

# Measuring Resilience for Management

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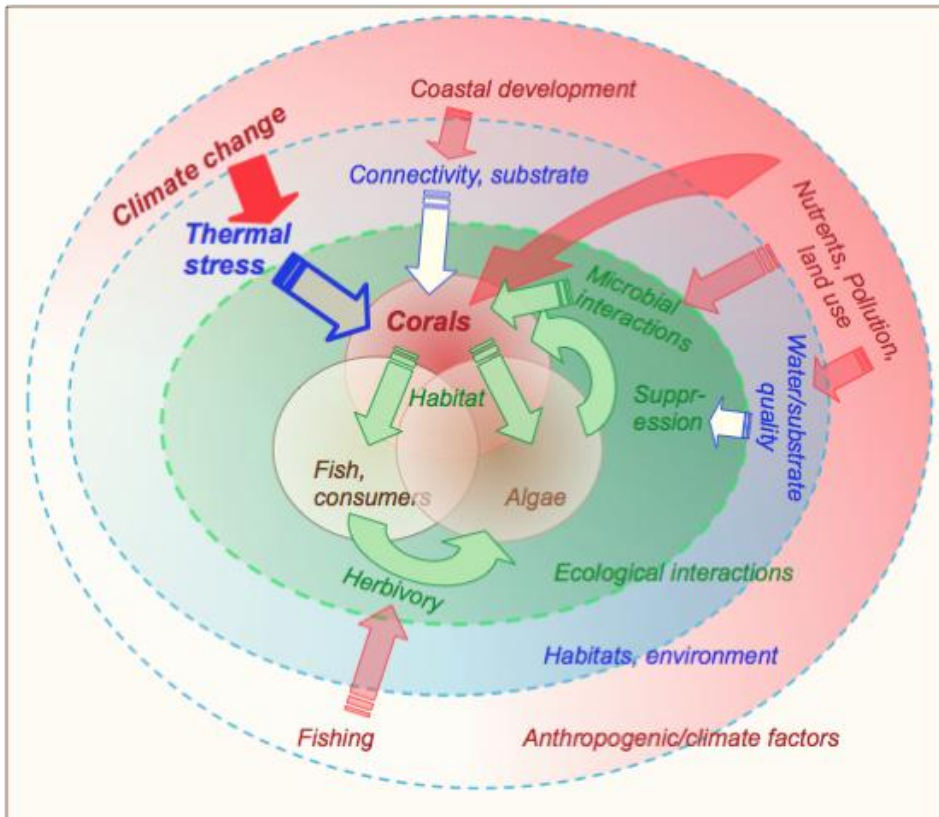
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The challenge, is how do you go from this ...



To this ...

**Good**



**Bad**



# IUCN-CCCR (Climate Change and Coral Reefs working group)

[www.iucn.org/cccr](http://www.iucn.org/cccr)



## Resilience Assessment of Coral Reefs

Rapid assessment protocol for coral reefs, focusing on coral bleaching and thermal stress

David Obura and Gabriel Grimsditch



IUCN Resilience Science Group Working Paper Series – No 4

MACARTHUR

CORDIO

The Nature Conservancy

Australian Government  
Great Barrier Reef  
Marine Park Authority

MINISTRY FOR FOREIGN  
AFFAIRS OF FINLAND

David Obura, Gabriel Grimsditch, with

Paul Marshall, Naneng Setiasih, Alison Green, Ameer Abdulla, and

Greta Aeby, Lizzie McLeod, David Bellwood, Haji Machano, Robert Steneck, Jerker Tamelander, Jeffrey Maynard

- 1 Benthic cover
- 2 Coral community structure - relative abundance of genera.
- 3 Coral size class distributions
- 4 Coral condition, including bleaching, disease, other conditions and mortality
- 5 Fish - functional groups (herbivores, predators)
- 6 Resilience indicators - for site resistance and resilience

Resilience variable
Hard Coral
Soft Coral
OCA
Recruitment
Fragmentation
Dominant size class
Largest corals (3)
Obligate feeders
Branching residents
Herbivores
Excavators
Scrapers
Grazers/ Browners
Piscivores
Rubble
Consolidation
Top. Compl. - micro
Top. Compl. - macro
Sediment texture
Sediment layer
Water quality
Self-seeding
Local seeding (10 km)
Distant seeding (100)
Currents
Dispersal barrier
Fleshy Algae
Fleshy Algae-height
Turf Algae
Inverts-other
Competitors
Bioeroders (external)
Bioeroders (internal)
Corallivores (negative)
Bleaching
Mortality-recent
Coral disease
Mortality-old
Recovery-old
Temperature (°C on Comment)
Currents
Wave energy/ exposure
Deep water (30-50m)
Depth of reef base (m on Comment)
Depth (m on Comment)
Visibility (m on Comment)
Compass direction/ aspect
Slope (degrees)
Physical shading
Canopy corals
Exposed low tide
Pending/pooling
Temperature variability
Proportion high susceptibility corals
Survival of past bleaching
Nutrient input
Pollution (chemical)
Pollution (solid)
Turbidity/Sedimentation
Physical damage
Fishing pressure
Destructive fishing
Dispersal barrier
Biodiversity
Resources
Environmental quality

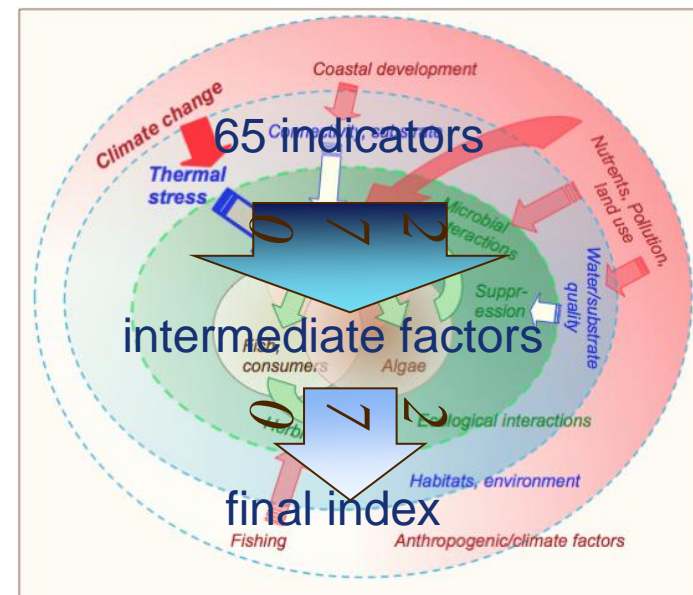
Factor
1-Coral
2-General Interactions
3-Fish - Herbivores
4-Fish - Piscivores
5-Substrate quality
6-Water quality
7-Connectivity
8-Algae
9-Negative factors
10-Past Impacts
11-Cooling
12-Screening
13-Extremes/ variability
14-Coral Susceptibility
15-Anthro stress
16-Management

Resilience/recovery

Resistance to bleaching

Management

# Resilience indicators



## Measuring/deriving indicators:

- applicable as an add-on to various different monitoring approaches - GCRMN, Reef Check, etc.

- semi-quantitative 5 point scale

1 - low

3-int

5 - high



# Sites

Site	Country	Mnth/Yr*	Region
1. Aceh/Bali	Indonesia	Mar 09	Asia-Pacific (A-P)
2. Raja Ampat	Indonesia	March 09	Asia-Pacific (A-P)
3. Bocas del Toro	Panama	Apr 09	Caribbean
4. Bonaire	Netherlands Antilles	May 09	Caribbean
5. Southern Line Islands	Kiribati	May 09	Central Pacific
6. Phoenix Islands	Kiribati	Sep 09	Central Pacific
7. Djibouti	Djibouti	Jan 10	NIO/Gulf Aden
8. Northern Red Sea (3 areas)	Saudi Arabia	Sep 07 -May 09	Red Sea
9. Egyptian mainland	Egypt	Dec 09-Aug 10	Red Sea
10. Kiunga Marine Reserve	Kenya	Nov 08	WIO
11. South coast	Kenya	Feb 09	WIO
12. Andavadoaka	Madagascar	Apr 09	WIO
13. Pemba Island, west coast	Tanzania	Feb 09	WIO
14. Aldabra, D'Arros	Seychelles	Apr 08	WIO
15. Farquhar	Seychelles	Feb 09	WIO
16. Nosy Hara, Diego Suarez	Madagascar	Nov 08	WIO
17. Ambodivahibe	Madagascar	Dec 08	WIO
18. Amirantes (Alphonse, Desroches)	Seychelles	Apr 08	WIO
19. Maldives	Maldives	May 08	WIO
20. Comoros	Comoros	Feb 10	WIO
21. Digeo - Vohemar	NE Madagascar	Mar 10	WIO
22. St. Brandons Island	Mauritius	Apr 10	WIO
23. Mayotte	Mayotte	May 10	WIO
24. Pemba/ Quirimbass	Mozambique	Jun 10	WIO
25. Mafia-Songo Songo	Tanzania	Nov 07	WO

### ***1st phase, 2008-11***

- method development
- field work

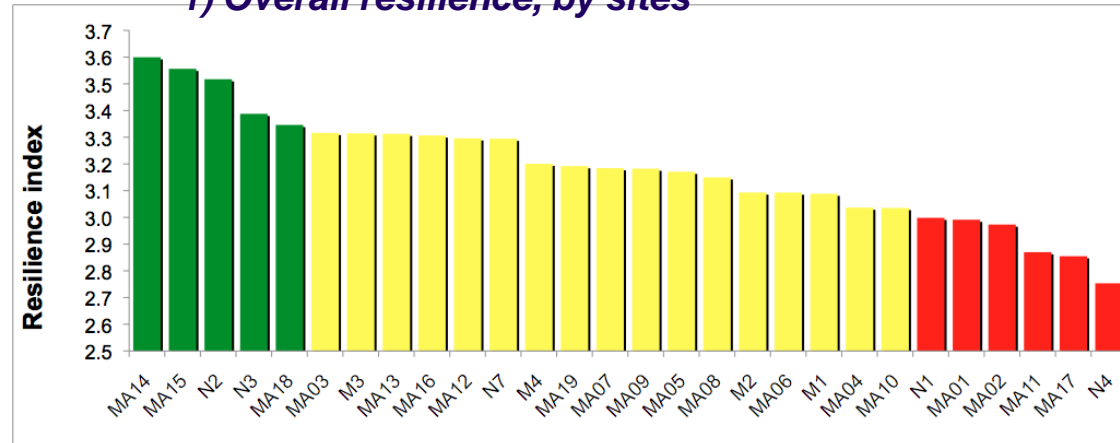
### ***2nd phase, 2011+***

- various initiatives/sources of funding
- TNC analysis/assessment workshop, Indonesia & CORDIO/WIO analysis and reporting**
- UNEP/IUCN/MEDTL Marine Spatial Planning/resilience integration**
- ITMEMS 4 - managing for reef resilience
- ICRS 12 - mini-symposium



# Resilience assessment

## 1) Overall resilience, by sites



'Good' sites, responses:  
1. improved management  
2. protection of fish

'Bad' sites, responses:  
1. improved management,  
2. recovery/rehabilitation from past impacts  
3. improved substrate quality  
4. protection of fish

## 2) Overall resilience vs. factors directly affected by management

	Overall	Management
MA14	3.60	3.48
MA15	3.56	3.54
N2	3.52	2.78
N3	3.39	2.31
MA18	3.35	2.81
MA03	3.32	2.41
M3	3.31	2.52
MA13	3.31	2.31
MA16	3.31	2.56
MA12	3.30	2.31
N7	3.29	2.38
M4	3.20	2.80
MA19	3.19	2.64
MA07	3.18	2.22
MA09	3.18	2.34
MA05	3.17	2.16
MA08	3.15	2.41
M2	3.09	2.30
MA06	3.09	1.84
M1	3.09	2.43
MA04	3.04	2.03
MA10	3.04	2.44
N1	3.00	1.88
MA01	2.99	1.44
MA02	2.97	1.44
MA11	2.87	1.41
MA17	2.85	1.56
N4	2.75	1.84

## 3) Guiding management at site levels

Factors	Factor	MA14	MA15	N2	N3	MA18	MA03	M3	MA13	MA16	MA12	N7	M4	MA19	MA07	MA09	MA05	MA08	M2	MA06	M1	MA04	MA10	N1	MA01	MA02	MA11	MA17	N4
Overall	Overall	3.14	3.14	3.00	3.00	3.14	3.29	3.57	3.14	3.29	2.86	3.29	2.57	2.57	2.86	2.43	3.57	2.86	2.86	2.29	2.86	2.86	2.71	2.71	3.29	2.71	2.86	2.57	1.86
1-Coral	2.92	3.14	3.14	3.00	3.00	3.14	3.29	3.57	3.14	3.29	2.86	3.29	2.57	2.57	2.86	2.43	3.57	2.86	2.86	2.29	2.86	2.86	2.71	2.71	3.29	2.71	2.86	2.57	1.86
2-Interactions	2.11	3.00	2.50	3.50	3.50	3.00	2.50	2.50	2.00	2.50	2.00	2.50	2.00	2.00	1.50	2.00	2.00	1.00	2.50	1.00	2.00	2.00	1.50	2.50	2.50	2.00	1.00	1.00	1.00
3-Herbivores	1.77	2.25	2.50	2.75	2.00	2.50	1.75	1.75	1.75	2.50	1.75	1.75	2.00	1.50	1.50	2.25	1.75	1.75	2.00	1.00	1.75	1.00	1.75	1.75	1.00	1.00	1.00	1.00	2.25
4-Piscivores	1.79	3.00	3.00	3.00	2.00	3.00	2.00	2.00	2.00	2.00	2.00	2.00	3.00	1.00	2.00	2.00	1.00	2.00	1.00	1.00	1.00	2.00	2.00	1.00	1.00	1.00	1.00	1.00	1.00
5-Cooling	2.89	3.40	3.40	2.80	3.00	3.40	1.00	2.60	2.60	3.40	2.60	2.80	2.60	3.20	3.20	3.00	3.20	2.60	3.00	2.60	2.80	3.20	2.60	2.00	2.20	2.60	2.60	3.20	3.20
6-Screening	2.82	3.00	2.50	2.67	3.00	3.00	1.17	2.50	3.17	3.00	3.33	2.67	3.17	2.83	2.33	3.17	2.33	2.67	2.33	3.00	2.50	2.67	2.67	2.83	3.17	3.50	2.50	2.83	2.50
7-Extremes	2.17	1.00	1.00	2.00	1.67	1.00	0.00	1.33	3.00	1.00	4.00	1.67	1.33	2.00	3.00	3.00	1.00	3.00	2.00	3.00	1.33	3.00	1.00	1.67	3.00	4.00	4.00	3.00	1.67
8-Substrate	3.05	4.33	4.17	3.67	3.50	4.00	0.83	3.33	3.33	4.17	2.33	3.50	1.83	3.00	3.00	2.50	3.50	2.83	2.00	3.67	2.83	2.17	2.17	2.33	2.83	2.50	2.33	2.83	3.00
9-Connect	3.98	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	3.80	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	3.80	4.00	4.00	4.00	4.00	3.80
10-Algae	3.73	4.00	3.67	3.00	4.50	4.00	0.33	4.00	4.00	4.00	3.67	3.50	3.50	3.33	4.00	3.67	4.33	3.67	3.50	3.67	3.50	3.33	3.33	4.00	3.33	3.33	3.33	3.33	2.50
11-Neg Assoc	3.24	3.00	3.40	3.00	2.60	2.60	1.00	3.00	3.60	2.80	3.60	3.60	3.00	3.00	3.40	3.40	3.80	3.60	3.00	3.60	3.40	3.40	3.40	2.80	3.60	3.20	3.20	2.80	2.80
12-Impacts	2.62	2.20	2.40	3.00	3.80	1.80	1.00	1.80	2.60	2.20	2.80	3.60	3.80	2.40	2.60	2.20	2.20	1.80	3.40	1.80	2.60	2.20	1.80	3.80	2.40	2.40	2.60	2.60	2.60
13-Anthro stre	4.20	5.00	5.00	4.38	4.25	4.75	4.88	4.00	4.50	4.75	4.50	4.75	3.88	4.38	4.38	4.13	4.88	4.88	3.88	4.38	4.50	4.13	5.00	3.75	2.75	2.75	2.63	3.25	3.13
14-Management	1.48	3.67	3.67	1.00	1.00	1.00	1.00	2.33	1.00	1.00	1.00	1.00	2.33	3.67	1.00	1.00	1.00	1.00	2.33	1.00	2.33	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Site																													
Overall	3.18	3.60	3.56	3.52	3.39	3.35	3.32	3.31	3.31	3.31	3.30	3.29	3.20	3.19	3.18	3.18	3.17	3.15	3.09	3.09	3.09	3.04	3.04	3.00	2.99	2.97	2.87	2.85	2.75
Management	2.31	3.48	3.54	2.78	2.31	2.81	2.41	2.52	2.31	2.56	2.31	2.38	2.80	2.64	2.22	2.34	2.16	2.41	2.30	2.43	2.43	2.44	1.88	1.44	1.44	1.41	1.56	1.84	



# Towards Integrating Reef Resilience into Marine Spatial Planning

*Ameer Abdulla<sup>13</sup>, Edward Game<sup>4</sup>, Gabriel Grimsditch<sup>37</sup>, David Obura<sup>23</sup>, Sam Purkis<sup>6</sup>, Anthony Roupheal<sup>1</sup>, Gwilym Rowlands<sup>6</sup>, Ole Vestergard<sup>7</sup>,*

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*<sup>2</sup>Coastal Ocean Research and Development in the Indian Ocean*

*<sup>3</sup>IUCN Climate Change and Coral Reefs Working Group*

*<sup>4</sup>The Nature Conservancy and University of Queensland*

*<sup>5</sup>Great Barrier Reef Marine Park Authority*

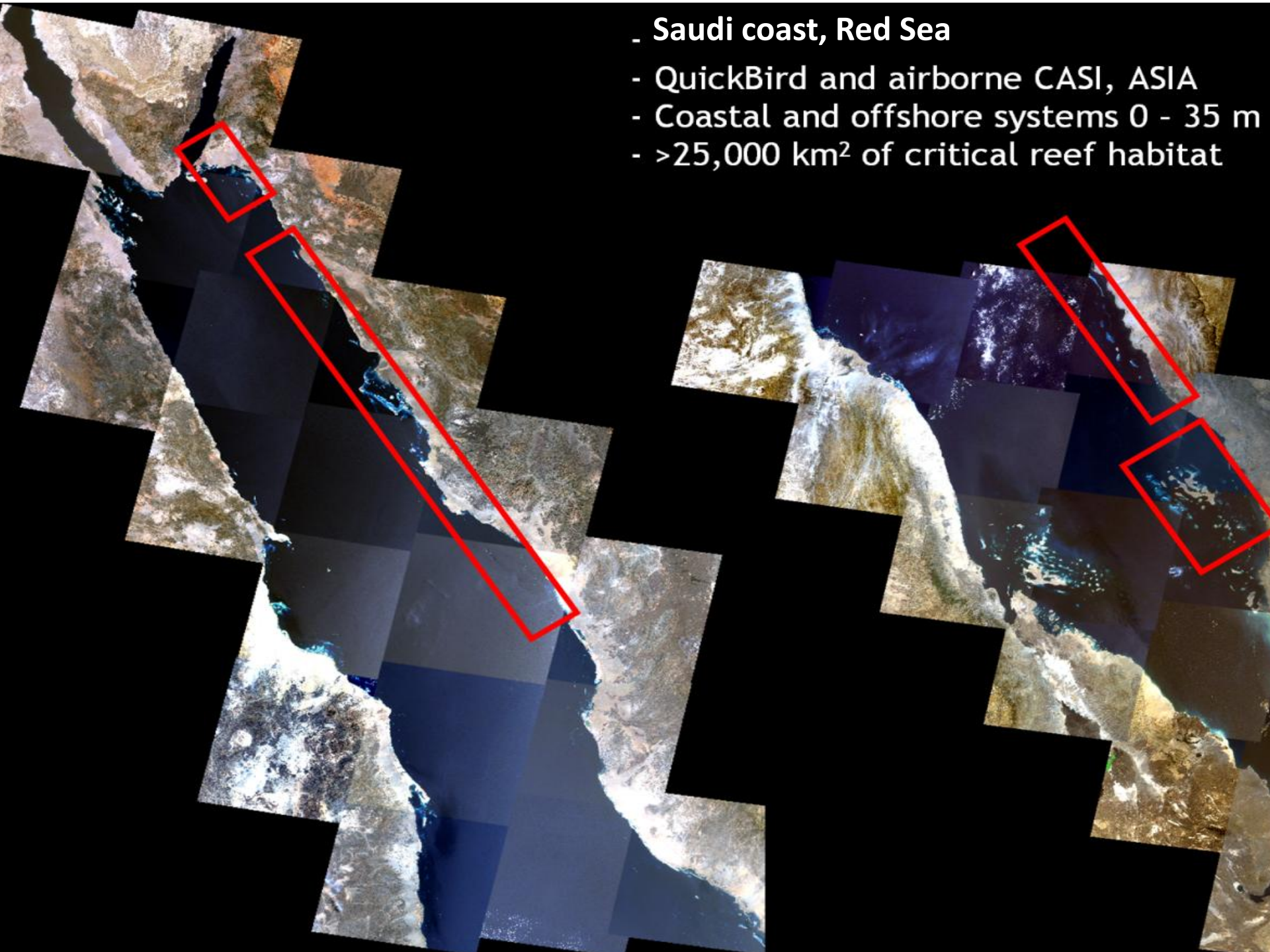
*<sup>6</sup>National Coral Reef Institute, Florida*

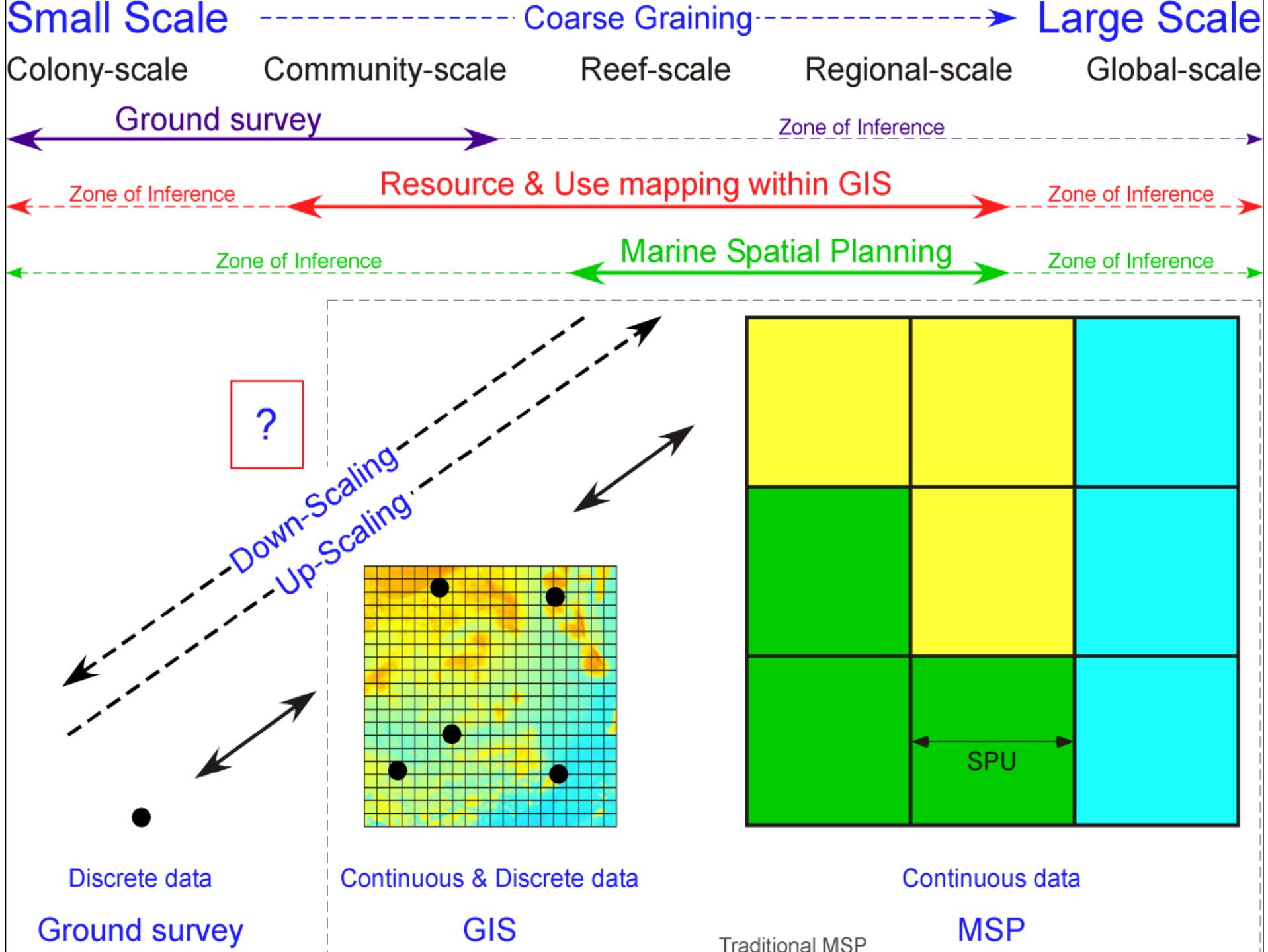
*<sup>7</sup>UNEP Marine and Coastal Division*



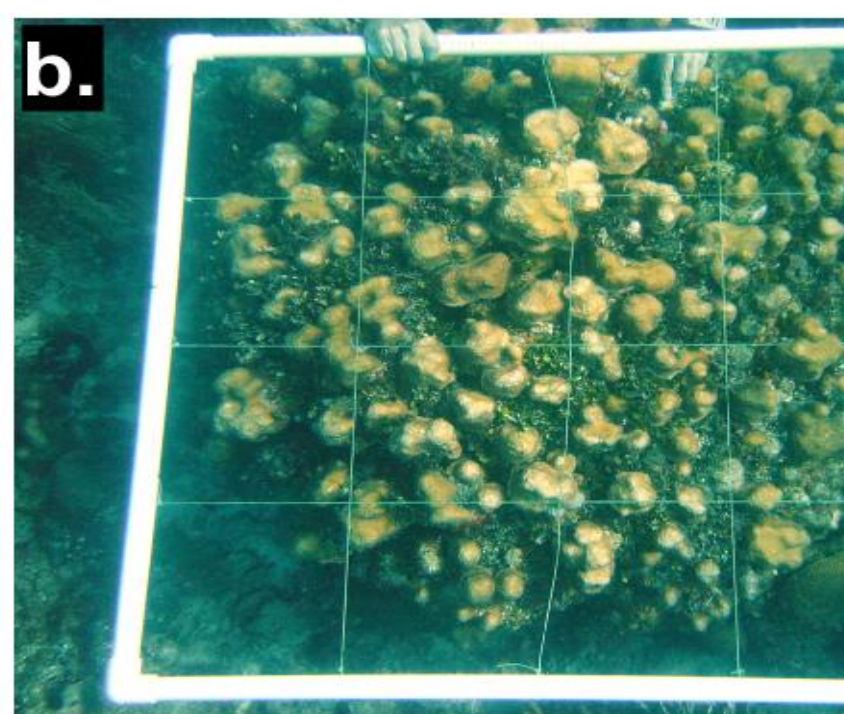
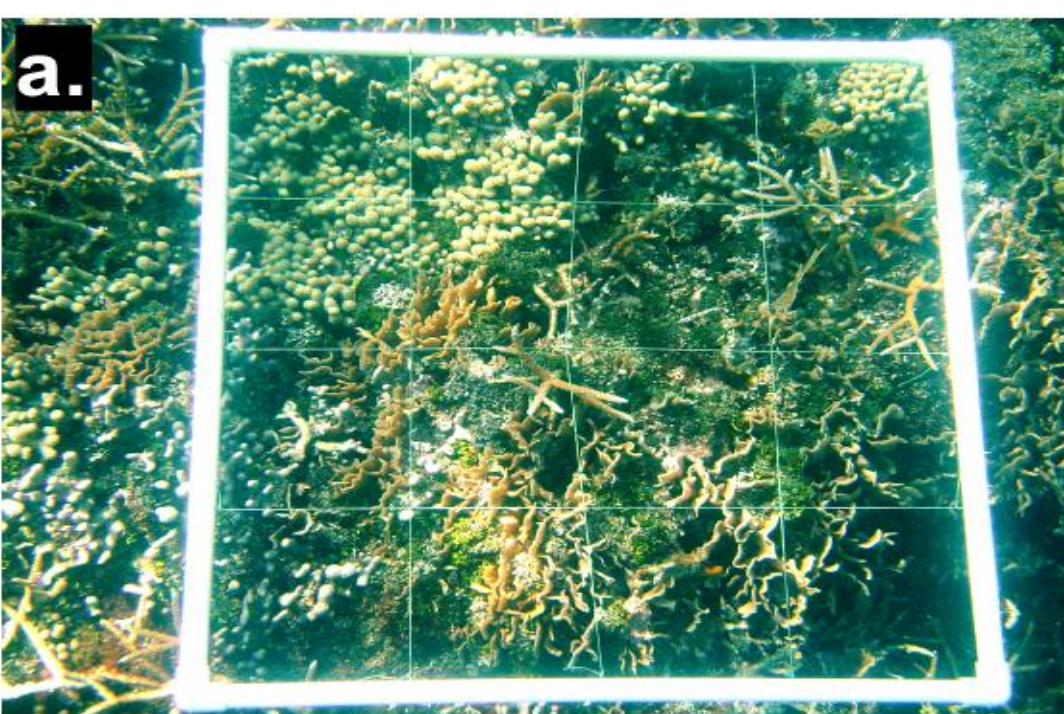
## Saudi coast, Red Sea

- QuickBird and airborne CASI, ASIA
- Coastal and offshore systems 0 - 35 m
- >25,000 km<sup>2</sup> of critical reef habitat









Farasan  
Islands

Ra's Qisbah

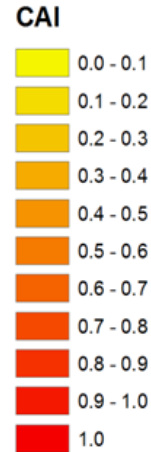
Al Wajh

# Abstraction Indices: bridging the gap between field and satellite sampling



10 km

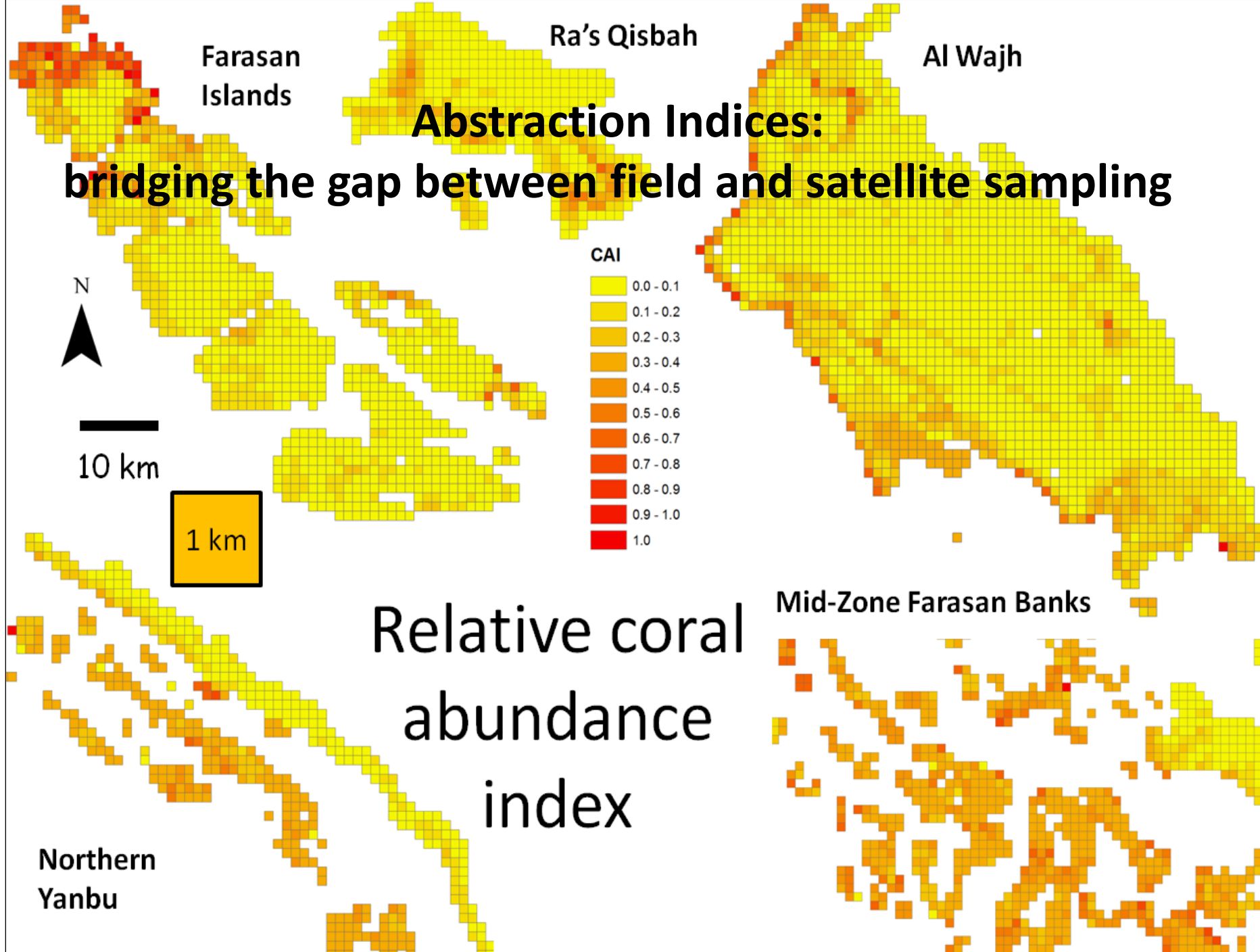
1 km



Relative coral  
abundance  
index

Mid-Zone Farasan Banks

Northern  
Yanbu



# SAUDI ARABIA



Ra's  
Qisbah

Al Wajh

Yanbu

Farasan  
Banks

Farasan  
Islands

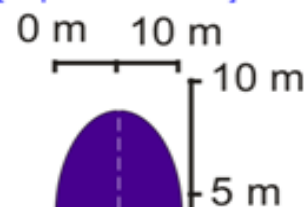
250 km

150 km

360 km

150 km

System Restriction  
[Depth Distribution]



Resource  
Quality  
[Normalized  
CAI(>0.5)/Total]

1.0  
0.5

System size

0.5  
1.0

Resource  
Capacity  
[Framework Index]

Environmental  
Stress  
[T°C (Mo above 30°C)]

7 mo  
3.5 mo

Anthropogenic  
Stress  
[Coastal Development]

0.5  
1.0

## Resilience components



### ***1st phase, 2008-11***

- method development
- field work

### ***2nd phase, 2011+***

- various initiatives/sources of funding
- ★ **NC analysis/assessment workshop, Indonesia & CORDIO/WIO analysis and reporting**
- ★ **UNEP/IUCN/MEDTL Marine Spatial Planning/resilience integration**
- ★ **MEMS 4 - managing for reef resilience**
- ICRS 12 - mini-symposium

### **★ *Integration with GCRMN***

- additional indicators and context for monitoring data
- iconic/observatory sites - research in different areas of resilience