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Impact at the Local-level, Coral Reef Restoration and Community Livelihoods

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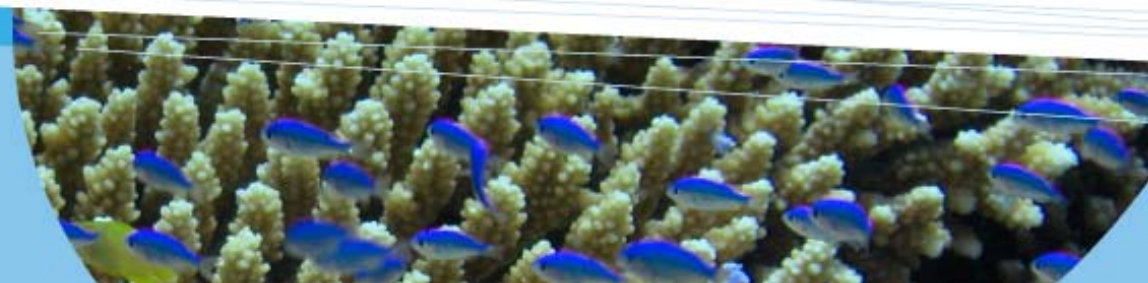
Plan of session

1. Issues of scale and conceptual framework for reef restoration.
2. Outline of technologies to assist reef restoration that have been developed by the CRTR and linked projects.
3. Community based reef restoration (Ed Gomez).

The Good, the Bad and the Ugly

1. The Bad – bad news about limitations
2. The Ugly – artificial reefs
3. The Good – low-cost methods and guidance to assist managers, NGOs and communities wanting to make a difference locally by rehabilitating reefs and their services.



Some definitions

- **Restoration:** the act of bringing a degraded ecosystem back into, as nearly as possible, its original condition.
- **Rehabilitation:** the act of partially or, more rarely, fully replacing structural or functional characteristics of an ecosystem that have been diminished or lost, or the substitution of alternative qualities or characteristics than those originally present with the proviso that they have more social, economic or ecological value than existed in the disturbed or degraded state.
- **Mitigation:** the reduction or control of the adverse environmental effects of a project, including restitution for any damage to the environment through replacement, restoration, or creation of habitat in one area to compensate for loss in another.

Some starting points

1. Reef restoration is in its infancy. We cannot create fully functional reefs.
   ("We know that there are a lot of known unknowns" – Donald Rumsfeld)
2. Restoration includes *passive* or *indirect* management measures to remove impediments to recovery as well as *active* or *direct* interventions like transplantation.
3. Reef restoration is expensive so resources need to be focused where they will be effective.

Two important caveats

"1. Although restoration can enhance conservation efforts, restoration is always a poor second to the preservation of original habitats.

2. The use of ex situ 'restoration' (mitigation) as an equal replacement for habitat and population destruction or degradation is at best often unsupported by hard evidence, and is at worst an irresponsible degradative force in its own right."

Truman P. Young (2000). Restoration ecology and conservation biology. *Biological Conservation*, **92**: 73-83.

Scale of the problem

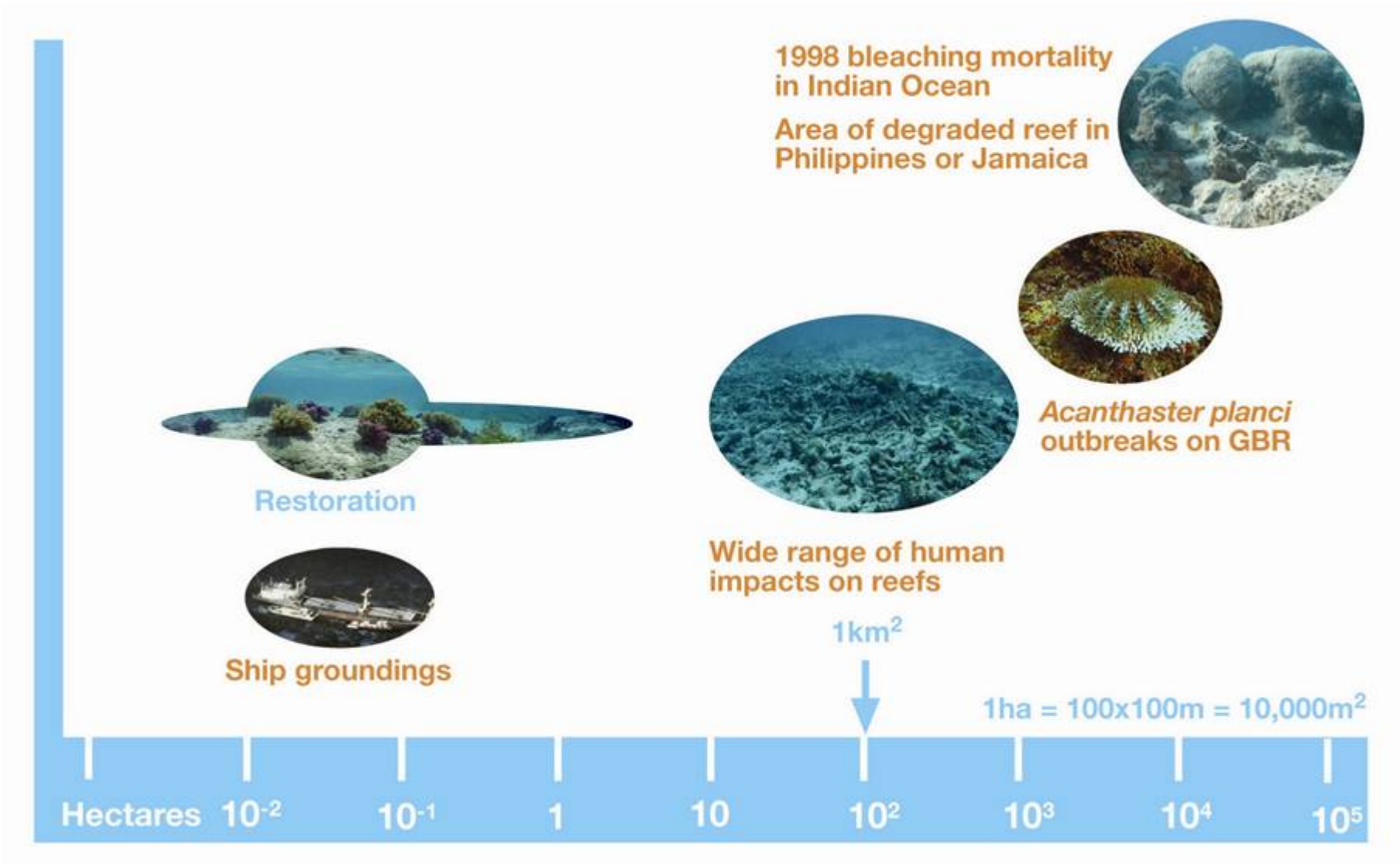
There are estimated to be around 255,000 km² of coral reefs worldwide in tropical seas.

An estimated 19% of these (~ 48,450 km²) are already severely degraded (GCRMN 2008).

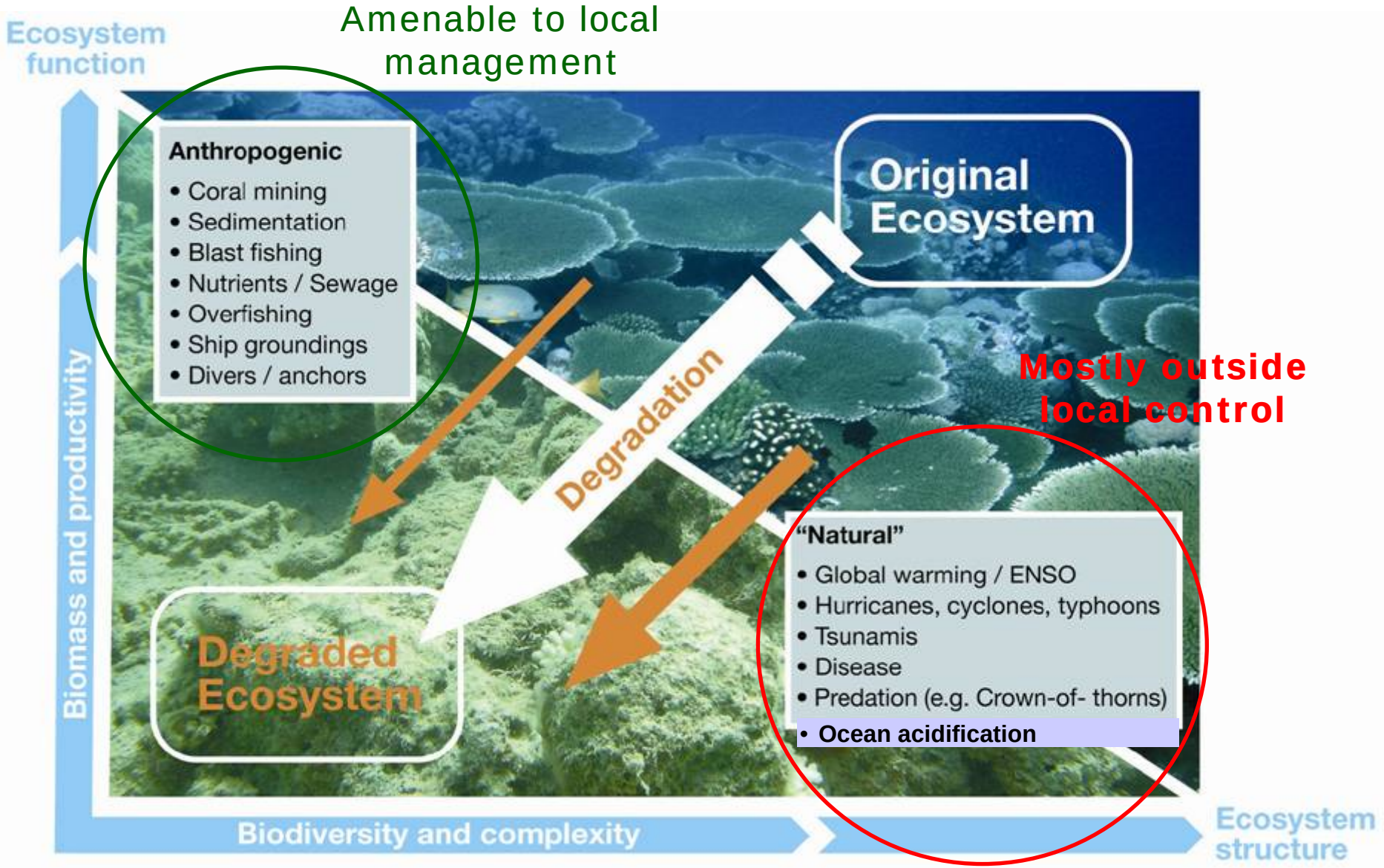
A further 15% (~ 38,250 km²) are thought to be under serious threat from human pressures and likely to be lost in next 10-20 years.

Largest active restoration to date = c. 7 hectares = 0.07 km² = <0.00015% of severely degraded area.

Scale of degradation vs. restoration



Drivers of degradation



Disturbance type matters

Healthy (resilient) reefs bounce back from natural disturbances and have been doing so for hundreds of millions of years.

Storms

Bleaching events

Tsunamis

But man's activities reduce resilience

Pollution

Overfishing

Goal of restoration

Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed.

Society for Ecological Restoration, 2004

1. If natural disturbance and reef ecosystem is resilient – be patient

2. If anthropogenic disturbance – implement management measures (*passive* restoration), then be patient

3. If management implemented and STILL poor recovery - consider *active* restoration interventions, then be patient

Do I need to assist recovery?

Passive or *indirect* restoration via management measures – creating the conditions for natural recovery.

+

Active or *direct* restoration via activities such as coral transplantation or algal removal.

(Actions should be part of an Integrated Coastal Management (ICM) plan or MPA Management Plan.)

Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed.

Society for Ecological Restoration, 2004

Costs of reef restoration?

If physical restoration included, then costs of US$ 2 million – 6.5 million per hectare are quoted. (Based on ship-grounding case-studies).

If we focus on biological restoration “low-cost” method proponents suggest US$ 2,000 – 20,000 per hectare to achieve “restoration”. (x 100 for costs per km^2)

On analysis, such costs are for transplanting x corals per m^2 (e.g. 2 transplants m^{-2}) or increasing live coral cover from 10% to 20% (immediately post-transplantation).

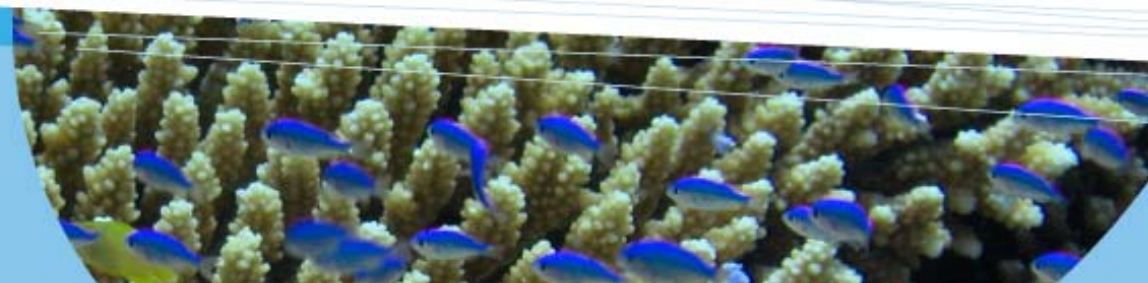
This is **not** the same as “restoration”.

Compare to Costanza et al. *Nature*, 1997: total value of ecosystem services for coral reefs @ US$ 6075 ha^{-1} yr^{-1}

Potential sustainable economic benefits from Philippines reefs @ US$ 320–1130 ha^{-1} yr^{-1}

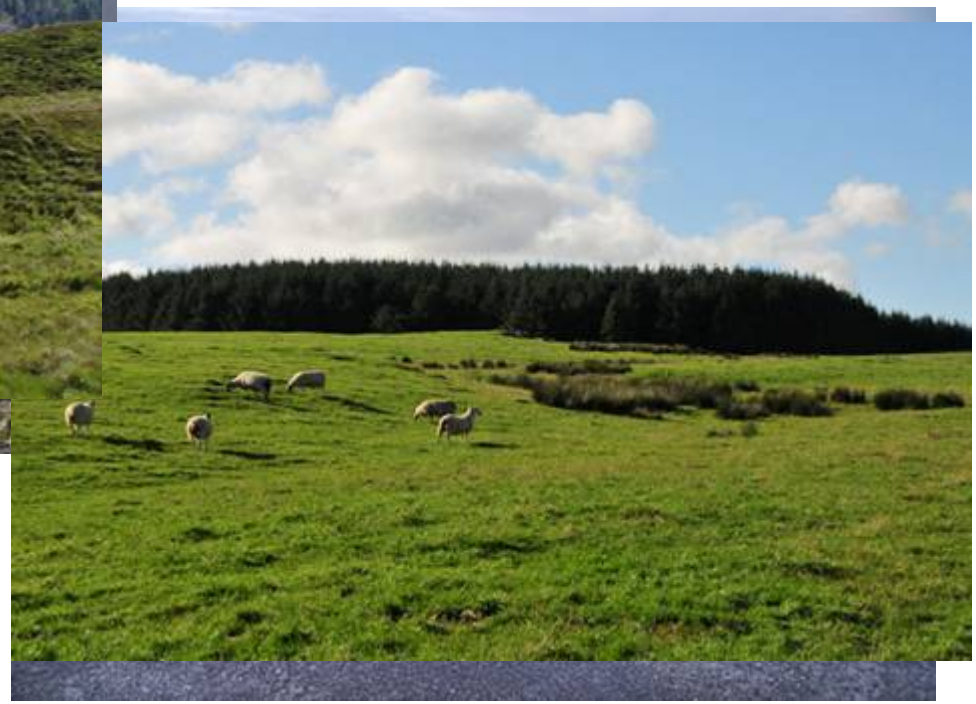
Artificial reefs

1. Perhaps one of most unfortunate things that has happened for reef restoration is that “artificial reefs” and “coral reefs” share the word “reefs”.
2. There are about 255,000 km² of coral reefs globally. Lack of hard substrate is not the critical issue. Management of the degradation of natural reefs is the critical issue.
3. If only 10% of the estimated 50,000 km² of degraded reefs remain as bare hard substrate, then ~500,000 ha of coral rock in need of restoration around the world.



Site selection for forestry

What do you start by trying to do when you want to reforest these sites?



“Artificial reefs” for forestry

Is this a cost-effective and sensible way of conducting large-scale reforestation?

Site selection for reef restoration

Would you start by trying to restore these sites?

Artificial reefs - rationale

1. Instant increase in topographic complexity,
2. Stable substrate for coral settlement or transplants,
3. Fish aggregation,
4. Sea-defence services,
5. Hard structures to discourage net-based fishing (trawling, seining) in coral areas,
6. Dive sites to reduce diver impacts on natural reefs, where lots of diving tourists.

Competing designs of AR

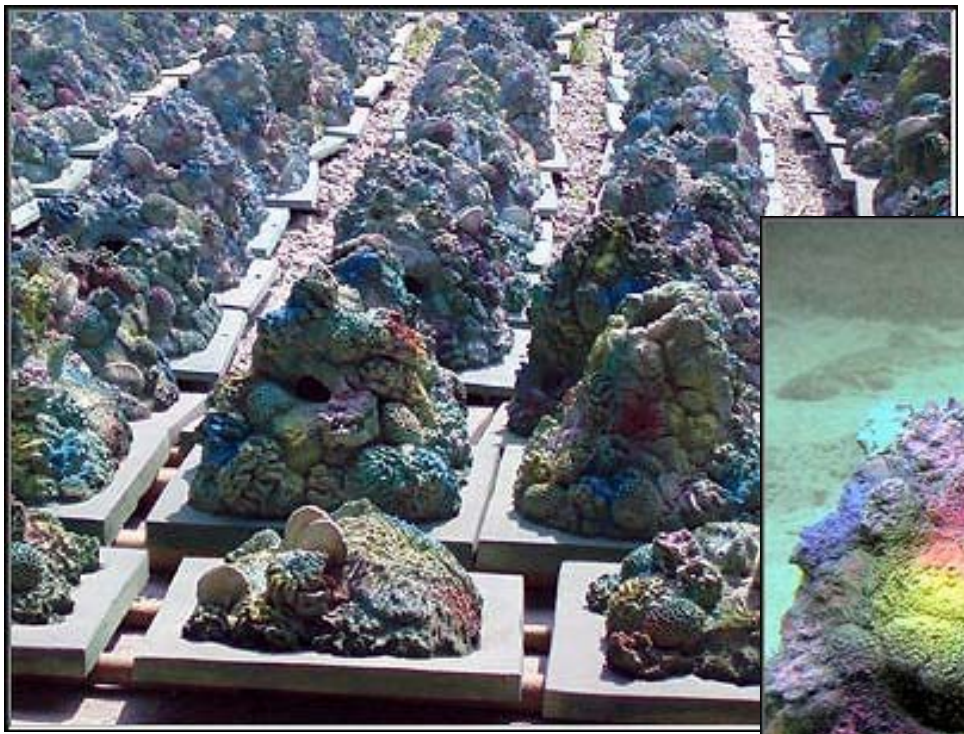
1. Concrete ReefBalls™: most widely deployed

Competing designs of AR

2. Ceramic EcoReefs™:

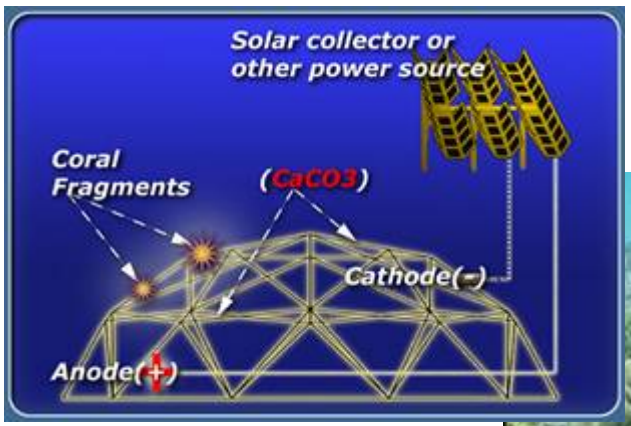
Competing designs of AR

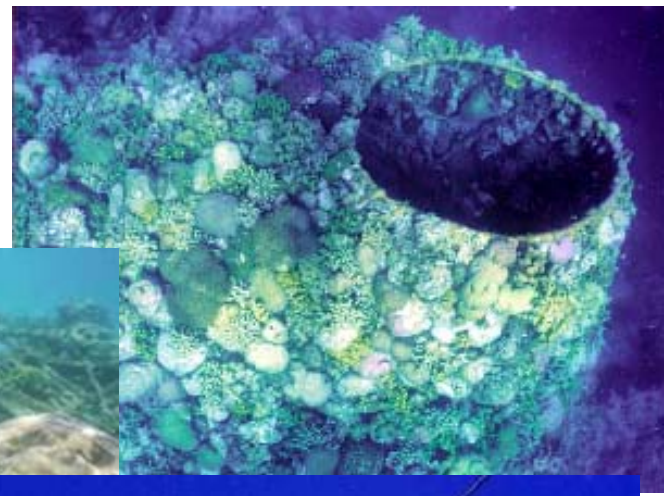
3. Concrete Eco-Corals™:



Competing designs of AR

4. Electrolytically deposited calcium carbonate (brucite and aragonite) on shaped wire mesh templates (BioRock™)





Competing designs

5. Any concrete structures or limestone blocks immersed in the sea.

If these are placed at suitable locations, they are likely to be well colonised by corals within a few years.

Impact of ARs on reef restoration

Adding in artificial reefs to any rehabilitation project raises cost per hectare from $10,000s to $1,000,000s.

Thus for 1 ha “restored” with artificial reefs, you could rehabilitate 1 km^2 of degraded natural reef.

Diverting research and restoration effort away from trying to rehabilitate damaged reefs into trying to create artificial habitat.

Very few instances where anything aesthetically pleasing with high coral cover has been created. Most of these were accidental using normal concrete sea defence structures that were naturally colonised by corals.

Final word

- Over 500,000 “reef balls” of varying types have been deployed worldwide – this provides about 2 km² of topographically diverse substrate, but at a cost of **US$10’s millions**.
- Use of artificial reefs in restoration needs to be considered carefully and critically in terms of NEED, COST-EFFECTIVENESS and AESTHETICS.

Approaches to active reef restoration

Reforestation focuses on trees, reef restoration focuses on corals as the ***keystone*** species.

Two main approaches to active restoration:

Asexual propagation: Take fragments of colonies (or rarely whole colonies) and either transplant directly or culture in nurseries and transplant later.

Sexual propagation: Take products of sexual reproduction, culture and transplant when big enough to survive reasonably well.

Outputs for managers

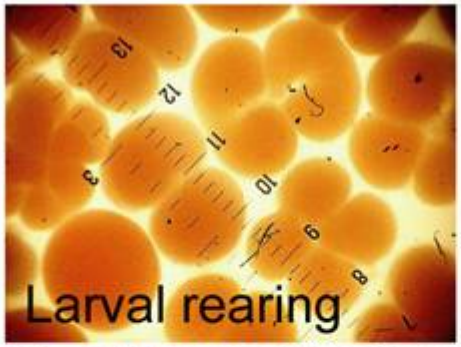
Reef Restoration Concepts and Guidelines: Making sensible management choices in the face of uncertainty (also in French and Indonesian; Spanish)

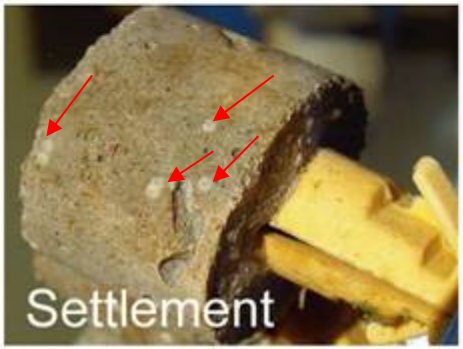
Reef Rehabilitation Manual due in late 2009 ***(***with REEFRES and CRISP)

European Commission
REEFRES project

CRISP
Coral Reef Initiative for the South Pacific
Initiative Corail pour le Pacifique Sud


Spawning


Larval rearing


Settlement


Nursery rearing


Approx. 5 mm
Favites halicora
4.5 months

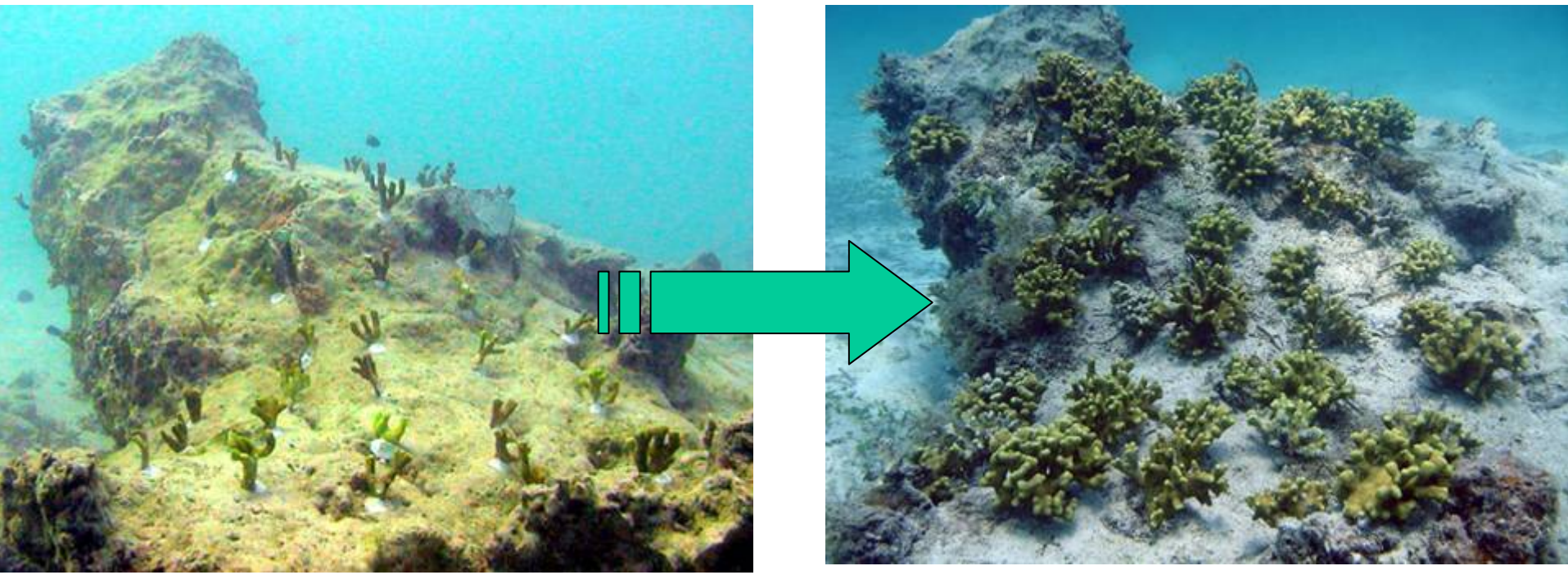

Approx. 15 mm
Acropora millepora
6.3 months


Approx. 5 mm
Outplanted
Acropora millepora

Asexual culture - minimising cost and collateral damage

Ex-situ coral nursery (Photo: Shai Shafir)

- More cost-effective
- Less damaging
- Larger scale



Direct transplantation using epoxy putty

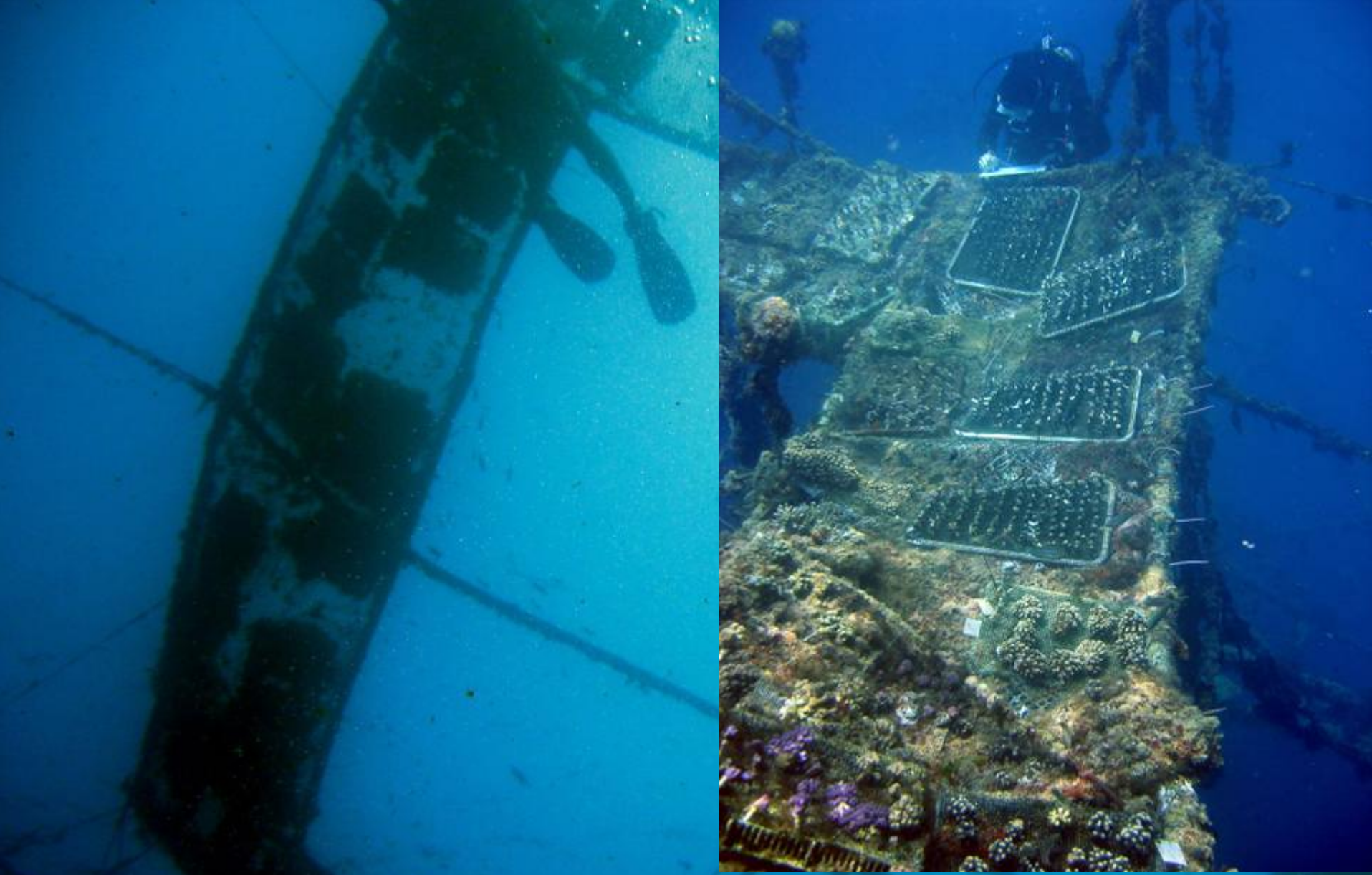
A small coral fragment mounted on a plastic pin (waste product of plastic injection moulding) with a drop of superglue. Scale on ruler is in mm.

Acropora fragment mounted on a plastic pin after ~4 months of growth.

A 20 cm diameter branching coral can generate up to 500 fragments.

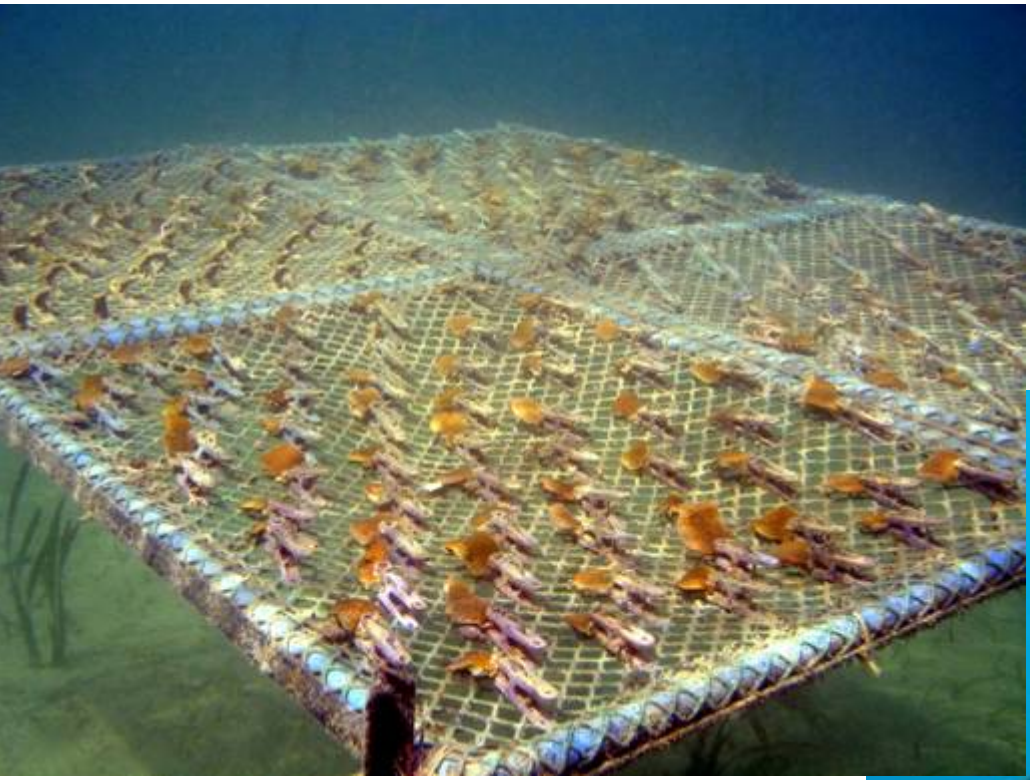
Millepora coral fragment wedged in a plastic wall-plug for nursery rearing

Acropora fragment mounted in a plastic wall-plug after ~6 months of growth.

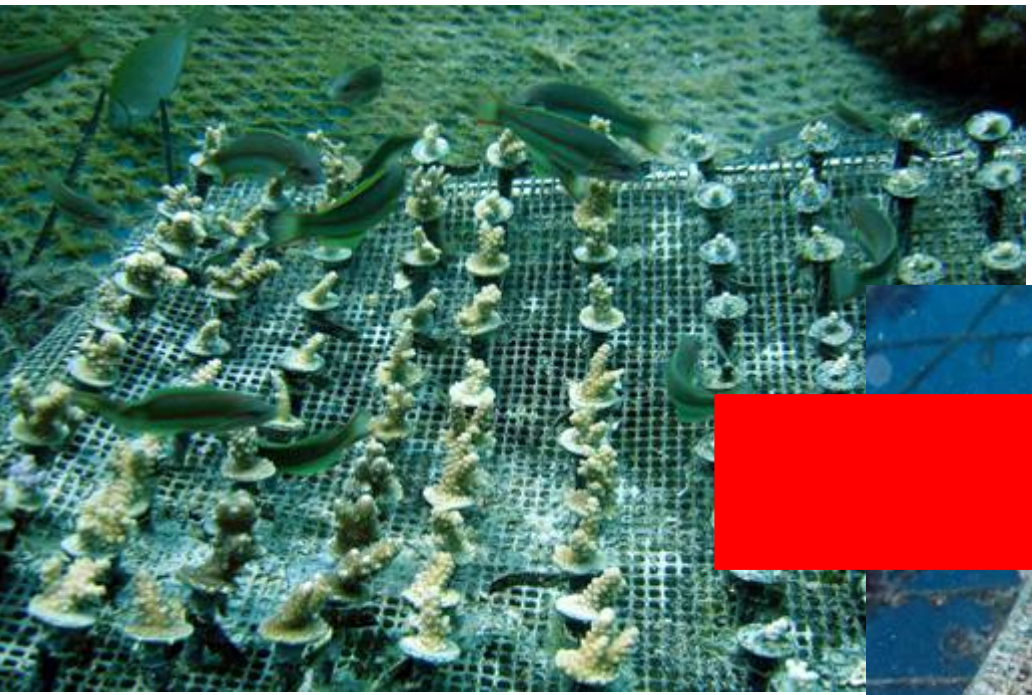


Modular 10 m x 10 m floating nursery able to mariculture up to 10,000 coral colonies per year (Photo: Shai Shafir)

Simple nurseries for community-based coral rearing



After 9-12 months rearing, you have small colonies about 7-10 cm in diameter which are suitable for transplantation



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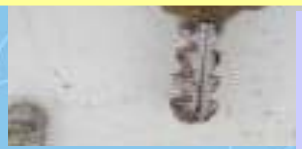


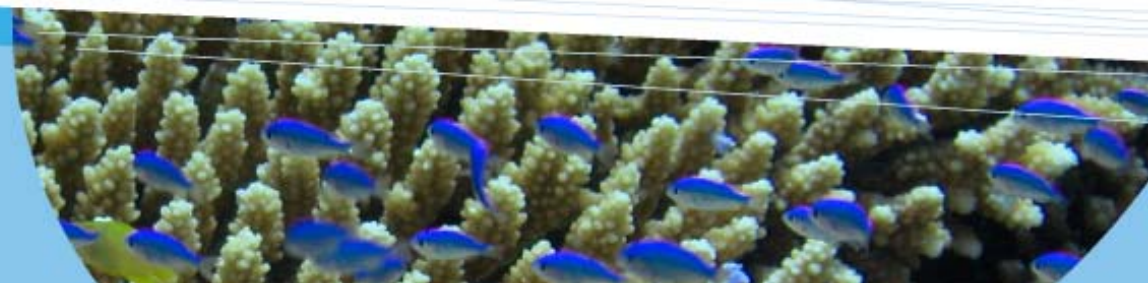
Nursery reared coral on wall-plug

Summary

Reef rehabilitation is in its infancy

Reef rehabilitation can make a difference at a local scale – hectares (but degradation is occurring over 10,000s km)

Techniques which allow reasonably cost-effective transplantation to hectares of reef are available – but still need piloting at the local level by MPA managers and communities.



Acknowledgements

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... as we know, there are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns - the ones we don't know we don't know. *D. Rumsfeld*

Some questions

1. What do you see as the role of active reef restoration methods?
2. How can scientists best help managers who are trying to rehabilitate degraded reefs?

3. Your questions?