Tuna FAD Fisheries in the Philippines from a Fishers' Perspective

Edison Roi D. Macusi

Propositions

1. FAD deployment is determined by fish abundance and the available space in the fishing area.
   (this thesis)

2. Educating fishers by increasing their awareness of conservation leads to improved fisheries policy implementation.
   (this thesis)

3. Rewilding in agroforestry coupled with protection measures will capture more carbon dioxide compared to carbon capture and storage technologies.

4. Protein extracts from fish waste products fortify nutrient contents of bread to help Filipino children grow their height.

5. Insects feed the world only if their protein is first converted to fish or livestock biomass.

6. Urban farming reduces carbon footprint.

7. Food security issues, including inadequate rice supply, cannot be solved by twinning biotechnology with commercial interests.

8. Weaning the economy from sugar importation will be difficult because almost all food processing requires sugar.

Propositions belonging to the thesis, entitled

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CHAPTER 1

General Introduction

1. Context in the Western Central Pacific

The Central Pacific plays an important role in the global tuna fisheries. Its geographic importance positions it prominently in the international industry, serving as essential habitats for breeding, feeding, and migration of marine species (Evans et al., 2015; Nepomuceno et al., 2020). With its unique oceanographic features and currents, this region constitutes also a migratory passage for diverse tuna species. The tuna fishery in the Western Central Pacific Ocean is composed of multi-gear fishers and targeting multiple species. It includes small-scale artisanal fishers near the coast of Pacific Island states as well as it includes large scale fishing operations using purse-seine, ring-nets, pole-and-line, and longline methods. These activities occur in the exclusive economic zones of Pacific Island states and in the high seas. The main types of tuna caught in these fisheries are skipjack tuna (*Katsuwonus pelamis*), yellowfin tuna (*Thunnus albacares*), bigeye tuna (*Thunnus obesus*), and albacore tuna (*Thunnus alalunga*) (Williams and Terawasi, 2010). The interaction between these different tuna species creates a complex system that needs careful management to guarantee long-term sustainability (Campling et al., 2017). However, overfishing, illegal, unreported and unregulated fishing, and ineffective management are major problems in the governance of this fishery (Miller et al., 2014). Inconsistent rules between countries, insufficient monitoring, and a lack of collaboration in the area are placing pressure on the tuna populations (Bailey et al., 2013). Therefore, adopting sustainable management practices is essential to address these issues and ensure the long-term sustainability of the Central Pacific tuna fisheries (Digal and Placencia 2017; Azmi and Hanich, 2021). A thorough comprehension of these ecological dynamics would be needed for sustainable management.

2. The tropical FAD fishery

In the Central Pacific, tuna fisheries mostly rely on Fish Aggregating Devices (FADs) for capture, which help to increase the catch of bigeye and yellowfin tunas (Griffiths et al., 2018). A Fish Aggregating Device (FAD) is a man-made structure strategically positioned in the open ocean to attract and gather fish, particularly tuna. It is frequently positioned in the open sea, taking the form of anchored or drifting structures that range from basic rafts to advanced setups complete with buoys, lights, and sensors (Moreno et al., 2016). Anchored FADs or payao are made of a floating structure consisting of bamboo raft, foam or steel drums with palm fronds tied with polypropylene rope underneath it. The use of FADs enhances fishing efficiency by attracting and concentrating tuna in a particular area, thus minimizing the time and resources to locate fish in the vast open ocean. Tunas are drawn to the increased abundance of prey around the FADs.

There are two types of anchored FAD fisheries involved, those taken by nets and those taken by hook and lines; the purse seine and ringnet fishery are usually focused on catching small juvenile tunas and other small pelagic species while the handline fishery targets the adult tunas. The former is supported by group seining fleet composed of a mother boat, a small support boat with multiple roles as guard boat, scout boat and as a lightboat during fishing operations while the bigger handline boats act to carry smaller boats on its platform (motherboat) (Babaran and Ishizaki, 2011; Villanueva, 2018). The main difference between a purse seine fishing vessel and a ringnet fishing vessel is the use of a power block to lift the net for a purse seine vessel; ringnet vessels rely on manual labor to pay-off the line of the net and to haul the catch. A school of tuna can aggregate in the surrounding of the FAD, establishing a focal point for fishing (Jaquement et al., 2011). Purse seine and ringnet fishers then deploy a large net around the school of tuna. The bottom of the net is then drawn closed like a purse, capturing the aggregated tuna within it (Leroy et al., 2013). The modern FADs may be equipped with technology such as GPS and underwater sensors. These aids assist fishers in tracking the FADs location and monitoring the concentration of fish around it (Toonen and Bush, 2020). Fishers improve their catch efficiency by concentrating on areas near theFADs, leading to less fuel usage. While FADs can boost fishing efficiency by providing the known location of fish in an expansive open ocean (Gomez et al., 2020; Dagorn et al., 2013), concerns about overfishing, bycatch, and environmental impact led to ongoing conversations about their sustainability (Moreno et al., 2016).

2.1 Ecology of Fish Aggregating Devices (FADs)

Introducing Fish Aggregating Devices (FADs) into marine environments bring both artificial structures and human activity into open waters. A thorough comprehension of the ecological implications of FADs is crucial for assessing their role in fisheries and the broader marine ecosystems. FAD's establish artificial ecosystems by offering a substrate for algae and small marine organisms. As a result, this attracts small juvenile fish, ultimately enticing larger pelagic predators such as tuna (Callier et al., 2018). In addition, FADs also attract baitfish and other small pelagic species. Baitfish gather around the FADs and this draws in larger predatory species, such as tuna, integrating them into the ecosystem associated with the FAD (Coelho et al., 2012; Lokkeborg, 2014). Altogether, it means that the structural complexity created by FADs attracts not only tuna but also a range of other species, such as juvenile fish, crustaceans, and sea turtles, fostering thereby the biodiversity and ecological connectivity (Taquet et al., 2007). Moreover, FADs have the potential to impact the thermal structure of the water column, generating variations in temperature. Alterations in temperature in the vicinity of FADs could attract species that require specific thermal condition for activities such as feeding, spawning, or other behavior (Marsac, 2000). A thorough comprehension of these ecological dynamics is essential for the sustainable management of the FAD fisheries. Although FADs can improve fishing efficiency, their deployment should be carefully assessed to minimize negative ecological impacts and ensure the long-term sustainability of the marine ecosystem (Dagorn et al., 2012; Fonteneau et al., 2013).

2.2 The management of FAD-based fisheries

The management of FAD fisheries aligns with the principles of sustainable development, aiming to balance the utilization of marine resources with conservation efforts (Salomon et al., 2011). The conceptual basis often revolves around establishing rules,regulations, and monitoring systems to prevent overfishing, protect biodiversity, and ensure the long-term health of the fisheries (Angel et al., 2019). The impact of spatial differences in effort allocation in FAD fisheries is thereby a critical aspect that significantly influences the overall sustainability and effectiveness of the management strategies (Cabral et al., 2014). Focusing fishing activities in areas with a high concentration of FADs, may lead to lower abundance and distribution of various marine species, encompassing both targeted (such as tuna) and non-targeted ones and can result in the depletion of tuna stocks in those specific regions (Fonteneau et al., 2000 and Griffiths et al., 2019).

Since juvenile bigeye tuna is difficult to distinguish from a juvenile yellowfin tuna, their unintended inclusion in the catch poses a challenge to its conservation (Dela Cruz et al., 2019; Pedrosa-Gerasmio et al., 2012). This is because when allowed to mature or grow to adult size, bigeye tuna has a higher value compared to yellowfin tuna in the market. Despite this, juvenile yellowfin and bigeye tuna are still caught, sold, and grilled or boiled which are cheaper alternatives to the costlier *bariles* (adult yellowfin and bigeye tuna). The catching of juvenile tuna also leads to overfishing while the non-intended removal of other non-target catch also impacts the pelagic diversity of the marine ecosystem (Dagorn et al., 2012b; Dagorn et al., 2013). Moreover, by using FADs, a greater proportion of juvenile tunas are caught because these are also attracted to other schooling fish found near the FADs (Noranarttragoon et al., 2013a). According to Babaran and Ishizaki (2011), almost all (95–99%) of the pelagic catch by ringnets were juveniles of skipjack, yellowfin (*Thunnus albacares*), and eastern little tuna (*Euthynnus affinis*).

In addition, the deployment of FADs in biologically poor but productive areas may cause tuna and other pelagic fish to be "trapped" in such areas (Hallier and Gaertner, 2008; Marsac et al., 2000). Thus, there has been a continued call to regulate the number of FADs deployed to reduce the non-target catch of juvenile yellowfin, bigeye tuna and other non-intended catch species (Bailey et al., 2012; Ingles and Pet-Soede, 2010). However, the industry and policy makers counteract that without FAD, it is difficult to reach a catch production of 443,713 MT comprised mainly of frigate (*Auxis thazard*), bullet (*Auxis rochei*), yellowfin (*Thunnus albacares*), bigeye (*T. obesus*), skipjack (*Katsuwonus pelamis*), and kawakawa (*Euthynnus affinis*) tunas (Dela Cruz et al., 2019).

The understanding that fish are inclined to be drawn to floating structures in the ocean has prompted the creation and application of FADs (Freon and Dagorn, 2000). Limited research has been conducted on fish behavior around anchored FADs, leading to a deficiency of information in this area. Knowledge and understanding of fish behavior is a crucial component of scientific expertise to aid in stock assessment and fisheries management (Jauharee et al., 2021). Moreover fishers are widely acknowledged to dedicate considerable time to observing, comprehending, and gathering information on fish behavior (Baird and Flaherty, 2005).

Local Ecological Knowledge (LEK) has thus been employed to make this knowledge accessible to science, serving as an alternative source of information (Ruddle and Davis. 2013). Employing fishers' local ecological knowledge proves to be valuable methodology to fill this information gap (Fréon and Misund, 1999; Mendoza et al., 2022, 2023). It is now well recognized that a successful fisheries system includes the management of fishers' effort allocation and fish stocks (Branch et al., 2006; Salas and Gaertner, 2004). Most fisheries systems are managed based on maximum sustainable yield (MSY), without considering other factors such as diversity of species, gears and local socioeconomics of the fishery. Hence, to change the present trajectory of the fishing effort of FAD fishers, there is a great need to study their spatial behavior, distribution, local ecological knowledge and decision-making (Macusi, 2023; Macusi et al., 2015).

2.3 Tuna FAD fisheries in the Philippines

Fish aggregating devices were first introduced in the Philippines as an accessory fishing gear in the 1970s to support the fishing operations of purse seiners and ring netters catching roundscads (*Decapterus macrosoma*) and skipjack (*Katsuwonus pelamis*) tuna (Babaran and Ishizaki, 2011; Macusi et al., 2015). This has been increasingly deployed in many coastal and offshore areas starting from 10 to 15 km from the shore in the Philippines at a depth of 200-3000 m farther offshore. Under the Philippine fishery law (RA 8550 and amended by RA 10654), municipal fishing grounds which start from 0 to 15 km from the shoreline are allotted for the exclusive use of subsistence or municipal fishers. However, there are times when fishing boats with > 5 tons (T) capacity encroaches on municipal waters and deploy their own FADs or fish on the FADs of municipal fishers. When this happens, conflict arises between small-scale and commercial fishers because of unequal capacity and efficiency, commercial boats can catch more fish compared to artisanal boats operating in municipal waters (Macusi et al., 2015). Thus, in terms of fishing operation, both the purse seine and ringnet fishing vessels operate mainly beyond 15 km of the municipal waters while the handline fishers may also operate in these waters despite smaller ringnet vessels (3GT), using smaller nets, may operate also within municipal waters.

On the other hand, purse seine fishers do not operate near municipal waters because they usually have bigger capacities (> 3GT). This conflict between small-scale fishers and commercial fishers have been the subject of several investigations and debates in the Philippine fisheries and policies, such as tracking that has been put into place but not implemented (Pomeroy et al., 2007; Fernandez et al., 2019; Geronimo et al., 2018; Macusi, 2023). The two fishing sectors utilize anchored FADs for fishing operations, for instance, commercial fisheries contribute 35.6% while municipal fisheries contribute 22.5% to the total capture fisheries production in the country (BFAR, 2020; BFAR, 2012). Municipal fishers are often engaged in small-scale tuna fishing, utilizing traditional techniques suchas handline or pole-and-line fishing

(Macusi et al., 2015). Small-scale fishers usually focus on the variety of tuna species, such as skipjack, yellowfin, and occasionally bigeye tuna. Their operations are usually limited to local regions, and the catch is often intended for local consumptions (Macusi et al., 2015). Commercial fishers typically utilize larger vessels, often equipped with advanced technologies such as echo sounders and longlines. These technological features play an important role in enabling these vessels to efficiently navigate and cover vast fishing grounds (Melvin et al., 2002). The captured tuna by commercial fishers is typically intended for global markets or exported abroad (Jeon et al., 2008). The commercial tuna fishing ventures into offshore and high seas territories, focus on regions where tuna populations migrate (Sunoko and Huang, 2014). Controversies arise concerning the competition for tuna resources between small-scale and commercial fisheries, with small-scale fishers declaring that the impact of large-scale operations adversely affects their access to traditional fishing grounds (Carvalho et al., 2011). Commercial tuna fisheries frequently employ techniques like purse seine and longlining, which can lead to concerns such as bycatch and habitat destruction. These matters raise environmental concerns and controversies regarding the sustainability of such practices (Swimmer et al., 2020).

Preventing illegal unreported and unregulated fishing has been a persistent problem because of a combination of factors, one of them, the inadequate implementation of the fisheries law in the country that lapsed into a law only in 2015. That said, FAD fishing is both practiced in municipal waters and offshore pelagic waters in the Philippines (Macusi, 2023; Palm et al., 2021), with progressive local governments supporting the monitoring of their municipal waters, and the tracking device to be installed on commercial fishing boats plying territorial waters which will be a big help to run after them, seize their boats and arrest them when they conduct illegal activities (Conde, 2020; Leilani, 2020). The effective management of tuna fisheries in the Philippines involves navigating the complexities of balancing small-scale and commercial operations, addressing environmental concerns, and formulating equitable solutions to ensure the long-term sustainability of the marine resource (Barboza et al., 2024).

At present, there are however, no census made on the number of FADs deployed in Philippine waters. BFAR personnel make a reasoning that FADs are just temporary fishing gears that can be carried away by strong wave action precluding accurate surveys or counting. Estimates have been mainly based on the minimum number of FADs (30) managed by one ringnet or purse seine fishing vessel. However, these do not include FADs deployed individually in municipal waters. FAD estimates are important to provide a measure of fishing efficiency in tuna fishing grounds (Dagorn et al., 2012b; Fonteneau et al., 2000). In addition, information on the distance between two adjacent FADs is essential to determine their distribution in the fishing grounds. Any estimatesprovided can give a measure of how many fish schools are associated to a given area where FADs are deployed.

3. Spatial distribution of fishing effort

A fishery system is a combination of subsystems e.g. human and natural resources and management that interact dynamically and are influenced by external and internal factors (Seijo et al., 1998). These external (new enforced fisheries regulations, cultural beliefs, and norms) and internal factors (market prices, stock collapses, and others), influence fishers' decision-making what, when and where to fish leading to a heterogeneous distribution of fishing effort (Wilen et al., 2002).

In the past, fish stock collapses such as the cod fisheries of British Columbia in Canada, the Peruvian anchoveta and the Orange roughly of New Zealand collapsed due to overfishing that can deplete fish stocks (Hilborn, 1985; Hilborn et al., 2005). From the point of view of fisheries development and management interventions, it is essential to understand fisher's spatial effort allocation (Abernethy et al., 2007; Forero et al., 2017). The success of intervention strategies and attempts to change the level of fishing effort of fishers requires a close cooperation between government regulators and conservation agencies and the ability of fishers to change for it (Warren and Steenbergen, 2021).

In this discussion on spatial effort allocation by fishers, a distinction has to be made between long-term strategies (such as investing in boats, gears, and modern technology (e.g., GPS, satellite radio etc.) and short-term decisions which deal more with the day-to-day operational decisions. Fishers usually develop long-term strategies for placing FADs with the aim of optimizing or maximizing their catch per unit effort. This involves selecting locations with abundant tuna to ensure a productive fishing ground (Moreno et al., 2007). Forecasting perspectives play an important role in long-term decision-making, taking into account factors like historical catch data, migratory patterns of tuna, and the oceanographic conditions. The goal of this strategic planning is to improve the overall efficiency of the fishery (Taquet et al., 2007). On the other hand, daily choices are often more immediate and individual centered, shaped by factors like personal needs, familial responsibilities, and real-time environmental conditions (Marsac et al., 2000).

By understanding the spatial distribution of fishing effort and the strategies that fishers use, an efficient management system can be established that allows fisheries managers to know how it impacts the everyday life of the fishers and their operation (Abernethy, 2010; Christensen and Raakjaer, 2006; Poos et al., 2010; Salas and Gaertner, 2004), thereby even avoiding conflicts (Aburto et al. 2009).

4. FAD deployment and the search for sustainable solutions

Fishing effort can be affected by multiple factors. For instance, uncertainty can affect the fisherman's decision where to cast his net or where to deploy his FAD or which fish to catch. Due to these uncertainties, it is a question to what extent fishers can perceive resource distribution and align their fishing effort to it (Abernethy et al., 2007; Pet-Soede et al., 2001). The deployment of FADs can save time in search for free schools of fish, thereby saving fuel cost plus it adds certainty to finding fish catch. When FADs are deployed in an area and available, this reducesthe fishers' encounter of zero catches, this also improves the fishers profitability and subsistence. There are many factors that can influence a fisher's decision making where to specifically deploy his FAD in a fishing ground. That decision can be motivated by his catch experience, and how productive his area of fishing was (Figure 1) (da Costa Neves, 2021). The location choice of FAD deployment is based on various environmental conditions. These conditions are supposed to favor his catching ability, e.g. wind and wave condition in the area must be just normal, not high or intense even during a weather disturbance, food or prey organism should be available or near the area and accessible for the fishers. Under these conditions, FAD deployment is highly probably as it minimizes disaster or vulnerability of the FAD accessory, the area is accessible to fishers, and other prey species can be found. While commercial fishers have no qualms in investing for FADs or taking higher risks by deploying more FADs in vaster areas, doing this for small scale fishers may not be sustainainable given their size ofoperation at smaller spatial scales and primarily meant for subsistence (Palm et al., 2021). Besides being limited by environmental factors, operational costs in terms of time and effort, can influence the long-term decisions of fishers in deploying their FADs. They can be Such decisions can be influenced by internal factors e.g. their attitude, values and belief system, social background (family or household, education), knowledge of fishing ground (experience, length of time in community pertains to navigation), and fishing technology. Likewise, external factors mainly, economic (e.g. fuel costs, catch price, FAD cost, crew salaries), community network (church, acquaintance, friendships), policy (management rules and regulations, customary laws), and including environment (mainly pertains to knowledge of birds, weather, currents, productivity in the area) (Table 1). Thus, FAD deployments are not irrationally done but planned and meant to provide harvested fish for the waiting tuna customers and clients. While conflicts exist between different government agencies and levels, fishers are resilient in that they continue fishing and are known to obey laws and policies when prompted and properly informed.

Table 1. Factors that influence fishers' decision making in relation to their fishing effort allocation.

Factors	Internal		
	Description	**Implication on effort**	**Reference**
Attitude (motivation)	Fishers' motivations are with regards to their most pressing need which is food and their livelihood or sustenance	Fishers will keep fishing unless there is an alternative and better paying job for them; To some of them fishing is also a way of life, and it brings them satisfaction;	(Pollnac et al., 2001; Pollnac et al., 2015)
Values and belief system	Some areas are kept as off-limits because these are kept as holy sanctuaries, others keep outsiders out to protect their area	Fishing effort will be limited only to those who are allowed to the area; this is comparable to spatial and temporal closure of a particular area;	(Cinner and Aswani, 2007; Drew, 2005; Macusi et al., 2020)
Social (family)	Social factors include demographic contexts of the fishers, level of education, wealth, relatives, family, and the community in general which may encourage fishing as occupation.	Serves as the main context for fishery exploitation; the more dependents and the less alternative livelihood available, the higher the fishing pressure;	(Cinner and Pollnac, 2004; Fauzi and Buchary, 2002; Libre et al., 2015; Nazarea et al., 1998)

Knowledge of fishing ground	The main context of knowledge of fishing ground includes length of time of fishing or experience as a fisher and having become a long-staying member of the community, the fisher already knows his fishing ground and navigating its ins and outs including customary laws in the area.	This can help increase the catch success of a fisher to a degree that he is knowledgeable of the area; he can also deal with other community members due to his vast experience and therefore ability to reason out and access fishing areas that normally could be limited to those who are members only of the community. His knowledge and connection gives him access to a fishing area;	(Gajardo et al., 2023; Karnad, 2017; Macusi et al., 2017a; Moreno et al., 2007)
Fishing equipment or technology (GPS, radio, mobile)	Access to technology or gadgets such as mobile phones, radios, GPS, and sonars as well as informal groups and newspapers can aid the fisher in gaining important information and defining a spatial map of his fishing ground to increase his catch success. Capacity building through technology transfers can also do the same.	Fishing efficiency increases given the access to technology which enhance the efficiency and catching power of fishers	(Christensen and Raakjaer, 2006; Daw, 2008; Sunoko and Huang, 2014; van Densen, 2001)

Factors	**External**		
	Description	**Implication on effort**	**Reference**
Economic (FAD costs, fuel costs, catch price)	High cost may hinder fishers from moving offshore or investing in FADs but high revenue from fishing may encourage them to fish longer and farther.	Fishing effort can either decrease or increase; when revenues are high, there is incentive to expand fishing areas and increase the fishing effort;	(Abernethy et al., 2007; Caddy and Carocci, 1999; Libre et al., 2015; Macusi et al., 2017b; Sarmiento et al., 2021)

Network (community, church, social)	This is also related to social factors in the context of a wider community of fishers and the immediate community which includes members of family, relatives, church and village in general which may encourage or discourage a fishing participation.	Social networks, community networks can encourage fishers to stay in the fisheries through providing information regarding location of productive fishing areas or it can also discourage fishers by helping them exit and find an alternative job for a more resilient future and better well-being when the catch or fisheries is in decline.	(Jara et al., 2020; Mendoza, 2022; Ramirez-Sanchez and Pinkerton, 2009; Turner et al., 2014)
Fisheries policies (boat size, mesh size, rules and regulations, informal rules among fishers)	Constraints on fishing vessels and gear use such as boats and nets, restrictions on distance as well as formal and informal rules where only certain fishers can fish in an area.	Fishing effort decreases; spatial and temporal effort are either aggregated or dispersed in very specific areas like near landing ports, specific region or within certain distances from the shore.	(Dela Cruz et al., 2019; Macusi, 2023; Macusi et al., 2022; Owusu, 2023; Owusu and Andriesse, 2020)
Environmental (birds, weather, currents, productivity)	Environmental factors include biotic and abiotic factors that can hinder or aid a fisher in locat-ing his prey. These include weather and current as well as bird movement, presence of dolphins, and whales as indicators of the presence of fish schools.	Fishing effort can decrease because of bad weather or disturbance but it can also increase because of strong upwelling currents or presence of birds that indicate a productive site.	(Pet-Soede et al., 2001; van Densen, 2001)

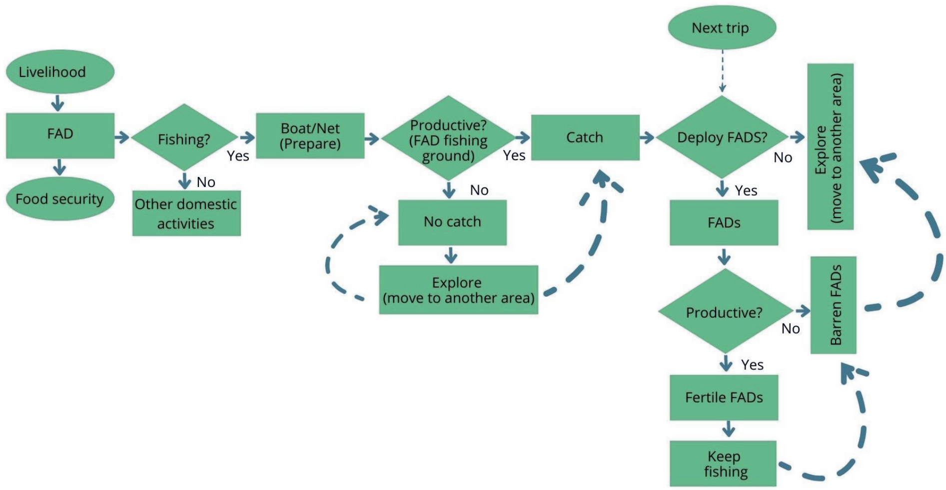

Figure 1. Conceptual model of how FADs are deployed in fishing grounds based on catch experience by fishers (boxes are activities; circles are motivations; diamonds are decision; the broken arrows signify a dynamic interaction or loop). Before the deployment of a FAD, fishing grounds (area available) are first explored whether it is productive or has favorable current, then if productive (abundant catches), FADs are deployed, otherwise they explore other areas.

4.1 Conservation through implementation of closed fishing seasons

The national policy emphasizes that conservation, protection, and sustainable management of the country's fishery resources are implemented. One of the identified conservation measures is the implementation of closed fishing seasons, which has shown positive effects. During a closure period, fishing grounds are entirely inactive for a specified period, leading to a potential reduction in annual fishing effort by up to 20% (Demestre et al., 2008). Typically, seasonal closure is implemented to safeguard demersal resources during their most vulnerable life stages and contribute to the enhancement of fish biomass (Pipitone et al., 2000). The implementation of a closed fishing season to a water body is a useful tool to control fishing effort (Napata et al., 2020). Although large tunas are usually caught beyond the municipal waters of the various coastal areas around the Philippines, small-scale fishers actually engage in fishing for large pelagics including bigeye or yellowfin tuna whenever they are present in the fishing ground (Macusi, 2016). Closed seasons are frequently enforced during the breeding period of the targeted species under the belief that it will increase their reproductive success (Arendse et al., 2007; Villanueva, 2018). Since 1995, the seas surrounding China have seen the consistent enforcement of seasonal closures from the month of June to September and the duration of these seasonal closures differs across the countries.

4.2 Closed fishing season in Davao Gulf

The implementation of a closed fishing season in Davao Gulf represents a major approach aimed at halting all fishing activities within the designated fishing sector or fishery (Samy-Kamal et al., 2015). This policy is implemented by the Bureau of Fisheries and Aquatic Resources (BFAR) of the Department of Agriculture and the Department of Interior and Local Government (DILG) in 2014 running from the first of June to the first of September (JAO-2014 series 02). Similar efforts were taken in other regions such as Zamboanga Peninsula, Visayan Sea, and Palawan waters (Villanueva, 2018). The primary goal is to combat the decline of fish stocks in the area (Bagsit et al., 2021; Macusi et al., 2021; Rola et al., 2018).

One specific aspect unique to Davao Gulf is the presence of both large pelagic and small pelagic species, which requires a tailored management strategy. Additionally, the fisheries in Davao Gulf utilize various fishing gears such as ringnets, bagnets, and hook and lines, which may have different impacts on fish stocks and ecosystems (Mahon et al., 2008). Effective fish stock management strategies aim to limit catches directly or indirectly. One such approach is gear type restrictions, which focus on minimizing the capture of immature or juvenile fish, and temporary closures, which reduce fish exploitation (Colloca et al., 2013).

The implementation of a closed fishing season in Davao Gulf required catch monitoring as well as impact assessment regarding the catch and effort of fishers as well as its impact to their livelihoods due to the three months of fishing ban for commercial fishers (Brillo et al., 2019). There are reports that in the Visayan Sea most of the subsistent fishers would continue fishing in periods that the commercial fishery was closed, making the ban seemingly ineffective (Bagsit et al., 2021; Napata et al., 2020). However, other reports showed that a closed season is effective to enable fish stocks to recover (Rola et al., 2018). Thus, there is a need to conduct studies to examine the impacts of the implementation of the closed fishing season and the factors that influence it.

5. Objectives

The main objective of this thesis is to examine the factors influencing fishers' utilization and deployment of FADs in the Philippine tuna fisheries. Since fishers' decisions regarding FAD utilization and deployment are closely tied to their local ecological knowledge of fish behavior and movement patterns, understanding these factors is crucial for effective fisheries management. By gaining insights into these components, this study seeks to contribute to the broader goal of fisheries sustainability through increasing fish stocks by implementing a closed fishing season in the fishing ground. Specifically, these were the questions explored in my research:

1. What are the tactics and strategies employed by purse seine, ringnet fishers and handline fishers in their deployment and use of FADs?
2. What are fishers' knowledge and perception with regards to fish distribution, movement and behavior around anchored FADs?
3. How do socioeconomic factors influence the change of fishing strategies when their catch declines?
4. What are the main factors influencing the catch and support of the implementation of a closed fishing season in fisheries?

5.1 Conceptual framework

The sustainable management of the tuna fisheries hinges in the implementation of effort control measures, among which a closed fishing season, controlling the number of FADs per fishing boat, and limiting the number of tuna catcher boats. The closed fishing season and effort control measures are policy tools annually imposed in Davao Gulf and other fishing grounds in the Philippines in hopes of addressing overfishing of tuna stocks and overexploitation of fishing grounds, and has its origins in the concept of maximum sustainable yield (MSY). This will limit fishing impacts to the marine ecosystem, and allow the attainment of ecosystem based fisheries management. Moreover, initial literature analysis of catch data and local ecological knowledge of fishers and their perceptions of catch and fish behavior (part of this study) have enabled validating earlier studies of tuna catch decline in various fishing grounds. Fishers can thus provide critical information on such things as habitat-related information, behavior, and abundance of target species which are essential in influencing fishing strategies. The combined knowledge of fishers, actual catch data and perception-based studies can point to trends in catch rates and historical changes which can help to develop a management in data-poor fisheries systems.

6. Outline of the thesis

This thesis reports my results on how tuna fishers allocate their effort, when, where and what they fish, and how do various fisher characteristics and factors influence their decision making. In relation to this, I also examined fishers' local ecological knowledge (LEK) with regards to fish behavior which enables them to fish effectively because of knowledge of their target fish behavior and their fishing grounds. Then I assessed the perception of fishers regarding their change in strategies when their fish catches decline due to high fishing effort especially for purse seine and handline tuna fishers. Furthermore, I also examined what factors influence the catch and support for the implementation of a seasonal fisheries closure in the Davao Gulf fisheries. This management aspect offers an overview on how effective fisheries policies when correctly implemented can increase fish stocks or help it recover, thereby avoiding fisheries collapse.

The first research question (see 5) was studied in **chapter 2** of this thesis, where I described and examined the purse seine and handline tuna fisheries in General Santos City, how they operate and to what extent this operation takes place. Based on the findings of this chapter, FAD fishers in nearshore coastal areas such as those in General Santos City gradually moved their fishing operations to international waters due to declining catches. The paper analyzed possible explanations on fishers' decision strategies regarding FAD deployment and conclude that fishers move to these distant fishing grounds because they expect better revenues. As larger companies fund these offshore operations, they also hope for more advanced fishing technologies that could enable them increasing their catches.

In **chapter 3**, which focused on the second research question, I conducted a study through a survey aided by questionnaire on the local ecological knowledge (LEK) of purse seine and ringnet boat captains from General Santos City to provide a good overview on their understanding of fish behavior and movement patterns of fish found inanchored FADs. Based on the findings of this chapter, fishers possess local ecological knowledge (LEK) of their target species, their movement, and behavior, including detailed knowledge on gradual mass buildup around the FAD of fish species from herbivorous to piscivorous and then to oceanic tuna species. This means that the information generated by them is reliable and useful for policy and management plans.

Research question 3 was studied in **chapter 4** where I investigated how various socioeconomic factors that were identified in the literature could contribute to decisions of fishers to remain, change/adapt or exit the various tuna fisheries. Based on the findings of chapter 4, fishers' decisions are affected by economic considerations, for example, those in General Santos City and Lupon were willing to adapt and change fishing strategies while those fishers in Governor Generoso and Mati wanted to keep fishing. Moreover, tuna handline fishers try to adapt by changing their fishing grounds and gears to offset low fish catches while ringnets, purse seines, and smallhook and line fishers, were not willing to change their fishing grounds due to higher costs.

Research question 4 was studied in **chapter 5**, the result of analyses of the survey of small-scale fishers regarding the implementation of a closed fishing season policy to manage fishing effort and allow the recovery of fish stocks in Davao Gulf. Based on the findings of chapter 5, fishers from the Davao Gulf were highly influenced by economic factors in their decision to support the implementation of the closed fishing season policy. This means that fishers were only willing to follow policy regulations when they perceived economic benefit to their livelihood. They were more receptive to the policy due to their awareness of the closed fishing season policy, membership to people's organizations and the hope for the fish stocks to recover their population. This will be useful in revealing insights on the response of fishers so that other important activities can be adjusted to accommodate their cooperation for better fisheries management policies. In **chapter 6**, I discussed the major findings of my research and their implications with regards to the current fisheries situation in the Philippines.

CHAPTER 2

Strategies and tactics of tuna fishers in the payao (anchored FAD) fishery from General Santos City, Philippines

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Abstract

Payaos or anchored FADs are used extensively in the Philippine tuna fishery. Currently, spatial regulations on FAD use are implemented with limited observance or understanding of their potential impacts. A combination of semi-structured interviews (n = 150) and a total of six focus group discussions (n = 61) from purse seine, ringnet and handline fishers of General Santos City provided a coarse indication of fishers operational patterns and decisions on fishing tactics and strategies. Over a period of about 25 years, Filipino FAD fishers moved from inshore areas to offshore areas to catch oceanic tuna's and FAD associated small pelagics and neritic tunas. Presently their catch rates are reported to be significantly higher at more distant sites. Due to the high density and spatial limitations of FADs deployment in nearshore areas, offshore deployment of FADs in a spatial network that is owned by a company has become a strategy to maintain hold of a fishing ground. Purse seine and ringnet fishers, as area specialists, operate from 70-1000 km from the fishing port and have an average reported catch rate of 14 tons per set. Handline fishers which roam freely between FAD areas claimed by purse seine and ringnet fishing companies operate from 90 to 1500 km from the fishing port with an average reported catch rate of 1.6 tons per fishing trip. Strategic decisions on the deployment of FADs in fishing grounds were strongly modulated by availability of fishing space, environmental considerations and both experience and information on areas with good catches. Day to day tactical decisions were mainly explained by socially mediated information flows, weather patterns and economic factors, and to a lesser extent by fish behavior and regulations.

Keywords: Fishing effort, General Santos City, handline, juvenile yellowfin tuna, purse seine, ringnet, weather and current

1. Introduction

With a predominantly coastal population, the Philippines is highly dependent on protein from fish and income arising from the fisheries industry. Given the challenges posed by overfishing, degradation of ecosystems and the impacts of climate change, the need to identify, document, and quantify fisher's adaptive responses to these changes is essential. Adaptation of fishers to changing conditions can be assessed by studying their effort allocation strategies and tactics, in other words their decisions on long term investments and on short term fishing operational decisions. Studies on the impacts of fishing around Fish Attracting Devices (FADs) and the strategies that small and medium scale tuna fishers employ to adapt to changing fisheries conditions are scarce (Dagorn et al., 2013a). It is generally assumed that knowledge on stock availability plays a key role in the decision making on fishing locations. However, fishing decisions are as much influenced by operational constraints, and effort allocation is in fact the dynamic outcome of economic, social, cultural, environmental factors, resource distribution as well as rules and regulations that result in heterogeneous distribution of fishing effort (Smith and Wilen, 2003, 2005).

This study focused on the context of strategic and tactical effort allocation decisions made by fishers utilising anchored Fish Attracting Devices (FADs) also known as *payao*'s operating in southern Philippines. FAD structures have been around for centuries in coastal areas with fishers exploiting the associative behavior of fish to floating objects (Dempster and Taquet, 2004). Fish and fish schools of tuna's, tuna-like species, sardines and anchovies associate with FADs (Aprieto, 1981; Aprieto, 1991; Dickson and Natividad, 2000; Fonteneau et al., 2000). Nowadays, more than 60% of the global tuna production of 2.5-3 million metric tons, consisting primarily of tropical tunas like skipjack (*Katsuwonus pelamis*), yellowfin (*Thunnus albacares*) and bigeye (*T. obesus*), are caught by large purse seine vessels that use drifting FADs (Dagorn et al., 2012a; Miyake et al., 2010). A *payao*, on the other hand, is an anchored structure composed of a floater made of bamboo, styrofoam or a steel drum with a series of palm fronds suspended underneath (Babaran and Ishizaki, 2011). This structure is anchored at depths ranging from about 200 m to more than 5000 m (Aprieto, 2011). In the Philippines, these structures initially supported the coastal operation of artisanal fishers using ringnets and line gears focusing on small pelagics but that also capture small neritic and oceanic tunas (Babaran and Ishizaki, 2011). In the 1970s, anchored FADs were introduced to support the operation of commercially employed surrounding nets like purse seines and ringnets to target skipjack tuna and yellowfin tuna. These fisheries increasingly used and deployed FADs in many coastal and offshore areas (Dickson and Natividad, 2000), as they efficiently aggregate fish thereby saving fuel cost and search time for fishers. Although the fisheries are important for fish export production and contribute to food security, the ubiquitous deployment of anchored FADs in many areas of the Philippines as well as their impacts on juvenile tunas have been in contention (Ingles and Pet-Soede, 2010; Macusi et al., 2014). Identification of relevant factors to the deployment of FADs and their utilization in the tuna fisheries is required to develop policies aimed at regulating fishing pressure.

Fishers' decision making on where to fish is influenced by a range of factors (van Densen, 2001) such as 1) social and cultural factors: fishers are embedded in a society with specific cultural norms, taboos and beliefs around seafaring; 2) technological factors: the availability and accessibility of technology around boats, fishing gears and implements as FADs, and accessory technology as fish finding equipment; 3) economic factors: related to long term strategic decisions as the costs of investments, FAD building and deployment cost, the presence and accessibility of landing facilities and short term operational costs and benefits as fuel and ice costs, crew salaries and revenues from catch, 4) environmental factors e.g. weather and sea conditions, sea currents, productivity and resource availability and accessibility, knowledge of which is part of the informational environment of fishers that includes 5) regulatory factors: rules and regulations on fishing operations and 6) other informational factors: a fisher's experience and knowledge of fishing grounds and environmental factors affecting resource availability is informed by external sources including cooperation and sharing of information within the fishing community and traders, education, extension, and public communication means (radio, television, internet, and mobile phones).

A fisher's perception on the state and availability of a resource is formed by his catch success in relation to his daily exposure to the elements. The processing of such information in the context of the factors just outlined is called fisher's experience (Oostenbrugge et al., 2001). It can be assumed that fishers will deploy and use FADs in areas where they expect to achieve good catches (Aprieto, 2011) (Caddy and Carocci, 1999; Pet-Soede et al., 2001), based on past experience, information from others and given their operational constraints. In other words, in their strategies to deploy new FADs, fishers may be strongly modulated by previous catch experience in fishing grounds visited. Their short term tactical decisions on when and where to fish in relation to these FADs, their movement behavior, is in turn influenced by their perception of the local behavioral dynamics of patches of fish within the wider resource area (Oostenbrugge et al., 2001;

Pet-Soede et al., 2001). With increasing fishing pressure catch rates of fishers invariably decrease and it is often assumed by coastal fishers that fishing grounds farther away are less affected by fishing and therefore would yield higher catch (Caddy and Carocci, 1999; Daw, 2008). The expected relationship between distance and catch rate may potentially influence the behavior and decision making of fishers in their deployment of FADs, the organization of the fishery and ultimately where to fish on a day-to-day basis.

In this study, this framework was used to gain an understanding of the development of the FAD purse seine, ringnet and handline fishery in General Santos City, Philippines. The framework was also used to gain an understanding of how fishers perceive their effort and catch rates, make strategic decisions on FAD deployment and take day to day tactical decisions on fishing events. In particular our objectives were to: a) describe the development of the payao fishery of the Philippines, focusing in particular on General Santos City; b) investigate what factors influence the strategic and tactical decisions to deploy FADs and to fish; and, in particular, c) determine whether distance from the port influences catch rates around anchored FADs.

2. Methodology

2.1. Data collection and interviews

This study was based on primary and secondary data collected between November 2012 and January 2015. Secondary data collected involved a survey of peer reviewed materials, grey literature, reports, and policy documents to provide a description on FADs and the development of the *payao* fishery in the Philippines; and to examine impact on the fishery of temporal changes in catch rates and fishing location as indicated by the fishing distance from the harbor. Primary data were collected based on three types of interviews with handline fishers and purse seine and ringnet fishers: key informant interviews (n=36), semi-structured interviews (n=150) and focus group discussions (n= 6). Key informant interviews were performed to scope ideas on how fishers utilize FADs, what fish species they target and how and where they operate (n = 36). These interviews held with FAD fishers, operations managers, company owners, fishery scientists and enumerators lasted from 30 minutes to one hour, and provided baseline information used to develop a semi-structured interview questionnaire that was administered to a sample of 150 fishers docked in General Santos City Fish Port in July 2013. For the semi-structured interviews, this was held generally with captains (*kapitan*) (72%), assistant captains (*segunda kapitan*) (11%) and their crew (16%) of handline boats and boat captains (63%), assistant boat captains (7%) and crew (30%) of carrier boats and motherboats of the purse seine and ringnet fishery. Captains and assistant boat captains of carrier boats are reliable source of information because the Philippine ringnet and purse seine fishery practise a group seining behavior. During a fishing operation a lightboat is a small fishing vessel with multiple roles: during the day it is used to to search for fish and during the night it is used to light up the FAD on which a set will be done. The lightboat works together with the motherboat and the carrier boat; the motherboat, the actual ringnet and purse seine vessel, is based offshore almost permanently, and only comes ashore for maintenance and repair or under dangerous weather conditions. While the motherboat is the instrument used for catching fish, these cannot operate without a carrier boat present to carry ashore the fish that was caught.

The interviews were held at the General Santos City Fish port since most of the carrier boats can be found docked in this area after landing their catch. Interviewers systematically selected vessels that are docked in the port and interviewed boat captains that are available (mostly carrier boat captains but sometimes the motherboat captain may be present for interview). If not available, the assistant boat captains were interviewed. In the case of the ringnet and purse seine carrier boats, crews that were included in the interview apart from the boat captains, assistant captains and masterfishers include those who can reliably speak about the catch and movement patterns of the boat such as lightboat captains, master netters and master divers. This was done to maximise information gathering. Data collected include individual characteristics (age, gear, boat, engine type, technology, and experience), spatial distribution of fishing effort, costs and inputs of fishing. Quantitative information was collected on the number of FADs, locations of and distances between FADs, harbor locations, sea-depth at FAD deployment; common species in the catch time and distances travelled to the fishing ground and at the fishing ground; fishing time; use of fuel and other inputs. To construct catch-rates of purse seine and ringnet and handline fishers, questions were asked about their daily normal, best, and worst catch rates, while the handline fishers were asked about their daily normal, best, and worst catch rates per fishing trip which normally lasts from two to three weeks. Qualitative data were also collected on socio-economic background, religion, ethnic origin, educational status, and factors influencing short-term decision making.

Third, a total of six focus group discussions (FGDs) with purse seine, ringnet and handline fishers were conducted in fish ports and in a company compound; three FGDs were made with purse seine and ringnet fishers and another three FGDs with handline fishers. This provided additional insights on changes in fishing location, catch per day, and numbers of FADs per motherboat over the past 20 years. Developments in minimum, normal and maximum distances travelled during a fishing trip over this period were discussed. Questions asked include what factors influences your decision making "where to fish" which was asked to both purse seine, ringnet and handline fishers. On the other hand, the question, what factors influences your decision making where to deploy FADs was asked to purse seine and ringnet fishers only. Answers to questions on fisher's decision making were summarized in charts in this paper. Moreover, the fishers were asked to rank the listed and suggested factors most relevant in influencing their decision-making. These factors were based on earlier key informant interviews done by the first author with fishers before the survey in 2013 and which were modified from Daw (2011)(Daw et al., 2011). As in the semi-structured questionnaire, fishers referred to in this case include boat captains, their crew and in the case of ringnet and purse seine fishers as well as master-fishermen who act as overall commanders of the fishing fleet of a company. Although most decision-making in the boat during fishing operations is done by boat captains, master-fishermen, company owners and operation managers, they also consult with their crew. In this study our main interest is not about who makes the decision, but about the influence of different factors on fishers' decision-making. Ranks given to the factors during the six FGDs were summed and then percentage distributions were compared. Variations of answers were discussed. Attendance during the six FGDs totalled 61 fishers and ranged from 7-20 fishers per FGD. Discussion time lasted from 45 min to about 2 hours (n = 6). The aim of the discussion was to elicit ideas and perceptions on factors that influence fisher's decision making, but participants were encouraged to add to the factors discussed and to explain the effects of these factors to the group. These added factors by participants were discussed but not included in the analyses because these were just mentioned once or twice in the discussion. The focus group discussions were kept open by allowing exchange of ideas and opinions of fishers who want to explain their views. This allowed additional information that fishers think are important or essential for discussion. Moreover the discussions were made lively by asking participants to pin their answers or to write down their volunteered information. To avoid one individual from dominating discussions, the interviewer explained from the start that all fishers were encouraged to give their answers while no answer is wrong.

2.2. Evaluation of distance-catch rate relationships

To test whether reported catch rates at sites farther from port was higher an analysis of covariance was performed based on answers provided by the forty purse seine fishers and ninety-three tuna handline fishers on their reported best, normal and worst catches at their fishing locations. Each of the reported catches by purse seine and ringnet captains are their catches in their respective fishing grounds. This is the same for the tuna handliners: although they are a bit nomadic compared to the purse seiners, they still provided a dominant fishing area which was used to calculate distance. The analysis was done as follows:

$Log_{10}(Catch)_{ijk} = a + b\ Distance_i + Typcatch_j + c\ (Distance_i*Typecatch)j + \varepsilon_{ijk}$ Equation number (1)

where:

catch = reported catch in ton.trip (handline) or ton.day-1 (purse seine), distance = distance from the coast (km), typectach = categorisation of catch in best, normal or worst encountered

a = intercept, b and c are regression parameters and the error term ε_{ijk}~N(0,σ2).

Reported catches were log10-transformed to conform to the assumption of normality of residuals of the model. The interaction effect turned out to be not significant for both the handline and purse-seine models and were removed for the final presentation and discussion of the results.

2.3. Fisher's short-term and long-term decision making

To analyse fisher's short-term decision making, in the questionnaire all interviewed were asked to rank factors important in considering fishing locations on a Likert scale of 1 (least important) to 9 (most important). There were nine factors considered based on key-informant interviews and from literature (Daw et al., 2011): social (other people's catch success and operations), environmental (weather and sea currents), fish availability (lunar phase), economic (price of fish, price of fuel, debts and loans), regulation (BFAR), information (previous catch, news of fish catch). During the FGDs the same sets of questions were asked as to the group and then ranked. In some cases where there were volunteered answers, these were noted by the researchers and discussed. The percentage distributions of their ranked responses were also compared. To compare relations between the nine factors, a principal component analysis (PCA) was performed and factor loadings were compared (Pollnac and Crawford, 2000a). The factors affecting long-term, strategic, decision making on FAD deployment for purse seiners and ring netters, as well as factors affecting short-term tactical decision on fishing locations.

3. Results

3.1. Payaos and surround net fisheries

The Philippine tuna anchored FAD fishery developed fairly recently (Table 1) and was due to growing tuna demand abroad. During the early years the lack of adequate postharvest facilities, transport logistics, and poor management of the industry led to problems that caused closures of many of the pioneering companies in the 1960s (Dickson and Natividad, 2000). Purse seines, using powerblocks to haul and close the net, were first introduced in the roundscad fishery which until then were caught with ringnet, bagnet and gillnet fisheries, that also targeted sardines using winches and manual labor (Aprieto, 2011). The introduction of purse seining earlier in 1969 and later FADs in 1975 revolutionized the fishery by enabling the tuna industry to land large volumes of catch and to save time searching for fish (Aprieto, 2011; Dickson and Natividad, 2000). The design of a *payao* which consists of a floating structure, with suspended nipa palm fronds and a cement block as an anchor to the seabed- has not changed since their first use (Fig. 1).

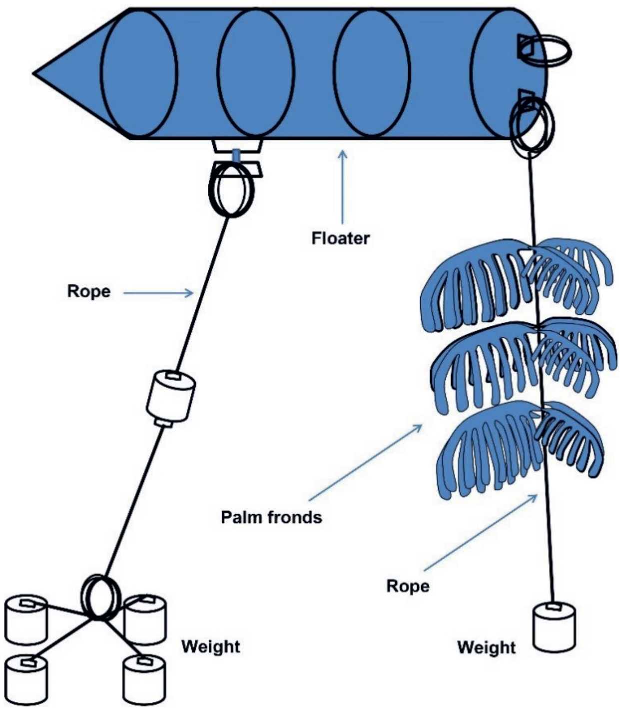


Figure 1. A cylindrical steel type payao with its parts that is commonly deployed in offshore waters by purse seine and ringnet fishers of General Santos City, Philippines.

Table 1. Milestones in the development of the tuna industry in the Philippines.

Year	Milestone	References
1885	The first book describing Philippine fish species entitled *"Peces de las Islas Filipinas"* was published in Madrid by Jose Gogorza y Gonzales	(Herre, 1953); (Lachica-Aliño L. et al., 2006)
1900s	The first 830 Philippine fish species were scientifically identified and described and eventually published in the paper *"Checklist of the species of fishes from the Philippine Archipelago"*	(Jordan and Richardson, 1910)
1920	Japanese and Taiwanese longline boats have been fishing in Philippine waters; start of real fisheries science in the Philippines with the first 830 fish species identified and catalogued	(Lachica-Aliño L. et al., 2006); (Aprieto, 2011)
1935	The first book under the US colonisation describing Philippine fish species entitled *"Philippine Fish Tales"* was published by Albert W. Herre	(Herre, 1935); (Lachica-Aliño L. et al., 2006)
1937	There were also records of boats 40 to 100 gross tons in capacity that have been based in Zamboanga City using pole and line fishing techniques with recorded catches of 1256.4 tons of skipjack and 264.5 tons of yellowfin tuna in 1937	(Aprieto, 2011)
1942-1945	Limited explorations of Philippine tuna during the Japanese occupation	(Vera and Hipolito, 2006); (Aprieto, 2011)
1947-1950	Philippine fishery program was launched with series of studies on oceanographic and fishing investigations in Philippine waters	(Aprieto, 2011)
1950	Bureau of Fisheries doing sporadic studies on principal fishing grounds	(Aprieto, 2011)
1950-1965	Launch of fishing exploration by the fishing industry through vessels acquired from Japan through war reparations program or joint business venture	(Barut et al., 2003);(Vera and Hipolito, 2006); (Aprieto, 2011)
1966	Most of the private tuna companies that begun in the 50s ceased to operate due to poor management, lack of experience, inadequate post-harvest facilities, shipping logistics and market	(Aprieto, 2011)
1970s	Commercial tuna fishing revived	(Aprieto, 2011)
1974	FAO confirmed the feasibility of using FAD in purse seining operations in Mindanao waters	(Babaran and Ishizaki, 2011); (Aprieto, 2011)
1990	The Philippines became the largest tuna producer in Asia	(Dickson and Natividad, 2000)

Because of the number of fishers involved in using this technology *payaos* played a critical role in Philippine fishery. The tuna fishing industry in General Santos City and Davao Gulf, which have around 117,705 fisherfolk, rely heavily on FAD usage (BFAR, 2015). Also, the Bureau of Fisheries and Aquatic Resources (BFAR) of the Philippines advocated and promoted the use of FADs as a livelihood project amongst artisanal fishers (Alave, 2012; Estabillo, 2013).

3.2. Fisheries production trend

Production data of purse seines and other commercial hooks and lines documented in the Philippines mostly covered the three oceanic tuna species. The production estimates were not deemed reliable mainly because data gathering activities were limited in scope to main harbors and to commercial species (Lewis, 2004). Annual tuna production in the Philippines have increased since the 70s because of purse seine FAD fishing (**Fig. 2**). The total annual production in 2004 was estimated at 325,000 tons (Williams and Reid, 2006). In contrast, Babaran (2007) estimates that during the late 1980s approximately 500,000 tons of tuna was produced for all boats and for all tuna species (skipjack, yellowfin and bigeye tuna), if catch per unit effort (tons per boat) were to be used. In his estimate, different purse seine vessels with different weight classes have different capacities e.g. 1114 tons for vessels with 30-50 GT and > 1200 tons for vessels with >250 GT.

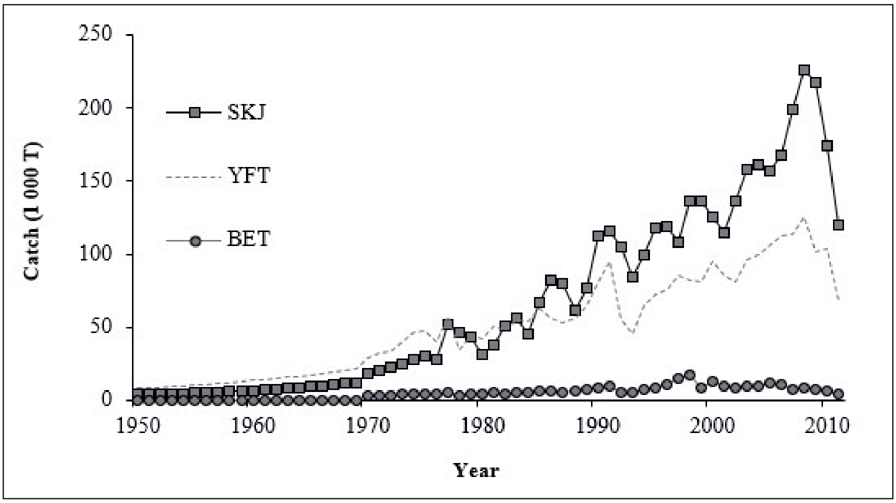


Figure 2. Estimated total catch production of large tuna species (skipjack, yellowfin and bigeye) from the Philippines (source: WCPFC data).

It seems that volume of catches were not properly recorded in the 1980s given that policies and monitoring was not effectively implemented nor there was any fisheries code drafted. Purse seines make 60% of the commercial total tuna production; the remainder is from other fishing gears such as bagnets, gillnets, troll lines, trawls, hook and lines, round haul seines, push nets, Danish seines, and ringnets (Aprieto, 2011).

About 60% of the total municipal production comes from hook and line. Purse seines, ringnet and hook and lines remain the dominant fishing gears closely associated with FADs. Recent catch-rate estimates by BFAR for fishers operating in General Santos City showed that purse seines caught 8.6 tons per day and 4,235 tons per month while ringnets caught 4.9 tons per day and 2,016 tons per month (based on NSAP data collection program from 2005-2012) (Bigelow et al., 2014). However, commercial tuna catch in the Philippines showed general decrease from 500,000 to 325,000 tons between 1990 and 2005 (Babaran, 2007; Barut and Garvilles, 2007).

3.3. Fishing operation

Purse seine fishing operation became simpler when fishers started deploying their *payaos* in specific territories claimed by their company since they simply have to return to their FADs. The FAD sites were then routinely monitored by ranger or scout boats primarily to find harvestable aggregations of tunas but also to guard FADs against theft and vandalism and to keep out other purse seine and ringnet fishing boats from other companies from setting their nets on their payaos. These scout or ranger boats are equipped with fish finders to monitor fish aggregations underneath the FADs. Once the amount of fish aggregated below a FAD was deemed “harvestable,” the captain from the scout boats will call on the master-fisher of the motherboat to approach the specific location of the FAD before midnight. Preparatory operations start by lighting the FAD to enhance the fish aggregation. FAD sets are done during early morning hours usually at 4 am which is sufficiently dark and before tuna dives to deeper waters during the day; FAD sets maybe done once or twice depending on the size of the fish aggregation (Aprieto, 2011; Mitsunaga et al., 2012; Mitsunaga et al., 2013). Before the start of the operation, ringnets and purse seiners will send divers (*boseros*) to assess the size, depth and composition of fish aggregation below FADs. Next, if the concentration is deemed sufficient, the attractor line with the palm frond from the FAD will be attached to the lightboat and towed away from the floating part of the FAD. The fish school follows the attractor line with the nipa palm frond attached. Then the motherboat begins positioning to pay off its net by using another auxiliary boat to surround the fish aggregation (**Fig. 3**). After hauling, the fish will be put on ice or soaked in brine and then transferred to the carrier boat that will land the fish to the homeport.

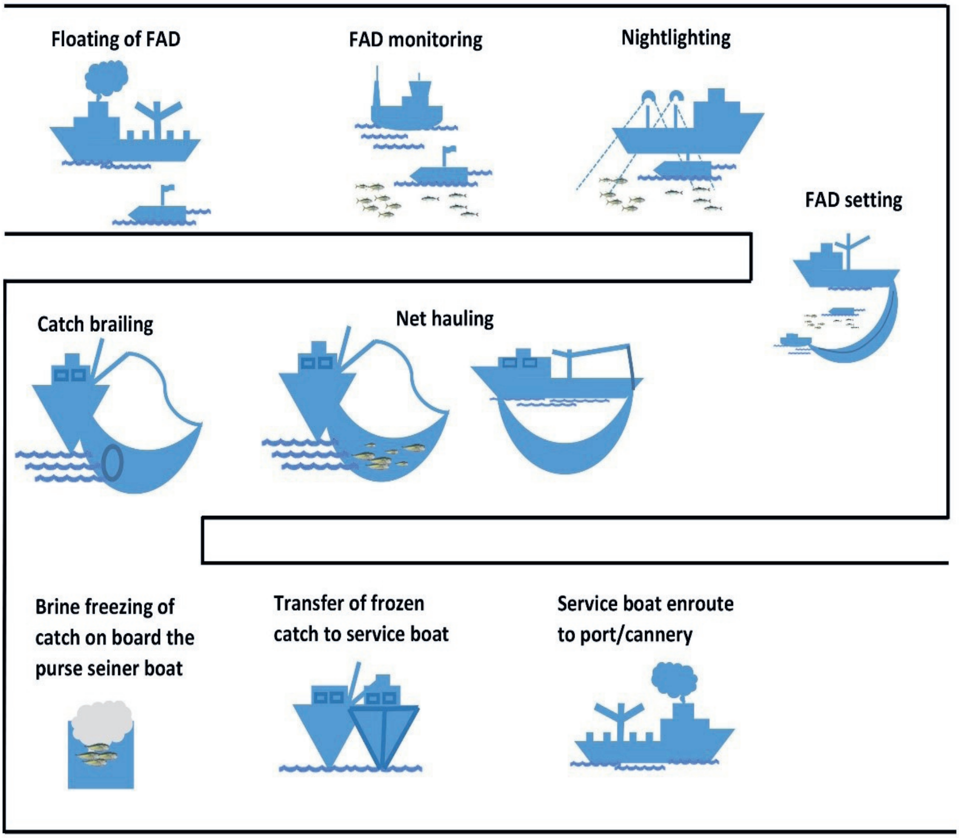


Figure 3. Fishing operation to haul the fish aggregation in a *payao* (Modified from Aprieto 2011).

3.4. Characteristics of the two fishing subsectors

Fishing strategies of purse seine and ringnet fishers differ from those of handline fishers: While the first two surround nets can be considered 'area specialists', the latter fishers are 'area roamers'. The two types of gears differ in their target species and their use of the *payao*. While both purse seine and ringnet focus on skipjack tuna and other small pelagics as round-scads, bullet and frigate tuna, swimming close to the surface the handliners focus on adult yellowfin and bigeye tuna found in deeper waters. But the main difference is in their choice of fishing grounds. Purse seine and ringnet fishers focus on maintaining their own fishing grounds with their payaos. FAD territories are claimed by fishers when they first deploy their FADs on a vacant sea-area. Sometimes, claims on an area depend on whether it is still guarded or already left by former occupants. The FAD territories are fixed because of the presence of strong regulation by the South Cotabato Purse Seiners Association (SOCOPA). This formal association of the purse seine and ringnet fishing companies in General Santos City and South Cotabato strongly regulates and implements their crafted rules among members and non-members alike. They are a well-respected governing body because of the high status of the members among the general populace. Among the serious offences considered by the association is to deploy FADs in areas already occupied by other companies. In cases where FADs are placed by a company in an area that is already claimed by a second company, the diplomatic resolution would be for the second company to pay or replace the cost of the FAD that was placed within its territory. Sometimes, an area can be claimed by another company if the area has been abandoned by the former owner. Abandonment happens when the company suffers bankruptcy, changes its fishing area or pulls out its motherboat and scout boats from the area for over two months or longer. Thus FAD territories are closely guarded to prevent FAD thefts and placement of other fisher's FADs.

The decision to move into a new fishing ground by purse seiners and ringnetters can be governed by three criteria: a) the company has no opportunity to expand its present territory; b) there is new area available that provides greater profit compared to the previous one; c) the company hears news of good fish catches in the new area from other companies or fishers operating in the area. These three reasons seem to govern the decision of most purse seiners and ringnetters to move and invest into a new fishing ground. When they move into a new area, they may abandon their past investments or FADs in the former area and invest in new FADs to be deployed in the new fishing ground. If in case the previous fishing area is not abandoned, this is guarded by a scout boat. On the other hand, the new fishing area must be able to provide them with steady supply of catch that can offset manpower, fuel cost and investments in boats and FADs. This will also mean that they have to add more lightboats or scout boats if their territory requires so. For instance, the minimum or usual number of FADs to be deployed or overseen by a company motherboat is usually 30 FADs. With this minimum deployment of 30 FADs per motherboat placed at a commonly mentioned distance between these FADs of about 5.5 km across and 9.3 km diagonally, a motherboat with two lightboats will have to scour daily a FAD deployment area of about 617 km2. With five motherboats, the combined total area for a company then will be 3085 km2 although this may not be strictly one contiguous area since companies may spread their motherboats in different locations and fishing grounds.

Handliners on the other hand move from one FAD fishing ground to another and thus are more nomadic: area roamers. Handliners do not pose a threat to purse seiners for a number of reasons: first of all, they differ in target species. Also, handliners inform purse seiners on the number of harvestable FADs in an area. Lastly, purse seiners allow handline fishers to fish on their FADs to avoid conflicts and the likely consequence of vandalism, theft or cutting of ropes of payaos. These different characteristics between purse seiners, ringnetters and handliners have consequences in terms of operation, mobility and information sharing. First that will be discussed will be the characteristics of purse seiners and ringnetters then those of handliners.

3.4.1 Area specialists: purse seiners and ringnetters

Purse seiners and ringnetters target fish species aggregating at the surface. As a rule, a purse seine fisher only sets on a FAD if the estimated catch is about 1000 kg. The breakdown of their catches from the interviews (n = 40) is: juvenile yellowfin tuna (15%), skipjack (19%), bullet and frigate tuna (21%), roundscad (25%), mackerel scad (8%), and bigeye scad (7%), rainbow runner (3%), golden trevally (1%), and dolphinfish (1%). Fishers consider a bad catch to be around 6 tons, a normal catch 14 tons, and a best catch 34 tons.

Based on the breakdown of the catches from the six focus group discussions (FGDs) on target species, fishers mentioned that the most frequent catch was skipjack (70%) followed by roundscad (20%-25%) and a mix of juvenile yellowfin tuna and other scads (5-10%). Table 2 gives the species commonly caught and their sizes as discussed by fishers during the FGDs.

Table 2. Common catch species of purse seine/ringnet and handline fishers and their common length and weight (based on six FGDs; PS=Purse seine, RN=Ringnet; n = 61).

Catch species (PS-RN)	Length (cm)	Weight (kg)	Catch species (HL)	Length (cm)	Weight (kg)
Skipjack tuna (*Katsuwonus pelamis*)	27	0.63	Yellowfin tuna (*Thunnus albacares*)	139	47
Yellowfin tuna (*Thunnus albacares*)	30	1.30	Bigeye tuna (*Thunnus obesos*)	152	50
Mackerel scad (*Decapterus macarellus*)	25	0.23	Sailfish (*Istiophorus platypterus*)	173	20
Bullet tuna (*Auxis rochei rochei*)	24	0.32	Swordfish (*Istiompax indica*)	185	74
Rainbow runner (*Elagatis bipinnulata*)	23	0.33	Skipjack tuna (*Katsuwonus pelamis*)	66	6

Fishers mentioned during the FGD that overall catches have declined from 18 tons to 7 tons per setting over a period of 20 years (**Table 3**) while handline fishers do not see much change in their daily catch rates. Furthermore, based on the FGD, fishers considered worst catches to be between 1-4 tons, normal catches 2-23 tons, and the best catches 18-47 tons. Purse seine and ringnet boat captains have indicated that they normally deploy 31 FADs per motherboat with estimates ranging from 3-5 to 60-100 depending on size and productivity of the area (n = 40). Area sizes based on a minimum of 30 FADs with a distance of five km between two FADs and a maximum of 90 FADs can range from 617 km2 to 1851 km2.

Purse seiners and ringnetters start their operation by planting FADs in their fishing ground. Operation will start within about two weeks after positioning FADs. By tacit agreement, companies that were able to first deploy their FADs in an area and map it out are entitled to have a hold over that fishing area. Although no one owns the sea and therefore the fishing grounds, and everyone are entitled to place their own FADs everywhere they may want to deploy their FADs, the more influential and the bigger a fishing company is, the greater their hold on their fishing grounds. The spacing of FADs can range from 2 to 9 km (1 to 5 miles) in the Sulu-Celebes area or 19 to 28 km (10-15 miles) in the Pacific by fishers operating from Mati. Handliners, when asked to estimate how many FADs the purse seine companies deploy per motherboat in their fishing grounds, gave an estimate of 27 to 89 FADs (n = 98). In addition, handline fishers identified during the interview that any number of their fishing areas may have 1000-2000 FADs deployed by various companies. According to boat captains based in the Sulu-Celebes Sea area or Moro Gulf, much of the area is already divided among fishers and fishing companies. A major concern expressed in the discussions was to find a place to deploy a FAD. Fishers thus are not free to search for productive areas! Because of the number of fishers deploying FADs, the area still available is just as important as the particular fishing ground in decisions to deploy FADs.

The distance between FAD deployment areas and the port has increased since the 1990s when FADs were first deployed up to 100 km offshore. By the year 2000, FAD areas have

Table 3. Mean number of catch and distance for purse seine/ringnet and handline fishers at different time periods. (Based on six FGDs; total fishers n = 61).

	Purse seine/Ringnet Catch (tons)	Distance (km)	Handline Catch (tons)	Distance (km)
Now	7	446	1.7	357
2000s	17	417	1.7	307
1990s	18	100	1.5	307

expanded on average to up to a reported 400km offshore, and currently, FADs are deployed on average up to 450km offshore (Table 3). Today, most of the purse seine and ringnet fishing companies in General Santos City have ventured in the three major fishing grounds to deploy their FADs: a) The East Philippine Sea, about 185-370 km of Mati; b) Sulu Sea, about 593 km from the homeport of General Santos City; and c) the borders of Malaysia and Indonesia, about 741 km from the homeport of General Santos City.

Purse seine and ringnet fishing boats are well equipped with compass (80%), short-wave and long-wave radios (60%), and GPS devices (83%). In addition they may carry radars (5%), and fish finders (3%). On average these instruments are deployed only fairly recently: GPS since 6 years, compasses since 8 years and radios since 6 years. However, some fishers have GPS and radio for as long as 17 years, while others have used the compass for as long as 20 years. As mentioned, during the 1990s, fishing operations took place relatively close to the shore and fishers relied mostly on the use of natural landmarks to guide them to their fishing grounds. However, since the early 2000s, distances from their homeports increased and precise navigation and communication handsets for monitoring fishing activities are required.

3.4.2. Roamers: handline fishers

In contrast to the area specialist, handliners are highly mobile and have knowledge of many locations. They generally fish as far as 500 km from General Santos City and they may roam to Celebes Sea, towards the Indonesian border while some reportedly also have operated in the Pacific and near Papua New Guinea. The typical distance to their fishing grounds is 407 km with a minimum of 185 km and a maximum of 556 km. To be a successful skipper of a handline boat, contacts with other handliners and skippers of lightboats are indispensable so that they can quickly decide to move into areas from which large fish catches are reported. Handliners mainly operate by moving to FADs and FAD areas where purse seiners may not have set their nets recently. Purse seine and ringnet operations disturb adult tunas, causing them to move away or move to deeper waters where they become impossible to catch. However, sometimes, there are fishing areas where an aggregation of tuna can be found and this is usually signified by presence of many tuna fishers. This is locally called “fiesta” by handliners as they try to catch as many fish as they could. The breakdown of handline catches (n=98 interviews) is: yellowfin (43%), swordfish (38%), sail fish (6%), sharks (7%), and sunfish (2%). The catch per trip is considered to be around 1 ton, a normal catch around 2 tons, and the best catch around

4 tons. During the focus group discussion on target species, fishers mentioned that the most frequent catch was adult yellowfin tuna (33%) followed by swordfish (33%), sailfish (14%), adult skipjack tuna (14%), and bigeye tuna (5%). Based on the FGD, catch per trip was considered to be worst at between 0.12 to 1.5 tons, normal between 0.34-1.83 tons, and best between 1-5 tons highly similar to the reports from the interviews.

Tuna handliners carry compasses (64%), radio (65%) and GPS (62%) for direction, communication and navigation. The GPS is used for precise navigational directions and for inputting FAD codes and their coordinates. Handliners bring with them cellphones, but these do not function further than 28 km into the sea, while radio signals can be useful at longer distances up to 93 km to contact base to monitor weather, directions, catches, financiers, friends or home contacts. On average, the use of communication equipment among handliners has been 6 year for GPS, 7 for compass and 7 for radio, again a relative recent development. However, some handliners have used GPS for 20 years and compass and radio for as long as 25 years.

3.5. Evidence for catch-rate distance relationships

The reported catch rates types (best, normal, worst catch) of purse seiners and ringnetters were positively related to distance of fishing ground to the port (r^2 =0.54, $p < 0.001$; **Fig. 4**). The model explains 48% of the variation in catches is explained (without interaction) for purse seine fishers, of which only 5 % of the variation in catch is explained by the increased distance irrespective of type of catch. Similarly, for tuna handline fishers there is a positive relationship between the reported type of catch rate (best, normal, worst catch) and the distance of a site from their homeport (r^2=0.33, $p< 0.001$; **Fig. 5**). The model for handline explains 28% of the variation of which only 4.3%of the variation in catch is explained by the increased distance irrespective of type of catch.

3.6. Decision-making of fishers where to fish and where to deploy FADs

Ranking the factors determining the fishing location for purse seine, ringnet and handline boat captains revealed that weather and currents are considered most important (25%), followed by price of fish (18%) and price of fuel (17%) (Fig. 6A). These three dominant factors are followed by lunar phase (8%), regulation (8%), other people's fishery (6%), debts and loans (5%) and previous catch (5%). Further analysis using PCA (**Table 4**) on the nine factors determining catch locations showed that the first two components explained

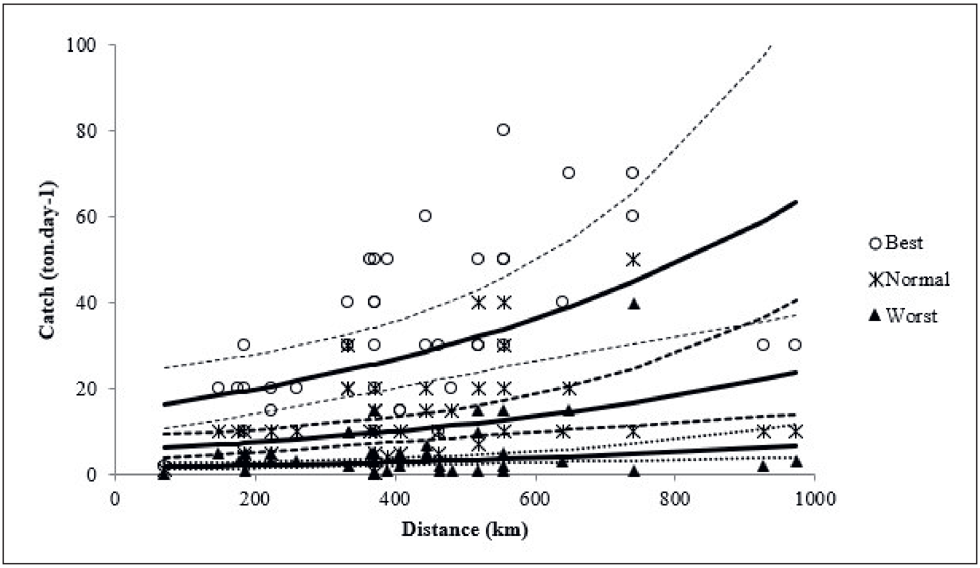


Figure 4. Best, normal and worst catch rates reported by purse seine and ringnet service boat captains plotted against distance from port of General Santos City. From top to bottom the black continuous trend lines show the best, normal and worst catches; the dotted lines are the confidence intervals for the respective trend lines (Best = Best catch; Normal = Normal catch; Worst = Worst catch).

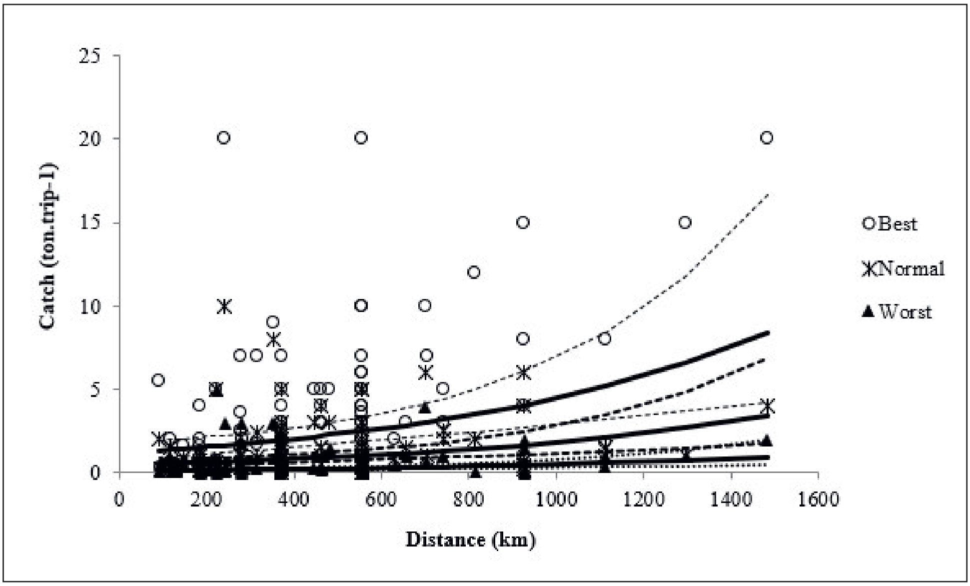


Figure 5. Best, normal and worst catch rates reported by handline boat captains plotted against distance from port of General Santos City. The trend lines show the upper and lower confidence limits of the best, normal and worst catches (Best = Best catch; Normal = Normal catch; Worst = Worst catch).

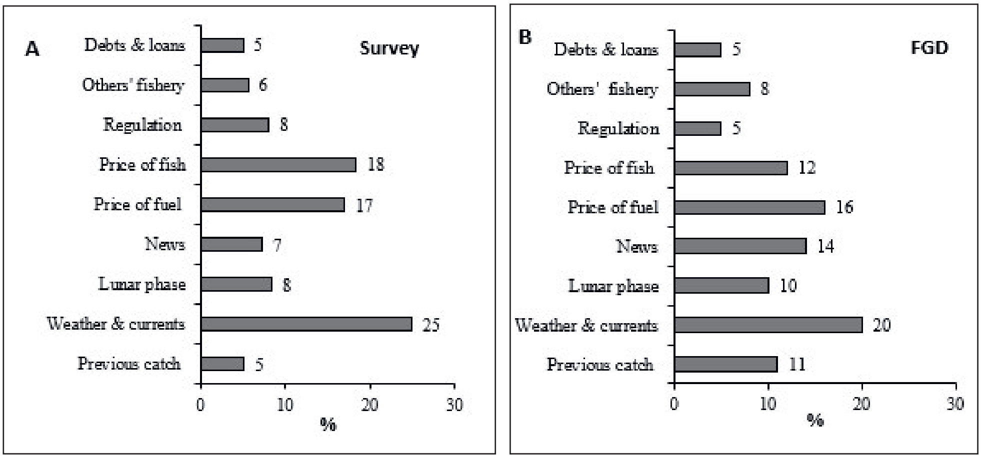
58% of the variation while an additional 11% was explained by the third component. The PCA showed that the nine factors could broadly be divided into three logically related components. The highest positive loadings (35%) on the first component showed three highly correlated factors considered by fishers when deciding where to fish pertaining to general flow of information (news, hearing from other fishers), experience (previous catch) and others' fishery (information on interference of other fishers such as theft and vandalism) and to a lesser extent regulations versus information on personal economic status through debts and loans that is strongly negatively correlated with these first three factors. The debts and loans referred to in this case are personal debts and loans of the captains and crews of fishing boats as the researchers particularly looked at the effects of debts/ loans at a personal level as motivation to stay employed in the fishing industry. These debts and loans thus have nothing to do with company debts or loans. The first component thus can be described as information axis where individual decisions to stay in the fishery are opposite and possibly override decisions to fish based on information and experience on fish availability.

Table 4. Factor loadings on the first three axes of the principal component analysis influencing fisher's decision making where to fish.

	Component		
Factors	**1**	**2**	**3**
Previous catch	**.867**	.067	-.054
News of fish catch	**.800**	.106	.050
Others' fishery	**.771**	-.043	.234
Debts & loans	**-.713**	.214	.280
Weather & currents	.181	**.656**	.150
Lunar phase	-.012	-.102	**.939**
Price of fuel	-.431	**.785**	-.004
Price of fish	.080	**.919**	-.195
Regulation	.495	.190	**.361**
% Total Variance	34.8	22.8	11.4

The second component (23%), pertains to short term economic considerations (price of fish and fuel) and the natural environment (weather and currents) that are almost orthogonal to flow of information and communication among fishers, indicating that these three considerations are largely uncorrelated with flow of information and communication. The third component explained 11% of the variation is dominated by lunar phase that in turn is uncorrelated with short-term considerations as well as weather and currents. This indicates that a monthly recurrent event as lunar phase is seen as of a different order in decision making than short term information driving decisions as weather and prices of fuel and fish on the one hand and socially mediated information and experience on fish catches. This also means that handline fishers that target adult deep diving tunas that are less affected by the lunar phase compared to surface fisheries such as purse seine and ringnets. Furthermore, results based on the focus group discussion in terms of short-term decision making with purse seine, ringnet and handline captains and crew show that the most important consideration are natural environment (weather and sea currents at 20%), economic in nature (price of fuel at 16%) and then socially mediated information (news at 14%; see **Fig. 6B**). Weather and sea currents go together as they both affect harvest efforts. A strong current may fold nets and give zero catch. With high waves during low atmospheric pressure or during typhoons, fishers usually stop fishing and look for a safe haven. Price of fuel heavily affects operation and maintenance because fishers need to routinely visit FADs to survey and catch fish. Moreover, oil as a commodity is not subsidized by the government in the Philippines and its price has always been prohibitive to fishing operation. News of good fish catches is indispensable especially in the case of the handline captains who must locate many fishing areas to obtain sufficient catch. Fish behaviour did not factor in the decision-making of fishers because they understood that a school of fish gets attracted to a FAD and do not stay there for a long time. Purse seine and ringnet fishers in general, refer back to previous records of catches to guide them in their FAD visits, especially when succeeding FAD catches are below 1 ton. In cases where abundant catches have been recorded on a FAD but the FAD does not exist anymore in the fishing ground the company may opt to replace the missing FAD. Other factors which were volunteered after the ranking was done include: vessel and equipment condition, net condition and the number of FADs. Boat captains and crew mentioned that even if you have an expectation of an abundant catch if your boats and nets are not working properly, you may lose the catch easily through broken nets. It was also mentioned that the minimal number of 30 FADs per motherboat enables rotation of at least one visit per FAD per month. According to captains and crew, the more FADs there are, the better because in their view this would increase the probability of higher day to day catches. For example, routine area visit of the FAD fishing grounds was the most important factor considered (39%), followed by previous catch or recent experience of good and best catch (28%), sonars and divers (21%) and catch of other fishers (12%).

Where to fish?



Where to fish?

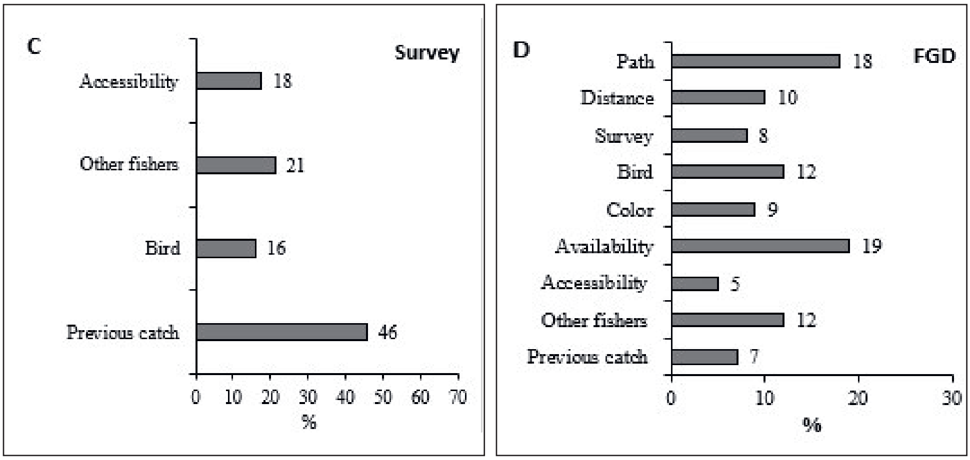


Figure 6. Factors considered by purse seine, ringnet and handline fishers influencing their tactic (A & B) and strategic (C & D) decision making based on semi-structured questionnaire survey and focus group discussion of different factors. (Debts and loans = Unpaid capital or fishing expenses; Others'fishery = Information on interference of other fishers such as theft, vandalism; Regulation = Rules and regulation on commercial and artisanal fishing by BFAR; Price of fish = Price of fish when landed; Price of fuel = Price of fuel expenses; News = News of fish catch from other fishers; Lunar phase = fish availability during lunar phases of the moon; Weather and currents = weather and sea state; Previous catch = Recent experience of good or poor catches; Path = Pathway of fish and current; Distance = distance between two FADs; Survey = Survey of area by fish finder and divers; Bird = Presence of birds in the fishing area; Color = Color of water in the fishing area; Availability = Availability of space in the fishing area; Accessibility = Nearness to the shore or homeport; Other fishers = Information from other fishers about feasible areas.

With regards to long-term decision making such as investing in FADs, the question where to deploy FADs was asked among purse seine and ringnet captains and crew. Previous good catches is considered to be the most important factor considered (46%), followed by information gained from other fishers (21%), accessibility of the fishing area (18%), and presence of birds (16%) (See **Fig. 6C**). During the focus group discussion, the same set of questions were asked among the fishers with regards to FAD deployment. Results showed that the availability of vacant space or site (19%) was the most important consideration for the fishers (**Fig. 6D**). This was followed by other three main considerations: fish migration routes and sea currents (18%), other fishers and presence of birds (12%).

Of the other factors influencing strategic decisions on when to deploy FADs in a fishing area, reports of having a good catch (68%) in the potential site location is deemed the most important criterion. This was followed by economic costs such as the price of FAD ropes and floater (16%).

4. Discussion

Anchored fish aggregating devices are a form of informal territorial claim over a small spot in a pelagic marine environment in an otherwise placeless marine space (Bush and Mol, 2015). Filipino purse seine and ringnet FAD fishers go one step further as they make informal property arrangements by claiming user rights over an extended marine space designated by the deployment of an array of anchored FADs that they monitor through scout boats operated from motherboats that are almost permanently at sea. Elsewhere, there are many examples of informal territorial arrangements enforced by the fishers in coastal marine and freshwater environments (Aburto et al., 2009; De Castro and Begossi, 1995) but the Filipino FAD arrangements are a unique for the pelagic realm. Because of the particular arrangement, fishers strategic decision-making on FAD deployment and consequently the limitation of their tactical options on where to fish are mainly governed by the availability of fishing space: purse seine and ringnet fishers are limited to fish only within their own territories and any extra-territorial fishing done within the territory of another fishing company is seen as theft. Such territorial conflicts between companies are often mediated by their own association that has defined a set of bylaws in addition to the customary laws of the fishers. For instance, if one fishing company abandons a fishing area, by pulling out all its motherboat and scout boats for a period of more than two months, another company may deploy their own FADs into that area, provided that they have fully decided to leave that area. The decision to fully transit into a new fishing area may take one year starting from the decision to find a new and available fishing area, to FAD deployment and FAD fishing operation. Interestingly there are no territorial conflicts with handliners who do not pose a threat to purse seiners, and are often used as informants about fish availability in the surface layers exploited by purse seiners. Handliners are thus able to roam freely over large spaces. The presence of FADs in many areas have provided new habitats to fish and has most probably increased the efficiency and space for movement of these gears as well.

FADs are highly efficient devices in attracting fish and were instrumental in the boost in tuna production all throughout the 1980s and the 1990s. However total catches appeared to be declining from 1990 onwards. Fishers who have been fishing for more than 20 years and who witnessed the boom of the fishery during the 1990s corroborate that catch rates are declining while fishing takes place at much larger distances than in the early days of the boom. General Santos City still receives a large amount of tuna but their origins are now predominantly sourced from international waters and from neighbouring countries rather than in Philippines alone (Babaran, 2006; Barut and Garvilles, 2012).

The changes in distance of FAD deployment is probably evidence of the decline experienced in the inshore fishing grounds during the late 1990s which also led to declining profits for tuna fishers. For example fishers based in Moro-Gulf report that they need to fish farther offshore or into other areas such as off the coast of Mati, in the Sulu Sea or border areas with Indonesia and Malaysia to remain profitable. This has led to technological change in these mediums scale fisheries: today, tuna fishing companies build bigger wooden and steel boats equipped with more powerful engines and stabilizers and FADs are now made of steel constructions with three compartments and are deployed in depths of more than 2500 m. In addition, fishing trips have become longer necessitating the use of bigger carrier boats. Another consequence of fishing farther offshore are concerns of labor issues with fishing crew who are required to remain on board of motherboats and are not enabled to go home for long periods of time while their passports or seaman's books are retained. Companies have a rotational system for their crew but extended stays of up to nine months are not uncommon. Motherboats rarely set back to the port unless for maintenance and repair or under emergency situations such as upcoming typhoon. All of these are adaptations by anchored FAD pelagic seine fisheries to the newer environment found offshore which poses greater risks of adverse sea conditions compared to fishing in more inshore areas.

4.1. Evidence for catch-rate distance relationships

The dynamic movement behavior of fishers in relation to availability of fished resources has been documented worldwide (Aburto et al., 2009; Bene and Tewfik, 2001; Caddy and Carocci, 1999; Daw, 2008). Migrations, redistribution of fishing effort and movement offshore of fishers are important strategies of fishers to offset their risk or losses or adapt to changes in stock sizes. The movements of Filipino FAD fishers, both handline and purse seiners into international waters are indirect evidences of how catch rates within Philippine waters have decreased (Babaran, 2006). The extension of fishing range of fishers is a common phenomenon observed in fisheries as they become exploited (Caddy and Carocci, 1999). Nevertheless, changes in ranges of fishing distance from ports or landing places do not necessarily indicate overexploitation of the fishery (Daw, 2008). Other reasons may be to avoid thefts, expectation of higher catches in areas less affected by fishing and access to technology as more powerful engines that can exploit territories deemed more pristine. However, in the case of fishers from General Santos City, the probability of occasionally obtaining higher catches per day or per trip, indicated by the "best" catches (**Figs. 4, 5**) is low in areas nearshore and increases further offshore. As fishers extended their fishing ranges to the east (Mati) and to the west (Sulu Sea) as well as down towards the Malaysian and Indonesian borders, this may tell us that the availability of tuna in coastal areas has decreased and that long-term declines of fish stocks in coastal areas maybe more severe than thought earlier (Aliño et al., 2004; Barut et al., 1997; Barut et al., 2003; Lavides et al., 2010) as the probability to obtain high catches has decreased. Although distance means more costs - fuel, labour and investments in FADs and vessels - the drive to remain profitable and the expectation of occasionally obtaining higher catches apparently offset these costs and motivate fishers to move further ashore.

4.2. Decision-making where to fish and when and where to deploy FADs

Factors influencing strategic decisions on when and where to deploy FADs are mainly prospects for a better catch in a new and available fishing area, economic reasons (price of FAD). Based on previous good catch experiences and what was heard and observed from other fishers, purse seine and ringnet companies make decisions to take risk by investing in new FADs to be deployed. Once FADs are operational, purse seine and ringnet fishers guard their territories but allow handline fishers to fish on their FADs. Tactical fishing decisions when and where to set nets are goverened by knowledge of the physical (weather) and biological (presence of fish) fishing condition in the area. Next are economic factors (price of fuel and fish) followed by flow of information (information from other fishers, news of fish catch, previous catches). Each of these factors may not necessarily be followed linearly as they are not correlated to each other. Fishers who fish on a FAD likely decide on the basis of his boat and gear condition to take risks informed by the expected weather condition and then weigh the economic cost (price of fuel) and benefits (fish catch) for an operation to take place. Other conditions such as lunar phase influencing fish availability and regulations are seldom factored in. However, regulations – state or informal - do contribute in the decision-making of fishers when considering whether they can fish freely on one location without distraction from other fishers, the navy or coastguard.

5. Conclusion

While FAD deployment maybe a long-term strategy to maintain hold of a fishing ground, FAD areas are not fixed. Possibly as a result of competition between companies over spaces to deploy FADs and/or reported reduction in inshore catch rates FAD areas moved from inshore to offshore areas. The purse seiners' and ringnetters' choice of factors that good catch and previous catch is necessary when and where to deploy FADs points to fisher's perception that a productive area must offset any fishing cost. Short-term tactical decision making of purse seine FAD fishers are mainly governed by this set of rules fishers only operate given the conditions that the boat and gear is ready, the weather is good and the information of presence of harvestable fish is positive. On the other hand, handline fishers' tactical decisions are mainly governed by consideration of good weather and information on presence of harvestable fish (news of good fish catch from other handline fishers or lightboat captains).

CHAPTER 3

Local Ecological Knowledge (LEK) on Fish Behavior Around Anchored FADs: the Case of Tuna Purse Sein and Ringnet Fishers from Southern Philippines

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Abstract

The use of anchored FADs (*payao*) transformed the Philippine tuna fisheries into a million-dollar industry that plays important role for food and employment of Filipino fishers. Minimal studies on exploitation rates and fish behaviour around anchored FADs have hampered further understanding of this fishery. Studies on fish behavior using local ecological knowledge (LEK) is a good complement where data is limited. A semi-structured interview (n=46) and three focus group discussions (n=39 participants) were used to record fishers' knowledge and observations on the behavior of different fish species around anchored FADs particularly on attraction, retention and departure behaviour of fish. Based on fishers' knowledge, tuna schools are attracted to anchored FADs at 10 km distance. In anchored FADs, tuna form schools segregated by species and size. There was no relationship between the attraction distance and the reported school size and the various waiting times for fish to aggregate below the FADs. There was no variation between the species present at day or night time although fishers have reported a distinction of species found near the surface (0-10 m) and those found at other depths (11-20 m). Juvenile yellowfin tuna (*Thunnus albacares*), skipjack (*Katsuwonus pelamis*) and frigate and bullet tunas (*Auxis spp.*) are found to stay at 25-50 m from the FAD at a depth of >20 m. Adult oceanic tunas reside in deeper waters (75 m). The fish visual census produced similar results with the semi-structured interviews and FGDs but did not observe oceanic tunas at depths of 15-20 m in the anchored FADs examined.

Keywords: FADs, Fish aggregating devices, LEK, *payao*, Philippines, tuna

1. Introduction

Fishers are highly dependent on marine resources in terms of food and income, which led to resource over-exploitation and decline (Bell et al., 2009; Nañola Jr et al., 2011). Some fisheries, such as tuna, have been fished down to its threshold sustainable yields, bordering towards unsustainability (Juan-Jordá et al., 2011). Increased demand for food due to burgeoning population and the improvement of fishing efficiency has caused marine species population declines because of the advent of technological advancement in fisheries such as real time weather monitoring, three dimensional sonars and chlorophyll a productivity patterns in many fishing grounds (Anticamara et al., 2011; McCauley et al., 2015; Pauly et al., 2002). Moreover, the increasing knowledge on fish behaviour has aided in the increased fishing efficiency of fishers, even further increasing the exploitation rates in the fisheries (Anticamara et al., 2011). For example, the knowledge that fish tends to be attracted to floating structures in the ocean led to the development and utilization of fish aggregating devices (FADs) (Dempster and Taquet, 2004; Freon and Dagorn, 2000). The effectiveness of FADs in increasing fish catch instigated its extensive use for both artisanal and industrial fishing (Fonteneau et al., 2000; Freon and Dagorn, 2000). According to Fonteneau et al., (2000), the proliferation of FADs globally introduced uncertainties to marine fishery. For instance, the application of FADs to artisanal fishery have led to difficulties in assessing the effects of this fishing method due to a high number of artisanal fishers, making assessment logistically challenging (Teh and Sumaila, 2013). Until now, the use of anchored FADs in the commercial tuna fisheries in the Philippines have not been investigated in terms of perceptions and local ecological knowledge of purse seine and ringnet fishers on the behavior of tuna and other pelagic fish species around anchored FADs. Fish schools often aggregate around anchored FADs and other floating objects possibly utilizing these objects as meeting points to form even larger schools (Soria et al., 2009). There are many factors that influence the schooling behavior of fishes which includes increasing its survival through predator avoidance and increasing foraging efficiency, among others (Hoare et al., 2000). The schooling behavior of fish also plays an important role on the time spent by fishes under the FADs, the mechanisms of fish aggregations under floating objects and other causes for fish departure. An understanding of the schooling behavior of tunas especially how they can replenish the harvested biomass under the FADs will be useful in predicting the catch of fishers per FAD. This study was carried out in the context of providing an overview on the tuna exploitation and fishing patterns of purse seine and ringnet fishers around anchored FADs especially on tuna behavior.

1.1 The Philippine tuna fisheries

Tuna fishery in the Philippines started after World War II. From 1947 to 1950, the fisheries program was launched, in conjunction with series of studies on oceanographic and fishing investigations in Philippine waters (Aprieto, 2011). However, real commercial exploitation of tuna started in 1974 to capture skipjack (*Katsuwonus pelamis*), yellowfin (*Thunnus albacares*), bigeye (*Thunnus obesus*) and roundscads (*Decapterus spp.*) as well as other small pelagics (*Auxis spp., Selar crumenophthalmus, Elagatis bipinnulata, Megalaspis cordyla, Coryphaena hippurus*) (Macusi et al., 2015b). The purse seine and ringnet fisheries pioneered the use of FADs to capture pelagic species and since then have been deployed in various coastal areas of the Philippines (Dickson and Natividad, 2000). The increase in FAD use has led to increase in fisheries production (Macusi et al., 2015b). In the 1980s, fishing operations were preferably close to the shore which ensured lower fuel costs and fresh catch (Libre et al., 2015). However, this changed in the 1990s as the distance between FAD deployment areas and the homeport increased from 100 km to 500 km offshore (Macusi et al., 2015b). This may be due to the fact that better catches were reported in FADs located farther away from the shore (Kakuma, 2000).

As the tuna fisheries developed further, more fishers and ancillary industries relocated to General Santos City, in southern Philippines. Investments in private shipyards, docking stations, net and rope factories and steel fabrications, preharvest and postharvest facilities, cold storage plants, ice plants and canning factories soon followed making General Santos City the tuna export capital of the country (Macusi et al., 2017b). At present, there are six tuna processing and canning plants in General Santos City and two processing plants in Zamboanga City. These processing plants have an annual capacity of 124,000 MT of tuna with an average total annual export value of 21.6 billion pesos in the last five years (2010-2014)(Barut and Garvilles, 2015).

According to the Philippine Fisheries Code of 1998, a fisher in the Philippines can be classified as a commercial fisher if he owns a motorized boat with a capacity of 3.1 GT and above and fishes offshore starting at 15 km. Anchored FADs are not cited as a requirement to be a commercial fisher in the Philippines but most of the commercial fishers utilize FADs (*payao*) to significantly increase their catch, for instance purse seines, ringnets and tuna handlines (Dickson and Natividad, 2000). The use of anchored FADs in the Philippines had been widely adapted by both artisanal and commercial fishers (Aprieto, 2011; Dickson and Natividad, 2000). Anchored FADs are distinguished from drifting FADs by the presence of a mooring system that anchors their floaters made of bamboo rafts, styrofoam, or steel drums to the sea bottom. One investment for a nearshore FAD to be deployed at 10-15 km would cost Php 30,000.00 (U$500) per unit. However, FADs that are anchored at depths of 2500-5000 m in Mati (Philippine Sea), Celebes and Sulu seas would cost Php 120,000.00 (U$2500) per unit. FAD deployments are modulated by the availability of space in the fishing grounds and productivity of the area in terms of catch (Libre et al., 2015; Macusi et al., 2015b).

A typical purse seine and ringnet fishing fleet in the Philippines is comprised of a catcher vessel, two carrier boats, and three lightboats manned by a master fisher aboard the catcher vessel overseeing and managing the daily fishing operations (Dickson and Natividad, 2000), . Since anchored FADs play a significant role in the fleet's fishing activities (Aprieto, 2011), the small multirole vessels (lightboats) are used together with the catcher vessel to guard the FADs and monitor the biomass of fish beneath the FADs (Macusi et al., 2015b). Once a sufficient biomass of fish has aggregated in the FADs, carrier vessels are sent to the site. To maximise the FAD's attraction efficiency, lighting of the FADs during the evening is conducted and nets are set at dawn after lighting. Carrier vessels with catcher vessels operating in the High Seas usually unload fish once a month while other carrier vessels that operate in Philippine waters may go back twice a month to bring the catch.

1.2 Local Ecological Knowledge

In the past, local ecological knowledge (LEK) was often dismissed as anecdotal and of lower scientific value (Johannes and Neis, 2007). However, LEK has played an important role in conservation studies and policies. For example, Rajamani (2013) and Rajamani and Marsh (2010) utilized LEK to identify gaps in dugong (*Dugong dugon*) conservation in data limited areas of the Sulu Sea.

Recent developments in the fisheries management recognize the significance of LEK, especially in cases where minimal empirical data are available (Silvano and Valbo-Jørgensen, 2008). Fishers spend substantial amount of time fishing at sea, accumulating important information on fish diversity, reproduction, ecology and behaviour through their experiences (Baird and Flaherty, 2005; Johannes and Neis, 2007; Lavides et al., 2010). LEK has been proven to be a good complement to empirical data. According to Johannes et al. (2000) when LEK was ignored, underestimation of biological samples or populations occurred.

Investigations on fish behavior were carried out with the aim of understanding fundamental behavior patterns (Cooke et al., 2004; Pitcher, 1993). Most researchers study fish behavior for various reasons, one of which is to understand its effect on physiological functions (Cooke et al., 2004). Fréon and Misund (1999) stated that there are very few studies on fish behavior around anchored FADs and therefore we lack knowledge on this field. Gathering fishers' LEK is a good methodology to help bridge this knowledge gap. In the case of Filipino purse seine and ringnet fishers, they spend so much time at sea acquiring detailed knowledge of their prey and of their fishing grounds. Among the ranks of FAD-based fishers, the master fishers, boat captains, master netters and divers are the ones with the most knowledge on fishing operations. These individuals have become experts in providing reliable information on fish behavior as they are responsible for planning and daily fishing operations. First, the master fisher (*piyado*) oversees the fishing fleet in the fishing ground. He has both navigational and leadership skills to lead in the boat; he crafts and executes fishing expeditions, uses his knowledge on when and where to deploy FADs. He is familiar and knowledgeable of the movement patterns of fish, current directions, waves as well as the local weather. Second, the boat captains (*kapitan*) have navigational skills based on using compass, maps, GPS and oceanographic knowledge; they are also exposed to daily fishing operations. Third, the master diver (*maestro bosero*) obtains estimates of the biomass of fish aggregated below a FAD during monitoring before a FAD can be lighted or set. Last, the master netter (*maestro pokotero*) oversees the deployment of a net during a fishing operation and works to keep it clean and orderly after a fishing operation.

Data from other sources show that they understand the three-dimensional aspect of fish movement, schooling and aggregation behavior around anchored FADs

(Moreno et al., 2007a; Moreno et al., 2007b). Thus, by having understanding on fish behavior such as the patterns of movement as well as abundance of tuna in their fishing grounds, they can decide where, when and how to deploy their fishing gears and accessories which aid them in capturing fish more effectively (Moreno et al., 2007b). As FAD deployment is not a random choice event, the fishers' decision-making is informed by risks, abundance of catch and operational factors or constraints (Libre et al., 2015; Macusi et al., 2015b). The daily experience of fishers become condensed information that can be gathered by field researchers providing detailed knowledge for our studies on fish behavior (Johannes et al., 2000; van Densen, 2001). Integration of behavioural studies in conservation biology has seen positive results (Sutherland, 1998). Caro (2007) recognizes the contribution of descriptive behavioural information in addressing specific conservation challenges. With dwindling fisheries resources (Anticamara and Go, 2016), understanding fish behaviour could aid in the conservation and management of these resources.

The objectives of this study are to: 1) catalogue fishers' knowledge and perceptions on tuna and other pelagic fish behavior around anchored FADs; 2) provide fish species characteristics and distribution and 3) test whether the reported school size, large or multiple schools have any association with attraction distance, fish aggregation and length of stay of tunas below the FADs.

2. Materials and Methods

2.1 Conduct of interview

All interviews were carried out in accordance with the Wageningen Code of Conduct for Scientific Practice, approved by the Executive Board of Wageningen University and Research on September 15, 2008. All interviewee information was de-identified in the analysis. Before the conduct of the survey, letters of consent for interviews were sent to the local offices of the Bureau of Fisheries and Aquatic and Resources (BFAR), Philippine Fisheries Development Authority (PFDA), and the Philippines Ports Authority (PPA), upon approval, interviews were then conducted in the landing sites. The interview was conducted between August 27 to October 25, 2013 in General Santos Fish Port Complex (GSFPC) and in Mati Port in Davao Oriental (**Figure 1**).

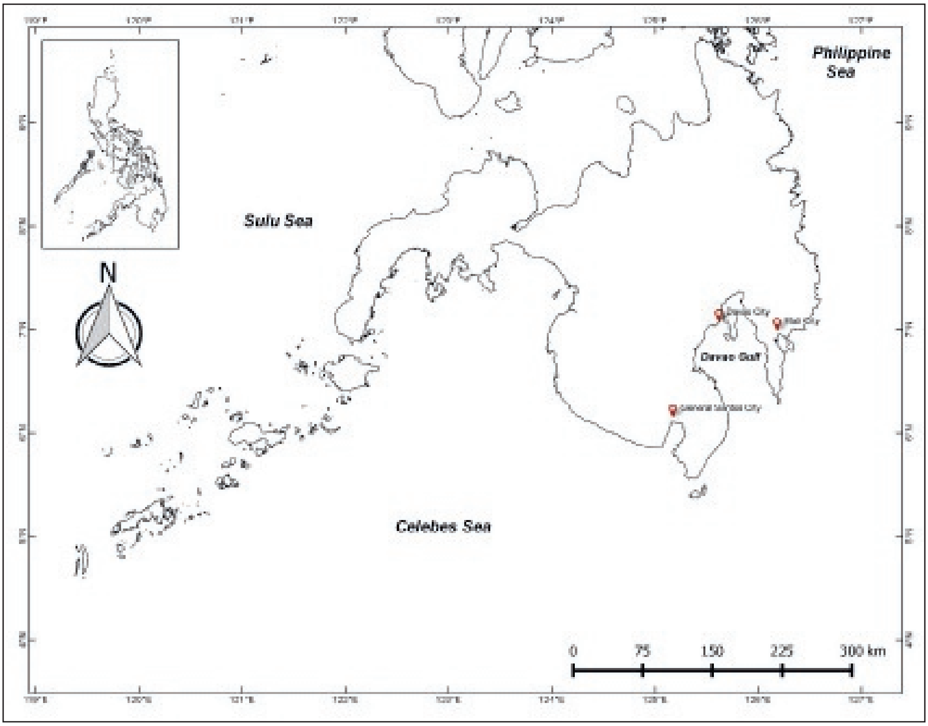

Figure 1. Map of the study sites and the fishing grounds adjacent to them.

The respondents in the two locations were both purse seine and ringnet fishers of various fishing companies based in General Santos City. The opportunistic interview conducted with the fishers at the Port of Mati was based on information relayed to the researchers that some fishers were docked in the port after a typhoon was forecasted to pass their fishing sites. Respondents were fishers who were identified to provide detailed information on catch trends, schooling behavior and movement patterns of fish around anchored FADs. A total of five master fishers, seven master divers and seven master netters and 27 carrier boat captains from 30 purse seine boats and 16 ringnet boats were interviewed individually (n=46). Among the respondents, the master fishers who direct the fishing operation and FAD deployment, were known to have over two decades of working experience at sea.

As the only difference between a purse seine and ringnet boat, is the mechanical or manual hauling of the net during a fishing operation, the respondents are considered to be of the same set, particularly in terms of knowledge and exposure to FAD fishing and fish behavior in their fishing ground. Our respondents were all purse seine and ringnet fishers from fishing companies based in General Santos City, Philippines. The interviews lasted from 15-45 minutes and interview was ceased when similar answers were already obtained.

2.2 Interview design and strategy

The interview dealt primarily with the respondent's perceptions of the behaviour of fishes associated with anchored FADs, specifically attraction, retention, and departure behaviours. We also added questions on species distribution and community characteristics below the FAD. The interviews were done in the local dialect (*Cebuano*). Questions on the general locations of FADs were asked from respondents but specific locations were withheld to keep this important information from competing fishing companies. Although interviews were done using a semi-structured format, respondents were allowed to answer freely.

The information that fishers providedduring the individual interviews was verified through three focused group discussions (FGD) particularly on fish species distribution during day time and night time in the anchored FADs. The three FGDs were conducted on August 27, 2013 (N=20), September 30, 2014 (N=11) and October 1, 2014 (N=7) and with total attendance of N=39 (masterfishers, boat captains and crews). During the FGDs, fishers were shown a drawing of a FAD with fish found at various depths then they were asked what species were found near the FAD (0-2 m) and at various depths of 0-10, 11-20, 21-50 and >50 m. The question was also repeated for fish species that could be far from the FAD (25-50 m) and at various depths of 0-10, 11-20, 21-50 and >50 m. The distances were based on the intranatant and extranatant (0.5-2 m) classification of Freon and Dagorn (2000).

2.3 Data analysis

The information gathered from the fishers were quantified as percentages of total responses per question. Similar answers were grouped together under themes and these were shown through tables and figures. To examine similarities or differences with scientific research based information on tuna behaviour, answers provided by fishers were compared with the available scientific literature on tuna behaviour and secondary data on fish species characteristics related to anchored FADs. Data was further analysed using one-way ANOVA after checking normality of distribution and homogeneity of variance using Shapiro-Wilk's test and Levene's test. If the data was not normally distributed, a one-way ANOVA was still used as

ANOVAS are robust to slight deviations from normality (Quinn and Keough, 2002; Underwood, 1997). We tested the association of reported school size whether single or multiple to attraction distance, normal wait time for fish, wait time for the first appearance of tuna, and wait time for fish after a fishing event (dependent variables). The association of various tuna species to attraction distance and the various wait times were also performed using one-way ANOVA. In addition, a paired sample t-test was used to compare the presence and abundance of species during day time and during night time at depths of 0-10 m and 11 to 20 m from the semi-structured interviews. All statistical tests were performed at significance level of $P < 0.05$. All statistical analyses were performed using IBM SPSS Statistics for Windows, Version 23 (Armonk, NY: IBM Corp.).

2.4 Verification and validation

Information were also gathered using dive survey of FADs to ascertain the species distribution from the semi-structured interview and the FGDs. Although the location of dive site was in Davao Gulf, the authors assumed that fish species found could be similar to those mentioned by fishers in the interview whose fishing grounds are located in Sulu/Celebes Sea and the Philippine Sea, much farther than Davao Gulf. Fish names, comparing local names and scientific names were confirmed using various local literature (Ganaden and Lavapie-Gonzales, 1999; Herre and Umali, 1948), trip to the market and the use of fish base (Froese and Pauly, 2016). A diver assessment survey was performed by three professional licensed divers equipped with scuba gears at depths of 0-20 m in ten randomly selected anchored FADs in Davao Gulf. The dives were performed on March 28 to 31, 2016 and lasted on average from 15 to 44 min. The divers went down together to reduce disturbance. The visualcensus was done only in clear waters with a horizontal visibility of 10-20 m. All throughout the 10 dives, one diver performed the fish species identification assessment and another one used the video to record and document the fishspecies and the third one watched for the safety of the group. The divers would enter the water scanning the various depths of 5, 10, 15 and 20 m of the FADs. All species at these depths were recorded and counted, including fish species found hiding inside the palm fronds. The time and GPS locations of the dives were recorded and the fish species found during the dive and their behavioral characteristics were observed and summarized in a table.

3. Results

3.1 Interview of fishers

The mean age of respondents was 42 (± 10 s.d.), with 16 years of fishing experience at sea (± 11 s.d.) and have a total cumulative years of experience of 653. The mean boat length was 88 feet (+30 s.d.) and the mean boat weight was 83 tons (± 60 s.d.) with a mean boat power of 342 HP (± 146 s.d.) (see **Figure 2** for typical purse seine boats used in the Philippines).

Figure 2. Purse seine boats docked side by side at the General Santos City Fish Port Complex preparing for deployment to the High Seas.

Figure 3. Materials ready for deployment offshore including steel FADs. Note the rocket like steel drum. The nose always points to the direction of the current; the fishers are standing on concrete anchors made of mixed gravel, stones, rocks and cement.

According to our respondents, they gave estimates of the deployed FADs at an average of 100 FADs (± 100 s.d.) per company in their fishing grounds and have a cumulative total of 4600 FADs for the various companies (see **Figure 3** for offshore FADs). The respondents also mentioned an average of 40 (± 17 s.d.) FADs per catcher vessel or motherboat. Respondents also reported that they used more than 30 FADs per motherboat, to rotate visiting the different FADs within a month. Moreover, the FADs could be lost due to vandalism or get entangled in the lines of other fishermen. They can also be lost due to strong currents or wave action.

Majority of the respondents mentioned five main motivations in selecting their present fishing grounds: fish abundance and bigger fish size (63%), fish abundance only (24%), available area to fish (7%), fish abundance and available area (4%) and bigger fish size (2%). In addition, the respondents described their fishing grounds as either characterized by calm current (30%) or affected by moderate to intense waves (70%). Areas that are wavy are described to have rough waves and strong currents; these fishing areas are exposed to typhoons during the rainy season.

The respondents also regularly mentioned their target species: skipjack tuna (*Katsuwonus pelamis*) (27%), roundscad (*Decapterus spp.*) (24%), juvenile yellowfin tuna (*Thunnus albacares*) (22%), bigeye scad (*Selar crumenophthalmus*) (9%), frigate/bullet tuna (*Auxis spp.*) (6%), rainbow runner (*Elagatis bipinnulata*) (5%), triggerfish (*Sufflamen fraenatum*) (2%), mackerel (*Rastrelliger spp.*) (2%), golden trevally (*Gnathanodon speciosus*) (2%) (**Figure 4A**). However, the respondents mentioned that rainbow runner (24%), golden trevally (24%), roundscad (18%), and triggerfish (9%) are the first species to aggregate in the anchored FADs (**Figure 4B**).

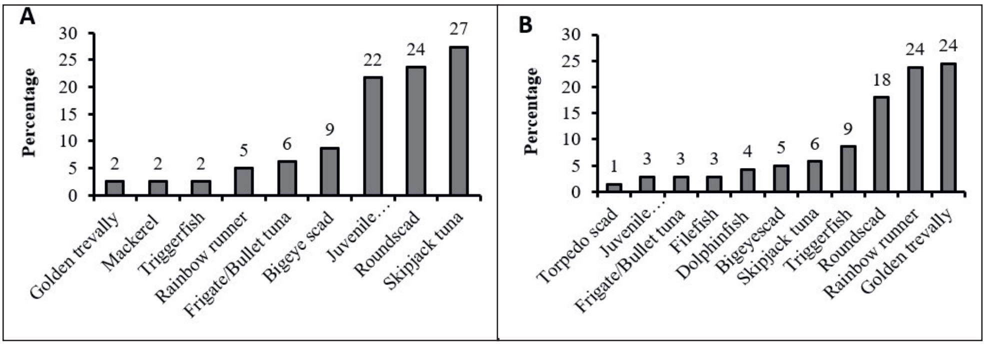

Figure 4. Target fish species mentioned by fishers during interview (a) and proportion of occurrence of various fish species as pioneers in anchored FADs according to respondents (b). Numbers are percent of the total interviewees that mentioned given information (n=46).

A few of the respondents also remarked that skipjack tuna (6%), bigeye scad (5%), dolphinfish (*Coryphaena hippurus*) (4%), filefish (*Aluterus monoceros*)(3%), frigate/bullet tuna (*Auxis spp.*) (3%), juvenile yellowfin tuna (3%) and torpedo scad (*Megalaspis cordyla*) (1%) are also sometimes observed to arrive first in the anchored FADs. These species were later followed by adult (big) tuna species such as bigeye tuna (*T. obesus*) (16%), skipjack tuna (*K. pelamis*) (26%) and yellowfin tuna (*T. albacares*) (30%) (**Figure 5**).

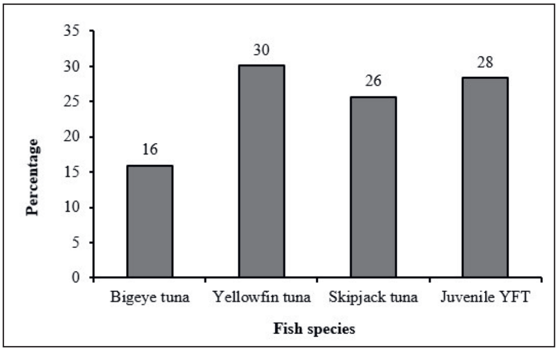

Figure 5. Proportion of occurrence of various tuna species around anchored FADs according to respondents. Numbers are percent of the total interviewees that mentioned given information (n=46).

3.2 Attraction, retention and departure behavior of fish in anchored FADs

Detailed answers from the respondents concerning the attraction behavior of fish to anchored FADs are summarized in **Table 1**. The respondents commented that tunas were attracted to FADs from 1 km to 10 km. This knowledge was based on the perception that tunas transfer from one FAD to the other FAD, which was estimated to be 10 km apart, on average (Macusi et al., 2015). According to the respondents, these tuna movements in between FADs are often characterized by the flocking of seabirds and fish leaping out of the water.

Detailed answers related to fish attraction were shown in **Table 1**. On average, the respondents have mentioned that fishers must wait for 11 days after the first deployment of the FAD before checking the biomass contents of their FADs. This waiting time could range from 2 to 30 days. After a fishing event on the FAD, fishers then have to wait on average about 10 days before the FAD will have a new aggregated biomass. The respondents have also proposed that these smaller fishes (e.g. triggerfish and golden trevally) serve as prey to attract other fish. On the other hand, waiting time for the first schools of skipjack, yellowfin and bigeye tunas take 22 days on the average; sometimes they appear as early as 5 days or as late as 2 months. Majority of the respondents have suggested that a school of tuna under a FAD is due to aggregation of multiple smaller schools of tuna (89%). Other fish species such as scads and mackerels of similar sizes also form their own schools (96%). Divers of the fishing fleet also observed that various fish species segregate based on sizes, with different size groups of the same species occupying different layers of the water. Tuna were also observed to exhibit vertical movement behaviour during early morning hours (4 to 8 AM) (35%) and move away from the FAD during day time hours (8 AM to 4 PM) (26%). Some respondents observed both behaviors (17%).

Table 1. Fishers responses related to attraction behavior of fish to anchored FADs.

Attraction behavior of fish to anchored FADs		
Attraction distance to FADs	**Meters**	
Average	1000	
Min	20	
Max	9000	
Wait time for fish to aggregate below FADs	**Days**	
Average	11	
Min	2	
Max	28	
Wait time for fish to aggregate after a fishing event	**Days**	
Average	9	
Min	3	
Max	21	
Wait time for other fish species to aggregate below FADs	**Days**	
Average	22	
Min	5	
Max	60	
What are the source of fish school?	**Response**	**%**
Single large school	5	11
Multiple school of fish	41	89
How are fish schools organized?	**Response**	**%**
Size	2	4
Species and size	44	96
Some observed behavior of tuna fish	**Response**	**%**
Fish moves up and aggregate near the FAD (early morning)	26	57
Fish moves away from the FAD (day time)	12	26
Fish moves up and aggregate near the FAD and fish moves away from the FAD	8	17

Majority of the respondents stated that the main reason for aggregation of fish under FADs is due to the presence of food and shelter (**Table 2**). The respondents claim that fish feed on algae, shells and barnacles on the ropes and the palm fronds. Other fishes prey on anchovies or smaller sized schools of frigate/bullet or skipjack tuna or early juveniles of other fish species. The presence of krill-like organisms had also been attributed to attract other fish species towards the FAD. Meanwhile, other respondents stated that social interaction is also a reason for fish aggregation under FADs. (Social interaction here is defined as the attraction of fish to other fish because of similar sizes or being conspecifics). According to interviewed respondents, the length of stay of tunas around anchored FADs is from less than a week to more than a month, with majority of the fishers agreeing that tuna stays for two weeks (48%) around the FADs (**Table 2**).

Table 2. Fishers responses related to retention and departure behavior of fish to anchored FADs

Retention and departure behavior of tunas		
Reasons why tuna aggregate around FADs	**Response**	**%**
Tunas find food around FADs such as algae, shells, barnacles	3	7
Tunas find shelter or protection from other predators	8	17
Combination of food and shelter	26	57
Combination of food and sointeraction	3	7
Combination of food, shelter and social interaction	6	7
How long do tunas stay around FADs	**Response**	**%**
< 1 week	1	2
1 week	5	11
2 weeks	22	48
3 weeks	1	2
1 month	13	28
> 1 month	4	9
Reasons for tuna to leave a FAD	**Response**	**%**
Distraction from passing of anchovies and from visits of marine mammals	10	22
Sudden change of currents due to winds, typhoons and seaquakes	1	2
Distraction from passing of anchovies and from visits of marine mammals and change of sea current	29	63

Distraction from passing of anchovies and from visits of marine mammals and change of sea temperature	1	2
Combination of all of the above reasons	5	11

As shown in **Table 2,** fish schools of small pelagics such as roundscads (*Decapterus spp*.), bigeye scads (*S. crumenophthalmus*) and other small tunas are mainly disturbed by distraction from a passing school of anchovies or visits of marine mammals and through change of current strength and direction either due to a typhoon, seaquake or strong winds (63%), while other reasons for disturbance mentioned by fishers is change in sea surface temperature. The presence of cetaceans is known to the fishers to distract the fish schools in the anchored FAD causing them to leave temporarily. Sea current was mentioned by fishers to affect the fish schools just as a school of anchovies and change in sea surface temperature. This usually happens when the current direction changes unpredictably due to the meeting of two currents or a sudden change of wind direction. Typhoons are also known to change sea current direction because of strong winds, as well as undersea earth quakes that jolt the fish.

Table 3. Variables tested for its association with the reported fish school size and various tuna species using one-way ANOVA.

		School size			Tuna species		
Variables	**Source**	***df***	***MS***	***P***	***df***	***MS***	***P***
Attraction distance	Between Groups	1	828017	0.572	7	2111912	0.582
	Within Groups	44	2558600		38	2595343	
	Error	45			45		
Wait time (fish)	Between Groups	1	22	0.431	7	36	0.410
	Within Groups	44	34		38	34	
	Error	45			45		
Wait time (tuna)	Between Groups	1	31	0.696	7	126	0.743
	Within Groups	40	197		34	207	
	Error	41			41		
Wait time (fishing event)	Between Groups	1	19	0.321	7	11	0.792
	Within Groups	44	19		38	20	
	Error	45			45		

On the other hand, the results of the ANOVA test on reported school size whether large or small and various tuna species on attraction distance to the FAD, waiting times for fish to arrive at a FAD, or for the first appearance of schools of tuna, or for fish to re-establish after a fishing event was not significant (**Table 3**). Other factors might explain better the association of various school sizes to FADs or whether the attraction distance and the various waiting times for fish arrival to a FAD are truly related to school sizes or not.

3.3 Fish species and fish behavior through FGD and diver assessment

There was little variation of species found at depths of 0-10 m (*t*= -0.149, *df*=6, *P*=0.887), and 11-20 m (*t*= -0.044, *df*=9, *P*=0.966) in the anchored FAD either during day time or night time. Results of pooled data comparing species at day time vs night time also showed no difference (*t*= -0.117, *df*=16, *P*=0.909). Triggerfish and filefish which are abundant at the surface and are known to inhabit the suspended palm fronds, are also found at lower depths such as at 11 to 20 m (**Table 4**).

Table 4. Depth distribution of fish species on anchored FADs during day time and night time based on semi-structured interviews (n=46) and based on three FGDs (n=39).

Semi-structured interview				**Focus Group Discussion (FGD)**			
Depth (m)	**Species**	**Day time (%)**	**Night time (%)**	**Depth (m)**	**Day time**	**Night time**	**Observations**
0-10	Golden trevally	33	25	0-10	x	x	These are thew first species that colonize the FAD
	Roundscad	10	18			x	Fish are separated by species, schools and size
	Rainbow runner	28	27		x	x	
	Common Dolphinfish	8	8			x	
	Bigeye scad	3	6		x		
	Triggerfish	5	8		x		
	Skipjack tuna	5	2				Fish usually aggregates or moves closer to the anchored FADs during the night and especially during night lighting of the anchored FADs
	Filefish		4				
	Juvenile Yellowfin tuna	8					
	Frigate/Bullet tuna		2				
11-20	Golden trevally	18	13	11-20			
	Roundscad	20	12		x	x	
	Rainbow runner	20	10		x	x	
	Skipjack tuna	10	22			x	
	Common Dolphinfish	6	7		x		
	Frigate/Bullet tuna	2	8			x	
	Mackerel scad				x	x	
	Triggerfish	8	4				These are usually found 25 to 50 meters from the anchored FADs and moving around during daytime

	Tripodfish	2	2			
	Bigeye scad	6	6			
	Juvenile Yellowfin tuna	8	17			
21-50	Frigate/Bullet tuna			x	x	These are species found 25 to 50 meters from the anchored FADs and moving around during daytime
	Skipjack tuna			x	x	
	Juvenile yellowfin tuna			x	x	
>50	Yellowfin, Bigeye tunas			x	x	

In terms of fish schools that are abundant at surface depths (0-10 m) as well as at depths of 11-20 m, and mentioned to occur during day and night time were golden trevally, roundscad, and rainbow runner. Tunas such as skipjack, juvenile yellowfin and frigate tunas were also discussed to appear frequently at 11 to 20 m and even deeper. Relevant observations by other fishers based on the FGD validate the statements that aggregations of fish under FADs are segregated based on species, sizes and water depth. For instance, rainbow runner, roundscad, mackerel scad and bigeye scad are observed to appear near the surface as well as at depths of 20 m. Fish species that occur near the surface are smaller in sizes. Both triggerfish and filefish are known to be associated with the floater or the suspended palm fronds and usually stay near the surface. Most of the bigger fish schools of skipjack, juvenile yellowfin tuna, and frigate tuna occur far from the FAD (25-50 m) and swim around. They also stay deeper at 21-50 m. Adult tunas are known to reside in deeper areas from >50 m.

Results from the fish visual census (Table 5) show nine species recorded from the ten FADs visited in Davao Gulf with most of the fish species observed similar to those recorded from the interview and from the results of the FGD. The main difference was the absence of skipjack, juvenile yellowfin tuna, frigate/bullet tuna in all the ten dives although visibility was more than 10-20 m in all the dive sites. About 88% of the fish species recorded can be equally found at depths of 5, 10 and 15 m and the other remaining species 8% and 4% at depths of 20 m and >20 m. The juveniles of sergeant fish were observed to associate near the floater of the FAD while the blue sea chub can be seen to move up and down the depths of 10, 15, and 20 m. The schools of trevally, bigeye scad and roundscad were observed to be swimming around the anchored FAD.

Table 5. Presence of various fish species at different depths found in 10 anchored FADs examined in Davao Gulf, Philippines. Numbers are record of frequency at different depths.

Species		Depths (m)				
English name	**Scientific name**	**0-5**	**10**	**15**	**20**	**>20**
Blenny	*Meiacanthus spp.*		(1) 50%	(1) 50%		
Blue sea chub	*Kyphosus cinerascens*	(7) 44%	(8) 50%	(1) 6%		
Indo-Pacific sergeant	*Abudefduf vaigiensis*	(12) 86%	(2) 14%			
Trevally	*Carangoides ferdau*		(4) 31%	(7) 54%	(1) 8%	(1) 8%
Filefish	*Aluterus monoceros*		(2) 18%	(9) 82%		
Rainbow runner	*Elagatis bipinnulata*		(2) 50%	(2) 50%		
Bigeye scad	*Selar crumenophthalmus*	(2) 28%		(1) 14%	(3) 43%	(1) 14%
Yellowstripe scad	*Selaroides leptolepis*				(1) 100%	
Roundscad	*Decapterus spp.*		(2) 40%	(1) 20%	(1) 20%	(1) 20%

4. Discussion

Most of the respondents have mentioned that demersals and small pelagics (mainly: triggerfishes, filefishes, dolphinfishes, sergeant fishes, blue sea chubs, golden trevallies and rainbow runners), are followed by scads and mackerels to be established around the anchored FAD. These fishes were then followed by skipjack, frigate, bullet and juvenile yellowfin tunas a few days or weeks after the non-tuna species are established in the FAD (Castro et al., 2002). Tunas are known to prey on a wide range of species which includes shrimps, squids, stomatopods, other non-tuna species (e.g. lanternfish, scads, mackerels) and other smaller tunas whether juvenile yellowfin, bigeye, skipjack, and frigate and bullet tunas (Barut, 1988; Jaquemet et al., 2011). In relation to this, the association of juvenile tunas to an anchored FAD seems to indicate that they feed primarily on prey species found in the FAD because of their rapid growth, 3.8 mm per day (Mitsunaga et al., 2012); other recent studies also indicate that tunas aggregate because of social interaction (Capello et al., 2012; Robert et al., 2013). The opportunistic feeding behavior of tunas and its predisposition to social interaction (Robert et al., 2013) may have implications on its movement from oneanchored FAD to another (Ménard et al., 2006).

The attraction distance of 10 km which fishers have mentioned about tunas is plausible given that the usual maximum inter-FAD distances between anchored FADs in the Philippines, is about the same distance (Libre et al., 2015; Macusi et al., 2015b). In addition, tunas are attracted to FADs and they associate with FADs for some time. The 10 km distance was a distance which many small multirole vessels of purse seiners and ringnets cover to navigate and check the fish biomass aggregation underneath the FAD. This attraction distance was also similar to the results of the interview of boat captains and master fishers who use drifting FADs (Moreno et al., 2007b).

Based on previous studies on the results of sonic tracking of juvenile yellowfin tunas, it was found out that tagged individual fish and fish schools associate in a network of FADs with 3 km distance from each FAD (Babaran et al., 2009a; Mitsunaga et al., 2012). These tagged juvenile yellowfin tuna seem to forage in a network of anchored FADs as they start to migrate outside the locations of these fishing grounds. Moreover, a follow-up study by the same authors also showed that a tagged juvenile yellowfin tuna was caught 12 km away from the original tagging site which means that juvenile yellowfin tunas can easily move or swim away from one FAD to the other (Mitsunaga et al., 2013). In contrast, investigations of adult yellowfin tunas by Ohta and Kakuma (2005) showed that the fish stayed for a maximum of 55 days around a single FAD while Dagorn et al. (2006) reported that they stayed for a maximum of 151 days on a network of FADs.

On the attraction of various fish species to floating objects like anchored FADs, the pioneer species are usually herbivorous and piscivorous such as the Indo-Pacific sergeant fish, the filefish, golden trevally and trevallies and juvenile tunas. While various reasons are hypothesized to explain this attraction such as sheltering, feeding, meeting point, indicative of productive areas (Castro et al., 2002; Freon and Dagorn, 2000), there is no single accepted explanation for this attraction to floating objects by fish. Moreover, it is thought that the biomass of fish around anchored FADs would not be enough to feed the biomass of oceanic tunas swimming around anchored FADs (Olson R.J. and Boggs, 1986). Majority of the fishers reported that the aggregation process of various fish species takes time, meaning there is a gradual build-up of biomass around anchored FADs mainly with the pioneer non-tuna species first and then followed by the attraction of oceanic tunas to the anchored FAD. In terms of the lack of difference between the species present during daytime and at night time, resident fish species seem to utilize FADs as their shelter as well as their foraging area but not the associated species which were loosely attached to the floating object. For example, juvenile and larger tunas are capable of swimming away to another anchored FAD when distracted.

Based on the reported tuna behavior in this study, there are three conditions involved in the attraction and retention process of tunas in a FAD area: 1) Number of FADs deployed in the site -the more FADs deployed by fishers, the more choices of FADs for the school of tuna to visit (Aprieto, 1981; Macusi et al., 2015b); 2) Area of FAD deployment (level of productivity of FADs), tunas are thought to visit productive (rich food areas) and therefore leave out non-productive (poor food areas), keeping those FADs located in poor food areas with less fish biomass (Jaquemet et al., 2011); 3) Size of tuna school that visit a FAD- because of differing individual productivity of FADs as well as the loosely associative behavior of tunas, there is no fixed amount of catch of fishers for every FAD because the school of tuna can visit and then leave the FAD afterwards. However, this can be obviated by the fishers' use of human sonars or divers as well as their acoustic fish finders. As mentioned earlier, several reasons can distract tunas in the FAD, which means that FAD visits by a school of tuna may last in hours or in days, the visit or association to a FAD is therefore highly variable (Mitsunaga et al., 2012; Ohta and Kakuma, 2005). Moreover, the lack of relationship between the reported school size of tunas and attraction distance, and various waiting times for their arrival in the FADs based on the fishers' LEK, could be an impetus to explore other factors that would explain the aggregation of fishes in FADs. Perhaps a more direct assessment might be needed such as using acoustic techniques to relate the size of schools of fish to these waiting times. The production of sounds by anchored FADs may help orient and attract tuna towards the structure (Babaran et al., 2008), since according to Tolimieri et al. (2000), sound can serve as a navigational cue for fishes.

Concerning the results of the actual dives to examine the fish composition of anchored FADs where no skipjack or yellowfin tuna was observed in the vicinity of the anchored FADs, the survey was done near the shore, for instance with FADs found less than 100 km compared to FADs located 500-1000 km offshore in Mati and in Celebes sea. This was a limitation of the study, although before the survey was conducted in Davao Gulf, catch data and catches were examined from the local fishing companies with fishing areas in Davao Gulf. Moreover, the local markets in Governor Generoso (a coastal municipality situated near the mouth of the Gulf) shows that juvenile skipjack, frigate and yellowfin tunas were part of the ringnet catches. Perhaps the other limitation of this study could be its lack of pilot study in terms of dive assessment of the fish composition of anchored FADs at different times of the day before the actual conduct of the survey. We also lacked a chartered vessel dedicated for this purpose to study the FADs used by fishers in their fishing grounds and which could go for more than 500 km from the shore. This study can be extended in the future through assessment program using fish visual census coupled with acoustics to understand fish schooling and association behavior in anchored FADs since acoustics can complement and address the limitations of FVC (e.g. limitations on effective distance of FVC) (Moreno et al., 2016; Taquet et al., 2007). This will examine the various behavioural characteristics of small non-tuna species, the oceanic tunas both the juveniles and adult ones.

The implications of this study support the growing literature on overexploitation of marine resources which leads to economic losses. According to Kompas et al. (2010), overharvesting of tuna can incur an economic loss of billions of (US) dollars. This is partly due to excess in fishing effort that places enormous pressure on global marine fisheries (Anticamara et al., 2011). Excessive fishing pressure is a result of the high food needs of a burgeoning global human population (Béné et al., 2015; Stobutzki et al., 2006). Excessive fishing pressure, however, can also be a result of the failure of fishers to capitalize on available information to optimize fisheries yield on harvesting target species and lower non-target species catch, which are often discarded and also incurs economic loss (Patrick and Benaka, 2013). The complexity of the dynamics of marine fisheries is further confounded by the lack of understanding on the role of fish behaviour and how it impacts marine fish population and marine fisheries in general. For example, in a model simulation conducted by Railsback and Harvey (2011) on brown trout (*Salmo trutta*) populations, it was shown that individual adaptive behaviour (e.g. activity selection) has contradicted the traditional understanding on food limitation and how it regulates populations, accentuating fish behaviour as a major factor to consider in formulating conservation and management strategies (Shumway, 1999). In this study, LEK has been proven to provide additional information to further understand the complexities of fish association to anchored FADs and how fish behaves. The knowledge extracted from fishers, for example, in attraction behaviour of fishes to FADs can help optimize FAD deployment (e.g. minimal number of FADs while achieving maximum sustainable yield by maximizing spacing between FAD deployments), lowering operational costs for fishing fleet that will lower fishing effort and overharvesting. Information generated by this study will be useful in designing formulating policies and management plans, especially in the regulation of FAD deployment in the country.

5. Conclusion

Our study shows that the high dependence on marine resources for food and livelihood has led to excess fishing capacity by exploiting fish behavior and deploying FADs to increase fish production. Fish aggregating devices (FADs) have been abundantly deployed in both nearshore and offshore areas and the deployment of FADs are un-registered and unregulated. Because of this massive deployment of FADs coupled with IUU (illegal, unreported and unregulated) fishing, fisheries production has been steadily declining. The target species of purse seine and ringnet fisheries around anchored FADs are large pelagic (e.g. tuna) and small pelagic fish (frigate & bullet tuna, roundscads, mackerel) while the average time of fish aggregation in FADs vary according to species and fish sizes; larger tuna (skipjack, yellowfin and bigeye) usually aggregate last. Moreover, fishers tend to move fishing operations to areas with more abundant, larger fish to increase prospective revenues. To help conserve our pelagic resources, there is a need for stricter enforcement of fisheries laws, and at the same time finding alternative jobs for fishers and subsidies for their families for daily survival and education to keep them out of the fisheries sector in the near future.

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CHAPTER 4

The influence of economic factors in the change of fishing strategies of anchored FAD fishers in the face of declining catch, General Santos City, Philippines

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Abstract

Decline in tuna fish stocks due to weak enforcement of regulations on fishing effort poses a challenge to the sustainability of tuna fishery. Intervention programmes to address this problem require an understanding of the operational behaviour of the fishers and how various socioeconomic factors may impact fishers' decisions to continue or discontinue their fishing efforts. A semi-structured interview questionnaire was developed to find whether fishers are willing to keep, change their fishing strategies or exit the fishery if their regular catch will decline by half. Boat captains, assistant boat captains and crew from General Santos City, Lupon, Mati City and Governor Generoso in the Philippines (n=293) were purposively selected for interviews. Results show that fishers from General Santos City with ancillary industries and Lupon with less economic development are more willing to adapt or change their fishing strategies. The catch value or price was found to have a strong influence on the likelihood that anchored FAD tuna fishers will adapt or change their fishing strategy when their catches decline. Fishers whose catch fetched a price of PhP 151.00 (US$ 3.48) and above Php 200 (US$ 4.61) have 80% probability to change their fishing strategy. The proportion of catch sold also had a high influence on the decisions to adapt in the fishery with fishers selling 36% and 73% of their catches have 100% and 70% probability to adapt. The results suggest a reluctance to exit the fisheries even when tuna fishing is no longer economically viable, fishers opt to adapt.

Keywords: Anchored FAD, commercial fishing, fish aggregating devices, fishing strategies, socioeconomics, tuna fisheries

1. Introduction

The decline of tuna fish stocks and other reef fish species in Philippine waters (Langley et al., 2009; Lavides et al., 2016; Muallil et al., 2014b) can be attributed to weak management measures to control the fishing efforts of the artisanal and commercial fisheries of the country (Tolentino-Zondervan et al., 2016). These measures, designed to protect the fisheries, have many loopholes so that their implementation has become a challenge to fisheries and conservation experts, posing a problem on the long-term sustainability of tuna and other fish stocks (Tolentino-Zondervan et al., 2016). This problem is not only confined in the Philippines, but also widespread in many developing countries (Muallil et al., 2014a). Although a marine hotspot (Roberts et al., 2002), the Philippines struggles in implementing its own management plans to conserve coastal resources upon which a vast majority of the population derive several benefits including food, income, livelihood, amenities, cultural and recreation(Go et al., 2015). Over the past years, the focus on the general management plan was to increase the number of marine reserves (Alcala and Russ, 2006; Courtney et al., 1999; White et al., 2005) and alleviate fishing pressure on existing coastal resources through increased and heightened alert on Illegal, Unreported and Unregulated (IUU) fishing (Palma, 2006). Other state-led fisheries management measures include gear prohibitions, catch ceilings, fish size limitations, restrictions on issuance of fishing licenses, establishment of marine reserves, and seasonal fishing bans (Bailey et al., 2012; Salayo et al., 2008; Tolentino-Zondervan et al., 2016). While these are substantive measures to address the declining fisheries, fishers still felt neglected. The feelings of neglect were rooted on poverty alleviation programs that did not sufficiently address their situations, from distribution of motorized boats, net and hook gears to FADs (fish aggregating devices) and establishing seaweed farms (Katikiro, 2016; Katikiro et al., 2015; Siason et al., 2004). These short-term programs temporarily helped the fishers in their daily survival but which precluded supporting the fishers financially towards the education of their children, to finding employment outside the fisheries (Allison and Ellis, 2001; Muallil et al., 2011). Since the root of dependency on the fisheries is mainly due to poverty coupled with high population growth (White, 1998), resulting to deteriorated fish stocks, the high number of fishers in many coastal areas led to the race to fish which is also common in many of the world's fisheries (Hilborn, 2007).

Over the last years, several unclear and contradictory rules of jurisdiction on fishing grounds have exacerbated the problem of protecting the coastal resources in the Philippines. For example, most of the laws that are supposed to prohibit the use of destructive fishing gears are made useless in the combat against IUU fishing. A case in point is the jurisdiction of municipal waters (15 km from the shore) which has been devolved to municipal government under the Fisheries Code of 1998 making the monitoring, conservation and surveillance job of BFAR (Bureau of Fisheries and Aquatic Resources) difficult in municipal waters. This devolution of authority weakens conservation efforts and becomes contradictory to the conservation effort as local governments often do not have the capacity to patrol their own municipal waters. Many of the local officials are involved in bribery and turn a blind eye on illegal fishing. In addition, some mayors will also intercede for the release of illegal fishers if they are part of his constituency. There are other apparent contradictions in the major laws: for example, the 1998 Fisheries Code advocates resource conservation while the 1997 Agriculture and Fisheries M odernization Act is production-oriented and may encourage excess capacity (Salayo et al., 2008).

As government institutions devise more rules and prohibit illegal and destructive fishing gears, fishers will also try to adapt to the fishing regulations. The common response of fishers to increasing regulations and law enforcement would be to either keep fishing, change gear or fishing location, or switch to other forms of livelihoods as it has been with fishers in other places of the globe (Cinner et al., 2009). This is certainly true where limitations are high on other options to reintegrate into the existing labor force in the larger economy (Pomeroy, 2012). In particular two prevailing suggestions are cited to increase the capacity of fishers to get reabsorbed in existing labor force; skills retraining and subsidized vocational schooling which will widen their options apart from fishing (Anticamara and Go, 2016; Muallil et al., 2011). Regardless of potential adverse consequences of decision of fishers to quit fishing when a preferable option is missing, there appears to be some consensus that an understanding of the factors which influence their decision is essential to the development of policies that will improve the lives of fishers.

Recent studies such as those by Daw et al. (2012) and Branch et al. (2006) have suggested that investigating the behaviour of fishers is important to help improve predictions of future responses of fishers under a myriad of different socioeconomic factors that could influence their livelihoods. Currently, 52% of global fish stocks are fully exploited, 28% are depleted and 20% are moderately exploited and only 1% showed signs of recovery because of high fishing effort (Anticamara et al., 2011; FAO, 2009). The case of the Philippines is not very different from this global picture, given the decline of fish catch whether in the coastal or offshore areas which is becoming a perennial problem (Go et al., 2015; Green et al., 2014; Salayo et al., 2008). There is high risk of over-exploitation in the fishing grounds primarily driven by incidence of high poverty rate which stands at 26% in the Philippines (PSA), 2016; Lundgren et al., 2006). Fishing is the last resort for those who are living below the poverty line, with the fishery sector having 1.6 million fishers using various gears and boats ((BFAR), 2016; Macusi et al., 2011). Numerous poverty alleviation strategies and programs have been implemented among coastal fishers some of which are envisaged through a shift to aquaculture using milkfish, tilapia, crabs fattening, oyster culture and seaweed farming as well as training for swine and broiler production towards supplemental livelihood (Bravo and Magnaye, 2014; Digal and Placencia, 2017; Salayo et al., 2008). Although these programs were implemented in the past, little follow-up were made after the training, little investments were put by the government on financial infrastructure such as credits for start-up micro- and small businesses which have limited the efficacy of these previous programs that could have lifted fishers from poverty (Allison and Ellis, 2001; Bacalso et al., 2016; Salayo et al., 2008). Previous studies on the exit of fishers from the fisheries have alluded to this resistance of some fishers due to inconsistent programs on assisting fishers how to exit the fisheries (Libre et al., 2015; Muallil et al., 2011). In particular, some fishers are known to find fulfillment and identification from fishing (Pollnac et al., 2001), others continue fishing because it is their sworn duty to continue their parent's heritage (Libre et al., 2015), for other fishers, they cannot quit because of old age, and lesser educational attainment (Muallil et al., 2011). Another reason for not leaving the fishery elaborated in literature include having a false positive perception on the abundance of fish masked by returns of carrier vessels and boats with full catches (Libre et al., 2015; Slater et al., 2013).

Fishers are widely known for deliberate efforts to diversify livelihoods as a means to reduce fishing effort and poverty alleviation (Allison and Ellis, 2001). Highly diversified fishers are known to reduce fishing pressure and will likely exit the fisheries (Cinner et al., 2009; Muallil et al., 2011). However it is also possible that the income derived from alternative livelihood activities gets reinvested in the fishery by buying gears and this will continue to increase adverse effects on dwindling fish stocks (Allison and Ellis, 2001). These complicate the issue leading to suggestions of more government subsidies for the fishers, essentially investing in the education of the younger generation of the family of fishers (Macusi et al., 2011) while at the same time providing subsistence cash income (Muallil et al., 2011). The complexity of the issue on fishers' short-term decision making on what and where to fish, includes the ramifications of high fishing effort, which renders the need to go beyond modelling fishing effort, catch or revenue when seeking to address high fishing effort (Daw et al., 2011). In response to understanding how fishers may relocate their fishing efforts, incorporating the complex behavior of fishers in models is recommended (Holland, 2008; Libre et al., 2015). Understanding how fishers would behave when the catch declines particularly in the multi-gear and multi-species tuna fishing sector as well as identifying and examining socioeconomic factors that are relevant to their decision-making is useful towards plans targeting to improve the management of fishing effort by keeping it at level to the total allowable catch (TAC) imposed on the tuna fishing sector (Digal and Placencia, 2017). Previous works have shown that tuna fishers often carry out their activities offshore and the likelihood that they catch more as they go farther is higher (Macusi et al., 2015b). Little is known on the influence of socioeconomic factors on various decisions of fishers whether to keep fishing, change strategy or quit their fishing activities despite substantial contributions that fishing makes to local economies and culture of many communities. This is especially true in the Philippines where the relationship between socioeconomic factors and fisher decision is not well understood. The purpose of this study is to investigate how decisions in the fishery can be influenced by prevailing socioeconomic factors based on the perception of fishers. The results of this study can be useful to inform policy directions for the commercial tuna fisheries in the Philippines in terms of the responses of fishers under a scenario of declining catch.

2. Materials and Methods

2.1 Study sites and sampling

The Philippines is a tropical and archipelagic country composed of 7,107 islands with a total coastline of 17,460 km (BFAR, 2012a). A huge share of tuna production in the Philippines is concentrated in General Santos City where seven canneries are located and more than 30 medium to large fishing companies are headquartered (Barut and Garvilles, 2012). The interviews for this study were conducted in the coastal towns and cities of Mati, Lupon, Governor Generoso, and General Santos in Southern Philippines. The sites were chosen based on the number and availability of FAD fishers living in the area. The interviews were done in the landing site or fishing villages based on referral by those previously interviewed fishers (n=293). A semi-structured interview questionnaire focused on fishers utilizing anchored FAD was developed to collect information in the four study sites in July 2013. The interviewed FAD fishers were boat captains, assistant boat captains, and crew. The boat captains and assistant boat captains were most privy to information with regards to fishing operations while some crew members, especially master netters and master divers were also knowledgeable to many aspects related to fish catch characteristics and fish behavior. Boat captains formed 66% of the respondents during the interview with majority of them coming from General Santos City; about 27% of the respondents were crew members mainly from General Santos City and Governor Generoso while the other 20% were assistant boat captains (**Table 1**). All questions used were in English and were translated into the local language (Cebuano) during the course of interview. All interviewers were briefed about the questionnaire prior to the conduct of the survey to standardize interpretation and delivery of questions. The questionnaire used included the following topics: age, educational level, number of years living in the area, places of origin, reasons for moving to new location, rank or position of fisher respondent, primary fishing gear used, ownership of boat and gear, type of housing and household facilities, gear and boat characteristics, and number of days fishing in a week of fisher respondents. Respondents were also asked about market access (to whom do fishers sell fish), financial access (where do fishers borrow money if they need financing for gear or boat), boat technology (what gadgets do you use at sea for navigation, communication and catching fish), wealth (what are your house structure made of, and what appliances do you possess), catch characteristics (what are you best, worst and regular catches in a day in kilograms), FAD fishing operation and other catch characteristics. The questionnaire was carried out by five enumerators including the first author.

Table 1. List of socio-economic variables derived from the interview surveys and considered in the analysis.

Study Site	Total (N)	Boat captain	Assistant boat captain	Crew
Mati City	59	45	1	13
Lupon	30	20	0	10
Governor Generoso	54	25	3	26
General Santos City	150	104	16	29

2.2 Socioeconomic indicators

Fourteen fishing variables that were identified to contribute to decisions of fishers to remain or exit the fisheries based on literature review were assessed: 1) market access, 2) financial access, 3) wealth of fishers based on house fixtures, 4) boat technology, 5) price of fish catch, 6) number of household members 7) alternative livelihood, 8) years fishing, 9) age of fisher, 10) years of education, 11) regular catch 12) fuel cost, 13) proportion of catch sold and 14) number of fishing days per month. The indicators for market, financial access, boat technology and wealth were calculated separately by running factor analysis with a varimax rotation of the different choices made by fishers based on: where to sell their catch (e.g. middleman, company, local market, financier), where to borrow money (e.g. cooperative, financier, boat owner, relatives and friends), what gadgets to take on for navigation and communication to the sea (maps, GPS, compass, radio, fish finder) and what type of house fixtures they possess (Cinner et al., 2009; Daw et al., 2012). All statistical analyses were done using SPSS (SPSS Statistics for Windows, version 23.0. Armonk, NY: IBM Corp). In developing countries, the material style of life such as owning a house or a TV set can be an indicator of the wealth or social status within the community (Pollnac and Crawford, 2000b).

Table 2. List of socio-economic variables derived from the interview surveys and considered in the analysis.

Variables	Description
Market access	Access to different markets for their catch e.g. middleman/trader, company, local market, financier
Financial access	Access to different financial institutions for their fishing operation e.g. cooperative, financier, boat owner, relatives and friends
Boat technology	Access to technology used for fishing e.g. Maps, GPS, compass, radio, fish finder
Wealth	Calculated based on the types of housing materials (G.I. sheet or nipa roof, cement or bamboo walls, cement or bamboo floors) and the appliances in the house (e.g. Ref., TV)
Price of fish	Based on the average of reported value of the best, worst and regular catches of fish caught per day
Number of household	The number of individual persons living in a household, including children
Number of occupation	This was calculated as the number of jobs within households including fishing
Years fishing	The number of years that a fisherman considers as his experience of fishing
Age of fisher	Number of years of the fisher
Level of education	The level of education that the fisher finished in formal schooling whether elementary, high school, college/university, technical/vocational, or no formal education
Regular catch	Normal daily catch in kilograms per fishing trip
Fuel cost	The reported amount of fuel consumed in liters /fishing trip multiplied by the cost of fuel per liter at the time of interview
Catch sold	The reported proportion of catch sold to the market whether all (>95%), most (51-95%), some (21-50%) or few (1-20%)
Number of fishing days month	The number of fishing days in a month minus bad weather days

Material style of life measures wealth based on house structure and household possessions. To do this, we examined the materials used for the wall, roof and floor in the respondent's house and inquired whether they had TV, electric fan and access to toilet and piped water. We then calculated a wealth indicator for each household in the survey by running a factor analysis with a varimax rotation on the presence or absence of these items in a household. The scores produced from this factor analysis were used as a regression variable called wealth. Other variables asked from the interview are the type of fishing gear used, the proportion of catch sold and number of fishing days (**Table 2** explains the variables used in the analyses and Table 3 shows the non-categorical variables used to explain the decisions of fishers whether to continue, change or exit the fisheries).

Table 3. Non-categorical variables of hypothesized explanatory variables for multinomial logistic model to explain decision to continue, change strategy or exit the fishery at 50% catch reduction (0=keep, 1=change, 2=exit).

Non-categorical variables	Mean (± SD)	Min	Max
Price of fish[1]	119 (±73)	10	310
Cost of fuel[1]	44438 (±69218)	105	521880
Number of household	6 (±3)	1	15
Number of livelihood including fishing	1.25 (± 0.57)	1	4
Daily catch	2521 (± 5716)	1	40000
Fishing days per month	17 (± 5)	5	28

[1] Php: Currency in Philippine pesos (1 U$:43.32 Php, July 2013)

Fishers were then asked hypothetically what they would do in case their daily catch will drop by 50%. Responses were recorded as either continue fishing (n=114), relocate to another fishing area (n=141), fish less (n=8), change gear (n=2) or completely stop fishing (n=23). The responses of fishers were then categorized into three broad outcomes: either keep fishing (coded as 0), change strategy (coded as 1) or exit fishing (coded as 2).

2.3 Analyses

A multinomial logistic regression was used to predict the outcome of fishers who reported that they would continue fishing, change their fishing strategies or exit the fishery when their regular catch will go down by 50%. We chose 50% catch reduction based on the literature (Muallil et al., 2013; Muallil et al., 2011) as well as based on the common complaints of interviewed fishers that their catch has gone down by 50%. A multinomial logistic regression does not have the assumption to be normally distributed, no linear relationship is assumed and no equality of variances is needed. It is used when the dependent variable has several categories of possible outcomes which can be influenced by variations in the independent variables being examined. The hypothesized socioeconomic factors were chosen based on the literature and exploratory tests done. In the modelling process, we included all the 14 variables as the variance inflation factors (VIF) ranged from 1.07 to 2.27 which indicate no multi-collinearity among the predictors that would affect the model estimates. A main effects model was chosen based on exploratory examination of predictor variables that best influences the decision making of fishers. Non-categorical variables (age of fishers, education level, years fishing and proportion of catch sold) were entered as factors while the other continuous variables were entered as covariates. The dependent variables were coded as follows: keep fishing (0), change strategy (1) and exit fishing (2). The goodness-of-fit was checked based on the Pearson and Likelihood ratio chi-square statistics of the model, the likelihood ratio test which show significant predictors was also checked and compared with the parameter estimates of the individual predictors of the model.

3. Results

Socio-economic characteristics of survey respondents are shown in **Table 4**. More than half (53%) of the fishers interviewed reported that they had completed primary school education (Grades 1 to VI) whereas 40% attained a high school education. Regarding the fishing experience, 60% had been fishers between 10 and 20 years, and 25% between 21 and 30 years. About half of the fishers mentioned that theysell all (>95%) of their catch and about 47% of them said that they sell most (51-95%) of their catch. A vast majority of fishers (81%) reported fishing as theirfirst job, 14% hold other occupations while 4% and 1% hold third and fourth jobs to feed their family.

Table 4. Socio-economic characteristics of the respondents (n=293).

Variables	Category	Frequency	Percentage
Age of fisher	20-30	w52	17.7
	31-40	94	32.1
	41-50	101	34.5
	51+	46	15.7
Educational attainment	Elementary	156	53.2
	High School	117	39.9

	College/University	11	3.8
	Technical/Vocational	3	1.0
	No Education	6	2.0
Years of fishing	10-20	180	61.4
	21-30	69	23.5
	31-40	35	11.9
	40+	9	3.1
Proportion of catch sold	Few (1-20%)	4	1.4
	Some (21-50%)	5	1.7
	Most (51-95%)	137	46.8
	All (>95%)	147	50.2

The factor analysis of wealth, boat technology, market and financial access resulted in loadings that explained 44%, 46%, 43% and 32% of the variation in the data of the factors examined (**Table 5**).

Table 5. Factor loadings of the different variables with the indicators used to calculate the predictors wealth, boat technology, market and financial access in the different study sites.

Wealth		**Boat technology**		**Market access**		**Financial access**	
Roof G.I. sheet	0.744	Map	0.231	Middleman	-0.924	Cooperative	0.337
Concrete wall	0.654	GPS	0.825	Local	0.896	Financier	-0.75
Concrete floor	0.651	Compass	0.874	Financier	0.193	Owner	0.766
Refrigerator	0.637	Radio	0.887	Company	-0.134	Relatives/Friends	-0.088
TV	0.614	Finder	-0.106				

In the initial analysis of material style of life, the housing materials were separated from the house appliances with the former explaining variance of 33% and the latter explaining the variation of data at 31%. The combined factors explained 44% of the data in the material style of life indicators particularly roof made of G.I. sheet (0.744), wall made of concrete (0.654), floor made of concrete (0.651); and TV (0.614) and refrigerator (0.637) appliances found in homes. In the combined factor loadings under the variable boat technology, compass (0.874) and radio (0.887) contribution was high and related positively. Under the variable financial access, the indicators "financier" (-0.750) contributes negatively while the indicator "owner" (0.766) contributes positively. Lastly under the variable market access, the indicator "middleman" contributes highly and negatively (-0.924) followed by local market (0.896). In association with the use of boat technology, most of the small-scale fishers make use of natural landmarks (about 14% of the total fishers) while the fishers that go further offshore made use of navigation technology such as GPS (27%), compass (32%) and radio (25%) (**Figure 1A**). Only a small proportion of fishers make use of maps (2%) and fish finder (1%). Fishing was the primary occupation (84%) of all the fishers interviewed with a number of other livelihoods mentioned particularly carpentry (7%) and trading (5%) as other jobs held when not fishing is carried out (**Figure 1B**). The operation of the fisherman to catch fish at sea is often financed by the financier (38%), the owner of the boat (34%), relatives and friends (15%) or the cooperative (14%) (Figure 1C). Among the different types of buyers, the middleman had the most proportion of catch sold to them at 61% followed by local market at 28% (**Figure 1D**).

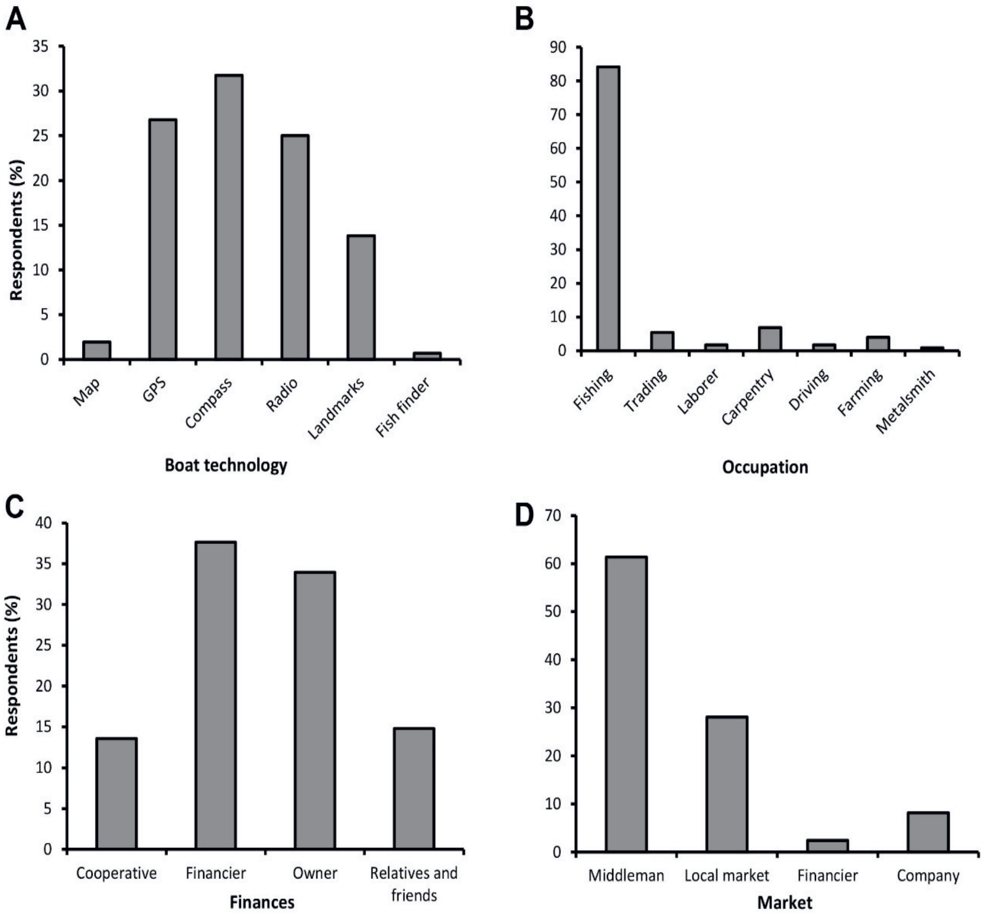

Figure 1. Different boat technology used by fishers (A), fishing and other occupations of fishers (B), financial (C) and market access (D) of fishers in the various study sites.

In determining whether socioeconomic factors were related to fishers decisions to continue fishing, change their strategies (by changing their fishing area or gear) or exit the fisheries if their regular catch went down by half, the variables: market access, financial access, household wealth based on house fixtures, boat technology, number of household members, number of alternative livelihood available, years fishing, years of education, regular catch, fishing days per month and cost of fuel did not have significant relationships. The other three relevant and significant factors related to the odds of whether continuing in the fishery or changing to other fishing strategies were the variables: price of fish catch (ß = 0.009, SE = 0.002, Wald= 15, P<0.001), proportion of fish catch sold, (ß = -0.67, SE = 0.26, Wald= 6.76, P<0.001), and age of fishers (ß = -0.04, SE = 0.018, Wald= 4.86, P=0.027) (**Table 6**).

Table 6. Socioeconomic factors that influences the decision making of fishers whether they will keep fishing or change their fishing strategies if their regular catch will be reduced by half. (The reference category was keep fishing; significantly different factors are in **bold**).

		95% Confidence Interval for Odds Ratio		
Variables	**B (SE)**	**Lower Bound**	**Odds Ratio**	**UpperBound**
Adapt vs. Keep fishing				
Intercept	**4.60 (1.45)*** **			
Regular catch	0 (0)	1.000	1.000	1.000
Fishing days month	-0.06 (0.033)	0.882	0.942	1.005
Price of fish	**0.009 (0.002)*** **	1.005	1.009	1.014
Proportion of catch sold	**-0.67 (0.26)** **	0.308	0.511	0.848
Years fishing	0.005 (0.02)	0.972	1.005	1.038
Cost of Fuel	1.06 (1.25)	1.000	1.000	1.000
Age	**-0.040 (0.02)***	0.927	0.961	0.996
Years education	-0.068 (0.06)	0.833	0.933	1.046
No. of household members	0.036 (0.06)	0.925	1.037	1.162
No. of livelihoods including fishing	-0.106 (0.27)	0.529	0.899	1.527
Market	0.19 (0.17)	0.869	1.220	1.715
Finance	0.26 (0.15)	0.964	1.294	1.737
Boat technology	0.20 (0.16)	0.832	1.222	1.795
Wealth	-0.04 (0.16)	0.702	0.961	1.315
Exit vs Keep fishing				
Wealth	-0.04 (0.16)	0.702	0.961	1.315
Intercept	-0.09 (2.29)			
Regular catch	-0.00014 (0.00009)	1.000	1.000	1.000
Fishing days month	-0.034 (0.05)	0.874	0.967	1.069
Price of fish	0.0009 (0.004)	0.993	1.001	1.009
Proportion of catch sold	0.08 (0.44)	0.459	1.092	2.601

Years fishing	-0.024 (0.025)	0.929	0.976	1.026
Cost of Fuel	0.0000002 (0.000002)	1.000	1.000	1.000
Age	-0.0094 (0.03)	0.943	0.991	1.041
Years education	-0.041 (0.09)	0.805	0.960	1.145
No. of household members	0.003 (0.086)	0.846	1.003	1.189
No. of livelihoods including fishing	0.26 (0.33)	0.683	1.306	2.496
Market	0.12 (0.25)	0.685	1.122	1.839
Finance	-0.046 (0.24)	0.600	0.955	1.520
Boat technology	0.32 (0.29)	0.776	1.377	2.442
Wealth	-0.019 (0.23)	0.619	0.981	1.554

Note: R^2= 0.24 (Cox and Snell), 0.29 (Nagelkerke). Model X^2=81.24, p<0.001,
* p<0.05
** p<0.01
***p<0.001

In terms of factors that influences the decision making of fishers whether to keep fishing or exit the fishery there was no significant variable that was related to exiting the fisheries even after the catches were halved.

In **Figure 2**, the fitted estimated response probability of fishers when 50% of their regular catch declines show that at the catch price of Php 151-200 (US$ 3.48-4.61) and greater than Php 200.00 (U$ 4.61) per kilograms have up to 80% probability of deciding to change their fishing strategies while there was less than 15% probability to exit the fisheries for all prices (**Figure 2A**). In terms of proportion of catch sold, fishers who are selling most of their catches (73% of their daily catch) are more likely to change their fishing strategies at 70% probability when their catch declines by half while those who sell some of their catches (36%) have 100% likelihood to change their fishing strategies (**Figure 2B**). In terms of site, the results show that fishers from General Santos City can have a 65% likelihood to change their fishing strategies in the fisheries followed by fishers from Lupon at 51% and Governor Generoso at 34% and Mati City at 33% probability (**Figure 2C**). The high likelihood to change in fishing strategy in General Santos City could be more related with the ancillary industries (engineering workshops, availability of companies related to supply and construction of fishing vessels, gears and nets, ice plants, pre-harvest and post-harvest facilities) found in the area, which favors high capacity to adapt during difficult times. This contrasts to Lupon which has poor economic development, making fishers more committed to their fishing occupation. While in terms of the various gears, tuna handlines have 80% of probability to change in their fishing strategy followed by purse seines and ringnets at 41% and 38%, ringnets and small hook and lines are at 36% probability to change their fishing strategies. The high likelihood of tuna handlines to change or adapt their fishing strategy could be related to its target catch, which is adult yellowfin (*Thunnus albacares*) and bigeye tuna (*Thunnus obesus*).

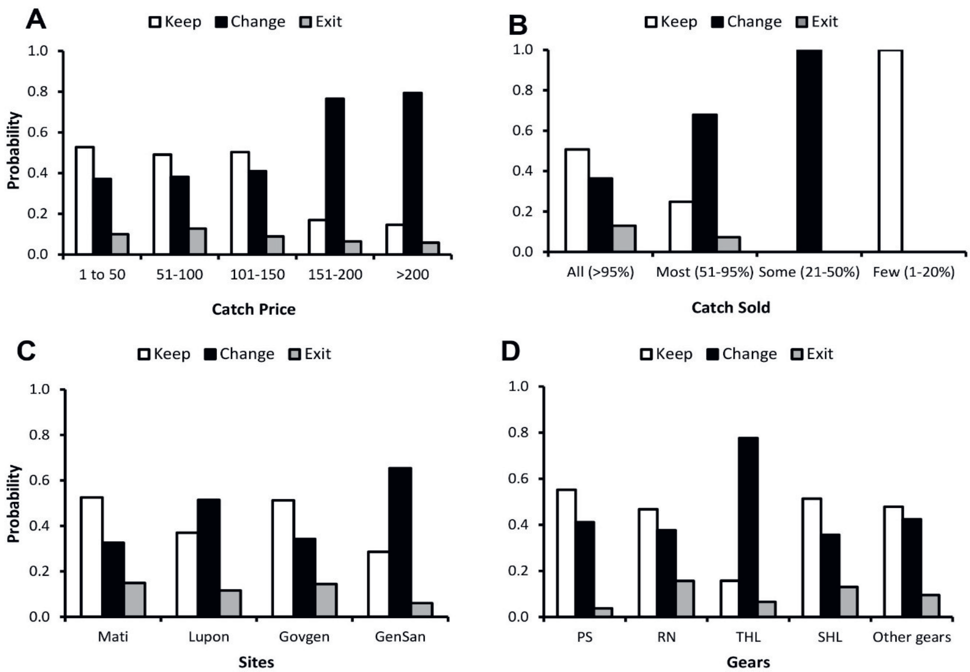

Figure 2. Response probabilities whether fishers will keep fishing, change their fishing strategy or exit the fisheries at a 50% decline in catch as a function of catch prices (A), proportion of catch sold (B), sites (C) and gears (D). The bar charts represent the means (open bar=keep, black bar=change, gray bar=exit fishery) of probability. (PS=purse seine, RN=ringnet, THL=tuna handline, SHL=small hook and line plus multiple hooks, Other nets are gillnets and scoopnets).

4. Discussion

The present study have attempted to unravel the adaptive responses of tuna fishers under a scenario of declining catch. While it is widely known that environmental change may bring about declines in catches in one fishing location leading to catch declines in individual CPUE of fishers (Deepananda and Macusi, 2012; Macusi et al., 2015a), the case in the Philippines seems different where intensifying fishing effort through building larger fishing boats and buying motorized boats is the alternative option (Anticamara and Go, 2016; Anticamara et al., 2011). The profit raised from tuna fishing activities is likely to encourage fishers to continue investing in bigger and better fishing gears that would increase fishing capacity. In General Santos City, the fisheries under the current study operate in a larger scale compared to those in Lupon, Mati City and Governor Generoso. Infrastructures found there are better compared to the other fishing areas that serve the commercial tuna fisheries, from modern roads and logistics, ice plants, modern fish port, shipyards, metallurgy, storage facilities and financial and market access, which gives them greater capacity to change their fishing strategies (Daw et al., 2012). Given this high economic development in the city, better alternative options to explore different fishing areas or change gear would be available for the fishers that are localized there. In addition, this renders the fisheries and the fishing companies located in this city to become resilient in the face of dwindling fish stocks by being able to politically negotiate fishing access of its fishing companies in the high seas as well as in neighbouring countries of Indonesia and Palau (2016; Fredeluces, 2012; Nawal, 2014).

As for small-scale fishers found in Lupon, Governor Generoso and Mati City the main issue on declining catches is a fair share on the supply of fish to nearshore fishing areas but with numerous fishers already engaged in the fishery, this may not happen in the short term (Muallil et al., 2014a; Salayo et al., 2008). Lupon, despite being poor on economic development has also high tendency for fishers to change or adapt because of less diverse livelihood opportunities. Interestingly, fishers in this location are more committed in their occupation and often find ways to change their strategy by relocating their fishing efforts to other fishing sites other than their traditional fishing grounds.

The commercial tuna fishers in the Philippines where the ringnet, purse seine and tuna handline fishers belong mainly utilizes FAD to increase their catch. However, even this fishing sector had experienced catch declines per unit of effort in the recent years because of the rise of new entrants in fishing activities (Digal and Placencia, 2017; Macusi et al., 2015b). Major reasons for the entry in the fisheries are related to perception of catch abundance and traditional family occupation (Libre et al., 2015), socio-demographic and occupational benefits (Pollnac et al., 2001), and perceptions of the future abundance of fish (Slater et al., 2013). The findings of this study report that the catch value of fish or its market price and the proportion of fish catch sold significantly influence the likelihood for tuna fishers to change their fishing strategies. A recent study by Libre et al. (2015) found that disinvestment in the tuna fishery is largely attributed to abundance of the catch which is related to economic factors such as the catch value of a fish and the proportion of fish sold in the market.

While there could be other reasons such as poor financial situation and lack of new fishing ground, the purely economic reason which affects the tuna handline fishery is more related to the way this fishery operates. The tuna handline fishery operates in distant fishing grounds that involve multiple crews who receive their shares based on their catch (Bailey et al., 2012). The level of sharing is unequal because fishers spend more time at sea with great risks but only receive a small share compared to the owner and financier of the fishing operation (Vera and Hipolito, 2006). Given this perverse sharing scheme with the boat owner and financier, a low catch or 50% reduction of their present catches and given the fluctuating prices of fish at the landing ports, this will lead to minimal income for the fisher, who works like a labourer of the fishing company. The risks for change in value of catches are higher for the tuna handline compared to the purse seine or ring net fisheries because they are mainly focused on catching yellowfin and bigeye tuna which is exported with a good price or rejected and sold in smaller value in the domestic markets. For the purse seine and ring net fisheries, they catch skipjack tuna and including other fish species (for instance bullet and frigate tuna, scads and mackerels) (BFAR, 2012b; Macusi et al., 2015b; Macusi et al., 2016; Vera and Hipolito, 2006). Given that the arrangements of financial considerations are dynamic there is a higher pressure to bring a catch to the shore. If this catch is reduced, then the level of revenue will also be reduced and the fisher's earnings will be lower.

The fisher's response to this lower earning will have a negative result for instance, a lower fishing income for the whole industry. But given the adaptive capacity of fishers, they will likely look for a solution to their dilemma and most mentioned relocating to other fishing grounds. Despite the unregulated nature of the coastal areas of the Philippines, migration to one coastal village or moving to another fishing ground will entail additional operational costs for relocating. The relocation costs such as fuel, transportation costs, and upfront investment costs for FADs would have to be factored in by the fishers if they decide to change their fishing sites. Moreover, even operating in offshore areas and changing locations are restricted nowadays with the strict boundary rules of Indonesia and lack of official fishing access agreements with surrounding nations like Palau, Brunei or Malaysia (Fredeluces, 2012). In the case when fishers decide to change their gears and chose to fish nearshore, there would be a need to augment the fishers' income through additional jobs. These seasonal jobs could be carpenter, welder, metalsmith, or as labourer in the farms. These adaptive mechanisms of fishers are meant to cope from changes that impact the fishery which may not be sustainable in the long-term. Although it appears that it is largely the economic factors that influence this adaptation strategy of fishers, there are also other formal and informal institutions which may facilitate this setup. For instance a fishing association that self-regulates its members by practicing respect for the fishing ground of other companies may prevent stealing, vandalism or indiscriminate deployment of FADs in areas already taken by another company (Macusi et al., 2015b). In that case, fishers must adapt by moving farther offshore to find a new site. Strong regulation by the government to control the number of licenses issued for new boats, gears and FADs will also lead to decreased effort in the fishing grounds. These are the challenges for both the fishers and policy makers and to create an enabling environment that will help fishers to change by reducing their fishing efforts which will lead to a sustainable livelihood (Digal and Placencia, 2017; Salayo et al., 2008).

While the results of this study find very weak relationship between regular catch and the response of fishers to exit the fishery when only half of their original catch is being attained during a fishing operation, other studies have mentioned social factors such as job satisfaction, cultural heritage or family tradition to have an influence on the decision of fishers to quit fishery (Libre et al., 2015; Pollnac et al., 2001). Family traditions are difficult to gauge because the decision comes from the top manager or owner and the only way to dissuade them from fishing may perhaps be due to total collapse or lack of revenue from fishing. On the other hand, job satisfaction can be shaped by duration of time spent in fishing activities, skills acquired, social connections and friendships developed and the way a job is perceived. Consequently, younger fishers with fewer fishing experience are more likely to exit the fishery than older and more experienced fishers who are often associated with limited options for non-fishing occupations (Muallil et al., 2011). Moreover, the level of wealth of fishers afford them ample opportunities to be able to integrate in the larger economy. Poorer fishers are commonly known to have less opportunities to overcome their dependence on fishing (Béné, 2003; Béné and Friend, 2011). When this dependence acts to oppress the fishers economically and socially, hindering their future development, this is called ‘poverty trap’ (Carter and Barrett, 2006). This was often used to describe the fishery as ‘rhyming with poverty’ because of the low household income of fishers and perennial food insecurity (Béné, 2003). In terms of livelihood opportunities, since most fishers have barely finished their primary or secondary schools, the prospect for better paying jobs are few. Because of this, fishers become entirely dependent on fishing which leads to resource depletion when efforts are not curbed (Pauly et al., 2003). The extent of this problem can only be described as requiring an interdisciplinary approach to address, because it requires biological, economic and social scientists to work together towards understanding the ecosystem and human behaviour (Phillipson and Symes, 2013).

Given this task, governments should craft livelihood programmes that are not beyond the developed skills of the fisher, or the ones that must be of low skills with high adoption rate. A diversified livelihood for the fisher will address their economic dependence on fishing which is a high risk occupation and full of fluctuations of resource abundance and prone to be highly unpredictable (Allison and Ellis, 2001). The age of fishers will also influence this diversification of livelihood as older fishers might no longer find retraining to be relevant because of the level of skills to learn. Younger fishers might be interested to skills retraining and continuing their education provided the government will shoulder the cost of their continuing education and financial subsidy for the subsistence of their families as they retrain (Muallil et al., 2011). Corbett (2005) also found that education helps achieve rural outmigration of many youths in coastal Canada, providing better income in the future as they seek employment elsewhere to urban areas. Generally, poor fishers are unable to mobilize in different situations to overcome their social traps unless they have access to credit, cash income opportunities, trainings and other employments (Carter and Barrett, 2006; Dasgupta, 1997). Some studies however have shown that people who escape poverty traps from the fisheries and farming sectors are those who remained in the agricultural sectors, weathered the challenges and gained better income prospects in the end (Christiaensen and Demery, 2007; Stanford et al., 2013). These are people who exhibit entrepreneurial resilience to survive and prosper using family economic, social and cultural capital, with or without credentials to maintain their living (Corbett, 2005). Moreover it is suggested that better living conditions and services, access to credits for business and purchase of land may encourage others to remain in these rural areas (Bednaříková et al., 2016). One example of a successful government intervention program in the agricultural sector includes the CPAR (community based participatory action research) which builds a technology demonstration site identified as needed in a community or region that is thenfunded by the government (Bravo and Magnaye, 2014). The farmers and fisher folk co-operators are identified and helped to adopt the technology, for instance organic vegetable gardening, planting of high yielding peanut variety, and polyculture of milkfish and black tiger prawn. While not all economic aids provided to fishers have led to escaping the poverty traps, positive economic boosts may help fishers gain the confidence they need to build their own lives. This would mean a greater involvement of the fishers and fishing companies in seeking suitable solutions in reducing their fishing effort as they are part of and depend on the fisheries.

5. Conclusion

The Philippine tuna industry is in danger of collapsing if appropriate measures to instil a change of attitude towards adopting sustainable fishing practices will not be mainstreamed in fishing regulations in the near future. Although the concept of sustainable fishing has been promulgated widely, only few fishing companies in the Philippines have adopted and operationalised it. The many years of profits in the industry have given confidence to fishing companies towards investing in bigger and better gears which led to excess fishing capacity in the tuna fishing sector. The main findings of this study show that tuna fishers are reluctant to exit the fisheries even when their regular catch had been reduced by half, perhaps, this is attributed to a lack of alternative jobs and long-term financial support for their families and children when leaving the industry. The other findings of this study report two contrasting situations where a site with high economic development index and another one with low economic development index have both high likelihood to change their fishing strategies given a declining catch. For the better off, a change of strategy is dependent on its capacity to negotiate fishing access rights and explore other fishing sites, while the poorer one, out of necessity to survive will either change gear or relocate to other fishing sites. In terms of gears, only tuna hand lines were willing to adapt. With fluctuations in the marine environment affecting the productivity of fishing grounds and intensifying levels of fishing effort, profits from the tuna fishing sector can be easily affected. Tuna handlines are more sensitive to these changes as demand for their target catch is dependent on good market and better environmental conditions. Slight change in catch value of tuna due to market forces or unpredictable events can increase or decrease the profitability of a tuna handline fisher, as they are export oriented. To remedy this, linkages and better market access locally and abroad will sustain this livelihood. Moreover, the proportion of catch sold also depends on the prices in the market, with higher prices, motivating a sell-off. Since state-led management initiatives of controlling the tuna fishing effort have failed, for instance from licensing and regulating gears and boats, private incentive led mechanisms to improve fishing practices provide an option for this undertaking (Tolentino-Zondervan et al., 2016). Alternatively, if a strong regulation by the government to control the number of licenses issued for new boats, gears and FADs will be attempted, this can improve the situation (Digal and Placencia, 2017). Finding alternative jobs and substitute livelihoods should augment these programs on effort control measures to help fishers exit the fishery. Additionally, employing a more technology driven control measures such as GPS trackers for commercial fishing boats, RFID barcodes for gears and FADs will enhance deterrence to IUU fishing. These are the challenges facing the tuna fishing sector and the policy makers and to create an enabling environment that will help fishers to change by reducing their fishing efforts which will lead to a sustainable industry.

CHAPTER 5

Factors influencing catch and support for the implementation of the closed fishing season in Davao Gulf, Philippines

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Abstract

The closed fishing season policy is annually imposed in Davao Gulf to allow the fish stocks to recover and address the declining fish catch. Up to now, there were no assessments conducted to determine multiple factors that could have been contributing to its proper implementation in the Davao Gulf. A mixed-methods approach was used through interviews of fishers (N=229) and supplemented by nine focus groups in Governor Generoso, Lupon, Davao City, Sta. Maria, Don Marcelino and Malita. Results of the regression analysis showed that the catch per unit effort (CPUE) was highly influenced by revenue and number of years of fishing experience (df=3, MS=7.38, F=47.90, p<.001). In addition, the main predictors for the support of the imposition of closed fishing season were the number of fishing hours, fish price, membership to community organizations, and awareness of policy among fishers. Economic motivation seems to predominate among fishers as both factors: revenue and fish price, are related and increase due to the imposition of the closed fishing season. The fishing experience and the number of hours of fishing can both determine the catch success of fishers in their fishing grounds. In addition, the flow of information between fishers is usually done through membership with community organizations due to the familiarity of members with one another. Moreover, fisher to fisher interactions also help transmit information in the fishing grounds. Ultimately, the fisher's willingness to cooperate and support the closed fishing season policy will help determine the fish stocks recovery.

Keywords: Closed fishing season, Davao Gulf, Davao region, fisheries management, small-scale fisheries

1. Introduction

1.1 The small-scale fisheries

The Philippines lies at the center of coral reef and marine shorefish biodiversity and is considered to be highly impacted by overfishing, marine pollution, and climate change (Lavides et al., 2016; Monnier et al., 2020; Muallil et al., 2020; Roberts et al., 2002). Coral reefs provide habitat to diverse marine life forms, making them essential in the marine ecosystem (Muallil et al., 2015). At present, there are more than 1,800 MPAs in the Philippines to actively promote coral reef conservation, fisheries sustainability, and tourism, and even recreation, among others (Cabral et al., 2014). It is expected that coral reef fish biomass will increase over time when protected, and this will seed adjacent fish habitat areas providing a “spillover effect” that will benefit the local fisheries (Muallil et al., 2015). Moreover, a well-designed and effectively managed marine reserve can reduce local threats and contribute to achieving fisheries management, biodiversity conservation, and adaptation to climate change impacts (Green et al., 2014). Yet, despite this aspect of marine conservation, the country’s small-scale fisheries are still apparently in decline. In particular, the coral reef finfish species have been disappearing and need a more aggressive approach to protection and conservation (Lavides et al., 2016; Lavides et al., 2010). There are also reports of illegal, unreported, and unregulated fishing, which contribute to their decline. Due to a burgeoning population, unequal economic opportunities between rural and urban areas, and an uptick in coastal tourism, there is still an increasing demand for coral reef fish food apart from available pelagic fish species (Fabinyi, 2008; Peralta-Milan et al., 2020). Indeed, coral reef fisheries constitute an important source of food and livelihood at a global scale and among Filipino small-scale fishers (SSF) (McManus, 1997).

1.2 Livelihood of coastal communities

In many coastal communities, fishers are highly dependent on the existence of coral reef ecosystems, with fishing as their primary means of livelihood and income sources. Livelihood is defined as the capabilities, assets, and activities that constitute a person’s means of living. A livelihood is sustainable only if it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and asset base both now and in the future, without undermining its natural resource base (Islam et al., 2020). The sustainable concept seeks to bring together the assets, events, and critical factors that affect household strategies' vulnerability or strength (Digal and Placencia, 2017). Many fisheries dependent communities remain vulnerable due to a lack of stable sources of income, alternative livelihoods and food insecurity, and poverty (Béné et al., 2016; Katikiro, 2016). This is because the major fishing grounds of the country are already considered to be highly exploited, ecologically threatened, and degraded (Anticamara and Go, 2016; Macusi et al., 2015b). Many programs in the past have tried to strengthen the conservation of the fisheries resources of the Philippines, particularly with regards to marine protected areas (Alcala and Russ, 2006; Cabral et al., 2013), community-based approaches in the 1980s, co-managements in the 1990s, alternative livelihoods, coastal resources management program (Slater et al., 2013), and until recently on the ecosystem approach to fisheries management (Gorospe et al., 2016; Pomeroy et al., 2017). However at present, it seems that alternative job provisions from outside the fisheries could be one of the key solutions being advocated in combination with effort control measures and including spatially explicit management of the fishing grounds (Macusi et al., 2017b; Muallil et al., 2011; Slater et al., 2013).

1.3 Decline in the fisheries

There are many reasons proposed with regards to the decline of the fisheries, including too many fishers, overfishing, use of destructive fishing practices, illegal, unreported and unregulated fishing, lack of strong deterrent in the fisheries laws with regards to IUU fishing, marine pollution and climate change impacts (Aliño et al., 2004; Bailey et al., 2012; Libre et al., 2015; Macusi et al., 2020; Muallil et al., 2013). In the case of having too many fishers, this could be driven by lack of available land-based jobs, or due to rapid increase in human population with jobs availability not being able to keep up with the number of new entrants to the workforce every year and the fisheries is a last resort or means of livelihood (Katikiro, 2016). Overfishing is the outcome of having too many fishers fishing at the same time or too much fishing effort so that there are fewer fish left to spawn again (Muallil et al., 2014a; Oguz et al., 2012). In the past, dynamite fishing was prominent, with the various information campaign and rehabilitation programs that have been widely disseminated, this practice has mostly disappeared. The use however, of plant-based poisons and fine-meshed nets is still widely practiced in hard-to-reach areas by inspecting teams from BFAR (Bureau of Fisheries and Aquatic Resources) and LGUs (Local Government Units). In this case, illegal fishing is still being practiced, including the intrusion of commercial fishers in municipal waters of the local government units (Salayo et al., 2008). Again, this was not being widely inspected or reported as a violation, and they are mostly ignored in the present. Climate change and disasters have recently come to the fore due to increased coral bleaching and warming of the oceans (Jacinto et al., 2015; Licuanan et al., 2019). It seems that the seasonality of the fish spawning and their distribution in many fishing grounds are being altered due to this (Geronimo, 2018; Macusi et al., 2020). The combination of these problems afflicting the small-scale fisheries has been regarded as a wicked problem, hard to disentangle, and continues to defy the solutions that have been advocated (Mahon et al., 2008). More interdisciplinary and cooperative efforts need to be seen.

1.4 Effort control and implementation of the closed fishing season

There are various control measures available to effectively manage fish stocks, which aims to limit the catches directly or indirectly (Colloca et al., 2013; Yıldız et al., 2020) et al., 2020). Catch quotas are a form of direct control with defined limits for catching fish. Gear type restrictions intend to reduce catching of immature/juvenile fish and discards and are indirect controls while temporal and spatial closures aim to reduce fish exploitation rates. Both direct and indirect controls are commonly used around the world in both small-scale to large and industrial fisheries (Maynou, 2020; Yıldız et al., 2020). In Davao Gulf, a closed fishing season policy has been advocated as a possible recourse to curb the high effort of commercial fishers (Brillo et al., 2016; Rola et al., 2018). Closed fishing season is one of the easiest management options to undertake since it completely stops the fishing activities of the targeted fishing sector or fishery (Samy-Kamal et al., 2015). It is also known to help the reproductive success and support the recruitment of target species (Arendse et al., 2007). The conservation, protection, and sustainable management of the country's fishery resources is a national policy and the establishment of closed fishing season is one of the identified conservation measures which has seen positive impacts specifically on sardine fish catch. When imposed, the closures of fishing grounds need a complete cessation of fleet activity for a certain period which can result in the reduction of annual fishing effort to 20% (Demestre et al., 2008). In all China seas, seasonal fisheries closure has been enforced and p racticed thoroughly since 1995 from June to September for some single-species stocks such as lobster, shrimp and limpet and also for fish species (Arendse et al., 2007; Cheng et al., 1999; Everson, 1986; Shih et al., 2009). Seasonal closures are generally imposed with the aim of protecting demersal resources at the most vulnerable point of their life cycles and to help increase fish biomass (Pipitone et al., 2000). These seasonality closures vary among countries and harbors, ranging from 30 to 45 days in Italy to two months in Spain or four to five months in Greece (Demestre et al., 2008; Dinmore et al., 2003; Smith et al., 2000). The government has imposed a closed fishing season policy from first of June to first of September every year (since 2014) in Davao Gulf mainly as a biological way to help improve the fish stocks due to a perennial decline in fish catch. It is vital to evaluate what contributory factors could be influencing the positive reception and cooperation of fishers towards the implementation of the closed season fishing policy. In addition, this study sought to characterize the small-scale fisheries of selected fishing communities, to describe their fishing characteristics in Davao Gulf, quantify their CPUE (catch per unit effort) and evaluate its relationship with other fisheries factors.

2. Materials and Methods

2.1 Framework of Analysis

In this study, we propose that the fisheries factors mainly influencing the CPUE and the support for the closed fishing season policy come from factors or characteristics of the fishers such as related to their age (years), fishing experience (years), number of hours fishing (hr), boat power (HP) and other socioeconomic variables like revenue (Php) and income (Php) and their connectedness to their community organizations, access to help and services. For instance, in the case of the fishers' CPUE, their long years of stay and fishing experience could predict a better CPUE as these fishers would have a more detailed local knowledge of their fishing grounds compared to the new entrants or younger fishers (Johannes et al., 2000; Silvano and Valbo-Jørgensen, 2008). In contrast for the support of the implementation of the closed fishing season policy, this is more related to the flow of information in the community and their motivation to follow or not such laws being implemented by the government. The network of information, how fast this information flow to the fishers could influence their decisions to accept its implementation or not; if they accept, the rewards are also possible yet it is still in the future as the promise was to increase the number of fish stocks in the long-term (Dreyfus-Leon and Gaertner, 2006; Whallon, 2006). However, the negative motivation is equally daunting as it is also possible that they could be apprehended by the coastguard and the navy if they will violate the provisions of the closed fishing season. So, the acceptance of this policy and its implementation stands a 50% chance among the fishers to reject or accept it see Figure 1.

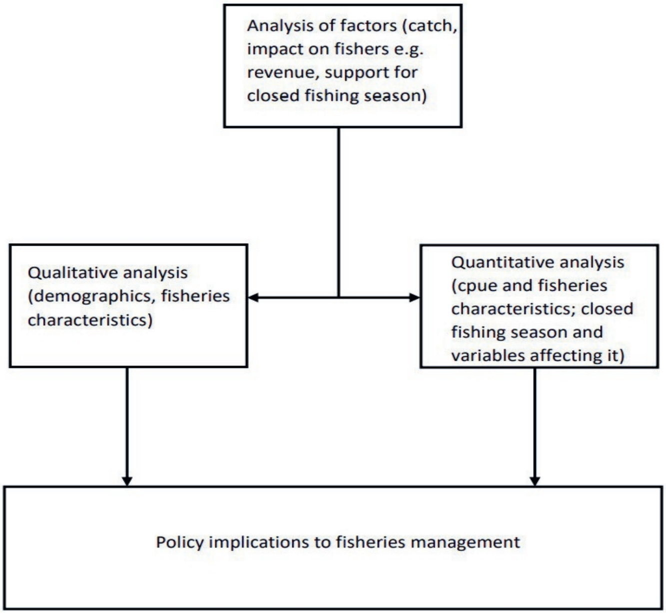

Figure 1. Framework for data analysis of the fisheries factors, CPUE (catch per unit effort) and factors that support the closed fishing season policy.

2.2 Description of the study site

The Davao Gulf is located in the southern Philippines on the Island of Mindanao. It lies approximately between 6°30′00″ North longitude and 125°58′35″ East latitude. The water surface area is about 3,087 km2 and tide in the area is predominantly semi-diurnal, with two high and two low water levels occurring in a day. Davao Gulf is a wide and deep (>1 km) and semi-enclosed basin located south of Mindanao Island. Two major islands are located near the head of the gulf, which partly blocks the entry of tidal currents and the propagation of long gravity waves (Villanueva, 2018). The description of the selected study sites and their characteristics are as follows: 1) Governor Generoso has a population of 55,109 people, with 2,300 registered fishers. It is well known for its commercial fishing and hosts four ringnet fishing companies in the area with boat building and small shipyards; 2) Lupon has a population of 65,785 people, well-known for its hook and line fishing with about 1,500 registered fishers and small boat-building industry; 3) Davao City, has a population of 1,632,991 people with about 5,500 registered fishers and two ringnet fishing companies that operate from the Toril fish port; 4) Santa Maria, has a population of 53,671 people with about 3,200 registered fishers and noted for its small-hook and line fishers as well as commercial bagnet fisheries; 5) Malita, has a population of 117,746 people and 800 registered fishers that operate mostly hook and line fishing gears; 6) The last study site is Don Marcelino, with a population of 44,554 people and 700 registered fishers, mostly hook and line fishers (see **Figure 2**).

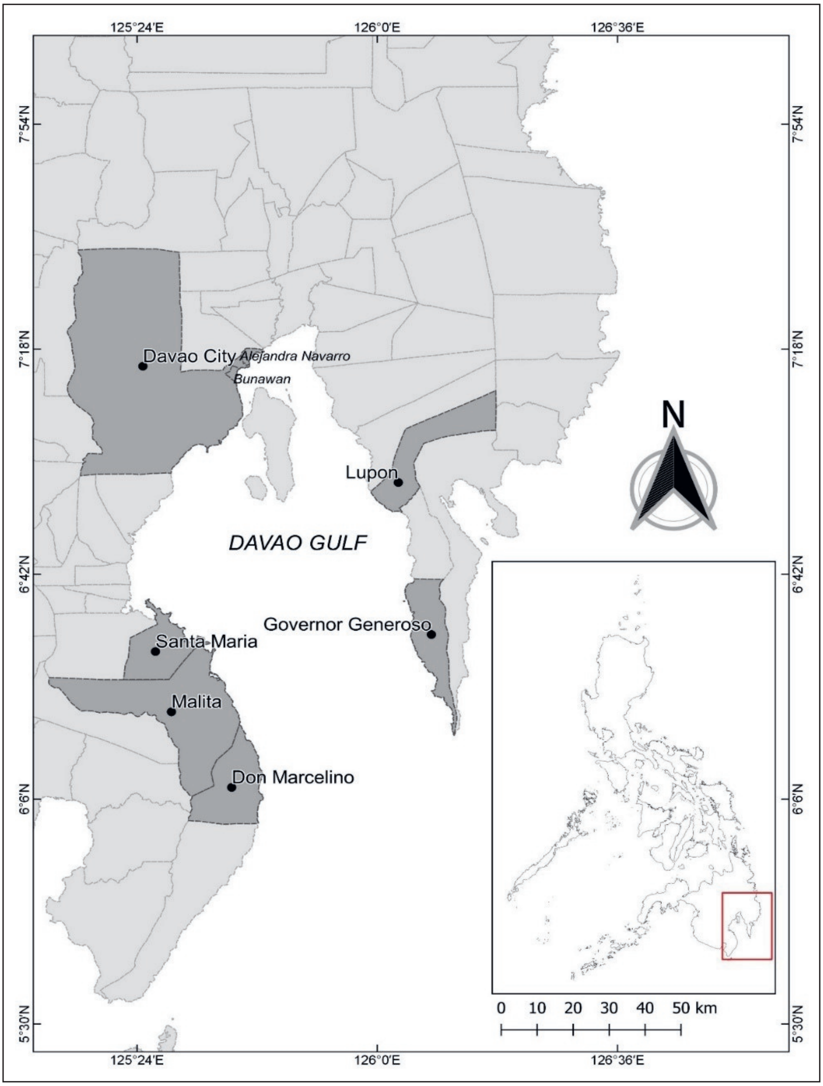

Figure 2. Map showing the different sites in Davao Gulf with the inset map showing the Philippines and Davao Gulf in the boxed area.

2.3 Data Collection

A) Questionnaire

For the data collection using a semi-structured questionnaire, letters of permission to gather interview data were sent to the Municipal Agriculturist Office (MAO) of the municipality as well as the office of the barangay captain in the area of study. The study began collecting data from 22 August to 3 October 2019 with respondents coming from fishing communities in Governor Generoso, Lupon, Davao City, Sta. Maria, Don Marcelino, and Malita for a total of N=339. The main criteria for respondents were fishers who have been fishing for at least one year in the study area and residents for at least a year or more in the fishing community where they stayed. A pilot test of the interview was conducted prior to the main interview with only 10 respondents per barangay in Tibanban and Monserrat in Governor Generoso, Ilangay and Poblacion in Lupon, Davao Oriental; Bunawan and Lasang and Toril in Davao City; San Agustin in Sta. Maria, Culian in Don Marcelino and Fishing Village in Malita, Davao Occidental. It took 30 to 40 minutes to answer the pilot questionnaire depending on the individuals that were interviewed. Since there were no updated lists of fishers from the various barangays visited prior to the conduct of interviews, fishing communities were directly visited upon the recommendation of the barangay chairman. Similarly, to get the necessary sample size of respondents in the visited barangays, snow-ball sampling technique was used through referrals from other fishers who have been interviewed.

The selection of study sites was based on the availability and number of the fishers living in the area as well as logistics to visit the area. Most of these study sites also lack prior studies with regards to closed fishing season nor any fishers' survey have been conducted in them. The number of sample size taken per barangay was N=30, and with this sample size, saturation of the responses was already possible (Macusi et al., 2020). There was a total of N=229 small-scale fishers out of the N=339 that were surveyed in Davao Gulf after separating incoherent responses, not qualifying as small-scale fishers, missing answers etc. The semi-structured questionnaire included the following topics: age, educational attainment, number of years of stay in the community, years of fishing, rank or position of respondent, primary fishing gears used, boat ownership and gear, type of boat, type of material the boat is made of, number of fishing trips in a week, numbers of hours spent per fishing trip and how far they usually fish from the shore. Respondents were also asked about market access (to whom do fishers sell catch), the proportion of catch kept for the family, catch characteristics, reasons for catch decline, and their agreement to implementation of the fishing ban during June up to end of August. Based on the 229 interviews performed with fishers in Davao Gulf, Don Marcelino had the highest number of respondents (53) while Sta. Maria had the lowest number of respondents (10) among the small-scale fishers (**Table 1**).

Table 1. Rank or position of the boat of small-scale fishers per site.

Study site	N	Boat Captain	Assistant Boat Captain	Crew	Operator
Governor Generoso	34	21		13	
Lupon	50	40		3	6
Davao City	52	51			1
Sta. Maria	10	8		2	
Don Marcelino	53	45		8	
Malita	30	15	1	14	
Total	**229**	**180**	**1**	**40**	**7**

The interviewed fishers were mainly boat captains, assistant boat captains, crew and operator. The boat captains and assistant boat captains were knowledgeable of the many aspects related to fisheries and catch characteristics of the fish and some also of the crews were knowledgeable in the aforementioned aspects related to fish and catch characteristics.

B) Focus Group Discussion

Additional data collected from the fishers from the various study sites include qualitative estimates of historical catches, reasons for catch decline, reasons for supporting the implementation of the closed fishing season and how fishers were informed in their villages of the policy and whether there was any help coming from the municipal or city agriculture office with regards to this knowledge campaign. For reasons on catch decline, the participants were asked to provide factors that they think are causing the decline and then to rank it based on a scale of 1 to 5, with 1 as highest. Later in the analysis, this ranking was reversed based on equivalents of 1 to 5 to the scale of 10 down to 2 using even numbers to come up with the scores. The scores were then averaged for the different factors. While for the success factors of implementation of the policy, the participants were asked how much proportion or percentage they would ascribe together in terms of whether there was any coordination that happened in their area, whether knowledge campaigns were effective and whether cooperation was functional between the villages, the local government and the coastguard. The results of the focus groups were summarized in table form. Stakeholders that participated in the FGD were fishers, their wives, some senior citizens, and each focus group was limited to 12-16 individuals per study site. This was to allow participants the freedom to talk without feeling intimidated. The facilitator kept the discussions free-flowing and directed them according to the selected topics. One facilitator among the researchers conducted and explained the topics, another recorded and kept notes of the discussion and the others helped to record the participants' attendance and provided refreshments. The focus groups were conducted from 22 October to 24 November 2020 in the same study areas, with total number of participants N=132.

2.4 Data Analysis

The qualitative data and quantitative data were encoded and summarized on Microsoft Excel (2016). The information was then analyzed through descriptive statistics and percentages to compare the different socio-demographics in the various study sites. Socioeconomic data such as the age of fishers, their fishing experience, and the number of years of stay in the community, together with data on fisheries characteristics such as fishing operation, travel time, fishing boat characteristics (engine size), number of fishing hours, number of times fishing in a week, fish price, revenue, the proportion of catch left for the family were then explored for the relationship with the CPUE of the fisheries. The CPUE was used as a dependent variable and the other factors as predictors for a multiple linear regression analysis to answer the question of what influences the CPUE of the fisheries. The CPUE was computed based on the normal catch of fishers and the corresponding number of hours fishing per day trip. (Since the CPUE was based on a normal catch and the fishing hours, these two variables were not included in the final computation, including fish price, to avoid the possible problem of endogeneity in the data analysis). The CPUE was log10 transformed to satisfy the assumptions of ANOVA. Preliminary analysis was done through scatterplots and histograms of the different variables to check the relationships of the predictors and the dependent variable. Furthermore, in a second model, the categorical variables such as levels of education as well as membership to a community organization, credit access and awareness of the closed fishing season were added as categorical covariates in addition to the continuous predictor variables (socioeconomic and fisheries factors) in a binary logistic regression to determine what influences the decision of fishers to support the implementation of the closed fishing season in Davao gulf. The predictor variables were not highly correlated as we did not include similar fisheries factors in the data analyses to avoid multicollinearity. As the first model was done with multiple linear regression analysis, the VIF (variance inflation factors) of the predictor variables in the analysis was checked (VIF=1.04 which was robust since a value between 5 to 10 canindicate multicollinearity in the predictor variables)(Field, 2005; Midi et al., 2010; Stoltzfus, 2011). In the logistic regression, where some of the variables used in the MLR were the same, the collinearity statistics using VIF, ranged from 1.00 to 2.02. Data analyses were conducted using MINITAB 17.0 (State College, Pennsylvania, USA) and IBM SPSS 21 (SPSS Statistics for Windows, version 21.0. Armonk, NY: IBM Corp).

3. Results

3.1 Fishing characteristics of the fisheries

The mean age of fishers reported was 43 and ranged from 18 to 74 years old, those from Lupon (39 yrs old) were the youngest and those from Davao City (45 yrs old) and Sta. Maria (45 yrs old) were the oldest (**Table 2**). The mean number of years of stay in the community was 35 years and ranged from 2 to 74 years, with Davao City having the highest recorded average number of years of stay (39 yrs) among all the study sites, followed by Don Marcelino (37 yrs) and Sta. Maria (36 yrs). The mean number of years fishing was 25 years and ranged from 1 to 64 years, respectively. Fishers from Sta. Maria (29 yrs) and Governor Generoso (27 yrs) proved to have the highest average fishing experience among all study sites. In terms of the number of household members, Governor Generoso has an average of 6 members, followed by Davao City, Malita, and Lupon with an average of 5 members with an overall range of 1 to 13 household members.

Table 2. Fishing characteristics and sociodemographic profile of the various study areas around Davao Gulf (values are average and standard deviation).

Fishing Characteristics	Davao City	Don Marcelino	Governor Generoso	Lupon	Malita	Sta Maria
Age	45.19 (11.81)	43.51 (14.29)	44.56 (12.87)	38.78 (13.02)	42.07 (12.51)	45.40 (11.40)
Years in community	38.86 (12.16)	37.03 (15.70)	32.65 (14.30)	32.48 (13.47)	35.73 (14.03)	35.90 (12.90)
Years fishing	26.34 (11.43)	21.77 (13.37)	26.82 (15.04)	24.20 (12.78)	24.96 (15.77)	28.60 (11.60)
Household size	5.44 (2.28)	4.26 (1.93)	5.56 (2.38)	4.80 (2.16)	5.06 (2.26)	4.30 (2.30)
Boat power (HP)	7.87 (1.76)	8.47 (1.84)	9.93 (2.53)	8.59 (2.68)	8.23 (2.47)	8.16 (1.16)
Fish price (Php)	156.39 (49.82)	106.26 (30.83)	128.58 (31.45)	150.03 (50.47)	135.43 (31.26)	111.36 (49.36)
Normal catch (kg/trip)	3.69 (3.67)	7.02 (4.72)	13.26 (6.46)	7.78 (5.69)	6.11 (6.02)	5.51 (3.51)
Hours fishing	4.80 (2.81)	9.89 (5.13)	6.84 (5.75)	6.94 (5.51)	8.88 (5.89)	15.10 (2.10)
Revenue (Php)	553.00 (471.10)	742.83 (591.36)	1695.20 (963.58)	1069.06 (742.10)	829.22 (963.83)	613.85 (471.85)
CPUE (kg.trip/hr)	1.32 (1.93)	1.50 (2.65)	3.75 (3.73)	1.78 (1.84)	0.89 (0.97)	0.52 (0.66)
Total Cost (Php)	205.63 (118.50)	353.91 (111.40)	565.06 (289.88)	354.67 (145.19)	333.93 (289.91)	329.10 (118.10)
Fish trip/wk	5.63 (2.84)	5.00 (1.13)	3.76 (1.79)	4.62 (2.18)	3.37 (0.97)	3.50 (2.50)
Proportion catch left	.72 (0.27)	.45 (0.50)	1.46 (1.32)	0.86 (0.64)	0.23 (0.43)	0.2 (0.42)

3.2 Fishing operation, costs, catch, and revenue

For a fishing operation, the total cost is very similar in terms of the overall average cost of Php 357 in the study sites and ranged from Php 63 to Php 1,525. The highest total cost was in Governor Generoso (Php 565), followed by Lupon (Php 355) and least in Davao City (Php 205). This total cost was mainly based on food and fuel per fishing trip. One fishing trip averaged 9 hrs and ranged from 1 to 24 hrs with the longest fishing hours in Sta. Maria (15 hrs), followed by Don Marcelino (10 hrs) and Malita (9 hrs) and least in Davao City (5 hrs). Their normal catch was 7 kg per trip and ranged from 1 to 29 kg/trip, with Governor Generoso catching an average of 13 kg/trip and followed by Lupon with an average of 8 kg/trip; CPUE was highest in Governor Generoso (4 kg.trip/hr) followed by Lupon (2 kg.trip/hr) and least in Sta. Maria (0.52 kg.trip/hr). The self-reported revenue per trip of small-scale fishers in Davao Gulf averaged Php 918, and ranged from Php 73 to Php 4,200 (see **Table 2**).

3.3 Catch decline, awareness, and perceived benefits of closed fishing season

Most fishers fishing in Davao Gulf were aware of the implementation of the closed fishing season (85%). Fishers from Governor Generoso (91%), Davao City (87%), and Sta. Maria (100%) gave the highest positive responses for their awareness. A majority of the fishers also think that there is a difference in terms of catches between closed and open season (56%) except in Don Marcelino and Malita. In addition, the fishers from Governor Generoso (76%), Malita (67%) Davao City (65%) gave high positive responses. Moreover, all the respondents in the study sites agreed on the implementation of the closed and open season (78%), which they perceived will help increase the fish stocks found in Davao gulf (81%). The fishers from Governor Generoso (88%) and Davao city (94%) highly agreed to its implementation and think that the outcome will be beneficial for the fish stocks (94 and 92%) (**Table 3**).

In addition, results from the FGD as ranked by the fishers showed that the main reasons for catch decline were mainly due to commercial fishing (10), agricultural and chemical wastes coming from banana plantations and waste water (9.67) followed by too many fishers (9.0), illegal fishing (7.33), climate change (7.0), solid waste disposal (5.0). In terms of success factors for keeping fishers informed of the closed fishing season, 51% and 64% agreed about the coordination and closed cooperation between the local governments, barangay, the coastguard and the navy as well as due to knowledge campaign (68%) (see **Table 4**).

Table 3. Cross-tabulation of self-rated awareness, agreement on implementation of closed fishing season and perceived benefits of closed fishing season (numbers are positive responses and numbers in brackets are percentages of positive responses; N=229).

Characteristics	Governor Generoso	Lupon	Davao City	Sta. Maria	Don Marcelino	Malita
Awareness of closed season (%)	31 (91)	42 (84)	45 (87)	10 (100)	39 (74)	22 (73)
Difference of closed and open season (%)	26 (76)	31 (62)	34 (65)	5 (50)	18 (34)	20 (67)
Agree with the implementation of closed fishing season (%)	30 (88)	40 (80)	49 (94)	7 (70)	38 (72)	20 (67)
Think closed fishing season help increase the number of fish in the area (%)	32 (94)	40 (80)	48 (92)	8 (80)	36 (68)	21 (70)

Table 4. Possible reasons for catch decline, and success factors for keeping fishers informed of the closed fishing season (FGD).

Reasons	Governor Generoso	Lupon	Davao City	Sta Maria	Malita	Don Marcelino	Ave
[a]Commercial fishing	10	10				10	10.00
[b]Agricultural/ chemical wastes		9	10		10		9.67
Too many fishers		8		10			9.00
[c]Illegal fishing	8				6	8	7.33
Climate change/ sea-level rise	4		8		8	6	6.50
Improper solid waste disposal	2	6	6	8	4		5.20

(1) Coordination with fishing village	10%	75.00%	90%	99%	30%	0%	51%
(2) Awareness campaign	53%	80%	75%	0%	100%	100%	68%
(3) Cooperation of the local government, navy and coastguard	10%	75.00%	100%	99%	100%	0%	64%
How fishers informed?	BFAR, [d]comm. fishers	BFAR,co-fishers	TV, co-fishers	Co-fishers	Co-fishers	Comm. fishers	
Who informed the fishers?	BFAR, [d]comm. fishers	BFAR,co-fishers	TV, co-fishers	Co-fisher	Co-fishers	Coastguard	
What method was used?	[e]Pers. inquiry	Pers. inquiry	Watch TV; personal inquiry	Pers. inquiry	Pers. inquiry	Pers. inquiry	
Other information from (MAO/CAO)	Yes	Yes	No	No	Yes	No	
Needs	Payao, cannery	Ice plant, capital for fishing	Ice plant	Fishport	Cooperative	Cooperative	

[a] small fishers put the blame on commercial ringnet and bagnet fishers

[b] Fishers particularly from Lupon, Davao City are blaming chemicals used to spray in banana plantations for decline of fish abundance

[c] Use of compressor and plant based poisons to harvest large bodied groupers and other coral reef fish are forbidden

[d] Commercial fishers informed them while fishing in their fishing ground

[e] Personal inquiry of fishers to their peers

3.4 Relationship between CPUE and the fishing characteristics

Results of the multiple linear regression show that the CPUE was highly influenced by the number of years fishing, revenue and proportion of catch left for family (df=3, MS=7.38, F=47.90, p<.001). The results for the predictor variable "number years of fishing" was significant (df=1, MS=0.658, F=4.27, p=.040), this was also true for the predictor variable "revenue" which was highly significant (df=1, MS=18.77, F=121.83, p<.001) and for "proportion of catch" left for the family, this was significant at 90% level probability (df=1, MS=0.537, F=3.49, p=.063).

The CPUE was then modelled with selected fisheries characteristics based on the survey data and shown below in Figure 3. It showed that age and the "number of years fishing" have a pyramidal pattern, which showed that fishers older, with a number of years of fishing experience, have higher CPUE. But this was only true up to a certain age and starts to decline by the age of 50 (**Figure 3A**) and after 40 years of fishing (**Figure 3B**). In the case of the number of "hours of fishing," it seems that fishers can catch more or less within two hours of fishing after arrival in their fishing ground. Contrary to the common assumption, that the more time you fish, the more you can catch, this was not true to fishers spending >12 hrs in their fishing ground. It seems that once a fisher reaches his 10th hour of fishing, it appears that he will be far better to go back to his homeport if he caught nothing (**Figure 3C**). For boat power, CPUE increased from 5 to 10 HP and then starts to decline at 11 HP (**Figure 3D**). For the cost of fishing, this was mainly concentrated between Php 300 and Php 500 where there was a dense aggregation of points (**Figure 3E**). And the revenue follows an almost perfect J curve where it then slowly increases peaking at Php 4,000 per trip (**Figure 3F**). The fisheries may not always be that profitable but it shows that the small-scale fishers still derive much benefit from the gulf as they have catches to bring home.

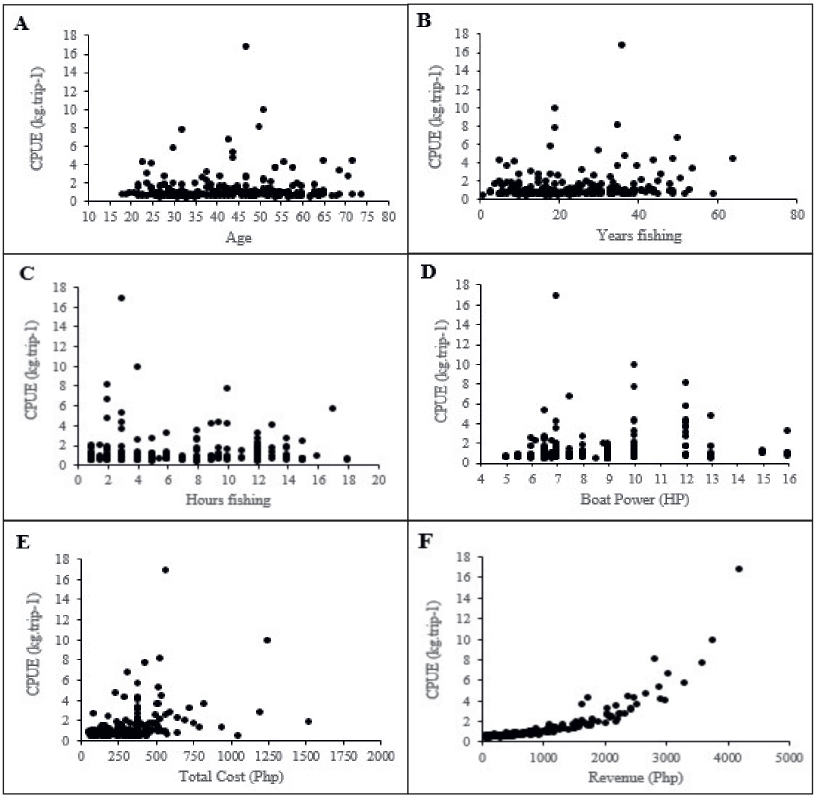

Figure 3. Relationship of the modelled CPUE (catch per unit effort) to selected sociodemographic and fisheries variables age (A), years fishing (B), number of hours fishing (C), boat power (D), total fishing cost (E), and revenue (F).

3.5 Factors influencing support for the implementation of closed fishing season

For the result of the logistic regression whether to support or not the implementation of the policy, four factors were selected, mainly, fish price [B=0.017 (SE=0.008), Wald=3.99, df=1, *p*=.046], the number of hours of a fishing trip by a fisher [B=-0.088 (SE=0.042), Wald=4.29, df=1, *p*=.038] and then followed by membership to a community organization [B=-2.28 (SE=0.518), Wald=19.54, df=1, *p*<.001] as well as awareness of the closed fishing season policy [B=-2.014 (SE=0.491), Wald=16.81, df=1, *p*<.001]. In addition, the equation showed that its predictors can predict 87% of agreement for the support of implementation of the closed fishing season policy in Davao Gulf. The model chi-square statistic was 72 and highly significant (df=14, *p*<.001; see **Table 5**).

Table 5. Predictors for support of the implementation of the closed fishing season policy in Davao Gulf (Significantly different factors are in bold).

		95% Confidence Interval for Odds Ratio		
Variables	B (S.E.)	Odds Ratio	Lower	Upper
Age of fisher	0.001 (0.026)	1.001	.950	1.054
Years in Community	-0.028 (0.021)	.972	.933	1.014
Years of Fishing	0.024 (0.025)	1.025	.977	1.075
Household size	-0.017 (0.099)	.983	.809	1.194
Engine Size	0.0021 (0.114)	1.002	.801	1.254
Fish Price	**0.017 (0.008)***	1.017	1.000	1.034
Regular catch	0.23 (0.15)	1.258	.934	1.695
Daily fishing trip (hours)	**-0.088 (0.042)***	.916	.843	.995
Revenue	-0.0017 (0.001)	.998	.996	1.000
Total Cost	-0.0012 (0.001)	.999	.997	1.001
Fishing trips in a week	-0.094 (0.107)	.910	.738	1.123
Proportion of catch for family	0.046 (0.336)	1.047	.543	2.022
Membership to organizations	**-2.288 (0.518)****	.101	.037	.280
Awareness to closed fishing season	**-2.014 (0.491)****	.133	.051	.349
Constant	3.18 (1.97)	24.130		

Note=R^2= 0.27 (Cox and Snell); 0.43 (Nagelkerke); Model X^2= 72 , *P*= <0.001
**P*<0.05
***P*<0.001

4. Discussion

4.1 Factors facilitating the implementation of the closed fishing season

Local consultative assemblies among fishers and other stakeholders are often the norm in coastal resources management in the Philippines which is also different from other neighboring coastal island states (Pollnac et al., 2001; Pomeroy et al., 2007). Cooperation among stakeholders and education for sustainable fishing practices are often touted as part of the solution to various problems plaguing the marine fisheries management programs implemented in the Philippines (Garces et al., 2013). The results from the focus groups, showed that most of the respondents learned or became aware of the closed fishing season mostly from their peers and their village leaders through personal inquiry or informal talk. The closed fishing season have been designed to protect commercial species such as the sardines in Zamboanga Peninsula at a particular stage of their life histories and may only benefit a few fish species from among a wide range of targeted organisms (Brillo et al., 2019; Rola et al., 2018), as many target species have different life cycles with different recruitment and spawning seasons (Shih et al., 2009; Yıldız et al., 2020). Nevertheless, since sardines were a top priority commodity in the Philippines, this was understandably a needed decision in Zamboanga to protect the industry from collapsing. Since there were observed increases in fish biomass after the implementation of the closed fishing season, this shows the effect of reducing the fishing effort of commercial fisheries (Pipitone et al., 2000; Yıldız et al., 2020). The present study provides an impetus for assessing the effectiveness of the closed fishing season, with regards to factors facilitating such closures. With the inclusion of the fisheries variables' number of fishing hours' and 'fish price' as influencing factors in terms of support for the implementation of the closed fishing season, this points to an economic motivation on the part of the small-scale fishers with their agreement to implement a closed fishing season policy. The benefit accrued includes a higher monetary incentive among fishers and vendors selling the fish, which commands higher prices during the periodic closure (Macusi et al., 2017b). Another element for effective implementation that can be easily missed includes communication gaps between fishers and the regulating agencies. This is a serious flaw as the lack of communication between fisheries managers at different levels in the government and the fishers, could hinder the development of adequate conservation strategies (Pino-Del-Carpio et al., 2011). Although there were visits in the field by government personnel, these are sometimes overshadowed by doubts or complaints because of lack of trust. The success of management programs necessitates the action of the government to direct resources, facilitate the conservation and sustainable use of natural resources (Ortega-Rubio and Arguelles-Mendez, 1999). The existing distrust between fishers could provide a better motivation to actually help start a knowledge awareness campaign that will help towards communicating better conservation information consistent of science-based practices (Danylchuk et al., 2017).

4.2 Fish catch and reasons of decline

Other results from this study have shown that the fish catch of fishers have decreased and was mainly attributed to commercial fishing activities, chemical and industrial wastes, too many fishers and illegal fishing. These have become common problems being experienced in most fishing grounds due to overexploitation, lack of consistent enforcement for effort control of the fishers and lack of religious monitoring for industrial and chemical residues dumped to fishing grounds (Abreo et al., 2020; Macusi et al., 2017b; Macusi et al., 2020; Muallil et al., 2014a). The first reason among fishers of the cause of catch decline involved the incursion of commercial fishers in municipal waters which can easily deprive them of their catch (Pomeroy et al., 2007; Salayo et al., 2008). Since this has not stopped as an allegation among municipal fishers against the commercial fishers and the conflict continues, this will not be solved by a rumor but a good amount of evidence that should come from vessel monitoring (Chang, 2016; Geronimo et al., 2018). A vessel monitoring system will provide the exact movement and track where the fishing vessels go; the coastguard or the navy can inform the vessel's captain if it veers from correct direction or boundary.

The second reason based on the feedbacks of the fishers concerned the dumping of chemical and waste residues of largescale industrial farms of banana and other agricultural plantations (Abreo et al., 2015; Porcher et al., 2010). Many of these feedbacks in terms of their livelihood experiences and issues could be valid concerns. Sometimes these are picked up by short-term studies such as this one. But the local knowledge of fishers concerning their fishing grounds while not apparent through their reasonings could be worthy for a deeper investigation (Andalecio, 2010). One such statement that has become common in the gulf during our interview is their complaint and association of banana farms to their declining fish catch; they make allegations of chemicals being released by the companies through pesticides and aerial sprays. These should not be ignored as it may help provide a balance between the needs of farmers and fishers to co-exist together (Johannes et al., 2000; Johannes and Neis, 2007). A third reason includes having too many fishers in the gulf, and use of illegal fishing gears such as fine meshed nets, and compressor fishing to catch juvenile and large bodied long-living fish. This may require a prolonged educational campaign in fishing communities to help shift the attention of fishers from their needs now to their future food security through fisheries conservation (Digal and Placencia, 2017; Foale et al., 2013; Villanueva, 2018).

4.3 Catch per unit effort (CPUE) and fishing characteristics

The CPUE was highly influenced by 'years of fishing', 'revenue' and as well as 'proportion of fish catch' left for the family. The age of fishers and their fishing experience matters in this type of livelihood as there is a learning phase involved for the exploration of fishing grounds and development of keen knowledge of the environment where they fish (Johannes and Neis, 2007). This experience and knowledge grow through time. Given this learning phase, fishers usually reach their peak of productivity by the time they are in their 40s and 50s and have been fishing for more than 30 years. Slow decline sets in after reaching that peak age leading to lower productivity among older fishers. Fishers in this study were motivated to live and work according to their social, cultural traditions, attitudes of perseverance related to their skills, their job satisfaction as well as their learned behaviors (Libre et al., 2015; Pollnac et al., 2001). Leaving the fisheries will be nearly impossible for most of them as they identify with their livelihood (Muallil et al., 2011). As for younger fishers, they might be interested in skills retraining and continuing their education since most fishers have barely finished their primary and secondary schools.

For the revenue, this would have been likely influenced by the fishers' economic motivation due to food security needs of their households (Fabinyi et al., 2016; Macusi et al., 2017b). Many of the fishers' spouses were housewives whose revenues depend highly on the fish caught by their husbands (Bradford and Katikiro, 2019; Siar, 2003). They sell their fish catch to other relatives, neighbors or in the local market, which leaves them only with about half a kilo or a kilo of fish for their food. To help augment their income, sometimes other family members also work to mend broken nets, do fish drying, or conduct buy-and-sell activities. Since fishers usually have larger households, they are highly vulnerable to malnutrition and diseases due to inadequate food when catches are diminished (Béné, 2003; Béné and Friend, 2011; Grebmer et al., 2020). Sometimes they also engage in fish processing and other livelihood activities that can free them to be less reliant on fisheries resources (Digal and Placencia, 2017).

5. Conclusion

The management programs for controlling fishing effort and leading actions to facilitate sustainable fisheries is required for food secure and resilient fisheries. Closed fishing season as a policy might be effective in protecting the commercially important species in Davao Gulf. The findings of this study revealed the cooperation of fishers and fishing communities towards its implementation and provided evidence for economic motivation, informed communication, better organization and perceived negative consequences of violations such as impounding of fishing gears and boats and the scale of operation promoted by the government. In Turkey, Spain and Italy, closed fishing season has also seen biological and economic evidence of success (Demestre et al., 2008; Pipitone et al., 2000; Yıldız et al., 2020). Better fisheries management requires an active commitment by the government as weak governance is one of the main causes of the poor condition of fisheries ecosystems (Cabral et al., 2013; Garces et al., 2013; Perez et al., 2012). Lack of continuity of fisheries management initiatives will only result in to lack of cooperation among fishers, and while there are debates surrounding the closure policy, we suggest that the economic benefits to small-scale fishers and biological benefits to the commercial fish stocks seem to favor keeping such policy in place. In previous coastal resource management projects, long-term benefits may not continue after project termination due to lack of support by the community or the government (Pomeroy et al., 2017; Yang and Pomeroy, 2017). To augment the effort control program, diversified economic activities such as cash for work, other subsidy programs like 4Ps (Pantawid Pamilyang Pilipino Program of the Republic Act 11310) cash grant targeting families with monthly income below Php 8,000 and with children to fend will help alleviate their immediate needs during the closed fishing season. Training and organizing fishers for supplemental livelihood packages may help them to eventually shift their livelihoods towards land-based activities in the long-term.

CHAPTER 6

General Discussion

Overview

This thesis aimed to examine the factors influencing fishers' utilization and deployment of Fish Aggregating Devices (FADs) in the Philippine tuna fisheries. Understanding these factors is crucial for effective fisheries management, as fisher's decisions regarding FADs utilization and deployment are closely tied to their local ecological knowledge of fish behavior and movement patterns. By gaining insights into these components, this study seeks to contribute to the broader goal of fisheries sustainability through increasing fish stocks by implementing a closed fishing season in the fishing ground.

Specifically, this research investigated four main questions:

1. What are the tactics and strategies employed by purse seine, ringnet fishers and handline fishers in their deployment and use of FADs?
2. What are fishers' knowledge and perception with regards to fish distribution, movement and behavior around anchored FADs?
3. How do socioeconomic factors influence the change of fishing strategies when their catch declines?
4. What are the main factors influencing the catch and support of the implementation of a closed fishing season in fisheries?

The study employs a diverse range of data sources, including direct engagement with fishers, comprehensive surveys, and ecological assessments. The synthesis of these multidisciplinary insights seeks to understand how fishers' strategies and local ecological knowledge shape the use and effectiveness of FADs in the Philippine tuna fisheries. This effort improves our scientific understanding of the ecosystem and provides insights for developing strategies to ensure the sustainability of tuna populations.

FAD deployment as a strategy to maintain and hold fishing grounds

In my study, we observed that anchored FADs serve as informal territorial claims. This is a strategy which was also identified in the Pacific Islands (Bush and Mol, 2015; Bell et al., 2015). This practice, enhances both economic and operational efficiencies, demonstrates the widespread use of FADs in optimizing fishing grounds (see Chapter 2). In the Pacific Islands, anchored FADs have notably improved tuna catch efficiency and provided substantial economic benefits to local communities (Leroy et al., 2013). Murua et al. (2023) underscored the need for policy reforms in Philippine tuna fisheries to address issues arising from the deployment of FADs. These issues encompass challenges related to the regulation and management of FADs, which include potential overconcentration of fishing efforts in specific areas, conflicts over territorial waters, and the impact on local fish populations and marine ecosystems. Filipino fishers and companies employ unique strategies such as using mother boat called "*unay*" and service boats to optimize catch efficiency and reduce fuel costs. This approach combines human skills, including "*boseros*" (human divers) for assessing fish biomass, with the technology like SONARs. Despite the operational efficiencies observed, the volume of fish caught depends significantly on aggregated biomass and gear specifications, necessitating careful management (Bush and Mol, 2015). Similar findings were reported in Mauritius, where FAD deployment increases catch rates while reducing fuel consumption, underscoring the need for regulatory frameworks to manage ecological impacts (Jena, 2022). Vera and Hippolito (2006) highlighted profit-sharing arrangements as a strategy to protect *payaos* (anchored FADs), preventing vandalism and ensuring sustainability amid substantial investment costs. However, the governance of temporary fishing areas dominated by FAD arrays often operated within supra-local and global networks rather than localized frameworks (Bush and Mol, 2015). This aligns with the observations in the Western Indian Ocean, where community-based FAD management improved compliance and fish stock management through local engagement in both benefit-sharing and decision-making processes (Kadagi et al., 2021). Regulation of high seas access is managed through agreements with regional fisheries management organizations (RFMOs), implementing stringent rules on vessel limits and at sea inspections to maintain sustainability (Miyake et al., 2010).

Handline fishers, roaming multiple areas for yellowfin tuna and bigeye tuna, play a crucial role, albeit without specific territorial constraints. Effective management in the Western Central Pacific Ocean and Celebes Sea necessities regulations on boat sizes, hygiene standards, and seamanship training to ensure equitable distribution and sustainable practices (Bailey et al., 2012; Voyer et al., 2017). However, challenges persist, especially regarding the informal nature of handline fishing and the need for improved education and professional development among fishers (Arthur et al., 2015; HLPE, 2019). For instance, Fernandez et al. (2019) and Macusi et al. (2023) emphasized the tractability of handline fishers for catch traceability and quota allocation programs, facilitated by VMS tracking. Collaboration among BFAR, DA, DTI, and NGOs like WWF could enhance market access and economic welfare for these fishers (Binondo, 2015; Grantham et al.,2022). Despite these efforts, addressing overfishing and declining catch rates requires comprehensive cooperation among stakeholders, including the academia and local community groups (Macusi et al., 2015b; Macusi et al., 2022a; Muallil et al., 2011). In adapting to declining near-shore catches, offshore FAD deployment represents a critical strategy, but it requires careful consideration of ecological impacts and long-term sustainability. Sustainable tuna fishing can be incentivized through trade policies, transparent monitoring systems, and on-going compliance assessments (Digal and Placencia, 2017; Doddema et al., 2020; Briones 2022). By critically examining these practices and their implications, we can better understand their effectiveness and potential drawbacks in the broader context of marine resource management. A study of Tsolakis et al. (2021) explored the significance of trade policies and transparent monitoring systems like blockchains in fostering sustainable fishing practices, which supports our recommendation for implementing these measures. Moreover, Alam et al. (2021) investigated the effects of regular monitoring and compliance assessments on fish stocks replenishment in the water of Bangladesh, which corroborates our findings regarding the necessity of effective regulation and oversight in the deployment of FADs. Additional insights from previous oceanic tuna landed catches monitored in General Santos City have shown increasing trend for five years and this aligns to better management schemes for tuna conservation (Pechon et al., 2022). Essentially this prevents overharvesting of monitored species and keeps the tuna fishers compliant to regulations imposed by regional fisheries management organizations.

Comparative studies in agriculture provide valuable insights through parallels drawn between agronomy and fisheries. For instance, agriculture techniques like crop rotation, which enhance soil nutrients and promote sustainability (Shah et al., 2021), have analogous applications in fisheries through the deployment of Fish Aggregating Device (FADs). Just as crop rotation strategically manages soil health, the strategic placement of FADs in the ocean can concentrate fish populations, thereby enhancing catch efficiency and supporting sustainable fishing practices. Crop rotation safeguards soil health by alternating crops to prevent nutrient depletion and mitigate pest infestations (Tanveer et al., 2019). Similarly, FADs attract marine species to specific locations effectively managing fish aggregation. This focused aggregation not only improves catch rates but also foster sustainable fisheries management by potentially reducing by-catch and facilitating more efficient resource allocation. The comparison of these agricultural and fisheries strategies underscores their common goal of optimizing resource utilization and promoting sustainability. Lessons learned from agronomy, such as the benefits of crop rotation in maintaining soil productivity, can inspire innovative approaches in fisheries management aimed at enhancing fish stocks and fostering ecological sustainability.

A practical application of sustainable practices includes regulating the deployment of anchored FADs, fixing their locations, and ensuring proper tax payments for observers and third-party audits. Regular monitoring of FAD areas by the government, using new sensors, digital tools, and remote sensing technologies, in cooperation with fishing companies, is essential (Geronimo et al., 2018; Macusi, 2023). The coordination of FAD deployment strategies can reduce operational costs, lower fishing effort, and minimize over-harvesting, thus supporting fish stock replenishment. Additionally, the professionalization and education of fishers can lead to better fisheries management and sustainability, ensuring the long-term viability of both the fishing industry and marine ecosystems.

Local Ecological Knowledge (LEK) as essential component in marine conservation

Local Ecological Knowledge (LEK), encompassing insights into fish behavior, catch methods, and fishing practices, is crucial for promoting sustainable harvesting practices. LEK's role in enhancing fisheries management and biodiversity conservation efforts in FAD fisheries and management are focused on coastal and archipelagic deployment of FADs because it requires long-term ecological knowledge of the fishing area and fish behavior (Moreno et al., 2007; Macusi et al., 2017). This is what my study on the LEK of tuna fishers contributes to in the literature (see Chapter 3). My study in the Davao Gulf illustrates how LEK guides efficient FAD deployment strategies, optimizing catch efficiency and reducing fishing pressure. Yet, challenges such as visibility during FVC (fish visual census) dives and environmental variability underscore the need for cautious interpretation of LEK data (Macusi et al., 2017). For instance, while local ecological knowledge enhances operational effectiveness, it is essential to critically assess its application in regulatory frameworks that govern FAD usage and fishing intensity. Integrating LEK into broader conservation policies requires continual dialogue and adaptive management approaches that address socio-economic factors and ecological uncertainties (Digal and Placencia, 2017; Doddema et al., 2020). By embracing a critical discourse that examines both the strengths and limitations of LEK, stakeholders can collaboratively shape sustainable practices that safeguard marine ecosystems and support resilient fisheries management. Moreover, studies of LEK also inform the design of marine reserves and the implementation of closed fishing seasons, which empowers stakeholders often marginalized by conventional scientific perspectives that overlook their expertise (Neis et al., 1999; Johannes and Neis, 2007; Macusi et al., 2021). It is essential to recognize that LEK operates within a framework that integrates natural and social sciences alongside nonacademic experts and practitioners. While LEK provides valuable perspective, it is imperative to acknowledge varying viewpoints and potential contradictions within the literature (Johannes, 1993; Johannes, 2000; Johannes and Neis, 2007). For instance, Nunes et al. (2011) and Tsehaye et al. (2007) highlight LEK's utility in data-deficient environments, where fishers' observations can fill gaps in long-term data sets crucial for effective marine conservation strategies. In tuna fisheries, the collaboration between traditional knowledge and modern technologies such as GPS tracking and fish visual census reveals nuanced insights into fish behavior around anchored FADs (Macusi et al., 2021a; Villanueva, 2018).

Modern technologies such as GPS tracking can validate or show the magnitude of fishing intensity among handline fishers moving between FAD areas to catch larger tunas (Fernandez et al., 2019; Behivoke et al., 2021). In GPS tracking, tracks can be associated with FAD areas and then used in mapping fishing grounds; once mapped, this can be provided or shown during fisher interviews (Macusi et al., 2023). Combining fish sampling, visual census, and catch logbooks can clarify differences between fish aggregating in nearshore and pelagic FADs. In addition, understanding fish behavior around anchored FADs can reduce fishing pressure by limiting daily FAD sets, provided FAD usage rules are based on actual data and both fisheries sectors are involved in monitoring. Limiting FADs per company and issuing fewer fishing licenses could help restore fish stocks. Industry-wide consultation and regulatory adjustments are needed to adapt to new administrative orders based on fishing effort.

While LEK emphasizes the variability in tuna aggregation patterns at FADs (Mitsunaga et al., 2012), studies like Castro et al. (2002) and Hallier and Gaertner (2008) suggest potential complexities in understanding the precise mechanisms driving fish attraction to FADs.

Furthermore, local ecological knowledge (LEK) is indispensable not only for marine conservation but also for promoting sustainable agriculture. Grounded in the experiences and practices of local farmers, LEK provides valuable insights into crop behavior, soil management, and traditional farming techniques, which are essential for fostering practices resilient to environmental challenges and enhancing long-term productivity (Bretagnolle et al., 2018; Macusi et al., 2023). In agriculture, LEK encompasses a wide range of knowledge pertaining to soil health and fertility management. Farmers utilize methods such as crop rotations, green manures, and organic composting to improve soil quality and promote sustainable land use, thereby conserving natural resources (Iderawumi and Kamal, 2022). Preserving crop diversity is paramount for enhancing agricultural resilience against impacts of climate change and market fluctuations (Adhikari et al., 2018). LEK plays a pivotal role in safeguarding and disseminating knowledge of diverse crop varieties and cultivation methods, enabling agricultural system to adapt effectively to unforeseen challenges (Sakapaji, 2021). Integrating Local Ecological Knowledge (LEK) into agriculture underscores its universal significance in advancing sustainability, boosting productivity, and fortifying resilience across diverse ecological settings (Macusi et al., 2023).

Earlier I mentioned about regulations in the FAD fisheries which includes reduction of fishing pressure by having a daily limit on FAD sets, catch quotas, limited number of FADs per fishing company and issuing fewer fishing licenses which could help restore fish stocks. These regulations are usually provided by the RFMOs (Regional Fisheries Management Organizations) which especially regulates tuna fishing in the Western Central Pacific Ocean where Filipino fishing companies usually go and fish. The regulations are then provided and adopted by the Bureau of Fisheries and Aquatic Resources (BFAR) for industry-wide implementation. Such regulations, while it can be beneficial for the government, may negate the active participation of fishers and fishing companies in terms of decision-making. Thus, there should be a moving away from this kind of command-and-control approaches and more towards enhancing cooperation between the regulatory agencies such as BFAR, the RFMOs and the fishing companies to sort out how they can fish and at the same time be sustainable for tuna fishstock resources. Adopting a reflexive regulation encourages a self-analytic process in businesses, promoting creative and continual strategies to minimize harm and maximize benefits for both the fishing company and the environment (Gunningham, 2012). Here, the knowledge of fishers can be integrated in the decision-making process of the regulatory agencies because then, they have an active participation. By integrating LEK into marine conservation strategies, this can lead to more active cooperation of fishers towards sustainable fisheries management. By recognizing the valuable insights of local fishers and combining them with scientific data, we can develop more effective policies and practices to protect marine ecosystems and ensure the long-term viability of fisheries resources.

Economic factors as drivers for change of fishing strategies

The efficiency of anchored Fish Aggregating Device (FADs) in tuna fisheries has significantly altered fishing dynamics, leading to localized depletion in areas where these devices are deployed. The widespread use of FADs in the Philippines has been a pivotal factor contributing to the overall decline in fisheries catches, impacting both commercial enterprises and small-scale fishers. This raises critical questions about the socioeconomic motivations influencing fishers to adapt their strategies amidst declining catches. In General Santos City, a hub for large scale tuna fisheries, robust infrastructure including ice plants, metal fabrication facilities, and integrated transport systems supports efficient fish handling and processing. These facilitates contribute to premium pricing for tuna catches, attracting fishers from neighboring provinces to unload their catches at General Santos City's fish port. The success of established fish tycoons in diversifying investments into secondary industries underscores the economic incentives driving fishers to maintain or enhance their fishing efforts, despite declining catch rates. In our study, we observed that economic factors significantly shape fishing strategies, akin to findings in General Santos City where infrastructure and economic incentives drive fishing practices (see Chapter 4). This demonstrates that economic pressures and opportunities, such as premium pricing and investment in the industries play a critical role in shaping fishing strategies. Studies highlight the fluctuations in fish prices and catch volumes significantly influence decision-making among tuna handliners and purse seiners (Macusi et al., 2017; Muallil et al., 2011).

For instance, a substantial decline in catch can jeopardize the livelihoods of handliners who depend on consistent catches for income, while purse seiners may navigate contractual arrangements that buffer them from immediate financial impacts. Moreover, while economic incentives often drive technological investments such as new FAD deployments and improvements in fishing gear, these strategies may exacerbate overfishing if not carefully managed (Andriesse, 2018; Pollnac et al., 2001). The economic pressure to sustain operations amid declining fish stocks may push fishers to seek alternate fishing ground or supplementary income sources during off-peak seasons, potentially contributing to broader ecosystem impacts. The decision-making processes of fishers are multifaceted, influenced by factors ranging from job satisfaction and skill development to the availability of alternative livelihoods and cultural ties to fishing (Libre et al., 2015; Pollnac et al., 2001). It is essential to recognize that not all the fishers have equal access to resources or opportunities for transition, highlighting disparities in socioeconomics impacts within fishing communities. Moving forward, a critical discourse on fisheries management must integrate diverse perspectives and consider the broader ecological implications of economic strategies.

Studies from other regions further illustrates these dynamics. For example, the study of Bell et al. (2015) on FADs in the Pacific Islands highlights how economic incentives and infrastructure investments, similar to those in General Santos City, drive fishing practices and influence the management of tuna fisheries. In my study, I found that economic incentives often drive technological investment such as FAD deployment and improvements in fishing gear, which may exacerbate overfishing by catching undersized or juvenile tuna (see Chapter 4). Among Filipino fishers, the catching of undersized and undervalued fish species undermines resource sustainability, economic potential, and food security (Banicod et al., 2021). Thus, there is a need to strengthen our regulatory frameworks to prevent economic and ecological impacts. While economic drivers play a pivotal role in shaping fishing practices, a balanced approach that incorporates ecosystem-based management principles and stakeholder collaboration is imperative (Andriesse, 2018; Pomeroy et al., 2017). This approach ensures that regulatory frameworks align with biological imperatives for sustainable fisheries, while also safeguarding the well-being of fishers and promoting long-term resource stewardship. By fostering dialogue and transparency among fishers, industry stakeholders, and regulatory bodies like the Bureau of Fisheries and Aquatic Resources (BFAR), we can develop adaptive strategies that mitigate overexploitation, reduce resource conflicts, and promote resilience in the fisheries sector. A holistic understanding of the economic motivations driving fishing strategies is essential for fostering sustainable fisheries and supporting the livelihoods of those dependent on marine resources.

In agriculture and agronomy, the economic factors that influence fishing strategies align with broader agricultural economics and management principles. Like agricultural commodities, the price and profitability of fish drive fishing decisions, similar to how farmers respond to market signals (Iudicello et al., 2012). Infrastructure development is crucial for fishing operations in places like General Santos City, just as agricultural regions benefit from processing plants and transportation networks for efficient production and distribution (Accorsi et al., 2016). Reinvesting fisheries profits into ancillary industries mirrors agricultural diversification strategies, mitigating risks from fluctuating yields. Both sectors rely on government support for training and technology adoption, while employing ecosystem based and adaptive management approaches to ensure sustainability and resource conservation (Reid, 2016).

Closed fishing season as an effective fisheries management strategy

Amidst declining fish stocks in the Philippines, the implementation of closed fishing seasons emerges as a critical fisheries management strategy, evidenced by its successful adoption in the Davao Gulf following early successes in the Zamboanga Peninsula's sardine fishery (Macusi et al., 2021b; Macusi et al., 2021c). This policy is intended to allow fish populations to recover from overexploitation, driven by various factors including inter user conflicts and environmental degradation. In my study, I observed that the implementation of closed fishing seasons is a critical strategy for fisheries management; similar to successful cases in the Zamboanga Peninsula's sardine fishery (see Chapter 5). Given the decline of tuna catches in Philippine waters, and other associated fish species, allowing fish populations to recover, including protecting their larvae and juveniles from overexploitation is essential for sustainable fisheries management (Villanueva 2018; Nepomuceno et al., 2020; Barbosa et al., 2024). The decline in fish stocks can be attributed to conflicts between small-scale and commercial fishers over fishing grounds, highlighting the need for equitable resource allocation and conflict resolution mechanisms (Pomeroy et al., 2007; Salayo et al., 2008). Moreover, environmental stressors such as pesticide run-off and siltation further exacerbate marine pollution, impacting coral reefs, mangroves, and seagrass habitats crucial for fish breeding and survival (Macusi et al., 2021a; Abreo et al., 2020; Porcher et al., 2010). Critically examining the socioeconomic dimensions, it becomes evident that economic motivations heavily influence fishers' responses to closed fishing seasons. For instance, the ability of fishers to sustain household food security and meet economic needs drives decisions on fishing effort and compliance with regulations (Fabinyi et al., 2016; Macusi et al., 2017b). The role of gender dynamics also plays a significant role, with fishers' wives often depending on fishing income and actively participating in ancillary activities like fish marketing and net mending (Maynawang et al., 2021; Bradford and Katikiro, 2019; Siar, 2003). While closed fishing seasons have demonstrated success in other global contexts such as Turkey, Spain, and Italy, where they contributed to the recovery of fish stocks and improved economic outcomes (Demestre et al., 2008; Pipitone et al., 2000; Yıldız et al., 2020), the Philippine experience underscores the need for adaptive and nuanced policy approaches. Challenges persist, including inadequate governance and enforcement capacities, which can undermine the effectiveness of regulatory measures (Cabral et al., 2013; Garces et al., 2013; Perez et al., 2012). Moreover, the sustainability of closed fishing seasons hinges on holistic approaches that integrate ecosystem-based management principles with community participation and stakeholder collaboration (Pomeroy et al., 2017; Yang and Pomeroy, 2017). While current evidence supports the benefits of closed seasons for small-scale fishers and biodiversity conservation in the short term (Bagsit et al., 2021; Macusi, 2023; Macusi et al., 2022b; Napata et al., 2020), long-term success requires supplementary measures such as diversified livelihood opportunities and targeted subsidy programs during closed seasons

(Republic Act 11310's Pantawid Pamilyang Pilipino Program). Moving forward, a reflexive governance approach is crucial, facilitating continuous policy evaluation, stakeholder engagement, and adaptive management to address evolving challenges and stakeholder needs (Feindt and Weiland, 2018). This includes ongoing assessments of policy impacts, transparent communication among all stakeholders, and proactive adjustments to regulatory frameworks based on scientific evidence and community f eedback. Closed fishing seasons offer promise as a tool for fisheries management in the Philippines, their effectiveness depends on robust governance, adaptive management strategies, and equitable engagement with all stakeholders. Embracing a critical scientific discourse ensures that policy decisions are informed by diverse perspectives, empirical evidence, and a commitment to long-term sustainability. Fisheries and agriculture are confronted with pressing sustainability challenges that demand strategic interventions. In fisheries, implementing closed seasons allows the recovery of the fish stocks, similar in crop rotation in agriculture alternates crops to maintain soil fertility and reduce pests and diseases (Francis and Clegg, 2020). Managing these resources also involves addressing conflicts between user groups, such as small-scale versus commercial fishers and smallholder farmers versus larger agribusinesses. Effective strategies include clear land tenure, equitable water distribution, and conflict resolution mechanisms (Smalley, 2013). Environmental impacts, like pesticide run-off affecting marine ecosystems and soil degradation from fertilizers, can be mitigated through sustainable practices such as integrated pest management (IPM), organic farming, and agroforestry (Ganguly et al., 2021; Mlambo, 2021). Economic incentives drive sustainable practices. Fishers and farmers benefit from subsidies, crop insurance, and market access. Diversified livelihoods for the farmers and fishers reduce their reliance on single-crop farming and in fishing (Jones, 2017; Macusi et al., 2023). With continuous learning and adaptation, ensures resilience and sustainability in both sectors. By drawing parallels between fisheries and agriculture, comprehensive strategies can be developed to support environmental health and human livelihoods (Adger, 2003).

Limitation of the study

This thesis investigates how tuna fishers allocate their effort in timing, location, and target species, exploring factors shaping their decisions. It also examines fishers' local ecological knowledge (LEK) of fish behavior, essential for effective fishing strategies. Additionally, the study assesses how fishers adapt when catches decline due to high fishing pressure, especially among purse seine and handline tuna fishers. Furthermore, it analyzes factors influencing catch rates and community support for seasonal fisheries closures in the Davao Gulf, highlighting the role of effective policies in bolstering fish stocks and averting fisheries collapse. While this thesis comprehensively examines tuna fisheries management in General Santos City and the Davao Gulf, it also reveals several limitations across its chapters.

In Chapter 2, methodological concerns arise due to the reliance on descriptive analysis and localized data from General Santos City, potentially restricting the applicability of conclusions beyond this specific geographic area. Moreover, the exclusive focus on purse seine and handline fisheries except insights from other fishing methods used globally, particularly those employing Fish Aggregating Devices (FADs), thereby limiting the diversity represented in the study.

Chapter 3 explores the local ecological knowledge of purse seine and ringnet fishers but faces methodological constraints related to sample size and the representativeness of participants. These limitations may hinder the extrapolation of findings to diverse global fishing communities with varying practices and ecological contexts. Additionally, while the study illuminates fish behavior and FAD utilization in local settings, the extent to which these insights apply to all FAD tuna fisheries worldwide remains uncertain due to potential ecological and behavioral variations.

In Chapter 5, the analysis of the closed fishing season policy in the Davao Gulf encounters methodological challenges in fully addressing broader socioeconomic and cultural factors influencing policy acceptance and compliance. The findings derived from this localized study may not seamlessly transfer to regions with different governance structures or distinct fishery dynamics, thereby limiting their broader applicability.

Overall, the thesis emphasis on specific local contexts may constrain its broader relevance to global tuna fishery management strategies. To enhance comprehensiveness and applicability, future research should involve larger and more diverse samples across various tuna fisheries worldwide. Longitudinal studies would be valuable for exploring evolving decision-making processes and assessing the long-term impacts of policies. Furthermore, comparative analyses across different fishing methods and regions could offer valuable insights into universal factors affecting fishery sustainability and management effectiveness at a global scale.

Implication of the research

The study examining factors influencing fishers' utilization and deployment of Fish Aggregating Devices (FADs) in the Philippines tuna fisheries has significant implications for both scientific understanding and practical fisheries management. By integrating local ecological knowledge, fishers' strategies, and comprehensive ecological assessments, the study provides a holistic view of the dynamics at play in FADs usage.

Enhanced Understanding of Fish Behavior

This study contributes to the scientific comprehension of tuna behavior and movement patterns, particularly in relation to Fish Aggregating Devices (FADs).These devices play an important role in shaping dynamics of the tuna, and understanding their impact is essential for the development of accurate ecological models. This research elucidates how FADs influence tuna aggregation, migration routes, and feeding behaviors, offering valuable insights for sustainable fisheries management. Furthermore, the study emphasizes the significance of integrating fishers' local ecological knowledge (LEK) with scientific data. Fishers possess extensive, experience-based knowledge of marine ecosystems, encompassing detailed observations of fish behavior, habitat use, and environmental changes. By incorporating this local knowledge, the research provides a more comprehensive and nuanced perspective on marine ecosystems. This integration enriches scientific data, resulting in more detailed and accurate ecological models that can better inform conservation and management strategies.

Data-Driven Fisheries Management

The integration of various data sources, including scientific surveys and direct collaboration with fishers, is crucial for developing a robust dataset essential for guiding future research and shaping effective policy decisions in fisheries management. Comprehensive datasets are constructed by integrating systematically gathered survey data with nuanced first hand insights from fishers. These datasets not only facilitate detailed ecological assessments but also establish foundational benchmarks for monitoring changes in fish populations and broader ecosystem health across different temporal scales.

Scientific surveys yield precise quantitative data on species distributions, population sizes, and habitat preferences, establishing a robust scientific framework for understanding ecosystem dynamics. Simultaneously, fishers' local ecological knowledge (LEK) provides qualitative insights into shifts in fish behavior, environmental conditions, and ecosystem resilience, accumulated through extensive direct observation. The integration of these diverse data sources enhances the accuracy and reliability of ecological assessments, enabling researchers and policymakers to discern trends, assess risks, and implement adaptive management strategies effectively.

Informed Fisheries Management

The study's findings serve as a critical foundation for developing tailored policies and regulations that reflect the practical experiences and expertise of fishers. Through the integration of empirical evidence supporting the implementation of closed fishing seasons, the research establishes a framework for designing temporal restrictions aimed at effectively enhancing the replenishment of fish stocks. These insights play a pivotal role in guiding informed decision-making within fisheries management, promoting sustainable practices that carefully balance conservation priorities with the socio-economic interests of fishing communities.

Moreover, the study's emphasis on evidence-based approaches bolsters the credibility and efficacy of policy interventions. It underscores the necessity of aligning regulatory measures with scientific data and local knowledge to ensure that management strategies are not only effective but also socially acceptable. By advocating for such integrated approaches, the research contributes to the resilience of marine ecosystems and supports the long-term sustainability of fisheries, thereby benefiting both environmental health and the livelihoods of individuals dependent on marine resources.

Sustainable Fishing Practices

A thorough understanding of the factors influencing Fish Aggregating Device (FADs) deployment is crucial for developing strategies that effectively balance ecological sustainability with economic benefits. By examining variables such as optimal FAD placement, innovative design features, and rigorous monitoring protocols, researchers can formulate best practices aimed at minimizing adverse environmental impacts associated with FADs, such as habitat alteration and unintended by catch.

Moreover, insights derived from these studies empower fisheries managers to implement adaptive management strategies. These strategies are essential for adapting fishing practices in response to dynamic environmental conditions, fluctuations in fish populations, and evolving behavior among fishing communities. Through continual assessment and adaptation of management approaches informed by real-time data and stakeholder engagement, managers can ensure the long-term sustainability of fisheries. This adaptive approach not only safeguards ecosystem health but also enhances the resilience of fishing communities, supporting their socio-economic stability.

Conclusions

- The unabated capture of wild fish will impact the marine ecosystem when this is not allowed to replenish itself. Fishing technology using GPS, sensors, and sonars coupled with fish demands from a fast-growing population resulted to widespread depletion of global fish stocks.
- Tuna handlines, known to be roamers, fishing from one FAD fishing area to the next, and purse seiners, which are area specialists, contribute to the social and economic well-being of fishing communities.
- Management programs for controlling fishing effort can facilitate sustainable fisheries, for food secure and resilient fisheries. However, the use of unsustainable fishing methods and techniques can also result to faster depletion of juvenile tunas which aggregate underneath the FADs.
- The adoption of sustainable fishing practices should be a priority for all fishing companies and must be enforced by the government to facilitate fish stock recovery. A regular inspection, monitoring and strengthening of anti-IUU fishing drives must be funded and compulsory.
- Moreover, a reflexive governance that includes all stakeholders towards sustainable development could be a welcome development in governance of the fisheries sector. Fishers, being stakeholders, must be involved in the process of understanding, monitoring and relocating when needed in response to perceived environmental degradation or decline.
- The closed fishing season as a policy might be the most effective in protecting the commercially important species in Davao Gulf and, if adequately implemented, will stop the decline of the fish stocks. In the future, pilot demonstration sites with tuna handlines for tuna traceability studies in General Santos City and Davao Gulf for access to premium markets can lead to more sustainable fisheries using market mechanisms.

- This research is grounded largely in perception-based data from surveys and interviews, supplemented by existing literature and reports. While this approach captures valuable subjective insights into fishers' strategies and experiences, it risks limited objectivity. The addition of direct, quantitative catch data from official sources, such as the Philippine Statistics Authority, could have provided a more balanced and data-driven perspective, strengthening the reliability of conclusions drawn.
- The study lacks historical catch data, limiting the ability to conduct a comprehensive analysis of species catch composition over time. Although catch information from ringnet boat captains and literature sources is included, the long-term data would have been instrumental in validating trends in species abundance and shifts in fisheries composition, offering a deeper temporal context for assessing fishing pressures and sustainability.
- While the research offers insights into tuna fishery dynamics, it does not systematically compare the practices, strategies, and outcomes of small-scale and commercial fishers across the four studies. A direct comparison could illuminate sector-specific trends, resource allocation disparities, and differential impacts on sustainability, which are critical for tailored policy recommendations.

Recommendations

- Expanding the study beyond General Santos City (Gensan) to other regions is crucial for several reasons. This expansion will help diversify the sample size and increase the capture of broader insights into ringnet and handline fishing practices, providing a more comprehensive and thorough understanding of these tuna fishing practices across different geographical and socio-economic contexts.
- Securing additional funding to conduct site visits to various fishing areas beyond the Davao Gulf is essential for gathering comprehensive Local Ecological Knowledge (LEK) data across different regions.
- Utilize GPS trackers extensively among handliners to accurately track their movements, thereby enhancing data reliability for understanding social implications based on fishers' perceptions.
- Advocate for BFAR and the National Tuna Commission to adjust FADs deployment policies, reducing the number of pelagic FADs for better sustainability, while ensuring uniform regulations for near shore FADs.
- Integrate fishers' ecological knowledge into policy development processes to enhance the effectiveness and relevance of fisheries management policies.

- Use of additional data sources from the Philippine Statistic Agency (PSA), while not at the temporal scale of daily or weekly fishing, or spatial scale that can be traceable may still be useful in providing a triangulation of catch data that are mentioned by fishers or collected by enumerators in the study. This addition of quantitative data can help provide a richer context and understanding for the daily catch, or normal catch of fishers and catch trends that maybe provided by fishers using their ecological knowledge.
- Historical data from BFAR especially its National Stock Assessment Program regarding tuna, small and large pelagic fisheries should be uploaded to a publicly available database without the need to keep on asking permission to be able to download the data and use it for legal/academic/research purposes because these are publicly funded and should be openly available to everyone.
- In the future a comparative study that covers both small-scale tuna fishers and commercial scale fishers in General Santos City, Davao Gulf and the Celebes and the Pacific Ocean should be designed to collect data on tactics, strategies, fishing practices and adoption of sustainable, safe and traceable principles while fishing or at sea.

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Summary

Summary

The tuna fisheries in the Philippines are based on anchored FADs (Fish aggregating devices). These are auxiliary fishing devices deployed by a purse seine or ringnet fishing vessel in the fishing ground at depths that range from 200 m to more than 5000 m. Anchored FADs support the coastal operation of artisanal fishers that capture small pelagics and including neritic and oceanic tunas. With the use of FADs, tuna production has greatly increased in the Philippines (from 11,000 mt in 1970 to about 500,000 mt in the 1980s and down to current production level of 350,000 mt). This has also increased the unintentional catch of juvenile tunas that include yellowfin tuna (*Thunnus albacares*), bigeye tuna (*Thunnus obesus*) as well as skipjack tuna (*Katsuwonus pelamis*) together with other small-pelagics such as roundscad (*Decapterrus* spp.), bigeye scad (*Selar crumenophthalmus*), bullet tuna (*Auxis rochei*), frigate tuna (*Auxis thazard*) and rainbow runner (*Elagatis bipinnulata*). Because of this, there are several implications for tuna stock management and conservation that needs to be considered. This study asked the following questions: 1) What are the tactics and strategies employed by purse seine, ringnet fishers and handline fishers in their deployment and use of FADs? 2) What are fishers' knowledge and perception with regards to fish distribution, movement and behavior around anchored FADs? 3) How do socioeconomic factors influence the change of fishing strategies when their catch declines? 4) What are the main factors influencing the catch and support of the implementation of a closed fishing season in fisheries?

In chapter 2, the result of the first question regarding FAD deployment and usage is largely determined by good catch rates of tuna fishers and the availability of fishing space. We conclude that while FAD deployment may be a long-term strategy to maintain hold of a fishing ground, FAD areas are not fixed. Possibly as a result of competition between companies over spaces to deploy FADs and/or reported reduction in inshore catch rates, FAD areas moved from inshore to offshore areas. Moreover, during the deployment of FADs, fishers consider it necessary to be well-informed about previous good catches in the area and that this is necessary to ensure a productive FAD area. In terms of short-term tactical decision-making of purse seines: fishers only operate when their boats and gears are prepared, there is a good weather and they are well-informed regarding the presence of a fish or school of fish in their fishing ground or FAD.

Moreover, in chapter 3, according to fishers' ecological knowledge, tuna schools are attracted to anchored FADs at 10 km distance and fishers also know by experience through observation that tunas form schools segregated by species and size. The small pelagic fish (frigate and bullet tuna, roundscads, and mackerel) and large pelagic (e.g., tuna) tunas, while they differ in average time of aggregation in FADs, larger tunas (skipjack, yellowfin, and bigeye) usually aggregate last. Because of the massive deployment of FADs, coupled

with illegal, unreported, and unregulated (IUU) fishing, fisheries production has been steadily declining. Fishers also tend to move fishing operations to areas with more abundant and larger fish sizes to increase their revenues.

In chapter 4, the results also show that tuna fishers were reluctant to exit the fisheries even when their normal catch declines by half. Perhaps, this is caused by a lack of alternative jobs when deciding to leave the industry. Moreover, in two contrasting sites, an area with higher development index (General Santos City) and another site with low economic development index (Lupon) both sites have high likelihood to change their fishing strategies when catch declines. For the better off (General Santos City), a change of strategy is dependent on its capacity to negotiate fishing access rights and explore other fishing sites, while the poorer one (Lupon), out of necessity to survive, will either change gear or relocate to other fishing sites. In terms of gears, only tuna handlines were willing to adapt. Tuna handlines were more sensitive to these changes as demand for their target catch is dependent on good market and better environmental conditions. Slight change in the catch value of tuna due to market forces or unpredictable events can increase or decrease the profitability of a tuna handline fisher. There is therefore a need for strong regulation by the government to control the number of licenses issued for new boats, gears and FADs which can then improve the situation of fishers. Additionally, employing more technology-driven control measures such as GPS trackers for commercial fishing boats, RFID barcodes for gears and FADs will enhance deterrence of Illegal, Unreported and Unregulated (IUU) fishing.

In chapter 5, regarding fisheries management, the main predictors for the support of the implementation of closed fishing season as a management strategy to increase fish stocks were the number of fishing hours, fish price, membership to community organizations, and awareness of policy among fishers. Economic motivation seems to predominate among fishers as both factors, revenue and fish price, are related and increase due to the imposition of the closed fishing season. Thus, the closed fishing season as a fisheries management policy tool can enhance the protection and livelihood of fishers not just in Davao Gulf but also in other fishing areas in the Philippines when the local government unit, the coastguard, and the Philippine Maritime Police and Navy jointly implement the law together with the Bureau of Fisheries and Aquatic Resources (BFAR) as a united effort to confront illegal fishing.

The synthesis in chapter 6 showed that adoption of sustainable fishing practices should be a priority for all tuna fishers and fishing companies and must be enforced by the government to facilitate fish stock recovery. A regular inspection, monitoring and strengthening of anti-IUU fishing measures must be funded and made compulsory. Our research was able to capture valuable insights into fishers' strategies and experiences on

FAD deployment and including understanding of fish behavior in their fishing grounds. These strategies are essential for adapting fishing practices in response to dynamic environmental conditions, fluctuations in fish populations, and evolving behavior among fishing communities. Moreover, integrating fishers' ecological knowledge into policy development processes can enhance the effectiveness and relevance of fisheries management policies. Despite this, our study has some limitations as it is largely based on perception data from surveys and interviews, supplemented by existing literature and reports. As policy changes can disrupt coastal fishers and communities, the success of fisheries management hinges on the cooperation of fishers, strict enforcement and livelihood assistance for affected communities. In the future, a more direct comparison could illuminate sector-specific trends, resource allocation disparities, and differential impacts on sustainability, which are critical for tailored policy recommendations in the tuna fisheries.

Kasumahan

Kasumahan

Ang pagpanagat sa tuna sa Pilipinas kay base sa nakaangkla nga FADs (Fish aggregating devices). Kini mao ang auxiliary fishing devices nga gipakatap sa Onay na barko or banca sa fishing ground nga adunay floater nga ginama sa steel drums o foam o kawayan ug semento nga angkla. Kini nga estraktura gi-angkla sa giladmon nga gikan sa 200 m hangtod sa kapin sa 5000 m ug nagsuporta sa operasyon sa baybayon sa mga ginagmay nga panagatan gamit ang mga ringnet ug line gears nga pangkuha sa gagmay nga mga isda apan nagakuha usab sa mga gagmay nga neritic ug oceanic tuna.Samtang kini nagpausbaw sa produksyon sa tuna sa Pilipinas (gikan 11,000 niadtong 1970 nga gagmay nga kuha ngadto sa mga 500,000 sa dekada 1980 ug ngadto sa kasamtangan nga produksyon nga 350,000), kini usab midugang sa wala tuyoa nga pagdakop sa mga juvenile tuna nga naglakip sa bariles (*Thunnus albacares*), tambakol (*Thunnus obesus*) ingon man tulingan (*Katsuwonus pelamis*) kauban ang ubang gagmay nga pelagic sama sa galunggong (*Decapterrus spp.*), matambaka (*Selar crumenophthalmus*), budburon (*Auxis thazzard, Auxis rochei*) ug salmon-salmon (*Elagatis bipinnulata*). Sa dekada 1970, kini nga mga payao nga pangisda nga naka-angkla sa tuna nagkadaghan nga naggamit ug nag-deploy sa mga payao sa daghang mga lugar sa baybayon ug sa layo pa nga baybayon, tungod kay sila episyente nga nagtipon sa mga isda sa ingon makadaginot sa gasto sa gasolina ug oras sa pagpangita alang sa mga mangingisda. Tungod niini, ug ang nagkadaghang deployment sa FADs sa duol nga baybayon sa kabaybayonan ug layo pa nga mga lugar sa Pilipinas, daghang mga implikasyon sa pagdumala ug pagkonserbar sa tuna stock ang gikonsiderar. Kini nga pagtuon nangutana sa mosunod nga mga pangutana: 1) Giunsa paggamit sa mga mangingisda kining mga payao ug ang ilang lokal nga ekolohikal nga kahibalo makapahibalo kanato sa siyentipikanhong paagi mahitungod sa kinaiya sa mga tuna sa palibot sa FADs? 2) Unsa ang mga stratehiya sa mga mangingisda sa tuna kung mogamay ang ilang mga nakuha? 3) Unsa ang buhaton sa mga tagdumala sa pangisdaan mahitungod sa pagkonserbar niining mga kahinguhaan sa pangisda sa duol nga baybayon ug sa mas layo nga mga baybayon?

Sa ika-duha nga capitulo, ang resulta sa unang pangutana mahitungod sa pagdeploy sa payao sa kadaghanan gitino sa maayong gidaghanon sa pagkuha sa mga mangingisda sa tuna ug ang pagkaanaa sa lugar sa pangisda. Kami nakahinapos nga samtang ang pagdeploy sa payao mahimong usa ka long-term nga estratehiya aron mapadayon ang paghawid sa usa ka lugar nga pangisdaan, ang payao nga mga lugar wala giayo. Posible nga resulta sa kompetisyon tali sa mga kompanya sa mga luna aron ipakatap ang mga payao ug/or gikataho nga pagkunhod sa mga rate sa kuha sa baybayon, ang mga payao nga mga lugar mibalhin gikan sa baybayon ngadto sa mga mas layo nga baybayon.

Ang pagpili sa mga onay ug ringnetters sa mga butang nga maayo nga kuha ug kanhing kuha gikinahanglan kanus-a ug asa ibutang ang payao nagpunting sa panglantaw sa mangingisda nga ang usa ka produktibong lugar kinahanglang makabawi sa gasto sa pagpangisda. Samtang bahin sa hamubo nga taktikal nga paghimog desisyon sa onay na banca, ang mga mangingisda sa payao nag-una nga gidumala sa kini nga hugpong sa mga lagda: ang mga mangingisda naglihok lamang kung adunay mga kondisyon nga andam na ang sakayan ug gamit, maayo ang panahon ug ang kasayuran sa presensya. sa maani nga isda positibo.

Dugang pa, sa ika-tulo nga capitulo, base sa kahibalo sa mga mangingisda, ang mga grupo sa bariles nadani sa mga nakaangkla nga payao sa 10 km nga gilay-on ug ang mga mangingisda nahibalo usab pinaagi sa kasinatian pinaagi sa pag-obserbar sa diving sa mga nakaangkla nga payao nga ang bariles nagporma og mga grupo nga gilain sa mga espisye ug gidak-on. Ang gagmay nga isda (budburon, galunggong, matambaka) ug dako nga pelagic (e.g., bariles), samtang magkalahi sila sa kasagaran nga panahon sa panagtapok sa isda sa FADs, mas dako nga tuna (tulingan, bariles, ug tambakol) kasagarang naulahi. Tungod sa kaylap nga deployment sa payao, inubanan sa illegal, unreported, and unregulated (IUU) fishing, ang produksyon sa pangisda padayon nga nagkunhod. Ang mga mangingisda usab adunay kalagmitan nga ibalhin ang mga operasyon sa pangisda ngadto sa mga lugar nga adunay mas daghan ug dagkong mga isda aron madugangan ang ilang kita.

Gipakita usab sa ika-upat nga capitulo, ang mga resulta nga ang mga mangingisda sa bariles nagpanuko sa paggawas sa mga pangisda bisan kung ang ilang regular nga nakuha nga mikunhod sa katunga, tingali, kini tungod sa kakulang sa mga alternatibong trabaho kung mobiya sa industriya. Ang ubang mga kaplag niini nga pagtuon nagtaho sa duha ka magkalahi nga mga sitwasyon diin ang usa ka dapit nga adunay taas nga economiya (General Santos City) ug laing usa nga adunay ubos nga economiya (Lupon) adunay taas nga posibilidad nga mausab ang ilang mga estratehiya sa pagpangisda tungod sa pagkunhod sa kuha. Para sa mas maayo, ang pagbag-o sa estratehiya nagdepende sa kapasidad niini sa pagnegosasyon sa mga katungod sa pag-access sa pangisda ug pagsuhid sa ubang mga dapit sa pangisda, samtang ang mas kabos, tungod sa panginahanglan nga mabuhi mag-ilis ug gamit o mobalhin sa ubang mga dapit sa pagpangisda. Sa termino sa mga gears, ang pamariles ra ang andam nga mopahiangay. Ang mga pamariles sa tuna mas sensitibo sa kini nga mga pagbag-o tungod kay ang panginahanglan alang sa ilang target nga makuha nagdepende sa maayo nga merkado ug mas maayo nga kahimtang sa kalikopan. Ang gamay nga pagbag-o sa presyo sa kuha sa tuna tungod sa mga pwersa sa merkado o dili matag-an nga mga panghitabo mahimong makadugang o makapakunhod sa ganansya sa usa ka mangingisda nga namariles. Busa gikinahanglan ang lig-on nga regulasyon sa gobyerno aron makontrol ang gidaghanon sa mga lisensya nga gi-isyu alang sa mga bag-ong bangka, gears ug payao nga makapauswag sa kahimtang sa mga mangingisda. Dugang pa, ang paggamit sa dugang nga teknolohiya nga gimaneho sa pagkontrol nga mga lakang sama sa GPS tracker alang sa komersyal nga mga sakayan sa pangisda, RFID barcodes alang sa mga gears ug payao makapauswag sa pagpugong sa IUU (Illegal, Unreported ug Unregulated) nga pagpangisda.

Sa ika-lima nga capitulo, mas maayong pagdumala sa pangisda, ang nag-unang tigtagna alang sa suporta sa pagpatuman sa sirado nga panahon sa pangisda isip estratehiya sa pagdumala aron madugangan ang stock sa isda mao ang gidaghanon sa mga oras sa pagpangisda, presyo sa isda, pagkamiyembro sa mga organisasyon sa komunidad, ug kahibalo sa polisiya sa mga mangingisda. Ang kadasig sa ekonomiya daw nag-una sa mga mangingisda tungod kay ang duha ka hinungdan: ang kita ug ang presyo sa isda, adunay kalabutan ug pagtaas tungod sa pagpahamtang sa sirado nga panahon sa pagpangisda. Busa, ang sirado nga panahon sa pagpangisda isip usa ka himan sa palisiya sa pagdumala sa pangisdaan makapauswag sa proteksyon ug panginabuhian sa mga mangingisda dili lamang sa Davao Gulf kon dili sa ubang mga dapit sa pangisda sa Pilipinas kung ang mga lokal nga gobyerno, ang coastguard, ug ang Philippine Maritime Police ug Navy maghiusa sa pagpatuman ang balaod kauban ang Bureau of Fisheries and Aquatic Resources (BFAR) isip hiniusang paningkamot sa pag-atubang sa ilegal nga pagpangisda.

Sa ika-unom nga capitulo, ang pagdawat sa mga malungtarong pamaagi sa panagat kinahanglan nga mahimong prayoridad sa tanang mananagat sa tuna ug mga kompanya sa panagat ug kinahanglan nga ipatuman sa gobyerno aron mapadali ang pagbalik sa kadaghan sa isda. Ang regular nga pagsusi, pagmonitor ug pagpahugot sa mga lakang batok sa IUU fishing kinahanglan nga pondohan ug himoon nga obligasyon. Ang among panukiduki nakakuha og bililhon nga mga panan-aw sa mga estratehiya ug kasinatian sa mga mananagat sa pagpakatap sa paggamit og FADs apil na ang pagsabot sa kinaiya sa isda sa ilang mga lugar sa panagat. Kini nga mga estratehiya importante alang sa paggamit og haum na mga pamaagi sa panagat isip tubag sa nagabag-o nga mga kondisyon sa palibot, pag-usab usab sa populasyon sa isda, ug naga-uswag nga kinaiya sa mga komunidad sa mananagat. Dugang pa, ang paghiusa sa ekolohikal nga kahibalo sa mga mananagat diha sa mga proseso sa pagpalambo sa polisiya makapadugag sa kaepektibo ug kalambigitan sa mga polisiya sa pagdumala sa panagat. Bisan pa niini, ang among pagtuon adunay pipila ka mga limitasyon tungod kay kini kadaghanan gibase sa datos sa pagtan-aw gikan sa mga survey ug interbyu, nga gisuportahan sa mga kasamtangang literatura ug mga report.Samtang ang mga pagbag-o sa polisiya mahimong makasamok sa mga mangingisda sa baybayon ug mga komunidad, ang kalampusan sa pagdumala sa mga isda nagdepende sa kooperasyon sa mga mananagat, hugot nga pagpatuman, ug tabang sa panginabuhi alang sa mga naapektuhan nga komunidad. Sa umaabot, ang mas direkta nga pagtandi mahimong muhayag sa mga uso nga espesipiko sa sektor, mga kalainan sa pag-apod-apod sa mga kapanguhaan, ug mga lahi nga epekto sa pagkasustentable, nga kinahanglan alang sa mga haum nga rekomendasyon sa polisiya sa mga panagat sa tuna.

Dagup

Dagup

Ti panagkalap ti tuna nga ikan iti Filipinas ket nasken a naibatay kadagiti nakangkla a FADs (Fish aggregating devices). Dagitoy ket auxiliary fishing devices nga i-wayat ti purse seine wenno nalawa a tabukol (ringnet fishing vessel) iti pagkalap nga addaan iti patapaw a naaramid iti sisim a bariles (steel drums) wenno kutson/goma (foams) wenno kawayan ken semento nga angkla. Daytoy nga estruktura ket naisanglad kadagiti naadalem a paset ti baybay a mangrugi manipud iti dua gasut a metro (200 m) aginggana iti nasurok a lima ribu a metro (5000 m) ken mangsuporta ti panagpataray iti aplaya dagiti artisanal a mangngalap nga agus-usar kadagiti nalawa a tabukol (ringnet) ken atiddog a tali a nakaikabitan ti banni-it (line gears) a maaramat naipangpangruna kadagiti babassit a pelagiko ken mangtiliw pay kadagiti babassit a neritiko ken tuna ti baybay. Daytoy ti nangpaadu iti produksion ti tuna iti Filipinas (manipud iti nagbaba nga 11,000 idi 1970 agingga iti 500,000 idi 1980s, ken 350,000 itata nga taw-tawen), immadu met ti di inggagara a makalap kadagiti babassit ken nauubing nga tunas a pakairamanan ti yellowfin tuna (*Thunnus albacares*), bigeye tuna (*Thunnus obesus*) kasta met ti skipjack tuna (*Katsuwonus pelamis*) agraman dagiti dadduma pay a babassit nga ikan nga pang-pelagiko a kasla kuma ti galunggong (*Decapterrus spp.*), matambaka (*Selar crumenophthalmus*), bodborun (*Auxis thazzard, Auxis rochei*) ken salmon (*Elagatis bipinnulata*). Idi tawtawen 70s, dagitoy payao nga pagkalap iti tuna ket adadda nga naus-usar ken naikabil kadagiti payao kadagiti adu nga lugar iti aplaya ken uray pay diya ad-adayo a paset ti aplaya, bayat nga mayat (episiente) launay nga mangtipon kadagiti ikan iti kasta makasalbarda kadagiti gastos ti gasolina ken panawen nga agsapul para kadagiti tuna. Gapu iti daytoy, ken ti umad-adu a pannakaipakat dagiti payao kadagiti asideg nga aplaya ken dagiti adayo nga baybay iti Pilipinas, adda sumagmamano nga maapektaran (implikasionda) iti panangtarawidwid ken pannakasalbar (konserbasion) ti tuna ti mairikomenda tayo (maikonsiderar tayo). Daytoy nga panagadal ket nagsamglad (nagsaludsod) kadagiti sumaganad a saludsod: 1) Kasano nga usaren dagiti mangngalap dagitoy a payao ken kasano da nga ipakaammo ti local wenno bukod da a pannakaammoda iti ekolohia kadagitti sientipiko nga maipapan iti kababalin dagiti tuna iti aglawlaw dagiti payao? 2) Ania dagiti wagas (estratehia) dagiti mangngalap iti tuna, no bumassit ti makalapda? 3) Ania ti aramiden dagiti mangiturturong (manedyer) ti panagkalap maipapan iti pannakasalbar (panangpreserba) kadagitoy a kababalin wenno wagas (rekurso) ti panagkalap, agpadpada kadi iti asideg ken adayo a lugar iti baybay?

Iti maikadua nga capitulo, ti resulta ti umuna a saludsod maipapan iti pannakaipakat ti payao ket naikeddeng wennoi naibasar babaen ti nasayaat a catch rates wenno panagkalkalap iti tuna ken ti kaadda met ti makuna nga pagkalapan nga espasyo ti pagkalapan ti lames (fishing space) wenno nalawa a lugar ti pagkalapan (fishing ground). Ipakdaar wenno ipakaammo mi (Ikonklusionmi) a bayat a ti pannakaipakat ti payao ket mabalin a napaut nga wagas (estratehia) tapno mataginayon ti panangtengngel iti maysa a pagkalap, dagiti lugar nga addaan iti payao ket saan a nakabasar lang ti kabassit wenno kaadu(wenno rukod) ti makalapan (naikeddeng lang). Mabalin (Posible) a kas resulta ti panagsasalisal dagiti kompania maipapan kadagiti espasio nga mangikabil kadagitoy payao ken/wenno naipadamag a pannakakisay da ta adu ti maikalap iti takdang, dagiti lugar ti payao ket mabalin maiyakar manipud kadagiti lugar iti aplaya agingga kadagiti lugar iti adadayo nga aplaya gapo iti panagbassit ti maala nga ikan. Ti panagpili dagiti purse seiners ken ringnetters nga mangkalap kadagit ikan ket kasapulan tapno adu makalapan. Kasta met ti nasayaat a wagas ti panagkalap ken dati nga pannakammo dagitoy ti pagkalapan iti ikan ken sadino pay nga lugar ti pangikabilan kadagiti payao. Daytoy ket pangilasinan dagiti mangngalap a ti produktibo a lugar ket masapul a makabael a mangbalanse iti gastos iti panagkalap kadagiti ikan. Bayat nga iti ababa nga panawen wenno ti kunkunada nga taktikal nga panagdesision ti purse seine, dagiti mangngalap gamit da diyay payao ket kangrunaan nga iturayan babaen daytoy nga pagannurotan: dagiti mangngalap ket agkalap (ag-operate) da laeng gapu kadagiti kondision a ti bangka ken gamit da ket nakasaganan, ti tiempo ket nasayaat ken ti impormasion ti kaadda dagit ikan ket positibo.

Maysa pay, idiay maikatalo nga capitulo, maibatay iti pannakaammo dagiti mangngalap, maallukoy dagiti kawan wennot grupo ti tuna kadagiti naisanglad a payao iti 10 km a kaadayo ken ammo met dagiti mangngalap babaen ti kapadasan da ken babaen ti panagpaliiw iti panangbatok (diving) kadagiti naisanglad a payao a mangbukel dagiti tuna kadagiti grupo da nga mabalin nga naisina babaen ti species ken kadakkel da. Dagiti babassit a pelagik nga ikan (frigate ken bullet tuna, roundscads, ken mackerel) ken dadakkel a pelagik (e.g., tuna), bayat a dagitoy ket agduduma iti promedio a panawen ti panagtitipon ti ikan kadagiti payao, dagiti dakdakkel a tuna (skipjack, yellowfin, ken bigeye) ket kadawyan nga agtitipon nga maudi. Gapu iti kaado ken kadakel ti pannakaipakat dagiti payao, agraman ti illegal nga panagkalap, agtultuloy a bumasbassit ti produksion ti panagkalap iti tuna ken nadumaduma pay nga ikan. Dagiti mangngalap ket agannayas met a mangyakar kadagiti operasion ti panagkalap kadagiti lugar nga ad-adu ken dakdakkel ti ikan tapno ad-adu ti matigedanda.

Maipakita met idiay pang-upat nga capitulo, dagiti resulta daytoy nga panagadal kadagiti mangngalap iti tuna ket ti panagkedked da mgaq agsardeng nga agkalap uray bimmassit iti kagudua ti makalapanda, nalabit, daytoy ket mainaig iti kinakurang ti alternatibo a trabaho no pumanawda iti industria. Dagiti dadduma pay a natakuatan daytoy a panagadal ket mangipadamag ti dua nga agdumaduma a kasasaad a ti maysa a lugar nga addaan iti nangato nga tukad (indeks) ti panagdur-as ti ekonomia (General Santos City) ken sabali pay nga addaan iti nababa nga tukad (indeks) ti panagdur-as ti ekonomia (Lupon) ket addaan iti nangato a posibilidad a mangbalbaliw kadagiti estratehia ti panagkalapda gapu iti bumasbassit a makalapan. Para iti nasaysayaat, ti panagbalbaliw ti estratehia ket agpannuray iti kapasidadna a makinegosio kadagiti kalintegan iti pannakagun-od iti panagkalap ken mangsukisok kadagiti dadduma a lugar a pagkalapan, idinto ta ti napanglaw, gapu iti kasapulan tapno agbiag ket agbaliw iti usar (gear) wenno umakar kadagiti dadduma a lugar a pagkalapan. No maipapan kadagiti usar (gear), dagiti laeng tuna handline ti mayat a makibagay. Ad-adda a sensitibo dagiti handline ti tuna kadagitoy a panagbalbaliw ta agpannuray ti panagkasapulan iti target catch-da iti nasayaat a merkado ken nasaysayaat a kasasaad ti aglawlaw. Ti bassit a panagbalbaliw ti presyo ti tuna gapu iti puersa ti merkado wenno dagiti di mapakpakadaan a pasamak ket mabalin a mangpaadu wenno mangkissay iti ganansia ti maysa a mangalap nga tuna handline. Kasapulan ngarud ti natibker a regulasion ti gobierno tapno matengngel (makontrol) ti bilang dagiti maited a lisensia para kadagiti baro a bangka, dadduma nga usar wenno kasapulan (gears) ken FADs a mabalin ngarud a mapasayaat ti kasasaad dagiti mangngalap. Mainayon pay, ti panangusar iti ad-adu a teknolohia-a-naiturong a wagas ti panangtengngel (panangkontrol) kas kadagiti GPS tracker para kadagiti komersial a bilog a pagkalap, RFID barcode para kadagiti gear ken FAD ket mangpasayaat iti pananglapped iti IUU (Illegal, Unreported ken Unregulated) a panagkalap.

Kasta met nga maipakita idiay maikalima nga capitulo, ti nasaysayaat a panangtarawidwid iti panagkalap, dagiti kangrunaan a mangipadto iti pannakasuporta ti pannakaipatungpal ti closed fishing season kas estratehia ti panangtarawidwid tapno mapaadu ti stock dagiti ikan ket ti bilang ti oras ti panagkalap, presio ti ikan, pannakaikameng kadagiti organisasion ti komunidad, ken pannakaammo iti patakaran dagiti mangngalap. Kasla ti ekonomiko a motibo ti kangrunaan kadagiti mangngalap ta agpada a dagiti banag: ti kita ken presio ti ikan, ket agkakanaig ken umadu gapu iti pannakaipakat ti naserraan a panawen ti panagkalap. Gapuna, ti closed fishing season kas fisheries management policy tool ket makaparang-ay iti proteksion ken panagbiag dagiti mangngalap saan laeng nga iti Davao Gulf no di pay ket iti dadduma pay a pagkalapan iti Pilipinas no agtitinnulong dagiti lokal a gobierno, ti coastguard, ken ti Philippine Maritime Police ken Navy a mangipatungpal ti linteg a kadua ti Bureau of Fisheries and Aquatic Resources (BFAR) kas nagkaykaysa a mangsango iti illegal fishing.

Ti maikainem nga capitulo, nakasaad ti panag-ampon ti sustainable fishing practices ket masapul nga agbalin nga prayoridad ti amin nga managkalkalap iti tuna, ken dagiti kumpanya nga managkalkalap ti tuna ket masapul ipatungpal ti gobyerno dayta nga polisiya tapno mapapartak ti panag-recover ti fish stock. Ken ti regular nga inspeksyon, panagsubaybay ken panagpabileg kadagiti regulasyon iti panagkalap laban kadagiti illegal nga panagkalkalap ket masapul nga pondohan ken aramiden nga obligatoryo ti gobyerno. Naaramid ti panagsuksukisokmi nga makaala kadagiti napateg a panag-tanaw iti estratehiya ken kapadasan dagiti managkalkalap lalo iti panag-deploy kadagiti payao ken kasangayan ti panakaawat iti panag-uugali ti ikan idiay lugar iti pagkalapan. Dagiti estratehiya ket napateg para iti panagbagay dagiti kasanayan iti panagkalap kas reaksyon iti dagiti dynamic a kondisyon iti aglawlaw, dagiti pag-ugoy iti populasyon ti ikan, ken panag-uddug ti panag-uugali iti ikikan para kadagiti komunidad ti panagkalkalap. Asideg daytoy, ti kapapanunutan ken panag-ammo kadagiti kapanunutan nga ekolohikal para kadagiti managkakaklap tapno maproseso ti panag-develop ti patakaran ket mabalin a mapapigsa ti epektibidad ken koneksiyon pay dagiti patakaran iti panagdaulo ti pagkalapan ti ikan. Iti bangir daytoy panag-adalmi ket adda dagiti limitasyon gapu ta daytoy ket nagapu iti datos nga survey ken interbyu, nga nadagdagan ti agdama a literatura ken report. Sakbay nga masukatan dagiti baro nga patakaran ket mabalin a makagulo kadagiti managkalap iti ikan ken komunidad idiay baybay. Ket dayta panangabak ti mayat nga panagdaulo iti mangangalap ti ikan ket nakadepende iti panagkaykaysa dagiti managkalap iti ikan, napigsa a panangipatumpal ken tulong para kadagiti maapektaran a komunidad. Iti masakbayan, ti maysa a mas direkta nga panagkumpara ket mabalin a maipakita kadagiti aramid tayo iti partikular nga sektor, dagiti panagsasabali iti nangruruna nga trabaho, ken dagiti epekto ti sabsabali iti panagpatungpal, amin dagitoy ket kritikal para kadagiti rekomendasyon iti patakaran para kadagiti managkalkalap ti tuna.

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About the Author

Short Biography

Edison Roi D. Macusi is a full-time faculty member and researcher at the Faculty of Agriculture and Life Sciences and the Regional Integrated Coastal Resources Management Center (RIC-XI) in Davao Oriental State University (DOrSU) based in Mati City, Davao Oriental, Philippines. He has three children: Germane Amber S. Macusi (18 years old), Daniel Amos S. Macusi (15 years old), and David Roi S. Macusi (8 years old) with his beloved wife Erna S. Macusi.

Edison was the first-born among five siblings of Mr. Desiderio W. Macusi Jr and Mrs. Christina D. Macusi, and was born on September 23, 1982 in Tabuk, Kalinga-Apayao. He attended his elementary education at the Tabuk Central School and graduated in 1995 graduated as salutatorian. He also finished his secondary education at the Tabuk National High School (science class) in 1999 and graduated also as salutatorian. He then took up BS Biology at the University of the Philippines Los Banos (UPLB) and majored in Cell Biology. Later he joined the faculty of the University of the Philippines Baguio (UPB) as a substitute teacher then joined the Philippine Rice Research Institute (PhilRice) before working at the University of the Philippines Diliman, Marine Science Institute (UPD-MSI). During his stint as a research assistant, he was able to secure a scholarship provided by the German Academic Exchange Service (DAAD) at the Center for Marine Tropical Ecology (ZMT), where he did his master's degree with the thesis: Variability and community organization in moderately exposed tropical rocky shore algal communities as influenced by different consumer groups.

Later, he again pursued graduate education through the BESTTUNA project, having been selected as a Sandwich PhD scholar for the project conducted in the Philippines in 2013. During his time at Wageningen University, he further trained with Ir. Paul A.M. van Zwieten, Prof. Dr. Ricardo P. Babaran, Prof. Dr. Larry N. Digal, Prof. Dr. Johan A.J. Verreth and Prof. Dr. Wolf M. Mooij in aquatic science and fisheries and learned from the subjects taken at WUR, including statistics, grant proposal writing, and fisheries management. Since then, he has won grants funded by SEARCA, DOST-PCAARRD, DOST-XI, DA-PRDP and recently DENR. His studies have been published in leading journals such as Marine Policy, Frontiers in Marine Science and Ocean and Coastal Management, and Fisheries Research and Philippine Journal of Science, Philippine Scientist, and Philippine Agricultural Scientist. For his work, he clinched International Publication Incentives award by the DOST-PCAARRD, the NRCP for best posters in Mindanao Cluster and in the National arena as well as the DA-BAR for best presentation of his study on fisheries and its various related aspects.

LIST OF PUBLICATIONS

Thesis Related Articles

Macusi, E.D., Babaran, R.P., Zwieten, P.A.M. 2015. Strategies and tactics of tuna fishers in the payao (anchored FAD) fishery from General Santos City, Philippines. Marine Policy 62: 63-73. https://doi.org/10.1016/j.marpol.2015.08.020

Macusi, E.D., Abreo, N.A.S., Babaran, R.P. 2017. Local ecological knowledge (LEK) on fish behavior around anchored FADs: the case of purse seine and ringnet fishers from Southern Philippines. Frontiers in Marine Science, 4: 188. doi: 10.3389/fmars.2017.00188

Macusi, E.D., Katikiro, R.E., Babaran, R.P. 2017. The influence of economic factors in the change of fishing strategies of anchored FAD fishers in the face of declining catch, General Santos City, Philippines. Marine Policy, 78: 98-106. https://doi.org/10.1016/j.marpol.2017.01.016

Macusi, E.D., Liguez, A.O. Macusi, E.S., Digal, L.N. 2021. Factors influencing catch and support for the implementation of the closed fishing season in Davao Gulf, Philippines. Marine Policy 130, 104578. https://doi.org/10.1016/j.marpol.2021.104578

OTHER SCIENTIFIC PUBLICATIONS

Scientific Journals

Macusi, E.D. 2010. Effects of various herbivores guilds on the abundance and distribution patterns of algae on a semi-exposed tropical rocky shore Cape d' Aguilar, Hong Kong. Philippine Scientist 47 (1): 173-203.

Macusi, E.D., Katikiro, R.E., Deepananda, KHMA, Jimenez, L.A., Conte, A.R. 2011. Human induced coastal degradation of marine ecosystems in Asia Pacific and implications on food security. Journal of Nature Studies 9(2)/10(1): 13-28.

Deepananda, K.H.M.A., Macusi, E.D. 2012. Human disturbance on tropical rockyshore assemblages and the role of MPAs in reducing its impact. Philippine Agricultural Scientist 95 (1): 87-98

Macusi, E.D. 2012. Grazing drives spatial variation in the abundance and distribution. patterns of autotrophs in a tropical rocky shore. Philippine Journal of Science 144 (2): 141-156.

Katikiro, R.E., Macusi, E.D. 2012. Impacts of climate change on West African fisheries and its implications on food production. Journal of Environmental Science and Management 15 (2): 83-95.

Deepananda, K.H.M.A., Macusi, E.D. 2012. The changing climate and its implications to capture fisheries. Journal of Nature Studies 11 (1&2): 71-87.

Macusi, E.D., Deepananda, K.H.M.A. 2013. Factors that structure algal communities in tropical rocky shores: what have we learned? International Journal of Scientific and Research Publications 3:12; 1-13.

Macusi, E.D., Fisscher, Gerardus. 2013. Can complaining modify a smoking environment? A study on the effects of complaining on smoking behavior in different bars using agent-based model implementation. Social Science Diliman. 9:2; 1-23.

Deepananda, K.H.M.A., Macusi, E.D. 2013. Human disturbance in a tropical rocky shore reduces species diversity. Philippine Scientist 50:39-58.

Katikiro, R.E., Macusi, E.D., Deepananda, K.H.M.A. 2014. Changes in Fisheries and Social Dynamics in Tanzanian Coastal Fishing Communities. Western Indian Ocean Journal of Marine Science 12 (2): 95-110.

Katikiro, R.E., Deepananda, K.H.M.A., Macusi, E.D. 2015. Interplay between perceived changes in fishery and social structures in Tanzanian coastal fishing communities. Fisheries Research 164: 249-253.

Katikiro, R.E., Macusi, E.D., Deepananda, K.H.M.A. 2015. Challenges facing local communities in Tanzania in realising locally-managed marine areas. Marine Policy 51: 220–229.

Cuenca, G.C, Macusi, E.D., Abreo, N.A., Ranara, C.T., Andam, M.B., Cardona, L.C., Conserva, G.G. 2015. Mangrove Ecosystems and Associated Fauna with Special Reference to Mangrove Crabs in the Philippines: A Review. IAMURE International Journal of Ecology and Conservation 15: 60-110.

Abreo, N.A., Macusi, E.D., Cuenca, G.C., Ranara, C.T., Andam, M.B., Cardona, L.C., Arabejo, G.F.P. 2015. Nutrient enrichment, Sedimentation, heavy metals and plastic pollution in the Marine marine environment and its implications on marine biodiversity: A review. IAMURE International Journal of Ecology and Conservation 15: 111-168.

Macusi, E.D., Babaran, R.P., Ingles J.T. 2015. Vertical movements, behavior and habitat utilization of adult yellowfin tuna (Thunnus albacares) tagged in West Philippine Sea, Mindoro Island, Philippines. IAMURE International Journal of Ecology and Conservation 15: 280-297.

Macusi, E.D., Abreo, N.A., Cuenca, G.C., Ranara, C.T., Andam, M.B., Cardona, L.C., Conserva, G.C., Katikiro, R.E., Deepananda, K.H.M.A. 2015. The potential impacts of climate change on freshwater fish, fish culture and fishing communities: A review. Journal of Nature Studies 14(2): 14-31.

Abreo, N.A.S., Macusi, E.D., Blatchley, D.D., Cuenca, G.C. 2016. Ingestion of Marine Plastic Debris by Green Turtle (Chelonia mydas) in Davao Gulf, Mindanao, Philippines. Philippine Journal of Science. 145:1

Abreo, N.A.S., Macusi, E.D., Blatchley, D.D. 2016. First evidence of plastic ingestion by the rare Deraniyagala's beaked whale (Mesoplodon hotaula). IAMURE International Journal of Ecology and Conservation 19:16-36.

Macusi, E.D., Katikiro, R.E., Babaran, R.P. 2017. The influence of economic factors in the change of fishing strategies of anchored FAD fishers in the face of declining catch, General Santos City, Philippines. Marine Policy, 78:98-106.

Macusi, E.D., Abreo, N.A.S., Babaran, R.P. 2017. Local ecological knowledge (LEK) on fish behavior around anchored FADs: the case of purse seine and ringnet fishers from Southern Philippines. Frontiers in Marine Science, 4:188. doi: 10.3389/fmars.2017.00188

Vidal, K.C., Macusi, E.D., Ponce, A.G. 2018. Inventory and Morphometrics of Anuran Species Found in Mt. Kilala of the Mt. Hamiguitan Range Wildlife Sanctuary, Governor Generoso, Davao Oriental, Philippines. Philippine Journal of Science 147 (4), 629-638.

Abreo, N.A., Macusi, E.D., Jimenez, L.A. 2018. A survey of subtidal anthropogenic marine debris (AMD) in Mayo bay, Mati City, Davao Oriental, Philippines. Philippine Journal of Science 147 (4), 599-602.

Macusi, E.D., Laya-og, M., Abreo, N.A. 2019. Wild lobster (*Panulirus ornatus*) fry fishery in Balete Bay, Mati City, Philippines: catch trends and implications. Ocean Coastal Management 168, 340–349. DOI.org/10.1016/j.ocecoaman.2018.11.010

Macusi, E.D., Morales, I.D., Abreo, N.S., Jimenez, L.A. 2019. Perception of solid waste management and rate of accumulation in schools in Mati City, Mindanao island, Philippines. Journal of Marine and Island Cultures 8 (2), 113-131. DOI: 10.21463/jmic.2019.08.2.09

Macusi, E.D., Macusi, E.S., Jimenez, L.A., Catam-isan, J.P. 2020. Climate change vulnerability and perceived impacts on small-scale fisheries in eastern Mindanao. Ocean and Coastal Management https://doi.org/10.1016/j.ocecoaman.2020.105143

Abreo, N.A.S., Siblos, S.K., Macusi, E.D. 2020. Anthropogenic marine debris (AMD) in mangrove forests of Pujada Bay, Davao Oriental, Philippines. Journal of Marine and Island Cultures 9 (1), 38-53. DOI: 10.21463/jmic.2020.09.1.03

Macusi, E.D., Martinez-Goss, M. 2020. Preservation in Fluids. In Methods in Microalgal Studies by Martinez-Goss, M., Rivera, W.L., Torreta, N.K. (eds). Philippine Science Letters, UP Diliman.

Macusi, E.D., Tipudan, C.D. 2020. Effects of bioturbation of fiddler crabs in relation to the growth of mangrove saplings (*Rhizophora apiculata*) in a mangrove reforested area. Journal of Marine and Island Cultures 9 (2), 1-10. DOI: 10.21463/jmic.2020.09.2.06

Macusi, E.D., Liguez, A.O. Macusi, E.S., Digal, L.N. 2021. Factors influencing catch and support for the implementation of the closed fishing season in Davao Gulf, Philippines. Marine Policy 130, 104578.

Macusi, E.D., Camaso, K.L., Barboza, A., Macusi, E.S. 2021. Perceived vulnerability and climate change impacts on small-scale fisheries in Davao gulf, Philippines. Frontier in Marine Science doi: 10.3389/fmars.2021.597385

Macusi, E.D., Geronimo, R.C., Santos, M.D. 2021. Vulnerability drivers for small pelagics and milkfish aquaculture value chain determined through online participatory approach. Marine Policy 133, 104710 doi: 10.1016/j.marpol.2021.104710

Macusi, E.D., Siblos, S.K., Betancourt, M.E.S, Erna S. Macusi, Calderon, M.N., Bersaldo, M.J.I., Digal, L.N. 2021. Impacts of COVID-19 on the catch of small-scale fishers (SSF) and their families due to restrictions policies in Davao Gulf, Philippines. Frontier in Marine Science publication status: accepted for publication.

Macusi, E.D., Rafon, J.K.A, Macusi, E.S. 2021. Impacts of COVID-19 and closed fishing season on commercial fishers of Davao Gulf, Philippines. Ocean and Coastal Management 217: 105997.

Discussion paper

Macusi, ED 2017. Fish aggregating devices and the Role of Socio-economic Factors in Driving Spatial Effort Allocation of Fishers. SEARCA Agriculture and Development Discussion Paper Series No. 2016-4, Southeast Asian Regional Center for Graduate Study and Research in Agriculture Los Banos, Laguna Philippines, 60p.

Awards

Macusi, E.D., Babaran, R. 2014. The Spatial distribution of FADs and short and long term decision making of tuna fishers from General Santos City, Philippines. DA-BAR, National Research Symposium, October 22, 24, 2014. Department of Agriculture (Bureau of Agricultural Research AFMA Silver Award for Best R&D paper in the National Research Symposium)

Macusi, E.D., Macusi, E.S., Jimenez, L.A., Catam-isan, J.P. 2019. Climate change vulnerability and perceived impacts on small-scale fisheries in eastern Mindanao, Philippines. 5th International Conference on Fisheries and Aquaculture (ICFAS), UP Visayas, Tacloban City, November 6-7, 2019. (Best in Oral Presentation Award)

Macusi, Edison Roi, Kampitan, Vince Ann, Martinez-Goss, Milagrosa. Preservation of Photosynthetic Euglenoids. Poster paper presented at the Third National Symposium of the Philippine Phycological Society Inc., (PPSI) held at Drilon Hall, SEARCA, UP Los Baños, College, Laguna on August 6, 2010. (Best poster award)

Deepananda, KHMA, Macusi, E. Human disturbance in a tropical rocky shore reduces diversity. Poster paper presented at the 13th SESAM anniversary symposium held at UPLB College Laguna, December 13, 2010. (Award of Commendation)

Diampon, D.O., Siblos, S.K., Macusi, E.D. 2021. Climate change impacts, variabilities, and the resilience of small-scale fisheries in Davao Gulf. NRCP Mindanao Regional Cluster Annual Scientific Conference and 19th Membership Assembly 27th October 2021, NRCP Taguig, MM (Best Poster Award)

Ilah Dianne G. Morales, Erna S. Macusi, Edison Roi D. Macusi. 2021. Impact of seasonal fisheries closures on catch, price and the fisheries maket chain: The case of Davao Gulf, Philippines. National Research Council of the Philippines Annual Scientific Conference and 88th General Membership Assembly, Bicutan, Taguig City Philippines. (Third place, cluster B division 1)

Charlen Mae Z. Gaab, Erna S. Macusi, Edison Roi D. Macusi. 2021. The role of women in the small-scale fisheries of Davao Gulf, Mindanao, Philippines. National Research Council of the Philippines Annual Scientific Conference and 88th General Membership Assembly, Bicutan, Taguig City Philippines. (First place, cluster B, division 1)

Training and Supervision Plan

Training and Supervision Plan	**Graduate School WIAS**
Name PhD student	Edison Roi D. Macusi
Project title	Effort allocation of mixed-fisheries on tunas and small pelagics with juvenile tuna by-catch and their interaction with FADs
Group	AFI
Daily supervisor(s)	Ir. Paul van Zwieten (WUR)
Supervisor 1	Prof. Dr. Adrian Rijnsdorp AFI (WUR)
Supervisor 2	Prof. Dr. Wolf Mooij AEW (WUR)
Local Supervisor:	Prof. Dr. Ricardo P. Babaran (UP visayas)
Project term from:	1 September 2022
Submitted certificate	

EDUCATION AND TRAINING (minimum 30, maximum 60 credits)

The Basic Package (minimum 3 credits)	year	credits *
WIAS Introduction Course (mandatory, 1.5 credits)	2013	1.5
Course on philosophy of science and/or ethics (mandatory, 1.5 credits)	2013	1.5
Subtotal Basic Package		**3.0**

Scientific Exposure (conferences, seminars and presentations, minimum 8 credits)	year	credits
International conferences (minimum 3 credits)		
Maritime Futures (MARE) (oral), June 26-28, 2013; Amsterdam, Netherlands	2013	1.0
International Conference on Agricultural Economics (ICAEM) (oral), Sept. 2-3, 2014; Davao City, Philippine	2014	0.6
2nd International Conference on Fisheries and Aquatic Sciences (ICFAS) (oral), Jan. 26-27, 2016; Iloilo, P	2016	0.6
Congress		
15th National Tuna Congress, September 6-7 General Santos City, Philippines	2013	0.6
16th National Tuna Congress, September 4-5 General Santos City, Philippines	2014	0.6
17th National Tuna Congress, September 3-4, Gernal Santos City, Philippines	2015	0.6
18th National Tuna Congress, August 31 to Sept 1-2, 2016 General Santos City, Philippines	2016	1.0
Seminars and workshops		
BESTTUNA Workshop, August 28-30, 2012 in Bogor, Indonesia	2012	0.5
WIAS Science Day (poster), February 28, 2013 in WUR, Wageningen, Netherlands	2013	0.3
DA-BAR, National Research Symposium (oral & poster), October 22, 2014, Quezon City, Philippines	2014	1.0
Training workshop in Capture Fisheries Research and Management tools, Dec. 15-17, 2014, Naawan, Phili	2014	1.0
Training on Application of GIS on Aquaculture Research, August 26-28, 2015, Panabo City, Philippines	2015	1.0
IFS-SEARCA Workshop on Collaborative Research, August 30 to Sept. 1, 2016, Los Banos, Laguna, Phili	2016	2.0

Presentations (minimum 4 original presentations of which at least 1 oral, 1 credit each)		
4 Oral presentations	2013-2016	4.0
2 Poster presentations	2013-2016	2.0
Subtotal International Exposure		**16.8**
In-Depth Studies (minimum 6 credits, of which minimum 4 at PhD level)	year	credits
Disciplinary and interdisciplinary courses		
WIAS Course Statistics for the Life Sciences	2013	2.0
BESTTuna interdisciplinary course	2013	2.5
Basic Statistics	2012	1.5
Linear Models	2016	0.9
Generalized Linear Models	2016	0.6
MSc level courses		
Agent-Based Modelling Course	2013	6.0
Subtotal In-Depth Studies		**13.5**
Professional Skills Support Courses (minimum 3 credits)	year	credits
Teaching and Supervising MSc students	2013	1.0
Project and Time Management	2013	1.5
Writing Grant Proposal	2012/13	2.0
Information Literacy including EndNote	2013	0.6
Techniques for Writing and Presenting a Scientific Paper (TWP)	2013	1.2
IAMURE Training on Journal System Management, Cagayan De Oro City Philippines	2015	1.0
PAIR workshop on research proposal writing for commissioned research, Davao City	2015	2.0
IAMURE International Training on Writing Review of Related literature, Cagayan De Oro	2015	2.0
Subtotal Professional Skills Support Courses		**11.3**
Research Skills Training (optional)	year	credits
Preparing own PhD research proposal (maximum 6 credits)	2012/13	6.0
Subtotal Research Skills Training		**6.0**
Didactic Skills Training (optional)	year	credits
Lecturing (real time including preparation)		
Supervising practicals and excursions (real time)		
Supervising theses (max 2 credits per Msc major, 1.5 c Msc minor, 1 c BSc thesis)		
Fish aggregation patterns around FADs by Kristian van Rooijen (Msc thesis)	2016	1.0
The influence of effort allocation on fishers' CPUE and revenues fished at anchored FAD's by Remco Willigenburg (Msc thesis)	2015	0.5
Ingestion of marine plastics by charistmatic marine animals by Neil Angelo S. Abreo (Msc thesis)	2016	1.0
Subtotal Didactic Skills Training		**2.5**

Management Skills Training (optional)		
Membership of boards and committees	year	credits
IAMURE International Journal of Ecology and Conservation (Associate Editor; Philippines)	2016	1.0
Education and Training Total (minimum 30, maximum 60 credits)		**54.1**

* one ECTS credit equals a study load of approximately 28 hours