Interannual variability of the biomass of Lake Victoria's decapod zooplankton *Caridina nilotica* (Atyidae) determined from acoustic survey and a new Target Strength model

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Presenter: Collins Ongore

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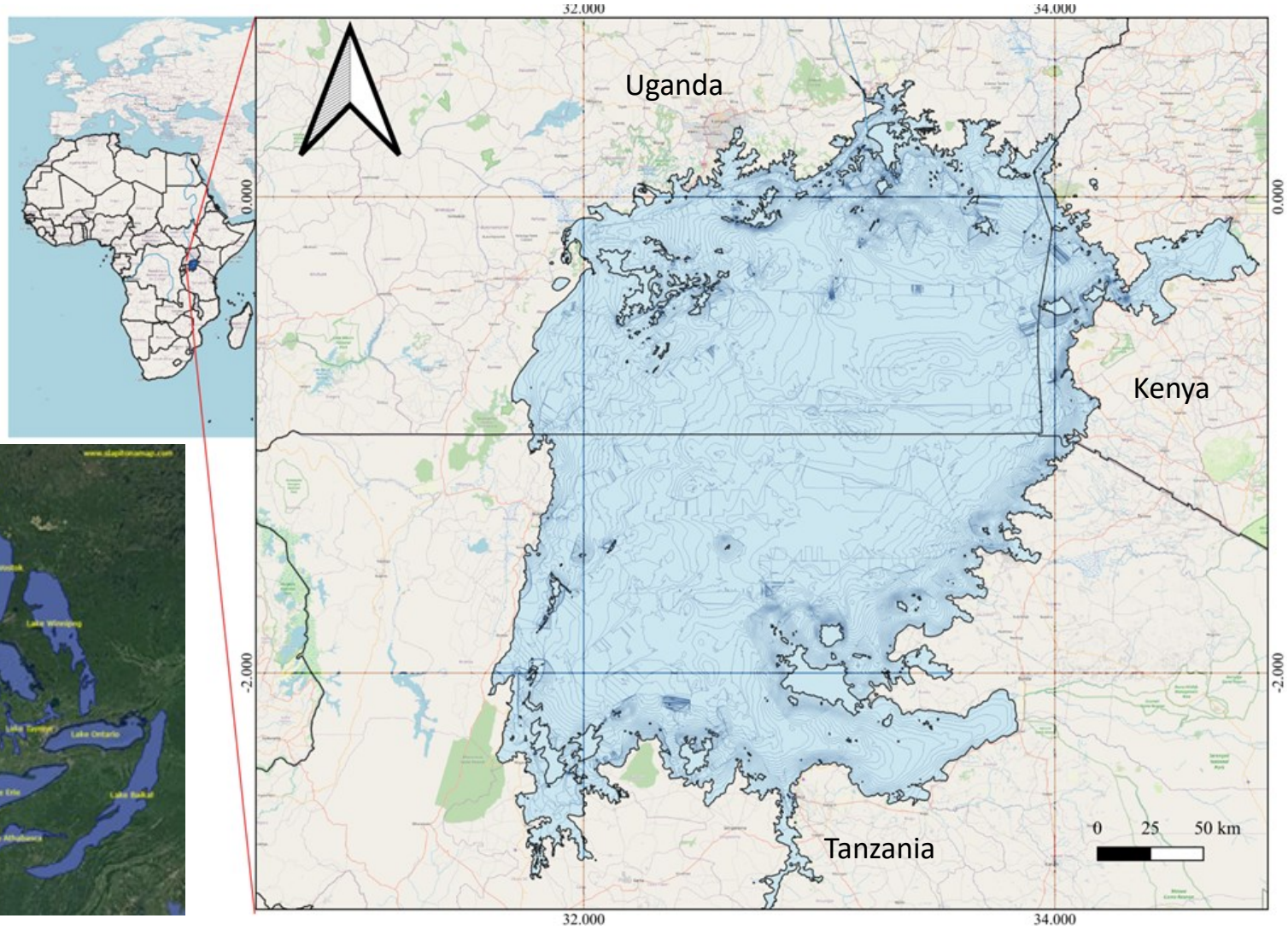
2021 2030 United Nations Decade of Ocean Science for Sustainable Development

University of St Andrews

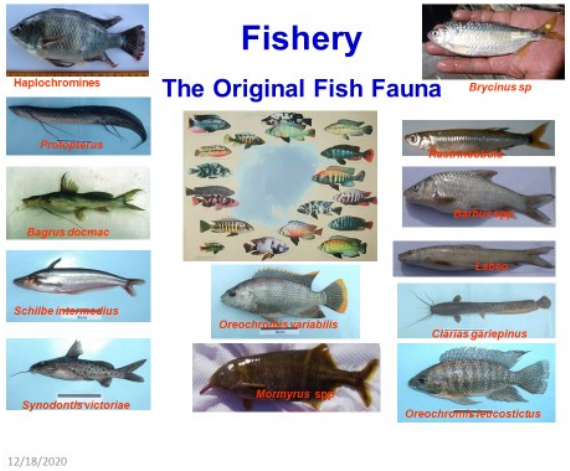
Lake Victoria, East Africa

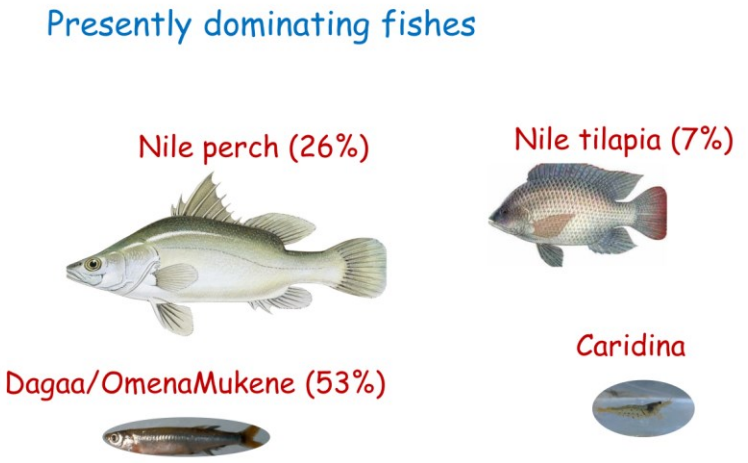
- Average depth = 40 m
- Catchment area of 193,000
- Shared among 3 East African states of Kenya (6%), Tanzania (51%) and Uganda (43%)
- Source of the Nile
- mean annual water temperature of about 25°C.



A Great Lake of the World

Key attributes of Lake Victoria





ecosystem services support >70 million people

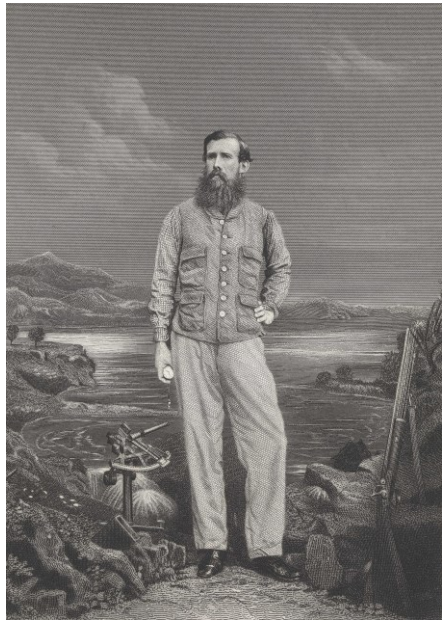
Site of most recent massive vertebrate adaptive radiation and the most recent mass extinction (cichlids)

Annual catch ~ 1 million tons (about 1% of the world's total & 8% of inland capture landings

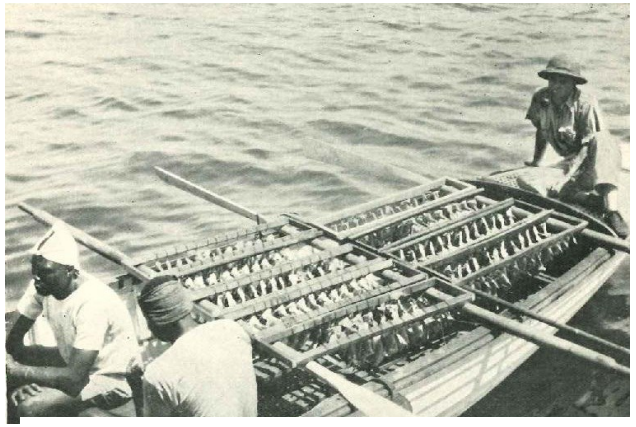
Home to over 600 endemic fish species (cichlids)

Multispecies fishery

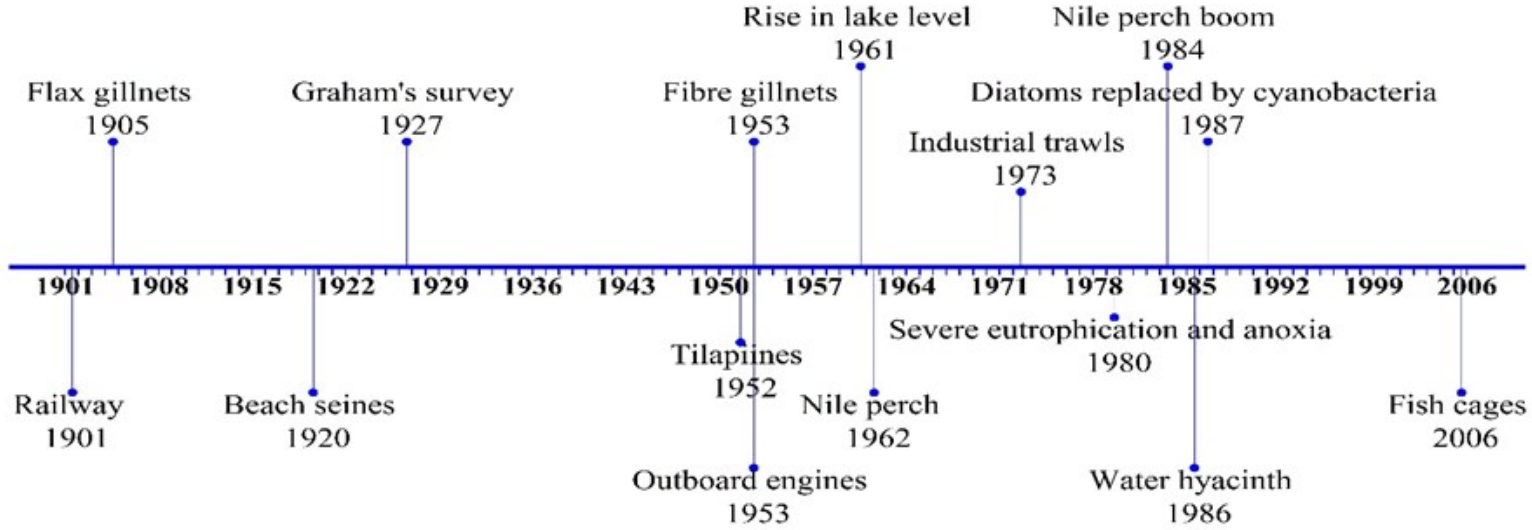
Historical changes in Lake Victoria ecosystem and fisheries



John Hanning Speke
(By S. Hollyer; Southwell Brothers.)
'Discovered' the source of the Nile in 1858



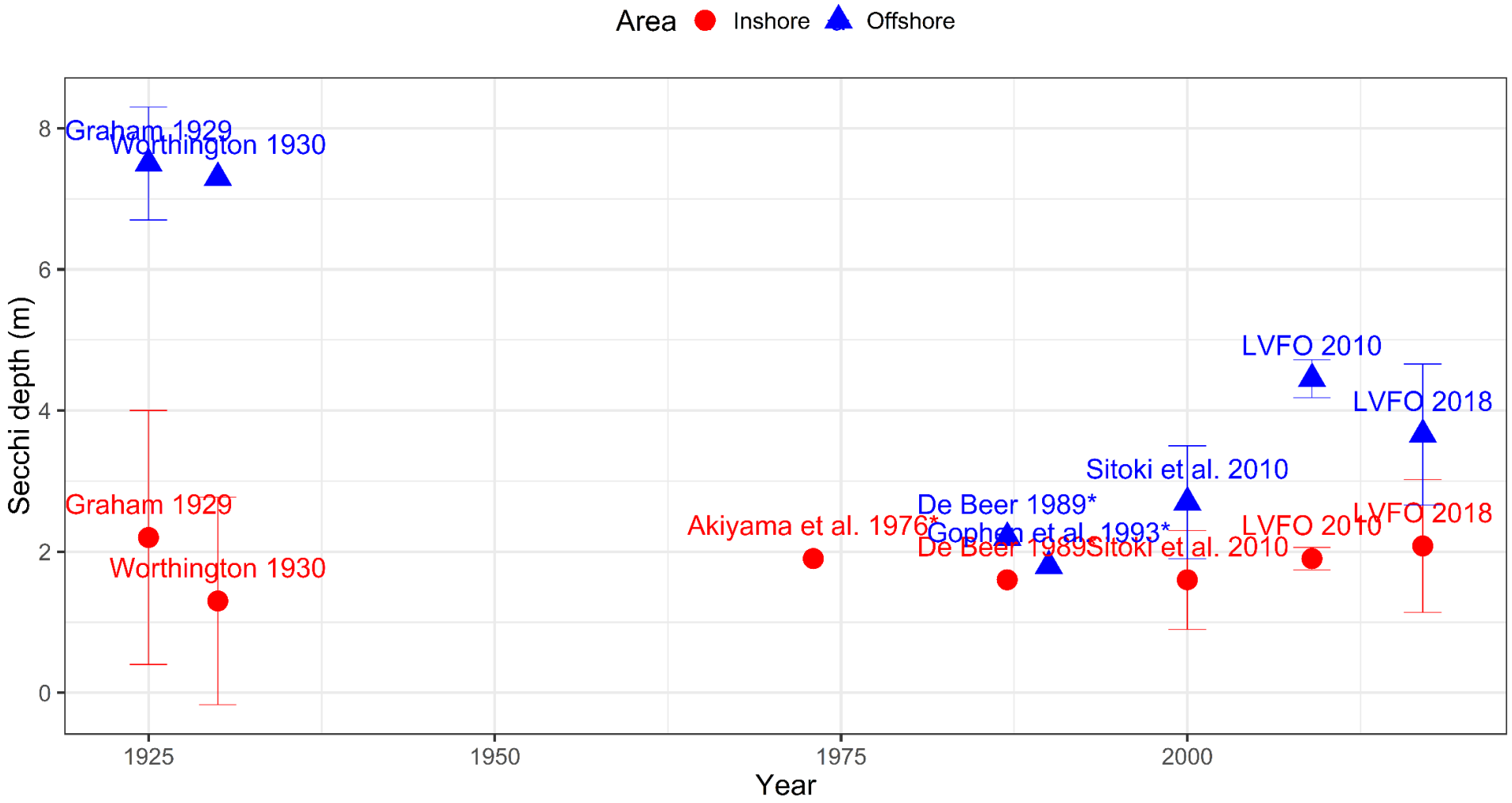
Graham in 1927,
Conducted the first comprehensive socio-ecological survey.
Photo from Cefas



Chronology of events in Lake Victoria since the advent of major infrastructural and industrial developments. (From Nyamweya et al., 2020).

Nyamweya, C.S.,Natugonza, V., Taabu-Munyaho, A., Aura, C.M., Njiru, J.M., Ongore, C., Mangeni-Sande, R., Kashindye, B.B., Odoli, C.O., Ogari, Z., Kayanda, R., 2020. A century of drastic change: Human-induced changes of Lake Victoria fisheries and ecology. Fish. Res. 230, 105564. https://doi.org/10.1016/j.fishres.2020.105564

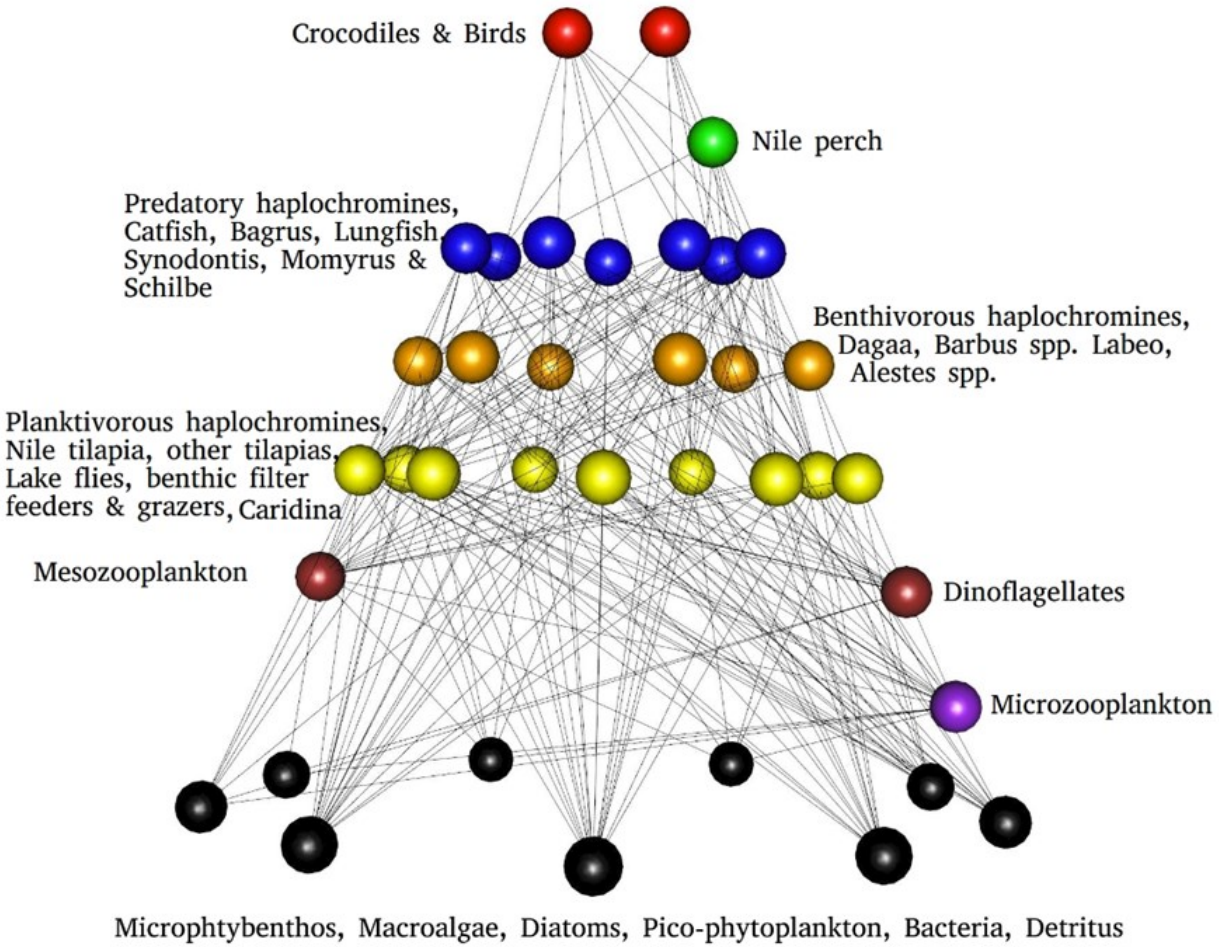
Water transparency



From Nyamweya et al., 2020

Nyamweya, C.S.,Natugonza, V., Taabu-Munyaho, A., Aura, C.M., Njiru, J.M., Ongore, C., Mangeni-Sande, R., Kashindye, B.B., Odoli, C.O., Ogari, Z., Kayanda, R., 2020. A century of drastic change: Human-induced changes of Lake Victoria fisheries and ecology. Fish. Res. 230, 105564. https://doi.org/10.1016/j.fishres.2020.105564

Trophic interactions in Lake Victoria

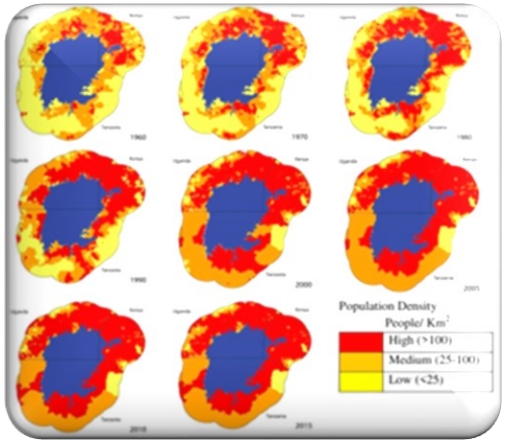


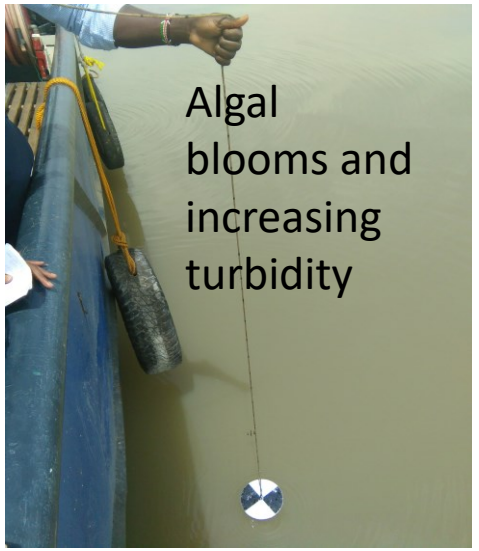
From Nyamweya et al., 2016

Nyamweya, C.S.,Sturludottir, E., Tomasson, T., Fulton, E.A., Taabu-Munyaho, A., Njiru, M., Stefansson, G., 2016. Exploring Lake Victoria ecosystem functioning using the Atlantis modeling framework. Environ. Model. Softw. 86, 158–167. https://doi.org/10.1016/j.envsoft.2016.09.019

Drivers of ecosystem change

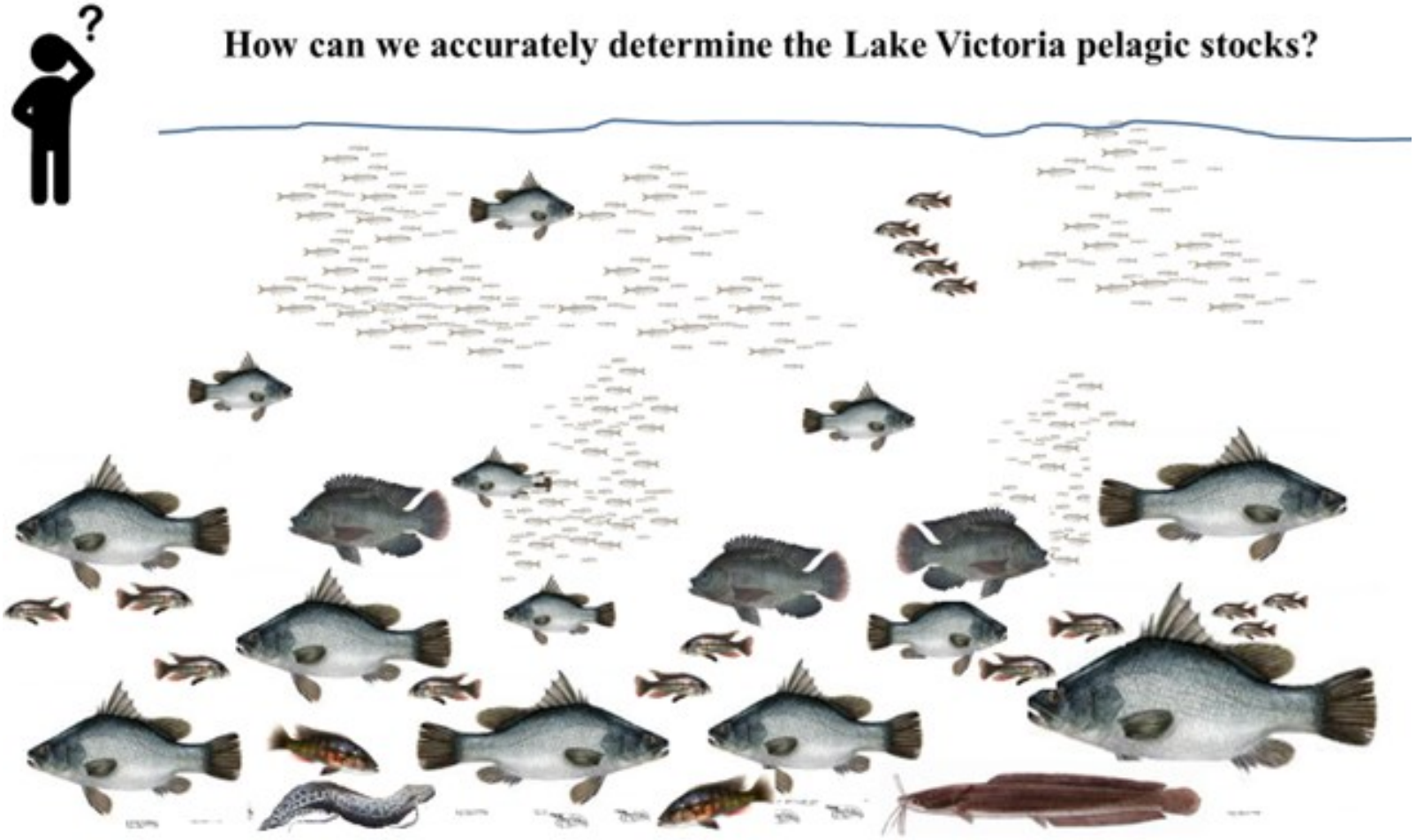
rapid catchment population growth





Macro & microplastics

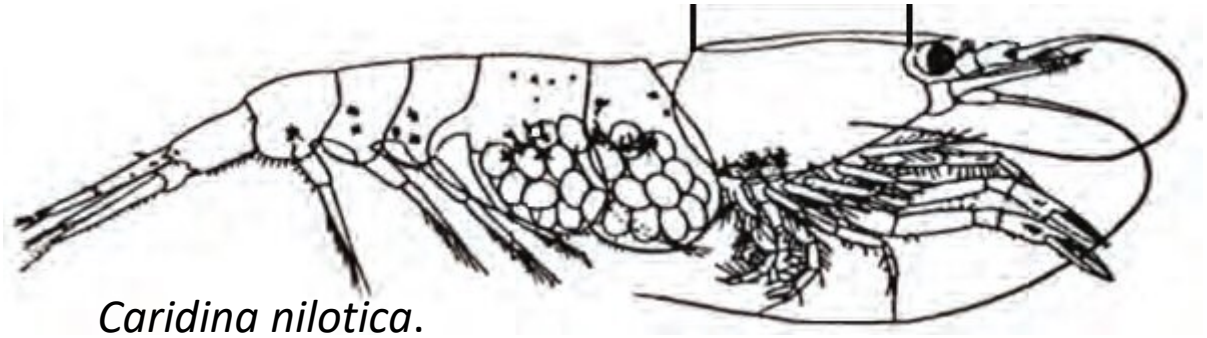
The present task



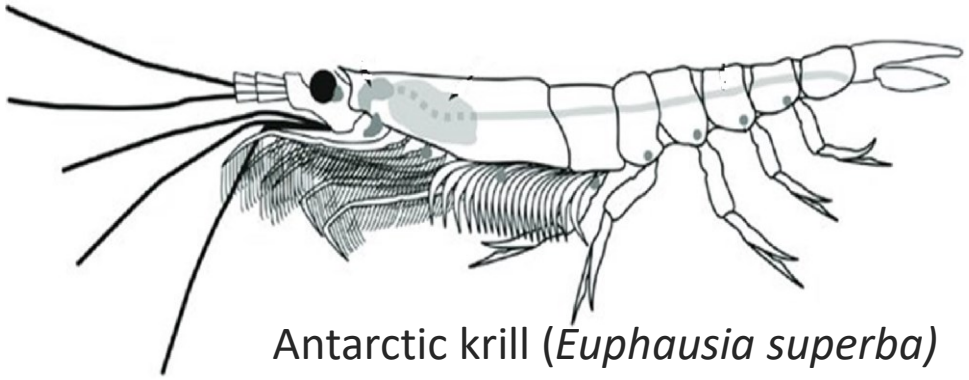
Use of fisheries acoustics data with **improved methods** for estimation of pelagic biomass and interannual variabilities with uncertainties;

- Caridina
- Haplochromines (Cichlids)
- Dagaa (Silver cyprinid)
- Nile perch

Caridina nilotica (Atyidae)

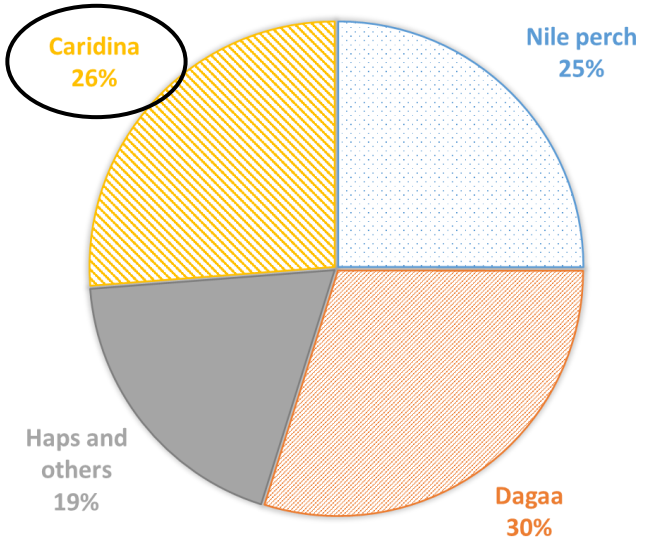


Caridina nilotica.
Diagram adapted from Hart (2001)



Antarctic krill (*Euphausia superba)*
Adapted from Drawing by Marcia Rackstraw

- Mesopelagic and exhibits diurnal vertical migration
- Most abundant at depth strata greater than 40m
- Grows to 25 mm TL
- TS is assumed to be close to the krill Tumwebaze et al (2002)
- Caught as by catch in the Dagaa fishery and previously discarded.
- Commercial exploitation has increased in recent years

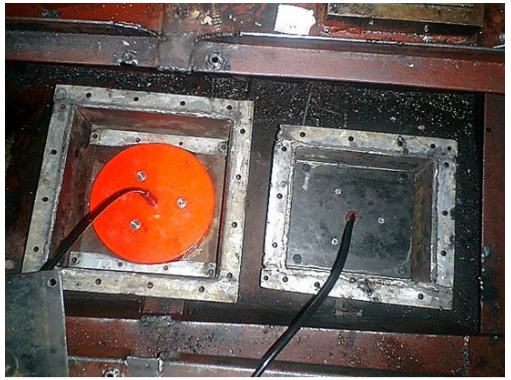


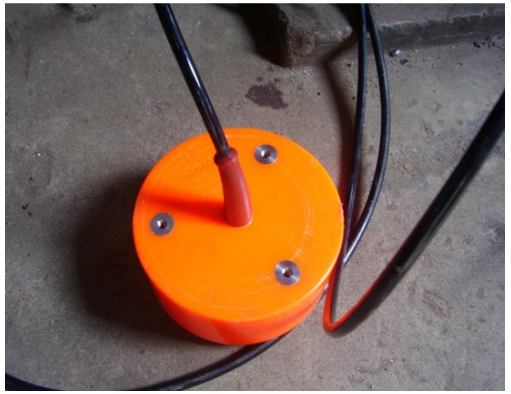
% Composition of the pelagic stocks of Lake Victoria

Hart, R.C., 2001. Rapid estimation of in situ growth rates of Caridina nilotica (Crustacea: Decapoda) in Lake Victoria: Description and pilot application of a simple, field-compatible technique. Limnology and oceanography, 46(3), pp.692-698.

Acoustic equipment

Research Vessel in Lake Victoria



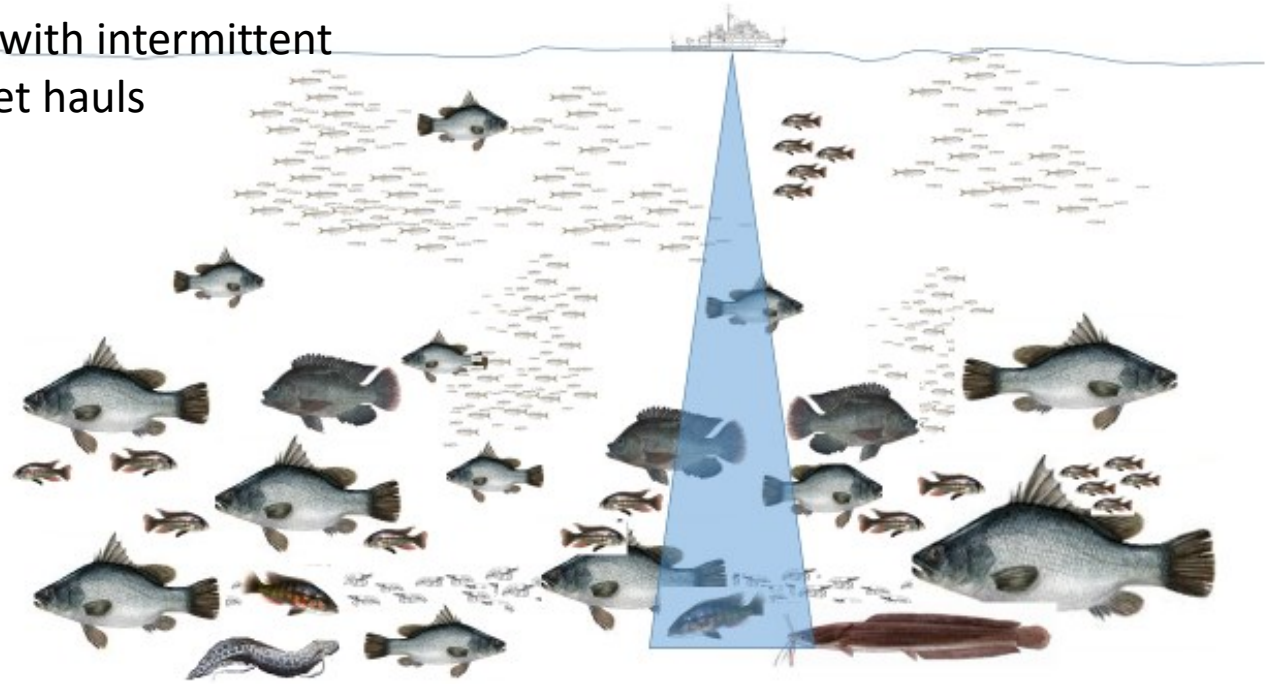


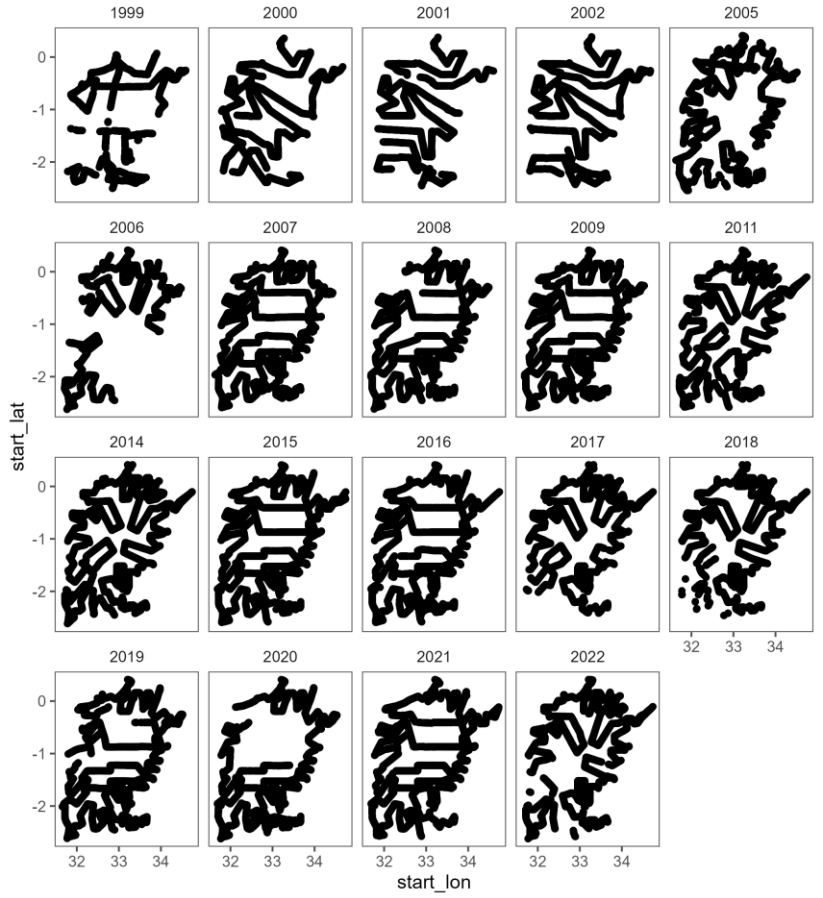
Simrad EK60 General Purpose Transceivers (GPTs)

- Two frequencies hull-mounted on *Victoria Explorer* (70 kHz and 120 kHz)
- 200 kHz mounted in 2020

The approach

Acoustic pings along track through predetermined transects with intermittent bottom net hauls



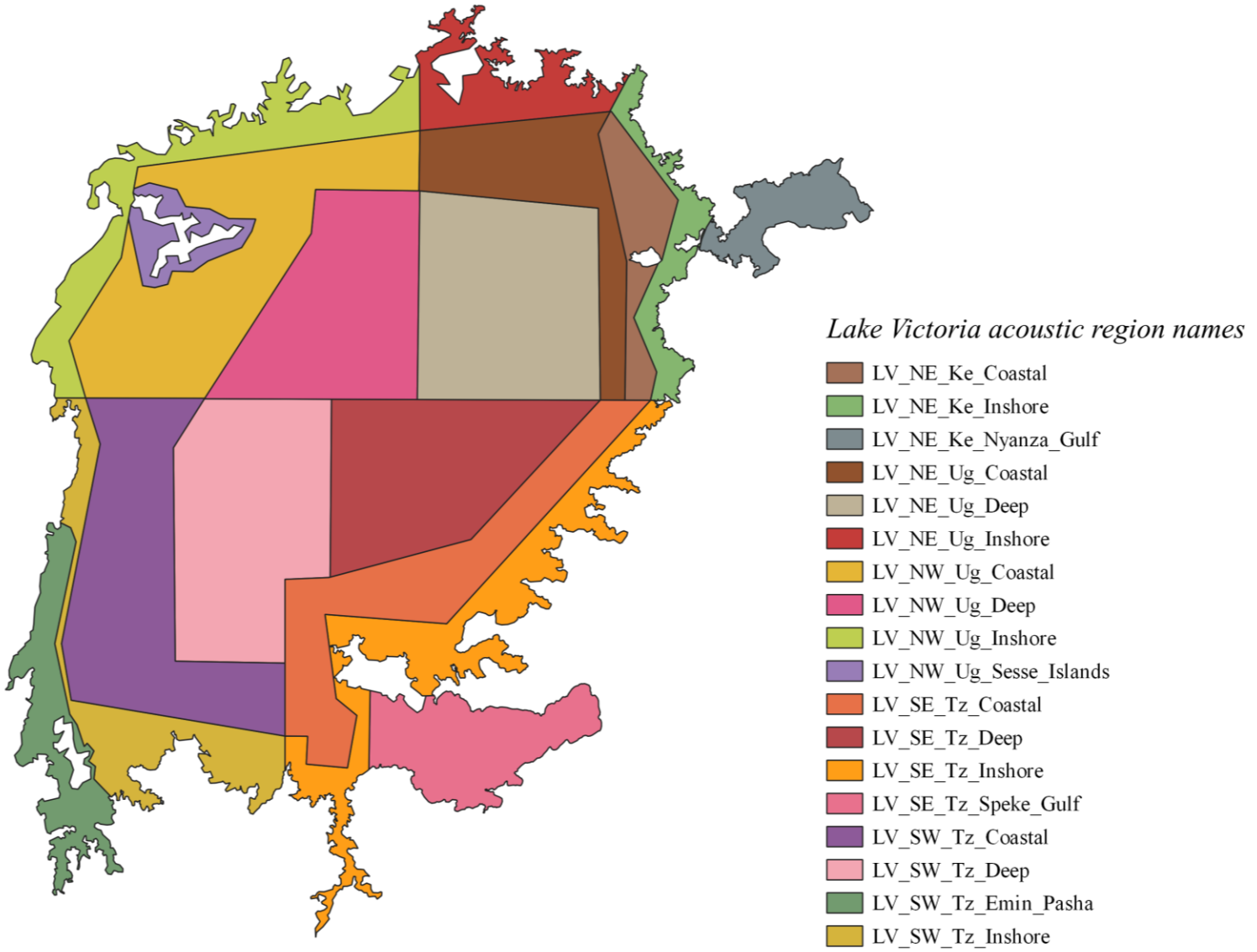


Plotted cruise tracks of L. Victoria Fisheries acoustics since 1999

The acoustic regions

- We have compartmentalized the like into ‘Acoustic Regions) following Quadrants, country boundaries, and depth strata

  These are Factors that influence the temporal and special distribution of pelagic stocks



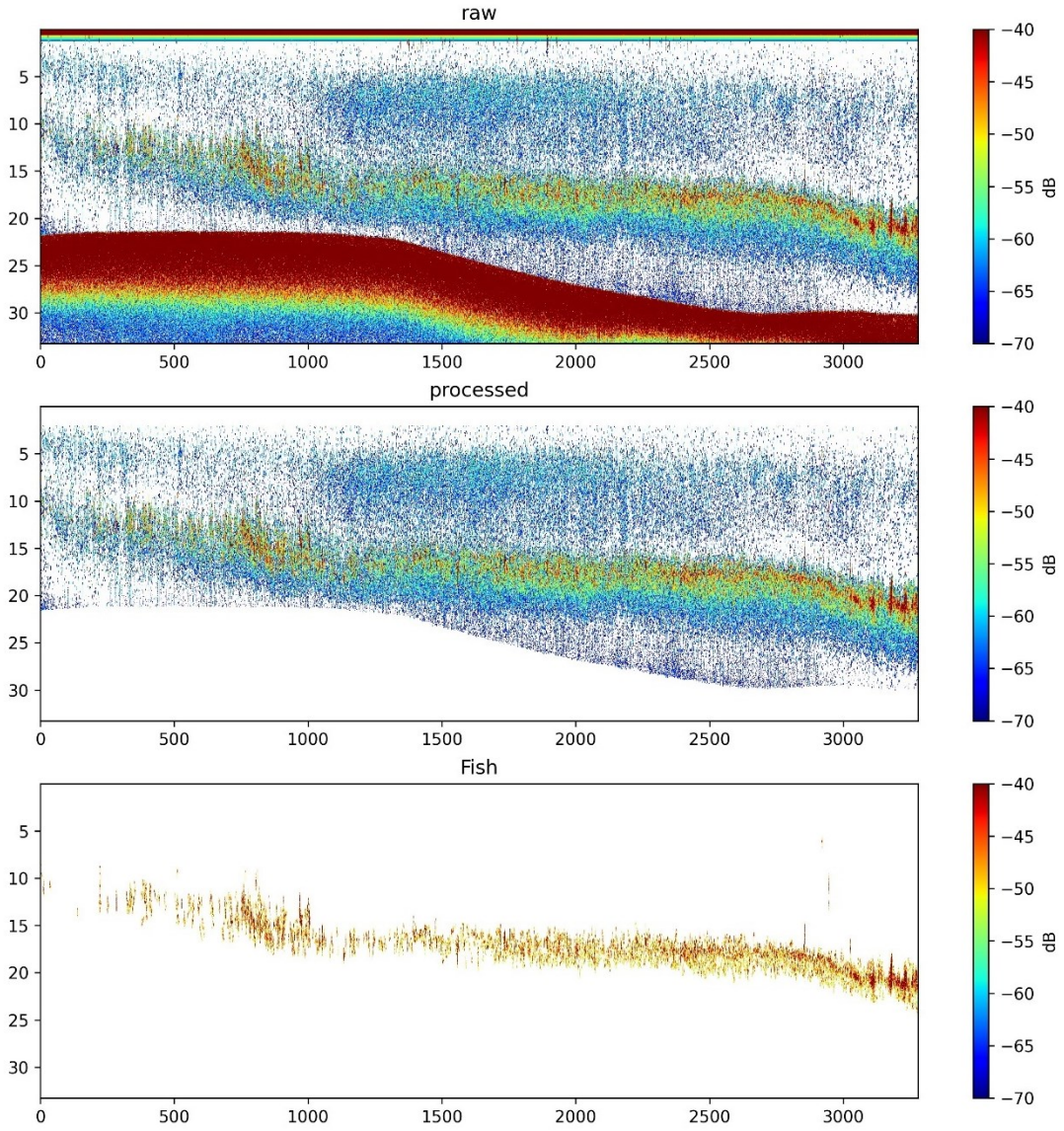
Data processing

The data was processed by reading the raw files into Python and running the 'echopype' Python package for

- data calibration,
- noise removal,
- bottom detection and exclusion, and
- dB diffrencing

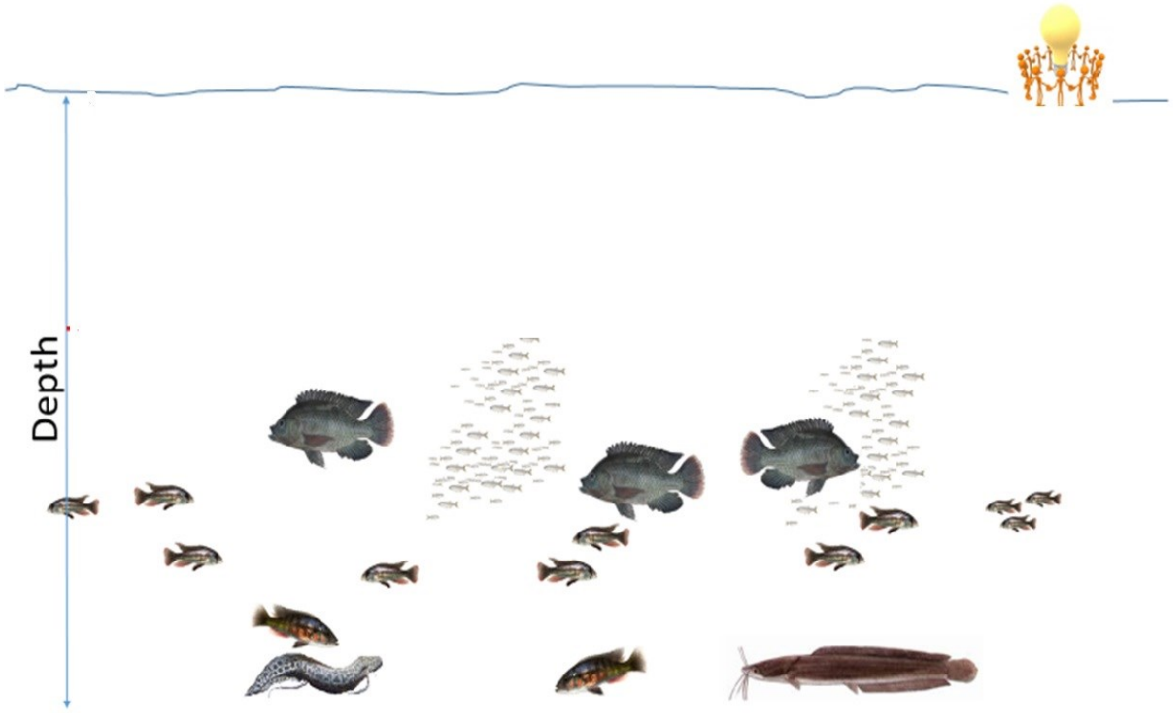
- The Caridina NASC = instances where the Sv differences 120-70 kHz data = -5 and -10 dB

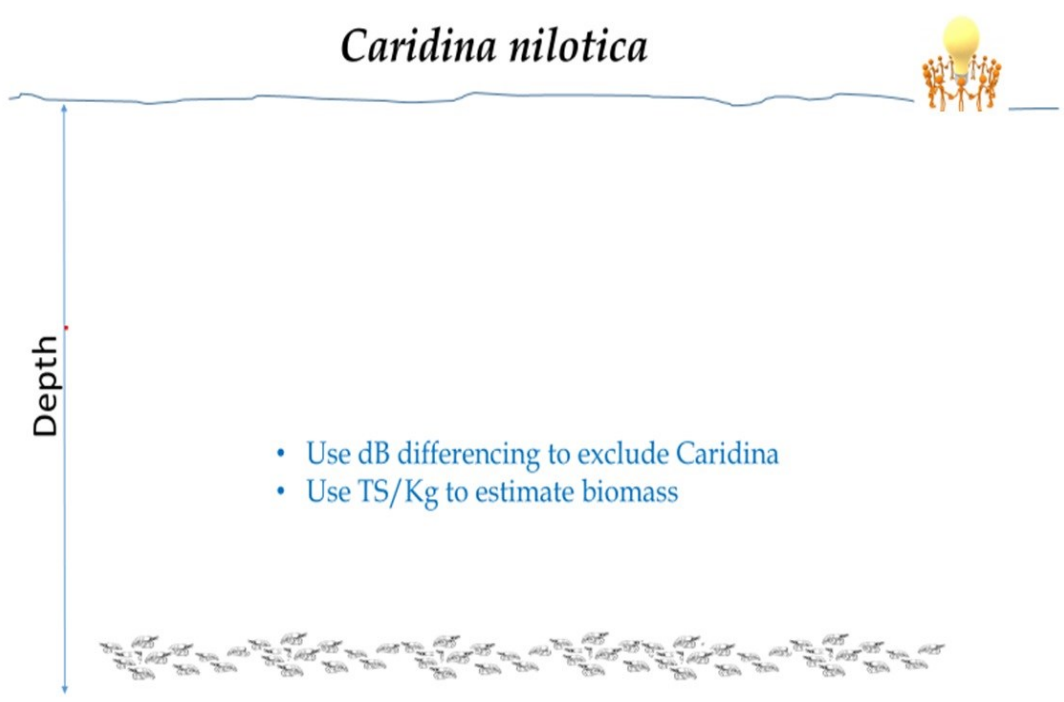
- The Sv values from the 120 kHz transducer in those layers accepted as Sv values due to *Caridina*.



Echograms illustration of the data processing

Db differencing between 70 kHz and 120 kHz



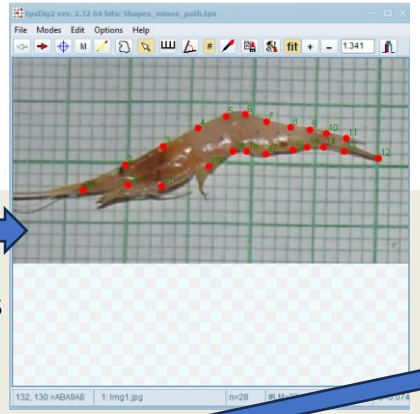


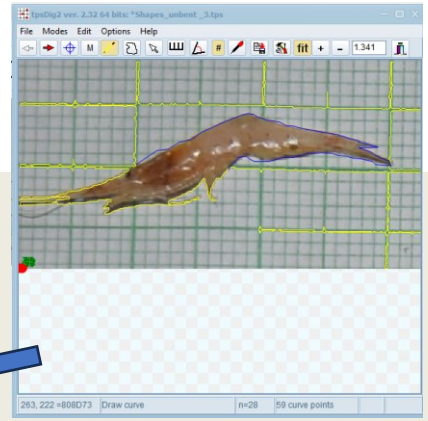
The Caridina TS Model

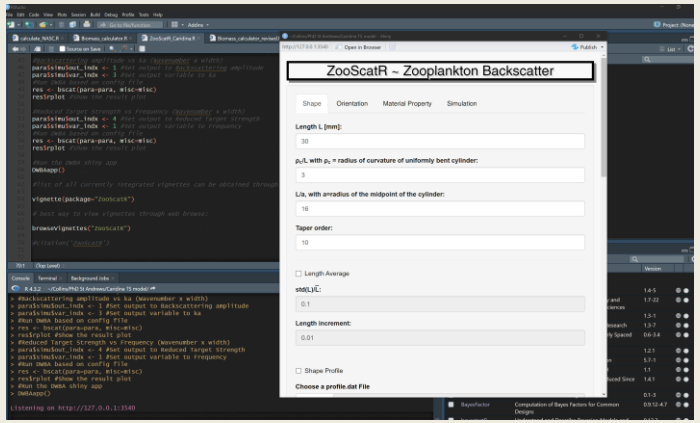
The approach follow the method proposed and applied by Bairstow et al. (2021)

Images of Caridina were used to collect landmarks using TPs Dig software.

The landmarks were transformed into coordinates using TPS config software







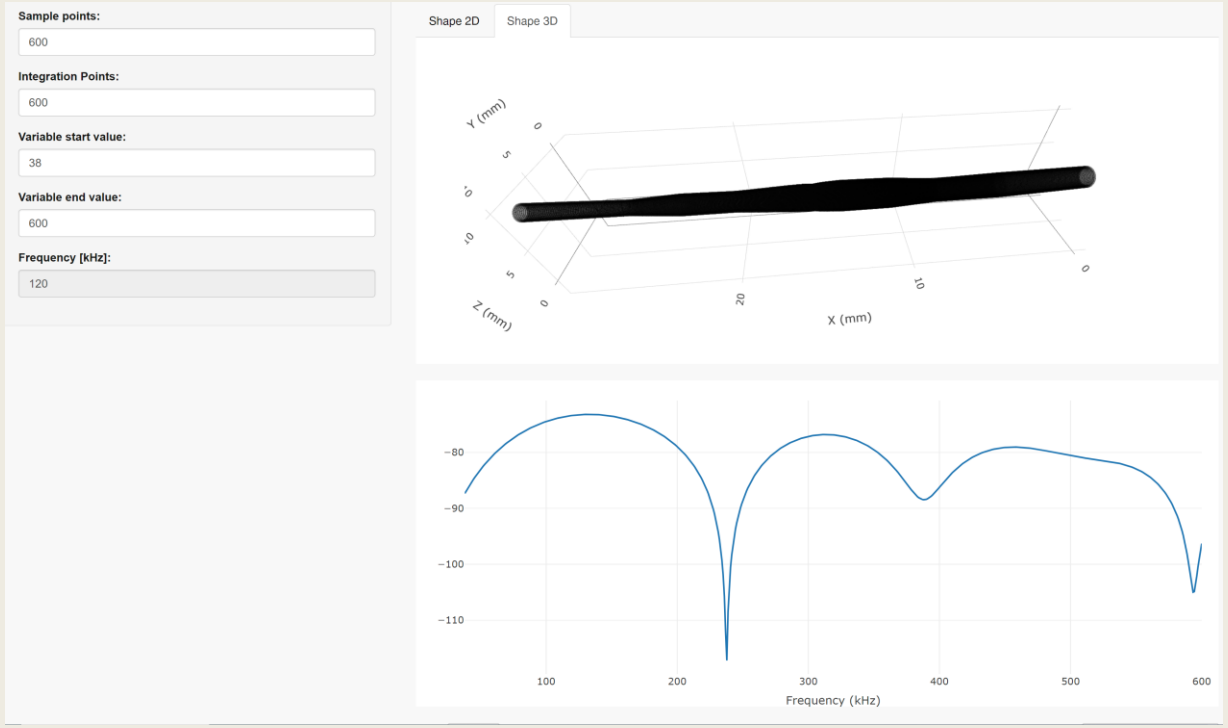
ZooScatR-master using the shapes profile applied to plot the TS model

Correct input of sound speed and material characteristics ensured

Consensus based Distorted wave Born approximation (DWBA) model was used to derive the TS for Caridina

Results

Results of the Caridina DWBA model



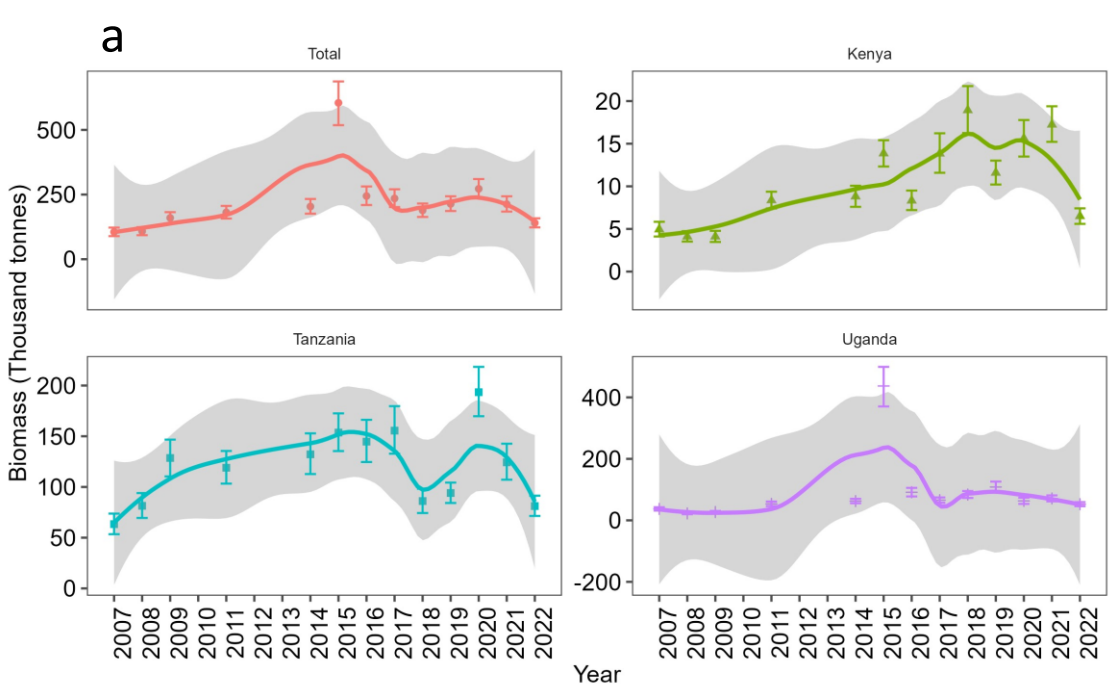
The *Caridina* TS estimation for the 120-70 kHz using the Distorted wave Born approximation (DWBA) model

A *Caridina* TS of -84.1 was derived and applied in the biomass calculations

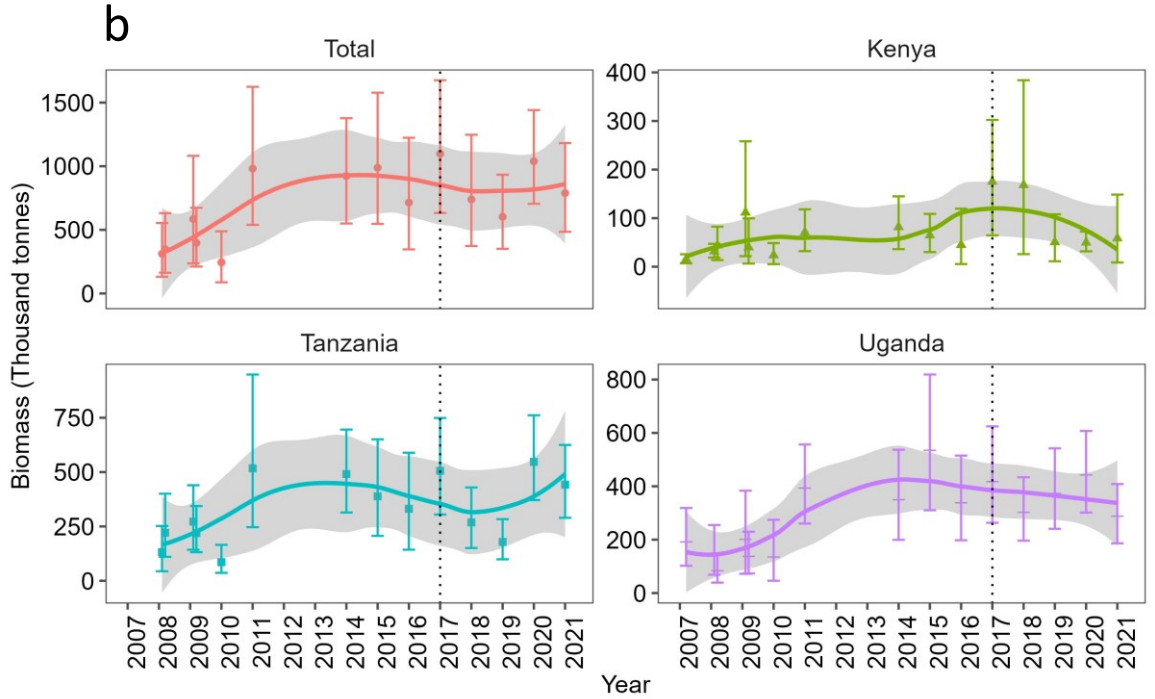
The *Caridina* TS model for the 120-70 kHz

	SL	70 kHz	120 kHz	dB difference (120 70
	11	-102	-93.6	8.4
	12	-99.8	-91.5	8.3
	13	-97.8	-89.7	8.1
	14	-96	-88.1	7.9
	15	-94.3	-86.6	7.7
	16	-92.7	-85.3	7.4
	17	-91.3	-84.1	7.2
	18	-89.9	-83	6.9
	19	-88.7	-82.1	6.6
	20	-87.5	-81.2	6.3
	21	-86.4	-80.4	5.9
	22	-85.3	-79.8	5.5
	23	-84.3	-79.2	5.1
	24	-83.4	-78.7	4.7
	25	-82.5	-78.3	4.2
Average	18	-90.7933	-84.1067	6.68

Interannual biomass estimates with CI



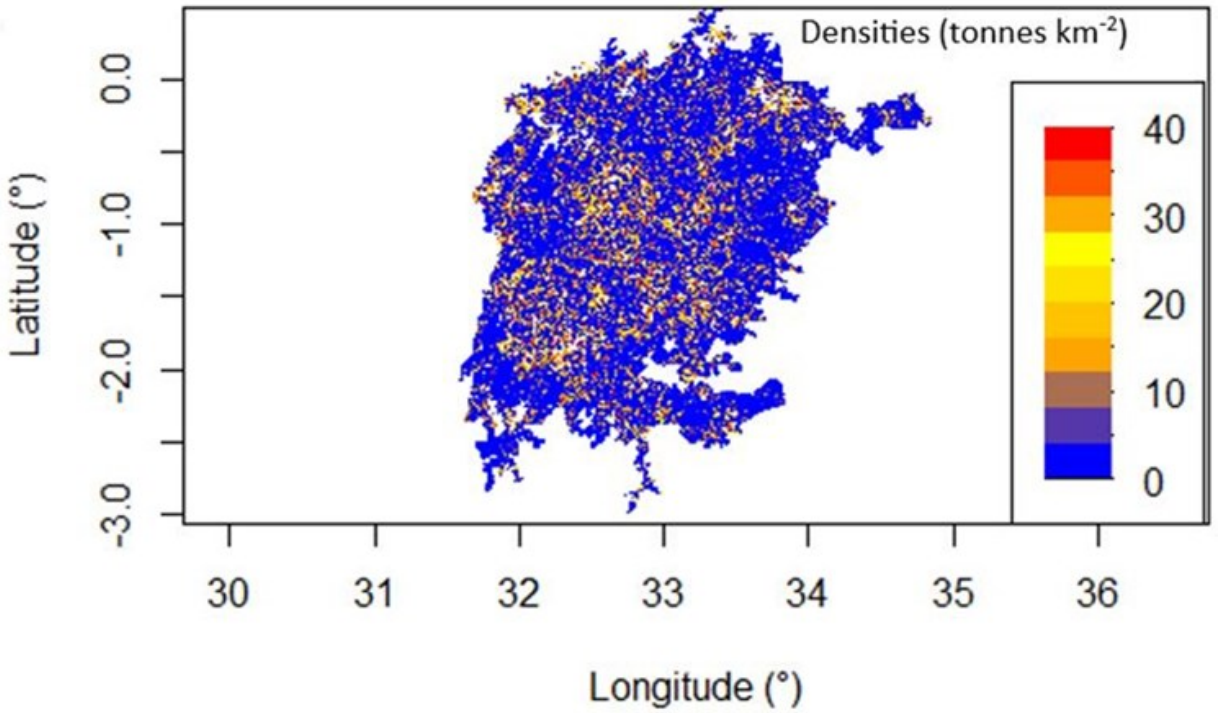
a. Biomass trajectories predicted using the current method



b. Biomass trajectories predicted using the old method

- Generally lower biomass was estimated with reduced uncertainties compared to the previous trajectories
- It depicts a general rise in the biomass of Caridina

Spatial occurrence of Caridina in 2022

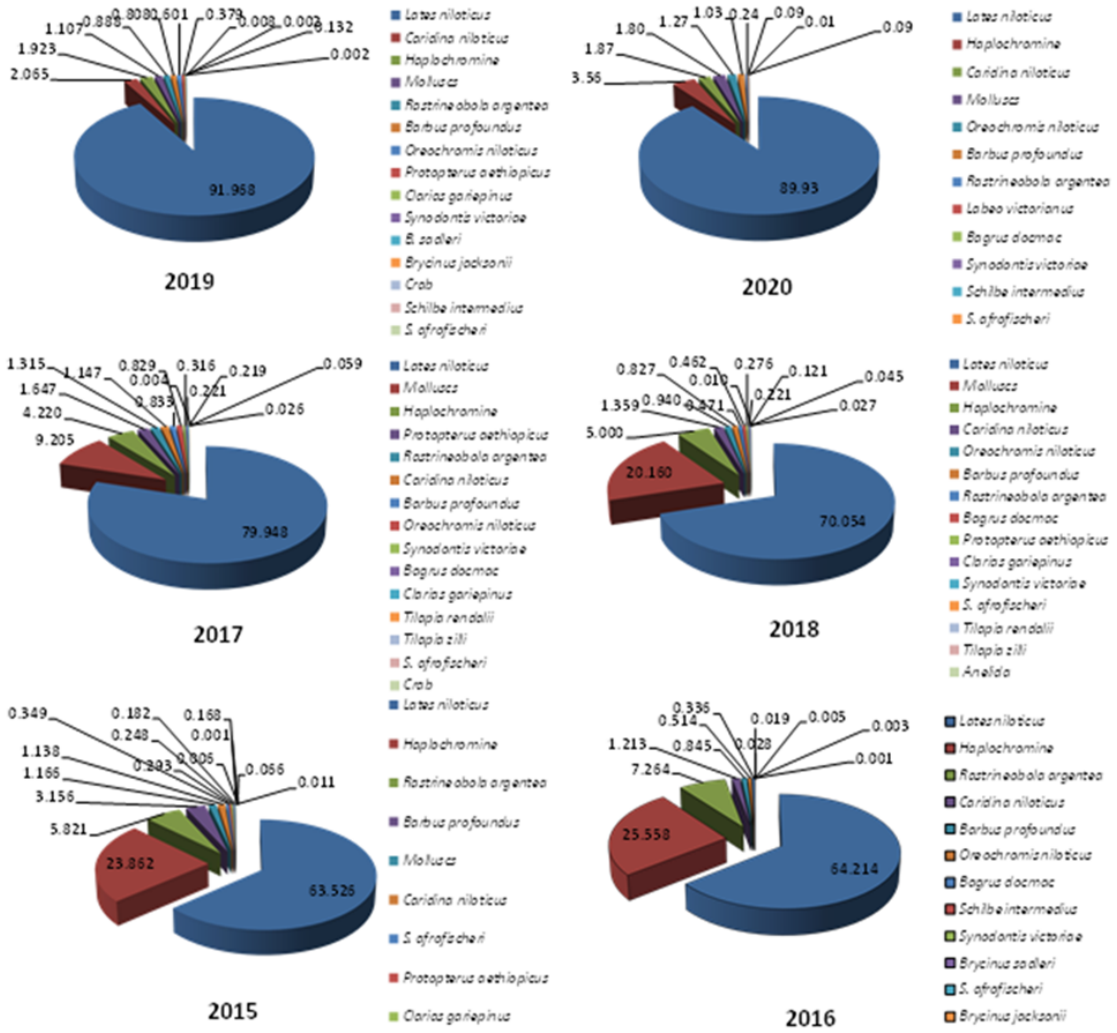


Heat map of the 2022 *Caridina* densities derived from kriging interpolation of the nautical interval data

Time series of the bottom trawls

Bottom trawl Catch composition for the survey period of 2015-2020.

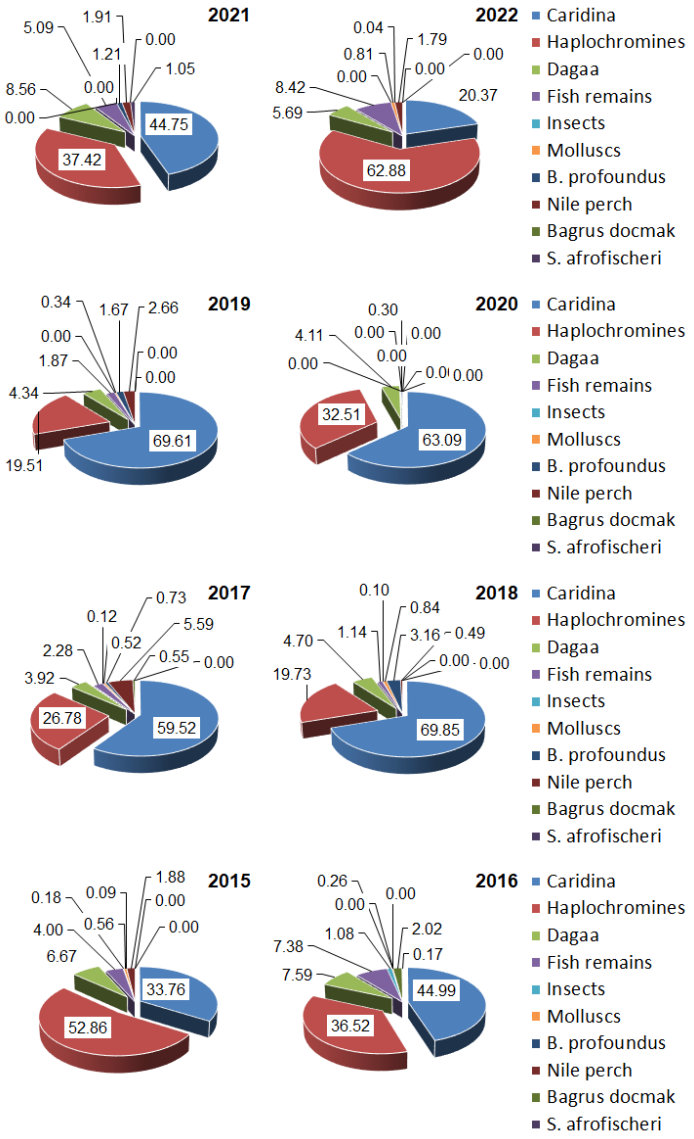
- The catch composition data is useful in explaining the acoustically observed fish densities.
- The dominant fish in the catch throughout the years is Nile perch (*Lates niloticus*) at above 60% in all the years
- Catches of *Caridina* increased from o.83% in 2015 to 2.065% in 2019 with a slump in 2020 at 1.87%



Cardina dominates as the Nile perch's prey

Nile perch, *Lates niloticus* is the top predator that also exhibits otogenic shifts for its prey, but prefers the haplochromines over other prey.

Despite that, *C. nilotica* is still the predominant prey in its diet from the biological samples collected during the acoustic surveys



Percentage contribution of different prey items to the diet of *Lates niloticus*

Key observations

- There has been a gradual increase in the Caridina biomass over time
- The dramatic drop in between 2017 and 2018 could be attributed to drastic enforcement measures at adopted by Uganda and Tanzania at the time that led to significant increase in population of Nile perch (predator)
- There's evidence that the present methods have contributed to reduction of uncertainties in biomass prediction
- *Caridina* productivity is so compulsive and resilient to increased predation and harvesting pressure

Next steps:

1. Geostatisticsal approach to map the spatial occurrences
2. Completion of the estimates of the biomass of the other pelagic stocks
3. Input of the biomass estimate data into ecosystem models to derive the best management scenarios

Thank you!

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