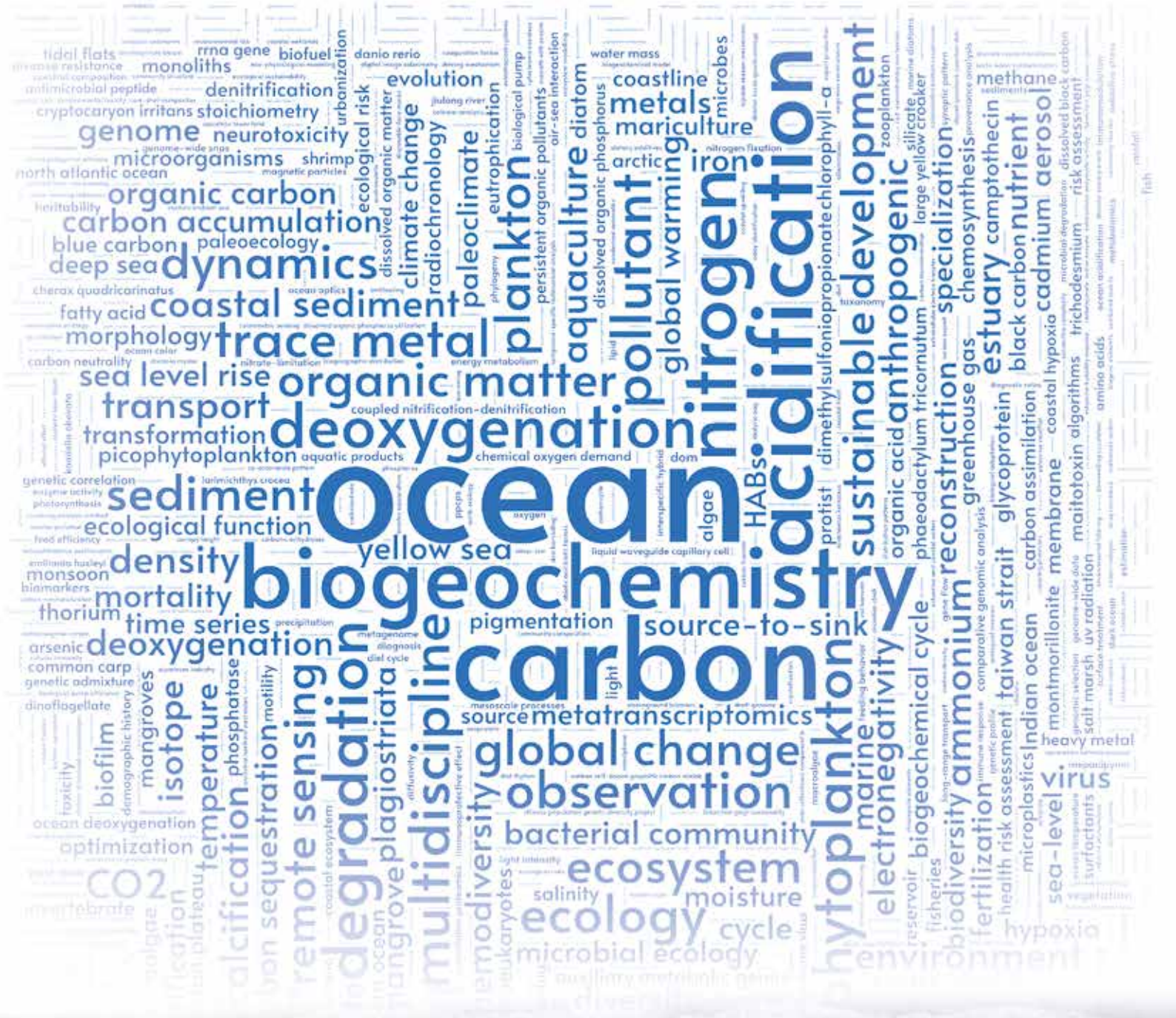

2022

ANNUAL REPORT

年度报告

近海海洋环境科学国家重点实验室（厦门大学）

State Key Laboratory of Marine Environmental Science
(Xiamen University)

MEL INTRODUCTION

近海海洋环境科学国家重点实验室（厦门大学）（英文缩写MEL）于2005年3月启动建设，2007年6月通过科技部验收，2010、2015年连续获评优秀国家重点实验室。实验室现有固定科研人员95人，技术人员及研究助理106人，行政人员8人。实验室瞄准全球变化这一国际前沿，面向碳中和、海洋强国、生态文明等国家战略需求，立足基础研究和应用基础研究，以多学科交叉和技术创新为动力，主攻海洋生物地球化学与生态系统动力学。实验室坚持走国际化发展道路，科学研究力求具备全球视野，管理体系参比国际标准，文化建设崇尚自由宽松，努力建设成为具有重要国际影响力的海洋环境科学研究和创新人才聚集基地。

实验室学术委员会

名誉主任：胡敦欣
主　　任：吴立新
副 主 任：刘丛强、焦念志
委　　员：柴　扉、傅伯杰、郭正堂、翦知湣、林群声、宋微波、唐启升、
　　王　凡、王　辉、魏庆琳、张　偲、赵美训、朱　彤、朱永官

实验室领导班子

名誉主任：洪华生、戴民汉
主　　任：史大林
副 主 任：张　瑶、刘志宇、曹知勉、马　剑、林孟妹

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序言
Message from Director

2022 年是近海海洋环境科学国家重点实验室（MEL）获批的第 18 年，在这个“成年”节点，新一届主任班子接过火炬，与实验室同仁一道，勤耕不辍，精业笃行，聚焦国际科学前沿和国家重大需求，助力创新驱动海洋强国建设。”

星火闪烁，榜样力量引领前行。

中坚之士躬先表率，分别当选俄罗斯科学院外籍院士、国际科学理事会会士，荣获亚洲 - 大洋洲地球科学学会“艾克斯福特奖”、第七届“曾呈奎海洋科技奖”青年科技奖等；更有众多俊良之才获批国家杰出青年科学基金项目、国家自然科学基金优秀青年科学基金项目。

潜精研思，责任担当不负使命。

获批纵向科研项目 42 项，含国家重点研发计划项目 3 项、国家自然科学基金重大研究计划集成项目 2 项，合同经费近 7000 万元。焦念志院士牵头的我国首个海洋领域国家基础科学中心“海洋碳汇与生物地球化学过程基础科学中心”启动。

极深研几，科学疆域探索新知。

发现真光层氧化亚氮释放抵消生物泵碳输出的气候效应，揭示西北太平洋生物固氮的营养盐调控机制，阐明由海洋浮游植物胰蛋白酶介导的氮磷协同利用新机制，探究气候与人类活动共同驱动下多种污染物对海岸带生态系统的胁迫效应，制定的 2 项海 - 气二氧化碳通量监测与评估技术规程、4 项海水痕量营养盐测定方法获批行业标准……

深稽博考，重器聚能以观沧海。

“海丝一号”“海丝二号”卫星执行近万次成像任务，在全球各类热点事件中接力应急观测；“嘉庚”号科考船全力以赴服务于海洋一线，乘风破浪向更远的大洋进发；福建台湾海峡海洋生态系统国家野外科学观测研究站挂牌成立，东山实验场完成第二代海底有缆珊瑚生态在线观测系统的研发与海试；大型仪器与技术服务中心继续致力于提供高效的技术支撑。

和合共生，共同体建设持续推进。

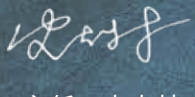
基于碳中和全球共识，领衔发起联合国海洋十年“海洋负排放（ONCE）”国际大科学计划；“表层海洋 - 低层大气研究（SOLAS）”计划国际项目办公室（中国）致力于为全球海气与气候变化研究提供合作与协调平台；主办、承办第八届国际镭氡研讨会、第四届“西太平洋海洋环流与气候”国际开放科学大会等 9 个国际会议。

薪火赓续，新生力量传承开拓。

海洋环境创新型人才国际合作培养项目获国家留学基金委专项滚动支持；与香港大学理学院的联合培养项目正式启动；杰出博士后基金、优秀博士生奖学金、本科暑期科研奖学金、研究生学术论坛等持续为新生代提供学习与交流的舞台；海洋科学开放日、少年蓝色先锋培养计划、海洋讲师团……我们不断探索多样化的大众海洋科普形式，进阶海洋科学传播 2.0 时代。

党的二十大报告强调，要“发展海洋经济，保护海洋生态环境，加快建设海洋强国”，这也是 MEL 作为国家战略科技力量肩负的使命。2023 年将是重启和开放的一年，更是海洋领域全国重点实验室重组的重要一年。历史的每一站，都是新的起点。

值此辞旧迎新之际，谨此向一直以来关心 MEL 成长的海内外同仁及各界伙伴致以新年问候。



主任：史大林

2022 年 12 月 31 日

年度焦点

2022 Headlines

◎1 月，实验室行政领导班子换届，史大林任主任，张瑶、刘志宇、曹知勉、马剑、林孟妹任副主任。

◎4 月，焦念志荣获厦门大学南强杰出贡献奖。

◎4 月，戴民汉、党宏月、高坤山、高树基、洪华生、焦念志、林森杰、陈曦、纪荣嵘、刘向阳、王传超入选爱思唯尔（Elsevier）公布的“2021 中国高被引学者”榜单。

◎6 月，戴民汉获 2022 年度亚洲 - 大洋洲地球科学学会“ 艾克斯福特奖 ”。

◎ 6 月，吕永龙当选俄罗斯科学院外籍院士，12 月当选国际科学理事会会士。

◎8 月，徐鹏获批国家杰出青年科学基金项目；郑强获批国家自然科学基金优秀青年科学基金项目。

◎11 月，柯才焕获第二届张福绥贝类学奖“ 杰出贡献奖 ”；刘志宇获第七届曾呈奎海洋科技奖 “ 青年科技奖 ”。

薪火

“新青年”传承匠心 开拓新局

检索 | 2022 关键词

新知

拓展认知疆域 探寻边界

◎2 月，史大林团队揭示西北太平洋生物固氮的营养盐调控机制，相关成果发表于 *Science Advances*。

◎3 月，戴民汉团队受邀于 *Annual Review of Earth and Planetary Sciences* 发表综述文章，全面总结全球近海碳源汇格局与控制过程，并展望未来碳中和路径下的发展趋势。

◎7 月，林森杰团队揭示了由海洋浮游植物胰蛋白酶介导的氮磷协同利用的新机制，相关成果发表于 *Nature Communications*。

◎9 月，实验室团队主持制定的 2 项海 - 气二氧化碳通量监测与评估技术规程、4 项（含 1 项主要参与）海洋环境监测行业标准，经全国海洋标准化技术委员会审查批准，由自然资源部发布实施。

◎11 月，史大林团队在海洋酸化对优势固氮蓝藻束毛藻影响的研究上取得重要进展，相关成果发表于 *Nature Communications*。

◎12 月，高树基团队揭示了真光层氧化亚氮释放抵消生物泵碳输出的气候效应，相关成果发表于 *Nature Geoscience*。

强音

聚合全球共识 为海发声

◎ 6 月，基于碳中和全球共识和海洋负排放国际研究前沿热点，焦念志牵头发起的“海洋负排放”正式获批为联合国“海洋十年”国际大科学计划，以期推出全球碳中和的海洋方案，建立海洋负排放生态工程新范式。

◎12 月，吕永龙等受《联合国生物多样性公约》第 15 次缔约方大会（COP15）邀请，在 *Science Advances* 联合发表社论文章“遏制万物生灵走向毁灭”。

◎“表层海洋 - 低层大气研究计划（SOLAS）”国际项目办公室（中国）深度参与拓展海洋大气科学领域国际网络，主办第八届 SOLAS 国际开放科学大会、SOLAS 国际暑期学校等活动。

先行

牧海者百家争鸣 共话未来

◎6 月，主办第八届镭 - 氡国际研讨会，探讨近年海洋学中镭、氡示踪运用及技术的最新进展，为相关科技工作者、管理者和政策制定者提供最新视角。

◎6 月，承办中国环境与发展国际合作委员会 2022 年年会主题论坛“ 海洋治理 — 过去和未来 ”，为国家提出多项海洋经济发展与环境保护相关的政策建议。

◎10 月，协办第四届“ 西太平洋海洋环流与气候 ”国际开放科学大会，国内外 260 多名专家学者云集，共同探讨西太平洋热点科学问题。

◎11 月，共同承办 2022 海上丝绸之路国际产学研用会议海洋科技与工程分会，推动迈向低碳的海洋新兴产业发展。

重器

科技赋能 “览天地 – 观沧海” 瞭望征途

◎“ 海丝一号 ”“ 海丝二号 ”卫星稳定在轨运行，累计执行成像任务破万次，为福建海洋经济和“一带一路”沿线区域发展提供宝贵的大范围数据支撑。1 月，海丝卫星接力关注汤加火山喷发对周边海域生态环境的影响，充分展现了其在应急响应和防灾减灾等方面的应用能力。

◎11 月，福建台湾海峡海洋生态系统国家野外科学观测研究站召开第一届学术委员会第一次会议暨战略规划研讨会，未来将进一步聚焦观测和科学目标，提高自主创新能力，为海洋生态环境健康和经济可持续发展提供重要科技支撑。

◎“ 嘉庚 ”号持续为海洋科考工作提供先进设备和技术支撑。本年度“嘉庚”号共完成 5 个海上科学调查航次，远赴西北太平洋、南海北部及中部等海域开展科学考察研究，累计作业天数 205 天，总航程近 23,000 海里。

观海图 2022

科研课题

42 项
新增项目

1 项
联合国“海洋十年”大科学计划

3 项
国家重点研发计划

2 项
国家自然科学基金重大研究计划集成项目

2 项
国家自然科学基金杰青/优青项目

4 项
国家自然科学基金委联合基金/外国学者研究基金项目

16 项
国家自然科学基金面上/青年项目

5 项
其他国家级项目

9 项
其他项目

新进人员

4
科研人员

4
研究员

5
杰出博士后

21
研究助理

4
行政人员

人才培养

301
硕士在读

345
博士在读

66
硕士毕业生

56
博士毕业生

公众教育

135 个
原创作品

30,000,000 传播量

以上数据截至 2022 年

合作交流

16 场
组织大型活动

108 人
大会报告人次

19 个
学术期刊任职

35.9%
产出成果国际合作占比

129 人
来访出访人次

31 个
学术组织任职

450 篇
学术论文

2 本
专著

3 个
章节

3 个
期刊专辑

6 项
海洋行业标准

航次

79 个
海上科学调查航次

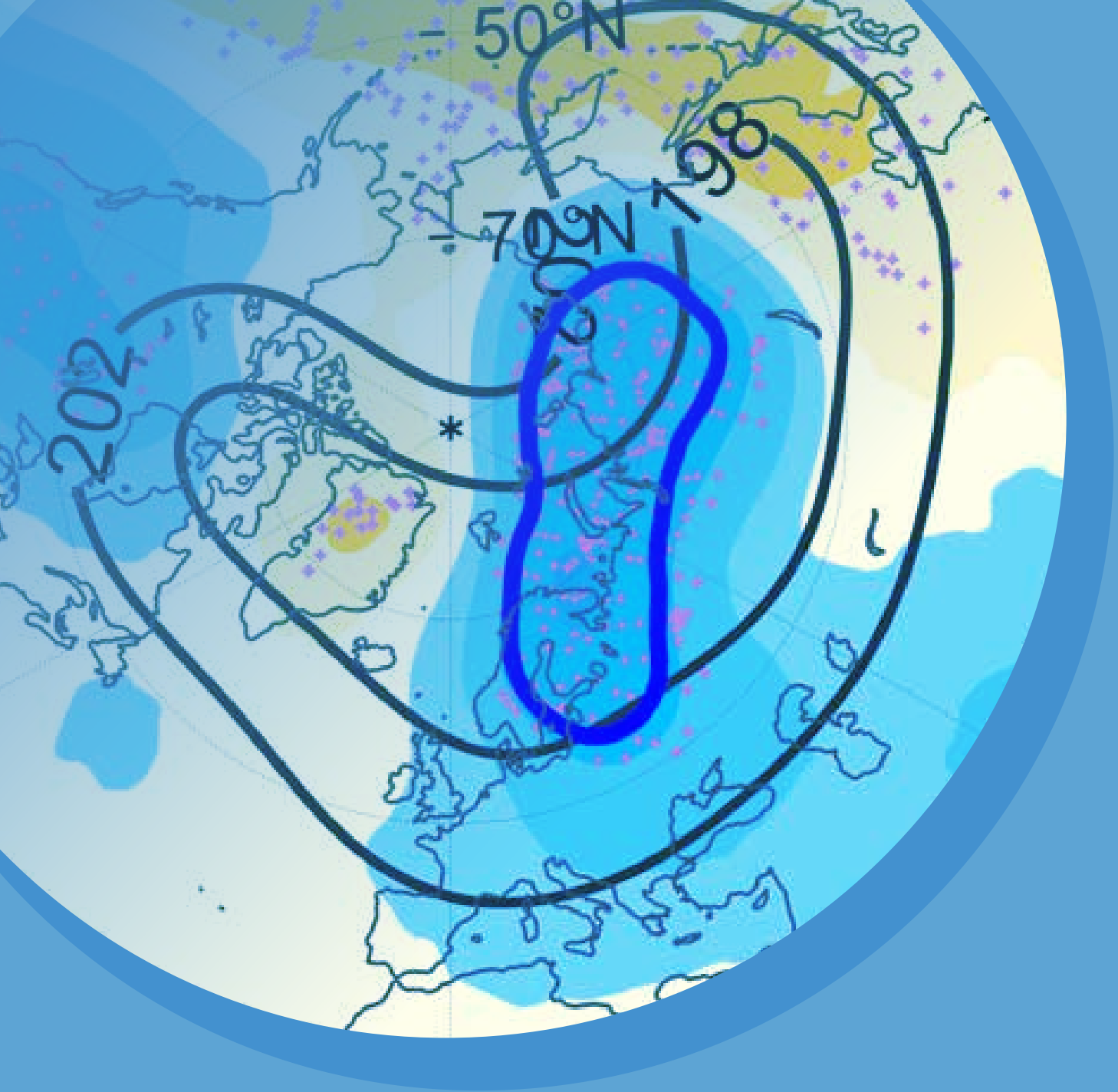
525 人次
参与科考人数

1130 天
累计航次作业天数

27 项
授权专利

2 个
软件登记著作权

研究区域：西北太平洋、南海、东海、福建近海等
航次目的：科学考察、海洋环境监测及调查、科学普及
搭载科考船：“嘉庚”号、“海洋 2”号、“中国海监 203”、“东方红 3”号、“科学”号等



研究亮点
Research Highlights

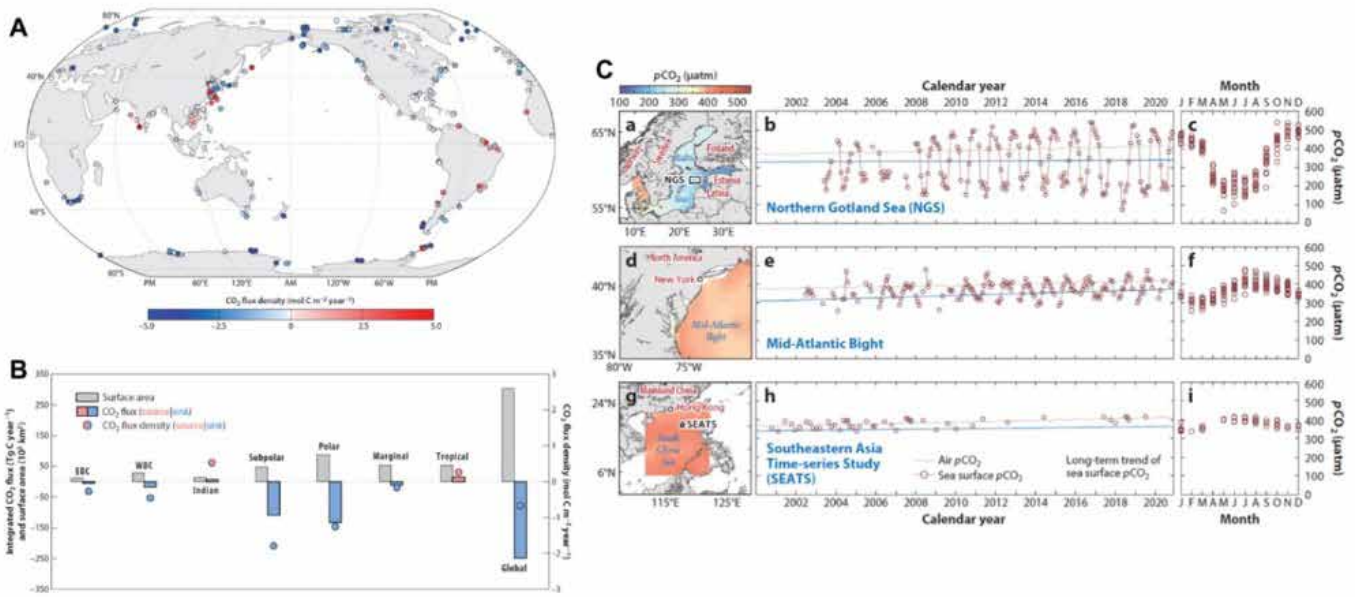
近海碳通量：综合集成、边界过程及未来趋势

海洋是重要的碳汇，自工业革命以来海洋吸收了大量人类活动排放的 CO_2，在调节大气 CO_2 浓度、应对气候变化方面发挥了重要作用。近海系统位于海 - 陆 - 气和人类活动交汇区，其碳通量与调控过程均具有高度的时空变异性，是全球碳循环研究的热点与难点区域，也是地球系统模式的缺失环节。近海是全球最重要的碳汇区之一，未来也是实施基于海洋碳移除措施的重点区域，准确评估其中的碳通量、源汇格局及演化趋势至关重要也颇具挑战。运用新的集成方法及来自全球 214 个近海系统的更新数据库，研究团队对全球近海系统的海 - 气 CO_2 通量进行重新评估，估算其碳汇量为 0.25±0.05 Pg C yr^{-1}（2.5±0.5 亿吨碳 / 年）。其中，亚极地和极地海域贡献了超过 90% 的碳汇量。

近海连接陆地与大洋，本研究特别强调了边界过程对近海碳循环影响的重要性，同时，基于河流主控型陆架海和大洋主控型边缘海两大系统碳循环的理论框架，定量解析了近海碳源汇格局及其控制机制。选取南海、波罗的海（Baltic Sea）、中大西洋湾（Middle Atlantic Bight）进行对比，分析不同近海系统海表 CO_2 分压的空间、季节及长时间变化特征。研究结果显示，除了大气 CO_2 浓度影响外，物理、生物、化学过程对海表 CO_2 分压也有着重要的调控作用。此外，从模拟近海碳循环关键过程和预测未来变化方面，本研究综述了由箱式模型到三维环流 - 生物地球化学耦合数值模式的发展与挑战。最后，本研究系统分析了从工业革命前至今，再到未来实现碳中和这三个阶段的全球碳循环（包括各碳库储量和碳库之间的碳通量）演变过程。同时提出以净零排放为目标的人为扰动，可从不同界面，对陆 - 海 - 气这一耦合、协同变化系统产生影响，这也是预测近海碳循环未来变化趋势的关键挑战。

> 以上工作于 2022 年 3 月发表于 *Annual Review of Earth and Planetary Sciences* 期刊，戴民汉教授为第一兼通讯作者。

Reference:
Dai, Minhan*; Su, Jianzhong; Zhao, Yangyang; Hofmann, Eileen E.; Cao, Zhimian; Cai, Wei-Jun; Gan, Jianping; Lacroix, Fabrice; Laruelle, Goulven G.; Meng, Feifei; Mueller, Jens Daniel; Regnier, Pierre A. G.; Wang, Guizhi; Wang, Zhixuan. Carbon fluxes in the coastal ocean: synthesis, boundary processes and future trends. *ANNUAL REVIEW OF EARTH AND PLANETARY SCIENCES*.2022. 50: 593-626.



（A）全球近海单位面积海 - 气 CO_2 通量新集成结果；（B）近海不同特征区域海表面积、单位面积碳通量及总碳通量；
（C）三个典型边缘海系统海表 CO_2 分压空间、季节及长时间变化特征

海洋生物泵调控的碳、氮复合效应：真光层氧化亚氮释放抵消生物泵碳输出的气候效应

生物泵是海洋碳封存（carbon sequestration）的主要机制，也是海洋调控大气CO_2浓度的关键过程，一直以来是海洋生物地球化学循环与全球气候变化研究的核心内容之一。生物泵运转过程中，来源于初级生产的有机碳仅有很小比例最终能够通过复杂的生物、化学、物理过程输出真光层，从而实现与大气隔绝。这意味着大部分有机质在真光层内部快速矿化，驱动了强烈的氮再生循环过程。然而，该过程中所蕴含的温室气体释放及其潜能，及其对生物泵的气候效应影响缺乏评估。

氧化亚氮（N_2O）是海洋氮循环过程中产生的一种痕量气体，因具有强力的温室效应与臭氧消耗能力而备受关注。但海洋 N_2O 源汇格局复杂，目前对于海洋 N_2O 的分布及其时空变异特点、驱动过程仍缺乏足够的认知，严重制约 N_2O 释放通量、气候效应的准确评估。近年来，研究团队聚焦海洋真光层的氮动力过程，通过高分辨率的同位素标记培养，证实海洋真光层中存在活跃的氨氧化过程，并揭示了营养盐分布对于真光层氨氧化分布的重要调控，这为真光层 N_2O 产生机制及其空间分布特点提供了重要的研究基础。

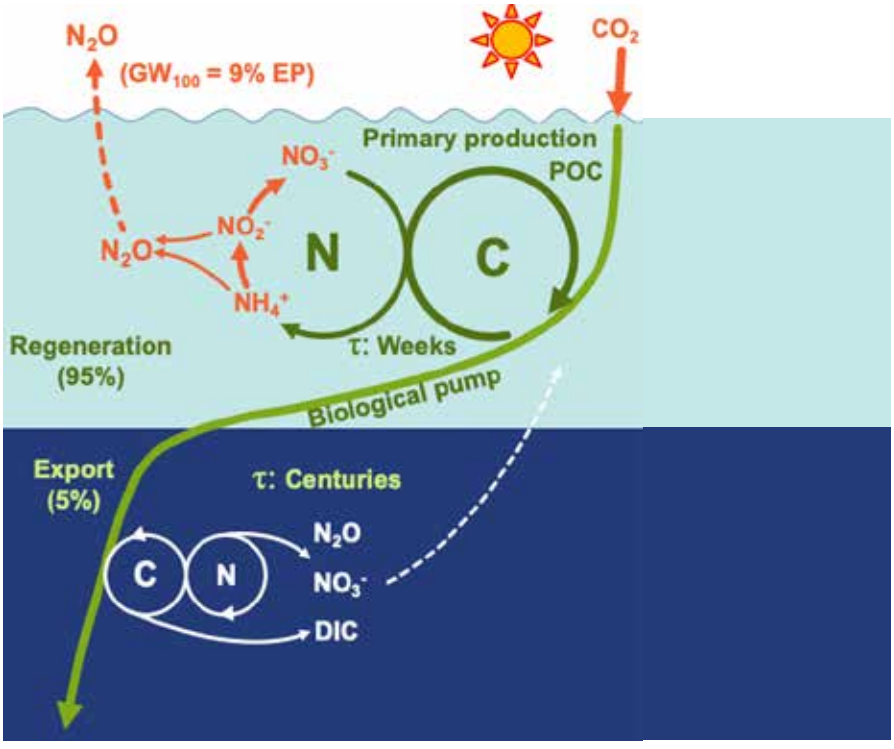
团队基于 2012-2019 年间 7 个航次的观测数据，系统探究了中国近岸、南海、北太平副热带洋流涡区上层 200 m 的碳、氮关键动力过程，利用多同位素示踪定量初级生产力、输出生产力、氨氧化以及 N_2O 释放速率，为海洋真光层存在活跃的 N_2O 原位生产过程提供了强力证据。研究结果显示，真光层底部存在显著的 N_2O 累积，且氮、氧双同位素负偏，证明了真光层中普遍存在的原位 N_2O 添加过程，结合同位素质量平衡模型首次估算出该生产过程可以贡献 40-60% 的海气 N_2O 通量。进一步应用同位素标记技术定量氮循环不同过程中 N_2O 的生产速率，发现真光层内部硝化过程是 N_2O 产生的重要机制，而在真光层底部亚硝酸盐积累具有最为活跃的 N_2O 生产行为。同时，真光层中 N_2O 生产速率与颗粒有机碳（POC）的储量和输出通量均呈现良好的正相关关系，即生物泵产生、输出的 POC 越多，其矿化再生触发的氮循环过程会释放出更多的 N_2O，可抵消 ~10% 的由生物泵固碳所降低的 CO_2 温室效应。该研究结果为海洋碳、氮循环的耦合与复合气候效应研究提供了新的科学思路，有助于全方面的理解与评估生物泵的气候调节能力。

> 以上工作于 2022 年 12 月发表于 *Nature Geoscience* 期刊，博士后万显会为第一作者，高树基教授为通讯作者。

Reference:

Wan, Xianhui Sean; Sheng, Hua-Xia; Dai, Minhan; Zhang, Yao; Shi, Dalin; Trull, Thomas W.; Zhu, Yifan; Lomas, Michael W.; Kao, Shuh-Ji*. Ambient nitrate switches the ammonium consumption pathway in the euphotic ocean. *NATURE COMMUNICATIONS*. 2018. 9, 915.

Wan, Xianhui S.; Sheng, Hua-Xia; Dai, Minhan; Casciotti, Karen L.; Church, Matthew J.; Zou, Wenbin; Liu, Li; Shen, Hui; Zhou, Kuanbo; Ward, Bess B.; Kao, Shuh-Ji*. Epipelagic nitrous oxide production offsets carbon sequestration by the biological pump. *NATURE GEOSCIENCE*. 16, 29-36.



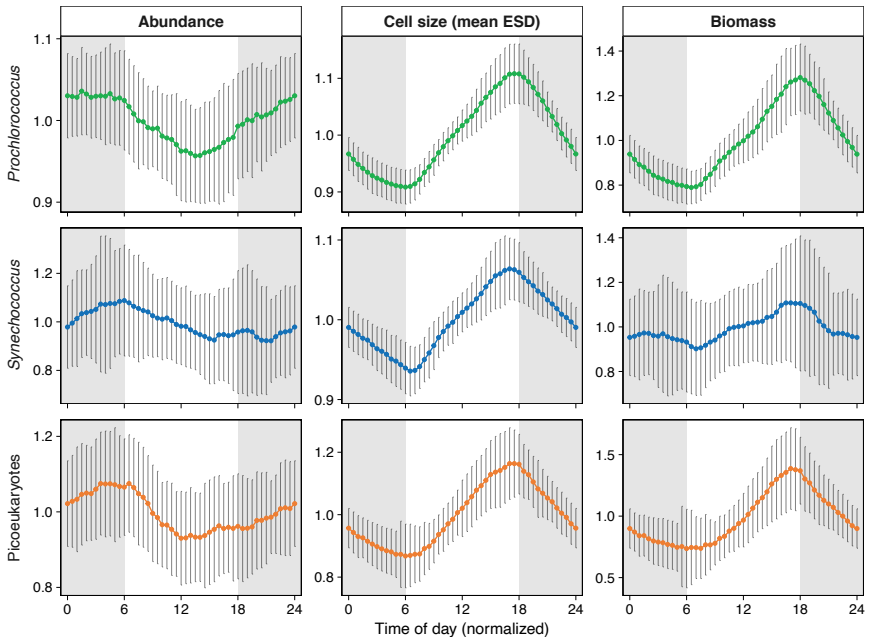
真光层碳 - 氮耦合循环关键过程及其复合气候效应示意图

寡营养海域中微微型浮游植物昼夜变动研究新进展

海洋微微型浮游植物是地球上粒径最小、丰度最高的产氧光合生物。作为广阔寡营养海域的优势微生物类群，微微型浮游植物是海洋初级生产力的重要组成部分，在海洋生态系统功能和生物地球化学循环中发挥着重要作用。早期研究表明微微型浮游植物细胞丰度的昼夜变动特征表现为夜间上升白天下降，而细胞大小表现为白天增大夜间变小。近年来的研究发现其碳生物量也呈现白天增加夜间下降的昼夜变动特征，而关于捕食者在调控微微型浮游植物昼夜变动上的作用的研究仍然有限且缺乏综合性。

研究团队在南海三个寡营养测站开展了高分辨率的时间序列观测，并通过经实验室藻株“校准”的流式细胞仪同时测定微微型浮游植物的细胞数量、细胞大小和碳生物量。研究结果表明微微型浮游植物的细胞数量和细胞大小 / 碳生物量与昼夜周期密切同步，但它们之间存在准反相关系；即细胞丰度夜间分裂上升、白天下降，而细胞大小和碳生物量均呈白天增大、夜间降低。此外，培养实验还发现在白天与夜间微型鞭毛虫对原绿球藻和聚球藻的捕食压力是相当的。研究进一步利用已公开发表的包含 37 个航次的高分辨率时空变动的 SeaFlow 数据集联合分析，证实了南海观测到的这种准反相昼夜变化模式在寡营养海区具有普适性。

本研究证实并扩展了先前关于寡营养海域中微微型浮游植物的昼夜周期变化的研究结果，指出了微微型浮游植物细胞丰度与细胞大小 / 碳生物量呈现的准反相昼夜变化关系极大可能是近稳态寡营养生态系统的一个普遍特征。该研究提高了自养生物的认知，有助于更好地理解寡营养海区生态系统和生物地球化学过程。



联合分析的 38 个航次每半小时平均的三个类群的微微型浮游植物细胞数量、细胞大小和碳生物量的变动结果（数值已标准化，误差线表示标准偏差，n 介于 181 和 218 之间）

以上工作于 2022 年 3 月发表于 *Geophysical Research Letters* 期刊，2022 届博士生李长林为第一作者，黄邦钦教授为通讯作者。

Reference:
Li, Changlin; Chiang, Kuo-Ping; Laws, Edward A.; Liu, Xin; Chen, Jixin; Huang, Yibin; Chen, Bingzhang; Tsai, An-Yi; Huang, Bangqin*. Quasi-antiphase diel patterns of abundance and cell size/biomass of picophytoplankton in the oligotrophic ocean, *GEOPHYSICAL RESEARCH LETTERS*, 2022, 49, e2022GL097753.

垂直生态模拟体系时间序列研究揭示近海环境中微生物介导的陆源有机碳去除过程

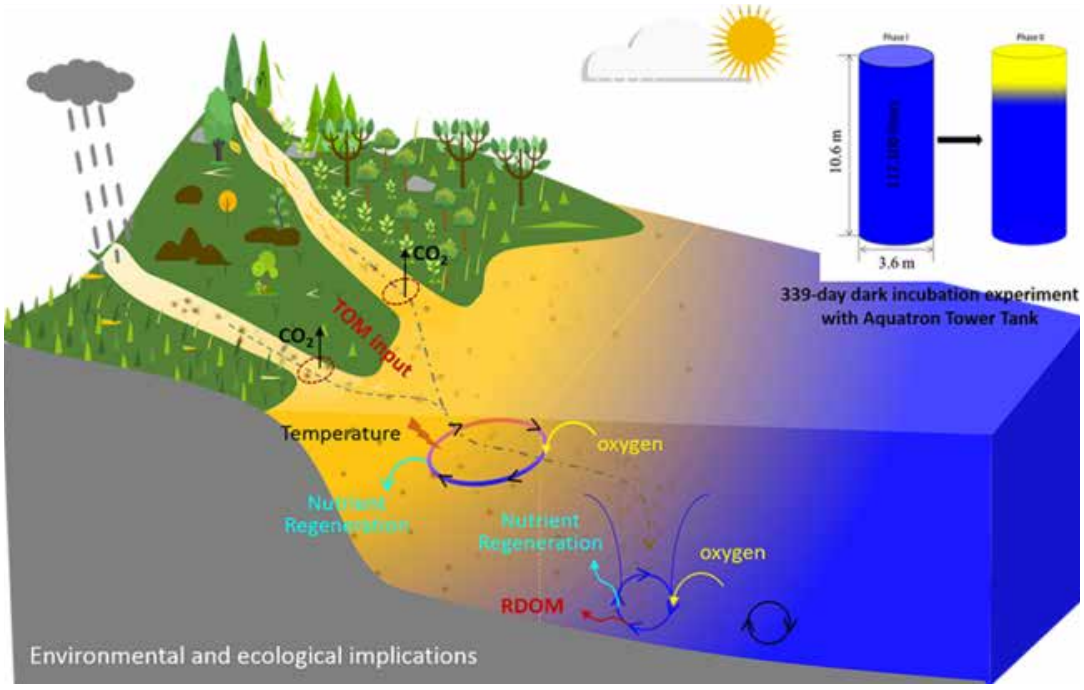
每年大量的陆源有机物通过河流进入海洋，在河流 - 近海 / 河口传输过程中通过埋藏、光降解和微生物降解等途径被移除。除了埋藏途径外，前人研究主要集中于光降解对微生物利用有机物的影响或者在原位环境下探究光降解和微生物降解过程对陆源有机物移除的相对贡献。有研究指出，光降解过程产生的小分子活性有机物会进一步促进微生物利用陆源有机物以及淡 - 海水混合过程中存在的“激发效应”（priming effect）均会进一步促进微生物利用陆源有机物。然而，上述结论并未形成统一认识，陆源有机物在海洋中的移除过程仍待深入探究。

基于加拿大达尔豪斯大学 Aquatron Tower Tank 垂直生态模拟体系（直径 3.66 m，高 10.46 m，总容积 117,100 L），研究团队人工构建了淡 - 海水垂直分层黑暗培养体系，以此模拟河流或者降雨等事件携带陆源有机物进入近海的场景。本研究通过 339 天高频率监测淡水层、淡 - 海水混合层和海水层有机碳含量与组成（光谱技术和 FT-ICR MS）、微生物丰度与群落结构（分粒径 RNA 水平）以及环境因素（温度、溶解氧和无机营养盐），探究了微生物在有机碳转化利用中的作用及其生态环境效应。

对于淡 - 海水混合层而言，二端元分析结果表明淡 - 海水混合过程促进了微生物的生长、有机物的利用、氧气的消耗和无机营养物质的再生，印证了淡 - 海水混合过程中确实存在促进有机物降解的“激发效应”。对于底部海水层而言，表层淡水添加后，荧光溶解有机物各组分累积速度增加，该物质被证实为惰性溶解有机物的组成部分。相关性分析结果表明，该惰性物质产生速度加快的可能原因是表层陆源有机物向底层的输送促进了微生物的代谢活动。本研究为认识近海生态系统中微生物对有机碳的转化及其伴随的生态效应提供新认识。

> 以上工作于 2022 年 5 月发表于 *Environmental Science & Technology* 期刊，博士后肖喜林为第一作者，焦念志教授为共同通讯作者。

Reference:
Xiao, Xilin; Powers, Leanne C.; Liu, Jihua*; Gonsior, Michael; Zhang, Rui; Zhang, Lianbao; MacIntyre, Hugh L.; Chen, Xiaowei; Hu, Chen; Batt, John; Shi, Qiang; Xu, Dapeng; Zhang, Yao; Jiao, Nianzhi*. Biodegradation of terrigenous organic matter (TOM) in a stratified large-volume water column: implication of the removal of TOM in estuarine systems. *ENVIRONMENTAL SCIENCE & TECHNOLOGY*. 2022. 56, 5234-5246.



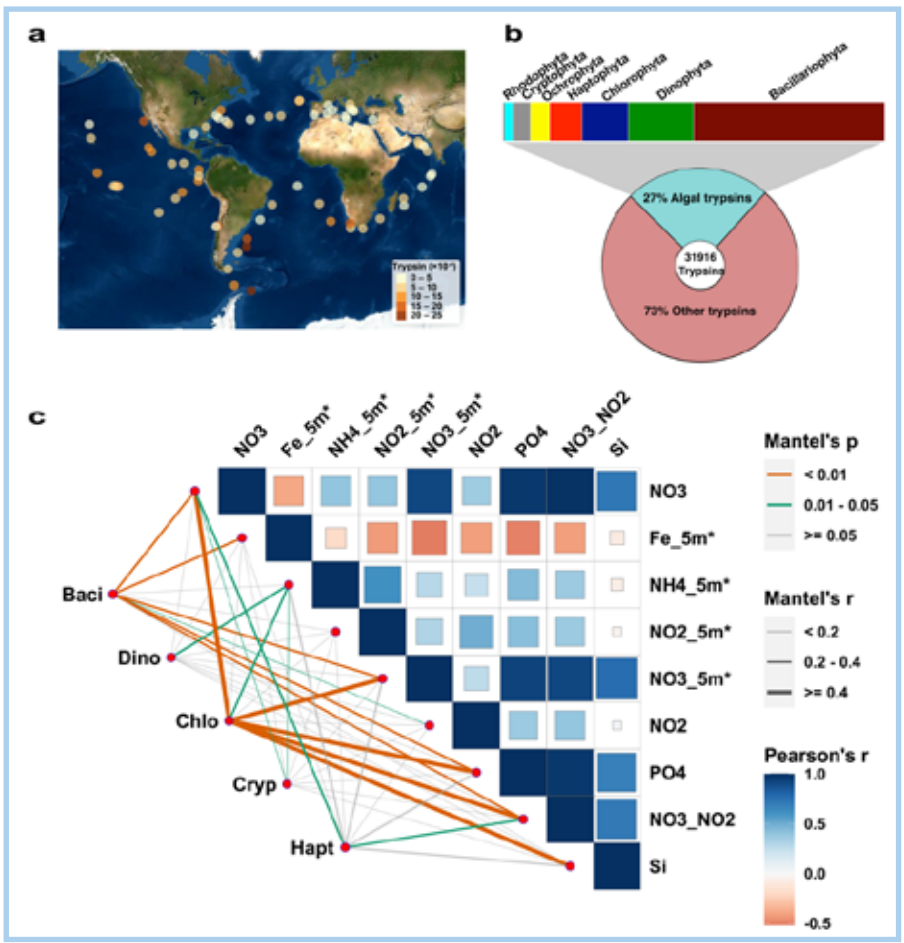
研究结果示意图
淡 - 海水混合促进了微生物利用有机碳、氧气消耗和无机营养盐生成；在海水深部，陆源有机物输入会促进微生物的代谢活动而加速惰性有机物的产生和氧气消耗等

浮游植物胰蛋白酶是调控氮磷营养平衡的双向开关

胰蛋白酶（trypsin）是一种普遍存在于动物消化系统中的蛋白水解酶，参与酶原激活、食物消化和免疫防卫等多个重要生理过程。胰蛋白酶研究已有很长的历史，但主要集中在动物领域。研究团队通过对 2014 年发生于中国东海的赤潮进行研究，于国际上首次发现硅藻拥有胰蛋白酶基因，且在甲藻赤潮爆发前、水体中磷营养盐急剧下降时有很高的表达量（占硅藻总转录本的 1%），这表明胰蛋白酶在硅藻对营养条件变化响应中扮演着重要角色。

研究团队进一步利用 *Tara* Ocean 的相关数据和藻类基因组数据库发现，胰蛋白酶在全球海洋浮游植物的主要类群中普遍存在，同时其表达水平与环境营养盐变化密切相关，且硅藻和绿藻胰蛋白酶对氮（N）和磷（P）营养盐变化的响应尤为显著。

为进一步揭示海洋浮游植物胰蛋白酶的功能，研究团队以三角褐指藻（*Phaeodactylum tricornutum*）为模式生物，通过综合运用 *CRISPR/Cas9* 基因编辑、转基因、过表达及亚细胞定位、RNA-seq、生理参数测定等分子生物学和细胞生物学理论和方法，揭示了三角褐指藻胰蛋白酶 2（*PtTryp2*）可通过调节自身的基因表达水平来应对营养盐变化，即通过新陈代谢调节，减小 N-P 平衡这个“跷跷板”的振幅，以达到促进不同营养盐的协同利用并维持胞内氮磷化学计量比稳态。该成果为深入研究浮游植物对营养环境变动的响应与适应机制指明了新方向，为构建可预测未来增温引起的大洋寡营养化与人类排放引起的近海富营养化如何影响浮游植物群落结构与功能的生态模型提供了理论基础。



胰蛋白酶在全球海洋浮游植物中的广泛分布及对环境营养盐的响应

（a）海洋浮游植物胰蛋白酶广泛的地理分布；（b）海洋浮游植物胰蛋白酶丰富的物种分布；（c）浮游植物胰蛋白酶对环境营养变化的响应

以上工作于 2022 年 7 月发表于 *Nature Communications* 期刊，博士后尤燕春为第一作者，林森杰教授为通讯作者。

Reference:
You, Yanchun; Sun, Xueqiong; Ma, Minglei; He, Jiamin; Li, Ling; Porto, Felipe Wendt; Lin, Senjie*. Trypsin is a coordinate regulator of N and P nutrients in marine phytoplankton. *NATURE COMMUNICATIONS*. 2022. 13, 4022.

海洋多尺度运动采样中的时空域混叠规律

海洋是一个典型的多尺度动力系统，海水运动呈现多时空尺度变化特征：空间上包含从千公里以上的海盆尺度至毫米量级的耗散尺度，而时间上则涵盖从年代际以上的气候变化尺度到秒量级的三维湍流尺度。因此，任何的海洋观测都是对时空连续过程的离散采样。根据信号处理理论，离散采样时连续信号中高于奈奎斯特频率（即折叠频率）的信号会与低频信号发生混叠，即产生混频现象（图 1）。由混频所造成的信号混叠给真实信号的提取及对相关过程的机理解析带来了极大困难。研究表明，内波在频率 - 波数谱上的混叠会严重影响对其它动力过程的准确刻画，但频率 - 波数谱上的二维混叠规律尚待精确量化，混叠对其它动力过程量化与机理解析的影响也有待详细阐明。

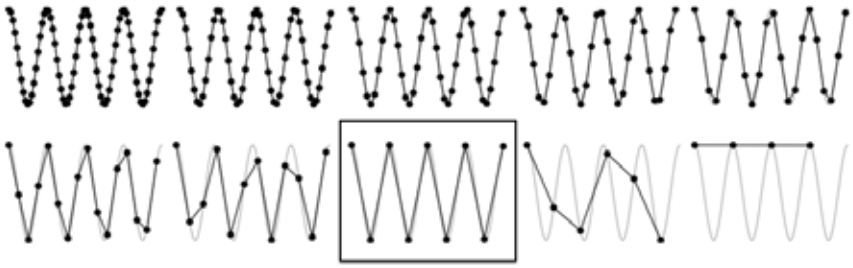


图 1 以不同频率对连续信号（灰色实线）进行离散采样（黑色圆点）的示意图。矩形框对应以奈奎斯特频率采样（引自 Cushman-Roisin & Jean-Marie （2011））

鉴于此，研究团队以内波在时空域的混叠规律为例，通过对高频观测数据与潮分辨、亚中尺度相容数值模拟数据进行时空域重采样，并结合海洋动力学与信号处理基础理论，指出（图 2）：（1）每小时一次的采样频率足以完整解析内潮水平流速的变化，但无法准确量化垂向速度在各频段的变化规律；（2）每小时采样一次内波的混频规律与理论预测完全相符，但每天采样一次内波的混频规律则非常复杂；（3）由于内波的时域周期性远强于空间域周期性，时间域重采样会造成高频信号的混频，因此高频信号的能量得以保留，而空间域重采样则倾向于导致高波数信号能量直接流失。研究结果对于由下一代卫星高度计数据中准确分离出不同时空尺度动力过程具有直接的指导意义。

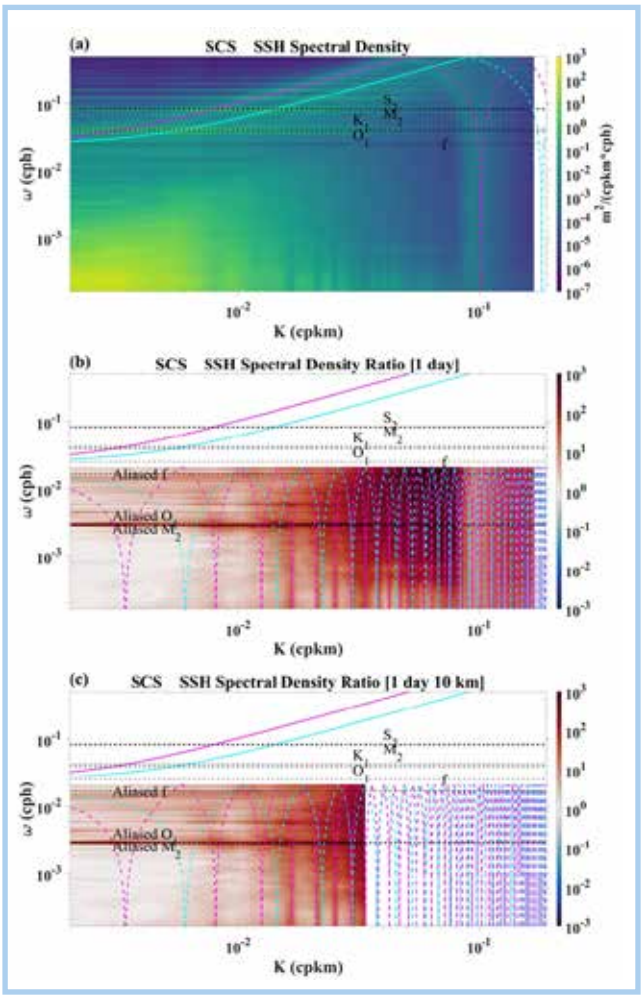


图 2 南海原始海面高度的频率 - 波数谱及其与重采样海面高度频率 - 波数谱的比率

以上工作于 2022 年 5 月发表于 *Limnology and Oceanography Letters* 期刊，2022 届博士生王传印为第一作者，刘志宇教授与林宏阳副教授为共同通讯作者。

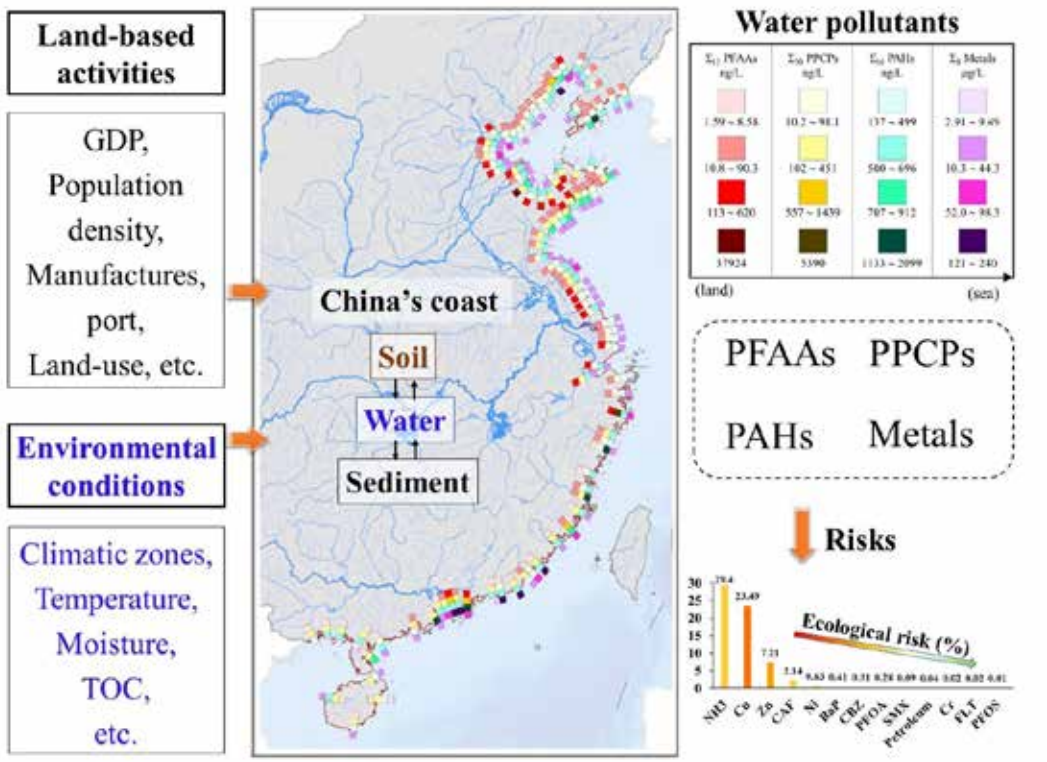
Reference:
Wang, Chuanyin; Liu, Zhiyu*; Lin, Hongyang*. Interpreting consequences of inadequate sampling of oceanic motions, *LIMNOLOGY AND OCEANOGRAPHY LETTERS*. 2022. 7: 385-391.

气候与人类活动共同驱动下多种污染物对海岸带生态系统的胁迫效应

海岸带高强度的人类活动对海岸带生态系统健康产生了持续的胁迫作用，其中污染物排放尤其值得高度关注。吕永龙教授率领其团队基于对中国 1.8 万公里海岸带的系统性环境样本采样和社会经济调查分析，研究了气候与人类活动共同驱动下多种污染物对海岸带生态系统的胁迫效应。通过分析全氟烷基酸（PFAAs）、药品和个人护理品（PPCPs）、多环芳烃（PAHs）和金属（Metals）4 大类共 66 种污染物，探究陆基社会经济活动与污染物排放的关系，以及气候因子对污染物分布的影响，并评估了各污染物的生态风险。

研究结果表明，无论是传统污染物还是新型污染物都在我国海岸带有广泛分布，而大的入海河流是此类污染物的重要载体。本研究进一步揭示了污染物空间分布差异所呈现的规律性，与传统污染物的重污染区主要集中在大流域入海口不同，新型污染物的高暴露水平更多出现于小流域入海口，这对污染监测和管理提出了新的挑战。研究发现部分高暴露水平已经产生了显著的生态风险，氨、铜和锌等污染物的生态风险最高，而对于每种污染物，不同气候带的生态风险不同。由于陆基人类活动是海岸带和海洋污染的主要驱动因素，因此应将陆地和海洋视为防治海岸带污染和恢复海岸带生态系统功能的一个整体，加强对沿海水域污染水平的持续监测，进一步控制源排放、改善废物管理、调整产业结构、改进土地管理政策，以应对海岸带污染。

> 以上工作于 2022 年 2 月发表于 *Journal of Hazardous Materials* 期刊，吕永龙教授为第一兼通讯作者。



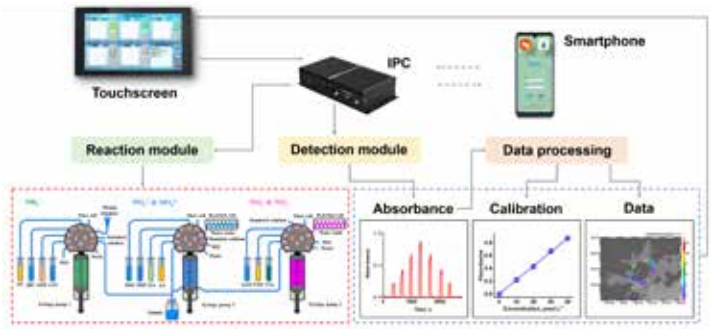
四大类污染物在我国海岸带水体中的空间分布及相关影响因素和风险分析

Reference:
Lu, Yonglong*; Wang, Pei; Wang, Chenchen; Zhang, Meng; Cao, Xianghui; Chen, Chunci; Wang, Cong; Xiu, Cuo; Du, Di; Cui, Haotian; Li, Xiaoqian; Qin, Wenyou; Zhang, Yi; Wang, Yichao; Zhang, Anqi; Yu, Mingzhao; Mao, Ruoyu; Song, Shuai; Johnson, Andrew C.; Shao, Xiuqing; Zhou, Xuan; Wang, Ting; Liang, Ruoyu; Su, Chao; Zheng, Xiaoqi; Zhang, Sheng; Lu, Xiaotian; Chen, Yuqing; Zhang, Yueqing; Li, Qifeng; Ono, Kotaro; Stenseth, Nils C.; Visbeck, Martin; Ittekkot, Venugopalan. Multiple pollutants stress the coastal ecosystem with climate and anthropogenic drivers. *JOURNAL OF HAZARDOUS MATERIALS*. 2022. 424, 127570.

基于自动化流动分析仪实时走航观测表层海水的营养盐浓度

受人类活动和全球变化影响，河口 - 近海区域富营养化、缺氧、酸化等生态环境问题严峻，且形成了复杂的多重效应耦合机制，是国际“未来地球（Future Earth）”研究计划聚集的区域。“工欲善其事，必先利其器”。为提升生物地球化学过程与生态系统过程等基础科学的研究水平，亟需对海洋环境参数进行现场多参数、高精度、高时空分辨率的自动测定。

本研究以科学需求为导向，结合分析化学、电子学、仪器科学、环境科学、海洋化学等多个学科，从快速简便、用户友好、环境友好、多目标同时测定四个方面入手，对课题组多年潜心钻研的集成式水环境营养盐分析仪（*i*SEA 系统）进行优化与升级，形成了全新的 iSEA-II 系统。该系统突破国内外在海水化学参数现场分析方面的技术瓶颈，并与自动在线过滤系统结合，成功应用于河口 - 海湾营养盐（氨氮、硝酸盐、亚硝酸盐、硅酸盐和磷酸盐）监测，实现获取高时空分辨率、高准确度的营养盐多参数同步走航观测数据的目标。



*i*SEA-II 营养盐测定系统流程图

*i*SEA-II 仪器的性能主要表现如下：

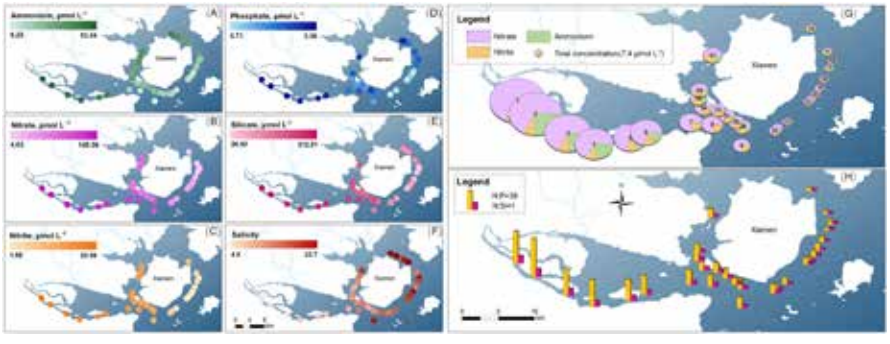
1. 结构紧凑，集成分析模块、检测模块及人机交互模块，做到即插即用，操作简便，适用于海洋现场调查的艰苦环境；

2. 自动化程度高，自主研发软件实现自动绘制工作曲线、自动质量控制、自动稀释高浓度样品、数据自动处理、保存和传输、自动启停和异常报警等功能，适用于长时间的全自动连续监测；

3. 测定速度快、测定范围宽、克服盐度干扰，适用于河口 - 海湾营养盐的走航观测；

4. 样品和试剂消耗量小，对于单个样品单参数测定，样品和试剂消耗量分别少于 500 μL、50 μL，适用于小体积样品的测定。

*i*SEA-II 系统现场应用实拍图



*i*SEA-II 应用于河口 - 海湾进行营养盐五参数的同步走航观测

以上工作于 2022 年 7 月发表于 *Analytical Chemistry* 期刊，2020 级博士生方腾越为第一作者，马剑教授为通讯作者。

Reference:
Fang, Tengyue; Bo, Guangyong; Zhang, Zijie; Ma, Jian*. Real-time underway mapping of nutrient concentrations of surface seawater using an autonomous flow analyzer. *ANALYTICAL CHEMISTRY.* 2022. 94, 11307-11314.

磷限制加剧海洋酸化对优势固氮蓝藻的抑制效应

工业革命以来，海洋吸收了约三分之一人为排放的 CO_2，以迄今 3 亿年来最快的速度酸化（CO_2 升高、pH 下降），这势必影响海洋生态系统的关键过程和功能。全球海洋面积一半以上海区的初级生产力受氮营养盐缺乏的限制，而优势固氮蓝藻束毛藻是寡营养海区中氮的重要来源，可贡献高达 50% 的海洋总固氮量，从而显著影响海洋初级生产力和气候调节功能。因此，海洋酸化对束毛藻的影响及其效应备受学界关注。

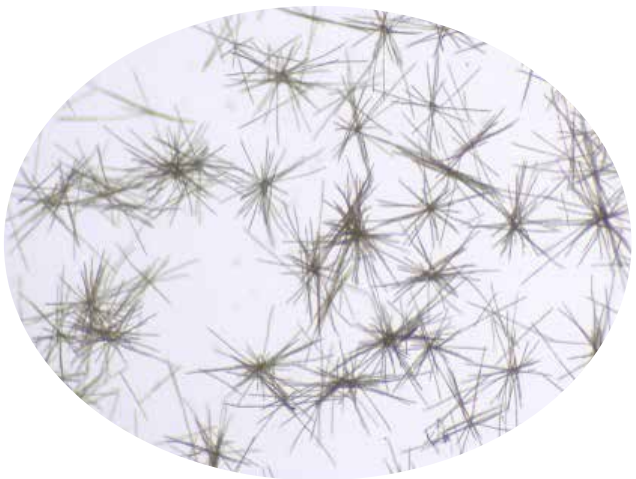
围绕这一重大科学问题，史大林课题组与合作者在前期研究工作的基础上，采用酸化长期驯化培养结合 chemostat 连续培养技术，深入探究了酸化对长期适应稳态磷限制的束毛藻的固碳、固氮以及磷代谢通路的影响及其机理。

研究发现，酸化显著抑制磷限制束毛藻的光合作用和固氮作用，细胞颗粒有机碳和氮含量相应降低，有机磷的含量显著增加，引起 C:P 和 N:P 比值下降，这预示酸化将导致磷限制束毛藻的单位磷所能支撑的固碳和固氮量下降。通过细胞内主要含磷物质、转录组学和对相关代谢产物的分析表明，酸化下调了催化 NAD 磷酸化的关键酶基因 ppnK 的表达，这可能是维持胞内高的 polyP 水平的原因。高的 polyP 含量伴随着胞内 NADP(H):NAD(H) 以及叶绿素浓度的下降，引起细胞产量受影响，进而抑制固碳和固氮，且该抑制效应较磷充分条件下更为显著。且开展的南海磷限制天然束毛藻群落现场实验印证了上述室内实验的发现。

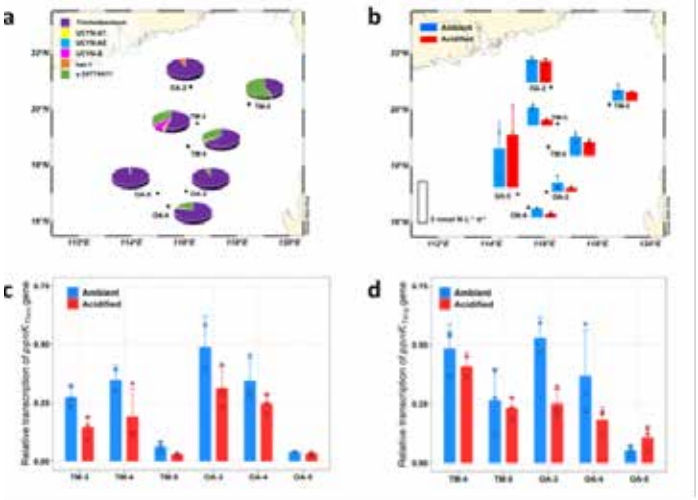
利用通用地球系统模型（CESM）模拟的结果表明，至本世纪末全球海洋束毛藻固氮作用将因酸化和磷限制的联合作用下降 22.8 Tg N yr^{-1}，以西太平洋和北印度洋下降程度最为显著。

> 以上工作于 2022 年 11 月发表于 *Nature Communications* 期刊，2019 届博士生张福婷和温作柱为共同第一作者，史大林和洪海征教授为共同通讯作者。

Reference:
Zhang, Futing; Wen, Zuozhu; Wang, Shanlin; Tang, Weiyi; Luo, Ya-Wei; Kranz, Sven A.; Hong, Haizheng*; Shi, Dalin*. Phosphate limitation intensifies negative effects of ocean acidification on globally important nitrogen fixing cyanobacterium. *NATURE COMMUNICATIONS*, 2022. 13: 6730.



簇状体束毛藻



海洋酸化对南海北部表层束毛藻的影响。(a) 固氮群落中不同固氮生物的相对贡献；(b) 酸化条件下固氮群落固氮速率；（c、d）酸化条件下固氮生物群落中两类主要束毛藻 *T. tenue* (c) 和 *T. erythraeum* (d) NAD 激酶基因 ppnk 的相对表达量

西北太平洋生物固氮作用的营养盐调控机制

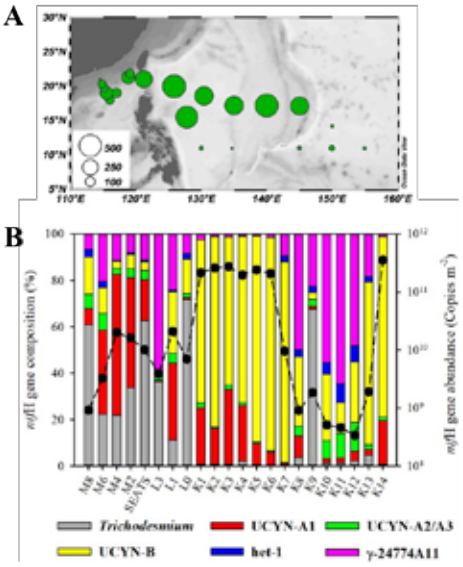
在全球约 70% 的海区，氮（N）是真光层中浮游植物生长最主要的限制性营养盐，固氮生物通过固氮酶将氮气（N_2）还原为氨（NH_3），可贡献高达 50% 的海洋外源生物可利用氮 ——“新氮”，对输出生产力有重要的贡献。然而，迄今为止我们对在全球尺度上海洋生物固氮分布的调控因子及其机理的了解十分有限，这影响到对海洋生物固氮的认识以及对其在全球变化背景下演变趋势的预测。

铁（Fe）和磷（P）是调控全球海洋生物固氮的重要营养盐。热带和亚热带西北太平洋是固氮作用的热点海区。然而，迄今针对该海区生物固氮的营养盐调控机理的研究仍存在诸多不足与挑战。首先，海盆尺度上高分辨率的观测非常有限，且其结果与模型预测并不吻合；其次，在观测固氮速率的同时匹配低浓度氮、磷和痕量金属铁的研究极其有限，且忽略了营养盐供给速率对生物固氮的潜在调控；再者，固氮作用营养盐限制因子的直接观测和实验证据十分缺乏。

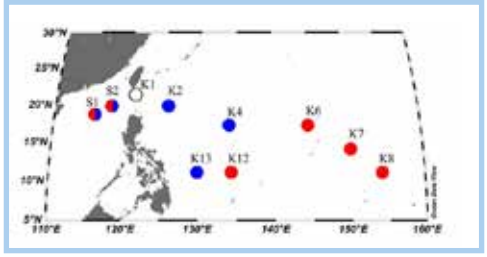
针对上述重大科学问题，史大林教授团队与合作者依托 GEOTRACES 计划西太平洋科学考察 GP-09 等航次，对热带西北太平洋海区的固氮速率和固氮生物群落开展了大尺度、高分辨率的观测，结合痕量洁净条件下原位培养实验开展研究，系统阐明了西太从边缘海到开阔大洋的固氮速率和固氮生物的空间格局受 Fe:N 比调控，并首次揭示了西太固氮作用的铁、磷限制及空间变异性。研究成果为解释海洋生物固氮分布的资源竞争性理论提供了重要的观测证据，同时为生物固氮在全球尺度上的预测提供了重要的理论依据。

> 以上工作 2022 年 2 月发表于 *Science Advances* 期刊，2019 届博士生温作柱为共同第一作者，史大林教授为通讯作者。

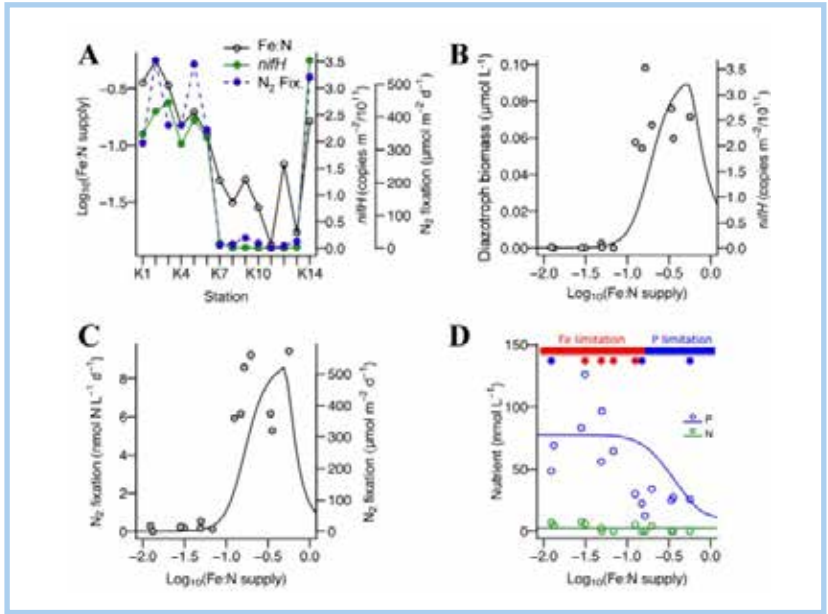
Reference:
Wen, Zuozhu; Browning, Thomas J.; Cai, Yihua; Dai, Rongbo; Zhang, Ruifeng; Du, Chuanjun; Jiang, Ruotong; Lin, Wenfang; Liu, Xin; Cao, Zhimian; Hong, Haizheng; Dai, Minhan; Shi, Dalin*. Nutrient regulation of biological nitrogen fixation across the tropical western North Pacific. *SCIENCE ADVANCES*. 2022. 8, eabl7564.



（A）固氮速率和（B）固氮生物群落结构



固氮速率对铁和磷营养盐添加的响应。红色为铁限制；蓝色为磷限制；红蓝为铁磷共同限制



Fe:N 供给比率对固氮速率和固氮生物丰度的调控作用。（A）Fe:N 供给比例与固氮速率和固氮生物丰度的相关性；（B）和（C）资源竞争模型输出结果与观测的吻合。灰色符为观测结果，实线为 Fe:N 比资源竞争模型结果；（D）模型输出的营养盐限制与现场试验结果吻合。实线为稳态 P 和氮浓度变化，空心符为上层 50 米水柱平均浓度；红蓝实心棒分别为铁、磷限制固氮模型结果，实心符为现场实验固氮作用的铁、磷营养盐限制结果

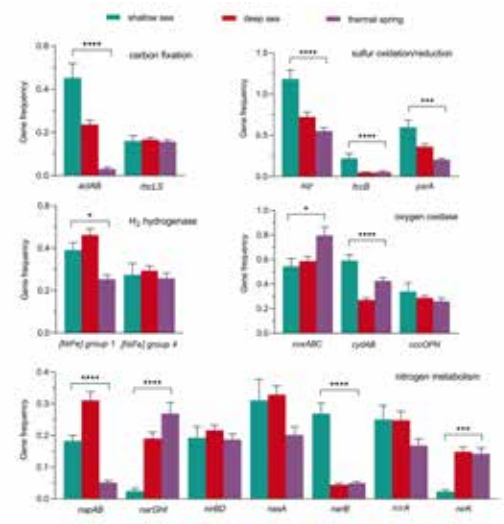
基于功能组学解析浅海热液喷口中代谢活跃的微生物种群

热液系统的发现拓展了我们对生命生存极限及其起源的理解。浅海热液所处的地理环境介于陆地热泉和深海热液之间，多出现在火山海面下翼部和海底火山顶部。相较于陆地热泉和深海热液，我们对浅海热液的微生态系统了解甚少。台湾龟山岛浅海热液系统具有独特的地球化学特性，是受光能和热能同时支持的复杂生态系统，因而是研究生命起源、生源要素循环过程、生态系统演变及资源环境效应的极好场所。

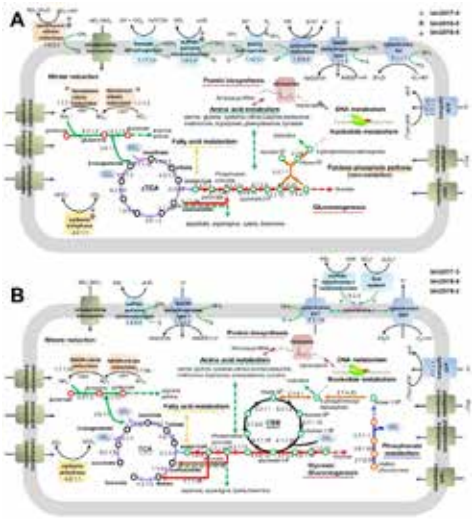
研究团队对龟山岛浅海热液喷口的微生物群落进行了为期三年的采样监测，通过宏基因组拼接和分箱分析，以及宏蛋白质组学方法，探究微生物优势类群的代谢功能潜力及其代谢模式。研究发现 Epsilonbacteraeota 的鹦鹉螺科 *Nautiliaceae* 和弯曲杆菌科 *Campylobacteraceae*，以及 Gammaproteobacteria 的硫微螺菌科 *Thiomicrospiraceae* 是龟山岛浅海热液喷口流体中的核心功能类群。该研究成功构建了 *Nautiliaceae* 和 *Thiomicrospiraceae* 类群的原位代谢模式，发现这些类群可以通过还原性三羧酸循环或卡尔文循环进行自养固碳，利用还原硫化合物、氢气或甲酸盐作为电子供体，通过细胞色素 bd 或 bb3 氧化酶利用氧气作为末端电子受体以获取能量。活跃于浅海热液喷口的 *Nautiliaceae* 和 *Thiomicrospiraceae* 的代谢机制可以映射栖息于深海中的微生物类群。海底热液系统和陆地热泉系统微生物群落之间在固碳途径和能量转换方面存在显著差异。多数深海热液和陆地热泉的微生物种类也可栖息于浅海热液系统中，而深海热液与陆地热泉之间共享的微生物种类则少得多。因而，浅海热液微生物体现了它们与深海热液和陆地热泉微生物在生态功能方面的联系。

以上工作于 2022 年 10 月发表于 *Microbiome* 期刊，2017 级博士生陈小凤为第一作者，汤凯和张瑶教授为共同通讯作者。

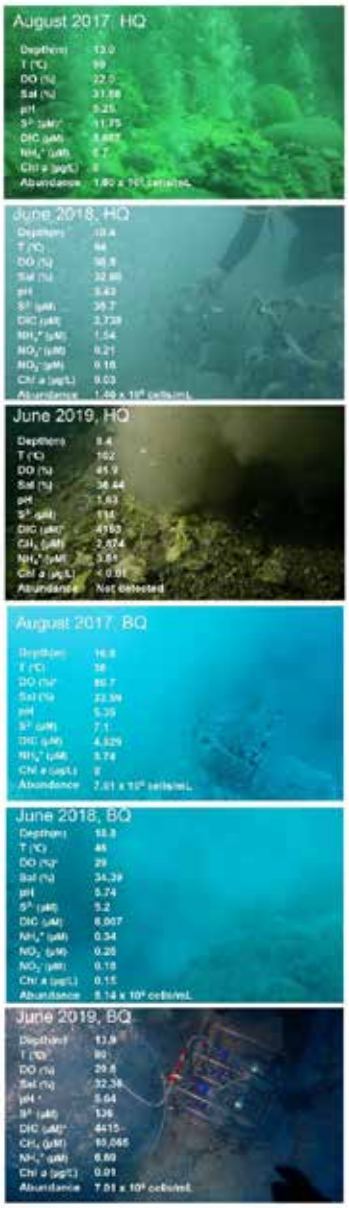
Reference:
Chen, Xiaofeng; Tang, Kai*; Zhang, Mu; Liu, Shujing; Chen, Mingming; Zhan, Peiwen; Fan, Wei; Chen, Chen-Tung Arthur; Zhang, Yao*. Genome-centric insight into metabolically active microbial population in shallow-sea hydrothermal vents. *MICROBIOME*. 2022. 10, 170.



浅海、深海和陆地热液系统的宏基因组中关键代谢基因频率分布



Epsilonbacteraeota（A）Gammaproteobacteria（B）的原位代谢机制



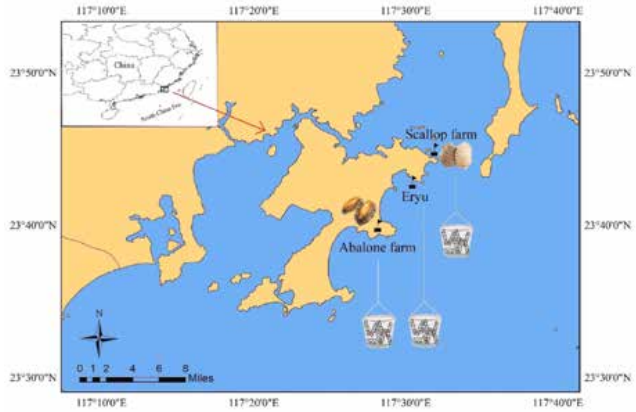
龟山岛黄泉、白泉取样环境状况（2017-2019 年）

海水养殖区微塑料对抗生素的选择性吸附促进机会性病原菌的定植

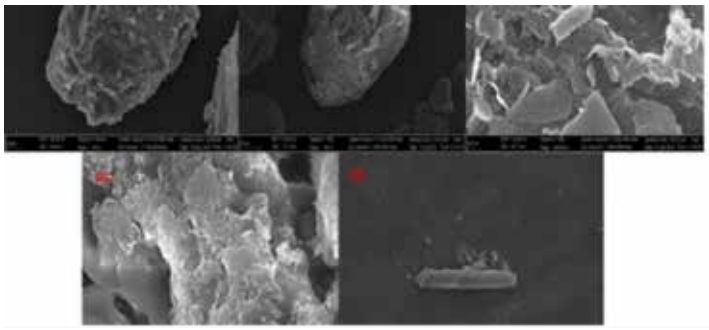
微塑料和抗生素作为两种主要的新兴污染物，因其在环境中广泛存在以及潜在的生态风险受到人们的密切关注。已有研究发现微塑料可以作为不同污染物和微生物的载体在环境中进行迁移。海水养殖区贝类的吊养和筏式养殖方式，存在微塑料和抗生素的共同污染。贝类作为一种滤食性无脊椎动物，可过滤水中的小型食物如浮游动、植物，但无法选择性避免摄入微塑料等颗粒物，并且贝类摄食的微塑料负载了病原菌等微生物并吸附了抗生素，从而提高了生物体对抗生素的可利用性，增加了其对生物体包括人体的潜在危害。近年来，微塑料分别对抗生素和微生物的实验室吸附行为均有研究，但在多种抗生素并存的实际环境下，微塑料对抗生素的实际吸附和积累及其对微生物种群的定植研究尚未开展。因此，研究海水养殖环境中两种新污染物的相互作用及其与微生物种群的定植关系，对评估人体摄食贝类的健康风险有重要参考作用。

基于以上研究背景，研究团队选取福建东山湾的 2 个海水贝类（扇贝和鲍鱼）养殖区，进行 5 种微塑料老化的原位吸附实验，探讨了抗生素和微塑料共同存在环境下微塑料对抗生素的吸附、影响因素及其对微生物种群尤其是对机会性致病菌定植的影响作用。结果表明，抗生素会选择性地吸附在微塑料上，其表现为在养殖水体中 29 种抗生素中仅有 6 种被吸附在 5 种微塑料上。微塑料吸附抗生素受微塑料种类和环境条件的影响，如老化的聚丙烯 (PP) 因具有发达的孔隙结构，其吸附能力较其他材质高。高通量测序显示微塑料附着的微生物相比周围水体具有更高的多样性和组成差异，其中机会致病菌 (如分枝杆菌) 在老化的微塑料上吸附的四环素和强力霉素呈正相关关系，表明在老化的微塑料上吸附抗生素可以使某些特定的病原体在微塑料上定植并扩散到未受影响的生态系统、海洋生物甚至人类。健康风险商数 (HQ) 反映了食用被抗生素污染的商业海产品和含有抗生素的微塑料对人体健康的存在潜在的风险。

> 以上工作于 2022 年 9 月发表于 *Environmental Pollution* 期刊，2021 级博士生于晓璇为第一作者，王新红教授为通讯作者。

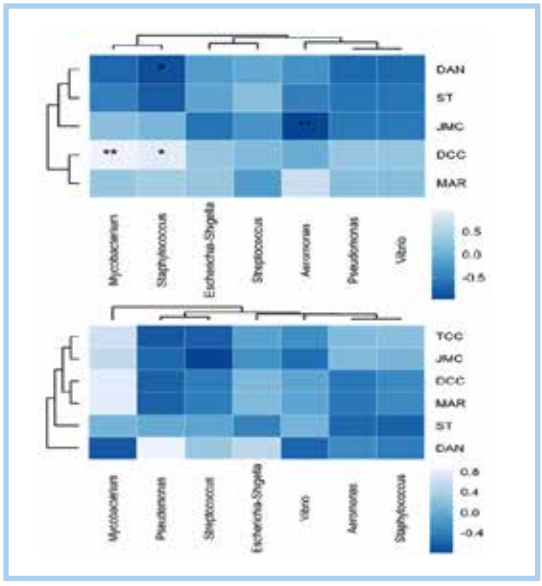


原位微塑料放置采样点图（福建东山湾）



微塑料老化电镜扫描电图

Reference：
Yu, Xiaoxuan; Du, Huihong; Huang, Yuhong; Yin, Xiaohan; Liu, Yawen; Li, Yongyu; Liu, Huatai; Wang, Xinhong*. Selective adsorption of antibiotics on aged microplastics originating from mariculture benefits the colonization of opportunistic pathogenic bacteria. *ENVIRONMENTAL POLLUTION*. 2022. 313, 120157.



不同养殖区微塑料吸附抗生素和机会性致病菌相关性图

基于集合敏感性分析揭示平流层爆发性增温对 2021 年年初寒潮事件的影响

平流层爆发性增温（Sudden Stratospheric Warming, SSW）是指冬季极区平流层内温度突然升高并伴随极涡减弱的异常事件。平流层异常信号的下传往往会导致对流层内北极涛动负相位的响应，从而引发中高纬地区地面温度异常；SSW 也因此成为冷空气爆发的重要前兆信号。尽管前人从统计合成的角度针对不同类型 SSW 对地面气候的影响进行了归纳，SSW 事件在具体寒潮过程中的作用仍亟待探究。2021 年年初接连发生在北半球的极端寒潮，给欧亚大陆和北美地区带来了严重的社会经济影响，也是全球变暖背景下北半球冬天愈发不稳定的又一力证。那么，在此期间的寒潮过程与平流层极涡的异常有何关联呢？

本研究基于季节 - 次季节尺度集合预报与敏感性分析，揭示了 SSW 对 2021 年 1–2 月发生在西伯利亚地区、加拿大西部和美国中部三次主要寒潮过程的影响。分析表明，平流层极涡在减弱期间，首先偏移向欧亚大陆一侧，随后回撤至极区并向北美大陆一侧分裂，经历了显著的形态转变过程（图 1）。

集合敏感性分析结果表明，相较于第三次寒潮过程，前两次寒潮过程与平流层极涡的早期（提前 1-2 周左右）变化特征关联更为密切（图 2）。平流层极涡在 1 月上旬愈发延展，且在西伯利亚地区有明显的位势增强，这将有助于约 2 周后位于西伯利亚的第一次寒潮爆发。随着极涡形态的演变，发生在加拿大西部的第二次寒潮，则与极涡从偏移转向分裂过程中向极区的回撤有关。研究进一步定量诊断了平流层前期预报的关键区域，该区域内位势的预报误差与引发寒潮的对流层天气尺度环流预报技巧呈现显著相关。上述研究结果首次明确了 SSW 事件中平流层极涡“偏移 – 分裂”的形态转变对极寒天气发展的具体影响，定量揭示了准确预报平流层极涡演变特征对次季节尺度寒潮预测的改善作用。

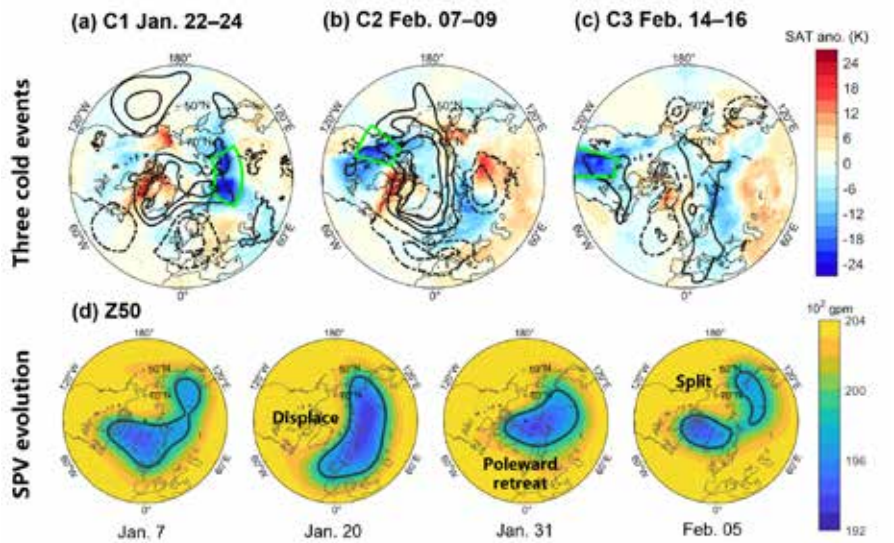


图 1 2021 年年初三次寒潮过程与平流层极涡的演变。(a–c)：三次寒潮期间地面气温异常（填色）和海平面气压异常（等值线），绿色框表示寒潮发生区域；（d）日平均 50-hPa 位势高度演变（填色），黑色实线为 19,800 位势米等值线

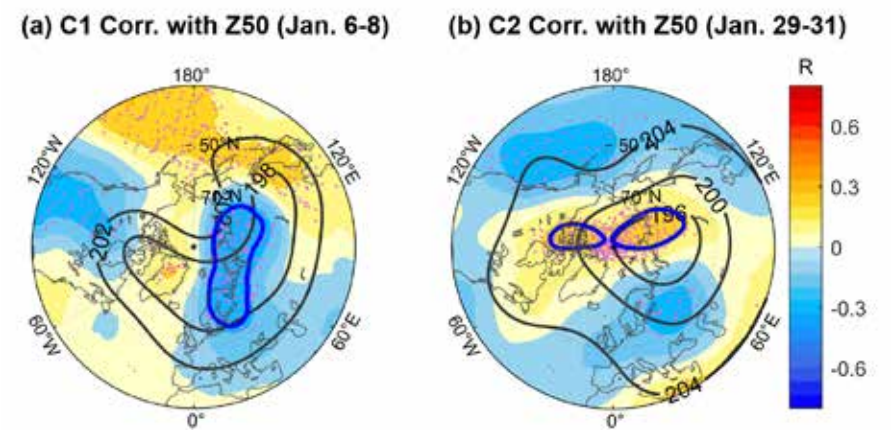


图 2 基于集合预报的寒潮强度与平流层极涡的相关性分布。（a）第一次寒潮过程（C1）区域平均地面气温与 50-hPa 位势高度的相关系数分布（填色）；黑色实线为集合平均的 50-hPa 位势高度，表征极涡位置；蓝色实线为集合敏感性分析得到的高相关区域。（b）与（a）相似但为第二次寒潮过程（C2）相关结果

以上工作于 2022 年 1 月发表于 *Geophysical Research Letters* 期刊，博士后张慕容为第一作者，杨小怡教授为通讯作者。

Reference:
Zhang, Murong; Yang, Xiao-Yi*; Huang, Yipeng. Impacts of sudden stratospheric warming on extreme cold events in early 2021: An ensemble-based sensitivity analysis. *GEOPHYSICAL RESEARCH LETTERS*. 2022. 49, e2021GL096840.

基于水色卫星数据估算海表离水反照度

海表反照度（α）定义为海表面上行辐照度（E_u）和下行辐照度（E_d）的比值，其代表太阳辐射在海 - 气界面处进入水体和返回大气的比例，是研究太阳辐射在海 - 气界面传输的核心参数。在传统的海气耦合和气候模型中，α 大多设为常数或仅考虑海表反射太阳辐射的贡献。然而，水体散射贡献的离水辐照度（E_w）也是 E_u 的重要组成，但现有模式中 E_w 的贡献极易被低估甚至被忽略。

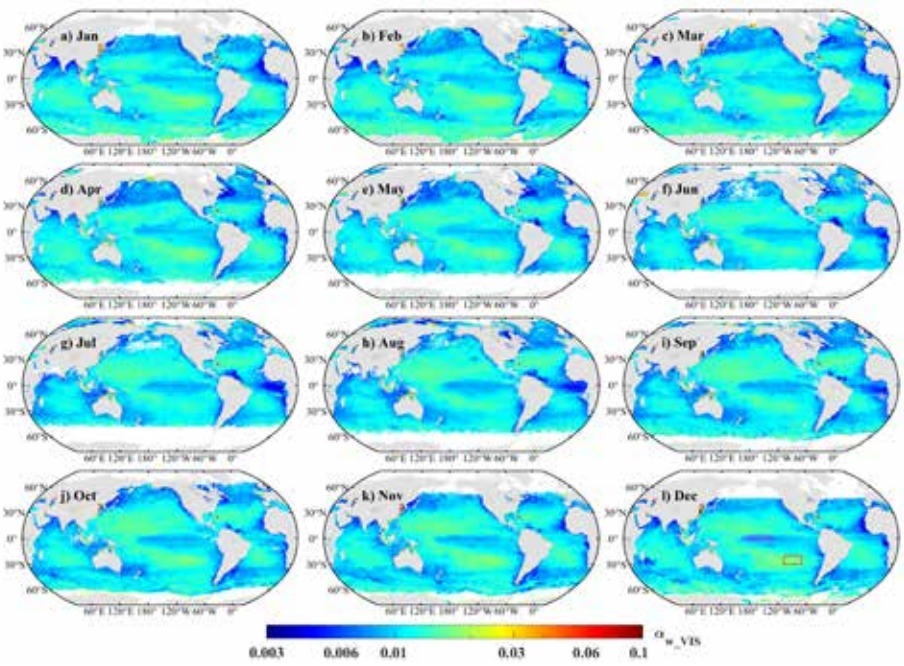
离水反照度（α_w）定义为 E_w 与 E_d 的比值，其基于理论推导是遥感反射比（R_{rs}）在上行方向各观测方位的积分。前期研究中 α_w 的遥感估算大多采用叶绿素 a 浓度（Chl）作为中间变量。然而，研究团队揭示了基于 Chl 的 α_w 遥感算法（Chl-α_w）存在光学不闭合的固有缺陷，即卫星观测的 R_{rs}（用于遥感反演 Chl）与算法中 Chl 模拟的 R_{rs} 不一致，导致 Chl-α_w 估算的 α_w 的误差可高达 1 倍以上。为了精确评估 α_w 对 α 的贡献，研究团队提出了基于水体固有光学特性（IOPs）的 α_w 遥感算法（IOPs-α_w），确保了光学闭合，从而实现了 α_w。相对于 IOPs-α_w 的精确遥感估算。研究结果显示，相对 IOPs-α_w，Chl-α_w 在寡营养海域可能低估可见光宽波段 α_w（α_{w_VIS}）超过 30%，而在部分近岸水体则低估 α_{w_VIS} 超过 50%。利用 VIIRS 月平均数据，研究团队揭示了 α_w 具有显著的时空变化特征。此外，数值模拟结果揭示 α_w 对 α 的贡献不可忽略。在中低纬度大洋水体，α_w 对 α 的贡献可达 20%，而在高浑浊水体贡献可超过 50%。因此，海气耦合和气候模型不应该忽视 α_w 的贡献及其时空变化，而耦合 IOPs-α_w 到模式中，将有助于准确估算大气下边界反射太阳能量，进而实现更加可靠的气候变化的预测。

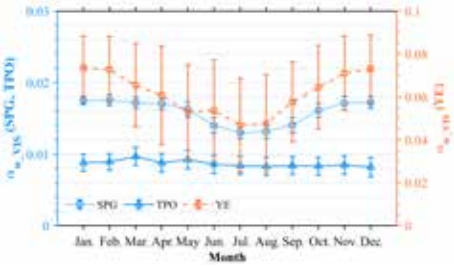
> 以上工作分别于 2021 年 11 月和 2022 年 9 月发表在 *Remote Sensing of Environment* 和 *Optics Express* 期刊，博士后余小龙为第一兼通讯作者。

Reference:

Yu, Xiaolong*; Lee, Zhongping. Scheme to estimate water-leaving albedo from remotely sensed chlorophyll-a concentration. *OPTICS EXPRESS*. 2022, 30: 36176-36189.

Yu, Xiaolong*; Lee, Zhongping; Shang, Shaoling; Wang, Menghua; Jiang, Lide. Estimating the water-leaving albedo from ocean color. *REMOTE SENSING OF ENVIRONMENT*. 2021, 269, 112807.





基于 IOPs-α_w 估算的全球水体 α_{w_VIS} 月际变化分布产品，及三个研究子区域 α_{w_VIS} 平均值的月际变化。SPG、TPO 和 YE 分别指代南太平洋流涡区、赤道太平洋和长江口

微生物驱动的陆源有机碳在海洋中的宿踪

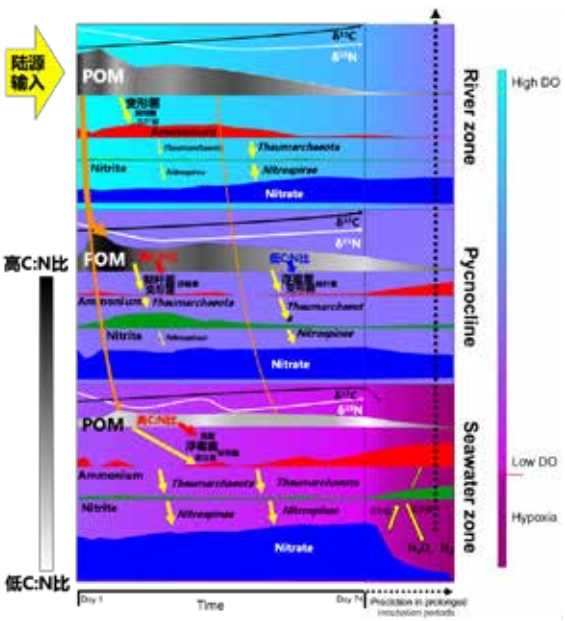
随着全球变暖，陆源有机质通过河流向海洋的输入越来越大。但地球化学的观测表明，海洋中陆源有机质的存留量远低于陆源的输入。这一矛盾长期困扰着海洋学界。以往研究表明，激发效应以及矿物组分可能显著影响海洋中陆源有机质的存留，但对其中涉及到的具体的微生物作用机制、及与其相关的有机质地球化学特征的转变仍不甚了解。

研究团队基于加拿大达尔豪斯大学的 Aquatron 大体积（约 117,000 L）海水培养装置，上层覆盖大约 20,000 L 的河水，形成稳定的河水 - 海水分层系统，对陆源颗粒有机质进入海洋环境后的命运进行了长时间的跟踪观测。结合颗粒物碳氮比和同位素组成、颗粒物化合物组成，以及微生物群落结构和功能多组学分析，研究发现陆源颗粒有机质进入海洋环境后，高分子量、高碳氮比的多糖类组分被优先降解，导致颗粒物的碳氮比值降低；其中相对低密度的多糖类物质在进入培养体系后存留于密度跃层，促进了该层位拟杆菌的生长；而在底部海水层，真菌类群的丰度及其编码的胞外糖苷水解酶的数量与陆源颗粒有机质的输入展现出极强的一致性，表明真菌类群显著促进了进入海水层的多糖类物质的降解；在拟杆菌和真菌作为先锋种发挥作用后，变形菌和浮霉菌随后偏好降解低碳氮比的有机质。陆源物质输入导致的上述一系列微生物再矿化过程的增强，进一步加强了海水层的硝化作用及其驱动的自养固碳，所形成的低碳氮比有机质一定程度上又加剧了颗粒物碳氮比的降低。微生物对陆源有机质的这种偏好性降解（偏好降解低 $\delta^{15}N$ 的有机质）以及微生物的合成作用（偏好利用高 $\delta^{13}C$ 的有机质种类）造成了系统中总颗粒有机质 $\delta^{13}C$ 和 $\delta^{15}N$ 的正偏，以及有机质年龄的快速老化。

该研究首次系统地阐明了陆源颗粒有机质在能量和物质限制的黑暗海洋中的微生物转化机制，为陆源输入与深海碳埋藏之间的巨大缺口提供了重要的解释。

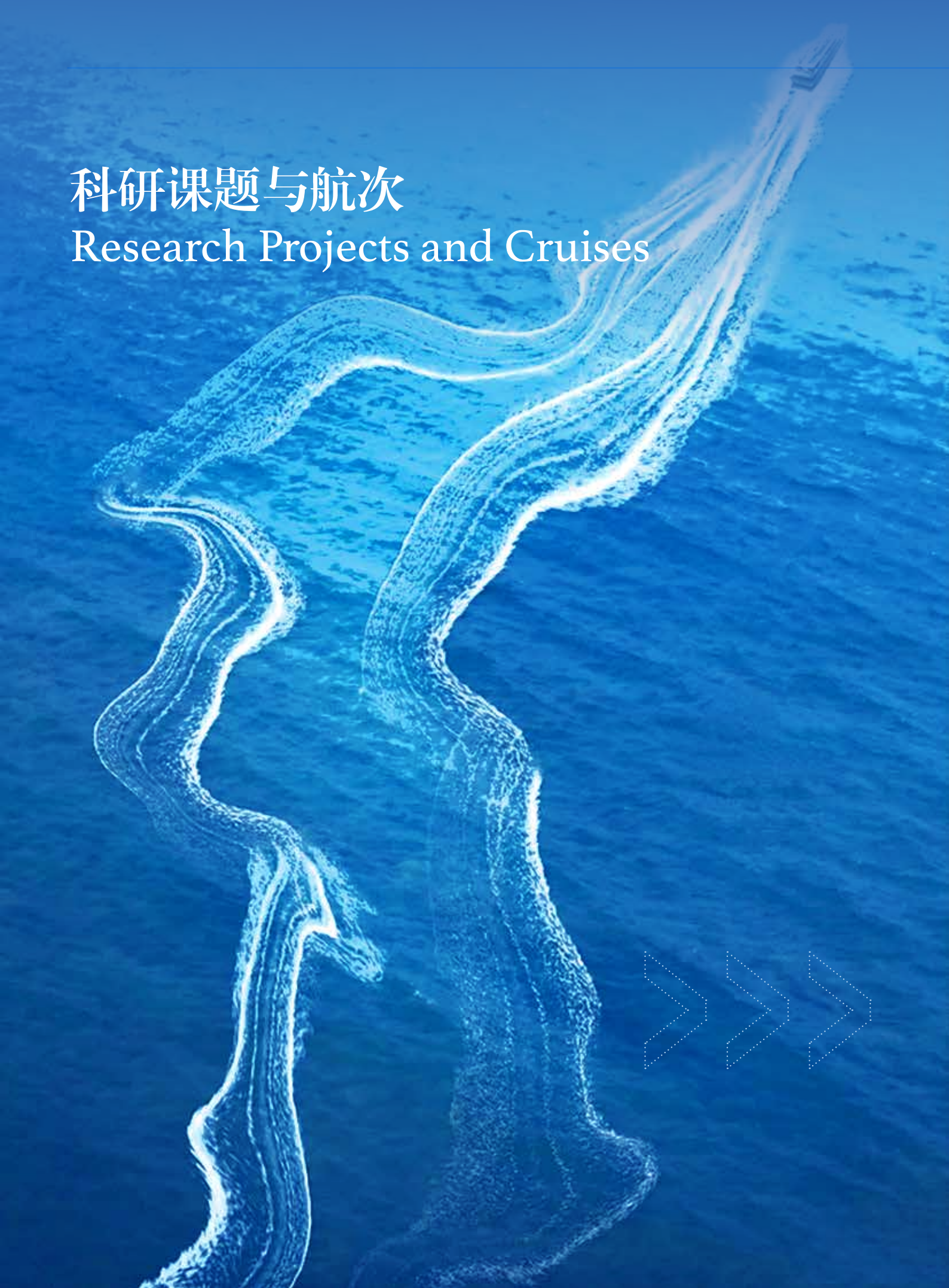
以上工作于 2022 年 11 月发表于 *Limnology and Oceanography* 期刊，2021 届博士生张连宝和 2021 级博士生陈明明为共同第一作者，张瑶和焦念志教授为共同通讯作者。

Reference：
Zhang, Lianbao; Chen, Mingming; Zheng, Yue; Wang, Jianning; Xiao, Xilin; Chen, Xiaowei; Hu, Chen; Shen, Jiaming; Liu, Jihua; Tang, Kai; Xu, Dapeng; Shi, Qiang; Ning, Xiaoyan; Thomas, Helmuth; Qin, Wei; Zhao, Meixun; Jiao, Nianzhi*; Zhang, Yao*. Microbially driven fate of terrigenous particulate organic matter in oceans. *LIMNOLOGY AND OCEANOGRAPHY.* 2022. 9999: 1–17.



大体积河水 - 海水分层模拟培养体系中微生物驱动的陆源有机质的转化模式图

加拿大达尔豪斯大学大体积海水培养装置



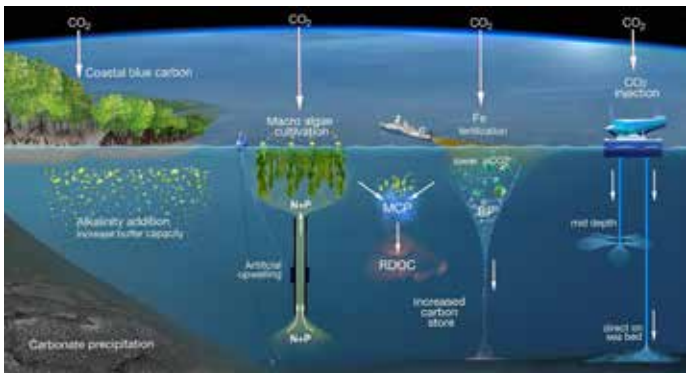
科研课题与航次
Research Projects and Cruises

海洋负排放国际大科学计划

联合国“海洋十年”获批行动计划 | 焦念志

碳中和是践行人类命运共同体理念的有力抓手。基于碳中和全球共识和海洋负排放国际研究前沿热点，焦念志院士领衔发起联合国“海洋十年”海洋负排放国际大科学计划（Global Ocean Negative Carbon Emissions, Global-ONCE）。该计划针对联合国可持发展目标（SDGs），将开展并促进对生态技术干预所需科学知识与技术的评估与实施工作，包括原始创新、古今结合、结合古海洋研究出发，研究气候演化过程、实现海洋负排放技术突破、预测未来气候变化；恢复受人类活动影响的海洋生态系统，促进基于自然的陆海综合管理系统，包括采用上升流，微生物固储碳，营养矿物调节、施肥、环境酸化、消除缺氧等诸多方面。Global-ONCE 的目标细化包括：

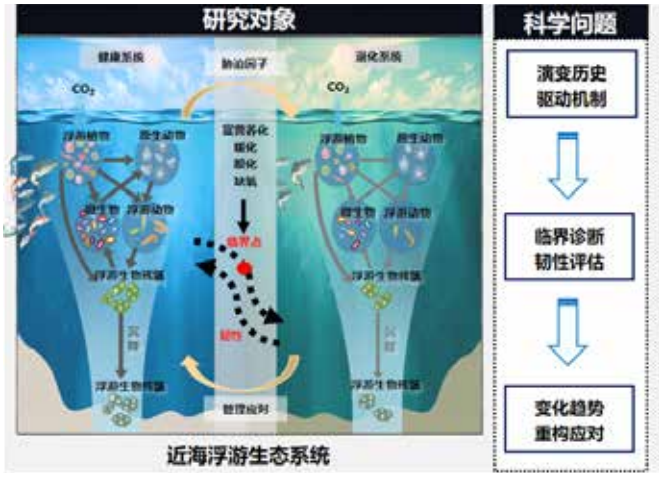
1）发展一个国际化的观测站与研究设施共享网络平台；
2）促进跨学科交叉合作；
3）为制定缓解气候方案提供科学的评估框架；
4）协调能力建设；
5）促进公平的政策、治理及社会认同。



我国近海典型海域浮游生态系统演变、临界点及重构

国家重点研发计划 | 王大志

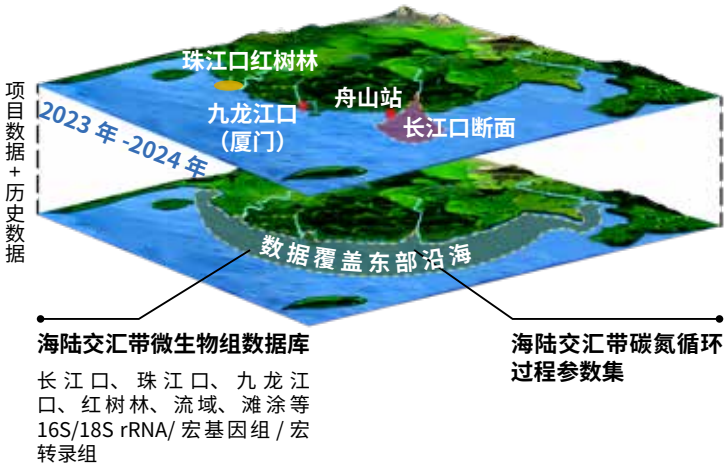
项目针对“人类活动和全球变化双重胁迫海域浮游生态系统的演变、临界点与重构”这一核心科学问题，以受人类活动和全球变化胁迫显著的长江口、珠江口及邻近海域的浮游生态系统为研究对象，综合浮游生物多样现存格局、历史数据、沉积记录以及不同胁迫环境和极端事件过程中系统稳态转化的集成分析，建立系统临界点表征量化的理论和方法，评估多重环境胁迫下系统韧性和恢复力，架构系统重建的理论和方法，研发系统演变趋势预测模型并实现智能化、情景化预测应用示范，提出适于我国近海经济、人类健康和生态环境协同发展的管理对策，夯实对浮游生态系统临界点、韧性和恢复力的科学认知，阐明全球变化和人类活动双重胁迫下浮游生态系统的演变历史、现存态势和驱动机制，为制定生物多性保护和气候变化策略，实施陆海统筹及碳中和等国家战略提供理论与方法支撑。



典型海陆交汇关键带微生物驱动碳氮硫循环的机制与碳源汇效应集成研究

国家自然科学基金重大研究计划集成项目 | 汤凯

项目在已有涉及海陆交汇关键带碳氮硫循环的5个项目基础上，形成具有海洋、生物、环境等学科交叉和优势互补研究团队，系统总结已有成果和历史数据，围绕微生物驱动的碳氮硫循环对海洋碳汇的影响及其对全球变化的响应这个重大科学问题，聚焦河口－滨海湿地－近海交汇区，通过微观与宏观的结合，进行研究区域的连通（河流－河口－近海、滨海湿地－近海、水体－沉积）、生物化学过程的量化、元素循环的耦合；在环境梯度上和时空尺度上探讨微生物群落动态变化规律；抓住微生物碳循环的关键过程，外延至相关氮、硫循环过程和环境调控机制；通过集成在海陆交汇关键带碳循环过程与机制的认识上获得新突破，形成具有宏观碳氮源汇效应的认识，实现多学科交叉，综合提升已有研究项目的总体水平，引导未来陆海统筹海洋增汇研发，为我国应对全球变化提供科学依据。

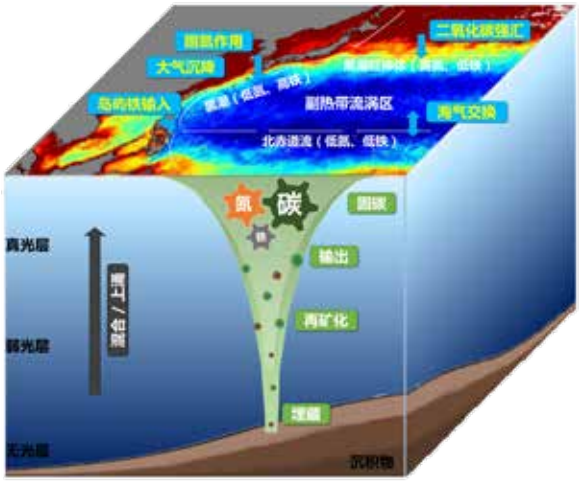


项目研究区域

西太平洋海气界面多尺度物质循环集成研究

国家自然科学基金重大研究计划集成项目 | 曹知勉

海洋生物泵是调节海气界面 CO_2 等物质交换的重要过程，也是探讨海洋增汇的科学基础。项目在综合分析基金委重大研究计划“西太平洋地球系统多圈层相互作用”已有成果与历史资料的基础上，聚焦西北太平洋西边界流影响海域，通过多学科交叉研究厘清不同时空尺度生物泵过程对海气界面物质交换及其气候效应的调控。基于深度集成，获得跨圈层、多尺度海洋碳、氮等关键元素循环的突破性认识：空间上，对比北赤道流、副热带流涡中心与黑潮及其延伸体的物质输运和交换，揭示碳、氮、铁等海 - 陆 - 气跨界面和水体内部的通量与过程以及相互间的耦合与分异；时间上，追踪现在和未来的生物泵和环流演变过程，评估全球变化背景下 CO_2、N_2O 的源汇发展趋势及其复合气候效应，从而显著提升西太平洋物质循环研究的总体水平。

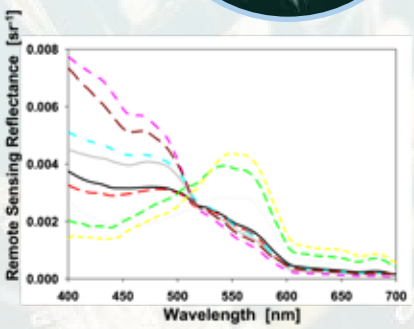


研究内容：物质通量、生物泵过程与气候效应

基于高光谱海洋水色遥感的全球海洋主要浮游植物类群识别与量化

国家自然科学基金外国资深学者研究基金项目 | 李忠平

浮游植物在水生态系统中发挥着独特的生态和生物地球化学作用，而对其丰度和组成在全球海洋中的认知是理解碳循环和海洋生态系统在气候变化中作用的关键之一。这些普遍存在的多样化浮游植物可以划分为不同的浮游植物类群（phytoplankton functional types，PFTs）。对于全球海洋，这些浮游植物类群的空间分布和时间变化只能通过海洋水色卫星遥感获得。自 20 世纪 70 年代推出海岸带水色扫描仪（Coastal Zone Color Scanner，CZCS）以来的约 40 年中，海洋水色卫星已经能够每天生成全球海洋叶绿素 a 浓度（chlorophyll-a concentration，CHL）产品，但 CHL 几乎没有浮游植物类群的信息。特别是，从多波段海洋水色卫星（如 CZCS 和 2000 年前后发射的卫星）中准确反演浮游植物类群的信息，即使不是完全不可能，也非常困难。计划发射的新一代海洋水色卫星，如中国的 HY-1E（约 2023 年发射）和美国的 PACE（约 2024 年发射），将配备高光谱传感器，这将为海洋水色遥感从估算叶绿素 a 浓度扩展到浮游植物类群，提供一个良好的机会。



海洋高光谱遥感反射比光谱（引自 Lee et al. 2007）

项目的核心目标是开发一个可靠的系统，通过高光谱海洋水色数据识别和量化海洋及近海水域中主要的浮游植物类群，包括原绿球藻、聚球菌、定鞭藻、硅藻、甲藻、球石藻等。项目将对高光谱时代的海洋水色遥感和海洋生物学做出及时、重要的贡献。

鱼类遗传学与遗传育种

国家自然科学基金杰出青年科学基金项目 | 徐鹏

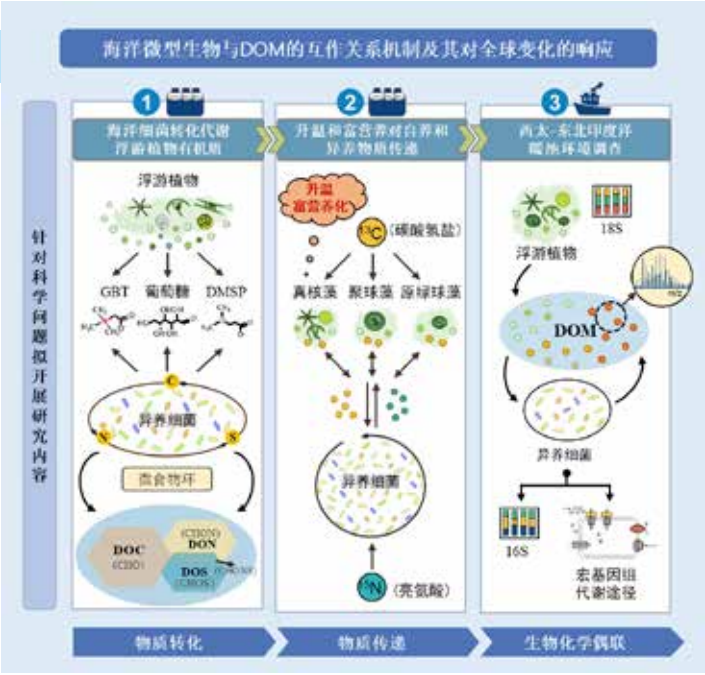
项目围绕大黄鱼养殖业可持续发展的良种需求，聚焦可反映大黄鱼综合抗性和健壮性的游泳能力性状，开展大黄鱼游泳能力测评技术和装置开发和优化，分析大黄鱼游泳能力性状与综合抗性、生长性能和营养利用等健壮性相关性状的关联性，进而开展游泳能力性状遗传基础解析和育种应用等创新性研究，为优质健壮大黄鱼良种选育探索新的选育策略和方向，并提供理论依据和研究基础。

鱼类遗传学和遗传育种领域的研究框架和代表性成果

海洋微型生物与溶解有机碳库的互作关系机制及其对全球变化的响应

国家自然科学基金优秀青年科学基金项目 | 郑强

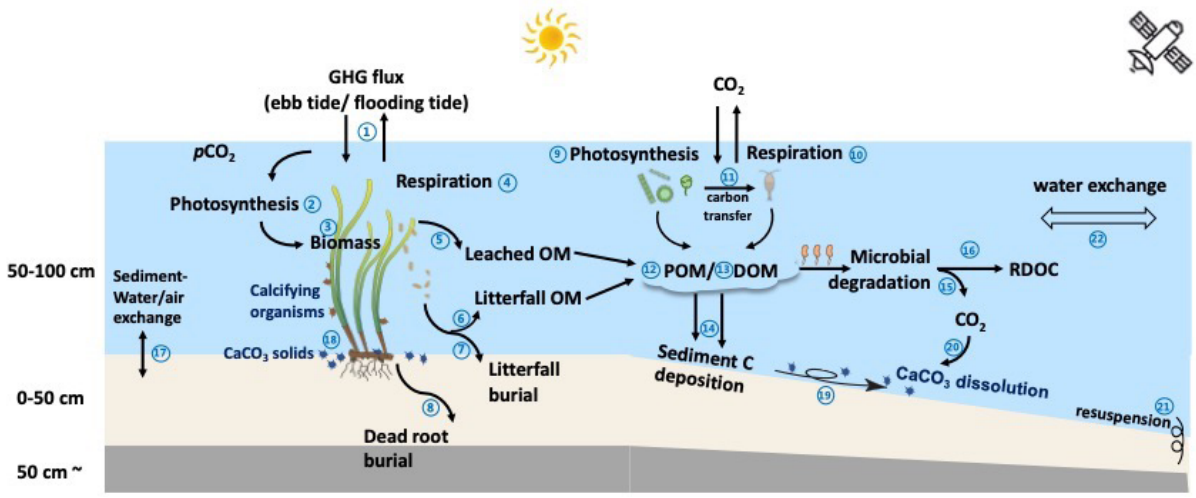
海洋微型生物处在一个相互联系的生态网络系统中，它们在微观尺度的代谢活动对全球生物地球化学循环起着重要的作用。项目围绕“海洋微型生物与溶解有机碳在全球变化背景下的互作过程和响应机制”这一主线问题，聚焦“浮游植物 - 有机质 - 异养细菌”为研究对象，结合现场观测采样、室内模拟实验和生态模型等方法相结合开展工作。阐释微生物代谢转化活性有机质过程中介导的 C-N-S 分子耦合过程，探究全球变化条件下（升温、缺氧、富营养化）光合自养与异养微生物之间的物质传递速率变化，解析西太 - 东印度洋暖池区浮游植物 -DOM- 异养细菌的动态变化规律以及时空关联。通过物质转化，物质交换和生物 - 化学偶联三个层面揭示微型生物介导的有机生物地球化学循环过程以及全球变化下的响应过程与机制。



蓝碳生态系统评估、恢复与核算

海洋碳汇技术开发项目 | 戴民汉

项目由厦门大学与腾讯公司联合开展，将围绕“厘清海草床生态系统固碳功能及机制”这一核心问题，开发符合中国实际的海草床碳汇方法学，为中国蓝碳交易中的碳汇计量与监测实践提供指导。通过海草床生态修复，实现固碳增汇并监测碳汇增量，进一步完成海草床碳交易。同时，构建基于自然的解决方案 (NbS, Nature-based Solutions) 范例，满足 CCB 标准 (Climate, Community, Biodiversity)，支撑区域可持续发展理念。项目通过社区帮扶计划，提升社区生态环境保护意识，实现综合生态服务功能与社区发展联动的示范效应。



海洋荒漠生物泵固碳机理及增汇潜力

国家自然科学基金重大项目 | 戴民汉

全球表层海洋面积约 30% 为低生物量的寡营养海域，通常称为“海洋荒漠”。尽管单位面积的生产力很低，然而海洋荒漠面积巨大，故而对全球海洋碳汇具有潜在的重要贡献，可能具有增汇潜力，显然是全球海洋碳循环的重要环节，但却是研究最为匮乏的海域，也缺乏理论框架。项目聚焦北太平洋副热带流涡区（NPSG），围绕真光层双层结构下海洋荒漠生物泵的物质基础、结构、时空格局、效率及其固碳和增汇潜力，构架寡营养海域生物泵新理论框架，并为海洋荒漠的增汇途径及其有效性提供科学论证。

图 1 项目于 2019 年春、2020 年夏冬实施的三个综合观测航次特色总结

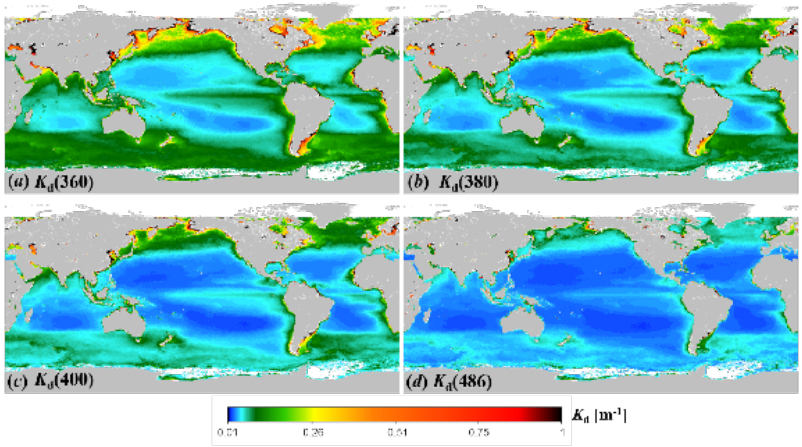


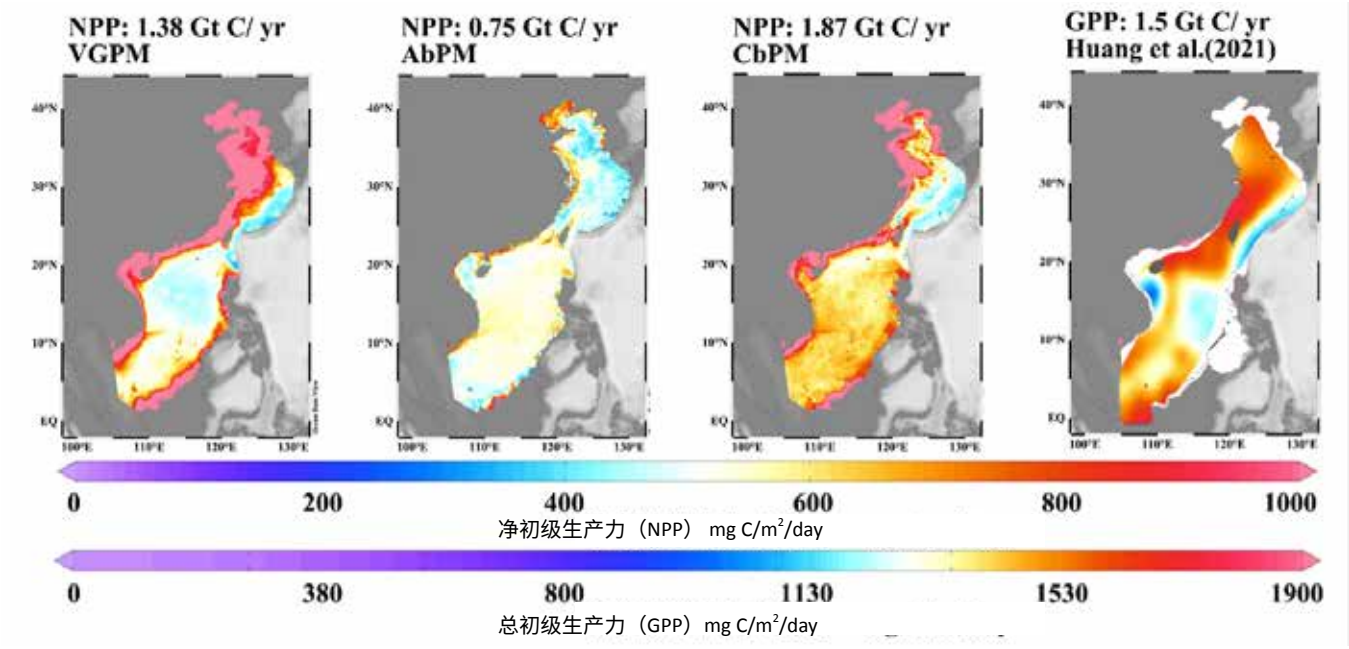
图 2 根据 VIIRS 卫星获得的气候态 K_d (λ) 的全球分布：(a) K_d (360)，(b) K_d (380)，(c) K_d (400) 和 (d) K_d (486)（汪永超等，2022）

该项目自 2019 年以来，在现场观测、遥感反演和数值模拟等方面开展了多项创新性的研究工作。项目组织实施了 3 个大型综合科考航次（图 1），采用严格的国际规范，并获得国际 GEOTRACES 研究计划认证，在方法与技术的优化与创新、数据产品的构建和科学理论认知等方面均取得突出的进展。（1）在方法与技术上，实现了若干个的开创性进展和成果，如建立国内首套痕量金属采样和分析系统、首次获得全球海洋 UV 辐射遥感（图 2）、构建适用于 NPSG 生物泵研究的三维高分辨率耦合模式等；（2）在数据产品上，初步建立以现场观测数据和遥感反演为特色的数据库；（3）在科学认识上，取得若干新发现和新认识：如揭示 NPSG 痕量（铁）和常量营养物质的来源、分布格局及通量，发现铁和氮输入真光层的主要来源途径存在不同；阐明 NPSG 固氮速率、固氮生物群落组成的时空格局，证实真光层有机质矿化驱动氮再生并释放温室气体氧化亚氮，从而部分抵消海洋生物泵碳封存的气候效应；发现海洋酸化使得束毛藻的磷需求增加，而固氮速率却显著下降，模型预测到本世纪末酸化和磷限制的协同作用将显著降低束毛藻的固氮作用；刻画 NPSG 颗粒有机碳输出通量在空间上的变异性，发现营养盐跃层变动可能是输出生产力的主控因子。上述新发现和新认识对厘清真光层双层结构下海洋荒漠生物泵的物质基础、结构、时空格局、效率这一核心科学问题具有重要意义，有望为进一步揭示海洋荒漠的增汇途径及其有效性提供科学论证。

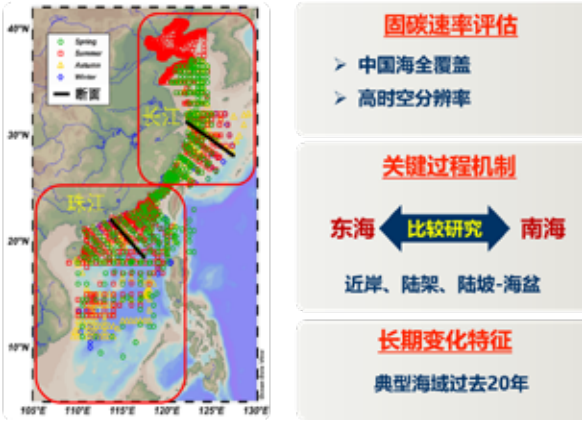
中国海生态系统固碳关键过程与调控机制

国家自然科学基金重点项目 | 黄邦钦

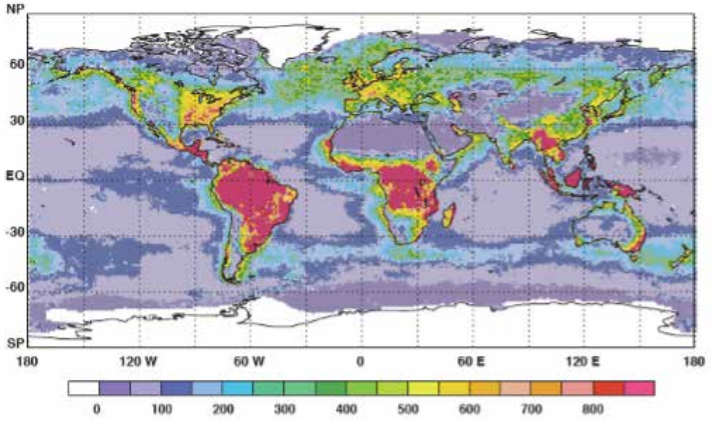
项目面向“国家碳中和的重大基础科学问题与对策”专项项目指南方向（二）：中国海生态系统固碳关键过程与调控机制，针对“如何准确评估中国海生态系统固碳速率？调控其时空变化的关键过程和机制是什么？”的核心科学技术问题开展研究。项目基于厦门大学和海洋二所联合团队大量现场实测数据和卫星遥感数据集成分析，在准确、全面、高时空分辨率地评估中国海生态系统固碳速率的基础上，探讨海水碳酸盐体系、浮游植物初级生产、群落净生产、浮游动物摄食和群落呼吸等关键碳汇过程的调控机制。评估近 20 年来中国海光合固碳速率的变化特征，揭示自然和人类活动（暖化和富营养化等）对生态系统碳汇功能的影响，最终阐明中国海典型生态系统结构和碳汇功能的关系。项目的实施将显著提升我国生态系统固碳研究水平，全面、准确评估中国海生态系统固碳速率，降低其不确定性，提供海洋碳汇清单，支撑国家碳中和路径优化和管理政策决策。目前，项目按照预期计划稳步推进中，主要开展历史资料收集、整理和数据分析工作，重点推进现场数据与卫星遥感数据的比对和验证分析工作。



基于主流遥感模型初步估算的中国海净初级生产力（NPP）和总初级生产力（GPP）



中国海集成分析的样本分布和研究思路



卫星遥感估算全球海洋和陆地净初级生产力，gC $m^{-2}yr^{-1}$ (Field et al., 1998)

西太平洋关键中小尺度过程能量串级与相互作用机理研究

国家自然科学基金重大研究计划重点支持项目 | 刘志宇

海洋是一个典型的多尺度强迫 - 耗散系统，为使不同尺度的运动达到准稳态，能量必须从强迫尺度传递到耗散尺度，这一跨越近十个数量级的能量传递过程称为能量串级。能量串级是物理海洋学研究中的一个基本问题，而受观测、数值模拟水平以及理论建模难度等各方面的限制，这也是一个经典难题。西太平洋拥有强劲的西边界流、活跃的中尺度涡与内波等各种尺度的运动，是研究海洋能量串级与多尺度运动相互作用的绝佳实验场。

2019 年以来，项目组围绕项目研究目标，综合利用现场与遥感观测、多尺度过程耦合模拟以及动力学理论分析等研究手段，在海洋多尺度过程的动力分解、潮致近惯性内波机制及其与风生近惯性内波的相互作用、内孤立波的浅化裂变机制等方面取得重要突破，深刻揭示了西太平洋多尺度运动相互作用与能量串级机理。具体包括：

1) 通过拓展海洋平衡模态与非平衡模态的动力理论，构造了分离海洋平衡运动与非平衡运动的动力滤波器，实现了对两类运动物理场及相应控制方程的动力分离（图 1），为量化跨尺度相互作用与能量传递提供了新的理论框架；

2) 揭示了潮致近惯性内波的新机制，指出单纯潮强迫即可生成满足大洋普适 GM 谱的内波场，并阐释了潮致近惯性内波与风生近惯性内波相互加强的非线性作用机制（图 2）；

3) 揭示了潮能经由内孤立波浅化裂变为高频内波的串级通道（图 3），并阐释了潮流通过改变陆架区等密度面深度而显著调控内孤立波极性转变与浅化裂变的动力机理。

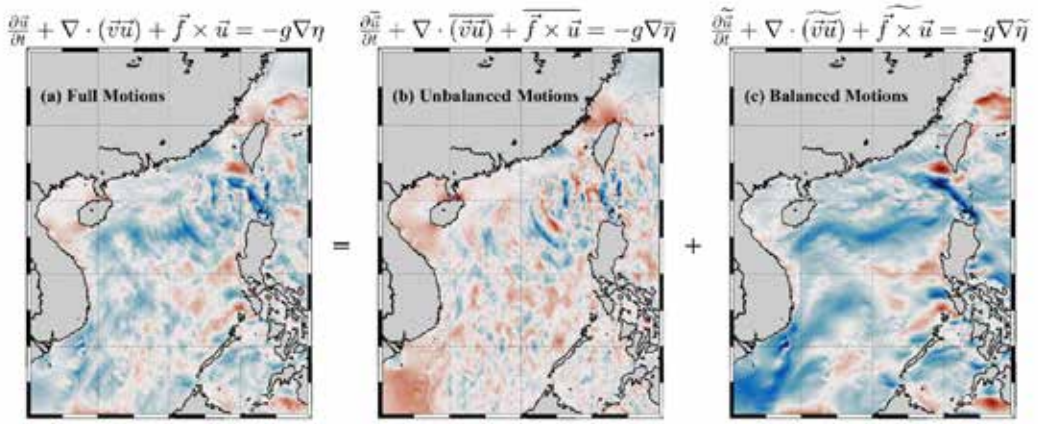


图 1 海洋平衡运动 - 非平衡运动动力分解方法在南海的应用示例

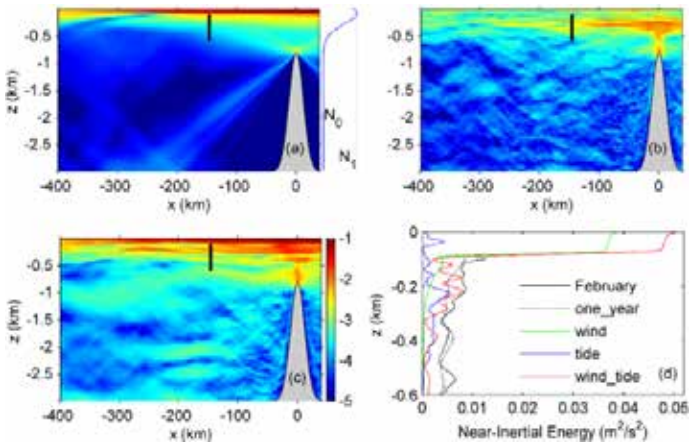


图 2 不同驱动条件下近惯性能量的分布：(a) 单独风驱动；(b) 单独潮驱动；(c) 风与潮联合驱动；(d) 观测与模拟的近惯性能量分布

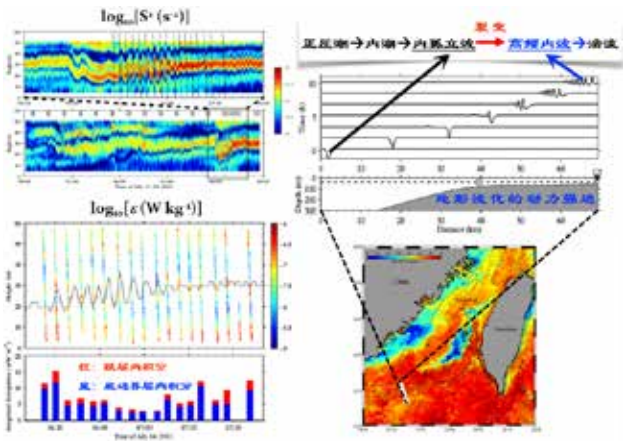


图 3 潮能经由内孤立波浅化裂变为高频内波的串级通道：观测与机制性数值模拟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“嘉庚”号海洋科学考察船

国家自然科学基金共享航次计划 2021 年度西北太平洋生物泵固碳的过程与机理及其演变规律重大科学考察实验研究 NORC2022-306

航次时间： 6 月 9 日至 7 月 25 日 **47** 天

项目首席科学家： 史大林教授
航次首席科学家： 曹知勉教授、蔡毅华教授、陈天宇教授（南京大学）

航次完成作业内容：

101 次	**13** 次	**25**
常规 CTD 作业	洁净大体积泵作业	多层生物拖网作业
19 次	**6** 次	**8**
洁净采水作业	箱式采泥作业	重力柱采样作业

依托“嘉庚”号配备的我国首套符合国际 GEOTRACES 标准的超洁净痕量元素专用采水系统“泰斯”（Trace Element and Isotope Sampling System，TEISS）进行洁净采水作业。

国内科考船中首次在同一航次中既进行洁净采水作业，又进行海底沉积物箱式和重力柱采样。

5 个海上科学调查航次

205 天
累计航次作业天数

23,000 海里
总航程

国家自然科学基金共享航次计划 2021 年度南海中部海盆科学考察实验研究 NORC2022-06

航次时间：9 月 19 日 -10 月 9 日 **21** 天（地质地球物理航段）

11 月 26 日 -12 月 28 日 **33** 天（水文生化航段）

首席科学家：沈渊副教授（地质地球物理航段）
柳欣教授（水文生化航段）

航次搭载国家自然科学基金委项目：33 项

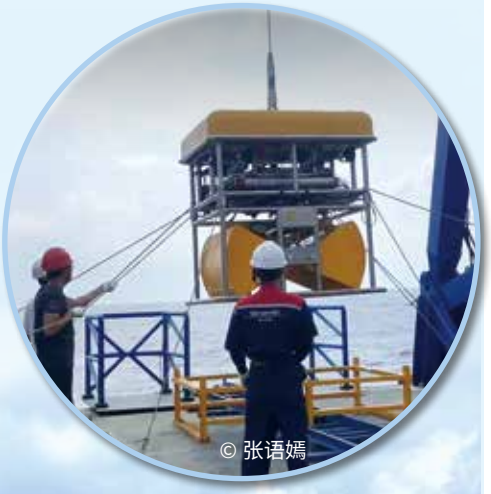
参航单位及人员：来自国内 12 家单位的 68 名科考人员参航

科学目标：深入了解南海中部海盆海洋地质构造、沉积记录、水动力机制、生物地球化学过程与生态功能、生物多样性及其相互作用。

航次完成作业内容：

38 个站位　**108** 项作业　重力柱作业 **19** 次　CTD 采水 **59** 次

原位大体积泵作业 **1** 次　拖网作业 **15** 次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交流与合作
Exchanges and Collaborations

第四届“西太平洋海洋环流与气候”国际开放科学大会

2022 年 10 月 24 - 27 日 · 厦门

会议包括 6 个主题报告和 22 个特邀报告，国内外 260 多名专家、学者通过线下线上参会，分享最新的研究成果，紧密围绕西北太平洋海洋环流与气候试验（NPOCE）国际计划关注的“西太平洋西边界流的动力特征及其变异、西太平洋西边界流与邻近环流系统的相互作用、西太平洋海洋环流在暖池维持和变异以及 ENSO 中的作用、西太平洋对区域及全球气候的影响、西太平洋对生物地球化学要素及过程的影响”五大主题，共同探讨热点科学问题，寻求更广泛的国际合作。研讨会由 NPOCE 及中国科学院海洋研究所主办，厦门大学承办，近海海洋环境科学国家重点实验室协办。

88 个 报告

260+ 名 专家学者

第八届镭 - 氡国际研讨会

2022 年 6 月 6 - 10 日 · 厦门

会议首次在中国举办，来自 11 个国家的 86 名相关研究的专家和青年学者参会。会议以“镭、氡同位素在海洋学中的示踪运用及测量技术的发展”为主题，聚焦镭、氡同位素示踪研究海底地下水排泄、孔隙水交换等过程对海洋碳循环、海洋酸化及近岸富营养化的影响等，探讨近年海洋学中镭、氡示踪运用及技术的最新进展，为相关科技工作者、管理者和政策制定者提供最新视角。会议共征集 21 份口头报告和 13 份海报报告。

11 个 国家

86 名 专家学者

2022 海上丝绸之路国际产学研用会议海洋科技与工程分会

2022 年 11 月 11 日 · 厦门

会议以“迈向低碳的海洋新兴产业发展”为主题，通过特邀报告与专题研讨相结合的形式深入探讨海洋科技国际合作，探索产学研用联合创新机制。会议共邀请 9 位专家学者，围绕“海洋蓝碳方法与技术”“低碳海洋产业发展”“低碳海洋发展政策与管理”三个议题作口头报告，并围绕全球蓝碳评估和监测方法标准问题、滨海蓝碳系统在生态修复方面的功能及实践难题等问题展开了专题研讨。会议共吸引来自德国、马来西亚、南非、印度尼西亚、缅甸等 12 个国家的 165 位专家学者和企业代表参加。

12 个 国家

165 名 专家学者

中国环境与发展国际合作委员会
2022 年年会主题论坛“海洋治理 - 过去和未来”

2022 年 6 月 13 日 · 线上

论坛特邀嘉宾、国合会首席顾问、国合会委员、国合会秘书处代表、海洋专题政策研究（Special Policy Study, SPS）项目组成员及媒体代表共 117 人参加论坛，吸引 2000 余人次在线观看。本次论坛围绕中国近 30 年海洋治理的经验教训、海洋未来如何在中国和全球议程中持续发挥重要作用等议题展开讨论，以期为第七届国合会海洋 SPS 项目的持续开展提供参考和建议。

117 人
参加论坛

2000 人次
在线观看

首届“大西洋翻转环流（AMOC）与气候变率研讨会”

2022 年 1 月 21 日 - 22 日 · 厦门

会议围绕 AMOC 及其在全球气候系统中所扮演的角色这一研究前沿，共同探讨相关领域中亟待解决的问题与未来聚焦的方向。会议内容涵盖 AMOC 的多尺度时空变率、驱动机制、古气候重建与气候模拟、大西洋与印度 - 太平洋交互作用等相关研究的最新进展。来自法国、英国、德国、美国等国家从事大西洋翻转流相关研究的专家和青年学者共 40 余人参会。

3 个
主题

18 个
口头报告

访问学者与开放课题基金

实验室访问学者基金（分为‘郑重’杰出 / 杰出、高级和青年 3 类）支持国内外知名专家及青年学者到实验室开展 1 至 6 个月的学术交流与合作。2020 年度共有 24 名学者获批该项基金，19 名学者来访，在项目资助下发表论文 10 篇。

其他交流与合作

实验室继续组织各类学术研讨，搭建交流平台，持续发挥“启迪新思想，促进学术融合”的重要作用：举办“周一午餐交流会”8 讲，内容涵盖学术探讨、平台建设等方面；召集凌峰论坛 3 讲，包含珊瑚共生与白化机制、台湾海峡海洋生态系统 2021 年度观测、极地海洋科学等主题；每月定期开展交流沙龙，为实验室成员提供良好的讨论平台与交流环境。

美国石溪大学大气与海洋学院杰出教授 Cindy Lee 来访实验室，开设本科拔尖班课程《Scientific Communication》，为本科生讲述如何在提出科学问题到撰写研究计划的过程中锻炼系统性科学思维；与在校师生开展多方位交流，并对多项科研工作提出指导意见。此外，Cindy Lee 教授还受邀前往厦门市槟榔中学开展科普讲座，向青少年介绍海洋化学家的实际工作与感受，传播海洋知识与科学情怀。

“表层海洋 - 低层大气研究”计划

“表层海洋 - 低层大气研究”计划（Surface Ocean - Lower Atmosphere Study，SOLAS）于 2004 年正式启动，SOLAS 研究海洋与大气间的生物地球化学与物理过程和机理，揭示海洋 - 大气圈层相互作用对气候和环境变化的影响和反馈。SOLAS 国际项目办公室（中国）于 2021 年 1 月正式落户我实验室。戴民汉院士为 SOLAS 计划国际科学指导委员会共同主席（2021-2023），李黎博士为共同执行主任暨中国办公室负责人。

2022 年，SOLAS 国际项目办公室协调发布了 SOLAS 2022–2023 项目实施计划，并持续为 SOLAS 31 个国家 / 区域科研网络、19 个资助 / 认证科学项目和 3 个海 - 气整合观测站提供宣传渠道和搭建交流合作平台。

20 场	24 份	5 份	12 期	69 项	378 条
国际会议	国家地区报告	活动总结报告	通讯月刊	社区公告	推文

① 9 月，首次采用线上线下相结合的方式在南非开普敦举办第八届 SOLAS 开放科学大会。会议围绕 SOLAS 五个核心主题和三个交叉主题展开，共同探讨全球海洋和大气领域最新研究成果与进展，共吸引超过 30 个国家约 200 名科研工作者参会。

② 6 月，举办第八届 SOLAS 国际暑期学校，共召集全球 31 名专家学者为来自 24 个国家和地区的 62 名学生在线授课。

③ 4 月，推出 SOLAS 季度研讨会，围绕 SOLAS 2015-2025 十年科学计划及核心科学问题设立每期主题，前三期研讨会已分别在中国，法国和葡萄牙举办。

SOLAS 持续致力于提升海洋和大气领域科研进展对全球气候变化和环境健康政策制定的支撑作用，积极参与联合国气候变化大会（COP27）和联合国海洋大会，响应联合国海洋科学促进可持续发展十年（2021-2030）倡议并与相关科学计划、科研机构一道践行共同设计、共同实施的理念。

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国际任职

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- 吕永龙 国际科学理事会会士
- 吕柯伟 世界气候研究计划“解释和预测地球系统变化”灯塔计划第二工作组成员
- 王桂芝 全球海洋氧气数据集指导委员会委员

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- 戴民汉 中国环境与发展国际合作委员会委员
- 焦念志 福建省人民政府参事
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- 刘志宇 中国海洋湖沼学会常务理事
- 史大林 稳定同位素生态学专业委员会副主任
- 张　瑶 中国海洋研究委员会青年委员会主席团成员

学术期刊新任职

国际任职

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- 柳　欣 周宽波 Guest Associate Editor / *Journal of Geophysical Research: Biogeosciences*
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- 胡建宇　副主编《热带海洋学报》
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- 史大林　副主编《海洋学研究》
- 王传超　编　委《人类学学报》

代表性国内 / 国际大会报告

★ Bingbing Wang. Micro-spectroscopic characterization and ice formation potential of marine related aerosol particles. 8th hybrid SOLAS Open Science Conference. September 25 - 29. Cape Town, South Africa. Online. (Invited talk)

★ Dalin Shi, The complex effect of ocean acidification on marine primary producers in a multi-stressor environment. 5th International Symposium on the Ocean in a High CO2 World. September 13 - 16, 2022. Lima, Peru. Online. (Plenary talk)

★ Minhan Dai. Ocean carbon cycle and ocean-based carbon dioxide removal. 19th Annual Meeting of the Asia Oceania Geosciences Society. August 1-5, 2022. Online. (AOGS Axford Medal Lecture)

★ Minhan Dai. Coastal-SOS and BRICS cooperation under UN Decade framework. The BRICS Workshop on Climate Prediction and Marine Disaster Prevention and Mitigation. December 12 - 13, 2022. Qingdao, China. Online. (Keynote speech)

★ Minhan Dai. Ecosystem-based integrated ocean management as an instrument for developing sustainable blue economy with special references to island countries. China-Island Countries High-level Forum on Ocean Cooperation. November 9, 2022. Pingtan, China. (Keynote speech)

★ Nianzhi Jiao. Global Ocean Negative Carbon Emissions (Global-ONCE). 7th BRICS Young Scientist Forum. August 29 - September 1, 2022. Xiamen China. (Invited talk)

★ Peng Xu. Genomic tools and genome selection for disease resistance breeding of large yellow croaker in China. 2022 International Symposium on Genetics in Aquaculture - ISGA XIV TALKS. January 20, 2022. Puerto Varas, Chile. Online. (Invited talk)

★ Senjie Lin. ENDS: Beginning of a holistic molecular ecological approach to understanding phytoplankton regime shift and algal blooms. 2022 International Conference on international Cooperation and Integration of Industry, Education, Research and Application for Future Ocean. November 27 - 28, 2022. Qingdao, China. Online. (Invited talk)

★ Stephan Steinke. Late quaternary environmental history of western and southern Indonesia. 1st International Symposium on Eastern Indonesian Marine Ecosystem (ISEIME). November 24, 2022. Online. (Invited talk)

★ Xin Liu. Progress of key biogeochemical parameters of plankton community in the NPSG. The Japan Oceanographic Society fall meeting - The 2nd Cooperative Study of the Kuroshio and Adjacent Regions (CSK2). September 3 - 7, 2022. Nagoya, Japan. Online. (Invited talk)

★ 柴扉 . 数字孪生中国近海 - 厦门湾和长江口两个案例 . 首届港澳海洋论坛 . 2022 年 11 月 23 - 27 日 . 中国澳门 .（大会特邀报告）

★ 张瑶 . 微生物驱动的陆源有机碳在海洋中的宿踪 . 第九届全国海洋生态研讨会 . 2022 年 12 月 2 - 3 日 . 中国厦门 .（大会主旨报告）

图为“海丝二号”卫星拍摄的山东海阳外海多层次的悬浮颗粒

人才培养
Education

MEL 海洋环境创新型人才国际合作培养项目

在国家留学基金委创新型人才国际合作培养项目“国家重点实验室专项”支持下，实验室于2020 年起设立该项目，每年向美国特拉华大学（UD）及德国亥姆霍兹基尔海洋研究中心（GEOMAR）选派联合培养博士研究生、博士后及访问学者。2022 年，项目获滚动支持，并新增英国南安普顿大学和法国索邦大学两个合作院校。本年度共 5 人获得资助。

刘浩然在 GEOTRACE GP21 航次中过滤实验样品

项目培养博士生刘浩然于 2022 年 1 月赴亥姆霍兹基尔海洋研究中心，在黄邦钦教授、Thomas Browning 研究员及 Eric Achterberg 教授的联合指导下，开展“评估南太平洋浮游植物营养物质的（共）限制状况”研究，并在 *Frontiers in Marine Science* 期刊发表文章，解构了南海海域营养盐，光和浮游植物群落结构对浮游植物光生理状态的影响。

刘浩然（最后一排左四）参加 GEOMAR 组织的南太平洋 GEOTRACES - GP21 国际合作航次，参与航次的厦大人员还包括项目联合培养博士后温作柱、2018 级博士生袁忠伟和 2019 届博士张周凌。

厦门大学地球科学与技术学部与香港大学理学院联合培养项目

实验室与太古海洋科学研究所（SWIMS）每年互派联合培养博士研究生及博士后并提供奖学金资助。项目于 2022 年启动，厦大和港大各录取 1 名联合培养学生。

在这个项目中，我结识了更多的朋友和科研工作者，体验到了不同的文化和科研环境，在双方的共同帮助下，有机会进一步拓展和完善我的课题，获得新的想法，博采众长并更好地实现它。

—— 黄嘉璐 2020 级海洋化学专业，合作导师为戴民汉和 Moriaki Yasuhara

黄嘉璐（右三）与香港大学太古海洋研究所 Moriaki Yasuhara 组成员在香港坪洲岛

MEL 杰出博士后基金

实验室于 2014 年设立“杰出博士后基金”，吸引国内外优秀博士毕业生开展博士后研究，以此促进学科交叉，提高人才培养能力。2022 年共有 5 人入选该基金，分别是华南理工大学王研、瑞士巴塞尔大学苏广毅、复旦大学张超、厦门大学马玲琪和付敬强。

2022 年共有 5 位博士后获国家自然科学基金面上项目或青年科学基金项目资助，分别是宋希坤、马玲琪、付敬强、高霄龙、王渊。李楠楠参加 2022 年国际古湖沼学会（IPA）和国际湖泊地质学会（IAL）联合会议青年学者分论坛并作口头报告，获得了国际第四纪研究联合会基金（INQUA Fellowship）的资助，将于 2023 年赴瑞士开展合作研究。

> MEL 就像行驶在世界海洋中的一艘开展科学探索的航空母舰，它立于时代潮头，不断斩浪前行。这艘巨舰上汇集了多领域众多优秀的科学家，他们深厚广博的学术造诣、严谨缜密的治学精神、废寝忘食的工作态度都深深地在我们心底留下了烙印，无形之中让我们不断受到启发，成为我们不断追求和学习的榜样。
>
> —— 付敬强

朱庆参加 2022 年国家自然科学基金夏季台湾海峡科学考察实验研究共享航次珠江羽流粤东观测航段测量

王智参加“海丝学堂”第一、第二航次，承担航次中底栖生物现场采样和室内分析任务

张慕容参加“沙漠绿洲辐合线与深对流观测试验（DECODE）”

MEL 博士生奖学金

实验室于 2016 年设立“MEL 优秀博士生奖学金”，吸引国内外优秀生源，培养杰出的博士研究生，每年提供 10 个资助名额，2022 年共有 9 名学生入选，已于 9 月入学。

> MEL 是世界一流的科研平台，多学科交叉的特色让我能在此学习到更多领域的海洋知识，优秀的导师团队能及时为我答疑解惑，丰富的学术讲座也开阔了我的视野。
>
> —— 黄昕辰 2022 级物理海洋学专业

> 海洋还存在很多未知，而科研则能够帮助我们认识世界、探索世界。
>
> —— 陈玮立 2022 级海洋生物学专业

李媛洁于 2022 年 11 月参加国家自然科学基金委台湾海峡共享航次

张明真于 2022 年 7 月参加 2022 年“环境、生态与未来地球”全国研究生论坛，获得成果展示优秀奖

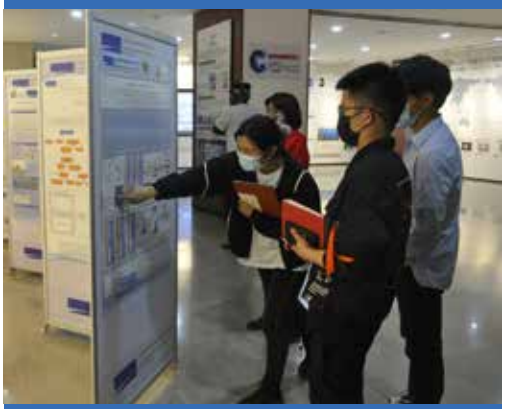
研究生学术论坛

2022 年 7 月 18 日 - 20 日，第七届 MEL 研究生学术论坛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）召开。论坛以“触摸·海洋”为主题，涵盖物理海洋学、海洋生物地球化学、海洋生物学、海洋生态学、海洋地质与古气候及环境科学等学科，有来自南京大学、汕头大学以及厦门大学等 40 余名研究生参与。

MEL 研究生学术论坛全程由研究生主导，形式包括口头报告、海报展示、专题研讨会、学术沙龙、海洋科普等。论坛特设“苏峰专题”，为依托东山实验场开展的科研项目及其成果提供分享平台，同时邀请东山二中的 35 名中学生参与科普活动。

水环境科学高校联盟研讨会

2022 年 3 月 27 日 - 31 日，第十四届水环境科学高校联盟研讨会以线上线下相结合的方式召开。研讨会为期 4 天，涉及海洋生态与生物多样性、生物地球化学、物理海洋学、水产养殖等科学领域，包含专家主旨报告、个人报告、海报展示、学术沙龙等多种形式。来自厦门大学、台湾海洋大学、台湾中山大学、香港大学、浙江海洋大学、上海海洋大学、自然资源部第一海洋研究所、台北大学、台湾大学、台湾中兴大学、马来西亚登嘉楼大学、马来亚大学等高校和科研机构的 70 余名研究生参会，实现了海峡两岸暨香港师生的云端交流。



海洋环境科学本科生暑期科研奖学金

实验室自 2004 年起启动“MEL 海洋环境科学本科生暑期科研奖学金”，鼓励本科生开展科研训练，培养学生创新能力和学术精神。2022 年录取了来自加拿大多伦多大学、厦门大学马来西亚分校、北京大学、中国海洋大学、中国地质大学等 15 所大学的 33 名本科生，在导师的指导下开展实验研究。

公众教育
Outreach

© 70.8 海洋媒体实验

“进阶海洋科学传播 2.0 时代”

实验室依托中国海洋卓越教育伙伴计划（COSEE China）和 70.8 海洋媒体实验室，奋力进阶海洋科学传播 2.0 时代，致力成为海洋科学的优质传播者，搭建海洋与社会各界的桥梁，以“科学”之力，为海洋“发声”。

海洋科普内容永动机：优质科普作品强力输出

★与福建省广播影视集团卫视中心联合制作 9 期科普节目 —— 东南卫视 “海洋季风”通栏节目带《原来是这样》。

★在科学顾问团的强力赋能下，以多种展示形式跨平台、多媒体创建科普节目、视频和图文，生产原创精品内容 135 篇。

★触达多元话题，在 3 月 8 日国际劳动妇女节聚焦女性科研工作者，让更多人看见“海洋科学她力量”；“海洋漫谈”带公众进行海洋、艺术和人文跨学科交流；“Ocean 理想家”分享海洋学者的成长与科学故事 ...

点燃星火：
持续孵化海洋科学与科普创新型人才

★联合中华环境保护基金会、桃花源生态保护基金会开展“少年蓝色先锋培养计划”，从全国公益招募 27 名优质高中生，组建多元化学科背景的导师团队，为学生开设海洋生物、海洋物理及物理海洋等科学课程。

★面向厦门市初中学生举办“2022 厦门大学水生科学暑期生态营”及“红树林探索营”，开展集中训练课程，将海洋生物多样性、渔业、观测等知识转化为简单易懂的模拟实验和趣味游戏，带领学生走进海岸带生境，培养其观察自然、动手学习和思辨能力。

★共同发起“海洋讲师团”，邀请厦门大学科学家及科普工作者，走进全国 20 余所中小学课堂演讲，将海洋文化从沿海传播至内陆，将科学的火种从城镇点燃到乡村；举办“70.8 海洋青年说”主题科普演讲大赛，搭建青少年讲述海洋故事的舞台，号召更多青年爱上海洋，逐梦深蓝。

★继续开展“70.8 海洋媒体训练营”，面向多学科背景学生，打造《海洋科学传播认知与实践课》；依托海洋 2 号科学考察船，开展以海洋科学为核心的课外项目，面向非海洋专业的大中学生策划“出海科考调查体验课”，为其提供沉浸式海洋科学调查与实践机会。

© 70.8 海洋媒体实验室

© COSEE China

© 杨位迪

蓝色朋友圈：开放日与科普论坛搭建专家与公众桥梁

★ 策划全国科技周公民海洋科学特辑暨“厦大 6·8 海洋季”，为公众带来九道“海”味科学大餐。

★ 主办“第十一届厦门大学海洋科学开放日”，联合主办“海洋嘉年华”、“海洋生物多样性保护科普实践”等活动，在疫情期间让科普活动回归线下，以亲身互动体验的形式，启蒙公众及青少年海洋兴趣与热情。

★ 70.8 海洋媒体实验室成立三周年之际，举办“70.8 海洋科普论坛”；继续与政府、企业、学校、基金会、媒体等优质平台机构开展战略合作。

© 70.8 海洋媒体实验

深海可移动集成抓斗取样平台

© 杨位迪

平台设施
Facilities

大型仪器与技术服务平台

“大型仪器与技术服务中心”（简称 COMET）于 2008 年成立，以“推动大型科研仪器的资源共享、提高仪器使用效率”为宗旨，为培养高层次人才，开展高水平科研项目提供高效率、高水准服务。COMET 致力于全面规范化管理实验室安全、仪器设备以及技术人员培训和考核，成功建立了大型仪器网上预约共享系统，真正实行仪器公开透明化管理。

COMET
Center of Major Equipment and Technology

216
大型预约共享设备

2900
注册会员

18500
年均预约次数

820
年均用户

| 现场观测设备管理平台 |

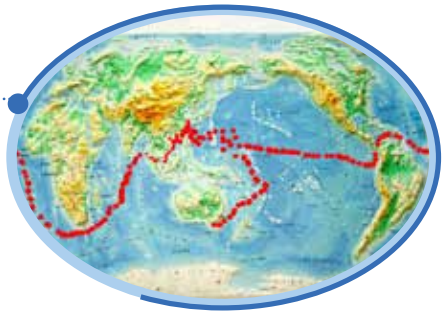
为提升野外台站在近岸海域现场布署海洋环境观测设备的运行监控与运维保障水平，COMET 现场观测设备管理平台于 2021 年 9 月上线运行。该平台现已对东山湾、漳江口、厦门湾等区域 24 台套观测设备进行自动化与可视化监控，通过实时记录观测系统的运行状态，在设备、通讯、电力等故障发生时及时示警并处理，使得各自动化观测系统数据有效获取率达到 87.3%，保障了科学观测仪器的正常运行和科学数据的连续产出。


© 陈纪新

| 海洋微型生物保种中心 |

海洋微型生物保种中心（CCMBA）包含海洋细菌种质中心（CCMB）和海洋藻类种质中心（CCMA），实现海洋微型藻类和细菌的分离、保藏、分类分析，同时为相关微型生物的筛选、保藏和基础分析提供系列环境、设备、技术。中心运行至今已分离和保藏藻类约 600 株、细菌超 3300 株，为实验室成员提供相关科研和应用支撑服务，同时也为国内外合作者、业内同行提供种质资源服务。

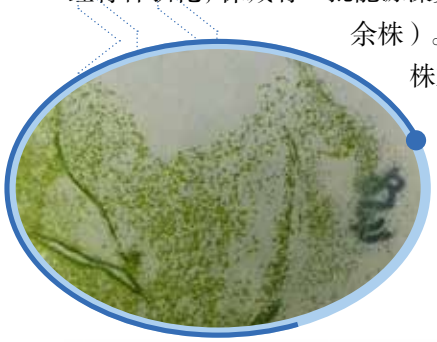
· 海洋细菌种质中心

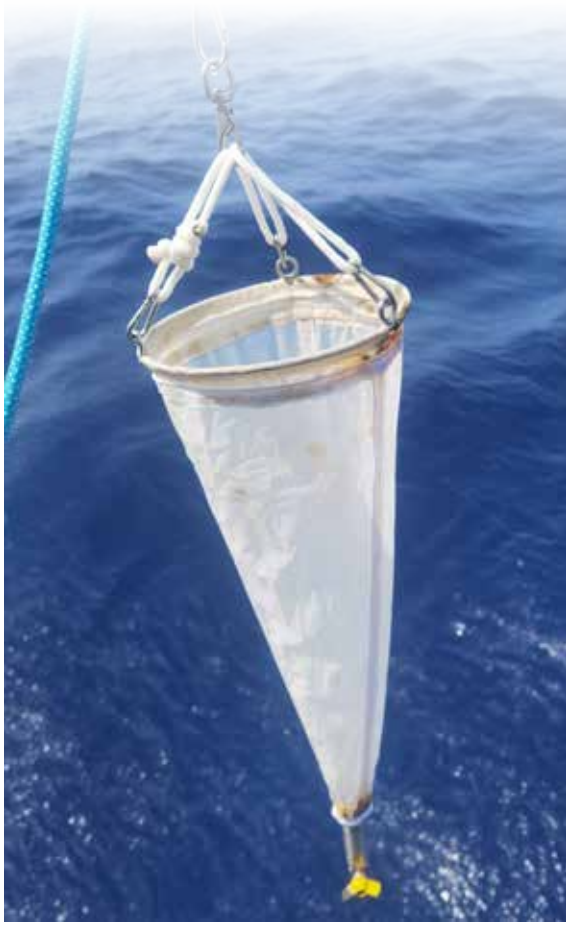


海洋细菌种质中心致力于海洋可培养性细菌资源开发，样品源于各中国海、大洋及南北极，涵盖海洋表层到深海、数百米岩芯及热液口等生境。中心目前已分离细菌 3309 株，近 2000 株细菌的初步分类涵盖了 7 个纲 178 属内的 461（亚）种。近年来在国际权威微生物分类期刊上共发表关于 30 多株新菌种资源的相关论文，形成了以有色菌株为目标资源的中心特色，为浙江大学、中国科学院、内蒙古大学等高校院所相关研究提供种质资源服务。

· 海洋藻类种质中心

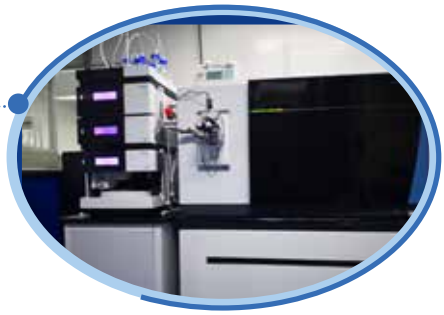
海洋藻类种质中心主要收集、分离鉴定及保藏中国近海及其邻近海域具有特殊生态功能的微型浮游植物（藻类），并根据科研需求提供藻类素材，为藻类分离、纯化及水体藻类多样性分析提供服务和技术支持。中心现保存有蓝、绿、硅、甲、裸、隐、金、黄、原绿球藻等门类合计 600 种 / 株，主要为赤潮藻类（450 余株系）。经育种驯化，保藏有一批能源藻类（30 余株）和生物饵料藻类（20 余株）。分离保藏有一批淡水藻类（100 株左右），如：微囊藻、纤细裸藻、莱茵衣藻、雨生红球藻、螺旋藻等。中心平均每年为校内外科研及教学单位提供 1200 株 / 次藻种。



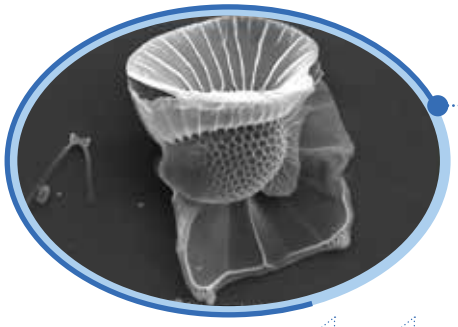


新增大型仪器设备

| 超高分辨率液相色谱—三合一质谱联用仪 |



该仪器广泛应用于复杂海洋样品中多肽、蛋白质、糖类、脂类和海水中天然有机物的分析，以及代谢组学、蛋白质修饰组学、生物化学等研究。仪器目前运行状态良好，承担了包括科技部重点研发计划、国家自然科学基金等多个项目实验样品的蛋白质质谱分析工作，获得了具有高分辨率、高可信度的蛋白质鉴定结果。

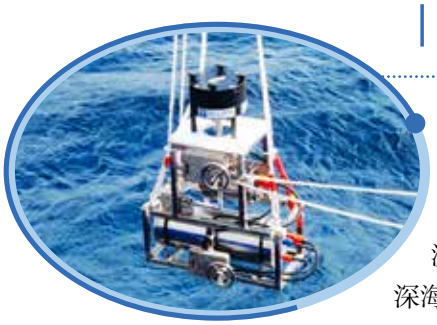


| 温湿度可控纳米级化学成像平台 |

该仪器以场发射环境扫描电镜（FEI Quanta 650）和能谱仪（EDAX Octane）为主，结合温度和湿度控制测量单元，可用于不同真空条件和温湿度下样品的物理和化学成像及表征，实现对样品的原位和动态观察。自2019 年 6 月份上线以来，该仪器已用于大气颗粒物、水样中硅藻的分类、地质样品的形貌及组分、细菌样品的形貌特征等分析。仪器年运行机时数在 800 h 以上。

仪器研制与系统升级

| 便携式原位深海颗粒物采样泵 |



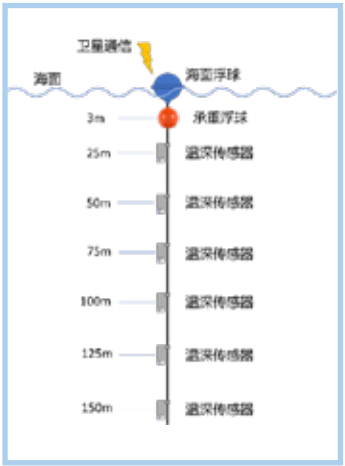
海洋仪器研发中心研发的便携式原位深海颗粒物采样泵采用无线传输通信方式，内置存储 U 盘，电池包独立可拆卸，且对气压过高和电流过大等具备保护功能，具有转速快、效率高、重量轻等优势，操作方便，可搭配不同粒径滤膜进行分级颗粒物采样，搭载于调查船、浮标等海上平台实现高频高通量的深海颗粒物采样，工作水深可达 4 km 。

| 海洋数据管理系统中台化架构升级 |

为满足各科研群体的个性化数据共享需求，COMET 海洋数据中心团队对海洋数据管理系统进行了全新架构升级，包含元数据服务业务中台和数据共享服务业务中台，为多场景航次船舶（如自有船舶和第三方船舶）管理系统、设备、外部应用资源的连接与集成方面提供了灵活的解决方案。各科研群体通过系统构建元数据，按需分布、集中部署，便利数据集成的同时实现了细粒度数据共享。该系统架构适应对数据知识产权的保护要求，是多科研群体数据共享生态方面的一次有益尝试。

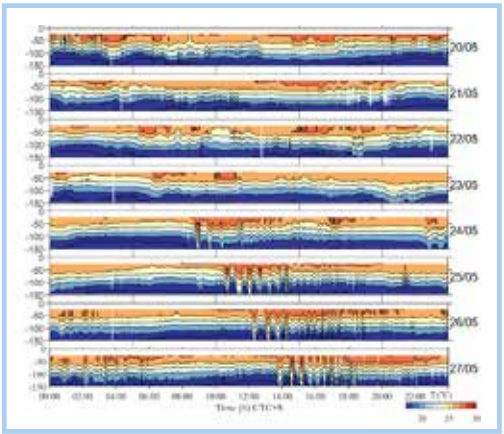
GeoTrace 航线作业轨迹图

| 漂流式温深链观测系统 |



漂流式温深链结构设计图

海上调查技术中心工作组研发的漂流式温深链观测系统可对海洋上层的温度剖面进行自主式的观测，并以卫星通讯的方式将观测数据实时传回岸基。该系统主要由海面浮球、温深传感器、感应耦合钢缆等部分组成，相对传统海洋观测浮标拓展了海面以下剖面观测的功能，并具有成本低、投放便捷、可大规模应用的优势。目前在海试投放中实现了对南海北部显著内波过程的捕捉和监测，可对内波的发生、振幅、传播等要素进行直接的监测和评估。



漂流式温深链观测到的南海北部内波过程

| 水下自动洁净采样系统海试 |

为实现海洋垂直剖面颗粒物及生物样品的自动原位过滤采样及固定，实验室和机器人学国家重点实验室的联合科研团队结合自主式水下航行器研制水下自动洁净采样系统。经过一年多的核心技术研发攻关，该系统于 2022 年 9 月利用“嘉庚”号进行海试，取得阶段性的成功，实现多层位颗粒物及水样的同时自动原位收集。通过获取的营养盐、颗粒物有机碳和生物分子样品数据与传统 CTD 采样结果比较分析，表明该系统已具备同步原位获取生物样品及化学参数的能力，有望促进对海洋关键生物地球化学过程及生态系统结构与功能演变的了解。团队未来将攻关溶解态及颗粒态痕量元素样品同步原位收集，以期为我国痕量金属研究提供一个崭新的平台。

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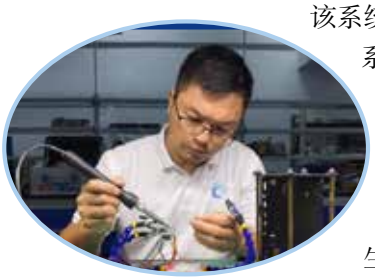
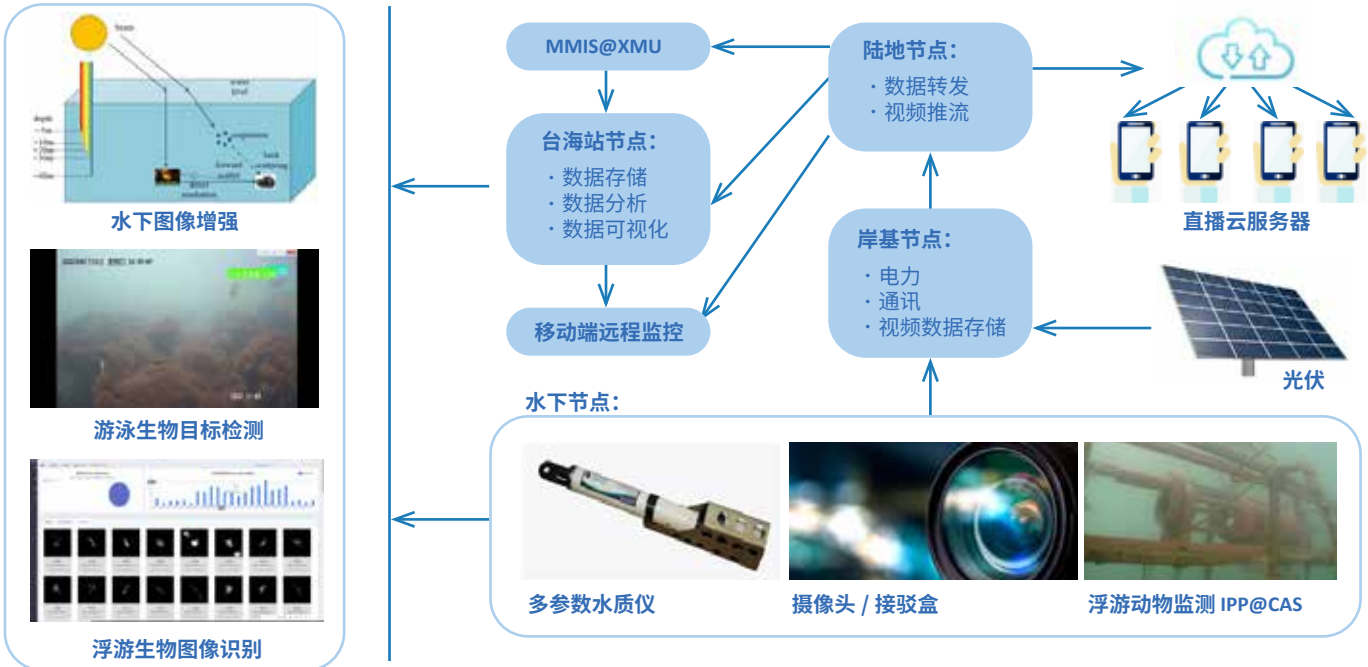
| 第二代海底有缆珊瑚生态在线观测系统 |



该系统已于台海站东山实验场完成研发与海试工作，东山站团队自主研发的水下摄像机作为系统核心部件，除了提供水下原位视频数据，还可搭载多种海洋观测仪器，实现海洋立体观测。该系统具有实时传输、水下宽视角、运行稳定、维护简便、环境友好等优点，系统观测参数包括了多种水质参数以及典型造礁珊瑚生物群落生长状态的实时监测，同时还运用图像增强技术，进一步优化近岸高浊度水体的水下视频影像数据。通过机器学习及目标识别算法，能实现珊瑚覆盖率、珊瑚生长率、鱼类密度、鱼类种类等衍生数据的产出。目前系统数据已入库至厦门大学海洋监测与信息服务中心（MMIS）的海洋云平台，可为近岸海洋生态学研究及多学科交叉研究提供关键技术支撑。



以上两个项目均获得 MEL 与机器人学国家重点实验室联合设立的
“海洋科学与技术交叉创新研究基金”资助

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

台海站是以长期连续野外定位观测与研究为基础任务，依托厦门大学建立的集综合监测、科学研究、示范服务、科普传播等为一体的国家野外站，通过对台湾海峡上升流、亚热带海湾、红树林滨海湿地等生态系统结构与功能的系统观测，解析全球变化影响下海峡生态系统的演变过程与响应机制，为保障海洋生态环境健康和促进经济可持续发展提供重要科技支撑。

本年度，台海站协同开展上升流、东山湾、厦门湾、漳江口四个观测区准同步季节性共享航次观测和野外定点连续观测，获取观测数据超过 35 GB；自主研发的第二代海底有缆珊瑚生态在线观测系统海试成功并正式上线；顺利完成漳江口红树林国家级自然保护区退养还湿成效及生物多样性评估；与红树林基金会联合主办的“2022 年全国红树林保护与修复会议”于 7 月 25 - 26 日在线上举行。

台海站首届学术委员会成立并于 11 月 16 日召开学术委员会议暨战略规划研讨会；拓展地方共建合作关系，与云霄县签订校地合作协议，与漳州市及其东山县、云霄县举行战略研讨，推进与漳州核电等企业的项目合作；积极开展科普工作，与福建漳江口红树林国家级自然保护区、云霄竹塔学校签订《红树林科普合作协议》；与非政府组织“东海卫士”等单位联合举办第六届全国净滩公益活动。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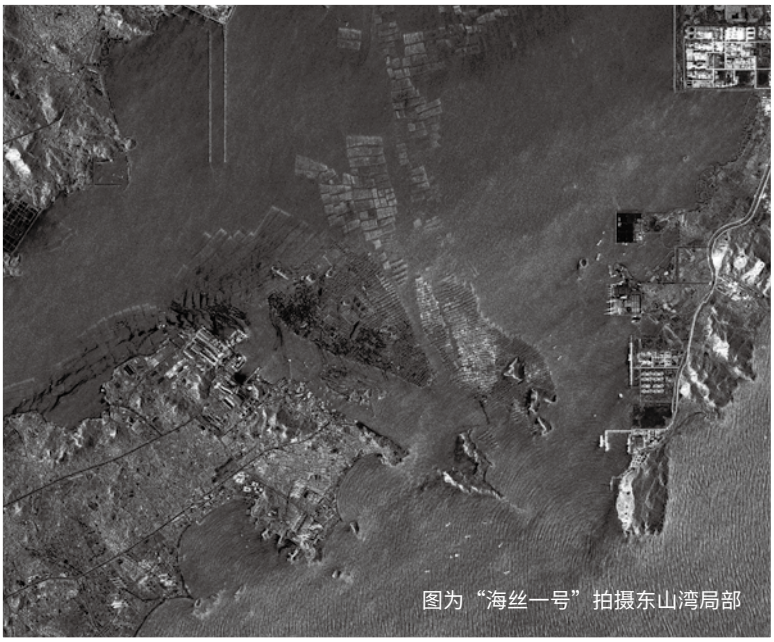
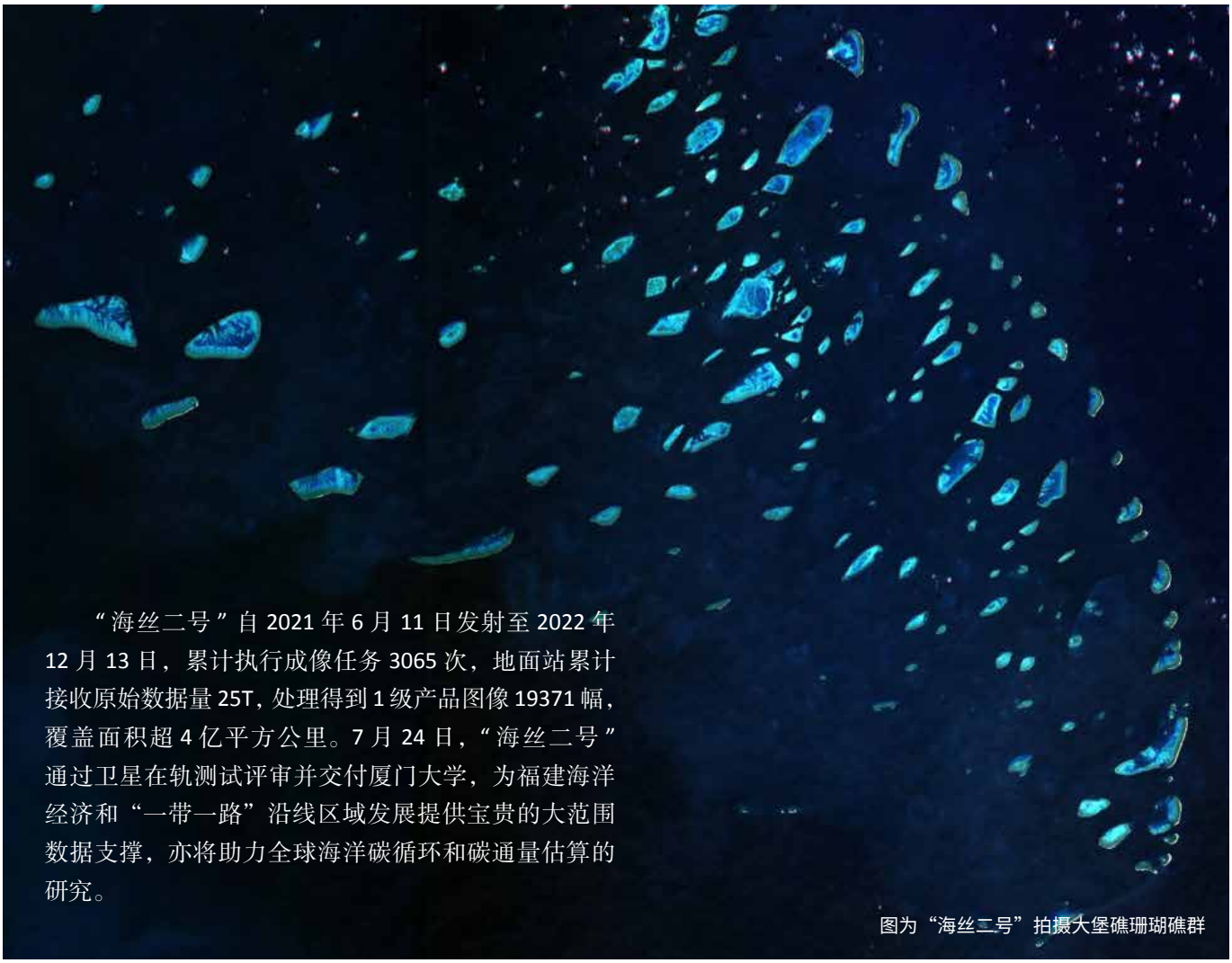
海丝卫星



图为“海丝一号”拍摄东山湾局部

“海丝一号”已稳定在轨运行两年，执行成像任务六千多次，获取高清地表雷达影像数万景，建立了海面风场和海浪的业务化反演系统，针对福建省制作完成全国首张“省级自主高质量米级SAR一张图”，开发完成多个包括舰船、飞机、水体等目标与环境要素的人工智能学习数据集，支撑了多个科研项目，为海洋、地震、气象、地质、水利、自然资源、应急、国防等领域相关部门及高校与科研院所共计50多家单位提供数据服务，并为苏伊士运河“堵船”、河南特大洪水、汤加火山喷发和俄乌冲突等国内外热点事件提供应急拍摄服务，充分展现了SAR卫星在应急响应和防灾减灾等方面的应用能力。2022年1月19日，央视《新闻联播》专题报道了“海丝一号”拍摄汤加火山喷发事件。



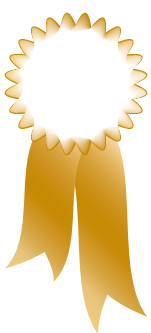
“海丝二号”自2021年6月11日发射至2022年12月13日，累计执行成像任务3065次，地面站累计接收原始数据量25T，处理得到1级产品图像19371幅，覆盖面积超4亿平方公里。7月24日，“海丝二号”通过卫星在轨测试评审并交付厦门大学，为福建海洋经济和“一带一路”沿线区域发展提供宝贵的大范围数据支撑，亦将助力全球海洋碳循环和碳通量估算的研究。

图为“海丝二号”拍摄大堡礁珊瑚礁群

人员情况
Personnel

人才计划、晋升及奖项

* 戴民汉荣获 2022 年度亚洲 - 大洋洲地球科学学会“艾克斯福特奖”
* 吕永龙获聘俄罗斯科学院外籍院士
* 刘志宇荣获第七届曾呈奎海洋科技奖“青年科技奖”
* 柯才焕荣获第二届张福绥贝类学奖“杰出贡献奖”
* 焦念志荣获厦门大学南强杰出贡献奖
* 史大林团队科研成果荣获教育部自然科学一等奖
* 柯才焕团队科研成果荣获福建省科技进步一等奖
* 徐鹏获批国家自然科学基金杰出青年科学基金项目
* 郑强获批国家自然科学基金优秀青年科学基金项目
* 游伟伟入选神农英才青年人才
* 戴民汉入选福建省级高层次特级人才
* 柴扉新聘为“唐世凤”海洋学科讲席教授
* 李忠平获聘“唐世凤”海洋学科讲席教授
* 徐鹏入选厦门大学南强特聘教授



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Publications

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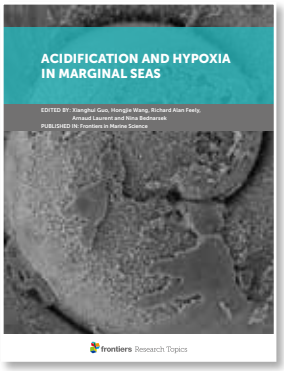

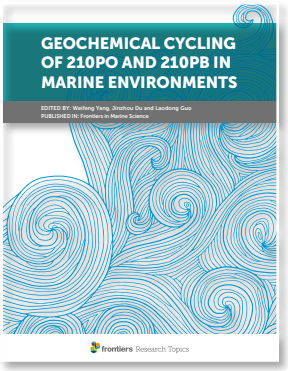

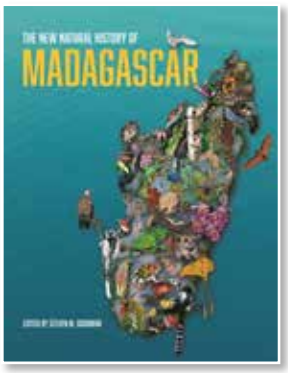

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