EFFECT OF CLIMATE CHANGE ON FISH PRODUCTION IN THE VOLTA LAKE.

BY:

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Sponsor: DANIDA

Duration: 3 years (2014 – 2017)
VOLTRES PROJECT – WP 3

WP 1. Climate change and catchment model
Lead: Emmanuel Obuobie
Co-lead: Hans Estrup Andersen
- Climate change projections
- Predictions of lake water inflow, sediments and water quality

WP 2. Lake models
Lead: Ruby Asmah
Co-lead: Dennis Trolle
- Predictions of lake physics and primary production
- PhD on the physical and biogeochemical functioning of Lake Volta

WP 3. Fish productivity
Lead: Hederick Dankwa
Co-lead: Esben Kristensen
- Predictions of fish productivity
- PhD on CC effects on fish productivity in Lake Volta

WP 4. Dissemination and education
Lead: Ruby Asmah
Co-lead: Hans Estrup Andersen
- Stakeholders
- Workshops
- Policy brief
- PhD students
- Scientists
INTRODUCTION

• Fisheries, an important sector of the economy: 4.5% of Agric. GDP (2014), 60% animal protein consumption

• Volta Lake, an important source of freshwater, contributes 80% of inland catches and houses 80% of aquaculture production

• Lake is rich in fish fauna: 132 different species dominated by Chrysichthys, Tilapia and Synodontis species

• Total inland catches from 1969-2015 shows an upward trend, with a decreasing CPUE due to increasing effort (number of canoes and fishermen)

• Environmental factors (Temp., nutrient availability) can also result in changes in fish composition, catches, nutrient loadings, phenological shift

• A climate-related warming of lakes and rivers has been observed over recent decades.
• The climatic condition in the Volta Basin, situated in West Africa, is likely to become warmer as the rest of Africa.

• Temperatures in the Lake region are expected to rise between 1°C and 1.5 °C by middle of the 21st century

• Ghana is listed among the countries that are most vulnerable to climate change because of the high vulnerability of the country’s fishery sector to climate change

Determining climate change impact of fish production in the Lake and establishing appropriate strategies for adaptation are key to ensuring sustainable exploitation, improvement of the socio-economic status of local communities thereby assuring food security.
OBJECTIVES

- To determine the catch composition, species diversity and relationship in seasonal trends in catch and environmental parameters in Stratum III of the Volta Lake

- To determine the effects of seasonal environmental changes on cage fish production in Stratum II of the Volta Lake

- To map out food preferences of some major fish species of economic importance in Stratum III of the Volta Lake

- To make prediction of future fish stocks of Lake Volta using the EcoPath model in the face of changing climate.
Volta Lake

- Located between 1° 30´ W and 0° 20´ N and 9° 10´ N
- Surface area, 8,500 km²; shoreline, 4,880 km
- Max and mean depth of 75 m and 14 m respectively
- Major tributaries: White Volta, Black Volta, Rivers Oti, Afram

Fig. 1: Map of study site
THEME 1: SEASONAL CHANGES IN ENVIRONMENTAL VARIABLES AND FISH CATCHES IN STRATUM III OF THE VOLTA LAKE, GHANA


- Gear type: 2 different types: mono filament, 12 (between 38.1 mm – 190.5 mm) and multi filament, 6 (between 12.5 mm – 40 mm) of length 25 m and 4 m depth

- Fishes caught sorted, identified, grouped into families and morphometric measurements taken

- Environmental parameters: water temp., DO, TDS, nutrients (ammonia, phosphates) and chlorophyll a taken during time of sampling

- Species sampled into and 3 designated hydrological seasons: dry season (Dec–Mar); major wet season (Apr–Jul) and minor wet season (Aug–Nov)

- Data gathered analyzed: diversity indices, ANOVA to describe and compare seasonal catches and PCA to establish relationship with species abundance and environmental parameters
PRELIMINARY RESULTS

A total number of 1557 individual fish samples of 42 species belonging to 13 families recorded in the sampling.

Fig. 1: Fish catch composition in numbers (a) and weight (b) sampled at Kpando Torkor, September, 2014 to August, 2016.
Fig. 2: Trends in monthly fish catch composition by family [in numbers (a.) and weight (b)] in the Volta Lake at Kpando Torkor
### ANOVA and Diversity Comparison of Seasons for Year 1 sampling at Kpando Torkor (Stra. III)

#### SUMMARY

<table>
<thead>
<tr>
<th>Groups</th>
<th>Count</th>
<th>Sum</th>
<th>Average</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major wet</td>
<td>24</td>
<td>293</td>
<td>12.208</td>
<td>233.041</td>
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<tr>
<td>Minor wet</td>
<td>31</td>
<td>258</td>
<td>8.322</td>
<td>114.825</td>
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<tr>
<td>Dry</td>
<td>26</td>
<td>291</td>
<td>11.192</td>
<td>161.041</td>
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</table>

#### ANOVA

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>P-value</th>
<th>F crit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>228.587</td>
<td>2</td>
<td>114.294</td>
<td>0.695</td>
<td>0.502</td>
<td>3.114</td>
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<tr>
<td>Within Groups</td>
<td>12830.7</td>
<td>78</td>
<td>164.497</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>13059.3</td>
<td>80</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Species diversity between seasons

<table>
<thead>
<tr>
<th>Sample</th>
<th>S</th>
<th>N</th>
<th>d</th>
<th>J'</th>
<th>H'</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major_Wet</td>
<td>24</td>
<td>293</td>
<td>4.049</td>
<td>0.8143</td>
<td>2.588</td>
</tr>
<tr>
<td>Minor_Wet</td>
<td>31</td>
<td>258</td>
<td>5.403</td>
<td>0.8101</td>
<td>2.782</td>
</tr>
<tr>
<td>Dry Season</td>
<td>26</td>
<td>289</td>
<td>4.235</td>
<td>0.8455</td>
<td>2.720</td>
</tr>
</tbody>
</table>
Fig. 3: Trends in environmental parameters (a-f) monitored at Kpando Torkor between September 2014 – August 2016.
Fig. 4: A PCA for fish abundance sampled on monthly basis at Kpando Torkor (Stratum III)

Fig. 5: A PCA for monthly fish abundance and environmental factor sampled at Kpando Torkor (Stratum III)
THEME 2: FOOD PREFERENCES OF SOME MAJOR FISH SPECIES IN STRATUM III OF THE VOLTA LAKE

• In each month of sampling (gill netting), the stomach content of five major fish species but of economic importance was collected.

• The content in the stomach will be removed by using dissecting scissors, weighed and collected in glass vials separately and fixed in 95% alcohol and labelled.

• Points method of analysis will be used for analyzing the stomach content.

• Samples will be taken to the Water Research Institute’s lab. for analyses.

• Different categories are allotted a certain number of points and the summations of the points for each food item are reduced to percentages to show the percentage composition of the diet.
Some Results on Stomach Analysis of major fish species of the Volta Lake

Fig. 6: Stomach content analysis of major fish species (Chrysichthys and Tilapia) of the Volta Lake
Fig. 7: Stomach content analysis of major fish species (Alestes, Synodontis and Bagrus species) of the Volta Lake.
THEME 3: THE FUTURE OF VOLTA LAKE FISH RESOURCES IN THE FACE OF CHANGING CLIMATE – THE USE OF PREDICTIVE MODELING

Data Acquisition

• Secondary Data
  - Fish Catch – (Data Source - Fisheries Commission)
  - Water level – (Data Source - Volta River Authority)
  - Water quality – (Data source – Literature)
  - EcoPath Parameters – (Data source – Fishbase)
  - Growth Parameters of major species – (from literature and sampling)

• Primary Data
  - Fish Diet (from stomach content analysis)
  - Zooplankton biomass

Lake Modelling using ECOPATH
Fig. 8: Ecosim multiple run of relative biomasses of groups
Fig. 9: Ecosim group plot for Bagrus species
Fig. 10: Ecosim group plots for Chrysichthys species
Fig. 11: Ecosim group plots for Alestes species
Fig. 12: Ecosim group plots for Synodontis species
Fig. 13: Ecosim group plots for Tilapia species
Comments on slides 9 - 13

Relative abundance of species showed five major families, each contributing more than 5% of total catch. These includes Chrysichthys, Tilapias, Alestes, Bagrus and Mormyrus. However, Chrysichthys and Tilapias were the two most dominate species in the lake forming about 72% of the total catch.

42 different species were encountered in the study, higher than 32 species encountered in a previous study in the stratum (Dankwa et al., 2011). This shows an increase in species diversity probably due to favourable climatic conditions and nutrient availability in the catchment area.
Comments on slides 15 and 16

Analysis of stomach contents identified 42 prey categories belonging to 8 major broad category consisting of: prey fish, zooplankton, green algae, blue-green algae, insects/invertebrates, detritus, diatoms and others (seeds, sand, unidentified items)

Classification of food habits of major species of the Volta Lake at stratum III

<table>
<thead>
<tr>
<th>Fish Species</th>
<th>Type of food habit</th>
<th>Main food items</th>
</tr>
</thead>
<tbody>
<tr>
<td>C. nigrodigitatus</td>
<td>Opportunistic omnivore</td>
<td>Insects, fish, molluscs, algae</td>
</tr>
<tr>
<td>T. zillii</td>
<td>Herbivore (phytophagous)</td>
<td>Algae</td>
</tr>
<tr>
<td>B. bayad</td>
<td>Benthic omnivore</td>
<td>Prey fish and insects</td>
</tr>
<tr>
<td>A. baremoze</td>
<td>Mainly insectivorous</td>
<td>Insects</td>
</tr>
<tr>
<td>S. velifer</td>
<td>Benthic omnivore</td>
<td>Insects and algae</td>
</tr>
</tbody>
</table>
Comments on slides 18 – 23

Figures shows a simulation of ecopath with ecosin multiple run of relative biomasses of the major fish species in the Volta Lake from 1969 – 2014. Actual fish biomass data obtained was from 1990 – 2014. Major fish groups in the Volta are Tilapias and Chrysichthys. Tilapia biomass saw an increase between periods of 1990 – 1998 after which Chrysichthys production took over till 2014. Bagrus and Synodontis biomasses has shown a decline rate since 1990 with marginal increase in Alestes production. Effort by fishermen deploying different gears for fish capture has been on the rise since 1969. Simulated group plots for Bagrus and Synodontis catches differ slightly from actual data plots and this may probably be due to the reliability of data obtained hence more calibration needs to be done to validate the results.