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Student Projects

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Project Title: Morphology and Sedimentation of Kigoma Bay and Vicinity

Introduction

Lake sedimentation is affected by four variables: (1) lake water chemistry, (2) fluctuations of shoreline, (3) relative abundance of river-derived clastics, and (4) autochthonous sediments. Lake Tanganyika, the world's second largest (volumetrically), deepest, and oldest lake, is known for its organic-rich deposits and for its rift lake characteristics. Lake Tanganyika occupies the deepest part of the northwest-southeast trending extensional system. Tectonic structures correlated with this location along the western branch of the East African Rift include a series of steeply sided half grabens and associated border fault system. The dominant sediments found along the border fault (Nondwa Point) are characterized by coarse-grained clastic material. Lateral deltaic sediments extend on the ramping side of the half grabens. Fine grained hemipelagic muds interbedded with fine clays comprise the deep-water sediments. The purpose of my study includes examining the bathymetry of Kigoma Bay and using samples to supplement evidence for structural control of the Kigoma area. In addition, I hope to examine samples for sedimentary transport processes from the Luiche Delta north of Nondwa Point.

Materials and Methods

Part I of my project consisted of creating a high resolution bathymetric map of Kigoma Bay from Bangwe Point north to Nondwa Point. Depth was recorded using a Raytheon 8100 Echosounder sonar system and transducer. The transducer was mounted onto a small Styrofoam float and towed behind a zodiac. Coordinates were recorded with a Garmin 45XL GPS. Tracklines were made using waypoints with spacing of approximately 0.25km apart. Data was analyzed using Surfer6 and various maps were produced. Ponar grab samples were collected along margins of topographic change.

Part II consisted of investigating three specific sites (Figure 1): Luiche Delta (1), Kigoma Bay (2), and shoreline beaches (3). The Luiche Delta represents an area of high sedimentation with an exposed and regular shoreline. The Kigoma Bay represents a semi-protected and irregular shoreline area. More than seventy grab samples were made of the surface sediment using a Ponar Grab Sampler and coordinates were recorded with a Garmin 45XL GPS. Samples were taken at 0, 2, 5, 10, 20, 30, 50, 100, 150m intervals. Where Ponar grab samples were not available, dive samples were taken. Sediments were analyzed for grain size using dry sieving and wet sieving methods with even sizes ranging from –2 to 4Phi. Complete descriptions will be made of the sediments, including variability of graphical mean grain size and degree of sorting, comparisons of detrital carbonate vs. lithics vs. biogenic grains, and Total Organic Carbon (TOC) and Total Carbon (TC) will be measured using loss on ignition procedures. These results will be related back to provenance and lacustrine sedimentary processes.

Preliminary Results

A series of tracklines were made with the echo sounder to record the changing bathymetry of the lake bottom from Nondwa Point south to Bangwe Point (Figure 2). These data points were used to create a counter map of Kigoma Bay (Figure 3). Multiple lineaments can be viewed from this map and are emphasized with dark lines (Figure 4). A 3-D perspective view of Kigoma Bay was also produced from this data set (Figure 5). I will examine these maps in conjunction with aerial photographs and topographic maps to match up exposed land with the bathymetry of the region. In addition, I will use my results from sediment analysis to supplement my interpretations of structural control.

Twenty-two samples have been described and analyzed for mean grain size and sorting. More samples must be examined before complete interpretations can be made. My preliminary work suggests four major points: (1) the greatest degree of sorting is found along exposed beaches, (2) fine clays and silts are found both onshore and offshore, (3) coarse gravels and pebbles dominate beach zones, and (4) grain size decreases with increasing depth.

Samples taken in less than five meters depth from the Luiche Delta north of Nondwa Point are highly variable in both grain size and their degree of sorting. Figures 6 and 7 show that the coarsest grained material is concentrated along the shoreline with fines restricted to deeper, offshore water. The general trend of sorting decreases with increasing depth and distance from shore (Figure 7). The highest energy of lake systems tends to be concentrated along beaches where frequent wave activity reworks the sediments to remove fines from coarser grained material. Along the northern margin of Ujiji and the Luiche Delta, the greatest degree of reworking was found. The beach exposures in this area are significantly different from the protected coves of Kigoma Bay. Here, broad gently sloping beaches extend twenty-five meters out into the lake with a water depth no greater than two meters. Marsh vegetation is patchy along this area and onshore topography consists of relatively flat, low lying terraces. The sediments are extremely fine grained with 3.4 Phi size and are homogeneous. The concentration of lithic fragments is greater near the delta than any other area of study.

Two kilometers north of the Luiche Delta, in the vicinity of Kitwe Point, coarse gravels and pebbles dominate the beach zone and range in size from large cobbles and boulders to coarse gravels. The clasts are composed largely of light minerals including an abundance of quartz and feldspars with some heavier minerals including iron oxides and amphiboles. Adjacent the beaches are twenty-meter high cliffs of meta-conglomerates. As erosion from the waves undercuts the bedrock, cobbles are weathered out and deposited along the beach shore and nearly all the fines are removed.

Carbonate cemented beach rock extends north of Kitwe Point and south of Bangwe Point. There is a noticeable increase in abundance of detrital carbonate and a sharp decrease in lithic fragments. In one small protected cove, pebble-conglomerate beaches give way to medium grained sands. Coated grains composed of calcium carbonate make up nearly the entire content of the beach sediments on the north beach and are absent from the south beach.

The sediments of Kigoma Bay are widely variable and possibly reflect provenance and sedimentary transport processes. I need to complete further analysis before I can describe this region with confidence. Grain size from –1Phi (coarse sand) to 4 Phi (coarse silt) and sorting is also highly variable. There is an observable change in sediment composition from our initial grab sample work. On average, below the depth of 60 meters fine clays and muds were collected. At approximately 50 meters and 30 meters there was a significant decrease in successful Ponar grab samples that were taken, possibly resulting from a blanket of coarse grained carbonate shells and sands. From 30 meters up to 10 meters patchy areas of sand alternating with shells dominate. Ripple marks characterize beaches from ten meters up to the shoreline.

I anticipate interesting results that may aid in offering some details to the structural control and sedimentary transport systems of Kigoma Bay and vicinity.

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Project Title: Étude de la population piscicole de la zone littorale a deux biotopes différentes: Cas des zones rocheuses et sableuses Kigoma (Jakobsen's Beach) et Gombe (Mwamgongo)

Introduction

Le lac Tanganyika contient, un nombre absolu d'espèces, une des plus grandes faunes de tous les lacs du monde ; environ 1500espèces de vertébrés et invertébrés dont 600 sont endémiques au lac(Coulter et al. , 1991). La faune du lac Tanganyika, comparée à d'autres faunes des autres eaux douces d'Afrique et d'ailleurs, montre les traits particuliers par sa diversité et son endémisme. Néanmoins, le peuplement biologique du lac Tanganyika varie en fonction des biotopes. Rappelons que les principaux biotopes sont : la zone supralittorale occupée par la végétation bordant le lac et les plages avec de temps en temps des zones de marais et des étangs permanents avec leur faune caractéristiques, la zone littorale qui peut être rocheuse, sableuse ou couverte de vase avec toute les situations intermédiaires ; la pélagique avec son plancton et toute la faune qui en dépend, la zone benthique dépourvue d'oxygène et donc d'organismes supérieurs. Les lacunes dans les connaissances actuelles sur la faune du lac Tanganyika sont nombreuses. En effet, les biotypes spéciaux cités ci hauts n'ont pas encore fait l'objet d'études approfondies.

Objectifs

L'intérêt du lac en tant que réservoir de ressources alimentaires et de possibilité de revenues monétaire pour la population riveraine mérite d'être bien connu. Nous avons choisi d'étudier la faune littorale a fond rocheux et sableuse d'une partie de KIGOMA(Jakobsen) et de GOMBE avec une importance spéciale attachée aux poissons. Ceux-ci sont inégalement répartis et diversifiés suivant que le littoral est rocheux, sableux ou autre. Par le biais de cette étude, nous voulons contribuer à une connaissance plus approfondie de la zone littorale en tant que lieu privilégié pour la diversité biologique du lac Tanganyika et support au développement des stocks de poissons. L'objectif principal de notre travail est de se rendre compte de la diversité spécifique de chacun des biotopes étudies et quelles espèces sont typiquement caractéristiques du substrat considéré

Méthodes d'Échantillonnages

Pèche expérimentale

Les engins les plus efficaces pour un échantillonnage qualitatif et quantitatif de la faune. Piscicole dans un lac sont : la senne plage pour les eaux peu profondes, a condition que le fond soit ferme et régulier et les berges dégagées. Ces conditions ne sont pas toujours réalisées dans toutes les zones, surtout sur les biotopes a fond rocheux ou ceux avec des berges recouvertes de végétation. La senne tournante ou chalut éventuellement électrifie, mais elle surtout efficace en zone pélagique. Il est aussi possible d'utiliser des ichthyotoxiques, mais se pose alors divers problèmes, légaux d'abord, technique ensuite, comme la récupération de poissons morts tombés sur le fond. Les filets maillant est l'engin le plus couramment utilisé, particulièrement dans les lacs ou le fond est encombre de matériaux divers, même s'il a l'inconvénient d'être passif c'est-à-dire qu'il ne capture que les poissons en mouvement, et qu'il est par ailleurs sélectif en fonction de la taille et de la morphologie générale du poisson.

Par la présente étude nous avons utilise deux filets maillants de taille croissant (9 ; 12,5 ; 15 ; 18 ; 20 ; 25 ; 30 ; 35 ; 40 ; 50 ; 60mm) appartenant au Projet Biodiversité du Lac Tanganyika (pblt) chacun ayant une longueur de 150m et 1,20m de large. Les filets ont été poses vers 17h00 dans deux endroits différents : GOMBE (Mwamgongo) et KIGOMA (Jakobsen's Beach) et dans chacun des deux respectivement deux fois pour une même zone rocheuse et sableuse, parallèlement a la berge a une profondeur de 3 a 4m.Les filets étaient relevés le lendemain matin a 8h30. Cette durée pose couvre deux périodes ou les cichlidés, famille de poissons dominante dans le lac sont connus pour être le plus actif a la recherche de leur nourriture, c'est-à-dire le couche et le levé du soleil (G. NTAKIMAZI ; 1985) Pour l'échantillonnage de la journée nous l'avons effectue uniquement dans le site de KIGOMA parce qu'il est plus proche du TAFIRI : station du PROJET NYANZA Les échantillons obtenus ont été mis d'abord dans du formol pour être déterminer ensuite au Laboratoire a l'aide du microscope. Dans le traitement de nos données nous avons utilisé les indices de diversités de SHANNON, SIMPSON, similarité de JACCARD

Observation sous lacustre

Même si on parvient à résoudre le problème de la sélectivité inhérente aux filets maillants ces derniers ne permettent pas capturer toutes les différentes espèces de poissons d'un endroit avec la même efficacité. Certaines espèces de poissons surtout ceux qui sont grand, semblent être plus méfiant à l'égard des filets que d'autres. Aussi certaines espèces particulièrement sédentaires se font capturer difficilement entre autre celles qui restent cantonnées dans les trous et autres recoins en dessous et derrières les rochers ou bien des individus qui suspendent temporairement la recherche de la nourriture pendant l'incubation des œufs et la surveillance de leur progéniture. Les données obtenues grâces aux filets maillants ont été complétées par l'observation in situ. Ceci a permis d'avoir une bonne idée de la distribution et de l'abondance relative des poissons dans les biotopes étudies et de compléter l'inventaire faunistique avec des observées mais non capturées par les filets.

Les Résultats

Les différents échantillonnages et observation de terrains permettent de livrer pour le moment les informations provisoires suivantes : un inventaire de la faune piscicole de la zone rocheuse et sableuse. Cet inventaire n'est pas au complète suite a la durée d'échantillonnage et d'observation (tableau : 1). L'abondance relative des populations de chaques espèces et les fluctuations de celles-ci au niveau de chacun des biotopes étudiés. On peut également a partir de ces résultats connaître la structure du peuplement piscicole des biotopes étudiés. La contribution de ces biotopes dans la constitution des stocks de poissons d'importance économique c'est-à-dire ceux trouvés couramment sur le marché pour la consommation humaine comme *Limnothrissa miodon*

Inventaire Faunistique

Inventaire faunistique qu'on a réalisé donne une liste de 61 espèces de poissons présentes aux sites étudiés. C'est à peu prés un quart de toutes les espèces connues actuellement pour l'ensemble du lac soit espèces lacustres et 337 pour tout le bassin versant(Devos, 1993.in G.NTAKIMAZI). Les espèces inventoriées appartiennent à 10 familles sur 16 connues pour l'ensemble du lac avec abondance des espèces de la famille des cichlidés.

Analyse Des Résultats

Peuplement par biotopes

Avec nos données d'échantillonnages effectuées sur les deux biotopes rocheuse et sableuse ; nous pouvons nous permettre provisoirement de faire la comparaison entre les peuples des deux biotopes étudiés

La diversité spécifique

La figure 1 montre que les deux zones sont riches en espèces (19 a 32 espèces) mais le nombre le plus élevé d'espèces a été trouvé dans zone rocheuse et cela été prouvé dans les deux sites KIGOMA(Jakobsen's Beach) et GOMBE(Mwamgongo) avec une dominance de la famille des cichlidés ROBERT Brbault.1997,signale que la richesse spécifique d'un peuplement n'est pas simplement le nombre d'espèces ,celui-ci est jugé insuffisante puisqu'elle ne permet pas de différencier les peuplement. Le tableau : 1 qui montre les indices de diversité met en évidence la diversité spécifique élevée des biotopes rocheux par rapport aux biotopes sableux. Pour l'utilisation des indices de diversité, nous avons utiliser l'indice maximal de Shannon car celui-ci nous permis de connaître le biotope le plus diversifier que l'autre Les autres indices n'ont pas permis de distinguer cela puisqu'il n'y a pas une grande différence des biotopes au point de vue de diversité spécifique EN plus très peu d'espèces ont un grand nombre d'individus.

Les espèces dominantes aux différentes zones

Il apparaît clairement dans figure 1qu'il y a des espèces qu'on rencontre uniquement dans un biotope rocheux ou sableux. Pour nos échantillonnages nous remarquons que les espèces *Cyprichromis microlepidotus* ,*Lamprologus brichardi* , *Lamprologus furcifer*, sont dominantes dans la partie rocheuse. Alors que les espèces comme *Ectodus descampi*, *Grammatotria lemairie*, *Callochromis pleurospils*, sont très abondantes dans la zone a substrat sableux. Il existe d'autres espèces communes aux deux biotopes comme *Lates mariae*, *Malapterus electricus*, *Aulonochranus dewindti*, etc.

A l'état actuel de nos données, il n'est pas encore temps de préciser que telle ou telle autre espèce est typique du substrat tel parce que les échantillonnages ne sont suffisant pour conclure.

Conclusion Et Recommandation

L'analyse de nos résultats nous permettons de constater qu'il n 'y pas une grande différence dans le peuplement piscicole étudié. Mais on notera que les biotopes rocheux sont le support a une diversité spécifique plus élevé qu'au niveau des substrats sableux. Ainsi les indices de diversité utilise le confirme pour nos échantillonnages. Pour le moment, le nombre d'échantillonnage ne confirme pas la spécificité des espèces aux substrats tel mais lors de l'observation in situ , nous dire que les espèces comme *Tropheus moorii Lamprologus brichardi Lamprologus furcifer* sont rocheuse tandis que les espèces comme *Ectous* d*escampi, Callochromis pleurospils, Grammatotria lemairie* sont sableuse.

Elles ne sont observées uniquement que dans les deux biotopes différemment. Concernant les espèces ubiquistes rencontrées partout dans les deux biotopes n'est pas facile a attribuer un substrat favorable. Vu la grande diversité et l'importance économique que peuvent présenter ces biotopes de la zone littorale ; il est intéressant d'associer à cette étude quantitative des populations piscicoles des études plus approfondies sur la limnologie de ces zones, l'écologie et l'éthologie des différentes espèces L 'é également de la diversité spécifique a différent niveau de profondeur peut renseigner les zones les plus diversifiées que d'autres. Mais d'ores et déjà le besoin de protection des biotopes se fait sentir car les contraintes de dégradation du milieu et en particulier la zone littorale susceptible de connaître toutes les formes de dégradation et de pollution. Ceci est vrai aussi bien pour la zone littorale que pour la zone pélagique.

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Title: Investigation of Possible Daily Coastal Upwelling Effect on two Different Relief Areas: High Relief Half-Graben Faults and Low Relief Coastal Plains in Lake Tanganyika, East Africa.

Introduction

Water movements influence the distribution of nutrients, microorganisms, and plankton in the mixolimnion of Lake Tanganyika. Catabatic and offshore winds may have a profound effect on these water movement patterns. Radiation by the sun and evaporation are other important contributing abiotic forces that influence water movements in the lake. A daily pattern of offshore winds in the morning and onshore winds in the evening generated by the difference in air temperature between the lake and the rifts surrounding it may give rise to a measurable upwelling effect in the early morning when the epilimnion is isothermal. Due to the strong temperature difference between the surface water and the high relief rift mountain surrounding much of Lake Tanganyika, the effects of the wind are likely to be stronger along the coast boarded by mountains compared with the lower relief, plain regions (mountain wind effect).

Along the Tanzanian coast of lake Tanganyika, temperature patterns suggesting strong upwelling currents from the metalimnion have been observed (from satellite imagery), which might be due to the combined effects of offshore winds and catabatic winds.

A horizontal and deep vertical sampling regime was performed to examine the thermocline and lower mixolimnion and to measure this effect of the wind on abiotic parameters of the water column in two different relief areas near Kigoma (i.e. highlands and low lands). The first sampling station was in Kigoma Bay, an area of low relief where the half-graben rift tips out into Lake Tanganyika. The basin is relatively shallow and flat until a depth of approximately 150 meters, then drops off quickly. The second sampling station was just north of Gombe National Park, near the outflow of the Mwamgongo River, which is bordered by high rift mountains. The basin drops off quickly near the shore and reaches depths of over a kilometer within a few kilometers offshore.

Objective of the study

The objective of the study was to measure the effect of daily coastal upwellings (at 0600 hrs and 1700 hrs) during the dry season on Lake Tanganyika. Previous data indicate that at 0600 hrs the epilimnion is cooling at night to the thermocline; this convective mixing of the epilimnion may be due to the advection mixing (upwelling) as the water is pushed by the catabatic and offshore winds in the early morning.

Material and Methods

Materials

YSI D.O./Temp meter
Secchi Disk
6 Thermistors and chain 2 L.
water sampler
Weather Monitor II weather station Wind
Anemometer
pH meter
HACH Co. DR/2010 Spectrophotometer
Conductivity meter
HACH Co. reagents for nutrient analysis
Turbidimeter

Sampling Site Location

The location of sampling sites was chosen based on the measured depth of the thermocline. Three sites at each station were chosen; Site 3 was located offshore at the depth of thermocline, Site 2 was located at approximately half the depth of the thermocline, and Site 1 was located close to shore. At both of the two sampling stations (Kigoma Bay and Mwamgongo area), Site 3 was located at a point of more than 60 meter depth (65-80m) so as to make sure that sampling to the metalimnion waters was possible. Site 1 of each sampling station was located at >20m from the shore where the depth of the lake was approximately 10 meters for Kigoma Bay (low relief) and 20 meters for Mwamgongo (high relief). Site 2 of each sampling station was in between site number one and three, located where the depth of the lake was about 40m. The position of each sampling site was recorded with a GPS (Table 1). Due to the difference in basin morphometry, distances between stations were much larger in Kigoma Bay than at Mwamgongo.

Table no. 1: Coordinates of sampling sites.

Location	Sampling sites	Latitude (S)	Longitude (E)
Kigoma Bay	Site 1	04^o 53.214’	029^o 36.948’
	Site 2	04^o 53.051’	029^o 36.797’
	Site 3	04^o 53.006’	029^o 36.528’
Mwamgongo	Site 1,2 and 3	04^o 37.725’	029^o 37.914’

Sampling Types

Two replicate morning and two replicate evening samples were obtained at each station. A regular sampling of one-day alternation between morning (at 0600hrs) and evening (at 1700hrs) was performed at Kigoma Bay for a period of four days. At Mwamgongo, there were intensive sampling of two times daily (at 7:30hrs in the morning and 1700hrs in the evening), for the period of two days.

Sampling Methodology and Instrumentation

A long term, continuous temperature depth profile at each site was obtained by placing the thermistor chain in the water to record temperature after every 10 min for the sampling period. At Kigoma Bay, thermistors were placed at 05 m, 15 m, 30 m, 45 m and 60 m depth. At Mwamgongo, thermistors were placed at 05 m, 30 m, 60 m and 80 m depth.

Water samples of 2.0 liters capacity were collected at 60m, 30m, and 5m for each sampling Site 3 at Kigoma Bay and 80m, 30m, and 05m at Mwamgongo. At Site 2, samples were collected at 30m, and 5m for each sampling station. At Site 1, samples were collected at 5m for Kigoma Bay and 5m and 20m for Mwamgongo. Water samples were measured for pH and conductivity (C) in the field, and turbidity (Turb), silicate (SiO_2), phosphate (PO_4-P or SRP) or total phosphorus (TP), nitrate (NO_3), nitrite (NO_2), and ammonia (NH_4) in the lab.

At each of the three sites, vertical profiles of DO and T were taken every 10 meters from the surface to the bottom and transparency was measured with a 20cm diameter secchi disk. *In situ* D.O. and T measurements could not be taken greater than 60m in depth due to the length of the cable attached to the probe.

Table 2: Parameters measured by spectrophotometer (HACH DR/2010), methods and corresponding precision and units (United States Environmental Protection Agency approved)

Parameters	Methods	Precision and units
Ammonia	Nessler	+/- 0.01 mg/L (NH_3-N)
Nitrate	Cadmium reduction	+/- 0.01 mg/L (NO_3-N)
Nitrite	Diazotization	+/- 0.001 mg/L (NO_2-N)
Total Phosphorus	Acid persulfate	+/- 0.01 mg/L (PO_4—)
Soluble Reactive Phosphates	Ascorbic Acid	+/- 0.01 mg/L (PO_4-P)

Results-Mwansa, P.K.

Wind direction and speed

As Plisnier et al. (1996) states, the best place to start to describe the limnological cycle of Lake Tanganyika is the wind, which regulates the energy input into the Lake through physical processes and causes mixing. During the study period, wind direction changed greatly. The prevailing winds were generally easterly winds during the night (19:00-0600hrs) and morning (7:00-11:00) and northwesterly wind in the afternoon (12:00-18:00). According to Coche (1968), better mixing due to greater turbulence within the coastal water mass exists if the shore lies perpendicular to the main wind.

Wind speed varied considerably during this period being strongest in the afternoons and low in the mornings. The average wind speed for Kigoma ranged between 1.28 and 2.15 m/second during the day and 0.28 to 0.54 during the night.

Air Temperature

Air temperatures at Kigoma Bay and Mwamgongo area were higher during the day and low during the night. Average daily temperature ranged from 27.7 °C to 25.4 °C and 18.53 °C to 38.37 °C for Kigoma Bay and Mwamgongo area respectively. The latter had the highest range of temperature about 19.84 °C during the two day sampling period.

Water Temperature

Water temperature data was obtained from the thermistor chains that were anchored at each sampling station as well as from our in situ digital thermometer coupled to an oxygen meter.

From the thermistor chain results (Appendix G), water temperature was high during the day and lower in the night during the study period. On a daily cycle, mixing was observed particularly in the early morning (2:00a.m. and 9:00a.m.) when high winds coincided (Fig. 1 and 2). Besides this, water temperature was high in the top 40meter and decreased to 6 meter at each sampling occasion for both sites. Near-shore sites for both Kigoma and Mwamgongo were always warmer than the mid-shore and far-shore areas (Fig. 3, a;b;c).

The thermocline depth was very distinct only at far shore areas for both sites. The thermocline depth was constant, at 50 meters during all the sampling occasions.

Transparency

Water transparency was reasonably high throughout the study period. The highest secchi disk reading of 19.6 meters was obtained at Mwamgongo area both in the morning and afternoon. Generally, transparency of water masses at Kigoma was lower compared to that of Mwamgongo area ranging from 10.6-13.2 meters and 12.2-19.6meters respectively.

Mwamgongo secchi disk readings were slightly higher in the morning than afternoon. In addition, far-shore readings were generally higher than the mid-shore and near-shore readings (Table 1). No clear cycle in water transparency was evident at Kigoma Bay site.

Results- Bungala, S.O.

Vertical profiles in the pelagic area

The general vertical profiles for chemical parameter are shown in the Appendix C. Thermocline depth was deep in highland areas, below 60m depth compared to lowlands, between 50 and 60m depth, probable due to high wind speed and intensity as wind speed data, dissolved oxygen data, and temperature data agrees.

Chemical parameters decreased with depth in the water except for conductivity, which tended to increase. This was probably due to an increase in the concentration of nutrients. Turbidity data was anomalous, 18NTU at 60 m depth, though probably due to sediments which were re-suspended in the water column when sampling.

Horizontal comparison

Variation of parameters detected in the pelagic area was also detected in coastal areas. (See appendix B) Generally mean values of chemical parameters (D.O, pH, Cond, and Turb.) were more varied in the pelagic areas compared to coastal areas.

Results – Hoffman, J.C.

Values of nitrates and phosphates were quite low at both stations during the entire sampling period (Appendix A); similar to long term data results from the Kigoma Bay area (Plisnier et al. 1996). Ammonium was problematic in field measurement. Silicate concentrations demonstrated a wide variation at both stations, from very low to unusually high concentrations. Generally, the ambient lake-water concentrations of the phosphates demonstrated less variability than the nitrate concentrations, suggesting that the system might by nitrogen limited and undergoes larger daily fluctuations.

Nitrate (NO3)

Nitrate at both sites was highly variable and failed to show a distinct upwelling pattern, with elevated nutrient concentrations in the early morning (Appendices D and E). Concentrations ranged from 0.090 to 0.00 mg/L at Kigoma Bay and from 0.04 mg/L to 0.00 mg/L at Mwamgongo (Appendix A). Kigoma Bay generally had higher average concentrations of nitrate present (Appendix A). At Kigoma Bay, nitrate tended to increase with depth and decrease over the sampling period (Appendix D). Concentrations at all depths varied widely. At Mwamgongo, nitrate did not increase with depth and remained present at similar concentrations over the sampling period (Appendix E). Any comparison over time, however, is tentative due to the shortened sampling period at Mwamgongo. Concentrations were less variable in the deeper waters.

Nitrite (NO_2)

Nitrite was also variable, however always present in the water column at both sites. At both stations, there was good evidence for daily upwelling, with values elevated in the morning over the previous afternoon (Appendices D and E). At Kigoma Bay, values ranged from 0.001 mg/L to 0.008 mg/L and at Mwamgongo from 0.003 mg/L to 0.014 mg/L (Appendix A). Average values were higher at Mwamgongo than at Kigoma Bay (Appendix A). At Kigoma Bay, concentrations varied at all depths, however Mwamgongo again illustrated less variation at the deepest sampling site (z = 60m).

Ammonium (NH_4)

Distilled H20 used for blanks to calibrate the spectrophotometer often had values of ammonia higher than the ambient lake-water concentrations. Most tests indicate some degree of contamination. Thus, while data recorded can be found in Appendix A, we feel that the poor data quality prevents any conclusive results.

Total phosphorus and orthophosphates (PO_4)

Phosphates were more stable in the water column than the nitrates and demonstrated less variability (Appendices D and E). Averages at Kigoma were slightly higher than at Mwamgongo, with values ranging from 0.88 mg/L to 0.24 mg/L (Appendix A). Values at Mwamgongo ranged from 0.004 mg/L to 5.00 mg/L. Contamination is suspected for the higher values at Mwamgongo; any values over 0.40 mg/L are probably inaccurate based on the data from the other sampling times. At both sites, phosphates decreased with depth and were less variable in the deeper waters (Appendices D and E). There was little evidence at either station for a pattern of morning upwelling.

Silicate (SiO_2)

Silicates showed a strong increase with depth at Mwangongo, generally only trace values were found at 5 m depth while over 60 mg/L was found at depths of 60 m (Appendix E). Results from 28 June 1998 morning sampling are highly elevated and may indicate contamination, however the depth gradient is present throughout all sampling periods. An opposite effect was found in Kigoma Bay, with concentrations decreasing with depths (Appendix D). Overall, measured concentrations were much higher at Mwamgongo, ranging from 0.0384 mg/L to 63.45 mg/L. Concentrations ranged from 0.883 mg/L to 12.275 mg/L at Kigoma Bay (Appendix A). At Kigoma Bay, silicates tended to increase in the afternoon periods and become less variable in concentration with depth. Variation also tended to decrease with distance from the shore. Concentrations from the surface waters failed to provide evidence for an upwelling pattern. Data from Mwangongo also fails to illustrate an obvious morning upwelling effect, though values were highly elevated the first morning at depths greater than 20 m. Data from the second morning failed to corroborate this pattern.

Discussion and Conclusions

Daily Wind Patterns

There were significant fluctuations in daily average air temperature and wind speed. Generally, air temperature showed a similar trend with wind speed, with 9 moderate correlation coefficient of 55.2%. From the multiple correlation coefficient table (Appendix F), it is clear that air temperature and wind speed have an influence on the physical processes of the water masses especially up to the top 30 meters. The significance of these two factors becomes minimal downwards to 60 meters depth. Table 2 illustrates the multiple correlation coefficient between meteorological factors and the water temperature.

For both sites mixing (upwelling) of water occurs in the early hours of the day, showing no significant variation in terms of their different relief.

The transparency readings obtained during the study period varies considerably, may be due to turbulence mixing. This turbulence mixing may have been responsible for a high level of heterogeneity not only in transparence but probably, nutrients as well.

Analysis of the meteorological data has lead to the following four conclusions. First, the wind speed at both Kigoma Bay and Mwamgongo were usually lower than the air temperature and thus no significant mixing of nutrient rich deeper water with the surface water masses. Second, upwelling occurred in the early hours of the morning (00:00 to 7:00) each day of the study period in both Kigoma Bay and Mwamgongo. Third, vertical fluctuations of water temperature were very significant during the study period. Fourth, future studies should try to quantitatively analyze the day and night variations in the lake resulting from meteorological factors.

Daily coastal upwelling effects

Winds cause the accumulation of warmer epilimnion water and thereby deepen the thermocline. When the forces of the winds weaken or cease, oscillations of the metalimnion forms internal waves which were mainly detected below the thermocline.

Upwelling effects reached its maximum in the evening (after the wind had reached its maximum at noon), when the effects of the winds (internal waves and water circulation), maximize. This was agreed by the data of chemical parameters, wind speed and thermistor chain data. Chemical parameters (D.O., pH, and conductivity) were generally high in the evening compared to the morning; for example, D.O. was more than 100% saturation in the evening.

The thermocline was deeper at Mwamgongo, the high relief area, compared to Kigoma Bay, the low relief area, temperature and D.O. data shows that.

Nutrient Dynamics

Nutrient data suggests four major conclusions in the data set. First, nitrate concentrations in the water column can vary widely over short periods of time. Stability in the upper metalimnion may prevent any major flux of nitrate to the surface waters, such that the wide variation may be a result of biological demand and nitrification in the mixalimnion.

Second, phosphorus concentrations in the water column remained relatively stable in the water column, suggesting both low biological demand and little contribution from the metalimnion. Based on both temperature and phosphorus data, it is unlikely that any morning upwelling actually entrains nutrients out of the metalimnion, though they may be entrained out of the lower epilimnion as the entire epilimnion cools.

Third, nitrite may be a good, measurable indicator of morning upwelling. Values were often higher in the morning hours, and because the nutrient must undergo further nitrification to be used by alga, it may remain long enough in the water column to be measured in the morning hours.

Finally, system dynamics and nutrient data appear to be closely correlated. Kigoma Bay generally showed more mixing in the upper layers and wider variability in the nutrient samples. The constant mixing in the upper layers may increase the patchiness. Further research between the relation of daily mixing brought on by the wind patterns (catabitic and onshore and offshore winds) and nutrient availability may yield valuable information regarding physical controls on nutrient availability in Lake Tanganyika.

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Student: Margaret Edattukaran

Affiliation: Boston University

Title: A preliminary study of trophic specialization with respect to pharyngeal jaw functional morphology of *Lobochilotes labiatus* and *Neolamprologus tretocephalus*

Introduction

There has been a lot of research on the East African Lakes and its diverse cichlid fauna. One of the more dynamic morphological features of the Family Cichlidae is its large pharyngeal jaw variability, not only between tribes and species, but also sometimes between the juvenile and adult of the same species.

Objective

My objective in the Nyanza project was to acquire an experimental understanding of this morphological characteristic of the cichlids in Lake Tanganyika. I had initially planned to select two sister species that show pharyngeal jaw variability but due to limited accessibility in acquiring these species, I selected two other cichlids, namely *Lobochilotes labiatus and Neolamprologus tretocephalus*.

Methods

I acquired n=28 individuals of *Lobochilotes labiatus* and n=29 individuals of *Neolamprologus tretocephalus* through a fisherman who snorkeled at the Jakobsen's beach (Kigoma) area and its vicinity. He collected the individuals of these two populations between 9:00am and 2:00pm. I first allowed them to freeze until they were dead and then injected 10% formalin in their gut area and then let them stay immersed in formalin for 3 days.

I conducted raw morphometry on all these individuals using two measures-standard length and buccal jaw width. The standard length, was a measure from the tip of the snout until the end of the lateral line at the base of caudal fin. The buccal jaw width measure was the two outer edges of the buccal jaw. I only did sex determination of the *L. labiatus* population and forgot to do the same with the *N. tretocephalus* individuals.

I performed gut dissections for the two populations by first removing the entire stomach and intestine onto a gridded petri dish, then teasing out the gut and stomach contents and spreading out the food contents gently. I used a hand counter and counted items into four categories: gastropods (Lavigeria, Martelia, Anceya, Raymondia and Syrnolopsis), insects, shrimps/crabs and ostracods/bivalves.

Results

The results are attached in figures 1 and 2 which shows all the gut content count for all the food categories.

Observations

The frequency of occurrence indices (food category present in the individuals of one population/the total number of individuals in the same population), shows that *N. tretocephalus* prefers gastropods (100% frequency) and insects (90% frequency). *L. labiatus* prefers insects (90% frequency), shrimps/crabs (90% frequency) and ostracods/bivalves (80% frequency).

The abundance indices (the total number of a single food category/the total of all the food categories for the whole population) for the two populations show very similar information as the occurrence frequency index. I compared abundance to the volumetric indices (volume of a food category/ total volume of all the food categories within the population) and I observed the following: in the case of *L. labiatus,* the ostracod/bivalve abundance was 45%, the actual total volume of ostracod/bivalve was less than 20%. Similarly the abundance of shrimps/crab is 15% but the volume is 40%. In the case of *N. tretocephalus,* the abundance and volume for its major food preferences are quite similar.

The distribution of gastropod predation preference shows that *N. tretocephalus* and *L. labiatus* prey heavily upon *Lavigeria* and *Martelia*. The gut contents of the *N. tretocephalus* shows a large quantity of sand grain particles, yet the occurrence of ostracods/bivalves is zero. There were several female *L. labiatus that* had juvenile *L. labiatus* in the stomach and not in the gut region. The ontogenetic series – though not a complete one – for *L. labiatus* shows that the larger the fish gets the more it preys on shrimps and the less it preys on gastropods.

Conclusions

Although this is only a preliminary research it is quite evident that *N. tretocephalus* prefers gastropods, mainly *Lavigeria* and *Martelia*. *L. labiatus* prefers insects, shrimps, ostracods and bivalves. The juveniles discovered in the gut of the fish of the *L. labiatus* is mainly because they were brooding females. *L. labiatus* females are mouth brooders and therefore perhaps during the catching of these fish they might have swallowed their juveniles.

Future Research

I intend to obtain an ontogenetic series of both the cichlids to study the development of the pharyngeal jaw morphology. I will also conduct pharyngeal jaw morphometry using SEM and X-ray. I intend to see if there is any correlation between pharyngeal jaw design and food particle size from the data that I have collected thus far.

Students: Kristin France and Pete McIntyre

Affiliation: KF-Williams College, PM-Harvard University

Title: Gastropod Community Ecology on the Rocky Eastern Shore of Lake Tanganyika

Introduction

The Lake Tanganyika gastropod fauna has interested systematists since the discovery of the Lake by Europeans over a century ago. Recent work has focused on resolving relationships between taxa, but very little is known of the autecology of any species. At the community level, predation by crabs has been studied extensively in the laboratory, but again, no comparable field work has been performed (West 1998). Our goal was to gather baseline data on the composition of the Tanganyikan gastropod community and some factors that may govern it. In particular, we were interested in the impact of sedimentation, algal abundance, predation intensity, and parasitism on snail diversity and abundance.

We were particularly interested in the interaction between trematode parasites and gastropods at our sites. Trematodes typically castrate their hosts, and thus reduce the effective genetic population size of their hosts in proportion to the frequency of infection. Thus, though a diverse community or large population may be present and ecologically important in the community, the population ecology of the snails may be altered. Thus differences between sites or with depth can be very important for the snails, if not the community as a whole.

We surveyed the gastropod community at four sites: Mwamgongo, Hilltop Hotel, Nyasanga, and Jakobsen's Beach. The first two sites receive high sediment loading as a result of shoreline land use, while the latter two are considered undisturbed. They are also paired along a north-south gradient; Mwamgongo and Nyasanga are near the Gombe Stream Reserve approximately 16 km north of Kigoma, while Jakobsen's Beach and Hilltop are immediately south of Kigoma. The two alternative pairings allow a balanced comparison in which the impact of sedimentation and location can be evaluated independently. In addition, the same four sites are being examined in current studies of primary productivity (Catherine O'Reilly) and ostracod community composition (Simone Alin), broadening the community profile at each site.

There are several questions that we hope to address in this study. What is the gastropod community composition at these four sites? Does species composition vary with depth and/or location? What regulates the community: primary productivity, resources, predation, and parasitism? Does sedimentation and/or nutrient pollution at disturbed sites alter the gastropod community? Do parasitism incidences vary with location or depth? Lastly, do gastropods alter their morphology or behavior in response to predation or parasitism pressures?

Methods

At each of our four sampling sites, we attempted to designate five transects, each of which was sampled at four depths (1, 2, 5, 10 m). We chose these depths to be consistent with previous and ongoing investigations (Michel, O'Reilly, Alin), and also in mind of the ~1m rise in lake level three months prior to our sampling period. Establishing transects was not always possible, particularly at the disturbed sites, where suitable rocky habitats were sometimes scarce. At Jakobsen's Beach, we established transects perpendicular to the shoreline, each approximately 20 m apart, and sampled at each depth along each transect. At the other three sites, rocky habitat was too patchy at 5 m and 10 m to establish evenly spaced transects that spanned all four depths. Consequently, at Nyasanga and Hilltop we collected the 1m and 2m samples along transects spaced approximately 20 m apart (Nyasanga) or 5 m apart (Hilltop). We collected the 5 m and 10 m samples from boulders at those depths within a region spanning approximately the same shoreline distance as that covered by the 1m and 2m sampling scheme. At Mwamgongo, rocky habitat was patchy at all four depths, and we could not establish transects across any depths. At this location, we attempted to space the quadrats at least 5 m apart.

Rope squares (2 m x 2 m), their corners weighted with sandbags, were used to delineate the quadrat sampling area. We attempted to keep the corners square and minimize the amount of slack in the quadrat line. In situating the quadrats, we attempted to keep the surface area sampled relatively constant. Boulder faces or bedrock was chosen whenever possible. In general, we avoided cobbly areas, but when we encountered cobbles in a quadrat we did not turn them over and collect underneath. When sampling a quadrat occupied by several small boulders, three-dimensionality of the substrate became an issue, and we tried to only collect snails from within a .75 m to 1m depth range (e.g. from .5 to 1.25m depth).

We collected all of the macroscopic snails (>4mm) within each quadrat. Snails were separated into two bags according to their position on the rock: top (anything visible from directly above it) or side (which included under overhangs, in crevices on the sides of rocks, and anything not at least partially visible from directly above). It is important to note that with this size distinction our survey undoubtedly excludes several species of snails, (e.g. *Ancya* sp.). Wave action often made collection difficult; we dropped snails and were unable to safely use dive knives to extract snails from crevices. In these instances, we recorded the number of each species either left or lost, and later included these numbers in our calculations of abundance and diversity.

We also recorded the proportion of the algal cover removed by grazing in each quadrat. Using a clear plexi-glass plate to delineate a 13 cm x 13 cm area, we estimated to the nearest quartile the percentage of rock covered with algae. We collected these data at the four corners and the center of each quadrat, providing 5 replicate measurements within each quadrat. At each quadrat we also noted the substrate lithology, the amount of sediment, the angle of the substrate and the structure of the substrate within the quadrat (boulder face, several small boulders, cliff face, etc.).

In the laboratory, we identified the snails to species and counted the number of individuals of each species at each depth and position within each quadrat. We conducted full morphometrics on all of the snails greater than 10 mm in height from Mwamgongo, Nyasanga and Jakobsen's Beach, with the exception of *Spekia zonata,* for which we only measured heights. Full morphometrics included: overall height (from apex to tip), overall width (maximum width, perpendicular to overall height), aperture height, aperture width, lip thickness (measured at point of maximum inflation), # scars (not recorded for *Reymondia horei* and *Spekia zonata*), and apex to last whorl length and apex to scar distance in the presence of scars. For quadrats that had more than 30 *Reymondia horei*, we completed full morphometrics on the 30 individuals with the greatest height, and only measured height on the remaining individuals. Scarring will be used as an index of predation intensity at a site/depth, since unsuccessful attacks by crabs often leave snails permanently scarred. We also noted the presence or absence of algae on the shell.

We collected morphometric and parasite data for a subsample of the snails collected at Hilltop. For each depth where one or more quadrats contained 100+ individuals of a single species, we measured the height of 100 snails of that species. We arranged these measurements from minimum to maximum, divided them into 10 groups of 10, and used the measurements of the first and last snail in each group to delineate a size class. Those 100 snails were placed back into the general pool. We then selected 30 snails for full morphometrics and crushing for parasites: 3 from each size class.

Once morphometrics were completed, we crushed the snails, examining their soft parts for life history and parasite data. We recorded the sex of each individual when possible, and if female, whether it contained eggs or brood. This will be used to determine the size at maturity for females, and thus give an indication of variation in life history at the species and population (depth and site differences). The gonad was searched for trematodes by crushing it between two glass plates and examining it under a dissecting microscope. The morphotype of cercaria was recorded in as much detail as possible and drawings of each designated type were made by Michel.

Results and Discussion

We collected 3886 snails. We measured 2221 snails. We crushed over 2000 snails.

We recorded 12 species of gastropods. Upon preliminary review of these data, the Thiarid *Nassopsidia/Lavigeria* clade studied by Michel accounted for most of the diversity and the abundance. Three species we found only at one of the locations (Small Zaire and Spiny Tanzanian (=L.B.S.) at Hilltop; *Nassopsidia spinulosa* at Mwamgongo; and *L. coronata* at Jakobsen's).

The disturbed sites have fewer species on average across the four depths than are present at the undisturbed sites (Figure 1), but this is a weak result. Species number varies with depth but with no clear trend. Calculating the Jaccard index of similarity between depths at each site illustrates that species composition changes over depth, but again, without a clear trend (Figure 1, above lines). Species composition at successive depths is more dissimilar at disturbed sites than at undisturbed sites, however.

Abundance varied widely between sites (Figure 2). Abundances at Hilltop exceeded those at any other site by an order of magnitude. Again, there is no apparent trend in abundance with depth. Indeed, abundance varied widely even between different quadrats at the same depth and site. Standard deviations for total abundances averaged from the five quadrats at each depth at each site often exceeded the mean and rarely dropped below 75% of the mean (see Analysis file). Preliminary ANOVAs on abundance (total and for each species) indicate a very strong depth/disturbance interaction, as well as strong disturbance and location (north/south) main effects. There was no apparent correlation between snail abundance and grazing intensity. Disturbed sites have higher Simpson's D values on average across all depths than undisturbed sites (Figure 2, second y-axis).

The parasite data showed low prevalence of infection and few trends. *Reymondia* was more heavily infected than any other snail species, but almost exclusively (one exception) with the unknown rocket-ship parasite. Rocket-ships were also found on one *Spekia*, suggesting that they are indeed parasitic and may be exclusive to the shallow water areas. Prevalence of infection was highly variable (Figure 3). Trematodes were the only group of parasites found on all other snails, and there was a relatively low prevalence of infection that varied considerably between quadrats, depths, and sites. The proportion of snails infected varied between 0-50%, and was highest on *Lavigeria baiziana*. There are apparent trends with depth and disturbance when all trematode morphotypes were lumped (Figure 3): at undisturbed sites, parasitism was much more common with increasing depth, while it was consistently low at all depths at both undisturbed sites.

Clearly, much analysis remains to be completed. For instance, we would like to look at the distributions of individual species with respect to depth gradients. Using our morphometric and life history data, we hope to detect differences in size at maturity within a species between sites. Size at maturity will also be mapped onto Michel's phylogenies to study life history variation. For example, a precursory look at these data suggests that the *L. baiziana* at Hilltop are reaching reproductive maturity at a much smaller size.

Furthermore, we suspect that there are complex interactions between disturbance, predation, and parasitism. We would like to look at scarring incidence variations between species, between sites within a species, and between depths within a species. This scarring measure will serve as a rough indicator for predation pressure by crabs.

Preliminary analysis indicates that parasitism incidence increases with depth and is greater at disturbed sites. Combined with the strong interaction between depth and disturbance indicated by ANOVA, this warrants further investigation.

References

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Acknowledgements

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Student: Giana A. Gelsey

Affiliation: University of Arizona

Project Title: Taphonomy of fish fossils and calibration of sediment cores using fish remains.

Introduction

Lake Tanganyika, an ancient, deep lake in the western part of the East African Rift Valley, is known for its large number of endemic fish, especially those within the family Cichlidae. Presently there is no fossil record for fish of Lake Tanganyika. In the absence of this record, there is a dearth of information involving the history of biodiversity, abundance, and paleoecology of the fish within the lake. For the greater part of a year, I have been working on this problem using sediment cores. I have gathered fish remains, including teeth, scales and various bones including vertebrae. However, there are some problems with this type of collection, particularly since no one has attempted to construct a fossil record using fragmentary fish remains. The identification of the fossils to even family level is presently difficult; there is no understanding of taphonomy or preservation patterns, nor is there any calibration for the fish remains found in the cores.

In the three week independent study session of the Nyanza project, I have attempted to correct this problem by gathering multiple surficial samples along depth gradients as well as collecting fish for an osteological collection. I intend to use these samples plus the 1998 multi-core tops to solve at least some of the problems mentioned above. Ideally, this includes: 1) the identification of the remains to the highest resolution possible, preferably to genus level, in an attempt to quantify biodiversity, 2) the generation of abundance numbers from a the remains, and 3) the calibration of the sites and sediment cores for paleobiological and paleolimnological understanding.

Materials and Methods

I have collected 5 transects, each consisting of a depth gradient sampled at 2 m, 5 m, 10 m, 15 m, and 30 m. The sites are located in two main areas: the Kigoma Bay area and in the vicinity of Gombe National Park. Within Gombe, two undisturbed sites were selected, Nyasanga and Kahama. Nyasanga was a fortuitous collection due to Sarah Pittiglio's use of the site, while Kahama was used due to its proximity to a multi-core site. North of Gombe, a disturbed site near the village of Mwamgongo was used, also partly chosen due to its proximity to a multi-core site. In the Kigoma Bay area, two sites were chosen: an area just inside Kigoma Bay designated as disturbed, and Bongwe, a supposedly undisturbed site. "Disturbed" versus "undisturbed" is based upon the presence or absence of human habitation, and hence deforestation and disturbance of the watershed. The reason these types of sites were chosen is that it is more likely to see patterns in preservation, sedimentation, abundance and biodiversity in such sites. Other samples are from around the Luiche delta area. Data replication will be achieved by repeated sampling of the 5 original transects, and also across different sites. Many of these sites and samples are being used in conjunction with Sarah Pittiglio's, Mark Woodworth's and Kirsten Bannister's projects. For further information on these sites, please refer to those papers.

In the time period of allotted during the Nyanza Project, only two sites were examined, Nyasanga and Mwamgongo. A fraction of the samples was wet sieved to separate the fish remains for ease of extraction as well as to determine grain size, mineralogy and texture of the sediment. Sample fractions were>4mm, >2mm, >1mm, >0.5mm, >250mm, >125mm, >63mm, and <63 mm (-2 to 4phi). The latter two sample fractions were not examined for fish remains. The samples were then dried, and then picked through using small paintbrushes to avoid damaging the specimens.

In addition to sediment fractions, I have also collected approximately 30 fish species. The fish will be digested by trypsin to isolate the bones, teeth and scales.

Data

Raw data concerning masses of fractions and samples are provided in the report by Sarah Pittiglio's Excel file. Other data are presented in the form of three figures (see attached Fig. 1, 2 and 3). Mineralogy and sediment texture is yet to be examined.

Results and Discussion

In the period of two weeks, I have only managed to pick through two sites: Mwamgongo and Nyasanga. No statistical analyses have been conducted yet. Though it is difficult to make any conclusions from such a small sample size, there are some speculations that may be proven or disproven later. Mwamgongo, in general, has a finer grain size than Nyasanga (see grain size figure in S. Pittiglio's paper). General observations of the samples show that Mwamgongo has a lesser degree of quartz grains than Nyasanga, and has a much higher abundance of charcoal and ostracods. All Nyasanga sediment fractions consisted primarily of subangular quartz grains. It also appears that Nyasanga has a higher diversity though lower abundance of ostracods. The reason why noting ostracod abundance is relevant is because of a pattern noticed in the dissection of two cores, 86-DG-32 and 86-DG-14. In these cores, there appeared to be an inverse relationship between ostracod and fish remains abundance. This pattern does not hold in these samples. The type and abundance of fish remains in the samples differed dramatically (see Figs. 1 and 2). Mwamgongo had much higher abundance, and also had many more scales and bones than Nyasanga. Nyasanga's abundance was lower, and fish remains recovered consisted primarily of teeth. There appears to be a general trend of increased abundance with depth (see Fig. 3). The reason for these patterns is presently unknown. It appears to be counter-intuitive, as it was expected that there would be a higher abundance of remains in the undisturbed site. This may be a result of a preservation/taphonomic difference, which could be the result of pulverization by quartz grains in a high energy environment. A higher influx of finer sediment in Mwamgongo may improve the preservation of fish remains. An influx of terrestrial sediment and/or higher fish abundance by depth may be responsible for the trend of increased fish remains abundance by depth. It is presently unknown if overall fish abundance is higher at one site than the other.

Conclusion

Much work remains to be done on this project, which will be conducted for the next two years. All of the samples need to be worked on, and many samples need to be replicated for statistical comparison. Objectives outlined in the introduction remain to be realized.

Student: Beverly J. Green

Affiliation: University City High School, Philadelphia, PA

Project Title: A preliminary investigation of the vertical distribution of bacteria in the water column of Kigoma Basin of Lake Tanganyika

Introduction

Bacteria are an integral part of any freshwater ecosystem. Bacterial mediated events in water include remineralization of particulate detritus, biodegradation, production of gases and microbial induced metal accumulation. Recent studies in the productivity of aquatic ecosystems place bacteria in a larger role as part of a microbial loop in the food chain that contributes dissolved organic carbon into a system. Seasonal and sometimes, daily changes in bacteria occur as physical, chemical and biotic conditions change in the water.

Large microbial communities such as biofilms or slime formations significantly influence water turbidity and color. Aquatic bacteria can also exist suspended within particulate matter or as smaller free-living cells in water with less impact on physical parameters, yet, detectable by diagnostic tools that identify the chemical processes mediated by the organisms. An amazing variety of inorganic and organic substances are used by bacterial to obtain energy for growth and there is often a symbiotic relationship among the various substrate users. So, an ecologically useful method of grouping bacteria is based on substrate utilization.

Objectives

This project will investigate the vertical distribution of bacteria at one site in the Kigoma Basin of Lake Tanganyika. Recent physical and chemical measurements of the water column were used to prepare the sampling scheme (see Appendix A).

Methods

Water samples were collected from various depths in the pelagic zone of Lake Tanganyika, GPS position: S 05°0010.79 E 029°33.831 between July1, 11:15 PM and July 2, 12:55 AM. Physical and chemical parameters measured at the time of sampling include temperature and dissolved oxygen. Other tests including water turbidity, pH, conductivity, and concentration of nitrates and soluble reactive phosphorus were analyzed in the laboratory within 24 hours of collecting the samples.

The samples were tested for specific substrate groups using Biological Activity Reaction Tests, BART™ (Droycon Bioconcepts, Hach Co., Regina, Canada). The BART method evaluates the rate at which bacteria metabolize substrate and generate an observable reaction as a result of oxidation, reduction, or enzymatic activity. Water samples were placed in BART system tubes on site and incubated at room temperature. There were five tests performed to detect the presence of environmentally significant bacterial functional groups.

(a) Aerobic bacteria use oxygen for respiration while degrading various substrates. The semi quantitative BART test was used to detect obligate aerobes found only in the oxic areas of the lake, and facultative anaerobes that exist in levels below the oxycline. Facultative anaerobes will use oxygen when it is available. Tests were examined after 6 hours and then once every 24 hours for 7 days.

(b) Nitrifying bacteria use several aerobic pathways to recycle organic nitrogenous compounds to nitrates and nitrites. Samples were taken from the upper 100 meters of the lake. Tests were examined for a reaction after 5 days.

(c) Denitrification is a reduction reaction that is the reverse of the nitrification process. Bacterial activity occurs most frequently in anaerobic environments. Denitrifying bacteria play a role in recycling organic nitrogenous material back to atmospheric nitrogen gas. Sampling included areas well below the oxycline. Tests were read every 24 hours.

(d) Sulfate reducing bacteria produce H_2S while using sulfate compounds as sources of energy. Sulfate reducers are obligate anaerobic bacteria and tend to grow in microbial biofilms. Water samples were taken from anoxic areas of the lake. Tests were examined for reactions after six hours and once every 24 hours.

(e) Photosynthetic bacteria, Cyanobacteria, use light as a source of energy. Samples were taken at night from the photic zone of the lake. Tests were first placed 1 meter away from a fluorescent light source for 12-16 hours per day. After 4 days the tests were moved to an area well lit by sunlight.

A sterile water sample was prepared in the lab and used to prepare control tubes for aerobic, photosynthetic, nitrifying, and sulfate reducing bacteria, on day 2 of the incubation of the water samples. No control was prepared for denitrifying bacteria since all 7 of the BART tubes had been used in the testing.

Results

Physical and chemical parameters of the water column at the time of sampling are shown in Table 1. Parameter data was generally within range of values typical for Lake Tanganyika's northern basin. The water column had a thermocline at 60-80 meters on the night of sampling. Although dissolved oxygen measurements were not taken at depths beyond 100 meters, the lake would normally be anoxic at 150 and 200 meters. Turbidity levels were typical for the pelagic zone with maximum turbidity occurring at the surface and at 150 meters. Turbidity is known to increase with the presence of communities of bacteria. Nitrate levels while relatively low, were highest at 80 – 100 meters just below the thermocline.

The results of BART tests are evaluated on the number of days needed for the reaction to occur (days of delay, dd) and the strength of the reaction as compared to a BART comparator chart. Aggressive reactions were observed on day 2 for total aerobic bacteria sampled at 80 meters. Within 4 days total aerobic tests at all depths except 150 meters had exhibited aerobic activity as detected by the complete bleaching of methylene blue dye in the test medium. The presence of Cyanobacteria and other photosynthetic microorganisms in the water column was not detected after 7 days of incubation. The presence of nitrifying bacteria was not detected after 7 days of incubation. Tests indicated the presence of denitrifying bacteria at all depths tested. The reaction was aggressive at 40 to 200 meters as measured by the color and dd for the reaction. Sulfate reducing bacteria produced an aggressive reaction at 200 meters. The reaction was not observed until day 7 of the incubation. Results of the tests are summarized in Table 2.

Discussion

Aerobic activity was detected down to 100 meters. A very aggressive reaction, 2dd, for aerobic bacteria in samples taken from 80 meters may indicate the presence of a community of facultative anaerobes. These groups of bacteria distributed in areas of low oxygen concentration use other substrates as a final electron acceptor during cellular respiration. Although the rate of the BART biological activity reaction is dependent on factors other than population size, such a strong reaction if confirmed in subsequent investigations, might indicate a large and diverse facultative community at that depth. A slightly less aggressive reaction of 3dd was observed at 100 meters and the reaction was not completed after 7 days for samples from 150 meters.

Nitrifying bacteria would normally occupy the oxic levels of the lake. However, the ammonia levels in the upper zones of Lake Tanganyika are so low, these groups of bacteria would certainly starve. Nitrifying bacteria tests were negative for activity after an incubation period of 7 days. Perhaps, further study of samples from the thermocline and upper hypolimnion may show activity. Although oxygen levels are quite low at that depth, nitrate concentrations are among the highest in the lake.

Denitrifying bacteria in anaerobic environments can reduce nitrates and nitrates to less oxygenated forms such as nitrogen gas. All tests from 40 meters to 150 meters indicated the presence of denitrifying bacteria. This was the only test run without a control, so results can be considered suspicious especially since activity was also detected in samples from oxic zones of the lake.

Photosynthetic microorganisms would be densest at the surface and decrease with depth. The testing method used could detect Chlorophycreae, Cyanobacteria, desmids, diatoms and euglenoids. The absence of any photosynthetic activity during the 7 days of incubation probably is due to a combination of inadequate light conditions and too short an incubation period.

Hydrogen sulfide gas, produced by the action of anaerobic bacteria on sulfate compounds, has a very distinctive odor. The odor was conspicuously present while sampling water from both 150 and 200 meters. After 7 days of incubation, the first evidence of a reaction, black iron sulfide precipitate in the test medium, was observed for the sample from 200 meters. Sulfate reducing bacteria are obligate anaerobes, grow as part of a biofilm that may need to adhere to a surface area and are difficult to culture and detect. A reaction after 7 days of incubation is considered very aggressive. More incubation time may be needed for less aggressive reactions. This bacterial community may also exist at much greater depths than that at which the gas' odor is first detected. Further investigations might consider sampling at greater depths.

Conclusion

This preliminary examination of the bacterial distribution in the lake bought out several problems that can be avoided with careful planning of subsequent investigations. First, the importance of the control can not be over emphasized. The control should be delivered to the testing medium at the same time and under the same conditions as the water samples. Sterile water for the control can be prepared in the lab and taken to the testing site. Commercial testing kits sometimes exhibit unusual patterns and colors that deviate slightly from the expected results. A control is essential to distinguish a reaction from a non-reaction. Of course, the control also monitors aseptic technique.

Secondly, enough time should be available for incubation periods up to 30 days for some tests.
Photosynthetic bacteria and sulfate reducing bacteria may require more time to establish a colony and mediate the reactions.

Finally, sampling from several areas may give a more accurate picture of the bacterial activity in a region of the lake. One should not expect to find a horizontally uniform community of bacteria spread across vast regions of the lake. Bacteria communities probably exhibit the patchiness seen in the distribution of other biota in aquatic ecosystems.

Some questions I still have about the bacterial distribution in the lake include; if there is a bacterial cycle in the lake, what are its characteristics? What is the depth of the sulfate reducing bacteria community? What is the level of nitrogen fixation by bacteria in the lake? What bacteria play a role in microbial food web? Are iron-related bacteria present in the lake sediment? What processes do they mediate? Future investigations might contain answers to these questions.

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Project Title: An Investigation of short-term variations in the thermocline depth in Lake Tanganyika and its effect on nutrient levels in Kigoma Basin

Introduction

The seasonal morphology of Lake Tanganyika sets up an internal seiche that oscillates throughout the lake. This unique oscillation has been found to be on the order of 26-33 days (Coulter and Spigel, 1991). Pulses generated by the internal wave can often be reflected in the level of the thermocline depth as well as in nutrient levels.

Objectives

An investigation of movements in the thermocline depth and its impact on fluctuations in the nutrient regime examined trends in the long-term and short-term internal waves. The long-term trend was studied by measuring physical and chemical parameters and chlorophyll *a* on a 3-day cycle. The presence of shorter-term fluctuations was investigated during an intensive 6-day morning and afternoon period.

Materials and Methods

Field Work: Sampling was performed on a wooden Ujiji boat at S 4°53.453' and E 29° 35.059' on June 24 and 26, and at S 4° 52.804' and E 29° 36.026' from June 30-July 6. The site was changed due to rough conditions at the former site. The sampling consisted of on-board temperature and dissolved oxygen measurements using an FAO-FINNIDA Temperature and DO meter at every 10m down to 60-100m. Radiation measurements were taken using a LICOR instrument at four surface water depths as well as secchi disk readings. Six one-liter water samples were obtained at 0, 20, 40, 60, 80, and 100m respectively. From July 1-6 a thermistor chain was placed at S 4° 52.945' and E 29° 35.958' at 5m, 50m, 60m, 70m, and 80m to measure the water column every 10 min.

Lab Work: Conductivity, pH and turbidity were measured using standard meters. Alkalinity tests were performed with a basic H_2SO_4 titration. The water samples, down to 60m, were filtered using a filter pump and the filter paper stored in 94.1% CH_3OH for spectrophotometric chlorophyll a analysis. The filtered water was then used to measure NO_3-N, PO_4-P, and SiO_2 following the HACH DR/2010 spectrophotometric methods.

Results

Physical (Temperature Data- Haupert): Appendix I and II show all of the raw data collected in the field and lab. The temperature data from the FAO-FINNIDA T° and DO meter did not reach far enough into the water column to determine the actual depth of the thermocline. The trend in the upper part of the metalimnion was determined and used to supplement the thermocline (Figure 1A). This exists between depths of 60-100+m. The trend at 24.6°C characterizes the long-term fluctuations in the thermocline depth. A short-term wave was not discernable due the small data set.

A compilation of thermistor data from this study and another team's study showed a distinct boundary between surface water and deeper water movements (Figure 2A). The water column appears to be stratified between 30-50m. Above this depth, daily warming trend peaks are present between 12:00 and 15:00 each day. Below the stratified layer, especially during July 1-6 there are many fluctuations, or pulses, that are completely separate from the surface waters. During the third of July, a dramatic increase occurred in the temperature. The chain had been lifted out of the water 3 hours earlier and replaced at a different location.

Discussion

Physical (Temp): The depth of the thermocline decreases starting after June 14 and hits a minimum around June 22, it begins to increase after that and peaks at a maximum late July 3(Figure 1A). This period is only 18 days long, however; previously recorded waves have been measured on order of 26-33 days. Perhaps the wave period was shorter this month. Without temperature readings from June 13 and 15-18 it is hard to know exactly what level the metalimnion was at during that period.

The thermistor data provided evidence that there are indeed fluctuations or some sort of water movement that is influenced only in the deeper water (Figure 2A). The phenomenon occurring on July 3 is somewhat disturbing. There is currently no logical reasoning for this phenomenon, but it can not be ruled out as erroneous data. In comparing previous records of the lake, there appears to be a lot of patchiness when small pulses travel through the lower water column. This anomaly may indeed be caused from some aperiodic pulse that surged through the lake.

B: Results (Physical/Chemical-Nahayo and Hazikimana)

Nous nous sommes intéressés par certains paramètres physiques et chimiques (turbidité, chlorophylle a, nitrates, phosphates et silicates). Nous devons signaler que les autres paramètres ont été mesures sur terrain et au laboratoire mais non pas été traite statistiquement ou graphiquement faute de temps (alcalinité, radiation a la surface de l'eau, conductivité etc.

1.) Comparaison de la turbidité et de la chlorophylle a (FIG 1B&2B)

Il apparaît que les deux paramètres varient en même temps et avec la thermocline (voir C. Haupert)
En principe la turbidité diminue avec la profondeur mais pas toujours car des faits il y a présence des patchiness. Mais avec la diminution de la profonde de la thermocline c'est-à-dire la montée de la thermocline il y a une montée die nutriments qui augmentent la turbidité (voir Fig. 2B) en date du 4 juillet. Da même, la chlorophylle a augmente la même date (voir Fig. 1B). En plus les deux paramètres continuent à varier dans le même sans que la thermocline. Une attention est à tirer sur les deux paramètres avec la variation de la thermocline.

2.) Analyse des phosphates, nitrates et silicates

Les trois nutriments ont une importance capitale dans la chaîne alimentaire au niveau des eaux. Tous les trois sont beaucoup concentres en profondeur avec la prédominance des silicates dans les eaux anoxiques. Pour le phosphates notre analyse le prouve (voir Fig. 3B).

En effet a partir du 2 juillet il y a une augmentation de la concentration des phosphates qui va avec le début de la montée de la thermocline. Par contre, nous ne voyons pas une montée de nitrates, ni des silicates, plutôt ils diminuent en même temps, alors que la thermocline monte. Nous ne croyons pas qu'il y a une liaison logique, mais on peut penser aux organismes qui en ont besoin pour la synthèse des aliments (voir Fig. 4B et 5B). Le 2, 3 et 4 juillet, nous n'avons pratiquement pas de silicates, nous croyons qu'il y aurait une grande activité des diatomées qui en utilisent pour la synthèse des frustules.

Discussion

Une conclusion préliminaire conduit a dire que certains paramètres, varient avec la profondeur. Ici nous pensons aux phosphates, nitrates, silicates, turbidité et chlorophylle a.

Si les moyens le permettent nous comptons continuer l'analyse de nos données et peut-être continuer l'analyse de l'échantillonnage.

Une meilleure connaissance de la périodicité de vagues internes pourrait renseigner sur la disponibilité des nutriments qui influence la présence des autotrophes et microorganismes qui en utilisent pour la synthèse d'aliments. Ici nous pensons aux diatomées, rotifères, etc. qui constituent la base de nourriture de poisson. Ainsi on pourrait renseigner aux pécheurs le moment de poser les filets pour une meilleure prise.

Toutefois, une connaissance interdisciplinaire (climatologique, biologique et limnologique) pourrait apporter de bons renseignements. Donc en même temps qu'il faille faire des analyses limnologiques il faut aussi une étude biologique et climatologique combine.

C: Présentation des résultats

24 Juin : La distribution de la concentration des nitrates est constante jusqu'à 40m puis augmente jusqu'à 80m. L'allure de la concentration des phosphates est similaire a celle de la chlorophylle et a tendance a s' accentuer avec la profondeur. La thermocline est à plus ou moins 60m de profondeur et l'oxycline aux environs de 75m.

26 Juin : L'allure de la concentration des nitrates dans les 40 premiers m augmente contrairement a la concentration de la chlorophylle comme indique la déviation standard. Entre-temps la concentration de la silice est grande. La thermocline descend avec l'oxycline. La quantité des phosphates n'est pas grande comparativement aux autres jours.

2 Juillet : L'échantillonnage s'est fait plutôt de 2 heures que les 2jours précédents. Une diminution des nitrates, de la silice, de la chlorophylle mais pas de variation sensible d'alcalinité. Entre-temps on observe une augmentation des phosphates contrairement au jour précèdent ou le boom était a 40 et 80m. La conductivité varie également avec la thermocline.

3Juillet: La concentration des phosphates est grande a la surface et a 40m de profondeur. Ceci est en corrélation avec la concentration de la chlorophylle a la même température. Il faut également souligner qu'a la même date que la concentration des nitrates au-dessus de la thermocline est grande. La thermocline et l'oxycline sont en dessous de 60m avec une alcalinité grande d'où une probabilité d'une activité métabolique. La quantité des silicates est encore presque nulle au-dessus de la thermocline.

4 Juillet : L'intervalle avec le jour précédant étant de 24heures, on n'observe pas de variation très sensible mais on peut noter au-dessus de la thermocline une grande quantité de nitrates surtout a 0m et 20m et la chlorophylle diminue avec la profondeur pour s' annuler à 60m. La conductivité qui augmente coïncide avec la grande quantité de nitrates, de phosphates, faible augmentation de silice et d' alcalinité. L'oxycline est descendus jusqu'à 50m et la thermocline a 55-60m sans oublier un niveau élevé de la chlorophylle.

5 Juillet : Coïncidé avec le 3e jour après le 2juillet. On remarque une montée très nette de presque tous les nutriments (nitrates, phosphates, silicates, et l'alcalinité).

6 Juillet : Une augmentation de la concentration de la chlorophylle entre 10 et 45m de profondeur. Quant a l'alcalinité,

elle augmente progressivement au cours de ces jours d‘ échantillonnage. Une autre remarque est que les nitrates et les silicates sont grandes au-dessus de la thermocline.

C: Discussion des résultats

A voir l'évolution ou la répartition des nutriments au-dessus, de thermocline, on constate quelques particularités. Au premier jour nous constatons une relation de proportionnalité entre la. Chlorophylle et les différents nutriments d‘ ou une grande probabilité d'une activité métabolique et photosynthétique. On contente que la stabilité des nitrates est liée également avec la profondeur de la oxycline. Qui est descendu parallèlement a la concentration des nitrates (voir tous les jours mesures).

D'une manière generale, que pour les nitrates nous avons du 24/06,une diminution avec un minimum au 2 juillet pour regagner le pic au 3 juillet soit environ 8 jours et par après on constate un autre faible diminution. On ne peut rien suggérer pour les autres 8 jours faute de donnes mais on pense que l‘ allure serait semblable. En outre l'augmentation de la concentration des nitrates vers la surface est en relation avec la thermocline sous l‘ impulsion d'une vague interne.

Quant aux silicates, on constate qu'il existe presque une similitude avec les allures des courbes des nitrates avec quelques resserve pour le 24/06 entre 80m et 100m de profondeur suite a la chute la courbe ; probablement la présence des diatomes qui ont consommes la silice dissoute.

Il est egalement important de souligner l‘allure inverse des phosphates et des silicates entre le 26/06 et le 6/07.

A voir les donnes du 2/07 pour les nitrates, on peut suggerer etaient soit defavorables pour la stabilite de de l‘ azote nitrique (potentiel d‘oxydo-reduction trop bas, absence d‘oxygene) (pas de donnes de D.O. ce jour) et nitrates tendent a disparaitre et sont boucoup moins stables (nitrites, ammonique) et ses sels ou soit des erreurs d‘ analyse.

Il est egalement interessant de signaler que du 24/06 au 6/07 les allures des phosphates, des nitrates, et de la chlorophylle a sont plus ou moins semblables. Meme si la variation est faible, l‘alcalinite est en correlation avec la chlorophylle a c-a-d quand l‘un augmente l‘autre diminue. L‘echantillonnage le matin avant l‘activite photosynthetique en plus de la brise du lac peuvent apporter quelques modifiction.

CONCLUSION:

A long-term wave in the thermocline depth was determined to be on the order of about 18 days. Thermistor data showed that the water column has a stratified layer that separates any fluctuations in the surface from those happening deeper. Trends in nitrate, phosphate and silicate followed the periodic motion of the internal wave. Therefore, periodic fluctuations in the thermocline depth have an impact on the level of nutrients, as well as the level of microorganisms.

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Title: Nitrogen or Phosphorous Limitation in Nearshore and Pelagic Waters of Kigoma Bay, Lake Tanganyika - East Africa

Abstract

Low concentrations of nutrients and strong spatial and seasonal dynamics in Lake Tanganyika have been problematic for determining the limiting factor for primary productivity. We attempted to determine a limiting factor by measuring phytoplankton growth response to nutrient addition. Ambient lake-water nutrient levels of Kigoma Bay, Lake Tanganyika were measured from 23 June 98 to 26 June 98. Following the sampling period, water from both the littoral zone and pelagic zone of Kigoma Bay was collected and phytoplankton growth response to nitrogen and phosphorus addition was measured. Opposite results were obtained for the different zones; addition of nitrogen failed to increase algal biomass in the treatments obtained from the littoral zone, while addition of phosphorus failed to increase algal biomass in the treatments from the pelagic. Results suggest that further work is needed on both nutrient dynamics and alga community dynamics in Lake Tanganyika.

Introduction

Lake Tanganyika, the deepest of the African Great Lakes, has been widely noted for low ambient nutrient levels (Coulter 1991, Edmond et al. 1993). Nitrite (NO_2) and phosphorus, both total and PO_4-P, have been particularly difficult to measure and are often too low to determine accurately. Nitrate (NO_3) and ammonium (NH_4) have been found at higher levels, though the seasonal average is still relatively low (Plisnier et al. 1996). Establishing a limiting factor in Lake Tanganyika has thus been difficult given the low levels of nutrients. Although it has long been argued that the lake is most likely nitrogen limited (Talling and Talling 1965, Moss 1969, Edmond et al. 1993), recent long-term research has found Lake Tanganyika to be seasonally dynamic in nutrient composition (Plisnier et al. 1996). Both Coulter et al. (1991) and Hecky and Kling (1981) have suggested that the lake may switch between nitrogen and phosphorus limitation based on the season. In Kigoma Bay, Tanzania ambient soluble reactive phosphorus (PO_4-P) levels have ranged from 0.8 mg/L to 0.0 mg/L and nitrate levels have ranged from 0.222 mg/L to 0.0 mg/L over a single year (Plisnier et al. 1996).

Nutrient levels have also been found to vary greatly over short periods of time (Plisnier, personal communication), suggesting that the physical features of the lake driving the dynamics of the lake can potentially operate over relatively short periods of time. Little is known about these processes or the levels of scale upon which they operate. Similarly, physical processes may have a profound effect on ambient nutrient levels over relatively small spatial scales. Upwelling processes, driven by the lake's catabatic and onshore winds, may raise nutrients to coastal regions of the lake early in the morning. Similarly, different planktonic communities in the littoral and pelagic zones may respond differently to available nutrients. In the summer months, the Kigoma Bay pelagic region has been dominated by cyanophyta, especially *anabaena* (Hecky et al. 1978). Although primary productivity is thought to be higher in the littoral zone (Plisnier et al. 1996), little research is available on the algal community. A combination of biological and physical effects have been invoked to help explain the nutrient patterns of Lake Tanganyika; Coulter (1991) suggests that nitrogen is primarily fixed in the mixalimnion with little eddy diffusion from below while phosphorus is brought into the mixalimnion almost entirely from mixing with deeper waters.

We investigated possible differences in nutrient availability and growth responses of phytoplankton to nutrient enrichment between the pelagic and littoral zones in Kigoma Bay, Tanzania during the summer dry season. We tested the hypothesis that the lake is nitrogen limited by measuring ambient lake-water nutrients in the morning and evening and by evaluating growth responses of phytoplankton to the addition of both nitrate and phosphorus.

Methodology

Water samples were taken at 5 m depth in the littoral zone and 5 m, 30 m and 60 m depth in the pelagic zone on alternating evenings and mornings from we June 98 to 26 June 98 (Appendix A, Table 1). Samples were 2.0 L in volume and analyzed for ammonia, nitrate, nitrite and total phosphorus with a Hach Co. DR/2010 spectrophotometer. All analysis methods are USEPA approved for water analysis.

Phytoplankton growth response experiments were conducted following Lehman and Branstrator (1994). Water was collected from one littoral and one pelagic site near Kigoma Bay, Tanzania (Appendix A, Table 1). Light intensity was measured with a LI-COR LI-1000 light meter and water was drawn at 20% surface water light intensity at each site. Treatment water was hand pumped from the determined depth and filtered with 100 uM mesh and transported in a closed cooler to the laboratory. Bath water for incubation was taken at surface depth and also transported in a closed cooler. Phytoplankton were incubated in 2 quart volume transparent polyethylene enclosures (Zip-Lock bags). Treatments were 2350 mL volume, enriched with either 10 *u*M nitrogen (NH_4NO_3), 1 *u*M phosphorous (Na_2HPO_4) or both in combination. Enclosures were incubated in bath at ambient lake-water temperature for 48 hr. Neutral density screen filters were used to reduce the ambient surface intensity of the sunlight to measured lake-water levels. Concentrations of

Chl *a* were obtained by performing overnight extraction in 94.1% methanol and measuring with spectrophotometer. Final values were determined by the following equation:

Chl *a* (*u*g/L) = ([665 nm] - [750 nm]) * {(13.9 * v)/(V * 0.40 cm)}

where v is the volume of extract, V is the total volume filtered, 13. 9 is the Chl *a* coefficient and 0.40cm is the path length of the spectrophotometer.

Results

The water used for treatment from the littoral zone was more nitrate rich than the pelagic, though nitrite and SRP levels were the same (Appendix A, Table 2). Ammonia was not present in the water drawn from the pelagic and data was not available for the littoral zone.

Week long data indicate that nitrate generally varies more than SRP and was frequently absent from the water column, suggesting that it may be a limiting factor in both zones (Appendix A, Tables 3 and 4). Phosphorus and nitrite were similar at both sites and present in low concentrations. Ammonia was not present in the samples though often it is only found in the deeper waters below the thermocline (Plisnier et al. 1996).

Results from the nutrient enrichment were not conclusive (Appendix A, Figures 1 and 2). Algal biomass did not increase in the littoral zone with addition of nitrogen. Phosphorus addition greatly increased algal biomass in one treatment, and just slightly above the control in the second. Because the second Chl *a* measurement was taken from the combination of two treatments of 2350 mL each, there were only two measurements to compare. The nitrogen addition failed to increase algal biomass beyond the control. Addition of both nitrogen and phosphorus in combination obtained a growth response similar to the control.

In the pelagic zone, the opposite results were obtained. Algal biomass did not increase with addition of phosphorus. No two replicates were combined for Chl *a* measurement so that three replicates could be obtained for each treatment. However, one of the nitrogen additions broke open during incubation, reducing the number of replicates to two. One nitrogen addition underwent a very large growth response and the other did only slightly better than the control. The phosphorus addition failed to obtain an algal biomass higher than the control, and the nitrogen and phosphorus in combination yielded an algal biomass similar to the control.

Discussion and Conclusion

While preliminary analysis suggests that the littoral zone was phosphorus limited and the pelagic zone was nitrogen limited, the large standard deviation in treatments where a growth response was invoked beyond the control suggests a larger number of replicates is required. However, a similar experiment performed with pelagic water from the middle of the lake had yielded similar results (Jarvinen et al. 1996). Although they found the greatest algal response was to a combination of carbon, nitrogen and phosphorus, phosphorus showed a large standard deviation among treatments for increased growth response and the nitrogen addition failed to surpass the control in algal biomass.

The responses we found may be a result of a difference in phytoplankton communities. A large amount of cyanophyta was observed in the shallows of Kigoma Bay. If they are forming heterocysts, the nearshore waters may obtain a stronger growth response from phosphorus. Similarly, if the offshore community is dominated by diatoms or green algae, a larger response to nitrogen may be observed. Continuing research both on nutrient fluxes in Lake Tanganyika and its algal communities are necessary to gain a better understanding of the seasonal and spatial differences in limiting factors to primary productivity.

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Title: Diatom assemblages in surface sediments of Lake Tanganyika

Diatom communities are an important part of aquatic ecosystems because they are the source of food for many organisms, and diatoms can be a useful tool for paleolimnology since they are sensitive to changes in water conditions and they usually preserve well in sediments. Previous studies of diatoms in Lake Tanganyika include an analysis of the diatom stratigraphy of a sediment core from the southern part of the lake (Haberyan and Hecky 1987), and a description of the benthic diatom flora found in the surface sediments of the northern part of the lake (Caljon and Cocquyt 1991). Little is known about the ecology of many diatom species in Lake Tanganyika. A systematic study of diatom assemblages found in surface sediments from other parts of the lake would be useful for comparing the similarity between the sites and for making conclusions about patterns of diversity. This type of information would also be useful for the interpretation of diatom assemblages in sediment cores. We have made a preliminary survey of the diatom assemblages in surface sediments near the Luiche River delta of Lake Tanganyika and determined the relative abundance of important genera. While sample sizes are too small and reliable identifications of several genera are lacking for making conclusions about diatom distributions, our study suggests directions for further investigations.

Surface sediment samples were collected with a Ponar grab sampler offshore of the Luiche River delta and in Kigoma Bay. I treated the sediments with HCl and Hydrogen Peroxide to remove carbonates and organics, respectively (see Appendix B for processing protocol). The cleaned diatoms were mounted on microscope slides with Permount and analyzed with an Olympus microscope at 1000x. Nine microscope slides were prepared, but only three were suitable for counting diatoms due to mineral debris in the residue and the low abundance of diatoms on the slides. I counted 300 frustules in samples from 19m and 43m water depth, but only 106 frustules in the sample from 108m water depth due to low abundance. The diatoms were identified to genera and placed in one of 10 categories: *Nitzschia*, *Navicula*, *Diploneis*, *Surirella*, 1, 2 (names unknown), *Melosira, Stephanodiscus*, *Amphora*, and other. The *Nitzschia* category refers to *N. fonticola*, as few "needle-like *Nitzschia*" (Haberyan and Hecky 1987) were observed.

Nitzschia, Melosira, and Stephanodiscus are planktonic genera; the other categories identified are benthic (Caljon and Cocquyt 1992). Although the analysis does not indicate that the relative abundance of identified planktonic genera increase in sediments from the anoxic zone, the percentage of genera in the "other" category does increase (fig. 1). Since most of the genera that were identified were benthic (Caljon and Cocquyt 1992), this suggests a shift in the pattern of diatom assemblages between sediments in the oxic and anoxic zones, but further analysis is necessary to determine the characteristic assemblage of these sediments. *Nitzschia fonticola* were common, and *Melosira* were rare. Since *Melosira* outcompetes other planktonic species when nutrients are abundant, this can indicate a stable water column with few nutrients (Haberyan and Hecky 1987, and references therein). *Surirella* and *Rhopalodia* are common genera in littoral sediments in Lake Malawi (Haberyan *et al.* 1986), but I found few *Rhopalodia* in the Tanganyika sediments. *Diploneis* was reported as a rare brackish-water genus in African waters by Gasse (1986), but it is common in the Tanganyika sediments. More ecological information is necessary in order to understand the dominance patterns of these species.

A more complete survey of diatom communities in surface sediments is necessary. Future studies should use diversity and dominance indices to compare diatom assemblages. Further research should also make use of microsphere markers (Battarbee 1986) during the sediment processing procedure in order to determine absolute abundance of diatoms and to test the processing method for problems with losing and/or damaging frustules. Comparisons should be made between the diatoms found in sediments and the diatoms collected with sediment traps, phytoplankton nets, and artificial substrates. Additional studies should also focus on the effects of grain size, nutrients, and physical limnological conditions on sedimentary diatom assemblages.

Protocol For Making Diatom Slides With Sediments

Place a small amount of each sediment sample into a test tube (less than 1cc). Add approximately 10 ml of 10% HCl. Place the test tube in a hot water bath for 15 minutes. Centrifuge, decant, rinse with distilled water, centrifuge, and decant again. Add ~10 ml of Hydrogen Peroxide. Place the test tube in a hot water bath for 30 minutes. Centrifuge, decant, rinse with distilled water, centrifuge, and decant (repeat rinse two more times).

Mix the remaining sediment with water and put a drop on a coverslip. If there is mineral debris in the solution, it may be necessary to experiment in order to find the best dilution. The solution can also be swirled and allowed to settle for about 30 seconds to separate the debris from the diatoms. Use a dropper to draw the liquid off the top after it settles. Let the coverslip dry –make sure that it is on a level surface.

Place labeled slides on a warm hot plate. Put a drop of the mounting medium on the slide. Then put the coverslip on the slide face down. When bubbles form, press down gently on the coverslip to squeeze out the excess mounting medium. It is better to have too much mounting medium than not enough as long as it does not make a mess. Let the medium cool and harden for at least two hours.

Avoid the possibility of cross-contaminating the samples during processing by using disposable stirring sticks during each step and not reusing them. Also, it may be helpful to add a known quantity of a marker to the sample prior to processing in order to determine the abundance and to estimate the amount of diatoms lost during processing.

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Title: Fisheries and limnological patchiness: An Investigation between Water Parameters and Fishing Results in Lake Tanganyika

Introduction

In Lake Tanganyika, a fishing vessel commonly ranges from night to night within an area of about 50 km2, and catch variation should be considerable if *Stolothrissa* distribution is discontinuous within such an area. This appears likely.

The acoustic survey of the Lake Tanganyika (Johannessson, 1975) showed biomass to be highly variable among 3.7 km survey tracks.

The uneven distribution of nutrients (nitrogen, phosphorus) is largely the consequence of the existence of thermal stratification in the Lake. Fluctuation in the existent stratification determines the degree of nutrient influx into the photic zone. The waves, mainly detected below the thermocline influence thermocline depth and the “Nutrient waves” might influence organisms adapted to capitalize on episodic events.

We are hypothesizing that there could be some relationship between fish patchiness, algal patch distribution and uneven distribution of nutrients.

Objective

The objective is to see if there is a relationship between variability of the fishing catch and spatial / temporal variability of the water parameter / zooplankton.

Materials and Methods

A comparison of the water parameters and fishing results of separate sampling units was used to study patchiness in the Kigoma Basin of Lake Tanganyika. Our group used a 12-meter research vessel, R/V Echo, to tow a catamaran fishing unit and fisherman to a site of their choice. Fishing is done at night, so the study data was collected on 4 different nights over a 2- week period between mid-June and mid-July 1988. A total of 7 sites were sampled with 4 of the sites in pelagic areas and 2 near shore areas of the lake.

Fishing units (one catamaran and one lift net) usually consist of 2 boats and 4 to 6 fishermen. The fisherman’s equipment generally consists of pressure lamps, used to attract the fish the first 2 to 3 hours at a site, a type of net and poles to haul in the net. Our research vessel was situated a shouting distance from the fishing unit. The GPS location was recorded then water sampling and physical measurements were begun about 1 hour before fishermen began hauling their nets.

Physical Parameters

One-liter water samples were taken from the surface of the lake and at 10, 20, 40, 60, 80 and 100 meters. Water temperature was measured every 10 meters to a depth of 60 meters and then at 80 and 100 meters by using a portable temperature and dissolved oxygen probe with a stirrer. Turbidity was measured the next day in the lab using a portable turbidimeter (Model 2100P, Hach Co.) Water samples that were analyzed in the lab were kept at 4°C in the field and frozen upon return to the lab. Analyses were performed within 24 hours of collecting the samples. The number of pressure lamps used to attract the fish was noted along with the moon phase, since it is known that a strong moon presence will inhibit the ability of the lamps to attract fish. The first sampling was during a new moon and last during ½ moon phase.

Chemical Parameters

Conductivity measurements for presence of salts in the water were taken at the site using a conductivity/TDS meter (Model 446000 Hach Co.) Measurements for water pH were conducted at the site also using the portable conductivity/TDS meter. Dissolved oxygen concentrations were taken at the site with a portable oxygen probe. The instrument was calibrated by correcting for altitude and temperature at Lake Tanganyika. Analysis for nitrates and soluble reactive phosphorus were done next day in the lab using the cadmium reduction method and test’N tube method (Hach Co.) The concentration was measured spectrophotometically.

Biological Factors

Zooplankton levels in the water column were studied by using either a 53 micron or 102 micron mesh net and collecting from a vertical depth of 20 meters. The sample was preserved in a solution of 1:1 distilled water and 10% formalin. The number of zooplankton was counted in a 1ml aliquot of the sample.

After each haul, a random sample of the catch was collected. The total weight of the fish catch was estimated. The type and % of each fish species in the random sample was recorded along with measurements of mass and length for each fish in the sample.

Preliminary Results

Physico-chemical Parameters

Temperature

There is a remarkable temperature variation from one day to another during the course of sampling. Temperature seem be decreasing from the first day to the last. The thermocline depth decreased from 60 m on the first day to 40 m on the last days.

Turbidity

Turbidity shows a positive increase from first day until the last day (between 0 m and 60 m) in the offshore sampling. However, it was also observed that on the first and second day, turbidity at the near-shore area was greater than at the offshore area. (Fig.1).

Conductivity

Conductivity during the first and second days remained constant down to 60 m, while the third and fourth days the conductivity was constant at 40 m. (fig.1.)

pH:

The pH-cline on first day was at 60 m, the second day was at 50 m. On the third and fourth days, it was at 40 m. but pH increases at this depth.

Dissolved Oxygen

The oxycline on first day at the offshore was at 60 m and on the third and the last days of the sampling was at 50 m.

Reactive Phosphorus

Soluble reactive phosphorus seems to be completely mixed but there was an increase in concentration from the first to the last day of sampling. (Fig.1.).

Nitrate

The nitrate chemocline was at 40 m the first and the last days, at 60 m the second and the third days of sampling. There is an increase in concentration with depth from the first to last day at the chemocline.

Zooplankton abundance

The number of zooplankton captured increased linearly through the sampling period. (Fig.2).

Fishing

The fish catch was evenly distributed for the whole period of sampling. (fig.3c). The *L. stappersii* (adults) catch was high at the first beginning, but stared to drop off, being replaced by catches of *Stolothrissa* and *L. stappersii* (juveniles.

Discussion

It seems that the temperature, thermocline, chemocline changed between the first day and the last day of sampling from 60 to 40 m depth. This could be due to internal waves. The turbidity, D.O., PO4-P concentrations increased greatly while conductivity showed a slight increase. These conditions slightly favored an increase in number of zooplankton and total catch of fishes. This is clearly shown by the fish catch.

Conclusion

The fish catch trend shows that there may be a relationship between variability of the fishing and spatial and temporal variability of the lake waters and zooplankton. However, these data are preliminary and the analysis should be extended before reaching any strong conclusions.

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Title: Contribution to the study of algal benthos of the littoral zone of Lake Tanganyika

Introduction

The rocky shore of Lake Tanganyika that is the habitat for many species of cichlid fishes bears a dense growth of epilithic algae. It is very probable that these primary producers are a main source of food for many fishes and invertebrates there. A knowledge and skill in the field of algal identification can be an important tool for the study of ecology, biodiversity conservation and pollution control of the lakes. Owing to the complexity of algal benthos, it is essential that studies be carried out in gradual stages. This study proposed to concentrate first on the epilthon, i.e. the forms and species associated with stones and rocks.

The aims of this preliminary study are:

*****To determine the taxonomic (species) composition of the epilithic assemblages.

*****To estimate the relative abundance of species observed.

*****And**,** in a later study, to assess the temporal variation in species composition and variation in the horizontal and vertical dimensions.

In this work I did not determine the specimens to the species level because of lack of appropriate taxonomic keys, and difficulties in identifying diatoms beyond genus or forms during initial scan (R.J.Stevenson et al, 1996).

For the collected samples, I chose three sites: (1) Site no.1, Jakobsen's beach (2) Site no.2, Mwamgongo village site probably impacted by human activities. (3) Site no.3, southern part of Mwamgongo (close to Gombe National Park).

Materials And Methods

All collections were made along the lakeshore, respectively on June 22 nd 1998 and June 23 rd at site 1 and on June 27th 1998 at site 2 and site 3.

Algae were scraped off from littoral rocks using an algae scraper. Small stones were brought out of water and washed in a bucket of water with a toothbrush. I preserved samples in 4% formalin solution and kept them in small bottles well re-corked (Smith, 1950).

To determine the taxonomic composition of algae I used an inverted microscope with a nannoplankton count chamber to enumerate different types of cells (diatoms), using the keys and plates from Prescott, 1970; L.Van Mell, 1954; H.G . Barber and E.Y.Haworth,1981 and B.Dussart, 1966.

In this first stage of study, I estimated only the relative abundance of diatoms. I will deal other phyla in a later study.

Results

Taxonomic composition.

Analysis of the samples from the three sites has given 13 genera belonging to Chlorophyta 15 genera of Bacillariophyceae (diatoms) and 1genus belonging to Xanthophyceae (table1: taxonomic list, appendix 1) Abundance estimation of diatoms (table 2 and graphic, appendix) Genera and individuals by site were as follows :-

Site	No of Genera	No of individuals.
1	11	624
2	10	230
3	8	157

Shannon diversity index (H' = - E Pi ln Pi) for the three sites gave :
site 1 : H' = 1.29
site 2 : H' = 1.05
site 3 : H' = 1.27
Thus we have diversity at site 1 > diversity at site 3 > diversity at site 2 .
Simpson's index ($D = E Pi^2$) for the three sites gave :
site 1: 0.28
site 2 : 0.39
site 3 : 0.32
This similarity test according to Jaccard index (Cj = j / a + b - j) gave:
* similarity between site 1 and site 2 : 0.61.
* similarity between site 1 and site 3 : 0.72.
* similarity between site 1 and site 2 : 0.50.

Discussion

Taxonomic composition Samples were collected at the sites mentioned above from eulittoral to approximately 2m depth on rocky substrates. A glance at table 1 and the taxonomic list, shows that site 1 is richer in both individual numbers and relative abundance of genera and species. I did not show the relative abundance and species dominance in general because I estimated the relative abundance of diatoms only.

The analysis of Shannon diversity index : (site 1: 1.29, site 2 : 1.05, and site 3 : 1.27) shows that site 1 > site 3 > site 2, but this difference is not very great from one site to another. This difference results from differences in numbers of individuals in different genera but the number of genera is almost the same (11, 10, and 8).

From the results from the Jaccard index of similarity respectively 0.61 between site 1 and site 2 ; 0.72 between site

1 and site 3, and 0.50 between site 2 and site 3), we can conclude that the floras of site 1 and site 3 are more similar than that of sites 1 and 2, or between sites 2 and 3. This can be also observed in e table 1 where

some genera are present on one or two sites only, most genera are common for the three sites.

Sampling was too limited in time and space to allow us to obtain a representative abundance in both species diversity and individual numbers that could be used to draw any general conclusions.

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Title: Comparative sedimentology, organic matter and pore water analysis of disturbed and undisturbed drainage basins of Lake Tanganyika

Introduction

This experiment was designed to examine the effects of deforestation and human inhabitance on lake sediments. Grain size, organic matter and pore water nutrients were analyzed at four sites near Gombe and Kigoma. Correlations between items were explored, as well as their relationships with depth.

Study Area

Sites were chosen due to similarities in bedrock geology, geomorphology and size. Two pairs of disturbed and undisturbed basins were compared for this report. The first two sites, near Gombe Park, were Mwamgango and Nyasanga. Mwamgango has been disturbed by deforestation and human inhabitance. Nyasanga is a basin in Gombe Park, and therefore, has remained undisturbed. The second set of sites is both located farther south down the eastern side of the lake near Kigoma. Kigoma bay was used as the disturbed site because both deforestation and human inhabitance have affected it. Bangwe, on the other hand, has been deforested in the past, but has no human inhabitants, and hence, was used as an undisturbed site because it has a greater amount of ground vegetation. When samples were taken from Bangwe it was noted that there were large pieces of charcoal that were recently deposited from a nearby fire.

Field Work

All of the samples collected at these four sites were obtained using SCUBA. The samples were taken from 2, 5, 10, 15 and 30 m water depths. At each depth, two types of samples were taken. First, a grab sample of sediment was retrieved. Second, using a 22-ml syringe, a mini core of sediments was taken and sealed. Pore water was later extracted using a filter. Due to the nature of this sampling technique, I was unable to take mini-cores at 2 meters from Kigoma and Bangwe because of the cobble sized sediments at that depth. In addition to these samples, a surface water sample was also taken at 2 and 30-m depths.

Lab Methods

All sediment samples were partitioned into three portions. The first portion was wet sieved to determine grain size distributions. A second portion of the sediments was used for loss on ignition to determine the amount of organic matter. These samples were first dried in an oven at 60℃ for 12 hours. After they had dried completely, 5 grams of sediment was added to sterilized crucible and weighed. They were then put in a furnace at 550℃ for two hours to burn off all organic matter. Percent organic matter was then determined by dividing the amount of material burned off, by the total original sample weight. A third portion of the sediments was put aside for the Nyanza archive.

Pore water analysis was done immediately after the samples were collected to limit water-sediment interactions and exchanges. These water samples, along with surface water samples were diluted with a known amount of distilled water and analyzed for nitrogen and phosphorus content using a spectrophotometer

Results

Three correlations were found in the data that was retrieved. First, there is a correlation between disturbance and grain size (see Appendix A and B). This result was clearly seen at the sites themselves. The water at Mwamgango (disturbed) was murky and filled with super-fine sediments, in contrast to Nyasanga (undisturbed) which had pristine waters. . The relationship between grain size and depth is only very weak. At Mwamgango and Nyasanga the grain a gravel/cobble sized sediment bar at 5 meters threw off grain-size data. The second correlation is between grain size and the amount of nutrients in the pore water (see Appendix C and D). Nyasanga has the highest grain size as well as an extremely high phosphorus content. In contrast, Mwamgango has very fine grain sediments and zero nitrogen in the pore water at three depths. Thirdly, there is a correlation between grain size and organic matter. This is clearly seen when comparing Nyasanga and Mwamgango (see Appendix E), however, this correlation is not as strong in Kigoma and Bangwe

Discussion and Conclusions

A large abundance of fine grain sediments is found at Mwamgango because almost the entire basin at has been cleared for Cassava production. When the land is cleared, fine grained topsoil sediments are allowed to erode away and drain into the lake. The increase in grain size at 5m at Mwamgango and Nyasanga is peculiar. This gravel bar could possibly be a past shoreline that has been submerged by the recent rise in lake level.

Grain size has shown to be a very important factor in determining the abundance of nutrients in pore water. Grain size is important because it determines the amount of surface area on the substrate. Phosphorus is known to react with iron-hydroxide to form iron-hydrophosphates on the surface of sediments, therefore, if there is less surface area on the sediments there will be more phosphorus left in the pore water. Surface area also gives an explanation for why there is little nitrogen at Mwamgango since nitrogen is also absorbed by clay particles. Larger grains also allow more water movement and hence reduce the boundary layer effect, providing easier access to nutrients.

Grain size is also an important factor in determining abundance of organic matter as well because sediments supply the substrate on which it grows. Smaller grains allow more surface area and consequently, more organic matter is allowed to colonize. In addition, a substrate made up of predominantly larger grain sizes is indicative of a higher energy environment, which may make it difficult for organic matter to inhabit the area.

When I return to the United States, I plan to continue my research on the sediments I have collected by examining the mineralogy of the grains, and the structure of clay particles. I am also curious about any correlations between disturbed sites and abundance/variation in ostracod populations.

Future Work

I strongly encourage future Nyanza project participant to determine the amount of nutrients that have been absorbed by the sediments at these sites, instead of just assuming that they are there. Also, new disturbed and undisturbed basins should be chosen and compared. This is particularly important because there is not enough variation between Kigoma and Bangwe. Bangwe is still affected by the presence of the Kigoma population.

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Title: Influence of Small Streams on the Hydrogeochemistry of Lake Tanganyika

Introduction

Lake Tanganyika has been classified by Kilham and Hecky (1973) a fresh lake belonging to the Sodium-Potassium-Magnesium bicarbonate type which also includes in Lake Albert, Edward and Kivu. Little sodium chloride was observed in its water by Beauchamp (1939, 1940), but high proportions of Sodium bicarbonates were found, mostly derived from surrounding volcanic rocks; (i.e. geochemistry of the catchment). He also pointed out that the inflowing rivers make up about one- third of the total water supply and are low in salt content, with the exception of the Ruzizi River, which may regulate the present ionic composition of the lake.

However, small streams cannot be overlooked with regards to their contribution to the geochemistry of lake water, because they enter the lake directly compared to big rivers that passes through many swampy areas with much deposition and dilution. This paper discusses on the influence of stream flows on hydrogeochemistry of lake. Two streams will be discussed here; Mitumba in Gombe and Ngonya in Mwamgongo village. These two drain different catchments, undisturbed and disturbed by human settlement respectively.

Objectives

The objectives of research were mainly, (1) to investigate the physical -chemical nature of the streams as related to their catchment disturbances, (2) to investigate the behavior of the ionic parameters of streams as compared to those of the lake at the mixed and open waters off shore about 100m**.**

Materials And Methods

General remarks

The following parameters have been measured during sampling: transparency (Secchi), temperature, dissolved oxygen, pH, conductivity, Soluble Reactive Phosphorus, Ammonia (NH_4-N), Nitrite (NO_2-N), Nitrate (NO_3-N), and Turbidity. The parameters were measured by HACH DR 2010 methods, HANNA Instruments: -, conductivity meter Model HI 8033, pH meter Model HI 9023 and conductivity / D.O meter probe Model YSI 58 -230 V.

Sampling Procedure

Due to the unavailability of a GPS (Global Positioning System) instrument at the time of sampling, the exact sampling position was not recorded. Sampling was performed at two separate localities;
(1) Mitumba stream -Gombe, samples were taken at gauge station placed about 15 m before entering the lake, at the mixed area (stream and lake), and lake at about 100 m offshore where a vertical transect from surface down to 40m was taken it was not possible to sample beyond because of depth limitations .The same procedure was also done at locality no. (2): Mwamgongo -Ngonya stream.

The following parameters were measured directly from the stream & lake (using ZODIAC), water Temperature, dissolved oxygen, pH, conductivity; from water samples taken to the Lab.; Turbidity, NH_4-N, PO_4-P, NO3-N, SO4. In the lake D.O, Temperature, pH, conductivity, and turbidity were measured at 10m depth intervals from the surface down to 40m. Chloride, silica, calcium, magnesium and hardness were not done due to lack of required chemical reagents

Instrumentation And Analytical Methods

Transparency measurements, taken at the lake were done with a 20cm diameter Secchi disk . Water samples from the river were collected by scooping water from the stream directly into sample bottles, and those from the lake were collected using a 2l van Dorn bottle. Water temperature was measured using digital thermometer, coupled to an oxygen meter. Dissolved oxygen (D.O) was measured with a dissolved Oxygen meter; Turbidity measurements (NTU) were made with a HACH Turbidimeter.

Results

Tables 1,2,3 &4 show the physical-chemical parameters obtained from the two localities: Gombe & Mwamgongo.

Physical & Chemical parameters

Temperature

The temperatures in the streams were 24.8 & 27.3 (Gombe and Mwamgongo respectively). Temperatures in the lake remained at an average of 27.0 ^{0}C while at the mixed point (where rivers enter the lake) was between 27.5& 27.8 ^{0}C. Gombe is much cooler than Mwamgongo, this could be due to thick forest covering the Mitumba stream as compared to Ngonya.

Conductivity

Conductivity ranged between 530uS/cm to 627 uS/cm with the exception of Gombe-Mitumba and Mwamgongo -Ngonya streams. Their corresponding conductivities were 26.0uS/cm and 45 uS/cm respectively.

pH

PHs at Gombe and Mwamgongo were 7.8 & 7.94 respectively, while those in lake ranged between 8.96 and 9.05.

Dissolved Oxygen (D.O)

The Gombe -Mitumba stream was better oxygenated than Mwamgongo, both in the stream and at the lake outlet. Temperature is the primary controlling parameter for this difference in D.O (Table5).

Turbidity

Mwamgongo-Ngonya stream is more turbid than both the lake and Gombe-Mituba stream; this indicates that it has more suspended matter.

Transparency

The Secchi depth was 8.50 and 7.60 m at Mwamgongo and Gombe respectively. However, these results might have been affected by wavy conditions during the measurements.

Silica

Mwamgongo has higher SiO_2 than other places visited, ranging from 11.50 to 17.50 (mg/L). The river has 17.50 (mg/L) as compared to 12.30 (mg/L) at Gombe -Mitumba.

Ammonia, Nitrate, and Nitrite.

Ammonia, Nitrate, Nitrite in both Gombe & Mwamgongo are present in proportions of $NH_4 > NO_3 > NO_2$, with much higher total concentrations at Gombe. This could be due to decomposition of debris or litter.

Phosphorus

The Mwamgongo sample had more phosphorus than either Gombe or and lake. This may result from the use of chemical fertilizers up stream.

Sulphate

No SO_4 was detected at Gombe -Mitumba stream, but little was obtained at Mwamgongo, This could be due to climatic changes and less use of sulphate fertilizers up stream.

Discussion

Since the two streams; Ngonya (Mwamgongo) and Mitumba (Gombe) are small, their flows are likely to have also small influence on the hydrogeochemistry of the near shore lake and the pelagic zone. This is shown by the relative close relationship between their flows and the ammonia concentration comparisons between the stream, mixed, and lake sites. The chemical parameters vary considerably from one place to another.

At Mwamgongo (the place where catchment geology is greatly disturbed), the variation is in the order of $SiO_2 > SO_4^{2-} > PO_4^{3-} > NH_4^+ > NO_3^- > NO_2^-$ and that of Gombe (the relatively undisturbed catchment) is $SiO_2 > NH_4^+ > NO3^- > NO_2^- > (PO_4^{3-}$ & $SO_4^{2-})$. Gombe has high concentrations of most of the parameters except SO_4^{2-} and $PO_4^{3-, \text{which}}$ were not detected in water samples from stream. It follows that climatic changes, course of the stream (composition of substrate) and perhaps the use of chemical fertilizers especially in Mwamgongo and other villages up stream have a major influence on the ionic concentration of the stream. Physical parameters behave differently also. At Mwamgongo, temperature was high (27.3 ^{0}C) as compared to Gombe (24.8 ^{0}C). This is a reflection of direct evaporation by solar energy due to little or no forest cover along the stream course. This greatly affects the D.O concentration because D.O has an inverse relationship with temperature. Turbidity was much higher at Gombe than Mwamgongo. This could be explained by the nature of the catchment which probably has big supply of suspended matter compared to Mwamgongo. No doubt, that Gombe has a lot of humus, organic detritus, and plants. This may also have an influence to the physical parameters of the near shore lake, but needs detailed study to confirm this.

Conclusions

The influence of stream flow for the hydrogeochemistry of the lake is confined to shallow regions, i.e. the near shore zone whereas the deep offshore areas appear to have little or no relationship with stream flow. However, this study cannot be considered conclusive because very little data could be collected during the available research time. A more detailed study is required in order to be able to come up with correlations that are more definitive.

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Title: Etude preliminaire de la vitesse de sedimentation des oeufs de *Stolothrissa tanganicae* (Regan, 1917)

Introduction

Stolothrissa et *Limnothrissa* sont deux genres de Clupeidae pelagique représentes par deux espèces endémiques du Lac Tanganyika : *Stolothrissa tanganicae* (Regan, 1917) et *Limnothrissa miodon* (Boulenger). Parmi ces espèces pélagiques du Lac Tanganyika, *S. tanganicae* est la plus abondant et plus importante commercialement (Katonda, 1992). L'intérêt économique de cette espèce et la place qu'elle occupe dans la Biodiversité du Lac Tanganyika sont deux raisons majeures qui justifient le choix de notre sujet.

Objectif

L'objectif de ce projet est de contribution a la biologie de *S. tangaicae*. Plus spécifiquement, nous cherchons à vérifier les hypothèses suivantes :

- La vitesse de sédimentation des œufs de *S. tanganicae*, une des espèces pélagiques du Lac Tanganyika, pourrait avoir un impact considérable pour son succès reproductif.

- Cette vitesse pourrait dépendre notamment de la vitesse du vent influençant l'état hydrodynamique du lac, et de la stratification thermique.

Matériel et Méthodes

Les poissons achetés le matin sont places dans un seau réfrigéré pris amenés au laboratoire pour des manipulations. Chaques poisson est pesé après avoir pris la longueur totale de son corps. Après la dissection, les gonades des femelles sont pesées à l'aide d'une balance de précision. La détermination du stade de maturation est faite suivant la description d'Aron (1993) cite par Ndaygamiye (1997). Les œufs des poissons au stade 4 de maturation sexuelle sont reportés :
- d'abord en 3 classes suivant la taille de poissons: classe A- 70-75mm; classe B- 76-79mm; et classe C 80-90mm.
-ensuite en 17 classes de taille suivant leur densité, a l'aide d'une pipette.
-Enfin en 3 classe de taille G (gros), M (moyen) et P (petite) suivant la vitesse de sédimentation.

La vitesse de sédimentation est observée dans une colonne en verre puis dans un aquarium. Trois principales expériences dont les donnes ont été traiter à l'ordination par un tableau d'Excel, résument nos résultats.

Résultats Préliminaires

On soit que les œufs des sardines doivent descendre après leur ponte pour edore avant d'atteindre la surface anoxique.

D'après nos résultats :

- les œufs de taille inférieure (qui voir entre 150-300 micromètres) coulent moins vite que les œufs de taille supérieure (300-500 micromètres), a raison d'un pourcentage :
- inférieure a 39% sans vent et sous stratification
- inférieure a 16% avec vent et sans stratification
- inférieure a 28% avec vent et avec stratification.

Le nombre d'œufs par individu est très variable. Pour les individus dont nous avons pu estime le nombre d'œufs, il varie entre 16200 a 34050.

Discussion Préliminaire

a. **Nombre d'œufs :** faute de temps, nous n'avons pas pu compter le nombre d'œufs de plusieurs individus. Pour les poissons dont le nombre d'œufs a été estimé par la méthode graimetrique, nos résultats sont très proches de ceux de Marlier (1957) et de Brichard (1989).

b. **La vitesse de sédimentation :** Les vitesses moyenne du sédimentation obtenue pour les 3 expériences nous ont permis de calculer le temps disponible avant l'éclosion des œufs

Suivant les resultats de ce tableau, les oeufs doivent faire leur descente pendent 12 a 24 heures en moyenne pour atteindre 100 a 200m de profondeur. Matthes (1967a) cite par Coulter (1991) parle de 24 a 36 h pour un profondeur de 75 a 150m. Nous ignorons les conditions experimentales de ces observations pour comparer ses resultats aux notres.

Conclusions Preliminaires

Nos resultats nous ont permi de conclure que le condition climatique ont un grande importance sur le succes reproductif de *Stolothrissa tanganicae*. Nous nous proposons de poursuivre les experiences pour etudier le taux de mortalite des oeufs par classe de taille en fonction des conditions variables de vent et de stratification thermique. Dans l'avenir une comparison de ces etudes devra etre taite entre *Stolothrissa* et *Limnothrissa* du Lac Tanganyika d'une part puis entre *Limnothrissa* du Lac Tanganyika et celui du Lac Kivu d'autre part.

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Title: Categorization of Organic Matter and Carbonate fractions of Surface Sediment Samples in Kigoma Bay Lake Tanganyika.

Introduction

Lake Tanganyika is located in the western branch of the East African Rift Valley, and is the second oldest (~ 10 Ma) and the second largest lake in the world. The lake is also 90% by volume anoxic and is supersaturated with respect to calcium carbonate. In marine environments, areas where anoxic water impinges on ocean sediments are enriched in organic matter and facilitate the burial of organic carbon (Hedges and Keil, 1995; Keil and Cowie, in press). Lake Tanganyika, with the anoxic hypolimnion and the possibility of calcium carbonate precipitate formation, could be a significant geochemical sink of carbon.

Methods

To examine the carbon content of surface sediments, a Ponar grab sampler was deployed from the R/V Echo. Stations and depths were chosen to provide representative sediment facies that comprise Kigoma Bay and the Luiche Delta (fig. 1). The grab samples were then sub-sampled into glass containers and transported back to Tanzania Fisheries Research Institute (TAFIRI). The sediment samples were then placed into an oven at ~ 60 °C until dry. Once dry roughly 5 grams of the sediment was transferred to a pre-weighed Coors ceramic crucible. Prior to weighing, the crucibles were placed into a muffle oven at 550 °C for 1h. Sample weight was defined as the total weight of the sample - the weight of the crucible. The sample was then placed into the muffle furnace and burned at 550 °C for 2h. The samples were then cooled to room temperature in a desiccator and weighed. The difference in the 550-burn weight and the total weight of the sample was defined as organic matter. The samples were then placed into a muffle furnace and burned at 925 °C for 4h to drive off the carbonates in the sample. The samples were then allowed to cool to room temperature in a desiccator and weighed. The difference in the 550-burn weight and the 925-burn weight was defined as carbonate.

Results and Discussion

Percent organic matter ranged in values from 0.6% to 14% (fig. 2) and carbonate ranged from 0.7% to 44% (fig. 3). The % organic matter showed a general trend increasing with depth (fig. 2) until ~100 m and then decreasing slightly. Organic matter is negatively correlated with dissolved oxygen (fig. 4) possibly indicating that organic preservation increases with decreasing dissolved oxygen. This may be due to the toxicity of the anoxic environment to most organisms, which prevents organic material from being consumed. The organic matter also shows a decrease at depths below the oxycline (fig. 4). This may be a result of anaerobic bacteria establishing communities below the oxycline. The region where there is a large change in dissolved oxygen may be too stressed for either aerobic or anaerobic organisms to establish a permanent community. A mid-depth (~ 70 to 90 m) sink for organic matter can be seen (fig. 5) in the just off the Luiche Delta. This increase in organic matter may be a result of rapid transport of terrestrial organic material from the Luiche River to the oxygen-starved waters of Lake Tanganyika. Organic matter was found to be slightly higher north of the Luiche River (fig. 6), perhaps supporting this hypothesis.

Besides the organic matter, the carbonate content of the sediments was examined. Although there was no clear correlation with depth (fig. 3), there were interesting observations within the sediments. Smear slides were made and examined under a microscope to determine the structure of the carbonate in the sediment. Couplets of light and dark laminae less than 1 mm were observed in the dried samples. The light samples were ~90% carbonate structures, consisting of long mineral rods and star-like clusters of carbonate structures.

Future Work

In the sampling regime established, high resolution of changes in both organic matter and carbonates was not achieved. This would be imperative to fully understand the distribution carbon in the sediment. These samples will be transported back to the Aquatic Organic Geochemistry laboratory at the University of Washington to be analyzed on a Carlo Erba CHN elemental analyzer. This will provide a more accurate measure the carbon in the sediment as well as C:N ratio. In addition, these samples will be analyzed for surface area using B.E.T flow analysis.

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