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PHYTOPLANKTON AND BIOMASS DISTRIBUTION AT POTENTIAL OTEC SITES

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Abstract

Net or large phytoplankton species composition and most phytoplankton abundance was measured at three OTEC sites. In the Gulf of Mexico and Hawaii, diatoms dominated while the blue-green algae Trichodesmium was most common at Puerto Rico. The species ratio of diatoms to dinoflagellates was approximately 1:1. The species diversity varied from site to site, Hawaii > Puerto Rico > Gulf of Mexico. Chlorophyll a, which is a measure of the pigment of all algae size ranges, showed a subsurface peak of 0.14 - 0.4 g per liter at 75 to 125 m. Occasional surface peaks up to 0.4 μg per liter occurred. Further refinement of collection techniques is needed to delineate the subtle environmental effects expected by OTEC plant discharges.

Introduction

Phytoplankton are microscopic floating plants which constitute the photosynthetic base of the food chain in tropical oceans. Phytoplankton in the surface waters of tropical oceans are normally scarce due to lack of nutrients. Upwelling of deep, nutrient-rich water from OTEC plants could increase phytoplankton growths, and various antifouling toxicants decrease phytoplankton. The effects on the food web could be severe and quite extensive. However deleterious consequences can be restricted to local areas if ecological knowledge is used in the design and maintenance of OTEC plants. Also, changes in environmental conditions may be reflected in the characteristic biota living in, or passing through, the areas involved.

To establish base-line data on phytoplankton abundance and taxonomic composition, samples were taken at potential OTEC sites. Proposed OTEC sites are at the following locations: Gulf of Mexico (GOTEC) near Tampa, Florida, 29°N 88°W; Hawaii (HOTEC) located off Kawaihae, Hawaii at 20°N 156°5'W; Puerto Rico (POTEC) located off Punta Tuna, Puerto Rico at 17°57'N 65°51' W. Sample counts were made for only one cruise from each station; from POTEC during July, 1978; from HOTEC during October 1978; and from GOTEC during June 1978.

Larger phytoplankton were collected using standard net tows. Total algal abundance was estimated by chlorophyll a concentrations from filtered water samples. Vertical net tows (25 μm mesh) and bottle casts for chlorophyll a were taken at each station within the photic zone (approximately 0- 200 m). The algae in the net tows (net phytoplankton) were identified and counted. Net tows provide a quantitative sampling of algae (larger than the mesh size) due to the large volume of water filtered. However, smaller algae are missed. In some, but not all, oceans smaller algae (the nannoplankton, 2-20 microns in diameter) are responsible for a large part of the primary productivity and/or biomass.[1,4,5]

An estimate of total phytoplankton biomass is provided by chlorophyll a pigment analyses. Unfortunately only small volumes of one or two liters could be filtered. This greatly increased the variability of replicate samples since large, uncommon algae may have been missed. Base-line data obtained from both net tows and chlorophyll a measurements must be considered together to compare algal standing crop and species composition through time.

Phytoplankton

Species Composition and Abundance

The net phytoplankton population at the Hawaii (HOTEC) site was diverse (Tables 1, 2). Seventy-six species were identified, with numerical abundance being dominated by four species of pennate diatoms: Dactyliosolen mediterraneus, Nitzschia closterium, Navicula sp., an unidentified pennate; and unidentified athecate dinoflagellates. D. mediterraneus is generally a neritic or nearshore species but is occasionally oceanic, while N. closterium is an ubiquitous species, found in many different oceanic areas.[2] Athecate dinoflagellates are difficult to preserve and identify but are common in many ocean areas.

The ratio of the number of diatom species to the number of dinoflagellate species (Table 1) gives some idea of community structure. HOTEC had a ratio of 1:1. This indicated that although diatoms dominated numerically, there were approximately the same number of dinoflagellate species as diatom species. The total number of species at the HOTEC site is probably larger than the 76 found on this one cruise. But most of the organisms of the area were probably represented in the sample taken since seasonal variations are much reduced in tropical oceans compared to temperate waters. The diversity index measures the evenness with which a group of individual organisms is distributed among the species present.[7] At the HOTEC site diversity was quite high (H' = 4.1).

All species and groups identified at the HOTEC, GOTEC, and POTEC sites, and their rank of abundance at each are listed in Table 2. In Hawaii, only a few species were present as more than a few individuals and most species were rare. Thirty-four species of diatoms and thirty-three of dinoflagellates were found. One species of blue-green algae, the colonial, filamentous Trichodesmium sp. occurred. This species is a facultative nitrogen-fixing organism that may be the most important replenisher of fixed nitrogen in oceanic waters.[3] Although in the sample examined their abundance was low, dense growths are known to occur. Trichodesmium sp. is not sampled very well using current single net tows.

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Table 1. Biological parameters at potential OTEC sites.

	Site		
	Hawaii	Gulf	Puerto Rico
Dominant organism	Dactyliosolen mediterraneus Navicula sp. Nitzschia closterium Uniden. pennate Athecate dinoflagellate	Chaetoceros lorenzianus Nitzschia sp.	Trichodesmium sp. Nitzschia closterium Thalassiothrix spp.
No. of species diatom vs. no. species dinoflagellates	32 : 32	10 : 9	23 : 14
Total number of species	76	19	40
Diversity (H')	4.0	--	2.8

Two species of silicoflagellates and five species of coccolithophorids were found. This contrasts with a study by Muller[6] in which small and large coccolithophorids were more important components of the plankton near Hawaii. These small cells may not have been sampled quantitatively with our net.

The chlorophyll a profile shown in Fig. 1 indicates a pigment maximum at approximately 125 m. Below this depth the concentration dropped off significantly approaching zero near 300 m. A deep chlorophyll a maximum (50-100 m) is a common feature of all oligotrophic waters including the Pacific Ocean.[8] The deep maxima have been attributed to differential zooplankton grazing, an increase in the chlorophyll a/carbon ratio of cells with depth, increased nutrient availability in deeper waters, and pycnocline location.[8] The maximum chlorophyll a concentration was 0.27 μg per liter which is a fairly typical value for the subsurface maximum near Hawaii.[1,4] Continued data collection will provide an accurate description of seasonal variations.

At the Gulf of Mexico (GOTEC) site two diatoms dominated the net phytoplankton, Chaetoceros lorenzianus, and Nitzschia sp. (Table 2). Also common were the dinoflagellates Exuviella sp., Peridinium pendunculatum, and Prorocentrum micans. The ratio of diatom species to dinoflagellate species was basically 1:1, which was similar to that found at the HOTEC site. A lesser total number of species were identified than at either the HOTEC or POTEC sites (Table 1). This may be a sampling artifact as the expected number of species from past records is greater than this. Diversity was not calculated because the initial phytoplankton counts were done using a qualitative rank abundance. The GOTEC site is probably less diverse than either the HOTEC or POTEC sites.

Trichodesmium sp. was not found in these GOTEC samples, but we have recently observed dense growths at the GOTEC site. No silicoflagellates or coccolithophorids were identified at the GOTEC site.

A subsurface chlorophyll a maximum occurred between 25 and 75 m (Fig. 2). A surface peak occurred in September 1978, with a pigment concentration of 0.4 μg per liter. The November 1977 and September 1978 subsurface maxima were of similar magnitude, as were the June 1978 and December 1978 values. These pairs differed in magnitude by a factor of 2.5. It appears that the depth of the chlorophyll a maximum decreased from early summer to winter. As in the HOTEC samples, pigment concentrations were greatly reduced below 150 m, with zero values being approached near 300 m.

At the Puerto Rico (POTEC) site, the dominant phytoplankters were Trichodesmium sp., Nitzschia closterium, and several species of Thalassiothrix (Table 1). Tichodesmium sp. was by far the most abundant both in terms of biomass and numbers of cells, and may have been responsible for the surface chlorophyll a peaks seen at the Puerto Rico site (Fig. 3). The large proportion of N. closterium was similar to the HOTEC site. The ratio of diatom to dinoflagellate species was weighted towards diatoms (60:40). Although numerically different from the HOTEC and GOTEC sites the basic relation of equal numbers diatom species and dinoflagellate species was preserved.

The total number of species identified from the POTEC site was less than the number from HOTEC, and greater than the number from GOTEC. The diversity index was lower than that shown for HOTEC. This is probably due to the great abundance of Trichodesmium sp. found at the POTEC site. Silicoflagellates were not found at the POTEC site and coccolithophorids were rare.

The chlorophyll a profiles for the POTEC site (Fig. 3) show quite large surface concentrations for October 1978, and February 1979, of approximately 1.9 to 2.5 μg per liter. Subsurface maxima from 0.14 to 0.35 μg per liter occurred between 75 and 150 m. A double-maximum was found in October 1978. Multiple peaks can be a common feature of chlorophyll a profiles.[9] As in Hawaii and in the Gulf of Mexico the chlorophyll a concentrations were very low below 200 m.

Table 2. Phytoplankton species and abundance at potential OTEC sites.

Phytoplankton	Hawaii	Gulf	Puerto Rico
Diatoms	Rank	Rank	Rank
Amphiprora sp.	--	--	Rare
Asterionella sp.	--	--	Rare
Bacteriastrum delicatulum	Rare	--	--
B. elongatum	Rare	--	--
Bacteriastrum sp.	Rare	--	Rare
Chaetoceros coarctatus	Rare	--	--
C. convolutum	Rare	--	--
C. didymus var. anglica	--	Rare	--
C. lorenzianus	Rare	Dominant	--
C. messancase	Common	--	--
Chaetoceros sp.	Common	--	Rare
Climacodium frauenfeldianum	Rare	--	--
Coscinodiscus excentricus	Common	--	--
C. lineatus	Rare	Common	--
C. marginatus	Rare	--	--
Dactyliosolen mediterraneus	Dominant	--	--
Eucampia zoodiacus	Rare	--	--
Grammatophora sp.	--	--	Rare
Guinardia flaccida	--	Rare	--
Hemialus hauckii	Common	--	Rare
Hemiaulus sp.	Rare	--	Rare
Leptocylindrus danicus	Rare	Common	--
Licomorpha abbreviata	--	--	Rare
Licomorpha sp.	--	--	Rare
Mastogloia rostrata	Rare	--	--
Navicula carnifera	--	--	Rare
Navicula sp.	Dominant	--	Common
Nitzschia closterium	Dominant	--	Dominant
N. delicatissima	Rare	--	--
N. longissima	Rare	Rare	Rare
Nitzchia sp.	--	Dominant	Common
Planktoniella sol	Rare	--	--
Pleurosigma sp.	--	--	Rare
Pseudoeunatia deliolus	Rare	--	--
Rhizosolenia alata	Rare	--	--
R. bergonii	--	Rare	--
R. cylindrus	Rare	--	--
R. hebetata f. hiemalis	Rare	--	--
f. semispina	Rare	--	--
R. imbricata var. shrubsolei	Rare	--	Rare
R. styliformis	--	--	Rare
Surirella sp.	--	--	Rare
Synedra vaucheriae	Rare	--	--
S. undulata	Rare	--	--
Thalassionema nitzschioides	--	Rare	Common
Thalassiothrix frauenfeldii	--	Rare	Common
T. longissima	--	--	Common
Thalassiothrix sp.	--	--	Common
Unidentified pennate	Dominant	--	Common
Unidentified centric	Rare	--	--
Total number Diatom species	34	10	25

Table 2 (continued)

Phytoplankton	Hawaii	Gulf	Puerto Rico
Dinoflagellates	Rank	Rank	Rank
Amphidinium sp.	--	--	Rare
Ceratium fusus	Rare	--	--
C. incisum	Rare	--	--
C. karsteni	Rare	--	--
C. pentagonum	Rare	Rare	--
C. setaceum	Rare	--	--
Ceratium sp.	--	--	Rare
Cochlodinium sp.	Common	--	--
Dinophyris exigua	Rare	--	--
Dinophysis sp.	--	--	Rare
Exuviella apora	Rare	--	--
E. baltica	Rare	--	Common
E. compressa	Rare	Common	--
E. vaginula	--	Rare	--
Exuviella sp.	--	Common	Rare
Goniaulax sp.	Rare	--	Rare
Gymnodinium sp.	Rare	--	Rare
Gyrodinium sp.	Rare	--	--
Ornithocercus quadratus	--	Rare	--
Oxytoxum gigas	Rare	--	--
O. variabile	Rare	--	--
Parahistioneis sp.	--	--	Rare
Peridinium globulus	Rare	--	--
P. hirobus	Rare	--	--
P. pendunculatum	--	Common	Rare
P. tube	Rare	--	--
Peridinium sp.	Rare	--	Rare
Phalacroma ovum	Rare	--	--
Podolampas bipes	Rare	--	--
P. elegans	Rare	--	--
P. palmipes	Rare	Rare	--
Podolampas sp.	Rare	--	--
Pronoctiluca pelagica	--	--	Rare
Prorocentrum lebourae	Rare	--	--
P. micans	--	Common	--
Prorocentrum sp.	--	--	Rare
Protoerythropsis crassicaudata	Rare	--	--
Pyrocystis fusiformis	Rare	--	--
P. hamulus var. semicircularis	Rare	--	--
P. lunula	Rare	--	--
P. pseudonoctiluca	Rare	--	--
P. robusta	Rare	--	--
Unidentified athecate dinoflagellates	Dominant	--	Common
Total number Dinoflagellate species	33	9	14

Table 2 (continued)

Phytoplankton	Hawaii	Gulf	Puerto Rico
Blue-green Algae	Rank	Rank	Rank
Trichodesmium sp.	Rare	--	Dominant
Silicoflagellates	Rank	Rank	Rank
Dictyocha fibula	Rare	--	--
Ebria sp.	Rare	--	--
Coccolithophroids	Rank	Rank	Rank
Discosphaera tubifer	Rare	--	--
Gephryocapso pcsamosa	Rare	--	--
Rhabdosphaera sp.	Rare	--	--
Umbellosphaera sp.	Common	--	--
Unidentified coccolithophorids	Common	--	Rare
Total number coccolithophorid species	5	0	1

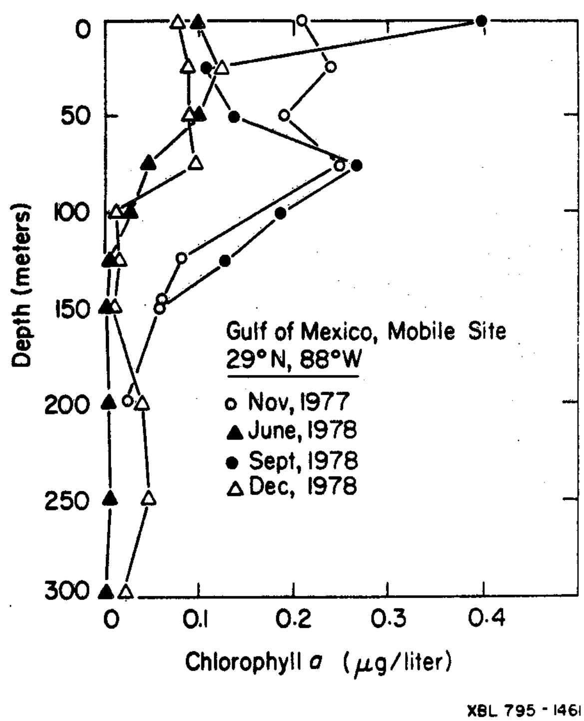

Fig. 2 Chlorophyll a concentrations with depth at the Mobile Site, Gulf of Mexico.

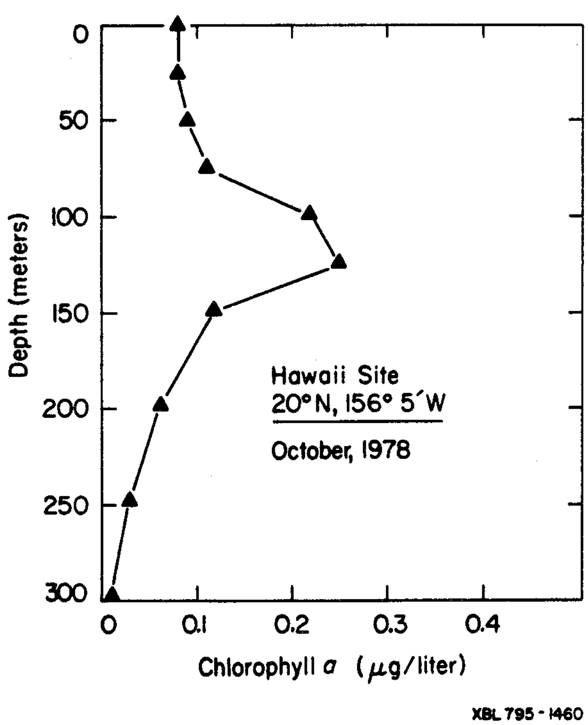

Fig. 1 Chlorophyll a concentrations with depth at the Hawaii site.

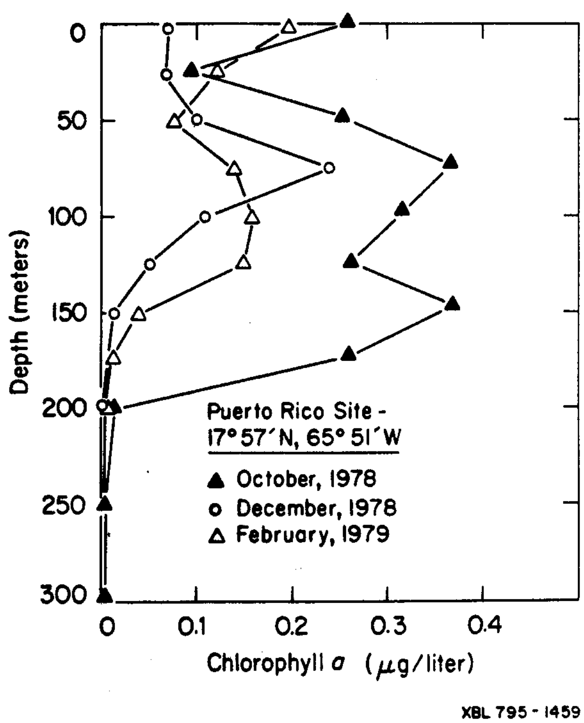

Fig. 3 Chlorophyll a concentrations with depth at the Puerto Rico site.

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