Principles & Components of Resilience

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The Nature Conservancy

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Principles & Components of Resilience

Section 1:

What is Resilience?

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What is lost when corals die?

Nature's Infrastructure provides …

Multiple direct benefits:

Shoreline protection, food, jobs, carbon sequestration (mangroves)

Sustainable development

Cost effective, sustainable solution:

Value of coral reefs: $31 – 600 thousand/sq. km

Shoreline protection cost: $250,000 – $15 million/km

What is resilience?

The ability of a system to maintain key functions and processes in the face of stresses or pressures by either resisting or adapting to change.

~Types~

Biological

Social

Biological Resilience

high cover
high diversity
low disease
broad size range

strong recovery
good substrate
good water quality
healthy herbivores

Social Resilience

Resilience of social systems is often related to three different characteristics:

- the magnitude of shock the system can absorb and remain stable
- the degree to which the system is capable of self-organization
- the degree to which the system can build capacity for learning and adaptation

Principles & Components of Resilience

Section 2:

The Four Principles of Resilience

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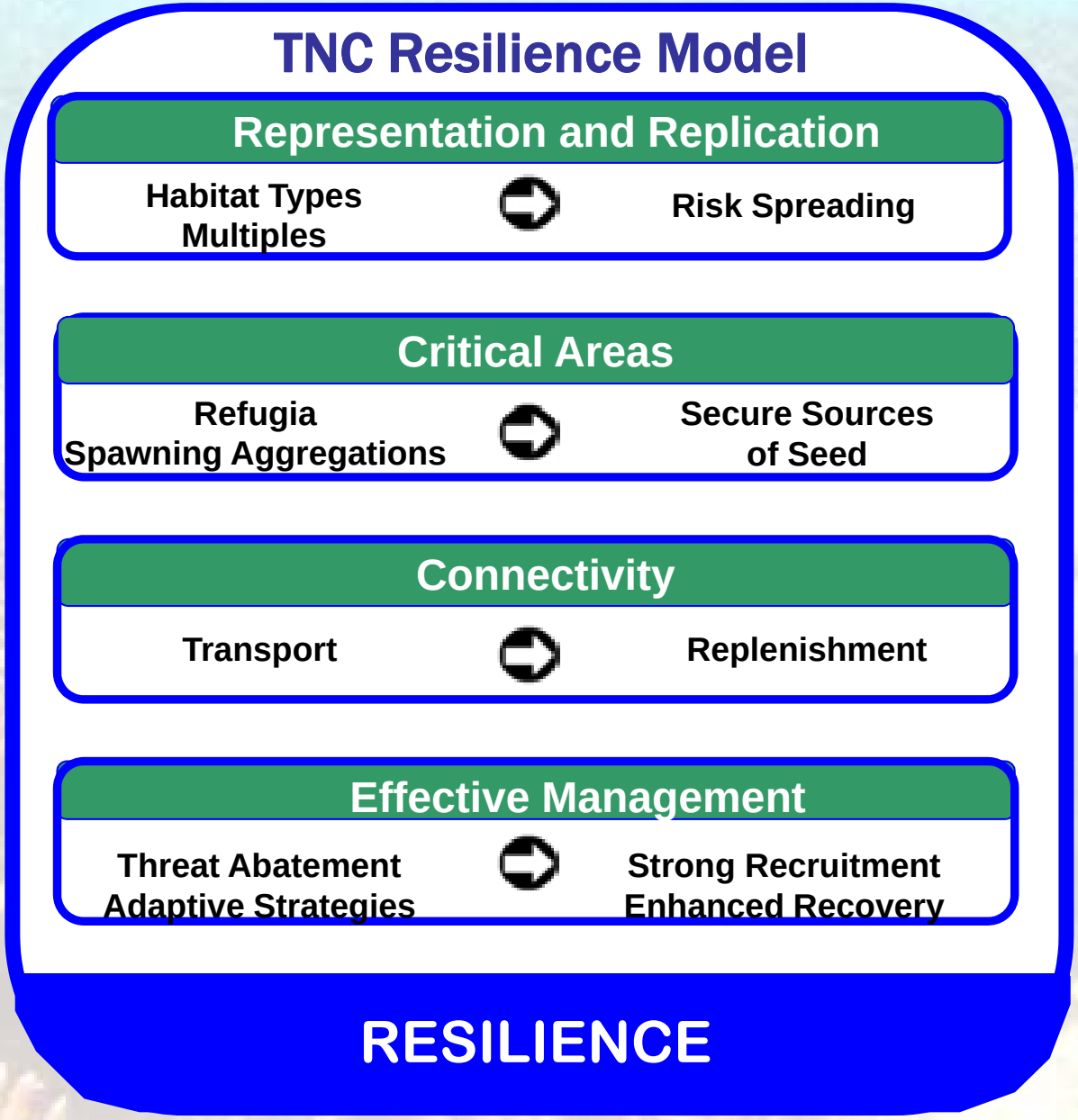
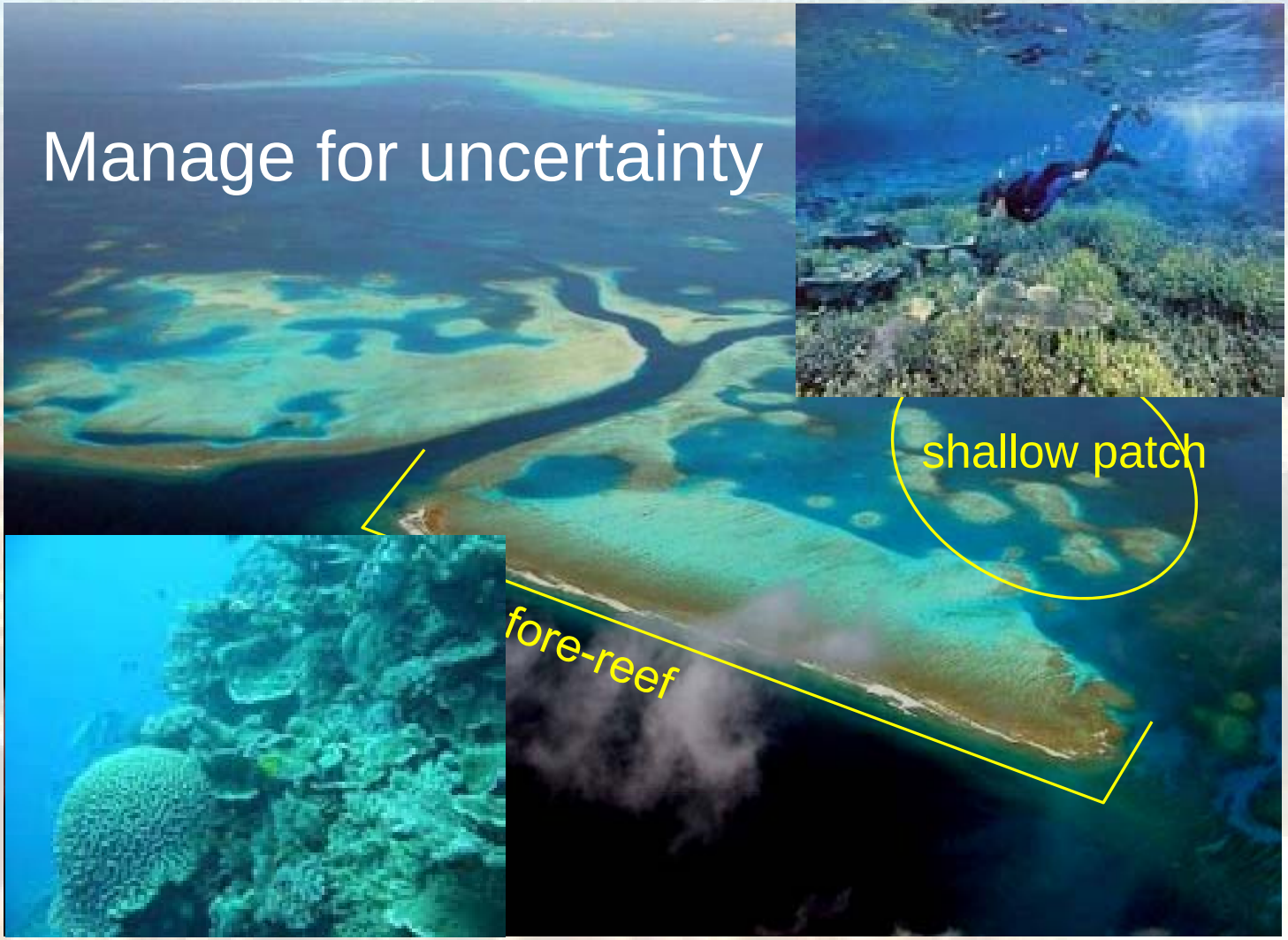
Four Principles of Resilience



Representation and Replication

Habitat Types
Multiples

Risk Spreading



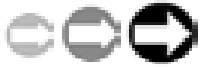
Critical Areas

Refuges
Spawning Aggregations

Secure Sources
of Seed

Protect refugia

Connectivity

Transport  **Replenishment**

Protect linkages

Effective Management

Threat Abatement
Adaptive Strategies

Strong Recruitment
Enhanced Recovery

Control threats – reduce stress

Effective Management

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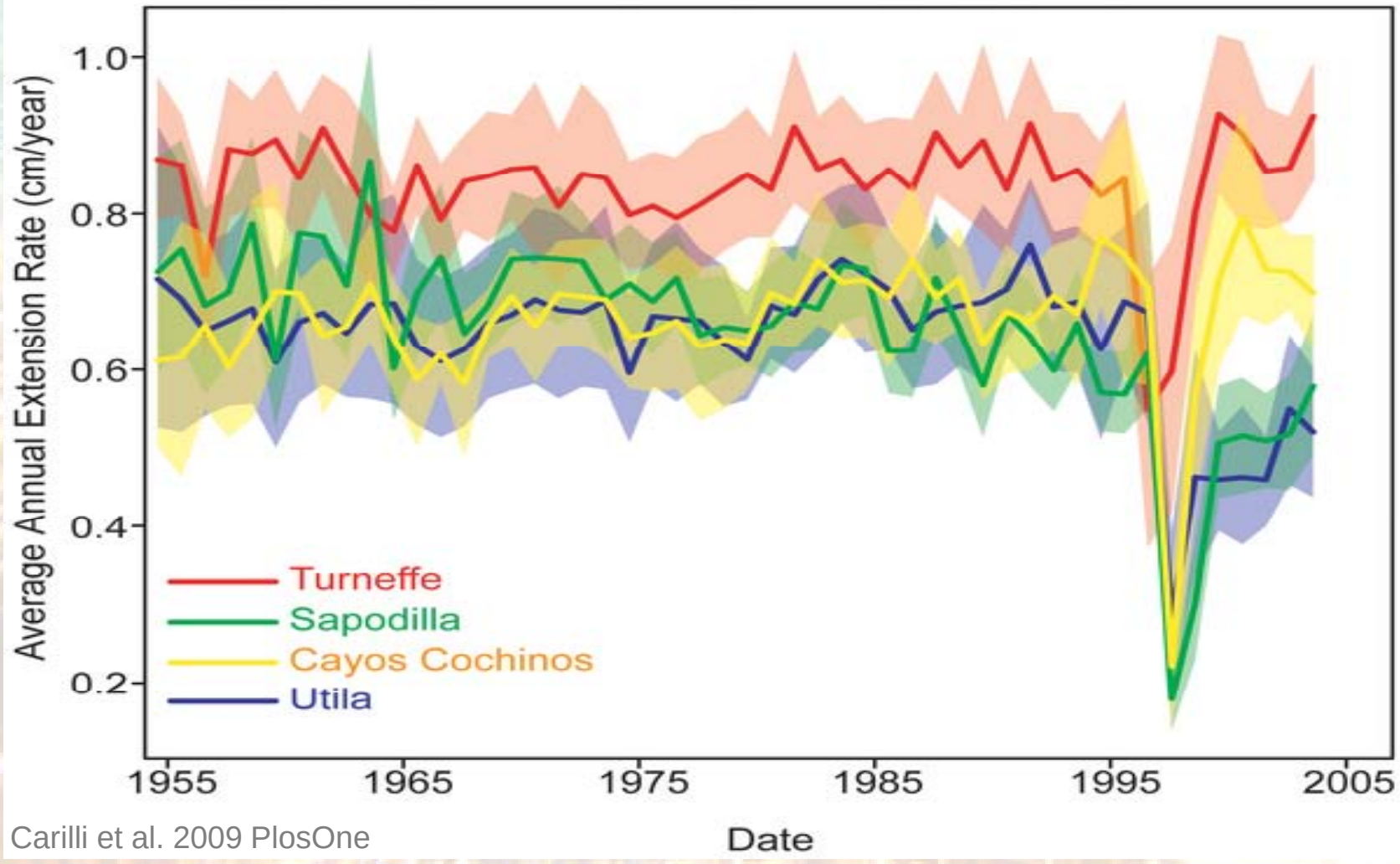
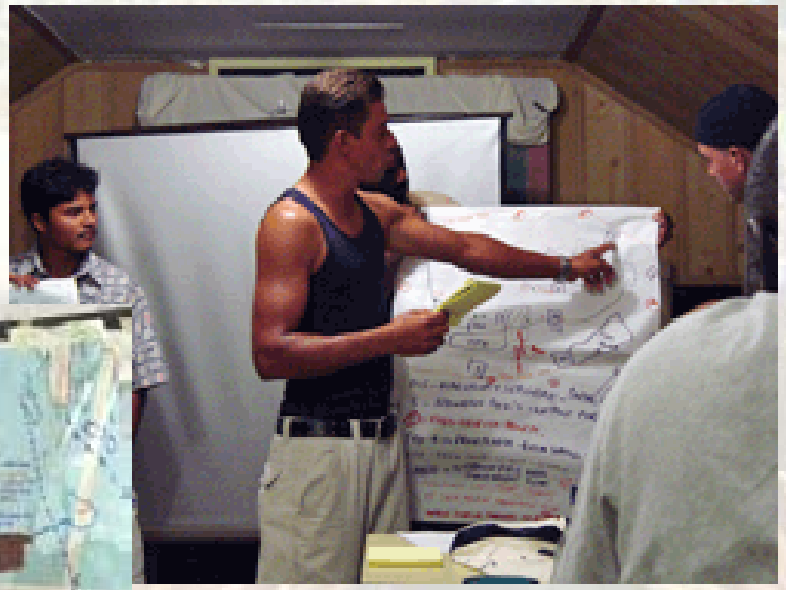


Stress Index
0.20
0.84
3.40
1.70

Carilli et al. 2009 PlosOne

Effective Management

- Communication
- Evaluation of Management Effectiveness
- Adaptive Management
- Precautionary Approach



Principles & Components of Resilience

Section 3:

Identifying Resilience

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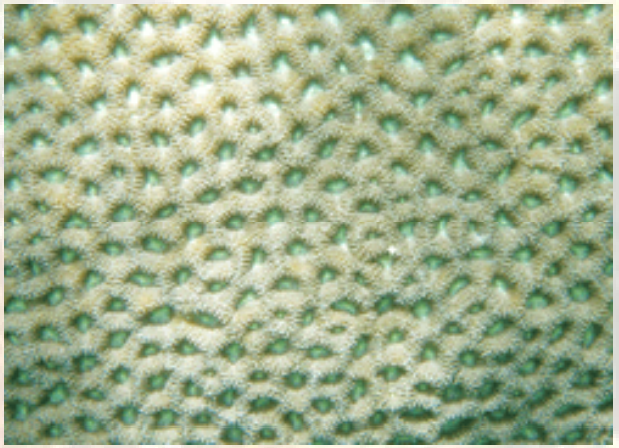
Identifying Resilience

- Ecological
- Biological
- Physical



Ecological Resilience Factors

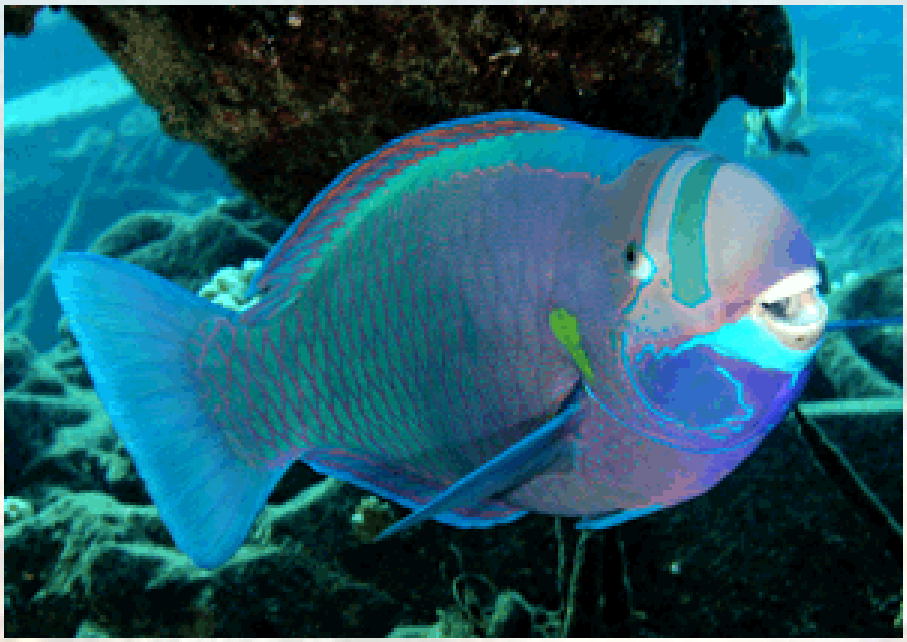
Food web interactions: herbivory, trophic cascades)

Reproductive cycles

Population connectivity

Coral & fish recruitment

Ecological Resilience Factors: Herbivory



- Facilitate coral recovery
- Regulators of community structure and function
- Regulate algal/coral competition

Key Species for Pacific Reefs

High Bite Rate (fast food!)

Steephead Parrotfish: Chlorurus microrhinos

Large Macroalgae Eatin'

Stareye Parrotfish: Calotomus carolinus

Ecological Resilience Factors: Herbivory

- Reef Herbivores (grazers, scrapers, bioeroders)
- Parrotfish (and long-spined urchins)
- Loss through overfishing – algal dominated
- Phase shift reversal? Sleeper functional groups

Ecological Resilience Factors: Herbivory

From the field: Exuma Land and Sea Park

Grazing ↑ + Coral Recruitment (x 2) + Top Predators ↑

Mumby et al. 2006, 2007

Ecological Resilience Factors: Recruitment

Recruitment = supply of new individuals to a population

Ecological Resilience Factors: Recruitment

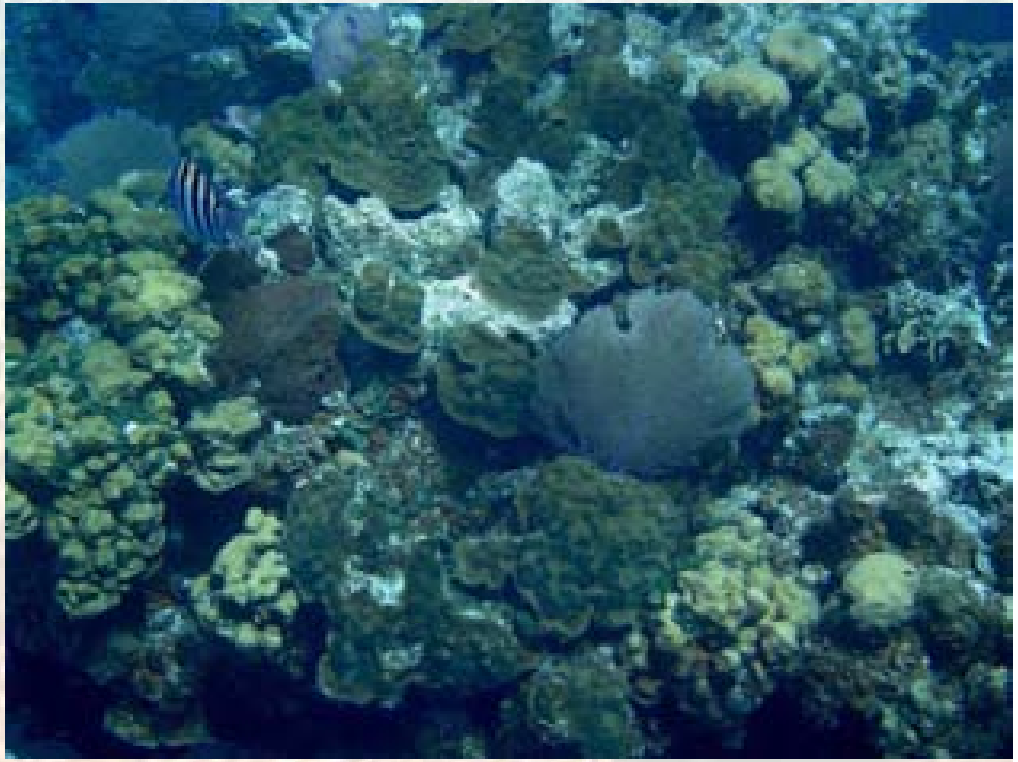
Determining Factors

- Physical oceanographic processes (e.g., upwelling)
- Abundance of larvae in water column
- Larval behavior (e.g., vertical migration in the water column)
- Availability of settlement substrate
- Ecological factors that affect survivorship after settlement (e.g., competition, predation, food supply)

Ecological Resilience Factors: Recruitment

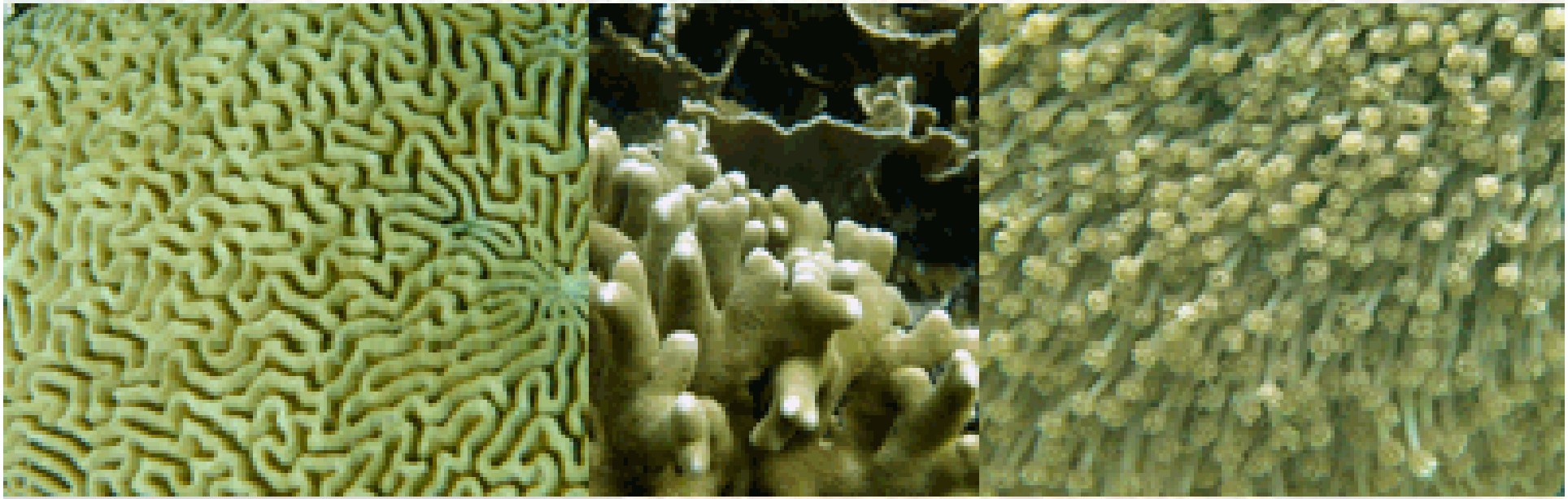
Suitable habitat for recruits?

- Diversity & abundance of species
- High herbivore densities
- Low corallivores, bioeroders, disease
- Presence of CCA



Biological Resilience Factors

- Genetic differences
- Species differences



Biological Resilience Factors: Genetic Differences

Coral differences:

- Fluorescent tissue pigment
- Colony integration
- Tissue thickness

Zooxanthellae differences:

- Heat tolerance

*Clade D symbionts are more tolerant

Biological Resilience Factors: Species Differences

Likely to bleach (e.g., Acropora, Millepora):

- Quick colonizers
- Fast growing
- Short-lived

Likely to survive (e.g., Porites, Montastrea):

- Massive growth forms
- Thick or less integrated tissues
- Slow growth rates

Biological Resilience Factors: Species Differences

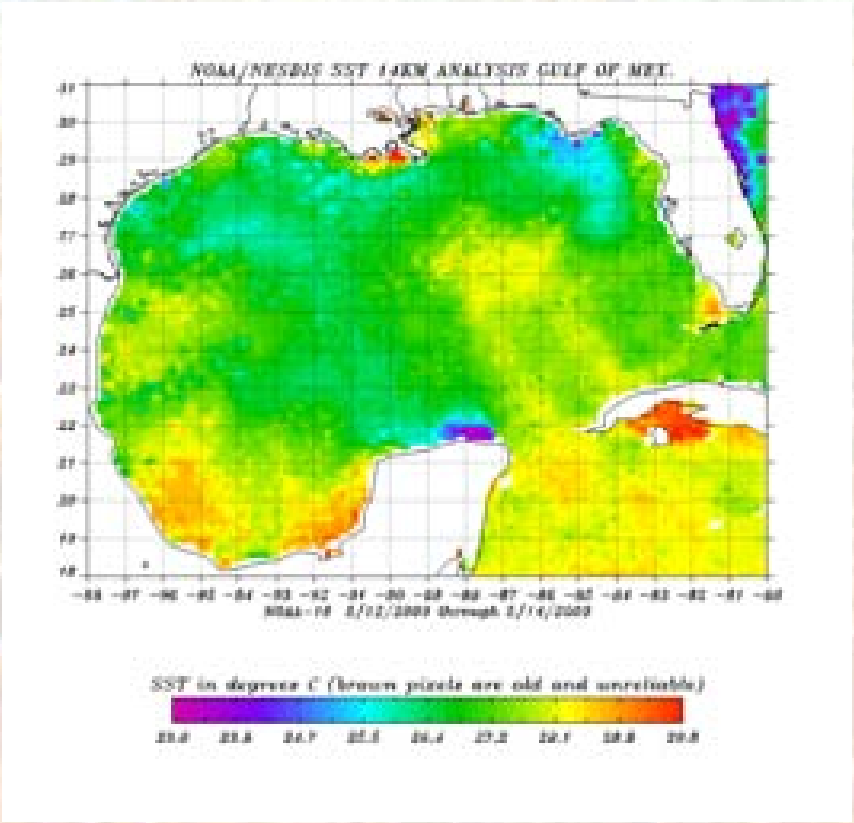
Resistance	Growth type	Coral Family	Examples
Low → High	Fine branching; thin or well-connected tissue	Pocilloporidae	Seriatopora
			Stylophora
			Pocillopora
	Branching, tabulate, encrusting/foliose	Acroporidae	Acropora
			Montipora
	Massive, brain	Faviidae	Favia
			Favities
			Leptoria
			Goniastrea
			Platgyra
	Massive, boulder; thick or less-integrated tissue	Poritidae	Porites
			Goniopora
			Galaxea
			Pavona

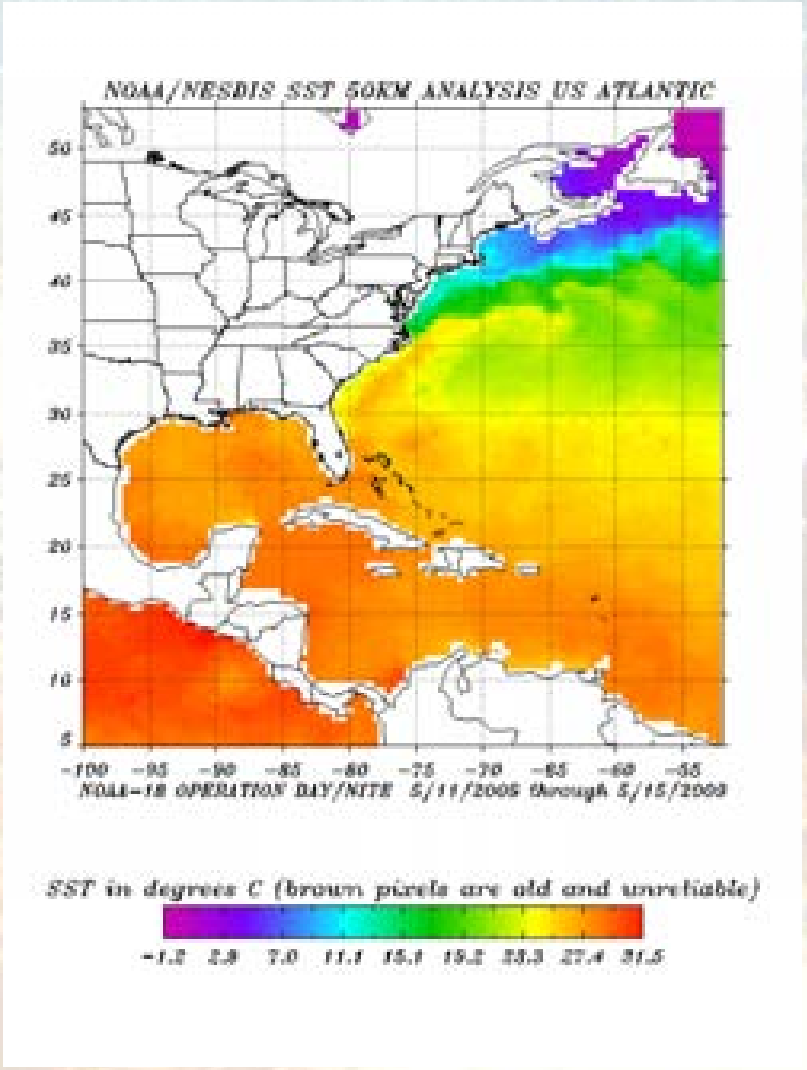
Physical Resilience Factors

- Cooling
- Shading
- Screening
- Stress Tolerance

Physical Resilience Factors: Cooling

- Broad scale (1000's of km)
- Regional scale (100's of km)
- Local scale (10s of km)



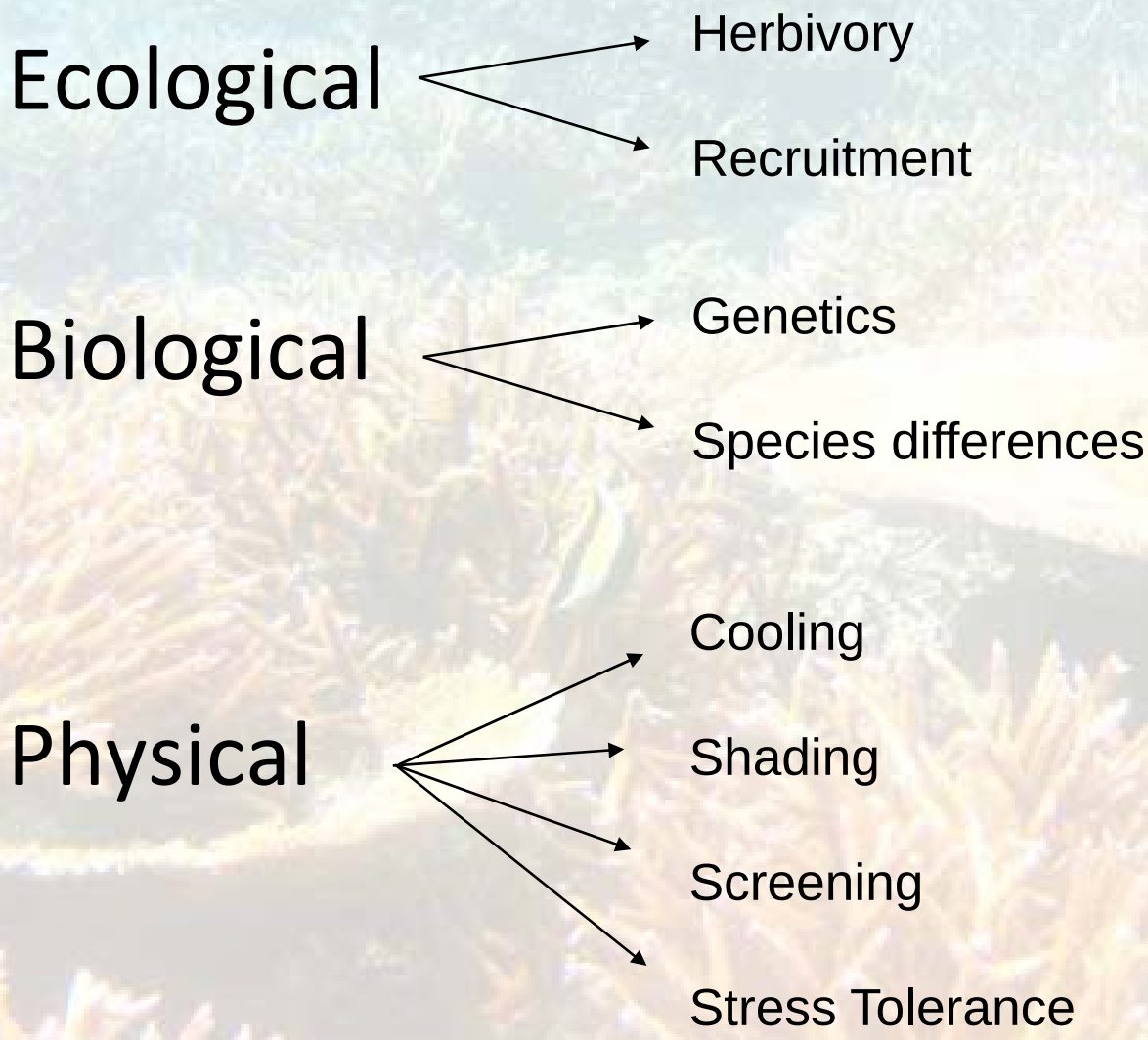


Physical Resilience Factors: Shading

Physical Resilience Factors: Screening

Physical Resilience Factors: Stress Tolerance

Summary of Factors



If the perils of our time are unprecedented, then so are the opportunities. – Anonymous