International Journal of Applied Sciences: Current and Future Research Trends
(IJASCFRT)
ISSN: 2790-3990

https://ijascfrtjournal.isrra.org/index.php/Applied_Sciences_Journal

Zooplankton Community of Cotonou Port Basin in Guinean Gulf: First Data

Hotèkpo Hervé Akodogbo[a*], Fridolin Ubald Dossou-Sognon[b], Fadéby Modeste Gouissi[c], Patrick Junior Kouglo[d], Arnaud Assogba[e], Emile Didier Fiogbe[f]

[a,b,d]*Research Laboratory in Applied Biology (LARBA), Polytechnic School of Abomey-Calavi (EPAC), University of Abomey-Calavi (UAC), 01 PO box 2009, Cotonou, Benin*

[c]*Laboratory of Ecology, Health and Animal Productions (LESPA), Faculty of Agronomy, University of Parakou, PO box 123, Parakou, Benin*

[a,f]*Research Laboratory on Wetlands (LRZH), Faculty of Sciences and Technical (FAST), University of Abomey-Calavi (UAC), PO box 526, Cotonou, Benin*

[e]*Institute of Halieutic and Oceanological Research of Benin (IRHOB), Cotonou 03 PO box 1665, Benin.*

[a]*Email: hakodogbo1@gmail.com,* [b]*Email: dosousognonfridolin@gmail.com,* [c]*Email: gouissi@yahoo.fr,* [d]*Email: patricjuniorkouglo@gmail.com,* [e]*Email: arno.assogba@gmail.com,* [f]*Email: edfiogbe@yahoo.fr*

Abstract

The Autonomous Port of Cotonou in Benin hosts several activities in its port basin exposing it to pollution and biological invasions risks. To provide a basic knowledge on this port basin's zooplanktonic community structure, four quarterly sampling campaigns (July and October 2020 then January and April 2021) were conducted to collect zooplankton using a plankton net of 53 µm mesh, weighted to a depth of 05 m. Thirty-five (35) taxa plus nauplii and other unidentified copepods were recovered from the port basin and then distributed into nine (9) groups, making an average density of 23613.62 ind/m^3. Copepods were the most abundant group (97.97% of the total density) with *Oithona* spp. as the most abundant taxon (20% of the total density). July was the most abundant month for zooplankton. These results will be used for future assessment of the status of this ecosystem.

Keywords: Zooplankton; Taxonomic composition; Autonomous Port of Cotonou; Benin; Gulf of Guinea.

1. Introduction

In aquatic environments, zooplankton, which are highly sensitive to changes in environmental conditions, play a crucial role in the transfer of energy from primary producers to higher levels of the food chain [1,2].

----

* Corresponding author.

They are a major food source for many aquatic animals, including fish and other economically important crustaceans at various stages of development [1, 4]. Thus any disturbance induced in the marine aquatic environment may affect the structure and composition of the zooplankton community and consequently immediately or temporarily the upper trophic levels of the food chain, consequently the whole ecosystem and the marine resources including economically important fish species [2, 5].

In ports, these disturbances can come from human activities such as loading and unloading of cargo, discharge of ballast and bilge water into aquatic ecosystems that can alter water quality through the introduction of nutrient sources, pollutants or non-native species [5, 6]. The study of zooplankton is therefore essential for the evaluation of the state of the ecosystems through the monitoring of certain environmental parameters in order to detect possible modifications induced by these disturbances and to propose preventive measures and restoration ways [4]. The knowledge of biodiversity and the study of the distribution of these organisms in these ecosystems is a crucial condition to be able to carry out this evaluation [4,7].

The Autonomous Port of Cotonou is located on the Atlantic coast in the Republic of Benin in West Africa. It is one of the country's economic bases. This port is the seat of several activities taking place in the area of the fishing port and the industrial port which, thanks to its port basin, welcomes ships for commercial exchanges. It is thus exposed to risks of introduction of exotic species and consequently of biological invasions. Knowledge of its biodiversity is therefore important, as it is necessary to identify native and non-native species in the long term for research on biological invasions. However, to date, no data have been published on the taxonomic composition and spatio-temporal distribution of zooplankton in the basin of the Autonomous Port of Cotonou. Several national and international research studies have been conducted in the African Atlantic, which was the subject of numerous oceanographic expeditions in the 20th century [8,9]. However, no data have been particularly published on the zooplankton of the Gulf of Guinea in Benin to date. To contribute to fill this gap, this work is part of the dynamics to provide preliminary data on the zooplanktonic community of this ecosystem through the spatio-temporal distribution of the zooplanktonic community in the basin of the Autonomous Port of Cotonou by shedding light on the taxonomic composition and abundance of zooplanktonic community in this basin.

2. Materials and Methods

2.1. Study area

The Autonomous Port of Cotonou, is a deep-water port located between latitudes 6.341 N and 6.351 N, and longitudes 2.409 E and 2.435 E, having a water body (Port Basin) in the Gulf of Guinea [10,11]. The coastal hydrography of the Gulf of Guinea is generally divided into four regimes: a minor upwelling period from December to January; a long thermocline period from February to June; a major upwelling period from July to September and another thermocline period from October to November [12].

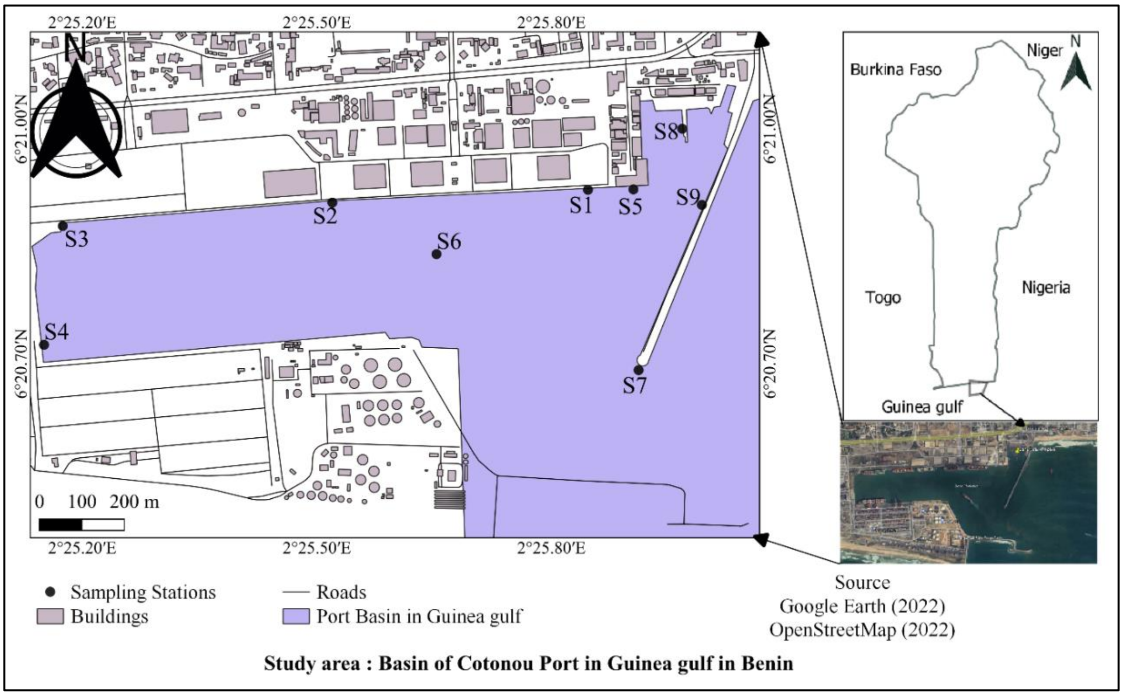

Figure 1: Sampling sites in the Cotonou Autonomous Port Basin.

2.2. Data collection and analysis

Nine (09) sites were selected in the port basin considering their accessibility for this study (Fig 1). Zooplankton were collected during 4 campaigns (July, October 2020 and January, April 2021). Samples were collected by vertical hauls (from certain depth to the surface) using a 53 µm mesh plankton net (with two openings: a large opening of 26 cm diameter and a small opening at the base with a 53 µm mesh screen lid) weighted to a depth of 05 m to filter a volume V= 0.26533 m^3 of water. The filtrates obtained on the lid after the vertical hauls performed are transferred to pillboxes and then stored in a final volume of 50 ml of 70° ethanol and kept in the refrigerator at 4°C. To estimate the density of individuals, 50% of each sample (25 ml) was then taken with pipettes into twelve 2 ml subsamples and one 1 ml subsample for observation on a counting cell under an optical microscope OPTIKA-MICROSCOPE-NUMERIC-B-290TB-E-PLAN-AVC-TABLET-PC type. All the remaining of the sample was then observed to identify and count only those taxa that were not abundant in the subsamples (25 ml) previously observed. Each individual was identified to the lowest possible taxonomic level using identification keys such as [13,22]. The names of the taxa were updated using the taxonomic databases: [23] (Catalogue of Life accessed at https://www.catalogueoflife.org/) and [24] (World Register of Marine Species consulted on https://www.marinespecies.org/). Individuals of calanoids that could not be identified at least to the genus level were grouped into taxa according to the number of furcal setae, as the number of setae can be considered to get an idea of the potential higher-level taxa they may belong to. Nauplii, copepodites and adult individuals that did not show all the characters to group them in one of the taxa identified with certainty (Calanoïda spp. and Cyclopoïda spp.), were counted and their number used for abundance estimation only.

The density of individuals (ind/m^3) of each taxon used to estimate abundance was calculated based on the formula proposed by [1] as follows:

$$\mathbf{D= (n/V_1) \times (V_F /V_{fe})} \qquad \mathbf{(1)}$$

Where: **n** = number of individuals counted,

$\mathbf{V_1}$ = volume taken for observation (25 ml),

$\mathbf{V_F}$**=** volume of concentrated filtrate (sample volume 50 ml) and

$\mathbf{V_{fe}}$ = volume of filtered water obtained by the formula $\mathbf{V_{fe} = л \times r^2 \times H}$ **(2)**

Where: **H** represents the depth (5 m);

$\mathbf{r = \frac{D}{2}}$ with D = 0.26 m (diameter of the large opening of the net).

The frequency of occurrence of taxa was determined by the relationship: % Occ = (Pa / P) × 100 **(3)**

Where Pa = total number of samples containing the taxon of interest, and

P is the total number of samples taken (taking into account the temporal or spatial distribution).

This frequency of occurrence allows us to categorize the taxa, according to their distribution:

- F ≥ 50%: constant taxon;
- 25% ≤ F < 50% accessory taxon;
- 5% ≤ F < 25% accidental or
- F < 5%) rare taxon [1,25].

Microsoft Excel version 2019 software was used to perform calculations, tables and figures. QGIS 3.16 software was used to make the spatial distribution maps of abundance and taxonomic richness by exploiting the data on OpenStreetMap 2022.

3. Results

3.1. Composition of the zooplankton community

3.1.1. Taxonomic richness

Organisms identified at the 9 stations in the port basin during the study period were grouped into 9 groups (Table 1) and then divided into 35 taxa plus nauplii and other copepods (Calanoïda spp. and Cyclopoïda spp.) (Table 2). Of the 35 taxa, 12 were identified to species, 9 to genus, 8 to order, one to subclass, 5 to class and two to phylum.

3.1.2. Zooplankton abundance

The average density was 23613.62 ind/m^3 (Table 1). Copepods were the most abundant group (97.97% of the total density), followed by Molluscs (1.05%), and the other seven groups accounted for only 0.98% of the total density (Table 1). Copepod nauplii contributed 44% of the total density, followed by *Oithona* spp (20.02%), Calanoïda spp1 (8.32%), *Microsetella norvegica* Boeck, 1865 (6.44%), Cyclopoïda sp2 (5.18%), Cyclopoïda spp (4.99%), *Euterpina acutifrons* Dana, 1847 (4.27%) (Table 2).

Table 1: Annual Abundance, Relative Abundance and Number of Taxa for each group of zooplankton recorded in the port basin of the Autonomous Port of Cotonou.

Groups	Annual abundance (ind/m^3)	Relative Abundance (%)	Number of species
Copepoda	23134,58	97,97	21
Rotifera	21,90	0,09	4
Cladocera	1,95	0,01	1
Mollusca	247,16	1,05	2
Cirripedia	86,78	0,37	1
Ostracoda	67,39	0,29	1
Chaetognatha	48,55	0,21	2
Decapoda	3,91	0,02	2
Ascidiacea	1,40	0,01	1
Total	23613,62	100	35

Table 2: List, density (ind/m^3) by campaign and abundance (%) of taxa.

Group	Order	Family	Taxa	July_20	October_20	January_21	April_21	Annual_total (ind/m^3)	Abundance (%)
Copepoda	Cyclopoida		Cyclopoïda sp1	0	18,42	0	13,39	7,95	0,03
			Cyclopoïda sp2	4290,18	150,68	187,51	267,87	1224,06	5,18
			Cyclopoïda sp3	422,74	195,88	15,07	5,58	159,82	0,68
		Oncaeidae	*Oncaea* spp	581,79	16,74	0	1,67	150,05	0,64
		Oithonidae	*Oithona plumifera* (Baird, 1843)	25,11	16,74	0	0,56	10,60	0,04
			Oithona spp	13569,51	410,18	3753,59	1178,65	4727,98	20,02
		Corycaeidae	*Corycaeus* spp	8,37	75,34	16,18	59,16	39,76	0,17
	Calanoida Sars	Acartiidae	*Acartia* spp	1,12	1,67	1,12	2,79	1,67	0,01
			Calanoïda spp1	5683,96	909,10	900,73	359,96	1963,44	8,31
			Calanoïda spp2	66,41	0,56	0,56	251,13	79,66	0,34
			Calanoïda spp3	58,60	130,59	5,02	23,44	54,41	0,23

		Temoridae	*Temora* sp	4,74	11,72	7,81	36,83	15,28	0,06
			Temora turbinata (Dana, 1849)	33,48	40,18	1,67	3,91	19,81	0,08
			Temora stylifera (Dana, 1849)	0	1,12	1,67	4,46	1,81	0,01
	Harpacticoïda	Tachidiidae	*Euterpina acutifrons* (Dana, 1847)	2461,10	661,31	463,76	450,36	1009,13	4,27
		Peltidiidae	*Clytemnestra* sp	217,65	11,72	8,37	1,67	59,85	0,25
			Harpacticoïda sp	0,00	0,00	23,44	35,16	14,65	0,06
		Ectinosomatidae	*Microsetella rosea* (Dana, 1847)	1,12	20,09	13,39	3,35	9,49	0,04
			Microsetella norvegica (Boeck, 1865)	3926,03	348,24	1170,28	642,90	1521,86	6,44
			Microsetella sp	100,45	25,11	14,51	24,00	41,02	0,17
		Miraciinae	*Macrosetella gracilis* (Dana, 1846)	217,65	39,07	36,83	28,46	80,50	0,34
Rotifera	Ploima	Brachionidae	*Brachionus falcatus* (Zacharias, 1898)	8,37	0	0,00	0	2,09	0,01
			Brachionus plicatilis (Müller, 1786)	12,56	0	1,67	0	3,56	0,02
			Keratella tropica (Apstein, 1907)	8,37	0	0	0	2,09	0,01
			Rotifera sp	54,97	0	1,67	0	14,16	0,06
Cladocera	Diplostraca	Sididae	*Penilia avirostris* (Dana, 1849)	0,56	5,02	2,23	0	1,95	0,01
Mollusca			Gastropoda spp	273,46	38,51	50,23	29,58	97,94	0,41
			Bivalvia spp	108,82	231,88	42,69	213,46	149,21	0,63
Cirripedia			Cypris larvae	2,23	6,70	0,00	3,35	3,07	0,01
Ostracoda			Ostracoda spp	155,14	37,39	30,69	46,32	67,39	0,29
Chaetognatha			Chaetognatha spp	6,70	21,76	70,32	90,41	47,30	0,20
	Aphragmophora	Krohnittidae	Krohnitta sp	1,67	1,12	0	2,23	1,26	0,01
Decapoda	Decapoda	Luciferidae	*Lucifer* sp (Protozoea)	0,56	0	5,02	1,67	1,81	0,01
			Decapoda spp	2,23	2,23	0,56	3,35	2,09	0,01
Ascidiacea			Ascidian larvae	0	0	0	5,58	1,40	0,01
Copepoda			Copepod nauplii	15055	10974	3915,	11615	10390	44,

			,38	,48	99	,70	,39	00
	Cyclopoida	Cyclopoïda spp	2302,05	1061,45	385,07	967,70	1179,07	4,99
	Calanoida	Calanoïda spp	46,04	98,78	0,00	1344,39	372,30	1,58
Cirripedia		Cirriped nauplii	5,02	16,74	264,53	48,55	83,71	0,35

3.2. Spatial and temporal variation

3.2.1. Frequency of occurrence (% Occ)

➢ ***Temporal frequency***

Seven (07) groups (Copepods, Molluscs, Cirripedes, Ostracods, Chaetognaths, Decapods and Cladocerans) were the most frequently present (at least 3 seasons) and two (02) groups (Rotifers and Ascidians) were the least frequent.

➢ ***Spatial frequency***

Spatial frequency of zooplankton showed that 5 groups were present in the basin at all stations (Copepods, Molluscs, Cirripedes, Ostracods, Chaetognaths); 1 group at 8 stations (Rotifers), 1 group at 4 stations (Decapods) and 1 group at 3 stations (Ascidians) and 1 group at 2 stations (Cladocerans). Taxa such as: Copepods, Molluscs, Cirripedes, Ostracods, Chaetognaths and Rotifers were constant spatially and temporally. Only Copepods were present at all stations during all seasons.

31 taxa were spatially and temporally consistent. *Oithona* spp. and copepod nauplii were present at all stations in all seasons. Cirripede nauplii were spatially and temporally consistent but were not present at all stations in all seasons.

3.2.2. Taxonomic richness

This study revealed that the taxonomic richness of the zooplankton community sampled at the Autonomous Port of Cotonou basin, ranged from 6 taxa (Station 9, April 2021) to 25 taxa (Station 7, July 2020). The total taxonomic richness varies relatively little with the seasons (28 to 33). It was 33, 30, 28 and 32 taxa in July, October, January and April respectively.

Temporal variation in taxonomic richness shows that in July 20 taxa of Copepods, 4 of Rotifers, 1 of Cladocerans, 2 of Molluscs, 1 of Cirripedes, 1 of Ostracoda, 2 of Chaetognaths, 2 of Decapoda were found (Fig 2). In October 22 taxa of Copepods, 1 of Cladocerans, 2 of Molluscs, 1 of Cirripedes, 1 of Ostracoda, 2 of Chaetognaths, 1 of Decapoda were recovered. In January 19 taxa of Copepods, 2 of Rotifers, 1 of Cladocerans, 2 of Molluscs, 1 of Ostracods, 1 of Chaetognaths, 2 of Decapods were found. In April 23 taxa of Copepods, 2 of Molluscs, 2 of Cirripedes, 1 of Ostracods, 2 of Chaetognaths, 2 of Decapods and 1 of Ascidians were found.

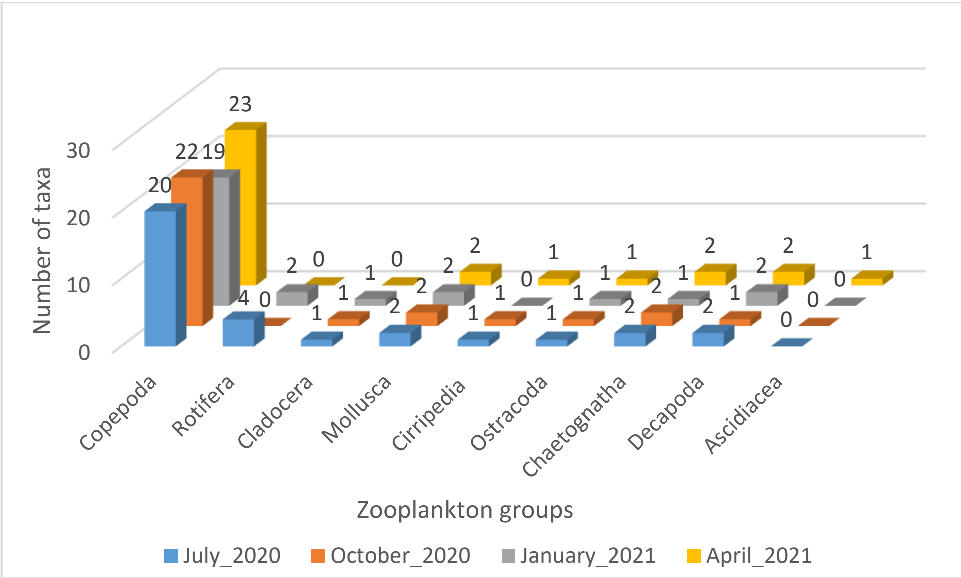

Figure 2: Temporal variation in zooplankton taxonomic richness in the port basin.

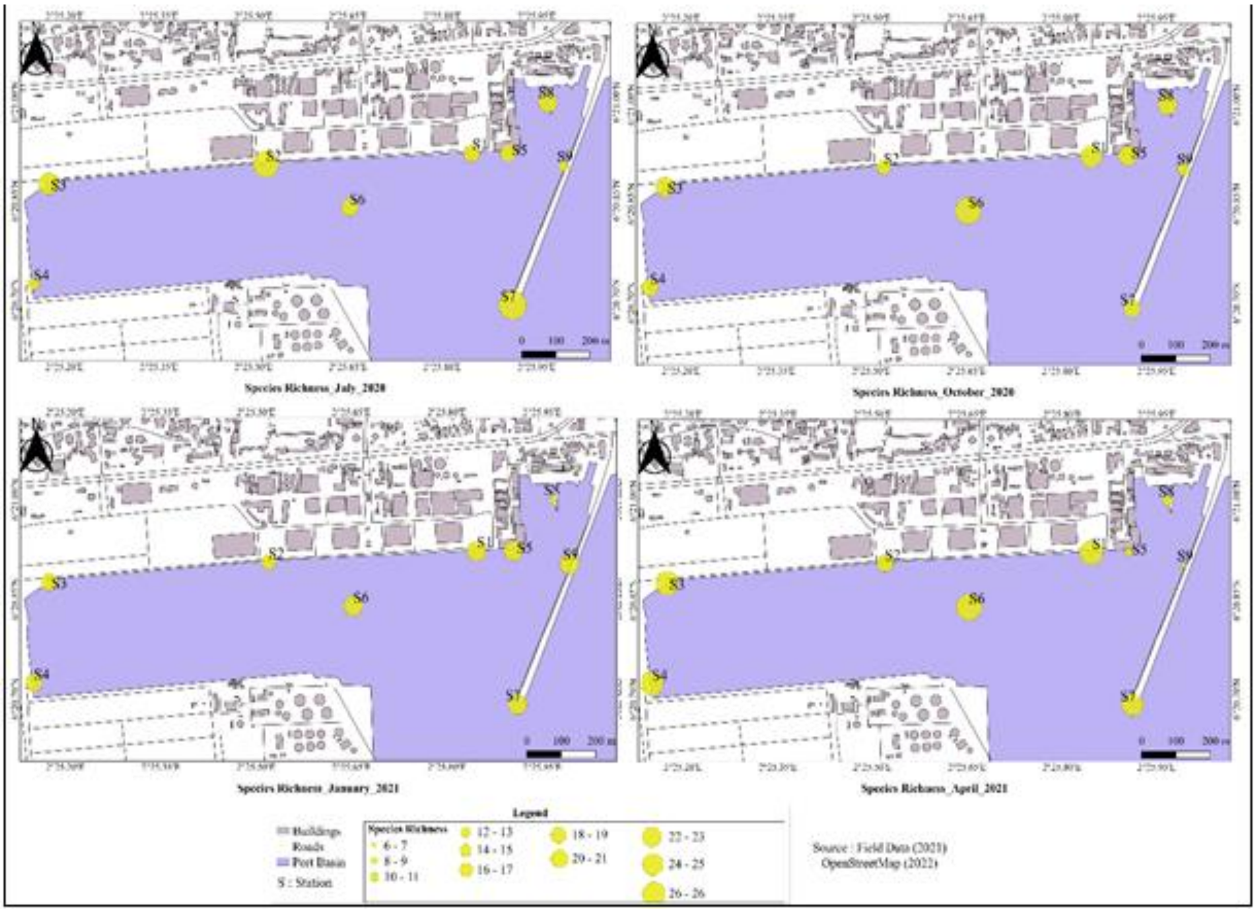

Figure 3: Spatial and temporal variation in zooplankton taxonomic richness in the port basin.

In July, stations S7, S2, S3, S6 and S8 are the richest in taxa while stations S1, S4, S5 and S9 are the lowest in taxa. In October, stations S6, S8, S1, S5 and S3 are the richest in taxa while stations S4, S2, S7 and S9 are the lowest in taxa. In January, stations S9, S7, S6, S5, S1, S4 and S3 are the richest in taxa while stations S8, S2 are the lowest in taxa. In April, stations S1, S3, S4 and S6 are the richest in taxa while stations S5, S8 and S9 are the lowest in taxa.

3.2.3. Zooplankton Abundance

Abundance of the zooplankton community sampled at the Autonomous Port of Cotonou ranged from 587.65 ind/m^3 (Station 9, April 2021) to 111259.13 ind/m^3 (Station 7, July 2020). Abundance varied relatively little with season (11392.20 ind/m^3 to 49714.15 ind/m^3). It was 49714.15; 15580.53; 11392.20 and 17767.61 ind/m^3 respectively in July, October, January and April. Copepods were most abundant in all seasons (49073.48 ind/m^3; 15219.17 ind/m^3; 10922.58 ind/m^3 and 17323.10 ind/m^3 in July 2020, October 2020, January 2021 and April 2021, respectively).

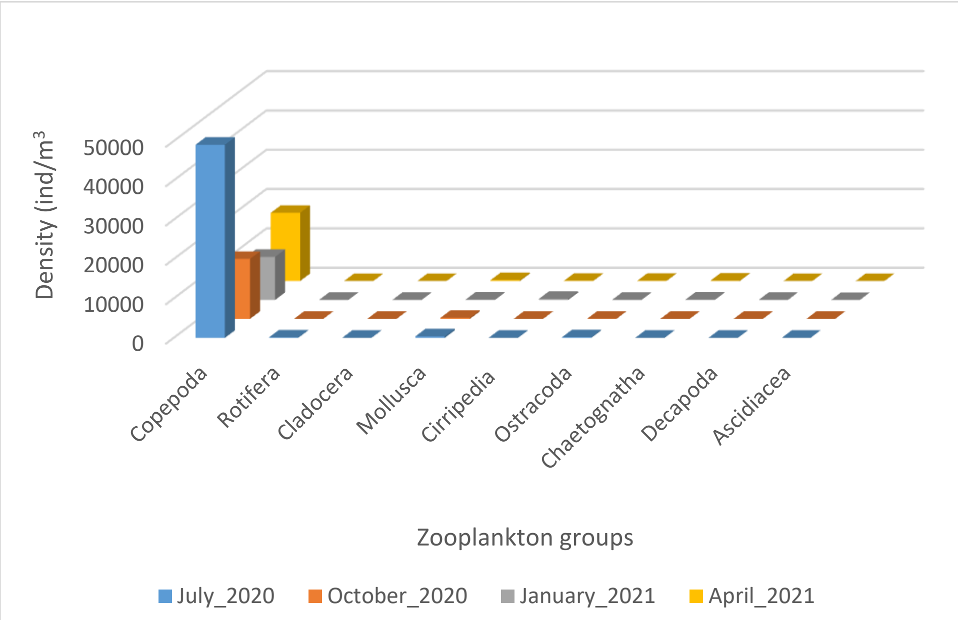

Figure 4: Temporal variation in zooplankton abundance in the port basin.

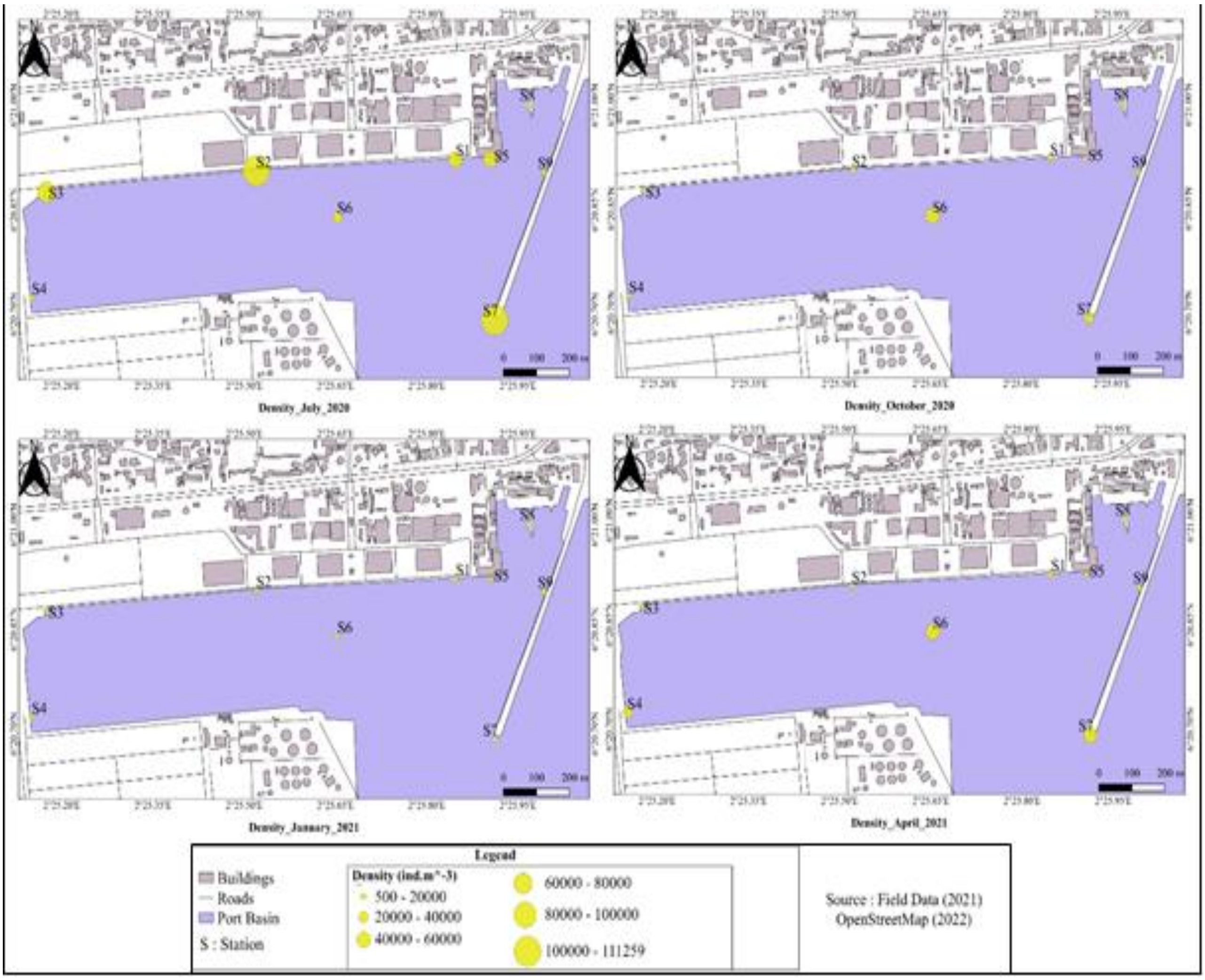

Figure 5: Spatial and temporal variation in zooplankton abundance in the port basin.

In July, the stations S7, S2 and S3 presenting respectively a density of 107451.97 ind/m^3; 76527.54 ind/m^3 and 111259.13 ind/m^3 are the richest in individuals while the stations S1, S5, S4, S6, S8 and S9 with a density of 47182.73 ind/m^3; 19535.58 ind/m^3; 43465.97 ind/m^3; 20954.48 ind/m^3; 3098.97 ind/m^3 and 17950.93 ind/m^3 respectively are the lowest in individuals. In October, stations S6, S7, S8 and S4 with a density of 44781.91 ind/m^3; 25100.67 ind/m^3; 15911.74 ind/m^3 and 19575.76 ind/m^3 respectively are the richest in individuals while stations S5, S3, S2, S1 and S9 with a density of 10595.27 ind/m^3; 9490.29 ind/m^3; 5715.77 ind/m^3; 5602.76 ind/m^3 and 3450.56 ind/m^3 respectively are the lowest in individuals. In January, stations S9, S1, S7, S3 and S5 with a density of 18327.63 ind/m^3; 15735.95 ind/m^3; 15386.87 ind/m^3; 15688.23 ind/m^3 and 11918.74 ind/m^3 are the richest in individuals while stations S6, S4, S2 and S8 having respectively a density of 8759.49 ind/m^3; 8611.33 ind/m^3; 6800.66 ind/m^3 and 1300.87 ind/m^3 are the lowest in individuals. In April, stations S6, S7, S3 and S4 with a density of 49483.1 ind/m^3; 43501.13 ind/m^3; 16092.56 ind/m^3 and 20803.8 ind/m^3 respectively are the richest in individuals while stations S1, S8, S2, S5 and S9 with a density of 11155.3 ind/m^3; 12340.64 ind/m^3; 3405.35 ind/m^3; 2538.95 ind/m^3 and 587.65 ind/m^3 respectively are the lowest in individuals.

4. Discussion

The zooplankton identified in the Autonomous Port of Cotonou basin during the period of the present study were grouped into 35 taxa in addition to nauplii and other copepods and then divided into 9 groups. This taxonomic richness is lower than that observed during several studies in the African Atlantic on the Ivorian continental shelf (52 taxa) by [26] and close to that observed during work on a part of the Gulf of Guinea on the Nigerian coast (36 taxa) by [27]. This low taxonomic richness of the zooplanktonic community in the present study compared to the other studies mentioned above could be linked to various reasons such as the difference in sampling stations, sampling methods, collection periods, and the mesh size of the nets used. According to [4] the application of different sampling methods leads to different results. Our sampling stations are located in the port basin which is more subject to the stresses of anthropogenic activities than the continental shelves. Our sampling method consisted in making a vertical haul over 5 meters in the water column with a net of 53µm mesh size, about 1 meter long and 26 cm in diameter at each sampling point. [26] used on the Ivorian continental shelf a cylindrical-conical net with an opening of 60 cm in diameter, 2.5 m long and 350 µm of mesh size by making a haul over 100 m. [27] used a plankton net of 55 µm mesh size attached to a vessel and dragged for 10 minutes at low speed. The methods used by these authors would allow to filter a larger volume of water and would increase the chance of having a wide range of organisms, which shows a weakness of our sampling that could explain our low taxonomic richness. According to [28], individuals can perform different types of vertical migrations such as ontogenic migrations. These migrations lead to an abundance of larval stages (which are difficult to identify) or adults at different times of the year at different depths in the water column. Sampling at several tens of meters depth in the water column increases the chances of having several stages and therefore more identifiable taxa. Also, our sampling periods during the day are not the same, a horizontal sampling of a large volume of water on the surface during a period when the adult stages are on the surface would allow to obtain a higher taxonomic richness than a sampling at depth of less than ten meters during a period when the adults are deeper. The weakness of our taxonomic richness, close to that of [27] study, could also be related to the fact that more than half of the taxa could not be identified to the specific level (especially the cyclopoid and calanoid copepods) in the framework of our study. The genetic identification approach would be very useful for more precise identifications for morphologically difficult to distinguish taxa. Of the 35 taxa identified during our study, 9 were identified to genus, 8 to order, one to subclass, 5 to class and 2 to phylum. Copepods were the most abundant group (97.97% of the total density). This dominance of copepods in the zooplanktonic community of the Cotonou port basin obtained in this study corroborates the results obtained in the literature review on the zooplankton of the neritic waters of the Atlantic Ocean at the level of the coasts of Ivory Coast (67%) [26]. This dominance of copepods is also observed in the eastern port of Alexandria in Egypt (81.97%) by and the port of Porto Montenegro in the Adriatic Sea by [4,29].

This group of crustaceans constitutes the most important element in abundance of zooplankton in any season and in any environment in the West African upwelling zone and even in Mediterranean marine waters [8,30]. Regarding the zooplanktonic community structure of the port basin, *Oithona* spp (20.02%), Calanoïda spp1 (8.32%), *Microsetella norvegica* (6.44%), Cyclopoïda sp2 (5.18%), Cyclopoïda spp (4.99%), *Euterpina acutifrons* (4.27%) constitute the main species of the zooplankton of the Cotonou port basin. The taxa Calanoïda spp1, Calanoïda spp2, Calanoïda spp3 represent several species of calanoids that could not be determined having respectively 3, four and 5 furcal setae. Taxa such as *Oncaea* spp, *Oithona plumifera*, *Oithona* spp, *Corycaeus* spp, *Acartia* spp, *Penilia avirostris, Temora turbinata, Temora stylifera, Euterpina acutifrons, Clytemnestra* sp, *Microsetella rosea*, *Microsetella norvegica*, *Macrosetella gracilis* observed during our study in the port basin, are among the main taxa of copepods found in the African Atlantic zooplankton [8]. They were found on the Ivorian and Nigerian coasts of the Gulf of Guinea [26,28].

The Copepods, Molluscs, Cirripedes, Ostracods, Chaetognaths, Decapods, and Cladocerans groups were the most seasonally frequent and Rotifers and Ascidians were the least frequent. These most frequent groups were also found in samples from on the Ivorian continental shelf and [26,27] in the Gulf of Guinea on the Nigerian coast. But the less frequent groups were not reported by these authors. However, according to [29-31], the presence of rotifers in an environment is characteristic of a eutrophied environment because they are indicators of organic pollution. Copepods were present at all stations during all seasons. The taxa *Oithona* spp and copepod nauplii were present at all stations during all seasons during our study. This predominance of the taxon *Oithona* spp. is similar to the observations of [29] in the port of Montenegro in the Adriatic Sea. It can be explained by the ability of this taxon to consume a variety of food compared to other copepods. With respect to spatial variation, the area grouping stations S9, S5 and S8 is, regardless of the period, the area including the station, the least rich in taxa and individuals. This zone corresponds to the area of the fishing port where several potential organic pollution sources are carried out. It seems to be less exposed to the renewal of the waters of the basin by the inflow of water from outside the port. This could explain the trend observed in the structure of the community in this area during our study. Station 3 is one of the richest stations in terms of taxa, whatever the period. It is the area least influenced by anthropic activities in the port basin during the study period. All this confirms the observations of [4,30] according to which, variations in environmental conditions induced naturally and by human activities lead to fluctuations in the distribution and assemblages of species. Concerning the temporal variation, the highest taxonomic richness of copepods was observed during this study in October and April, which are thermocline months. As for the lowest, they were observed during the months of July and January, which constitute the months of Upwellings. But when considering the overall taxonomic richness, this trend is no longer observed: the highest in October and January and the lowest in July and April. This observation corroborates [9] that the species richness is lower during Upwelling periods than during thermocline periods, but this effect may be masked by meroplanktonic taxa. The highest abundance during our study was observed in the month of July, which is the major upwelling period in the Gulf of Guinea. This observation agrees with that of [9] which reports that during the Upwelling period, zooplankton is more abundant. But the same observation is not made during the minor upwelling period in January. The second peak in zooplankton abundance is instead observed during the April thermocline period during our study in the port basin. This is contrary to the statement of [9]. Other variations in environmental conditions induced by human activities may be responsible for these fluctuations.

5. Conclusion

The knowledge of the biodiversity of the port basin is important for the evaluation of the state of this marine ecosystem and its protection. This work provides a first faunistic list and the structure of the zooplanktonic community of the Cotonou port basin in Benin, thus contributing to the inventory of the zooplanktonic community of the Gulf of Guinea in Benin. This study allowed us to identify 35 taxa in total. This community is largely dominated by copepods (97% of the abundance). The main taxon of the stand in terms of abundance is *Oithona* spp. (20% of the total abundance). Although the results obtained are interesting, it is necessary to consider a regular monitoring of the environment by using genetics for identifications at specific levels.

Acknowledgements

Our thanks go to the Autonomous Port of Cotonou for having given us the authorization and having facilitated our sampling campaigns in the basin.

References

[1] D. Adandedjan, E. Makponse, L. Hinvi, and P. Laleye. “Preliminary data on the diversity of the zooplankton of Lake Nokoue (South Benin).” *Journal of Applied Biosciences*, vol. 115, pp. 11476–11489, 2017.

[2] A. M. Houssou, E. Montchowui, and C. A. Bonou. “Composition and structure of zooplankton community in ouémé river basin, republic of Benin.” *Journal of Entomology and Zoology Studies*, vol. 5, no. 6, pp. 336–344, 2017.

[3] H. H. Akodogbo, C. A. Bonou, and E. D. Fiogbe. “Effet de la fertilisation à base des déjections de porc sur la production du zooplancton.” *International Journal of Biological and Chemical Sciences*, vol. 8, no. 6, pp. 2721–2730, 2014.

[4] A. F. Mansour, N. A. El-Naggar, H. A. El-Naggar, H. Y. Zakaria, and Fekry M Abo-Senna. “Temporal and spatial variations of zooplankton distribution in the Eastern Harbor, Alexandria, Egypt.” *Egyptian Journal of Aquatic Biology and Fisheries*, vol. 24, no. 4, pp. 421–435, 2020.

[5] S. M. S. Shaikh, J. P. Tagde, P. R. Singh, S. Dutta, L. N. Sangolkar, and M. S. Kumar. “Impact of Port and port activities on plankton distribution and dynamics: A multivariate approach.” *Marine Pollution Bulletin*, vol. 165, p. 112105, Apr. 2021, doi: 10.1016/j.marpolbul.2021.112105.

[6] C. Gaonkar, S. Sawant, A. Anil, K. Venkat, and S. Harkantra. “Mumbai port, India: gateway for introduction of marine organisms.” *Environmental monitoring and assessment*, vol. 163, no. 1, pp. 583–589, 2010.

[7] A. M. Houssou, R. Yaovi, S. A. Montcho, C. A. Bonou, and E. Montchowui. “Diversity and seasonal variation of zooplankton of Lake Hlan, Republic of Bénin (West Africa).” *Journal of Applied Biosciences*, vol. 102, pp. 9723–9737, 2016.

[8] A. Thiriot, “Zooplankton Communities in the West African Upwelling Area,” in *Upwelling Ecosystems*, Berlin, Heidelberg: Springer Berlin Heidelberg, 1978, pp. 32–61. doi: 10.1007/978-3-642-

66985-9_5.

[9] G. Wiafe, H. B. Yaqub, M. A. Mensah, and C. L. J. Frid. "Impact of climate change on long-term zooplankton biomass in the upwelling region of the Gulf of Guinea." *ICES Journal of Marine Science*, vol. 65, pp. 318–324, 2008.

[10] H.-J. Dossou, N. Adjovi, G. Houéménou, T. Bagan, G.-A. Mensah, and G. Dobigny. "Invasive rodents and damages to food stocks: a study in the Autonomous Harbor of Cotonou, Benin." *Biotechnologie, Agronomie, Société et Environnement/Biotechnology, Agronomy, Society and Environment*, vol. 24, no. 1, pp. 28–36, 2020.

[11] Autonomous Port of Cotonou. *GUIDE OFFICIEL - Port Autonome de Cotonou*. 2017.

[12] E. K. Dovlo. "Seasonal Variations in Temperature and Salinity in the Gulf of Guinea." *Journal of Aquaculture & Marine Biology*, vol. 4, no. 2, pp. 1–6, 2016, doi: http://dx.doi.org/10.15406/jamb.2016.04.00074.

[13] J. B. J. Wells. "Copepoda - I : Sub-order Harpacticoida." *Zooplankton*, vol. Sheet 133, pp. 1–7, 1970, doi: 10.17895/ICES.PUB.5108.

[14] M. Issanga N'gamissimi. *Clé de détermination des chaetognathes planctoniques de l'Atlantique équatorial et tropical africain*. 1975.

[15] B. H. Dussart. "Copépodes," in *Flore et faune aquatiques de l'Afrique sahélo-soudanienne*, 1980, pp. 333–356.

[16] R. Pourriot. "Rotifères," in *Flore et faune aquatiques de l'Afrique sahélo-soudanienne*, vol. 53e année, 1980, pp. 219–244.

[17] J. A. McLelland. "An Illustrated Key to the Chaetognatha of the Northern Gulf of Mexico with Notes on their Distribution." *Gulf Research Reports*, vol. 8, pp. 145–172, 1989, doi: https://doi.org/DOI: 10.18785/grr.0802.07.

[18] F. Y. Al-Yamani, V. Skryabin, A. Gubanova, S. Khvorov, and I. Prusova. *Marine zooplankton: practical guide for the northwestern Arabian Gulf.* Kuwait: Kuwait Institute for Scientific Research, 2011.

[19] J. H. Hecq, A. Collignon, and A. Goffart. *Atlas du zooplancton des eaux côtières corses, version du 04/06/2014. Travail de synthèse réalisé à la demande de l'Agence de l'Eau RMC*. France: Agence de l'Eau RMC, 2014.

[20] D. V. P. Conway. *Marine zooplankton of southern Britain. Part 3: Ostracoda, Stomatopoda, Nebaliacea, Mysida, Amphipoda, Isopoda, Cumacea, Euphausiacea, Decapoda, Annelida, Tardigrada,*

Nematoda, Phoronida, Bryozoa, Entoprocta, Brachiopoda, Echinodermata, Chaetognatha, Hemichordata and Chordata. United Kingdom: Marine Biological Association of the United Kingdom, 2015.

[21] M. G. Mazzocchi. "Oithona Baird, 1843," *ICES Identification Leaflets for Plankton*, no. 188, p. 16 p, 2019, doi: http://doi.org/10.17895/ices.pub.5254.

[22] I. Di Capua. "Temora Baird, 1850," *ICES Identification Leaflets for Plankton*, no. 195, p. 17 pp, 2021, doi: http://doi.org/10.17895/ices.pub.7719.

[23] COL. "The Catalogue of Life." Internet: https://www.catalogueoflife.org/, 2021. (accessed Jan. 03, 2022).

[24] WoRMS Editorial Board. "WoRMS - World Register of Marine Species." Internet: https://www.marinespecies.org/, 2022. (accessed Jan. 03, 2022).

[25] R. Dajoz, *Précis d'ecologie*. Paris: Bordas, 1985.

[26] N. M. Aka, R. N. Etile, T. Joany, and K. N'Da, "Peuplement zooplanctonique du plateau continental ivoirien: diversité, abondance et biomasse." *International Journal of Biological and Chemical Sciences*, vol. 12, no. 1, pp. 129–140, 2018.

[27] T. A. Adesalu, O. A. Kunrunmi, and M. O. Lawal, "Water quality assessments: A case study of plankton and macrobenthic invertebrates of Porto-Novo and parts of Gulf of Guinea." *Journal of Aquatic Sciences*, vol. 31, no. 1, Art. no. 1, May 2016, doi: 10.4314/jas.v31i1.4.

[28] D. Binet, "Le zooplancton du plateau continental ivoirien. Essai de synthèse écologique." *Oceanologica. Acta*, vol. 2, no. 4, pp. 397–410, 1979.

[29] B. Pestorić, D. Drakulović, M. Mandić, and M. C. López Abbate, "Distribution changes of plankton communities in the port Porto Montenegro (South Adriatic Sea)." *Studia Marina*, vol. 31, no. 2, pp. 5–31, 2018.

[30] H. Y. Zakaria, M. A. Hassan, H. A. El-Naggar, and F. M. Abou-Senna, "Abundance, distribution, diversity and zoogeography of epipelagic copepods off the Egyptian Coast (Mediterranean Sea)." *Egyptian Journal of Aquatic Research*, vol. 42, no. 4, pp. 459–473, 2016.

[31] A. M. Heneash, H. R. Tadrose, M. M. Hussein, S. K. Hamdona, N. Abdel-Aziz, and S. M. Gharib, "Potential effects of abiotic factors on the abundance and distribution of the plankton in the Western Harbour, south-eastern Mediterranean Sea, Egypt." *Oceanologia*, vol. 57, pp. 61–70, 2015.