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Structure of Zooplankton Communities in Tropical Shipping Waters (Mellacorea, Guinea, West Africa)

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Abstract: In West Africa, the intensification of human pressures, combined with strong seasonal hydrological variability, influences the functioning of estuarine and lagoon systems. This study aims to analyze the combined effect of human activity and hydrological dynamics on the spatial and seasonal variability of zooplankton communities in the navigable waters of Mellacorea in Guinea. Zooplankton samples were collected along an anthropogenic pressure gradient during the rainy season using a plankton net (60 µm mesh). Environmental parameters (temperature, salinity, turbidity, dissolved oxygen, pH, and nitrates) were measured in situ. Community structure was characterized using diversity, species richness, and abundance indices. The results reveal marked monthly variability in zooplankton abundance and composition, primarily linked to hydrological fluctuations. Twenty taxa were identified, with a clear dominance of copepods (89%), with Calanoida predominating (39%). The rainy season is characterized by an increase in taxonomic diversity and abundance. Salinity, turbidity, pH, dissolved oxygen, and transparency significantly influence community distribution and structure. The hydrological conditions, marked by heavy rainfall and a relatively flat coastal topography, favor a stable dynamic, with a notable influence of the marine regime in the estuarine zone. The structuring of zooplankton communities in Mellacorea results from the interaction between seasonal hydrodynamics and anthropogenic pressures. Compared to other West African estuarine systems, Mellacorea exhibits a moderate level of disturbance while maintaining resilience. This study provides essential baseline data for Guinean coastal ecosystems and underscores the importance of long-term monitoring to anticipate the impacts of coastal development and climate variability. It also provides scientific support for the sustainable management of floodplains and port infrastructure, particularly the mining port of Konta.

Key words: Zooplankton, anthropogenic pressure, seasonal hydrodynamics, spatial variability, coastal ecosystems, Guinea, West Africa.

1. Introduction

Global population growth, estimated at nearly 9.5 billion by 2050, is accompanied by an intensification of human activities and increased pressure on natural resources, particularly aquatic ecosystems [1-3]. In developing countries, rapid urbanization, industrialization, and the expansion of agricultural activities contribute to increased discharges of domestic and industrial wastewater, often released without adequate treatment into aquatic environments, leading to a progressive degradation of water quality, habitat alteration, and biodiversity loss [4, 5].

The Mellacorée River, located in the Forécariah prefecture of the Republic of Guinea, illustrates this problem. Initially used as a source of drinking water, this river system is now subject to multiple pressures, including population growth, urban expansion, domestic wastewater discharge, the use of agricultural inputs, and the development of port activities related to mineral transport. These pressures can degrade water quality and affect fish stocks, which are essential for local populations dependent on artisanal fishing. The river flows into Tabounsou Bay, a coastal ecosystem that plays a key role in regional trophic dynamics [6].

In this context, zooplankton occupies a central position in aquatic food webs. As primary consumers

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of phytoplankton and prey for higher trophic levels, they ensure the transfer of matter and energy within ecosystems [7-9]. Their high sensitivity to variations in environmental conditions (temperature, salinity, nutrients, dissolved oxygen) makes them excellent bioindicators of ecological disturbances, particularly those related to eutrophication and pollution [10-12]. Changes in the structure of zooplankton communities, such as the dominance of certain groups or the reduction of species diversity, often reflect ecological imbalances induced by human activities.

Furthermore, physicochemical parameters play a crucial role in the distribution and dynamics of aquatic organisms. Variations in salinity, turbidity, pH, dissolved oxygen, and nutrients influence the composition, abundance, and diversity of zooplankton communities [13-16]. The combined analysis of these parameters and biological communities thus allows for a better understanding of the mechanisms structuring aquatic ecosystems.

Despite the ecological and socio-economic importance of Guinea's coastal systems, data on the structure and dynamics of zooplankton communities in shipping waters remain limited, particularly in the Mellacoree region. This scientific gap hinders the implementation of appropriate sustainable management strategies.

This study aims to analyze the composition, structure, and spatio-temporal variability of zooplankton communities in the navigable waters of Melcorea, highlighting the combined role of seasonal hydrodynamics and anthropogenic pressures. More specifically, it seeks to (i) characterize zooplankton diversity and abundance, (ii) assess the influence of environmental parameters on their distribution, and (iii) provide baseline data for improved management of Guinean coastal ecosystems.

2. Materials and Methods

2.1 Study Area

The study was conducted in the Mellacorée River, located in the Forécariah Prefecture of the Republic of Guinea. This region is characterized by a low-lying coastal landscape, crisscrossed by numerous watercourses. The Mellacorée River is part of the coastal watershed and extends for approximately 50 km, covering a basin area of about 1,049 km².

Geographically, the study area is located around latitude 9°07′39″ N and longitude 13°17′58″ W. The river originates at the foot of the foothills of the Kindia highlands and flows into Tabounsou Bay, forming a transitional estuarine system influenced by both freshwater inputs and marine conditions (Fig. 1).

Sampling was carried out at eight stations distributed along the river continuum during the rainy season, a period characterized by high freshwater flow and significant hydrological variability. These stations were selected to represent different levels of anthropogenic influence (nutrients) as well as the environmental gradients present in the study area.

2.2 Materials for Studying Environmental Variables

The equipment used for zooplankton collection included cylindro-conical plankton nets (Hydro-Bios plankton net model), with a diameter of 30 cm at the opening and a total length of 3 meters. These nets, made of 64 µm mesh silk, are commonly used for microzooplankton sampling (UNESCO (United Nations Educational, Scientific and Cultural Organisation) Zooplankton Sampling Manual).

The samples were preserved in 50-100 ml pill bottles and fixed with 5% formalin, a classic method for preserving the morphological structures of planktonic organisms [17]. Identification and enumeration were performed using a Dollfus tank and a Leica M250C stereomicroscope at 10x and 50x magnifications, supplemented by optical zoom. This approach is widely recommended for the morphological analysis of zooplankton (Marine Plankton: A Practical Guide).

Environmental parameters (temperature, salinity, dissolved oxygen, conductivity, turbidity, and pH) were measured using Hanna Instruments portable multiparameter meters (type HI) equipped with probes.

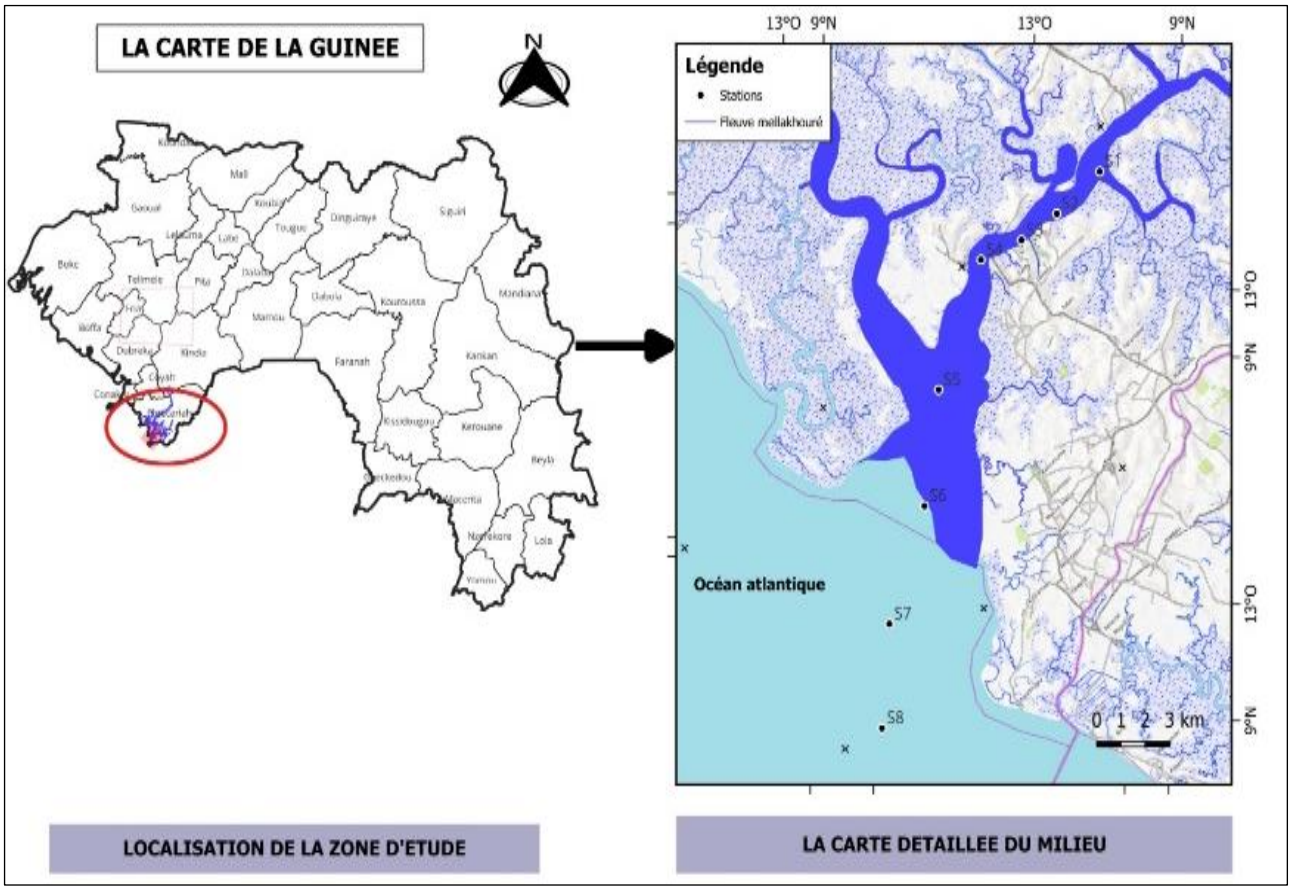

Fig. 1 Map of the study area and sampling stations.

Calibration was performed using a rapid field method, supplemented by detailed calibration for certain critical parameters such as pH and turbidity to improve measurement accuracy [18].

2.3 Methodology

2.3.1 Zooplankton Sampling and Identification

The biological material studied consists of zooplankton collected from the Mellacorea River. Sampling was carried out from May to October 2021, covering the entire rainy season, between 7 a.m. and 6 p.m., at the various study stations.

Zooplankton was collected using a 60 µm mesh plankton net, along a vertical line drawn from the bottom to the surface. Zooplankton organisms were identified using reference taxonomic keys [19, 20] for copepods, and for cladocerans [21]. The organisms were counted to estimate their abundance.

The data obtained allowed the calculation of several biological descriptors, including taxonomic richness, density (ind/m³), and diversity indices. Frequency of occurrence (F) was determined according to the formula

$$F = \frac{S_i}{S_t} x100 \quad (1)$$

where Si represents the number of samples in which taxon i is present and St the total number of samples.

2.3.2 Measurement of Environmental Characteristics

The physicochemical parameters of the water were measured simultaneously with biological samples throughout the study period. Temperature (°C), pH, conductivity (µS/cm) and dissolved oxygen (mg/L) were measured in situ using a multiparameter meter.

The transparency of the water was estimated using a Secchi disk.

Nutrient analysis, particularly for nitrates (NO3-), was performed on surface water samples (250 mL)

collected in polyethylene bottles. Each sample was kept in a cooler at a low temperature until laboratory analysis.

Nutrient concentrations were determined using a multiparameter photometer, according to standard methods including filtration, chemical reactions and colorimetric measurements.

2.3.3 Data Analysis and Statistics

The structure and dynamics of zooplankton communities were assessed using several ecological indicators, including taxonomic richness, density, frequency of occurrence, and diversity indices.

Shannon diversity index (H') and evenness (E) were used to characterize species distribution within communities.

The frequency of occurrence (F) was calculated using the following formula:

$$F = \frac{S_i}{S_t} x100$$

The taxa were classified according to their frequency of occurrence, following the classification of Dajoz (2000):

F ≥ 50%: constant (or persistent) taxa;

25% ≤ F < 50%: accessory taxa; and

F < 25%: accidental taxa.

A Pearson correlation analysis was applied to assess the relationships between environmental factors (temperature, salinity, turbidity, dissolved oxygen, pH and nutrients) and zooplankton descriptors (abundance, diversity indices and taxonomic richness).

A PCA (principal component analysis) was carried out to identify the main environmental gradients structuring the study area and to explore the distribution patterns of sampling stations according to their physico-chemical characteristics.

In addition, regression analyses were performed to assess the influence of key environmental variables on zooplankton abundance and diversity.

Finally, a classification analysis (hierarchical classification using Ward's method) was applied to group sampling stations according to similarities in zooplankton community composition and environmental conditions.

3. Results

3.1 Species Richness of Zooplankton Families

Twenty species have been identified, distributed among 10 families and various orders, including Calanoides, Paracalanidae, Eucalanidae, Oithonidae, Temoridae, Cyclopides, and Sapphirinidae. The Calanidae and Paracalanidae families exhibit the greatest diversity, with four species each, representing 39.27% and 22.19% of the species richness, respectively. The Eucalanidae, Oithonidae, Sididae, Chetognathes, Centropagidae, and Cyclopidae families contribute the remaining proportions (Table 1).

The number of species varies from 3 to 15 species across stations (Table 2). Maximum species abundances were recorded at stations 8, 6 and 7.

3.2 Quantitative Analysis of the Population

The zooplankton assemblage of the Mellacorea River is numerically dominated by copepods, representing 88.98% of the relative frequency, followed by cladocerans (6.62%) and other zooplanktonic organisms (4.41%) (Table 1). Among the copepods, the most abundant species are *Nannocalanus minor* (18.31%), *Paracalanus parvus* (14.54%), *Calanus minor* (11.24%), *Oithona nana* (6.52%), *Eucalanus minor* (6.52%), another specimen of *Eucalanus minor* (6.14%), and *Clausocalanus furcatus* (6.04%). The cladoceran population is mainly represented by *Penilia avirostri* (3.42%).

Spatiotemporal fluctuations reveal a clear dominance of copepods with an average abundance of 377.43 individuals/m³. Cladocerans and other taxa have average abundances of 224.59 and 149.73 individuals/m³, respectively. The highest zooplankton abundance was observed at Station 8 (1,825.39 individuals/m³), followed by Station 6 (1,694.28 individuals/m³), while Station 1 had the lowest density (70.60 individuals/m³) (Fig. 2). Biological diversity is particularly low at

Table 1 Composition of the zooplankton community recorded in the Mellacorée River in 2021.

Groups	Families	Taxon	Mellacorea (ind/m^3)	% Occurrence	(%) Frequencies
Copepods	Calanidae	*Clausocalanus furcatus*	410,266	30.55	6,044
		Calanus minor (Claus, 1863)	762,622	44.44	11,235
		Nannocalanus minor (Claus, 1863)	1,243,027	66.66	18,313
	Eucalanidae	*Calanus gracilus (Dana, 1849)*	249,635	23.61	3.68
		Eucalanus minor (Claus, 1863)	418,235	33.33	6,161
		Eucalanus elongatus (Dana, 1849)	388,067	27.77	5.72
	Paracalanidae	*Paracalanus parvus (Claus, 1863)*	989,326	48.61	14.58
		Paracalanus indicus	67,251	4.86	0.99
		Paracalanus scotti	354,466	27.77	5,222
		Paracalanus aculeatus	94,935	6.94	1,398
	Oithonidae	*Oithona plumifera*	63.72	2.08	0.938
		Oithona nana (Giesbrecht, 1892)	442,524	34.72	6,519
	Temoridae	*Temora stylifera (Dana, 1849)*	92.06	6.94	1,356
	Sapphirinidae	*Sapphirina sp*	176,964	6.94	2,607
	Cyclopidae	*Afrocyclops sp*	86.64	4.16	1.28
	Centropagidae	*Centropages furcatus (Dana, 1849)*	199,144	12.5	2,933
Cladocera	Sidida	*Daphnia pulex*	217.08	1.38	3,198
		Penilia avirostis	232,101	17.36	3,419
Others organizations	Chetognath	*Sagitta hispida (Conant, 1895)*	274,256	25	4 04
		Sagitta minima (Grassi, 1881)	25,204	1.38	0.371
Total	10	20	6,787,523		100.00

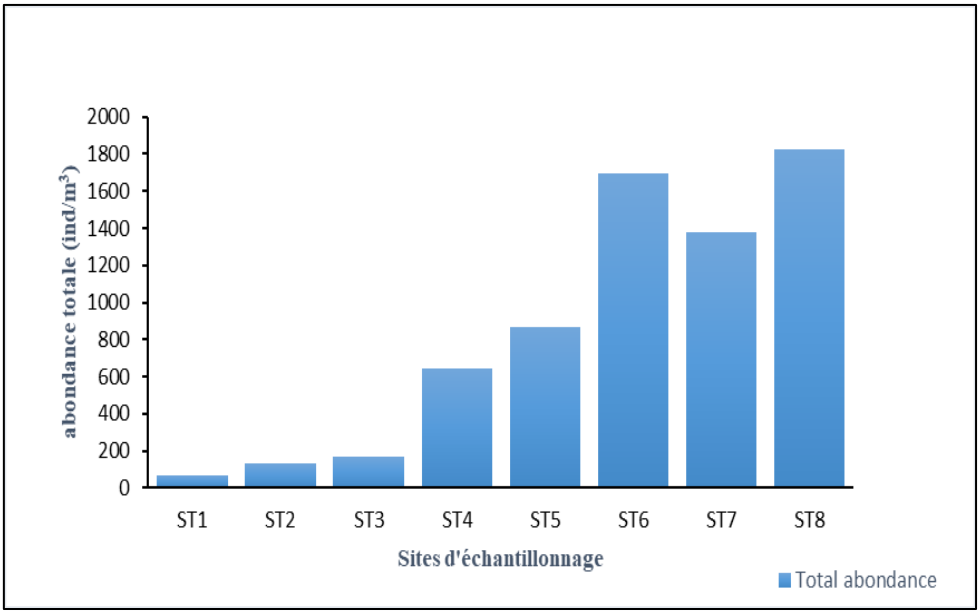

Fig. 2 Total abundance per sampling site in the Mellacoree River in 2021.

oligohaline stations (Stations 1, 2, and 3), with only four species recorded, while an increase in diversity is observed downstream, due to the increased presence of certain copepods.

3.3 Diversity and Equity Index

The Shannon index (H') obtained is 0.998, with an evenness (E) of 0.333. The theoretical maximum for 20

species is H'max = ln(20) ≈ 2.996. Although the species richness is high, the actual diversity is low and the distribution of individuals is uneven, with some species largely dominating the community (*Nannocalanus minor, Paracalanus parvus, Calanus minor,* and *Oithona nana*), while others are in the minority (< 2%) (Fig. 3).

Shannon's and Pielou's fairness indices show significant variations between stations: H' varies from 1.860 (Station 4) to 0.209 (Station 2), and fairness from -1.565 (Station 2) to 0.704 (Station 5) (Table 2). These results indicate:

Stations 1 and 2: low biodiversity with a dominance of limited species.

Station 3: moderate diversity but uneven distribution.

Stations 4 and 5: high and relatively balanced biodiversity.

Station 6: low biodiversity.

Station 7: high biodiversity with reduced dominance.

Station 8: moderate diversity but not a completely balanced community.

This graph shows that certain species such as *Nannocalanus minor* (14.1%), *Paracalanus parvus* (12.6%), *Calanus minor* (10.5%) and *Oithona nana* (9.4%) dominate, while several other species are very much in the minority (< 2%).

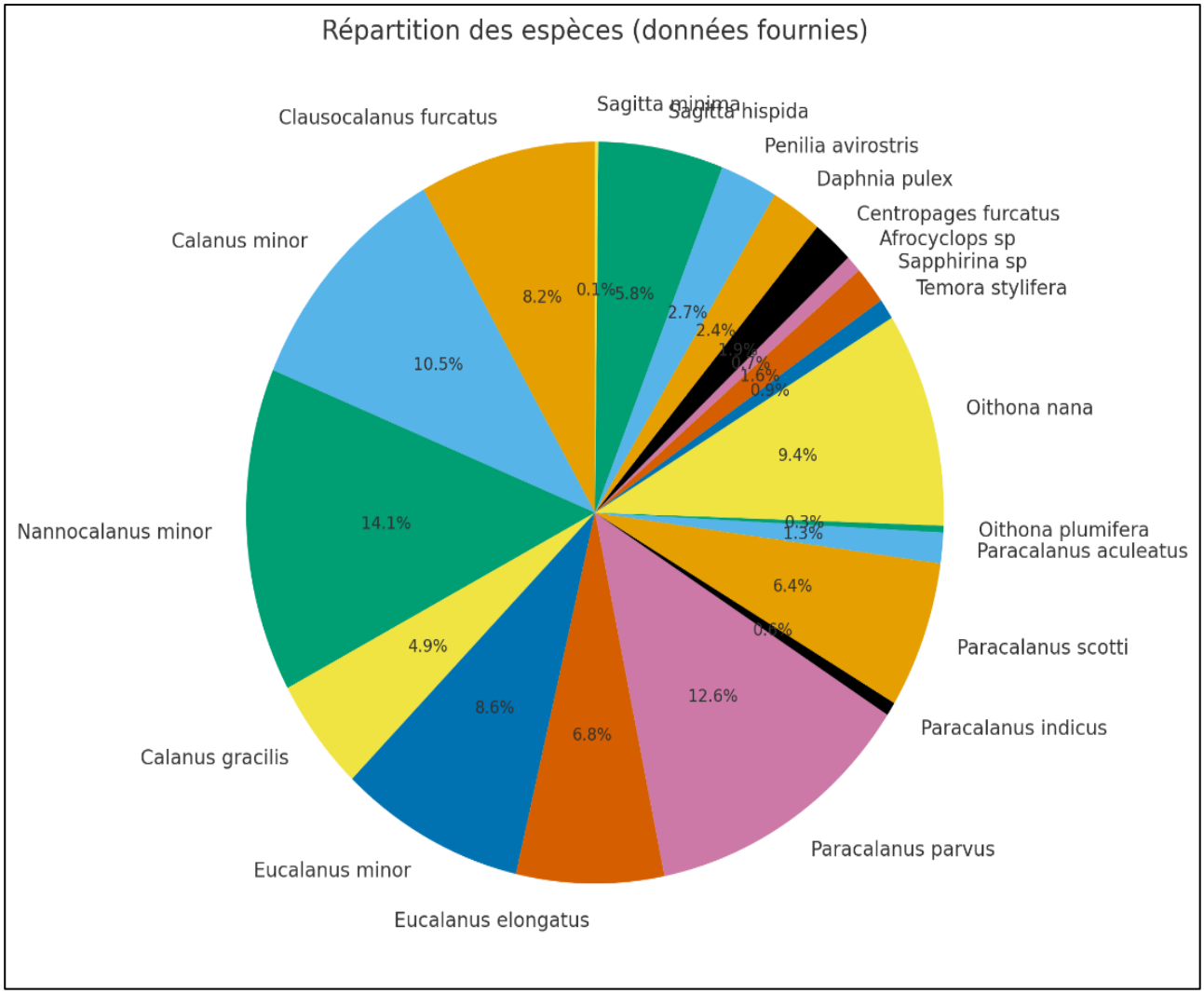

Fig. 3 Distribution of zooplankton species in the Mellacorea River in 2021.

Table 2 Variation in taxonomic richness and diversity indices of the zooplankton community with Mellacorea.

Environments / Diversity indices	St 1	St 2	St 3	St 4	St 5	St 6	St 7	St 8
Specific richness	3	3	4	9	11	14	14	15
Shannon index (H)	0.636	0.209	1.034	1.860	2.022	0.522	1.535	1.349
Fairness index	-0.452	-1.565	0.033	0.620	0.704	-0.650	0.428	0.299

Table 3 Seasonal average values of the main physico-chemical parameters at the stations.

Stations	T (°C)	pH	Oxy. (mg/L)	Salinity (g/l)	Turb. (NTU)	NO3- (µg/l)	Transp.
St 1	28.3	6.69	4 3	0.38	12	0.15	2.1
St 2	27	6.77	494	0.46	19.7	1.3	2
St 3	27.4	7.01	5.44	1.5	21.5	2	1.8
St 4	26.6	7.18	5.65	18.66	32.3	18.2	1.75
St 5	26.71	7.27	6.35	19.7	28.6	1.6	1.4
St 6	27	7.44	5.7	24.3	29.6	0.2	1.7
St 7	27.1	7.07	5.28	20.1	35.2	0.5	1.65
St 8	26.82	7.43	5.58	19.82	32.7	1.7	1.65
Average	27.11	7.10	5.40	13.11	26.45	3.20	1.75

3.4 Variation in Taxonomic Richness and Zooplankton Community Diversity Indices

The parameters associated with the Shannon diversity index and the Pielou equity index show a maximum of 1.860 (Station 4) to a 0.209 (Station 2); for the equity index, the variation was observed between -1.565 (Station 2) and 0.704 (Station 5) (Table 2).

Shannon's H-index quantifies biodiversity by assessing both species richness and abundance distribution. A relative comparison with equity values (Table 2) suggests that Station 1 exhibits a low level of biodiversity, characterized by the predominance of a limited number of species within the community.

Station 2 exhibits a distinctly low diversity, characterized by the overwhelming prevalence of a single species, indicative of a severely impoverished community.

Station 3 exhibits a moderate level of diversity, encompassing several species; however, their distribution remains particularly uneven.

Station 4 reveals a high level of biodiversity, which is correlated with a commendable wealth associated with a relatively equitable distribution between the species present.

Station 5 offers an exceptional level of diversity, marked by rich and balanced communities.

Station 6 illustrates a low level of biodiversity, which approaches the threshold of extremely low diversity.

Station 7 exhibits a high level of diversity, with several species well represented and showing reduced dominance.

Finally, Station 8 presents a moderate level of diversity for a relatively diverse, but not totally balanced, community.

3.5 Physico-Chemical Characterization of the Stations

The abiotic parameters of the Mellacoree River exhibit spatial and temporal variability influenced by human activities (agriculture, mining, and deforestation). The mean sea surface temperature was 27.1 °C (26.6-28.3 °C), the mean pH was 7.10 (6.69-7.44), the mean dissolved oxygen was 5.40 mg/L (4.3-5.7 mg/L), the mean salinity was 13.11 g/L (0.38-24.3 g/L), the turbidity ranged from 12 to 35.2 NTU, and the mean transparency was 1.75 m. Nitrate concentrations showed little spatial variation, except at Station 4 in July (19.4 µg/L), likely related to local agricultural activity (Table 3, Figs. 4-10).

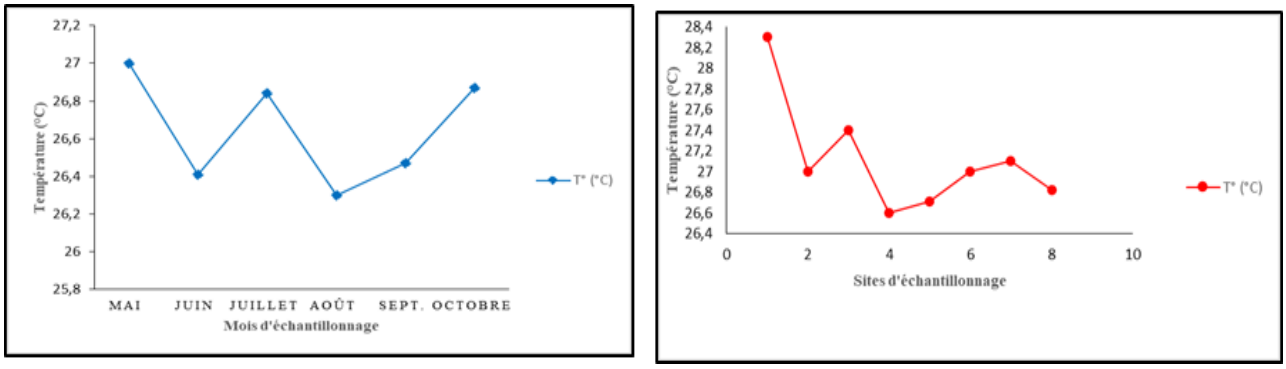

Fig. 4 Spatio-temporal variation of temperature in the Mellacoree River.

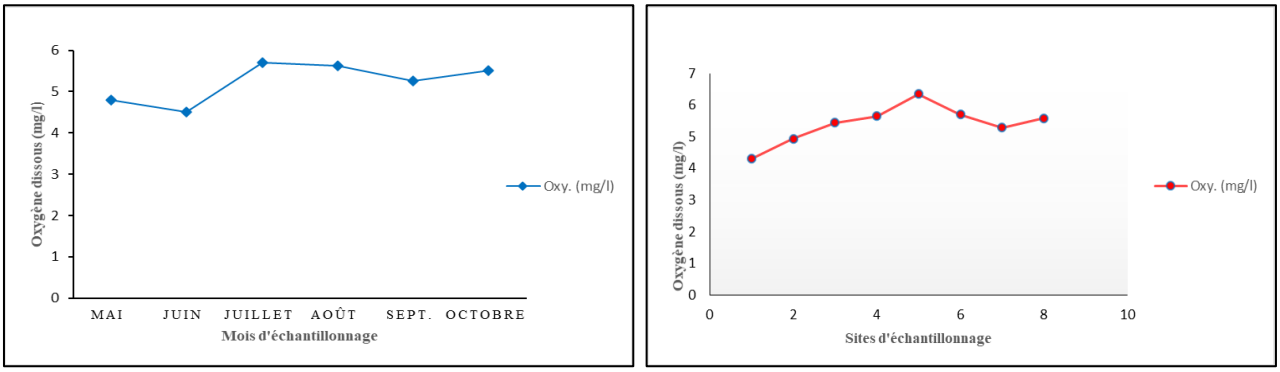

Fig. 5 Spatio-temporal variation of dissolved oxygen in the Mellacoree River.

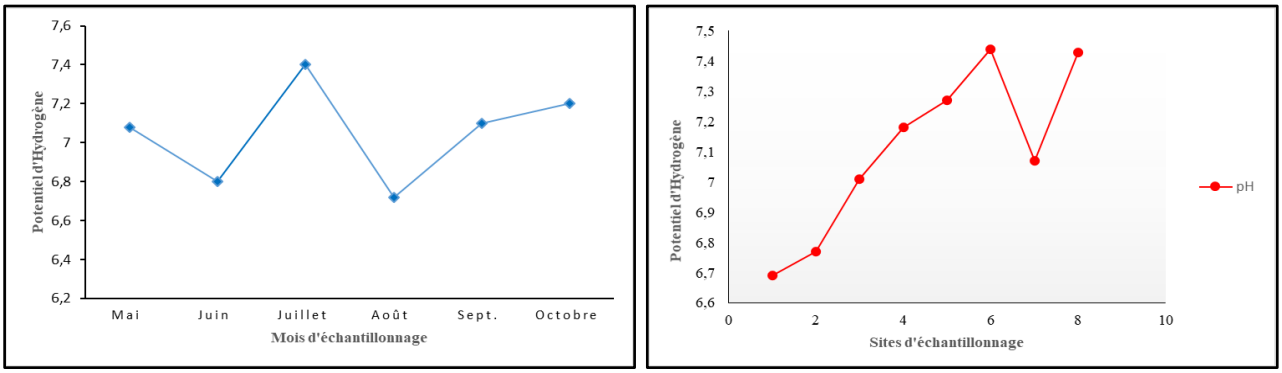

Fig. 6 Spatio-temporal variation of the hydrogen potential in the Mellacoree River.

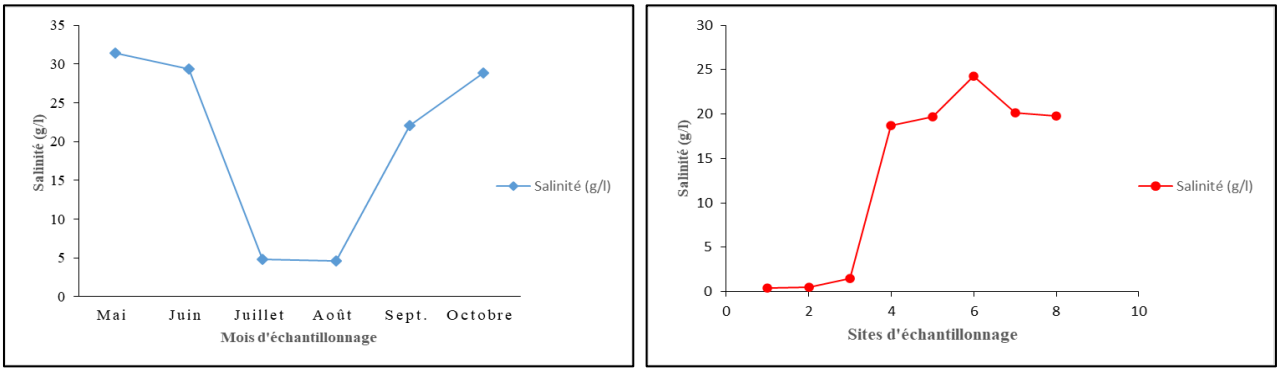

Fig. 7 Spatio-temporal variation of salinity in the Mellacoree River.

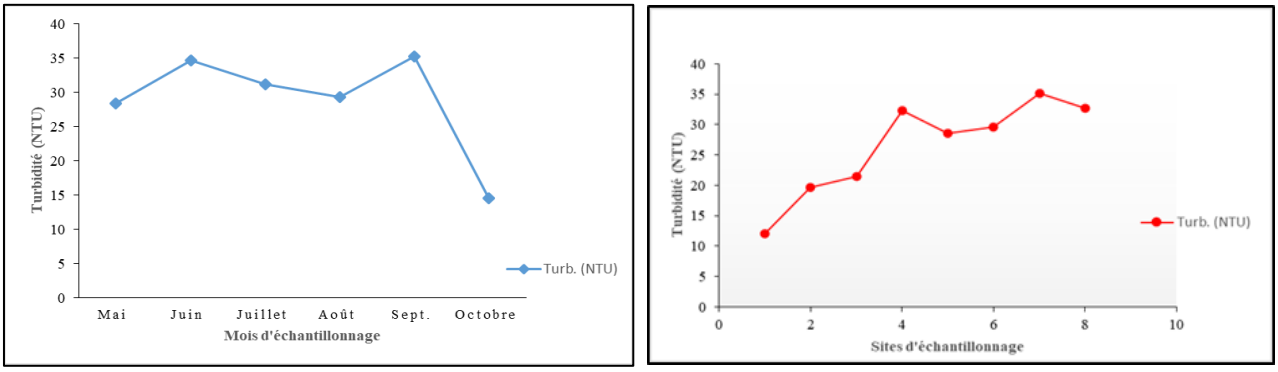

Fig. 8 Spatio-temporal variation of turbidity in the Mellacoree River.

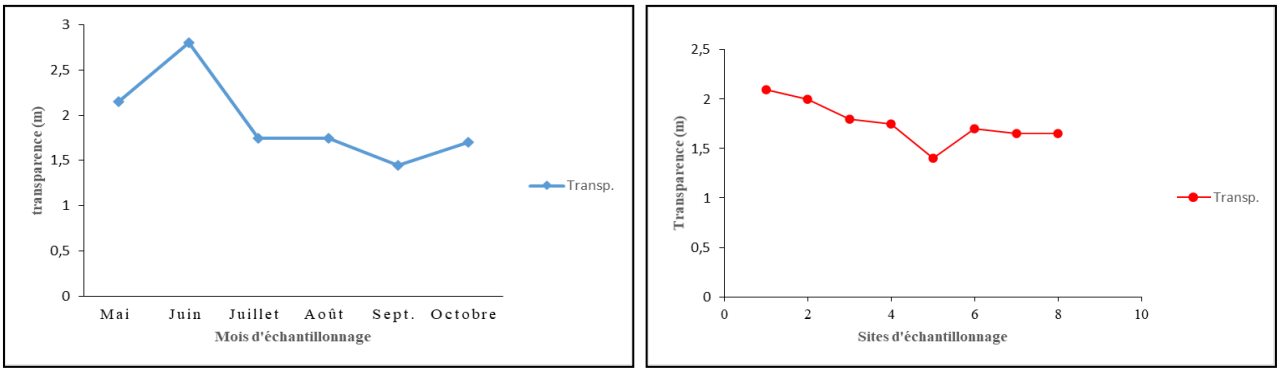

Fig. 9 Spatio-temporal variation in the transparency of the Mellacoree River.

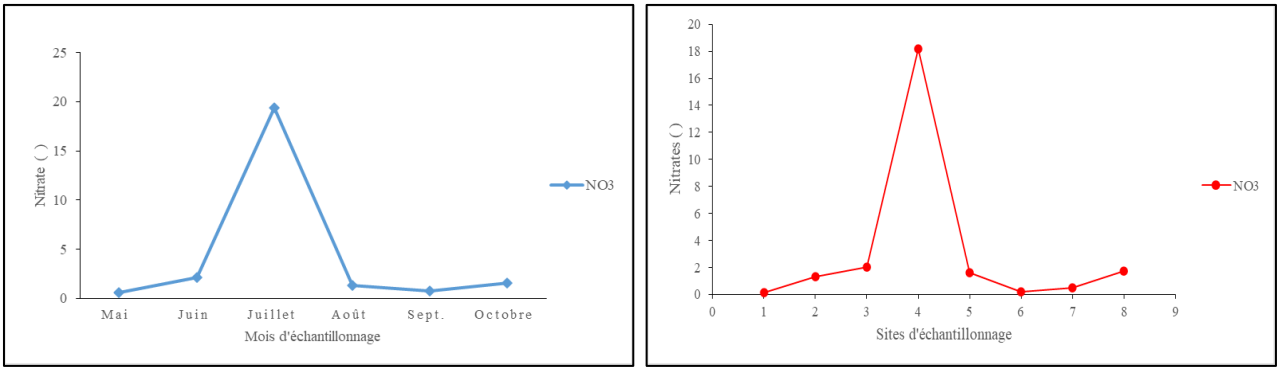

Fig. 10 Spatio-temporal variation of Nitrate in the Mellacoree River.

3.6 Impact of Environmental Variables on the Distribution of Zooplankton Populations

Statistical analysis using Pearson's test and principal component analysis (PCA) shows that the first two axes explain 85.43% of the total variance. Axis 1 (69.91%) and Axis 2 (15.51%) reflect the major influence of the variables pH, salinity, dissolved oxygen, and turbidity on the distribution of organisms (Fig. 11). In this analysis, two groups of stations were distinguished:

Group 1 (Stations 5, 6, 7, 8: species rich, associated with high values of pH, salinity, oxygen and turbidity, and correlated with the density of dominant copepods), and Group 2 (Stations 1, 2, 3: rare species, low diversity and higher transparency), with Station 4 being affected by organic effluents (NO_3^-).

These results show that the structuring of zooplankton communities in the Mellacorea River is strongly modulated by physico-chemical gradients and anthropogenic influence.

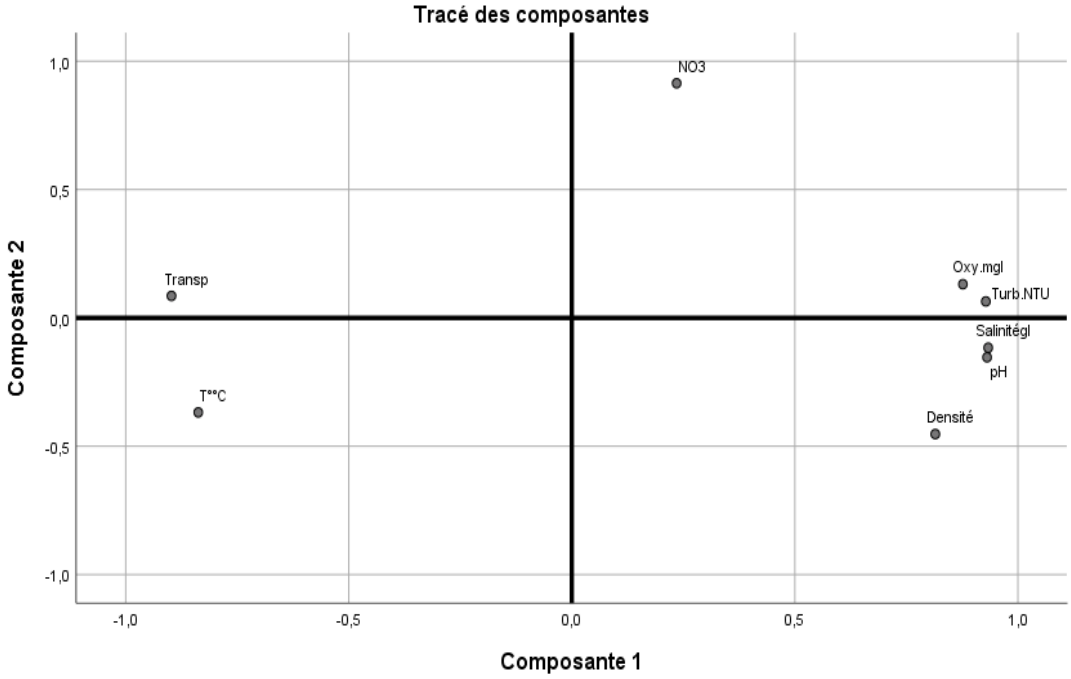

Fig. 11 PCA of the relationships between environmental variables and zooplankton density.

4. Discussion

4.1 Physico-Chemical Characteristics

The results obtained highlight a marked spatial variability of physico-chemical parameters along the studied gradient, reflecting a gradual transition between fluvial and estuarine conditions. This structuring is mainly controlled by salinity, which appears to be the determining factor in the organization of environmental characteristics, as has been widely demonstrated in estuarine ecosystems [22, 23, 3, 9].

The water temperature remains generally stable (26.6 to 28.3 °C), which is characteristic of tropical environments where temperature variations are generally small. This stability can be attributed to climatic homogeneity, but also to mixing processes between continental and marine waters. Similar observations have been reported in several estuarine systems in West Africa [24, 5].

The pH shows a slight increase from upstream to downstream, moving from slightly acidic to neutral values towards more alkaline conditions. This evolution reflects the increasing influence of marine waters, generally richer in bicarbonate ions, and is a classic characteristic of estuarine mixing zones [25, 9].

Dissolved oxygen concentrations range from 4.3 to 6.35 mg/L, indicating a generally well-oxygenated environment. The lower values observed upstream could be linked to high bacterial activity associated with the degradation of organic matter or to more limited water circulation. Conversely, the increase in oxygenation downstream could be explained by greater hydrodynamic mixing, promoting gas exchange with the atmosphere [26, 27].

The relatively high turbidity, particularly in downstream stations, reflects a high concentration of suspended matter. This situation results from both terrigenous inputs from the catchment area and sediment resuspension due to tides and currents. High turbidity is known to limit light penetration into the water column, thus reducing primary phytoplankton production [28, 16].

Nitrate concentrations show significant variability, with a particularly high peak at the intermediate station

(18.2 mg/L). This value suggests occasional inputs of anthropogenic origin, such as agricultural runoff or domestic wastewater. Nutrient enrichment can stimulate primary production but can also disrupt the ecological balance of the environment by promoting eutrophication [29, 30, 12].

Finally, the relatively low water transparency (1.4 to 2.1 m) is consistent with the high levels of turbidity observed. This low light penetration is a limiting factor for photosynthetic processes and can indirectly influence the structure of biological communities [16].

Overall, these results highlight a strong environmental heterogeneity along the studied gradient, characterized by a clear transition between upstream fluvial conditions and downstream estuarine conditions. This physicochemical variability is likely to play a key role in shaping zooplankton communities.

4.2 Influence of Seasonality on Zooplankton Structure

The results obtained reveal significant seasonal variability in the structure and composition of zooplankton communities. The increase in abundance observed during the rainy season appears to be linked to increased terrigenous inputs and nutrient enrichment.

This trend is consistent with observations made in the Ébrié Lagoon (Côte d'Ivoire) [31], where seasonal hydrological variations strongly influence zooplankton assemblages via salinity and turbidity gradients. Comparable dynamics have also been documented in the Niger Delta (Nigeria) [32], where the rainy season promotes the proliferation of rotifers and cladocerans due to nutrient enrichment. Thus, the seasonal variability observed at Mellacorea fits within a regional pattern characteristic of West African estuarine and lagoon systems subject to strong hydrological fluctuations.

4.3 Effects of Human Impact on Diversity and Species Dominance

Spatial analysis reveals a structuring of zooplankton communities according to the gradient of human impact. Stations located near shipping lanes and human activities show a change in species composition, with an increased dominance of opportunistic and euryecic species.

Similar observations have been reported in the Nokoué Lagoon (Benin) [33], where urbanization and domestic wastewater promote assemblages dominated by taxa tolerant to environmental disturbances. Likewise, in lagoon ecosystems in Ghana [27], organic pollution gradients are associated with reduced species diversity and simplified planktonic food webs. However, unlike some hypereutrophic systems in the subregion, Mellacorea maintains a relatively moderate to high level of diversity, suggesting either ecological resilience linked to hydrodynamic mixing or a still limited level of human impact compared to large urban lagoon complexes.

4.4 Structuring Role of Water Mass Circulation

Water mass circulation is a determining factor in structuring the environmental and biological conditions of the system under study. In estuarine environments, hydrodynamic processes, such as the mixing of continental and marine waters, control the spatial distribution of physicochemical parameters as well as nutrient availability [34, 35, 6].

In the study area, the observed transition between upstream and downstream stations suggests the existence of an active mixing gradient, characterized by marine intrusions and variable fluvial inputs [36, 3].

This mixing promotes a redistribution of nutrients and suspended particles, directly influencing biological productivity and the structuring of planktonic communities [37, 9].

Recent studies have shown that estuarine circulation processes, including stratification and vertical mixing, play a key role in the transport and retention of zooplankton, and can modulate the availability of essential nutrients for phytoplankton [6, 30].

Furthermore, the circulation of water masses can modulate the impacts of anthropogenic pressures.

Indeed, inputs of nutrients or contaminants from continental sources can be diluted or, conversely, concentrated depending on the intensity of hydrodynamic mixing [12, 5]. This buffering role of physical processes is particularly important in tropical estuaries, where seasonal variations in river flow and tides strongly influence environmental conditions [34, 35, 3].

Thus, hydrodynamic circulation appears as a key mechanism regulating the ecological balance of the system, by controlling both the distribution of nutrients, turbidity and the dynamics of biological communities [37, 16].

4.5 Regional Ecological Implications

The results obtained highlight that the structure of aquatic communities in the Mellacorea River is governed by the interaction of several major factors:

Seasonal hydrological regimes, which control freshwater inputs, nutrient fluxes, and salinity variability, shape planktonic communities.

The nutrient enrichment observed in areas under continental influence, and in estuarine systems, suggests a predominant role of terrigenous inputs in the regulation of primary production.

The interaction of these factors generates strong environmental heterogeneity, promoting a complex spatial structuring of zooplankton communities. This type of functioning is characteristic of tropical estuarine systems, but remains poorly documented in the West African region.

In this context, the present study makes an original contribution by proposing an integrated analysis of physico-chemical and biological parameters in a Guinean estuarine system.

Seasonal hydroclimatic variability, characteristic of the Gulf of Guinea, plays a key role in the dynamics of zooplankton communities. Alternating dry and rainy seasons modulate nutrient inputs, salinity, and water column stratification, inducing seasonal successions of species [38]. These natural cycles are essential for maintaining productivity, but their disruption by climate change could amplify the instability of these assemblages.

These results are also of interest for the sustainable management of aquatic resources, highlighting the importance of taking into account environmental variability and hydrodynamic processes in conservation and ecological monitoring strategies.

5. Conclusion

This study highlights the crucial role of water mass circulation in the spatial and seasonal structuring of zooplankton communities in the navigable waters of Mellacorée (Republic of Guinea). The observed variations reflect a complex interaction between seasonal hydrological inputs, environmental gradients, and local anthropogenic pressures.

Seasonality appears to be a major factor modulating abundance and species composition, confirming the structuring role of the rainfall regime typical of West African estuarine systems. Furthermore, the influence of human activity is reflected in a modification of assemblages, with a tendency towards the dominance of tolerant species in the most impacted areas.

However, local hydrodynamic dynamics appear to exert a regulatory effect, limiting the major ecological imbalances observed in other confined lagoon systems in the sub-region. These results position Mellacorea as an intermediate ecosystem, showing signs of disturbance while retaining a degree of ecological resilience.

Finally, this study highlights the importance of an integrated approach combining physicochemical, biological, and statistical analyses to better understand the functioning of tropical estuarine ecosystems. It underscores the need to strengthen environmental monitoring efforts in these sensitive environments, ICZM (integrated coastal zone management), pollutant control, the protection of critical habitats, and fisheries regulation in order to better anticipate the impacts of human pressures and climate change.

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Conflict of Interest

The authors declare that they have no financial conflicts, competing interests related to this work, nor any known conflicts of interest associated with this publication.

Authors' Contribution

All authors contributed equally to this work, as reflected by their position in the list of authors.

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