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SPATIAL AND TEMPORAL DISTRIBUTION OF FISH IN THE FLOODPLAIN OF KUMBE RIVER, PAPUA

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ABSTRACT

Expansion of land clearance mostly for plantation is the big issue in Indonesia including in Papua. Its effect is not only to the catchment area but it also affects fisheries resources. The stress effect occurs worsen in Kumbe River and its floodplain area by the present of introduced fish species such as snakehead (*Channa striata*) and nile tilapia (*Oreochromis niloticus*). Spatial and temporal fish distributions are important information for the sustainable fisheries resource and theirs utilization. Study on spatial and temporal fish distribution covering four types of swamp ecosystem of Kumbe River was conducted during April-September 2014 and Mei-November 2015. Explorative field survey was conducted in four different ecosystem types in Kumbe River floodplain areas. Ecological data was collected from four sampling sites in each ecosystem type during high water precipitation (April and May) and low water precipitation (August, September and November), and fish samples were collected with different mesh sizes of gillnet fishing experiment conducted in four sampling sites. Parameters measured were fish important relative index and physical and chemical water quality parameters. The results noted 18 fish species deriving from 13 families. The Arridae with its blue catfish (*Neoarius graeffei*) dominated almost 90% of fish catch both spatial and temporal. Hydrological dynamic seems the key of trigger factor for the spatial and temporal distribution of fish and dynamic of habitat and water quality characteristic in the floodplain of Kumbe River.

Keywords: Distribution; important relative index; floodplain; fish; Kumbe River; Papua

INTRODUCTION

Floodplains, seasonal wetland formed by overspill of floodwaters from the rivers to which they are connected, are typically highly productive ecosystem of inland waters and play as nursery grounds for many riverine species (de Silva-Funge-Smith, 2005). Most tropical wetlands are belong to floodplain category. River-floodplain system is very dynamic system because of hydrological energy of flowing water that permanently reshape the area by erosion and sediment deposition. Flood pulse is the principal driving force responsible for the existence, productivity, and interaction of the major biota in river-floodplain system (Junk, 1989).

Many fish species are adapted to take advantage of seasonal flooding by reproducing at the beginning of the wet season, which allow early life stages to feed and grow within inundated floodplain habitat. Species-specific habitat association has been shown to determinastically structure tropical floodplain fish assembalages. Duration and timing of floodplain inundation may strongly influence large-bodied fish assamblage structure in floodplain creek during the subsequent low-water period (Hoeinghaus *et al*., 2003).

Kumbe River and its floodplain areas reserve variety of fish resources and fishing activities much often found in the middle and the upper reaches of the river (Satria *et al*., 2012). Kumbe River is characterized by the present of large swampy areas (floodplain areas) covered with dense aquatic vegetation and riparian forest locally known as red and white bush (*Melaleuca sp*). In addition this river is inhabited by commercial Irian arowana fish (*Schelerophages jardinii*), toraja snake head (*Channa striata*) and an introduced nile tilapia (*Oreochromis niloticus*).

The existence of fish resources, habitat and its utilization in Kumbe River are threaten by the expansion of land clearance along the river catchment area and by the present of introduced nile tilapia and toraja snakehead. Balai Pengelolaan DAS Membramo

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(2013) recorded about 20.13% of Kumbe River drainage areas being at the stage of fair to very critical areas.

Research on the distribution and diversity of fish resource in Papua specially in Kumbe River are limited, and most of them area conducted in Bintuni Bay, West Papua (Simanjuntak *et al*., 2011), Bian and Maro river (Satria *et al*., 2006; Kartamihardja *et al*., 2010; Binur, 2010), and Sentani Lake (Satria *et al*., 2006). Spatial and temporal fish distributions are important information for fishermen and decision makers since it provides information on the fishing and feeding ground. These information are a part of many data needed to support the management of fisheries resources of the floodplain Kumbe River. Due to this fact, study on the spatial and temporal distribution of fish of Kumbe River was conducted for two years (2014-2015).

MATERIALS AND METHODS

Study Site

Kumbe River, one of the rivers in Merauke Regency, Papua, is a part of Digul Einlanden-Bikuma river basin and geographically is located at 140^{o}37’140^{o}13 ‘East and to8^{o}00’ to 8^{o}21 South. The river has catchment area of 3,765.90 km^{2} and length of 300.42 km (Ministry of Public Works, 2008 *after* Satria *et al.*, 2012). Like other area in Merauke Regency, the catchment area of Kumbe River is classified as lowland area situated at 0-60 m above sea surface level with average temperature of 26.7^{o}C and high precipitation in April (482.70 mm) and the lowest on in October (BPS-Merauke Regency, 2014). The soil surrounding Kumbe village is categorized as swamp deposition with litology of black silt covered by 10-15 cm humic layer.

Data Collecting

Four sampling sites covering Mahayulumb, Inggun, Yakau and Sakor, were chosed based on their micro habitat characteristic and their longitudinal position along Kumbe River (Figure 1 and Table 1). Data collectings were conducted in April and September 2014, representing high and lowest rainfall, and continued to May, August, November 2015 representing recede, lowest and rise water rainfall (Figure 2).

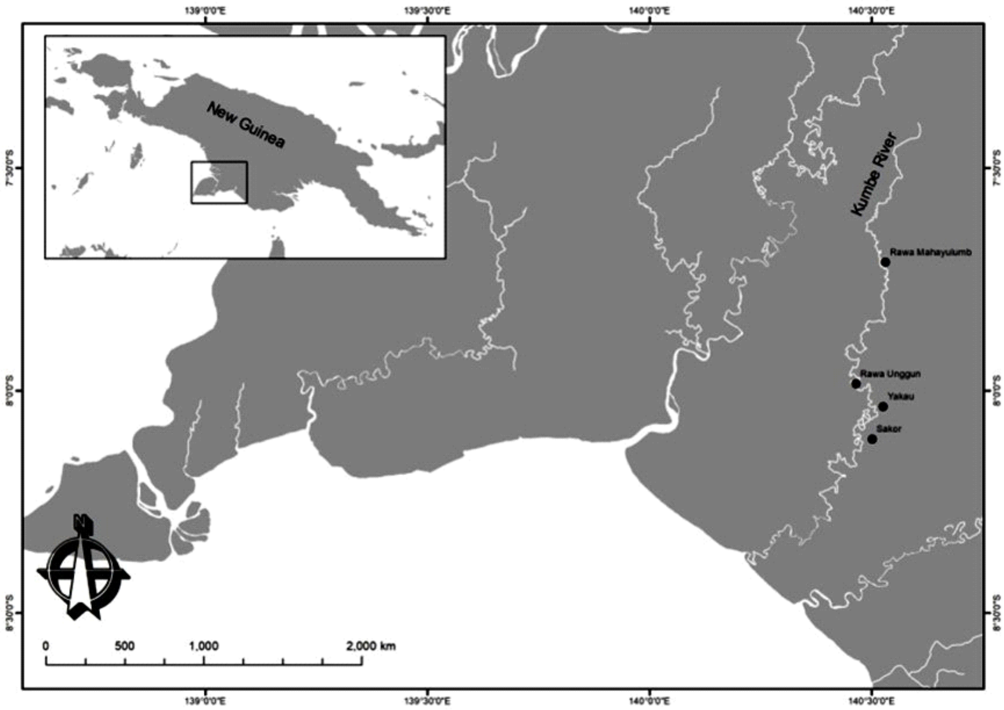

Figure 1. Map of study site in Kumbe River, Merauke.

Table 1. Geographical, Name and Characteristic of Sampling Site in Kumbe River, 2015

Geographical Position of Sampling Site	Name and Characteristic of Sampling Site
Mahayulumb Site 07°42'40.9"South 140°31'52.6"East	Mahayulumb (Kaisa) floodplain forest, is located downstream of Kaisa villages. It is characterized by brownish tea colour swamp covered by trees and shrubs. During high rainfall season, the inundated swamp area reached 9 ha and functioned as shelter and spawning ground of fish
Inggun Site 07°59'05.3"South 140°27'53.3"East	Inggun flood plain savannah is located downstream of Wayau villages. This savannah is dominated by aquatic plants or grasses with brownish colour waters. During high flood season the area reached 25 ha and acted as feeding and nursery ground of fish.
Yakau Site 08°02'07.8"South 140°31'34.2"East	Yakau, a river canal connecting the river and the swamp area. It is located at the down stream of Inggun and characterized by brownish tea colour water and riparian trees (known by the local people as white bush). During the high flood season, the inundated area reached 16 ha and become the shelter and spawning area of the fish.
Sakor Site 08°06'31.5"South 140°30'04.7"East	Sakor, a river and swamp ecosystem, is located at the down stream of Yakau swamp and characterized by darkish floodwater covered by decomposed fallen tree. During the high flood season, the area inundated reached and become the shelter and spawning habitat of fish.

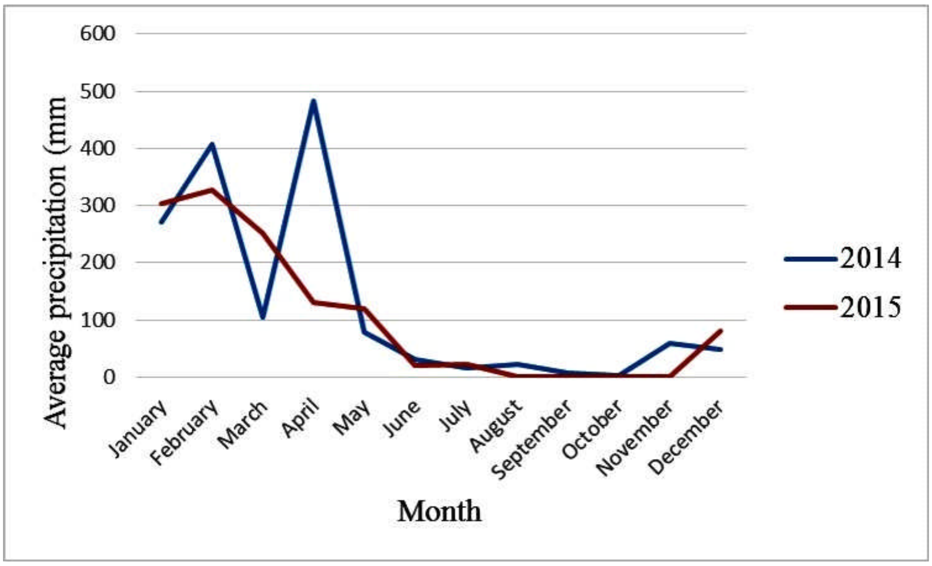

Figure 2. Average level of precipitation in Merauke regency in 2014-2015. (BPS-Statistic of Merauke Regency, 2014;BPS-Statistic of Merauke Regency, 2015).

Fish distribution information was collected from different mesh sizes of gillnet fishing experiment conducted in four sampling sites. At each site, fish samples were obtained from seven gill net of different mesh sizes such as: 1.0,1.5, 2.0, 2.5, 3.0, 3.5 and 4.0 inches. Each net has the size of 1.5 m depth and 15 m long. All nets fishings were operated for 12 hours started from 5:00 P.M. and hauled at 7.00 A.M. Fish samples were measured for their length and weight. Species identification followed the reference of Allen (1991) and Allen *et al*. (2000) then cross-checked with data by FishBase (Froese & Pauly, 2011). Fish identification could not be done in the field, then fish samples were preserved with 10% formaldehyde for further identification in the laboratory.

Spatial and temporal distributions of fish in river floodplain are influenced by water quality condition changing along the hydrological dynamic. To get information on water quality condition, some physical and chemical water quality parameters were measured for each site in May, August and November

2015 (Table 2). Water samples were collected by using 2-L Kemmerer bottle sample at 0.5 m depth below the water surface. Some of water quality parameters such as water temperature, transparency, water depth, turbidity, pH, dissolved oxygen (DO), carbon dioxide, total alkalinity and total hardness, were measured directly on site. For other parameters, water samples were kept in 1-L plastic bottle and stored in 4°C cool box for further analysis in the laboratory according to the methods suggested by American Public Health Association (APHA, 2005).

Table 2. Water quality parameters measurement in Kumbe River

No.	Water Quality Parameters	Unit	Method	Analysis
1	Water Temperature	°C	YSI Proffesional	On site
2	Transparency	Cm	Secchi Disc	On site
3	Water Depth	M	Echodepth meter	On site
4	pH		YSI Proffesional	On site
5	Dissolved Oxygen (DO)	mg/l	Winkler	On site
6	Carbondioxide (CO_2)	mg/l	Winkler	On site
7	Total Alkalinity	mg CaCO3/l	Titrimetry	On site
8	Total Hardness	mg CaCO3/l	Titrimetry	On site
9	Turbidity	NTU	Turbidimeter	Laboratory
10	Total Phosphorus	mg/l	Ascorbic acid with digester	Laboratory
11	Ortho Phosphate	mg/l	Ascorbic acid	Laboratory
12	Ammonia (NH_3)	mg/l	Phenate	Laboratory
13	Nitrate	mg/l	Brusin Sulfate	Laboratory
14	Nitrite(N	mg/l	Sulfanilamide	Laboratory
15	Total Suspended Solids	mg/l	Graphimetric	Laboratory
16	Chemical Oxygen Demand	mg/l	Titrimetry	Laboratory
17	Chlorophyll-a	mg/m3	Spektrofotometri	Laboratory

Data Analysis

All water quality data were tabulated according to sampling site and time. To get more picture about the characteristic of water quality spatial and temporally, the data were analyzed in multivariate by using hierarchical cluster analysis. Ecologists have used multivariate statistical methods, such as cluster analysis, as standard analytical tools for many decades. Such methods provide mechanisms to summarize large amounts of community and environmental data (Jackson *et al*., 2010). Hierarchical analyses lead to dendrograms (or “trees”). The branching structure of these trees indicates which objects (e.g., species; sites) are more similar to each other. The analysis was conducted with Statistica software program version 10. The result of cluster analysis was presented in a dendogram. The sampling sites having a similar water quality characteristic will be pooled in one group. Each group has its specific water quality characteristic.

Fish composition was analyzed by using important relative index (IRI). Formerly, this index is applied to get information on the composition of fish diet. Recently this index is applied to measure fish composition in the nature by measuring not only based on the number of species but also including the weight of individual of fish species. The IRI is calculated based on this formula (Panchan *et al*., 2013):

$$\%IRI = \left(\frac{(\%Wi + \%Ni)x\%Fi}{\sum_{i-1}^{n}\left(\%Wi + \%Ni\right)x\%Fi} \right) X100 \quad \text{.............(1)}$$

where;

% Wi and % Ni = percentage weight and number of of the i th in the total catch

%Fi = the percentage of occurence of each species in the total number of species

RESULTS AND DISCUSSION

Results

Spatial and Temporal Distribution of Individual Fish

The number of fish is the reflection of the season and place (Figure 2- 3). Except in Inggun sampling site, it tends to decrease during high precipitation (April and May) and increase during low precipitation (August, September and November). In 2014, the individual numbers of fish in Inggun and Yakau sampling sites are looked with a similar pattern, but not in Sakor sampling site. The number of individual fish in April is less than that in September. In 2015, Mahaluyumb, Yakau and Sakor showed a common pattern of the number of fish. They tend to increase along with decreasing precepitation and low during high precipitation. However in Inggun sampling site, the number of individual fish high during the high precipitation and low during the low precipitation.

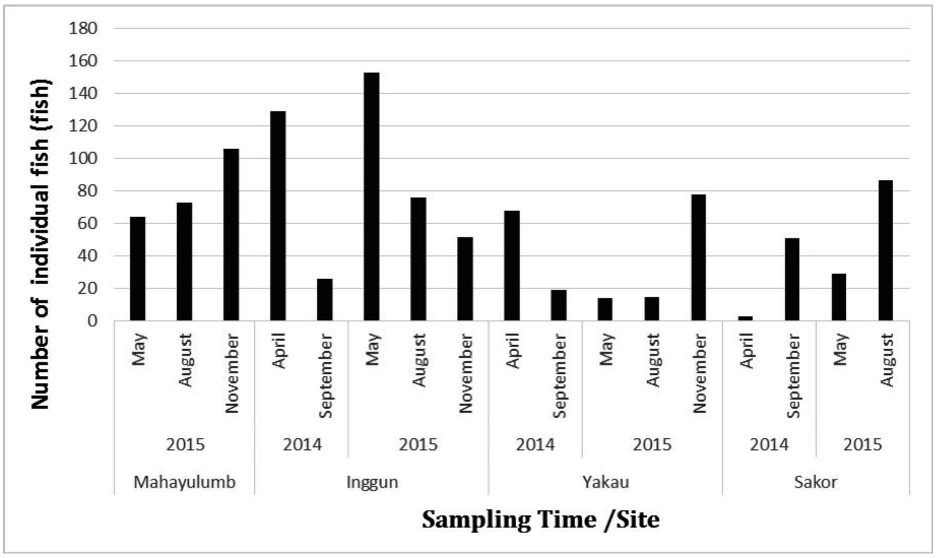

Figure 3. The number individual fish in Kumbe River in 2014 and 2015.

The number of individual fish in Kumbe River was also related to the longitudinal position of the sampling site. Sampling sites (Mahaluyumb and Inggun sites) closed to the upper stream of Kumbe River have individual fish higher than that closed to down stream (Yakau and Sakor sampling sites). Total individual fish recorded in Mahaluyumb, Inggun, Yakau and Sakor during the study was 243, 436, 194 and 170 fish respectively deriving from 13 families and 18 species (Table 2).

Spatial and Temporal Distributions of Fish Species

The structure community of fish in Kumbe River is unique. It can been seen from the number of fish families recorded was almost similar with the number of species fish with the ratio in the range of 0.67-1.0 (Figure 4). Like the individual fish number, the composition of fish population was also reflected by the season and place. The number of fish family in Mahaluyumb, Inggun, Yakau, and Sakor was in the range of 5-7, 4-8, 5-10 and 3-6 respectively, while their species number was in the range of 5-9, 4-10, 5-10 and 3-9 respectively. Except in Sakor sampling site, the number of fish families and species tends to be higher during high precipitation than that during low precipitation. The differences number of fish species and families between the season reached 100% such as in Inggun, Yakau dan Sakor sampling site.

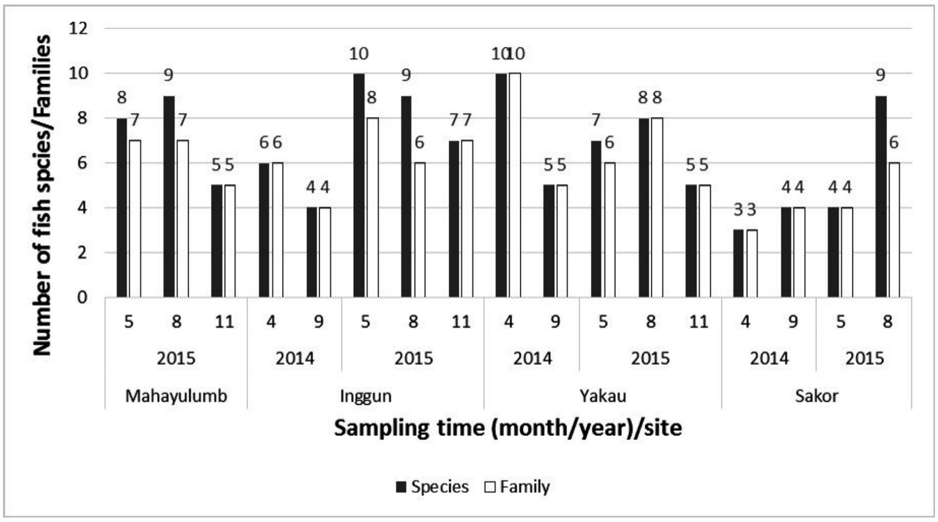

Figure 4. The number of fish species/families in Kumbe River in 2014 and 2015.

Fish community structure in most sampling sites was dominated by three families, such as: Arridae (*Neoarius graeffei*), followed by Clupeidae (*Cluepeoides venulosus* and *Namatolosa flyensis*) and Tetrapontidae (*Hephaestus raymondi* and *Pinggala lorentzi*). Except in Mahaluyumb sampling site, other fish families recorded were Anabantidae (Anabas testudineus), Cichlidae (*Oreochromis mossambicus*, *Oreochromis niloticus*), and Plotosidae (*Neosilurus ater* and *Porochilus meraukensis*).

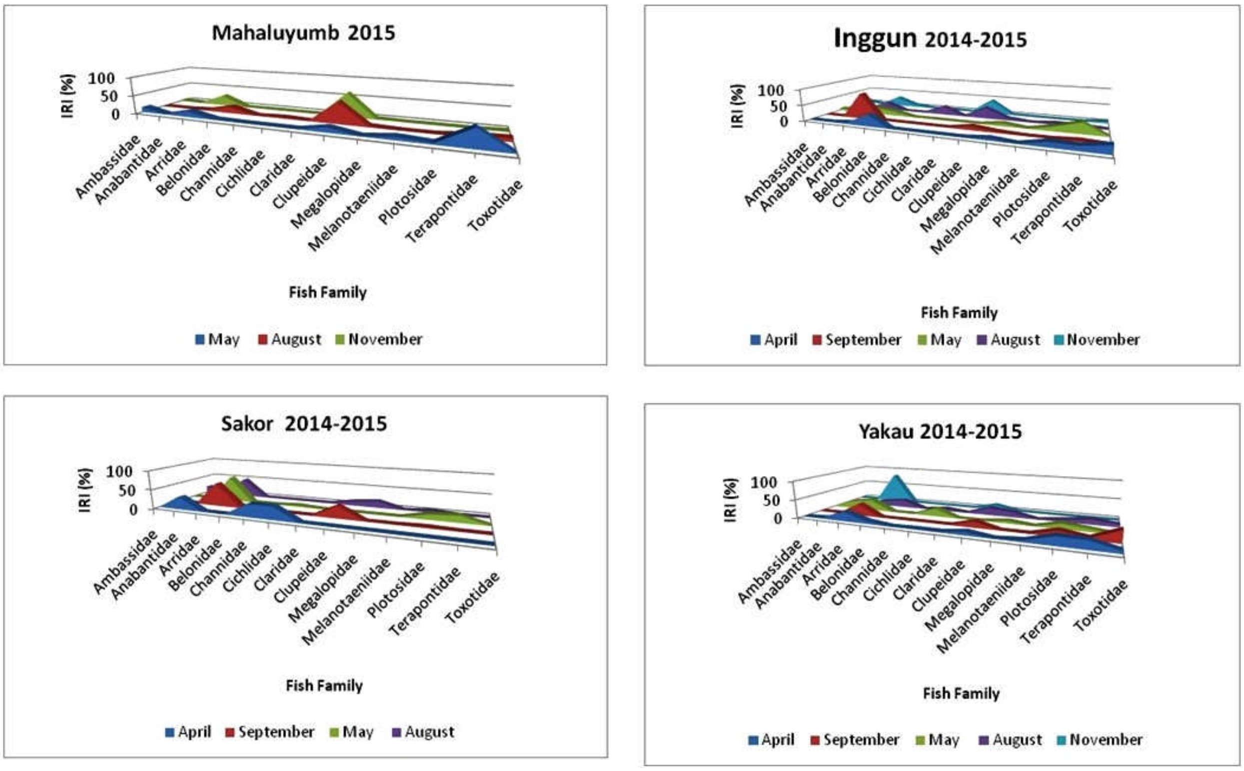

Figure 5. Important relative index of fish family in Kumbe River 2014-2015.

Out of three dominant fish families recorded, Arridae with only one species, *Neoarius graeffei*, was the dominant fish species with percentage almost up to 90% caught in all sampling sites and periods (Figure 5-6 and Appendix 1) with mean, minimum, and maximum important relatif index value were 0.35, 0.03, and 0.80 respectively. Important relative index of this species was higher during low precipitation season (August, September and November) than that during high precipitation season (April and May). The highest IRI value was recorded in Yakau site in November 2015 followed in Inggun site in September 2014 (IRI 0.81) then in Sakor site in May 2015 (IRI, 0.66).

Unlike Arridae family, two species *Clupeoides venulosus* and *Clupeoides flyensis* of Clupeidae family were mostly caught during low precipitation time, August to November. The highes IRI value of *Clupeoides venulosus* recorded in Mahaluyumb and in Inggun in November 2015 with IRI value of 0.64 and 0.44 respectively. Contrary with Clupeidae, the presence of Terapontidae family mostly related to high water precipitation (April and May). Out of two species of Terapontidae recorded, *Pingalla lorentzi* could not be caught in Sakor sampling site and so *Hephaestus raymondi* could not found during low precipitation in all sampling sites. Out of 18 fish species caught, *Parambassis gulliver* (Ambassidae) and *Anabas testudienus* (Anabantidae) were not found in Mahaluyumb and Inggun sampling sites. Mean while *Clarias batracus* (Clariidae) was not recorded except in Yakau sampling site. On the contrary *Channa striata* (Channidae) was found only in Yakau sampling site.

The phases of larval and juvenile fish Western archerfish (*Toxotes oligolepis*) detected at all sampling locations but today very little is known about the biology and ecology of this species. Another archer fish like *T. chatareus* and *T. jaculatrix* who has type euryhaline and inhabit brackish mangrove forests, especially areas in the South Pacific and Indian Oceans, and their life cycle involves migration routes are long, although they can also be found in the coastal waters and upstream in freshwater (Allen, 1991; Allen *et al*., 2002; Temple *et al*., 2010).

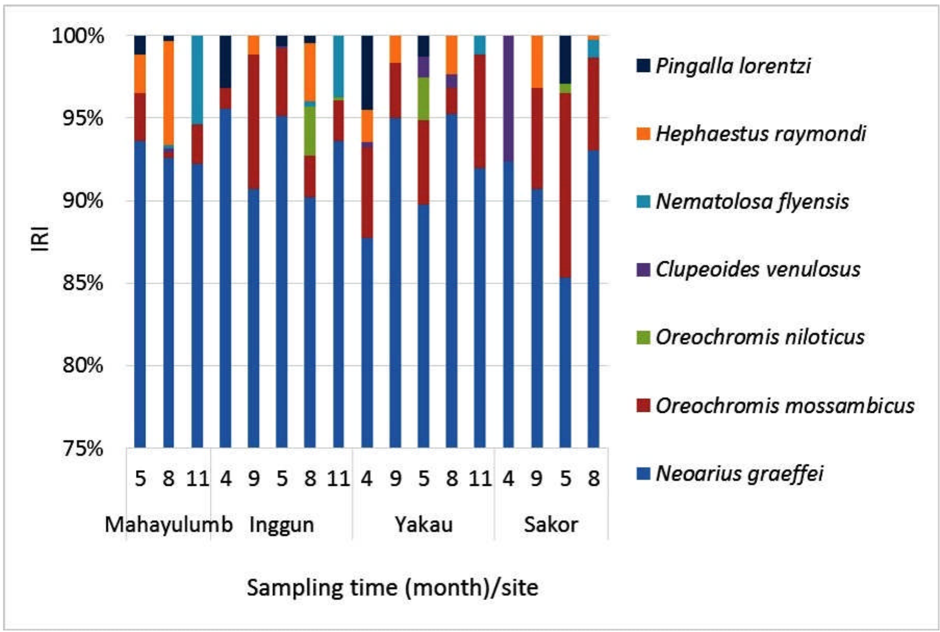

Figure 6. Spatial and temporal fish composition in Kumbe River, Papua.

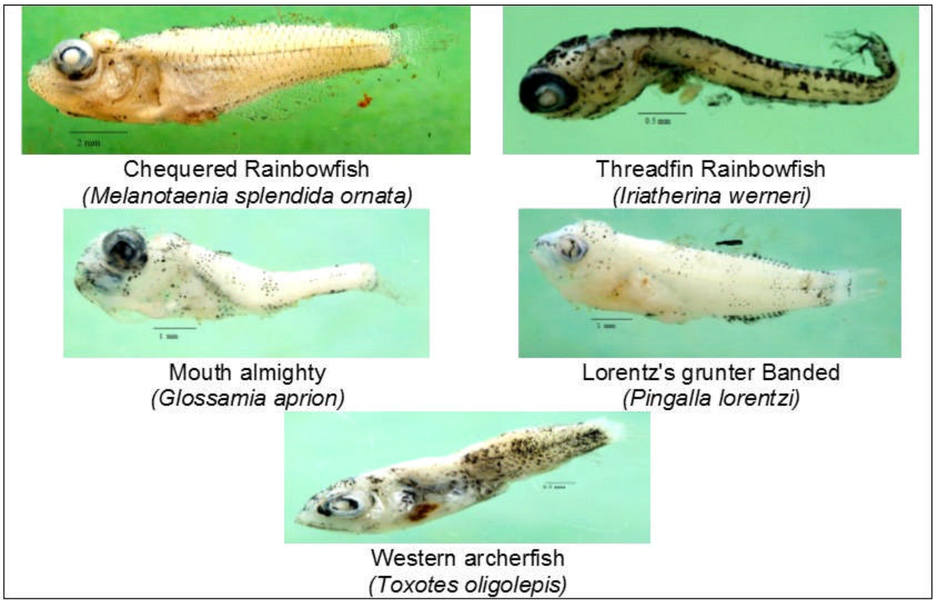

Figure 7. The initial phase of the growth phase of larval fish identified in Kumbe River.

Discussion

Spatial and Temporal distribution of individual fish

A tendency of high number of individual species caught during less precipitation (August, September and November) in most of sampling sites could relate to concentrating of most fish in less water area than that during high precipitation. During high precipitation fish are more distributed in wide water areas resulting to be more difficult to cath. This phenomenon is supported by Patrick (2016) that recovery of the fish stock occurs as typically during high water season, when fishing efficiency is low due to dispersion of fish in newly inundated areas. During high precipitation the inundated floodplain area in Mahaluyumb, Inggun and Sakor reached 9. 25 and 16 ha respectively. An increasing individual fish number during high precipitation in Inggun site in both year and in Yakau in 2014 than that in Mahaluyumb and Sakor might relate to the synergic effect of the present of inundated shrubs and water depth (Table1 and Appendix 2). Both Inggun and Yakau sampling sites are categorized as savannah floodplain covered by shrubs and aquatic macrophyte. Satria *et al*. (2012) recorded some aquatic macrophyte in Inggun and Yakau such as *Equisetum sp*., *Nymphaea alba* and *Hydrilla verticillata* able for the habitat of insects. During less precipitation (May), the water depth in Inggun and Yakau sampling sites were shallower (1.1-1.3 m) than other sampling sites (2.0-3.6 m) on the contrary during high precipitation (August, November) they were deeper (3.1-5.1 m) than that other sampling sites 1.9-2.8 m. This type ecosystem provides a suitable nursery and feeding ground for the floodplain fish so that more individual fish number in this sampling area than that in Mahaluyumb and Sakor during less precipitation that that during high precipitation. It is supported by the discovery of larvae and juvenile Western archerfish (*Toxotes oligolepis*), fish larvae and juveniles of other fish species such as Lorentz's grunter Banded (*Pingalla lorentzi*), Chequered Rainbowfish (*Melanotaenia splendida inornata*) and threadfin Rainbowfish (*Iriatherina werneri*) at several locations.

The effect of water depth dynamic on water quality characteristic was reflected from cluster analysis (Figures 8, 9, 10). In May in accordance of high precipitation, it showed three different groups of sampling sites. The first group was Inggun, followed by Yakau dan Mahaluyumb as the second group, and Baad and Sakor as the third group. High different lingkage distance (more than 0.3) recorded between Inggun sampling site the other two groups (Figure 8). Water quality of Inggun sampling site characterized by higher water temperature (29.7), 2.8, 10.48 and 1.99)), dissolved oxygen/DO 2.8 mg/L, chemical oxygen demand (10.48) and lower turbidity (1.99) (Appendix 2).

High different linkage distance (2.0) was still occured in August. Mahaluyumb sampling site had water quality different to other sampling sites. Its water quality is characterized by lower water transparency (33 cm) and higher concentration of turbidity (52.50 mg/L), ammonia (0.12 mg/L), total suspended solids/ TSS (46 mg/L) and water hardness (22.5 mg/L).

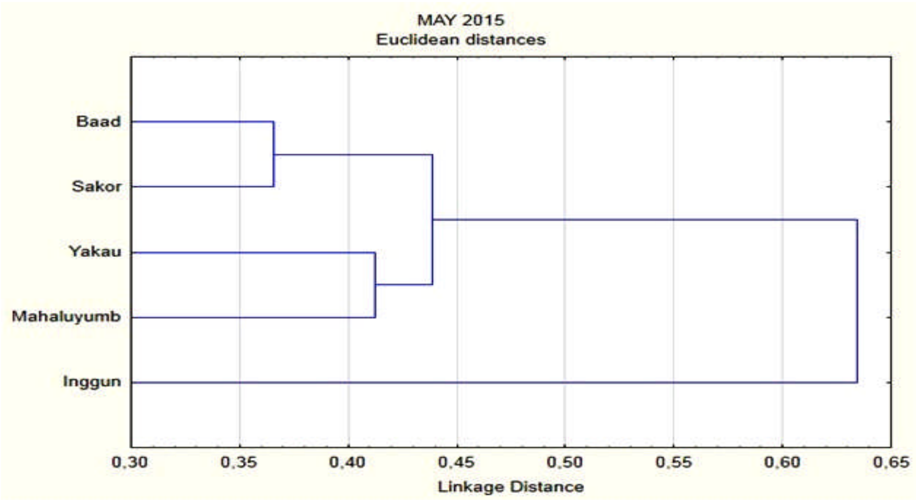

Figure 8. Dendogram of water quality parameters of sampling sites in Kumbe River in May 2015.

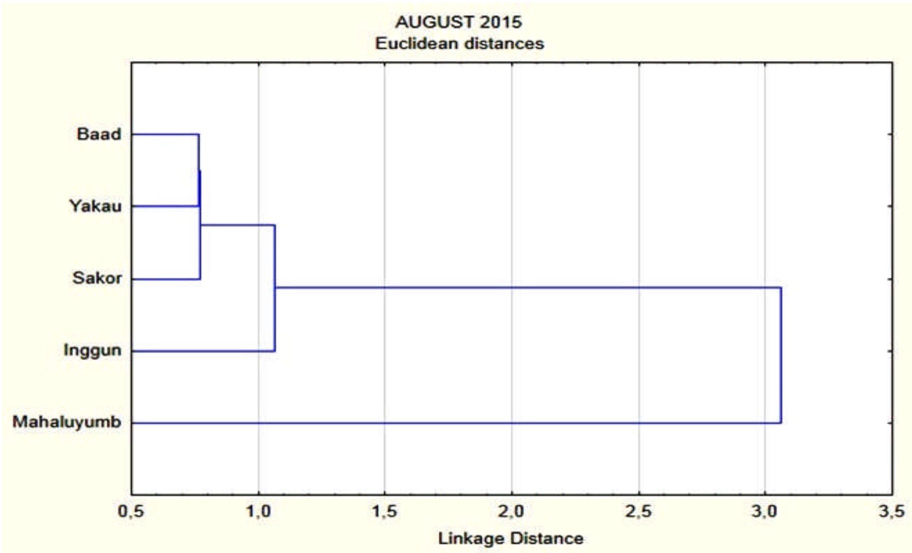

Figure 9. Dendogram of water quality parameters of sampling sites in Kumbe River in August 2015.

In November, the linkage distance between Baad and Mahaluyumb sites with Yakau and Inggun sites was 1.2. Yakau and Inggun sites characterized by high water tranparency (155-175 cm) while other sampling sites they were in the range of (44-55 cm).

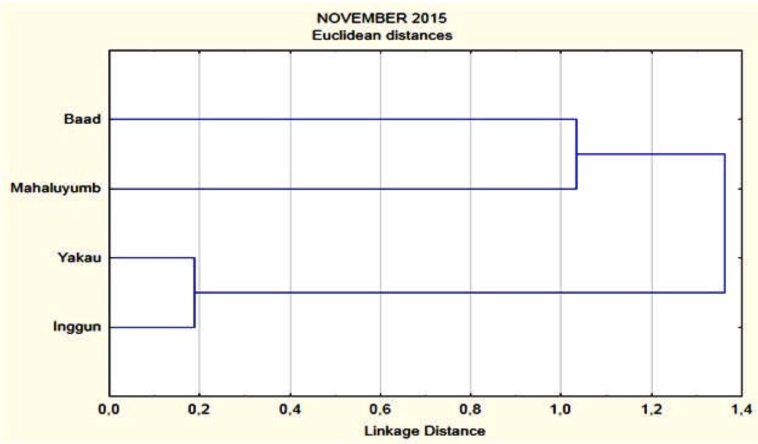

Figure 10. Dendogram of water quality parameters of sampling sites in Kumbe River in November 2015.

Spatial and Temporal Distribution of Fish Species

Phenomenon that the number of fish families and species tends to be higher during high precipitation than that during low precipitation in all sampling sites but not in Sakor site could relate to the present of large floodplain area in most of sampling sites positioning in the middle part of Kumbe River than that in Sakor site located in the lower part of the river. The present of more habitat during high precipitation could explain this phenomenon. On the other hand, Sakor sites is positioned in the lower part of Kumbe River which more affected by the tide from the gulf of Arafura sea. The differences number of fish species and families between the season reached 100% such as in Inggun, Yakau dan Sakor sampling site. It is also supported by Patrick (2016) who reported that the changes in the rainfall fluctuation significantly ($p<0.05$) influenced the species composition due natural recruitment. Low ratio between the number of fish species and families reflected less fish diversity in Kumbe River (Krug *et al*., 2008). The ratio was less than what had been recorded in Musi River South Sumatra in 2006-2007 (Husnah & Suryati, 2008) which reached 3.89 (214 species/55 families). It might relate to large floodplain and river areas in South Sumatra than that in Kumbe River. It can been seen from higher river order of Musi River than in Kumbe River. In addition to having more river drainage area (nine sub river drainage area), the main channel Musi River had a meander shape indicating higher inuosity and litoral zone than that Kumbe River.

High percentage of *Neoarius graeffei* in fisherman and experimental fishing experiment catchs could relate to its biological characteristics. *Neoarius graeffei* is categorized as an anadromous fish (Fish Base, 2017) which during their adult phase inhabites freshwater rivers and lagoons, as well as brackish estuaries and coastal marine waters. Gomon & Bray (2011) stated that this fish found in the northern half of Australia from the Ashburton River and the Houtman Abrolhos islands, Western Australia, to the Hunter River, New South Wales inhabitedon soft-bottom freshwater environments in rivers, estuaries and inshore coastal marine environments.In addition, *Neoarius graeffei*can live at wide temperatures range of 11- 38°C and migrate from marine to freshwater ecosystem in groups. High percentage of this dominant fish relates to the suitable feeding habitat with a lot of aquatic vegetation as habitat of their natural food such as aquatic insects in floodplain savannah and forest. Satria *et al*. (2012) recorded that the stomach content of *Neoarius graeffei* in Kumbe River was dominated by 75% of aquatic insects and 25% of fish. While Allen (1991) had found various types of food of *Neoarius graeffei* such as arthropods, insects, aquatic plants, mollusks, shrimp, lobster, fish and detritus. Table 3 also reveals that macrophyte, aquatic insect and fish have a lot role to the live and abundance of fish species in Kumbe River. It mean that most of the fish that are found categorized as eurifagus fish (Effendie, 2002).

Table 3. Index preponderance several species of fish in Kumbe River (Satria *et al.*,2012)

Food type	*Oreochromis niloticus*	*Neosilurus ater*	*Channa striata*	*Neoarius graffei*	*Toxotes jaculatrix*	*Hephaestus raymondi*	*Parambassis gulliveri*	*Megalops cyprinoides*
Phytoplankton	6.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Zooplankton	0.00	1.73	0.00	0.00	0.00	0.00	0.00	0.00
Macrophyte	93.01	2.13	40.00	0.00	0.00	2.50	0.00	0.00
Molluscs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Insects	0.00	93.78	60.00	75.00	95.42	47.50	57.95	0.00
Worms	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fish	0.00	0.00	0.00	25.00	0.00	50.00	40.91	100.00
Crustacea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Detritus	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

CONCLUSION

Hydrodynamic of Kumbe River gives a significant role to spatial and temporal distribution of fish species in Kumbe River. Increasing in individual and fish species number is in accordance with receding water level starting from August to November. *Neoarius graeffei* of Ariidae family, is the dominant fish species with percentage almost reached 90% of the fish caught in all sampling sites and periode. Most of fish species recorded in Kumbe River specially in Inggun site depends on the present of macrophyte and aquatic insect.

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Appendix 1. Spatial and temporal fish composition in Kumbe River, Papua
Note: 4:April 2014; 9 : September 2014; 5: May 2015; 8: August 2015; and 11: November 2015

Family	Fish species	Mahayulumb			Inggun					Yakau					Sakor			
		5	8	11	4	9	5	8	11	4	9	5	8	11	4	9	5	8
Ambassidae	*Ambassis agrammus*	0.140		0.037			0.065		0.096									0.046
	Parambassis gulliveri													0.013				0.126
Anabantidae	*Anabas testudineus*									0.029		0.214			0.333			0.011
Arridae	*Neoarius graeffei*	0.156	0.027	0.283	0.054	0.808	0.216	0.224	0.288	0.250	0.316	0.286	0.133	0.820		0.608	0.655	0.482
Belonidae	*Strongylura kreffti*	0.015	0.178		0.364		0.137		0.076	0.073			0.200	0.013		0.059		
Channidae	*Channa striata*														0.333			
Cichlidae	*Oreochromis mossambicus*							0.263	0.019			0.143					0.034	
	Oreochromis niloticus		0.027				0.006			0.015		0.071	0.066		0.333			
Claridae	*Clarias bratachus*									0.015								
Clupeidae	*Clupeoides venulosus*		0.013	0.641				0.026	0.442					0.141				0.092
	Nematolosa flyensis	0.125	0.548			0.115		0.316		0.088	0.158		0.200			0.312		0.023
Megalopidae	*Megalops cyprinoides*		0.027	0.018	0.062	0.038	0.091	0.066	0.019			0.071	0.133	0.013				0.172
Melanotaeniidae	*Melanotaenia goldie*	0.078					0.006			0.044								
Plotosidae	*Neosilurus ater*				0.147		0.117	0.013		0.220	0.158	0.143	0.066			0.020	0.137	0.023
	Porochilus meraukensis	0.031					0.026	0.039										0.023
Terapontidae	*Hephaestus raymondi*	0.062	0.027		0.132		0.033	0.039		0.206		0.071					0,172	
	Pingalla lorentzi	0.391	0.041			0.038	0.301	0.013			0.053		0.133					
Toxotidae	*Toxotes jaculatrix*		0.082	0.018	0.240				0.057	0.059	0.316		0.066					

Appendix 2. Physico-chemical parameters in Kumbe River, Papua 2015

Note: St.1 = Baad; St.2 = Sakor; St.3 = Yakau; St.4 = Rawa Inggun; St.5 = Mahayulumb

No	Water Quality Parameters	May					August					November			
		St.1	St.2	St.3	St.4	St.5	St.1	St.2	St.3	St.4	St.5	St.1	St.3	St.4	St.5
1	Water Temperature(°C)	27.4	27.4	27.7	29.7	27.7	28.4	27.8	28.1	28.1	27.4	28.9	29.3	31.9	31.5
2	Tranparency (cm)	160	220	100	100	130	70	81	90	90	33	55	175	155	44
3	Water depth(m)	3.0	3.6	1.1	1.3	2.0	2.7	2.8	4.5	5.1	1.9	1.3	4.6	3.1	5.8
4	pH	5.34	5.18	5.40	5.36	5.43	5.51	5.48	5.38	5.32	5.22	6.75	6.99	6.30	6.89
5	DO	0.5	1.2	0.7	2.8	1.4	5.7	6.9	6.7	7.3	7.8	1.66	2.74	3.26	5.56
6	CO_2 (mg/l)	9.68	11.08	8.62	7.92	9.86	6.16	7.04	5.28	5.28	6.16	3.96	3.52	3.96	2.20
7	Alkalinity(mg/l)	8	9	7	9	10	5	7	7	5	6	10	7.5	4	6
8	Turbidity	3.99	3.77	7.40	1.99	6.82	14.10	21.40	7.52	8.70	52.50				
9	TP (mg/L)	0.2734	0.0064	0.0584	0.0974	0.0214	0.0267	0.0155	0.0338	0.0267	0.0520	0.0019	0.0063	0.0013	0.0539
10	O-PO_4 (mg/l)	0.0024	0.0054	0.0005	0.0025	0.0054	0.0115	0.0153	0.0099	0.0161	0.0092	0.0054	0.0048	0.0048	0.0302
11	NH_3 (mg/l)	0.1602	0.1093	0.2031	0.0625	0.0781	0.0391	0.0376	0.0569	0.0531	0.1201	0.1513	0.0633	0.0119	0.5370
12	NO_3 (mg/l)	2.2959	0.1793	0.8878	0.1928	0.2959	1.4685	0.4056	0.5618	0.2471	1.6457	0.6115	0.0019	0.0058	0.6135
13	NO_2 (mg/l)	0.0007	0.0021	0.0009	0.0012	0.0016	0.0057	0.0046	0.0060	0.0049	0.0193	0.0004	0.0017	0.0007	0.0102
14	TSS (mg/l)	6	17	13	27	16	28	38	29	5	46				
15	Hardness (mg/l)	12.0	27.0	12.0	15.0	24.0	18.9	9.0	10.8	9.0	22.5	17.3	7.0	10.0	6.0
16	COD	7.16	8.65	6.99	10.48	7.99	2.16	2.83	2.00	1.50	1.66				
17	Chlorophyl a (mg/m^3)	69.90	2.19	4.24	5.62	1.72	5.06	2.90	5.41	3.95	3.14	1.78	4.28	6.67	4.28