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Occurrence of Potentially Toxic *Phytoplankton* in Butrinti Lagoon

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Abstract

The consumption of shellfish can be life-threatening when marine biotoxins exceed certain safety thresholds. One of the most important of shellfish harvesting and farming areas in Albania, is Butrint Lagoon, a long-standing aquaculture site for the Mediterranean mussel (Mytilus galloprovincialis).
In 2023, we monitored phytoplankton in Butrint Lagoon on a monthly basis to identify seasonal bloom patterns and the environmental conditions. Pseudo-nitzschia clearly dominated the system. Algal concentrations remained low throughout winter and spring, began to rise in late summer, and peaked in autumn. Monitoring recorded up to 9.3×10^4 cells L^{-1} in October, while in November revealed a bloom of Pseudo-nitzschia (4.5×105 cells L^{-1}). Alexandrium was scarce, appearing only briefly and at low concentrations in May and August.
The autumn bloom developed under warm (23–26 °C), moderately saline (26–28 ‰), and low-oxygen (7–8 mg L^{-1}) conditions, with increased rainfall. A simple regression model suggested a tendency for higher phytoplankton counts during warmer, rainier, and slightly higher-pH conditions, and lower counts when salinity and dissolved oxygen increased.
The lagoon shows more frequent Pseudo-nitzschia increases, than Alexandrium events typically below critical thresholds. Results suggest that autumn poses a higher risk for harmful algal blooms (HABs), emphasizing the need for continuous monitoring to ensure food safety and protect public health.

Keywords: Harmful algal blooms, Pseudo-nitzschia, phytoplankton seasonality.

1. Introduction

Butrint Lagoon, a semi-enclosed coastal system in southern Albania, is shaped by freshwater from the Bistrica River and marine exchange with the Ionian Sea. Its complex hydrology and seasonal risks, such as harmful algal blooms (HABs) and oxygen depletion make it a hotspot for ecological monitoring (10). Due to its importance for shellfish farming, the lagoon is under routine surveillance by the Institute of Food Safety and Veterinary (ISUV).
This study tracks 288 water samples for the seasonal patterns of potentially toxic phytoplankton in Butrint Lagoon per months in 8 stations during 2023, focusing on bloom timing, dominant species, and environmental influences including temperature, salinity, dissolved oxygen, pH, and rainfall. The aim is to better understand bloom dynamics and guide safer aquaculture practices for Mytilus galloprovincialis.While most phytoplankton are harmless, around 90 species can produce toxins (4, 11). Of particular concern in Butrint is Pseudo-nitzschia, a diatom capable of producing domoic acid, which causes Amnesic Shellfish Poisoning (15, 1). In earlier years, other toxin-producing dinoflagellates like Alexandrium minutum, Karenia spp., and Gonyaulax spinifera were also observed during summer (17; 8). These events highlight the lagoon's vulnerability to environmental changes and the need for early detection systems.

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2. Material and Methods

Butrint Lagoon covers 16 km² in southwestern Albania, with depths ranging from 11 to 21.4 m (5). It connects to the Ionian Sea via the Vivari Channel and experiences a Mediterranean climate, wet winters (1,200–1,300 mm rainfall annually) and hot, dry summers (9).

Mussel farming, particularly of Mytilus galloprovincialis, has long been practiced here, though production fell in the 1990s after a Vibrio cholerae outbreak (6).

From January to December 2023, monthly samples were collected as part of the national monitoring program (13).

Phytoplankton data included total and species-specific counts of harmful taxa following (11) the Utermöhl method (1958) and the European standard EN 15204:2006 (16, 3). Simultaneously, environmental variables: temperature, salinity, dissolved oxygen, pH, and rainfall were recorded.

To assess how environmental drivers influenced phytoplankton abundance, we applied multiple linear regression. Due to the limited sample size ($n = 12$) and collinearity among variables, results were interpreted as exploratory and indicative rather than predictive.

3. Results and Discussion

Throughout 2023, the Butrint Lagoon showed strong seasonal dynamics in the abundance of potentially harmful phytoplankton, especially Pseudo-nitzschia spp. and Alexandrium spp., as previous studies (2). These taxa exhibited distinct seasonal peaks and were influenced by key environmental factors, including temperature, dissolved oxygen, pH, and rainfall.

Table 1 shows descriptive statistics such as mean, standard deviation, and skewness for both taxa, highlighting the significantly higher variability and peak values for Pseudo-nitzschia spp.

Pseudo-nitzschia spp. dominated the phytoplankton community in terms of both mean and maximum concentrations. This genus showed a marked seasonal increase starting in August, with a sharp bloom observed in October and a peak in November reaching 1,376,312 cells/L. Mean values followed a similar trend, reaching their maximum in November (454,847 cells/L) and remaining elevated through December (103,022 cells/L) (Figure 1). This autumnal dominance was consistent with domoic acid-producing species typically thriving in warm, stratified waters with low oxygen conditions (15). Alexandrium spp., however, exhibited weak or negative correlations with most variables, including temperature ($r = 0.12$), oxygen ($r = 0.13$), and rainfall ($r = -0.31$), suggesting different ecological preferences.

Dissolved oxygen (mg/L) and temperature were negatively correlated ($r = -0.74$), as expected due to seasonal stratification. Similarly, oxygen saturation and temperature were inversely related ($r = -0.22$), supporting the idea that low-oxygen, high-temperature environments in autumn likely favored diatom blooms such as Pseudo-nitzschia (Bates et al., 2018).

Pseudo-nitzschia spp. abundance positively correlated with rainfall ($r = 0.54$) and slightly with salinity ($r = 0.25$), and pH ($r = 0.15$). It showed a weak positive correlation with temperature ($r = 0.12$) and dissolved oxygen in mg/L ($r = 0.13$). Seasonal averages and maximums for both genera are detailed in Table 2, highlighting autumn as the most active period.

ANOVA results indicated no statistically significant spatial variation in mean or maximum values for either species across sampling sites ($p > 0.99$), suggesting consistent bloom behavior throughout the lagoon. For Pseudo-nitzschia spp., mean ANOVA results showed $F = 0.0185$, $p = 0.9999$. For Alexandrium spp., $F = 0.0027$, $p = 0.9999$.

These findings reinforce the idea that seasonal and environmental factors, rather than site-specific conditions, drive bloom events in Butrint.

Table 1. Descriptive Statistics.

Metric	*Alexandrium spp.*	*Pseudo-nitzschia spp.*
Count	288	288
Mean	28	53747
Std	227	218935
Min	0	0
25%	0	0

50% (median)	0	0
75%	0	570
Max	3440	1376312
Range	3440	1376312
Cv (%)	801	407
Skewness	13	5
Kurtosis	183	28
Variance	51443	47932651120
Frequency	0.1	99.9

Table 2. Seasonal Mean and Maximum Algae Concentrations (cells/L)

Season	Average Algae Concentration	Max Algae Concentration
Winter	105051	314433
Spring	1147	3440
Summer	1267	1680
Autumn	555203	1376312

Table 3. Seasonal Mean and Maximum Algae Concentrations (cells/L)

	***Alexandrium* spp**	***Pseudonitzschia* spp**	**O_2 mg/L**	**O_2 %**	**Temp. °C**	**pH**	**Salinity ‰**	**RainFall m)**
***Alexandrium* spp**	1.00	-0.19	0.13	-0.22	0.12	0.16	-0.20	-0.31
***Pseudonitzschia* spp**		1.00	0.13	0.32	0.12	0.15	0.25	0.54
O_2 mg/L			1.00	0.75	-0.74	-0.06	-0.75	0.56
O_2%				1.00	-0.22	-0.35	-0.35	0.46
Temperature °C					1.00	-0.21	0.77	-0.56
pH						1.00	0.25	0.37
Salinity ‰							1.00	-0.15
Rainfall mm								1.00

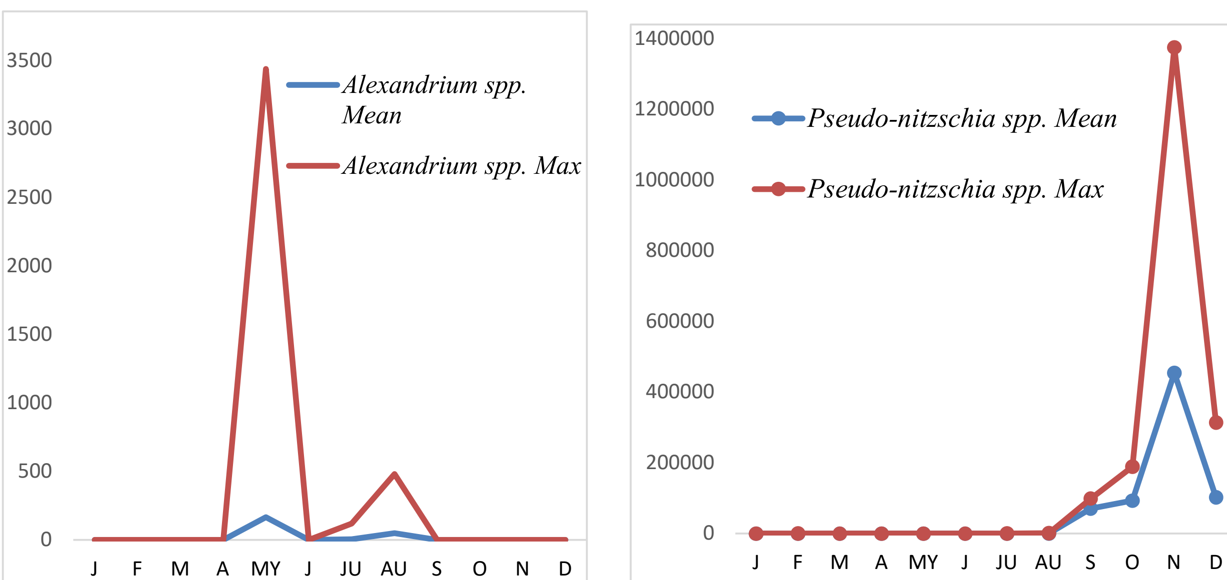

Figure 1. Mean and Maximum Concentrations of *Pseudo-nitzschia* spp. and *Alexandrium* spp. per months 2023.

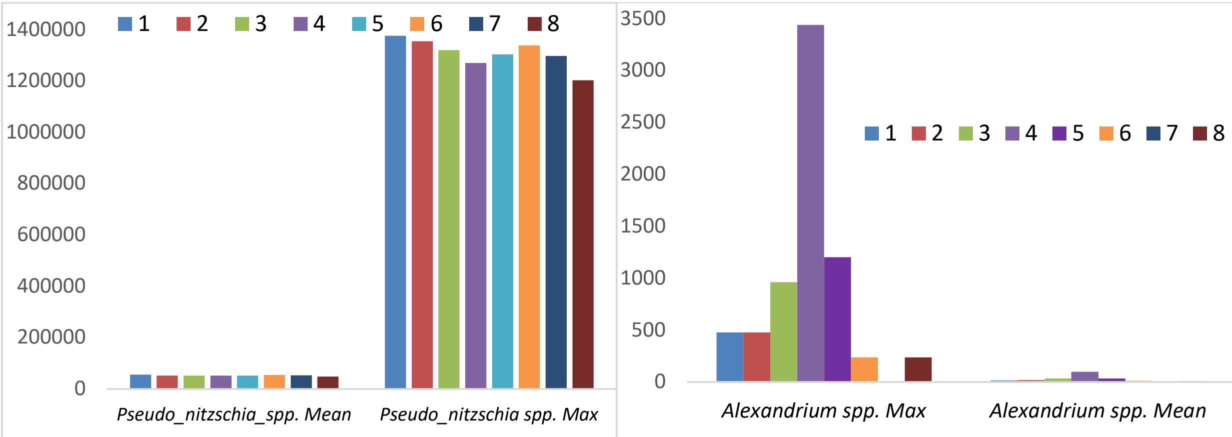

Figure 2. Mean and Maximum Concentrations of *Pseudo-nitzschia* spp. and *Alexandrium* spp. per months 2023.

The results highlight the significant role of Pseudo-nitzschia spp. as the dominant potentially harmful phytoplankton in Butrint Lagoon, particularly during autumn. This seasonal pattern aligns with similar findings in other Mediterranean lagoons, where warm post-summer waters, low oxygen levels, and increased rainfall create ideal bloom conditions (15, 7). While Pseudo-nitzschia concentrations exceeded alert thresholds in November, no domoic acid measurements were available to confirm toxicity, underlining the need for integrated toxin screening.

The weak presence of Alexandrium spp. and lack of consistent blooms suggest that dinoflagellates are less competitive in the lagoon's current ecological regime, possibly due to nutrient limitations, turbulence, or grazing pressure. Their sporadic appearance in warmer months supports their known thermophilic nature, but concentrations were well below PSP risk levels (11, 8). The correlation patterns observed—particularly between Pseudo-nitzschia and rainfall—suggest that nutrient loading from runoff may be an important bloom driver. Rainfall likely enhances nutrient input and stratification, fostering bloom initiation and maintenance (4, 1).

Although the regression and correlation analyses should be interpreted cautiously due to limited sample size and multicollinearity between variables, the trends provide valuable guidance for timing future monitoring efforts. The sharp autumn peaks point to September–December as a critical window for intensified monitoring of both cell counts and toxins, especially domoic acid.

Finally, the uniformity of bloom patterns across sampling stations suggests that a lagoon-wide management strategy is appropriate. Local aquaculture stakeholders could benefit from predictive tools that combine environmental data and historical bloom trends to anticipate periods of elevated risk.

4. Conclusions

This study confirms that Pseudo-nitzschia spp. is the key harmful phytoplankton of concern in Butrint Lagoon, showing strong seasonal increases during autumn under warm, low-oxygen, and rainy conditions. While Alexandrium spp. appeared sporadically and at low levels, its presence highlights the need for continued vigilance.

The findings underscore the importance of targeted, seasonal monitoring from September to December, integrating both phytoplankton counts and toxin analyses to safeguard shellfish farming and public health. Future studies should consider expanding toxin screening and incorporating nutrient data to better understand bloom dynamics and improve early warning capabilities.

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