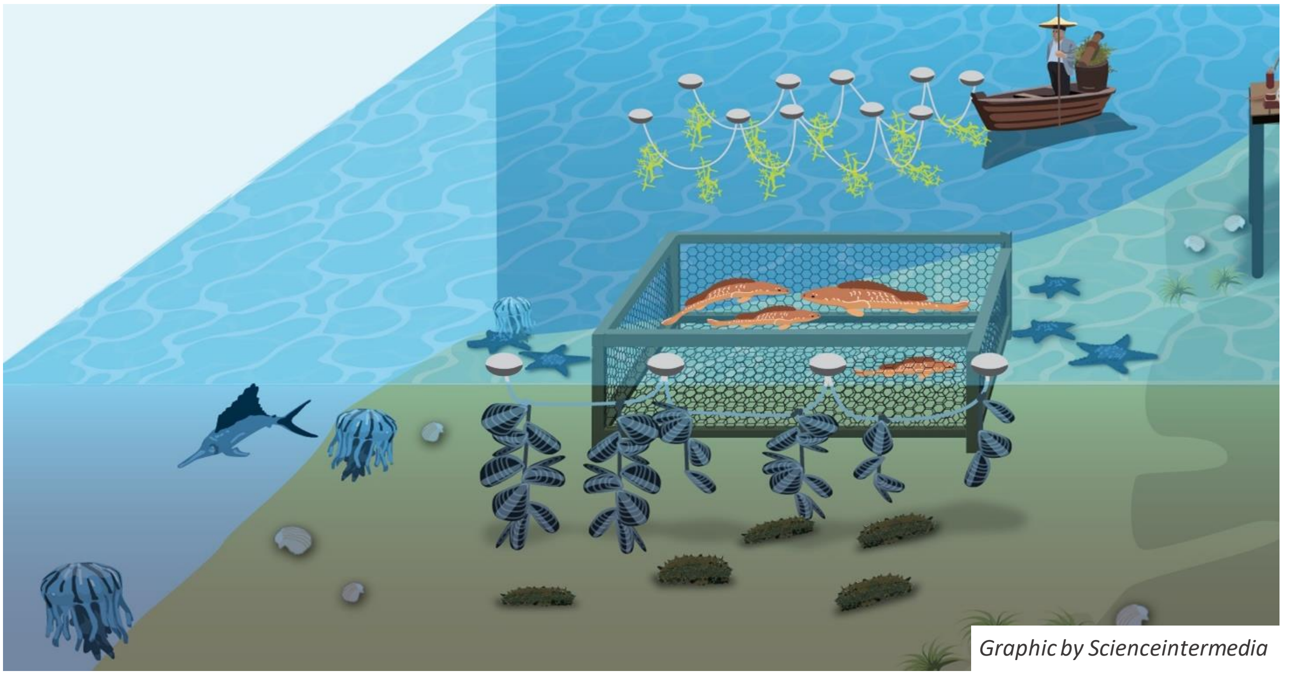
FACT ! SHEET

ZMT LEIBNIZ CENTRE for Tropical Marine Research

AQUACULTURE

Food provisioning on our planet is progressively challenged by population growth, resource scarcity and climate change. Aquatic resources are of major importance to cover nutritional needs, foremost protein, especially in countries of the Global South. While capture fisheries production stagnates, further growth of aquaculture production is often considered as last resort to increase aquatic yields. But, the aquaculture sector faces imminent challenges to realize sustainable intensification.



Graphic by Scienceintermedia

FACTS

Why do we need aquaculture?

We need aquaculture to **ensure equal, sustainable and resilient food systems** in the future. Aquaculture, especially the culture of marine organisms (mariculture) has the potential to grow food independent from key resources (e.g. land, freshwater and mineral fertilizer) that limit agricultural food production.

What is the problem?

Aquaculture practices often focus on the **monocultures of carnivorous specie**s (e.g. finfish and crustaceans). These practices are considered as **unsustainable** because of their dependence on fishmeal and fish oil as **feed input**. Additionally, highly intensive aquaculture has negative environmental impacts such as, habitat loss, eutrophication and disease transmission to wild species.

Aquaculture species and production systems

Aquaculture is the farming of aquatic organisms like fish, crustaceans (e.g. crabs), molluscs (e.g. mussels and snails) and other invertebrates (e.g. sea cucumbers and jellyfish), as well as reptiles, amphibians aquatic plants and algae. There is an immense variety of potential aquaculture species. However, merely a fraction is fully studied and only a handful nearing full domestication (e.g. Salmon and Carp). The **broad spectrum of cultured species** is reflected by the **numerous categories** of production systems, which can be classified according to four main criteria:

Criteria	System divisions
1) Type of enclosure	Ponds, tanks, raceways, cages, pens
2) Rate of water exchange	Static, open, semi-closed, recirculating
3) Culture density	Intensive, semi-intensive, extensive
4) Feed input	Fed aquaculture, enhancing natural feed, none-fed aquaculture


ponds


raceways


line culture

Examples of systems for fed aquaculture


floating cages


recirculating aquaculture systems (RAS)

Table 1: Comparison of system features	Ponds	Race-ways	Floating cages	RAS	Aqua-ponics[3]	IMTAs[3]	Line culture[4]
Land usage	red	red	green	yellow	yellow	green	green
Investment costs	green	yellow	yellow	red	red	yellow	yellow
Feed input	red	red	red	red	yellow	yellow	yellow
Energy demand/ emission of GHGs[1]	green	yellow	yellow	red	yellow	yellow	yellow
Environmental risks/impacts[2]	red	red	red	yellow	green	green	green

[1]e.g. feed production, water pumping and boat engines; GHG = Greenhouse Gases ; [2]e.g. clearing of natural habitat, disease transmission and eutrophication; [3]Information regarding Aquaponics and IMTAs: see next page; [4]Cultures of none-fed species such as mussels and algae

Images

Ponds: „Desert aquaculture in El Minya, Upper Egypt" by Tang Dalsgaard, Raceways: „Raceways" by taberandrew , Line culture: „mussels on line" by NHSeaGrant , Floating cages: „Fish farm" by Artur Rydzewski , RAS: „File:Recirculating Aquaculture System 6.jpg" by Narek75
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Is sustainable aquaculture intensification possible?

The most crucial sustainability concerns in aquaculture pertain farming intensity and feed input. To rise to its full potential, with regards to enhancing global nourishment, a **rethinking of current aquaculture practices** is needed: Instead of high intensive monocultures of carnivorous species, which require other fish as feed-input, more species from the lower end of the food chain (such as herbivorous fish, molluscs, invertebrates and algae) should be targeted more often. Overall, the share of so called non-fed species needs to grow.

Non-fed aquaculture

Farming marine primary producers (e.g. algae) and plankton feeding-animals (e.g. mussels and jellyfish) represents the most resource efficient aquaculture approach. These organisms provide the bulk of marine biomass and feed on naturally occurring nutrient sources by which they even clean the water.

Besides lowering the trophic-level of aquaculture species, an advanced use of nutrient cycles by mimicking natural ecosystems can enhance the efficiency and yield of aquaculture systems. Mixed culture approaches like Integrated Multitrophic Aquaculture (IMTA) and Aquaponics illustrate promising solutions.

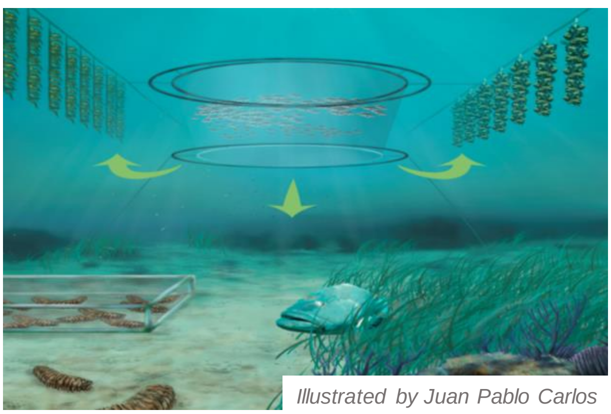
"Aquaponics" by Ryan Somma (CC BY-SA 2.0)

Aquaponics

- **Land-based** systems combining the aquacultural production of **fish** with a hydroponic **plant culture**
- The effluent/excretions from the fish provide **nutrients for plant growth**
- Water **recirculates** within the system, allowing minimal freshwater use

IMTAs

- Feed **residues** and **excretions** from the fed species are reused along a cascade of other species that fill different trophic positions along the food chain
- IMTA can provide **economic** rewards (e.g. more efficient feed use and species diversity) and mitigate **environmental impacts** (less discharge)



Illustrated by Juan Pablo Carlos

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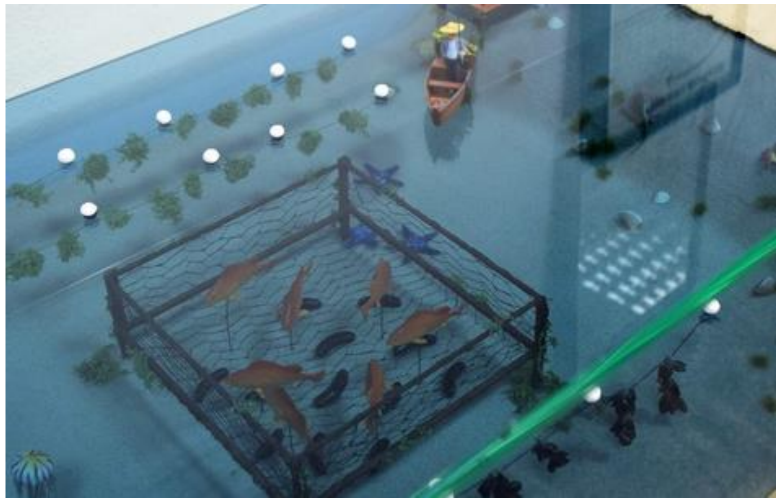
Mission of ZMT

At ZMT the research about sustainable aquaculture combines natural- (NS) and social sciences (SS) to enable **socio-ecological system approaches**. The NS side investigates **candidate species from lower trophic levels** (e.g. sea cucumbers, jellyfish and macroalgae) and synergistic **co-culture options in IMTA systems.** SS looks at societal and institutional changes to provide a better understanding of future aquaculture concepts and **their role for global food security and nutrition**.



*To illustrate the approach of Integrated Multitrophic Aquaculture to a broad public, ZMT created an **interactive showcase.** Visitors can use a touchpad to display further information on the respective stations as well as graphics and videos.*

Sea Grapes (top left), sea cucumber (middle), jellyfish (right) and harvesting Pearl Oysters (bottom left) (Images by L. Stuthmann, P. Senff and H. Kühnhold)

Current ZMT projects

Food for the Future (F4F): Culture and utilization of jellyfish biomass, primarily as alternative animal protein source for food and feed

Sea Grapes (Green Caviar): Optimizing aquaculture practices for the high-value edible macroalgae *C. lentillifera*

Pilot-scale IMTA studies on Zanzibar and in Indonesia

Science communication: Winner of the University Competition 20/21 – Bioeconomy (see QR-Code below)

Take home messages

- → **Aquaculture will be important to ensure global nourishment and food systems resilience in the future**
- → **Current approaches are often considered as unsustainable due to dependency on fishmeal and fish oil and negative environmental impacts**
- → **Non-fed aquaculture is among the most resource-efficient forms of animal protein production**
- → **Next to lowering the trophic level of cultured species, multi-species approaches such as IMTA and Aquaponics forebode the vastest sustainability gains**

Imprint

Editors
Dr. Holger Kühnhold, Wyona Schütte
Leibniz Centre for Tropical
Marine Research (ZMT)
Fahrenheitstr. 6
28359 Bremen

Webpage
ZMT Project on sustainable aquaculture

Leibniz Gemeinschaft

ZMT LEIBNIZ CENTRE for Tropical Marine Research