Nkhata Bay Monitoring Report 2019

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Introduction

Lake Malawi, situated in the African Rift Valley, is well known as a biodiversity hotspot and as a site of rapid speciation events, most notably the adaptive radiation of cichlid fishes. Across their wide range, spanning the Americas and Africa, cichlid fishes are known for their proclivity to diversify and form new species at astonishing speeds (forming approximately 10% of all bony fishes) (Seehausen 2015; Koblmüller et al. 2011). However, even by cichlid standards, Lake Malawi is truly remarkable, likely containing over 1000 cichlid species, which is more fish species than any other lake in the world (Lyons et al. 2015; Kornfield and Smith 2000). Moreover, new species are discovered regularly with some estimates suggesting that the lake may contain more than 2000 species, all evolving with astonishing speed within the last 1.5-2 million years (Turner et al. 2001). Incredibly, all but a handful of these species are found nowhere else outside the Lake Malawi system, making the lake a global biodiversity treasure (Konings 2016; Weyl, Ribbink, and Tweddle 2010).

The lake is immense, covering 29,000 square kilometres and containing 7% of the earth's available surface freshwater. However, despite its great size, Lake Malawi is under threat from human activities. For example, from deforestation in the lake's catchment area, extensive irrigation and from over-fishing, which are all taking their toll on the lake. A recent assessment has estimated that up to 9% of the species in Lake Malawi are at high risk of extinction (IUCN Red List 2018). This is worrying not only from a biodiversity perspective, but also because this is one of Africa's poorest countries and people rely on fish from the lake for their livelihoods and for food. Moreover, the population of Malawi is growing rapidly, from only 2 million people in the 1950's, Malawi now has a population over 18 million, and with a majority of the population under 17 years of age (World Population Prospects), the population is likely to continuing rising quickly and placing increasing strain on the lake and the surrounding environment.

Here, we aim to establish a longitudinal study of the diversity and abundance of cichlid fishes in a specific area on the west coast of the central region of Lake Malawi. Specifically, we aim to determine the impacts on species richness and individual abundance in the rocky close shore regions (where most biodiversity occurs) of Lake Malawi as the human population increases, and presumably fishing and land-use pressures also intensify. We use two distinct methods for quantifying species richness and abundance, first snorkel and SCUBA observations (depending on the depth) and second underwater remote operation vehicle observations (ROV), along transect lines at different depths. By using these two methods, we are also able to make a direct comparison between the two to determine which is the most effect at estimating fish species richness and abundance. We use a combination of student volunteers (high school and undergraduate), dive professionals and researchers to collect the data.

Methods

Study site

We collected data from four distinct locations in Nkhata Bay, a region in Northern Malawi near the regional centre of Mzuzu, in the central area of the lake's western bank, in June-August 2019. The four areas are separated by several hundred metres, a distance that most rock dwelling cichlids will not be able to travel, and therefore are highly likely to represent independent observations in this area.

Snorkel/SCUBA observations

Observations of species richness and individual abundance were taken using snorkel and SCUBA at each site. Snorkel observations were taken at shallow depths, 1 and 3 metres, and SCUBA at deeper depths, 5 and 10 metres. In each case, a 25 metre transect line was laid out along the bottom. After a 5-minute acclimation time, to allow fish to return to normal behaviours, two divers (or snorkelers) moved alongside each side of the transect line (no faster than 5 minutes per 25 metres). Each diver estimated 3 metres to one side away from the transect line, and identified (to the lowest possible taxonomic level) and marked on a dive slate each individual they saw, from a pre-determined set of 25 common species that fill a diverse range of ecological roles (see Table 1, appendix), in this area. This allowed us to determine the species richness, at each site and depth, and the number of individuals present. At the end of the transect line, this process was repeated in the opposite direction. The number of snorkels/divers ranged from 3 to 8, site A was accessible from the shore, sites B-D were only accessible by boat.

ROV observations

Observations of species richness and individual abundance were taken using an underwater ROV (Deep Trekker) at the same sites, but at depths of 10 metres, 20 metres and 30 metres. ROV observations were always taken with the operator located on a boat. It was previously determined that the ROV travelled at approximately 25 metres per 30 seconds, therefore rather than using a transect line, the ROV was driven in as straight a line as possible for 30 seconds, to replicate the distance travelled by snorkel/SCUBA. Video files were saved and taken from the ROV and all fish were identified later on a computer. Only one video was taken at each site at each depth, on any particular sampling event.

Results

Snorkel/SCUBA observations

We obtained 93 snorkel/SCUBA observations from 40 independent transect runs. Across the four depths and four sites, all 25 species from the pre-determined sub-set were observed (Figure 1). The most abundant species were Cynotilapia afra, a small plankton and algae feeder, and Copadichromis “Utaka” sp. Across different depths, species richness was very similar, with 23 species being observed in the snorkel range (1-3 metres) and all 25 species being observed at 5 and 10 metre depths. Individual abundance (mean number of individuals observed along a transect) was lowest at 1-3 metres, peaked at 5 metres depth and declined slightly by 10 metres (Figure 2).

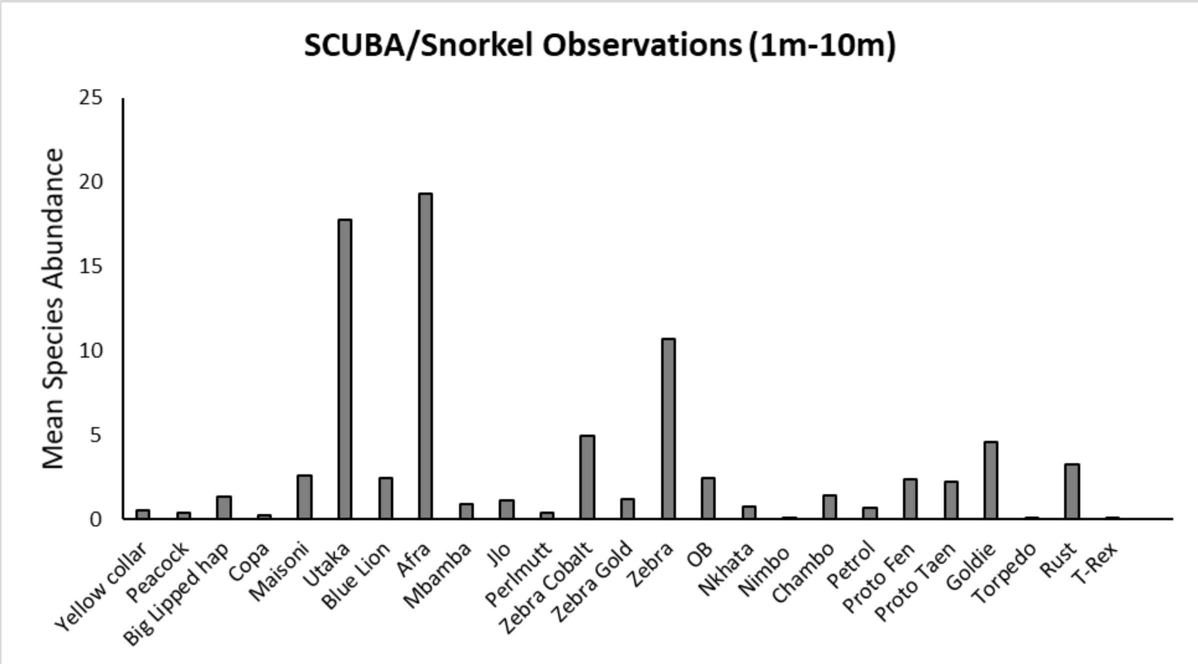

Figure 1. The species observed via snorkel and SCUBA from all depths (1 metre, 3 metres, 5 metres and 10 metres), and the mean abundance of each species per transect, across all four sampling locations in Nkhata Bay, Lake Malawi.

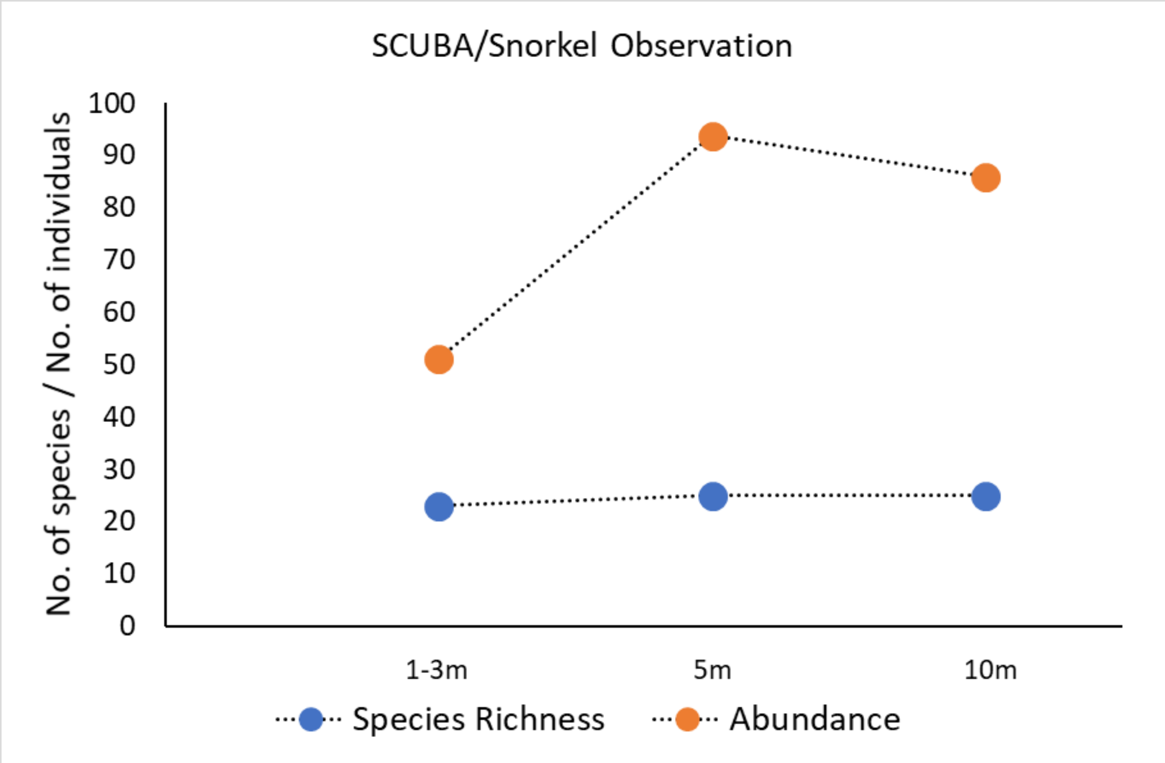

Figure 2. Species richness (blue circles) and mean individual abundance (orange circles), observed via snorkel and SCUBA, at each depth across the four sampling sites.

ROV observations

We obtained 38 observations, across the four sites and three different depths, 10 metres, 20 metres and 30 metres (Figure 3). Species richness observations were much lower using the ROV compared to snorkel/SCUBA. For example, at the overlapping 10 metre depth, only 13 species were observed, compared to 25 using SCUBA. Seven species were observed at 20 metres and 6 species at 30 metres (Figure 4). Cynotilapia afra and Copadichromis "Utaka" sp. were again the most commonly observed species. Individual abundance peaked at 20 metres deep, and was lowest at 30 metres (Figure 4).

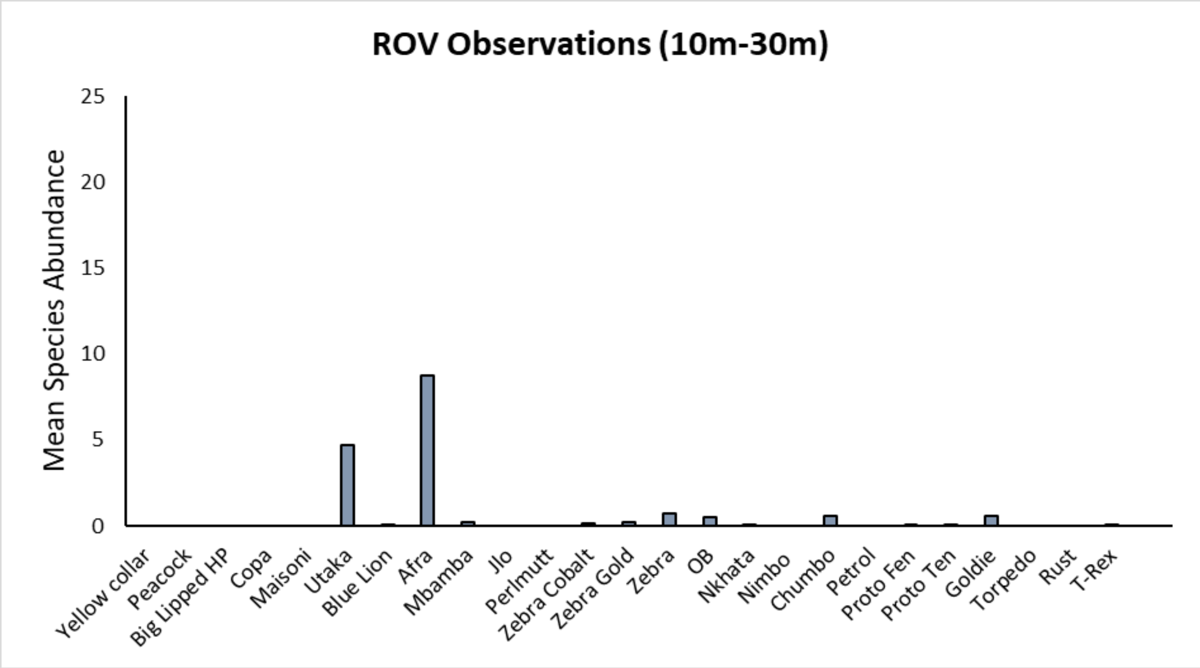

Figure 3. The species observed via ROV from all depths (10 metres, 20 metres and 30 metres), and the mean abundance of each species, across all four sampling locations in Nkhata Bay, Lake Malawi.

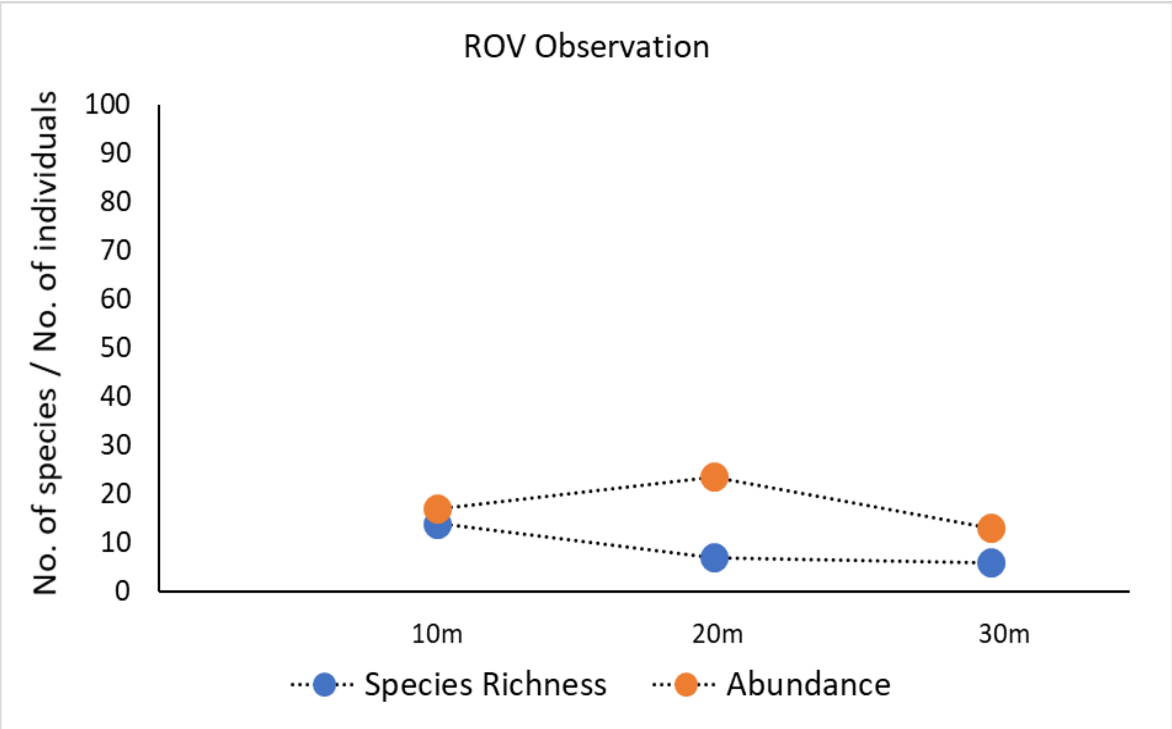

Figure 4. Species richness (blue circles) and mean individual abundance (orange circles), observed via ROV, at each depth across the four sampling sites.

Discussion

Across four separate sites and at different depths in Nhkata Bay, Lake Malawi, we observed all 25 species which we had pre-determined as important markers of biodiversity health in this region. Specifically, because these species represent either very common species, species that fill different ecological roles, and species that are economically important.

We found that biodiversity peaked between 5 and 10 metres deep, and that individual abundance was highest between 10 and 20 metres deep. The number of species and individuals was still high in shallower waters, but to a lesser extent, perhaps because bird predation could be a factor at these depths (1-3 metres). Species richness and individual abundance declined quite rapidly by 30 metres deep, however this is not unexpected, as less light will penetrate at this depth (Pearsall and Ullyott 1933), resulting in less algae and less primary food sources.

Interestingly snorkel/SCUBA observations resulted in many times more species and individual observations compared to the ROV, even at the overlapping depth of 10 metres (i.e. independent of any depth effects). Some potential explanations could be that snorkel/SCUBA divers are able to detect more cryptic species by looking in between rocks and in crevices, the ROV may scare many fish resulting in them hiding before they come into view, or perhaps because the ROV was driven by largely inexperienced operators.

In conclusion, this dataset represents a good starting point, which can be developed into a long-term monitoring program (Dodds et al. 2012) of cichlid species richness and abundance in this unique biodiversity hotspot, that will be coming under increasing human pressure in the near future.

References

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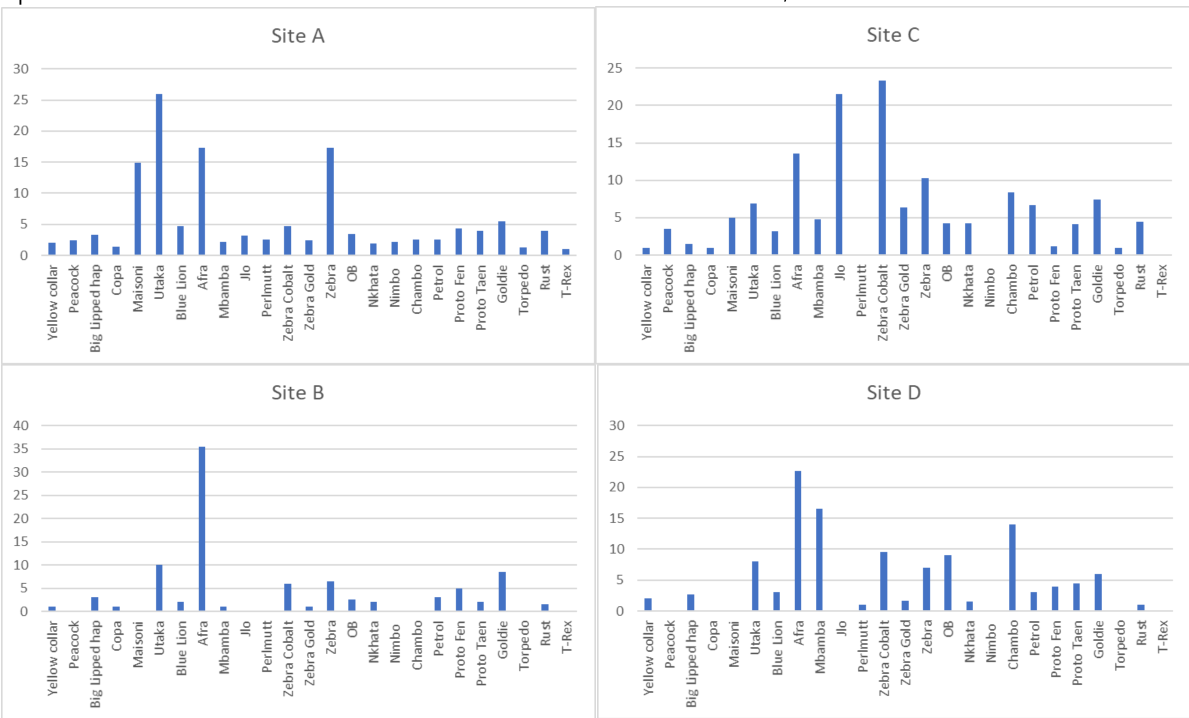
Appendix

Common Name	Species Name
Yellow collar	*Aulonocara sp*. 'yellow collar'
Peacock	*Aulonocara stuartgranti*
Big Lipped Hap	*Haplochromis sp.*
Copa	*Copadichromis borleyi*
Maisoni	*Aulonocara masoni*
Utaka	*Copadichromis sp.*
Blue Lion	*Metriaclima sp*
Afra	*Cynotilapia afra*
Mbamba	*Cynotilapia "Mbamba"*
Jlo	*Labidochromis sp.*
Perlmutt	*Labidochromis sp. "Perlmutt"*
Zebra Cobalt	*Metriaclima sp*
Zebra Gold	*Metriaclima "zebra gold"*
Zebra	*Metriaclima zebra*
OB	*Metriaclima zebra "OB"*
Nkhata	*Copadichromis "Nkhata"*
Nimbo	*Nimbochromis linni*
Chambo	*Oreochromis sp.*
Petrol	*Petrotilapia sp.*
Proto Fen	*Protomelas fenestratus*
Proto Ten	*Protomelas teaniolatus*
Goldie	*Metriaclima "Gold"*
Torpedo	*Stigmatochromis pholidophorus*
Rust	*Tropheops "Rust"*
T-Rex	*Tyrannochromis sp.*

Table 1. The pre-determined species that were surveyed for in this study

Supplementary Figures A

Species richness and abundance at each site as observed via snorkel/SCUBA



Supplementary Figures B

Species richness and abundance at each site as observed via ROV.