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RESTORING AND SUSTAINING SMALLHOLDER *Kappaphycus alvarezii* FARMING POST-TYPHOON HAIYAN/YOLANDA IN MOLOCABOC, CENTRAL PHILIPPINES

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RESTORING AND SUSTAINING SMALLHOLDER *Kappaphycus alvarezii* FARMING POST-TYPHOON HAIYAN/YOLANDA IN MOLOCABOC, CENTRAL PHILIPPINES

By

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Abstract

The farming of marine seaweed has the potential to provide both nutritional and financial resources to developing communities such as the Molocaboc Islands in the Philippines. To foster this mariculture development approximately $1,000 USD in grant funds received from the US-Philippines Society was used to purchase materials needed to replace seaweed production infrastructure lost to Typhoon Haiyan (known as Super Typhoon Yolanda in the Philippines). The goal was to restore and expand smallholder farming of the seaweed *Kappaphycus alvarezii* (locally known as '*guso'* in the Visayan dialect) in the Molocaboc Islands, thereby increasing harvest yields as compared to those obtained before the typhoon. Although monthly post-typhoon yields were nearly doubled at first (~800 kg pre- vs. 1,900 kg post-typhoon), they dropped precipitously approximately 6 months in to the project due to numerous factors and have yet to recover. By contrasting the yields from our project with those of other similar small-scale farming operations elsewhere in the Philippines and the greater Southeast Asian region, potential inferences can be drawn as to whether continued small-scale investments in this livelihood are wise and/or sustainable.

Chapter 1: Peace Corps Service in Sagay Leading Up to Typhoon Yolanda

Kappaphycus alvarezii (formerly *Eucheuma cottonii*) along with other species of algae colloquially known as seaweeds have been farmed in the Philippines and the surrounding Southeast Asian region since the so-called "blue revolution" in the 1960s (Neushul and Badash 1999), and the provincial island of Negros is no exception. It has widely been considered a viable supplemental or even primary livelihood for fisherfolk in coastal areas where household incomes average around $2 USD per day, and over the decades a somewhat lucrative industry has developed in the region. However, the inherently exposed nature of this form of open water mariculture to increasingly severe typhoons and sea surface temperature rises (Emanuel 2005) as well as recent developments forecasting a narrowing of markets in the United States (Charles 2016) could jeopardize the future of smallholder seaweed farming and subsequently the families of those who have come to depend on the industry.

As a student in the Peace Corps Master's International program of Michigan Technological University, I was assigned as a Coastal Resource Management volunteer (Fig 1.1) in the Philippines (Fig 2.1) at the Environment and Natural Resources Office of Sagay City (SCENRO) in Sagay City, Negros Occidental. My counterparts in the Social Development Section of SCENRO and I were responsible for overseeing sustainable alternative livelihoods such as seaweed farming, as well as managing related environmental conservation and solid waste management efforts in the Sagay Marine Reserve (Fig. 2.2), an approximately 32,000 ha reserve nearly the size of the adjacent land area of the municipality (33,034 ha).

Soon after arrival, I was asked by my supervisor to try to improve the state of alternative livelihoods for Sagay's fisherfolk as well as to implement Information, Education and Communication campaigns (IECs). These IECs were primarily aimed at discouraging illegal fishing methods such as dynamite fishing and compressor diving as well as educating the public on the importance of protecting their natural resources. Though my ultimate assignment was to be the offshore islets of Molocaboc, during my first year I worked in all of Sagay's coastal *barangay* (similar to a county designation here in the US, Sagay City is composed of 25 *barangay*, 6 of which are coastal). The majority of my first year of service was spent on the islet of Suyac assisting with various efforts including aiding with the establishment of a mangrove "eco-park" by helping to train local fisherfolk to work as tour guides to potential visitors, as well as working with the youth of Suyac who were organized as the "Jr. Eco-patrol" and helped advocate for proper waste management and sustainable fishing practices. This was intended to serve as an ideal training ground to prepare me for tackling the more numerous and challenging problems facing the nearby archipelago of Molocaboc, where I intended to focus on education and alternative skills training to reduce illegal fishing methods. Planning for these endeavors was put on hold however in the aftermath of Typhoon Yolanda (known internationally as Haiyan; for the purposes of this paper, we will exclusively use the Filipino storm name of Yolanda), as restoring the livelihoods of Sagay's fisherfolk became our primary focus during my second and third years as a volunteer.

Figure 1.1 The author (front row, far left) alongside some of the local fisherfolk and researchers from the Southeast Asian Fisheries Development Council (SEAFDEC) participating with livelihood projects at the '*bantay dagat*' guard house in Molocaboc Daku.
Photo by R. J. Castel, used with permission.

On November 8th, 2013, super typhoon Yolanda devastated the Visayan region of the Philippines, causing not only major loss of life but also of livelihood (Fig 1.2). Sagay and the nearby cities of Escalante and Cadiz took the brunt of the effects of typhoon Yolanda on Negros Island, and this was especially true for the offshore island *barangay* of Molocaboc. According to a rapid assessment done December 3rd 2013, less than one month after typhoon Yolanda swept through the region, 447 (42%) of Molocaboc's 1,067 houses were "totally damaged" (meaning damaged to the point of being unlivable) and 560 (52%) were "partially damaged". The report also notes a 40% inflation of local nipa (a type of palm used to make roofing) and bamboo prices since the storm, which made the task of rebuilding increasingly difficult for the impoverished community (Humanitarian Response 2013).

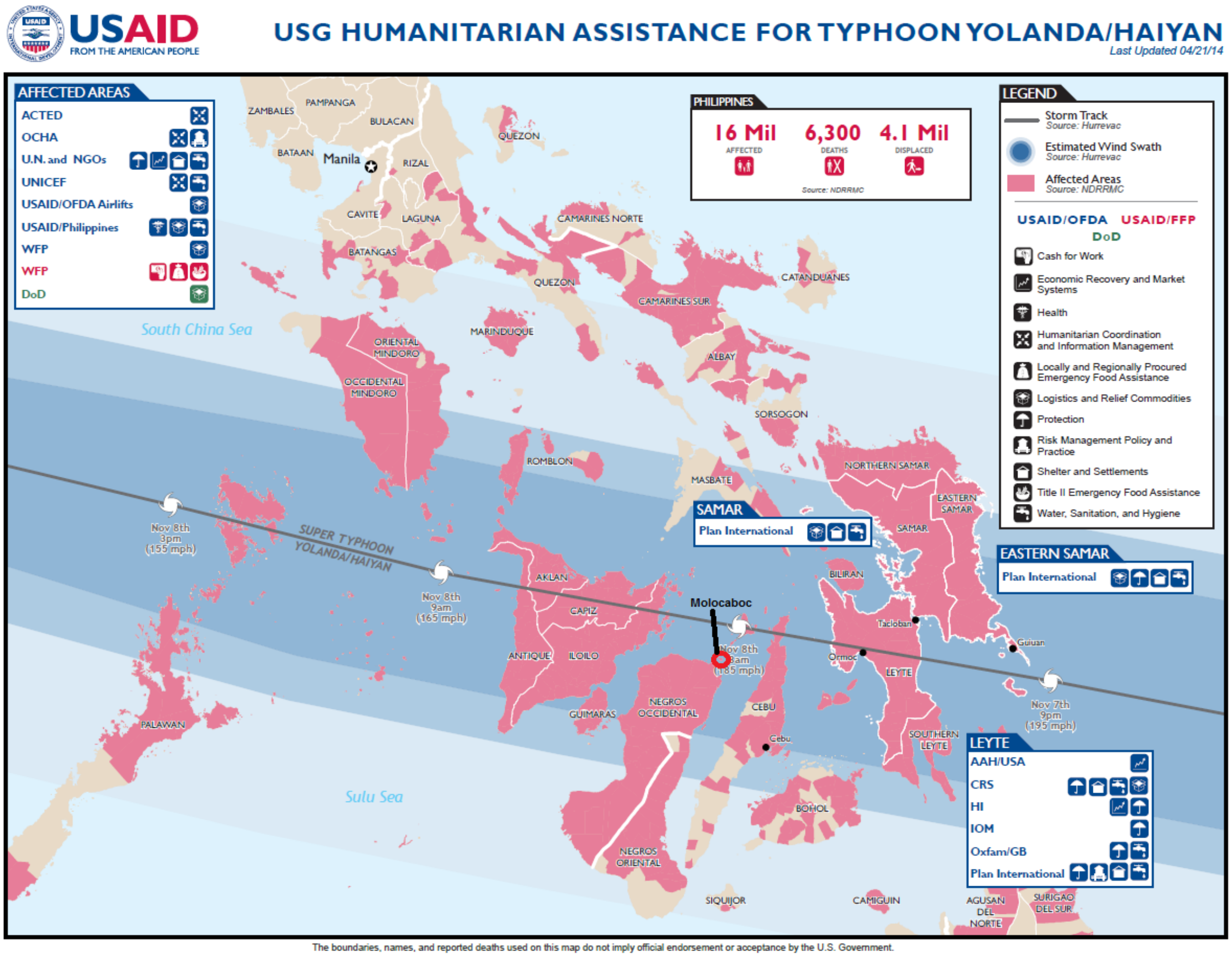

Figure 1.2 Map of super typhoon Yolanda/Haiyan's path through the Visayas Region of the Philippines and its relation to the Molocaboc Islands as well as statistics and regional relief efforts related to the typhoon.
Base map from the public domain of the U.S. Agency for International Development (USAID). Adapted by D. Fenlon.

Though remarkably no deaths were reported in Sagay City as a direct result of the typhoon, the coastal *barangay* and offshore islands were hit with winds gusting over 300 km/hr (~200 mph) and a pseudo-tidal wave effect known as storm surge that leveled homes and washed away nearly all the boats and fishing infrastructure in the area. Our initial efforts in the wake of the storm involved dispersing relief goods to those hardest hit in the form of canned food and rice, but it quickly became apparent that this was a "band-aid" solution; livelihoods needed to be restored in order for families to generate income and, especially for the region's fisherfolk, direct sustenance. This meant that our office's top priority would become replacing the 200+ small fishing vessels and ferries lost to the storm surge.

Once we deemed that the need for boats was being attended to, my primary counterpart Maria Lyn Lacson hosted a *pulong-pulong* (a town hall-style meeting) with residents and community leaders in Molocaboc to determine the next best course of action. After repeatedly hearing calls for the need for infrastructure and materials to help revitalize the ailing seaweed farming industry, we decided to apply for a grant from the US-Philippines Society.

Chapter 2: Geography, Climate and Seaweed Farming History of the Region

2.1 Geography and Climate of the Philippines

Figure 2.1 Location of the Philippines within the Southeast Asian region (shown in brown).
Map retrieved from the public domain of the U.S. Central Intelligence Agency. Modified by D. Fenlon.

The Philippines is an archipelagic country located off the southeast coast of Asia composed of 7,107 islands, 11 of which are significantly larger than the rest and make up 95% of the total land area. The nearest island nations are Taiwan to the northwest and Borneo (Malaysia) to the south (Fig 2.1). The country is surrounded by three main bodies of water: the South China Sea to the west and north; the Pacific Ocean to the east; and the Celebes Sea and the coastal waters of Borneo to the South. The total land area of the archipelago is 299,404 km^2, or approximately 30 million ha (slightly larger than the US state of Nevada) and spans 1,839 km north-to-south between the latitudes 4° and 21° north and longitudes 116° and 127° east (Moog 2006).

The climate of the Philippines is tropical with a mean annual temperature of 27 °C, and alternates between wet and dry seasons. The hottest months of the year are April, May and June when average temperatures range between 27.8 and 28.4 °C, while the coldest months are December, January and February with average temperatures of 26.1 to as low as 25.5 °C (Moog 2006). The country is divided into four climatic types based on annual rainfall patterns (Figure 2.2).

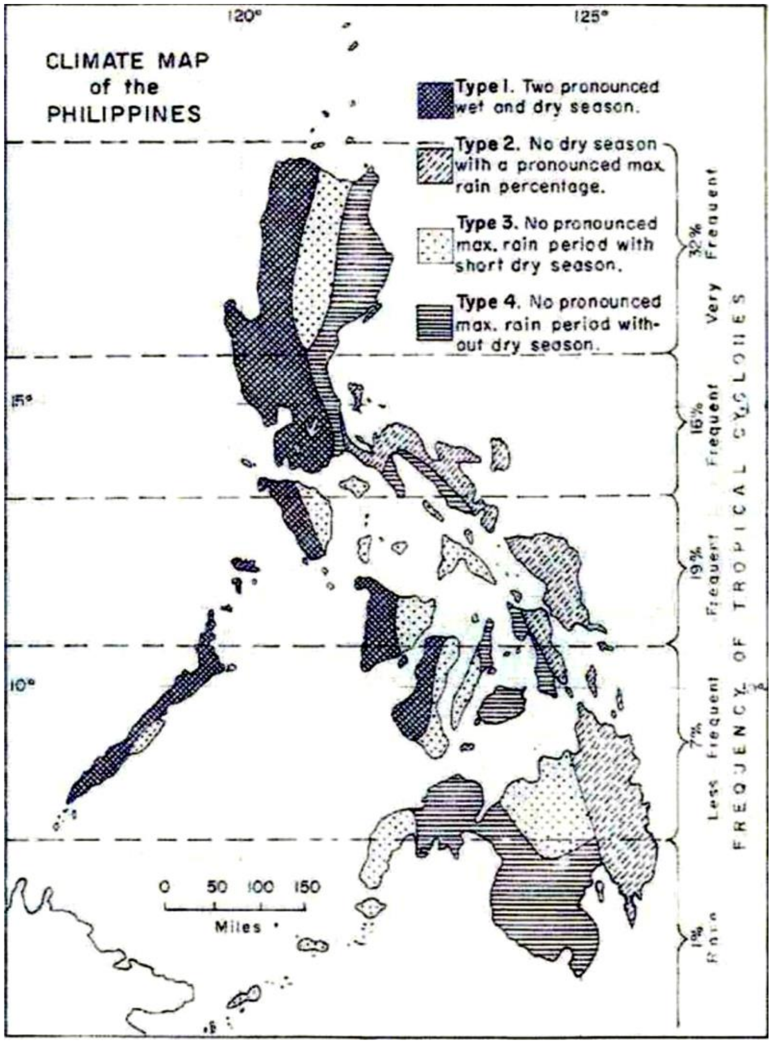

Figure 2.2 Climate map of the Philippines showing the four recognized climate types and zones of typhoon frequency.
Adapted from Moog 2006. Modified by D. Fenlon. © 2006 by FAO.

Given the archipelago's location in the Northwest pacific basin, the Philippines regularly experience numerous typhoons each year, about 18-21 on average (Valderrama et al. 2013). These storms can strike any time of the year, but are more frequent during the southwest monsoon season from June to October (Moog 2006). Due to the nature and usual direction of the prevailing winds, different regions of the Philippines are more likely to be directly affected by typhoons that make landfall (Fig 2.2).

2.2 Description of *Barangay* Molocaboc, Sagay

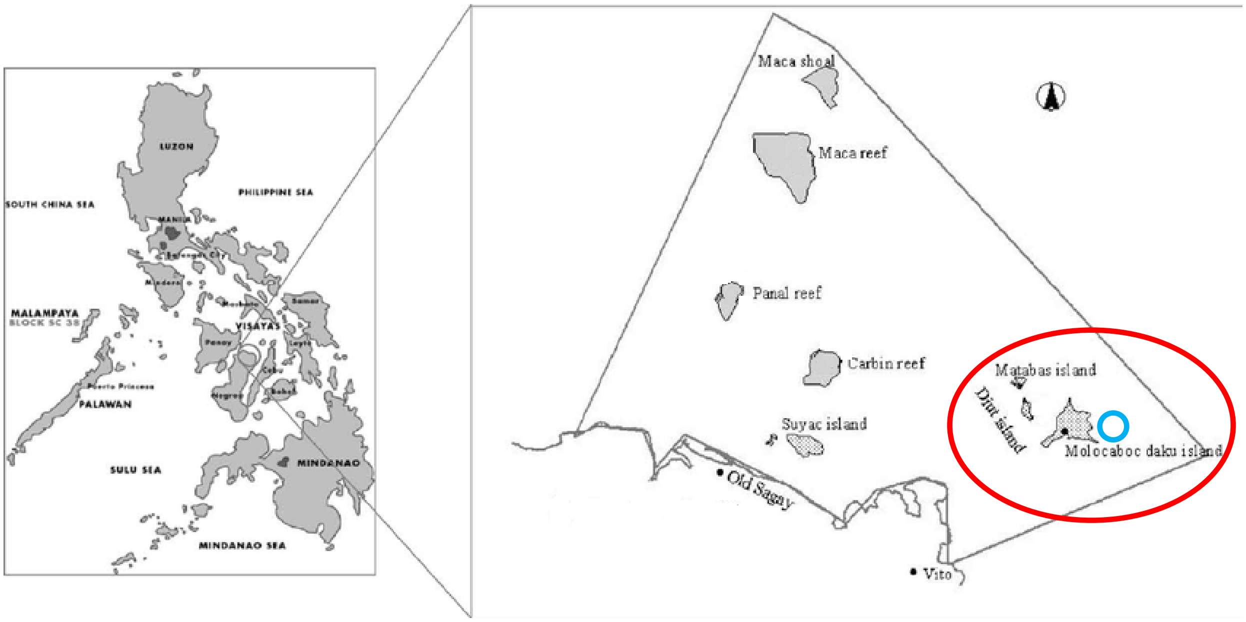

Figure 2.3 Map showing location of Sagay Marine Reserve in relation to the country as a whole and a magnified view showing the boundary of the reserve, the location of islets and reefs within it, as well as the locations of Old Sagay and Vito ports. *Barangay* Molocaboc is circled in red, and the approximate location of the seaweed farming project is circled in blue.
Base map from Maliao et. al. 2004. Modified by D. Fenlon. © 2004 by Fisheries Research.

Molocaboc is Sagay City's only island *barangay* and is home to more than 5,000 residents, most of whom are fisherfolk that rely directly on the sea for their livelihood. Situated 7 kilometers from the northeast coast of Negros Island, Molocaboc faces the open Visayan sea on all other sides save the southwest which faces mainland Sagay (Fig 2.3). The archipelago of Molocaboc lies wholly within the Sagay marine reserve and consists of three islets; Molocaboc Daku, [Molocaboc] Diut and Matabas. The islets are connected by a narrow concrete footpath that is submerged at high tide but passable during low tide (Fig 2.4). Many of the islands residents must commute daily to the nearby "mainland" for work and/or schooling, a task frequently made difficult by inclement weather.

Fig 2.4 The very shallow gradient of the beach face in the Molocaboc Islands makes it impossible for medium to large boats to reach or travel between the islands during low tide. Residents instead use concrete footwalks such as the one pictured (which connects the 'bantay dagat' guard tower approximately 1.5 km to Molocaboc Daku) to load and unload boats and walk the remainder of the way to shore. The footwalks are inundated during high tide, and can be treacherous when still damp shortly after the tide has receded due to algal growth.
Photo by D. Fenlon.

With the exception of denuded Matabas islet, all the populated islets have sizeable mangrove forests and all three islets are surrounded by fringing coral reefs and seagrass beds. Because the islets are within the Sagay Marine Reserve, explicit regulations restrict the types of fishing methods and gears permitted; enforcement is overseen by the '*bantay dagat'*, similar to a local-level Coast Guard. Though commercial fishing is banned within the reserve, encroachment from larger fishing vessels, both foreign and domestic, is a persistent problem in the area. Illegal fishing methods such as dynamite fishing and compressor diving are also still prevalent in the area, the latter of which is actually not currently enforced within the reserve due to a perhaps well-intentioned but ultimately self-hindering effort on behalf of the local government to attempt to phase out the practice gradually rather than prosecute fisherfolk.

2.3 History and Economics of Seaweed Farming

While commercial marine farming or “mariculture” of seaweeds in Asia began in the 1960s, they have been harvested from the wild in the Philippines and elsewhere for millennia (Neushul & Badash 1998). Although some varieties such as *Pyropia* (in Japanese ‘nori’, used among other things as a wrap for sushi) are prepared for direct human consumption, the vast majority of red seaweeds (Rhodophyceae) are processed to extract hydrocolloids such as agar and carrageenan. The latter has proven to be highly useful to industries in myriad food and household products for its’ thickening, gelling and stabilizing properties (McHugh 2003, Valderrama 2012). Through the work of Professor Maxwell Doty, who pioneered experiments with seaweed farming techniques in the Philippines, *Kappaphycus alvarezii* (formerly *Eucheuma alvarezii, E. cottonii*) quickly became recognized as one of the fastest growing and commercially viable strains (Neushul & Badash 1998).

Due to the livelihood’s relatively low requirements of capital and material inputs as well as the perceived viability for even relatively small-scale operations (Valderrama 2013), production of seaweeds in developing countries such as the Philippines has grown remarkably in the past few decades. The FMC Corporation, a major producer of refined carrageenan, estimates 5,000 tons of seaweed was harvested for carrageenan production in 1970 and that figure is currently up to more than 200,000 tons annually (Charles 2016). The U.N.'s Food and Agriculture Organization (FAO) recently reported global carrageenan use has increased more than five-fold from 2000 to 2010 alone, with *Kappaphycus* and *Eucheuma* production specifically increasing from 944,000 wet tons (48 percent of total red seaweed production) in 2000 to 5.6 million wet tons (63 percent) in 2010 (Villanueva et al. 2011).

This rapid increase in demand for raw dried seaweeds has caused an expansion and introduction of seaweed farming in numerous tropical nations throughout Asia, Africa and South America (Valderrama et al. 2015), though industries in the Philippines and neighboring Indonesia still dominate the market with a combined 94% of global output in 2009 (Villanueva et al. 2011). The Philippines had been the lead producer of eucheumoid seaweeds for the carrageenan industry since it quickly surpassed Canada in the early 1960's, but around 2007/2008 Indonesia displaced the Philippines to become the world's leading producer (Valderrama 2012, Hurtado et al. 2015). In 2009, production in Indonesia was estimated at 85,000 metric tons (dry) while the Philippines produced an estimated 61,000 metric tons. For comparison, in the same year Tanzania's production was estimated at 10,000 metric tons, mostly of the less marketable *E. denticulatum* (Valderrama 2012).

Chapter 3: Methods

3.1 US-Philippines Grant Details

My primary counterpart Maria Lyn Lacson and I applied for a livelihood restoration grant from the US-Philippines Society in the amount of $1,000 USD in May of 2015. The budget portion of the grant application (Fig 3.1) encompassed materials such as lumber, bamboo and monofilament nylon to construct the farming plots, as well as transportation fees and an initial purchase of propagules in order to begin the first cultivation cycle. It's important to note that the materials listed in the grant application were not intended to be sufficient on their own in terms of assembling a seaweed farming operation, rather the grant funds were meant to supplement existing materials and infrastructure salvaged after the storm. This included such items as assorted buoys or makeshift "floats", monofilament nylon lines and '*tie-ties*' used to attach propagules to cultivation lines, as well as assorted livelihood materials distributed by agencies such as the Bureau of Fisheries and Agricultural Resources (BFAR).

Funds were disbursed in June 2015 and we then began the process of allocating resources to 15 fishermen and their families. These participants were selected by Maria Lyn and Joeffrey "*Nong Palong*" Seronda, a local fisherfolk community leader and frequent participant in livelihood trainings and project management in Molocaboc Daku. The materials were sufficient for 10 new plots, some of which were co-managed by fishermen and their families, which brought the total area of the seaweed farming area near Molocaboc to an estimated 1 hectare.

Item Description	Budget Category	Unit Cost	Qty	Total Cost	Grant Amount Local	Grant Amount $US	Community Contribution Cash (Local/$US)	
Fisherfolk construction labor (per 15 person per day)	Labor	3750.00	7.00	26250.00	0.00	$0.00	26250.00	$596.05
Hauling of materials by truck (per trip)	Materials Transport	150.00	4.00	600.00	600.00	$13.62	0.00	$0.00
Hauling of materials by ferry (per trip)	Materials Transport	200.00	4.00	800.00	800.00	$18.17	0.00	$0.00
Nails (per kilo)	Materials/Supplies	80.00	1.00	80.00	80.00	$1.82	0.00	$0.00
Nipa roofing	Materials/Supplies	500.00	1.00	500.00	500.00	$11.35	0.00	$0.00
Concrete sack	Materials/Supplies	150.00	5.00	750.00	750.00	$17.03	0.00	$0.00
Lumber (2x3x14)	Materials/Supplies	588.00	2.00	1176.00	1176.00	$26.70	0.00	$0.00
Galvanized iron	Materials/Supplies	120.00	14.00	1680.00	1680.00	$38.15	0.00	$0.00
Lumber (2x3x8)	Materials/Supplies	336.00	6.00	2016.00	2016.00	$45.78	0.00	$0.00
Bamboo poles	Materials/Supplies	80.00	100.00	8000.00	8000.00	$181.65	0.00	$0.00
Nylon twine #14 (per bundle)	Materials/Supplies	1300.00	10.00	13000.00	13000.00	$295.19	0.00	$0.00
Seaweed seedlings (per kilo)	Materials/Supplies	20.00	750.00	15000.00	15000.00	$340.60	0.00	$0.00
Total					**43,602.00**	**$990.05**	**26,250.00**	**$596.05**

Fig 3.1 Section of the grant application showing proposed budget for Molocaboc seaweed livelihood restoration project, with local currency in Philippine pesos (PHP). Note that the "community contribution cash" value was estimated from anticipated unpaid labor (250 pesos per person per day) the participants would forego in setting up the project over 7 days. This estimate was given in order to meet the Peace Corps requirements of at least a 25% percent contribution "in-kind" from the community relative to the requested grant total; no cash contributions were taken from participant fisherfolk.

3.2 Farming Plot Setup

The farming plots were assembled in the fixed-off-bottom (FOB) style (Fig 3.2) in an offshore area East of Molocaboc Daku. The area chosen for the project by Joeffrey "*Nong Palong*" Seronda had historically been used for seaweed farming by local fisherfolk in Molocaboc, and was deemed an ideal location due to the presence of moderate ocean currents which circulate nutrients and are believed to help protect against outbreaks of '*ice-ice*'. At first mistakenly believed by fisherfolk and scientists alike to be a disease, '*ice-ice*' (so named for its slick texture and ice-like appearance, see Fig 5.1) is now widely considered to be a condition linked to stress. Symptoms of '*ice-ice*' begin with a slowing of seaweed growth followed by a greening and softening of the tissue. Dead spots will then form within the branches of the seaweed, causing fragmentation and severe loss of biomass. Bacteria and other pathogens can then invade the necrotic patches of tissue, further advancing the spread of the '*ice-ice*' (Collén et al. 1995).

Plots were constructed such that cultivation lines ran parallel to the aforementioned currents as much as possible, with lanes between plots so that fisherfolk could navigate small '*bangkas*' (a traditional type of boat resembling a shallow canoe with bamboo outriggers) throughout the farm when harvesting. Once "seedlings" (read "propagules", shown in Fig 3.6) we had ordered from the Bureau of Fisheries and Aquatic Resources (BFAR) arrived on site, they were then attached to cultivation lines with small ribbon plastic '*tie-ties*' (Fig 3.4) and the lines were assembled in floating grids offshore. Though plots were irregular in size, each consisted of 20-30 cultivation lines each approximately 15-20 meters long and spaced .5 meters apart (Fig 3.5). These dimensions led us to our approximation of 3 km total of cultivation lines and 1 hectare total for the area of farming plots combined.

In addition to the farming plots themselves, a simple storage shed was also constructed out of lumber and bamboo on Joeffrey "*Nong Palong*" Seronda's property (Fig 3.3) to store dried seaweeds in preparation for shipment to processing facilities in Cebu City. This was seen as an integral part of making the project sustainable, since buyers were reportedly not interested in small, infrequent shipments, instead preferring bulk shipments to maximize profit and minimize overhead costs. This required that the harvested algae be stored properly to maximize quality and ensure the highest possible farm-gate prices.

Due to numerous delays in construction and inclement weather conditions, the project took around three months to complete and was not finalized until September 2015. Unfortunately, this was around the same time that I finished my Peace Corps service and I subsequently returned to the United States soon after. Though I personally was unable to be present for the harvests, monthly yields were recorded by the BFAR beginning in October 2015, whose data were then relayed to me via my counterpart.

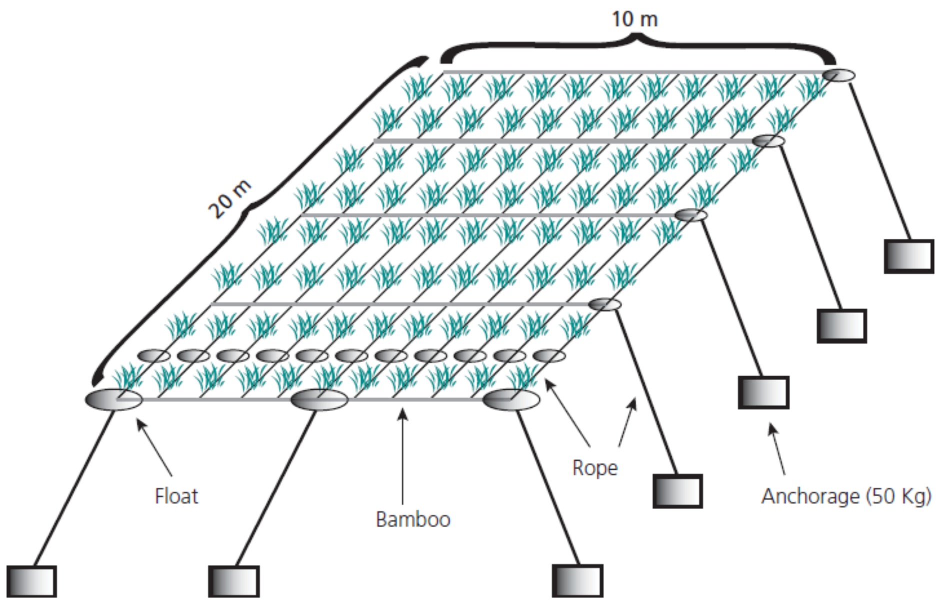

Figure 3.2 Diagram showing typical fixed-off-bottom (FOB) plot setup for farming seaweed. The farming plots used in Molocaboc are largely identical to the diagram aside from the sample dimensions given and the use of polypropylene ropes rather than bamboo (although bamboo is occasionally used) with parallel monofilament nylon lines to which seaweed cuttings are tied. Floats are typically chunks of Styrofoam or capped plastic bottles, and improvised anchors range from cinderblocks to rocks.

Modified from Robledo et al. (2013). © 2013 by Aquaculture Economics & Management.

3.3 Photo Documentation of Project

Figure 3.3 Construction of drying shed.
Photo by: D. Fenlon.

Figure 3.4 Maria Lyn and Joeffrey "*Nong Palong*" Seronda inspect cultivation lines.
Photo by D. Fenlon.

Figure 3.5 Maria Lyn inspecting lines on one of the new project plots.
Photo by D. Fenlon.

Figure 3.6 Close up of *K. alvarezii* seaweed propagules showing morphology.
Photo by D. Fenlon.

Chapter 4: Results

4.1 Molocaboc Project Yields

Prior to typhoon Yolanda, seaweed farmers in Molocaboc reportedly harvested an estimated 800 kilos of fresh (~80 kilos dried) *K. alvarezii* per month. The exact number of plots that were being maintained leading up to the storm is unclear; however anecdotal evidence suggests that the total area was significantly less than one hectare. After cultivation began in September, harvests were completed approximately every 6 weeks and fresh (wet) yield was recorded monthly by the BFAR. Using our predetermined values for total farming area (1 hectare) and total cultivation line length (3 km), yields were converted to industry standard units for comparison with other similar scaled projects as follows.

Table 4.1 Monthly and average *Kappaphycus alvarezii* yield amounts and corresponding extrapolated annual rates. Dried yields are given in metric tons and production rates in kilograms per meter of cultivation line per year.
*Dried yield values based on an estimated 87.5% loss of mass during the drying process (roughly 8 kg wet seaweed yields 1 kg when dried for 3 days (Wakibia et al 2011)), as reported data were in fresh (wet) mass values.

Month/Year	Fresh (Wet) Yield (kg)	Dried Yield per Hectare* (t/ha)	Extrapolated Production Rate* (kg/m/yr)
10/15	1,900	0.238	0.950
11/15	1,755	0.219	0.878
12/15	1,800	0.225	0.900
1/16	800	0.100	0.400
2/16	1,200	0.150	0.600
3/16	1,500	0.188	0.750
4/16	50	0.006	0.025
5/16	50	0.006	0.025
6/16	157	0.020	0.079
7/16	150	0.019	0.075
8/16	189	0.024	0.095
9/16	250	0.031	0.125
Total/Avg.	**9,801 Total**	**1.224 Total**	**0.409 Avg.**

4.2 Comparison of Yields to Similar Scaled Projects

As is immediately apparent when looking at the data as a whole, our project has thus far averaged a much lower yield per hectare when compared to other seaweed farming endeavors, which (although highly varied depending on conditions and setup types) can harvest as much as 20 tons of dried *K. alvarezii* per hectare annually through optimal commercial farming methods (Doty et. al. 1975). Considering the relatively tiny scale and investment size of our project however, it may be more useful for our purposes here to compare our project's data to that of other small-scale projects within the Philippines (Figs 4.1, 4.2).

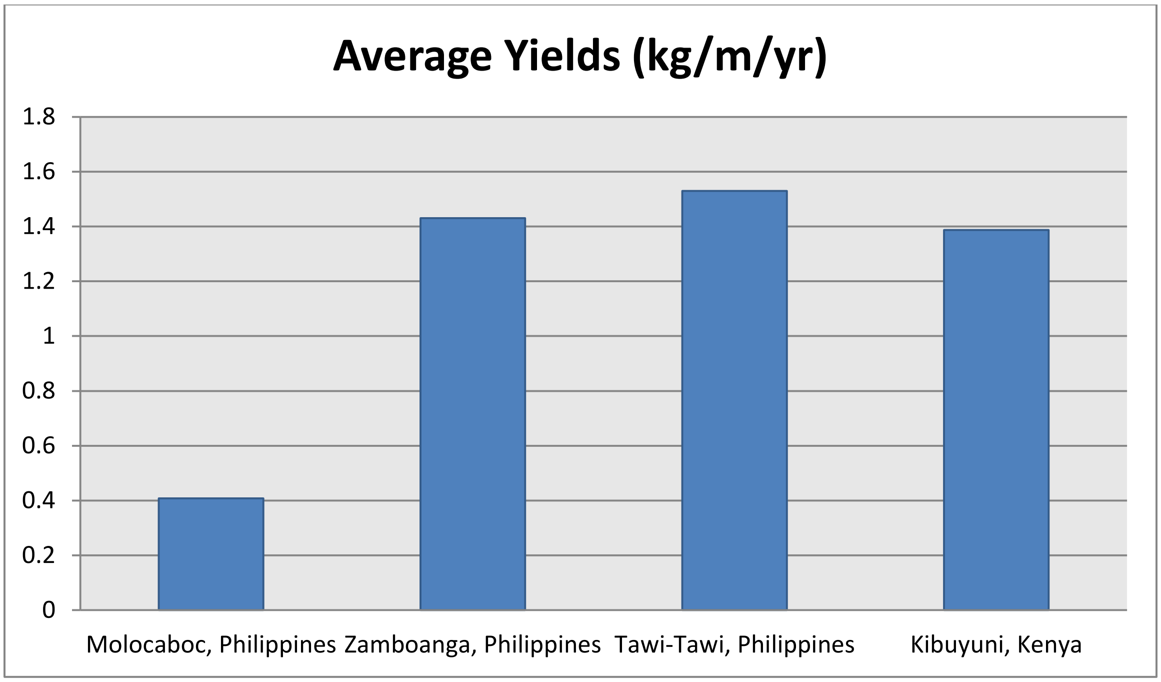

Figure 4.1 Comparison of annual yield of Molocaboc project site to other sites in the Philippines and Kenya (Valderrama 2012, Valderrama et al. 2013, Wakibia et al. 2011, sequentially). Standard productivity units are in kilograms per meter of cultivation line per year.

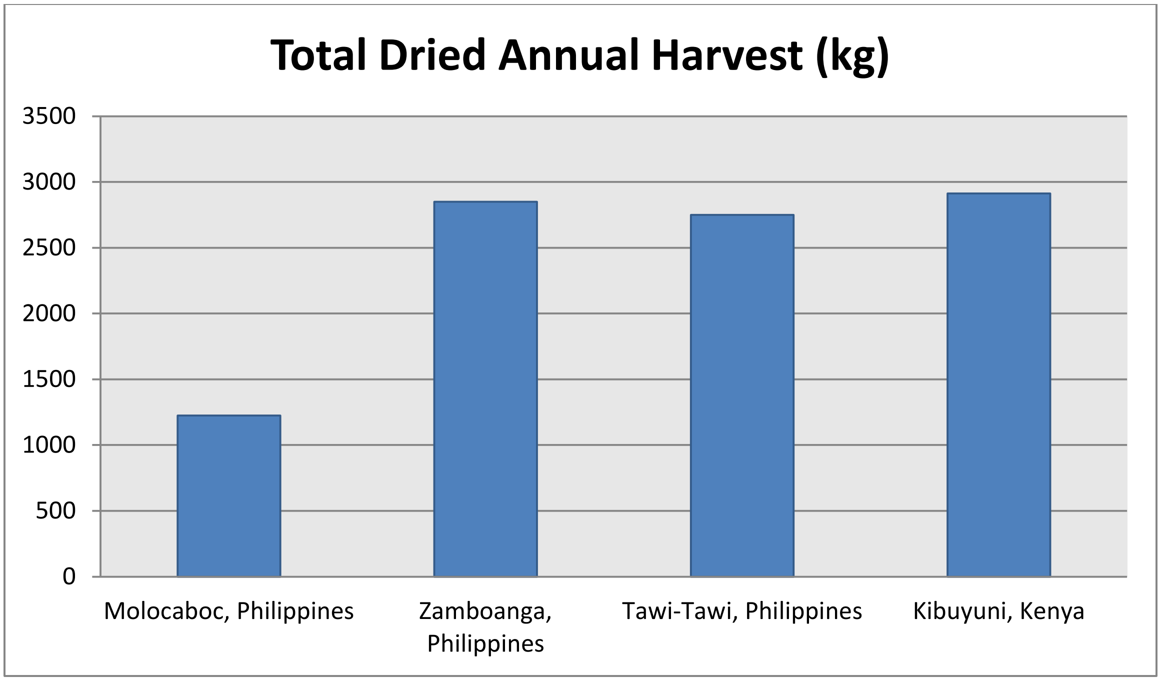

Figure 4.2 Comparison of total annual production at Molocaboc project site to other sites in the Philippines and Kenya (Valderrama 2012, Valderrama et al. 2013, Wakibia et al. 2011, sequentially). Units are in kilograms per farm site.

One such recent project in Zamboanga City (south Philippines, Mindanao region) was cited in a global review of seaweed farming by D. Valderrama (2012), and entailed a Multiple Raft Long Line (MRLL) setup which covered about 500 m^2 and consisted of around 2 km of lines total (approximately two-thirds of the total cultivation lines in Molocaboc). The project reported yields of 1.43 kg/m/yr (as compared to our 0.327 kg/m/yr overall) and a total annual production of 2,850 kg (as compared to our 980 kg). It should be noted here that the MRLL strategy chosen to be highlighted by Valderrama is a relatively novel and innovative design which should have been expected to generate yields superior to our more simple traditional floating line setup, and yet underperformed according to the author (Valderrama 2012).

The following year, an expansive paper by Valderrama et al. (2013) discussed data on smallholder farms from six different case study countries; India, Indonesia, Mexico, the Philippines, Solomon Islands, and the United Republic of Tanzania. The section on the Philippines was authored by A. Q. Hurtado, and covered six farms throughout the central and southern Philippines. One farm site in particular, designated “Farm 4” in the paper and located in Tawi-Tawi, a province in the extreme southwest of the Philippines, was similar in size to that found in Molocaboc and utilized a variety of *K. alvarezii* known as ‘tambalang’. The farm’s hanging long-line (HLL) plot setup contained 1.8 kilometers of cultivation lines and was found to produce 1.53 metric tons per kilometer of line with 2,750 dry kilograms total yield over five harvests.

Another example of a similar case study comes from Wakibia et al at two coastal sites in southern Kenya. The study is part of an ongoing experiment by the authors to see if small-scale eucheumoid farming is viable in the region. *K. alvarezii* and *E. denticulatum* cuttings used for this study were brought from Zanzibar, which had originally sourced stock from the province of Bohol in the Philippines. Though the study only covers a 6 week period, the authors extrapolated to calculate projected annual productivity for each location (in t/ha/yr). For the purposes of our comparison in this paper, total meters of growing lines were calculated from the described methods to be 2,100 m per 0.1 ha plot (420 lines per plot each 5m long). The projected productivity value was then converted accordingly to match units (kg/m/yr). Among other facets of the study, two different locations were chosen to contrast environmental impacts on yields. Since the study site described in Kibuyuni more closely matches the reef flat conditions present in the Molocaboc project site, the yield data from this site was chosen to be included here (Wakibia et al. 2011).

It should be mentioned here that, as is often the problem with case studies, comparisons such as those in Figures 5.2 and 5.3, while useful in the general sense of contrasting Molocaboc's farming project with those of similarly-scaled farms, should be taken with a grain of salt. As Hurtado et al. (2015) explained in regards to the case studies described in Valderrama et al. (2013), variation in productivity between different seaweed mariculture systems studied in the Philippines "do not demonstrate any particular distinctive patterns". This is true whether one is comparing average yields per meter of cultivation line per year or total yield per hectare, and can be attributed to the inherent variation of a wide range of factors affecting in-situ mariculture such as sea surface temperatures, salinity, water quality and ocean currents to name a few (Hurtado et al. 2015).

Chapter 5: Discussion

According to the harvest data, initial farming of *K. alvarezii* post-project implementation increased yields more than two-fold compared to pre-typhoon Yolanda levels (1,900 kg and 800 kg respectively), but dropped sharply after only 6 months starting in April 2016. This roughly ten-fold decrease corresponds with the persistence of unfavorable weather conditions which reportedly have forced fisherfolk in Molocaboc to remove most of their farming lines from the water, not only for fear of loss of infrastructure due to rough waves and currents, but also to possibly sustaining losses due to '*ice-ice*' (Fig 5.1). During a return visit to the site in late September 2016, I was informed that many of the lines had been pulled out of the water for some time due to a breakout of '*ice-ice'* which had been compounded by inclement weather conditions. Fortunately, nearly all of the lines are reportedly still intact with minimal losses to the project's infrastructure since its inception. As of December 2016, only one family has reportedly been maintaining their plot in order to keep a stock of "seedling" propagules for a re-expansion when more favorable conditions return.

Fig 5.1 Close-up view of '*ice-ice'* on *E. cottonii* (*K. alvarezii*).
Adapted from Arisandi et al. 2013. © 2013 Indonesian Journal of Marine Sciences.

Aside from the obvious implications of adverse weather conditions on our results, another possible culprit for lower than average yields may be competition from other algae (Fig 5.2) and overgrazing (e.g. from rabbitfish species such as *Siganus canaliculatus*), both of which were noted in abundance on repeated visits to the site. Improvement in the maintenance of lines to prevent buildup of wild competitors as well as perimeter netting to limit loss to grazers could improve yields; however the latter would require additional infrastructure funding and could cause unintended consequences by accidentally entangling animals such as sea turtles and seahorses.

Figure 5.2 Unmaintained cultivation line at low tide showing excessive buildup of wild brown and green algal growth crowding out *K. alvarezii* propagules.
Photo by D. Fenlon.

Volatility of farm-gate prices (price of seaweed paid by initial buyer to farmers) also appears to be threatening the sustainability of seaweed farming in the area. During my return visit to the site in September 2016, local fisherfolk reported that prices for dried '*guso'* had recently dropped suddenly, which motivated many farmers to forego drying and storing their harvests and instead to sell fresh (wet) seaweed at market for around 35 pesos (~$0.70 USD) per kilo. This price can be compared to the "seaweed bubble" of 2008, when prices in nearby Indonesia rose from around $0.50 USD per kg to as much as $1.80 USD per kg for dried *K. alvarezii* (Valderrama 2012).

Further compounding this fragility is the speculation surrounding the recent proposal to ban carrageenan from the national list of approved substances used in the production of organic food by the National Organic Standards Board (NOSB), a 15-member citizen advisory committee of the U.S. Department of Agriculture (USDA) (Charles 2016). The move to delist the seaweed extract seems to have begun with the findings of Tobacman (2001), which found correlations of relatively high doses of carrageenan (specifically degraded forms of carrageenan) with intestinal inflammation in rats. These findings, though widely disputed by the scientific community, were spread online by health food bloggers touting the perceived health benefits of eliminating carrageenan from one's diet (Bixler 2017). This combined with heavy lobbying from organizations such as The Cornucopia Institute brought the NOSB to a vote on November 17th 2016, which resulted in a majority decision to remove carrageenan from the national list. The USDA now has until November 2018 to decide whether to follow through with the NOSB's recommendation in a final ruling (Siegner 2016). The ruling of the NOSB is expected to be approved by the USDA despite a lack of consensus in the scientific community (with studies such as McKim et al. (2016) reporting negative correlations with cytotoxicity in human intestinal cell lines) as well as continued support for the use of carrageenan in food products from organizations such as the U.S. Food and Drug Administration (FDA), the European Commission and the World Health Organization (WHO) (Charles 2016).

Chapter 6: Conclusion

While our initial yields attained in the first months of the project seemed to support the widely held notion that small-scale seaweed farming through modest grant amounts is still feasible in the Philippines post-Yolanda, the dramatic decrease in yields once faced with unfavorable weather conditions does not bode well for the long term sustainability of the local industry. Inevitable future low pressure systems and typhoons or a sudden decrease in farm-gate prices could jeopardize this ultimately somewhat fragile alternative livelihood. This would perhaps come as little surprise to many Filipinos; large tropical storms and the destruction they can wreak are practically enmeshed in the way of life in the Philippines. It behooves future development workers to consider the inevitability of such conditions, as areas prone to winds from typhoons could see repeated loss of infrastructure, which would likely require further subsidization from either the Philippine government, NGOs or organizations such as Peace Corps. Perhaps it would be wise to invest grant funds in other aspects and sectors of development work, at least in areas usually prone to direct typhoon landfall such as open Pacific-facing Samar and Leyte, or even areas such as Molocaboc which are exposed to relatively large inland seas.

Furthermore, though its exact impacts are difficult to predict in advance, the USDA delisting of carrageenan from the national list of organic substances will certainly reduce industry demand for raw materials coming from seaweed production countries such as the Philippines. Furthermore, it would set a clear precedent for the continued stigmatization of using carrageenan in the broader spectrum of non-organic products that currently utilize the hydrocolloid, possibly causing a chain reaction of companies substituting other similar compounds in its' place. The effects of such a sudden drop in demand for and subsequently price of seaweeds in the Philippines and elsewhere in Southeast Asia would be immediately felt in small fishing communities such as those in Sagay where seaweed farming has been, to varying degrees, a viable alternative income for decades. Unless fisherfolk are able to adapt and find other means of supplementing their incomes from subsistence fishing, an already tenuous daily existence will become all the more challenging for them.

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