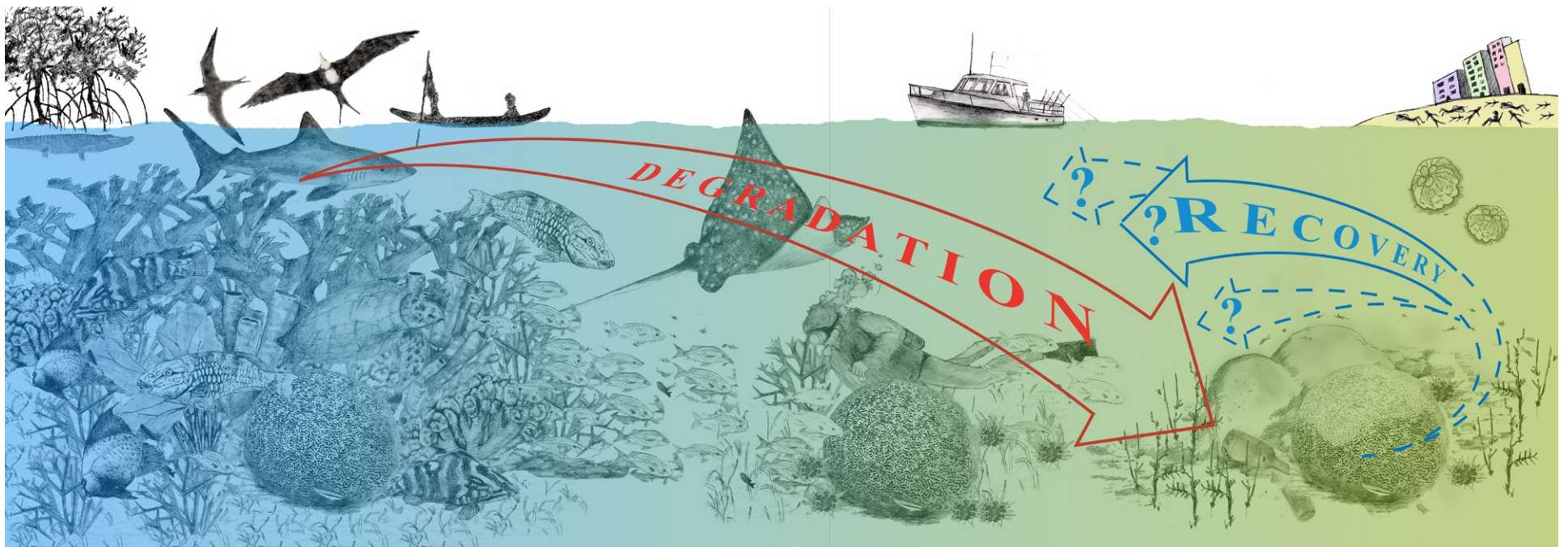


QuickTime™ and a
decompressor
are needed to see this picture.

The future of the Florida Keys?

Jeremy Jackson

Scripps Institution of Oceanography &
Smithsonian Tropical Research Institute



Coral reefs in the Florida Keys are severely degraded because of us.

Which begs the questions:

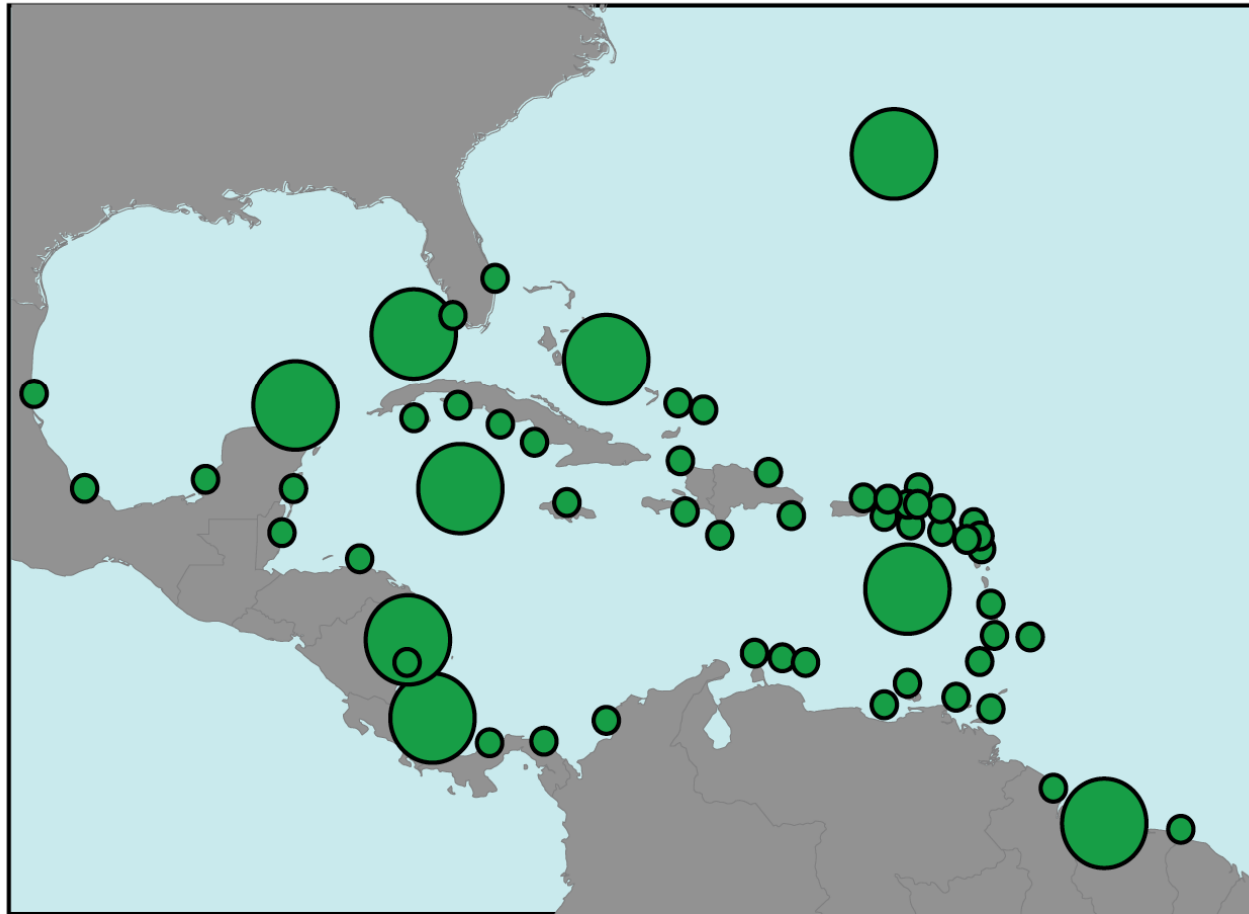
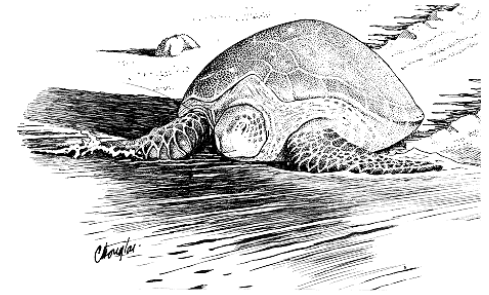
1. What were the reefs like just before we started to degrade them and when did they begin to decline?
2. Why have reefs degraded?
3. What are the most likely scenarios for the future?

1. Baselines and trajectories of decline: What were the Keys like centuries ago?

McClenachan & Jackson ms.

1. Very high coral cover with strong dominance by *Acropora*, *Montastrea*, or other massive corals
2. Superabundant megafauna including tetrapods, sharks and fish
3. Superabundant invertebrates including sea urchins, conchs and lobsters
4. Crystal clear waters

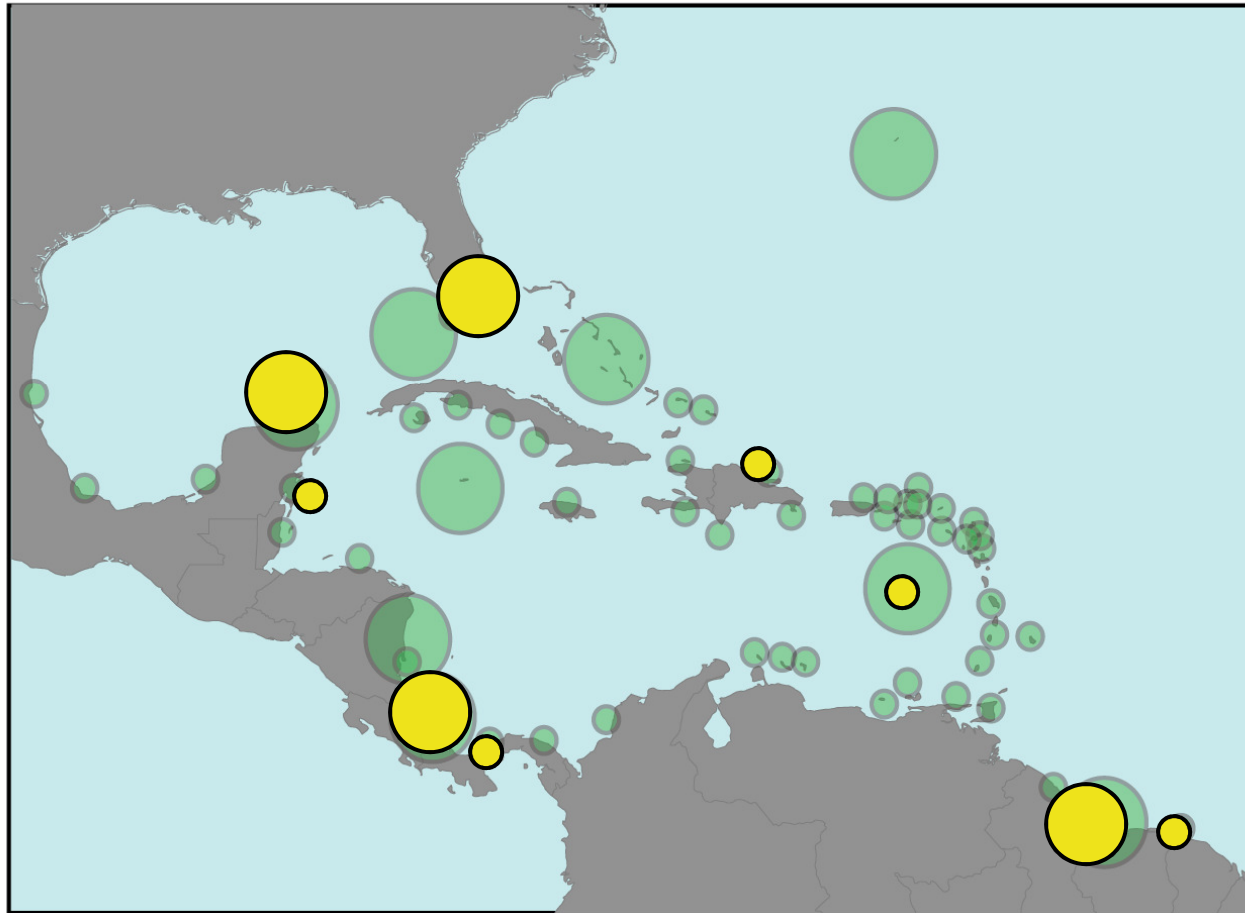
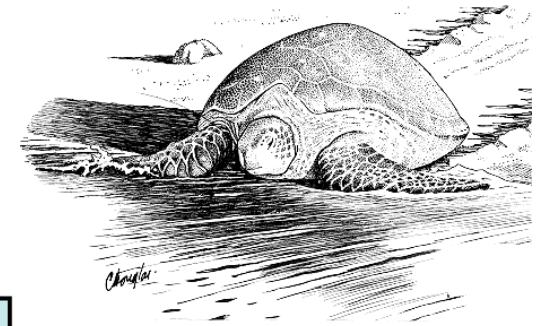
Historical Green Turtle Nesting Beaches



- = Historic nesting beach (major)
- = Historic nesting beach

Historic population
91 million turtles that consumed 45% of the total annual productivity of Caribbean turtlegrass.

Modern Green Turtle Nesting Beaches



Modern population

<300,000 turtles that today consume <0.1% of total annual Caribbean turtlegrass productivity with outbreaks of turtlegrass fungal disease.

 =modern nesting beach (>500)

 =modern nesting beach (100-500)

McClenachan et al. 2006. *Frontiers Ecol.* 4:290.

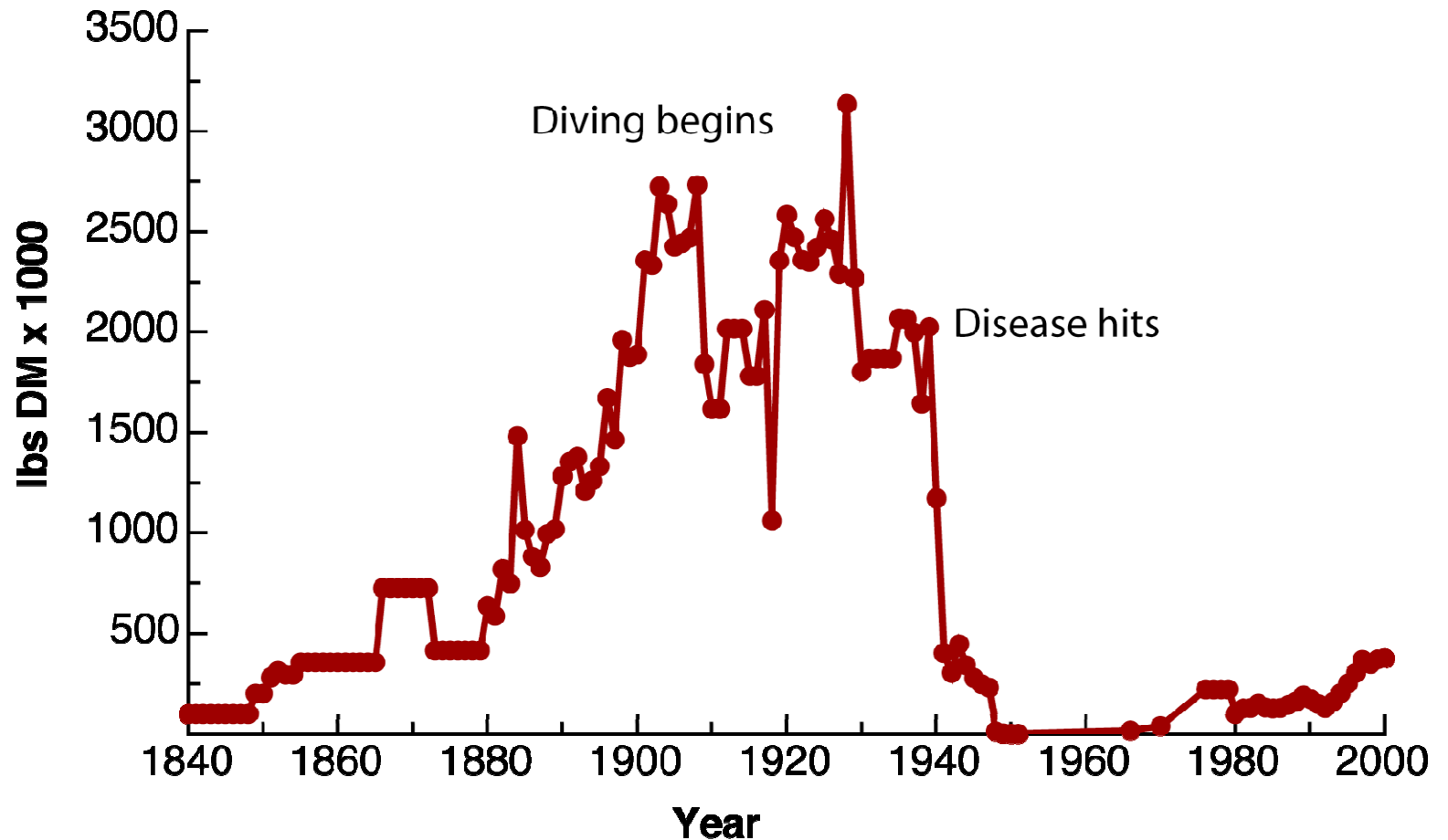


Sponge fishery

McClenachan 2008. In *Oceans Past*

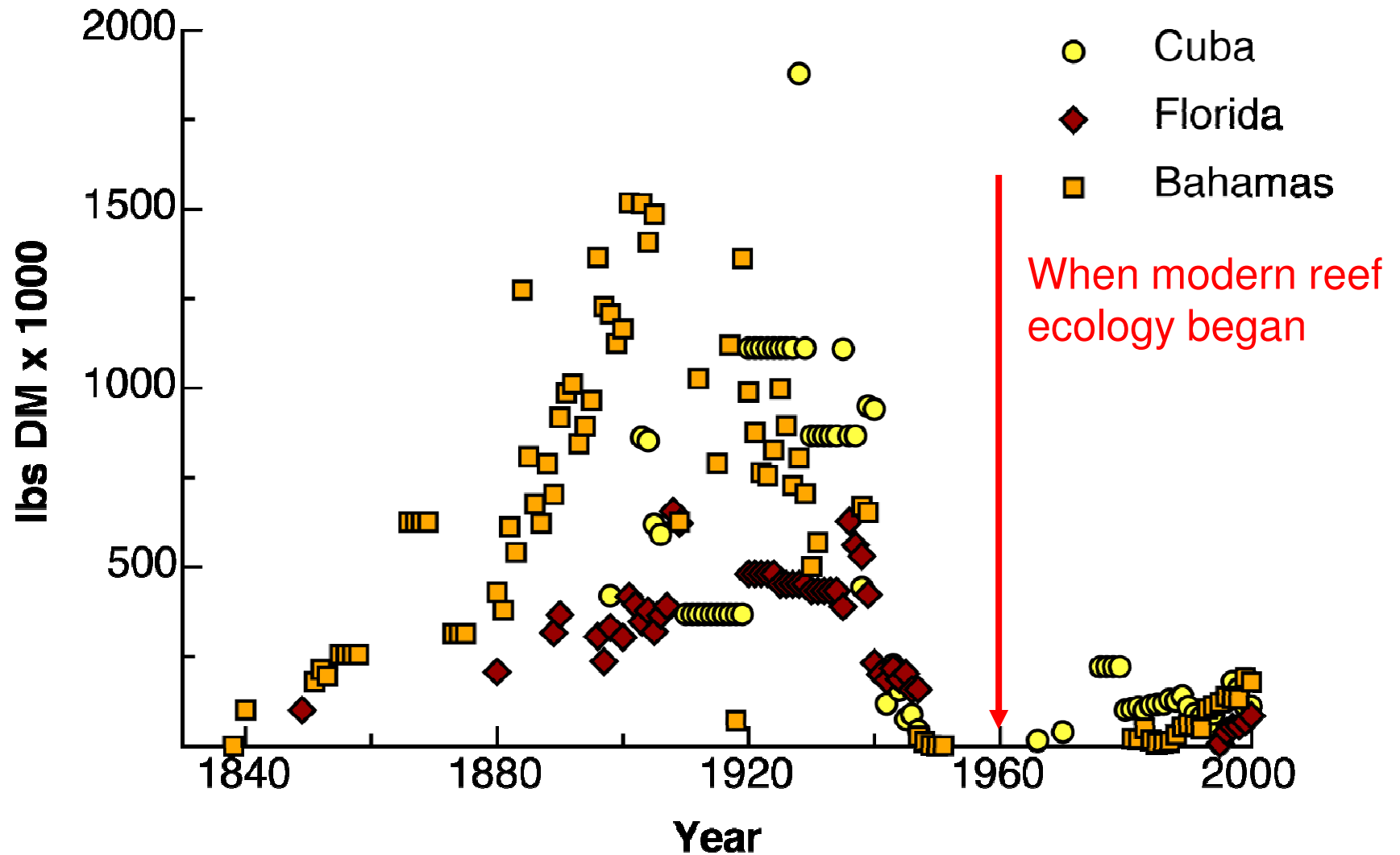
Lost filtration capacity >70 metric tons of microbes, algae, and fungi/year.

Did overfishing of sponges cause the outbreak of sponge disease and whatever else....



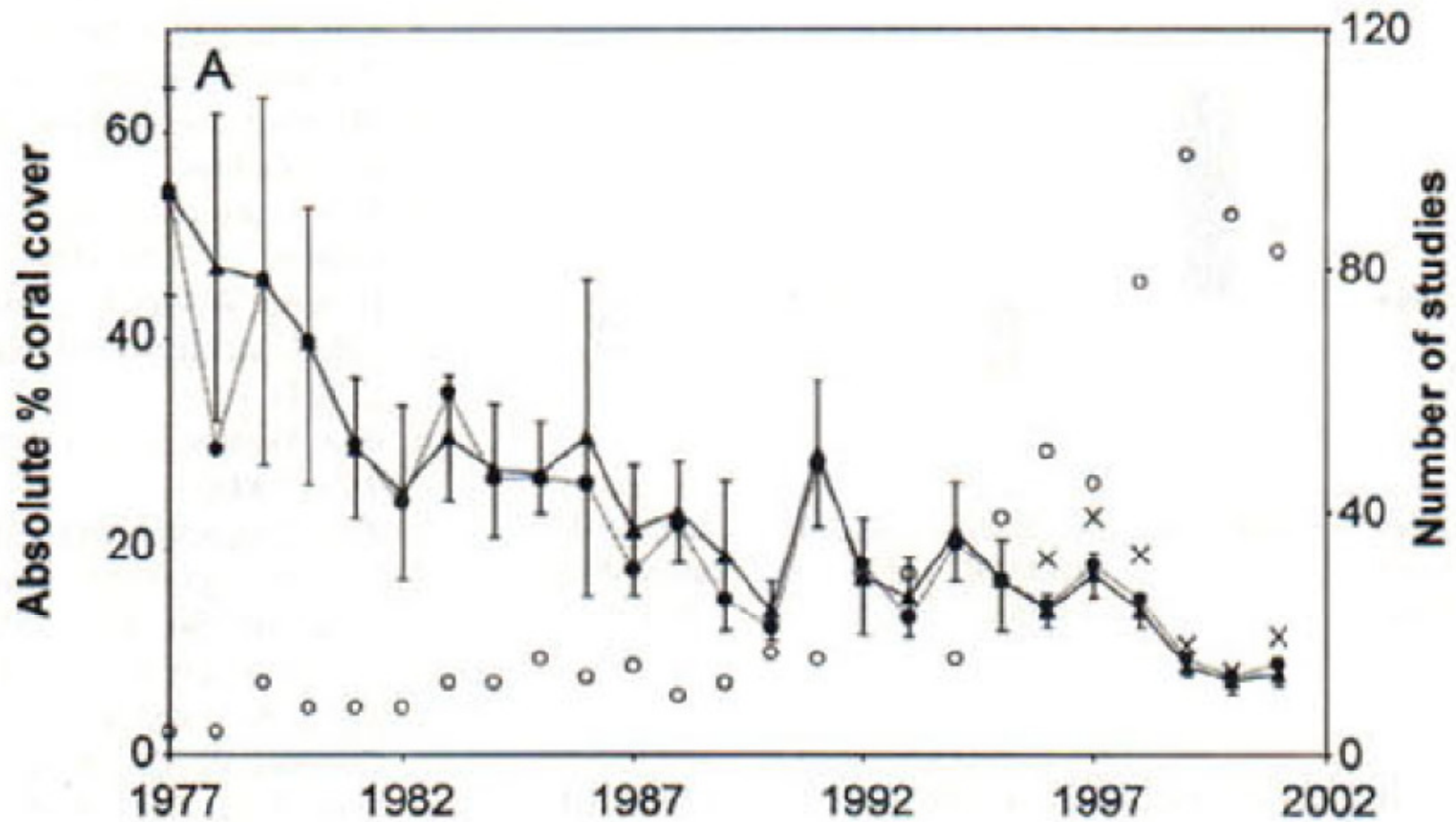
Fish and sharks were decimated before we began to study them

McClenachan & Jackson unpubl.



Recent coral decline

Gardner et al. 2003. *Science* 301:958



*But acroporids began to decline long before
the 1980s*

Jackson et al. 2001 *Science* 293:629.

QuickTime™ and a
decompressor
are needed to see this picture.

Jackson *et al.* 2001. *Science* 293:629-638

In some places as early as the 19th century

Katie Cramer and Jackson, unpublished

Relative abundance of coral species in 18 0.25 m² pits dug beneath the reef surface at Bocas del Toro, Panama

QuickTime™ and a
decompressor
are needed to see this picture.

QuickTime™ and a
decompressor
are needed to see this picture.

Pleistocene to Recent reef communities in Barbados

Where we know from the work of John Lewis that vast meadows of acroporids disappeared early in the 20th century

Lewis, J. B. 1983. *Coral Reefs* 4:117 & 2002, *Coral Reefs* 21:49

- 4 Late Pleistocene high sea level stands:

220 Ka, 195 Ka, 125Ka, & high stand 104 Ka

- Recent 1981-82

- Quantitative surveys coral community composition for all 5 time periods

- Ordinate all survey data for just the Pleistocene and fossil and recent combined

QuickTime™ and a decompressor are needed to see this picture.

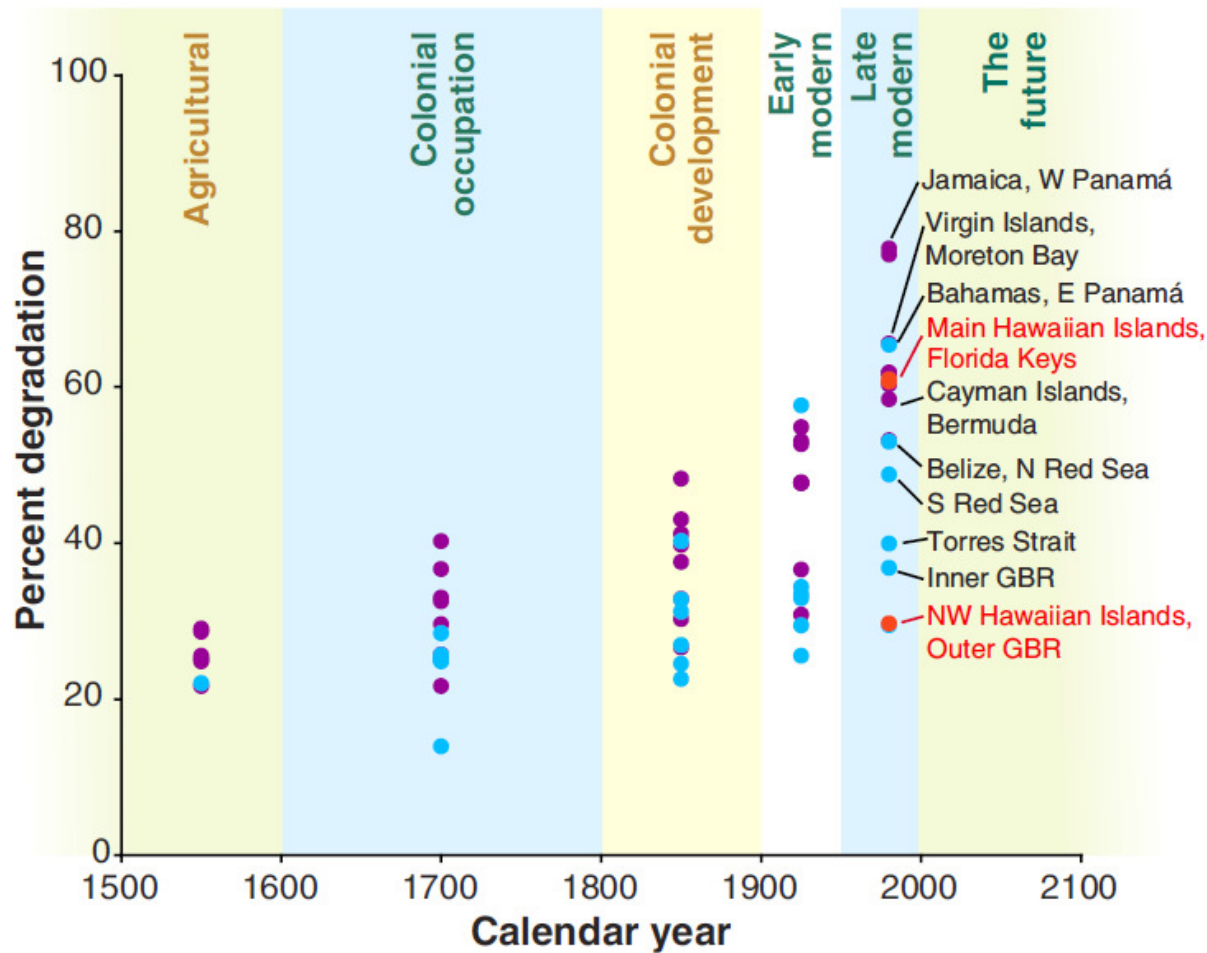
Modern reefs bear no resemblance to reefs at any time in the last 220,000 years

QuickTime™ and a
decompressor
are needed to see this picture.

Summary of when populations collapsed

- Seals middle 1800s
- Green turtles middle 1800s
- Sponges 1930s
- Fishes and sharks 1930s
- Corals: 1970s/1980s general Caribbean but early 1900s in Barbados and late 1800s in western Panama and ??? elsewhere

Which matches previous more general historical analyses showing increases in Caribbean degradation early in the 20th century



II. Why have reefs degraded?

- Overfishing
- Higher temperatures
- Lower temperatures
- Hurricanes
- Increased sedimentation
- Coastal development
- Boat groundings and anchoring
- Introduced species
- Oil pollution
- Nutrient pollution and eutrophication
- Sewage
- Fishing gear and other debris
- Lower pH
- Overgrowth by macroalgae
- Coral disease
- Diadema disease
- Too many people!

QuickTime™ and a
decompressor
are needed to see this picture.

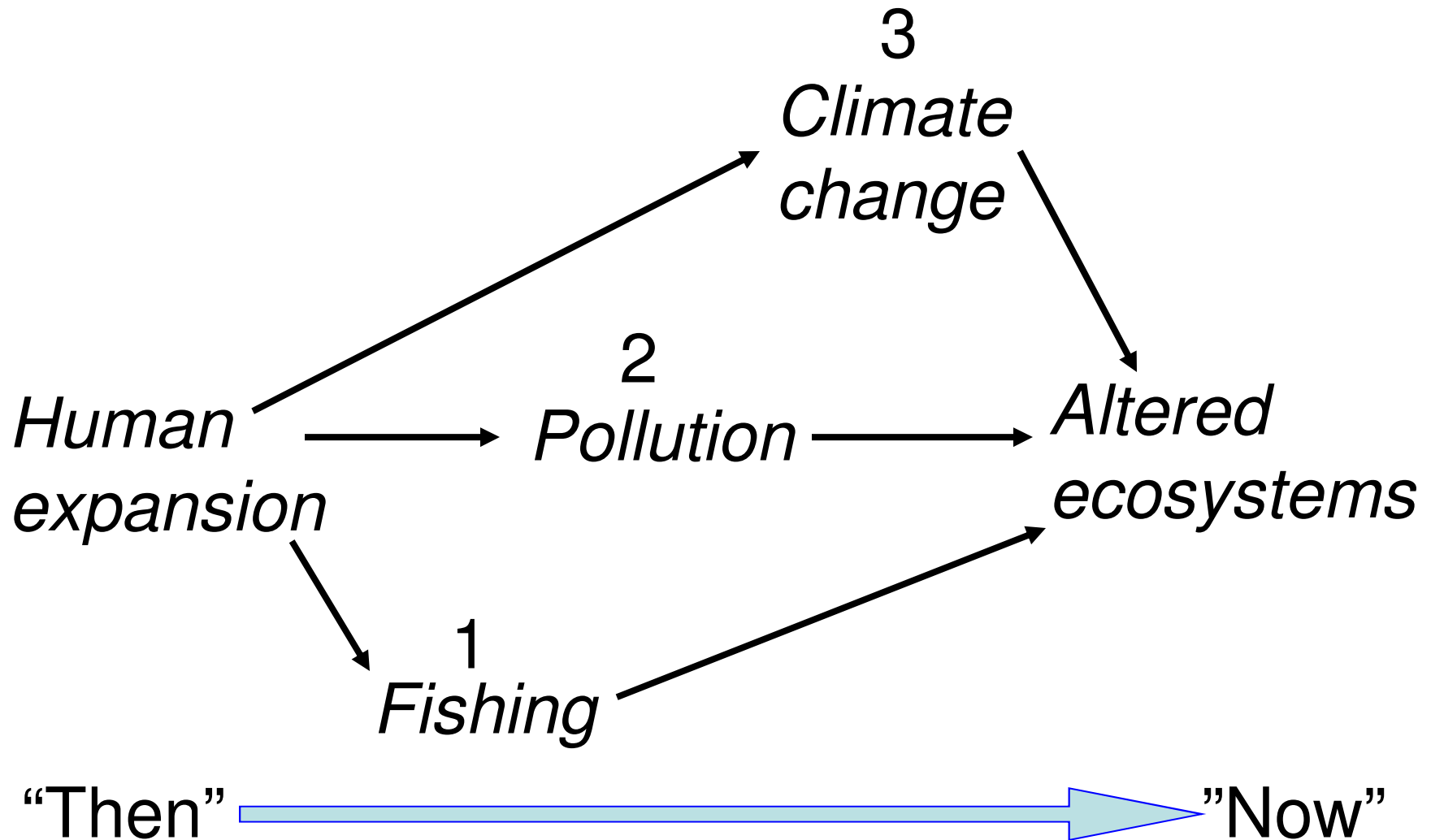
And the answer is all of the above

Although I think most of us would agree that the primary drivers of degradation have been

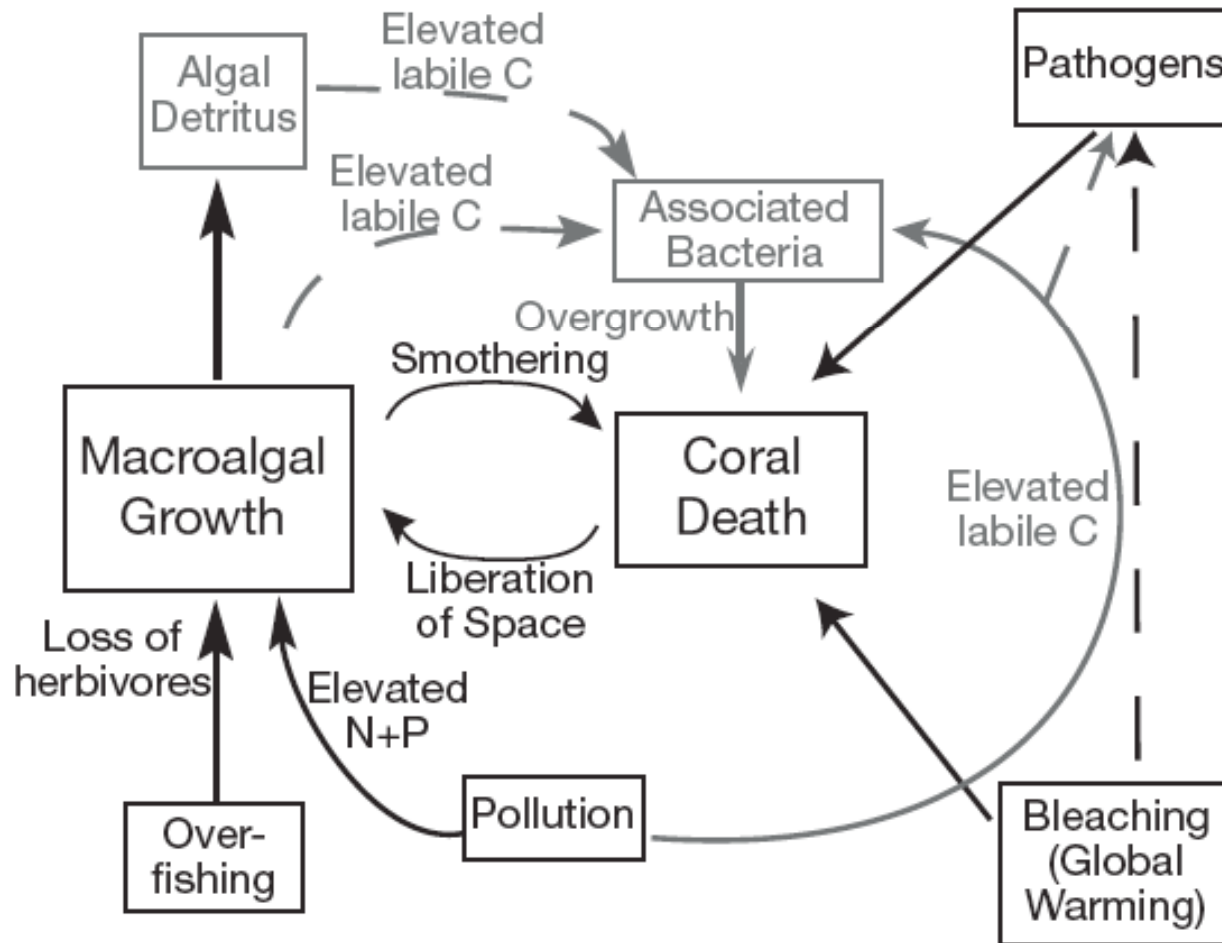
1. Overfishing,
2. organic and nutrient pollution, and
3. Increased sea surface temperatures

that have in turn set off population explosions of macroalgae that overgrow corals, disease of corals and sea urchins, and coral bleaching that in turn have set off new episodes of mortality through positive feedbacks.

*And that their relative importance
has changed greatly over time*



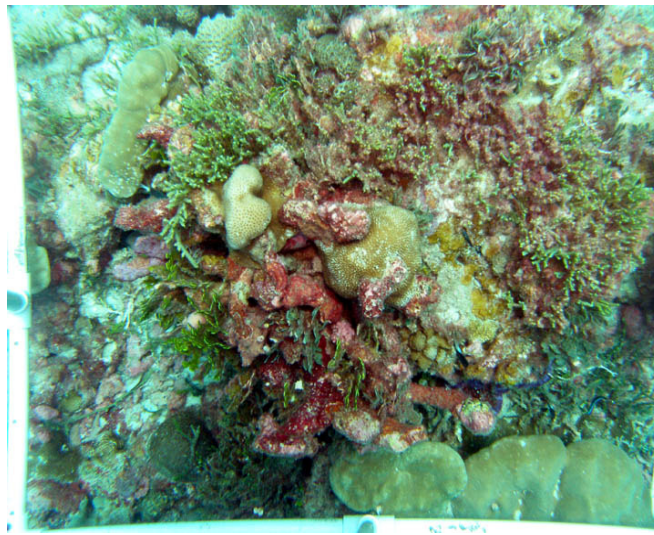
Positive feedbacks in the death of reef corals



Which is why reefs protected from overfishing and pollution are more resilient (not resistant!) to effects of climate change

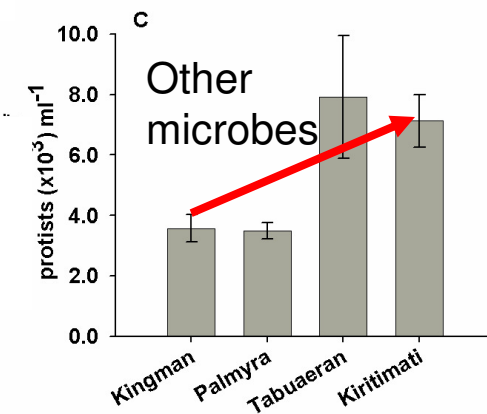
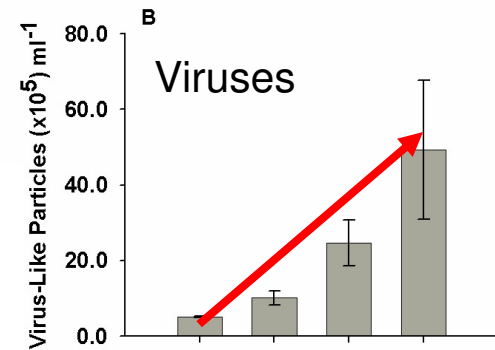
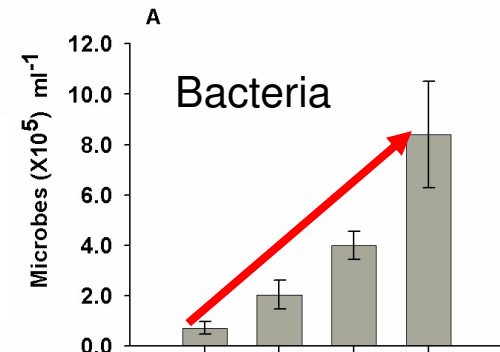
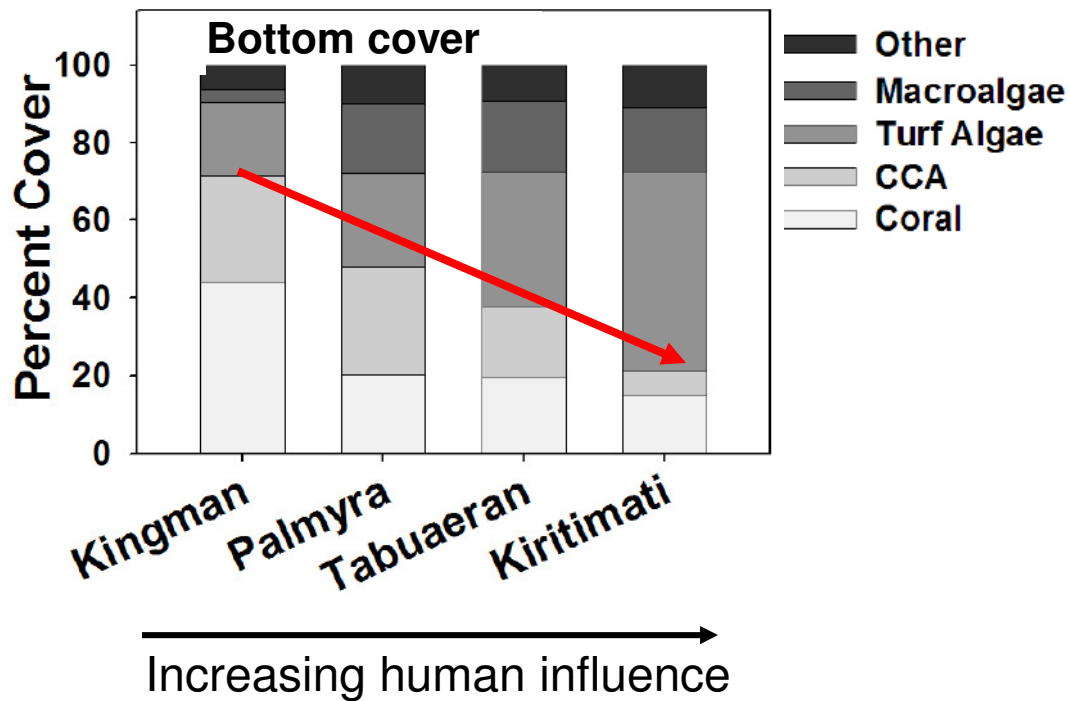
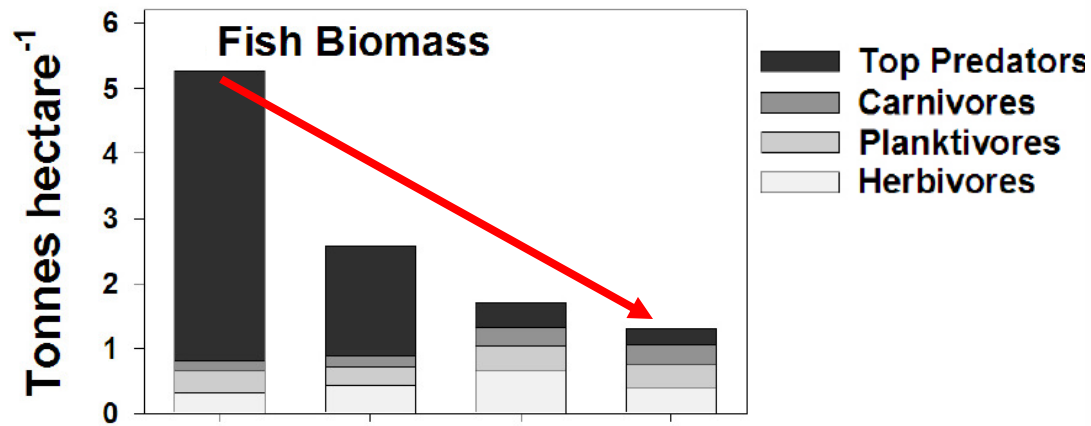


Kingman Reef
0 people



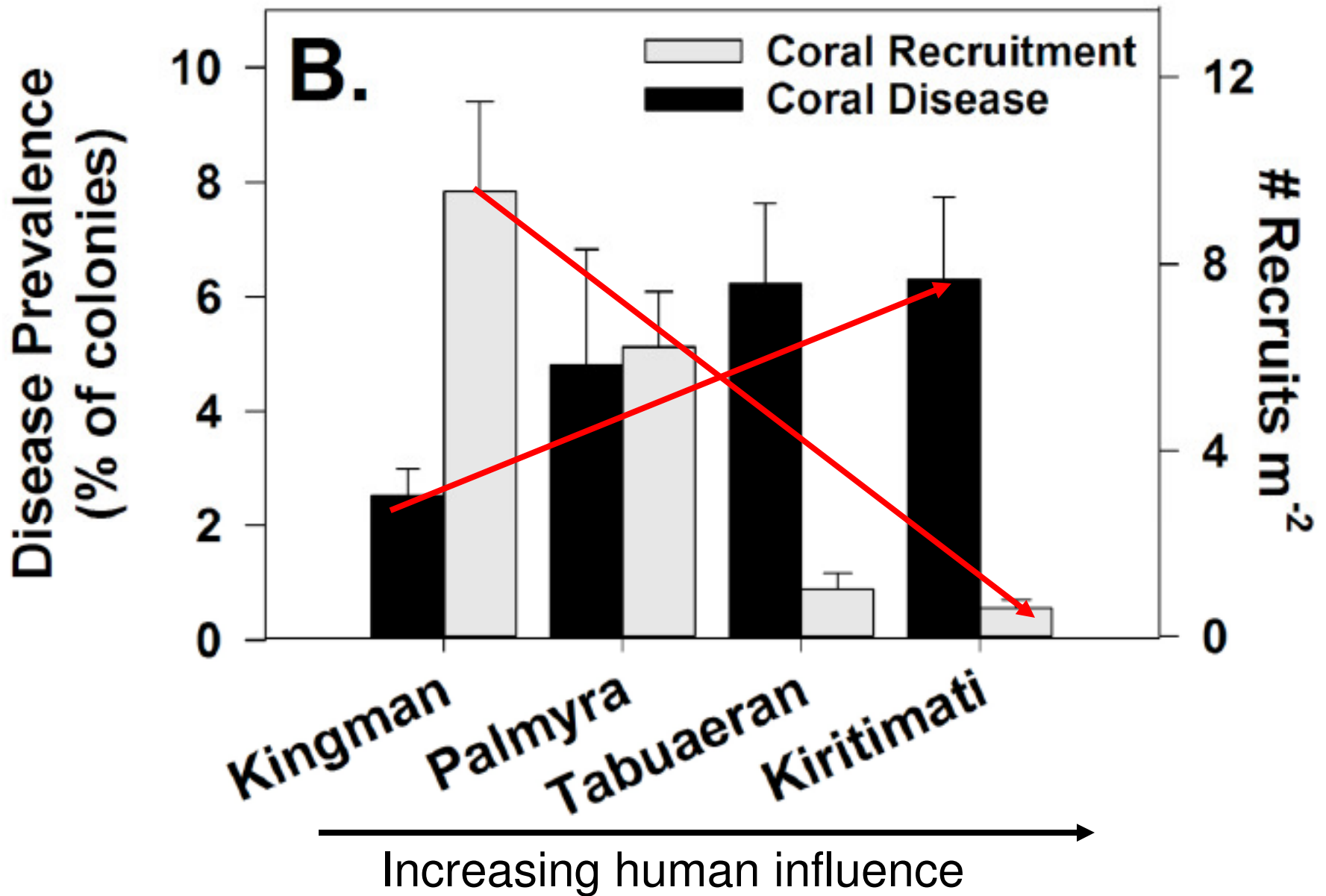
Kiritimati
5,000 people

Sandin et al. 2008.
PLoS One 3:e1548



Increasing human influence

Altered Communities due to fishing

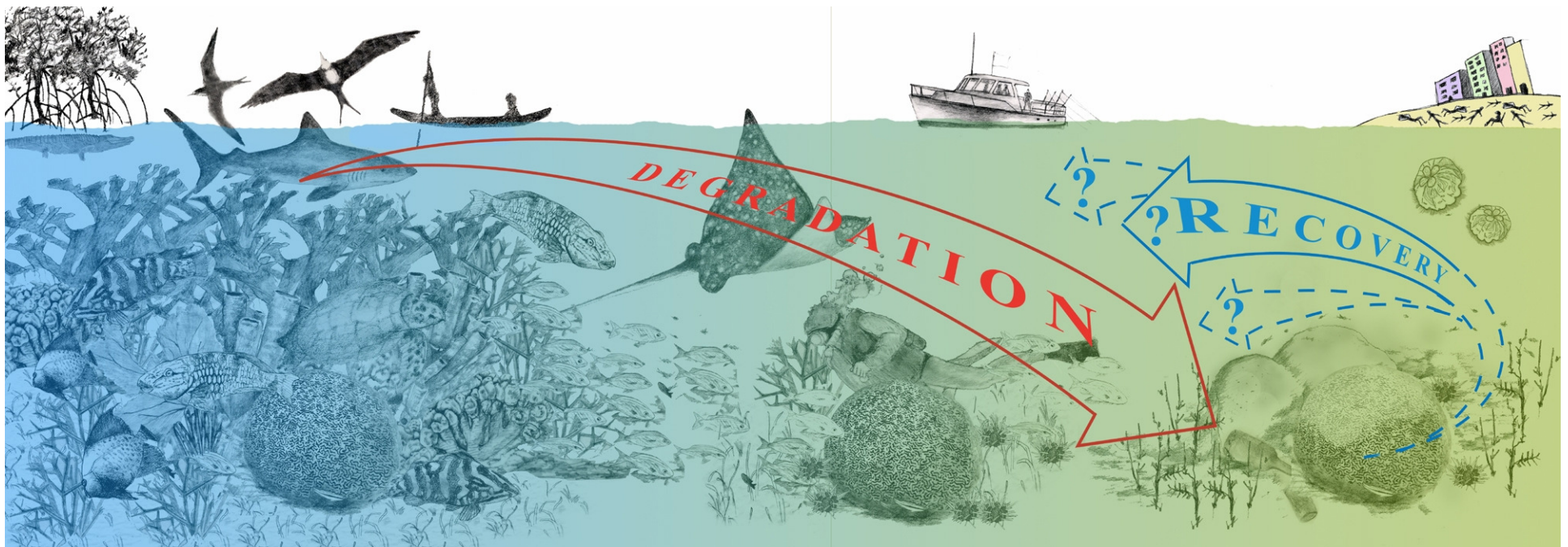


Greater Resilience with local protection

Increased resilience with protection from fishing and pollution emphasizes:

1. Urgent and immediate need for very large, strictly enforced marine protected areas covering at least one third of the area of the Florida Keys and associated ecosystems.
 - Because local protection buys time for reefs while humanity dithers.
2. Irresponsibility of focusing exclusively on climate change and its consequences as inevitably causing the death of reefs.
 - Because the impacts of climate change on people in South Florida will be even worse than for corals.

III. So what is the future of the Florida Keys?



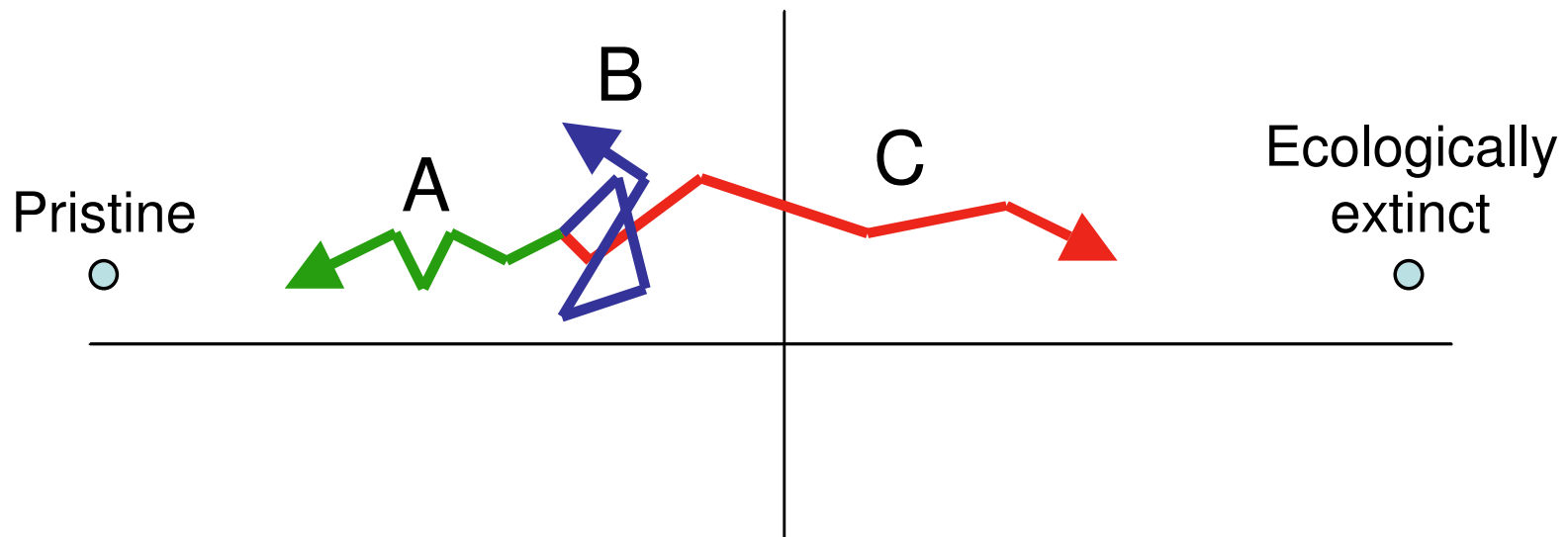
*Let's consider two approaches
to the question:*

- A. Conventional short-term scientific and social scientific data and arguments that so far have had frustratingly limited success in doing more than perhaps slowing down rates of degradation, or
- B. Stand back to ask whether we are on the verge of a tipping point within the next 2-3 decades that will utterly change the dimensions of the question.

A. Business-as-usual

- Fight courageous battles to increase the total protected (sort of) area to perhaps 20%
- Slowly start to address the septic tank and sewage outfall problems
- Have lots of meetings about reducing coastal development while development continues to increase because of failed government and corruption
- Maybe in the next 10-20 years achieve a watered down version of the Australian GBR management plan when they may have gone to 50%

And under these circumstances we don't know whether restoration is even possible or not?



But on the longer term the future for reefs is much rosier because people are on the way out

QuickTime™ and a
decompressor
are needed to see this picture.

Sea level rise and stronger storms are coming faster than predicted by the IGPPC

QuickTime™ and a decompressor are needed to see this picture.

QuickTime™ and a decompressor are needed to see this picture.

2007. *Science* 315:368

QuickTime™ and a decompressor are needed to see this picture.

QuickTime™ and a decompressor are needed to see this picture.

2008. *Science* 321:1340

2010 *Science* 327:454

Refinement of analyses makes things worse

QuickTime™ and a
decompressor
are needed to see this picture.
PNAS 106:21527

QuickTime™ and a
decompressor
are needed to see this picture.

*Most everything related to
climate change is
happening faster than it is
supposed to - and sea
level rise is the worst.*

QuickTime™ and a
decompressor
are needed to see this picture.

Blue and red lines are data,
dashed lines are IGPPC
projections

Rahmstorf et al. 2008. *Science* 316:709

*With even 1 m of sea level rise by 2100 the
Keys and Miami will be uninhabitable*

QuickTime™ and a
decompressor
are needed to see this picture.

Florida's irresponsibility in promoting continued coastal development is criminal negligence.

“It’s an outlaw state. Florida has been particularly irresponsible and it’s going to pay the price very soon.” Orrin Pilkey, 2010

QuickTime™ and a
decompressor
are needed to see this picture.

But aside from human stupidity, there are fundamental questions about conservation policy in the face of disappearing environments.

- What are we managing for when all the environments are going to change radically very soon?
- How should we be planning to take advantage of changing conditions?
- For example, the evaporation of sports fishing when people are losing their homes and their livelihood?
- Or the migration 100 km northward of Florida Bay and the Everglades?

Florida is one of thousands of examples where the exodus of people will be good for coral reef ecosystems.

- Most of the atolls of the Indo-Pacific
- All the low lying tropical (or soon to be tropical) coasts

All of which offer new opportunities for large-scale expansion of mangroves, seagrass meadows, and coral reefs, maximal blue carbon credits, etc.

How we act and react to these changes will be the essence of the future of the Florida Keys.

*One way or another nature
will win and life will go on.*

The question is what will nature
be like and to what extent we will
be around to enjoy or abhor it in
the future.