# Connectivity of coral reefs and other nearshore habitats: implications for marine resource management in the Philippines

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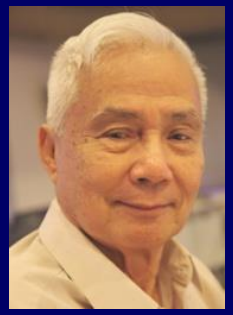
# Collaborators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giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

ARC Centre of Excellence Coral Reef Studies

KAUST King Abdullah University of Science and Technology

NAST - DOST

# Talk Guide

1. **Marine Protected Areas (MPAs)** – status, successes, shortcomings
2. **MPA networks & connectivity** – theory and evidence for enhancement
    - Larval connectivity
    - Habitat connectivity

    mangroves ⟷ seagrass beds ⟷ algal beds ⟷ coral reefs
3. **Five challenges** for marine resource management



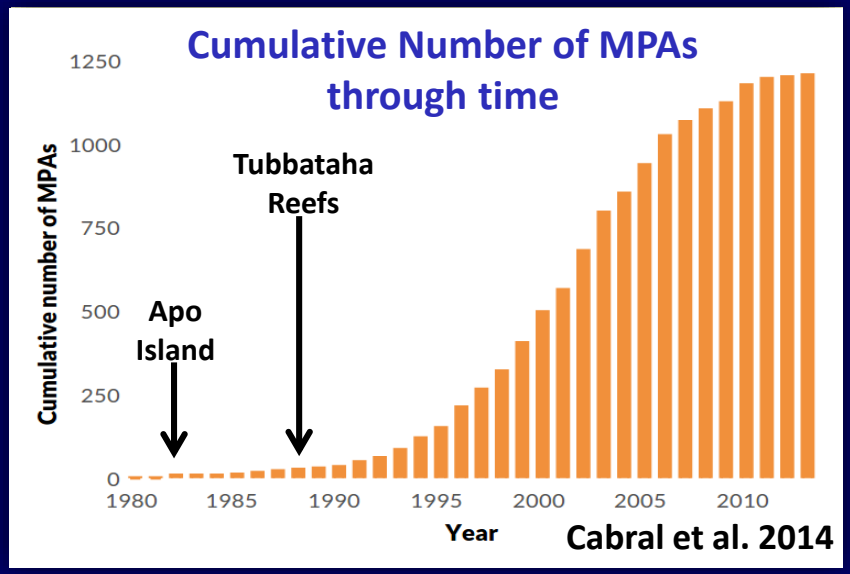
# Marine Protected Area (MPA)

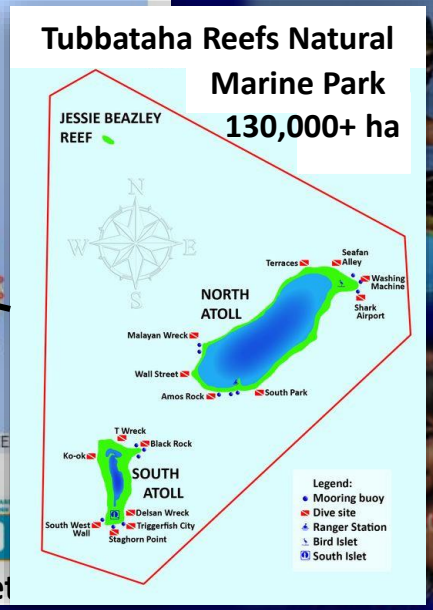
- "Any area of intertidal or sub-tidal terrain, together with its overlying water and associated flora, fauna... which has been reserved by law or other effective means to protect part or all of the enclosed environment" (IUCN definition in Kelleher, 1999)

# Marine Protected Area (MPA)

- May in itself be, or include, a “no-take” area – e.g. Fish Sanctuary, Core Zone, No-Take Marine Reserve (NTMR)
- Can help overfished species to recover – biodiversity conservation and fisheries management
- Not a “cure-all” or “magic bullet”
- >15,000 MPAs worldwide, 6% coverage (Targets: 10% in 2020; 30% in 2030)

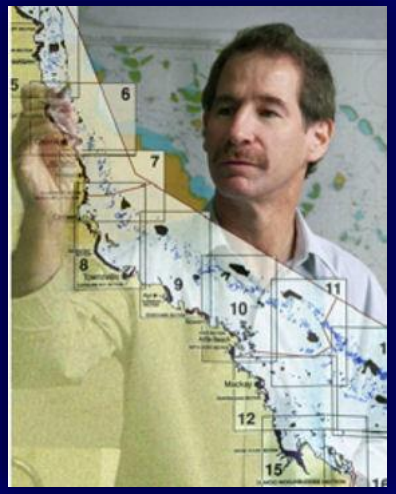
# ~1800 MPAs for 100 million Filipinos

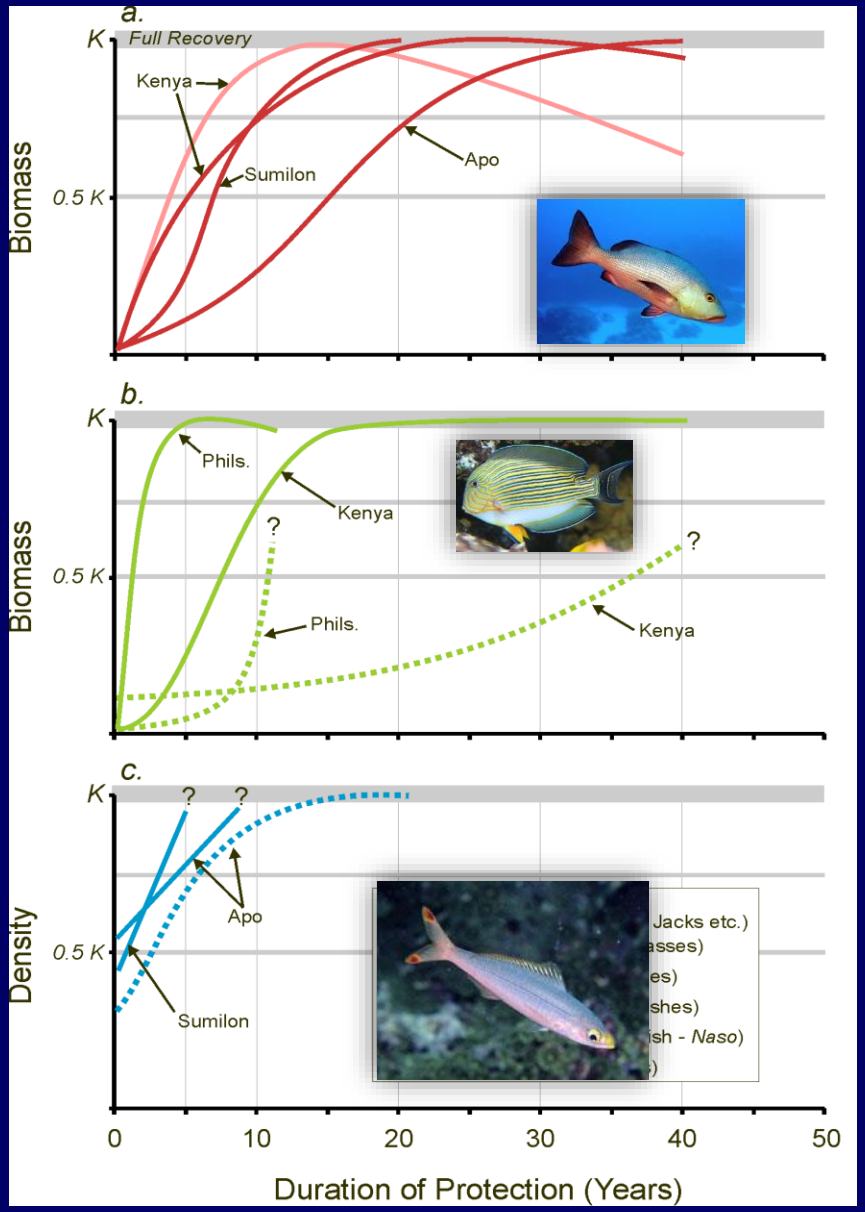




# Do MPAs really work? – Yes!

Angel Alcala (ca.1980s)



Garry Russ



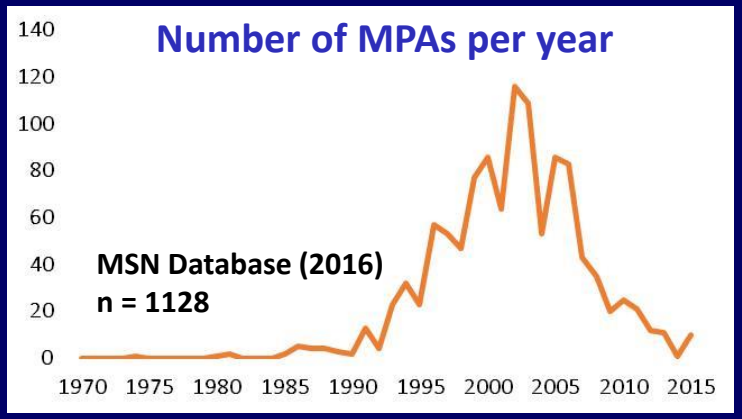



**..but many species may need decades to fully recover**

Abesamis et al. 2014;
Russ and Alcala 2010;
McClanahan et al. 2007

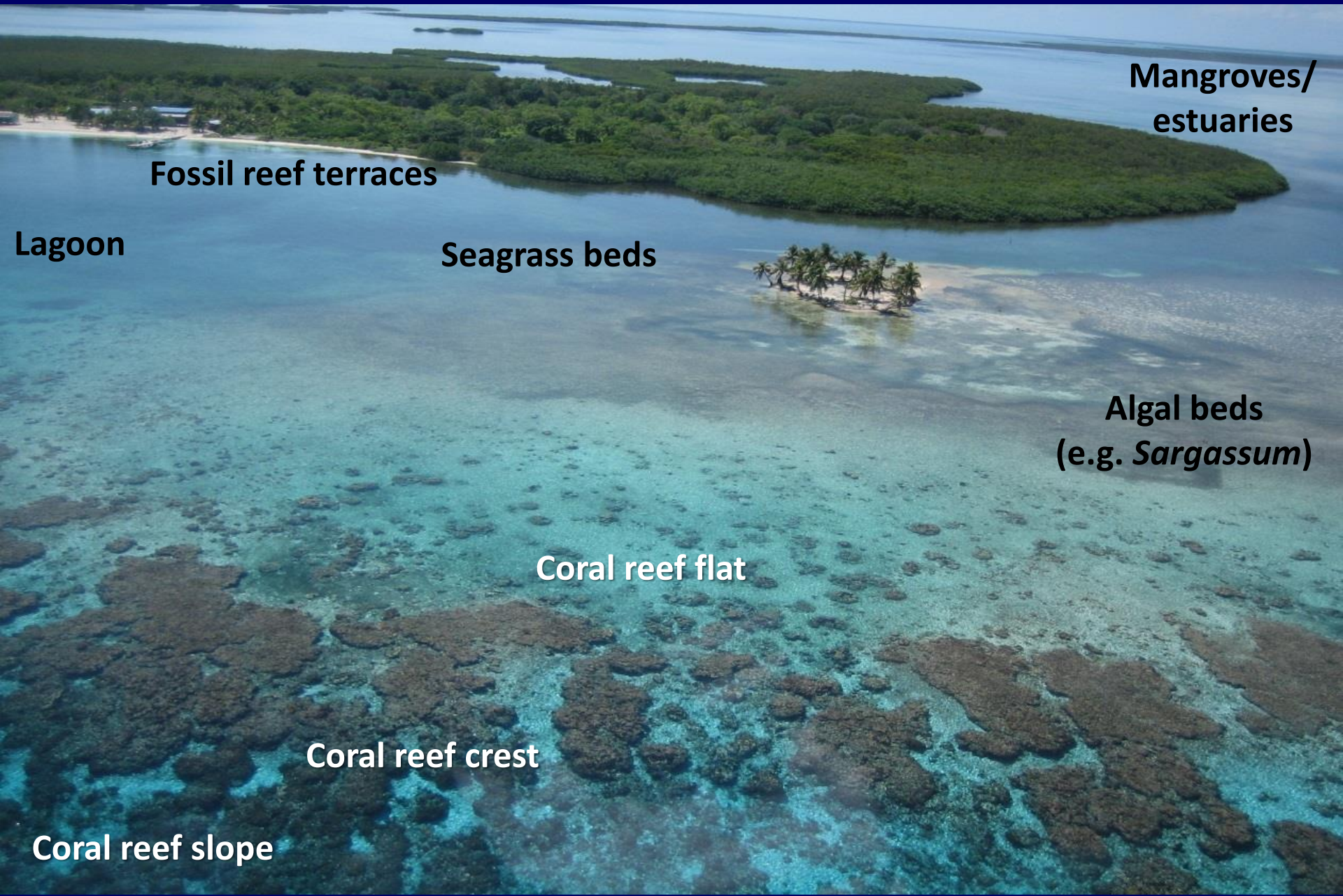
# Do we need more Philippine MPAs? – Yes!

- 90% of existing MPAs are small (<1km$^2$, usually just 10-50 ha)
- Only 0.5% of municipal waters protected (target at least 20%)
- Only 3/10 of MPAs functional (rest are "paper MPAs")
- Rate of MPA establishment slowing down?
- Most are coral reef MPAs that protect <4% of total reef area




Alcala et al. 2008; Weeks et al. 2010

# Mosaic of fish habitats in a seascape



# MPAs lacking in other important habitats

- MPAs that include mangroves – 7% (123 of 1778)
- MPAs that include seagrass beds – 1% (21 of 1778)
- MPAs that include algal (*Sargassum*) beds - ???



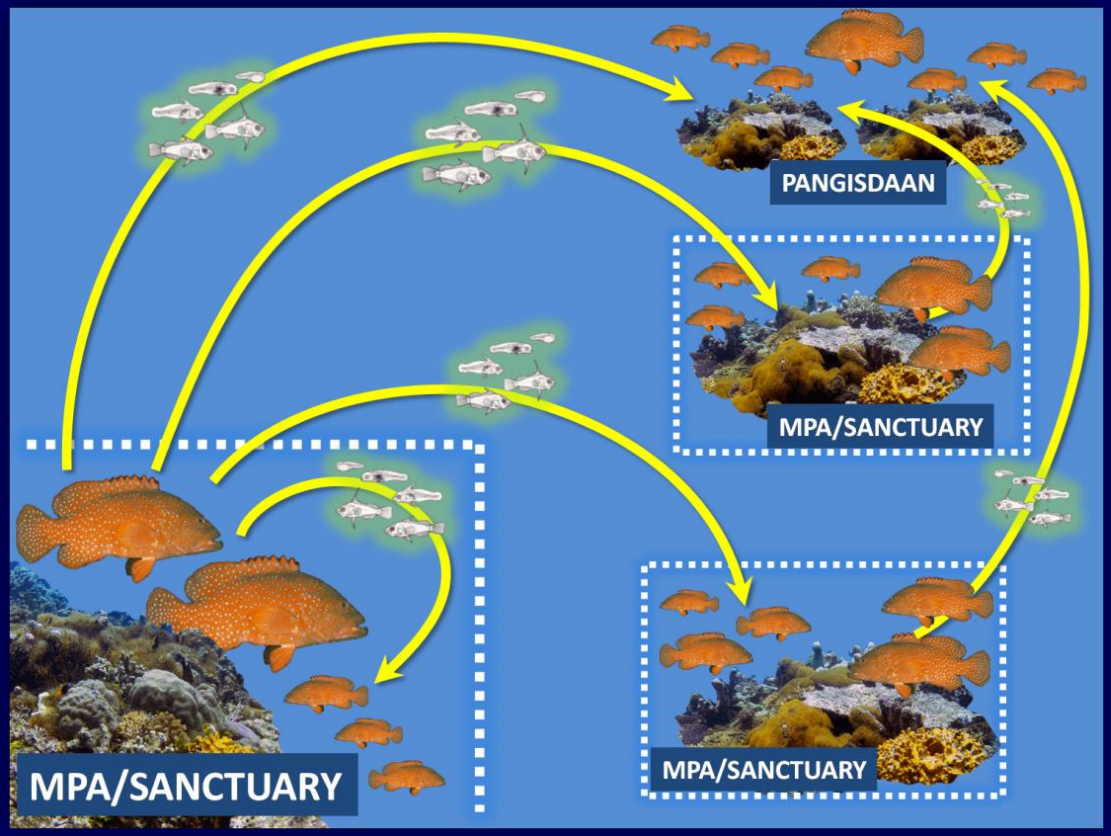


MPA Support Network
Phil. MPA Database (2017)

# MPA Networks

- System of MPAs that protects a sufficient proportion of the population of at least one species during vulnerable life stages (juveniles and adults)

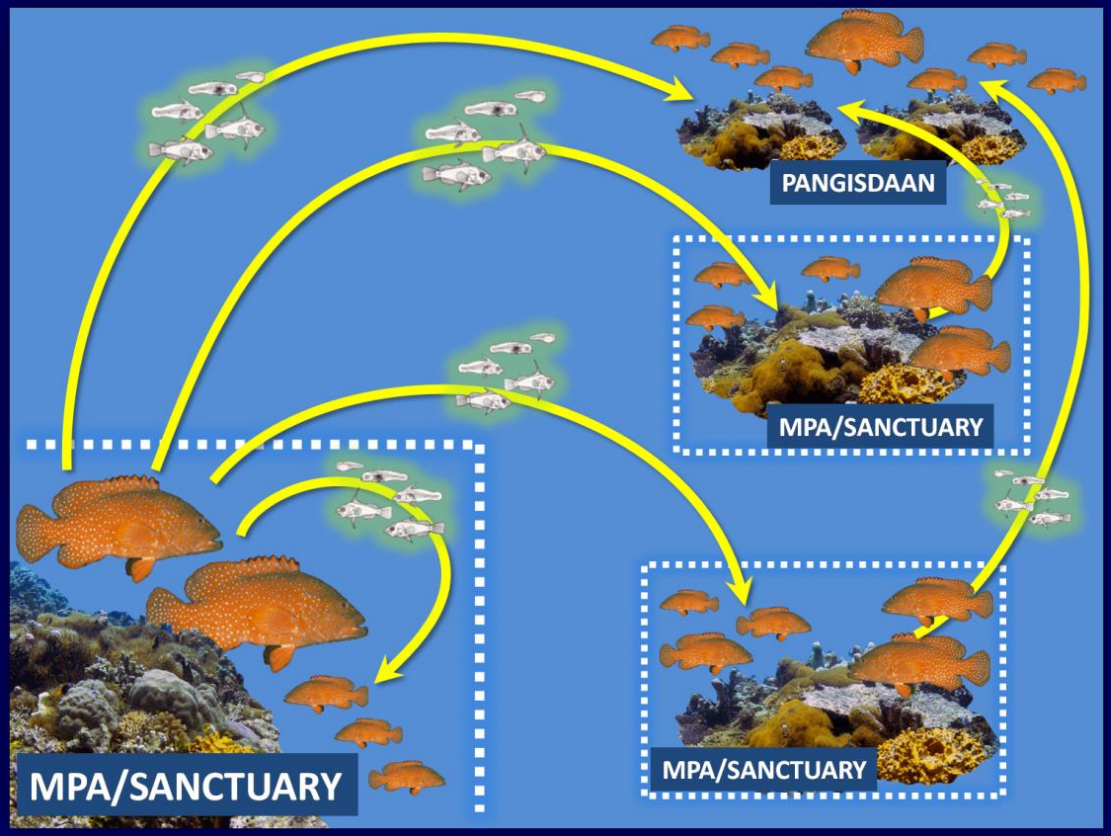
- Connectivity – the linking of local populations through the dispersal or movement of larvae, juveniles, or adults




Sale et al. 2005

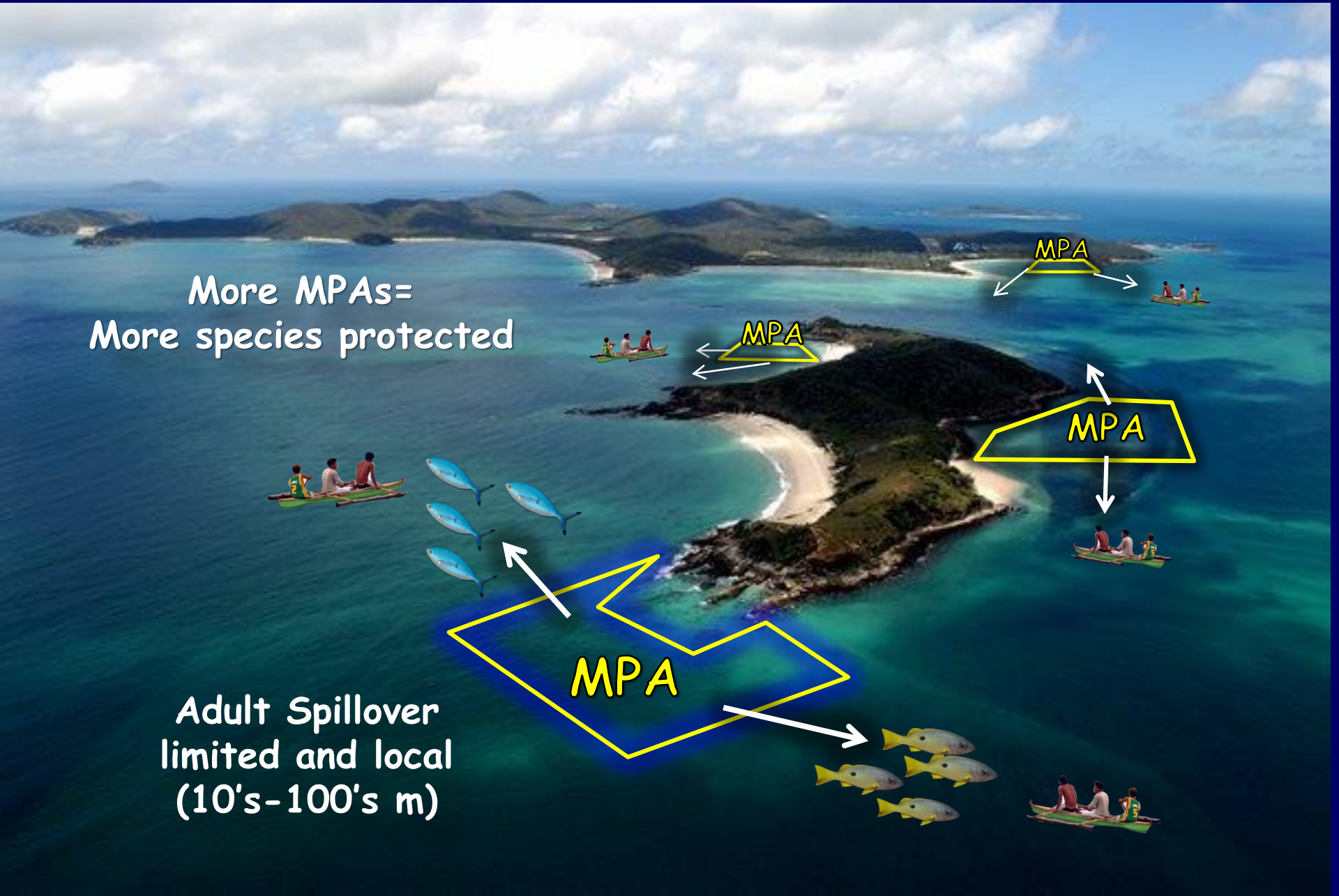
# MPA Networks

- Connectivity is a major consideration in network "rules of thumb":
  - Size, spacing and location of MPAs
  - Representation of important habitats in MPAs (target 20-40%)
  - Replication of MPAs within each important habitat

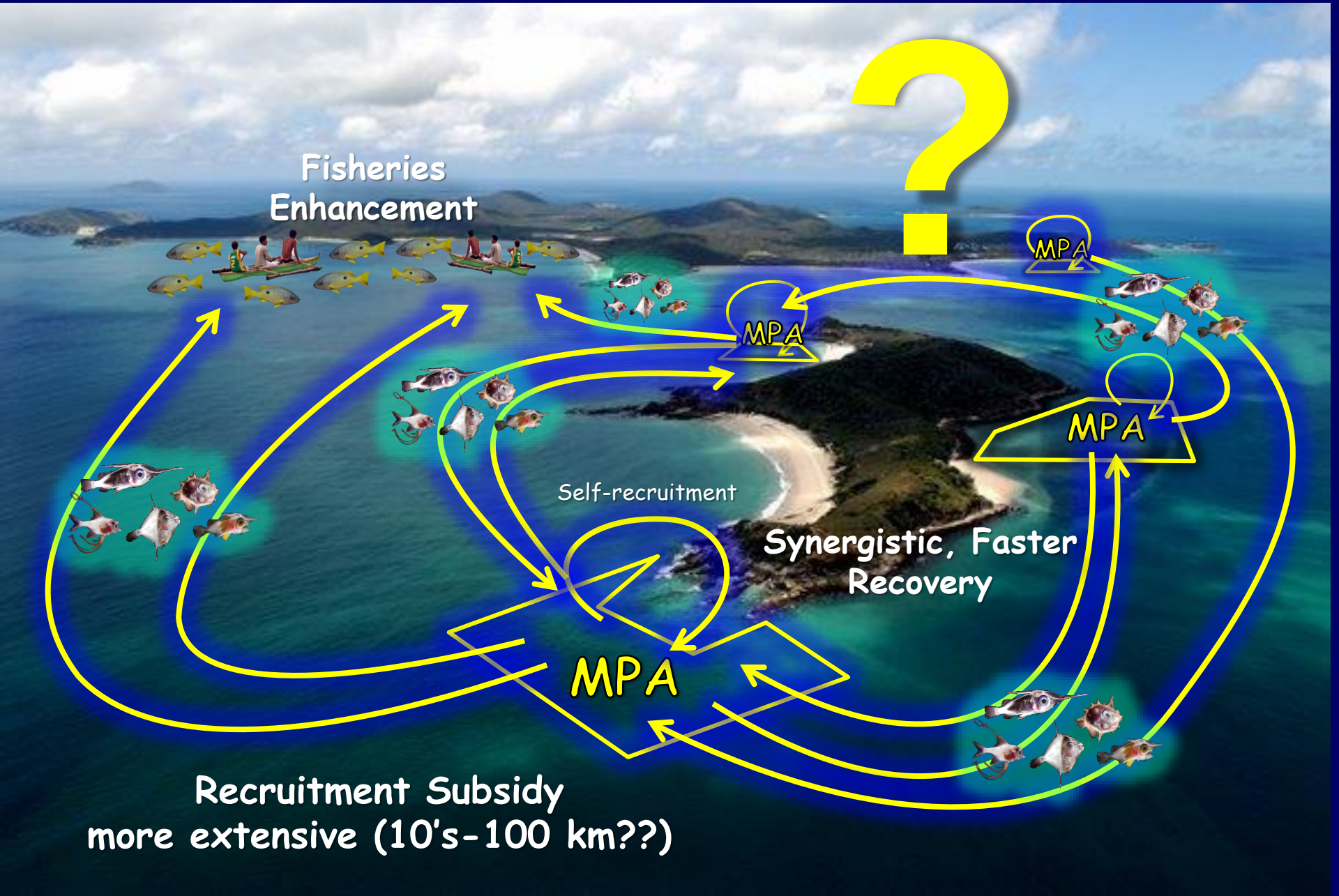



Fernandes et al. 2012
Green et al. 2013

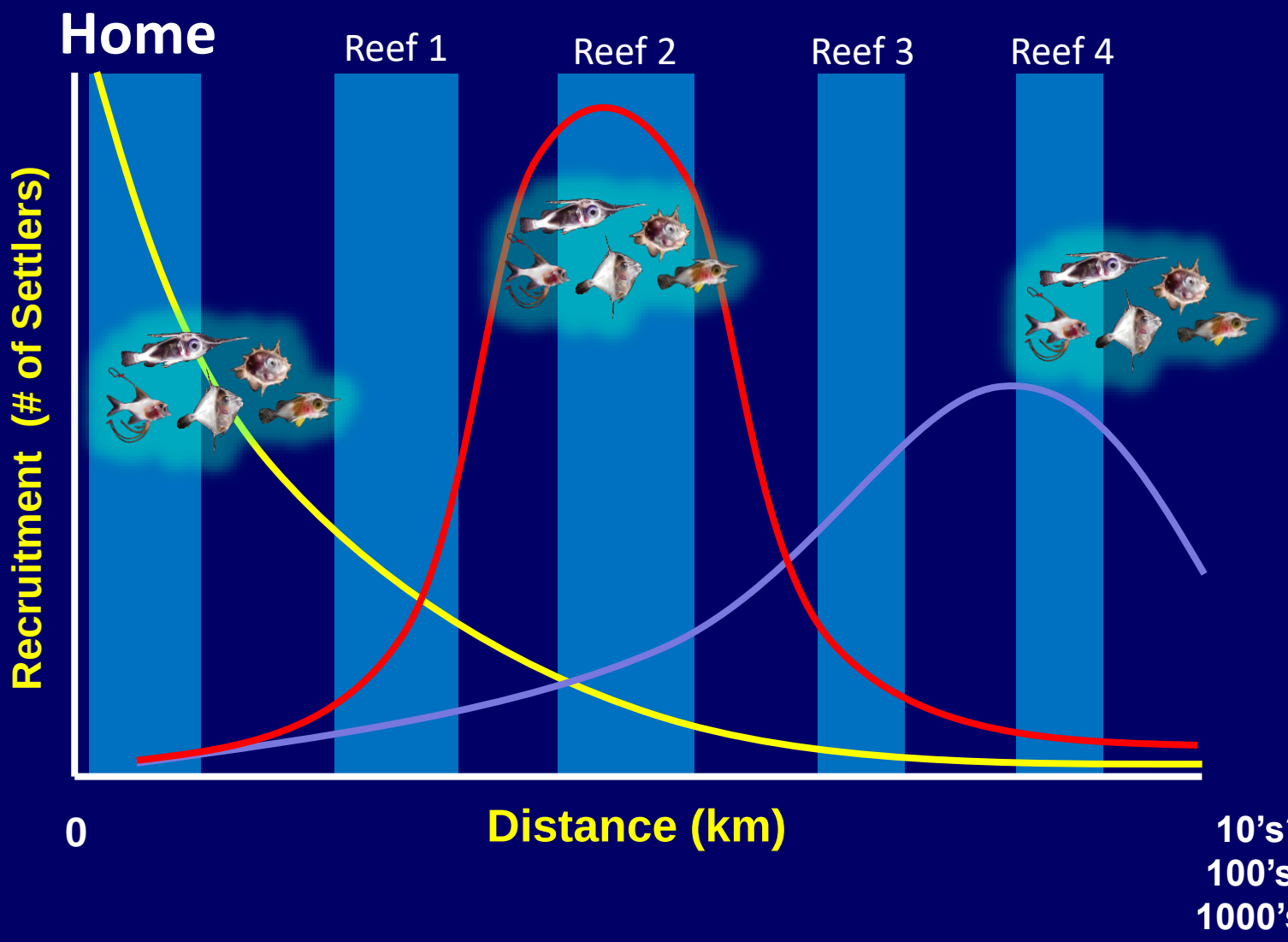
# Additive MPA effects and adult spillover



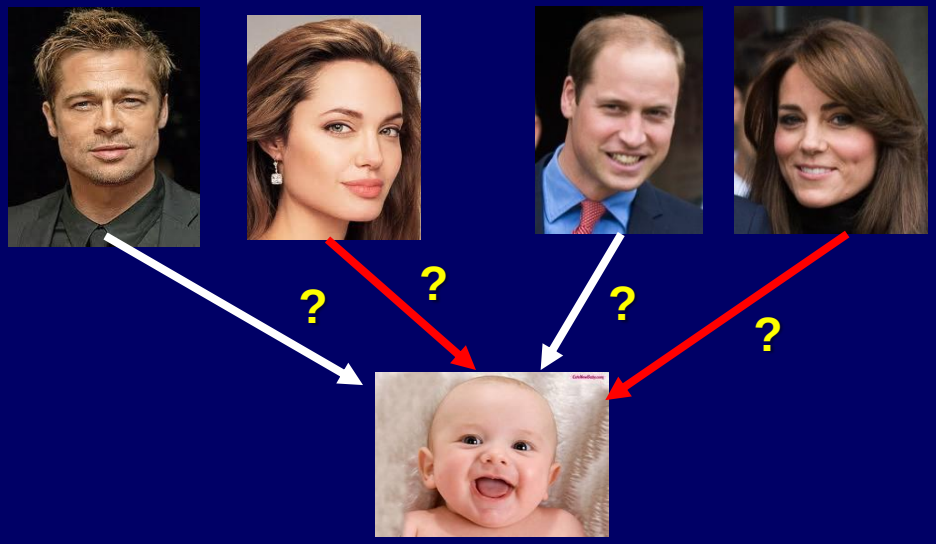
# Larval connectivity - Synergistic effects



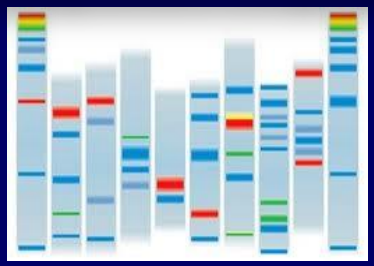
# What is the ‘shape’ of the larval dispersal kernel?

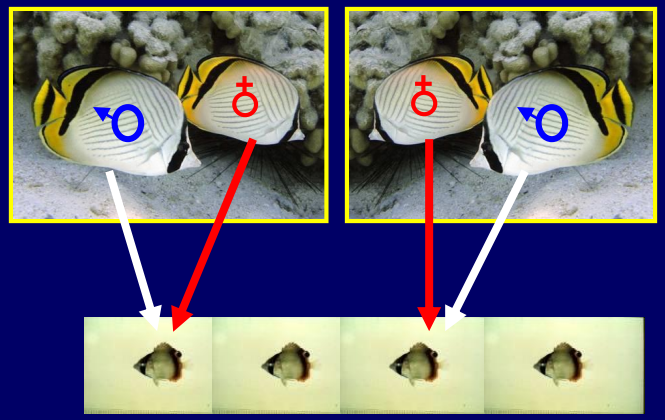


# Validating larval connectivity



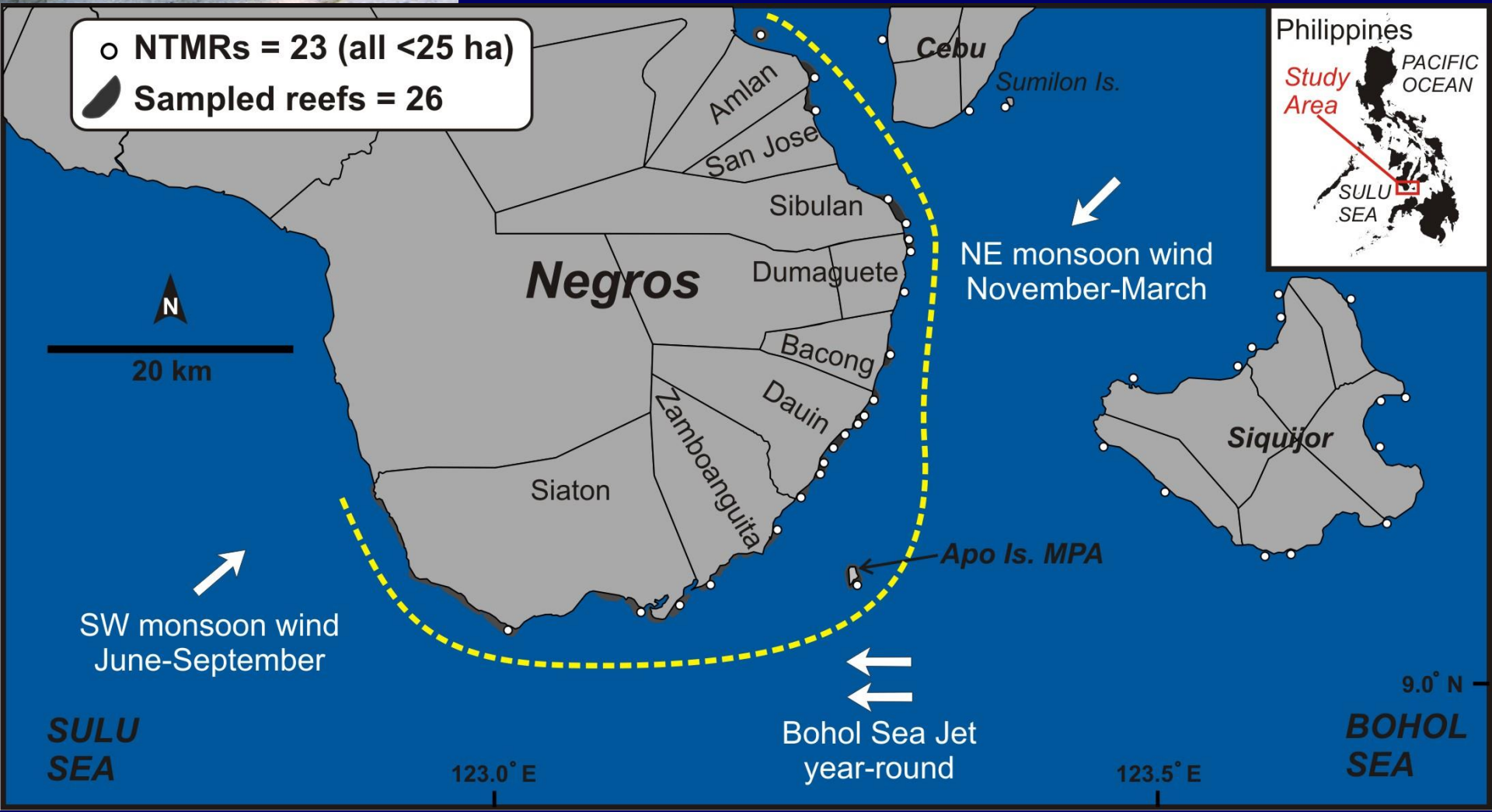

**Genetic Parentage Analysis using DNA 'fingerprint'**

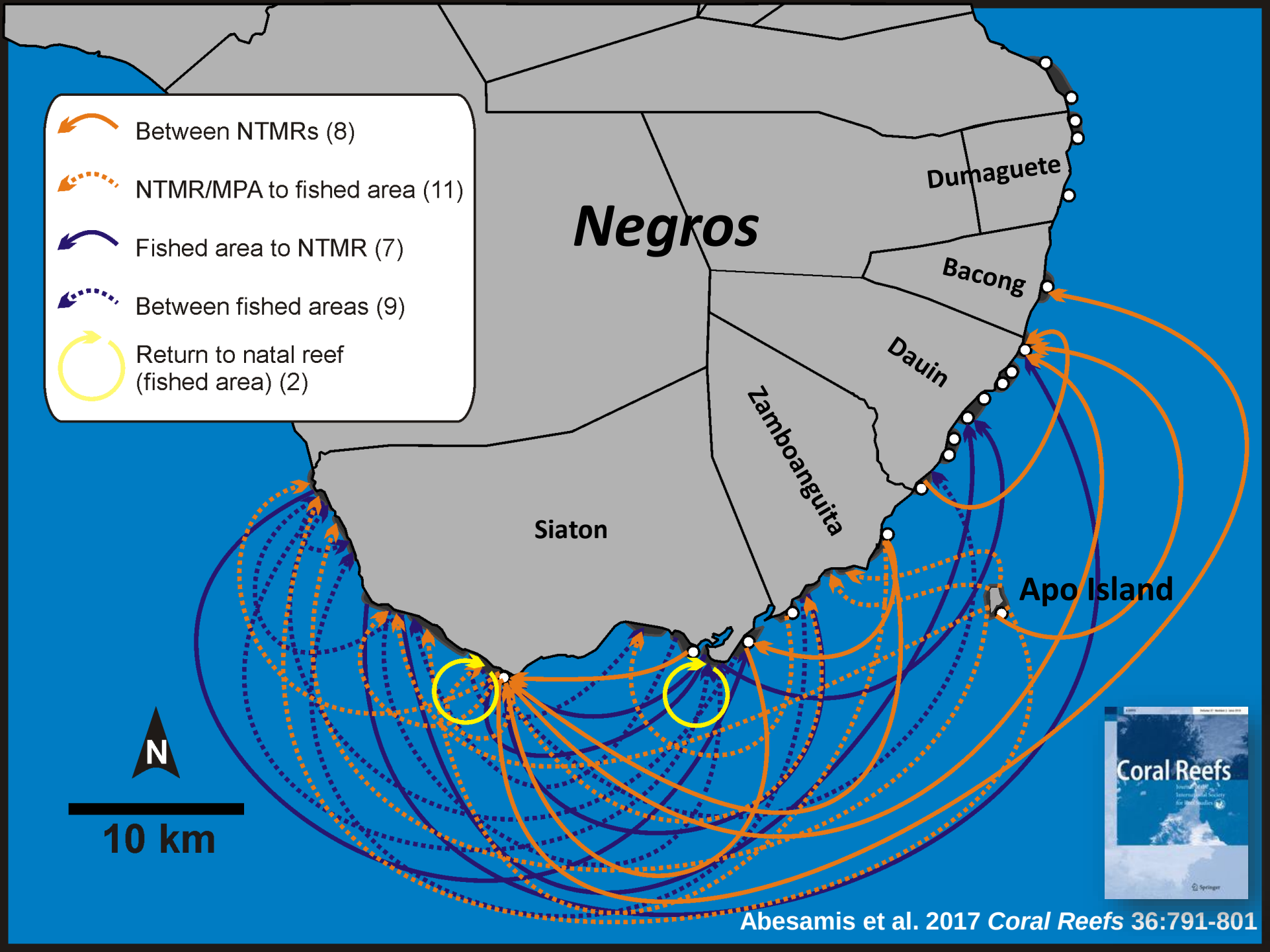




# Genetic parentage analysis

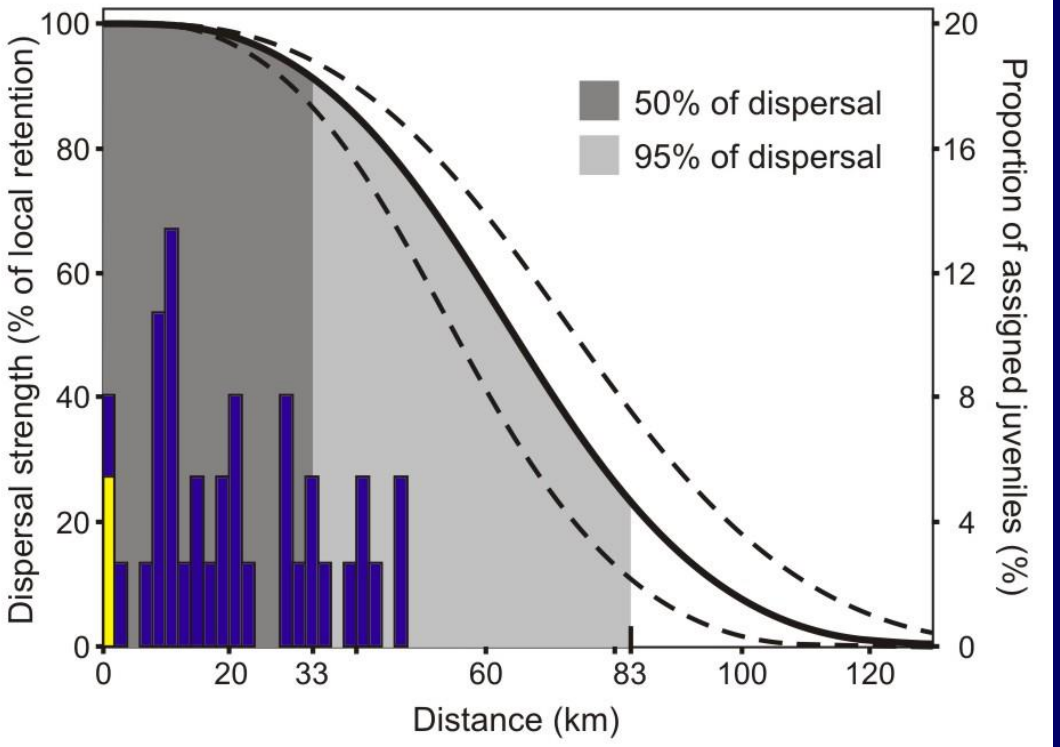
- *Chaetodon vagabundus* (butterflyfish)
- Pelagic spawner; 20-30 day larval life
- Exhaustive sampling across 90 km coastline
- 23 MPAs/NTMRs protect <<1% of reef area






Abesamis et al. 2017 *Coral Reefs* 36:791-801

# Estimated larval dispersal kernel



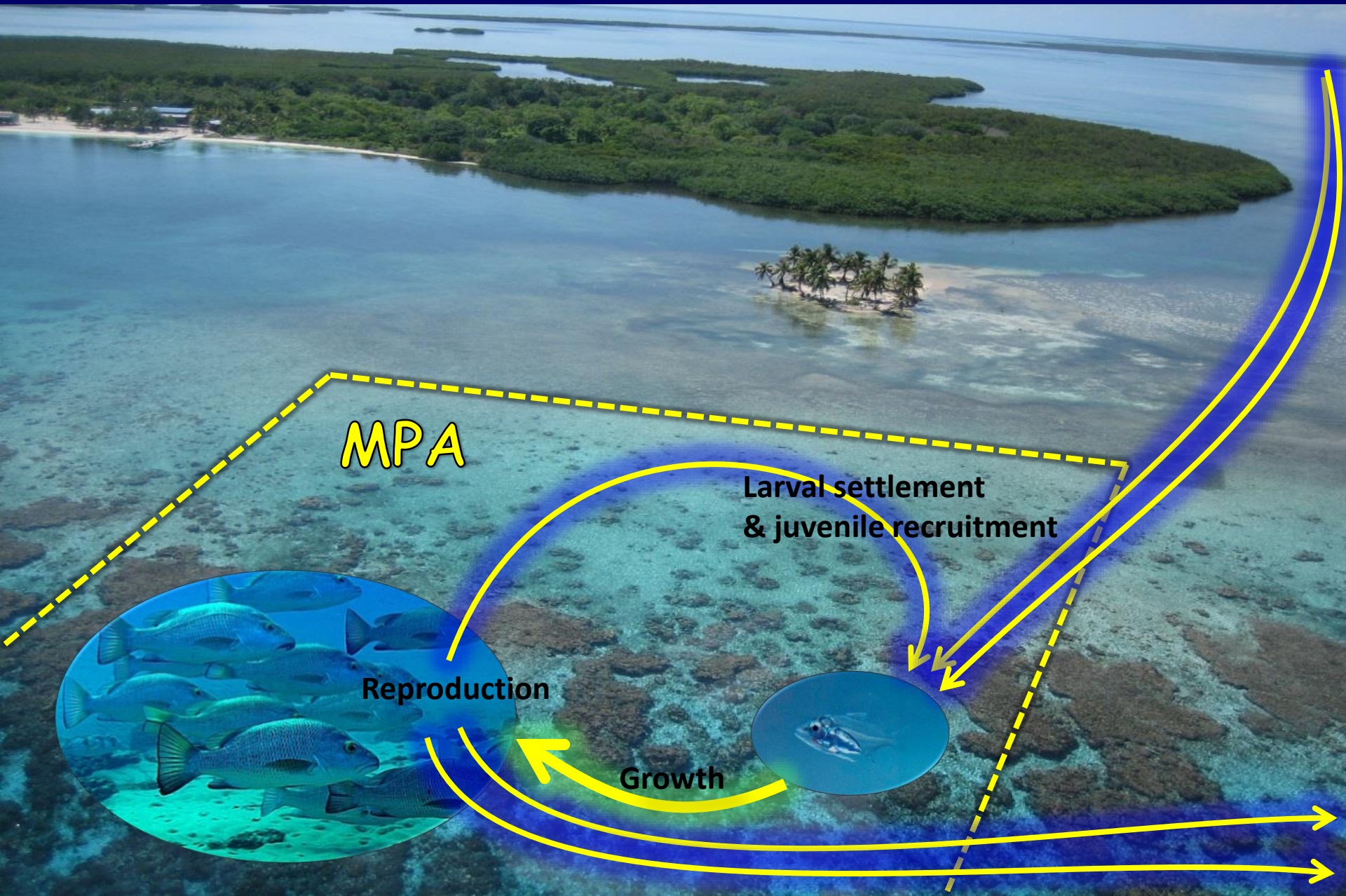

**Key features:**

- **50%** of dispersal within **33 km**; **95%** within **83 km**
- **Average** dispersal : **36.5 km** (vs. 0.6 km largest MPA length)
- **Variability** (SD): **44.2 km** (vs. 3-4 km reef habitat and MPA spacing)

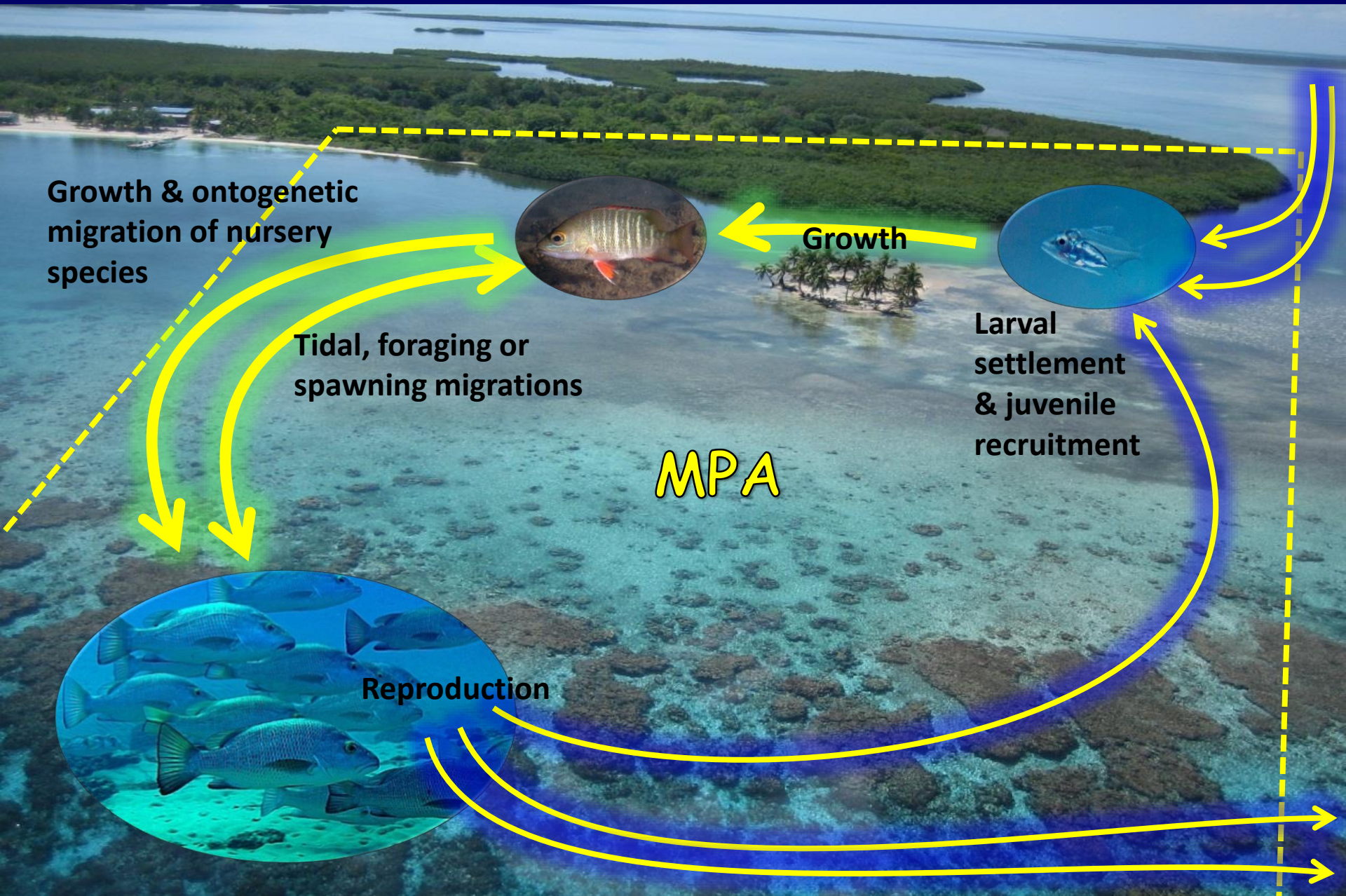
**Implications:**

- **Synergy** among MPAs within few 10's of km very likely
- MPAs **unlikely to be self-sustaining** (sizes << mean dispersal)
- MPAs and fished areas **rely on larval import** from external sites within range of dispersal (habitat spacing << SD)

# Habitat connectivity via juvenile/adult migrations



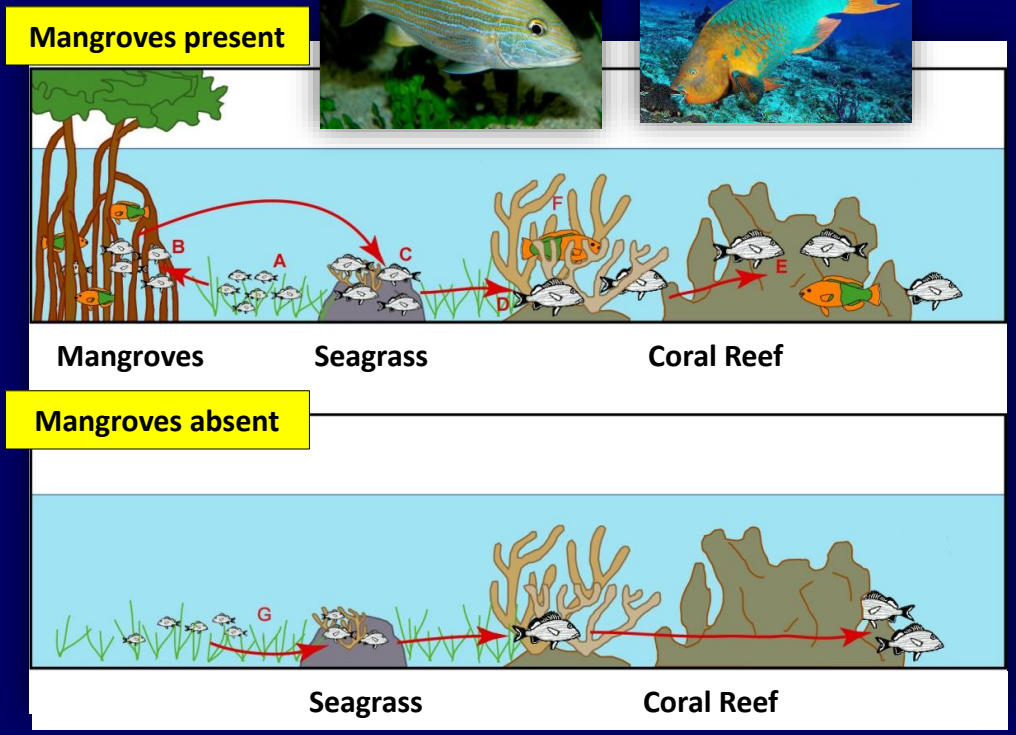
# Habitat connectivity via juvenile/adult migrations



# Habitat connectivity can enhance fish populations

## Belize (Atlantic)

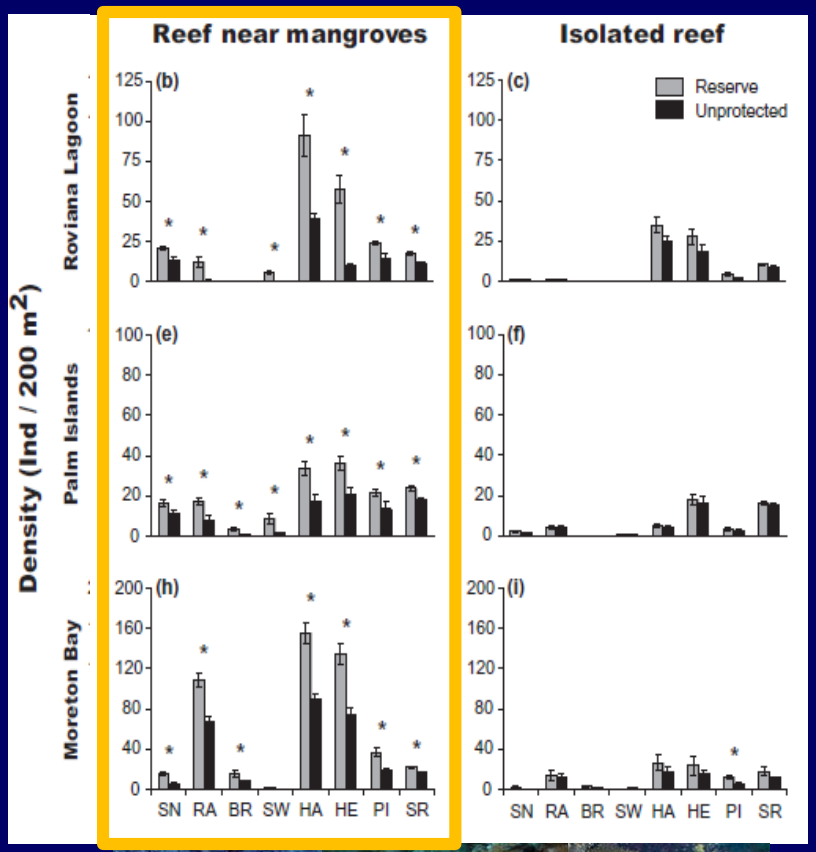
- Fish use mangroves as intermediate nursery habitats (seagrass ➡ coral reef)
- Fish biomass up to 25X more in mangrove-rich vs. mangrove-poor reefs




Mumby et al. 2004 *Nature*

## Solomon Is and Australia (Pacific)

- MPA effect on fish density much stronger in reefs closer to mangroves




Olds et al. 2013 *Global Ecol Biogeography*

# Philippine case studies on habitat connectivity

## Puerto Galera & Laguindingan

- Distinct fish assemblages among mangroves (47 spp), seagrass (38 spp) and coral reefs (234 spp)
- 23% (10 spp) of fishery species use nearshore habitats as nursery/feeding

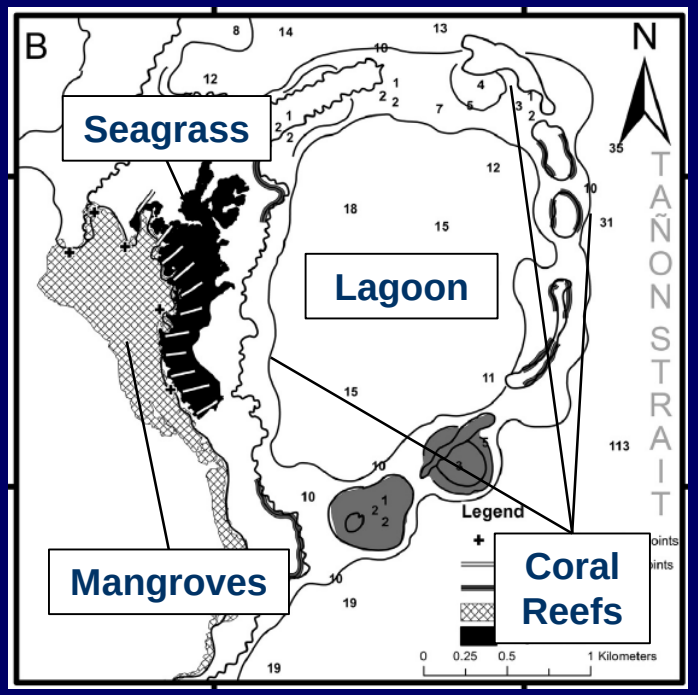
PLOS ONE
A peer-reviewed, open access journal

Honda et al. 2013 *PLOS ONE*

## Mantalip Reef System, Negros Or.

- 53% of reef fish catch use mangrove and seagrass for nursery/feeding
- Mangroves and seagrass beds can enhance annual fish yield by 40 tons
- Yet not included in MPAs!

Ramos et al 2015 *Ocean Coast Manage*

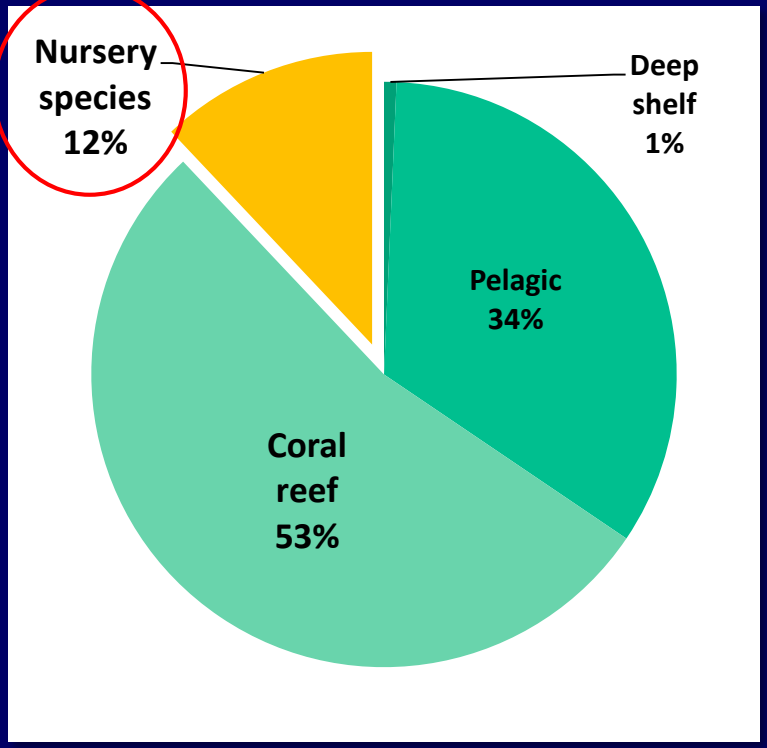
# Philippine case studies on habitat connectivity

## San Juan, Siquijor

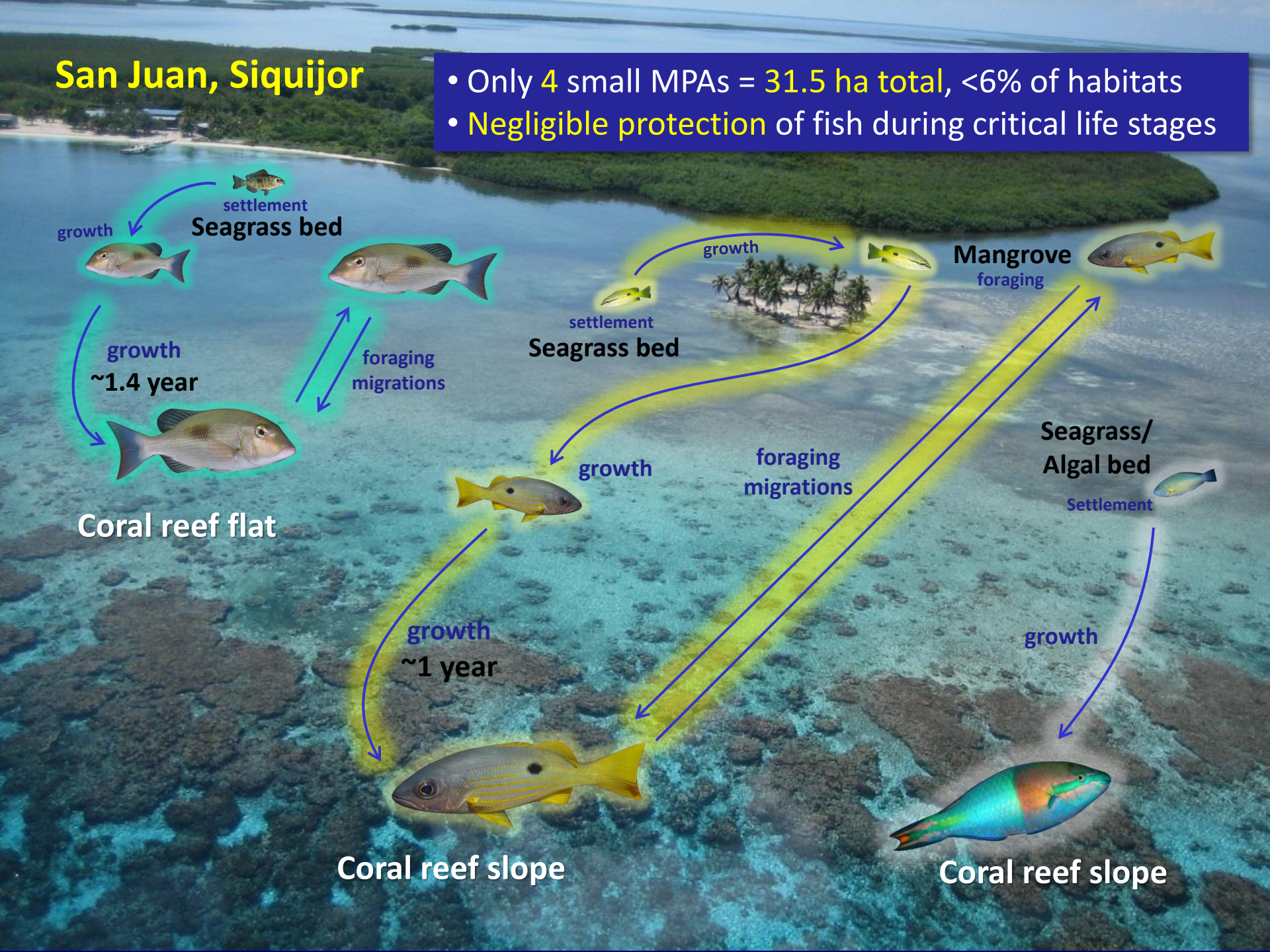
### Species richness by habitat

| Habitat | Number of fish species | Shared with Coral Reef |
|---|---|---|
| Coral Reef | 239 | - |
| Mangrove | 26 | 27% |
| Seagrass Bed | 60 | 47% |
| Algal Bed | 82 | 56% |

### Catch composition by weight



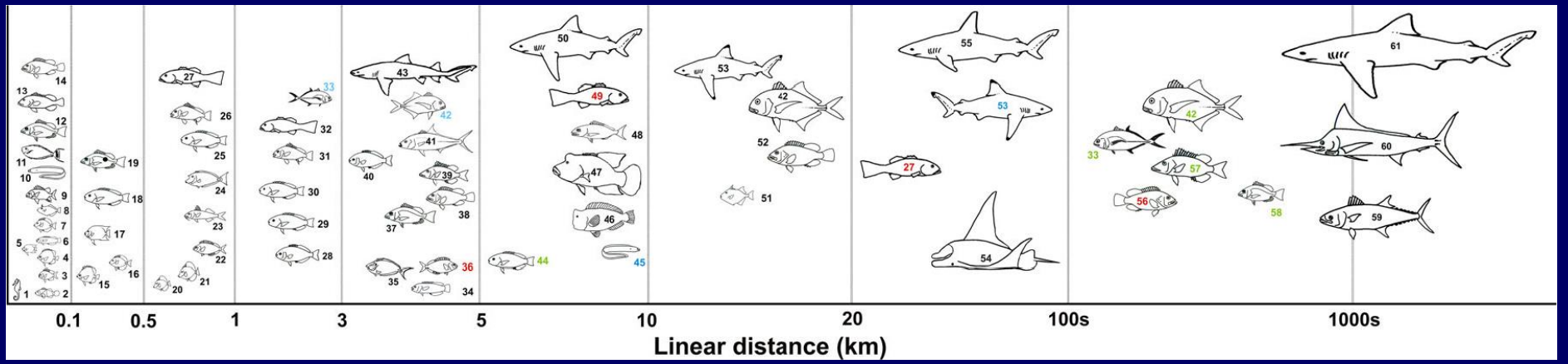

Abesamis et al. - unpublished data (DOST-GIA funded project)


San Juan, Siquijor
• Only 4 small MPAs = 31.5 ha total, <6% of habitats
• Negligible protection of fish during critical life stages
settlement
growth
Seagrass bed
growth
~1.4 year
foraging
migrations
Coral reef flat
growth
settlement
Seagrass bed
Mangrove
foraging
growth
foraging
migrations
Seagrass/
Algal bed
Settlement
growth
~1 year
growth
Coral reef slope
Coral reef slope

# 5 Challenges for marine resource management

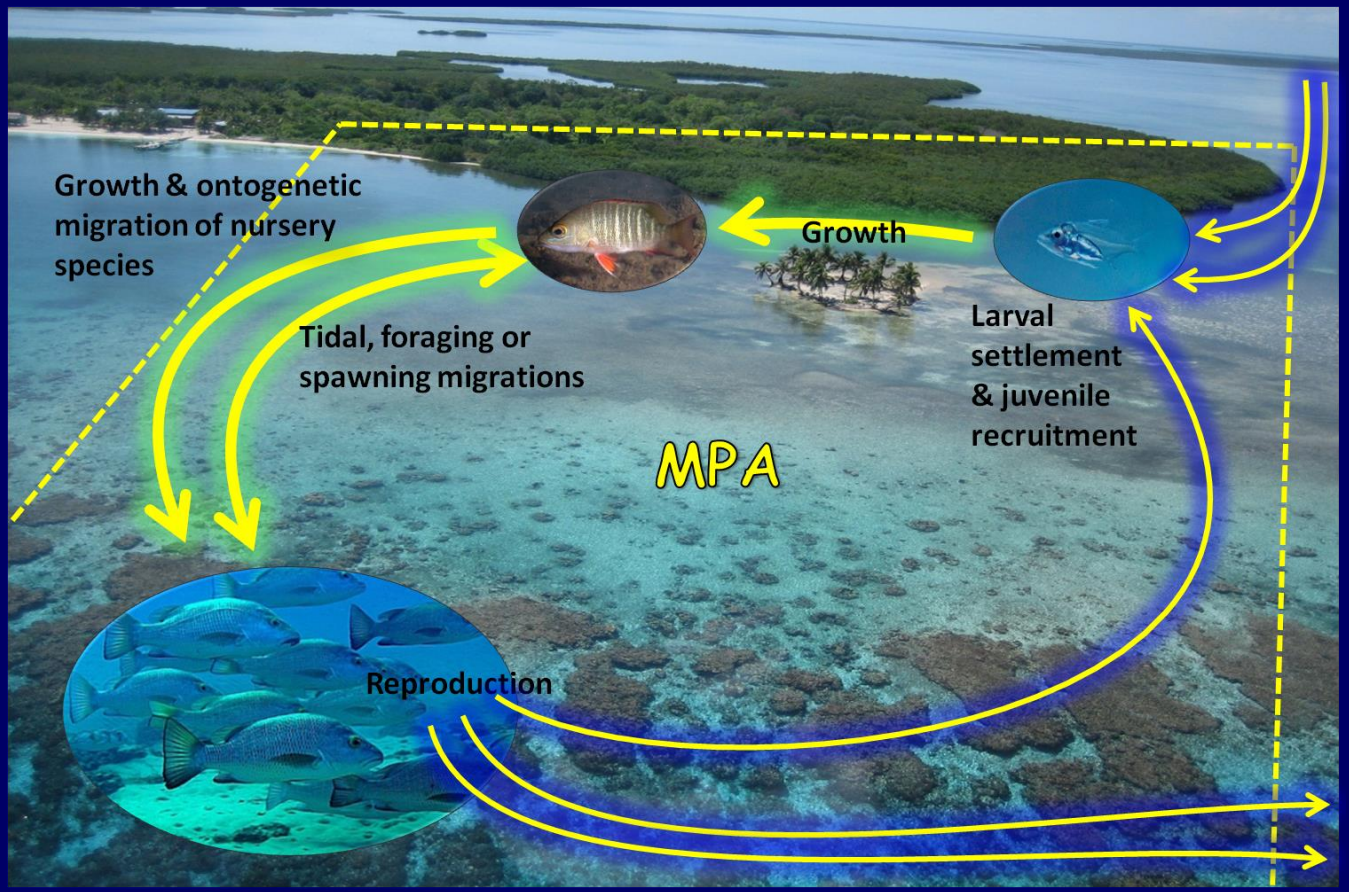
## 1. Create more no-take MPAs that encompass scale of fish home ranges

- 0.5-2 km across (15 to 60 ha of habitat) : OK for smaller species and some targeted species (groupers, snappers, surgeonfishes, parrotfishes)
- 2 to >5 km across (60 to >150 ha of habitat): will include more species with larger home ranges, but not all



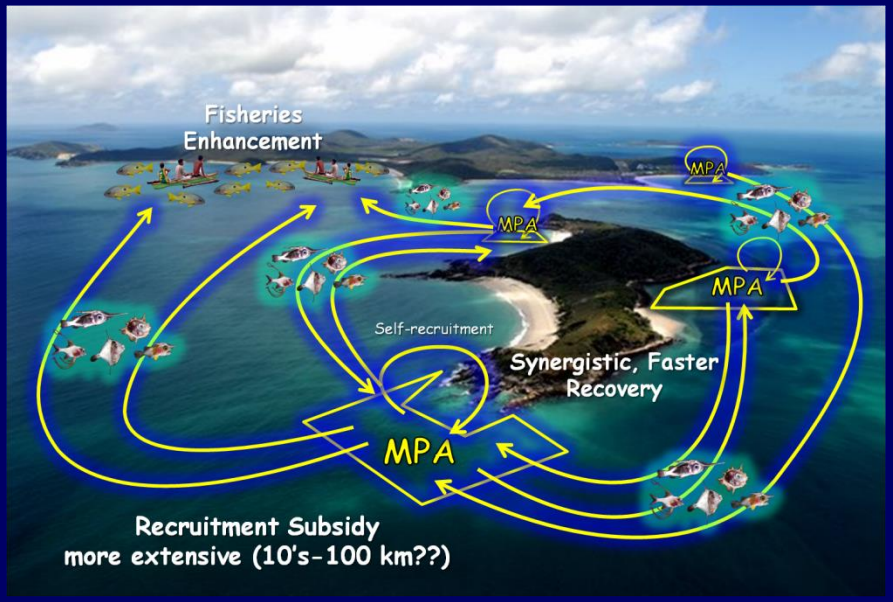

Green et al. 2015 *Biological Reviews* 90:1215

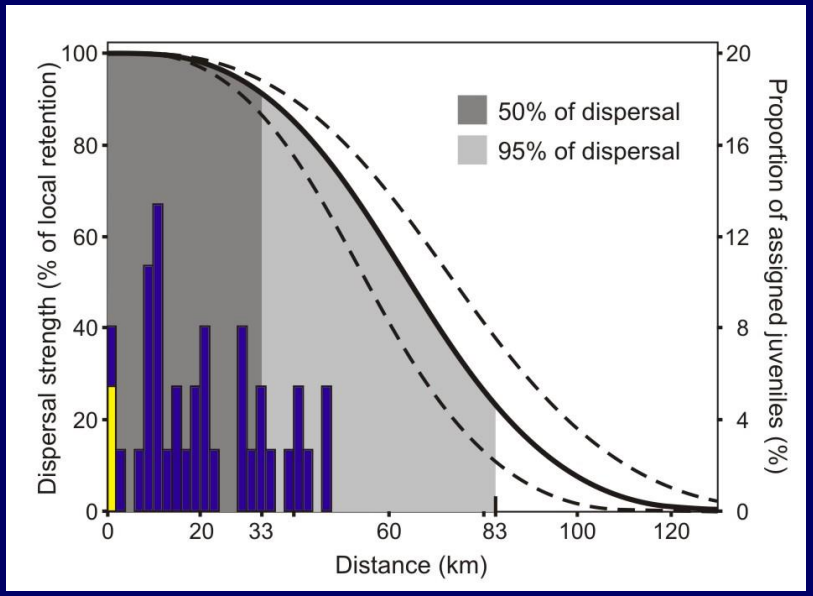
## 2. Create more no-take MPAs that include mangroves, seagrass, algal beds, coral reefs in a continuous swath, rather than in isolation




Green et al. 2013 *Designing MPA Networks...A Practicioner's Guide...*

**3. Create dense system of closely-spaced no-take MPAs (<<15 km apart) that protect at least 20% of all important habitats at the local, provincial and regional levels**



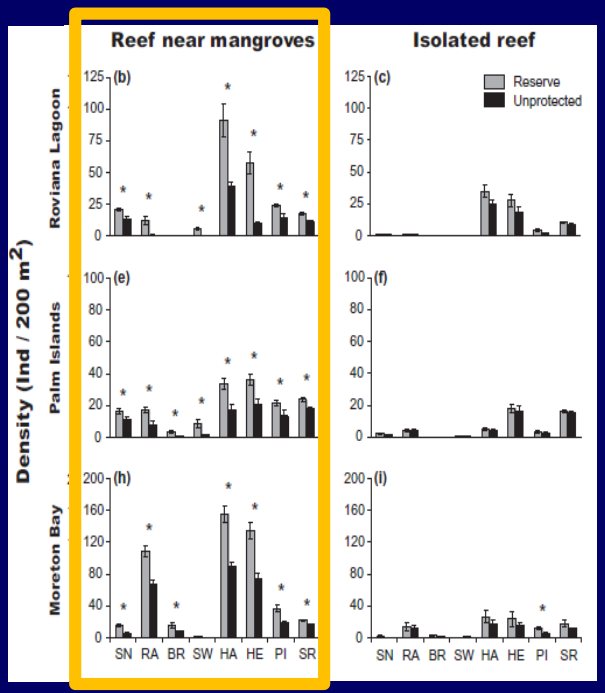

Green et al. 2015 *Biological Reviews* 90:1215

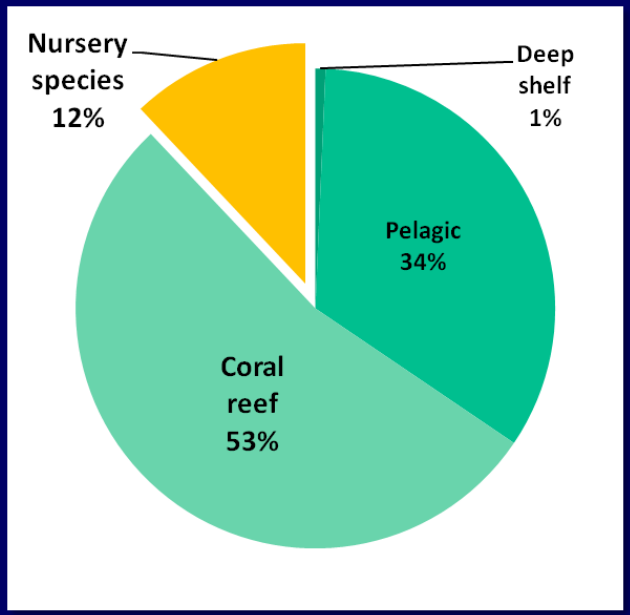
**4. Manage fisheries outside of no-take MPAs especially if there are still big shortcomings in 1.-3. (if MPAs protect less than 20% of habitats)**

- Seasonal closures
- Fishing gear restrictions
- Fishing effort restrictions

## 5. Empirically evaluate whether larval and habitat connectivity can enhance MPA network performance and fisheries

- Invest in long-term (decadal-scale) monitoring
- Quantify effects across various ecological settings



# Maraming Salamat Po!

Funding and other support: Australian Research Council-Centre of Excellence for Coral Reef Studies at James Cook University; King Abdullah University of Science and Technology; GIZ-ACCCoast Program; DOST-NAST

LGUs, communities and NGAs: Negros Oriental – Amlan, San Jose, Sibulan, Dumaguete, Bacong, Dauin, Zamboanguita, Siaton; Siquijor – San Juan, Siquijor, Larena, Enrique Villanueva, Maria, Lazi; DENR-PAMB Apo Island Protected Landscape and Seascape; Department of Agriculture-Bureau of Fisheries and Aquatic Resource, Fisheries Regulatory and Quarantine Division (DA-BFAR, FRQD); Province of Negros Oriental-Environment and Natural Resources Division (ENRD); M. Teves, M. Barillo

Research assistants, volunteers, students: D. Linog, M. Shodipo, T. R. Santos, D. Inocencio, R. Tuble, T. Yucor, R. Tubat, M. Pascobello, S. Leahy, A. Regalado, O. Paderanga, M. Martin, J. Maypa