6th International Symposium DeepSeaCorals
11-16 SEPTEMBER 2016, BOSTON, MA, USA

GOA-ON
Global Ocean Acidification Observing Network

Monitoring the effects of ocean acidification on cold-water corals: Recommendations for GOA-ON

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Harborview Ballroom

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Background

"The Global Ocean Acidification Observing Network (GOA-ON) is a collaborative international approach to document the status and progress of ocean acidification in open-ocean, coastal, and estuarine environments, to understand the drivers and impacts of ocean acidification on marine ecosystems, and to provide spatially and temporally resolved biogeochemical data necessary to optimize modelling for ocean acidification" *www.goa-on.org*

The 3rd GOA-ON Workshop was held in Hobart, Australia in May 2016 following the 4th Ocean in a High CO_2 World Symposium. One of the key aims of this workshop was to update requirements for biology and ecosystem response measurements (full details at www.goa-on.org) for specific regions and ecosystem types. Lists of parameters were produced including one explicitly developed for coral habitats. However, the coral biologists present overwhelmingly specialised in shallow, tropical water corals and deep-sea biologists were under-represented. This workshop aims to advise GOA-ON on which of their identified measurements are appropriate for cold-water corals, and if any further measurements would be useful in monitoring these ecosystems for the effects of ocean acidification.

Aims of this workshop

1. To assess the OA monitoring indicators identified for tropical corals and determine which are and are not appropriate for cold-water corals.
2. To identify cold-water coral specific OA indicators.

Outcome

Following the discussions we will compile a document of feedback to GOA-ON to enable them to include a section on coral reefs relevant to CWCs in their biological monitoring guidelines.

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GOA-ON recommended measurements for coral habitats

- Recommendations from the GOA-ON Requirements and Governance Plan 2nd Edition (Newton et al. 2015) and the corals breakout groups in Hobart 2016

In addition to carbonate chemistry measurements:

1. Biomass of biota
2. Changes is net ecosystem processes
3. Nutrient input
4. Sediment input
5. Trace metals
6. Primary production
7. Export flux rate
8. Calcification rates
9. Remineralisation
10. Dissolution
11. Bioerosion
12. Particulate organic carbon/dissolved organic carbon
13. Particulate organic nitrogen/dissolved organic nitrogen
14. Nitrate/phosphate ratios
15. Oxygen levels
16. Satellite imagery
17. Algal pigments/chlorophyll
18. Currents (e.g. ADCPs)
19. Flow rates
20. Zooplankton (spatial and temporal variation/grazing rates)
21. Area of live coral cover
22. Evidence of disease
23. Community structure
24. Species distributions

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Notes from the Boston workshop

Firstly the group went through the list of criteria identified at previous GOA-ON workshops (extracted from the GOA-ON Requirements and Governance Plan an meeting notes from the Hobart workshop provided by Jan Newton) and discussed which criteria were appropriate for cold-water coral (CWC) reefs, which were unlikely to provide useful information with regards to ocean acidification (OA) monitoring and which were likely to be infeasible. The outcome of this discussion is recorded in Table 1.

Table 1

Variable	Priority of OA impact monitoring?	Comments
Biomass of biota	Y	Abundance estimates might be more appropriate and obtainable than biomass measures for deep-sea ecosystems. Grab sampling and video transects likely to be useful methods.
Changes is net ecosystem processes	Y	Could collect ADCP. Would be particularly useful at fixed mooring sites.
Nutrient input	Y	None
Sediment input	Y	None
Trace metals	N	Depending on the metal this could be very expensive and labour intensive (although possible for some, e.g. barium from sediment samples). This was not considered a priority for OA monitoring of CWCs.
Primary production	N	Noted that knowing the primary production in the surface waters above the reefs is useful for a holistic understanding of the ecosystem as plankton will sink.
Export flux rate	N	Likely to be impractical
Calcification rates	Y	This information would be useful but it is unlikely that it could be measured outside of cruises specifically targeting CWCs
Remineralisation	Y	This information would be useful but it is unlikely that it could be measured outside of cruises specifically targeting CWCs
Dissolution	Y	This information would be useful but it is unlikely that it could be measured outside of cruises specifically targeting CWCs
Bioerosion	Y	This information would be useful but it is unlikely that it could be measured outside of cruises specifically targeting CWCs
Particulate organic carbon/dissolved organic carbon	Y	None
Particulate organic	Y	None

nitrogen/dissolved organic nitrogen		
Nitrate/phosphate ratios	Y	Could get at this through CTD casts. Useful to take
Oxygen levels	Y	Could get at this through CTD casts. Useful to take. Requires care and specialist skill to take high quality measurements
Satellite imagery	N	None
Algal pigments/chlorophyll	N	Important for a holistic understanding of the ecosystem as plankton will sink.
Currents (e.g. ADCPs)	Y	Considered critical to assess
Flow rates	Y	Considered critical to assess
Zooplankton (spatial and temporal variation/grazing rates)	N	Important for a holistic understanding of the ecosystem as plankton will sink.
Area of live coral cover	Y	Area of dead coral cover is equally important for monitoring the impacts of OA on CWC reefs
Evidence of disease	Y	Can be assessed from photos and videos
Community structure	Y	This would be difficult to assess without specialist training, however some estimates could be made from photos and videos if these were made accessible to people with those skills
Species distributions	Y	This would be difficult to assess without specialist training, however some estimates could be made from photos and videos if these were made accessible to people with those skills

Secondly the group discussed the practicalities of opportunistic sampling for monitoring cold-water coral habitats on research cruises where cold-water coral studies were not the primary objective. It was recognised that data/sample collections can be labour intensive and require specialist expertise or equipment that may not be available. We focused on what low effort, high reward data and sampling collection might be feasible under different scenarios. We focused on measurements/samples specific to CWC reefs, taking it as a given that temperature, salinity and carbonate chemistry measurements at depth are required. We have attempted to restrict our recommendations to those we consider to require minimal time/effort and specialist expertise to obtain.

Where the vessel has the capacity to take CTD casts:

- Nutrients
- Dissolved oxygen
- POC/DOC and PON/DON

Where there is the capacity to take photographs or videos:

- Ratio of live to dead coral cover
- Extent of live coral cover (total area and maximum depth)

- Extent of dead coral framework (total area and maximum depth)

Where there is the capacity to take physical samples:

- Any coral sample!
- Living corals should be preserved in ethanol on deck
- Dead corals are also useful, especially if it is known when they died. Coral rubble that comes up with a sediment core or a box core could be of value.
- Depth, location and carbonate chemistry of sampling location are important

Key recordings for long term monitoring:

- Deepest extent of reef
- Deepest living coral
- Deepest extent of dead coral framework

Further discussions

To facilitate global monitoring of the effects of OA on CWCs it will be important to develop standardised sampling and data sharing protocols.

Long term monitoring sites which can be regularly returned to would be invaluable in distinguishing natural fluctuations from anthropogenic effects. Monitoring buoys at these locations would be good. Identifying key deep water sites which can be regularly surveyed and incorporated into cruise plans would be useful.

Strength testing coral skeletons could be a useful metric for monitoring OA as laboratory studies have shown changes in biomineralisation patterns under OA conditions (Hennige et al. 2015, Proc Roy Soc B). A standardised method will be important.

Access to photographs and videos collected for other purposes (e.g. habitat mapping, geology) could provide insight into the condition of CWCs, however this would need to be from a dedicated benthic survey (e.g. ROV videos often pan towards fish making an opportunistic coral survey difficult).

If samples are collected for gene expression, corals need to be preserved in concentrated RNAlater.

Making cruise reports open access and easily available would make it easier to identify what data/samples have been collected that could be relevant to CWCs.

Create a list of key contacts to report samples, data or sampling opportunities to. The CWC community is relatively small in comparison to other disciplines, keeping an up-to-date contact list e.g. with GOA-ON should be achievable.