Fishing in Troubled Waters

A Case Study on Local Ecological Knowledge & Freshwater Resource Management in Peñablanca, the Philippines

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For
Olivier and Matthijs
With Love

Abstract

This study focuses on the value of local ecological knowledge of fishers for fisheries management in the Philippines. Many rural communities depend on freshwater fish for their subsistence. Since a couple of decades freshwater fish stocks have been at decline. In order to improve the management of fish stocks, it is essential to know the factors related to fish stock decline. This research was undertaken with the goal to identify how local ecological knowledge of fishers in the municipality of Peñablanca in Northern-Luzon is valuable to understand these factors. During three months of fieldwork this question was studied through interviewing, observation, and the calculations of Catch-per-Unit-Efforts. It was found that conservationists – those responsible for the formulation and execution of fisheries policy – underestimated the knowledge of the people who live in close interaction with fish stocks: fishers. Conservationists assume that they need to be educated about the ecological threats to riverine resources in order to restore fish communities. However, this research shows that fishers possess rich ecological insight that can potentially help in restoring fish stocks. They listed the fish communities that degraded most and where in the river. Fishers observed that many fish species are disappearing, except for one: the giant tilapia. Fishers regret this, because they prefer to catch one the (higher-value) disappearing species. Giant tilapia is known for successfully invading ecosystems and driving away native and endemic species. In case this applies for Peñablanca, the BFAR – responsible for the annual dispersal of this fish – perhaps should research the possible consequences of its practice. This thesis argues that there is a need for a holistic approach to fisheries management in order to improve it. Which means multi-level cooperation, including both fishers and conservationists, and the incorporating and acknowledgement of the credibility and knowledge of those who use aquatic resources. The ecology of fishing can be construed more properly through a multi-level dialogue, in which political, socio-economic, cultural, and biological interests are adopted.

Acknowledgement

This study on local ecological knowledge and freshwater resource management in the Philippines is conducted as part of the Master degree Cultural Anthropology and Development Sociology at Leiden University in the Netherlands. My first day of school was in September 2012. It has been the first one since one-and-a-half year. Full of excitement I wandered my way to the lecture room while I fantasized about the upcoming academic year. Little did I know that only three months from then I would rock-climb the foothills of the Northern Sierra Madre with a bag of rice on my back and a tray of eggs in my hand. I would brave rough rivers, fanatically scoop out water from leaky boats, slaughter chickens, hook fishes, eat developing duck embryos, bake *badoyas*; and discover that arachnophobia was only a fictive existence in my head. Together with my *kuya* and companion Sandy, I entered the world of versatile and rich knowledge of the fishers of Peñablanca. Living and working among them and their exceptionally hospitable families for three months, yielded major contentment and minor discomfort, both personally and academically.

Now, almost one year after my departure to the Philippines, I am about to hand in the results of this journey of discovery. This will finish off my life as a student and mark the beginning of a new phase. This achievement, however, was not a one woman's job. Hereby, I would like to express my gratitude to everyone who helped me achieving this. Jan van der Ploeg, Gerard Persoon (Leiden University), Mercy Masipiqueña (Director Centre of Cagayan Valley Program on Environment and Development), Dr. Aleth Mamauag (President Isabela State University), Merlijn van Weerd, Tess Balbas, Edmund José, Arnold Macadangdang, Dominic Rodriquez (Mabuwaya Foundation), Rob Moolenbeek (Biodiversity Centre Naturalis), Olivier van Lieshout, Matthijs Muller, and most of all *kuya* Sandy Ranay and your family, thank you very much!

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List of Abbreviations

CI	Conservation International
CpUE	Catch-per-Unit-Effort
BFAR	Bureau of Fisheries and Aquatic Resources
DENR	Department of the Environment and Natural Resources
LGU	Local Government Unit
PPLS	Peñablanca Protected Land- and Seascape

Terminology

Agama	Native crab (*Sundathelphusa cagayana)*
Agurung	Shell*
Agwat	Squaretail mullet (*Liza vaigiensis)*
Ala	Asian/ Golden clam (shell) (*Corbicula fluminea)*
Ammori	Cast net
Anayut	Poisonous leaf of plant*
Anzikkan	Shell (*Jagora dactylus)*
Arabang	Landing net
Arapang	Rocky, fast streaming part of river
Awan	Local expression, meaning "no way!"
Badoya	Local snack of bananas fried in dough
Balawat	Eel spear
Baltut	Pole spear
Banwet	Hook and line
Bangus	Milkfish
Barangay	Village
Baring	Gill net
Basikul	Golden apple snail (*Pomacea diffusa)*
Batit	Trident spear
Birut	Various small goby species*
Black tilapia	Mozambique tilapia (*Oreochromis mossambicus)*
Blasting	Dynamite
Bubu	Basket trap
Dalag	Mudfish (*Channa striata)*
Dulang	Halfbeak (*Dermogenys spp.)*
Dumut	Pile of stones built to catch fish
Fuliag	*Sicyopterus lacrymosus*
Hasag	Gaslamp
Hunug	Largesnout goby (*Awaous melano chephalus)*
Hursi	Silver perch (*Leiopotherapon plumbeus)*
Ifun	Fingerlings/ baby fishes
Iroho	Crucian carp (*Carassius carassius)*
Jeepney	A popular means of public transportation in the Philippines
Kamachile	Manila Tamarind tree (*Pithecellobium dulce)*
Kuya	Elder brother
Kuryente	Electricity
Lasit	Shrimp*
Lumut	Hair algae*
Mori	Marble goby (*Oxyeleotris marmorata)*
Pandal	Speargun
Pattat	Walking catfish (*Clarias batrachus)*
Rashan	Common carp (*Cyprinus carpio carpio)*
Rattan	Reed from the Malay rotan palm *(Calamus spp.)*
Sarep	Fine mesh net
Sihin	Luzon mottled eel (*Anguilla luzonensis)*
Siid	Cage trap
Trapa	Big type of landing net
Yellow tilapia	Giant tilapia (*Oreochromis niloticus)*

* Scientific and/or common English names could not be identified.

1. Introduction

1.1 Rationale

Mid-July 2012 fisherman Romel Lopez died of a dynamite blast during a fishing trip on the Pinacanauan de Tuguegarao River in the municipality of Peñablanca in the Philippine province Cagayan. Dynamite fishing is dangerous and illegal, but effective. A fisher throws a self-made explosive into the water and waits until the blast stuns fishes. This makes them to float up or sink to the riverbed whereby they become an easy prey for the fisher. Although outlawed, some people still use dynamite as a means to maintain a livelihood (PIA 2012).

In 2003 the Philippines was ranked eleventh on the world's list of countries in which, in absolute terms, most fish is caught (World Bank 2008). Fish is an important source of food and income for millions of Filipino's. Around 1,3 million people directly depend on fish for income (Green *et al.* 2003). However, the availability of fish in Philippine waters is shrinking due to overfishing. Overfishing means that fish capture exceeds the regeneration of fish populations. Once the carrying capacity is surpassed, fish stocks decline (Daan *et al.* 2011). This has both environmental and socio-economic consequences. Environmentally, overfishing leads to loss of biodiversity and deterioration of aquatic environments. Socio-economically, human food security and the livelihoods of people are jeopardized (Green *et al.* 2003). One of the main driving forces related to overfishing is expansion of the Philippine population. With an annual rate of 2,75% the country has one of the fastest growing populations in the world (FAO 2012). A growing number of mouths to feed increased fish capture (White *et al.* 1998). Another factor involved is intensive use of highly efficient fishing equipment (Van Weerd & Van der Ploeg 2006), such as motorized boats, trawlers, explosives, and electricity. These refinements in fishing contributed to major increases of fish yields (Green *et al.* 2003).

In order to preserve fish for current and future generations, the Philippine government formulated the Philippine Fisheries Code of 1998. In this code a set of regulations and restrictions is formulated to develop, manage, and conserve fisheries and aquatic resources (BFAR 2013). Despite this, effective implementation and rule enforcement is difficult, because fish stocks continue to decline (White *et al.* 2003) (and as the case of Peñablanca shows, rules are not always followed.) Green *et al.* (2003) argue "there is an urgent need for better management and protection of the fisheries, which contribute substantially to the economy, food security and livelihood of many Filipinos (p. viii)".

When attempting to manage fishing practices and preserve fish for present and future generations, it is important to understand the processes that influence fish stocks. Whereas natural scientists traditionally focus on the ecology of fish, anthropologists are mainly interested in the ecology of fishing: how do people interact with nature? The latter has been gaining growing attention, since it is increasingly acknowledged that people themselves are a rich source of knowledge to understand alterations of fish bases. This acknowledgement is especially true for people who have a history of living in close interaction with their aquatic environment and depend upon it to survive. This often resulted in a wealth of knowledge about ecological factors that change the aquatic environment they live in (Berkes 1993; Drew 2005; Johannes 1981).

However, the emphasis in most scientific studies generally lies on marine fishers. Knowledge of those that operate on inland waters, such as rivers and lakes (known as freshwater fishers) is often overlooked (FAO 2012). This is also the case in the Philippines. Being an archipelago, it comprises over two million square kilometer of productive oceans, providing fish to millions of people (World Bank 2008). Since a couple of decades, signs of overfishing have been reported (White *et al.* 1998). Both governmental and academic attention is largely focused on marine environments (Green *et al.* 2003; Barut 1997). Yet, this eclipses the issues that thousands of inland fishers, who comprise 13,3% of all fishers in the Philippines, experiencing (FAO 2012). Those who experience such issues are the inland fishers in Peñablanca.

The people in Peñablanca have a history of fishing. After farming, fishing is the most important source of livelihood (Bennagen *et al.* 2006). The number of inhabitants of the municipality rose in the period 2000-2010 with 12,8% from 37,872 to 42,737 people. Today, approximately 10,000 people live in close interaction with the municipality's most important and longest river: the Pinacanauan de Tuguegarao River (NSO 2010). Two decades ago the first signs of overfishing and degraded aquatic resources were reported (DENR 2003). The case of Romel Lopez exemplifies the difficulty of managing fishing activities. Even though dynamite fishing is illegal, some people still do it as a source of livelihood (PIA 2012).

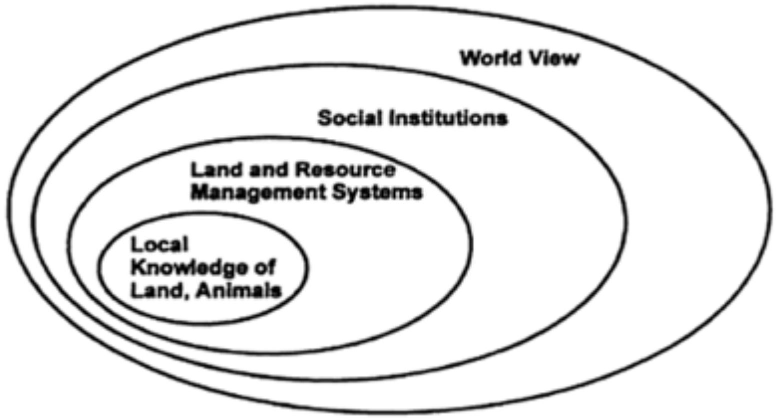
This field study aims to investigate how knowledge of fishers in Peñablanca can be used to improve fisheries management. The people of Peñablanca, who are traditionally engaged in fishing for livelihood and subsistence purposes, can be viewed as a valuable source to improve fisheries management. An incorporation of fishers' ecological insight could contribute to restoration of fish stocks. The integration of such knowledge has the potential to assist scientists and managers to understand the ecology of fisheries and to build credibility with local communities. This is important to create shared vision in fisheries management. Studies with regard to fishers' ecological expertise in the Philippines are scant. However, various studies showed the wealth of this expertise and its significance to fisheries management (Berkes 1999; Johannes 1981; Sillitoe 1998; Mackinson & Nøttestad 1998; Neis *et al.* 1999). Therefore, a study on fishers' knowledge in Peñablanca could be valuable to integrate in Philippine fisheries management. This is explored through qualitative (12 long semi-structured interviews and 80 short semi-structured interviews) and quantitative (statistical analysis of observations and recordings of 45 fish yields) research methods.

1.2 Defining and Understanding Local Ecological Knowledge

During the past decades, a new movement within natural resource management emerged. There has been growing attention for the voice of communities with a resource dependent livelihood (Davis & Wagner 2003; Blakie & Brookfield 1987). Former science-driven approaches have been tackling natural resource problems from a top-down perspective, with only limited inclusion of local stakeholders. These approaches were gradually replaced by bottom-up methods, which involve grassroots interventions: movements that are spontaneously driven by a community's micro-level politics (Brosius *et al.* 2005). This movement stimulates participation of resource users themselves in decision-making, planning, acting and evaluating processes. They incorporate available *local ecological knowledge* in natural resource management (Armitage 2005; Berkes 1993; Warren 1991; Flavier 1995; Davis & Wagner 2003). This knowledge relates to any knowledge that people collectively hold about their ecosystems, generated through interpreting the world (Sillitoe 1998). Berkes (1993) states that this knowledge is acquired through direct contact with nature. "It includes an intimate and detailed knowledge of plants, animal, and natural phenomena, the development and use of appropriate technologies for hunting, fishing, trapping, agriculture, and forestry, and a holistic knowledge, or world view which parallels the scientific discipline ecology" (p. vi). Such knowledge represents information required for survival, is site specific, and is adopted through trial and error over many years (Drew 2005).

To explain this concept, Berkes (1999) introduces the *knowledge-practice-belief complex*. Knowledge is perceived as an entity that consists of four interrelated levels that build upon each other (figure 1). The first level refers to *knowledge.* This reflects the knowledge that people have of flora, fauna, and natural habitats. It derives from observations and has survival value, but may not be adequate enough to secure sustainable use of resources. The second and the third level build upon the first and refer to *practice*. The second reflects a resource management system, which refers to the way people use environmental knowledge together with a set of tools and methods for using natural resources. Resource management systems need some form of social control and organization to operate effectively. The third level, social institutions, therefore refers to the institutional practices that are needed to manage resource uses. Social institutions provide social codes, rule enforcement, and social restraints that people formulate to organize management systems. The fourth level, worldview, reflects *belief*. This involves holistic knowledge that shapes environmental perceptions, which gives substance to people's observations. It involves perceptions of the relationship between people and their nature of how people believe nature should be managed, religion, and ethics.

Figure 1 – Knowledge-practice-belief complex (Berkes 1999)



Local ecological knowledge is practical, holistic, and of limited geographic relevance. Thus, it differs from scientific knowledge, which is theoretical, monistic, and of universal relevance (Berkes 1993; Roth 2004). Local ecological knowledge resembles science in the sense that both types evolve from practices that are drawn from observations of actors and phenomena that are active in particular socioeconomic, political, cultural, and/or ecological contexts. Usually, however, local ecological knowledge is considered unscientific and for that reason unreliable (Brodt 2002; Davis & Wagner 2003).

Nevertheless, integration of science and local ecological knowledge is increasingly supported. Agrawal (1995) states that politicians, scientists and development workers should move beyond the existing dichotomy, because local ecological knowledge is a significant and useful source of information and tool for natural resource management. Neis *et al.* (1999) explain this for management of fisheries. They start their argument by describing what fishers precisely know. Fishers primarily gain knowledge of aquatic resources to optimize fish catches with minimized efforts. Fishers have the tendency to closely observe environmental attributes that relate to fishing success – habitat preferences; reproduction patterns; feeding behavior; seasonal movements; and abundance dynamics – as well as physical features, such as velocity, wind direction, water visibility, water temperature, and weather conditions, that affect the performance of gear, fishing time, and fish distribution. This knowledge comes compiled: it is based on experiences of present fishers, and also on what their parents and grandparents experienced. Through these experiences, they gathered an extensive, albeit unscientific, body of practical knowledge about fishing. Neis *et al.* argue that when combining this non-scientific knowledge with hard scientific data the general knowledge base of fisheries management will increase. Mackinson (2001) clarifies this by pointing out that predicting spatial dynamics of fish populations is difficult without complete understanding of ecological features that influence fish species. He points to the existence of large gaps in basic scientific knowledge. Knowledge of fishers is often not incorporated, despite its rich ecological observations. Integrating fishers' observations with theoretical interpretations and scientific studies will increase the general knowledge base of fisheries management. This leads to deeper understanding of fisheries' problems and ways through which to improve them (Mackinson & Nøttestad 1998). The following famous quote summarizes the argument for the integration and use of local ecological knowledge with regard to fishery management:

> "When it comes to understanding fish behavior and the many environmental factors that help determine and predict it, marine biologists must often take a back seat. This is hardly surprising. There are hundreds of times as many fishermen today than there are marine biologists, and their forebears were playing their trade and passing on their accumulated knowledge tens of centuries before anyone ever heard of marine biology. What is surprising is how little effort has been made by scientists to search out and record this information" (Johannes 1981, p. vii).

The potential value of local ecological knowledge is often ignored, also in Peñablanca. In order to conserve natural resources, Dirain (2004) argues, "the people of Peñablanca have come to realize […] the need for a systematic and rational biological conservation framework" (p. 3). The Local Government Unit (LGU), Conservation International (CI), and the Department of the Environment and Natural Resources (DENR) collectively work on a conservation education campaign. These conservationists share the belief that knowledge of ecological threats is inadequate and insufficient among inhabitants of Peñablanca. The first objective is to: "increase knowledge amongst general public on the major threats to PPLS […] by providing them with appropriate information about the forest and its relationship with the health and productive condition of the freshwater and marine resources" (Dirain 2004, p.116). The aim is to create awareness of threats to natural resources (Dirain 2004).

Conservationists – the ones responsible for the formulation and execution of fisheries management – consider local ecological knowledge in Peñablanca inadequate and insufficient. This ignores its potential value to natural resource conservation and management. It can produce useful information on how to improve resource management (Neis *et al.* 1999; Mackinson 2001; Mackinson & Nøttestad 1998). Such a study also gives voice to resource dependent people (Davis & Wagner 2003; Blaikie & Brookfield 1987). This research will therefore do what Johannes (1981) has been pleading for: record what fishers in Peñablanca know about riverine species and their environment and try to find out how this can contribute to improve fisheries management.

1.3 Main Goal and Research Question

The main theme of this research is: how is local ecological knowledge valuable to fisheries management? The aim is to describe local ecological knowledge with regard to fishing practices and management measures and to help formulate strategies to improve existing fisheries management. Within this purview, the following two objectives are formulated:

1. To determine which aspects of any local ecological knowledge are relevant to restoring degraded fish stocks.
2. To describe the role of fishers' knowledge to improve fisheries management.

Given these objectives it is important to investigate *riverine knowledge* and *riverine management systems* (Berkes 1999). The first refers to all knowledge that fishers have of riverine species – fishes, crustaceans, and mollusks – they harvest. This includes their local names, knowledge of their behavior, spatial and temporal distributions (which species occur, where, and when?), abundance, density, changes in populations overtime, reproductive and spawning behavior (when do they have eggs and where?), specific habitat preferences, predator-prey relationships (how are species positioned in the food chain?), processes that influence them, and their value in terms of catch composition, catch preference, and money. Catch preference refers to species that people prefer to catch plus their reasons. Catch composition refers to species actually caught. The second theme relates to *riverine management systems*. It studies how people use riverine knowledge to manage riverine resources. Included are all methods that people use to harvest riverine species, the way they utilize them, and their fish yields. The latter will be expressed in Catch-per-Unit-Effort. This term attempts to indicate the efforts that are made to harvest species, per hour, per person. This concept will be further explained in the chapter *Methodology*. The sub-questions that examine this are listed below.

Riverine Knowledge

- Which riverine resources do fishers extract and what do fishers know of them?
- How have populations of riverine species changed over time?
- What is the importance of riverine species?

Riverine Management Systems

- What fishing methods do people use?
- Which methods are used most?
- What are fish yields of these methods?
- How can fishers contribute to fisheries management?

1.4 Thesis Outline

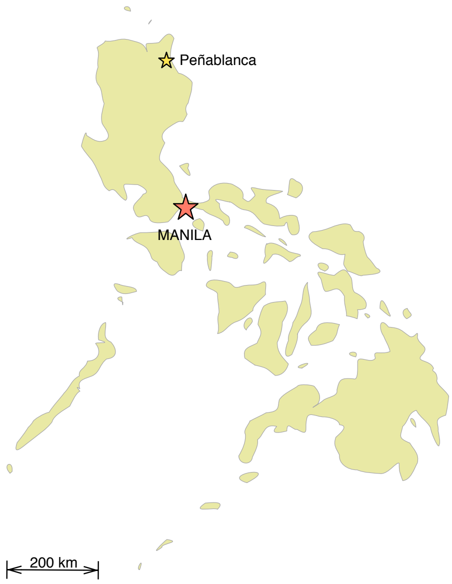
This chapter introduced freshwater fishing in the Philippine municipality Peñablanca and the related research questions. Chapter 2 describes the methodology that is used to address the research themes, which involves a description of the studied areas, the research population, and the techniques used to explore the main theme of this thesis. The following three chapters describe the results per theme. Chapter 3, *Riverine Knowledge,* describes the local names given to riverine resources, everything fishers know about them, the current status of abundance of the encountered species, and processes that influence their status. Chapter 4, *Resource Management System,* explains how fishers use riverine knowledge to catch fish. Discussed will be the fishing methods and tools that people use, how they use them, what they yield, and the fishing efforts invested. The Catch-per-Unit-Efforts will be presented in this chapter. Additionally, it will be discussed how fishers believe they can improve fisheries management in Peñablanca. Finally, in chapter 5, the main findings will be summarized, research questions will be answered, and the main goal and objectives of this research shall be reviewed.

2. Methodology

2.1 The Research Area

This thesis' research activities are focused on the Philippine municipality Peñablanca. The municipality is located in the south of Cagayan province. It is close to the provincial capital Tuguegarao and 462 kilometers north of national capital Manila (figure 2). It borders with the Sierra Madre Mountain range in the east. The landscape is mountainous and marked by wetlands, old-grown forests, brush lands, and agriculture (Balangue 2005).

Figure 2 – Geographical location of Peñablanca



Peñablanca is home to 42,737 people (NSO 2010). Almost 90% of the population has a rural lifestyle. This means that most people reside outside cities and live from farming as their main source of livelihood. Many people keep livestock and cultivate cash crops[1] like hybrid corn and rice. Farmlands are mainly cultivated through slash-and-burn agriculture: a technique whereby vegetation is burned to fertilize the soil. Besides farming, people engage in alternative sources of livelihood, such as hunting, charcoal making, timber wood cutting, firewood gathering, and most important: fishing (Bennagen *et al.* 2006). Half a century ago logging was an important means to generate income. This industry peaked in the 1980s and stagnated a decade later when the number of corporate and licensed companies dropped. One million hectares of old-grown forest remained. Logging was lucrative and brought welfare to region (Van den Top 2003). Peñablanca now ranks among one of the richest municipalities in the region. However, not everyone in Peñablanca has bore the fruits of logging. A few thousand people in Peñablanca live of less than 2 USD a day (NSO 2010).

[1] Cash crops are agricultural crops that people grow for sale.

The people of Peñablanca belong to various cultural groups that inhabit the region for centuries. Those participating in this research are the Itawes, who comprise almost 80% of the total population in Peñablanca, and the Agta who form 4% of the population. Other groups are the Ibanag and the Ilokano. The Agta inhabit the region the longest. They descent from the Autraloids who arrived in the Philippines approximately 35,000 years ago (Van der Ploeg & Van Weerd 2010). Agta residents are divided into a river valley oriented and coastal oriented community. Those in Peñablanca live in upland Buyag. They are river dwellers residing on the Sierra Madre forest fringes or along clearings (Minter 2010). Locally, they are known as *negritos,* because of their features. Their skin is dark, they are small, and they have frizzy hear. Most Agta in the Philippines speak Ilokano, but those in Peñablanca speak besides Itawes another dialect, which they themselves call Agta. Their main sources of livelihood are hunting, gathering, and fishing (Dirain 2004). Although the Agta live a forest or aquatic oriented lifestyle for many centuries, small-scale slash-and-burn agriculture and trade connections have been emerging since the 17th century (Headland & Reid 1989).

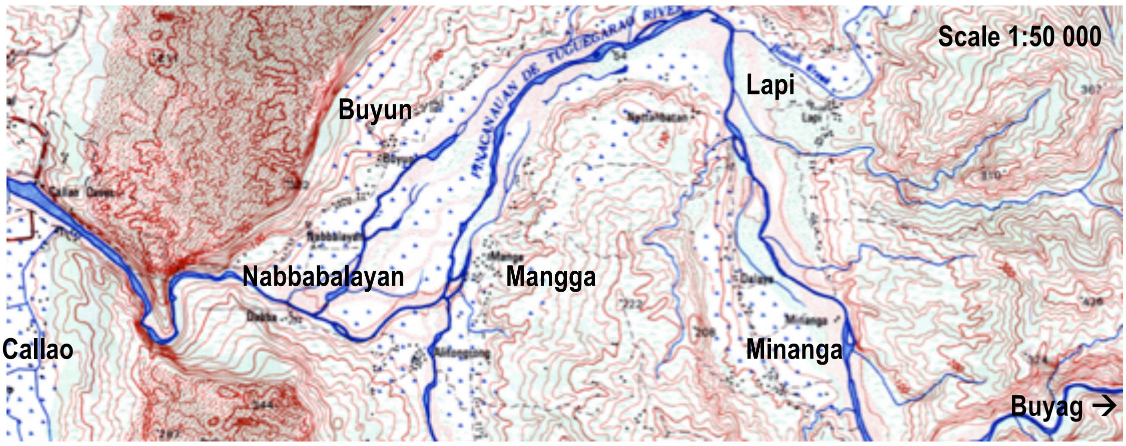
A few centuries ago, during Hispanic occupation the Itawes arrived in the area (Keesing 1962). Many Itawes people used to live more land inwards, but Spanish colonization forced them to move to Cagayan. The Spaniards arrived in the north of the Philippines in 1572. The first Spanish encounter came after missionaries aimed to convert the Itawes. Converted people were established in small settlements, known as *rancherias,* in order to serve colonial rule and to separate them from those who were not converted. Spanish safeguards had the task to protect the native people by keeping peace and order and to assist efforts of conversion. In return, they were authorized to claim food and services from the Itawes people. However, the safeguards abused their right to make claims and they put little effort in peace keeping. Many Itawes could no longer stand the colonial rule and fled to forest fringe of the Sierra Madre Mountain range.

The word Itawes derives from the prefix '*I*', which means 'people of' and '*tawid*' meaning 'across the river.' Literally, Itawes means 'the people from across the river.' Besides the mother tongue Itawis, most Itawes people, nowadays, speak the national language Tagalog and other regional languages, such as Ibanag and Ilokano. Linguistically, Itawis is most similar to Ibanag. The language is rooted in the Malayo-Polynesian language. During Hispanic colonization the language mixed with Spanish (Keesing 1962). Christianity is the predominant religion in the region, professing various religious movements, such as Babtism, Mormonism, Presbyterianism, Catholicism, and Jehovah Witness (Bennagen *et al*. 2006).

People in Peñablanca live in *barangays*. Barangay is the local word for village and it refers to the smallest administrative division after the municipality. A barangay captain and barangay officials govern these villages. The latter include counselors, a secretary, and a treasurer (Silliman 1985). Peñablanca encompasses 24 barangays of which seven are situated along the Pinacanauan de Tuguegarao River (NSO 2010). Locally, people call it the Pinacanauan River. This river is one of the largest tributaries of the Philippines' longest and widest river: the Cagayan River (Watanabe *et al.* 2009). In Peñablanca, the Pinacanauan is one of the most water sources. It is over 50 kilometers[2] in length and it provides people with resources: a) water for bathing, washing, cooling for domestic animals, and irrigation of farmlands; b) cobbles for house- and road construction; and c) fish for daily consumption and income. In summer season (December to May) the river is intensively used. Rainfall is minimal and the weather is warm and sunny. The water level drops, velocity is low, and the water temperature is comfortable to access. Typhoons and high levels of precipitation in the rainy season (June to November) cause high water levels, strong currents, and low water temperatures (DENR 2003). The river is less accessible, thus, used less.

The sites specifically studied in this survey are six villages along the Pinacanauan. The people living in these villages, together with the remaining people in barangay Lapi, comprise one-fourth of the total population of Peñablanca. From down- to upstream these involve: Callao, Nabbabalayan, Mangga, Buyun, Minanga, and Buyag[3] (figure 3). These sites will be briefly described in the following section. Scientific information about this area is limited. Descriptions of the specific sites are merely based on results from this fieldwork.

Figure 3 – Map of studied sites in Peñablanca



Site 1: Callao

Callao is situated most downstream and close to provincial capital Tuguegarao. Its population counts over 1,500 people and majority is Itawes (NSO 2010). Many people have a paid job in Tuguegarao, own a small shop or farm to make a living. The dominant cash crops are yellow corn and rice. People in Callao, compared to inhabitants of other studied villages, generally have higher incomes. Most villagers live in a concrete house and nearly every family possess

[2] The length of the Pincanauan River is measures with help of Google Maps.
[3] From now, whenever is referred to Peñablanca in this research, these six sites are meant.

a tricycle or a horse drawn carriage (*kalesa*). Callao is famous for its many caves. The most important landmark is the seven chambered Callao Cave, which attracts many tourists. In order to increase influx of tourists, infrastructure connecting rural Callao to urban Tuguegarao, was improved. Around PhP 100 million was spent to asphalt and widen the eight-kilometer road from the provincial capital to the Callao Cave. Apart from greater accessibility to the cave for tourists, these infrastructural improvements increased the mobility of people in Callao. Tuguegarao is easier to reach now. This increased the number of tricycle[4] users (PIA 2012). The Pinacanauan River in Callao is wide (50-100 meters) and deep (>3 meters in the deepest parts). The most important river uses involve irrigation of rice paddies and recreation (swimming and picnicking). Few people fish for income. Fish is sold to neighbors or to merchants in Tuguegarao (DENR 2003). Different than in other villages in this research, people in Callao do not need the river for washing and bathing. They have water facilities at home.

Site 2: The Lagum Area

The Lagum area of Peñablanca begins a few kilometers east from Callao. Lagum is locally called the 'hidden valley', because it is surrounded by limestone mountains. Four villages are studied in this valley. From down- to upstream these involve: Nabbabalayan, Mangga, Buyun, and Minanga. Minanga is biggest (>2,200 inhabitants), followed by Mangga (>1,600 people), Buyun (>1,100 people), and Nabbabalayan (>900 residents). In total, more than 8,000 people covering 1,300 households reside in this research area, including the residents of Lapi (NSO 2010). Most residents are Itawes. People live in houses made of wood and bricks. Their main source of subsistence is farming. Many people do not own the land they till. The main crops they grow are yellow corn, white corn, mongo beans, and peanuts. Yellow corn is the cash crop. The other crops are grown for personal consumption. Besides farming people keep livestock and grow fruit trees for food. After farming, fishing is the most important source of livelihood. Self-sufficiency in food-production is higher in Lagum than in Callao, probably because Lagum is more remote from Tuguegarao. Approximately 10 years ago, a local boat service was the only connection between both places. Today, the Lalongan dirt road – an old logging road – serves the majority of transportation needs in Lagum, especially in summer season when it is passable to public *jeepneys*[5] (a four-wheel drive cargo type vehicle) (DENR 2003). Since March 2013 this road has been asphalted from Callao to Mangga. In Lagum people use the Pinacanauan River mainly for washing, bathing, fishing, cobble-extraction for road- and house construction, as cooling area for domestic animals in summer. The river is well accessible in Lagum. Most parts are shallow and slow streaming. The largest tribute to

[4] Common means of passenger transport.
[5] A *jeepney* is a popular means of public transportation in the Philippines.

the river is the Natulud Creek (DENR 2003). This creek runs through Mangga and provides people with an alternative fishing ground and water facility.

Site 3: Buyag

Buyag is the smallest and most upstream village in this research. It is an Agta village located on the foothills of the Sierra Madre mountain range. It lies along the narrow, deep, and fast-streaming part of the Pinacanauan River. Currently, Buyag counts 15 households. Throughout the years the number of inhabitants declined, because many people moved from the highlands to Callao for permanent settlement. In Callao they formed a small Agta community. They live close to each other and they established their own school and spiritual center. Around 30 people are now settled in Callao, including the barangay capitan of Buyag. Most of the Agta in Callao started farming.

In the mountains life is different. People live in small wooden huts built of natural materials. The shelters are elevated floors with a roof. Houses are positioned by kinship. The stronger the family tie, the closer people live to each other. Main sources of nutrition are gathering fruits, seeds, and roots from the forests; hunting wild pig and deer; and fishing. Contemporary methods for hunting and fishing are quite similar the implements that were used a couple of decades ago. The main modifications comprise refinement of gear and availability of modern tools, such as steel rods, flashlights, goggles, rubber bands, and guns to shoot wild animals. For instance, goggles improved underwater visibility for fishers; flashlights enabled night fishing; and wooden fishing spears were replaced by the use of iron pole spears (Rai 1990; Minter 2010).

2.2 Research Methods

This section provides a description of the methodology that is used to explore the sub-questions. The study was conducted from January 2013 to April 2013. In total, six visits to the research site are made. The first visit was introductory. It included the search for a host family, introduction to *barangay* captains and important officials, and the exploration of the research site. Four visits were planned to collect data. The final visit was made to recollecting missing and incorrect data. Data collection was done in cooperation with an interpreter from Lagum, who helped finding respondents and translated questions and answers.

The table below shows an overview of the methodology. For each sub-question it is indicated what method of collecting the required information is used. Three main methods were used: a) interviewing; b) Catch-per-Unit Effort measurements; and c) observation of fishing activities. These techniques are further described on the next page. Table 1 shows which methods are used to study the formulated research questions from section 1.3.

Table 1 – Methodology

What to explore?	How to explore?
Riverine Resources	
Which riverine species do fishers catch and what do people know about them? Explores all fish species, crustaceans and mollusks that people harvest from the river and studies nomenology and identification of species; spatial and temporal distributions; abundance; density; reproductive and behavior of species (when and where do species have eggs?); specific habitat conditions (do species need light, certain plants, caves, running water, clear water et cetera); predator-prey relations (how are species positioned in the food chain?); and knowledge of ecological changes.	*Interviewing* *Observation*
How have populations of riverine species changed overtime? Describes processes that influenced the abundance and occurrence of specific populations, and provides an indication of the current status of occurrence per species, per studied site.	*Interviewing*
What is the importance of riverine species? Explores which species are most important for fishers. Variables that indicate this include catch composition (which species are caught most); personal preference (which species do people prefer to catch); and market value (for how much are species sold?).	*Interviewing* *Observation*
Riverine Management Systems	
What fishing methods do fishers use? Examines what methods people use to catch certain species. This includes the way it is practiced and specific techniques to use it.	*Interviewing* *Observation*
Which fishing methods are used most? Assesses popularity of methods and indicates which methods require attention within freshwater resource management.	*Interviewing*
How much fish do fishing methods yield? Studies the Catch-per-Unit effort of specific methods. What is the effectiveness in terms of total fish catch in grams per hour, per method, per person?	*CpUE measurement*
How can fishers contribute to fisheries management? Investigates the perceptions of fishers towards current and future fisheries management and describes the contributions – as defined by fishers – that fishers themselves could make to improve fisheries management.	*Interviewing*

The first research element involves interviewing. Frey and Oishi (1995) describe interviews as “purposeful conversations in which one person asks prepared questions (interviewer) and another answers them (respondent)”. This can be done to gather information about a certain theme or area. In this research three types of interviews are held: long semi-structured, short semi-structured, and informal. Semi-structured interviews are open-ended and suitable to deeply explore people’s perceptions and knowledge about topics, resulting in rich background information (Nichols 1991). Discussion topics and interview-questions are pre-designed and formulated in such a way that respondents cannot answer with a simple “yes” or “no”. When it comes to investigating local ecological knowledge, Davis and Wagner (2003) highlight the importance of identifying experts. An expert is regarded someone who is experienced and knows much about something. In this study 12 long semi-structured interviews are held with expert fishers: experienced fishers who fish on a regular basis and know much about fishing. These interviews will be referred to as expert-interviews. To identify experts, people were asked which fishers they consider experts. As for the rest, interviews were structured in topics. In total 12 interviews were held, two in each village, taking 2-4 hours of questioning.

Interviews consisted of several topics that required discussion (see interviews in Appendix II and III). This method was practiced in the beginning and at the end of the research period. In the beginning these interviews were held to get an overall impression of freshwater fishing in the research area, indicating species that can be harvested, fishing methods, and local terminology. Later, this tool was practiced to intensively explore all research questions one more time to close gaps in the gathered information base and acquire clarification on topics that were still unclear or ambiguous. This method studied: species that are harvested from the river; their local names; fisher's riverine knowledge of them; their importance; their level of abundance (see Appendix V); fishing methods that people use; motivations for the use of certain methods; the rules that people maintain in villages regarding fishing; the species that certain methods catch (see Appendix IV).

Short semi-structured interviews were held with fishers, who are not necessarily considered experts. In total, 80 interviews were held spread over six research sites, taking approximately one hour per interview. The first part of interviewing consisted of closed questions with multiple-choice answers yielding quantitative data, and the second part was dedicated to open topic questions yielding qualitative data (see interview in Appendix I). Quantitative methods are useful to collect comparative and measurable data. For instance, regarding differences in fishing method-use and fish catches among various villages and they are useful to gain understanding in certain fishing practices and knowledge aspects (Davis & Wagner 2003). Through short semi-structured interviewing it was aimed to explore: general data of informants (age, sex, fishing experience, hometown, and occupation); knowledge of species; knowledge of fishing methods; the value of species; motivations for use of specific method; and knowledge of informal institutions in their hometown. Knowledge of species was assessed on: a) recognition of species; b) identification of species; and c) knowledge of species. During interviewing flashcards of common local freshwater species were shown. This was important to unambiguously identify species. Participants were found through the *snowball principle* (Atlas 2013). People were asked whether they knew people who might want to participate in the research. When someone was found, this person was asked to provide names of other fishers as well. Few requirements were addressed to sampling, including: the person fishes on a frequent basis (weekly or couple of times a month); lives in Lagum, Callao or Buyag and operates on the Pinacanauan River; and is willing to participate in one or more research activities.

A final interview technique is informal interviewing. Informal interviews are not structured through predesigned questions or topics of discussion. The interviewer is free to come up with questions on the spot and these questions can be asked in any order. Open-ended questions can yield deeper and more detailed responses from interviewees. The quality and the richness of the obtained information base depend on the interview skills of the interviewer (Nichols 1991; Wimmer & Dominck 1997). In this study unplanned interviews were done informally. Such interviews involve conversations with other villagers, employees of the Bureau of Fisheries and Aquatic Resources (BFAR) and the Local Government Unit (LGU) in Peñablanca, and shop owners of fishing gear about fishing. These people proved a valuable source of information. Through this method, information was collected about riverine species, fishing methods, and current management practices.

Another used research method is observation. Observations are useful to gather facts. Every fact is the result of combined actions. It would be hard to understand them on their own, but when compared to each other they can be interpreted (Degérando 1800). In order to get better understanding of fishing practices observation is a prerequisite. It is, for instance, hard to understand how certain fishing methods work if they cannot be observed. Information on fishing methods, gained through interviewing, can be compared with field observations and the fishing practices can be compared with each other. During the fieldwork 45 fishing trips with fishers were done. Meanwhile it was recorded which species they catch, with how many people they were operating, which methods they used, how they used them, and under which circumstances (water and weather conditions) they fished. When possible, the actions that people undertook to protect riverine resources were observed, such as throwing back fingerlings. Often, fishing trips were appointed with fishers who responded in interviews. Sometimes they were made on the spot (with people who just started fishing).

The third research element is Catch-per-Unit-Effort (CpUE) measurements. CpUE refers to the quantity of fish, crustacean or mollusk caught with a standard unit of effort (Hill *et al.* 2005). Efforts are related to the abundance of species: the more abundant the species, the less effort required to catch it. Decreasing CpUE means a catching less fish with the same effort. This usually implies overfishing. A stable or increasing CpUE points to sustainable use of the resources (Puertas & Bodmer 2004). The acquired CpUE results of this research will be one of the first CpUE data recorded in this study research area. This study's results can be compared to CpUE measurements in similar research areas. This will be elaborated in chapter 4. Furthermore, this research provides a basis for future research on dynamics of and fluctuations in fish stocks in Peñablanca. In this study, the CpUE is the total weight of the catch in grams per species, per fishing method, per person, per hour. Time was recorded from the moment the fisher(s) entered the river until he/she/they finished fishing. During the trial it was noted that people sometimes take a long time – chatting with neighbors or waiting for other fishers – before actually starting fishing. Time recordings, therefore, started when the fisher actually started fishing. In this research this will be referred to as *active fishing time*. In total, 45 catches were measured. Recorded was: general information about the fishers (name, sex, age, and hometown); location of fishing spot; hydrological characteristics; weather conditions; time of departure and return; used fishing methods and tools; catch composition;

total weight of catch per species in grams; physical characteristics of catches (length, weight, and color); and what was done with the catch afterwards (consumed, shared, sold, processed or disposed). The following tools were used: a digital scale with one gram readability and a capacity of five kilograms; a measuring tape to measure the length; a watch to record the fishing time; a camera to capture (unknown) species; and fill out field forms to register the above described features (see Appendix VI for the format).

2.3 Data Analysis

Interviewing and observation generated a qualitative set of data about riverine species, fishing grounds, fishing methods, gear types and fishing time. Analysis of these data is done through *observer impression*. This means that the researcher creates an impression of the observations and or answers to interview questions. These observations can be reported and structured in quantitative forms. This is called *coding*. Coding is an interpretive method that aims to organize data (Field 2005). In this research coding is used to analyze qualitative data from semi-structured interviewing, informal interviewing, and observation. The data derived from these methods are structured into categories such as: riverine species; fishing methods; fishing purposes; and fisheries management. Most interviews were structured in themes and topics about fishing, which provided the basis for the coding process. Keywords from responses to interview topics were listed per topic. Later, recurring answers were clustered to discover patterns. Clustering enables to detect patterns. Eventually, the responses could be linked to the research questions in order to extract answers.

Apart from qualitative data, interviewing and observation yielded quantitative data. Quantitative data produced by observations were organized into frequency tables, typologies (list of categories), or taxonomies (typologies with multiple concepts). Excel was used to process quantitative data, acquired through semi-structured interviewing and CpUE measurements. The structured part of short semi-structured interviews consisted of multiple closed questions, testing various variables, such as: sex; age; main occupation; home town; number of years being a fisher; preferred fishing season; predominantly used fishing method; predominantly caught species; and destination of fish catch. Some questions yielded unreliable answers; these are eventually excluded from the questionnaire. For instance, one question was about the average weight of a usual fish catch. Most fishers found it difficult to express their catch in terms of grams. Other questions were weakly formulated. Therefore, they had to be reformulated in order to be comprehensive and to yield data they were supposed to yield. This has been the case for a question about the number of years that a fisher is fishing. Initially, fishers were asked how long they are fishing for, but it turned out that many people did not know this. A better question seemed to be: when did you start fishing? Then people usually referred to a certain period in their lives (childhood, adolescence, high-school et cetera), which simplified the estimating of a person's fishing experience in terms of years. The generated data are processed and analyzed in Excel Microsoft Office 2010.

CpUE measurements yielded quantitative data derived from the recorded fishing trips. A compiled database could be established including various variables, such as the number of the fishing trips; total fishing time; number of fishers per method; chosen fishing spot; preferred weather conditions; preferred river conditions; used fishing method; fish species caught; total fish catch; fish catch per person; sizes of caught species; and weight of caught species. The most important variables shall be discussed. Total fishing time was recorded from the moment a fisher entered the river until he/she quit fishing and is expressed in minutes. Total fish catch refers to the total weight of total fish catch expressed in grams, including all species caught. Fish catch per person refers to the average fish yield per person, which is calculated through dividing the total fish catch by the number of fishers involved in the fishing trip. The sizes (lengths and weights) of most caught species during a fishing trip are measured, including their contribution to the weight of the total fish catch. Sizes of unusual or exceptional species were documented separately from the sample. The lengths and weight of species are measured in order to determine how many individual fishes get caught before reaching (sexual) maturity. This is important to indicate signs of overfishing in the Pinacanauan River. Eventually CpUE – total fish catch in grams per method [g], per hour [h], per fisher – could be calculated through the following equation:

$$CpUE\ \left[\frac{g}{h}\right] = \frac{(Total\ Fish\ Catch\ of\ Method\ [g])}{(Number\ of\ Fishers) * (Total\ Fishing\ Time[h])}$$

2.4 Limitations

While conducting research, a couple of challenges were experienced. First, an interpreter was indispensable for translation of local languages. Translation, however, is a subjective interpretation of what participants are saying or meaning. During interviewing I discovered a couple of wishful translations: translations of which the interpreter thought I would be pleased to hear. Besides this, both my interpreter and I were struggling with language – he with English and I with the local language. Therefore, sometimes it was difficult to translate and understand what fishers were saying during interviews. However, as the research continued and the days passed by my interpreter and I were improving the way we communicated with each other. And as we worked together in close cooperation for quite a while we got to know each quite well. Eventually, we managed to form a team with a unified goal and we became experienced in conducting the research. Altogether, data collection improved step by step.

Second, the proportion of male participants is high. Over 95% of the respondents is male. This may not necessarily violate the representativeness of this study's research population, given the fact that the majority of fishers are male. Men therefore hold most local ecological knowledge. Nevertheless, there are still a number of women involved in fishing. It would have been interesting to talk to a few more women to hear out their ecological insight and perceptions and to study their way of fishing.

Third, a temporal limitation involves the fact that data-collection took place from January until April. In this season, the weather was relatively dry. This influenced the fish species that people catch and the methods they use. Some species are mostly abundant in summer season, others in rainy season. As the research progressed, it was discovered that fishers mainly mention species and fishing methods that were relevant to them at that very moment. Collecting data about fishing in the other seasons required specific and purposeful interviewing.

Fourth, within three months six villages were studied. Not every village could be studied in same detail. Mangga, for instance, is studied most intensively. The majority of interviews are held in Mangga and a most observations of fishing trips took place there. Much time was spent in this village, because my interpreter lived there and he and his family hosted me most of the time. Additionally, Mangga is centrally located, for that reason we stayed in Mangga while making day trips to other villages. For that reason, the people and their lifestyle are explored most intensively in this town. Buyag on the contrary, is remote from Mangga and the other villages. Getting there requires a lot of time and physical effort. Unfortunately, I could not make it to go there more than once, because I lacked time for a second visit. Especially, data derived from observations of fishing trips and CpUE recordings in this village are little compared to in other sites. The aimed number of 10 short semi-structured interviews with Agta is achieved. Partly thanks to the fact that the inhabitants of Buyag were often in Minanga to trade fish and meat. Therefore, they could be interviewed in Minanga. Consequently, the remark that can be addressed involves that the overall number of fish trip observations per village is low. This means that the number of observations per method per village is even lower. These small sample sizes inhibit the analysis of fish yields per method on a village level. Therefore, the data are analyzed at an aggregated level. Fish yields will be compared per method instead of per method per village.

Fifth, another important limitation involves the possible existence of *blind spots* in this study of local ecological knowledge. Unseen fishing habits and knowledge of fishers in Peñablanca may lead to inaccurate portrayal and interpretation of fishers' ecological insight. For instance, fishing practices and knowledge that have not been witnessed/ studied in the rainy season may cause such blind spots.

Finally, due to a given time span of three months, Berkes' (1999) knowledge-practice-belief complex, social institutions and cosmology, could not be studied. This is pitiful, because this would provide insight in social codes with regard to fishing behavior and people's worldview. How do they perceive freshwater fishing from a holistic perspective? And how does this worldview shape their local ecological knowledge? What are formal and informal rules on fishing? These questions could not be studied in this research.

Having said this, I am confident that the results of this research provide useful insight in what local fishers know and how they fish. In total 41 days were spent in the field; over 100 interviews, including long semi-structured, short semi-structured, and informal interviews are held; and 45 fishing trips were observed and recorded. I think that these respondents and observations generated valuable information about how local ecological knowledge of people in Peñablanca can improve fisheries management.

3. Riverine Knowledge

This chapter describes what fishers in Peñablanca know about riverine species and the processes that influence them. A list of encountered species is provided together with an individual description of each species. The second paragraph describes how their populations changed overtime. This includes an indication of the current status of the species and natural and human factors that influenced them. In the final paragraph the importance of these species shall be described in terms of catch composition, personal preference, and market value.

The results in this chapter are acquired through 12 long semi-structured, 80 short semi-structured interviews, and 45 observations of fishing trips. Regarding interview results, it will be attempted to make distinction between *emic* and *etic* information. In anthropology, "emic constructs are accounts, descriptions, and analyses expressed in terms of the conceptual schemes and categories regarded as meaningful and appropriate by the native members of the culture whose beliefs and behaviors are being studied" (Lett 1990, p. 130). The emic perspective takes the beliefs and words of the observant as starting point. "Etic constructs are accounts, descriptions, and analyses expressed in terms of the conceptual schemes and categories regarded as meaningful and appropriate by the community of scientific observers" (Lett 1990, p. 130). An etic account uses theories, concepts and hypotheses from outside the research area as starting point. In this research emic refers to information directly generated from fishers in Peñablanca and etic reflects my personal interpretations of observations sometimes using external theory and knowledge.

Note: most information provided in this thesis is *emic* (based on fishers' knowledge and insights). When the account is *etic* this will be explicitly mentioned.

3.1 Description of Riverine Species

While interviewing fishers and observing fishing trips, 20 riverine species are encountered: 14 fishes, 4 mollusks, and 2 crustaceans. Table 2 presents them. Their local names can be viewed in the first two columns and their English names are presented in the third. In this thesis, the species will be referred to with their English names when that name is available, otherwise the local non-scientific name will be used. The fourth and fifth column provides the scientific name and the name of the family to which a species belongs. The final column shows whether the species is native, endemic, or introduced to the Philippines. The English, scientific, and family names and origin of these species are found on the online database Fish Base (www.fishbase.org). Shells in this research are identified with help of Rob Moolenbeek, employee of the Naturalis Biodiversity Centre in Leiden, the Netherlands. Images of all species can be viewed in figure 4. The descriptions of species follow with exception of the Crucian carp. This fish is first encountered at the end of the research period during a fishing trip. There was not enough time to study fishers' knowledge of this species.

Table 2 – Names of encountered riverine species

FRESHWATER FISHES					
Itawes	**Agta**	**English**	**Scientific name**	**Family**	**Origin**
Agwat	*Purung*	Squaretail mullet	*Liza vaigiensis*	Mugilidae	Native
Birut	*Buhoko*	Goby	Not Available	Gobiidea	Not Available
Dalag	*Dalag*	Mudfish	*Channa striata*	Channidae	Native
Dulang	*Dulang*	Halfbeak	*Dermogenys spp.*	Hermiramphidae	Native
Fuliag	*Paleling*	Goby	*Sicyopterus lacrymosus*	Gobiidea	Native
Hunug	*Bunug*	Large snout gobies	*Awaous melano chephalus*	Gobiidea	Native
Hursi	*Buhasi*	Silver perch	*Leiopotherapon plumbeus*	Terapontidae	Endemic
Iroho	*Karpa*	Crucian carp	*Carassius carassius*	Cyprinidae	Introduced
Mori	*Mori*	Marble goby	*Oxyeleotris marmorata*	Gobiidea	Native
Pattat	Not Available	Walking catfish	*Clarias batrachus*	Claridae	Introduced
Rashan	*Rashan*	Common carp	*Cyprinus carpio carpio*	Cyprinidae	Introduced
Sihin	*Iget*	Luzon mottled eel	*Anguilla luzonensis*	Anguillidae	Native
Yellow tilapia	*Tilapia*	Giant tilapia	*Oreochromis niloticus*	Cichlidae	Introduced
Black tilapia	*Tilapia*	Mozambique tilapia	*Oreochromis mossambicus*	Cichlidae	Introduced

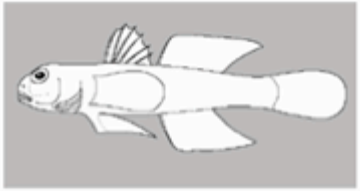
FRESHWATER CRUSTACEANS & MOLLUSKS					
Itawes	**Agta**	**English**	**Scientific name**	**Family**	**Origin**
Ala	Not Available	Asian/ Golden clam	*Corbicula fluminea*	Corbiculidae	Native
Agama	Not Available	Not Available	*Sundathelphusa cagayana*	Gecarcinucidae	Native
Agurung	*Aguhung*	Not Available	Not Available	Thiaridae	Native
Anzikkan	Not Available	Not Available	*Jagora dactylus*	Pachychilidae	Native
Basikul	Not Available	Golden apple snail	*Pomacea diffusa*	Ampullariidae	Introduced
Lasit	*Hipon*	Not Available	Not Available	Palaemonidae	Native

Source: Fish Base 2013; Naturalis 2013

Figure 4 – Images of encountered riverine species

Agwat – Squaretail mullet
Source: Mabuwaya Foundation

Fuliag – No common name
Source: Fish Base (2013)



Mori – Marble goby
Source: Mabuwaya Foundation

Yellow tilapia – Giant tilapia
Source: Fish Base (2013)

Agurung – No common name
Source: Van Lieshout 2013

Birut – Various small gobies
Source: Van Lieshout (2013)

Hunug – Largesnout goby
Source: Fish Base (2013)

Pattat – Walking catfish
Source: Van Lieshout (2013)

Black tilapia – Mozambique tilapia
Source: Fish Base (2013)

Anzikkan – No common name
Source: Van Lieshout 2013

Dalag – Mudfish
Source: Van Lieshout (2013)

Hursi – Silver perch
Source: Mabuwaya Foundation

Rashan – Common carp
Source: Fish Base(2013)

Ala – Golden clam
Source: Van Lieshout (2013)

Basikul – Golden apple snail
Source: Van Lieshout 2013

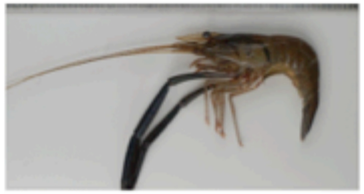
Dulang – Halfbeak
Source: Van Lieshout (2013)

Iroho – Crucian carp
Source: Van Lieshout (2013)

Sihin – Luzon mottled eel
Source: Fish Base (2013)

Agama – No common name
Source: Van Lieshout (2013)

Lasit – No common name
Source: Van Lieshout 2013



Agwat: Squaretail mullet

Fishers say this mullet is an olive-brown or silver colored species, which can grow over half a meter. It feeds on *lumut* (green hair algae[6], see figure 5) and small species, such as (aquatic) insects and *ifun* (fingerlings) of other species. The fish is fast and strong, it has hard scales and is difficult to catch. The fish can be found everywhere in the Pinacanauan, but best chance to catch it is in deep and large waterways, such as in Callao. The occurrence of this mullet is low. Fishers observed a decline of its stock and a diminished seasonal presence. The explanations for this will be discussed later in this chapter. Best time to catch mullet is in rainy season. Heavy rainfall silts the water. This is ideal to catch mullet, because silted water blurs the species' view allowing it to get caught. This will be further discussed in the next chapter. Mullet is a slow-breeding species. Once a year it "moves to other waters" for reproduction. During this period it is not abundant. Roughly 50% of the interviewees said that mullet moves in summer season, the rest say in rainy season. A minority of the interviewees (<10%) knows that this species breeds in brackish waters close to Appari and that fingerlings moves back to Peñablanca when grown big enough to survive. According to biologists, mullet spawns in saltwater, but usually lives in freshwater. In the rainy season adult fishes move in large aggregations offshore to breed (Colin 2012).

Figure 5 – *Lumut* (hair algae)
Photo by K. van Lieshout (2013)

Birut: Various goby species

Fishers mentioned the existence of various goby species, including *birut*, *mori* (marble goby), *hunug* (largesnout goby), and *fuliag*. Remarkable is that most small-sized goby species (<10 centimeters) are figured among the same name *birut*. Marble goby, largesnout goby, and *fuliag* are considered distinct species. Their descriptions will follow later. Fishers say that *birut* can be black, transparent grey or brown. Their distinctive scientific names could not be identified in this research. *Birut* are among the most common fish species in the river. The fishes occur in pairs. For shelter and reproduction they build borrows under rocks and stones in shallow waters. The species reproduces fast and several times a year, fishers say. It attaches the eggs to aquatic vegetation or the surface of rocks. The larvae look transparent after

[6] Specific common name and scientific name could not be identified.

hatching and grow fast. For habitat *birut* prefers rocky areas where they can dig in between and under cobbles, according to interviewees. They are bottom-dwellers that sometimes live in the shells of aquatic invertebrates, such as mollusks. Although quite fast, *birut* can be caught by hand in shallow waters. *Birut* feeds on *lumut* and is eaten by predators like mullet, mudfish, and eel. The species occurs in all studied parts of the river and remains in Peñablanca all year round.

Dalag: Mudfish

Adult mudfishes are black/brown with "a light-colored belly". Sometimes they appear with faint dark bands across their bodies. Their heads are snakelike and they can grow up to one meter. Nowadays, these sizes are not found anymore in the Pinacanauan, fishers say. The species has become rare, because its population has declined. Mudfishes are shy and prefer to dig burrows in dark muddy places, such as irrigation systems and natural ponds, to hide in. According to fishers, mudfishes tends to search for flooded places in rainy season. In the summer season they usually return to permanent water bodies. Sometimes mudfishes are found in deep channels of the river (>2 meters). In these places they are hard to catch, because it is difficult "to swim very deep". Mudfish preys on (aquatic) insects, crustaceans, worms and frogs. With regard to the breeding process, fishers said that it spawns once a year in rainy season. Mudfishes move to muddy and flooded places for reproduction. They form pairs and lay/ hatch eggs. After hatching the fingerlings are red-orange. Later they turn greenish.

Dulang: Halfbeak

According to fishers, the halfbeak is a long-shaped, small, and silver-colored transparent fish that gets 10-15 centimeters. It is abundant all year and can be found in all studied waterways. It swims right below the water surface where it hunts on insects on the surface. Halfbeaks are swift swimmers that move sig-sawing through the water, one fisher said while moving his hand from left-to-right. Most fishers (98%) agree that the species breeds fast. It lays eggs between stones in shallow waters several times a year. It is one of the most abundant fishes.

Fuliag: No common name available

This goby species has gone extinct in most parts of the Pinacanauan, most older fishers said. It can only be found far upstream where the Agta live. *Fuliag* mainly stays in shallow waters near or under big stones and in mud. How it reproduces is unknown for all interviewees. Young fishers (<25-30 years) have never seen or caught this species. Older fishers (>45 years) hooked this species on a rare occasion when they were young. Generally, not much is known about this species.

Hursi: Silver perch

Fishers describe this fish as a silver-colored species with a golden gleam. It has a forked tail, spiny fins and can grow half a meter. Silver perch feeds on *lumut* and preys on crustaceans, eggs of other fishes, and insects. Silver perch is rare and occurs only upstream where the Agta live. This perch used to be abundant in other parts of the Pinacanauan, but it disappeared in most parts of the river. Silver perch breeds slowly, once a year in summer. Fishers find this perch hard to catch. It stays in the deepest parts of the river and is very fast. Agta catch this species only once or twice a year. The best chance to catch it is in summer when the water level is low (to be further explained in chapter 4). Agtas often trade their fish catches with people from downstream villages (mainly Minanga) for products they do not have in the mountains, respectively rice, coffee, and liquor. Silver perch is not traded. One Agta interviewee said: "we like the taste of this fish so much that we want keep it to ourselves".

Mori: Marble goby

Marble goby can be yellow with brown spots or dark brown, fishers say. It can reach up over 50 centimeter. This goby is a large, slow, and solitary fish. It preys on crustaceans, small fishes, and (aquatic) insects. For habitat it prefers to stay on the bottom of the river in low velocity areas. The abundance of marble goby in the Pinacanauan River is low and seasonal. In summer, marble goby can be found in Peñablanca, but it moves to brackish waters in North-Luzon as soon as the rainy season starts. Most fishers know this, but most of them do not know why it moves. Only a couple of fishers (5%) mentioned that it moves to brackish water for reproduction. They know that marble goby prefers to spawn in sandy and salty waters. The fingerlings return to Peñablanca in summer "to grow". Marble goby has become rare. Fishers observed a decline of its stock during the past 20 years. Old fishers (>40 year) remember catching this species on a regular basis in their adolescence. But today: "*nomori, no more mori*", some fishers joke.

Pattat: Walking catfish

The walking catfish has, according to fishers, a brown-black color, a smooth skin, and it can grow over half a meter. The fins are spiny and sharp. People prefer not to hold it with bare hands, because they can get themselves cut. This fish is a slow-moving species that mainly rests on the bottom of unclear, stagnant waters, irrigation systems, or slow-moving streams between the roots of trees. Remarkable is the species' ability to "walk". It can stay out of the water for a while and "crawl forward". Walking catfish eats crustaceans, mollusks, small fishes and *lumut*. Its abundance is low. Fishers observed a decline in its population. The best time to catch catfish is summer when the water level is low. For reproduction the species forms a pair with a species of the other sex. They spawn in small burrows or caves near riverbanks. In Callao some fishers stated that irrigated rice paddies are preferred spawning habitats. Some fishers observed eggs on rock surfaces. Best time for reproduction is rainy season, when the water level is high. The species moves to flooded places to spawn. In the summer season it returns to the permanent water bodies.

Rashan: Common carp

The origin of this species can be explained by an etic account. This carp was introduced to the Philippines from Hong Kong in 1915. It was bred and stocked by the BFAR in inland waters, such as the Pinacanauan River (Guerrero 1988). Employees of the BFAR say that the BFAR is responsible for the annual release of 10,000 fingerlings in the Pinacanauan River. This is done to maintain the carp population and to supply rural fishing communities of enough food and income. According to fishers, common carp had grey-yellowish scales and can grow up to one meter. It is the largest species in the Pinacanauan River and it can mainly be found in Callao. The river provides a suitable environment for the species to survive: wide, deep and slow steaming. It usually hides deep in the river under rocks or in "mini-caves". The carp lives in a school and eats small fishes, crustaceans, mollusks, aquatic insects, and *lumut*. Reproduction happens fast and several times a year.

Sihin: Luzon mottled eel

The Luzon mottled eel has an olive-brown color with dark spots and a white-yellowish "belly", fishers say. The species can grow over a meter with "a body as big as an adult male leg". Due to its high market value, large size, and taste, it is a desirable species. However, eel is not abundant. Its population declined and the species became rare. Today, it can be found in less accessible and/or in areas sparsely populated by people. Highest chance to find eel is upstream in Buyag or in deep, rocky water bodies, which can be found in Minanga, Nabbabalayan and Callao. On a rare occasion this eel is found under big stones in shallow creeks that drain into the river, such as the Natulud Creek in Mangga. Catching eel is not easy to catch for several reasons. First, a fisher has to be experienced and needs to possess the right fishing gear (will be further described in the next chapter). Second, eel is sleek and fast. And third, it is a shy creature that is mainly active at night. For habitat it prefers spots under big stones or in "mini caves" in stony areas. Eels like to burrow themselves into sand or mud under stones. Eel eats small fishes, crustaceans, and shrimps. The reproduction is slow. Agta who observe this fish most often, notice less eel in the rainy season. Then the species "moves elsewhere" to breed. In external scientific sources it was found that Watanabe et al. (2009) clarify that this species moves from freshwater bodies to brackish water to spawn. Sometimes they move more than a 100 kilometer away.

Tilapia: Giant and Mozambique Tilapia

Fishers distinguish two kinds of tilapia in the Pinacanauan River: giant tilapia *tilapia*, locally named *yellow tilapia*, and the *Mozambique tilapia*, referred to as *black* or *native tilapia*. Nonetheless, both are introduced. *Mozambique tilapia* was introduced first in the 1950s from Thailand. It originates from Mozambique. Giant tilapia was released in Philippine waters in the 1970s (Smith *et al.* 1985). Fishers in Peñablanca describe giant tilapia with vertical stripes, extending from head to tail, which colors may vary from to olive-yellow to greyish. Mature fishes can grow 60 centimeters. The Mozambique tilapia usually has a red tail and a dark-brown body. It is smaller in size than giant tilapia. The fins of both types can be spiny. For habitat tilapia has no specific requirements. It occurs everywhere in the river often in small schools. Biggest fishes, however, are usually caught in deeper portions of the river. Tilapia mainly feeds on *lumut* and small (aquatic) insects and has, when adult, no direct natural enemies. About its reproduction, tilapia is a reproductive species. It spawns several times a year and the females carry the eggs until hatching. The eggs are yellow, peppercorn-sized and pear-shaped. After hatching, the mother takes care of her fingerlings until they have grown big enough to survive alone. Whenever a predator is noticed, the mother will open her mouth to protect her fingerlings in there. Because of its reproductiveness tilapia has become dominantly abundant, fishers stated.

Giant tilapia is the most caught species in Peñablanca. Like common carp, fingerlings of this species are released in the river to secure the presence of fish as source of livelihood. According to employees of the BFAR, 192,000 fingerlings are yearly released in Callao (almost twenty times as many as carps). Both the release of fingerlings and its high reproductiveness led to a true invasion of giant tilapia in the Pinacanauan River. Over 70% of total fish catch in the region comprises giant tilapia. (To be discussed in the next paragraph). Mozambique, on the contrary, is less common, but still available. Although abundant, both types get caught before they reach the mentioned size of adult fishes. The biggest catches are 20-25 centimeters and weight 100-200 grams.

Mollusks & Crustaceans

Shells and crustaceans are harvested by hand often by picking them from stones or overturning large cobbles submerged in shallow waters with a low velocity. Shell and mollusk collection is not considered fishing, many male fishers state: “it is a women’s job”. Shell picking is time-consuming and the revenues in terms of nutrition are low. Fishers therefore regard this “waste of time.” With exception of shrimps, mollusks and crustaceans are considered irrelevant species for fishing. In total, four shells and two crustaceans are encountered. Each species shall be separately described below starting with shells. These descriptions are based on information provided by fishers. The local names are used for the species, because for the majority no common English name could be identified.

The best time to harvest shells is in summer from January to May, fishers say. Outside these months Peñablanca is frequently hit by tropical storms and typhoons, causing high-water levels and strong currents that flush away mollusks from stones. People harvest four different species from the river and its creeks: *ala*, *anzikkan*, *agurung*, and *basikul*. *Ala* is a small yellow-green shell that can be found in stagnant water on muddy riverbeds. Stagnant waters mainly refer to small ponds aside of the river that are not or poorly connected to the main flow. High water levels due to heavy rainfall form them. The *anzikkan* is smallest of all. It has "the size of a fingernail" and it lives on rocks in shallow parts everywhere in the Pinacanauan River. This species is not substantial for food considering its little edible parts. *Agurung*, on the contrary, is liked very much and therefore the most harvested mollusk. It can be found in creeks on rocks in shallow water. *Basikul* also lives on rocks. It is hard to find, because it is difficult to distinguish it from a stone. But people in Peñablanca know how to find it. Whenever they search for *basikul* they search for their pink eggs, which are released out of the water on rocks or branches. The presence of eggs, suggests the presence of *basikul*. Once the eggs are spotted, their eye is trained to distinguish *basikuls* from pebbles. In scientific literature it was found that *basikul* was introduced to the Philippines in the 1980s to provide people with a food source (Mohan 2002).

The last two studied species involve *lasit* (shrimp) and *agama* (crab). Of these two, shrimps are more important for food collection. The species is quite abundant and people like catching it, because they enjoy its taste, especially when fried. Shrimps are found under stones and can be caught by hand. The species is quite fast and swims backwards moving its tail up and down. This shrimp can grow up to the length of "a mature human hand". However, shrimps often get caught before they reach that size. Crabs are abundant too. This species is found in rocky places in the river. The people of Peñablanca are not interested in this species, because they dislike the taste. Fishers use it for bait to catch other species, such as eel.

3.2 Changes in Fish Populations

The abundance of various species changed throughout the years. This paragraph describes these changes and how fishers in Peñablanca explain them. Mollusks and crustaceans are excluded, because fishers pointed out that they are of least importance for them. This will be elaborated later in this chapter.

A remarkable result of interviewing is that the majority of interviewees (95%) stated that populations of all species declined except for one species: giant tilapia. Declines are observed for squaretail mullet, Luzon mottled eel, marble goby, mudfish, walking catfish, silver perch and *fuliag*. The first five have always been less common compared to other species, but today they are rare and/or uncommon. The latter two are nearly extinct. They occur upstream in Buyag's water bodies. Other populations, such as of *birut*, halfbeak, Mozambique tilapia, and largesnout goby declined as well. Though, they are still common. See section 3.4 on page 38 for the current status of fish species as indicated by fishers.

Through interviewing five explanations for fish stock decline are identified. First, a 87% of the interviewees explain a diminished availability of fish by today's high number of fishers. The high number of fishers is addressed to human population growth. "People make so many babies," one fisher joked. Second, 68% of the interviewees address the use of certain fishing methods, dynamite and gill nets in particular, to fish stock decline. Dynamite fishing is the most effective to attain high catches, but today it is prohibited and barely used anymore. Fishers claim that it is dangerous: "it kills all fishes", and destroys the riverbed. Gill nets – in particular the small-meshed that capture the young and immature ones – contribute to present fish stock decline. Third, 19% of the fishers (they usually come from lower stream villages – Buyun, Mangga, Nabbabalayan, and Callao) refer to farming as contributor to fish stock decline. They say that pesticides used in agriculture drain into the river and "make fishes ill." They then die and make their population decline. Fourth, fishers in Minanga address past logging activities to the disappearance of fish. Minanga is close to past logging sites. Logging decimated forests far upstream on the Sierra Madre forest fringe, whereby they cannot preserve soils well anymore during tropical storms in rainy season. Muddy streams pollute the Pinacanauan River. This is an "unpleasant condition" for fish species and forces "fish species move elsewhere": where to is unknown. Fifth, according to 12% of the interviewees, typhoons evoke changes in fish abundance. One specifically mentioned is super typhoon Megi in October 2010. Before then, Buyun was not directly connected to the Pinacanauan River, but to a small side-stream. The landscape was modified after the typhoon split the river in two: one main stream alongside Mangga and a shortcut alongside Buyun. Ever since, fishers in Mangga have been observing less fish.

Apart from fish stock decline, the increase of giant tilapia in the river was questioned. Fishers provided three factors related. First, the majority of fishers (82%) stated that giant tilapia reproduces faster than other species. For that reason it is able to quickly grow in number and outgrow the populations of other species. Second, fishers (68%) said that giant tilapia is a strong species. For instance, whenever a typhoon impacts aquatic communities, the population of giant tilapia does not seem to alter much. Third, a small group of fishers (16%) refer to the dispersal of giant tilapia fingerlings in the Pinacanauan River by the BFAR. Since they are aware of this, they have been noting an increasing abundance of giant tilapia. Employees of the BFAR explained in an interview that fingerlings are dispersed to secure food and sources of livelihood of fish-dependent people. This is done because of the decreased availability of fish in the river.

3.3 Comparing Emic-Etic Explanations of Changes in Fish Populations

In this paragraph the emic (fishers') explanations will be compared to external, scientific, etic theory. This is important to determine how much both explanations differ from/ resemble to each other. First the five factors related to fish stock decline will be discussed, followed by the driving forces concerning the increase of giant tilapia.

The first explanation provided by fishers involves the growth of the human population in Peñablanca. White *et al.* (1998) claim the same. They explain fish stock decline by the fact that the Philippines has one of the fastest growing human populations in the world. This increases demand and consequently capture of fish. The National Statistics Office (2010) reported indeed a growth of 12,8% of Peñablanca's population from 2000-2010 (NSO 2010).

The second factor provided by fishers involves the use of highly effective fishing methods, especially dynamite and fine-meshed gill nets. This is supported by Green *et al.* (2003) who state that refinements in fishing gear, in particular the introduction and popular use of explosives, trawlers, fine nets, and electricity, have contributed to major increases of fish yields over the past years. Different is that fishers in Peñablanca do not mention electricity a major destructive fishing method.

The third claim is that agricultural pesticides drain in the river and "make fishes ill." Often they die, whereby the fish population diminishes. Kemp *et al.* (1983) investigated the decline of submerged aquatic vegetation in various wetlands and found that agricultural runoff often contains herbicides. This destroys various kinds of vegetation and stimulates algal growth. Loss of vegetation can lead to a decline of food provision for species and lead to their extinction. Although fishers do not mention this, this could also be the case in Peñablanca. *Lumut* (hair algae) is namely the only observed vegetation in the river.

The fourth claim is that logging pollutes the river and forces fishes to move, because they cannot adapt to the changing water condition. This aligns with the results of a study by Porter *et al.* (2000). They showed that certain species in British Columbia's freshwater basins are tolerant to changes in habitat due to timber extraction. Some aquatic populations decreased in number, some disappeared.

The fifth factor related is the impact of typhoons. They reshape the landscape of the river and cause changes in the abundance of various species. This idea is supported by a study on the effects on typhoon disturbance on the abundance of fish populations in water bodies in Taiwan. Chuang *et al.* (2008) argue that tropical storms can drastically modify channel morphology, landforms, aquatic vegetation, and aquatic communities. Rubble streams and landslides generated by floods cause changes in streams and cause high mortality rates of fish species. As a consequence, major floods alter fish behaviors, structures of fish communities, and significantly decline or even demolish aquatic species from their natural habitats.

Concerning the increase of giant tilapia, fishers name three contributing factors: 1) giant tilapia breeds fast; 2) it is a “strong species”; and 3) the BFAR disperses fingerlings in the river. These explanations relate to what Martin et al. (2010) describe about giant tilapia. However, what both fishers and employees of the BFAR did not refer to in this research, is a possible correlation between the dispersal of tilapia fingerlings and the observation that giant tilapia population increased while those of other species decreased. Martin *et al.* (2010) describe giant tilapia as an invasive species that successfully dominates ecosystems worldwide. Tilapia can be introduced either intentionally (such as in Peñablanca) or unintentionally (for example, when fishes escape from aquaculture ponds). Several features of the species contribute to a rapid expanding population: giant tilapia is able to survive in all kinds of ecosystems; it is fast breeding, which is also mentioned by interviewees in Peñablanca; and its feeding habit is omnivorous: it eats almost everything, which improves chance of survival. These attributes explain why giant population grows so fast. Additional attributes explain how giant tilapia can lead to disappearance of other species. Namely, giant tilapia tends to exclude other fish species from their preferred habitat due to predative (aggressive) behavior and its omnivorous diet involves eating eggs of other fish species. This impacts the reproductiveness of other fish populations. Therefore, the annual release of giant tilapia in the Pinacanauan River could be a plausible explanation for the fact that this species increased in number while other species declined.

3.4 Current Status of Fish Populations

To indicate the current level of abundance per species per village fishers were asked to address labels to the abundance of individual fish species per village (see Appendix II and III.) The labels that fishers could attribute include: *dominant* (the species is dominantly abundant compared to other species); *common* (the species is abundant); *less common* (this species is abundant, but cannot be caught every day); *rare* (this species can be found on a rare occasion); *extinct* (the species does not exist anymore); or *non-existent* (the species did never occur in the village). The results are visible in table 3. The species are listed from most to least abundant and villages from down- to upstream. The labels presented in the table are those that the majority of interviewees per village addressed to a certain species.

Table 3 – Level of abundance of fish species by village

Species/Village	**Callao**	**Nabbabalayan**	**Minanga**	**Mangga**	**Buyun**	**Buyag**
Giant tilapia	Dominant	Dominant	Dominant	Dominant	Dominant	Dominant
Birut	Common	Common	Common	Common	Common	Common
Mozambique tilapia	Common	Common	Common	Common	Common	Common
Largesnout goby	Common	Common	Common	Common	Common	Common
Halfbeak	Common	Common	Common	Common	Common	Common
Common carp	Common	Less common	Non existent	Non existent	Non existent	Non existent
Squaretail mullet	Less common	Less common	Rare	Rare	Rare	Less common
Luzon eel	Less common	Rare	Less common	Rare	Rare	Common
Marble goby	Rare	Rare	Rare	Rare	Rare	Less common
Walking catfish	Rare	Rare	Rare	Rare	Rare	Rare
Mudfish	Rare	Rare	Rare	Rare	Rare	Rare
Fuliag	Extinct	Extinct	Extinct	Extinct	Extinct	Rare
Silver perch	Extinct	Extinct	Extinct	Extinct	Extinct	Rare

Reading the table shows that giant tilapia is dominantly abundant in every village. *Birut*, halfbeak, largesnout goby, and Mozambique tilapia are also common species and can be found in all studied areas. Squaretail mullet can only be found in downstream waterways of Callao and Nabbabalayan, and far upstream in Buyun. Fishers explain this by stating that mullet needs wide and/or deep waterways, which is present in these villages. The waterways in the other villages are too shallow for this fish to survive. Eel is rare in most villages. Only in Callao, Buyag, and Minanga this species can be caught on a regular basis. As mentioned before, common carp requires deep, wide and slow-streaming waterways to live. The waterway in Callao meets these requirements. Therefore, most carps can be found in Callao and few in neighboring Nabbabalayan. Further upstream waters are too shallow (Mangga, Buyun, and Minanga) or too fast flowing (Buyag). Marble goby is very rare. Apart from its seasonal presence stocks of this species are nearly depleted. The abundance of mudfish and walking catfish is similar in all studied parts of the river. Both fishes are rare in all villages. Silver perch and *fuliag* can exclusively be captured in Buyag on a rare occasion.

Considering the diversity of different species in every village, then the presence of distinctive species is highest in Buyag. Agta fishers who live in Buyag observed declines as well during the past year, but in comparison to the declines in other parts of the Pinacanauan, these declines are slight. They explain this by the small size of their community (±50 people). The total fish catch in Buyag is relatively low compared to downstream villages where the number of inhabitant starts at 900 people. In addition, Agta state that they do not use dynamite. For that reason, fish populations upstream are healthier in Buyag.

After Buyag, diversity of species is highest in Callao. This has mainly to do with the assumption that Callao provides “good water” for fishes, two fishermen stated. With “good”, the fishers generally mean deep, wide, and slow streaming. Especially when riding a boat one or two kilometer upstream towards Nabbabalayan, fishing grounds offer more variation of fish species. Boat riding is the only mean by which people can catch fish there. High rock walls and dense vegetation limit people’s access to the river. Only a few fishers can afford a boat. For this reason, the number of fishers who fish upstream is low. What fishers did not mention, but what could serve as explanation for the high variety of species in Callao compared to other villages as well, is the site of the famous Callao Caves is protected (Dirain 2004). The Callao Cave is situated upstream towards Nabbabalayan. Fishing activities are controlled stricter in this area than in other parts, employees of the BFAR stated. Another explanation could be that a lower number of fishers in Callao contribute to higher diversity of species. Different than in other villages, fishers in Callao rather fish for income than for food. Infrastructure and the geographical situation connect Callao to urban center Tuguegarao. Many people in Callao work in the city and/or run a small business. A few people farm. Many people rely on money to make a living. They do not need to fish, hunt or grow crops for daily nutrition. Those who fish in Callao are often the ones without a paid job or farm. Fishing is their alternative to generate an income.

In other villages the availability of fish is lower. Over 50% of the present species is rare, extinct or less common. Least fish is observed in Nabbabalayan, Minanga, Mangga, and Buyun. Especially in Mangga and Buyun, people have little choice in what they can catch. Fishers' explanation this by biophysical characteristics of the river. The river in these villages is quite shallow and has a low velocity. This increases the accessibility to the river even for those who cannot swim. This allows more people to catch fish. Another more etic approach is that people in the named villages need fish for food. Although most people farm for income, this is usually not sufficient to buy food the whole year. An additional complication is that people have poor access to urban resources (jobs), because they live far from urban centers (2-5 hours ride by jeepney) such as Tuguegarao. This encourages self-sufficiency with regard to food production. Many people therefore fish.

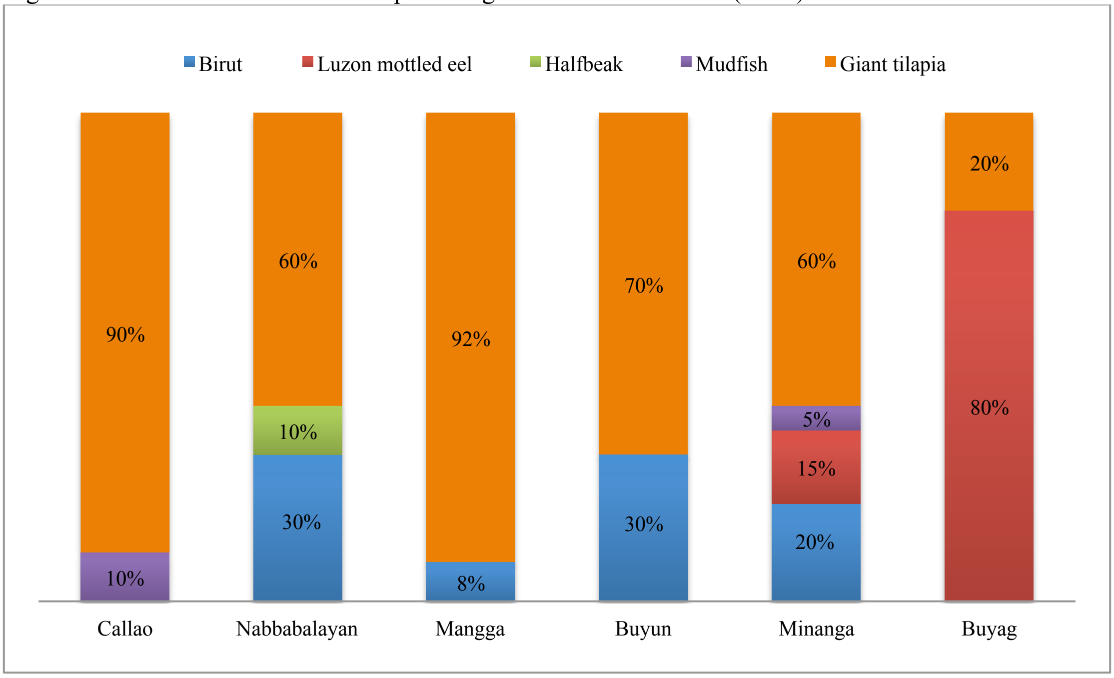
3.5 Importance of Riverine Species

In this paragraph the importance of species is measured through three variables: catch composition (which species are caught?); personal preference (what species do fishers prefer to catch and why?); and market value of species (for how much are species sold?). Catch composition is measured through recording fishing trips and interviewing. The market value and personal preference are indicated through interviews.

In total, 45 fishing trips are recorded. Giant tilapia comprised 85% of the total weight of the catch; *birut* 12%*;* and only 3% of the total catch consisted of other species. These percentages match the results from the interviews. Around 73% of the interviewees named giant tilapia as their main catch, followed by *birut* (15%), Luzon mottled eel (9%) and other species (4%). Figure 6 shows the catch-distribution per village that is generated through interviewing. Evidently, giant tilapia is caught most in most villages. Older fishers stated that the share of tilapia in their daily catch increased over time. "When I was young I caught many different species. But today, giant tilapia stocks the river and is the only species I can catch", one fisher said. Many species disappeared. The minority of fishers (7%) claimed to catch *birut* and argued that they prefer its taste to tilapia. Even though it costs much more effort to gain enough fish, "the taste is rewarding", some say.

A remarkable interview result is the high catch percentage of eel in Buyag. On an etic account, this can be explained by two factors. First, eel is most abundant in Buyag's water bodies as mentioned before. Second, eel is an important species for the Agta. It is their trade product. They exchange eel with people from lower-stream villages for coffee, rice, cigarettes, canned products (such as sardines), and liquor; for products they do not have in the mountains. Usually, eel is traded with the richest people in the lower-stream villages, such as barangay officials. These people can afford eel. Eel is much wanted by them, because they like the taste and it is difficult to find down-stream from Buyag.

Figure 6 – Distribution of fish catch per village based on interviews (n=80)



Although people mainly catch giant tilapia in most villages, fishers wish to catch other species. Most preferred are eel, squaretail mullet, marble goby, silver perch and *fuliag*. Fishers like their taste, but they can barely be found anymore. Their scarcity increases their market price. In table 5 shows an overview of the current prices. They are expressed in Philippine Peso per kilogram and for small species per cup (coffee mug or something similar): PhP 1 = €0,02. The highest prices will be discussed. Marble goby is most expensive because of high demand, seasonal abundance and rarity. Sales price ranges PhP 100-300/kg (±€2-6). Interviewees said that the price rose during the past 20 years due to decline of its population. Eel is sold for PhP 200/kg (±€4), fresh. When dried, prices run up to PhP 500/kg (±€10). Mullet costs ranges PhP 100-200/kg (±€2-4). Silver perch and *fuliag* are not even priced anymore, because fishers do not sell them when sporadically caught. With exception of Buyag, prices are more or less the same in every barangay. Agta in Buyag, however, do not express their fish prices in terms of money, but in terms of goods.

Table 4 – Market value of species (PhP 1 = €0,02 in Oct. 2013)

Species	Current price
Marble goby	PhP 100-300/kg
Luzon mottled eel	PhP 200-500/kg
Squaretail mullet	PhP 200/kg
Walking catfish	PhP 100-120 / kg
Mudfish	PhP 100-120/kg
Silver perch	Not priced
Fuliag	Not priced
Tilapia	PhP 70-90/kg
Birut	PhP 15-20/cup

On these accounts, a few species can be determined most important. Regarding food and income, giant tilapia and *birut* are most important, because they are caught, eaten, and sold most. In Buyag, most important species is eel. However, fishers (with exclusion of those in Buyag) mention that they wish to catch other species, such as eel, squaretail mullet, marble goby, silver perch and *fuliag*. Unfortunately, they stated, these species' populations are declining. Today, they have become uncommon or even rare. This resulted in high market prices. Prices that are, for most fishers, too high to purchase.

These results bring forward a group of *key species*: species that are most important for the people in Peñablanca. These involve: Giant tilapia, *birut*, marble goby, Luzon mottled eel, squaretail mullet, walking catfish, mudfish, silver perch, and *fuliag*. These will be referred to as key species. These fishes will be focused on further in this thesis.

4. Resource Management Systems

The previous chapter described what fishers in Peñablanca know about riverine species and processes that influence these species. In this chapter it is explained how people fish and how much. An overview of common fishing methods is provided together with a description of the ways they can be used. To indicate which methods yield most fish, it is assessed through semi-structured interviewing and observations, which methods are used most and yield most fish. To measure their efficiency, individual Catch-per-Unit-Efforts are calculated. But first, a general overview of the freshwater fishing activities in Peñablanca will be provided.

4.1 Used Fishing Methods

In this study 15 fishing methods, categorized under net, spear, trap, and other types of fishing, have been researched, see table 5. In the first column the local name of the method is presented, in the second, the English term, which will be used in this report, and in the third, which species can be caught with the particular method. Each method will be separately described. These descriptions are derived from demonstrations that fishers gave of fishing methods and what they said about them in interviews.

Table 5 – Used fishing methods in Peñablanca

Local name	English name	Target species
Net fishing		
Ammori	Cast net	Tilapia[7], mullet, mudfish, halfbeak, marble goby, catfish.
Baring	Gill net	Tilapia, mullet, mudfish, marble goby, catfish, common carp.
Arabang	Landing net	Tilapia, halfbeak, common carp.
Spearfishing		
Baltut	Pole spear	Tilapia, mudfish, catfish, common carp.
Balawat	Eel spear	Tilapia, common carp, eel.
Batit	Trident spear	Crab, goby, shrimp.
Pandal	Spear gun	Tilapia.
Trap fishing		
Bubu	Eel trap	Tilapia (fingerlings), goby, shrimp, halfbeak.
Banwet	Hook & line	Tilapia, mullet, mudfish, catfish, marble goby, common carp, eel.
Siid	Cage trap	Tilapia (fingerlings), crabs.
Trapa	Net trap	Tilapia, mullet, goby, mudfish, halfbeak,
Other fishing		
Blasting	Dynamite	Everything.
Kuryente	Electricity	Crabs, *birut*, largesnout goby, shrimps, eel.
Anayut	Poisoning	Everything.

Cast net

A *cast net* is a circular nylon net with small weights that are attached to the outer perimeter. It can be thrown in the water in such a way that it opens and spreads out over a school of fish, trapping it underneath. Most nets have hand lines that are held in the fishers' wrist on the one end and that are attached to brails in the center of the net on the other. After a net has been thrown and sunk to the bottom, pulling the brail lines brings the weights at the outer perimeter to the middle of the net, through which the net captures fishes inside. Cast nets are available in various sizes. Usually, a fisher selects a net by choosing a mesh. This selection depends on

[7] Tilapia refers to both giant tilapia and Mozambique tilapia.

the size of fish he/she wants to catch. The smaller the mesh the more can be caught. When a mesh is too small the chance increases that someone is catching species he/she does not want to catch (for instance, very small fishes). Therefore, people's choice depends on the kind of fish they want to catch. Since tilapia is has been caught most, people choose nets that are suitable to capture tilapia. Cast nets are expensive purchases for most people in Peñablanca. Generally, prices start at PHP 1000 (±€ 20).

There are two main tactics to use a cast net. One is to slowly walk up- or downstream in shallow parts of the river searching for fish to catch. Once fishes are spotted, the net can be thrown. Sometimes a fisher throws stones into the water to control the swimming direction of fishes. Walking upstream can be exhausting, especially in strong currents. Most fishers, therefore, prefer to move downstream. Another tactic is to build a *dumut.* A *dumut* is a big pile of cobbles built in shallow waters. Building takes around two hours. When built, the fisher waits a couple of weeks before returning. "The longer you wait, to more you catch", some say. In the meantime, fishes settle in the *dumut*. Among them are all kinds of small gobies, crabs, shrimps, and young tilapias. When returning after two weeks, the fisher throws some stones around the *dumut* to make other surrounding fishes hide in it. Afterwards, the fisher casts the net over the pile of stones. He/she then slowly removes the stones one by one. The best time to build a *dumut* is summer. During rainy season strong currents destroy it.

Gill net

Gill nets are vertical nylon nets that are usually longer than 50 meter. It consists of a float line with small plastic or cork floats on top and a lead line along the bottom with small leads attached to it. The net is fenced in the water straight up and down. Gill nets catch fishes by their gills. There are several ways in which gill nets can be used. Usually, people "encircle fishes". Encircling is useful in shallow waters and is often done with companions. The float line surfaces the water and the lead line is set out on bottom of the river. One fisher attaches one side of the gill net to some rocks on a riverbank and "hangs the net like a circle in the water", following the current. Meanwhile, other fishers stand around the net and throw stones to force fishes swimming in the net. Afterwards, the net can be checked for catches. This practice is done in a group (5-15 people) and generally takes a whole day. The activities are rotated among members of the group. The best time to use a gill net is in summer. Fishes stay in the water for a while. Warm water temperatures and sunny days are preferred. Gill nets exist in various sizes. The mesh sizes that are used most often are those suitable to catch giant tilapia. Most fishers buy their net in hardware stores in nearby provincial capital Tuguegarao. Hardware stores are shops where people can buy tools and construction materials. Nets can be bought from 100 meter. A net costs over PHP 2000 (±€40 euro), which is expensive for many fishers. Sometimes, people collectively buy one.

Figure 4 – Gill netting
Photos by K. van Lieshout (2013)

Landing net

The *landing net* is a small hand-made net with the size of a tennis racket. This net is used at night together with a *hasag* (gaslamp). At night most fish species are non-active; they simply "hang" in the water, as fishers described. Fishes are therefore easy to scoop out of the river with this gear. The gaslamp is used to spot them. This method can exclusively be implemented on cloudy nights when there is no or not much moonlight. Moonlight is said to make certain fish species, such as tilapia, more active, whereby it becomes harder to catch them. Most fishes can be found in the middle of the river where the river is deepest. Summer is the best time to use this gear, because the water level is lower and the water temperature is nice. Fishers often bring a companion to carry the catch or hold the gaslamp.

Figure 8 – Fisherman holding a landing net and gaslamp
Photo by K. van Lieshout (2013)

Pole spear

Approximately 40% of the interviewees predominantly use a spear to catch fish. Used spears include: pole spear, eel spear, trident spear, and speargun. The *pole spear* is a metal spear of circa 30 centimeters that is attached to an elastic rubber loop. This tool is operated through stretching the rubber band and grabbing the needle while holding the loop under tension. Once a fish is targeted the fisher releases the grasp of the spear while using the hand like the barrel of a gun to steer the spear to penetrate the fish right. An advantage of this gear is that the fisher can choose a target. People prefer the biggest fishes. This method is used underwater. A goggle is required for underwater visibility. Pole spearfishing is done by day and night. The fishing strategies differ. At daytime people fish more effectively with companions. While forming a line, fishers swim against the current throwing stones upstream. This frightens fishes, which makes them hide. Fishers need to stay in line to make sure that fishes stay in front of them. Good hiding places are rocky, shallow and bushy places in the river. Most fishes are caught in these spots. Catch-rates are usually higher a night, because fishes are less active and easier to catch. People do not need assistance, but fishing with others is more fun. For night fishing fishers need a headlight. Also for spearfishing moonlight is not preferred, because it diminishes the fisher's view and it is said that fish species become more active. Pole spearfishing is suitable to catch big species. In the Pinacanauan River this involves species, such as tilapia, mudfish, walking catfish, marble goby, and common carp.

Figure 5 – Pole spearfishing
Photos by K. van Lieshout (2013)

Young fisherman is holding a pole spear

Fishers fishing in a line

Way to hold the spear under tension

Eel spear

Eel cannot be caught with a pole spear: this species is too slippery to penetrate with a normal spear, as it has no scales. Therefore, fishers use an *eel spear* when they target this species. The eel spear is a self-made spear with crooks and a rope attached to it. People tie this spear to a pole spear and operate the tool in the same way. They firmly hold a rope that is knotted to the spear while doing that. Once an eel is shot the crooks pinch the eel's body and snag the skin in such a way that it cannot escape. Eel fishing is mostly done by night. By day eels are passive and hidden in self-dug holes deep in the river. At night they hunt. Fishers need a flashlight and google for underwater visibility. Similar to fishing with a landing net, moonlight is unwanted. It blurs the fisher's view and deters eels. Most eels have been caught in Buyag, since they are most abundant over there. The Agta use the eel spear most, because they need eel for trade. They fish all year, also in the rainy season.

Trident spear

Another implement is the *trident spear*. It is a homemade, long stick with a trident fork at the end. The one used in Peñablanca is small and catches gobies, shrimps, and crabs. A fisher catches them in the *arapang* (local word for rocky, fast-streaming parts in the river), shallow parts of the river. When spotted, the fisher tries to fork them to the trident. The method can be used all year. Today, few people use this gear. It takes long to yield some fish.

Speargun

The *speargun* is, similar to the pole spear, an underwater fishing method that aims to shoot fishes with a spear. The main components are a spear and a wooden stick and grip to which a trigger mechanism is assembled. Target species is tilapia. Fishers use a technique whereby they need live tilapia to attract other tilapia. The fisher wires them to a wooden branch, which he/she sticks out in the water in front of him/her while lying down on the belly in the shallow parts of the river. The fisher has to be quiet and patient while waiting for other tilapia to approach the ones on the stick. The fisher uses a goggle to look underwater. After every shot the gun has to be "reloaded", which means placing the spear in the barrel again. The advantage of this method is that the fisher can choose the target. Big fishes are prefered. Some fishers stay at the same spot all the time, others move up- or downstream. Fishers sometimes borrow live tilapias from another or try to pierce a few themselves. Speargun fishing requires patience. It is a daytime activity that it is mostly practiced in summer when the water is clear and the temperature is pleasant.

Figure 10 – Fisherman fishing with a speargun
Photo by K. van Lieshout (2013)

Hook & Line

With hook and line fishing it is aimed to attract fish by placing bait, or lure, on a metallic hook at the end of a line fixed to a wooden stick, on which they should get caught. What kind of bait is used depends on the target species. Table 6 provides a list of the lure that is used to catch certain species. Using a long line and the right bait enables the fisher to catch species on rough grounds and in deep hiding places between rocks or near "mini caves". This gear is mainly used in Callao, as the river is deep- and widest there. Sometimes, fishers use a boat to reach the deep, middle parts of the river. This method can be used all year under any water/

weather condition. Some fishers use it as alternative in the rainy season when they cannot use their "summer equipment" anymore.

Table 6 – Overview of bait used to catch species

Fish Species	Used Bait
Squaretail mullet	*Lumut*, earthworms
Birut	Earthworms
Mudfish	Cockroaches
Halfbeak	Earthworms
Largesnout goby	Earthworms
Silver perch	*Birut*
Walking catfish	*Birut*, earthworms
Common carp	Earthworms
Luzon mottled eel	Earthworms, *birut*, shrimps
Tilapia	Earthworms

Basket trap

The basket trap is used aiming to catch small species, such as *birut*, shrimps and halfbeak. People build dams in shallow *arapang* parts of the river to facilitate this fishing method. Small, shallow side streams are excellent places for this. Dams are built by hand. They are constructed of rocks and sealed with gravel to prevent leaking. It takes 3-6 hours to complete. Dam building is quite enervating and requires the effort of several people. The dam drains a part of the river and makes it fall dry. Fishes try to find water and seek protection underneath rocks where they can be caught by hand. Additionally, fishers imitate hiding places by placing woven basket traps in parts of the river where the water is still flowing. When the basket is full fishers quickly collect the caught fishes and set up the trap again. Basket traps are homemade and woven out of *rattan* (type of reed). One side has an entry that is designed in such a way that once a fish lures in it cannot escape. People use this trap in summer when the water level is low and the weather is good.

Figure 11 – Fishermen building a dam
Photo by K. van Lieshout (2013)

Cage trap

The cage trap is another homemade trap. It is baited with steamed corn flour. A fish enters the cage through an entry that narrows cage inwards. The tips are pointy which makes it difficult for fishes to exit. Fishers place the trap in shallow, calm waters with the entry faced downstream. In rougher waters a small, rocky wall is built upstream of the cage. A stone on the cage prevents it from flushing away. It is fenced off with thorny branches of the *kamachile* tree (*Pithecellobium dulce*) serving as marking point and protection against bathing animals. Species that are caught through this method are mainly fingerlings of tilapia, shrimps and crabs. Crabs are unwanted: they prevent other fishes coming in, because they eat them. Most fishes can be caught during daytime. Fish species are most active then, fishers say.

Figure 12 – Cage trap
Photo by K. van Lieshout (2013)

Net trap

The *net trap* is a big triangle shaped landing net that is constructed of net and wooden laths or sticks. This trap is usually placed at the end of a small funnel-shaped stream. The rainy season is best season to use it, because the water is muddy and unclear. Fishes do not see the net and are easier to trap them. Another way to use this trap is to scoop in muddy (sometimes stagnant) waters, hoping to catch something. Typhoons create small, muddy torrents along the river, which are often stocked with fish. The main stream provides too little protection during tropical storms. Due to heavy rainfall the river has to drain more water. The current strengthens and flushes away trees and rocks that fishes use as hiding places. For that reason, all sorts of species seek safety in slow-streaming ponds next to the river. The net trap is suitable to catch species that are normally hard to catch, such as squaretail mullet. Fishers who fish all year use this trap in the rainy season and another fishing gear in summer.

Figure 13 – Fisherman demonstrating the net trap
Photo by K. van Lieshout (2013)

Dynamite fishing

Dynamite *fishing* refers to use of explosives to shock or kill many fishes for easy collection. This method is effective – it does not require specific conditions regarding weather, water, and season – but destroys entire fish schools and their natural habitat that serve as feeding and breeding ground. This threatens the continued existence of species. The shells that people use are self-made bombs constructed of a glass bottle stuffed with explosive materials. Sometimes these bombs explode prematurely, whereby people get severely injured or even killed. Today, this technique is prohibited. Although outlawed, two people in Minanga claim that dynamite fishing still is a problem. They say that people use dynamite in upstream waters where fish populations are bigger. In other barangays, this fishing method is barely used. Only in Nabbabalayan three fishers said that some people still use it.

Electrofishing

Electrofishing is the use of an electrically charged stick or bow to stun fish by poking them. When stunned, they can easily be harvested with a small landing net. Electricity is generated by a 12V battery and transported through electric wires. The power source is carried on the back when fishing in shallow parts of the river. In these parts people search for small species, such as *birut* or shrimps. When targeting species in deeper waterways (such as eel), fishers attach the battery to a rubber band that floats on the water surface while they search underwater (with a mask) for fishes. The first type of electrofishing can be done throughout the year, with exception of rainy days, as rain destroys the battery. The second time is usually implemented in summer season when the water is clear and warm.

Figure 14 – Electric fishing gear
Photo by K. van Lieshout (2013)

Poisoning

Poisoning is the use of venominous plants or sodium to catch fish. When fishing with the aid of plants, *anayut* is used. Anayut refers to the poisonous leaves of a tree. This tree could not be identified in this research. Anayut serves as bait that kills fish. It is unclear whether this method is harmful for people who eat fishes that are caught with help of this method. However, no one uses this method anymore, people state. Another method involves the use of sodium. People throw an excessive amount of sodium in the water on places where people spot fishes. The salt affects the sight of species, whereby they get blinded and become easy preys. This method is out of date. People do not use it anymore.

4.2 Most Used Fishing Methods

The popularity of the described fishing methods varies. Fishers were asked which method they use most in 80 semi-structured interviews. The results are visible in figure 15. Most people predominantly use a pole spear, a cast- or gill net. Less popular are the: landing net, speargun, electricity implement, basket trap, and eel spear. The other methods are hardly used these days. Generally, people say they prefer to use methods that are easy to use and that yield most fish. They strive to limit their fishing efforts while maximizing fish catch. Some fishers explain the use of their fishing method by stating that it is the only method they know how to use or they have at home. Others choose a method that suits their physical condition. Pole spears, for instance, cannot be used when the person is unfit and/or unable to swim. The fishing efforts per fishing method will be discussed in paragraph 4.3.

Figure 15 – Fishing methods that are used most (n=80)

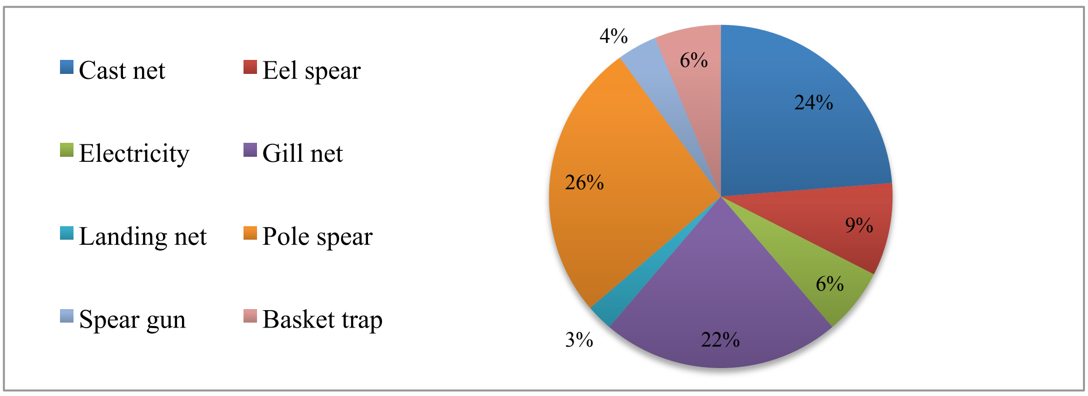
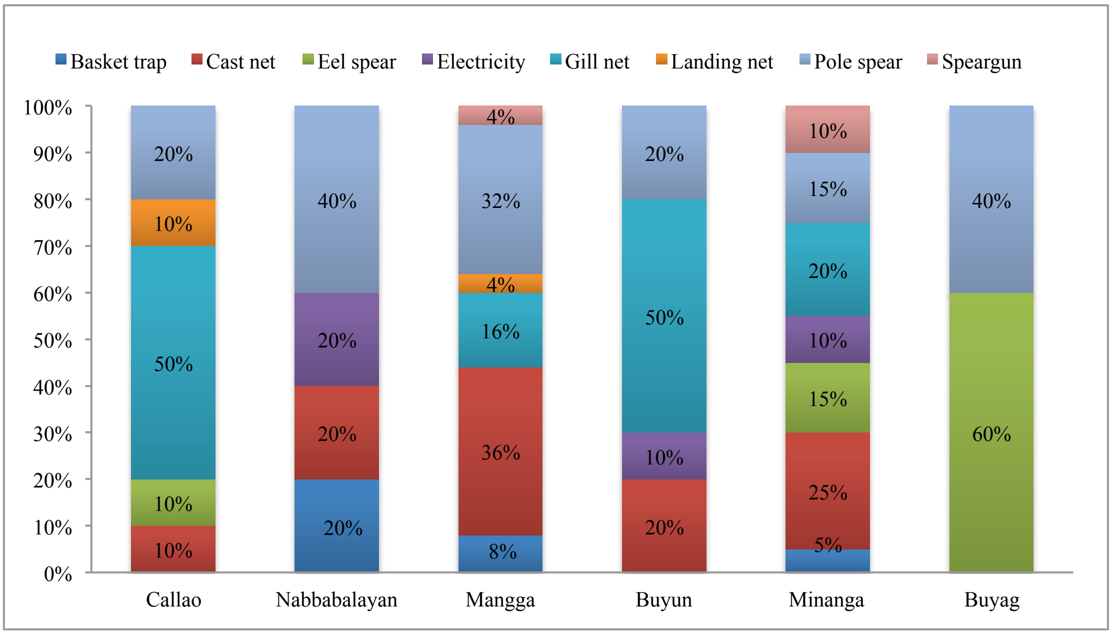


Figure 16 shows the uses of individual methods per village. These are more or less the same in most villages: spear and net fishing are dominant in every village. However, there are a few remarks. The most evident one is the predominant use of spears in Buyag. As mentioned before, the Agta catch eel. An eel spear is needed for this, but eel spears can only be operated when bound to a pole spear. This explains why the Agta mainly use pole and eel spears. Apart from Buyag, eel appears in Callao and Minanga. That explains why the eel spear is used in these villages as well. Another feature is the high use of electricity in Nabbabalayan, compared to other villages. When asking why people use the method in Nabbabalayan, they state that they need this in order to get food. Despite prohibited by law, barangay officials and fishers say that poor people are allowed to practice electrofishing. Someone is regarded poor when having little food and/or income compared to other villagers. Electrofishing is an easy way to catch fish. People do not need to be skilled or trained. Apart from Nabbabalayan, use of electric fishing gear is minimal in the studied area.

Figure 16 – Used fishing methods by village (n=80)

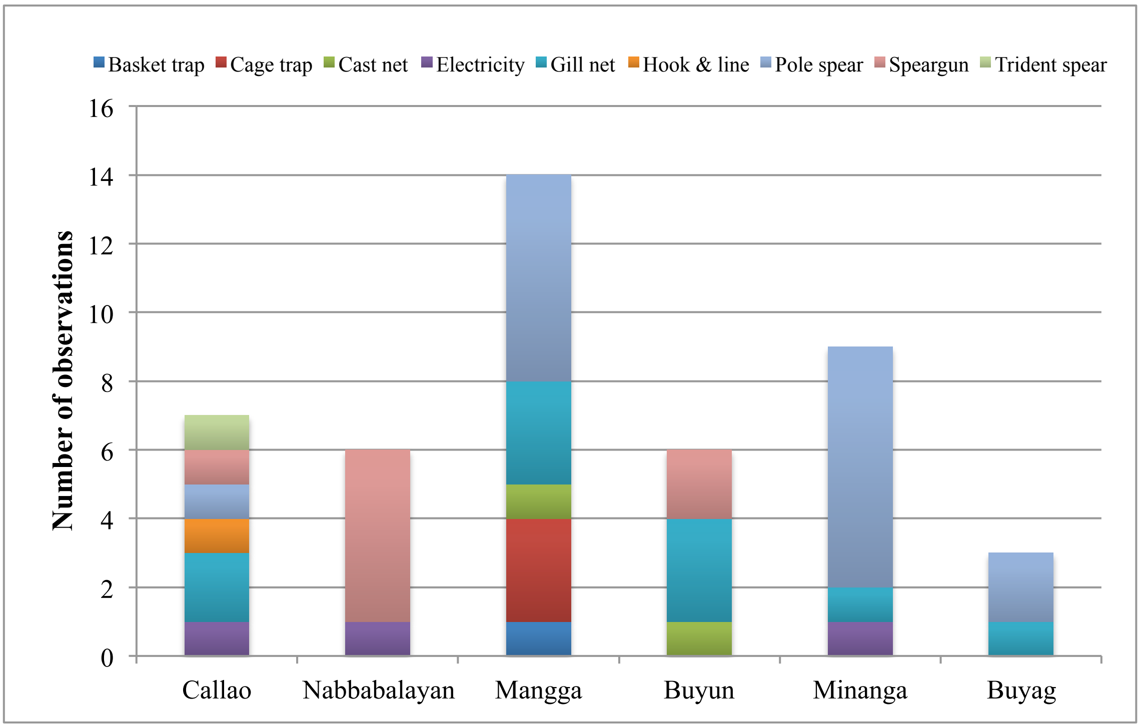


4.3 Analysis of the Fish Yields

Analytical Context

To allow for comparison of the efficiency of different fishing methods, the fish yields are calculated in terms of Catch-per-Unit-Effort. As mentioned in the methodology, for a given fishing method and species the CpUE reflects the weight of catch in grams, per person, per hour. During fishing trips the following data were collected: used fishing method; number of participating fishers; total fishing time per trip; total fishing time in man-hours; total weight of catch; and the weight and sizes of individual caught species. The number of fishers involves everyone who is taking part in fishing. The total fishing time per trip reflects the total time a fishing method that was practiced. Time is recorded from the moment people enters the river until he/she/they finishes fishing. In this thesis this will be referred to as *active fishing time*. The total fishing time in man-hours (*total fishing effort*) refers to the number of minutes that all participating fishers jointly invested in active fishing. During fishing trips the total catch per trip was weighted and expressed in grams. Finally, the sizes and weight of individual species were documented. Since giant tilapia dominated the total fish catch, this species has been measured most. When catches were large (circa >2000 grams) a sample of 20 fishes was taken for measurement.

Figure 17 – Overview of observed fishing methods per village (n=45)



In total, 45 fishing trips were observed in six different villages. Figure 17 provides an overview of the number of observed fishing methods per village. Mangga counts most observations (n=14), because most time was spent there. Due to a lack of time, only three trips could be observed in Buyag. Apart from Buyag, and with exception of Mangga, the overall number of observations per village is low: circa seven observations per village. This means that the number of observations per method per village is even lower. These small sample sizes inhibit the analysis of fish yields per method on a village level. Take the speargun for instance, it is difficult to acquire a statistically significant result when comparing yields of this method, because this method is only observed once in Callao, once in Buyun, five times in Nabbabalayan and zero times in the remaining three villages. Therefore, the data will be analyzed at an aggregated level. Fish yields will be compared per method instead of per method per village.

An additional complication is that fish yields were measured per fishing trip instead of per fishing person. Not every fishing trip had an equal number of fishers. For instance, fishing trips involving gill nets usually require a group of participating fishers. The fish yield cannot be attributed to individuals, only to the entire group. The speargun, however, is implemented alone. To correct for this, the results per trip are weighted by the number of participating fishers. The average CpUE is calculated using the following equation:

$$Average\ CpUE = \frac{\sum\ CpUE_i * N_i^{fishers}}{\sum N_i^{fishers}}$$

The sum runs over all fishing trips. $CpUE_i$ and $N_i^{fishers}$ stand for, respectively, the CpUE and number of participating fishers for a given trip. Table 7 illustrates a hypothetical example of the difference between a simple unweighted average and the weighted method. Two fishing trips, one with a CpUE of 200 and one with 400 would give a simple average of 300. Note that the fishers from the second trip work more efficient, catching twice as much fish with the same effort. In the example, the second fishing trip also has more participants. A simple average ignores this. The weighted average does not, as it calculates the average per person.

Table 7 – Hypothetical example of CpUE [g/h/fisher] calculation

	Fishing trip 1	**Fishing trip 2**
CpUE [g/h/fisher]	200	400
Number of fishers per fishing trip	2	8
Unweighted average CpUE [g/h/fisher]	300	
Weighted average CpUE [g/h/fisher]	360	

Results Fish Yields and CpUE

Before addressing the CpUE results, some general findings of the recorded fishing trips will be discussed. As mentioned, 45 fishing trips are documented. An average fishing trip is at daytime, takes 115 minutes, and yields an average of 1158 grams of fish per fisher. In total, 88 fishers participated in these 45 trips and invested 14544 minutes of active fishing time. Together they caught 101912 grams of fish, of which around 85% consisted of giant tilapia. Table 10 shows the results that generated data through observing fishing trips. Per method, the first column shows the number of participating fishers; the second shows the total time in man-hours invested; the third provides the calculated average of invested time in man-hours; the fourth gives an indication of the relative time invested in man-hours; the fifth shows the total quantity of fish that is yielded; and the last column shows the relative share of each method of the total catch. Reading the table shows that gill net fishing is responsible for

77,1% of the total recorded fish catch. The total fishing effort invested in using this method comprises 66,6% of the total measured fishing time in man-hours.

To explain the large share of gill net fishing in the total documented fish catch, we must look at the average invested fishing effort per method. The methods in which most time is invested are: the basket trap, the cast net, and the gill net. As mentioned before, fishers pointed out that usage of the basket trap is a time-consuming process that achieves low fish yields. Although a low number of observations, the results in table 8 confirm this. After gill netting, most time is invested in implementing this trap. However, its total fish yield comprises only 1,9% of the total measured fish catch. Additionally, an average fishing trip with the cast net is time-consuming too. One trip takes about 228 minutes. This average is computed over only 2 fishing trips, in which one fisher per trip was involved and may be not representative. Gill netting, however, is observed 10 times involving 46 participating fishers. An average trip takes approximately 211 minutes. Compared to the other observations, gill net trips take most time. Obviously, when fishing a couple of hours in a row one expects to catch more fish than when fishing only one hour. Fishers who use this net generally fish the whole day or afternoon together with a couple of relatives or friends. When someone is tired of fishing, his/her companion is taking over. Because of this, gill net fishers are able to keep on fishing and attain large catches. On the contrary, fishers who use a pole spear are not able to achieve such yields, because fishing with this gear is energy consuming. People cannot keep going for hours. The time invested in pole spearing is, therefore, lower than the time invested in gill netting. The same applies for other fishing methods. For that reason, the shares in terms of fishing effort are low compared to gill net fishing.

Table 8 – Results of fishing efforts by method

Fishing Method	Total Number of Observations	Total Number of Participating Fishers	Total Fishing Time in Man-Hours [min.]	Average Fishing Time in Man-Hours [min.]	Relative Time in Man-Hours [%]	Total Catch [gr.]	Total Catch [%]
Basket trap	1	3	1530	510	10,5%	1930	1,9%
Cage trap	3	3	82	27	0,6%	988	1,0%
Cast net	2	2	455	228	3,1%	6293	6,2%
Electricity	3	4	399	100	2,7%	2181	2,1%
Gill net	10	46	9697	211	66,7%	78544	77,1%
Hook & line	1	1	34	34	0,2%	61	0,1%
Pole spear	16	20	1197	60	8,2%	7072	6,9%
Speargun	8	8	1120	140	7,7%	4836	4,7%
Trident spear	1	1	30	30	0,2%	7	0,0%
Total	45	88	14544	165	100,0%	101912	100,0%

The results discussed do not indicate the efficiency of the measured methods. In order to determine which method yields most fish with the least effort, the CpUEs of each recording are calculated. These results are presented in table 9. Per method, the first column shows the number of participating fishers; the second the lower bound of CpUE; the third the upper bound; the fourth the average CpUE; and in the sixth shows the standard deviation of the CpUE measurements. The results relevant to this research will be discussed. When looking at the average yield of fish per method, per person, per hour (CpUE) then pole spearfishing by night is most efficient. One fisher yields, on average, 1100 grams of fish per hour. At daytime, CpUE is much lower. The pole spear is the only method in this research that is observed both at day and night. Although documented only six times at night, the results are more confident than those of cast netting. This method has an average CpUE of 903 grams calculated over two data. The same applies for the cage trap that is in third place. Three observations resulted in an average fish yield of 737 grams per person, per hour. Nevertheless, this method is worth discussing, because of the low time-investments that are made to implement this method. As can be seen in table 8, the average time invested per fisher, per fishing trip is 27 minutes. This is the lowest documented average fishing effort. Previously, it was clarified that the active fishing time for this method is low. All the fisher has to do is to prepare some bait and place the cage in river. Even though it requires time to yield fish, this cannot be included in the recording of active fishing time, because the fisher is not actively fishing after the cage is placed. He/she can do other things in the meantime. The results of gill netting are most confident, as this method is measured most. The average CpUE is 549 grams. According to the generated data in this research, this is half the yield of pole spearfishing. Despite this method attains highest fish catches, it is in terms of fishing effort per person, per hour, not the most efficient fishing method.

Table 9 – Results of CpUE calculations per method

Fishing Method	Total Number of Observations	Number of Participating Fishers	Minimum of CpUE [gr.]	Maximum of CpUE [gr.]	Average of CpUE [gr.]	StdDev of CpUE [gr.]
Basket trap	1	3	76	76	76	0
Cage trap	3	3	289	1236	737	476
Cast net	2	2	724	1082	903	253
Electricity	3	4	270	442	325	81
Gill net	10	46	152	2778	549	505
Hook & line	1	1	108	108	108	Not Available
Pole spear	16	20	0	2850	447	660
Day	11	14	0	317	167	93
Night	5	6	255	2850	1100	950
Speargun	8	8	31	538	268	185
Trident spear	1	1	14	14	14	Not Available
Total	45	88	0	2850	477	510

In order to determine whether the differences in CpUE per method are significant, the Student's *t*-test is used. The *t*-test considers the problems associated with small samples. The mean [μ] and standard deviation [σ] of the samples may deviate from the 'real' mean and 'real' standard deviation of the population. The latter can be calculated when the sample sizes are large. Commonly, when these values are known test statistics follow the normal distribution. When these values are unknown and based on estimation a Student's *t* distribution follows (Field 2005).

In this research the samples sizes of observed fishing methods are low. The 'real' mean and the 'real' standard deviation are unknown. These values are estimated. The *t*-test is required to determine whether the CpUEs per method significantly vary from each other. The two-sample *t*-statistic is used to calculate the levels of significance (*P*-value). The formulas that are used to calculate the significances of the observations are described in Appendix VII. The results of the analysis are presented in table 10. Fishing methods that are observed only once are excluded from statistical analysis. This table shows the calculated *P*-values. When *P* is ≤0.05 the difference between methods is significant. When *P* is ≥0.05 the differences are insignificant. Fishing methods that are observed only once are excluded. These involve the basket trap, the trident spear, and the hook & line (see table 9). When reading this table, it can be viewed that the average CpUE of the gill net significantly differs from the speargun. Other comparisons among fishing methods are insignificant.

Table 10 – *P*-value results of comparing fishing methods with each other using the *t*-test

	Speargun	Cage trap	Cast net	Electricity	Gill net	Pole spear
Speargun	-	0.24	0.19	0.51	**0.03**	0.30
Cage trap			0.70	0.28	0.58	0.45
Cast net				0.20	0.32	0.30
Electricity					0.08	0.48
Gill net						0.54
Pole spear						-

To put these results in perspective, they shall be compared to the CpUE results that Engelhart (2009) generated in an area comparable to the research site in this fieldwork. The study is conducted in the Philippine district San Mariano, which around 80 kilometers south of Peñablanca. People in San Mariano have a lifestyle similar to the people in Peñablanca. Fishing is an important source of nutrition and income as well and they use more or less the same fishing gear as in Peñablanca. For these reasons, both areas allow for comparison. Engelhart recorded 23 fishing trips. The trips lasted 3691 minutes in total and collectively yielded 21527 grams of fish. The average CpUE per method is 735 grams. In this research, 45 method uses are documented. The total invested fishing time is 5160 minutes yielding 101912 grams of fish. The average CpUE per trip is 485 grams. The calculated CpUE in San Mariano is 52% higher than in Peñablanca.

Three methods are observed both in San Mariano and in Peñablanca. These include the cast net, gill net, and the speargun. When comparing their mean CpUEs it turns out that they are insignificant. The same applies for the total average CpUE that runs over all methods (also the methods non-overlapping methods). These results are presented in table 11. The mean CpUE refers to the average CpUE. And N refers to the number of observations. The *P*-

value indicates the significance; because all values are ≥ 0.05 the differences among methods in San Mariano and Peñablanca are insignificant. Therefore, it cannot be stated that people in Peñablanca catch significantly less fish than people in San Mariano. Even though, the difference between the total average CpUEs (485 and 735 grams) of the two regions is relatively high (52%) the large standard deviation inhibits the drawing of significant conclusions.

Table 11 – Results CpUE comparison between Peñablanca and San Mariano

	Cast net	Gill net	Speargun	Total
Mean CpUE Peñablanca	903	549	268	485
Std. Dev. CpUE Peñablanca	253	505	185	592
N	2	46	8	45
Mean CpUE San Mariano	720	85	515	735
Std. Dev. CpUE San Mariano	537	487	861	831
N	4	4	7	23
***P*-value**	0.63	0.14	0.48	0.21

To conclude, the methods that yielded most fish in this research are the gill net, the cast net, and the pole spear. When comparing CpUEs of methods, it turns out that only the gill net and the speargun significantly differ. All other comparisons among methods are insignificant. The same applies for CpUE comparisons with another region, San Mariano. Although the average CpUE in San Mariano is 52% higher than in Peñablanca, the difference is insignificant at a 0.95 confidence level. The research illustrates the problem for doing research on this topic. The calculated standard deviations are high, despite a considerable number of observations. This means that the CpUEs vary much every fishing trip. The consequence is that future analyses of trends in fish catches become challenging.

Results Measured Fish Lengths and Weights

Finally, fish yields can be expressed in sizes of captured fish species. This subsection will describe them. As mentioned, 85% of the total fish catch consists of giant tilapia. Therefore, the measured sizes and weights of this species will be discussed in this report. In total, the body lengths and weights of 364 individual giant are documented. On average, a caught giant from the Pinacanauan River is 13,6 centimeters long (range = 5-30 centimeters; median = 13) and weights 52,5 grams (range 1-231 grams; median = 41). The average length of a mature giant is 18,6 centimeters with a range of 6-28 centimeters (Fish Base 2013). This means that an average caught giant in Peñablanca is not mature (adult/ fully grown) yet. From the 364 giant that are measured; 33 of them had a body length >18,6 centimeter and 331 a length <18,6 centimeter. Speaking on average terms, this means that only 9,1% of the sample was adult when caught; a majority of 91,9% was immature. Usually, when giants reach their sexual maturity – age when they can start reproducing – their body lengths range 9-15 centimeter. Concerning the measured giants in the Pinacanauan River, 227 fishes (62,2%)

were >12 centimeter (9-15 centimeter; median = 12) and 138 fishes (37,8%) were <12 centimeter. The majority of caught giants got captured after they reached sexual maturity. For a giant to reach sexual maturity is dependent on weight, size and environmental conditions. The average age to mature is between 10-12 months (Popma & Masser 1999). The longest reported age of a giant is nine years (Fish Base 2013).

Table 12 shows the average sizes of captured giant per village. In most villages, the average sizes and weights of captured giant lie close to each other. When indicating whether people catch significantly bigger fishes in particular villages, the means of the lengths are compared, using the *t*-test. The results are visible in table 12 and 13. Most *P*-values are ≤ 0.05, which means that the captured lengths of giant tilapias in most villages insignificantly differ. However, between Buyun and Callao, Buyun and Mangga, and Buyun and Minanga, average lengths of captured giant tilapias significantly vary from each other. Thus, in Buyun, people catch significantly bigger fishers than in Callao, Mangga, and Minanga. When comparing the weights of captured fishes per village it turns out that fishes caught in Buyun are significantly bigger than fishes caught in all other villages, except for Nabbabalayan. The *P*-levels of compared average weight of Buyun and the other villages are ≤0.05. Giants captured in Nabbabalayan are significantly biggest in this research. Confidence levels are in all comparisons ≤0.05. Thus, it can be concluded that biggest fishes are captured in Nabbabalayan, followed by Buyun.

Table 12 – Results lengths and weight of captured giant tilapia per village

Village	Count of Giants	Min. Length [cm.]	Max. Length [cm.]	Average Length [cm.]	StdDev of Length [cm.]	Min. Weight [gr.]	Max. Weight [gr.]	Average Weight [gr.]	StdDev of Weight [gr.]
Callao	60	5,0	30,0	12,8	3,2	1,0	222,0	42,9	30,9
Nabbabalayan	38	11,5	20,0	17,8	1,8	33,0	151,0	101,5	27,2
Mangga	138	5,5	24,0	12,3	4,0	3,0	223,0	42,2	41,3
Buyun	60	11,5	19,0	15,2	1,9	28,0	126,0	62,0	22,0
Minanga	58	6,5	25,5	12,9	3,7	4,0	231,0	43,3	43,4
Buyag	10	12,0	22,0	14,5	3,0	32,0	189,0	62,7	48,4
Total	**364**	**5,0**	**30,0**	**13,6**	**3,8**	**1,0**	**231,0**	**52,5**	**40,6**

Table 13 – *P*-value results comparison lengths of caught giants between villages

	Callao	Nabbabalayan	Mangga	Buyun	Minanga	Buyag
Callao	-	0.36	0.17	**0.00**	0.84	0.11
Nabbabalayan			0.31	0.63	0.37	0.56
Mangga				**0.00**	0.32	0.06
Buyun					**0.00**	0.49
Minanga						0.17
Buyag						-

Table 14 – *P*-value results comparison weights of caught giants between villages

	Callao	Nabbabalayan	Mangga	Buyun	Minanga	Buyag
Callao	-	**0.00**	0.90	**0.00**	0.95	0.24
Nabbabalayan			**0.00**	**0.00**	**0.00**	**0.04**
Mangga				**0.00**	0.87	0.22
Buyun					**0.00**	0.97
Minanga						0.27
Buyag						-

The fact that bigger species are captured in Nabbabalayan and Buyun may be explained by the kinds of methods they use. In order to test this, the average lengths and weight of giant must be compared among fishing methods, again using the *t*-test. These results are presented in table 15, 16 and 17. Previously, it was mentioned that gill nets yield most fish in terms of grams. But do they also yield the biggest fishes in terms of length and weights? Reading table 16 provides that the speargun yields significantly bigger fishes in centimeters. All comparisons of average lengths and weights of captured giant, with exception of the cast, net are significant (≤0.05). The pole spear comes second; again with exception of the cast net and of the speargun, this method significantly catches bigger fishes (in length and weight) than other methods. The gill net comes in third place, catching significantly bigger fishes than the cage trap, electricity, and hook & line, and significantly smaller fishes than the speargun and pole spear. The cage trap catches significantly the smallest fishes. It was observed that the cage trap mainly catches fingerlings of giant tilapia.

Although gill nets catch most fish, spearguns catch bigger fishes. When comparing sizes of captured fishes in the villages with used methods, it may well be that people in Nabbabalayan and Buyun caught bigger fishes due to of their relative use of spearguns. In figure 17 on page 55 it is visible that most observed fishing methods (six out of seven) in Nabbabalayan involved the speargun. In Buyun, two-third of the observed fishing methods involved the speargums. It is plausible that the use of spearguns contributes to the fact that that people in Nabbabalayan and Buyun capture bigger fishes. As mentioned in section 4.1, an advantage of the speargun involves, according to fishers, the possibility to "choose" the target. Obviously, fishers prefer to catch bigger fishes to small fishes.

Table 15 – Results of measured sizes and weights of captured giant tilapias per fishing method

Method	Count of Giants	Min. Length [cm.]	Max. Length [cm.]	Average Length [cm.]	StdDev of Length [cm.]	Min. Weight [gr,]	Max. Weight [gr.]	Average Weight [gr.]	StdDev Weight [gr.]
Cage trap	51	5,5	13,0	8,4	1,4	3,0	31,0	11,5	6,0
Cast net	10	10,0	22,0	15,1	3,4	17,0	183,0	64,0	47,8
Electricity	8	5,0	11,5	8,5	2,4	1,0	22,0	9,3	8,1
Gill net	173	10,0	25,5	14,6	2,9	16,0	231,0	60,2	37,8
Hook & line	3	9,5	10,5	9,8	0,6	17,0	26,0	20,3	4,9
Pole spear	64	9,0	22,0	13,1	2,6	12,0	189,0	42,2	28,2
Speargun	55	10,0	30,0	16,4	3,6	12,0	222,0	84,4	43,3
Total	**364**	**5,0**	**30,0**	**13,6**	**3,8**	**1,0**	**231,0**	**52,5**	**40,6**

Table 16 - *P*-values results comparison lengths of caught giants between fishing methods

	Cage trap	Cast net	Electricity	Gill net	Hook & line	Pole spear	Speargun
Cage trap	-	**0.00**	0.63	**0.00**	0.07	**0.00**	**0.00**
Cast net			**0.00**	0.72	**0.04**	0.12	0.27
Electricity				0.00	0.18	**0.00**	**0.00**
Gill net					**0.01**	**0.00**	**0.00**
Hook & line						**0.02**	**0.01**
Pole spear							**0.00**
Speargun							-

Table 17 – *P*-values results comparison weights of caught giants between fishing methods

	Cage trap	Cast net	Electricity	Gill net	Hook & line	Pole spear	Speargun
Cage trap	-	**0.01**	0.49	**0.00**	0.10	**0.00**	**0.00**
Cast net			**0.01**	0.81	0.10	0.19	0.24
Electricity				**0.00**	0.11	**0.00**	**0.00**
Gill net					**0.01**	**0.00**	**0.00**
Hook & line						**0.04**	**0.01**
Pole spear							**0.00**
Speargun							-

4.4 Towards A Better Future

The main focus of this research was on riverine knowledge and fishing methods. This paragraph briefly discusses the management of fisheries in Peñablanca. The perceptions of conservationists and fishers towards fisheries management and fish stock preservation will be described and some aspects of riverine knowledge that are relevant to management. This information is acquired through informal interviews (n=4) with members of the BFAR and long semi-structured interviews (n=12) with expert fishers. First, it will be described how authorities formulate fisheries management. Second, it will be discussed how fisheries management can be reformulated and carried out in practice.

Current Fisheries Management

Fisheries law in the Philippines is constituted under the Republic Act no. 8850. This act, known as the Philippine Fisheries Code of 1998, aims to develop, manage, and conserve fisheries, and aquatic resources, through a set of restrictions and regulations. The governmental agency the BFAR – nested under the Department of Agriculture – is responsible for this. Locally, regional bodies of the agency have the task to implement law and enforce it by imposing penalties for violations. The regional office of the BFAR governs fishing practices in Peñablanca and is located in provincial capital Tuguegarao. Regulations in Peñablanca are controlled in cooperation with the LGU of the municipality (BFAR 2013). In a nutshell, the most important regulations with regard to fishing in the area involve the definition of outlawed fishing methods and penalties for unauthorized practices. According to members of the BFAR, it is considered unlawful to use explosives, electricity, fine nets, and poisonous or noxious substances like sodium cyanide that kill, disable, mutilate or stun aquatic species. Violating these rules results in fines varying from PhP 500-1,500 (±10-30 euro), confiscation of fishing gear, fishing ban, and/or imprisonment. The sanction depends on how many offences the person had and the severity of the outlawed act. A final rule involves that small-scale commercial fisheries in Peñablanca require a permit extract aquatic resources. The annual fee is PhP 200 (±4 euro). However, most fishers in Peñablanca do not require a permit, as they do not fish for commercial purposes.

On a provincial level, the LGU, CI and the DENR declared large part of Peñablanca a protected area in 2004 in order to conserve natural resources. The LGU, CI and the DENR formulated a project plan to achieve this. Their main objective is to: "increase knowledge amongst general public on the major threats to PPLS […] by providing them with appropriate information about the forest and its relationship with the health and productive condition of the freshwater and marine resources" (Dirain 2004, p.116). These parties believe that the knowledge of people in Peñablanca about ecological threats is inadequate and insufficient. They therefore aim to create awareness of these threats through an education campaign, involving the implementation of awareness programs as schools and the organization of stakeholder meetings with local people. The BFAR meanwhile annually disperses fingerlings of common carp and giant tilapia in the Pinacanauan to maintain availability of fish and fish-dependent livelihoods.

Reformulate Fisheries Management

In practice, this research reveals that fishers *do* seem to be aware of the ecological threats within freshwater fishing. They know well how fish stocks changed overtime. In chapter 3 it was already shown that fishers have detailed knowledge of the current status of abundance per species and processes that influence them. Fishers claim that giant tilapia increased in number, while other fish communities declined. Decreases are, as noted in chapter 3, explained by a growing number of mouths to feed, the use of dynamite and gill nets, farming, logging, and typhoons. Even though giant tilapia is expanding, the overall fish stock is at decline. In long semi-structured interviews it is discussed with fishers, which riverine species should be protected, where, when, and how. The results are described below.

Fishers feel the fish stock decline in their daily catch. Apart from capturing less and smaller fishes, the variety of the catches diminished. Species that used to be available in the past are now rare or extinct. The only species available is giant tilapia. Interviewed fishers are in agreement that this is a worrisome development, because fish is an important means for people's subsistence. Although being aware of this, people continue fishing. Fish is considered a healthy and free source of food, apart from the investment in fishing gear, is does not cost money to catch fish. In addition, it is a substitute for expensive meat – one kilogram of meat cost between PhP 200-300 (±4-6 euro) – and increases variation in local diets. Large part of the total fish catch is namely used for personal consumption. Apart from this, the income people generate from fishing declines. Giant tilapia is not a valuable species. Other species – that decline in number – yield more money.

When asking *which* fishes people wish to be preserved, they name: Luzon mottled eel, squaretail mullet, walking catfish, mudfish, and marble goby. Their populations declined most. People prefer to preserve them, because they are big and tasteful, and they bring variation to the aquatic products they derive from the river. "I always catch tilapia. My family eats tilapia almost every day. Sometimes I wish I could bring a big eel home," on fishers said.

This quote illustrates that people mainly catch tilapia, but wish to catch other species. In the eyes of fishers, fisheries management should target to preserve the named fishes.

According to fishers, species require to be preserved most in Nabbabalayan, Mangga, Buyun, and Minanga. Fishers from these villages noted the biggest declines in fish communities and mentioned to worry about future availability of fish (compared to in other villages). One fisherman from Mangga said: "When I was young the fishes were much bigger, bigger than my hand. Today, all fishes are only three fingers[8]. […] I do not know how big they will be in the future. […] I hope my sons will have enough fish. There are so many fishermen in the river." In Callao and Buyag fishers are less concerned about the status of the future fish stocks. In Callao fishing is not an important source of livelihood compared to in other sites. Many people have a paid job and buy their food. "I buy fish on the market. Tilapia, *bangus*[9], catfish or mudfish," a fisher in Callao said. Another explanation is that people in Callao depend less on the river and its resources, whereby they are less concerned about the future. For the Agta in Buyag, fisheries management is a different story. Since their kin-group very small compared to populations of other villages, human impact on aquatic resources has been limited. Agta interviewees claimed that they do not experience any problems related to fishing. They are satisfied with the species available and they did not note remarkable declines of preferred species.

In cooperation with expert fishers it is assessed *when* fishes need to be protected. The seasons that fish species spawn and get captured are determined. These results are listed in table 18 for the key species defined in section 3.5 on page 42. *Fuliag* is sporadically caught and its spawning season is unknown. The table shows that most key species spawn in rainy season, and that most species get captured in summer. This is because most people fish in summer when the water level goes down. Giant tilapia and *birut* spawn in both seasons and are also caught in both. Marble goby and silver perch get caught in the season they spawn. Marble goby moves to brackish water to spawn in early summer and returns in summer with its fingerlings. Silver perch does not move and slowly reproduces in summer. This fish does not get caught in rainy season, because the water level is too high. The species mainly resides on the bottom of the river. Walking catfish, mudfish, Luzon mottled eel, and squaretail mullet, spawn in rainy season. Except for mullet, these fishes mostly get captured in summer. As explained in section 4.1, squaretail mullet is usually caught with a cast net right after tropical storms. This species can then be found in muddy pools beside the river.

All experts prefer to catch big fishes. In theory it would be ideal to catch fish species outside spawning season and to throw back caught fingerlings. Fishes are given the chance to

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[8] Fishers in Peñablanca indicate the size of fishes with a certain number of fingers. The more fingers the fish, the bigger it is.
[9] Local name for milkfish.

grow and to get caught when mature and big. However, in practice this is difficult to realize. People mainly catch tilapia. It sporadically happens that a fisher catches another species.

Table 18 – Overview of spawning season per species

	When does the species spawn?		When gets the species caught?	
	Summer season	Rainy season	Summer season	Rainy season
Fish species	Dec-May	Jun-Nov	Dec-May	Jun-Nov
Giant tilapia	X	X	X	X
Birut	X	X	X	X
Walking catfish		X	X	
Mudfish		X	X	
Luzon mottled eel		X	X	
Squaretail mullet		X		X
Marble goby	X		X	
Silver perch	X		X	
Fuliag	Unknown	Unknown	X	

The final topic discussed was how fishers believe they can contribute to fisheries management. Overall, the majority of fishers pointed out to be willing to participate in management, but most fishers do not know how. “The BFAR is responsible for fisheries management.” Fishers have never been engaged. When asking what fishers can do to protect fish communities, most fishers (92%) do not know. One fisher said “throw back the baby fishes and catch them when they are big”. However, this is hard to realize.

5. Discussion

The central theme of this research is: how can local ecological knowledge in Peñablanca be relevant to fisheries management? Through this study it was expected to find results that may help improve fisheries management and benefit the people of Peñablanca. The main goal of this study was to indicate the present status of local ecological knowledge and fishing practices and to help formulate strategies to improve fisheries management. First, the formulated objectives and main goal of this research will be revised. Second, a summary of the main findings will be provided, followed by the discussion and conclusion of this thesis.

5.1 Summary Main Findings

In order to improve fisheries management in Peñablanca conservationists believe that fishers should be informed about the ecological threats related to freshwater fishing. This study on local ecological knowledge reveals that fishers do not need to be informed, because they are already aware of these threats. Instead, they provided valuable insight about ecological processes relevant to fisheries management.

Throughout the years, the fishers of Peñablanca have observed diminishment of fish in the Pinacanauan River. Many species have become rare or have even disappeared. This is felt in daily fish catches. Catch-rates have lowered, captured fishes reduced in size, and certain species are disappearing. As a result of these declines, the effort to attain the desired quantity of fish increased. Even though there is still fish available, people worry about the future. In response, the BFAR started to annually disperse fingerlings of giant tilapia and common carp in the river in order to maintain the livelihoods of fish-dependent people. Ever since, fishers in Peñablanca have been observing an increase of giant tilapia and a decrease of other species' populations. Giant tilapia has become the "only fish available". Approximately 85% of the total catch consists of this species today, resulting in homogenous catch compositions. Even though the available giant tilapia has become the most important catch in terms of food and income, fishers wish to catch other species: species that are tastier or can be sold at higher prices.

However, these species are disappearing. The people of Peñablanca provided a detailed overview of the species that are prevalent in the Pinacanauan River and their current status of abundance. Stocks of squaretail mullet, Luzon mottled eel, mudfish, walking catfish, marble goby, silver perch, and *fuliag* are at depletion. The latter three barely exist anymore. Fishers wish to preserve these species. These species have the highest market price, are most tasty, and bring variation to their diet.

The fishers of Peñablanca explain the declines of these fish communities by five factors: 1) human population growth; 2) the use of efficient fishing methods and the use of dynamite in the past and the gill net today in particular; 3) the use of pesticides; 4) logging; and 5) typhoons. The increase of giant tilapia community is explained by the fact that this species reproduces fast and several times a year. It is considered a strong species that is able to survive tropical storms and which can survive in all sorts of water conditions. Another explanation involves the dispersal of fingerlings of the species by the BFAR, which maintains, according to fishers, the population.

When comparing these emic explanations to etic theory some resemblances and differences are notable. For instance, both fishers and scientists claim that human population growth lead to the decline of fish stocks. A grown number of mouths to feed leads to increased demand for and capture of fish (White *et al.* 1998). Another resemblance is both fishers and scientists claim that fish species disappear due to logging as it alters the water conditions. Porter *et al.* (2000). They showed that certain species in British Columbia's freshwater basins are tolerant to changes in habitat due to timber extraction. Differences are noted in the explanation regarding the use of pesticides in agriculture. According to fishers, pesticides drain into the river which "makes fishes ill and die". Kemp *et al.* (1983) claim that agricultural run-off destroys various kinds of vegetation and stimulates algal growth. Loss of vegetation can lead to a decline of food provision for species and lead to their extinction. This is plausible in Peñablanca, because *lumut* (hair algae) is the only observed aquatic vegetation.

Concerning the increase of giant tilapia, fishers name three contributing factors: 1) giant tilapia breeds fast; 2) it is a "strong species"; and 3) the BFAR disperses fingerlings in the river. These explanations relate to what Martin et al. (2010) describe about giant tilapia: it is able to survive in all kinds of ecosystems and is a fast breeding species. However, fishers do not refer to a possible correlation between the dispersal of tilapia fingerlings and the observation that giant tilapia population increased while those of other species decreased. Martin *et al.* (2010) claim that giant tilapia is an invasive species that successfully dominates ecosystems worldwide. They showed that giant tilapia excludes other fish species from their preferred habitat due to predative (aggressive) behavior and its omnivorous diet involves eating eggs of other fish species. This impacts the reproductiveness of other fish populations. The annual release of giant tilapia could therefore be a plausible explanation for the fact that this species increased while other aquatic communities declined in number.

Six sites were studied in this research: Callao, Nabbabalayan, Mangga, Buyun, Minanga, and Buyag. In Nabbabalayan, Mangga, Buyun, and Minanga, fishers observed most declines of fish communities. Diversity and abundance of present species is lowest in these villages. Fishers in these villages expressed worries about the current trends. In Callao and Buyag fishers are less concerned about the status of the future fish stocks. In Callao fishing is not an important source of livelihood compared to the other studied sites. Many people have a paid job. People in Callao depend less on the river and its resources, which makes them less concerned about the status of future stocks. The diversity and abundance of species is highest in Buyag. Fishers face minor fish stock decline. Though, they observed an increase of giant tilapia. The Agta community living in Buyag is small (± 50 inhabitants) compared to the number of inhabitants of other villages (±1000 inhabitants). Therefore, human impact on aquatic resources is limited.

Apart from the qualitative investigation of local ecological knowledge, this research conducted quantitative research related to fishing methods. The CpUEs of 45 fishing trips are recorded. The results showed that the gill net, the cast net, and the pole spear yield most fish. When comparing the average CpUEs of fishing methods with each other it turns out that most comparisons are statistically insignificant. The only significant result is that gill nets yield significantly more fish than spearguns. This illustrates the problem for researching CpUEs. The calculated standard deviations remain high, despite a considerable number of observations. This means that the CpUEs vary much every fishing trip. The consequence is that future analyses of trends in fish catches become challenging.

The data about fish lengths and weights, on the contrary, are significant. When comparing sizes of captured fishes in the villages with used methods, it may well be that people in Nabbabalayan and Buyun caught bigger fishes, due to of their relative use of spearguns. Thus, main conclusions of the quantitative part are: a) gill nets yield more fish, but pole spears yield bigger fishes; b) future comparisons of trends in fish catches become challenging, because the CpUEs vary much every trip.

5.2 Conclusion

The goal of this study is to indicate how local ecological knowledge can contribute to improved fisheries management. It is aimed to describe the current status of people's ecological knowledge and to help formulate strategies to improve fisheries management. Within this purview two objectives are formulated.

The first objective is to determine which aspects of local ecological knowledge are relevant to restoring degraded fish stocks. Fishers in Peñablanca showed they are well versed in fish ecology. They know much about fish habitat selection, migration patterns, seasonal cycles, fish behavior, nutrition, and the current statuses of fish communities. Regarding the latter, fishers observed that many fish species are disappearing, while one species is *increasing* in number: the giant tilapia. Socio-economically, this impacts the diets of people that become increasingly homogenous and the incomes of people (valuable species are disappearing, while low-value species grow in number). When aiming to restore fish stocks it is important to know which fish stocks require to be restored, where, when, and most important: what caused their degradation?

The fishers in Peñablanca provided a detailed indication of the changes in aquatic communities. They listed which stocks degraded – squaretail mullet, Luzon mottled eel, mudfish, walking catfish, marble goby, silver perch, and *fuliag* – and in which parts of the river. These mainly involve the waterways of Nabbabalayan, Mangga, Buyun, and Minanga. In Callao and Buyag fishers said to experience minor fish stock degradation, compared to the fishers in the other villages. In addition, fishers provided information about the seasons when certain fish species mostly get caught and when they spawn. It is found that some species – squaretail mullet; marble goby, and silver perch – get captured in their spawning season. In order to protect the renewal process of fish populations it is important to avoid catching fingerlings. Furthermore, fishers also explained how fish stocks degraded. Their explanations show much resemblance to scientific explanations for fish stock decline. However, there is one specific explanation that is found in scientific literature that plausibly applies to the situation in Peñablanca. Namely, that the increase of giant tilapia contributes to stock decline of other species (Martin *et al.* 2010). The fact that fishers have not mentioned does not mean that they could not. This may be a blind spot in this research.

The second objective is to describe the role of fishers' knowledge to improve fisheries management. Currently, the LGU, CI, DENR and BFAR are responsible for the formulation and implementation of fisheries management in Peñablanca. The BFAR started dispersing giant tilapia fingerlings in order to secure availability of fish for people's livelihoods. More recently, an education campaign was launched to improve the management of natural resources. The LGU, CI and the DENR published a report in which they assume that people in Peñablanca hold inadequate and inefficient knowledge about ecological threats to these resources and therefore need to be educated. However, this research shows that fishers do have knowledge this. Understanding fishers could play an important role to avoid ineffective management measures, such as educating people who do not need to be educated. In addition, the consultation and incorporation of local ecological knowledge can also be useful to define ecological threats and possible causes to them (Berkes 1999; Johannes 1981). Understanding the ecology of fishing – the relationship between natural resources and their users – is essential to improve management (Mackinson 2001; Mackinson & Nøttestad 1998).

This study shows that fishers can contribute to this. They illustrated their current ecological situation: the decline of certain species, together with an *increase* of giant tilapia. However, it remains unclear how this situation emerged. Does it have to do with the factors as defined by the fishers? Or is what Martin et al. (2010) describe – giant tilapia has lead to the disappearance of other species – more plausible? When this is valid for Peñablanca, the second objective becomes challenging. Improving fisheries management through the incorporation of local ecological knowledge namely encourages bottom-up management practices (Brosius *et al.* 2005; Davis & Wagner 2003; Blakie & Brookfield 1987). This means that fishers themselves are supported to engage in the preservation of fish species. The cause of fish stock decline is significant to determine whether bottom-up fisheries management is possible or not. In case giant tilapia turns out to be an invasive species, then management merely lies in the hands of those who control and execute dispersal of fingerlings of giant tilapia in the river. Thus, defining the cause to fish stock decline is required to formulate strategies to tackle it. As long as the cause remains unclear, strategies cannot be formulated and the knowledge aspects relevant to fish stock preservation cannot be effectively used.

To summarize, this study had two goals: a) describing the current status of people's local ecological knowledge; and b) to help formulate strategies to improve fisheries management. The first goal is met. This research shows fishers have rich information about fish species and fish behavior and that they can help understanding and illustrating the problems related to fishing. They also revealed knowledge aspects that are potentially relevant to restore degraded fish stocks. These involve knowledge about: a) which fish stocks degraded; b) the villages where fish stocks degraded; and c) the species that get caught in the season they spawn. The goal to formulate strategies to improve fisheries management with the help of local ecological knowledge is not met. In order to improve fisheries management it is essential to identify the nature of ecological problems. This thesis therefore pleads for a holistic approach to fisheries management. Which means a multi-level cooperation, including both fishers and conservationists, and the incorporating and acknowledgement of the credibility and knowledge of those who use aquatic resources.

Effective management can only be attained when the ecology of fishing – the relationship between natural resources and their users – is well understood. With this research on local ecological knowledge and freshwater fishing I hope to make one step forward to accomplish this. The results of this thesis show the urge to further study the ecology of fishing on a larger ecological, geographical, and temporal scale. To succeed in this, scientists and scholars must adopt an integrated multi-disciplinary approach to be able to comprehend the complexity of freshwater fishing involving political, socio-economical, cultural and biological interests. This thesis gives voice to the fishers of Peñablanca. It tells their fishy story and shows their rich ecological insight. It is hoped that, once the ecology of fishing is properly understood, this insight can be used to bring back the fish species fishers prefer and that they do not have to fish in troubled waters anymore.

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Appendix I: Short Semi-Structured Interview

Structured Questions

1. Name
2. Sex
3. Age
4. Barangay
5. Occupation/ main source of income
6. Main reason for fishing
7. For how long are you a fisher?
8. Where do you fish?
9. When do you fish?
10. How often do you fish in rainy season? And in summer season?
11. What part of the day you fish the most?
12. Which fishing methods do you have at home?
13. Which method do you use the most? (Rainy and summer season).
14. Which species do you catch the most? Why?
15. How many hours do you fish per trip?
16. How much do you catch?
17. How many fingers are most of your catches?
18. Do you mostly fish with companions or alone?
19. With how many people do you fish?
20. Do you divide the catch?
21. During what kind of weather do you have the best catch? Why?
22. With what kind of water do you have the best catch? Why?
23. With what current do you have the best catch? Why?
24. With what water temperature do you have the best catch? Why?
25. With which water level do you have the best catch? Why?
26. In what part of the river do you have the best catch? Why?
27. What do you do with the catch after fishing?

Unstructured Questions about Riverine Knowledge

- Identification of species with help of images of common freshwater species
- Nomenology (local names of species)
- Spatial- and temporal distribution (which species occur, where, and when?)
- Nutrition
- Abundance
- Changes in populations overtime
- Reproduction (when do they have eggs and where?)
- Specific habitat preferences
- Predator-prey relationships
- Processes that influence them
- Market value of species

Appendix II: Long Semi-Structured Interview Itawes Fishers

General Information
- Name
- Age
- Gender
- Barangay
- Duration of fishing

Fishing practices
- Mostly used methods in the area: why used?
- Differences between younger-elder people
- Difference between Barangays
- What species have you caught in your life?
- Fishing strategies per method: how do you attract fish?
- When do people fish most?
- Where do people fish most?

Local Ecological knowledge
- Identify species with laminated images
- Predator-prey relationship
- Seasonal cycles
- Nutrition
- Migration patterns
- Places of breeding
- Reproduction behavior
- Nutrition and behavior
- What is the most special fish? Why? And for others?
- What is the most delicious fish? Why? And for others?

Riverine uses
- Importance of fishing for food and income
- Selling fish (market prices)
- To whom is fish sold?

Historic changes
- Changes in fish populations
- Changes in species (disappeared & new species)
- Changes in catch rates
- Changes in size of species
- Changes of methods
- Changes of riverine landscape

Legislation
- Illegal methods (which methods; when prohibited; who controls; who implemented)
- Use of illegal methods & violations
- Penalties

Problem definition
- Define problems with freshwater fishing in the area.
- What are the problems that the fisher encounters?
- How is future perceived?

Fisheries Management
- Is the fisher willing to participate in management?
- Does the fisher believe it is important to protect species/ habitat?
- How can people themselves contribute to protect species/ habitat?
- What should be focused on in management?
- How can fish communities be protected?
- What fishing methods are destructive?
- What could the local government unit do to protect species?

Appendix III: Long Semi-Structured Interview with Agta Fishers

General Information
- Name
- Age
- Gender
- Barangay
- Duration of fishing

Agta Settlement Callao
- History (since when existent, why established, facilities etc.)
- Main sources of livelihood?
- Administrative data: how many households/ people?
- Presence: main occupations; schooling; stratification.
- Fishing? Where, what methods, species etc.

Buyag
- How many households/ people?
- Main sources of livelihood?
- How often fishing? What do they catch?
- Who fish? What are their tasks?

Fishing Methods
- Mostly used methods: why used?
- Who participate in fishing?
- When and where are people fishing?
- Differences between younger-elder people
- What species have you caught in your life?
- Fishing strategies per method: how do you attract fish?

Local Ecological knowledge
- Identify species with laminated images
- Predator-prey relationship
- Seasonal cycles
- Nutrition
- Migration patterns
- Places of breeding
- Reproduction behavior
- Nutrition and behavior
- What is the most special fish? Why? And for others?
- What is the most delicious fish? Why? And for others?

Riverine uses
- Importance of fishing for food and income
- Selling fish (market prices)
- To whom is fish sold?

Historic changes
- Changes in fish populations
- Changes in species (disappeared & new species)
- Changes in catch rates
- Changes in size of species
- Changes of methods
- Changes of riverine landscape

Appendix IV: Assessment Form Target Species per Fishing Method

	Ammori	*Balawat*	*Baltut*	*Baring **	*Batit*	*Bubu*	*Hasag + Arabang*	*Hands*	*Hook + Line*	*Kuryente*	*Pandal*	*Siid*	*Trapa*
Agama													
Agwat													
Ala													
Birut													
Dalag													
Dulang													
Hunug													
Hursi													
Lasit													
Mori													
Pattat													
Rashan													
Sihin													
Tilapia													

Legend:

X = Usually caught

F = Fingerlings

* = Caught with regular sizes 6 – 6,5 – 7

Appendix V: Assessment Form Level of Abundance per Species by Village

	Callao	Nabbaba-layan	Buyun	Mangga	Minanga	Agta
Ala						
Agama						
Agwat						
Birut						
Dalag						
Dulang						
Fuliag						
Hunug						
Hursi						
Lasit						
Mori						
Pattat						
Rashan						
Sihin						
Tilapia G.						
Tilapia M.						

Legend:

D = Dominant species

L = Less abundant / seasonally abundant species

R = Rare

E = Extinct

Appendix VI: Catch-per-Unit-Effort Form

Nr. form:	**Date:**	**Starting time:**	**Ending time:**
	/ / 2013	:	:

Name fisher:	**Name barangay:**		
Weather conditions:			
Conditions river:			
Used method:			
Fish species:	**Size:**	**Weight:**	**Fingers:**
	cm	gram	
	cm	gram	
	cm	gram	
	cm	gram	
	cm	gram	
	cm	gram	
	cm	gram	
	cm	gram	
	cm	gram	
	cm	gram	
	cm	gram	
	cm	gram	
	cm	gram	
	cm	gram	
	cm	gram	
	cm	gram	
	cm	gram	
	cm	gram	
	cm	gram	
	cm	gram	
Total/ average:	cm	gram	
Weight total catch:	Gram		

Appendix VII: Comparing Two Means when σ is Unknown

This is the equation for the two-sample test statistic *T*, which is Student's *t* distributed with *k* degrees of freedom.

$$T = \frac{(x_1 - x_2) - (\mu_1 - \mu_2)}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \sim t_k$$

In this formula *x* stands for the sample mean, μ for the population mean, *s* for the sample standard deviation, and *n* stands for the sample size. The 1 or 2 refer to sample 1 or sample 2. This statistic has a t_k distribution with: $k = \min\,(n_1 - 1, n_2 - 1)$.

To test the hypothesis $H_0 : \mu_1 = \mu_2$ the following formula is used:

$$T = \frac{(x_1 - x_2)}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \sim t_k \text{ under } H_0$$

The *P*-value is the probability (under H_0) that an obtained result is equal or higher/lower than the actual observation. For a two-tailed test this means that $(T \geq t)$ or $(T \leq t)$.

The P-value is calculated: $2\min(P\,(T \leq t \mid H_o), P\,(T \geq t \mid H_0))$. For the results applies: the smaller the P-value, the larger the significance. H_0 is rejected when any of the P-values ≤0.05 confidence level (Field 2005).