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COMPARISON OF NUTRIENT DATA FROM FOUR POTENTIAL OTEC SITES

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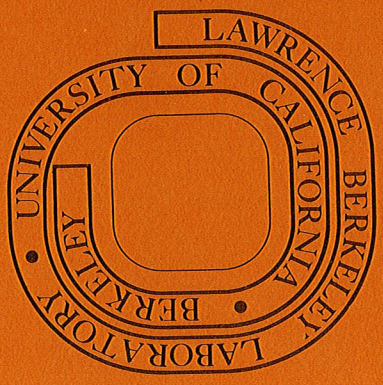

COMPARISON OF NUTRIENT DATA FROM FOUR POTENTIAL OTEC SITES LBL9052

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Abstract

An in-progress assessment of nutrient chemical data (phosphate, nitrate, nitrite, and silicate) from four potential OTEC sites (Puerto Rico, the Gulf of Mexico, Hawaii, and the South Atlantic) show reasonable comparison with archival data. At this time sufficient data is available only at the Tampa site (Gulf of Mexico) to discern seasonal variations which show an influx of nutrient-rich water in February, which decreases with time to a minimum in December. Results show a greater potential for stimulation of primary productivity at the Hawaii site than in the northern Gulf of Mexico due to the discharge of the cold water pipe into the photic zone.

Introduction

The operation of an Otec plant will transport nutrient-rich waters from the deep ocean and discharge them into nutrient-poor waters nearer the surface. This 'artificial upwelling' could potentially alter the local species composition near each OTEC site by increasing primary productivity.

In order to adequately assess the impact of artificial upwelling and other possible ecological impacts of OTEC operations on the chemistry of the water column at OTEC sites, a study was initiated at LBL to establish baseline levels of nutrients at four potential OTEC sites: the Gulf of Mexico

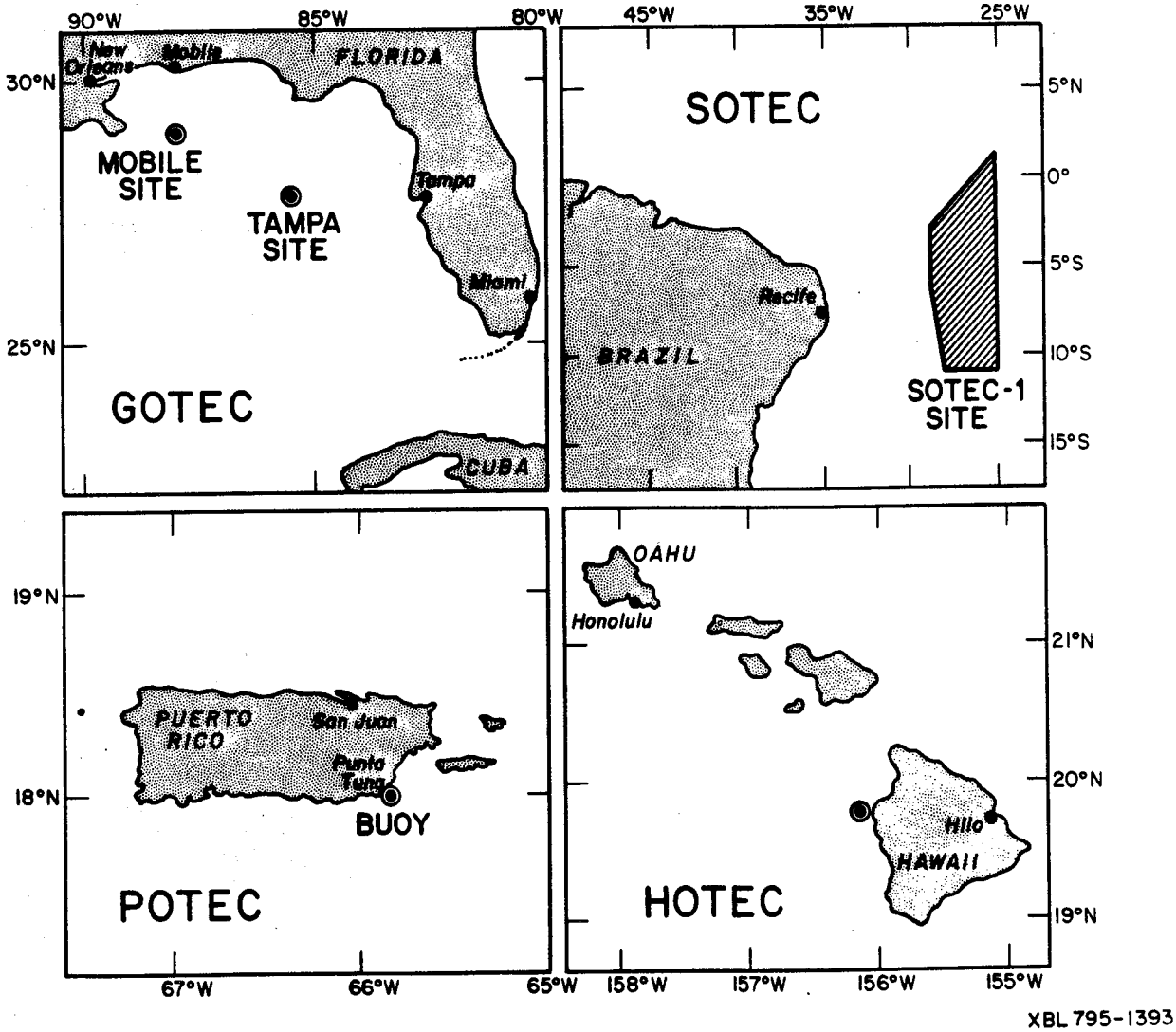

Fig. 1. Maps of four general OTEC areas, the northern Gulf of Mexico (GOTEC), Puerto Rico (POTEC), the South Atlantic (SOTEC), and Hawaii (HOTEC) showing the location of the areas where samples were taken.

Table 1. Results of nutrient measurements at the Tampa GOTEC site, GOTEC 04-08, June 1978-February 1979

Std. Depth (m)	Phosphates (µg-at/ℓ) 04 Jun	05 Aug	06 Oct	07 Dec	08 Feb	Nitrates and Nitrites (µg-at/ℓ) 04 Jun	05 Aug	06 Oct	07 Dec	08 Feb	Silicates (µg-at/ℓ) 04 Jun	05 Aug	06 Oct	07 Dec	08 Feb
0	0.05	0.05	0.1	0.2	0	1	0	0	0	0	0	0	1	1	0
50	0.2	0.0	0.05	0.2	0	0	0	0	1	1	0	0	0	0	0
100	0.2	0.1	0.2	0.2	0.7	5	3	8	3	11	1	0	2	0	2
150	0.4	0.2	0.3	0.2	0.9	8	6	13	4	15	2	2	4	0	5
200	0.6	0.4	0.4	0.2	0.5(?)	14	9	16	4	8(?)	4	3	6	0	0(?)
300	0.9	0.4	0.5	0.2	1.6	20	13	21	7	26	6	6	8	0	12
400	1.2	0.6	0.4	0.3	1.9	26	16	16	4	31	10	10	7	1	16
600	1.5	0.8	0.6	0.3	2.1	31	20	24	10	33	15	17	13	2	21
800	N.D.	0.8	0.8	0.4	1.9	N.D.	19	29	12	31	N.D.	20	18	9	23
1000	1.5	0.6	0.8	0.6	1.8	35	17	23	15	28	16	20	16	5	24

(GOTEC sites), Puerto Rico (POTEC site), the South Atlantic (SOTEC site), and Hawaii (HOTEC site). All are shown in Figure 1. Serial data were taken on a bimonthly interval and thus cover both temporal fluctuations, as well as variation with depth.

This paper will present and compare preliminary data on nitrates and nitrites, phosphates and silicates from each of the potential OTEC sites shown in figure 1. The data will also be compared to archival data from all four locations. Details of the analytical schemes and discussion of specific sets of data will not be presented here. In general, analyses have been performed by researchers whose laboratories are located near each potential site. They are: Dr. John Morse of the University of Miami (Gulf of Mexico and South Atlantic sites), Dr. Gary Goldman of the University of Puerto Rico (Puerto Rico site), and Dr. S. Allen Cattell of Aecos, Inc. for Dr. Gary Niemeyer of the University of Hawaii (Hawaii site).

Results

Gulf of Mexico—GOTEC. Eight cruises were made to the GOTEC sites from July 1977 to February 1979. The Mobile site (29°N 88°W, see Figure 1) was visited in GOTEC cruises 01-06 (01 - July 1977; 02 - November 1977; 03 - February 1978; 04 - June 1978; 05 - August 1978; and 06 - October 1978). Samples were taken at the Tampa site (27°30'N 85°30'W) in in GOTEC's 07-08 (07 - December 1978, and 08 - February 1979). Samples were collected at several depths and a series of nutrients were determined: dissolved oxygen, nitrates and nitrites, nitrites, ammonia, phosphates, and total phosphate.

The data is most complete for the Tampa site and is presented for phosphates, nitrates and nitrites, and silicates in table 1 and figure 2. As can be seen from both the table and figure, preliminary data show seasonal fluctuations which are pronounced and the envelope of concentrations over an entire year's time is extremely broad as can be seen from the shaded areas in figure 2.

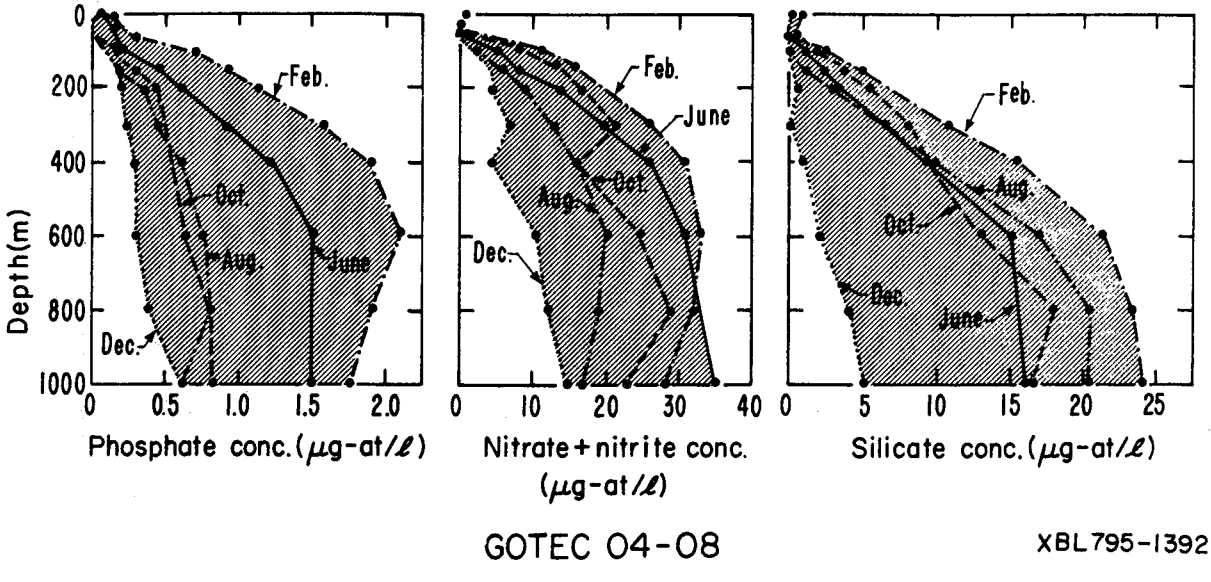

Fig. 2. Phosphate, nitrate and nitrite, and silicate concentrations determined during GOTEC's 04-08.

Table 2. Results of nutrient measurements made during SOTEC-01 (July-August 1978). Comparison of analyses made on shipboard and later at Rosenstiel School of Marine and Atmosphere Science.*

Std. depth (m)		Phosphates (µg-at/ℓ)		Nitrates and Nitrites (µg-at/ℓ)		Silicates (µg-at/ℓ)	
		STA. 20	STA. 42	STA. 20	STA.42	STA. 20	STA. 42
30	Ship	0.2	0.2	N.D.	1	3	2
	RSMAS	0.0	0.7	0	11	0	
1							
250	Ship	1.8	2.1	N.D.	26	22	27
	RSMAS	0.8	1.2	21	28	10	18
500	Ship	--	--	--	--	--	--
	RSMAS	1.0	--	26	--	16	--
1000	Ship	2.2	2.2	N.D.	31	35	32
	RSMAS	0.9	1.7	24	29	25	29

*Measurements made at Oceanographic station 20 (3°S x 26°30'W., 8 August, 1978, 1500 hrs. local) and station 42 (6°S x 26°30'W, 8 August, 1978, ∿1700 hrs local).

The envelopes seen for these three nutrients generally correspond to those reported by Cummings, Atwood, and Parker[1], although in all cases the December results (GOTEC 07) appear to be lower than have previously been reported.

The February data represent the maximum values for all three nutrients; the phosphates, nitrates, and nitrites reach a maximum value (2.1 and 33.2 µg at/ℓ, respectively) at 600 m. This corresponds to the values reported for northern Gulf of Mexico by Cummings, Atwood, and Parker[1]; also to those reported by Sverdup, Johnson, and Fleming[2] for the Atlantic Ocean. The February data for silicates show a similar correspondence to the earlier data; no maximum is seen at depths less than 1000 m in either the GOTEC or archival data. The concentrations reported increase steadily until 600 m at which point the rate of increase decreases.

Several questions remain about this data. The nitrogen/phosphorus ratio is extremely high for October data (29:1 to 46:1) and the December values for all three nutrients are noticeably lower than those found in the archives. Before any real conclusions can be drawn, the values should be substantiated and then must be considered in conjunction with other oceanographic data which was taken simultaneously.

South Atlantic—SOTEC. Results are available from one cruise to the south Atlantic to an area roughly between 1°N-11°S and 26°W-29°W (shown in figure 1). Fifty-six oceanographic stations were visited, samples were taken and preserved to be analyzed in Miami upon the ship's (OSS *Researcher*) return. Determinations were made for dissolved oxygen, phosphates, nitrates and nitrites, nitrites, silicates, ammonia, and total phosphate.

At two stations samples were taken in duplicate. One sample at each depth was preserved, stored and analyzed at a later date in Miami. The other sample was analyzed at sea for phosphates, nitrates and nitrites and silicates. The results of both sets of analyses are given in table 2 and the results of the shipboard analyses are plotted in figure 3.

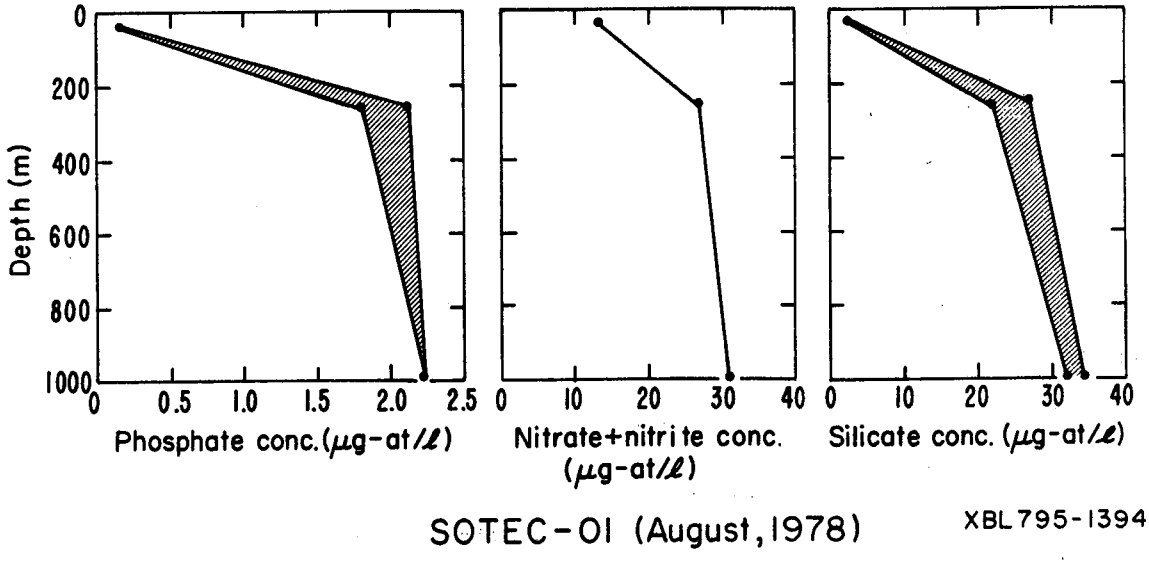

Fig. 3. Concentrations of phosphates, nitrates and nitrites, and silicates observed at the south Atlantic site and analyzed at sea.

Table 3. Results of nutrient measurements made during POTEC-02 (October, 1978) and POTEC-03 (December, 1978)

STD Depth (m)	Nitrates and Nitrites (μg-at/ℓ) POTEC-02	POTEC-03
0	2	0
50	3	N.D.
100	3	0
150	3	1
200	4	3
250	5	4
300	8	4
400	13	15
600	35	25
800	27	35
1000	38	39

The concentrations found for phosphates and silicates in samples analyzed in Miami are with one exception significantly lower than those found in the samples analyzed at sea. The nitrate and nitrite results were comparable. The results for phosphates and silicate, however, have raised questions about the preservation or storage of the samples analyzed in Miami. As a result a comprehensive nutrient preservation study will be undertaken this summer.

The values for the nutrients obtained in the shipboard analyses correspond well to preliminary results of the GEOSECS expedition[3] to the same area. The phosphate values are significantly higher than those reported by the "Meteor" expedition of 1925-1927[4]. Silicate values are somewhat less than those reported by Armstrong[5].

Puerto Rico—POTEC. Four cruises have taken place to the Punta Tuna (18°N 66°W, Puerto Rico) and Punta Vaca (18°N 65°W, Vieques) sites, however, nutrient data reports have been limited to the nitrate and nitrite results for POTEC 02 and 03 (October and December 1978). These are presented in table 3 and figure 4. While the values determined fall within the envelope reported by Atwood et al.[6] for nitrates at this site, the maximum which they report at 600 m does not appear. The data from this site is so incomplete that it is impossible to draw any conclusions.

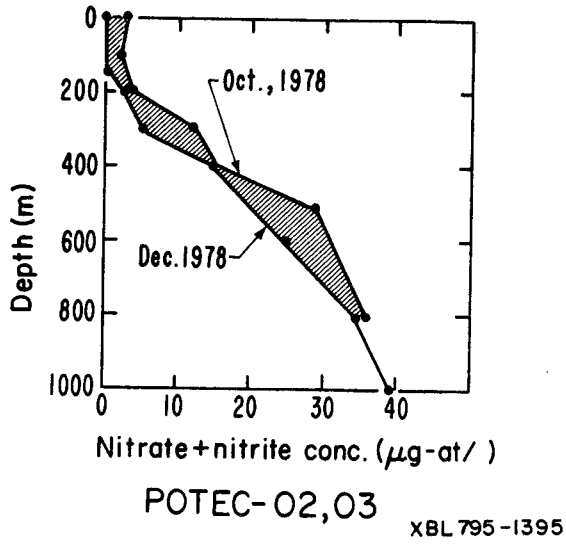

Fig. 4. Nitrate and Nitrite concentrations observed at the Puerto Rico OTEC site.

Hawaii—HOTEC. Data is available from only one cruise (HOTEC 01) to this site off the Kona Coast, 20°N 156°W, which took place in October 1978. The data are presented in figure 5 and table 4.

The nitrate results show the same general curve shape and approximate maximum values (slightly lower) as that reported by Gunderson et al.[7] Sverdup, Johnson, and Fleming[2] report slightly lower values

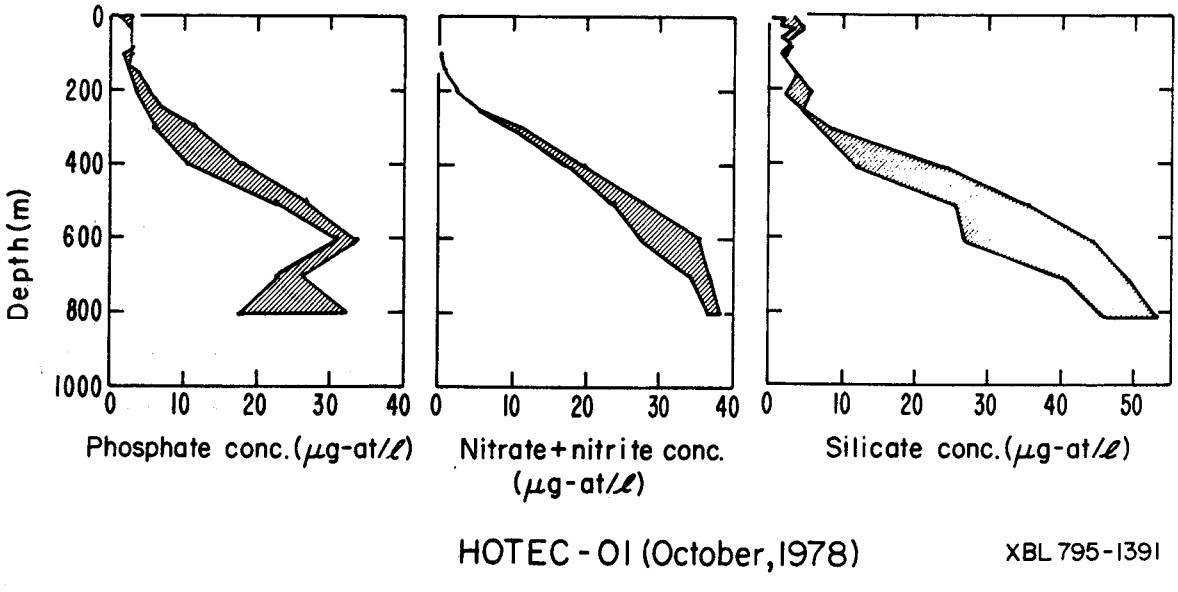

Fig. 5. Phosphate, nitrate and nitrite, and silicate concentrations observed at the Hawaii OTEC site.

Table 4. Results of nutrient measurements taken on HOTEC-01 (October, 1978).

STD Depth (m)	Phosphates (μg-at/ℓ)	Nitrates & Nitrites (μg-at/ℓ)	Silicates (μg-at/ℓ)
0	0.2 - 0.3	0	2 - 3
50	0.2	0	1 - 3
100	0.1 - 0.3	0	1 - 2
150	0.3 - 0.4	1	3
200	0.3 - 0.5	2	2 - 5
250	0.4	5	4
300	0.6 - 1.1	11 - 12	7 - 8
400	1.5 - 1.8	18 - 25	12 - 24
500	2.2 - 2.7	24 - 33	25 - 35
600	3.0 - 3.3	28 - 36	26 - 44
700	2.2 - 2.6	35 - 37	40 - 49
800	1.8 - 3.2	37 - 38	45 - 53

at 800 m. None of the archival data shows a maximum in the concentration depth curve at depths less than 800 m which agrees with these preliminary results. The concentrations found for phosphates are somewhat higher than those reported by Sverdup, Johnson, and Fleming[2] for the Pacific Ocean, and by Gundersen and Palmer[8] for Hawaiian waters. Sands reports no archival data for silicates at this site[9] however the values reported agree with those reported for the Pacific Ocean.[2]

Discussion

When reliable data covering a minimum of a year is available from all four OTEC sites, it will be valuable to compare them and to project corresponding responses to the perturbation produced by an operating OTEC plant. At this stage, the value of such a comparison is questionable for at least two important reasons. First, the quantity of the data which has been collected so far is uneven in terms of quality and extent, and must be rechecked. Secondly, the possibility of temporal variation at each site which has been raised by the GOTEC (Tampa) results and suggests that until an entire year's data has been collected, it will be impossible to assure that corresponding seasons, minima, maxima (etc.) are being compared.

Nonetheless, an initial comparison has been made of the data reported by the cruises to the three sites in the northern hemisphere; GOTEC 06, HOTEC 01, and POTEC 02, which took place in October 1978. The data from these three cruises are shown and related in figure 6.

The results for phosphates and silicates are generally what might be expected from the archives, roughly similar values from the upper 200 m of the water column and then, by 800 m in depth the values reported from Hawaii are nearly three times those reported at the Mobile site. Although the differences are less, the values for nitrates at the HOTEC site are generally higher than those at the GOTEC site in waters beneath the photic zone.

From these preliminary results, it is possible to conclude that a greater increase in primary productivity might be expected at the Hawaiian site than at the Gulf of Mexico site if the water from the cold water intake pipe is released in the photic zone. When the results of these experiments are more complete it should be possible to make more quantitative predictions regarding these potential effects.

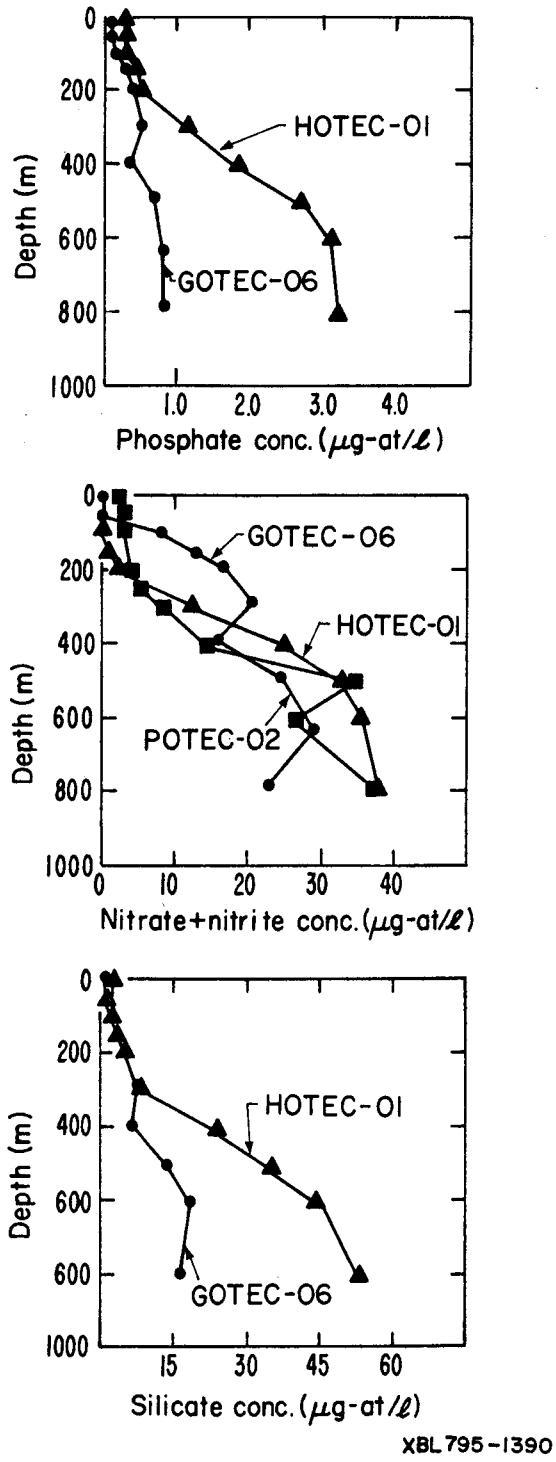

Fig. 6.

Comparison of phosphate, nitrate and nitrite, and silicate concentrations observed during October cruises to the Gulf of Mexico (Tampa) site, Puerto Rico (Punta Tuna) site, and Hawaii sites.

References

[1] Cummings, S. R., Jr., D. K. Atwood, and J. M. Parker (1979). Inorganic nutrients and dissolved oxygen variation determined from historical data at three proposed Ocean Thermal Energy Conversion (OTEC) sites; Puerto Rico, St. Croiz and northern Gulf of Mexico. NOAA Technical Memo. ERL AOML-36, Miami, Florida 67 pp.

[2] Sverdup, H. V., M. W. Johnson, and R. H. Fleming (1942). The Oceans: Their Physics, Chemistry and General Biology. Prentice-Hall, Inc., Englewood Cliffs, N. J., 1087 pp. (pp.241-245).

[3] Morse, J. W. (1979). Private communication.

[4] Wattenberg, H. (1933). Das Chemische Beobachtungs —Material und Seine Gewinnung, Kalzium Karbonat und Kohlensauregehalt des Meerwassers. In: Deutsche Atlantische Expedition auf dem Forschungs und Vermessungschiff "Meteor." 1925-1927, A. Defand, editor, VIII, Verlag von Walter de Fruytes Co. 333 pp. (pp. 78 et seq.).

[5] Spencer, C. P. (1975). The Micronutrient Elements In: Chemical Oceanography, J. P. Riley and G. Skirrow, eds., Second edition, Academic Press, 2, 245-300.

[6] Atwood, D. K., P. Duncan, M. C. Stalcup, and M. J. Barcelona (1976). Ocean thermal energy conversion: Resource assessment and environmental impact for proposed Puerto Rico site. Final report for NSF Grant No. AER 75-00145, August 1976, 104 pp.

[7] Gundersen, K., C. W. Mountain, D. Taylor, R. Ohye, and J. Shen (1972). Some chemical and microbiological observations in the Pacific Ocean off the Hawaiian Islands. Limnol Oceanogr.,17(4), 524-531.

[8] Gundersen, K. and R. O. Palmer (1972). Report on Aquaculture and Ocean Energy Systems for the County of Hawaii, Center for Engineering Research, University of Hawaii, Honolulu, Hawaii.

Sands, D. et al., (1978), Draft Environmental Impact Assessment: Ocean THermal Energy Conversion (OTEC) Program, Preoperational test platform, Interstate Electronics Corporation, Anaheim, CA. U.S. Department of Energy, Washington D.C. 20545, DOE/EA-0062, 2 vols. Available as: U.S. Department of Energy (1979) Environmental Assessment.

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