主 编：黄邦钦、江毓武、王文卿、马　剑、毛　勇、游伟伟、周晓平、朱旭东
编 辑：陈纪新、方许闻、方志山、黄水英、李灿如、罗　辉、孙圣垚、张雅棉、赵小雨
设 计：李灿如

Editor-in-Chief: Bangqin Huang, Yuwu Jiang, Wenqing Wang, Jian Ma, Yong Mao, Weiwei You, Xiaoping Zhou, Xudong Zhu
Editors: Jixin Chen, Xuwen Fang, Zhishan Fang, Shuiying Huang, Canru Li, Hui Luo, Shengyao Sun, Yamian Zhang, Xiaoyu Zhao
Design: Canru Li

台海站办公室

Tel: 0592-2881169
E-mail: tsmart@xmu.edu.cn
Website: http://t-smart.xmu.edu.cn/

东山实验场

地址：中国福建省东山县苏峰山路岩仔121号
Dongshan Swire Marine Station (Xiamen University)
Address: No. 121, Yanzi, Su Feng Mt. Road, Dongshan County,
Fujian Province, China
Tel: 0596- 5862891 / 0592-2880198
E-mail：sysun@xmu.edu.cn

漳江口实验场

地址：中国福建省云霄县竹塔村塔北路528-1号
Zhangjiang Estuary Mangrove Wetland Ecosystem Station (Xiamen University)
Address: 528-1 Tabei Road, Zhuta Village, Yunxiao County,
Fujian Province, China
Tel: 0592-2180502 / 18959288317
E-mail: yamian_zhang@xmu.edu.cn　fangzs@xmu.edu.cn

太古

海洋生物地球化学
全国重点实验室（厦门大学）
State Key Laboratory of
Marine Environmental Science

滨海湿地生态系统教育部重点实验室（厦门大学）
Key Laboratory of the Coastal and Wetland Ecosystems
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T-SMART

福建台湾海峡海洋生态系统
国家野外科学观测研究站
National Observation and Research Station
for the Taiwan Strait Marine Ecosystem

福建台湾海峡海洋生态系统国家野外科学观测研究站

Annual Report

2024年度报告

2024年度报告

台海站简介 / T-SMART INTRODUCTION

福建台湾海峡海洋生态系统国家野外科学观测研究站（以下简称“台海站”，英文缩写T-SMART）依托厦门大学，于2021年10月获科技部批准建设。台海站由“东山太古海洋观测与实验站”（简称“东山实验场”）和“漳江口红树林湿地生态站”（简称“漳江口实验场”）两个分站组成，涵盖台湾海峡上升流、东山湾、漳江口三个观测区，致力于台湾海峡海洋生态系统结构与功能的长期观测和实验生态研究，为保障海洋生态环境健康和促进经济可持续发展提供科技支撑。

National Observation and Research Station for the Taiwan Strait Marine Ecosystem (T-SMART) was approved by the Ministry of Science and Technology of China in October 2021. T-SMART consists of two substations, "Dongshan Swire Marine Station (D-SMART)" and "Zhangjiang Estuary Mangrove Wetland Ecosystem Station (M-ECORS)", which covers three observation areas including Taiwan Strait Upwelling, Dongshan Bay and Zhangjiang Estuary. It is mainly committed to the long-term monitoring and experimental research on marine ecosystem structure and function, which provides science and technology support for the marine health and the sustainable economic development.

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Advisers

Huasheng Hong, Dongxing Yuan, Changyi Lu, Yan Li, Yanjie Liu, Sheng Wang

T-SMART Leadership Team

Director: Bangqin Huang

Associate Director: Yuwu Jiang, Wenqing Wang

D-SMART: Yuwu Jiang, Jian Ma, Weiwei You, Yong Mao

M-ECORS: Wenqing Wang, Xudong Zhu, Xiaoping Zhou

Technical and Administrative Team

Jixin Chen, Xuwen Fang, Zhishan Fang, Shuiying Huang, Canru Li, Chichi Liu, Hui Luo, Shengyao Sun, Jinhua Xue, Yamian Zhang, Xiaoyu Zhao

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序言 / Message from Director

2024年，台海站全体同仁秉承“观测、研究、示范、服务”的使命，以科技创新驱动发展，以服务国家战略为己任，在台湾海峡及邻近海域生态系统观测与研究取得显著成效。

科学观测扎实推进。全年完成11次季度航次观测，覆盖上升流区、东山湾、漳江口等重点区域。14套自动观测系统持续运行良好。首次与自然资源部海西野外站开展协同观测，探索跨平台协作新模式，为区域生态系统研究提供了更全面的数据支撑。

科研创新成果丰硕。在近海上升流–海湾–滨海湿地生态系统研究等取得新进展。新获批纵向科研项目25项，包括国家重点研发计划项目、基金委重点项目、联合基金重点项目、国际（地区）合作与交流项目等。共发表研究论文98篇，授权发明专利11件，彰显了台海站在海洋生态领域的学术引领力。

队伍建设成效显著。获批基金委创新群体项目1项、青年科学基金（A类）1项。1人当选美国地球物理联合会会士，并获地球与空间科学大使奖，1人获俄罗斯科学院300周年禧年奖章，3人当选中国生态学会会士，1人获国务院政府特殊津贴。培养博士后1名，博硕士研究生53名，为海洋生态环境领域输送了高质量人才。

合作交流持续深化。成功举办第二届国际咨询委员会第一次会议，主办“海峡两岸海洋生物资源与技术研讨会”，牵头承办“全国红树林保护与修复研讨会”“中国湿地保护协会红树林专委会成立大会”。再度获太古集团捐赠，启动东山太古海洋观测与教育计划。

示范服务能力显著提升。中国首个海草床碳汇方法学通过专家评审，积极开展科普传播，举办培训和科普活动10场，与海洋生物地球化学全国重点实验室等共同承办“第十三届厦门大学海洋科学开放日”，受众超12000人次。创立"苏峰讲坛"，有效推动了海洋保护理念的传播。

回望2024年，台海站以坚实的步伐书写了高质量发展的新篇章。展望未来，我们将继续坚守国家野外站的宗旨，深化能力建设，强化资源共享，拓展区域及国际合作，推动海洋生态系统观测和研究迈向新高度。台海站全体同仁将以更加昂扬的姿态，为构建人与自然和谐共生的美丽海洋贡献更多智慧与力量。

站长：

于2025年3月

In 2024, all colleagures at the T-SMART remained committed to the mission of "Observation, Research, Demonstration, and Service." Propelled by technological innovation and dedicated to supporting national strategic objectives, the T-SMART achieved remarkable results in the observation and research of ecosystems in the Taiwan Strait and adjacent waters.

Scientific observations were solidly advanced. Throughout 2024, a total of 11 quarterly research cruises were successfully completed, with coverage of key areas including upwelling zones, Dongshan Bay, and Zhangjiang Estuary. Fourteen sets of automated observation systems maintained seamless and continuous operation. For the first time, T-SMART carried out collaborative observations in cooperation with the Haixi Field Station of the Ministry of Natural Resources. This initiative pioneered a new cross - platform cooperation model, providing more comprehensive data support for regional ecosystem research.

Scientific research and innovation yielded abundant fruits. New advancements were achieved in the research on coastal upwelling - bay - coastal wetland ecosystems. The T-SMART newly obtained approval for 25 scientific research projects. These projects encompassed those under the National Key Research & Development Program, Key Projects of the National Natural Science Foundation of China (NSFC), Key Projects of Joint Funds, and international (regional) cooperation and exchange programs. In total, 98 research papers were published and 11 invention patents were authorized, highlighting T- SMART's academic leading role in the field of marine ecology.

Notable achievements were attained in the construction of the research team. The T-SMART was awarded for one NSFC Innovative Research Group Project and one NSFC Young Scientists Fund (Category A). One team member was elected as a Fellow of the American Geophysical Union (AGU) and was conferred the Earth and Space Science Ambassador Award. Another team member received the Russian Academy of Sciences Tercentenary Jubilee Medal. Three members were elected as Fellows of the Ecological Society of China, and one was granted the Special Allowance from the State Council. Moreover, the T-SMART nurtured one postdoctoral researcher and 53 master's and doctoral students, thus providing a steady stream of high-quality talent to the marine ecological environment field.

Cooperation and exchanges witnessed continuous deepening. The T-SMART successfully held the first meeting of its Second International Advisory Committee and sponsored the "Cross-Strait Symposium on Marine Biological Resources and Technology." Moreover, it took the lead in hosting the "National Mangrove Conservation and Restoration Workshop" and the "Inaugural Meeting of the Mangrove Committee of the China Wetland Conservation Association." Thanks to another donation of the Swire Group, the T-SMART initiated the Dongshan Swire Marine Observation and Education Program.

The capabilities of demonstration and service witnessed a remarkable boost. China's first seagrass carbon sink methodology passed the expert review. The T-SMART was actively involved in science popularization and communication. It organized 10 training programs and public outreach activities. In cooperation with the State Key Laboratory of Marine Environmental Science (MEL) of Xiamen University and other institutions, the T-SMART co-hosted the "13th Xiamen University Marine Science Open Day," attracting an audience of over 12,000. T-SMART also established the "Sufeng Forum" to further promote the dissemination of marine conservation concepts.

Looking back on 2024, the T-SMART has taken firm and resolute steps, writing a new chapter of high-quality development. As we look forward, we are determined to consistently adhere to the mission of the National Field Station. We will deepen capacity-building efforts, intensity resource sharing, broaden regional and international cooperation, and propel marine ecosystem observation and research to new pinnacles.

All colleagues at T-SMART will maintain an even more high-spirited attitude and remain committed to contributing even greater wisdom and strength to constructing a beautiful ocean where humanity and nature coexist in harmony.

Director. **Bangqin Huang**

March, 2025

數字台站 2024


11 RESEARCH CRUISES
98 RESEARCH PAPERS
11 AUTHORIZED INVENTION PATENT
571 STUDENTS AT THE STATION
10 OUTREACH EVENTS
30 INSTITUTIONS AND UNIVERSITIES
2000+ VISITORS

25 项

新增纵向项目
Newly Funded Projects

1 项

国家重点研发计划项目
National Key Research and Development Programs

1 项

国家杰出青年科学基金
NSFC Outstanding Youth Science Fund

1 项

国家自然科学基金创新研究群体项目
Innovative Research Group Project

1 项

国家自然科学基金重点项目
NSFC Key Program

2024 年度焦点
2024 Headlines

January 1月

- *Nature Ecology & Evolution* 发表有关红树林生态系统生产力在气候变化响应方面较陆地生态系统的特异性和贡献度的研究成果

  Research on "Stronger increases but greater variability in global mangrove productivity compared to that of adjacent terrestrial forests" was published in *Nature Ecology & Evolution*

March 3月

- “台海站第二届国际咨询委员会第一次会议”在厦门召开

  "The First Meeting of the Second International Advisory Committee of the T-SMART" was held in Xiamen

- 东山实验场“2024年苏峰讲坛”成功举办三讲

  The "2024 Sufeng Forum" of D-SMART was successfully held three times

April 4月

- MEL、T-SMART主导的中国首个海草床碳汇方法学通过专家评审

  China's first Seagrass Bed Carbon Sink Methodology, led by MEL and T-SMART scientists, passed its panel review

May 5月

- 校党委书记张荣带队赴实地调研台海站建设发展情况

  Zhang Rong, Secretary of the University Party Committee, led a delegation to conduct a field investigation on the construction and development of the T-SMART

- “全球海洋生物碳泵估算研究”获“2023 年度中国海洋科技十大进展”

  Research on "Biological carbon pump estimate based on multidecadal hydrographic data" won "Top 10 Science and Technology Advances in Oceanology" of China

June-July 6-7月

- 第十六届水环境科学研究高校联盟（UCAS）与第九届 MEL 研究生学术论坛在东山实验场顺利举办

  The 16th University Consortium on Aquatic Sciences Symposium and The 9th MEL Graduate Academic Forum successfully held at D-SMART

August 8月

- 台海站与自然资源部海西野外站联合开展夏季航次

  The T-SMART and the Haixi Field Station of the Ministry of Natural Resources jointly conducted a summer research cruise

- “海洋新陈代谢与元素循环”研究群体获批国家自然科学基金创新研究群体项目

  The Group of Excellence on "Ocean metabolism and elemental cycles" was awarded by the NSFC Science Fund for Innovative Research Groups

September 9月

- 台海站数据中心开发的“生态环境数据共享服务平台”在厦门大学海洋云门户网站正式上线运行

  The "Ecological Environment Data Sharing Service Platform" developed by the T-SMART Data Center was officially launched on the Xiamen University Ocean Cloud Portal

- 戴民汉当选美国地球物理联合会会士并获地球与空间科学大使奖

  Minhan Dai was awarded the AGU Fellow and received the AGU Ambassador Award for Earth and Space Science

- 曹玲获批国家杰出青年科学基金项目

  Ling Cao received the NSFC Fund for Distinguished Young Scholars

- 承办蓝色先锋加速器特别研讨活动

  Hosted the Blue Pioneers Accelerator Special Seminar and Workshop

October 10月

- 国家林业和草原局湿地管理司姬文元处长一行调研台海站漳江口试验场

  Wenyuan Ji, Director of the Wetland Management Department of the National Forestry and Grassland Administration and his delegation conducted a research visit to the M-ECORS of the T-SMART

- 主办“海峡两岸海洋生物资源与技术研讨会”

  Hosted the "Cross-Strait Symposium on Marine Biological Resources and Technology"

- 举办“海洋负排放”大科学计划第三届开放科学大会，发布《宜居地球》本研一体化课程等系列教育成果

  The 3rd Global-ONCE Open Science Conference was held, where the integrated undergraduate-graduate course on *Habitable Earth* was launched

November 11月

- 太古集团海洋生态保护和教育捐赠签约仪式

  Signing ceremony for marine ecological protection and education project with Swire Group

- “海洋负排放”国际大科学计划主导全球首个海洋碳中和国际标准提案并推动其立

  The world's first international standard proposal on ocean carbon neutrality, titled "Ocean Negative Carbon Emissions and Carbon Neutrality—General Principles and Requirements" was approved, led by Global ONCE

- 与印尼茂物农业大学渔业和海洋科学学院签订SIS-MAR协议共建红树林姊妹站

  Signed the SIS-MAR Agreement with the Faculty of Fisheries and Marine Sciences at IPB University (Institut Pertanian Bogor), Indonesia, to establish a sister station for mangrove research

- 共同承办第十三届厦门大学海洋科学开放日科普活动

  Co-organized the 13th Xiamen University Marine Science Open Day Science Popularization Event

December 12月

- 台海站承办“2024年全国红树林保护与修复研讨会”

  The T-SMART hosted the "2024 National Mangrove Protection and Restoration Seminar"

- 台海站承办“中国湿地保护协会红树林湿地保护专业委员会成立大会暨红树林湿地保护交流会”

  The T-SMART hosted the " The Inaugural Meeting of the Mangrove Wetland Conservation Professional Committee of China Wetland Conservation Association"

- 获批生态环境部福建漳州东山生态质量综合观测站（海洋）

  Approved the Fujian Zhangzhou Dongshan Comprehensive Ecological Quality Monitoring Station (Marine) under the Ministry of Ecology and Environment

科学观测与实验

Observation & Experiment

台湾海峡上升流观测区观测航次

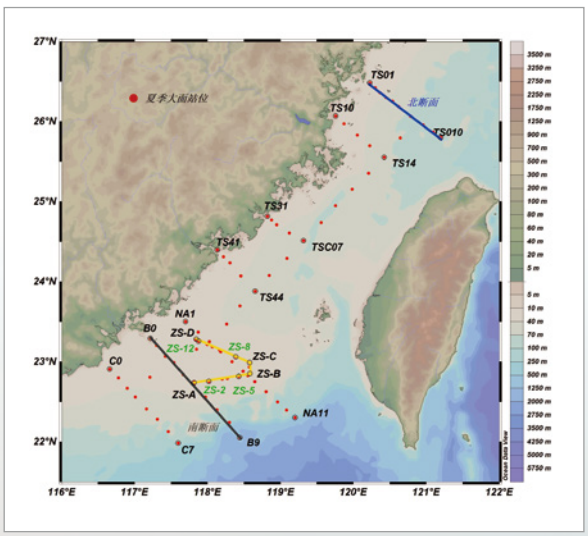
Cruises of the T-SMART in the Taiwan Strait Upwelling Observation Area

台海站台湾海峡上升流观测区位于台湾海峡南部，台海站在东山外海至南澳岛以东海域设置3条断面，进行长期观测，获取上升流区域海水物理、化学、生物参数，以探究台湾海峡上升流区生态系统特征、动态变化及其驱动机制。

2024年，台海站完成台湾海峡上升流观测区春季（5月）、夏季（7-8月）、秋季（11月）3次大面站航次观测。并在NA上升流断面加密观测，开展海洋水文特征及海洋环境要素连续观测，研究东山外海和台湾浅滩上升流的特征，分析台湾海峡南部南海北部陆坡物质交换关键过程、动力机制及其生态环境效应。

The Taiwan Strait Upwelling Observation Area is located in the southern part of the Taiwan Strait. Three transects have been established in the waters east of Dongshan to the east of Nan'ao Island for long-term observational research. The aim is to obtain physical, chemical, and biological parameters of the seawater in the upwelling region to explore the ecosystem characteristics, dynamic changes, and driving mechanisms of the upwelling area in the Taiwan Strait.

In 2024, the Taiwan Strait Station completed three large-scale survey cruises in the upwelling observation area during spring (May), summer (July-August), and autumn (November). Additionally, intensive observations were conducted along the NA transect to carry out continuous monitoring of marine hydrological characteristics and various marine environmental factors. The research focused on identifying upwelling signals in the waters east of Dongshan and the Taiwan Bank, analyzing the role of the Taiwan Strait in material exchange with the northern slope of the South China Sea, and investigating key processes, dynamic processes, and their ecological and environmental effects.



夏季站位
Summer Cruise Stations

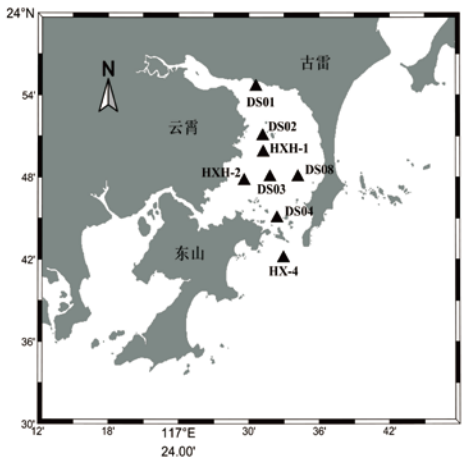
东山湾观测区
Dongshan Bay Observation Area

东山湾观测区位于福建省漳州市东山湾及邻近海域，以上升流、珊瑚保护区、水产养殖密集区、核电站及石化基地附近海域为重点观测区域，观测项目包括物理、化学、生物、底质等要素内容。2024年，台海站东山实验场继续开展季度航次观测，累计完成冬季（1月）、春季（4月）、夏季（8月）、秋季（11月）4个季度的航次观测。台海站联合自然资源部第三海洋研究所在东山海域开展的夏季共享航次圆满完成了取样作业。本次共享航次旨在通过充分利用双方在东山海域的科研人员、出海用船及观测设备等资源，实现对东山湾重点海域物理、化学、底质生化、生物要素的全面观测。

The Dongshan Bay Observation Area is located in Dongshan Bay and its adjacent waters in Zhangzhou City, Fujian Province. It focuses on key observation regions such as upwelling zones, coral protection areas, intensive aquaculture zones, and the nearby waters of nuclear power plants and petrochemical bases. The observation projects include physical elements, chemical elements, sediment biochemical elements, and biological elements. In 2024, the D-SMART continued its quarterly survey cruises, completing investigations in winter (January), spring (April), summer (August), and autumn (November). The joint summer shared cruise conducted by the Taiwan Strait Station and the Third Institute of Oceanography of the Ministry of Natural Resources in the Dongshan waters also successfully completed sampling operations. This shared cruise aimed to achieve a comprehensive survey of physical, chemical, sediment biochemical, and biological elements in key areas of Dongshan Bay by fully utilizing the resources of both parties, including scientific researchers, vessels, and survey equipment in the Dongshan waters.

航次完成合影
Voyage Completion Group Photo

东山湾观测航次照
Photos From the Dongshan Bay Observation Cruise



东山站站位
D-SMART Cruise Stations

岸基气象观测
Land-based Meteorological Observation

东山实验场目前使用的自动气象站为DZZ4型区域自动气象站，是完全满足中国气象局《新型自动气象（气候）站功能规格书（业务试用版）》的新一代自动气象站，其技术指标完全满足或优于业务化部门的要求，并获得气象专用技术装备使用许可证和国家高新技术产品认证。该气象站采用当今成熟的、稳定的、先进的电子测量、数据传输和控制系统技术，能满足现有气象观测站的气候观测、天气观测和区域观测业务的需要，具有高可靠性、高准确性、易维护等特点。

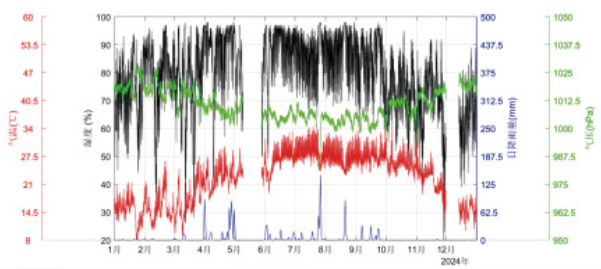
2024年1月1日零时起，截止至2024年12月31日，数据接收率在88%以上，系统运行情况稳定。系统观测参数包含：风速、风向、温度、相对湿度、大气压强及雨量。

根据观测，东山实验场在春、秋、冬季受东北风影响为主，在夏季则是以西南风为主。其中春季主要风力为5级及以下，夏季以2~4级风为主，秋季天气多变，各等级风力出现频率相近；在冬季以四级以上风力居多。

The D-SMART currently uses the DZZ4 regional automatic weather station, which is a next-generation automatic weather station fully compliant with the "Functional Specifications for New Automatic Weather (Climate) Stations (Trial Operational Version)" issued by the China Meteorological Administration. Its technical indicators fully meet or exceed the requirements of operational departments, and it has obtained the Meteorological Specialized Equipment Usage License and National High-Tech Product Certification. This weather station employs mature, stable, and advanced electronic measurement, data transmission, and control system technologies, meeting the needs of climate observation, weather observation, and regional observation operations at existing meteorological stations. It features high reliability, high accuracy, and ease of maintenance.

From 00:00 on January 1, 2024, to December 31, 2024, the data reception rate has been above 88%, and the system has been operating stably. The observed parameters include wind speed, wind direction, temperature, relative humidity, atmospheric pressure, and precipitation.

According to observations, the D-SMART is primarily influenced by northeasterly winds in spring, autumn, and winter, while southwesterly winds dominate in summer. In spring, the main wind force is level 5 and below; in summer, winds of levels 2 to 4 are predominant; in autumn, the weather is variable, with similar frequencies of wind forces across all levels; and in winter, wind forces above level 4 are more common.



2024气象观测时序图
Meteorological Observation Time Series Chart

东山气象观测场
Dongshan Meteorological Observation Field

地下河口观测
Subterranean Estuary Observation

从2024年3月6日到12月31日，井深依次为20m、48m、58m和98m的地下水观测井W4、W1、W3和W2的水位、温度、电导率的高精度连续观测如图1所示。

W4地下水水位（m）从3月逐渐上升，在11月底开始下降，其变化范围为12.61−14.39，平均值为13.54 ± 0.37。温度（℃）呈现明显的季节特征，高值见于5月、6月，应是夏季较强的太阳辐射导致。温度（℃）变化范围为23.76−23.87，平均值为23.82 ± 0.02。电导率（μs/cm）的变化趋势较复杂，其变化范围为521.1−532.8，平均值为524.8 ± 1.7。在9月和10月期间，电导率变化幅度最大。

和W4水位变化趋势一致，W1地下水水位（m）也从3月逐渐上升，在11月底开始下降，其变化范围为15.95−17.74，平均值为16.87 ± 0.37。温度（℃）则不存在明显的变化趋势，其变化范围为23.81−23.82，平均值为23.814 ± 0.003。电导率（μs/cm）也与水位相同，有随时间上升的趋势，其变化范围为547.2−608.9，平均值为574.9 ± 13.59。与水位不同的是，在10月、11月，电导率下降；在12月，电导率不仅出现最高值，还发生了最强的变化。

W3水位变化趋势和W4、W1相同，从13.81 m上升到15.58 m, 均值是14.72 ± 0.37 m。水温没有明显的季节特征，其变化范围为24.01−24.06℃，平均值为24.021 ± 0.008℃。W3电导率（μs/cm）的变化和W1相同，随时间上升。然而，不同之处在于10−11月期间，W3电导率出现最强波动。其变化范围为515.2−529.1，平均值为520.8 ± 3.2。

W2水位变化趋势和其他3口井相同，从13.26 m上升到15.11 m, 均值是14.24 ± 0.38 m。温度（℃）则不存在明显的变化趋势，其变化范围为25.27−25.30，平均值为25.291 ± 0.002。电导率（μs/cm）在3月发生突增，而后逐步下降，从6月起没有明显变化。总的来说，电导率的变化范围为422.0−951.2，平均值为862.9 ± 22.2。

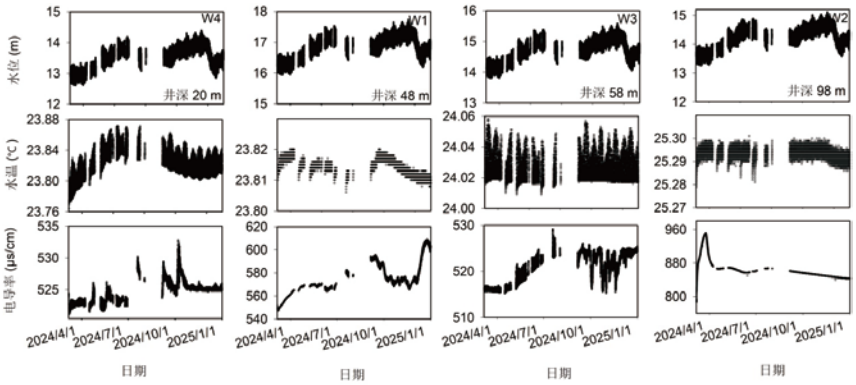
Time-series observations of groundwater level, temperature and conductivity at W4, W1, W3 and W2 with well depth 20 m, 48 m, 58 m and 98 m, respectively, from 6th March to 31st December are illustrated in Figure 1.

The groundwater level at W4 generally exhibited an increasing trend from March , and then began to decrease at the end of November, ranging from 12.61 m to 14.39 m, with an average of 13.54 ± 0.37 m. Groundwater temperature displayed a noticeable seasonal change influenced by strong solar radiation in summer, peaking between May and June. Specifically, the temperature varied from 23.76 to 23.87°C, with a mean value of 23.82 ± 0.02°C . The variation in conductivity was more intricate, ranging from 521.1 to 532.8 μs/cm, with an average of 524.8 ± 1.7 μs/cm. From September to October, the fluctuation in conductivity was the largest.

Similar to W4, the groundwater level of W1 also first rise, then fall, ranging from 15.94 m to 17.74 m, with an average value of 16.87 ± 0.37 m. Temperature exhibited very subtle changes, ranging from 23.81°C to 23.82°C, with a mean value of 23.814 ± 0.003°C. The conductivity exhibited a similar pattern to the level, increasing over time. Unlike groundwater level, the conductivity decreased during October and November, and reached a transient highest value in December. Overall, the conductivity varied from 547.2 to 608.9 μs/cm, with a mean value of 574.9 ± 13.6 μs/cm.

The variation of groundwater level in W3 shared the same pattern as W4 and W1, ranging from 13.81 to 15.58 m, with an average of 14.72 ± 0.37 m. Groundwater temperature didn't show a seasonal change, ranging from 24.01 to 24.06°C, with an average of 24.021 ± 0.008°C. The variation in conductivity was similar to W1, exhibited an increasing trend. However, unlike W1, the fluctuation in conductivity was the largest between October and November. In general, the conductivity varied from 515.2 to 529.1 μs/cm, with an average of 520.8 ± 3.2 μs/cm.

The variation in level of W2 resembled that of other three, ranging from 13.26 m to 15.11 m, with an average value of 14.24± 0.38 m. Temperature exhibited very subtle changes, ranging from 25.27°C to 25.30°C , with a mean value of 25.291 ± 0.002°C. The conductivity experienced a sudden increase in March and then gradually decreased, with no significant change since June. In general, the conductivity varied from 422.0 to 951.2 μs/cm, with an average of 862.9 ± 22.2 μs/cm.



观测井W4, W1 ,W3 和 W2水位、水温和电导率在2024的连续观测

Time-series Observations of Groundwater Level, Temperature and Conductivity at W4, W1, W3 and W2 From 6th March to 31th December, 2024

东山湾养殖区水环境参数实时观测

Real-time Observation of Water Environment Parameters in Dongshan Bay Aquaculture Area

东山实验场依托渔排基海洋观测平台，利用物联网技术，在东山湾养殖密集区布放温盐链，实现温度、盐度、电导率等参数的实时观测。2024年度渔排基养殖水体观测系统，收集数据10.2MB。期间共计运行维护8次；主要进行传感器清洁校准维护，传输系统维护。

据统计，在平均水深5.23米处的温盐深仪测量得平均水温为21.84±4.76℃，平均盐度为32.15±1.51；在平均水深12.07米处的温盐深仪平均水温为22.44±3.42℃，平均盐度为33.05±0.89。

The D-SMART relies on the marine observation platform of the fishing raft base and utilizes IoT technology to deploy temperature and salinity chains in the intensive aquaculture area of Dongshan Bay, enabling real-time observation of parameters such as temperature, salinity, and conductivity. In 2024, the aquaculture water observation system at the fishing raft base collected 10.2 MB of data. During this period, a total of 8 maintenance operations were conducted, primarily involving sensor cleaning, calibration, and transmission system maintenance.

According to statistics, the CTD (Conductivity, Temperature, Depth) instrument at an average depth of 5.23 meters recorded an average water temperature of 21.84 ± 4.76°C and an average salinity of 32.15 ± 1.51. At an average depth of 12.07 meters, the CTD instrument recorded an average water temperature of 22.44 ± 3.42°C and an average salinity of 33.05 ± 0.89.

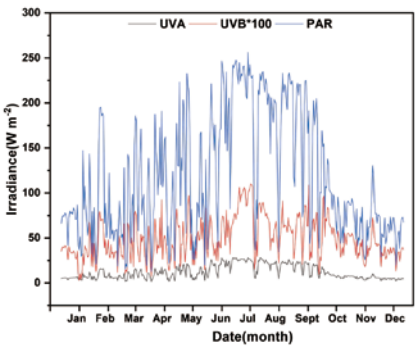
现场观测图
Field Observation Diagram

东山太阳紫外辐射数据

Solar Ultraviolet Radiation Observation System

通过对每日平均太阳紫外辐射强度进行作图，结果表明，从1月到7月PAR、UVA和UVB总体呈增加趋势，且在7月份达到最大值，从7月份到12月份呈现降低趋势。PAR、UVA和UVB的最大日平均辐射强度分别为256.01 W m^{-2}（7月18日）、27.86 W m^{-2}（7月31日）和1.09 W m^{-2}（7月21日）；最小日平均辐射强度分别为12.21 W m^{-2}（4月6日） 1.00 W m^{-2}（4月6日） 0.02 W m^{-2}（1月20日）。

By mapping the daily average solar UV radiation intensity, the results show that PAR, UVA, and UVB generally increase from January to July, and reach the maximum value in July, and then decrease from July to December. The maximum average daily radiation intensity of PAR, UVA, and UVB was 256.01 W m^{-2} (July 18), 27.86 W m^{-2} (July 31), and, 1.09 W m^{-2} (July 21), respectively. The minimum average daily radiation intensity was 12.21 W m^{-2} (April 31), 1.00 W m^{-2} (April 31), 0.02 W m^{-2} (January 20).



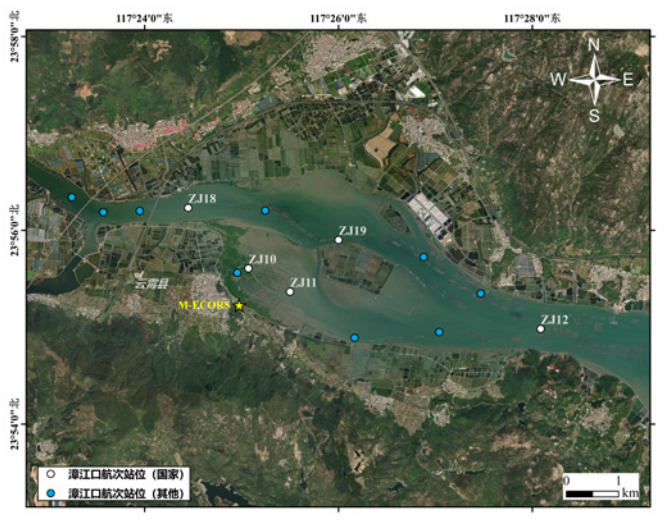
2024年太阳PAR、UVA和UVB辐射的日平均变化
Average Daily Changes in Solar PAR, UVA, and UVB Radiation in 2024

漳江口观测区航次观测

Survey Cruise in the Zhangjiang Estuary Observation Area

漳江口滨海湿地的长期定点观测是台海站的核心任务之一，也是研究人类活动和全球变化对滨海湿地生态系统长期影响的重要基础。漳江口观测区位于福建省漳州市云霄县漳江口，涵盖红树林潮沟及漳江下游至入海口水域。结合潮汐周期进行人工取样，2024年台海站在漳江口观测区顺利完成了冬季（1月）、春季（4月）、夏季（8月）和秋季（11月）的航次观测，获取了包括水体理化参数、浮游生物、底栖生物等多方面的观测数据。这些数据不仅用于观测漳江口生态系统的长期变化，还用于量化地表水与地下水之间的垂向交换水量及物质通量，以及红树林/互花米草–河口系统的横向物质交换通量，为深入研究滨海湿地生态系统的动态变化提供了重要支撑。

The long-term fixed-point observation of the Zhangjiang Estuary coastal wetland is one of the core tasks of the T-SMART and serves as a critical foundation for studying the long-term impacts of human activities and global changes on coastal wetland ecosystems. The Zhangjiang Estuary observation area is located at the Zhangjiang Estuary in Yunxiao County, Zhangzhou City, Fujian Province, encompassing mangrove tidal creeks and the waters from the lower reaches of the Zhangjiang River to its estuary. By conducting manual sampling in conjunction with tidal cycles, the T-SMART successfully completed survey cruises in the Zhangjiang Estuary observation area during winter (January), spring (April), summer (August), and autumn (November) of 2024. The collected monitoring data included physicochemical parameters of water bodies, plankton, and benthic organisms. These data are not only used to monitor the long-term changes in the Zhangjiang Estuary ecosystem but also to quantify the vertical exchange of water and material fluxes between surface water and groundwater, as well as the lateral material exchange fluxes in the mangrove/*Spartina alterniflora*-estuary system. This provides essential support for in-depth research on the dynamic changes of coastal wetland ecosystems.



漳江口航次站位（国家）和漳江口航次站位（其他）
Zhangjiang Estuary Cruise Stations (National) and Zhangjiang Estuary Cruise Stations (Others)

航次现场照片
On-site Photos of the Cruise

滨海湿地植物样方观测

Flora Biodiversity Surveys for Coastal Wetlands

为持续观测红树林及盐沼湿地植被的生长状况、湿地面积变化、外来物种入侵情况，及其对全球气候变化和人类活动的响应，漳江口实验场设立了6个红树林永久样地，每年进行1次观测。观测内容包括红树植物群落的种类、高度、密度、胸径，以及红树植物凋落物的类别和质量等。此外，实验场还设置了10个盐沼植物样地。

2024年，漳江口实验场完成了红树林和盐沼固定样方的各1次观测，观测指标涵盖盐沼植物群落的种类、高度、密度和基径等。这些观测数据为红树林生态系统研究、红树林湿地蓝碳研究，以及互花米草入侵红树林的格局、过程和机制研究提供了重要的科学依据。

To continuously monitor the growth status of mangrove and salt marsh wetland vegetation, changes in wetland area, invasive species, and their responses to global climate change and human activities, the M-ECORS has established six permanent mangrove plots, with observations conducted once a year. The observation content includes the species, height, density, and diameter at breast height of mangrove plant communities, as well as the categories and quality of mangrove litter. Additionally, the experimental site has set up ten salt marsh plant plots.

In 2024, the M-ECORS completed one round of monitoring for both mangrove and salt marsh fixed plots, with observation indicators covering the species, height, density, and basal diameter of salt marsh plant communities. These observational data provide crucial scientific support for research on mangrove ecosystems, blue carbon in mangrove wetlands, and the patterns, processes, and mechanisms of *Spartina alterniflora* invasion into mangrove areas.

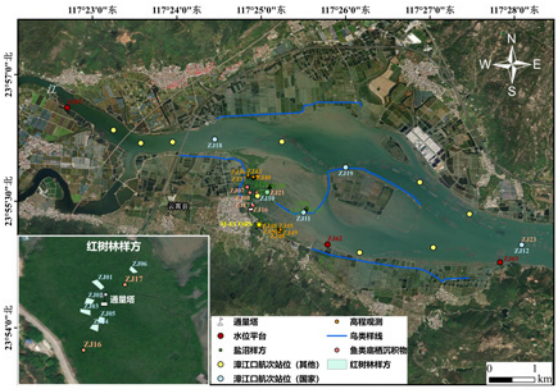
盐沼观测照片
Salt Marsh Observation in Zhangjiang Estuary

滨海湿地动物样方观测

Faunal Biodiversity Observations for Coastal Wetlands

为长期跟踪观测漳江口红树林湿地的动物多样性，漳江口实验场为鸟类、鱼类和潮间带底栖动物等动物的多样性观测设置了观测样线、样点和样方，观测指标包括动物的种类、数量、生物量和分布等。2024年，漳江口实验场完成动物多样性观测2次。在漳江口红树林国家级自然保护区的支持下，漳江口实验场开展了多年的鸟类、鱼类、底栖动物等观测，掌握了动物类群长期的种群动态和分布，为生物多样性保护提供了重要的基础数据支撑。

To conduct long-term monitoring of animal diversity in the mangrove wetlands of the Zhangjiang Estuary, the M-ECORS has established monitoring transects, sampling points, and quadrats for observing the diversity of birds, fish, and intertidal benthic animals. Monitoring indicators include species, population, biomass, and distribution of these animals. In 2024, the M-ECORS completed two rounds of animal diversity monitoring. With the support of the Zhangjiang Estuary Mangrove National Nature Reserve, the experimental site has conducted multi-year observations on birds, fish, and benthic animals, capturing long-term population dynamics and distribution patterns of animal groups. These efforts provide essential foundational data for biodiversity conservation.



漳江口样线样点图
Map of Transects and Sampling Points in the Zhangjiang Estuary

底栖动物采样现场照片
On-site Photos of Benthic Fauna Sampling

鸟类观测现场照片
On-site Photos of Bird Monitoring

水位梯度控制实验

Water Level Gradient Control Experiment

实验系统位于云霄漳江的河口区域，通过沿流域水位梯度控制平台实现自然水—盐梯度的调控，旨在探究海平面上升背景下淹水时长与海水盐度协同变化对红树植物幼苗更新与生长的驱动机制。截至2024年，该系统已顺利完成全年持续观测任务。

The experimental system is located in the estuary area of the Zhangjiang River in Yunxiao. By utilizing a water level gradient control platform along the watershed, it achieves the regulation of natural water-salinity gradients. The system aims to investigate the driving mechanisms of the synergistic changes in inundation duration and seawater salinity on the regeneration and growth of mangrove seedlings under the context of sea-level rise. As of 2024, the system has successfully completed its annual continuous monitoring tasks.

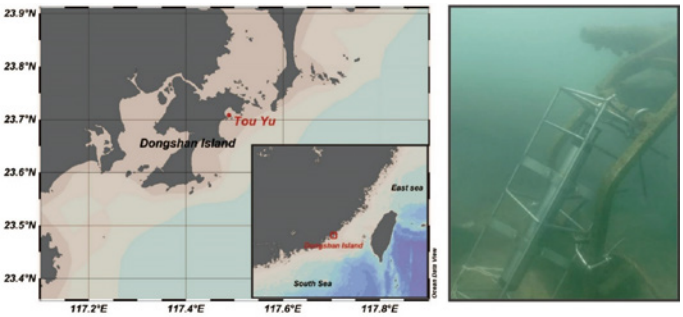
水位梯度控制实验系统
Water Level Gradient Control Experimental System

鼓虾发声行为探究

Faunal Biodiversity Surveys for Coastal Wetlands

该研究依托东山实验场开展，对东山湾珊瑚礁保护区及东山湾一鱼排进行长期声学观测，充分利用珊瑚礁保护区生态数据及东山实验场气象观测系统所测得的气象数据，建立声学环境因子联合观测系统。该研究证明鼓虾声行为对温度、盐度、溶氧量、浑浊度等环境生态因子变化存在显著响应，并且对渔船噪声敏感。鼓虾此种声行为的响应调整可能会影响其种间的声线索作用及种内的交流作用。

This study, conducted at D-SMART, implemented long-term acoustic monitoring in the Dongshan Bay Coral Reef Reserve and a fish Platoon in Dongshan Bay. By leveraging ecological data from the coral reef reserve and weather data obtained from the weather observation system at D-SMART, A joint acoustical and environmental factors monitoring system was established. The work proves that the acoustic behavior of snapping shrimp exhibits significant responses to changes in environmental ecological factors such as temperature, salinity, dissolved oxygen, and turbidity, and is sensitive to the noise of fishing boats. Such behavioral adjustments in snapping shrimp may impact their interspecific acoustic signaling and intraspecific communication.

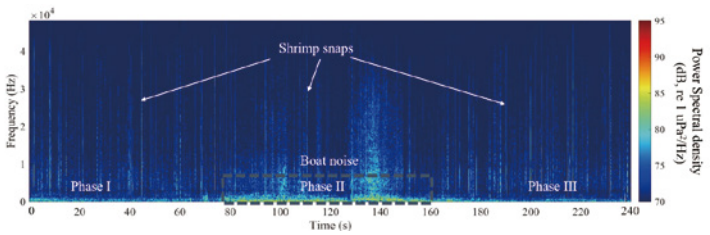


东山珊瑚礁保护区声学观测

Acoustic Monitoring in the Coral Reef Protection Area at Dongshan Bay

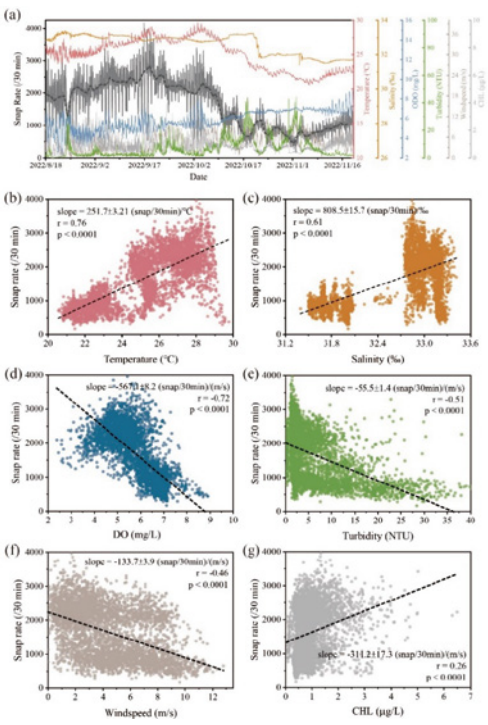
东山鱼排声学观测及船舶噪声来源

Acoustic Monitoring at a Fish Platoon in Dongshan Bay and the Boat Noise Source



东山鱼排声景时频图

The Spectrogram of Soundscape at a Fish Platoon in Dongshan Bay



鼓虾发声率及部分环境因子变化

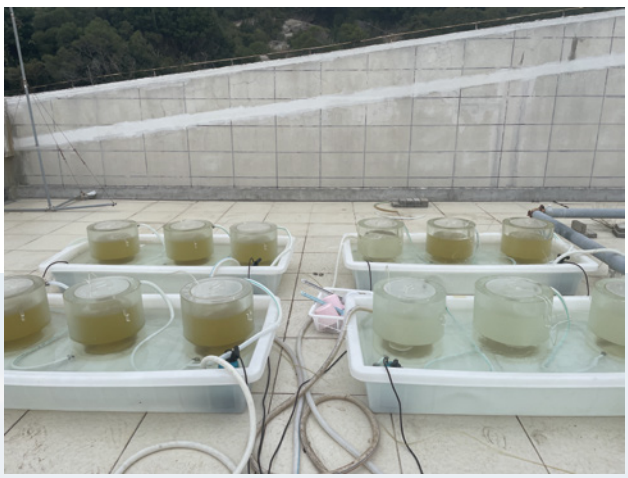
Change Trend of Snap Rate and Some Environmental Factors

东山近海浮游植物群落固碳与环境变化关系研究

Study on the Relationship Between Carbon Sequestration and Environmental Change of Phytoplankton Community in Dongshan Coastal Area

该研究依托东山实验场开展了东山近海浮游植物群落固碳与环境变化关系的研究。建立了微尺度实验系统，通过模拟海洋热浪、海洋暖化和海洋酸化等环境条件，开展微尺度培养实验。研究结果表明，在中国南部沿海水域，关键的浮游植物功能类群在经历3℃升温的MHWs影响下表现出显著的韧性、恢复能力和时间稳定性。然而，在MHWs期间，初级生产力的下降以及生物量密度的减少可能会显著影响次级生产者。此外，浮游植物群落结构的改变至少在MHWs期间可能会对沿海食物网过程产生影响。

This study investigated the relationship between carbon sequestration by phytoplankton communities in the coastal waters near Dongshan and environmental changes, utilizing data observed at D-SMART. A microscale experimental system was established at D-SMART to conduct microscale culture experiments under simulated environmental conditions, including marine heatwaves (MHWs), ocean warming, and ocean acidification. This study indicates that key phytoplankton functional groups in the southern coastal waters of China exhibited significant resilience, recovery capacity, and temporal stability under the influence of MHWs with a temperature increase of 3°C. However, reduced primary productivity during MHWs events, along with decreased biomass density, might significantly impact secondary producers. In addition, changes in the phytoplankton community structure may influence coastal food web processes, particularly during MHW events.



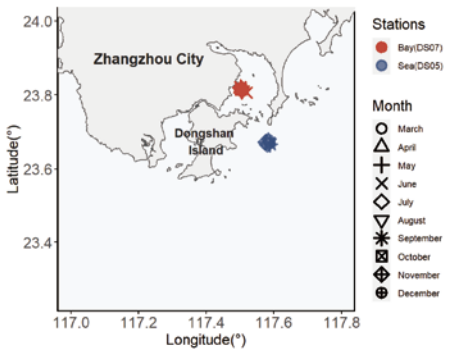
微尺度培养系统
Microscale Cultivation System

亚热带近岸海域浮游植物对温度和营养盐耦合作用的响应

Response of Phytoplankton Growth to Temperature and Nutrient Interaction in Subtropical Coastal Waters

该研究依托东山实验场开展了一系列温度和营养盐调控的稀释实验，以此探究温度和营养盐耦合作用的效应对亚热带近岸海域浮游植物群落的影响。目前该实验得到初步的实验结果：东山湾浮游植物群落的内禀生长率对温度变化的响应特征基本满足左偏的单峰函数，升温促进浮游植物群落的生长，但当温度超过其最适生长温度之后，即便是微小的升温都会导致浮游植物的生长率快速下降。在升（降）温基础上加入营养盐浓度变化后，东山湾浮游植物群落生长的热相应出现了明显变化。当营养盐浓度较低时，浮游植物群落的最大生长速率和最适生长温度都受到了不同程度的抑制，说明当环境中营养盐缺乏时，会加剧升温对浮游植物群落生长的不利影响。

This study conducted a series of temperature- and nutrient-manipulated dilution experiments at D-SMART, focusing on two subtropical coastal sites in Dongshan Bay, to investigate the effects of temperature and nutrient coupling on phytoplankton community growth rates. The intrinsic growth rate of the phytoplankton community in Dongshan Bay exhibits a left-skewed unimodal response to temperature variations. While warming enhances phytoplankton growth, a rapid decline in growth rate occurs when temperature exceeds the optimal threshold, even with minor increases. The thermal response of phytoplankton community growth in Dongshan Bay shows significant changes when nutrient concentration variations are combined with temperature fluctuations. Under low nutrient conditions, both the maximum growth rate and the optimal growth temperature of the phytoplankton community are significantly reduced. This indicates that nutrient limitation exacerbates the negative effects of warming on phytoplankton community growth.

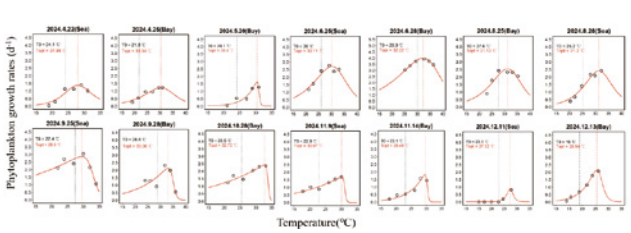


东山湾的采样站位

The Location of the Stations in Dongshan Bay

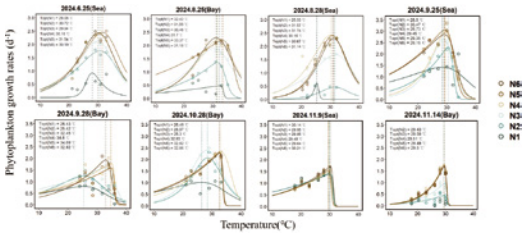
东山实验场的温控培养系统

Temperature-regulated Incubation System in D-SMART



不同月份浮游植物群落内禀生长率对升温的响应。红色垂直虚线表示浮游植物群落的最适生长温度（T_{opt}），而黑线表示原位海表温度（SST）

Responces of phytoplankton community intrinsic growth rates to warming in different months. The red vertical dashed lines represents the optimal growth temperature (T_{opt}) of the phytoplankton community, while the black lines represents the in situ sea surface temperature (SST).



不同月份不同营养盐条件下浮游植物群落生长对升温的响应。图中不同颜色的曲线代表了不同的营养盐梯度，N1到N6表示营养浓度从低到高逐渐增加

Response of phytoplankton community growth rates to warming under different nutrient conditions across various months. The curves of different colors in the figure represent distinct nutrient gradients, with N1 to N6 indicating increasing nutrient concentrations from low to high.

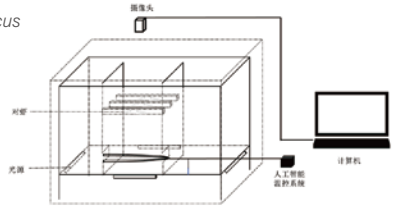
日本囊对虾多性状测评选育研究

Multi-trait Evaluation and Selection of Kuruma Shrimp, *Penaeus japonicus*

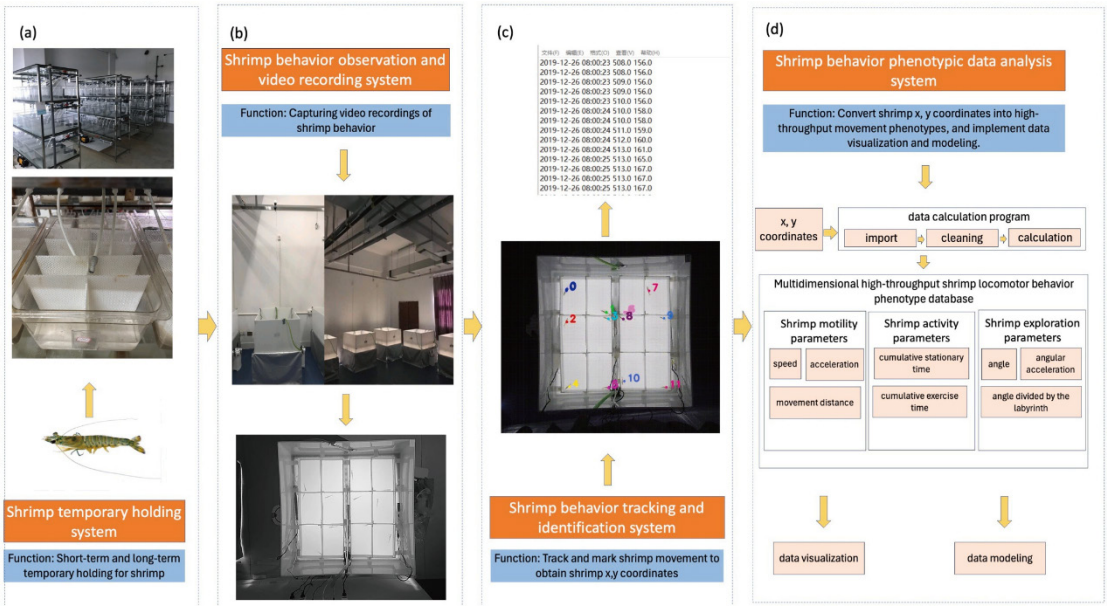
该研究依托东山实验场的场地与实验资源开展，开发设计了对虾高通量行为表型观测平台及对虾心率观测装置。基于这两套装置，采用传统测评方法及高通量表型观测方法相结合的方式，对日本囊对虾耐WSSV、耐低盐、耐亚硝酸盐及耐高温等性状进行了研究探索，制定了基于计算机视觉技术高效筛选优良性状个体的新方法并应用在对虾选育工作中。当前已成功选育出能够稳定性状遗传的耐高温日本囊对虾新品系，耐热性能显著提升，针对其他抗性性状的选育工作也得到了快速推进。

The research, conducted by utilizing the facilities and experimental resources at D-SMART, led to the development and design of a high-throughput behavioral phenotype monitoring platform and a heart rate monitoring device for shrimp. Based on these two systems, the group adopted a combination of traditional evaluation methods and high-throughput phenotypic monitoring techniques to investigate the traits of *P. japonicus*, including resistance to WSSV (White Spot Syndrome Virus), low salinity, nitrite toxicity, and high temperatures. We established a new method for efficiently screening individuals with desirable traits based on computer vision technology, which has been applied in the shrimp breeding process. To date, the group has successfully bred a new *Penaeus japonicus* line with stable genetic inheritance of high-temperature resistance, significantly improving heat tolerance. Additionally, the breeding efforts for other resistance traits have been rapidly advanced.

日本囊对虾
Penaeus japonicus



对虾心率表型观测装置
Shrimp Heart Rate Phenotype Monitoring Device



高通量对虾行为表型平台架构
The Architecture of the High-throughput Shrimp Behavioral Phenotyping Platform

科研课题
Research Projects

新增项目介绍 Introduction of New Projects

海洋新陈代谢与元素循环

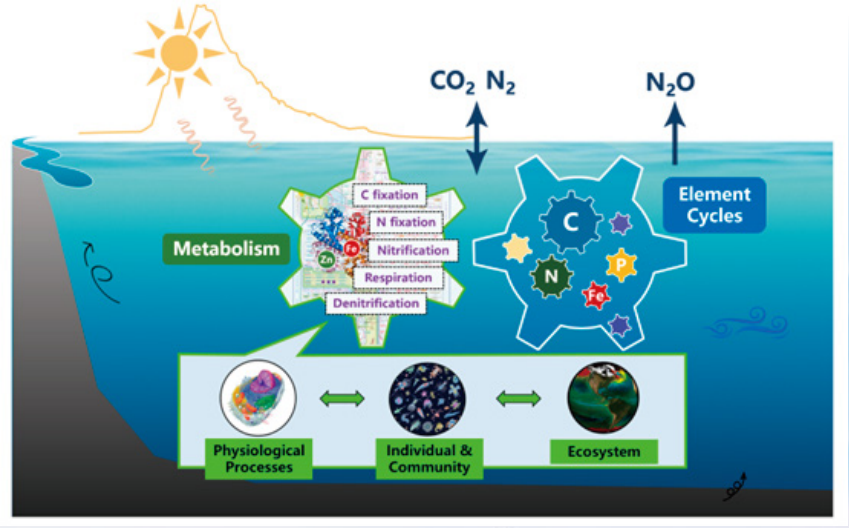
Marine Metabolism and Element Cycles

国家自然科学基金创新研究群体项目 2025–2029 | 史大林、张瑶、洪海征、曹知勉、柳欣、沈渊

NSFC Innovation Research Group project 2025–2029 | Dalin Shi, Yao Zhang, Haizheng Hong, Zhimian Cao, Xin Liu, Yuan Shen

群体汇聚海洋生理生态学、微生物海洋学、海洋生物地球化学的优势力量，围绕“海洋新陈代谢与元素循环”这一前沿研究方向，在海洋微生物代谢与碳氮循环、浮游植物碳氮及能量代谢、痕量元素生物地球化学循环等方面取得一系列重要进展。群体成员将进一步深化合作研究，揭示海洋浮游生物新陈代谢的时空格局和调控因子，阐明其与元素循环的耦合关系和机制，进而评估和预测其对全球变化的响应和反馈，以期在海洋浮游生物新陈代谢与元素循环领域取得突破性成果，在国际上占有一席之地。

The group brings together expertise in marine ecophysiology, microbial oceanography, and marine biogeochemistry, united by a shared research interest in marine metabolism and element cycles. Through collaboration, group members have made important advancements in understanding marine microbial carbon and nitrogen metabolism, phytoplankton carbon, nitrogen, and energy metabolism, and the biogeochemical cycling of trace elements in the ocean. Looking ahead, the group aims to deepen collaborations to unveil spatiotemporal patterns and regulatory mechanisms of marine plankton metabolism, reveal its coupling relationships and mechanisms with element cycling, and evaluate and predict its responses and feedbacks to global change. The ultimate goal is to achieve breakthroughs and establish international prominence in the field of marine plankton metabolism and elemental cycles.



群体研究方向：海洋新陈代谢与元素循环

The Research Direction of the Group: Marine Metabolism and Element Cycles

新增项目介绍 Introduction of New Projects

海洋生物资源保护与可持续利用

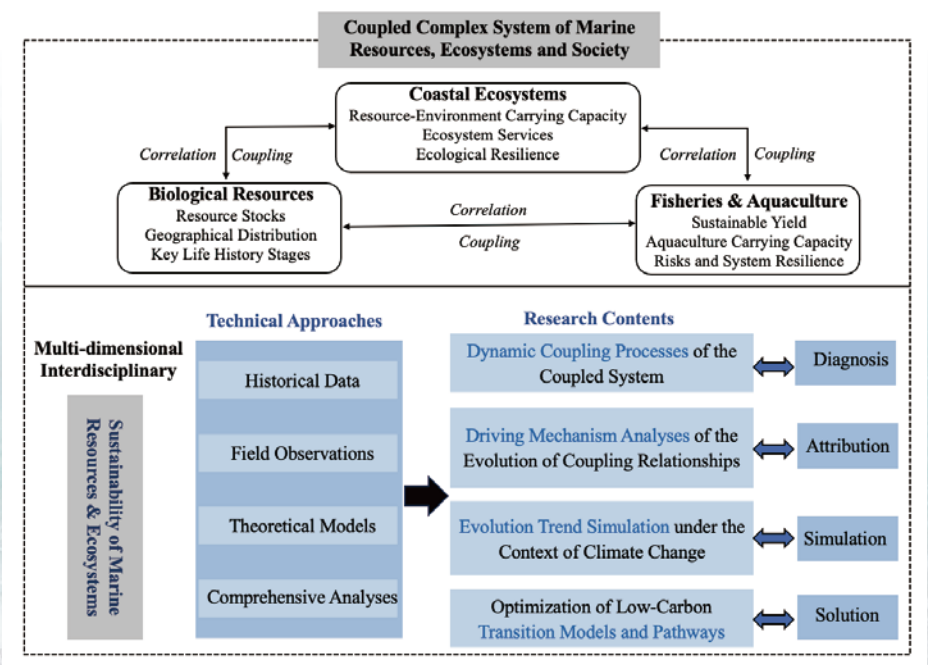
Marine Biological Resource Conservation and Sustainable Utilization

国家杰出青年科学基金项目 2025–2029 | 曹玲

National Science Fund for Distinguished Young Scholars | Ling Cao

项目针对我国及全球海洋生物资源开发利用过程中已经累积和正在形成的生态环境和产业效能两大问题，重点建立全球变化压力下近海渔业资源–生态–社会复合系统耦合互馈的动态综合分析框架。研究采用诊断–归因–模拟–应对的多层次研究路径，深入探究气候变化驱动下的近海渔业资源–生态–社会复合系统的动态演变规律、响应特征及协同机制。通过多维风险评估与定量解析，项目为提出兼顾资源养护、生态安全、减碳增汇、价值产出的协同可持续发展与调控策略提供科学支撑与决策依据。

This project addresses the longstanding and emerging ecological, environmental, and industrial efficiency challenges arising from the development and utilization of marine biological resources in China. It aims to establish a dynamic, integrative analytical framework that captures the coupled feedback mechanisms among coastal fishery resources, ecosystems, and socio-economic systems under global changing conditions. Employing a multi-tiered research strategy encompassing diagnosis, attribution, simulation, and response, the project will examine the dynamic evolution, adaptive responses, and synergistic processes within these coastal resource–ecology–society networks. Ultimately, it seeks to quantify and identify multidimensional risks and to propose integrated, sustainable development and regulatory strategies that balance resource conservation, ecological security, carbon reduction and sequestration, and enhanced economic value creation.



海洋渔业资源–生态–社会复合系统

Marine Fishery Resources-Ecology-Society Integrated System

新增项目介绍 Introduction of New Projects

全球暖化下海洋典型自养微生物的生态进化策略及其对元素循环的影响

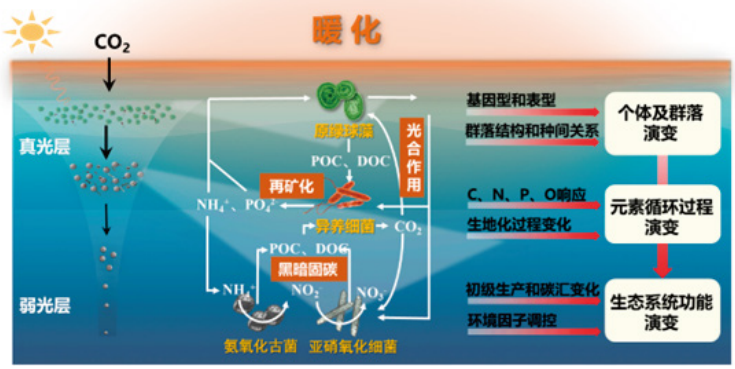
Ecological and Evolutionary Strategies of Marine Autotrophic Microorganisms under Global Warming and Their Impacts on Biogeochemical Cycling

国家自然科学基金委重点项目 2025–2029 | 张瑶

NSFC Key Project 2025–2029 | Yao Zhang

本项目拟聚焦海洋最优势的自养微生物——真光层光合自养的原绿球藻和深海化能自养的硝化菌，通过结合室内长期传代实验、海域现场观测、全球宏组学分析和地球系统数值模拟，开展海洋典型自养微生物的基因组演化、物质和能量代谢的响应、进化和生态学策略及其对全球尺度海洋生态系统和元素循环的影响研究。本项目将明确典型物种对海洋升温的短期响应和长期适应的差异，揭示其长期适应下的基因组演化特征、生理表型的变化，以及种间关系的演变趋势；阐明温度对种群结构、关键功能基因特征和表达谱、微生物介导的固碳储碳、氮磷吸收和转化、产氧耗氧等重要元素循环关键过程的调控机理；形成一套升温影响下的典型物种、种群、群落生长和代谢过程参数，通过优化构建模型，预测全球变暖驱动的自养微生物变迁对海洋关键元素循环的影响和对气候变化的反馈。

This project focuses on the most dominant/key groups of marine primary producers, namely *Prochlorococcus* in the euphotic zone and nitrifiers in the dark ocean. Through a combination of long-term serially propagated experiments in the laboratory, field observations, global multi-omics analysis, and Earth system numerical simulations, this project will investigate the genome evolution, responses of matter and energy metabolism, and the evolution and ecological strategies of typical autotrophic marine microbes, as well as their impacts on the global-scale marine ecosystem and elemental cycling. This project will achieve the following three objectives: (1) Clarify the differences in short-term responses and long-term adaptation of typical species to ocean warming, unveil their genome evolution characteristics and physiological phenotype changes under long-term adaptation, as well as explore the evolution trends of interspecies relationships; (2) Elucidate the regulatory mechanisms of temperature on population structure, key/functional genefeatures and expression profiles, as well as important biogeochemical cycling processes such as microbial-mediated carbon sequestration, nitrogen/phosphorus assimilation and transformation, and oxygen production and consumption; (3) Establish a set of parameters for the growth and metabolic processes of typical species, populations, and communities under warming effects; and construct and optimize models to predict the impact of warming-driven shifts of autotrophic microbes on key element cycles in the ocean and their feedback to climate change.



项目关键科学问题和主要研究内容

The Key Scientific Issues and Main Research Contents of the Project

新增项目介绍 Introduction of New Projects

南方典型海岸带生态系统和生态廊道近自然修复技术研发与集成示范

Research and Integrated Demonstration of Near-natural Restoration Techniques for Typical Coastal Ecosystems and Ecological Corridors in Southern China

国家重点研发计划项目 2024–2027 | 黄凌风

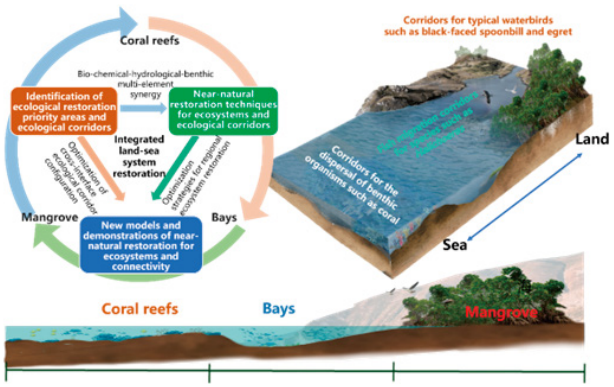
National Key Research and Development Program 2024–2027 | Lingfeng Huang

海岸带是国家生态安全与社会经济可持续发展的战略区域。但是，由于生态脆弱性高，在人类活动和气候变化剧烈影响下，海岸带生态系统面临着退化甚至发生稳态转换的巨大风险，科学保护修复和准确观测预警是扭转退化、防范风险的关键。

项目围绕南方典型海岸带生态系统和连通性近自然修复关键技术研究与示范任务，选取福建云霄到东山沿海的红树林、海湾和珊瑚礁等典型海岸带生态系统，以陆海统筹和系统修复理念为指导，基于自然的解决方案，研发并集成多项近自然修复关键技术，采用跨生态系统界面的生态廊道优化配置和区域生态系统修复优化策略，构建生物–化学–水文–底质多要素协同的、以“红树林–海湾–珊瑚礁”为代表的我国南方典型海岸带生态系统和连通性近自然修复新模式，并开展应用示范和修复成效评估，从而为科学开展南方海岸带区域生态系统和连通性修复提供关键技术支撑，并为突破海岸带生态保护修复从局部单一生态系统类型向区域多种生态系统转变的技术瓶颈提供新范式。

The coastal zone is a strategic area critical for national ecological security and sustainable socio-economic development. However, due to its high ecological vulnerability, coastal ecosystems are at significant risk of degradation and even potential regime shifts, which are further exacerbated by intense human activities and climate change. Therefore, scientific protection, restoration efforts, and accurate monitoring and early warning systems are essential to reversing degradation and preventing further risks.

The project focuses on the research and demonstration of key near-natural restoration techniques for typical coastal ecosystems and their connectivity in the southern regions of China. It specifically selects representative coastal ecosystems along the Fujian coast, from Yunxiao to Dongshan, including mangroves, bays, and coral reefs. Guided by the principles of integrated land-sea management and system restoration, the project aims to develop and integrate multiple near-natural restoration technologies based on nature-based approaches. By optimizing the configuration of ecological corridors across ecosystem interfaces and implementing regional ecosystem restoration strategies, the project seeks to establish a new model for the near-natural restoration of southern China's typical coastal ecosystems and their connectivity, represented by the "mangrove-bay-coral reef" system. This model will be characterized by the synergistic collaboration of biological, chemical, hydrological, and substrate factors. Additionally, the project will carry out demonstration applications and evaluation of restoration effectiveness. The goal is to provide critical technical support for the scientific restoration of regional coastal ecosystems and their connectivity, offering a new paradigm for overcoming the technical bottlenecks in transitioning coastal ecosystem protection and restoration from focusing on isolated, single ecosystem types to a broader, multi-ecosystem approach.



南方典型海岸带生态系统及连通性近自然修复新模式

New Approaches for Near-natural Restoration of Typical Coastal Ecosystems and Connectivity in Southern China

新增项目介绍 Introduction of New Projects

中法海洋微型生物生态学联合实验室

Sino-French Joint Laboratory of Marine Microbial Ecology

国家重点研发计划 2025–2027 | 黄邦钦（参与）

National Key Research and Development Programs 2025–2027 | Bangqin Huang（Co–PI）

海洋病毒、细菌、自养生物、鞭毛虫和纤毛虫等生物类群构成的微食物网，是海洋生态系统中碳流和能流的主要承载者，目前对于不同营养状态海区微食物网结构差异及其调控机制、微食物网对环境胁迫和海洋过程的响应等关键科学问题的研究仍相对薄弱。

本项目聚焦于微食物网生态学研究的前沿领域，通过中法合作，深入探讨微食物网生物在不同营养状态海区的结构差异、短时动态及其与环境胁迫的关系，以及微食物网生物对海洋中小尺度物理过程的响应机制。项目基于中国近海的胶州湾、东山湾和地中海沿岸的马赛湾，开展周年逐月观测和高频原位观测，结合SWOT卫星遥感技术，解析微食物网生物的时空分布特征及其与海洋物理过程的耦合关系。

项目拟开展以下主要工作：

（1）在胶州湾、东山湾和马赛湾开展了系统的微食物网生物观测，揭示了不同营养状态海区微食物网结构的显著差异，验证了寡营养海区微食物网生物量较低且结构更简单的假设。

（2）利用高频原位流式细胞仪在浮标和海洋野外台站岸基观测平台进行连续观测，解析了微食物网生物对短时环境变化（如天气事件和水团移动）的快速响应机制。

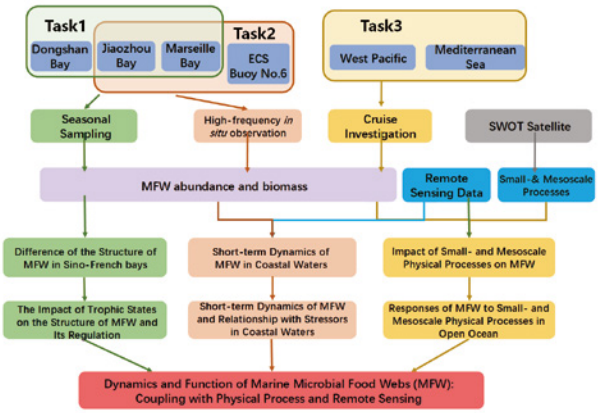
（3）结合SWOT卫星数据和船基现场观测，研究了微食物网生物在海洋中小尺度涡旋和锋面中的分布特征，揭示了海洋物理过程对微食物网生物分布的调控作用。

本项目中方团队由中国科学院海洋研究所张武昌牵头（项目负责人）、厦门大学（黄邦钦）、中国海洋大学、上海交通大学和南方海洋科学与工程广东省实验室（广州），法方团队为地中海海洋研究所。

The project focuses on the structure and dynamics of marine microbial food webs in different trophic states of oceanic regions. It aims to provide a comprehensive understanding of the differences in microbial food web structures between eutrophic and oligotrophic areas, the short-term dynamics of microbial food web organisms in response to environmental stressors, and the responses of microbial food web organisms to small- and mesoscale oceanic physical processes.

The work plan in the project includes: 1) Conducting systematic surveys of microbial food web organisms in Jiaozhou Bay, Dongshan Bay, and the oligotrophic Marseille Bay, revealing significant differences in microbial food web structures between different trophic states. 2) Using high-frequency in situ flow cytometry for continuous observations at the East China Sea buoy and Jiaozhou Bay shore-based observation platform, elucidating the rapid response mechanisms of microbial food web organisms to short-term environmental changes such as weather events and water mass movements. 3) Combining SWOT satellite data and ship-based field surveys to study the distribution characteristics of microbial food web organisms in small- and mesoscale oceanic eddies and fronts, revealing the regulatory effects of oceanic physical processes on the distribution of microbial food web organisms.

The Chinese team is led by Zhang Wuchang from the Institute of Oceanology, Chinese Academy of Sciences (project leader), and includes Xiamen University (Huang Bangqin), Ocean University of China, Shanghai Jiao Tong University, and Guangdong Provincial Laboratory of Southern Marine Science and Engineering (Guangzhou). The French team is the Mediterranean Institute of Oceanography.



技术路线
Project Framework

在研项目进展 IProgress of Ongoing Projects

海洋酸化与暖化对浮游植物光合固碳与甲烷释放的影响及其机制

Impacts of Ocean Acidification and Warming on the Mechanistic Coupling Between Photosynthetic Carbon Fixation and Methane Release By Phytoplankton

国家自然科学基金国际(地区)合作与交流项目 2024–2026 | 高坤山

NSFC International (Regional) Cooperation and Exchange Program 2024–2026 | Kunshan Gao

甲烷分子温室效应是CO_2的约30倍。浮游植物在光合固碳的同时释放甲烷，削弱自身通过生物碳泵“抑”温室效应的贡献。浮游植物产甲烷过程对气候变化的响应，关系到海洋对气候的反馈效应。本项目开展了不同规模的实验（受控、中尺度及甲板培养），探讨酸化与暖化条件下浮游植物甲烷释放与光合固碳等过程的关联，揭示近海浮游植物甲烷产量与固碳量的比值，为认知海洋温室气体汇源通量与变化趋势提供科学认知与参数。

Methane (CH_4), a key greenhouse gas, is about 30 times more potent than CO_2 per mol in terms of warming the earth. The recently proven methane release by phytoplankton during photosynthesis has been hypothesized to be partly responsible for net oceanic CH_4 emission. Impacts of ocean acidification (OA) and warming (OW) on the coupling of phytoplankton CO_2 fixation and CH_4 production can affect the capacities of the oceanic sink and source of these greenhouse gases and are closely related to feedbacks of marine ecosystems to climate change. We perform differently scaled experiments: from controlled laboratory experiments under future OA and OW scenarios on cyanobacterial diazotrophs, coccolithophores, and diatoms, to mesocosm, and on-deck incubations of coastal phytoplankton populations, to research the phytoplankton CH_4 production and its relationship with photosynthetic C fixation, and assess its ratios to photosynthetic C fixation under influences of OA and OW. The generated data from this project provide fundamental understanding of the proportional changes of phytoplankton CH_4 production and photosynthetic C fixation and related mechanisms, which is essential for predicting oceanic sinks and sources of these greenhouse gases and their climate change feedbacks and for better constraining the current global CH_4 budget.

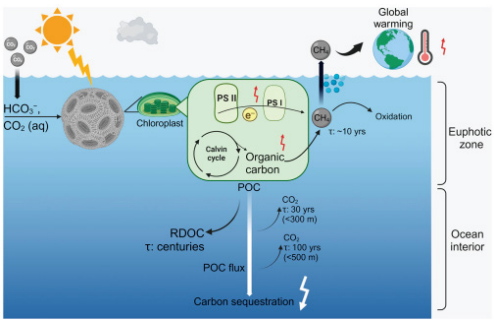
项目已取得的主要进展如下：

（1）东山湾（中国东海南部）浮游植物群落甲烷产量与光合固碳量、浮游植物生物量及主要营养盐呈明显的正相关关系；

（2）束毛藻每同化227–494 mol CO_2释放1 mol CH_4，因产生甲烷而削弱其固碳效应 (抑温室效应) 超过1%；

（3）颗石藻仅在光照下产生甲烷，甲烷产量与相对电子传递速率、与光合固碳量之间呈显著正相关关系，在最适光强下，颗石藻每固定一个二氧化碳能释放出7×10^{-5}个甲烷。

The main progresses achieved in the project are as following:
(1) there is a significant positive correlation between the methane production of the phytoplankton community in Dongshan Bay (southern part of the East China Sea) and the photosynthetic carbon fixation amount, phytoplankton biomass, and major nutrients;
(2) the methane production rates of Trichodesmium showed robust positive correlations with the assimilation rates of carbon, resulting in the methane production quotients of 227-494 for carbon, which can offset about 1% of its CO_2 mitigation effects;
(3) the bloom-forming marine microalga *Emiliania huxleyi* released methane during photosynthesis (did not generate it in darkness) while grown under different light levels, the amount of methane released correlated positively with photosynthetic electron transfer and carbon fixation. The microalga released up to 7 moles methane while fixing about 10^5 moles of carbon dioxide.



微藻赫氏颗石藻（*E.huxleyi*）产生甲烷（CH_4）的概念性图示。甲烷在光合作用过程中产生，微藻的碳封存对全球变暖呈现出拮抗反馈作用。海洋中由光合作用驱动产生的甲烷可能会影响其向上的通量，从而很可能抵消涉及难降解溶解性有机碳（RDOC）和生物二氧化碳泵（BCP）的浮游植物碳封存作用

Conceptual illustration of CH_4 production by the microalga *Emiliania huxleyi*. The CH_4 produced during photosynthesis and the microalgal carbon sequestration exhibit antagonistic feedbacks to global warming. The photosynthesis-driven CH_4 in the oceans may affect its upward flux, thereby likely counteract phytoplankton carbon sequestration involving refractory dissolved organic carbon (RDOC) and biological CO_2 pump (BCP).

在研项目进展 IProgress of Ongoing Projects

海水养殖区微塑料污染与微塑料际微生物多样性特征及降解机制研究

Microplastic Pollution, Microbial Diversity and Degradation Mechanism of Microplastics in Maricultural Area

国家区域创新发展联合基金项目 2024-2027 | 王新红

National Science Joint Fund for Regional Innovation and Development | Xinhong Wang

微塑料被称为“海中的PM2.5”，对海洋生态系统造成潜在的影响，污染周围环境并危害海洋生物和人类健康。作为生物体内菌群关系最复杂、多样的微生物群落，肠道微生物既是微塑料胁迫的主要关卡，也是重要的“生物反应器”，其对微塑料的降解潜力在昆虫等无脊椎动物体内已被证实。相比于无脊椎动物，水生动物肠道作为微塑料生物富集和微生物互作的重要场所，水生动物肠道微生物可能是水体环境中微塑料生物降解的驱动力之一，其在微塑料污染严重的海水养殖区域中对微塑料的生物降解潜力尚不明确，其生物降解潜力和降解机制亟待进一步地探索和研究。

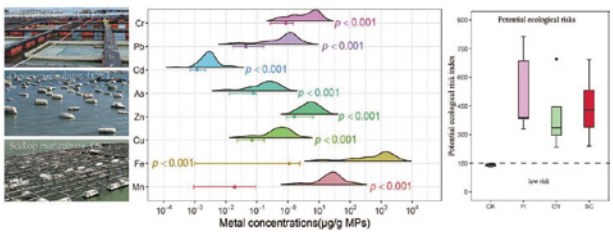
本项目以福建省典型集约化海水养殖区为主要研究区域，通过现场观测、原位实验和实验室模拟，采用显微成像系统以及多组学技术，阐明海水养殖区微塑料的污染特征和微塑料际微生物的多样性特征；构建微塑料-海水-海洋模式鱼类（海水青鳉，*Oryzias melastigma*）微宇宙体系，研究鱼体肠道微生物组成、丰度及多样性等特征，结合微塑料降解的关键过程，评估微生物降解微塑料的潜力；筛选、分离、鉴定微塑料关键降解菌，基于生物信息处理，揭示微生物降解微塑料的关键机制。该研究将为深入研究微塑料和微生物相互作用机制和养殖海域微塑料防治提供重要科学依据。

本年度主要完成了海水养殖区微塑料对金属的吸附特征及其影响因素研究、构建了微塑料-人工海水-海水青鳉实验室微宇宙体系；研究微塑料暴露海水青鳉对肠道微生物多样性的影响；构建了海水养殖区沉积物-微塑料降解体系，对潜在微塑料降解菌进行分离与筛选。

Microplastics, known as "PM2.5 in the sea", have the potential impact on marine ecosystems, pollute the surrounding environment andhazard to wildlife and human health. As the most complex and diverse microbial community in organisms, intestinal microbes are not only the main checkpoint of microplastic stress, but also an important "bioreactor". Their degradation potential for microplastics has been confirmed in insects and other invertebrates. Compared with invertebrates, aquatic animal gut is an important site for microplastic bioaccumulation and microbial interaction. Aquatic animal intestinal microbes may be one of the driving forces for the biodegradation of microplastics in the aquatic environment.However, their biodegradation potential for microplastics in marine aquaculture areas with severe microplastic pollution is still unclear, and its biodegradation potential and degradation mechanism need to be further explored and studied.

In this project, the typical intensive marine aquaculture area in Fujian Province is taken as the main research area, and the pollution characteristics of microplastics and the diversity characteristics of microplastics in the marine aquaculture area are clarified through field investigation, in-situ experiments and laboratory simulations. Analytical instrument such as flourier infrared spectroscopy (μ-FTIR), nano-scale hyperspectral microscopic imaging system, pyrolysis gas chromatography-mass spectrometry (PY-GC-MS) and new technologies such as transcriptome, metagenome and microfluidic chip were used to clarify the pollution characteristics of microplastics and the diversity characteristics of microplastics in maricultural areas. We also aim to investigate the composition, abundance and diversity of fish gut microbes and evaluate the potential of microbial degradation of microplastics by combining with the key processes of microplastic degradation by constructing microplastic-sea water-marine fish (*Oryzias melastigma*) microcosmic system. Finally, the key microplastics degrading bacteria were screened, isolated and identified. The degradation products and degradation pathways of microplastics were analyzed through bioinformatics processing, and the key mechanism of microbial degradation of microplastics was revealed. This study will provide an important scientific basis for understanding the interaction mechanism between microplastics and microorganisms and preventing and controlling microplastic pollution in the aquatic environment.

In this year, the adsorption characteristics and influencing factors of microplastics on metals in marine aquaculture areas were studied, and the microcosmic system of microplastics-artificial seawater-medaka laboratory was constructed. To study the effects of microplastic exposure to medaka on intestinal microbial diversity,asediment-microplastic degradation system was constructed in marine aquaculture area, and potential microplastic-degrading bacteria were isolated and screened.



养殖区微塑料对重金属的吸附加剧了其对海洋生物的潜在风险

Adsorption of Metals on Aged Microplastics in Intensive Mariculture Areas

在研项目进展 IProgress of Ongoing Projects

科学传播类：依托国家野外站和国际重要湿地联合推进“保护红树林生态系统”科普宣教

Science Communication: Jointly Promote “Protect the Mangrove Ecosystems” Popular Science Education Based on National Observation and Research Station and Ramsar Site

国家自然科学基金科普项目 2024–2025 | 张雅棉

NSFC Science Popularization Project 2024–2025 | Yamian Zhang

项目针对公众尤其是青少年群体对红树林的保护意识依然欠缺等问题，依托厦门大学福建台湾海峡海洋生态系统国家野外科学观测研究站和漳江口国际重要湿地，充分发挥高水平科研平台的研究优势和人才优势，以及国际重要湿地的资源优势，精准对接中小学生群体，构建红树林科普服务平台，打造多层次、专业化、系统性科普课程体系，培训以中小学教师为主的科普骨干，建设科普学校，并向区域乃至全国推广，服务我国红树林保护管理科普宣教工作。

The project focuses on the issue that public awareness of the protection and management of mangroves is still lacking, especially among the teenagers. In this case, by taking the advantages of research and talents of high-level scientific research platform, as well as the resources of Ramsar Site of International Importance, this project will establish a mangrove science popularization platform, create a multi-leveled, specialized, and systematic mode of mangrove popular science curriculum system, train the primary and secondary school teachers to become the backbone of mangrove science popularization, and set up a demonstration in primary and secondary schools based on the National Observation and Research Station for the Taiwan Strait Marine Ecosystem and Zhangjiang Estuary Ramsar Site. All the activities included in our project will be promoted widely to the region and even the whole country, and serve the popularization and education of mangrove conservation and management.

项目进展：

（1）组建了红树林科普活动团队；

（2）面向福建省云霄第一中学师生，开展红树林科普讲座等系列活动。

Project Progress:

(1) Mangrove science popularization team has been established;

(2) A series of educational activities, including lectures on mangrove ecosystems,and workshops have been organized for teachers and students of Yunxiao No.1 Middle School.

项目工作思路
Project Work Plan

红树林科普进校园
Mangrove Educational Workshop for Students of Yunxiao No.1 Middle School

成果亮点
Research Highlights

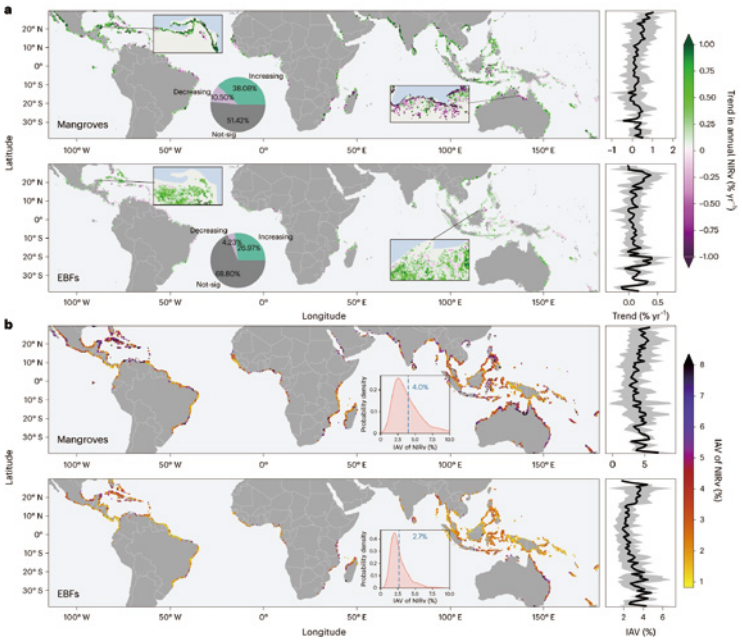
红树林较之陆地森林有更强的绿化趋势和年际变异

Stronger Increases but Greater Variability in Global Mangrove Productivity Compared to that of Adjacent Terrestrial Forests

红树林是一种重要的蓝碳生态系统，但现有研究极少关注红树林在响应气候变化方面相较陆地森林的特异性，且目前针对陆地生态系统的研究也常因使用低分辨率数据而忽略了面积相对较小的红树林生态系统。

本研究运用遥感MODIS较高分辨率（250m）波段数据分析了全球红树林和其邻近常绿阔叶林（EBFs）在2001–2020年的趋势和年际变异，发现红树林发生了显著且广泛的生产力增加现象，生产力增长趋势较陆地森林更强，但与此同时也显示出更大的生产力年际波动性。通过构建多变量线性模型进行各因子贡献度分解，研究进一步揭示红树林生产力比邻近 EBFs 受到更强的 CO_2 施肥效应，二者生产力增加趋势的差异可被 CO_2 施肥造成的趋势差异解释，而温度、降水、风速和水汽压赤字等气候因素对生产力趋势影响较小。红树林生产力更大的年际波动性可归因于其受到海平面年际波动的独特影响以及比陆地森林更高的降雨敏感性。红树林对降雨等水文气候条件更强的敏感性以及 CO_2 施肥效应更强的原因是其有更少的冠层蒸腾和更高的边际水分利用效率，因此在水分可获得性增加或气孔导度下降引起的水分丧失减少（即间接的水分增加）的情况下红树林生产力会有更大的变化。

Mangrove forests are a highly productive ecosystem with important potential to offset anthropogenic greenhouse gas emissions. Mangroves are expected to respond differently to climate change compared to terrestrial forests owing to their location in the tidal environment and unique ecophysiological characteristics, but the magnitude of difference remains uncertain at the global scale. Here we use satellite observations to examine mean trends and interannual variability in the productivity of global mangrove forests and nearby terrestrial evergreen broadleaf forests from 2001 to 2020. Although both types of ecosystem experienced significant recent increases in productivity, mangroves exhibited a stronger increasing trend and greater interannual variability in productivity than evergreen broadleaf forests on three-quarters of their co-occurring coasts. The difference in productivity trends is attributed to the stronger CO_2 fertilization effect on mangrove photosynthesis, while the discrepancy in interannual variability is attributed to the higher sensitivities to variations in precipitation and sea level. Our results indicate that mangroves will have a faster increase in productivity than terrestrial forests in a CO_2-rich future but may suffer more from deficits in water availability, highlighting a key difference between terrestrial and tidal ecosystems in their responses to climate change.



2001–2020 年全球红树林及其邻近陆地常绿阔叶林生产力指标近红外反射率 (NIRv) 时空变化

Changes in NIRv During 2001–2020 for Mangroves and EBFs at the Dlobal Scale

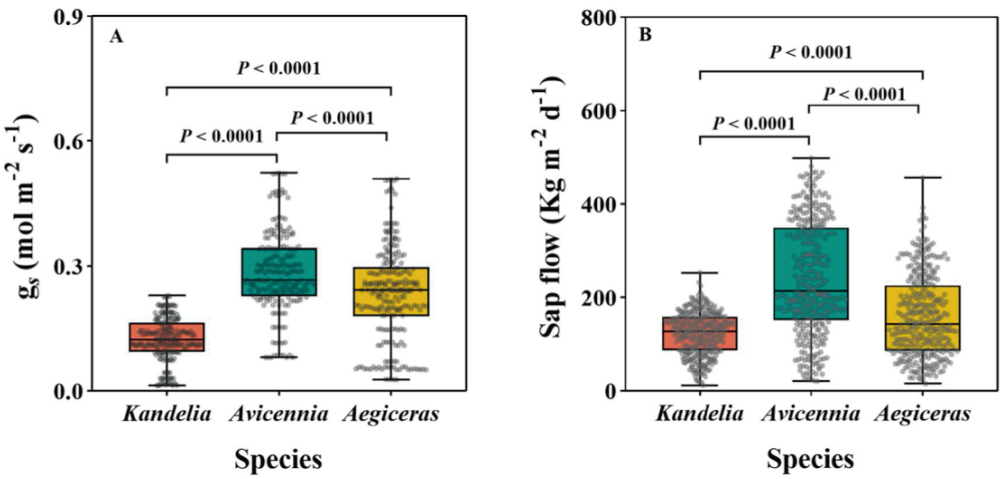
以上工作于2024年1月发表在 *Nature Ecology & Evolution* 期刊上，2019级博士生张振为第一作者，李杨帆教授为共同通讯作者。

Reference:
Zhang, Z; Luo, XZ*; Friess, DA; Wang, SH; Li, Y; Li, YF*. Stronger increases but greater variability in global mangrove productivity compared to that of adjacent terrestrial forests. *NATURE ECOLOGY & EVOLUTION*, 2024, 8(2): 239-250.

亚热带三种红树植物的水分利用策略研究：基于液流与气体交换的定位观测

Comparative Analysis of Water-use Strategies in Three Subtropical Mangrove Species: A Study of Sap Flow and Gas Exchange Monitoring

红树林在高盐生境中面临着独特的水分胁迫挑战，维持水分平衡是其重要的生理适应策略。尽管如此，关于不同红树物种水分利用策略及其对环境的响应机制仍缺乏深入研究。团队依托厦门大学台海站，在云霄选取亚热带三种主要红树林物种——白骨壤、桐花树和秋茄为研究对象，通过长期的树干液流观测、叶片气体交换和树干直径变化测量，揭示了不同物种的水分利用策略及其对环境因素的响应机制。研究发现，三种红树植物表现出不同的水分利用策略：白骨壤液流密度峰值较早出现，且其树干水分储存与液流同步调节；秋茄和桐花树则依赖树干储存水来满足水分需求高峰。此外，秋茄表现出更高的水分利用效率和更保守的水分利用策略，表明其在未来气候变化和潮间带环境变化中具有更强的适应潜力。研究还发现，光合有效辐射、饱和蒸汽压差和气温是驱动红树林液流的主要环境因素。通过对气象因素与液流关系的分析，本研究揭示了红树林在不同季节对环境变化的响应机制。



三种红树物种气孔导度（A）和单位边材面积的日茎干液流量（B）（n=4）

The Stomatal Conductance (Gs) (A) and the Daily Sap Flow in Per Sapwood Area (B) of Three Mangrove Species (*Kandelia, Avicennia* and *Aegiceras*) （N=4）

This study investigated the water-use strategies of three mangrove species—*Avicennia marina*, *Aegiceras corniculatum*, and *Kandelia obovata*—through sap flow monitoring, gas exchange, and stem diameter measurements. Results showed that *Avicennia* and *Aegiceras* peaked in daily sap flow density 1 hour earlier than *Kandelia*. During strong transpiration, *Kandelia* and *Aegiceras* utilized stem water storage, while *Avicennia* synchronized its storage. *Kandelia* exhibited lower sap flow but higher water-use efficiency, indicating a more conservative strategy. Environmental factors like photosynthetically active radiation, vapor pressure deficit, and air temperature were key drivers of sap flow. *Kandelia* was identified as the most adaptive species for future intertidal conditions. These findings highlight the diverse water-use strategies among the species and provide a theoretical basis for mangrove afforestation and ecological restoration.

以上工作于2024年3月发表于*Tree Physiology*期刊，2020级硕士生伍思攀为第一作者，陈鹭真教授为通讯作者。

Reference:
Sipan Wu, Xiaoxuan Gu, Xiufan Peng, Luzhen Chen*, Comparative analysis of water-use strategies in three subtropical mangrove species: a study of sap flow and gas exchange monitoring, *TREE PHYSIOLOGY.* 2024.44, tpae102.

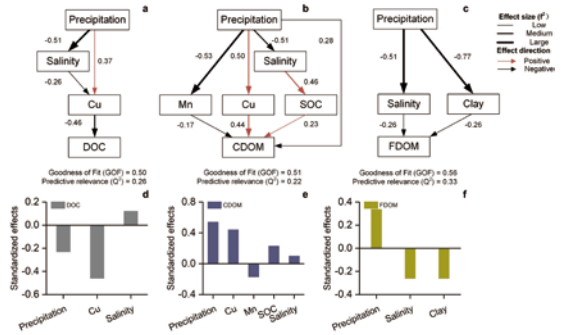
降水对红树林湿地溶解有机质的调控作用

Regulation of Precipitation on Soil Dissolved Organic Matter in Perturbed Mangrove Ecosystems

红树林生态系统作为蓝碳生态系统的重要组成部分，具有极高的碳封存和储存能力，其土壤碳库在全球碳循环中扮演着关键角色。红树林土壤中的碳储量占全球红树林湿地碳储量的75%以上，因此理解红树林土壤碳动态对于应对气候变化具有重要意义。溶解有机质（DOM）是红树林土壤中活性有机质的主要形式，具有高流动性和生物可利用性，是连接陆地和水生生态系统的重要碳库。然而，目前在大地理尺度上对于红树林土壤DOM的来源、组成及其环境调控机制的研究仍存未清晰。

卢豪良课题组研究团队采集全国范围内跨纬度及降水模式下的红树林湿地土壤样品，分析全国尺度下红树林湿地土壤DOM库特征，并量化湿地DOM库与降水、土壤参数等环境因素间的关系。结果表明红树林土壤中的DOM主要由类腐殖酸和类富里酸组成，其来源受陆地输入的显著影响。降水是调控红树林湿地DOM库的重要因素。降水具有对DOM的双重调控机制，既能直接控制湿地 DOM 的输入和输出，也能通过与土壤参数（Cu、Mn、盐度、SOC、黏粒）形成级联反应，进而间接影响DOM的稳定性和迁移。

本研究在全国尺度上揭示了降水对红树林土壤DOM的调控机制，为蓝碳生态系统的评估和管理提供了新的视角；通过创新性地构建具有预测性的红树林湿地DOM库的结构方程模型，这一成果有效促进了理解DOM如何响应红树林湿地环境变化。这项研究有助于促使湿地外源输入管理、水盐调节等蓝碳管理行动的改善，并为探索地球上其他蓝碳栖息地的DOM 库提供理论基础。



环境因素影响红树林土壤DOM库（DOC、CDOM、FDOM）的结构方程模型

Structural Equation Models of Environmental Factors Affecting Mangrove Soil DOM Pools (DOC, CDOM, FDOM)

以上工作于2024年10月发表于*Ecosystem Health and Sustainability*期刊，2023届博士毕业生吴圣捷作为第一作者，卢豪良教授为通讯作者。

Reference:
Wu S.J., Li H.Y., Yuan B., Chen X.C., He L., Li Q.C., Song T.Y., Liu J.C., Hong H.L., A. Pavao-Zuckerman Mitchell, Lu H.L.*. 2024. Regulation of precipitation on soil dissolved organic matter in perturbed mangrove ecosystems. *Ecosystem Health and Sustainability*, 10, 11.

Mangrove ecosystems, as a crucial component of blue carbon ecosystems, exhibit exceptional capacities for carbon sequestration and storage. Their soil carbon reservoirs play a pivotal role in the global carbon cycle. Specifically, over 75% of the global mangrove wetland carbon reservoir is stored in mangrove soils. Therefore, understanding the dynamics of carbon within mangrove soils is of vital importance for addressing climate change. Dissolved organic matter (DOM) represents the primary form of active organic matter in these soils, characterized by its high mobility and bioavailability. It serves as a critical carbon reservoir linking terrestrial and aquatic ecosystems. However, significant gaps remain in our understanding of the sources, composition, and environmental regulation mechanisms of DOM in mangrove soils, particularly at large geographical scales.

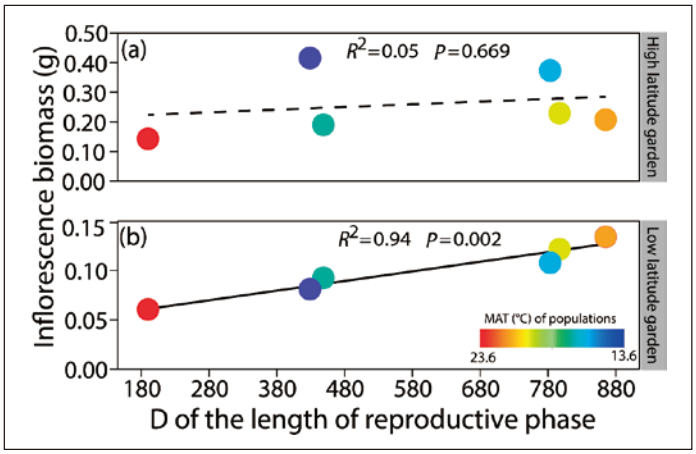
To address these gaps, a research team collected soil samples from mangrove wetlands across the country, spanning diverse latitudes and precipitation patterns. They analyzed the characteristics of the DOM reservoir in mangrove soils on a national scale and quantified the relationships between the DOM reservoir and environmental factors such as precipitation and soil parameters. The results indicate that DOM in mangrove soils is primarily composed of humic and fulvic acids, with its sources significantly influenced by terrestrial inputs. Precipitation emerged as a key factor regulating the DOM reservoir in mangrove wetlands. It exerts a dual regulatory mechanism on DOM: directly controlling its input and output in the wetlands, and indirectly influencing its stability and migration through cascading interactions with soil parameters (e.g., Cu, Mn, salinity, soil organic carbon (SOC), and clay content).

This study elucidates the regulatory mechanisms of precipitation on DOM in mangrove soils at the national level, offering a novel perspective for the assessment and management of blue carbon ecosystems. By innovatively constructing a predictive structural equation model for the DOM reservoir in mangrove wetlands, this research enhances our understanding of how DOM responds to environmental changes in these ecosystems. The findings contribute to improving blue carbon management practices, such as regulating external inputs and hydro-salinity balance in wetlands, and provide a theoretical foundation for exploring DOM reservoirs in other blue carbon habitats on Earth.

入侵种分布边缘种群具有较低的生活史可塑性：揭示遗传基础和生态效应

Limited Life History Plasticity in Marginal Population of an Invasive Foundation Species: Unraveling the Genetic Underpinnings and Ecological Implications

植物的生活史可以在不同时空尺度下发生演变，但多物种研究忽略了单一物种种内特异性（尤其是奠基种）的生态效应和遗传基础。对于一个物种来说，成功入侵一个地区可能使其成为奠基种，入侵植物的生活史变异对被入侵生态系统具有相当大的生态和进化影响。我们通过同质种植园实验，研究了入侵奠基种互花米草在中国沿纬度梯度的生活史变异。两个同质种植园分别位于互花米草在热带的分布边界和温带的主要分布区内。对于每个同质园中的每个种群，我们观测记录了构成有性生殖阶段的三个连续物候事件的开始时间和一个适合度性状。在温度较高的低纬度同质园中，我们发现有性生殖阶段提前出现且持续时间延长，这可能是因为成熟时间的可塑性较低导致。此外，有性生殖阶段长度的可塑性与低纬度同质园中的种群适合度呈正相关。来自热带的边缘种群可塑性和适合度最低，应对环境变化的能力较差可能导致该种群数量减少。这些结果反映了互花米草在中国的生活史的遗传分化。我们的研究为通过整合植物的生活史来评估中心–边缘假说提供了新的视角，并强调了考虑进化的意义。这些见解有助于我们理解生活史变异的长期生态后果，及其对植物适合度、物种相互作用和生态系统功能在气候变化下的影响具有启示意义。



在高低纬度两个同质园中，互花米草不同种群有性繁殖期长度可塑性与花序生物量的相关关系。每个点代表一个种群，每个点的颜色代表种源地的年均温。实线代表有显著相关关系，虚线代表无显著相关关系

The correlation between the scope of plastic response (D) of the length of the reproductive phase against the inflorescence biomass in the high latitude garden (a) and low latitude one (b). Each point represents an individual population. The color of the points indicates the mean annual temperature (MAT) of populations. Solid line indicates significant correlation and dash line indicates non-significant correlation.

以上工作于2024年6月发表于*Ecology and Evolution*期刊，博士后陈欣淙和2020级博士生王佳瑜为论文共同第一作者，张宜辉教授为通讯作者。

Reference:
Xincong Chen, Jiayu Wang, Wenwen Liu, Yihui Zhang*, Limited life history plasticity in marginal population of an invasive foundation species: unraveling the genetic underpinnings and ecological implications, *Ecology and Evolution*, 2024, 14, e11549.

Plants life history can evolve in response to variation in climate spatio-temporally, but numerous multiple-species studies overlook species-specific (especially a foundation species) ecological effects and genetic underpinnings. For a species to successfully invade a region, likely to become a foundation species, life history variation of invasive plants exerts considerable ecological and evolutionary impacts on invaded ecosystems. We examined how an invasive foundation plant, *Spartina alterniflora*, varied in its life history along latitudinal gradient using a common gardens experiment. Two common gardens were located at range boundary in tropical zone and main distribution area of *S. alterniflora* in temperate zone in China. Within each population/garden, we measured the onset time of three successive phenological stages constituting the reproductive phase, and a fitness trait. In the low-latitude garden with higher temperature, we found that reproductive phase was advanced and its length prolonged compared to the high-latitude garden. This could possibly due to lower plasticity of maturity time. Additionally, plasticity in the length of the reproductive phase positively related with fitness in the low-latitude garden. Marginal population from tropic had the lowest plasticity and fitness, the poor capacity to cope with changing environment may result in reduction of this population. These results reflected genetic divergence in life history of *S. alterniflora* in China. Our study provided a novel view to test the center-periphery hypothesis by integration across a plant's life history, and highlighted the significance in considering evolution. Such insights can help us to understand long-term ecological consequences of life history variation, with implications for plant fitness, species interaction, and ecosystem functions under climate change.

基于生物合成的自发荧光缩合单宁空间代谢组学揭示其在非泌盐红树植物秋茄耐盐性中的作用

Biosynthesis-based Spatial Metabolome of Condensed Tannin Reveals its Role in Salt Tolerance of Non-salt-secretor Mangrove *Kandelia Obovata*

红树植物是热带海洋潮间带特有的木本植物，以其卓越的耐盐性著称。其中，非泌盐红树植物的叶片缺少盐腺，积累的盐分无法外排，但其耐盐机制仍不清楚。研究发现非泌盐红树植物叶肉细胞中存在一种自发荧光物（Autofluorescent inclusion, AFI），这种自发荧光物在叶片中的积累量与盐浓度呈正相关，但其生物合成和空间分布特征尚未明晰。

本研究选取典型非泌盐红树植物——秋茄（*Kandelia obovata*）作为研究对象，于福建省漳州市漳江口国家级红树林自然保护区采集了不同生长阶段的秋茄叶片样本。通过蔗糖密度梯度超速离心技术，我们对AFI进行分离与纯化。随后，借助傅里叶变换红外光谱分析及高效液相色谱技术，我们鉴定出AFI的主要化学成分为缩合单宁（Condensed tannin, CT），即自发荧光缩合单宁聚集体（Condensed tannin accretion, CTA）。

为进一步探究CTA与盐响应的关系，研究团队对秋茄幼苗施加不同浓度的NaCl处理，系统观测其生理指标变化。结果显示，在高盐胁迫下，秋茄叶片纯化CTA中的Na^+含量显著提升，而叶肉细胞内的Na^+外排速率则显著低于未受盐胁迫的对照组。体外模拟实验进一步证实，Na^+的引入会诱导CTA发生聚集现象。利用液相色谱–质谱联用技术，本研究团队在纯化的CTA中鉴定出了与Na^+/H^+转运及囊泡运输功能密切相关的蛋白质。透射电子显微镜（TEM）观察揭示了高盐条件下，叶绿体中参与CT生物合成的特定结构以及液泡内CT积累现象的显著增强。空间代谢组学分析针对参与CT生物合成的类黄酮代谢物展开，结果显示，这些类黄酮化合物及三种CT单体与叶肉细胞内的盐分含量呈正相关趋势。实时荧光定量PCR技术验证了编码CT生物合成关键酶的基因在高盐胁迫下的上调表达。

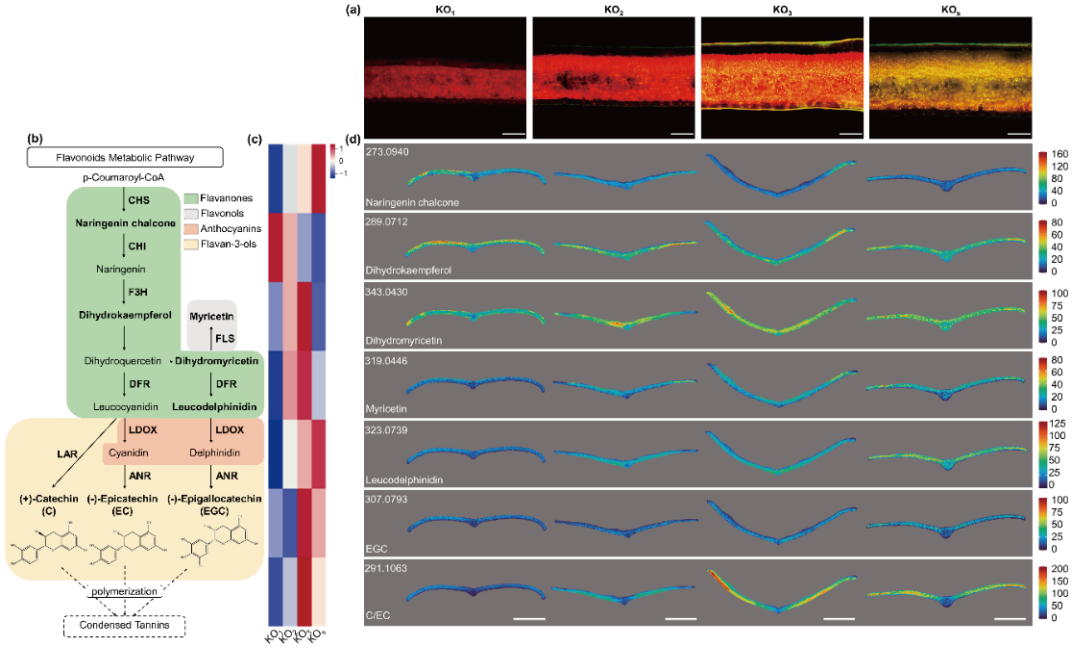
综上所述，本研究揭示了秋茄叶片中CT的生物合成与Na^+积累之间的正相关关系。在叶绿体中合成的CT通过细胞质被输送至液泡，这一过程促进了过量Na^+在液泡中的有效隔离与区室化，从而赋予了非泌盐红树植物秋茄叶片更高的耐盐性能。本研究为理解CTA在非泌盐红树植物耐盐机制中的关键作用提供了新颖的视角。

An autofluorescent inclusion (AFI) specifically accumulated in mesophyll cells (MCs) of non-salt-secretor mangrove was found to be related to salt, but its biosynthesis and spatial distribution characteristics remain unclear. Here, *Kandelia obovata* served as the experimental material, and the composition of AFI was identified as condensed tannin (CT). Na contents increased in purified AFIs under NaCl treatment, while Na^+ efflux in MCs was lower than the control. *In vitro,* Na^+ addition caused aggregations of AFIs. Proteins related to Na^+/H^+ and vesicle transport were identified in the purified AFIs by liquid chromatography-mass spectrometry. TEM images revealed the structures involved in CT biosynthesis in chloroplasts and CT accretions in vacuoles were more visible under higher salinity. Spatial metabolomics analysis on flavonoid metabolites involving in CT biosynthesis illustrated those flavonoids and three CT monomers were positively related to salt in MCs. Real-time quantitative PCR verified the genes encoding enzymes for CT biosynthesis were up-regulated accordingly. Taken together, CT biosynthesis is positively correlated with Na accumulation in leaves. The CTs synthesized in chloroplasts are transported as shuttles to vacuole via cytoplasm, facilitating the sequestration and compartmentalization of excessive Na^+ ions into the vacuole, which confers non-salt-secretor mangrove *K. obovata* a higher salt tolerance.

以上工作于2024年10月发表于*Plant, Cell & Environment*期刊，2024级博士生黄鬻子为第一作者，朱学艺教授与郑海雷教授为通讯作者。

Reference:
Hezi Huang, Lihan Zhuang, Hanchen Tang, Zhaoyu Guo, Qinghua Li, Zejin Lin, Mingjin Dai, Xiuxiu Wang, Yifan Wang, Hailei Zheng*, Xueyi Zhu*. Biosynthesis-based spatial metabolome of condensed tannin reveals its role in salt tolerance of non-salt-secretor mangrove *Kandelia obovata*, *PLANT, CELL & ENVIRONMENT*, 2024, 48(3), 1874-1889.

成果亮点
Research Highlights



自然生境中生长的不同发育阶段秋茄叶片中与CT合成相关的类黄酮代谢物空间代谢组成像。（a）不同生长阶段叶片徒手切片的荧光图像，在蓝光激发下显示秋茄第一片叶（KO_1）、第二片叶（KO_2）、第三片叶（KO_3）和老叶（KOs）中CTAs的分布。（b）秋茄叶片中与缩合单宁合成相关的主要类黄酮代谢途径。（c）基质辅助激光解吸电离质谱成像（MALDI-MSI）分析缩合单宁生物合成途径中主要类黄酮代谢物的单位面积平均含量的热图，以及（d）其对应的图像。每个处理选取一个代表性样本用于空间代谢组学的成像。EGC表示表没食子儿茶素（Epigallocatechin），C/EC表示儿茶素（Catechin）和表儿茶素（Epicatechin）。比例尺：（a）为200μm，（d）为5 mm。

Spatial metabolomics of flavonoid biosynthesis related to condensed tannin (CT) synthesis in K. obovata leaves at various growth stages in natural condition. (a) Fluorescence images of free-hand sections of leaves at various growth stages excited with blue light exhibiting the distribution of CTAs in the first (KO_1), second (KO_2), third (KO_3) and senescent (KOs) leaves of K. obovata. (b) The main flavonoid metabolism pathway related to CT synthesis in the leaves of K. obovata. (c) Heat-map of the average content per unit area for main flavonoids in the CTs biosynthesis pathway analyzed by MALDI-MSI and (d) their corresponding images. One representative sample from each treatment was used for imaging in spatial metabolomics. EGC, epigallocatechin; C/EC, catechin and epicatechin. Bars: 200 μm for (a) and 5 mm for (d).

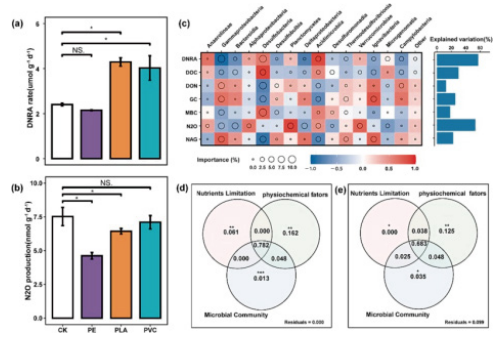
微塑料通过加强红树林生态系统中沉积物的氮限制来增强氮保留

Microplastics Strengthen Nitrogen Retention by Intensifying Nitrogen Limitation in Mangrove Ecosystem Sediments

红树林湿地是全球N循环的热点区域，同时也是高度N限制的系统。不同于将N从体系中去除的反硝化和厌氧氨氧化过程，异化硝酸盐还原成铵（DNRA）过程可以在高碳、低氮的环境中通过将硝酸盐和亚硝酸盐转化为铵氮以维持红树林生态系统的高生产力，是红树林重要的氮保留机制。尽管一些研究表明微塑料可以刺激沉积物中DNRA微生物生长，但关于微塑料对DNRA过程的影响以及影响因素的研究较少。此外，红树林湿地还是氧化亚氮的重要产生源，但微塑料对红树林沉积物中氧化亚氮排放的影响仍然大部分未知。

研究团队设计了培养实验，通过向红树林沉积物中加入聚乙烯（PE）、聚乳酸（PLA）和聚氯乙烯（PVC）三种微塑料，以探究：（1）微塑料对沉积物的理化性质和养分限制的影响；（2）微塑料对沉积物细菌群落组成的影响；（3）沉积物的DNRA速率和氧化亚氮排放速率如何响应微塑料的加入；（4）微塑料对两种氮转化速率产生影响的生物和非生物机制。

研究结果表明，微塑料的加入会影响红树林沉积物的理化性质、酶活性以及微生物活动。首先，作为高碳含量的聚合物，微塑料释放了溶解有机碳并影响了沉积物的氮周转过程。其次，微塑料暴露后沉积物的碳氮比的变化加剧了沉积物中的氮限制。结合微生物群落变化的证据，微塑料的加入可以促进DNRA速率，但有效抑制氧化亚氮的排放。特别是，可生物降解的微塑料可以将DNRA率提高50%以上。然而，由于DNRA过程保留了大量的活性氮，微塑料可能会给沿海富营养化带来更多的挑战。因此，在提倡生物降解塑料制品的使用时，应避免其在滨海湿地的积累。总体而言，本研究强调，微塑料通过加强沉积物氮限制，改变了沉积物氮循环，削弱了红树林生态系统对氮负荷的缓冲能力，导致红树林的脱氮能力被削弱。



不同处理中的（a）DNRA速率和（b）N_2O产生速率，（c）细菌类群对氮转化和沉积物特性的潜在生物贡献，理化因素、营养限制和微生物群落对（d）DNRA速率的贡献，以及对（e）N_2O产生的贡献。* 表示 $p < 0.05$;** 表示 $p < 0.01$;*** 表示 $p < 0.001$

(a) DNRA rates, (b) N_2O production in different treatments, (c) Potential biotic contributions of the bacterial taxa at the class level to N transformations and sediment properties, (d) Contribution of physicochemical factors, nutrient limitation, and microbial community to DNRA rates, and (e) N_2O production. * represents $p < 0.05$; ** represents $p < 0.01$; and *** represents $p < 0.001$.

Conceptual illustration of CH_4 production by the microalga Emiliania huxleyi. The CH_4 produced during photosynthesis and the microalgal carbon sequestration exhibit antagonistic feedbacks to global warming. The photosynthesis-driven CH_4 in the oceans may affect its upward flux, thereby likely counteract phytoplankton carbon sequestration involving refractory dissolved organic carbon (RDOC) and biological CO_2 pump (BCP).

Mangrove wetlands are hotspots of the global nitrogen (N) cycle and important sinks of microplastics (MPs) due to their ecotone location between terrestrial and marine ecosystems. However, the effects of MPs on N cycle processes in mangrove ecosystems are still poorly understood. Thus, the present study assessed the impacts by adding MPs to mangrove sediments in a microcosm incubation experiment. The results showed that MPs increased dissolved organic carbon and nitrate but reduced ammonium contents in the sediments. MPs increased C:N stoichiometric and N:C-acquiring enzymatic ratios, indicating an intensified N limitation in mangrove sediments following exposure of MPs. MPs decreased microbial community diversity and shifted sediment microbial communities from r- to K-strategists, consistent with the intensified N limitation. In response, dissimilatory nitrate reduction to ammonium (DNRA) rates increased while nitrous oxide (N_2O) production reduced suggesting more efficient N utilization in MPs treatments. The MPs with heteroatoms such as PLA- and PVC-MPs, increased DNRA rates by 67.5–78.7%, exhibiting a stronger impact than PE-MPs. The variation partitioning analysis revealed that the variances of DNRA rates and N_2O production could be attributed to synergistic effects of physicochemical properties, nutrient limitation, and microbial community in mangrove sediments. Overall, this study provides pertinent insights into the impacts of MPs as a new carbon source on nutrient limitation and N turnover in mangrove ecosystems.

以上工作于2024年3月发表于*Environment International*期刊，2022届硕士生戴泽涛为第一作者，曹文志教授和杨盛昌副教授为通讯作者。

Reference:
Zetao Dai, Ning Zhang, Xiao Ma, Feifei Wang, Jiarui Peng, Shengchang Yang*, Wenzhi Cao*, Microplastics strengthen nitrogen retention by intensifying nitrogen limitation in mangrove ecosystem sediments, *Environment International*, 2024, 185, 108546.

成果亮点
Research Highlights

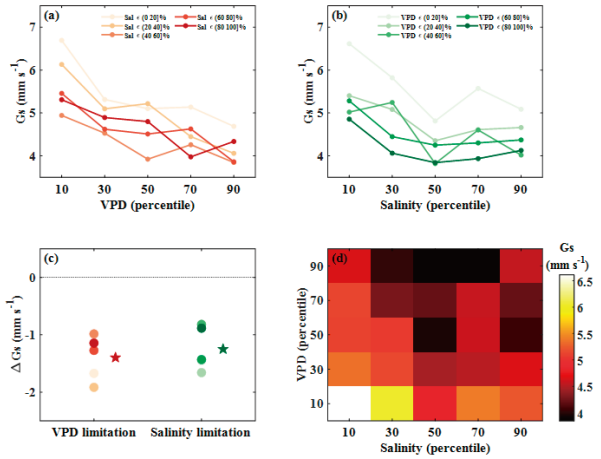
盐度胁迫与大气干燥共同限制红树林湿地蒸散发

Salinity Stress and Atmospheric Dryness Co-limit Evapotranspiration in a Subtropical Monsoonal Estuarine Mangrove Wetland

高盐度和大气干燥引起的生理干旱胁迫通过限制地表导度（Gs）和蒸散发（ET）对红树林的生长产生负面影响。类似于陆地植被经历极低的土壤湿度，红树林高盐度土壤的低渗透势限制红树林的水分供应，导致Gs和ET降低。大气干燥与饱和水汽压差（VPD）直接相关，高VPD会诱导红树植物关闭气孔以防止过度失水。由于数据不足，红树林ET的时间动态及其在生态系统层面受干旱胁迫的控制知之甚少。因此，准确理解盐度胁迫和大气干燥在限制ET方面的作用对评估红树林对气候变化的脆弱性至关重要。

研究团队利用2017–2023年的涡度相关高频连续观测数据解析中国东南沿海福建漳江口红树林湿地蒸散发的时间变异模式，获得以下科学认识：（1）红树林ET在日尺度和季节尺度上表现出强烈时间变异，其中与光合有效辐射、气温和VPD密切相关；（2）红树林ET的季节性随月气温和降雨量的变化而变化，反映出典型季风气候的时间格局；（3）当盐度和VPD解耦时，发现高盐度和高VPD都显著抑制红树林Gs；（4）降雨的变化对红树林Gs产生类似的约束作用，年最大持续降雨量可以解释ET年际变化的65%。该研究表明盐度胁迫（或降雨减少）和大气干燥共同限制亚热带季风河口红树林湿地ET的时间变化。未来气候变化中气温升高对红树林ET的负面影响和极端降雨增加的正面影响可能会相互抵消。

该研究依托台海站红树林湿地碳水通量长期观测平台，开展了红树林湿地与大气之间的蒸散发及相关气象、水文要素的长时序高频连续观测，揭示了亚热带季风河口红树林湿地蒸散发的多时间尺度变异规律及其环境控制机制，阐明了盐度胁迫（或降雨减少）和大气干燥共同限制红树林蒸散发的时间变化，研究结果为未来气候暖干化对红树林蒸散发限制作用的评估提供科学依据。



盐度胁迫和大气干燥对红树林Gs的限制作用

Limitation Effects of Salinity Stress and Atmospheric Dryness on Mangrove Surface Conductance.

以上工作于2024年10月发表于*Environmental Research Letters*期刊，2022级硕士生王相学为第一作者，朱旭东教授为通讯作者。

Reference:
Xiangxue Wang, Xudong Zhu*, Salinity stress and atmospheric dryness co-limit evapotranspiration in a subtropical monsoonal estuarine mangrove wetland, *Environmental Research Letters*, 2024, 19(11), 114067.

Physiological drought stresses induced by high salinity and atmospheric dryness exert negative effects on mangrove growth by constraining surface conductance (Gs) and evapotranspiration (ET). However, accurate assessments of mangrove vulnerability under changing climate are hindered by limited understanding of the relative importance of these drought stresses. To close this knowledge gap, we utilized the eddy covariance approach to acquire a 7-year (2017–2023) time series of ET and auxiliary measurements over a subtropical monsoonal estuarine mangrove in southeast China, aiming to examine the temporal patterns of mangrove ET across time scales and its environmental controls, in particular for drought stresses. The results indicated that (a) over the study period, mangrove ET showed strong temporal variations at diurnal and seasonal scales, which were strongly correlated with photosynthetically active radiation, air temperature, and vapor pressure deficit (VPD); (b) the seasonality of mangrove ET followed the changes in monthly air temperature and rainfall, reflecting the temporal pattern of typical monsoonal climate; (c) both increasing salinity and VPD were found to significantly constrain mangrove Gs when salinity and VPD were decoupled; (d) the variability of rainfall exerted a similar constraining effect on mangrove Gs, with annual maximum sustained rainfall accounting for 65% of the inter-annual variability of ET. These findings suggest that salinity stress (or less rainfall) and atmospheric dryness co-limit the temporal variability of ET in subtropical monsoonal mangroves. Future climate change with warmer air temperatures (negative effect) and more extreme rainfall (positive effect) could counteract each other in affecting mangrove ET.

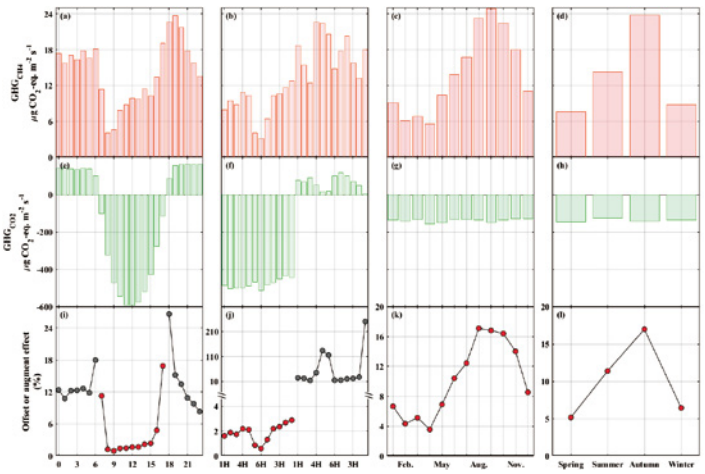
长时序野外观测揭示红树林湿地甲烷排放的碳汇抵消效应

Asynchronous Methane and Carbon Dioxide Fluxes Drive Temporal Variability of Mangrove Blue Carbon Sequestration

红树林湿地可以高效吸收大气二氧化碳（CO_2），因具有长期且持续的碳固存能力而产生较强的气候效益。同时，红树林湿地也向大气排放温室效应更强的甲烷（CH_4），部分抵消红树林湿地碳汇的气候效益。由于CH_4和CO_2通量具有极强的昼夜、季节等时间变化规律，以往基于非高频连续观测的抵消效应评估具有较大的不确定性。为降低上述评估的不确定性，提高对红树林湿地CH_4通量时间变化规律及其对碳汇抵消效应的认识，迫切需要同步开展两种温室气体通量的长时序高频连续观测。

研究团队利用2019–2023年的涡度相关高频连续观测数据解析中国东南沿海福建漳江口红树林湿地CH_4通量及其碳汇抵消效应的时间变异模式，获得以下科学认识：（1）土壤温度与潮汐因子主导着红树林湿地CH_4通量的昼夜和季节变化，其中CH_4排放量夜间高于白天、夏秋高于冬春；（2）按20年尺度的持续通量全球增温潜势计算，红树林湿地CH_4源平均抵消10%的CO_2汇；（3）由于CH_4和CO_2通量存在非同步变化特征，碳汇抵消效应存在极强的昼夜和季节差异。该研究表明夜间排放对红树林湿地CH_4收支具有显著贡献，并证实了温室气体通量的非同步变化对评估红树林湿地气候效益的重要影响。

该研究依托台海站红树林湿地温室气体通量长期观测平台，开展了红树林湿地与大气之间的CH_4和CO_2通量及相关气象、水文要素的长时序高频连续观测，揭示了亚热带河口红树林湿地CH_4通量的多时间尺度变化规律及其环境控制机制，阐明了CH_4和CO_2通量的非同步变化影响CH_4排放对碳汇的抵消效应，研究结果为科学评估红树林湿地碳汇与气候效应提供了科学依据。



红树林湿地CH_4排放的碳汇抵消/增强效应

Limitation Effects of Offsetting/enhancement Effects of Mangrove Wetland CH_4 Emissions on Carbon Sinks

以上工作于2024年6月发表于*Geophysical Research Letters*期刊，朱旭东教授为第一兼通讯作者。

Reference:
Xudong Zhu*, Jingke Chen, Lichun Li, Mingjie Li, Tingting Li, Zhangcai Qin, Fan Wang, Xiaosong Zhao, Asynchronous methane and carbon dioxide fluxes drive temporal variability of mangrove blue carbon sequestration, *GEOPHYSICAL RESEARCH LETTERS*, 2024, 51(11), e2023GL107235.

The climate benefit of blue carbon sequestered by mangrove forests can be partially offset by CH_4 emission, but this offset is rarely assessed using multi-year high-frequency measurements. Here, four-year eddy covariance measurements were used to examine temporal patterns of CH_4 flux and its blue carbon offset (i.e., reduced climate benefit) in a subtropical estuarine mangrove in China. We found both diel and seasonal CH_4 fluxes were mainly driven by soil temperature and tidal activities, showing greater nighttime emission. On average, one-tenth of CO_2 uptake was offset by CH_4 emission using the sustained-flux global warming potential metric at a 20‐year time horizon, while this offset could vary over an order of magnitude due to asynchronous fluxes of CH_4 and CO_2 across diel and seasonal cycles. These results highlight the significant contribution of nighttime emission to mangrove CH_4 budget and the importance of asynchronous flux variations in assessing mangrove's climate benefit.

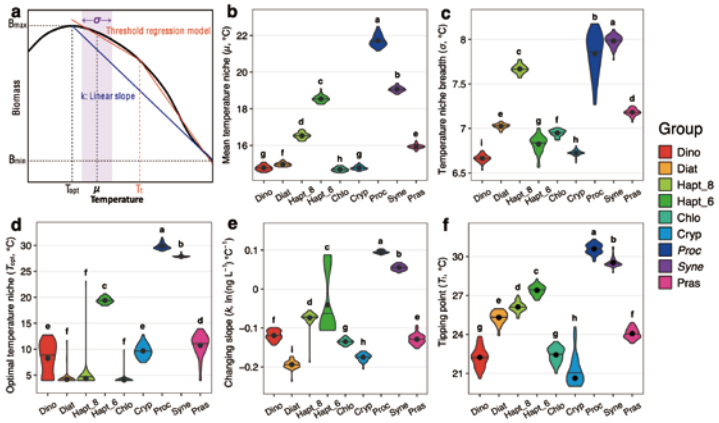
揭示中国海域浮游植物的热敏感性差异

Unveiling Differential Thermal Sensitivities in Marine Phytoplankton Within the China Seas

随着全球气候变暖，海洋浮游植物的温度响应成为关键研究议题。长期以来，学界更多关注的是硅藻、甲藻等大粒级浮游植物，或是聚球藻、原绿球藻等小粒级原核浮游植物，而对隐藻这一类群的关注却相对较少。隐藻通常在淡水中是优势类群，而在海洋中主要分布于极地海域，在中低纬度生物量较低，但其在海洋生态系统中的角色尚不清晰。虽然从理论上预判隐藻对温度变化会有较高的敏感性，但之前并没有明确的证据揭示它们的温度敏感度，以及与其他浮游植物类群的比较。

研究团队基于2002至2015年间近3000个表层实测光合色素数据，首次系统性地探讨了全粒级浮游植物类群对温度变化的响应，结果令人惊讶：隐藻在所有浮游植物类群中表现出最强的热敏感性，一旦水温超过20.63°C将显著降低隐藻的生物量，暗示隐藻在温升的海域中可能面临严重的生态风险，甚至可能成为全球气候变暖下海洋生态系统变化的早期指示类群。该发现不仅填补了隐藻在海洋温度响应领域的研究缺陷，也为预测升温背景下的海洋生态变化提供了新的视角。

该研究的独特性在于方法的创新——通过结合GAMMs和MaxEnt建模技术，提出了一个全新的GAMEs框架，用以精准拟合不同浮游植物类群的温度生态位曲线。同时，定量估算了平均生态位、生态位宽度、最适温度、临界温度等生态位性状，分析不同浮游植物类群的热响应差异。该方法超越了传统的单一指标分析，综合考虑了多重生态位性状，尤其是临界点的分析，成为识别隐藻敏感性的关键性状。



以上工作于2024年5月发表于*Limnology and Oceanography Letters*期刊，2024届博士生王昌运为第一作者，肖武鹏副教授为通讯作者。

Reference:
Changyun Wang, Shujie Cai, Zhuyin Tong, Jixin Chen, Lizhen Lin, Wupeng Xiao*, Xin Liu, Bangqin Huang, Unveiling differential thermal sensitivities in marine phytoplankton within the China Seas. *Limnology and Oceanography Letters*, 2024, 9(5), 583-592.

各浮游植物类群的热敏感性特征。（a）主要热敏感性特征总结。图（b）至（f）中的小提琴图展示了关键热敏感性特征的分布：（b）平均温度适宜区间（μ）、（c）生态位宽度（σ）、（d）最佳温度适宜区间（T_{opt}）、（e）生物量随温度变化的斜率（k）、（f）临界温度（T_t）

Realized thermal traits for each phytoplankton group. (a) Summary of key thermal traits. Violin plots in panels (b) to (f) illustrate the distribution of critical thermal traits: (b) mean temperature niche (μ), (c) niche breadth (σ), (d) optimal temperature niche (T_{opt}), (e) slope of biomass change with temperature (k), and (f) tipping point (T_t) for each group.

In the context of global climate change, understanding the thermal sensitivities of different phytoplankton groups is crucial for predicting changes in marine ecosystems. While it is known that phytoplankton are key primary producers in the ocean, the specific thermal responses of diverse phytoplankton taxa to warming have remained unclear. This study sheds light on this issue by analyzing a comprehensive dataset from China Seas, focusing on the thermal traits of various phytoplankton groups. We found that different phytoplankton groups exhibit distinct thermal sensitivities, with cryptophytes showing the most pronounced response to temperature changes. This finding is pivotal in recognizing the potential impact of lesser-studied phytoplankton on marine ecosystems and global biogeochemical cycles in a warming world.

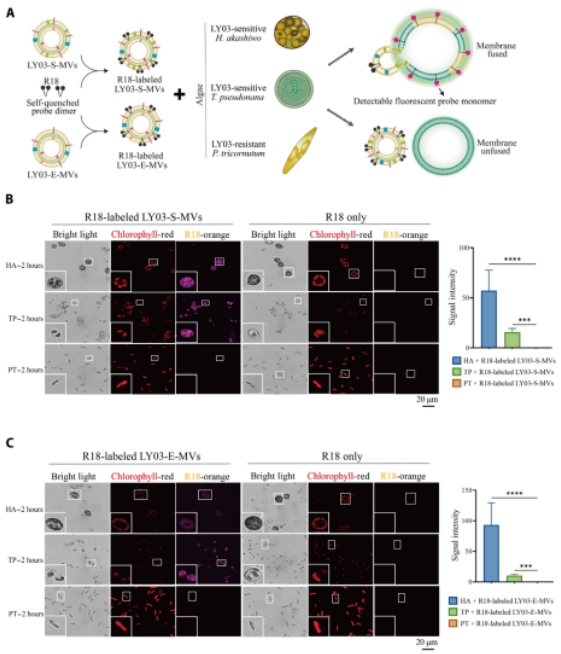
杀藻细菌膜囊泡作为生物穿梭体介导细菌和真核微藻的跨界通讯

Algicidal Bacteria-derived Membrane Vesicles as Shuttles Mediating Cross-kingdom Interactions Between Bacteria and Algae

细菌与真核微藻之间的相互作用是跨界生物互作的典型代表，是微生物之间及其与环境之间相互作用的重要功能单元，在自然生态系统和工程系统中都发挥着举足轻重的作用。在各种自然生境中，细菌和微藻可以形成跨界的微生物群落，代谢产物和信息化合物的交换决定了二者之间错综复杂的关系。尽管人们意识到菌–藻相互作用的重要性已有40年的历史，但由于菌–藻互作微环境的时空复杂性以及研究技术手段的限制，目前人们对菌–藻互作方式、菌–藻跨界串扰的分子背景、菌–藻互作的生物学和生态学功能等等的理论认知还十分有限。细菌膜囊泡（BMVs）作为生物纳米穿梭体已被证明在介导生物间的相互作用中扮演着重要的角色，但是对于BMVs是否以及如何通过识别微藻生物屏障的分子通道参与菌–藻跨界串扰仍知之甚少。

研究团队发现杀藻菌*Chitinimonas prasina* LY03在生长过程中释放大量BMVs，并且在稳定期分泌的BMVs具有与菌株细胞一致的杀藻活性。进一步的分子和生理实验以及显微成像发现，菌株LY03产生的新型杀藻化合物能被BMVs选择性装载并跨越微藻细胞壁屏障，通过与藻细胞膜脂质融合实现杀藻化合物的高效递送。此外，研究团队通过荧光示踪及生理表型测定，证明BMVs还可以封装核酸和铁离子等其他货物递送至微藻细胞。研究还发现，杀藻菌LY03稳定期产生的BMVs会诱导微藻细胞的裂解死亡，而指数期产生的BMVs则可以促进缺铁微藻的生长，表明BMVs从“杀手”到“助手”的功能角色转变，可能会导致菌–藻串扰通道及其相互作用模式的变化。

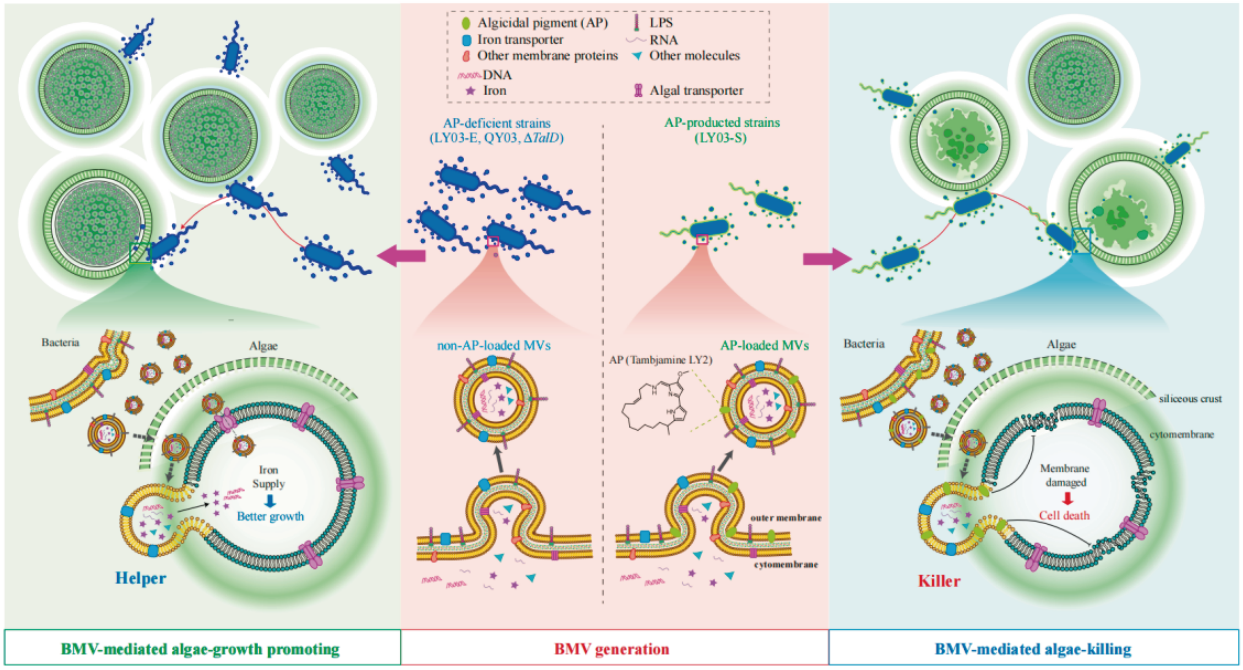
本研究首次提供了多种功能性货物通过BMVs从细菌细胞水平转移至微藻细胞进而介导菌–藻跨界互作的直接证据，揭示了BMVs介导的新型溶藻机制，拓宽了人们对细菌膜囊泡生物学功能的理解。基于工程化改造的BMVs有望成为一种高效、特异性的杀藻纳米材料，应用于有害藻华治理的实践中。更为重要的是，该研究还发现BMVs对货物的选择性装载能力，使其能够动态转换角色以调节菌–藻跨界互作。这为研究者打开了一扇窗，得以从独特的视角来认识和理解复杂的菌–藻互作方式，也为进一步表征甚至操控菌–藻互作提供了强有力的理论和技术支撑。



基于荧光标记技术的LY03–BMVs与目标微藻膜融合的可视化

Visualization of membrane fusion between MVs with the targeted algae by confocal microscopy. (A) the schematic diagram of membrane fusion test experiments. the confocal tracking of algal cells after incubating with and without R18-labeled LY03-S-Mvs (B) and LY03-e-Mvs (C) for 2 hours. Algal cells and Mvs were stained with R18 by incubation for 1 hour. the three targeted microalgae were *H. akashiwo* (hA), *T. pseudonana* (tP), and *P. tricornutum* (Pt). Asterisks indicate statistically significant (***$P < 0.001$ and ****$P < 0.0001$) differences.

成果亮点
Research Highlights



BMVs介导的菌株LY03与微藻的跨界通讯模型

A Conceptual Model of BMV-mediated Interkingdom Interaction Between LY03 and Microalgae

Bacterial membrane vesicles (BMVs) are crucial biological vehicles for facilitating interspecies and interkingdom interactions. However, the extent and mechanisms of BMV involvement in bacterial-algal communication remain elusive. This study provides evidence of BMVs delivering cargos to targeted microalgae. Membrane vesicles (MVs) from *Chitinimonas prasina* LY03 demonstrated an algicidal profile similar to strain LY03. Further investigation revealed *Tambjamine* LY2, an effective algicidal compound, selectively packaged into LY03-MVs. Microscopic imaging demonstrated efficient delivery of *Tambjamine* LY2 to microalgae *Heterosigma akashiwo* and *Thalassiosira pseudonana* through membrane fusion. In addition, the study demonstrated the versatile cargo delivery capabilities of BMVs to algae, including the transfer of MV-carried nucleic acids into algal cells and the revival of growth in iron-depleted microalgae by MVs. Collectively, the results of our study provide the direct evidence of the horizontal transfer of functional biomaterials from bacteria to individual microalgae cells via BMVs, which not only shedding light on a previously unknown algicidal mechanism mediated by BMVs but also opens a window that allows us to obtain distinctive insight to understand, characterize, and even manipulate bacteria-algae interactions.

以上工作于2024年8月发表于*Science Advances*期刊，2021级博士生李依心为第一作者，田蕴教授为通讯作者。

Reference:
Yixin Li, Yuezhou Wang, Xiaolan Lin, Shuqian Sun, Anan Wu, Yintong Ge, Menghui Yuan, Jianhua Wang, Xianming Deng*, Yun Tian*, Algicidal bacteria-derived membrane vesicles as shuttles mediating cross-kingdom interactions between bacteria and algae, *SCIENCE ADVANCES*, 2024, 10 (32):eadn4526

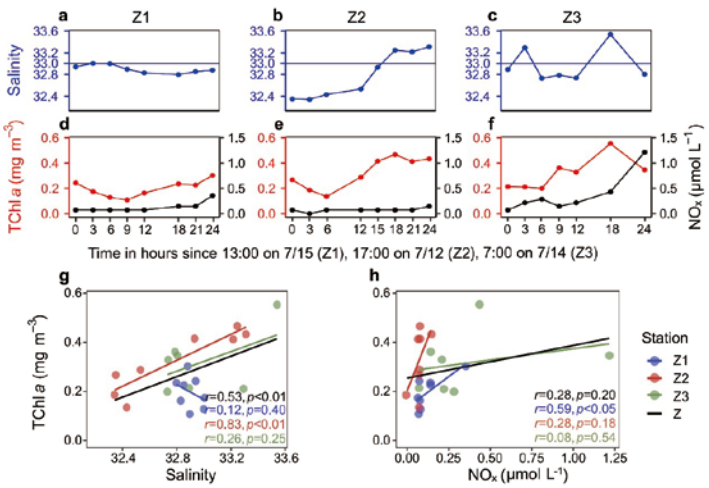
珠江羽流入侵台湾海峡导致当地营养盐耗竭和浮游植物群落演变

Nutrient Depletion and Phytoplankton Shifts Driven by the Pearl River Plume in the Taiwan Strait

传统观点认为，河口冲淡水羽流通常含有丰富的营养物质，能够促进近海浮游植物的生长，但远离河口的羽流营养盐逐渐被消耗，对当地浮游植物的生长是否有益呢？在西南季风驱动下，夏季珠江羽流可入侵至台湾海峡，为回答该问题提供了理想研究案例。

研究团队基于2014年夏季的现场观测数据，对该区域的营养盐动态和浮游植物群落组成进行了系统分析。结果表明，随着珠江羽流向海扩散，表层水体中的营养物质逐渐减少，尤其是氮的显著耗竭，导致氮限制现象加剧，从而显著降低了当地浮游植物的生物量。此外，珠江羽流驱动的水体垂直层化进一步影响了营养盐和光的空间分布，为不同浮游植物类群创造了独特的生态位。在形成的三层结构中，中层出现了叶绿素最大值，而表层则逐渐被微微型浮游植物所主导。浮游植物优势类群从硅藻向聚球藻的转变，将对区域碳循环和食物网结构产生深远影响。

与以往研究不同，珠江羽流对台湾海峡的影响并非典型的营养物质富集效应，而是突显了近海生物地球化学过程的复杂性。同时，该研究揭示了河流羽流在营养盐限制条件下对生态系统结构的潜在影响。这些结果深化了对大型河流羽流生态效应的理解，并强调了在受大型河流系统影响的沿海生态系统中，研究其生物地球化学过程的必要性。



以上工作于2024年10月发表于*Frontiers in Marine Science*期刊，2022级博士生佟竺殷为第一作者，马玲琪博士后为通讯作者。

Reference:
Zhuyin Tong, Changyun Wang, Lizhen Lin, Lingqi Ma* and Bangqin Huang, Nutrient depletion and phytoplankton shifts driven by the Pearl River plume in the Taiwan Strait. *Frontiers in Marine Science*, 2024, 11, 1485670.

Z1、Z2和Z3站位表层盐度、TChl a和NOx浓度的关系。（a–c）表层盐度的时间变化，（d–f）表层TChl *a*和NOx浓度的时间变化，（g）TChl *a*与盐度的关系，（h）TChl *a*与NOx浓度的关系

Relationship between surface salinity, TChl a and NOx concentration at Z1, Z2 and Z3 stations. (a-c) Temporal change of surface salinity, (d-f) temporal change of surface TChl *a* and NOx, (g) relationship between TChl *a* and salinity, (h) Relationship between TChl *a* and NOx.

The intrusion of the Pearl River plume into the Taiwan Strait provides a unique case study that challenges traditional assumptions about the impacts of nutrient-rich river plumes on coastal phytoplankton communities. In this study, we conducted a detailed analysis of nutrient dynamics and phytoplankton composition within the Taiwan Strait, focusing on the effects of the Pearl River plume. Our findings reveal significant nutrient depletion, particularly of nitrogen, in the surface waters as the plume extends seaward, resulting in nitrogen limitation and a marked reduction in phytoplankton biomass. Vertical stratification within the Taiwan Strait creates distinct ecological niches, with the mid-layer supporting a deep chlorophyll maximum and the surface layer becoming dominated by the picophytoplankton *Synechococcus*. This shift from diatom-dominated communities to *Synechococcus* dominance has far reaching implications for carbon cycling and food web dynamics in the region. Our results suggest that the Pearl River plume's influence on the Taiwan Strait represents a departure from the typical nutrient enrichment associated with river plumes, highlighting the complexity of coastal biogeochemical processes.

成果亮点
Research Highlights

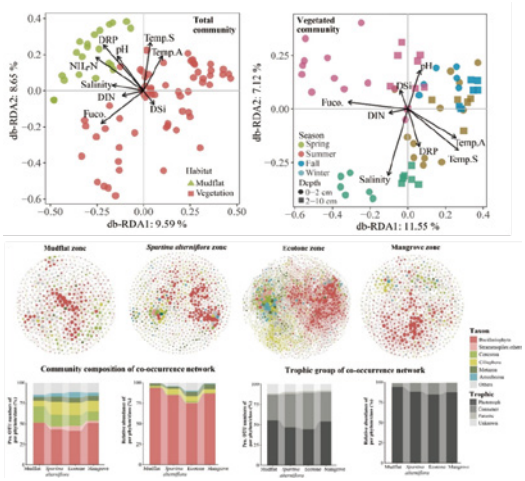
米草入侵红树林背景下底栖微型真核生物群落的动态变化

Dynamics of Benthic Microeukaryotic Communities in a Mangrove Wetland Invaded By *Spartina Alterniflora:* Effects of Vegetation, Seasonality, and Sediment Depth

红树林湿地是海岸带“蓝碳”生态系统的重要贡献者。互花米草是全球危害最严重的外来入侵物种之一，也是我国红树林湿地突出的入侵物种。底栖微型真核生物作为红树林湿地微生物群落的关键组成部分，在该生态系统的物质循环和能量流动中发挥着至关重要的作用。针对互花米草入侵对红树林湿地底栖微真核生物群落的影响，本工作系统探究了植被类型、季节变化及沉积物深度的交互作用。通过18S rRNA基因转录本的高通量测序技术，对福建漳江口红树林保护区内红树林区、互花米草区、红树与互花米草交错区、光滩区的沉积物样品进行了跨季节、不同深度的系统分析。

研究发现，地上植被覆盖与否显著影响了底栖微型真核生物的群落组成，这一效应主要是地上植被通过调控土壤中的营养物浓度和pH值变化，进而影响土壤中微型真核生物群落组成。此外，温度、盐度和pH值是驱动植被覆盖区底栖微型真核生物群落发生季节性变化的主要原因，而微藻群落中表征硅藻的岩藻黄素则影响了群落的垂直分布。共现网络分析表明，交错区的共现网络最为复杂且稳定性最高，其次是互花米草区，而红树林区和光滩区的网络复杂度较低。硅藻在所有共现网络中占据主导地位，相对丰度介于75.12%至93.50%之间，是最具优势的类群。而异养生物（如纤毛虫、变形虫、后生动物）在植被区共现网络中占据关键位置，尤其是互花米草区与交错区。这表明，互花米草入侵显著重塑底栖微型真核生物的共现模式。针对季节性模块进一步分析表明，硅藻类群在冷季（春季）与暖季（夏秋季）分别形成独立生态模块，表明其具有明显的季节性生态位分化。

本研究深化了对米草入侵背景下红树林底栖微型真核生物群落分布特征的认知，为理解湿地生态系统功能及其响应环境变化提供了重要科学依据。



采样区及植被覆盖区底栖微型真核生物群落的分布特征及其驱动因素，以及不同生境中底栖微型真核生物的共现网络分析

The distribution patterns and driving factors of benthic microeukaryotic communities across all sampling sites and vegetated areas; the co-occurrence networks of benthic microeukaryotes in different habitats.

Benthic microeukaryotes are crucial mediators of biogeochemical cycles in coastal wetland ecosystems, yet their spatial and temporal variability remains poorly understood. This study delineates the diversity patterns of benthic microeukaryotes in a *Spartina alterniflora*-invaded mangrove ecosystem in Fujian, China. Using highthroughput sequencing of 18S rRNA gene transcripts, we identified the influences of vegetation, seasonality, and sediment depth on microeukaryotic communities. We discovered that vegetation cover significantly affects community composition, primarily driven by nutrient concentrations and pH. The community structure of microeukaryotes varied seasonally and vertically, correlating with changes in sediment temperature, pH, salinity, and fucoxanthin concentration. Notably, invasive *Spartina alterniflora* habitats showed enhanced heterotrophic interactions, suggesting that invasive species can reshape benthic microeukaryotic co-occurrence patterns. Seasonal co-occurrence patterns revealed dominant Bacillariophyta assemblages exhibited distinct network modules enriched in the cold (spring) and warm (summer and fall) seasons, respectively, which indicated potential ecological niche differentiation. Our findings reveal the complex relationships between environmental factors and benthic microeukaryotic diversity, offering insights into microbial responses to natural and invasive vegetation influences.

以上工作于2024年1月发表于*Science of the Total Environment*期刊，2022级博士生王莹为第一作者，黄邦钦教授、孙萍教授为通讯作者。

Reference:
Ying Wang, Jie Kong, Songsong Gu, Bangqin Huang*, Ping Sun*, Dynamics of benthic microeukaryotic communities in a mangrove wetland invaded by *Spartina alterniflora*: Effects of vegetation, seasonality, and sediment depth, *SCIENCE OF THE TOTAL ENVIRONMENT*, 2024, 916, 170231.

九龙江口海底地下水排放的水文指标及其全球意义

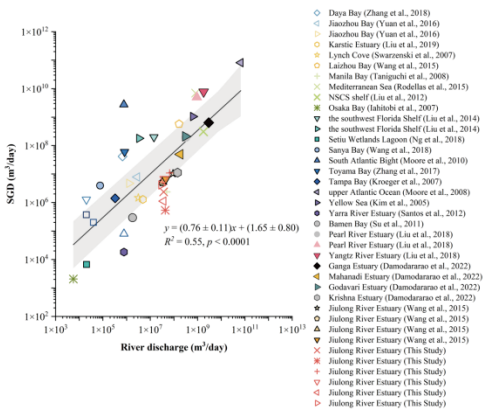
Hydrographic Proxies for Submarine Groundwater Discharge in the Jiulong River Estuary and Global Perspectives

海底地下水排放（Submarine groundwater discharge，SGD）指在陆架边缘从海底向近岸地表水体排放的所有水流，因其携带大量碳和营养盐，对近岸水生态系统具有重要影响，一般包括再循环海水地下水（RSGD）和淡水地下水（FSGD）。现有地下水模型应用渗透系数、含水层厚度、地形坡度等空间差异大且不易直接观测的参数来模拟估算SGD通量。近几十年，镭、氡等化学示踪剂开始被广泛用于估算SGD通量。然而，由于缺乏可常规观测的用于SGD通量估算的指标，近岸生物地球化学模型中通常忽略SGD这一重要过程。

研究团队以长半衰期镭同位素（^{226}Ra和^{228}Ra）作为SGD示踪剂，基于一年内隔月连续观测的数据，建立了镭的质量平衡模型，揭示了九龙江口海底地下水排放通量在两个月的时间尺度上的变化，并通过定点时间序列观测，探讨了九龙江口地下水排放通量的驱动因子。结果显示，2014年总SGD通量的月变化显著，6月最高，4月最低，相当于同期河流径流量的10 ± 1.67%，且与河流径流量之间存在着显著的正相关关系（p<0.05）。通过统计分析还发现，SGD 通量与河口回流率以及冲刷时间之间都有显著的负相关关系（p<0.0001）。回流率是每个涨潮期间河口流出的水返回河口的比例，冲刷时间是河口水被河流和潮汐替换所需的时间。这些发现表明，河流径流量、河口回流率和冲刷时间可以作为九龙江口SGD通量的水文指标，可能在其他近岸生态系统也有较好的应用潜力。

课题组对全球范围内已发表的同时具有海底地下水排放通量与同期河流径流量数据的不同空间尺度的河口、陆架和海盆系统等进行了整合分析。结果显示，地质结构和潮汐效应等多种驱动因素可能导致SGD的空间异质性，但总体而言，这些系统的SGD通量与同期河流径流量之间在对数尺度上呈现出显著的线性正相关关系（p<0.0001），表明这些空间尺度迥异的系统中，河流径流量可以作为SGD的潜在预测指标。该成果为近岸生物地球化学模型中海底地下水排放通量的参数化方案提供了重要的科学依据。

Submarine groundwater discharge (SGD) significantly impacts most coastal waters. However, its quantification, depending on chemical tracers/proxies, limits its parameterization in numerical models. This study explored the hydrographic proxies of SGD in the Jiulong River estuary (JRE) using ^{226}Ra and ^{228}Ra as SGD tracers. Our results showed significant monthly fluctuations in the flux of SGD, with a peak in June and a minimum in April. On average, the flux of SGD was equivalent to 10 ± 1.67 % of the concurrent river discharge, with the areanormalized rate of 0.007 ± 0.017 to 0.13 ± 0.04 m/day. Positive SGD response to river discharge implies a connection with the surface runoff of the shallow aquifers. Furthermore, the flux of SGD presented a significant negative correlation with the return flow factor and flushing time of the estuary. The radium activities in the estuary were positively correlated with water depth, indicating that SGD was not driven by tidal pumping. Instead, physical mixing in low to middle salinity regions predominated such behavior of radium. Our results indicate that river discharge, flushing time and return flow factor may serve as hydrographic proxies of SGD in the JRE and potentially be applicable in parameterization of SGD in numerical models in similar coastal eco systems. Globally, a positive correlation between SGD flux and river discharge emphasizes the latter as a general proxy in estuaries.



全球范围内不同空间尺度的河口、陆架、海盆等系统海底地下水排放通量vs. 河流径流量。两者均为对数尺度

The Flux of SGD and River Discharge in Various Systems. The Solid Line is the Linear Regression Line and the Shading Area Denote the 95 % Confidence Band.

以上工作于2024年8月发表于*Water Research*期刊，2024届博士生杜墨戈为第一作者，王桂芝教授为通讯作者。

Reference:
Moge Du, Shilei Jin, Siqi Wu, Yanzhen Liao, Guizhi Wang*. Hydrographic proxies for submarine groundwater discharge in the Jiulong River estuary and global perspectives. *WATER RESEARCH*, 2024, 121854.

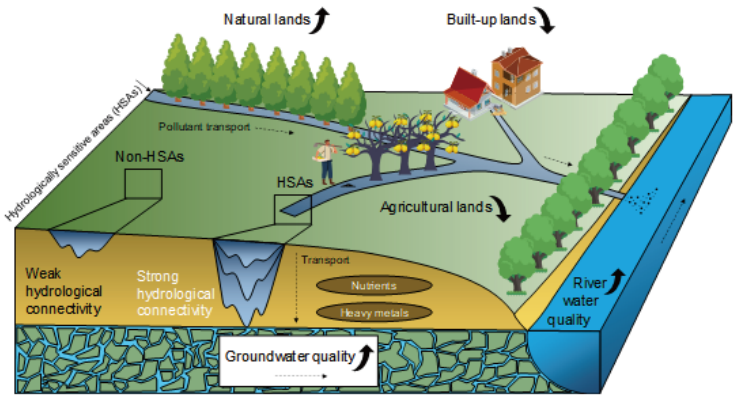
水文敏感区优先生态修复可有效提升地下水水质

Prioritizing Ecological Restoration in Hydrologically Sensitive Areas to Improve Groundwater Quality

国家“双碳战略”的实施推动了一系列生态修复与保护措施的开展。“植树造林”和“退耕还林还草”等绿色工程被认为是缓解气候变化和水质恶化问题的重要途径。根据《全国国土绿化规划纲要（2022–2030年）》，“十四五”期间，我国拟规划完成造林种草等国土绿化5亿亩。然而，利用有限的资金重点在哪些区域进行绿化有助于发挥生态修复“四两拨千斤”的作用，实现环境和经济的“双赢”，值得深入研究。

研究团队首先对全国范围90个站位地下水营养盐（硝氮、氨氮、无机磷）和重金属（钒、铬、锰、铁、钴、镍、铜、砷、锶、钼、镉、铅）进行取样分析；随后，结合全球和国家土壤属性数据库，应用机器学习方法（随机森林），外推了取样站位周边土壤饱和导水率的分布，进一步基于地理空间分析获取了水文敏感区的空间分布；最后，从水文连通性的角度分析了水文敏感区土地利用（尤其是自然用地占比）与地下水水质的关系。

研究揭示了水文敏感区是营养盐和重金属从地表向地下水迁移的热点区域。在占陆地面积约20%的水文敏感区内增加自然用地占比，能够显著减少地下水营养盐和重金属浓度（$p < 0.05$），且这一效果与在全域增加自然用地的做法相当。未来在水文敏感区内优先进行生态修复（如“造林种草”）有助于实现环境（改善地下水水质）和经济（减少治理资金投入）的“双赢”。



基于水文连通性的土地利用格局优化可改善河流与地下水水质概念图

Schematic Showing the Land Management Strategies Based on Hydrological Connectivity to Improve River Water and Groundwater Quality

以上工作于2024年3月发表于*Water Research*期刊，2023届博士生王曜为第一作者，陈能汪教授与王德利教授为通讯作者。

Reference:
Yao Wang, Yiqi Yu, Xin Luo, Qiaoguo Tan, Yuqi Fu, Chenhe Zheng, Deli Wang*, Nengwang Chen*, Prioritizing ecological restoration in hydrologically sensitive areas to improve groundwater quality, *WATER RESEARCH*, 2024, 252, 121247.

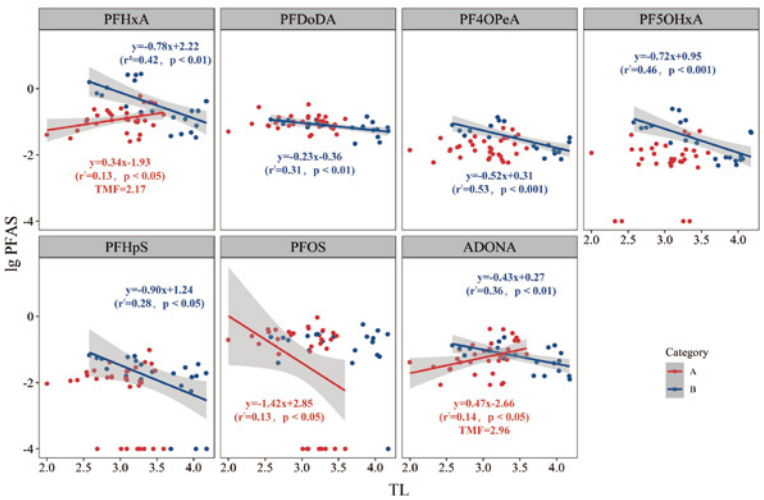
Greening is the optimal way to mitigate climate change and water quality degradation caused by agricultural expansion and rapid urbanization. However, the ideal sites to plant trees or grass to achieve a win–win solution between the environment and the economy remain unknown. Here, we performed a nationwide survey on groundwater nutrients (nitrate nitrogen, ammonia nitrogen, dissolved reactive phosphorus) and heavy metals (vanadium, chromium, manganese, iron, cobalt, nickel, copper, arsenic, strontium, molybdenum, cadmium, and lead) in China, and combined it with the global/national soil property database and machine learning (random forest) methods to explore the linkages between land use within hydrologically sensitive areas (HSAs) and groundwater quality from the perspective of hydrological connectivity. We found that HSAs occupy approximately 20% of the total land area and are hotspots for transferring nutrients and heavy metals from the land surface to the saturated zone. In particular, the proportion of natural lands within HSAs significantly contributes 8.0% of the variability in groundwater nutrients and heavy metals in China ($p < 0.01$), which is equivalent to their contribution (8.8%) at the regional scale (radius = 4 km, area = 50 km^2). Increasing the proportion of natural lands within HSAs improves groundwater quality, as indicated by the significant reduction in the concentrations of nitrate nitrogen, manganese, arsenic, strontium, and molybdenum ($p < 0.05$). These new findings suggest that prioritizing ecological restoration in HSAs is conducive to achieving the harmony between the environment (improving groundwater quality) and economy (reducing investment in area management).

亚热带红树林河口食物网中全氟和多氟烷基物质的生物累积和营养转移

Bioaccumulation and Trophic Transfer of Per-and Polyfluoroalkyl Substances in a Subtropical Mangrove Estuary Food Web

红树林河口是重要的陆海过渡生态系统，面临各种污染压力，但缺乏对红树林河口生物中全氟和多氟化合物（Per-and polyfluoroalkyl substances, PFAS）的研究。考虑到PFAS具有生物累积潜力，且对生物具有一定的生理毒性，因此对红树林河口系统中水生生物PFAS进行研究具有重要意义。

研究团队在福建省漳江口红树林河口采集夏冬两个季节的生物样品，将采集的生物样品进行分类解剖，获取组织样品。测定生物组织的碳氮稳定同位素，以计算生物营养级。采用离子配对法对生物样品进行PFAS提取，最终将制备的样品使用高效液相色谱串联4500三重四级杆质谱测定PFAS浓度。研究发现，鱼类组织中PFAS浓度整体上呈现内脏>头部>残骸>肌肉的趋势。经过夏秋季的快速生长，漳江口冬季鱼类普遍比夏季鱼类成熟，由于PFAS的生物累积性，鱼类越成熟，其累积PFAS的时间越久，因此，漳江口鱼类冬季PFAS的全鱼负荷高于夏季。与PFAS浓度混合较均匀的开阔海域相比，在污染物环境浓度梯度变化较大的红树林河口区，PFAS的生物营养级传递富集被栖息环境PFAS的梯度稀释所掩盖，活动区域范围越大的生物梯度稀释效应也越明显。



漳江口A、B类生物lg PFAS (ng/g ww)与TL的回归关系

Regressions Between TL and lg PFAS Concentration (ng/g ww) in Category A and B Organisms From ZRE

以上工作于2024年6月发表于*Science of The Total Environment*期刊，2019届博士生解兴伟为第一作者，吕永龙教授为通讯作者。

Reference:
Xingwei Xie, Yonglong Lu *, Haojie Lei, Jianhua Cheng, Xupeng An, Wenqing Wang, Xudong Jiang, Jianglin Xie, Yunting Xiong, Ting Wu, Bioaccumulation and trophic transfer of per- and polyfluoroalkyl substances in a subtropical mangrove estuary food web, *Science of The Total Environment,* 2024, 927, 172094.

Mangrove estuaries are an important land-sea transitional ecosystem that is currently under various pollution pressures, while there is a lack of research on per- and polyfluoroalkyl substances (PFAS) in the organisms of mangrove estuaries. In this study, we investigated the distribution and seasonal variation of PFAS in the tissues of organisms from a mangrove estuary. The PFAS concentrations in fish tissues varied from 0.45 ng/g ww to 17.67 ng/g ww and followed the order of viscera > head > carcass > muscle, with the highest tissue burden found in the fish carcass (39.59 ng). The log BAF values of PFDoDA, PFUnDA, and PFDA in the whole fish exceeded 3.70, indicating significant bioaccumulation. The trophic transfer of PFAS in the mangrove estuary food web showed a dilution effect, which was mainly influenced by the spatial heterogeneity of PFAS distribution in the estuarine environment, and demonstrated that the gradient dilution of PFAS in the estuary habitat environment can disguise the PFAS bio-magnification in estuarine organisms, and the larger the swimming ranges of organisms, the more pronounced the bio-dilution effect. The PFOA-equivalent HRs of category A and B fish were 3.48–5.17 and 2.59–4.01, respectively, indicating that mangrove estuarine residents had a high PFAS exposure risk through the intake of estuarine fish.

河口和近岸海水亚砷酸盐和总溶解态无机砷的现场船载分析

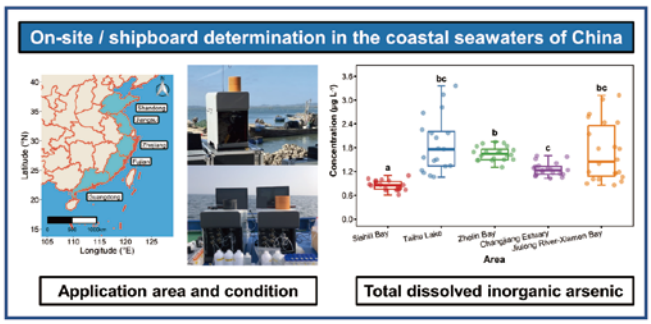
Shipboard Determination of Arsenite and Total Dissolved Inorganic Arsenic in Estuarine and Coastal Waters with an Automated On-site-applicable Atomic Fluorescence Spectrometer

砷（Arsenic，As）作为一种类金属元素，毒性较强且存在多种形态。As广泛分布于各类海洋环境之中，河口中As的迁移转化，是连接陆地与海洋中As循环的关键纽带。近岸海域的As污染，也是我国普遍且长期存在的环境问题之一。此外，As与磷属于同族元素，其在海洋里的生物地球化学过程，与磷循环紧密相关。因此，对海水中无机砷的形态进行分析，对于研究河口–海湾As迁移转化、评估近岸海域As污染状况，以及探究海洋中As和磷的生物地球化学循环过程，都具有极其重要的意义。

目前，能提供大量As形态数据的研究，大多基于采样保存以及实验室分析。然而，亚砷酸盐在环境中极易被氧化为砷酸盐，这一过程甚至在酸化样品中就会发生。海水中的 As 浓度处于痕量水平，许多分析方法的灵敏度不够或受盐度等影响而无法应用。常用的分析方法多依赖大型实验室仪器，并不适用于现场和船载分析。

针对上述问题和挑战，研究团队研制了小型原子荧光光谱仪，使用自制氢气发生器和固态光电检测器，可提供稳定的燃气火焰和光路系统。基于此，团队开发出快速、灵敏的海水中无机砷形态（亚砷酸盐和总溶解无机砷）现场船载分析方法。该方法分析速度快（样品通量10 h^{-1}）、灵敏度高（检出限0.02 μg L^{-1}）、线性范围宽（0.02 ~ 8 μg L^{-1}，R^2>0.999）、准确性好（一年内相对标准偏差1.6~2.1%）且基本不受盐度干扰（加标回收率96.3~105.3%）。利用该方法，对福建漳江口–东山湾2021和2022年无机砷形态的时空变化与季节性差异进行了系统研究；同时，对中国近岸海域（包括山东烟台四十里湾、江苏无锡太湖水域、浙江舟山长江口水域、福建九龙江–厦门湾和广东潮州柘林湾）的无机砷形态空间分布进行了现场或船载分析，深入探讨了我国沿海不同区域总溶解态无机砷浓度的空间分布特征，特别是对九龙江–厦门湾无机砷形态的区域性差异及其成因进行了详细解析。

本研究成功开发了适用于海水复杂基质的痕量砷现场船载分析方法，填补了该领域的技术空白；通过大量现场应用验证了方法和仪器的稳定性和准确性，为后续砷、锑、铋、硒等元素的船载和走航分析奠定了方法学基础；研究成果已成功应用于中国痕量元素和同位素海洋生物地球化学循环计划（GEOTRACES）首个西太平洋航次（GP09）的大洋垂直剖面样品分析，为海洋砷循环和痕量金属研究提供了重要的数据支撑。



中国近岸海域无机砷形态现场/船载分析（左图：现场应用区域和应用情况；右图：总溶解态无机砷空间分布特征和区域性差异分析）

On-site/shipboard determination of inorganic arsenic in the coastal waters of China(left: application area and condition; right: spatial distribution and regional difference of total dissolved inorganic arsenic in these areas).

以上工作于2023年8月发表于*Talanta*期刊，2023届硕士生薄光永为第一作者，马剑教授为通讯作者。

Reference:
Guangyong Bo, Tengyue Fang, Luodan Chen, Zhenbin Gong, Jian Ma*, Shipboard determination of arsenite and total dissolved inorganic arsenic in estuarine and coastal waters with an automated on-site-applicable atomic fluorescence spectrometer, *TALANTA*, 2023, 266, 125082.

The speciation of trace level arsenic (As) in estuarine and coastal waters is crucial for both biogeochemical and toxicological studies of this toxic metalloid. However, the accurate and on-site determination of As in complex seawater matrices is challenging because of the low concentration of As, the easy conversion of arsenite (As(III)) to arsenate (As(V)), and the considerable effect of salinity on the determination of As via conventional methods. In this study, a custom-made shipboard atomic fluorescence spectrometer (AFS) is reported for the on-site speciation of inorganic As in estuarine and coastal waters. After comprehensive optimization of the instrumental and chemical parameters, the method demonstrated high sensitivity (limits of detection: 0.02 μg L^{-1}), good linearity (R^2 > 0.999 for all calibration curves up to 8 μg L^{-1}), high precision (relative standard deviations (RSDs) of less than 2% at 1 μg L^{-1} over a year-long evaluation), and excellent performance for sample analysis for different matrices with varying salinities (recoveries: 96.3%–105.3%). The portable and field-applicable AFS was successfully applied to the on-site and shipboard simultaneous determination of As(III) and total dissolved inorganic arsenic (TDIAs) in the coastal waters of Shandong, Jiangsu, Zhejiang, Fujian, and Guangdong province of China, demonstrating its robustness and applicability in harsh conditions.

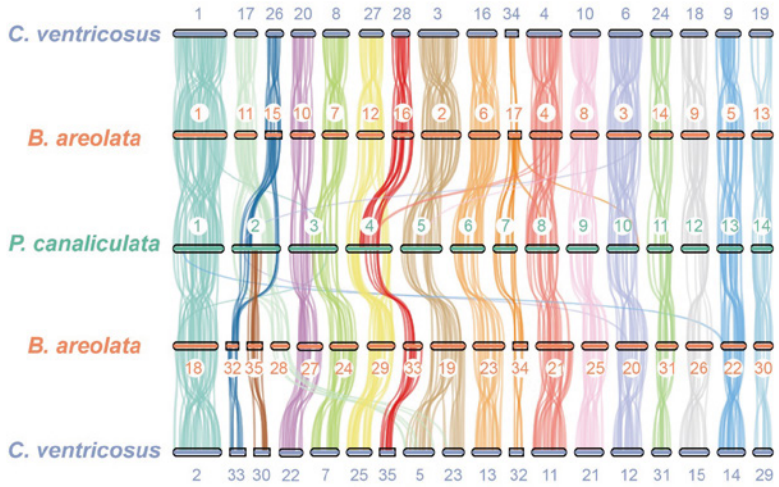
方斑东风螺基因组研究进展

Chromosome-level Genome Assembly of the Ivory Shell *Babylonia Areolata*

方斑东风螺（*Babylonia areolata*）是一种生长迅速、营养丰富的经济性海洋底栖螺类，主要分布于东南亚及中国东南沿海，是我国重要的水产经济物种，其年产值已接近百亿元。然而，环境污染与气候变化导致病害频发，亟需基因组资源支撑遗传改良研究。

研究团队首次破译了方斑东风螺染色体水平的高质量基因组。通过采用PacBio、Illumina和Hi-C技术，并整合多种组装方法，获得了包含35条染色体的1.65 Gb的基因组序列，其contig N50和scaffold N50分别达2.64 Mb和53.17 Mb，重复序列占比64.46%。鉴定出26,130个蛋白编码基因，BUSCO完整性达96.75%，为目前已公开的新腹足目物种中注释质量最高的基因组。进一步利用多组织转录组数据验证基因结构，结合系统发育分析揭示方斑东风螺与芋螺（*Conus ventricosus*）约1.43亿年前分化，并发现两者染色体高度共线性，支持基因组组装的可靠性。

本研究为解析方斑东风螺生长、抗逆等性状的遗传机制提供了关键数据，同时为贝类进化、环境适应及分子育种奠定了重要基础，对推动水产养殖业可持续发展具有重要意义。



方斑东风螺、芋螺、福寿螺染色体共线性。与福寿螺染色体相比，方斑东风螺和芋螺染色体数量加倍

The chromosomal collinearity between B. areolata, C. ventricosus, and Pomacea canaliculate. Compared to *P. canaliculate*, *B. areolata* and *C. ventricosus* exhibited significant chromosomal doubling.

The ivory shell *Babylonia areolata* is an economically important marine benthic gastropod known for its rapid growth and high nutritional value. *B. areolata* is distributed in Southeast Asia and the southeast coastal areas of China. In this study, we constructed a high-quality genome for *B. areolata* using PacBio, Illumina, and Hi-C sequencing technologies. The genome assembly comprised 35 chromosomal sequences with a total length of 1.65 Gb. The scaffold and contig N50 lengths were 53.17 Mb and 2.64 Mb, respectively, with repeat sequences constituting 64.46% of the genome. Furthermore, 26,130 protein-coding genes and 96.75% of the genome's BUSCOs were identified. This inaugural report of a *B. areolata* genome provides crucial foundational information for further investigations into the biology, genomics, and genetic improvement of economic traits of this species.

以上工作于2024年11月发表于*Scientific Data*期刊，2019级博士生邹禹与博士后付敬强为第一作者，柯才焕教授和游伟伟教授为通讯作者。

Reference:
Yu Zou, Jingqiang Fu, Yuan Liang, Xuan Luo, Minghui Shen, Miaoqin Huang, Yexin Chen, Weiwei You*, Caihuan Ke*, Chromosome-level genome assembly of the ivory shell *Babylonia areolata, SCIENTIFIC DATA*, 2024, 11 (1): 1201.

成果亮点
Research Highlights

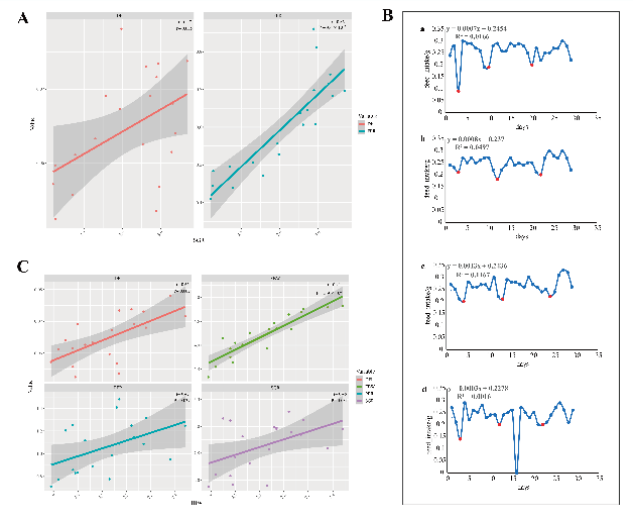
通过个体养殖评估饮食变化对日本囊对虾的影响及个体差异探究

Impact of Dietary Variations on Kuruma Shrimp (*Penaeus japonicus*) Assessed Through Individual-Based Rearing and Insights into Individual Differences

日本囊对虾因其体色艳丽、肉质鲜美、具有重要经济价值等优点被公认为是优良的养殖对象。我国自上世纪七八十年代成功养殖日本囊对虾以来，其养殖产业得到迅猛发展，当前我国已成为日本囊对虾第一养殖大国。早期的日本囊对虾养殖营养供应主要来源于活饵料的投喂，随着研究的发展，配合饲料作为稳定可持续的营养来源，已广泛应用于日本囊对虾养殖生产中。然而，关于活饵料与配合饲料之间的比较研究仍然较为匮乏。在传统的养殖方式中，日本囊对虾一般以群体形式在水中饲养，已有大量研究探讨了群养条件下对虾的生长、营养和蜕皮等方面。然而，受饵料影响的存活率、饲料转化率等关键指标，可能受到未受控制的种内相互作用（如残食行为）影响，从而导致结果不准确。已有研究表明，个体饲养方法有助于更精确地研究水生生物的生长与摄食特性，同时能最大限度地减少残食等非饮食因素的干扰。因此，本研究采用个体养殖模式，探讨不同饵料对日本囊对虾的影响以及个体间的差异性。

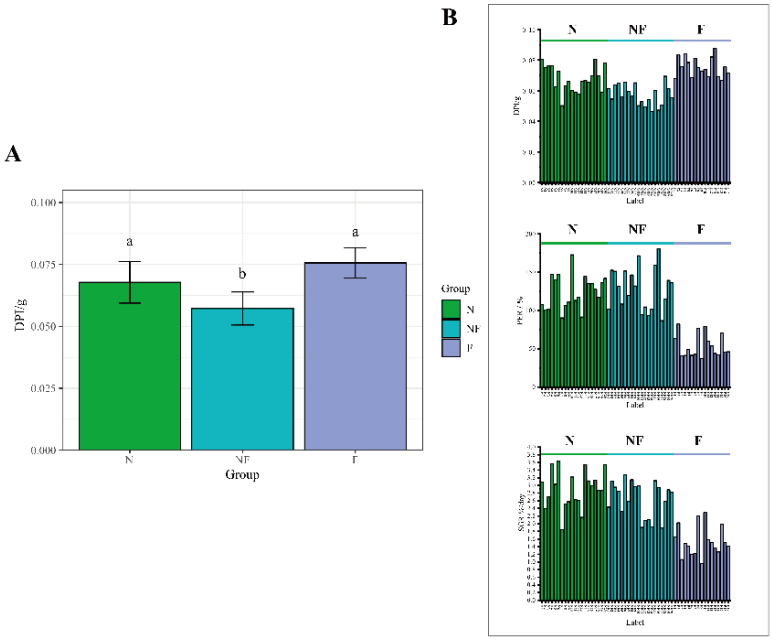
研究团队在福建台湾海峡海洋生态系统国家野外科学观测研究站东山实验场设计了一种个体养殖方法，比较了活饵料沙蚕、配合饲料及沙蚕和配合饲料混合投喂对日本囊对虾的影响。实验结果表明，相较于配合饲料，活饵料沙蚕能显著提高对虾的生长性能，并促进肠道菌群的健康与稳定。沙蚕与配合饲料混合投喂时，对虾的生长与摄食表现与活饵料组相当，且显著提高了蛋白质利用率，同时降低了生产成本。此外，个体养殖方法揭示了个体间在生长和摄食方面的差异，且每尾虾的最终体重、特定生长率、蛋白质利用率和平均日摄食量与初始体重呈正相关。研究还发现，虾的每日摄食量随蜕皮周期呈周期性变化。

本研究结果揭示了日本囊对虾的饲料偏好及其生长和摄食特性。与活饵料相比，配合饲料的营养供应相对不足，通过策略性地添加活饵料可以显著提升养殖效率。根据对虾的蜕皮周期调整日粮供应，也能优化饲料的利用效率，从而提高养殖效果。综上所述，个体养殖方法为详细评估和观测日本囊对虾饲料提供了有效的途径，对饲料选择、开发和养殖策略的改进具有重要意义。



（A）对虾个体特定生长率（SGR）的饲料效率比（FER）与日摄食量（DFI）的皮尔逊相关性。（B）实验期间对虾日摄食量的变化。（C）初始体重（IBW）与平均日摄食量（DFI）、最终体重（FBW）、蛋白质利用效率（PER）和特定生长率（SGR）之间的关系(a、b、c、d 分别代表 NF 组的 4 只对虾，红点代表对虾当天蜕壳)

Pearson's correlations of variation coefficients of feed efficiency ratio (FER) and daily feed intake (DFI) for shrimp individual's specific growth rate (SGR) (A). Changes in daily feed intake during the experiment (B). Relationship between initial body weight (IBW) and average daily food in-take (DFI), final body weight (FBW), protein efficient rate (PER), and specific growth rate (SGR), and of the experiment shrimp housed individually (C). (a, b, c, d represent 4 shrimp from group NF respectively, and the red dots represent shrimp molting on this day.)



（A）三个分组之间每日蛋白质摄入（DPI）的比较。（B）不同组中不同个体的DPI，PER和SGR的直方图。（不同的颜色代表不同的分组;带有不同字母的数据表明显着差异（p <0.05），N：沙蚕组，F：配合饲料组，NF：混合饵料组）

Comparison of daily protein intake (DPI) between three groups (A). Histogram of DPI, PER, and SGR for different individuals in different groups (B).(Different colors represent different group-ings , a, b mean values unlike superscript letters were significantly different (p < 0.05).

This study developed an individual rearing method to compare the effects of live feed (sand-worms *Perinereis aibuhitensis*), formulated pellet diet, and a mixture of live feed and formula feed on the kuruma shrimp *Penaeus japonicus*, aiming to minimize the influence of non-dietary factors on the growth of *P. japonicus* like cannibalism. Results indicated that live feed, with its higher protein, essential amino acids, and fatty acids content, led to significantly better growth and feeding performance in *P. japonicus* (p < 0.05) compared to pellet diets. A mixed diet resulted in a lower average daily protein intake yet maintained growth and feeding performance comparable to live feed. The intestinal microbiota of shrimp, dominated by Proteobacteria, Bacteroidetes, Firmicutes, and Actinobacteria, showed significant shifts with diet changes. Specifically, formulated feed increased the relative abundance of Vibrio and Photobacterium, while decreasing *Shimia* and *Rhodobacterales* (p < 0.05), and feeding live food resulted in a more complex and stable bacterial network. Notably, individual variances in growth and feeding were observed among shrimps, with some on formulated diets showing growth comparable to those on live feed. Each shrimp's final weight, specific growth rate, protein efficiency rate, and average daily food intake positively correlated with its initial body weight (p < 0.05), and daily intake varied cyclically with the molting cycle. These findings suggest that individual rearing is an effective approach for detailed feed evaluation and monitoring in *P. japonicus*, contributing to improved feed selection, development, and feeding strategies.

以上工作于2024年8月发表于*Animals*期刊，2021级博士生陈传曦为第一作者，徐鹏教授和毛勇正高级工程师为通讯作者。

Reference:
Chuanxi Chen, Chunxiang Ai, Wenzhi Cheng, Huiyang Huang, Yiling Hou, Xiaojie Deng, Siqi Li, Yue Liu, Peng Xu*, Yong Mao*, Impact of Dietary Variations on Kuruma Shrimp (*Penaeus japonicus*) Assessed Through Individual-Based Rearing and Insights into Individual Differences *Animals*, 2024, 14(15): 2267.

数据管理
Data Management

2024年，厦门大学海洋观测与信息服务中心暨台海站数据中心围绕数据中心的总体建设框架和任务，持续推进台海站数据库建设、数据管理与数据应用服务。分别于2024年9月和12月正式上线“生态环境数据共享服务平台”和“海岸带与海洋时空大数据平台”，提升了数据资源开放共享服务能力。

In 2024, the Marine Monitoring and Information Service Center of Xiamen University, along with the Taiwan Strait Station Data Center, continued to advance the construction of the Taiwan Strait Station database, data management, and data application services within the overall framework and tasks of the data center. The "Ecological Environment Data Sharing Service Platform" and the " Coastal Zone and Ocean Spatiotemporal Big Data Platform" were officially launched in September and December 2024, respectively, enhancing the capacity for open sharing of data resources.

生态环境数据共享服务平台

Ecological Environment and Data Sharing Service Platform (EEDS)

“生态环境数据查询共享服务平台”整合了台海站两场三区观测数据资源，可实现数据的在线查询、申请、审批、上传、下载等功能，用户通过该系统能够在线申请数据，实现分级审批，保障了数据权利人、生产者、管理者等利益相关者的权益，从而达到高效服务、共建共享、权限分级，提升了数据管理水平和数据价值。首批上线共享数据主要为台海站在线观测系统高频数据集，未来，平台还将持续拓展数据资源，逐步纳入共享服务平台，以满足不同领域、不同层次的需求。

生态环境数据共享服务平台用户页面

User Interface of the Ecological Environment Data Sharing Service Platform

The "Ecological Environment Data Query and Sharing Service Platform" integrates observation data resources from the two fields and three zones of the Taiwan Strait Station. It enables online data query, application, approval, upload, and download functions. Users can apply for data online through this system, achieving hierarchical approval, which safeguards the rights and interests of data rights holders, producers, managers, and other stakeholders. This ensures efficient service, co-construction and sharing, and hierarchical permissions, thereby improving data management levels and data value. The first batch of shared data primarily includes high-frequency datasets from the Taiwan Strait Station's online observation system. In the future, the platform will continue to expand data resources, gradually incorporating them into the sharing service platform to meet the needs of different fields and levels.

生态环境数据共享服务平台第I期共享数据目录

Catalog of the First Phase of Shared Data on the Ecological Environment Data Sharing Service Platform

观测区域	系统类型	观测系统	数据时间范围	观测参数
漳江口	陆-气通量站	滨海湿地涡度通量观测系统	2016.7-2020.12	二氧化碳通量、能量通量等
	气象站	滨海湿地气象观测系统	2019.12-至今	降水量、光合有效辐射等
	水质站	滨海养殖塘生态观测系统	2020.12-至今	水温、盐度、酸碱度、溶解氧等
东山湾	浮标	上升流水文生态观测系统	2019-2023.9	气象、水文基础参数；酸碱度、浊度、叶绿素等
	海床基系统	海底有缆珊瑚生态在线观测系统	2018.4-2023.10	水温、盐度、电导率；酸碱度、溶解氧、浊度；营养盐、叶绿素等
	气象站	滨海界面大气环境观测系统	2022.3-至今	气象基础参数、能见度、紫外辐射等
	水质站	地下河口观测系统	2020.4-至今	地下水文基础参数、酸碱度、溶解氧、氧化还原电位等
	其他	渔排基生态观测系统	2021.2-至今	水温、盐度、电导率、颗粒物等
	其他	岸基海水在线观测系统	2023.1-2023.9	水温、盐度、电导率；酸碱度、溶解氧、浊度、叶绿素；浮游植物、有机质等

海岸带与海洋时空大数据平台

Coastal and Ocean Spatio-Temporal Big Data Platform (COSD)

海岸带与海洋时空大数据平台，实现遥感数据与遥感产品的在线检索、申请审批、在线处理、在线分发以及数据统计和管理等功能。平台为用户提供丰富的基础数据资源，包括资源、高分、海丝、VIIRS、Modis、Landsat、Sentinel、葵花等系列的卫星遥感数据，以及近岸海域营养盐、渔排、叶绿素a、浊度、岸线变化等遥感产品。同时，基于COSD平台，用户也可以上传并自我管理无人机等影像数据、专题评估产品等。此外，即使是非专业用户，也能通过平台的在线处理模块，轻松完成遥感影像的裁剪、拼接、波段选择等操作，无需下载即可在线完成空间数据的快速处理。

The Coastal and Ocean Spatio-Temporal Big Data Platform (COSD) enables online retrieval, application and approval, online processing, online distribution, as well as data statistics and management of remote sensing data and remote sensing products. The platform provides users with a wealth of foundational data resources, including satellite remote sensing data from series such as ZY, GF, HaiSi, VIIRS, Modis, Landsat, Sentinel, and Himawari, as well as remote sensing products such as nearshore nutrient salts, fish farms, chlorophyll-a, turbidity, and shoreline changes. Additionally, based on the COSD platform, users can upload and self-manage data such as drone imagery and thematic assessment products. Furthermore, even non-professional users can easily perform operations such as remote sensing image cropping, mosaicking, and band selection through the platform's online processing module, enabling rapid spatial data processing without the need for downloading.

COSD访问首页
COSD Homepage

专业制图与智能分析模块
Professional Mapping and Intelligent Analysis Module

团队建设与人才培养
Team Building and Talent Development

团队建设与人才培养
Team Building and Talent Development

2024年台海站现有固定人员73人，其中研究人员62人，技术人员和管理人员11人。研究人员由43名教授、1名教授级高工、16名副教授、2名助理教授组成，其中中国科学院院士2人，欧洲科学院/俄罗斯科学院/发展中国家科学院院士1人，国家杰出青年科学基金获得者5人，国家优秀青年科学基金获得者5人，国家高层次人才1人；技术人员和管理人员共11名，由4名高级工程师、2名工程师、3名助理工程师、1名驻站科学家、1名秘书组成。

2024年，新增固定人员2人，包括1名助理工程师，1名办公室秘书。戴民汉院士当选美国地球物理联合会会士并获地球与空间科学大使奖，焦念志院士获生态环境保护产业创新发展杰出贡献奖，吕永龙院士获俄罗斯科学院300周年禧年奖章，焦念志、戴民汉当选中国生态学学会创始会士，吕永龙当选中国生态学学会首批会士，黄邦钦获国务院政府特殊津贴，曹玲获批国家杰出青年科学基金项目。

As of 2024, the T-SMART has a total of 73 permanent staff members, including 62 researchers and 11 technical and administrative personnel. The research team consists of 43 professors, 1 professor-level senior engineer, 16 associate professors, and 2 assistant professors. Among them, there are 2 Academicians of the Chinese Academy of Sciences, 1 Academician of the European Academy of Sciences/Russian Academy of Sciences/Academy of Sciences for the Developing World, 5 recipients of the National Science Fund for Distinguished Young Scholars, 5 recipients of the National Science Fund for Excellent Young Scholars, and 1 national high-level talent. The technical and administrative team comprises 11 members, including 4 senior engineers, 2 engineers, 3 assistant engineers, 1 resident scientist, and 1 secretary.

In 2024, two new permanent staff members were added, including one assistant engineer and one office secretary. Academician Minhan Dai was elected as a Fellow of the American Geophysical Union (AGU) and received the Ambassador Award for Earth and Space Science. Academician Nianzhi Jiao was awarded the Outstanding Contribution Award for Innovation and Development in the Ecological and Environmental Protection Industry. Academician Yonglong Lu was honored with the Russian Academy of Sciences Tercentenary Jubilee Medal. Both Nianzhi Jiao and Minhan Dai were elected as Founding Fellows of the Ecological Society of China, while Yonglong Lu was elected as one of the first Fellows of the Ecological Society of China.Bangqin Huang has been awarded the Special Government Allowance of the State Council. Ling Cao has been granted the National Science Fund for Distinguished Young Scholars.

新增人员 New members

罗辉
助理工程师
Hui Luo / Assistant Engineer
Email：lh30@xmu.edu.cn
2023年获厦门大学海洋事务硕士学位。2025年入职厦门大学并加入台海站，从事海洋浮游生物生态学和分类学等研究工作。

李灿如
办公室秘书
Canru Li / Office Secretary
Email：tsmart@xmu.edu.cn
2024年获厦门大学海洋生物学硕士学位。2025年入职厦门大学并加入台海站，从事办公室行政等工作。

2024年，台海站为厦门大学海洋、生态等相关学科的科研和教学实习实践提供了硬件支撑和保障。依托台海站培养博士后1名，博士研究生14名，硕士研究生39名，在东山实验场和漳江口实验场开展珊瑚保育与河口红树林湿地相关研究达703人。来自厦门大学海洋与地球学院、环境与生态学院、生命科学学院以及社会与人类学院的硕博研究生在站内开展生产实习活动达571人次。

In 2024, the T-SMART provided hardware support and guarantees for scientific research and teaching internships and practical activities in relevant disciplines such as oceanography and ecology at Xiamen University. Relying on the T-SMART, 1 postdoctoral fellow, 14 doctoral students, and 39 master's students were trained. A total of 703 people carried out research related to coral conservation and mangrove wetlands in estuaries at the D-SMART and M-ECORS. Master's and doctoral students from the College of Ocean and Earth Sciences, College of the Environment and Ecology, College of Life Sciences, and College of Social Sciences and Humanities of Xiamen University carried out production internship activities at the station, with a total of 571 person-times.

合作交流
Exchanges & Collaborations

台海站第二届国际咨询委员会第一次会议召开

The First Meeting of the Second International Advisory Committee of the T-SMART was Successfully Held

2024年3月25日至27日，台海站第二届国际咨询委员会第一次会议在厦门成功召开。 本次会议汇聚了来自全球多所知名高校及研究机构的14位教授及专家。会议全面总结了台海站的建设进展，深入探讨了亟需解决的问题，并就未来观测研究、人才培养、科学普及、社会服务及发展规划等方面提出了建设性意见。

此次会议进一步推动了台海站与国际及台港地区一流野外站的交流与合作，显著提升了台海站的区域影响力。戴民汉院士出席会议并致辞，台海站站长黄邦钦教授主持了开幕式及敦聘仪式并作台海站发展报告，漳江口实验场副站长朱旭东教授和东山实验场副站长游伟伟教授共同主持了25日的国际咨询委员会会议。26日，委员们实地考察了台海站漳江口实验场和东山实验场，进一步了解了台海站的科研设施与成果。

From March 25 to 27, 2024, the first meeting of the second International Advisory Committee of the T-SMART was successfully held in Xiamen. The meeting brought together 14 professors and experts from renowned universities and research institutions worldwide. It comprehensively summarized the construction progress of the T-SMART, thoroughly discussed urgent issues to be addressed, and provided constructive suggestions for future observational research, talent development, science popularization, social services, and development planning.

This meeting further promoted exchanges and cooperation between the T-SMART and top-tier field stations internationally and in the Taiwan-Hong Kong region, significantly enhancing the regional influence of the T-SMART. Academician Dai Minhan attended the meeting and delivered a speech. Professor Huang Bangqin, Director of the T-SMART, presided over the opening ceremony and the appointment ceremony, and presented a report on the development of the station. Professor Zhu Xudong, Deputy Director of the M-ECORS, and Professor You Weiwei, Deputy Director of the D-SMART, co-chaired the International Advisory Committee meeting on the 25th. On the 26th, committee members conducted field visits to the Zhangjiangkou and D-SMART of the T-SMART, gaining further insight into the station's research facilities and achievements.

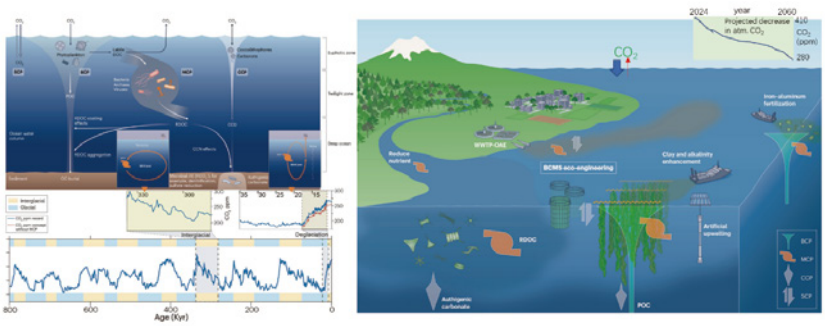
全球海洋负排放计划（Global-ONCE）

Global Ocean Negative Carbon Emissions (Global-ONCE) Programme

Global-ONCE是“联合国海洋科学促进可持续发展十年（2021-2030）”倡议计划框架（“海洋十年”）下的大科学计划，由焦念志院士发起，基于“微型生物碳泵（MCP）”原创理论框架，通过多学科交叉融合，创建“生物碳泵（BCP）-碳酸盐泵（CCP）-MCP-溶解度泵（SCP）”综合储碳理论体系（BCMS）。2024年10月22日，第三届 ONCE 开放科学大会在厦门大学举办。2024年11月22日，国际标准化组织（ISO）宣布全球首个海洋碳中和国际标准提案《海洋负排放与碳中和 —— 总则和要求》发布并立项。

Global-ONCE Programme is in the framework of the United Nations Decade of Ocean Science for Sustainable Development (2021-2030). Initiated by Prof. Nianzhi Jiao, Global-ONCE is based on his original theoretical framework for the Microbial Carbon Pump (MCP). Through multidisciplinary integration, Global-ONCE aims to establish a comprehensive carbon storage system combining the Biological Carbon Pump (BCP), Carbonate Counter Pump (CCP), MCP, and Solubility Carbon Pump (SCP), collectively forming the BCMS framework.

On October 22, the 3rd Global-ONCE Open Science Conference was held in Xiamen University. On November 22, the International Organization for Standardization (ISO) announced the approval of the world's first international standard proposal on ocean carbon neutrality, the “Ocean Negative Carbon Emissions and Carbon Neutrality—General Principles and Requirements,” with a 100% approval rate.



微型生物碳泵与全球气候变化
Microbial Carbon Pump and Global Climate Change

海洋碳中和国际标准提案正式发布
Approval of the “Ocean Negative Carbon Emissions and Carbon Neutrality-General Principles and Requirements”

“融通科学、管理和社会参与：助力海岸带可持续发展”(COASTAL-SOS)

Coastal Zones Under Intensifying Human Activities and Changing Climate: A Regional Programme Integrating Science, Management and Society to Support Ocean Sustainability (COASTAL-SOS)

COASTAL-SOS 由戴民汉院士牵头，携手国内外多家高水平科研单位、龙头企业、非营利性基金会、国际组织共同策划，为“海洋十年”项目。

2024年6月，BLUE-CARE蓝碳项目举行蓝碳科普游园会，通过不同类型的活动推进蓝碳知识普及，共300多名厦门小学生参加。

2024年4月，首席科学家戴民汉院士参加 2024 年海洋十年大会和第 2 届联合国海洋十年区域大会，在多个场合向国际社会展示COASTAL-SOS 项目及其在近海脱氧、数字孪生海洋领域取得的最新进展，与其他国际组织负责人共话未来合作。

COASTAL-SOS is UN Ocean Decade endorsed project led by Minhan Dai. It partners cross-sectoral stakeholders, including leading academic institutions, industrial enterprises, non-profit foundations, and nongovernmental/intergovernmental organizations from East Asian countries to advance scientific understanding of critical coastal ocean health issues.

In June, the BLUE-CARE Project held a Blue Carbon Science Fair, with the participation of over 300 elementary school students in Xiamen. The Fair promoted knowledge of blue carbon through different types of activities.

In April, Prof. Minhan Dai, Chief Scientist of COASTAL-SOS, presented the latest research on offshore deoxygenation and digital twin oceans at the 2024 Ocean Decade Conference and 2nd UN Ocean Decade Regional Conference, engaging in discussions with international organization leaders for plan future collaborations.

戴民汉院士参加2024年海洋十年大会
Prof. Minhan Dai attended the 2024 Ocean Decade Conference

戴民汉院士参加第 2 届联合国海洋十年区域大会
Academician Minhan Dai attended the 2nd United Nations Ocean Decade Regional Conference

蓝碳科普游园会
Blue Carbon Science Fair

中国湿地保护协会红树林湿地保护专业委员会成立大会暨红树林湿地保护交流会

The Inaugural Meeting of the Mangrove Wetland Conservation Professional Committee of China Wetland Conservation Association

2024年12月14日，“中国湿地保护协会红树林湿地保护专业委员会成立大会暨红树林湿地保护交流会”在厦门大学举办，来自全国百余家相关单位200余名代表参会。会议由中国湿地保护协会主办，厦门大学环境与生态学院、台海站等多单位承办。来自全国百余家红树林相关领域科研院所、规划院、自然保护地、企事业单位代表200余名齐聚厦门参加了会议。会上，多位专家围绕红树林湿地保护作特邀报告，并实地考察了漳江口实验场红树林基地。

此次大会的成功举办标志着我国红树林湿地保护工作开启新篇章，为提高红树林湿地保护、管理与可持续利用以及服务国际红树林中心建设贡献力量。

On December 14, 2024, the "Inaugural Meeting of the Mangrove Wetland Protection Committee of the China Wetland Conservation Association and Mangrove Wetland Protection Exchange Conference" was held at Xiamen University, attracting over 200 representatives from more than 100 related institutions across the country. The conference was hosted by the China Wetland Conservation Association and co-organized by the College of the Environment and Ecology of Xiamen University, the T-SMART, and other institutions. Representatives from research institutes, planning agencies, protected areas, enterprises, and institutions in the mangrove-related field gathered in Xiamen to participate in the event.

During the conference, several experts delivered keynote reports on mangrove wetland protection, and participants conducted a field visit to the M-ECORS's mangrove base. The successful hosting of this conference marks a new chapter in China's mangrove wetland protection efforts, contributing to the enhancement of mangrove wetland protection, management, sustainable utilization, and the development of the International Mangrove Center.

王文卿作特邀报告 ▶
Wenqing Wang Delivered an Invited Lecture

世界海洋野外站大会
World Congress of Marine Stations (WCMS)

2024年11月27日至29日，台海站站长黄邦钦教授出席在日本静冈举办的第二届世界海洋野外站大会，在会议介绍了台海站在河口–海湾–近海连续体的观测和区域合作的实践和进展，同时参加世界海洋野外站联盟科学指导委员会会议，积极推进台海站的国际合作交流。

From November 27 to 29, 2024, Professor Bangqin Huang, Director of the T-SMART, attended the 2nd World Ocean Observatory Conference held in Shizuoka, Japan. At the conference, he presented the practices and progress of the T-SMART in the observation of the estuary-bay-offshore continuum and regional cooperation. Additionally, he participated in the Scientific Steering Committee meeting of the World Ocean Observatory Network, actively promoting international collaboration and exchange for the T-SMART.

海峡两岸生物资源与技术研讨会
Cross-Strait Symposium on Biological Resources and Technology

2024年10月28日，为切实推动海峡两岸学术交流，台海站作为共同承担单位，在厦门大学翔安校区举办“海峡两岸生物资源与技术研讨会”。台湾海洋大学原校长张清风教授等10多人前来交流，会议在海洋生物资源、生物多样性与生物技术达成进一步合作意向。

On October 28, 2024, to effectively promote academic exchanges across the Taiwan Strait, T-SMART, as a co-organizer, hosted the "Cross-Strait Symposium on Biological Resources and Technology" at Xiang'an Campus of Xiamen University. Professor Ching-Fong Chang, former President of the National Taiwan Ocean University, and more than 10 other scholars attended the event. The symposium reached further cooperation intentions in the fields of marine biological resources, biodiversity, and biotechnology.

2024年全国红树林保护与修复研讨会

2024 National Mangrove Protection and Restoration Seminar

2024年12月13日至16日，“2024年全国红树林保护与修复研讨会”在厦门大学翔安校区顺利举办。本次会议由中国湿地保护协会、福建省湿地保护中心和红树林基金会（MCF）联合主办，台海站和厦门大学环境与生态学院承办。会议以“红树林保护与可持续管理”为主题，吸引了来自全国各省市红树林保护地、相关科研院所、企业单位和NGO组织的近100名代表参与交流。

此次研讨会进一步强化了红树林生态系统保护与修复工作的技术指导体系，提升了红树林保护管理及生物多样性保护的科学性与专业性，为红树林的可持续管理提供了重要的理论支持和实践指导。

From December 13 to 16, 2024, the "2024 National Mangrove Protection and Restoration Seminar" was successfully held at Xiang'an Campus of Xiamen University. The seminar was jointly organized by the China Wetland Conservation Association, the Fujian Wetland Protection Center, and the Mangrove Conservation Foundation (MCF), and co-hosted by the T-SMART and the College of the Environment and Ecology of Xiamen University. With the theme of "Mangrove Protection and Sustainable Management," the seminar attracted nearly 100 participants from mangrove protected areas, research institutions, enterprises, and NGOs across the country.

The seminar further strengthened the technical guidance system for mangrove ecosystem protection and restoration, enhanced the scientific and professional standards of mangrove conservation management and biodiversity protection, and provided important theoretical support and practical guidance for the sustainable management of mangroves.

2024 蓝碳生态系统国际专题研讨会

2024 International Symposium on Blue Carbon Ecosystems

2024年1月24日，由厦门大学联合腾讯碳中和实验室主办的2024年蓝碳生态系统国际专题研讨会在厦门成功举办。本次研讨会依托腾讯“蓝碳生态系统的评估、修复及核算（BLUE-CARE）”项目，吸引了10名国内外专家线上线下参会，现场参会人数超百人，线上直播观众总人数近万。会议设置了20多场主旨报告、主题报告、快闪报告及闭幕式环节，内容丰富，反响热烈。

会议以“From Science to Trading（从科学到交易）”为主题，汇聚了来自国内外的海洋科学家、生态学家、碳金融学家及优秀青年学者，共同探讨蓝碳生态系统的机理与蓝碳市场的机制，开启了挖掘海洋“蓝色价值”的经济新篇章。

On January 24, 2024, the 2024 International Symposium on Blue Carbon Ecosystems, co-hosted by Xiamen University and Tencent Carbon Neutrality Laboratory, was successfully held in Xiamen. Supported by Tencent's "Assessment, Restoration, and Accounting of Blue Carbon Ecosystems (BLUE-CARE)" project, the symposium attracted 10 domestic and international experts participating both online and offline, with over 100 attendees on-site and nearly 10,000 viewers online. The event featured more than 20 sessions, including keynote speeches, thematic reports, flash talks, and a closing ceremony, offering rich content and generating enthusiastic responses.

Under the theme "From Science to Trading," the symposium brought together marine scientists, ecologists, carbon finance experts, and outstanding young scholars from around the world to explore the mechanisms of blue carbon ecosystems and the blue carbon market. This event marked the beginning of a new economic chapter in unlocking the "blue value" of the ocean.

与太古集团开启海洋生态保护和教育新篇章

Initiating a New Chapter in Marine Ecological Conservation and Education in Collaboration with the Swire Group

2024年11月9日，东山实验场获太古集团旗下厦门太古飞机工程有限公司捐资人民币546万元，用于支持厦门大学东山太古海洋观测与实验站（东山站）的海洋生态保护及教育工作。此次捐赠签约仪式在厦门大学教育发展基金会完成，资金将用于未来三年在东山湾地区开展长期观测和科研实验、区域内珊瑚物种的保护和修复。基于双方建设东山太古海洋观测与实验站的显著成果，本次活动得到了国内外20多家媒体的广泛报道，进一步提升了台海站在海洋生态保护与教育领域的影响力。

On November 9, 2024, the D-SMART received a donation of RMB 5.46 million from Xiamen Taikoo Aircraft Engineering Co., Ltd., a subsidiary of the Swire Group, to support the marine ecological protection and education initiatives of the Xiamen University Dongshan Taikoo Ocean Observation and Experiment Station (Dongshan Station). The donation signing ceremony was completed at the Xiamen University Education Development Foundation. The funds will be used over the next three years to conduct long-term monitoring and scientific research experiments in the Dongshan Bay area, as well as the protection and restoration of coral species in the region. Building on the significant achievements of the Dongshan Taikoo Ocean Observation and Experiment Station, this event received extensive coverage from more than 20 domestic and international media outlets, further enhancing the influence of the T-SMART in the fields of marine ecological protection and education.

与印尼茂物农业大学渔业和海洋科学学院签订SIS-MAR协议共建红树林姊妹站

Signed the SIS-MAR Agreement with the Faculty of Fisheries and Marine Sciences at IPB University (Institut Pertanian Bogor), Indonesia, to Establish a Sister Station for Mangrove Research

2024年11月7日上午，印度尼西亚茂物农业大学（IPB University）渔业和海洋科学学院水生资源管理系系主任Hefni Effendi教授一行3人到访厦门大学环境与生态学院，双方就共建红树林野外观测站事宜举行了SIS-MAR签约仪式。

此次协议签订拉开了双方建立更加紧密的交流合作的序幕，希望通过深入的合作和学术交流，促进红树林生态系统高水平研究成果产出。

On the morning of November 7, 2024, Professor Hefni Effendi, the Head of the Department of Aquatic Resources Management at the Faculty of Fisheries and Marine Sciences, Bogor Agricultural University (IPB University), Indonesia, along with two colleagues, visited the College of the Environment and Ecology at Xiamen University. The two parties held a signing ceremony for the SIS-MAR agreement regarding the joint establishment of a mangrove field observation station.

The signing of this agreement marks the beginning of closer exchanges and cooperation between the two institutions. It is hoped that through in-depth collaboration and academic exchanges, high-level research achievements in the field of mangrove ecosystem studies will be promoted.

中国海洋保护智库联盟2024年会

China Marine Protection Alliance (ChinaMPA) 2024 Annual Meeting

2024年11月8日，中国海洋保护智库联盟（ChinaMPA）在厦门国际海洋周期间成功举办了联盟成立后的首次年会。国内外海洋领域的科研机构、管理部门、社会公益组织代表共70余人出席会议并展开热烈交流。联盟重点关注海洋保护与可持续渔业议题，由戴民汉院士和苏纪兰院士担任科学指导委员会联合主席，台海站曹玲教授担任秘书长，秘书处设于厦门大学。

ChinaMPA旨在搭建一个汇聚我国各界力量的交流平台，协助国合会海洋治理专题政策研究产出政策建议，解析海洋协作治理的“公约数”与“金钥匙”，应对人海和谐共生的重大挑战。此次会议为中国海洋保护领域的跨身份、跨部门、跨学科协作开启了新机遇。

On November 8, 2024, the China Marine Protection Alliance (ChinaMPA) successfully held its inaugural annual meeting during the Xiamen International Ocean Week. Over 70 representatives from domestic and international research institutions, management departments, and non-profit organizations attended the event and engaged in lively discussions. The alliance focuses on marine conservation and sustainable fisheries, with Academicians Minhan Dai and Jilan Su serving as co-chairs of the Scientific Steering Committee, and Professor Ling Cao from the T-SMART serves as the Secretary-General., with the secretariat based at Xiamen University.

ChinaMPA aims to establish a collaborative platform that brings together diverse stakeholders in China, supporting the policy research output of the International Cooperation Committee on Ocean Governance. It seeks to identify common ground and key solutions for collaborative ocean governance, addressing major challenges in achieving harmony between humans and the ocean. This meeting marked a new opportunity for cross-sector, cross-disciplinary, and cross-identity collaboration in China's marine protection efforts.

蓝色先锋加速器特别研讨会

Blue Pioneer Accelerator Special Workshop Event

2024年9月10日至13日，ChinaMPA在厦门大学和东山县举办了蓝色先锋加速器特别研讨活动。来自国内各个公益NGO和高校的40名海洋保护事业的倡导者和践行者前来参与，在台海站东山实验场开展了全天的工作坊研讨，并在东山的养殖场、渔港、渔村进行实地调研。此次旨在促进海洋保护领域的专业人才高效交流，提升跨领域合作与知识共享，推动海洋保护事业的进一步发展。

From September 10 to 13, 2024, the China Marine Protection Alliance (ChinaMPA) hosted the Blue Pioneer Accelerator Special Workshop Event at Xiamen University and Dongshan County. The event brought together 40 advocates and practitioners of marine conservation from various domestic non-profit NGOs and universities. Participants engaged in full-day workshops at the D-SMART and conducted field investigations at local aquaculture farms, fishing ports, and fishing villages in Dongshan. This initiative aims to facilitate efficient communication among professionals in the field of marine conservation, enhance cross-disciplinary collaboration and knowledge sharing, and further advance the development of marine protection efforts.

校党委书记张荣带队赴实地调研台海站建设发展情况

Zhang Rong, Secretary of the University Party Committee, led a Delegation to Conduct a Field Investigation on the Construction and Development of the T-SMART

2024年5月7日，校党委书记、中国科学院院士张荣带队赴实地调研台海站建设发展情况，台海站站长、南强特聘教授黄邦钦详细介绍了台海站建设发展情况及存在的问题，并结合详实案例和数据，生动展示了厦门大学打造“海-陆-空-天”海洋立体观测实验体系布局的长期探索与成效。

On May 7, 2024, Rong Zhang, the University Party Secretary and Academician of the Chinese Academy of Sciences, led a team to conduct an on-site investigation into the development and construction of the T-SMART. Bangqin Huang, the Station Director and Nanqiang Distinguished Professor, provided a detailed overview of the station's progress and existing challenges. Supported by comprehensive case studies and data, he vividly demonstrated Xiamen University's long-term efforts and achievements in building a comprehensive marine observation system integrating "sea, land, air, and space."

国家林业和草原局湿地管理司调研漳江口实验场

National Forestry and Grassland Administration Inspects M-ECORS

2024年10月31日，漳江口保护区积极推进国际重要湿地修复方案的批准工作。期间，姬文元处长调研了漳江口实验场，国家林业和草原局华东观测规划院高级工程师钱逸凡、漳江口保护区局长朱添泉、台海站副站长王文卿等陪同调研。

姬文元对台海站在观测体系建设、科学研究、社会服务和科普教育等方面的成效表示充分肯定。他指出，近年来，我国不断加大对红树林的保护力度，出台了《红树林保护修复专项行动计划（2020-2025年）》，并在深圳市打造了全国首个国际红树林中心。厦门大学在红树林研究方面历史悠久、成果显著，在服务国家战略需求、推动红树林科普宣教等方面发挥了重要作用。未来，台海站继续发挥高水平科研平台优势，立足自身特色，推动红树林保护修复和可持续利用，进一步提升国家野外台站的影响力。

On October 31, 2024, the Zhangjiangkou Protected Area actively advanced the approval process for the restoration plan of the internationally important wetland. During this period, Director Wenyuan Ji conducted a research visit to the M-ECORS, accompanied by Yifan Qian, Senior Engineer of the East China Survey and Planning Institute of the National Forestry and Grassland Administration, Tianquan Zhu, Director of the Zhangjiangkou Protected Area, and Wenqing Wang, Deputy Director of the T-SMART, among others.

Director Wenyuan Ji fully affirmed the achievements of the T-SMART in observation system construction, scientific research, social services, and science popularization education. He noted that in recent years, China has continuously strengthened its efforts in mangrove protection, issuing the "Mangrove Protection and Restoration Special Action Plan (2020-2025)" and establishing the nation's first International Mangrove Center in Shenzhen. Xiamen University has a long history and remarkable achievements in mangrove research, playing a significant role in serving national strategic needs and promoting mangrove science popularization. In the future, the T-SMART will continue to leverage its strengths as a high-level scientific research platform, build on its unique characteristics, promote mangrove protection, restoration, and sustainable utilization, and further enhance the influence of the national field station.

公众教育与社会服务
Outreach & Social Services

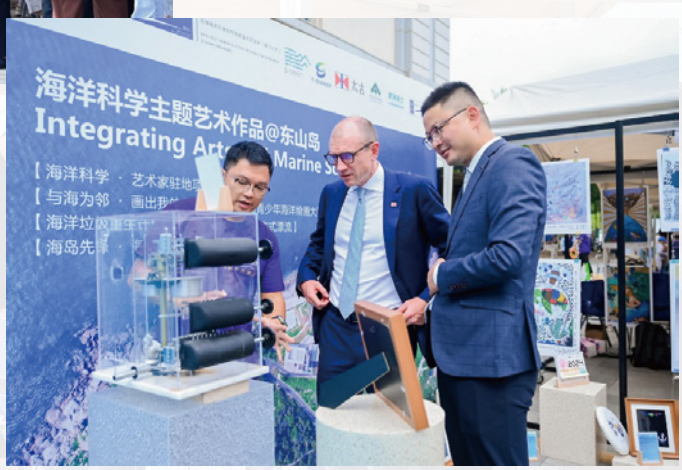
第十三届厦门大学海洋科学开放日成功举办

The 13th Xiamen University Marine Science Open Day Successfully Held

2024年11月9日，第十三届厦门大学海洋科学开放日在厦大翔安校区举行，丰富多彩的活动，吸引了超过1万名参访者。台海站科普展位以其妙趣横生的科普内容与丰富多彩的互动活动吸引着中小学生、亲子家庭、海洋爱好者驻足探索近海生态系统的奥秘。台海站设置了特殊的海洋科学艺术作品展区，集中展示了中央美术学院师生在台海站东山实验场与海洋科学工作者共同创作的海洋科学主题作品（暨由太古集团支持的艺术家驻地项目）。利用雕塑、摄影、装置艺术等多种形式，巧妙实现科学与艺术的“跨界”融合，赋予了海洋保护新的生命力和传播力。

On November 9, 2024, the 13th Xiamen University Marine Science Open Day was held at the Xiang'an Campus of Xiamen University. The diverse and engaging activities attracted over 10,000 visitors. The science popularization booth of the Taiwan Strait Station captivated primary and secondary school students, families, and marine enthusiasts with its fascinating content and interactive activities, allowing them to explore the mysteries of coastal ecosystems.

The T-SMART also set up a special marine science art exhibition area, showcasing works created by teachers and students from the Central Academy of Fine Arts in collaboration with marine scientists at the D-SMART of the T-SMART (as part of the artist residency program supported by the Swire Group). Through various forms such as sculptures, photography, and installation art, the exhibition achieved a clever "cross-disciplinary" integration of science and art, infusing marine conservation with new vitality and communication power.



槟榔中学滨海湿地与海洋蓝碳暑期实践活动

Binlang Middle School Summer Practice Activity on Coastal Wetlands and Marine Blue Carbon

2024年7月14日至16日，滨海湿地生态系统教育部重点实验室、台海站携手厦门市槟榔中学举办“厦门大学—槟榔中学滨海湿地与海洋蓝碳暑期实践活动”，槟榔中学42名师生代表在协办单位福建省漳江口保护区体验了一场特别的科普盛宴。本次实践中，我们共进行了5场报告，2次野外实践活动，2场参观和2场研究与讨论，为同学们架起了理论与实践的桥梁，让槟榔中学的同学们收获颇丰，满载而归。

通过此次研学活动，同学不仅带走了在红树林三天的美好记忆和滨海湿地海洋蓝碳的系列知识，更带走了人与自然和谐共生的理念，并在小小的心田中埋下了保护环境、探索科学的种子。

From July 14 to 16, 2024, the Key Laboratory of Coastal Wetland Ecosystems of the Ministry of Education and the Taiwan Strait Station, in collaboration with Xiamen Binlang Middle School, organized the "Xiamen University–Binlang Middle School Summer Practice Activity on Coastal Wetlands and Marine Blue Carbon." Forty-two teachers and students from Binlang Middle School participated in this special science popularization event, hosted by the Zhangjiangkou Protected Area in Fujian Province. During the activity, five lectures, two field practice sessions, two site visits, and two research and discussion sessions were conducted, bridging the gap between theory and practice for the students. The participants gained valuable knowledge and returned with a wealth of experiences.

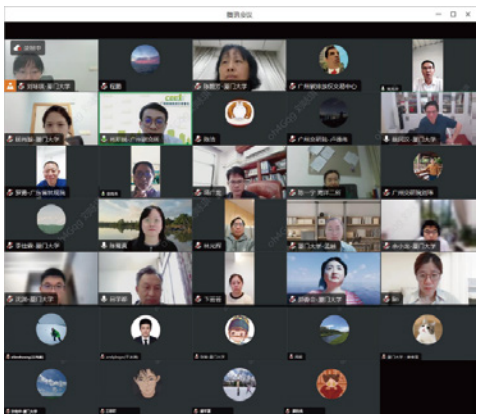
Through this research and learning activity, the students not only took away fond memories of their three-day experience in the mangroves and a series of knowledge about coastal wetlands and marine blue carbon but also embraced the concept of harmonious coexistence between humans and nature. This experience planted the seeds of environmental protection and scientific exploration in their young minds.

MEL、T-SMART主导的中国首个海草床碳汇方法学通过专家评审

China's first Seagrass Bed Carbon Sink Methodology, Led by MEL and T-SMART Scientists, Passed its Panel Review

2024 年 4 月 30 日，由戴民汉院士、陈鹭真教授团队编制完成《海草床生态修复碳汇计量与观测方法》通过专家评审。该观测方法支撑全国首笔海草床蓝碳意向认购与全国第二笔盐沼蓝碳意向认购签约，获批蓝碳观测领域福建省标准 1 项，并开展两岸蓝碳交易标准共通试点，充分结合我国实际，广泛适用于我国海草床碳汇项目的计量与观测，对海草床碳汇功能维持和生态服务价值功能协同提升具有重要意义。

On April 30, 2024, the *"Methodology for Carbon Sequestration Measurement and Monitoring in Seagrass Bed Ecological Restoration"*, compiled by the team of Academician Minhan Dai and Professor Luzhen Chen, passed expert review. This monitoring methodology supports the signing of the nation's first seagrass bed blue carbon intent purchase agreement and the second salt marsh blue carbon intent purchase agreement. It has been approved as a Fujian Provincial Standard in the field of blue carbon monitoring and has initiated a cross-strait pilot project for common standards in blue carbon trading. Fully aligned with China's practical conditions, this methodology is widely applicable to the measurement and monitoring of seagrass bed carbon sequestration projects in China. It holds significant importance for maintaining the carbon sequestration function of seagrass beds and synergistically enhancing their ecological service value.



第九届MEL研究生学术论坛

The 9th MEL Graduate Academic Forum Successfully Held at Dongshan Experimental Field

2024年7月17日至20日，第九届MEL研究生学术论坛东山实验场成功举办。本次论坛以 Deeper Blue, Deeper Thoughts为主题，吸引60余名来自厦门大学、北京大学、上海海洋大学等高校的同学，8位海洋环境科学领域的专家、学者参与，共设计6个报告专题，辅以破冰活动、圆桌讨论、专题研讨会、科普专场等活动。

20日下午，论坛特别邀请了福建省东山第一中学、第二中学及县第二实验小学共计70余位学生来到东山站参与论坛的科普活动。同学们深度参与到参会研究生们精心设计的11个科普摊位的活动中。科普摊位寓教于乐，引导同学们亲身体验，感受海洋环境科学的魅力，激发青少年们对海洋的关注和热爱。

From July 17 to 20, 2024, the 9th MEL Graduate Academic Forum was successfully held at the D-SMART. Under the theme "Deeper Blue, Deeper Thoughts," the forum attracted over 60 students from Xiamen University, Peking University, Shanghai Ocean University, and other institutions, as well as 8 experts and scholars in the field of marine environmental science. The forum featured six thematic report sessions, complemented by ice-breaking activities, roundtable discussions, specialized seminars, and science popularization events.

On the afternoon of July 20, the forum specially invited more than 70 students from Dongshan No.1 Middle School, Dongshan No.2 Middle School, and the County No.2 Experimental Primary School in Fujian Province to participate in the science popularization activities at the D-SMART. The students actively engaged in 11 science booths meticulously designed by the participating graduate students. These interactive booths combined education with entertainment, allowing the students to experience the charm of marine environmental science firsthand and inspiring their interest and passion for the ocean.

2024年少年蓝色先锋培养计划

2024 Junior Blue Pioneers Training Program

2024年7月18日至28日，台站站协办由桃花源生态环境基金会支持的“少年蓝色先锋培养计划”，已举办到第三届，今年共有20位包括中国香港、新西兰等地的少年们，集结漳江口和东山实验场，完成了海洋人才培养之旅。

From July 18 to 28, 2024, the T-SMART co-hosted the third edition of the "Young Blue Pioneers Training Program," supported by the Taohuayuan Ecological Environment Foundation. This year, 20 young participants from regions including Hong Kong, China, and New Zealand gathered at the M-ECORS and D-SMART to complete their marine talent development journey.

东山实验场“2024年苏峰讲坛”成功举办三讲

The "2024 Sufeng Forum" of D-SMART was Successfully Held Three Times

2024年，“苏峰讲坛”在东山实验场成功举办三场。“苏峰讲坛”第一讲邀请了台湾海洋生物博物馆研究员、东山站国际咨询委员会委员樊同云教授作以“珊瑚保护与保育”为主题的讲座报告；第二讲邀请厦门大学刘敏教授作以“龟去来兮——走进海龟的世界”为主题的讲座报告；第三讲邀请东山站驻站科学家李炎教授作以“河口–海湾的‘自我调节’：从漳江口到台湾浅滩”为主题的讲座报告。

讲座吸引了来自政府职能部门、公益组织、学校、社区、水产养殖企业的代表，以及东山站驻站老师和硕博研究生等不同职业、不同年龄的人员参与。现场气氛热烈，听众们积极提问，与主讲人进行了深入交流。

In 2024, the "Sufeng Forum" was successfully held three times at the D-SMART. In the first lecture of the "Sufeng Forum", Professor Tongyun Fan, a researcher at the Taiwan Museum of Marine Biology and a member of the International Advisory Committee of the D-SMART, was invited to deliver a lecture report on the theme of "Coral Protection and Conservation". In the second lecture, Professor Min Liu from Xiamen University was invited to give a lecture report with the theme of "The Return of Turtles - Stepping into the World of Sea Turtles". In the third lecture, Professor Yan Li, a resident scientist at the D-SMART, was invited to present a lecture report on the theme of "Self-regulation of Estuaries and Bays: From Zhangjiang Estuary to the Taiwan Shoal".

These lectures attracted participants from different occupations and age groups, including representatives from government functional departments, public welfare organizations, schools, communities, aquaculture enterprises, as well as resident teachers, master's and doctoral students at the D-SMART. The atmosphere at the scene was enthusiastic, and the audience actively asked questions and had in-depth exchanges with the keynote speakers.

第十六届高校研究生水环境科学研讨会(UCAS)在东山实验场顺利举办

The 16th University Consortium on Aquatic Sciences Symposium Successfully Held at D-SMART

2024年6月12日，第十六届UCAS研讨会在厦门大学东山太古海洋观测与实验站暨福建台湾海峡海洋生态系统国家野外科学观测研究站东山实验场顺利举办。本次研讨会共有海峡两岸暨香港地区5所高校51名师生参与，围绕海洋生物、海洋生态、海洋物理、海洋地质、渔业与水产养殖、生物地球化学循环、数据科学与方法7个议题设置6场主题报告、33个口头报告、2个快闪报告，以及R语言技能培训工作坊、趣味辩论、水环境科学剧场、“蓝色星球，人海共生”主题科普和东山野外调研等多元活动。

On June 12, 2024, the 16th UCAS Symposium was successfully held at the D-SMART. The symposium brought together 51 faculty members and students from five universities across the Strait, including mainland China, Taiwan, and Hong Kong. The event focused on seven key topics: marine biology, marine ecology, marine physics, marine geology, fisheries and aquaculture, biogeochemical cycles, and data science and methods. It featured six keynote presentations, 33 oral presentations, two flash talks, as well as a variety of activities such as an R language skills training workshop, a fun debate, a water environment science theater, a popular science session themed "Blue Planet, Harmony Between Humans and the Ocean," and field research in Dongshan.

造礁石珊瑚观测和保育成果、经验和技术分享会

Symposium on Monitoring and Conservation Achievements, Experiences, and Technologies of Reef-Building Corals

2024年10月19日，在东山实验场开展了“造礁石珊瑚观测和保育成果、经验和技术分享会”，此次分享会邀请了自然资源部南海生态中心、海南南沙珊瑚礁生态系统国家野外科学观测研究站、厦门大学、东山县人民法院等7位专家学者，分享关于在南海和东山开展的珊瑚礁生态系统观测和修复、以及公众宣传的成果、经验和技术。

On October 19, 2024, the "Symposium on Monitoring and Conservation Achievements, Experiences, and Technologies of Reef-Building Corals" was held at the D-SMART. The event invited seven experts and scholars from the South China Sea Ecological Center of the Ministry of Natural Resources, the National Field Scientific Observation and Research Station for Coral Reef Ecosystems in Nansha, Hainan, Xiamen University, and the Dongshan County People's Court. They shared achievements, experiences, and technologies related to the monitoring and restoration of coral reef ecosystems, as well as public awareness initiatives, conducted in the South China Sea and Dongshan.

志愿者净滩活动 | Beach Cleanup Volunteer Activity

2024年10月20日，联合东山县海洋保育志愿者协会、东山二中蓝源社团在金銮湾海滩开展志愿者净滩活动（东山分会场）。志愿者们走了 500 米海岸线，共计收集 39.55千克垃圾，387个饮料瓶，为构建美丽健康的海洋环境迈出了坚实的一步。

On October 20, 2024, in collaboration with the Dongshan County Marine Conservation Volunteer Association and the Blue Source Club of Dongshan No. 2 High School, a volunteer beach cleanup activity (Dongshan sub-venue) was held at Jinluan Bay Beach. Volunteers covered a 500-meter stretch of coastline, collecting a total of 39.55 kilograms of trash and 387 beverage bottles. This initiative marked a solid step forward in building a beautiful and healthy marine environment.

苏峰读海：对话历史，探寻未来

Sufeng Reads the Ocean: Dialogues with History, Explorations of the Future

苏峰，作为福建台湾海峡海洋生态系统国家野外科学观测研究站东山实验场所在地，承载着厦门大学海洋研究的深厚历史底蕴。为追溯海洋科学发展的源头，跟随历史的足迹，读懂老一辈海洋人的坚守与奉献，并探寻野外站的未来发展方向，我们特别开设了“苏峰读海”专栏。

该专栏以虚拟观测员“小苏”与资深海洋人“老海”的对话形式，带领读者走近那段波澜壮阔的海洋科研历程。自2023年8月专栏开设以来，已陆续更新13期，通过生动的故事与深刻的洞察，展现了海洋科研的传承与创新。

Sufeng, home to the D-SMART of the T-SMART, carries the profound historical legacy of Xiamen University's marine research. To trace the origins of marine science development, follow the footsteps of history, understand the dedication and contributions of senior marine scientists, and explore the future direction of the field station, we have launched the "Sufeng Reads the Ocean" column.

This column, presented through dialogues between a virtual observer "Xiao Su" and a seasoned marine scientist "Lao Hai," guides readers through the magnificent journey of marine scientific research. Since its inception in August 2023, the column has released 13 issues, showcasing the heritage and innovation of marine research through vivid stories and profound insights.

东山珊瑚与鱼类智慧保护

Smart Conservation of Corals and Fish in Dongshan

2024年，台海站联合华为TECH4ALL数字包容团队和福建人工智能计算中心，共同开发了针对珊瑚和鱼类的智能识别与分析系统，建立东山生物多样性观测平台。目前，该平台已成功应用到东山珊瑚保护省级自然保护区日常工作中，为东山海域珊瑚群落生态系统的保护工作提供了坚实的技术支撑，显著提升保护区监管水平和宣教能力。

In 2024, the T-SMART collaborated with Huawei's TECH4ALL Digital Inclusion Team and the Fujian Artificial Intelligence Computing Center to jointly develop an intelligent recognition and analysis system for corals and fish, establishing the Dongshan Biodiversity Monitoring Platform. Currently, this platform has been successfully integrated into the daily operations of the Dongshan Coral Protection Provincial Nature Reserve, providing robust technical support for the conservation of coral reef ecosystems in the Dongshan sea area. It has significantly enhanced the reserve's regulatory capabilities and public education efforts.

东山珊瑚与鱼类智慧保护简介

Introduction to Xiamen University's Smart Conservation of Corals and Fish in Dongshan

新型光纤地震台阵在海洋地震观测中的应用研究

Application of Novel Fiber-Optic Seismic Arrays in Marine Seismic Observation

2024年，中国地震局地震预测研究所及中国地震局厦门海洋地震研究所等团队，在台海站东山实验场开展新型光纤地震台阵方面的相关研究。自新型光纤地震台阵在东山岛苏峰山海域布设以来，该项目已取得显著成效。依托分布式光纤振动传感（DAS）技术，成功构建了高密度、低成本的海洋地震观测网络，大幅提升了漳州近海及台湾海峡区域的地震观测能力。目前，该系统已捕捉到多次海域微震信号，为区域地震活动性分析提供了高精度数据支撑。

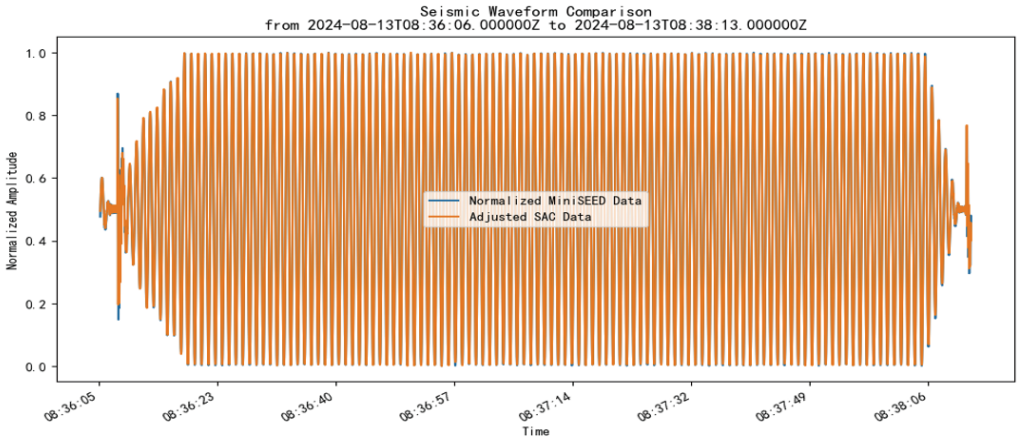
In 2024, research teams from the Institute of Earthquake Forecasting, China Earthquake Administration, and the Xiamen Institute of Marine Seismology, China Earthquake Administration, conducted related studies on novel fiber-optic seismic arrays at the D-SMART. Since the deployment of the novel fiber-optic seismic array in the Sufeng Mountain offshore area of Dongshan Island, the project has achieved remarkable results. Leveraging Distributed Acoustic Sensing (DAS) technology, a high-density, low-cost marine seismic observation network has been successfully established, significantly enhancing the seismic monitoring capabilities in the offshore Zhangzhou area and the Taiwan Strait region. To date, the system has captured multiple microseismic signals, providing high-precision data support for regional seismic activity analysis.

光纤台阵及地震台阵布设站位示意图

Schematic Diagram of Fiber-Optic Array and Seismic Array Deployment Locations

波形互相关：时间校正后，相关系数99. 9%

（节点地震仪，短周期地震仪）



已开展的振动台比测工作

Comparative Testing of Vibration Tables Conducted

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