Estimating coral feeding habits from space

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The plan for today

• Basics of coral nutrition
• Using satellites to inform global patterns of coral feeding
• Future directions and the big picture
The plan for today

- Basics of coral nutrition
- Using satellites to inform global patterns of coral feeding
- Future directions and the big picture

Goals

1) Explain the importance of coral nutrition and why we need to study it more closely
2) Provide some coral reef optimism!
Coral reef ecosystems exist in 5 National Marine Sanctuaries.
7 Additional coral reef islands protected in the Pacific Remote Islands Marine National Monument
Mixotrophy is the most common nutritional strategy
Mixotrophic, reef-building corals create some of the world’s largest living structures.
Symbiotic microalgae \textit{\text{(endosymbionts)}} are corals primary source of food

Mullen et al. 2016, Jules Jaffe SIO
During bleaching corals lose this important food source

Mullen et al. 2016, Jules Jaffe SIO
Galaxea fascicularis
Galaxy Coral

Tim Wijgerde, Coral Publications
Heterotrophic nutrition in reef-building corals

Heterotrophic nutrition increases

- Tissue growth
- Skeletal growth
- Energy reserves
- Symbiont density
- Fecundity (more babies)

Reduces negative impacts of

- Ocean Acidification
- Bleaching
- Nutrient Pollution
- Light limitation (turbid environments)

Ferrier-Pages et al. 2011
Coral aquaculture accelerated by food

Ambient conditions

High food supply

Petersen et al. 2008 *Aquaculture*
Coral survival of bleaching linked to heterotrophic nutrition

Heterotrophic plasticity and resilience in bleached corals

Andréa G. Grottoli¹, Lisa J. Rodrigues² & James E. Palardy³

Heterotrophy promotes the re-establishment of photosynthate translocation in a symbiotic coral after heat stress

Pascale Tremblay², Andrea Gori², Jean François Maguer³, Mia Hoogenboom³,⁴ & Christine Ferrier-Pages²,

Primarily studied in laboratory experiments due to logistical challenges in the field
Will all reefs suffer the same?

Great Barrier Reef 'cooking and dying' as seas heat up, warn scientists

Coral sanctuary is now a 'graveyard' due to record warm oceans, scientists find

Coral reefs on Christmas Island dead after El Niño

'Looks like a ghost town,' says UVic scientist after month long scuba diving expedition
Coral reefs classically considered oceanic deserts

Purkis 2018
Primary production highly variable across the tropics
"The equatorial cold tongue"

Wind and current driven upwelling across the central Pacific
Satellite chl-a measurements may predict food abundance for corals

Gove et al. 2016; Hazen and Johnston 2010
Animal diets can be studied using stable isotopes.
You are what you eat…

- Carbon Isotope Value ($\delta^{13}$C)
- Nitrogen Isotope Value ($\delta^{15}$N)

Trophic Level

Low (Terrestrial)

High (Marine)

C₃ (Wheat) - C₄ (Corn)
You are what you eat…
You are what you eat...

Alaskan Inuit Communities

Trophic Level (δ¹⁵N)

Nantucket Island
Massachusetts
(1000–1600 A.D.)

Ancient Puebloans
Southern Utah
(0–1300 A.D.)

SW Native Americans

Carbon Isotope Value (δ¹³C)

C₃ (Wheat)  →  C₄ (Corn)
You are what you eat…

- Alaskan Inuit Communities
- Nantucket Island Massachusetts (1000–1600 A.D.)
- Ancient Puebloans Southern Utah (0–1300 A.D.)
- SW Native Americans
- Modern New Mexicans
- Vegans
- New Protocols
15 species of coral from 16 locations across 3 ocean basins
A three-fold gradient in Chl-α

Fox et al. 2018 Current Biology
Water along this gradient still clear

This study = 0.09 – 0.35 µ Chl-a

Photo: Brian Zgliczynski
Water along this gradient is still clear

This study = 0.09 – 0.35 µ Chl-a

CA Kelp forest= 3.0 – 10.0 µ Chl-a

Photo: Brian Zgliczynski

Photo: Scott Gabara
Global patterns in Chl-a predict how much coral are likely to eat

$\Delta^{13}C_{\text{host-endosymbiont}}$ (%) vs. Chl-a (mg m$^{-3}$)

Increased feeding

More food available

Fox et al. 2018 Current Biology
More dining options for corals on productive reefs
Can we use this information to understand where corals are most likely to survive?
Current understanding of coral nutrition isn’t good enough...we need better tools.

Stable isotope analysis of individual amino acids.

Mixotrophic coral

Pocillopora meandrina
Fox et al. *in revision*
Fox et al. *in revision*
High variability in feeding among individual coral colonies

Fox et al. *in revision*
Key take home messages

- Corals feed more on reefs that have more food

- Food availability for corals can differ widely from reef to reef

- New techniques and technologies are providing insights to coral nutrition at scales previously impossible

- Understanding how coral feeding varies may provide important information about reef survival
Key take home messages

• Corals feed more on reefs that have more food

• Food availability can vary widely from reef to reef
Key take home messages

- Corals feed more on reefs that have more food
- Food availability can vary widely from reef to reef
- New techniques and technologies are providing insights to coral nutrition at scales previously impossible
Key take home messages

• Corals likely feed more on reefs with more food

• Food availability can vary widely from reef to reef

• New techniques and technologies are providing insights to coral nutrition at scales previously impossible

• Understanding how coral feeding varies may provide important information about reef survival
Can feeding help corals survive repeat bleaching?
Continually uncovering the importance of oceanic production

Sustains fish biomass following mass coral mortality on the Great Barrier Reef

Upwelling provides nitrogen to corals in the Maldives

Morais and Bellwood 2019 *Current Biology*

Radice et al. 2019 *Functional Ecology*
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