1999 Nyanza Project

Student Projects

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COMPARATIVE DE LA SUSCEPTIBILITE MAGNETIQUE DES SEDIMENTS DES TRANSECTS DE CAROTTAGE EST-WEST AU DROIT DE LA BAIE DE KIGOMA ET DES RIVIERES LUICHE ET MALAGARAZI

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Mentor: Dr KIRAM LEZZAR

INTRODUCTION

Les sediments qui se deposent dans le lac Tanganyika proviennent de la destruction de son bassin versant par des processus aussi bien physiques, chimiques, que biologiques. Ces sediments sont ensuite transportes vers le lac par le ruissellement epidermique en general mais surtout par les nombreux cours d'eau qui se jettent dans le Lac (Bennet J. et al, 1996 ; Soreghan J.M.,1994). Malgre les modifications que subissent les sediments au cours de leur transport et remaniement bien des proprietes sont conservees et peuvent renseigner sur les caracteristiques geologiques, geomorphologiques, climatiques, chimiques, physiques,… du milieu d'origine.

Parmi les proprietes caracteristiques des sediments, nous nous interessons plus particulierement, dans cette etude, a la susceptibilite magnetique des sediments preleves par carottage suivant des profils Est-Ouest au droit de trois sites a savoir: la baie de Kigoma, le delta de la Luiche et celui de la Malagalazi. La susceptibilite magnetique est une mesure de la facilite avec laquelle un materiau peut etre magnetise lorsqu'il est expose dans un champ magnetique. Elle se definit par la relation $k= M/H$ ou M est le volume du magnetisme induit dans un materiau et H le champ magnetique applique. Des lors, la susceptiptilite magnetique est une grandeur relative. Il est admis que La susceptibilite magnetique des sediments est intimement liee a la presence des mineraux magnetiques (Thomson et Oldfield, non date).

BUT DE L'ETUDE

- Montrer qu'a partir des mesures de susceptibilite magnetique sur des sediments il y a lieu de faire une demarcation entre les apports lacustres et les apports fluviatiles
- Etudier les variations laterale et verticale de la suceptibilite magnetique des sediments et leurs relations aves les regimes d'ecoulement des rivieres

METHODES

a)Echantillonnage

Les echantillonnage de sediments ont ete preleves par carottage gravitaire et a la benne (pour les sediments grossiers). Au total, nos investigations ont porte sur 9 carottes et 3 echantillons preleves a la benne :

- Malagarazi : 4 carottes (MAL1, MAL3, MAL4 et MAL5) (Figure1)
- Luiche : 3 Carottes (NPG7, NPG8, NPG9) (Figure 2)
- Kigoma bay : 2 Carottes (NPG2 et NPG3)+ 3 echantillons preleves a la benne (Figure 3)

b) Preparation des echantillons

- Les carottes ont ete echantillonnees tous les 10 cm jusqu'a 50cm et tous les 15 cm pour la partie restante sauf les carottes MAL4 et MAL5 dont nous avons echantllones tous les 20 cm.
- Les echantillons preleves ont ete mis dans des boites cubiques en plastiques d'environ 10 cm^3. Au total nous avons travaille sur 106 echantillons.

C) Mesure de la susceptibilite

La susceptibilite magnetique a ete mesuree a l‘aide d‘un appareil de type Bartington MS2. Nous avons utilise le protocole de mesure indique pour les echantillons de faible susceptibilite magnetique:

- mesurer de la suceptibilite magnetique de l‘air avant l‘introduction de l‘echantillon, valeur A1
- mesurer la susceptibilite magnetique de l‘echantillon, valeur K
- mesurer de la suceptibilite magnetique de l‘air apres retrait de l‘echantillon, valeur A2
- Mesurer chaque echantillon 10 fois
- corriger les 10 valeurs de K suivant la relation Kc = K - (A1 + A2)/2, valeur Kc
- faire la moyenne des 10 valeurs Kc, on trouve alors la valeur Kc pour l‘echantillon considere (voir tableau 1)

Au total nous avons travaille sur 106 echantillons, soit 1060 mesures.

Tableau 1: Exemple de calcul de la valeur de la susceptibilite magnetique pour les echantillons

Core	Box number	A1	K	A2	Kc
MAL1	2	0	28.9	-0.3	29.05
		-0.3	29	-1	29.65
		-1	28.3	-1.6	29.6
		-1.6	27.7	-2.5	29.75
		-2.5	26.7	-3.2	29.55
		-3.2	24.7	-4.6	28.6
		-4.6	24.4	-5.6	29.5
		-5.6	23.5	-6.5	29.55
		-6.5	22.4	-7.6	29.45
		-7.6	21.5	-9.1	29.85
Average					29.46

PRESENTATION ET DISCUSSION DES RESULTATS

Les figures 4 a 10 permettent de visualiser les resultats auxquels nous sommes aboutis. Elles montrent la variation de la susceptibilite magnetique en fonction des niveaux des carottes en dessous de la colonne d‘eau pour les carottes d‘un meme transect . Aussi, la comparaison de la susceptibilite magnetique des carottes des differents transects a des profondeurs proches est egalement est-elle presentee.

L‘analyse de ces graphiques fait ressortir les considerations ci-apres :

- La susceptibilite magnetique a tendance a augmenter de la base au toit des carottes sauf pour la carotte peu profonde de la Luiche ou l‘on remarque des fluctuations quasi cycliques des valeurs tres elevees.
- A l‘exception de la carotte du transect de la Luiche, l‘on observe, de maniere generale, que l‘importance des pics augmente egalement depuis la base vers le sommet de la carotte
- Les valeurs de susceptibilite magnetique pour les carottes du transect au droit de la Luiche sont de loin superieures a celles des transects au droit de la Malagalazi et de Kigoma bay et cela a toutes les profondeurs de la colonne d‘eau.
- Les valeurs de susceptibilite magnetique pour les carottes du transect de la Malagalazi sont superieures a celles du transect de Kigma bay
- Pour tous les transects l‘on constate une dimunition de la susceptibilite magnetique quand on s‘eloigne de la cote.

- Le graphique des 3 echantillons preleves a la benne ne degage pas une tendance claire ; neanmoins, l‘onconstate que l‘echantillon le moins profond montre la valeur de susceptibilite magnetique la plus elevee

CONCLUSIONS ET RECOMMENDATIONS

A. Conclusions

L es considerations precedentes nous amenent aux conclusions ci-apres :

- la suceptibilite magnetique des sediments est essentiellement controlee par les apports continentaux. Cela est confirmee par le fait que les valeurs les plus elevees de susceptibilite magnetique sont trouvees dans les carottes des transects au droit des cours d‘eau et diminuent progressivement vers le large.

- les fluctuations de la suscptibilite magnetique des sediments seraient dues a certains parametres notamment les changements climatiques et l‘utilisation des terres dans le bassin versant. Cela semble etre confirme par l‘importance des pics qui croit de la base au sommet des carottes exprimant ainsi l‘intensification des facteurs evoques plus haut au fil des temps.

- Bien que la Malagalazi soit plus importante que la Luiche au niveau des apports de sediments –a cause des differences au niveau de la geomorphologie, la superficie et la geologie de leurs bassins versants-, il apparait clairement que la Luiche draine un bassin versant riche en mineraux magnetiques.

B. Recommendations

Cette etude etant, a notre connaissance, le premier du genre sur les sediments du lac Tanganyika dans la region de Kigoma, il serait plus interessant, dans le future, qu‘elle soit completee suivant les axes ci-dessous :

- Faire une datation des carottes pour identifier les causes des fluctuations de la susceptibilite magnetique dans le temps
- Faire une etude mineralogique des sediments et etablir une correlation entre les valeurs de la susceptibilite magnetique et la geologie du bassin versant
- Faire une etude des pollens et des charbons de bois dans les sediments pour preciser l‘influence des changements climatiques et des actions anthropiques sur les apports de sediments dans le lac Tanganyika.

Remerciements

Cette etude a ete realise grace au concours precieux de certaines personnes que nous tenons a remercier sincerement. Il s‘agit de John King et Carol Gibson de l‘Universite de Rhode Island aux USA qui ont bien voulu nous preter leur appreil de mesure de la susceptibilite magnetique et de Dr Kiram Lezzar et Mark Woodworth respectivement Professeur de Geologie et Assistant du projet Nyanza pour leur encadrement.

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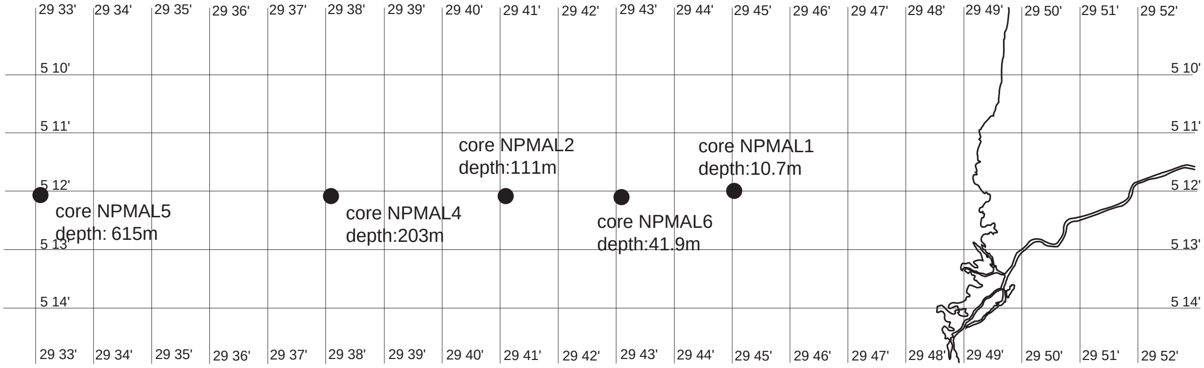


FIGURE 1: Transect de la Riviere de la Malagarasi

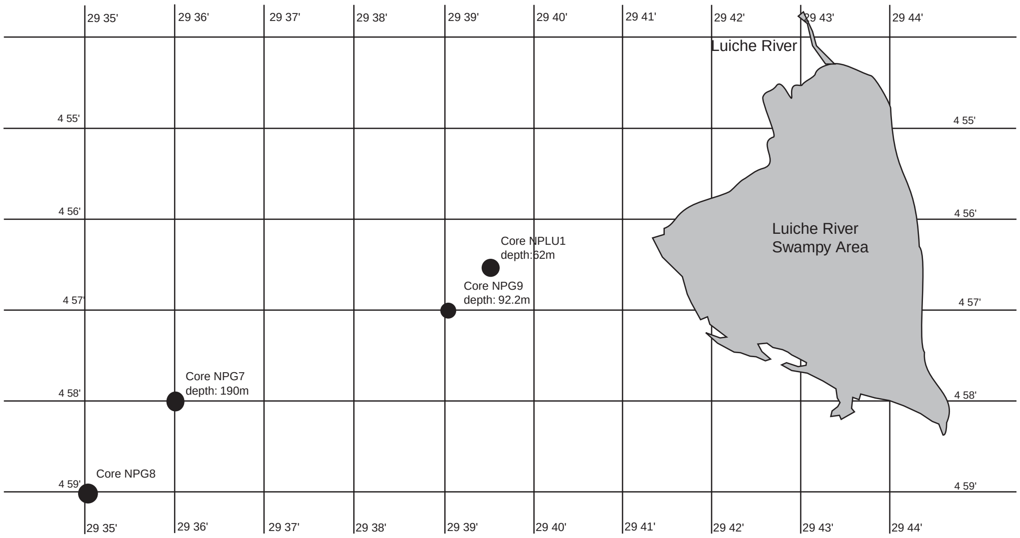
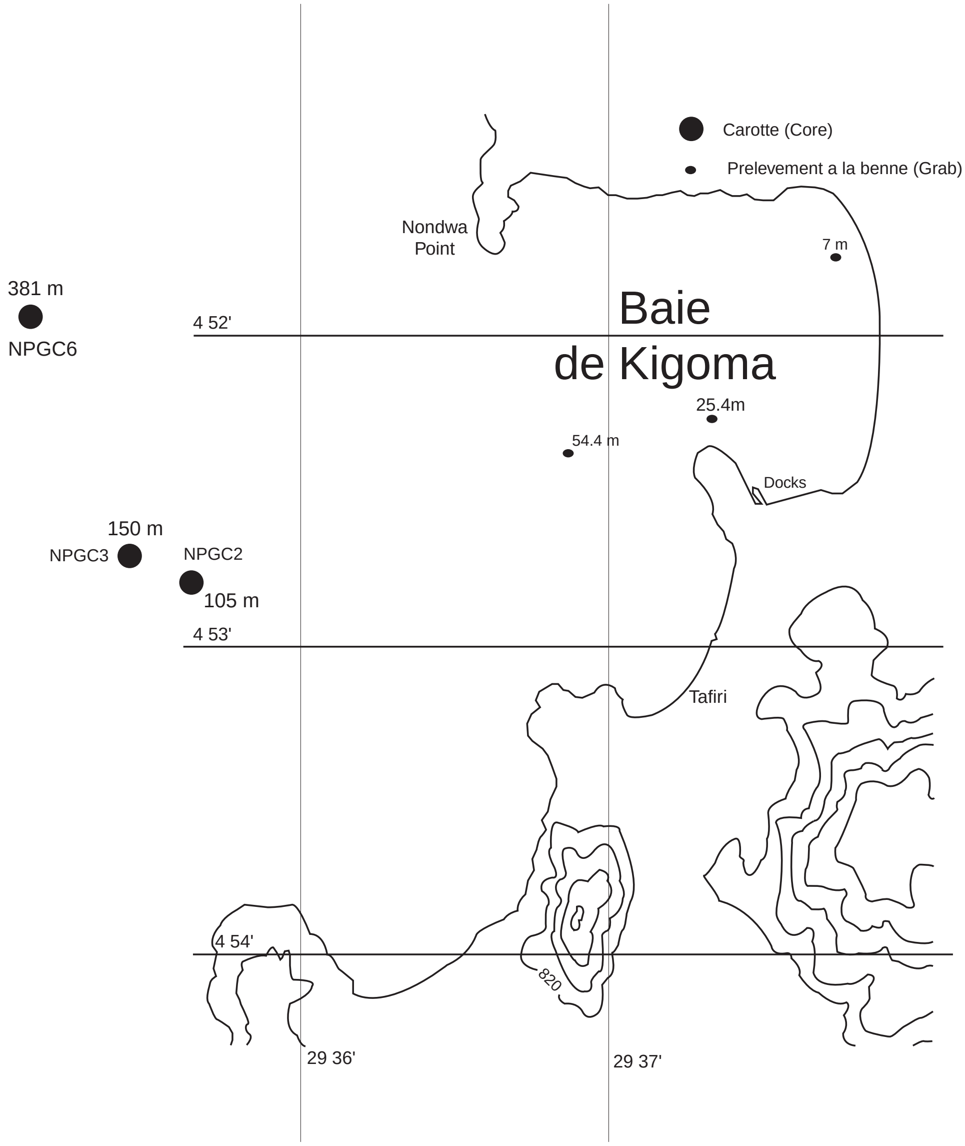


FIGURE 2: Transect de la Riviere Luiche

Figure 3: Localisation des carottes etudiees du transect de Kigoma.
A noter que la carotte a 381 m n'a pas ete selectionnee pour cette etude.



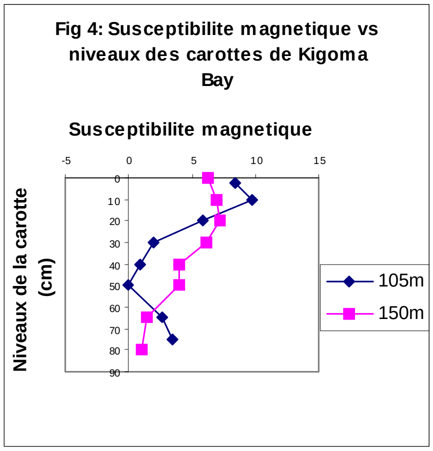


Fig 4: Susceptibilite magnetique vs niveaux des carottes de Kigoma Bay

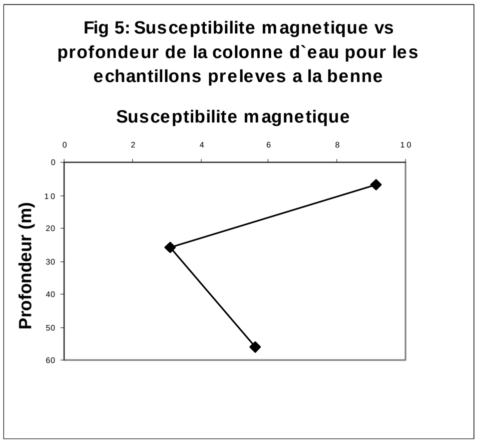


Fig 5: Susceptibilite magnetique vs profondeur de la colonne d`eau pour les echantillons preleves a la benne

Fig 6: Comparaison de la susceptibilite magnetique des carottes du transect au droit de la Malagarazi

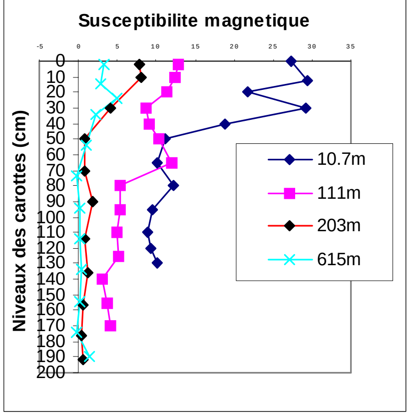


Fig 7: Comparaison dela susceptibilite magnetique pour les carottes du transect au droit de la Luiche

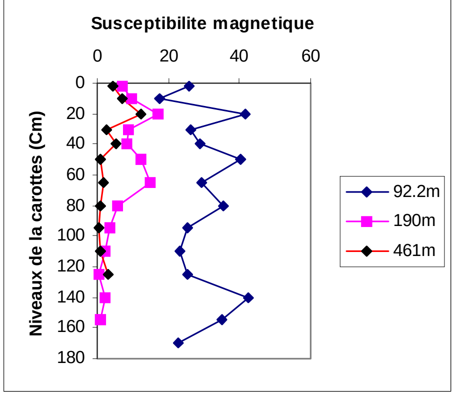


Fig 8: Comparaison de la susceptibilite magnetique des carottes de la Luiche. Malagalazi et Kigoma bay respectivement a 190m, a 203m et a 150 m

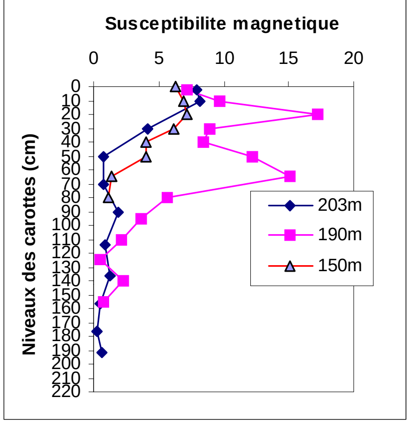


Fig 9: Comparaison de la susceptibilite magnetique des carottes de Kigoma bay, Luiche et Malagalazi respectivement a 105 m, a 92.2m et a 111 m

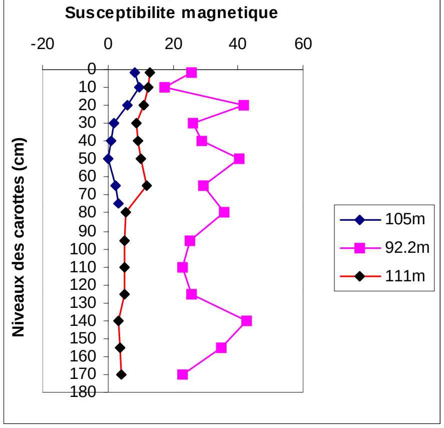
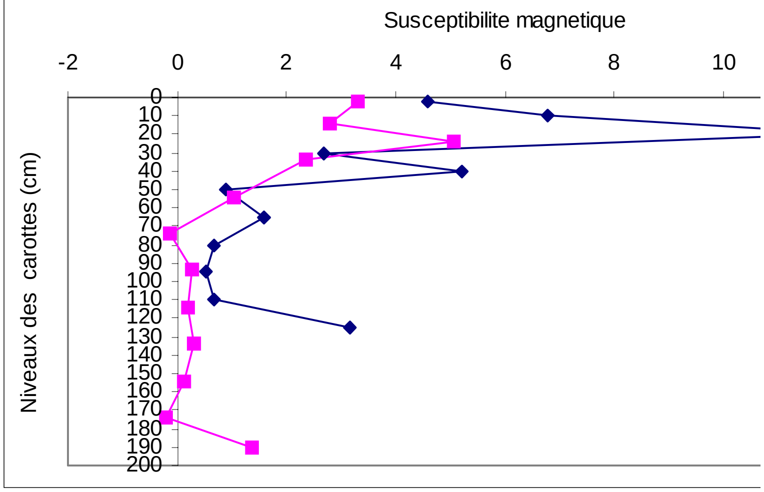


Fig 10: Comparaison de la susceptibilite magnetique des carottes c
la Luiche et de la Malagarazi respectivement a 461 m



Investigation préliminaire sur la possibilité d'une relation entre les variations de l'environement limnologique,du plancton et des poissons pélagiques au lac Tanganika.

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INTRODUCTION

La pêche commerciale au lac Tanganika est basée principalement sur les Clupéides planctonophages pélagiques: ***Stolothrissa tanganicae*** (Regan,1917) appelé communément Dagaa et ***Limnothrissa miodon*** dont le nom vernaculaire est Lumbu. Quatre autres espèces pelagiques font partie de la famille des Centropomides: ***Lates stappersi*** (Mukebuka), ***L. mariae*** (sangara), ***L. microlepis*** (nonzi) et ***L. angustrifrons*** (Gombe)**.** ***S.tanganicae*** et ***L. stappersi*** occupent une place très importante dans l'économie des pêches en Tanzanie et représentent une source appréciable de protéines animales pour les populations riveraines (Katonda and Kalangali,1994). Par ailleurs, cette faune pélagique d'eau douce souvent endémique offre plus d'un point de convergence avec celle du milieu marin, et présente de ce fait un intérêt scientifique incontestable.

OBJECTIF

Notre objectif est d'essayer de mieux comprendre certains aspects de la dynamique du lac (limnologie, biologie) en étudiant quelques facteurs abiotiques, et la composition du zooplancton en comparaison avec les contenus stomacaux des poissons pélagiques capturés au même moment que l'échantillonnage.

Les variations limnologiques liées notamment aux vagues internes conditionnent-elles les communautés planctoniques et piscicoles ?

Cette étude s'inscrit dans un objectif plus vaste de compréhension des raisons des variations très marquées de la composition des espèces des poissons pélagiques capturées par les pêcheurs

Matériels et Méthodes

Quatres sorties ont été effectuées en dates du 22 /07/99 et 2,4 et 8/8/99. Toutes ces sorties étaient nocturnes et effectuées ensemble avec l'équipe de pêcheurs. Les sites d'échantillonnage ont été choisis par les pêcheurs et localisés a l'aide d'un GPS (Global positioning system) (Tableau.1). L'état de la lune et l'activté de pêches correspondant aux nuits d'échantillonnages sont présentés dans le tableau 2.

Les paramètres abiotiques ont été mesurées (T°, D.O., pH, cond.) et un échantillonnage d'eau a été effectué environ deux heures avant le relevé du filet pour analyse ultérieure au laboratoire. Au laboratoire, les paramètres suivants ont été mesurés: NO_3-N,NH_4-N,PO_4-P,SIO_2,Chl a) selon la méthode décrite dans le rapport de Edith Mwijage et Jennifer Schmitz (ce volume). Le filet à plancton avait des mailles de 100µm entre-noeuds et une ouverture de 30cm de diamètre. Un échantillonnage vertical était effectué d'une profondeur de 100m vers la surface. Du formol (40%) a été utilisé pour la préservation. L'échantillonnage des poissons capturés par les pêcheurs et l'analyse des contenus stomacaux préservés au formol a été effectué selon la methode décrite dans le rapport de Cris Oppert (ce volume). L'identification des espèces des zooplancton a été faite selon la clé d'indentification de Coulter (1991) en utilisant au laboratoire un microscope d'inversion, un microscope binoculaire et une balance électronique. Pour le comptage, un sous-échantillon de 1ml fut observé en totalité pour les micro-organismes (>100 individus). Quant aux macro-zooplancton presque la totalité de l' échantillon est observée, et les résultats exprimés en nombre d'individus/m^3.

Résultats preliminaires

I.Facteurs abiotiques

1.2. La température de l' eau

La température et l'épaisseur de l'épilimnion ont varié au cours de notre expérience . La thermocline, la première nuit était à 90m, puis 80 m la nuit suivante et de nouveau 90m pour les deux dernières nuits. L'épilimnion présentait une température moyenne de 25.5°C à la surface tandis que l'hypolimnion sous les 100m une température de 24.3 °C. D'après Plisnier et al (1996) , cette température change peu dans le fonds du lac. Quand la température diminue la nuit la densité de l'eau augmente et l'action du vent entraîne un mélange des eaux mais reffroidit aussi les eaux.

1.3. La turbidité

Les valeurs de turbidité enrigistrées la première nuit était élevée avant de diminué progressivement les nuits d'expérience suivante La turbidité était particulièrement faible le 04/08/99. L'eau était très transparente avec une bonne diffraction de la lumiere qui pourrait être corrélée à une capture élevée de *Lates stappersi.*

1.4. L'oxygene dissous

La concentration en oxygène dissous présentait une diminution entre 60 et 80m excepté une diminution très prononcée le 08/08/99 vers 50 m.

II.Composition des captures de poissons pélagiques.

Au cours de notre expérience, la communauté des poissons capturées était composée principalemnt de deux espèces seulement: un Clupeide (*Stolothrissa*) et un Centropomidé (*L. Stappersi*). *Limnothrissae miodon* (Lumbu) était presque inexistant. De fortes fluctuations d' abondance et de composition sont observées au tableau 3. L'observation des contenus stomacaux a de plus montré que *L. stappersi* adulte est un vorace incontestable des petites sardines *Stolothrissa*. Ces dernières par contre avaient un estomac souvent vides mais on a observé la présence de copépodes (cfr le rapport de Cris Oppert).

III.Composition du zooplancton

Le zooplancton pélagique capturé était dominé par les Crustacé Copépodes *Tropodiaptomus simplex* et Cyclopoides (Figure 1). Les autres espèces étaient moins représentées tels que les *Limnocnida* (=méduses), *Limnocaridina* (=crevettes) *et* larves de poissons (Figure 2). *Vorticella sp*.était presque inexistant. Durant la période restreinte de notre expérience, le copépode Cyclopoide était toujours dominant et les nauplii avait augmenté jusqu'atteindre un pic au début du mois d'aôut .

IV.Discussion

Cette étude préliminaire, nous a permis d'observer des relations possibles entre la fluctuation en abondance des poissons capturées par les pêcheurs et des variations de l' environnement, notamment la turbidité (rapports de Edith et Jennifer), le moment du cycle lunaire. Le vent et les courants qu'il provoque, peuvent aussi influencer la production primaire ou la position du plancton dans la colonne d'eau.

La densité du zooplancton présentait au cours des quatre nuits d'échantillonnage, une tendance des fluctuations suivant la taille des individus vis-à-vis des prédateurs. L'augmentation de densité du zooplancton semble entraîner les Clupéides suivis des *L. stappersii* adultes. La diffèrence de comportement proie-prédateur entre les deux espèces a été remarqué durant notre expérience. La présence des petites sardines *S. tanganyicae* dans les contenus stomacaux. des *Lates* juvénile plus importante confirme la prédation.

VI.Conclusion

Bien que le nombre des nuits de notre investigations soit insuffisant pour tester notre hypothèse, les variations très marquées des compositions des espèces des poissons pélagiques capturées par les pêcheurs pourraient être liés notamment aux vagues internes elles-même liées aux variations de production primaire et de turbidité. Les différentes tailles des espèces dans la chaîne trophique conditionnent aussi une prédation selective.

Cette étude nous a permis de nous interroger aussi sur l'effet de la lune sur le comportement des différentes espèces en complémentarité avec d'autres facteurs limnologiques. Cette hypothèse exige d'entreprendre des recherches sur une longue période d'au moins deux à trois ans. Les facteurs biologiques influencent l'abondance des espèces mais de nombreux facteurs environnementaux jouent aussi un rôle primordial (Coenen et al, 1998).

Une expérience de collecte régulière d'échantillon de plancton dans une colonne d'eau effectuée au même moment que la pêche serait particulièrement interessante pour mieux comprendre la dynamique du lac.

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Total organic matter, carbonate, and grain size determination in two east-west coring transects, Luiche and Malagarasi River Deltas, Lake Tanganyika, East African Rift Valley.

Students: Isla Castañeda , Ivan Erchak, Melissa Harper

Introduction

Lake Tanganyika is a 9-12 Ma (Cohen et al., 1993) rift lake situated in the western branch of the East African Rift Valley. The geomorphology of the lake and its tributary rivers is largely determined by tectonic features associated with rifting. The Malagarasi River is a well-integrated, meandering stream system that drains much of western Tanzania (Tiercelin, J.J & Mondeguer, 1991) and is the largest sediment contributor to the lake in the Central Kigoma Basin (Tiercelin et al., 1994). The Luiche River is also a meandering stream system, but its extent and drainage is much smaller than that of the Malagarasi. The character and distribution of sediments in the river deltas are controlled by fluvial geomorphology, drainage size, source area lithology, and tectonic structure of the depositional basin. The differences in the geomorphology, drainage size, and depocenter structure between the Malagarasi and Luiche Rivers result in contrasting sediment character and distribution in the two river deltas. Consequently, sediment cores collected from similar water depths at each of the deltas will differ significantly in grain size, percent organic matter (OM) and percent carbonate (CO_3).

Geologic Setting

The Malagarasi River drains a large portion of western Tanzania and is the largest river entering the Tanganyika basin (Tiercelin et al., 1994). The Malagarasi River Delta is a birds-foot delta and has a prodelta area extending down to 1150m depth (Tiercelin & Mondeguer, 1991). Approximately 2.5m of sediment are exposed along the banks of the Malagarasi suggesting that the river is currently incising. The width of the river varies considerably, but is between 30-40m in most places. By comparison, the Luiche River is a meandering system with a minor drainage area of 1065km^2 (Cohen & Palacios, 1998). The outlet of the Luiche River is a marshland, and the Luiche system is orders of magnitude smaller than the Malagarasi system.

The Malagarasi and Luiche River Deltas are located near the region of Kigoma, Tanzania, and the mouths of the two rivers are approximately 25km apart. These two systems are an ideal place to examine sedimentation processes between a major (Malagarasi) and a minor (Luiche) rift delta system. The two systems have the same source lithology, climate, age, and depocenter structure. The regional bedrock consists of granites, gneisses, mica schists, amphiboles and quartzites of Precambrian age (Tiercelin & Mondeguer, 1991). The climate is subhumid tropical (Soreghan, 1993). Additionally, both river deltas have similar tectonic styles defined by a large platform margin bordered to the west by a major N-S ridge. River size and drainage basin size are the influential variables affecting sedimentation within these two delta systems.

Materials and Methods

Core Collection

Two East-West transects of 2 meter gravity cores were collected from the M/V Maman Benita in the areas of the Luiche and Malagarasi River Deltas near Kigoma, Tanzania (Figure 1, Figure 2, Table 1). Nine successful cores were obtained from the platform and slope of the Luiche and Malagarasi Deltas. The geomorphology of these river deltas was examined using single-channel reflection seismic data collected during Project Tanganyika ’97 (RSMAS-University of

Miami). Cores NPG7 and NPG8 were taken along transect T-97-2C (Figure 3); NPG9 and LU1 along transect 2D in the Luiche Delta (Figure 4). All Malagarasi cores were taken in the proximity of seismic line T-97-12 (Figure 5).

Organic Matter and Carbonate

Cores were subsampled at 2cm intervals for the upper 50cm, and at 5cm intervals thereafter. Samples were prepared for analysis by drying in an oven for a minimum of 72 hours at 50° C. A representative portion of the dry sediment was transferred into a pre-weighed crucible and sample weight (A) was determined using an analytical balance. Samples were transferred into a Thermolyne 1400 muffle furnace and burned at 550° C for 2 hours to remove organic matter. After cooling in a dessiccator, samples were reweighed (B) then burned at 925° C for 4 hours to remove carbonate. The samples were reweighed (C), and organic matter and carbonate percentages were determined as follows:

$$\%OM=100-(A-B)/A*100$$

$$\%CO_3=[100-(A-C)/A*100]-\%OM$$

Grain Size

Smear slides were examined for cores LU1 (depth: 62m), G8 (depth: 461m), MAL6 (depth: 41.9m) and MAL5 (depth: 615m) to assess presence/absence of diatoms and changes in grain size. Additionally, a rough estimation of grain size was determined in cores LU1 and MAL6 by wet sieving. Samples were prepared for grain size analysis by drying sediments under drying lamps. Samples were then homogenized smoothly with a mortar and pestle, weighed, and placed in glass jars. Samples observation at the microscope after this step shows that the homogenized sediments did not contain broken shells or other debris. Distilled water was mixed in with sediment, and the mixture was frozen overnight to promote deflocculation of clays. Samples were wet sieved through a standard 63 um sieve. The sandy portion was then re-dried under drying lamps, and re-weighed to determine the percentage of sand. This procedure was meant to be a rough approximation of percentage sand, due to time constraints. This procedure used to determine grain size was done to provide a rough approximation of grain size in a limited amount of time. More extensive and accurate grain size analysis should be conducted soon to confirm or not these results.

Age Control

^{210}Pb dating techniques show that sedimentation rates in the Malagarasi have been approximately 3.5mm/year since the 1960's and approximately 1.1mm/year prior to this time (Cohen, pers.comm; unpublished data). In order to compare with ^{210}Pb data, the clearly defined annual laminations of core MAL4 were counted from the top of the laminations to the core bottom. The lamination count suggests a sedimentation rate of approximately 1.3mm/year. This rate is in close approximation with the results of the ^{210}Pb dating.

Results and Interpretations

Organic Matter and Carbonates

The percent organic matter and percent carbonate data obtained from the Luiche Delta Area cores show the same general trend (Figures 6A-6D). Each core has a distinct high in percentage carbonate and a corresponding low in organic matter at the top. The trend continues downcore with alternating high and low percentages of organic matter and carbonate values. The Luiche cores show peaks and lows in percentage organic matter and percentage carbonate at similar depths downcore. Distinct peaks in organic matter and corresponding lows in percentage carbonate occur at core depths of ~30cm, 60-65 cm, and ~110-115cm. Core G8 (461m) has an additional peak in organic matter and low in percentage carbonate at a core depth of 100cm. Pronounced high %CO_3 values and low %OM values occur at depths of ~0-2cm, 50cm, and ~90-95cn in each of the cores. Core G8 has an additional low in %OM and high in %CO_3 at the ~135cm depth.

The cores from the Malagarasi Delta also show increased percentages of carbonate values at the top of cores MAL4 (203m) and MAL6 (41.9m) (Figures 7A-7E). MAL1 (10.7m) also shows an increasing trend towards the top of the core. Core MAL5 (615m) shows a decrease in %CO_3 at the top of the core. All of the Malagarasi cores excluding the deepest core (MAL5) have increased %CO_3 values at approximately 50cm depth in the core. This may correlate with the %CO_3 peaks that are observed at the same core depth in the Luiche Delta cores. Cores MAL4 and MAL5 show a slight consistent decrease in %CO_3 below ~100cm core depth.

The mean %OM in each of the cores shows a general increase as water depth of the core increases (Figure 8). This trend occurs in both the Malagarasi and the Luiche Delta systems. The Luiche Delta cores, however, do show a slight decrease in mean %OM from cores G7 (190m) to G8 (461m). The increase in mean %OM as a function of increasing core water depth may be the result of anoxic water conditions. Anoxia results in better preservation of organic matter, as there are fewer organisms to decay the OM in anoxic environments. The increase in mean %OM as core water depth increases may also be a result of a decrease in clastic dilution. Allochthonous (terrestrial) sediments are more abundant and tend to dilute the weight percentage OM and CO_3 in cores taken nearer to the river mouth. In deeper water, clastic dilution is less influential. Much of the sediment accumulation in deep water, therefore, is the result of organic-matter rich autochthonous (lacustrine) sedimentation. Preliminary assessments of smear slides from the Luiche and Malagarasi cores taken from greater water depths show a large amount of diatoms.

The mean %CO_3 value is high in the 10.7m Malagarasi gravity core. The general trend of mean %CO_3 in the Malagarasi and Luiche cores shows an increase in mean % CO_3 until cores MAL2 (111m) and G9 (92.2m) are reached. Thereafter, the mean %CO_3 values decrease as water depth increases. This trend in mean %CO_3 is explained by the anoxic boundary that exists at around 100m water depth in the lake. In anoxic waters, there is a decrease in organism activity which results in a low CO_3 production. Thus, carbonate precipitation decreases.

Smear Slides

The results of the smear slide analyses show that the grain size of the sediments in core LU1 (62m) is generally greater than the grain size in core G8 (461m). Similarly, the grain size of the sediments in core MAL6 (41.9m) is greater than the grain size found in core MAL5 (615m). All of the examined sediments contained diatoms, and diatoms appeared to be more abundant in the sediments taken from the deepest Luiche and Malagarasi cores (G8 and MAL5). Diatom species identification was not possible due to the limiting magnification of the available microscope.

Grain Size

Grain size data for Luiche core LU1 show a sand content of approximately 0% to be relatively consistent throughout the core (Figure 9). However, from 20cm-0cm, there is an increase in sand percentage to ~1%. Grain size data for core MAL6 indicate much higher percentages of sand, as is expected with a major river system (Figure 10). The percentage of sand in the Malagarasi core varies from ~25% to ~68%, and a cyclicity is visible throughout the core.

Percentage sand values dramatically increase from ~5% at ~35cm core depth to ~68% near the top of the core. Assuming a sedimentation rate of ~1.3mm/yr, the increase in sand observed in the Malagarasi core would have begun ~300 yrs B.P., and the increase in the Luiche would have begun ~250 yrs B.P. The increase in grain size correlates well with magnetic susceptibility data for the same cores (see NYANZA Project report '99-Charles Bakundukize). Magnetic susceptibility data indicates increased terrestrial input during these intervals.

It is likely that deltas in Lake Tanganyika are prograding as the result of two factors; 1) rivers in the area have been incising since the 1877 high lake-level stand (Cohen et al., 1997) resulting in increased sediment input to the deltas and, 2) increased erosion around the drainage basin due to deforestation promotes delta progradation. Preliminary grain size results of this study indicate that delta progradation may be occurring. The Luiche core exhibits a slight percent sand increase upcore, and the Malagarasi core shows a dramatic increase followed by a slight decrease. Both cores display the general trend of increasing sand percentages upcore. The procedure used to determine grain size was done to provide a rough approximation of grain size in a limited amount of time. More extensive grain size analysis will be conducted to confirm these results.

The "Carbonate Paradox"

Of the 9 cores examined in this study, 7 have relatively high carbonate percentages at shallow depths in core. Percent CO_3 begins to increase at ~35 cm core depth. Using a sediment accumulation rate of 1.3mm/yr, as estimated through an annual lamination count, a core depth of 30-35cm corresponds to an age of approximately 270 yrs B.P. In many areas of northern Lake Tanganyika, sedimentation rates began to increase around this time as a result of anthropogenic activities (Cohen, pers.comm). Magnetic susceptibility also increases at depths shallower than 30cm in all Malagarasi and Luiche cores (see NYANZA Project Report '99-Charles Bakundukize) supporting increased terrestrial input. Furthermore, preliminary sand percentage distribution data displays an increase in sand upcore. These lines of evidence would seem to suggest that clastic sediment dilution should be occurring and therefore, percent CO_3 should be decreasing. However, the reverse trend is observed as almost all cores display an increase in carbonate percentage at shallower core depths. One possible explanation for this "carbonate paradox" follows; if clastic influx is increasing in these deltas, the production of carbonate by organisms must be increasing at an even faster rate as there is no lithologic source for carbonate in the drainage basin. Increased CO_3 production could result from an increase in nutrient flux to the deltas. Unusually high nutrient levels observed at the mouths of the Luiche and Malagarasi rivers (NYANZA Project Report '99-Kamina Chororoka) support this idea.

Conclusions

The %OM, %CO_3, and grain size data obtained from the Malagarasi and Luiche Delta areas show that sedimentation differs considerably between these two systems. Sediments taken from the deltas at comparable water depths differ in grain size, %OM, and %CO_3. Both the Malagarasi and Luiche Deltas appear to be prograding based on available grain size, magnetic susceptibility, and historical data. In addition, high carbonate values at shallow core depths may indicate increased productivity as there is no carbonate present in the source lithology.

Future Research

More detailed geomorphological descriptions of the Malagarasi and Luiche delta systems need to be made. A more extensive study of grain size in the two deltas should also be conducted. A thorough analysis of grain size in the Luiche and Malagarasi deltas may provide more evidence that the deltas of Lake Tanganyika are prograding. In addition, more research needs to be done on the "carbonate paradox". Dating terrestrial plant material within the Malagarasi and Luiche sediments would be useful for correlating a specific time period with the increases in $\%CO_3$ observed upcore.

Acknowledgements

We would like to thank our mentor Dr. Kiram Lezzar, Dr. Andy Cohen, Mark Woodworth, and Nick Mathieu for their help and encouragement. We would also like to thank the crew of the M/V Maman Benita, the NYANZA Project, the Lake Tanganyika Biodiversity Project (LTBP), and the Tanzanian Fisheries Research Institute (TAFIRI).

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Influence of Malagarasi and Luiche Rivers Input on Central Lake Tanganyika Dissolved and Suspended Particles

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1.INTRODUCTION

Lake Tanganyika (3° 30' - 8° 50' S, 29° - 31° 20' E) is the largest of the African Great Lakes. It lies in the Western Rift Valley of Central Africa, at an altitude of 773 m. The climate of the Lake Tanganyika region is semihumid-tropical, with a variable intensity rainy season lasting eight to nine months, alternating with a pronounced dry season of three to four months duration (June-September) (Peguy, 1961). The average annual rainfall is about 1000-1100 mm. Lake Tanganyika is the second largest fresh water Lake in the world. It is meromictic with stable hypolimnetic waters, and the salt content is low for this type of lake (Degens et al,1972).

This equatorial lake is elongated along a N-S axis, and is approximately 650km long and 50km wide in average. It is divided into three main basins, north, central and south, separated by the major Kalemie-Mahali and Ubwari bathymetric shoals (Tiercelin et al., 1988; Cohen, 1989; Lezzar et al., 1996; Cohen et al., 1997).). The deepest part of the lake basin shows a maximum depth of 1472m in the Moba Basin in the southern lake Tanganyika. Our study area is located in the eastern part of the central Lake Tanganyika, near the Malagarasi and the Luiche Rivers Platforms. The Malagarasi River is the most important sediment supply entering Lake Tanganyika, after the Rusizi River in the northern basin.

Many studies deal indirectly with the mixing and the substance transport in Lake Tanganyika. The stability of 70% of the lake volume and the great age, about 12 Ma (Cohen et al., 1993) of the Lake should lead to a high depth gradient of salts. However, the measurements by Degens et al (1973) show that no such a gradient exists in the lake deep waters. This indicates some kind of deep water circulation. The vertical mixing has been discussed also by Tietze (1982) in connection with his study on the methane content of the Lake Tanganyika waters. He estimated that the decrease in density due to temperature changes within the metalimnion was about 1kg/m3. He also conducted laboratory studies on density variation in the lake due to dissolved substances. The results indicates that these density variations were 5% of those due temperature variations. Malagarasi and Luiche Rivers have a major share of the inflowing waters to the lake. Similarly they obviously contribute most of the suspended solids load to the lake. There is little information about actual measured suspended sediment concentration in the incoming rivers. Patterson (1996) reported about the present status of the river monitoring and sediment yield estimates around the Lake without doing input estimation of different rivers. Hecky (1992) estimated that the Rusizi River is the main source of salts entering the lake.

OBJECTIVES

A major goal of this study is to understand the brought effect about by the river systems on an east african great lake particularly Lake Tanganyika.
Physical and chemical parameters of the Malagarasi and Luiche Rivers are compared to those of the rivers mouth and open waters off shore.

METHODOLOGY

Sampling: Water samples were collected from the surface of the rivers and the Lake and brought at Tafiri research facilities for analysis and interpretation. In the Malagarasi River area, samples were collected up stream about several km as well as off the shore. This is in contrast with Luiche area were the access to go upstream could not be possible. Figure 1 & 2 represent the location map for both Malagarasi and Luiche Rivers areas respectively.

The following parameters have been measured : Conductivity, Turbidity, pH, Soluble reactive phosphate , Nitrate (NO3-N), Nitrite(NO2-N), Ammonia(NH4-N) and suspended Particulate Matter(SPM).

Parameters were measured by HACH DR 2010 methods, HANNA instrument, Conductivity meter model HI8033 and pH meter model HI 9023 . The SPM was obtained after filtering ~1000ml of water sample using 47mm diameter cycles filter paper. The filtrate was then placed into an oven at ~60 *c until dry. SPM was defined as the total weight of the sample and the filter paper minus the weight of the filter paper.

RESULTS

The main results are represented in the following graphs and tables

- **Table** 1. Showing the results obtained after measuring different physical and chemical parameters
- **Figure** . 3. Graphs showing the physical and chemical parameters in Malagarasi
- **Figure** . 4. Graphs showing the physical and chemical parameters in Luiche.
- **Figure**. 5. Graphs showing the averages of different chemical and physical parameters in Malagarasi as compared with the averages in the lake and the mouth of the lake.
- **Figure**s. 6 & 7 Graphs showing the averages of different chemical and physical parameters in luiche as compared with the averages in the lake and the mouth of the lake.

INTERPRETATION

Almost every nutrient is more abundant at the mouth of the rivers. The amount of suspended particulate matters (SPM) tends to increase as we move from the river towards the lake. On entering the lake, this amount decreases rapidly, indicating a possible influence of the lake water circulation and/or sedimentation type on the rivers input (SPM entering the lake). At the river mouths, suitable environmental conditions for deposition are more prevalent than the within the river system. This rapid decrease of SPM can also be explained as the result of other nutrients being used by organisms within the lake community at the river mouth and offshore.

The relationship between different species within-the-lake and in the river community is not cleary understood. There is a need for further study on the influence of dissolved particles on Lake Tanganyika.

CONCLUSION

Even though our results shows that both rivers, the Malagarasi and Luiche, play an important role on influencing Lake Tanganyika waters, both in terms of dissolved as well as suspended particles. Eventhough the actual amount brought about by these two river systems is not enough and clearly understood, investigating these parameters in the future on seasonal basis should be very helpful.

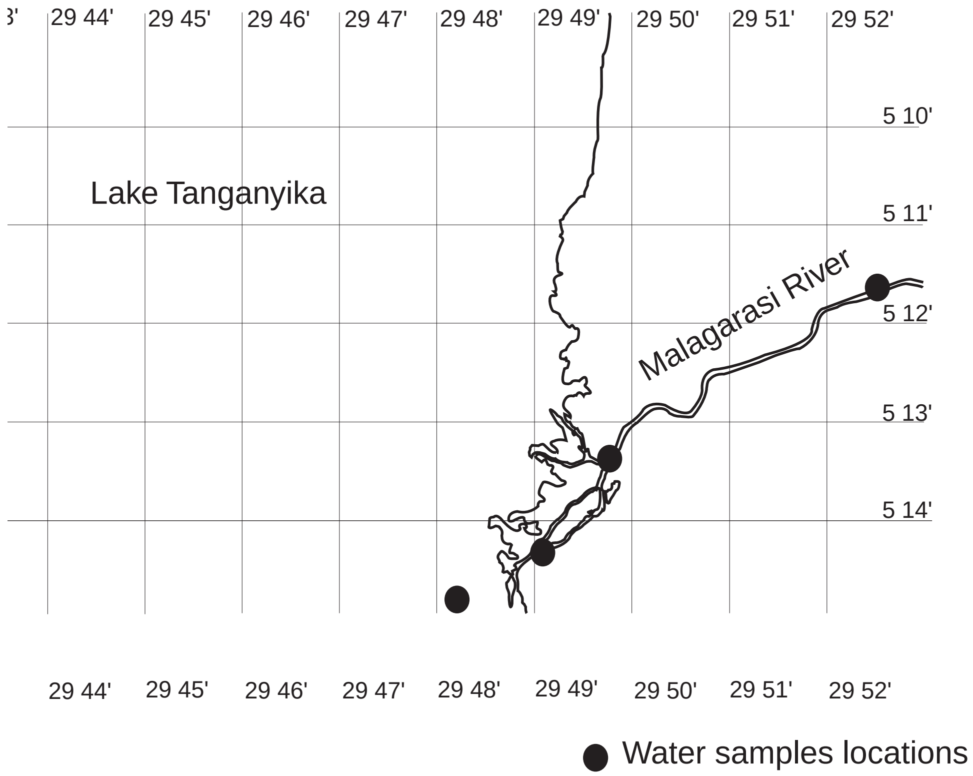


Figure 1

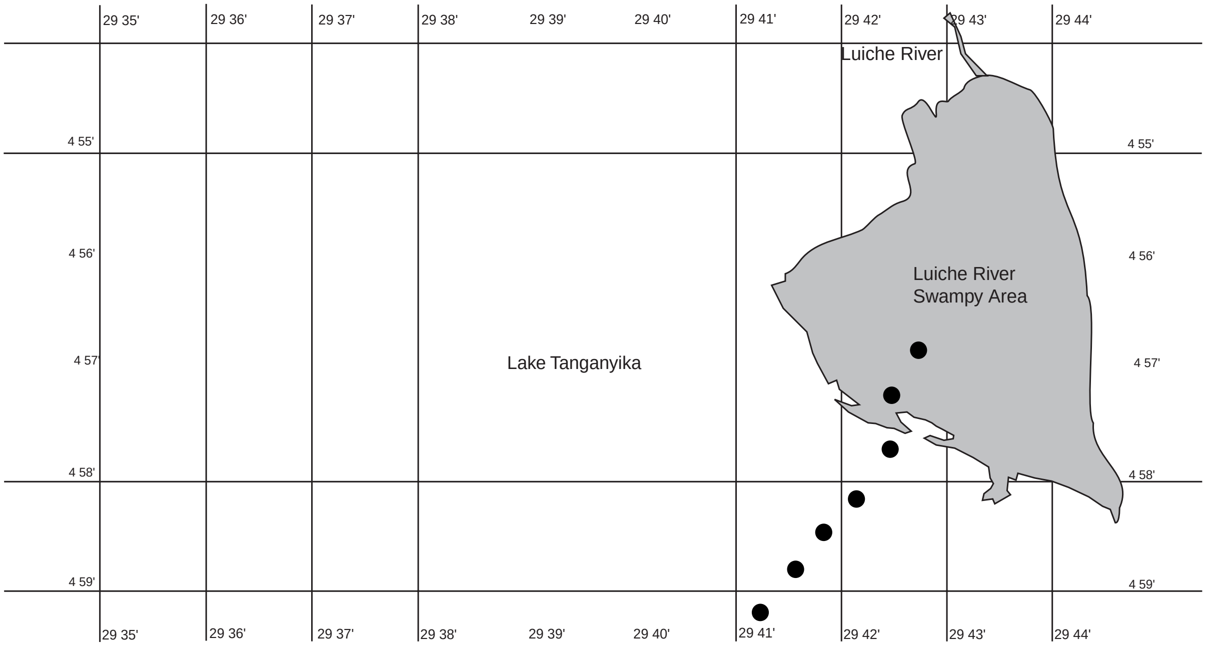


Figure 2: Location map of the Luiche River water samples transect

● Water Samples used in this study

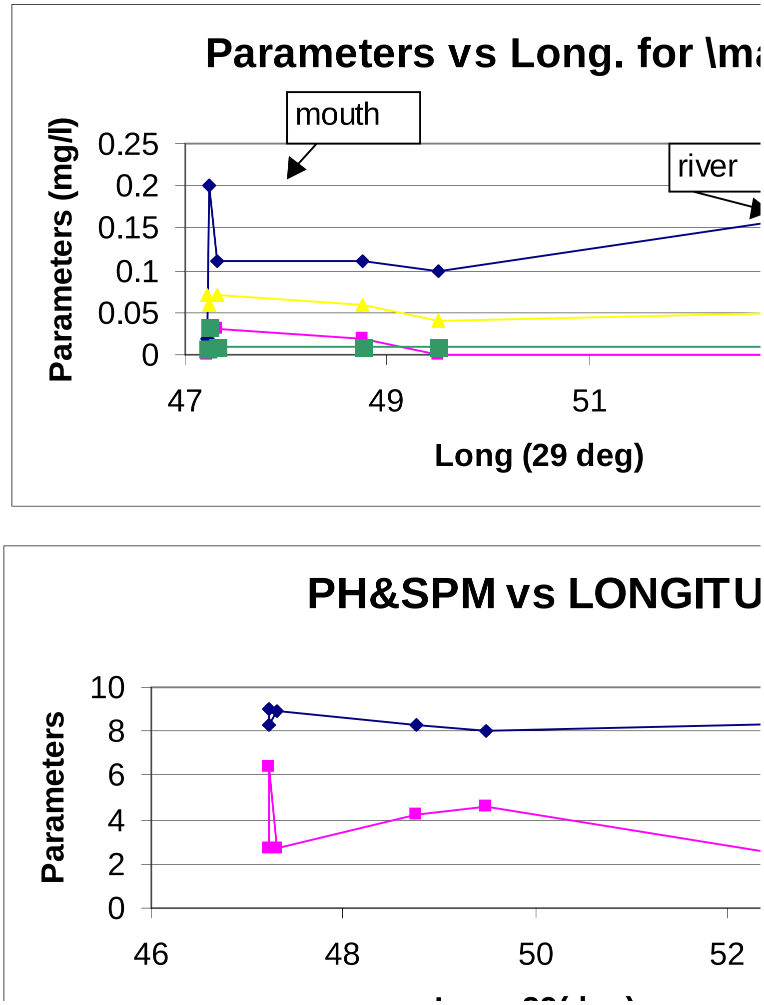
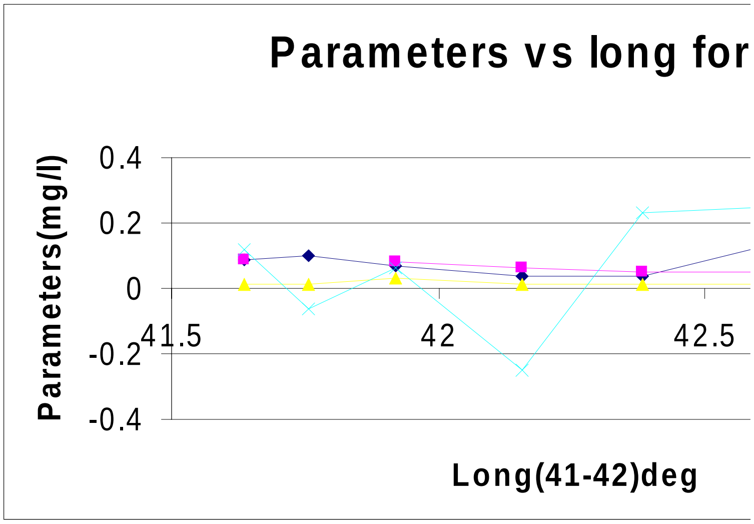


Figure 3. Physicaland chemical parameters in the Malagarasi.



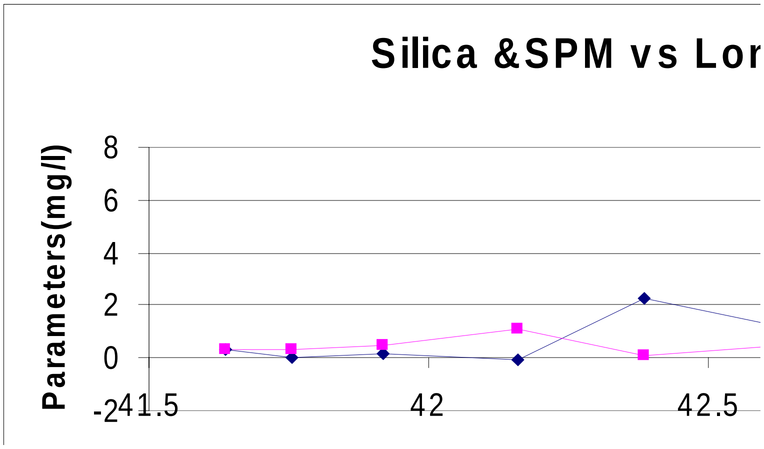


Figure 4. Physicaland chemical parameters in the Luiche.

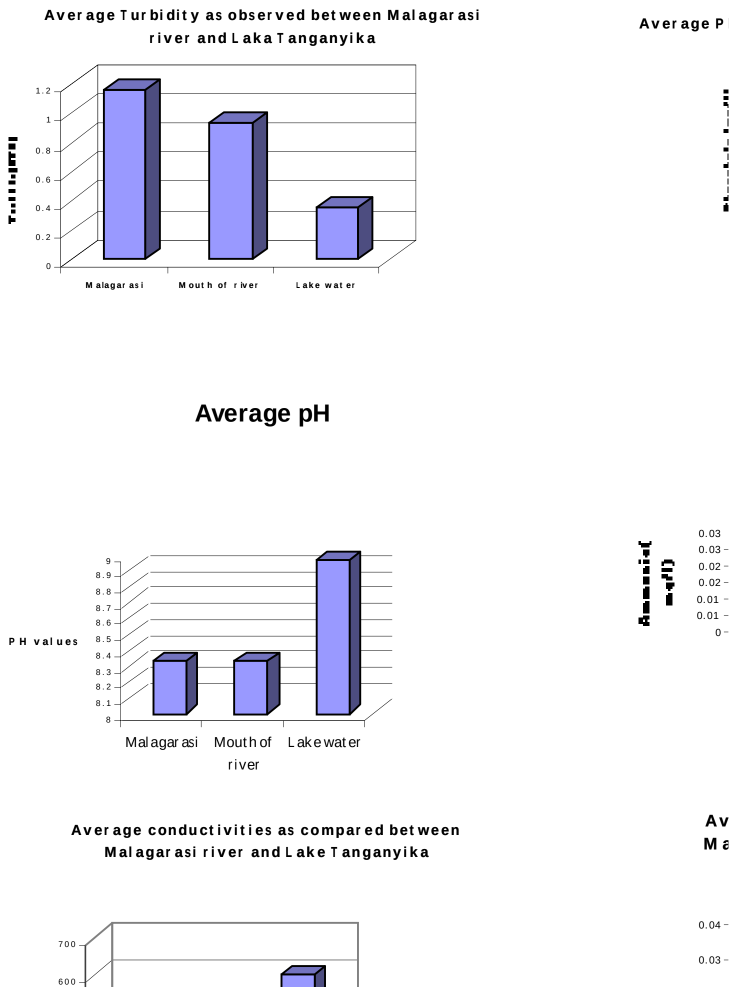


Figure 5. Averages of physical and chemical parameters between Malagarasi River and Lake Tanganyika waters.

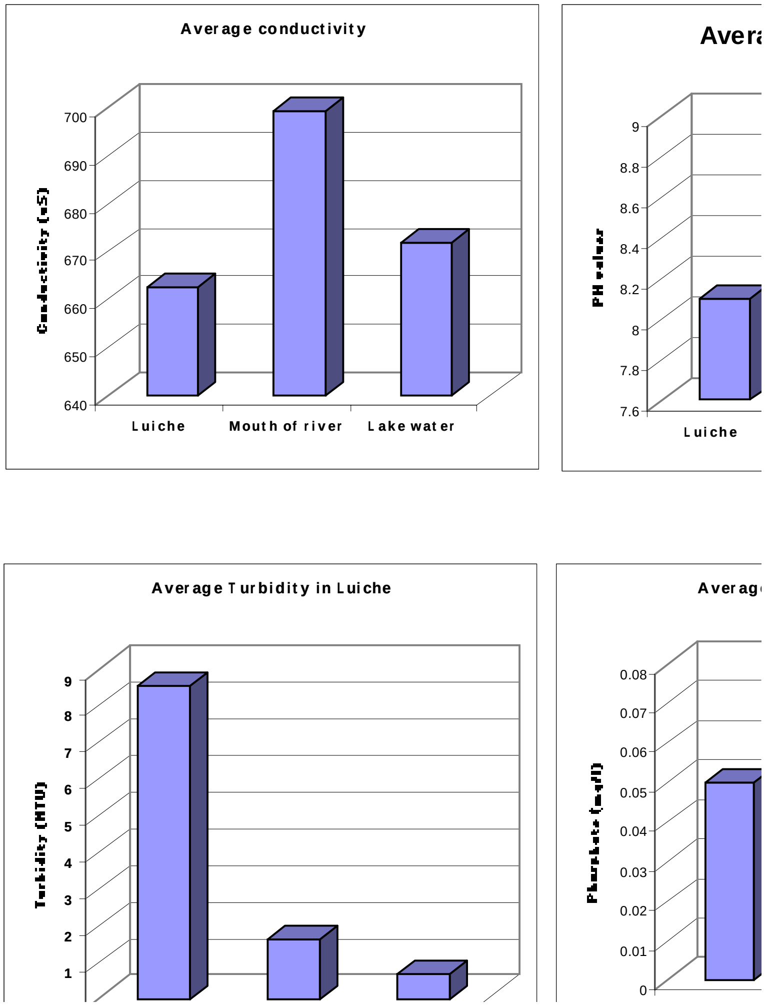


Figure 6. Averages of physical and chemical parameters between Luiche River and Lake Tanganyika waters.

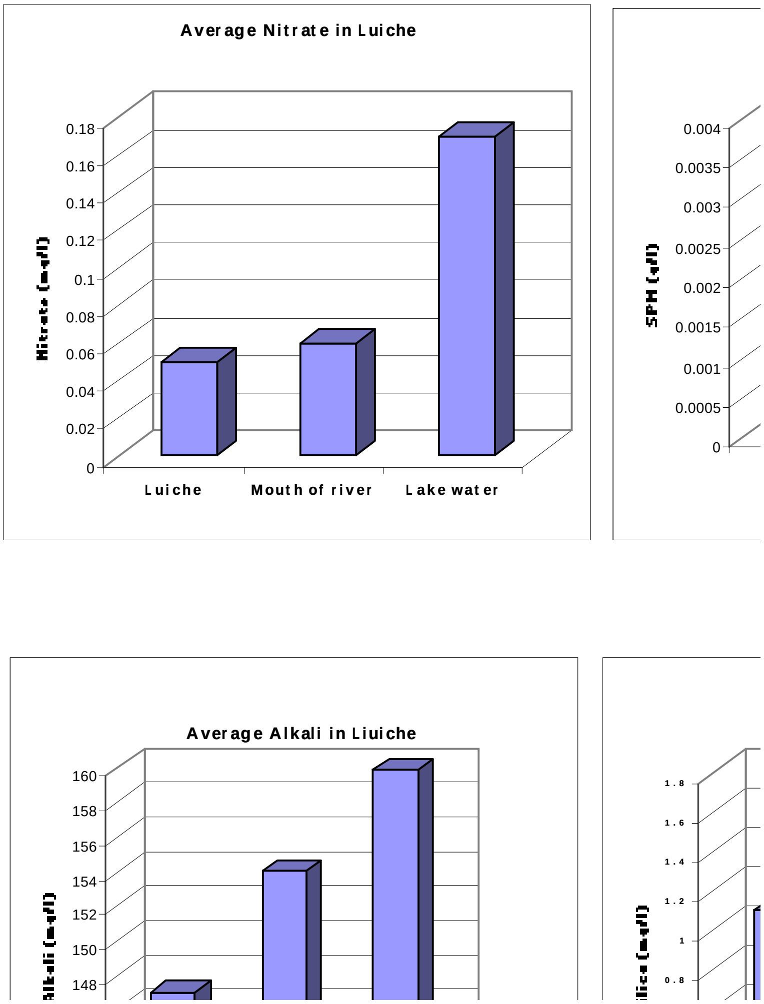


Figure 3. Averages of physical and chemical parameters between Luiche River and Lake Tanganyika waters.

A Morphometric Analysis of the Endemic Crab *Platytelphusa armata*, from Lake Tanganyika, with Reference to *P. tuberculata*

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Introduction

Lake Tanganyika, dated at 12 million years old (Cohen, A., peronal communication), is the longest and most tropical East African Rift Lake. With some parts of the lake reaching 1470 meters, it is the second deepest lake in the world. The lake is characterized by alternating shorelines and a large range of habitats, which are relatively stable. Lake Tanganyika is well known for its cichlid fish, and over two hundred species have been recorded to date. Also endemic to the lake are the lesser known and studied *Platythelphusa* crabs. Originally, there were thought to be seven species of *Platythelphusa* in Lake Tanganyika, but recent cladistic studies and revisions have cited only six (Cumberlidge et al., 1998). Of those six species, two are riverine, and do not enter the lake. *P. armata* is the largest and most predominant, and thus, the most studied of the lacustrine species. First recognized by A. Milne-Edwards in 1887, *P. armata* was the first of its sub-genera documented, being characterized by its striking resemblance to marine species; robust square shaped carapace outline, horizontally projecting carapace front, flattened carapace shape with large spines on the edges, strongly developed mouth parts, and stout chelipeds. Perhaps because of their large sizes, adult *P. armata* are ubiquitous across many habitats, while its smaller relatives, *P. maculata*, *P. echinata*, and *P. polita*, are confined to the sub-littoral zone. *P. armata* juveniles are also commonly found in this zone (Coulter, 1991). Reproduction in *Platythelphusa* is direct, with no larval stage, and females have a marsupial pouch, where they carry their young. Adult females can be distinguished from males by their abdomens, which cover the bases of the coxae of the legs (first visible joint) and reach the base of the third maxillipeds. Adult and juvenile males can be distinguished by their gonopods, as they are not as well developed in juveniles and sub-adults. In addition, the chelipeds of adult males are heterochelous, but those of juveniles are of equal size.

While there has been some investigation of predator-prey interactions between *P. armata* and snails of Lake Tanganyika (West et al., 1991), only limited morphological analyses have been conducted on the crabs. Coulter has defined the habitat range of each of the six species, but no one has directly surveyed species abundance at different habitats. Almost nothing is known about dimorphism, allometry, life history patterns, or genetic relationships between or within species.

Objectives

The aim of this study is to conduct a morphometric analysis of Tanganyikan endemic crabs, focusing on patterns of allometry or dimorphism. My hope is to create a foundation upon which more studies can be conducted. This information is critical to understanding crab life history, and ultimately, deciphering the relationship between the crabs and their environment. Such studies have implications reaching towards understanding, and ultimately, conservation of Lake Tanganyika and its diverse habitats.

Materials and Methods

I purchased all of my crabs (40 Tsh each) from fisherman at Ujiji, a small fishing town south of Kigoma. This was the most effective way to obtain them, as they were caught in the fishing nets. The crabs I received came from two locations – in the benthic zone at Sinzo, west of Ujiji, and the littoral zone at Kangamoja, southwest of Ujiji. All of the crabs used were in good condition, with the carapace intact and unbroken. Most chelipeds were attached, with the exception of an occasional missing propodus. I kept the individuals separate by location, and conducted a visual inspection before the freezing the crabs for analysis. Any females with broods or eggs were placed in separate bags allowing me to link females with their broods. Crabs were labeled by placing a identification tab on their rearmost cheliped, and all of the appropriate information was placed in my notebook.

I used digital calipers to make the following morphometric measurements (Figures A and B): a. width between exorbital teeth (first spike outside eyes), b. width between epibranchial teeth (second spike), c. front width (distance between eyes), d. carapace diagonal from exorbital tooth to opposite posterior margin at the hindmost cheliped, e. carapace length from anterior to posterior margins, f. carapace height (body thickness at central point of carapace) [not shown], g. posterior margin length (carapace width between hindmost chelipeds), h. tip of telson (a7) to base of abdominal segment one (a1), i. width of a6 abdominal segment, j. width of a5 abdominal segment, k. distance from tip of telson to base of third maxillipeds [not present on figured individual], l. distance from top of telson to frontal margin, m. length of basal margin of propodus of chelipeds, n. length of dacytylus of cheliped, o. length of propodus of cheliped from hinge to tip, p. height of propodus of cheliped at joint, and q. claw diagonal from top of propodus at joint to lower propodus tip. I made an estimate of the number of teeth on each claw, and also noted the characteristics of the dentition. I took several pictures with a digital camera for reference. My analyses consisted of two principal components analyses (PCA) using SYSTAT 7.0. The first PCA was conducted for males with both claws, and the variables selected were width between exorbital teeth, width between epibranchial teeth, front width, carapace diagonal, and carapace length (shown in Figure 1). A second PCA for Figure 2 used all females, and included the same variables as the male PCA.

Results and Conclusions

I collected a total of 233 crabs, of which approximately two thirds were male. Most of the crabs were *P. armata,* while about thirty were a smaller red species, believed to be *P. tuberculata* (Cumberlidge et al., 1998). The second species was considerably smaller than *P. armata* (see Pictues C and D), with its largest individual having 28.67 mm width between the epibranchial teeth (widest point of the carapace). In comparison, the *P. armata* width ranged between 19.46 mm and 53.67 mm. The carapace of *P. tuberculata* was less robust than that of *P. armata*. Their propodus was longer in relation to the rest of the leg, their claws had a greater curvature, and their teeth were much smaller, as well. Perhaps the most distinguishing characteristic of *P. armata* was their extremely large and robust propodus. The longest one I recorded was 60.71 mm in length from hinge to tip. While most crabs had larger right claws, there were several crabs whose left claw was the dominant one. The largest dentition of the dominant claw resembled molars in humans – broad, dull, yet durable for grinding or crushing. Almost all of the very large claws had worn dentition, and some appeared to be battered, indicating snail predation. *P. tuberculata* claws typically had smaller, sharper dentition. In both species, the dentition became smaller and harder to distinguish as it approached the tip of the claw.

Although previously documented (Coulter, 1991), I found it unusual that almost all of *P. tuberculata* were found at Sinzo (benthic zone location) , given their small size. It is necessary to take into consideration the depth at which the nets were placed. While placed in sandy habitats as opposed to rocky ones, they most likely did not reach the lake floor, but only a few meters under the water's surface. It is possible that the crabs caught were those that lived in that part of the water column or came to feed on the fish caught in the nets. Some of the *P. armata* from Kangamoja had algae covering their carapaces. This could be an indication that they inhabit the phototrophic zone, or that they haven't molted in a while. Even though the fisherman returned to the same general location everyday, they did not return to the precisely same place, so the habitat could have varied slightly, as well.

I used PCA on SYSTAT to attempt to distinguish juvenile and adult males by the ratio of their claw lengths, and also determine the distribution of juvenile and adult males at the two different locations. I plotted the ratio of their claw lengths (right:left) against the growth component of a PCA (Figure 1). None of the crabs exhibited an exact 1:1 ratio of right to left claws, yet many individuals had a ratio of 1:1.1 (right claw larger) or 1:0.9 (left claw larger). I assumed these were juveniles. Those crabs with ratios outside this bracket – the outliers – are assumed to be adults. However, it is possible that some of the crabs could have regenerated claws. Thus, some of the juveniles may have higher ratios, causing them to fall in the range of adult ratios. There seemed to be little correlation between growth (or size) and maturity among male *P. armatas*, as juvenile and adult males were distributed along the entire growth component axis. Furthermore, there seemed to be no habitat preference for either juveniles or adults, as they were found both at Sinzo and Kangamoja. This was not expected, and is not in accord with Coulter's 1991 information. My results indicate that juvenile crabs inhabit both sub-littoral and benthic zones.

There was only one adult female *P. tuberculata* obtained, while both mature and juvenile female *P. armata* were collected. Allometry between the juvenile and adult females is illustrated in Figure 2. It appears that the juvenile female abdomens grow wider much faster compared to their overall growth than do abdomens of adult females. Mature female crabs have a slower growth rate, and the rate of their abdomen growth per unit is even lower than their overall growth.

I found it intriguing that some mature females were in a smaller class size than some juvenile females. The smallest and largest distances between the epibranchial teeth of juveniles recorded were 22.35 mm and 39.14 mm, respectively. In comparison, the same measurements among mature females were 31.37 mm and 52.53 mm. This raises several questions. Do the females mature at the same age and grow at different rates? Or do they grow at approximately the same rate and mature at different ages? The females mature at the same size, as most of the adult females have abdomen widths greater than 3 mm, and the juveniles have abdomen widths less than 3 mm (Figure 3). This seems to be the point of intersection for the two life stages. The distance between the tip of the abdomen and the third maxillipeds decreases continually as the abdomen width increases, until they molt and enter adulthood. It is because the females molt into maturity that there is a sharp drop at the 3 mm abdomen length. Once they have reached maturity, the female abdomens do not grow wider than approximately 3.7 mm. This is the upper size limit for *P. armata* females. Yet, it is unknown how old each of the female crabs were when they reached this stage of their life.

Several of the adult female crabs contained broods, and different developmental stages could be identified among the different mothers. Several of the females had bright orange eggs in their pouch in the early stages of development. Another female had the same size eggs, but hers contained small crabs inside, their eyes and other features clearly visible by the naked eye. Finally, two females contained fully developed baby crabs in their marsupial pouch, ready to emerge.

Also of interest was the number of eggs or young each female carried. Two of the pregnant females, with abdomen length and width varying by only 6 mm, had approximately 900-1000 orange eggs in their marsupial pouch. Yet, a third female of the same size carried only 700 of the more developed eggs. The two females with baby crabs in their pouch carried 175 and 75 offspring. While the latter female was much smaller in size, I hypothesize that the females discard any undeveloped eggs or dead crabs as they mature. It is still not known whether or not the size of the female's abdomen determines the number of eggs they produce. It may be possible that a smaller female is capable of holding the same number of eggs as a larger one at the beginning of her pregnancy, but later loses some of her brood.

In summary, allometry does exist between juvenile and adult females. I was also able to determine an approximate size (carapace width) that female *P. armata* molt into adulthood. It appears that male *P. armata* mature at smaller sizes than females, and that the juveniles can be found in both benthic and sub-littoral zones. Furthermore, I could confirm Coulter's 1991 information regarding the habitat preference of *P. tuberculata*.

While I was able to draw some preliminary conclusions, much work still needs to be done. If time permitted, I would have liked to examine the males again and distinguish the adults from juveniles. I would also have liked to record even more morphometric data on the crabs for an extension of the multivariate analysis. Future studies could build upon this one by conducting morphometric studies on crabs from different habitats dispersed along the Kigoma basin, eliminating any ambiguity of geographic location or habitat depth. Also, a more in depth examination of brood sizes would provide much information about life history patterns. Finally, any genetic study of the crabs to would complement nicely any of the aforementioned ideas. I hope to continue analysis on my data in the future.

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I would like to thank the National Science Foundation for creating research training such as the NYANZA project. I would also like to extend my sincerest appreciation and gratitude to Dr. Ellinor Michel, Dr. Andrew Cohen, and all of the NYANZA teachers and assistants for all of their help and guidance. Their endless support and patience was critical to the success of my research. Finally, I would like to thank Dr. Neil Cumberlidge for graciously donating the *Platythelphusa* key.

A Survey of the Physical Parameters that affect Biological Diversity in Jacobsen's Bay, Kigoma Lake Tanganyika

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Introduction

For the past few years, Jacobsen's bay in the Kigoma region of Lake Tanganyika, East African Rift valley, has been a popular site for studies on physical parameters and for biological studies of species diversity and distribution. The bay is considered an undisturbed site for many biological studies since the surrounding land is relatively uncultivated. Since it is used as an undisturbed site, it is important to know the various habitats that exist in the bay. For this reason, we constructed an underwater habitat map down to 30m using SCUBA. In addition to the habitat map, we created a bathymetric map of the bay using an echosounder. Heather Heuser of the University of Arizona is currently studying the diversity and abundance of ostracodes in Jacobsen's Bay. Ostracodes are thought to be detritus feeders on soft bottoms. Based on the feeding patterns of ostracodes on soft bottoms, we tried to determine if the same was true for rocky bottoms. We did this by measuring the amount of Total Organic Matter (TOM) accumulated on the rocks where the ostracodes live. The bathymetric and habitat map will be very useful to future biological and geological studies in the bay.

Materials and Methods

Bathymetric Map

With the assistance of Mark Woodworth, we made the bathymetric map stretching from the Southern point of Jacobsen's bay to the northern tip of the bay just South of Bangwe point. We recorded depth using a Raytheon 8100 Echosounder sonar system and transducer and a Garmin 45XL GPS for position. The transducer was mounted to a Styrofoam float that was anchored to side of the zodiac. We made East-West transects of the bay in a zodiac. During the transects, we recorded the GPS positions by hand while Mark called out the depth. To get an accurate shoreline we used an aerial photograph from the Division of Maps of the Ministry of Lands, Dar-es-Salaam of the bay and superimposed it on the bathymetric map.

Habitat Map

We constructed the underwater habitat map down to 30m using SCUBA. We did nine transects in total stretching from the Southern rocky wall off of beach 1 to the Northern rocks off beach 2 (refer to fig. 1 for transect locations). To construct the habitat map, we took a compass bearing on the surface and swam down to 30m along that bearing. At 30m, we turned around 180° using the compass to swim back up along the compass bearing. Every 2.5m in depth, We stopped, measuring the distance from the previous depth and recorded the habitat type. We described the habitat type by the bottom substrate type, prominent rock characteristics and the slope of the bottom. If the bottom substrate was mixed, we estimated the percentage of each substrate type i.e. Bedrock 60%, Boulders 40%. When describing the rock characteristics, we recorded the relative amount of crevices, stromatolites, overhangs, etc. We used a scale of 1-5 to estimate the abundance of each (1=rare and 5=abundant). Refer to figure 2 for a sample data sheet. At each transect point, we took a GPS position so the transect could be plotted on the bathymetric map along with the habitat map.

Total Organic Matter

On transects 1-5 along the Southern rocky wall off of beach 1, we collected ostracodes using an ostracode pump at 5m and 10m within a 0.0625m^2 quadrant. Adjacent to the ostracode samples, we collected sediment samples using a 0.125m^2 quadrant. We transferred the sediments from the collection bottles into glass jars and then dried them in a drying oven at 50ºC. After drying the samples we placed them into crucibles of known weight in order to get the dry weight of the sediments before burning them. After weighing all crucibles and sediments, we placed them in a Thermalyne 1400 Muffle furnace for two hours at 550ºC. After two hours, we allowed the samples to cool to 100ºC and then placed them in a dessicator until they reached room temperature. We weighed them again to measure the amount of organic matter lost on ignition. We measured the abundance and diversity of ostracodes (Heuser Nyanza 1999).

Results

The bathymetric map, the transect points, and the locations of the ostracode sampling at Transects 1-5 are given in figure 3. There is a decrease in bedrock/boulders and an increase in sand as you move from transect 5 North to transect 8 in the bay as shown in figure 1. Figures 4, 5, and 6 represent the prominent habitat at each depth for all 9 transects. In these figures the distance off shore is given along the x-axis and the habitat type is represented at each 2.5m interval in depth. Due to the nature of the graph, the area is decreasing as you increase depth, but the symbols shown are still a representative of the whole habitat. The amount of TOM/m^2 ranged from 0.01689g/m^2 to 10.6236g/m^2 as shown in figure 7. There does not appear to be any correlation between the number of individuals/m^2 and the TOM in terms of both TOM/m^2 or the %TOM (figure 8).

Discussion and Conclusion

Bathymetric Map

The bathymetric map shown in figure 3 reveals some interesting characteristics about the underlying geology in Jacobsen's Bay. In the bay there are two dominant types of bedrock, the Manoyovu red beds (MRB) and the Kigoma Quartzite (KQ). The MRB are characterized by cobble conglomerate and the KQ is consists mainly of white or grey medium to coarse-grained orthoquartzitic sandstone (Yairi and Mizutani, 1969). The contact point between the two bedrocks is at beach 1. The MRB is comprised of conglomerate rock and is therefore easily eroded and is most likely the source of the sand on beach 1. Beach 2 is situated on the KQ but situated on a hill above the KQ is the MRB. The MRB above beach 2 can easily be eroded and deposit sediments down the hill on beach 2. Another possible scenario is the transportation along the shoreline of sand from beach 1 to beach 2. But this is unlikely because of the rocky headlands between them. Beach 1 and 2 are both local sands comprised of coarse grain sands and are not easily transported by hydrodynamic action on the beach (Mwenyemali Dieudonne, Nyanza 1999).

The dominant fault trends in this area generally run N-S and E-W (Yairi and Mizutani, 1969). Evidence of these faults can be extended offshore in the bathymetric map. There is an E-W fault located just South of beach 1 as indicated on the map in figure 3 (Popo fault). A possible continuation of this E-W fault can be seen in the water at point P by the steep slope lineaments. The same is true for North of Beach 2. The fault location is indicated on the map in figure 3 and the continuation of the fault can again be seen in the underlying bathymetry (Mzungu Mwehu fault). There is a fault referred to as the Mzungu Mwehu fault indicated by the MM point and the steep slope to the South of the point. There is another lineament near transect 9 and this again can be distinguished by the steep slopes. There are also dominant fault trends running N-S in this bay. The N-S faults most likely make both beach 1 and 2 fault-controlled beaches. The beach 1 shoreline is a good example of a N-S fault segment controlling the beach geometry. This is also true for beach 2 even though it is not as long of a fault segment. In general, the two dominant fault trend families (N-S and E-W) are totally controlling the geometry of Jacobsen's beach 1 and 2. Interactions between these two fault trends in the Bay associated with the fault activities themselves due to the Tanganyika Rift extension, does not allow the development of wide, large, and shallow beaches.

Habitat Map

All nine of the transects for the habitat map are shown in figure 1. In general, the habitats South of beach 1 on the rocky wall (Transects 1-5) are mostly bedrock or boulders down to 30m. This Southern rocky wall is a high energy coastline that is susceptible to lots of wave action explaining the abundance of rocky substrate with little to no sand. For example, in figure 4 transect 2 is all boulders and bedrock down to 30m. There is an accumulation of sands in the inner portion of the bay on the gentler sloping areas. This is shown in figure 5 on transects 6 and 7 where there is increasingly more sand because it is a little more protected. On figure 5, transect 8 is all sand from 17.5m to the surface because of the very gently sloping beach and the increased accumulations of sand.

Total Organic Matter

The fact that there is little to no correlation between the number of ostracodes and the TOM in terms of both the actual amount of TOM available per m^2 or the %TOM suggests some interesting conclusions (Figure 8). The total amount of organic matter available for food is not a factor controlling their distribution. This suggests that the ostracodes are selective detritovores feeding on particulate matter or algae that are more firmly attached to the rocks. The ostracode pump may not provide enough suction to detach the algae or other matter attached more firmly to the rocks.

Future Research

Perhaps next year, a comprehensive study of the sediments in the area could be done to link that data with the bathymetric map and the preliminary results collected by Mwenyemali Dieudonne. This same type of study (bathymetric and habitat) map could also be done at a disturbed/deforested site for next year to compare the differences between the two habitats. For the TOM and the ostracodes, one could try to examine the amount of algae on the rocks and see if that is a factor limiting their distribution.

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Acknowledgements

I would like to thank Dr. Andrew Cohen and Dr. Kiram Lezzar for their guidance and support with this project. I would also like to thank Mark Woodworth, Nicholas Mathieu, and Catherine O'Reilly for their help in preparing the bathymetric and habitat maps.

Is Variation in Shell Morphology of *Lavigeria grandis* an Ecophenotypic Response to Wave Energy?

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Introduction

The endemic gastropods in Lake Tanganyika often vary significantly in shape within species, to the point that sometimes they are misplaced, or mistaken for a different species. The genus *Lavigeria* forms a species flock, in which some species have high morphological variation while in others variation is limited. This has frustrated taxonomists such that some named over fifty species in this group (e.g. Bourguignat 1898) while others recognized only one (Leloup 1953). Examples of this kind of variation in shell morphology are found within the species *Lavigeria grandis* in the characters of shell shouldering, coarse ribbing and lip flaring., although it is recognized as a good, single species based on independent genetic, anatomical, and early ontogenetic shell data. *Lavigeria grandis* inhabits the wave-swept boulder zone throughout much of the lake.

Studies on marine gastropods have suggested that simple changes in shell morphology are a functional response to an increase in wave energy (*Nucella lapilus*, *Thais lamellosa*, Palmer 1985). It is my goal to test the hypothesis that changes in *Lavigeria grandis* shell morphology are an ecophenotypic effect of wave energy in the habitat.

Null Hypothesis: Shell morphology of *Lavigeria grandis* varies independently of habitat differences in wave enegery.

Methods

- I sampled seven sites within easy small boat distances of Kigoma: Jacobsen's Beach, Hilltop Beach, Gombe Stream National Park Putumba, Kitwe Point, Nandwa Point, Bangwe Beach, Bangwe Point. I deleted two sites, Kitwe and Hilltop, after an initial survey revealed they were devoid of *Lavigeria grandis*.
- I assessed the site wave energy levels by comparing the prevailing winds, onshore offshore winds, sediment and substrate types, and water currents and relative exposure. See table 1 for site descriptions.
- I collected snails by snorkelling to the sites, collecting snails from the surfaces of boulders along a shoreline distance of maximum 100m.
- Seven shell morphological characters were measured on each snail collected: overall length, overall width, aperture length, aperture width, and aperture to the protochonch lip thickness, aperture angle. I recorded observations on other morphological differences: shouldering, scarring and growth discontinuities.
- All snails were replaced after measurement.
- I began analyses with basic univariate statistics on log-transformed data. I subsequently did multivariate analyses using Systat 7.0. I used PCA as an exploratory technique to look for natural clusters among all samples, then used a discriminate analysis as a more powerful method to test for differences among the sites. Multivariate morphometrics maximizes the chances of recovering similarities and differences between sites that might result from interactions among the measured variables.

Results

- See charts 1-5 for all data.
- Univariate statistics are shown in chart 3. The

means show a size differences among snails at the different sites.

- I used multivariate analyses to explore this pattern in greater detail. PCA shows that growth (PC1) accounts for the majority (79%) of the variation between the sites. The figure 3 graphs (pc1vspc2) plots PC factor 1 vs. PC factor 2, which together account for 91% of the variation in all specimens. Factor 1 is most influenced by size; factor 2 is most influenced by lip thickness (factor loadings are shown in chart 4).
- The plots do not show obvious variation determined by site differences, so I used a discriminant analysis to try to separate the sites more definitively. Discriminant analysis of these factors could not separate the sites significantly. See fig. 4 graphs
- F –matches (see chart 5) indicate that the morphology of gastropods at sites that are closer to each other, such as sites 1, 3 and 4, or 2 and 5 is more similar than among sites grouped by wave energy patterns, 1 and 2, or 3, 4 and 5. See table 2 for site distances
- I recorded shouldering recorded as either presence or absence. Fig. 4 graph shows the percentage of individuals at each site exhibiting this shell morphology. This data shows again a similarity between sites 1 and 4, then 2 and 5, which helps support the idea that the similarity in shell morphologies between sites may be more due to geographic proximity than wave energy. Unfortunately site 3 data was not taken on shouldering.

Conclusion

The null hypothesis cannot be refuted based on the results. There was no consistent, statistically significant difference among gastropods from sites with different wave energy. There does not appear to be an ecophenotypic effect on shell morphology caused by differences in wave energy.

Discussion

Although the hypothesis was not refuted by the data, an alternative hypothesis surfaced. The results from multivariate analyses suggest the ecophenotypic effect (size/shouldering) I observed could be a function of geographical location. This hypothesis requires further testing.

Although I documented morphological differences in the *L. grandis* populations I sampled, I am directed by the data to believe these differences are strongly controlled by geographic proximity and, by inference, genetic connections. I believe that by broadening the sampling boundaries to include sites farther north and south, a better understanding of the morphological differences will be revealed. If we could correlate genetic similarities and differences among snail populations with different morphologies, we could test this hypothesis.

Some observations were made on growth discontinuities and scarring. This data was not used to complete this study, but may be used by others working on similar projects on growth or predation pressure in the future. Data collected on aperture angle was also discarded in the analysis because of poor measurement techniques, but for future work a more reliable technique should be used, as aperture features seem important for growth and maturity statistics.

Future Project Ideas

1. Species map for *L.grandis* spanning the Tanzanian borders.
2. Does disturbing a site by sampling the gastropods alter the death rate for the replaced snails? Could we do transplant experiments?
3. Growth rates in *L.grandis* need to be established.
4. Is *L.grandis* an indicator species for pollution? Is there another pollution indicator

species, perhaps microfauna in the sediments?

5. Why are there no L.grandis in Kigoma Bay? Is there a geological boundary?
6. Prey avoidance techniques in immature L.grandis. Baby L.grandis seem to hide in cracks, crevices and under rocks, but where do immature L.grandis hangout.
7. Genetic analysis of L. grandis along the whole coast.

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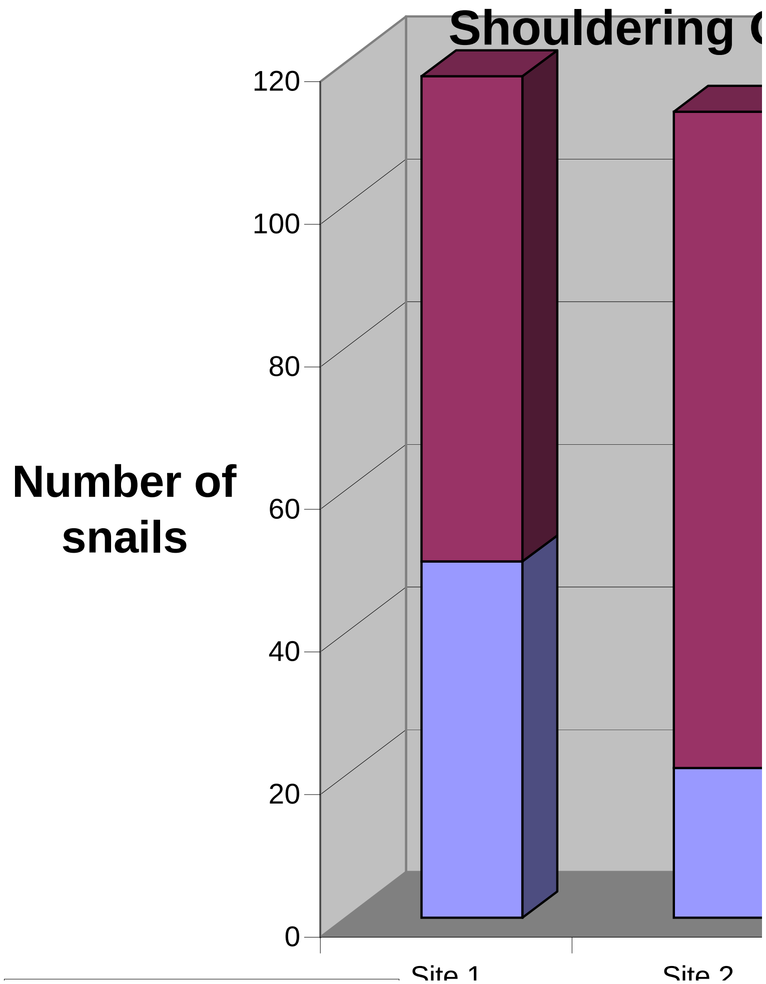
Acknowledgments

I would like to thank Dr. E. Michel for all her ideas and support, Dr. A Cohen for making this all possible, and Dr. Plisnier for help with wave and wind stuff, Nick Mathieu for endless computer gliche repairs and Mark Woodworth for endless problem help. My deepest thanks go to Nathan Zorich for teaching me how to drive the boat, recording data, countless lunches and interesting banter.


Shouldering C
Number of snails
120
100
80
60
40
20
0
Site 1
Site 2

Title: An investigation of the short-term fluctuations in the water column and its relation to weather patterns: Kigoma Bay, Lake Tanganyika.

Students: Emily Johannes, Miami University (OH), Juliette Nowak, State University of New York, at Buffalo, Marie Goretti Nzeyimana, Universite du Burundi, Louisette Wimba, ISTM, Democratic Republic of Congo

Introduction

It has been found that seasonal morphology has an impact on internal movement in the water column of Lake Tanganyika. Specifically, southeast winds from May to September have an impact on a 26 to 33 day internal wave (Coulter 1991). In addition, fluctuations in physical, chemical, and biological limnological parameters suggest that a smaller movement of 3 to 4 days may be occurring within this cycle. Surface waters can be greatly impacted by changes in wind speed and air temperature, which induce convection currents that mix the upper layers of water column (Verburg et. al. 1997). Stability of the thermocline can impact whether or not the epilimnion waters will mix with the lower hypolimnetic layers. Thus, the internal movement of the thermocline can have an impact on the redistribution of favorable nutrients towards the euphotic zone. Therefore, even organisms in the water column (phytoplankton, zooplankton and ultimately, fish) could be influenced by a shorter period internal wave. An investigation of the physical, chemical, and biological parameters could detect an internal movement which would impact the limnological system of Lake Tanganyika.

Objectives

Through intensive field sampling we intend to determine variation in thermocline depth, and physical, chemical, and biological limnological parameters. We expect to answer two questions: are these parameters correlating with a 3 to 4 day internal movement, and is there a correlation between these parameters and changes in weather patterns?

Methods

Field sampling occurred every other day from 24 July 1999 to the 30 July 1999. Intensive sampling began every day from 2 August – 7 August 1999 at an approximate position of 4°52.19’ E and 29°35.99’ S in Kigoma Bay, Lake Tanganyika. Water samples were taken back to the lab for chemical analysis upon which 0, 20, and 40 meter depths were mixed as those depth constitute the mixolimnion.

Weather data was collected every half-hour using a Davis Weather Monitor II. Wind speed (m/s) and air temperature were averaged for three time periods based on wind direction: morning, afternoon, and night. Weatherlink 4.0 software was used to download and process the data collected by the weather station.

A thermistor chain (Onset Computer Corperation) was placed at the same location as water sampling for the entire time period from 24 July 1999 to 7 August 1999. Measurements of temperature (°C) were taken by StowAway Tidbit Temp Loggers and twice during the sampling period, an optic shuttle was used to download data from each temp logger. Loggers were placed at the following depths: 1, 25, 50, 60, 70, 80, 90, 100 meters. BoxCar Pro software was used to process the data collected by the thermistor.

The detail of climatic, physical and chemical methods is presented in table 1.

Results

Climate (Johannes)

Periodic wind speeds were relatively high from 24 July 1999 to 31 July 1999, ranging from night winds around 0.3 m/s to afternoon winds up to 2.4 m/s. Air temperature during this time was lower, ranging from night temperatures of 22 °C to afternoon temperatures around 27 °C. From the 1 August 1999 to the 5 August 1999, wind speeds decreased during all periods, although most dramatically during the night, falling to almost 0 m/s. Air temperatures began to rise at the end of this time period, with the greatest increase occurring during the morning as temperatures rose to approximately 24 °C (Figure A1).

Thermocline Change (Johannes, Nowak)

At the beginning of the sampling period the thermocline decreased and then maintained a stable depth around 80 meters from 28 July 1999 to 3 August 1999. After this time, the thermocline gradually rose to a higher depth of approximately 60 meters (Figure A2). Surface waters at 1 meter depth show a cyclic night cooling as temperatures dropped to 25.60 °C. Temperatures at 25 and 50 meters rose to above the coolest surface water temperatures over a large percentage of the sampling period. Specifically, on the 27 July 1999, the temperatures at 50 meters were well above those of upper surface waters (Figure A3). The thermocline was unstable at the beginning and the end of the sampling period, excluding the time from 28 July 1999 to 3 August 1999 when stability of the thermocline was greatest. Decreasing temperatures at the end of the period show that the thermocline is gradually rising (Figure A4). Waters below the thermocline (100 meters depth) show an internal movement that has low correlation ($r^2= 0.13$, $r^2=0.39$) with both the surface waves and change in thermocline depth respectively (Figure A5).

Light extinction, transparency, turbidity and chlorophyll (Johannes)

Light extinction within the water column decreased towards the end of the sampling period. Extinction coefficients ranged from 0.09 to 0.122 over the time scale (Figure A6). In relation, secchi depth lowered during the same time that the light extinction was lower in the water column. In general, secchi depth was variable, although it was higher at the beginning and end of the sampling period (Figure A7). Euphotic zone depth was fairly constant ranging between 42 to 48 meters (Figure A8).

Turbidity was high in concentration at 40 to 80 meters from the 24 July 1999 to the 26 July 1999. From 2 August 1999 to 7 August 1999 turbidity was more stable in concentration, although towards the end of the time period there was an increase in turbidity at lower depths in the water column (Figure A9). Chlorophyll a concentration was remarkably higher from the 24 July 1999 to the 28 July 1999 in the epilimnetic waters. From 2 August 1999 to 5 August 1999, concentrations of chlorophyll were the same throughout the water column and another period of high chlorophyll a concentrations began again on the 6 and 7 August 1999 (Figure A10.).

Physical and Chemical Parameters (Nzeyimana, Wimba)

Nous nous sommes interessees a certains parametres physico-chimiques qui exercent une influence directe ou indirecte sur la vie en milieu aquatique. Il s’agit du pH ,de l’oxygene dissous ,de la conductivite, des nitrates, des phosphates et des silicates .

1. pH et Oxygene Dissous

Ces deux parametres sont lies via la photolyse de l’eau lors de la photosynthese. D’ une part, le pH de la zone pelagique de Kigoma fluctue autour de 8.5-9.06 et d'autres parts l' O.D.oscille entre 0 et 7.5 mg/l au cours des deux periodes de mesure (Fig.B2 etB4) . Pendant les deux periodes on observe que la concentration en oxygene dissous (O.D.) est toujours plus grande a la surface qu'a la profondeur . Du 2 au 7/8/99 le pH est plus eleve a la surface (0 a 40m) et un peu moins alcalin en profondeur (60 a 100m) .

2.La conductivite

La conductivite est un facteur indiquant principalement la mineralisation de l'eau .Elle augmente avec la teneur en sel mineraux. La conductivite varie entre 610 et 680 ms/cm pour les deux periodes (Fig.B3). On remarque des valeurs plus elevees en profondeur (pour les deux periodes).

3.Phosphates(PO$_4^{3-}$-P), Nitrates(NO$_3^-$-N), Silicates(SiO$_2$)

La teneur en ces éléments montre une allure generalement croissante de la premiere periode etudiée vers la deuxieme avec une faible decroissance du 24 au 26 juillet. Cette allure est plus réguliere entre 80 et 100m et moins réguliere vers la surface (figs C1, C2 et C3), avec un comportement inverse entre le PO$_4^{-3}$-P et le NO$^-_{3-}$N tres remarquable le 5 aout (fig.C1et C2).

Zooplankton community (Nowak)

Cyclopoid densities were generally greater then that of calanoid, with a peak in the population on 28 July 1999. An overall increase in total cyclopoid and calanoid density is seen with time (Figure D1). The density of cyclopoid copepodites was continuously greater than that of the cyclopoid adults; however, calanoid adult density was seen to rise above calanoid copepodites. From 28 July 1999 to 3 Aug 1999, the calanoid population dynamics are changing as the number of nauplii and copepodites are decreasing while adults are increasing (Figure D2). With time, the density of both cyclopoid and calanoid females with eggs increased. Specifically, the density of calanoid females with eggs rose from approximately 6 organisms/m^3 on 26 July 1999, to 120 organisms/m^3 on 6 August 1999. Jelly fish and fish larvae densities increased, peaking on 28 July 1999, and then decreased. As an observation, jellyfish found on 26 and 28 July 1999 averaged 1.5 mm; however, jellyfish counted on the later sampling dates averaged 3.0 mm. Shrimp density was generally low; however, their abundance was greatest on the third and sixth of August 1999 (Figure D3).

Discussion

Climate (Johannes)

At the beginning of the sampling period, the high winds and low temperatures were excellent conditions for convection mixing within the upper layers of the water column. In addition, interactions of afternoon temperatures and night cooling can be seen with temperature changes in surface waters over the same time period. Towards the end of the sampling period as temperatures and morning winds rose, mixing would again be occurring within the water column as can be seen in the limnological parameters given in later sections. Overall, there was a relationship between wind speeds and air temperature and mixing in the upper layers of the water column on two occasions at the beginning and end of the sampling period (Figure A1 and A2). Weather patterns did not have an impact on the deeper layers within the water column, however, these changes occurred due to an internal movement which will be discussed in the following section.

Thermocline Change (Johannes, Nowak)

Changes in thermocline depth occurred due to a larger internal wave movement as seen in previous studies (Plisnier 1996). It was found that during our study, the thermocline depth had greater variance, rising from 80 to 60 meters (20 meter difference), whereas in 1995, Plisnier noted a thermocline change of only 10 meters. There were three periods which can be defined during this study, two of mixing of the upper waters and one of a period of stablility of the thermocline (Figure A2). There were three specific interactions of temperature within the water column. First, surface temperatures show that there was daily warming and cooling occurring as air temperatures rose during the afternoon and cooled during the night. Also, there were two periods of surface water mixing as seen by the changes in temperature at 1, 25, and 50 meters which relate to the optimal conditions for mixing seen in weather data (Figure A1 and A3). Lower in the water column, thermistor data shows mixing and stability of the thermocline at 60, 70, and 80 meters depth which correlates well with the periods of surface water mixing and the pattern of the larger internal movement (Figure A4). In sum, data from the surface, thermocline and deeper hypolimnetic waters show that an internal movement is occurring below the thermocline which does not correlate well with the surface water changes in temperature. This could be due to some kind of periodic movement, although more data will be needed to quantify whether or not periodicity is happening at this level (Figure A5).

Light extinction, transparency, turbidity, and chlorophyll (Johannes)

Relationships between light extinction and secchi depth show that during the period of stablity of the thermocline, there was a greater amount of light penetrating the water column (Figs A6 and A7). During this same time, euphotic zone depth remained stable, showing that the photic zone depth will not change with changes in the thermocline (Figure A8). When relating the amount of light in the water column with turbidity and chlorophyll, it can be seen that the phytoplankton utilized this source of light as they become more abundant some time after this occurred (Figs A9 and A10). Therefore, due to greater light in the water column, physical parameters such as turbidity and chlorophyll show that phytoplankton were utilizing this period of stability in order to photosynthesize. As the thermocline rose at the end of the sampling period, turbidity and chlorophyll a concentrations rose as transparency decreased, showing that phytoplankton was becoming abundant within the epilimnetic waters as nutrients rose up from the deeper layers.

Physical and Chemical Parameters (Nzeyimana, Wimba)

Le rapprochement vers la surface des isoplethes de pH et d' O.D. caracteristiques des eaux profondes (Figs B2 et B4) peut s'expliquer par des mouvements internes liés aux vagues internes.

L'augmentation de la conductivite en profondeur est parallèle à la diminution du pH, de l'O.D et de la chlorophylle a. Cela est probablement lié au phenomene de photo-inhibition (Fig C4) et à la production primaire vers la surface. L'intensité du phénomène est probablement liée au mouvements internes permettant un apport des nutriments, à l'utilisation de ceux-ci par les organismes et aux conditions climatiques permettant un mélange effectif vers la surface (temperature et vents particulièrement).

En effet, les mouvements de la thermocline(fig.A1) presentent presque la meme allure que celles des teneurs en nutriments(fig.C1,C2etC3). Les periodes des fortes concentrations en nutriments correspondent à celles de faible profondeur de la thermocline (fig.C1,C2,C3 et A2) tels que le 24 juillet et du 4 au 7aout. A ce moment, on observe des pics correspondant à ces jours moins chauds et présentant des vents importants (fig.C1,C2,C3 et A1). Cela correspond probablement à un bon melange des eaux.

Les fluctuations observees dans l'allure de la teneur en nutriment seraient dues soit a un melange moins important (fig.C1,C2,C3 et A1), tels que du 3 au 4 aout, soit a l'utilisation des nutriments par les organismes comme le montre les fluctuations inverses de PO_4^{3-}-P et NO_3^{-}-N (fig.C1 et C2):le 28 juillet et du 4 au 7 aout.

Zooplankton community (Nowak)

Copepods, specifically two species of cyclopoid, and one of calanoid dominate the zooplankton community of the pelagic waters of Lake Tanganyika (Lindberg 1951). In accordance with previous data, cyclopoid abundance was found to be consistently greater than that of calanoids (Rufli 1976; Rufli and Chapman 1976). A general increase in the density of copepods was observed throughout the sampling period (Figure D1). This increase in abundance can be weakly correlated to the rising of the thermocline and its associated nutrients after 3 August 1999 (Figure A2). Also following this pattern, is the increase in copepodite and adult copepods during the proposed time of nutrient upwelling. Conversely, the nauplii abundance decreases during this time period for cyclopoids (Figure D2). This may be explained by a delayed response of copepod population dynamics to the redistribution of phosphate, nitrate, and silicate in the epliminetic waters. As these parameters are made plentiful, the density of female calanoid and cyclopoid with eggs began to increase dramatically, and it would be expected that later sampling dates would show a significant increase in hatched nauplii for both calanoids and cyclopoids (Figure D3).

The macro-organisms present in the water column, such as jellyfish, shrimp, and fish larvae, were not found to follow the rising thermocline. Overall, shrimp and fish larvae were in low abundance. It can be hypothesized that the density of jellyfish gradually decreased with time due to the maturation of smaller, undeveloped individuals observed in the samples taken on 26 and 28 July 1999 (Figure D3).

General Conclusions

The increased thermocline at the end of the sampling period seemed to follow the 26-33 day internal wave cycle, which has been found by previous studies. Shorter periodic movement could not be determined by such a small data set. There was a correlation between high wind and low temperatures and mixing of the surface waters. The physical and chemical parameters examined in this study generally followed the thermocline pattern of the long-term wave. Zooplankton abundance, although delayed, followed the same trends.

Future Research

In the future, placing a thermistor chain in the bay to record temperature throughout the year would give a more sufficient data set for this study. These data can be used to determine periodic movements lower in the water column which may show the shorter 3-4 day movement. In addition, logging weather throughout the year to correlate with the change in surface water temperatures would give a more complete relationship to this phenomenon. Also, zooplankton tows should be repeated each day of sampling to account for extreme patchiness between sites. To provide a clearer relationship between the internal wave and zooplankton abundance, it may be useful to sample every 2 days, with simplified identification (for example, general calanoid vs. cyclopoid).

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Research title: Factors influencing the distribution of hydrocarbons in surface sediments, in different bays of Lake Tanganyika around Kigoma urban.

Researcher: Christine Kabumbu
Affiliation: University of Zambia

Mentor: Kiram Lezzar
Affiliation: University of Syracuse

Introduction

Wherever human beings are, they interact with the natural environment. Often times, it is nature which suffers from the destructive tendency in humans. Anthropogenic activities do play a major role in the alteration of the natural environment by introducing toxic substances, which are lethal to biodiversity and in turn to humans themselves who are dependent on this biodiversity for food and recreational activities. Lewis (1994) contends that over the past few decades there has been a rapid increase in the awareness of the interaction of environmental processes and the consequences of human impact on the environment. One such human impact is the pollution of the aquatic environment through accidental and intentional oil spillage and discharge.

Kigoma, as a result of it's location on the shore of Lake Tanganyika, has a measurable impact on the lake because of the number of inhabitants in the region. The main oil polluters around Kigoma are the ships and boats that dock at the harbor, possibly the oil storage plant just along the coast, and the Tanzania Electricity Supply Corporation which releases waste oil directly into the lake.

Rationale

The purpose of this research was to assess the impact of human activities on Lake Tanganyika and specifically to see how the handling of petroleum products was affecting the lake's natural environment in Kigoma. Looking at the vulnerability of Lake Tanganyika whose water residence time is about a thousand years (Craig, 1974), constant monitoring of pollutants like hydrocarbons is quite essential. Too much oil on Lake Tanganyika would have the potential of limiting the oxygen content of the lake because oil prevents penetration of oxygen in water. This lack of sufficient oxygen would have negative repercussions on the biodiversity of this valuable world resource. Already, according to Hackabay(1971) about three quarters of the total volume of water in Lake Tanganyika is devoid of oxygen and aerobic life.

Locations and Sampling Points

I collected grab sediment samples from Katabe, TAFIRI, Kigoma, Jacobsen Bay and a small core sample from the Luiche River delta. The Luiche sample was used as a control because of its location 25km south of Kigoma. The samples were from taken at varying depths as a result of the geological formations of the bays. I chose to sample sediments for oil because sediments often act as reservoirs for a lot of material and so they can be good evidence of present and past pollution.

Hypothesis

1. The bays close to TANESCO oil inlet and the harbor are highly polluted with hydrocarbons.
2. There are high levels of hydrocarbons in the littoral zone close to the docks and TANESCO oil inlet.

Objectives

1. Determine the concentration levels of oil in the surface sediments.
2. Assess the factors influencing the distribution of oil in the surface sediments.

Methodology

1. I sun-dried the samples under very clean conditions and free from much influences of the winds and dust.
2. When samples were dry, I weighed 40g of each sediment sample into a bottle with an airtight lid. I added 100ml of acetone to each weighed sample of dissolution of oil from the sediments.
3. I left samples with acetone in the sun for about 6 hours just to allow the acetone to boil and dissolve all the oil in the sample sediments. (Bottles were regulary and uniformly shaken to allow more mixing of acetone and sediment).
4. I separated 50ml of acetone from the sediments through filtration after shaking the bottles vigorously for proper mixing of the liquid and sediments.
5. I poured the separated 50ml of acetone in pre-weighed plastic cups and left the cups in the usn to allow the acetone to evaporate completely.
6. After all the acetone had evaporated from the cups I re-weighed the cups.
7. I calculated the concentration of total oils in the sediment sample as 100 times the weight gained by the plastic cup (2x the weight gained in order to account for the oil which remained with the other 50ml of acetone which was not separated from the sediments) divided by the original sample weight.

Results

Results for the samples are shown in Figures 2-13. There are no results shown for the Luiche sample because the amount of oil water was 0.

Discussions

From the results illustrated in the graphs and table of correlation, Figure 12 shows that Kigoma Bay has the highest concentration levels of oil, followed by TAFIRI bay, then Jacobsen and then Katabe. In most of the graphs the trend is that there is some kind of relationship between oil and fine grain distribution. In Kigoma Bay, looking at the correlation, there is a strong relationship between fine grains and depth with oil levels. However, there is a weak relationship between fine grains and depths, which implies that fine grains in the bay are randomly distributed at different depths whether shallow or deep. This trend is the same at TAFIRI bay.

In TAFIRI bay, none of the three variables seem to have much effect on oil levels, there is however a low correlation between fine grains and depth with oil levels. In Katabe, there is a strong relationship between depth and fine grains with oil levels and the same applies for fine grain size and depth therefore more oil is found at deeper ends where fine grains are found. For Jacobsen's beach, only depth has a strong relationship with oil levels. Distance from the point of pollution does not seem to have any effect at all in the concentration levels of oil in the surface sediments.

Conclusions

Kigoma Bay has the highest levels of oil due to the fact that it has more fine grains widely distributed at varied depths and so chances of oil being spread and retained within the bay are high. TAFIRI bay has less oil than Kigoma Bay despite the fact that both of these bays are sources of oil pollution. This could mean that there are other factors apart from distance from the inlet, fine grain distribution as well as depth which are reducing the amount of oil within TAFIRI bay.

On Lake Tanganyika, there is a rotational movement of currents from south to north affecting the eastern coast and move from north to south affecting the western coast (Plisnier and Mbemba, 1999). TAFIRI Bay being more open than the enclosed Kigoma Bay is in the way of this motion and possibly oil in the water is carried away and deposited further away into deep waters and distant areas. This could be the explanation for the presence of oil in Katabe and Jacobsen's Bay though they are from pollution sources. This could also explain the reason for there being more oil in Kigoma Bay than TAFIRI Bay. It can also explain why distance from pollution sources is not playing enough roles because even distant places could end up being polluted due to wave motion.

What I would finally conclude after my preliminary research on oil distribution in the five bays is that there are is a lot of evidence of oil pollution in the bays except for the Luiche river delta. Also, the main factor in the distribution of oil is the proportion of fine grains in the sediments.

Recommendations

Due to the short time in which this research was done, many questions still remain unanswered. For instance, since two factors in TAFIRI Bay had only weak correlations and one had no correlation at all, it is implied that other unknown factors could be at work. In this research, oil levels have only been presented as weight percentages and so levels in terms of parts and actual level of pollution of the bays has not been presented. Further research into the actual level of pollution of the bays is needed. The research was done during the dry season and so it would be good to do a comparative research to see oil distribution between high and low water levels. Research could also be done to determine the influence of waves and wind action on the distribution of oil in the surface sediments. There is also an urgent need to do research into background information on the presence of natural hydrocarbons in Lake Tanganyika.

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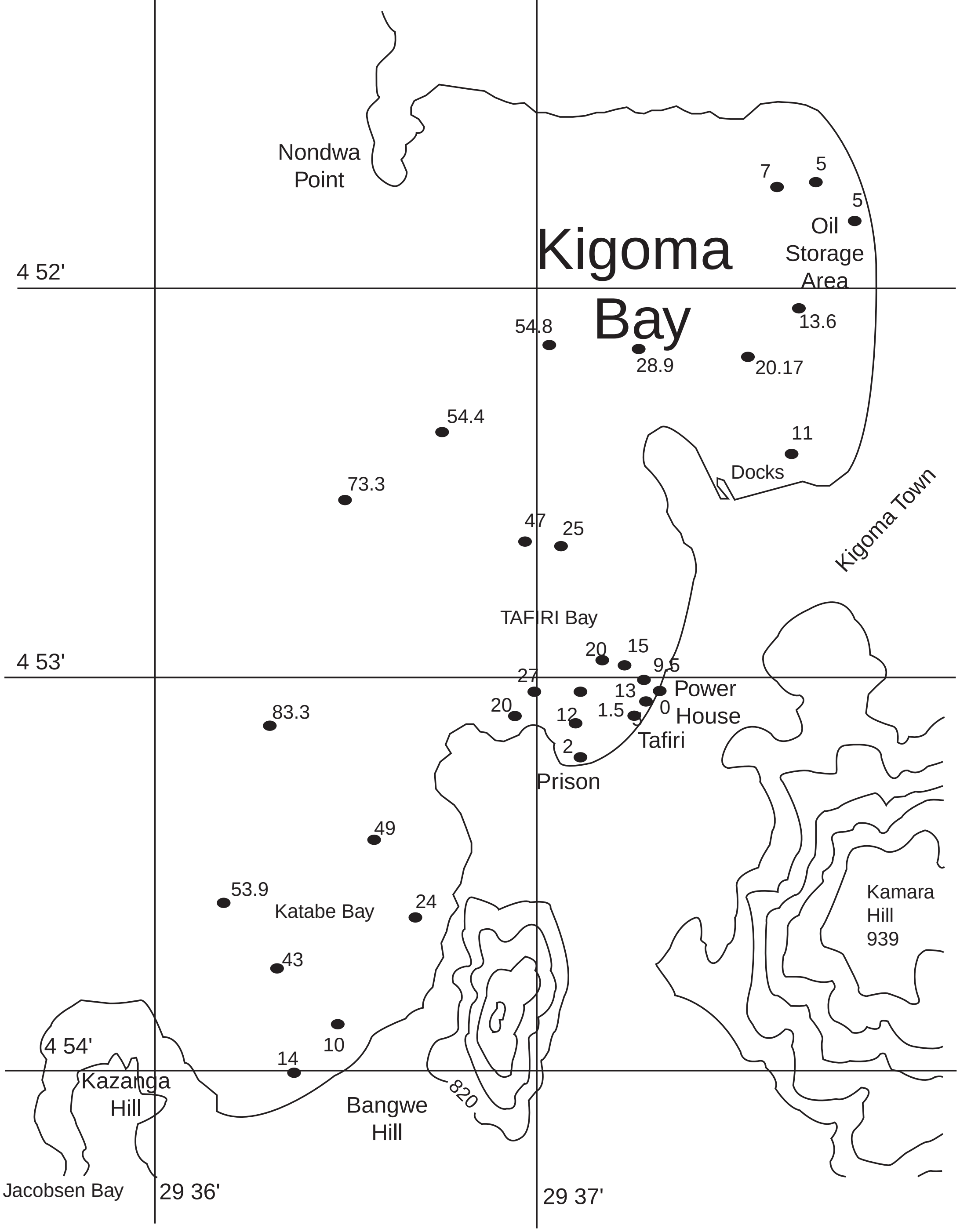
Figure 1: Location map of the grab samples colelcted in the 4 bays investigated in this study.



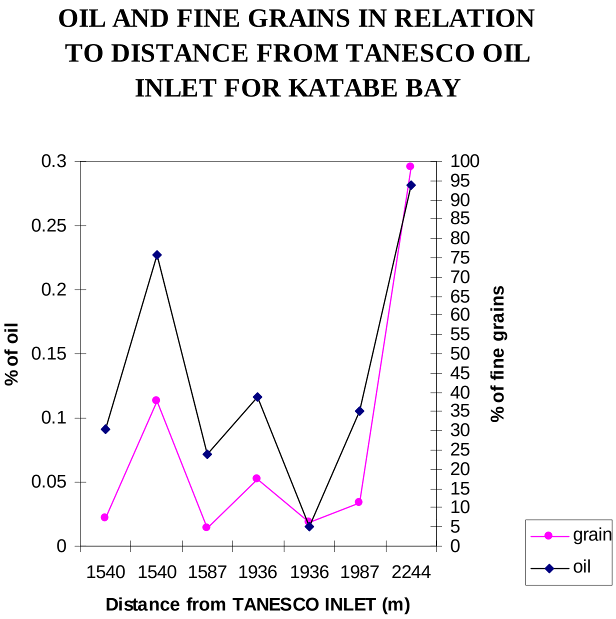


Figure 2

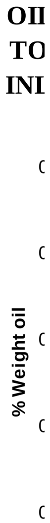
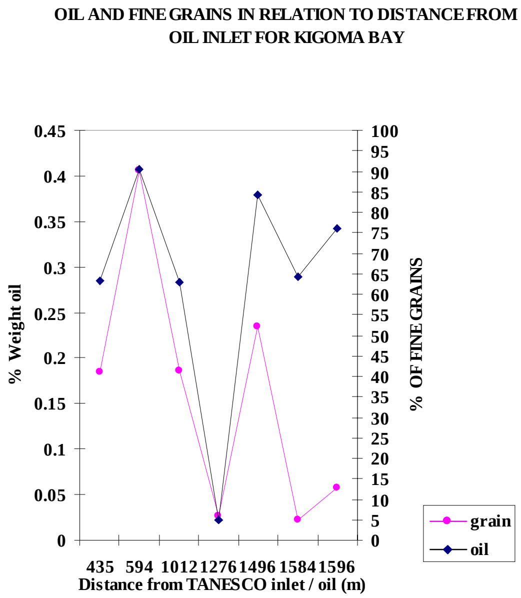


Figure 5



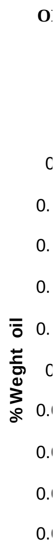


Figure 6

Figure 8

Figure 9

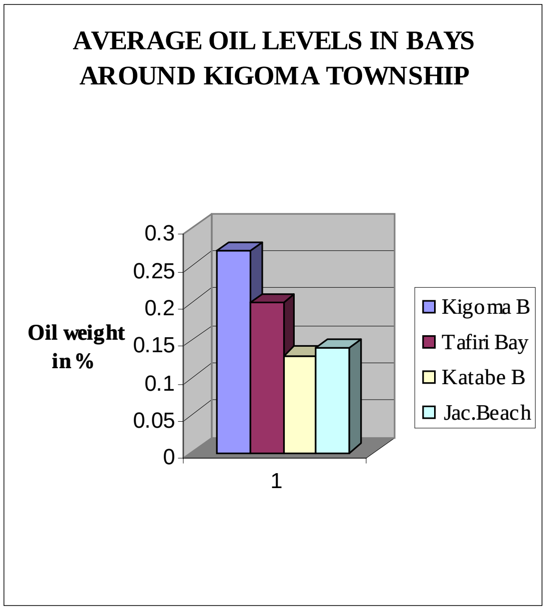


Figure 10

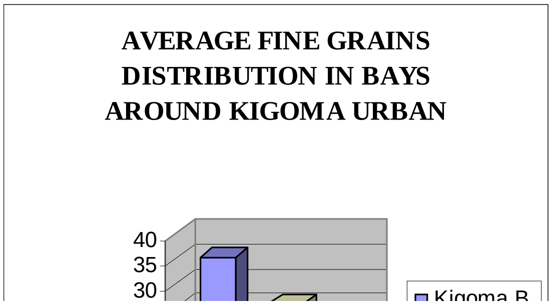


Figure 11

Table 1

FACTOR CORRELATION MATRIX

KIGOMA	Depth	Distance	Fin.Grain	Oil
Depth	1			
Distance	0.93687	1		
Fin.Grain	0.48275	0.64556	1	
Oil	0.073309	0.11308	0.625419	1

TAFIRI	Depth	Distance	Fin.Grain	Oil
Depth	1			
Distance	0.936785	1		
Fin.Grain	0.434675	0.442084	1	
Oil	0.364479	0.099746	0.399239	

KATABE	Depth	Distance	Fin.Grain	Oil
Depth	1			
Distance	0.038002	1		
Fin.grain	0.744969	0.576603	1	
Oil	0.747326	0.279384	0.896302	1

JAC.BEAC

Depth	Depth	Fin.Grain	Oil
Fin.grain	-0.70656		
Oil	0.781024	-0.10991	

Ostracode Abundance and Diversity within Rocky Habitats of Jacobsen's Bay, Lake Tanganyika

Heather Heuser and David Knox

Introduction

Lake Tanganyika, East Africa, is one of the oldest and deepest freshwater lakes in the world. As such it has come to support a varied and largely endemic flora and fauna. In recent years the shores of Lake Tanganyika have been subject to deforestation and the rapid expansion of subsistence agriculture that may have led to dramatic changes in habitat quality and availability within the lake. In order to understand these changes and how they affect ecological processes of the lake it is necessary to examine habitat conditions and the abundance and diversity of organisms at both disturbed and undisturbed sites.

In this study we determined the abundance and diversity of live ostracodes at Jacobsen's Beach, a relatively undisturbed site south of Kigoma Bay. Ostracodes are small bivalved crustaceans that feed on organic detritus and algae along rocks and the sandy bottom of the lake. Although little is currently known about the specific ecological constraints of different ostracode species, their excellent preservation potential as fossils makes them potentially important faunal indicators of long term environmental change. Before their potential can be realized, a connection needs to be made between the appearance of specific ostracode species and specific environmental conditions. Once this connection is established specific fossil ostracode species can be used as specific paleoenvironmental indicators. In this study we sought to provide preliminary data on the watershed surrounding our study area, and to establish a connection between ostracode abundance and diversity and environmental conditions of Jacobsen's Beach, Kigoma, Tanzania.

Methods

We created a map of the Jacobsen's Beach watershed (Fig 1) by personal observation to help provide an environmental context for future studies of disturbance variables affecting the biota of Jacobsen's Bay. This map may prove useful to other workers investigating possible correlations between patterns in ostracode species abundance and diversity and specific shoreline conditions and watershed ground cover and land use. We used Adobe Illustrator 7.0 to draw the map after scanning the shoreline and contour lines from the topographic map (Sheet 92/3 by the Surveys and Mapping Division, Ministry of Lands, Housing and Urban Development of the United Republic of Tanzania). We created habitat maps along nine underwater transects at Jacobsen's Bay to help determine the offshore environmental parameters that may contribute to structuring ostracode abundance and diversity within the bay (methods outlined in Knox, this volume).

To establish the connection between habitat and ostracode abundance and diversity we focused on live ostracodes of the rocky habitat south of Jacobsen's Beach One. We collected samples by SCUBA diving to depths of 5 and 10 meters and collecting the ostracodes using a hand-held underwater suction pump over a 25 cm^2 quadrat. Suctioning cleared the collection surface of all detritus and any ostracodes present. Each sample was collected along a series of transects that extended lakewards from the southern wall of Jacobsen's Bay (Fig 2). If there was no rocky surface directly on the transect we collected from the nearest rock large enough to accommodate the quadrat. Once the samples were brought to the surface we transferred them from collection bottles to glass jars, using a 63 mm sieve to replace the lake water with ethanol. This was necessary in order to preserve the ostracode bodies within their shells and distinguish between living individuals and empty carapaces.

We used an Olympus stereomicroscope and a gridded plastic petri dish to identify the first 200 ostracodes of each sample, transferring representative individuals of each species onto micropaleontoloogy slides for more precise identifications. To determine ostracode abundance we allowed what remained of each sample to dry out on a pre-weighed petri dish and determined the total weight of the dry sample. We transferred a fraction of the total sample onto a second pre-weighed petri dish and counted the number of ostracodes in the subsample after determining its weight. In cases where the ostracode abundance was very low (Transect 4) we counted all individuals in the total sample.

We calculated ostracode abundance per square meter and used this number to convert proportionate species abundance data to number of individuals per species per square meter (Table 1). We calculated species diversity (Fig 3) using the Fisher's Alpha Diversity Index (Rosenzweig 1995) and used these values to compare species diversity with the slope of the rock surface from which the ostracodes were collected (Fig 5). We used the Chao-1 Diversity Estimator to estimate the total diversity of the ostracode community using the observed distribution of singletons and doubletons within the analyzed sample to represent the distribution of rare species within the community (Fig 4). We then employed the Jaccard Similarity Index to illustrate assemblage differences between all sampled localities along the bay at 5m and 10m depths (Table 2).

We utilized the cluster analysis subroutines of Systat 7.0 (Systat 1997) to group sites into 4 clusters based on similar patterns of species abundance and diversity. We performed this first by K-Means Clustering (Fig 4) and then by Hierarchical Clustering (Fig 5) after standardizing data to transform the values of each variable to z-scores (SD option) to keep the influence of all variables comparable.

Results

Figure 1 illustrates the ground cover, roads, houses, and elevation of the Jacobsen's Beach Watershed. This site has been considered to be relatively undisturbed in this and prior studies, because there are very few roads, houses, and agricultural plots. However, ground cover consists primarily of previously cleared, secondary woodland. The map will become more useful as more sites are examined to encompass a range of disturbed and undisturbed sites, as it may then be used as a basis for comparison. Figure 2 shows the locality and corresponding habitat of each transect within Jacobsen's Bay.

The abundance and diversity of Jacobsen's Beach ostracodes are presented in Table 1, expressed as number of individuals per species per square meter. We used this data to calculate the Fishers Alpha Diversity Index (Fig 3) and the Chao-1 Diversity Estimator (Fig 4). Fisher's Alpha combines ostracode abundance and diversity into a single value and is based on the assumption that species abundances fit a log-series distribution. Chao-1 estimates total population diversity based on the occurrence of singletons and doubletons within the analyzed sample. The graphs show that ostracode populations are more diverse at 10m than 5m. The high 10m Chao-1 values illustrate that there is also a higher abundance of rare species at 10m sites. This may be because in deeper water there is less wave energy and more available food for ostracodes as more detritus settles to the bottom and a greater variety of algae is able to establish on the rocks. However, the true explanation will not be known until more research is done to test this hypothesis. Sample T1:5m, located closest to Beach One has the lowest Chao-1 value, with very little species overlap with other samples. The reason for this is not yet understood, though it may be related to the fact that this is the most sheltered transect. Figure 5 shows the relationship between rock surface slope and ostracode diversity as indicated by the Fishers Alpha Diversity Index. No correlation is apparent, as diversity remains fairly constant as slope increases.

Table 2 shows a Jaccard Similarity Index matrix of ostracode data by site. Jaccard-based values show that there is little difference for species presence/absence between transect localities, but there is a much greater difference between 5m and 10 m depths. Ostracode populations at 10m are more similar to each other than populations at 5m are to each other. Five meter samples are largely characterized by an overwhelming number of 2 species (*Mecynocypria* spp A and B) with few rare species, whereas 10m samples are characterized by a more even distribution of species abundances. This may be because the 10m environment is more stable and therefore allows a wider variety of species to flourish.

Systat K Means Clustering (Systat 1997) grouped the sampled sites into 4 clusters based on species abundance and diversity patterns. Figure 6 shows that Cluster 1, including sites T1-4:5m and T4:10m is determined by a very high abundance of *Mecynocypria* spp A and B. Cluster 2, sites T3:10m and T5:10m, is determined most strongly by similar abundance of *Candonopsis* sp 2, *Cyprideis* sp 2, *Gomphocythere* sp 18, *Mesocyprideis irsacae*, M. sp 1 sensu lato, and *Romecythere* ampla. Cluster 3 includes sites T1:10m and T2:10m and is determined most strongly by *Allocypria inclinata*, *Cypridopsis* spp 5 and 6, *Gomphocythere alata*, *G. cristata*, *Romecytheridea tenuisculpta*, R.. sp 13, *Tanganyikacypridopsis depressa*, and T. sp 3. Cluster 4 consists only of site T5:5m and is determined most strongly by *Allocypria inclinata*, *Cyprideis* spp 2 and 24, *Gomphocythere curta*, *Mecynocypria conoidea*, *M. quadrata*, and *Mesocyprideis* sp 1 sensu lato. This clustering shows that sample T4:10m is more similar in ostracode species abundance patterns to 5m samples as opposed to other 10m samples. The abundance of ostracodes/m^2 is very low along this entire transect (Table 1). The reason for this sharp decrease is unclear. An explanation for the decreased abundance of this transect will be achieved only by increasing sampling density and examining additional environmental variables along the transect. Similarly, sample T5:5m is characterized by a very high abundance of individuals comparable to those seen at 10m. In order to understand why ostracode abundance is so high the sampling density must be increased and additional variables such food availability, predator abundance, and wave energy must be included. Figure 7 illustrates the Cluster Tree resulting from Systat Hierarchical Clustering. Clusters 1 and 2 generated by K Means are supported, strengthening the correlation described above. Clusters 3 and 4, containing sites T5:5m, T1:10m, and T2:10m, are not supported and are therefore less strongly correlated.

Conclusions

At this point in time much remains unknown regarding the specific ecological constraints of different ostracode species. By comparing observed patterns in species abundance and diversity with corresponding watershed and habitat maps it may be possible to correlate the occurrence of certain species with specific environmental conditions. However, until a more intensive study is done to include a wide variety of sites encompassing both disturbed and undisturbed sites it will be very difficult to establish a pattern, as there is no basis for comparison. Although this study does not stand on its own to establish a connection between ostracode abundance and diversity and environment it may be used as the basis for comparison to more sites examined in the future.

We had hoped to include the disturbed site of Lemba in our ostracode and habitat analyses, but due to the time constraints of the Nyanza Project we had to limit our study to Jacobsen's with the hope that future research may encompass Lemba or a similar disturbed site. The patterns that emerge will be understood only by continued research into ostracode abundance and diversity at various disturbed and undisturbed sites, and how these results compare to the specific conditions of the adjacent watersheds.

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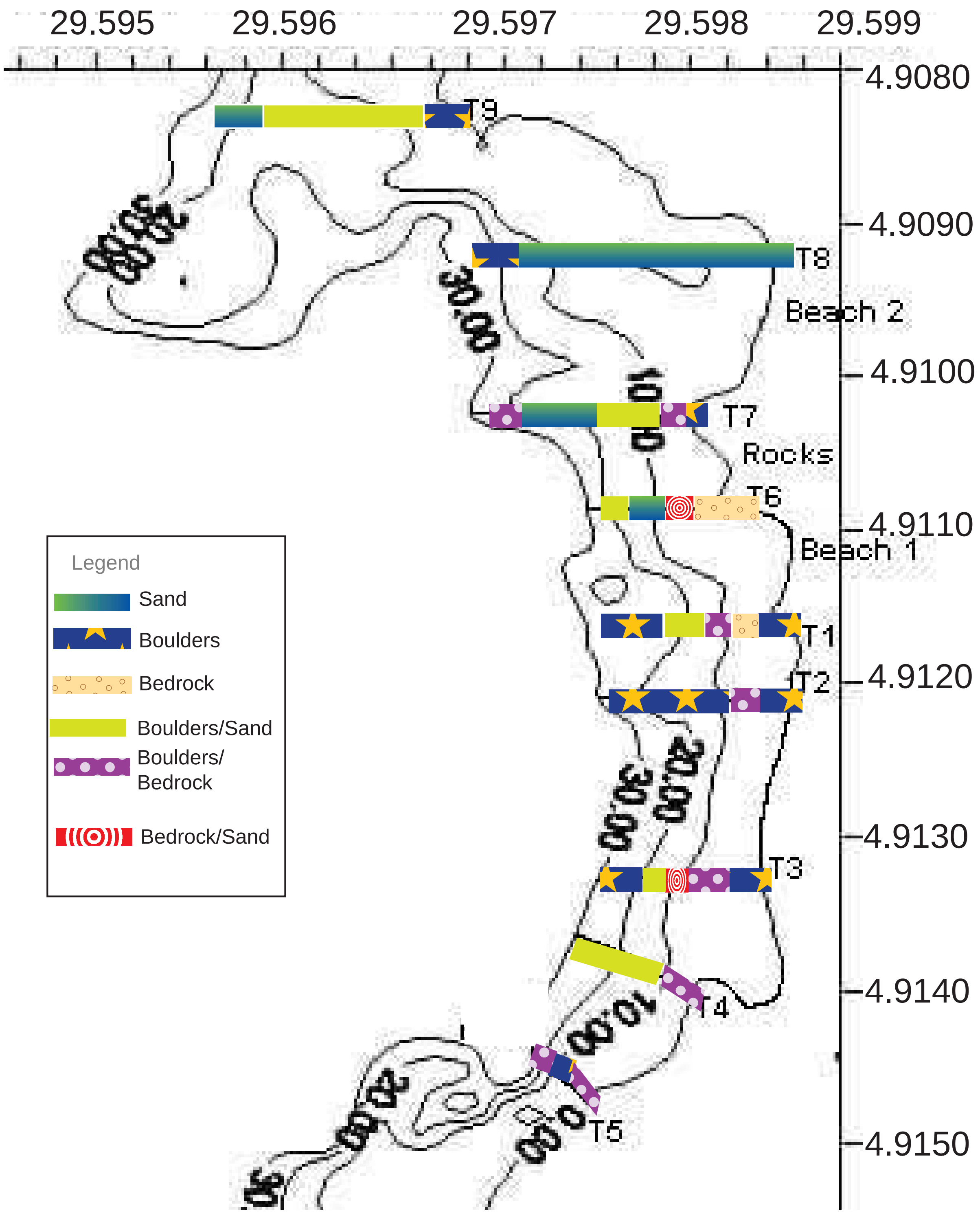
Acknowledgements

I would like to thank Dr. Andy Cohen for all of his help in identifying ostracodes and in developing my project ideas and methodology, and for all of the support he has provided me in my undergraduate research.

Figure 1

Habitats of Jacobsen’s Bay



THE DISTRIBUTION OF NUTRIENTS IN THE SUBSURFACE SEDIMENTS IN THE KIGOMA BAY – LAKE TANGANYIKA

B. M. Musonda (Zambia)
Dr. K. Lezzar (Mentor)

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INTRODUCTION

Location of Study Area

The Kigoma Bay is located in the N.E. part of Lake Tanganyika. It is bounded by longitudes 29°35’ S /29°38’S and latitudes 4°51’ S/ 4°54’S.

Selection of the study Area

The Kigoma Bay was selected on the basis of accessibility and its proximity to an urban area where the human activities are likely to have an impact on the sediment geochemistry.

Rationale for the study

Primary productivity in a fresh water lacustrine environment depends upon the availability of nutrients in the in the water column for phytoplankton development. Recycling of nutrients in the lake column plays an important role in the replenishment of nutrients that are assimilated by phytoplankton in the photic zone. Movement of nutrients from the sediment column to the water column is an important process whose significance depends upon the efficiency of the mixing mechanism. Bioturbation, diffusion, internal waves and thermal gradients can induce mixing.

Hypothesis

This study is testing the hypothesis that ‘the sediment column is a major sink for nutrients such as organic matter, phosphorous, nitrogen, silica and calcium.

OBJECTIVES OF THE STUDY

1) To establish the distribution of Nitrogen, phosphorous, silica, alkalinity, pH and conductivity in the subsurface sediment cores in the Kigoma Bay.
2) To establish the possible sources of these nutrients.
3) To make suggestions on the major factors which are controlling the distribution of these parameters.

Previous Work

Little data are available on the chemistry of the sediment column in lake Tanganyika.

METHODS

Sampling and splitting of sediment cores

The three sediment cores used in this study were collected on the Kigoma transect. The geographical coordinates of coring sites are given in table 1 and figure 1. The sub-surface sediment cores were collected using motor and gravity coring equipment belonging to University of Arizona. The coring equipment was mounted on a boat and powered by a three phase diesel generator.

Table 1

CORE NUMBER	DEPTH OF WATER COLUMN	LENGTH OF CORE(cm)
NPG2	105	87
NPG3	150	130
NPM1	100	34

The sediment cores were split into smaller fragments ranging in length from 2 cm to 5 cm. Each core segment was placed in a labeled sample bag. Two aliquots were taken from each core segment for extraction of pore fluids and determination of total organic carbon.

Preparation of Samples

A fraction of each segment of the core was placed in a vial and centrifuged at about 2500 rpm for 30 minutes in a centrifuge. The pore fluid was separated from the remaining sediment and placed in a sealed clean plastic bottle. The pore fluids from three to ten core segments were added together to form a composite sample which was stored in the refrigerator at 4° C prior to chemical analysis.

An aliquot of two to ten core segments was placed on a petri dish and dried in an oven at 50° C.

Analytical Measurements

The following types of measurements were carried out on the solid and liquid components of the sediment cores: pH, conductivity, total alkalinity, dissolved phosphorous. ammonia, nitrate-N, silica and total organic carbon. The pH of pore fluids was measured using a calibrated Hatch selective ion electrode while the conductivity was measured using a conductivity meter of the same model. The total alkalinity of the pore fluids was measured using a digital titrator and a standard solution of sulfuric acid and bromocreso methyl red as an indicator. The fluids were titrated to a violet pale gray color corresponding to a pH of about 4.8. Then the alkalinity was calculated following a standard procedure documented by the manufacturer of the Hatch titrator.

The total organic carbon of sediments was measured by placing samples dried in an oven at 50° C into the furnace and igniting them for two hours at 550° C and determining the relative loss in weight. The concentration of nitrate, phosphate, silica and ammonia in the pore fluids was determined by colorimetric methods using a UV/VIS Hatch 2032 spectrophotometer. The procedures which were used in these determinations are those which are prescribed by the manufacturer of the equipment.

RESULTS

The results are given in figures 2 to 8. It is clear that the pH varies from 8.0 to 8.6. The pH generally increases with depth though there are some slight variations. The total alkalinity generally varies from 250 to 300 m S/cm with a few exceptions. The conductivity varies from 620 to about 750 with a few exceptions. The high conductivity of some of the core segments in the upper part of core number NPG3 is a major deviation from the general trend. The total organic carbon content of cores varies from 12 to 21 %. The content of nitrate in the pore fluids decreases exponentially with increase in depth. The mean content of nitrate-N at the top of the sediment cores is about 0.11 mg/l. The content of ammonia increases with depth and varies from .1 to about 15 mg/l with the exception of two values, which are above 15 mg/l. The content of silica varies from 2 to about 50 mg/l and generally increases with depth. The content of phosphorous varies from about .1 to about 0.35 mg/l. The correlation between phosphorous content and depth is very weak.

CONCLUSIONS

The pH of the pore fluids is highly buffered and appears to be controlled by the precipitation and dissolution of carbonates as well as microorganisms mediated reactions such as those given below:

Aerobic oxidation

$$CH_3COO^- + O_2 \rightarrow HCO3^- + H_2O \qquad (1)$$

Anaerobic Sulfate reduction

$$CH_3COO^- + SO_4^{2-} \rightarrow 2HCO_3^- + HS^- \qquad (2)$$

Methanogenesis

$CH_3COO^- + H_2O \rightarrow CH_4 + HCO_3^-$ (3)

$HCO_3^- + 4H_2 + H^+ \rightarrow CH_4 + H_2O$ (4)

Ammonia is the most dominant species of nitrogen because of the denitrification process for which the general reaction is given below.

$CH_2O + NO_3^- + H^+ \rightarrow CO_2 + 0.5N2\,O + 1.5H_2O$ (5)

The salinity of the pore fluids is relatively low. The speciation of nitrogen is likely to be controlled by denitrification reactions and the pH. The increase in the silica content in pore fluids with depth suggests that the silica level is controlled by pH and the kinetics of the dissolution reactions involving siliceous bearing materials such as diatom fragments and minerals.

$SiO_2 + H_2O \rightarrow H_4SiO_4$

The content of phosphorous is likely to be controlled by the dissolution and precipitation reactions involving P-bearing materials such as minerals and organic matter.

The sediment column is an important sink for nutrients and it is likely that during mixing across the sediment-water interface some nutrients may be transported from the sediment column to the overlying water column.

The composition of the pore fluids depends upon the chemistry of the water column at the time of deposition of the sediments and the extent to which this is altered by the processes taking place in the sediment column.

The high content of total organic carbon in the sediment column suggests that the relative rate of deposition of organic matter is high and that anoxic conditions are likely to have prevailed in the lake during the deposition of the investigated part of the sediment column.

FUTURE RESEARCH

Further research on geochemistry of sediments is required in order to address other aspects such as the ones outlined below:

- Distribution of heavy metals.
- Mineralogical composition
- C/N ratios for organic matter
- Stable isotopes of C and O.

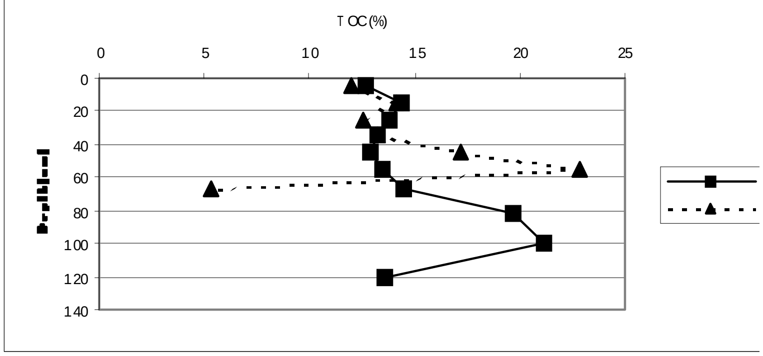


Figure 1B:TOC VS DEPTH IN KIGOMA BAY

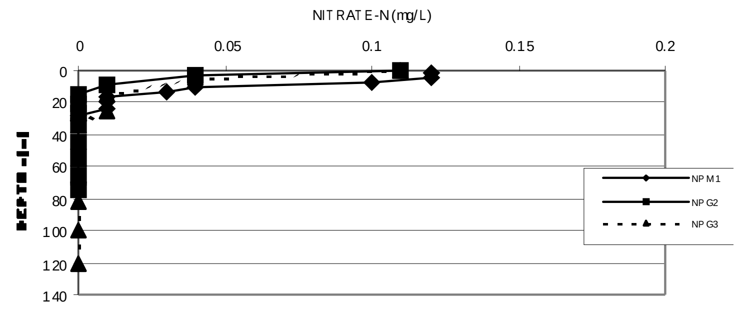


Figure 2: THE DISTRIBUTION OF NITRATE- N IN PORE FLUIDS OF SEDIMENT CORES IN THE KIGOMA BAY

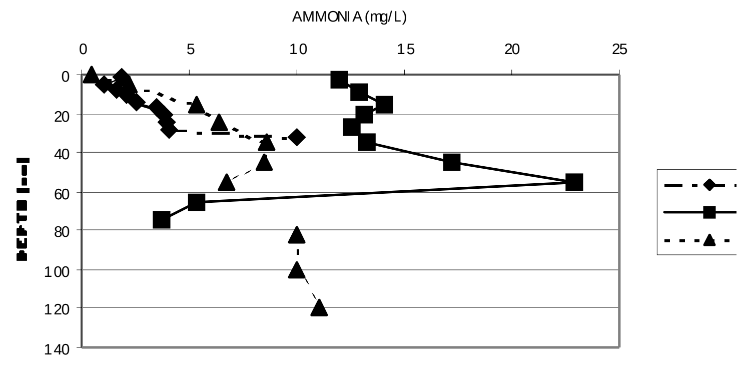


Figure 3: THE DISTRIBUTION OF AMMONIA IN PORE FLUIDS OF SEDIMENT CORES FROM KIGOMA BAY

Figure 4: THE DISTRIBUTION OF SILICA IN THE PORE FLUIDS OF THE CORE SEDIMENTS IN THE KIGOMA BAY

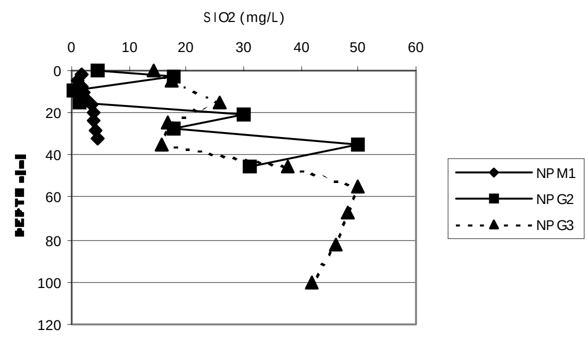


Figure 5: THE DISTRIBUTION OF PHOSPHOROUS IN THE KIGOMA BAY

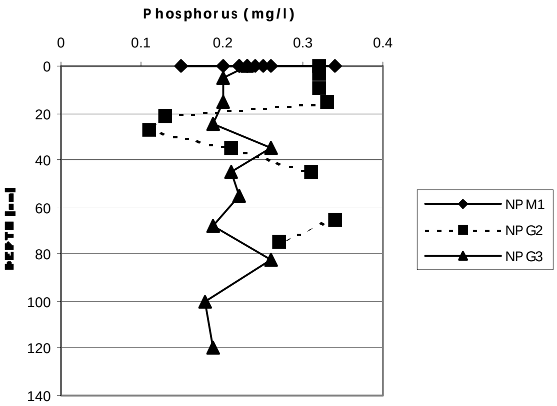


Figure 6: THE DISTRIBUTION OF pH IN PORE FLUIDS OF THE SEDIMENT CORES IN KIGOMA BAY

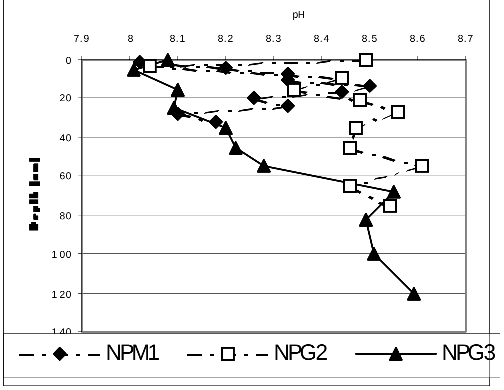


Figure 7: THE DISTRIBUTION OF ALKALINITY IN PORE FLUIDS OF KIGOMA BAY SUBSURFACE SEDIMENTS

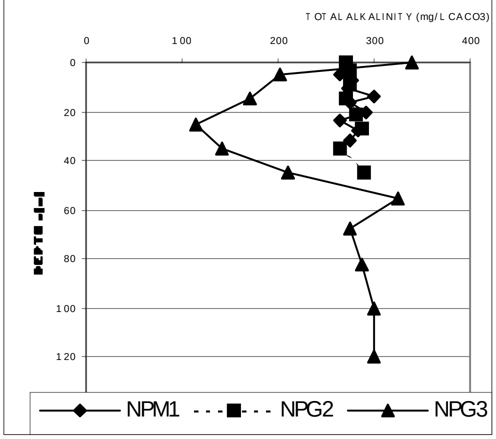
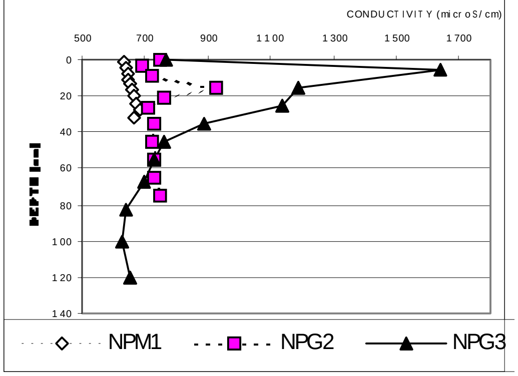


Figure 8: THE DISTRIBUTION OF CONDUCTIVITY IN PORE FLUIDS OF SEDIMENT CORES IN KIGOMA BAY



Relationships of fecundity and body size of *Lates stappersii* in central Lake Tanganyika, East Africa.

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University of Zambia

MENTOR: Dr. Ellinor Michel

Introduction

Although *Lates stappersii* is critically important fisheries biology in Lake Tanganyika, and is a major predator of the pelagic zone, its biology is still poorly understood. In this work I address a cornerstone in understanding the life history of this important fish with data on the relationship between female body size and fecundity. This relationship will be useful both for understanding pelegic ecosystem dynamics and in management of this species.

Lates stappersii one of the four endemic *Lates* species found in Lake Tanganyika. Unlike the other three *Lates* (*L. mariae, L. angustifrons, L. microlepis*, generally referred to as large Lates), *L. stappersii* is a pelagic water fish through out its life. Though it is found in different lake habitats, it generally occurs in deep and steep basins (Mannini 1998). It seems to aggregate more strongly than other *Lates* species especially during main spawning seasons. It is concentrated at night by fishing lights and caught mainly by using lift nets and purse seines. *L. stappersii*, together with clupeids, form the major commercial species and contribute greatly to the people in the region at least at two levels. Economically they are a source of income to stakeholders (fishermen and fish traders) and nutritionally, they provide relatively the best (and perhaps cheapest) animal protein to the local people.

Fecundity is the number of ripening eggs found in the female prior to the spawning act (Bagenal 1978). This contrasts with fertility, which is the number of eggs shed. Fecundity varies greatly in individuals of one species of the same weight, length and age, but in many species it increases in proportion to the size of fish (Lowe-McConnell 1975). Except for the preliminary Pearce (1985) study on the reproductive potential of *L. Strappersii*, no detailed investigation has ever been done to determine fecundity of *Lates* spp. No work information existed previously on how fecudity is related to maternal body size.

Research Objectives

- Define the relationship between fecundity and body size.
- Test how strongly seasonal reproduction is in *L. stappersii*.
- Determine whether sex ratios are even or biased.

Methods

A. Maturity Stages

I bought fish samples of *Lates stappersii* (n=407), the largest available daily from different fish markets around the Kigoma area. I weighed, sexed, measured total length,for each fish. Then I identified the different stages of maturity based on macroscopic observation of the gonads (i.e. color, shape, transparency, and vascularisation of ovaries). I supplemented this with microscopic observation of egg size distribution at different stages of maturity. Before opening the fish I also pressed lightly on the belly of the fish to check if white milt (for males) and eggs (for females) were running (stage IV).

B. Fecundity

I counted ripe (big size) eggs from ovaries of female fish at stage IV only using volumetric sub- sampling technique. I weighed both ovaries and emptied one of them into the beaker of water and the volume of the mixture recorded (sample). Generally I used 100ml of the sample. Then I swirled the contents of the beaker to ensure uniform mixing of eggs. Quickly I pippeted 1.0ml sub-sample from the beaker using a 1.0ml plastic dropper and counted the number of eggs in the sub-sample under the microscope (30X). I repeated this process ten times and fecundity was taken as a mean of counts in sub-samples. Fecundity formula:

$$F=n * (A/a) * (G/g)$$

n = mean number of eggs in sub-sample
A = volume of eggs and water (100ml)
a = volume of sub-sample (1ml)
G = total weight of both ovaries (g)
g = weight of ovary used in the sample

Results

Preliminary maturity stage observations in *L. stappersii*
Stage I (immature). Gonads not developed. Sex of fish is difficult to differentiate. Stage II. (Maturing). In females, small slender ovaries, reddish in color due to increased number of blood vessels. Gonads are small, flat, and appear translucent in males.
Stage III (mature). Ovaries appear reddish-yellow (not completely ripe). White milt comes out when gonad is cut and pressed in males.
Stage IV (ripe-running). Ovaries are big (finger-size) and ripe, yellow in color. A slight press on belly of fish results in some eggs being released, so are sperm for males at this stage.
Stage V (spent). Eggs already shed. Ovaries appear like Stage 2 but longer.

Egg size distribution

I observed about three to four size groups of eggs in mature ovaries. Each egg is contained in an oil droplet. The diameter of big eggs measured about 0.5mm, medium (0.3mm), small (<0.2mm) and very small eggs (<0.1mm).

Sex Ratio

I found the sex ration between females and males to be 1:2 respectively, n=407. Females at stage IV to mature males; the sex ratio was 1:7. The percentage of females at stage IV was 9%, n=407.

Fecundity

I found fecundity for *L. stappersii* varying from 60,000 to 800,000 per fish (average 256,000). These refer to one big size group of eggs at stage IV. The relationships between total length of *Lates stappersii* with gonad weight, with fecundity, and between gonad weight and fecundity are shown in Figure 1.

Interpretation of Results

Fecundity for *Lates stappersii* is expected to be high because of small eggs. There is probably no parental care, predation and mortality of eggs and juveniles must be high. Pearce (1985) estimated the eggs to range between 7,600 and 287,000 per fish (average 107,000) and estimated the total number of eggs spawned by a female each year to probably range between 100,000 to 1,000,000 (sample size n=14). I found fecundity to be higher ranging between 60,000 and 800,000 per fish (average 256,000) as shown in Table 1. Since I saw three to four size groups of eggs in mature ovaries, probably spawning may occur several times within a protracted spawning season. Fecundity may thus range between 180,000 and 2.4 million eggs per fish per year (sample size, n=37).

According to Aro and Mannini (1995), the spawning season for *Lates stappersii* in Zambia and Rukwa (Tanzania) is from November to April with peak in March when there are more mature females. In August there are more producing males. My study shows that fecundity is still high in the summer dry season (July and August). Sex ratios are highly biased in this study with most fish being male (1:2 females:males). Bias becomes more extreme at large sizes 1:7. This supports earlier observations (Aro and Mannini(1995), Chitamweba, pers.comm.) and suggests that large mature males remain at this stage for a relatively longer period of time.

Fecundity and body size have an approximately a linear relationship in current data sets. (r^2=0.4472), similarly for gonad weight and body size (r^2=0.5095). There is a stronger correlation between fecundity and gonad weight (r^2=0.8603). The relationship between fecundity and body size may be increasing and non-linear at large sizes, however this is a suggestion based only on a single data point (fig.1). Further tests must be based on samples with more large fish.

Future Work

- Detailed sampling year round it compare in-season and off-season differences in fecundity.
- Increased sampling of the largest females to determine linearity of body size and fecundity relationships.
- More data on differences in sex ratios.
- This project is the cornerstone of my M .Sc. thesis.

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Table 1.

TOTAL SAMPLE SIZE	FEMALE IN STAGE IV	FECUNDITY RANGE	AVERAGE FECUNDITY	ANNUAL FECUNDITY ESTIMATE	SOURCE	
407	37	60,000 - 800,000	256,000	180,000 - 2.4 million	Musonda 1999	(this study)
?	14	7,600 - 287,000	107,000	100,000 - 1 million	Pearce 1985	

Analyse granulometrique des sables et des debris de charbons dans les plages 1 et 2 de Jacobsen (Cap de Bangwe). Lac Tanganyika, Kigoma-Tanzanie.

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Uvira, Republique Democratique du Congo
Sous la responsabilite du Dr. Kiram Lezzar

Les deux plages 1 et 2 de Jacobsen (Lac Tanganyika 4.54 S et 29.35 E) constitue une accumulation importante de sables contenant des debris vegetaux (Racines et charbons). Une etude granulometrique de ces sables, et analyse de la frequence d'apparition des charbons permettrait de reconnaitre les caracteres de leur sedimentation et l'influence des activites humaines sur le lac au niveau de ces deux plages.

La presente etude se propose comme but de determiner les conditions de sedimentation sableuse (fraction >63 microns = < +4Phi) au niveau de ses deux plages depuis le rivage jusqu'a des profondeurs de l'ordre de 60m. Le second but est d'investiguer les proportions de debris de charbons present dans les echantillons brut recoltes.

Les formations geologiques entourant les deux plages de Jacobsen sont d'age Precambrien. Nous retrouvons principalement a l'affleurement deux grandes formations. Les Quartzites de Kigoma et les Bancs rouges conglomeratiques de Manyovu (Yairi et Mizutani, 1969). Les conglomerats de ces bancs rouges sont egalement formes de gros galets pluricentimetriques de quartzite. La dominance de materiel quartzifere dans cette region expliquerai le fait que les sables echantillones, produit de l'erosion des roches du rivage, soient tres riches en grains de quartz. Aussi, la couleur rouge vif des bancs de Manyovu serait egalement a l'origine des sables rouges formant les plages 1 et 2 de Jacobsen jusqu'a des profondeurs de l'ordre de 10-20m.

Les echantillons ont ete recoltes a l'aide d'une benne suspendue a un cable metallique lie a un treuil fixe sur une embarcation. Ce treuil permets l'investigation de zones atteignant une pronfondeur de 200m. Cependant, considerant la petite taille de notre embarcation et la presence d'un vent tres fort et par consequent un lac tres agite nous nous sommes limites a des profondeurs de l'ordre de 60 a 70m. Au dela, le cable prenait un angle trop important et la derive du au vent et vagues aurai entrenai des erreurs de positionnement que nous ne pouvions pas nous permettre vu la petite densite de la maille l'echantillonage que nous nous sommes fixe (Figure 1).

Vingts neufs (29) echantillons ontb ete recoltes et seulement 22 ont ete analyse. Sur base d'un papier graphique de probabilite , nous avons dresse des courbes cumulatives des echantillons et en appliquant les formules ci - dessous de R. I. Folk and W.C ward (1957). Nous avons pu evaluer 2 caracteristiques essentielles du sable : diametre moyen (Mz) et l'ecart - type ou deviation standard (Phi) pour le classement des sediments.
Mz = Phi 16 + Phi 50 +Phi 84 / 3
Phi = Phi84 - Phi 16 / 4 + Phi95 - Phi5 /6.6.

En outre, nous avons aussi dresse les histogrammes de frequences pour evaluer la valeur modale (mode) de chaque echantillon, c'est a dire la classe granulometrique la plus representative. A partir du Tableau 1 des resultats bruts , des graphiques de correlations entre parametres de l'echantillons ont ete . Nous en avons tire les constatations ci-dessous:

1-la fraction grossiere (Sable: <+4 Phi)) presente des tres fortes proportions et est quasi dominante aussi bien dans les zones moins profondes que dans les zones des profondeurs elevees. La fraction fine (silt et argile: >+4 Phi)) etant presqu'inexistante, sauf dans les zones profondes (> 50 m) (Figure 2 a 4) Ceci s'expliquerait par la faiblesse de l'alteration chimique dans le versant qui supplombe la baie. Et une fois liberees, ces particules sont entrainees par les forts courants de vagues vers les zones profondes.

2- le charbon est present dans toutes les profondeurs ,avec une fort pourcentage dans les hautes (figure 3) . Il se trouve irregulierement repartis dans les fractions ganulometriques sableuses. Toutefois, le pourcentage eleve a ete observe dans la fraction de sable grossier. On constate aussi que le charbon varie en fonction de la valeur modale de l'echantillon (mode) : pourcentage en poids tres eleve dans le mode 1 et diminue progressivement dans les modes 2, 3 et 4 (figure 5 et 6).

3- Les sables moyens et grossiers dominent dans les zones des basses profondeurs alors que les sables fins et tres fins dans les zones de hautes profondeurs. Cette distribution s'expliquerait par la competence de la vague et courant cotiers ; l'energie de vague etant puissante vers les cotes et diminue au large . Egalement nous avons observe que la moyenne croit avec la profondeur (figure 5).

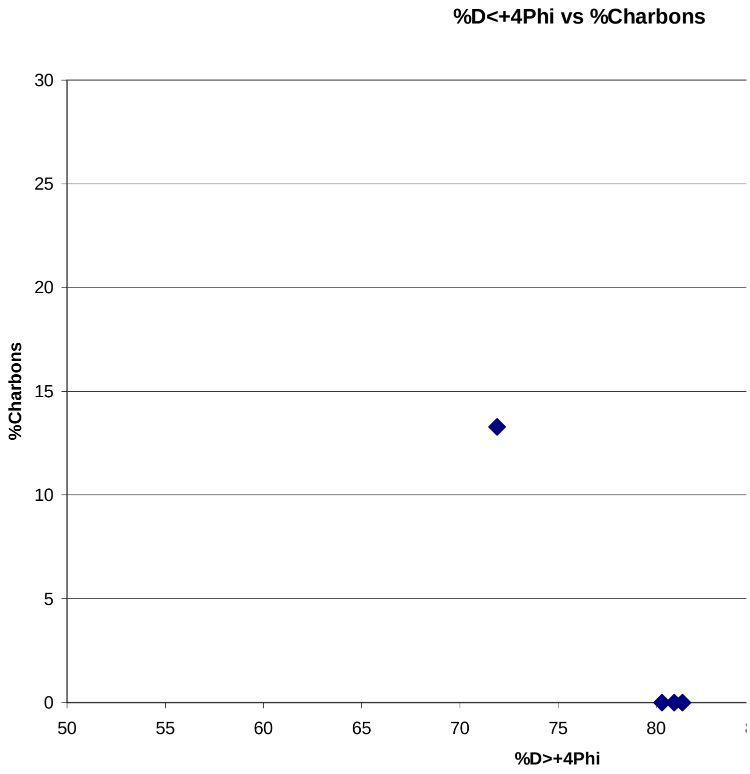
4-Le classement varie suivant la profondeur (figures 8 et 9): les sediments tres bien classes (very well sorted), bien classe (well sorted), moderement bien classe (moderately well sorted) et moderement classe (moderately sorted) sont dans les basses profondeurs,alors que les sediments mals classes (poorly sorted), tres mal classe (very poorly sorted) et extremement mal classe (extremely poorly sorted) sont localises dans les moyennes et hautes profondeurs. En general, on note un classement moyen dans la partie littorale et un mauvais classement dans les parties profondes.

En conclusion

- Le sable de la plage de la baie de Jacobsen a un classement moyen; par contre celui des zones profondes a un classement mauvais. On note une augmentation de la moyenne avec la profondeur.
- Les debris de charbon sont presents dans le sable de la baie de Jacobsen avec un fort pourcentage dans les parties profondes. Ce charbon proviendrait du feu de brousse pratique dans le versant de la baie.

Recomandations

- Cette etude devra etre continuer sur une longue periode en vue de saisir l'influence de l'activite humaine sur la baie de Jacobsen. En cela une etude comparative avec d'autres sites littoraux humanises permetrait d'apprehender cette influence.
- La vitesse de sedimentation du charbon pourrait etre etudier en laboratoire afin de comprendre la vitesse de sedimentation du charbon dans la baie.
-Une etude morphoscopique du charbon s'avererait aussi indispensable ; ce qui revelerait l'origine et le mecanisme du transport.


%D<+4Phi vs %Charbons
%Charbons
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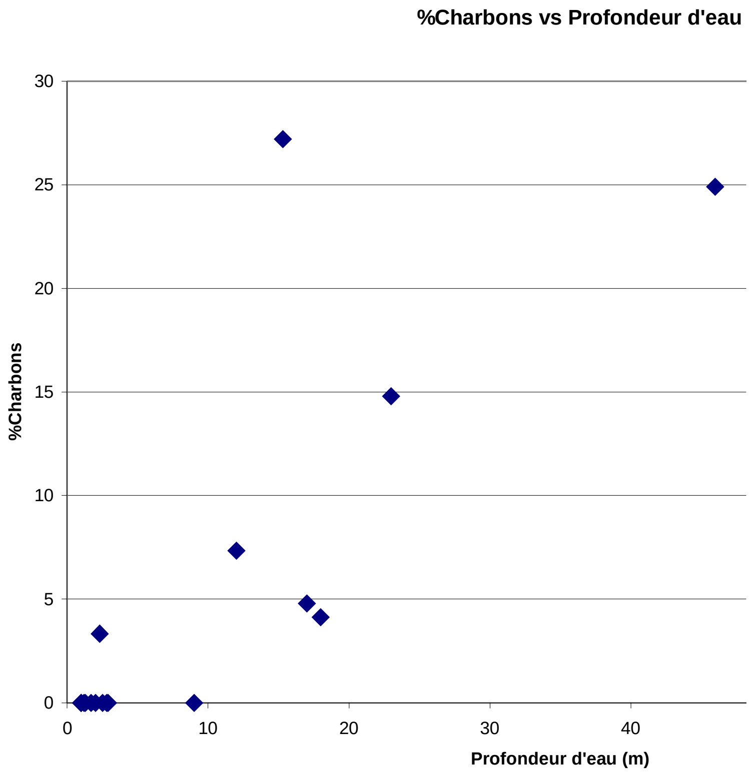
%Charbons vs Profondeur d'eau
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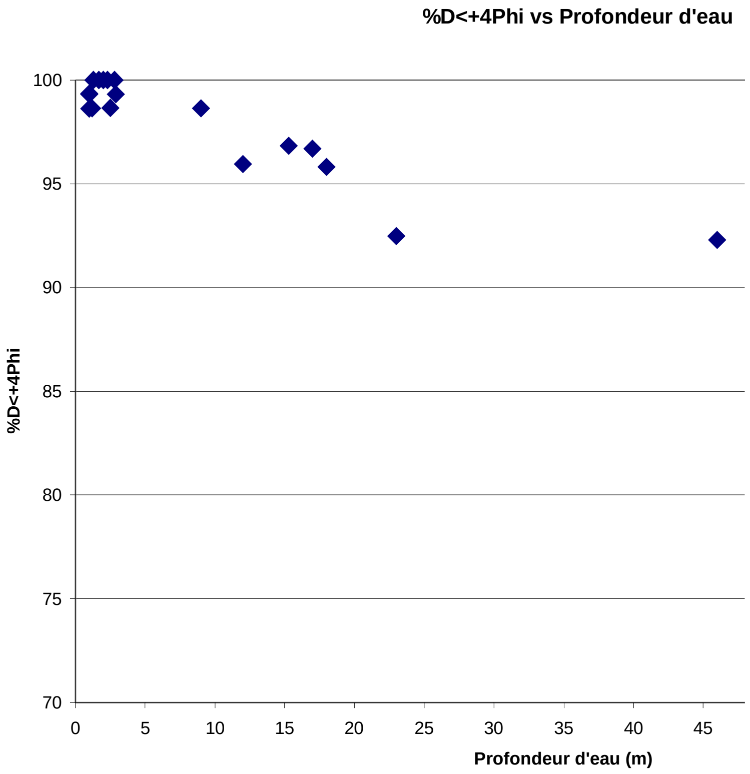
Profondeur d'eau (m)


%D<+4Phi vs Profondeur d'eau
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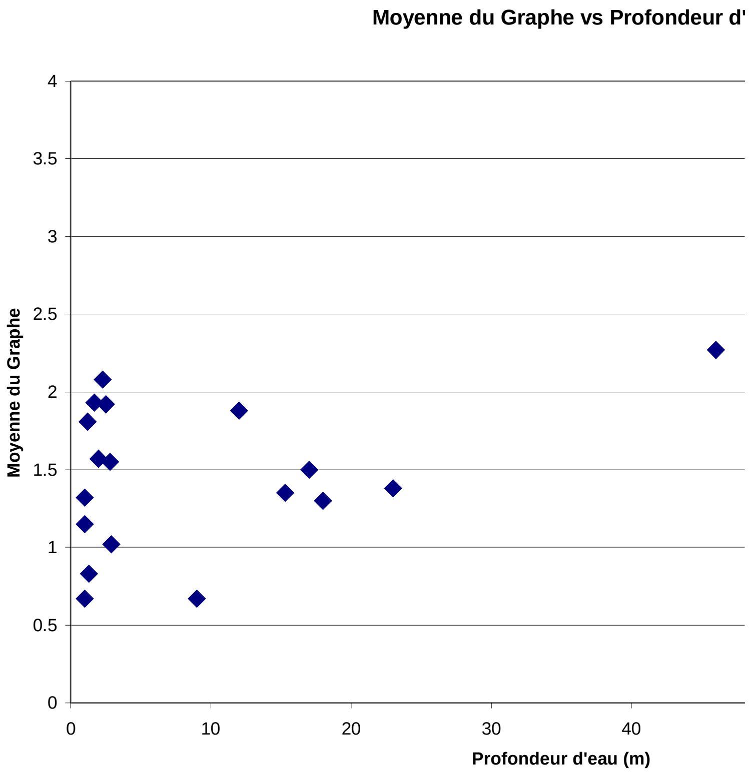
Profondeur d'eau (m)


Moyenne du Graphe vs Profondeur d'
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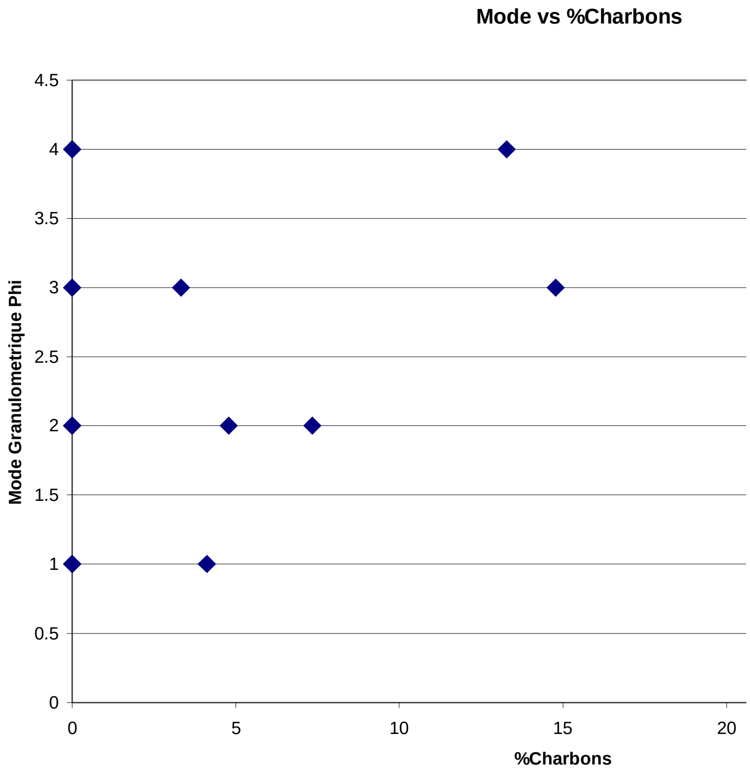
Mode vs %Charbons
Mode Granulometrique Phi
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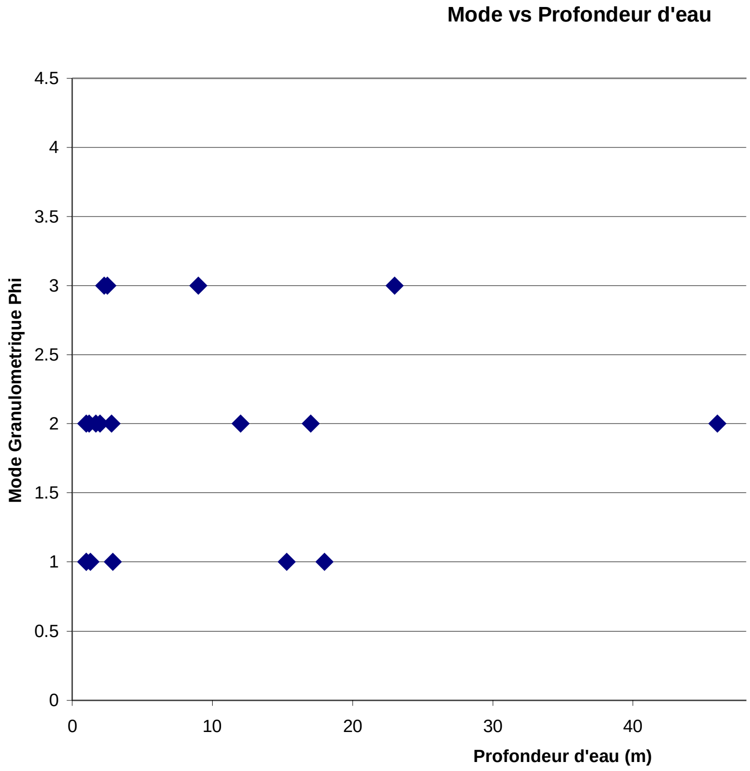
Mode vs Profondeur d'eau
Mode Granulometrique Phi
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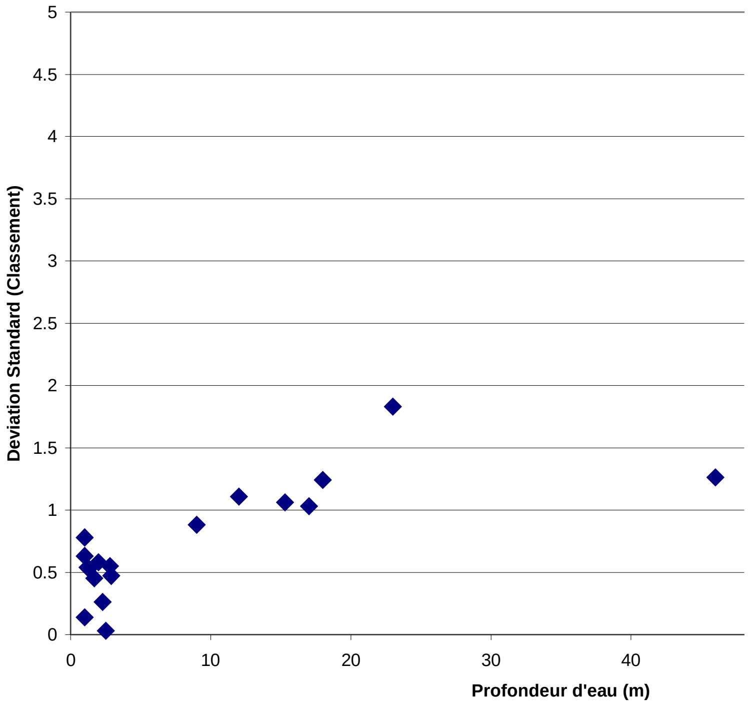
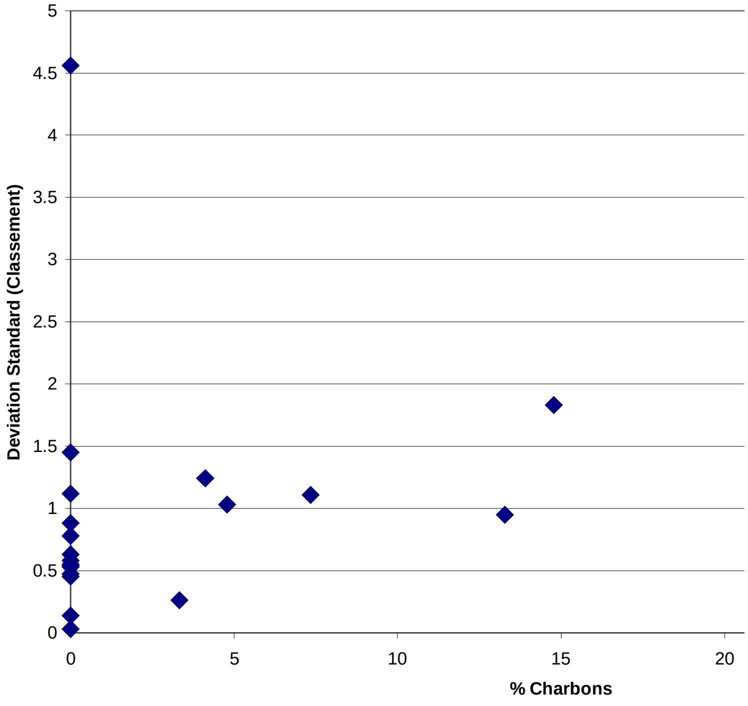
Profondeur d'eau (m)



Deviation Standard vs profondeur d'



Deviation Standard vs % Charbon

Limnology related to zooplankton changes and pelagic fisheries catches in Lake Tanganyika with special emphasis on physico-chemical parameters.

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Affiliation: EM-University of Dar Es Salaam, JS-University of Minnesota-Twin Cities
Mentor: Dr. Pierre-Denis Plisnier

Introduction

Among the oldest of freshwater lakes in the world and situated in the Great Rift Valley of East Africa, Lake Tanganyika has a rich ecosystem that remains to be fully understood. It has been widely known for low ambient nutrient levels but high fisheries patchiness and production (Coulter 1991). The biological productivity of Lake Tanganyika is of primary concern to the local communities dependent on the annual fisheries yield. Current estimates approach 200,000 tons per year, enough food for two to three million people (Plisnier, unpub.). The "Tanganyika sardines" (*Stolothrissa tanganikae* and *Limnothrissa miodon*) as well as *Lates stapersii* make up the majority of the fisheries yield. Fishermen use kerosene pressure lanterns shining brightly from wooden boats during the night to attract the fishes (Coulter, 1991). As the zooplankton make their nocturnal ascent, they are followed by *Stolothrissa* which in turn lure their predators, *Lates stappersii*.

Biomass of the lake is highly variable in the lake (Beadle, 1974) and consequentially, fishing success is also highly variable. Nutrient distribution in the lake is dependent on the existing thermal stratification that can vary with temperature and weather changes. The availability of these nutrients influences plankton communities and ultimately, fish populations. We hypothesize that the physical and chemical parameters measured during four sampling nights will show a relationship to the fish catch.

Objective

The objective is to determine physical and chemical parameters across four sampling nights and to see if there is a relationship between these parameters and the pelagic fish community.

Materials and Method

On four nights during the end of July and the beginning of August 1999, a team of four students studied chemical, physical and biological parameters at various sites in the Kigoma Bay pelagic zone and compared them accordingly to the fish catch. Fishing stopped for one week of the month during the full moon phase that occurred on July 28. We used a 12-meter research vessel, the R/V Echo, to tow a catamaran fishing unit out to the site of their choice and remained a shouting distance from them. Fishermen work in pairs with one large, fine-meshed scoop net dropped to a depth of about 100m and mounted on long poles extending from each corner of the catamaran. Fishermen generally spend two or three hours with the lanterns burning brightly to attract the fish before hauling in the nets and often repeat the procedure two or three times a night. We made note of the GPS location, lake condition and time of sampling and began measurements about an hour before the nets were brought up.

Physical and Chemical parameters.

We took measurements of temperature and dissolved oxygen at every 10m depth up to 60m with a portable temperature and dissolved oxygen probe calibrated for altitude and temperature at Lake Tanganyika. We measured conductivity with a conductivity meter/TDS (Model 19820 Cole Parmer Co.), pH with a pH meter (Orion Model 210A) and turbidity with a portable turbidimeter (Model 2100, Hach Co.) from water samples taken with a water sampler at surface 0m, 20m, 40m, 60m, 80m, and 100m. Temperature and dissolved oxygen were also taken at 80m and 100m. We bottled two liters from these depths for next-day chemical analysis and kept them chilled on ice in a cooler until refrigerated in the morning. When the fishermen were ready to bring in their nets, we rowed out to the catamaran in an inflatable Zodiac. We collected a random sample of the catch and weighed the *Stolothrissa*, *Limnothrissa* and the *Lates* separately. We determined the percentages of each species and estimated the total catch.

The morning after the night sampling we filtered our water samples taken from each depth and saved the filter paper for chlorophyll a analysis. We analyzed the filtered water for nitrate, soluble reactive phosphorus, ammonia and silica by using cadmium reduction method and test'N tube method (Hach Co.) The concentration in mg/l was measured with a spectrophotometer. We placed the filter paper from each depth into individual plastic containers and added 11ml of 94.1% methanol to each container. To prevent any additional photosynthetic reactions, we covered the containers with foil and placed them in the refrigerator for 24 hours. We then removed the filter paper and centrifuged the solution for 10-15 minutes at 2500 rpm. We prepared a blank with methanol and derived concentrations with a spectrophotometer (JANWAY 6300 Spectrophotometer).

RESULTS

Temperature (Figure 1)

Thermocline depth was at 90m on Aug 1, 80m on Aug 4 and 90m again on Aug 8. Surface temperature was the same at 25.5°C on Aug 1 and Aug 8 and 25.6°C on Aug 4. Temperature decreases with depth, with an average temp of 24.4°C at 100m.

Dissolved Oxygen (Figure 2)

Dissolved oxygen profiles were similar for Aug 1 and Aug 4, with an oxycline occurring at 80m. On Aug 8, there was a significant decrease of dissolved oxygen in the metalimnion and the oxycline was observed at 50m.

Conductivity (Figure 3)

There was a significant variation between Jul 22 and Aug 1 showing a displacement of deep isoline toward the surface. At 60 m, conductivity thus increased during this period from 640 uS/cm to 680 uS/cm. In general, conductivity increased with depth and showed an average of 689 uS/cm at a depth of 100m.

pH (Figure 5)

Average surface pH was 8.97 and average pH at 100m was 8.67. On Jul 22 there was significant variation with depth, with a value of 8.98 at 60m and a value of 8.63 at 80m.

Turbidity (Figure 4)

Turbidity shows a remarkable variation on Jul 22. Average surface turbidity was around 0.32 NTU and values at 100m were around 0.15 NTU.

Soluble Reactive Phosphorus (Figure 7)

Soluble reactive phosphorus concentration demonstrated a fairly consistent overall increase in the epilimnion as well as in the hypolimnion from 22 Jul to 8 Aug. Higher concentrations were found in the hypolimnion with values averaging around .08 m/l compared to average value of the epilimnion found around .03 mg/l.

Nitrate (Figure 8)

Nitrate concentration was consistently higher in the hypolimnion than in the epilimnion with significant differences between layers observed on Jul 22 and on Aug 1. There was a slight decrease in the epilimnion between Aug 4 and Aug 8.

Silica (Figure 10)

Values for silicate concentration ranged around 1.00 mg/l and 1.50 mg/l in the epilimnion with higher values found in the hypolimnion for all four days.

Ammonia (Figure 9)

Ammonia concentration was remarkably high on Jul 22 with epilimnion values decreasing during the following three days. There was a slight increase in hypolimnion concentration on Aug 8.

Chlorophyll a and abundance of copepods (Figure 6)

Chlorophyll a was much higher on Jul 22 than the following three days with an epilimnion concentration around 1.8 ug/l. The average for the other three days was around 0.9 ug/l in the epilimnion. Copepods were highest in abundance on the second day.

Fishing Results (Figures 11 & 12)

Jul 22 and Aug 8 had the highest catch in total kilograms, with a total of 65 kg and 275 kg, respectively. The catch of Aug 1 was the lowest with a total of only 2 kg. Aug 4 had a total of 52 kg. The basic trend in percent composition was from a domination of Stolothrissa and juvenile Lates on the first two days to a significant decrease on the third day and a domination of adult Lates. On the fourth day, the percent composition was a majority of Stolothrissa with a smaller percentage of adult Lates.

Lake Sampling Results

DATE	22 Jul 99	1 Aug 99	4 Aug 99	8 Aug 99
LAKE CONDITION	very choppy	calm	choppy	calm
SURFACE TEMPERATURE	n.a.	25.5°C	25.6°C	25.5°C
THERMOCLINE	n.a.	90m	80m	90m
ZOOPLANKTON (n/m3)	7,7	31,2	19,3	21,6
kg of Stolotrissa	7.54	.8	.52	215.6
kg of Limnothrissa	0	0	0	0
kg of Juv. Lates stappersii	0	1.2	0	15.4
kg of Ad. Lates stappersii	57.46	0	51.48	44

DISCUSSION AND CONCLUSION

A significant change in water movement occurred during the sampling period. Thermocline depth was changing from the second to the last sampling day and the hypolimnion rose towards the surface (Fig 1). This movement led to an exchange of nutrients from the deep water up to the oxygenated epilimnion and was therefore available to the aerobic organisms. This was seen in the increase of soluble reactive phosphorus, nitrate and silicate concentration (Fig 7-10). This dynamic may have contributed to the high total fish catch on Aug 8.

Chlorophyll a was high on Jul 22 with corresponding trends seen in pH and turbidity. This indicates high photosynthesis, or high primary production, which may have had an effect on the abundance of zooplankton which followed roughly the same trend with a time lag. However the exact dynamic between these communities is uncertain and therefore this relationship is inconclusive.

Undoubtedly, the success of the fish catch is dependent on a number of variables. Certainly the moon was a deciding factor in the efficiency of the lanterns to attract the fish. Adult Lates are known to be visual predators depending on light for their success (Coulter, 1991). The new moon phase fell on Aug 4, the same day that lows were seen in water conductivity and turbidity (Figures 3 &4). The effects are clearly seen in the dramatically high percent composition of Lates (Figure 11).

Finally, the richness and complexity of Lake Tanganyika's food web makes interactions like these difficult to determine during a three week period. In addition to many uncontrollable variables such as moon phase and weather patterns, there were other variations to consider such as fishermen's choice of location and exact time of sampling. A continuation of this work would contribute significantly to the results. Nonetheless, an increase in nutrients due to the mixing of waters from the hypolimnion into the surface layers in addition to the low turbidity and period of stabilization on the third night of sampling suggests a relationship to the catch composition and total weight.

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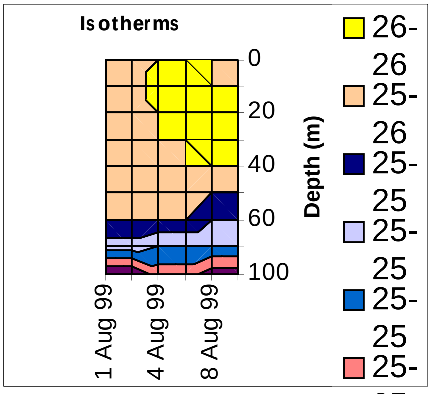
ACKNOWLEDGEMENTS
Thanks to Dr. Plisnier and Willy for their help with this project.



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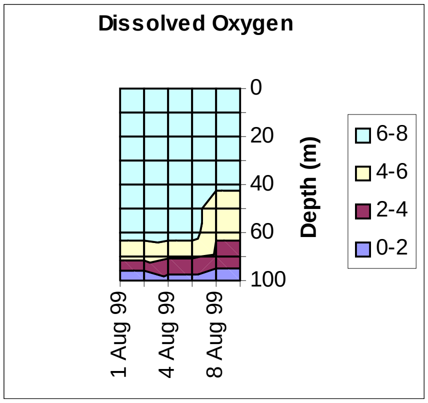

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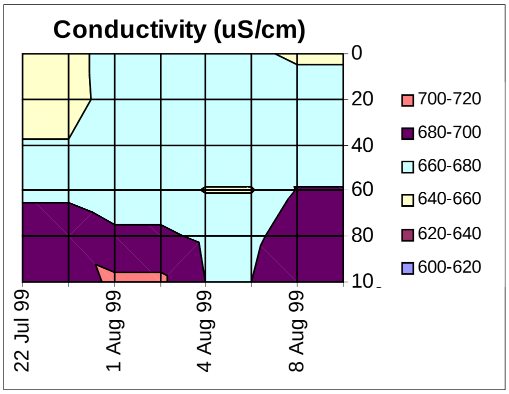

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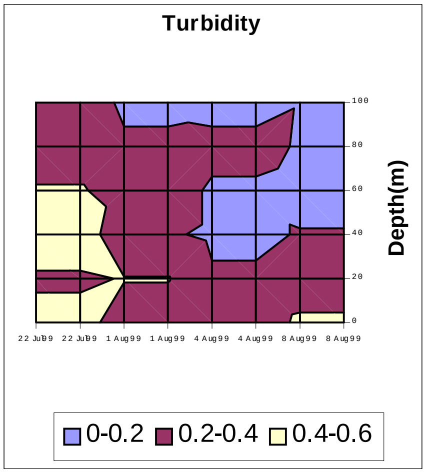

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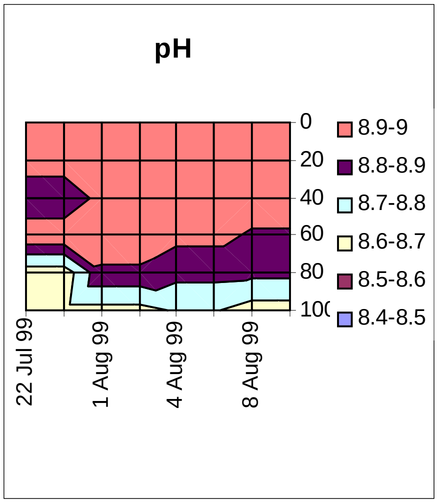

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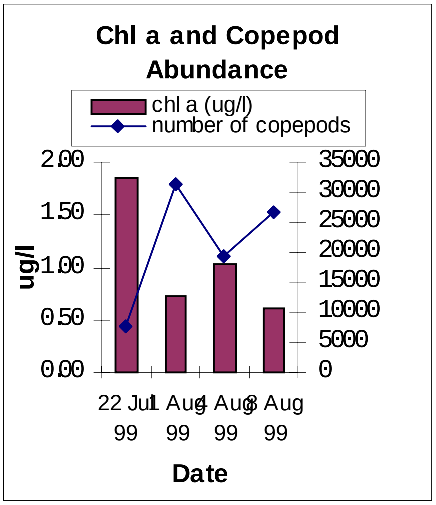

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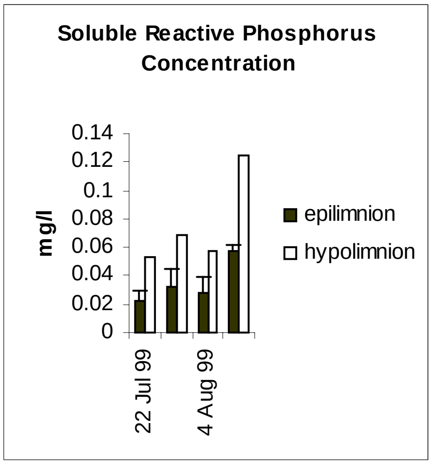

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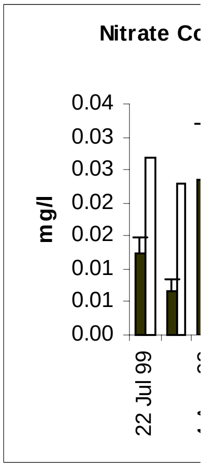

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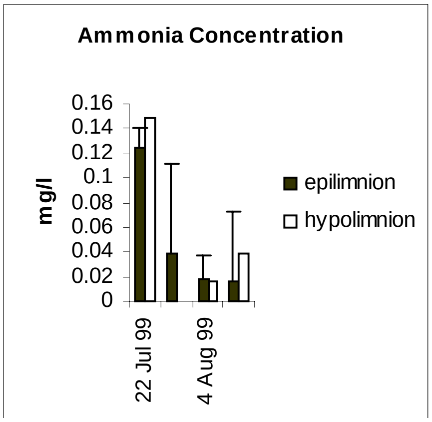

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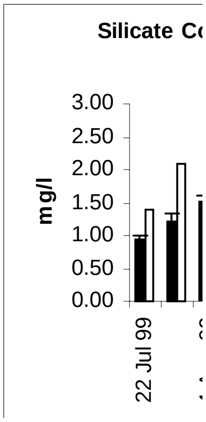


Figure 10

Figure 11

Figure 12

CONTRIBUTION A L ETUDE DU REGIME ALIMENTAIRE DE *LOBOCHILOTES LABIATUS* ET *NEOLAMPROLOGUS TRETOCEPHALUS* .

NDUWARUGIRA Felicite, Universite du Burundi
encadreur: Dr MICHEL Ellinor

Introduction

Le lac Tanganyika constitue, grace a sa richesse biologique, un centre d'interet tant scientifique que socio-economique. Ses caracteristiques geomorphologiques et sa faune endemique ont attire beaucoup de chercheurs. La peche dans la zone pelagique apporte pas mal de revenus a la population des quatre pays riverains du lac Tanganyika. La diversite biologique de la faune littorale font actuellement objet de plusieurs recherches, notamment dans le domaine de l'evolution.

La connaissance de la systematique, de la biologie, des processus ecologiques et notamment des relations trophiques au sein du lac est necessaire pour une exploitation rationnelle de ses ressources. C'est a cet objectif que tente de contribuer ce travail.

Objectifs

La connaissance du regime alimentaire d'un poisson permet de definir sa niche ecologique et par extension son habitat. L'analyse des contenus stomacaux permet de determiner la composition du regime alimentaire et d'apprecier l'utilisation de la nourriture disponible dans le milieu.

L'etude de la composition du regime alimentaire informe sur le niveau trophique d'une espece donnee par rapport aux ressources nutritives disponibles dans le lac et au reste de la communaute piscicole. Elle permet aussi d'observer les changements pouvant apparaitre dans l'alimentation en fonction du biotope, de la taille, de la periode de la journee, de la saison et voire des phases lunaires (CORBET, 1961).

Dans ce travail, nous avons choisi d'etudier le regime alimentaire de deux especes littorales et benthiques de la famille des Cichlidae, a savoir *Neolamprologus tretocephalus* et *Lobochilotes labiatus.*

Materiel et Methodes

Notre echantillon comporte 91 specimen de *Neolamprologus* et 14 specimen de *Lobochilotes labiatus* captures a la ligne ou aux filets maillants a Jakobsen Beach et ses environs. Ces poissons ont ete directement injectes de formol 10% pour arreter la digestion qui continue meme apres la mort, et place dans un recipient contenant lui meme du formol 10%.

Au laboratoire, nous avons pris la longueur totale et le poids de chaque individu, et ensuite disseque le poisson pour recuperer le tube digestif et reconnaitre le sexe par observation des gonades. Le tube digestif a ete recueilli dans une boite de petri et les contenus separes et identifies sous binoculaire .

Il existe plusieurs methodes qualitatives ou quantitatives pour l'analyse des contenus stomacaux. Dans notre travail, nous avons choisi d'utiliser la methode numerique qui est quantitative et la methode d'occurrence qui est qualitative. Le temps nous a manque pour adopter la methode gravimetrique qui aurait pu apporter plus de precisions a nos analyses.

Presentation des resultats

1.Relation entre le poids et la longueur totale chez *Neolamprologus tretocephalus* et chez

Lobochilotes labiatus.

Cette relation donne une information sur la croissance du poisson. La figure 1 montre la relation entre le poids et la longueur totale chez *Neolamprologus tretocephalus*. Le speciman le plus petit a une longueur totale de 7 cm et pese 6 gr tandis que le plus grand mesure 11.7 cm avec le poids de 23 gr. Nous constatons que le poids augmente en fonction de la longueur et l'allure de la courbe montre une croissance rectiligne.

La figure 2 montre la relation entre le poids et la longueur totale chez *Lobchilotes labiatus*. Le plus petit speciman mesure 6.7 cm avec un poids de 7 gr et le plus grand a 23 cm de longueur et 194 gr de poids. La courbe montre une inflexion aux environs de 15 cm, ou la croissance en poids depasse celle de la longueur. Cette taille correspond vraissemblablement au debut de la taille adulte

2. Etude du regime alimentaire de *Neolamprologus tretocephalus* et de *Lobochilotes labiatus*

Nous presentons une analyse des resultats obtenus avec l'analyse des contenus stomacaux par la methode numerique. Suite a un manque de temps, nous nous proposons de faire ulterieurement l'analyse des donnees obtenus par la methode d'occurrence.

Dans les differents contenus stomacaux analyses, les types d'aliments rencontres sont les suivants: alevins de poissons, insectes (Trichopteres, Ephemeropteres, Chironomides), crevettes; gasteropodes (*Lavigeria, Reymondia, Martelia, Syrnolopsis, Anceya*), ostracodes, nematodes, indetermines et sable.

La methode numerique indique l'importance quantitative de chaque type de proie denombrable. Ainsi les indetermines sont exclus de cette analyse.

La figure 3 montre l'importance relative, en %, de differents types d'aliments dans le regime alimentaire de *Neolamprologus tretocephalus*. Nous constatons que les insectes (54%) sont dominants, suivis des gasteropodes (34%) et des ostracodes (12%). Les crevettes et les poissons prennent une part negligeable dans le regime alimentaire.

Cherchant a voir s'il y a une variation dans le regime alimentaire en fonction de la taille, nous avons regroupe les differents individus en 4 classes de taille : 7 a 8.5 cm, 8.6 a 9.5 cm, 9.6 a 10.5 cm et les individus de plus de 10.5 cm.

La figure 4 montre qu'il y a une tendance au changement dans le regime alimentaire suivant les classes de taille. L'importance relative des insectes dans le regime alimentaire semble diminuer quand la taille augmente, alors que celle des gasteropodes semble augmenter avec celle de la taille augmente.

Dans la figure 5, nous mettons en evidence l'importance relative de chaque type de gasteropodes dans le regime alimentaire de *N. tretocephalus*, l'une des rares especes du lac Tanganyika connue pour consomer ce type d'aliment. Nous constatons que presque tous les individus ont quelques gasteropodes dans leurs contenus stomacaux. *Lavigeria* sont plus abondants dans les contenus stomacaux (37%), suivis de *Reymondia* (22%), *Syrnolopsis* (21%), puis viennent *Martelia* (18%). La presence de *Anceya* est negligeable.

Signalons que parmi les contenus stomacaux, les coquiles de *Lavigeria*, de *Reymondia* et de *Syrnolopsis* sont souvent cassees en plusieurs pieces; ceux de *Martelia* et de *Anceya* le sont generalement moins.

Les *Lavigeria* et *Reymondia* observes etaient plutot des juveniles. Ceci est en conformite avec une communication faite par Zorich N., un collegue du cours du Projet Nyanza, qui a suivi lors d'une experimentation la predation de *N. tretocephalus* et *L. labiatus*. Selon son observation, aucun gasteropode de plus de 6 mm n'a ete mange effetivement, apres meme avoir ete pris en bouche par le poisson. Les petits de *L. coronata* juste apres l'eclosion etaient manges par *N tretocephalus*, mais ceux de *L. grandis*, plus grands en taille, etaient plutot evites.

La figure 6 montre l'importance relative, en %, des differents types d'aliments dans le regime alimentaire de *Lobochilotes labiatus*. Il apparait que les insectes sont encore les plus abondants (39%), suivis des ostracodes (24%), des crevettes (22%) et enfin des gasteropodes (17%).

Nous avons regroupe aussi les specimen de *L. labiatus* en 4 classes de taille (moins de 10 cm, 10-15 cm, 15-20 cm et plus de 20 cm) pour voir s'il y a une variation dans le regime alimentaire avec la croissance. La figure 7 montre l'importance relative en % de differents types d'aliments en fonction des classes de taille. Nous constatons aussi que l'importance relative des insectes diminue considerablement dans les contenus stomacaux avec l'augmentation de la taille du poisson, tandis que celle des crevettes augmente la taille.

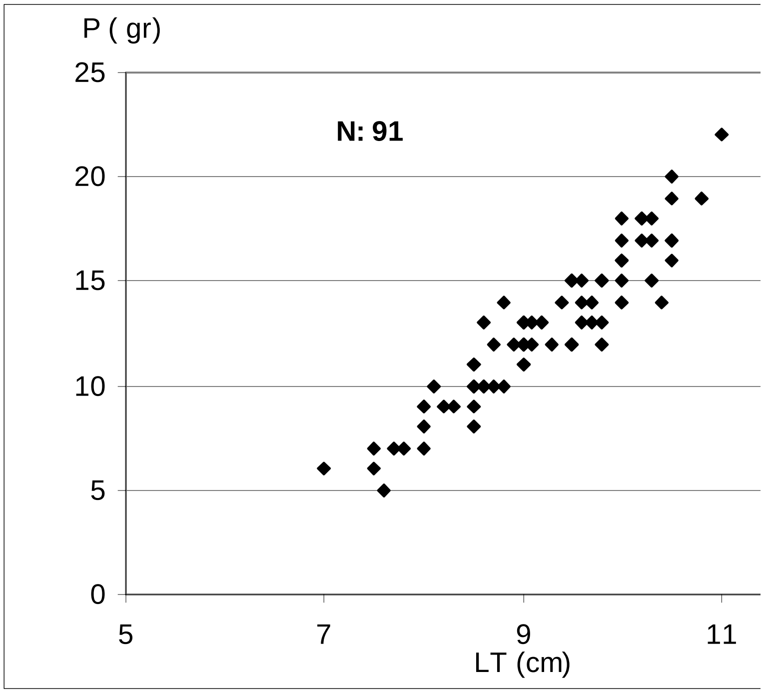
Conclusion

- Le regime alimentaire de *N. tretocephalus* et de *L. labiatus* est compose des meme types d'aliments, avec une dominance des insectes, des gasteropodes et des ostracodes. Chez *L. labiatus*, ce sont les crevettes qui viennent en troisieme position, avant les gasteropodes. Nous signalerons toutefois que notre echantillon de *L. labiatus* etait insuffisant en nombre (14 individus) et quil ne couvre pas les tailles au dessus de 25 cm.

- Les nematodes, toujours present en petit nombre, pouraient etre des parasites et non des aliments (a confirmer par une etude approprie).

Propositions pour des recherches ulterieures

Lobochilotes labiatus et *Neolamprologus tretocephalus* sont les rares especes du lac Tanganyika a avoir ete identifie comme se nourrissant de mollusques. Des etudes approfondies tant ce qui est de l'echantillonage, dans le temps et dans l'espace, que de l'analyse des donnees, sont encore necessaire pour tirer des conclusions pertinentes quand aux preferences alimentaires de ces 2 especes et leur comportement vis a vis des differents types d'alements disponibles dans le milieu.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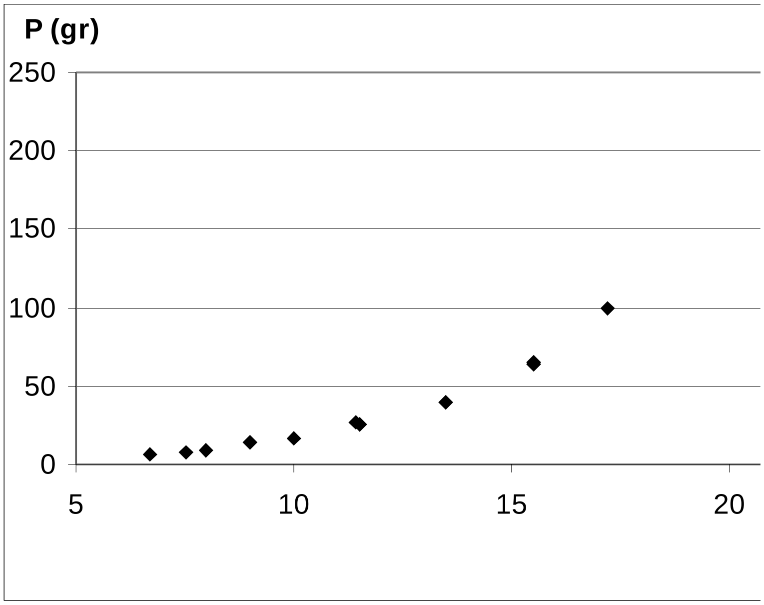
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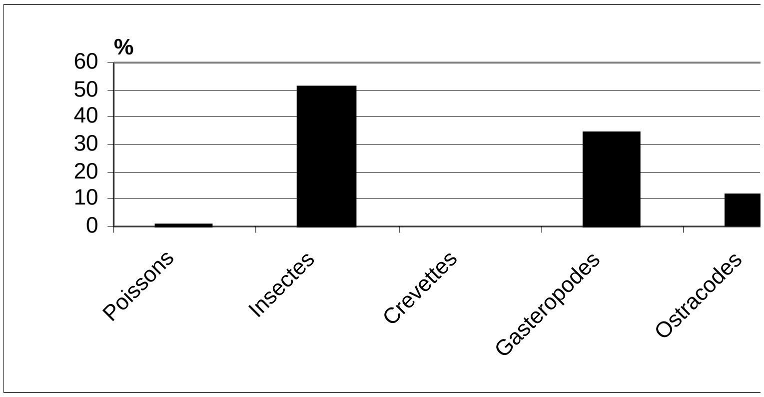
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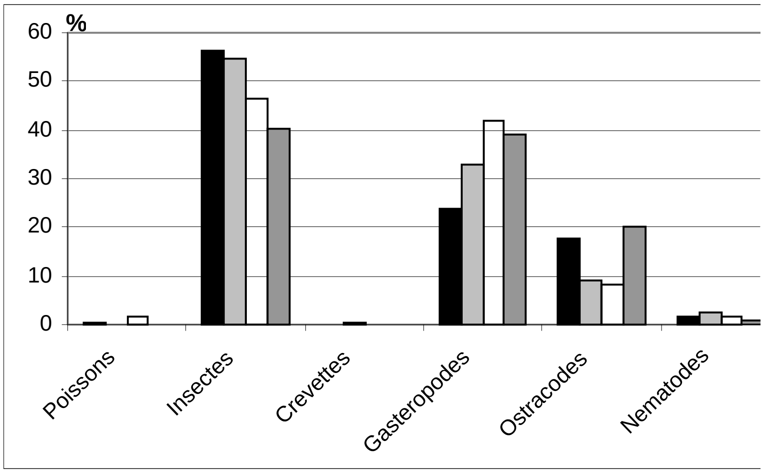
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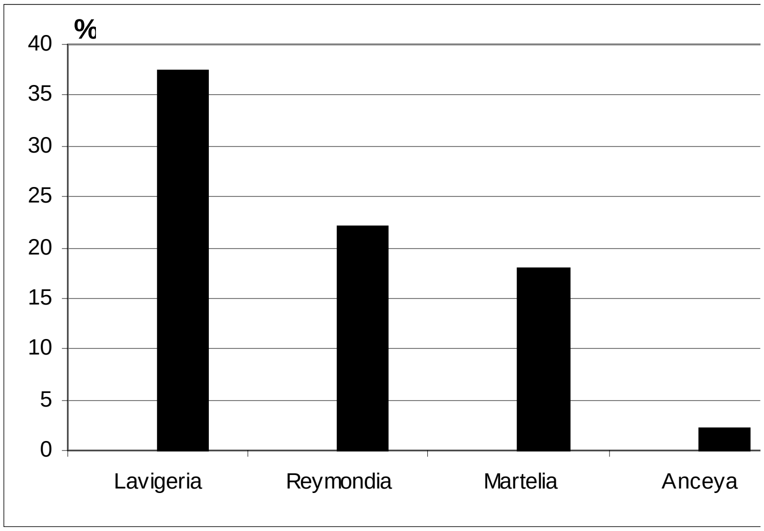
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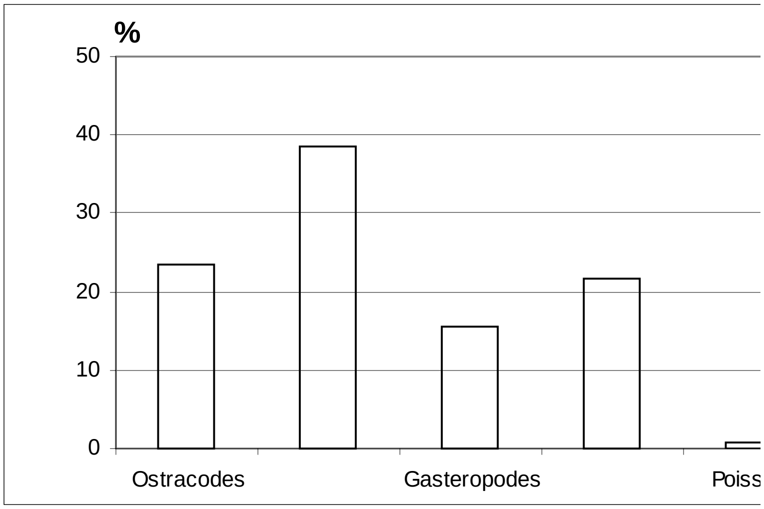
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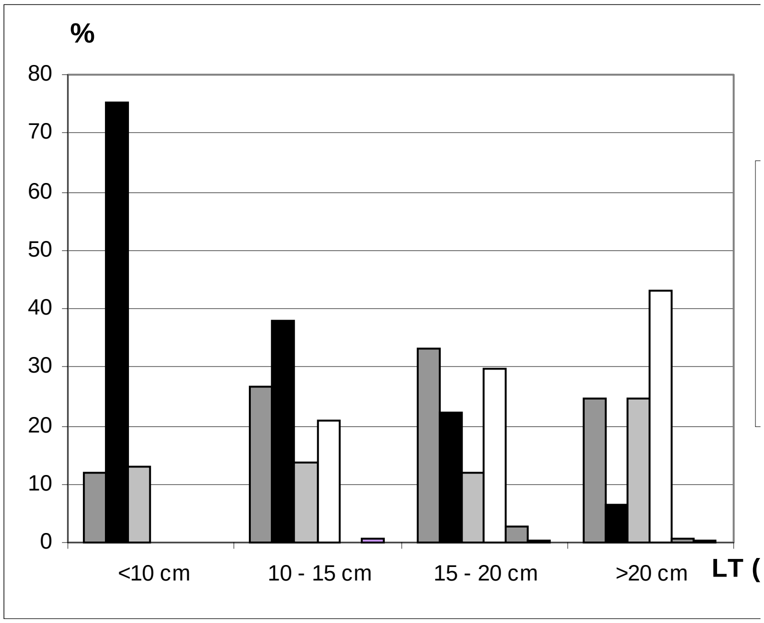
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Limnological patterns in relation to pelagic fish stomach contents in Lake Tanganyika (Kigoma, Tanzania)

Cris Oppert
Kansas State University

Pierre-Denis Plisnier
Project Mentor

Introduction

Lake Tanganyika is an extraordinarily ecologically diverse lacustrine system with over 650 endemic species (Coulter, 1991). The relatively low input and output of river systems in the lake results in an extremely long residence time. This creates a unique opportunity for the evolution of the lake. Ecological relationships between the abiotic and biotic interactions in Lake Tanganyika can be useful tools to help understand better the future conditions of the lake. Studies of the limnological environment, plankton, and pelagic fisheries catches are beneficial in providing information for the lake's fishing economy. Improved management strategies, for example, may possibly arise as a result of lake research.

To gain added knowledge about fish ecology, stomach contents of pelagic fish were analyzed to determine fish prey composition and numbers. Water chemistry and zooplankton tows were also examined. The study site was less than ten kilometers northwest of Kigoma, Tanzania. Results of the water chemistry analyses, zooplankton tows, and stomach contents were compared to determine relationships between the three, if any.

Objective

This study is designed to correlate patterns between water chemistry, zooplankton composition, and stomach content of pelagic fish.

Methods

Four night boat trips on the R/V Echo were undertaken to collect fish, water, and zooplankton samples in the pelagic zone. Water samples were taken at 20-meter intervals from 100 meters to the surface. Temperature, pH, and dissolved oxygen were measured as the water samples were taken. Water samples were further analyzed in a laboratory using a spectrophotometer. Turbidity, conductivity, nitrates, soluble reactive phosphorous, ammonia, silicates, and chlorophyll a were determined. Zooplankton tows were taken from 100 meters to the surface using a 100 mm net. Zooplankton abundance and composition was estimated under a microscope in a laboratory. Zooplankton and water chemistry analyses were performed as a part of research conducted by other Nyanza Project participants.

Local fishermen were towed to a site near where the water sampling was performed. Fishing was conducted from a catamaran using a lift net from ca. 100 meters to the surface. An estimate of the total weight of the fish catch was determined. Between 20 and 33 fish of each species were taken from each catch. In addition, age cohort sub-samples were also taken for *L. stappersii* (i.e. juvenile and adult). Stomach contents were preserved as soon as possible after catching the fish. This was done by either injecting the abdominal cavities of the fish with 10% formalin or by dissecting the digestive tract into vials filled with 10% formalin. Fish sub-samples were numbered and their total length determined. In a laboratory, stomachs were examined under a stereomicroscope to determine their relative fullness and composition. Fullness was approximated using a scale of 0 to 5, with 0 indicating an empty cavity and 5 denoting those which are very full.

Results

The four night samplings were conducted on July 22 (4° 49' S, 29° 23' E), August 1 (4° 50' S, 29° 29' E), August 4 (4° 49' S, 29° 32' E), and August 8 (4° 49' S, 29° 33' E). Moon phases for July 22 was between full and half moon, half moon for Aug. 1, between half and new moon for Aug. 4, and new moon for Aug. 8. Species of fish caught included *Lates stappersii*, *Stolothrissa tanganicae*, and *Limnothrissa miodon*. Total catch weights varied from 2 to 275 kg (fig. 1). Juvenile *L. stappersii* composed the majority of the catch by weight on July 22 and Aug. 1 (fig. 2). Adult *L. stappersii* and S. tanganicae were the major catch species on Aug. 4 and Aug. 8, respectively. *L. miodon* was caught on only Aug. 4 and did not make up a significant proportion of the total catch.

Average length of juvenile *L. stappersii* increased from July 22 until Aug. 8 (fig. 3). Average length of *S. tanganicae* increased from July 22 to Aug. 4, but decreased on Aug. 8. Profile length frequencies for juvenile *S. tanganicae* (with the exception of the Aug. 8 sampling) and *L. stappersii* were composed of a high number of fish within a relatively narrow length range. Adult *L. stappersii*, on the other hand, showed a broad distribution of lengths (fig. 4). Length vs. weight profiles for *S. tanganicae* and adult *L. stappersii* produced a positive correlation (fig. 5 and 6).

Fish was found in the most abundance for *L. stappersii* (fig. 7), with adult stomachs containing nearly all adult *S. tanganicae*. *S. tanganicae* stomachs were composed mostly of copepods and unknown material (fig. 8). Juvenile L. stappersii stomachs contained more calanoids than the smaller-sized cyclopoids whereas in *S. tanganicae* stomachs the opposite was true (fig. 9).

Turbidity decreased for the first three sampling dates and increased on the last (fig. 10). Chlorophyll a was highest on the first sampling date, lowest on the second, and at intermediate levels on the last two samplings (fig. 11). In contrast, total copepod numbers in the water column followed chlorophyll a levels in an inverse relationship. Ratios of cyclopoids to calanoids in the water column were 1.94 for July 22, 3.81 for Aug. 1, 5.63 for Aug. 4, and 4.19 for Aug. 8.

Conclusions

Data obtained from this study suggests several predator-prey interactions in the food web dynamics of Lake Tanganyika. When copepod levels are low, algae is consumed in lower numbers resulting in higher chlorophyll a values (see July 22, fig. 11). In contrast, when copepod levels are high, chlorophyll a concentrations are lower (see Aug. 1, fig. 11). This, in turn, can effect population sizes of juvenile *L. stappersii* and *S. tanganicae*. For example, an increase in copepod abundance from July 22 to Aug. 1 corresponds with an increase in the length frequency of both fish species (fig. 3). On July 22, juvenile *L. stappersii* composed most of the catch (fig. 2). This finding corresponds with the low cyclopoid:calanoid ratio observed on the same date and with the high number of calanoids found in juvenile *L. stappersii* stomachs (fig. 9). On Aug. 1, *S. tanganicae* becomes a more significant portion of the catch. This also corresponds with the higher cyclopoid:calanoid ratio on this date and the higher number of cyclopoids found in *S. tanganicae* stomachs.

The large percentage of adult *L. stappersii* caught on Aug. 4 corresponds with a low turbidity level. Clarity of the water column effects predator-prey relations between *L. stappersii* and *S. tanganicae* (Coulter, 1991), with a decrease in *L. stappersii* numbers with increasing turbidity. Therefore, low turbidity combined with the half moon phase providing light could be providing the right conditions for the adult *L. stappersii* to dominate the water column on Aug. 4. On Aug. 8, turbidity slightly increases and there is a new moon resulting in a drop in adult *L. stappersii* numbers.

Size of prey rather than their abundance appears to be more of a determining factor in prey selection. Juvenile *L. stappersii* are roughly twice the size of *S. tanganicae*, and eat a more calanoids than the smaller cyclopoids. *S. tanganicae*, however, eat cyclopoids. Adult *L. stappersii* eat almost entirely fish, all of which found were adult *S. tanganicae.* These findings do not always agree with the zooplankton composition of the water column. For example, on July 22 there were roughly twice as many cyclopoids in the water column but stomach content of juvenile *L. stappersii* was about 90% calanoid.

Future Research

These conclusions are based on general trends interpreted from data collection. Trophic level interactions are very complex and often will depend upon several factors which may or may not be available in the data. For this reason, this type of study is best done over a long period of time with many sampling dates conducted.

One addition which would help increase the value of the data is an echo sounder. Using this device, it would be possible to find the depth where fish are present during the fish catches. This would be useful for making stronger correlations between the water chemistry, zooplankton, and fish.

Acknowledgements

The author would like to thank the National Science Foundation, World Wildlife Federation, and the Tanzanian Fisheries Research Institute for their financial support of this study. In addition, the Nyanza Project and Lake Tanganyika Biodiversity Project are greatly appreciated for providing the opportunity, facilities, and equipment for this research.

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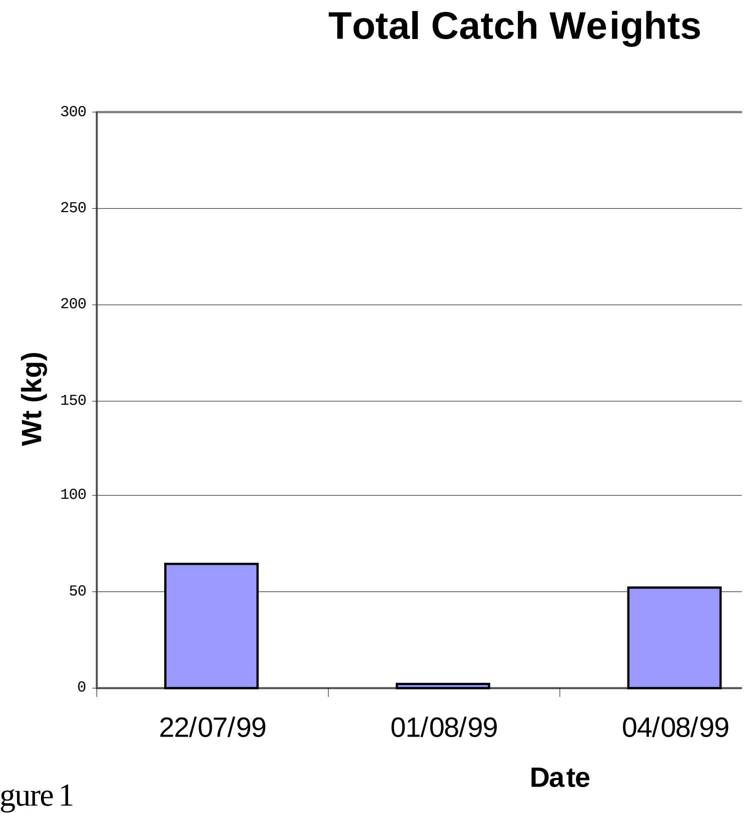
Coulter, G. Lake Tanganyika and Its Life. 1991



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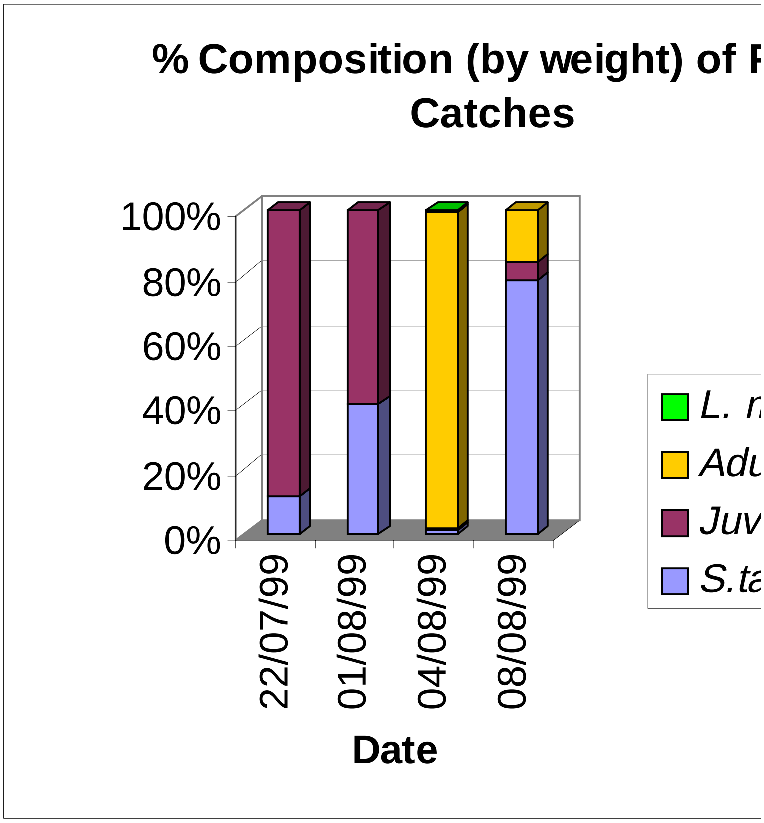

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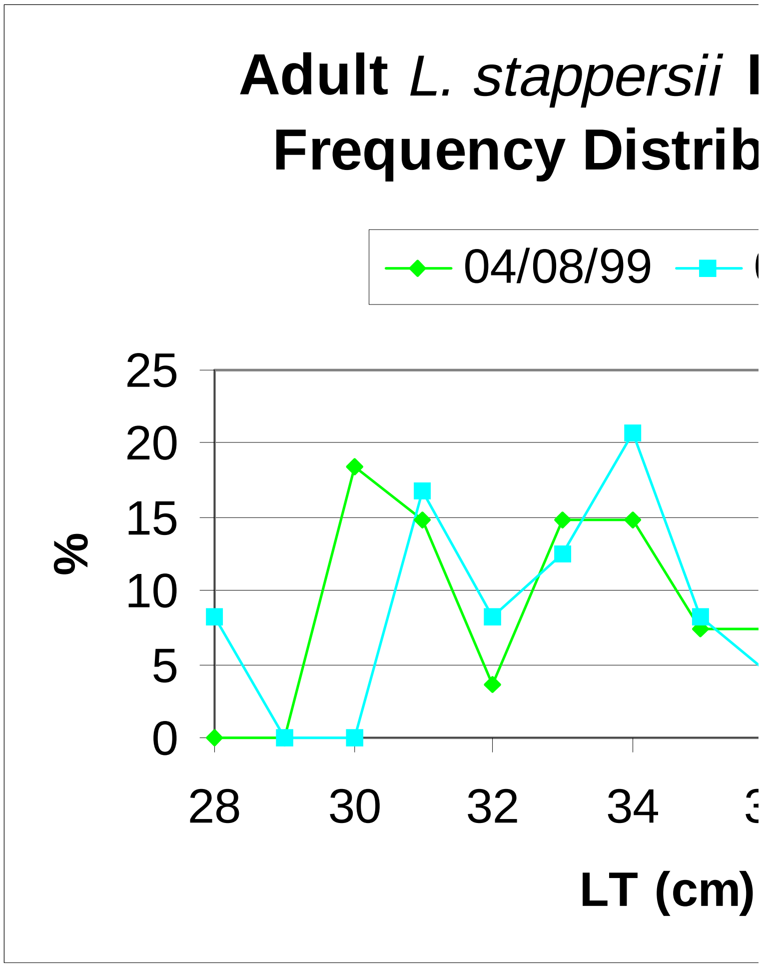

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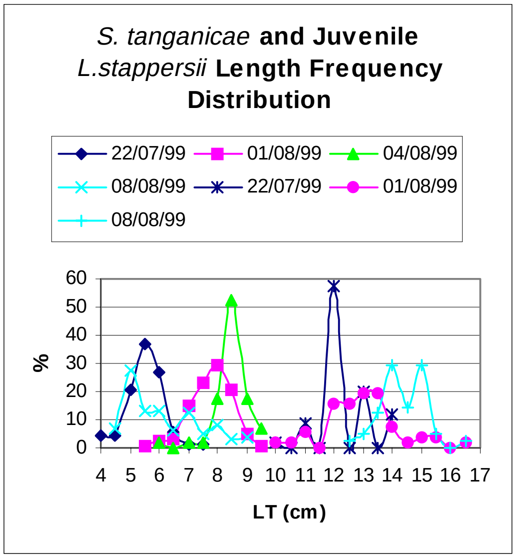

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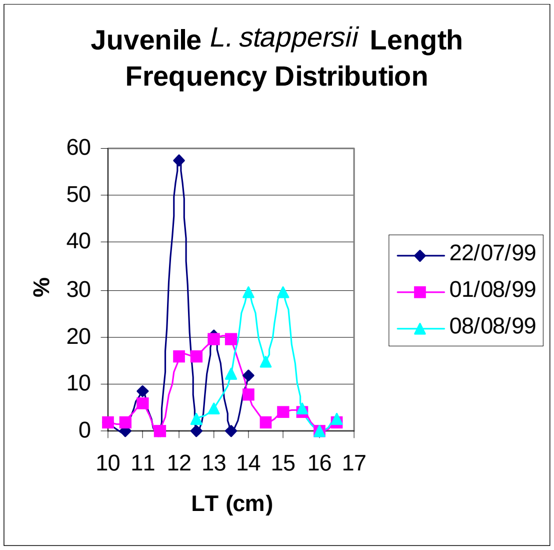

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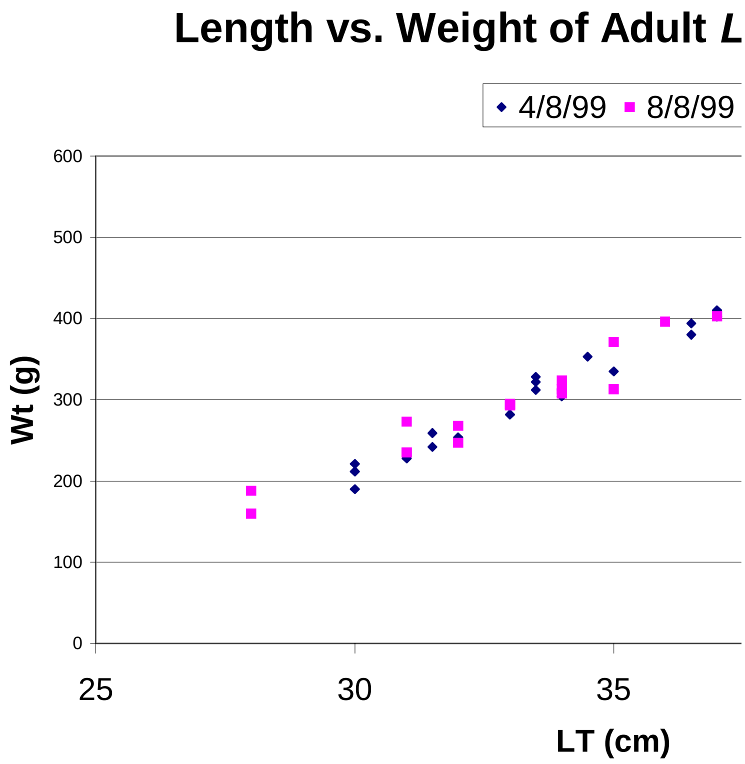

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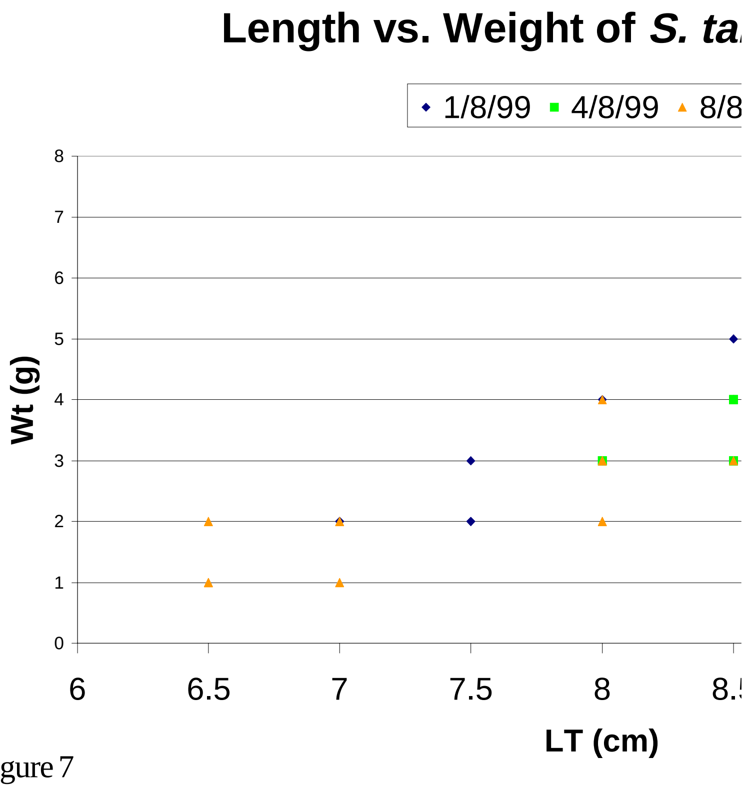

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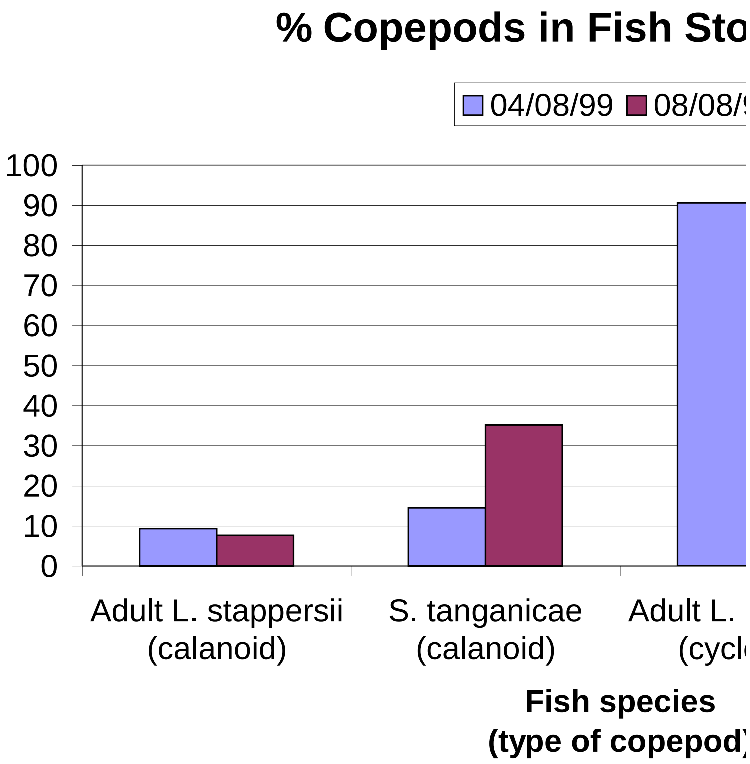

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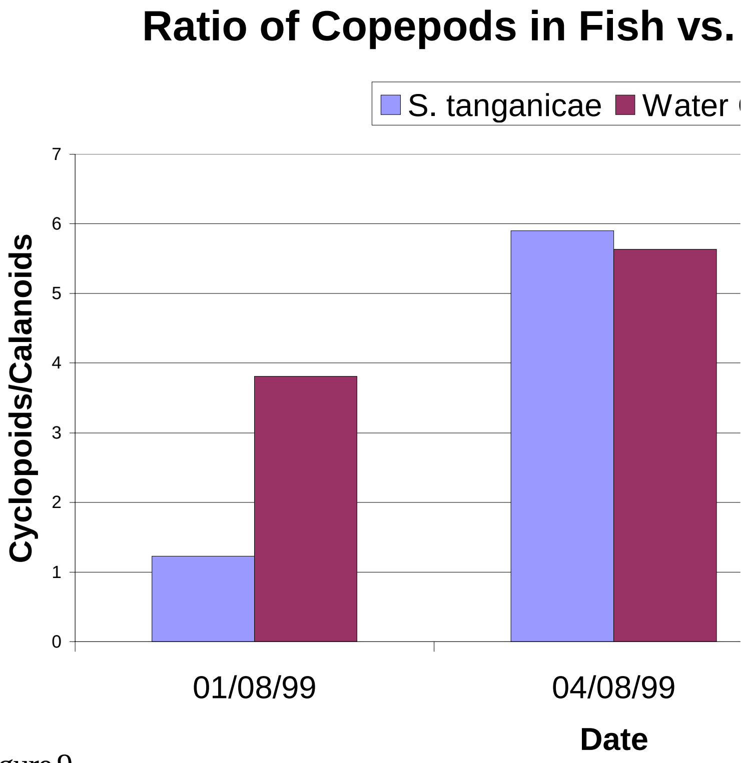

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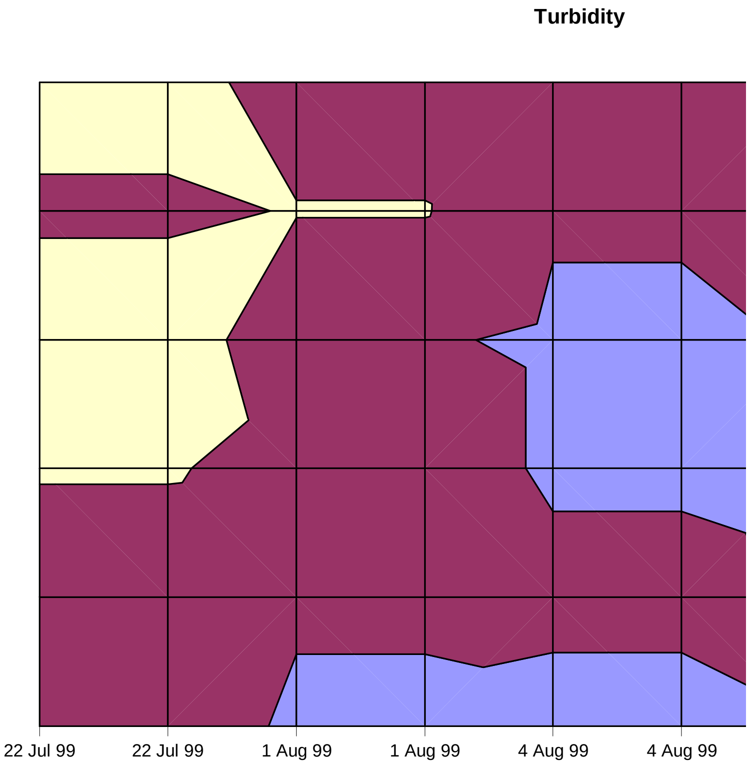

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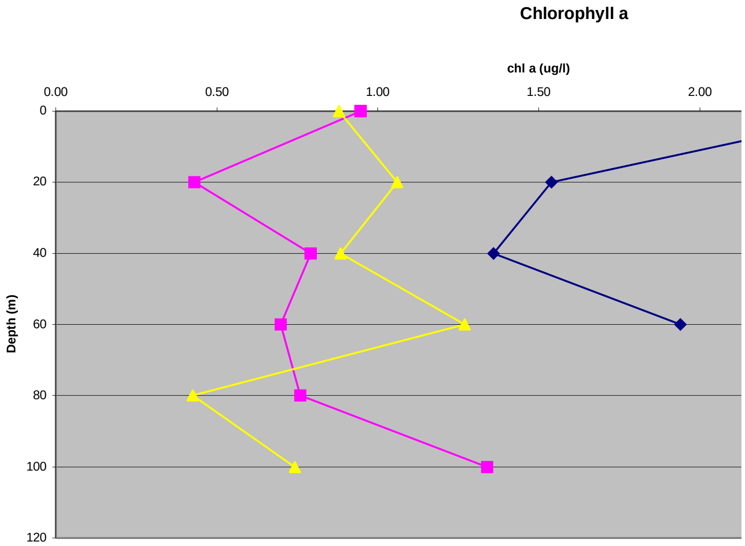

Figure 11

Patchiness in Gastropod Abundance and Diversity at Jakobsen's Beach: A Depth Survey using SCUBA

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University of Dar es Salaam, Tanzania
Mentor: Ellinor Michel

Objectives

To quantify variation in abundance and species richness of rocky substrate gastropods across depths and along N-S geographic gradient at Jakobsen's beach, Kigoma. Ultimately this will provide data for a temporal comparison with last year's Nyanza Project gastropod diversity team, an macroinvertebrate parallel with Heuser's ostracod data, and a benthic grazer link with Knox's physical map of aquatic substrates at Jakobsen's beach.

To test the suggestion that there is a general biogeographic boundary that can be specified at Jakobsen's beach #1. *L. coronata* is known to have the current end of its range here, and does not seem to occur on the rocky substrates between beaches 1 & 2, or to the north of Jakobsen's beach. I sought to quantify diversity across taxa to test whether there are there effects for other gastropods as well?

Materials and Methods

Sampling sites were determined by the sediment sampling protocol established by Knox, with transect lines placed every 20m shoreline distance. I counted all gastropods in a 2m^2 quadrat (made from rope, sand bagged at the corners to allow definition of uneven surfaces) placed over large rock surfaces that were horizontal, to slightly inclined (i.e. no vertical surfaces were sampled). With the help of a dive buddy, I collected all visible snails in the quadrat at 1, 2, 5 and 10 m depths, identified them underwater to species, and returned them to their habitat. At the same locations, just at the base of the rocky surfaces, I collected sediment samples from appoximately 0.25m^2 quadrats at the same sites. I sieved these samples in the laboratory, separated dead from live collected shells using rose bengal (a protein stain) as an indicator, then identified the number of individuals in each of the species using a binocular microscope. In this manner, I sampled both large and small gastropods quantitatively. Analyses are presented here on live material only.

Analysis

Preliminary analyses were graphical, showing abundance by species at each site and depth with histograms. Fisher's alpha was used as a combined index of diversity and abundance, while similarities between sample transects and sites was done with cluster analysis (K-means (not shown) and heirarchical clustering of sites by depth). Generally I analyzed the data in two blocks: sites to the north of beach #1 and sites to the south of beach #1.

Results and discussion

Fig. 1 shows the gastropod species abundance, as sampled by SCUBA on rocky substrates, on the northern side of beach #1. *Reymondia*, *L.nassa* and *L.grandis* decrease with depth while *Nov. gen.* increased with depth. Fig.2 , shows the comparably sampled species abundance to the south of beach #1. Here both *L. nassa* and *Nov. gen.* increased with depth. The overall abundance in the southern side was higher compared to the northern side, perhaps because the rocky substrate in the southern part covers a much greater area compared with the northern part. The differing extents of the substrates are shown clearly in Knox's substrate map from this year. Additionally, there are roads down to the beach near the northern section which might contribute to the increase sedimentation and thus reduce the abundance of gastropods in the northern side.

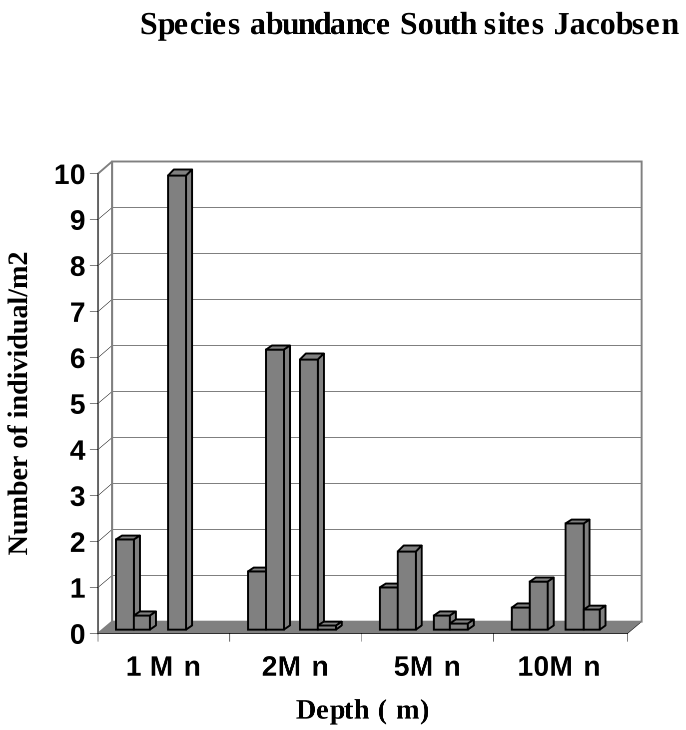
Figs. 3 & 4 show the results from the sieve sample analyses of smaller gastropods in sand sediment at the base of the rocks sampled in the dive data above. Both figures indicate that most of the species increased in abundance with depth in both the northern and southern sampling areas. I suggest that microgastropods were found mainly in deeper waters because it is below wave base and less disturbed when comparing with shallow waters. Figure 4 indicates that overall microgastropod abundance is greater in the deep waters of the northern sampling area than the southern area, perhaps because it receives more sediment input. Since the quantity of sediments was higher , the amount of detritus might be higher too compared to the predominantly rocky area of the southern area.

Fig.5 shows Fisher's alpha index for each sampling site. The general trend shows that the diversity is higher in the southern part, decreasing towards the north. Transects #6 and #7 had low diversity over all depths. This indicates the patchiness in gastropod distribution and abundance on the local scale of 10s-100s of meters, and cautions us against overinterpretation of spatially limited sampling.

Fig.6a shows the results of the cluster analysis of faunal similarity of sites at 2m depth. At this depth there still is an overriding similarity among sites to the south that contrasts with sites to the north, of Jakobsen's beach #1. Transects 1, 2, 4, and 5 of the north had very similar abundance and diversity, while transects 8, 9, and 10 clustered strongly with each other. However, cluster analyes of transects at other depths did not show this pattern, indicating that the north-south distinction may be a depth dependant pattern.

Conclusions:

Some species might be used as depth indicators, e.g. *Nov. gen.* , and *Anceya* are common in deep waters while *L.grandis* is common in shallow waters. Patchiness was observed to be high between quadrats on rocky substrates at Jacobsens beach. Fisher's alpha varies greatly between transects and depths, indicated highly localized patchiness. Based on cluster analyses, there is no indication of a biogeographic boundary between rocky areas north and south of Beach 1 except for the distribution of *Lavigeria coronata*.The sharpness of a biogeographic boundary at Jakobsen's beach #1 was not supported across taxa, though the overall patchiness of results suggest that more replicate sampling is needed.



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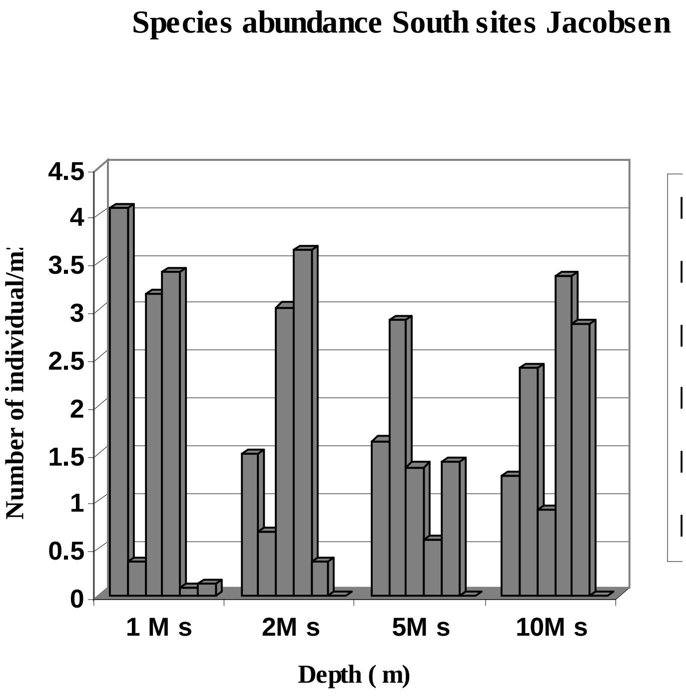

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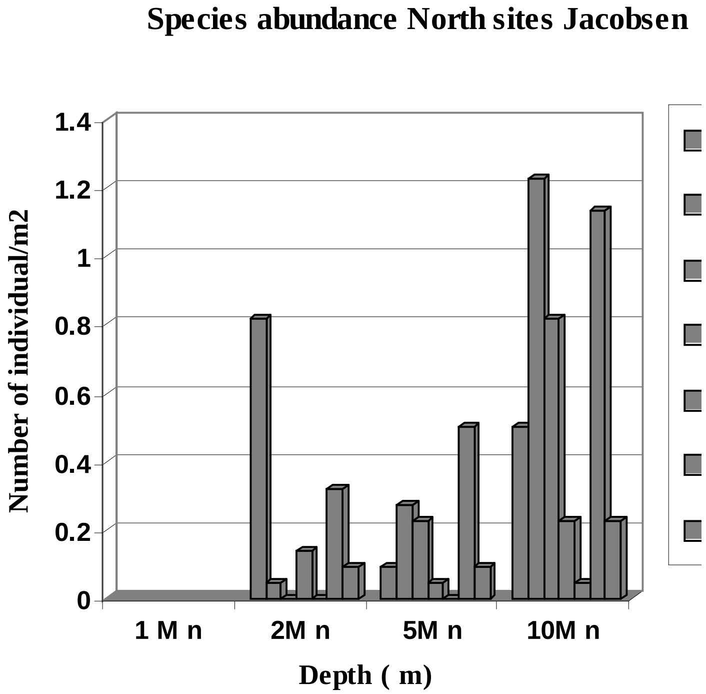

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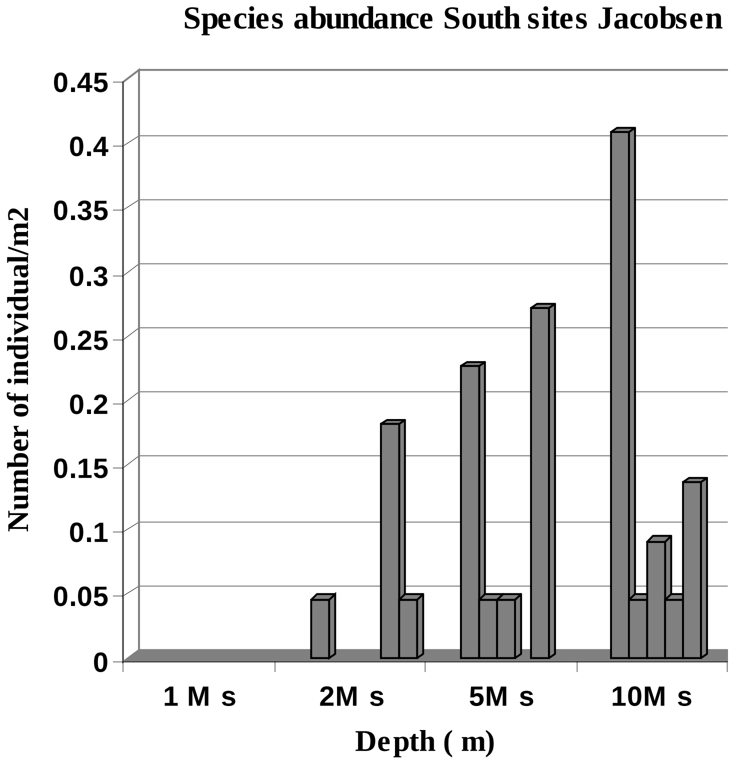

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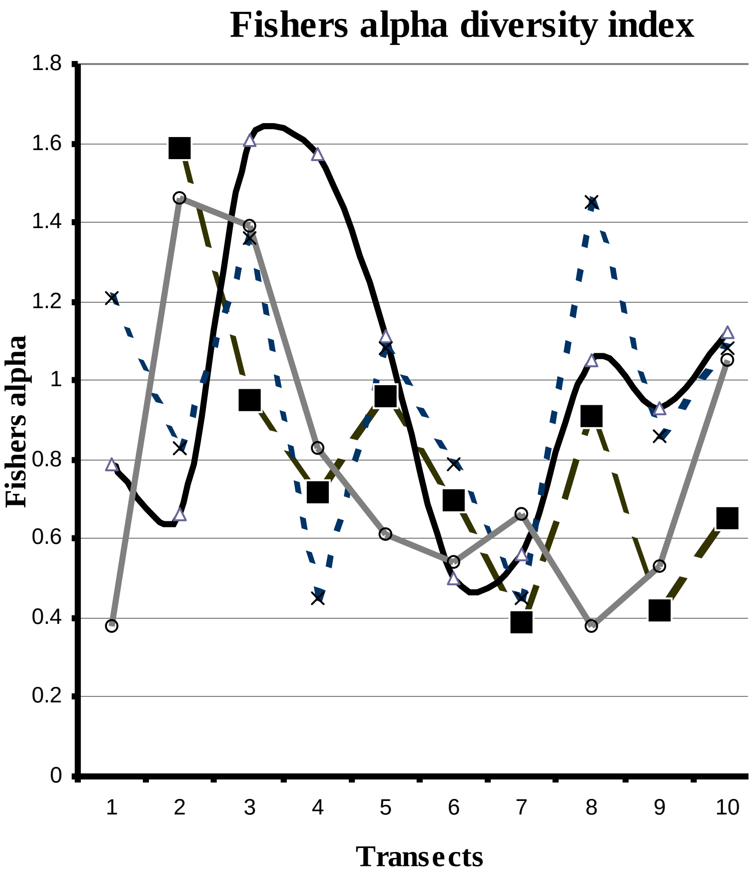
Fishers alpha diversity index
Fishers alpha
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1
2
3
4
5
6
7
8
9
10
Transects

Figure 5

Snail Distribution and Diversity South of Kigoma Bay, Lake Tanganyika, East Africa

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Northern Arizona University, Flagstaff, AZ, USA
Mentor: Ellinor Michel

Introduction

At 12 million years old and 1470m deep Lake Tanganyika is one of the most unique places on earth. It is the birthplace of many species flocks including those found in cichlid fish and algae-grazing gastropods. The highly sculptured endemic snails of Lake Tanganyika have been a source of amazement and questions since they were first brought to the attention of the European scientific community. Due to their striking similarity to marine gastropods they were a key element in the formation of "The Tanganyikan Problem" (Moore 1903). This hypothesis attempted to explain the many apparently marine elements of the L. Tanganyika fauna (large crabs, freshwater sardines, and jellyfish) by claiming it was, at one time, connected to the Indian Ocean. While this hypothesis finds little support today, the unique fauna of L. Tanganyika continues to draw the attention of evolutionary biologists. Due to its remote location, the logistical difficulties of performing research here has slowed our understanding of gastropod phylogeny and ecological relationships. The goal of my Nyanza Project was to develop a distribution and diversity map that can serve as a base of knowledge to help forward our ecological and evolutionary understanding of L. Tanganyika's gastropod community.

Methods

I sampled the eastern shore of L. Tanganyika, from Kigoma Bay south to Kitwe Point every kilometer at seven sites (Figure 1). I also sampled two sites at Gombe Stream National Park which had been sampled by last year's team as well, however these sites are not included on the map. Sites were reached by boat as most were unreachable by road. Although this project was my own, I sampled cooperatively with K. Hinkely and B. At each site we used snorkel gear or SCUBA to collect all macroscopic snails from a 2m x 2m quadrat delineated by a rope with sandbag corners. We collected gastropods only from the tops or sides of rock. Cobbles were not overturned, following last years protocol (France and McIntyre 1998) allowing for a temporal comparison. This technique, while time saving, excluded many juvenile gastropods and as many as six individual Reymondia horei per cobble. We did three replicates at each of 1m and 2m water depth at each site. We chose representative substrate types for the shoreline at each site and did three replicates, with consistent substrates, at approximately 20m distance from each other. All collected gastropods were counted, determined to species and then returned. Each site was categorized as boulders, cobbles, sand or mixed, and sedimented or unsedimented. If substrate was mixed types, we estimated the relative percentages of each type. Snail densities were calculated for each site/depth, as was Simpson's D and Fisher's Alpha and the Jaccard Index of faunal similarity.

Results

During this survey I found eight species of snails falling into three genera: Lavigeria grandis, L. "nassa", L. coronata, L. paucicostata, L. sp."F", Lavigeria "spiny tanzanian", Reymondia horei, and Spekia zonata. Gastropod species richness changed from site to site. Sites 2, 4, and 5 had the maximum species number with 5 and site 6 had the minimum of two species (Fig. 1). The 2m depth at site 3 was the most even with 41% R. horei, 38% L. grandis, and 20% L. coronata. At the other sites species abundance was skewed. L. nassa had the widest distribution, Jaccard Index

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7
Site 1							
Site 2	0.33						
Site 3	**0.20**	**0.33**					
Site 4	0.33	1.00	**0.29**				
Site 5	0.33	0.67	**0.13**	0.67			
Site 6	0.67	0.40	**0.20**	0.40	0.40		
Site 7	0.40	0.80	**0.14**	0.80	0.80	0.50	

being found at all sites except 3 (Jacobsen's Beach) while L. paucicostata and L. coronata were only found at one place each (sites 1 and 3 respectively). Gastropod density and diversity also changed between and within sites with site 5 (2m) showing highest density (125/m^2) and site 2 (1m) the lowest (6/m^2) (Fig.2). L. grandis was always found at bouldered sites and was frequently the dominant species. Here it was joined by S. zonata and R. horei. This situation shifted as the coast turned to sedimented cobbles where L. nassa took the dominant role supported by L. sp. "F" and L. "spiny tanzanian" both uncommon in the low sedimented, bouldered habitat type. Species richness between sites was measured using the Jaccard Index and varied from most similar J = 1 (sites 2 & 4) to J = .13 (sites 3 & 5). Site 3 (Jacobsen's Beach) was the least similar to all sites using the same index (Table 1).

Conclusion

Due to the time crunch involved with this type of program no statistical analysis have been performed. This is my obvious next step as it will allow for comparison between and within sites and hypothesis testing and further interpretation of results. R. horei was found at all sites and was frequently observed under cobbles, though these individuals were not included in the sample, sticking with last year's protocol. This led to an under reporting of the real density of this species and for actual snail density overall. An excellent project for next year would be to do a more complete sampling, counting all snails with a higher number of replicates, which could be extrapolated to gastropod standing biomass of Lake Tanganyika. Gastropods concentrate not only energy and protein, but also calcium carbonate. If they are removed from the ecosystem there might be potential for large-scale water chemistry change. Therefore I also call for an extension of this distribution and diversity map that could be used to learn more about the ecology and evolution of gastropods, as well as monitor their health. One element I would have liked to add was a field measure of sediment and wave energy that would allow for between-site comparisons. These parameters are difficult to quantify, and surely change temporally (from wet to dry season). I will also compare the re-sampled site with last year's results lending an important temporal aspect to this report that is so often missing in science today.

Finally, I wish to stress that from a gastropod and substrate view Jacobsen's Beach is the least similar to all sites. This is reflected in its consistently low Jaccard Indices and low species richness (3) and in being the only site were L. coronata was found. It is also reflected in the geology of Jacobsen's Beach. Of the seven kilometer of coast surveyed it was the only area with a pure sand substrate – not mixed with any cobbles. Because so many Nyanza Projects take place at Jacobsen's Beach it is important to recognize the uniqueness of that site and care must be taken not to over-extrapolate data collected there. This site is commonly used because it is easily accessible by car or boat but we must not let access affect our conclusions.

Acknowledgements

My warmest thanks to Dr. Andy Cohen for organizing the Nyanza Project, Dr. Ellinor Michel for mentoring and support, and Karen Hinkley for all her help and humor.

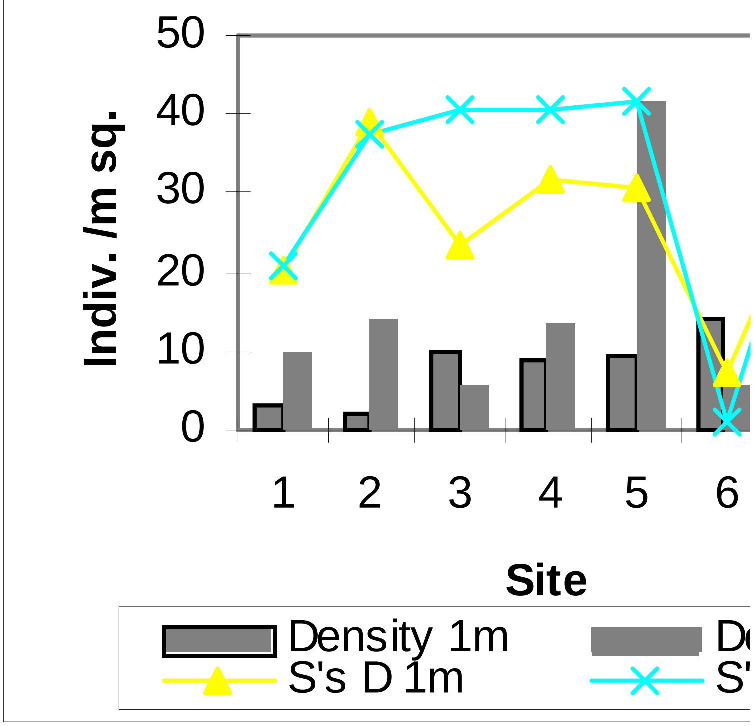

Figure 2. Gastropod Der
Diversity