Evaluating the effectiveness of Marine Protected Areas (MPA) in Belize – Bacalar Chico Marine Reserve

Aaron Wong

2016 GITAPNW Scholarship recipient

Master in Geographic Information Systems Applications

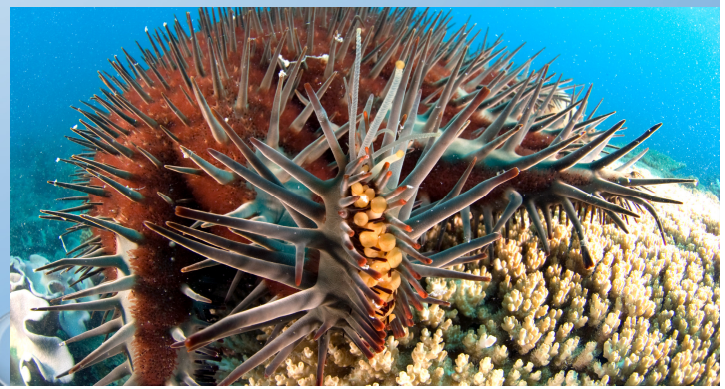
Vancouver Island University

The Belize Barrier Reef Reserve System (BBRRS)

- Part of the second largest coral reef ecosystem on Earth – Mesoamerican Barrier Reef System.
- 1.4 million visitors in 2016.
- $385 million USD income
  - Fishing
    - Lobster
    - Conch
    - Finfish
  - Tourism
    - Snorkelling
    - Diving

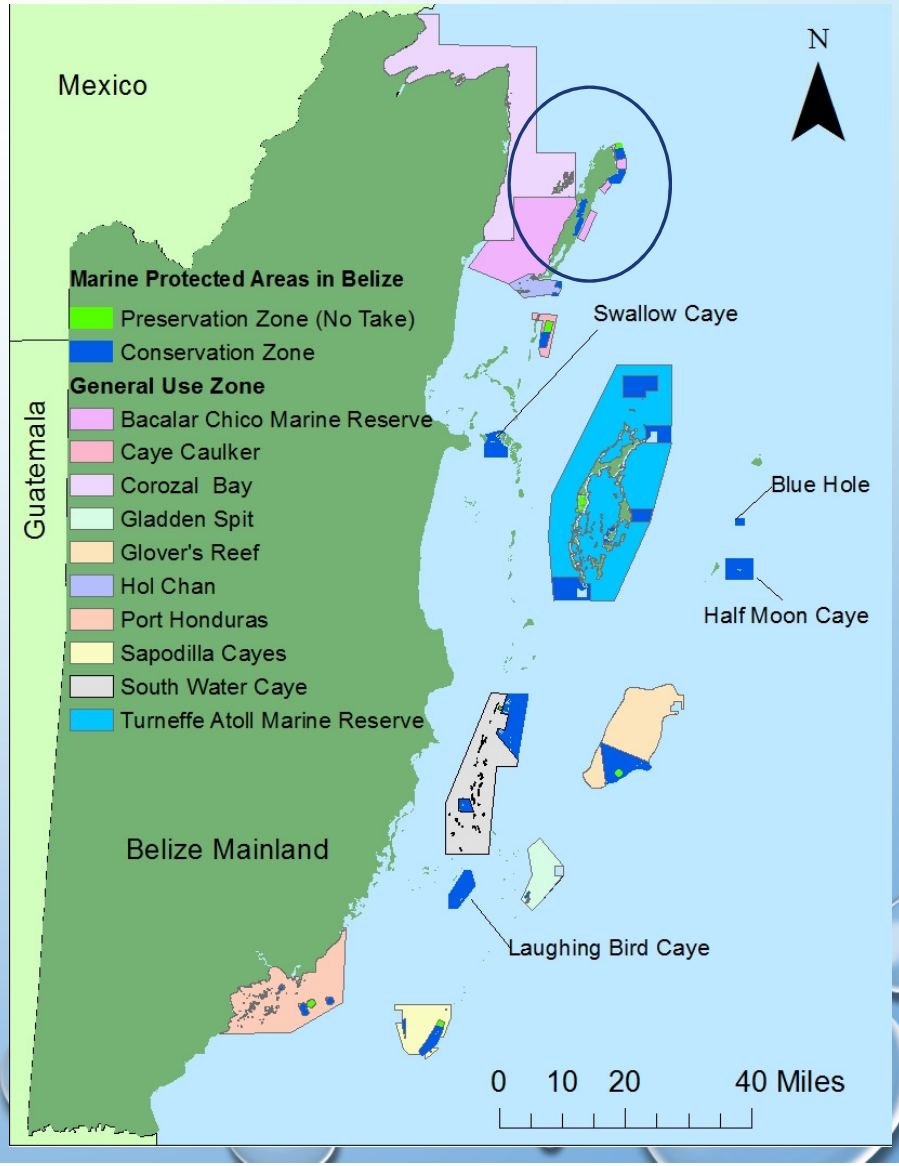
Coral reefs are under risk

- 2015 report from Coastal Zone Management Authority and Institute (CZMAI) indicated that coral reefs are under risk.
  - 81% of BBRRS under medium risk (Approx 100 sq miles)
  - 18% under high risk
  - 1% under low risk
- Risks are from the increasing demands of fish and tourism, as well as development plans in the country.
- Management has to be efficient in maintaining balance between human activities and ecosystem recovery → risk mitigation



Marine Protected Areas (MPA) in Belize

- To protect the valuable and prestigious ecosystem. 14 Marine Protected Areas have been established since 1982
- MPA in Belize covers 20% of the marine area.
- 3 zones:
  - General Use Zone
    - Traditional use is retained
  - Conservation Zone
    - Some extraction is permitted
  - Preservation Zone
    - No access (Special permission needed)
- How do we know the MPA are doing their job??



Purpose

- This research aims to evaluate the effectiveness of MPA in Belize using a few indicators:
  - Coral Cover (%)
    - Basic information about the area covered by coral colonies.
  - Algal Cover (%)
    - Direct competitor with coral.
  - Herbivorous Fish Biomass (g/100m^2)
    - Parrotfish and surgeonfish
    - Critical in controlling algal population
  - Commercial Fish Biomass (g/100m^2)
    - Grouper and Snapper
    - Critical for income generation and livelihood.
- This research will look into…
  - The changes of the above variables across years.
  - Whether the changes are different amongst different zones.

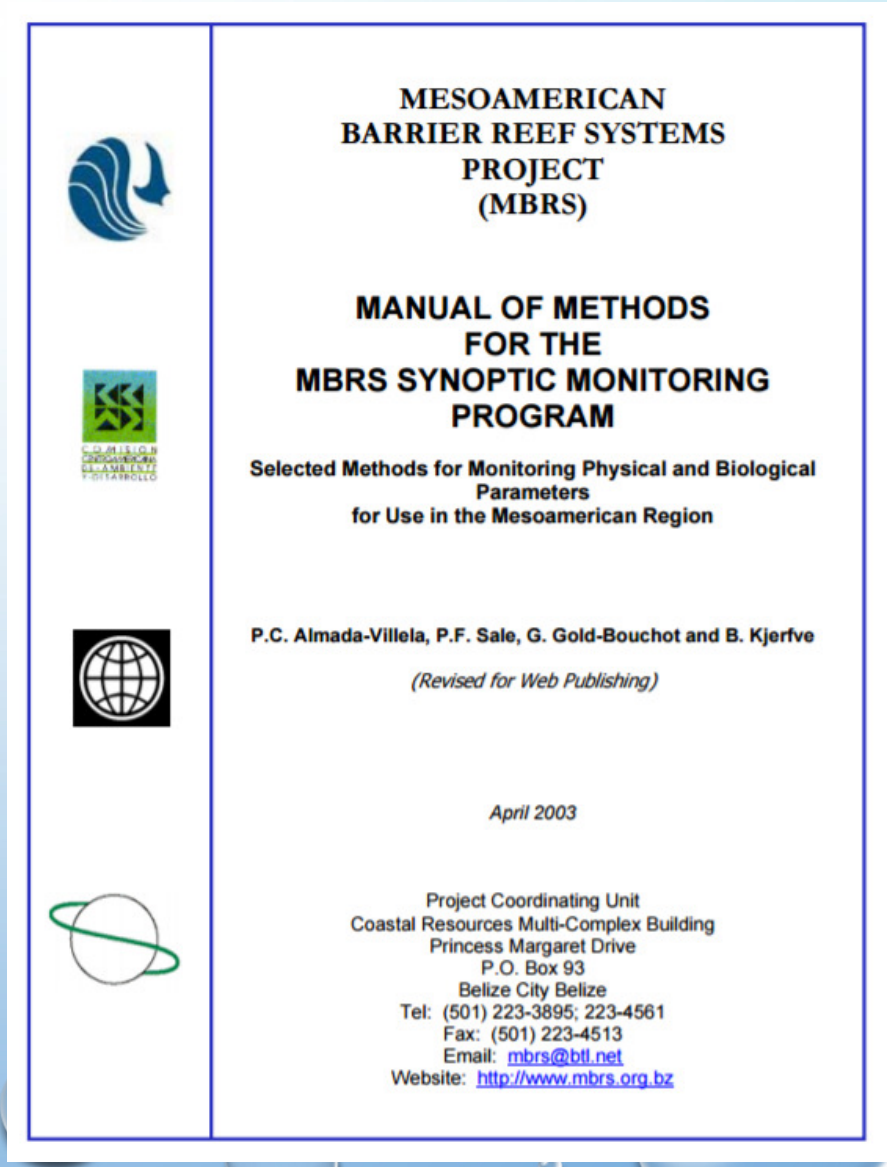
Significance??

Challenges to MPA management

- Fishermen usually are against MPA
  - As MPA would mean less catch and less profit for them
- Only short term.
- Proof needed to show fishermen that MPA are a benefit to them as well.
  - Last report was in 2009..

Data Collection

- Methodology was adopted from the Synoptic Monitoring Program (SMP).
- Bi-annual monitoring is conducted by government or conservation organisation (Blue Venture).
- Monitoring is conducted in pre-defined sites, the same sites are visited every time
- Monitoring from 2004 but data from 2011 is obtained.



MESOAMERICAN
BARRIER REEF SYSTEMS
PROJECT
(MBRS)

MANUAL OF METHODS
FOR THE
MBRS SYNOPTIC MONITORING
PROGRAM

Selected Methods for Monitoring Physical and Biological Parameters
for Use in the Mesoamerican Region

P.C. Almada-Villela, P.F. Sale, G. Gold-Bouchot and B. Kjerfve

(Revised for Web Publishing)

April 2003

Project Coordinating Unit
Coastal Resources Multi-Complex Building
Princess Margaret Drive
P.O. Box 93
Belize City Belize
Tel: (501) 223-3895; 223-4561
Fax: (501) 223-4513
Email: mbrs@btl.net
Website: http://www.mbrs.org.bz

Bacalar Chico Marine Reserve

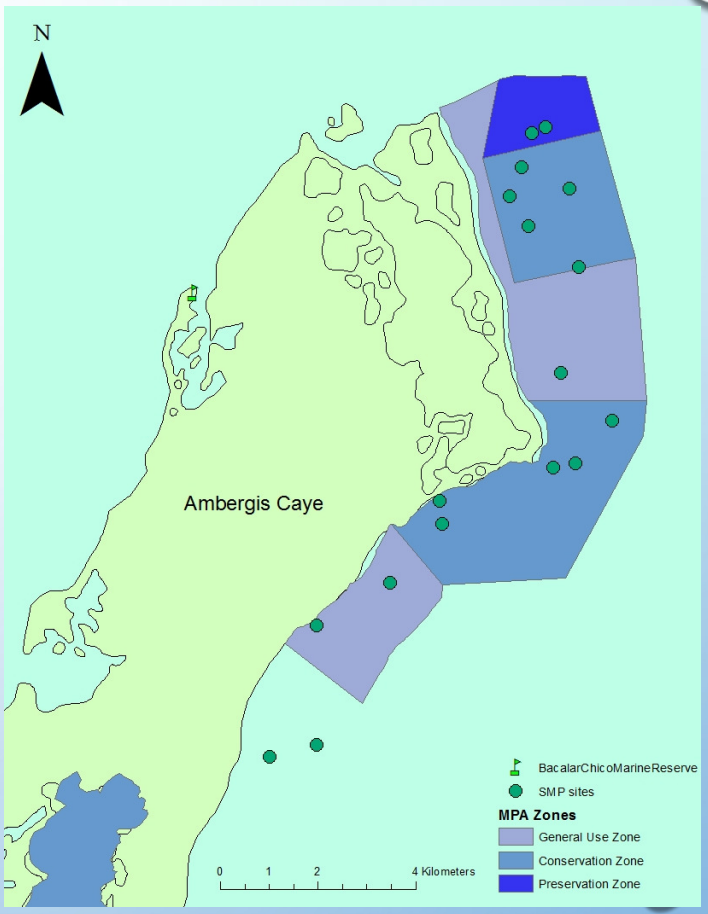
- Northernmost MPA in Belize.
- Area – 22 square miles

General Use Zone – 18 sq miles

Conservation Zone – 3 sq miles

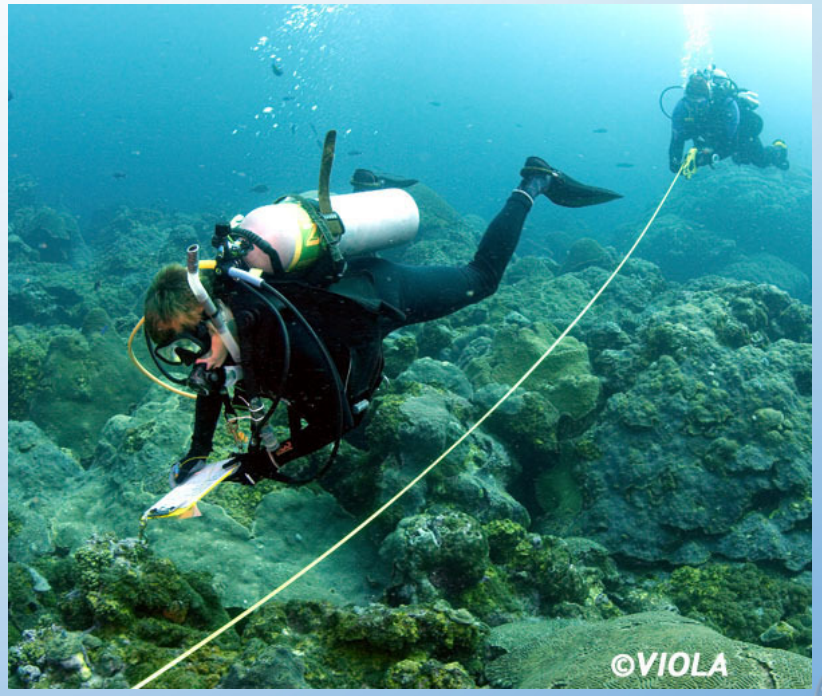
Preservation Zone – 1 sq miles

- SMP sites – 17 (4 Zones)
  - Fisheries – 4 (Conservation)
  - Blue Ventures – 13 (All Zones)



Coral and Algal cover

- Point intercept transect
- 30m transects, with marks on every 25cm
- Diver lays the transects at 5 random locations within 100m diameter of a site
- Diver swims the transect, and records the benthic composition directly beneath the transect
    - Corals
    - Macroalgae - > 1cm above substrate
- Percentage Cover from points



Data output

- For each of the years, the 4 variables of each site were measured, calculated and stored in a spreadsheet.
- A response ratio was calculated
  - The earliest date : The most recent date.
  - 1 = no change
  - > 1 = the variable has increased
  - < 1 = the variable has decreased.

	A	B	C	D	E	F	G	H	I	J
1	Site Name	Month	Reserve	Zone	Year	Organisation	Coral Cover	Algal Cover	Herbivorous	Commercial
2	Goliath	September	BCMR	General Use Zone	2011	Blue Ventures	20.33	40.83	2141	568.55
3	Peccary Patch	March	BCMR	General Use Zone	2011	Blue Ventures	3.54	21.25	815.1	73.31
4	Alleys	November	BCMR	Conservation Zone	2011	Blue Ventures	22.67	40.83	1219.87	926.4
5	Last Resort	October	BCMR	Conservation Zone	2011	Blue Ventures	8.33	41.17	1453.89	1397.68
6	Rocky Point North	December	BCMR	Conservation Zone	2011	Blue Ventures	12.83	33.33	4249.51	481.09
7	Rocky Point South	July	BCMR	Conservation Zone	2011	Blue Ventures	6.46	37.92	616.88	713.98
8	BZBCB01	April	BCMR	Conservation Zone	2011	Fisheries	13	32.5	2415.62	157.69
9	BZBCB02	April	BCMR	Conservation Zone	2011	Fisheries	14.5	27.67	3045.05	730.97
10	BZBCD03	April	BCMR	Conservation Zone	2011	Fisheries	20	45.33	387.82	224.32
11	BZBCD02	April	BCMR	Conservation Zone	2011	Fisheries	19.33	37.33	1260.18	644.46
12	BZBCB01	October	BCMR	Conservation Zone	2011	Fisheries	12.67	36.17	7192.6	2197.23
13	BZBCB02	October	BCMR	Conservation Zone	2011	Fisheries	14.17	38	6056.08	124.77
14	BZBCD03	October	BCMR	Conservation Zone	2011	Fisheries	16.83	48.83	990.29	123.4
15	BZBCD02	October	BCMR	Conservation Zone	2011	Fisheries	19.33	35.17	2023.68	88.16
16	Garden Wall	February	BCMR	Preservation Zone	2011	Blue Ventures	13.54	23.75	1083.57	208.25
17	Pig Sty	October	BCMR	Preservation Zone	2011	Blue Ventures	2.67	25.5	1050.23	0
18	Tarpon Patch	February	BCMR	Preservation Zone	2011	Blue Ventures	5.33	7.5	624.03	325.42
19	Hot Point	May	BCMR	Preservation Zone	2011	Blue Ventures	6.46	53.54	1194.33	20.97
20	Canyons	June	BCMR	Conservation Zone	2011	Blue Ventures	16.67	65.83	367.99	3.16
21	Moose Country	August	BCMR	Preservation Zone	2011	Blue Ventures	15.83	47.5	871.56	265.79
22	Control	July	BCMR	Non-MPA	2012	Blue Ventures	13.33	48.5	2098.09	600.92
23	Palm Springs	July	BCMR	Non-MPA	2012	Blue Ventures	9.83	31.17	1483.19	158.09
24	Goliath	October	BCMR	General Use Zone	2012	Blue Ventures	12.5	46.17	1490.72	263.28
25	Peccary Patch	March	BCMR	General Use Zone	2012	Blue Ventures	5	33.67	1148.19	354.42
26	Rainbow Reef	June	BCMR	General Use Zone	2012	Blue Ventures	6.67	27.33	1721.43	62.39
27	Alleys	November	BCMR	Conservation Zone	2012	Blue Ventures	14.33	47.67	1740.64	192.06
28	Last Resort	December	BCMR	Conservation Zone	2012	Blue Ventures	8.33	42.67	2987.79	494.23
29	Rocky Point North	October	BCMR	Conservation Zone	2012	Blue Ventures	9.17	28	4369.02	1604.44
30	Garden Wall	February	BCMR	Preservation Zone	2012	Blue Ventures	15	28.5	2308.07	161.76
31	Pig Sty	October	BCMR	Preservation Zone	2012	Blue Ventures	1.5	38.33	1872.32	400.9
32	Tarpon Patch	January	BCMR	Preservation Zone	2012	Blue Ventures	7.67	6	2645.9	879.01
33	The Anchor	July	BCMR	General Use Zone	2012	Blue Ventures	8.17	25.5	370.62	754.9
34	Control	July	BCMR	Non-MPA	2013	Blue Ventures	11.83	38	2480.68	560.17
35	Palm Springs	August	BCMR	Non-MPA	2013	Blue Ventures	7.33	25	1919.24	448.22
36	Goliath	May	BCMR	General Use Zone	2013	Blue Ventures	15.5	31.83	1786.72	351.08
37	Goliath	October	BCMR	General Use Zone	2013	Blue Ventures	13.17	44	1714.96	664.62
38	Peccary Patch	March	BCMR	General Use Zone	2013	Blue Ventures	5.83	21.67	1495.79	709.89

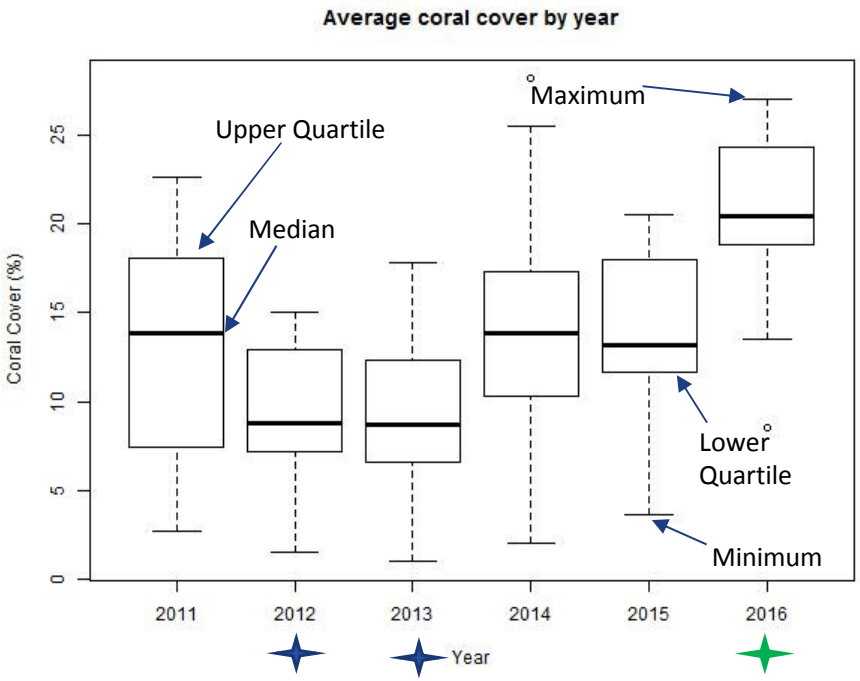
Analysis

- Box Plot to show the distribution
  - Variable vs Year
  - Response Ratio vs Zone
- Kruskal-Wallis test
  - Rank test to determine whether the different samples are from identical populations. (Whether the different zones would statistically be classified as different zones).
- Post – Hoc Dunn test
  - Figure out which zone is different to which other zone(s).

We would hope to see…

- An increase in coral cover over the years.
- A decrease in algal cover over the years.
- Higher increase in coral cover in MPA than outside MPA.

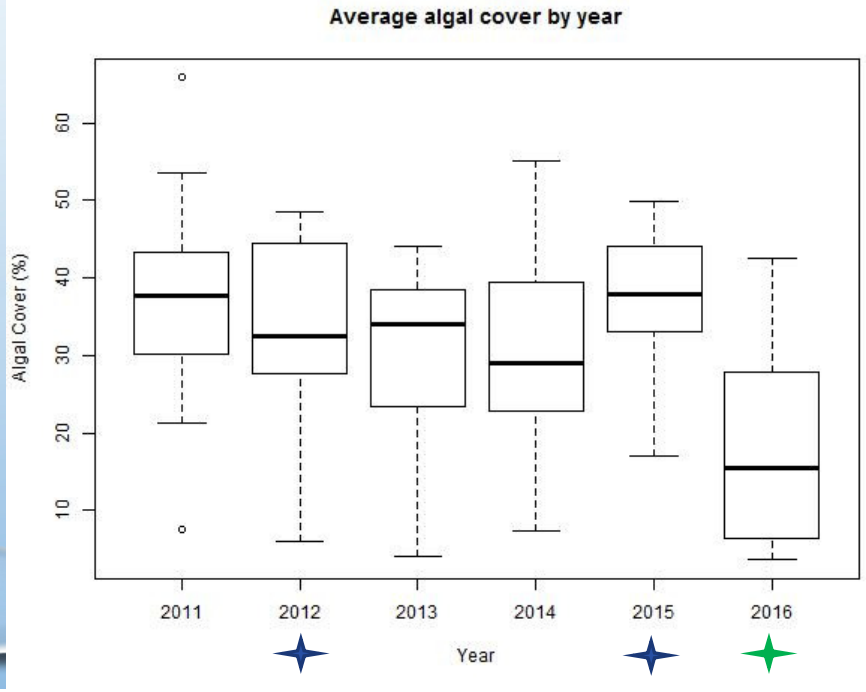
Results



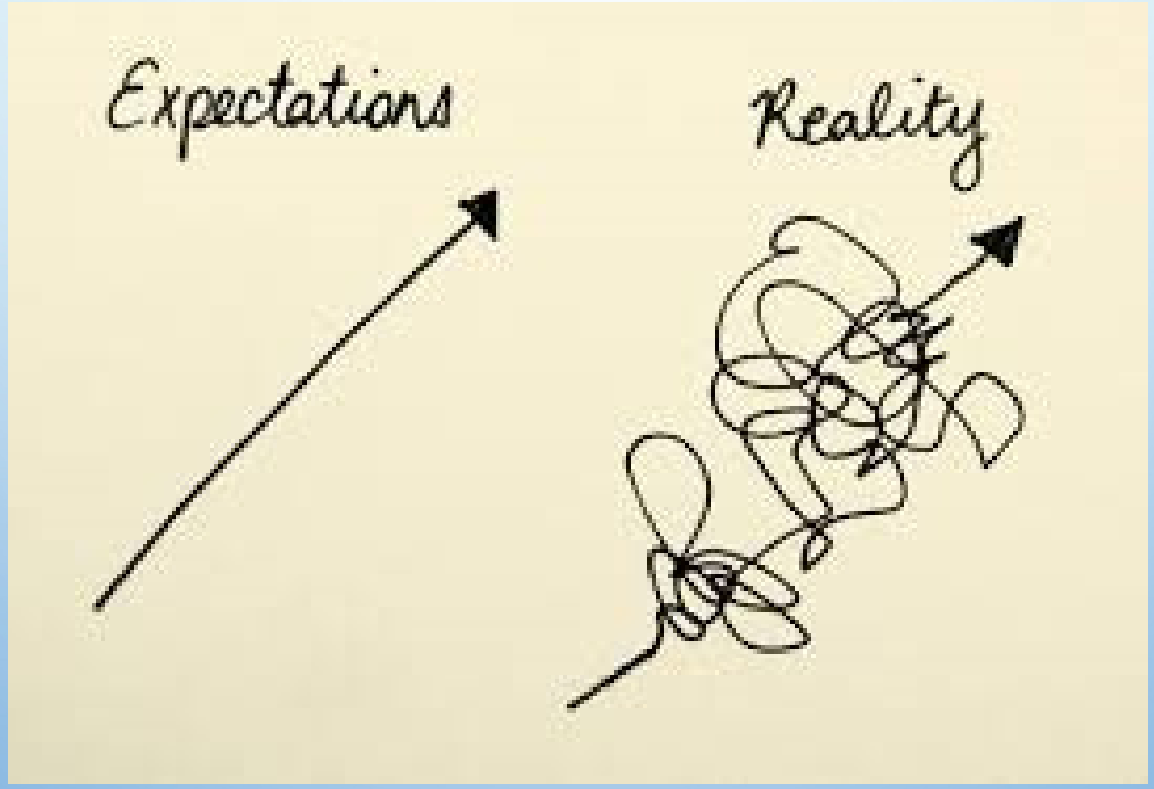
By year

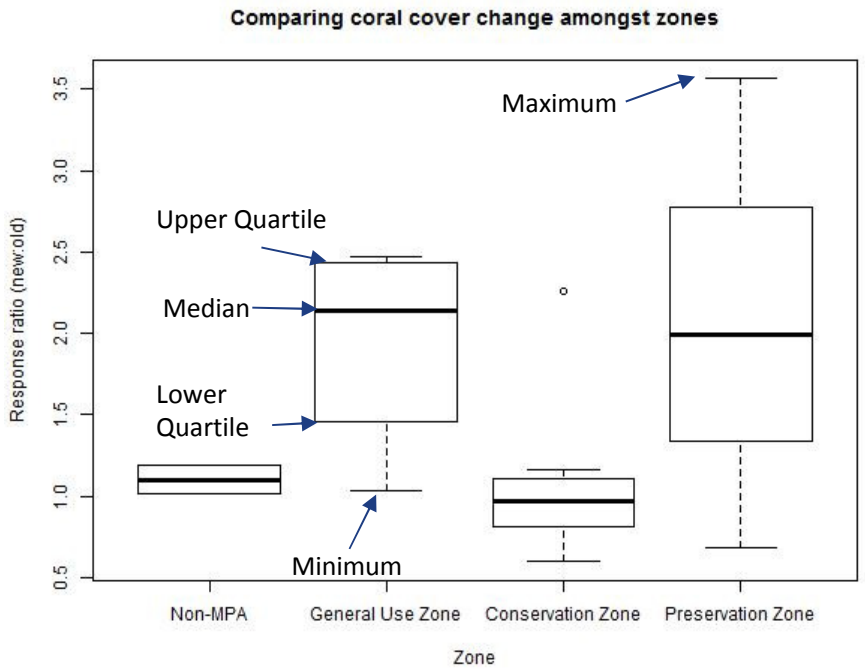
Denotes significance between the two zones at $p < 0.1$

- Higher coral cover in 2016 than 2012 and 2013
- Lower algal cover in 2016 than in 2012 and 2015



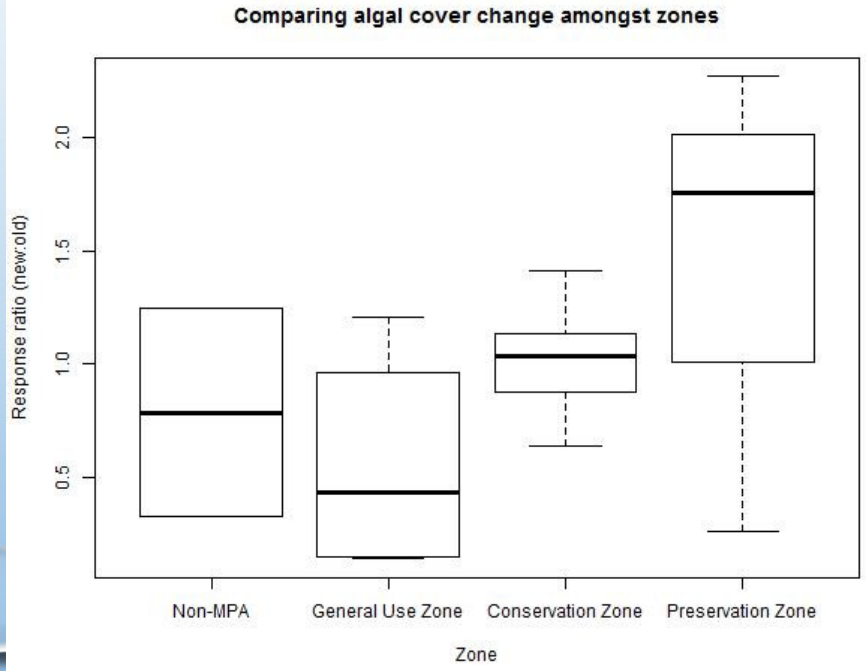
When you think everything is going well…





Response Ratio

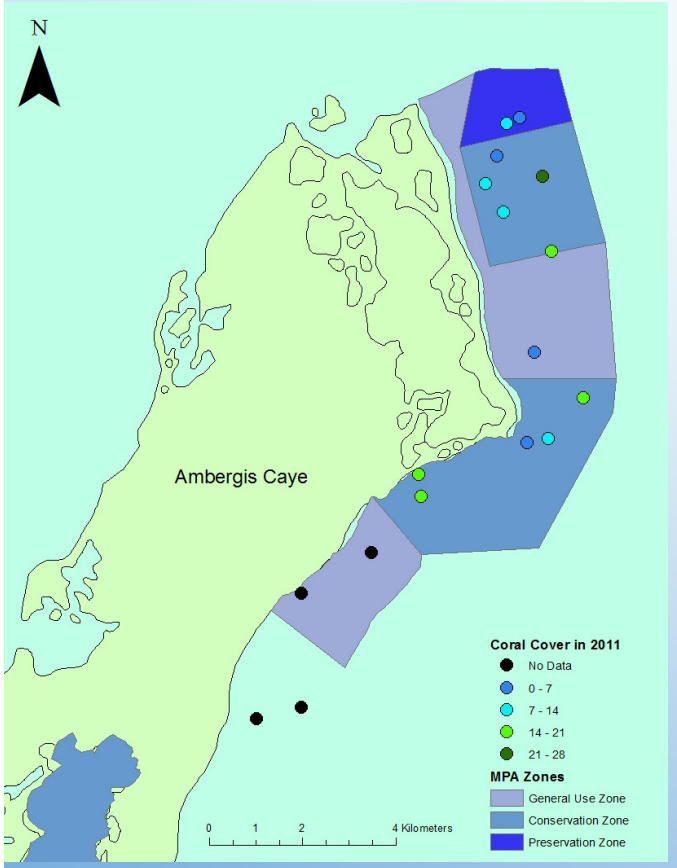
- High ratio for coral cover in preservation zone and general use zone
- High ratio for algal cover in preservation zone
- Sample size too small to determine difference between zones



A different perspective…

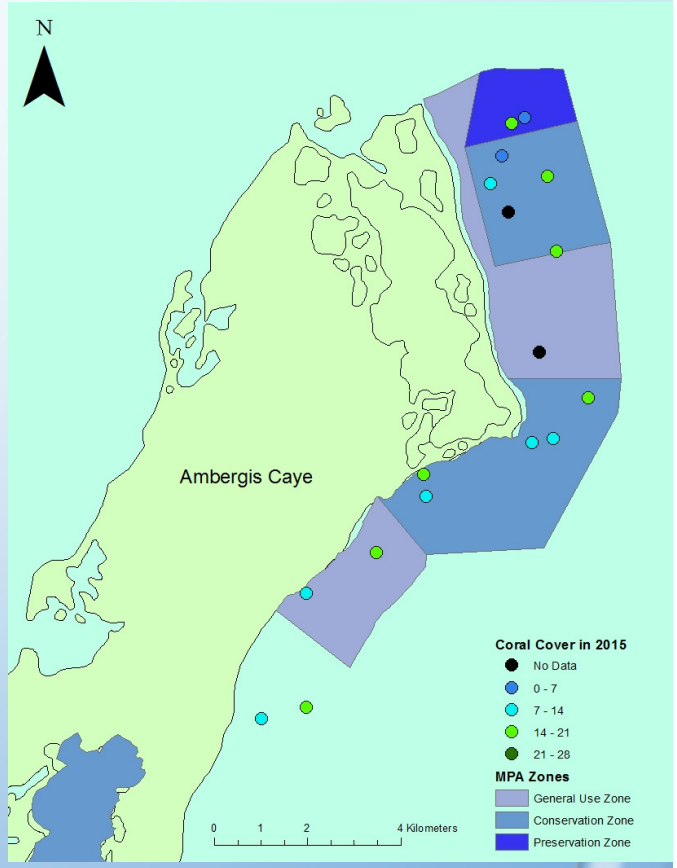
Coral Cover by site

2011



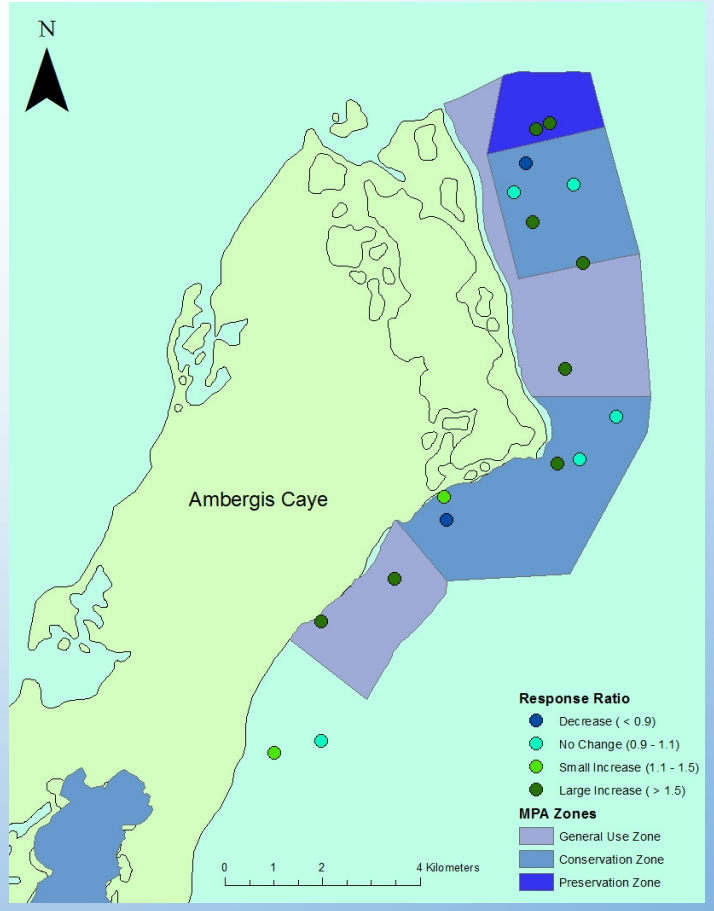
- Coral Cover is pretty much random across zones.
- Some experience an increase and some a decrease.

2015



Response Ratio by site

- Increase – 10 sites
  - 8 sites more than 50% increase
- Decrease – 2 sites
  - All within Conservation Zones
- Large increase all within MPA
  - Could be they started off with a small cover



Next steps??

- Merge some zones together
  - Increase the statistical power.
  - E.g. Non-MPA vs MPA.
  - Less protected vs more protected
- Explore any spatial patterns
  - North vs South
  - Fore reef vs Back reef
- Explore any correlation with enforcement statistics
  - Illegal fishing → lower Coral Cover?

Lessons learned

- A trend can be seen
  - Coral cover highest in 2016
  - Algal cover lowest in 2016
- Sample size is too small
  - Significance in year analysis
  - No significance in zone analysis

In the long term…

- More convincing that MPA are doing their job.
- A baseline methodology for future reports.
- Let the general public know the reef condition
- Fishermen would understand the benefit and support.

Acknowledgement to contributors

Scholarships:

- Queen Elizabeth Diamond Jubilee Scholarship.
- Geospatial Information & Technology Association – Pacific Northwest chapter.
- One World Scholarship.

Organisations:

- Vancouver Island University
- Belize department of fisheries
- Blue Ventures