CLP Project No. 0347311
Conserving Endemic and Globally Threatened Fishes
in Lake Manguao, Palawan, Philippines

Philippines, Palawan Island, Lake Manguao in Municipality of Taytay
September 2011 to August 2012

Implemented in collaboration with

Western Philippines University and the Municipal Government of Taytay

“To promote appropriate management/conservation and outreach initiatives
for the globally threatened fishes of Lake Manguao”

Prepared by:

Joie Dicar Matillano
Lorivel Oyendo Atrero

College of Fisheries and Aquatic Sciences
Western Philippines University Puerto Princesa Campus
Rafols St. Sta Monica Puerto Princesa City
5300 Philippines
Email: jmatillano@gmail.com

August 2013
# Contents

Acknowledgements ........................................................................................................... 3

Section I ................................................................................................................................. 4

Summary ................................................................................................................................. 4

Introduction ............................................................................................................................. 5

Project Members ..................................................................................................................... 7

Section II ................................................................................................................................. 9

Aim and Objectives ................................................................................................................ 9

Methodology .......................................................................................................................... 9

- Assessing fish habitat association/habitat quality ................................................................. 9
- Identifying anthropogenic threats and sources of habitat shift in catchment ................. 10
- Studying exotic species impact .......................................................................................... 10
- Conducting conservation education programs .................................................................. 11

Outputs and Results ............................................................................................................. 11

- Species Diversity ................................................................................................................ 11
- Spatial distribution and habitat association ..................................................................... 14
- Farming practices in Lake Manguao .................................................................................. 15
- Exploitation of fishes ......................................................................................................... 17
- Nile tilapia diet .................................................................................................................... 17
- Conservation Education in the Local Community and Schools in Taytay .................. 21
- Participation of Local Village Leaders, Municipal Government, and NGOs ............... 21
- Participation of Research Institutions .............................................................................. 21

Achievements and Impacts .................................................................................................. 22

Section III ............................................................................................................................... 25

Conclusion ............................................................................................................................. 25

Problems Encountered and Lessons Learned .................................................................... 25

In the Future .......................................................................................................................... 27

Section 4 ................................................................................................................................ 28

Appendices ............................................................................................................................ 28

Bibliography .......................................................................................................................... 33

Distribution List ..................................................................................................................... 34
Acknowledgements

The team members are grateful to the funding provided by the Conservation Leadership Program through its Future Conservationist Award which enabled the team to accomplish this project. We are equally indebted to Rufford Small Grants Program, the Idea Wild, and The Ford International Fellowship Program-Philippines for contributing funding for this project. We are also thankful to the Western Philippines University (WPU), the State University of New York College of Environmental Science and Forestry (SUNY ESF) and the World Wild Fund for Nature (WWF) project in Taytay for allowing us to use their facilities and equipment during the conduct of this project in Lake Manguao.

We would like to extend our gratitude to the municipal government of Taytay particularly to Mayor Romy L. Salvame and the Sangguniang Bayan Members for extending various supports to our project team including both logistics and professional advises during the implementation of this project. We are also thankful to Mr. Jojie Laurente for all his insights about conservation of Lake Manguao. We are equally grateful to the late Evelyn Rodriguez, former mayor of Taytay for her full support while she was in office.

We dedicate the success of this work to the late Madam Ester Dacuan, who served as our most staunch supporter, collaborator, and at the same time our inspiration in pursuing the conservation of Lake Manguao and its unique flora and fauna. Lastly, we are most grateful to the community around Lake Manguao, particularly the Edep family who had been very warm, friendly, and supportive to us, not only during the conduct of this project but during all of our field visits in the lake.
Section I

Summary

This project aimed to develop appropriate management, conservation, and outreach initiatives for globally threatened fishes of Lake Manguao through assessment of fish habitat association and habitat quality, identifying anthropogenic threats, studying the impact of the exotic species Nile tilapia, and conducting conservation education programs for the local populace. We used standardized fish surveys and field interviews and actualy field surveys to assess the fish habitat and human threats to the lake. For the diet analysis of tilapia, standardized gut content analysis was used. Implementation of the outreach program to promote conservation used focused group discussion, workshops, and visits to schools to present results of the project. We also conducted multiple meeting with the local government of Taytay and the members of its Sangguniang Bayan regarding the establishment of Lake Manguao as a protected area.

Results indicated that the key threatened species in the lake and the lake endemics have specific habitat preference in the littoral area and one species restricted in the open water zone of the lake. The coastline survey of the lake indicated the variability in water level between dry and wet season in ranges of between one to four meters and the surface area of the lake ranging between 660-900ha. It was found out that the vegetation cover in the catchment did not change significantly. For the diet of fishes, tilapia was predominantly planktivore during dry season and partly omnivore during rainy season while the lake endemic fishes were mainly omnivorous to detritivorous, except for one species, which is purely carnivore. For the conservation outreach, we have conducted series of environmental education campaign, raising the awareness of local studentry. However, the biggest achievement that we could boast so far is the move of the municipality of Taytay to pass a legislation that will declare the lake as a protected area.

We have already submitted the final reports of the project to the municipality and this will serve as the basis for the drafted resolution establishing the lake as a municipal conservation area. Through this project, a draft Memorandum of Agreement (MOA) between Western Philippines University (WPU) and the municipality of Taytay was proposed and is currently in the process of review before the formal signing. This MOA may pave the way for the establishment of the Lake Manguao Biological Field Station that will house a museum for the lake flora and fauna, a dorm for visiting researchers, a visitor center, and a weather station and limnology and general biology laboratory.
Introduction

This project is the most comprehensive assessment of the fish fauna of Lake Manguao. As such, the results that we have generated in this project are vital in the management and conservation of Lake Manguao and its watershed. As a comprehensive survey of the lake’s fish fauna, this research and conservation activity addresses the data gaps on the habitat association of the threatened fish species, particularly on where within the lake the fish are during the different life history stages. It also addresses the concerns on the impact of the exotic Nile Tilapia to the native fishes in Lake Manguao, with emphasis on its potential as a pest that may feed on the indigenous fish fauna. In addition, we also assessed the anthropogenic threats within the lake, particularly habitat destruction and denudation of the lake’s catchment and the farming and fishing practices that may affect the fishes and habitats. Lastly, many people outside the lake’s basin have low awareness on conservation significance of the lake and this was highlighted and given priority in this work.

Lake Manguao is the only freshwater lake in mainland Palawan. It is located in the rolling hill zone of Taytay, a municipality in northern Palawan, Philippines. The lake is about 640-900ha, endorheic (no surface outflow), and was formed after a volcanic eruption blocked an ancient river valley that drained to the east coast of Palawan Island (Davies and Green 1990). It has a catchment area of 4,425 hectares with primary and residual old growth forest. The lake has a maximum depth of 14 meters during rainy season and about 11 meters during dry season (Matillano 2004). On the periphery of the lake are marsh areas and swamp areas (Figure 1 and 2).

As the only sizeable freshwater lake in Palawan with its own set of unique fish species, Lake Manguao is one of the two major lakes of the Philippines that harbors distinct endemic cyprinid populations, the other being Lake Lanao (Herre 1924, Day, A. L. 1914). The Lake Manguao basin has three endemic freshwater fish and over ten globally threatened fish and other vertebrate species (Matillano 2004, IUCN 2010). The three endemics, *Puntius bantolanensis*, *P. manguaoensis*, and *Bostrhycus expatria* are the flagship of this project. Lake Manguao is also a Philippine Key Biodiversity Area and priority research area (CI 2007, Anda & Tabangay-Balder 2004) owing to the presence of relatively good habitat and numerous threatened species. Its catchment is also home to at least 10 species of birds, one freshwater turtle, and at least one species of freshwater crab, all of which are endemic to the Palawan faunal region (CI 2007, IUCN 2013).

The key partners that we have worked with in this project are the municipal government of Taytay, particularly the office of the Mayor, the Sangguniang Bayan of Taytay (SB), and the municipality’s Environmental Monitoring and Protection Section (EMPS). In addition, we have worked closely with the Western Philippines University particularly with the students and faculty members of the College of Fisheries and Aquatic Sciences.
Figure 1. Lake Manguao panorama viewed from the western coast.

Figure 2. Topographic map of Lake Manguao, municipality of Taytay, Palawan Island, the Philippines.
Project Members

Joie Matillano – Team leader. In charge of overall implementation of the project and spearheaded student mentoring and conservation planning workshops and fish habitat sampling. Did several studies on freshwater fish taxonomy in Palawan and have been teaching biology and ecology courses in. Have experience in gut content analysis of fishes and relevant trainings in freshwater fish taxonomy, IUCN Redlist Assessment, and conservation education. Currently an Assistant Professor at WPU and at the same time a Ph. D. Student at State University of New York (SUNY ESF).

Daniel Gurdak - Daniel is certified in GIS software application at City University of New York (CUNY Lehman). His research activities in the tropics have taken him to Australia, Peru, Ecuador, and India where he has conducted ecological research and conservation activities. Recently he has become involved in conservation education and outreach in both the US and abroad. Daniel is currently a 4th year Ph.D. student at SUNY College of Environmental and Forestry. His thesis will focus on fisheries conservation and management in the Amazonian Region of Brazil. Daniel is also in charge of the GIS component and the medical officer of the project.

Eduardo Bolen. Eduard finished his bachelor's degree in Aquatic Biology from Western Philippines University. A fisherman by profession, he has extensive experience in fish trapping and netting and worked with WWF for two years conducting fisheries inventories. He is a seasoned fisherman that has more than a decade of fishing experience using multiple gears. He is also fluent in at least three local dialects spoken in Lake Manguao. Eduard has extensive field experience in Lake Manguao and has been participating in fieldworks in the lake since his college days 5 years ago. He is currently employed at WWF Philippines.

Lorivel Atrero - Lorivel has dual Bachelor of Science Degree, one in Aquatic Biology and another in Secondary Education. She is in charge of the Conservation education, fish taxonomy and ecology components of the project. She is also the team representative during the CLP Alumni Training in Canada. She is currently preparing for her Licensure Exam for teachers while being a full time mom to her kids.

Shiela Rose Jimenez. Sheila was not able to join the team after she got hired on a full time job in Manila. However, several students from WPU participated in the project and joined us during the field season and in effect, provided replacement for her.

Patrick Anthony Saclet. BS Fisheries graduate of WPU. He was responsible for fish sampling particularly in the littoral zones of the lake. He also conducted his undergraduate thesis in Lake Manguao. After the project, he applied for and is currently employed as Field Coordinator at WWF Philippines.

Kymry Delijero. BS Fisheries graduate of WPU. Another student volunteer that ended up joining our project team for most of the sampling and meetings/workshops. Helped in the efficient sampling of gut contents of Tilapia and in capturing sample specimens during this project. After the project, he applied for and is currently employed as research assistant at WWF Philippines.
Kristine Amador. BS Aquatic Biology graduate. She was also one of our student volunteers that eventually we decided to make as one of the regular participants during the fieldwork. She did an undergraduate thesis in the lake and took care of sampling of gut contents of fishes, particularly for Tilapia. She is currently working as a research assistant for a research project of Palawan State University.

Other student volunteers that provided invaluable help during the field season are Vanessa Rose Dicar, Jeheil Puno, Meia Gabuat, and Jaymark Bantiling. These students conducted their undergraduate thesis in Lake Manguao in collaboration with this project.
Section II

Aim and Objectives

The endemic fish fauna of Lake Manguao is poorly known and increasingly threatened by habitat conversion and introduction of exotic species (Matillano 2004). The catchment area of the lake is also threatened by habitat destruction due to slash and burn farming. Despite uniqueness of the lake’s fish fauna, the introduction of an exotic species occurred in the early 1990s, releasing more than 10,000 nile tilapia in the lake, thereby posing threat to the native fishes. This project aims to develop appropriate management, conservation, and outreach initiatives for globally threatened fishes of Lake Manguao by 1) assessing fish habitat association/habitat quality, 2) identifying anthropogenic threats, 3) studying exotic species impacts, and 4) conducting conservation education programs. We hope to achieve these objectives by using standardized fish surveys and implementing local/regional outreach program to promote conservation of these taxon, ultimately advocating for establishment of protected area in Lake Manguao with integrated sustainable watershed land use practices.

Methodology

Assessing fish habitat association/habitat quality

a. Fish habitat association
   i. Nine sampling sites were sampled within the littoral zones of Lake Manguao (Figure 3 L1-9) representing different substrate conditions: sandy beach with sandy bottom, rocky bottom, muddy bottom, and sandy-muddy. Two sites each were sampled for Open water (O1-2) and stream habitat (S1). Sampling were done in October and December 2011. Beach seine was used for the sampling in the littoral zone (specs: 12 m wide, 1m high, with a bag length of 4m and mesh size of 3mm). Triplicate sampling was done for each station. Seining is parallel to the shore covering a distance of 40m. In the two biggest cove of the open water zone of the lake (O1-2), three different sizes of gill nets were used (no. 4, 6, and 9). Each gill net was set 100m from each other and was checked within an hour upon set up for three hours each day. Trawling was done in mid depth water (4-5m), however, since we were catching the same species as that in the gill net, we just used this method once. For the stream stations (S1), seine, scoop net and cast nets were used. Specimens caught were identified, counted, and measured (in mm). Within/between habitat diversity in the littoral zone were analysed using Shannon-Weiner Diversity Index.

b. Habitat quality
i. Data on depth, temperature, water clarity, substrate, ambient water parameters, and type of aquatic and riparian vegetation were gathered to characterize sampling areas.

Figure 3. Sampling stations in Lake Manguao during the fish habitat survey (L-littoral, S-Stream, O-Open water).

Identifying anthropogenic threats and sources of habitat shift in catchment

a. Satellite images acquired from the municipal and provincial government were used to analyze changes in catchment vegetation and water level, coupled with site validation and ground-truthing, including surveying the entire coastline of the lake. Interviews on land use practices were done using structured interviews and asked in a way that the interviewees can express themselves freely. Relative frequency of responses were analysed graphically.

Studying exotic species impact

a. This was done by examining the diet of the introduced Tilapia to determine predation and competition for food with the endemic fishes. Samples were collected from the lake for both high and low water season and were compared seasonally and by size class. To emphasize the variation of food items of *O. niloticus* in different size classes, three (3) size ranges were established (class
size 1 (5.5-10cm), class size 2 (10.5-15cm) and class size 3 (15.5-20cm). Gut contents were preserved in formalin for permanent fixation. Gut content analysis of Tilapia followed the method of Bowen (1983).

Conducting conservation education programs
   a. We presented our results to the local communities in Lake Manguao through focus group discussions with local fishers and their families in the area. In addition, we conducted presentation and workshop in the municipal proper of Taytay. While doing our field samplings in the lake, we also visited local residents and conducted opportunistic Environmental Education Campaigns (EEC) with the community members to update them about the progress of this project. We gave out posters of fishes in Lake Manguao, as well as conducted PowerPoint presentations and meetings. Part of the results of this research was also presented in national and international conferences.

Outputs and Results

   A. Assessing fish habitat association/habitat quality in the littoral zone

Species Diversity
   Twelve species were recorded in this study. Eight species were collected in the littoral zone sampling sites while three species were collected from the stream. One species P. bantolanensis is exclusively caught in the open water zone of the lake (Fig 4). Species richness is highest in L1 (7) while the least number of species was recorded in L3 (2) (Table 2). The diversity indexes suggests stations 2, 4, and 6 have the highest Shannon (H') index, while 4, 5, and 7 exhibited higher values for Inverse Simpson index. Diversity indices shows similar pattern for both high and low water sampling.
Table 1. Fishes collected in Lake Manguao during this study (Appendix 1).

<table>
<thead>
<tr>
<th>Family name</th>
<th>Scientific name</th>
<th>L1</th>
<th>L2</th>
<th>L3</th>
<th>L4</th>
<th>L5</th>
<th>L6</th>
<th>L7</th>
<th>L8</th>
<th>L9</th>
<th>O1</th>
<th>O2</th>
<th>S1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anabantidae</td>
<td><em>Anabas testudineus</em></td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>Channidae</td>
<td><em>Channa striata</em></td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>Clariidae</td>
<td><em>Clarias macrocephalus</em></td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>Cichlidae</td>
<td><em>Oreochromis niloticus</em></td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>Cyprinidae</td>
<td><em>Nematabramis alestes alestes</em></td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td></td>
<td><em>Puntius bantolanensis</em></td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td></td>
<td><em>Puntius manguaoensis</em></td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td></td>
<td><em>Rasbora everetti</em></td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td></td>
<td><em>Rasbora taytayensis</em></td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>Eleotridae</td>
<td><em>Bosthrycus expatria</em></td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>Hemirampidae</td>
<td><em>Dermogenys palawanensis</em></td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>Siluridae</td>
<td><em>Hito taytayensis</em></td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
</tbody>
</table>
Table 2. Fish species diversity indices in the littoral sampling areas in Lake Manguao.

<table>
<thead>
<tr>
<th></th>
<th>L1</th>
<th>L2</th>
<th>L3</th>
<th>L4</th>
<th>L5</th>
<th>L6</th>
<th>L7</th>
<th>L8</th>
<th>L9</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7</td>
<td>5</td>
<td>6</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Dominance_D</td>
<td>0.89</td>
<td>0.90</td>
<td>0.71</td>
<td>0.73</td>
<td>0.53</td>
<td>0.53</td>
<td>0.44</td>
<td>0.46</td>
<td>0.33</td>
</tr>
<tr>
<td>Simpson_1-D</td>
<td>0.11</td>
<td>0.10</td>
<td>0.29</td>
<td>0.27</td>
<td>0.47</td>
<td>0.47</td>
<td>0.56</td>
<td>0.54</td>
<td>0.67</td>
</tr>
<tr>
<td>Shannon_H</td>
<td>0.28</td>
<td>0.25</td>
<td>0.66</td>
<td>0.61</td>
<td>0.67</td>
<td>0.67</td>
<td>0.98</td>
<td>0.95</td>
<td>1.25</td>
</tr>
<tr>
<td>Evenness_e^H/S</td>
<td>0.19</td>
<td>0.26</td>
<td>0.32</td>
<td>0.31</td>
<td>0.97</td>
<td>0.97</td>
<td>0.67</td>
<td>0.65</td>
<td>0.58</td>
</tr>
</tbody>
</table>

Figure 4. Top view of species records of Lake Manguao fishes in sampling stations.
Spatial distribution and habitat association

Gill net sampling in the open water zone (O1 and O2) showed that only B. expatria, P. bantolanensis and O. niloticus occupy the open water zone of the lake while the rest of the endemics are restricted in the littoral zone or in the inflows. Likewise, P. bantolanensis was observed to inhabit the bottom of the lake while O. niloticus is more concentrated near the surface, but the latter is also present in all habitat type in the lake and disperses in the floodplains during high water level (Figure 4 and 5). In the sampling stations along the stream, the dominant species are R. everetti and O. niloticus.

<table>
<thead>
<tr>
<th>Lake endemics</th>
<th>Palawan endemics</th>
<th>Native, non endemic</th>
<th>Exotic</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. bantolanensis</td>
<td>D. palawanensis</td>
<td>N. alestes alestes</td>
<td>O. niloticus</td>
</tr>
<tr>
<td>P. manguaoensis</td>
<td>R. everetti</td>
<td>C. striata</td>
<td></td>
</tr>
<tr>
<td>B. expatria</td>
<td>R. taytayensis</td>
<td>C. macrocephalus</td>
<td></td>
</tr>
<tr>
<td></td>
<td>H. taytayensis</td>
<td>A. testudineus</td>
<td></td>
</tr>
</tbody>
</table>

Figure 5. Cross section illustration of Lake Manguao (not to scale) showing the fish community assemblages in the water column.

Sandy-muddy habitats showed the most number of individuals and species with more than 6,515 specimens while the substrate conditioned with the least abundance is sandy beach (Table 3). Both Rasbora species and D. palawanensis are most commonly caught in sandy-muddy areas while P. manguaoensis, O. niloticus, and H. taytayensis prefers muddy bottom habitats. The habitats with the least number of species are rocky shores.
Table 3. Number of individuals per species for each different substrate condition in littoral zone during October and December 2013.

<table>
<thead>
<tr>
<th>Species Name</th>
<th>Sandy-muddy (L1, S6, S9)</th>
<th>Muddy (L3, L5)</th>
<th>Rocky (L7, L8)</th>
<th>Sandy (L2, L4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Oct</td>
<td>Dec</td>
<td>Oct</td>
<td>Dec</td>
</tr>
<tr>
<td>Bosthrycus expatria</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Dermogenys palawanensis</td>
<td>39</td>
<td>30</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Hito taytayensis</td>
<td>2</td>
<td>1</td>
<td>22</td>
<td>19</td>
</tr>
<tr>
<td>Nematabramis alestes alestes</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Oreochromis niloticus</td>
<td>13</td>
<td>11</td>
<td>527</td>
<td>499</td>
</tr>
<tr>
<td>Puntius manguaoensis</td>
<td>139</td>
<td>128</td>
<td>871</td>
<td>884</td>
</tr>
<tr>
<td>Rasbora everetti</td>
<td>6264</td>
<td>5989</td>
<td>322</td>
<td>312</td>
</tr>
<tr>
<td>Rasbora taytayensis</td>
<td>56</td>
<td>51</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>Total Species</td>
<td>8</td>
<td>8</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>TOTAL INDIVIDUALS</td>
<td>6515</td>
<td>6215</td>
<td>1760</td>
<td>1731</td>
</tr>
</tbody>
</table>

Littoral habitats of Lake Manguao also showed similar water transparency (>1m), and high levels of DO (7.1-8.5 mg/l) and pH (7.2-7.8), all of which are well within acceptable levels. Littoral vegetation ranged from emergent reeds in windy areas and floating water hyacinth in quiet coves (Appendix 2 and 3).

**B. anthropogenic threats and sources of habitat shift in catchment**

**Farming practices in Lake Manguao**

Results of our interviews (n=39 families) revealed that majority of the households (63%) are subsisting on farming and fishing or a combination of the two. Among the farmers, the biggest percentage are into rice production and planted their farm with fruit trees (Fig. 6). Illegal logging and kaingin (slash and burn farming) are the most cited causes of habitat degradation in the catchment (100% of the respondent) while forest fires was also mentioned (Appendix 4).
GIS data for Lake Manguao showed that the lake’s forest cover is still around 50% original forest (Fig. 7). For water level fluctuation, results showed that the lakes depth varied more than three meters between dry and flooding season. Also, the lake’s area considerably increase from ca. 640ha to almost 900ha between dry and wet season. In the map below, the white lines represent the dry season water level and the blue water is the flooded lake level (Figure 6). Photodocumentation of the lakes western coast also shows the big difference in water level during flooded and dry periods (Fig. 8).

Figure 6. Area in hectares and percentage of farming practices in Lake Manguao (N=69ha).

Figure 7. GIS Map showing the vegetation cover and changes in water level in the lake during flooding and dry season.
Figure 8. Photo of the west coast of Lake Manguao during dry (left) and flood (right) season.

**Exploitation of fishes**

Of the 12 species of fish recorded during this study, only *O. niloticus* is regularly harvested for trading and local consumption. *Clarias* and *Channa* are targeted but mostly for local consumption, together with *Hito*. The lake endemic species are locally consumed if present as bycatch but are usually discarded. Smaller species (*Rasbora, Dermogenys, Nematabramis, Anabas*) are not exploited at all.

**C. Assessment of potential impacts of *O. niloticus* to the native fishes**

**Nile tilapia diet**

Cyanobacteria, leaf particles and wood particles represented by plant parts and sand particles are the natural food items found in the stomach of *O. niloticus*. Cyanobacteria was the most abundant food in the stomach where it accounted for 55% of all the food items found, while sand particles (5%) was the least abundant item (Table 4). Subsequently, relative importance of determined food categories in the diet of *O. niloticus* shows that cyanobacteria (58%) were the most important food. Sand particles accounted for 1%.

Table 4. Summary of stomach contents analysis of all *O. niloticus* samples collected in Lake Manguao.

<table>
<thead>
<tr>
<th>FOOD ITEMS</th>
<th>Frequency of Occurrence</th>
<th>Volumetric Analysis Index</th>
<th>Importance Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyanobacteria</td>
<td>31%</td>
<td>55%</td>
<td>58%</td>
</tr>
<tr>
<td>Leaf Particles</td>
<td>29%</td>
<td>19%</td>
<td>19%</td>
</tr>
<tr>
<td>Wood Particles</td>
<td>31%</td>
<td>21%</td>
<td>22%</td>
</tr>
<tr>
<td>Sand Particles</td>
<td>9%</td>
<td>5%</td>
<td>1%</td>
</tr>
</tbody>
</table>

Seasonal occurrence of different food items in the stomach of *O. niloticus* shows that during low water level, *O. niloticus*’ gut contains more cyanobacteria and leaf particles while for the period of high water level cyanobacteria and wood particles (31.8%) are more common (Fig. 9).
For relative abundance of different food items observed in the stomach of *O. niloticus* during low and high water level, cyanobacteria was found to be the most abundant at 49.17% and 59.61 respectively (Fig. 10).

The relative importance of the particular food item in the diet of *O. niloticus* varies between the two different seasons, Figure 11 shows that cyanobacteria is the more important food item in the diet of *O. niloticus* during low and high water period (63.93 and 50.83% respectively).
Since fish size is one of the factors that determine feeding changes of fish species (Akinwumi 2003), we also analyzed the food items of different size classes. Figure 12 shows that all size classes have higher occurrence of cyanobacteria in their diet. However, the most striking contrast is the higher occurrence of sand particles in the diet of size classes 1 and 2.

In terms of abundance and importance, the same general pattern is observed for the different size classes where the importance of cyanobacteria in the diet increases as the fish grows (Fig. 13 and 14) (Appendix 5).
Figure 13. Volume of food items in three size classes of *O. niloticus*.

Figure 14. Importance of food items in three size classes of *O. niloticus*. 
D. Conducting conservation education activities

Conservation Education in the Local Community and Schools in Taytay

At least 90 percent of the population of Lake Manguao (ca 250) was reached during the information education campaign that we conducted. We also distributed posters and pamphlets about the lake and its unique wildlife and habitats. The largest target audience we have reached was during the local festival of Taytay where we presented a powerpoint show of Lake Manguao. This festival is attended by more than 5000 residents of Taytay from all its villages. We also presented the results of this project to the local schools with combined studentry of more than 1500 (Appendix 6).

Participation of Local Village Leaders, Municipal Government, and NGOs

We held meetings and workshops with the village leaders and community members of Barangay Poblacion, the LGU with jurisdiction over Lake Manguao. We also had four presentation with the Sangguniang Bayan of Taytay to update them with the results of this project and discuss the next steps to protect Lake Manguao. We also participated in two workshops of the municipal Tourism Council to provide inputs for Lake Manguao tourism package. Lastly, we met with the Office of the Municipal Mayor (both the former and present mayor) who facilitated the presentation of the results of this research to the key officials and employees of Taytay Municipal government such as the Office of the Municipal Agriculture (and Fisheries), the Municipal Environment Monitoring Service, Planning and Development Office, and the Tourism Office. In most of these presentations, we are joined by WWF Philippines staff, which are implementing conservation programs in coastal areas of Taytay (Appendix 7).

Participation of Research Institutions

Aside from our presentations in Western Philippines University during ecology week (audience of ca 300), have also involved more than 50 students from WPU during the conduct of this project. Students got involved in field sampling methods and during seminars on Palawan freshwater fish biodiversity. Six undergraduate thesis has been completed in collaboration with our project, the results of which are currently being prepared for publication in local journals. The results of this project was also presented in two international and one national conference. Three papers are currently being prepared for publication in international journals. In addition, six WPU students, 8 personnel from the LGU of Taytay, and four staffs of WWF project in Taytay were trained in GIS use and resource mapping (Appendix 8).
Achievements and Impacts

A. Assessing fish habitat association/habitat quality in the littoral zone

The availability of data on species composition and diversity, spatial distribution, and habitat association of the fishes in Lake Manguao serves as the most comprehensive baseline data for the ecology of the lake’s ichthyofauna. Our results showed that one endemic species is restricted in the open water zone of the lake (P. bantolanensis) while showing that the littoral habitat is most important as a nursery ground and exclusive habitat for the other lake-endemic and Palawan endemic species (P. manguaoensis, R. everetti, R. taytayensis). On the other hand, our result also showed that the exotic Nile tilapia has successfully colonized the entire lake ecosystem, occupying a vacant niche but at the same time cohabiting with the endemic fishes in the littoral zone of the lake. Lastly, among the littoral habitats, sandy muddy coves have the highest diversity and abundance, suggesting the importance of this type of habitat.

The generated information for this objective enabled us to identify critical sites for fish conservation and relay this information to the local community and the government leaders on how to go with the conservation and protection of the lake’s fishes. The results of this project are also included in the drafting of the municipal ordinance declaring the lake as a municipal conservation area. The results also show that we have attained our objective of assessing the fish habitat association in the lake.

B. Identifying anthropogenic threats and sources of habitat shift in catchment

We have validated and updated the forest cover of the lake. This is still similar to the forest cover from the 1998 data. The number of slash and burn farming in the lake was also significantly reduced compared to two decades ago. During this study, we have only recorded less than ten kaingin and these are also on areas that had been farmed before in the brushlands. Old growth forests have not been subjected to kaingin for the last decade due to a local legislation that prevented informal settlers in the area. The new map for the forest cover and denuded areas will also help in the programs of the municipality to reforest Lake Manguao’s catchment.

Our results showed that farming in Lake Manguao is more of subsistence than commercial scale, hence, this is not a major concern for now. On the otherhand, a more important future concern that we have discussed during presentation and workshops in with the local stakeholders is the acquisition of most of private lots surrounding the lake, which may be developed into new farms or real estate properties.

The availability of the map for water level fluctuation will assist in the disaster reduction and mitigation efforts of the municipality. At the same time, this is also critical in delineating the protection zones of the critical fish habitats in the lake, particularly the littoral zones, which will change depending on the water level at a given season. The current water level fluctuation in
Lake Manguao is more than three meters between dry and flooding season and this should be looked into, specifically in light of management of the lakes littoral areas and floodplains. Overall, the objective has been attained and we are confident that the results will contribute in the overall management of the lake’s catchment and its floodplain areas.

Lastly, the data on fish consumption and exploitation suggests that the endemic fishes in Lake Manguao are far from being threatened via exploitation as human food. Fisheries in Lake Manguao is primarily focused in Nile tilapia while the other larger species are of very minor importance. The endemic fishes are not exploited as food by the locals, despite its congeners being known as palatable fishes e.g. in Lake Lanao in Mindanao. The regulation of using a mesh size that is mainly intended for catching tilapia has very limited bycatch effect on the native and endemic species as well. The current mesh size being used in the lake is big enough for non-target species to escape.

C. Assessment of potential impacts of *O. niloticus* to the native fishes

The availability of data on the diet and food items consumed by Nile tilapia in Lake Manguao is one of the major achievements for this project. It showed that this species has been very successful at colonizing the lake and its environs, while at the same time we have not observed any predation of Nile tilapia on the native fishes.

Results of all analysis of the stomach content of *O. niloticus* showed that the major food items of this fish species in the lake were cyanobacteria. Even though there was a change in season, the food preference of *O. niloticus* did not shift. The results of this study also indicated that Davies and Green's (1990) suggestion of introducing Nile tilapia in Lake Manguao may be correct in a sense that *O. niloticus* actually occupied a unique niche in the lake, feeding on the abundant cyanobacteria, which is not being exploited by any other native or endemic fish in the lake.

Our results also revealed that *O. niloticus* in the lake has the ability to feed at different trophic levels and was found to occupy all available habitats within the lake, from littoral zone, to open water and even in the tributaries. It is worth noting that smaller specimens of juvenile *O. niloticus* are exclusively caught in the shallow littoral zone of the lake while the adult individuals migrate to the open water. We attributed this to migration of the fish to pelagic habitat as it grows and therefore opt to feed on available food in the pelagic zone. In spite of this capability *O. niloticus* to adapt to different habitats, it seems that it is consuming only the natural foods available in the lake. Although there are widespread beliefs that *O. niloticus* may prey on the native fishes when they are introduced into a particular water body, there were no observations of fish parts like scales in the stomach of any of the fishes examined during this study. The results of this study is somewhat similar to the findings of Shalloof and Khalifa (2009), and Oso et al. (2006).
D. Conducting conservation education activities

In terms of conservation education activities, we are happy that we have achieved our goals by working closely with the municipal government of Taytay during the implementation of our project. Aside from providing conservation education campaigns in the local community in Lake Manguao, we were able to train more than 50 undergraduate students in WPU on freshwater fish sampling. Eight local students and 15 personnel from the LGU of Taytay participated in the GIS training that we conducted. The impact of sharing the information that we have generated during this project contributed to Lake Manguao being the current focal point of conservation and eco-tourism development in the municipality of Taytay. In addition, as one of the additional outcome and achievement of this project, a stronger partnership has been established between our university and the Taytay LGU for conduct of research in Lake Manguao and the entire municipality of Taytay. A memorandum of agreement between WPU and Taytay LGU has been agreed upon and is scheduled to be formalized in the last quarter of 2013. In appreciation of the efforts of our project efforts, the local team members were also requested by the LGU to assist in the drafting of the municipal ordinance declaring Lake Manguao as a local conservation area.
Section III

Conclusion

The fish fauna of Lake Manguao stands at 12 species today, including three lake endemic species, four Palawan endemics, four asian widespread species and one exotic species. Spatial distribution of the fishes is biased towards the littoral zone, with only two to three species exploiting the open water zone of the lake. Critical habitats for conservation of endemics are the littoral sandy muddy environs and the deeper open water zones. These areas should be the focus of conservation and protection measures to effectively protect the endemic species. In terms of habitat degradation in the catchment, kaingin farming and selective illegal logging are the major threats but it is currently mitigated by presence of local forest rangers in the lake. In Lake Manguao, farming is more of a subsistence activity while fishing is the major livelihood source. Nonetheless, commercial fishing in the lake poses no direct threat to the endemic fishes of Lake Manguao. Nile tilapia predation on indigenous fishes was not documented, however, it remains to be seen what are the long term impacts of its successful colonization to the native species and the lake ecosystem as a whole. The impacts of the three meter water level fluctuation to the littoral habitat cannot be ascertained within the scope of this project but it needs to be monitored on a longterm basis. Lastly, by incorporating the results of this project to the conservation education component, we provided an avenue to increase the awareness of local stakeholders, particularly the leaders of Taytay.

Problems Encountered and Lessons Learned

- Which project activities and outcomes went well and why?
  The activities for objectives 1, 2, and 3 went pretty well particularly the sampling and collection of fishes, and the sampling for diet analysis. We attribute our success to the expertise of the team members and the active participation of the locals during our project implementation. We also have very good rapport during the sampling and the LGU has been supportive of us, especially in mapping and delineating the flood plains and different habitats.

- Please detail any problems that the project encountered or deviations from original project plans. Describe how these problems were addressed and what solutions were found to deal with these issues.
  1) Changing of sampling method for the open water sampling. Trawling proved to be ineffective. Instead of trawling, we decided to mainly use gill nets. Plankton sampling for fish larvae was largely unsuccessful due to the late start of the project, which did not coincide with the onset of the rainy season.
  2) Mapping was delayed due to inclement weather. We were able to continue mapping by rescheduling our sampling.
  3) We could not bring another motorized during sampling due to an existing ordinance than bans motorized boat in the lake (except the municipal owned boat). As a
compromise, we used the motorized boat of the LGU and used the budget for boat to provide incentives to volunteer fisher folks that accompanied us during the sampling. We also paid for boat fuel and per diem for the rangers that helped us.

4) The conduct of workshop for the conservation of Lake Manguao was rescheduled due to the untimely demise of two of our main partners during the implementation of this project. We rescheduled it last July 2012. Only one of the two workshops materialized due to last minute conflicts in schedules of intended participants. Instead of the first workshop, we conducted focused group discussions with the different stakeholders, which proved to be more effective in facilitating uninhibited discussion that served as the basis for second workshop and the ongoing discussions for establishment of a protected area in Lake Manguao.

5) One of our team members had experienced severe abdominal pain due to indigestion and gassing during October 2011 sampling. We had to rush him to the hospital and had him confined overnight. Consequently, we had to cancel the last day of field sampling. After then, we became more careful with our meals and we never encountered any similar incident.

6) We were not allowed to camp in the lake for security concerns. What we did is stay in a modest accommodation in Taytay and drive to the lake in the morning and at dusk to sample. We had to stretch our budget to accommodate this additional expense.

- Briefly assess the specific project methodologies and conservation tools used.
  - Beach seine sampling in the littoral zone. This proved to be most effective sampling methodology. We have covered the areas that we delineated for sampling.
  - Satellite imagery, coupled with site validation was very useful in assessing habitat quality and human impacts in the catchment. On the other hand, interviews and informal conversations with the locals are also useful in gathering more obscure information about threats and impacts caused by locals.
  - Conservation education. The different means of communicating our results are very useful in reaching a diverse audience. Reports are most helpful with the LGU while for local communities, posters and presentations work well. Direct participation during fieldwork enhanced our working relationships with the residents of Lake Manguao.

- Please state important lessons that have been learnt through the course of the project and provide recommendations for future enhancement or modification to the project activities and outcomes.
  - Personal experience and direct participation of local community members during the implementation of this project is more effective in eliciting positive response from the stakeholders.
  - Workshops sometimes works against us by bringing into one venue a lot of people who had known each other for decades and are from opposite political groups or have differing opinions. Focused group discussion worked better and should be utilized more often to facilitate a more intimate response and participation from the community.
As a project implementer in the area, we cannot get ahead of the local community’s pacing, but instead learn from them and attune our pacing with them.

We have also learned that importance of having multi stakeholder participation and having several collaborators from the LGU. When our local collaborator passed away, it was very helpful that we have been working closely with other members of the LGU that enabled us to continue our project albeit we had some delays.

We ended up spending more fieldwork days than originally planned mainly due to complications with sampling sites (flooded/dry, boat not working, boat not available). In terms of modification to the project activities, we strongly suggest to put more days for our fieldwork to prepare for unforeseeable delays brought by weather or changes, security concerns, and changes in the political field in our project site.

In the Future

Our collaborative efforts with the LGU of Taytay was strengthened during this project. To continue this good relationship with the LGU and the residents of Lake Manguao, WPU is planning to establish a permanent Biological Field Station in the lake as part of the Memorandum of Agreement that is currently lined up for signing towards the last quarter of 2013. This MOA was conceptualized during the initial phases of this project and has already passed the final stages of approval of the municipal legislative council. This is part of the long term goals of Taytay LGU and WPU for sustaining research and conservation efforts in the lake. As requested by the LGU, the team members are now involved in the drafting of a local legislation declaring Lake Manguao as a local conservation area. This local legislation is slated for enactment before the end of 2013.
Section 4

Appendices
Appendix 2. Tabular description of sampling sites

<table>
<thead>
<tr>
<th>Station No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sandy-muddy to rocky without aquatic vegetation.</td>
</tr>
<tr>
<td>2</td>
<td>sandy with aquatic vegetation</td>
</tr>
<tr>
<td>3</td>
<td>muddy areas without aquatic vegetation</td>
</tr>
<tr>
<td>4</td>
<td>sandy without aquatic vegetation</td>
</tr>
<tr>
<td>5</td>
<td>muddy with aquatic vegetation</td>
</tr>
<tr>
<td>6</td>
<td>sandy-muddy without vegetation</td>
</tr>
<tr>
<td>7</td>
<td>volcanic rock-rock with aquatic vegetation</td>
</tr>
<tr>
<td>8</td>
<td>sandy-rocky without aquatic vegetation</td>
</tr>
<tr>
<td>9</td>
<td>sandy-muddy with aquatic vegetation</td>
</tr>
</tbody>
</table>

Appendix 3. Plates of sampling sites and sampling efforts in Lake Manguao.

The following plates shows the littoral areas of the lake sampled during this study. Each station was selected based on the presence or absence of vegetation in each of the three different substrate conditions namely muddy, sandy, and rocky areas of the littoral zone (Plate. 1-9, Table 1).

Plate 1. Sampling Station 1. Muddy substrate without vegetation.

Plate 2. Sampling Station 2. Sandy with vegetation.

Plate 4. Sampling Station 4. Sandy beach without aquatic vegetation.

Plate 5. Sampling Station 5. Muddy with aquatic vegetation.
Plate 6. Sampling Station 6 Sandy-muddy with aquatic vegetation.

Plate 7. Sampling Station 7 Volcanic rock-Rocky with aquatic vegetation.

Plate 8. Sampling Station 8 Sandy-Rocky without aquatic vegetation.

Plate 10. Open water station in Lake Manguao.

Plate 11. Sampling station in the inflow of Lake Manguao.
Bibliography


Distribution List

- Office of the Municipal Mayor, Poblacion, Taytay, Palawan 5312, Philippines
- Palawan Council for Sustainable Development Office, Poblacion, Taytay, Palawan 5312 Philippines
- Office of the Municipal Planning and Development, Taytay, Palawan, 5312 Philippines
- Office of the Sangguniang Bayan, Municipality of Taytay, Poblacion Taytay, Palawan 5312 Philippines
- Municipal Environment and Natural Resources Office, Taytay, Palawan, 5312 Philippines.
- Municipal Tourism Office, Taytay, Palawan 5300 Philippines
- Library, Western Philippines University Puerto Princesa Campus, Sta Monica, Puerto Princesa City, 5300 Philippines
- Palawan Council for Sustainable Development, Sta Monica Heights, Puerto Princesa City, 5300 Philippines