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Community Structure of Fish in Nanji Islands National Nature Reserve and Its Relationship with Environmental Variation

Cheikh Sarr[1*], Cungen Yu[1], Ousmane Ndiaye[2], Hamet Diadhiou[3], Ngor Ndour[4]

[1]Laboratory of Fishery Resources, Zhejiang Ocean University, Zhoushan, China
[2]Laboratory of Agricultural and Environmental Sciences, National High School of Agriculture, Thies, Senegal
[3]Senegalese Institute of Agriculture Recherche, Oceanographic Research Center of Dakar Thiaroye, Dakar, Senegal
[4]Laboratory of Agroforestry and Plant Production, Assane Seck University of Ziguinchor, Ziguinchor, Senegal
Email: *csarr4015@gmail.com

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Abstract

Community structure of fish in relation to environmental variation was investigated in Nanji Islands National Nature Reserve (NINNR). In order to test this relationship, we delineated 25 survey stations with bottom trawling and measured environmental variables. Samples were taken from November 2013 (autumn), February 2014 (winter), May 2014 (spring) and September 2014 (summer). We found a very strong correlation in space and time between temperature and salinity; abundance and biomass in winter; depth and DO in summer then a strong correlation was found respectively between temperature and biomass; salinity and biomass in winter too and finally a moderate correlation between depth and biomass in spring, (P-value < 0.01) with positive correlation (that the other variable or factor has a tendency to increase). We also found out a negative correlation (P-value < 0.05), respectively between salinity and DO; DO and chlorophyll in summer; temperature and salinity; salinity and DO in spring period (mean that the other variable or factor has a tendency to decrease). A negative correlation observed between temperature, salinity and chlorophyll in winter, spring and autumn period were due by a temperature and salinity window open for species blooms through the movement of the TWC and Jiangzhe coastal current close to shore. By comparing diversity of fish species with environmental factors, the community structure of fish varied significantly as physicochemical parameters changed between different stations for each season. As results and according to the species referencing of environmental factors; species diversity, abundance and evenness vary among different stations, corresponding to significant differences of environmental factors (e.g. physicochemical parameters and chlorophyll-*a* concentration in different sites). Species richness of microfauna was negatively correlated with salinity levels. Furthermore, they were related to the fish community according to the results. This may be due to the fish community's adaptability in these different variations of environmental factors, but only tolerant members remaining.

Keywords

Nanji Islands, Community Structure, Fish Species, Environmental Variation

1. Introduction

Nanji Islands National Nature Reserve (NINNR) is located in the East part of Ping Yang County, Zhejiang Province. It covers a total area of 201.06 square kilometers, among which sea waters account for 190.71 square kilometers. Its center is located at 27˚27''N, 121˚25''E. It is 56 kilometers away from Aojiang Port of Ping Yang County and about 150 kilometers away from Taiwan Island. The biggest island of the Reserve is Nanji Island with an area of 7.64 square kilometers, and that's why the Reserve was named after it. Established in 1989 after the approval of Ping Yang County Government, the Reserve, the first one of its kind, was classified as a national reserve in 1990. The shellfish, algae and the natural environment are the main targets for protection. In July 1998, Nanji Islands National Nature Reserve was approved by UNESCO as a member of the International Man and Biosphere Reserve Network. NINNR lies in a coastal area where the Taiwan warm current and Jiangsu-Zhejiang coastal current fluctuate in alternate. Climate of the region is oceanic monsoon climate, so it is temperate without being too hot in the summer and too cold in the winter with an average annual temperature of 16.5˚C. Most parts of the reserve are washed and eroded by seawater, and the coastline is tortuous. Nanji Island is a bedrock island mainly composed of 23 islands and 14 reeves. Nanji Island is the biggest one in the reserve; it covers an area of 7 square kilometers. The highest peak of Nanji Island is 229 meters above sea level.

Nanji Island is surrounded by 5 capes including Longzhuitou Cape, and 3 bays including Mazu'ao Bay and Niji Port. There is a sea beach along the island, 800 meters wide and 600 meters long. The sea water is so limpid and transparent that one can see 5 meters of deepness. Rocks washed and eroded by waves for a long time make it a picturesque landscape of cliffs, pillars, caves and terraces. The reserve was divided into core areas (8.04 km^2), buffer Area (34.04 km^2) and experimental area (158.98 km^2). The 28 km long coastline consists of exposed bedrock and sharp cliffs, bays and islets. The biosphere reserve offers a multitude of diverse marine habitats which host a rich number of shellfish and algae species. They are appraised as fairy hills over blue sea. Favorable climate, special hydrologic and physical features result in a unique ecological system and wildlife species. The Reserve is especially rich in sea life.

Research has identified 403 species of shellfish, among them, 19 were reported first in China; 174 species of seabed algae, of which an algae species is newly discovered in the world. These species account for more than 20% respectively of total shellfish and algae in China. The shellfish and algae are not only abundant, but also have fauna and geographical disjunction characteristics of temperate and tropical zones. Therefore, the Reserve is called important species database of shellfish and algae. In addition, in the Reserve there are 368 species of fish and 180 species of shrimps and crabs such as precious abalones and groupers, as well as 317 terrestrial seed plants and 55 vertebrates (Cultural-China.com). In this paper, it was examined fish abundance and biomass according to the environmental variation in 25 stations of the reserve. The main objectives were to document species richness and relative abundance-biomass during four seasons and to seek patterns of association between fish assemblage structure and physicochemical and biotic variables. Such patterns were identified, and resulting inferences support a general model of population and community response to habitat heterogeneity and dynamics in environmental factors. Conclusions from this comparative analysis have strong implications for the management of aquatic biodiversity in Nanji Islands Marine Nature Reserve. This work aims to test the hypothesis that there is environmental influence on the distribution of fish species. These factors most influence on the distribution of fish in four seasons that the habitat partition of these closely related species is a mechanism to optimize the use of available resources, with each species responding in different ways to such gradient.

2. Materials and Methods

2.1. Materials

The samples were constituted mainly of fish species and environmental data. Thus for fish species each sample's label and put into the sample bags, which in turn will be registered in a database and for the environmental factors, the data were manipulated in the lab for more precision then registered in another database, the database number recorded into the record up. Following a successful trawl, the net was hauled aboard and the catch was released into a plastic trough, or a fish sorting table, the environmental data comprised physical and chemical measurements. For the storage of samples in the field, we used a refrigeration cabin; informally; the length is equal to the multiple correlation of the variable with the displayed ordination axes.

2.2. Methods

As used herein, the data from November 2013 (autumn), February 2014 (winter), May 2014 (spring) and September 2014 (summer) survey stations, mainly in Nanji Islands main reef area (large lei Hill, a small island lei mangosteen, after the mountain deer, Nanji Island, a small island, firewood Island, Lantau door, broken islands, under saddle, pointed Island, flat island, small diesel Island) around, etc. A total of 25 fixed trawl sampling stations (**Figure 1**). Therefore, an

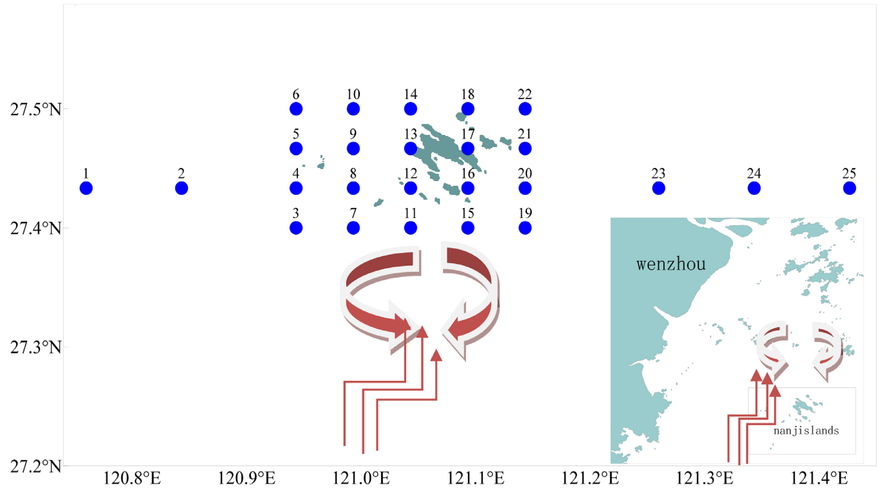

Figure 1. Survey stations of fishes in Nanji Islands marine nature reserve.

important consideration in designing any large-scale study is the benefit of additional replication, either at the lowest level of a design or at the level of sites within each region sampling devices are implemented with the survey boats and nets: survey ship "flat 501 fishing moratorium" Host power of 58.8 kW, tonnage of 10 t; investigation nets for 52.8 m × 50.0 m of cystic bottom trawl, and its network of high net width of 4.3 m respectively. 22.0 m. Each station trailer is 3.5 km, 1 h long while dragging. Survey sampling and measurement are provided "specification for oceanographic survey—Marine Biological Survey" of the relevant standards. On the low cabin chilled preservation, sample identification analysis in the laboratory, the use of electronic weighing scales, with an accuracy of 0.1 g. Informally, the length is equal to the multiple correlation of the variable with the displayed ordination axes. Additionally, Pearson correlation matrix (n) was used to determine if the relationship was significant or not between each environmental variables and fish abundance-biomass data. Calculation of the total catches of fish in different seasons and analysis the environmental variation using XLSTAT 2015. Pearson correlation matrix (n) was also used to found out the relationship between different factors in each season. CCA was used to visualize and to describe the relationship between environmental variation and fish diversity and to find out not only the diversity of fish species but also the influence of environmental factors for the abundance and biomass of the fish species.

Quantity surveying stations bitmaps and fish distribution software Surfer8 draw.

3. Results

3.1. Relationship between Environmental Variations, Survey Stations and Diversity of Fish Species for Four Seasons

Distinct hydrographic conditions of different stations according to each factor into each season are shown in Tables 1-4 below.

Table 1. Environmental factors, survey stations and the diversity of fish species according to the different stations in winter.

Variables	Stations		Minimum	Maximum	Average	Standard deviation
	Min.	Max.				
Temperature	1	24	19.84	21.89	20.66	0.42
Salinity	1	24	26.29	31.79	28.98	1.05
Chlorophyll	24	15	0.79	3.16	1.67	0.72
Depth	3	23	4.00	39.4	18.68	9.73
DO	-	-	-	-	-	-
Biomass	1	23	-	**3118.52**	431.19	828.26
Abundance	12	21	-	98.03	21.25	22.59

St = station.

Table 2. Environmental factors, survey stations and the diversity of fish species according to the different stations in Spring.

Variables	Stations		Minimum	Maximum	Average	Standard deviation
	Min.	Max.				
Temperature	3	24	9.29	11.47	9.80	0.56
Salinity	7	3	22.44	74.56	31.91	9.30
Chlorophyll	1	13	2.16	3.30	2.48	0.25
Depth	1	25	−10	48.62	27.15	10.98
DO	1	6	22.19	243.11	84.68	54.20
Biomass	1	23	1.51	435.36	144.96	118.27
Abundance	1	23	0.17	22.64	7.44	5.33

Table 3. Environmental factors, survey stations and the diversity of fish species according to the different stations in Summer.

Variables	Stations		Minimum	Maximum	Average	Standard deviation
	Min.	Max.				
Temperature	6	1	17.42	19.28	17.65	0.34
Salinity	8	1	21.98	78.45	37.51	12.34
Chlorophyll	19	3	2.73	16.97	6.44	2.83
Depth	1	19	9.57	43.58	23.19	7.84
DO	22	16	82.10	93.75	23.58	7.77
Biomass	10	17	22.44	933.15	239.11	232.19
Abundance	4	**17**	5.31	**356.75**	70.69	82.44

Table 4. Environmental factors, survey stations and the diversity of fish species according to the different stations in Autumn.

Variables	Stations		Minimum	Maximum	Average	Standard deviation
	Min.	Max.				
Temperature	2	24	25.85	27.50	26.53	0.44
Salinity	1	25	23.53	33.11	28.51	2.45
Chlorophyll	22	1	0.58	9.77	1.42	1.77
Depth	22	23	-	37.20	13.11	9.12
DO	-	-	-	-	-	-
Biomass	1	**23**	45.99	**4780.38**	954.16	1090.65
Abundance	1	23	3.762	230.00	63.15	59.08

The Correspondence Analysis based on the environmental factors, the survey stations, the biomass and the abundance of the species shown relationship on the distribution of the species into different stations. Based on this four seasons; winter, spring and autumn maximum's biomass was found at St_{23} and the minimum at St_1. But in summer, maximum biomass was found at St_{17} and minimum in St_{10}. The higher abundance was found at St_{23} and minimum at St_1 in spring and autumn; winter and summer maximum abundance were found respectively at St_{21} and St_{17}, where minimum at St_{12} and St_4. Maximum water temperature was recorded 21.89˚C at station 24 (St24), where minimum water temperature was found with 19.84˚C at St_1, with the average seasonal value 20.66˚C and the standard deviation 0.42 during winter 2013. Spring maximum water temperature was recorded 11.47˚C at St_{24}, where minimum was found with 9.29˚C at St_3, with the average seasonal value 9.81˚C and the standard deviation 0.56˚C. Maximum summer water temperature occurred 19.28˚C at St_1 and minimum water temperature was recorded 17.42˚C at St_6, with the average seasonal value 17.65˚C and the standard deviation 0.34. In autumn, water temperature was recorded 27.50˚C at St24 and minimum water temperature was recorded 25.85˚C at St_2, with the average seasonal value 26.53˚C and the standard deviation 0.44. No significance difference was found in temperature among the stations. Salinity was recorded at highest values (31.79) during winter period at St_{24} and where minimum value (26.29) at St_1, with the average seasonal value 28.98 and the standard deviation 1.05. Spring salinity was recorded at highest values in St_3 (with 74.56) and where minimum value (22.44) at St_7, with the average seasonal value 31.91 and the standard deviation (9.31). Summer highest salinity value was recorded at St_1 (78.45) and minimum value at St8 (21.98), with the average seasonal value (37.51) and the standard deviation (1.34). And autumn salinity was recorded at highest value (33.11) at St25 and minimum value at St_1 (23.53), with the average seasonal value (28.51) and the standard deviation (2.45). DO was recorded at highest value at St_6 (243.11) and DO minimum value at St_1 (22.19), with the average seasonal 84.68 and the standard deviation 54.20, during spring period. Summer highest DO value was recorded at St_{16} (93.75) and minimum value at St_{22} (82.10), with the average value (23.58) and the standard deviation (7.77). Winter chlorophyll value was recorded at St_{15} (3.16) and minimum value at St_{25} (0.79), with the average value (1.67) and the standard deviation (0.72). Chlorophyll was recorded at highest value at St_{13} (3.30) and minimum value at St_1 (2.16), with the average seasonal value (2.48) and the standard deviation (0.25) in spring period. Summer average chlorophyll was recorded at St_3 (16.97) and minimum value at St_{19} (2.73), with the average seasonal value (6.44) and the standard deviation (2.83). Autumn was recorded at highest value at St_1 (9.77) and minimum value at St_{22} (0.58), with the average seasonal value (1.42) and the standard deviation (1.77). Depth was recorded at highest value at St_{23} (39.4) and minimum value at St_3 (4.00), with average seasonal value (18.68) and the standard deviation (9.73) during winter period. Spring depth highest value appears at St_{25} (48.62) and minimum value at St_1 (with 10), with the average seasonal value (27.15) and the standard deviation (10.98). Summer highest value was recorded at St_{19} (43.58) and minimum value at St_1 (9.57), with the average seasonal value (23.19) and the standard deviation (7.84). Autumn was recorded at highest value at St_{23} (37.2) and minimum value at St_{22} (0.2), with the average seasonal value (13.11) and the standard deviation (9.12). No clear trend of depth variation was found among these four seasons.

3.2. Correlation between Different Factors According to the Spatial and Temporal Distribution of Fish Species during Four Seasons

The study is interested to the relationship between different parameters according to the temporal and spatial on species diversity. In fact, each environmental parameter been assessed on each station based on each season. Pearson Correlation Matrix (n) based on parameters such as temperature, salinity, chlorophyll, DO, depth, biomass, abundance, was carried out. Tables 5-8 below show the relationship between different parameters. Several quantitative variables are

Table 5. Pearson correlation matrix between temperatures, salinity, chlorophyll, depth, DO, biomass and abundance in winter.

Variables	Temperature	Salinity	Chlorophyll	Depth	Abundance	Biomass
Temperature	1					
Salinity	0.983	1				
Chlorophyll	−0.511	−0.519	1			
Depth	0.686	0.648	−0.521	1		
Abundance	0.751	0.739	−0.445	0.531	1	
Biomass	0.752	0.740	−0.453	0.549	0.903	1

Values in bold are different from 0 with a significance level alpha = 0.05.

Table 6. Pearson correlation matrix between temperatures, salinity, Chlorophyll, depth, DO, biomass and abundance in spring.

Variables	Temperature	Salinity	DO	Chlorophyll	Depth	Abundance	Biomass
Temperature	**1**						
Salinity	−0.080	**1**					
DO	0.188	−0.162	**1**				
Chlorophyll	−0.016	−0.224	0.140	**1**			
Depth	**0.660**	0.060	0.148	−0.240	**1**		
Abundance	0.383	−0.010	0.037	−0.019	**0.442**	**1**	
Biomass	**0.613**	0.011	−0.018	0.048	**0.699**	**0.760**	**1**

Values in bold are different from 0 with a significance level alpha = 0.05.

Table 7. Pearson correlation matrixes for temperature, salinity, Chlorophyll, depth, DO, biomass and abundance in summer.

Variables	Temperature	Salinity	DO	Chlorophyll	Depth	Abundance	Biomass
Temperature	**1**						
Salinity	**0.709**	**1**					
DO	−0.385	−0.284	**1**				
Chlorophyll	0.077	0.268	**−0.525**	**1**			
Depth	−0.378	−0.262	**0.983**	**−0.530**	**1**		
Abundance	0.027	−0.048	−0.085	**0.471**	−0.114	**1**	
Biomass	0.138	0.002	−0.131	**0.504**	−0.131	**0.870**	**1**

Values in bold are different from 0 with a significance level alpha = 0.05.

Table 8. Pearson correlation matrixes for temperature, salinity, Chlorophyll, depth, biomass and abundance in autumn.

Correlation matrix (Pearson (n)):						
Variables	Temperature	Salinity	Chlorophyl	Depth	Av. Abundance	Av. Biomass
Temperature	**1**					
Salinity	**0.898**	**1**				
Chlorophyl	−0.093	**−0.445**	**1**			
Depth	0.352	**0.471**	−0.188	**1**		
Av. Abundance	−0.168	0.019	−0.127	0.011	**1**	
Av. Biomass	0.207	0.345	−0.157	0.229	**0.793**	**1**

Values in bold are different from 0 with a significance level alpha = 0.05.

measured on each member of a sample. Considering a pair of such variables, it is frequently of interest to establish if there is a relationship between the two variables. The type of correlation make it possible to categorize the stations by considering the variables:

- Positive correlation (the variable has a tendency to also increase);
- Negative correlation (the other variable has a tendency to decrease);
- No correlation (the other variable does not tend to either increase or decrease);
- (*Value* **1** *means the two variables are exactly correlated*, *that is exactly the case of a linear relationship between two variables*);
- (Bolt values of correlation are significant at P < 0.05).

According to the Pearson correlation matrix and the correlation is an effect size and we can verbally describe the strength of the correlation using the guide that [1] suggests for the absolute value of r (between: 0.0 - 0.19 = very weak; 0.20 - 0.39 = weak; 0.40 - 0.59 = moderate; 0.60 - 0.79 = strong; 0.80 - 1.0 = very strong) and r^2 represents the percent of the data that is the closest to the line of best fit.

A highly significant correlation was observed between temperature and salinity with 96.62% (r = 0.98; P < 0.01) mean that we have a positive correlation (the variable has a tendency to also increase) and the relationship between this two variables or factors is very strong, which is probably related to the preferential association of this relationship with the P < 0.01. Temperature and salinity are both critical for the survival and distribution of fish community. A significant correlation was found between abundance and biomass with 81.54% (r = 0.90; P < 0.01) mean that the relationship between this two variables or factors is very strong according to the guide. A strong correlation between temperature and biomass was found out with 56.55% (r = 0.75; P < 0.01) and also a strong correlation was found out between salinity and biomass with 54.76% (r = 0.74; P < 0.01); another strong correlation was found between temperature and depth but also between salinity and depth with respectively 47.05% (r = 0.68; P < 0.05) and 41.99% (r = 0.64; P < 0.05) and a moderate correlation was found with 30.14% (r = 0.54; P < 0.05) during winter period. In spring period a strong correlation was found respectively between temperature and biomass; biomass and abundance with 37.57% (r = 0.61; P < 0.01) and (r = 0.76; P < 0.01) but also a moderate correlation was found with 35.64% (r = 0.59; P < 0.01). We also found out a negative correlation respectively between temperature and salinity; salinity and DO with −0.006% (r = −0.08; P < 0.05) and −0.026% (r = −0.16; P < 0.05) and finally a very weak correlation between DO and chlorophyll with 0.020% (r = 0.14; P < 0.05). Summer period was characterized by two very strong correlation respectively between depth and DO; abundance and biomass with 96.62% (r = 0.98; P < 0.01) and 75.69% (r = 0.87; P < 0.01) but also a strong correlation between temperature and salinity with 50.26% (r = 0.70; P < 0.01). We also found out respectively two negative correlations between salinity and DO; DO and chlorophyll with −8.06% (r = −0.28; P < 0.05) and −27.56% (r = −0.52; P < 0.05). A very strong correlation was found between temperature and salinity with 80.64% (r = 0.89; P < 0.01) and a strong correlation between abundance and biomass with 62.88% (r = 0.79; P < 0.01) but also a moderate correlation was found between salinity and depth with 22.18% (r = 0.47; P < 0.05) and a very weak correlation between depth and abundance with 0.01% (r = 0.01; P < 0.05). A negative correlation was observed during winter, spring and autumn between temperature, salinity and chlorophyll.

According to Pearson correlation matrix P-value < 0.01, tested between different variable showed a significant association respectively between temperature and salinity; abundance and biomass; depth and DO; could explain more than 80% of variability during the four seasons.

3.3. Correlation Analysis of Abundance and Biomass Linked to the Environmental Factors

Grouping stations functions of environmental parameters influencing the abundance and biomass. Figures 2-5 below show the variables and factors of goshawks axes F1 and F2 for each season and carrying the information that can distinguish different groups by circles. In each circle we have not only the variables such as survey stations but also parameters. The Biplot of sample sites or stations, species abundance and biomass with environmental variables on the two main axes of each season as determined by the CCA and was shown in figures below.

According to the Correspondence Analysis (CA), P-value < 0.0001 is less than alpha = 0.5. This made we must reject the null hypothesis even if true and less than 0.01% with F1 and F2 mean factors. For Winter conditions the Bartlett's sphericity test shown a Chi-square Observed value (149.41) higher than the Chi-square Critical value (24.99) with a DF of 15 and a P-value < 0.0001 attesting significant correlations between variables for alpha = 0.05. The Temperature,

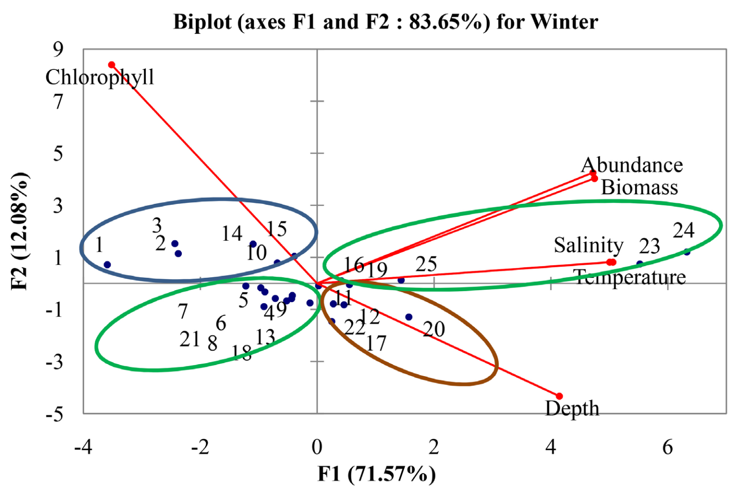

Figure 2. Tests of independence between the rows and the columns show a significant dependency between the stations and parameters rely highlighted with P-value < 0.0001 in winter.

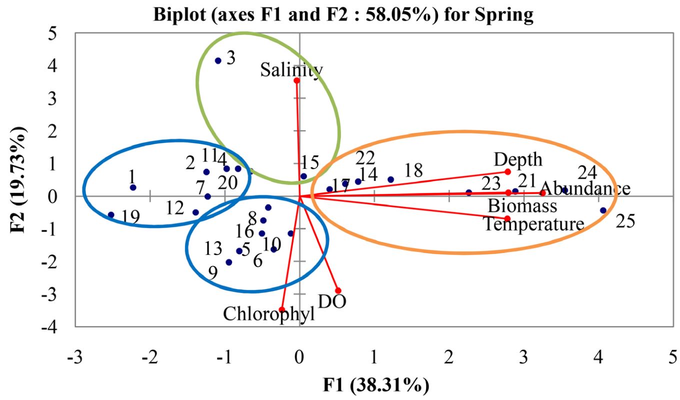

Figure 3. Tests of independence between the rows and the columns show a significant dependency between the stations and parameters rely highlighted with P-value < 0.0001 in spring.

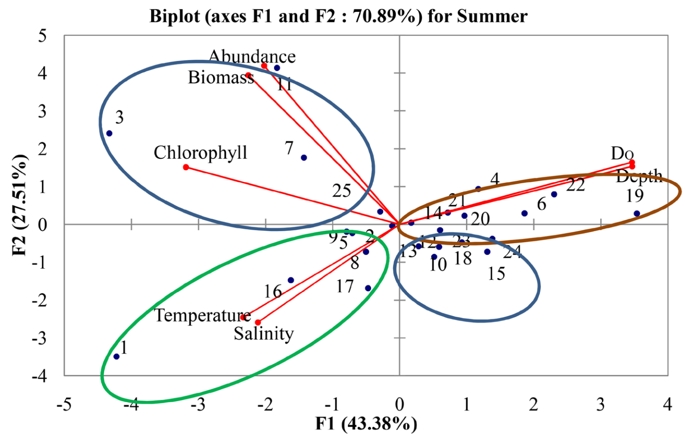

Figure 4. Tests of independence between the rows and the columns show a significant dependency between the stations and parameters rely highlighted with P-value < 0.0001 in summer.

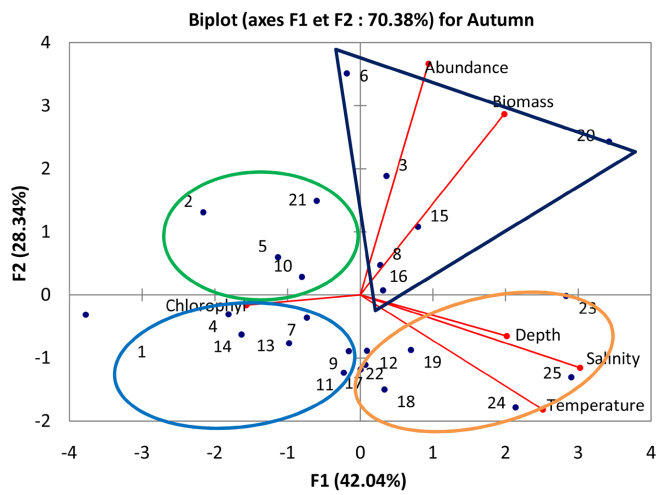

Figure 5. Tests of independence between the rows and the columns show a significant dependency between the stations and parameters rely highlighted with P-value < 0.0001 in autumn.

the Salinity, the Deepness, the Abundance and the Biomass contributed as variables up to 90.09% to F1 axis while the Chlorophyll was the component F2 axis up to 56.46%. On winter season, the deepest stations with their Salinity and Temperature appropriated, provided biomass in abundance. For Spring conditions the Bartlett's sphericity test shown a Chi-square Observed value (56.32) higher than the Chi-square Critical value (32.67), with a DF of 21 and a P-value < 0.0001, attesting significant correlations between variables for alpha = 0.05. The variables Temperature, Depth, Abundance and Biomass contributed up to 98.87% to F1 axis while the variables Salinity, Chlorophyll and DO contributed up to 97.29% to F2 axis. On spring season, the deepest stations with their temperature appropriated, provided biomass in abundance. For Summer conditions the Bartlett's sphericity test shown a Chi-square Observed value (144.39) higher than the Chi-square Critical value (32.67) with a DF of 21 and a P-value < 0.0001 attesting a significant correlations between variables for alpha = 0.05. The variables Depth (22.53%), DO (22.49%), Chlorophyll (19.08%) and Temperature (10.23%) contributed up to 74.34% to F1 axis, while the variables Abundance (33.06%), Biomass (29.21%), Salinity (12.59%) and Temperature (11.32%), contributed up to 86.19% to F2 axis. On summer the environmental conditions such as salinity and Temperature can increase Biomass in some sites. For Autumn conditions the Bartlett's sphericity test shown a Chi-square Observed value (104.52), Chi-square Critical value (24.99) with a DF of 15 and a P-value < 0.0001, for alpha = 0.05 attesting a significant correlation between the variables.

The variables such as Salinity (34.14%), Temperature (23.56%), Depth (15.15%) and Biomass (14.66%) contributed up to 87.52% to F1 axis while Abundance (50.26%), Biomass (30.70%) and Temperature (12.35% participated up to 93.32% to the F2 axis.

CCA amounted to 83.65% of the explained variance according to the F1 and F2 axes in winter. Axes F1 separated the zones along the spatial gradient, with the inner zone located on the left part of the figures and the outer zone on the right side. Winter results show that the stations 1; 3; 2; 14; 10; 15; 7; 18; 21 and 24 are characterized by a high chlorophyll; stations 11; 19; 20; 22; 12 and 17 are characterized by depth and stations 16; 25; 23; 24; 5; 6; 7; 8 and 9 are characterized by temperature, salinity, abundance and biomass. Spring amounted to 58.05% of the explained variance. CCA analysis show that the stations 1; 2; 4; 11; 20; 15; 7 and 3 are characterized by salinity; stations 17; 14; 22; 18; 23; 21; 24 and 25 are characterized by temperature, depth, biomass and abundance and the stations 8; 12; 19; 16; 5; 10; 13; 9 and 6 are characterized by DO and chlorophyll. Summer amounted to 70.89% of the explained variance. CCA analysis show that the stations 2; 25; 7; **3** and 11 are characterized by abundance, biomass and chlorophyll; stations 1; 16; 17; 9; 5; 8; 12; 10 and 13 are characterized by a high temperature and a high salinity; stations 14; 23; 18; 24; 20; 21; 4; 6; 19 and 22 are characterized by depth and DO. Autumn amounted to 70.38% of the explained variance. CCA analysis show that the stations 1; 4; 14; 13; 7; 10; 5 and 2 are characterized by a high chlorophyll; station 11; 17; 18; 12; 9; 19; 24; 25; and 23 and are characterized by depth, a high temperature and a high salinity; stations 16; 6; **3**; 21; 15; 8 and 20 are characterized by a high biomass and a high abundance.

4. Discussion

This study in Nanji Islands National Nature Reserve was also carried out in different survey stations the influence of environmental factors to the fish species abundance and biomass and three factors were examined to explain their relationship (such as environmental factors, survey stations and fish diversity) during four seasons.

Based on the quantity distribution of the fish community in different survey stations, our analysis indicated that a highly biomass and abundance were located at St_{23}, mostly the species is likely to benefit from the combination of high temperature, high salinity and high nutrient water conditions within the interaction zone between Taiwan warm current (TWC) and coastal fresh water. This type may also disperse species into coastal areas without immediately triggering a bloom as was observed in the East China Sea (ECS) during the 2005 season when spring time warming was delayed [2]. The importance of such offshore source populations should be investigated further as they may play a significant role in the development of other species. Mostly, minimum biomass and abundance was observed at St_1; located at the near shore characterized by the high chlorophyll, high nutrient concentration, low temperature (temperature < 12˚C, is unfavorable for growth or even survival of the community. According to Pearson correlation matrix ($P < 0.001$; $P < 0.005$) found out a very strong correlation between temperature and salinity; abundance and biomass in winter; depth and DO in summer then a strong correlation also was found between temperature and biomass; salinity and biomass in winter too and finally a moderate correlation between depth and biomass in spring with P-value < 0.001 mean positive correlation (that the other variable or factor has a tendency to increase). We also found out a negative correlation P-value < 0.005, respectively between salinity and DO; DO and chlorophyll in summer; temperature and salinity; salinity and DO in spring period mean that the other variable or factor has a tendency to decrease. A negative correlation observed between temperature, salinity and chlorophyll in winter, spring and autumn period were due by a temperature and salinity window open for species blooms through the movement of the TWC and Jiangzhe coastal current close to shore. Previous studies have reported that the optimal temperature range for phytoplankton species growth is between 20˚C and 27˚C in cultures [3], and between 18.5˚C and 21.3˚C in situ [4]. However, this likely reflects the reality that many phytoplankton species live in suboptimal conditions in nature because of the trade-offs among many different environmental conditions [5]. Nutrient concentrations were quite suitable for growth but the temperature and salinity were low within the coastal zone, while the temperature and salinity were optimal but the nutrient concentrations were low offshore. As a result, the distribution of the species was correlated to the environmental factors according to each season. Climate, energy, and primary productivity have a major influence on species richness at the regional, continental and global scales [6]. Studies conducted at small grain also indicate that environmental variables can influence the occurrence of species and abundance in local fish communities in both space and time. In contrast to these findings, we did not observe any direct effect of the magnitude of individual environmental conditions, including salinity, chlorophyll-*a* concentration and water temperature, on the species richness of local fish communities in either Marine nature reserve area.

By comparing diversity of fish species with environmental factors, we found that community structure of fish varied significantly as physicochemical parameters changed between different stations for each season. Coral reefs are complex systems, with a high degree of functional diversity and variability in different interactions. From winter to autumn, the dominant species varied. These variations were correlated to the environmental factors. Water temperature and salinity were correlated to the diversity of fish species and reached highest values during winter period at St_{24} (with 21.89˚C and 31.79 mg/L, respectively). In spring period, three environmental factors as temperature, salinity and depth were correlated with diversity of fish species and reached highest values in different stations (with 11.47˚C at St_{24}, 74.56 mg/L at St_3 and 48.62 m at St_{25}, respectively). Depth and DO were correlated to the abundance and biomass and reached highest values during summer period at different stations (with 43.58 m at St_{19} and 93.75 mg/L at St_{16}, respectively). In autumn period, salinity and temperature were correlated to the abundance and biomass of fish species and reached highest values (with 27.25˚C at St_{24} and 33.11 mg/L at St_{25}, respectively). As results and according to the species referencing of environmental factors; species diversity, abundance and evenness vary among different stations, corresponding to significant differences of environmental factors (e.g. physicochemical parameters and chlorophyll-*a* concentration in different sites). Salinity has long been considered an important influence on the composition of the community structure and dynamics of aquatic ecosystems [7], and species richness of microfauna was generally negatively correlated with salinity levels. [8] Found zooplankton species richness and abundance reduced at salinities between 1000 and 5000 mg/L. Although both temperature and DO changed significantly during survey period in different stations, they were significantly correlated with the main CCA axes. Furthermore, they were related to the fish community according to the results. This may due to the fish community adaptability in these different variations of environmental factors, but only tolerant members remaining.

5. Conclusion

This work shows the variation of conditions such Temperature, Chlorophyll, Salinity, DO and also Depth from one Station to another. And those variations induced significantly the Biomass and the Abundance of fish resources. The Station St_{23} recorded the highest biomass production mostly in winter (3118.52) and autumn (4780.38). Abundance records were registered during summer (356.75) in Station 17 and during autumn (230.00) in Station 23. Since the survey data limitations, this article could be a preliminary study of the seasonal variation of fish communities and the effects of environmental variations. Fish resources survey should be long-term continuous to show community interannual variability, from a more macro perspective by comparing changes in the community. The consistency of trophic interactions found in this study provides compelling evidence of the importance of some factors in ecosystems and holds important implications for the development of ecological paradigms, as well as conservation and management. Further research should focus on temporal, environmental and human effects, as well as their relative importance in reefs.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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