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Chautengo Lagoon, Guerrero (February 2009): estimation of primary production and phytoplankton biomass and their association to some environmental conditions.

Estimación de la producción primaria y biomasa del fitoplancton y su relación con algunas condiciones ambientales en la Laguna de Chautengo, Guerrero (Febrero de 2009).

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ABSTRACT

Phytoplankton´s biomass and primary production was estimated in Chautengo Gro coastal lagoon, during February 10 to 11, 2009. Primary production was quantified by oxygen changes in light and dark bottles method, which was incubated in situ at intervals of two hours. The values of gross production in pier ranged from 158.56 and 1352.42 mg C m^3h^{-1}, while those in the bar were between 349.77 and 116.56 mg C m^3h^{-1}. In addition, data was obtained in temperature, salinity, pH, depth, transparency, dissolved oxygen, percent oxygen saturation and wind speed. Biomass was calculated by spectrophotometric analysis of pigments. The maximum values of chlorophyll a in the pier and the bar was 31.27 and 3.32 mg m^3, respectively. We found that gross production is higher in the pier, and the concentration of chlorophyll a. It is concluded that the gross production as the concentration of chlorophyll a range of spatial and temporal manner and that the influence of physical and chemical factors may be involved directly in such variations. The predominant organism in the lagoon was the dinoflagellates, with the seasonal cycle characteristic of this time of year.

Key words: choropyll a, phaeopigments, photosynthetic pigments

RESUMEN

Se estimó la producción primaria y biomasa fioplanctónica en la laguna costera de Chautengo Gro, durante los días 10 y 11 de febrero de 2009. La producción primaria se cuantificó por el método de cambios de oxígeno en botellas claras y oscuras, para lo cual se realizaron incubaciones in situ en intervalos de dos horas. Los valores de la producción bruta en el muelle oscilaron entre 1352.42 mg C m^3h^{-1} y 158.56 mg C m^3h^{-1}, mientras que en la barra fueron entre 349.77 mg C. m^3h^{-1} y 116.56 mg C. m^3h^{-1}. Además, se obtuvieron datos de temperatura, salinidad, pH, profundidad, transparencia, oxígeno disuelto, porcentaje de saturación de oxígeno y velocidad del viento. La biomasa fue calculada mediante el análisis espectrofotométrico de pigmentos fotosintetizadores. Los valores máximos de clorofila a en el muelle y la barra fueron de 31.27 mg m^3, y 3.32 mg m^3, respectivamente. Se encontró que la producción bruta es mayor en la zona del muelle, así como la concentración de clorofila a. Se concluyó que tanto la producción bruta como la concentración de clorofila a variaron en espacio y tiempo, y que la influencia de factores físicos y químicos intervinieron directamente en tales variaciones. Los organismos predominantes en la laguna fueron los dinoflagelados, correspondiendo a los ciclos estacionales característicos de esta época del año.

Palabras clave: clorofila a, feopigmentos, pigmentos fotosintetizadores.

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INTRODUCTION

Coastal lagoons are characterized by the balance between internal and external factors that influence their physical behavior, chemical and biological. One of the most important biological components of these ecosystems are phytoplankton, which plays a major role in the cycle of materials and energy, which gives them a high potential productivity for this reason, coastal lagoons are the most productive areas marine ecosystem and food webs have high diversity and high biomass of secondary producers (Odum 1972, Margalef 1974, Varona and Gutierrez 2006).

The study of the rates of primary production in aquatic ecosystems is of great importance, since it is the production of organic material in the initial part of the food web, but this process can be limited by several factors, including the low penetration of light into the water column, due to haze in environments rich in nutrients, which are one of the mechanisms regulating the production of phytoplankton. It has been reported that the photosynthetic activity of phytoplankton is associated with variations of vertical mixing, which results in phytoplankton adaptation to light and shade by changing endogenous cycles using chlorophyll a per cell (Millan et al. 1999). So then, a set of biotic and abiotic factors that limit or regulate phytoplankton primary production and cause temporal and spatial variations of the same (Spiniello et al. 2006).

The estimation of phytoplankton primary productivity is of great importance as it is the process that converts inorganic carbon into organic matter by photosynthetic CO^2 assimilation, carbon entering the aquatic food web. Chlorophyll a concentration was used as an indicator of phytoplankton biomass and therefore the quantification of the distribution is essential for determining the primary production (Barocio et al. 2007).

The records made by Koblenz-Mishke et al. (1970) reported the global distribution of phytoplankton primary production and increases toward the coastal region and in upwelling zones. Millan and Lara (1995), say the Mexican Pacific coastal regions are areas of high phytoplankton production. The Mexican coastal studies have focused on phytoplankton composition to the description of changes in their biomass (chlorophyll a) and its relation to the magnitude of primary production (Varona and Gutierrez 2006). Klimek (1978) compared the primary production Nuxco gaps, Chautengo and Coyuca during April, July, and August 1976, recorded in the lagoon of Chautengo values 1.64 g C m^2 day^{-1} in June and 0.49 g C m^2 day^{-1} in July. Mee (1978), primary production was estimated by the method of oxygen changes during the months in which the bar was open and during that closed, obtaining values of 4.5 and 10.4 g C m^2 h^{-1}, respectively (Millan and Lara 1995). Contreras (1985), analyzing the hydrology and nutrients in Mexican coastal lagoons, both in the Atlantic Ocean and the Pacific, obtained the following values of chlorophyll a and primary production in the Lagoon of Chautengo. 7.9 mg m^3 and 0.95 gCm^3 h^{-1}, respectively. Bulit (1996) analyzed the surface distribution of chlorophyll a in the lagoon of Chautengo. This ranged from 0.69 to 21 mg m^3 while its average value for the rainy season doubled the value for dry seasons, 25.72 and 13.17 mg m^3, respectively.

This work aims to quantify primary production of phytoplankton in the lagoon Chautengo, by the method of changes in the concentration of dissolved oxygen in light and dark bottles, and determine the influence of abiotic factors in this process, as well as, phytoplankton biomass estimate by the spectrophotometric method (concentration of photosynthetic pigments), qualify the phytoplankton present in the lagoon.

MATERIALS AND METHODS

Fieldwork was conducted from 10 to 12 February 2009. The February 10 worked in spring (16 º 37 '06 "N, 99 ° 05' 38" W) and February 11 in the bar area (16 º 36 '10 "N, 99 º 06' 55.5) (Fig.1). To estimate phytoplankton primary production method was used to changes in the concentration of oxygen in light and dark bottles. While for the quantification of phytoplankton biomass the method employed was trichomatic by spectrophotometry.

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In addition to the two sets of sampling in areas of the bar and the dock, on February 12 were sampled by boat along the lagoon at eight stations previously established. In this sampling were physical parameters such as depth, transparency, water temperature, salinity, and percent saturation performed in the field by the Winkler method and was calculated in mg of dissolved oxygen and carbon in mg added (Barreiro and Signoret 1999).

At the end of the incubation periods, all bottles were processed similarly. Titrations were performed in duplicate and reported spending sodium

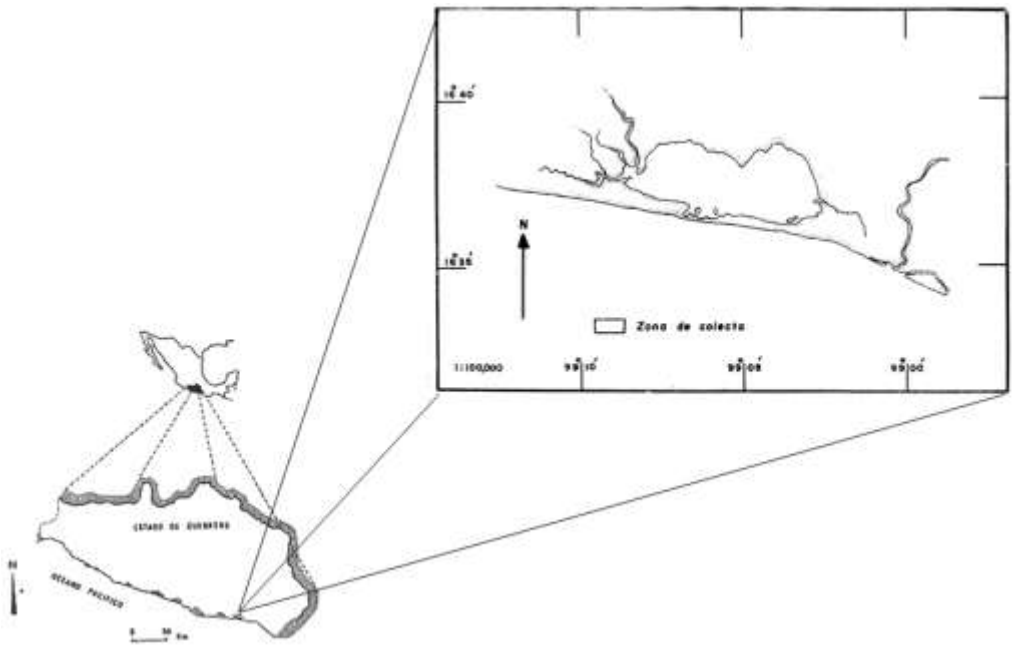

Fig.1 Localización geográfica de la laguna de Chautengo, Gro.

Fig. 1. Chautengo, Gro. lagoon geographical location.

concentration of dissolved oxygen in surface and bottom in different seasons. Also, phytoplankton samples were collected with a trawl 10 µm pore opening.

I. Estimating the primary production method changes in oxygen concentration in light and dark bottles.

Incubations were five days along with two hour intervals; the water samples were obtained using a bottle 4 L Van Dorn, at a depth of 50 cm. BOD nine bottles were filled to avoid introducing bubbles.

The incubations were done *in situ* in triplicate in 300 mL BOD bottles (initial light and dark), the incubation system was installed in a traditional tide gauge. The determination of dissolved oxygen was thiosulfate used in each, the results were averaged. To calculate the correction factor of normal (f), the following formula was used:

$$F=5.0/V$$

Where: V= thiosulfate spent

Calculations for determining the concentration of dissolved oxygen

Dissolved Oxygen (µmol L^{-1}) = 0.1006 x f x v

Underwent conversion µmol mg L^{-1} to L^{-1} by multiplying 16 by the dissolved oxygen mol

f = correction factor normality of thiosulfate. Over time, the initial normality of the solution prepared is changing and that change needs to be

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estimated through and enter the correction factor in the calculations.

V = volume of thiosulfate used (in mL)

Net production, gross and respiration were expressed in terms of oxygen and release of carbon incorporation. To estimate the output expressed in release of oxygen (mg L^{-1}) was used the following formulas (Barreiro and Signoret 1999):

Pn = (clear - initial), R = (initial - dark) and
Pb = (clear - initial) + (initial-dark)

Primary production expressed as carbon incorporation (mg C. m^3h^{-1}) was determined based on the following formulas (Barreiro and Signoret 1999):

$$Pn = \frac{605 \text{ x } f \text{ x } (Tc - Ti)}{N \text{ x } FQ}$$

$$R = \frac{605 \text{ x } f \text{ x } (Ti - To) RQ}{N}$$

$$Pb = \frac{605 \text{ x } f \text{ x } (Tc - To)}{N \text{ x } FQ}$$

Where:
f = correction factor thiosulfate.
T = spent of thiosulfate.
c = BOD clear.
o = DBO dark.
i = initial BOD.

FQ = photosynthetic coefficient (1.2). Relationship between oxygen delivery and incorporation of carbon dioxide

RQ = respiratory quotient (1.0). Relationship between the release of carbon dioxide and oxygen incorporation and

605 = factor of oxygen release correspondence regarding carbon incorporation.

At each interval incubations were some physical and chemical parameters of the water. Oxitermohalinoconductividimetro brad YSI Model 85 was used to measure salinity (± 0.1), pH (± 0.1), temperature (±0.1 °C), oxygen saturation percentage (± 2%) and dissolved oxygen (± 0.25 mg L^{-1}).

To estimate the salinity was used brand American Optical refractometer (± 2 units of salinity), to determine the visibility in the water body used a Secchi disk (± 1 cm). To determine the pH was used Conductronic digital potentiometer pH 10 (± 0.01).

The wind speed recorded by an anemometer Luft (m s^{-1}) (± 3 in 3 m s^{-1} in strong wind and ± 1 in 1 m s^{-1} in light winds). The tidal range was measured with a tide gauge craft and geographic coordinates were determined using a GPS mark Garmyn (± 1').

II. Estimation of phytoplankton biomass

To estimate phytoplankton biomass samples were collected from water dock area and the bar with a bucket of considerable volume. System was used Millipore vacuum filtration of 47 mm diameter and GF/F Whatman pore opening of 0.7 µm, which, when filter, covered with a saturated solution of magnesium carbonate. The filtration system was covered with a black cloth to prevent decomposition of the photosynthetic pigments. The filter is folded using flat nose pliers and placed in tubes lined with foil, then were placed, uncovered, in a container with silica gel, which was covered and kept in a cooler for further analysis in the laboratory (Barreiro and Signoret 1999).

Tricromático method was used to quantify by spectrophotometry photosynthetic pigments.

To make the extraction of the pigments used 90% acetone which was added to each tube in a volume of 10 mL. The filter was crushed with a glass rod the tubes were capped and refrigerated for 24 hours. After the extraction period, the samples were centrifuged for 15 minutes at 3500 rpm in a centrifuge Sol bat C-600. The supernatant was transferred to cells and proceeded to take readings. We used a spectrophotometer Spectronic 20 Genesys ™ 4001/4 (± 0.01 nm).
The samples were subjected to a first reading at 750 nm Concentrations of chlorophylls a, b, c1 and c2 (trichromatic method) were determined by performing readings 664, 647 and 630 nm and were applied formulas Jeffrey and Humphrey (1975):

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$$\text{Clorofila } a \text{ (mg m}^3\text{)} = \frac{11.8\,A_{664} - 1.54\,A_{647} - 0.08A_{630} \text{ x V}}{\text{V x 1}}$$

$$\text{Clorofila } b \text{ (mg m}^3\text{)} = \frac{-5.43\,A_{664} + 21.03\,A_{647} - 2.66\,A_{630} \text{ x V}}{\text{V x 1}}$$

$$\text{Clorofila } c1 \text{ y } c2 \text{ (mg m}^3\text{)} = \frac{-1.67\,A_{664} - 7.60\,A_{647} + 24.52\,A_{630} \text{ x V}}{\text{V x 1}}$$

Carotenoids in determining readings were performed at 480 nm and 510 nm and were applied formulas Strickland and Parsons (1972).

$$\text{Carotenoides (mg m}^3\text{)} = \frac{10.0\,A_{480} \text{ x V}^3}{\text{V x 1}}$$

All samples were read at 430 nm (wavelength where the photosynthetic pigments absorb).

Determining chlorophyll concentrations phaeopigment readings were taken at 665 nm before and after acidification (two drops of hydrochloric acid, 0.3 M of each sample) were homogenized and waited two minutes readings at 750 and 665 nm. For calculations were applied formulas proposed by Lorenzen (1967).

$$\text{Clorofila } a \text{ (mg m}^3\text{)} = \frac{26.7(A_{665a} - A_{665a}) \text{ x V}}{\text{V x 1}}$$

$$\text{Feopigmentos (mg m}^3\text{)} = \frac{26.7(A_{665a} - A_{665a}) \text{ x V}}{\text{V x 1}}$$

Index was calculated Margalef pigment with the readings obtained at 430 and 665 nm (D430/D665), (Margelef 1974).

III. Cualificación del fitoplancton

Water samples were collected during each incubation performed in both study areas, were added a solution of Lugol -acetate to obtain an amber color. In the case of the samples collected during the tour in the lagoon, we performed a similar procedure. Once in the laboratory, the samples were observed under an optical microscope with objectives Cx21FS1 Olympus model dry and immersion. Taxonomic identification (gender) was based on literature as identifing marine phytoplankton. (Tomas 1997), phytoplankton (Lara et al. 1996) and Marine plankton a practical guide (Newell and Newell 1979).

RESULTS AND DISCUSSION

a. Chemical and physical parameters (Table 1)

Temperature: In the spring and bar areas was a change of 1-2 ° C. in each time interval recorded. Ranged between 25.7 and 30.2 °C in spring, while in the bar were recorded between 26.5 and 29.4 °C. In both areas there was a decrease of 1 ° C after 16:00 hours. Contreras (2004) mentions that the sea surface temperature has great influence on the variations recorded in the entire coastal area. In this study, temperature fluctuation was not as significant over time.

Salinity: This parameter was recorded using two different computers, the data obtained by oxitermohalinoconductividimetro (YSI 85) show at the pier minimum salinity maximum of 29.4 and 29.8, while in the bar was recorded as 29.7 as minimum and maximum 32.3. When using a refractometer following data were obtained on the pier a minimum of 29 and a maximum of 31 in the bar 29 and 34 respectively. However when comparing the salinity recorded in both areas can be seen that the bar has increased salinity, these differences are due mainly to the location of sampling areas, the bar is in direct contact with the sea so that there is a mixture constant water epicontinental with seawater that causes salinity values are higher compared to the spring, which is much further from the sea and has no such direct contributions of seawater. Coral and Segura (1979) reported a minimum of 8.46 to a high of 16.85, in the present study reported a salinity of 29.1 being more established data, so does the maximum salinity, which was 34 and is almost twice the maximum recorded by these authors.

pH: At 8:00 h the spring provided with a slight pH 6.8 acid increasing trend throughout the day and

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Tabla 1. Parámetros físicos y químicos del método botellas claras y obscuras en la laguna de Chautengo Gro. H=hora, pH, T=transparencia, T°C=temperatura, P=profundidad, Salinidad (g L^{-1}) O=oxitermohalinoconductividimetro, A (cm)=amplitud de marea, DV=dirección del viento, V=velocidad del viento (cm s^{-1}), Oxigeno, #tubo, VF (mL)= volumen filtrado (mL).

Table 1. Physical and chemical values, using light and dark bottle technique in Chautengo lagoon, Gro. H = hour, pH, T = transparency, T ° C = temperature, P = depth, salinity (g L^{-1}) O = oxitermohalinoconductividimetro, A (cm) = tidal amplitude, DV = wind direction, V = wind speed (cm s^{-1}), oxygen, # tube, VF (mL) = filtered volume (mL)

H	pH	T	T(°C)	P(m)	Salinidad (g L^{-1})		A(cm9)	DV	V (cm s^{-1})	Oxígeno		# tubo	VF(mL)
					O					[O_2] Mg L^{-1}	[O_2] %		
MARTES													
10:00	7.79	32	26.5	48	29.7	30	1	Ne	0	4.23	66.5	2	700
12:00	7.83	30	27.8	53	29.8	29	2	Ne	4	5.58	83.5	3	300
02:00	7.19	10	29.4	50	29.7	31	3	Ne	5	6.40	157.0	4	250
04:00	7.98	5	30.2	50	29.4	-	7	Ne	7	6.52	100.2	5	-
06:00	7.87	5	29	55	29.8	-	7	Ne	3	5.30	81.7	6	-
MIÉRCOLES													
08:00	5.9	116	26.6	116	32.3	-	-	Ne	0	4.75	69.2	6	1,650
10:00	7.3	110	26.5	115	30	-	-	Ne	0	5.10	65.9	7	2,000
12:00	7.7	115	27.2	115	32.2	-	-	Ne	3.5	4.62	62.8	8	2,000
02:00	7.8	115	28.9	115	29.7	-	126	Ne	7.5	5.48	83.4	9	2,000
04:00	8	113	29.4	113	32.1	-	-	Ne	5	6.44	99.8	10	2,850
06:00	7.7	110	28.6	110	30.3	-	-	Ne	3.5	6.35	89.8	-	-

maintaining an alkaline pH with a maximum value of 7.9. Bar shown in a lower pH at least 5.9 and a maximum of 8.0. The correlation between the pH values with the values of dissolved oxygen, said that when there was an acid pH, the dissolved oxygen concentrations were low whereas at alkaline pH these increased.

Tidal amplitude and wind speed: The recorded data of wind speed in the spring and rod are shown in Table 1, data were maximum at 16 h and 14 h respectively. The tidal range gradually increased over time to the last record**.**

Euphotic layer thickness: The minimum value of the spring was 12.5 cm at 16:00 and 18:00 h and a maximum of 95 cm at 8:00 h. The decrease in the euphotic layer thickness is attributed to biotic factors such as the presence of organic matter and abiotic factors such as wind, turbulence, currents and rain, this causes a significant impact on the photosynthetic activity of phytoplankton, reducing primary production of the same. The bar is perceived in the presence of benthic phototrophic communities benefit from even light penetration into the substrate, having regard to the values obtained in the calculations for obtaining Euphotic layer thickness. Increasing wind velocity and tidal range, influence the layer thickness Euphotic in spring and bar, however in both zones the Euphotic layer thickness does not vary 16:00 and 18:00 h and at 14:00 and 16:00 h.

Extinction coefficient of light: In the spring, the maximum value recorded was 0.34 and the minimum of 0.04, on the bar extinction coefficient values ranging between 0.1 and 0.2. These values

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indicate a light attenuation faster spring that bars. It was observed that the light extinction increased significantly between 12:00 and 16:00 h in spring. This effect may be the result of the suspension of sediments caused by tidal range since in this zone is obtained an increase of 7 cm. Another factor was the turbulence caused during sampling. The bar did not show a significant change in the attenuation of light as there was an increase in tidal range of only 2 cm

The extinction coefficient of light is greater in water bodies where there is presence of organic or inorganic matter suspended or dissolved (Parsons 1984), this relates to the values obtained in the lagoon Chautengo as coefficient values extinction was highest in the spring (0.34), which showed higher sediment suspension. Bar values presented relatively low extinction coefficient.

Concentration (mg L^{-1}) and saturation (%) dissolved oxygen: The dissolved oxygen concentration in the spring had a minimum value of 2.25 mg L^{-1} at 8:00 pm and the maximum 6.52 mg L^{-1} at 16:00 h. Wind velocity and tidal amplitude modified oxygen concentrations. A possible mixture of oxygen atmospheric oxygen and water may be the cause of the variations along the time. The bar had a minimum value of 4.62 mg L^{-1} at 12:00 h and 6.44 mg L^{-1} at 16:00 h. The percentage of dissolved oxygen saturation of water in the spring was 36 % at 8:00 h minimum and maximum at 14:00 hrs with 157 %. One can see that the gap is high in relation to the bar. These difference in the dissolved oxygen saturation were lower, the minimum was 62.8 % at 12.00 h and the maximum 99.8 % at 16:00 h .

b. Primary Production

In the spring was recorded maximum gross production value was 1352.43 mg C m^{-3} h^{-1} at 14:00 h The minimum values of carbón incorporation were observed at 10:00 and 12:00 h recording 209.86 and 158.56 mg C m^{-3} h^{-1} respectively (Table 2).

Bar area recorded a gross production of 349.77 mg C m^3h^{-1} at 14:00 h. However, the gross production decreased at 10.00 and 16.00 h showing values of 116.56 and 158.56 mg C m^3h^{-1} respectively.

Gross production is equivalent to the total production of phytoplankton. When comparing gross production obtained in both study areas, it was determined that the pier area has higher rates of gross primary production.

Millán-Nuñez et al. (1999), describes some regulatory factor photosynthetic processes such as

Table 2. Net production and respiration values obtained from Chautengo, Gro. lagoon.

Tabla 2. Valores de la producción neta y respiración obtenidos de la laguna de Chautengo, Gro.

Site	Hour	Respiration	Net production	Gross production
Dock	8	251.83	289.14	499.00
	10	128.71	102.60	209.86
	12	100.73	74.62	158.56
	14	761.09	718.19	1352.43
	16	173.46	298.47	443.04
Bar	8	187.47	72.28	228.51
	10	50.37	74.62	116.59
	12	44.77	177.21	214.52
	14	156.70	219.19	349.77
	16	16.79	144.57	158.56

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the penetration of light and the availability of nutrients (especially NH^{4+} and $PO4^{-3}$). In the spring, the light penetration in the water column decreased throughout the day, however net production higher was recorded at 14:00 h, which was estimated a value for k of 0.17 (indicating that the light extinction was greater with respect to the area of the bar) and a euphotic layer thickness of 25 cm. This showed that the maximum photosynthetic rate does not require large amounts of irradiance.

According to the records made by Lee (1978), using the same quantification method, gross output recorded was 4.5 g C m^3h^{-1} , to compare this estimate with that obtained in this study reported lower values.

The gross production Chautengo lagoon fluctuated within the range proposed by Subba Rao (1981) for mid-latitude coastal lagoons, which range from 4-236 mg C m^3h^{-1}.

Net production and respiration: Net production in the spring showed a maximum production of 718.18 mg C m^3h^{-1} at 14:00 h. The minimum values were observed at 12.00 h recording m^3h^{-1} 74.62 56 mg C m^3h^{-1}. In Zone 2, the maximum net production was 219.19 mg C m^3h^{-1} at 14:00 h and the minimum of 72.28 mg C m^3h^{-1} (Table 2).

The estimated data breathing in zone 1 are: a maximum of 761.09 mg C m^3h^{-1}, and a minimum of 100.73 mg C m^3h^{-1}. In Zone 2, the following values were obtained 187.47 mg C m^3h^{-1} and 16.79 respectively.

Evaluation of respiration rates and net production help define efficiency of marine microbial food web, which is critical for the determination of global carbon fluxes (Robinson et al. 2002).

When analyzing the above data, we can see that in the spring, the maximum values of gross net production and respiration are presented in the same period of time (14:00 h). However, it shows that respiration was greater than the net production, i.e. overshoot compensation point, so it has a negative balance with respect to the energy available to higher trophic levels.

In the bar area, the metabolic processes of the phytoplankton showed slight temporary varies throughout the day. The maximum rate of gross and net production was recorded at 14:00 h, the maximum values of breath at 8:00, but in this range the same thing happens in the spring, the respiration values are greater than net production values if considering the time factor this can be attributed to that in the early morning hours photosynthetic rates are high due to the low number of incident irradiance in the water column.

The gross, net and respiration in both areas of study related whit to temperature, one of the main factors regulating photosynthetic activity, as this can speed up the metabolic processes to increase phytoplankton production rates or when it exceeds the optimum temperature can affect or inhibit the production of organic matter affecting directly the enzymatic activity of phototrophs Temperature was considered only as a regulatory factor, since when placed at different levels of the water column were more likely to show variations by technical errors. Factors such as salinity or pH showed minimal or no changes, given that they are closed systems (BOD bottles) these parameters were kept constant to no water exchange with the environment, so it does not significantly influence the results.

In the spring, net production and respiration showed similar values, remaining at the compensation point between 8:00 and 14:00 h. Gross production is minimal between 8:00 and 12:00 h, however no clutch between 14:00 and 16:00 h there was a significantly increased. Respect to time the water temperature, it increased with time, the gross output peak coincides with one of the maximum temperatures registered (29.4 ° C).

In the bar was no difference between the data recorded breathing and net production. Only at 8:00 h respiration was higher than the net production, indicating that there is a negative balance between what is produced and what is consumed, this is likely related to temporary factors such as the penetration of irradiance on water column. However from 10:00 h net production increased compared to breathing, maintained until 16:00 h. The gross production peak corresponds to one of the highest recorded temperatures (28.9 ° C).

c. Quantification of biomass

Chlorophyll a concentration is an indicator of phytoplankton biomass present in a water system, so

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that it is essential for the determination of primary production (Barocio et al. 2007).

The chlorophyll a quantified estimate of the spring (Table 3) showed a maximum of 31.27 mg m^3 at 16:00 h, the minimum value was 2.90 mg m^3 at 10:00 hrs. However higher values recorded in carotenoids, obtainig a minimum of 3.71 mg m^3 and a maximum of 53.4 mg m^3. Considering the prevalence of carotenoids indicating dinoflagellates are organisms phytoplankton more abundant in the Lagoon, since they are characterized by chlorophyll a, c1, c2 and carotenoid pigments such as major (Thomas 1997).

In the area of the bar chlorophyll quantifying presented a maximum value of 3.32 mg spring active chlorophyll maximum 20.60 g m^3 and a minimum of 1.14 g m^3, while the m^3 in the corresponding sample at 12:00 h, while the value was recorded at 16:00 h obtaining a value of 0.42 mg m^3. Carotenoids estimated values recorded on the bar at least 1.30 mg m^3 and a maximum of 5 mg m^3. By comparing the data recorded by Bulit chlorophyll a (1996) ranging from 0.69-21 mg m^3, an increase was observed, since the maximum values ranging from 0.4-31.2 mg m^3.

The concentration of pigments quantified Chautengo lagoon, it was found that the carotenoids showed the highest peaks, followed by chlorophyll a. The analysis of the pigments present in the samples indicated the type of phytoplankton that abounds in the lagoon, considering in this case as most abundant dinoflagellates.

d. Quantification of chlorophyll a and phaeopigments (acidification method)

Chlorophyll a was quantified activated by acidification of the samples, obtained in the spring active chlorophyll a maximum 20.60 g m^3 and a minimum of 1.14 g m^3, while the phaeopigments recorded 16.2 g and 1.1 g m^3 respectively. The percentage of active chlorophyll in this area was 16.32 %.

The bar chlorophyll a values drastically decreased compared to active spring , recording a maximum of 2.0 g m^3 and a minimum of 0.37 g m^3 Phaeopigment regarding recorded maximum 2.1 g m^3 and a minimum of 0.08 g m^3 . Chlorophyll active in this area was 17.8 % (Table 4).

Phaeopigments determination permitted to know the actual concentration of chlorophyll which is involved in the photosynthetic process, in terms of biomass, can be directly related to the rate of primary production recorded in the lagoon. In aquatic systems phaeopigments are naturally occurring as a result of grazing, senescence or decay of fitoplánteres (Barreiro and Signoret 1999).

Table 3. Chautengo lagoon pigment concentration values (2009 February).

Tabla 3. Concentración de pigmentos en la laguna de Chautengo (Febrero 2009).

Sitio	Horas	Clorofila a mg m^3	Clorofila b mg m^3	Clorofila c1 y c2 mg m^3	Carotenoides mg m^3
Muelle	8	15.3	2.50	5.0	23.7
	10	2.9	1.90	2.3	3.7
	12	10.9	0.60	0.1	14.6
	14	5.3	1.10	1.6	9.2
	16	31.2	1.20	10.3	53.4
Barra	8	2.4	0.70	0.9	4.5
	10	0.6	0.30	0.1	1.3
	12	3.3	0.30	0.5	5.0
	14	2.0	0.07	0.2	3.1
	16	0.4	0.20	0.2	0.7

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e. Pigment Margalef Index

The Margalef index indicates pigment relationship between the total amount of pigments (as all accessories photosynthetic pigments absorb a wavelength of 430 nm) and amount of chlorophyll pigments (chlorophylls because absorb wavelengths of 665 nm) (Perez and Romero 2001).

The results obtained in calculating pigment Margalef index, ranging between 2.8 and 3.3, only reported a minimum value of 1.95 (Table 5). These values show a photosynthetic pigments and accessories heterogeneity, determining that the phytoplankton community is mature, since there were no minimum values, which indicate a greater amount of chlorophyll a (Margalef 1974).

f. Diurnal curve of oxygen changes in water

The change in oxygen curve quantifies the overall metabolism of the body of water (Barreiro and Signoret 1999). The curve made with the values obtained from the lagoon of Chautengo described in the dock area, oxygen concentrations in mg L^{-1} increased proportionally with the time intervals until 16:00, after this time there was a slight decrease. With respect to the reported values of the bar dissolved oxygen concentrations showed slight fluctuations throughout the day.

Registered oxygen variations are closely related to the biological processes of photosynthesis and respiration, the latter both phytoplankton organisms as other bodies of water column and benthic organisms and nekton, this aspect is one of the major disadvantages of this method. Another major disadvantage is that such monitoring is recommended along 24 hours a day, but in the case of this research the monitoring only performed for a period of 10 h.

g. Qualification of phytoplankton

Was determined by microscopic observation and analysis of pigments, that the major components of the phytoplankton of Lagoon Chautengo (February 2009) are the dinoflagellates.

Gomez (1980) determined by sampling bimonthly quantitative and qualitative variations of phytoplankton in the lagoon of Chautengo, reporting that the phytoplankton group that dominated quantitatively and qualitatively during the annual cycle, which constituted diatoms pennales. However, such variation could be because in temperate climates there is typically a diatomeico flowering in spring with the greatest increase in biomass due to the high temperatures and nutrient availability, followed by a series of slight variations in which the dinoflagellates, who do not require large amounts of nutrients and abundant light energy, increase towards the summer and winter months to finally show an increase in end autumn, quantitatively less than the spring bloom (Dawes 1986), (Fig.2).

h. Horizontal distribution of some physical and chemical parameters

pH and salinity. Surface three of the eight stations have slightly acidic pH values (Chautengo, Tamarindos and Copala) (Table 7), while the other five have pH above 7.

Salinity was recorded using two different computers, the data obtained by oxitermohalinoconductividimetro (YSI 85) had a salinity minimum of 25.1 to a high of 32.3 on the surface, while in the background showed minimum values 23.9 and as high as 32.6. When using a refractometer was obtained on the surface a minimum of 25 and maximum of 32, the refractometer was not used in background.

Stations with slightly acidic pH values are influenced by human activities as they are close to the dock areas, except the river mouth station Copala.

We observed a spatial variation in salinity little changed throughout the Lagoon, suggesting heterogeneity of the system compared to salinity.

Depth and transparency. Table 7 shows the different depths corresponding to each station. The maximum depth recorded was 105 cm in the rock station and minimum bar station with 68 cm. This evidences the characteristic shallow or shallow lagoon. Transparency only recorded at the stations shown in Table 7, these are few reliable data during sampling since not had the Secchi disk, so it was improvised with a device that simulated a disc.

Saturation concentration of dissolved oxygen. Dissolved oxygen concentrations at the surface were higher than 3 mg L^{-1} , at the level of the tip stations and the bar had values of 5.6 and 6.1

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mg L^{-1} respectively. In the background values were less than 1 mg L^{-1} in six of the eight stations. Dissolved oxygen concentration of the stations and the top bar at bottom were 6.6

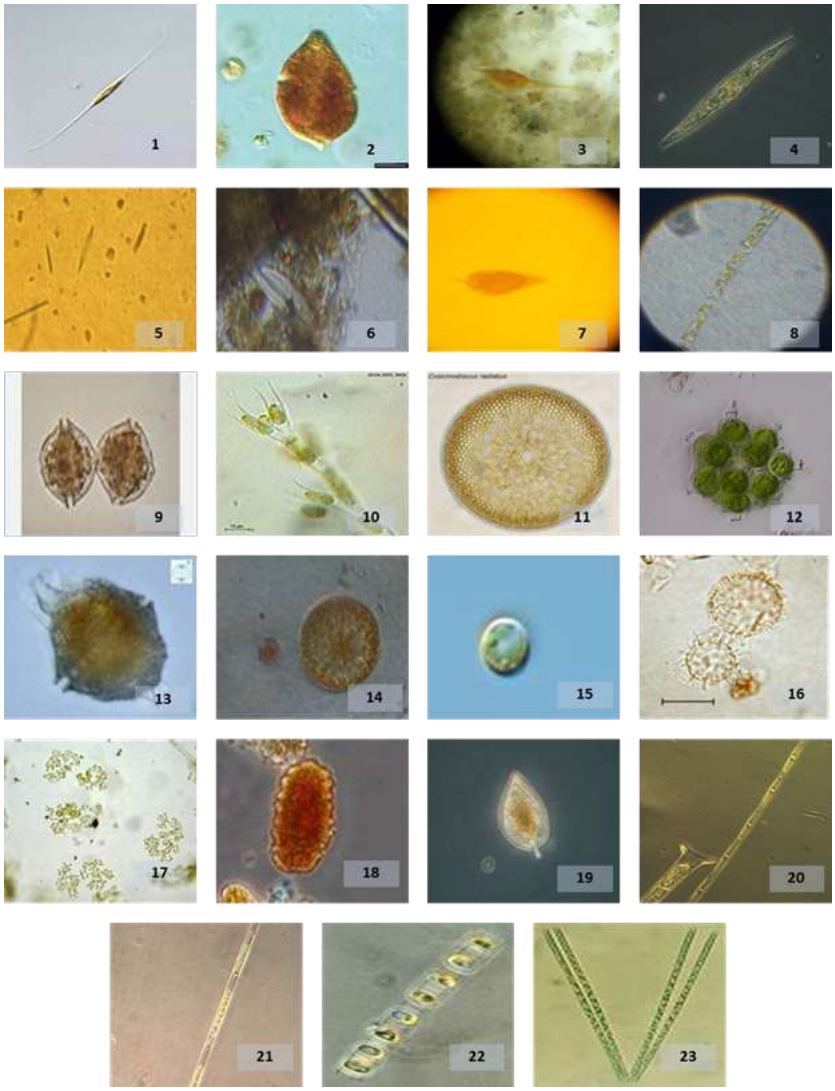

Fig. 2. Cualificación de fitoplancton. Organismos encontrados en el área de estudio (muelle y barra) en la laguna Chautengo. 1. *Nitzschia*, 2.*Gymnodinium*, 3.*Ceratium*, 4.*Pleurosigma*, 5.*Navicula*, 6.*Diatomea pennal*, 7.*Euglenoide*, 8.*Colonia de Clorofitas*. Organismos encontrados a lo largo de la laguna Chautengo. 9.*Alexadrium*. 10. *Chromulina*, 11. *Coscinodiscus*, 12.*Coleastrum*, 13.*Gonyaulaux*, 14.*Halosphaera*, 15.*Isochrysis*, 16.*Pentapharsodinium*, 17.*Phaeocystis*, 18.*Polykrikos*, 19.*prorocentrum*, 20.*Pseudonitzschia*, 21.*Rhizolenia*, 22.*Skeletonema*, 23.*Talassiathrix*.

Fig. 2. Phytoplankton qualification. Organisms found at study geographic zone (dock and sea bar) at Chautengo, Gro. Lagoon. 1. *Nitzschia*, 2.*Gymnodinium*, 3.*Ceratium*, 4.*Pleurosigma*, 5.*Navicula*, 6.*Diatomea pennal*, 7.*Euglenoide*, 8.*Colonia de Clorofitas*. Organisms found at all Chautengo lagoon zone. 9.*Alexadrium*. 10. *Chromulina*, 11. *Coscinodiscus*, 12.*Coleastrum*, 13.*Gonyaulaux*, 14.*Halosphaera*, 15.*Isochrysis*, 16.*Pentapharsodinium*, 17.*Phaeocystis*, 18.*Polykrikos*, 19.*prorocentrum*, 20.*Pseudonitzschia*, 21.*Rhizolenia*, 22.*Skeletonema*, 23.*Talassiathrix*.

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Table 7. Distribution of physical and chemical parameters obtained from Chautengo, Gro. lagoon (February, 2009).
Tabla 7. Distribución de parámetros físicos y químicos en la Laguna de Chautengo (Febrero 2009).

Chautengo lagoon surface data (February 12th)											
Station	pH	T	T(°C)	P(m)	Salinity (g L^{-1})		V (cm s^{-1})	Oxigen		Geographical coordinates	
					O			[O_2] mg L^{-1}	[O_2] %	Latitude	Longitude
Chautengo	6.1	-	26.3	1	32.2	30	-	3.03	43.6	16°37'56.6" N	99° 06' 06.6" O
Tamarindos	6.9	-	26.3	-	29.1	29	-	3.54	53	16°38'12.2" N	99° 07' 24.9" O
Desenbocadura Nexpan	7.4	-	25.2	-	27.8	27	-	4.72	63.4	16°37'9.7" N	99° 07' 46.5" O
LaBarra	7.1	-	25.7	-	32.3	32	-	5.6	63.4	16°36' 10" N	99° 06' 55.5" O
Pozos	7.2	-	27	-	30	30	-	3.7	59.5	16°36' 14.3" N	99° 05' 42.6" O
Desenbocadura Copala	7	-	28.6	-	26.1	26	-	4.12	61	16°36' 29.3" N	99° 05' 12.8" O
Las peñas	7.3	34	27.8	1.05	25.1	25	3	5.06	80.1	16° 37' 31.5" N	99° 03' 37.9" O
La punta	7.5	50	27.6	92	28.6	29	5	6.15	91.3	16° 37' 25" N	99° 05' 4.4" O
Chautengo lagoon bottom data (February 12th)											
Station	pH	T	T(°C)	P(m)	Salinity (g L^{-1})		V (cm s^{-1})	Oxigen		Geographical coordinates	
					O			[O_2] mg/L^{-1}	[O_2] %	Latitude	Longitude
Chautengo	-	-	26.5	100	29.4	-	-	0.07	1.2	16°37'56.6" N	99° 06' 06.6" O
Tamarindos	-	-	26.5	100	28.6	-	-	0.83	1.1	16°38'12.2" N	99° 07' 24.9" O
Desenbocadura Nexpan	-	-	26	85.3	28.9	-	-	0.09	1.5	16°37'9.7" N	99° 07' 46.5" O
La Barra	-	-	26.2	68	32.6	-	-	6.6	112.5	16°36' 10" N	99° 06' 55.5" O
Pozos	-	41	26.4	90	28.7	-	-	0.1	1.6	16°36' 14.3" N	99° 05' 42.6" O
Desenbocadura Copala	-	51	28.6	94	26.7	-	-	0.09	0.9	16°36' 29.3" N	99° 05' 12.8" O
Las peñas	-	-	27	1.05	23.9	-	-	0.07	1.6	16° 37' 31.5"N	99° 03' 37.9" O
La punta	-	-	27.2	-	29.1	-	-	3.96	58.7	16° 37' 25" N	99° 05' 4.4" O

and 3.9 mg L^{-1} respectively. The percentage of oxygen saturation in the bar at levels were surface and bottom were 63.4% and 112.5 %, respectively, while values presented dock 91.3% and 58.7 % by downhole and surface. The value of the concentration of dissolved oxygen in the station bar is higher at all concentrations in both surface and bottom, due to the large number of macro benthic algae found in this station and close communication with the sea. The vertical distribution of oxygen responds to different biological processes and physicochemical such as greater photosynthetic production and higher respiration rates , as aeration processes caused by the effect of wind on the

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surface and oxidation processes result of the decomposition of organic matter on the bottom (Rendón 2002).

Temperature. The temperature distribution is generally uniform. Spatially there are slight variations between in each level (surface and bottom) and between each of the stations. Temperatures were between 25.2 °C and 28.6 °C at the surface and 26 °C and 28.6 °C in background. The little fluctuation in temperature may be attributed to the shallowness recorded as it is does not exceed 105 cm. Local factors such as shallow high insolation and consequent high evaporation rates tend to magnify the effect of the temperature of coastal ocean currents (Contreras 1985).

CONCLUSIONS

We conclude that the dock area recorded higher gross and net. Quantification of chlorophyll also has high values in the same area. Temperature is the main abiotic factor that can influence the primary production of phytoplankton as the highest peaks in gross production coincided with the maximum temperature recorded. The most prevalent type of diatoms was the dinoflagellates, corresponding to the characteristic seasonal period in the temperate waters of the date that the study was conducted.

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