

(Sogreah, 1974). Catfish, on the other hand, is omnivorous, using a large range of food items from algae, snails, shrimps, up to fish (de los Reyes, 1995).

Based on the food habits of the major species in the lake, Sogreah in 1974 suggested that only 0.7 percent of the algal production is converted into fish flesh. This value is calculated for a population of fish feeding mainly on the planktonic algae. It is not probably possible nor advisable to eliminate completely the predators from the lake. On the average, about 20 percent predators should be maintained in the population to eliminate the weaker fishes. This proportion is maintained in a well-balanced natural waters.

On the other hand, the conversion factor of 1/25 or 4 percent from algae to fish could still be used for strictly planktivorous species, as in the fishpen culture of milkfish.

Another precautionary measure in converting algal production yield to fish production is that not all the algae will be taken up by the various organisms in the various trophic levels, because some of them may "leave" the lake thru outflow when the lake's water is higher than Manila bay, or some of the algae may die and sink and become part of the detritus or sediment. Furthermore, it is not possible for all the algae to be "harvested" by the different organisms - otherwise there won't be any left in the lake.

MATERIALS AND METHODS

Sources of Primary Data

Sampling was conducted in the four bays of the lake from July 25 up to September 3, 1997. *In situ* measurements were done for air and water temperature, water depth, secchi disk transparency, pH and salinity. Salinity was measured using a hand refractometer (ATAGO - S/mill) while the pH was determined using a portable Corning Check-mate 90 pH meter. Water samples were collected at various depths (surface, 0.5 meters and 1.0 meters) using a Van Dorn water sampler. Dissolved oxygen (DO) samples were fixed in the field while the primary production experiments were incubated for three hours using the light and dark bottle technique. A detailed analysis of this method is given in the section for Estimation Methodology.

Within four hours after sampling, the chemical analyses for the primary production experiments and the biological analyses were conducted in the Phycology Laboratory of the Institute of Biological Sciences at UP Los Baños. A 300-milliliter water sample from the three different depths for each bay was filtered through GF/C Whatman filter paper and kept in the freezer until ready for analysis. Likewise, one liter water samples that were collected from the three depths at each bay were concentrated by centrifugation for 10 min at 2,500 rate per minute using a Kubota KS - 5200C centrifuge and preserved in buffered formalin to make a final concentration of 3 percent, v/v.

The algae were identified and enumerated using the Neubauer improved bright line haemocytometer and an AO Spencer compound microscope following the method of Martinez, et al. (1975). The volume of each cell was computed based on the shapes of the cells. In this case a volume of one cubic centimeter is assumed to be equivalent to one gram. A detailed estimation method using biovolume is discussed in section for Estimation Methodology.

Sources of Secondary Data

Most of the information was obtained from the Environmental Protection Division of the Laguna Lake Development Authority (LLDA-EPD), the Southeast Asian Fisheries Development Corporation (SEAFDEC), the International Center for Living and Aquatic Resources Management (ICLARM), and the Philippine Council for Aquatic Marine Resources Development (PCMARD).

Some values used for the estimation of the various parameters were obtained from

the Ph. D. dissertation of de los Reyes (1995).

Unpublished data of net primary productivity data (1985 to 1995) and chlorophyll analysis for 1996 were obtained from LLDA-EPD. Other data were obtained from the Freshwater Research Station of the Bureau of Fisheries and Aquatic Resources, Region IV, under the Department of Agriculture (DA-BFAR Region IV, FRS). Production data of finfishes for 1979 to 1996 were obtained from the Bureau of Agricultural Statistics (BAS).

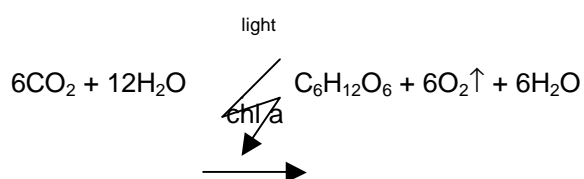
Estimation Methodologies

The estimation of potential fish production on the basis of primary productivity (NPP and biomass) is summarized in the schematic diagram in Figure 2.

The estimation of the potential fish production of the lake was determined by measuring primary productivity or the oxygenic photosynthetic activity of the algae using the oxygen method or the light and dark bottle technique. Another method used was to measure the standing crop or the biomass of the algae either by getting their biovolume or analyzing their chlorophyll a content.

1. Oxygen Method

This method is based on the fact that in photosynthesis, the production of organic matter goes simultaneously with the evolution of oxygen; see chemical equation below:



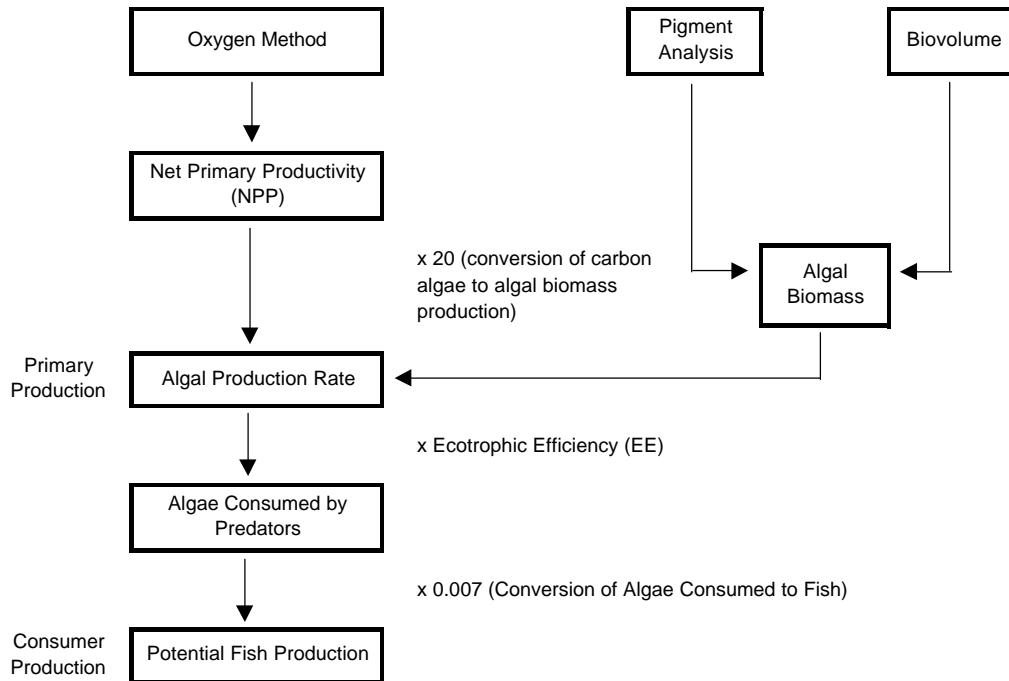
Hence, productivity is calculated on the basis that one atom of carbon is assimilated for each molecule of oxygen released.

Light and Dark Bottle Technique

The net oxygen evolved was determined using the light-and-dark-bottle technique which was adapted from Strickland and Parsons (1972). In this case 300 ml-BOD (biological oxygen demand) bottles were divided into two lots, i.e., the clear or light bottles (LB) and darkened bottles (DB). The light bottles (LB) presumably measure the amount of oxygen evolved during photosynthesis minus the amount of oxygen consumed by the animals and other microorganisms while at the same time the DB measure the decrease in oxygen due to respiration only. This serves also as a check.

Four stations were selected around Laguna Lake, i.e., Central Bay, West Bay, East Bay, and South Bays and sampling depths were at regular of 0.5 meters from the surface up to 1 meter depth for our study while the LLDA used 0.2 meters regular intervals from the surface up to 1m depth. Earlier studies showed that the compensation depth for the lake was about 1 meter i.e., the depth where respiration equals photosynthesis (LLDA-WHO, 1978), hence, our studies were done only up to this depth.

Figure 2. Schematic Diagram for the Three Alternative Methods of Estimating Potential Fish Production



Water sample was drawn from each depth and filled the two light bottles and one dark bottle. These filled up bottles were returned to their original depths for incubation of three hours (as in our study) or twelve hours (as in the case of LLDA). A wooden frame with floaters was used to incubate all the bottles at one time (Fig. 3).

Figure 3a. Biological Oxygen Demand (BOD) Bottles with Incubated Water Sample

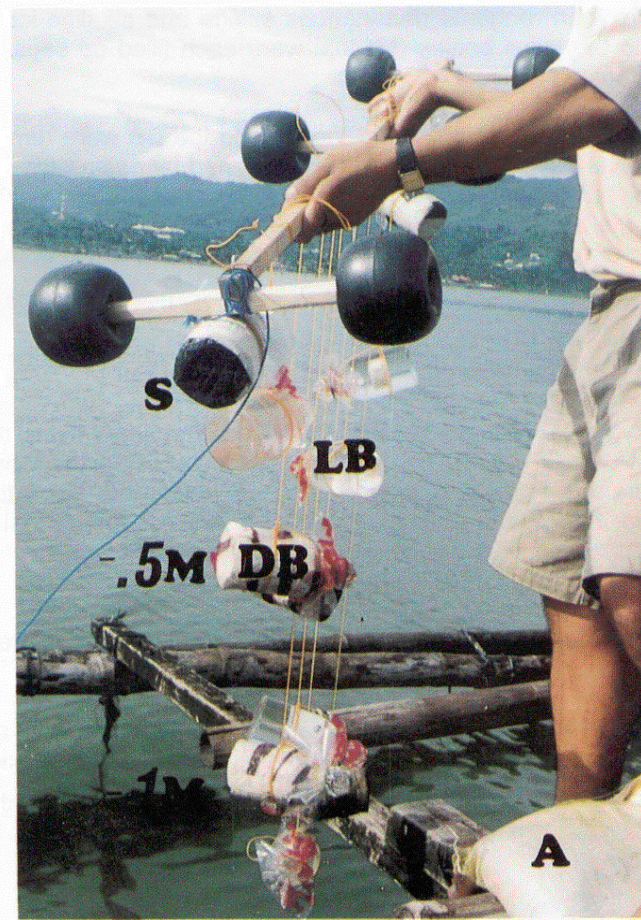
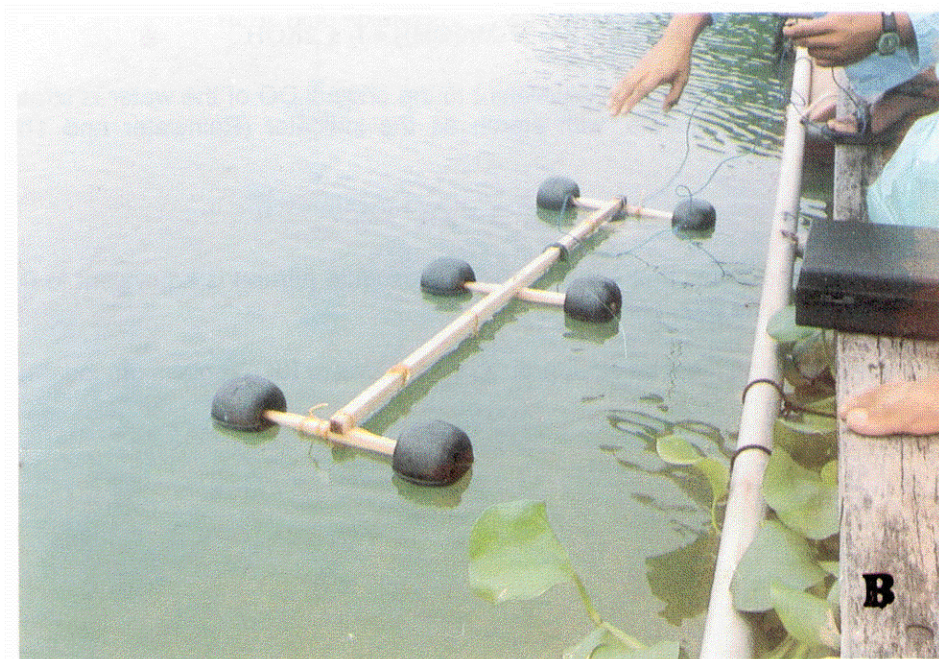


Figure 3b. BOD Bottles Suspended in Laguna Lake with a Wooden Frame Supported by Floaters (F)



Conversion of Dissolved Oxygen from Net Photosynthesis to Carbon-Algae

As soon as the photosynthesis experiment started, the pickling solution of the Winkler's dissolved oxygen reagents (manganous sulfide and alkaline-iodide-azide solution) (Fig. 4) was added to the initial bottles (IB) that were each filled up separately with the lake water for each depth being studied.

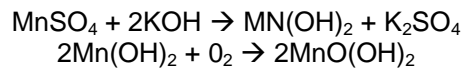
Likewise, after the incubation period the LB and the DB were removed without delay and pickled as in IB. Net oxygen evolution was determined by getting the difference between the amount of dissolved oxygen in the light bottle (LB) after the incubation period and the dissolved oxygen in the initial bottle (IB) or at the beginning of the experiment. At the same time, the decrease in oxygen in the darkened bottle determined any respiration that occurred simultaneously with photosynthesis.

Determination of Dissolved Oxygen

Dissolved oxygen in the bottles was determined chemically using the Modified Azide Winkler's method (MAW; APHA, 1976) or electrometrically using the Corning Check-mate model No. 90 membrane electrode. However, in the course of our study the DO membrane electrode broke down, hence, the chemical method was used throughout the study. In the MAW Method, it is assumed that the DO content of the water was mainly due to the net oxygenic photosynthetic activity.

Figure 4 shows the reagents and the step by step procedure used. The method is based on the following principle:

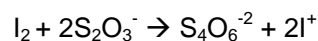
1. Manganese ions (II) are precipitated to manganous hydroxide in an alkaline solution;
2. The DO in the water is rapidly absorbed by the manganese hydroxide that may be in the following form:



2. On acidification with sulfuric acid, the liberated Mn(III) ions then react with previously added iodide ions and oxidized to iodine, which in turn forms a complex with the surplus iodide, thus it is protected from partial evaporation. Therefore, the iodine released is equivalent to DO present.



3. The liberated iodine, which is equivalent to the original DO of the water is titrated with 0.025N sodium thiosulfate, with starch as the indicator (Rainwater and Thatcher, 1960).



4. This method assumes that 1.0 ml of 0.5N thiosulfate (titrant) is equivalent to 0.25 mg at O₂, per L or one g O₂ per ml.

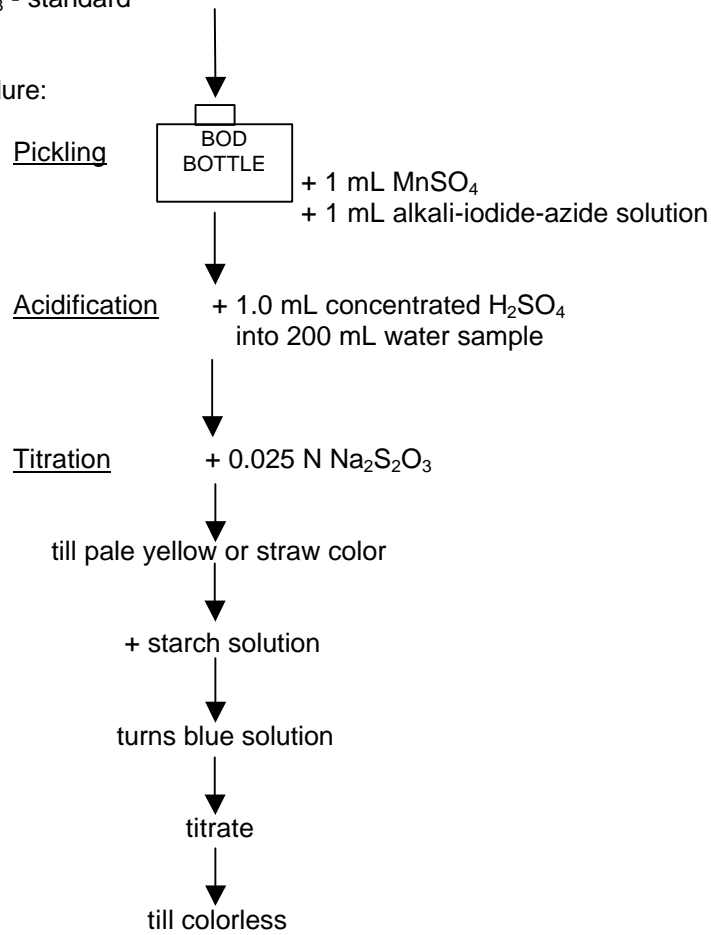
The titrant solution must be standardized with standard KIO₃ (potassium iodate).

Figure 4. The Reagents Used and the Flow Sheet in Determining Dissolved Oxygen in the Open Water of Laguna Lake Based on Modified Azide Winkler's Method (APHA, 1976; Lind, 1979).

I. Reagents

- a. Pickling solution : $\text{MnSO}_4 \cdot 2\text{H}_2\text{O}$ alkali-iodide-azide solution (with NaOH)
- b. concentrated H_2SO_4
- c. Titrant - 0.0125 N $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O} + \text{Na}_2\text{CO}_3$
- d. soluble starch solution
- e. KIO_3 - standard

II. Procedure:



Conversion of Dissolved Oxygen from Net Photosynthesis to Carbon-Algae

Initial study on the dissolved oxygen-versus depth curve for Laguna Lake showed a surface inhibition with optimum value at about 0.2m and gradually decreasing up to about 1m depth (LLDA,1978). Based on this observation, the amount of dissolved oxygen was determined only up to 1-meter depth, hence, expressed beneath the 1 m² area. The area in the curve was determined by integration.

Net photosynthesis was initially expressed as O₂/ml after titration with Winkler's reagents. However, after integration the amount of dissolved oxygen within the 1m² area was converted to g O₂/m². The oxygen value was converted to C atom by multiplying by a factor of 0.375 or 12/32 on the basis that one mole of O₂ (32 g.) is released for each mole of carbon fixed (12) (see chemical equation of photosynthesis). The value that is obtained is expressed as gC/m²/day, which is also designated as net primary productivity.

Conversion of C-algae to Algal Biomass

A factor of 20 was used to convert tons of C to wet weight of algae based on the assumption that in a given lake, all other elements are present in excess of the physiological needs, then carbon can generate between 10-12.5 times its fresh weight or 2 to 2.5 times its dry weight (Vallentyne, 1974; Lind, 1979).

Figure 5 summarizes the method of estimating algal biomass based on oxygen method. Below is a sample calculation based on the data we obtained in South Bay (SB) of Laguna Lake on July 25, 1997.

1. Initial dissolved oxygen (I. B.), g/mL*
IB surface(s) --- 7.10
IB 0.8m --- 7.05
IB 1.0m --- 6.65
ave. 6.93 g/mL

2. Dissolved oxygen in the light and dark bottles (LB and DB) after three hours incubation at different depths in the lake.

Depth (m)	LB (g/mL)	DB (g/mL)
s (surface)	10.2	7.0
0.2	10.1	6.9
0.4	10.1	6.9
0.6	9.9	6.9
0.8	9.7	6.8
1.0	8.9	6.8

3. Net dissolved oxygen (Net DO) and gross dissolved oxygen (Gross DO) at various depths.

a. $LB - IB = \text{Net DO}$ b. $LB - DB = \text{Gross DO}$

Depth (m)	Net DO (g/mL)	Gross DO (g/mL)
s (surface)	3.27	3.2
0.2	3.17	3.2
0.4	3.17	3.2
0.6	2.97	3.0
0.8	2.77	2.9
1.0	1.97	2.3

1 mL of 0.025 N $\text{Na}_2\text{S}_2\text{O}_3$ is equivalent to
 1 g. of O_2 per mL

4. Net primary Productivity

$$\text{NPP} = \frac{\text{Net DO at s} + \text{Net DO at 0.2m}}{2} \times \text{depth interval, etc.}$$

Then add all NPP	g O_2 /ml
$\frac{3.27 + 3.17}{2} \times 0.2 =$	0.644
$\frac{3.17 + 3.17}{2} \times 0.2 =$	0.634
$\frac{3.17 + 2.97}{2} \times 0.2 =$	0.614
$\frac{2.97 + 2.77}{2} \times 0.2 =$	0.574
$\frac{2.77 + 1.97}{2} \times 0.2 =$	0.474
summ. =	2.94 g O_2 /mL

$$\text{NPP} = \frac{2.94 \text{ mg } \text{O}_2}{\text{m}^2 \cdot 3 \text{ hrs}} \times \frac{12 \text{ C}}{32 \text{ O}_2} \times \frac{24 \text{ hr}}{\text{day}}$$

$$\text{NPP} = 8.8 \text{ g C/m}^2/\text{day}$$

* For every mole of O_2 released there is a corresponding 12 C fixed.

5. Gross Primary Productivity (GPP) at various depths.

$$\text{GPP} = \frac{\text{Gross DO at s} + \text{Gross DO at 0.2m}}{2} \times \text{depth difference, etc.}$$

Then add all GPP's	g/O ₂ /mL
$\frac{3.2 + 3.2}{2} \times 0.2 =$	0.64
$\frac{3.2 + 3.2}{2} \times 0.2 =$	0.64
$\frac{3.2 + 3.0}{2} \times 0.2 =$	0.62
$\frac{3.0 + 2.9}{2} \times 0.2 =$	0.59
$\frac{2.9 + 2.3}{2} \times 0.2 =$	0.52
summ. =	3.01 g O ₂ /mL

$$\text{GPP} = \frac{3.01 \text{ mgO}_2}{\text{m}^2 \cdot 3 \text{ hr}} \times \frac{12\text{C}}{32\text{O}_2} \times \frac{24}{\text{day}}$$

6. Respiration = GPP - NPP

$$= 9.02 - 8.8$$

$$= 0.22 \text{ g C/m}^2/\text{day}$$

7. Conversion of NPP to tons C-algae

$$\text{NPP} = 8.8 \text{ g C/m}^2/\text{day} \times 3.65 = 32.12 \text{ tons C/ha/yr.}$$

8. Algal (biomass) production rate

$$32.12 \times 20 = 642.4 \text{ tons algae/ha/yr.}$$

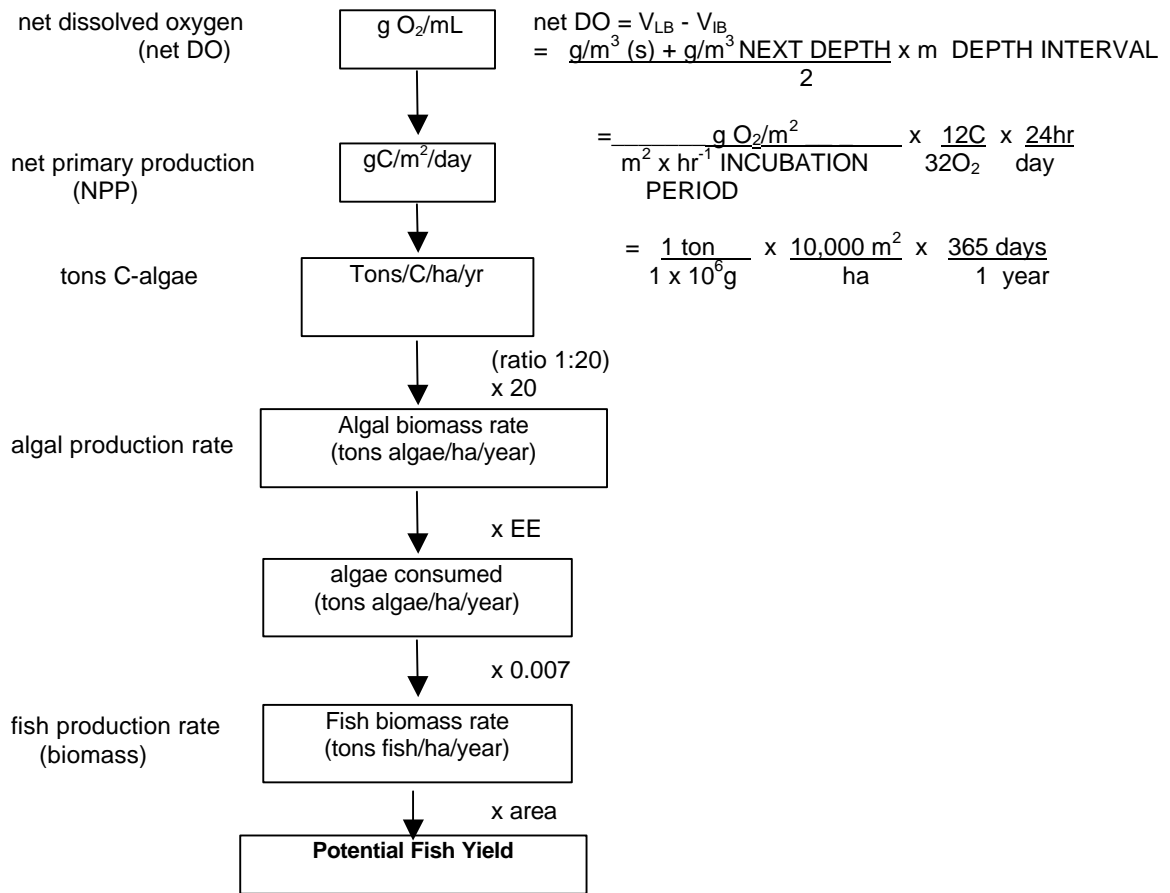
Advantages of this method

- This is straightforward method that is applicable in relatively toxic waters, as Laguna Lake.
- Easy to follow method and cheap.
- Samples can be pickled and stored for about 24 hours before titration is done.
- Ensures that live, oxygenic photosynthesizers are measured.

Disadvantage

- Laborious.

Figure 5. Schematic Diagram Showing The Estimation of the Potential Fish Yield Based on Net Primary Productivity in the Open Water of Laguna Lake (Adapted From LLDA's Method)



Summary:

Potential fish yield = $\frac{g\ O_2/m^2}{m^2 \times hr^{-1}} \times \frac{12C}{32O_2} \times \frac{24hr}{day} \times \frac{ton}{1 \times 10^6 g} \times \frac{10,000\ m^2}{ha} \times \frac{365\ days}{1\ year} \times 20 \times EE \times .007 \times area$

2. Chlorophyll Analysis

Chlorophyll pigments are indeed the basic biological pigments involved in light absorption and photochemistry of photosynthesis in plants and algae. Chlorophyll (chl) content, particularly chl a, is widely accepted as a component in measuring biomass and the physiological condition of the algae. It is also a useful indicator of water quality when the ratio of algal biomass to chl a is taken (autotrophic index).

Chlorophyll a is a universal pigment to the algae because they are oxygenically photosynthesizing organisms. Other chlorophyll pigments are accessory pigments that transfer light energy to chlorophyll a. These accessory chlorophyll pigments include chl b that is common among green pigmented algae; chl c is found among the predominantly brown pigmented types, e. g., the diatoms; and chl d constitutes a minor component of some red pigmented algae.

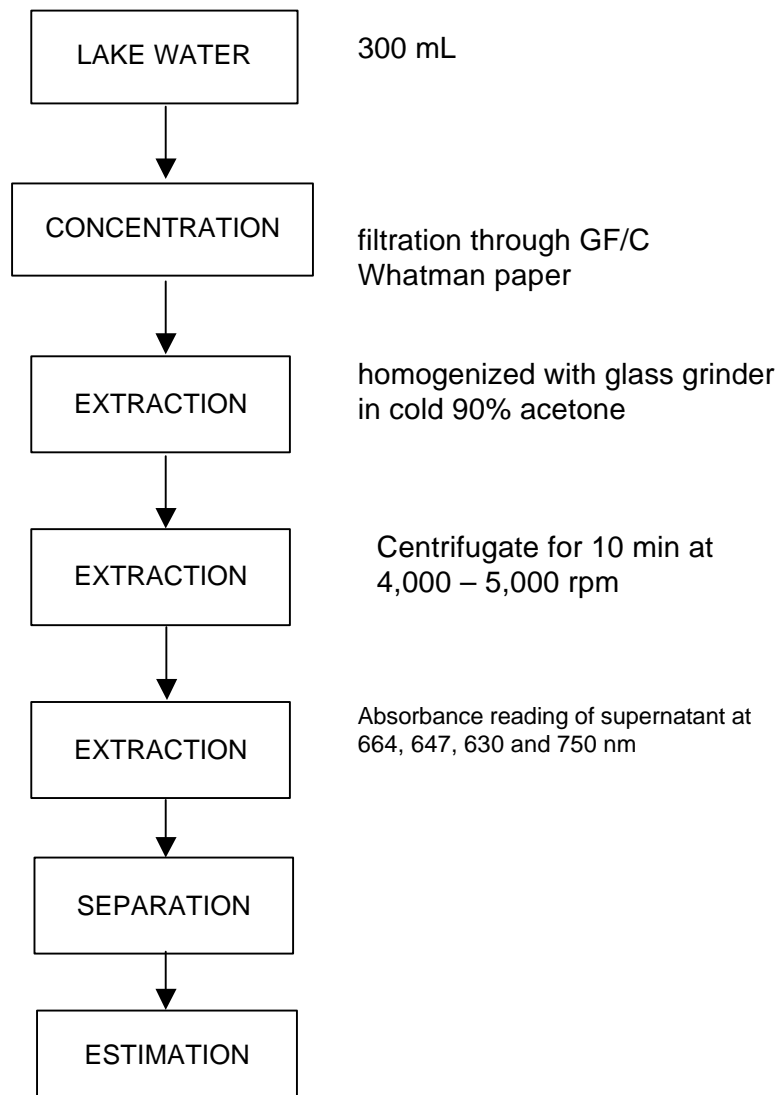
Chlorophyll a constitutes from 0.1 to 2 percent of the dry matter (DM) of algae (Martinez and Dionisio-Sese, 1995), hence, it is a part of their biomass. Although a greater bulk of the finfishes in Laguna Lake prefers feeding on diatoms, which constitute mainly

chlorophyll as its accessory pigments, the conversion of chl c to fish biomass has not yet been reported. However, this may be feasible.

Methodology

Figure 6 shows the schematic diagram for chemical and colorimetric analyses for chlorophyll content of the algae.

Figure 6. Schematic Diagram for Chemical and Colorimetric Analyses for Chlorophyll (Adapted From Jeffrey And Humphrey, 1975)



Chemical and colorimetric analyses for chlorophyll concentration. A known volume of the lake water (usually 300 ml) was concentrated by filtration through a 4.7 mm GF/C filter paper (Whatman glass fiber). The filter paper was folded with the algae inside and wrapped in aluminum foil. At this state, the algae was frozen for several days' storage.

Extraction

The algae together with the glass fiber filter paper was homogenized with a pinch of $MgCO_3$ under dim lights and in ice (Jeffrey and Humphrey, 1975).

Sedimentation

The extracted mixture was centrifuged for 10 min. at 4,000 - 5,000 rpm and the supernatant was saved in a stoppered cuvette in ice and in the dark.

Estimation

The concentration of the different chlorophyll pigments was estimated colorimetrically using the Bausch and Lomb, Spectronic 20 spectrophotometer. Chlorophyll absorbance of the supernatant was read at the following wavelengths (nm): 630, 647, 664 and 750 using 90% cold acetone as blank. The absorbance at 750 nm was subtracted from each of the other absorbances to correct for turbidity. The following equations were followed for estimating chlorophyll pigments (microgram chl/mL) of a mixed phytoplankton populations based on Jeffrey and Humphrey (1975).

$$\begin{aligned} \text{chl } \underline{a} &= 11.85 A_{664}^* - 1.54 A_{647} - 0.08 A_{630} \\ \text{chl } \underline{b} &= -5.43 A_{664} + 21.03 A_{647} - 2.66 A_{630} \\ \text{chl } \underline{c}_1 + \underline{c}_2 &= -1.67 A_{664} - 7.60 A_{647} + 24.52 A_{630} \end{aligned}$$

Calculation

i. chl a concentration

$$\text{mg/m}^3 = \frac{\text{chl } \underline{a} \text{ (ug/mL)} \times \text{extract vol. (mL)}}{\text{vol. of lake water filled (L)}}$$

ii. integration

$$\begin{aligned} \text{chl } \underline{a}, \text{ mg/m}^3 &= \frac{\text{chl } \underline{a}, \text{ mg/m}^3_s + \text{mg chl } \underline{a} \text{ m}^3_{\text{next depth}}}{2} \times \text{depth interval} \\ &= \text{chl } \underline{a}, \text{ mg/m}^2 \end{aligned}$$

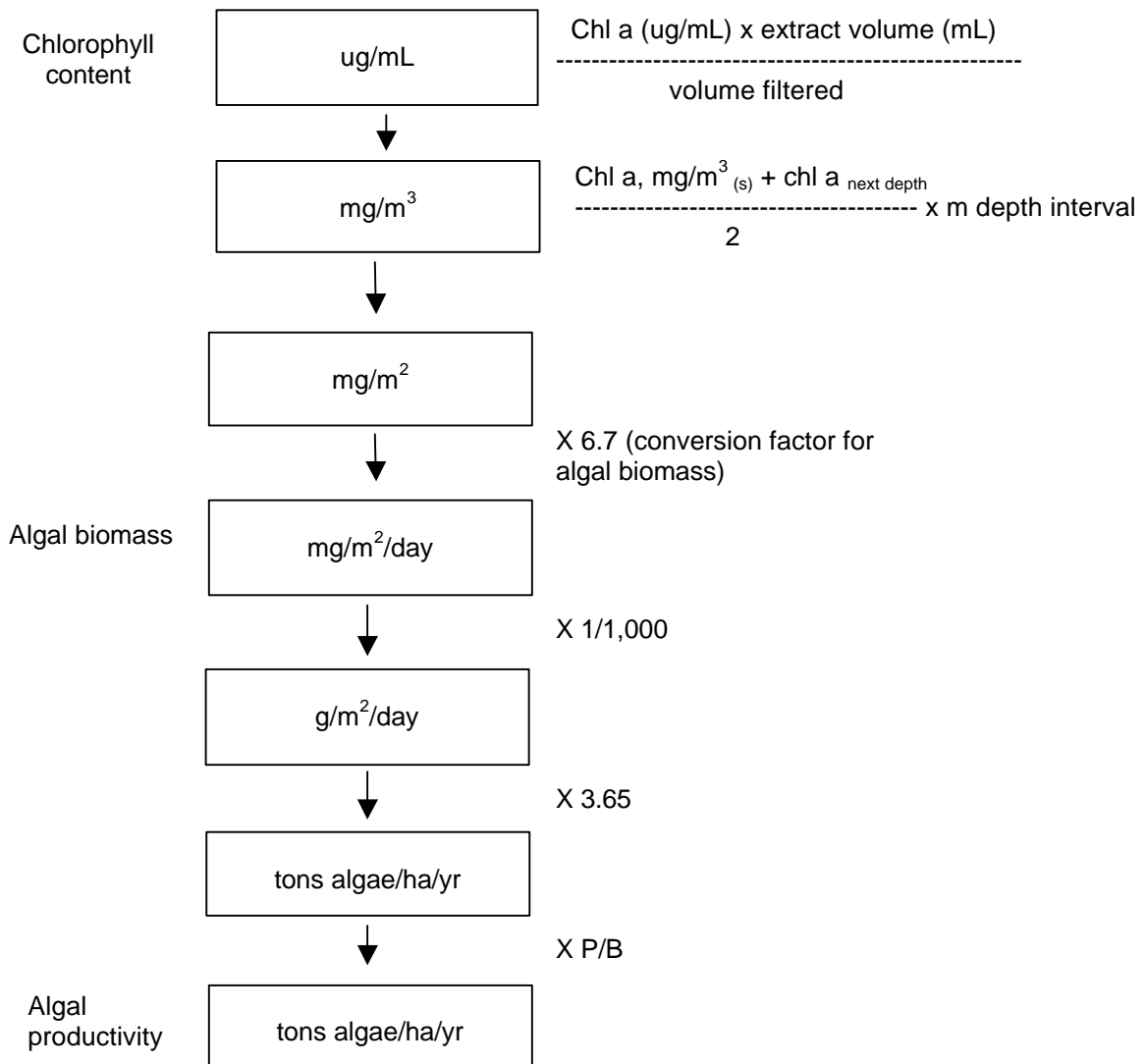
Conversion of chlorophyll a content to algal biomass

Chlorophyll content (mg/m^2) was multiplied by a factor of 67 to convert it to algal biomass (APHA, 1976; Greitz and Richards, 1955). This is based on the assumption that chl a constitutes, on the average, 1.5% of the dry matter (ash-free) of the algae.

Calculations

Figure 7 shows the estimation of algal biomass based on chlorophyll analysis and below is the sample calculation for estimating biomass based on chlorophyll analysis taken from our data in the south bay (SB) of Laguna lake on July 25, 1991.

Figure 7. Schematic Diagram Showing the Estimation of the Algal Biomass Based on Chlorophyll A Analysis



Summary: $\text{tons algae/ha/yr} = \frac{\text{Chl a ug/mL x extr. mL}}{\text{volume filtered (L)}} \times 6.7 \times 3.65 \times \frac{\text{P/B}}{1,000}$

a. Surface water chl analysis: chl a mg/mL

$$\begin{aligned} \text{i. chl } \underline{a} & \\ &= 11.85 (0.18) - 1.54 (0.12) - 2.66 (0.06) \\ &= 2.133 - 0.1848 - 0.0048 \\ &= 1.9434 \text{ ug/mL} \end{aligned}$$

$$\begin{aligned} \text{ii. chl } \underline{b} & \\ &= -5.43 (0.18) + 21.03 (0.12) - 2.66 (0.06) \\ &= -0.9774 + 2.5236 - 0.1596 \\ &= 1.3866 \text{ ug/mL} \end{aligned}$$

$$\begin{aligned} \text{iii. chl } \underline{c} & \\ &= -1.671 (0.18) - 7.60 (0.12) + 24.52 (0.06) \\ &= -0.30078 - 0.912 + 1.4712 \\ &= 0.25042 \text{ ug/mL} \end{aligned}$$

b. chl a in mg/m³

$$= \frac{\text{chl } \underline{a} \text{ (ug/mL)} \times \text{extract volume (mL)}}{\text{volume of lake water filtered (L)}}$$

$$\begin{aligned} \text{Ex.} &= \frac{1.96855 \text{ ug/mL} \times 3 \text{ mL}}{0.3 \text{ L}} \\ &= 52.494 \text{ mg/m}^3 \end{aligned}$$

c. integration to convert chl a mg/m³ to chl a mg/m²

$$= \frac{\text{chl } \underline{a}_s \text{ (mg/m}^3\text{)} + \text{chl } \underline{a}_{\text{next depth}} \text{ (mg/m}_3\text{)}}{2} \times \text{depth interval (m)}$$

$$= \text{chl } \underline{a} \text{ (mg/m}^2\text{)}$$

$$\begin{aligned} \text{Ex. i.} &= \frac{52.494 + 29.793}{2} \times .5 \text{ m} \\ &= 20.442 \text{ mg/m}^2 \end{aligned}$$

$$\begin{aligned} \text{ii.} &= \frac{29.273 + 49.063}{2} \times .5 \text{ m} \\ &= 19.584 \text{ mg/m}^2 \end{aligned}$$

$$\text{Sum} = 40.026$$

d. chl a conversion to algal biomass (g/m²/day)

$$= \text{chl } \underline{a} \text{ (mg/m}^2\text{)} \times 67 \times \frac{1 \text{ g}}{1,000 \text{ mg}}$$

$$\begin{aligned} \text{Ex.} &= 40.026 \text{ (mg/m}^2\text{)} \times 67 \times \frac{1 \text{ g}}{1,000 \text{ mg}} \\ &= 2.682 \text{ g/m}^2\text{/day} \end{aligned}$$

e. conversion from algal biomass to tons algae/ha/yr

$$= \text{chl } \underline{a} \text{ mg/m}^2/\text{day} \times 3.65$$

$$\begin{aligned} \text{Ex.} &= 2.682 \text{ g/m}^2/\text{day} \times 3.65 \\ &= 9.7893 \text{ tons algae/ha/yr} \end{aligned}$$

Advantages

- A rapid method of estimating algal biomass;
- Can differentiate between groups of algae by the absorption peak of their accessory chlorophyll pigments.

Disadvantage

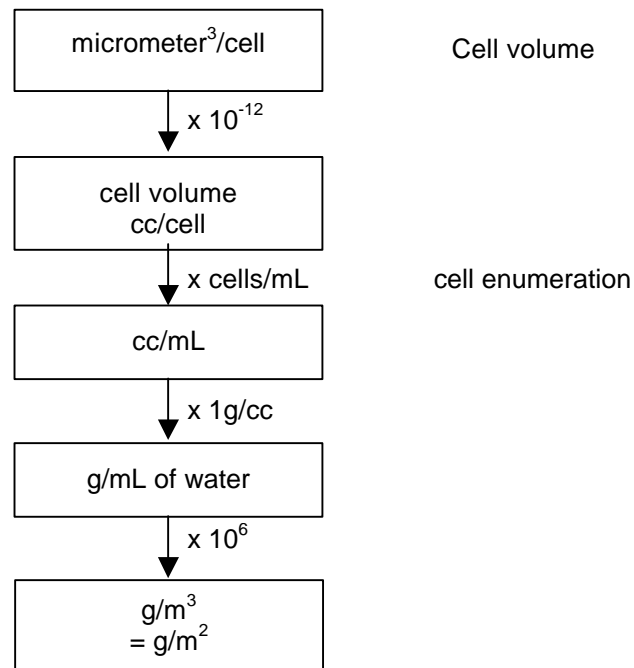
- Chlorophyll a concentration varies with groups of algae and state of nutrition of the algae.

3. Cell volume

One liter water sample was collected from three depths (surface, 0.5 m and 1.0 m depth) at every station around Laguna lake. These were preserved in buffered formalin to make a final concentration of 4 percent v/v. The samples were concentrated by centrifugation for 10 min at 2,500 rpm using a Kubota KS-5200C centrifuge.

The algae were identified and enumerated using the Neubauer improved bright line haematocytometer and an AO Spencer compound microscope following the method of Martinez, et al., (1975). The volume of each cell was computed based on the shapes of the cells. In this case, a volume of one cubic centimeter is assumed to be equivalent to one gram (Figure 8).

Figure 8. Schematic Diagram Showing the Calculation of Algal Biomass Based on Cell Enumeration



Advantages

- Inexpensive and readily available equipments;
- Allows identification of algae;
- Provides information on the viability and structural features of the algae.

Disadvantages

- Time consuming;
- Difficulty in obtaining the dimensions of some species.

4. Estimation of Potential Fish Production from Algal Production

Conversion of algal production rate was multiplied by the ecotrophic efficiency for that period (EE) to get the amount of algae consumed by the predators. Then the product obtained was multiplied by 0.007 to convert the algal biomass to fish biomass (Figure 5).

Parameters Used

1. Biomass

Biomass (B) or the standing crop is the living weight present of the algae at any given time. Historically, the biomass of the algae in the lake was based on cell enumeration and conversion of the cell number to cell volume. No biomass data were gathered earlier than 1968. Therefore, the values for 1968 were based on the averages of the 1973, 1974, 1976 as recorded by LLDA-WHO (1978). The biomass during this period was reported as 27.5 mg/L or 0.825 MT/ha in wet weight (delos Reyes, 1995). During the fishpen period, a value of 0.6055 MT/ha was obtained from Nielsen (1983). This was the average value taken from the Central bay (0.966 MT/ha) and West bay (0.245 MT/ha). For years prior to 1973, biomass was calculated by ECOPATH II model (delos Reyes, 1995). Some data on algal biomass were based on chlorophyll content.

On the other hand, fish biomass for the different years was based mainly from the production data from BAS (Bureau of Agricultural Statistics). Production value for each fish species was divided by the P/B (Production / biomass ratio) of that species to get its corresponding biomass.

2. Production/Biomass Ratio (P/B)

Under steady-state conditions, P/B is equal to the instantaneous rate of total mortality (Z), if the growth of individual organisms is describable through the von Bertalanffy Growth Function (VBGF) (Allen, 1971). The P/B of the phytoplankton was more difficult to estimate in the lake, hence, this was assumed simply as the ratio of the estimated production and biomass (delos Reyes, 1995). Although, earlier studies indicated that the growth rates of algal biomass could range from 0.2 to 6 doublings per day (LLDA-WHO, 1978).

3. Ecotrophic Efficiency

Ecotrophic efficiency (EE) is that part of the total production which is consumed by predators or caught by a fishery. This parameter was difficult to determine and it was assumed to be between 0.1 to 1.0 (delos Reyes, 1995). All values were estimated by the ECOPATH II using the biomass values inputted (delos Reyes, 1995). The EE used for given year was very subjective based on the author's perception of the prevailing condition in the lake at that time. The higher the EE the greater was the amount of the algal production utilized, hence, assuming also more consumers, and vice-versa.

4. Production

Production includes all matter elaborated by the algae (whether it is ultimately eaten, washed out or dies of other causes) over the period considered. Total mortality, when constant, is equal to production over biomass. Therefore, in steady-state models, it is safe to treat estimates of total mortality (Z) as equivalent to production/biomass ratio (P/B), (Allen, 1971). Hence, the budget equation is in the form below (delos Reyes, 1993).

$$P_i = M_{pi} - M_{ni} - C_i = 0$$

Where: P_i is the production of species i ,
 M_{pi} its predator mortality,
 M_{ni} other mortality, and
 C_i : the fisheries catch of species i .

The production data obtained from various sources, including that from the Bureau of Agricultural Statistics (BAS) were taken to mean as is.

5. Conversion Factors Used

Calculations of algal production from net primary productivity (NPP) was based on the conversion factor of 20 or it means that there is 20-fold times algal biomass production from algal-carbon assimilated. While the ratio of algae to fish production used was 0.007 in the open water and 1/25 was used in fishpens where planktivorous species of fish are cultivated in captivity. The conversion factor of chlorophyll content to algal biomass was 6.7 instead of 67 (APHA, 1976) based on 1.5 percent chlorophyll content in algae (DM) and 100 percent moisture content of the algae.

Reliability of Data

The primary and secondary data gathered were compared in a tabular form to examine whether there were some data that showed big discrepancies, hence, the latter were analyzed and/or discarded.

RESULTS AND DISCUSSION

Water Quality of the Lake

The variation of the water temperature over the entire lake was small, within a magnitude of three degrees (28-31°C) (Table 1). Time series analysis done for this parameter in the lake showed a decreasing trend over a period of twelve years, that is, from 1980 to 1992 (delos Reyes, 1995).

The depth of the lake had an average value of 3.34 meters (Table 1), although the usual average depth reported for the lake was 2.8 meters (Sogreah, 1974; Santiago, 1988).