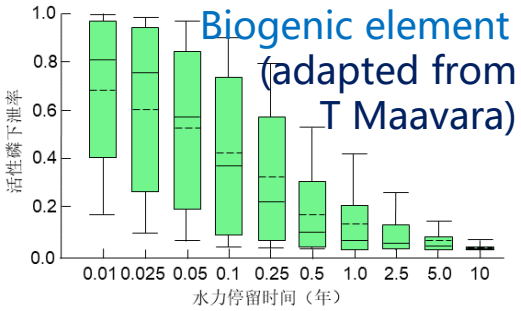
River damming



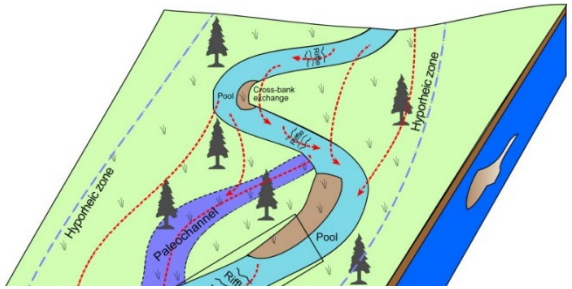
Hydrological alteration



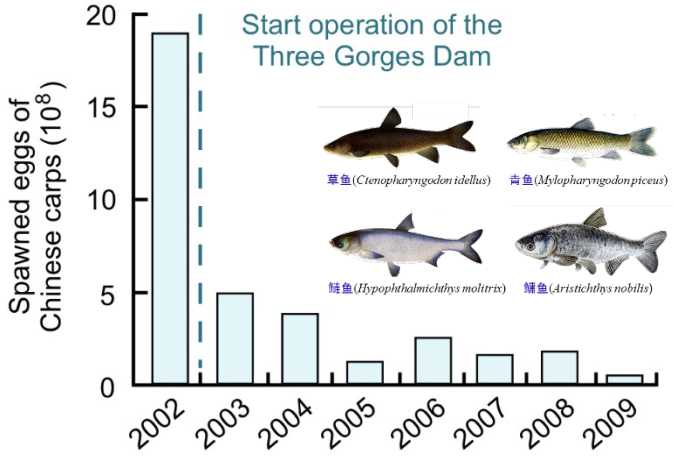
Water temperature



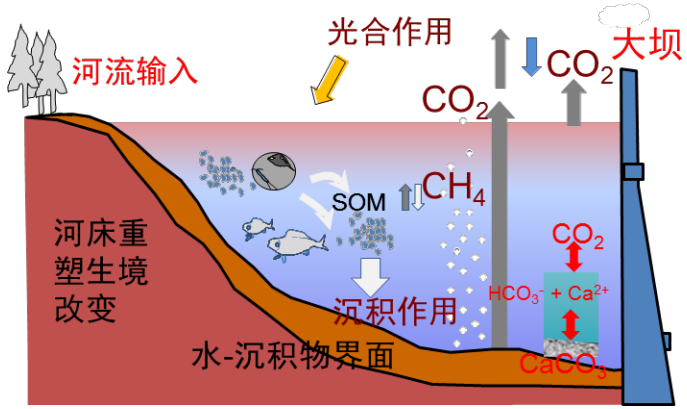
Biogenic element (adapted from T Maavara)



Morphology (from D Tonina)



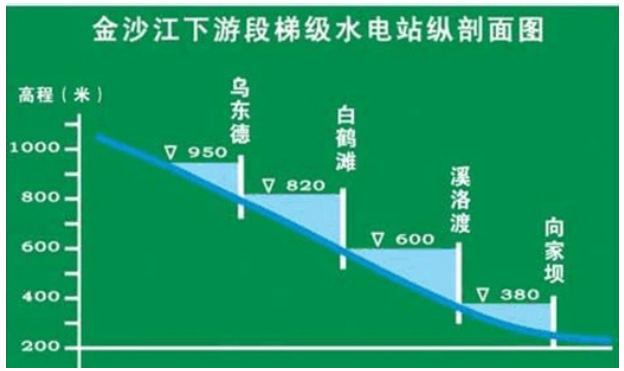
Clean energy? Green energy?

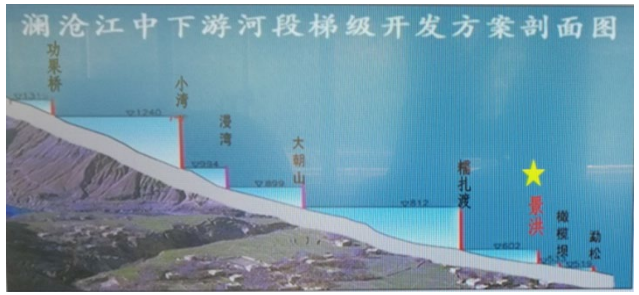


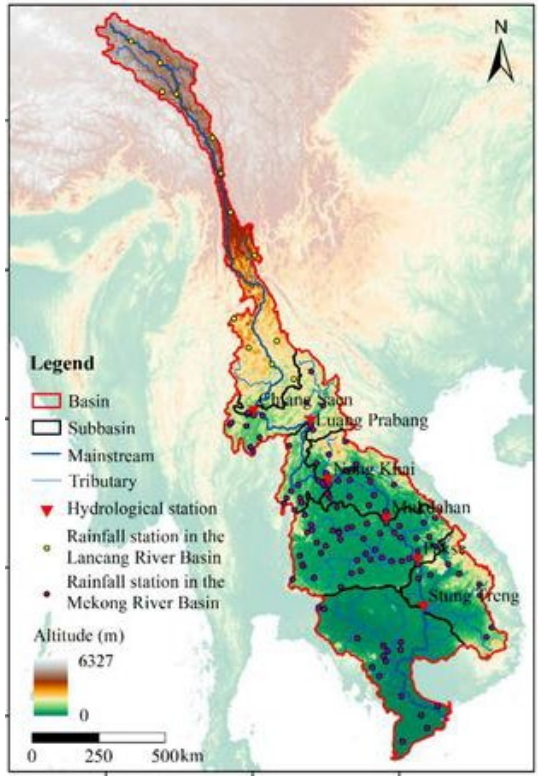
1. Research background

❑ Main study area

- ✧ The upper Yangtze River with 5 large dams
- ✧ The upper Mekong River with 5 large dams







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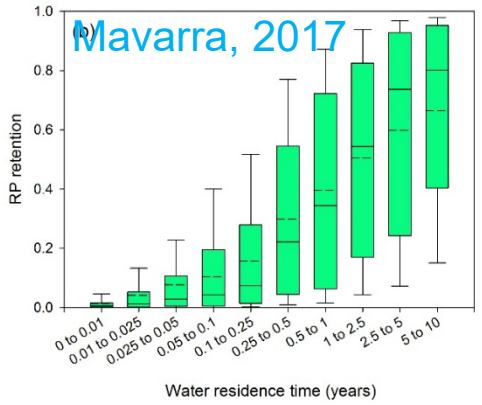
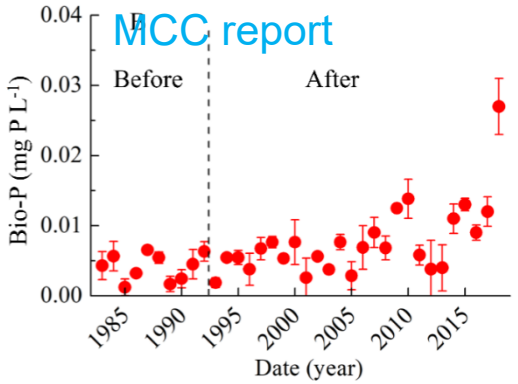
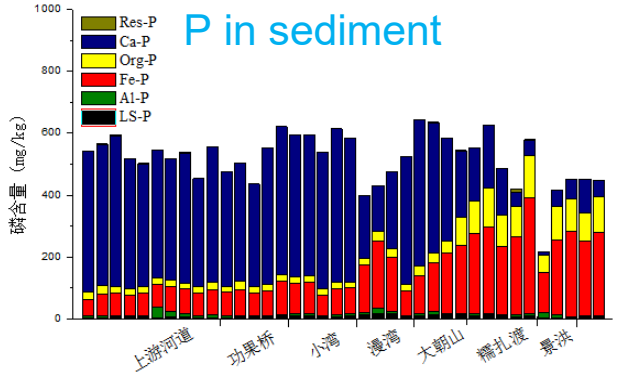
2. Impact on biogeochemical cycles

❑ Knowledge gaps





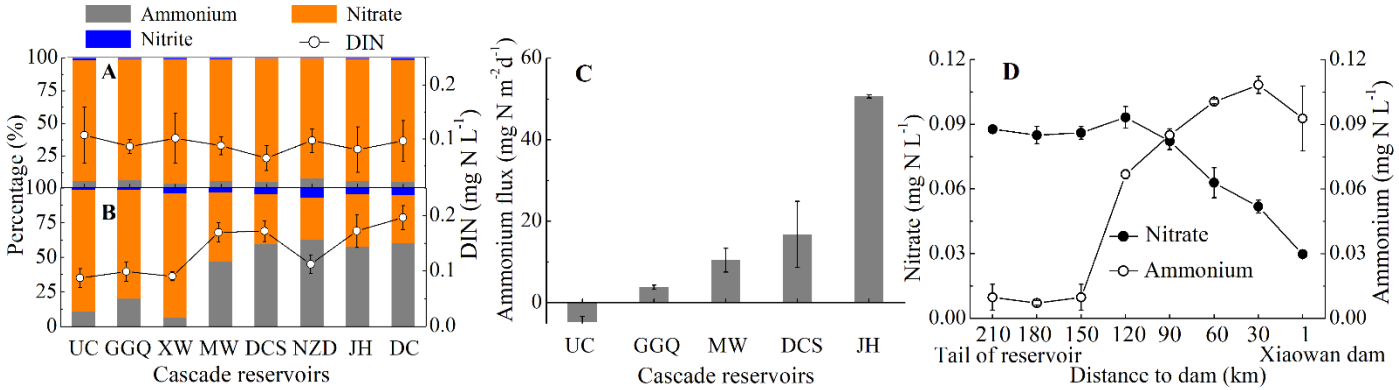


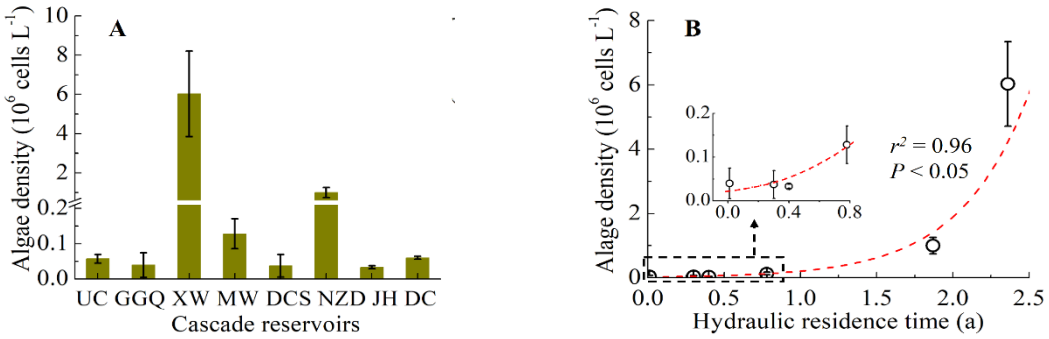
❑ The challenges

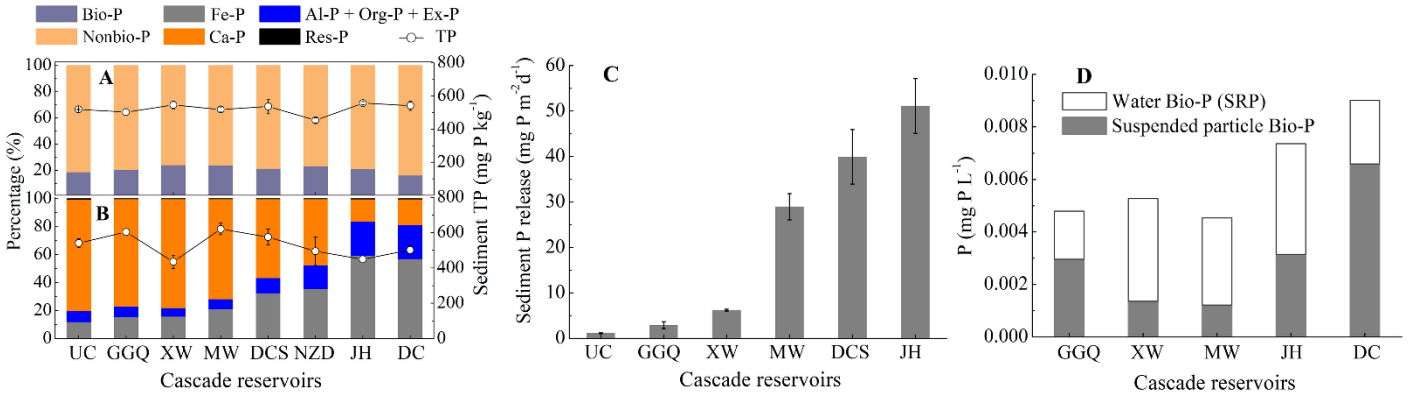
1. What happen to the trapped biogenic elements in the reservoirs?
2. What spatial patterns are the GHG emission in reservoir cascade?

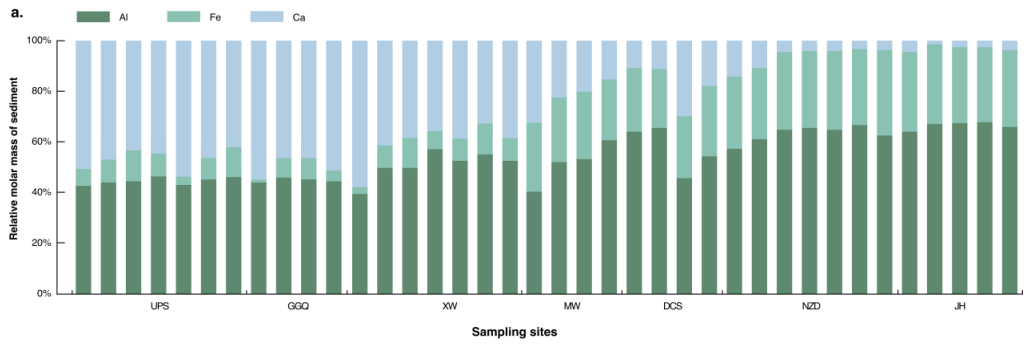
2. Impact on biogeochemical cycles

❑ Deep reservoirs enhance N & P bioavailability downstream





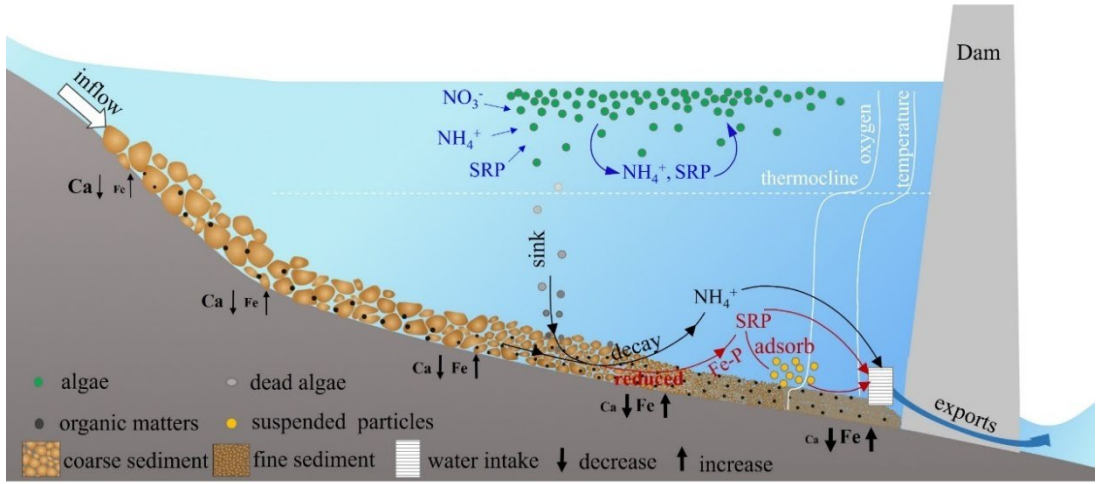




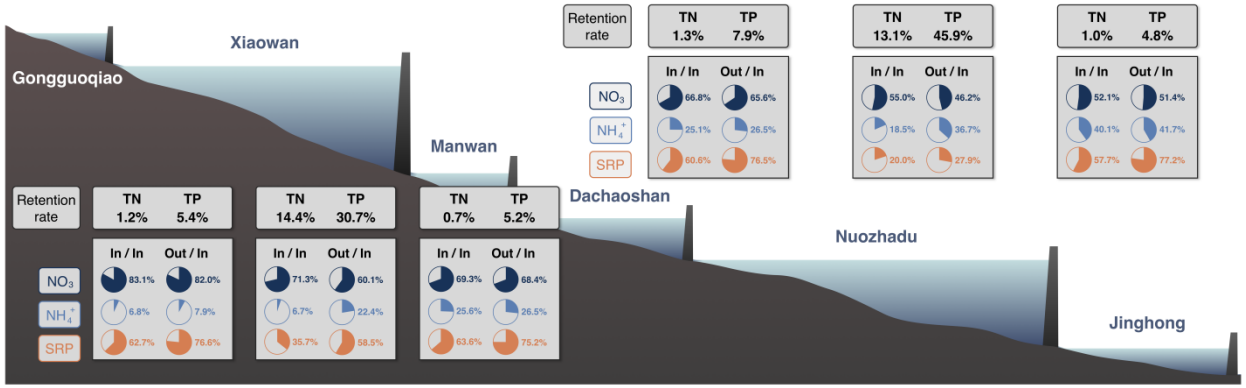
Chen Q., et al., 2020, *National Science Review*, 7: 1449-1457

2. Impact on biogeochemical cycles

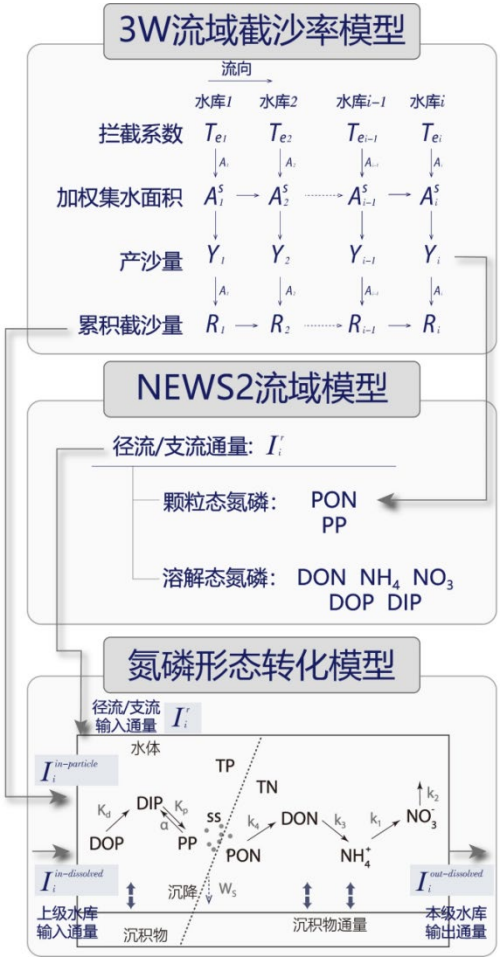
❑ Quantified the interception and delivery of N and P in cascade reservoirs

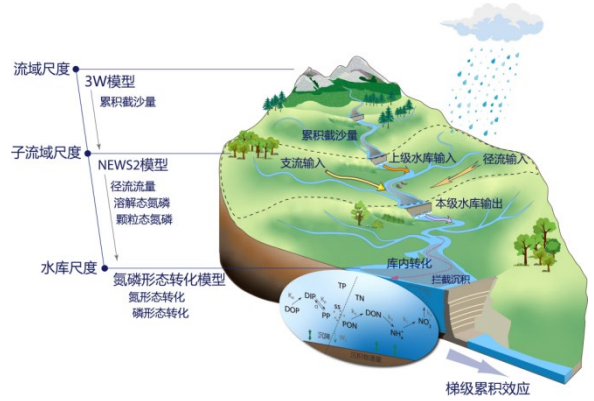


Biogeochemical cycles in deep reservoir



Interception and delivery N and P in cascade reservoirs

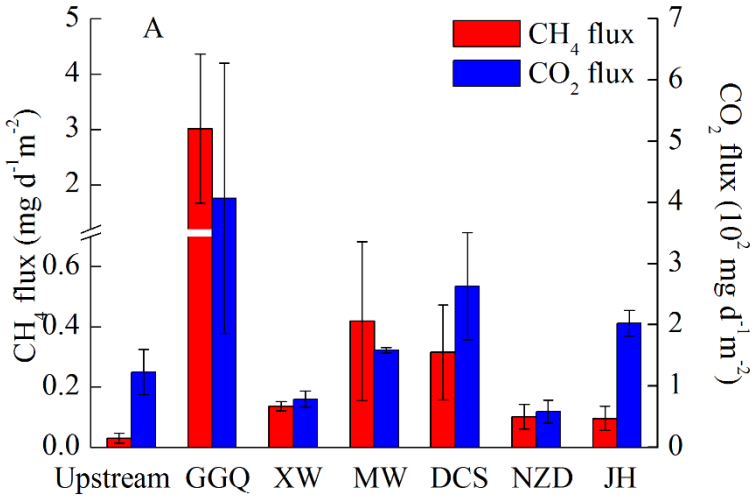


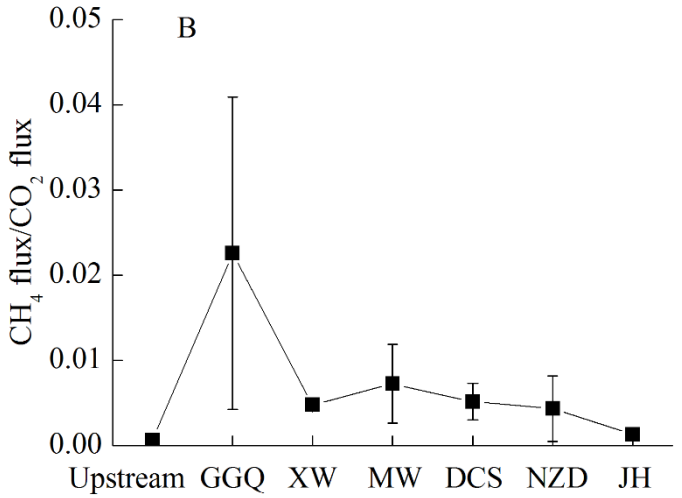


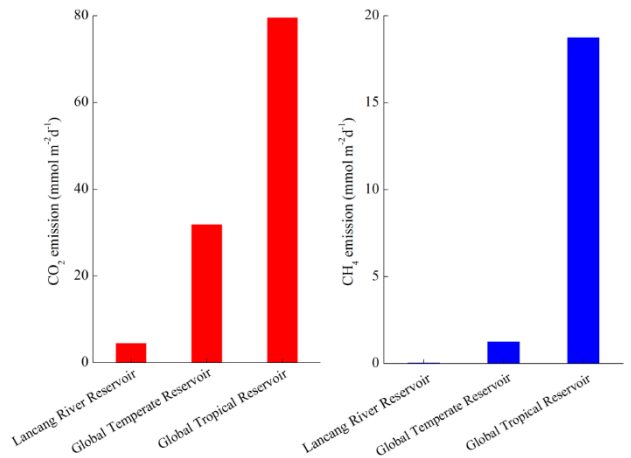
- Interception of TN and TP, regeneration of bioavailable N and P are well correlated to HRT
- The regeneration of N & P is more strong in deep reservoirs with large HRT

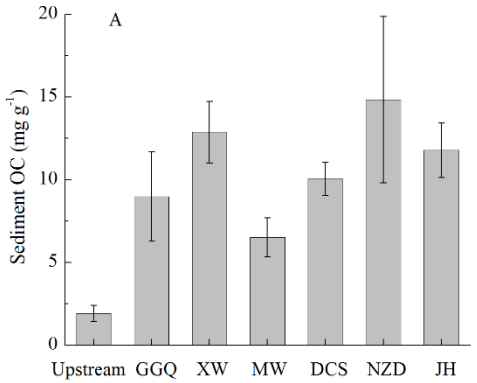
2. Impact on biogeochemical cycles

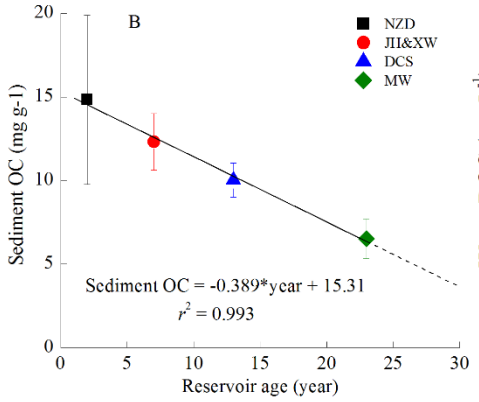
- Carbon based GHG is extremely low and decrease with reservoir age

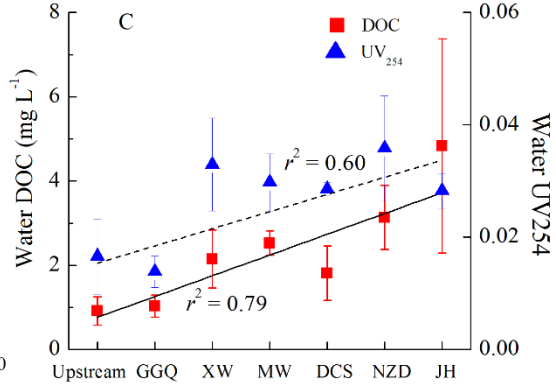


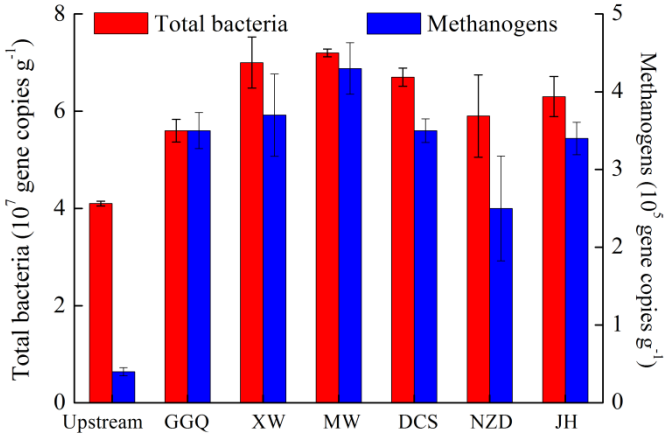








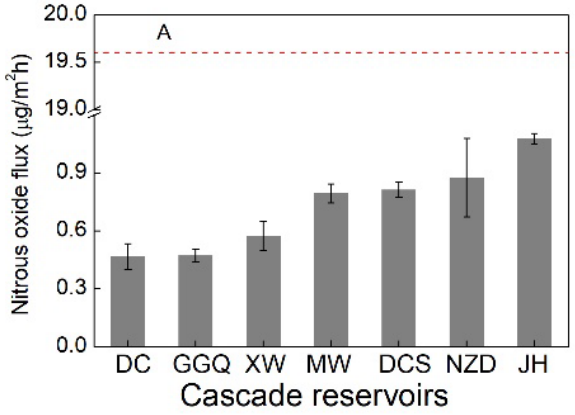


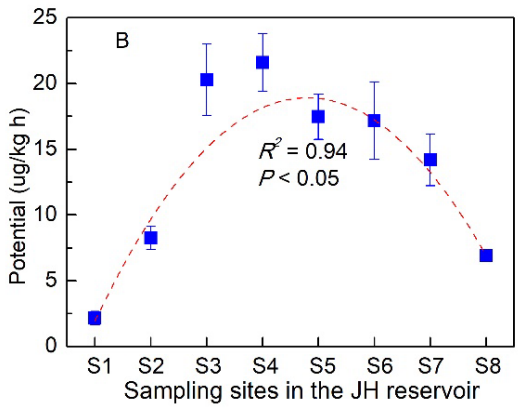


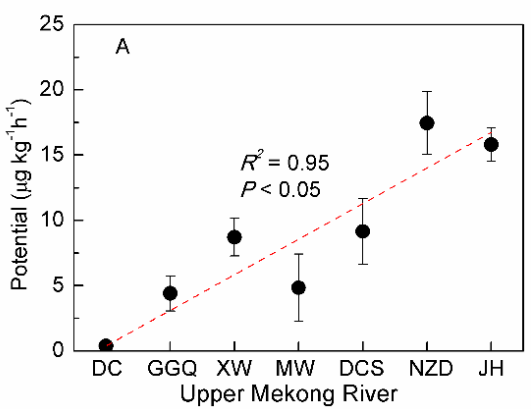
Shi et al., 2017, *ES&T*, 51: 12175-12181

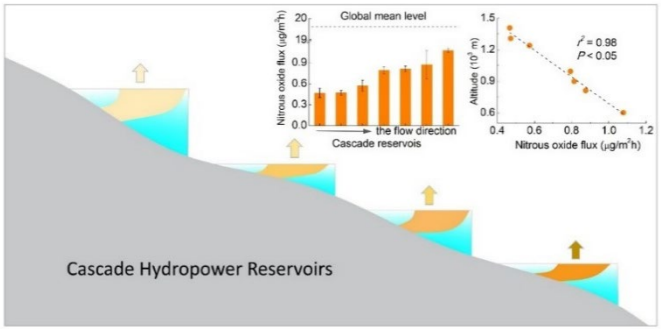
2. Impact on biogeochemical cycles

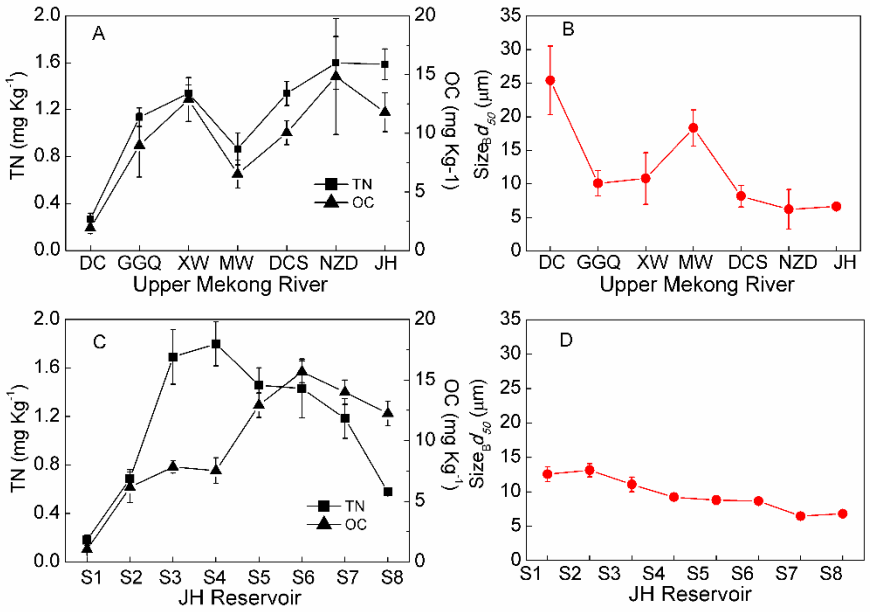
- Nitrogen based GHG is low but increased by N inputs and temperature

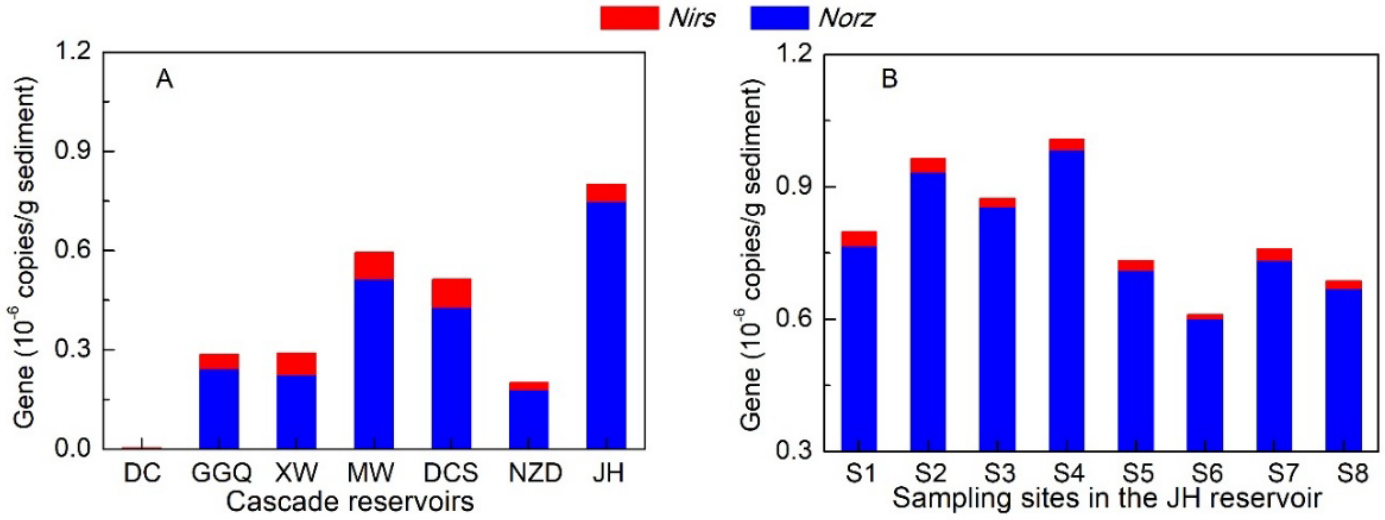








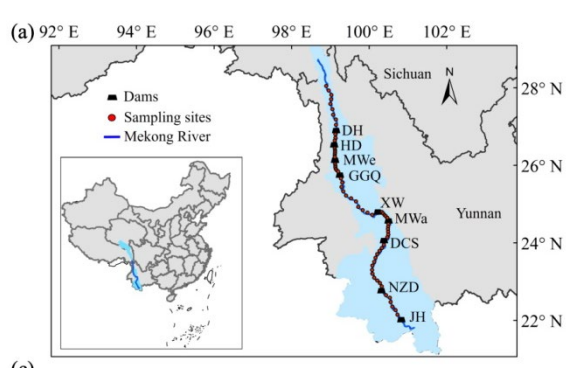


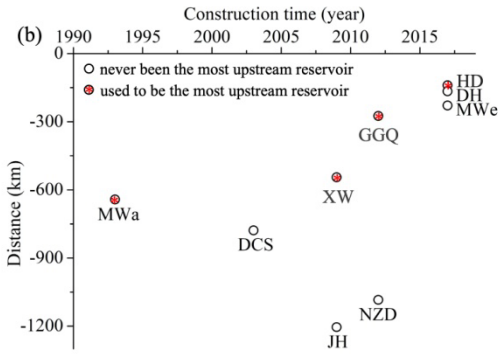


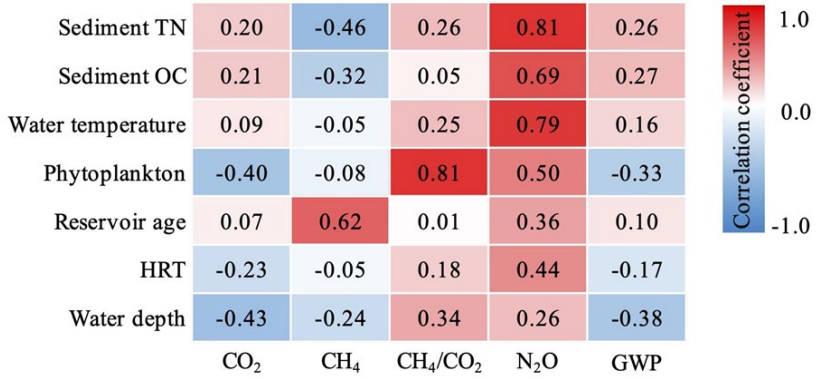
Shi et al., 2020, *Water Research*, 173, 115582

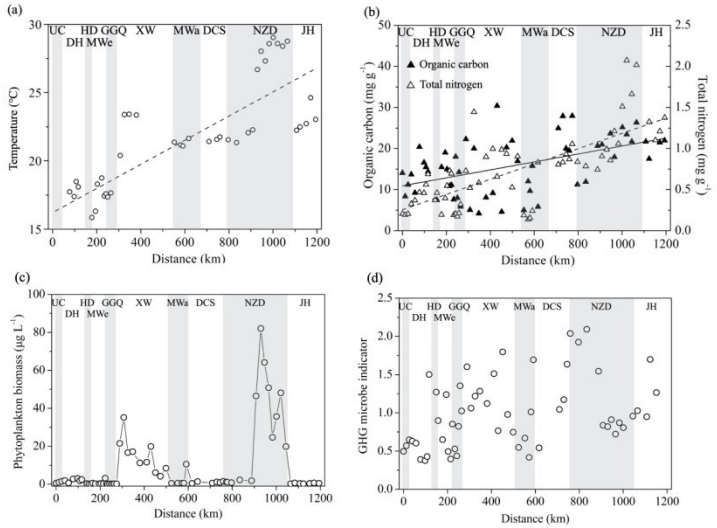
2. Impact on biogeochemical cycles

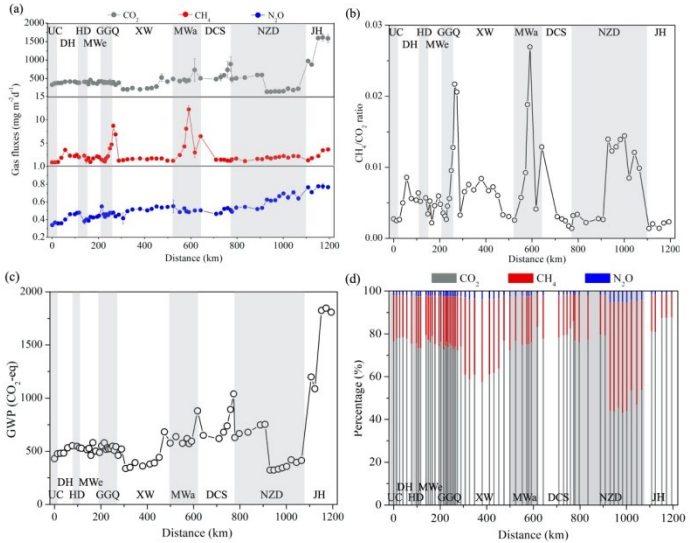
- Spatial pattern of GHG in reservoir cascade and implication for planning

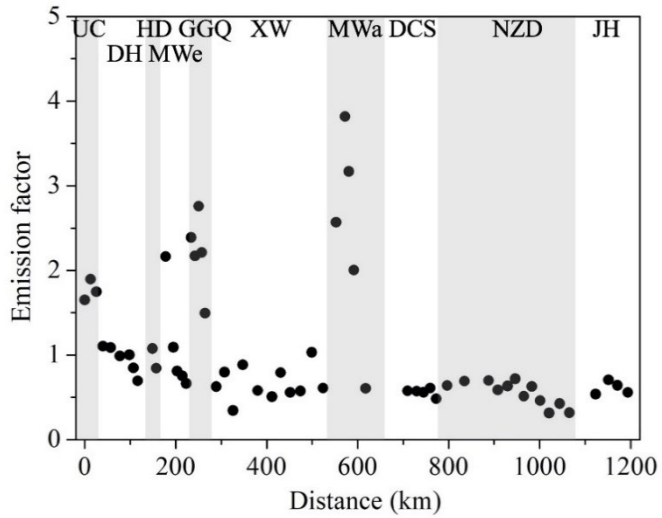












Shi et al., 2022, *Journal of Hydrology* (revision under review)

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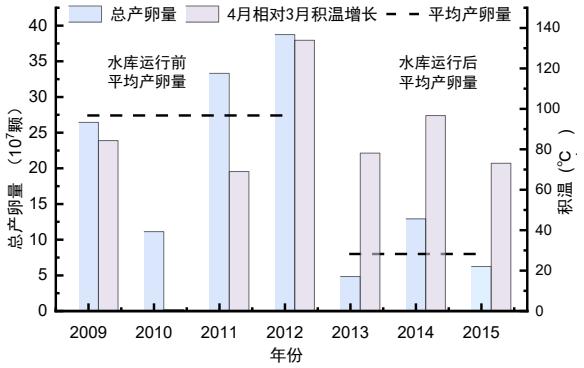
❑ Knowledge gaps



Costly and complex stoplogs gate has not increase spawning

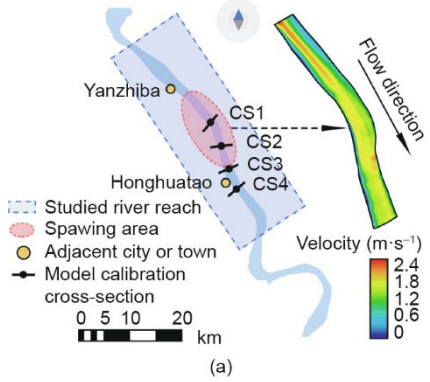
The impounded upstream permanently lost habitat

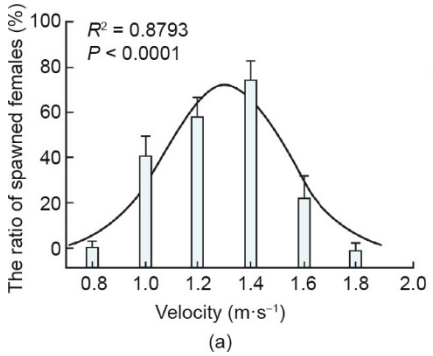
❑ The challenges

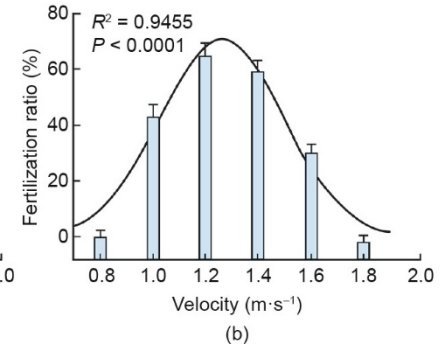
1. The physiological plausibility of reservoir ecological operation for downstream?
2. The proper measure for fish conservation in permanently impounded upstream?

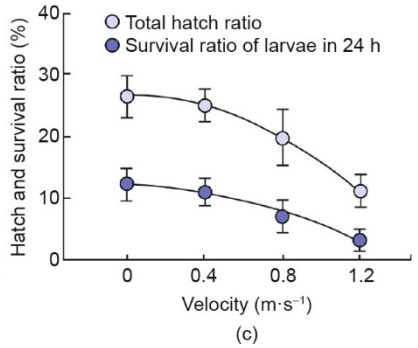
3. Impact on fish and conservations

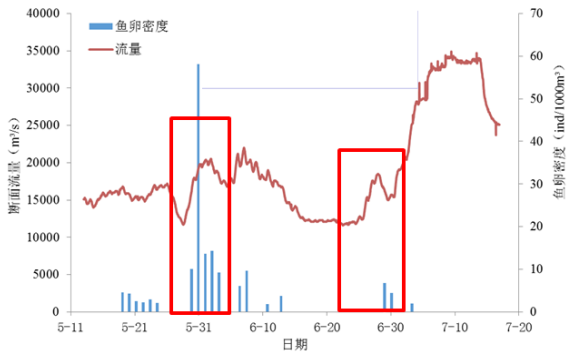
❑ Pulse of high velocity for spawning and low velocity for hatching

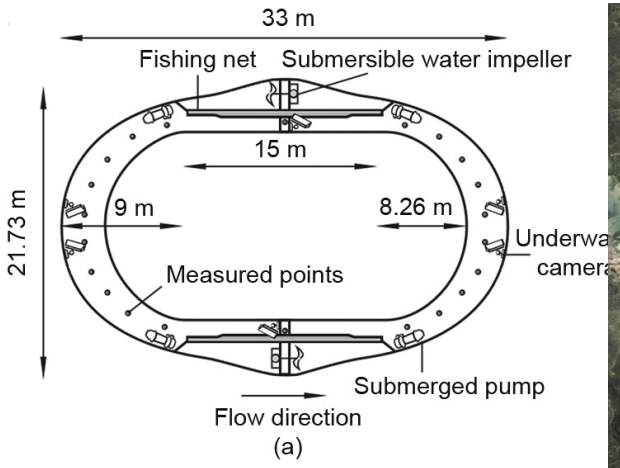


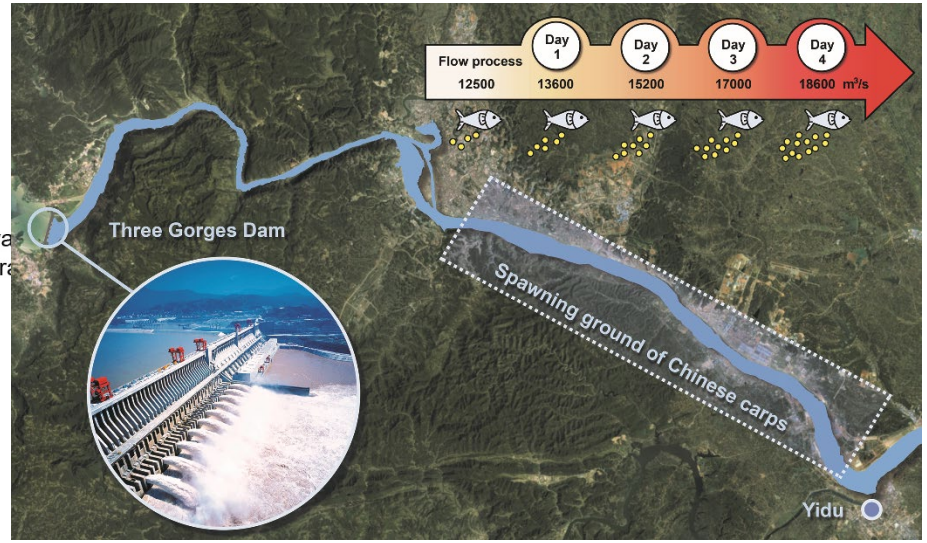


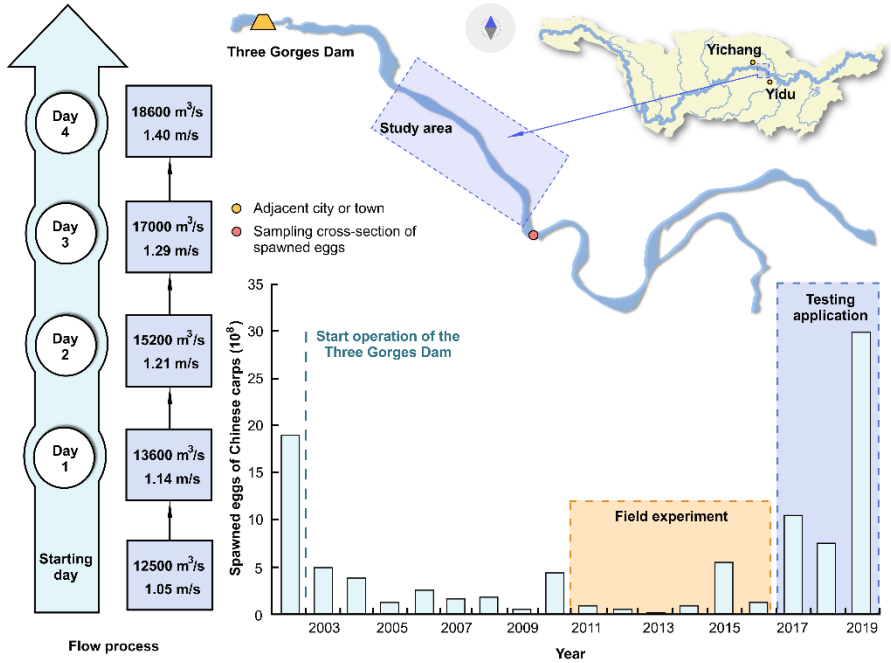








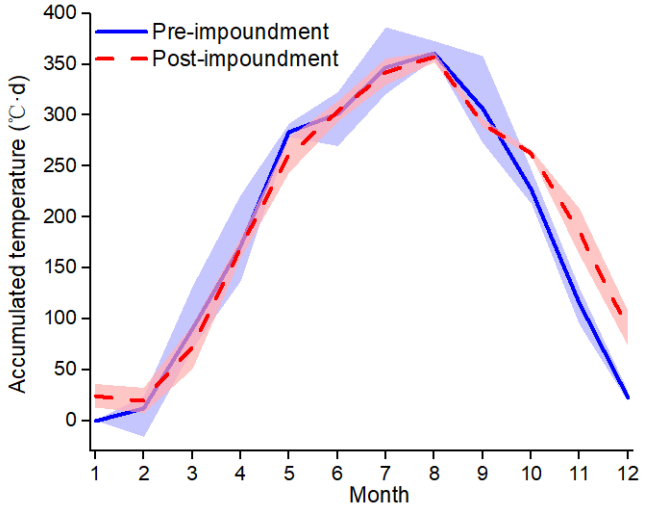


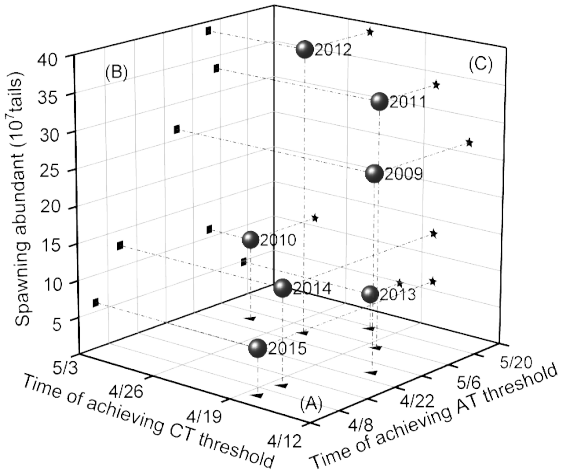


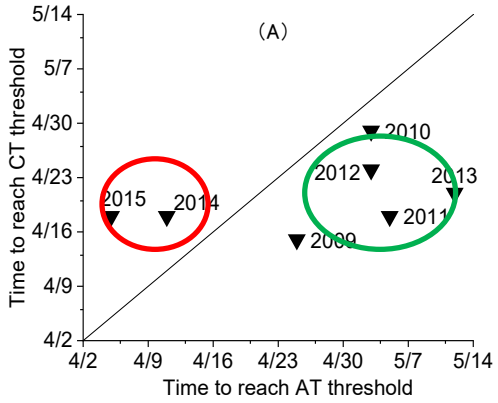
Chen Q., et al., 2021, *Engineering*, 7: 178-186

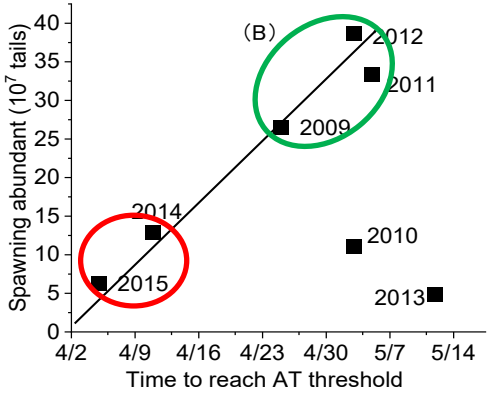
3. Impact on fish and conservations

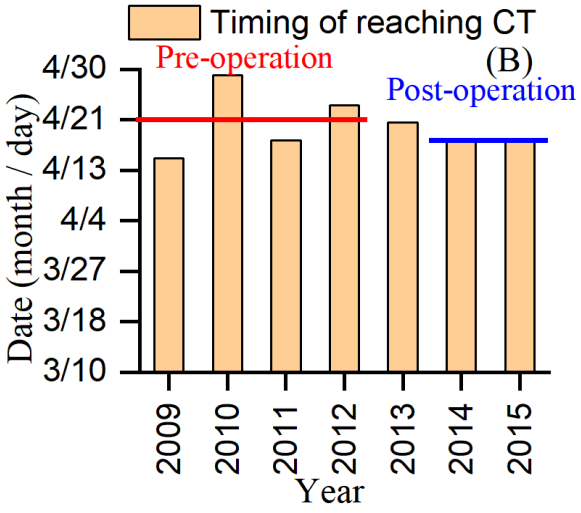
❑ Time mismatch of accumulated and critical temperature reduce spawning

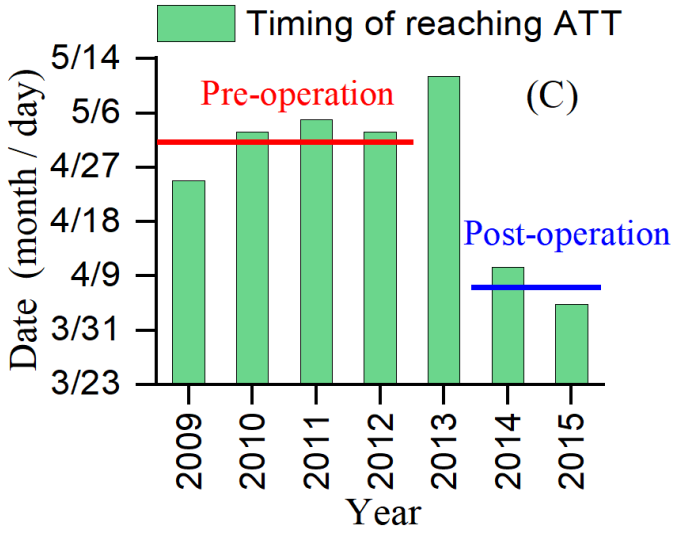


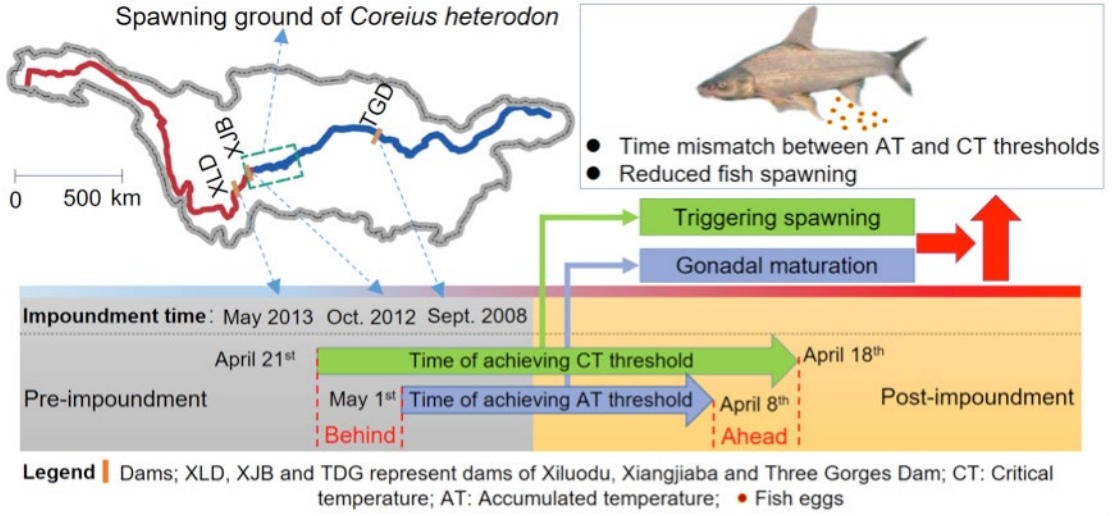












Li T, et al., 2021, *Science of the Total Environment*, 144052

3. Impact on fish and conservations

❑ Optimized operation coupled e-flow and water temperature requirement

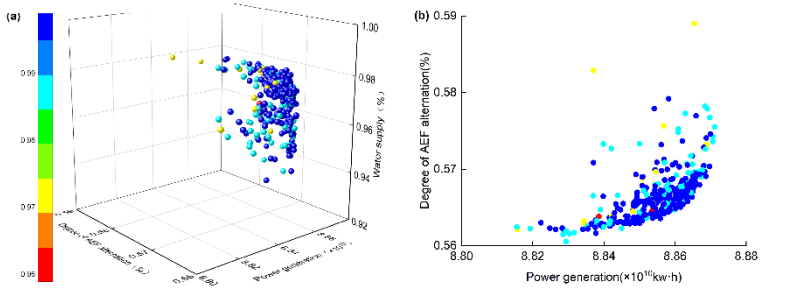
Objective & constrains

① Obj: hydropower production $f_1 = \max \sum_{t=1}^{T} \sum_{i=1}^{2} N_{i,t} \Delta t \qquad N_{i,t} = K_i \cdot Q_{i,t}^{g} \cdot \Delta H_{i,t}$

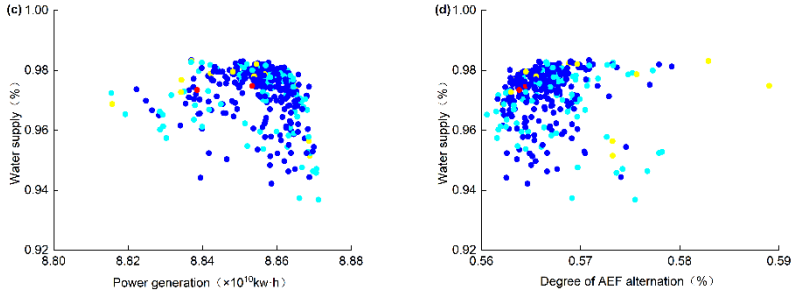
② Constrain :e-flow demand $f_2 = \min \frac{1}{2T} \sum_{t=1}^{T} \left(\left| \frac{Q_{\mathrm{XLD},t}^{\mathrm{out}} - Q_{\mathrm{AEF},t}}{Q_{\mathrm{AEF},t}} \right| + \left| \frac{Q_{\mathrm{XLD},t}^{\mathrm{out}} - Q_{\mathrm{AEF},t}}{Q_{\mathrm{AEF},t}} \right| \right)$

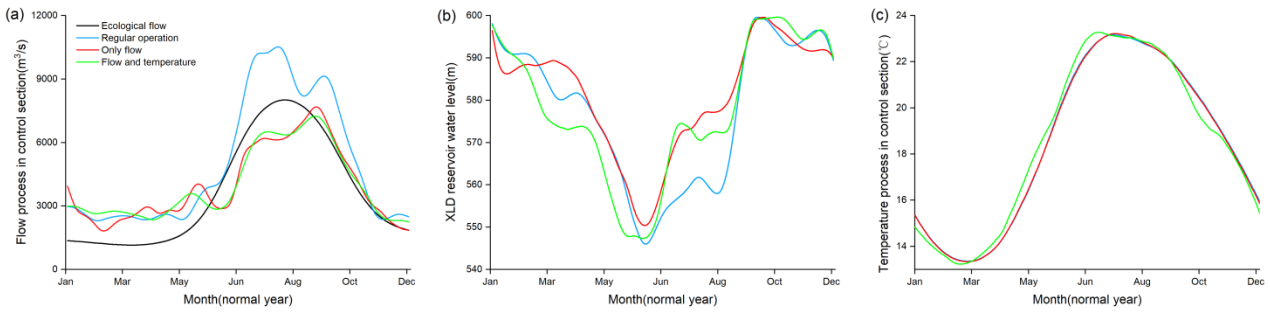
③ Constrain: WT demand $f_3 = \max \frac{1}{T} \sum_{i=1}^{T} \frac{Q_{\mathrm{sw},t}}{Q_{\mathrm{sw},t}^{\mathrm{demand}}}$

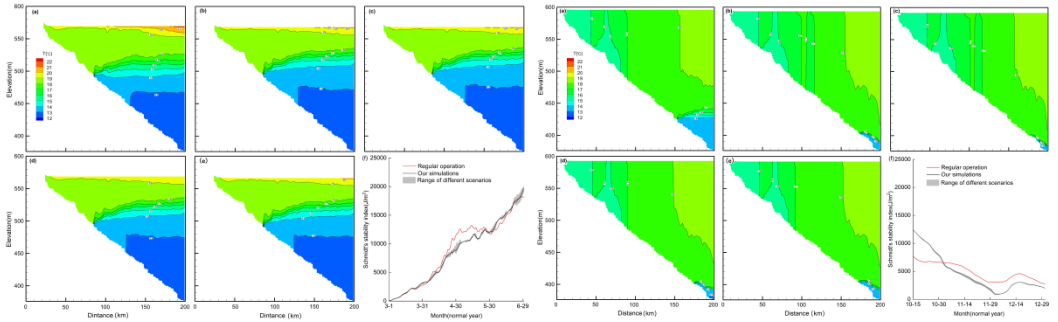
④ Constrain: navigation demand $f_4 = \max \left\{ \frac{T_{\mathrm{nav}}}{T} \times 100\% \right\}$



The Pareto non-inferior solutions



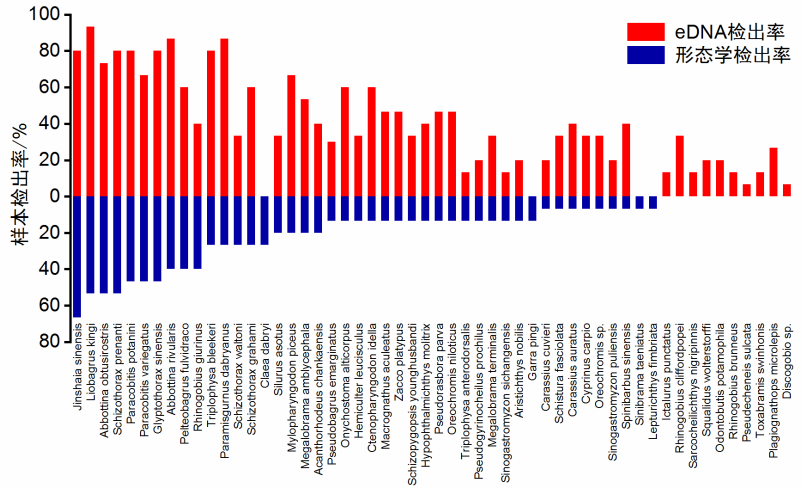




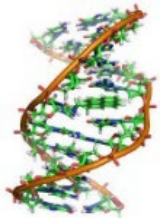
Water temperature distribution in the reservoir

3. Impact on fish and conservations

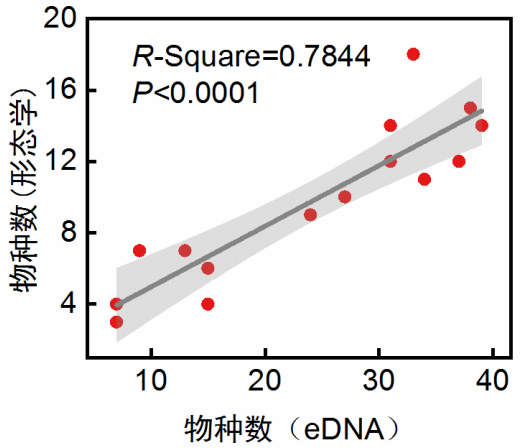
❑ Alternative habitats in tributaries of reservoir section



sample → drying → DNA distill → 12S amplify → HTS → analyses



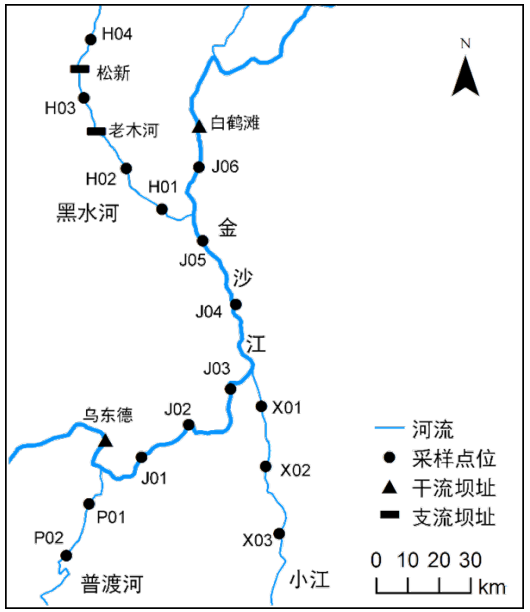
Fish community

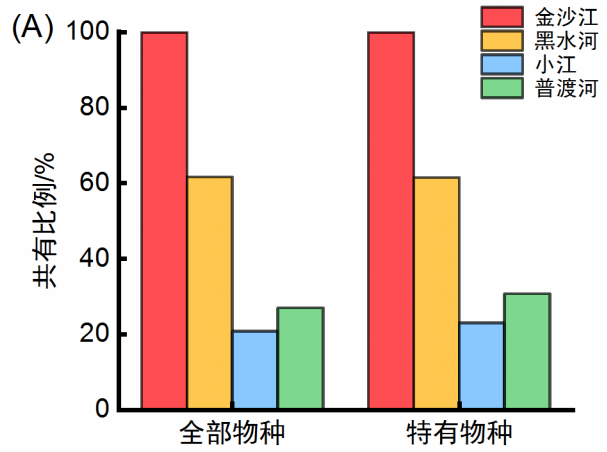


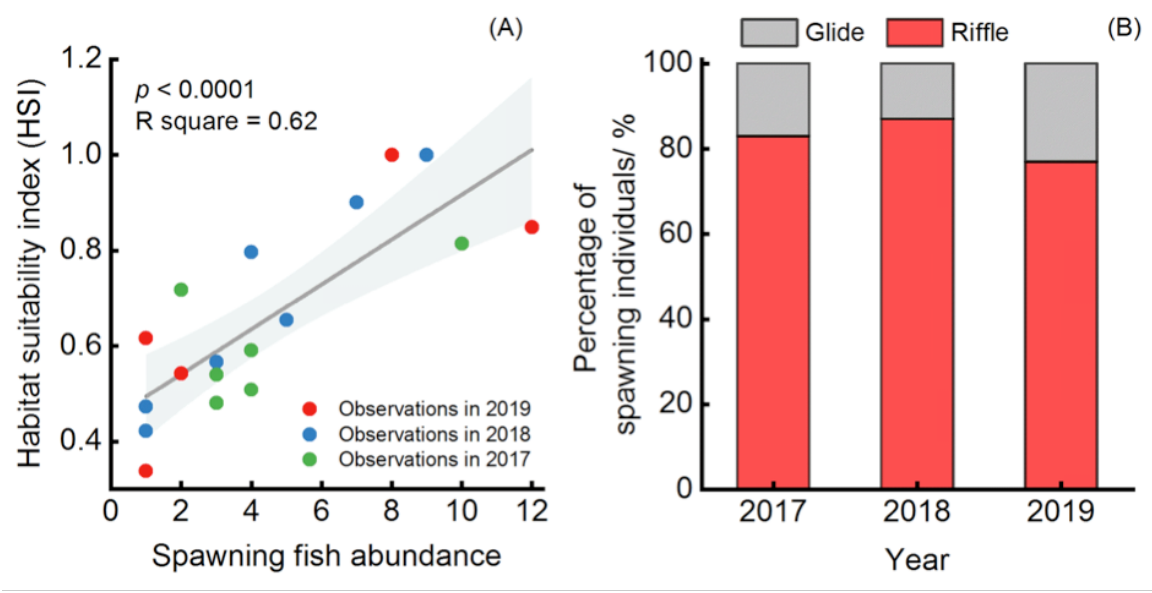
eDNA meta-barcoding for fish biodiversity

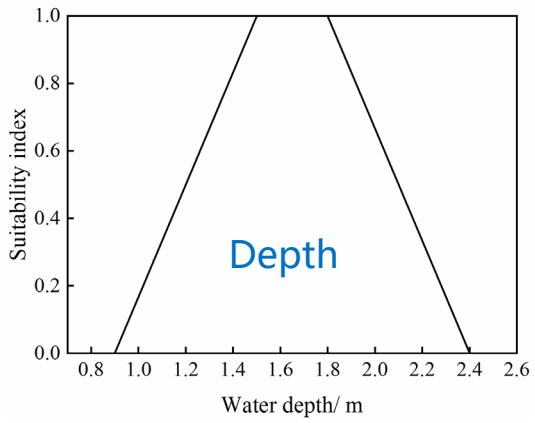
3. Impact on fish and conservations

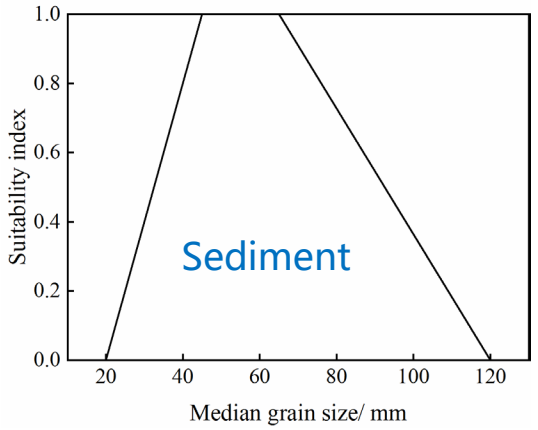
❑ Alternative habitats in tributaries of reservoir section

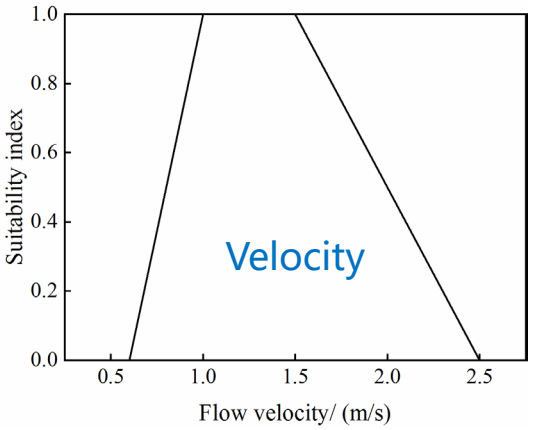






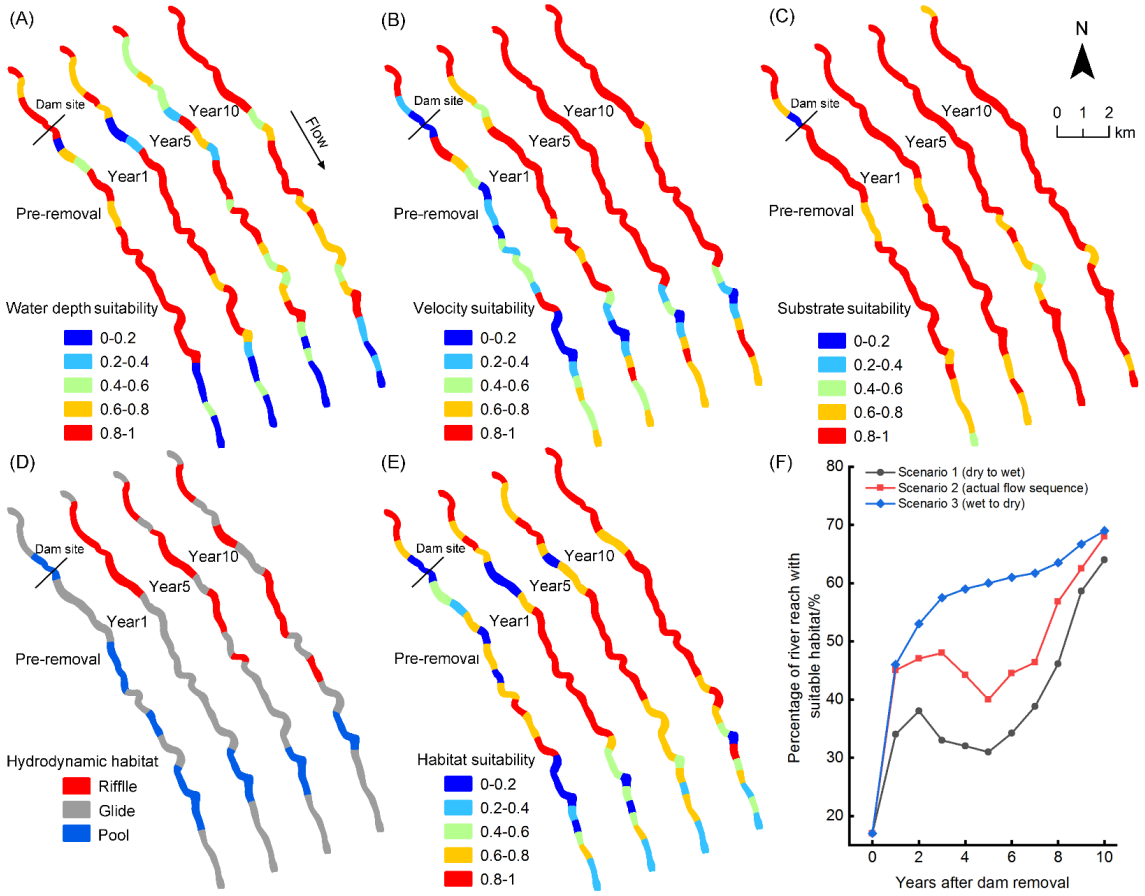


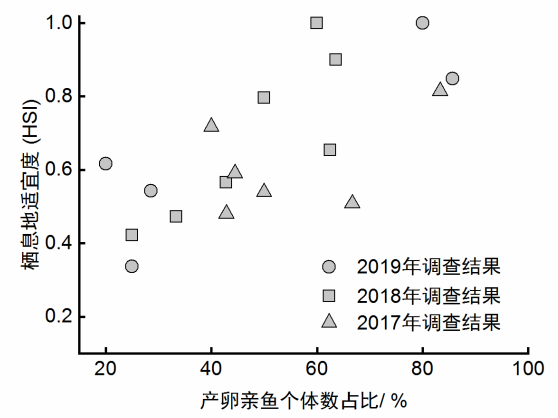


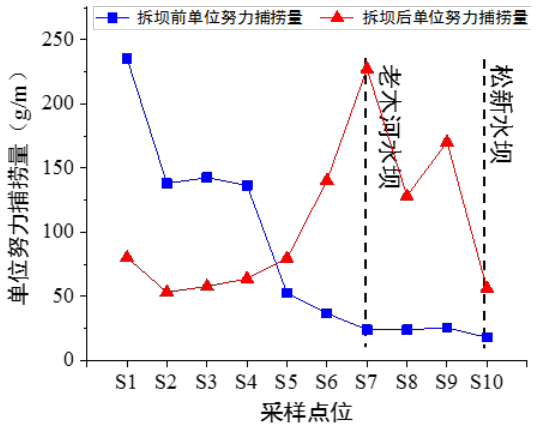


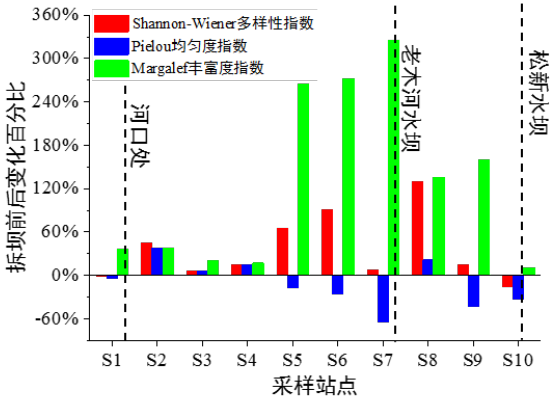
3. Impact on fish and conservations

❑ Alternative habitats in tributaries of reservoir section









Tang., et al., 2021, *Journal of Hydrology*, 598: 126204

Outlines

1. Research background
2. Impact on biogeochemical cycles
3. Impacts on fish and conservations
4. Remarks and perspectives

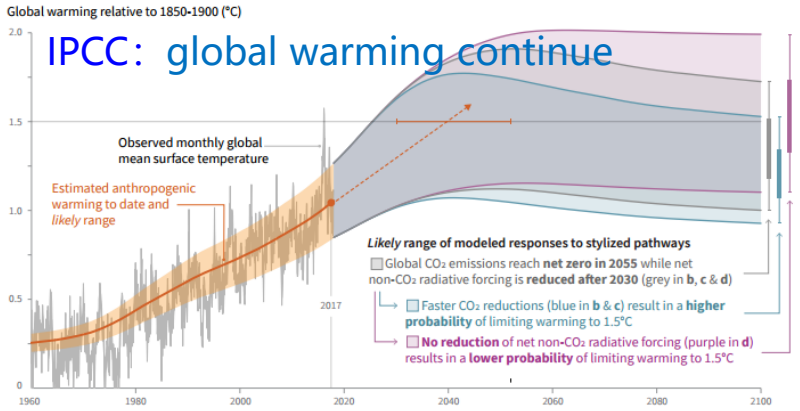
4. Remarks and perspectives

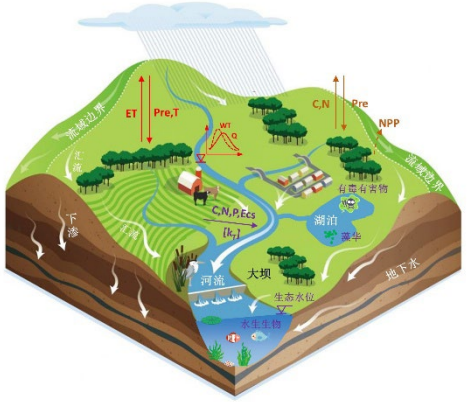
❑ Key remarks

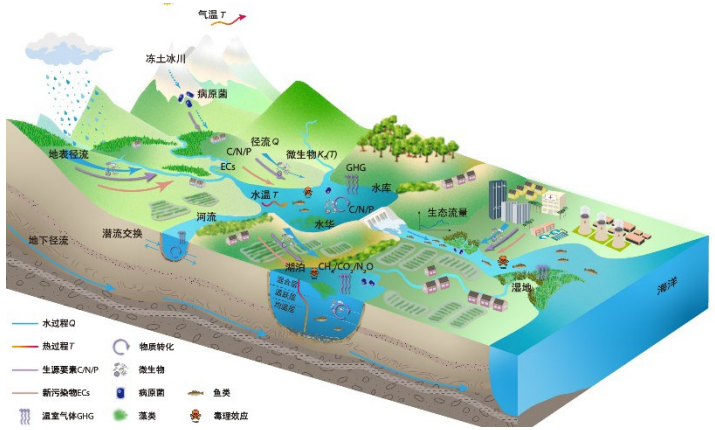
- ✧ Reservoirs intercept total phosphorus and nitrogen, but modify nutrient bioavailability downstream due to biogeochemical process in reservoirs.
- ✧ The reservoirs in the upper Mekong River has very low GHG emissions, and river damming does not increase GHG emission .
- ✧ Ecological flow can largely improve fish spawning; however, it is essential to rematch the time of reaching accumulated and critical temperature thresholds.
- ✧ Tributaries can provide alternative habitat for impounded mainstream, where original habitats are permanently lost

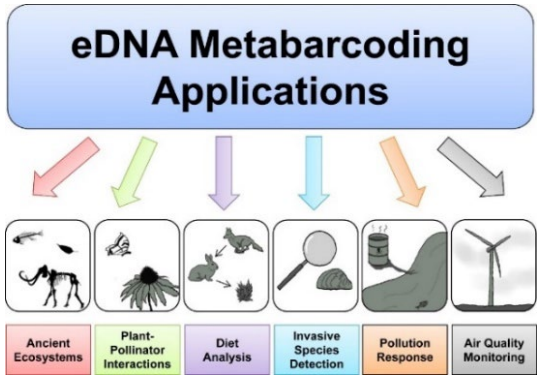
4. Remarks and perspectives

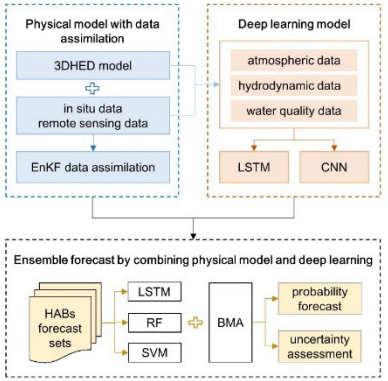
Key element: Climate change, Information technology

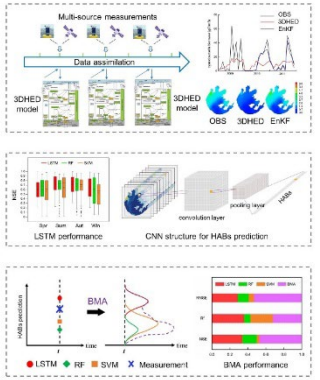












Thank you very much