

DEEP REEF OBSERVATION PROJECT (DROP): A SMITHSONIAN-SUBSTATION CURAÇAO COLLABORATION

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Scientists have studied shallow Caribbean reefs for more than a century. In contrast tropical mesophotic and deep reefs, which are below the depths accessible by traditional scuba gear and above the depths typically visited by deep-diving submersibles, are underexplored ocean ecosystems that science has largely missed. Little is known about the diversity of life on deep reefs, how it changes over space and time, and what role deep reefs may play in the survival of shallow reefs above. Shallow reefs are in peril circumtropically but what is the status of deep reefs? Are water temperatures on deep reefs rising and are these ecosystems exhibiting degradation and loss from major agents of environmental impact? Are shallow reef inhabitants moving deeper in response to warming surface waters? Are deep-reef populations re-seeding shallow populations that have been impacted by reef demise?

In 2011 the Smithsonian initiated Deep Reef Observation Project (*DROP*), a research effort that utilizes Substation Curaçao's *Curasub* submersible (<http://www.substation-curaçao.com/>, Fig. 1) to address questions related to biodiversity and conservation of deep reefs. *DROP*'s three main research objectives are to (1) document local biodiversity to a depth of 300 m in a small, 0.2 km² "plot" of water directly off the Curaçao Seaquarium shoreline (the "Seaquarium plot") and create specimen and DNA libraries for diversity and monitoring studies; (2) implement standardized sampling methods for monitoring long-term changes in environmental and biological conditions on deep and shallow reefs off Curaçao; and (3) transport the *Curasub* to other Caribbean deep reefs to obtain comparative samples to broaden the evolutionary and biogeographic research questions that can be addressed.



Figure 1. The *Curasub* submersible. Photo by Barry Brown.

In 2011-2013 Smithsonian marine scientists made 32 exploratory submersible dives in the Seaquarium plot and collected approximately 600 deep-reef specimens. Samples were photographed, processed for genetic analysis, and exported for archiving into Smithsonian collections. This material

contains at least 30 new species of fishes and invertebrates (e.g., Baldwin and Robertson, 2013) and, for fishes, each submersible dive has yielded species new to the *DROP* project. This is remarkable considering the small size of the study area and it demonstrates the need for additional sampling. The increasingly comprehensive collection of specimens and DNA sequences resulting from specimens collected during submersible diving is invaluable for ongoing and future diversity and monitoring studies.

Progress also has been made in implementing standardized sampling methods for monitoring deep and shallow reefs in the Seaquarium Plot. In 2012, *DROP* broke new ground by deploying nine autonomous reef monitoring systems (ARMS) at depths up to 224 m using the hydraulic arms of the *Curasub* (Fig. 2). Three additional ARMS were placed on the shallow reef for comparative purposes and 11 oceanographic temperature loggers (set to record hourly temperatures) were deployed along a transect at regular intervals from 15 to 250 m. All of this equipment will remain in place for one year and then be retrieved, processed and redeployed. Successful acquisition of annual data on temperatures and invertebrate/algal diversity on a reef slope from 15 to 250 m will be a unique scientific accomplishment: there is no comparable dataset from anywhere else in the world. Repeated over time, these standardized sampling methods will provide information on long-term changes in temperatures and biodiversity on shallow and deep reefs off Curaçao.



Figure 2. Deploying autonomous reef monitoring structure (ARMS) with the hydraulic arms of the *Curasub* submersible off Curaçao. Photo courtesy of Substation Curaçao.



Figure 3. Deploying the *Curasub* at Klein Curaçao from the R/V *Chapman*. Photo by Barry Brown.

Regarding transporting the *Curasub* away from its home port at the Curaçao Seaquarium to investigate other southern Caribbean deep reefs, renovations to a former NOAA ship, the R/V *Chapman*, were completed in 2012 and sub dives are now being made from the shipboard platform (Fig. 3). Smithsonian marine scientists have participated in *Curasub* dives at Klein Curaçao, a 1.7 km² uninhabited island southeast of Curaçao, and off Bonaire. Putative new species were collected at both sites and additional dives at Klein Curaçao are planned. Genetic data from dives at the three localities will enable preliminary assessment of genetic connectivity among certain taxa inhabiting geographically distinct reefs. Ultimately, given sufficient submersible collections from numerous Caribbean deep reefs, biogeographic patterns of shallow and deep taxa can be compared.

In conclusion, facilities and staff at Substation Curaçao are enabling exploration and monitoring of deep reefs off Curaçao. Deep and shallow reefs are not isolated ecosystems and their interconnectedness may be significant. Like shallow coral reefs Caribbean deep reefs should be candidates for designation as marine-protected areas but such management decisions require scientific data on a multi-year basis. Results of *DRDP* research will be used as a foundation for establishing Curaçao as a permanent site in the Smithsonian's Marine Global Earth Observatory (SI MarineGEO) and to inform international marine policy related to the establishment of deep reefs as marine protected areas

Literature Cited

Baldwin, C.C., and D.R. Robertson. 2013. A new *Haptoclinus* blenny (Teleostei, Labrisomidae) from deep reefs off Curaçao, southern Caribbean, with comments on relationships of the genus. *Zookeys*, **306**: 71-81.