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Seasonal variations in primary productivity and biomass of phytoplankton in the waters of the southern part of the general estuary / Dhi Qar/Iraq

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ABSTRACT

The Current study estimated the primary productivity and identified the biological characteristics associated with it by measuring chlorophyll-a and phytovitin-a in the southern part of the general estuary in Dhi Qar Province, Iraq on a seasonal basis for the period from autumn 2020 to summer 2021. three stations were selected: The first station (St. 1) was located beside the Al-Hollandi bridge, the second (St. 2) was 20 km far from the south of St. 1, adjacent to the siphon pump, and the third (St. 3) was 20 km from the south of St. 2, close to the sub-channel that feeds the marshes. The biological characteristics indices showed an obvious variation in the different stations and seasons. The productivity values in the general estuary, south of Nasiriyah City ranged between 38.99 - 130.05 mg carbon m $^{-3}$ hour^{-1}. These values showed two peaks during the fall and spring. The chlorophyll-a and phytovitin-a concentrations ranged between 3-6.44 µg L^{-1} and 0.66-3.22 µg L^{-1}, respectively. The highest concentrations of both pigments were found in St. 1. In addition, the highest concentration of chlorophyll-a (6.44 mg L^{-1}) during autumn at St. 1, while the highest concentration of phaeophytin-a (3.22 mg L^{-1}) during winter at St. 2. The lowest concentration of chlorophyll-a (3 mg L^{-1}) was at St. 1, in winter, while the lowest of phaeophytin-a (0.66 mg L^{-1}) during spring at St. 3. In general, the autumn and spring was marked by the highest concentration of chlorophyll a, while the winter and summer by the highest phaeophytin.

Keywords: Primary productivity, Biomass, Chlorophyll –a, Phaeophytin - a, General estuary.
Article type: Research Article.

INTRODUCTION

The assessment of photosynthetic rates and ecosystem production has a long tradition. Macfadyen (1948) recapitulated the early history and defined production, productivity and energy. Sakshaug *et al.* (1997) summarized theories, definitions and interpretations of photosynthetic parameters. A comprehensive recount of the history of plankton productivity measurements was compiled by Barber & Hilting (2002). Based on ecological energetics introduced by Lindemann (1942), the International Biological Program (IBP) analysed the transfer efficiency between trophic levels of ecosystems worldwide from 1964 to 1974 (Lith 1975). The formation of the biological productivity of aquatic ecosystems and the assessment of the quality of the natural environment remain relevant over the past decades. A quantitative assessment of the transformation of matter, energy flows and information forms the basis of the modern theory of biological productivity of water bodies. Together with production hydrobiology, the theory of the functioning of aquatic ecosystems, it is important for the advancement of science, to being developed (Alimov 2001). In recent years workers in the field of primary production have

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shown considerable interest in factors that affect the rate of plant production and the standing crop in the aquatic environment (Goldman 1965). The measurement of plant pigments, especially chlorophyll a, is one of the rapid chemical methods available to estimate the amount of living particulate plant matter. Attention in this paper will be given mainly to analytical methods of chlorophyll analysis and phaeophytin-a as important factors for primary production, field sampling, chlorophyll-standing crop estimates, and interpretation of the relationship of photosynthesis to chlorophyll. The study of primary productivity in an ecosystem is important because it provides information about understanding the available energy in the environment, the nature of its preoccupation within that system, and the abundance of biotic and abiotic requirements for the life of living organisms. The concept of primary productivity includes the process of converting solar energy (light) into chemical energy that is used to build organic compounds, where green plants and algae are unique in the environment by doing this process because they contain pigments that receive light and use raw materials (carbon dioxide or bicarbonates; Al Saadi 1993). Primary productivity depends on a combination of factors such as temperature from solar energy, depth of the illuminated zone, and the amount of chlorophyll a (Vatova 1961). The primary productivity is also divided into gross primary productivity, which represents the total rate of organic materials resulting from the photosynthesis process, including the organic materials consumed by the respiration process during the measurement period (Ruttner 1963), as well as the net primary productivity, which includes materials residual organic stored during the measurement period after consuming part of it during respiration (Reid 1961). Biodiversity is the variation between living organisms in ecosystems (aquatic and terrestrial) and environmental components that include diversity in species (Ehrlich & Wilson 1991) and is usually seen at three different levels: genetic diversity, species diversity, and ecosystem diversity (Al Haffar 1998). In any ecosystem, the diversity of the community of living organisms is strongly correlated with the type and nature of biological relationships and with various environmental factors (Thompson 1997; Hector 2000). Joshi & Thompson (1996) also mentioned the importance of knowing the number of species and the fluctuations that occur. It is produced by understanding the interactions between different species and groups that led to these numerical fluctuations in the density of species and the extent to which those fluctuations affect the function of the ecosystem. Primary productivity is defined as a manifestation of life production in the water body, or it is the outcome of photosynthesis, which has a primary role in the function of the ecosystem and a source for making chemical energy and organic materials for the various communities of the existing aquatic environment, and chlorophyll plays an active role in converting solar energy into chemical energy that benefits the living organism (Mishra & Saksena 1992). Accordingly, primary productivity has received several global and local studies, while studies on primary productivity in Iraqi aquatic environments were few, except for the regions of southern Iraq. Among these studies, which were conducted on the marshes region of southern Iraq, is the study of Al Zubaidi (1985) for seasonal changes and locational differences in productivity. The primary ones generally associated with the total number of phytoplankton and the concentration of chlorophyll a. As Al Lami (1986) pointed out in a study on the primary productivity of phytoplankton in some marshes in southern Iraq, the seasonal changes were bimodal, as two increases in values occurred during spring and autumn, and they also follow the increases in chlorophyll-a concentrations and the preparation of phytoplankton. Rivers in studies on primary productivity, the Shatt al-Arab has the best luck among the rivers in studies on primary productivity, being one of the distinctive water environments because it is the confluence of the two most important and largest rivers that cross Iraq from north to south, as well as because of its proximity to the Persian Gulf and its impact on tidal currents. It undergoes two cycles. Al Saadi & Antoine (1981) confirmed that the study of Hameed (1977) was the first study on the primary productivity of plant sedges in the Shatt al-Arab. The primary productivity of phytoplankton in the Al-Ashar Canal polluted by the sources of organic matter coming from the city's sewage is high compared to the waters of the Shatt Al-Arab. The primary productivity in the waters of one of the estuaries in San Antonio Bay in the state of Texas, USA were studied by Macintyre & Cullen (1996). Lohrenz *et al.* (1997) studied primary productivity in the Gulf of Mexico and its relationship to changes in the concentration of final nutrients released with the waters of the Mississippi River, and Nair *et al.* (1998) examined the estuary waters of the Ashtamudi River and the estuary of the Vashishti River in India and reported that the primary productivity of surfactants is low. A study by Kumari *et al.* (2002) was performed on the primary production, chlorophyll and phytoplankton mass in three estuaries in Goa, India, and the highest value of primary productivity was 67.7 mg carbon m^{-3} $hour^{-1}$. The primary productivity of phytoplankton in the Finger ponds in Uganda was studied by Ssanyu (2003) and it was shown that the rate of production was low due to the high turbidity and levels of nutrients were low in the ponds. The broad

objective of the study is to determine and compare the phytoplankton productivity, chlorophyll-a and phaeophytin-a in the southern part of the general estuary and how they are influenced by changing seasons in study area.

MATERIALS AND METHODS

Study Area

The general estuary extends from the Saqlawiya area beside Baghdad to the Shatt al-Basra and then the Persian Gulf. The length of the estuary is 565 km and its path is between the Tigris and Euphrates rivers. The general estuary crosses the Euphrates River by a siphon south of Nasiriyah City to complete its path between the Hammar marsh in the east and the Baghdad-Basra highway in the west and after to the Shatt al-Basra. Three stations were selected in the southern part of the estuary at Dhi Qar Governorate to carry out the current study as shown in Fig. 1. The first station (St. 1) was located beside the Al-Hollandi bridge, into which the sewage pipe from Nasiriyah flows. The second station (St. 2) was 20 km away from the first station, located beside the Fadliyah Bridge, to the south of the Siphon pumping station, The third station (St. 3) was 20 km away from the St. 2 and is located adjacent the sub-channel that feeds the marshes.

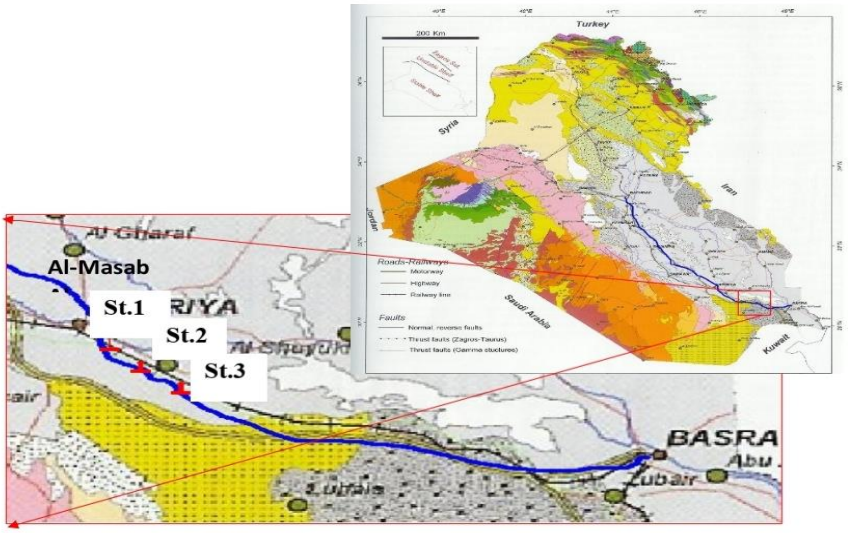


Fig. 1. Studied stations of the southern part of the general estuary, Dhi Qar, Iraq.

Biological Factors

1. Chlorophyll-a and phaeophytin-a.

The method followed that described by RD 52.24.784-2013 (Vollenweider 1974) according to the following steps:

Nomination

The sample was agitated well and 500 mL was taken from it and filtered using a Phycum Millipore device with a capacity of 300 mL connected to the air intake pump and using filter papers whose holes diameter is 0.45 micron and the diameter of the leaf is 47 cm. Before completing the filtration process, 2 mL of carbonate solution was added. Magnesium (1%) on the surface of the paper and after the filtering was completed, the paper was extracted by forceps and folded three times and placed between large filter papers for the purpose of getting rid of the remaining water in it at 20 °C after installing all the information on it.

Extraction of chlorophyll-a and phaeophytin-a

Eight mL acetone (90%) was added as a solvent to extract the dyes to the vial, closed and shaken well until the dried filter paper dissolved, then covered the tube with aluminium foil and kept in the dark at a low temperature (4 ° C). For 18-20 h, the extract was shaken after a quarter of an hour after placing it in the refrigerator in successive periods. On the second day, the extract was shaken well and concentrated by means of a centrifuge for 15 min and quickly 3,000 r min^{-1}. Then the concentrated liquid was transferred to a graduated test tube and the volume was added to 10 mL of acetone.

Determination of chlorophyll-a and phaeophytin-a

The dye extract was placed in a glass cell with a length of 4 cm made of quartz, then the cell was placed in a spectrophotometer and the absorbance was read at a wavelength of 665 nm, and 750 nm using acetone with the same concentration as blank for the purpose of zeroing. After the readings were completed, we added a drop of 2N HCl to the extract and left it for 10 min. The absorbance was re-read at the previous wavelengths for the purpose of reading the phytochemicals. Then the concentrations of chlorophyll a and phytovitin-a were calculated based on the Lorenzo's equation, which is explained in Vollenweider (1974) as follows:

µg Chl - a per sample = 11.9 [2.43 (Db - Da)] (Ve/L) x Vf.

µg Phae - a per sample = 11.9 (Ve / L) (1.7 Da) - Chl-a

where Da = the optical density of the chlorophyll extract after adding the acid;

Db = the optical density of the extracted chlorophyll before adding the acid.

Ve = volume of acetone used for extraction (mL).

L = length of the photocell in cm.

Vf = Size of the candidate sample.

The product was expressed in units (µg L^{-1}).

Note that the optical density of chlorophyll extract = absorbance at wavelength 665 nm - absorbance at wavelength of 750 nm.

Primary production

The oxygen method was used, employing transparent and opaque bottles with a capacity of 250 mL. The relevant bottles were wrapped with a layer of thick aluminium foil, so that it was completely opaque. The six transparent and opaque bottles were filled from a depth of approximately 30 cm below the surface of the water, which is the depth of the incubation process, either hanging the bottles. A piece of wood in the form of a cross was used with ropes and a weight prepared for this purpose, taking into account that the bottles are far from any source of deception, as the fortification period ranged from 3-4 h and after the end of the incubation period the samples were dealt with in the same way as dealing with the special bottles.

For measuring the concentration of dissolved oxygen, the following equation was used in calculating the net primary productivity (Net photosynthesis = A - B - C - B)

where A: Light bottle DO concentration.

B: the concentration of dissolved oxygen in the dark bottles Do conc.

C: the concentration of dissolved oxygen in a bottle Start (calculated before the fort process),

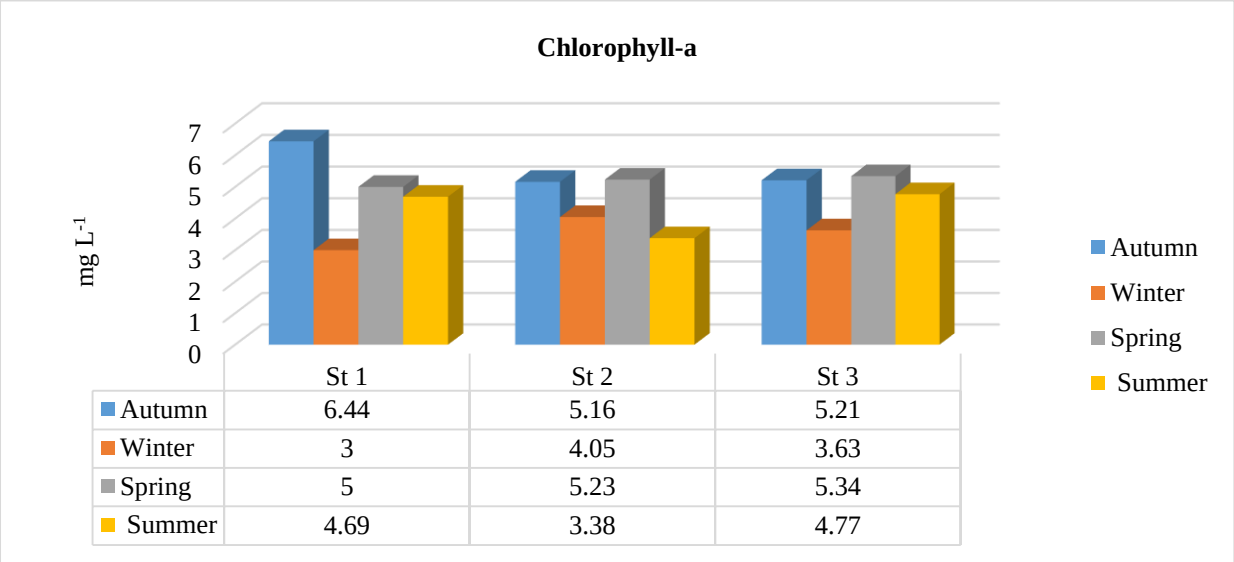
mg carbon m^{-3} h^{-1} = O_2 mg L^{-1} (12/32) × 1000, where 32 / 12 is for the purpose of converting oxygen into carbon, assuming that for a carbon, atom one molecule of oxygen is absorbed and released, and the result was expressed on the basis of mg carbon m^{-3} h^{-1}, developed by the American Health Association (APHA 1979).

RESULTS AND DISCUSSION

Chlorophyll-a is an important factor for monitoring the phytoplankton biomass and its efficiency in the photosynthesis process of the water surface, and its calculation gives a clear idea of the extent of the physiological responses of plant groups to changes in environmental factors (Barlow 1980) and an evidence for the relative numbers of living organisms that can carry out the building process. Photosynthesis in the aquatic environment (Vollenwieder 1968) is an important indicator of the productivity of the water body and a commonly used measure of growth metrics (Joint & Pomory 1981). The current study recorded two increases (two peaks) in chlorophyll a concentrations. The first increase was in chlorophyll concentrations during the autumn, the second during the spring. Between all stations, the highest values were found at St. 1 and St. 2 (6.44 mg L^{-1} and 5.34 mg L^{-1} respectively). The reasons for these two increases in chlorophyll-a concentrations may be due to the flowering of phytoplankton during these two seasons and their thick as well as obvious growth due to the moderation in temperature and the abundance of nutrients, since chlorophyll concentrations depend on the blooming times of algae (Al Kinani 2011).

In a study (Matloop 2004a,b) on the sewers of the northern part of the general estuary, the lowest value in chlorophyll concentrations was recorded during the winter. The reason for this is the low numbers of phytoplankton during the winter season. As for the second decrease in chlorophyll concentrations during the summer, it may be due to changes in temperature levels, which leads to the variation in the density of

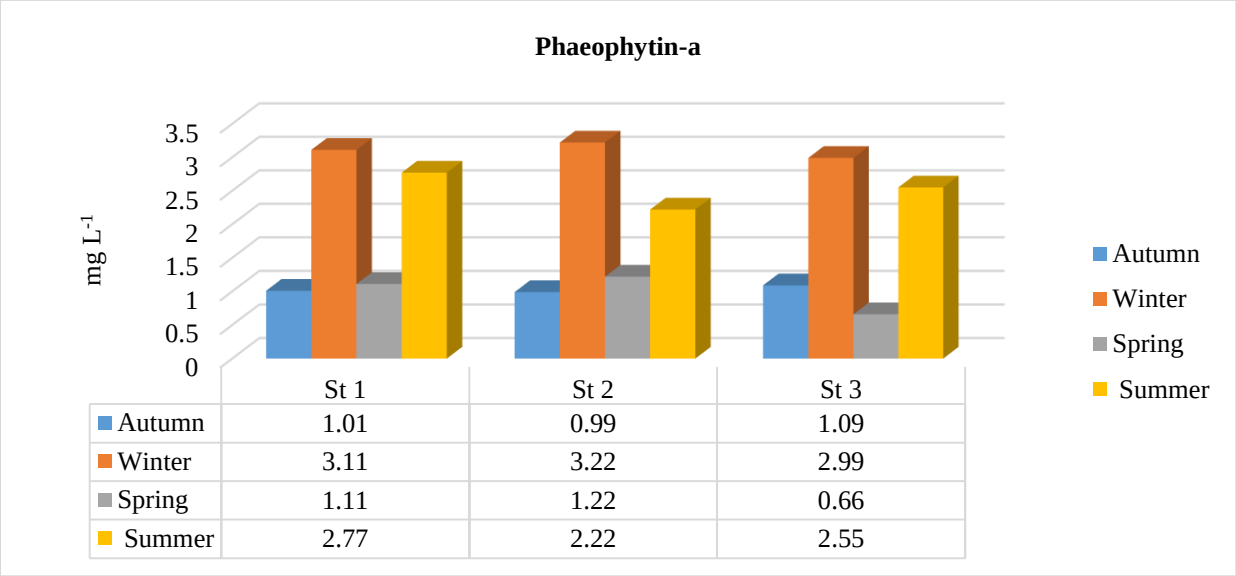
phytoplankton (Gowda *et al.* 2002). The increase in chlorophyll concentrations is affected by the density and abundance of phytoplankton (Umani & Beran 2003).



	St 1	St 2	St 3
Autumn	6.44	5.16	5.21
Winter	3	4.05	3.63
Spring	5	5.23	5.34
Summer	4.69	3.38	4.77

Fig. 2. Chlorophyll-a (mg L^{-1}) values in the southern part of the general estuary during the study period 2021.

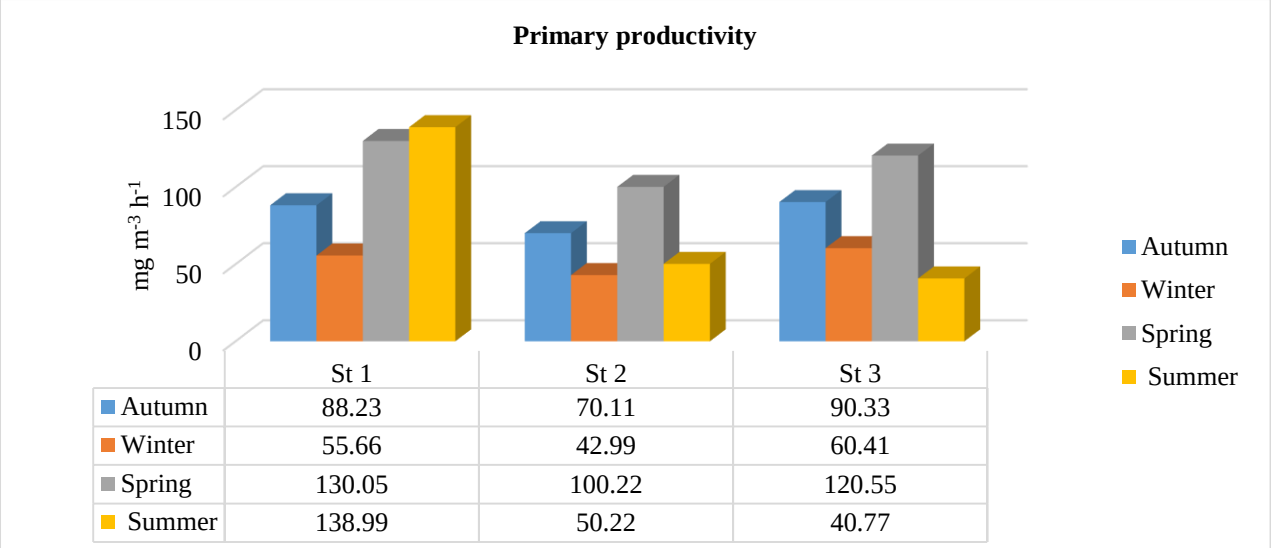
As for the phaeophytin-a, they took the opposite pattern of chlorophyll-a. The first increase occurs during the winter and the second during the summer in all stations. The highest values were found in St. 2 and St. 1 (3.22 mg L^{-1} and 2.77 mg L^{-1} respectively). The concentrations of chlorophyll and phytophytin depend on the blooming times of algae and the different types of phytoplankton when collecting the sample (Karlstron & Backlund 1977; Matloop 2004).



	St 1	St 2	St 3
Autumn	1.01	0.99	1.09
Winter	3.11	3.22	2.99
Spring	1.11	1.22	0.66
Summer	2.77	2.22	2.55

Fig. 3. Phaeophytin-a (mg L^{-1}) values in the southern part of the general estuary during the study period 2021.

The current study recorded an increase in the total productivity, as this rise corresponded with the concentrations of chlorophyll pigment in most of the stations and during the study period, where the highest initial productivity values were recorded in the St. 1 in the range of 55.66 - 138.99 mg m^{-3} h^{-1}, followed by St. 3 (40.77-120.55 mg m^{-3} h^{-1}), while the St. 2 recorded the lowest limits for the productivity values (42.99-100.22 mg carbon m^{-3} h^{-1}). This indicates the high photosynthesis process of phytoplankton relative to the height of the mass vitality, light supply, and other factors that affect the primary productivity of a water body, such as nutrients and vertical mixing systems (Amarasinghe & Vijverberg 2002).



	St 1	St 2	St 3
Autumn	88.23	70.11	90.33
Winter	55.66	42.99	60.41
Spring	130.05	100.22	120.55
Summer	138.99	50.22	40.77

Fig. 4. Primary productivity (mg m^{-3} h^{-1}) values in the southern part of the general estuary during the study period 2021.

CONCLUSION

The primary production of phytoplankton, the main producer of autochthonous organic matter in the ecosystem of water surfaces, constitutes the energy base for all subsequent stages of the production process in the general estuary. The results of the study on the primary production of plankton in the general estuary made it possible to reveal the production of organic matter in study area. Chlorophyll a and pheophytin a, are the carriers of the most diverse information from the abundance and production capabilities of phytoplankton to the ecological state of water bodies and water quality. In the general estuary, a convergent range of Chlorophyll a concentrations (from <3 to> 6.44 mg L^{-1}) and phaeophytin-a (0.66-3.22 mg L^{-1}) was found, due to both the seasonal dynamics of phytoplankton with its maxima, their increased assimilation activity in mesotrophic areas and a high abundance on eutrophic. The contribution of primary production to the fund of labile organic matter in the water column of reservoirs was 40.77-138.99. Stability of primary production in the general estuary was supported too by phytoplankton physiological response apparent in variation of such parameters as chlorophyll and pheophytin contents in algae biomass.

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