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GOTEC-02

OCEAN THERMAL ENERGY CONVERSION
PRELIMINARY DATA REPORT
FOR THE NOVEMBER 1977 GOTEC-02 CRUISE
TO THE GULF OF MEXICO MOBILE SITE

Marine Sciences Group
Earth Sciences Division

March 1980

Prepared for the U.S. Department of Energy
under Contract W-7405-ENG-48

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Prepared for the
U.S. Department of Energy
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ABSTRACT

This is the second in a series of preliminary data reports from cruises to potential Ocean Thermal Energy Conversion (OTEC) sites in the Gulf of Mexico. The data are from the GOTEC-02 cruise to a site at approximately 29°N, 88°W, the Mobile Site. Twelve oceanographic stations were visited. Due to bad weather, the results are scanty. The reader will note that much of the data is questionable.

Current meter results are presented elsewhere (Molinari, Hazelworth and Ortman, 1979). Determinations of the biomass indicators - chlorophyll a, phaeophytins and adenosine triphosphate - and zooplankton, are presented. Results were generally those that might have been predicted from previous studies in the area.

FOREWORD

This is one in a series of data reports derived from oceanographic cruises in support of the OTEC program. The purpose of such reports is to make the uninterpreted data available as soon as possible after post cruise corrections have been made.* After the equivalent of one year's data have been taken at any one site or region, an annual review will be published that will recapitulate the data in the cruise reports and include interpretations, summary graphs and tables, and topical discussions by the various project workers.

P.W.

PREFACE

The operation of an Ocean Thermal Energy Conversion plant will involve the pumping of immense volumes of deep ocean and surface waters through heat exchangers and condensers followed by release into the environment. This operation could perturb the structure of the water column possibly disrupting the local species composition. A list of the environmental concerns from OTEC operations is given in the Environmental Development Plan (U.S. Department of Energy, 1979). In order to assure adequate knowledge of the oceanic environment in which the OTEC plant is operating, which will allow more reliable prediction of the possible consequences of operating an OTEC plant on the oceanic environment and also the impact of the ocean on the OTEC plant, a series of cruises to potential OTEC sites were initiated.

*Data will be available from: National Oceanographic Data Center; Attention: E. Franklin Johnson; 2001 Wisconsin Avenue; Washington, D.C. 20235.

One of the first sites to be investigated was the Mobile Site in the Gulf of Mexico. This report gives the data collected on the second cruise to that site. In addition a number of archival studies of the ecosystem in the Gulf of Mexico have been made or are in progress:

Historical data on the thermal resource and currents were explored by Molinari and Festa (1978), and Craig et al. (1978). Thermal data taken since 1977 is given in Thomas, Minton and Molinari (1979) and Molinari, Hazelworth and Ortman (1979). Data concerning the Loop Current have been reported on by Tidwell, Cardwell, Molinari and Ortman (1978), and Molinari et al. (1977).

Cummings, Atwood and Parker (1979) reviewed the literature on nutrients and dissolved oxygen of the area. Literature reporting concentrations of trace metals in the Gulf is notably scarce although a survey is currently in progress at Lawrence Berkeley Laboratory (LBL).

El-Sayed (1972) carried out an extensive survey of phytoplankton which included a review of previous studies in the area.

Currently at LBL, archival studies are in progress on a variety of chemical (i.e. nutrients and toxics), physical, geological, and biological (i.e. phytoplankton, zooplankton, mammals, fish and pigments) oceanographic topics.

M.Q.H.

ACKNOWLEDGEMENT

The authors wish to thank the officers, crew and other scientists who participated in the data collection efforts on this cruise aboard the NOAA ship R/V Virginia Key. Scientists from LBL who participated in this cruise were J. Sandusky and M. Tatro.

In particular we appreciate the efforts of the following analysts: R. Molinari who took the current meter and XBT data (Molinari, Hazelworth and Ortman, 1979), J. Sandusky who did the nutrient and biomass analyses and J. Steen who analyzed the zooplankton samples.

We also wish to thank our board of consultants, R. Beardlsey, Woods Hole Oceanographic Institute; J. McGowan, Scripps Institute of Oceanography; H. Michel (Owre), University of Miami, Rosensteil School of Marine and Atmospheric Science; and K.K. Turekian, Yale University for reviewing this work.

I. INTRODUCTION

Ecological measurements important for environmental assessment of the impact of an operating Ocean Thermal Energy Conversion plant began with an initial cruise, GOTECH-01, in July 1977 to the Mobile site located near 29°N, 88°W (see Figure 1) (Quinby-Hunt et al., 1979). The second cruise to this site, GOTECH-02 took place from 17 to 20 November 1977 on the R/V Virginia Key. This second cruise was also a joint effort between the Atlantic Oceanic and Meteorological Laboratories (AOML) of the National Oceanic and Atmospheric Administration (NOAA) and the Lawrence Berkeley Laboratory (LBL). Stations at which samples were taken within the general area of the site are shown in Figure 1.

Oceanographic measurements were made at 12 stations during GOTECH-02. See Figure 2 for a Station location map. The Station Log appears as Table 1. Water was analyzed for trace metals, nutrients, chlorophyll a (Chl a), phaeophytin (phaeo), and adenosine triphosphate (ATP). One study of $T^{14}C$ uptake was conducted at Station 4. Zooplankton samples were taken at eight stations and have been analyzed by John Steen of Gulf Coast Research Laboratories, Gulfport, Mississippi.

This report presents the thermal and biological data collected during GOTECH-02. The data set is sparse due to bad weather during the cruise. Current meter data will be published by R. L. Molinari and coworkers at AOML. Results taken at ecological stations are presented here. A more detailed analysis of the data will be included upon completion of a serial survey at this site. Appendix A gives the data graphically as profiles as a function of depth. Appendix B lists the station data in tables.

II. STATION MEASUREMENTS

The measurements made and depths of collection for each station are listed in the Station Log in Table 1. Hydrocasts were made using a 12-bottle rosette sampler equipped with 1.7 and 2.5 liter Niskin® bottles. Analytical methods are described in Section III. The following samples were taken and observations made.

Physical Oceanographic Measurements

Temperature, Salinity and Dissolved Oxygen. Bottle thermometers were not read nor STD data taken on this cruise. The salinity was measured at Stations 2, 4, and 10. However, the data is highly irregular and will not be presented until its validity can be established. No dissolved oxygen measurements were made.

XBL 797-2048A

Figure 1. Gulf of Mexico: GOTEC-02 Station Location off Mobile, Alabama.

XBL7910-4663A

Figure 2. Gulf of Mexico: GOTECH-02 Mobile site station off Mobile, Alabama, Detail. (Positions given do not show drift or motion during tow.)

Table 1. Station log, RV VIRGINIA KEY, Gulf of Mexico, 17-20 November 1977 (GOTEC-02)

Station	Date	Time Z (CST) ^a	Position	Operations
1	17 November 1977	322:03:02Z (2102), tow underway	29°00.0'N, 87°59.0'W	Plankton net tow at 1088 m, hor. (LBL-01)
2	18 November 1977	322:07:05Z (0105), start cast (0216), messenger down	29°00.0'N, 87°59.8'W	Hydrocast to 1000 m Temp at 5,25,50 m Sal at 0,25,50 m Nut at 0,25,50 m Chl <u>a</u> at 0,25,50 m ATP at 0,25,50 m Org at 0,25,50 m
3	18 November 1977	322:11:18Z (0518), start tow	28°58.1'N, 88°00.4'W	Plankton net tow at 81 m, hor. Scattering layer (LBL-02)
4	18 November 1977	323:00:13Z (1813), messenger down	29°01.0'N, 88°00.4'W	Hydrocast to 500 m Temp at 200 m Sal at 0,25,50,75,100,150 m Nut at 50,150 m Chl <u>a</u> at 0,25,50,75,125,150,200 m ATP at 50,150 m Org at 0,25,50,75,100,125,150 m Primary productivity (¹⁴ C uptake) from 25,50,75,100,125,500 m
5	18 November 1977	323:01:57Z (1957), start tow	29°01.3'N, 88°01.6'W	Plankton net tow at 15 m, hor. Surface (LBL-03)
6	19 November 1977	323:13:56Z (0756), start tow	28°59.5'N, 88°01.4'W	Plankton net tow at 17 m, hor. Surface (LBL-04)
7	19 November 1977	323:15:31Z (0931), start tow	29°00.5'N, 88°00.3'W	Plankton net tow at 103 m, hor. Chl <u>a</u> max (LBL-05)
8	19 November 1977	323:16:20Z (1020)	29°00.5'N, 88°00.4'W	Plankton net tow from 971 m, obl. Aborted (LBL-06)
9	19 November 1977	323:17:30Z (1130)	29°01.6'N, 88°01.3'W	Plankton net tow from 983 m, obl. (LBL-07)
10	19 November 1977	323:21:05Z (1505), messenger down	29°00.0'N, 88°00.9'W	Hydrocast to 200 m Sal at 25,50,75,100,150,200 m Nut at 25,50,75,100,150,200 m Chl <u>a</u> at 25,75,100,150,200 m ATP at 25,50,75,100,150,200 m Org at 50,75,100,150 m

Table 1. Station log, RV VIRGINIA KEY, Gulf of Mexico, 17-20 November 1977 (GOTEC-02), continued

Station	Date	Time Z (CST) ^a	Position	Operations
11	19 November 1977	323:21:40Z (1540), start tow	29°00.3'N, 88°01.3'W	Plankton net tow from 919 m, obl. (LBL-08)
12	19 November 1977	324:01:25Z (1925), messenger down (2000), retake 150 m bottle	28°59.7'N, 88°00.4'W	Hydrocast to 500 m Metals at 25,75,150,300,500 m Chl <u>a</u> at 25 m Nut at 150,300 m Org at 25,75,150,300 m

Abbreviations and procedures:

^aTime is given as Universal Time (Zulu) with colons, and Central Standard Time in parentheses.

ATP = Adenosine triphosphate - sea water filtered through 0.45 m Millipore® filter, filter placed in boiling tris buffer for 20 min., then test tube, filter, and buffer frozen.

Org = Organisms - sea water doped with Lugol's solution, decanted into 500 ml polyethylene bottles for microscope analysis, quantitative analysis indicated by phaeophytin.

Chl a = Chlorophyll a - sea water filtered through glass filter.

Metals - sea water decanted into 500 ml bottles and refrigerated.

Nut = Nutrients - sea water decanted into glass or polyethylene bottles and frozen.

Temp = Temperature

Sal = Salinity

hor = Horizontal

obl = oblique

Chemical Oceanographic Measurements

Nutrients. Samples were taken at Stations 2, 4, 10 and 12. They must be considered questionable and will not be presented until they have been more carefully examined.

Trace Metals. Samples were taken at Station 12. The results were questionable and are discussed below under Results.

Biomass Indicators. Samples to be analyzed for adenosine triphosphate (ATP), chlorophyll a (Chl a) and phaeophytin (Phaeo) were collected at Stations 2, 4, 10 and 12. Results appear in Figure A-1 with the exception of Station 12 for which there was insufficient data, in Appendix A and in Table B-1 in Appendix B. Appendix B.

Biological Oceanographic Measurements

Primary Productivity. Water to be used for a primary productivity experiment was collected on Station 4. The radiocarbon used a tracer was later found to have been contaminated with bacteria and thus incubations did not give meaningful results.

Zooplankton. Zooplankton samples were taken at Stations 1, 3, 5, 6, 7, 8, 9 and 11. The operations performed at each station are described in Table 2. Results appear in tabular form in Appendix B, Tables B-2 and B-3.

Nekton

Squid were observed on the evening of 17 November 1977, during calm weather.

Weather

Little wind and calm seas were experienced during the first night on station. The second day, 18 November 1977, was stormy. Winds were reported gusting to 20 meters/second, southeasterly with 10-20 ft. swells (Molinari, Mayer and Chew, 1979) associated with the passage of a warm front; the sky was overcast with intermittent rain. The third day was only slightly better. Bad weather on station prevented more extensive operations.

III. ANALYTICAL METHODOLOGY

Physical Oceanographic Measurements

Depths were estimated from length of wire between Niskin® bottles for this cruise as rough weather prevented accurate thermometer readings. Salinity samples, drawn from Niskin® bottles, were collected in 500 ml polyethylene bottles and measured at LBL using a Bisset-Berman

Table 2. Zooplankton net tows from RV Virginia Key, Gulf of Mexico, 17-20 November 1977 (GOTEC-02), after Steen (1979).

Station No.	LBL sample No.	Date	Time (CST)	Wire Length (m)	Mean wire ^a Angle (deg)	Tow length (min)	Tow Type	Depth ^b (m)	No. splits Counted	Plankton Counted	Plankton density (No./m ³)
1	01	17 Nov	21:02	1200	25	15	Hor.	1088	0	428	6.07
3	02	18 Nov	05:18	95	31	15	Hor.	81	7	448	461.55
5	03	18 Nov	19:57	20	41	15	Hor.	15	8	781	1891.65
6	04	19 Nov	07:56	20	31	15	Hor.	17	8	490	1244.15
7	05	19 Nov	09:31	120	31	15	Hor.	103	6	526	320.38
8	06	19 Nov	10:20	1100	28		Obl.	971		ABORTED	
9	07	19 Nov	11:30	1200	35	25	Obl.	983	6	480	74.73
11	08	19 Nov	15:40	1300	45	29	Obl.	919	5	723	55.63

^aAngle is measured from vertical.

^bDepth given is mean depth for horizontal tows, starting (maximum) depth for oblique tows to surface.

induction salinometer calibrated with IAPSO standard sea water.

Chemical Oceanographic Measurements

Nutrients. Samples for phosphate, nitrate plus nitrite and silicate analyses were collected from Niskin® bottles by filtering sea water (0.2 μ m millipore filters) which was then frozen in acid washed polyethylene bottles. Additional samples for nitrate plus nitrite and phosphate were stored frozen in glass stoppered glass reagent bottles. Storage time before analysis was approximately 3 1/2 weeks.

(1) Orthophosphate was measured using the method described by Murphy and Riley (1962). This procedure depends on the reduction of a stable phospho-molybdate complex by ascorbic acid in the presence of antimony. Absorbance of the produced blue sol ("molybdenum blue") is measured at 7700 Å and compared with standards made from potassium phosphate.

(2) Nitrate plus nitrite was measured using the methods described by Hendriksen (1965) and Mullin and Riley (1955). This procedure uses a buffered hydrazine-copper reagent to reduce nitrate to nitrite. Diazotization of sulfanilamide by nitrite followed by a coupling reaction with N-(1-Naphthyl)-ethylenediamine dihydrochloride produces a red azo dye whose absorbance is measured at 5430 Å and compared with standards made from potassium nitrate and surface sea water. Incubation times for hydrazine reduction were 20 hours at 20° to 22° C.

Care must be taken with interpretation of results obtained when using the hydrazine method. Both reaction speed and total coloration depend on pH. Thus, standards made by adding known amounts of NO_3^- to deep sea water samples could result in absorbances different from those observed by using surface water as a base. Despite the disadvantages of the hydrazine method, it is fast, inexpensive and if carefully used, accurate.

(3) Silicate was measured using the methods of Strickland and Parsons (1972). This procedure involves the formation of a silico-molybdate complex which is subsequently reduced using oxalic acid and metol. This reaction results in a blue complex which is measured at 8100 Å.

Trace Metals. Water samples were collected with 2.5 liter Go-Flo bottles, filtered through 0.45 μ m filters, acidified to pH 2 with doubly distilled NBS nitric acid, and stored in acid washed polyethylene bottles. Duplicate acidified subsamples were solvent extracted and analyzed by flameless atomic absorption spectroscopy at Lawrence Berkeley Laboratory. 200 ml of acidified seawater is adjusted to pH 5.3 $\pm$ 0.2 with 2M trisodium citrate and extracted with 5.0 ml of 1% APDC-DDDC (1-pyrrolidinedithiocarbamate, APDC and diethyldiammonium diethyldithiocarbamate, DDDC) aqueous solution and 10 ml MIBK (methylisobutyl ketone). The MIBK extract immediately is back extracted with 3.0 ml of 6N NBS HNO_3 to stabilize the trace metals in solution prior to

flameless AAS analysis. All reagents are purified to reduce the metal contribution from reagent blank. The method is efficient for the determination of Cd, Cu, Fe, Ni, Pb, and Zn in natural waters with a precision of better than 10% (Girvin et al., 1978).

Biomass Indicators. Chlorophyll a (Chl a), Phaeophytin (Phaeo), and Adenosine Triphosphate (ATP) were measured using the methods described by Strickland and Parsons (1972). About one liter of seawater (absolute volume varied) was filtered for each Chl a/ Phaeo and ATP measurement. Analyses and filter papers were kept frozen until analysis at Lawrence Berkeley Laboratory and other University of California facilities.

Biological Oceanographic Measurements

Zooplankton. The following methods, described by John Steen, of the Gulf Coast Research Laboratory, Ocean Springs, MS, Steen (1979) were used to collect and analyse samples. A 0.5 m diameter 5:1 cone and 202 nylon mesh plankton net, equipped with a digital flow meter, was used to make each zooplankton tow. The net also was equipped with a double-trip mechanism which allowed samples to be taken only at a determined depth and not be contaminated by return to the surface.

The duration of each tow was timed with a stopwatch, beginning when a messenger opened the net and ending as the net was closed. The depth of each tow was determined trigonometrically using the angle of declination and the length of the wire out during the tow. The mean from eight wire angle measurements taken during each tow was used to calculate net depth. Wire length was determined from a meter block reading. The volume of water filtered during each tow was calculated from digital flow meter counts. When the nets were returned aboard ship, they were washed down immediately and the zooplankton was concentrated into a one-liter container and preserved in a 5% buffered formalin solution.

Sample Analysis. All seven of the zooplankton samples were taken to the Gulf Coast Research Laboratory for analyses. One sample was counted in its entirety, and from six of the samples an aliquot containing approximately 200 copepods was taken by a Folsom Plankton Sample Splitter. The number of splits needed to obtain a proper aliquot was recorded and used later in calculating numbers of individuals per cubic meter of water sampled. The zooplankton was separated into taxonomic groups by identification using a dissecting microscope. Copepods were identified, if possible, to genus and species and all other plankters were identified to their smallest recognized taxonomic unit. Copepods also were separated according to female, male, adult and copepodid. Results of those analyses with the exception of female, male and copepodid separation, are given in Table B-2. All individuals were counted and preserved for future reference. The portion of each sample that was not included in the analysis was returned to its proper container and retained for future analyses.

IV. RESULTS

Physical Oceanographics Measurements

Salinity. Results were extremely unusual and will not be published until their validity can be established and they can be interpreted.

Chemical Oceanographic Measurements

Nutrients, Trace Metals and Biomass Indicators. The nutrient data from this cruise was too limited to draw general conclusions. It was also found to be questionable and until it has been interpreted will not be published.

The trace metal results are not consistent with those reported earlier by Slowey and Hood (1971). And further, the concentrations show an erratic variation with depth. Recently, researchers have established that the concentrations of many trace metals in open ocean water show the same concentration gradients as the nutrients (Bruland et al., 1979 and Boyle, Sclater and Edmond, 1976 and 1977). Since the GOTEC 02 results are not consistent with Slowey and Hood and are erratic with depth, these results are questionable and they will not be presented.

Depth profiles for Chlorophyll a phaeophytin are available only from Stations 4 and 10. Chl a showed a peak near the surface at both Stations 4 and 10 and a subsurface peak at Station 4. Phaeophytin a was usually much lower than Chlorophyll a and showed an inverse relationship with it down to approximately 100 m after which both fell to insignificant levels by 200m. ATP levels were low, usually less than 0.06 g/l and were only collected with sufficient frequency at Station 10 where values declined evenly with depth from the surface between 0 and 200m.

Biological Oceanographic Measurements

Zooplankton. Seven zooplankton samples were collected at the times and depths stated in Section II. One collection attempt at Station 8 was aborted. Total zooplankton abundances and the abundances of major groups, copepods, non-copepod crustaceans, other invertebrates, and fish larvae, are shown in Table B-2. The total zooplankton in these samples ranged from 1,892 organisms per m³ taken from 15 m at night to a low of 6 per m³ taken from 1,088 m also at night. Numerically, copepods dominated the samples and ranged from about 65% to 75% of the total plankton. Non-crustacean invertebrates comprised most of the remaining plankton, ranging from 19% to 29%. Non-copepod crustacean made up 4% to 15% and fish larva 0.2% to 0.6% of the samples.

The calanoid and cyclopoid copepods were nearly equal in number in the night tows but the calanoids were much more numerous than the cyclopoids during the day, except in the 103 m tow. Harpacticoids comprised only a small percentage of the copepods collected.

The dominant genera of copepods present in the samples are shown in Table B-3.

All organisms were more abundant near the surface (15-17 m) than at 100 m and the fewest organisms occurred at 1,088 m.

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Appendix A

Figure Containing Data

This appendix contains a figure displaying the results obtained on Cruise GOTECH-02 (17-20 November 1977) to the Gulf of Mexico.

Figure A-1 shows the biomass indicators phaeophytin, chlorophyll a and ATP (adenosine triphosphate). No standard deviations were obtained for the chlorophyll a determinations as only one sample from each depth at each station was taken. This was due to constraints on the volume of water available for biological analysis from each hydrocast. The same constraints prevented duplicate sampling to determine variance in the values for adenosine triphosphate and phaeophytin.

BIOMASS INDICATORS

Chlorophyll a, Adenosine Triphosphate, Phaeophytin

GOTEC-02

Station 2: Gulf of Mexico, Mobile Site, 29°00.0'N, 87°59.8'W

18 November 1977, 0216 h CST (322:08:16Z)

Station 4: Gulf of Mexico, Mobile Site, 29°01.0'N, 88°00.4'W

18 November 1977, 1813 h CST (323:00:13Z)

Station 10: Gulf of Mexico, Mobile Site, 29°00.0'N, 88°00.9'W

19 November 1977, 1505 h CST (323:21:05Z)

Chl a ($\mu\text{g/L}$)ATP ($\mu\text{g/L}$)Phaeo ($\mu\text{g/L}$)

0.1

0.2

0.04

0.2

0.4

0.08

0.3

0.6

0.12

0.4

0.8

0.16

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XBL 7910-4664A

Figure A-1.

Appendix B

Tables

Table B-1 Biomass Indicator Data

Table B-2 Zooplankton Vertical Distributions

Table B-3 Zooplankton Species Data

Standard deviations were not routinely calculated for the data in Table B-1.

As has been mentioned in the introduction to Appendix A, volume constraints prevented statistical analysis for the biological data.

Table B-1. Biomass indicators from R/V Virginia Key, Gulf of Mexico,
17-20 November 1977 (GOTEC-02)

Observed Depth (m)	Chlorophyll <u>a</u> ($\mu\text{g/l}$)	ATP ($\mu\text{g/l}$)	Phaeophytin ($\mu\text{g/l}$)
Station 2. Position: $29^{\circ}00.0'\text{N}$, $87^{\circ}59.8'\text{W}$ (Mobile Site), 18 November 1977 Time: 322:08:16Z (0216 CST) trip bottles.			
5 ^a	0.12	0.03	0.055
25 ^a	0.16	0.03	0.055
50 ^a	0.26	0.05	0.046
Station 4. Position: $29^{\circ}01.0'\text{N}$, $88^{\circ}00.4'\text{W}$ (Mobile Site), 18 November 1977 Time: 323:00:15Z (1815 CST)			
0	0.21	- ^b	0.04
25 ^a	0.24	-	0.04
50 ^a	0.19	0.032	0.06
75 ^a	0.25	-	0.08
100 ^a	0.08	-	0.11
150 ^a	0.06	0.10	0.05
200 ^a	0.02	-	0.04
Station 10. Position: $29^{\circ}00.0'\text{N}$, $88^{\circ}00.9'\text{W}$ (Mobile Site), 19 November 1977 Time: 323:21:05Z (1505 CST)			
25 ^a	0.42	0.059	0.00
50 ^a	-	0.044	-
75 ^a	0.23	0.032	0.04
100 ^a	0.14	0.029	0.14
150 ^a	0.05	0.023	0.06
200 ^a	0.05	0.017	0.03
Station 12. Position: $28^{\circ}59.7'\text{N}$, $88^{\circ}00.4'\text{W}$ (Mobile Site), 19 November 1977 Time: 324:01:25Z (1925 CST) trip bottles			
25 ^a	0.36	-	0.06
75 ^a	-	-	x ^c
150 ^a	-	-	x
300 ^a	-	-	x

^aWire out

^bNot taken

^cAnalysis error

Table B-2. Zooplankton Density and Percent Occurrence Data from R/V Virginia Key, Gulf of Mexico, 17-20 November 1977 (GOTEC-02)

LBL sample no. and tow description	Copepods		Non-copepod Crustaceans		Other invertebrates		Fish larvae		Total zooplankton Density
	Density ^a	Percent	Density	Percent	Density	Percent	Density	Percent	
1. 1088 m night hor.	4.65	76.6	0.5	8.2	0.92	15.2	-	-	6.07
2. 81 m day hor.	339.98	73.7	28.85	6.2	92.72	20.1	-	-	461.55
3. 15 m night hor.	1276.56	67.5	75.66	4.0	534.55	28.3	4.88	0.3	1891.65
4. 17 m day hor.	815.98	65.6	184.75	14.8	240.49	19.3	2.93	0.2	1244.15
5. 103 m day hor.	214.39	67.8	11.58	3.7	92.58	29.3	1.83	0.6	320.38
7. 983 to 0 m day obl.	49.81	66.7	5.45	7.3	19.47	26.1	-	-	74.73
8. 919 to 0 m day obl.	35.24	62.9	4.77	8.7	15.47	28.2	0.15	0.3	55.63

^a Density measured as number of organisms per cubic meter.

Table B-3. Zooplankton species data from R/V Virginia Key, Gulf of Mexico, 17-20 November 1977 (GOTEC-02)

LBL Sample No.	Tow type	Depth ^a (m)	Dominant genera (% total copepods)		% composition by order		No. of taxa
01	Hor. night	1088	Oncaea	32.0	Calanoida	51.2	28
			Conaea	10.0	Cyclopoida	46.2	
			Rhincalanus	5.8	Harpacticoida	2.6	
			Monocilla	2.8			
			Temora	2.8			
			Oithona	2.8			
02	Hor. day	81	Oithona	14.2	Calanoida	69.9	26
			Oncaea	8.2	Cyclopoida	30.1	
			Clausocalanus	6.4			
			Paracalanus	4.6			
			Farranula	4.2			
03	Hor. night	15	Oncaea	23.3	Calanoida	56.9	26
			Paracalanus	18.9	Cyclopoida	42.3	
			Oithona	15.3	Harpacticoida	0.8	
			Clausocalanus	12.8			
			Euchaeta	4.2			
04	Hor. day	17	Clausocalanus	23.7	Calanoida	85.9	25
			Paracalanus	20.5	Cyclopoida	13.9	
			Euchaeta	6.1	Harpacticoida	0.2	
			Calocalanus	5.8			
			Temora	5.8			
			Farranula	5.8			
05	Hor. day	103	Oncaea	24.7	Calanoida	51.9	25
			Oithona	21.0	Cyclopoida	47.9	
			Lucicutia	5.7	Harpacticoida	0.2	
			Haloptilus	5.1			
			Pleuromamma	3.7			
07	Obl. day	983	Oncaea	22.2	Calanoida	60.1	31
			Oithona	11.9	Cyclopoida	39.6	
			Paracalanus	8.4	Harpacticoida	0.3	
			Clausocalanus	6.6			
			Calocalanus	3.4			
08	Obl. day	919	Oncaea	25.8	Calanoida	60.6	38
			Clausocalanus	8.3	Cyclopoida	38.5	
			Paracalanus	6.1	Harpacticoida	0.9	
			Oithona	4.8			
			Pleuromamma	4.4			

^aDepth is mean depth for horizontal tows, starting (maximum) depth for oblique tows to surface.