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Evaluating Patterns of Fish Assemblage Changes from Different-Aged Reforested Mangroves in Lingayen Gulf

Shielameh A. Peralta-Milan[1] and Severino G. Salmo III[2]

ABSTRACT

Fish assemblages in planted mangroves of different ages in northwestern Lingayen Gulf, northwestern Philippines, composed of: seven-year (Tondol, Anda), nine-year (Pangapisan, Alaminos), 11-yr (Imbo, Anda), 12-yr (Pilar, Bolinao), and 19-yr stands (Bangrin, Bani) were investigated. A modified local triangular trap net was deployed ~1 m from the edge of the plantation of each site at low tide for three days (before, during, and after spring tide) in December 2008 and February 2009. Fish samples were collected the following day, measured, then weighed in the laboratory. Fish species were categorized based on trophic level and habitat preferences. A total of 593 individuals belonging to 50 species from 22 families were recorded. There were no apparent trends in terms of fish abundance, fish biomass, and trophic categories with age of mangrove stands. In terms of habitat preference, mangrove-associated species dominated the mature plantation (> 12 yr) while reef-associated species were mostly found in younger stands (< 12 yr). The fish assemblages have 43 % similarity between seven-year and nine-year plantation, and 35 % similarity between 11-year and 12-yr plantation. In contrast, the 19-yr old plantation was clearly separated from the younger plantations, indicating a possible shift of fish assemblage with age of mangrove stands.

Key words: *mangroves, planting, fish assemblage, triangular trap net, trajectory pattern, Lingayen Gulf*

INTRODUCTION

Mangrove forests perform several important ecological and socio-economic functions. They serve as habitat for various marine and terrestrial organisms, produce organic detritus, protect shoreline, and provide forest and fishery products (*White and Cruz-Trinidad 1998*). Mangroves are also considered as one of the most degraded coastal ecosystems in the country. The Philippines used to have about 450,000 ha of mangroves in 1918 but due to natural and anthropogenic stresses, mangrove cover shrunk to 288,000 ha in 1970 and was drastically reduced to only 256,185 ha in 2000 (*Long and Giri 2011*). At least sixty percent of mangrove loss can be attributed to conversion to aquaculture ponds particularly during the 1970s (*Primavera 2005*).

Similarly, mangroves in Pangasinan (west Lingayen Gulf, NW Philippines) are severely degraded. From an estimated area of 990 ha in 1978, only 400 ha in 2002 remains (*MSI 2002*). To address mangroves loss, mangrove restoration programs were implemented. Around 136 ha of planted mangroves were established in the municipalities of Bolinao, Anda, Bani, and Alaminos. This planting strategy, which has been implemented for almost two decades, aims to restore forest cover and ecological functioning of mangroves (*Salmo III et al. 2007*).

There have been interests on how planted mangroves contribute in fisheries production. Mangroves are known to attract fish because of the habitat complexity, food and refuge they provide (*Huxham et al. 2004*). Robertson and *Duke* (*1987*) proposed that mangroves are very important nursery habitat for commercially important fish species. *Ronnback et al.* (*1999*) further proved that mangroves are extensively used as habitat by various fish species.

However, planted mangroves offer a unique case. Being monospecific and with oftentimes stunted growth (*Samson and Rollon 2008*), it reduces habitat complexity and detritus production that may diminish their attractiveness as fish habitat (*Salmo III 2011*). The planted mangroves have to undergo developmental stage before it reaches a forest state comparable with that of a mature mangrove. Unfortunately, studies that compare the performance of natural and planted mangroves in enhancing fish assemblages are limited.

Recently, however, there has been an increase in the number of studies that examine fish assemblages in planted mangroves, comparing them to natural or mature mangrove stands. These studies have contrasting findings. For example, *Huxham et al.* (*2004*) compared the fish assemblages between vegetated mangroves and unvegetated sites in Gazi Bay, Kenya and results revealed significant difference in assemblage structure between the two sites. Species richness and abundance were found to be significantly higher at clear site than that of the vegetated site. In contrast, *Crona and Ronnback* (*2007*) showed no significant differences in juvenile fish recruits between planted and natural mangrove stands in Pagbilao, Philippines.

[1] Institutional Research Assistant, Bolinao Marine Laboratory, The Marine Science Institute, College of Science., University of the Philippines, Diliman, Quezon City 1101, Philippines. Email: s.peralta0122@gmail.com
[2] Assistant Professor, Department of Environmental Science, Ateneo de Manila University, Loyola Heights, 1108 Quezon City and Adjunct Faculty, College of Agriculture, Central Luzon State University, Science City of Muñoz, 3120 Nueva Ecija

Studies that evaluate the progress and impact of mangrove planting programs in enhancing fish assemblages are rarely undertaken. Thus, this study conducted documentation and evaluation of fish assemblages in planted mangroves representing a gradient of ages from young to mature plantation. The researchers tested the hypothesis that the fish assemblage will change as mangrove stands mature. Such shift in pattern could be used as a possible indicator of restoration trajectory in restored mangroves.

MATERIALS AND METHODS

Site description

The study utilized the mono-specific mangrove plantations of the species *Rhizophora mucronata* in Lingayen Gulf (**Figure 1**). These plantations are of varying ages and sizes located in Tondol in Anda (7 yrs old, 12 ha; P7), Pangapisan in Alaminos (9 yrs old, 10 ha; P9), Imbo in Anda (11 yrs old, 8 ha; P11), Pilar in Bolinao (12 yrs old, 8 ha; P12) and Bangrin in Bani (19 yrs old, 20 ha; P19). The planted mangroves in Bangrin have another separate 20 ha block in the eastern side composed of several cohorts of unknown ages. For this site, the study was conducted in the pure 19-yr stand.

Sites in Anda, Alaminos and Bolinao facing Lingayen Gulf are exposed to coastal currents while Bani is in a more sheltered area found in Tambac Bay. The average depth of the study sites is about 2 m during high tide but is generally exposed at low tide particularly during September to February. There are two pronounced seasons: dry from the months of November to April (northeast monsoon) and wet from the months of May to October (southwest monsoon) with an average annual precipitation of at least 2,500 mm (*FAO 2001*).

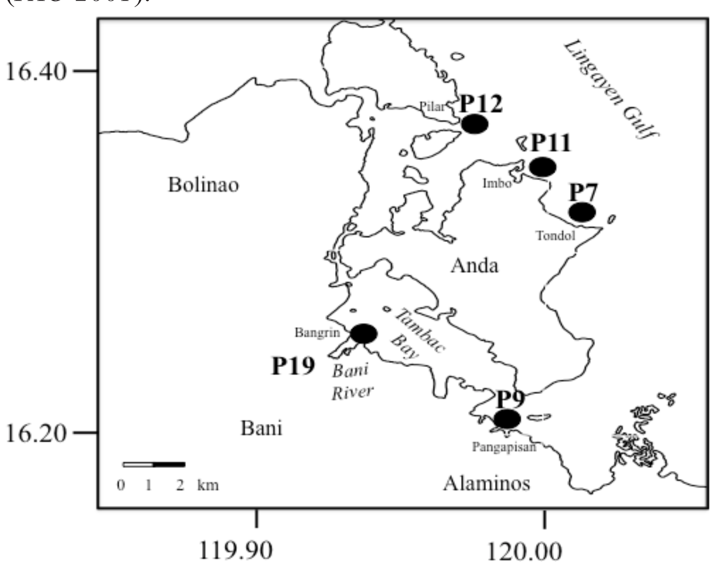

Figure 1. Location of mangrove plantations of different ages used in the study. The numbers indicate the ages of mangrove stands.

Experimental design

We used a space-for-time (SFT) substitution approach in inferring temporal trends from different aged sites to generate patterns in the trajectory of the restored system (*cf Pickett 1989*). Such approach has been used in similar studies in restoration ecology where optimal sampling design (i.e. presence of experimental controls and age replicates within one site) may not be possible (*cf Michener 1997*). Thus, the ages of the planted sites were used as a temporal point in the restoration trajectory of mangroves.

Field sampling

Fish sampling were carried out during spring tides in December 2008 and February 2009. Modified local triangular trap nets locally known as “baklad” were used to collect samples. The net has a 10-m wingspan on each side (area: 43.3 m^2) with a three-m pocket connected at the cod end.

All nets had a stretched mesh size of 2 mm. The trap net was assumed to catch fish that came in during high tide and trapped as tide recedes. One trap net was deployed at each site ~1 m from the edge of the plantation at low tide for three days (before, during, and after spring tide). Fish samples were collected the following day during low tide, early in the morning from the pocket of the net. All collected individuals were sorted from other catch (e.g. crustaceans, mollusks) and then identified to species level using *Kuiter and Debelius* (*2006*) and *Allen et al.* (*2003*). The collected fish samples were measured and weighed within the same sampling day in the Bolinao Marine Laboratory (Marine Science Institute of the University of the Philippines). Data on trophic category, habitat preference and juvenile size for each species were obtained from FISHBASE (*Froese and Pauly 2004*).

Data analysis

The fish assemblage was analyzed using a non-parametric approach. Relative abundance and relative biomass were computed for each species that were determined as the count and weight of a species divided by the total abundance and total biomass per site, respectively. Data for the two sampling periods were pooled since no temporal differences were observed (Analysis of Similarity test). Trophic categories and habitat preferences of all fish species per site were analyzed through frequency analysis. Species diversity (H’) was calculated using the Shannon-Weiner index. A similarity matrix was constructed using Bray-Curtis index on standardized, fourth root-transformed biomass data. Cluster analysis was performed from this similarity matrix. Discriminating species was obtained using a similarity percentage procedure with a cut off of 90 % per site (*SIMPER; Clarke and Warwick 2001*). All multivariate analyses were implemented in PRIMER 6 (*Clarke and Gorley 2006*).

RESULTS

Fish species composition

A total of 593 fish individuals belonging to 50 species from 23 families were collected (**Table 1**). All collected samples were identified as juveniles except for *Plotosus lineatus* and *Upeneus guttatus* from P11 that were identified as adult. Species richness and diversity index exhibited high variability across sites. Species richness was highest in P9 (24 species) and lowest in the oldest plantation (P19; 14 species). Diversity index was highest in P12 (2.34) and lowest in P19 (1.56).

Fish abundance and biomass

Fish abundance and biomass highly varied across sites (as represented by high standard deviation) and did not show clear pattern with age of the mangrove stands (**Table 1**). Highest fish biomass was observed in P9 (74 ± 1.33 g m^{-2} d^{-1}) followed by P19 (56.3 ± 1.78 g m^{-2} d^{-1}), P7 (32.6 ± 0.60 g m^{-2} d^{-1}), P12 (28.6 ± 0.52 g m^{-2} d^{-1}) and P11 (6 ± 0.06 g m^{-2} d^{-1}). The youngest plantation obtained the highest fish abundance (428 ± 7). The dominant species (both by abundance and by biomass) are from the families Ambassidae, Apogonidae, Atherinidae, Gobiidae, Hemirhamphidae and Tetraodontidae.

Different fish species dominated in different mangrove stands. *Hyporhamphus dussumieri* was the most abundant species in P7 (28.6 %), P9 (37.4 %) and P12 (25.6 %). In P11, *Arothron manilensis* was the most abundant species (16.7 %) followed closely by *P. lineatus* (11.1 %), *Siganus fuscescens* (11.1 %) and *Sphyraena barracuda* (11.1 %). In P19, *Atherinomorous lacunosus* has the highest relative abundance (46.2 %). Almost similar patterns were observed in relative biomass wherein *H. dussumieri* dominated in P9 (30.9 %) and P12 (27.6 %) while *A. lacunosus* prevailed in P19 (60.4 %). The species *A. manilensis* and *Conger* sp. have the highest relative biomass in P7 (23.2 %) and P11 (34.3 %).

Trophic category

The trophic categories of recorded fish species included carnivores, detritivores, herbivores and omnivores (**Figure 2**). A general pattern of changes in trophic categories with age of mangrove stands can be inferred. All mangrove stands have high proportion of carnivores but with varying amount. The youngest plantation has high proportion of carnivore (74.00 ± 14.60 %) and herbivore species (25.00 ± 14.67 %). Other plantations of intermediate age (P9, P11 and P12) were also dominated by carnivores (50-60 %) but showed a mixture of omnivores and detritivores as well (range: 1-25 %). Carnivorous species dominated in all sites but was most dominant in the oldest stand (P19; 96.00 ± 1.53 %).

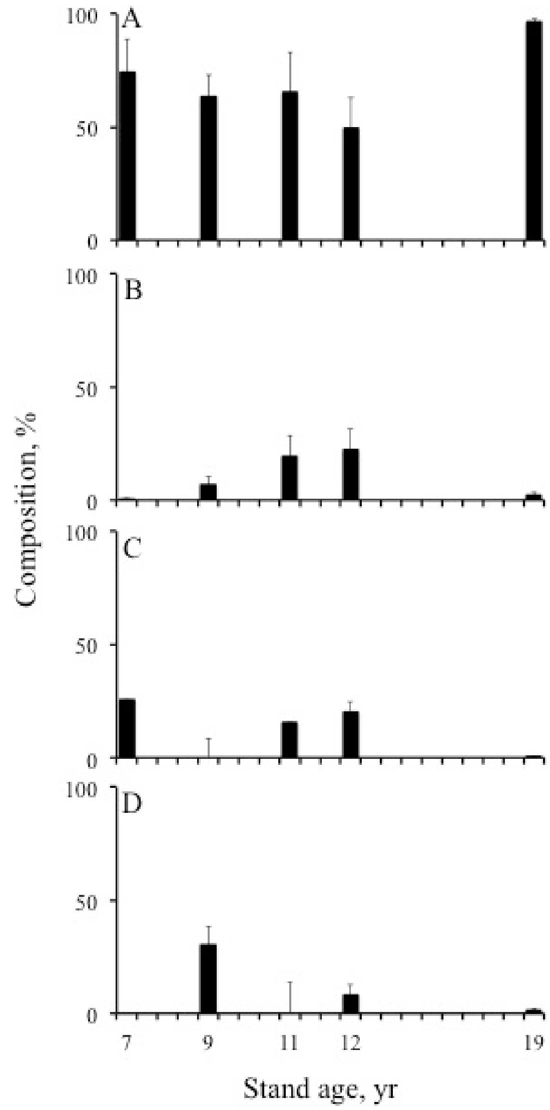

Figure 2. Trophic composition (A: Carnivore; B: Detritivore; C: Herbivore; and D: Omnivore) of fish species from different mangrove stands. The carnivore species have high proportion (at least 50 %) in all sites but have varying dominance with mangrove stand ages. Other trophic categories have minimal contribution (< 30 %).

Habitat preference

The habitat preference of recorded fish species varied across plantation ages (**Figure 3**). More than half of the fish collected in P7 and P19 are mangrove-associated species. In P9 and P12, there are more reef-associated species than the mangrove-associated species. Reef-associated species had the highest proportion in the youngest plantation (P7; 47.00 ± 33 %). In contrast, the mangrove-associated species dominated in the oldest plantation (P19; 60.00 ± 43 %).

Table 1. Fish species with relative density (%) and relative biomass (%) recorded from each mangrove stand. There were no apparent trends on species abundance and biomass with stand age. However, certain species appear to be more abundant in younger stands (e.g. *Hyporhamphus dussumieri*) and there are species that are more dominant in older stands (e.g. *Atherinomorus lacunosus*).

Family	Species	Relative density, %					Relative biomass, %				
		P7	P9	P11	P12	P19	P7	P9	P11	P12	P19
Ambassidae	*Ambassis* sp.		21.20		4.70	2.40		14.73		1.15	0.84
Antennaridae	*Histrio histrio*	1.00					1.17				
Apogonidae	*Apogon fraenatus*	14.30			5.80		14.09			8.80	
Atherinidae	*Atherinomorus lacunosus*	9.20	0.50		2.30	46.20	9.18	0.96		2.75	60.42
	Atherina sp.	7.10					9.63				
Blenniidae	*Blenny* sp. *1*					1.80					1.82
	Blenny sp. *2*				3.50					4.14	
Chanidae	*Chanos chanos*				7.00					9.18	
Clupeidae	*Clupeidae* sp.		0.50					0.25			
Clupeidae	*Conger cinereus*	1.00					7.99				
	Conger sp. *1*	1.00	0.50	5.60			6.01	7.65	34.33		
	Conger sp. *2*	1.00	0.90	5.60			4.23	10.94	5.40		5.08
	Conger sp. *3*				2.30	0.60				8.45	
Ephippidae	*Platax orbicularis*		0.90					0.20			
Gerreidae	*Gerres oblongus*		9.90					2.89			
	Gerres sp. *1*				2.30					0.07	
	Gerres sp. *2*		7.20	5.60					1.82	0.17	
Gobiidae	*Exyrias puntang*	2.00			1.20		0.77			5.25	
	Goby sp. *1*		6.80					2.99			
	Goby sp. *2*	1.00				3.00	0.07				4.62
	Goby sp. *3*				8.10	16.00				2.92	6.25
	Goby sp. *4*					0.60					0.93
	Goby sp. *5*		0.50	5.60	20.90	18.30		0.25	0.13	6.37	7.88
	Goby sp. *6*					0.60					0.56
	Oplopomus caninoides		4.10			4.10		2.23			1.17
	Yongeichthys criniger			5.60	5.80			2.61	2.23		
Hemirhamphidae	*Hyporhamphus dussumieri*	28.60	37.40		25.60	0.60	15.00	30.89		27.62	0.19
Lethrinidae	*Lethrinus harak*	2.00					2.17				
	Lethrinus sp.	1.00					0.02				
Lutjanidae	*Lutjanus fulviflamna*			5.60					1.29		
Mugilidae	*Valamugil* sp.				2.30					2.71	
Mullidae	*Upeneus guttatus*	1.00		5.60					6.09		
	Upeneus tragula		0.50				1.47	0.01			
Platycephalidae	*Cymbacephalus beauforti*		0.90					0.71			
	Platycephalus sp. *1*					0.60					4.10
	Platycephalus sp. *2*		0.50					1.57			
	Platycephalus sp. *3*					1.20					2.00
	Platycephalus sp. *4*		0.50			3.60		0.76			4.10
Plotosidae	*Plotosus lineatus*			11.10					12.56		
Siganidae	*Siganus fuscescens*	7.10	3.20	11.10	5.80		0.30	0.35	5.27	7.79	
	Siganus guttatus		0.50	5.60				8.20	1.67		0.05
	Siganus sp.		0.50				0.02	0.01			
	Siganus virgatus	1.00	0.01					0.01			
Soleidae	*Synaptura marginata*		1.80					8.46			
Sphyraenidae	*Sphyraena barracuda*			11.10					18.56		
Terapontidae	*Pelates quadrilineatus*	1.00					0.98				
	Terapon jarbua		0.50					0.76			
Tetraodontidae	*Arothron hispidus*	1.00		5.60	2.30		3.67		9.30	10.57	
	Arothron manilensis	19.40	0.90	16.70			23.21	1.77	2.61		
	Chelonodon patoca		0.50					1.62			
Species richness, S		*18*	*24*	*13*	*15*	*14*					
Diversity index, H'		*2.3*	*2.3*	*1.0*	*2.3*	*1.6*					

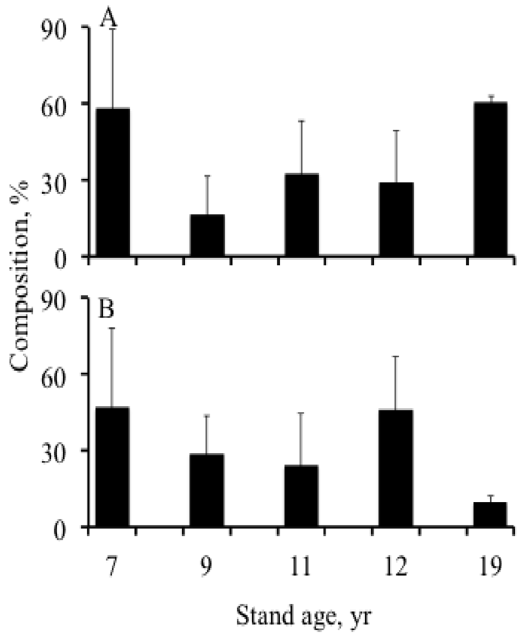

Figure 3. Habitat preference of collected fish species: (A) mangrove-associated; (B) reef-associated. Mangrove-associated species are more dominant in the youngest and oldest plantation, while reef-associated (B) species are more dominant in the intermediate-aged plantations.

Fish assemblages

The SIMPER Analysis identified the fish species that contributed most to the similarities and dissimilarities between and among mangrove stands (**Figure 4**). Two major clusters on fish assemblages can be inferred: the mature group (P19) and the young group (P7, P9, P11 and P12). The oldest plantation was clearly separated from the young plantations (56 % dissimilarity). Young plantations were further subdivided into two groups: P7 and P9 (43 % dissimilarity), and P11 and P12 (intermediate age stands; 35 % dissimilarity).

There were no consistent patterns in the similarities and dissimilarities of stand-discriminating fish species between and among mangrove stand ages. However, some general patterns can be inferred. The species *A. manilensis* and *A. fraenatus* occurred in all stands but have decreased dominance as mangrove stand age increased. The intermediate-aged stands have mixture of *H. dussumieri*, *Ambassis* sp., *Goby* sp., *S. fuscescens*, *S. marginata*, and *G. oblongus*. The species *A. lacunosus*, *Goby* sp. and *H. dussumieri* occurred in most sites but have increased dominance as stand age increased.

DISCUSSION

The study provide new and valuable information that could be used in assessing impacts of mangrove planting programs in terms of its relationship with fish assemblages. To the knowledge of the researchers, this is the first study that evaluates the differences in fish assemblages in planted mangrove stands of different ages in the country. Mangroves are known to attract fishes because of the structural complexity, refuge and food that it provides (*Robertson and Duke 1987; Parrish1989; Nagelkerken et al. 2008*). Planted mangroves are expected to provide the similar ecological function (*Salmo III et al. 2007*). The potential to increase fish abundance and biomass has been essentially one of the primary motivations in the proliferation of mangrove rehabilitation programs in the Philippines (*Salmo III and Duke 2010*). But studies that evaluate impacts of planted mangroves in enhancing fish assemblage are still rare, casting doubts whether these rehabilitation programs are really effective or not.

Fish species composition, abundance and biomass not correlated with mangrove age

The 50 fish species (from 23 families) we collected in Lingayen Gulf are higher than the fish species documented from Pagbilao mangroves (South Luzon; 37 species; *Ronnback et al. 1999*). Almost all collected fish species are at their juvenile stage consistent with several studies that suggest mangroves as an effective nursery grounds to many juvenile fish species (*Robertson and Duke 1987; Crona and Ronnback 2007; Bosire et al. 2008*). The dominant species (both by abundance and biomass) are from the families Ambassidae, Apogonidae, Atherinidae, Gobiidae, Hemirhamphidae and Tetraodontidae. These species are the typical species that inhabit tropical mangrove forests (see for example *Ronnback et al. 1999; Feutry et al. 2010*).

Across sites, the mean fish abundance and biomass are higher by at least five-folds from the reported fish catch in Pagbilao mangroves (*Ronnback et al. 1999*). The study of *Ronnback et al.* (*1999*) used stake net method in different mangrove species (with *Avicennia marina* and *Rhizophora apiculata* stands) and geographical settings (mostly located in coves). But contrary to what is expected in planted mangroves, our study showed no clear patterns in fish assemblage with age of the mangrove stands. In fact, the younger mangrove stands have higher fish species diversity, species richness, abundance and biomass than the oldest stands.

Carnivorous and mangrove-associated species dominate in the oldest mangrove stands

The trophic categories of caught fish species varied in young and intermediate-aged mangrove stands. The trophic compositions in young and intermediate-age stands (< 12 yrs) are a mixture of detritivores, omnivores, herbivores and carnivores. But in the most mature stands, carnivores dominate the species composition. Conversely, carnivorous species exhibits low abundance in young mangrove stands, which was similarly observed in Pagbilao, Quezon (*Ronnback et al. 1999*).

	P7	P9	P11	P12
P9	66.51% *A. manilensis* — *Ambassis sp.* *A. fraenatus* — *G. oblongus* *A. lacunosus* — *Gerres sp.* *Atherina sp.* — *Goby sp.* *S. fuscescens* — *S. fuscescens*			
P11	71.86% *H. dussumieri* — *P. lineatus* *A. fraenatus* — *S. barracuda* *A. lacunosus* — *G. oblongus* *Atherina sp.* — *Goby sp.* *E. puntang* — *Y. criniger*	70.31% *H. dussumieri* — *A. manilensis* *Ambassis sp.* — *P. lineatus* *Goby sp.* — *S. barracuda* *S. fuscescens* — *S. fuscescens* *S. marginata* — *Y. criniger*		
P12	58.27% *A. manilensis* — *Goby sp.* *A. fraenatus* — *C. chanos* *A. lacunosus* — *Y. criniger* *Atherina sp.* — *A. fraenatus* *L. harak* — *Ambassis sp.*	62.80% *H. dussumieri* — *H. dussumieri* *Ambassis sp.* — *Goby sp.* *G. oblongus* — *C. chanos* *Gerres sp.* — *A. fraenatus* *Goby sp.* — *Y. criniger*	67.62% *A. manilensis* — *H. dussumieri* *P. lineatus* — *Goby sp.* *S. barracuda* — *C. chanos* *Goby sp.* — *A. fraenatus* *C. cinereus* — *Ambassis sp.*	
P19	81.42% *H. dussumieri* — *A. lacunosus* *A. manilensis* — *Goby sp.* *A. fraenatus* — *Platycephalus sp.* *A. lacunosus* — *Ambassis sp.* *Atherina sp.* — *Blenny sp.*	79.26% *H. dussumieri* — *H. dussumieri* *Ambassis sp.* — *Goby sp.* *G. oblongus* — *Platycephalus sp.* *Gerres sp.* — *Ambassis sp.* *S. fuscescens* — *Blenny sp.*	90.54% *A. manilensis* — *A. lacunosus* *P. lineatus* — *Goby sp.* *S. fuscescens* — *Goby sp. 2* *S. barracuda* — *Platycephalus sp.* *C. cinereus* — *Ambassis sp.*	56.61% *H. dussumieri* — *A. lacunosus* *Goby sp.* — *Goby sp.* *C. chanos* — *Platycephalus sp.* *A. fraenatus* — *H. dussumieri* *S. fuscescens* — *A. fraenatus*

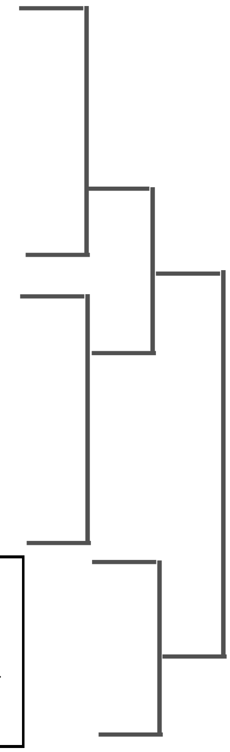

Figure 4. Summary results of SIMPER and cluster analyses showing the fish species that contributed most strongly to the similarities (left) and dissimilarities (right) between and among mangrove stand ages. Species are listed in order of their contribution of similarities and dissimilarities. The percentages indicate the dissimilarities between the two compared mangrove stands.

The researchers suspected that resident species (those species that are known to be mangrove-dwellers) would tend to become more abundant with age of mangrove stands. Among resident species, the longer-lived species (mostly the carnivores) would tend to be more dominant in the older stands. Carnivorous species are known to be long-lived species (*P. Aliño, pers. comm.*). It could be possible that carnivorous species prefer mature mangroves due to higher availability of food as compared to young, developing mangrove stands.

There was no consistent pattern on habitat preference of fish with age of mangrove stands. Mangrove-associated species dominates in both the youngest and the most mature plantation while reef-associated species have relatively higher dominance in the younger plantations. However, younger mangrove stands seem to attract more generalist species (i.e. species that are not exclusively mangrove dependent) but tend to have more mangrove-associated species in mature mangroves. This pattern probably indicates that certain fish will dominate as mangroves grow and develop. Many of these species might show ontogenetic shifts in habitat preference as they grow, probably as a response to increasing availability of food and complexity of forest structure.

Different fish species may use mangrove as a nursery ground at different stages of their life cycles. For example, the catadromous species barramundi, *Lates calcalifer* (Bloch), migrate from inland freshwaters to estuaries and mangroves during spawning (*Russell and Rimmer, 2004*). There are also some fish species that complete their entire life cycle in estuaries near mangroves (e.g., members of the Gobiidae and Atherinidae). Certain fish species such as *Mugil cephalus*, *Sillago* spp. and *Platycephalus* spp. spawn offshore. Their eggs are then carried by currents, and eventually, their post-larval or early juvenile stages settle in estuaries and mangroves (*Manson et al. 2005*).

Alternatively, the habitat preference of the caught fish species can be explained by localized site differences (i.e. proximity to reef and riverine systems) where particular trophic group of species naturally thrive. Notably, mangrove stands with nearby reefs (< 1 km in 9-, 11- and 12-yr stands) obtained more reef-associated species while site located in a bay (at least > 2 km from reef; 19-yr stands) has more riverine-associated species.

Fish assemblage shifts with age of mangrove stands but is weakly correlated

While the study did not find consistent patterns in changes in fish species composition, abundance, and biomass with age of mangrove stands, the cluster and SIMPER analyses however indicated general groupings of mangrove stands (**Figure 4**). Although weakly evident, a possible shift in fish assemblages with age of mangrove stands can be inferred. It is suspected though that such shift in fish assemblages is not mainly related to the age nor the presence of the mangrove stands per se but rather with other inherent localized environmental factors. The proximity of the reef to the young and intermediate-age stands (9-, 11- and 12-yr stands) probably influenced the composition of reef-associated catch. Similarly, the 12-yr and 19-yr stands that are located near an estuary, obtained more mangrove-associated species.

In the Philippines, most planted mangroves are monospecific and have stunted growth (*Samson and Rollon 2008; Salmo III and Duke 2010*). Thus, habitat complexity is reduced as compared to natural mangrove stands. It is also possible that since planted mangroves can resemble the vegetation and soil characteristics of natural stands only after 25 yrs (*Salmo III 2011*), it may probably need the same amount of time for planted mangroves to effectively perform its ecological function as fish nursery.

There are contrasting views on the relationship, or lack thereof, between fish and mangroves (*Nagelkerken and van der Velde 2004*). The dependency of fish on mangroves is questioned (see *Blaber 2007* for example) citing that fish only use the seaward fringe of mangroves (*Halliday and Young 1996*) to forage or seek refuge from predation for a limited time (i.e. during high tide; *Lewis and Gillmore 2007; Lugendo et al., 2007*). Unlike crustaceans and shrimps that have stronger dependence on organic detritus produced by mangroves, fishes are considered transient species and may only be partially dependent on mangroves (*Halliday and Young 1996*). Fish species can migrate to adjacent ecosystems like coral reefs and seagrass beds for shelter and food. In addition, *Mumby et al.* (*2004*) proved that mangroves play an important role as an intermediate nursery habitat to increase the survivorship of young fish.

Inherent site-specific geographic and environmental conditions (e.g. proximity to reef or estuary, salinity, elevation, among others) possibly influence the availability of fish on mangroves (*Nagelkerken et al. 2008; Salmo III 2011*). In addition, tidal inundation is one of the known factors that affect the length of stay of fish in mangroves (*Ellis and Bell 2008*). While we acknowledged the role of environmental factors on fish assemblages in mangroves, these factors are beyond the scope of this study. We suggest that future studies that will investigate the impacts of mangrove rehabilitation programs should incorporate the contribution of environmental parameters on fish assemblage. In addition, the effects of the design of the trap nets used (e.g. fish activity or mobility, soak time) are some of the important factors that need to be considered.

CONCLUSION AND RECOMMENDATIONS

There were no consistent patterns in terms of fish species diversity, abundance and biomass with age of mangrove stands contrary to what is expected. Younger mangrove stands have higher fish species diversity, species richness, abundance and biomass than the more mature stands. In terms of trophic category and habitat preferences, there was higher dominance of carnivorous and mangrove-associated species in mature stands. Fish species may show ontogenetic changes as they grow, thus, a shift in their diet and habitat preferences can be expected. This could be inferred as a shift in fish assemblage with age of the mangrove stands. However, fish assemblages in mangroves may not necessarily be solely influenced by the age or presence of mangrove stands but rather can be attributed to some localized environmental factors, e.g. proximity to reef or estuary, salinity, elevation, tidal height, etc. Long-term studies focused both on temporal (month or season of sampling) and spatial (more replicate fish traps) aspects are necessary to document trends on changes in fish assemblage and if such can serve as a possible indicator of restoration trajectory in planted mangroves.

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