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CHLOROPHYLL PIGMENTS IN A COASTAL AREA OF THE NORTHERN GULF OF PARITA, PACIFIC OF PANAMA

PIGMENTOS CLOROFÍLICOS EN UN ÁREA COSTERA DEL GOLFO DE PARITA, PACÍFICO DE PANAMÁ

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ABSTRACT

A study was carried in a sector of the coast of Aguadulce between Estero Palo Blanco and Estero Salado in the dry season of 2015. Three sampling stations named Palo Blanco, La Torre y El Salado were established. At each station, three surface samples of 500 ml each were taken using a Van Dorn bottle and analyzed spectrophotometrically for chlorophyll a, b and c. Readings of salinity and transparency were recorded using a hand refractometer and a Secchi disk. Salinity was higher at La Torre station (36.0 ppm) and lower at Palo Blanco (34.5 ppm) and El Salado (34.8 ppm). Lower water transparences were found at Palo Blanco (extinction coefficient 4.02) while La Torre and El Salado showed higher values (extinction coefficients 1.42 y 1.96 respectively). Amounts of the chlorophyll -a varied from non-detectable levels to 12.6 mg m^3. The highest monthly averages were registered at the mouth of the Palo Blanco and El Salado estuaries (7.7 mg m^3 and 5.4 mg m^3 respectively) with high values in the months of March, April and May when the first winter rains begin to fall. Chlorophyll b values were lower, and the mean monthly varied little between sampling stations (0.5 mg m^{-3} for Palo Blanco estuary, 0.6 mg m^{-3} for La Torre and 0.4 mg m^{-3} for El Salado estuary). The highest mean values of chlorophyll c were observed at the Palo Blanco (4.0 mg m^{-3}) while La Torre and El Salado showed lower values (2.0 mg m^{-3} and 2.4 mg m^{-3} respectively). The values found in the present study were higher than those reported for the Gulf of Panama in the coastal upwelling period, although they are within what is expected for an area where interact different oceanographic patterns.
KEY WORDS. Chlorophyll pigments; phytoplankton biomass; coastal pigments

RESUMEN

El estudio se efectuó en la estación seca de 2015 entre los esteros Palo Blanco y el Salado en la costa de Aguadulce. Se establecieron estaciones de muestreo en los sectores de Palo Blanco, La Torre y El Salado. En cada estación se recogieron tres muestras superficiales de 500 ml utilizando una botella Van Dorn. Las determinaciones de clorofila a, b y c se hicieron por espectrofotometría mientras que las de salinidad y transparencia, con la ayuda de un refractómetro de mano y un disco Secchi. La Torre mostró los mayores valores de salinidad (36.0 ppm) mientras que Palo Blanco y El Salado registraron valores más bajos (34.5 ppm y 34.8 ppm respectivamente). La transparencia de las aguas fue baja en la estación Palo Blanco (coeficiente de extinción 4.02) mientras que La Torre y El Salado mostraron valores más altos (coeficientes de extinción 1.42.y 1.96 respectivamente). Los valores de clorofila a variaron desde niveles no detectable hasta valores de 12.6 mg m^3. Los mayores promedios mensuales se registraron en las desembocaduras de los esteros Palo Blanco y El Salado (7.7 mg m^3 and 5.4 mg m^3 respectivamente) con valores altos los meses de marzo, abril y mayo cuando las primeras lluvias comienzan a caer. Los valores de clorofila b fueron bajos y el promedio mensual varió poco entre estación (0.5 mg m^{-3} en Palo Blanco, 0.6 mg m^{-3} para La Torre and 0.4 mg m^{-3} para El Salado). Los mayores

valores de clorofila c se observaron en la estación Palo Blanco (4.0 mg m^{-3}) mientras que La Torre y El Salado mostraron valores más bajos (2.0 mg m^3 and 2.4 mg m^3 respectivamente). Los valores encontrados en el presente estudio fueron mayores que lo reportado para el Golfo de Panamá en el periodo del afloramiento costero, aunque se encuentran dentro de lo esperado para un área expuesta a patrones oceanográficos variables.
PALABRAS CLAVES. Pigmentos clorofílicos; biomasa del fitoplancton; pigmentos costeros.

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INTRODUCTION

A primary algal characteristic is the presence of photosynthetic pigments as chlorophyll, carotenoids aside the variable presence of diverse types of degradation products some of which have similar absorption spectrum of active pigments and may overestimate the chlorophyll concentration. Analysis of pigments provide information of the dominant group of algae and the chlorophyll a concentration is a commonly used as a measure of eutrophication (Paerl et al, 2003; Wright and Jeffrey, 2006; Boyer et al, 2009; Yacobi and Zohary, 2010). Higher values of chlorophyll a are a consequence of the excessive algae growth and it may be related to increased nutrient inputs, reduction of natural predators, increased levels of light penetration, increased water temperature and reduction in flushing rates. On the other hand, the amount of phaeopigments can have an ecological significance and reveal aspects such as the health of the phytoplankton populations or the grazing pressure to which it is subjected (Jeffrey, 1980). In marine waters diatoms and dinoflagellates are the major phytoplankton groups and whichever group and/or species dominates the ecosystem would depend on environmental factors that would provide the competitive advantage to the specific group (Hilaluddin et al, 2020).

The Aguadulce coast at the western side of the Gulf of Panama is an area dedicated to the shrimp production and sea salt extraction although both industries are in decline due to the effects of strong international competition on the price of salt and to the white spot syndrome, a disease that affected the shrimp industry in Panama in 1999 (Morales and Cuéllar-Anjel, 2014). Sporadically the area is affected by phenomena of water discoloration causing alarm among fishermen and as result the Panamanian government developed a saxitoxin early warning program and a monitoring of phytoplankton species in a joint effort between the University of Panama, the National Marine Service, Ministry of Health and the Marine Authority. Data from several years depicted occasionally values over critical 400 UR/100mg in *Anadara tuberculosa* at El Salado, Aguadulce (Alfredo Soler, pers. comm., April 2002). Unfortunately, the resources allocated to the monitoring program and red tide research were scarce and the program was discontinued. This work is a first effort to provide data on the pigment signature of an area of the western gulf of Panama where sporadically occur episodes of water discoloration.

MATERIALS AND METHODS

Area of study

El Salado is located at the northern of the Parita Gulf. The area is surrounded by a topography of mangroves, salt marshes, and low semi-emergent vegetation that are subject to flooding and which are great importance as a nursery for fish and crustacean species. Dominant mangrove species include *Rhizophora mangle*, *Avicennia germinans* and *Laguncularia racemosa*. El Salado is under the influence of weather patterns that dominate the Gulf of Panama which is successively influenced by the Northeast Trade Winds of the Atlantic, the Equatorial Calm Belt (Doldrums), and the Southeast Trade Winds of the Pacific during a calendar year. From January through April the Gulf of Panama is influenced by the Northeast Trade Winds which cause an upwelling of colder, more saline and nutrient rich water to the surface. In May weakening of winds result in an abrupt cessation of upwelling and the gulf becomes increasingly influenced by the Doldrums Belt and the rainy South East Trade Winds which usually persist until mid-December. The study was carried in summer in a coastal fringe between the mouth of Estero Palo Blanco and Estero Salado rivers in the upwelling period (Fig. 1).

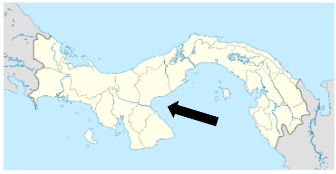
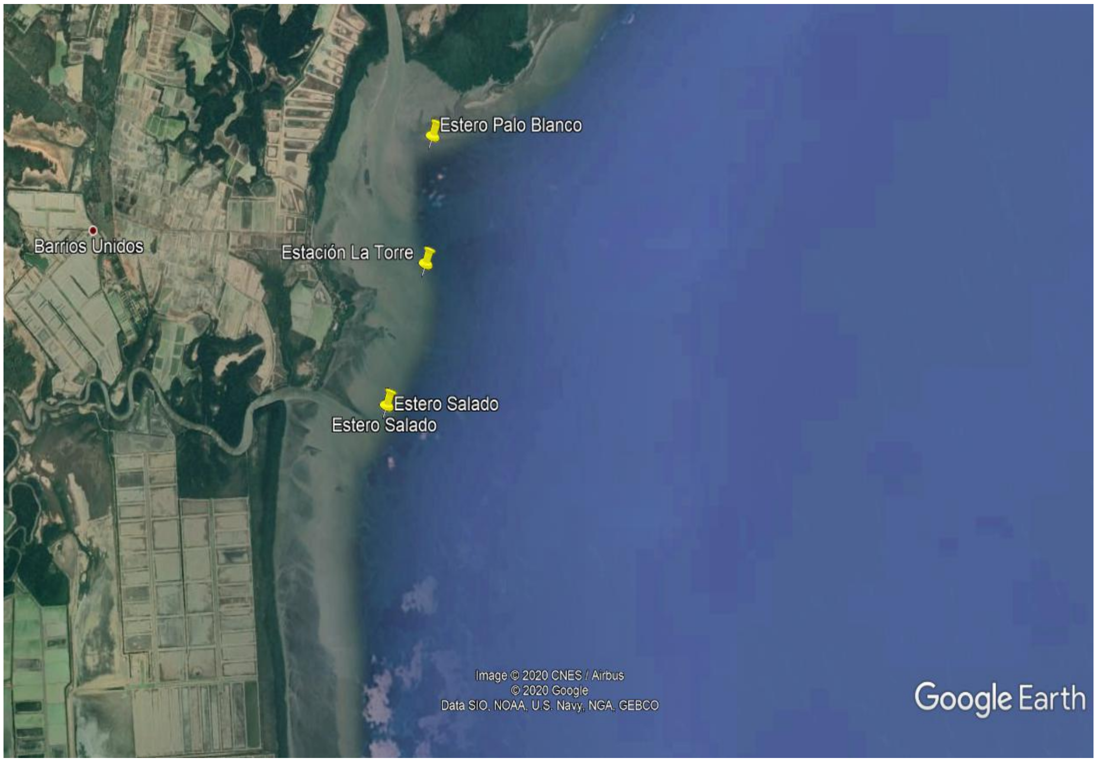


Figure 1

Sampling station at the mouth of Palo Blanco estuary (Station 1), La Torre (Station 2) and the mouth of Salado estuary (Station 3), northern gulf of Parita, Pacific of Panama (Image of Google Earth, date: 12/11/2018).



Sample Collection

Samples for pigment analysis were recollected from three stations of the Aguadulce coast named Estero Palo Blanco (lat. 8°12'45.64", long. 80°27'57.27"O), La Torre Station (Lat. 8°11'46.89"N, Long. 80°28'1.04"O) and Estero Salado (Lat. 8°10'41.54", Long. 80°28'21.93"O). The study was conducted in the dry season of 2015. At each station three 500 ml surface water were taken using a Van Dorn bottle. Samples were analyzed spectrophotometrically using the equations of Strickland and Parsons (1972). Spurious negative values of Chlorophyll were considered no detectable. Readings of salinity and light penetration were recorded using a hand refractometer and a Secchi disk.

RESULTS

Hydrological patterns

The average salinity for the studied area was 35.1 ppm with higher values at La Torre station (36.0 ppm) and lower at the level of the Palo Blanco (34.5 ppm) and El Salado (34.8 ppm). Lower transparences were found at Palo Blanco (extinction coefficient 4.02) while La Torre and El Salado showed higher values (extinction coefficients 1.42 y 1.96 respectively). The average monthly transparency for the study period was 2.5 $\pm$ 0.3.

Analysis of pigments

The following tables summarize the values found in the sampling areas both in terms of the amount of pigment and the percentage that this amount represents of the total pigments found.

Chlorophyll’s biomass

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Table 1

Surface concentrations of chlorophyll pigments (mg/m^3) obtained in three 500 ml samples from the Palo Blanco estuary on the dry season of 2015.

	January	February	March	April	May	MEAN
Chlorophyll a	6.8	4.6	8.6	12.6	5.4	7.6
	5.1	6.4	8.8	11.0	5.3	7.3
	6.4	8.3	8.6	11.8	5.6	8.1
Mean	6.1	6.4	8.7	11.8	5.4	7.7
Chlorophyll b	0.0	0.0	0.8	0.8	0.3	0.4
	0.0	0.3	0.6	0.6	0.7	0.4
	0.8	0.9	0.7	0.7	0.2	0.7
Mean	0.3	0.4	0.7	0.7	0.4	0.5
Chlorophyll c	4.1	3.1	3.1	5.1	3.4	3.8
	8.7	2.5	4.3	3.9	4.3	4.8
	2.1	3.2	4.4	4.5	3.2	3.5
Mean	5.0	3.0	3.9	4.5	3.6	4.0

Table 2

Surface concentrations of chlorophyll pigments (mg/m^3) obtained in three 500 ml samples from the La Torre Station on the dry season of 2015.

	January	February	March	April	May	MEAN
Chlorophyll a	1.6	3.2	1.1	9.6	5.3	4.2
	2.4	2.4	1.6	8.6	5.6	4.1
	2.6	0.8	1.9	7.7	5.6	3.7
Mean	2.2	2.2	1.5	8.6	5.5	4.0
Chlorophyll b	0.8	0.4	0.0	1.5	1.0	0.8
	0.5	0.0	0.0	0.7	0.1	0.2
	1.2	0.0	0.2	0.9	1.0	0.7
Mean	0.8	0.1	0.1	1.0	0.7	0.6
Chlorophyll c	0.0	1.1	0.0	5.4	5.2	2.3
	0.0	0.0	0.3	4.4	4.5	1.8
	0.0	0.0	0.0	6.1	3.8	2.0
Mean	0.0	0.4	0.1	5.3	4.5	2.0

Table 3

Surface concentrations of chlorophyll pigments (mg/m3) obtained in three 500 ml samples from El Salado Station on the dry season of 2015.

	January	February	March	April	May	MEAN
Chlorophyll a	4.1	7.3	3.5	6.4	5.9	5.4
	5.1	8.6	2.4	6.4	6.7	5.8
	4.3	7.3	2.4	5.9	5.1	5.0
Mean	4.5	7.7	2.8	6.3	5.9	5.4
Chlorophyll b	0.0	0.0	0.2	0.5	1.1	0.3
	0.2	0.7	0.7	0.3	0.5	0.5
	0.4	0.0	0.2	0.6	0.1	0.3
Mean	0.2	0.2	0.4	0.5	0.6	0.4
Chlorophyll c	2.4	3.5	2.3	1.2	2.3	2.3
	0.0	4.4	1.4	2.5	4.7	2.6
	1.5	3.5	1.8	2.7	1.2	2.2
Mean	1.3	3.8	1.8	2.1	2.7	2.4

Amounts of the chlorophyll a varied from non-detectable levels (0 mg/m^{-3}) to 12.6 mg m^{-3}. Higher mean monthly values were observed principally at the mouth of the estuaries Palo Blanco and El Salado, 7.7 mg m^{-3} (63.1%) and 5.4 mg m^{-3} (65.9%) respectively and principally in the months of April and May when the first winter rains begin to fall. La Torre station registered monthly mean of chlorophyll a of 4.0 mg m^{-3} (60.6%). Chlorophyll b values were lower and the mean value varied little between sampling stations, 0.5 mg m^{-3} (4.1%) for Palo Blanco, 0.6 mg m^{-3} (9.1%) for La Torre and 0.4 mg m^{-3} (4.9%) for El Salado estuary. The highest mean values of chlorophyll c were observed at the Palo Blanco, 4.0 mg m^{-3} (32.8%) while La Torre and El Salado showed lower values, 2.0 mg m^{-3} (30.3%) and 2.4 mg m^{-3} (29.3%) respectively. These results are compatible with coastal areas although the sporadic appearance of algal blooms could alter these values.

DISCUSSION

The values found in the present study were higher than those reported for the Gulf of Panama in the coastal upwelling period (D'Croz et al, 2016), although the relative amount of pigment remained within the expected for tropical coastal waters where diatoms and to a lesser extension, dinoflagellates, are the predominant organisms. Chlorophyll a was higher in the Palo Blanco station which is under the influence of the aquaculture farm that use the waters of the estuary. Occasionally, the overflow from oxidation tubs at a nearby sugar mill or leachate from the city's sewage system also pollute the estuary. Near population centers, cyanobacteria make up an important part of the amount of chlorophyll a detected (Subramaniam et al, 2001) while in coastal waters, where phytoplankton is dominated by diatoms, chlorophyll c is the main photosynthetic pigment after chlorophyll a (Hilaluddin et al, 2020). Chlorophyll b occurs principally in green freshwater algae and in some groups such as euglenoids. Its presence in abundance is almost always related to eutrophication process or decomposing organic matter. The values were low in all stations. On the other hand, during the dry season from January to April, northerly winds induce upwelling in the gulf of Panama which not only fertilizes the photic zone but also affects circulation patterns (Smayda, 1966). The circulation is now dominated by the great gyre of Panama Bight that flows counterclockwise (Kessler, 2006; Fiedler and Lavin, 2017) and the Panama current which moves predominantly southwest. This current helps to transport nutrients that have risen to the surface and that benefit the phytoplankton found in the zone of influence of the current such as the Gulf of Parita (Chong, 2020). Another factor that could raise chlorophyll values is the flow of rivers such as the Palo Blanco and the Rio Salado, which provide nutrients of continental origin that are necessary for the growth of phytoplankton. Rodríguez-Rubio and Stuardo (2002) have observed in the coastal zone bands of high pigment concentration (> 40 mg m^{-3}) which remain in spite of the appearance and disappearance of oceanic upwelling. All of this can result in high chlorophyll records in the north of the Gulf of Parita especially when the first rains begin to fall.

CONCLUSIONS

The gulf of Parita is a complex zone where they interact in the dry season factors such as the counterclockwise gyre of the Panama Bight, the southwest flow of the Panama current, the upwelling of the gulf of Panama and the influence of the rivers that carry the discharges of the aquaculture farms that are in the area. All these factors influence the chlorophyll values that are observed at a given time.

REFERENCES

Boyer, J. N., Kelble, C. R., Ortner, P. B. and Rudnick, D. (2009). Phytoplankton Bloom Status: Chlorophyll a Biomass as an Indicator of Water Quality Condition in the Southern Estuaries of Florida, USA. *Ecological indicators* 9, 56–67

Chong, C. N. (2020). *Caracterización de la clorofila a satelital en el Panamá Bight (Pacífico Este Tropical). Variabilidad espacio temporal y forzantes ambientales*. PhD Tesis. Pontificia Universidad Javeriana, Bogotá, Colombia.

D'Croz, L., J. B. Rosario and J. A. Gómez. (2016). Upwelling and phytoplankton in the Bay of Panama. *Revistas U Cr. Ac.* Cr.

Fiedler, P. C. and Lavin, M. F. (2017). Oceanographic conditions of the Eastern Tropical Pacific. In Glynn et al (Eds), Coral Reef of the Eastern Tropical Pacific. *Springer Science + Business Media Dondrecht.*

Hilaluddin, F., Yusoff, F. and Tatsuki, T. (2020). Shifts in Diatom Dominance Associated with Seasonal Changes in an Estuarine-Mangrove Phytoplankton Community. *J. Mar. Sci. Eng.*, 8(528).

Jeffrey, S.W., (1980). Algal pigment systems. pp 33-58 In Falkowski, P.G., (Ed.), *Primary productivity in the sea.* Plenum.

Kressler, W. S. (2006). The circulation of the Eastern Tropical Pacific: A review. *Progress in Oceanography,* 69(2),181-217.

Morales, V. y J. Cuéllar-Anjel (eds.). (2014). *Guía Técnica – Patología e inmunología de camarones Penaeidos*. OIRSA, Panamá.

Paerl, H. W., L.M. Valdes, J.L. Pinckney, M.F. Piehler, J. Dyble, P.H. Moisander. (2003). Phytoplankton photopigments as indicators of estuarine and coastal eutrophication. *BioScience,* 53(10), 953-964

Rubio-Rodríguez, E. and J. Stuardo. (2002). Variability of photosynthetic pigments in the Colombian Pacific Ocean and its relationship with the wind field using ADEOS-I data. Proc. *Indian Acad. Sci*. 111(3), 227-236.

Smayda, T. J, (1966). A quantitative analysis of the phytoplankton of the Gulf of Panama. 38. Inter-Amer. *Trop. Tuna Comm. Bull*. 11, 355-612.

Strickland, J. D. H. and T. R. Parsons. (1972). *A Practical Handbook of Seawater Analysis*. Fisheries Research Board of Canada.

Subramaniam, A., Brown, C. W., Hood, R. R., Carpenter, E. J., and Capone, D. G. (2001). Detecting *Trichodesmium* blooms in Sea WiFS imagery. *Deep-Sea Res*. 2(49), 107-121,

Wright, S. W. and S.W. Jeffrey. (2006). Pigment markers for phytoplankton production. The Handbook of Environmental Chemistry, 2, 71-104

Yacobi, Z. Y. and T. Xohary. (2010). Carbon: Chlorophyll a ratio, assimilation numbers and turnover times of Lake Kinneret phytoplankton. *Hydrobiología* 639(1), 185-196.