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POLICY BRIEF 2020/3

Sustaining China's coastal resources: Recommendations to improve the state of the coasts in Hainan

SUMMARY

The coasts of the tropical Chinese island of Hainan, located in the South China Sea, are lined by ecologically and economically important ecosystems such as coral reefs, seagrass meadows and mangrove forests, but which are also particularly vulnerable to global environmental change. In the past decades, Hainan's population and economy grew rapidly with expanding industry, tourism and aquaculture sectors. This, in turn, imposes a challenge on the delicate balance between the use and the wellbeing of the valuable coastal ecosystems.

This policy brief summarizes the major findings of a long-term Sino-German research collaborative and presents recommendations for a sustainable management of Hainan's coastal ecosystems. They are derived from the newly acquired understanding of the ecosystem structure and functioning under the pressure of anthropogenic environmental change as well as of climate change. Coastal ecosystem health and the supply of ecosystem services, hence the natural resource potential, are severely threatened along the Hainan coast.

Detail information can be found on the project website: https://ecoloc.leibniz-zmt.de.

KEY RESULTS

- Aquaculture effluents, municipal sewage and antifouling paint of ships impair water quality and organisms; Aquaculture is the most serious threat.
- Pathogenic Vibrio bacteria abundance and CO_2 emission from aquaculture ponds largely depend on pond operation mode.
- Long-term (>20 years) exposure to aquaculture effluents caused massive seagrass loss.
- Corals are contaminated with anthropogenic organic substances.
- Drastic mangrove loss (>72%) has been observed along Hainan's east coast in the last 50 years.

RECOMMENDATIONS

- For aquaculture facilities, it is recommended to: (i) operate sealed ponds, (ii) reduce the use of agrochemicals and artificial feed, (iii) treat effluents, (iv) use bacteriophages.
- Municipal sewage needs to be treated.
- Antifouling ship paint containing organotin compounds should not be used.
- A dialogue between science and society shall be established to facilitate the better use of scientific results and to improve targeted research.

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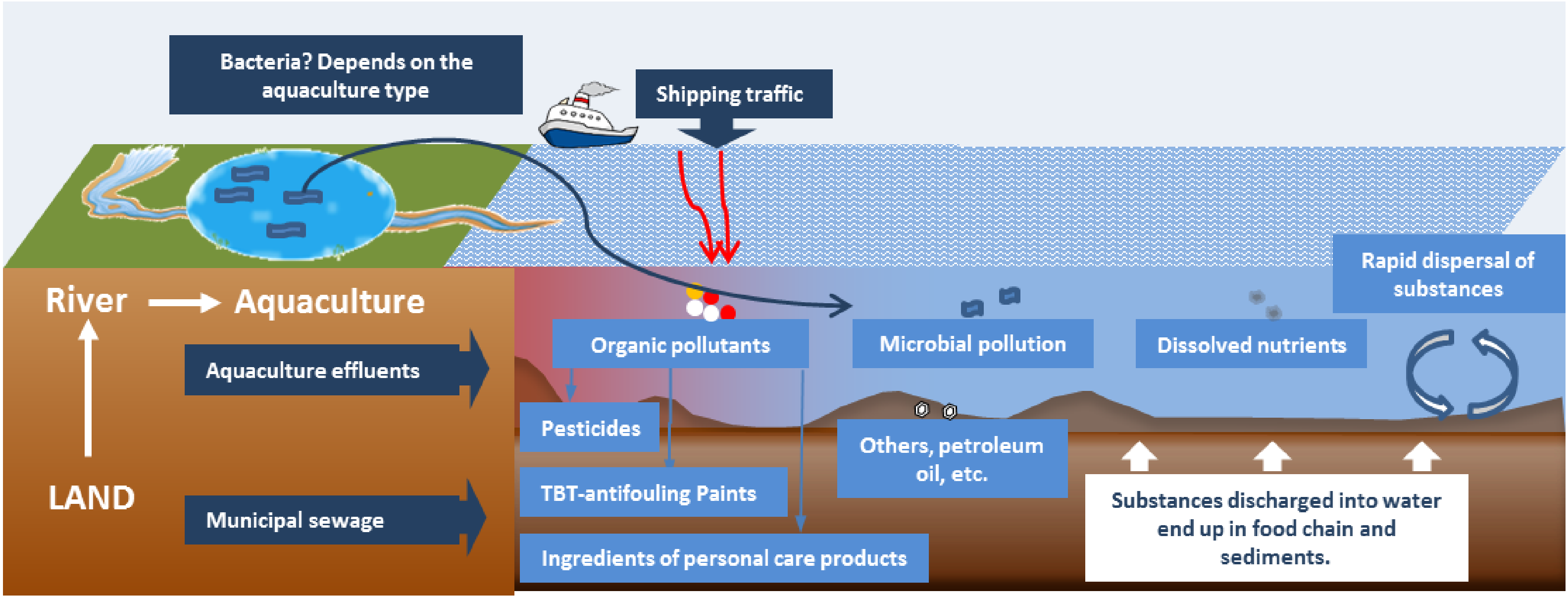


RESULTS: Threats

The most harmful substances in coastal waters of Hainan originate from aquaculture effluents, shipping traffic and municipal sewage.

Aquaculture

The effluents from aquaculture facilities are a major source of dissolved inorganic nutrients and organic matter leading to coastal eutrophication for more than 20 years. Brackish water aquaculture ponds are the major threat because of the large areal cover and long-term operation.

Aquaculture effluents are also a source of triazine herbicides which are persistent and accumulate in the food chain. As yet, no acute toxic effects on local coral reefs and seagrass beds are observed. However, it is likely that herbicide contamination has deteriorating effects in the long-term, especially in combination with other stressors such as rising sea surface temperature, which can enhance the sensitivity of organisms to pollutants.

The aquaculture operation mode determines the abundance of the bacterial genus Vibrio, which threatens the survival of the cultivated organisms. The release of effluents bears the risk of also contaminating coastal waters.

Aquaculture ponds emit the greenhouse gases carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). The pond operation mode defines to some extent the emission of carbon dioxide; CO_2 emissions from unsealed ponds are higher than from sealed ponds.

Shipping traffic

Despite China's ban on the usage of organotin compounds in antifouling products for ships since 2011, high concentrations were found in sediments from harbor areas in Hainan. This contamination has potential to impair the health of aquatic organisms.

Municipal sewage

Pharmaceutical drugs, personal care product ingredients, detergent residues, antimicrobials, and household pesticides were the most frequently detected compounds in municipal sewage.

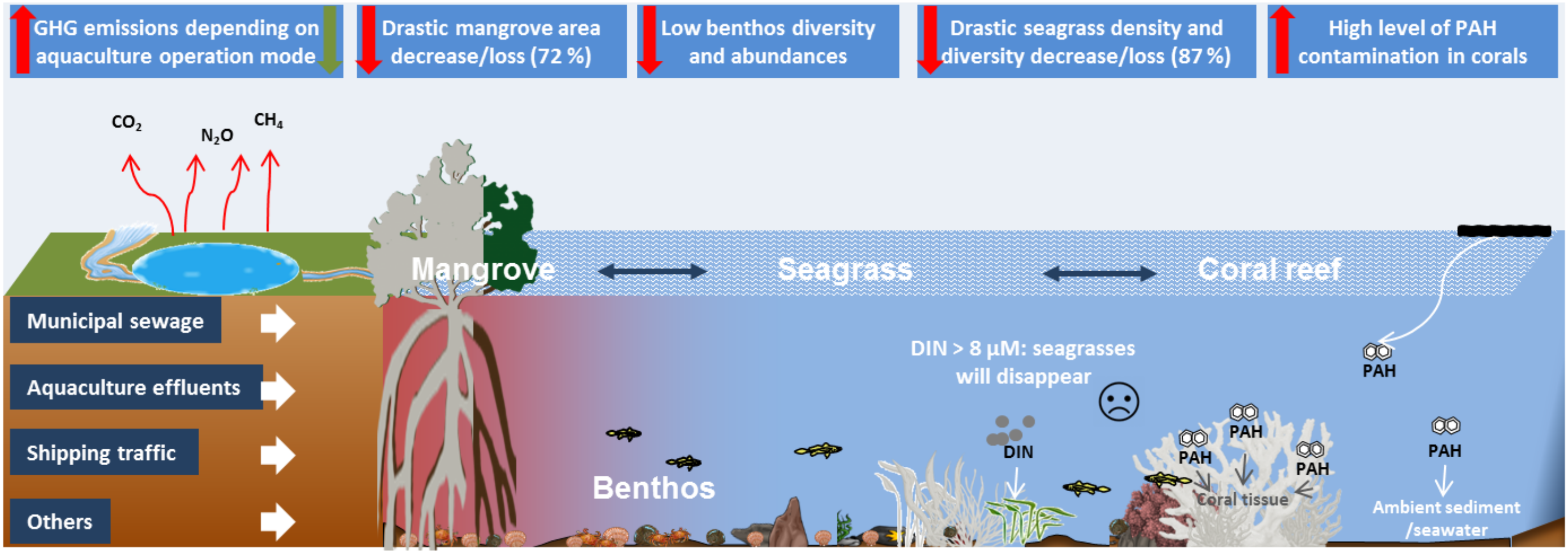
Mangrove loss

Drastic losses of mangrove area (72%) and direct conversion to aquaculture ponds (55%) were observed along Hainan's east coast between 1966 – 2009. The replacement of a sink for land-derived substances (mangroves) with a source (aquaculture) impairs the functions and services of adjacent ecosystems.

Useful tools and indicators

The herbicide prometryn is a source-specific molecular indicator to trace aquaculture emissions in the environment.

$\delta^{15}N$ in seagrass leaf and benthic animal tissue is a sensitive indicator to trace nutrient pollution from aquaculture effluents in coastal waters.



RESULTS: Environmental Response

Mangrove forests: Eutrophication and siltation of estuarine and coastal waters, entailing direct impairment of adjacent seagrass beds and coral reefs, is directly linked to mangrove loss and fragmentation.

Seagrass meadows: Seagrasses usually thrive in nutrient-poor waters. Off Hainan, coastal eutrophication driven by nutrient and organic matter input from aquaculture has led to a massive decrease of seagrass abundance and species number, in some places to total loss between 2009 and 2017. The dissolved inorganic nitrogen (DIN) concentration in the water is a proxy for the intensity of pollution. A threshold for seagrass presence was identified: seagrasses will disappear upon long-term exposure to concentrations >8 µM DIN.

Benthos (organisms living on and inside the sediment): Effluents from aquaculture and industry and mangrove loss and fragmentation also affect benthic diversity, community composition and the food web. Gastropod diversity and abundances in the study sites were very low. Diversity of trees and benthic invertebrates was higher in the larger mangrove area of Bamen Bay than in the small area in Changqi. No gastropods were found in Quinglan harbor, which is likely a response to high concentrations of organotin compounds used in antifouling paints on ships and to low oxygen concentrations.

Coral reefs: The mean PAH (polycyclic aromatic hydrocarbon) concentrations values in corals were markedly higher than in ambient seawater and sediments. The PAHs in seawater and sediments originate mainly from petroleum pollution and oil spills, whereas the major sources of PAHs in coral are combustion activities.

Greenhouse gas emission: Unsealed ponds acted as CO_2 source to the atmosphere due to decomposition of soil organic matter, accumulating surplus feedings and possibly intrusion of CO_2-rich groundwater. In contrast, a sealed and well-managed pond could absorb atmospheric CO_2 through conversion into phytoplankton and finally shrimp biomass.

Overall, the preliminary results of a well-managed aquaculture system looked promising to balance productivity and sustainability from a climate perspective.

Useful tools and indicators

The crab *Parasesarma bidens* and the mussel *Geloina expansa* are indicators of nutrient pollution.
'Citizen science' is a useful tool to collect data on seagrasses by engaging the public.

POLICY RECOMMENDATIONS

- **Coastal eutrophication mitigation** through reduced input and treatment of aquaculture effluents and municipal sewage is required in order to keep long-term coastal DIN <8 μM, which is essential for the survival of seagrasses and coral reefs.
- **Aquaculture effluent treatment** and a more efficient use of feed and fertilizer will reduce the nutrient and organic matter load of coastal waters.
- **Herbicide pollution treatment** is required to reduce direct contamination of corals and to reduce the overall sensitivity of corals against global stressors such as the increasing sea surface temperature.
- **Municipal sewage treatment** will reduce the nutrient and organic matter load of coastal waters, as well as of other anthropogenic organic contaminants.
- **Use of sealed aquaculture ponds** with improved operational and management strategies will reduce CO_2 emissions.
- **No use of organotin compounds** is recommended to remediate the pollution and impacts of these compounds. It will help to prevent human health risk from consuming oysters heavily contaminated with organotin. The development of alternative, environmentally friendly antifouling substances is suggested.
- **Avoiding further mangrove fragmentation** and protection of all mangrove areas are needed to maintain biodiversity and related ecosystem functions.
- **'Citizen science'** is recommended as a tool to sensitize and engage the general public. In the case of seagrass it has proven useful to collect data with the help of volunteers (https://ecoloc.leibniz-zmt.de/citizen-science-in-seagrass-monitoring/). A yet to be established online monitoring system can contribute to the protection of local seagrasses.
- **Monitoring coral reef status** is essential to better inform management and policy, thus long-term ecological monitoring system and stations in Hainan are recommended to be established. A well-guided restoration of degraded reefs is recommended.
- **Coastal habitat conservation and restoration** (mangroves, seagrasses, coral reefs) is highly recommended to benefit from their valuable ecosystem services.
- **Knowledge exchange activities** among different stakeholders should be initiated to facilitate the communication of relevant experience and to make scientific results effective for management and the society.

Recommendations are based on the research findings of the Sino-German project ECOLOC (Environmental change affecting COastal ecosystems of tropical China during the Anthropocene: Landward vs. OCeanic influence).

You can find more information about this project here: https://ecoloc.leibniz-zmt.de

ABOUT THIS POLICY BRIEF

This Policy Brief is part of a series aiming to inform policy-makers on the key results of the ZMT research projects and provide recommendations to policy-makers based on research results. The series of ZMT Policy Briefs can be found at www.leibniz-zmt.de/policy_briefs.html. This publication was commissioned, supervised and produced by ZMT. DOI: https://doi.org/10.21244/zmt.2020.004

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IMPRINT

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