Are mesophotic coral reefs a potential refuge for fishery targeted reef fish species in the US Virgin Islands?

¿Proveen refugio los arrecifes mesofóticos para especies importantes para las pescaderías de arrecife en las Islas Vírgenes de los Estados Unidos?

Les récifs coralliens mésophotiques sont-ils un refuge potentiel pour les espèces de poissons de récif ciblées par la pêche dans les îles Vierges américaines?

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EXTENDED ABSTRACT

In the U.S. Caribbean, information is needed to better understand the overall ecological and management importance of the mesophotic reef habitat (e.g., fish population dynamics, as possible refuge for juvenile or larger reproductive fishes, etc.). Limited research has shown that the deeper reefs are biologically important, supporting annual spawning aggregations for recreationally and commercially valuable yellowfin grouper, red hind, and dog snapper (Nemeth et al. 2005, 2006, 2008; Kadison et al. 2006). Similarly, the mesophotic reefs are known to be biologically important for Nassau grouper (Nemeth et al. 2008), a species that is prohibited from capture and recently listed as threatened under the Endangered Species Act (ESA; NMFS 2016).

The implementation of a mesophotic reef survey was scored as high priority by the U.S. Caribbean Fishery-Independent Survey Working Group, which was tasked with developing goals to improve federal stock assessment capabilities in the U.S. Caribbean (Cass-Calay et al. 2015). In the U.S. Caribbean, fishery stock assessments have relied on fishery-dependent data even though there is low confidence in the reported landings and a multitude of other complicating factors (e.g., changes in fishing regulations, inconsistent reporting forms, lack of discard information). Fisheries managers continue to use fishery-dependent data, partly because landings are reported from the entire nearshore coral reef tract (0–60m; Costa et al. 2009). In contrast, reliable fishery-independent reef fish monitoring data has only been collected in shallower waters (<30m) missing up to half of the St. Thomas and St. John reef shelf (30 to 60 m) near important management areas. The failure to collect fishery-independent monitoring data on deeper reefs has been particularly problematic since declines in shallow water catches have resulted in fishermen regularly targeting economically valuable species (e.g., snappers and groupers) over the deep mesophotic reef habitat (Kojis and Quinn, 2006).

The Deep Coral Reef Monitoring Program (DCRMP) was recently implemented to provide reef fish quantity (i.e., abundance, density) and size (i.e., length frequency) data for the mesophotic reefs off St. Thomas and St. John, U.S. Virgin Islands (USVI). DCRMP surveys from 30 to 50m using the same survey design and methodology as NOAA's National Coral Reef Monitoring Program (NCRMP) that surveys from 0 to 30m. Combined DCRMP and NCRMP fishery-independent surveys encompass the majority of the regional reef tract shelf (0–60m).

Exact protocols can be referenced in peer-reviewed publications (e.g., Bohnsack and Bannerot, 1986; Smith et al. 2011; Bryan et al. 2016). Briefly, DCRMP sites were selected using a stratified random sampling design that incorporated three habitat classes (aggregate, patch reef, and pavement) and strata (e.g., depth) within a gridded reef-scape. Highly trained SCUBA divers from the University of the Virgin Islands used the reef visual census (RVC) stationary point count (SPC) method to count and measure fish to the nearest cm at depth. In RVC-SPC, two divers simultaneously collected a snapshot (<10 minutes) of reef fish species while centered within an imaginary 15-m diameter cylinder that extended from the seafloor to sea surface.

To allow for comparisons between NCRMP and DCRMP surveys, DCRMP divers used open circuit, mixed gas, and decompression SCUBA diving methods to provide similar diving conditions (i.e., bubbles) to the NCRMP surveys (e.g., Gray et al. 2016). Similarly, all comparisons reported herein restricted NCRMP surveys, which samples on all available hard-bottom habitat, to the same aggregate, patch, and pavement strata as DCRMP.

Deeper surveys (n=162) occurred over three years (2018–2020) and were compared to one year of NCRMP data (2019, n=262). Of the 20 fishery target species tested (Table 1), 45% (9 out of 20) of mature fish had significantly ($p<0.05$) higher densities in the DCRMP surveys suggesting that for some species deeper reefs may offer a potential refuge. Size distributions varied by species and survey depth. Some fishery targeted species such as yellowtail snapper (*Ocyurus chrysurus*), red hind (*Epinephelus guttatus*), stoplight parrotfish (*Sparisoma viride)*, queen triggerfish (*Balistes vetula*) showed larger sizes more frequently in the DCMRP surveys, although, largest sizes classes were observed in both DCRMP and NCRMP surveys. In contrast, other fishery targeted species such as Caribbean hogfish (*Lachnolaimus maximus*) showed largest sizes (≥55 cm fork length) at similar frequencies in both the DCRMP and NCRMP surveys.

Our initial assessment suggests that a potential refuge from fishing may exist in deeper waters for some fishery-targeted species. However, it is also possible that the increased densities and sizes observed at depth may be related to a natural ontogenetic shift to deeper waters by some species. For species where similar densities and sizes were observed in both the DCRMP and NCRMP surveys, the data suggest a uniform use of the available reef habitat (i.e., no refuge). However, these observations may also be related to selective fishing pressure. For example, St. Thomas and St. John support an active trap fishery (NMFS CFMC 2019) and this gear selectively targets fish smaller than the trap's funnel size, which may explain why the largest size classes were more readily observed in both the DCRMP and NCRMP surveys.

For management purposes, the disparity between DCRMP and NCRMP densities and size compositions for many economically important species supports the continued collection of surveys on the mesophotic reefs in St. Thomas and St. John, USVI. Combined these data capture a critical snapshot of reef fish populations and provide a complete fishery-independent dataset of the reef shelf for fisheries managers. These surveys may be similarly useful in other regions that have more pronounced shelfs (e.g., Puerto Rico). In other cases, traditional NCRMP shallower water sampling may be sufficient and reflective of a selected fish population. Importantly, the data reported in these preliminary analyses are limited by low annual sample size. Robust sampling occurred in 2021 and is planned in 2022 (≥100 survey sites). These additional years of data are needed to more rigorously evaluate trends and inter-annual variability.

Together DCRMP and NCRMP data can be used to provide accurate and unbiased information on fish sizes, densities, and habitat preferences. Future research and efforts will be made to distribute data through peer-reviewed scientific literature and in formats appropriate for Caribbean island-based stock assessments. We hope these data will be used to: 1) Alleviate concerns with previous assessments (SEDAR 2016) that fishery-dependent length data reflect changes in the fishery (e.g., regulations, selectivity, market demands) rather than the stock; 2) Provide data on fishes of economic importance (e.g., groupers and snappers) that are "data-poor" (common in the USVI) and on ESA fishes that cannot be sampled using traditional fishery-dependent methods; 3) Develop a metric to quantify the amount of the targeted reef fish resources located below traditional reef fish monitoring to be used in a working document for Southeast Data Assessment and Review (SEDAR) stock assessments in the USVI; 4) Compare mean length of fishes in shallow and deep water and conduct length-based assessments using fishery-independent data to infer stock status of reef fishes in the USVI (completed in Hawaii; Nadon 2017); and 5) Conduct ecological and community analyses to better understand how varying fish assemblages are using the reef shelf (e.g., by depth, habitat, etc.).

KEYWORDS: fishery-independent survey, density and size composition, snappers, groupers, parrotfishes

Table 1. List of 20 targeted species. Asterisk (*) denotes significantly higher densities of mature fishes (length at maturity, L_m, Stevens et al. 2019) in the DCRMP surveys.

Target Species	L_m (cm)
*Cephalopholis fulva**	22
*Cephalopholis cruentata**	17
Epinephelus striatus	44
*Epinephelus guttatus**	22
Mycteroperca tigris	34
Mycteroperca venenosa	54
Mycteroperca interstitialis	42
*Lutjanus cyanopterus **	54
*Lutjanus jocu **	48
Lutjanus griseus	23
Lutjanus synagris	24
Lutjanus analis	32
*Lutjanus apodus **	25
*Ocyurus chrysurus**	23
Haemulon sciurus	20
Haemulon flavolineatum	16
Haemulon album	31
Haemulon plumieri	17
*Balistes vetula**	22
*Lachnolaimus maximus**	18

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