'OURSMARTING THE TUNA': *PAMARILIS,* TECHNOLOGICAL INNOVATION AND LOCAL KNOWLEDGE IN THE DAVAO GULF

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Pamarilis is deep-sea hook-and-line fishing that aims to catch tuna or *barilis*. Tuna fishers from Governor Generoso, Davao Oriental recount that tuna have learned to identify and evade their fishing lines, resulting to declining fish catch. They consider tuna to be intelligent and sentient beings capable of evading their fish gears and techniques. Thus they find it necessary to apply technological innovations on fishing gear and seek to enhance and expand their understanding of the tuna behavior. This paper examines how technological innovations for catching tuna have been adopted. Key findings show that the knowledge of the tuna fishers has developed through long experience. Sharing of fishing experiences among tuna fishers resulted to the proliferation of technological innovations. Fishers' observations on the changing behavior of tuna, together with its high market value and the social interactions between fishers are key factors for technological innovation. The data were gathered through key-informant interviews, participant observation, and audio-visual recordings.

Keywords: *Technology, ethnoecology, tuna fishing, innovations, tuna*

Introduction

In Governor Generoso, Davao Oriental, the small-scale tuna fishers think that the fish have learned to identify their handlines and evade them, resulting to their declining tuna catch. Consequently, fishers create innovations to outsmart the fish. This observation echoes an earlier study also in the Davao Gulf, where it was found that fishers attributed the decline in yield to the agency of fish, their increasing evasiveness, and "smartness" (Mangahas 2003). In her study, Mangahas stated that fishers

consider themselves to be engaged in a "knowledge race" with the fish. Pitting human ingenuity against increasingly elusive resources, the fishers' constantly figure out how to keep abreast, or ahead, of the fish by a strategy of constant innovation in technology. In this paper I examine data from fishers of Governor Generoso and explore the factors behind the adoption of innovations in gear and techniques among small-scale tuna fishers.

It has been noted that the study of technology tends to focus mostly on its impact and needs to pay more attention to the reasons *why* technological innovation happens (Acheson 1981:295). Some would question the term's utility in anthropological discourse (Pfaffenberger 1988). If technology is defined as 'any tool or technique, any product or process, any physical equipment or method of doing or making, by which human capacity is extended' (Schon 1967), the approach is more focused on material and technique. Whereas technology should be conceived of as a 'total social phenomenon' that marries the material, the social and the symbolic in a complex web of associations (Pfaffenberger 1988). Pfaffenberger adds, techniques and artifacts are secondary to the social coordination of labor in shaping human adaptation. The sociotechnical system (STS) concept of Pfaffenberger (1992), refers to distinctive technological activity that stems from the linkage of techniques and material culture to the social coordination of labor that constitutes a human population's adaptation to its environment.

Thus, my objective in this paper is to examine the relationship between technology and society. What comprises a small-scale tuna fishing operation includes description of the fishing vessel, crew organization of tuna fishers and allocation of income shares, as well as patterns of interaction between fishers. While discussing the components of each fishing gear I show how both techniques and the material culture prevalent among tuna fishers *and* social factors are considered in the adoption and rejection of a technology. All these together with perception or understanding of the behavior of tuna species are factors in the adoption of innovations of their fishing gears and methods.

The fisherfolk of Governor Generoso, Davao Oriental. The Municipality of Governor Generoso extends to the sea in the Davao Gulf on the west, while the east side encroaches on the mountains of Davao Oriental (Figure 1). Fishing is the primary source of income of the people living in the coastal communities. Different ethno-linguistic groups are distributed all over the municipality, but the "*Bisaya"* comprise the largest segment of

the population. Intermarriages between migrants and local folk have resulted to a heterogeneity of lineages presently living in the municipality.

Small-scale tuna fishing is widely practiced in three locations that we have visited[1]. I have noticed a common practice when the fisher unloads his catch from the boat—the neighbors, usually men, gather around and inspect his catch. Sometimes they help the fisher transport his catch to his house. Later, after the fisher has weighed most of the catch, a portion thereof is divided equally among the neighbors who have helped the fisher. Each of these individuals usually receive three to five pieces of fish. The sharing seems natural among the fisherfolk; no matter how small the catch is, they still manage to share a portion with the community. As I observe this social practice, I have come to realize that sharing plays an important role in maintaining social cohesion. This eventually translates to a sense of social responsibility wherein the neighbors ultimately feel the need to reciprocate such acts of kindness. Possibly, this may also translate to sharing and reciprocity behavior between fishers.

Ethnographic research. Data for this study come from semi-structured interviews, participant observation, and audio/video recordings. Ten small-scale tuna fishers were interviewed. Eight of them were from Montserrat, one was from Nangan and one from Surop. These were the criteria for key informants: they must be tuna fishers who have a lineage of fishers in their families which means that tuna fishing has been passed on from their parents down to the present generation. Attention has also been paid to their fishing experience. Key informants have fished within Davao Gulf and as far as the fishing grounds of Indonesia. Included in this paper are two cases illustrating the experiences of two fishers and relating to the adoption and rejection of innovations in tuna fishing. Bad weather prevented me from being joining any actual tuna fishing activity. The strong *habagat* (southwest monsoon) wind made fishing trips almost impossible and my safety was a serious concern for my key informants, who considered that the big waves brought by the *habagat* might be absolutely unbearable for a non-fisher like me.

[1] Senior anthropology students of the University of the Philippines in Mindanao, as part of the summer field school 2015.

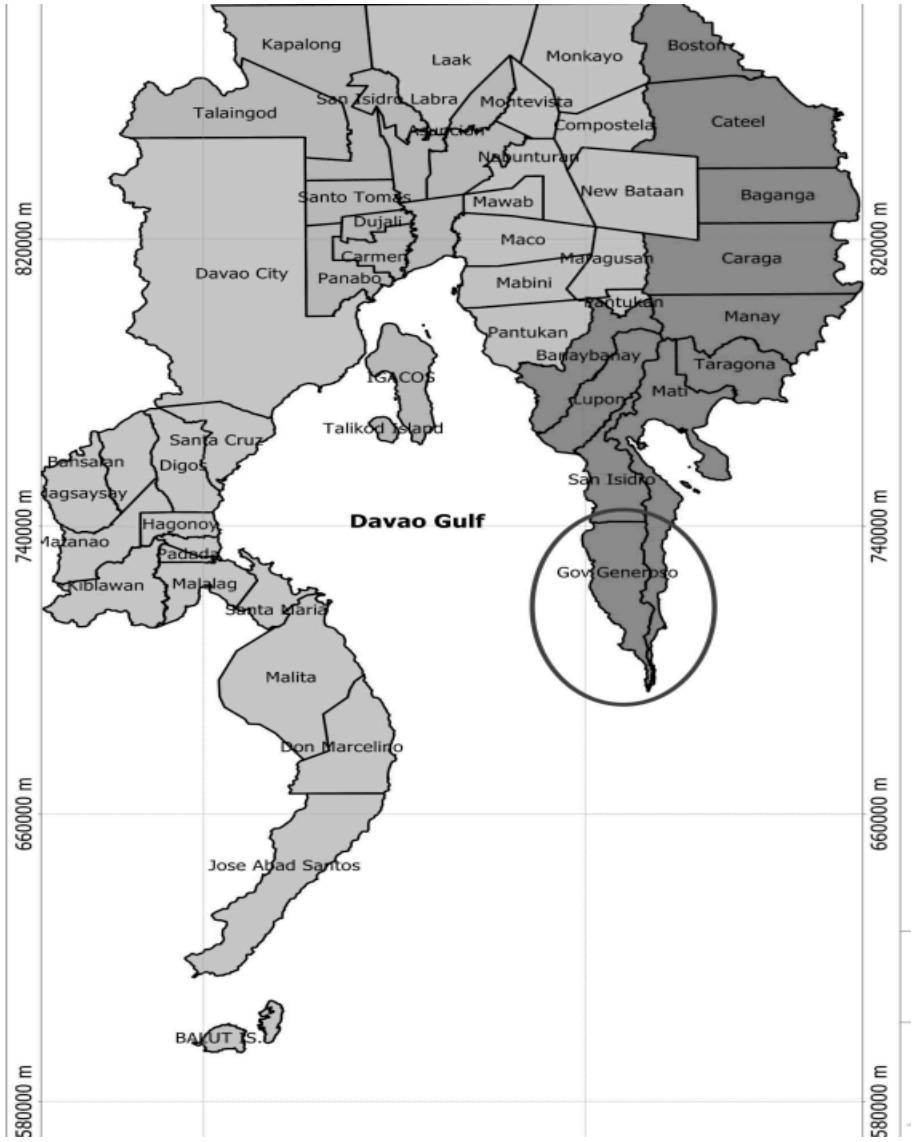

Figure 1. Map of Region 11 showing the Municipality of Governor Generoso. *[Source: MP-LGU of Governor Generoso]*.

Small-scale tuna fishing in the Davao Gulf

The target resource in *pamarilis* is tuna or *barilis (*esp. *Thunnus* and *Katsuwonus* species*)* using a hook-and-line. However, different techniques have also emerged. Municipal fisheries use a wider variety of fishing gears compared to commercial fisheries.[2] Although the fishers' target is to catch tuna, they may also attempt to catch small pelagic fish[3]. In the event that they are not able to catch some tuna, income from these other fish can compensate for the costs of the fishing trip.

Fishing Boats. The fishers use motorized boats with two outriggers. Said boats do not weigh more than three tons[4]. The boats measure from 12 feet to 18 feet in length. The engine size depends greatly on the boat size. A diesel engine with a range of 6-10 horsepower is commonly used depending on the size of the boat.

There are two types of fishing boats used in small-scale tuna fishing: the *banca* and the *lantang*. These boats differ in size, passenger capacity, and engine size.

Most *banca* are 12 feet in length and can carry up to nine people. A *banca* usually has a 6-horsepower engine. Some boat owners install two engines. The second engine usually serves as a backup, but some would use both engines to increase speed. The overall components of a *banca* cannot sustain stress from too many huge waves. This is why boat owners and fishers are dissuaded from going outside the Davao Gulf and would rather skip fishing whenever a storm rages.

A *lantang* has a capacity of 10-15 passengers and reaches a length of 18 feet. It requires at least a 10 horsepower engine. Compared to a *banca*, a *lantang* can withstand big waves and stay for more days at sea before going back to shore. At the time of fieldwork in 2015, a *banca* usually

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[2] Various fishing gears are employed to catch tuna. The use of purse seines, ringnets, and handlines accounts for over 80% of the annual tuna catch in the Philippines (Zaragoza et al. 2004a).

[3] Predominantly roundscads (*Decapterus* spp.*,* Carangidae), anchovies (*Stolephorus* spp., Clupidae), mackerels (*Rastrelliger* spp., Scombridae), round herrings (Clupidae), fusiliers (Caesionidae), bigeye scads (Carangidae), flying fishes (Exocoetidae), and halfbeaks (Hemiramphidae) (Zaragoza et al. 2004a).

[4] Otherwise, they are classified as commercial fishing vessels (Dickson & Natividad 1999:142). Commercial fishing vessels are not allowed to fish within municipal waters, 15 kilometers from the shore or less than seven fathoms deep (RA 8550, Article II, Sec 26).

cost around ₱20,000–₱50,000, while a *lantang* usually cost around ₱50,000–₱80,000. These costs already include the boat engines.

Basic supplies at sea. There are necessary supplies that the fishers need to bring during their trip to the sea. First they need to bring rice and drinking water. The amount of food they bring depends on the number of days they plan to stay at the sea. A two-man fishing crew needs ten kilograms of rice and 80 liters of water for a five-day fishing trip. The fishing boats are equipped with a charcoal stove (see Figure 4) where they can cook their food and boil water using.

Figure 2. Typical banca docked at Montserrat during low tide.

Figure 3. Typical *lantang* (larger hull than a banca).

A supply of ice is also important. Fishers bring iceboxes on the boat as storage for their fish. A two-day trip at the sea usually needs three blocks of regular sized ice or two *laton.* A *laton* is a metal container used in measurement. One *laton* holds one and a half blocks of ice. The ice sets a time limit on fishing. When most of the ice has melted, this means that the fishers need to hurry back to the shore to prevent spoilage and not incur loses. In one instance, the fishers sold their catch at sea. It was a good time for tuna fishing and they had already caught seven tunas on their first night. Each tuna weighed at least 30 kilos. But the ice [and the space in the storage ice boxes] they brought was not sufficient, some of the tuna were outside the iceboxes exposed to the wind and sea water. Aware that if they tried to reach shore, it would be too late to salvage the tuna, the fishers searched for other fishers in neighboring *payao*. Fortunately, there were fishers from Davao del Sur who happened to be in the area. They sold the tuna to them and immediately returned to the shore and delivered the rest of their catch.

Other basic provisions needed for a fishing trip include fuel, coffee, milk, sugar, and cigarettes. The cost of all these is called "*starting"* which is equivalent to the initial capital outlay for every fishing trip. The amount for *starting* ranges from ₱700 to ₱3,500. Some fishers go to financiers to provide them the *starting* and agree on an incomesharing scheme. Financiers are businessmen who provide the *starting* or capital. They are not directly involved in the fishing operation. While it is easy to get *starting* or capital, there exists, however, the risk of debt accumulation among many fishers. Debt management among small-scale tuna fishers is a common problem among the fishermen when dealing with their financiers. Sometimes a long-term relationship is developed between the fisher and the financier. Some are unhealthy relationships because they are only bound by the accumulating debts of the fishers.

Payao. Finding a good spot to fish is one of the first decision-problems for fishers. The presence of *payao* or fish aggregating devices has created good fishing places in areas of Davao Gulf. The *payao* attracts small pelagic fish, which are a staple part of a tuna's diet. Consequently, the tuna stay around the *payao* where their food prey gather. For the tuna fishers, a big group of small pelagic fish (*apong)* is an indicator of a high possibility of tuna presence. Tuna fishers do not spend time looking for a good spot to fish because they head straight for *payao*. If there is no sign of fish, they transfer to another *payao*.

The tuna fishers leave the shore either at dawn or early evening during high tide when fishers' boats are afloat, making it easier to navigate their way out. When they leave, they already have in mind which *payao* they are going to target. There are more than a hundred *payao* in Davao gulf. According to my informants, the *payao* are set up by municipal government and by some private fishing companies. The 'municipal *payao'* are actually owned by small-scale fisher cooperatives or associations. These *payao* are installed near or adjacent to their villages for easy monitoring and to provide safeguarding from illegal fishers (cf Dickson & Natividad 2000). There exists no formal agreement between the fishing companies and the small-scale fishers with regards to fishing in a company's *payao*, however small-scale fishers are 'allowed' to fish in *payao*. With only hook-and-line fishing gear, small-scale fishers are seen as not able to exhaust the fish aggregating in a *payao*. Fishing companies do not take any part of the small-scale fishers' catch. However, small-scale fishers may help in monitoring the *payao* and protecting the same from being destroyed for example by illegal fishers.

Crew organization and income sharing. A fishing trip is usually composed of a boat operator joined by 'accompanying fishers' called *pasahero* (literally 'passengers')[5]. The number of *pasahero* is at the discretion of the boat operator or boat owner. Usually, two to three *pasaheros* are taken [on a *lantang*]. *Banca* boat operators usually do not take any *pasahero* as they can easily manage the *banca* on their own.

When they reach the *payao*, each fisher prepares his gear and begins to fish. They take turns in cooking food and in cleaning the boat. However the boat operator has the added task of the maintenance and repair of the engine as well as of sailing the boat, which merit him added compensation in the allocation of income shares.

The income of each fisher depends on their catch. Interestingly, the income share depends on what type of fish is caught, and on who caught the fish, and. Table 1 below summarizes the income shares system of the *pamarilis* fishers.

The after the *starting* is deducted, the income is divided between the fishers and the financier. But sometimes financiers are at the same time the boat operators or boat owners. In such cases, the *starting* is not first

[5] [Editor's comment: this rhetoric formulates a different relationship between the boat operator/skipper and crewmembers. Not formally recognized as contracted labor necessary for a fishing expedition, the crew are instead characterized as freeriders being given the opportunity to catch their own fish.]

deducted from the gross income; they immediately proceed to the division of gross income.

Income shares are determined based on the type of fish caught by the fishers, and the one who caught the fish. If the boat operator catches a tuna, the income from the tuna will be split in half between him and the financier. *Pasahero* do not receive any part of the boat operator's catch. In case a *pasahero* catches a tuna, his share amounts to less than half of the income from his catch. One half of the total sale of the tuna caught by a *pasahero* goes to the financier. As for the other half, the *pasahero* gets 70% and the remainder 30% is divided between the boat operator and the financier. Income from other small pelagic fish is divided equally among the financier, boat operator, and the *pasahero* regardless of who caught the fish.

Table 1. Income shares allocation among small-scale tuna fishers of Governor Generoso, Davao Oriental.

Catch species	**Division of income**	
	Income from boat operator's catch	**Income from *pasahero*'s catch**
Tuna and other large pelagic fish	1/2 → boat operator 1/2 → financier	1/2 → pasahero (70%) boat operator & financier (30%) 1/2 → financier
Other small pelagic fish	Divided equally (among financier, boat owner and pasahero)	Divided equally (among financier, boat owner and pasahero)

The fishers consider the small pelagic fish as a lifesaver when there is no tuna catch. It will compensate for the initial cost or *starting*. During off-peak season in the time of *habagat* or southwest monsoon, however, their catch is sometimes not enough to cover for the *starting*. This commonly results to the accumulation of debts of the fisher to the financier.

"Bililhon kaayo ang barilis sa amoa"- ***the value of tuna.*** Tuna, or *barilis*, is a highly valuable commodity. Tuna as well as other tuna-like species, such as swordfish, marlin, and billfish, are migratory fishes capable of attaining large sizes.[6] Catching a single tuna can easily translate to a large amount of money. For the Governor Generoso fishers in 2015, such fishes had a sale value of at least ₱100 per kilogram and up to ₱400 per kilogram or even more depending on its meat quality as determined by the fish buyers.

Due to its high cash value, tuna has been a highly sought marine resource. Political fishing boundaries are oftentimes trespassed just to fish for tuna. According to Zaragoza et al. (2004b), the tuna fisheries became the largest and most valuable fisheries in the Philippines during the mid-1970s when *payao* (fish aggregating devices) were introduced.

Tuna is usually sold to a *comprador* or fish trader by the fishers. It is taken to other markets outside the municipality (one rarely finds fish peddlers in Governor Generoso selling tuna). Tuna from General Santos City and Davao City are distributed to markets in other parts of the country, particularly in Metro Manila, and a large portion to Hong Kong, Taiwan, and Japan (Dickson & Natividad 2000:154). In the 1980s, the Philippines became the number one producer of tuna in Southeast Asia. However the catch started declining in the late 1980s, and tuna fishers in the Philippines started to fish in international waters (Zaragoza et al. 2004b:38).

It has been reported that tuna catch in all locations I have visited (in 2015) has been very low. According to the fishers, yield in other types of fish has declined but the yield in tuna has declined far more by comparison. Fishers said that tuna catch had reached its lowest ever. Some fishers had not caught a single tuna for more than two months.

The fishers believe that tuna has not yet entered the gulf. Interestingly, some fishers also relate the dwindling tuna stock as the cause for the tuna to become 'smart'. "*Brayt na sila karon kay gamay na lang man sila." (*They have become smart because their number is decreasing.*)*

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[6] Zaragoza et al. (2004b) state that six of the 21 recorded tuna species in Philippine waters are caught in commercial quantity and form the basis of the tuna fishing industry. The Philippine fisheries catch statistics listed four species of tuna namely: yellowfin (*Thunnus albacares*), skipjack (*Katsuwonus pelamis*), eastern little tuna or *kawakawa* (*Euthynnus affinis*) and frigate tuna (*Auxis thazard*). An adult blue fin tuna weighs about 500kgs.

Decline in other types of fish is also observed, such as the small pelagic fish. This decline in yield is mainly attributed to the growing number of commercial boats fishing inside the Davao Gulf. According to the fishers, the commercial fishers have overfished their fishing grounds. Once their nets are dropped, all types and sizes of fish are harvested. There are not enough juvenile fish to replenish the fish stock.

The decline in the small pelagics is also linked to the decreasing tuna catch. Since the tuna's primary source of food has decreased, the fishers conjecture that tuna have migrated to other locations where their food supply is more abundant. Nevertheless, the fishers are hopeful that things will change for the better after the fishing ban[7] in Davao Gulf. They are expecting an abundant supply of fish and a chance to recuperate from the low yield experienced during the first two quarters of 2015.

The fishing operation. The fishers go out to sea at night. The fishers tie their boats to a *payao* (a fish aggregating device, discussed further below). While it is still dark, they drop squid jigs or a multiple handline to fish for bait. When they have caught enough bait, they prepare their tuna handlines.

In tuna fishing, the common method is to drop the handline into the water using a heavy stone. The baited hook is coiled around a stone weighing 1-3kgs. The stone acts as additional weight aside from the lead sinker. The handline is dropped near a *payao,* and when it reaches the depth where tuna regularly forage for food the line is suddenly jerked to release the dropstone and expose the baited hook.[8] The use of squid-ink, also known as *ata-ata,* is also a common technique among the Governor Generoso small-scale tuna fishers. In this technique, squid ink in a small plastic bag is placed together with the bait. Sometimes, sliced squid or fish meat is also added when coiling the line around the stone. These give off a distinct scent and serve as added attractants for the tuna. Tuna fishers observe the sea current before they drop their line. The current might carry the baited hook away from the foraging area of the tuna.

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[7] The Bureau of Fisheries and Aquatic Resources XI has been imposing a fishing ban inside Davao Gulf. For three months, commercial fishing is prohibited to operate. This fishing ban is aimed to conserve marine resources and to secure the spawning period of pelagic fishes.

[8] Tuna usually forage between the depths of 80-200 meters (Dickson & Natividad 2000). [Dickson & Natividad have also expressed concern over the possible negative effect of the sinking of stones on the fishing area in general (2000:154).]

When a tuna takes on the baited hook, the fisher allows it to swim away but maintains the line to be tight. This ensures that the hook will not detach from the tuna's mouth. According to my informants, an average tuna usually weighs about 30kgs. Some tuna weigh over 100 kgs. Thus landing them on the boat is far from an easy task. As fishers haul the fish manually, this can take hours. A very big tuna can weigh almost 200 kgs and is much more challenging. When the tuna is within arms' reach, they use a gaff hook, or *ganso,* to grab hold of it and then carefully stun the fish by hitting its head with a wooden bat, or *poras*. Accuracy must be observed in hitting the tuna to avoid damage to its body, which reduces the market value of the fish. The tuna is then stored in an icebox with crushed ice. The fishers continue to fish as long as their ice supply is sufficient.

Most of my informants have witnessed a tuna capture its prey. According to them, there are times that a tuna jumps out of the water in chasing a small fish. There are even times when tuna snatch bait straight from the *undak* line. Such experiences have taught the fishers about the feeding behavior of tuna. From long experience at sea and close encounters with the fish, fishers consider tuna as intelligent and sentient beings that think and learn. Below is a statement that one could often hear: *"Brayt na ang isda (tuna) karon."* [Fishes – tuna – are now 'bright'/intelligent].

One of my informants recalled that three to four decades ago, tuna were not evasive. They could easily be caught regardless of the type of bait used. Taking home at least two tunas per night was easy. Tuna fishing during those times was vibrant and economically efficient. However, over time, the fishers said, tuna have come to recognize the handlines used by the fishers. This is why the handlines have become less effective. Hence, it has become necessary for the tuna fishers to adopt technological innovations.

Customizing fishing gear— innovations in hooks, bait, and lures

Three sets of fishing gears are employed for *pamarilis* among the Governor Generoso fishers. One set is for catching squid, another set is for small pelagic fish, and the last set is for catching tuna. Each set has variations in the materials and design. Most parts of the gear are bought from a fishing shop but many fishers prefer to customize said parts by making their own design of stainless hooks and artificial baits, and which may also cut costs. The fishers believe that their customized fishing gear are more efficient. Fishers observe, for example, that the hooks do not

easily detach from the tuna's mouth due to an adjusted bend of the hook. Fishers also adjust and replace the colors of microfibers of artificial baits bought from fishing shops.

I have identified these examples of innovations, modifications or improvements in gear and techniques in fishing for tuna:

***Saranggat* or squid jig with flasher.** In catching squid, the fishers employ a squid jig or *saranggat* (see Figure 9). The traditional squid jig is made up of the following components: wooden spool, nylon monofilament twine as main line, lead (*Pb*) sinker, and 'hook' or prongs. A set of 10 to 12 prongs is attached to the end of a cylindrical lead sinker. The prongs are five centimeters long and the lead sinker is four inches in length with a diameter of 0.5 centimeter. This gear had been used with a submersible incandescent light. Like other marine species, squid is also attracted to light. When the light is submerged, the squid jig is dropped and it is jerked up and down. The squid is caught or hooked anywhere on its body.

According to my informants, in the mid-2000s fishers adopted an innovation for the squid jig of adding a waterproof flasher. They made the flasher component out of a 20 ml plastic syringe sealed with marine adhesive. A switch is embedded at the adhesive that can be activated by a push button. The flasher is attached about one meter from the sinker and prongs. It flashes either a bright blue or bright green light which excites the squid, making them swarm around the flashing light. With, this innovation catch increased and the use of an incandescent light in catching squid was eliminated.

***Undak* or multiple handline**. *Undak* is used to catch smaller-sized pelagic fish. It is made up of four components: plastic spool, nylon monofilament twine as main line, lead (*Pb*) sinker, and hooks. Each hook has a length of 20mm. A cylindrical lead sinker is attached to one end of the main line. When fishing, the sinker is dropped in the water and the main line follows along with the hooks. The fisher repeatedly jerks the main line and this continuous movement animates the artificial bait. Fishers believe that fish construe anything that moves and fits in their mouth as food. Using *undak*, it is common to catch five to ten fish in one hauling. At least 15 hooks to a maximum of 80 hooks are arranged along the main line with a distance of half a meter between each hook. Multicolored microfibers (silk threads) are attached to each hook. The microfiber lures are a couple of millimeters longer than the hook. The usual dominant colors used in artificial baits are bright orange and bright

green. According to fishers, these colors are observed to be attractive to small pelagic fish. A single strand of silver microfiber is added, which shines when illuminated by incandescent light.

***Pasol* or tuna hand line**. This is made up of at least five components: wooden spool, nylon monofilament twine, swivel, lead (*Pb*) sinker, and hook (see Figure 8). The target catch of *pasol* are tuna that weigh 100kgs or more. Hence, the diameter of the nylon monofilament twine and the hook of a *pasol* are definitely bigger than those of other fishing gears. The hook of a *pasol* is located at the end of the main line. Iron swivels are used to connect the main line and the sinker to prevent the main line from getting tangled should the tuna try to escape from the hook. Fishers use live bait for the *pasol*. The two types of fresh bait commonly used by fishers are squid and frigate tuna. The fishers have observed that tuna preys on these two species. The live bait will try to escape from the hook but it will be unable to free itself. Tuna rushes to the bait and quickly seizes it, then struggles to free its mouth from the hook. This struggle would last for hours depending on the size of the tuna.

Fishers much prefer circle hooks to J-hooks for *pasol*. The major difference between the two is the effort exerted to keep the fish on the line. J-hooks need to be jerked quickly after a tuna has taken the bait and the line has to be kept tight. With circle hooks, the effort exerted in keeping the tuna hooked is less than with J-hooks. Circle hooks are better at keeping a tuna on the line and have been observed to result in less tuna escapes. When the tuna takes the bait, the fisher waits for the circle hook to find it way to the jaw of the tuna since jerking it might result to losing the tuna. When the fish struggles, the circle hook locks tightly on the jaw of the tuna. It is then a matter of time before the tuna gets landed on the boat.

The efficiency of the J-hook is also attributed to the degree of experience of the fisher. A fisher has a high chance of losing the fish while using the J-hook if he cannot maintain the line tight for a long period of time. Once the line slackens, the tuna can use its strength to try to shake off the hook. Thus, experienced fishers suggest novice fishers use circle hooks to achieve their first catch.

***Selopin* or cellophane bait**. Transparent cellophane, or "*selopin*" as the locals call it, is cut into a diamond kite-shape with the two bottom sides longer than the upper sides. The length of the *selopin* is twice the length of the hook. The bottom part of the *selopin* is suspended in water. When the line is jerked, it creates a movement similar to a fish or squid.

The *selopin* may be used with the dropstone. Small slices of squid or fish meat are also included in the coiling of the hook around the stone. When the bait reaches a certain depth (around 80 fathoms), the line is jerked thereby exposing the *selopin* and scattering the slices of meat. The *selopin* creates a wiggling movement whenever it is jerked, and it is further animated by the sea current.

While most fishers prefer clear *selopin*, other colors may be used. Fishers liked using *selopin* because of its availability and because fresh bait is not necessary. However this innovation was not used for long. According to the tuna fishers, from around the early 1990s tuna seemed less attracted to the *selopin* and even ignored it. This prompted the fishers to go back to using the traditional hook and line with fresh bait.

***Limbag* or artificial metal lure**. This uses a metal plate or spoon attached to the hook. The hook may be either attached to one end of a spoon, or the shank of the hook is attached to the whole spoon. *Limbag* comes in different sizes. Although *limbag* is available commercially, most of my informants prefer to make their own. They customize the *limbag* according to the size of the hook. The efficiency of the customized *limbag* is based on its capability to attract the tuna and its hooking accuracy, which means the hook does not easily detach from the tuna's mouth.

***Subid* or artificial squid bait.** This artificial lure uses multicolored microfibers (threads) which can be procured at hardware or fishing stores. The length of the microfibers is longer than the hook thereby partially hiding the latter. One variation is the addition of a lead (*Pb*) sinker at the eye of the hook. The sinker is shaped like a bullet. Sometimes they attach artificial eyes to the sinker. The whole combination of materials effectively resembles a squid. When jerked, the microfibers simulate the moving tentacles of a squid. The tuna preys on the *subid* and tries to swim away with it. The hook, however, pierces through the tuna's mouth or jaw as the fisher tightens the line.

***Ata-ata* or *Shabu-shabu*, cuttlefish ink as lure**. In the year 2000, tuna fishers started using "*ata-ata*". *Ata* is a *Bisaya* term, which means 'squid ink'. Squid ink (preferably cuttlefish ink), is prepared and placed in small plastic bags. The plastic bag is placed at the tip of the barb together with the fresh bait. A small pin made of a sharpened piece of plastic is also attached thereto to act as a puncture. When the hook and ink are dropped, the pin is then detached to release the squid ink out of the plastic bag. The cloud of squid ink effectively lures the tuna.

Special attention is given to the squid ink when fishers discuss this innovation. Cuttlefish ink is considered by fishers as ideal due to its longer shelf life. A 500ml bottle (usually a *Tanduay Rum Sr.* '*lapad'*) of pure ink costs around ₱500- ₱600. There are also fishers who make and sell artificial ink, allegedly a mixture of flour, carbon and manganese dioxide mixture (from a dry cell battery) and water. However most fishers prefer natural ink. It has been observed that the artificial ink does not last long when released underwater.

With this technological innovation, other types of bait became comparatively less effective in catching tuna. Tuna fishers claim that tuna species are quickly attracted to *ata-ata.*

Figure 4 below illustrates the use of different types of gear for fishing for tuna from around 1960 up to present. It shows how some of them replaced the others as time progressed.[9] My informants told me that the ordinary handline, *selopin, limbag,* and *subid* already existed before they were even born and had already been used by their fathers. Most of my informants started fishing around said decade. In addition, my informants do not have a clear memory of what occurred before 1960s.

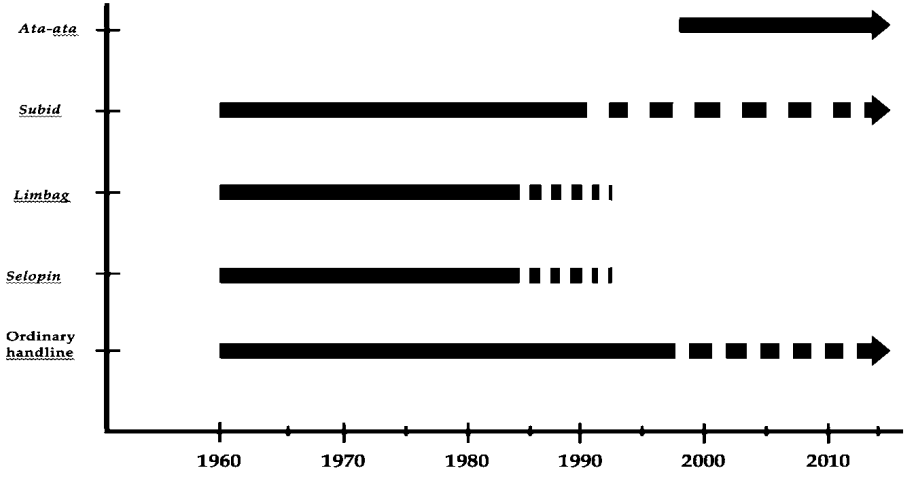

Figure 4. Timeline of frequency of use and extinction of various kinds of tuna fishing gear.

[9] Unfortunately, there was not enough data to support arranging them in chronological order prior to the 1960s.

The arrows represent the continuity of the use of fishing gears up to the present, but broken lines signify their decline, which is directly related to decrease in productivity or yields. The lines with no arrow tips depict discontinued use. At this point fishers shifted to other kinds of tuna fishing gear.

Some tuna fishing gear have stayed even though they are less actively used. When the *ata-ata* came into the picture, the *subid* or artificial squid bait and ordinary handline with live bait became alternative fishing methods used as second options whenever the fishers run out of ink. Fishers stress that tuna have not yet learned to avoid these two fishing gears thus they are still suitable as backup fishing gear. However, these fishing gears can not be used if other nearby fishers are using *ata-ata*. Apparently, tuna is more attracted to *ata-ata*. Hence fishers will not even try to compete with the other fishers using *ata-ata*. This is also why they were compelled to also use *ata-ata* like the other fishers.

Two case studies

Below are narratives about two fishers' experiences of picking up new techniques as well as their observations on other of these innovations impacts besides what can be measured by the catch. The range of their experiences extend to fishing beyond Davao Gulf and across the border to Indonesia. Profiles of each fisher may be found in the appendix.

Case 1. Fishing beyond the border, adopting innovations, new players. Nacio used to work in a large fishing boat based in General Santos City, but he left said employment when his younger brother asked him to become his boat operator and come back to Montserrat. He has been fishing together with his younger brother since then. When I asked him why he did not have a boat of his own, he told me that he could only focus on maintaining one boat. Before he came back to Montserrat, he was already engaged in *pamarilis* or tuna fishing. He had spent two years fishing near the borders of Indonesia. Although the demand for tuna was high the supply was not enough. He said they were forced to trespass into foreign fishing grounds due to the dwindling catch in the Davao Gulf. Despite said danger, Nacio delightfully recalled his experiences in the borders of Indonesia. This was around early to mid-1970s.

While in Indonesia, Nacio observed that the country is abundant in marine resources. They were hauling lots of tuna every fishing trip. At first, Nacio used the typical hook and line in tuna fishing. However he

observed that compared with other fishers, it took time before he was able to start dropping his line. This is because he still needed to catch some fresh fish or squid for his bait. Then he observed that the other fishers did not use fresh bait. They used artificial lures like the *selopin* and *limbag*. The catch rate was still the same but the difference lay in the preparation time. Since the income sharing was based on who caught the tuna, everyone on the boat needed to be competitive. Hence, Nacio adopted the innovation on his fishing gear.

In the early 1980s, Indonesia started to impose stricter border patrols. Trespassers were detained in prison when caught. Nacio knew a group of tuna fishers who were caught by the coastguard and imprisoned for two years in Indonesia. Nacio and his crew were fortunate that they were not caught. He decided to leave his post on the boat and go back to Montserrat.

Nacio continued fishing within the Davao Gulf but found the tuna catch declining. This decline was felt by the fishers from the late 1980s up to the mid 1990s. Fewer tuna were captured in every fishing trip. Nacio concluded that the tuna had become intelligent enough to evade their handlines. Fishers began to use the three types of tuna fishing gears alternately. Nacio explained that he would begin using fresh bait for half an hour. If it had been unsuccessful, he would switch to the other fishing gears.

During the early 1990s, the *selopin* and *limbag* were no longer as effective as before. As a result, the fishers went back to the traditional hook and line using fresh baits. The *ata-ata* or *shabu-shabu* was introduced to Davao Gulf during the early 2000s. It was said that it came from fishers from Zambales who managed to enter the gulf and local fishers noticed their different method of fishing. One time when they were fishing in a particular *payao*, Nacio asked the other fishers about the gear they were using. The other fishers, without hesitation, showed him their method. Nacio copied the innovation and when he applied it in his next fishing trip he noticed that it took less time for the tuna to take on his bait. He caught more tuna. Soon this new method was adopted all throughout the gulf.

Eventually, the innovation opened the way for a new "player" to be involved in tuna fishing. I refer to the important role of the ink suppliers, who are also fishers. Theirs is a specialized type of fishing as it is cuttlefish ink that is preferred. Cuttlefish are caught near the reef areas. A 500ml bottle of ink costs ₱500. In other words, it is worth a peso per milliliter.

Case 2. Concerns over artificial squid ink. Bobby was well aware of the series of innovations in tuna fishing gears, including the cost of the squid ink for *ata-ata*. As mentioned earlier, some fishers have created artificial squid ink which has the texture and appearance of the real squid ink. It costs around ₱245 per 500ml bottle, which is a lot cheaper than real squid ink. Some fishers claim that it is as effective as the real ink. Bobby has tried this artificial ink and he is not convinced of its efficiency. Bobby also is concerned regarding the ingredients of the artificial ink, particularly the carbon and manganese dioxide mixture, which have undetermined toxicity. He is also concerned that excessive use of the artificial ink might affect the performance of the real squid ink because the tuna may learn to avoid any type of squid ink on the impression that it has an awful taste. Thus, Bobby strongly disagrees with the use of artificial squid ink. Other fishers in Governor Generoso also echo this sentiment.

Conclusion: technology, economic and social relations, and tuna behavior

Small-scale tuna fishers in Governor Generoso recount that tuna have learned to identify and evade their fishing lines. This is why they find it necessary to apply innovations on their fishing gears.

Due to its economic value, tuna is fished not only for subsistence. In fact it has become unusual to see tuna as a part of their diet. Instead, tuna is directly delivered to markets that demand a large supply of this resource. As a result, fishers have relied on other marine resources as their source of protein. The fishers typically aim to capture tuna in order to generate a large cash income. Consequently, the typical tuna handline has been subjected to innovations to increase the catch rate. Variations of tuna fishing gears have been recorded and have been consistently innovated on. Fishers strongly believe that tuna are capable of identifying a baited hook and consequently avoid it. In order to catch tuna, fishers must outsmart them.

Fishers understand that the resource they are after is scarce and elusive. Thus, competition is inevitable among small-scale tuna fishers. Fishers need to focus to get a competitive edge over other fishers. While non-disclosure of abundant tuna spots is an option, it appears that fishers are committed to a fair competition. Instead of competing for tuna spots, fishers resort to focus on improving their gears to increase efficiency and catch rate.

The recorded technological innovations are not originally from Governor Generoso. My key informants maintain that said innovations came from other coastal communities, and were only copied and adopted by them. This study has revealed how social relations among fishers are maintained through the sharing of new technologies. In the context of small-scale tuna fishers, this relationship helps fishers to keep them abreast of new fishing gears and keep up with existing competition. On the other hand, fishers need to increase their productivity to compete in the market; the economic relationship between fishers and fish buyers is effectively maintained through the supply of a valuable resource – tuna. In totality, the main goal is to sustain these social and economic relationships and resist disruption of the sociotechnical system.

Acknowledgements

Fieldwork was a collective effort among senior Anthropology students from the University of the Philippines in Mindanao. Each of us had chosen a topic to delve into during fieldwork. The locations for our fieldwork were three coastal communities of Governor Generoso, namely: Montserrat, Nangan, and Surop. I would like to express my sincere gratitude to our field school director, Prof. Jessie Varquez, for his patience, motivation, and immense knowledge. His continuous guidance helped me in doing research in the field and in making this paper. My sincere thanks also go to Prof. Myfel Paluga for the significant insights in improving my paper and for providing us the workshops. I am also thankful to Prof. Aya Ragragio, Prof. Sheila Tampos, Prof. Janus Cabazares, and Prof. Ana Trinidad for spending time in visiting us in the field. Besides my professors, I would like to thank the people of Montserrat, Nangan, and Surop for making us part of their lives. Special thanks to Ate Dada, Kuya Boy, Kuya Nacio, and Kap Zaldy for all the help and support while we were in Monstserrat. To Team GG: Ara, Cha, Chuckie, Deanna, and Jeck, thank you for the fun and laughter despite the sleepless nights of painfully reviewing and analysing our field data. I would also like to thank my wife, Alia, for the love, support, and understanding. Last but not least, I would like to thank Allah (SWT) for everything. Allahu Akbar!

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APPENDIX A- Ethnoecology: tuna behavior and fishing

Ecological knowledge is acquired from long experience of conducting one's life in a particular environment (cf Ingold 2000:25). In my engagements with my key informants during fieldwork, in all locations I have visited, I have consistently heard this line *"Marunong na ang isda (tuna) karon*" [Fish now are smart.] "*Nakaseminar na sa fisheries,*" [They have attended seminars on fisheries]. Fishers claim that the tuna species already know how to identify and evade the handlines. This has allegedly made a great impact in the catch rate of tuna in the past decade. According to my informants, tuna can learn and think because it has a brain. How a tuna behaves or responds to its environment is attributed to its sense organs. Tuna is not a passive organism that will only take anything given by fishers. This is one explanation for the creative innovations in designing bait.

Feeding behavior of tuna. Tuna preys on squid and small pelagic fish like frigate tuna. With its torpedo-like shape, tuna can burst into speed,. The active feeding time of the tuna is from dawn until early in the morning. Feeding activity decreases as the day gets brighter until the sun starts to settle. Bait is made to fit with the observed feeding behavior of the tuna species.

Seasonality. The data on the seasonality of fish in the Davao Gulf are depicted in Table A. Since tuna is a migratory species, there are times when there is very minimal tuna catch. The data in the fish calendar is based on the fishers' catch in the past two years.

Table A. Seasonality: commonly caught fish inside Davao Gulf.

Fish Species	**Months**											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tuna (*Thunnus albacares*)			■	■		■	■	■				■
Matambaka (*Selar crumenophthalmus*)	■	■	■	■	■	■	■	■	■	■	■	■
Burot (*Decapterus macarellus*)			■	■	■	■	■					
Pirit (*Auxis rochei*)	■	■	■	■		■	■	■				
Tulingan (*Auxis thazard*)	■	■	■	■	■	■	■	■	■	■	■	■
Nukus (*Loligo* spp.)	■	■	■	■	■	■	■	■	■	■	■	■
Tabas				■	■	■	■					
Pandawan (*Coryphaena hippurus*)			■	■								
Tangigue (*Scomberomorus commerson*)	■	■	■						■	■	■	■

Seascapes. Fishers are very well acquainted with the different marine resources that can be caught in every section. Table B depicts the data on the different sections of the sea with their estimated depths and available marine resources. [*Lapiyahan* refers to the area close to shore, *hunasan* is the 'low tide zone', *kantil* is a shoreline with a sudden drop, *bahura* are coral reefs, *lawod* refers to the open sea.

Table B. Seascapes and resources.

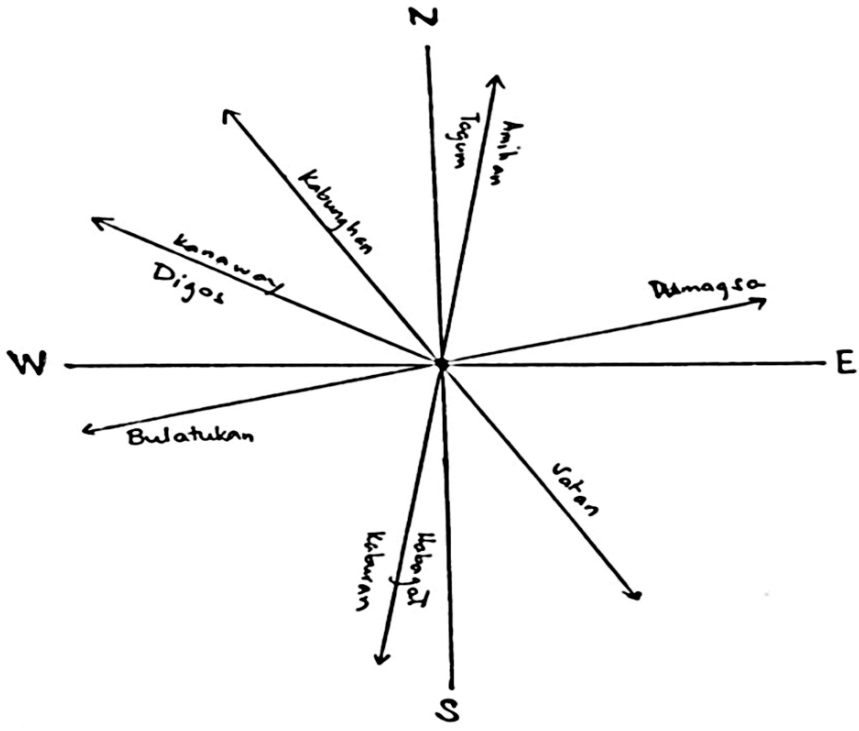
Seascapes	Depth	Marine Resources
Lapiyahan / baybayon	0-1 fathom*	*bugaong, talakitok(juvenile), auman, guno, ibis, tigi, kai-kai, kinhason, hipan-hipan, umang, karaskas*
Hunasan	1 fathom	*kinhason, sikad-sikad, litub, bug-atan, tuwad-tuwad, sa-ang, sigay, liswe, pata, hitu, ubod, bakasi, walo-walo, pasayan, alimango, lambay*
Kantil	40 fathoms	*molmol, kitang, banak, sapsap, auman, talakitok, samin-samin, tanglaron, guno-guno*
Bahura	1 fathom	*taklobo,budyong, kinhason, sikad-sikad, litub, bug-atan, tuwad-tuwad, sa-ang, sigay, liswe, pata, hitu, ubod, bakasi, walo-walo, pasayan, alimango, lambay*
Lawod	>300 fathoms	*barilis, tabas, burot, matambaka, tulingan, tangigue, pirit, karabalyas, tamban, nukos, dulipapa, dugho, nipnipan, diwit, pating, marang, malasugi*
*a *dupa* is the full length of a fisher's two arms extended sideways.		

Wind Directions. Wind directions have significant effects on how the sea "behaves". To be fully aware of the occurrence of different types of wind reduces the risk of life-threatening incidents at sea such as severe damage to the boat. Some fishers, however, still go out to fish regardless of the weather conditions. This holds true especially to those who depend on fishing as their main source of income. At one point during my fieldwork, bodies of fishers were found along the coastline while there were others who went missing.

Hearing reports like these reminds me of the uncertainty one befaces while at sea. Fishers earn their living in an environment that is very unpredictable. The life of a fisher is not easy. I consider it as one of the most difficult jobs there is. Whenever they set out to fish, there always lies the uncertainty of whether or not they can still come back to shore.

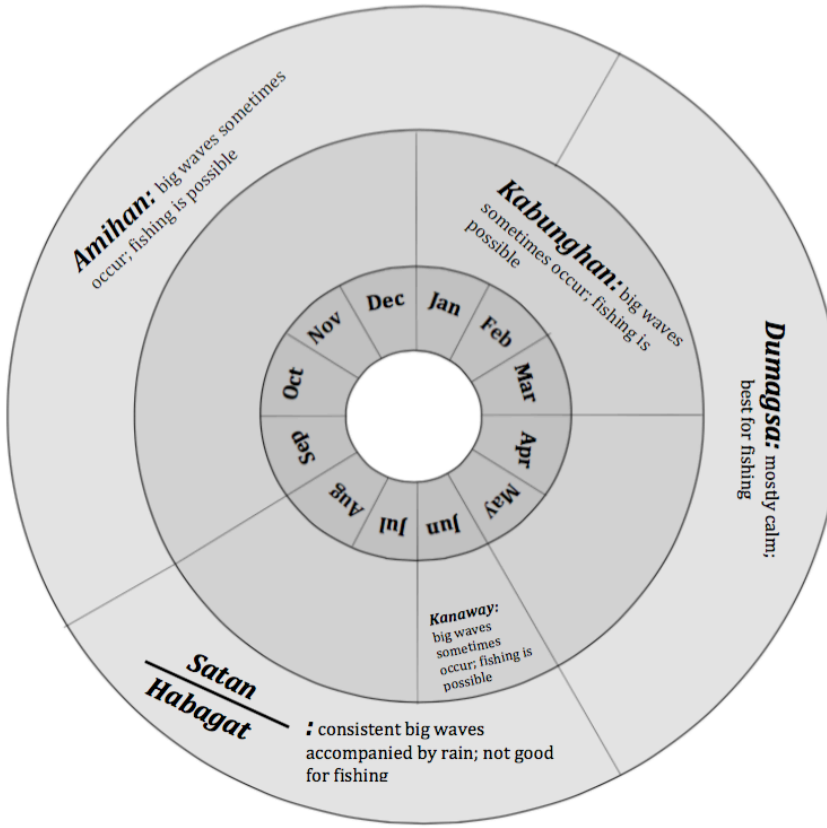
I took out a compass and drew the four directions. I oriented both the compass and the drawn directions to the North. When it was set on the table, I started asking my informant to point which direction each wind type blows. Then I plotted each direction that he pointed out (Diagram I):

Diagram I. Different wind directions as identified by Nacio.



The schedule of the wind directions is shown in Diagram II. There are six identified wind directions that fishers observe each year which affect their fishing practices.

Diagram II. Wind calendar in Governor Generoso, Davao Oriental.



The *Amihan* (northeast monsoon) arrives from the direction of Tagum from September to January. It is accompanied by cold winds. There are seldom big waves, or they are tolerable, and fishing is still possible during this time. A month before *Amihan* ends, the *Kabunghan* wind arrives from the northwest from January to March. *Kabunghan* sometimes brings big waves but fishing is possible. After *Kabunghan*, *Dumagsa* comes from the northeast. It blows from February to May, and the sea is mostly calm. This period is considered the best time for fishing. *Kanaway* arrives in June from the direction of Digos. It brings a few big waves but fishing is possible. The next wind directions are quite alarming for the fishers.

Habagat (southwest monsoon) blows from June to August and brings consistent big waves and heavy rain. Fishers consider this as the lean season or *nihit*. Fishing activity is disrupted during this time given a great possibility that the big waves will destroy the boats. This is the time when fishers' debts increase, especially for those who mainly depend on fishing as their source of income. On the other hand, the prices of fish spike up due to low supply. Other fishers have already engaged in other strategies during this time. Some fishers strategically switch to occupations that do not involve fishing, such as farming, or work in the labor economy, small-scale business like *sari-sari* store, etc.

The wind *Satan* is similar to *Habagat* but it comes from the southeast. This aggravates the weather conditions during this time because at some point, three types of wind may blow alternately (i.e. *Habagat, Satan,* and *Kanaway*). Reports of missing fishers during this season are common.

Phases of the moon. Fishers also consider the moon in deciding whether or not to go out fishing. Details are depicted in Table C.

Table C. Local knowledge relating to phases of the moon.

Moon Phases		
	*Takdul* – full moon	- Fishers do not go fishing
	*Dili Aya-ay* (not *aya-ay*)	- This is a good time for fishing; active feeding activity
	*Aya-ay* – gibbous moon	- This not a good time for fishing

APPENDIX B- Profiles of key informants for case studies
* These are not their real names

Nacio

Born and raised in Montserrat, Nacio was the fifth child in a brood of 16. His family was one of the first seven families that settled in Montserrat. His father was both a fisher and a farmer. It was Nacio's father who taught him how to fish. He started fishing by 18 years old. Like his father, Nacio learned to engage in other sources of income aside from fishing. He knew that there would be times when they could not fish. He raised domesticated animals such as chickens, ducks, turkeys, and pigs. He also bred tilapia. Nacio has eight children. Most of his sons are fishers, two of them are into *kompresor* fishing. (*Kompresor* fishing is dive fishing using compressor tanks as an artificial breathing apparatus. It is illegal in many places and has health risks.)

At 62, Nacio is of small build but seems physically fit for his age. His sunburnt skin is the result of long fishing experience. According to him, wearing protective clothing would just be an impediment to fishing. He gained the reputation of being a very skilled fisher among the other small-scale tuna fishers. He was able to adopt most of the innovations on fishing gears. Nacio is known for his sense of humor and his talkativeness. Coming from a family of fishers, he said he could not imagine leaving his place near the ocean where he can freely go fishing. As long as he can still set his handlines and wrestle with a tuna, he will not stop fishing in the gulf of Davao.

Bobby.

Bobby is 50 years old and said he has been fishing for 35 years. At present, he works as a boat operator for their barangay captain. Interestingly, the fishing boat he uses is equipped with a GPS, which enables them to navigate outside of Davao Gulf. Their usual fishing ground is towards the Pacific Ocean or what they call "*East coast*". He also owns a small motorized boat that he uses whenever he does not have a fishing trip with the bigger boat.

Bobby was a crew member of a boat that transported various goods to be sold or bartered in Indonesia. Said goods included porcelain, steel cooking pots, machetes, and other commodities. They would go to

Indonesia twice a month to do business with Indonesian and Chinese businessmen. Bobby admitted that he liked the experience, but not the salary. In resistance, he and his companions often stole from the goods of their boss and sold them directly to the locals in Indonesia. He did not feel regret because according to him, their boss was stingy and he exploited them.

In their last trip, the crew encountered a major engine problem that required a replacement of some parts of the engine. Bobby found out that the broken part of the engine needed to be ordered from another place in Indonesia. He found some helpful locals who assisted them in finding a place to stay. Their boss, however, suggested they stay on the boat so they can also guard it from thieves. Since he was the boss, the crew obliged and stayed on the boat while their boss stayed with his mistress. In order for Bobby and his fellows to survive in Indonesia, they made every effort to become part of the local community. They accepted menial jobs from the locals. A school administrator hired Bobby as a house helper. He cleaned the school administrator's house and filled the empty tanks with water. Bobby and two of his fellows also attended services in a Christian church in the locality. Later, they were baptized and became active members therein.

After being stranded in Indonesia for two months, the members of their church raised enough money so they were able to go back to the Philippines. By this time their boss had already abandoned them. They took a boat going to General Santos City then a bus ride to Davao City, and finally another bus ride to reach home. After his failed stint in Indonesia, Bobby went back to fishing in the Davao Gulf.