The extinction risk of corals: the past, the present and the future

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Photo: T. Nakamura

Rationale

- **The risk of global extinction of corals is currently evaluated from trends in population reduction and isolation.**

- **This approach suffers from (i) missing data on population trends, (ii) too brief of a time series for long-lived organisms, and (iii) an inability to validate the results.**

Objective

Compare the vulnerability of modern and Plio-Pleistocene corals to thermal stress events.

Biological traits + Processes = *Resilience score*

Methods

- Compiled a list of biological traits and ecological processes.

- A consensus was reached on the general principle underlying each trait and on the scoring methodology - *a priori.*

Trait- and Process-Based Assessment of Extinction Risk: Thermal Stress

Table 1. Biological traits and processes of coral taxa with the rationale for their tolerance to and recovery from a thermal stress.

physical trait	rationale
morphology	influences thermal and light exposure
tissue thickness	provides energy storage
distance between corallites	promotes partial mortality
calcification rate	increases demand for energy
colony size	increases available energy
corallite size	promotes energy storage
association with *Symbiodinium* Clade D	gives thermal tolerance
skeletal structure	creates refuge for tissue
biological process	**rationale**
mode of sexual reproduction	low investment and high numbers good in disturbed environments
recruitment density	high numbers good in disturbed environments
colony regrowth	allows recovery from partial mortality
colony growth	allows recovery after disturbance

van Woesik et al. Proc. R. Soc. B doi:10.1098/rspb.2011.2621 (2012)

Methods

- Select dominant corals in Caribbean and Indo-Pacific
- Corals evaluated on tolerance to a two-month +3^{o}C thermal stress anomaly during solar insolation maximum.
- Traits and processes were scored; scores were summed as a *resilience score*.

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Trait- and Process-Based Assessment of Extinction Risk: Thermal Stress

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physical trait	rationale	tolerant	intolerant
morphology	influences thermal and light exposure	massive	branching
tissue thickness	provides energy storage	thick	thin tissues
distance between corallites	promotes partial mortality	large	small: no coenosteum
calcification rate	increases demand for energy	low	high rate
colony size	increases available energy	large	small
corallite size	promotes energy storage	large	small
association with *Symbiodinium* Clade D	gives thermal tolerance	greater than10% D by numbers reported	≤10% D by numbers
skeletal structure	creates refuge for tissue	porous	non-porous
biological process	**rationale**	**high recovery**	**low recovery**
mode of sexual reproduction	low investment and high numbers good in disturbed environments	broadcasting	brooding
recruitment density	high numbers good in disturbed environments	high	low
colony regrowth	allows recovery from partial mortality	regrowth from remaining tissue	no regrowth
colony growth	allows recovery after disturbance	high	low

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Region	Genus	Traits Score	Process Score	Resilience Score
Caribbean	*Madracis*	-6	0	-6
	Acropora	0	2	-2
	Agaricia	-4	2	-2
	Manicina	0	-2	-2
	Meandrina	0	-1	-1
	Stephanocoenia	-3	2	-1
	Dichocoenia	0	0	0
	Eusmilia	-2	2	0
	encrusting *Porites*	0	0	0
	branching *Porites*	-4	1	1
	Colpophyllia	2	0	2
	Dendrogyra	3	0	3
	Favia	3	0	3
	Montastraea cavernosa	5	-2	3
	Montastraea annularis	4	0	4
	Diploria	4	1	5
	Siderastrea	2	3	5

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Region	Genus	Traits Score	Process Score	Resilience Score
Indo-Pacific	*Stylophora*	-5	0	-5
	foliose *Pavona*	-4	0	-4
	Pocillopora	-3	0	-3
	encrusting/submassive *Pavona*	-2	0	-2
	Seriatopora	-3	2	-1
	Acropora	-2	3	1
	branching *Porites*	-1	2	1
	encrusting *Montipora*	-2	4	2
	Platygyra	-1	3	2
	Favites	-1	4	3
	Cyphastrea/Leptastrea	1	2	3
	Echinopora	3	0	3
	massive *Porites* (*lobata*)	2	2	4
	Favia	1	4	5

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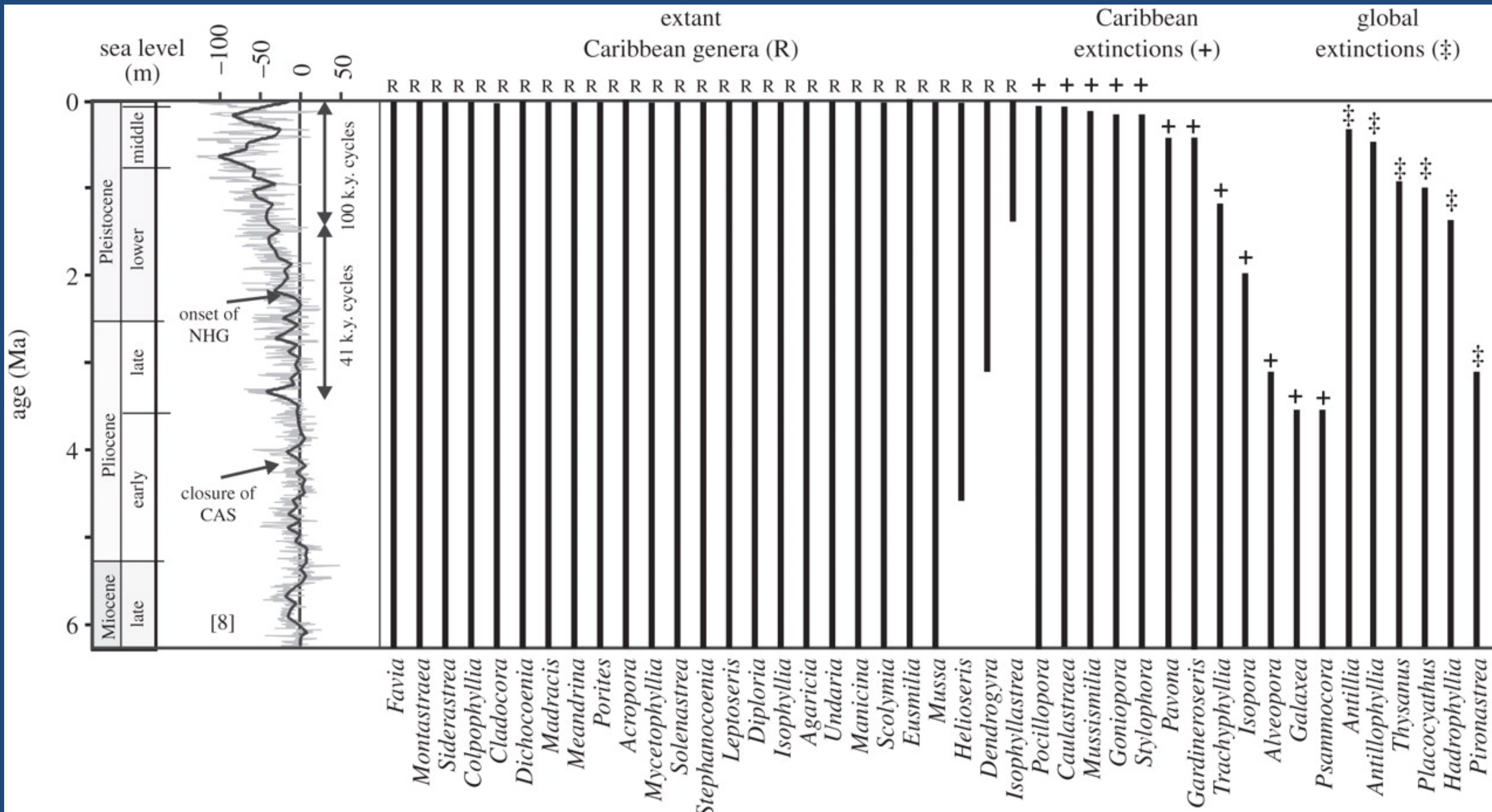
Stratigraphic ranges of recorded reef coral genera (total = 43) within the Caribbean region from 6.8 Ma to Recent.



Of the 43 coral genera, 18 went regionally extinct, and 12 persist in the Indo-Pacific

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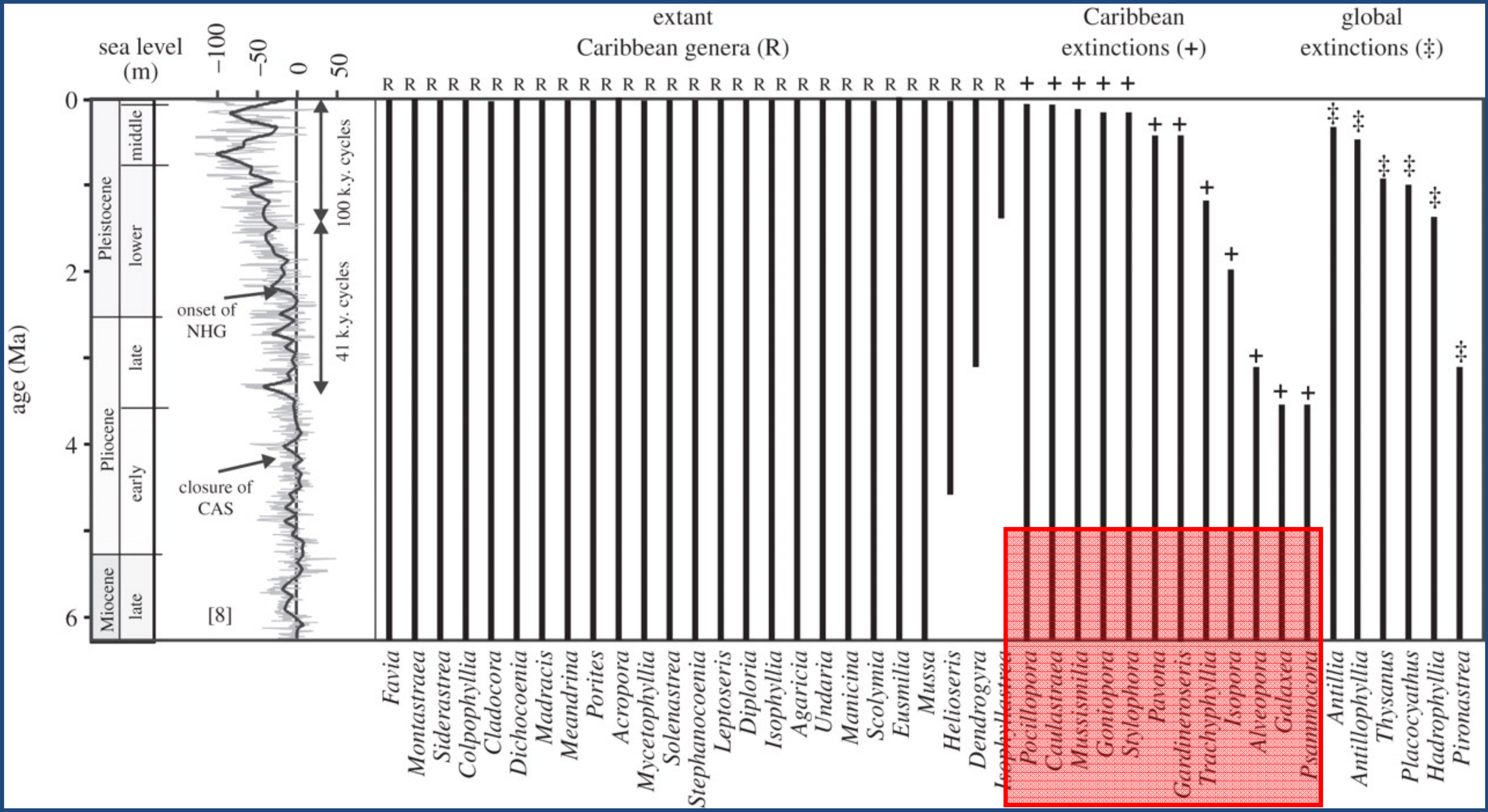

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The probability that a coral went extinct in the Plio-Pleistocene , Pp(x), was 0.42

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	Platygyra	-1	3	2
	Favites	-1	4	3
	Cyphastrea/Leptastrea	1	2	3
	Echinopora	*3*	0	3
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The probability that a modern species was listed among the least resilient coral in the Indo-Pacific, Mp(x) = 0.21

Probability that it went extinct in the Caribbean and was vulnerable in the modern Indo-Pacific

$Pp(x)* Mp(x) = 0.09$ (Bayesian credible intervals 2% to 16%).

Against the odds, it happened 3 times…

Pocillopora, Stylophora, and foliose *Pavona* all went extinct in the Caribbean and are also the top three most vulnerable coral taxa in the Indo-Pacific



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Species traits matter

Coral extinctions are trait-based.

Pocillopora damicornis (Cauliflower Coral) - Mozilla Firefox

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Pocillopora damicornis (Cauliflower ...

http://www.iucnredlist.org/apps/redlist/details/133222/0

The IUCN Red List of Threatened Species™ 2010.4

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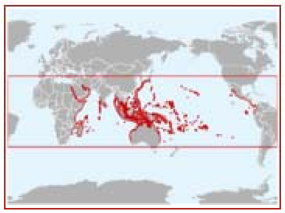

Pocillopora damicornis

NOT EVALUATED	DATA DEFICIENT	LEAST CONCERN	NEAR THREATENED	VULNERABLE	ENDANGERED	CRITICALLY ENDANGERED	EXTINCT IN THE WILD	EXTINCT
NE	DD	LC	NT	VU	EN	CR	EW	EX

Summary | Classification Schemes | Images & External Links | Bibliography | Full Account

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Taxonomy [top]

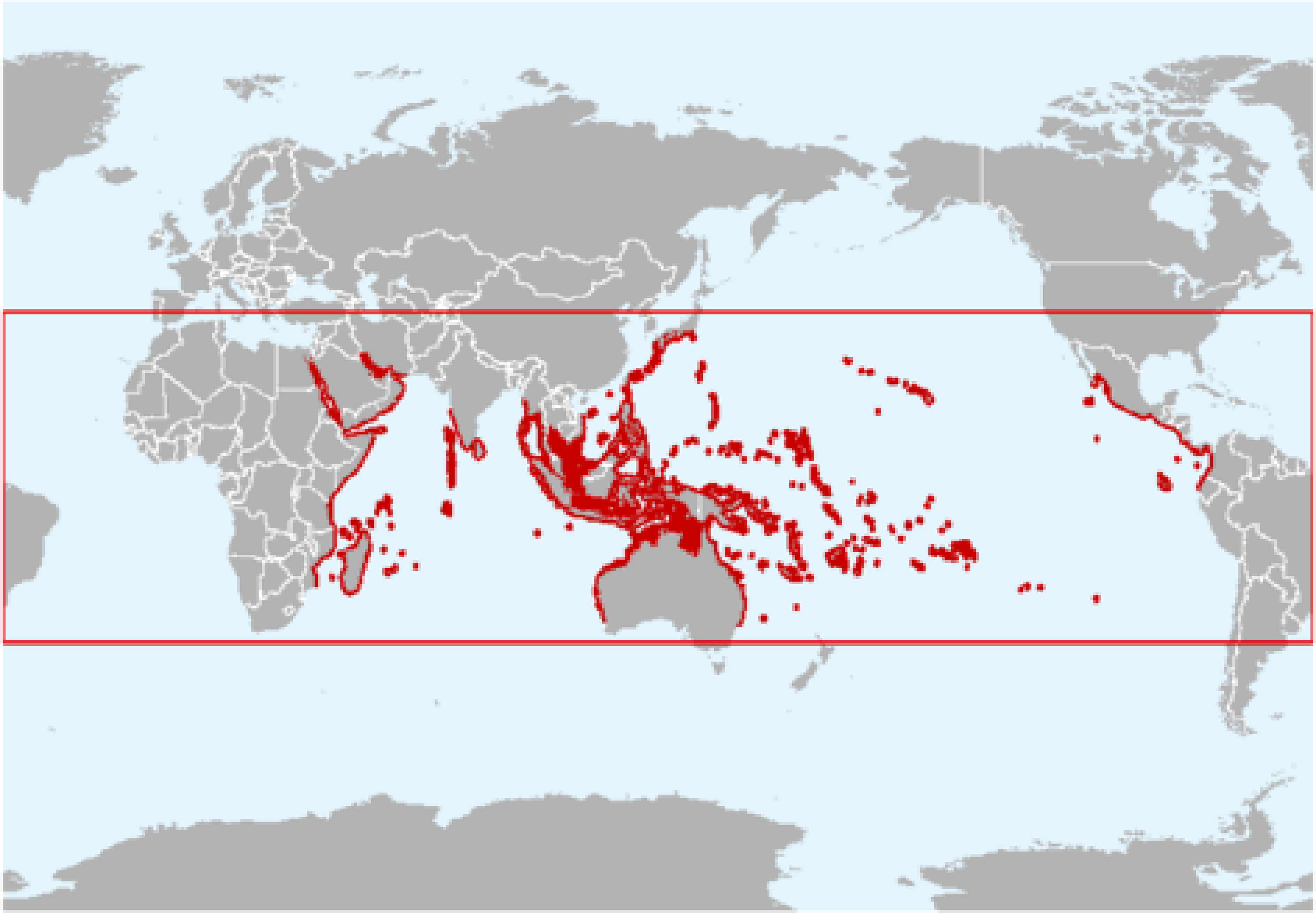
Kingdom	Phylum	Class	Order	Family
ANIMALIA	CNIDARIA	ANTHOZOA	SCLERACTINIA	POCILLOPORIDAE

Scientific Name:	*Pocillopora damicornis*
Species Authority:	(Linnaeus 1758)

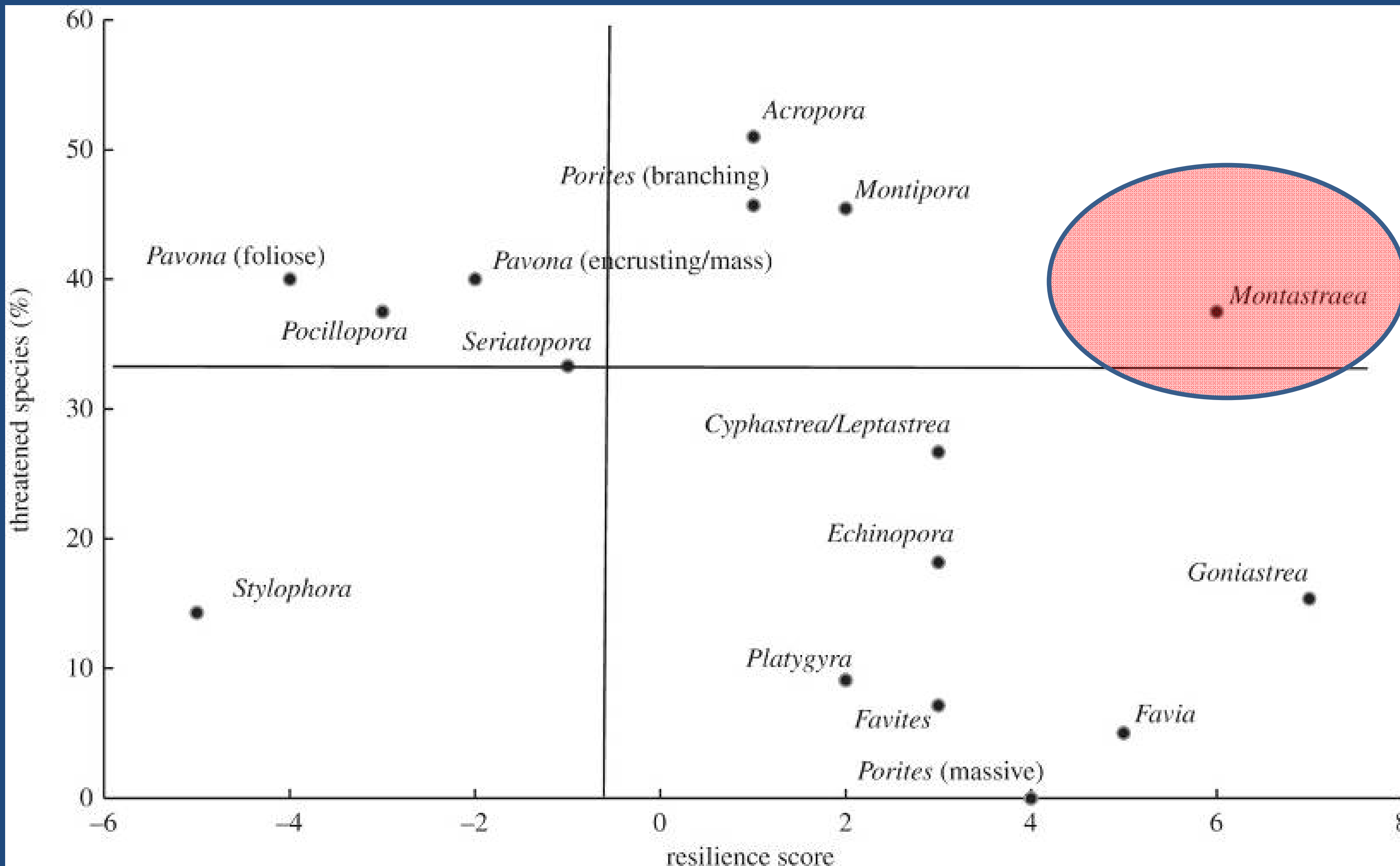
Common Name/s:
- English – Cauliflower Coral
- French – Corail Choufleur
- Spanish – Coral Coliflor

Assessment Information [top]

Red List Category & Criteria:	Least Concern ver 3.1
Year Assessed:	2008
Assessor/s	Hoeksema, B., Rogers, A. & Quibilan, M.
Reviewer/s:	Livingstone, S., Polidoro, B. & Smith, J. (Global Marine Species Assessment)
Contributor/s:	



The relationship between the resilience score and the percentage of threatened species within coral genera using the IUCN Red List criteria for Indo-Pacific coral taxa .



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	Colpophyllia	2	0	2
	Dendrogyra	3	0	3
	Favia	3	0	3
	Montastraea cavernosa	5	-2	3
	Montastraea annularis	4	0	4
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Vulnerability to Extinction

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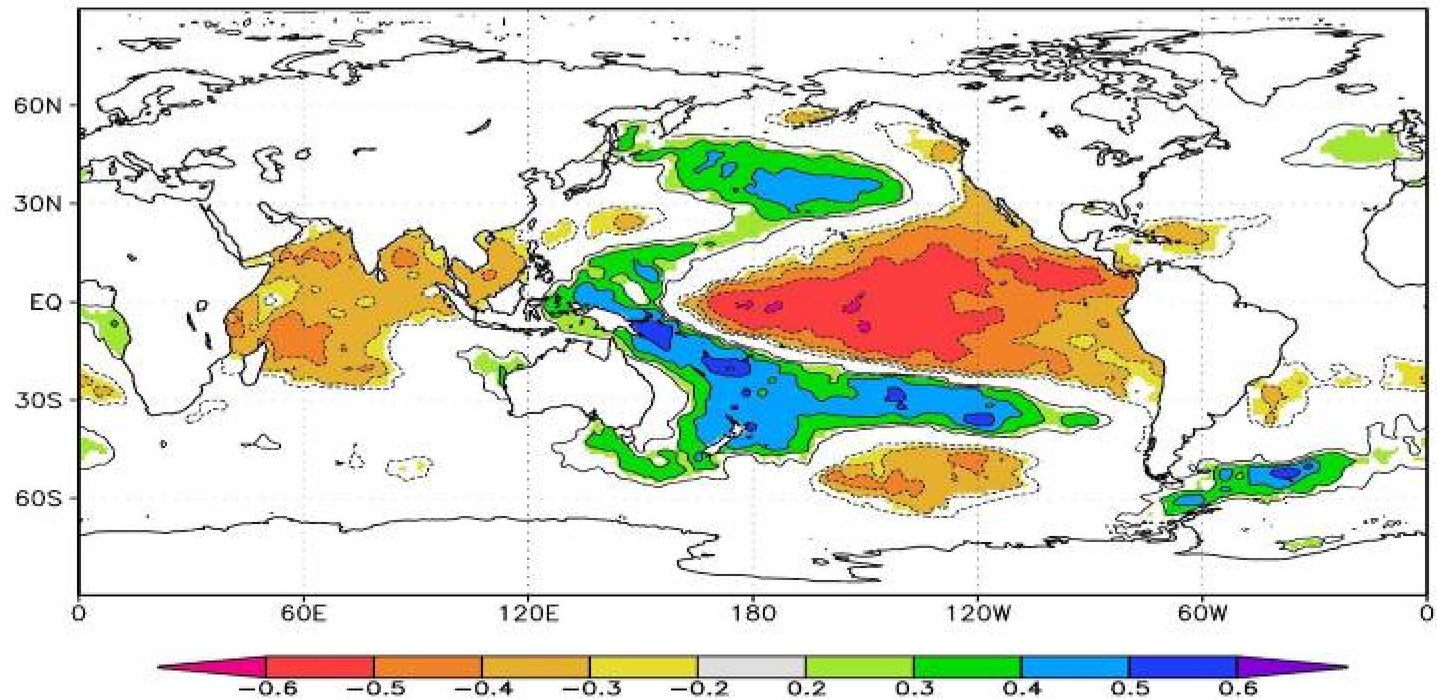
- Maps are static – there is no *date* on them
- No biological traits
- No evolutionary adaptation

Corals at sites with historically high-frequency temperature anomalies are most likely to adjust to contemporary thermal stress events.



Thompson & van Woesik (2009) Proc Royal Soc 276: 2893-2901

Other considerations of relative extinction risk

- Phenotypic variance, range expansion, acclimation, a**daptation…**

- Environmental variance, environmental range, environmental thresholds, median climate year experience, return frequency of thermal anomalies …

Predictions

- Biological traits will influence species' vulnerability to climate change.
- Some species will adapt to rapid climate change.
- *Montastraea* will likely persist.