

CORAL REEFS IN CRISIS

Causes, Consequences and Solutions

CORAL REEF FACTS

Coral reefs are home to **over 600 coral species**, which vary in size, color and shape, and cover an area of **600.000 km²** worldwide.^{1,2}



WHY CORAL REEFS ARE BEING DEGRADED

Coral reefs challenging various **anthropogenic stressors** including the effects of **climate change**.^{1,3,4}

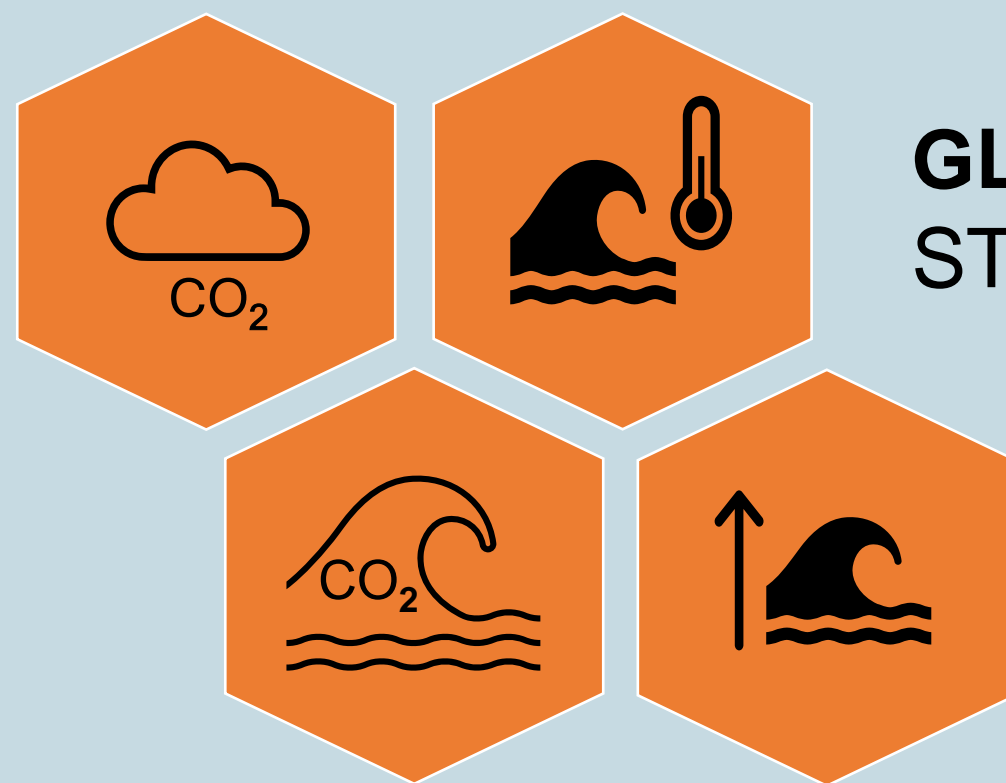
LOCAL STRESSORS



+



GLOBAL STRESSORS



exacerbate the effects of climate change

Fig. 3: Partly co-occurrent local and global factors influencing coral degradation.

- **Tourism:** damage by divers, garbage, boat anchors.^{1,2,4}
- **Booming coastal development:** Increasing population density along coastlines (e.g. tropical Asia) → building boom (resorts etc.) → high promotion of sediment erosion.^{1,2,3,4,5,6}
- **Land-based pollution: Industrial pollutions, runoff of untreated sewage** from factories, urban areas, holiday resorts pollute the coastal waters with **pathogens and nutrients**.^{1,2,3,4,5}
- **(Over-)Fishing and destructive fishing practices:** Coral destruction through the loss of their “cohabitation partner” and as side effect of the type of fishing (dynamite, poison (cyanide), fine-mesh nets).^{1,2,3,4,5,6,14}

The increase of **atmospheric greenhouse gas emissions**, especially of CO₂, has changed **ocean chemistry and sea surface temperatures**, which promoted the decline in coral reefs.^{1,4,6,7}

- **Ocean warming is causing thermal stress in corals**, affecting **carbonate accretion of coral reefs**.^{4,6}
- Through dissolved CO₂ in seawater, the acidity of the ocean increases (**ocean acidification**), affecting the living conditions of corals, their physiology and growth.^{4,6,7}
- As further effect **sea level is rising** and changing morphology of reefs.^{3,4,5}

„Reef builders“ are corals:^{6,7,8}

Corals are characterized by a **calcareous skeleton**, that is formed by **polyps**. They live in **symbiosis** with photosynthetic algae - the **zooxanthellae**. These accumulate in the tissue of the coral polyps and **color the coral**. In addition, they supply the coral with oxygen and energy (sugar, amino acids and glycerin) through photosynthesis and in return benefit from the metabolic products of the coral (→ **nutrient exchange**).^{1,3,5,7,8,14}

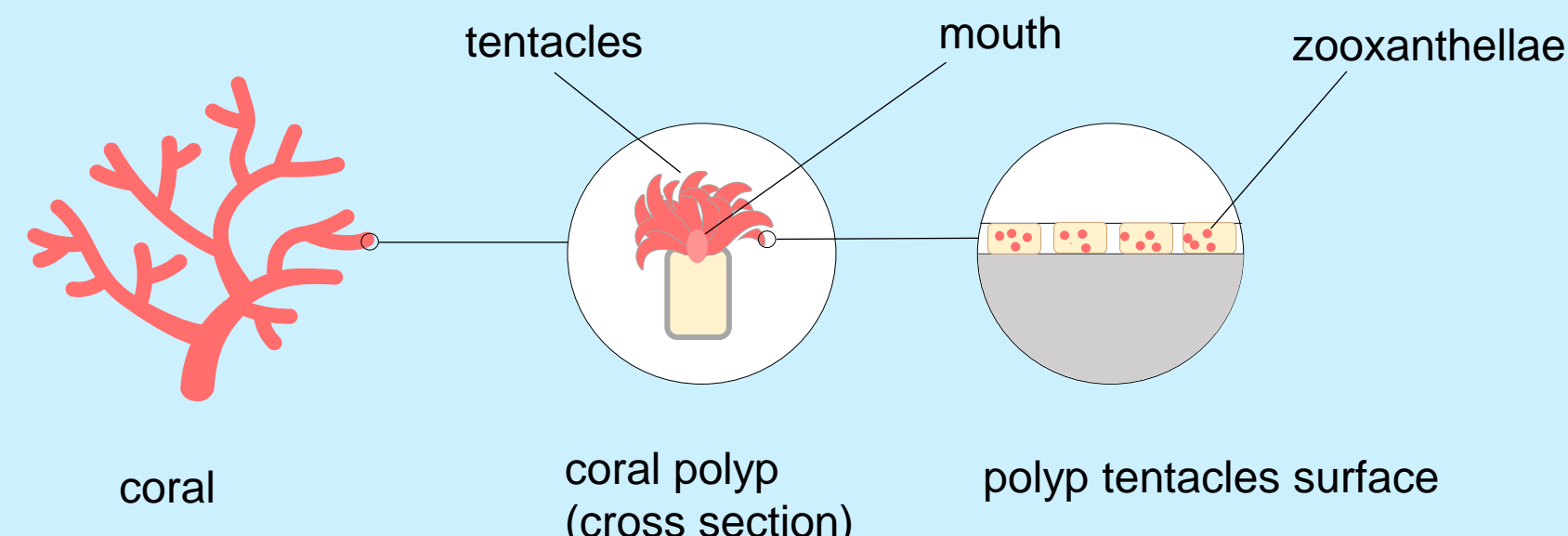
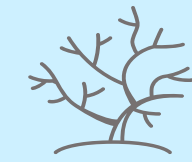


Fig. 2: Simplified structure of a coral.

61 %

of the reefs worldwide are affected by local and global stressors.^{3,4}



THE CURRENT CRISIS: MASS CORAL BLEACHING through global warming

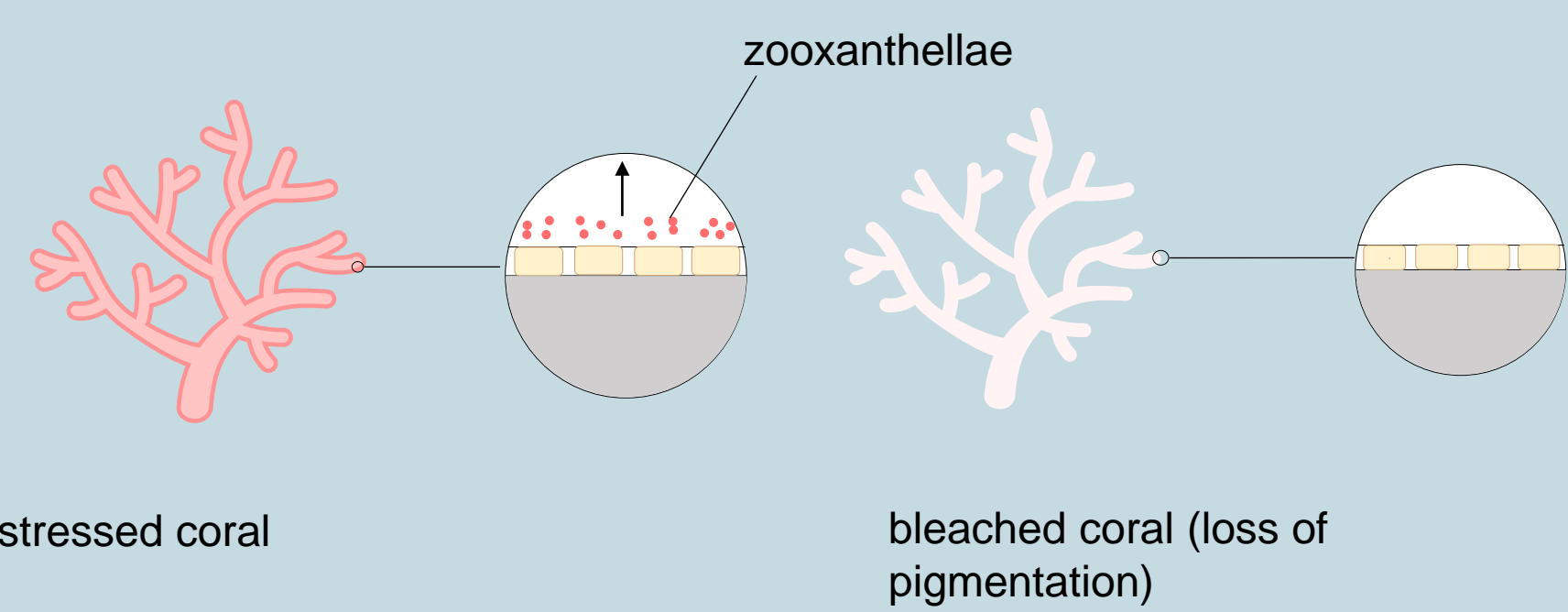


Fig. 4: Coral bleaching process.

With seawater temperatures raising and alterations in El Niño and La Niña events, caused by climate change, the **thermal stress** on the corals increases and **algae are expelled** - white “bleached” limestone skeletons remain. Especially affected: Great Barrier Reef, Caribbean.^{1,2,3,4,5,6,7,9,10,14,15}

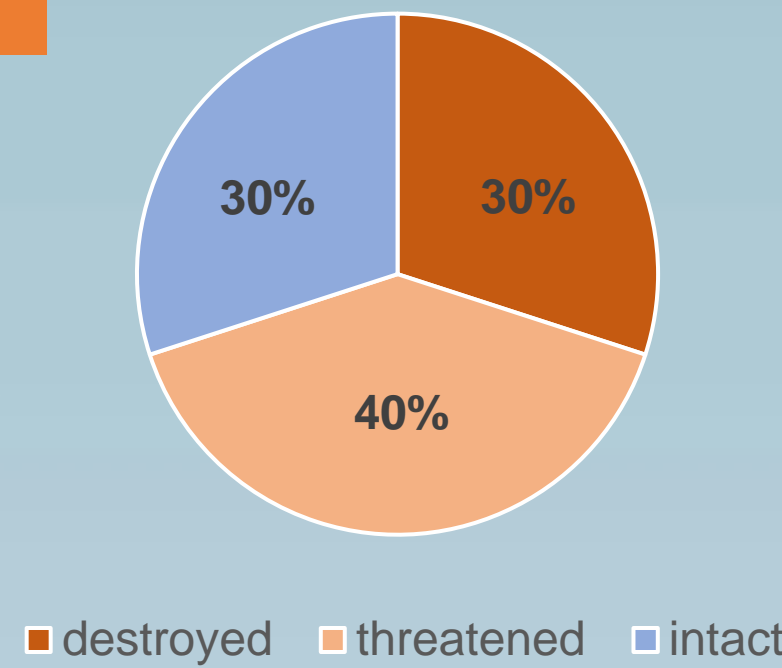


Fig. 5: Actual state of coral reefs 2020.

“Coral reefs are more valuable than Google, Apple and Co.”¹³

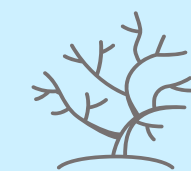


Fig. 6: Distribution of coral reefs / reef areas worldwide (between 30th degree of latitude north and south).

BENEFITS OF HEALTHY CORAL REEFS

1. **Biodiversity:** Although coral reefs only cover > 0,1% of the ocean floor, they provide habitat for 25% of all marine species (Fig. 7).^{1,2,4,5,6,7}
2. **Diverse ecosystem:** There are close and complex interlinkages between corals and coral dependent species. Removal or destruction of one component may release a collapse of the ecosystem.^{2,6}
3. **Reefs cycling nutrients** from mangrove swamps to open-ocean fisheries.^{2,7}
4. **Medical/pharmaceutical potential** because of chemicals with antileukemic or antimicrobial properties produced by reef plants.^{1,2,6}
5. **Animal protein source** for >1 billion people in the tropics (fish, mollusks, shellfish etc.).^{1,2,4,5,6}
6. **Coastal erosion protection:** Corals act as “natural barrier” against flooding hazards and storm damages, by reducing wave energy, because of their structure and their vertical accretion.^{1,2,3,4,5,6,8}
7. **Livelihood:** Economic benefits for many locals in holiday regions.^{1,2,4,5,6,7}

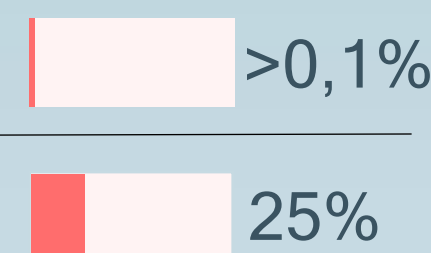
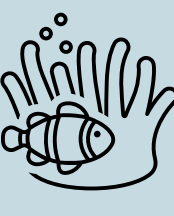


Fig. 7: Ratio of covered ocean floor area to species diversity of reefs.

CONSEQUENCES OF REEF DEGRADATION



Diversity loss of reef communities: Only the most resistant will survive the multiple stressors → loss of sensitive tax.^{1,3,5,7,14}

Lack of O₂: Eutrophication (excessive nutrient accumulation) promotes the algae growth and decline of oxygen, which weakens corals and forces them to compete for resource with (macro-)algae.^{2,4}

Collapse of nearshore fisheries: Due to changes in fish biomass greater effort for fishing is required.^{5,7,9}

Increased number of Crown-of-thorns starfish (Indo Pacific Region) – predators, who feed on corals (“reef eater”), are attracted by the nutrients and exacerbate the degradation.^{2,3,5,14}

Suffocation hazard: Due to sedimentation, the water becomes increasingly cloudy, which limits the coral's ability to photosynthesize.^{2,4,6}

Reduction of resilience and stability: Stress and ocean acidification lead to growth disturbance, less recruitment, reductions of skeleton density, structural complexity and disturbance of postbleaching recovery of corals.^{3,4,7}

Financial losses: With the disappearance of the corals, holiday regions losing an important source of income: e.g., the tourists.^{2,4}

Higher risk of coastal flooding & higher coastal protection costs.^{1,7}



POTENTIAL SOLUTIONS

Local management & monitoring programs:^{1,3,4}

Creation of marine parks, incl. division of the reef complex in zones (general-use, natural park- & restricted) to improve coral reef administration and protection.^{2,3,4,6}

Observation of environmental dynamics, risk assessment & calculation of habitat suitability to locate areas, which can constitute ecological refugia for corals.^{1,3,4}

Structural measures: **Wastewater management** to reduce local eutrophication → This could raise areas of temporary refugia from 6% up to 28%.^{3,4,5}

Bans & regulations: Prohibition of dynamite and scuba spearfishing & fine-mesh nets; Reduction of fish harvest, building regulations with distance regulations to the ocean and green areas for future resorts.^{2,4,5,6}

Sensibilization: Creating public, social and political awareness to the need of sustainable use of coral reefs. → Public relations + environmental education: workshops, social media campaigns, documentaries (e.g., Netflix: Chasing Corals).^{2,4,6}

International agreements^{1,4,5,6}

- **Paris Agreement 2015**, as a global framework for reducing emissions (preservation of coral reefs).^{1,4,6,9}
- **International Coral Reef Initiative** (strengthening of national coral conservation activities for research and resources coordination).²
- **Sustainable development goals (UN)** (preservation of the sustainable use of the oceans, seas and marine resources).¹



Ecotourism: Establishment of sustainable tourism in sensible areas to contribute to the financing of nature protection and the promotion of regional development.^{4,12}

Reef restoration: Translocation of corals & transplantation of conspecific corals within the species' current range or stress-tolerant species (**coral gardening**).^{1,3,4,11}

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Illustrations:
Fig. 1: Biedermann, R. (2022): Map of Lake Constance. URL: <https://www.stocklib.de/media-76170382/map-of-lake-constance.html?keyword=bodensee> (Accessed 14.03.2022).
Fig. 2: Own illustration after Hantzschel, O. (2019), in: Bräckel, B. von (2019): *Korallen am Limit*. EWS Energiewende-Magazin (Mai 2019). <https://www.ews-schoenau.de/energiewende-magazin/zur-sache/korallen-am-limit/> (Accessed 10.03.2022).
Fig. 3: Own illustration.
Fig. 4: Own illustration after Hantzschel, O. (2019).
Fig. 5: Own illustration after Universität Bremen (2020).
Fig. 6: Kimmmer, H. (2017) and Universität Bremen (2020) modified.
Fig. 7: Own illustration after Röder, C.; Heiss, G.A. (2016); Veron, J.E.N. et al. (2009); and Universität Bremen (2020).
Fig. 8: United Nations 2022. URL: <https://www.un.org/sustainabledevelopment/loceans/> (Accessed 12.03.2022).
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