How Will Coral Reefs Survive Global Change?

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FOOD











Talk outline

What creatures live on coral reefs?

2 How is there so much diversity on coral reefs?

3 How do coral reef species interact?

4 How does global change impact coral reefs?

5 What is the future of coral reefs?

6 Is there still hope for coral reefs?

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Often overlooked critter because it is tiny and/or well camouflaged











Most cryptic critters remain undescribed

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6 Should we be optimistic about the future?





Coral reefs are home to 830,000* species worldwide

estimates from 500,000 – 10 million

Lyons et al. 2024, *Cell Reports Sustainability* Knowlton et al. 2010, *Life in the World's Oceans*

Cryptobenthic fishes





Brandl et al. 2018, *Biological Reviews*

The Caribbean

Cassiopea

Tusked goby



Tusked goby





Bohlke & Robins 1968 (Proc Acad Nat Sci Phila)

Tusked goby









Speciation

The evolution of new species due to the genetic divergence of populations








Wang et al. 2024, Coral Reefs

SCUBA Collections



Deep Sea Submersible



Seven distinct genetic lineages



What we thought was one species is probably seven!



Wang et al. 2024, Coral Reefs



Goby specialization

Sponge host specialization contributes to genetic diversification



Wang et al. 2024, Coral Reefs





Base of the food web









Food Web

Network of feeding relationships, demonstrates who eats whom underwater



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DNA = barcode of an organism





GAC CTT TAT ATA CGC CTC TTA



DNA Barcoding





Octopus briareus

DNA Metabarcoding



Mass amplification of DNA barcodes from samples containing a multitude of organisms

Mo'orea, French Polynesia











Casey et al. 2019, Methods

Large reef fishes



Photos: Jennifer Adler



Cryptobenthic fishes





Fish dissections





Video: Chris Hemingson

Photo: Jennifer Adler

Mo'orea food web



Highest resolution food web ever assembled for a coral reef ecosystem





80% of dietary items in closely related fish species are unique

Each fish species is special and has a unique role on coral reefs

Casey et al. In prep.















Photo: Sheila Sund



Fish species have narrow dietary preferences

Coral reef food webs are vulnerable to local consumer extinctions

Pozas-Schacre et al. 2020, PNAS










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What is a coral?





Zooxanthellae

Photosynthetic micro-algae that produce energy for corals and give corals color





Marine heatwave

Prolonged periods of high sea surface temperatures

Coral Bleaching



2018 – Mo'orea, French Polynesia

2019 – Mo'orea, French Polynesia



Healthy \rightarrow Bleaching \rightarrow Algae



Four global coral bleaching events

% of bleached corals



NOAA Coral Reef Watch Bleaching Alert 24 May 2023





Butterflyfishes: coral-feeding fishes





Ornate butterflyfish

Reticulated butterflyfish



Semmler et al. 2025, J Animal Ecology



40% mortality of corals after bleaching event

50% population decline of butterflyfishes

Semmler et al. 2025, J Animal Ecology

Coral-feeding fishes:

do not shift their diets to target non-coral prey items

have difficulty digesting nutrients from stressed corals

Recurrent bleaching events may jeopardize the survival of coral-feeding fishes





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The status of coral reefs

Since 1950:

Live coral has declined by 50%

Catch of coral reef fishes has declined by 60%

Eddy et al. 2021, One Earth

What will coral reefs look like in the future?

Algae-covered reef



Bocas del Toro, Panamá

Sponge-covered reef

Florida, USA

bleaching

healthy



López-Legentil et al 2010, Microbial Ecology

Sediment-covered reef

Abu Dhabi, United Arab Emirates

Healthy coral reef

Carrie Bow Cay, Belize
Why do coral reefs matter?

Biophilia

Our innate love for the natural world and living things

Ecosystem services

Coastal protection Food production Pharmaceutical bioprospecting Tourism and recreation Education Carbon sequestration Spiritual value

The economic value of coral reefs

1

The value of coral reefs worldwide







fisheries, tourism, shoreline protection





benefit from ecosystem services

Funding for ecology

2024 Budget = \$6.9 trillion



People versus planet?

Ecological research (NSF & NOAA)



Healthcare for vulnerable people (Medicare & Medicaid)



Funding trajectory

Federal funding for major science agencies is at a 25-year low

SCIENCEINSIDER | FUNDING

Final U.S. spending bills offer gloomy outlook for science

Key research funding agencies get sizable cuts or flat budgets

4 MAR 2024 · 4:10 PM ET · BY SCIENCE'S NEWS STAFF

Millions in science funding in limbo after Trump's rejection

By Andres Picon | 03/27/2025 04:06 PM EDT

Trump seeks to end climate research at premier U.S. climate agency

White House aims to end NOAA's research office; NASA also targeted

11 APR 2025 • 11:18 AM ET • BY PAUL VOOSEN

Coral reef scientists



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Three pillars of action







REDUCE GREENHOUSE GAS EMISSIONS MITIGATE LOCAL STRESSORS CONDUCT RESTORATION TO RETAIN CORALS

Reimer et al. 2024, Coral Reefs

#OceanOptimism

Ocean Optimism: Moving Beyond the Obituaries in Marine Conservation. 2021, Annual Review of Marine Science



Dr. Nancy Knowlton



Success stories





Coral restoration



Boström-Einarsson et al. 2020, PLOS One

Coral restoration debate

"Unfortunately, current and future heatwaves will continue to kill these regrown corals..."

Streit et al. 2024, *Nature Climate Change*

"Last ditch sort-of insurance policy"

Jennifer Moore, NOAA







Eradication of invasive rats

Graham et al. 2018, Science

Nutrients from islands to reefs in the presence and absence of rats





Graham et al. 2018, Science

After rat eradication, seabird biomass increases and nutrients return to islands and surrounding coral reefs within 16 years.

Benkwitt et al. 2021, *Current Biology*

Marine protected areas

13.



Cinner et al. 2016, Nature

International policy needs



ESTABLISH COMMITMENT

PROMOTE COHERENCE

DRIVE INNOVATION

The time for action is now!

Knowlton et al. 2021, Rebuilding Coral Reefs: A Decadal Grand Challenge



Future emissions scenarios















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Thanks! Questions?

