Community Engagement supports the Scientific Integrity of Reef Restoration

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Introduction

- **Reef restoration** is implemented by coastal communities to intervene in local coral decline, often relying upon **Acropora nurseries**, as a **low cost** solution requiring **easy to learn** in-water skills.
- This approach is **limited** because **asexual propagation** of coral fragments results in **low genetic diversity**, reducing reproductive potential and long-term ecosystem resilience.
- Inclusion of corals produced through **sexual reproduction** during spawning events in reef restoration programs **increases diversity** and **resilience** of restored coral populations, however high associated costs and expertise exclude many small community initiatives.
- The **Integrative Reef Conservation Research Laboratory**, at the National Autonomous University of Mexico have written **a practical guide** (Banaszak et al., 2018.) based on 10 years of research, making techniques to introduce sexually produced corals **accessible**.
- We began a **pilot** coral spawning study in Akumal, Quintana Roo, Mexico, using this guide.
- Building upon the principles of restoration ecology, our **objective** is to increase **ecosystem function** and to monitor the long-term success / impacts of restoration.
- **Engaging the community** through t**raining** and practical citizen science programs supports long-term monitoring, large-scale data collection, and reduces research costs. Participation has **socio- economic benefits**, providing alternative livelihoods (eco-tourism), **training** opportunities, conservation **education** and **cultural shifts** towards sustainability.
- Akumal's **economy rests on the health of the coral reef**. Local support and participation is a critical component for the research integrity and for conservation efforts in the area.

Project Aim: To work in collaboration with international and regional experts, organisations and stakeholders to build a community program which encourages participation in conservation, increases awareness, opens doors for education and maximises scientific progress.

Collaboration and Community Engagement

Expedition Akumal reef restoration project was initiated in 2014 by a team of **professional divers** when they observed the collapse of large *Acropora cervicornis* colonies. **Collaboration** with **international** organisations and **local stakeholders** began with the introduction of *in-situ A. cervicornis* fragment nurseries. In 2016, the project expanded through **partnership** with the UNAM to introduce sexually reproduced **recruits**.

Figure 1: Photographs of community participation August 2018 (a) night spawning dive volunteers (b) local tradesmen constructing wet laboratory on site.

- **30 local dive staff** trained to assist night monitoring at 3 sites (Fig1.a).
- Community **consultation** with tourism operators and divers provided access to **local expertise** and knowledge.
- Dive center **participation** provided hundreds of volunteer hours to transplant coral, in exchange staff were trained in reef ecology.
- Videographers document activities as part of **exchange program.**
- Volunteers **promote restoration** by sharing with **tourists**.
- **University students** and graduates from Operation Wallacea trained as field **research assistants** for large-scale data collection: coral mapping (Fig. 3), reef monitoring, and measuring the impact of reef restoration.
- **Local Stakeholders investment** in coral restoration provides financial and logistical support, **lowers costs** of the research, and provides training opportunities, outreach and fundraising for staff and a long-term future for Akumal's coral reef.
- **Technical support** from Ridge To Reefs, Puerto Rico, with **on-site wet laboratory** design and build. Construction by Hotel Akumal Caribe staff (Fig.2.b) with small grant support from Coral Conservation Society.

Methodology

Study Area

Research was conducted within the Comisión Nacional de Áreas Naturales Protegidas (CONANP) Protected Area of Akumal on the crest and fore reef between 3 – 16m depth (20° 23'43.73"N, 87° 18'22.42"W).

Coral mapping

Divers conducted simultaneous belt transects to survey the abundance, individual size, health and reproductive status of *Acropora spp.* Colonies (Fig.4). GPS coordinates collected at marker surface buoy and time into dive recorded with each observation of coral colony (>0.5m), fragment (<0.5m) or patch (>10 colonies in 10m^2). Live tissue cover estimated and measurements of height / width recorded *in situ*.

Coral nurseries

Following guidelines provided by Oceanus A.C., (pers. com.), Bowden-Kerby *et al.* (2001), and the manual by Johnson *et al.* (2011), nurseries were installed (2014-5) starting with 35 fragments (<25cm TLE) collected from the seafloor surrounding 2 donor colonies of *A. cervicornis* (Fig.3.a). Propagation of fragments and transplantation onto the reef continued at intervals 2015 – 2018. Nurseries maintained by dive center volunteers.

Coral sexual reproduction

Acropora spp. spawning monitoring in Akumal was initiated in 2017. Gametes collected from ~20 colonies during spawning seasons of 2017 and 2018. Assisted fertilisation (Fig.2.a) (Banaszak *et al.* 2018), was conducted on site (Fig.2.b) and resulting larvae incubated and settled (Fig.2.c) before transfer to aquaria at Xcaret / UNAM.

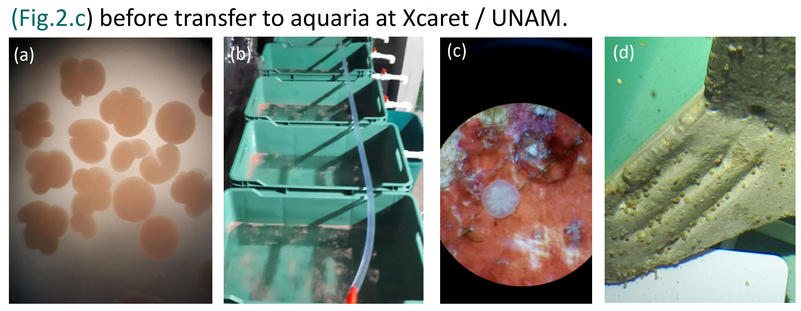

Figure 2: Photos of *A.palmata* September 2018 (a) development under microscope (b) incubation of larvae, (c) primary polyp, (d) settlement on tetrapod substrate (Secore).

Comparing Transplantation Methods and Monitoring

We trialled distinct transplantation techniques (epoxy, nail and cable ties, novel plastic structure design (Fig.3.b), underwater drill with no other materials), to increase quantity of out plants and their survival, decrease costs, and reduce negative impact to the reef substrate.

Standardised techniques for long-term monitoring include fish transect and herbivory 'bite type' observation techniques (adapted from AGRRA protocol V5.2) to measure abundance, diversity and ecological function of fish populations before and after transplantation.

Results

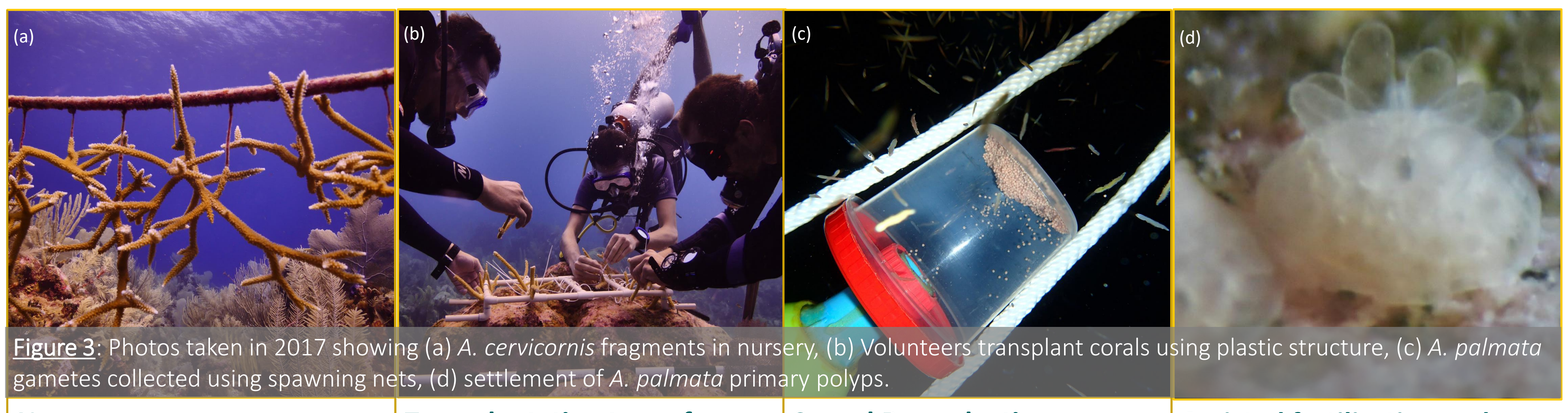

Figure 3: Photos taken in 2017 showing (a) *A. cervicornis* fragments in nursery, (b) Volunteers transplant corals using plastic structure, (c) *A. palmata* gametes collected using spawning nets, (d) settlement of *A. palmata* primary polyps.

Nursery

- Coral fragments (10 – 25cm length) propagated from 35 to ~250 fragments within year 1.
- 8 nursery lines installed with annual propagation (30-40 fragments per line).
- Survival in the nurseries >85%.

Transplantation to reef

- Plastic structures resulted in rapid substrate attachment (<2 weeks). Limitation of damselfish colonization 40% of trials.
- Increased abundance and diversity of reef fish 2 weeks post transplantation of 50 fragments (<20cm each) (Jones *et al.* 2017).
- Drill-only technique had 100% survival since September 2018.

Sexual Reproduction

- Night divers recorded and collected coral spawn for the first time in Akumal (2017).
- High volunteer participation allowed for 3 sites to be monitored (e.g., 10 nights, 3 boats, 30 volunteers for 2018).
- Collected gamete bundles from ~20 colonies.

Assisted fertilization and settlement

- Volunteers assisted to build 30 coral spawning nets.
- Assisted fertilisation of coral gametes yielded high success rates (>80%).
- Settlement of >100 primary polyps per substrate.

Coral mapping

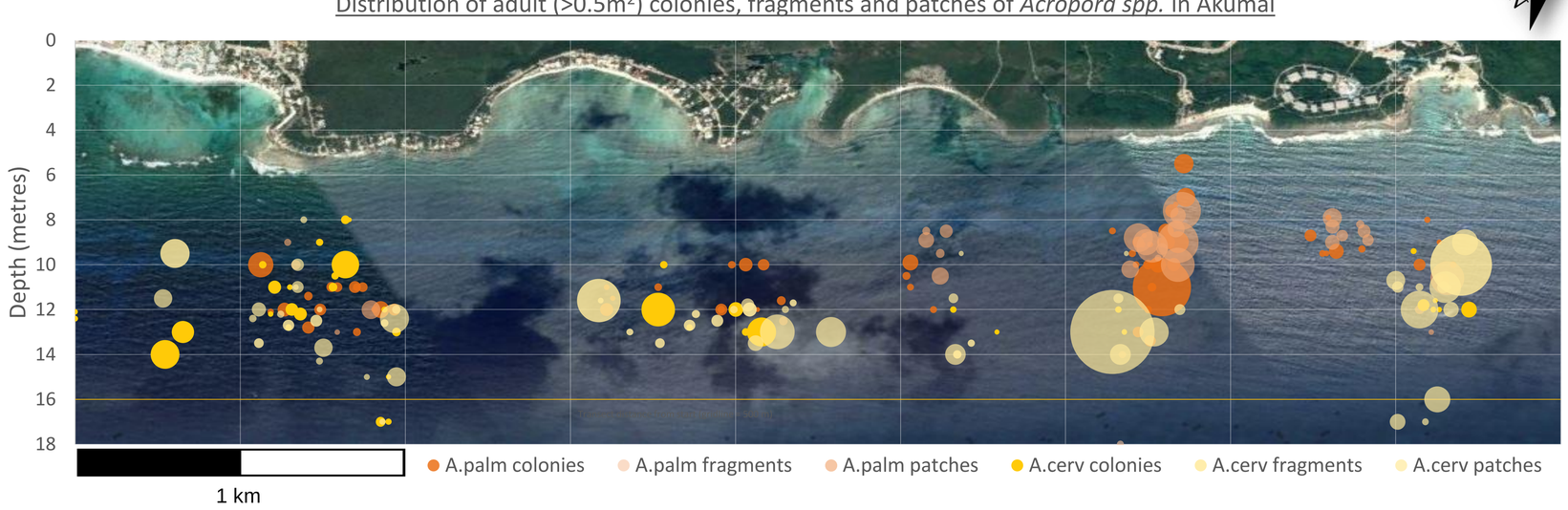

Figure 4: Mapped data from benthic surveys of *Acropora spp.* colonies, fragments (<0.5m in groups of 5+), and patches (>10colonies in 10m2) across 14 dive sites at depth approx. 8 – 16m.

Conclusions

The restoration project in Akumal is still in the early stages, and here we have summarised the key developments in the 4 years since project inception, highlighting the **progress achieved through collaboration and community engagement.**

- **Many hands make light work** → through engaging students and professional divers it was possible to map large areas of reef and to expand restoration work.
- **Baseline data** for the distribution and reproduction of *Acropora spp*. Akumal was generated, which can be **built upon** and compared in future years.
- Community engagement effectively **lowered costs** associated with in-water work, whilst **increasing outreach** and **access to training**.

Project Future direction

We propose to expand the number of species we work with, to document their distribution and reproductive status in Akumal. Our objective is to restore ecological function to the coral reef, developing the science and our community program, including::

- **Evaluation** of training and community **impact factor**
- Ecological **certification** for dive master volunteers
- Increased monitoring with **tourist** participants
- **Funding** applications to support project expansion
- Development of **techniques**, e.g., micro-fragmentation

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Collaborations

Expedition Akumal reef restoration is supported by multiple organisations , this list is not exhaustive.

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