CORAL REEF ECOSYSTEM: A MODEL FOR HUMANITY

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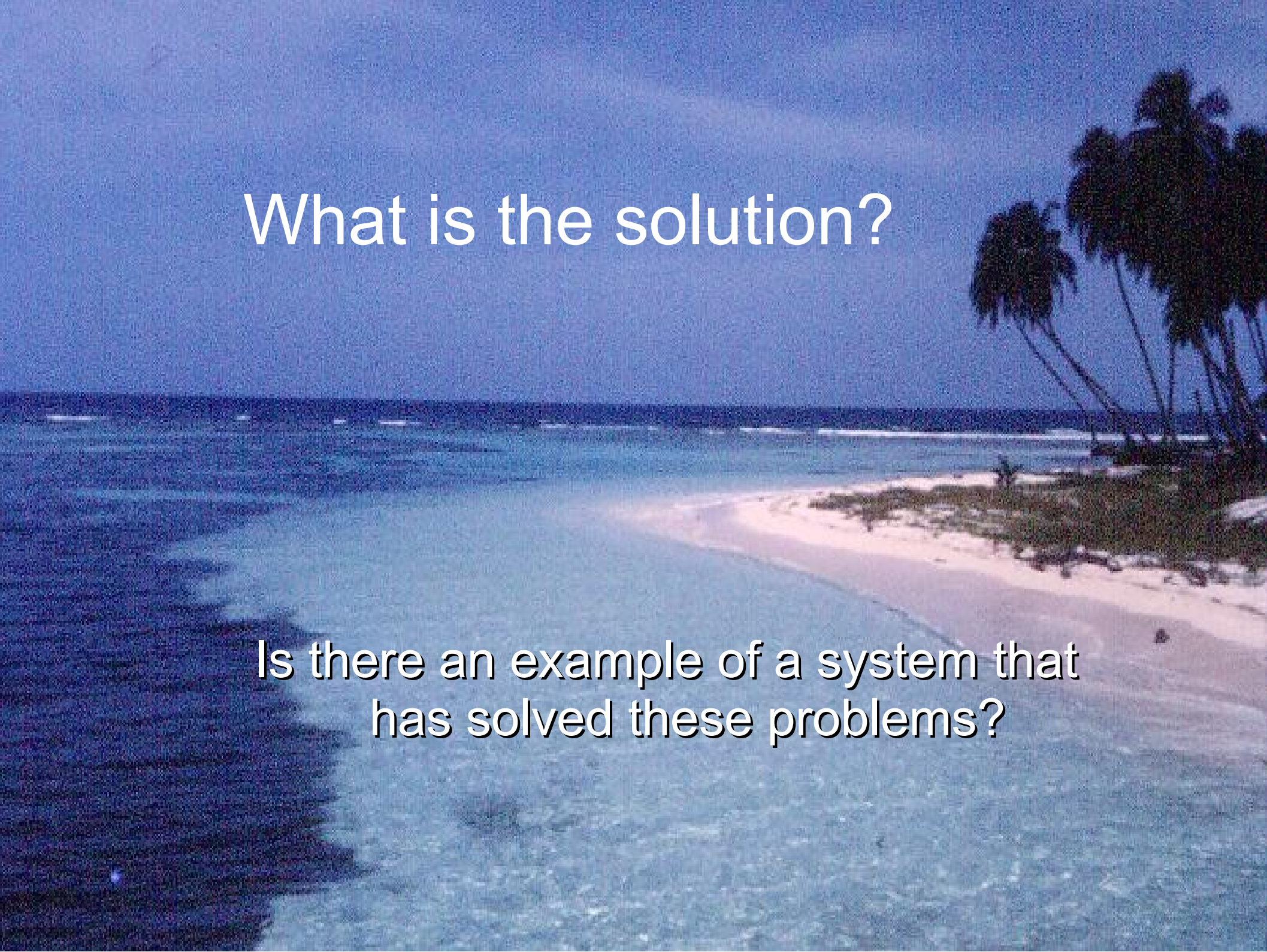
(www.iefworld.org)

Photos taken in the Caribbean and the South Pacific 1969-1980

Our challenge: unsustainable development

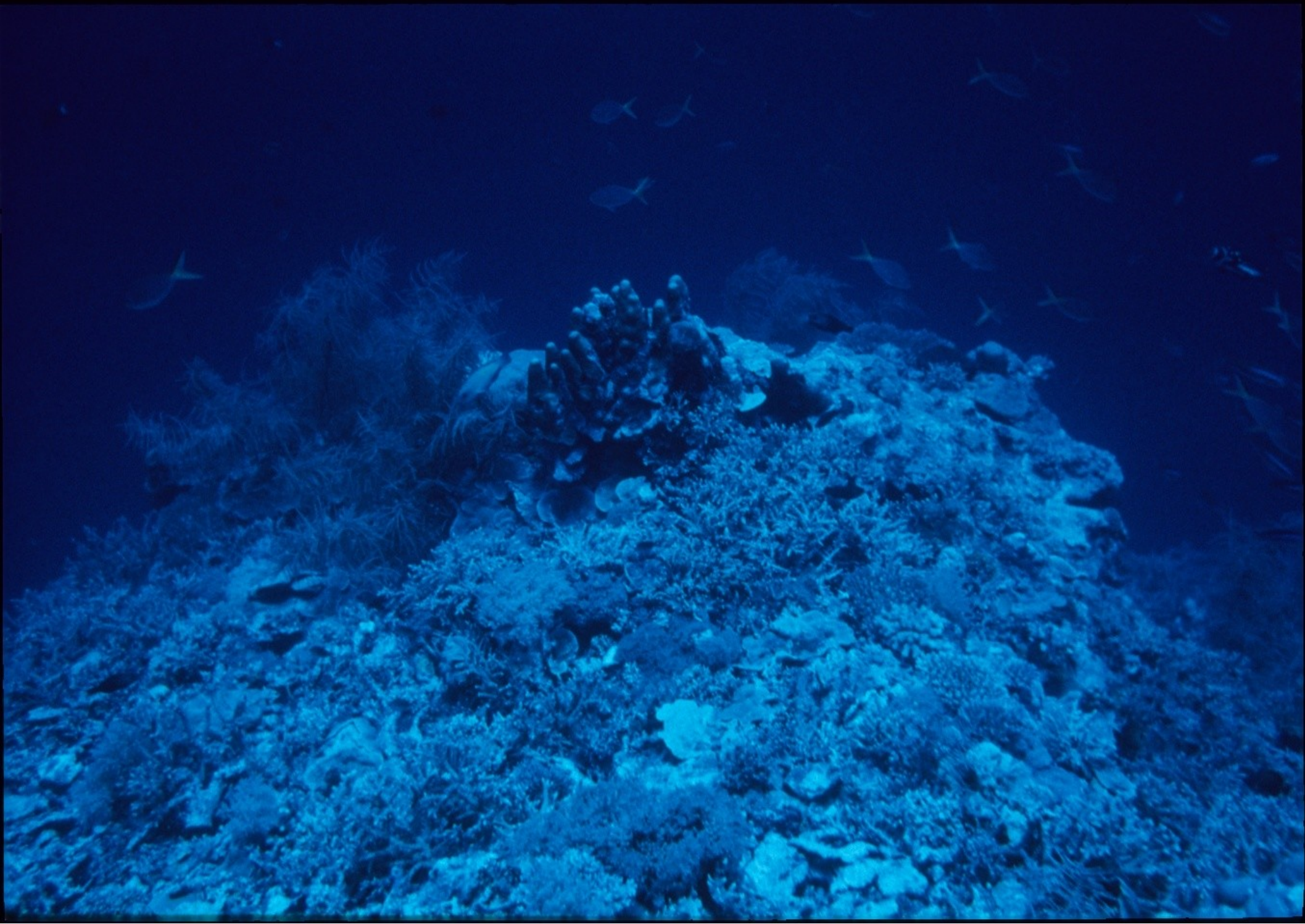
- Rising population
- Increasing urbanization
- Excessive consumption
- Waste disposal, pollution
- Resource depletion
- Energy crisis
- Social tensions, conflicts
- Economic imbalance
- Materialistic, selfish, hedonistic value system


What is the solution?
Is there an example of a system that has solved these problems?

Principles of system organization

- Organized systems follow similar principles and models
- Organization is determined by information content
- Information is stored in various ways: physical, chemical, biological, social (two knowledge systems: science and religion - values)

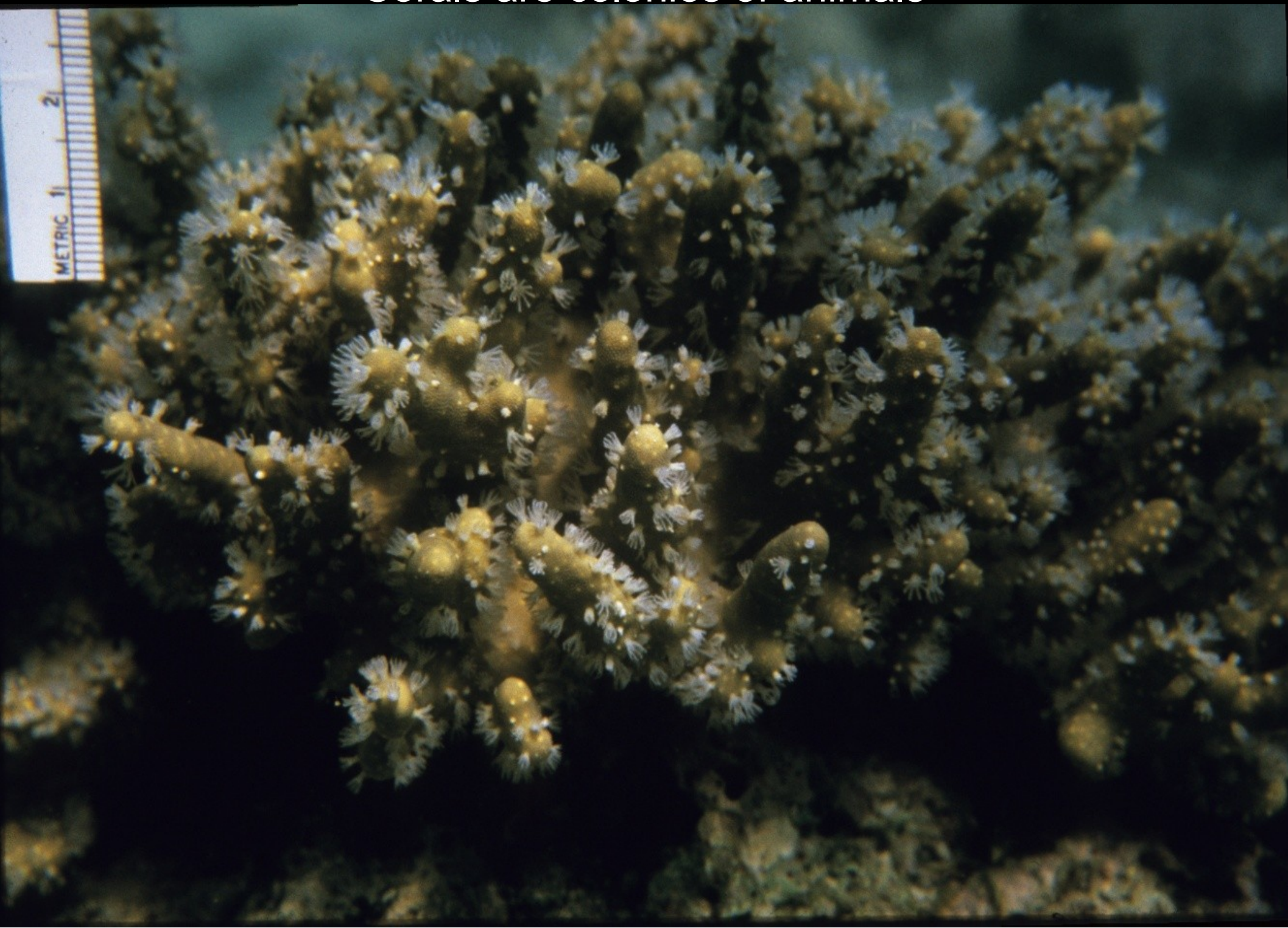
Coral reef ecosystem



What is a coral reef?

- Ancient highly-evolved ecosystem
- Rich in its diversity
- Highly productive
- In a resource-poor environment
- Dynamic, changing but resilient

Corals are colonies of animals



Coral reefs line many tropical coasts

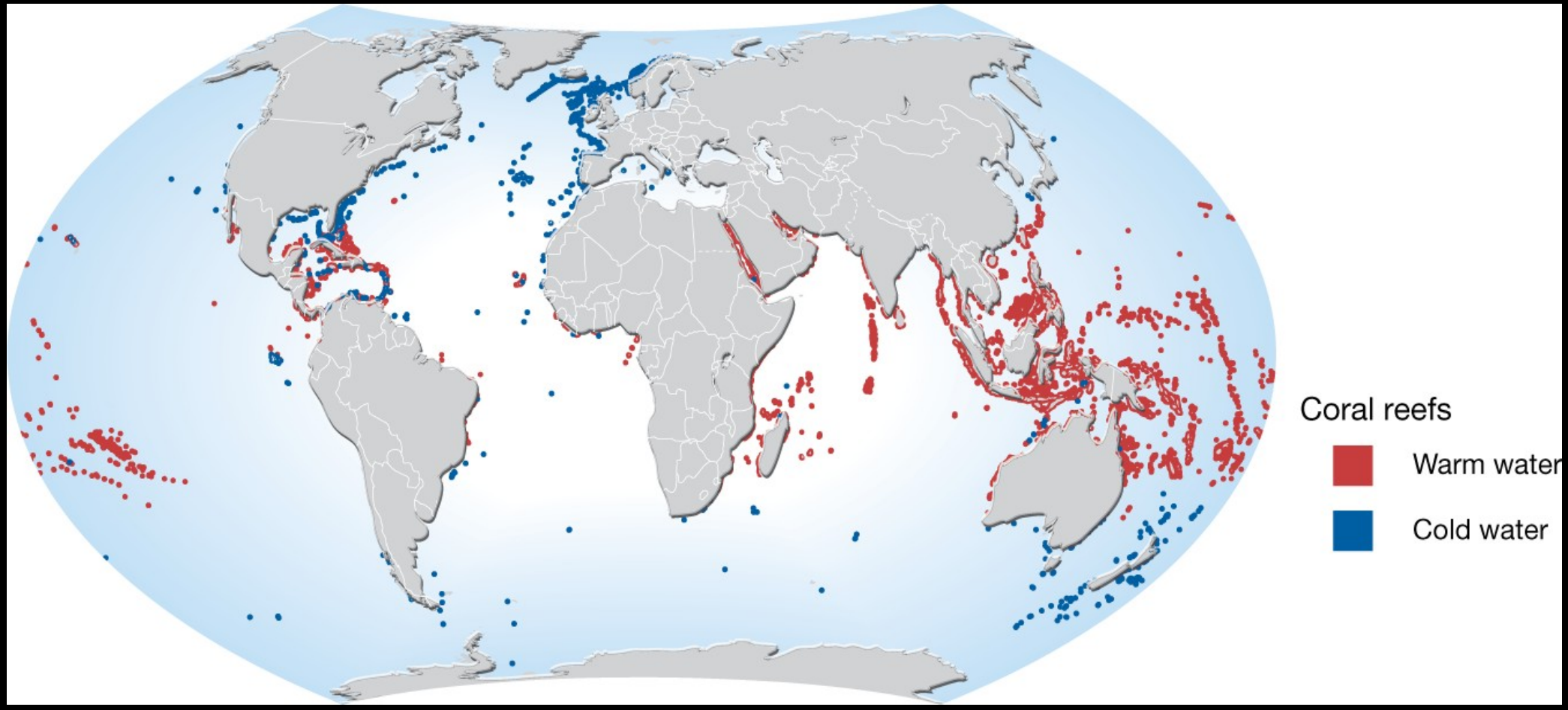
The world's largest structures built by biological activity

Visible from space

Thickness: + 1 km of biological skeletons

500 million people live within 100 km of reefs

Coral Reef Distribution



Grows in shallow tropical waters

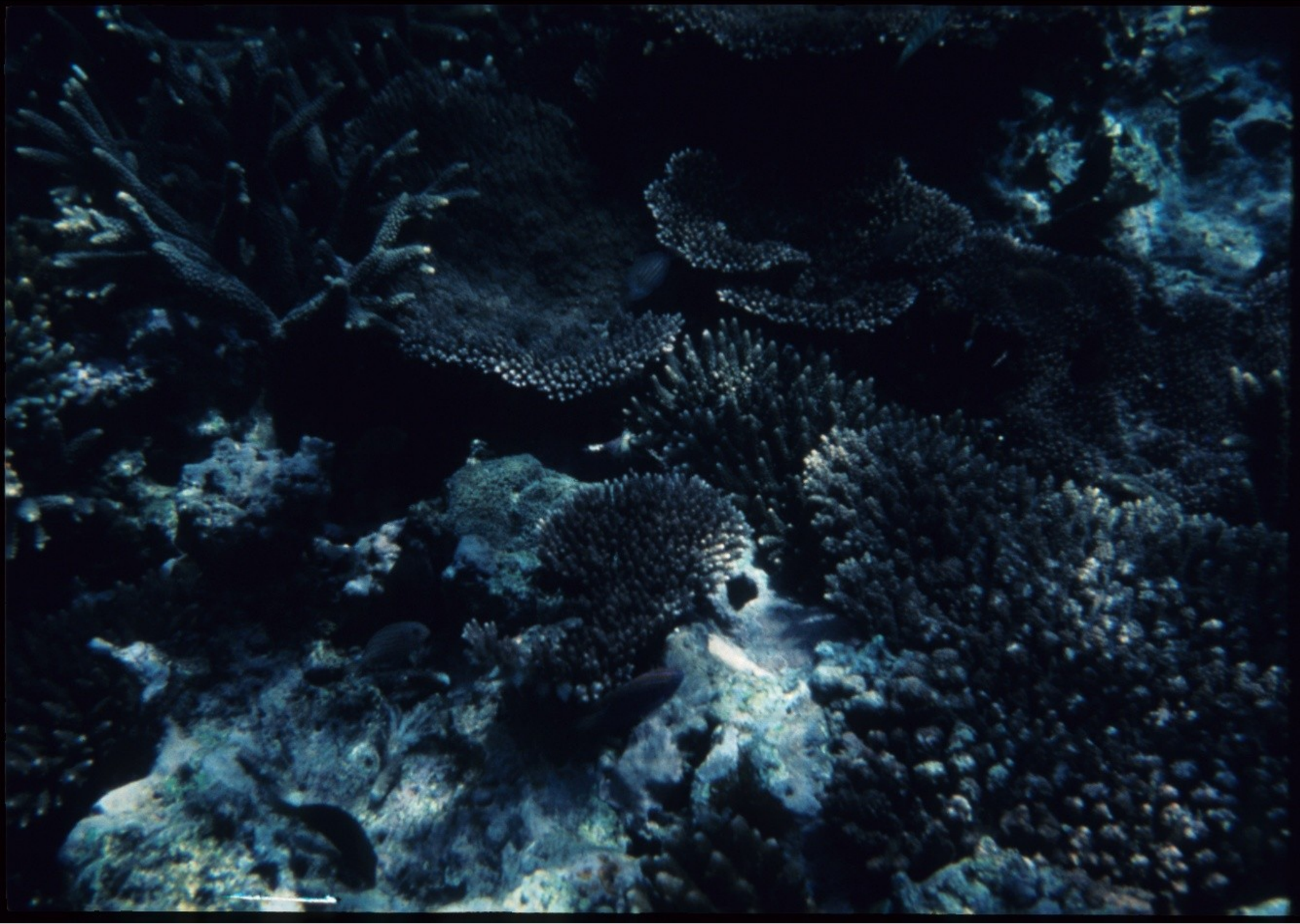
Barrier
Reef

Atoll: Rose Atoll, American Samoa

Atoll: Butaritari, Kiribati

Raised reef : Nauru

Builds its own environment



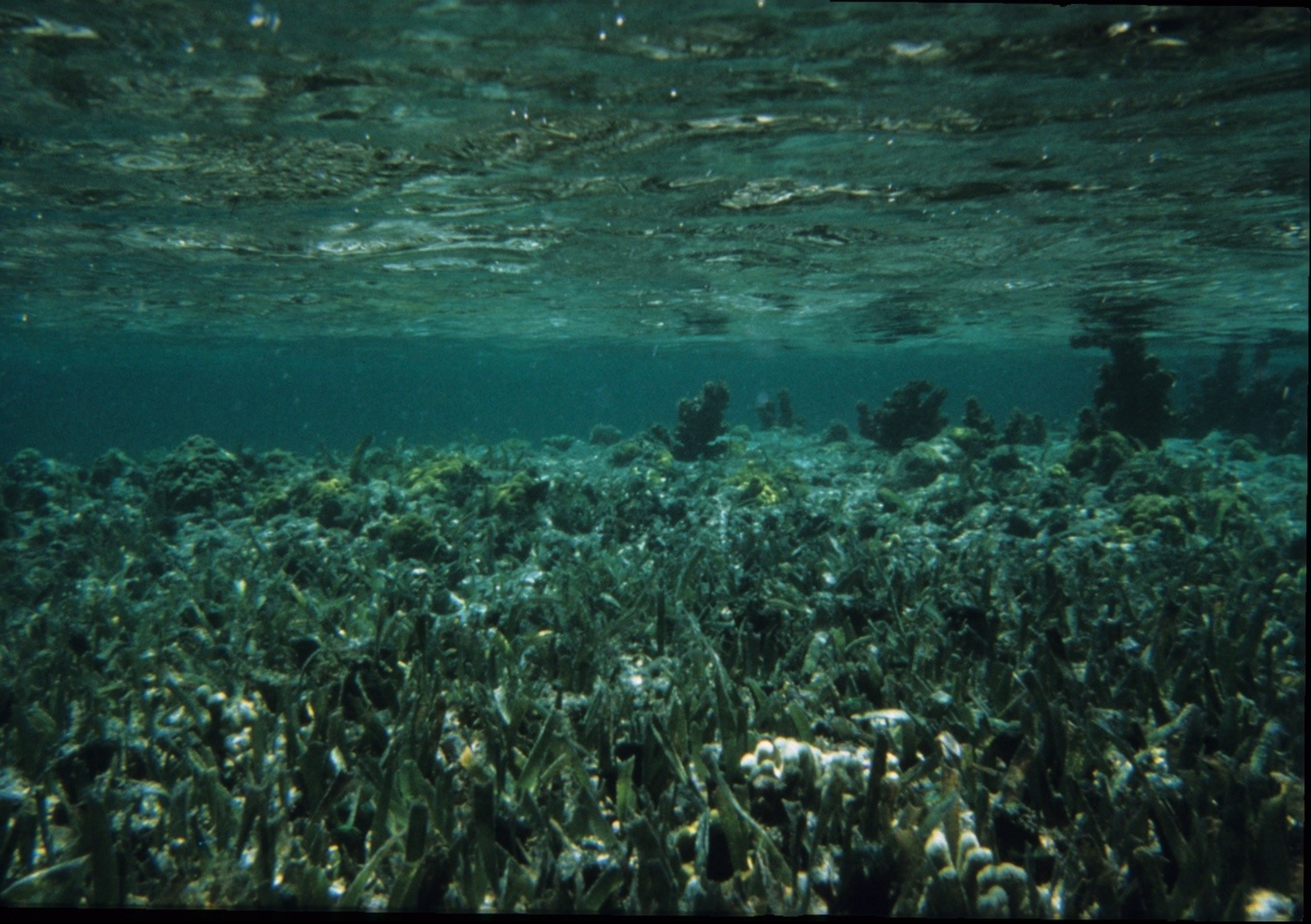
Reef zones

Deep reef

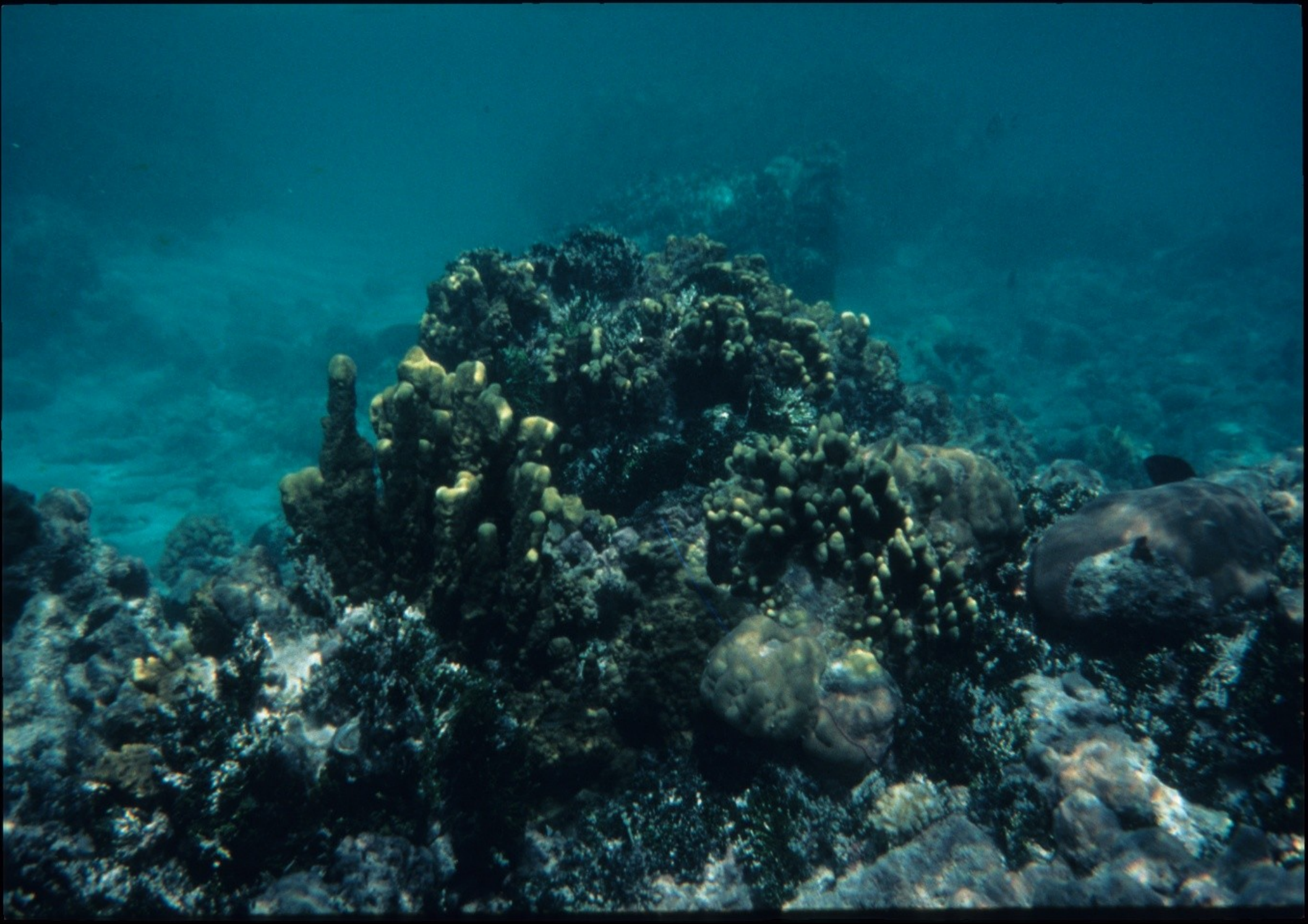
Reef slope

Reef crest algal ridge (Pacific)

Reef crest (Caribbean)



Seagrass behind reef



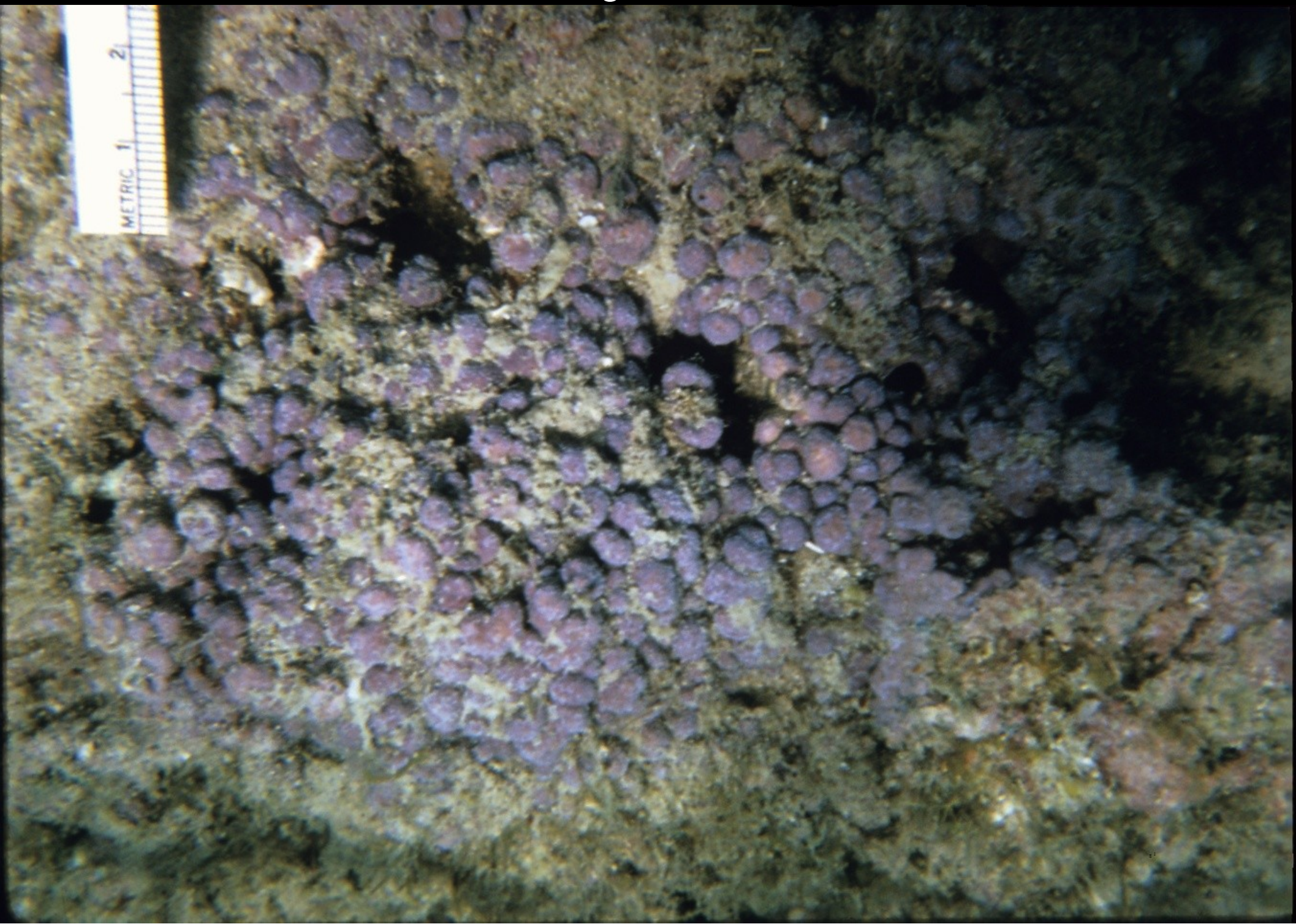
Patch reefs in lagoon

Builds a whole community

Stable and dynamic
(Old coral 4-5 m diameter)

Each organism has its form and function: corals

Coralline algae cement reefs

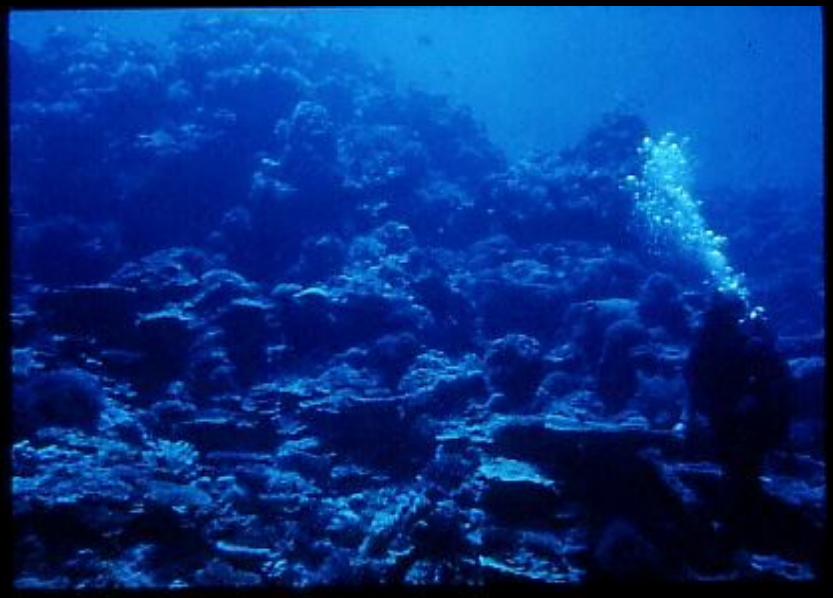


Halimeda algae generate sand

Tropical beaches of biological origin

Reef construction: a delicate balance

Corals



Algae

How can the reef help us to find solutions to our problems?

Carrie Bow Cay, Belize, Research Station of the Smithsonian Institution

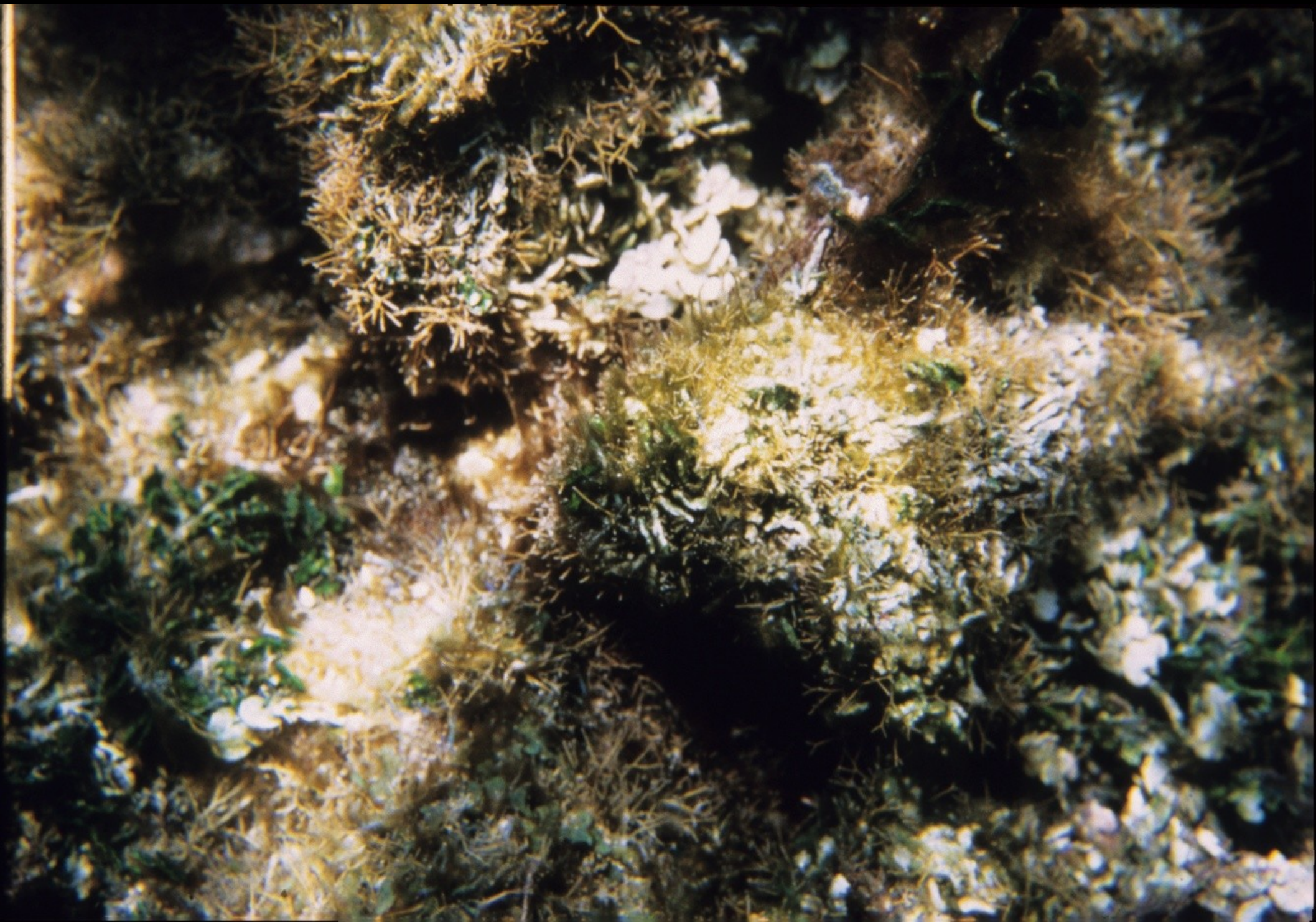
Energy crisis

- Effective capture of maximum solar energy
- Total productivity, not highest productivity
- Rapid energy transfer
- Efficient energy use
- Little waste

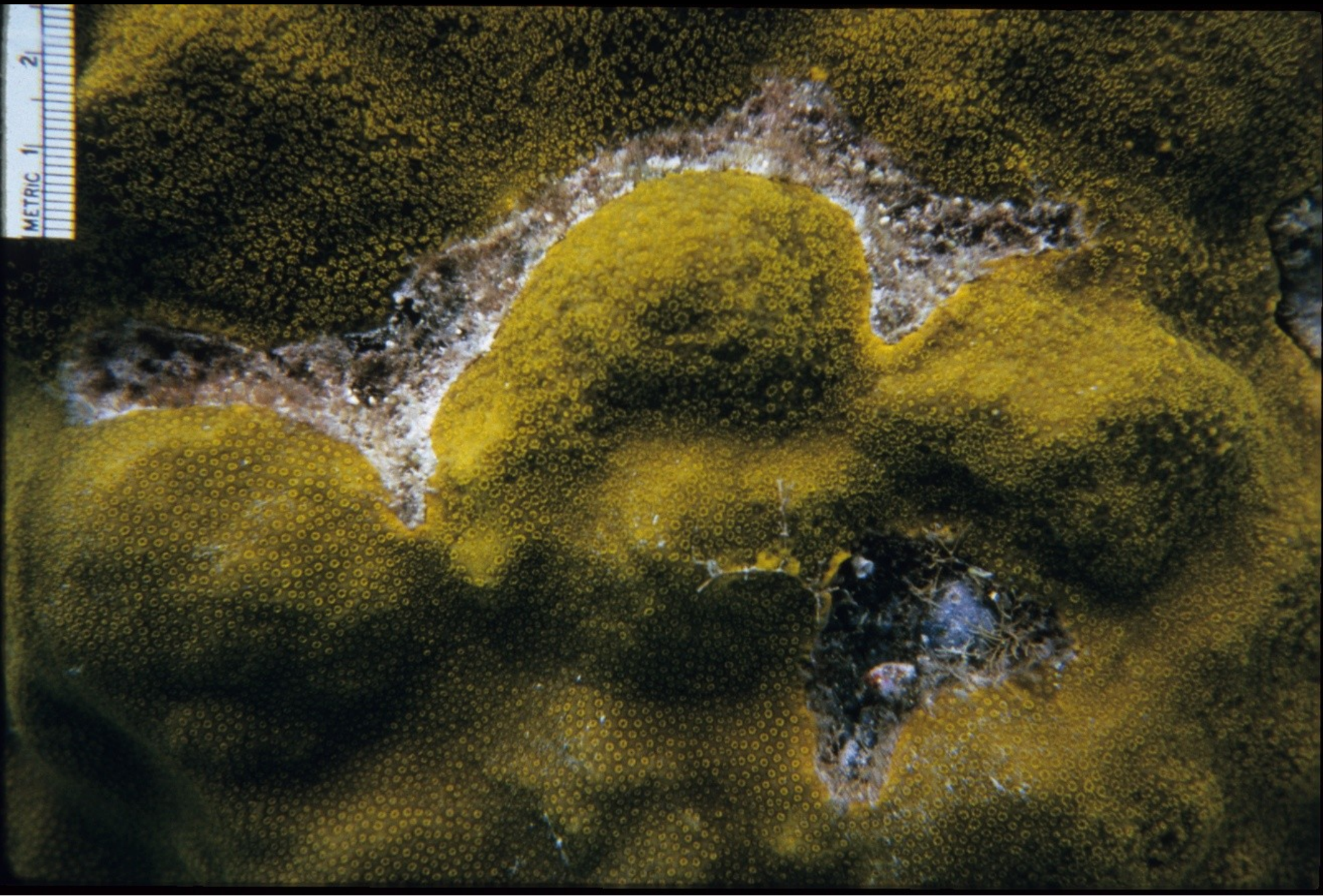
Generates large surface to absorb light

Light is required for coral growth

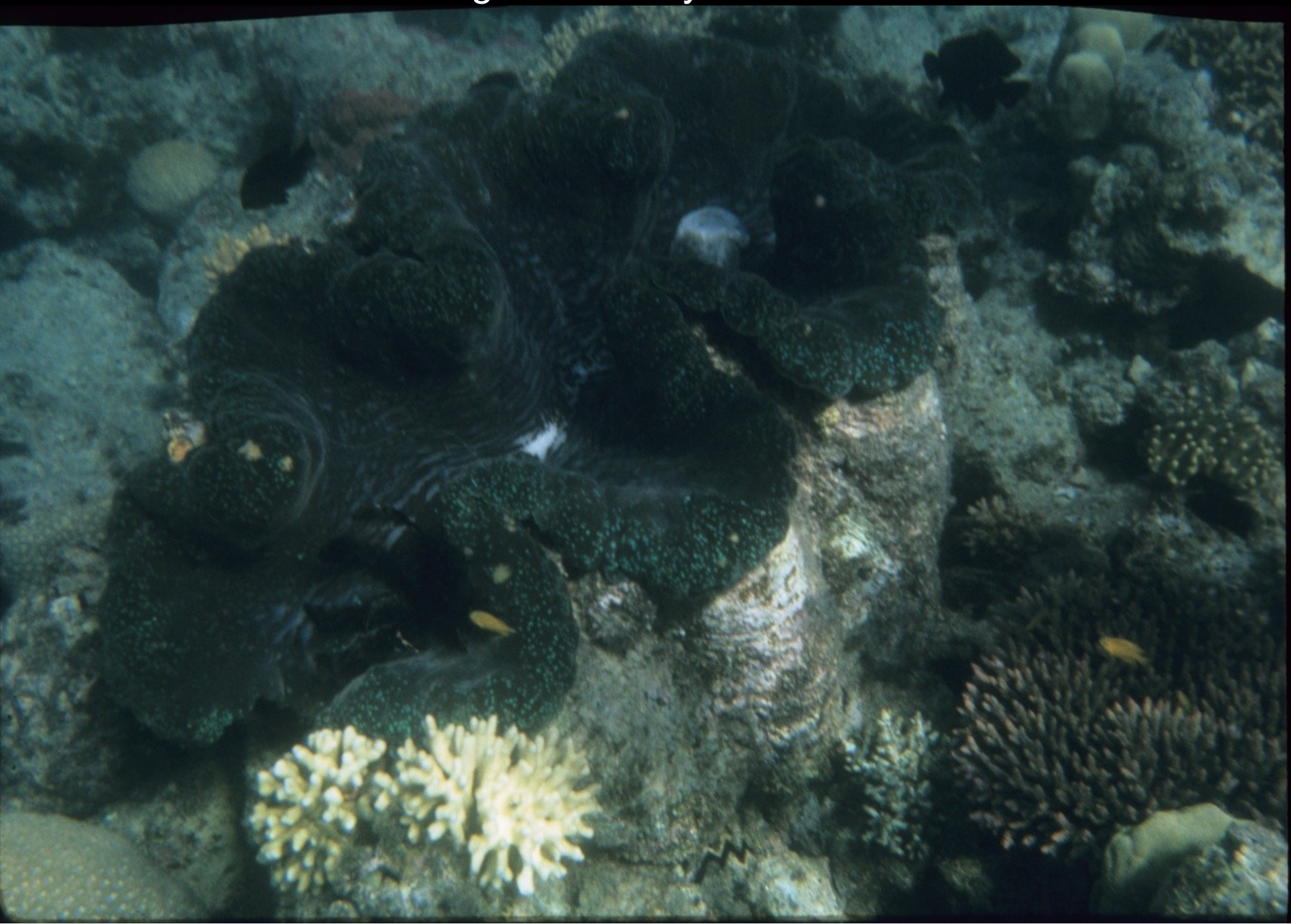
Algal turf is highly productive



Symbiosis coral/algae



Algal-animal symbioses

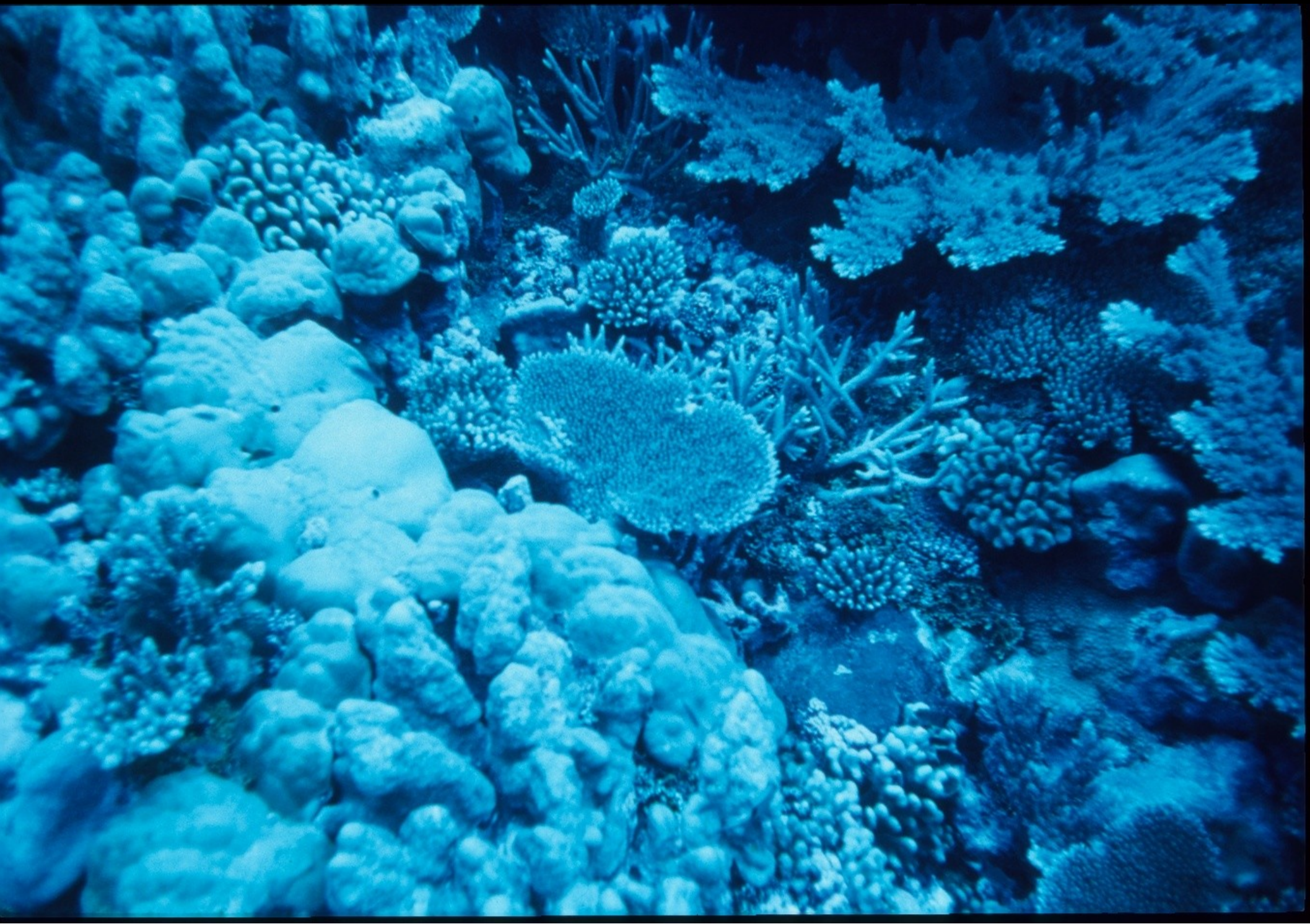


Population

- Multiple levels of control, balance, dynamic change
- High efficiency in energy capture allows high density
- System creates additional space for population increase
- Diversity of forms and niches allows higher overall density

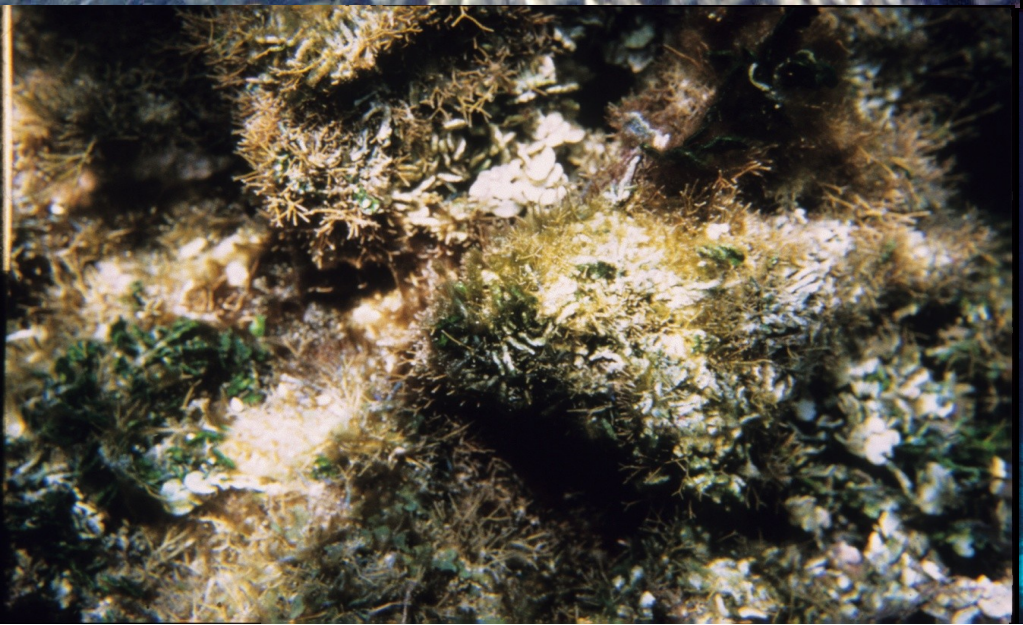
High density

High diversity



High reef biodiversity

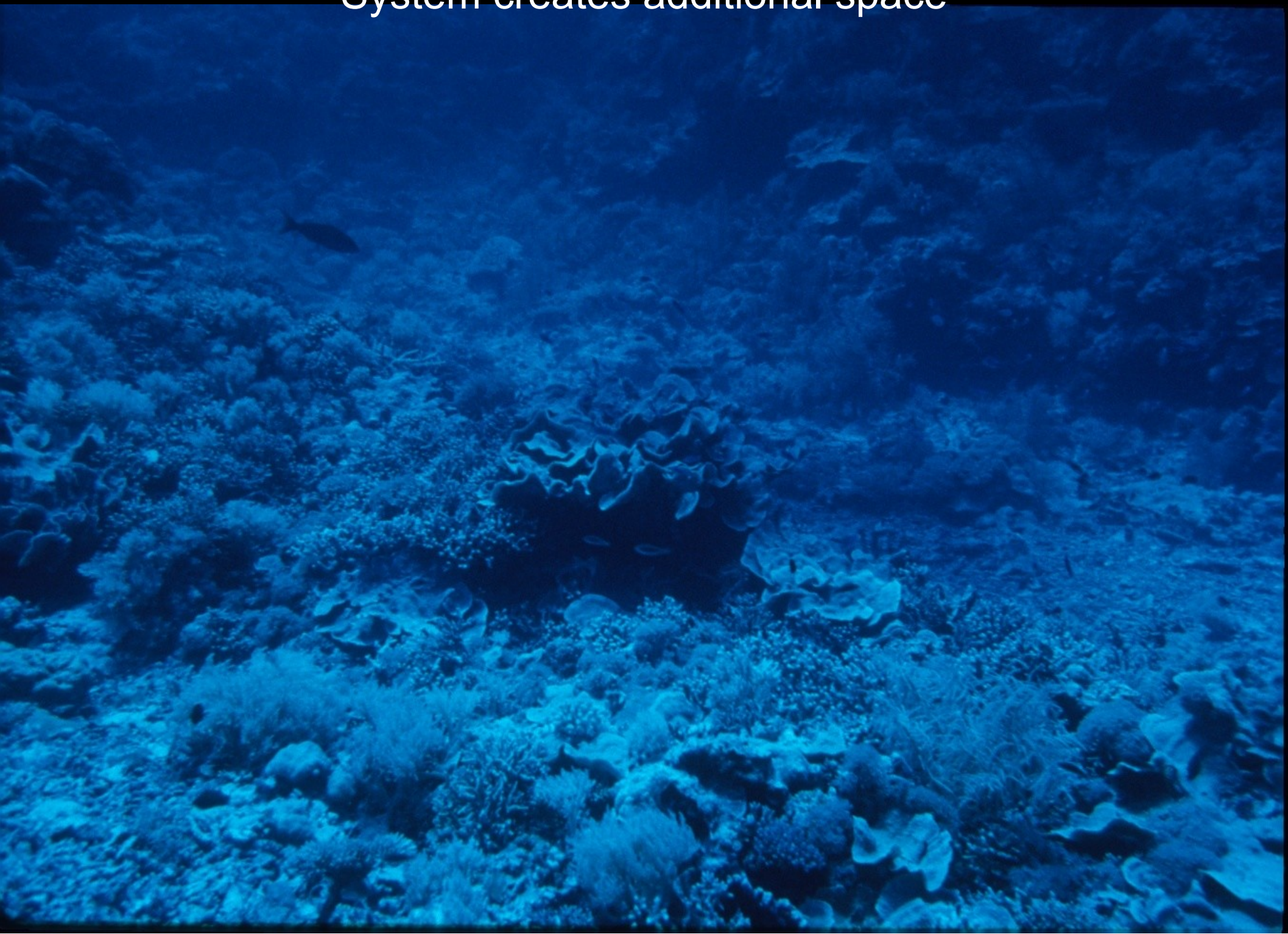
400 corals, 4000 molluscs, 1500 fish just on the Great Barrier Reef



Complex spatial organization

Coral reef like a city

System creates additional space



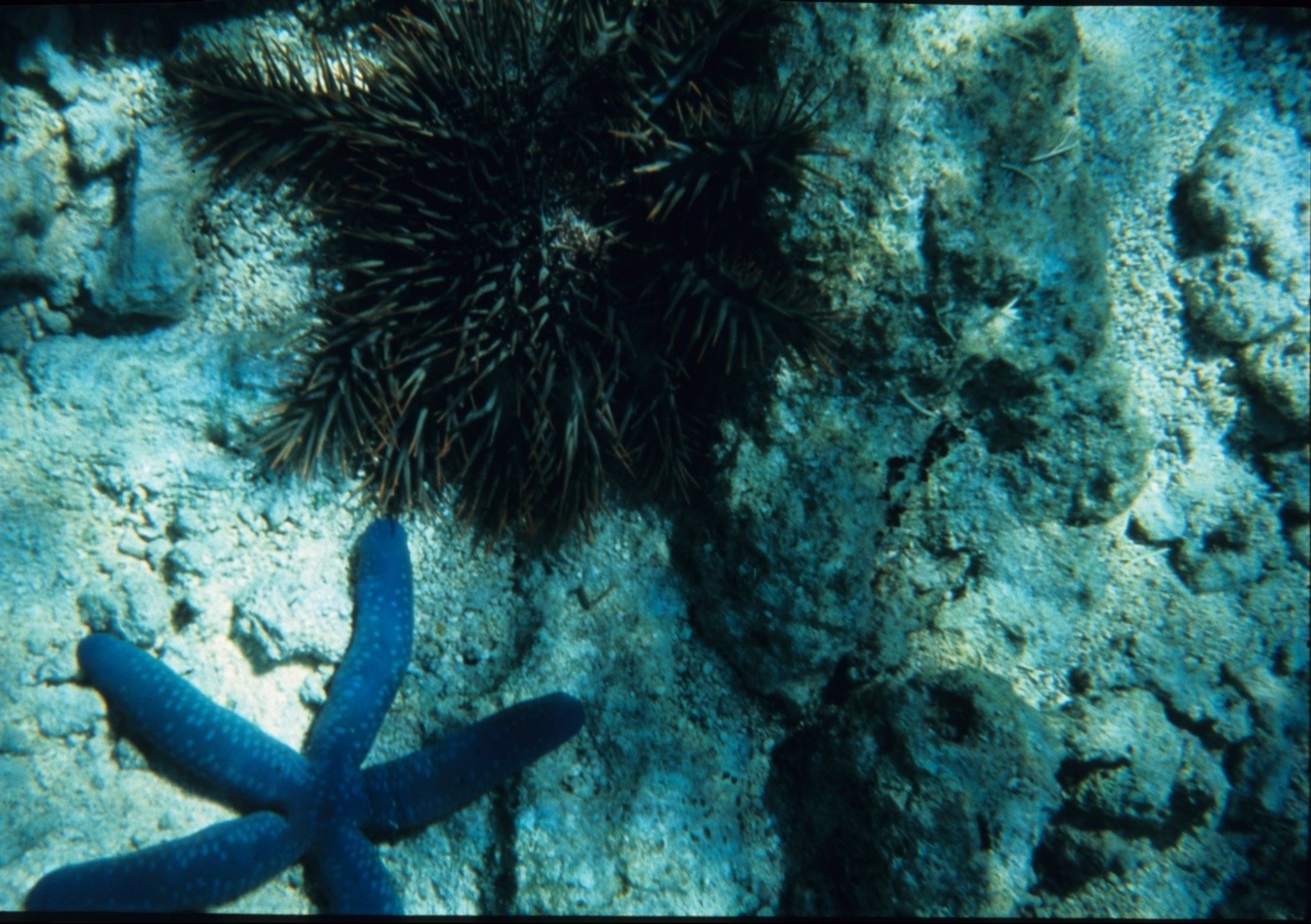
Generates large functional surface

Like an apartment building

Coral like a building

Many forms of coral

Reef able to regenerate after damage



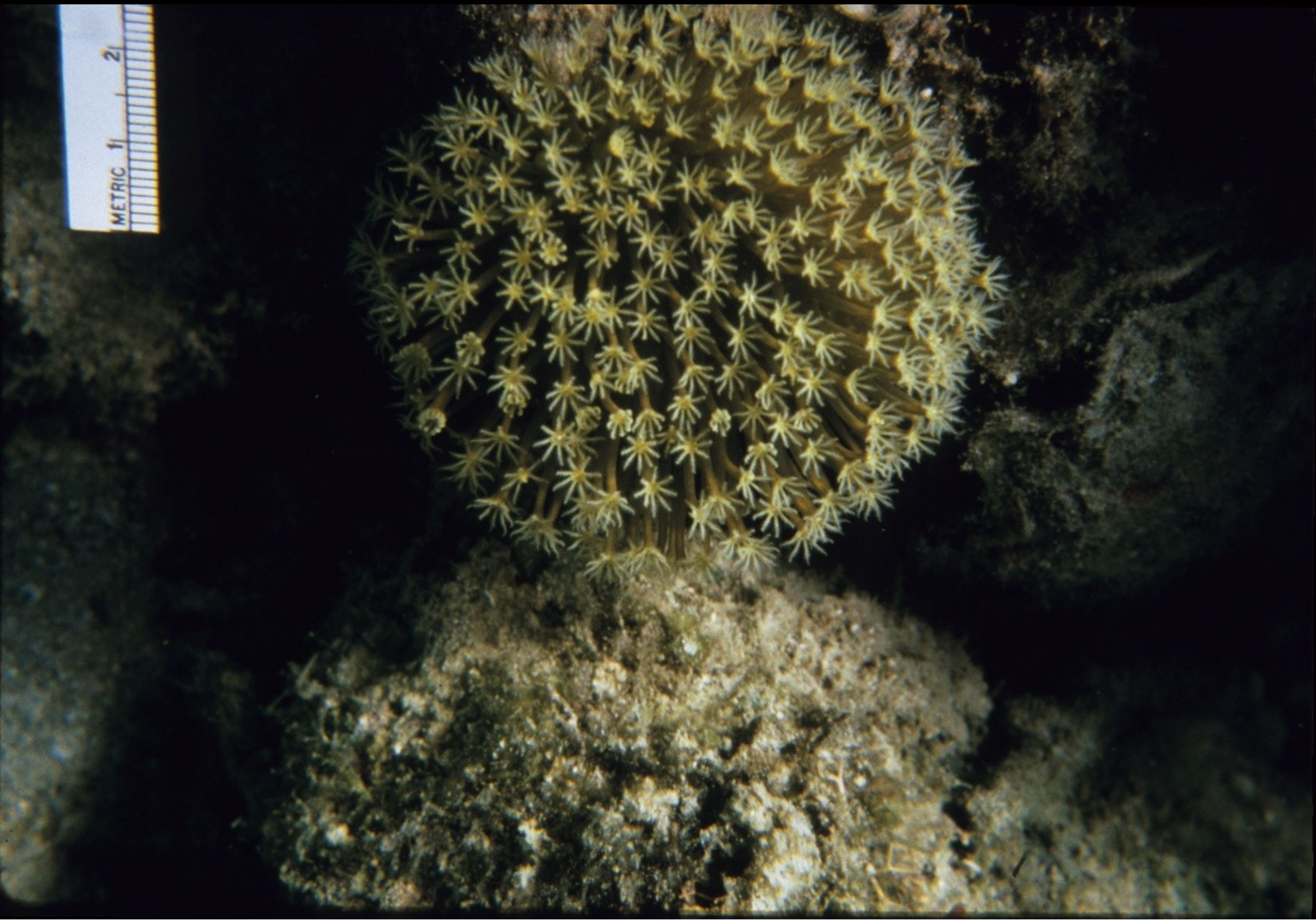
Multiple forms of population control - *Acanthaster*

Parrotfish creating space for coral regeneration

Resource depletion

- Highly evolved integrated system
- High standing stock at upper system levels
- Effective capture and storage of scarce resources
- Efficient management of materials flows

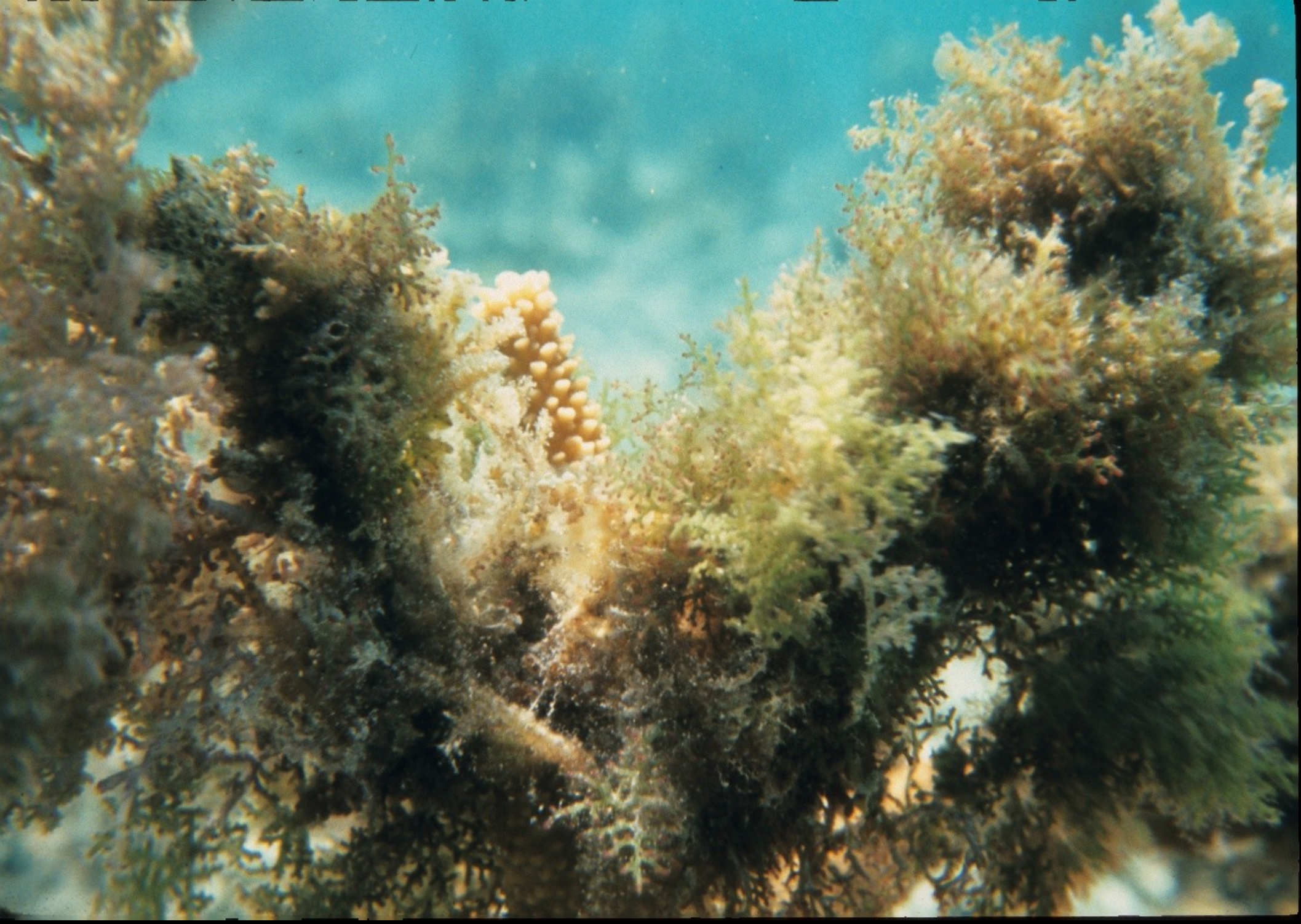
Capture of scarce resources



Alternative replacement systems

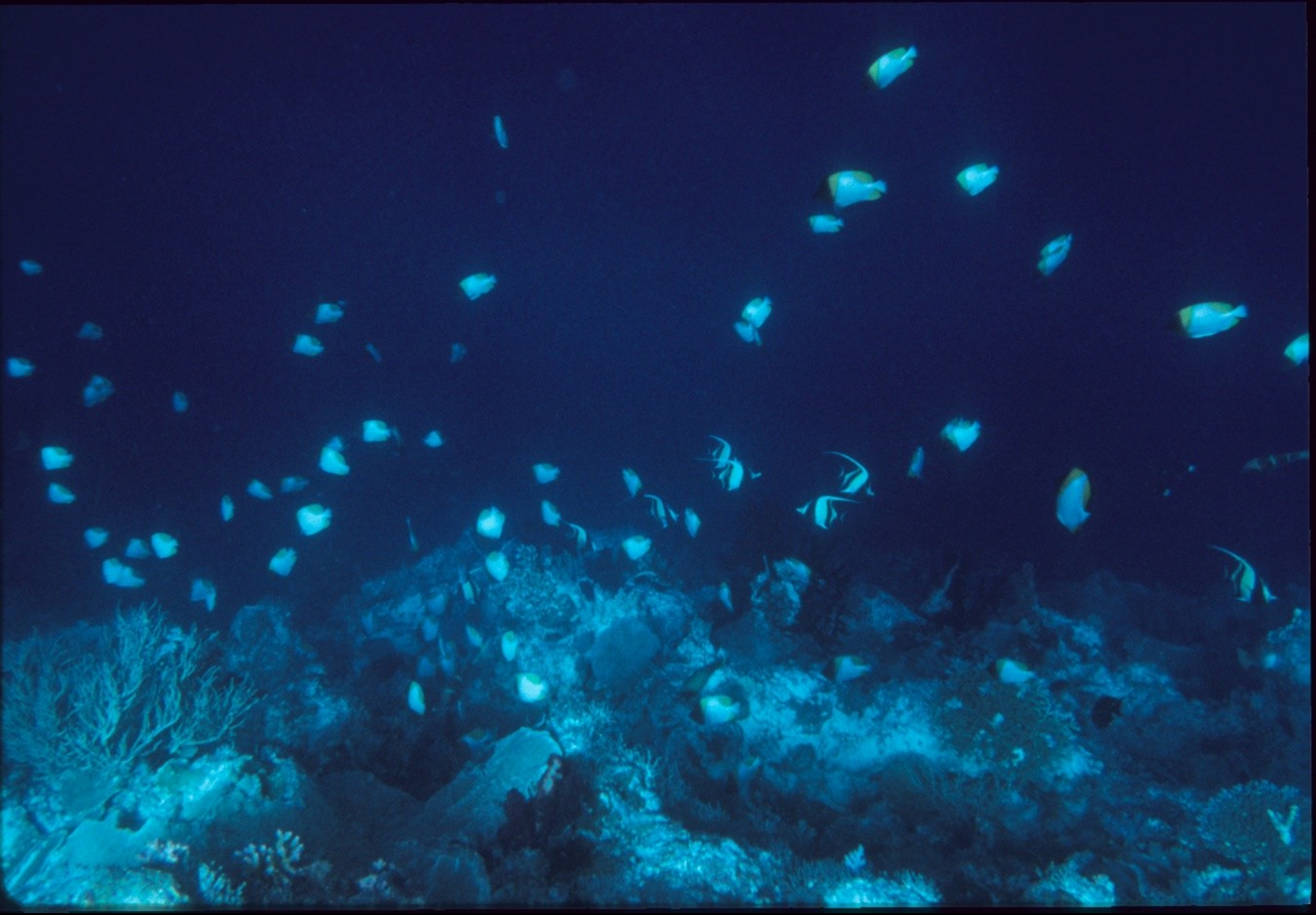
Excessive consumption

- High productivity
- Energy efficiency
- Efficient transfers in the system
- Recycling



High algal productivity

Padina (Glovers Reef, Belize)

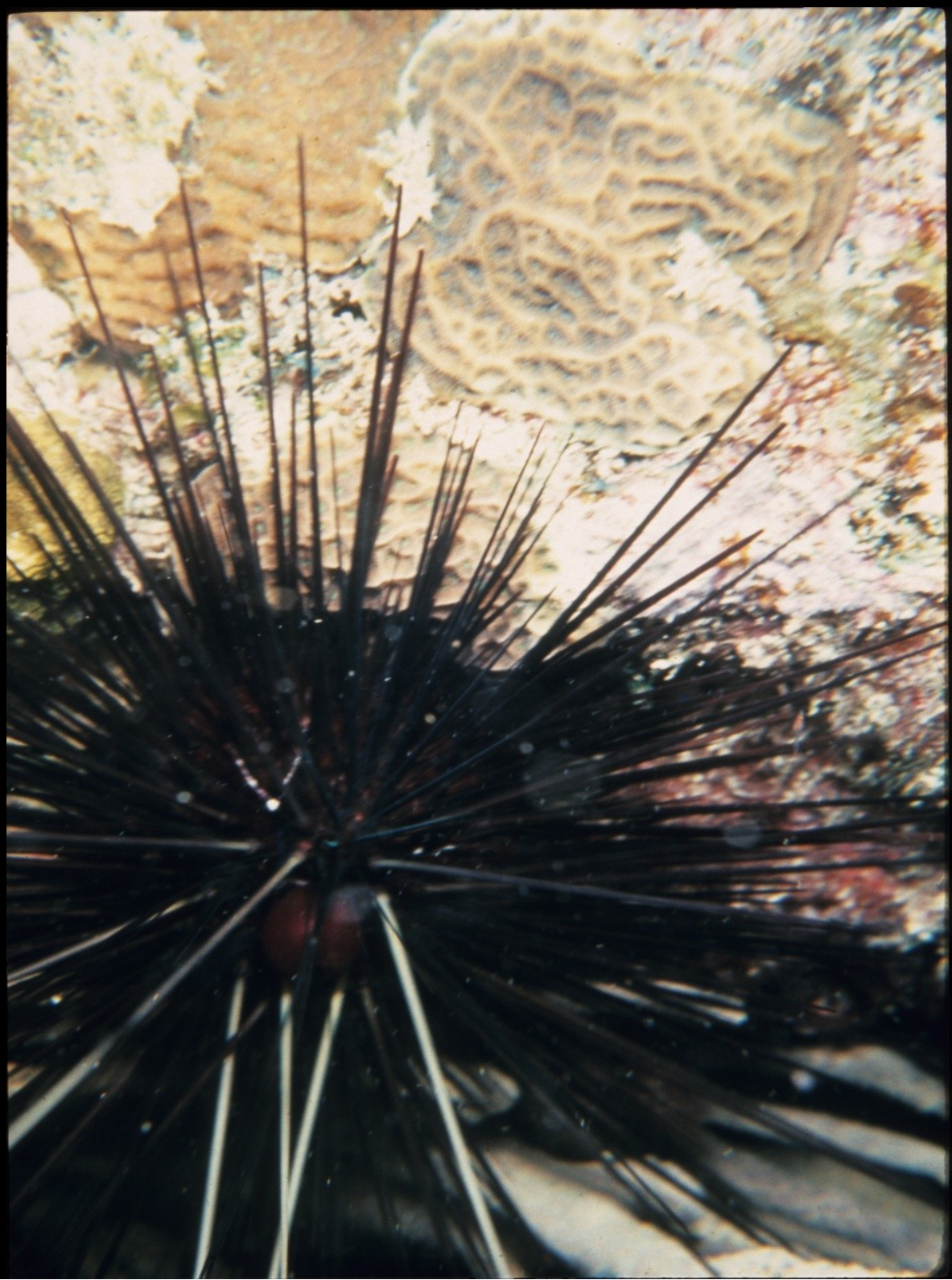


High stock of fish

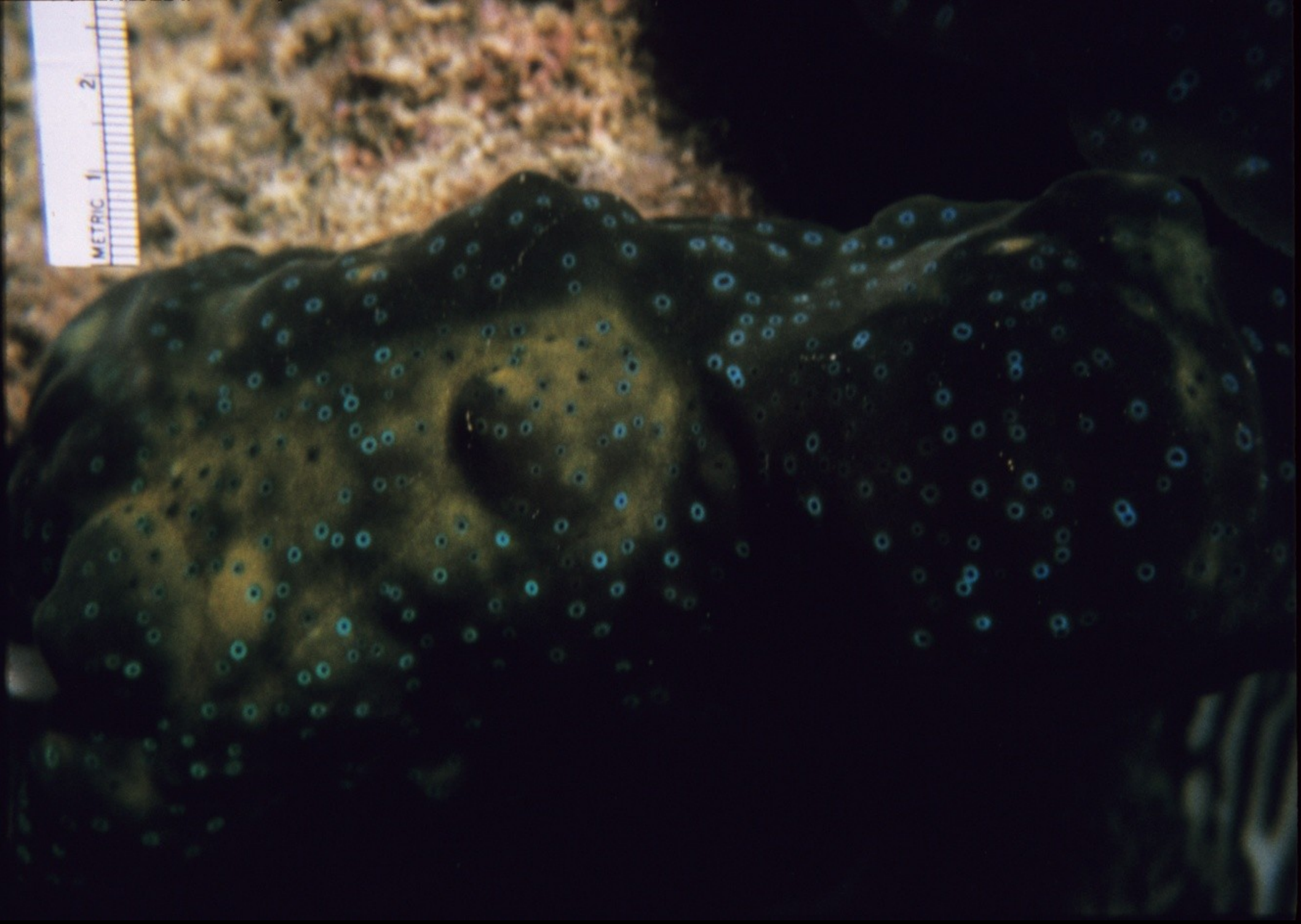
Waste, pollution

- High recycling rate
- Little loss from the system
- Diversity in the system
- Multiple control mechanisms, pathways

Efficient waste collection and recycling



Multiple layers of organisms



Sponges filter water

Intense competition for space

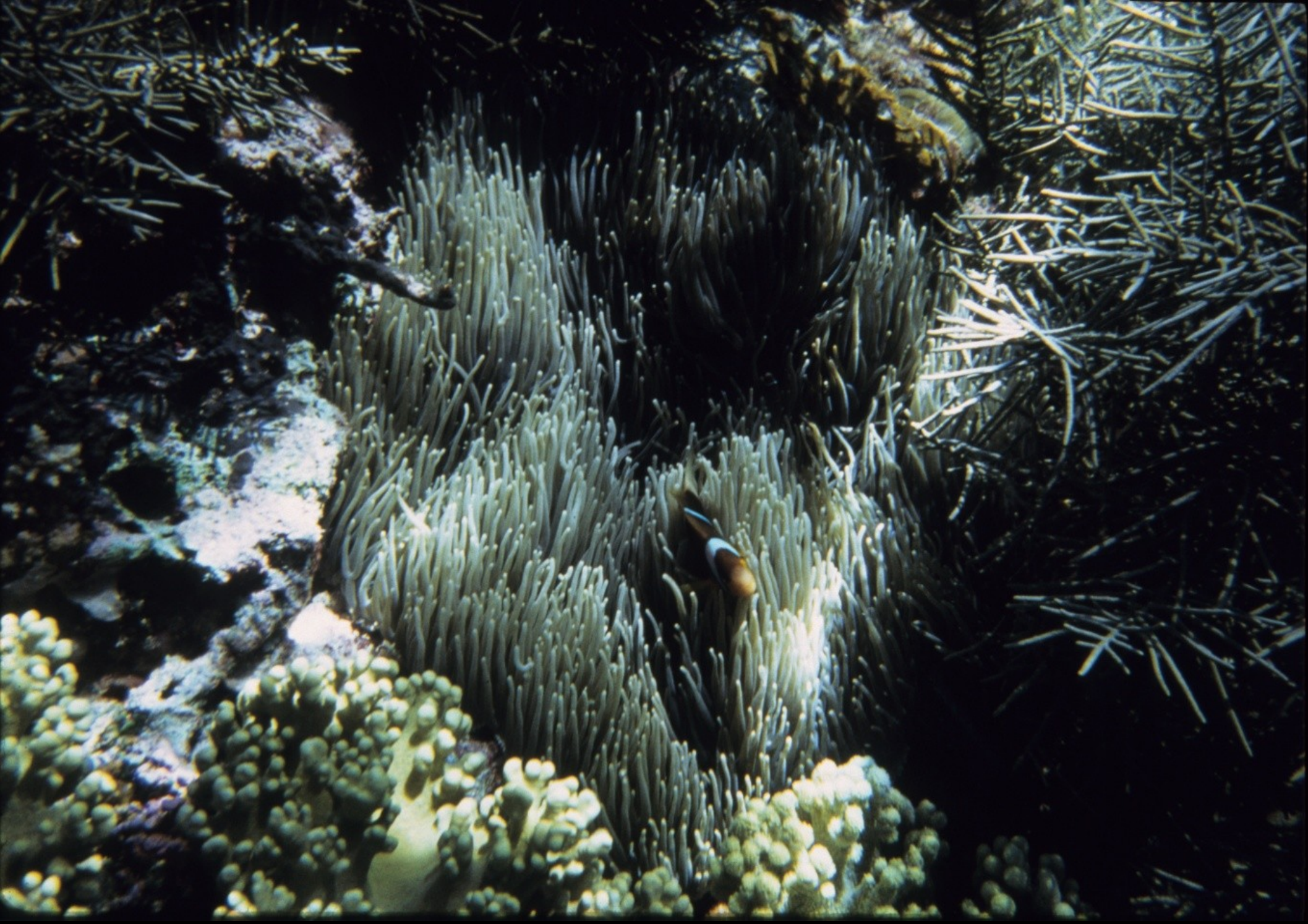
Interactions

- Many symbioses
- Inter-specific collaboration, mutual assistance
- Balanced systems of control and regulation

Shelter

Cultivation of resources

Cleaner fish (collaboration)



Clownfish and anemone (mutual assistance)

Equivalent human values

- Symbiosis = cooperation, respect, solidarity
- Balance = moderation
- Justice – a place for everyone
- Decentralization with coordination
- Like wealth creation in an economy

Coral reef vulnerability

- Delicately balanced ecosystems
- Subject to local and global stresses
- The accumulation of interacting impacts multiplies damage
- Today coral reefs no longer have the time to recover

Now rapidly declining – like our society

LOCAL IMPACTS: Over fishing

Removing top predators or major herbivores upsets the reef balance

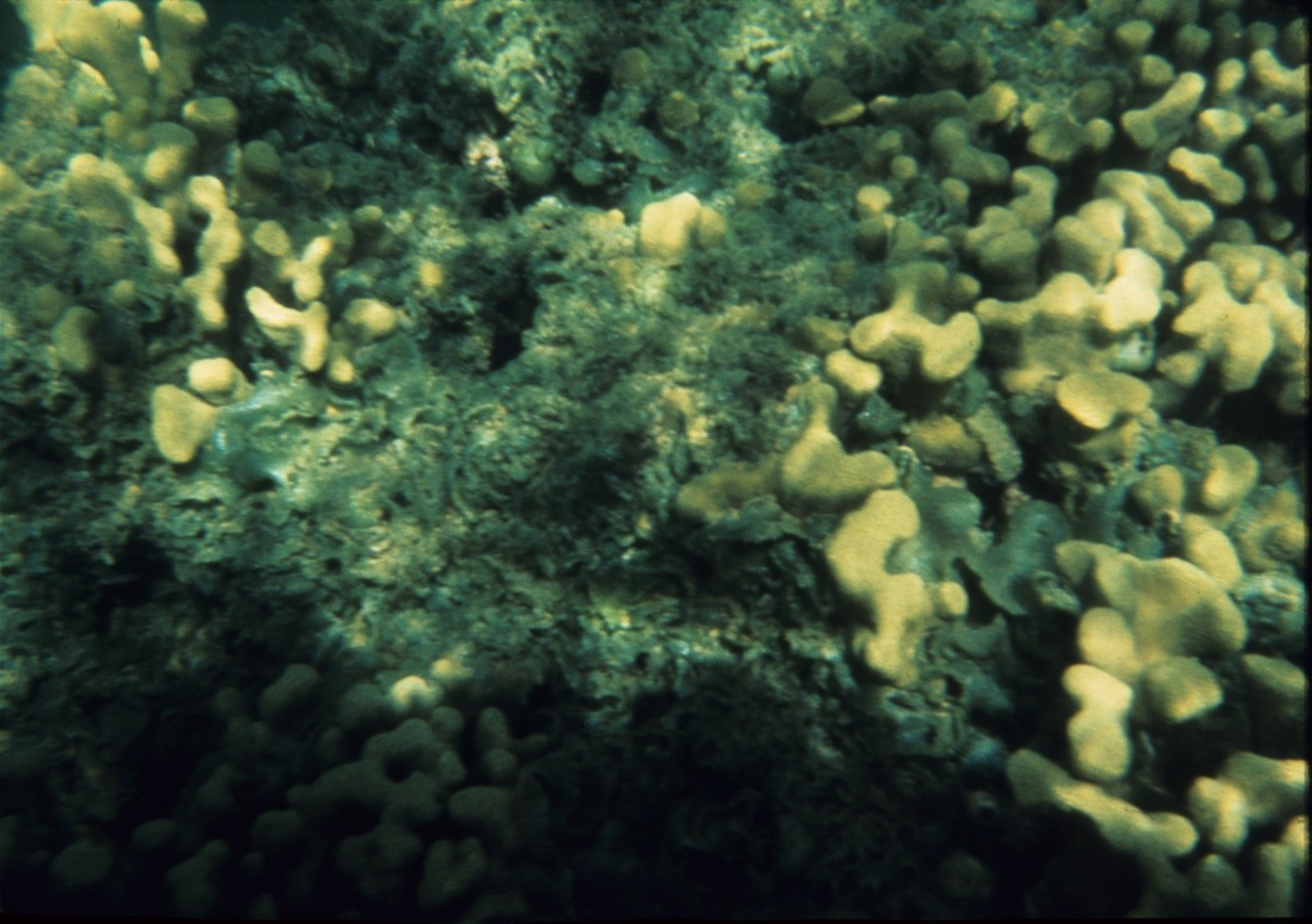
Fishing with dynamite, cyanide or iron bars destroys the reef

Dynamite fishing

Impacts from terrestrial runoff

- Land-based sources of sediment smother reefs
- Polluted runoff from cities and agriculture causes eutrophication

Kaneohe Bay, Hawaii, with urban pollution



Eutrophication causes algal overgrowth

Reef smothered by *Dictyosphaeria* (green bubble algae)

Construction and dredging

physically damage reefs, change water circulation and block species movements

Reefs are the first ecosystem impacted at a planetary scale

Reefs are declining everywhere

In the Caribbean, living coral cover has declined 80% (from 50% to 10%) in 30 years

(Toby Gardner, *Science*, 2003)

Is this the canary in the coal mine for ecosystems?

Why?

Coral bleaching

- In the stable tropical climate, corals live close to their maximum temperature limit. One degree more can be fatal if it lasts too long. Stressed corals eject their zooxanthellae (algae living inside them) and bleach. If the stress lowers, they can recover their algae. Otherwise they die.

Planetary risk from climate change and CO_2

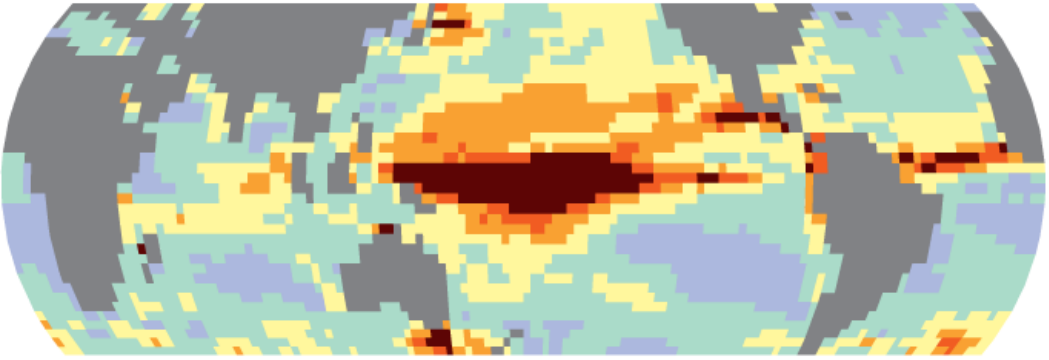
CO_2 must be kept below 350 ppm

Dissolved carbon dioxide makes the water more acid and reduces calcification

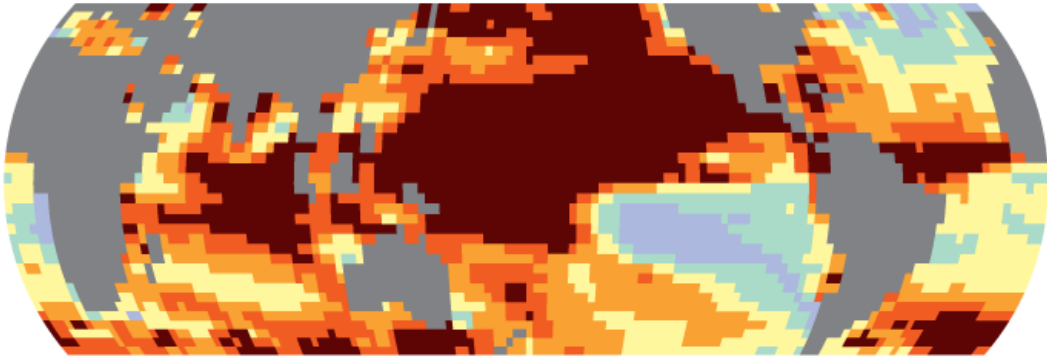
Climate change: predicted hot spots

HadCM3 model, SRES A2a scenario

2030-2039

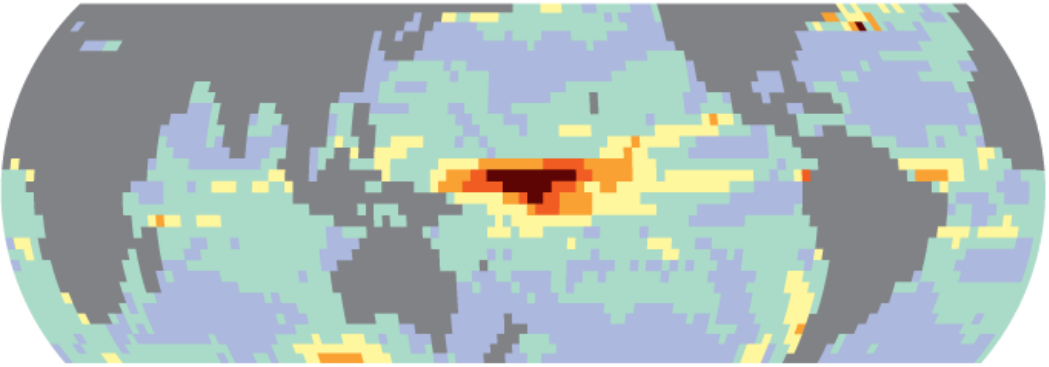


2050-2059



PCM-PCM model, SRES A2a scenario

2030-2039



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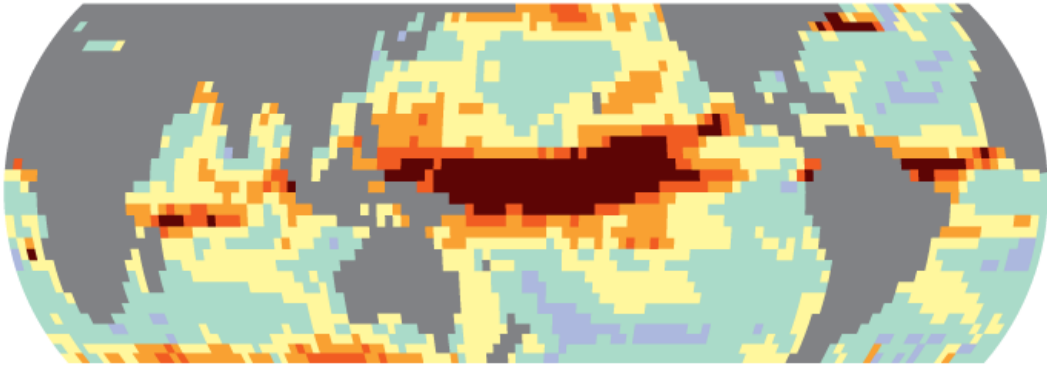

Climate scenarios

Annual degree heating months

If the corals die, algae take their place

Many reefs have shifted from coral to algae, and it is difficult to return to dominant coral cover as algae prevent larval settlement

If growth slows, erosion can exceed construction

State of the reefs

(Wilkinson, *Status of Coral Reefs of the World:* 2004, 2008)

- 19% of world reefs are destroyed
- Of the 16% damaged in 1998, 40% are recovering, but 60% were too badly affected, or subject to other human pressures
- 15% of reefs are threatened by an immediate collapse
- 20% are threatened in the longer term
- So 54% of reefs are destroyed or in danger (70% in 2004)
- The remaining 46% are only threatened by climate change and acidification


Are we destroying the best model for our own future?

The future for coral reefs?

- Dawn of reef sustainability?

- Sunset on a wasted heritage?