CRUISE PLAN
Defying Dissolution Cruise 2021
RV Kilo Moana and ROV

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Project Overview

An unexpected opportunity to better understand the potential impacts of changing the aragonite saturation horizon (ASH) depth on deep-sea scleractinian reefs has emerged in the North Pacific. In contrast to the North Atlantic and South Pacific, the North Pacific has a much shallower ASH (50-600m) and a higher carbonate dissolution rate, which peaks at depths of 400-600m (Feely et al 2004). These two factors, along with a lack of observations of deep-sea reefs in the North Pacific despite a reasonable amount of exploration, led to the hypothesis that scleractinian reefs would not occur in the North Pacific because the carbonate chemistry is not favorable for accumulation of $CaCO_3$ and reef formation (Guinotte et al 2006).

Despite these expectations, during NSF-funded explorations with the AUV Sentry (2014, 2015) and HURL (2017, 2018), we discovered scleractinian reefs in the Northwest Hawaii Islands (NWHI) and Emperor Seamount Chain (ESC) from 535 to 732 m. These depths overlap with those where the highest $CaCO_3$ dissolution rates are observed in the North Pacific (between 400-600 m) (Feely et al. 2004, 2012), and Ω_{ar} at these reef sites ranges from 0.71–1.33 (Baco et al. 2017). This discovery begs the question: **How is it that these deep-sea scleractinian coral reefs can occur in undersaturated water, well below the hypothesized reef development limit of Ω_{ar} = 0.9?** To address this overarching question, the goals of this project are to 1) Investigate the environmental factors that determine the distribution of deep-sea scleractinian reefs, and 2) Explore the effects of decreasing Ω_{ar} on these reefs.

Operational Overview

• The target depth for all operations will be in the observed reef depth range of ~500-1000m. Recent habitat suitability modeling suggest suitable habitats may extend as deep as 2000m, thus there is the potential for some dives from 1000-2000 m.
• Working at 9 sites (Table below), all but 2 of which we've dove on with HURL in 2017 and 2018, (but not necessarily the exact same areas on these seamounts).
• Planning on 72 hours at each sites.
- ~24 hours total of ROV dive time
- ~36 hours for CTD ops
- ~12 hours for mapping, with extra time saved for ROV when mapping is not required

<u>ROV operations</u>
• 2 instrument landers will be deployed directly in the reef area by the ROV, 1 at Colahan Seamount and 1 at SE Hancock Seamount which have the most well-developed reef below the ASH. We will also conduct a 24-hour instrument deployment at Academician seamount, and possibly a second one at Yuryaku Seamount.
• Carbonate dissolution blocks will also be deployed at all 9 sites using the ROV at 2 depths on each seamount.
• Collect water samples at the reef sites using Niskins on the ROV. Minimum of four ~2-liter Niskins required.
• Coral specimens will be collected at all reef sites with two goals in mind. The first will be to obtain vouchers specimens for validation of identifications of specimens observed in the video. Collected specimens will be photographed *in-situ* and on shipboard to aid in identifications. The second goal will be collection of corals for aging, mineral composition, skeletal densities, growth rates, boron isotopes,

and genetics. In contrast to our previous work, the primary focus of these collections will be on the scleractinians (*Solenosmilia, Madrepora* and *Enalopsammia*) associated with the reefs but with opportunistic sampling of other species we normally collect depending on space availability.
• Remaining ROV time at each site will be used for ROV Video Transects to determine how large are the reefs on each seamount? What is the full depth range of reef at each site? Which species are forming the reefs? How does the species composition vary by site and by depth within a site? What is the percentage of live coral, dead coral with exposed $CaCO_3$, and dead coral with Mn coatings? To accomplish this in a quantitative manner, we will conduct a combination of video transects at the same depth on each seamount, as well as focused transects within reef sites. During transects, the HD video camera will be in a fixed position and zoom, with parallel laser beams visible in the field of view.

Sites

Figure 1 and Table 1 list the seamounts to be investigated and which sites have scleractinian reefs. We have designed our study to include sites across a gradient of Ω_{ar}, all within the same depth range (500-1000 m). Reef sites both above and below the ASH are included. To better constrain the species distribution models, we have also included 1 site below the ASH with no reef and 2 sites below the ASH that have unknown reefs status. Ladd and Bank 9 are unexplored sites at approximately evenly spaced geographic intervals between the known reef at Academician, and Pioneer, which has been explored in this depth range with no evidence of reefs present. These sites will help us determine the southeasternmost extent of the occurrence of reefs and give clearer boundaries for environmental parameters that may impact reef distribution, thereby allowing us to better constrain the model domain.

Table 1. Target seamounts for our study. The target depth range will be 500-1000m. NE = not explored in target depth range. * = Lander site

Seamount	~ Lat °N	~ Long	Reef Observed	Primarily Above/Below ASH
Koko	35.25	172.00	Yes	Above
Yuryaku	32.67	172.25	Yes	Above
Kammu	32.17	173.00	Yes	Above
*Colahan	30.98	175.93	Yes	Below
SE Hancock	29.79	179.07	Yes	Below
Academician	28.80	-178.84	Yes	Below
Ladd	28.51	-176.66	NE	TBD
Bank 9	26.94	-175.59	NE	TBD
Pioneer	26.10	-173.27	No	na

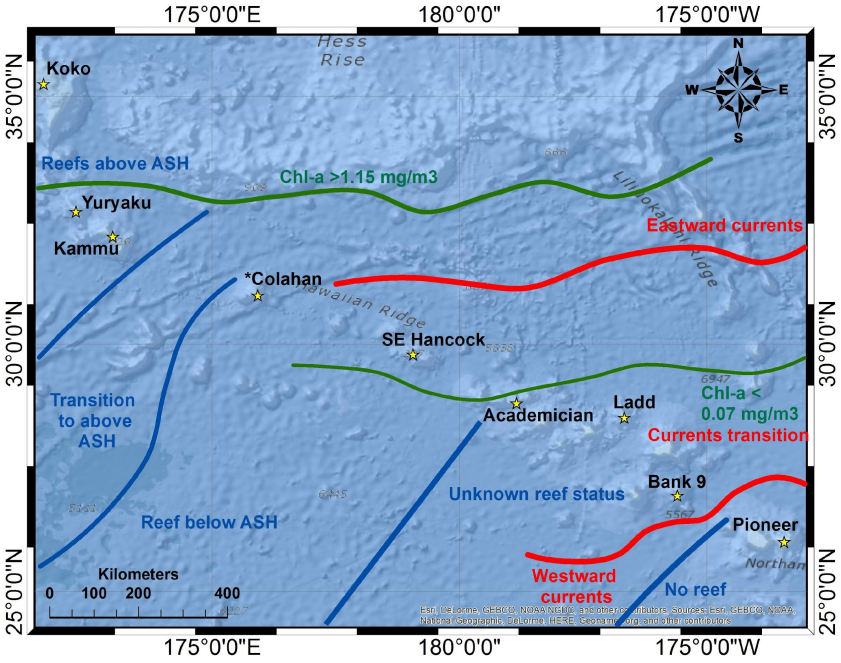

Figure 1. Map of target sites in the NWHI and ESC. Green lines indicate the gradient in surface chl a concentrations, red lines indicate changes in surface currents, and blue lines indicate presence of observed reefs above or below the ASH.

Transits and sequence of sites.

The cruise plan and transit times are calculated assuming an average transit speed of 10 knots.

Site sequence:

Academician is 6 days (122 hrs) from port
SE Hancock Smt
Colohan Smt
Koko Smt
(working our way back)
Yuryako Smt
Kammu Guyot
Ladd Smt
Bank 9
Pioneer Smt

Notes

Bank 9 - an unknown site is ~1 day closer, 5 days
We can adjust site sequence to avoid losing days to weather issues.

Load: 9 Aug 2021
Dep: 13 Aug 2021 Honolulu
Arr: 27 Sept 2021 Honolulu
Unload: 29 Sept 2021

Multibeam

High resolution bathymetry (<10m resolution) and backscatter is required to derive several terrain parameters (e.g. slope, rugosity, etc) for species distribution modeling. Additional multibeam bathymetry required for a few of our target sites will be collected using the EM302 multibeam echosounder (30kHz)

system. Multibeam time averages out to < 24 hours per site. We will be processing multibeam data fairly rapidly

Note part of the cruise is occurring in the Papahānaumokuākea Marine National Monument (PMNM) with a number of limitations noted in the permits for both the ship and science.

CTD work

In order to characterize the carbonate chemistry around our study site, to develop ^{14}C and trace element water column profiles for biogeochemistry work and characterize environmental parameters to feed into species distribution models we will conduct CTD and water sampling in NS and EW transect cross pattern from ~1500m to the top of the seamount. We will collect 18 with 6 duplicate water samples at a minimum of 5 stations at standard WOCE depths for carbonate chemistry, nutrients, ^{14}C, and trace elements. Oxygen and Chl A sensors will also be included on the CTD. CTD ops will take ~36 hours per site with additional CTD casts performed as time allows. We are targeting doing a minimum of 5 CTD cast per site.

CTD Configuration for the KM – Seabird SBE 9/11plus CTD with a 24-bottle frame (12 L PVC sampling bottles)

Additional Sensors we would like to include if they are available

- Biospherical QSP-2300 log scalar PAR sensor (2,000 m depth rating),
- Wetlabs ECO FLNTU Chlorophyll Fluorometer & Turbidity sensor (6,000 m depth rating),
- Seapoint SCF Chlorophyll Fluorometer (6,000 m depth rating)(if the ECO FLNTU is not available then we would like to use this sensor)
- Wetlabs C-Star 25 cm transmissometer (6,000 m depth rating),

If a pH sensor is available we would like to have the option of adding it to the CTD but understand the shallower depth constraints.

Cast will be conducted near the sea bottom so including an altimeter would be good.