Metagenomic Time Series of Winam Gulf, Lake Victoria from 2022-2023 (ASI Lake Victoria project)

Website: https://www.bco-dmo.org/dataset/931936
Data Type: Cruise Results
Version: 1
Version Date: 2024-07-09

Project
» IRES Track II: Advanced studies institute on water quality and harmful algal blooms in Lake Victoria (ASI Lake Victoria)

Contributors	Affiliation	Role
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Abstract
Compared to the other "Great Lakes" (Laurentian Great Lakes of North America and Lake Baikal of Russia) the African Great Lakes have remained widely unstudied. This serves as a substantial research gap within the limnological literature given the African Great Lakes contribute approximately 25% of all global, accessible freshwater. Lake Victoria of the African Great Lakes is notable for its large size - serving as the second largest freshwater lake in the world by surface area. Yet, Lake Victoria is also known for the prolific year-long cyanobacterial blooms that occur throughout her waters such as the Winam Gulf. These blooms are fueled by intense agricultural and anthropogenic development much like other freshwater harmful algal blooms. However, unlike other freshwater blooms such as those occurring in Lake Erie and Lake Taihhu - these cyanobacterial blooms have remained widely uncharacterized (especially using molecular techniques). The central study area is the Winam Gulf of Lake Victoria, Kenya. This is a relatively shallow, hypereutrophic system that has various rivers serving as nutrient loading sources (such as the Sondu River). This dataset also contains opportunistic samples collected from a variety of riverine systems and Lakes Simbi and Naivasha. Here, we present the biological, chemical and physical data corresponding to a two year metagenomic time series of the Winam Gulf, Lake Victoria. We further present the physiochemical data of eight outgroup samples including adjacent riverine systems and Lakes Simbi and Naivasha.

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Coverage

Location: Winam Gulf, Lake Victoria
Spatial Extent: **N**:-0.0623 **E**:36.425 **S**:-0.7586 **W**:34.03812
Temporal Extent: 2022-06-24 - 2023-06-03

Methods & Sampling

Water samples were collected from Lake Victoria were depth discrete (1.0 meters) collections performed using a Van Dorn sampler. Samples were collected on 0.22 micron sterivex filters for subsequent DNA extraction and stored at room temperature in DNA/RNA Shield (Zymo). Concurrently, a multiparameter sonde was deployed to record temperature, pH, dissolved oxygen, conductivity, turbidity etc. In addition, sterivex filtrate was collected and stored at -20 degrees Celsius for subsequent dissolved nutrient analysis at the Ohio State Stone Laboratory.

In turn, samples were collected for chlorophyll a and processed using a 24 hour 90% acetone extraction performed at -20 degrees Celsius followed by quantification using a fluorometer. Samples for toxin analysis (microcystin) were collected and stored at -20C until processing using standard ELISA kits.

In situ analysis was performed with a field Algae Torch (bbe Moldaenke) fluorometer, which was equipped with chlorophyll a and phycocyanin probes. We collected data in the form of cells per liter by lowering the fluorometer into the water column at the same depths where water samples were collected. We then converted the data to percentages to determine the relative abundance of cyanobacteria in the context of the full phytoplankton community (Brown, et al. 2024).

The toxin data was collected and processed as follows: whole water samples were collected at the designated sample depth (refer to the “Sampling_depth” column within the primary data file of this dataset) and lysed using three freeze / thaw cycles. The lysate was investigated for the presence of the cyanobacterial toxin / secondary metabolite “microcystin” using the Microcystins/Nodularins (ADDA) ELISA kit (Gold Standard Diagnostics, Warminster, PA) (Brown, et al. 2024). Absorbance was read at 450 nm on a Multiskan FC Microplate Photometer (Thermo Fisher Scientific Inc).

Data Processing Description

In the data file, "NA" values are not applicable because that type of data was not collected for that site. The same equipment was not readily available at each site or each year.

If the analysis was run for a sample but no "data" could be detected (meaning it read "too low to detect" or some on-numerical output indicating a negative result), this is indicated by "ND" values in the primary data file (meaning not detected).

BCO-DMO Processing Description

- Changed date format from %M/%D/%Y to %Y-%M-%D
- Removed units from parameter names
- Replaced special characters in parameter names with underscores ("_") (e.g. "TN:TP" renamed "TN_TP_ratio"; "Algal_Torch_%_cells_cyano" renamed "Algal_Torch_percentage_cells_cyano"

Problem Description

Due to logistical limitations - not all the measurements performed in 2022 could be repeated in 2023. Hence, there exists some discontinuity/gaps in the time series.

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Data Files

File
931936_v1_Winam_Gulf_metagenomic_time_series.csv (Comma Separated Values (.csv), 19.07 KB) MD5:dfafe96a96b20b1b561ba3814c5f1a4d Primary data file for dataset ID 931936, version 1

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Related Publications

Brown, K. M., Barker, K. B., Wagner, R. S., Ward, C. S., Sitoki, L., Njiru, J., Omondi, R., Achiya, J., Getabu, A., McKay, R. M., & Bullerjahn, G. S. (2024). Bacterial community and cyanotoxin gene distribution of the Winam Gulf, Lake Victoria, Kenya. Environmental Microbiology Reports, 16(3). Portico. https://doi.org/10.1111/1758-2229.13297
Methods

Hart, L.N., Zepernick, B.N., Natwora, K.N., Brown, K.M., Obuya, J.A., Lomeo, D., Barnard, M., Owino, E., 2022-2023 NSF-IRES Lake Victoria Research Consortium, Kiledal, E. A., Uyl, P.D., Olokotum, M., McKay, R. M. L., Drouillard, K.G., Sherman, D.H., Sitoki.L., Achiya, J., Getabu, A., Otiso, K.M., Bullerjahn, G.S., Dick, G.J., (2024 in prep). Metagenomics Reveals Temporal Variation in Cyanobacterial Composition, Function, and Biosynthetic Potential in the Winam Gulf, Lake Victoria, Kenya.
Results

Zepernick, B.N., Hart, L.N., Chase, E.E., Natwora, K.N., Obuya, J.A., Olokotum, M., Houghton, K., Kiledal, E. A., 2022 NSF-IRES Lake Victoria Research Consortium., Sheik, C.S., Sherman, D.H., Dick, G.J., Wilhelm, S.W., Sitoki, L., Otiso, K.M., McKay, R. M. L., Bullerjahn, G.S., (2024 in prep). Molecular investigation of toxigenic cyanobacteria reveals risks and niche partitioning in three anthropogenically and ecologically important Kenyan lakes.
Results

Zepernick, B.N., Hart, L.N., Natwora, K.N., Brown, K.M., Obuya, J.A., Olokotum, M., Owino, E., Keating, N.G., Lomeo, D., Tebbs, E.J., 2022-2023 NSF-IRES Lake Victoria Research Consortium, Sheik, C.S., Sherman, D.H., Dick, G.J., Wilhelm, S.W., Sitoki, L., Otiso, K.M., McKay, R. M. L., Bullerjahn, G.S., (2024 awaiting submission). Metagenomic Sequencing of Cyanobacterial-Dominated Lake Victoria - an African Great Lake.
Results

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Parameters

Parameter	Description	Units
Library_ID	Label the raw sequence library is listed as on the NCBI Sequence Read Archive.	unitless
Site_Name	The site number and name assigned to the sample site by the captain during that survey.	unitless
Replicate_id	The biological replication ID.	unitless
SampleID	Raw sequence sample ID assigned by sequencing core.	unitless
StudyID	Raw study ID assigned by the sequencing core.	unitless
Sample_type	Type of bioinformatic analysis sample was sequenced for.	unitless
Lake_or_river	The name of the lake or river the sample was collected from.	unitless
Lat	Latitude coordinates of sample site in decimal degrees; a positive value indicates a Northern coordinate.	decimal degrees
Lon	Longitude coordinates of sample site in decimal degrees; a negative value indicates a Western coordinate.	decimal degrees
Collection_date	The date the sample was collected.	unitless
Env_broad_scale	Environment sample corresponds to broadly and corresponding ID.	unitless
Site_depth	The maximum depth of the water column.	meters (m)

Sampling_depth	The depth at which the sample was collected in the water column.	meters (m)
Preservation	Type of preservation sample was subjected to for later DNA extraction.	unitless
Filter_size	The size of the sterivex filter that was used to collect the water sample.	um
pH	The pH (in negative log of hydrogen ions).	unitless
Temp	Temperature of the water column.	degrees C
Nitrate	Dissolved nitrate concentration in water sample.	ug / L
Diss_oxygen	Dissolved oxygen concentration in the water column.	mg / L
Conductivity	Conductivity of the water column.	uS / cm
Secchi	Measure of water transparency.	meters
Turbidity	Measure of water transparency / cloudiness.	NTU
Microcystin	Concentration of cyanobacterial toxin - particulate microcystin - in water column.	ug / L
TN_TP_ratio	Ratio of total particulate nitrogen to total particulate phosphorus in the water column .	unitless
Chlorophyll_a	Measurement of total chlorophyll a concentration in the water column (greater than 0.22 __m size).	ug / L
Total_phosphorus	Total particulate phosphorus concentration in the water column.	ug / L
Dissolved_phosphorus	Dissolved phosphorus concentration in the water column.	ug / L
Soluble_reactive_phosphorus	Dissolved soluble reactive phosphorus concentration in the water column.	ug / L
Ammonia	Dissolved ammonia concentration in the water column.	ug / L
Nitrate_Nitrite	Dissolved nitrate + nitrite concentration in the water column.	umol / L
Nitrite	Dissolved nitrite concentration in the water column.	umol / L
Silicate	Dissolved silicate concentration in the water column.	umol / L
Total_nitrogen	Total particulate nitrogen concentration in the water column.	umol / L
Total_dissolved_nitrogen	Total dissolved nitrogen concentration in the water column.	ug / L
Weather	Weather observations during sample collection.	unitless
Wave_height	Wave height in body of water.	meters
Wind_speed	Wind speed at time of sample colelction.	knots
Salinity	Salinity of the water column.	g / kg
Atmospheric_temperature	Temperature of the air.	degrees C
Particulate_cylindrospermopsin	Concentration of cyanobacterial toxin - particulate cylindrospermopsin - in water column.	ng / mL
ORP	Oxidation-Reduction Potential of water column.	mV
Algal_Torch_cyano_sonde	Concentration of cyanobacterial cells (those possessing phycocyanin pigment) in the water column.	cells / L
Algal_Torch_sonde_total_cells	Concentration of all photosynthetic cells (those possessing chlorophyll a) in the water column.	cells / L
Algal_Torch_percentage_cells_cyano	Percentage of cyanobacteria cells compared to the entire photosynthetic community.	unitless

Site_Description	Additional sample site descriptors that have regional or ecological context.	unitless
Station_observations	Additional sample site descriptors that have regional or ecological context.	unitless
Site_Classification	Additional sample site descriptors that have regional or ecological context.	unitless
Notes	Further observations made that correspond to data interpretation or would be of use to researchers (including those who collaborated on this project).	unitless

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Project Information

IRES Track II: Advanced studies institute on water quality and harmful algal blooms in Lake Victoria (ASI Lake Victoria)

Website: https://www.agl-acare.org/bgsu-habs

Coverage: African Great Lakes (Lake Victoria, Kenya)

NSF Award Abstract:
The North American and African Great Lakes are vital global freshwater resources. These lakes contain nearly half of the world's available surface fresh water and therefore the security and health of these lakes is critically important especially as freshwater supplies continue to dwindle globally. One of the most prevalent concerns is human-influenced nutrient (nitrogen and phosphorus) pollution that causes a phenomenon known as a harmful algal bloom. Harmful algal blooms are overgrowths of algae that can have negative impacts to the environment and/or the health of humans, pets or cattle due to the toxic compounds that can be produced. Freshwater harmful algal blooms have become more prevalent worldwide over the past few decades. They occur in lakes, ponds, rivers and reservoirs across all 50 states and in many of the world's most socioeconomically-important waterbodies. Lakes Victoria (African Great Lake) and Erie (North American Great Lake) are the 3rd and 11th largest lakes by surface area and both have regions that are plagued by toxic harmful algal blooms. Western Lake Erie and Kisumu Bay, Nyanza Gulf, Lake Victoria are similar in that they are both shallow systems that experience heavy nutrient pollution, which results in annual Microcystis-dominated toxic harmful algal blooms. However, they are different in that Lake Erie is a temperate system dominated by agricultural nutrient pollution, whereas Kisumu Bay is a tropical system that receives a mixture urban and agricultural nutrient pollution. While much is known about the ecology of the Microcystis-dominated blooms in western Lake Erie, little is known about the ecology, spatial distribution and toxicity patterns of the Microcystis-dominated harmful algal blooms in Kisumu Bay. The Advanced Studies Institutes will provide US graduate students the opportunity to expand their research on water quality and harmful algal blooms in Lake Erie to Lake Victoria. Their research will help fill critical knowledge gaps on the similarities and differences between the blooms that occur in each lake to help us better understand the ecological strategies that Microcystis uses to be able to form blooms in fresh waters across the globe. Furthermore, the graduate students will have the opportunity to learn about Kenyan culture and begin to develop their international collaborations by conducting joint research projects with their Kenyan peers and mentors.

Earth's surface fresh waters, including the Laurentian and African Great Lakes, are under assault from multiple stressors. One of the most prevalent concerns is increased anthropogenic nutrient pollution into these waters leading to many negative effects including harmful algal blooms. Under these conditions, cyanobacteria, commonly referred to as blue-green algae, can grow to dense concentrations in fresh waters across the globe forming what are known as cyanobacterial harmful algal blooms (cyanoHABs). Many cyanoHABs can produce toxins that can sicken or kill humans, cattle and other domestic animals. Indeed, in the last decade major cities in China, the United States, Africa and other parts of the globe have suffered from impaired drinking water due to cyanoHABs. Notably, many of these events are dominated by a single cyanoHAB-forming genus, Microcystis spp. This is important since Microcystis–dominated cyanoHABs form in lakes in temperate to tropical latitudes. Therefore, Microcystis must be able to adjust its ecological strategies to maintain dominance in lakes transcending major latitudinal boundaries. Lake Victoria (Africian Great Lake) and Lake Erie (Laurentian Great Lake) are two socioeconomically-important systems that have regions (Nyanza Gulf, Kenya and western Lake

Erie, respectively) that experience annual toxic cyanoHABs dominated by Microcystis. As such, they are ideal comparative sites to study the differences in ecological strategies employed by Microcystis in a tropical and temperate system. The proposed Advanced Study Institutes (ASIs) will provide the opportunity for 10 US graduate students per year (30 US graduate students total) to participate; each ASI will have the duration of three weeks. Each ASI will include lectures by US and Kenyan scientists, two 5-day research cruises, followed by laboratory analysis of samples. Every US student will be teamed with a Kenyan graduate student who has a mutual research interest. The student teams will collaborate with their US and Kenyan mentors to develop experimental plans and the teams will give joint presentations during the ASI. Each team will co-author a scientific presentation that will be given by the US student at an international conference post-ASI. The impact of the ASIs will be broadened by developing innovative contributions to STEM education including training STEM educators. Students participating in the ASIs will help develop a case study that explores the top-down and bottom-up controls of cyanoHABs in Nyanza Gulf. This will include discussing culturally-relevant topics such as the influence of point- and non-point nutrient sources, while incorporating all results from the ASI projects.

This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

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Funding

Funding Source	Award
NSF Office of International Science and Engineering (NSF OISE)	IRES-1953468

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