HO20: Spatial and temporal patterns in reef health and fish community structure

Dr Dan Exton, Operation Wallacea

Coral reefs are highly dynamic and biologically diverse ecosystems of great conservation and economic value. Although coral reef fisheries make up less than 1% of global commercial fisheries, they contribute approximately 6 million tons of fish, valued in the region of $6 billion, per year. Coral reef fisheries also supply food for over a billion people each year through subsistence, 85% of which are dependent upon the reefs for the majority of their protein. Thus, managing coral reef fisheries sustainably is critical to the economies of the countries where coral reefs are found, but also to the coastal communities that are heavily reliant on these fisheries for their daily sustenance.

Sustainable management of healthy reef fish populations is also essential for the continued functioning of the reef system as a whole. For example, overfishing important herbivores can decrease grazing pressures and ultimately result in phase shifts from coral dominated to algal dominated systems. Maintaining the dynamic equilibrium within coral reef systems is vital for ensuring both biological diversity and local fisheries are safeguarded. Thus, annual monitoring of economically and/or ecologically important species is essential for assessing the health of the reef system and to provide early warning signs of any negative trends in fish populations.

The Caribbean island of Utila, on the Mesoamerican Barrier Reef System, has a local economy that is heavily reliant on SCUBA diving tourism. However, by specialising in budget travellers there is a lack of economic resources and incentive to adequately protect nearby marine resources, in particular the coral reefs and their associated fish communities. Utila's reefs therefore suffer from the suite of impacts seen throughout the Caribbean, and can be considered representative of the region as a whole. In particular, phase-shifts where benthic dominance changes from scleractinian corals to macroalgae has been observed, typically caused by a reduction in herbivores combined with organic enrichment.

Traditionally, surveys of reef fish populations, as well as benthic and invertebrate community structure, have been conducted by underwater visual census (UVC) by a team of scuba divers. However, the recent development of stereo video equipment for surveying reef fish communities is allowing large volumes of data to be collected within a single dive and analysed in detail back in the laboratory. An added advantage of stereo video surveys (SVS) over UVC, or even surveys that use a single video camera, is that SVS allows the researcher to accurately measure the size of the fish observed on the transect with computer analysis. The ability to accurately assess fish size makes it possible to estimate and compare biomass of fish populations. Although fish size has often been approximated during UVC, it has been shown that these approximations introduce a large degree of error and, thus, it is very difficult to make reliable comparisons of fish biomass between areas. Therefore, SVS provides a sophisticated and novel approach to reef fish surveys that is allowing the first accurate assessment of the biomass of fish populations in Honduran reef systems.

Stereo Video Surveys (SVS) are carried out by a small team of scuba divers with the principal investigator operating the stereo video equipment. Up to six consecutive transects can be filmed per dive using this method, although the actual number will depend on the dive site and the experience of the surveyors. On Utila these surveys are conducted at 5m (reef crest) and 10m (slope). Stereo-video footage is converted from MTS to AVI format using MTS converter and then analyzed using the program *EventMeasure*. Footage from the left and right cameras is then synchronized in *EventMeasure* so that the frames are perfectly aligned. Once the setup is complete, individual fish are identified by family, genus, and species, and lengths calculated from snout to base of tail.

In addition to collecting fish community data, students will use GoPro video cameras to conduct benthic surveys using line-point-intercept transect techniques. This will provide them with data pertaining to the health of the reef and enable them to make inferences about the relationships that exist between fish population structures and benthic community health and composition. From 2019, students may also be able to use cutting-edge 3D modelling technology in order to investigate how fish abundances and diversity are affected by the underlying architecture of the reef. This has potentially major implications for conservation as reef flattening processes in the Caribbean continue to gain momentum.

Students may design projects that look at differences in fish community assemblages, abundance and biomass within and between sites around Utila, and also look at depth distributions and the impact of environment on shaping reef benthic and fish community structure. This project has been running annually for over five years now, and it will also therefore be possible to use data from previous years in order to investigate temporal changes in parameters of interest.

Reading List

Adam TC, Burkepile DE, Ruttenberg BI, Paddack MJ (2015) Herbivory and the resilience of Caribbean coral reefs: Knowledge gaps and implications for management. Marine Ecology Progress Series 520

Andradi-Brown DA, Gress E, Laverick JH, Monfared MAA, Rogers AD, Exton DA (2017) Wariness of reef fish to passive diver presence with varying dive gear type across a coral reef depth gradient. Journal of the Marine Biological Association of the UK

Andradi-Brown DA, Macaya-Solis C, Exton DA, Gress E, Wright G, Rogers AD (2016) Assessing Caribbean shallow and mesophotic reef fish communities using baited-remote underwater video (BRUV) and diver-operated video (DOV) survey techniques. PLOS One 11(12): e0168235

Andradi-Brown DA, Gress E, Wright G, Exton DA, Rogers AD (2016) Reef fish community biomass and trophic structure changes across shallow to upper-mesophotic reefs in the Mesoamerican Barrier Reef, Caribben. PLOS One 11(6): e0156641

Barlow J, Franca F, Gardner TA, Hicks CC, Lennox GD, Berenguer E, Castello L, Economo EP, Joice F, Guenard B, Leal CG, Isaac V, Lees AC, Parr CL, Wilson SK, Young PJ, Graham NAJ (2018) The future of hyperdiverse tropical ecosystems. Nature 559:517–526

Bodmer MDV, Rogers AD, Speight MR, Lubbock N, Exton DA (2015) Using an isolated population boom to explore barriers to recovery in the keystone Caribbean coral reef herbivore *Diadema antillarum*. Coral Reefs 34(4): 1011-1021

Bruno JF, Bates AE, Cacciapaglia C, Pike EP, Amstrup SC, Van Hooidonk R, Henson SA, Aronson RB (2018) Climate change threatens the world's marine protected areas. Nat Clim Chang 8:

Cinner JE, Huchery C, MacNeil MA, Graham NAJ, McClanahan TR, Maina J, Maire E, Kittinger JN, Hicks CC, Mora C, Allison EH, D'Agata S, Hoey A, Feary DA, Crowder L, Williams ID, Kulbicki M, Vigliola L, Wantiez L, Edgar G, Stuart-Smith RD, Sandin SA, Green AL, Hardt MJ, Beger M, Friedlander A, Campbell SJ, Holmes KE, Wilson SK, Brokovich E, Brooks AJ, Cruz-Motta JJ, Booth DJ, Chabanet P, Gough C, Tupper M, Ferse SCA, Sumaila UR, Mouillot D (2016) Bright spots among the world's coral reefs. Nature 535:416–419

Cox C, Valdivia A, McField M, Castillo K, Bruno JF (2017) Establishment of marine protected areas alone does not restore coral reef communities in Belize. Mar Ecol Prog Ser 563:

Harborne, A.R., Afzal, D.C., Andrews, M.J. (2001) Honduras: Caribbean coast. *Marine Pollution Bulletin*, 42(12): 1221-1235.

Harvey, E., Fletcher, D., Shortis, M. (2001) A comparison of the precision and accuracy of estimates of reef-fish lengths determined visually by divers with estimates produced by a stereo-video. *Fishery Bulletin*, 99(1): 63-71.

Harvey, E., Fletcher, D., Shortis, M. (2002) Estimation of reef fish length by divers and by stereo-video: A first comparison of the accuracy and precision in the field on living fish under operational conditions. *Fisheries Research*, 57(3): 255-265

Hughes TP, Barnes ML, Bellwood DR, Cinner JE, Cumming GS, Jackson JBC, Kleypas J, Van De Leemput IA, Lough JM, Morrison TH, Palumbi SR, Van Nes EH, Scheffer M (2017) Coral reefs in the Anthropocene. Nature 546:82–90

Ledlie, M.H., Graham, N.A.J., Bythell, J.C., Wilson, S.K., Jennings, S., Polunin, N.V.C., Hardcastle, J. (2007) Phase shifts and the role of herbivory in the resilience of coral reefs. *Coral Reefs*, 26(3): 641-653.

Mora, C. (2008) A clear human footprint in the coral reefs of the Caribbean. *Proceedings of the Royal Society B-Biological Sciences*, 275: 767-773.

Mumby, P.J., Harborne, A.R. (2010) Marine reserves enhance the recovery of corals on Caribbean reefs. *PLOS ONE*, 5(1): e8657.

Newman SP, Meesters EH, Dryden CS, Williams SM, Sanchez C, Mumby PJ, Polunin NVC (2015) Reef flattening effects on total richness and species responses in the Caribbean. J Anim Ecol 84:

Young GC, Dey S, Rogers AD, Exton DA (2017) Cost and time-effective framework for multi-scale measures of rugosity, fractal dimension, and vector dispersion from coral reef 3D models. PLOS One 12(4): e0175341