京都大学　防災研究所
Disaster Prevention Research Institute
Kyoto University

国際共同研究

2021W-01

中国沿岸平野の低湿地・河口干潟における洪水流入土砂の調節および生態機能

Evaluating roles of riverside wetlands and lagoons on controlling flood-derived sediment and enhancing ecosystem services in coastal plain areas of China

令和 5 年 3 月

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Principal Investigator　Aimin HAO

課題名：　中国沿岸平野の低湿地・河口干潟における洪水流入土砂の調節および生態機能の評価に関する研究
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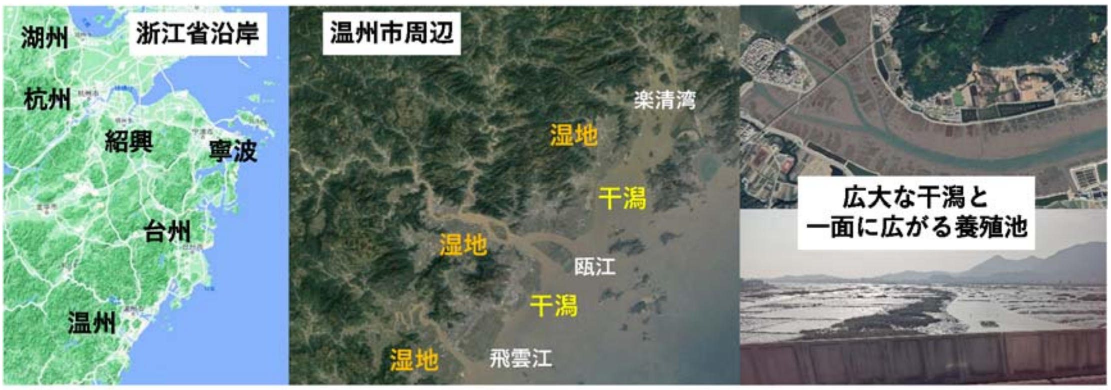
所属機関名：温州大学
所内担当者名：角　哲也
研究（滞在）期間：令和 3 年 4 月 1 日 ～ 令和 5 年 3 月 31 日
共同研究参加者数：　15 名 (所外 12 名，所内 3 名)

(1) 目的・趣旨

中国浙江省の沿岸部では、良好な湿地や河口干潟が埋め立てられずに残されているが、近年の経済発展により環境が大きく変化している。本課題は、低湿地や河口干潟が、洪水流入土砂を受け止めて調節し、生態機能の場として高いポテンシャルを持つこと、湿地や河口干潟の維持再生の意義を日本と中国の比較を通じて明らかにすることを目的とする。



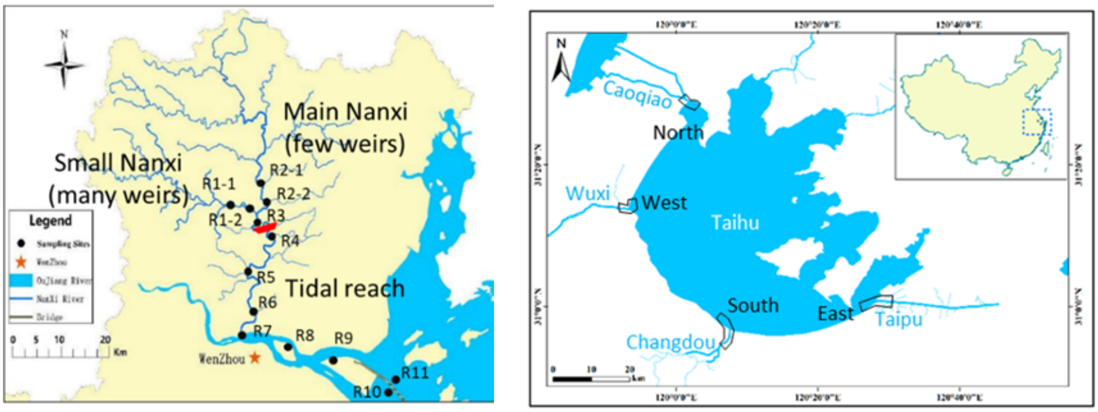
中国浙江省の沿岸に広がる湿地・干潟

(2) 研究経過の概要

1 年目は、オンライン会議を数回開催して、温州大学と京都大学で研究対象地や調査内容を中心に議論を重ね、研究の連携や学生交流の可能性について確認した。温州周辺の河川、干潟、湿地を中心に、これまでの関連研究の資料を収集し、環境の現状と問題点について整理した。温州周辺の複数の調査地を選定し、また浙江省の重要な湿地の 1 の太湖でも、水質、底質、水生生物に関する現地調査を始めた。

2 年目は、1 年目の結果をもとに、温州大学と京都大学の間でこれまでの不足点や今後の可能性について意見交換を行い、研究の方向性について確認した。各水域で現地調査を定期的に行い、2 年間で計 4-7 回分の現地調査データを収集した。また、研究成果の一部をまとめて国際シンポジウム等で発表し、中国や日本の研究者と意見交換を行った。

オンライン会議



調査対象地（左：温州周辺の河川－河口－干潟；右：太湖）

調査地風景

(3) 研究成果の概要

各水域において水質、底質、水生生物の空間的変異を中心に解析・整理し、水循環と生態系健全性の関係、淡水－海水や河川－湖といった移行帯のユニークさ、生態系健全性の指標生物を明らかにした。

小規模取水堰の多さが異なる隣り合う 2 河川の間で比較を行い、堰の少ない河川で濁度が低く溶存酸素が高いこと、付着藻類を食物基盤とする底生動物の現存量や種多様性が高いことを明らかした。堰が少なく砂礫の移動が適度にあることで、河床の濾過機能が高まり、また適度な浅さと速さの流れ場が広く存在し、自生生産（付着藻類、藻類食底生動

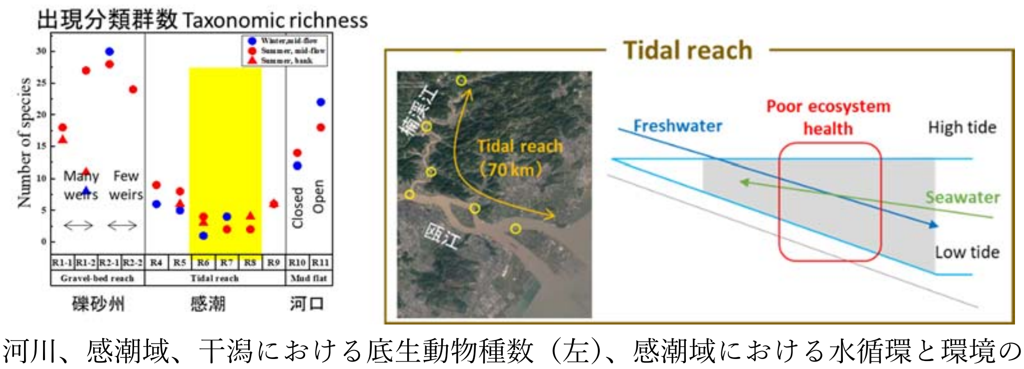
物）の活動が高まることが示唆された。

河川感潮域において水質、底質、生物の縦断分布を中心に解析し、感潮域中流程で水中の濁度が最大、溶存酸素が最低、底泥の有機物含有は低いが揮発性硫黄が高まりやすく、底生動物の現存量や種数が最低であることを明らかにした。感潮域の中間は上流からも海からも新鮮な水が最も届きにくいこと、干潟を構成する細かい成分が潮流によって堆積しにくい一方で様々な汚染物質が蓄積し生物に不適となることが示唆された。

堤防建設で半閉鎖的な干潟と、開放的な干潟の間で比較を行い、半閉鎖的な干潟の方で底泥は柔らかいが有機物含有が高く揮発性硫黄も高まりやすく、底泥環境に作用し魚類の餌であるゴカイ類の種数や現存量が低いことを明らかにした。閉鎖的な干潟では波の作用が小さく安定的で付着藻類の生産は高まるが底泥の撹乱が少なく底生動物に不適となることが示唆された。また、開放的な干潟において、日本では有明海にのみに分布するエビカニ類、二枚貝類、ゴカイ類の希少種が頻繁に出現した。

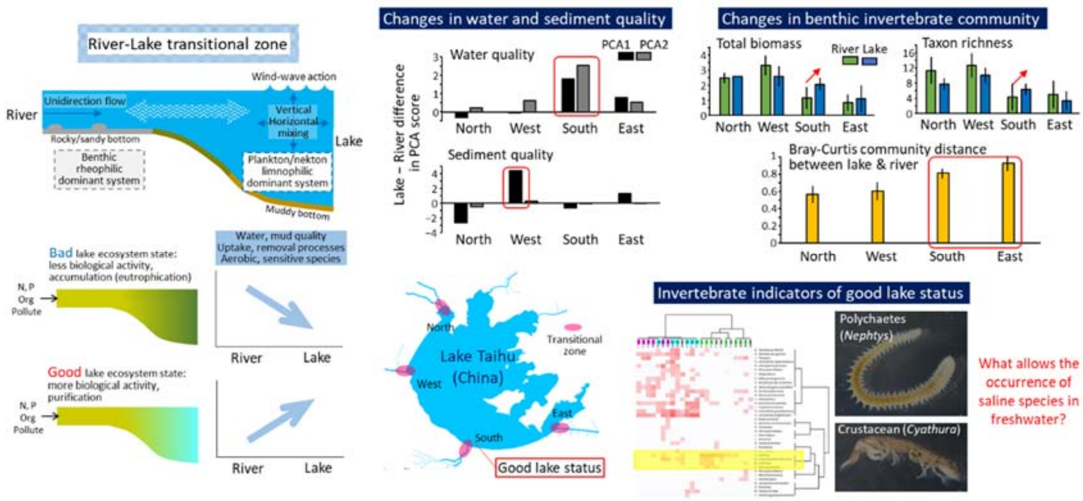
中国第三の広さの太湖において、河川－湖移行帯を中心に、東西南北地域間の比較を行った。南において河川と湖内の水質、底泥、底生動物の違いが大きいことを明らかにし、風と波の強さによって水の混合が大きいことでプランクトン光合成や底生動物活動が高く自浄能力が高いことが示唆された。元々汽水湖であるため淡水種と海水種が共存し、健全度が高い場所ほど海水種の比率が高まることを示した。

一連の調査から、健全な干潟では底生動物の多様性と魚類生産の高さが確認された。また、感潮河口域における生物多様性に、細粒土砂成分の堆積と水交換に影響する淡水－海水バランス、河道形状と潮流の作用の重要性が示された。感潮域や河口沿岸に干潟が発達していた 70 年代以前は、干潟での濁りや有機物除去によって周辺水域全体の水質が良好で生物生産が高かった可能性から、全体の生態系健全性と生物生産を高める上でも良好な干潟を保全する重要性が示された。



河川、感潮域、干潟における底生動物種数（左）、感潮域における水循環と環境の概念図

干潟で頻繁に出現した貴重種

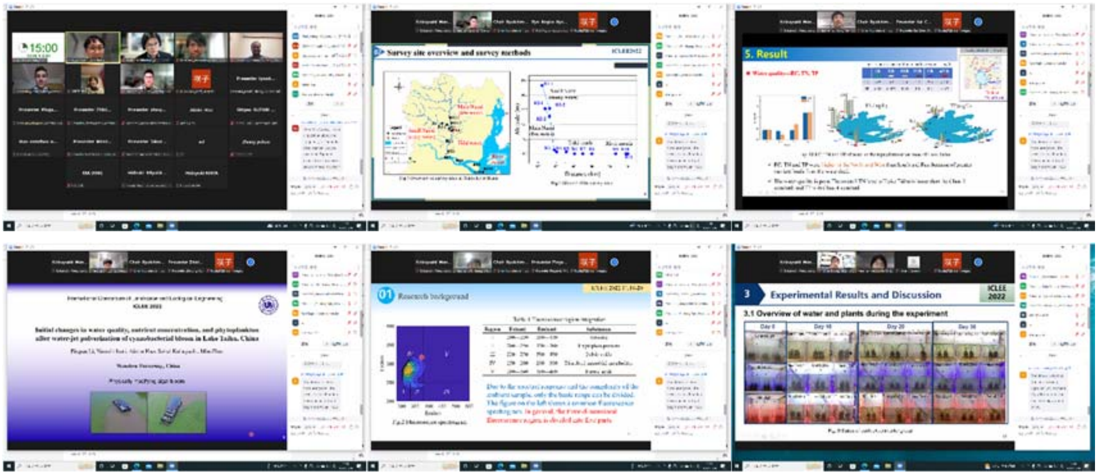


河川－湖移行帯から健全な生態系の評価、指標種の特定

(4) 研究成果の公表

The 12th Conference of the International Consortium of Landscape and Ecological Engineering (ICLEE), Nov. 11-12, 2022, online

- Kai Chen: Longitudinal changes in water quality, sediment quality, and benthic organisms in the downstream gravel-bed and tidal sections of Nanxi River (Wenzhou, China)
- Zhixiong Yan: Spatial distribution of the dormant cyanobacteria in sediments of the transitional zones in a large shallow lake
- Ping-an Li: Initial changes in water quality, nutrient concentration, and phytoplankton after water-jet pulverization of cyanobacterial bloom in Lake Taihu, China
- Wei Huang: Spatial and temporal distribution of dissolved organic matter and its sources in Lake Taihu, China
- Xiaoyu Shi: Effects of red and blue LED irradiation on the growth and antioxidant responses of submerged plant, *Vallisneria natans*



国際会議での発表

令和 4 年度 京都大学防災研究所研究発表講演会

- 郝愛民・小林草平・井芹寧・陳凱・角哲也・竹門康弘・渡邉紹裕：中国温州市楠甌江の礫床区間、感潮河口における水質底生動物から態系健全性評価

学術誌

- Kobayashi, S., Kantoush, S. A., Al-Mamari, M. M., Tazumi, M., Takemon, Y., & Sumi, T. (2022). Local flow convergence, bed scour, and aquatic habitat formation during floods around wooden training structures placed on sand-gravel bars. Science of the Total Environment, 817, 152992.
- Kobayashi, S., Otsubo, Y., Sumi, T., & Takemon, Y. (2023). Long-term trajectory of the macroinvertebrate community in the downstream channel of a hydropower dam after the operation of a sediment bypass tunnel. Ecological Indicators, 147, 109988.
- Hao, A., Kobayashi, S., Chen F., Yan, Z., Torii, T., Zhao, M., & Iseri, Y. (accepted). Exploring invertebrate indicators of ecosystem health by focusing on the flow transitional zones in a large, shallow eutrophic lake. Environmental Science and Pollution Research.

1. 温州近辺の湿地・干潟の生態系研究情報の整理

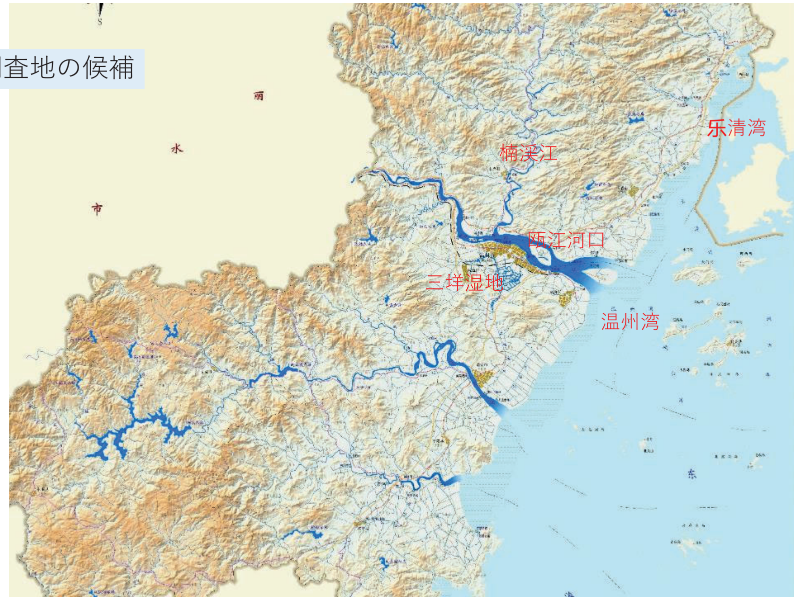
一般的な干潟の定義

干潟（ひがた、英: mudflat）とは、海岸部に発達する砂や泥により形成された低湿地が、ある程度以上の面積で維持されている、朔望平均満潮面と朔望平均干潮面との潮間帯。潮汐による海水面の上下変動があるので、時間によって陸地と海面下になることを繰り返す地形である。砂浜と比べ、波浪の影響が少なく、勾配が緩やかで、土砂粒径が小さく、生物相が多様な平坦地形である。環境省の定義は「干出幅100m以上、干出面積が1ha 以上、移動しやすい基底（砂，礫，砂泥，泥）」を満たしたものを干潟と呼んでいる。

Mudflats or mud flats, also known as tidal flats, are coastal wetlands that form in intertidal areas where sediments have been deposited by tides or rivers. A global analysis published in 2019 suggested they are as extensive globally as mangroves. They are found in sheltered areas such as bays, bayous, lagoons, and estuaries; they are also seen in freshwater lakes and salty lakes (or inland seas) alike, wherein many rivers and creeks end. Mudflats may be viewed geologically as exposed layers of bay mud, resulting from deposition of estuarine silts, clays and aquatic animal detritus. Most of the sediment within a mudflat is within the intertidal zone, and thus the flat is submerged and exposed approximately twice daily.

滩涂（tantu），是海滩、河滩和湖滩的总称，指沿海大潮高潮位与低潮位之间的潮浸地带，河流湖泊常水位至洪水位间的滩地，时令湖、河洪水位以下的滩地，水库、坑塘的正常蓄水位与最大洪水位间的滩地面积。在地貌学上称谓"潮间带"。由于潮汐的作用，滩涂有时被水淹没，有时又出露水面，其上部经常露出水面，其下部则经常被水淹没。

調査地の候補



瓯江河口、温州湾における研究：流量、土砂量の変遷

宋乐等（2012）瓯江河口入海水沙通量的变化规律
张伯虎等（2017）瓯江河口潮汐特征变化及其原因分析

图 1　瓯江流域示意图

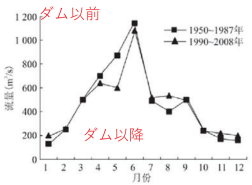


图 7　水库蓄水前后多年月均流量变化（据文献 7 改绘）

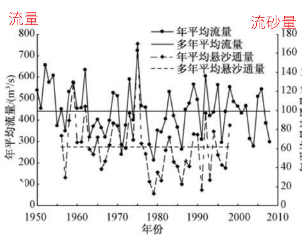


图 2　瓯江入海流量和悬沙通量年际变化

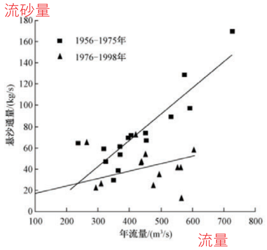


图 6　圩仁站年流量与年悬沙通量的相关关系

1975年に大きな出水があり大量土砂流出
その後土砂流出が少なくなった

上流に大型ダムが建設されたのは1981年と2004年

河床の変遷

张伯虎等（2017）瓯江河口潮汐特征变化及其原因分析

表 3　近期瓯江河口各河段冲淤变化

Tab. 3　Erosion and Deposition Situation at Oujiang Estuary in Recent Year

河段	面积(km²)	冲刷量(万 m³)	平均幅度(m)	数据尺度
温溪至西洲 ①	3.67	1 513	4.12	2002~2013 年
西洲至江南 ②	4.08	1 199	2.94	
江南至梅岙	4.10	529	1.29	
梅岙至楠溪江口	16.46	1 879	1.16	
楠溪江口至黄华	96.62	1 256	0.13	2002~2010 年

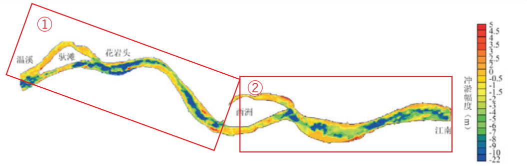


图 9　瓯江采砂剧烈河段 2002~2013 年江道变化图

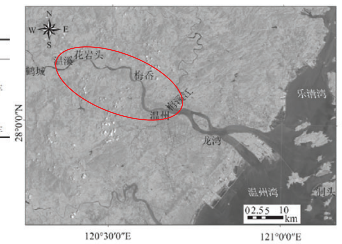


图 1　瓯江河口形势和潮位站位置图

瓯江全体的に侵食傾向にあるが、特に上流区間で4m河床低下
90年代以降に砂利採取が激しくなった

湾床の変遷

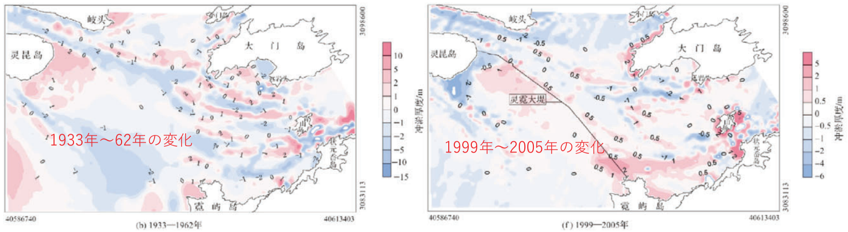
徐海等（2017）瓯江口外潮汐通道区滩槽冲淤演变分析及其调整机制的探讨
周春煦（2018）瓯江河口及温州浅滩冲淤演变分析

表 2 瓯江口外潮汐通道区各时段冲淤幅度统计结果

Tab. 2 Erosion and deposition in the tidal inlet out of Oujiang Estuary at different periods

时间段	淤积区面积/km²	冲刷区面积/km²	淤积区平均淤积厚度/m	冲刷区平均冲刷厚度/m	计算区域淤积量/万 m³	计算区域冲刷量/万 m³	平均冲(－)淤(＋)厚度/m	计算区域净冲(－)淤(＋)量/万 m³
1933—2005 年	145.63	149.51	1.63	2.12	23 794.49	31 757.55	－0.27	－7 963.06
1933—1962 年	123.30	171.83	1.40	1.51	17 265.85	25 884.92	－0.29	－8 619.07
1962—1992 年	125.95	110.90	0.97	1.44	12 207.81	15 969.24	－0.16	－3 761.43
1992—1997 年	97.80	139.04	0.94	0.86	9 202.63	11 910.01	－0.11	－2 707.38
1997—1999 年	159.59	135.55	0.92	0.56	14 755.67	7 603.12	0.24	7 152.55
1999—2005 年	140.83	154.30	0.71	0.75	9 985.82	11 631.26	－0.06	－1 645.74

1933年　海域図
1962年　海域図
1992年以降　深浅測量



流心は侵食、浜辺や堤防沿いは堆積傾向
近年の侵食は砂利採取の影響？それ以前は何の影響？

河口潮汐の変遷

张伯虎等（2017）瓯江河口潮汐特征变化及其原因分析

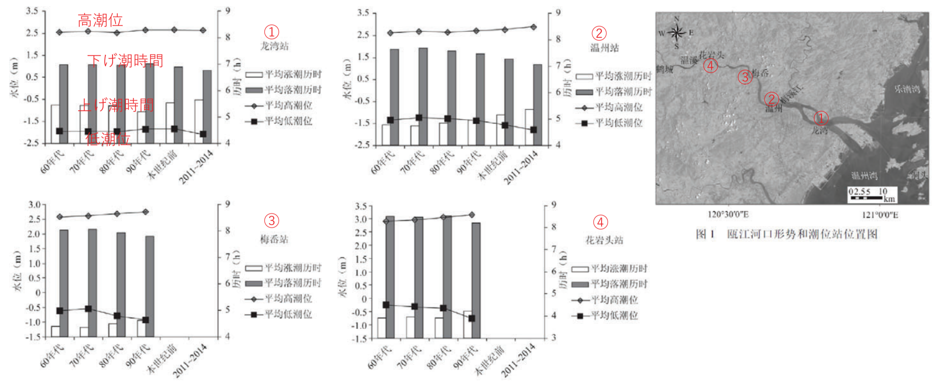
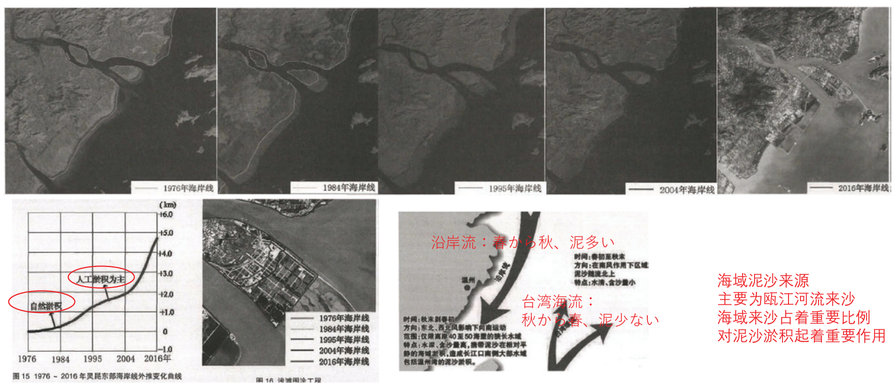


图 2 1960~2014 年各年代潮汐特征值变化过程

年々、潮位差が増加。上げ潮時間増加、下げ潮時間減少。上流地点ほど
河川流量変化と関係なく、堤防建設、埋立、砂利採取の影響と考察

海岸線の変遷

仓飞等（2018）温州瓯江河口近代海岸线变迁研究

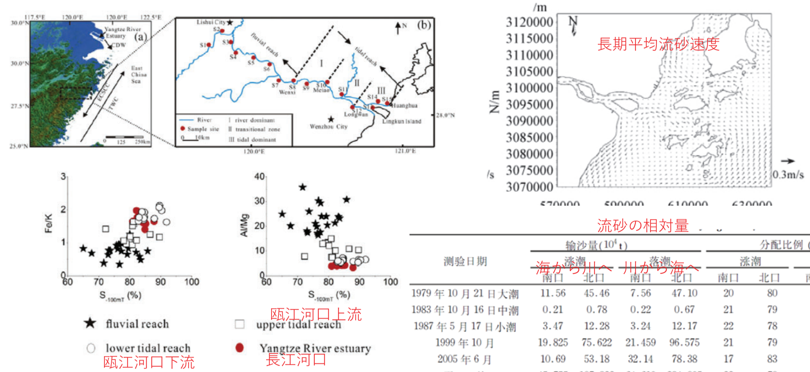


海域泥沙来源
主要为瓯江河流来沙
海域来沙占着重要比例
对泥沙淤积起着重要作用

70年代は自然の堆砂、90年代は埋立が主な理由
現在、埋立地での沈降問題、浅瀬の堆砂問題が顕在化

河口の砂の由来

Li et al.（2017）Influence of provenance and hydrodynamic sorting on the magnetic properties and geochemistry of sediments of the Oujiang River, China
林伟波等（2013）瓯江口海域悬浮泥沙输运特性研究
郑敬云等（2008）瓯江口水文泥沙特征分析



流砂の相対量

测验日期	输沙量(10^4 t) 涨潮 南口	输沙量 涨潮 北口	输沙量 落潮 南口	输沙量 落潮 北口	分配比例(%) 涨潮 南口	分配比例 涨潮 北口	分配比例 落潮 南口	分配比例 落潮 北口
1979 年 10 月 21 日大潮	11.56	45.46	7.56	47.10	20	80	14	86
1983 年 10 月 16 日中潮	0.21	0.78	0.22	0.67	21	79	25	75
1987 年 5 月 17 日小潮	3.47	12.28	3.24	12.17	22	78	21	79
1999 年 10 月	19.825	75.622	21.459	96.575	21	79	18	82
2005 年 6 月	10.69	53.18	32.14	78.38	17	83	29	71
平均	45.755	187.322	64.619	234.895	22	78	22	78

涨潮：海から川へ　落潮：川から海へ

瓯江の土砂輸送は小さいとのこと
河口土砂に対して海側からの貢献度がある程度ある

瓯江河口、温州湾の開発

张伯虎等（2017）瓯江河口潮汐特征变化及其原因分析
李文丹等（2017）采砂工程对瓯江河口河势影响分析

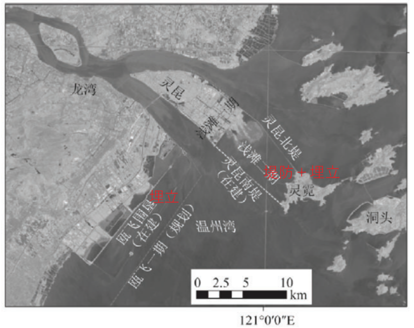


图 8　瓯江口门现状及规划工程布局

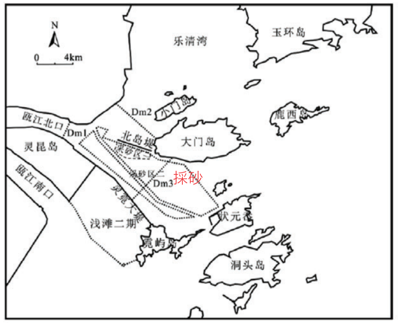
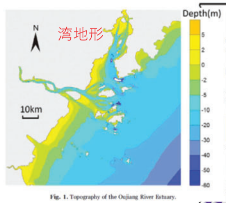


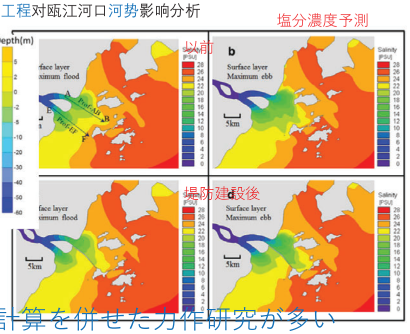
图 1　工程方案示意图

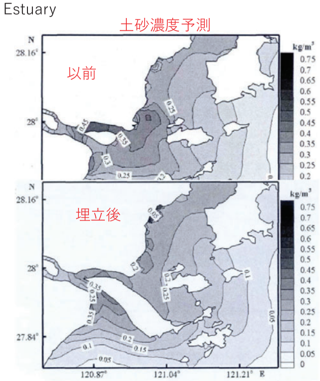
埋立と堤防建設、既に完成している部分と今後の予定
大規模な採砂もありそう

瓯江河口、温州湾における水、土砂、塩分、水質の数値計算 埋立や堤防建設の影響評価

Xu and You (2017) Numerical simulation of suspended sediment concentration by 3D coupled wave-current model
Xu and You (2017) Effects of large-scale embankments on the hydrodynamics and salinity in the Oujiang River Estuary
Li and Liu (2020) Salt intrusion and its controls in the macro-tidal Oujiang River Estuary
许婷（2017博士論文）岛群河口开发利用的水环境效应研究
杨茂盛（2017修士論文）温州浅滩围涂开发对周围海域泥沙输运和水环境的影响
李文丹等（2017）采砂工程对瓯江河口河势影响分析







実測と数値計算を併せた力作研究が多い
いろいろ細かい変化が予測されているが、実際はどうか分からない

瓯江河口、温州湾における 土砂、水質の衛星画像評価

许婷（2017博士論文）岛群河口开发利用的水环境效应研究
周春煦（2018）瓯江河口及温州浅滩冲淤演变分析

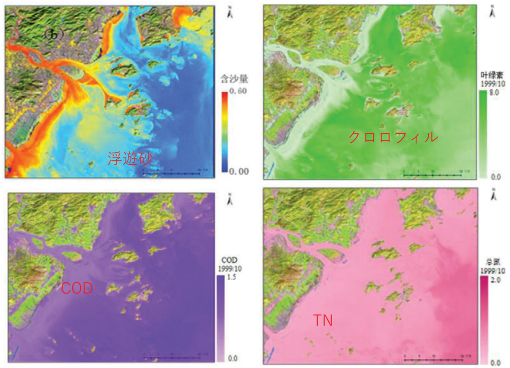


表 3-4 同步取样各站位表层含沙量

站位	S1	S2	S3	S4	S5	S6	S7	S8
含沙量(mg/l)	260	235	203	210	190	154	90	131
	S9	S10	S11	S12	S13	S14	S15	
	152	141	134	142	28	19	8	

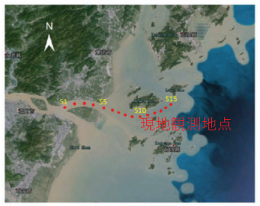
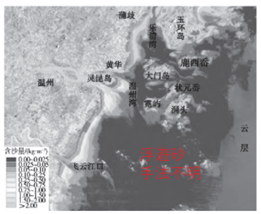


图 3-4 现场卫星同步实测悬浮泥沙站位分布



瓯江河口、温州湾における生物、生態系

Jiang et al. (2019) Migration patterns and habitat use of the tapertail anchovy *Coilia mystus* in the Oujiang River
寿鹿等（2009）瓯江口海域大型底栖动物分布及其与环境的关系
卢周等（2016）洞头南北爿山海洋特别保护区潮间带大型底栖生物群落的时空分布
李超男（2017修士論文）温州湾游泳动物群落结构及多样性研究
王航俊等（2020）玉环国家级海洋公园夏季潮间带大型底栖生物群落结构研究

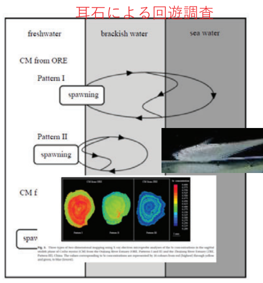


Fig. 4. Diagrammatic sketch of the life history patterns of *Coilia mystus* (CM) from the Oujiang River Estuary (ORE, Patterns I and II) and the Zhujiang River Estuary (ZRE, Pattern III). The arrows represent the possible dispersion patterns in and during the non-spawning migratory phases.

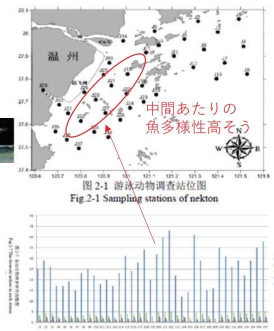
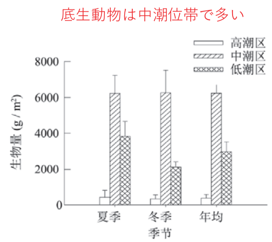


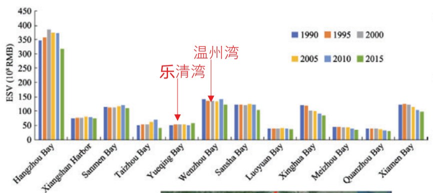
图 2-1 游泳动物调查站位图
Fig.2-1 Sampling stations of nekton



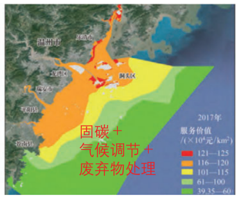
個別の調査はあるが、全体像、時空間パターンはよくわからない

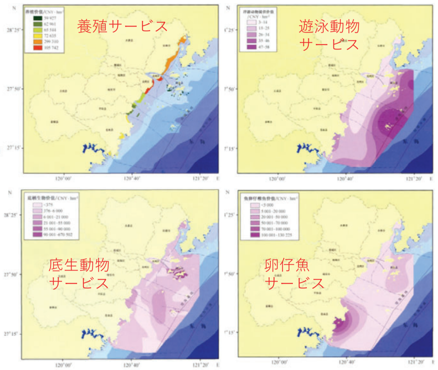
瓯江河口、温州湾における生態系サービス評価

Ruiqing et al. (2020) Ecosystem service valuation of bays in East China Sea and its response to sea reclamation
李爱等（2016）温州海域生态系统的供给服务价值评估
郝林华等（2020）海洋生态系统调节服务价值评估方法及应用———以温州市为例



Forest
Grassland
Waters
Wetland
Desert
Farmland





温州湾南端、苍南の干潟利用

陈余将（2015修士論文）温州市苍南县海滩涂养殖观光旅游业发展的研究

图 1-2 苍南县滩涂风光

Figure. 1-2 Beach scenery in Cannon county

图 2-1 苍南滩涂风景

Figure 2-1 Beach scenery in Cannon county

图 5-1 苍南滩涂旅游

Figure 5-1 Beach tourism in Cannon county

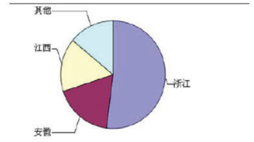


图 2-2 苍南县国内市场客源结构

Figure 2-2 domestic tourist structure in Cannon county

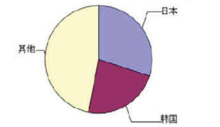


图 2-3 苍南县入境旅游客源国

igure 2-3 Foreign tourist structure in Cannon county

瓯江河口、温州湾　まとめ

- 河川の流砂濃度は80年以前より減少。ダムの影響は小さいと見られているが、もう少し詳しく見る必要がある。
- 河道や河口の砂利採取が90年代から盛んか。
- 海岸線は埋立などによりどんどん沖へ（2000年以降3km前進）。
- 河口では、流心は侵食が進んでいるが、浜辺や堤防沿いは堆積が進行している。海側からの土砂供給がそれなりにあるかもしれない。
- 潮位差、平均で４m、最大で6m以上。年々、潮位差が増えている。その原因と土砂への影響について、もう少し詳しく見る必要がある。
- 水生生物や生態系の研究はたくさんあるが（生物研究者というよりは管理者がまとめたものが多い）、温州の特徴や時空間パターンがまだよくわからない。河口の人的改変が生態系に及ぼす影響（例えば、埋立→潮流→土砂堆積→生息場、回遊パターン）がもう少し見えてくるといい。
- 今回の台風時は河口はどうなるか？

乐清湾、潮汐の特徴

童朝锋等（2020）乐清湾内外潮波变形及不对称性分析

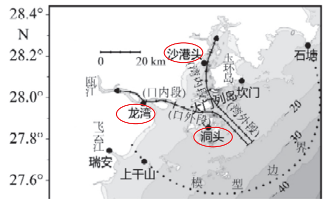


表 1 瓯江口外海各站潮汐特征值

Tab. 1 Tidal characteristic values of each station in Oujiang Estuary

区域	测站	潮差/m 最大潮差	潮差/m 最小潮差	潮差/m 平均潮差	涨落潮历时/min 平均涨潮历时	涨落潮历时/min 平均落潮历时
湾内	沙港头	6.89	2.82	4.75	382	362
	龙湾	6.16	1.95	4.19	368	375
河口口内	瑞安	5.92	2.02	4.36	317	425
	石塘	5.26	1.23	3.40	375	369
	坎门	5.67	1.42	3.74	384	360
	洞头	5.65	1.46	3.71	381	363

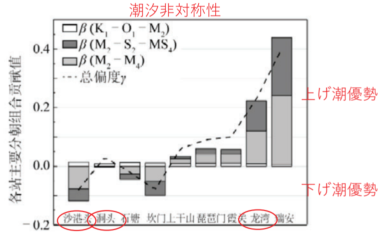
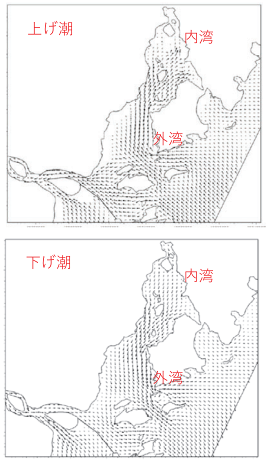


图 7　各站主要分潮组合对潮汐不对称贡献值

乐清湾は潮汐が特に大きい
（潮位差約7m）
潮汐の対称性にも特徴がある

乐清湾、水交换

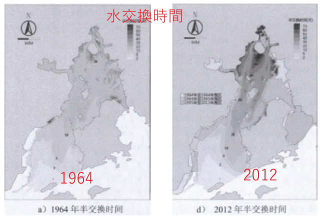
田野（2017修士論文）乐清湾资源环境对围垦工程的累积响应探究
穆锦賦等（2017）滩涂围垦对乐清湾水交换影响研究



潮流量変化

表 1 乐清湾历史潮量变化统计表　10⁸ m³

年份		1964	1984	1995	2002	2005	2016	2016 年与 1964 年变化/%
外湾	涨潮	22.85	21.75	20.62	18.97	18.96	18.29	-19.96
	落潮	20.66	20.08	19.08	17.41	17.40	16.75	-18.93
中湾	涨潮	12.50	11.23	10.58	9.03	9.03	8.97	-28.24
	落潮	11.26	10.45	9.95	8.39	8.38	8.32	-26.11
内湾	涨潮	7.76	6.91	6.41	4.96	4.96	4.92	-36.60
	落潮	7.02	6.56	6.15	4.70	4.70	4.65	-33.76



内湾ほど潮の往来が小さい
年々、潮流量、交換速度が低下（特に内湾）

乐清湾、土砂濃度、堆積

毛龙江等（2005）浙江乐清湾现代沉积与悬沙质量浓度分布特征及意义
夏若琪等（2014）乐清湾水动力及泥沙环境特征
童朝锋等（2018）基于潮位含沙量观测数据的乐清湾悬沙交换分析

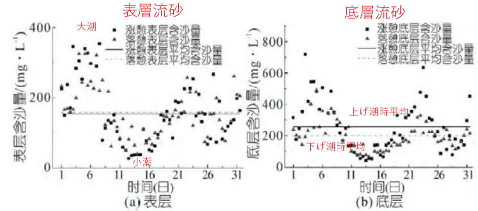


图 6 沙港头 2003 年 1 月涨落憩时刻表、底层含沙量分布图

土砂濃度は潮位差と関係あり
上げと下げ潮でフラックスに違いなし
内湾ほど濃度低い、粒径小さい

乐清湾の変遷

田野（2017修士論文）乐清湾资源环境对围垦工程的累积响应探究

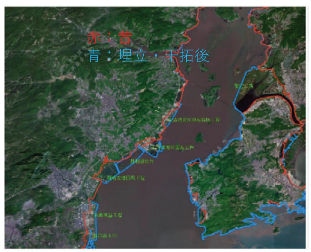
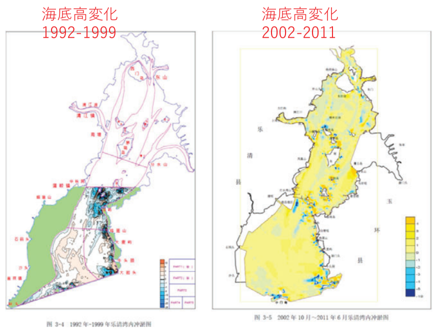


图 4-1 乐清湾西侧围垦工程概况图



埋立や堤防の建設により、年々
潮流が低下→土砂堆積

乐清湾の水質

金永平等（2005）乐清湾水质变化及其成因探讨
徐国锋等（2009）乐清湾养殖区富营养化现状分析与评价

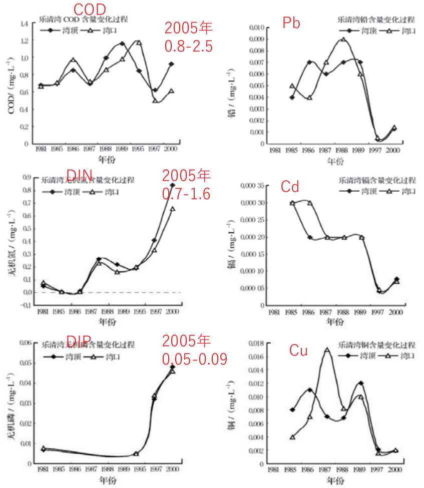


图 2 乐清湾海域各水质指标时空变化图

水質は年々悪化していると思われる
流域からの負荷、魚養殖により

底泥の重金属の研究もあるが
Cu以外は環境基準以下という結果

乐清湾、底生動物

Junyi et al. (2007) Characteristics of macrofauna and their response to aquiculture in Yueqing Bay, China
郑荣泉等（2007）乐清湾滩涂大型底栖动物群落结构的时空变化
王航俊等（2018）乐清湾大型底栖动物种类和数量组成特征及变化

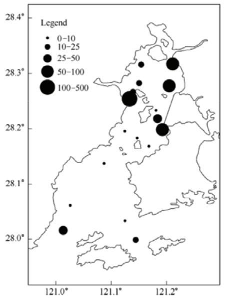
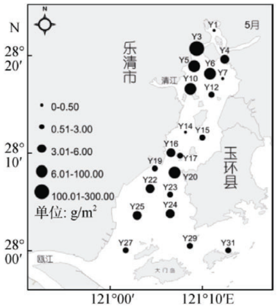


Fig. 4 Distribution of macrofauna biomass in Yueqing Bay

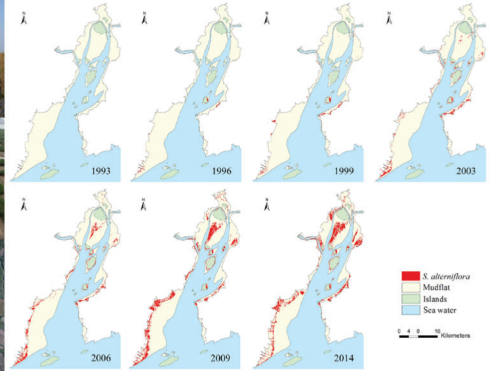


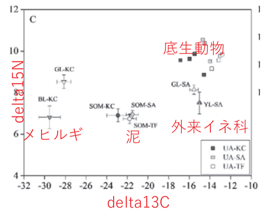
空間パターンが研究によって様々

乐清湾、外来植物の拡大

30－40年前に導入、中国全体で拡大、イネ科植物

Wang et al. (2015) Monitoring the Invasion of *Spartina alterniflora* from 1993 to 2014 with Landsat TM and SPOT 6
Liao et al. (2020) Effects of non-indigenous plants on food sources of intertidal macrobenthos in Yueqing Bay, China: Combining stable isotope and fatty acid analyses





90年代に護岸と埋立のために導入、特に2000年代に拡大
生態系への悪影響が懸念されている

乐清湾　まとめ

- 潮汐の大きさ（最大７ｍ）、非対称性に特徴
- 内湾ほど潮流、水の交換速度が小さい。年々、潮流は低下。
- 潮位差に応じて流砂濃度が決まる。上げ潮と下げ潮の土砂フラックスは同等のレベル
- 湾内は年々堆積傾向。埋立や堤防建設により潮の流れが悪くなったことが原因に考えられている。
- 上流域や瓯江からの土砂流入はあまりないと見られているが、もう少し詳しく見ていく必要がある。
- 水質も悪化傾向か。魚養殖による富栄養化が懸念されている。
- 90年代から外来イネ科が分布拡大。
- 乐清湾の生物や生態系サービスにおける特徴、時空間パターンはまだよくわからない。

三垟湿地

陈余钦等（2006）温州湿地资源
陈秋夏等（2009）温州三垟湿地本底生境及植物资源现状与分析_陈秋夏
夏蓓蕾（2014修士論文）温州三洋湿地植物资源及其配置研究

海迹湖即潟湖，同源于我国的太湖
在第三世纪末期

水网密布，纵横交错的河道将其地分割成
大小不一的160个岛啤

大量の肥料→富栄養化の原因

表 10　瓯柑农药化肥施用情况

种类	药(肥)名称	施用次数	每次每公顷施用量
农药	氧化乐果	5~8	7 500 mL
	杀灭菊酯	5~8	4 500 mL
	托布津	5~8	4 500 mL
化肥	尿素	1~3	300 kg
	复合肥	1~3	450~600 kg
	钾肥	1	750~900 kg

主要陆生栽培经济植物
瓯柑（オウカン）、杨梅（ヤマモモ）、
蚕豆（ソラマメ）、油菜、普通白菜、
香樟苗（クスノキ）

水生植物27種　魚類18種

三垟湿地

南春容等（2018）
温州三垟湿地水生生态系统现状调查及修复思路

2017 年湿地北部发生水华
4 月绿眼虫(*Euglena viridis*)
水色浓绿，透明度18cm，
5 月尖尾蓝隐藻(*Chroomonas acuta*)
卵形隐藻(*Cryptomonas cvata*)
黑绿色，透明度23 cm
7 月膝口藻(*Gonyostomum semen*)，
黄绿色云彩状，透明度21 cm，

表1　2014～2017年三垟湿地各水质指标
Table 1　Water quality index in Sanyang wetland from 2014 to 2017

		2014 年	2015 年	2016 年	2017 年
NH_3	氨氮质量浓度(mg/L)	5.78	5.21	3.27	2.68
TP	总磷质量浓度(mg/L)	0.34	0.31	0.20	0.20
MnO_4	高锰酸盐指数(mg/L)	3.77	4.20	4.00	2.76
DO	溶解氧质量浓度(mg/L)	3.17	4.81	6.19	7.31

やや改善

北部连接温州城市内河温瑞塘河
南部接受来自大罗山的泉水

優占種：大型水生植物
表2　2016年三垟湿地水体中的大型水生植物
Table 2　Types of macrophytes in the water of Sanyang wetland in 2016

	植物名称	优势度
ヒシ	菱 *Trapa bispinosa*	优势种(人工种植，5～10月)
	水花生 *Alternanthera philoxeroides*	常见种(野生，全年)
	水蓼 *Polygonum hydropiper*	常见种(野生，全年)
	稗 *Echinochloa crusgalli*	常见种(野生，全年)

優占種：水生動物
表3　2016年三垟湿地水体中的水生动物
Table 3　Types of aquatic animals in the water of Sanyang wetland in 2016

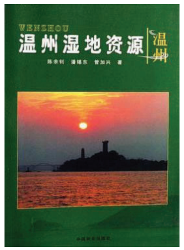
	动物名称	优势度
ハクレン	鲢 *Hypophthalmichys molitrix*	优势种(人工放养)
コクレン	鳙鱼 *Aristichthys nobilis*	优势种(人工放养)
ジャンボタニシ（問題外来種）	福寿螺 *Pomacea canaliculata*	优势种(入侵物种)
	鲤 *Cyprinuscarpio*	常见种(野生)
	鲫 *Carassiusauratus*	常见种(野生)
	方形环棱螺 *Bellamya quadrata*	常见种(野生)
	鲦 *Hemiculter leucisculus*	常见种(野生)

三垟湿地　まとめ

- もともと海跡湖。
- 周辺の市街地拡大、瓯柑やヤマモモ生産で富栄養化
- 最近は水質がやや回復
- 水生植物はヒシが優占
- 放流魚が優占、ジャンボタニシ問題
- 南側に湧水箇所？良い環境が残る場所があるかも。

その他

陈余钦等（2006）温州湿地资源



少し古いが、
養殖やその他の資源量について記載されている

有用な情報がないか詳しく見てみる

濁度の衛星画像分析について：
８０年代は干潟がきれいに見える、サメ先生に分析可能かを相談

埋立→潮流悪化→堆積、富栄養化の進行、自浄能の低下
のような関係が見られないか期待

2. 調査対象地楠渓江の生態系について

楠溪江流域水生态环境

Water ecological environment in nanxi river basin

问渠哪得清如许，为有源头活水来

CHEN KAI（陈凯）：硕士一年生

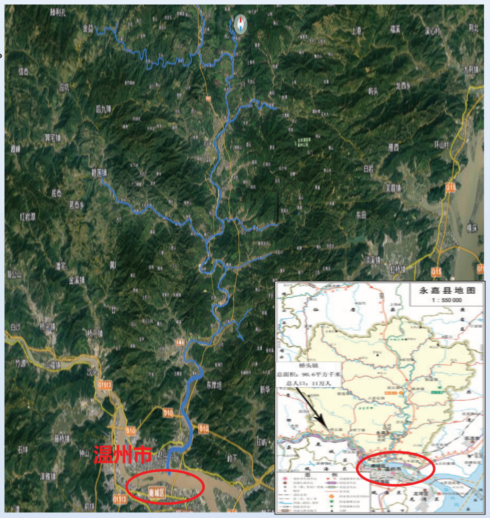
Outline

- Watershed profile
- Flood disaster
- Fish ecology
- conclusion

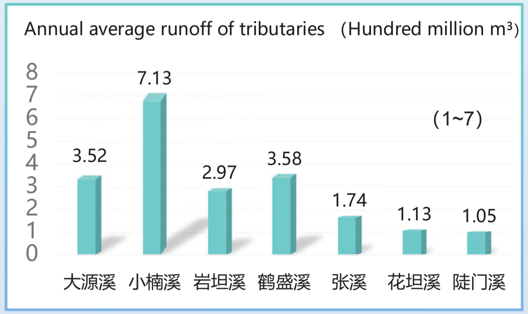
1、Overview of Nanxi River Basin

- **The geographical position:** watershed is located in Yongjia（永嘉）county, Wenzhou（温州）city, north bank of oujiang（瓯江）, originated in xianju, across three counties and the city area,（永嘉） county, jinyun county, qingtian county, （温州） city, （乐清） city, huangyan district), And, Nanxi River belongs to the county level drinking water (water supply scope: YongJia county, yueqing,DongTou district), The basin area of Nanxi River is 2,436km2 (square kilometre) , the main river is about 142km long, and there are several first-level tributaries
- **The topography:** river basin is dominated by mountains and hills. The terrain slopes from northwest to southeast and the mountain stream is a curved river, known as 36 bays and 72 beaches, and it 's tributaries are fan-shaped in distribution.
- **The Hydrology and meteorology:** Nanxi River basin is located in the rainstorm area of southern Zhejiang, with large mountainous area and steep stream slope.**belonging to subtropical monsoon climate**, with the average annual temperature of 18.2℃ (degrees centigrade) , the highest temperature is 38.2℃, and the lowest temperature is -4.2℃. The average annual precipitation is 1500~2000millimeter, and the average evaporation is 850mm. According to the characteristics of precipitation in the basin, the whole year can be roughly divided into The plum rainy, high water and non-flood season.

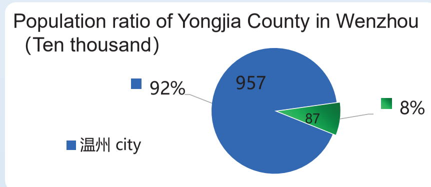
(The geographical location of Nanxi River Basin)

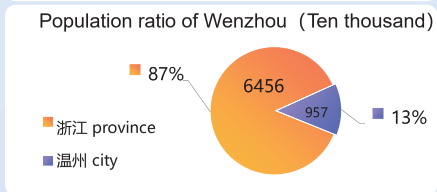


- **River basin population:** The basin has a population of nearly 87 ten thousand, accounting for 8% of Wenzhou's population
- **The water resources:** Rich in water resources and hydraulic resources, the average annual runoff is 2.86 billion m³（Cubic meters）, fresh water, fishery and tourism are developed, which is the guarantee of local life and economic development.
- **Water resource storage capacity:** The theoretical water energy is 279,800 kW, among which the exploitable water energy is 151,000 kW, according to "Yongjia County Drinking Water Source Protection Planning".



（中国水利水电科学研究院，马里，2017）

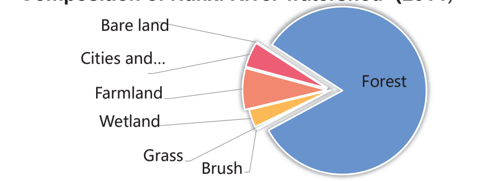




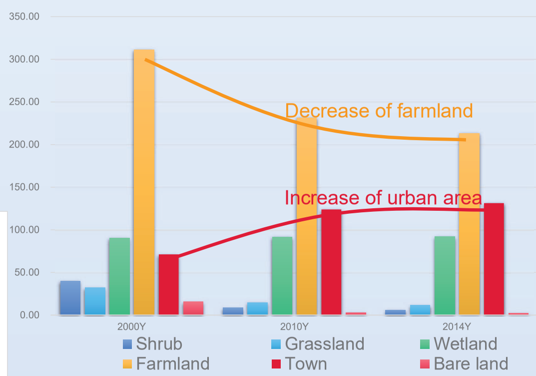
Vegetation and soil types of watershed (2010 / 2014)

- **Vegetation types:** There are various types of forest vegetation,
- **Woody plants**: There are 102 families, 320 genera and 861 species, of which 45 species are rare and endangered.
- **Arbor species**: Masson pine, poplar tung, Chinese fir, mountain willow and so on.
- **Economic tree species**: Citrus, Chinese chestnut, persimmon, tea and so on.
- **Soil type**: There are 5 soil groups, 13 subgroups, 29 soil genera and 54 soil species, mainly red soil, paddy soil and yellow soil.

Composition of Nanxi River watershed (2014)



Changes of ecological structure in Nanxi River Basin



(浙江大学, 黄舟, 2017)

2、Current situation of flood disaster in Nanxi River basin

- **The upstream:** The current is swift and the flood peak flow is large, and the downstream reaches from the Shatou（沙头镇） to the estuarine reach are subject to tidal support. In the event of a heavy rainstorm, the flood quickly gathered and surged down .
- **Downstream:** the terrain is flat, low-lying, the river is gentle, and the population and economy gather together.

◆ **During typhoons and rainstorms, the local area is easily threatened by mountain torrents and geological disasters,** and the downstream area along the river plain is easy to cause river water backfilling and waterlogging.

◆ Nowadays, under the premise of ensuring flood control safety, it is an urgent task to plan and manage scientifically, protect and utilize water resources , and provide services for sustainable development of economy and society.

Shanzaovillage（山早村） (2019) upstream

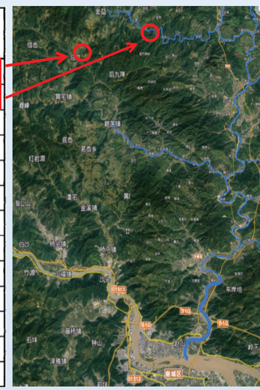
Shangtangtown（上塘镇） (2007) downstream

◆ Nanxi River water resources

- Large reservoir hydraulic resources: Most of them are concentrated in the upper reaches of the Nanxi River and are mainly used for power generation. The total storage capacity of Jinxi Hydropower Station is 19.72 million m3 and that of Beixi Hydropower Station is 38.2 million m3.
- Minor hydropower project: There are ten small (1) type reservoirs and forty-four small (2) type reservoirs.

水库名称	水库等级	所属流域	集水面积（km²）	总库容（万 m³）	正常库容（万 m³）	主要功能
金溪水库	中型	楠溪江金溪	118	1937	1735	发电
北溪水库	中型	楠溪江大源溪	132	3820	2830	发电
岩坦水库	小(1)型	楠溪江岩坦溪	3.25	156	120	发电
石田坑水库	小(1)型	楠溪江小楠溪	5.0	131	108	发电
下岙水库	小(1)型	楠溪江鹤盛溪	26.44	217	110	发电
西章水库	小(1)型	西溪	5.7	132	115	发电
朱坑垟水库	小(1)型	西溪	4.9	110	88	发电
小子溪水库	小(1)型	楠溪江陡门溪	20.4	470	366	发电
半岭水库	小(1)型	楠溪江	4.78	228	174	灌溉、供水
山溪头水库	小(1)型	楠溪江陡门溪	9.25	367	282	发电
毛竹水库	小(1)型	楠溪江张溪	60.10	228	133	发电
佳溪水库	小(1)型	楠溪江大源溪	25.0	139	89	发电
共 44 座	小(2)型		545.57	1510	1153	

jinxi reservoir（金溪水库）

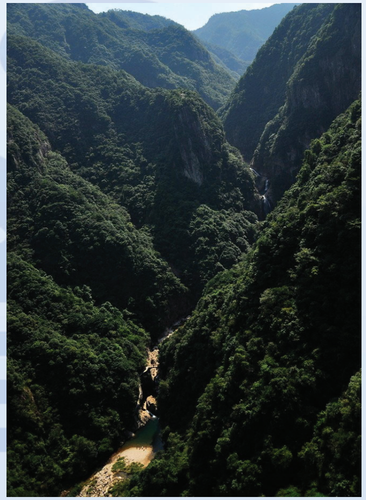


beixi reservoir（北溪水库）

- **The project plan:** The government has proposed to build Nanan Reservoir、Yuantou Reservoir, Xiyuan Reservoir and Shiran Reservoir, To adapt the socio-economic development。《永嘉县楠溪江流域水利规划修编报告，浙江省水利水电勘测设计院，2004年》。
- **After the completion of the project:** The Nanan Reservoir is located about 25km downstream of Dayuan Xi Nanan Village, with a catchment area of 319 million square meters and an average annual storage capacity of 353 million m3. The total storage capacity is 378 million m3, the adjusted storage capacity is 286 million m3, and the flood control storage capacity is 74 million m3. After the completion of the project, it will be operated jointly with the water supply project of Shatou Town in Nanxi River, so that the long-term economic development of Yongjia County, Yueqing, Yuhuan, Dongtou and other places will be guaranteed with good water resources.**However**, due to the need for residents to relocate, the ecological impact on the watershed, and still under discussion with the plan . (WenzhouMetropolis Daily)

◆ Characteristics of Nanxi River Basin

- Channel evolution is extremely complex
- The terrain and climate are special
- Soil erosion is extremely serious
- Construction of flood control facilities is Outdated



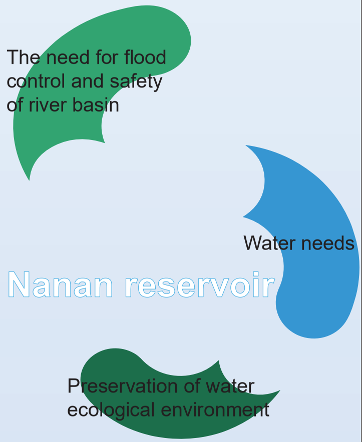
◆ Problems faced by Nanxi River Basin

Nowadays, the flood disaster is one of the most serious natural disasters

The Nanxi River basin has more mountainous areas and less plains, and there are more floods in flood season. Especially, when the upper reaches are in the rainstorm center. In the flood season every year, it is easy to see the situation of flooding and inundation , which has caused great harm to the local people's livelihood. Therefore, for the downstream villages and market towns, it is necessary to build a control project in the upstream to retain the flood, reduce the water level of the river in the flood season and improve the flood control standard in the downstream.

The Nanxi River basin is rich in water resources, but there is no large backbone reservoir project, so the utilization of water resources is low. Yueqing, Dongtou, Yuhuan and other places adjacent to Yongjia County are in serious shortage of water resources, and their own water supply is insufficient, which restricts the regional economic and social development. The construction of Nanan Reservoir needs to be accelerated。

There is much precipitation in the Nanxi River basin but the amount of water in the dry season is seriously uneven. With Nanan Reservoir , the excess water in the upstream can be stored in the flood season, so that the downstream will not have the situation of flood surge. At the same time, the water stored in the dry season will be continuously release into the Nanxi River, The dry season from October 15 to April 15 of the next year can also ensure that the main stream of the Nanxi River will not be intermittent



3、Fish resources in Nanxi River

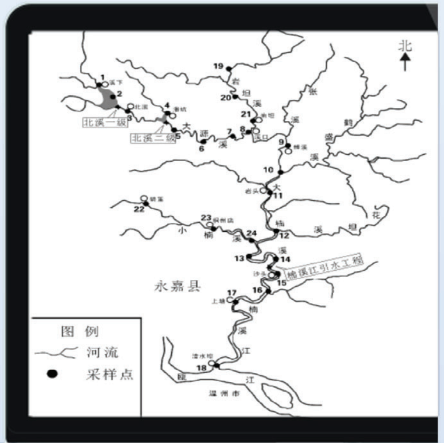
- ◆ According to the investigation results of fish resources in 24 locations in the Nanxi River during low , normal and high water period, the following results were obtained:
- ◆ Perciformes (15.4%), Cypriniformes (53.8%) and Siluriformes (10%) were in the majority.

The survey time: Dec. 2013, Mar. and Apr.2014

Perciformes	15.4%	6 families, 9 gener and 10 species
Cypriniformes	53.8%	3 families, 31 genera and 35 species
Siluriformes	10%	6 families, 9 genera and 10 species

Clupeifor mes

Anguilla japonica etc.



(水生态学杂志，高少波，池仕运，2017)

◆ The dominant fish of Nanxi River

Site	Dominant species
Beixi reservoir	Zacco platypus，Acrossocheilus fasciatus
Dayuan stream	Zacco platypus，Acrossocheilus fasciatus，Pseudobagrus ondan Shaw
Big Naxi river	Zacco platypus
Nanxi Rive section	Coilia mystus
Yantan river	Acrossocheilus fasciatus，Misgurnus anguillicaudatus
Small Naxi river	Zacco platypus，Odontobutiobscurus，

- According to the history and related literature records：**There are 78 species of fish**, belonging to 65 genera, 26 families and 12 orders, distributed in Nanxi River.
- Among them，64 species of freshwater fish, 8 species of estuarine fish and 6 species of migratory fish。

Cypriniformes are the main group in the Nanxi River，There are 38 species and 34 genera, accounting for 48.7% of the total fish population **（浙江省淡水水产研究所）**

◆ In this survey, **65 species of fish were found**, the number of species was less than the 78 species recorded in the literature, which also indicated that the ecological environment of Nanxi River had deteriorated in recent decades. （水生态学杂志，高少波，池仕运，2017）

◆ Changes of fishes in Nanxi River

Before the 1980s, the production of sweet fish, knife fish and other was more, but now the production is low, with the overfishing and environmental factors, especially the number of sweet fish has decreased sharply.now，the species completely rely on cultivation and artificial release.Resources of knife fish, including Coilia nasus, have declined sharply, and the flower eel, a second-class national protected aquatic animal, is very rare.

《温州府志》记载，香鱼“长三四寸，味佳而无腥，生清流惟十月时有，与乐产少异”

Sweet Fish of Nanxi River

Nanxi River sweet fish habitat distribution（2016~2017）

Correspondence relationship between fragrant fish and feeding habit in different periods

时 间	香鱼生命周期	体长（cm）	食性阶段
1~2月	鱼卵孵化期	2~5	动物食性阶段
3~5月	上溯洄游期	5~8	食性转换阶段
6~8月	育肥期	<20	植物食性阶段
9~10月	产卵期	20~30	植物食性阶段
11~12月	仔鱼降河期	-	动物食性阶段

The body length of adult sweet fish can reach 10-30 cm， and the main habitat of sweet fish in Nanxi River is divided into fattening ground and spawning ground.

◆ Nanxi River sweet fish habitat water quality environment

- The Nanxi River is weakly alkaline
- The water temperature is between 21 and 25 degrees, suitable for the growth of sweet fish.
- The spatial distribution of water quality is quite different
- The Fish growing and spawning area：Dissolved oxygen is above 7.4mg/L, MnO4 index, ammonia nitrogen, total nitrogen and total phosphorus concentration are low,It is beneficial to the growing and spawning of sweet fish。
- Tidal reaches of the lower reaches: The water quality is poor, the permanganate index is high, the water body is polluted by organic degree high, nitrogen, phosphorus pollution is serious.
- The pollution of the downstream tidal reach is more serious than that of the upstream, which is the necessary passage for the migration and the wintering of sweet fish. The main reason is that the downstream is easily affected by tidal surge and pollution of the Oujiang River. In addition, the downstream industries such as papermaking, electroplating and leather are developed, which discharge a large amount of untreated sewage and waste residue, leading to the deterioration of water quality.

Test results and analysis of water environment indexes（2016~2017)

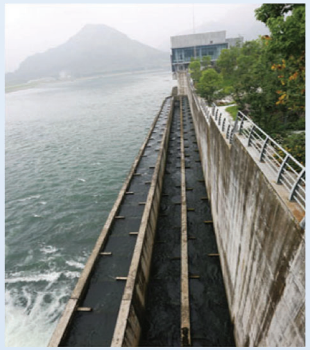
指 标	时间	育肥场				产卵场				下游感潮河段	
		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
水温 (℃)	上溯期	21.8	25.5	25.1	24.5	-	25.0	27.4	26.4	26.1	-
	产卵期	22.1	24.1	22.9	22.9	23.5	23.6	23.5	23.8	24.6	-
	育肥期	21.2	21.2	23.0	24.4	22.9	23.7	23.7	23.3	23.4	23.8
pH 值	上溯期	7.70	7.45	7.70	8.08	-	7.88	7.94	7.99	7.79	-
	产卵期	7.82	7.61	7.80	7.39	7.61	6.98	7.55	7.23	7.36	-
	育肥期	8.46	8.04	8.05	8.02	7.94	8.16	7.78	7.58	7.33	8.41
透明度 (cm)	上溯期	＞100	＞100	＞100	＞100	-	＞100	＞100	＞100	25	-
	产卵期	＞100	＞100	＞100	＞100	＞100	＞100	＞100	＞100	32	-
	育肥期	＞100	＞100	＞100	＞100	＞100	＞100	＞100	＞100	22	18
DO (mg/L)	上溯期	9	8.5	9.04	8.73	-	8.37	8.41	8.21	6.85	-
	产卵期	8.05	10.27	-	-	7.96	8.45	7.92	8.36	6.09	-

Jinxi reservoir（金溪水库）

Beixi reservoir（北溪水库

- The sweet fish is a sea-river migration fish**. The construction of water conservancy projects impeded the migration route of sweet fish. At present, the basic production is brought by the fish cultivation and release**.
- After the dramatic change of environment, a land-locked type of sweet fish appeared, that is completely reproduces and grows in fresh water.
- According to the analysis and inference, the fish released in the Nanxi River belongs to the land-locked type of sweet fish, which completely reproduces and grows in the Nanxi River, rather than migrating between the Oujiang River and the Nanxi River as in the past.

◆ Fishing path of sweet fish in Nanxi River



- Fish way design ramp: 1:63.8; The theoretical flow rate is 0. 6 m/s (the optimal flow speed of sweet fish is 0. 3-0. 6 m/s);
- The whole fishway is composed of many small baffle, each baffle is 2. 4 meters long, and there is a hole on the two adjacent stalls respectively, and a fish restroom is set up between every 10 small cells for the fish to rest when tired of running against the current.

◆Nanxi River landscape spot

Pastoral scenery、Bamboo raft drifting、mountains、The waterfall、Nanxi river（It is often said that Wenzhou is a good place with mountains, water and scenery)

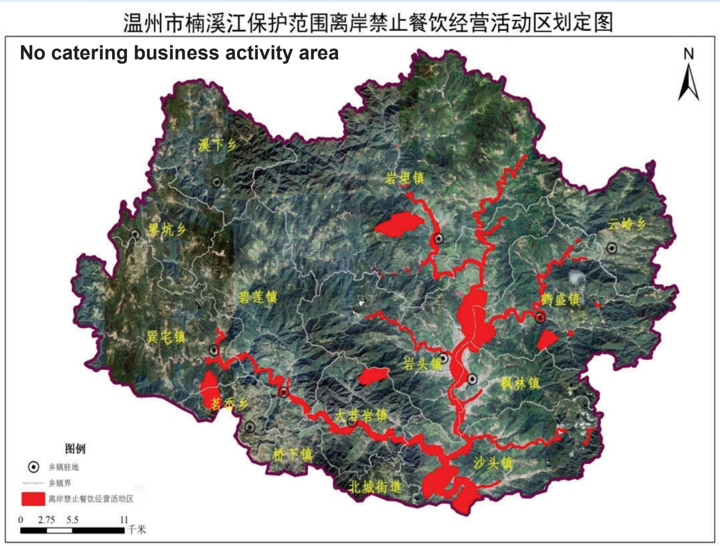
楠溪江Nanxi river

THANKS!

For development

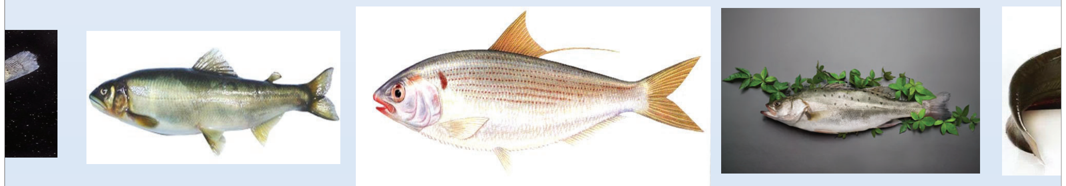
(1) Improving the legal system for governance
(2) Establish an overall governance mechanism
(3) Establish the concept of co-governance by the main body
(4) Raising the awareness of strict law enforcement

Raise Environmental Awareness



Nanxi River fish

The Nanxi River is rich in fish resources and fish diversity, which not only provides a lot of fish food for the local people, but also provides more vitality for the Nanxi River basin.



3. 礫河川、感潮域、河口干潟における水質、底質、底生動物の空間分布

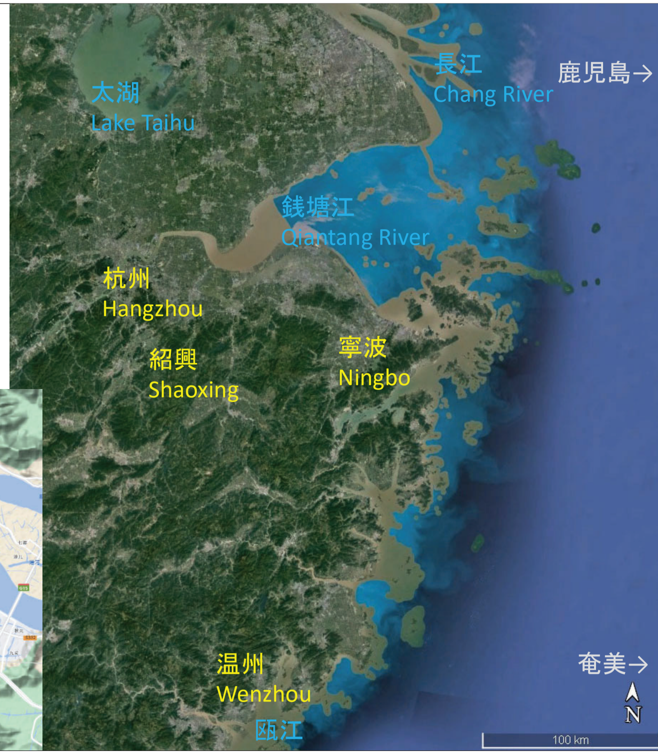
中国温州市楠瓯江の礫床区間、感潮区間、河口における水質、底質、底生動物からの生態系健全性評価

Evaluating ecosystem health based on water, sediment quality, and benthic invertebrates in the gravel-bed, tidal reaches, and river mouth of Nan-Ou River, Wenzhou, China

郝愛民・〇小林草平・井芹寧・陳凱・角哲也・竹門康弘・渡邉紹裕
（温州大学生命環境科学学院・京都大学防災研究所）
Aimin HAO・〇Sohei KOBAYASHI・Yasushi ISERI・Kai CHEN・Tetsuya SUMI・Yasuhiro TAKEMON・Tsugihiro WATANABE

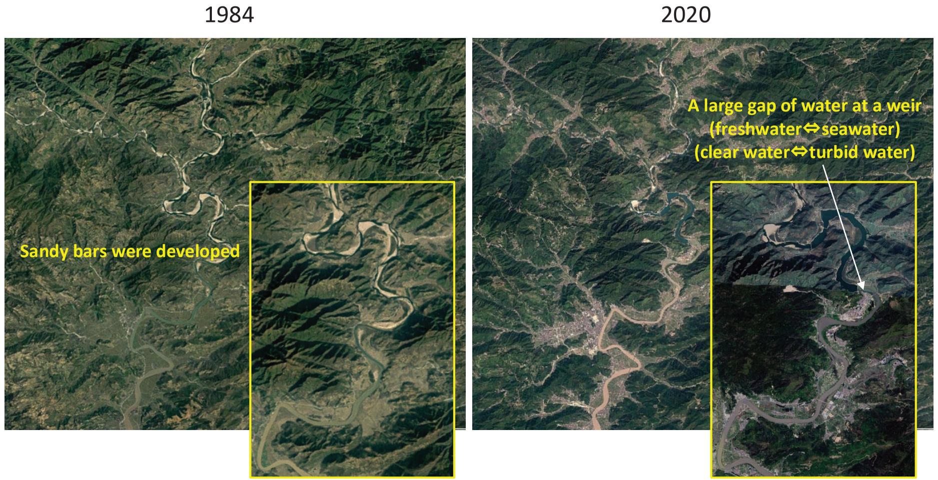
浙江省沿岸
Zhejiang coastal area

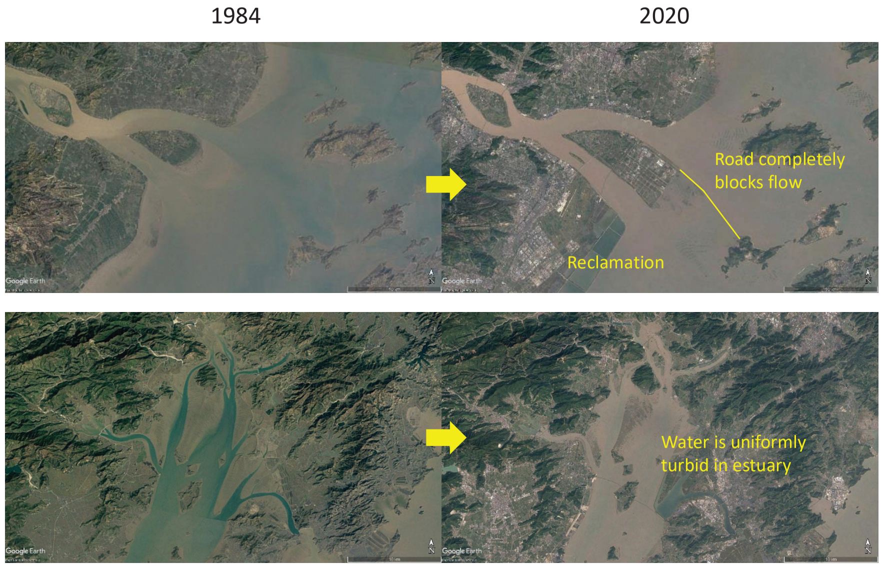
- N27.2～N30.6
- Many estuaries, mud flats
- Freshwater wetlands, water networks
- Large tidal change
- Lake Taihu: The 3rd largest
- Qiantang River : tidal bore



Changes in water environment

- Pollution and eutrophication of wetlands due to rapid economic growth since 1990s
- Frequent occurrence of cyanobacteria-bloom in lakes and red tide in coastal areas
- Changes in flow and sediment dynamics after the constructions of dams and weirs

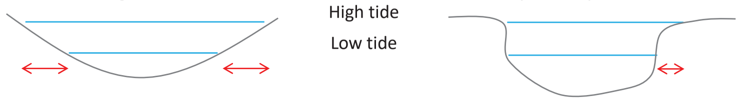




- Changes in flow and morphology by reclamation, dredging, and bank protection
- Increase in turbidity in estuary (though sediment supply decreased due to dam)

Why the turbidity of water increased while sediment supply decreased?

Past (shallow, gentle, wide) | Now (deep, steep, narrow)



More tidal area — Higher potential of production purification

Less tidal area — Lower potential of production purification

Study Purpose

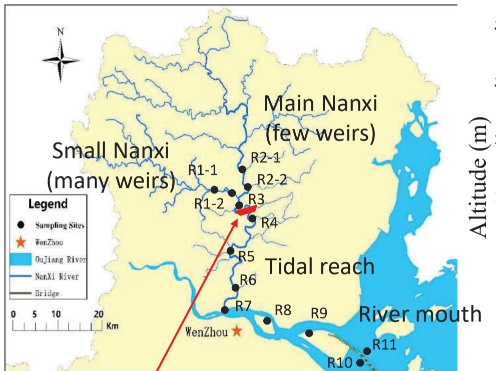
Clarify spatial variation in **ecosystem health** and explore important factors controlling the health, based on field investigation of **water and sediment quality, and benthic community** in Nanxi-Ou river, Wenzhou, China

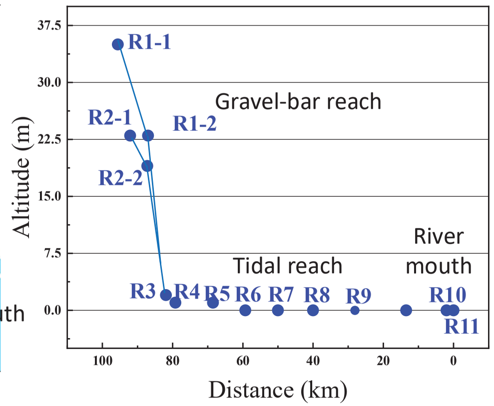
With a focus on turbidity, oxygen concentration, and species richness.

Study sites

- Ou River and its tributary (Nanxi) in Wenzhou City (10million people)
- Ecosystem and fishery production were rich in the estuary in the past
- Nanxi watershed is famous for site seeing of beautiful mountains and valleys
- Many dams in the upstream and large weirs in the main stem downstream
- Tidal change of 3-6m and tidal flow of 1.5m/s

Study sites



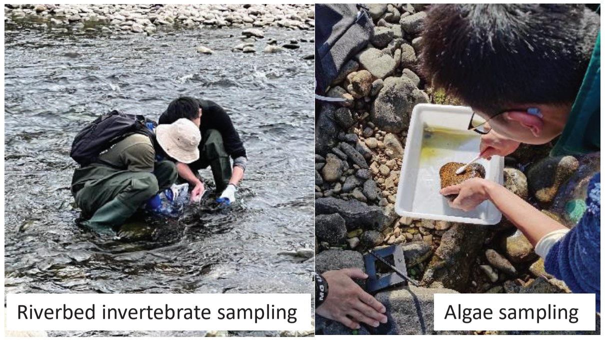


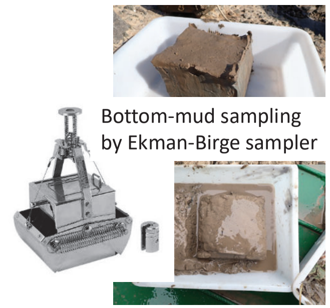
1. Gravel-bed reach
   Difference between streams with many or few weirs
2. Tidal reach
   Longitudinal (streamwise) pattern
3. River mouth
   Difference between open and partially closed areas

Measurements and sampling

Survey sites: Gravel-bed (5), Tidal (9), Mouth (2)
Survey periods: Winter (Dec/2021), Summer (Jul/2022)

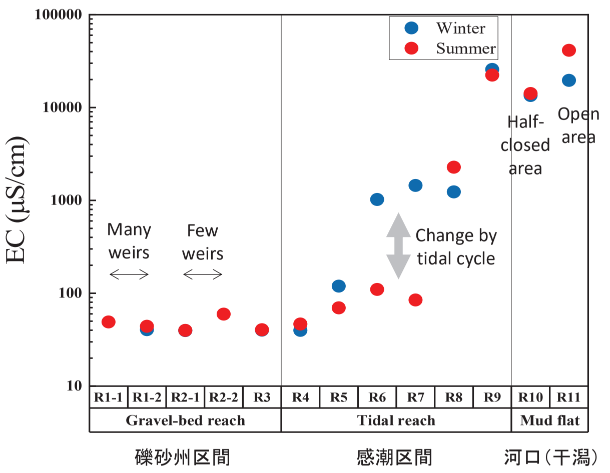
1. Water quality
   WT, DO, pH, EC, Turbidity, Chl-a, POM, TN, TP, etc
2. Sediment quality
   Moisture, Silt-clay%, Organic%, AVS, pH, ORP, TN, TP, TOC, Heavy metals
3. Biological community
   Gravel-bed reach: algae, benthic invertebrates
   Tidal reach, River mouth: benthic invertebrates





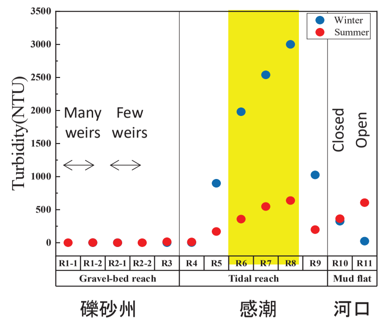
Results　1-Water quality

電気伝導度　Electric conductivity (μS/cm)

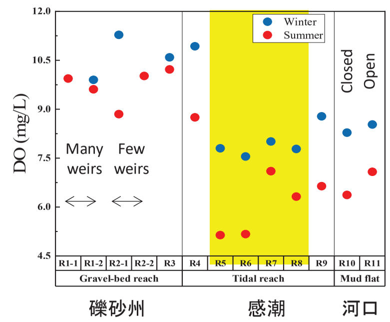


- EC increased steeply in the tidal reach, from freshwater to seawater.
- In the river mouth, EC was lower at the closed than open site.

濁度 Turbidity (NTU)



溶存酸素 DO (mg/L)

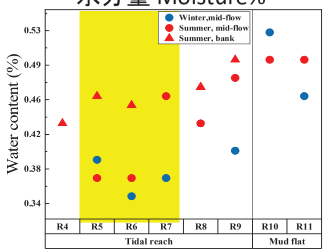


- In the gravel reach, DO tended to be lower in the river with many weirs.
- In the tidal reach, turbidity was high and DO was low in the middle sites
- In the river mouth, DO was slightly low at the closed than open sites.

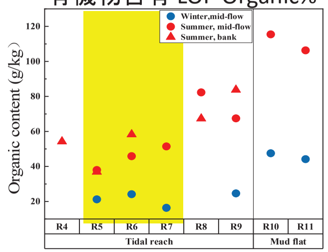
- Tidal change of the day was greater in winter (5.5m) than summer (4.3m), which can affect the turbidity.

Results　2-sediment quality

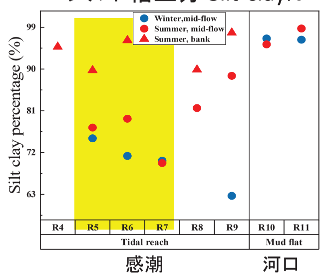
水分量 Moisture%



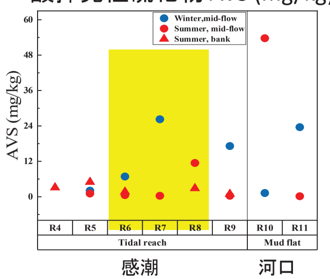
有機物含有 LOI=Organic%



シルト粘土分 Silt-clay%



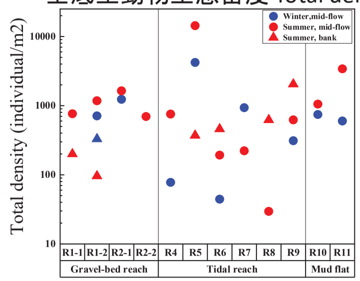
酸揮発性硫化物 AVS (mg/kg)



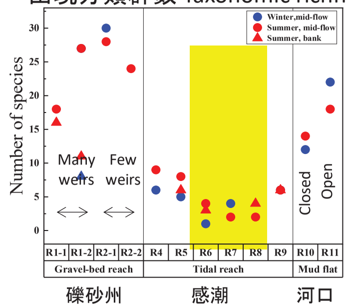
- In the tidal, sediment tended to be more consolidated (low water, organic, silt-clay) and sulfur-emitted at the middle sites.

Results　3-Benthic invertebrates

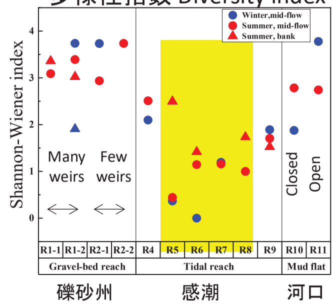
全底生動物生息密度 Total density



出現分類群数 Taxonomic richness



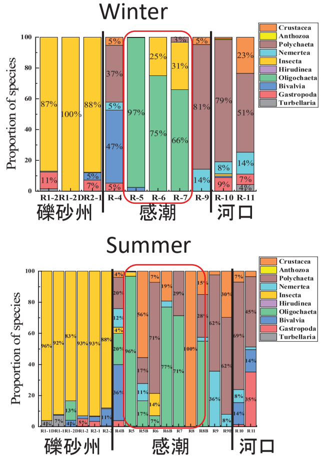
多様性指数 Diversity index



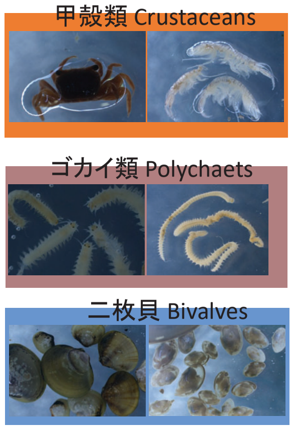
- In the gravel-bed, benthic species diversity was lower in the river with many weirs.
- In the tidal, the species diversity was lower at the middle sites.
- In the mouth, the species diversity was lower at the closed site.

底生動物分類群組成 Species composition of benthic invertebrates

Freshwater species



Seawater species

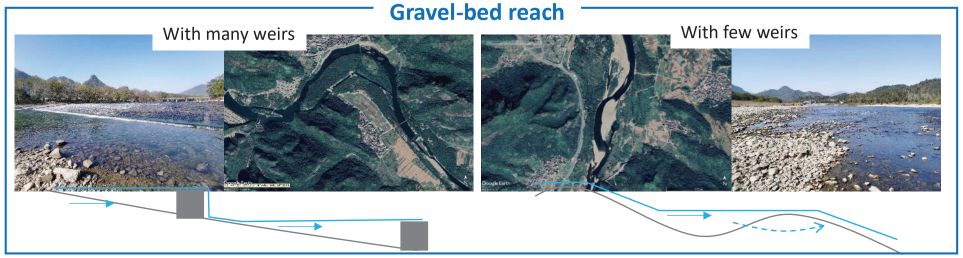


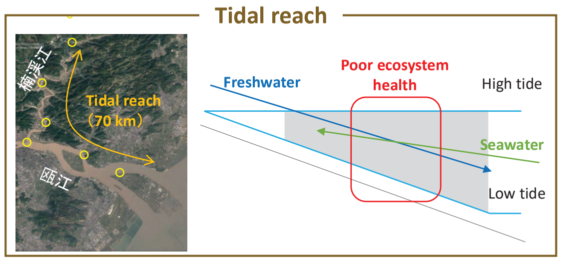
- Freshwater species dominated in the gravel-bed reach.
- Seawater species dominated in the river mouth.
- Freshwater species dominated at the middle site in the tidal reach.

Summary

According to turbidity and DO of water, mud softness, and benthic invertebrate community, ecosystem health was lower

- in the river with many weirs than few weirs in the gravel-bed reach
- at the middle sites in the tidal reach
- at the partially closed area than open area in the river mouth.



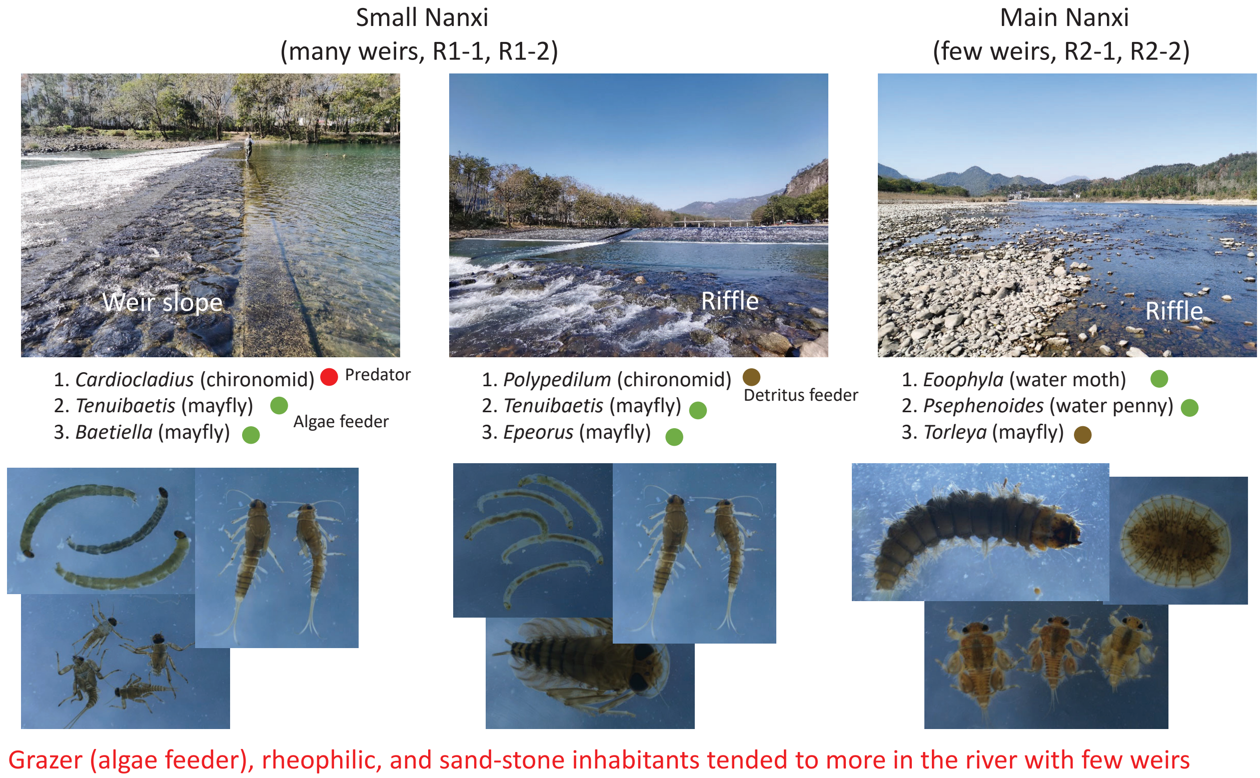


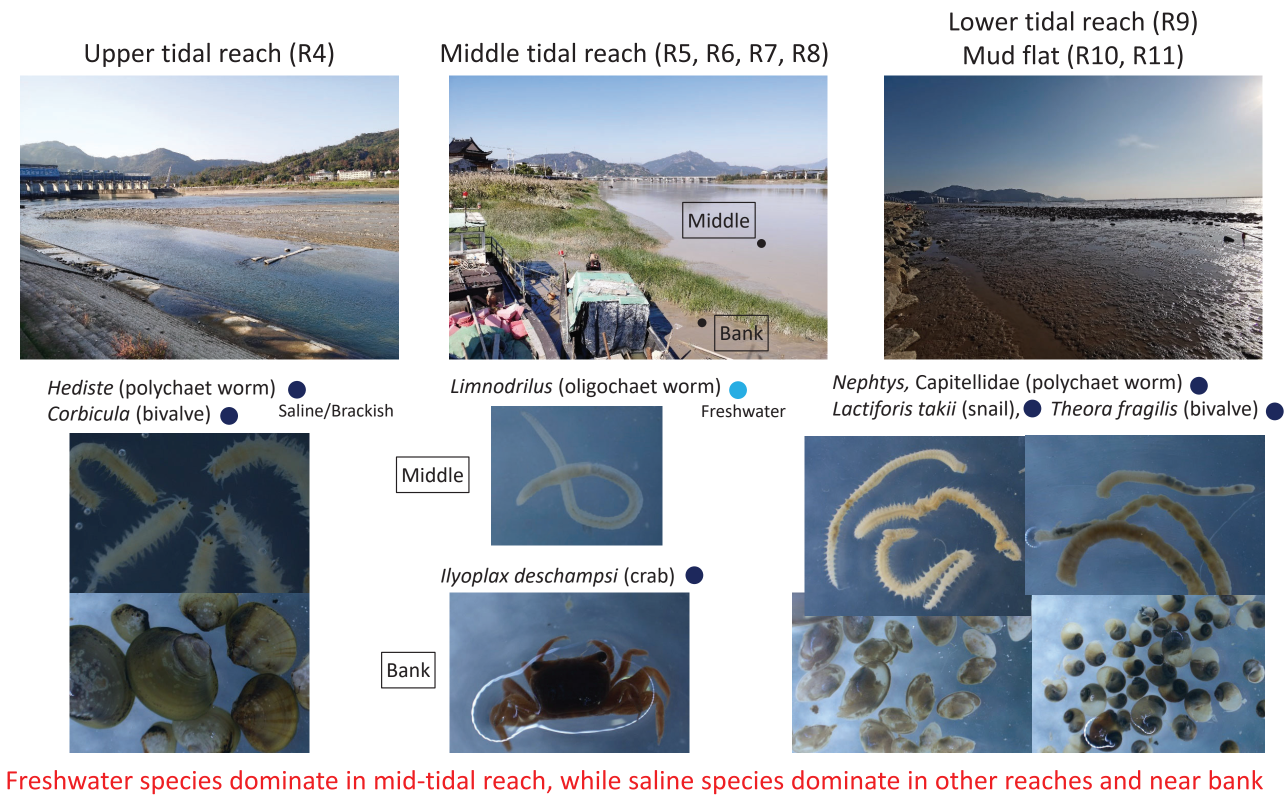
Unique mud-flat species

Occurrence of several mud flat species, which also distribute but rare in Japan

Thank you for listening

4. 礫河川、感潮域、河口干潟における底生動物の優占種、希少種


Small Nanxi
(many weirs, R1-1, R1-2)
Main Nanxi
(few weirs, R2-1, R2-2)
Weir slope
Riffle
Riffle
1. Cardiocladius (chironomid)
Predator
2. Tenuibaetis (mayfly)
3. Baetiella (mayfly)
Algae feeder
1. Polypedilum (chironomid)
Detritus feeder
2. Tenuibaetis (mayfly)
3. Epeorus (mayfly)
1. Eoophyla (water moth)
2. Psephenoides (water penny)
3. Torleya (mayfly)
Grazer (algae feeder), rheophilic, and sand-stone inhabitants tended to more in the river with few weirs


Upper tidal reach (R4)
Middle tidal reach (R5, R6, R7, R8)
Lower tidal reach (R9)
Mud flat (R10, R11)
Middle
Bank
Hediste (polychaet worm)
Corbicula (bivalve)
Saline/Brackish
Limnodrilus (oligochaet worm)
Freshwater
Nephtys, Capitellidae (polychaet worm)
Lactiforis takii (snail), Theora fragilis (bivalve)
Middle
Ilyoplax deschampsi (crab)
Bank
Freshwater species dominate in mid-tidal reach, while saline species dominate in other reaches and near bank

Unique mud-flat species

Occurrence of several mud flat species, which also distribute but rare in Japan

5. 河川－湖移行帯における生態系の健全性評価、指標種の特定

Exploring invertebrate indicators of ecosystem health by focusing on the flow transitional zones in a large, shallow eutrophic lake

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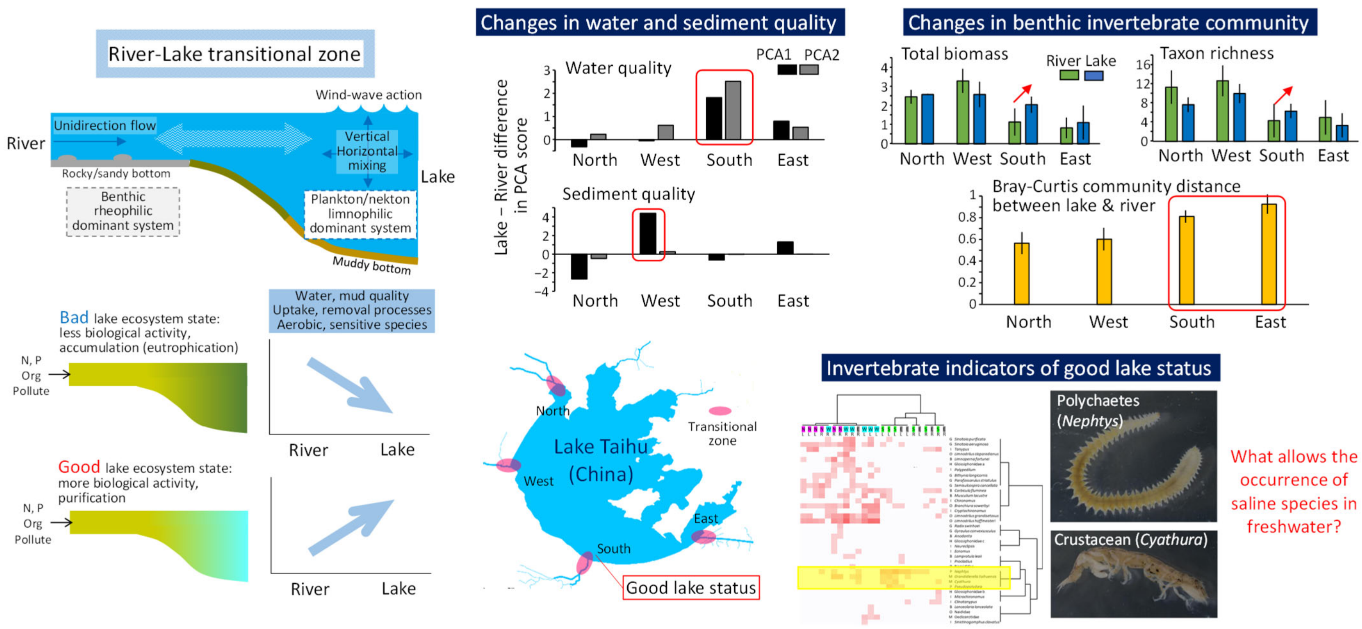
Abstract

The river–lake transitional zone provides a unique environment for the biological community and can reduce pollution inputs in lake ecosystems from their catchments. To explore environmental conditions with high purification potential in Lake Taihu and indicator species, we examined the river-to-lake changes in water and sediment quality, and benthic invertebrate communities in the transitional zone of four regions. The spatial variations in the environment and invertebrate community observed in this study followed the previously reported patterns in Taihu; the northern and western regions were characterized by higher nutrient concentrations in water, higher heavy metal concentrations in sediment, and higher total invertebrate density and biomass dominated by pollution-tolerant oligochaetes and chironomids. Although nutrient concentrations were low and transparency was high in the eastern region, the taxon richness was the lowest there, which disagreed with the previous findings and might be due to a poor cover of macrophytes in this study. The river-to-lake change was large in the southern region for water quality and the invertebrate community. Water circulation induced by strong wind-wave actions in the lake sites of the southern region is assumed to have promoted photosynthetic and nutrient uptake activities and favored invertebrates that require well-aerated conditions such as polychaetes and burrowing crustaceans. Invertebrates usually adapted to brackish and saline environments are suggested to be indicators of a well-circulated environment with active biogeochemical processes and a less eutrophic state in Taihu, and wind-wave actions are key to maintaining such a community and natural purifying processes.

Keywords: lakes, rivers, eutrophication, benthic invertebrates, purification, transitional zones, wind-wave actions, saline species


River-Lake transitional zone
Wind-wave action
Unidirection flow
River
Vertical
Horizontal
mixing
Lake
Rocky/sandy bottom
Benthic rheophilic dominant system
Plankton/nekton limnophilic dominant system
Muddy bottom
Bad lake ecosystem state: less biological activity, accumulation (eutrophication)
N, P
Org
Pollute
Water, mud quality
Uptake, removal processes
Aerobic, sensitive species
River
Lake
Good lake ecosystem state: more biological activity, purification
N, P
Org
Pollute
River
Lake
Changes in water and sediment quality
Lake – River difference in PCA score
Water quality
PCA1
PCA2
North
West
South
East
Sediment quality
North
West
South
East
Changes in benthic invertebrate community
Total biomass
River
Lake
North
West
South
East
Taxon richness
North
West
South
East
Bray-Curtis community distance between lake & river
North
West
South
East
North
Transitional zone
Lake Taihu (China)
West
East
South
Good lake status
Invertebrate indicators of good lake status
Polychaetes (Nephtys)
Crustacean (Cyathura)
What allows the occurrence of saline species in freshwater?