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Developing indicators for monitoring coral reef resilience in Kenya

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2021 2030 United Nations Decade of Ocean Science for Sustainable Development

A UN Ocean Decade Event

#MSEAS2024

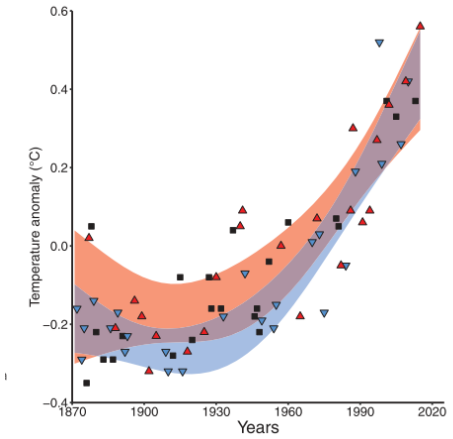
Marine Socio-Ecological Systems Symposium

Climate change and coral reefs

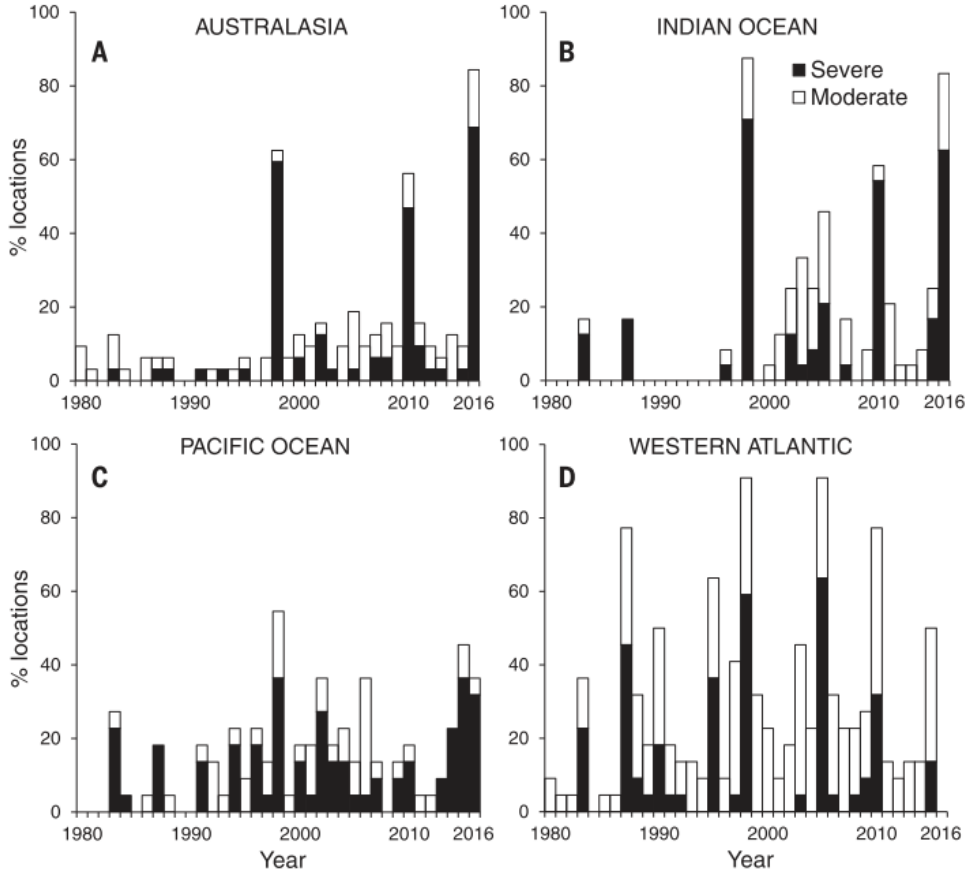
Coral bleaching

- ✓ Increasing in frequency
- ✓ Geographically larger

Hughes et al 2018



Global warming throughout ENSO cycles

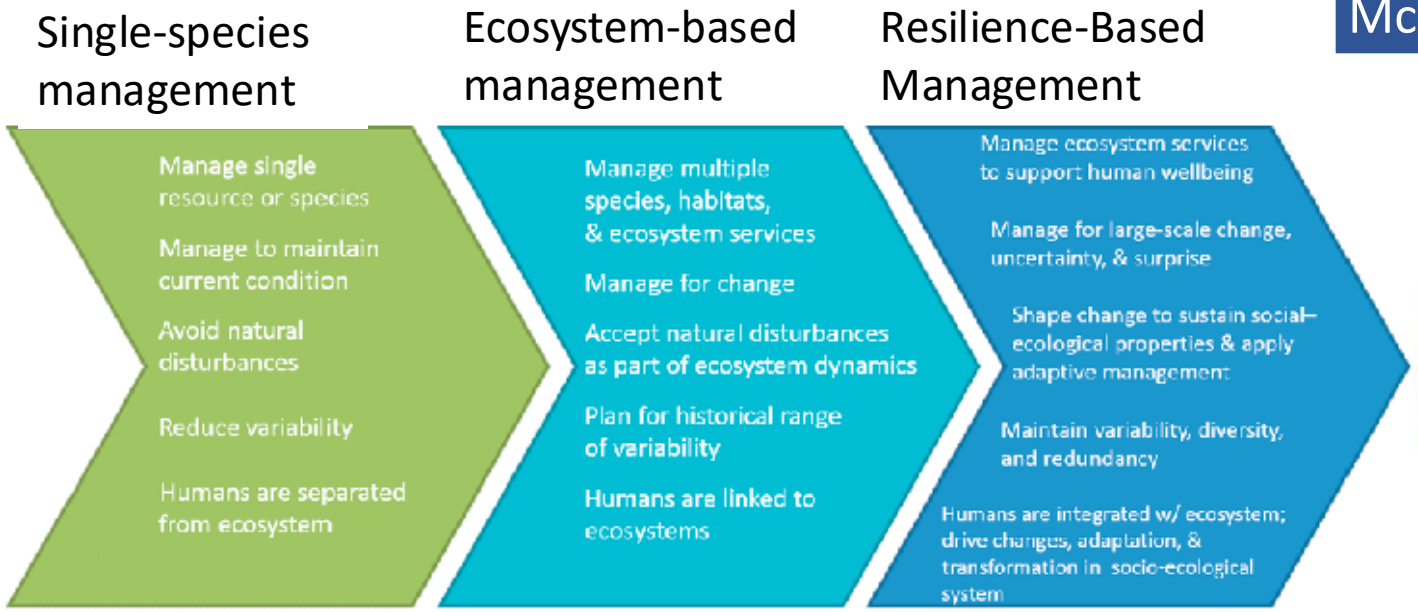


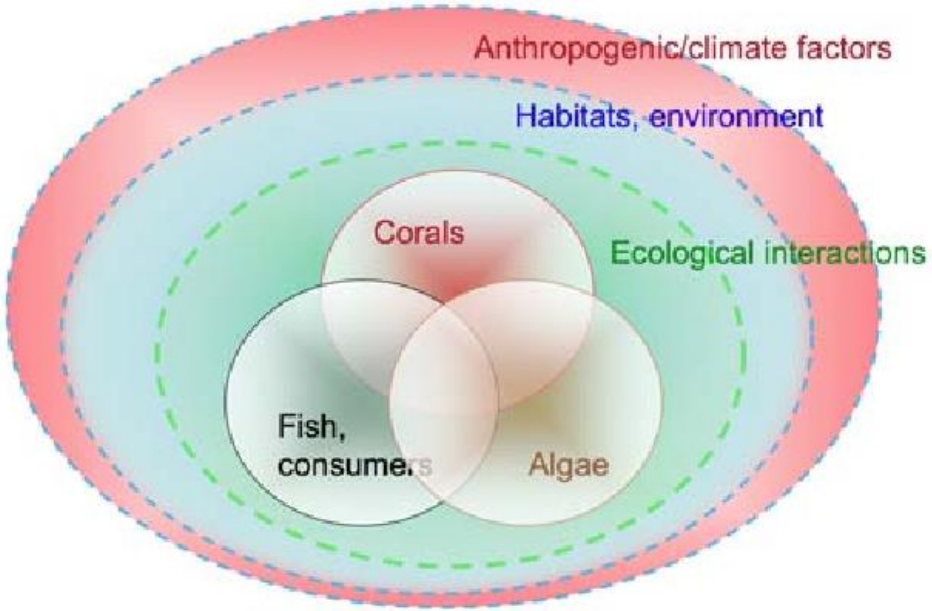
Geographic variation in the timing and intensity of coral bleaching from 1980 to 2016.

Resilience-Based Management (RBM)

Indicators to monitor ecological resilience

Obura and Grimsditch 2009 – 61 Broad-scale
McClanahan 2012 – 11 Global indicators





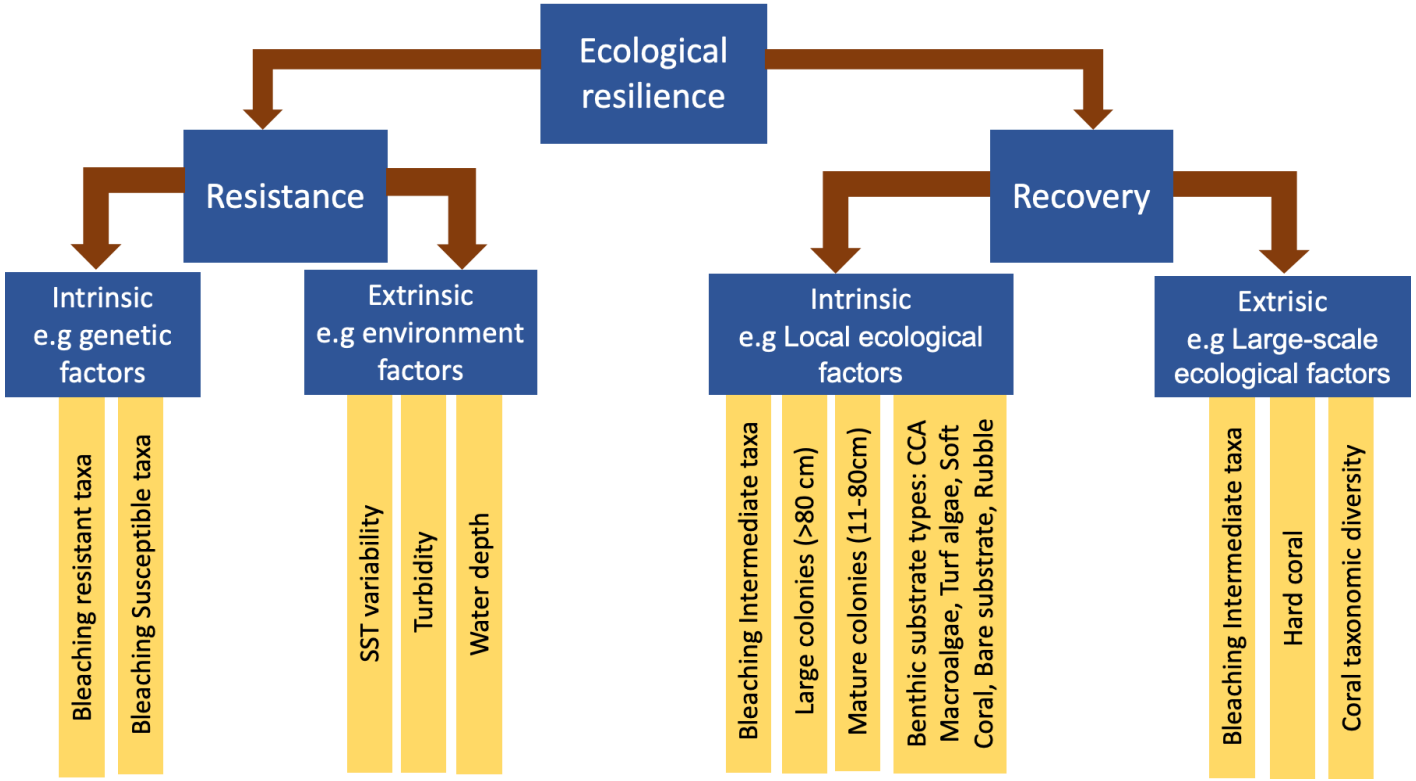
Definition of ecosystem resilience:

- ….ability to resist, reorganize and re-establish from disturbance and still maintain structure and function. (Nystrom *et al*. 2000, Gunderson 2000)

Properties of reef resilience (West and Salm 2003)

- Resistance → ability of coral community to withstand/survive disturbance e.g bleaching
- Recovery → capacity of a reef system to maintain or return its coral assemblage and function after a disturbance/ bleaching event

A simple classification of resilience indicators



Resilience property	Rationale	Variable	Variable Code	Measure	Direction
Resistance	Bleaching resistance	Bleaching resistant	B-resistance	Density	1
Resistance	Bleaching resistance	Bleaching susceptible	B-susceptible	Density	-1
Resistance	Bleaching protection	SST-sd	SST-sd	^{0}C	-1
Resistance	Bleaching protection	Depth	Depth	m	1
Recovery	Recolonization ability	Intermediate bleaching	B-intermediate	Density	1
Recovery	Substrate suitability	CCA	CCA	% cover	1
Recovery	Substrate suitability	Macroalgae	MA	% cover	-1
Recovery	Substrate suitability	Turf algae	TA	% cover	-1
Recovery	Substrate suitability	Soft Coral	SC	% cover	-1
Recovery	Substrate suitability	Bare substrate	BS	% cover	1
Recovery	Substrate suitability	Rubble	RB	% cover	-1
Recovery	Recolonization ability	Largest colonies (>80 cm)	L-colonies	Density	1
Recovery	Recolonization ability	Mature colonies (11-80cm)	M-colonies	Density	1
Recovery	Recolonization ability	Recruitment (1-10cm)	Recruitment	Density	1
Recovery	Recolonization ability	Hard coral	HC	% cover	1
Recovery	Recolonization ability	Genera richness	G-richness	No. of genera	1

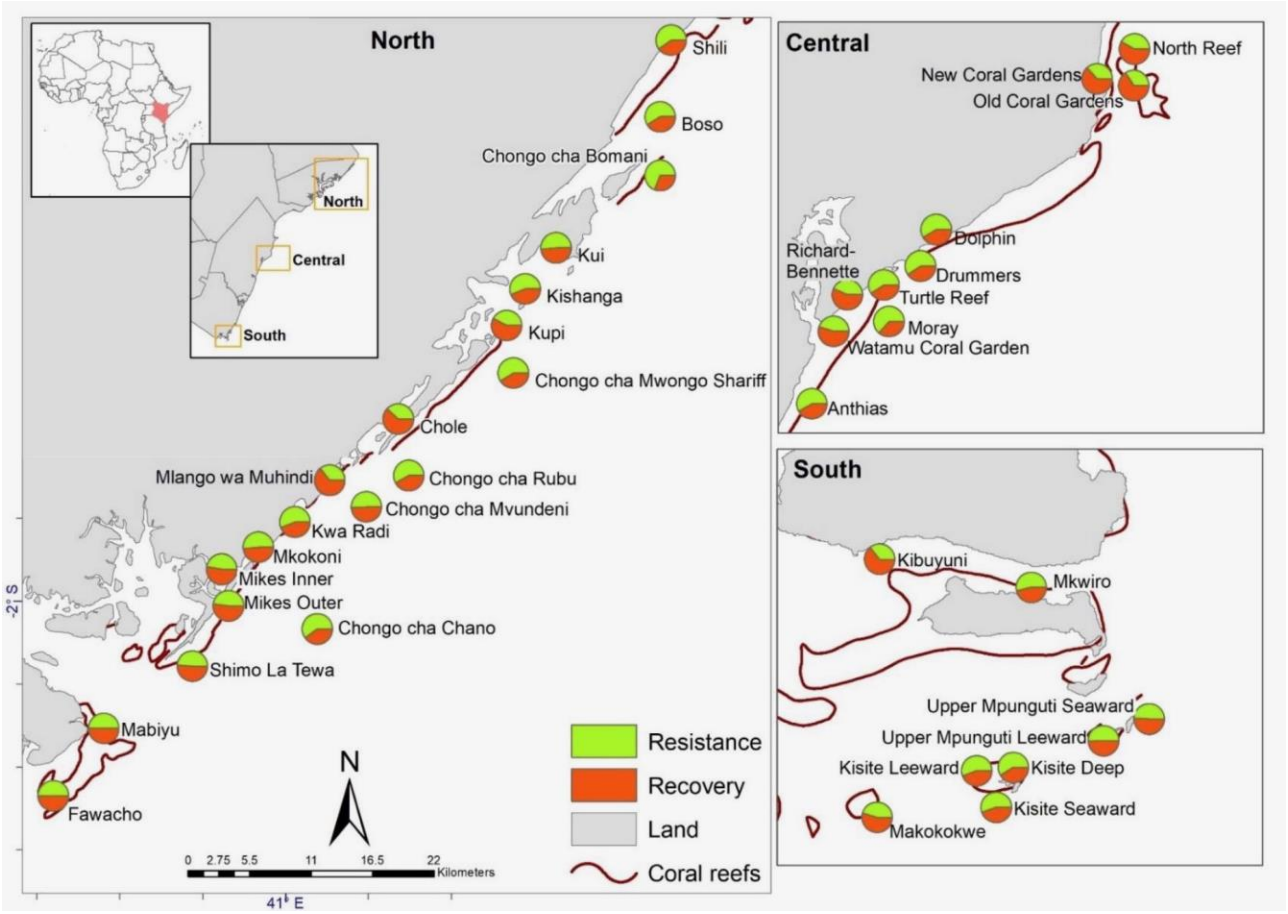
Spatial pattern - resistance and recovery potential

Effect of geography, habitat factor and management on resistance, recovery and resilience potential

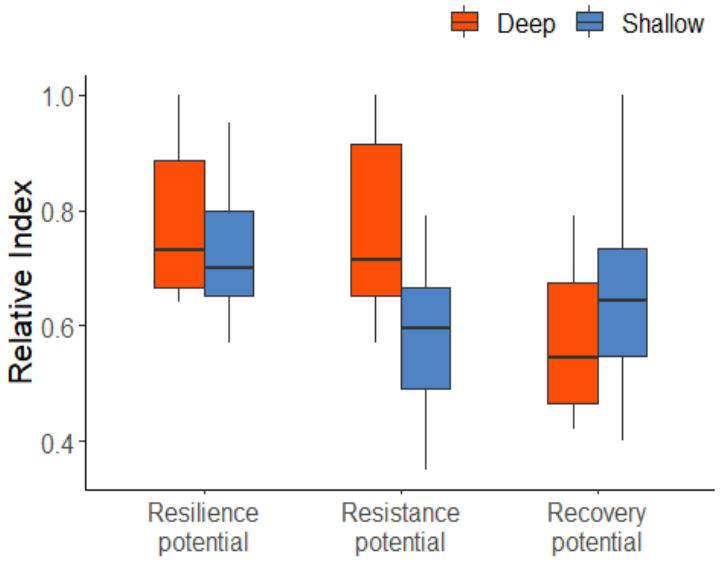
(A). Response variable: Resistance potential	Type III Mixed-Effects NumDF	F value	Pr(>F)
Geographic zone	2	2.534	0.097
Depth	1	18.360	<0.001***
Exposure	1	1.401	0.247
Reef type	3	0.772	0.519
Management	2	0.274	0.762

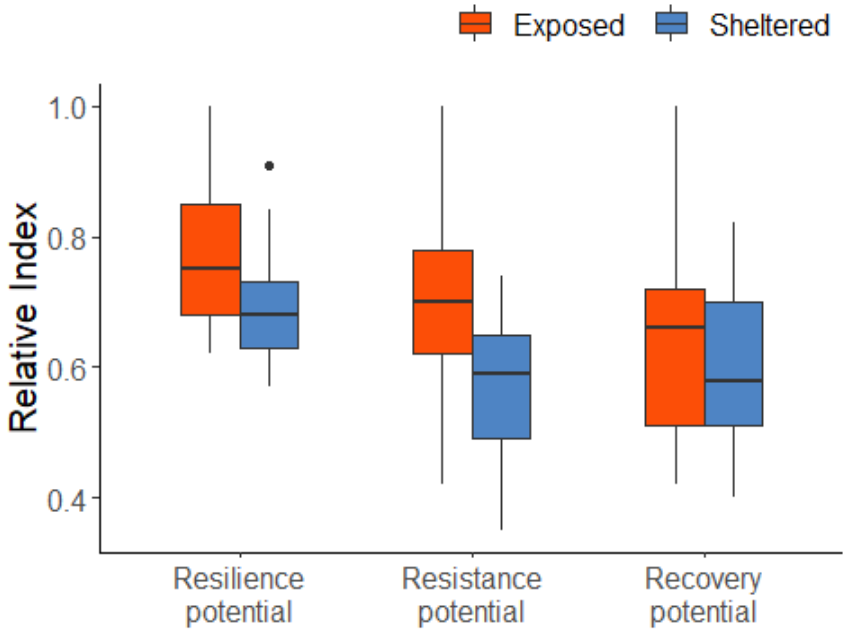
(B). Response variable: Recovery potential	Type III Mixed-Effects NumDF	F-value	Pr(>F)
Geographic zone	2	0.765	0.475
Depth	1	2.868	0.102
Exposure	1	6.911	<0.01*
Reef type	3	3.874	<0.01*
Management	2	0.591	0.560

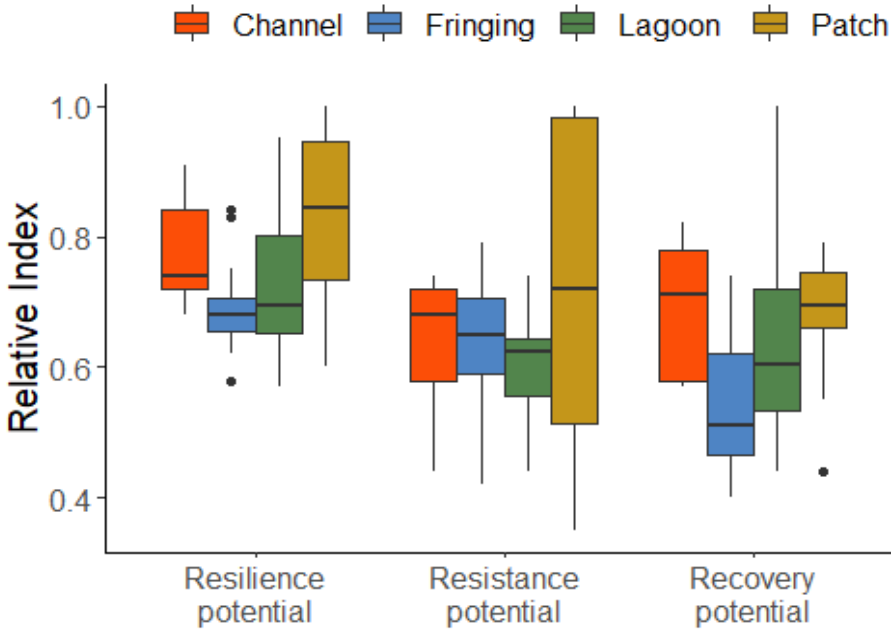
(C). Response variable: Resilience potential	Type III Mixed-Effects NumDF	F-value	Pr(>F)
Geographic zone	2	1.053	0.362
Depth	1	3.848	0.060
Exposure	1	10.16	<0.001**
Reef.type	3	5.474	<0.001**
Management	2	0.742	0.485



Relative index of resilience, resistance & recovery potential across different habitats







Conclusion

- ✓ Using resistance and recovery indicators offers a better measure to quantify resilience
- ✓ Current MPAs are not necessarily located in areas with coral comunitities that's have high resistance or recovery potential
- ✓ Sites with high resistance potential- these are going to maintain coral cover even after bleaching and will be a source of larvae to other sites. Good to protect these.
- ✓ Sites with higher recovery potential – These are also going to act as sinks for larvae coming from other sources. Good to protect these
- ✓ Sites with equal measure of resistance and recovery potential- prime sites to protect as they provide more opportunity to recover coral populations

Thank you