Phytoplankton along the southeastern coast of Taiwan[1]

Rang HUANG, Young-Meng CHIANG[2]

(*Received Oct. 31, 1974*)

臺灣東南沿海岸植物性浮游生物之研究

黃 穰・江永棉

本篇報告係研究一九七三年九月臺大研究船九連號在臺灣東南部沿岸附近採得之海水。分析葉綠素A含量及植物性浮游生物種類和細胞數量的分佈情形。

結果顯示葉綠素A最高含量之深度分佈均在 Thermocline 之上層。而沿岸海水葉綠素A含量平均較離岸海水爲高。

植物性浮游生物之分佈亦以沿岸爲多，而以臺東卑南溪河口附近海水含量最高。藍綠藻多分佈在表面海水 (0～10 m)，惟其葉綠素產量在比例上不如矽藻類多。

INTRODUCTION

Although the photo taken from the satellite Gemini X on July 20, 1966, showed the presence of upwelling along the southeastern coast of Taiwan, exact information about this is still incomplete. Several studies have been made on the topography of this region (TOMINAGA 1972; EMERY *et al.*, 1972), the distribution of its zooplankton (TAN, 1971), the plankton community (TSENG, 1971), and the nutrients (HONG *et al.* 1972) of this area. However, the composition and distribution of the phytoplankton of this region has not been previously studied.

This report describes the standing crops of phytoplankton collected on cruise 55 of the R/V Chiu-Lien, Institute of Oceanography, National Taiwan University along the eastern coast of Taiwan between September 19-25, 1973.

MATERIALS AND METHODS

The area studied extends southwards along the mideast coast of Taiwan (Fig. 1). Water samples were obtained from fifteen stations using a bucket and 10 liters sampler equipped with

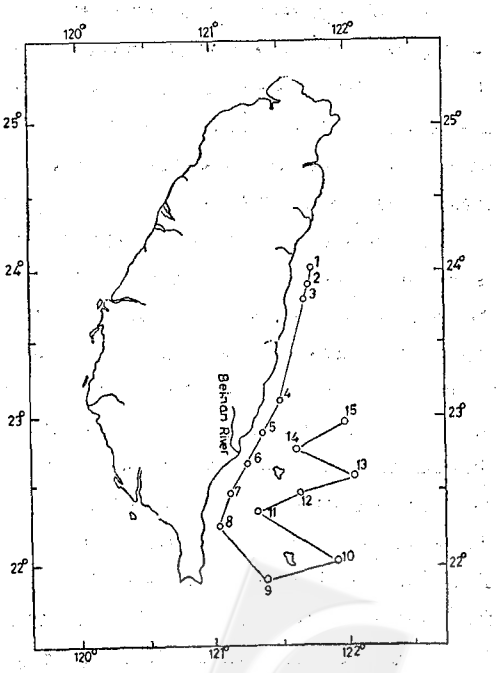

Fig. 1. Collecting stations of cruise 55, Chiu-Lien, Sept., 1973.

1. *This Study was supported by National Science Council of the Republic of China.*

2. *Institute of Oceanography, National Taiwan University, Taipei, Taiwan, Republic of China,*

a reversed thermometer. Samples were taken to a depth of 150 m, but at some near shore stations water samples were only collected down to 50 m. The methods and formulae of STRICKLAND and PARSONS (1968) were used to make spectrophotometric determinations of chlorophyll *a*. Five liters of water were filtered in situ through a 47 mm dia., 0.45 μ Selectron millipore filter paper. Magnesium carbonate was added to the water samples at the time of filtration to avoid the destroying of chlorophyll. The filter papers were then kept in a refrigerator for about nine days until they could be processed in the laboratory. The pigments were extracted in the dark with 90% acetone overnight in the cold (−5°C).

Samples for phytoplankton identification and enumeration were dispensed equally into one liter plastic bottles and were preserved with aqueous formalin. A modified method of microfiltration was used for this purpose (MCNABB, 1960; MOORE, 1963). For quantitative analysis one liter water samples were concentrated by passing through 0.45 μ filter paper and then washed with several drops of distilled water to avoid salt crystals formation before the filter paper was taken off from the filter holder. Then the filter paper was placed on a cleaned slide, 2 or 3 drops of immersion oil was added to the membrane before it was completely dry. After the filter paper became transparent, it was examined under a microscope. Species and number of phytoplankton were counted.

The hydrological and chemical data were provided by our Institute of Oceanography.

RESULTS

The average salinities at the surface of the coastal and offshore waters were 33.59‰ and 34.15‰ respectively, and slight deviations were noticed in the water column from the different stations. Average water temperatures of surface layers at the time of collecting specimens of coastal and offshore waters were 28.35°C and 28.94°C respectively, and the temperatures (σ_t) were variable for each stratification (Fig. 2). The average depth of the thermocline of the coastal and offshore waters were found approximately at 50 m and 75 m respectively.

The amounts of nitrates, phosphates, and silicates increased at depths below 50 m (Fig. 3) especially at station 4. A small amount of nitrate associating with maximum production above the thermocline was noted at station 6. Silicates were frequently present at most of depths among the coastal stations and it increased in amount at deeper layers. But it was rarely found above the thermocline in offshore waters. The value of phosphates was rather irregular in the water column. The concentration of chlorophyll *a* varied with the vertical profiles and was homogenous at or near the surface area with the range of 0.05–0.33 $\mu g/l$ and at the average of 0.19 $\mu g/l$. However, the data showed that there was a distinct variation of chlorophyll *a* distribution with high value occurring along the coast and a low value in the offshore waters (Fig. 2). In the majority of coastal stations chlorophyll *a* concentrated at depths between 10

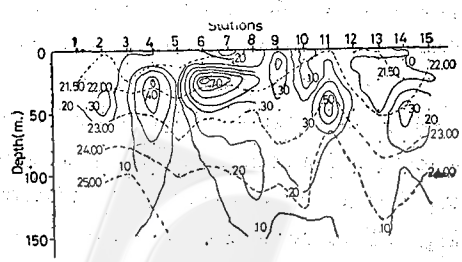

Fig. 2. Spatial distributions of chlorophyll *a*, $\mu g/l$, (solid lines) and σ_t, (broken lines) of 15 stations.

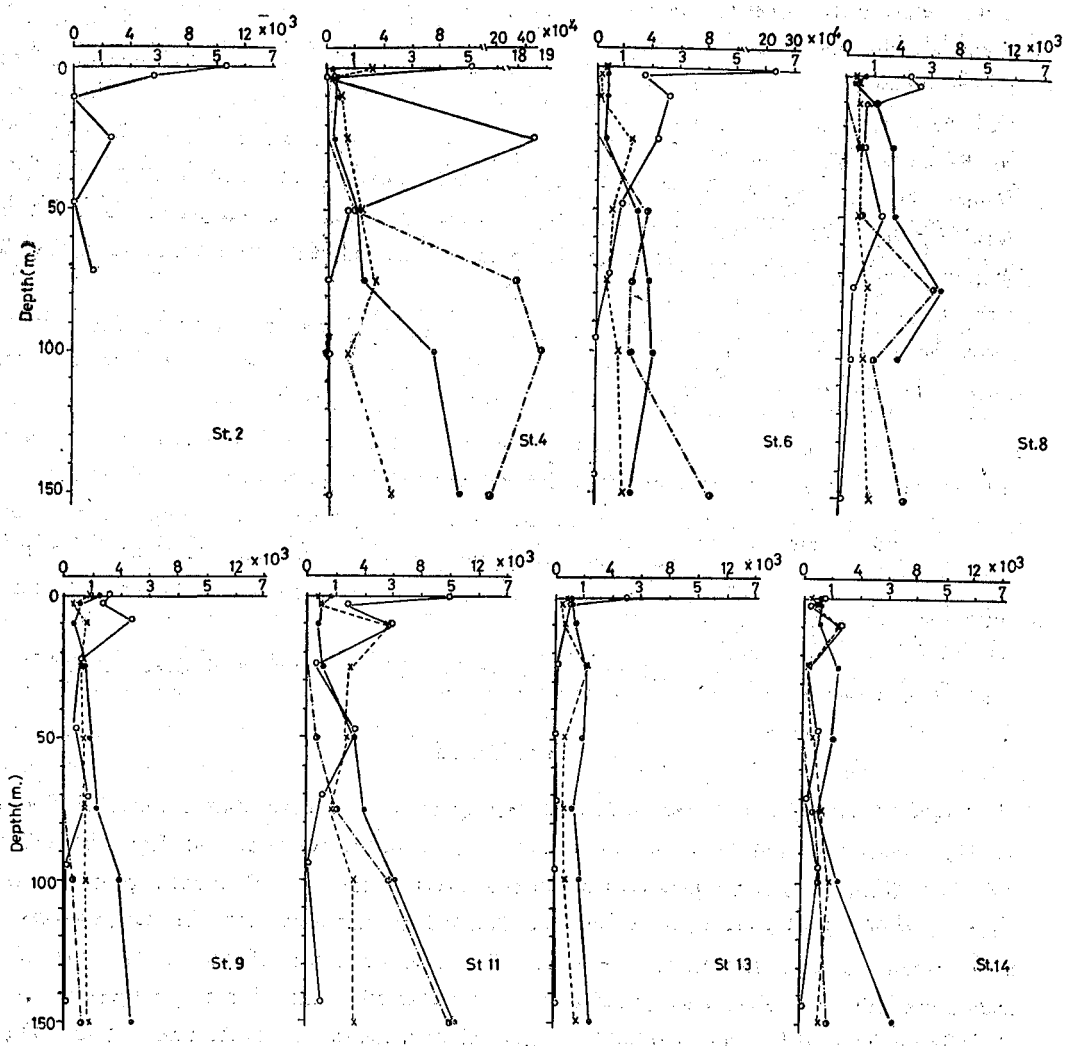

Fig. 3. Vertical distributions of phytoplankton, upper scale,cells/*l*, (open circles), and nutrients, lower scale, μg-at/*l*: NO_3-H (closed circles), PO_4-P (Crosses), and SiO_3-Si (half closed circles), in some spatial stations.

and 50 m, and reached its maximum at 25 m (0.73 μg/*l*); below that chlorophyll *a* concentration greatly decreased. Whereas the vertical displacement of maximum chlorophyll *a* depth was reflected in the range of chlorophyll value observed at different stratifications.

At most of the stations phytoplankton varied greatly in cell number as well as in chlorophyll *a* concentration. High cell counts were found mostly at depths above 25 m, and was rare below the thermocline. It ranged irregularly from 0.35 to 7.70×10^7 cells/m^3 at coastal stations and 0.90 to 4.67×10^6 cells/m^3 at offshore stations. Concentrated chlorophyll connected with high cell counts of diatoms showing that diatoms were most significant in relation to phytoplankton production. Maximum diatom counts for each station were irregular in the upper part of the thermocline but below the thermocline diatoms were rarely observed. The highest density of the diatoms were 4.17×10^7 cells/m^3 and 7.38×10^7 cells/m^3 were found at station 4

and 5 respectively. *Skeletonema costatum, Chaetoceros sp.*, and *Bacteriastrum elongatum* were the dorminant diatoms observed at all stations. The results show that a large number of the small centric diatom, *S. costatum* was observed throughout the coastal areas. *Trichodesmium erytheraeum* was the dorminant blue-green algae. It appeared at most of the stations, and was normally limited to the surface layers and decreased rapidly as the depth increased. Blue-green algae was extremely abundant and the maximum cell number reached 28.03×10^7 cells/m^3 at station 6 which was near the mouth of Bei-nan River (Fig. 1). Although flagellates were often present in samples, they were rather negligible in comparison with diatoms and blue-green algae. There were 40 genera and 114 species of diatom found in the samples collected from this area. The most common and frequently occurring species were; *Thalssionema nitzschioides, Thalassiothrix frauenfeldii, Bacteriastrum varians, B. elongatum,* and *Chaetoceros atlanticus.*

DISCUSSION

The results show that chlorophyll *a* and phytoplankton concentration increased gradually from north to south along the eastern coast of Taiwan and decreased in offshore waters. The highest production was found on the southeastern coast near Taitung (stations 6 and 7). This observation of high production in coastal water agrees with the result published by RYTHER and YENTZSCH (1958) in the study of the primary production of continental shelf waters off New York. The river discharge occurring in this area (CHU, 1971) was the most important facts in nutrient enrichment. The significant silicates have been reported by STEFÁNSSON and RICHARD (1963) in their studies of the nutrient distributions off the Columbia River and strait of Juan de Fuca. In our results the nitrate concentration was variable between the different stations, and substantial changes were also observed with changes in depth. It has been observed at station 6 that low nitrate concentration is correlated with high phytoplankton production at depth 25 m.

It is known that chlorophyll *a* is influenced by the concentration of phytoplankton due to nutrients, grazing, growth rate, and river runoff (ANDERSON, 1964). Marked chlorophyll variation and a relationship between the vertical distribution and thermocline oscillation have been noted (COLTON, 1972). Therefore, it seems that the fluctuation of temperature associated with chlorophyll variation should be important. This has been shown by the data indicating that the maximum chlorophyll *a* depth was located above the thermocline, below which concentrated chlorophyll *a* was rare. The concentrations of chlorophyll *a* in waters above the thermocline of this area ranged from 0.06 to 0.73 $\mu g/l$ in coastal water and 0.04 to 0.53 $\mu g/l$ in offshore water respectively. These values of chlorophyll were higher than those found in the euphotic zone of of South China Sea of the same season (HONG and TSAI, 1972).

In the study of phytoplankton collected from the coastal waters around Taiwan, CHIANG (Unpublished data) found that the phytoplankton of the coastal water in Taiwan mainly composed of diatoms, and their maximum growing depth was above the thermocline. In reviews of analysis of upwelling systems MUSATOV and SAPOZHNIKOV (1972) showed the same results that the primary production and chlorophyll content depended on the amount of diatom population. Stations with high concentration of blue-green algae did not show proportionally high produc-

tion of chlorophyll *a*. Thus the blue-green algae play a less significant role in the production of chlorophyll *a* although it occurs abundantly on surface waters. Maximum blue-green algae found in the South China Sea (CHIANG, unpublished data) reached 0.88 to 2.80×10^7 cells/m^3 at surface layers, which was tenth to one hundredth of the value found in our coastal waters.

From this study it was found that the number of phytoplankton at most of stations along the southeastern coast of Taiwan was higher than that of waters surrounding other parts of Taiwan during the same season (CHIANG, unpublished data) especially a high phytoplankton numbers were found at stations 6, 7 and 8.

TAN (1971) and TSENG (1971) also found the abundant zooplankton population in the waters of this area. However, whether the high populations in this area is due to an upwelling phenomenon needs further study.

REFERENCES

1. ANDERSON, G. C. (1964). The seasonal and geographic distribution of primary productivity off the Washington and Oregon coasts. *Limnol. Oceanog.*, **9**, 284–302.
2. CHU, T. Y. (1971). Environmental study of the surrounding waters of Taiwan. *Acta Oceanographica Taiwanica*, **1**, 15–32.
3. COLTON, J. B. (1972). Short-term variatons in estimates of chlorophyll abundance. *ICNAF Res. Bull.* **9**, 81–84.
4. EMERY, K. O. and R. E. STEVENSON (1972). Taiwan-a ship at sea. *Acta Oceanographica Taiwanica*, **2**, 1–10.
5. HONG, T. C. and C. H. TSAI (1972). Study on photosynthetic pigments and chemical nutrients in South China Sea. *Acta Oceanographica, Taiwanica* **2**, 83–92.
6. MCNABB, C. D. (1960). Enumeration of freshwater phytoplankton concentration on the membrane filter. *Limnol. Oceanog.*, **5**, 57–61.
7. MOORE, J. K. (1963). Refinement of a method for filtering and preserving marine phytoplankton on a membrane fiter. *Limnol. Oceanog.*, **8**, 304–305.
8. MUSATOV, A. P. and V. V. SAPOZHNIKOV (1972). Analysis of upwelling systems. *Oceanology*, **12**, 635–637.
9. STEFÁNSSON, U. and F. A. RICHARD (1963). Processes contribution to the nutrient distribution off the Columbia River and strait of Juca de Fuca. *Limnol. Oceanog.*, **8**, 394–410.
10. STRICKLAND, J. D. and T. R. PARSONS (1968). A practical handbook of sea water analysis. *Bull. Fish, Res. Bd. Can*, **167**, 1–311.
11. RYTHER, J. H. and C. S. YENTZSCH (1958). Primary production of continental shelf waters off New York. *Limnol. Oceanog.*, **3**, 327–335.
12. TAN, T. H. (1971). On the distribution of biomass and abundance of zooplankton in waters surrounding Taiwan with attention of upwelling at region near station 14. *Sino-American Sci. Cooperation Colloquium on Ocean Resources*, **2**, 307–323.
13. TOMINAGA, M. (1972). Brief analyses of the upwelling phenomena near the eastern coast of Taiwan. *Acta Oceanographica Taiwanica*, **2**, 25–38.
14. TSENG, W. Y. (1971). Plankton community in the upwelling region of Taiwan. *Sino-American Sci. Cooperation Colloquium on Ocean Resources*, **2**, 324–345.