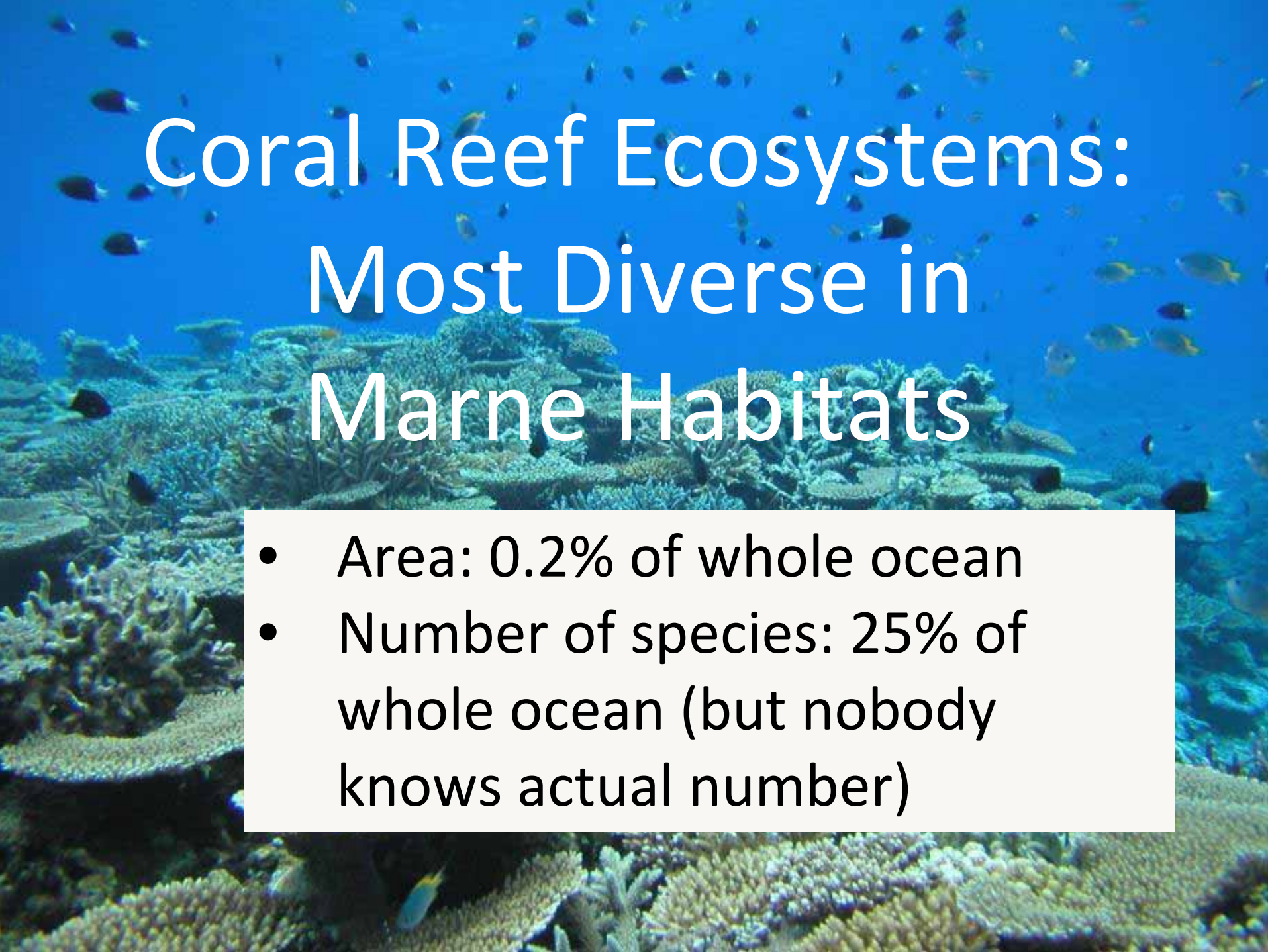
Session 2

Biodiversity Conservation

TPM 8 at Nago, Okinawa
Nov. 22, 2011

Anthropogenic effects on coral reefs: at local and global scales

Kazuhiko Sakai
Tropical Biosphere Research Center,
University of the Ryukyus

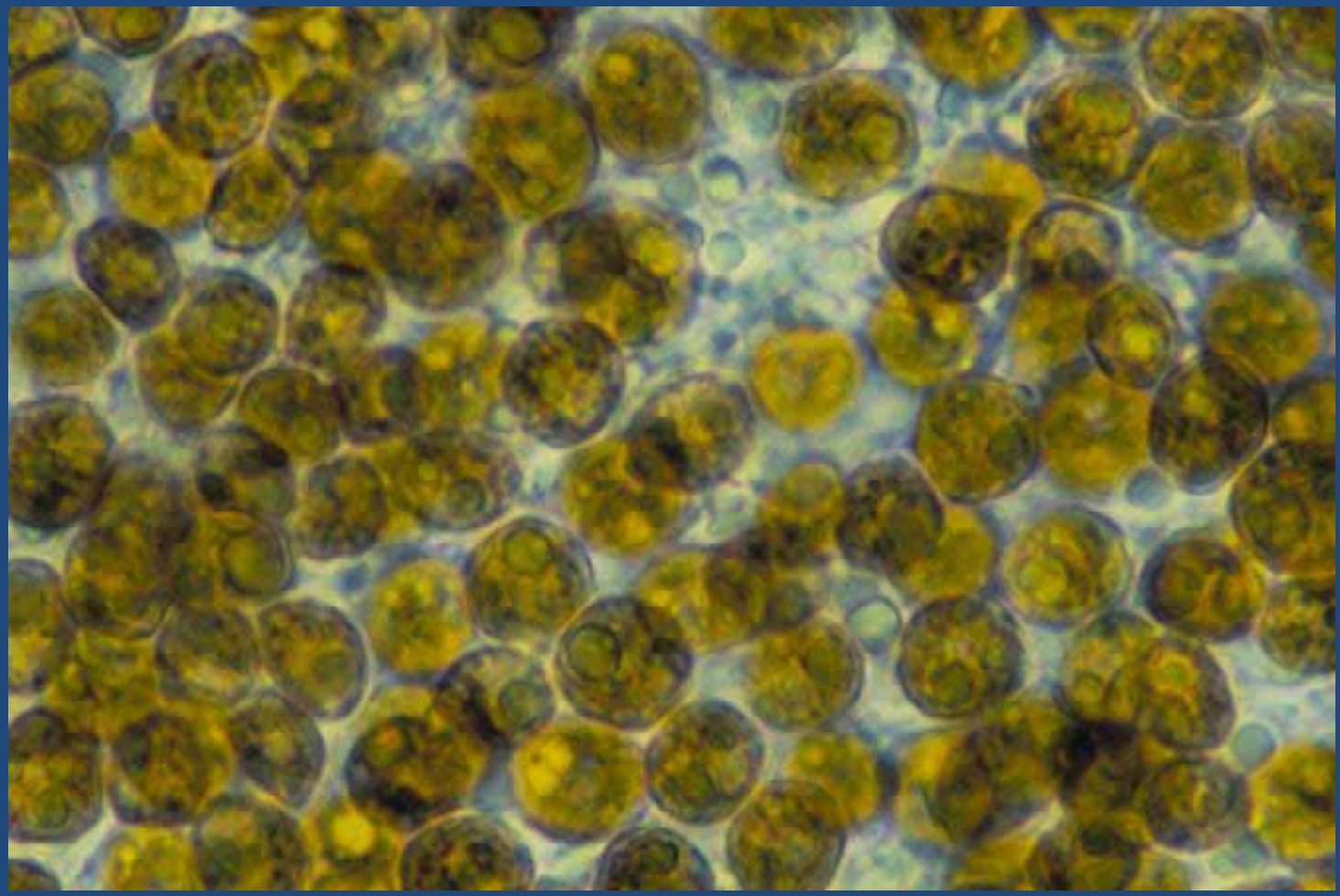


Coral Reef Ecosystems: Most Diverse in Marne Habitats

- Area: 0.2% of whole ocean
- Number of species: 25% of whole ocean (but nobody knows actual number)

Hermatypic (reef-building) corals are dominant primary space users in coral reefs

Zooxanthella (unicellular organism)
lives in cells of corals.
Zooxanthellae photosynthesize within the cells.

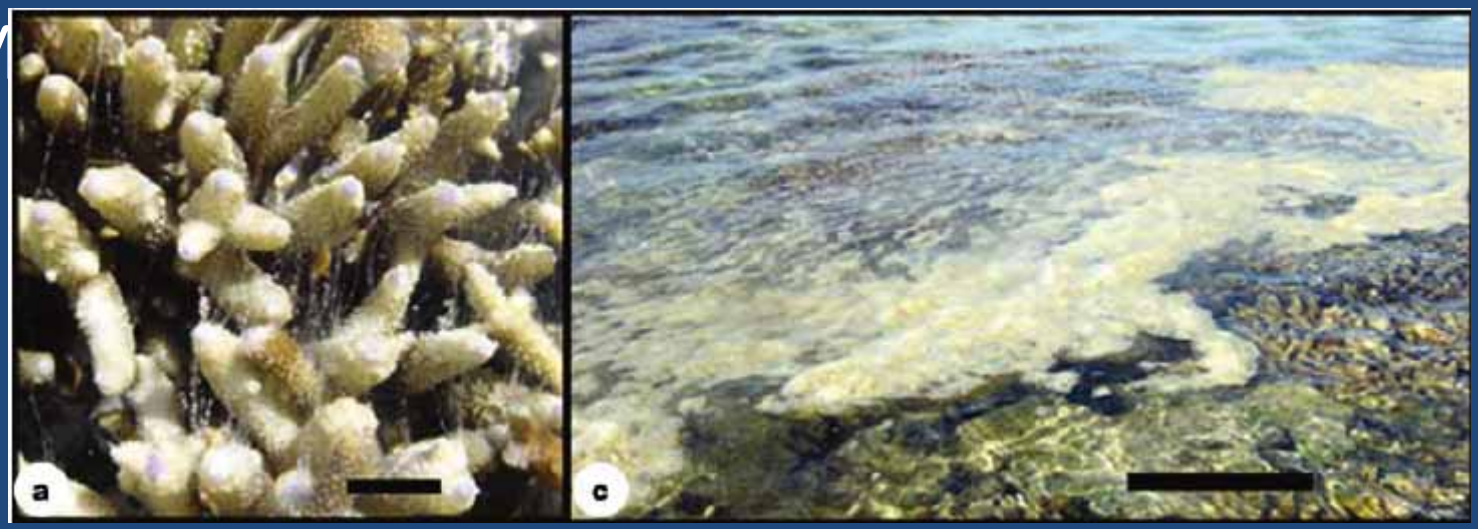


Photosynthate (product of photosythesis) of zooxanthellae

In general, about 20-50% of photosynthate is “lost” from coral cells, and entered to coral reef ecosystem.

Extra photosynthate is released as coral mucus from corals

- Coral mucus contains much arabinose.
  Animal cells contains very little arabinose
  →mucus is originated from zooxanthellae
- M



(Wild et al. 2004. Nature, 428:66-70)

Coral-Zooxanthella is main primary producer in coral reefs

Coral community and coral reef community

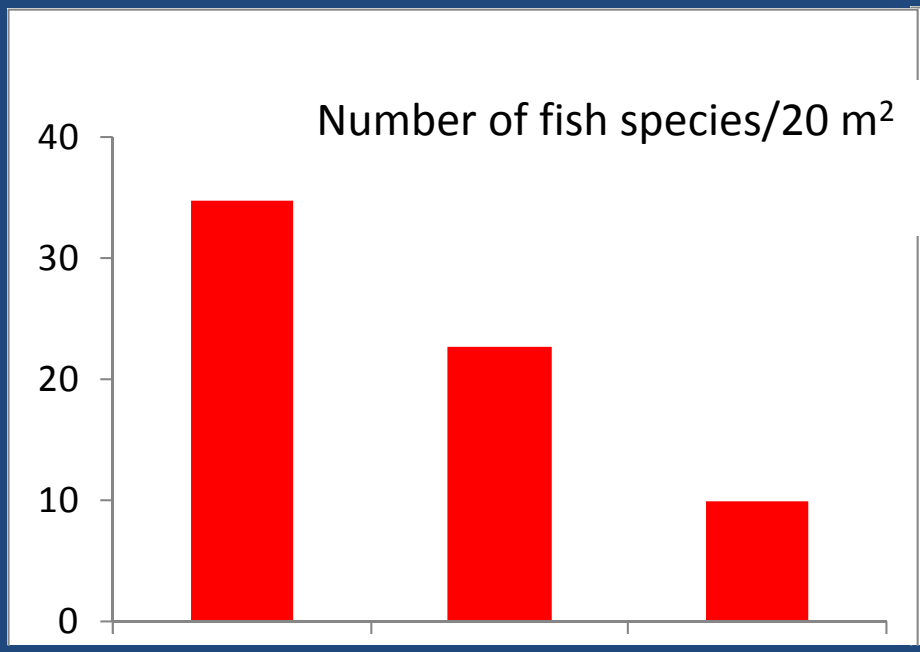
- Coral community: assemblage of coral and soft coral populations that occur together in space and time
- Coral reef community: assemblage of all species that occur together in space and time on a coral reef (corals, fishes, crustaceans, algae etc.)
- Biodiversity of coral reef communities is considered to be the highest on the earth as tropical rain forest communities.

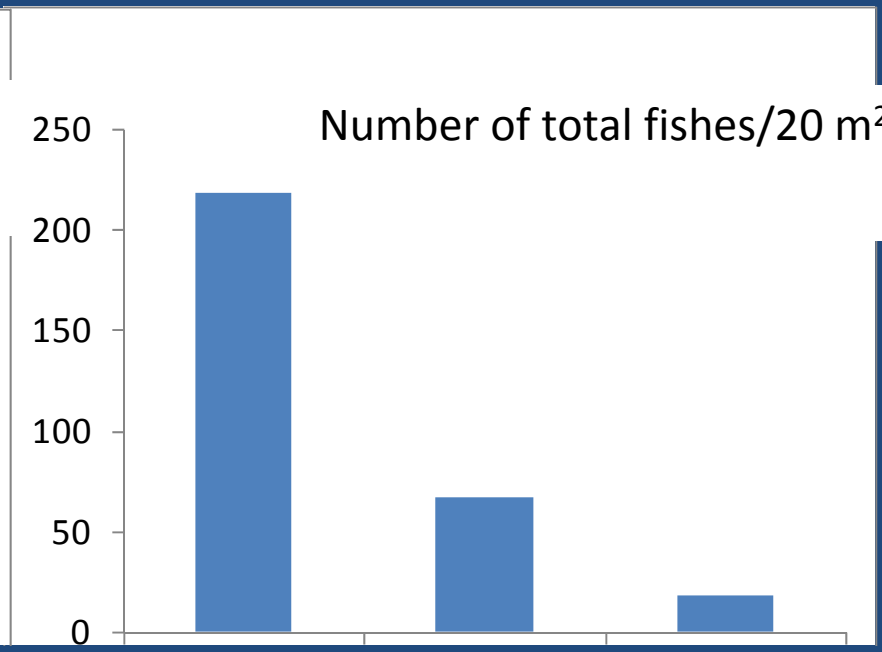
A. Living *Acropora* colonies

C. *Acropora* colonies had died, and skeletons had collapsed

B. *Acropora* colonies had died, but skeletons still remained

State of coral community and fish community structure





Sano et al. (1984) in Okinawa

Crustaceans inhabit in corals-1

Pocillopora eydouxi

Trapezia cymodoce

Trapezia septata

Trapezia rufopunctata

Size and shape of the holes are diverse

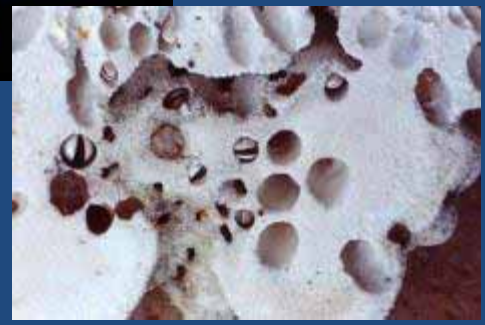
Many animals make holes in coral skeletons for their living, and…

Borers

1

2,3

Lithophaga



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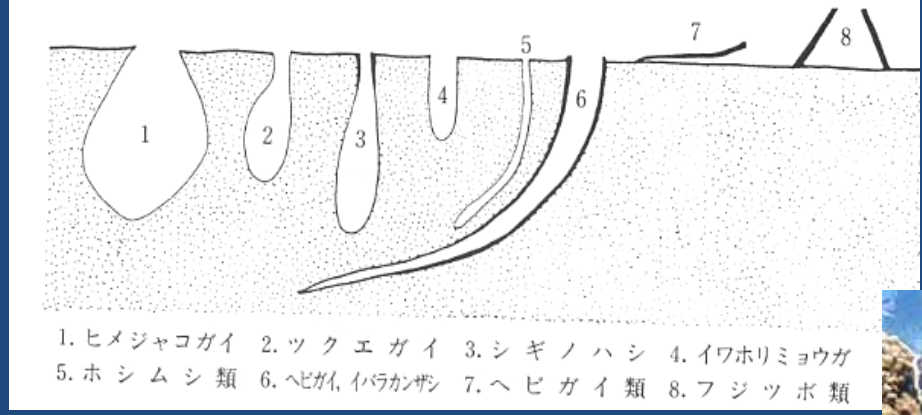


Dendropoma

6

Spirobranchus

5

Sipunculids

the holes are utilized by other animals after death of borers; the world after death

Neoclinus nudus

blennies

Istiblennius chrysospilos

Paguritta vittata (hermit crab) lives in hole after death of Christmas tree worm

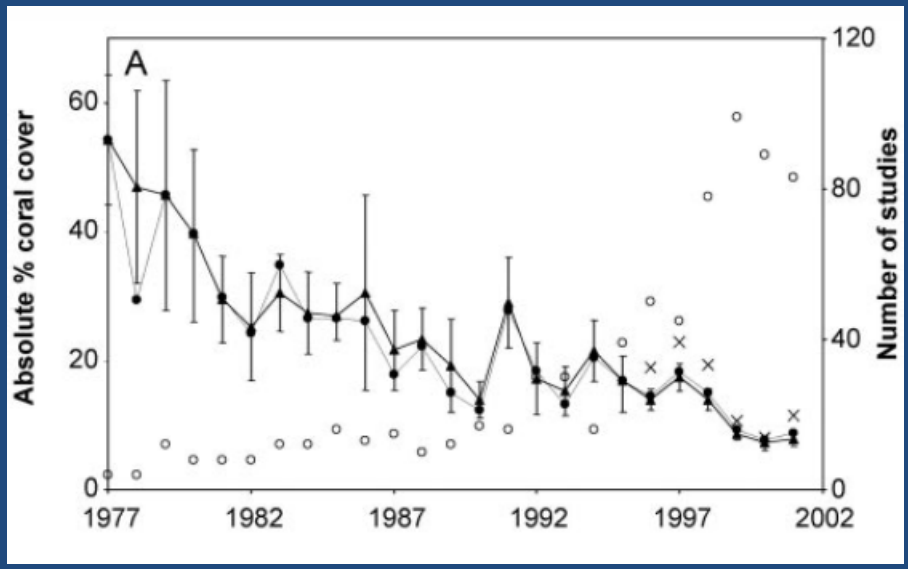
Corals in coral reef community

- Coral-zooxanthella provides food source
- Corals provide habitat to other organisms

Living corals support coral reef communities of high biodiversity and large biomass

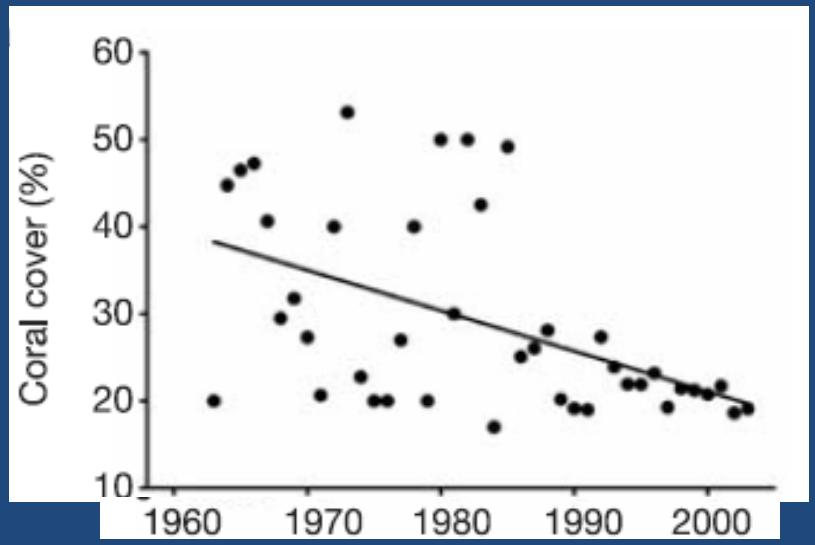
Anthropogenic impacts on corals

Corals are declining world-wide



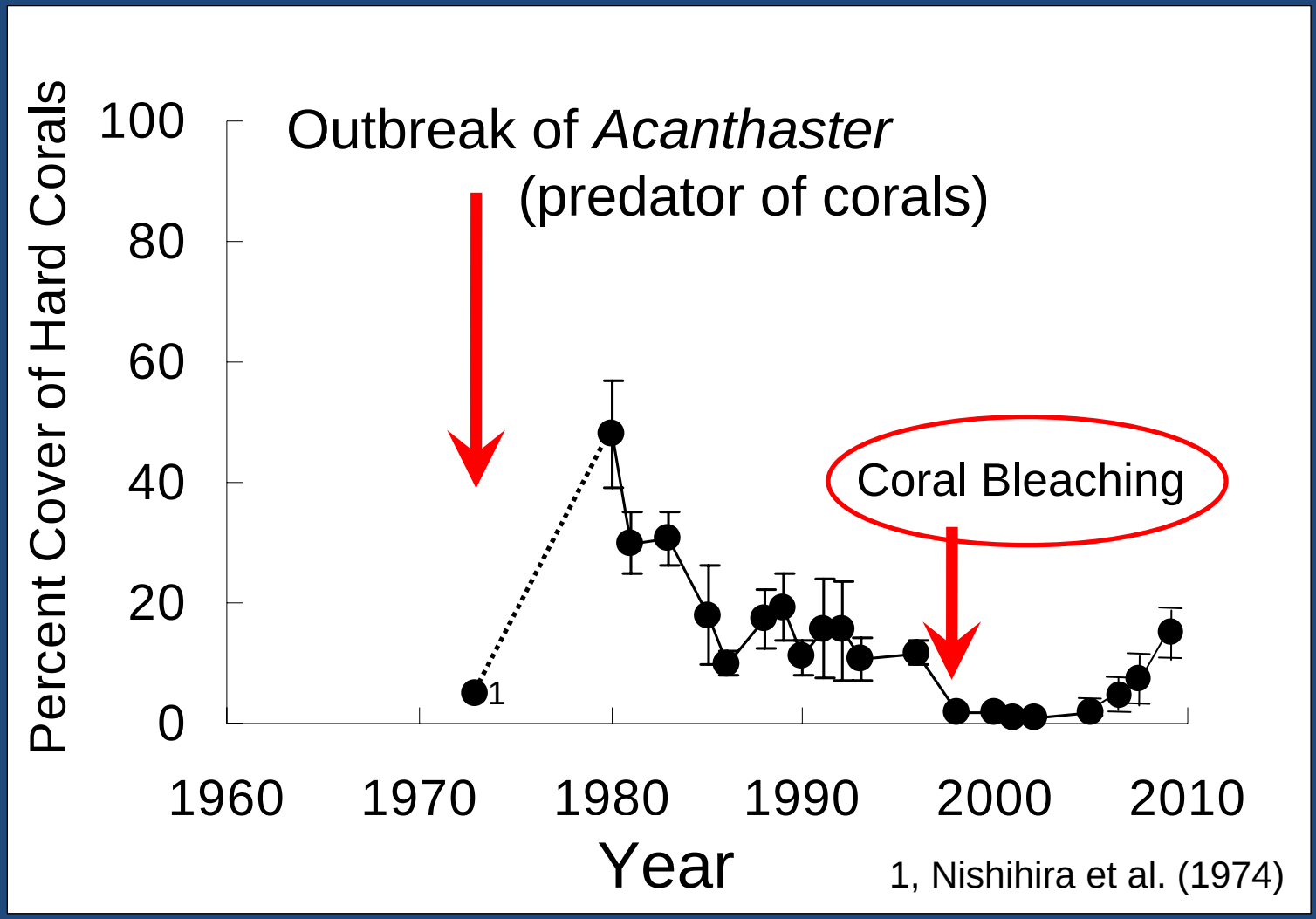
Caribbean (**Gardner et al. 2003**)

http://www.uea.ac.uk/env/ceec/coral%20decline.htm



Great Barrier Reef (**Bellwood et al. 2004**)

Sesoko Island (Okinawa, Japan)



Why corals have been declined ?

Mainly due to Environmental change by human

Biodiversity of coral reefs will be much reduced, if corals are decreased (great reduction in primary productivity and habitats provision)

1. Local Environmental Impacts on Corals

“Confronting the coral reef crisis”
Bellwood et al. (2004)

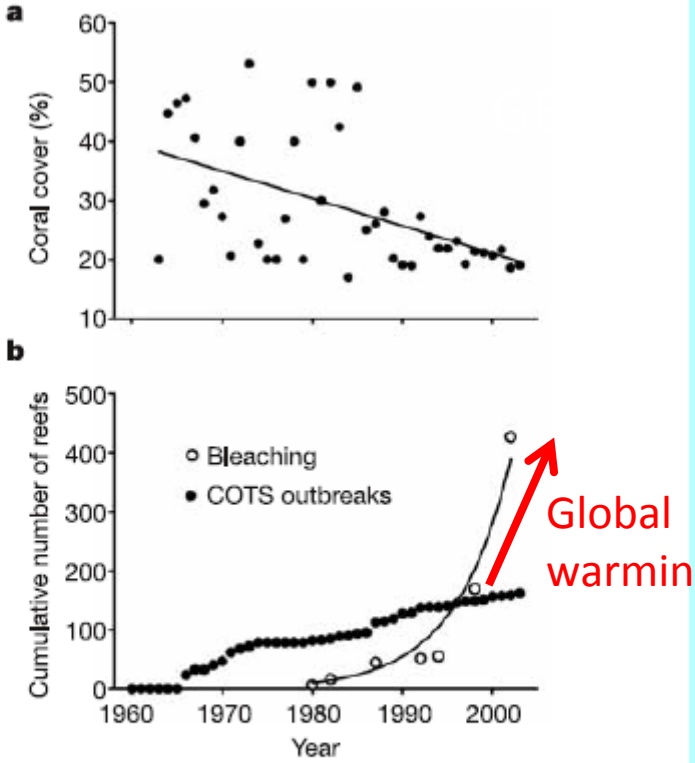


Figure 1 Degradation of coral reefs. **a**, Results of a meta-analysis of the literature, showing a decline in coral cover on the Great Barrier Reef. Each point represents the mean cover of up to 241 reefs sampled in each year. **b**, The recorded number of reefs on the Great Barrier Reef, Australia, substantially damaged over the past 40 yr by outbreaks of crown-of-thorns starfish (COTS) and episodes of coral bleaching.

Their message: Phase shift may caused by overfishing of herbivores and by eutrophication of seawater in coral reefs.

Originally, herbivores (mainly fish in Pacific coral reefs) were abundant, and seawater was oligotrophic (low nutrients) in coral reefs

↓

Macro-algae could not bloom

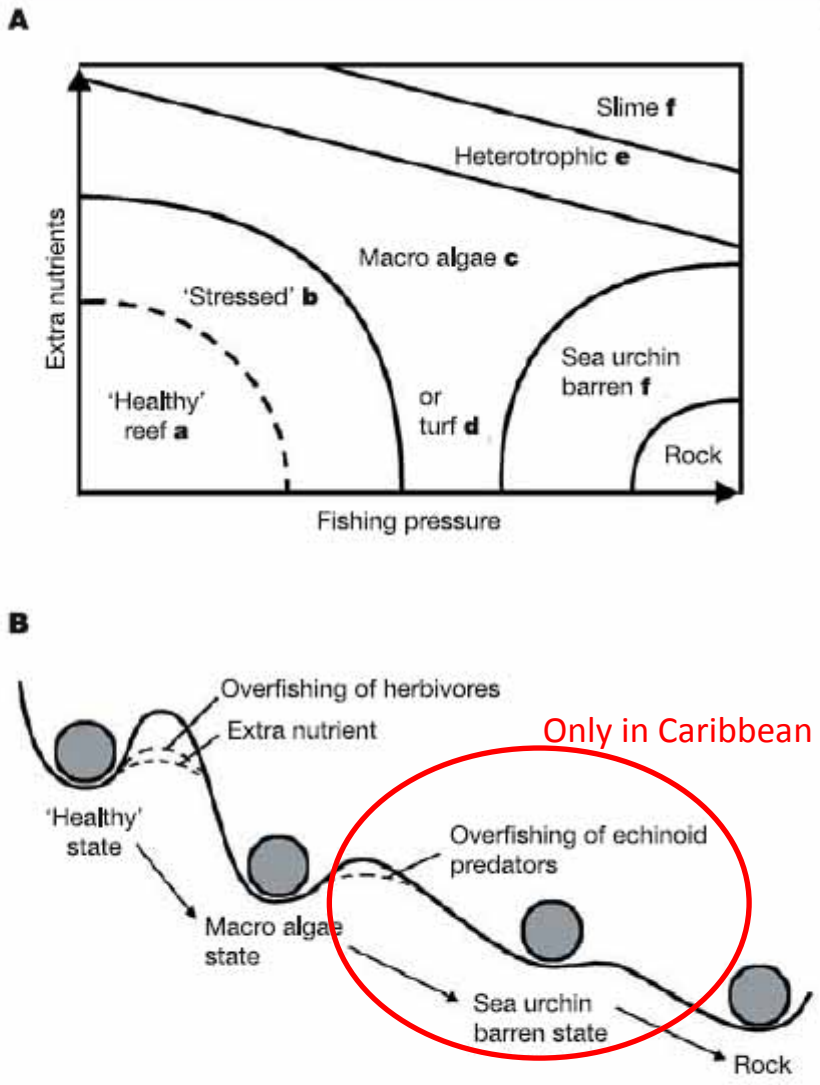
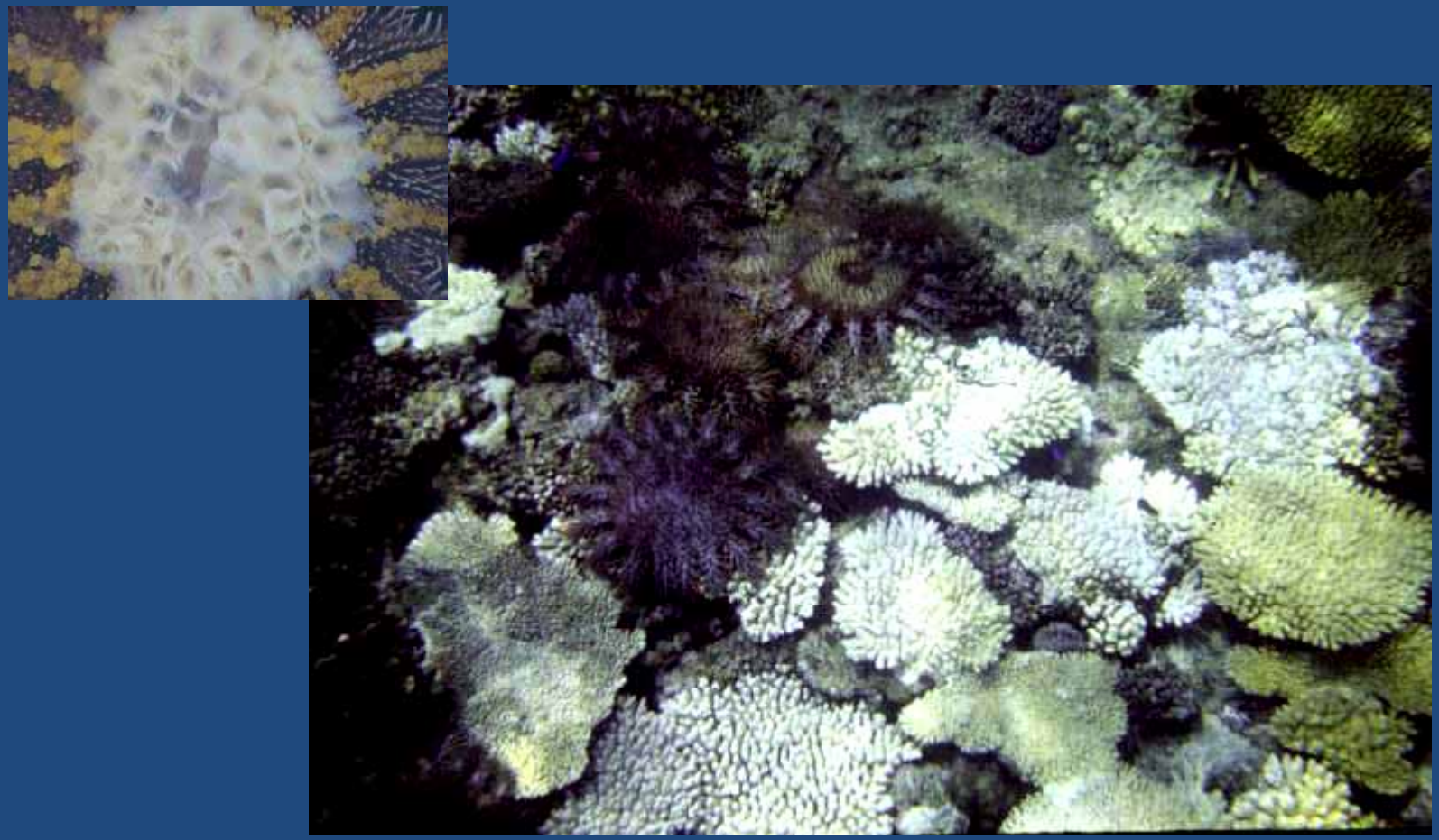
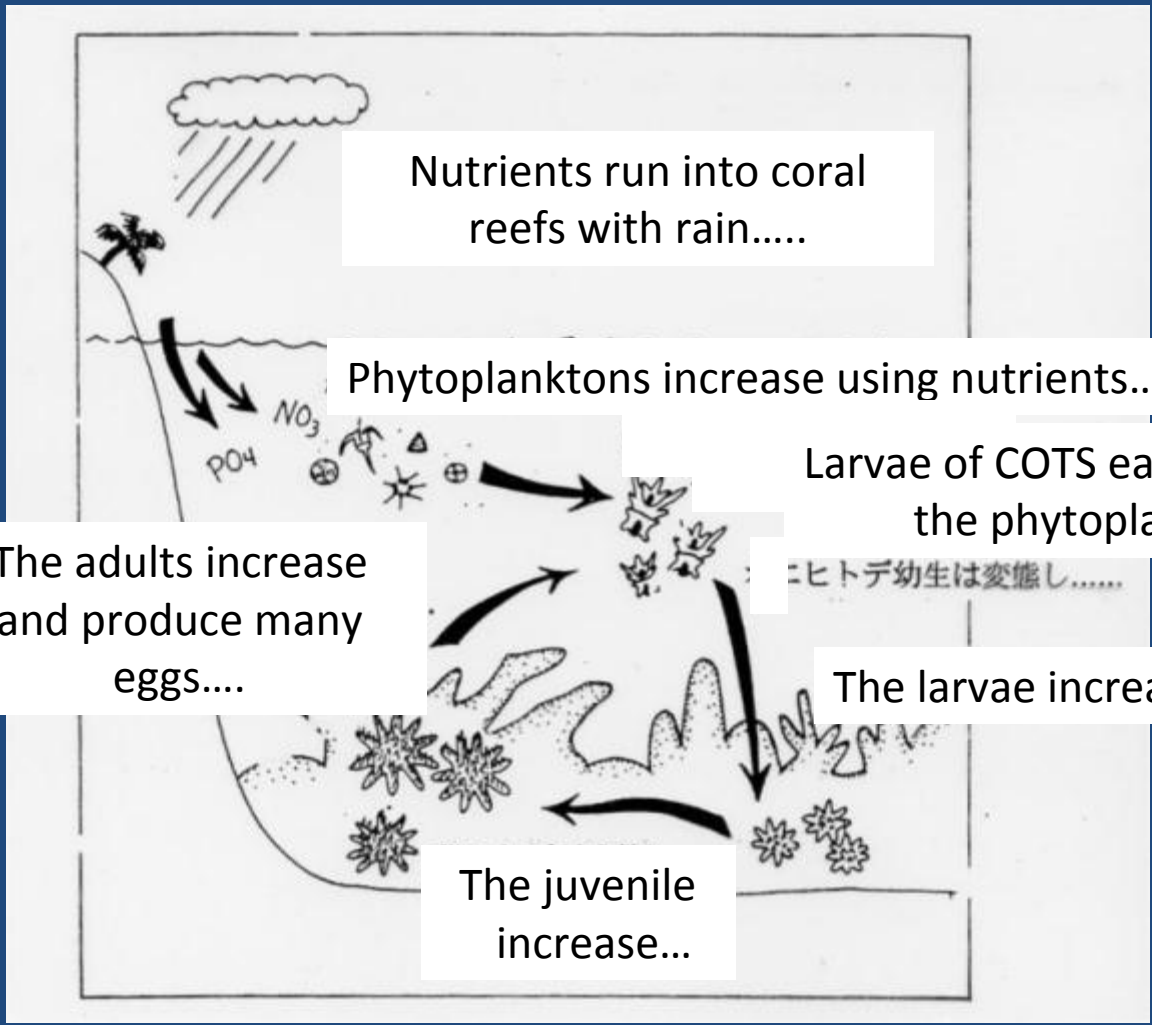


Figure 2 Alternate states in coral reef ecosystems. **A**, A conceptual model showing human-induced transitions between alternate ecosystem states based on empirical evidence of the effects from fishing and excess nutrients[15–17]. The 'stressed' state illustrates loss of resilience and increased vulnerability to phase-shifts. **B**, A graphic model depicting transitions between ecosystem states. 'Healthy' resilient coral-dominated reefs become progressively more vulnerable owing to fishing pressure, pollution, disease and coral bleaching. The dotted lines illustrate the loss of resilience that becomes evident when reefs fail to recover from disturbance and slide into less desirable states. **C**, Six characteristic reef states (as in **A**) from sites on the Great Barrier Reef (**a**, **c**, **d**, **e**) and in the Caribbean (**b**, **f**).

Eutrophication may cause population outbreaks of *Acanthaster*, or COTs



Originally, seawater was oligotrophic in coral reefs, but human activity on land may cause eutrophication, hence *Acanthaster* outbreaks



Brodie et al. (2005)

Nutrient discharges from rivers have increased at least four-fold in the central GBR over the last century, and concentrations of large phytoplankton (>2 μm) of the inshore central GBR shelf in the wet season when *A. planci* larvae develop, is double that of other places and times. Larval development, growth and survival increase almost ten-fold with doubled concentrations of large phytoplankton. This and other lines of evidence suggest that frequent *A. planci* outbreaks on the GBR may indeed be a result of increased nutrient delivery from the land.

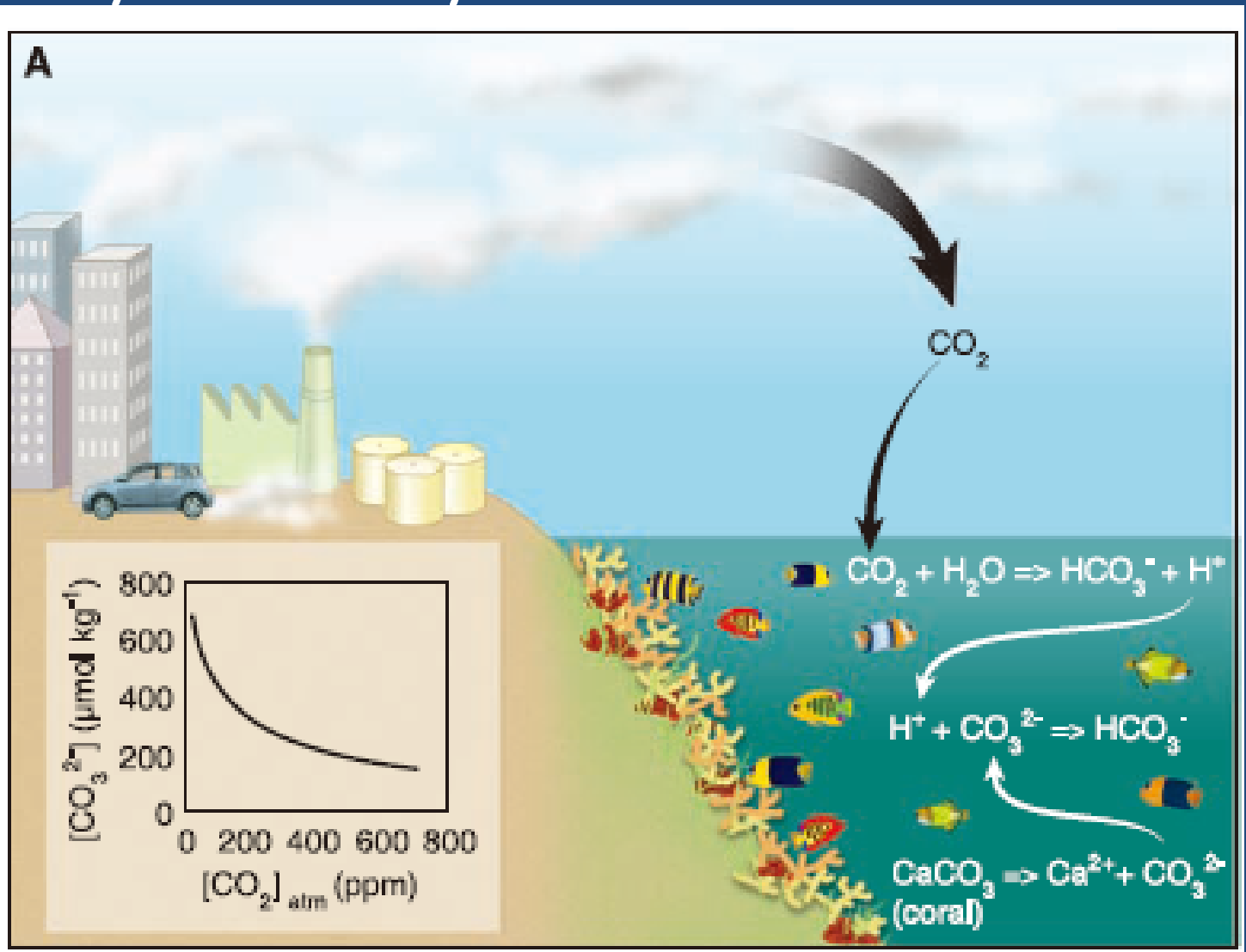
2. Global Environmental Impacts on Corals

Global Environmental Impacts

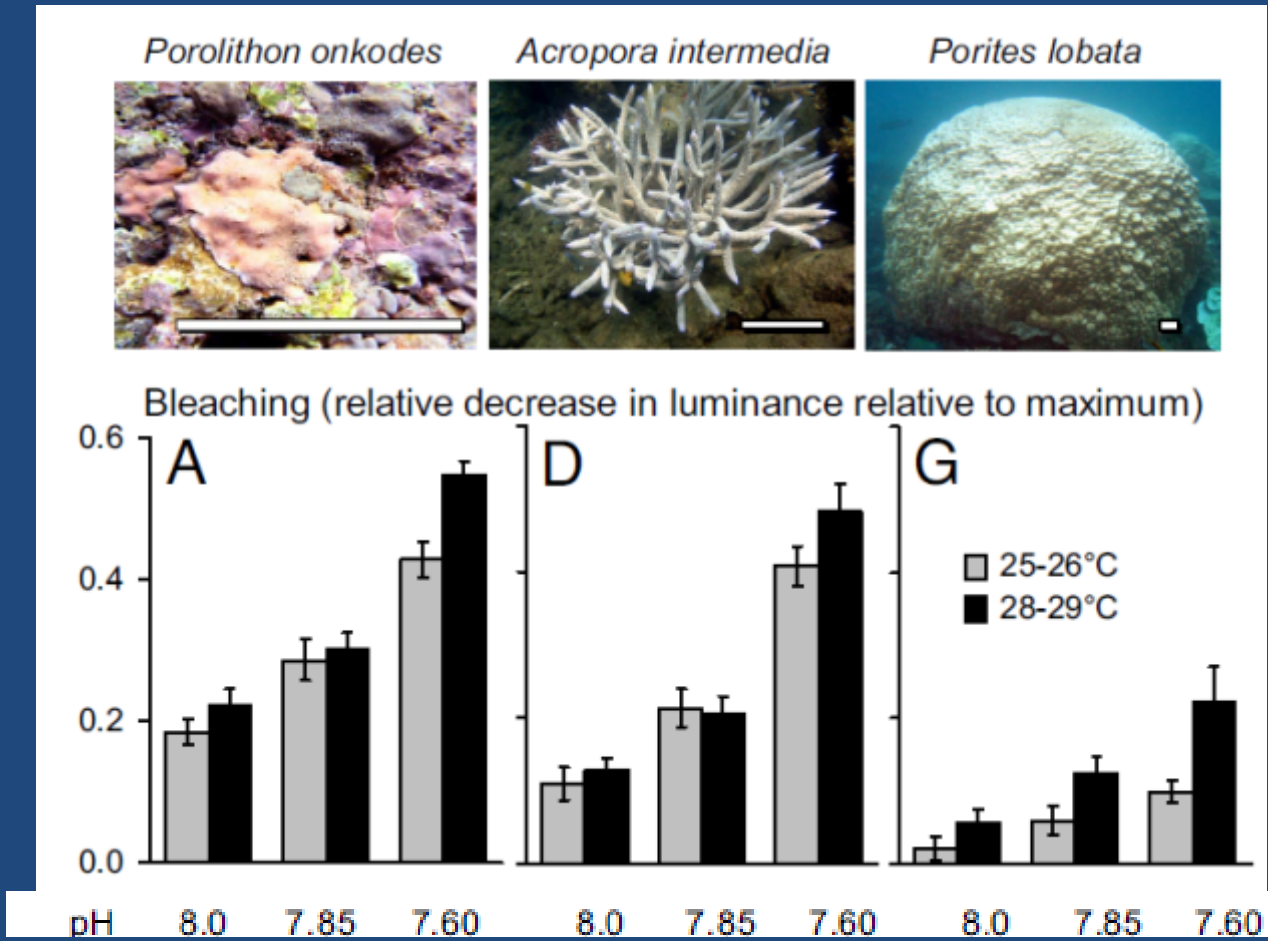
- Global warming
- Ocean acidification

  Both are caused by increase in pCO_2 in atmosphere

Increase in pCO_2 by using fossil fuel by humanity: Ocean Acidification



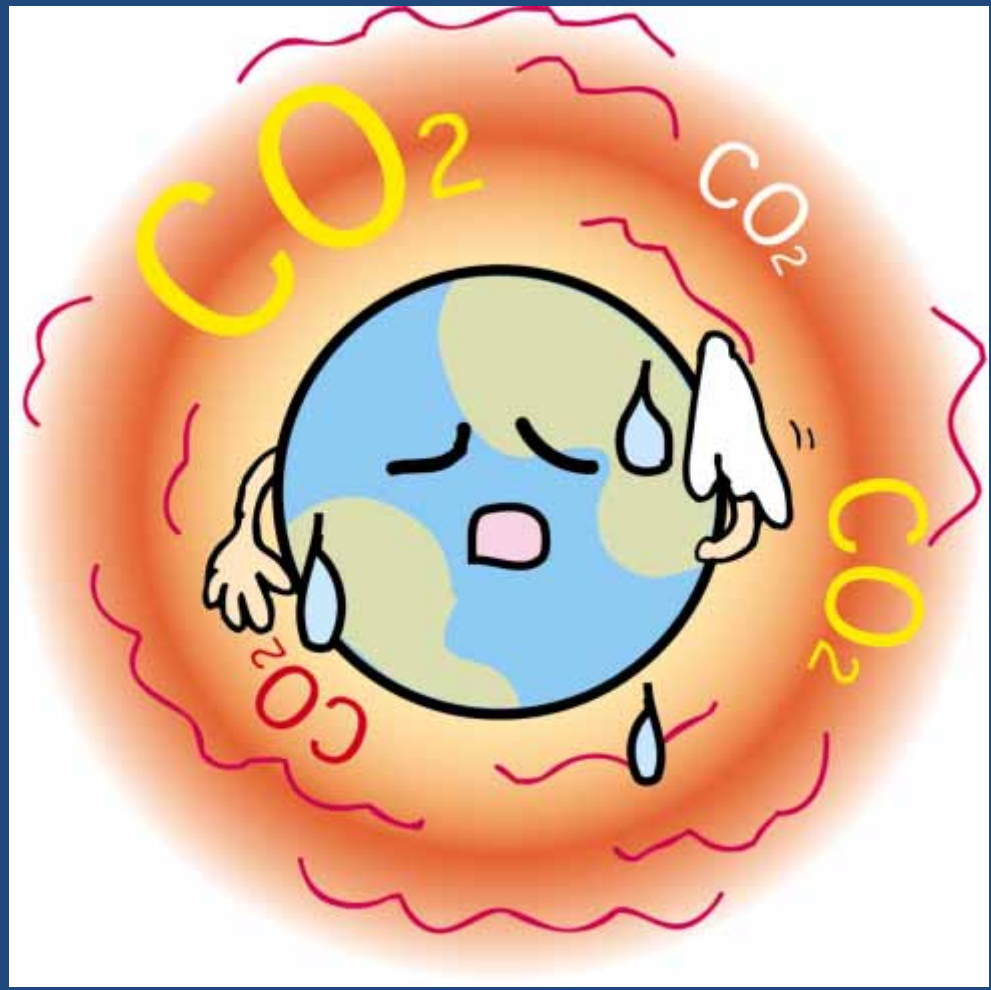
Effect on corals and coralline algae-1



pH 8.0 at present; Mean ph value of seawater in 2100 is expected to be 7.7 – 7.9.

Anthony et al. (2008) PNAS 105:17442

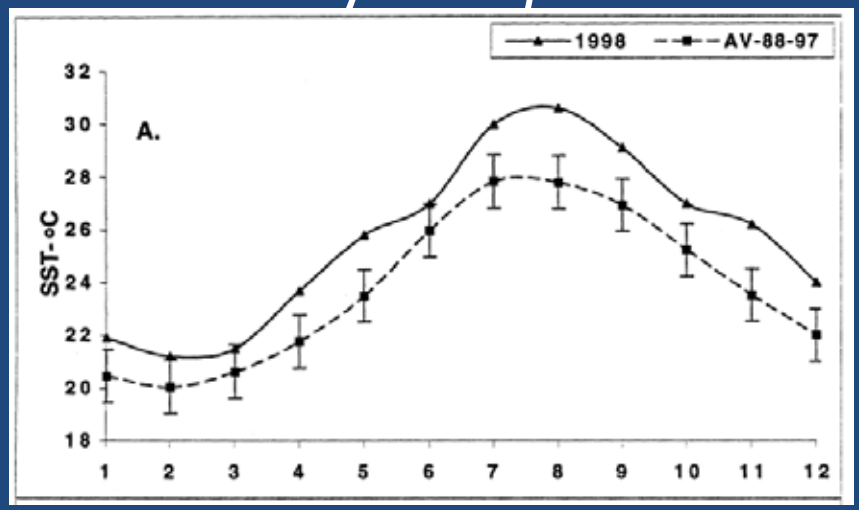
Increase in pCO_2 by using fossil fuel by humanity: Global Warming



1997-98, Year of Coral Bleaching world-wide
An example at Sesoko Island

Healthy *Acropora*

Bleached *Acropora*



Bleaching is response of corals to stresses. Corals are bleached by losing zooxanthellae. In 1997-98, the stress was high temperature and strong light.

Sesoko Island, before and after coral bleaching

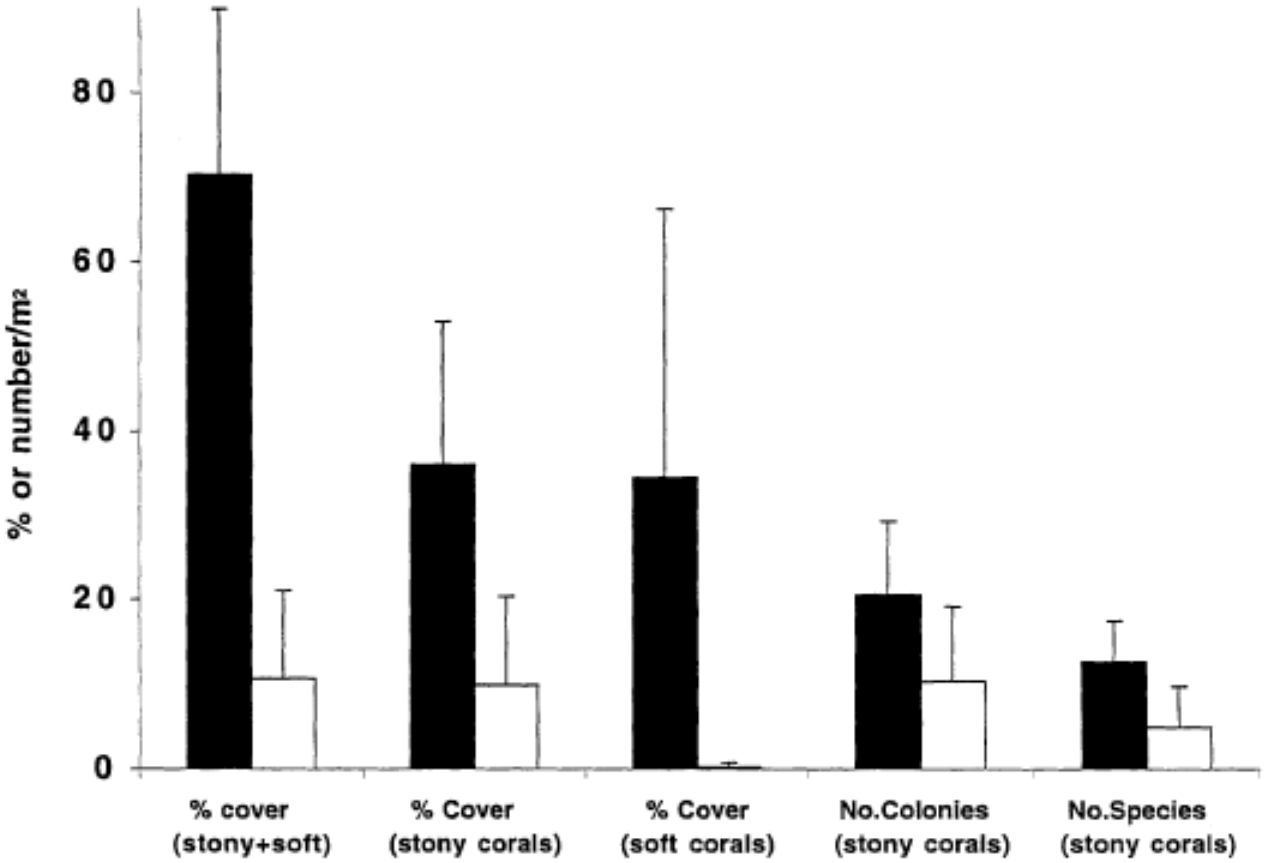


Figure 2 Community descriptors of stony corals and soft corals: number of species, number of colonies, and percent living cover per m^2 in the reef moat. Values are means $\pm$ SD; black bars, 1997; empty bars, 1999.

(Loya et al. 2001)

Consequence of Coral Bleaching

- Percent cover of corals and soft corals was decreased by 85%
- Species richness of corals was decreased by 61%
- There were winners and losers in corals (Branching ↓ Massive→)

Growth form and tolerance to high temperature

Branching

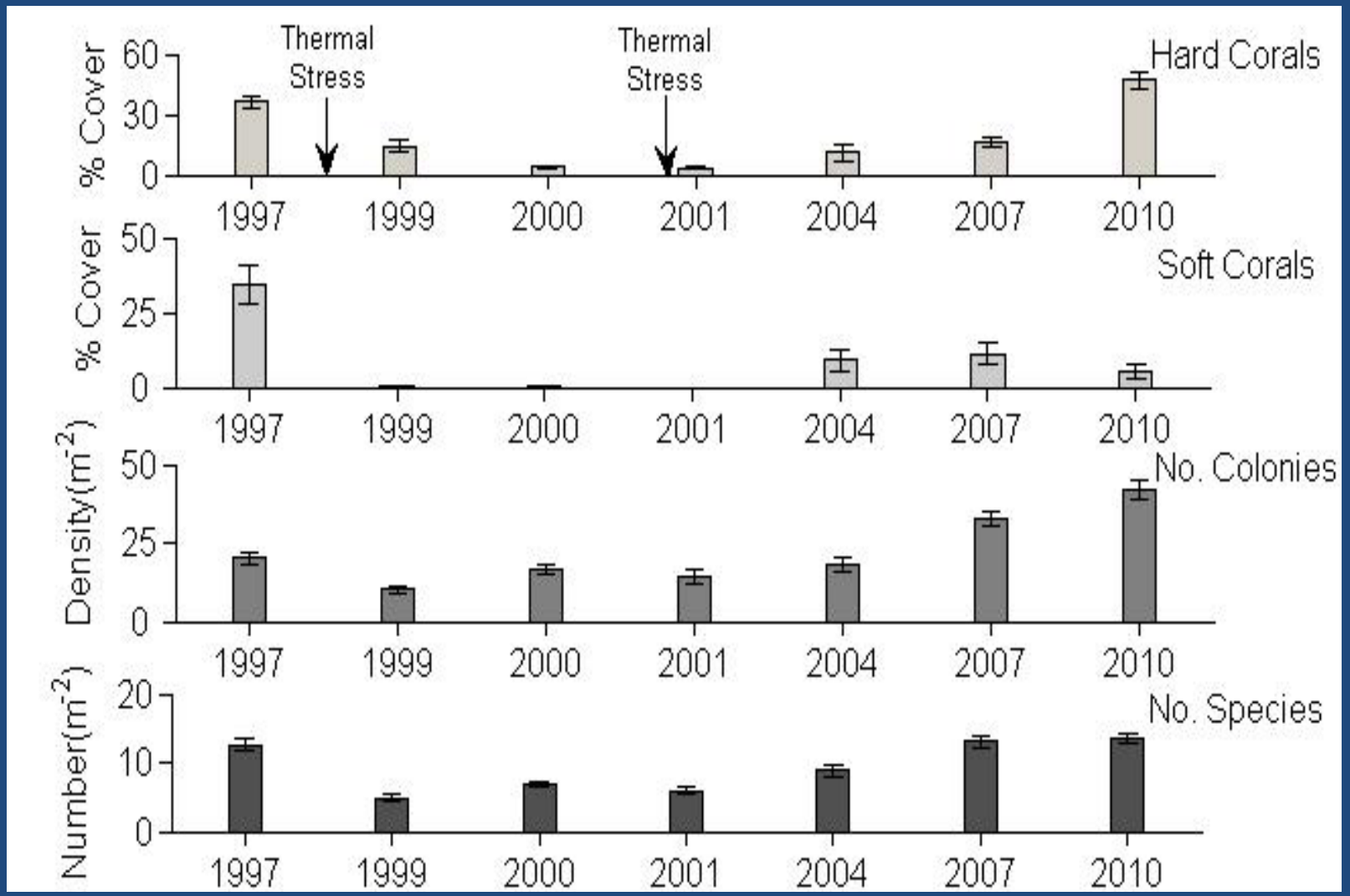
Table-like

Foliaceous

Encrusting

Massive

Corals can still recover!
Changes after the bleaching at Sesoko



(Woesik et al. 2011)

Message

If the global climate change and the degradation of local coral reef environment occurred simultaneously, coral communities may collapse rapidly. So, local environment should be preserved in the era of the global environmental change by humankind.

Biodiversity of coral reefs will be much reduced