# THE SOCIAL AND ENVIRONMENTAL EFFECTS OF SHRIMP MARICULTURE: CASE STUDIES OF TWO COASTAL VILLAGES IN ECUADOR

by

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This thesis was prepared under the direction of the candidate's dissertation advisor, Dr. Maria Fadiman, Department of Geosciences, and has been approved by the members of her supervisory committee. It was submitted to the faculty of the Charles E. Schmidt College of Science and was accepted in partial fulfillment of the requirements for the degree of Master of Science.

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ABSTRACT

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Shrimp mariculture expansion in developing countries has been criticized for its ecological destruction and the resulting social conflicts. In Ecuador, shrimp pond development particularly affects rural, coastal communities. This study addresses the environmental and social effects of shrimp farming in two Ecuadorian villages, Muisne and Bunche. Interview and survey responses indicate that locals have an overall negative view of the industry. In some instances, such as increased class marginalization through reduced access to subsistence collection areas, shrimp farming directly results in conflict. However, the data also demonstrates that ponds are only one of various stressors on mangrove ecosystems. Furthermore, mariculture provides benefits to the community, including increasing employment opportunities, the local economy, and shrimp availability. In spite of these benefits, local negative perception suggests modifications to existing regulations and educational programs are necessary to minimize impacts and

help the community understand the multiple factors affecting their ecosystem and livelihoods.

# DEDICATION

I would like to dedicate this manuscript to my parents, Michelle Crislip and Kenneth Crider, for their support of this project and my travels to Ecuador.

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# 1. INTRODUCTION

The spread of modern shrimp mariculture has caused environmental damage and social shifts (Landesman, 1994; Tacon, 1999). Environmental problems associated with shrimp farming development include mangrove habitat destruction, marine population declines, and decreased water quality through increases in nutrients and chemicals (Bailey, 1988; Landesman, 1994; Parks and Bonifaz, 1994; Primavera, 1997; Deb, 1998; Larsson et al., 2002; Stokstad, 2010). The destruction of mangroves has displaced marine harvesters and created food insecurity (Landesman, 1994; Pollnac 1994; MacKenzie, 2001; Lugo, 2002; Islam et al., 2004; Bostock, 2010). These social implications have enhanced the marginalization between classes and sometimes resulted in violent protests between locals that collect marine resources and shrimp farmers (Landesman, 1994; Deb, 1998; Thornton et al., 2003).

However, some studies indicate that shrimp mariculture is only partially to blame for the damage to the mangrove ecosystem and that pond waste discharge has minimal effects (Landesman, 1994; Trott and Alongi, 2000; Chamberlain, 2001; Epa and Wijeyaratne 2008). Thus, limiting the contribution of the industry to the environmental destruction and resulting social implications. Furthermore, shrimp farming is currently the only way to meet growing consumer demand, because wild populations are depleted (Bailey 1988, Primavera, 2006). Shrimp mariculture also has economic benefits for the

countries involved, can increase the local standard of living, and creates employment opportunities (Primavera, 1997; Hernandez-Rodriguez et al., 2001; Hossain et al., 2002; Islam et al., 2004; FAO, 2011b). Due to the economic benefits, the Ecuadorian government encouraged the adoption of shrimp mariculture in the 1970s (Islam et al., 2004). Rapid expansion caused Ecuador to become the number one producer by 1987 (Bravo, 2003). Even though the arrival of the Taura syndrome (TSV) and the White Spot Syndrome Virus(WSSV) in the 1990s reduced Ecuador's global ranking to the fifth largest manufacturer, this country is still a major producer in the western hemisphere (Chamberlain, 2001; Hernández-Rodríguez, 2001; Bunting, 2006; Primavera, 2006; Epa andWijeyaratne, 2008; FAO, 2011b).

Although shrimp farming development has effects in coastal areas throughout Ecuador, the environmental destruction caused by this industry especially impacts individual livelihood opportunities and the local economy in rural areas. In these communities, locals are still highly dependent on natural resources, so the environmental effects of mariculture expansion disrupts traditional ways of life (egs. Bailey, 1988; Primavera, 1997; Joffre and Schmitt, 2010). Even though most of the mariculture development has occurred in the Guaya and El Oro Provinces of Ecuador, the evident impact on rural villages makes research in the small communities within the Esmeraldas province geographically important (MacKenzie, 2001). Furthermore, environmental damage in this region has been expansive. Shrimp farming and urban development have removed 84% of the mangroves in Muisne, a village within this province (Ministerio del Ambiente et al., 2008). In this area, the environmental destruction has displaced marine harvesters and social conflicts have resulted. For instance, in 1998, locals and non-profit

organizations arranged a protest to destroy an illegal shrimp pond (Martinez-Alier, 2001). Regardless of these consequences, mariculture is responsible for generating employment in these rural villages, which have few job opportunities (MacKenzie, 2001).

In spite of the significance, only a few formal studies have documented the impacts of shrimp mariculture in remote areas. Information on the current environmental issues and the social shifts experienced by coastal villagers is lacking. This study fills a gap in the literature by addressing both the positive and negative effects of shrimp farming within two rural, coastal communities in the Esmeraldas province, Muisne and Bunche. Interviews and surveys with locals were used to investigate 1) the social implications associated with mariculture, 2) the industry's environmental impacts, and 3) the benefits of shrimp farming in this area. The resulting information was then analyzed in order to provide feasible suggestions in rural villages to increase the benefits and improve the sustainability of shrimp mariculture.

# 2. LITERATURE REVIEW

## Background on Global Shrimp Aquaculture

Mariculture is the cultivation of marine organisms, where farmed species can range from salmon to algae (Tacon, 1999). Traditional aquaculture has been practiced since 1122 B.C., beginning in China with hand dug, small-scale fish ponds (Costa-Pierce, 1987; Bailey, 1988; Landesman, 1994). Coastal communities in China and India first developed shrimp mariculture in tidal areas as a polyculture system with fish (Bailey, 1988). Even though these traditional systems had low production rates and generated minimal profits, their environmental impacts were small due to the use of natural resources for nutrients and recruitment (Bailey, 1988; Landesman, 1994; Epa and Wijeyaratne, 2008).

In 1934, Hudinaga (a Japanese scientist) was the first to describe shrimp farming methods and successfully developed shrimp larvae rearing techniques using kuruma shrimp (*Penaeus japonicus*). Approximately thirty years later, Laio and his colleagues successfully bred black tiger shrimp (*P. monodon*), which would become the most commonly cultured shrimp in the world (Treece, 1999; Epa and Wijeyaratne, 2008). These methods, along with the creation of industrialized shrimp feed production, led to the development of modern mariculture. In the early 1960s, the first commercial pond

began in Japan (Epa and Wijeyaratne, 2008; Warne, 2011). Modern shrimp farmers stock the ponds at higher densities than traditional ponds to increase production rates and profit. In the last 60 years, production rates rose to 5000-10,000kg/hector/yr. from the traditional rates of 50 to 500 kg/hector/yr. However, modern techniques are associated with extensive environmental costs (Landesman, 1994).

Current mariculture is divided into three different categories; extensive, semi-intensive, and intensive systems. In extensive shrimp mariculture, shrimp farmers use techniques similar to the ones traditionally practiced. Tides are responsible for stocking the ponds and the shrimp feed mostly on natural nutrients. Farmers of semi-intensive ponds increase the carrying capacity of the system by adding fertilizers or feed. In this system, the workers also manually add post-larval shrimp to increase the density and production of the ponds. Finally, in an intensive system, all of the shrimp's diet is composed of commercialized feed or fertilizer. In addition, the last two types of systems require varying amounts of chemicals, filters, and pumps (Bailey, 1988; Landesman, 1994).

The techniques used to create shrimp ponds are generally uniform with slight variations, beginning with a pond that has a depth of one meter or greater. The shrimp farmers fill the pond with a mixture of freshwater and saltwater and then add post-larval shrimp from a hatchery. Employees then wait three to six months for the shrimp to reach harvestable size. During this phase of production, workers feed the shrimp a pelleted diet and add fertilizer to create the algal blooms necessary to support a planktonic diet (Chien, 1992; Landesman, 1994; Lebel et al., 2002). Various devices and additives help maintain the water quality in the ponds and increase shrimp health; pumps replace water,

paddlewheel aerators increase gas exchange, and calcium carbonate prevents acidic and anaerobic benthic conditions (Chien 1992; Boyd, 1982; Landesman, 1994). At the end of the production cycle, shrimp farmers use pumps to drain the ponds and use nets to harvest the crop (Landesman, 1994).

Due to government incentives, private investors, and a decline in fisheries, commercial shrimp mariculture has grown rapidly since the 1980s, with production rates increasing by 250% between 1985 and 1995 (Bailey, 1988; Landesman, 1994; Dewalt and Vergne,1996; Primavera, 1997, 2006; Jory and Cabrera, 2003). Growth has been particularly rapid in Asia and Latin America (Beveridge et al., 2010), with developing countries composing 97.5% of shrimp farm production in 1998 (Tacon, 1999). Even though the growth of the shrimp industry has slowed since the 1990s due to disease, 1.5 million metric tons of shrimp were still produced in 2002 (Jory and Cabrera, 2003; Epa and Wijeyaratne, 2008). In 2007, the global shrimp and prawn industry's production increased to approximately 3.0 million metric tons (Stokstad, 2010).

## Background on Shrimp Mariculture in Ecuador

Shrimp mariculture began in Ecuador in 1968. Development initially started in the Santa Rosa area (El Oro province), with roughly 600ha of mariculture in production by 1974. Two years later, farmers began using semi-intensive techniques, resulting in the rapid expansion of this industry (FAO, 2011b). Shrimp farms specifically developed in the El Oro and Guaya Provinces, because 1) they possessed a large quantity of salt pans which are ideal areas for shrimp mariculture and 2) white shrimp (*Litopenaeus vannamei*)

and blue shrimp (*L. stylirostris*) post-larvae were readily available (FAO, 2011b). In the 1970s, the government offered incentives for mariculture construction, such as low interest loans for new infrastructure (Islam et al., 2004). As a result in 1982, Ecuador had the largest amount of hectares devoted to shrimp mariculture in the world and by 1987 Ecuador became the largest exporter of shrimp (Ocampo-Thomason, 2006; Bravo, 2003). Rapid growth characterized this time period with the country's production peaking at 114,795 metric tons, worth $875million, in 1998 (FAO, 2011b).

In 1999, exports sharply declined due to White Spot Syndrome Virus (WSSV), costing Ecuador its number one producer status (Hernández-Rodríguez, 2001). As mentioned, by 2000, the nation was only the fifth largest global manufacturer (Epa and Wijeyaratne, 2008). However, Ecuador is still the main producer in the western hemisphere (Chamberlain, 2001; Hernández-Rodríguez, 2001; Bunting, 2006; Primavera, 2006; FAO, 2011b). Furthermore, shrimp mariculture in this country has begun recovering and in 2008, generated 150,000 metric tons (Hall, et al., 2011). High production rates have resulted in regional and national benefits, but not without significant environmental and social consequences (Landesman, 1994; Primavera, 1997; 2006, Joffre andSchmitt, 2010).

## Environmental Effects

Researchers have studied the environmental problems caused by past and present shrimp mariculture techniques in many different regions (egs. Dewalt, et al., 1996; Deb, 1998; Lebel, et al., 2002). Due to the attention that these problems have received in the

literature and media, the shrimp industry has developed new technology and methods in an attempt to mediate its effect.

### *Mangrove Forest Destruction*

Since mangrove destruction causes multiple environmental and social problems, the literature commonly mentions shrimp mariculture's contribution in the removal of these forests. Mangrove habitats support a high level of species biodiversity and act as a nursery for a wide variety of marine species, including many commercially harvested organisms (Landesman, 1994; Aguero and Flores, 1996; Primavera, 1997; Joffre and Schmitt, 2010). Mangrove forests provide protection and nutrients to juvenile invertebrates and fish before these species return to offshore habitats (Landesman, 1994; Primavera, 1997; Lugo, 2002). Studies have shown that catches of shrimp and fish are correlated to the amount of mangrove habitat available, with researchers attributing declines in many species' populations to this ecosystem's destruction (Bailey, 1988; Parks and Bonifaz, 1994; Primavera, 1997; Deb, 1998; Larsson et al., 2002).

Mangrove forests also provide many other services to coastal communities including protecting villages from storms, limiting erosion, and filtering pollutants discharged from industrial, agricultural, and maricultural sources (Landesman, 1994; Dewalt and Vergne,1996; Dierberg and Kiattisimkul, 1996; Parks and Bonifaz, 1994; Primavera, 1997; Deb, 1998; Thornton et al., 2003; Primavera, 2006; Barbier et al., 2008; Joffre and Schmitt, 2010; Stokstad, 2010). In addition to these benefits, many coastal populations depend on the mangrove ecosystem for their livelihood. The locals use the

trees primarily for fuel, charcoal, tannins, building materials, and medicines (Landesman, 1994; Primavera, 1997; Deb, 1998; Lugo, 2002; Zhengyun et al., 2003; Joffre and Schmitt, 2010; Veuthey and Gerber, 2011). They also collect and sell marine species found within this ecosystem (Kuhl and Sheridan, 2009; Beitl, 2011; Hamilton, 2011; Veuthey and Gerber, 2011). Furthermore, mangrove habitat biodiversity also attracts tourists who come to witness the wildlife (Lugo, 2002). As a result, this ecosystem provides income for local people (Primavera, 1997; Joffre and Schmitt, 2010). Mangrove destruction may therefore lead to a decrease in job opportunities (Deb, 1998; Ocampo-Thomason, 2006; Joffre and Schmitt, 2010).

Even with all these apparent services, mangrove forests were largely undervalued by governments and the public until recently (Primavera, 1997; Hernandez-Rodriguez, 2011). Urban expansion and industrial development, including agriculture and mariculture practices, have destroyed these ecosystems. Shrimp farmers initially did not use mangrove habitats because their soil is highly acidic and contains elevated levels of aluminum and sulfate (Bailey, 1988; Deb, 1998). Furthermore, the ponds in this habitat cannot be completely drained, which is necessary to dry out the benthic soil after harvests (Chamberlain, 2001). However, the rapid expansion of mariculture in the 1980s and 1990s caused the depletion of optimal salt flats and forced shrimp farmers to construct ponds in mangrove areas, resulting in the further destruction of this ecosystem (Bailey, 1988; Islam et al. 2004). Due to the suboptimal conditions in mangrove forests the growth and health of the shrimp declines, which can eventually result in pond abandonment (Bailey, 1988; Landesman, 1994; Lebel et al., 2002).

The global loss of mangroves due to mariculture is estimated to be between 20-50% (Primavera, 1997; Thornton et al., 2003). Critics argue that this approximation is an exaggeration and state that most shrimp farms occupy mangrove habitat that population expansion or agricultural practices had previously destroyed (Chamberlain, 2001). If areas cleared in the past for other purposes are not included, then shrimp mariculture is only responsible for removing 3% of mangrove forests (Chamberlain, 2001). Regardless of the cause, mangrove destruction in Ecuador has been extensive. Estimates of destruction in this country range from 20-50% in the last thirty years (Deb, 1998; Twilley, 1999; Chamberlain, 2001; Thornton et al., 2003; Zhengyun et al., 2003; Ocampo-Thomason, 2006). Forest loss is large considering that the country started with between 204,000ha to 362,000ha of mangrove cover (Twilley, 1999; Stickney and McVey, 2002; Zhengyun et al., 2003; Ocampo-Thomason, 2006).

On a positive note, the government now acknowledges the consequences of mangrove destruction by shrimp mariculture and is increasing legislation to protect these habitats (Thornton et al., 2003). Beginning in 1978, the government banned the destruction of mangroves for mariculture development, but officials still granted shrimp farmers concessions to build within this ecosystem (Veuthey and Gerber, 2011). However, increased awareness about the importance of mangrove forests caused the government to stop assigning concessions for pond development in 1985 (FAO, 2011a; Veuthey and Gerber, 2011). Due to enforcement difficulties, the government established a program in 1998 to pay shrimp farmers to report violations (Chamberlain, 2001). Furthermore in 2002, Ecuadorian officials outlined a specific process that shrimp farmers must follow in order to establish new facilities under the General Regulation to the

Fisheries and Fisheries Development Law (FAO, 2011a). However, laws are often not enforced or are ignored, especially in rural areas (Chamberlain, 2001; Ronnback, 2001; Thornton et al., 2003). There have been several reports in Ecuador of people not obeying the current policies (Thornton et al., 2003).

In spite of enforcement issues, the mangrove cover in many countries, including Ecuador, began increasing in the late 1990s reducing concern over habitat destruction from shrimp mariculture (Chamberlain, 2001; Islam et al. 2004). In Ecuador and Thailand, shrimp farmers have actually started planting mangroves around, and in ponds, to decrease erosion rates and filter waste (Landesman, 1994; Epa and Wijeyaratne, 2008; Bunting, 2006; Bostock, 2010). Use of mangroves around shrimp farms can increase wild shrimp populations and other populations that use this habitat (Landesman, 1994). Education is important for further increasing mangrove forest protection and encouraging replanting (Chamberlain, 2001).

### *Chemical and Waste Discharge*

Another environmental problem associated with shrimp mariculture is the discharging of chemicals and waste water into the surrounding environment. Some shrimp farmers discharge small amounts of waste everyday for clean water exchange and release large amounts when they harvest (Landesman, 1994). Workers add chemicals throughout the shrimp farming process that they discharge from the ponds at the end of the production cycle. The additives are mostly fertilizers, pesticides, and disinfectants (Islam et al., 2004). As a result, researchers have discovered high levels of ammonia in

estuarine and mangrove areas near shrimp farms (Deb, 1998; Trott and Alongi, 2000; Epa and Wijeyaratne, 2008). These chemicals negatively affect organisms in the area. Malchite green and calcium carbide have adverse impacts on marine species (Landesman, 1994; Primavera, 1997). Furthermore, some shrimp farm substances bioaccumulate in organisms and can cause human health risks if consumed (Primavera, 2006). Antibiotic presence in marine fish or invertebrates can also cause humans, or animals, that consume affected species to develop antibiotic resistance (Landesman, 1994; Primavera, 1997). Due to these problems, the Ecuadorian government now offers tax incentives to encourage shrimp farmers to reduce the pollutants in their discharge water (Holland, 1999).

Water released from shrimp farms also contains a high level of nitrogen, undigested feed, and organic waste (Landesman, 1994; Deb, 1998; Stokstad, 2010). The release of these wastes can damage benthic communities through structure alteration (Dierberg and Kiattisimkul, 1996; Deb, 1998; Lebel et al., 2002; Hernandez-Rodriguez, 2011). Waste discharge may also result in increased turbidity, bacteria levels, and frequencies of eutrophication (Larsson et al., 2002). The latter can result in decreased dissolved oxygen levels, which causes stress or even death in marine organisms (Landesman, 1994; Deb, 1998).

On the other hand, researchers working in an estuary in Queensland, Australia reported that nutrient concentrations and total suspended solids near shrimp mariculture operations were not higher than natural levels (Trott and Alongi, 2000). Other studies presented in Epa and Wijeyaratne (2008) and Chamberlain (2001) indicated that nitrogen, phosphorous, and organic matter are similar to natural levels. Finally, in Honduras, a

water quality program revealed that water quality has not decreased around shrimp farms (Landesman, 1994).

### *Spread of Disease and Parasites*

Many diseases have spread throughout the world due to mariculture activities, such as Taura syndrome (TSV), infectious hematopoietic and hypodermal necrosis virus (IHHNV), and white spot syndrome virus (WSSV) (Dierberg and Kiattisimkul, 1996; Deb, 1998; Jory and Cabrera, 2003; Primavera, 2006; Hernandez-Rodriguez, 2011). Viruses are especially damaging to shrimp culture operations because invertebrates do not have an antibody-antigen immune system (Chamberlain, 2001). Diseases not only kill a large amount of shrimp in the infected pond, but also spread to shrimp farms in the nearby area by the release of contaminated water into the environment. The result is often a large loss in production and profit. If viral outbreaks occur repeatedly, smaller shrimp culture operators may be forced to abandon their ponds (Martinez and Pedini, 1998; Lebel et al., 2002). To date, white spot syndrome virus has caused the worst worldwide economic impact on the shrimp mariculture industry. The virus was first reported in Asia in 1993 and spread to the Western hemisphere in 1999 (Chamberlain, 2001; Hernandez-Rodriguez, 2011). In 2001, WSSV reduced global production by 300,000 metric tons and cost the industry more than one billion dollars (Jory and Cabrera, 2003).

A positive outcome of the WSSV epidemic has been that shrimp farm owners now practice more sustainable techniques in an attempt to minimize the amount of stock

that becomes infected. These modified techniques include exchanging water less often to reduce the probability of getting diseases from other farms, using less shrimp feed, and stocking ponds at lower densities (Deb, 1998; Martinez and Pedini, 1998). Owners have also started testing for infected individuals in stock from hatcheries in order to minimize contamination and have begun using shrimp larvae bred to be disease resistant (Chamberlain, 2001; Hernandez-Rodriguez, 2011). Researchers have also been developing promising gene therapies involving dsRNA to try to reduce the impacts of disease (Bostock, 2010). New technology combined with the more sustainable techniques described above, may lessen the threat from viruses and other disease causing pathogens in the future.

### *Saltwater and Freshwater Use*

Shrimp mariculture requires brackish water, which is a mixture of fresh and salt water, for operation. Since some ponds are located near a freshwater source, the main fear with brackish water use is that it will cause salinization of this resource (Landesman, 1994; Deb, 1998; Larsson et al., 2002). Salinization could cause drinking water to become contaminated (Hossain et al., 2002). In some instances, saltwater from these ponds has caused the soil on nearby agricultural lands to become saline (Dierberg and Kiattisimkul, 1996; Primavera, 1997; Deb, 1998; Primavera, 2006; Hernandez-Rodriguez, 2011; Joffre and Schmitt, 2010). Saline soil causes the farms to be less productive and in many cases forces farmers to sell their land to large, commercial mariculture industries and migrate in order to look for other employment (Deb, 1998).

Even though there are laws in place in Ecuador to protect agricultural fields from salt water intrusion, these policies are often ignored by shrimp industry developers (Holland, 1999; Ronnback, 2001).

Another problem is that some ponds require a large amount of fresh water each day to reduce waste concentration. In the past, farmers replaced about 10-15% of the total pond volume daily, which resulted in land subsidence in some areas from the overuse of groundwater (Landesman, 1994; Primavera, 1997). Also, the water requirements of mariculture reduced the amount of freshwater available for other uses, such as agricultural and domestic needs (Thornton et al., 2003). However, with the adoption of new technology to minimize diseases, shrimp farmers have recently reduced water input to 1-3%, or to 0% (Chamberlain, 2001; Sonnenholzner, 2002).

### *Depleting Fishery Population*

In addition to indirectly reducing fish populations from mangrove destruction, shrimp maricultural techniques directly cause a decline through the use of fishmeal and fish oil in feeds (Dewalt and Vergne, 1996; Primavera, 2006; Stokstad, 2010). In 2005, shrimp farming required 18.1% of the total 23.13 million metric tons of feed produced for mariculture (FAO Fisheries and Aquaculture Department, 2009). In 2020, the shrimp industry's consumption of this product is expected to increase to 9.274 million metric tons. However, this prediction may be high because less fish meal and oil are now being used in feeds, with the percentage reduced from 28% to 20% between 1995 and 2006 (Tacon, 2008). Also, as the price of feed increases, due to decreased availability of fish,

this input will have to be used more efficiently (Chamberlain, 2001). The use of vegetables and animal proteins could reduce the shrimp industry's dependence on wild fish stocks. Organic shrimp farms in Bahia de Caraquez, Ecuador have used vegetables grown on nearby farms and leguminous trees around the ponds for the protein in their feed since 2003 (Ellison and Jacobs, 2005; Bunting, 2006). Thus, eliminating reliance on wild fish stocks in the future is a possibility.

## Social Conflicts

In addition to environmental damage, the rapid expansion of mariculture has changed the traditional livelihoods of many people in coastal villages. Shrimp farming affects coastal communities because locals depend on the marine systems that this industry degrades (Deb, 1998; Primavera, 1997; 2006; Islam, et al., 2004; Joffre and Schmitt, 2010). As a result, many social conflicts have arisen between villagers and shrimp farmers (Deb, 1998).

The main social conflict results from shrimp mariculture development destroying coastal habitats that traditionally were public lands. Shrimp farmers either buy these lands or sign a financial agreement with the government for a certain number of years. In both cases, the mariculture farmers make the land private and often deny locals access to the area (Bailey, 1988; Parks and Bonifaz, 1994; Landesman, 1994; Dierberg and Kiattisimkul, 1996; Dewalt and Vergne, 1996; Primavera, 1997; Deb, 1998; Islam et al., 2004; Primavera, 2006; Epa and Wijeyaratne, 2008). Limiting access is a problem because many of the locals depend on the resources provided by the coastal ecosystems,

such as mangrove forests (Landesman, 1994). Furthermore, restricted access and habitat loss results in the decline in fisheries and creates food insecurity (Bailey, 1988; Landesman, 1994; Primavera, 1997; Martinez-Alier, 2001; Thornton et al., 2003). In certain parts of the world, the shrimp on the farms do not help mitigate this problem because the product is too expensive for the locals and is exported to the United States, Japan, and Europe (Dewalt and Vergne,1996; Wurmann et al., 2004; Primavera, 1997,Hernandez-Rodriguez, 2011; Lebel et al., 2002; FAO, 2011b).

In addition to creating food insecurity, shrimp mariculture activities reduce the locals' traditional source of income. Habitat destruction results in marine harvesters being forced to collect in a smaller area, which can lead to overharvesting (Islam et al., 2004). Often the decline in local marine organism populations forces fishermen to travel to other areas to meet their catch quota, which takes time and money for transportation (Pollnac 1994; MacKenzie, 2001; Islam et al., 2004). The mangrove destruction in Bunche, Ecuador caused mollusk and crab population depletion, forcing fishermen to go to other villages to get these species (MacKenzie, 2001). In many cases, decreases in marine populations force fishermen to leave the area to look for other kinds of employment, because there are not enough mariculture jobs available to mitigate this displacement (Ocampo-Thomason, 2006; Veuthey and Gerber, 2011). Stanich (1993) estimates that less than one worker is needed per hectare of shrimp farm (Islam et al., 2004). Other studies, primarily in Asia, have shown that shrimp mariculture only uses ¼ of the labor required by the farming of rice, which is often grown in the area before the arrival of mariculture (Bailey, 1988; Landesman, 1994; Deb, 1998). Fewer job

opportunities, combined with increasing land values through growing demand from the mariculture industry, causes urban migration (Primavera, 1997, 2006).

The increase in unemployment intensifies the separation between the classes, because people who are already well-off tend to be the sole benefactors of the development of this industry (Landesman, 1994; Deb, 1998). Owners are often investors from outside the community and they tend to hire people from their original location for the higher paid and more skilled jobs (Deb, 1998). Thus, the employment opportunities available for local community members are generally low-level and short-term (Joffre and Schmitt, 2010). Furthermore, locals rarely start their own shrimp farms, because they cannot afford the land and technology necessary (Primavera, 1997; Lebel et al., 2002; Joffre and Schmitt, 2010; Van Brakel and Ross, 2010). Also, the lower class generally does not have the experience or the education to begin the project (Bailey, 1988; Lebel et al., 2002). Even if the coastal villagers are able to obtain a loan to start their own farms, they often cannot pay the investment back due to factors, such as disease, reducing their production (Lebel et al., 2002; Joffre and Schmitt, 2010). As a result, small-scale culturists often sell their farms to larger corporations because they cannot compete. Further exacerbating the inequality of mariculture ownership, governments tend to support the large-scale mariculture corporations (Bailey, 1988). Unless these social problems are addressed, shrimp mariculture will continue to separate the classes and will not be able to alleviate poverty as claimed.

Tension between shrimp farmers and local villagers due to forced livelihood shifts and the removal of resources necessary for local survival, has resulted in violent quarrels and protests in at least eleven countries that have shrimp mariculture (Environmental

Justice Foundation, 2003). Government intervention may be necessary to solve these conflicts. However, government officials are often corrupt or are involved in the shrimp industry themselves, which has been the case in Ecuador (Primavera, 1997; Rönnbäck, 2001). Thus, the local people have little political influence and technically have no legal rights to the public lands being developed (Bailey, 1988). As a result, locals have little say in the location of the new ponds and other infrastructure construction (Dewalt and Vergne, 1996). Political changes and involvement of the coastal community in the policy making process could help ease the conflicts (Primavera, 1997).

## Benefits of Shrimp Mariculture

Due to the benefits of shrimp farming, many countries have adopted this industry in spite of the social and environment costs. Governments have encouraged the development of shrimp mariculture to increase foreign exchange and better their economy (Landesman, 1994; Primavera, 1997). Furthermore, shrimp mariculture is currently the only way to meet growing consumer demand, because wild shrimp stocks are depleted (Bailey, 1988; Primavera, 2006). There are multiple other advantages of shrimp farming, which will be discussed in detail below, but whether these benefits counteract the costs of mariculture is controversial.

### *Employment Opportunities*

During the peak year of shrimp farm production in Ecuador (1998), mariculture generated a total of 250,000 jobs (FAO, 2011b). However, after the arrival of WSSV, FAO (2011b) estimates that employment declined by over 100,000 positions by 2001. In spite of this decline, shrimp farming has often created jobs in areas that traditionally have few opportunities (Hernandez-Rodriguez et al., 2001; Islam et al., 2004). In Southern Honduras, shrimp farming quadrupled the number of jobs and in Vietnamese villages this industry supplied the majority of household income (Chamberlain, 2001; Hossain et al., 2002). Although most mariculture jobs pay poorly and are seasonal (35 days per year), they provide opportunities to people with a wide variety of qualifications and who may be landless (Bailey, 1988; Dewalt and Vergne, 1996; Primavera, 1997). Shrimp farms also create employment in areas that are not suited for agriculture (Epa and Wijeyaratne, 2008). However, the creation of these jobs is at the costs of the traditional livelihoods of the coastal fishermen, cockle harvesters, and crab collectors (Bailey, 1988; Primavera, 1997; Joffre and Schmitt, 2010). Moreover, many jobs are associated with processing companies, which are usually in urban areas (Hossain et al., 2002; Lebel et al., 2002; Joffre and Schmitt, 2010). Thus, whether shrimp mariculture increases or decreases rural unemployment can be controversial (Deb, 1998; Hernandez-Rodriguez et al., 2001).

### *Improved standard of living*

Traditionally, locals in coastal areas are either fishermen or agricultural laborers and are relatively poor. In areas of Thailand and Vietnam, shrimp mariculture

development improved the overall living standards for 90% of the studied villages. Furthermore, 96% of the locals in these communities claimed that they made more money as a shrimp farmer than in their last jobs (Lebel et al., 2002). This industry is also responsible for reducing the amount of people living below the poverty line in some coastal areas (Hossain et al., 2002; FAO, 2011b). Prosperity increases in these villages, because shrimp is worth more than other products traditionally grown and relatively large amounts of money can be made quickly (Deb, 1998; Hossain et al., 2002). Thus, even though the main economic benefactors are generally higher class individuals, lower-class locals have financially benefited in some villages (Landesman, 1994; Primavera, 1997).

# 3. METHODOLOGY

## Study Site Description

This study was conducted in Muisne (Population: 25,500 (Veuthey and Gerber, 2011)) and Bunche (Permanent population:700; Temporary population: up to 1,000 (Trejo-Cagua, 2011)), which are small coastal fishing villages located in northeastern, Ecuador within the Esmeraldas Province (Figure 1).


Figure 1: Map of Study Sites: Muisne and Bunche

Most of Muisne (0° 36' 41.73"N, 80° 01' 14.45"W) is on an island separated from the mainland by a narrow river, but some of this village's development has spread across this waterway around the main road and dock (Hamilton, 2011). Along the river, mangrove ecosystems composed of *Acrostichum aureum*, *Avicennia germinans*, *Conocarpus erectus*, *Pelliciera rhizphorae*, *Rhizophora harrisonii*, and *Rhizophora mangle* border the island and mainland (Ministerio del Ambiente, 2008; Hamilton, 2011). The opposite side of the island consists of beaches with a large sandy, intertidal zone.

Bunche (0° 38' 13.44"N, 80° 02' 39.20"W) is located 5km north of Muisne and is bordered by coastal mangroves and a small river, Bunche River. Along the coast and river the habitat is similar to that of the island. However, further inland the elevation generally increases and the habitat changes to rainforest (Gerber, et al., 2009). The entire coastal region falls in Koppen's Tropical Monsoon climatic zone with generally hot and humid conditions (relative humidity: 70-80%). Another characteristic of this climatic zone is distinct wet (April-November) and dry seasons (December-March). Mean annual rainfall is greater than 1000mm and the average annual temperature ranges from 24-26.5°C (Federici and Rodolfi, 2004).

Inhabitants of Muisne and Bunche are generally Afro-Ecuadorians (Figure 2) from within the Esmeraldas Province, with a small group of *mestizos* from the Manabí province. Most locals live in poverty (Figure 2) and largely depend on the natural resources provided by mangrove and tropical forests (Hamilton, 2011). Traditional livelihoods consist of the selling and consumption of marine resources, mainly fish, shrimp, and the black mangrove cockles (*Anadara tuberculosa*) (Figure 3). In addition, some people sell mangrove charcoal or cash crops within the forests, such as cocoa and

palm oil. In the last 25 years, the shrimp mariculture industry has also provided employment in this area (Mackenzie, 2001).

Figure 2: Afro-Ecuadorians inside a Typical House in Muisne

Figure 3: Black Mangrove Cockle (*Anadara tuberculosa*), Main Resource Collected by Marine Harvestors

Currently, in Muisne, there are 197 shrimp farm owners and their ponds cover 2,607.99 ha (Ministerio del Ambiente and FUNDECOL, 2009) (Figure 4). Shrimp farming statistics are not available for Bunche, because of the relatively small population size of the village and the limited amount of shrimp ponds. However, the researcher approximates a total of 45 ponds in this area, each with a mean size of 2.73ha (Figure 5). Due to the relatively small amount of shrimp farms, jobs opportunities are minimal and many locals still travel to the nearby city of Atacames for the tourist season (June-August) in order to find work. Others leave the area for part of the year for various employment opportunities in major cities, such as Quito or Guayaquil.

Figure 4: Shrimp Farms in Muisne, Ecuador

Figure 5: Typical Shrimp Pond Size in Muisne, Ecuador

## History of Shrimp Farming in Muisne and Bunche

A small group of entrepreneurs first developed shrimp mariculture in Muisne and Bunche in the early 1980s (Hamilton, 2011; Ledergerber, 2011; Quiroga, 2011; Trejo-Cagua, 2011). By the late 1980s, and through the 1990s, the popularity of shrimp farming in the area increased (Hamilton, 2011). Due to the profitability of this industry, private investors and banks provided the capital necessary to start pond construction (Ledergerber, 2011). The available funds enabled foreigners, Ecuadorians from other provinces, and some locals, to begin building ponds, which led to the rapid development of coastal habitats, especially mangrove forests. Although there were laws at the time protecting mangroves, the government failed to enforce the regulations (Ledergerber, 2011; Góngora, 2011). In many cases, locals cut the mangroves in order to sell the land to shrimp farmers (Ledergerber, 2011). Shrimp pond construction and urban

development (Figure 6) from increased migration to the area destroyed 16, 920 ha of the original 20,093 ha of mangroves (Ministerio del Ambiente, 2008). The reduction in mangrove habitat limited the area available for cockle harvesters and fishermen (Ledergerber, 2011; Góngora, 2011; Proaño, 2011; Quiroga, 2011; Trejo-Cagua, 2011). In spite of the social and environmental problems, shrimp farming boosted the local economy and raised the standard of living for many of the locals. Thus, the community initially supported shrimp mariculture, because most of the locals were able to get jobs within the industry (Ledergerber, 2011).

Figure 6: Example of Urban Development in a Past Mangrove Ecosystem in Muisne

1. Urban development has a slightly different meaning in this area than in larger, modern cities. During interviews and surveys, individuals referred to the increase in concentration of local residences as urban development. For this reason, throughout the document urban development is used to describe the residential expansion in this figure.

However, by the late 1990s, the environmental problems caused by shrimp farmers' rapid pond construction and the arrival of WSSV, through local experimentation

with tiger prawn, caused the local economy to crash and for social issues to arise (Beitl, 2011; Ledergerber, 2011). Initially, many mariculture farmers abandoned their ponds (~300 hectares) (Ledergerber, 2011). Others tried new inputs and methods to increase production yields (Ledergerber, 2011; Quiroga, 2011). The decrease in shrimp farm productivity forced many locals to resort back to selling mangrove ecosystem resources or travel to nearby cities to look for employment (Beitl, 2011; Ledergerber, 2011).

In the last eight years, shrimp mariculture has begun recovering in Muisne and Bunche, with shrimp farmers reusing abandoned ponds (Ledergerber, 2011; Quiroga, 2011). Owners' use of shrimp larvae bred in hatcheries to be disease resistant and new inputs have increased production. However, many shrimp farmers are still in debt and can no longer obtain loans to expand or improve their facilities (Beitl, 2011; Ledergerber, 2011). Furthermore, WSSV and new environmental policies cause production rates to remain below that of the peak period of the 1990s and also limit future growth (Ledergerber, 2011).

## Interviews & Surveys

In order to determine the role shrimp mariculture plays in the Ecuadorian villages of Muisne and Bunche, surveys and interviews were conducted with locals in July 2011. In addition, the researcher observed the daily activities associated with shrimp farming by viewing ponds directly behind the housing facilities at the Congal Biomarine Station, where the researcher stayed. Initial contacts were made through the director of the station, which is part of Jatun Sacha (a non-profit organization focused on environmental

and community improvement activities). Interviews and surveys were completed with a local guide, who also helped with initial connections with respondents. All interviews were conducted in Spanish, with the aid of translators from the research station.

The researcher interviewed 137 people (Muisne: 95; Bunche: 39; Part-time residents: 3). Participants were divided into four basic groups based upon their main source of income; 1) marine harvesters (Cockle harvesters, 32; Fishermen: 5; and Mangrove charcoal makers: 2; Total=39) 2) shrimp farmers (Owners: 8; Managers: 8; Harvesters: 15; Other: 5[1]; Total=36), 3) other locals (Shop owners: 17; Other: 30[2]; Total=47), 4) government officials (Muisne townhall: 2; Bunche mayor: 1) and members of non-profit organizations ( Fundación de Defensa Ecológica (FUNDECOL): 7; Jatun Sacha: 4) (Total=14). In addition to each respondent's occupation, gender, age, and hometown were recorded. Then, formal and informal interviews were conducted with individuals within each group. Participants were asked a predetermined list of questions, with certain topics being investigated further when valuable information was discussed (see appendix 1 for a list of interview questions). Interviews generally ranged from five to twenty minutes.

Questions asked during the interviews varied between groups. Specifically, shrimp mariculture industry owners' and managers' questions addressed their current and past culture methods and the demographics of their employees. When interviews were performed on shrimp farming sites, observations were also conducted for comparison to what was visually noted at the farm near the Congal Station. Additionally, short interviews were conducted with the shrimp mariculture workers, recording their job satisfaction and employment history.

For the second group, fishermen, cockle harvesters, and charcoal makers, questions were asked about the impact that shrimp farming has on their livelihood. The third group, other locals, was asked about perceived effects of shrimp farms on community health and water quality. Finally to obtain outsider perceptions, the fourth group, local government and non-profit employees, was asked about the past and present effects of shrimp farming on the community.

In addition to the interview questions, a short five question Likert-scale survey was read to all groups to quantify respondants' attitudes toward mariculture's development (see appendix 1 for survey questions).

## Statistical Analysis

The IBM SPSS Statistics 19 computer program was used to statistically analyze the Likert-scale survey responses of three groups, marine harvesters (n=38), shrimp farmers (n=34), and other locals (n=36), to compare their opinions about shrimp mariculture within Musine and Bunche. The difference between the median responses for each group was analyzed for significance by the Independent Samples Median Test. To provide further insight, the median responses were also analyzed using the Jonckheere-Terpstra Test. Since the Jonckheere-Terpstra Test specifically evaluates the difference in median responses that have a natural ordering to them (like the sample responses of the likert-scale survey), this test was preferred for further examination of the data. Comparison of the median was more ideal than the mean for the Likert-scale survey analysis because the sample responses (i.e., strongly disagree, disagree, neutral,

agree, and strongly agree) are weighted differently. Thus, the median value more accurately represents the overall opinion of the group. However, the mean for each group's responses were also evaluated using Kruskal-Willis 1-way ANOVA to provide additional support for the median results.

Analysis was also performed by comparing differences in gender and age-specific group responses through the use of the Mann-Whitney U Test. Participants were assembled in two groups for age-specific analysis, $\leq 30$ and $> 30$. The reason for this division was because shrimp farming first arrived in the area approximately 30 years ago. Thus, respondents greater than thirty were expected to have a different opinion of shrimp farming because they witnessed the community before and after the arrival of this industry, unlike respondents who were thirty or less.

In addition, all the statistical tests previously described, except for the Independent Samples Median Test, were all performed again on the responses after they were placed into a binomial format. The original five sample responses were divided into either agree or disagree, while the neutral responses were not included. This small modification served to simplify the data and eliminate any uncertainty in the scale between the original sample responses. For the binominal statistical tests, and all the other tests described above, the null hypothesis for each survey question was that the distribution of the responses would be the same between groups. The alternative hypothesis was that the distribution of the group's responses would be significantly different.

For various reasons, some of the questions and respondents were not included in the binomial and original data analysis. The results for question five were not analyzed,

because it addressed too similar a subject matter as question one. Thus, the responses for these two questions were not different, unlike all of the others. However, the answers to question five were used for qualitative analysis, because participants further elaborated on their opinions of shrimp farming than they previously had done in question one.

Furthermore, analysis was not performed on incomplete surveys, so the sample size for all groups was reduced to: Marine harvesters (n=38), Shrimp farmers (n=34), and Other locals (n=36). Non-profit members and government officials were also not included in the statistical analysis because the sample group size (n=15) was too small for accurate results. However, their responses, along with those of the incomplete surveys, were included in the evaluation of qualitative data to provide further insights into the shrimp farming situation.

# 4. RESULTS

## Environmental Effects

### *Negative Environmental Effects*

According to 78.1% of the respondents (Marine harvesters: 25.5%; Shrimp farmers: 12.4%; Other locals: 30.7%)[3], shrimp farming development causes negative environmental effects within Muisne and Bunche (Table 1). The main environmental problems locals list are mangrove destruction and shrimp farm discharge. Additionally, a small percentage of the respondents indicate abandoned ponds are an issue.

Table 1

Qualitative Results Summary for Environmental Effects

| Environmental Effects | Total | Marine Harvesters | Shrimp Farmers | Other Locals |
|---|---|---|---|---|
| **Negative Environmental Effects** | 78.1%[1] | 25.5% | 12.4% | 30.7% |
| Mangrove destruction | 41.6% | 14.9% | 9.4% | 14.6% |
| *Past issue* | 14.6% | 3.6% | 3.6% | 2.9% |
| *Present issue* | 27.7% | 9.5% | 4.4% | 11.7% |
| Chemical/Waste discharge | 56.3% | 26.2% | 5.1% | 17.5% |
| H*uman health issues* | 29.9% | 15.3% | 0.7%[2] | 10.2% |
| S*kin problems* | 21.2%[3] | 11.7% | 0.7% | 5.1% |
| *Other health issues* | 5.1%[3] | 1.5% | 0.0% | 1.5% |
| *Marine population decline* | 37.2% | 17.5% | 2.9%[2] | 10.9%[2] |
| *Fish Population Decline* | 8.0% | 2.9% | 0%[2] | 4.4%[2] |
| *Crab Population Decline* | 2.9% | 0.7% | 1.5%[2] | 0.7%[2] |
| *Cockle Population Decline* | 17.5% | 13.1% | 1.5%[2] | 2.9%[2] |
| Chemical/Waste discharge has no effect | 10.2% | 2.9% | 5.8% | 0.0% |
| *on the environment* | 7.3%[3] | 0.7% | 5.1% | 0.0% |
| *on human health* | 3.7%[3] | 2.2%[2] | 1.5% | 0.0% |
| Abandoned Ponds | 0.7% | 0.0% | 0.7% | 0.0% |
| **Positive Environmental Effects** | 2.1% | 0.0% | 1.5% | 0.0% |
| reduce pressure on wild shrimp stock | 2.1% | 0.0% | 1.5% | 0.0% |

1. Government officials and non-profit employees were included in all total percentages.
2. Percentage not representative of the entire group because individuals were not asked questions about a specific topic, due to the controversial nature of the subject or lack of knowledge. The percentage recorded represents individuals that discussed the topic without being specifically prompted.
3. If individuals did not list specific health issues, their responses were not included in these percentages. Also, if they mentioned skin and other health issues there were included in both percentages. Similarly, individuals that listed that chemical/waste discharge from shrimp farms had no affect on the environment and on human health were included in both percentages.

*Mangrove Destruction*

A total of 41.6% of the respondents (Marine harvesters: 14.9%, Shrimp farmers: 9.4%, Other locals: 14.6%) perceive the destruction of mangroves from shrimp farming as an environmental problem (Table 1). Shrimp farmers cut mangroves to build the ponds, which can range from 1-4 hectares in this area (Figure 5). Also, because they want a clear view of trespassers, shrimp mariculture employees often clear mangroves directly along the perimeter of the farm. Due to the fact that most of the mangrove destruction occurs when the shrimp farmers are constructing the ponds, a minority of respondents, 14.6% (Marine harvesters: 3.6%, Shrimp farmers: 3.6%, Other locals: 2.9%), state that mangrove destruction was only an issue in the past (Table 1). They perceive that people are no longer building or expanding their farms due to a decrease in productivity and lack of funding. Furthermore, government officials and members of Jatun Sacha emphasize that in the past, when people were migrating into the area to work on the newly developed shrimp farms, urban development also contributed largely to mangrove destruction.

However, more of the respondents, 27.7% (Marine harvesters: 9.5%, Shrimp farmers: 4.4%, Other locals: 11.7%), believe that mangrove destruction is still a problem (Table 1). FUNDECOL (a radical non-profit organization run by local community members and aimed at mangrove protection) strongly agrees with this view because the organization still catches shrimp farmers cutting these trees, with the last incident being only a few weeks before the interview. Due to this current impact, when survey responses were divided based upon age the p-values were not significant (Significance

level, $\alpha=0.05$), because each group ($n\geq30$; $n<30$) had similar opinions of shrimp farming (Appendix 2, Table 5, 6).

According to FUNDECOL and some locals, shrimp farmers are still cutting mangroves in spite of greater governmental enforcement. Many locals and non-profit organizations resist the development of mangroves as well and often aid in alerting the authorities of destruction. Even with the help of environmental organizations and locals, according to FUNDECOL, approximately 90% of the shrimp farms in the Esmeraldas province are illegally built in mangrove areas.

The resistance from FUNDECOL and the locals stems from their recognition that mangrove destruction has detrimental environmental effects. A total of 12.4% of the locals elaborated about the specific implications of this ecosystem's destruction including; decrease in marine species populations, loss in species diversity, and fewer ecosystem services. In addition, the reduction in the populations of traditionally harvested marine species, specifically clams, crabs, and fish, results in lower catch rates. According to two respondents, since mangroves serve as a nursery, mangrove destruction is one cause for the decrease in marine organisms. Another respondent notes that waste and garbage from the shrimp farms now enter Muisne, because the forests are no longer present to filter out these contaminates. Furthermore, a clam harvester states that the destruction of mangroves is damaging, because the trees clean the water and air, while protecting the coastline from natural disasters. Thus, locals in the area are beginning to recognize the negative implications of mangrove destruction.

*Chemical and Waste Discharge*

According to 56.3% of the respondents (Marine harvesters: 26.2%; Shrimp farmers: 5.1%; Other locals: 17.5%), shrimp farmers' release of chemicals and other waste into the environment has negative environmental and human health effects (Table 1). Shrimp farm owners and managers state that they add chemicals during various parts of the culture process in order to kill species that compete with the shrimp larvae or to improve water quality. Before the employees in Muisne and Bunche add water or shrimp larvae to empty ponds, they add a natural fertilizer to neutralize the mud and replenish nutrients. Then, depending on the owner, rotenone (a natural fish toxin) or bleach is added to the remaining water in the ponds to kill fish and other organisms that may compete with, or consume, the shrimp larvae. Additionally, shrimp mariculture employees add fluoride when pumping the water into the ponds to kill unwanted organisms that enter during this process.

After the employees fill the ponds with water, they add shrimp, various natural fertilizers, antibiotics, vitamins, and bacteria to maintain water quality and shrimp health. Shrimp farmers specifically use calcium carbonate to maintain the pH within the ponds to lower the stress levels of the shrimp. The employees also add calcium carbonate to prevent algal blooms within the ponds and in the surrounding environment when they release the water for harvest. Interestingly, one shrimp farm owner also uses a chemical to darken the color of the water within the ponds to prevent birds from being able to see the shrimp.

According to owners and managers, they did not use many of the chemicals described above until after the arrival of WSSV. Before the spread of this disease, minimal inputs were required to ensure shrimp survival. The threat of WSSV now requires shrimp farmers to add the various compounds to prevent the shrimp from dying before harvest. However, shrimp mariculture owners insist that most of the additives are now organic, such as Rotenone or *barbascos*. Even though organic compounds are generally more expensive than their inorganic counterparts, shrimp farm owners state that they are more efficient and are better at preventing the shrimp from dying of WSSV.

In spite of shrimp farmers' positive perception of organics, substituting them for inorganic chemicals was not solely by choice. The use of organic chemicals is now a requirement of the Ecuadorian government, specifically *Instituto Nacional de Pesca*, and buyers from other countries. The Ministry of the Environment and the Ministry of Defense periodically check the shrimp farms to ensure the pollution remains within certain parameters. If a shrimp farmer continually violates regulations, the government can take their pond or deny them their allotment of gasoline for the pumps.

Due to these policies and the use of organics, a small percentage of respondents think that shrimp farm waste has no affect on the environment (7.3%; Marine harvesters: 0.7%; Shrimp farmers: 5.1%; Other locals: 0.0% ) or human health (3.7%; Marine harvesters: 2.2%; Shrimp farmers: 1.5%; Other locals: 0.0%) (Table 1). However, many locals argue that shrimp farmers are still using strong chemicals and releasing them into the surrounding rivers. Even though officials do not test the water quality, locals perceive the use of restricted chemicals because there are negative human and marine organism health effects in areas around shrimp ponds. In spite of the lack of testing, one

government official believes the locals are correct, stating that 90% of the supposed organic products purchased by shrimp farmers are actually inorganic chemicals. In addition, many of the respondents note that the pumps shrimp farmers use to bring water into the ponds release oil into the surrounding environment, affecting water quality and human health.

A total of 29.9% of locals (Marine harvesters: 15.3%; Shrimp farmers: 0.7%; Other locals: 10.2%) complain of health issues when they spend time near the rivers doing laundry or collecting marine organisms (Table 1). A majority of these respondents (21.2%; Marine harvesters: 11.7%; Shrimp farmers: 0.7%; Other locals: 5.1%) state that after the arrival of shrimp ponds they began getting rashes, itching, and/or breaking out in pimples. A total of 5.8% of the locals believe the cause of these skin problems is *pica pica* ("itch, itch") or *pelusa*. According to one cockle harvester, *pica pica* is a new organism in the soil that bites her hands when she collects cockles. These bites result in a rash and/or pimples, depending upon the sensitivity of the locals' skin. However, other locals indicate that *pica pica* is not an organism whose population has exploded due to increased nutrient load, but is just a way to describe the effects of certain chemicals or waste from shrimp ponds. According to a local marine biologist, both *pica pica* and *pelusa* are plants that grow at river mouths and produce seeds that itch, however, they do not naturally grow within this region. Thus, the locals may have borrowed the common names of these plants as a way to describe the symptoms they experience when coming into contact with the shrimp pond waste.

In addition to skin issues, 5.1% of the respondents (Marine harvesters: 1.5%; Shrimp farmers: 0.0%; Other locals: 1.5%) identify other health problems with shrimp

farm waste (Table 1). For instance, one respondent believes chemicals from shrimp ponds weaken the immune system, resulting in the flu, headaches, and other illnesses. Other participants believe that they can become sick if they eat marine organisms near shrimp ponds because the chemicals bioaccumulate. Finally, a rancher notes that even though he has not noticed any symptoms of the shrimp pond waste, he believes that long-term exposure will cause higher levels of cancer and birth defects within the community.

In addition to negative human health effects, 37.2% of the respondents (Marine harvesters: 17.5%; Shrimp farmers: 2.9%; Other locals: 10.9%) believe that the discharge from shrimp ponds harms marine species (Table 1). Respondents note that shrimp farmers' use of chemicals, in addition to their destruction of mangrove habitat, have resulted in population declines of the species commonly harvested for profit and consumption including; fish, cockles, shrimp, and crabs. The chemicals especially damage cockles and other benthic organisms, because this is where these substances accumulate. Furthermore, 5.8% of the respondents that believe shrimp farm waste kills marine species also note that the chemicals harm the mangroves themselves. A member of FUNDECOL states that mangroves currently grow at a slower rate because the shrimp farm chemicals have contaminated the soil.

Finally, it should be noted that even though many locals solely blame the development of mariculture for environmental and health issues, according to members of Jatun Sacha, population expansion also contributes. Raw sewage is still dumped into the rivers, along with trash and other pollutants. Due to these other sources of contamination, 6.6% of respondents (Marine harvesters: 1.5%; Shrimp Farmers: 0.7%;

Other locals: 2.2%) believe that shrimp farming waste is only one contributor to the environmental problems within the area.

### *Abandoned Ponds*

Only one respondent, a shrimp farmer, noted the environmental problems associated with abandoned shrimp ponds (Table 1). According to this individual, abandoned ponds are a problem because natural processes cannot restore the original ecosystem in these areas. The limited amount of references to abandoned ponds can be attributed to the fact that few unused ones exist in this region. The researcher only observed one abandoned pond in Bunche and one in Muisne within the areas visited. In both instances, mangroves were naturally recolonizing the habitat. Thus, in comparison to other environmental problems, abandoned shrimp ponds appear to be a minimal issue.

### *Positive Environmental Effects*

A small number of locals, 2.1%, believe shrimp farming is aiding the environment by reducing anthropogenic pressure on wild shrimp populations (Table 1). Employees within the shrimp industry now harvest more often from ponds than from the wild. As a result, the majority of the community's supply of shrimp is farm raised. Finally, wild shrimp larvae are now difficult to find, so shrimp farmers raise stock in hatcheries for their ponds. Thus, mariculture employees are no longer depleting wild populations for use in their ponds.

## Social Effects

### *Negative Social Effects*

In addition to the negative and positive environmental effects, there are social drawbacks and benefits of the development of shrimp farming in Muisne and Bunche. Approximately 73.0% of respondents (Marine harvesters: 27.0%; Shrimp farmers: 13.1%; Other locals: 24.8%) perceive that this industry's environmental destruction has negative social implications (Table 2).

Table 2

Qualitative Results Summary of Negative Social Effects

| **Social Effects** | **Total** | **Marine Harvesters** | **Shrimp Farmers** | **Other Locals** |
|---|---|---|---|---|
| **Negative Social Effects** | 73.0%[1] | 27.0% | 13.1% | 24.8% |
| Loss of Traditional Livelihoods | 22.6% | 8.0% | 3.7% | 7.3% |
| Restricted Access | 30.0% | 14.6% | 3.7%[2] | 6.6%[2] |
| Marginalization of Classes | 19.0% | 6.6% | 1.5% | 7.3% |
| Social Conflicts | 57.7% | 19.7% | 11.7% | 20.4% |

1. Government officials and non-profit employees were included in all total percentages.

*Loss of traditional livelihood*

According to 22.6% of the locals (Marine harvesters: 8.0%; Shrimp farmers: 3.7%; Other locals: 7.3%), one of the main social problems with shrimp farming in rural areas is that this industry contributes to the loss of traditional livelihoods (Table 2).

Before the arrival of shrimp farming, locals' main source of income was from fishing, cockle collecting, crab harvesting, and/or mangrove charcoal production. In the last thirty years, shrimp farming, and the affiliated increase in urban development, reduced mangrove habitats and increased water pollution.

Fishermen, cockle harvesters, crab collectors, and other locals blame shrimp mariculture for the diminishing populations of mangrove species. A small group of locals (8.0%; Marine harvesters: 2.9%; Shrimp farmers: 0.0%; Other locals: 4.4%), perceive a decline in fish populations, which negatively affects traditional local livelihoods (Table 2). One housewife emphasizes that the decline in fish is also detrimental for the locals because this resource is one of their major food sources. Additionally, four respondents (2.9%; Marine harvesters: 0.7%; Shrimp Farmers: 1.5%; Other locals: 0.7%) believe there has been a decline in crab populations (Table 2). Furthermore, 17.5% (Marine harvesters: 13.1%; Shrimp farmers: 1.5%; Other locals: 2.9%) believe that cockle populations have been falling, with an employee of the environmental branch in Muisne mentioning that this resource is in the worst decline (Figure 3). Locals suggest that populations have declined by 80-90% in the last 10-15 years, with a few also noting that the organisms' size has decreased within this time period.

Population declines of mangrove species have caused many of the locals to abandon this traditional way of life or forced them to travel further to meet their catch quota. A total of 8.0% of marine harvesters state that they have to travel further away, because of depleted marine resources close to home. These respondents travel up to two

hours by canoe to collect cockles, fish, and/or crabs. On some days, locals are still unable to find any organisms even after traveling these distances.

Further hurting traditional livelihoods, is reduced access to collecting areas. Numerous respondents, 30.0% (Marine harvesters: 14.6%; Shrimp farmers: 3.7%; Other locals: 6.6%), state that it is more difficult to collect marine resources, because shrimp farmers restrict the use of mangrove forests adjacent to shrimp farms (Table 2). These locals state that the shrimp farmers have converted areas that traditionally had public access into private lands. Locals now have to ask the shrimp farmers' permission to enter areas in which village residents have been harvesting for years. If locals try to go near the ponds without authorization, shrimp farmers will fire warning shots or their dogs will attack the intruders. Of the shrimp farmers interviewed, only one stated that he allows cockle harvesters onto his land. This exception could be, because the farmer also collects this marine resource. A unique case on the other side is one fisherman who states that he is never barred access to mangroves around a pond.

According to 8.0% of the respondents (Marine harvesters: 0.07%; Shrimp farmers: 3.6%; Other locals: 1.5%), mariculture employees do not allow marine resource collectors near the shrimp farms because of the fear that the outsiders will try to steal shrimp. Poaching is still a prominent issue according to these respondents. However, one participant implies that the group of locals attempting to steal the shrimp is limited, noting that they are the "crazy ones" within the village. Since not everyone steals shrimp, a fishermen, who is frustrated for being blamed for the actions of these individuals, exclaims that "…[shrimp farmers] don't let [us] in…[and] call [us] thieves. However the shrimp farmers are the thieves, they steal land and work [from the locals]."

*Marginalization of classes*

The combination of restricted access and habitat loss is the reason locals complain that they can no longer support their family on mangrove ecosystem resources. According to 19% of respondents (Marine harvesters: 6.6%; Shrimp farmers: 1.5%; Other locals: 7.3%) the employment the shrimp farming industry generates does not mitigate this problem, because this industry only supplies employment to a few individuals. Supporting local perception, one government official notes that shrimp mariculture only provides jobs for 5-10% of the population.

Furthermore, 8.8% (Marine harvesters: 3.6%; Shrimp Farmers: 0.7%; Other locals: 2.2%), specifically mention that only the owner, and not the shrimp farm employees, receives the main benefits from shrimp farming. Since most of the locals indicate that shrimp farm owners are relatively rich before they start their own farms, the conversion of common lands into shrimp ponds provides more money to the upper classes while hurting the income of the lower classes still practicing traditional jobs.

Many of respondents also note that the transformation of mangrove habitat into shrimp farms especially impacts the livelihood of women in the lower classes, because cockle harvesting is one of the few jobs available to them. Traditionally, cockle harvesting was a poor woman's job. Recently, the activity has expanded to include women of other classes and even some men. However, locals performing this job are still predominantly women, with 21 of the 31 cockle harvesters interviewed being female. Thus, many women are financially dependent on cockle harvesting.

Unfortunately, the arrival of shrimp farming in the area decreases this source of income and only provides a few alternative options for employment. Employment

opportunities within the shrimp mariculture industry are usually limited to males, because owners perceive that most jobs are too difficult for women. A governmental official emphasizes this point by stating that approximately twenty women used to be able to survive by collecting cockles on twenty hectares of mangroves, but after the land is converted into shrimp ponds it only supports five male employees. Thus, not only does shrimp farming development prevent female cockle collectors from being able to support themselves, but also generally does not provide them with new employment options. As a result, when the respondents were separated based upon gender for statistical analysis, the p-values were significant (Significance level, $\alpha$=0.05) for the first three questions (Appendix 2, Table 7, 8). Thus, female respondents believe shrimp farming provides fewer benefits to the community and is more damaging to the environment, than males. Furthermore, most women perceive the industry as negatively impacting their own lives, while men, whom normally get the opportunity to work on the ponds, have a more positive view.

However, some shrimp farm owners do hire a few women. One owner in Bunche hires women for shrimp processing, while another female respondent mentions that one hires her during harvest. Another exception to the norm is one female respondent who owns a shrimp farm. Regardless of this employment, many respondents argue shrimp farming is not beneficial to the community because only the owner and a few shrimp mariculture employees benefit at the expense of women and other locals still performing traditional jobs.

*Social Conflicts*

Social conflicts have resulted from loss of traditional livelihoods and the further marginalization of the classes. A majority of respondents, 58.4% (Marine harvesters: 20.4%, Shrimp farmers: 11.7%, Other locals: 20.4%), note that shrimp farmers have conflicts with cockle harvesters, FUNDECOL, and the government (Table 2). Additionally, all p-values were not significant (significance level, $\alpha$=0.05) for survey question four about social conflicts, regardless of how the respondents were grouped (based upon main job, age, or gender) for statistical analysis (Appendix 2, Table 5-10). Thus, indicating that all locals recognize this social effect of shrimp farming within the community.

According to participants, conflicts arise from the fact that shrimp farmers have opposite interests than those of other locals, the government, and non-profit organizations in this region about how to utilize mangrove ecosystems. For this reason, many locals emphasize that social conflicts occur when shrimp farmers destroy mangroves for new ponds.

Most groups express these social conflicts verbally. However, there are instances of physical violence. Many members of FUNDECOL state that they have gotten into fights with shrimp farmers. In some cases, members of both groups report assaults to the police and some end up in the hospital. Due to these specific conflicts with the local non-profit organization, 8% of respondents (Marine harvesters: 2.2%; Shrimp farmers: 0%; Other locals: 2.9%) believe that shrimp farmers only have conflicts with FUNDECOL and not other locals. Shrimp farmers also have problems with the authorities, the

Ministry of the Environment and the Ministry of Defense, because the government is now strictly regulating shrimp farming techniques and expansion.

Even though there are these social conflicts, members of the local non-profit organizations emphasize that the shrimp farmers' quarrels with FUNDECOL and the locals are lessening. The tension was so severe in the past that shrimp farmers shot at members of FUNDECOL and sent them death threats. Another respondent says that a shrimp farm owner in Bunche killed two boys that attempted to steal shrimp from his ponds. However, greater governmental involvement in the shrimp farming industry and slowing of the development rate of new ponds has likely reduced the violence.

On the other hand, a smaller group of respondents, 37.2% (Marine harvesters: 9.5%, Shrimp farmers: 13.1%, Other locals: 12.4%), believe that social conflicts no longer occur at all within their community. A couple of shrimp farmers within this group state that there are no social conflicts with the community because of pond location. These shrimp farmers build their ponds far away from common harvesting areas, or put them on land, instead of in mangrove communities. Thus, their farms do not interfere with traditional jobs or violate governmental regulations, resulting in fewer conflicts.

### *Positive Social Effects*

Even though the development of shrimp farming in Muisne and Bunche has social consequences, approximately half of the locals, 51.1% (Marine harvesters: 10.2%; Shrimp farmers: 22.6%; Other locals: 14.6%), view shrimp mariculture as beneficial to their community (Table 3). Positive effects of this industry include providing

employment opportunities, stimulating the local economy, increasing the availability of shrimp, and providing additional local benefits.

Table 3

Qualitative Results Summary of Positive Social Effects

| Social Effects | Total | Marine Harvesters | Shrimp Farmers | Other locals |
|---|---|---|---|---|
| **Positive Social Effects** | 51.1%[1] | 10.2% | 22.6% | 14.6% |
| Employment Opportunities | 43.8% | 8.0% | 21.9% | 9.5% |
| Increased Availability of Shrimp | 9.5% | 0.7% | 2.2% | 3.6% |
| Stimulating the Local Economy | 7.3% | 1.5% | 3.7% | 0.7% |
| Additional Local Benefits | 7.3% | 0.7% | 3.7% | 1.5% |

1. Government officials and non-profit employees were included in all total percentages.

*Employment Opportunities*

Since there are few employment opportunities in Muisne and Bunche and many locals have a low standard of living, the main benefit of shrimp farming is that the industry generates jobs. According to 43.8% of the locals (Marine harvesters: 8.0%; Shrimp farmers: 21.9%; Other locals: 9.5%) job creation is a definite benefit to having shrimp mariculture in the region. The majority of locals with this view are shrimp farmers.

Mariculture employees and researcher observations indicate that shrimp farming generates a wide variety of jobs; one of which is the position of manager. Since some shrimp farm owners come from other Ecuadorian provinces, South American countries,

or Asia, they need someone to run their ponds when they are not present. They often hire a family from another Ecuadorian province for every three to five ponds (Figure 7). Even when shrimp farm owners are local and stay on site year round, they hire two or three permanent employees to help maintain their ponds. Additionally, the owner may consult a marine biologist about the maintenance process and necessary inputs. Maintenance includes caring for the shrimp by providing them with food, adding chemicals and fertilizers, continually removing vegetation from the dikes, and guarding the shrimp from poachers. Additionally, managers pump water into and out of the ponds, add shrimp larvae, and help harvest.

Figure 7: Typical Residence of Shrimp Farm Manager and His Family

Additional labor is necessary during harvest, which depending on the shrimp farmer's methods ranges from every two and half to four months. Only three to five men, in addition to the manager(s), are hired for harvesting (Figure 8), because most ponds in this area are relatively small (~3.5 ha) (Figure 5) and have low stocking densities (90,000-150,000 per hectare). However, since shrimp farmers do not harvest all the ponds at the same time, outside labor is usually necessary various times within the month. After the harvesters remove the shrimp from the ponds, depending on the preference of the vendor, the owner may hire additional employees to process the shrimp, by removing shells, heads, tails, and legs, before they export the product. Finally, shrimp farmers in Muisne often employ boat drivers to bring food and employees to the ponds, because some sites are only accessible by the river.

Figure 8: Manager (2nd from the left) From Pedernales Works Along Side Three Locals During Harvest

However, according to 17.5% of the respondents (Marine harvesters: 3.7%; Shrimp farmers: 8.8%; Other locals: 1.5%), the generation of a wide variety of jobs by shrimp mariculture is not a benefit to the local community, because owners only hire foreigners. This response is likely sparked by the fact that shrimp farm owners only hire locals for temporary positions, such as harvesting or shrimp processing, and give the more desirable permanent position of manager to outsiders. For the manager position, shrimp farm owners usually hire employees from the other provinces, such as Guayas, Manabí, Perdernales, or even from other countries, such as Columbia and Argentina. In this study, only one of the permanent employee respondents was a local.

Many owners do not hire locals because they prefer to bring employees from their hometown. A shrimp farm owner notes that he hires people from Manabí, because he believes that they work harder than the locals. Finally, according to a member of a non-profit organization, the main reason shrimp farmers do not hire within the community for permanent positions, is because locals are likely to steal shrimp from the ponds to sell or give to poor relatives.

*Job Profitability and Satisfaction.* Overall, the shrimp farm employees perceive their jobs as well-paid and less demanding than other employment opportunities within the community. Of the shrimp farm employees asked about their job satisfaction (n= 11), including managers (n=8) and temporary harvesters (n=3), 81.8% were positive about working with the industry. They appreciated learning new skills and/or thought the work was easier than their past jobs.

Furthermore, two managers who worked on shrimp farms, but had lost their jobs due to decline in productivity after the arrival of WSSV, speak positively of their experiences. One of the respondents notes that "it was easy work. [I] just had to watch over the ponds and give the shrimp food." A member of a local non-profit organization further emphasizes this point by stating that before shrimp farming many employees performed traditional jobs, such as cockle harvesting and fishing. These jobs are physically demanding and require workers to put in long hours to be profitable, while shrimp farm managers generally only work for part of the day and often have long periods of relaxation time.

In spite of the positive view of shrimp farming jobs by the majority of employees and shrimp farm owners, one shrimp farm manager and one harvester favor their old jobs, with the manager originally owning an agricultural farm and the harvester having been in business. A local tourism guide also shares this negative view of shrimp farm jobs and no longer works on a pond, because he does not feel that he was paid enough for the required labor.

Regardless of the latter respondent's perception, the pay for shrimp farm labor is greater than most jobs in the region. The owners pay harvesters $18 to $30 per day, depending on their role in the process and the particular owner. Even more lucrative is the job of the managers, who take home a salary of $260 per month, including social security. The set salary gives managers a sense of security, which the traditional jobs of collecting marine resources do not provide. Traditional jobs generate low profit, with cockle harvesters for instance, selling a day's catch of approximately 100 clams for only $7 to $10.

Even other jobs available in Muisne and Bunche pay considerably less than shrimp farming. For instance, machete work only pays $8 per hour. Due to the marked difference in income between shrimp farming and other activities, all the harvesters and managers asked about their income state they make more money within the industry than at their past jobs. Thus, much of the reason that employees are satisfied with their job may be attributed to the financial benefits.

In a category of their own, are the owners of shrimp farms and their opinions on profitability and satisfaction within the shrimp mariculture industry (Figure 9). Owner job satisfaction depends highly on their profit. They invest a large amount of money throughout the shrimp rearing process and do not get paid until the end of the cycle. Thus, owning a shrimp farm is a risky endeavor. Depending on the market during the time of harvest and the size of the shrimp, the product can sell for $1 to $3.15 per pound. In addition, disease and environmental factors can affect the owner's profit. For instance, if a large amount of shrimp dies from WSSV or other natural causes, their economic gain is further reduced. Thus, many factors contribute to an owner's profitability and thus his or her satisfaction.

Figure 9: Local Shrimp Farm Owner Supervising the Harvesting Process

Demonstrating their general satisfaction, most owners were enthusiastic to talk to the researcher about their ponds and farming techniques. Many owners have been involved in the shrimp farming industry their whole lives, starting as a manager or helping relatives, before deciding to invest in their own ponds. Another respondent participated in a government educational program to improve his skills before becoming an owner, while another one took classes at a university. However, the latter was not positive about his decision to invest in this industry. This owner has not benefited from his ponds since the arrival of WSSV, but keeps them only to avoid going into further debt. The other owners were either making money on their ponds or perceived an increase in their investment in the future.

*Stimulating the local economy*

A small percentage of locals, (7.3%; Marine harvesters: 1.5%; Shrimp farmers: 3.7%; Other locals: 0.7%), suggest that shrimp farming benefits Musine and Bunche by bringing money into the community and increasing the local economy. Local employees spend their paychecks on products in town. This expenditure indirectly benefits local business owners and raises the prosperity in the region. However, when owners are from another region they send most of their profit back to their original city, so they only minimally benefit the local economy. Furthermore, a government official and two other locals believe that shrimp farmers avoid paying taxes, so they are not increasing the money within the community. In spite of this belief, two shrimp farm owners specifically mentioned that they are helping the community by paying taxes for local governmental services.

*Increased Availability of Shrimp*

In addition to stimulating the local economy, 9.5% of the locals (Marine harvesters: 0.7%; Shrimp farmers: 2.2%; Other locals: 3.6%), believe shrimp mariculture also benefits their community, because of increased shrimp availability. Even though owners of large shrimp farms export most of their product to the United States and Europe, the development of shrimp farms in the area provides farmed shrimp to locals as well. The increased availability of shrimp has lowered the price of this product in the area. Shrimp is approximately $1.50/lb, which is only slightly more expensive than

chicken ($1.40/lb) and cheaper than some other protein sources, such as beef ($1.80/lb) and pork ($2.00/lb).

*Additional local benefits*

Finally, a total of 7.3% of the locals (Marine harvesters: 0.7%; Shrimp farmers: 3.7%; Other locals 1.5%) perceive the shrimp mariculture industry as an advantage to the community, because owners give the locals and shrimp farm employees bycatch from the harvests. Locals note that during harvest, the shrimp farmers allow both workers and local residents to collect fish, crabs, clams, and other marine organisms that also live in the ponds with the shrimp. However, one respondent contradicts these claims by specifically saying that not all shrimp farmers allow locals to collect bycatch and instead let the organisms die in the empty ponds. Other owners only allow shrimp farm workers, and not other locals, to collect the bycatch. In addition to this benefit, some shrimp farm managers also receive gifts from owners.

## Overall View of Shrimp Farming

Statistical analysis of all respondents indicates that the locals recognize both the positive and negative effects of shrimp farming that were discussed above (Table 4). However, when the respondents were divided into groups based upon main jobs (i.e. marine harvesters, shrimp farmers, and other locals), their opinions of shrimp mariculture were significantly different (Significance level, $\alpha$=0.05; Figure 10; Appendix 2, Table 9,

10). Specifically, the medians of the shrimp farmers' responses for the first three questions on the survey about the role the industry plays in the community, the respondent's livelihood, and environmental damage were significantly different from marine harvesters and other locals (Appendix 2, Table 9, 10). For instance, shrimp farmers thought that the mariculture industry played a positive role in their lives and in the community, while causing minimal environmental destruction (Table 4). On the other hand, marine harvesters had an opposite view of the industry (Table 4), with one cockle harvester even noting that "[shrimp farming] is not a benefit for her life, the community, or the country". Other locals generally had a similar view (Table 4). Finally, even though government officials and non-profit employees were not included in the statistical analysis; the median value of their responses indicates they also had a negative view of mariculture's presence within their community (Table 4).

Table 4

Summary of Median Responses Grouped Based on Main Job

| **Main Job** | **Question 1** | **Question 2** | **Question 3** | **Question 4** |
|---|---|---|---|---|
| Marine Harvesters[1] | 2[2] | 2 | 4 | 4 |
| Shrimp Farmers | 4 | 4 | 2.5 | 3.5 |
| Local Business Employees | 2 | 2 | 4 | 4 |
| Overall Local Opinion[3] | 3 | 2 | 4 | 4 |
| Government and Non-profit Employees | 2 | 2 | 4.5 | 4 |

1. Sample sizes for the groups were the same as for the statistical analysis (marine harvesters =38, shrimp farmers=34, and other locals=36). Also, as mentioned the sample size for government and non-profit employees was 14.
2. Median of the sample responses, where 1- strongly disagree, 2-disagree, 3- neutral, 4-agree, and 5-strongly agree.
3. This value excludes government and non-profit employees.

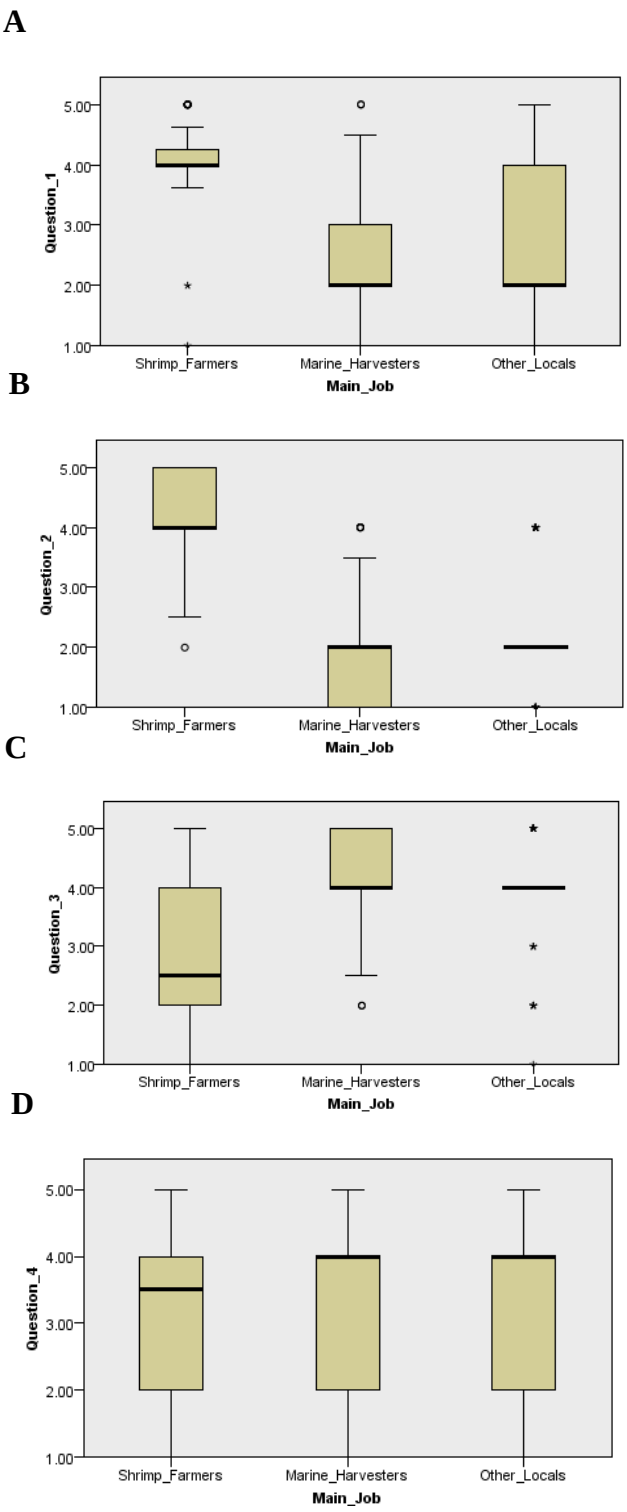


Figure 10: Independent-Samples Joncheere-Terpstra Test Results for Survey Responses Grouped Based on Main Job a) Question 1 Response; b) Question 2 Response; c) Question 3 Response; d) Question 4 Response

# 5. DISCUSSION

## Environmental Effects

The environmental effects of shrimp farming have been intensely studied (egs. Bailey, 1988; Thornton, et al., 2003; Islam et al., 2004; Epa andWijeyaratne, 2008) and their consequences are often the main reasons that many people have a negative perception of shrimp farming. However, the relatively small-scale ponds found in Muisne and Bunche are only one contributor to the environmental issues in the area. Pressures from urban development and population increase are also to blame. Furthermore, many people often overlook the fact that shrimp farming can be an environmental benefit by alleviating the pressure of wild shrimp stock, while still providing for consumer demand.

### *Negative Environmental Effects*

#### *Mangrove Destruction*

Much of the literature (egs. Primavera, 1997; Thornton, *et al.*, 2003; Epa andWijeyaratne, 2008) and certain media (egs. Owen, 2004; Warne, 2011; Stokstad, 2012) have a negative perception of shrimp farming, because this industry's development causes mangrove destruction. However, in this region shrimp farming was a large

contributor to deforestation in the past, but contributes little to present destruction (Hamilton, 2011). As previously discussed, during the peak period, building of shrimp farms in developing countries led to the destruction of large tracts of this ecosystem (Bailey, 1988; Islam *et al.*, 2004). Specifically, the Muisne area lost over 80% of its mangroves (Ministerio del Ambiente et al., 2008). Although there has been mangrove destruction in this region, according to non-profit members, government officials, and shrimp farmers, shrimp ponds are only one of various contributing factors. During the mariculture boom in this area, in addition to the expansion of shrimp ponds, urban development also spiked (Figure 4, 6). This differs from the situation in other areas, such as Guayaquil, where shrimp farming development is the main source of destruction (Total hectares of shrimp farms in Guayas Province: 146,796 ha (Montaño, 2010)).

In this region, the reason urban growth also played a major role in mangrove destruction is, in 1989, the government built a paved road to Muisne from Atacamas, connecting this remote area to other major cities. Before this road's construction, the nearest paved road was five kilometers from Muisne. The dirt roadway in place was only accessible during part of the year, forcing most people to travel into and out of the city by boat. The paved road made transportation more convenient. More importantly, this street increased accessibility for outside laborers to migrate into the area to work for the newly developed shrimp industry. The migrants were usually poor and unable to purchase property for a house. Thus, they built within the mangroves, because this land was public. Due to the fact that this land was free, and initially the government did not prevent the mariculture industry from building in these areas, shrimp farmers also constructed ponds in these areas. Thus, a combination of urban development and shrimp

farming caused mangrove destruction. According to Hamilton (2011), by 2005 within the Muisne Estuary, shrimp farmers had developed approximately 48% of past mangrove forests and locals had destroyed another 36% for other uses.

In recent years, shrimp farming's destruction of mangroves in this region has slowed due to stricter governmental regulations, lack of resources to expand, and environmental education. However, almost half of the respondents mentioned mangrove destruction as an environmental problem associated with shrimp farming. One reason that many of the respondents listed this as an environmental problem, may be because they are presently experiencing the repercussions of past mangrove deforestation. The loss of mangroves in this area is likely one of the major reasons that marine species, especially organisms traditionally harvested, have declined. In fact, mangrove destruction in other areas of Ecuador, such as San Felipe, has been found to reduce cockle populations (Kuhl and Sheridan, 2009). Thus, this loss of habitat hurts people still practicing traditional jobs, who make-up the majority of the community.

The fact that the consequences of the environmental effects of shrimp farming development are still evident also is likely the reason that opinions of this industry were the same among age groups (Appendix 2, Table 5, 6). Another possible explanation for the respondents greater than thirty having a similar view as the ones thirty or less is that many of the older locals are migrants from the shrimp farming boom period, when a greater amount of employees were needed for the ponds. Thus, these locals would not have a more negative view of shrimp farming, as expected, because they do not know what the community was like before the arrival of this industry.

Another reason a large percentage of locals mentioned mangrove destruction as a problem can be attributed to FUNDECOL's influence in the area. Activists originally created this organization to empower locals practicing traditional livelihoods to fight against shrimp farming development in the mangroves. FUNDECOL currently works on reforesting past destruction, and reporting current deforestation (Veuthey and Gerber, 2011). Since FUNDECOL's main focus is mangroves, they constantly highlight its destruction within the community. Therefore, many locals may have listed this issue as a problem with shrimp farming, because FUNDECOL communicates this message to them. Regardless of the reason that locals perceive mangrove destruction as an environmental consequence of shrimp farming, the combination of this industry and urban development has caused considerable damage to the mangrove ecosystems in the area.

*Chemical and Waste Discharge*

Even though locals blame chemical and waste discharge from shrimp farms for multiple environmental and human health problems, in Muisne and Bunche this industry is only one cause of these issues. Over half of the respondents perceive shrimp farming chemicals as having a negative impact on water quality, marine organisms, and/or human health. The majority of this group was fishermen, cockle harvesters, or crab collectors, likely because they spend a large amount of time in or near the waterways affected by this waste and are the ones that have the most health issues. Another reason that many marine harvesters likely mentioned the chemicals released by shrimp farms is because they believe that these substances are one of the reasons for the decline in the populations

of the marine organisms they collect. Many studies of the effects of shrimp farming have shown that indeed pond discharge decreases water quality and does have a negative effect on marine organisms (egs. Landesman, 1994; Primavera, 1997; Trott and Alongi, 2000; Epa and Wijeyaratne, 2008). These results suggest that shrimp farmers' release of chemicals most likely does play a role in marine population decline in this region. Since the reduction in marine organisms' populations affects these local's livelihoods, it is not surprising that this group listed shrimp farm waste as a major environmental problem.

However, contrary to local perception, these environmental effects are not solely the fault of the mariculture industry. Multiple other industries generate pollution, and the locals themselves pollute the river by dumping trash and raw sewage. Furthermore, the effect shrimp mariculture's effluent has on the ecosystem is limited by the fact that shrimp farmers rarely harvest more than one pond in the same area within a short time period. Since the pollution from shrimp farming is occasional, the likelihood of eutrophication and other environmental problems is reduced.

However, the majority of locals disregard both these facts and believe the shrimp mariculture industry is solely at fault for the decrease in water quality and mangrove ecosystem health. One possible explanation for why so many of the respondents blame the shrimp mariculture industry is that the majority of locals' believe the pond chemicals are responsible for *pica pica* and *pelusa.* *Pica pica* and *pelusa* cause a skin reaction, which in some cases can be severe. In a mangrove forest adjacent to a shrimp farm in Muisne, the researcher experienced a skin rash accompanied by a burning sensation. Her experience was comparable to that of some locals, thus making it understandable that some individuals chose to stop harvesting marine resources in attempt to avoid this health

issue. Since locals perceive that these skin reactions are worse near shrimp ponds, they have concluded that problems with their health are solely due to the shrimp farm chemicals. In support of local perception, Veuthey and Gerber (2011) suggest fertilizers used by shrimp farmers cause skin conditions. Since locals associate health issues with shrimp farm waste, they are likely to only focus on mariculture pollution in their responses.

Another probable reason for locals singling out this industry is unlike the contamination of the river from raw sewage and trash, only a small percentage of the community causes shrimp farming pollution. Locals can more easily blame the shrimp farmers because they are the minority. Furthermore, owners and managers are often from other provinces or other South American countries, so locals are more likely to blame these foreigners rather than themselves for the environmental problems. Additionally, shrimp farming is relatively new to the community and has disrupted the traditional way of life, so locals are already angry with the industry for the social problems that they have caused. This resentment likely makes shrimp mariculture an easy scapegoat for the environmental problems as well.

Finally, the community's lack of understanding about their role in polluting the environment, leads the locals to blame the shrimp mariculture industry. Since the community grew dramatically during the period of pond development, environmental problems coincidently began to occur after the arrival of shrimp farming. Thus, locals have concluded that this industry is the reason for all environmental effects. Many may not realize that the increase in human population density is also a source of environmental problems, because locals have always discarded waste into the waterways.

However, due to the increase in population density, ecosystems can no longer withstand these traditional methods of waste dumping. On a positive note, recent environmental education programs have slightly reduced local contribution to the pollution problem, by convincing people to properly dispose of trash and plastics. In spite of this increase in environmental awareness, until the government builds a sewage treatment plant within the area, the consequences of urban development will only worsen.

Unfortunately, the physical extent of the effects of sewage, trash, and shrimp farm waste in this community is unknown. In order to determine the role shrimp farm waste actually plays in the community, officials need to test the water around the ponds. The environmental branch of the local government has the equipment necessary to test water quality, but lacks the training to perform the task. Without proper testing, officials cannot know if the tide or other natural sources dilute the anthropogenic inputs to safe levels within the natural ecosystems. Furthermore, the lack of monitoring likely adds to confusion about the sources of water pollution and leads locals to solely blame shrimp farming, instead of recognizing this industry as only one contributor.

### *Positive Environmental Effects*

The alleviation of anthropogenic pressure on wild stocks is shrimp farming's main positive environmental effect; however, this was rarely mentioned by respondents or the literature. As noted, many wild shrimp populations are currently depleted (Bailey, 1988; Primavera, 2006). The decline in wild population is even noticeable in Muisne and Bunche, with respondents stating that wild shrimp larvae are now difficult to find. This

problem is likely to escalate as more locals harvest wild shrimp populations to meet increasing consumer demand. Thus, the best way to lessen the pressure on the wild stocks and continue to provide a supply of shrimp is through the mariculture industry.

Due to the immediate importance of addressing shrimp population declines and the role that shrimp mariculture plays in offering a solution, it is interesting that only a limited number of shrimp farmers and no marine harvesters or other locals mentioned the positive effect on wild populations. Furthermore, only one non-profit member made a positive connection between shrimp farming and wild populations. He believed that the shrimp mariculture industry's hatcheries were benefiting the wild populations by producing larvae, which in turn limits the pressure on wild larvae for use in shrimp farms. Additionally, the same non-profit member offered another positive environmental effect of shrimp mariculture. He emphasized that shrimp farming expansion in this area results in moving away from the damaging activity of shrimp trawling. Not only does reducing this activity benefit the wild shrimp population, but it also helps alleviate the pressure on populations of other organisms that are common bycatch (Alverson et al., 1994; Pope et al., 2000).

It is likely that most locals' lack of recognition of positive influences on wild shrimp populations is because the decline in shrimp populations does not play a role in their lives. They have a constant supply of farmed raised shrimp. Furthermore, part of the reason for many locals not discussing the positive effect mariculture has on wild shrimp stocks is because shrimp farmers, marine harvesters, and other locals were not directly asked questions about perceived environmental benefits of the ponds.

However, even though members of local non-profit organizations and government officials were asked about positive environmental effects, only the respondent mentioned above discussed positive effects. One reason that the majority of non-profit members and government officials did not describe positive environmental effects was, because many members of this group were part of FUNDECOL. As mentioned, this organization was partially created to fight against the negative effects of shrimp farming. Thus, this organization's agenda is to emphasize the negatives of this industry to gain political and financial support for their cause. Therefore, the members of the organization are expected to discuss the negative effects. Additionally, in general the positive environmental effects of shrimp farming are rarely mentioned, because they are overshadowed by the negative environmental effects.

## Social Effects

The negative environmental effects discussed above have many social consequences. However, since shrimp farming is only one contributor to mangrove destruction and estuarine pollution, this industry is also only partially responsible for some of the social effects, such as traditional livelihood loss. Nevertheless, in Muisne and Bunche shrimp farming is mainly at fault for further increasing the marginalization of classes and restricting access to some mangrove areas. These social issues have caused conflicts between shrimp farmers and locals, but they have lessened in recent years. In spite of these occasional quarrels and other negative social effects, the shrimp mariculture industry does benefit the community by generating some employment

opportunities, stimulating the local economy, increasing the availability of shrimp, and providing bycatch and other gifts to shrimp farm employees.

## *Negative Social Effects*

### *Loss of traditional livelihoods*

Even though multiple researchers (egs. Bailey, 1988; Primavera, 1997; Joffre and Schmitt, 2010), as well as participants in this study, blame shrimp farming development in rural areas for traditional livelihood loss, in Muisne and Bunche this industry appears to only be one of numerous contributors. The main reason that the locals associate shrimp mariculture industry with the loss of these jobs is because this business causes mangrove habitat destruction, resulting in a decrease in marine organisms populations. A decline in these species is a pertinent issue, because many locals are living below the poverty line and need to collect fish, cockles, and/or crabs to survive. The following respondent's statement summarizes the key role that these marine organisms play in many locals' lives: "…if [we] don't go harvest cockles [then we] don't have food." Thus, due to the industry's involvement in the declining marine populations, it is not surprising that many of the locals would dislike shrimp farmers.

However, as mentioned, the locals disregard the fact that shrimp farming is not the only factor negatively affecting the mangrove habitat, and consequently the species they harvest. The shrimp farming industry does add chemicals and occasionally cuts mangroves, but the spread of urban development also plays a key role in the deterioration of the environment.

Regardless of the cause, approximately one-fourth of the locals are concerned about traditional livelihood loss, because they perceive a decline in fish, crabs, and cockles. Specifically, about 10% of the locals believe mangrove fish populations are falling. This reduction is significant in these rural villages because many locals are dependent on the fish for a main food source. Since mangrove fish species play a key role in locals' diet, other studies have found that shrimp farming creates food insecurity (Bailey, 1988; Landesman, 1994; Primavera, 1997; Thornton et al., 2003). Although as noted, in Muisne and Bunche, shrimp farming is not the only factor contributing to loss of fish populations, so it cannot be fully blamed for this social issue.

In addition to a decline in fish, a much smaller number of respondents mentioned a decrease in crab populations. Mackenzie (2001) found similar results in Bunche, with crab collectors being forced to go to nearby villages in order to meet their quota, due to the mangrove destruction. Mackenzie's results suggest that crab abundance has been decreasing for at least a decade, which could explain the reason so few respondents chose to discuss the population decline of this organism in comparison to the others. According to Warne (2011), crab collecting used to be a major traditional job for males in this area, but the limited amount of references to crabs in this study suggests that only a small amount of locals still gain their main source of income from this resource.

According to the locals, cockle populations (Figure 3) have followed a similar trend as crab and fish populations. Most locals believe the same factors affecting the other species populations, shrimp farmers' habitat destruction and waste discharge, also cause cockle decline. Yet, overharvesting of cockles is also likely a large contributor to the decrease in population. Traditionally, only poor women collected cockles. However,

now this job is not gender or class specific. The crash of the shrimp mariculture industry forced many migrants that had arrived to work on the ponds to start collecting the cockles. Thus, the amount of people collecting this resource has increased, while the mangrove habitat has decreased. This combined pressure likely has contributed to population declines, which was also concluded by Beitl (2011). Furthermore, some of the cockle harvesters themselves make the situation worse by not respecting the minimum size limit when collecting these organisms. The government banned the collection of cockles smaller than 4.5cm in an attempt to protect the population from overharvesting. Furthermore, the vendor is not supposed to accept any cockles below this size. However, some respondents have suggested that some members of both parties do not abide by this law. Therefore, these cockle harvesters and vendors are also likely contributing to the population decline.

Interestingly, besides one member of a non-profit organization and one cockle harvester, most locals did not recognize overharvesting as a contributing factor to the decrease in any of the marine organism populations. Even when one respondent was asked directly if the decrease in marine species could also be due to overharvesting, he became confused by the question. His reaction suggests that locals either are uneducated about their own involvement in the population decline through overharvesting, or would rather blame shrimp farmers as they do for the other environmental effects.

In spite of the perceptions of most of the locals, more than likely it is a combination of overharvesting, shrimp farming, and urban development that have caused the decline in cockle populations. Although this concerns many of the locals, the results of this study and of Hamilton (2011) indicate that population declines impact poor

women the most. Cockle harvesting is one of the few jobs that society deems acceptable for the women. Thus, the decrease in cockles displaces women from their main source of income. The arrival of shrimp mariculture does not alleviate this problem, because this industry does not usually hire women. Most owners claim that females are not physically capable of harvesting. However, one respondent states that she helps harvest the ponds, so it is more societal restrictions than the reality of gender specific ability. Thus, it is no wonder that women were found to generally have a more negative view of shrimp farming than men (Appendix 2, Table 7, 8). Women see this industry as destroying their collecting areas and livelihood, without offering them another option for employment. Even women that are fortunate enough to have another source of revenue, have an overall negative view of this industry, likely because they occasionally harvest cockles for additional income.

In addition to population declines of marine organisms, reduced accessibility to harvesting areas contributes to local traditional livelihood loss. In contrast to the other factors discussed, the shrimp mariculture industry is solely at fault for limiting the areas where locals are allowed to harvest. Shrimp farmers prevent locals from harvesting in areas around the ponds. In Muisne, Veuthey and Gerber (2011) found women cockle harvesters were especially harassed if they attempted to collect around shrimp farms, which could be another reason that they have a more negative view of the industry than men.

Shrimp farmers claim that they do not allow harvesters to enter forests near the ponds, because these managers have problems with locals trying to steal shrimp. However, combined with habitat loss due to urban and shrimp farming development,

these restrictions further limit areas where locals can harvest. Although numerous literature sources discuss the situation (egs. Dewalt and Vergne, 1996; Environmental Justice Foundation, 2003; Primavera, 2006), as well as a media source (Warne, 2011), it should be emphasized that in Muisne and Bunche, even though shrimp farmers do use dogs and warning shots to deter locals, the situation is not as intense as the sources describe in other areas. Presently, no locals mentioned anyone getting murdered over entering mangroves near a shrimp farm. Even though the current situation is not as bad as in other locations; the sometimes violent restriction of access still affects locals' livelihoods in this area.

Furthermore, reduced accessibility, habitat destruction, and population declines force locals to travel further in order to collect marine resources. Since locals have to travel further, they complain that it takes them more time to meet their catch quota. On a positive note, some locals are taking action against the negative social and environmental effects of shrimp farming in an attempt to reduce the impact of this industry. Cockle harvesters have formed an association called FUEMBOHT (Federación de Usuarios del Ecosistema Manglar y del Bosque Húmedo Tropical de Muisne) and FUNDECOL also exists in the area. These organizations have been fighting politically to preserve traditional livelihoods. They are also attempting to retrieve some land from the shrimp farmers for restoration.

However, establishing new protected areas is a slow process. Many of the locals in these organizations have fewer resources and education than shrimp farmers. Furthermore, the national government generally supports shrimp farming, because it is a way to increase the nation's economy. Additionally, some locals stated that numerous

government officials are actually shrimp farmers themselves, which Primavera (1997) and Rönnbäck (2001) also found as a problem in other locations. Even though there are some road blocks, as discussed, the government has recently been placing more mangroves into protection and creating stricter shrimp farming regulations.

*Marginalization of classes*

In addition to contributing to the displacement of locals practicing traditional jobs, shrimp farm development results in the further marginalization of the classes by benefiting the higher-class shrimp farm owners at the expense of the lower classes dependent on marine resources. As previously noted, many of the locals in Muisne and Bunche live in poverty and selling fish, cockles, and /or crabs provides their only source of income. Due to human population increase, a decline in marine organism populations, and restricted access to harvesting areas, locals practicing traditional jobs are now having a difficult time supporting themselves. The arrival of shrimp farming does not mitigate this problem, because this industry only generates consistent work for about 5-10% of the locals. Thus, shrimp mariculture contributes to the factors affecting traditional livelihood loss, without providing most locals with another option. Landesman (1994) and Deb (1998) also report these results in other regions. Even though many of the owners in Muisne and Bunche report that the arrival of WSSV reduced their profit and in some cases caused them to go into debt, they still have more resources than the locals. Due to the fact that most of the profit goes to people that are already well-off, it is not surprising that many locals have a negative view of this industry.

This negative attitude may also stem from the fact that locals no longer have the opportunity to be owners of shrimp farms in the area. After the arrival of WSSV, banks no longer provide individuals with the necessary loans to get started. After the crash of the shrimp industry, many people could not repay their loans, so banks banned these mariculture owners from obtaining future loans. Furthermore, new government taxes and regulations on shrimp farms make it more difficult for locals to obtain ponds. The combination of these factors contributes to locals not being able to become shrimp farm owners and results in the further marginalization of classes.

*Social conflicts*

Although shrimp farming's contribution to the loss of traditional livelihoods and the marginalization of the classes has created social conflicts between the mariculture industry, locals, non-profits, and the government, there are now relatively few instances of physical violence in comparison to the past situation. Even though the current social conflict issue in Muisne and Bunche is of lesser intensity than in the past, many locals still listed examples of current quarrels. Over half the locals stated there are conflicts, and all groups (i.e. marine harvesters, shrimp farmers, and other locals) agreed about the presence of this problem (Appendix 2, Table 7, 8). This consensus among locals suggests that the magnitude of the conflicts may have decreased, but the frequency of the conflicts likely has not.

On a positive note, the only physical disputes discussed were between shrimp farmers and members of FUNDECOL. Members of this organization have more severe

conflicts with the shrimp farmers, because they are usually the ones that report or confront them for mangrove destruction. Due to the role that FUNDECOL plays in impeding shrimp farm expansion, nearly 10% of the locals state that the shrimp farmers and this organization are the only ones that have social conflicts. It is interesting that these participants would blame FUNDECOL for the disputes within the community when the organization is acting to protect the traditional livelihoods of the locals.

The fact that the locals only listed occasional physical confrontations between shrimp farmers and FUNDECOL, and only verbal confrontations with other groups, demonstrates the improvement in the social conflict situation. Several factors likely influenced this shift. First, as mentioned, shrimp farmers are not expanding as rapidly as during the boom, because the arrival of WSSV has minimized their profit. Secondly, the government is now strictly regulating the industry and no longer allowing owners to freely expand into mangrove ecosystems. Finally, as noted, a paved road was built to Muisne in 1989, which made this area more accessible, not only for migrants, but also for government officials to regulate shrimp farming activities and control violent confrontations. The combination of these factors limits the amount of social conflicts because shrimp farmers are destroying less of the mangrove ecosystem where locals practice traditional livelihoods.

## *Positive Social Effects*

### *Employment opportunities*

Although the generation of jobs in rural areas is one of the main benefits of shrimp mariculture, the findings of this study and other literature (Stanich, 1993; Hamilton, 2011) emphasize that this industry employs only a small percentage of locals. When asked about the benefits of shrimp farming, nearly half of the respondents mentioned that this industry generates jobs. Furthermore, the locals out of this group of participants who take advantage of the opportunity to work on the ponds state their current job pays more and is easier than their past one. Their perceptions contradict Bailey's (1988), Dewalt and Vergne's (1996), and Primavera's (1997) conclusions that the industry provides locals poorly paid jobs. In Muisne and Bunche, harvesters and managers make relatively more than locals practicing traditional jobs. Thus, relative to other employment options, shrimp farm employees are well-paid. Furthermore, traditional jobs are more difficult because locals have to work more of the day to earn enough money to survive. Also, they often have to travel and risk coming into contact with poisonous marine organisms.

However, the shrimp mariculture industry can only provide jobs to a few locals. Since the ponds are relatively small in this area, the owners only hire three to five harvesters, in addition to the manager(s), for the day. In addition to the fact that owners only employ a couple of locals for this job, Joffre and Schmitt (2010) emphasize that harvesting positions are occasional. In Muisne and Bunche, since owners only hire harvesters for a fraction of the year, they must also perform other jobs, such as fishing,

cockle harvesting, or crab collecting. Even though harvesting only provides employment for these individuals for part of the year, these jobs provide them with additional income. This profit is important, because individuals make little from traditional jobs and recently have been earning even less due to declines in marine organisms' populations.

Due to the fact that harvesters still have to depend on natural resources for much of their income, most locals want to be hired as managers. The manager position earns higher pay and requires relatively easy labor. However, manager opportunities are even more limited then harvesting positions. The shrimp farm owner only employs one individual for every three to five ponds. Furthermore, locals are usually not considered for this position, because shrimp farm owners prefer to hire people from other provinces, such as Manabí, or their home town. Owners state that they do not hire locals for the job, because they are more likely to steal shrimp. Since locals are often not hired for this superior job within the industry, it is not surprising that almost 20% complained that owners only hire foreigners. The exclusion of locals from the managerial positions further reduces the number of jobs generated for the community.

Moreover, shrimp mariculture employment in Muisne and Bunche is limited by the fact that these villages do not possess hatcheries or large-scale processing plants. In Bunche, only a few people work processing shrimp for local consumption and the hatchery in Muisne shut down after a loss of business due to WSSV. The nearest processing plant and hatchery to Muisne and Bunche is over an hour away in Atacamas. Thus, many jobs created by the shrimp farm industry are located far from the local communities that the shrimp farms impact (Joffre and Schmitt, 2010).

*Stimulating the local economy*

Several studies (egs. Hossain, et al., 2002; Lebel, et al., 2002) have indicated that shrimp farming stimulates the local economy, especially in rural areas; in this region shrimp farming brings a relatively small amount of money into the community. Ponds are relatively small scale (2ha) (Figure 5) and have low stocking densities (90,000-150,000 per hectare), so the owner's profit is limited. This in turn affects the amount of money indirectly made available to the community, because the owner cannot buy as many goods and services from locals. Also, as previously stated, the owner is often from another region, so the bulk of the profit leaves the community. Furthermore, since these farms are small-scale only a small percentage of the community has the opportunity to work within this industry. In spite of these limitations, shrimp farming does benefit the few mariculture employees, indirectly increasing the local economy.

Even though small in magnitude, since this industry does somewhat benefit the local economy, it is surprising that less than 10% of respondents mentioned this benefit. This percentage is small, likely because most locals do not directly benefit from shrimp mariculture. Since the benefits to non-mariculture employees are indirect and thus are not as evident as the negative environmental and social issues, locals are more likely to discuss the drawbacks of this industry. In doing so, they ignore the benefits of the stimulated local economy.

*Increased Availability of Shrimp*

In addition to stimulating the local economy, in Muisne and Bunche shrimp farming benefits the locals by increasing the availability of shrimp, which in turn lowers the price per pound. About 10% of the locals mentioned this positive result, with the relatively low price of shrimp in this region supporting their perception. This contradicts the results of multiple studies of shrimp mariculture industry in developing countries (egs. Bailey, 1988; Dewalt and Vergne, 1996; Lebel, et al., 2002). These researchers found that the availability of shrimp did not increase when it was farmed in rural areas, because the shrimp could be sold to developed countries for a higher price than within the community.

The different situation in Muisne and Bunche could be because some of the shrimp farms are small-scale, which was also suggested by Hamilton (2011). The owners of these shrimp farms likely do not have the resources to export to other countries, so they sell to local vendors. However, the owners that have larger ponds in the area do export to the United States and Europe. This implies that rural communities need to contain some relatively small-scale shrimp farms in addition to large-scale farms, in order to provide an affordable food source to the locals while increasing the national economy. Furthermore, if the wild shrimp populations continue to decline, most locals in rural areas will probably not have access, or be able to afford, shrimp without mariculture development in a nearby area.

*Additional local benefits*

A small number of locals mentioned either getting to keep the bycatch from the ponds during harvest or receiving gifts from their shrimp farm employer. These advantages of the shrimp mariculture industry have not been mentioned by any other published studies, likely because they mostly only benefit mariculture workers. For instance, owners allow their employees to take edible bycatch when harvesting the ponds. The bycatch benefits the employees, while cutting down on the organisms wasted during this process. If workers do not collect these animals, they are discarded on land because they have low monetary value in comparison to shrimp. However, even though shrimp mariculture employees' collection of bycatch is a positive, it only benefits a limited group within the community. According to a small percentage of respondents and personal observation, owners prohibit locals not working on the farm from collecting the bycatch. Perhaps owners and/or managers do not allow other locals to participate in this collection process, because they are afraid the outsiders will steal shrimp.

In addition to owners allowing all shrimp mariculture employees to keep bycatch, some give presents, but only to the managers. It is not surprising that the owners only offer presents to their managers, because these individuals are in charge of the shrimp in the owners' absence. The managers are responsible for the quantity of shrimp harvested at the end of the season. Thus, the owner depends on these individuals for the farm's profit. Therefore, it is in the owners' best interests to encourage a positive relationship with the managers. Furthermore, unlike the harvesters, the manager's position is more permanent and they usually come from the same province or country as the owner. Thus,

it makes sense that they are more likely to have a closer relationship with these employees and only give presents to these individuals. However, even though the gifts are only a direct advantage for a few individuals, the entire community indirectly benefits from their increase in prosperity.

## Overall view of shrimp farming

Clearly, there are both benefits and problems associated with shrimp farming. Overall, the local perception agrees with this statement (Table 4). However, when respondents were divided based upon main job, shrimp farmers had an overall positive view and marine harvesters had an overall negative view of the industry (Table 4). As expected, shrimp farmers support mariculture development, because they personally benefit from this enterprise. In contrast, marine harvesters do not believe shrimp farming is advantageous for the community, likely because of its role in habitat destruction and marine population decline. In addition to these factors, this industry impacts their traditional way of life by restricting access to some harvesting areas, which causes direct conflicts. Thus, it is not surprising that marine harvesters and shrimp farmers have significantly different opinions of mariculture development within the community (Figure 10; Appendix 2, Table 9, 10).

Since the above results were expected, more interesting is that government officials, non-profit members, and other locals, have a negative view of shrimp farming (Table 4). Since the industry does not directly impact these individuals, it was expected for them to have a more neutral opinion and recognize that this industry has both positive

and negative effects. Instead, their view matched that of the marine harvesters. However, the government and non-profit employees had an overall negative perception, because FUNDECOL employees compose half of the group. In fact, if FUNDECOL's responses are removed from this group, the remaining government officials and non-profit members perceive shrimp farming as an overall benefit to the community. Thus, FUNDECOL's negative replies skewed the medians. As previously mentioned, this organization usually refers solely to the negatives, because shrimp mariculture contributes to the destruction of the mangrove ecosystem that they are trying to protect.

FUNDECOL may also be the reason that other locals have a negative opinion of shrimp farming (Table 4). Since these locals do not experience the effects of the shrimp mariculture industry daily, like marine harvesters, they could be unaware of the reality of the situation. As a result, their view stems from the information and the negative perception that FUNDECOL chooses to share with the community. On the other hand, the other locals may have a view similar to marine harvesters, because they may occasionally collect marine resources on the side. Harvesting fish, cockles, and/or crabs as a source of additional income is common within this community. Thus, the shrimp mariculture industry may actually be personally affecting other locals. Since FUNDECOL, marine harvesters, and other locals all have a negative perception of this industry, resource managers need to improve shrimp farming regulations and education programs to mediate local conflict with the industry.

# 6. CONCLUSION

Shrimp mariculture's rapid development in the last couple of decades has received much attention due to its environmental and social consequences. However, in the rural villages of Muisne and Bunche, shrimp farming is only one contributor to the environmental and social problems that the locals currently experience. In this area, urban development and population increase have also significantly contributed to mangrove destruction and river pollution. The main consequence of these environmental impacts is traditional livelihood loss. In addition to being partly at fault for this social effect, shrimp farming is mostly to blame for intensifying the separation between the classes and restricting access to already limited mangrove forests.

Due to mariculture's involvement in these social issues, locals have conflicts with the shrimp farmers. On a positive note, these conflicts are lessening, because of stricter government regulations and the fact that shrimp farming is no longer expanding as rapidly. Furthermore, in spite of the problems shrimp farming has partially created within this community, this industry does provide some benefits by creating employment (although limited), stimulating the local economy, and increasing the availability of shrimp. In addition to these social benefits, shrimp farming is one solution to decreasing the pressure on exploited wild populations, while providing for consumer demand. Since shrimp farming benefits rural communities and wild shrimp populations, it is important to

make changes to reduce this industry's contribution to the environmental and social impacts.

In Muisne and Bunche, the government and non-profit organizations can reduce the impact of shrimp mariculture through modification of existing management strategies and educational programs. For example, one of the main problems with shrimp farming is that owners are mostly of higher class and they gain their profit at the expense of lower-class locals. Thus, increasing the marginalization between the classes. In order to mitigate this problem, the government should make it easier for locals to become small farm owners. If locals could own some ponds, rural communities would benefit more directly from this industry. To facilitate this process, the government or non-profit organizations could provide the start-up investment for small shrimp farms, like they did in the past, because locals often do not have the resources to build ponds on their own (Islam et al., 2004). At the very least, the government could modify the new shrimp farming regulations and taxes to make them more practical for small-scale shrimp farm owners.

Furthermore, the government could minimize the separation between the classes by lessening the impact on lower class locals. Shrimp farming and urban development negatively affect the locals through the destruction of mangroves, because the clearing of these forests results in the decline of traditionally harvested marine species. Positively, the government is already making shrimp farmers reforest part of the mangroves they destroyed and creating new protected areas. Additionally, non-profit organizations in the area are working to reforest abandoned ponds. However, since marine populations still seem to be declining in the area, greater protection is likely necessary. Since there are

laws in place to prevent shrimp farmers from destroying mangroves, but some destruction still occurs, the government needs to find a more effective method to ensure that shrimp farmers comply with regulations.

Furthermore, managers need to implement a monitoring program to determine the roles shrimp farming and urban development currently play in the decline in mangrove cover, so that officials can modify policies accordingly. Also, environmental impact assessments should be part of the management process, so that the local government can predict and address environmental and social implications before the construction of any future ponds (Landesman, 1994; Deb, 1998). Greater protection of the mangrove ecosystem can minimize traditional livelihood loss and marginalization of the classes. Furthermore, these methods could further reduce social conflicts within the area, because an increase in mangrove cover would reduce locals' need to harvest in forests near shrimp farms.

In addition to providing more mangrove protection, the government can minimize other environmental impacts of this industry as well. Some studies (Landesman, 1994; Primavera, 1997) have suggested that polyculture, or the farming of several species within the same pond, is a natural way to reduce shrimp waste and chemical discharge. However, some of the local shrimp farm owners stated that they tried to do polyculture with tilapia in this area and the method was not practical. According to these shrimp farmers, tilapia did not survive well in the climate and there was no market for the fish. Furthermore, shrimp farmers do not have incentive to practice polyculture, because they can sell shrimp for more money than many other organisms that they could farm within the same pond. Thus, in order for polyculture to be effective in this area, the government

could offer subsidies to farmers that practice polyculture and find organisms that survive within the ponds in this area. A possibility would be to perform polyculture with the black mangrove cockle, which is currently harvested by locals in the wild. Filter feeding organisms, such as cockles, can be grown with the shrimp to improve water quality (Landesman, 1994). Furthermore, there is already an existing market for the black mangrove cockle. However, more research on culturing this species is likely necessary before this type of polyculture can be implemented in the area.

Since practicing polyculture in this area currently has some limitations, the government could also consider encouraging shrimp farmers to reduce their waste through technological improvements. Currently, shrimp farmers do not treat their water before they discharge it into the estuary. As a result, the chemicals and waste are most likely having negative environmental and human health effects. In an attempt to minimize this issue, the government began offering tax incentives for the reduction in waste discharge (Holland, 1999). However, shrimp farmers claim that they do not make enough profit to implement the technology necessary to accomplish this task and, as stated, the banks are now hesitant to give loans to this industry. Thus, the government may have to offer loans with low interest rates, in addition to the tax incentive, to encourage shrimp farmers to buy the infrastructure necessary to treat their water.

In addition, the government should also carry out environmental testing of the waterways to ensure that shrimp farmers do not use banned chemicals. Furthermore, resource managers could implement a voluntarily monitoring program with the locals to ensure that pond effluents do not exceed levels beyond which the surrounding environment can absorb. A successful example is in southern Honduras, where a

monitoring program ensures the quality of the water discharged from the ponds in the area (Landesman, 1994).

To further minimize the environmental impact of the industry other changes to governmental policies may be necessary. To make current policies more manageable and enforcement more practical in rural areas, the government needs to enact new regulations integrating the concerns of the coastal communities and shrimp farmers (Primavera, 1997; Hernandez-Rodriguez et al., 2011). Officials should consult the community in this process, because the locals have knowledge about the ecological ecosystems that mariculture development affects and are often involved in the social conflicts. Furthermore, the mariculture industry is more likely to follow regulations if they are involved in the creation process. In St. Lucia, Columbia, laws were successful when officials decided to discuss their requirements with the community before implementation (Larsson et al., 2002). Thus, changes to the regulations can make them easier to enforce and reduce the overall impact of shrimp farming on the environment.

Finally, education programs can help alleviate the environmental and social impacts of this industry. Non-profit organizations and the government already perform environmental education programs in the area. As a result of these programs, the locals are becoming more environmentally conscious. According to the locals, this increase in environmental awareness has encouraged the government to create new laws and conservation areas to limit future mangrove destruction and to increase current cover. For instance, within the next three years, shrimp farmers are required to reforest 10% of the mangroves they destroyed for pond development. In addition, shrimp farmers have to pay taxes on ponds that were constructed in mangrove forests. To further protect the

coastal habitats, the government created a 5,000ha conservation area in Muisne, which is currently being reforested with the aid of the local non-profit organizations. Similarly, in Bunche and its neighboring town, Cabo San Francisco, the government placed a combined 2,700ha of mangroves under protection. Thus, increasing awareness through educational programs can initiate the creation of new environmental policies to minimize the environmental, as well as the associated social consequences, of the industry.

Due to the importance of education, in addition to continuing the existing programs, non-profit and government employees should teach locals that shrimp farming is not solely responsible for estuary contamination. Since urban pollution also contributes, educational programs can help locals recognize ways that they themselves add to the environmental damage. Since most locals within the community depend on the natural resources, these people will likely modify their own actions once they understand their contribution.

Furthermore, shrimp farmers could be educated about the impacts of their actions to encourage these individuals to follow current environmental regulations (Landesman, 1994). By educating both the shrimp farmers and locals, the tension surrounding this industry would hopefully be reduced. Thus, in addition to lessening the anthropogenic impact on the environment, these programs can minimize social conflicts as well. With more educational programs and modifications to current shrimp farming regulations, the negatives of the shrimp farming industry likely could be mitigated. Addressing the issues with this industry is necessary before shrimp farming can significantly improve the livelihoods of the local communities of Muisne and Bunche and become more sustainable in rural villages.

Since the conclusions of this study were limited by the fact that the environmental impact of the shrimp farming industry are solely based upon local perception, future research would need to address some of the environmental issues through scientific monitoring. Environmental testing of the estuary is necessary to determine the role that shrimp farming plays in polluting this body of water. Through water testing, the actual chemicals shrimp farmers use could be predicted and steps could be taken to better regulate the industry in order to minimize human health issues. Furthermore, the local government needs to analyze the effect of these chemicals on the ecosystem to determine if the natural environment can absorb the waste load discharged from the shrimp farms.

In addition to testing the water, future research on the populations of marine species traditionally harvested by the locals is necessary to determine the impact pond discharge has on these organisms. The role the industry plays in reducing these populations in comparison to that of urban development is important, because the government needs this information in order to make regulations more specific. Furthermore, the impact of these contributors on marine organism populations is necessary to consider when making catch and size limits to prevent overharvesting. Through this future research, resource managers can further understand the overall environmental impact of this industry and can better mitigate social issues.

## END NOTES

1. The remaining individuals (5) that worked within the shrimp farm industry had the following occupations; marine biologist, shrimp farm technician, boat driver specifically for shrimp farmers, farm-raised shrimp vendor, and shrimp processor.

2. Besides shop owners, the occupations of respondents within this group are as follows; restaurant owners, bar/nightclub owners, boat drivers, homemakers, agricultural farmers, students, construction workers, taxi drivers, business employees, secretaries, tourism guides, and firemen. In addition, some of the participants within this group were retired or unemployed.

3. Non-profit and government employees were only included in the total percentages, and not the subgroup calculations, due to the limited number of respondents.

# APPENDIX 1: LIST OF INTERVIEW AND SURVEY QUESTIONS

## Interview Questions

### Mariculture owners and employees

*Techniques-Owners and Managers*

1) How do you construct the ponds?
2) What species of shrimp do you use? Are they wild or hatchery raised shrimp?
3) Do you grow other animals in the ponds or just shrimp? (i.e. polyculture)
4) How long is the culture period? How many harvests do you perform each year? What methods do you use to harvest?
5) What is the average density of shrimp in the ponds? Roughly how much shrimp is produced by each pond?
6) What do you feed the shrimp? Where do you get this product?
7) Where do you get the water for the ponds? (i.e. ground water, rivers, lakes)
8) How much water do you replace in the ponds daily? Do you reuse the water?
9) Do you treat the water before filling or emptying the ponds?
10) Do you remove bottom sediment after you drain ponds? If so, where do you dispose of this sediment/sledge? Do you use a chemical or substance to neutralize it?

11) Do you have problems with disease? If so, how do you handle these issues? (pesticides, other chemicals) Specifically, have you changed any shrimp farming techniques since the arrival of White Spot Syndrome Virus (WSSV)?

*Shrimp Farm Employees-Owners*

12) What type of people do you hire? (locals, people from your hometown, etc?) How many managers and harvesters do you hire?

13) How much do you pay your managers and harvesters?

*Personal-Owners*

14) When did you start shrimp farming? Why did you start? How did you learn?

15) What did you do before you got involved in shrimp farming?

16) Is your shrimp farm profitable for you?

*Personal-Managers and Pond Harvesters*

17) Do you enjoy your job?

18) Do you earn more at this job than in past occupations? What did you do before you started working on shrimp farms? How long have you been working on shrimp farms?

**Interview questions for marine harvesters and other locals**

1) Have you noticed a decrease in water quality?

2) Do you think that shrimp mariculture waste affects your health?

*Marine harvesters only*

3) How many cockles, fish, and/or crabs do you collect in a day? How long does it take to gather this amount?

4) Have you noticed a decline in marine species populations? Are you catching less? Does it take longer to catch a certain amount?
5) Are you allowed to harvest in mangrove forests near shrimp farms?

**Non-Profit Organization Employees (Jatun Sacha and FUNDECOL), Government Officials**

*Before mariculture*

1) What was the community like before shrimp mariculture? What was people's main source of income? Were there agriculture farms or ranches in the area?

*Start of mariculture*

2) Who funded the development of shrimp mariculture in this area? (i.e. government or private investors)
3) Did locals or marine harvesters protest mariculture development or support it? Did their livelihoods change?
4) Did the unemployment rate increase, decrease, or stay the same after the development of mariculture? What other jobs are available in the area besides those provided by mariculture?

*Shrimp Mariculture Employees*

5) How much do owners pay mangers and pond harvesters? How does this compare to the pay from other jobs in the area? (i.e. marine harvesters)
6) What is the general education level of owners? Of mangers? Of pond harvesters?

*Environmental Effects of Shrimp Mariculture*

7) Has there been a decrease in water quality?
8) Has mariculture caused any human health issues in the area?

9) Have there been population declines of marine organisms?

10) Is mangrove cover increasing, stable, decreasing?

11) Are there any environmental benefits of mariculture?

*Recommendations*

12) Have you provided suggestions to the owners or managers to make mariculture practices more sustainable?

13) Have you implemented any environmental education programs?

**Likert-Scale Survey for all locals**

**1-Strongly disagree 2-disagree 3-neutal 4-agree 5-strongly agree**

Shrimp mariculture benefits the community (i.e. Muisne, Bunche).

1 2 3 4 5

Shrimp mariculture positively affects your livelihood.

1 2 3 4 5

Shrimp maricuture negatively effects the environment.

1 2 3 4 5

Shrimp mariculture causes social conflicts within the community.

1 2 3 4 5

The benefits of shrimp mariculture outweigh its problems within the community.

1 2 3 4 5

APPENDIX 2: SUMMARY OF SURVEY STATISTICAL ANALYSIS

Table 5

Statistical Analysis Results of Survey Responses Grouped Based on Age

| | Null Hypothesis | Test | Sig. | Decision |
|---|---|---|---|---|
| 1 | The distribution of Question_1 is the same across categories of Age_Group. | Independent-Samples Mann-Whitney U Test | .492 | Retain the null hypothesis. |
| 2 | The distribution of Question_2 is the same across categories of Age_Group. | Independent-Samples Mann-Whitney U Test | .619 | Retain the null hypothesis. |
| 3 | The distribution of Question_3 is the same across categories of Age_Group. | Independent-Samples Mann-Whitney U Test | .314 | Retain the null hypothesis. |
| 4 | The distribution of Question_4 is the same across categories of Age_Group. | Independent-Samples Mann-Whitney U Test | .943 | Retain the null hypothesis. |

1. Significance level, $\alpha=0.05$

Table 6

Statistical Analysis Results of Binomial Responses Grouped Based on Age

| | Null Hypothesis | Test | Sig. | Decision |
|---|---|---|---|---|
| 1 | The distribution of Binom_Resp_1 is the same across categories of Age_Group. | Independent-Samples Mann-Whitney U Test | .290 | Retain the null hypothesis. |
| 2 | The distribution of Binom_Resp_2 is the same across categories of Age_Group. | Independent-Samples Mann-Whitney U Test | .440 | Retain the null hypothesis. |
| 3 | The distribution of Binom_Resp_3 is the same across categories of Age_Group. | Independent-Samples Mann-Whitney U Test | .867 | Retain the null hypothesis. |
| 4 | The distribution of Binom_Resp_4 is the same across categories of Age_Group. | Independent-Samples Mann-Whitney U Test | .909 | Retain the null hypothesis. |

1. Original sample responses (i.e., strongly disagree, disagree, neutral, agree, and strongly agree) were grouped into either agree and disagree, while the neutral responses were not included, for all binomial analyses.
2. Significance level, $\alpha=0.05$

Table 7

Statistical Analysis Results of Survey Responses Grouped Based on Gender

| | Null Hypothesis | Test | Sig. | Decision |
|---|---|---|---|---|
| 1 | The distribution of Question_1 is the same across categories of Gender. | Independent-Samples Mann-Whitney U Test | .008 | Reject the null hypothesis. |
| 2 | The distribution of Question_2 is the same across categories of Gender. | Independent-Samples Mann-Whitney U Test | .020 | Reject the null hypothesis. |
| 3 | The distribution of Question_3 is the same across categories of Gender. | Independent-Samples Mann-Whitney U Test | .005 | Reject the null hypothesis. |
| 4 | The distribution of Question_4 is the same across categories of Gender. | Independent-Samples Mann-Whitney U Test | .648 | Retain the null hypothesis. |

1. Significance level, α=0.05

Table 8

Statistical Analysis Results of Binomial Responses Grouped Based on Gender

| | Null Hypothesis | Test | Sig. | Decision |
|---|---|---|---|---|
| 1 | The distribution of Binom_Resp_1 is the same across categories of Gender. | Independent-Samples Mann-Whitney U Test | .012 | Reject the null hypothesis. |
| 2 | The distribution of Binom_Resp_2 is the same across categories of Gender. | Independent-Samples Mann-Whitney U Test | .004 | Reject the null hypothesis. |
| 3 | The distribution of Binom_Resp_3 is the same across categories of Gender. | Independent-Samples Mann-Whitney U Test | .003 | Reject the null hypothesis. |
| 4 | The distribution of Binom_Resp_4 is the same across categories of Gender. | Independent-Samples Mann-Whitney U Test | .622 | Retain the null hypothesis. |

1. Significance level, $\alpha=0.05$

Table 9

Statistical Analysis Results of Survey Responses Grouped Based on Main Job

| | Null Hypothesis | Test | Sig. | Decision |
|---|---|---|---|---|
| 1 | The medians of Question_1 are the same across categories of Main_Job. | Independent-Samples Median Test | .000 | Reject the null hypothesis. |
| 2 | The distribution of Question_1 is the same across categories of Main_Job. | Independent-Samples Kruskal-Wallis Test | .000 | Reject the null hypothesis. |
| 3 | The distribution of Question_1 is the same across categories of Main_Job. | Independent-Samples Jonckheere-Terpstra Test for Ordered Alternatives | .000 | Reject the null hypothesis. |
| 4 | The medians of Question_2 are the same across categories of Main_Job. | Independent-Samples Median Test | .000 | Reject the null hypothesis. |
| 5 | The distribution of Question_2 is the same across categories of Main_Job. | Independent-Samples Kruskal-Wallis Test | .000 | Reject the null hypothesis. |
| 6 | The distribution of Question_2 is the same across categories of Main_Job. | Independent-Samples Jonckheere-Terpstra Test for Ordered Alternatives | .000 | Reject the null hypothesis. |
| 7 | The medians of Question_3 are the same across categories of Main_Job. | Independent-Samples Median Test | .017 | Reject the null hypothesis. |
| 8 | The distribution of Question_3 is the same across categories of Main_Job. | Independent-Samples Kruskal-Wallis Test | .000 | Reject the null hypothesis. |
| 9 | The distribution of Question_3 is the same across categories of Main_Job. | Independent-Samples Jonckheere-Terpstra Test for Ordered Alternatives | .000 | Reject the null hypothesis. |
| 10 | The medians of Question_4 are the same across categories of Main_Job. | Independent-Samples Median Test | .814 | Retain the null hypothesis. |
| 11 | The distribution of Question_4 is the same across categories of Main_Job. | Independent-Samples Kruskal-Wallis Test | .152 | Retain the null hypothesis. |
| 12 | The distribution of Question_4 is the same across categories of Main_Job. | Independent-Samples Jonckheere-Terpstra Test for Ordered Alternatives | .120 | Retain the null hypothesis. |

1. Significance level, $\alpha=0.05$

Table 10

Statistical Analysis Results of Binomial Responses Grouped Based on Main Job

| | Null Hypothesis | Test | Sig. | Decision |
|---|---|---|---|---|
| 1 | The distribution of Binom_Resp_1 is the same across categories of Main_Job. | Independent-Samples Kruskal-Wallis Test | .000 | Reject the null hypothesis. |
| 2 | The distribution of Binom_Resp_1 is the same across categories of Main_Job. | Independent-Samples Jonckheere-Terpstra Test for Ordered Alternatives | .000 | Reject the null hypothesis. |
| 3 | The distribution of Binom_Resp_2 is the same across categories of Main_Job. | Independent-Samples Kruskal-Wallis Test | .000 | Reject the null hypothesis. |
| 4 | The distribution of Binom_Resp_2 is the same across categories of Main_Job. | Independent-Samples Jonckheere-Terpstra Test for Ordered Alternatives | .000 | Reject the null hypothesis. |
| 5 | The distribution of Binom_Resp_3 is the same across categories of Main_Job. | Independent-Samples Kruskal-Wallis Test | .000 | Reject the null hypothesis. |
| 6 | The distribution of Binom_Resp_3 is the same across categories of Main_Job. | Independent-Samples Jonckheere-Terpstra Test for Ordered Alternatives | .000 | Reject the null hypothesis. |
| 7 | The distribution of Binom_Resp_4 is the same across categories of Main_Job. | Independent-Samples Kruskal-Wallis Test | .153 | Retain the null hypothesis. |
| 8 | The distribution of Binom_Resp_4 is the same across categories of Main_Job. | Independent-Samples Jonckheere-Terpstra Test for Ordered Alternatives | .185 | Retain the null hypothesis. |

1. Significance level, $\alpha=0.05$

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THE SOCIAL AND ENVIRONMENTAL EFFECTS OF SHRIMP MARICULTURE: CASE STUDIES OF TWO COASTAL VILLAGES IN ECUADOR

by

Mary C. Crider

This thesis was prepared under the direction of the candidate's dissertation advisor, Dr. Maria Fadiman, Department of Geosciences, and has been approved by the members of her supervisory committee. It was submitted to the faculty of the Charles E. Schmidt College of Science and was accepted in partial fulfillment of the requirements for the degree of Master of Science.

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