An Assessment of the Biodiversity and Abundance of Deep-Water Species In Exuma Sound

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Background

In the deep-ocean, very few fisheries independent data exist. Due to commercial interests in the deep sea, scientists are always playing catch up to assess the diversity of this environment. This is largely due to the propagation by fishermen to the deep sea as shallow and costal ecosystems become depleted.

The primary goal of this research is to create a baseline assessment of the abundance and diversity of deep-water species with a particular focus on elasmobranchs. Deep-sea species are *K*-selected, meaning they have conservative life history characteristics. This means they reach sexual maturity slower, have fewer young, and live longer. Therefore, sharks particularly will have a lower resilience to extrinsic pressures such as overfishing. Continued pressure over prolonged time frames may have the potential to exacerbate population recoveries in certain locations.

Figure 4a: Medusa being deployed from boat

Figure 4b: Medusa attached to crane

Part A: Medusa is set up (CTD turned on, bait box loaded, magnet removed, sandbags added) and deployed.

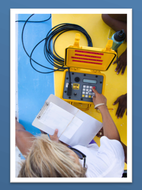

Figure 5a: Deck box in use

Figure 5b: Transducer being submerged

Part B: Medusa sinks and decent is recorded through communications module and transducer's acoustic signals.

Methods

The Medusa is a BRUV (Baited Remote Underwater Video) system that can stand the pressures of the deep ocean. Our sampling and drop sites were haphazardly chosen using the distance from the wall as a proxy for depth. With this we created two zones: shallow and deep (<750m , >750m). We also monitored available light, salinity, temperature, and depth using the PAR (Photosynthetic Active Radiation) and CTD (Conductivity, Temperature and Depth) which are attached to the Medusa. The communications module coupled with the transducer's acoustic signals enable us to broadcast instructions to the Medusa. We monitor rate of decent and ascent.

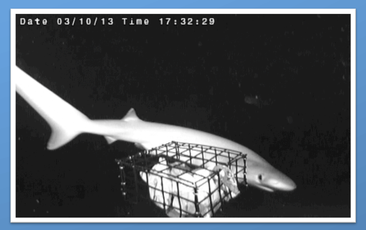

Figure 6a: Sixgill circling bait box

Figure 6b: Medusa being inspected after retrieval

Part D: Medusa is brought back to lab where data is retrieved and analyzed.

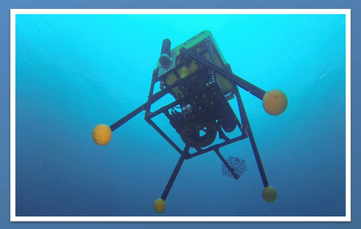

Figure 7a: Medusa ascending to surface

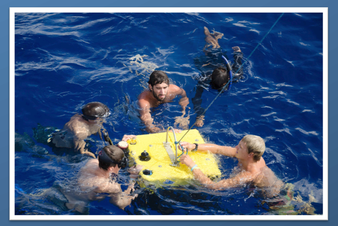

Figure 7b: Medusa being retrieved from ocean

Part C: Medusa signaled to drop sandbags and rise to the surface (ascent is recorded).

Results

Overall, the biodiversity and abundance within the Exuma Sound were high, and as depth increased, both biodiversity and abundance increased. Eight taxonomic groups were recorded, including five species of shark, teleosts, squid, lobsters, *Bathynomus* sp., and other crustaceans. *Bathynomus* sp. was the most prolific species that we observed through our research. Interestingly, the abundance of *Bathynomus* sp. increased as the depth increased.

For the sharks, the most prolific species were the Cuban Dogfish (*Squalus cubensis)* and the Gulper Sharks (*Centrophorus* sp.). The Cuban Dogfish was most abundant in the shallower depths, under 750 meters, and the Gulper sharks exhibited a higher abundance in the deeper depths, over 750 meters

Discussion

High levels of biodiversity sampled here may be attributable to increased opportunity for ecological niches to be exploited, correlated with depth. Both Cuban dogfish and gulper sharks are apex predators and therefore possibly compete for resources. This may have led to competitive exclusion, evidenced here by an inverse relationship in depth occupancy.

The scavenging isopod, *Bathynomus* sp. was more abundant with increasing depth which is perhaps a function of increased foraging opportunities, although this needs to be tested.

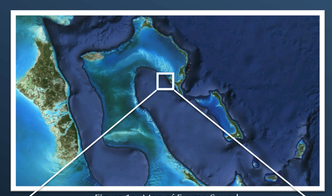

Figure 1a: Map of Exuma Sound

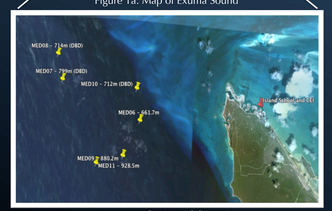

Figure 1b: Map of drop sites

Study Site

The Exuma Sound (Figure 1a) is a large expansion of ocean that reaches a maximum depth of 1600 meters. CEI and Island School are in close proximity to Exuma Sound, which makes it logistically easy to sample off the wall. So far we have collected data from six sites within the Exuma Sound (Figure 1b).

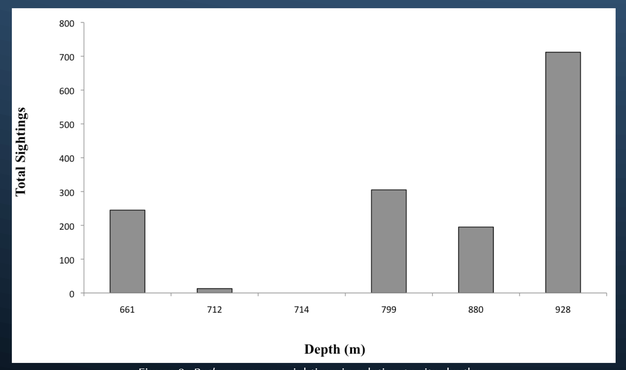

Figure 8: *Bathynomus* sp. sightings in relation to site depths (m)

Table 1: Species *MaxN* values, total time on screen, and total sightings of each drop (Shallow vs. Deep)

Shallow (<750m)

Depth	Taxa	*MaxN*	Total Time (min)	Total Sightings
661m	*Bathynomus* Sp.	3	36:45	245
	Decapoda	3	35:00	46
	Ophubroidea	3	18:40	16
	Stomatopoda	3	59:38	114
	Teleosts	2	6:35	36
	Squalus Cubensis	5	70:15	487
712m	*Bathynomus* Sp.	1	8:05	13
	Teleosts	2	00:59	11
	Squalus Cubensis	5	124:38	713
	Centrophorus Sp.	1	00:04	1
	Hexanchus sp.	1	2:31	9
	Scyliorhinidae	1	2:20	7
714m	Decapoda	2	11:16	15
	Stomatopoda	5	55:36	249
	Teleosts	1	00:45	7
	Squalus Cubensis	1	00:21	2
	Centophorus Sp.	3	64:58	316

Deep (>750m)

Depth	Taxa	*MaxN*	Total Time (min)	Total Sightings
799m	*Bathynomus* Sp.	7	092:23	305
	Decapoda	3	10:26	32
	Ophidiidae	1	00:27	2
	Stomatopoda	2	4:15	33
	Squalus Cubensis	2	1:28	9
	Centroscymnus owstoni	2	00:43	7
	Centophorus Sp.	3	68:33	299
880m	*Bathynomus* Sp.	8	197:21	195
	Decapoda	1	19:06	11
	Ophidiidae	3	9:30	37
	Stomatopoda	3	8:01	34
	Teleosts	2	27:16	54
	Centroscymnus owstoni	2	4:23	16
	Centophorus Sp.	1	3:15	8
928m	*Bathynomus* Sp.	12	275:10	712
	Decapoda	2	3:26	7
	Ophidiidae	2	12:35	30
	Opuhroidea	1	00:09	1
	Stomatopoda	2	5:18	16
	Synaphobranchidae	1	00:12	1
	Teleosts	2	00:50	3
	Centophorus Sp.	10	9:33	27

Conclusion

We have demonstrated that there is a high abundance and biodiversity in the deep-sea Exuma Sound. This provides critical baseline data for future conservation measures, not only in the Bahamas, but also in the wider Caribbean context.

Analytical Methods

We have gathered about ninety hours of footage and analyzed 18. The most important metric that we use to estimate abundance is called *MaxN*, which is the number of species on a screen at any given time. This is a conservative measure, allowing a more realistic abundance estimate. All organisms are identified to the highest taxonomic resolution, which is species level in most cases. The sites were separated into deep and shallow strata where the shallow sites range at a depth less than 750m and deep sites are at 750m and deeper.

Figure 2: Picture of Isopod from Medusa footage

Figure 3: Picture of Cuban Dogfish from Medusa footage

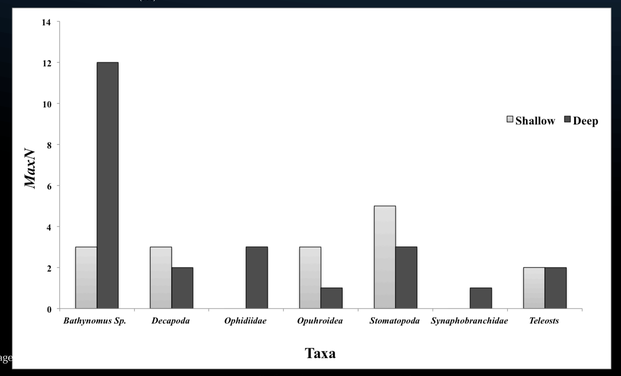

Figure 9: Species *MaxN* values (Deep vs. Shallow)

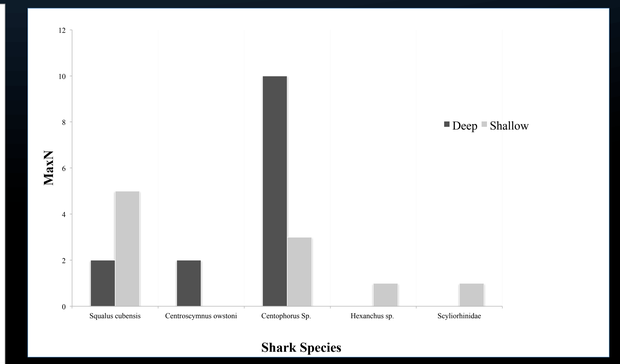

Figure 10: The *MaxN* (individual) values for shark species documented (deep vs. shallow)

Literature Cited

Bailey, D. M., Collins, M. A., Gordon, J. D. M., Zuur, A. F., Priede, I. G., (2009) Long-term changes in deep-water fish populations in the northeast Atlantic: a deeper reaching effect of fisheries? *Proceedings of the Royal Society, Biological Sciences,* **276**, 1965-1969

Banon, R., Pineiro, C., Casas, M., (2006) Biological aspects of deep-water sharks *Centroscymnus coelolepis* and *Centrophorus squamosus* in Galician waters (north-western Spain), *Journal of the Marine Biological Association of the United Kingdom*, **86**, 843-846

Cappo, M., Harvey, E., Malcolm, H., Speare, P., (2003) Potential of Video Techniques to Monitor Diversity, Abundance, and Size of Fish in Studies of Marine Protected Areas, Aquatic Protected Areas - what works best and how do we know? World Congress on Aquatic Protected Areas proceedings, Cairns, Australia, August- pages: 455-464

Norse, E. A., Brooke, S., Cheung, W. W. L., Clark, M. R., Ekeland, I., Froese, R., Gjerde, K. M., Haedrich, R. L., Heppell, S. S., Morato, T., Morgan, L. E., Pauly, D., Sumaila, R., Watson, R. (2011) Sustainability of deep-sea fisheries, *Marine Policy*: **36** 307-320

Ramirez-Llodra, E., Tyler, P. A., Baker, M. C., Bergstad, O. A., Clark, M. R., Escobar, E., Levin, L. A., Menot, L., Rowden, A. A., Smith, C. R., Van Dover, C.L. (2011) Man and the Last Great Wilderness: Human Impact on the Deep-sea. PLoS ONE 6(7): e22588. DOI: 10.1371/journal.pone.0022588

Wetherbee, B. M., (1999) Assemblages of deep-sea sharks on Chatham Rise, New Zealand *Fishery Bulletin* **98**:189-198

Widder, E. A., (2010) Bioluminescence in the Ocean: Origins of Biological, Chemical, and Ecological Diversity, *Science* **328**, 704; DOI: 10.1126/science. 1174269

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