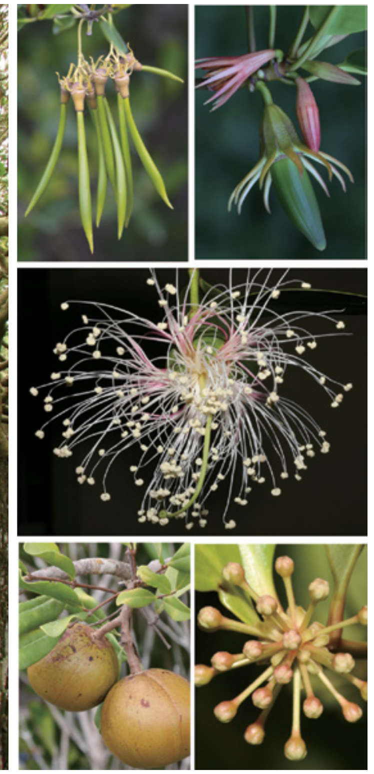
ADVERTISEMENT FEATURE

RESERVOIRS OF KNOWLEDGE LEAD TO IMPROVEMENT

Exploration through oceanology, and environmental and ecological sciences by XMU researchers has led to innovations to improve marine ecosystems.

Qingshun Quinn Li and his team have revealed the reproductive mechanisms, and restorative strategies for mangroves.



Central to the agenda of climate change discussions is the role of the ocean as Earth's largest active carbon pool. Integrating geological, environmental, biological, ecological and chemical sciences, researchers at XMU's College of Ocean and Earth Sciences (COE) and College of the Environment and Ecology (CEE) have introduced new theories and models that inspire global solutions for improving marine and coastal ecosystems and beyond.

Bringing new insights on ocean carbon cycles

Influenced by land-ocean-atmosphere interactions, coastal ocean carbon cycling is an important component of the Earth's climate system. However, mechanistic understanding of the coastal ocean carbon cycle is limited, and the question of why some coastal systems are sources of atmospheric CO_2, while others are sinks, remained unanswered. Studies by XMU marine scientist, Minhan Dai, a member of the Chinese Academy of Sciences (CAS), have addressed this, making progress in understanding and modelling the role of the coastal ocean in the global carbon cycle.

Dai's team started by synthesizing spatial and temporal variations in air-sea CO_2 fluxes in the South China Sea and East China Sea. They identified the former as the carbon source, releasing 13.3 million tonnes of CO_2 into the atmosphere annually; while the latter is a carbon sink. Extending these studies, they integrated carbon flux data of 58 marginal seas around the world, and estimated that as carbon sinks, these marginal seas sequester 360 million tonnes of CO_2 per year.

Based on interdisciplinary studies, Dai's team found that both land input and exchange with the ocean influence CO_2 fluxes in the coastal ocean. Accordingly, they proposed a semi-analytical framework to explain the mechanisms underlying carbon cycles of marginal seas. In his framework, they classified ocean-dominated margin (OceMar) and river-dominated margin (RiOMar), with carbon and nutrients sourced from the ocean and land, respectively. The framework is used to diagnose CO_2 dynamics and fluxes in marginal seas globally.

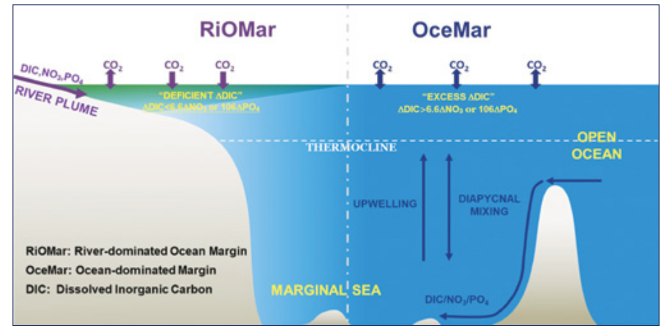
Oceans hold a tremendous reservoir of dissolved organic carbon (DOC), approximately 95% of which resists microbial degradation, known as recalcitrant DOC (RDOC). It plays an important role in carbon cycling and climate change. A team led by an XMU professor, Nianzhi Jiao, also a CAS member, proposed a new mechanism called Microbial Carbon Pump (MCP) that unravels the mysterious processes underlying the formation of the vast oceanic RDOC reservoir.

Through generation of intrinsic RDOC (RDOCt) under specific environmental conditions, as well as derivation of diverse organic molecules at extremely low concentrations (RDOCc), the MCP links the seemingly contrary 'intrinsic recalcitrance hypothesis' and 'dilution hypothesis', and provides a framework for testable hypotheses linking microbial activities with the behaviour of organic compounds for future studies into carbon sequestration in the ocean.

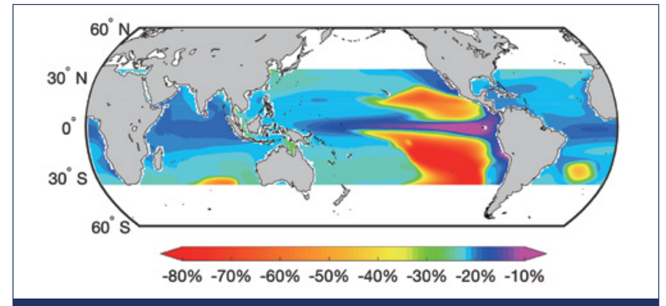
Based on the MCP theory, new approaches regarding carbon sequestration and water quality can be designed. A recent work led by Jiao has shown that MCP-based artificial upwelling in aquaculture areas help increase aquaculture output and remove excessive inorganic nutrients from the water, providing protection against algal blooms, oxygen depletion, water acidification, and CO_2 emissions.

Quantifying environmental effects on water systems

Excessive nutrients, such as nitrogen and phosphorus, are key factors affecting coastal marine ecosystems. Trying to quantify these effects, Wenzhi Cao, a CEE professor, has led a team to measure the fluxes of dissolved inorganic nitrogen (DIN) over the past five decades in China's major rivers. They found that



Minhan Dai classified OceMar and RiOMar in his semi-analytical framework that explains the mechanism of marginal sea carbon cycles.



Projected *Trichodesmium* N_2 fixation potential from the 1990s to 2090s

given increased human activity, DIN fluxes are increasing over time, having a detrimental impact on estuary and coastal environments. They lead to more frequent red tides (toxic algal blooms), which can harm marine life. Cao's team also studied nitrogen cycling in mangroves, which can help alleviate the harm caused by excessive DIN. They found that the mangrove ecosystem equilibrium is threatened by the increasing nutrient input, triggering responses.

Nitrogen cycling is studied more extensively by Shuh-ji Kao's team at XMU's State Key Laboratory of Marine Environmental Science, who explores the microbial process of nitrogen removal, and how that is compounded by global warming. By differentiating temperature sensitivity between denitrification and anammox (anaerobic ammonium oxidation), two major microbial pathways of nitrogen removal, they illustrated how temperature increase may weaken anammox, but stimulate sediment denitrification, which releases N_2O, and exacerbates warming.

Based on these findings, they predicted significant increases of N_2O production, informing better understanding of climate feedback mechanisms.

In addition to global warming, increasing atmospheric CO_2 can also trigger responses in phytoplankton, which seeks to adapt to the multifaceted environmental changes. A team led by CEE professors, Banqing Huang and Dalin Shi, has revealed mechanisms underlying those responses, including changes in phytoplankton's key physiological-ecological processes, such as nitrogen or carbon fixation.

Shi's studies have shown that seawater acidification will inhibit nitrogen fixation of *Trichodesmium*, known as sea sawdust, countering findings from previous experiments. They confirmed the result in field experiments, and explained how the inhibition works. Their simulation studies predicted that ocean acidification, by the end of this century, could reduce nitrogen fixation potential of *Trichodesmium* by 27%.

Ecological effects of ocean acidification can be more multifaceted, according to Kunshan Gao, a XMU marine environmental scientist. His studies have shown that acidification, while reducing primary productivity of the ocean, can promote nearshore seaweed growth. It will reduce the carbon fixation capacity of algae by reducing calcification and strengthening the negative effect of UV on algae.

By influencing metabolic processes of phytoplankton, acidification also leads to increased intracellular toxic substances, which can be passed up along the food chain to animals that graze on these plant-like organisms.

Driving sustainable aquaculture

Coastal environmental pollution threatens sustainable aquaculture development. Tackling antibiotic pollution, a team led by COE dean, Kejian Wang, are developing safe and effective alternatives to avoid bacterial resistance caused by excessive antibiotic use. They have identified novel antimicrobial peptides from marine fish and crabs, including new peptides Scygonadin and SCY2 purified from the seminal plasma of edible mud crab. Their research has led to 15 invention patents, and their production and processing techniques have been commercialized.

XMU is also known for its research on abalone genetic breeding. A team led by COE professor, Caihuan Ke, has collected rich germplasm resources of abalones for breeding. Using selection and hybridization, they have developed new abalone varieties with improved properties.

Focusing on coastal wetland protection and restoration, CEE dean, Qingshun Quinn Li, and his colleagues, Hailei Zheng and Wenqing Wang, have studied adaptability of wetland plants for developing ecological restoration technologies. They revealed the molecular and genetic mechanisms of salt and flood tolerance in mangroves, along with their unique reproduction process, known as vivipary, in which embryos grow outwards into seedlings while attached to the mother plant.

Along with CEE professor, Yihui Zhang, they also revealed the ecological and genetics mechanisms of a coastal invasive plant, *Spartina*, which threatens Chinese coastal ecosystems. Wang's team has established a holistic system for coastal ecological restoration that integrates mangrove restoration and weed control, with bird habitat building, and shellfish farming.

For the control of harmful organisms, like those causing toxic algal blooms, a CEE team led by Mindong Bai has created effective and safe control technologies based on hydroxyl radical (OH). Shortening processing time, Bai's technology also reduces energy consumption, by-products, and system complexity. ■

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