



Mapping coral reef habitat from space

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- Strategy focused to fulfill the objectives of the NCRI Monitoring Network
- High resolution monitoring of a limited study area tuned to detect changes in benthic character at metre - kilometre scale
- Sites selected on the basis of the abundance of communities susceptible to disturbance and perceived to react with a pronounced phase-shift (i.e. live corals and in particular Acroporid dominated areas)
- Integrated multi-sensor approach to ensure the production of ecologically relevant and accurate thematic maps of carbonate depositional environments
- Primarily satellite based, with ancillary use of airborne Lidar (E.A.A.R.L) and vessel-based acoustic systems (QTC, Echoplus and RoxAnn)

Middle East

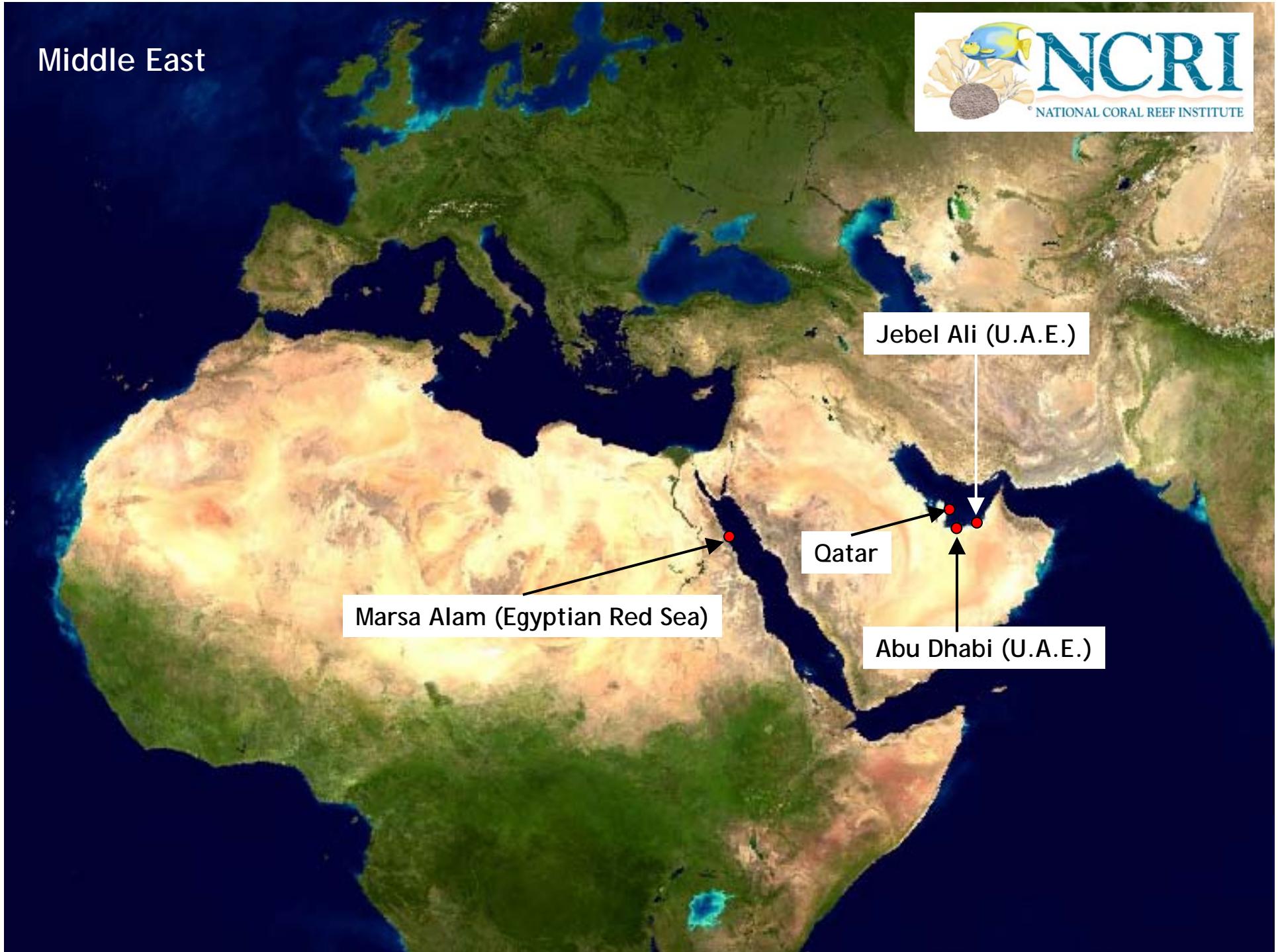


Marsa Alam (Egyptian Red Sea)

Jebel Ali (U.A.E.)

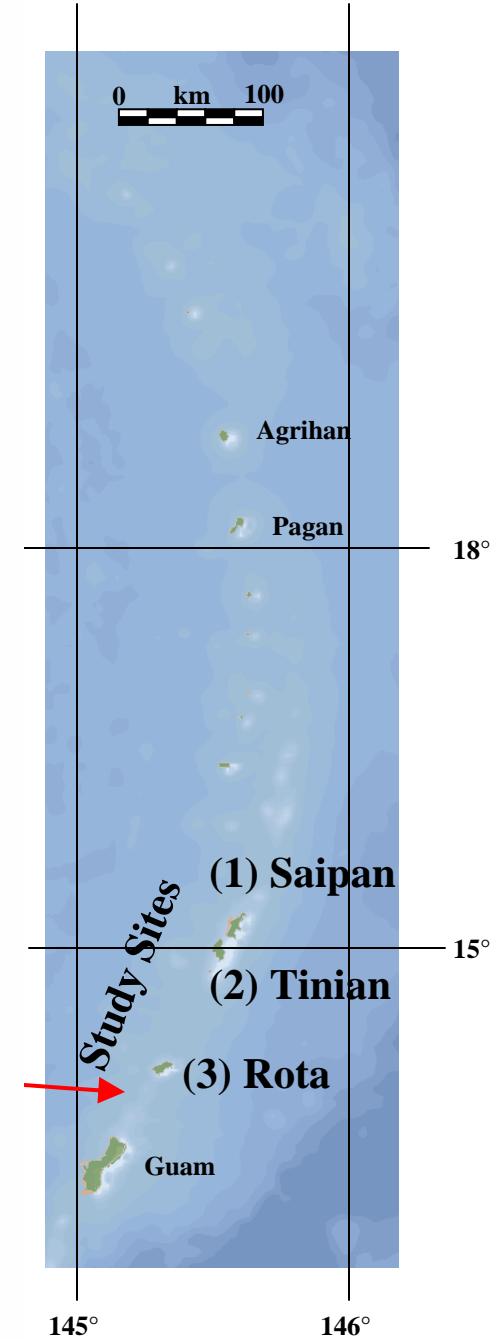
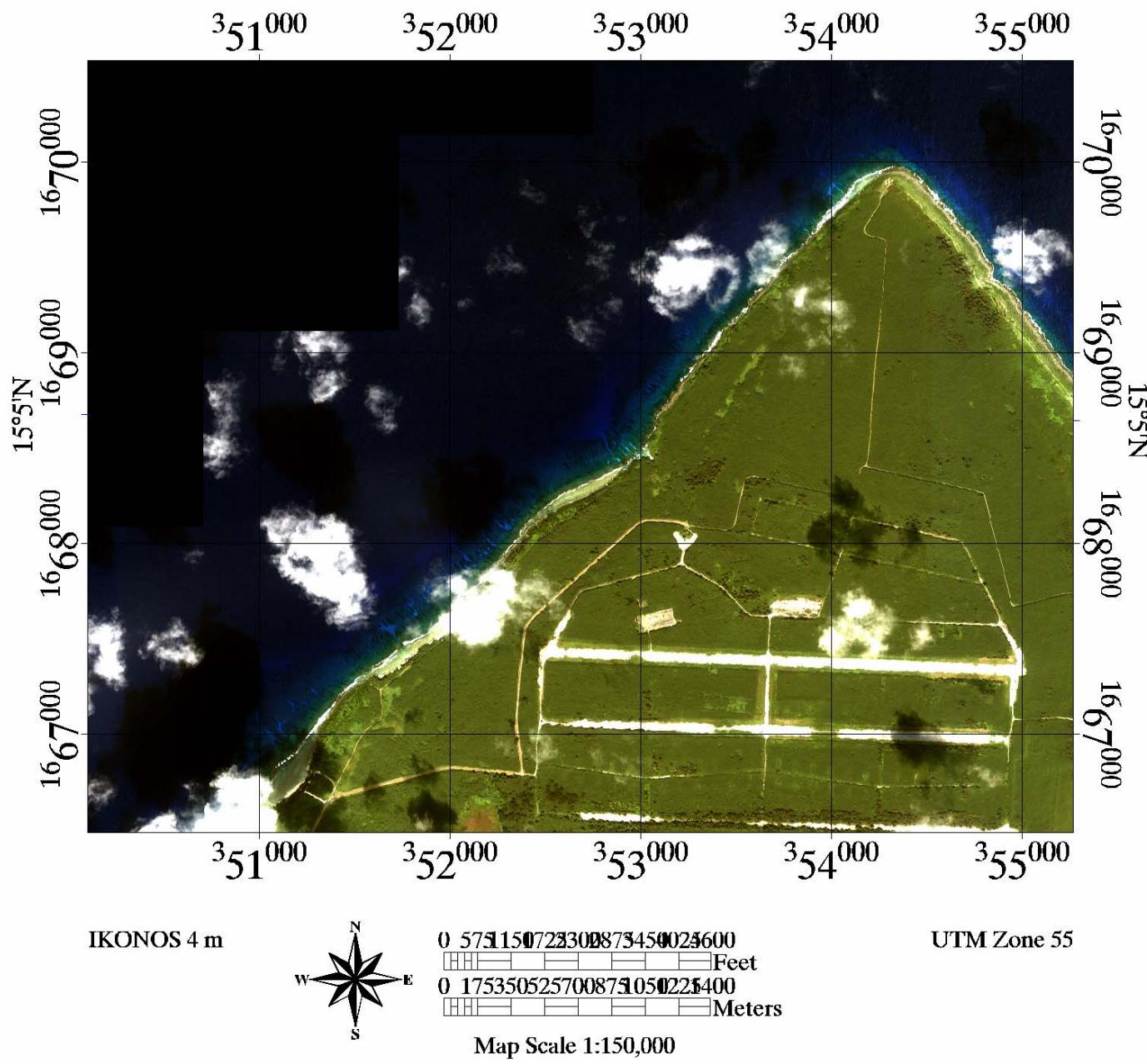
Qatar

Abu Dhabi (U.A.E.)





Tinian Chulu Beach



Strategy



Site selection

ASTER - ETM+ - ground-verification

IKONOS 11-bit raw-product

Radiometric / atmospheric correction
MODTRAN4 RT, FLAASH, empirical against invariant spectral targets

Deglinting (sea-surface effects)
Hochberg et al. 2003

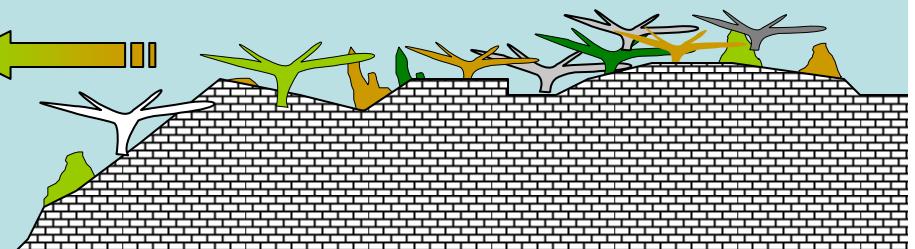
Water-air transmission

Depth measure
• Marine Lidar
• Vessel-based acoustic
• From-image
(e.g. Stumpf et al. 2003)

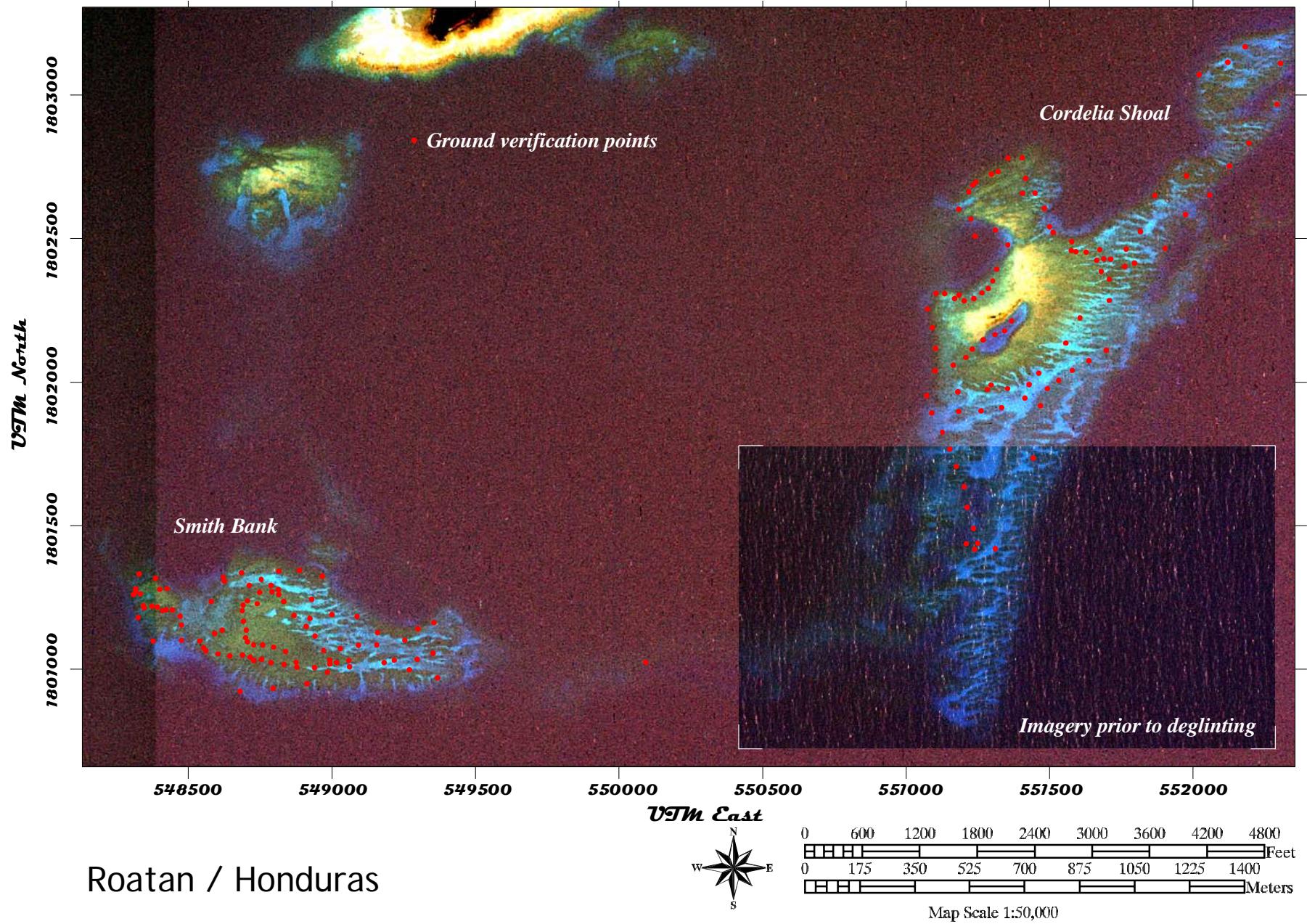
Water column correction
Empirical reef-up

Probability driven classifier

- 1) *in situ* optics
- 2) from-image stats



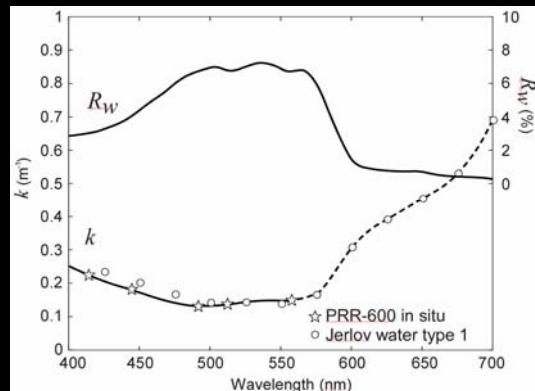
Sea-surface correction after Hochberg et al. 2003



'Reef-up' empirical radiative transfer solution

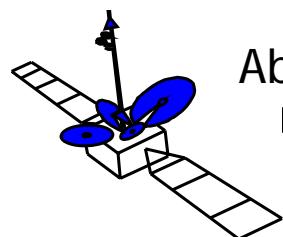
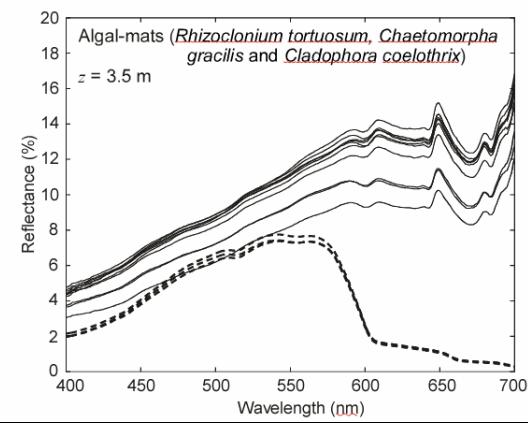
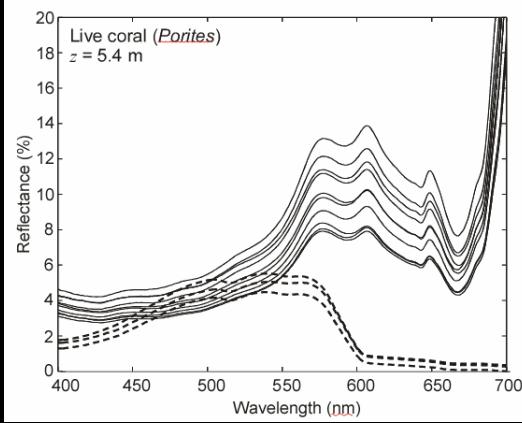
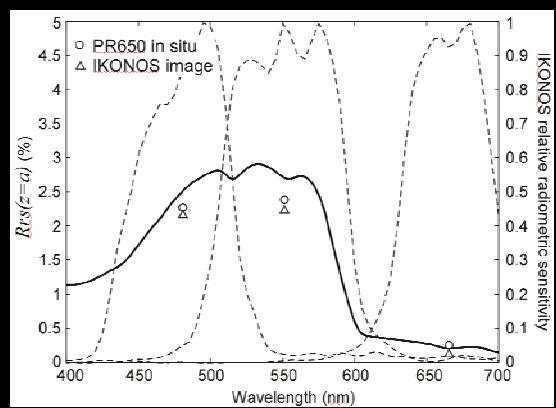
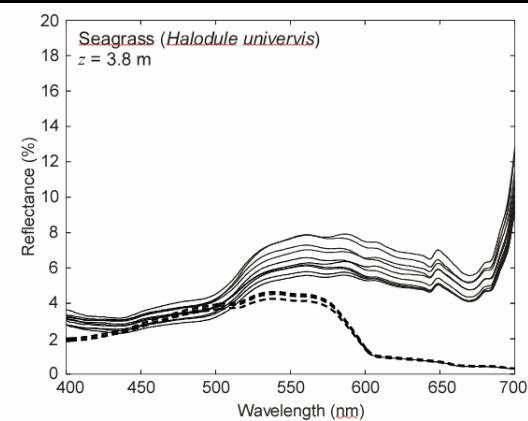
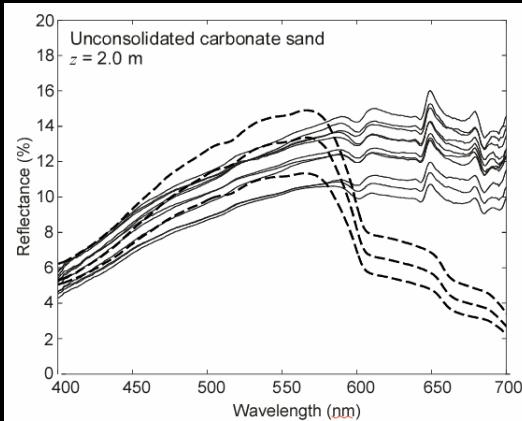
$k \setminus R_w$

Inherent optical properties

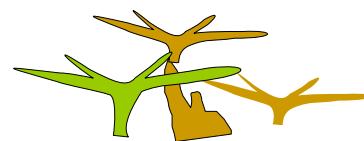


$R_{rs(z=a)} \setminus R_b$

Substrate reflectance spectra



Absolute error in visible bands <0.15% R_{rs}



(1) Purkis & Pasterkamp, 2004 (2) Purkis, in press, IEEE-TGARS

Tidal logger

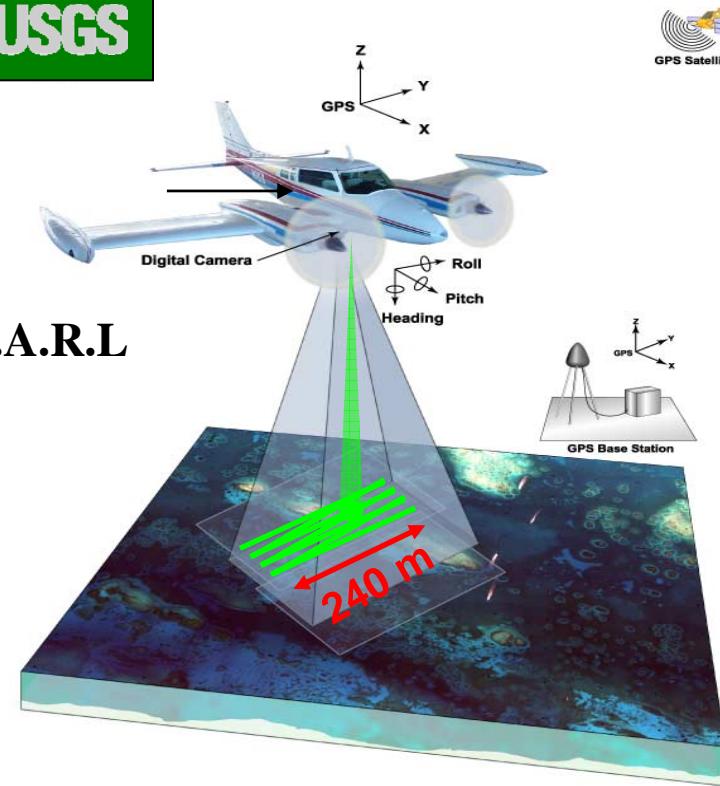
'Reef-up' is a best-case scenario

Requirements:

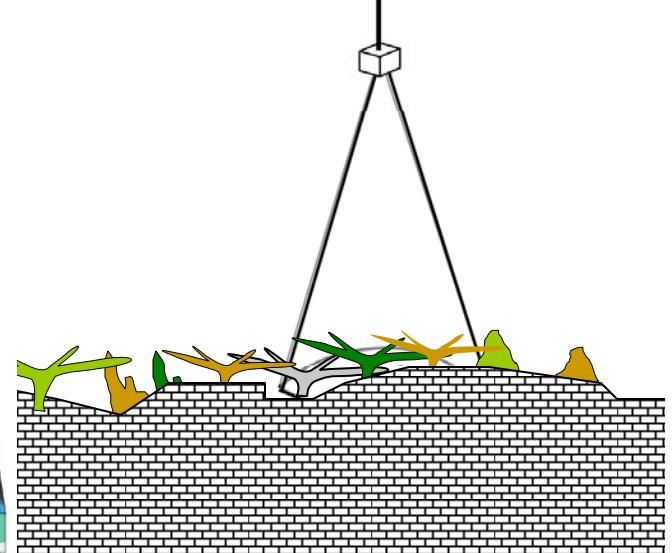
- High resolution and accurate measure of bathymetry
- Handle on tidal influence
- Exhaustive *in situ* spectral campaign with multiple radiometers

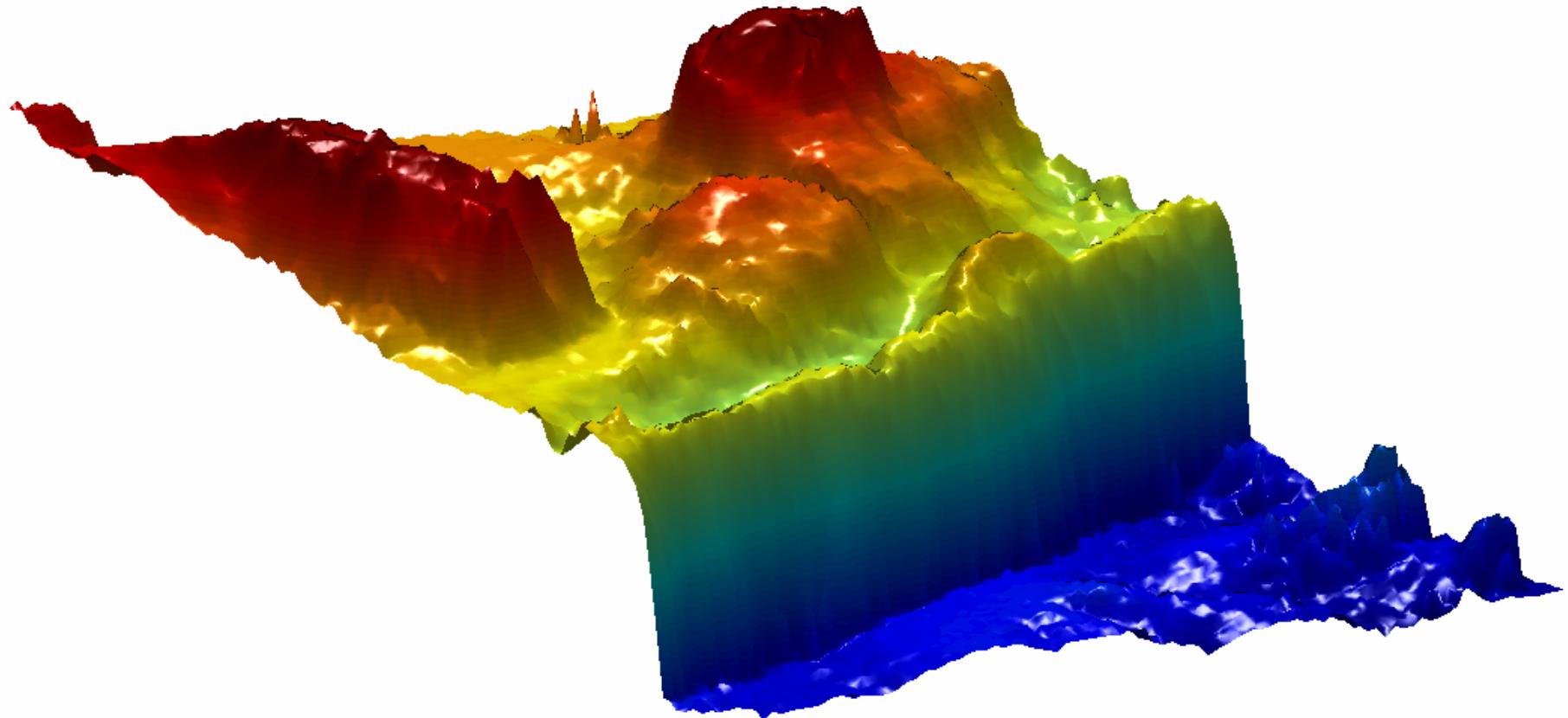


E.A.A.R.L

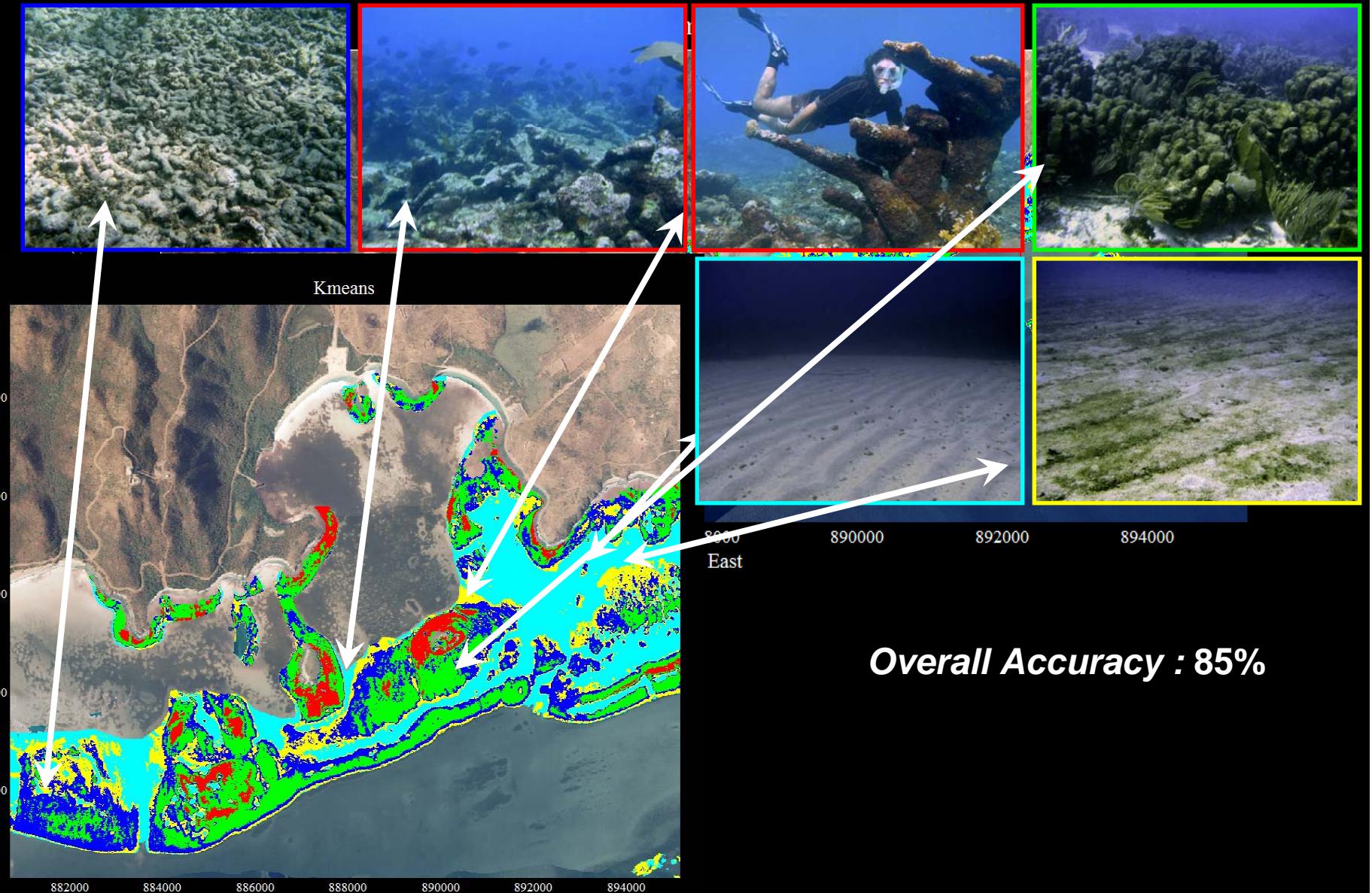


50 - 200 kHz acoustic system



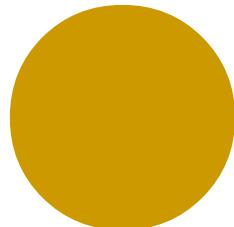


Viques, Puerto Rico - Hernández-Cruz et al.

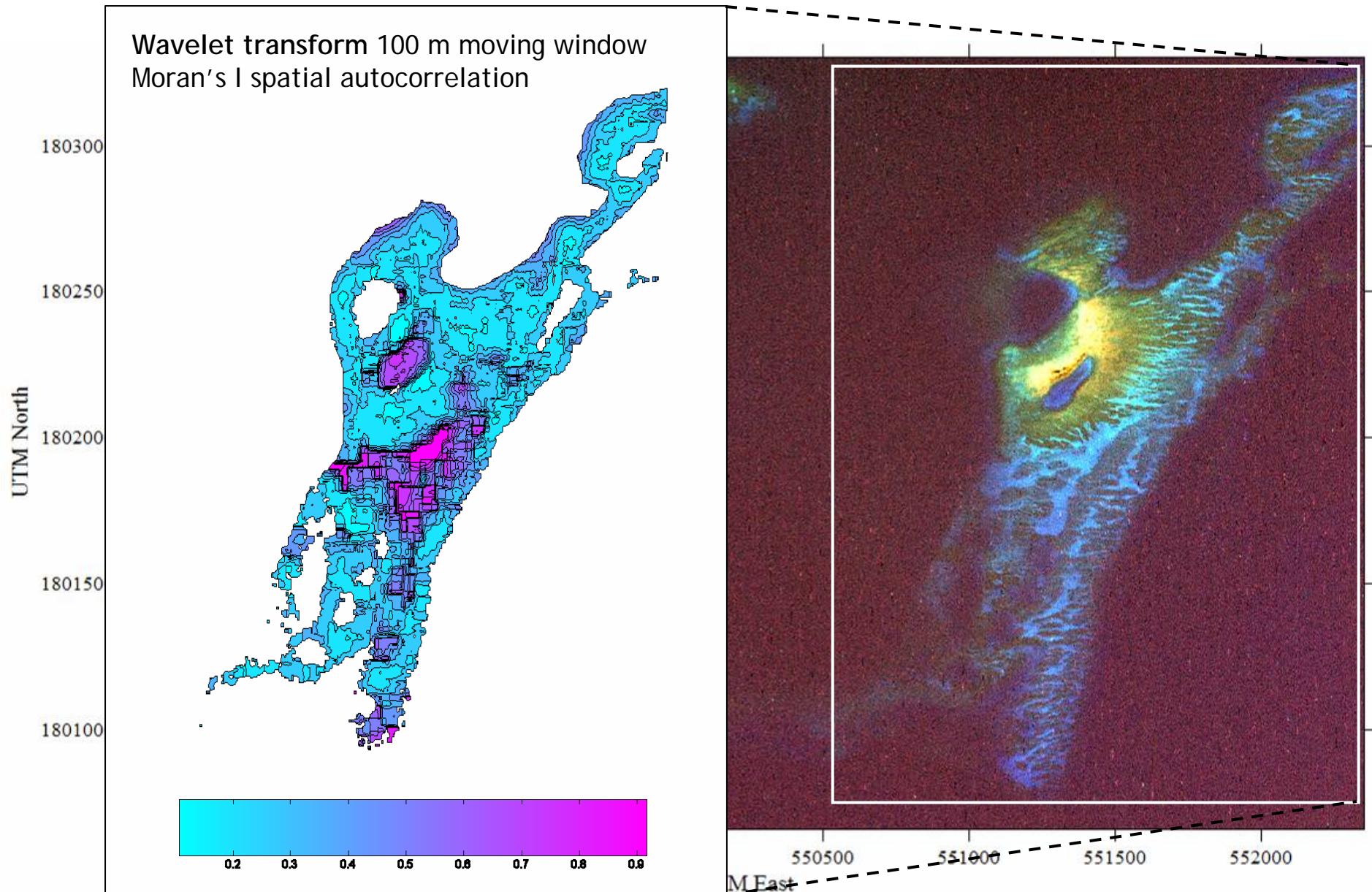


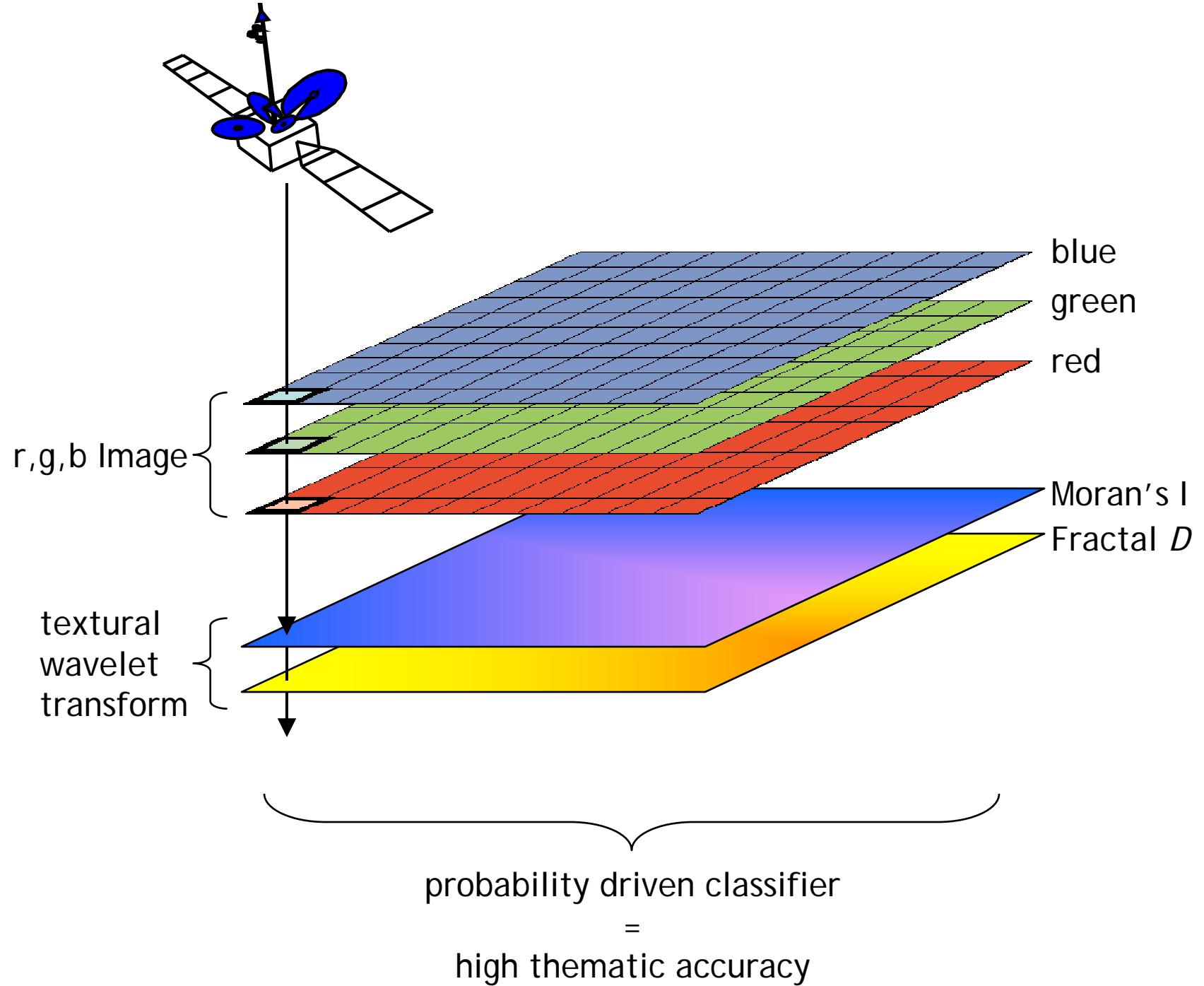
BUT

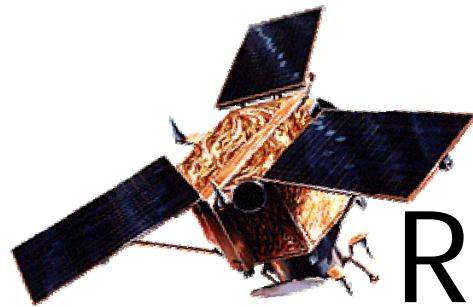
...what happens when
we lack the required
ancillary data ?



Novel classifiers







Remote Sensing



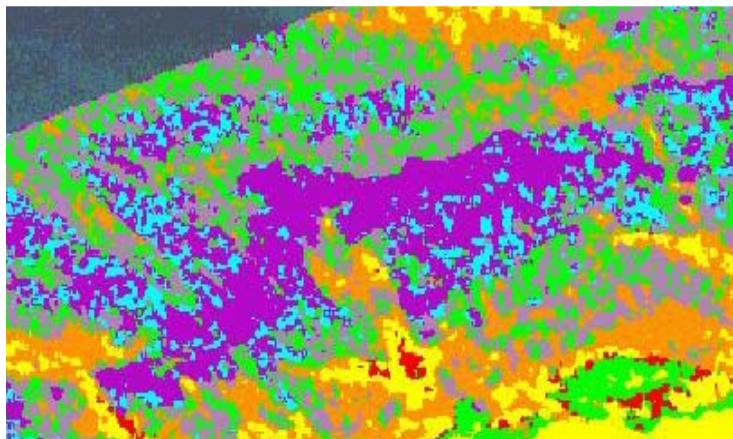
Ecology



Geospatial analysis (from pixel to population)

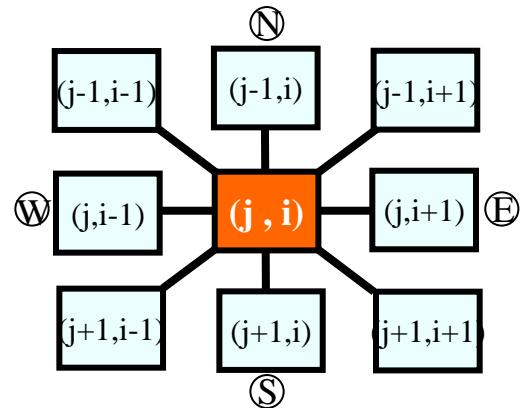
IKONOS

0 km 1

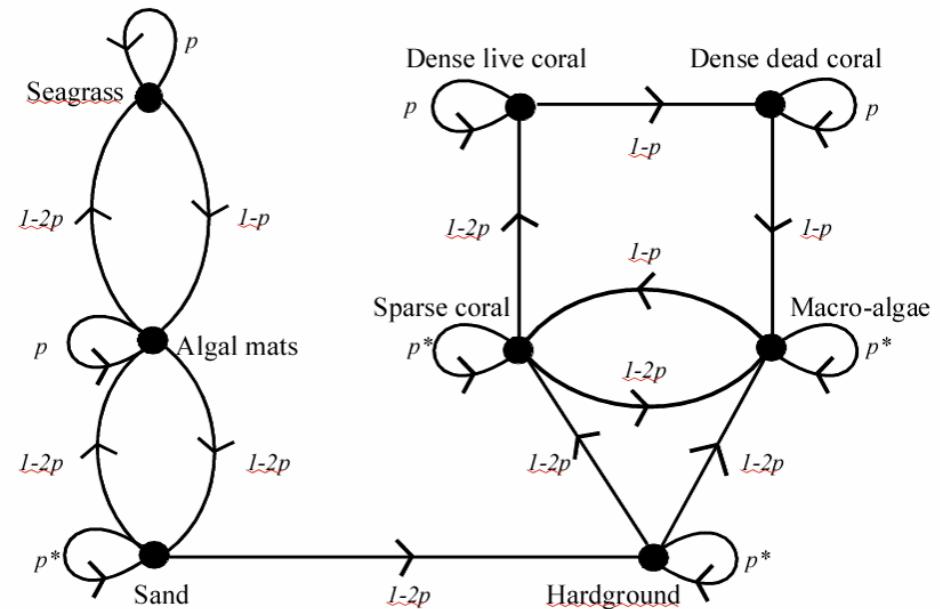


Dense live coral	Hardground
Dense dead coral	Sand
Sparse coral	Shallow algae
Seagrass	Deep algae

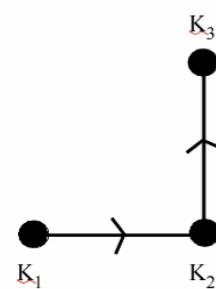
Pixel connectivity



A



B



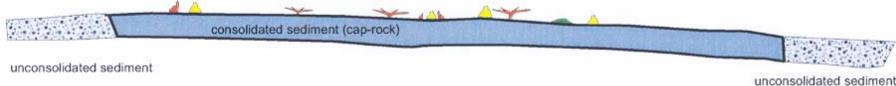
C

	sand	algal mats	seagrass	hardground	sparse coral	dense live coral	dense dead coral	macro-algae
sand	p^*	$l-2p$	0	$l-2p$	0	0	0	0
algal mats	$l-2p$	p	$l-2p$	0	0	0	0	0
seagrass	0	$l-p$	p	0	0	0	0	0
hardground	0	0	0	p	$l-2p$	0	0	$l-2p$
sparse coral	0	0	0	0	p^*	$l-2p$	0	$l-2p$
dense live coral	0	0	0	$l-2p$	0	p	$l-p$	0
dense dead coral	0	0	0	$l-2p$	0	0	p	$l-p$
macro-algae	0	0	0	0	$l-p$	0	0	p^*

Markovian models - population dynamics

Ecological dynamics

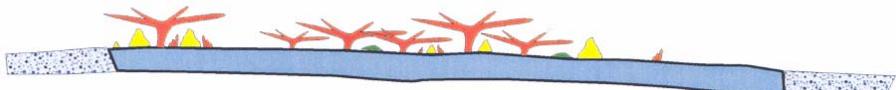
(1) Recruitment onto hardground



(2) Establishment of community



(3) Climax stage with competitive displacement of weaker species



(4) Bleaching and selective, compensatory mortality



(5) Framework breakdown and new recruitment



(6) Re-establishment of community and lateral spread

