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February 1980

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OTEC ENVIRONMENTAL BENCHMARK SURVEY OFF KEAHOLE POINT, HAWAII

BY

EDWARD K. NODA, PAUL K. BIENFANG AND DAVID A. ZIEMANN

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OTEC ENVIRONMENTAL BENCHMARK SURVEY

OFF KEAHOLE POINT, HAWAII

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PREFACE AND ACKNOWLEDGEMENTS

The research project described herein was started in September 1978 under the direction of Dr. Gary Niemeyer, principal investigator for the University of Hawaii. Dr. Niemeyer organized the project and carried out the first cruise, designated HOTEC-1 in October 1978. During the second bi-monthly cruise in December 1978, the chartered survey vessel M/V Holoholo and its entire crew of 10, including 8 scientific personnel under the direction of Dr. Niemeyer, were not heard from after leaving Honolulu Harbor and have been presumed lost.

In March 1979 Dr. Edward K. Noda was designated the new principal investigator for the University of Hawaii and the contract period was extended in order to complete the six required bi-monthly cruises. For the entire project Dr. Paul K. Bienfang was responsible for the phytoplankton, salinity and dissolved oxygen analysis and Dr. David A. Ziemann was responsible for the zooplankton and nutrient analysis.

The authors would like to express appreciation to the following individuals for their help toward the successful completion of this project: Mr. Frederick M. Casciano, who was invaluable during logistics preparation and outboard operations; Messrs. Russel Luke and Eiji Nakazaki, graduate students in the Department of Ocean Engineering, who provided data analysis and at-sea operation services; Dr. James Szyper, Ms. Wendy Johnson, Ms. Debbie Singer, Ms. Elaine Tamaye and Mr. Jim Vansant, who provided onboard technical services during sample acquisition and analysis; Mr. Pat Wolter, owner and skipper of the M/V El Greco; Mr. Henry Ho, who built and repaired many of the items crucial to the shipboard operation; Messrs. William Clark and William Harkness, Snug Harbor marine center operations, who provided shoreside support; Mr. William Coops, Research Corporation of the University of Hawaii, who endeavored to keep the program on the straight-and-narrow; and Dr. Pat Wilde, Lawrence Berkeley Laboratory, who as technical administrator was very understanding during very trying times.

Finally, the authors would like to pay special tribute to friends and colleagues lost onboard the M/V Holoholo.

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1.1 INTRODUCTION

As part of the Department of Energy's (DOE) research, development and demonstration effort towards the ultimate goal of the commercialization of Ocean Thermal Energy Conversion (OTEC), DOE has contracted with the Lawrence Berkeley Laboratory (LBL), University of California to carry out a shipboard measurement program to provide critical baseline biological and physical oceanographic data at potential OTEC sites. Hawaii is a potential OTEC site region and consequently LBL has sponsored a research study with the University of Hawaii to obtain and analyze the required environmental data.

The objective of this study is to evaluate the variability in physical, chemical and biological parameters at an OTEC benchmark site off Keahole Point, Hawaii, latitude 19°55'N and longitude 156°10'W in a water depth of about 1300 meters as shown in Figure 1-1. While the primary focus of this project is the study of environmental variability, the primary goal of the study is to utilize the field results to aid in the design of subsequent OTEC monitoring programs. In particular, the measurements are intended to provide, at a specific location, one year of background data which will form the basis, in conjunction with available information for the region, for defining longer term and more extensive environmental surveys necessary to evaluate the siting and eventual operation of an OTEC plant in the region.

In order to meet the objectives of this study, six occupations of the HOTEC benchmark site occurred during the course of this project and Table 1-1 describes the designation, dates and vessels used for each cruise.

Table 1-1: Designation, Dates and Vessels for all HOTEC Cruises

Cruise Designation	Dates	Vessel
HOTEC-1	October 28-29, 1978	M/V Holoholo
HOTEC-2	April 12-13, 1979	R/V Noi'i
HOTEC-3	June 17-18, 1979	M/V El Greco
HOTEC-4	July 29-August 1, 1979	R/V Kana Keoki
HOTEC-5	October 2-5, 1979	R/V Kana Keoki
HOTEC-6	December 7-8, 1979	R/V Noi'i

On each cruise four hydrocasts were made consisting of two deep hydrocasts to 1000m taken at noon and midnight (approximately), designed to describe the distribution of parameters over the full water column and two shallow hydrocasts to 300m taken at sunset and dawn (approximately), designed to provide more detail information on the euphotic zone. For the deep hydrocasts water temperature, salinity, dissolved oxygen and nutrient parameters nitrate-nitrite, ammonia, urea, total nitrogen, ortho-phosphate, total phosphate and reactive silicate were measured. For the shallow hydrocasts, in addition to all parameters measured in the deep hydrocasts, chlorophyll, phaeo-pigments and adenosine triphosphate (ATP) measurements were obtained and finally for the dawn shallow hydrocast *in situ* carbon fixation rates were also obtained.

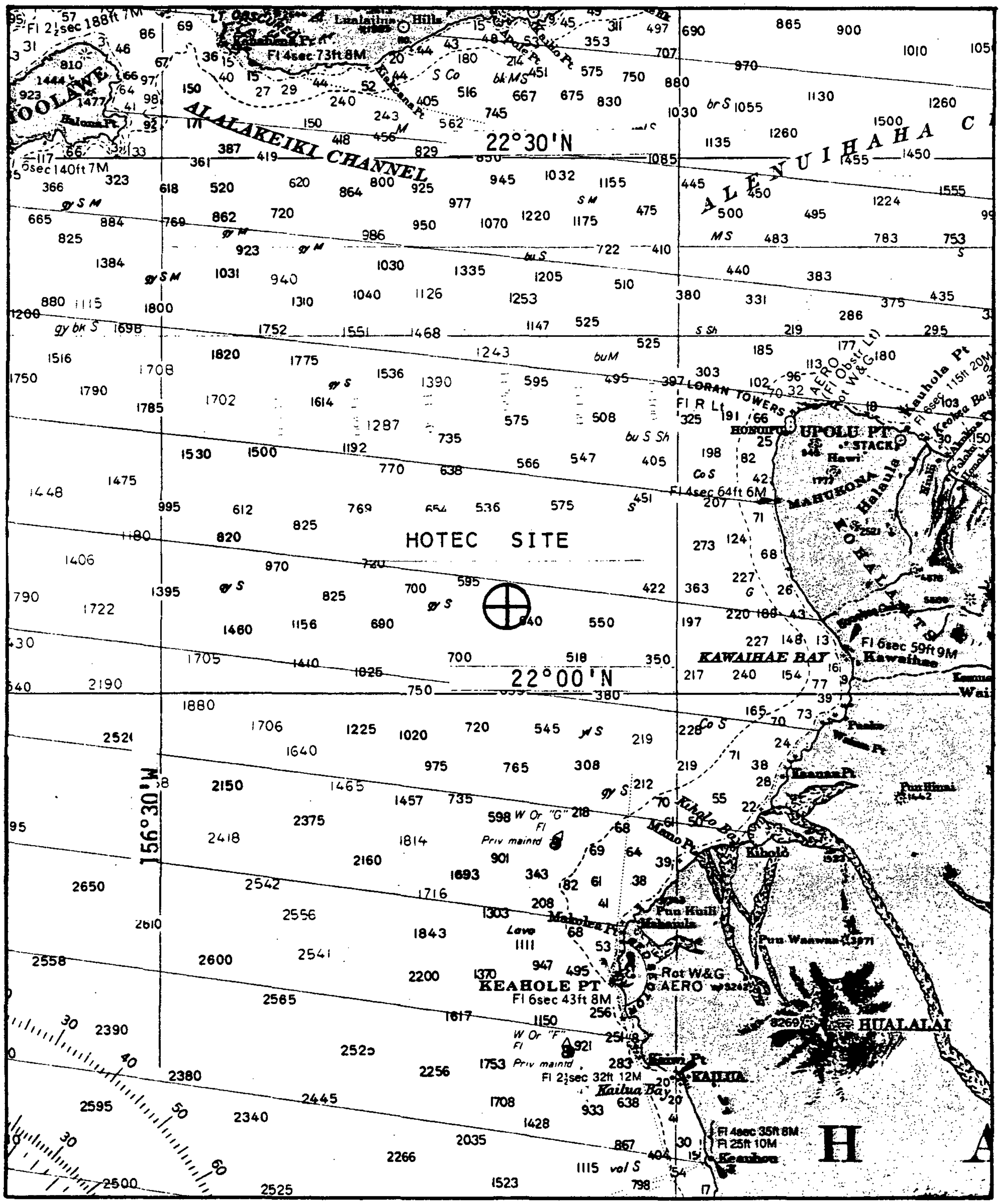

Fig. 1-1. HOTEC SITE LOCATION OFF KEAHOLE POINT, HAWAII

The measurements of chlorophyll, phaeo-pigments and ATP concentrations and the carbon fixation rates were designed to focus on the standing stock and photosynthetic activity of the natural phytoplankton. If the operation of an OTEC system has effects on the surrounding biological community, effects to the phytoplankton which are producers for the entire trophic structure will be the most fundamental and among the first to be detectable. Many, if not most, aquatic organisms would be affected by entrainment, and by temperature changes and chemical discharges of sufficient magnitude. Phytoplankton, in addition, can respond to another OTEC effect, the discharge of micronutrients into the lighted zone. The biological impact of OTEC operation is best assessed by monitoring the stocks and activity of the phytoplankton.

The parameters used here to characterize the stock and activity of the phytoplankton were chosen to give a pertinent and reasonably comprehensive picture, within the requirements and constraints of an open-sea monitoring program. Chlorophyll a is the most common and most taxonomically general measure of phytoplankton biomass. Phaeo-pigments are measured because: (1) they absorb and emit light at wavelengths very similar to those characteristic of chlorophyll; thus they can interfere with accurate chlorophyll analyses if they are present in large amounts but not measured; and (2) phaeo-pigments, as natural degradation products of chlorophyll, indicate some physiological properties and ecological factors (such as grazing pressure) important to the phytoplankton. Adenosine triphosphate (ATP), an important component and energy-currency of all living cells, is used here as a supplementary measure of microbial biomass and physiological condition. Much current research is directed toward developing the relationship between ATP and other more familiar ecological parameters. Finally, primary production is determined by carbon-14 uptake experiments, known for the past 25 years as the most sensitive indicator of carbon fixation. This photosynthetic activity of the plants is important, not only as the initial carbon source for all living things in the marine food web, but also because it may well be one of the first parameters to respond to the discharge of the nutrient-enriched waters from OTEC systems.

On each cruise zooplankton samples were taken with a 0.75 meter mouth diameter, 202μ mesh net equipped with an opening-closing device and flowmeter. For the first three cruises, single oblique samples were taken over three depth intervals during the day; 1200-800 meters, 800-200 meters, and 200-0 meters. Single horizontal tows were taken at 25 meters day and night. On the fourth cruise, these oblique tows were replicated during the day. In addition, a series of shallow oblique tows covering the upper 25 meters were made both day and night. On the last two cruises, the sampling effort was greatly increased. Replicate oblique samples covering three depth intervals were taken both day and night: 600-200 meters, 200-25 meters, and 25-0 meters. Aliquots of all samples were analyzed for dry weight and ash-free dry weight. Other aliquots were used for taxonomic analysis.

Finally, during each cruise a minimum of 12 expendable bathythermograph probes were launched usually at two-hour intervals while on-site, range-range positioning data was obtained utilizing an electronic positioning system with data printouts usually every 10 minutes while on-station and meteorological data (wind speed and direction, atmospheric pressure, wave height and direction and wet- and dry-bulb air temperatures) were measured every 4 hours. The migration of the deep scattering layer (DSL) was to have been observed using a 12 KHz recording depth sounder, but since the system was lost with the M/V Holoholo, no DSL information was obtained during this study.

2.1 MATERIALS AND METHODS

2.1.1 Water Sample Measurements

Each hydrographic water cast was made with twelve (12) 10-liter, plastic, Niskin, sampling bottles with the deep hydrocasts consisting of bottles being placed at 2, 25, 50, 75, 100, 150, 200, 300, 400, 600, 800 and 1000m of measured wire depths below the water surface. The shallow hydrocasts involved bottle placements of 2, 10, 30, 50, 70, 90, 110, 130, 150, 200, 250 and 300m of measured wire depths below the water surface. A meter wheel was utilized to measure wire length. The following subsections describe materials and methods used to analyze the water samples.

2.1.1.1 Temperature and Calculated Depth

In situ temperatures were measured using deep-sea reversing thermometers attached to each water bottle. A set of 3 reversing thermometers, 2 protected and 1 unprotected, were placed in a reversing assembly and attached to individual water sample bottles. Prior to the initial cruise all reversing thermometers were recalibrated at 5°C intervals using a temperature-controlled water bath to an accuracy of 0.01°C. A computer program was utilized to adjust the observed temperatures for index correction and the relative expansion to mercury and glass (Lafond, 1951). Following these temperature corrections, the *in situ* density $\rho_{s,t,p}$ was also computed and fianlly the calculated depth was evaluated by integrating the density vertically to obtain the mean density of the water column above the level of reversal as described by Lafond (1951).

2.1.1.2 Salinity and Dissolved Oxygen

Salinity samples were collected from all depths from both the deep and shallow hydrocasts. One-liter samples were collected, stored in clear plastic bottles with tight-fitting caps, and returned to the laboratory. Salinity analyses were performed in triplicate using a Bisset-Berman Inductive Salinometer which was calibrated from each cruise using Standard Copenhagen Water. Results are expressed as °/₀₀, i.e. parts per thousand, ± the standard deviation of the replicate trials.

Dissolved oxygen samples were collected from all depths from both the deep and shallow hydrocasts, and were in all cases the first samples to be removed from the Niskin samplers. Sample waters were transferred to 300 ml BOD bottles, allowing the contents to spill over ca 2X the bottle volume, and immediately "pickled" by the addition of manganous sulfate and alkaline iodide. Bottle contents were well mixed, the precipitate allowed to settle, then mixed again to ensure complete binding of oxygen in the precipitate, and transferred to the laboratory for analysis by titration. Dissolved oxygen was the first analysis performed and in all cases took place within the first week following return from the cruise. Dissolved oxygen was determined by Winkler titration (described in detail in Strickland and Parsons, 1972), using sodium thiosulfate on subsamples which were acidified with H_2SO_4. The thiosulfate titrant was standardized against a KIO_3 solution as per Strickland and Parsons

(1972). Triplicate titrations were performed on 50 ml subsamples from each BOD bottle. Results are reported in units of ml O_2/ℓ, ± the standard deviation of the three replicate trials.

2.1.1.3 Nutrients

Two subsamples of water were taken from each of the twelve Niskin bottles of each of four hydrocasts made during the HOTEC cruises. The water samples were taken in 60 ml amber polyethylene screw-cap bottles. One set of samples, to be analyzed for total nitrogen and total phosphorus, was frozen immediately. The other set of water samples was filtered through pre-washed Whatman GF/C or Gelman A-E glass fibre filters and frozen. Samples remained frozen until just before analysis. They were then placed upright in a shallow water bath and thawed rapidly. Care was taken that the caps remained tight, and that no contamination of the samples by the bath water occurred.

All chemical analyses were performed on a Technicon AutoAnalyzer II system. The chemical analyses were performed according to standardized methods of analysis in sea water, with some modifications where necessary for use on the AutoAnalyzer, or for increased sensitivity. The methods used were:

Nitrate-nitrite: cadmium-copper reduction of nitrate to nitrite and coupling with an azo dye (Strickland and Parsons, 1972; Technicon, 1977).

Ammonium: alkaline phenol method (Solorzano, 1969) modified for autoanalyzer use (Patton and Whitledge, 1977).

Urea: diacetyl monoxime reaction (Demanche, et al., 1973).

Total persulfate nitrogen: alkaline persulfate oxidation (Grasshoff, 1976) followed by nitrate analysis.

Ortho-phosphate: phospho-molybdate reaction (Strickland and Parsons, 1972).

Total persulfate phosphorus: acidic persulfate oxidation (De'Elia et al., 1977) followed by ortho-phosphate analysis.

Reactive silicate: silico-molybdate reaction (Strickland and Parsons, 1972).

Limits of detection for all of the above chemical analyses have been determined on several occasions. The limit of detection for the dissolved nutrients has been calculated as twice the standard deviation of a series of twenty sea water blanks. For a normal distribution, 95% of the values will fall within approximately plus or minus two standard deviations from the mean. Thus any value which is less than two standard deviations greater than zero cannot be statistically differentiated from zero at the $p = 0.05$ level. The term "ND" (not detectable) has been used to report data which is below the limit of detection. The limits of detection for the total nitrogen and phosphorus analyses have also been determined from a series of twenty sea water blanks. In addition to these initial determinations of detection limit, a series of at least five blanks was run with each determination of total nitrogen or phosphorus. If the values of these blanks were outside the range of expected values, the whole run was repeated.

2.1.1.4 Phytoplankton

Phytoplankton pigment samples were taken from all depths from only the shallow hydrocasts. Triplicate 100 ml subsamples from each depth were filtered under gentle (≤ 1/3 atmosphere) vacuum immediately after sample collection. Gelman cellulose acetate filters (similar to Millipore HA filters) having a rated pore size of 0.45μm were used. Just prior to the completion of each filtration, a few drops of saturated $Mg\ CO_3$ solution was added to each volume to avoid acidification during processing. Immediately following filtration, filters were folded and placed into darkened centrifuge tubes containing 90% acetone, agitated to disintegrate materials, placed in the freezer, and maintained in subzero temperatures prior to analysis. Chlorophyll a and phaeo-pigment concentrations were measured using fluorometric techniques for extracted pigments (Strickland and Parsons, 1972). Following elution, samples were again agitated and then centrifuged to obtain clear extracts. Analyses employed a Turner Model 111 fluorometer which had been calibrated against the tri-chromatic, spectrophotometric method (also Strickland and Parsons, 1972) using in vitro diatom cultures, similar to procedures used in Bienfang (1977a; 1977b) and Bienfang and Gundersen (1977). Results are reported in units of μg/ℓ (- mg/m^3) and confidence limits about the means represent the standard deviation of the triplicate subsamples.

Samples for ATP analysis were taken from all depths from only the shallow hydrocasts. Triplicate 1 ℓ subsamples were taken from each depth and immediately filtered under gentle (≤ 1/3 atmosphere) vacuum through sterile Gelman cellulose acetate filters. Immediately upon completion of filtration, filters were folded and plunged into screw-top digestion tubes containing 5 ml of boiling TRIS buffer and allowed to extract for 10 minutes, after which tubes were removed, placed into the freezer and kept frozen prior to subsequent analysis. In the laboratory analysis was performed using an SIA ATP Photometer (Model 2000). Details of the enzyme preparation and ATP analysis are given in Karl and LaRock (1975) and Karl (1978). Calibration was performed for each cruise using ATP standard solution and running linear regression analysis on no less than 5 serial dilutions covering a range of 0.5 - 30 ng/ℓ. Results are presented in units of ng ATP/ℓ and confidence limits about the means reflect the standard deviation of triplicate analyses.

Samples for determination of primary productivity rates were taken from nine depths from the dawn hydrocast. Triplicate light bottle samples were drawn from the 2, 10, 30, 50, 70, 90, 110, 130 and 150m samplers, injected with ca 40μ Ci $H^{14}CO_3$ and incubated *in situ* at the depth of sample origin throughout the day. The general procedures for the radiocarbon method described in Strickland and Parsons (1972) were followed. Samples were lowered to depth prior to sunrise to avoid preincubation shock of deep samples to surface light levels. All samples for primary productivity analysis were prescreened through 202μm mesh Nitex (to remove large grazers) and incubated in glass 300 ml BOD bottles. The taking of dark bottle counts to account for nonphotosynthetic ^{14}C uptake was discontinued after cruise 2, in favor of the determination of zero-time blank values. Zero-time blank values were determined by injecting at least a pair of samples with ^{14}C, mixing, and immediately filtering the contents; confidence limits about the means of these duplicates were in all cases very low. All ^{14}C solutions were prepared from sterile, aqueous $NaH^{14}CO_3$ stock solutions from New England Nuclear Corporation. Working ^{14}C solutions were prepared by dilution of 5m Ci stock solutions with filtered distilled water which had been buffered to pH ≥ 9.0, and made to a 5% salt solution by addition of NaCl (to give a density greater than seawater). Following the incubation the samples were retrieved and immediately injected with DCMU (a photosynthetic inhibitor) and immediately filtered. Introduction of DCMU takes a short time relative to the filtration time and thus improves the comparability of samples first and last filtered. Filtration (≤ 1/3 atmosphere vacuum) was done through Gelman membrane filters having a rated pore size of 0.45μm. Following filtration, the funnel walls and filters were rinsed with filtered seawater and the filters placed in scintillation vials containing 0.5 ml of 10% HCl to drive off dissolved ^{14}C (Lean and Burnison, 1979). In the laboratory the vials were flushed with air and 10 ml of counting cocktail added. Standardization of ^{14}C activities was performed for each cruise. Five serial dilutions of the working stock were made using pH ≥ 9.0 buffered distilled water; aliquots of the diluted stock were added to vials containing phenethylamine and subsequently admixed with counting cocktail. Linear regression analysis of disintegrations per minute versus dilution factor was employed to give the working activity used for the samples. All samples were counted on a Searle Delta 300 Liquid Scintillation Counter. The unit was calibrated to provide conversion of counts per minute (cpm) to disintegrations per minute (dpm) using a set of quenched ^{14}C solutions having a wide and evenly-spaced range of external standard ratios (ESR); these dpm and ESR data were fit to a fourth-order polynomial (r^2=0.99) to give counting efficiency from ESR data to provide dpm data from CPM and ESR data. All introduction and serial dilutions of ^{14}C solutions were done with Pipetman Automatic pipets, found to be accurate and highly reproducible. Total carbonate carbon present was determined by carbonate alkalinity determinations (Strickland and Parsons, 1972). Results of carbon-fixation determinations are reported in units of $\mu g\ carbon \cdot \ell^{-1} \cdot hr^{-1}$, and confidence limits about the means reflect the standard deviation of triplicate trials.

2.1.2 Zooplankton

Zooplankton samples were usually taken with a 0.75 meter mouth diameter, 202μ mesh net equipped with an opening-closing device. On several occasions when the net had been lost, a 0.5 meter, 202μ mesh net was used. The net was fitted with a digital flowmeter which was read before and after each tow. In addition, a time-depth recorder was fitted to the hydrographic cable directly below the net to record the actual depths sampled.

The sampling program as originally developed consisted of three single oblique tows taken during the day and covering separate depth intervals: 1200-800 meters, 800-200 meters and 200-0 meters. Single horizontal tows at

25 meters were to be taken during the day and at night. The oblique tows were to be replicated on alternate cruises to provide an estimate of sampling variability. This program was followed for the most part for the first four cruises. The sampling effort was increased for the last two cruises. Replicate oblique samples covering three depth intervals (600-200 meters, 200-25 meters and 25-0 meters) were taken both day and night on these two cruises.

After each tow, the sample was washed into the cod-end using a portable water sprayer filled with salt water. The sample was removed from the cod-end, placed in a glass quart jar, and preserved with a 5% buffered formalin-sea water solution. In the laboratory, the sample was split in a Folsum Plankton Splitter. One aliquot (generally 1/4th of the sample) was saved for biomass (dry weight and ash-free dry weight) determinations. The other portion was further split for taxonomic analysis. The aliquot for biomass analysis was placed in a plastic cylinder fitted with a bottom made of 500μ Nytex nylon mesh. The sample was successively passed over this mesh, effectively separating the sample into two-size classes: the "macro" fraction which was retained on the 500μ mesh, and the "meso" fraction which passed through the mesh. Each of these fractions was thoroughly rinsed with fresh water and collected on individual tared, pre-combusted glass fibre filters. The samples were dried to constant weight at 60°C and weighed to give values for dry weight of plankton. The filters and sample were then placed in a muffle furnace and combusted at 500°C for three hours. The weight of the residue, when subtracted from the value of plankton dry weight, gave a value of ash-free dry weight.

Aliquots for taxonomic analysis were placed in a counting chamber with a grid bottom and counted under a dissecting microscope. The aliquot size was chosen such that 500-1000 individuals were counted. Identification of individuals for the first three cruises consisted of identifying all copepods (as far as possible) to species, and all other organisms to family. For the last three cruises, where many more samples were to be counted, animals were identified only to general taxa, i.e., calanoid copepod, gastropod, etc. Because the benchmark is located in an area important to sport and commercial fishermen, the larval fish taken in the plankton samples from HOTEC-3 were identified to species where possible to provide information as to the species of fish which might be directly affected by the operation of an OTEC facility.

Using the information generated by the flowmeter on each tow, the abundances of plankton in terms of numbers per cubic meter were calculated for each tow. Biomass estimates for each size fraction were also converted to terms of mg dry weight or mg ash-free dry weight per cubic meter.

2.1.3 XBT Data

Expendable bathythermograph data was obtained using T-7 XBT probes (750m) and a launcher/recorder system manufactured by Sippican Corporation. For each cruise at least 12 XBT probes were launched with the initial probe deployed on the first even-numbered hour at the site. Typically probes were then launched every two hours. Immediately following each probe launch, water surface temperatures were obtained using a bucket thermometer and the range-range position of the launch was noted. During cruises 1 and 3, the recorder malfunctioned and would only operate in the T-4 mode (450m) and consequently although T-7 probes were deployed, XBT temperature data is only available for the upper 450 meters.

2.1.4 Navigation Data

In order to accurately locate the survey vessel at the benchmark site, a range-range electronic positioning system was employed called the Trisponder System manufactured by Del Norte Technology, Inc. This system has a maximum range capability of 80,000m with a range accuracy of ± 3m. To utilize this system, two shorebased transponder units were set up at locations 155°50.19'W longitude, 20°10.32'N latitude and 155°56.92'W longitude, 19°46.02'N latitude. From these two shore locations distance ranges to the interrogation unit onboard the survey vessel were available every second, with a hard copy print-out of each range and the time of day recorded every 10 minutes while in the site area. Following the cruise, the range-range data was converted to latitude-longitude pairs.

2.1.5 Meteorological Data

Wind speed and direction information was obtained using a Remote Indicating Wind System, Model No. W221-100 manufactured by Weather Measure Corporation. Wind direction was measured relative to vessel heading and the vessel compass heading was also recorded to obtain true wind direction. Wet and dry bulb air temperatures were obtained using a sling psychrometer.

3.1 RESULTS

3.1.1 Salinity

A compilation of the salinity data from the four casts for all six cruises is given in tabular form included as Appendix A, and vertical distributions of values over the 0-900m range are presented in Figure 3-1. Overall, the maximum range of salinity values encountered was 34.003 - 35.173 $^{o}/_{oo}$. The vertical profiles display several typical features: (1) a surface region ca 70 meters in depth having uniform values, overlies (2) a subsurface region of high salinity which attains maximum values at ca 100-125m, below which (3) a region of salinity minimum occurs at ca 250-300m, followed by a deeper region where slightly higher values occur.

The range of averaged (± S.E.) salinity values from the upper 70m mixed layer was 34.227 ± 0.006 - 34.774 ± 0.005 $^{o}/_{oo}$; these were observed on cruises #2 (April 1979) and #6 (December 1979), respectively. In the salinity maximum, values ranged from 34.575 - 35.173 $^{o}/_{oo}$. Near the salinity minimum, values from 34.003 - 34.340 $^{o}/_{oo}$ were measured. Below 700m salinity values ranged from 34.333 - 34.467 $^{o}/_{oo}$. It is noted that the average (± S.E.) salinity in the 625m region, the region from which OTEC deep water will be drawn, was 34.369 ± 0.012 $^{o}/_{oo}$; this value differs by only 0.094 $^{o}/_{oo}$ from the overall average value of 34.463 ± 0.017 observed within the mixed layer, the projected region of discharge.

3.1.2 Dissolved Oxygen

Dissolved oxygen concentrations from all 24 hydrocasts are plotted in Figure 3-2, and are found in numerical form in Appendix A. The plot shows a "mixed layer" of about 90m depth, in an annual-average sense. There is a region of rather linear decrease in concentration with increasing depth between 100 and 450m, followed by a deep region of uniform low concentrations from 450m to the deepest sampled depths at about 900m.

In the upper 90m, oxygen concentrations ranged from 4.8 - 6.3 ml/ℓ, with a mean of 5.4 ml/ℓ and a standard error of 0.02 ml/ℓ, for 143 data points. Variation is similar at most depths through the "slope" region and in the deep uniform region. Below 400m, the mean O_2 concentration is 1.0 ml/ℓ, with S.E. = 0.06 ml/ℓ (n = 34 points). The five points indicating concentrations of less than 0.5 ml/ℓ, below 500m, are all from the HOTEC-6 cruise. We have no reason to question the validity of these observations. The five samples received treatment identical to other samples from that cruise having O_2 concentrations that fall among values from the other cruises. If these 5 points are ignored, the mean concentration for depths greater than 400m is not greatly changed, but the estimate of variability in that part of the water column would be rather less.

Deep water drawn up for OTEC operation will have a concentration of dissolved oxygen of about 1 ml/ℓ; effluent will be discharged into waters having concentrations of 5 to 6 ml/ℓ. The mixed-layer values are at or above O_2 saturation levels for waters of the temperatures and salinities observed here.

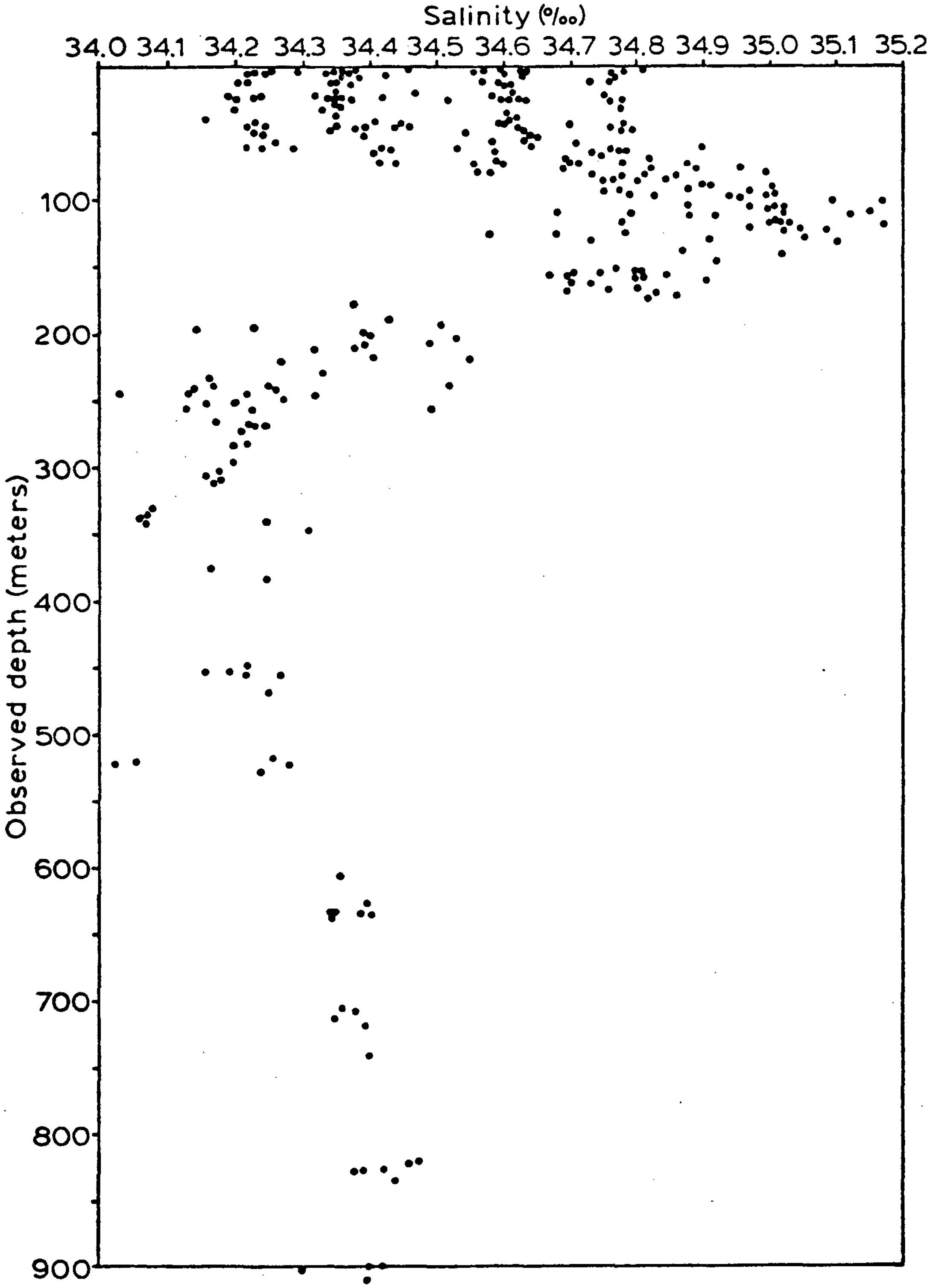

Fig. 3.1. A plot of all salinity determinations (°/oo) made during the six cruises of the HOTEC Benchmark Survey, October 1978 to December 1979.

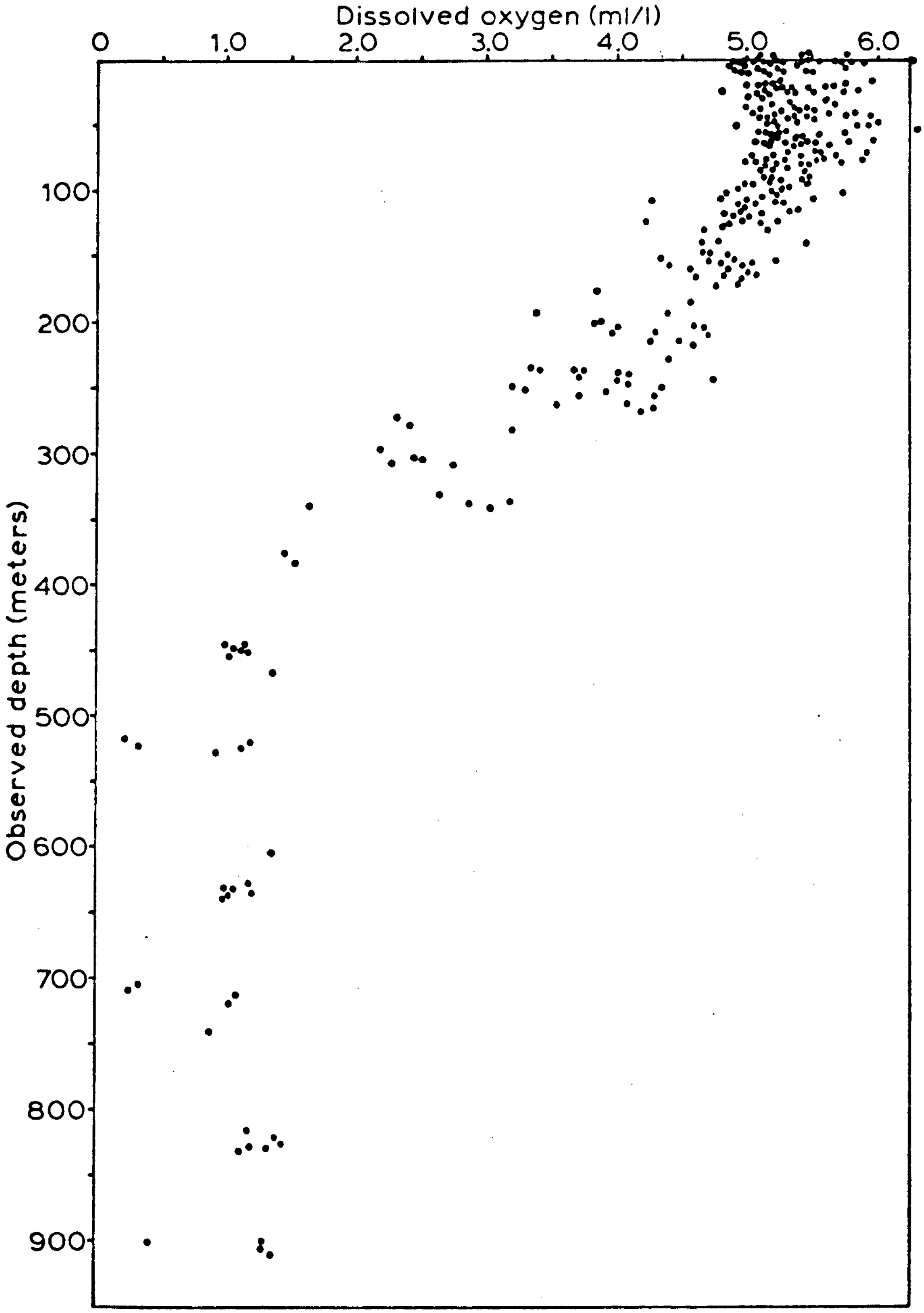

Fig. 3-2. A plot of all determinations of dissolved oxygen concentrations ($ml \cdot \ell^{-1}$) made during the six cruises of the HOTEC Benchmark Survey.

3.1.3 Nutrients

Results for the chemical analyses of the water samples from HOTEC cruises 1-6 are presented in Appendix B, Tables B-1 through B-6, respectively. A preliminary observation of the data indicated that, for five of the seven nutrients, three depth layers with different chemical concentrations were present: a mixed layer about 100 meters thick with concentrations which were relatively low and uniform with depth; a layer extending between 150 and 400 meters in which concentrations increase rapidly with increasing depth; and a layer between 600 and 1000 meters of relatively high and uniform concentrations. The vertical distributions of ammonium and urea, however, appeared to be relatively uniform over the whole 1000-meter water column.

Nutrient data for each layer (upper 100 meters, 200 to 400 meters, and 600 to 1000 meters) was analyzed by a three-way analysis of variance. The three variables in the analysis were date of cruise, time of day, and depth. For the mixed-layer analysis, data from each of the four hydrocasts on the last five cruises were utilized. The upper five samples taken on the deep hydrocasts (0, 25, 50, 75, and 100 meters) and five of the upper six samples on the shallow hydrocasts (0, 30, 50, 70, and 90 meters) were utilized. Thus, five levels of date, four levels of time of day, and five levels of depth were available for the mixed-layer analysis. The analysis of variance calculations generated an overall mean and standard deviation for each nutrient, mean values for each cruise, time of day, and depth, and overall standard deviations for each of these variables, as well as providing statistical tests of signifance.

The results of the statistical analyses for the mixed layer are presented in Table 3-1. All the nutrients showed significant seasonal (cruise) variations. However, the patterns of these variations were not uniform. Nitrate-nitrite showed the highest concentrations in October 1979, with levels nearly as high in June. Lowest concentrations occurred in April and August. The concentration of total nitrogen (which includes dissolved and particulate organic nitrogen as well as the dissolved nitrogenous compounds), was highest in December and lowest in October 1978. Total phosphorus and ortho-phosphate levels were highest in October 1978. Low values of ortho-phosphate occurred in April, June and December, while low values of total phosphorus occurred in August and October 1979. The highest values of reactive silicate occurred in June, while the lowest levels were observed in October 1979.

Variations in concentration with time of day were not significant for total phosphorus, but were significant for the other chemical species. Concentrations of nitrate-nitrite were high and uniform during the day, and low and uniform at night. Total nitrogen and reactive silicate were highest at sunset and lowest during the pre-dawn period. Ortho-phosphate was highest at sunset.

Variations in concentration with depth within the upper 100 meters were not significant for nitrate-nitrite and reactive silicate. Total nitrogen and ortho-phosphate were present in highest concentrations in the near surface (0 or 2 meter) samples, and were relatively uniform with depth below this

Table 3-1. Means, standard deviations, and levels of significance for five nutrients in the mixed layer (0-100 meters).

	Nitrate-Nitrite	Total Nitrogen	Phosphate	Total Phosphorus	Reactive Silicate
SEASON - Significance	<.01	<.01	<.01	<.01	<.01
April 1979	.38	11.71	.19	.52	2.48
June	.48	6.36	.21	.55	2.51
August	.08	12.85	.11	.45	2.20
October	.05	11.13	.10	.42	1.14
December	.09	17.99	.02	.54	1.45
Standard Deviation	.90	18.61	.35	.24	2.80
TIME OF DAY - Significance	<.01	N.S.	<.01	N.S.	N.S.
Noon	.34	12.77	.13	.50	1.78
Sunset	.12	12.39	.14	.49	2.23
Midnight	.27	11.55	.10	.49	2.16
Pre-Dawn	.14	11.31	.13	.49	1.66
Standard Deviation	.52	3.44	.10	0	1.39
DEPTH - Significance	N.S.	<.01	<.01	<.01	N.S.
0 meters	.35	13.83	.16	.58	2.37
25 (30) meters	.22	11.40	.13	.49	1.95
50 meters	.22	11.89	.12	.50	2.00
75 (70) meters	.17	11.49	.11	.46	1.81
100 (90) meters	.13	11.42	.10	.43	1.66
Standard Deviation	.38	14.54	.10	.24	1.19

N.S. = Not Significant

level. Total phosphorus was distributed relatively uniformly between the surface and 50 meters, and decreased to its lowest levels at 100 meters.

The magnitudes of the standard deviations of the five chemical constituents in the mixed layer indicated that, in general, the variability associated with the bi-monthly sampling schedule (seasonality, roughly) was greater than that due to time of sampling or depth. The variability due to depth of sample was generally smallest.

Because of incomplete sampling in October 1978, only data from the last five cruises was used in the analysis of the data from the two subsurface layers. Data from the 200, 300, and 400 meter samples from the noon and midnight hydrocasts were analyzed for the transition layer. The results of the statistical analyses for this layer are presented in Table 3-2. All five chemical species exhibited significant seasonal variations. Nitrate-nitrite was found in highest concentrations in December and was lowest in October. Total nitrogen was highest in December, lowest in June and October, and intermediate in April and August. Ortho-phosphate was found in highest concentrations in April, and decreased through the course of the year to its lowest values in October and December. Total phosphorus was highest in June and lowest in April. Reactive silicate was highest in April and December and lowest in June and October.

There was no significant difference between the overall means of total phosphorus at noon or midnight. The other four nutrients did exhibit significant variations, nitrate-nitrite, ortho-phosphate and reactive silicate being higher at noon than midnight, and total nitrogen being higher at midnight. All five nutrients showed the same pattern of sharply increasing concentration with depth.

Data for the deep (600 to 1000 meter) layer were again taken from the noon and midnight hydrocasts of the last five HOTEC cruises. The results of the statistical analyses for the deep layer are presented in Table 3-3. Seasonal variations were significant for nitrate-nitrite, total nitrogen, and total phosphorus. All three had their highest concentrations in December. Nitrate-nitrite was lower but relatively uniform throughout the rest of the year, while total nitrogen was lowest in June and August, and total phosphorus was lowest in April and August.

None of the five nutrients showed any significant differences between the noon and midnight means. Only reactive silicate showed a significant change in concentration with depth, increasing in concentration by 40% between 600 and 1000 meters.

Data from all twelve of the noon and midnight hydrocasts for the last five cruises were utilized in the analyses for ammonium and urea. The results of these statistical analyses are presented in Table 3-4. Seasonal variations for ammonium were not significant. Urea was relatively uniform in April, August, and December, but more than twice that level in June, and only half that level in October.

Table 3-2. Means, standard deviations, and levels of significance for five nutrients in the transition layer (200-400 meters).

	Nitrate-Nitrite	Total Nitrogen	Phosphate	Total Phosphorus	Reactive Silicate
SEASON - Significance	<.01	<.01	<.01	<.01	<.01
April 1979	15.27	27.15	1.32	1.20	19.37
June	14.51	21.21	1.18	1.68	17.05
August	15.61	27.43	1.25	1.42	18.31
October	13.87	23.35	0.95	1.53	17.02
December	16.76	31.82	0.98	1.59	19.40
Standard Deviation	2.70	10.03	0.40	.46	2.88
TIME OF DAY - Significance	<.01	<.01	<.01	N.S.	<.01
Noon	15.65	24.35	1.19	1.47	18.72
Midnight	14.76	28.03	1.08	1.50	17.74
Standard Deviation	2.44	10.10	0.31	0.10	2.67
DEPTH - Significance	<.01	<.01	<.01	<.01	<.01
200 meters	4.10	14.13	0.32	0.63	4.40
300 meters	16.09	24.94	1.17	1.44	16.11
400 meters	25.43	39.50	1.92	2.30	34.17
Standard Deviation	33.80	40.25	2.53	2.76	47.40

N.S. = Not Significant

Table 3-3. Means, standard deviations, and levels of significance for five nutrients in the deep layer (600-1000 meters)

	Nitrate-Nitrite	Total Nitrogen	Phosphate	Total Phosphorus	Reactive Silicate
SEASON - Significance	.04	.01	N.S.	.01	N.S.
April 1979	35.88	50.63	2.97	2.99	88.11
June	36.06	42.57	2.91	3.63	77.91
August	36.10	42.29	2.91	3.11	75.65
October	35.96	51.02	2.85	3.62	66.14
December	40.62	53.87	2.89	4.06	81.95
Standard Deviation	5.07	13.04	0.10	1.07	19.89
TIME OF DAY - Significance	N.S.	N.S.	N.S.	N.S.	N.S.
Noon	37.62	47.50	2.96	3.62	80.64
Midnight	36.23	48.63	2.86	3.34	75.27
Standard Deviation	3.79	3.10	0.26	0.77	14.71
DEPTH - Significance	N.S.	N.S.	N.S.	N.S.	.01
600 meters	36.75	47.69	2.85	3.28	65.96
800 meters	36.83	49.29	2.94	3.61	75.48
1000 meters	37.20	47.22	2.94	3.54	92.42
Standard Deviation	0.76	3.43	0.17	0.55	42.37

N.S. = Not Significant

Table 3-4. Means, standard deviations, and levels of significance for ammonium and urea over the 0-1000 meter water column

	Ammonium	Urea
SEASON - Significance	N.S.	0.01
April 1979	0.12	0.44
June	0.23	0.94
August	0.17	0.46
October	0.32	0.23
December	0.30	0.47
Standard Deviation	0.41	1.27
TIME OF DAY - Significance	N.S.	N.S.
Noon	0.25	0.48
Midnight	0.20	0.53
Standard Deviation	0.28	0.30
DEPTH - Significance	N.S.	0.045
0 meters	0.20	1.12
25 meters	0.10	0.40
50 meters	0.17	0.77
75 meters	0.15	0.57
100 meters	0.18	0.55
150 meters	0.09	0.42
200 meters	0.10	0.33
300 meters	0.45	0.44
400 meters	0.18	0.32
600 meters	0.40	0.29
800 meters	0.30	0.42
1000 meters	0.41	0.43
Standard Deviation	0.41	0.74

Neither ammonium or urea showed significant noon-midnight variations. The variation of ammonium with depth was not significant, and was just significant ($p = 0.045$) for urea, probably due to the high concentrations observed in the surface samples.

3.1.4 Chlorophyll a

Results of the chlorophyll a measurements for all cruises are given in tabular form as Appendix C and presented graphically in Figure 3-3 a-f. Mean values are plotted separately for the dawn and dusk hydrocasts to allow inspection for diurnal variability. For each datum, error bars represent the standard deviation about the means of triplicate subsamples.

The vertical profiles show (1) a shallow, mixed region having relatively low chlorophyll levels which grade into (2) a region of the deep chlorophyll maximum below which (3) chlorophyll values decline.

The data from all the cruises show chlorophyll a values which are fairly uniform with depth above 60m. Within this mixed surface region, values ranged from 0.03 $mg \cdot m^{-3}$ (cruise #2, April 1979) to 0.18 $mg \cdot m^{-3}$ (cruise #6, December 1979). Overall, the average mixed-layer chlorophyll a concentration was 0.11 ± 0.06 $mg \cdot m^{-3}$.

The presence of a deep chlorophyll maximum is a characteristic feature in all the profiles. The depth at which this maximum occurred ranged from 64 to 94 meters and was generally situated at ca 85 meters. There was no consistent variation in the depth of the deep chlorophyll maximum between the dusk versus dawn hydrocasts. The chlorophyll levels encountered in this region showed considerable variability (0.17 - 0.62 $mg \cdot m^{-3}$); the mean value encountered in this region was 0.31 $mg \cdot m^{-3}$.

Below the chlorophyll maximum, values were seen to show a sharp decline with depth to a region of fairly uniform low levels (0.01 - 0.05 $mg \cdot m^{-3}$); the depth marking the upper boundary of this region ranged from 110-200m.

In order to quantitatively deal with the topics of diurnal variation and seasonal variability, the chlorophyll data were numerically integrated over depth. This was done over the entire vertical range investigated,

$$C_t = \int_0^{260} C(z)dz$$

and over the 60 meter range describing the surface mixed zone.

$$C_s = \int_0^{60} C(z)dz$$

The results of these calculations, having units of $mg \cdot m^{-2}$, are given in Table 3-5, and plotted in Figure 3-4 a-b.

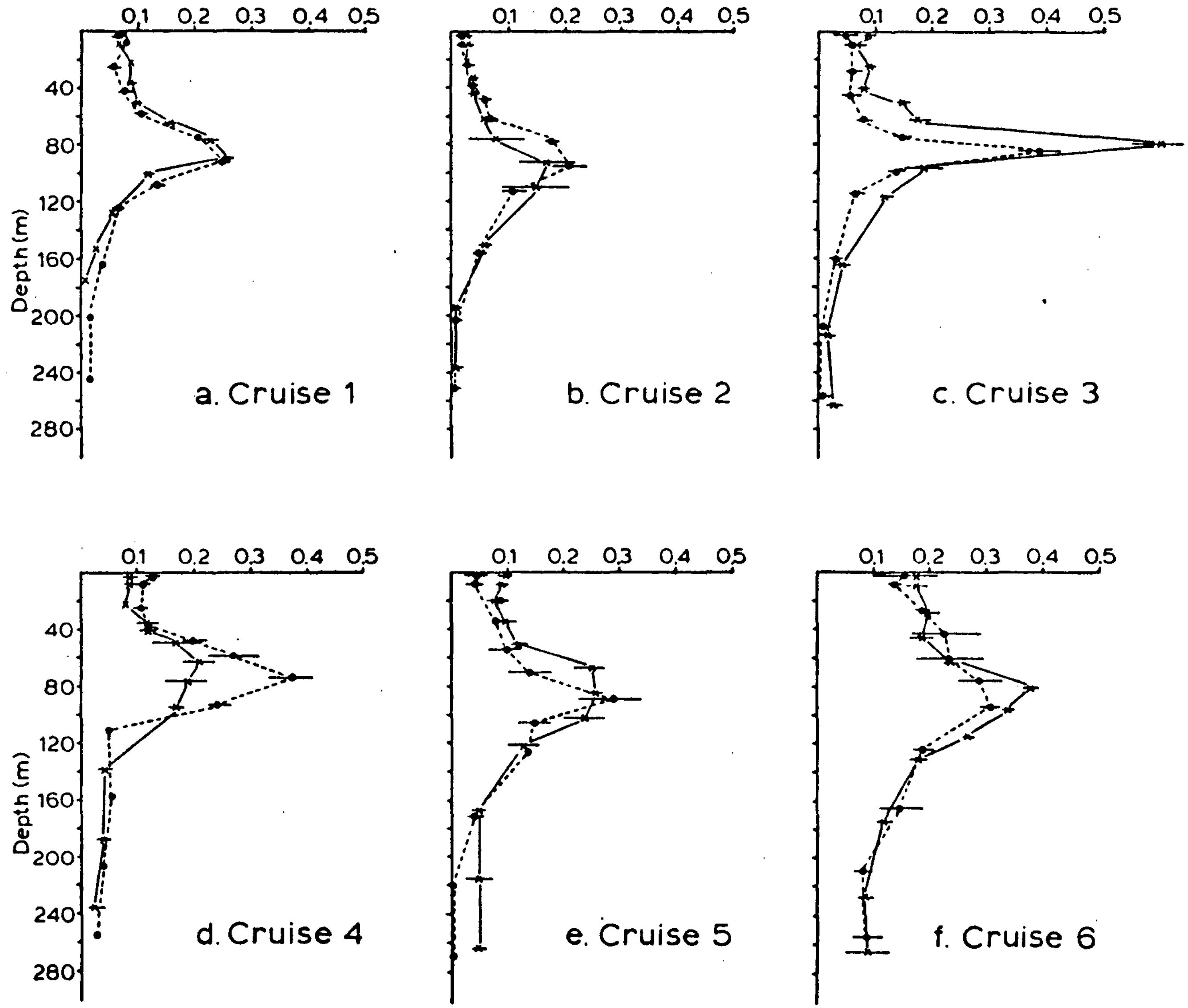

Fig. 3-3. Vertical profiles of chlorophyll a concentrations ($mg \cdot m^{-3}$) in the water column at the HOTEC site. The "dawn" hydrocasts are represented by the dotted-line plots, and "dusk" hydrocasts by the solid-line plots. The horizontal bars indicate the standard deviations about the means of triplicate analyses.

Table 3-5. Depth-integrated values of phytoplankton parameters at the HOTEC site during the Benchmark Survey. Units of measurement are given in the left-hand column with the name of each parameter. Depth ranges for integrations are given in parentheses.

Parameter		Cruise 1 Oct. 1978	Cruise 2 April 1979	Cruise 3 June 1979	Cruise 4 Aug. 1979	Cruise 5 Oct. 1979	Cruise 6 Dec. 1979
Chlorophyll *a*, $mg \cdot m^{-2}$							
(0–260 m)	dawn	17.87	15.50	16.87	25.67	21.20	43.77
	dusk	16.93	13.77	27.60	22.13	28.20	45.13
	mean	17.40	14.64	22.24	23.90	24.70	44.45
(0–60 m)	dawn	4.13	1.93	3.20	7.20	3.73	10.30
	dusk	5.13	1.93	4.93	5.67	5.53	10.23
	mean	4.63	1.93	4.07	6.44	4.63	10.27
Percent in layer above 60 m	dawn	23	12	19	28	18	24
	dusk	30	14	18	26	20	23
Phaeo-pigment, $mg \cdot m^{-2}$							
(0–260 m)	dawn	21.20	4.87	10.47	12.67	22.47	4.47
	dusk	13.73	5.00	22.53	6.93	13.67	3.67
	mean	17.47	4.92	16.50	9.80	18.07	4.07
ATP, $mg \cdot m^{-2}$							
(0–260 m)	dawn	1.42	0.56	2.25	3.29	5.46	4.07
	dusk	1.34	1.13	2.90	3.34	5.72	4.47
	mean	1.38	0.84	2.58	3.32	5.59	4.27
Primary productivity, $mg\ C \cdot m^{-2} \cdot h^{-1}$	(0–125 m)	18.70	3.12	10.01	2.86	17.32	0.72
$g\ C \cdot m^{-2} \cdot day^{-1}$	(0–125 m)	0.224	0.037	0.120	0.034	0.208	0.009

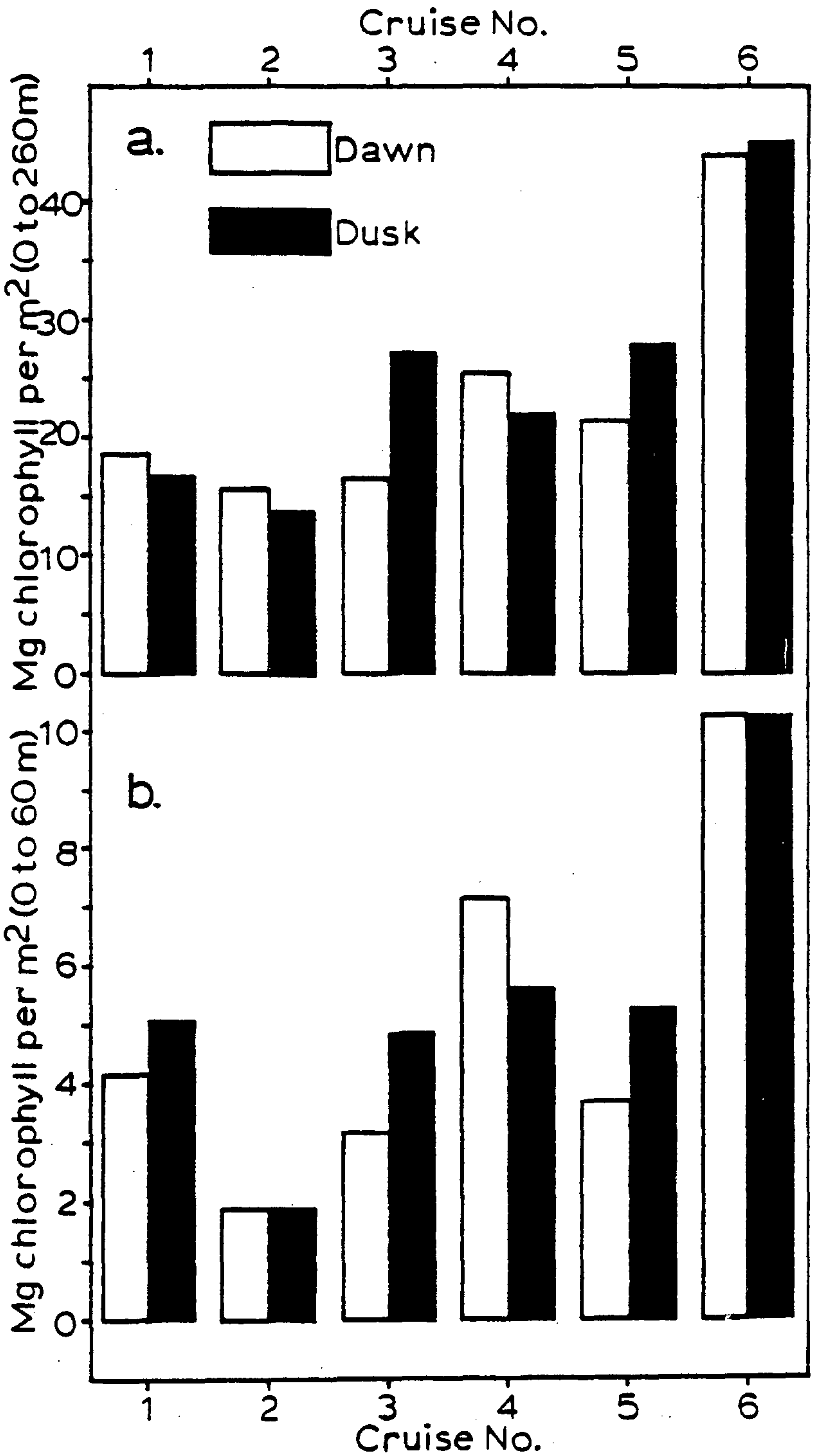

Fig. 3-4. Depth-integrated standing stocks of chlorophyll a ($mg \cdot m^{-2}$) for two depth ranges during the six cruises of the HOTEC Benchmark Survey.

Considerable variability was seen in the total standing stock of chlorophyll biomass (z = 0-260) in the six site visits. Integrated chlorophyll values ranged from 13.77 - 45.13 $mg \cdot m^{-2}$; the average (± s.d.) integrated chlorophyll level was shown to be 24.55 ± 10.42 $mg \cdot m^{-2}$. The lowest and highest values for integrated levels were found on the same cruises when the surface chlorophyll levels attained minimum and maximum values. No consistent seasonal trend is apparent in the integrated chlorophyll data (Figure 3-5a). No statistically significant (all $p > 0.05$) correlation was seen between the chlorophyll concentration at the maximum, and the integrated value taken over the entire water column, in these 12 sets of data.

Integrated values for the surface-to-60m layer (C_s) also showed considerable variation, ranging from 1.93 - 10.30 $mg \cdot m^{-2}$ (Table 3-5). On a relative basis, this range was greater than that observed for either the region of the deep chlorophyll maximum, or for the water column taken as a whole. The overall average value of integrated chlorophyll (C_s) in the surface layer was 5.33 ± 2.77 $mg \cdot m^{-2}$ (Figure 3-5b). The chlorophyll biomass in this region constituted from 12-30% of the total for the water column as a whole.

The data (Figures 3-3, 3-4; Table 3-5) show no evidence for a consistent diurnal variation of chlorophyll levels. Inspection of the integrated values (Table 3-5, Figure 3-4a) shows that levels from the dusk hydrocasts exceeded those from dawn hydrocasts on three of the six comparisons. The absolute differences between the dawn-dusk casts ranged from 0.94 - 10.72 $mg \cdot m^{-2}$; these variations ranged from 3-48% of the means of the two casts. The mean (± s.d.) dawn-dusk difference in total chlorophyll was -2.15 ± 5.56 $mg \cdot m^{-2}$ and is not significant (t-test $p > 0.10$). It is noted that since these data come from single hydrocasts each time, it is not possible to isolate sampling variability from the diurnal variability implied by the timing of the hydrocasts.

3.1.5 Phaeo-pigment

Results of the phaeo-pigment measurements for all cruises are given in tabular form as Appendix C, and presented graphically in Figure 3-5 a-f. Mean values are plotted separately for the dawn and dusk hydrocasts to allow for inspection for diurnal variability. For each datum-point, error bars represent the standard deviation about the means of triplicate subsamples.

The vertical distributions of phaeo-pigments are similar in character to those for chlorophyll, and show (1) a shallow mixed layer having relatively low values, (2) a subsurface region having maximum levels, (3) below which phaeo-pigment levels decline.

In mixed layer (<u>ca</u> 0-60m), phaeo-pigment concentrations ranged from undetectable levels to 0.09 $mg \cdot m^{-3}$ and showed an average (± s.d.) value of 0.04 ± 0.07 $mg \cdot m^{-3}$.

The depth of the maximum phaeo-pigment concentration ranged from 76-111 meters, and was generally found at 94 ± 11 meters. Phaeo-pigment values encountered in this region varied from 0.05 - 0.45 $mg \cdot m^{-3}$; the mean (± s.d.) phaeo-pigment value at the maximum was 0.15 ± 0.11 $mg \cdot m^{-3}$.

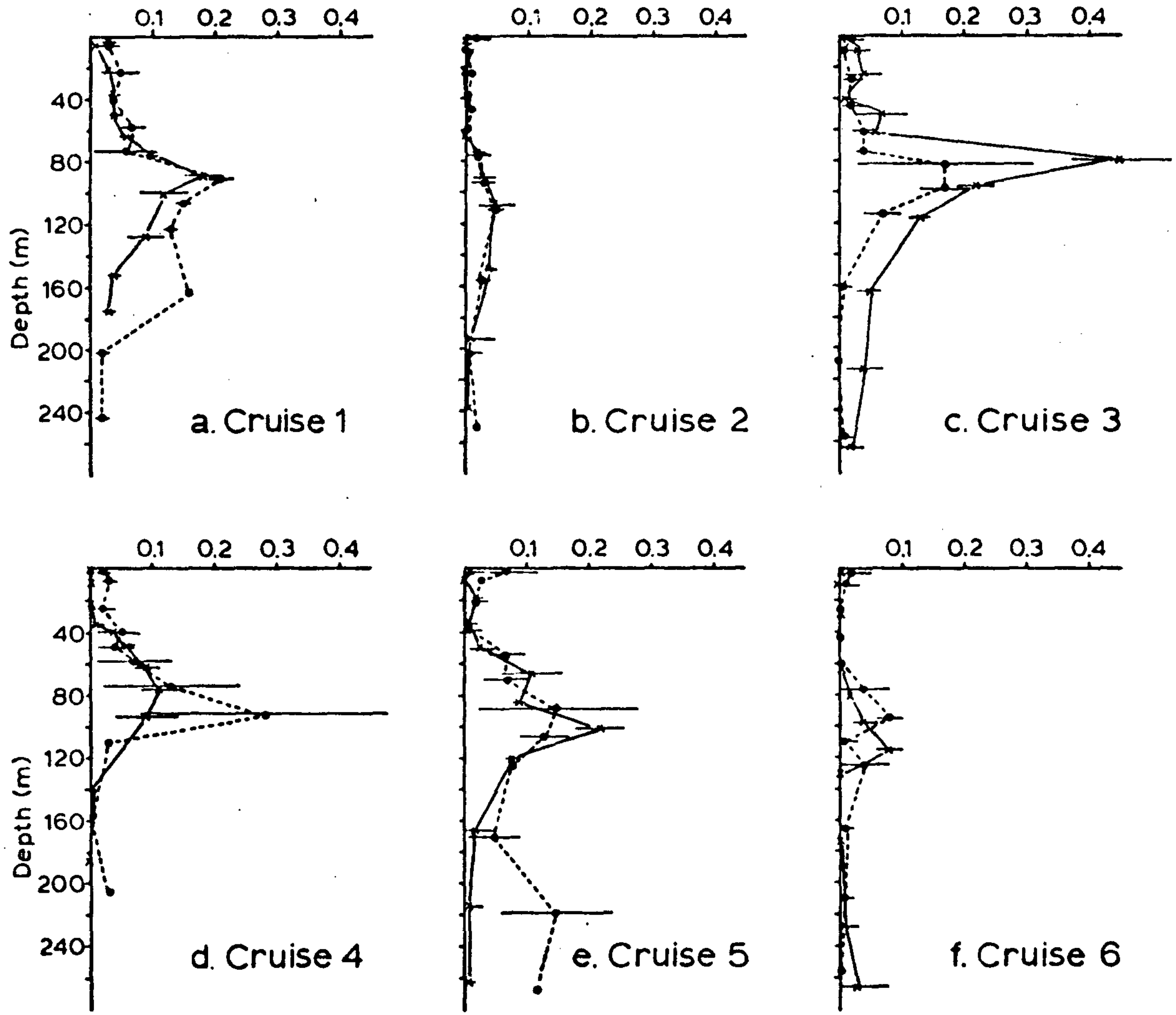

Fig. 3-5. Vertical profiles of phaeo-pigment concentrations ($mg \cdot m^{-3}$) in the water column at the HOTEC site. The "dawn" hydrocasts are represented by the dotted-line plots, and "dusk" hydrocasts by the solid-line plots. The horizontal bars indicate the standard deviations about the means of triplicate analyses.

Below the zone of the maximum, levels showed a sharp decline, paralleling the distributions seen for chlorophyll. Below approximately 160m, phaeo-pigment levels were usually $< 0.05\ mg \cdot m^{-3}$.

Vertical profiles of phaeo-pigment (P) were also numerically integrated over depth,

$$P_t = \int_0^{260} P(z)dz$$

in order to quantitatively address seasonal and diurnal variation. The results of the calculations, having units of $mg \cdot m^{-2}$, are given in Table 3-5. Integrated phaeo-pigment values ranged from 33.67 - 22.53 $mg \cdot m^{-2}$ over the 12 hydrocasts and had a mean (± s.d.) value of 11.81 ± 7.17 $mg \cdot m^{-2}$.

There is no evidence of a consistent trend of diurnal variation in the phaeo-pigment data (Figure 3-5, Table 3-5). Integrated values from the dawn cruises exceeded those of the dusk cruises in 4 of 6 comparisons. The difference between the dawn versus dusk P_t values ranged from 0.13 - 12.06 $mg \cdot m^{-2}$; expressed as percent of the mean, the dawn-dusk differences ranged from 3-73%. The depth of the phaeo-pigment maximum was also similar between the six dawn (92 ± 11m) and the dusk (97 ± 12m) hydrocasts. Overall the average (± s.d.) dawn-dusk differences in P_t were 1.77 ± 7.66 $mg \cdot m^{-2}$.

The depth of the phaeo-pigment maximum was found to be at or below the depth at which the chlorophyll maximum was found. In the twelve comparisons, the phaeo-pigment maximum occurred deeper than the chlorophyll maximum in six instances; the two maxima were found at the same depth in six instances; there were no cases in which the phaeo-pigment maximum was found above the chlorophyll maximum. Comparison of the ratios of the integrated phaeo-pigment and chlorophyll values, P_t/C_t, gave values which ranged from 0.08 - 1.19 and showed that, on the average, total phaeo-pigment levels were ca 55 ± 36% of total chlorophyll levels in these waters.

3.1.6 Phaeo-pigment:Chlorophyll a Ratios

The ratios of the P(z) (Figure 3-5 a-f) and C(z) (Figure 3-3 a-f) values are presented in Figure 3-6 a-f. Vertical distributions of these data are less similar from cast to cast than the distributions of either of the determinants of the ratio taken alone. The irregularity among casts is most pronounced in the region below which the subsurface maxima of P(z) and C(z) occurred. Generally the P(z):C(z) plots reveal that in the surface waters the ratios are generally low; values show a general tendency to be higher at depths greater than ca 60m. There was not an appearance of pronounced subsurface peaks of P(z):C(z) as was apparent for both the P(z) and C(z) distributions. Overall most (87%) of the 144 P(z):C(z) comparisons gave ratios which were < 1; the average P(z):C(z) ratio (± s.d.) observed in the surface waters for the twelve hydrocasts was 0.28 ± 0.25.

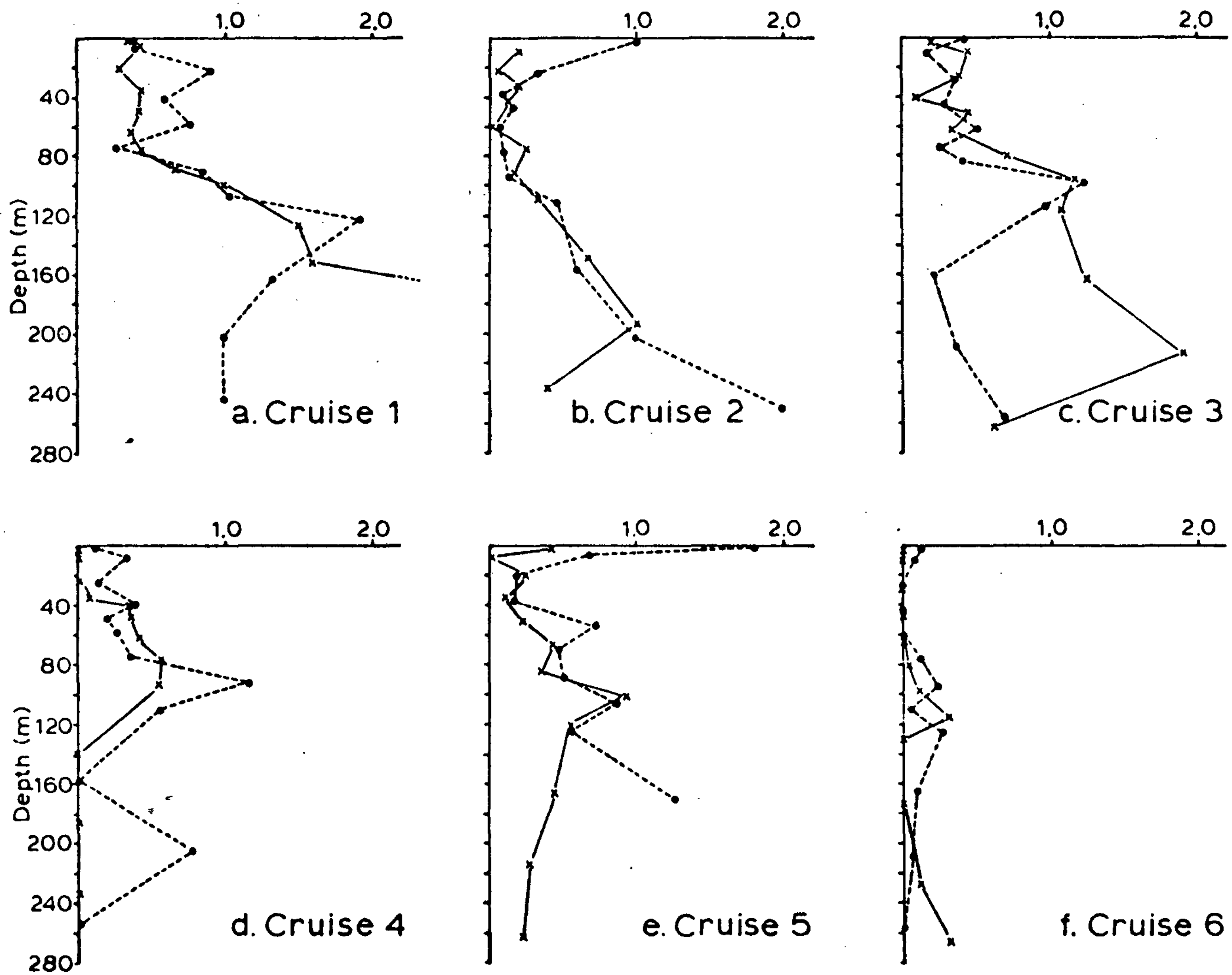

Fig. 3-6. Vertical profiles of the phaeo-pigment:chlorophyll ratios (P/C) in the water column at the HOTEC site. The "dawn" hydrocasts are represented by the dotted-line plots, and "dusk" hydrocasts by the solid-line plots.

3.1.7 ATP Concentrations

The means (± s.d.) of the triplicate ATP determinations are tabulated in Appendix C, and presented graphically in Figure 3-7 a-f. Vertical distributions of ATP concentrations are characterized by high and variable values in the mixed layer, followed by declining concentrations below 100m. The subsurface concentration maximum usually seen in pigment profiles is, in general, not apparent with ATP. High variability in mixed-layer concentrations, which cannot be entirely accounted for by analytical variation, creates an appearance of one or more minor subsurface maxima in some ATP profiles. Such peaks are not generally found at the same depth as the pigment maxima, however.

ATP concentrations in the upper 100m ranged from 2.37 $\mu g \cdot m^{-3}$ to 52.75 $\mu g \cdot m^{-3}$, with a mean of 20.60 $\mu g \cdot m^{-3}$ (s.d. = 11.82 $\mu g \cdot m^{-3}$, n = 91). Below 100m, the overall mean was 7.30 $\mu g \cdot m^{-3}$(s.d. = 5.23, n = 51).

Inspection of the depth-integrated (0-260m) ATP concentrations, expressed as $mg \cdot m^{-2}$, shows that the differences between dawn and dusk hydrocasts was quite small, compared with cruise-to-cruise differences expressing annual variation. The means from the six cruises ranged from 0.56 to 5.72 mg $ATP \cdot m^{-2}$, with a mean of 3.00 and s.d. equal to 1.78 $mg \cdot m^{-2}$ (n = 6). This tenfold range in integrated values over the year of the survey is rather more than the three-to-fivefold ranges exhibited by the plant pigment estimates.

3.1.8 Primary Productivity Rates

Results of the primary productivity determinations are given in tabular form in Appendix C, and presented graphically in Figure 3-8 a-f. The vertical distributions of primary production show great variation among the six site visits; this variation is apparent in the general shape of the distributions, the maximum depth at which production was measurable, and the values of the integrated production rates (Table 3-5). The distributions (Figure 3-8 a-f) do not show the presence of either photoinhibition near the surface or distinct subsurface maxima; rather the profiles are fairly uniform at depths above which truncation occurs. There was no clear correlation between the standing stocks (measured as either chlorophyll a or ATP) and the primary productivity rates observed on the six site visits.

Numerically integrated primary productivity rate estimates, having units of mg $carbon \cdot m^{-2} \cdot h^{-1}$, ranged from 0.72 - 18.70 mg $carbon \cdot m^{-2} \cdot h^{-1}$ and showed a mean (± s.d.) rate of 8.79 ± 7.81 mg $carbon \cdot m^{-2} \cdot h^{-1}$. These data showed a 26-fold variation in integrated production, with values of 18.70, 3.12, 10.01, 2.86, 17.32 and 0.72 mg $carbon \cdot m^{-2} \cdot h^{-1}$, over the six site visits. The considerable variability seen in the primary production data is noteworthy. On three occasions (cruises #2, #4, and #6) the primary productivity in the water column was found to be so low as to stress the detection limits of the method.

The integrated primary productivity data (in units of mg $carbon \cdot m^{-2} \cdot h^{-1}$) can be converted to daily rate estimates by multiplication by 12 (assuming 12

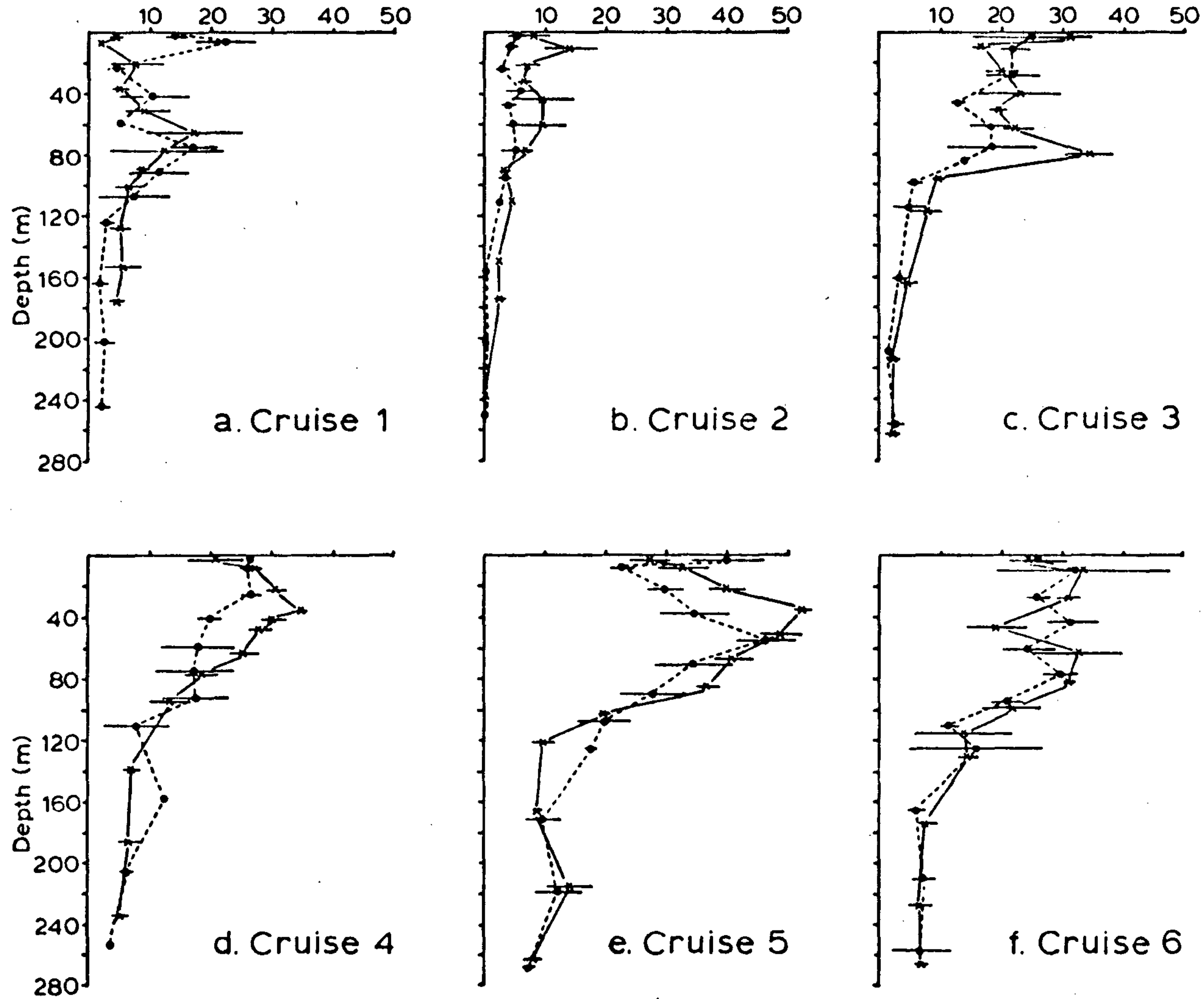

Fig. 3-7. Vertical profiles of ATP concentrations ($\mu g \cdot m^{-3}$) in the water column at the HOTEC site. The "dawn" hydrocasts are represented by the dotted-line plots, and "dusk" hydrocasts by the solid-line plots. The horizontal bars indicate the standard deviation about the means of triplicate analyses.

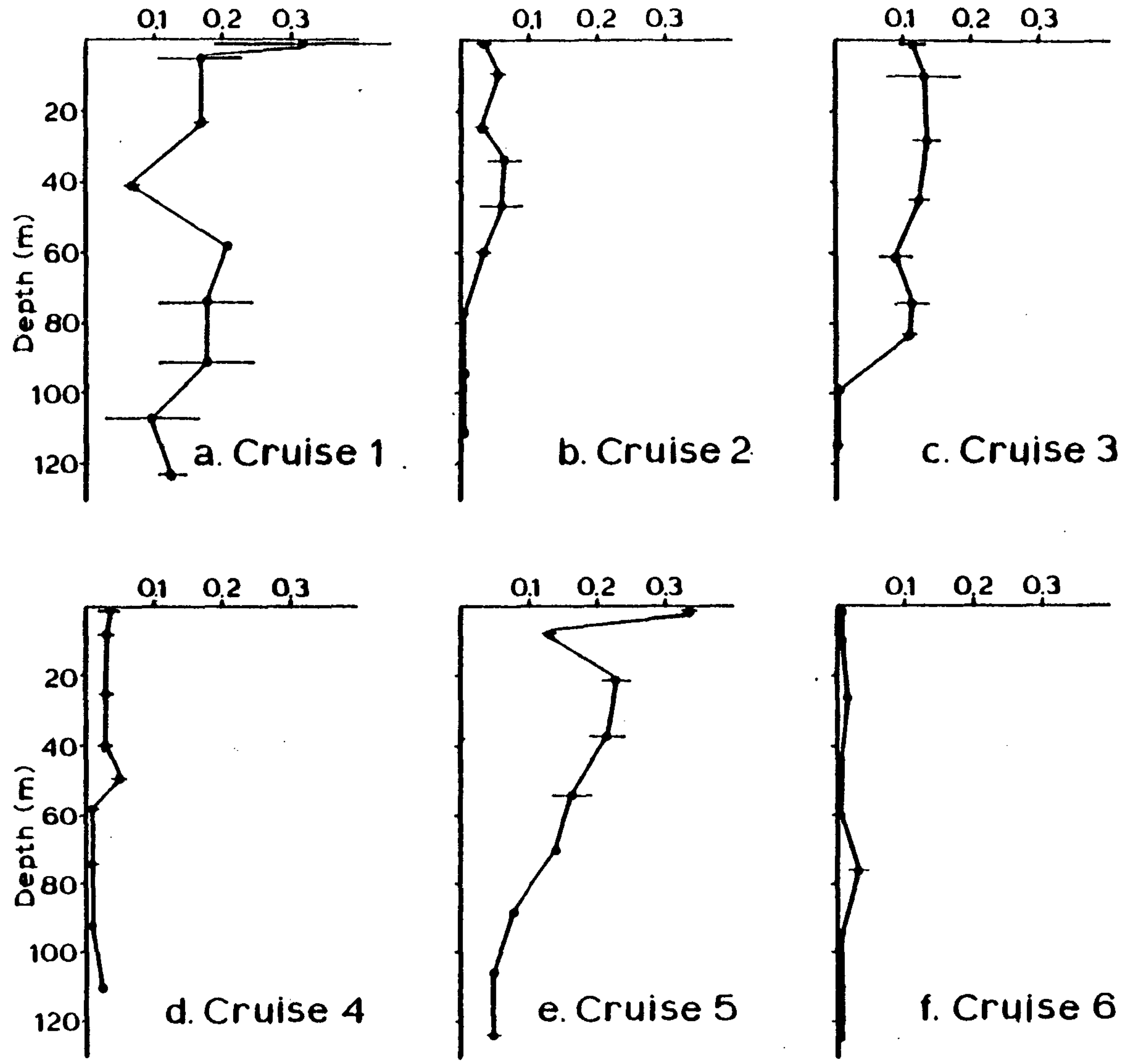

Fig. 3-8. Vertical profiles of the rates of primary production (mg $C \cdot m^{-3} \cdot h^{-1}$) at the HOTEC site. The horizontal bars indicate the standard deviations about the means of triplicate analyses.

hours of light per day). Expressed in terms of daily productivity, the data from cruises #1 through #6 give values of 0.224, 0.037, 0.120, 0.034, 0.208, 0.009 g carbon$\cdot m^{-2} \cdot day^{-1}$, respectively. Using these values, we see that the average (± s.d.) daily primary productivity throughout the water column in question becomes 0.105 ± 0.094 g carbon$\cdot m^{-2} \cdot day^{-1}$. Conversion of these values to yearly production values (multiplication by 365) gives an average annual primary productivity rate of 38.4 ± 34.3 g carbon$\cdot m^{-2} \cdot year^{-1}$, and an estimate of the annual range based on the six cruises of 4.2 - 72.6 g carbon$\cdot m^{-2} \cdot year^{-1}$. These data, i.e., the annual average primary production, the applicable range estimate, and the indication of considerable natural variability, represent important synoptic information describing phytoplankton dynamics at the subject site.

3.1.9 Light

Vertical profiles of scalar (nondirectional) irradiance were taken six times during each of the carbon-fixation experiments on cruises #4 and #5. Measurements were made with a profiling quantum scalar irradiance meter (Biospherical Instruments, Inc.) in units of quanta$\cdot cm^{-2} \cdot s^{-1}$. The instrument is designed to be sensitive to photosynthetically-active radiation (PAR) in the wavelengths 400-700nm.

Extinction coefficients were calculated from each profile, as the slope of the regression of log (I_Z) on depth, where I_Z is the measured irradiance at each depth. The coefficients were quite uniform during the day on the HOTEC-4 cruise, having a mean value (± s.d.) of -0.033 ± 0.005 m^{-1}. They were lower and slightly more variable on the HOTEC-5 cruise: -0.027 ± 0.008 m^{-1}. These coefficients are typical of open-ocean waters of high clarity.

3.1.10 Zooplankton

Summaries of the net tow data (time of tow, depth and volume filtered, etc.) for HOTEC cruises 1 through 6 are presented in Appendix Tables D-1 through D-6, respectively. Biomass data are presented in Appendix Tables D-7 through D-10. The biomass data for the first three cruises, since they are from single samples which covered different depth intervals and were taken with two different nets, can give no more than rough estimates of biomass for those periods. They cannot be used in any analysis of variance computations which require balanced experimental design.

The biomass data from HOTEC 4 can be used to compare the estimates of zooplankton biomass in the upper 25 meters which are derived from two different sampling regimes: horizontal tows at 25 meters, or oblique tows covering 0-25 meters. A three-way analysis of variance with replication can be calculated, with the three variables being time of day (day vs night), depth (horizontal vs oblique), and size fraction (macro vs meso). The results of such an analysis of variance are presented in Table 3-6, along with the mean values for each of the three main variables and the time-depth interaction term. Note that whereas the overall differences between day and night and between horizontal and oblique samples are not significant, the interaction term between these two variables is highly significant. The mean values for the four interaction terms show that during the day the biomass estimate from the horizontal tow is much larger than that from the oblique tow, whereas at night the estimate from the oblique tow is larger. The overall difference between the size fractions is significant, with the meso fraction making up about 38% and the macro fraction making up about 62% of the total dry weight biomass. As indicated by the non-significant interaction terms (time vs size, depth vs size, and time vs depth vs size), this difference was not affected by the time of sampling or the depth of sample.

Table 3-6. Results of three-way analysis of variance with replication for the data for zooplankton biomass in the upper 25 meters during HOTEC-4

	MEAN (mg/m^3)	STANDARD DEVIATION	SIGNIFICANCE LEVEL
TIME			
Day	2.84		
Night	3.23	0.79	0.30
DEPTH			
Horizontal	3.04		
Oblique	3.03	0.01	0.50
SIZE			
Macro	3.78		
Meso	2.29	2.97	0.01
INTERACTION			
Day-Horizontal	3.60		
Day-Oblique	2.08		
Night-Horizontal	2.48	3.03	0.01
Night-Oblique	3.98		
OVERALL	3.04	1.28	
Sampling Variability		0.72 (24% of Overall Mean)	

While an analysis of variance computation covering the whole year cannot be performed on the biomass data due to differences in sampling procedures, computations covering the 0-25 and 25-200 meter intervals for the last two cruises can be done. As well as testing for significant differences between bi-monthly abundance estimates, the analysis of variance computation provides an estimate of sampling variability from the paired samples. The results of the analysis of variance for the dry weight of plankton during HOTEC 5 and 6 are presented in Table 3-7. The differences in zooplankton biomass between the two cruises, between the three depth intervals, and between day and night were all significant. The biomass increased by 60% between October and December 1979. Overall biomass levels were 50% higher in the upper 200 meters at night, the result of diel vertical migrations of zooplankton from below 200 meters. The sampling variability, expressed as a fraction of the overall mean biomass, was about 22%.

Table 3-7. Results of three-way analysis of variance with replication for the zooplankton biomass data from HOTEC 5 and 6

	MEAN (mg/m^3)	STANDARD DEVIATION	SIGNIFICANCE LEVEL
CRUISE			
HOTEC 5	3.07		
HOTEC 6	5.13	4.12	0.01
DEPTH			
0-25m	5.11		
25-200m	3.09	4.03	0.01
TIME			
Day	3.27		
Night	4.93	3.32	0.01
OVERALL	4.10	2.08	
Sampling Variability		0.90 (22% of Overall Mean)	

The statistical analysis of the 25 meter horizontal and 0-25 meter oblique tows suggests that a reasonable estimate of the biomass in the upper 25 meters may be obtained from the average value of the day and night biomass estimates from either the 25 meter horizontal or the 0-25 meter oblique tows. Such biomass estimates for the six HOTEC cruises are presented below.

	HOTEC-1	HOTEC-2	HOTEC-3	HOTEC-4	HOTEC-5	HOTEC-6
Dry Weight (mg/m^3)	2.58	3.56	2.33	4.15	3.61	6.60

Biomass levels for the 0-200 meter depth interval can be calculated directly from the sample biomass measurements for the last four HOTEC cruises. A rough estimate of the biomass in the upper 200 meters for HOTEC 1 and 2 can be derived from the assumption (taken from the analysis of variance for HOTEC 5 and 6 above) that the biomass in the 25-200 meter interval is 60% of the value in the 0-25 meter layer. Biomass estimates for the 0-200 meter layer thus derived are presented below.

	HOTEC-1	HOTEC-2	HOTEC-3	HOTEC-4	HOTEC-5	HOTEC-6
Dry Weight (mg/m^3)	1.68	2.31	5.19	3.45	3.28	4.02

Biomass levels in the upper 25 meters were highest in December and lowest in October 1978 and June 1979. Levels in the upper 200 meters were highest in June and lowest in October 1978.

Numerical abundances of zooplankton are presented in Appendix Tables D-11 to D-20. For the first three HOTEC cruises, copepods were identified, as much as possible, to species, and the other organisms at least to family. These data are presented in Appendix Tables D-11 through D-13, respectively. For HOTEC 4 through 6 more samples were taken and identifications were limited to more broad taxonomic categories, i.e., calanoid copepod, etc. Data from the first three cruises were combined to conform to the general categories used for the last three cruises. These data for all six HOTEC cruises are presented in Appendix Tables D-14 through D-19.

In general, the calanoid copepods were the numerically most abundant taxonomic group of zooplankton. In most cases the group of small calanoid copepods here termed "microcalanoids" was the single most abundant group, although in some cases the abundances of the cyclopoid copepods, mainly Corycaeus and Oncaea, were as or more numerous.

Large changes in numerical abundance occurred between day and night samples, reflecting the changes in diel vertical distribution which most plankton exhibit. The general pattern of change in abundance which was observed was an increase for most groups in the 0-25 meter depth interval and a decrease in abundance in the 25-200 meter interval during the night. Since no night samples were taken below 25 meters during the first three cruises, and night samples were taken only in the upper 200 meters during the fourth cruise, the data describing the changes in vertical distribution for the whole water column are necessarily sparse. It appears from the data generated during HOTEC 5 and 6 that the patterns of diel changes in abundance in the 200-600 meter depth interval may be quite variable. During HOTEC 5 the numerical abundances of most of the taxa in the 200-600 meter interval decreased at night. However, numerical abundances increased in this layer at night during HOTEC 6.

Estimates of sampling variability were generated from the paired sample data from HOTEC 4, 5, and 6. For each pair of samples, the mean difference and standard deviation of the differences were calculated, and Student's t-value calculated. Calculations were made on both the untransformed data and after a x' = log (x+1) transformation. The mean difference ± the standard deviation for the untransformed data was 1.19 ± 1.40. The mean difference for the log-transformed data times/divided by the standard deviation (the standard deviation being multiplicative instead of additive is a result of the log transformation) was 1.20 times/divided by 1.20. For the sixteen sets of paired samples, the t-values for the differences between pairs were significant for only one data set (HOTEC 5, 200-600 meters, night).

The results of the identification of fish larvae in the samples from HOTEC 3 are presented in Appendix Table D-20. The majority of the fish larvae were members of the family Myctophidae, which are not of direct economic significance but which may be a major dietary item of some of the sport fish found in the HOTEC region. Numbers taken were relatively low.

3.1.11 XBT Data

The XBT data for all six HOTEC cruises have been both digitized at 1°C isotherm intervals and graphical overlays plotted as shown in Appendix E. For OTEC resource evaluation purposes Figure 3-9 describes the monthly temperature-depth distribution at the Keahole Point benchmark site obtained from the average of the XBT data shown in Appendix E.

3.1.12 Meteorological Data

Appendix F tabulates the meteorological observations for all 6 HOTEC cruises.

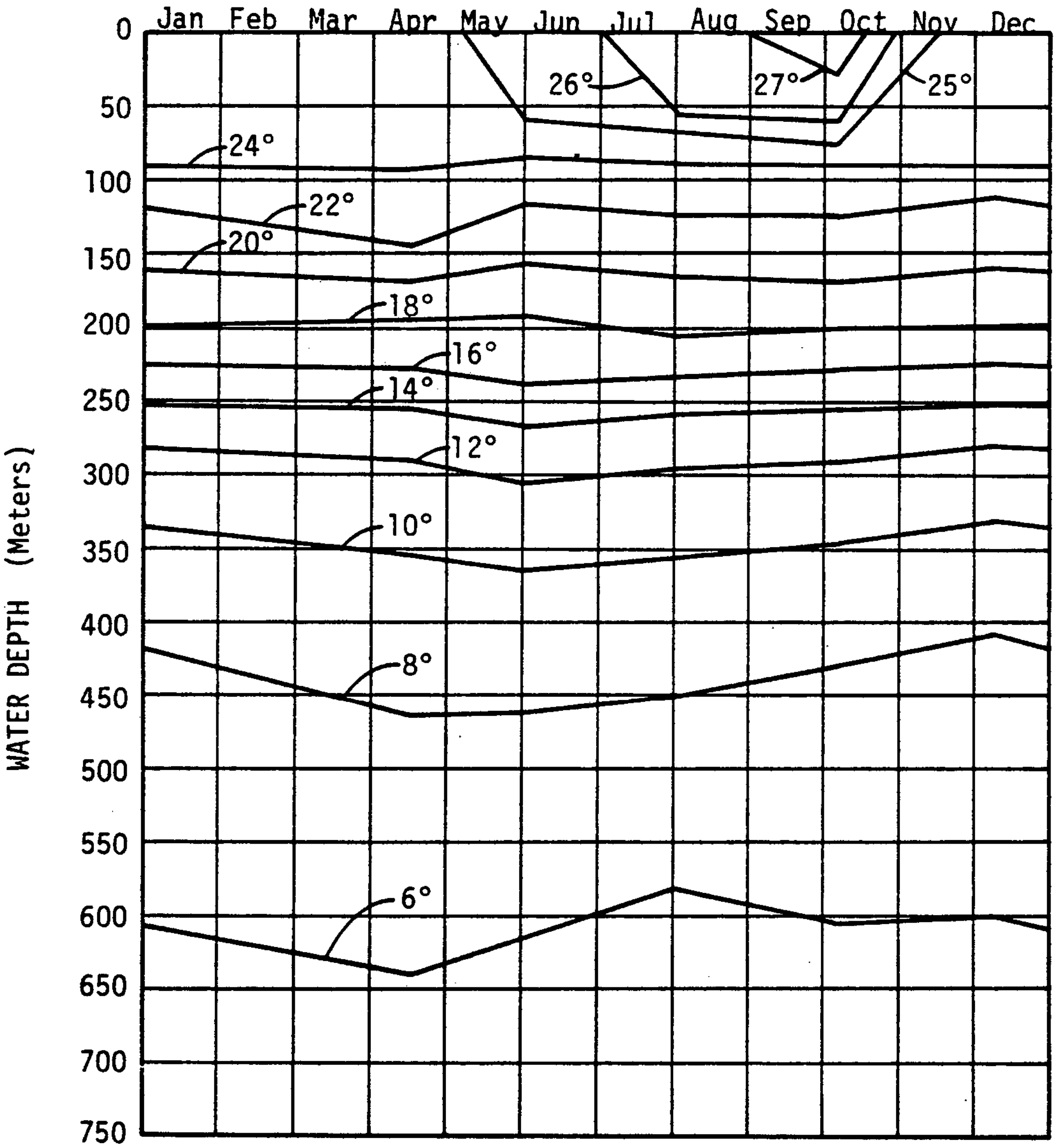

Fig. 3-9. Monthly Temperature (°C) - Depth Distribution at the Keahole Point Benchmark Site

4.1 DISCUSSION

4.1.1 Salinity and Dissolved Oxygen

The vertical variations in salinity denote different water masses encountered through the water column. The vertical sequence protrayed is: subtropical surface water (0-70m mixed layer), North Pacific central water (salinity maximum centered at 100-125m), North Pacific intermediate water (salinity minimum centered at 350m), and Pacific deep water (showing slightly higher salinity values in deeper samples). Within the surface mixed layer, salinity showed clear temporal variability, where values ranged from 34.227 to 34.774 $^{o}/oo$ during the cruises in April 1979 and December 1979, respectively. This variation may reflect the combined effects of local weather (e.g., rainfall and solar irradiance levels), influencing the dilution and evaporation of local seawaters. The salinity variation seen in deeper regions was much less distinct from cruise to cruise, and is probably not due in any appreciable degree to local events.

The salinity profiles that have been taken off Keahole Point by other researchers (Gundersen and Palmer, 1972; Bathen, 1975; U.S. DOE, 1979) are consistent with the vertical structure to be expected from the influences of the Pacific water masses in the area (see, for example, Sverdrup et al., 1942), and with observed profiles in other nearby waters (Gundersen et al., 1972; Gundersen and Mountain, 1973; Gundersen et al., 1976).

Dissolved oxygen concentrations in the water column in the Keahole area (Bathen, 1975; U.S. DOE, 1979) have shown near-saturation levels of about 5 ml/ℓ in surface waters, some uniformity in the mixed layer of 50-100m depth, followed by decreasing concentrations to levels of about 1 ml/ℓ at 800m. This is a typical pattern for this part of the Pacific; similar observations have been made off Oahu by Gordon (1970) and by Gundersen et al. (1976).

The present study shows that the vertical distributions of dissolved oxygen portray a 90m mixed region having high levels overlying a layer (100-450m) exhibiting rather constant declines in dissolved oxygen with depth, below which low and uniform levels prevail. Oxygen is not a conservative property in seawater; rather the levels of dissolved oxygen are markedly affected by biological activity. For the upper mixed layer, levels ranged from 4.8 - 6.3 ml $O_2 \cdot \ell^{-1}$, showed little clear cruise-to-cruise variation and represent values which are at or above saturation levels for the prevailing temperature and salinity conditions. High values in the surface waters reflect the combined inputs from photosynthetic activity and contact with the atmosphere. The region of declining oxygen concentrations occurs below the area of extensive mixing with surface waters, and lies below the region to which sufficient light penetration permits photosynthesis. Oxygen utilization in these and deeper waters occurs via the respiration of all biologically active communities.

4.1.2 Nutrients

Two of the seven nutrients sampled during the six HOTEC cruises did not exhibit any structure in their vertical distributions. The concentration of ammonium did not change significantly with depth, although the data do suggest that there was an increase in concentration below 300 meters. The level of sampling effort (no replicates) and large relative standard deviations make the confidence limits for the concentration with depth so wide that slight differences, if present, cannot be detected. The vertical distribution of urea, although just barely significant ($p = 0.045$) and quite variable, showed no real structure with depth. The significance of concentration with depth is most likely due to the high levels of urea found in the surface samples.

The other five nutrients exhibited a three-layered depth distribution: low and variable concentrations in the mixed layer (0 to 100 meters); sharply increasing concentrations with depth in the transition layer (200 to 400 meters); and high, relatively uniform concentrations below 400 meters. Within the mixed layer, nitrate and silicate were uniformly distributed with depth, while total nitrogen, ortho-phosphate, and total phosphorus exhibited distributions in which the concentrations were highest at the surface and decreased with depth. Although the depth distributions of nitrate and silicate were not statistically significant, the data suggest that they, too, had a decrease in concentration with depth. Again, lack of replicate samples and high variability result in wide confidence limits.

Within the mixed layer, the biological processes of nutrient uptake by phytoplankton and excretion by zooplankton and the physical process of vertical mixing are the factors which control the concentrations of the dissolved nutrients. The biological processes occur at a more rapid rate than vertical mixing in the surface waters. Small scale differences (both in space and time) are therefore most likely a reflection of recent biological activity. The patterns of vertical distribution and variations over the course of a day which have been observed appear to be independent (the interaction term for these two variables in the analysis of variance calculations were not significant for any of the dissolved nutrients in the mixed layer). In general the dissolved nutrient concentrations tended to decrease with depth. This suggests that the balance between uptake and excretion is tipped in favor of uptake in the deeper part of the mixed layer, and that excretion exceeds uptake in the shallow part of the layer. Data from the phytoplankton portion of the HOTEC program indicate that the levels of chlorophyll and productivity are higher in the lower portion of the mixed layer, which would support the hypothesis of increased uptake.

Only nitrate and phosphate concentrations showed significant variations over the course of the day. The input of nitrate to the mixed layer is probably mostly through vertical mixing from below, which would tend to be a relatively constant process. Uptake by phytoplankton would be the main process by which nitrate was removed from the water. It has been shown that nitrate uptake by some marine phytoplankton occurs for the most part only during the day, and is reduced to near zero at night (Caperon and Ziemann, 1976). One would expect to observe, therefore, lowest concentrations of nitrate at sunset and highest concentrations just before dawn or in the early morning. In fact, the highest concentrations of nitrate were observed at noon and the lowest concentrations at sunset, indicating uptake that exceeds input due to mixing. Also as expected, nitrate levels rose after sunset, as uptake shut off. However, nitrate levels were observed to fall between midnight and 0400 hours. The reason for the decrease at this time is not clear.

The daily distribution of phosphate was relatively constant, with slightly lower concentrations only at midnight. This would suggest that phytoplankton uptake of phosphate and zooplankton excretion and vertical mixing are in relative balance.

The concentrations of total nitrogen and total phosphorus did not change over the course of the day. The majority of these fractions are made up of particulate material, mainly phytoplankton. Changes in particulate nitrogen and phosphorus would be due mainly to growth of phytoplankton and grazing on phytoplankton by zooplankton. While the data for total phosphorus are so uniform as to show no pattern, the data for total nitrogen, assuming a large part of this is in the particulate form, suggests increased losses due to increased grazing at night. This increased grazing would most likely be the result of vertically migrating zooplankton adding to the grazing pressure.

Seasonal changes in concentration were significant for all the nutrients in the mixed layer. The patterns of seasonal change appeared to be unrelated, however. Correlation coefficients for all combinations of nutrients by season were not significant.

Within the transition zone (here taken as being between 200 and 400 meters) all five nutrients showed sharp increases in concentration with depth. The major processes controlling concentrations in this layer are probably vertical diffusion for the dissolved nutrients and sinking of particulate material from above for total nitrogen and total phosphorus. Seasonal changes in concentration were significantly correlated between nitrate and total nitrogen. The concentration of total nitrogen in this layer was also significantly correlated with the concentration of total nitrogen in the mixed layer, suggesting that the sinking of particulate material from the productive mixed layer is the source of some of the total nitrogen found in the transition zone. The concentrations of total nitrogen and reactive silicate were also correlated by season. This, along with the evidence of sinking presented above, suggests that some of the reactive silicate found in the transition zone is the result of the dissolution of the siliceous shells of diatoms sinking through the water column.

In the deep layer, only the seasonal concentrations of ortho-phosphate and silicate were significantly correlated. These two nutrients were the only ones which did not show significance in their overall seasonal concentrations. Apparently the slight variations in concentration with season for these two nutrients were in the same direction.

There were no observed significant changes in concentration with time of day for any of the nutrients in the deep layer. Since the layer is well below the surface layer where most of the biological activity, which generally exhibits changes on a daily cycle, takes place, the processes which cause changes in concentration occur on a longer time scale.

Only silicate showed any evidence of significant changes in concentration with depth in the deep layer. The increase in reactive silicate with depth is generally attributed to the increased dissolution of siliceous diatom shells due to increasing pressure (Riley and Skirrow, 1965).

4.1.3 Phytoplankton

The distributions of phytoplankton biomass, expressed as chlorophyll a. show a vertical structure which is similar for all site visits, i.e., a surface mixed layer of relatively low chlorophyll concentrations lying above a subsurface chlorophyll maximum, below which values show marked decline to negligible levels. This is a fairly typical feature of oceanic water columns and has been reported in many regions of the world's oceans (Lorenzen, 1967; Saijo et al., 1969; Hobson and Lorenzen, 1972; Venrick et al., 1973; Jeffrey, 1976; Bienfang and Gundersen, 1977). Several explanations have been offered for the presence of the deep chlorophyll maximum. Phytoplankton sinking rate deceleration has been suggested as an important factor maintaining this distribution at the base of the mixed layer (Menzel and Ryther, 1959; Steele and Yentsch, 1960; Steele, 1961; Anderson, 1972; Goering et al., 1970; Venrick et al., 1973; Jamart et al., 1977). The maximum has also been suggested to result from an increase in the cellular content of chlorophyll via adaptation to the reduced light levels prevailing in the area (Steele, 1964; Eppley et al., 1973; Kiefer et al., 1976; Jeffrey and Vesk, 1977).

Despite the similarity in the shapes of the vertical chlorophyll distributions among the six cruises, considerable variation was seen in absolute values of chlorophyll observed. Levels in the surface mixed layer ranged from 0.03 - 0.18 $mg \cdot m^{-3}$. The depth of the subsurface chlorophyll maximum ranged from 64-94m, and showed levels which ranged from 0.17 - 0.62 $mg \cdot m^{-3}$. The temporal variability in phytoplankton stocks is also shown by comparison of the integrated levels. Within the mixed layer (z = 0-60), integrated chlorophyll ranged from 1.93 - 10.30 $mg \cdot m^{-2}$, and for the entire upper 260m, values ranged from 13.77 - 45.13 $mg \cdot m^{-2}$. The variability in the standing stock of phytoplankton seen in the six site visits was not clearly correlatable with variations in any of the other parameters (e.g., nutrients, primary productivity) measured in the study. One might expect that periodic nutrient inputs to the waters could account for the temporal variations in phytoplankton biomass; unfortunately, the turnover time of nutrients in such nutrient-impoverished systems is so rapid that it precludes measurement.

Other researchers have found that concentrations of chlorophyll in the waters near the HOTEC site are, in general, typical of other subtropical areas, which showed low surface concentrations (0 to 0.10 mg/m^3) increasing to a maximum of about 0.3 mg/m^3 at depths ranging from 50 to over 100m (Beers and

Stewart, 1971; Gilmartin and Revelante, 1974; Gundersen et al., 1976; Bienfang, 1977; Bienfang and Gundersen, 1977; U.S. DOE, 1979). There appears to be a wide range of variation among the results of these studies, both in the surface concentrations and in the concentrations at the deep maximum.

The fraction of the total chlorophyll, $\int_0^{260} C(z)dz$, found in the mixed layer $\int_0^{60} C(z)dz$, was fairly constant over the six cruises in spite of the variations in overall levels observed. The percent of phytoplankton chlorophyll present in the upper 60 meters ranged from 12-30% and showed an average of 21.3 ± 5.4%.

There is little reported information on phaeo-pigment concentrations at the site or in the general area, which is not surprising in view of Shuman's (1975) observation that phaeo-pigment determinations are usually done to correct chlorophyll measurements for possible contamination. Bienfang (1977) found that a phaeo-pigment profile at Keahole followed the shape of the chlorophyll profile, with the concentrations generally about 1/3 to 1/2 the chlorophyll levels. In the region of the pigment maximum, however, the phaeo-pigment concentrations increased to 0.8 to 0.9 times the chlorophyll levels. These observations are similar to those of Gundersen (1977) off Oahu.

The present study shows that the distribution of phaeo-pigments displays a vertical structure similar to that of chlorophyll, showing low surface levels, a subsurface maximum, and declining levels in deeper waters. The shape of vertical profiles showed similarity for all six cruises, and appears to be a typical feature of the water column. The general similarity in the distribution of phaeo-pigments and chlorophyll _a_ arises in part from the fact that the former are derived from the latter. Phaeo-pigments are degraded forms of chlorophyll, produced in large part by the grazing activity of herbivores. The measured concentrations of phaeo-pigments at any time are also, however, affected by prevailing light levels and to some degree chemical degradation to forms which are not measured by this method.

Phaeo-pigment levels showed considerable variation over the six cruises. Within the mixed layer, values ranged from undetectable levels to 0.09 $mg \cdot m^{-3}$, which subsurface maximum values ranged from 0.05 - 0.45 $mg \cdot m^{-3}$, integrated phaeo-pigment levels $\int_0^{260} P(z)dz$ ranged from 3.67 - 22.53 $mg \cdot m^{-2}$ over the 12 hydrocasts.

In spite of the fact that phaeo-pigments originate from chlorophyll, there was not a strong correlation between the depth-integrated values of the two pigment types in the six sets of comparisons. This may be due to coincident variations in the light fields and/or the grazing pressure exerted upon the phytoplankton stocks over some time prior to the measurement.

The depth of the phaeo-pigment maximum was, in all 12 inspections, at or below the depth of the chlorophyll maximum. This may be due in part to the fact that phaeo-pigments are light-labile and the higher light intensities in the surface waters caused photo-oxidation to unmeasurable byproducts. Higher phaeo-pigment concentrations at depths below the chlorophyll maximum may also reflect phaeo-pigment production in a region where low light levels inhibit both phaeo-pigment degradation and chlorophyll production.

Evaluation of depth- and hydrocast-specific P(z):C(z) ratios shows that in the surface mixed layer, ratios are characteristically low ($\bar{x} \pm$ s.d. = 0.28 ± 0.25), and, over all depths, nearly 90% of the ratios were < 1.00. Comparison of these parameters over the 260m water column inspected in the shallow hydrocasts may also be done by the ratio of the integrated values, P_t/C_t. Over the six cruises, P_t/C_t ratios ranged from 0.08 - 1.19 and showed that the average phaeo-pigment concentrations in the water column were 55 ± 36% of the chlorophyll levels.

The vertical profiles of ATP concentration show a general pattern of decreasing values with depth. Levels were high and variable in the surface (0-100m) waters and ranged from 2:37 - 52.72 $ng \cdot l^{-1}$ (= $\mu g \cdot m^{-3}$). There is no indication of a subsurface maximum in the ATP levels as is apparent for the chlorophyll a and phaeo-pigment concentrations. ATP is a biomass indicator that is found in all living tissue; thus biomass due to bacteria, phytoplankton ciliates, and microzooplankton (< 202μm) might be represented in these values. Depth-integrated ATP values showed variations of 0.56 - 5.72 $mg \cdot m^{-2}$ over the 12 hydrocasts. The average (± s.d.) of the depth-integrated ATP values for the six cruises was 3.00 ± 1.78 $mg \cdot m^{-2}$.

Rates of carbon fixation by photosynthetic microorganisms have been measured off Keahole by Bienfang (1977) and off Oahu by Gundersen et al. (1976), and Gundersen (1977). The profile done by Bienfang at Keahole may, however, be atypical because it was done on a dark day of cloud cover and volcanic debris in the air. Near-surface fixation rates were about 0.03 mg $C \cdot m^{-3} \cdot h^{-1}$, and had declined to about 0.002 at 110m depth. It was noted that the profile of P/B ratios decreased exponentially, as is common for profiles of light transmittance. This is taken as evidence of light-limitation of photosynthesis on that day. Eppley et al. (1973) presented a profile of P/B ratios from Central Pacific waters, which has surface values very similar to Bienfang's, but with a rather different profile shape, since light was not limiting in the upper regions of the photic zone during their experiments. The profiles near Oahu (Gundersen et al., 1976; Gundersen, 1977; Bienfang and Gundersen, 1977) are probably more representative of the Keahole area than Bienfang's (1977), but it should be noted that wide ranges of variation may be expected for carbon fixation rates, as for chlorophyll concentrations. The profiles show some uniformity of rates (0 - 0.2 mg $C \cdot m^{-3} \cdot h^{-1}$) in the upper mixed layer, a subsurface maximum between 50 and 90m (~ 0.05 - 0.60 mg $carbon \cdot m^{-3} \cdot h^{-1}$), and sharply declining rates with depth to very low levels below 110m. Similar profiles were constructed by Gilmartin and Revelante (1974) at several offshore stations in the islands, using deck incubation with simulated subsurface light levels.

Distributions of primary productivity taken on the six cruises describe a photic zone which extends to ca 125m in most cases. Primary productivity rates, although highest in the shallower samples, generally showed a surprising degree of uniformity throughout much of the photic zone. An outstanding feature of these data is the amount of variation among the six cruises.

This variation was not directly correlatable with the size of the phytoplankton population (in chlorophyll a levels) responsible for the carbon fixation activity. Neither is the variation accounted for by light levels (indexed by % cloud cover) prevailing during the incubations. A plausible explanation for the variations in primary productivity observed is variation in nutrient inputs at some time prior to the measurements; this may be the case even in the face of the absence of observable changes in the levels of ambient nutrients. The turnover time of regenerated nutrients in oligotrophic environments is very rapid, and so the small nutrient inputs most frequently escape detection. In addition to contributing nutrients to the ambient pools, the process of grazing also transforms chlorophyll to phaeo-pigments. Inspection of the data from the six cruises revealed a correspondence between the levels of phaeo-pigment measured and the rates of primary productivity observed. Correlation covariance analysis was performed between the average depth-integrated phaeo-pigment values and the depth-integrated primary productivity values; this analysis gave a correlation coefficient $r = 0.92$ which connotes statistical significance at the $p < 0.01$ level (d.f. = 4). The same test between the depth-integrated chlorophyll and the integrated primary production did not show statistical significance ($p > 0.05$). The implication from these findings is that the input rate of regenerated nutrients, indexed by the presence of the degradation products of grazing, has a strong effect on the rates of primary production in these waters.

The six inspections of total primary productivity showed values ranging from 0.72 - 18.70 mg carbon$\cdot m^{-2} \cdot h^{-1}$; this converts to a range of daily production estimates of 0.009 - 0.224 g carbon$\cdot m^{-2} \cdot day^{-1}$. It is concluded from this data that large natural variation in the rates of primary productivity is a typical feature of this environment.

A relevant synoptic finding of these data is that the average annual primary production in the subject area is 38.4 g carbon$\cdot m^{-2} \cdot year^{-1}$. The standard deviation about the estimate ($\pm$ 34.2 g carbon$\cdot m^{-2} \cdot year^{-1}$) is large as a result of the range of the six estimates involved. Note that if the estimate of annual primary production is made by numerical integration over time, to account for the variable intervals between cruises, the estimate of the annual production differed by only about 4% from the estimate acquired by calculating the mean of the six cruises and multiplying by 365; the latter approach was taken so that the standard deviation about the mean estimate could be reported. The range in annual primary production implied by the s.d. of the data from the six site visits is 12.04 - 101.11 g carbon$\cdot m^{-2} \cdot year^{-1}$.

Since primary production values represent the rate at which the phytoplankton are performing ecological work, i.e., putting energy into the trophic system, and chlorophyll values represent the size of the population performing that work, the ratio of the two (called P/B) is employed as an indication of the specific rate of activity of each biomass unit. A detailed discussion of P/B ratios (mg carbon$\cdot$mg chlorophyll $a^{-1} \cdot h^{-1}$) is given in Bienfang and Gundersen (1977). The six data sets discussed here show P/B ratios which vary from 0 - 8.31 mg carbon$\cdot$mg chlorophyll $a^{-1} \cdot h^{-1}$; P/B ratios show variation both vertically and temporally. Vertically, values from all cruises show rapidly declining values with increasing depth; this reflects in part the diminishing supply of light for photosynthesis. The temporal variations in P/B ranges over the water column were marked; ranges for the six cruises were 0.72 - 4.57, 0 - 2.80, 0 - 2.27, 0.03 - 0.52, 0.32 - 8.35, and 0 - 0.11 mg carbon·mg chlorophyll $\underline{a}^{-1} \cdot h^{-1}$, respectively. Nearly all of these values, particularly in the near-surface samples, represent P/B ratios which suggest strong nutrient impoverishment. This indication that nutrient limitation is exerting control over the phytoplankton dynamics of the area is in agreement with the indication from the phaeo-pigment/primary production relationship suggesting that variable levels in the input of regenerated nutrients are related to variations in water column productivity in the area.

The timing of the hydrocasts for this study was established to inspect for diurnal variations in the parameters measured. Upon inspection of the data, there is, without exception, no evidence for a consistent diurnal variation in any of these parameters. Since replicate casts were not made at any of the sampling times, it is not possible even to unequivocably separate sampling variability from whatever differences are seen between any pairs of hydrocasts. The salinity and dissolved oxygen measurements, which were made in both the shallow and deep hydrocasts, did not show any significant ($p > 0.05$) variations, or general trends for dirunal variation. For both the chlorophyll a and phaeo-pigment data, neither the average values in the surface or the maxima, the depth of the maxima, nor the depth-integrated values showed significant diurnal variation. Average ATP levels, and depth-integrated values likewise, showed no evidence of diurnal variation.

4.1.4 Zooplankton

The lack of uniformity in the sampling program over the course of the year, and the lack of matching day and night samples for the first four cruises make anything more than general statements about the zooplankton populations difficult to support. In general, calanoid copepods were numerically the most abundant taxonomic group. Many species appeared to undergo extensive diel vertical migrations. The biomass levels of the zooplankton exhibited significant seasonal changes. The seasonal levels of biomass were not significantly correlated with any of the other parameters measured during the HOTEC program, however. Sampling variability, both for numerical abundance and biomass was about 22% of the mean.

5.1 RECOMMENDATIONS

Temporal variations in the physico-chemical parameters, dissolved oxygen and salinity appear to be well described by the existing sampling frequency. While surface oxygen determinations showed saturation levels in all cases, the surface salinity values showed appreciable variation, probably due to local weather. Since the salinity values are used in the calculation of σ_t and actual depth measurements, salinity determination should take place on all hydrocasts.

The large temporal variations observed in all phytoplankton parameters (chlorophyll a, phaeo-pigments, ATP, primary productivity) indicate that the frequency of measurement should definitely not be decreased. In view of the wide variations recorded for these parameters, it is open to question whether the outer bounds of natural variability are expressed by these data. Since the number of observations has a direct bearing on the statistical limits about the means, improved confidence limits about the delineation of natural conditions could result from an increased sampling frequency and/or an extended sampling program. The issue of the magnitude of confidence limits may be of particular relevance since: (1) these data are to describe a baseline condition against which conditions during OTEC operations are to be compared, and (2) the injection of nutrient-rich deep water to the photic zone is likely to have the most immediate and direct influence on the phytoplankton components of the trophic structure. Impacts to the phytoplankton during OTEC operation can be determined (or inferred) where parameter levels exceed the means and boundaries describing natural conditions. The wider those limits, the poorer the detection capability of the comparison; thus improvements in the description of natural levels and variability will directly enhance the ability to perceive and evaluate environmental impacts.

The existing sampling program was conceptually designed to inspect for diurnal variability. None of the parameters measured under this portion of the program showed evidence of diurnal variations. Further, since only one cast was made at each time, it is not possible to isolate any observed variability (apparently diurnal) from natural sampling variability. It is suggested that the sampling regime be modified to omit this ineffective attempt at measuring diurnal variation which apparently does not exist. Several (eight) of the target depths of the deep (0 - 1000m) and shallow (0 - 300m) hydrocasts (taken at noon-midnight and dusk-dawn, respectively) overlapped; this results in a redundancy in measurement of several parameters. To overcome the aforementioned shortcomings in the sampling program, and to incorporate assessment of natural sampling variability, it is recommended that future programs perform (a) triplicate hydrocasts, (b) as closely spaced as possible between 0200-0700 hours, (c) to take samples from 15 target depths (2, 10, 30, 50, 70, 90, 110, 130, 150, 200, 300, 400, 600, 800, 1000m). This represents a combination of the deep and shallow hydrocasts, and reduces by one the number of casts required per cruise. The performance of these casts in the early morning is to provide for daylong primary productivity incubations without subjecting the populations from deep in the water column to high surface light intensities.

It is recommended that the incubation of primary productivity samples be done in an on-deck incubator (constructed to simulate both light quality and quantity at the depth of sample origin), rather than *in situ*. Maintenance *in situ* of the proper depths of incubating suffers from the same uncertainties as those affecting actual sampling of the target depths. Since the incubation depth strongly influences the light regime to which the samples are subjected, uncertainties in actual incubation depth can influence the primary productivity values. It is believed that the simulation of subsurface light conditions can be done with equal or better confidence in establishing target light fields than can *in situ* incubation.

It is recommended that future OTEC baseline monitoring programs evaluate two stations (spaced ca 10 miles apart) rather than only one. This will permit assessment of areal variability under the prevailing climatic conditions, and in the face of measured sampling variability at a given site. The sampling program at both sites should be identical, and should be done on successive days of each cruise. The recommended hydrocast and incubation revisions are workable within this modification. The designation of areal variability in this study is extremely relevant since OTEC effluent impacts will be field effects rather than point effects, and assessment of the areal variation in natural conditions is likely to have a great bearing on the ability and certainty with which "downstream" effects are able to be evaluated.

This effort did not include any analysis of the taxonomic composition of the phytoplankton community evaluated by the biomass and productivity measurements performed. Some degree of taxonomic baseline information (e.g., dominant species, principal taxonomic groups) should be performed.

The way in which the natural phytoplankton communities respond to nutrient enrichment via encounter with deep water is a subject that has great relevance to the impacts of OTEC. The results from ancillary experiments performed during the course of this program suggest that the phytoplankton response to nutrient enrichment is highly variable, and would appear to be related to the preconditioning history of the population prior to sampling, rather than to prevailing conditions during the experiment. Data from three sets of experiments showed that the degree of enhanced primary productivity in natural samples enriched with water from 600m ranged from no effect to more than 300% increase. These results indicate that there exist compelling unknowns regarding the response of natural populations to deepwater nutrients, and commensurate uncertainty concerning the environmental response to deep water brought up by operation of OTEC facilities. Initiation of a program to supplement the description of baseline primary productivity of the natural populations, with evaluation of the nature and degree of response to nutrient enrichment, could take optimum advantage of the occasion of baseline measurement and provide extremely valuable information concerning the reasons for and the magnitude of variable degrees of biostimuation in natural populations. Since it is hypothesized here that phytoplankton response to nutrient enrichment is controlled by the preconditioning history of the population, it would be useful to have an index of that history, when experiments are performed. Analysis of particulate carbon and nitrogen would be a convenient and appropriate measure, since plant C/N ratio is often used to index plants' nutritional state. Although oceanic particulate matter has a large and variable detrital component, the wide variation in plant response to enrichment (see above) suggests that nutritional history (and thus C/N ratio) would be different enough, at different times, to be detectable with such analysis.

All the nutrients measured during the first year of environmental baseline survey are of potential importance during the operation of an OTEC palnt. The high concentrations of dissolved nutrients in the deep water would be added to the nutrient-poor shallow water, and, depending on the final concentrations of the discharge from the plant, could induce increased productivity. However, reactive silicate is rarely a limiting nutrient, and continued measurement of this parameter is probably unnecessary. Urea was found to be distributed relatively uniformly with depth, to be uniform over the course of the day, and to be quite variable seasonally. Although urea is utilized by phytoplankton, its importance in the presence of much larger concentrations of nitrate is probably not great. Continued measurement of urea is therefore not recommended.

All the nutrients measured during the first year of HOTEC showed significant variations between the bi-monthly cruises. Therefore, continued sampling on a bi-monthly schedule is recommended.

Daily variations in the concentrations of the dissolved nutrients were significant within the mixed layer and the underlying transition layer. These variations are of biological origin, and the reasons behind them are relatively well understood. Unless a program specifically designed to examine daily variations is desired, it is probably better to change the emphasis of the sampling from four hydrocasts taken at four different times during the day to several replicate hydrocasts taken at one time. The best time would seem to be in the early morning before sunrise, when nutrients are at their highest levels of the day, before uptake by phytoplankton begins. This sampling period would also best fit the requirements of the phytoplankton program.

Since the distribution of nutrients in the deep layer is relatively uniform, a minimum number of samples needs to be taken there. The sample spacing in the upper two layers should probably be a combination of the close sampling intervals used in the shallow hydrocasts within the upper 150 meters, and the more separated samples in the transition layer. There is no reason that all samples cannot be taken on a single hydrocast.

The level of replication to be used will have to be a balance between the ideal large number of replicates and the cost of analysis for each replicate. A minimum of two replicates must be taken. The statistical analyses for the data from the first year of baseline surveys suffered a decrease in sensitivity due to the lack of replication. How many more replicates to take is indicated by the increase in sensitivity of an analysis of variance calculation with two, three, or four replicates. The f-ratio value at $p = 0.05$ for a 6x2 analysis of variance without replication would be computed with the interaction term as the denominator. This term would have only 5 degrees of freedom, and the f-ratio for the first term would have 5x5 degrees of freedom.

This value is 5.05 (Snedecor and Cochran, 1967). With two, three, or four replicates, the f-ratio would be computed from the "error" term which would have 13, 25, or 37 degrees of freedom, respectively. The f-ratio for the 5x13, 5x25, and 5x37 degrees of freedom situations would be 3.02, 2.76, and 2.47, respectively. These are increases in sensitivity of 40%, 45%, and 51%. Obviously, the increase in sensitivity is greatest with the addition of replication to the program. The analysis of four replicates is probably not warranted by the slight increase in sensitivity of the statistical analyses, but three replicates are probably the most reasonable balance between sensitivity and cost.

Both numerical abundance and biomass levels of the zooplankton population showed significant changes between the bi-monthly cruises. This has also been shown in previous studies in the area (see AECOS, 1979, for a review of the historical data). The zooplankton sampling program should continue to collect samples on a bi-monthly schedule.

Variations between day and night levels of abundance and biomass were also very large. In order to utilize the statistically powerful analysis of variance, care should be taken that sampling on each of the future HOTEC cruises be as uniform as possible and that the design be balanced between day and night.

Several depth intervals should again be sampled. Oblique samples probably produce samples more representative of the depth layer sampled than either vertical or horizontal tows. The zooplankton conference held at LBL earlier during the HOTEC program proposed the following depth intervals to be sampled: 0-25 meters, 25-200 meters, and 200-600 meters. The data generated during the first year of the HOTEC program, while somewhat scant, suggests that these are probably a reasonable separation of the water column.

As was the case for the nutrients, the level of replication is a very important consideration in the design of a sampling program. For the zooplankton program, however, the cost of additional replicates is much greater, since analytical time is longer and additional expensive sea time is required to acquire the replicates. Two replicate samples for each depth interval day and night is probably the most cost-effective program.

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APPENDIX A

Temperature, Salinity, Dissolved Oxygen, σ_t and $\rho_{s,t,p}$
Data For HOTEC 1-6 Cruises

Cruise : HOTEC-1 Date (GMT) : 28 Oct. 1978 Time: 1412Z, 0412HST
Ship : M/V Holoholo Water Depth: 1000m Wire Angle: 0°
Location: 19°59'N, 156°08'W Weather: Beaufort-1, Sea State-Calm

Observed Depths (M)	Temperature (°C)	Salinity (o/oo)	Dissolved Oxygen (mℓ/ℓ)	σ_t	$\rho_{s,t,p}$ (g/cc)
0	25.62	34.600	4.90	22.85	1.02285
5	26.36	34.610	4.87	22.63	1.02270
23	26.34	34.520	5.14	22.56	1.02292
41	26.34	34.600	5.05	22.62	1.02326
58	26.37	34.900	5.14	22.84	1.02377
74	24.81	34.690	5.05	23.16	1.02423
91	23.27	34.880	5.47	23.76	1.02494
107	22.15	35.150	5.01	24.29	1.02559
123	--	34.780	4.91	--	--
163	--	34.760	5.01	--	--
202	--	34.530	4.59	--	--
243	14.48	34.320	4.01	25.57	1.02731

Cruise : HOTEC-1 Date (GMT) : 28 Oct. 1978 Time: 2307Z, 1307HST
Ship : M/V Holoholo Water Depth: 1000m Wire Angle: 0°
Location: 19°59'N, 156°08'W Weather: Beaufort-1, Sea State-1

Observed Depths (M)	Temperature (°C)	Salinity (o/oo)	Dissolved Oxygen (mℓ/ℓ)	σ_t	$\rho_{s,t,p}$ (g/cc)
0	27.34	34.630	5.23	22.33	1.02233
23	26.38	34.630	5.12	22.63	1.02299
43	26.33	34.630	5.19	22.65	1.02336
79	23.49	34.820	5.43	23.66	1.02479
110	21.97	35.140	4.94	24.33	1.02587
140	20.11	35.020	5.47	24.75	1.02652
199	14.35	34.390	3.83	25.65	1.02741
248	11.93	34.270	3.21	26.05	1.02814
295	8.80	34.200	2.19	26.54	1.02892
339	7.57	34.250	1.64	26.77	1.02958
382	--	34.250	1.55	--	--
523	6.01	34.280	1.15	27.00	1.03070

Cruise : HOTEC-1 Date (GMT) : 28 Oct. 1978 Time: 0415Z, 1815HST
Ship : M/V Holoholo Water Depth: 1000m Wire Angle: 0°
Location: 19°59'N, 156°08'W Weather: Beaufort-1, Sea State-Calm

Observed Depths (M)	Temperature (°C)	Salinity (o/oo)	Dissolved Oxygen (mℓ/ℓ)	σ_t	$\rho_{s,t,p}$ (g/cc)
0	26.31	34.663	5.08	22.68	1.02268
5	26.24	34.614	4.98	22.67	1.02274
21	26.21	34.612	5.01	22.67	1.02302
36	26.19	34.604	5.01	22.67	1.02330
50	26.11	34.640	4.92	22.72	1.02363
64	25.70	34.744	5.08	22.93	1.02408
76	24.37	34.736	5.05	23.33	1.02461
89	22.48	35.006	5.19	24.09	1.02541
100	--	35.173	4.85	--	--
127	--	34.908	4.83	--	--
152	--	34.706	4.34	--	--
175	14.16	34.387	3.86	25.69	1.02741

Cruise : HOTEC-1 Date (GMT) : 28 Oct. 1978 Time: 0930Z, 2330HST
Ship: : M/V Holoholo Water Depth: 1150m Wire Angle: 0°
Location: 19°58'N, 156°10'W Weather: Beaufort-1, Sea State-Calm

Observed Depths (M)	Temperature (°C)	Salinity (o/oo)	Dissolved Oxygen (mℓ/ℓ)	σ_t	$\rho_{s,t,p}$ (g/cc)
0	26.32	34.630	4.98	22.65	1.02265
24	26.22	34.630	4.81	22.68	1.02304
46	26.16	34.630	--	22.70	1.02340
84	24.02	34.780	5.21	23.47	1.02465
117	21.65	35.170	4.83	24.45	1.02595
148	19.40	34.920	4.66	24.86	1.02653
207	14.28	34.140	3.97	25.47	1.02721
282	--	34.200	3.21	--	--
375	6.93	34.170	1.48	26.79	1.02912
468	6.25	34.250	1.37	26.95	1.02973
606	--	34.360	1.37	--	--
740	--	34.400	0.88	--	1.03065

Cruise : HOTEC-1 Date (GMT) : 29 Oct. 1978 Time: 1830Z, 0830HST
Ship : M/V Holoholo Water Depth: 700m Wire Angle: 0°
Location: 19°59'N, 156°05'W Weather: Beaufort-1, Sea State-1

Observed Depths (M)	Temperature (°C)	Salinity (o/oo)	Dissolved Oxygen (mℓ/ℓ)	σ_t	$\rho_{s,t,p}$ (g/cc)
5	26.30	34.630	--	22.66	1.02273
23	26.15	34.630	--	22.70	1.02305
42	26.04	34.650	--	22.75	1.02345
60	26.55	35.060	--	22.90	1.02400
78	23.89	34.810	--	23.53	1.02470
143	19.61	34.980	--	24.85	1.02655
198	12.88	34.320	--	25.90	1.02754

Cruise : HOTEC-1 Date (GMT) : 29 Oct. 1978 Time: 2138Z, 1138HST
Ship : M/V Holoholo Water Depth: 950m Wire Angle: 0°
Location: 20°05'N, 156°04'W Weather: Beaufort-1, Sea State-1

Observed Depths (M)	Temperature (°C)	Salinity (o/oo)	Dissolved Oxygen (mℓ/ℓ)	σ_t	$\rho_{s,t,p}$ (g/cc)
5	26.62	34.640	--	22.56	1.02264
21	26.36	34.630	--	22.64	1.02300
39	26.22	34.640	--	22.69	1.02339
56	26.67	35.050	--	22.86	1.02397
74	24.64	34.750	--	23.26	1.02450
142	19.59	34.870	--	24.77	1.02646
205	11.34	34.250	--	26.14	1.02768

Cruise : HOTEC-2 Date (GMT) : 12 April 1979 Time: 2016Z, 1016HST
Ship : M/V Noi'i Water Depth: 1325m Wire Angle: 0°
Location: 19°55.6'N, 156°08.8'W Weather: Beaufort-2, Sea State-2

Observed Depths (M)	Temperature (°C)	Salinity (o/oo)	Dissolved Oxygen (mℓ/ℓ)	σ_t	$\rho_{s,t,p}$ (g/cc)
0	24.87	34.253	5.68	22.82	1.02282
23	24.75	34.240	5.47	22.84	1.02315
43	24.71	34.242	5.47	22.86	1.02347
58	24.18	34.238	5.57	23.01	1.02389
74	23.65	34.595	5.68	23.44	1.02458
102	21.70	34.883	5.23	24.21	1.02570
131	18.28	34.733	4.67	25.00	1.02653
199	11.76	34.239	3.82	26.06	1.02761
278	8.85	34.219	2.39	26.55	1.02846
450	5.98	34.272	1.14	27.00	1.02978
635	4.91	34.410	1.20	27.24	1.03094
822	4.24	34.459	1.39	27.35	1.03197

Cruise : HOTEC-2 Date (GMT) : 13 April 1979 Time: 0322Z, 1722HST
Ship : M/V Noi'i Water Depth: 1250m Wire Angle: 0°
Location: 19°56.1'N, 156°08.5'W Weather: Beaufort-3, Sea State-3

Observed Depths (M)	Temperature (°C)	Salinity (o/oo)	Dissolved Oxygen (mℓ/ℓ)	σ_t	$\rho_{s,t,p}$ (g/cc)
0	25.10	34.226	5.47	22.73	1.02273
9	24.86	34.209	5.52	22.79	1.02291
22	24.78	34.204	5.61	22.81	1.02318
32	24.75	34.201	5.59	22.81	1.02342
43	24.59	34.216	5.38	22.87	1.02372
60	24.29	34.223	5.43	22.97	1.02403
75	23.47	34.563	5.41	23.47	1.02470
91	--	34.780	5.43	--	--
109	21.84	34.923	5.23	24.20	1.02571
149	18.91	34.772	4.87	24.87	1.02647
193	16.23	34.508	4.40	25.32	1.02697
237	12.36	34.219	3.42	25.92	1.02752

Cruise : HOTEC-2 Date (GMT) : 13 April 1979 Time: 0959Z, 2359HST
Ship : M/V Noi'i Water Depth: 1200m Wire Angle: 0°
Location: 19°53.7'N, 156°10.9'W Weather: Beaufort-2, Sea State-2

Observed Depths (M)	Temperature (°C)	Salinity (o/oo)	Dissolved Oxygen (mℓ/ℓ)	σ_t	$\rho_{s,t,p}$ (g/cc)
0	25.02	34.246	5.47	22.77	1.02277
22	24.73	34.234	5.23	22.84	1.02315
40	24.70	34.233	5.25	22.85	1.02346
55	24.39	34.260	5.30	22.96	1.02386
69	23.72	34.443	5.18	23.30	1.02444
95	21.86	34.944	4.99	24.21	1.02573
124	17.43	34.681	4.24	25.17	1.02661
192	--	34.227	3.40	--	--
272	8.74	34.213	2.32	26.56	1.02847
444	6.21	34.314	1.02	27.00	1.02979
628	5.07	34.398	1.18	27.21	1.03091
816	4.10	34.467	1.18	27.38	1.03200

Cruise : HOTEC-2 Date (GMT) : 13 April 1979 Time: 1345Z, 0345HST
Ship : M/V Noi'i Water Depth: 1250m Wire Angle: 0°
Location: 19°56.2'N, 156°08.8'W Weather: Beaufort-1, Sea State-3

Observed Depths (M)	Temperature (°C)	Salinity (o/oo)	Dissolved Oxygen (mℓ/ℓ)	σ_t	$\rho_{s,t,p}$ (g/cc)
0	24.95	34.222	5.41	22.77	1.02277
9	24.94	34.221	5.28	22.77	1.02289
24	24.73	34.192	5.32	22.81	1.02318
38	24.71	34.166	5.38	22.80	1.02341
47	24.57	34.226	5.38	22.88	1.02373
60	24.08	34.286	5.38	23.08	1.02412
77	23.36	34.582	5.14	23.51	1.02474
94	--	34.746	5.18	--	--
111	21.42	34.792	5.05	24.22	1.02567
156	18.27	34.674	4.40	24.96	1.02648
202	14.61	34.395	4.04	25.60	1.02709
250	11.74	34.204	3.30	26.03	1.02759

Cruise : HOTEC-3 Date (GMT) : 17 June 1979 Time: 2215Z, 1215HST
Ship : M/V El Greco Water Depth: 1350m Wire Angle: 0°
Location: 19°55.5'N, 156°09.2'W Weather: Beaufort-2, Sea State-1

Observed Depths (M)	Temperature (°C)	Salinity (o/oo)	Dissolved Oxygen (mℓ/ℓ)	σ_t	$\rho_{s,t,p}$ (g/cc)
0	25.72	34.339	5.90	22.62	1.02262
23	25.13	34.353	5.85	22.81	1.02313
43	25.17	34.396	5.96	22.83	1.02347
60	24.80	34.428	5.54	22.97	1.02390
72	23.52	34.588	5.92	23.47	1.02460
106	20.62	35.004	5.52	24.60	1.02598
154	17.74	34.702	4.71	25.11	1.02658
239	12.81	34.257	4.00	25.87	1.02749
309	9.33	34.174	2.75	26.43	1.02836
448	5.81	34.223	1.07	26.98	1.02976
632	5.20	34.356	1.01	27.16	1.03086
826	4.29	34.423	1.43	27.32	1.03194

Cruise : HOTEC-3 Date (GMT) : 18 June 1979 Time: 0415Z, 1815HST
Ship : M/V El Greco Water Depth: 1100m Wire Angle: 0°
Location: 19°56.8'N, 156°08.7'W Weather: Beaufort-1, Sea State-1

Observed Depths (M)	Temperature (°C)	Salinity (o/oo)	Dissolved Oxygen (mℓ/ℓ)	σ_t	$\rho_{s,t,p}$ (g/cc)
0	25.76	34.360	5.47	22.62	1.02262
9	25.62	34.342	5.14	22.65	1.02278
25	25.55	34.374	5.38	22.70	1.02309
40	25.58	34.411	5.41	22.72	1.02338
50	24.83	34.240	5.94	22.82	1.02368
62	23.67	34.589	5.43	23.43	1.02446
79	22.70	34.859	5.12	23.91	1.02509
96	21.09	34.986	5.05	24.46	1.02570
116	20.17	35.023	4.96	24.74	1.02607
163	17.65	34.694	4.98	25.13	1.02659
213	15.16	34.412	4.27	25.49	1.02703
262	12.13	34.237	3.54	25.98	1.02756

Cruise : HOTEC-3 Date (GMT) : 18 June 1979 Time: 0943Z, 2343HST
Ship : M/V El Greco Water Depth: 950m Wire Angle: 0°
Location: 19°56.4'N, 156°08.1'W Weather: Beaufort-1, Sea State-1

Observed Depths (M)	Temperature (°C)	Salinity (o/oo)	Dissolved Oxygen (mℓ/ℓ)	σ_t	$\rho_{s,t,p}$ (g/cc)
0	25.72	34.349	5.47	22.63	1.02263
23	25.21	34.340	5.77	22.78	1.02310
45	25.26	34.386	5.52	22.80	1.02344
65	24.72	34.421	5.63	22.99	1.02391
70	23.49	34.696	5.57	23.56	1.02469
104	20.34	34.967	4.81	24.65	1.02600
152	18.55	34.809	4.69	24.99	1.02656
237	12.46	34.241	3.69	25.94	1.02754
304	9.00	34.176	2.50	26.49	1.02840
454	5.95	34.219	1.03	26.96	1.02974
638	4.78	34.392	1.01	27.24	1.03094
831	4.12	34.437	1.12	27.35	1.03197

Cruise : HOTEC-3 Date (GMT) : 18 June 1979 Time: 1400Z, 0400HST
Ship : M/V El Greco Water Depth: 1350m Wire Angle: 0°
Location: 19°55.8'N, 156°08.7'W Weather: Beaufort-2, Sea State-1

Observed Depths (M)	Temperature (°C)	Salinity (o/oo)	Dissolved Oxygen (mℓ/ℓ)	σ_t	$\rho_{s,t,p}$ (g/cc)
0	25.60	34.368	5.25	22.68	1.02268
10	25.48	34.345	5.01	22.70	1.02275
28	25.21	34.335	5.01	22.77	1.02291
45	25.24	34.344	5.32	22.77	1.02306
61	24.85	34.427	5.23	22.95	1.02322
74	23.93	34.563	5.54	23.33	1.02342
83	22.17	34.845	5.10	24.05	1.02367
98	20.60	34.963	5.21	24.58	1.02394
114	20.29	35.000	4.78	24.69	1.02420
160	17.85	34.733	4.56	25.11	1.02473
208	14.77	34.382	4.29	25.55	1.02515
256	12.19	34.232	3.73	25.97	1.02551

Cruise : HOTEC-4 Date (GMT) : 30 July 1979 Time: 2213Z, 1213HST
Ship : R/V Kana Keoki Water Depth: 1325m Wire Angle: 0°
Location: 19°56.0'N, 156°08.5'W Weather: Beaufort-2, Sea State-1

Observed Depths (M)	Temperature (°C)	Salinity (o/oo)	Dissolved Oxygen (mℓ/ℓ)	σ_t	$\rho_{s,t,p}$ (g/cc)
0	27.28	34.352	5.74	22.14	1.02214
21	27.01	34.322	5.76	22.20	1.02257
42	26.04	34.445	5.83	22.60	1.02329
62	23.98	34.535	5.78	23.30	1.02417
75	22.88	34.890	5.59	23.89	1.02497
103	20.88	35.017	5.74	24.54	1.02595
152	17.83	34.745	5.23	25.12	1.02661
236	11.67	34.164	3.72	26.01	1.02756
304	9.16	34.158	2.49	26.45	1.02837
451	5.83	34.188	1.04	26.95	1.02972
633	4.79	34.335	1.06	27.20	1.03089
828	4.15	34.384	1.20	27.31	1.03192

Cruise : HOTEC-4 Date (GMT) : 1 Aug. 1979 Time: 0303Z, 1703HST
Ship : R/V Kana Keoki Water Depth: 1350m Wire Angle: 0°
Location: 19°55.3'N, 156°09.2'W Weather: Beaufort-4, Sea State-3

Observed Depths (M)	Temperature (°C)	Salinity (o/oo)	Dissolved Oxygen (mℓ/ℓ)	σ_t	$\rho_{s,t,p}$ (g/cc)
0	26.75	34.378	5.80	22.33	1.02233
8	26.77	34.375	5.25	22.32	1.02246
22	26.44	34.359	5.25	22.41	1.02283
35	26.35	34.353	5.34	22.43	1.02313
40	25.85	34.448	5.52	22.66	1.02361
48	24.46	34.545	5.99	23.16	1.02425
62	23.08	34.728	5.96	23.70	1.02491
76	22.08	34.991	5.01	24.19	1.02552
93	21.42	35.024	4.98	24.40	1.02587
138	18.85	34.870	4.66	24.96	1.02657
185	15.36	34.431	4.56	25.46	1.02702
233	11.64	34.522	3.33	26.30	1.02787

Cruise : HOTEC-4 Date (GMT) : 1 Aug. 1979 Time: 1035Z, 0035HST
Ship : R/V Kana Keoki Water Depth: 1360m Wire Angle: 0°
Location: 19°55.6'N, 156°09.5'W Weather: Beaufort-3, Sea State-2

Observed Depths (M)	Temperature (°C)	Salinity (o/oo)	Dissolved Oxygen (mℓ/ℓ)	σ_t	$\rho_{s,t,p}$ (g/cc)
0	26.54	34.361	5.19	22.38	1.02238
21	26.52	34.355	5.65	22.38	1.02274
42	26.18	34.349	5.78	22.49	1.02318
62	25.58	34.413	5.21	22.72	1.02371
71	22.97	34.714	5.19	23.73	1.02481
107	20.56	35.004	4.28	24.62	1.02599
152	18.21	34.797	4.90	25.07	1.02660
236	11.90	34.170	3.70	25.97	1.02753
304	8.96	34.182	2.28	26.50	1.02841
451	5.55	34.157	1.16	26.96	1.02973
633	4.96	34.333	1.06	27.17	1.03087
828	4.28	34.390	1.33	27.30	1.03191

Cruise : HOTEC-4 Date (GMT) : 1 Aug. 1979 Time: 1425Z, 0425HST
Ship : R/V Kana Keoki Water Depth: 1355m Wire Angle: 0°
Location: 19°55.7'N, 156°08.9'W Weather: Beaufort-2, Sea State-2

Observed Depths (M)	Temperature (°C)	Salinity (o/oo)	Dissolved Oxygen (mℓ/ℓ)	σ_t	$\rho_{s,t,p}$ (g/cc)
0	26.59	34.291	5.57	22.31	1.02231
8	26.61	34.381	5.45	22.37	1.02252
25	26.32	34.353	5.52	22.44	1.02286
40	26.11	34.372	5.63	22.52	1.02321
49	24.80	34.391	5.85	22.94	1.02381
58	23.59	34.642	5.21	23.49	1.02452
74	22.70	34.875	5.54	23.93	1.02511
92	21.99	34.970	5.25	24.20	1.02552
110	20.90	35.023	4.92	24.54	1.02595
157	18.47	34.846	4.96	25.04	1.02660
205	15.24	34.494	4.66	25.54	1.02709
253	12.70	34.494	3.92	26.07	1.02771

Cruise : HOTEC-5 Date (GMT) : 3 Oct. 1979 Time: 2146Z, 1146HST
Ship : R/V Kana Keoki Water Depth: 1375m Wire Angle: 0°
Location: 19°56.9'N, 156°09.0'W Weather: Beaufort-0, Sea State-Calm

Observed Depths (M)	Temperature (°C)	Salinity (o/oo)	Dissolved Oxygen (mℓ/ℓ)	σ_t	$\rho_{s,t,p}$ (g/cc)
0	27.36	34.457	6.27	22.19	1.02219
17	26.90	34.457	5.96	22.34	1.02245
36	26.63	34.610	5.67	22.54	1.02272
54	24.61	34.708	6.29	23.24	1.02305
74	23.18	34.961	5.89	23.85	1.02343
114	20.78	35.028	5.38	24.58	1.02411
156	18.42	34.827	5.03	25.04	1.02465
243	11.51	34.003	4.50	25.92	1.02544
334	8.44	34.065	3.19	26.49	1.02606
521	5.65	34.057	1.20	26.87	1.02704
712	4.87	34.351	1.09	27.20	1.03785
904	4.03	34.305	1.29	27.26	1.03855

Cruise : HOTEC-5 Date (GMT) : 4 Oct. 1979 Time: 1038Z, 0038HST
Ship : R/V Kana Keoki Water Depth: 1000m Wire Angle: 0°
Location: 19°50.4'N, 156°08.4'W Weather: Beaufort-2, Sea State-1

Observed Depths (M)	Temperature (°C)	Salinity (o/oo)	Dissolved Oxygen (mℓ/ℓ)	σ_t	$\rho_{s,t,p}$ (g/cc)
0	27.65	34.594	5.76	22.20	1.02220
19	27.06	34.615	5.23	22.41	1.02278
38	26.84	34.618	5.47	22.48	1.02322
57	26.06	34.632	5.74	23.04	1.02400
78	23.51	34.810	5.72	23.64	1.02478
118	21.59	35.088	5.12	24.40	1.02589
160	19.43	34.911	4.87	24.84	1.02652
249	11.55	34.161	4.34	26.03	1.02757
340	8.31	34.069	3.04	26.51	1.02840
527	5.46	34.238	0.93	27.04	1.02981
718	4.69	34.374	1.04	27.24	1.03093
909	4.10	34.403	1.37	27.32	1.03194

Cruise : HOTEC-5 Date (GMT) : 5 Oct. 1979 Time: 0406Z, 1806HST
Ship : R/V Kana Keoki Water Depth: 850m Wire Angle: 0°
Location: 20°00.7'N, 156°04.4'W Weather: Beaufort-2, Sea State-Calm

Observed Depths (M)	Temperature (°C)	Salinity (o/oo)	Dissolved Oxygen (mℓ/ℓ)	σ_t	$\rho_{s,t,p}$ (g/cc)
0	27.83	34.565	5.07	22.12	1.02212
7	27.41	34.570	5.12	22.26	1.02241
20	27.45	34.592	5.10	22.26	1.02273
34	27.14	34.599	5.19	22.37	1.02312
50	26.08	34.647	5.23	22.74	1.02371
66	24.22	34.695	5.36	23.34	1.02442
84	23.52	34.765	5.45	23.61	1.02486
101	22.19	35.097	5.25	24.24	1.02559
120	20.88	35.044	4.96	24.56	1.02597
166	18.50	34.831	4.61	25.02	1.02658
214	16.13	34.551	4.48	25.38	1.02702
262	12.21	34.225	4.08	25.96	1.02754

Cruise : HOTEC-5 Date (GMT) : 5 Oct. 1979 Time: 1536Z, 0536HST
Ship : R/V Kana Keoki Water Depth: 1360m Wire Angle: 0°
Location: 19°56.8'N, 156°08.0'W Weather: Beaufort-2, Sea State-Calm

Observed Depths (M)	Temperature (°C)	Salinity (o/oo)	Dissolved Oxygen (mℓ/ℓ)	σ_t	$\rho_{s,t,p}$ (g/cc)
0	26.92	34.574	4.94	22.42	1.02242
7	26.88	34.595	4.92	22.45	1.02260
21	26.72	34.587	5.27	22.49	1.02293
37	26.67	34.459	5.10	22.41	1.02313
54	26.21	34.584	5.10	22.65	1.02363
70	23.65	34.784	5.32	23.58	1.02462
88	22.60	34.911	5.14	23.98	1.02515
106	21.51	34.678	5.10	24.11	1.02537
124	20.58	34.583	5.12	24.29	1.02564
170	18.63	34.866	4.94	25.01	1.02659
218	15.01	34.269	4.59	25.41	1.02693
267	12.10	--	4.19	25.98	1.02756

Cruise : HOTEC-6 Date (GMT) : 7 Dec. 1979 Time: 2247Z, 1247HST
Ship : M/V Noi'i Water Depth: 1025m Wire Angle: 0°
Location: 19°55.9'N, 156°8'W Weather: Beaufort-1, Sea State-1

Observed Depths (M)	Temperature (°C)	Salinity (°/oo)	Dissolved Oxygen (mℓ/ℓ)	σ_t	$\rho_{s,t,p}$ (g/cc)
0	25.75	34.807	5.74	22.51	1.02251
24	25.21	34.785	5.34	23.11	1.02344
46	25.15	34.783	5.16	23.13	1.02378
65	25.16	34.783	5.43	23.13	1.02410
84	22.49	34.810	5.45	23.93	1.02499
119	20.83	35.024	5.01	24.56	1.02596
155	18.46	34.805	4.79	25.01	1.02657
240	11.49	34.142	4.10	26.03	1.02757
329	8.33	34.083	2.66	26.52	1.02841
517	6.00	34.255	0.24	26.99	1.02976
708	4.71	34.377	0.27	27.24	1.03093
901	4.26	34.404	0.42	27.31	1.03192

Cruise : HOTEC-6 Date (GMT) : 8 Dec. 1979 Time: 0434Z, 1834HST
Ship : M/V Noi'i Water Depth: 1350m Wire Angle: 0°
Location: 19°55.3'N, 156°9.2'W Weather: Beaufort-2, Sea State-1

Observed Depths (M)	Temperature (°C)	Salinity (°/oo)	Dissolved Oxygen (mℓ/ℓ)	σ_t	$\rho_{s,t,p}$ (g/cc)
0	25.67	34.779	5.23	22.69	1.02269
9	25.37	34.730	5.01	23.02	1.02315
27	25.28	34.784	5.12	23.09	1.02348
46	25.20	34.788	5.16	23.63	1.02420
62	25.14	---	5.27	23.14	1.02404
80	24.12	34.783	5.23	23.44	1.02452
97	22.04	34.828	5.30	24.08	1.02520
114	21.40	34.777	5.34	24.21	1.02547
130	20.88	35.101	5.16	24.60	1.02602
173	18.37	34.816	4.76	25.04	1.02659
227	14.18	34.331	4.39	25.64	1.02709
265	11.80	34.170	4.28	25.99	1.02755

Cruise : HOTEC-6 Date (GMT) : 8 Dec. 1979 Time: 1055Z, 0055HST
Ship : M/V Noi'i Water Depth: 1230m Wire Angle: 0°
Location: 19°54.6'N, 156°11.1'W Weather: Beaufort-0, Sea State-1

Observed Depths (M)	Temperature (°C)	Salinity (°/oo)	Dissolved Oxygen (mℓ/ℓ)	σ_t	$\rho_{s,t,p}$ (g/cc)
0	25.46	34.757	5.10	23.01	1.02301
21	25.36	34.754	5.12	23.04	1.02337
44	25.29	34.765	5.10	23.07	1.02373
63	25.16	34.780	5.14	23.12	1.02410
82	22.62	34.899	5.30	23.97	1.02503
121	19.94	34.970	4.87	24.76	1.02607
161	17.52	34.702	4.83	25.17	1.02661
246	11.24	34.130	4.10	26.07	1.02759
336	8.46	34.073	2.88	26.49	1.02838
522	5.94	34.239	0.33	26.98	1.02975
705	4.79	34.362	0.33	27.22	1.03091
899	4.06	34.415	1.29	27.34	1.03196

Cruise : HOTEC-6 Date (GMT) : 8 Dec. 1979 Time: 1505Z, 0505HST
Ship : M/V Noi'i Water Depth: 925m Wire Angle: 0°
Location: 19°56.4'N, 156°7.8'W Weather: Beaufort-1, Sea State-1

Observed Depths (M)	Temperature (°C)	Salinity (°/oo)	Dissolved Oxygen (mℓ/ℓ)	σ_t	$\rho_{s,t,p}$ (g/cc)
0	25.47	34.756	3.12	23.01	1.02301
9	25.40	34.758	5.16	23.03	1.02317
26	25.32	34.755	5.16	23.06	1.02345
43	25.21	34.779	5.19	23.11	1.02376
60	25.14	34.755	5.21	23.11	1.02402
76	24.31	34.824	5.30	23.41	1.02451
94	22.01	34.775	5.47	24.05	1.02516
109	21.15	34.881	5.27	24.36	1.02560
124	20.57	34.050	5.23	24.65	1.02603
164	18.19	34.797	5.05	25.07	1.02660
209	14.08	34.317	4.70	25.65	1.02710
256	11.49	34.132	4.30	26.02	1.02756

APPENDIX B

Nutrient Data For HOTEC 1-6 Cruises

Cruise : HOTEC-1
Ship : M/V Holoholo
Location: 19°59'N, 156°08'W

Date (GMT) : 28 Oct. 1978
Water Depth: 1000m
Weather : Beaufort-1, Sea State-Calm

Time : 0415Z, 1815HST
Wire Angle: 0°

Observed Depths (M)	Dissolved Oxygen (mℓ/ℓ)	Phosphates (μg-at/ℓ)	TOTAL Phosphorous (μg-at/ℓ)	Nitrates & Nitrites (μg-at/ℓ)	Silicates (μg-at/ℓ)	Ammonium (μg-at/ℓ)	Urea (μg-at/ℓ)	TOTAL Nitrogen (μg-at/ℓ)
0	5.08	0.27	0.60	0.03	3.03	0.02	0.77	5.10
5	4.98	0.21	1.03	ND	0.88	0.19	0.80	5.64
21	5.01	0.27	0.91	ND	2.88	0.08	0.75	5.74
36	5.01	0.24	0.53	ND	1.13	0.11	1.10	7.02
50	4.92	0.28	0.70	ND	2.32	ND	0.69	5.70
64	5.08	0.27	0.56	0.02	1.99	ND	0.60	5.14
76	5.05	0.29	0.87	0.03	2.56	ND	0.83	6.02
89	5.19	0.24	0.77	ND	2.36	0.31	0.72	6.15
100	4.85	0.37	0.92	0.64	3.07	ND	0.65	6.30
127	4.83	0.48	1.02	2.15	5.05	0.09	1.44	7.21
152	4.34	0.69	1.05	5.29	4.32	--	0.75	12.22
175	3.86	1.11	1.66	12.28	8.25	0.08	1.31	18.32

Cruise : HOTEC-1
Ship : M/V Holoholo
Location: 19°58'N, 156°10'W

Date (GMT) : 28 Oct. 1978
Water Depth: 1150m
Weather : Beaufort-1, Sea State-Calm

Time : 0930Z, 2330HST
Wire Angle: 0°

Observed Depths (M)	Dissolved Oxygen (mℓ/ℓ)	Phosphates (μg-at/ℓ)	TOTAL Phosphorous (μg-at/ℓ)	Nitrates & Nitrites (μg-at/ℓ)	Silicates (μg-at/ℓ)	Ammonium (μg-at/ℓ)	Urea (μg-at/ℓ)	TOTAL Nitrogen (μg-at/ℓ)
282	3.21	1.76	1.98	24.88	24.00	ND	0.67	24.68
375	1.48	2.69	3.06	32.67	35.09	ND	0.56	36.26
468	1.37	3.07	3.30	35.52	44.34	ND	0.67	35.75
606	1.37	2.60	2.78	37.10	49.01	ND	0.53	39.04
740	0.88	3.23	5.79	37.93	52.67	ND	0.98	38.85

Cruise : HOTEC-1
Ship : M/V Holoholo
Location: 19°59'N, 156°08'W

Date (GMT) : 28 Oct. 1978
Water Depth: 1000m
Weather : Beaufort-1, Sea State-Calm

Time : 1412Z, 0412HST
Wire Angle: 0°

Observed Depths (M)	Dissolved Oxygen (mℓ/ℓ)	Phosphates (μg-at/ℓ)	TOTAL Phosphorous (μg-at/ℓ)	Nitrates & Nitrites (μg-at/ℓ)	Silicates (μg-at/ℓ)	Ammonium (μg-at/ℓ)	Urea (μg-at/ℓ)	TOTAL Nitrogen (μg-at/ℓ)
5	4.87	0.18	0.78	ND	1.21	0.11	1.42	6.10
23	5.14	0.22	0.78	ND	1.33	0.06	0.99	1.88
41	5.05	0.18	0.78	0.07	2.09	0.09	0.84	1.70
58	5.14	0.24	0.82	ND	2.11	0.15	1.05	2.34
74	5.05	0.10	0.70	0.19	1.08	0.06	0.97	2.17
91	5.47	0.26	0.90	0.03	1.74	0.20	1.17	3.05
107	5.01	0.29	0.70	0.05	2.59	0.13	1.52	2.44
123	4.91	0.18	0.85	0.24	1.13	0.03	0.75	4.83
163	5.01	0.63	1.06	1.10	4.39	0.32	1.71	4.78
202	4.59	0.88	0.96	3.87	7.42	0.07	1.59	7.40
243	4.01	1.00	1.45	9.91	6.75	0.27	2.70	14.60

Cruise : HOTEC-1
Ship : M/V Holoholo
Location: 19°59'N, 156°08'W

Date (GMT) : 28 Oct. 1978
Water Depth: 1000m
Weather : Beaufort-1, Sea State-1

Time : 2307Z, 1307HST
Wire Angle: 0°

Observed Depths (M)	Dissolved Oxygen (mℓ/ℓ)	Phosphates (μg-at/ℓ)	TOTAL Phosphorous (μg-at/ℓ)	Nitrates & Nitrites (μg-at/ℓ)	Silicates (μg-at/ℓ)	Ammonium (μg-at/ℓ)	Urea (μg-at/ℓ)	TOTAL Nitrogen (μg-at/ℓ)
0	5.23	0.17	0.17	ND	1.47	0.02	0.75	1.91
23	5.12	0.26	0.66	ND	3.46	0.15	0.63	3.13
43	5.19	0.24	1.12	0.02	2.56	0.06	0.51	2.77
79	5.43	0.14	0.88	ND	1.29	0.10	0.51	1.94
110	4.94	0.26	0.42	0.44	3.05	0.02	0.74	2.21
140	5.47	0.33	0.70	2.08	2.18	0.08	0.72	2.23
199	3.83	0.60	0.87	10.73	7.43	0.04	0.65	21.05
248	3.21	1.52	2.22	17.93	11.60	0.06	0.60	27.90
295	2.19	2.23	2.56	23.69	24.76	0.15	0.98	31.89
339	1.64	2.30	2.64	27.48	26.08	0.15	0.98	33.54
382	1.55	2.25	2.57	34.62	39.82	0.13	0.55	36.71
523	1.15	1.76	2.01	36.92	45.40	0.07	0.73	38.46

Cruise : HOTEC-1
Ship : M/V Holoholo
Location: 19°59'N, 156°05'W

Date (GMT) : 29 Oct. 1978
Water Depth: 700m
Weather : Beaufort-1, Sea State-1

Time : 1830Z, 0830HST
Wire Angle: 0°

Observed Depths (M)	Dissolved Oxygen (mℓ/ℓ)	Phosphates (μg-at/ℓ)	TOTAL Phosphorous (μg-at/ℓ)	Nitrates & Nitrites (μg-at/ℓ)	Silicates (μg-at/ℓ)	Ammonium (μg-at/ℓ)	Urea (μg-at/ℓ)	TOTAL Nitrogen (μg-at/ℓ)
5	--	0.19	0.56	0.06	1.35	0.03	0.80	10.04
23	--	0.26	0.56	0.03	3.55	ND	0.68	10.42
42	--	0.20	0.64	ND	1.23	ND	0.58	8.49
60	--	0.13	0.43	ND	1.38	0.02	0.65	8.59
78	--	0.26	0.50	0.02	1.99	ND	0.64	9.76
143	--	0.41	0.57	2.59	2.43	0.02	0.69	12.09
198	--	1.21	1.24	14.32	10.03	0.03	0.58	19.35

Cruise : HOTEC-1
Ship : M/V Holoholo
Location: 20°05'N, 156°04'W

Date (GMT) : 29 Oct. 1978
Water Depth: 950m
Weather : Beaufort-1, Sea State-1

Time : 2138Z, 1138HST
Wire Angle: 0°

Observed Depths (M)	Dissolved Oxygen (mℓ/ℓ)	Phosphates (μg-at/ℓ)	TOTAL Phosphorous (μg-at/ℓ)	Nitrates & Nitrites (μg-at/ℓ)	Silicates (μg-at/ℓ)	Ammonium (μg-at/ℓ)	Urea (μg-at/ℓ)	TOTAL Nitrogen (μg-at/ℓ)
5	--	0.25	0.35	ND	2.63	0.03	0.76	9.76
21	--	0.19	0.46	0.03	1.17	ND	0.57	8.46
39	--	0.18	0.69	ND	2.43	0.03	0.70	9.45
56	--	0.17	0.33	0.02	1.59	ND	0.71	8.44
74	--	0.21	0.43	ND	1.97	0.03	0.59	8.51
142	--	0.28	0.64	1.16	1.56	ND	0.58	16.74
205	--	1.48	1.71	20.75	14.95	ND	0.63	22.12

Cruise : HOTEC-2
Ship : M/V Noi'i
Location: 19°55.6'N, 156°08.8'W

Date (GMT) : 12 April 1979
Water Depth: 1325m
Weather : Beaufort-2, Sea State-2

Time : 2016Z, 1016HST
Wire Angle: 0°

Observed Depths (M)	Dissolved Oxygen (mℓ/ℓ)	Phosphates (μg-at/ℓ)	TOTAL Phosphorous (μg-at/ℓ)	Nitrates & Nitrites (μg-at/ℓ)	Silicates (μg-at/ℓ)	Ammonium (μg-at/ℓ)	Urea (μg-at/ℓ)	TOTAL Nitrogen (μg-at/ℓ)
0	5.68	0.39	0.56	1.87	2.42	0.64	3.64	26.89
23	5.47	0.23	0.51	1.43	1.86	0.35	0.51	11.34
43	5.47	0.24	0.47	0.43	1.74	0.17	0.47	10.69
58	5.57	0.27	0.40	1.52	3.93	0.36	0.83	12.87
74	5.68	0.13	0.40	0.20	1.78	0.16	0.28	9.74
102	5.23	0.28	0.33	0.60	3.31	0.12	0.31	14.40
131	4.67	0.56	0.42	4.99	4.99	0.11	0.40	13.08
199	3.82	1.51	1.12	16.48	18.21	0.12	0.24	26.14
278	2.39	2.16	1.86	24.44	36.43	0.15	0.42	41.48
450	1.14	3.04	2.79	34.65	71.48	0.09	0.21	53.08
635	1.20	2.80	3.02	33.84	80.92	0.19	0.44	53.14
822	1.39	3.20	3.13	37.53	124.26	0.04	0.26	57.08

Cruise : HOTEC-2
Ship : M/V Noi'i
Location: 19°56.1'N, 156°08.5'W

Date (GMT) : 13 April 1979
Water Depth: 1250m
Weather : Beaufort-3, Sea State-3

Time : 0322Z, 1722HST
Wire Angle: 0°

Observed Depths (M)	Dissolved Oxygen (mℓ/ℓ)	Phosphates (μg-at/ℓ)	TOTAL Phosphorous (μg-at/ℓ)	Nitrates & Nitrites (μg-at/ℓ)	Silicates (μg-at/ℓ)	Ammonium (μg-at/ℓ)	Urea (μg-at/ℓ)	TOTAL Nitrogen (μg-at/ℓ)
0	5.47	0.18	0.80	.38	6.19	ND	.10	10.35
9	5.52	0.19	0.58	.15	--	ND	--	8.70
22	5.61	0.17	0.57	.07	3.32	ND	.11	8.88
32	5.59	0.16	0.55	.11	1.81	ND	.15	14.36
43	5.38	0.18	0.52	.06	2.25	ND	ND	10.49
60	5.43	0.15	0.53	.10	2.27	ND	.43	9.18
75	5.41	0.15	0.54	.10	1.93	ND	ND	10.34
91	5.43	0.21	0.45	.07	8.83	ND	.61	10.17
109	5.23	0.19	0.54	.52	2.87	ND	.43	10.62
149	4.87	0.45	0.83	3.86	4.16	ND	.26	11.65
193	4.40	0.73	0.81	8.22	7.72	ND	.20	16.94
237	3.42	1.40	1.21	17.15	16.09	ND	.27	21.09

Cruise : HOTEC-2
Ship : M/V Noi'i
Location: 19°53.7'N, 156°10.9'W

Date (GMT) : 13 April 1979
Water Depth: 1200m
Weather : Beaufort-2, Sea State-2

Time : 0959Z, 2359HST
Wire Angle: 0°

Observed Depths (M)	Dissolved Oxygen (mℓ/ℓ)	Phosphates (μg-at/ℓ)	TOTAL Phosphorous (μg-at/ℓ)	Nitrates & Nitrites (μg-at/ℓ)	Silicates (μg-at/ℓ)	Ammonium (μg-at/ℓ)	Urea (μg-at/ℓ)	TOTAL Nitrogen (μg-at/ℓ)
0	5.47	0.18	0.49	0.39	3.74	0.02	0.61	9.65
22	5.23	0.15	0.49	0.09	1.93	ND	0.17	9.16
40	5.25	0.07	0.40	0.10	3.86	0.10	0.55	11.62
55	5.30	0.12	0.32	0.06	1.75	0.07	0.16	10.58
69	5.18	0.12	0.30	0.08	2.30	0.04	ND	15.90
95	4.99	0.19	0.29	0.56	2.13	ND	ND	8.59
124	4.24	0.52	0.49	5.69	6.11	0.14	0.20	15.90
192	3.40	1.37	1.21	17.08	17.46	ND	0.11	26.13
272	2.32	1.80	2.08	22.94	33.00	ND	0.20	40.16
444	1.02	2.81	2.97	34.61	66.47	0.04	0.26	51.78
628	1.18	2.93	2.94	36.90	84.58	ND	0.11	51.56
816	1.18	2.97	2.07	37.77	100.95	ND	0.11	37.14

Cruise : HOTEC-2
Ship : M/V Noi'i
Location: 19°56.2'N, 156°08.8'W

Date (GMT) : 13 April 1979
Water Depth: 1250m
Weather : Beaufort-1, Sea State-3

Time : 1345Z, 0345HST
Wire Angle: 0°

Observed Depths (M)	Dissolved Oxygen (mℓ/ℓ)	Phosphates (μg-at/ℓ)	TOTAL Phosphorous (μg-at/ℓ)	Nitrates & Nitrites (μg-at/ℓ)	Silicates (μg-at/ℓ)	Ammonium (μg-at/ℓ)	Urea (μg-at/ℓ)	TOTAL Nitrogen (μg-at/ℓ)
0	5.41	0.18	0.68	0.45	11.30	ND	--	14.82
9	5.28	0.28	0.64	0.09	0.17	ND	0.16	10.83
24	5.32	0.24	0.64	0.11	1.83	ND	0.15	9.65
38	5.38	0.24	0.55	0.08	1.71	ND	0.11	8.63
47	5.38	0.19	0.59	0.07	1.75	ND	0.18	9.72
60	5.38	0.20	0.57	0.10	1.74	ND	0.25	9.62
77	5.14	0.22	0.53	0.46	2.96	ND	0.21	9.81
94	5.18	0.15	0.50	0.07	2.51	ND	0.10	9.44
111	5.05	0.28	0.56	0.75	2.52	ND	0.05	10.07
156	4.40	0.57	0.72	5.12	4.63	ND	0.19	14.10
202	4.04	0.77	1.10	8.98	7.91	ND	ND	19.25
250	3.30	1.48	1.56	17.64	18.50	ND	0.16	26.03

Cruise : HOTEC-3 | Date (GMT) : 17 June 1979 | Time : 2215Z, 1215HST
Ship : M/V El Greco | Water Depth: 1350m | Wire Angle: 0°
Location: 19°55.5'N, 156°09.2'W | Weather : Beaufort-2, Sea State-1

Observed Depths (M)	Dissolved Oxygen (mℓ/ℓ)	Phosphates (μg-at/ℓ)	TOTAL Phosphorous (μg-at/ℓ)	Nitrates & Nitrites (μg-at/ℓ)	Silicates (μg-at/ℓ)	Ammonium (μg-at/ℓ)	Urea (μg-at/ℓ)	TOTAL Nitrogen (μg-at/ℓ)
0	5.90	0.23	0.53	1.11	3.50	0.47	0.84	12.97
23	5.85	0.20	0.54	0.43	2.23	0.17	0.47	8.36
43	5.96	0.16	0.66	0.24	1.37	0.50	0.71	7.94
60	5.54	0.15	0.69	0.28	1.49	0.21	0.67	7.52
72	5.92	0.13	0.48	0.17	1.36	0.24	0.91	2.19
106	5.52	0.22	0.67	1.28	2.35	0.35	1.29	4.12
154	4.71	0.50	0.86	5.65	5.30	0.21	0.62	7.01
239	4.00	1.08	1.61	13.34	12.89	0.31	1.89	19.90
309	2.75	2.06	2.55	25.61	35.22	0.14	0.50	29.33
448	1.07	2.92	3.53	36.28	71.01	0.14	0.34	39.91
632	1.01	2.98	3.77	36.87	79.12	0.37	1.19	45.53
826	1.43	2.83	3.77	35.30	85.67	0.17	0.47	45.79

Cruise : HOTEC-3 | Date (GMT) : 18 June 1979 | Time : 0415Z, 1815HST
Ship : M/V El Greco | Water Depth: 1100m | Wire Angle: 0°
Location: 19°56.8'N, 156°08.7'W | Weather : Beaufort-1, Sea State-1

Observed Depths (M)	Dissolved Oxygen (mℓ/ℓ)	Phosphates (μg-at/ℓ)	TOTAL Phosphorous (μg-at/ℓ)	Nitrates & Nitrites (μg-at/ℓ)	Silicates (μg-at/ℓ)	Ammonium (μg-at/ℓ)	Urea (μg-at/ℓ)	TOTAL Nitrogen (μg-at/ℓ)
0	5.47	0.35	0.63	0.15	1.97	0.54	2.23	7.93
9	5.14	0.33	0.56	0.09	2.24	1.06	4.09	13.01
25	5.38	0.26	0.40	0.12	3.65	0.22	0.78	6.17
40	5.41	0.26	0.44	0.23	3.64	0.33	1.49	2.77
50	5.94	0.26	0.41	1.38	4.76	0.34	1.60	3.11
62	5.43	0.21	0.46	0.21	1.81	0.19	0.77	4.58
79	5.12	0.23	0.48	0.43	1.95	0.25	1.38	4.58
96	5.05	0.28	0.49	1.02	1.79	0.18	0.49	5.59
116	4.96	0.35	0.56	2.29	2.54	0.15	0.38	4.20
163	4.98	0.51	0.82	4.73	3.95	0.21	0.76	6.80
213	4.27	0.90	1.09	9.82	7.95	0.26	0.94	10.83
262	3.54	1.36	1.74	15.83	14.50	0.45	1.90	22.33

Cruise : HOTEC-3
Ship : M/V El Greco
Location: 19°56.4'N, 156°08.1'W

Date (GMT) : 18 June 1979
Water Depth: 950m
Weather : Beaufort-1, Sea State-1

Time : 0943Z, 2343HST
Wire Angle: 0°

Observed Depths (M)	Dissolved Oxygen (mℓ/ℓ)	Phosphates (µg-at/ℓ)	TOTAL Phosphorous (µg-at/ℓ)	Nitrates & Nitrites (µg-at/ℓ)	Silicates (µg-at/ℓ)	Ammonium (µg-at/ℓ)	Urea (µg-at/ℓ)	TOTAL Nitrogen (µg-at/ℓ)
0	5.47	0.25	0.67	0.61	2.23	0.18	1.68	9.19
23	5.77	0.23	0.52	1.18	3.84	0.16	1.60	8.52
45	5.52	0.32	0.50	2.32	6.54	0.64	3.80	8.36
65	5.63	0.14	0.52	0.12	1.31	0.09	0.34	8.23
70	5.57	0.12	0.63	0.78	1.63	0.17	1.81	9.28
104	4.81	0.22	0.58	1.53	2.15	0.13	0.68	11.29
152	4.69	0.33	0.82	3.57	3.61	0.10	0.45	12.47
237	3.69	1.11	1.67	14.39	13.64	0.12	0.56	22.54
304	2.50	1.99	2.59	24.47	31.66	0.21	0.41	36.29
454	1.03	2.75	3.45	33.95	57.93	0.16	0.29	40.41
638	1.01	2.99	3.62	36.85	80.88	0.05	0.32	42.17
831	1.12	3.00	3.62	37.12	92.83	0.18	0.61	41.25

Cruise : HOTEC-3
Ship : M/V El Greco
Location: 19°55.8'N, 156°08.7'W

Date (GMT) : 18 June 1979
Water Depth: 1350m
Weather : Beaufort-2, Sea State-1

Time : 1400Z, 0400HST
Wire Angle: 0°

Observed Depths (M)	Dissolved Oxygen (mℓ/ℓ)	Phosphates (µg-at/ℓ)	TOTAL Phosphorous (µg-at/ℓ)	Nitrates & Nitrites (µg-at/ℓ)	Silicates (µg-at/ℓ)	Ammonium (µg-at/ℓ)	Urea (µg-at/ℓ)	TOTAL Nitrogen (µg-at/ℓ)
0	5.25	0.27	0.67	1.03	3.49	0.04	1.69	4.07
10	5.01	0.21	0.58	0.18	1.61	ND	0.35	2.44
28	5.01	0.20	0.58	0.13	1.47	ND	0.36	4.87
45	5.32	0.18	0.56	0.13	1.35	0.02	0.24	2.90
61	5.23	0.17	0.58	0.12	1.29	0.02	0.20	1.97
74	5.54	0.14	0.52	0.12	1.29	ND	0.24	6.26
83	5.10	0.20	0.50	0.69	1.73	0.07	0.44	3.82
98	5.21	0.26	0.53	1.41	2.04	0.05	0.32	5.42
114	4.78	0.27	0.82	1.77	3.44	ND	0.40	5.00
160	4.56	0.49	0.82	5.34	4.70	0.11	0.35	7.10
208	4.29	0.80	1.25	9.24	7.60	0.02	0.37	12.93
256	3.73	1.29	1.63	15.72	14.39	0.44	0.35	22.54

Cruise : HOTEC-4
Ship : R/V Kana Keoki
Location: 19°56.0'N, 156°08.5'W

Date (GMT) : 30 July 1979
Water Depth: 1325m
Weather : Beaufort-2, Sea State-1

Time : 2213Z, 1213HST
Wire Angle: 0°

Observed Depths (M)	Dissolved Oxygen (mℓ/ℓ)	Phosphates (μg-at/ℓ)	TOTAL Phosphorous (μg-at/ℓ)	Nitrates & Nitrites (μg-at/ℓ)	Silicates (μg-at/ℓ)	Ammonium (μg-at/ℓ)	Urea (μg-at/ℓ)	TOTAL Nitrogen (μg-at/ℓ)
0	5.74	0.10	0.53	ND	1.97	0.14	0.36	16.32
21	5.76	0.10	0.44	ND	1.97	0.10	0.18	13.61
42	5.83	0.08	0.52	ND	1.57	0.04	0.30	12.17
62	5.78	0.11	0.43	0.03	1.99	0.02	1.11	13.85
75	5.59	0.15	0.43	0.09	2.04	0.04	0.19	13.85
103	5.74	0.18	0.34	1.30	2.36	0.04	0.51	18.57
152	5.23	0.38	0.51	4.52	4.81	0.13	0.30	15.68
236	3.72	1.39	1.52	18.34	17.91	0.16	0.34	25.29
304	2.49	2.16	2.32	26.84	33.69	0.26	0.30	33.79
451	1.04	2.95	2.87	37.60	70.90	0.24	0.33	35.10
633	1.06	3.15	3.23	40.35	88.71	0.26	0.33	41.17
828	1.20	2.66	3.22	33.50	81.73	0.35	0.47	44.73

Cruise : HOTEC-4
Ship : R/V Kana Keoki
Location: 19°55.3'N, 156°09.2'W

Date (GMT) : 1 August 1979
Water Depth: 1350m
Weather : Beaufort-4, Sea State-3

Time : 0303Z, 1703HST
Wire Angle: 0°

Observed Depths (M)	Dissolved Oxygen (mℓ/ℓ)	Phosphates (μg-at/ℓ)	TOTAL Phosphorous (μg-at/ℓ)	Nitrates & Nitrites (μg-at/ℓ)	Silicates (μg-at/ℓ)	Ammonium (μg-at/ℓ)	Urea (μg-at/ℓ)	TOTAL Nitrogen (μg-at/ℓ)
0	5.80	0.11	0.55	0.11	3.04	0.05	0.14	12.41
8	5.25	0.12	0.40	0.16	2.01	ND	0.29	12.97
22	5.25	0.11	0.35	0.11	2.01	0.03	0.44	13.21
35	5.34	0.10	0.43	0.10	1.91	ND	0.43	16.80
40	5.52	0.09	0.37	0.10	1.82	ND	0.27	11.37
48	5.99	0.10	0.35	0.10	2.46	0.03	0.42	11.77
62	5.96	0.10	0.69	0.11	2.63	0.09	0.33	10.97
76	5.01	0.14	0.49	0.49	2.63	0.09	0.28	9.45
93	4.98	0.16	0.46	0.85	3.95	0.07	0.31	12.41
138	4.66	0.31	0.54	4.08	4.53	0.10	0.19	15.12
185	4.56	0.58	0.72	8.14	7.05	0.09	0.29	20.49
233	3.33	1.48	1.64	21.02	17.96	0.10	0.17	36.80

Cruise : HOTEC-4
Ship : R/V Kana Keoki
Location: 19°55.6'N, 156°09.5'W

Date (GMT) : 1 Aug. 1979
Water Depth: 1360m
Weather : Beaufort-3, Sea State-2

Time : 1035Z, 0035HST
Wire Angle: 0°

Observed Depths (M)	Dissolved Oxygen (mℓ/ℓ)	Phosphates (μg-at/ℓ)	TOTAL Phosphorous (μg-at/ℓ)	Nitrates & Nitrites (μg-at/ℓ)	Silicates (μg-at/ℓ)	Ammonium (μg-at/ℓ)	Urea (μg-at/ℓ)	TOTAL Nitrogen (μg-at/ℓ)
0	5.19	0.14	0.43	0.12	2.61	0.13	0.32	11.37
21	5.65	0.10	0.44	0.10	2.46	0.10	0.26	11.29
42	5.78	0.10	0.42	0.09	2.16	0.12	0.36	11.69
62	5.21	0.09	0.42	0.07	1.85	0.12	0.40	11.93
71	5.19	0.13	0.41	0.09	2.07	0.29	1.01	12.19
107	4.28	0.18	0.48	1.60	2.83	0.13	0.42	13.21
152	4.90	0.24	0.56	3.25	4.12	0.20	0.33	17.12
236	3.70	1.35	1.31	16.81	17.21	ND	0.29	38.65
304	2.28	1.96	2.30	23.89	32.10	0.24	0.39	34.02
451	1.16	2.95	3.20	37.25	69.63	0.40	0.60	43.65
633	1.06	1.98	2.71	24.23	50.51	0.37	0.62	35.50
828	1.33	2.78	3.41	33.67	92.43	0.24	1.29	43.56

Cruise : HOTEC-4
Ship : M/V Kana Keoki
Location: 19°55.7'N, 156°08.9'W

Date (GMT) : 1 Aug. 1979
Water Depth: 1355m
Weather : Beaufort-2, Sea State-2

Time : 1425Z, 0425HST
Wire Angle: 0°

Observed Depths (M)	Dissolved Oxygen (mℓ/ℓ)	Phosphates (μg-at/ℓ)	TOTAL Phosphorous (μg-at/ℓ)	Nitrates & Nitrites (μg-at/ℓ)	Silicates (μg-at/ℓ)	Ammonium (μg-at/ℓ)	Urea (μg-at/ℓ)	TOTAL Nitrogen (μg-at/ℓ)
0	5.57	0.11	0.66	0.11	3.80	0.05	0.51	13.37
8	5.45	0.10	0.51	0.08	1.63	0.14	0.41	12.49
25	5.52	0.15	0.41	0.11	2.56	ND	0.56	11.45
40	5.63	0.10	0.52	0.09	2.19	0.09	0.23	11.69
49	5.85	0.14	0.45	0.09	1.70	0.14	0.40	15.20
58	5.21	0.11	0.37	0.10	2.29	0.15	0.27	11.37
74	5.54	0.13	0.38	0.14	1.97	0.18	0.45	11.13
92	5.25	0.15	0.36	0.67	2.25	0.14	0.61	10.81
110	4.92	0.20	0.37	1.92	2.99	0.15	0.47	11.37
157	4.96	0.40	0.55	4.77	4.46	0.13	0.30	14.97
205	4.66	0.58	0.77	8.12	6.93	0.08	0.32	20.33
253	3.92	1.30	1.45	18.81	15.60	0.17	0.49	33.76

Cruise : HOTEC-5
Ship : R/V Kana Keoki
Location: 19°56.9'N, 156°09.0'W

Date (GMT) : 3 Oct. 1979
Water Depth: 1375m
Weather : Beaufort-0, Sea State-Calm

Time : 2146Z, 1146HST
Wire Angle: 0°

Observed Depths (M)	Dissolved Oxygen (mℓ/ℓ)	Phosphates (μg-at/ℓ)	TOTAL Phosphorous (μg-at/ℓ)	Nitrates & Nitrites (μg-at/ℓ)	Silicates (μg-at/ℓ)	Ammonium (μg-at/ℓ)	Urea (μg-at/ℓ)	TOTAL Nitrogen (μg-at/ℓ)
0	6.27	0.08	0.56	0.02	1.09	ND	0.18	10.08
17	5.96	0.07	0.46	0.02	1.06	ND	0.18	9.28
36	5.67	0.09	0.53	0.03	1.18	ND	0.18	9.32
54	6.29	0.07	0.46	0.03	1.19	ND	0.24	10.36
74	5.89	0.09	0.35	0.04	1.35	0.46	0.22	9.05
114	5.38	0.08	0.43	0.94	1.85	ND	0.19	9.58
156	5.03	0.27	0.79	3.71	3.46	ND	0.19	10.76
243	4.50	0.99	1.54	14.89	14.84	ND	0.17	21.10
334	3.19	1.85	2.43	25.63	34.69	ND	0.20	39.11
521	1.20	2.71	3.59	35.09	54.39	ND	0.25	52.36
712	1.09	3.09	3.77	38.32	68.00	2.71	0.44	55.51
904	1.29	3.08	3.77	38.84	79.57	ND	0.20	50.11

Cruise : HOTEC-5
Ship : R/V Kana Keoki
Location: 19°50.4'N, 156°08.4'W

Date (GMT) : 4 Oct. 1979
Water Depth: 1000m
Weather : Beaufort-2, Sea State-1

Time : 1038Z, 0038HST
Wire Angle: 0°

Observed Depths (M)	Dissolved Oxygen (mℓ/ℓ)	Phosphates (μg-at/ℓ)	TOTAL Phosphorous (μg-at/ℓ)	Nitrates & Nitrites (μg-at/ℓ)	Silicates (μg-at/ℓ)	Ammonium (μg-at/ℓ)	Urea (μg-at/ℓ)	TOTAL Nitrogen (μg-at/ℓ)
0	5.76	0.02	0.59	ND	1.20	ND	0.20	10.39
19	5.23	ND	0.47	ND	1.16	ND	0.19	10.76
38	5.47	ND	0.49	ND	1.18	ND	0.23	10.69
57	5.74	ND	0.41	ND	1.29	ND	0.43	8.58
78	5.72	ND	0.38	ND	1.29	0.31	0.19	7.51
118	5.12	0.02	0.36	0.26	1.78	0.02	0.25	7.98
160	4.87	0.12	0.50	2.26	2.56	ND	0.20	9.99
249	4.34	0.92	1.45	14.79	15.28	2.53	0.19	19.44
340	3.04	1.52	2.45	21.95	31.28	1.21	0.31	39.70
527	0.93	2.76	3.53	36.46	60.12	ND	0.19	50.29
718	1.04	2.67	3.50	33.58	61.85	ND	0.17	48.76
909	1.37	2.81	3.53	33.47	72.92	0.34	0.21	49.11

Cruise : HOTEC-5
Ship : R/V Kana Keoki
Location: 20°00.7'N, 156°04.4'W

Date (GMT) : 5 Oct. 1979
Water Depth: 850m
Weather : Beaufort-2, Sea State-Calm

Time : 0406Z, 1806HST
Wire Angle: 0°

Observed Depths (M)	Dissolved Oxygen (mℓ/ℓ)	Phosphates (μg-at/ℓ)	TOTAL Phosphorous (μg-at/ℓ)	Nitrates & Nitrites (μg-at/ℓ)	Silicates (μg-at/ℓ)	Ammonium (μg-at/ℓ)	Urea (μg-at/ℓ)	TOTAL Nitrogen (μg-at/ℓ)
0	5.07	0.24	0.48	0.14	1.18	ND	3.09	15.81
7	5.12	0.20	0.38	0.08	1.18	ND	1.32	12.28
20	5.10	0.17	0.39	0.06	1.23	ND	1.21	11.65
34	5.19	0.16	0.35	0.05	1.08	ND	0.80	9.71
50	5.23	0.13	0.50	0.09	1.11	ND	0.41	8.74
66	5.36	0.13	0.30	0.06	1.11	ND	0.46	8.64
84	5.45	0.15	0.33	0.06	1.17	ND	0.39	7.96
101	5.25	0.16	0.31	0.06	1.44	2.61	0.42	7.98
120	4.96	0.21	0.50	0.83	1.69	ND	0.40	9.27
166	4.61	0.37	0.57	3.72	3.17	ND	0.35	11.00
214	4.48	0.57	0.78	6.94	5.87	ND	0.38	13.00
262	4.08	1.17	1.43	15.16	6.90	ND	0.28	19.72

Cruise : HOTEC-5
Ship : R/V Kana Keoki
Location: 19°56.8'N, 156°08.0'W

Date (GMT) : 5 Oct. 1979
Water Depth: 1360m
Weather : Beaufort-2, Sea State-Calm

Time : 1536Z, 0536HST
Wire Angle: 0°

Observed Depths (M)	Dissolved Oxygen (mℓ/ℓ)	Phosphates (μg-at/ℓ)	TOTAL Phosphorous (μg-at/ℓ)	Nitrates & Nitrites (μg-at/ℓ)	Silicates (μg-at/ℓ)	Ammonium (μg-at/ℓ)	Urea (μg-at/ℓ)	TOTAL Nitrogen (μg-at/ℓ)
0	4.94	0.16	0.41	0.15	1.08	3.78	8.22	15.46
7	4.92	0.13	0.31	0.05	1.20	0.04	0.26	16.14
21	5.27	0.12	0.30	0.06	1.01	0.63	2.50	14.71
37	5.10	0.19	0.40	0.06	0.95	3.37	2.32	15.77
54	5.10	0.12	0.35	0.05	1.02	0.07	0.95	11.71
70	5.32	0.12	0.30	0.06	1.03	0.45	1.76	14.16
88	5.14	0.14	0.30	0.07	1.31	0.11	1.03	10.64
106	5.10	0.17	0.40	0.25	1.48	0.09	0.82	10.70
124	5.12	0.15	0.40	0.55	1.55	ND	0.51	12.44
170	4.94	0.29	0.45	3.22	2.89	0.12	0.79	13.39
218	4.59	0.64	0.87	8.74	7.72	0.16	0.78	18.47
267	4.19	1.07	1.35	14.59	14.11	0.07	0.78	23.92

Cruise : HOTEC-6
Ship : M/V Noi'i
Location: 19°55.9'N, 156°8.0'W

Date (GMT) : 7 December 1979
Water Depth: 1025m
Weather : Beaufort-1, Sea State-1

Time : 2247Z, 1247HST
Wire Angle: 0°

Observed Depths (M)	Dissolved Oxygen (mℓ/ℓ)	Phosphates (μg-at/ℓ)	TOTAL Phosphorous (μg-at/ℓ)	Nitrates & Nitrites (μg-at/ℓ)	Silicates (μg-at/ℓ)	Ammonium (μg-at/ℓ)	Urea (μg-at/ℓ)	TOTAL Nitrogen (μg-at/ℓ)
0	5.74	0.10	0.55	0.16	1.68	0.37	3.07	19.03
24	5.34	0.02	0.65	0.09	1.51	ND	0.18	15.23
46	5.16	ND	0.45	0.07	1.41	ND	0.40	17.56
65	5.43	0.02	0.47	0.10	1.33	0.28	1.05	20.07
84	5.45	ND	0.51	0.08	1.54	ND	0.33	18.94
119	5.01	0.02	0.73	1.06	2.61	ND	0.26	20.27
155	4.79	0.14	0.60	3.68	4.63	ND	0.29	17.40
240	4.10	0.93	1.45	17.09	16.29	0.09	0.27	21.14
329	2.66	1.89	2.47	29.53	37.38	0.10	0.19	43.98
517	0.24	2.85	3.40	40.37	68.40	0.31	0.27	47.50
708	0.27	3.06	5.96	42.69	89.07	0.12	0.20	47.12
901	0.42	3.10	4.49	43.05	96.35	0.09	0.18	44.35

Cruise : HOTEC-6
Ship : M/V Noi'i
Location: 19°55.3'N, 156°9.2'W

Date (GMT) : 8 December 1979
Water Depth: 1350m
Weather : Beaufort-2, Sea State-1

Time : 0434Z, 1834HST
Wire Angle: 0°

Observed Depths (M)	Dissolved Oxygen (mℓ/ℓ)	Phosphates (μg-at/ℓ)	TOTAL Phosphorous (μg-at/ℓ)	Nitrates & Nitrites (μg-at/ℓ)	Silicates (μg-at/ℓ)	Ammonium (μg-at/ℓ)	Urea (μg-at/ℓ)	TOTAL Nitrogen (μg-at/ℓ)
0	5.23	0.03	0.71	0.11	1.78	ND	0.21	22.89
9	5.01	ND	1.44	0.10	1.52	ND	0.18	22.37
27	5.12	ND	0.47	0.10	1.44	0.07	0.34	22.72
46	5.16	ND	0.71	0.08	1.48	ND	0.33	21.54
62	5.27	ND	0.46	0.09	1.38	ND	0.33	22.75
80	5.23	ND	0.46	0.08	1.45	0.21	0.47	21.99
97	5.30	ND	0.48	0.08	1.64	ND	0.39	22.15
114	5.34	0.35	0.39	0.30	1.70	11.18	0.30	22.47
130	5.16	0.07	0.53	0.97	1.85	0.14	0.24	24.35
173	4.76	0.21	0.78	3.78	4.61	0.06	0.24	26.30
227	4.39	0.64	1.10	10.44	11.53	0.07	0.21	29.63
265	4.28	1.05	1.37	16.62	15.48	0.32	0.32	32.16

Cruise : HOTEC-6
Ship : M/V Noi'i
Location: 19°54.6'N, 156°11.1'W

Date (GMT) : 8 December 1979
Water Depth: 1230m
Weather : Beaufort-0, Sea State-1

Time : 1055Z, 0055HST
Wire Angle: 0°

Observed Depths (M)	Dissolved Oxygen (mℓ/ℓ)	Phosphates (μg-at/ℓ)	TOTAL Phosphorous (μg-at/ℓ)	Nitrates & Nitrites (μg-at/ℓ)	Silicates (μg-at/ℓ)	Ammonium (μg-at/ℓ)	Urea (μg-at/ℓ)	TOTAL Nitrogen (μg-at/ℓ)
0	5.10	0.16	0.62	0.11	1.65	0.06	0.31	18.08
21	5.12	0.06	0.94	0.09	1.53	0.10	0.26	14.75
44	5.10	0.02	0.55	0.08	1.35	0.10	0.73	17.13
63	5.14	ND	0.47	0.10	1.40	0.31	0.47	15.81
82	5.30	ND	0.43	0.10	1.54	0.86	0.55	16.18
121	4.87	0.06	0.58	1.97	3.22	0.15	0.33	15.55
161	4.83	0.11	0.77	3.67	4.43	0.15	0.28	21.93
246	4.10	1.03	1.52	17.65	17.40	3.42	0.34	29.07
336	2.88	1.79	2.73	28.96	36.26	0.69	0.32	57.40
522	0.33	2.79	3.51	41.25	69.31	0.11	0.19	62.83
705	0.33	2.55	3.60	34.62	71.12	ND	0.35	62.40
899	1.29	3.00	3.41	41.75	97.46	ND	0.47	59.03

Cruise : HOTEC-6
Ship : M/V Noi'i
Location: 19°56.4'N, 156°7.8'W

Date (GMT) : 8 December 1979
Water Depth: 925m
Weather : Beaufort-1, Sea State-1

Time : 1505Z, 0505HST
Wire Angle: 0°

Observed Depths (M)	Dissolved Oxygen (mℓ/ℓ)	Phosphates (μg-at/ℓ)	TOTAL Phosphorous (μg-at/ℓ)	Nitrates & Nitrites (μg-at/ℓ)	Silicates (μg-at/ℓ)	Ammonium (μg-at/ℓ)	Urea (μg-at/ℓ)	TOTAL Nitrogen (μg-at/ℓ)
0	3.12	ND	0.51	0.06	1.31	0.29	0.35	15.43
9	5.16	ND	0.60	0.08	1.33	0.31	0.24	17.15
26	5.16	ND	0.30	0.04	0.91	0.11	0.31	12.35
43	5.19	ND	0.55	0.07	1.35	0.12	0.33	16.49
60	5.21	ND	0.47	0.11	1.40	0.11	0.48	14.90
76	5.30	ND	0.41	0.08	1.49	0.12	0.32	15.99
94	5.47	ND	0.45	0.08	1.64	0.45	0.54	14.94
109	5.27	ND	0.47	0.35	1.34	0.05	0.31	17.45
124	5.23	ND	0.74	0.76	1.69	0.03	0.26	13.90
164	5.05	0.16	0.67	3.79	4.71	0.07	0.26	15.61
209	4.70	0.59	0.91	10.64	11.94	0.08	0.33	26.58
256	4.30	1.04	1.06	16.99	20.40	1.03	0.27	30.64

APPENDIX C

Chlorophyll, Phaeo-pigments, ATP and Primary Productivity
Data For HOTEC 1-6 Cruises

Cruise : HOTEC-1 | Date (GMT) : 28 Oct. 1978 | Time: 0415Z, 1815HST
Ship : M/V Holoholo | Water Depth: 1000m | Wire Angle: 0°
Location: 19°59'N, 156°08'W | Weather : Beaufort-1, Sea State-Calm

Observed Depths (M)	Chlorophyll-a (μg/ℓ)	Phaeo-Pigments (μg/ℓ)	A.T.P. (ng/ℓ)
0	0.08	0.03	4.93
5	0.07	0.01	2.37
21	0.09	0.03	8.10
36	0.09	0.04	5.26
50	0.10	0.04	9.63
64	0.16	0.06	17.47
76	0.23	0.10	12.67
89	0.26	0.18	9.23
100	0.12	0.12	6.60
127	0.06	0.09	5.40
152	0.03	0.04	5.87
175	0.01	0.03	4.87

Cruise : HOTEC-1 | Date (GMT) : 28 Oct. 1978 | Time: 1412Z, 0412HST
Ship : M/V Holoholo | Water Depth: 1000m | Wire Angle: 0°
Location: 19°59'N, 156°08'W | Weather : Beaufort-1, Sea State-Calm

Observed Depths (M)	Chlorophyll-a (μg/ℓ)	Phaeo-Pigments (μg/ℓ)	A.T.P. (ng/ℓ)
0	0.07	0.03	14.5
5	0.08	0.03	25.25
23	0.06	0.05	4.70
41	0.08	0.04	10.75
58	0.11	0.07	5.55
74	0.21	0.06	17.45
91	0.25	0.21	11.59
107	0.14	0.15	7.55
123	0.07	0.13	3.20
163	0.04	0.16	2.15
202	0.02	0.02	2.70
243	0.02	0.02	2.35

Cruise : HOTEC-1
Ship : M/V Holoholo
Location: 19°59'N, 156°05'W

Date (GMT) : 29 Oct. 1978
Water Depth: 700m
Weather : Beaufort-1, Sea State-1

Time: 1830Z, 0830HST
Wire Angle: 0°

Observed Depths (M)	Chlorophyll-a (μg/ℓ)	Phaeo-Pigments (μg/ℓ)	A.T.P. (ng/ℓ)
5	0.08	0.02	--
23	0.08	0.01	--
42	0.09	0.03	--
60	0.16	0.04	--
78	0.27	0.16	--
143	0.05	0.06	--
198	0.01	0.02	--

Cruise : HOTEC-1
Ship : M/V Holoholo
Location: 20°05'N, 156°04'W

Date (GMT) : 29 Oct. 1978
Water Depth: 950m
Weather : Beaufort-1, Sea State-1

Time: 2138Z, 1138HST
Wire Angle: 0°

Observed Depths (M)	Chlorophyll-a (μg/ℓ)	Phaeo-Pigments (μg/ℓ)	A.T.P. (ng/ℓ)
5	0.09	0.02	--
21	0.09	0.02	--
39	0.12	0.03	--
56	0.18	0.05	--
74	0.27	0.12	--
142	0.12	0.14	--
205	0.01	0.02	--

Cruise	: HOTEC-1	Samples Obtained:	Date (GMT) - 28 Oct. 1978
Ship	: M/V Holoholo		Time ------- 1400Z, 0400HST
Location	: 19°59'N, 156°08'W	Incubation:	Date (GMT) - 28-29 Oct. 1978
Water Depth	: 1000m		Time ------- 1600Z, 0600HST to 0400Z, 1800HST
Weather	: Beaufort-1, Sea State-Calm		

Depth (M)	Primary Productivity (μg C/ℓ/hr)
5	0.32
10	0.17
30	0.17
50	0.07
70	1.21
90	0.18
110	0.18
130	0.10
150	0.13

Cruise : HOTEC-2 Date (GMT) : 13 April 1979 Time: 0322Z, 1722HST
Ship : M/V Noi'i Water Depth: 1250m Wire Angle: 0°
Location: 19°56.1'N, 156°08.5'W Weather: Beaufort-3, Sea State-3

Observed Depths (M)	Chlorophyll-a (μg/ℓ)	Phaeo-Pigments (μg/ℓ)	A.T.P. (ng/ℓ)
0	0.03	0	8.07
9	0.03	0.006	14.13
22	0.03	0.002	7.43
32	0.04	0.008	6.80
43	0.04	0.005	9.93
60	0.06	0.002	9.77
75	0.08	0.02	7.07
91	0.17	0.03	3.80
109	0.15	0.05	4.87
149	0.06	0.04	2.70
193	0.01	0.01	3.10
237	0.01	0.004	--

Cruise : HOTEC-2 Date (GMT) : 13 April 1979 Time: 1345Z, 0345HST
Ship : M/V Noi'i Water Depth: 1250m Wire Angle: 0°
Location: 19°56.2'N, 156°08.8'W Weather: Beaufort-1, Sea State-3

Observed Depths (M)	Chlorophyll-a (μg/ℓ)	Phaeo-Pigments (μg/ℓ)	A.T.P. (ng/ℓ)
0	0.02	0.02	5.47
9	0.02	--	4.87
24	0.03	0.01	3.20
38	0.04	0.004	6.27
47	0.06	0.01	4.27
60	0.07	0.005	5.03
77	0.18	0.02	5.50
94	0.21	0.03	3.67
111	0.11	0.05	2.95
156	0.05	0.03	0
202	0.01	0.01	0
250	0.01	0.02	0

Cruise	: HOTEC-2	Samples Obtained:	Date (GMT) - 13 April 1979
Ship	: M/V Noi'i		Time ------- 1345Z, 0345HST
Location	: 19°56.2'N, 156°08.8'W	Incubation:	Date (GMT) - 13-14 April 1979
Water Depth:	1250m		Time ------- 1600Z, 0600HST
Weather	: Beaufort-1, Sea State-3		to 0230Z, 1630HST

Depth (M)	Primary Productivity (μg C/ℓ/hr)
0	0.034
10	0.056
30	0.031
50	0.067
70	0.062
90	0.033
110	--
130	--
150	--

Cruise : HOTEC-3 Date (GMT) : 18 June 1979 Time: 0415Z, 1815HST
Ship : M/V El Greco Water Depth: 1100m Wire Angle: 0°
Location: 19°56.8'N, 156°08.7'W Weather: Beaufort-1, Sea State-1

Observed Depths (M)	Chlorophyll-a (μg/ℓ)	Phaeo-Pigments (μg/ℓ)	A.T.P. (ng/ℓ)
0	0.09	0.02	31.64
9	0.07	0.03	16.88
25	0.09	0.04	20.28
40	0.08	0.01	23.25
50	0.15	0.07	19.59
62	0.18	0.06	22.57
79	0.62	0.45	34.61
96	0.19	0.22	10.15
116	0.12	0.13	8.31
163	0.04	0.05	5.08
213	0.02	0.04	2.93
262	0.03	0.02	2.68

Cruise : HOTEC-3 Date (GMT) : 18 June 1979 Time: 1400Z, 0400HST
Ship : M/V El Greco Water Depth: 1350m Wire Angle: 0°
Location: 19°55.8'N, 156°08.7'W Weather: Beaufort-2, Sea State-1

Observed Depths (M)	Chlorophyll-a (μg/ℓ)	Phaeo-Pigments (μg/ℓ)	A.T.P. (ng/ℓ)
0	0.05	0.02	25.20
10	0.06	0.01	22.16
28	0.06	0.02	21.81
45	0.06	0.02	13.11
61	0.08	0.04	18.46
74	0.15	0.04	18.91
83	0.39	0.17	14.46
98	0.14	0.17	6.14
114	0.07	0.07	5.22
160	0.03	0.01	3.58
208	0.01	ND	2.08
256	0.01	0.01	3.30

Cruise	: HOTEC-3	Samples Obtained:	Date (GMT) - 18 June 1979
Ship	: M/V El Greco		Time ------- 1400Z, 0400HST
Location	: 19°55.8'N, 156°08.7'W	Incubation:	Date (GMT) - 18-19 June 1979
Water Depth	: 1350m		Time ------- 1630Z, 0630HST
Weather	: Beaufort-2, Sea State-1		to 0200Z, 1600HST

Depth (M)	Primary Productivity (μg C/ℓ/hr)
2	0.113
10	0.130
30	0.136
50	0.127
70	0.089
90	0.115
110	0.110
130	--
150	--

Cruise : HOTEC-4 Date (GMT) : 1 Aug. 1979 Time: 0303Z, 1703HST
Ship : R/V Kana Keoki Water Depth: 1350m Wire Angle: 0°
Location: 19°55.3'N, 156°09.2'W Weather: Beaufort-4, Sea State-3

Observed Depths (M)	Chlorophyll-a (μg/ℓ)	Phaeo-Pigments (μg/ℓ)	A.T.P. (ng/ℓ)
0	0.09	ND	20.94
8	0.09	ND	27.44
22	0.08	ND	31.18
35	0.12	0.01	35.31
40	0.12	0.04	30.65
48	0.17	0.06	28.28
62	0.21	0.09	25.55
76	0.19	0.11	18.65
93	0.17	0.09	13.61
138	0.04	ND	7.19
185	0.04	ND	6.81
233	0.03	ND	5.28

Cruise : HOTEC-4 Date (GMT) : 1 Aug. 1979 Time: 1425Z, 0425HST
Ship : R/V Kana Keoki Water Depth: 1355m Wire Angle: 0°
Location: 19°55.7'N, 156°08.9'W Weather: Beaufort-2, Sea State-2

Observed Depths (M)	Chlorophyll-a (μg/ℓ)	Phaeo-Pigments (μg/ℓ)	A.T.P. (ng/ℓ)
0	0.13	0.02	26.75
8	0.11	0.03	25.84
25	0.11	0.02	26.75
40	0.12	0.05	20.16
49	0.20	0.04	--
58	0.27	0.07	17.88
74	0.37	0.13	17.39
92	0.24	0.28	17.73
110	0.05	0.03	7.89
157	0.06	ND	12.77
205	0.04	0.03	6.24
253	0.03	ND	3.60

Cruise	: HOTEC-4	Samples Obtained:	Date (GMT) - 1 August 1979
Ship	: R/V Kana Keoki		Time ------- 1425Z, 0425HST
Location	: 19°55.7'N, 156°08.9'W	Incubation:	Date (GMT) - 1-2 Aug. 1979
Water Depth:	1355m		Time ------- 1700Z, 0700HST to 0300Z, 1700HST
Weather	: Beaufort-3, Sea State 1-2		

Depth (M)	Primary Productivity (µg C/ℓ/hr)
2	0.035
10	0.029
30	0.032
50	0.028
70	0.051
90	0.010
110	0.011
130	0.008
150	0.026

Cruise : HOTEC-5 Date (GMT) : 5 Oct. 1979 Time: 0406Z, 1806HST
Ship : R/V Kana Keoki Water Depth: 850m Wire Angle: 0°
Location: 20°00.7'N, 156°04.4'W Weather: Beaufort-2, Sea State-Calm

Observed Depths (M)	Chlorophyll-a (μg/ℓ)	Phaeo-Pigments (μg/ℓ)	A.T.P. (ng/ℓ)
0	0.10	0.01	27.66
7	0.09	ND	32.90
20	0.08	0.02	40.11
34	0.10	0.01	52.72
50	0.12	0.03	49.12
66	0.25	0.11	41.09
84	0.26	0.09	36.83
101	0.24	0.22	19.96
120	0.13	0.08	9.80
166	0.05	0.02	9.20
214	0.05	0.01	14.43
262	0.05	0.01	8.27

Cruise : HOTEC-5 Date (GMT) : 5 Oct. 1979 Time: 1536Z, 0536HST
Ship : R/V Kana Keoki Water Depth: 1360m Wire Angle: 0°
Location: 19°56.8'N, 156°08.0'W Weather: Beaufort-2, Sea State-Calm

Observed Depths (M)	Chlorophyll-a (μg/ℓ)	Phaeo-Pigments (μg/ℓ)	A.T.P. (ng/ℓ)
0	0.04	0.07	40.27
7	0.04	0.03	22.74
21	0.09	0.02	30.11
37	0.08	0.01	35.19
54	0.10	0.07	46.50
70	0.14	0.07	34.70
88	0.29	0.15	28.15
106	0.15	0.13	19.79
124	0.14	0.08	17.99
170	0.04	0.05	9.96
218	ND	0.15	12.58
267	ND	0.12	6.68

Cruise	: HOTEC-5	Samples Obtained:	Date (GMT) - 5 Oct. 1979
Ship	: R/V Kana Keoki		Time ------- 1536Z, 0536HST
Location	: 19°56.8'N, 156°08.0'W	Incubation:	Date (GMT) - 5-6 Oct. 1979
Water Depth:	1360m		Time ------- 1700Z, 0700HST
Weather	: Beaufort-2, Sea State-Calm		to 0330Z, 1730HST

Depth (M)	Primary Productivity (μg C/ℓ/hr)
2	0.334
10	0.130
30	0.228
50	0.216
70	0.164
90	0.142
110	0.082
130	0.048
150	0.052

Cruise : HOTEC-6 Date (GMT) : 8 Dec. 1979 [Time: 0434Z, 1834HST]
Ship : M/V Noi'i Water Depth: 1350m Wire Angle: 0°
Location: 19°55.3'N, 156°9.2'W Weather: Beaufort-2, Sea State-1

Observed Depths (M)	Chlorophyll-a (μg/ℓ)	Phaeo-Pigments (μg/ℓ)	A.T.P. (ng/ℓ)
0	0.18	ND	24.91
9	0.18	ND	33.96
27	0.20	ND	31.46
46	0.19	ND	19.62
62	0.24	ND	32.99
80	0.38	0.02	31.46
97	0.34	0.04	21.85
114	0.27	0.08	14.19
130	0.18	ND	14.75
173	0.12	ND	7.93
227	0.09	0.01	6.81
265	0.09	0.03	7.23

Cruise : HOTEC-6 Date (GMT) : 8 Dec. 1979 [Time: 1505Z, 0505HST]
Ship : M/V Noi'i Water Depth: 950m Wire Angle: 0°
Location: 19°56.4'N, 156°7.8'W Weather: Beaufort-1, Sea State-1

Observed Depths (M)	Chlorophyll-a (μg/ℓ)	Phaeo-Pigments (μg/ℓ)	A.T.P. (ng/ℓ)
0	0.16	0.02	26.17
9	0.14	0.01	32.57
26	0.19	ND	26.17
43	0.23	ND	31.87
60	0.24	ND	24.63
76	0.29	0.04	29.79
94	0.31	0.08	20.88
109	0.19	0.01	11.55
124	0.15	0.04	16.28
164	0.08	0.01	6.40
209	0.09	0.01	7.51
256	0.10	ND	6.95

Cruise	: HOTEC-6	Samples Obtained:	Date (GMT) - Dec. 8, 1979
Ship	: M/V Noi'i		Time ------- 1505Z, 0505HST
Location	: 19°56.4'N, 156°7.8'W	Incubation:	Date (GMT) - Dec. 8-9, 1979
Water Depth:	925m		Time ------- 1630Z, 0630HST
Weather	Beaufort-1, Sea State-1		to 0130Z, 1530HST

Depth (M)	Primary Productivity (μg C/ℓ/hr)
1	0.001
10	0.002
30	0.013
50	0.001
70	0
90	0.032
110	0.002
130	0
150	0

APPENDIX D

Zooplankton Data For HOTEC 1-6 Cruises

Appendix Table D-1. Zooplankton tow data summary for HOTEC 1.

Cruise: HOTEC-1

Ship: M/V HOLOHOLO

Station: $19^{o}59'$, $156^{o}08'$W

Sample Number:	1	2	3	4	5*
Date:	10-27-78	10-27-78	10-27-78	10-27-78	10-29-78
Time Start (Local):	0915	1130	1610	2110	0925
Net Diameter (m):	0.5	0.5	0.5	0.5	0.5
Mesh Size (μ):	202	202	202	202	202
Tow Type:	Vertical	Vertical	Horizontal	Horizontal	Vertical
Depth Covered (m):	800-0	800-0	25	25	800-0
Wire Out (o):	800	800	50	50	800
Wire Angle (o):	0	0	60	60	0
Flowmeter Revs.:	3225	5655	8893	7276	4855
Volume Filtered (m^3):	96	166	262	214	143
Length of Tow (min):	105	75	15	15	75

*Sample No. 5 - LBL Check Sample

Appendix Table D-2. Zooplankton tow data summary for HOTEC 2.

Cruise: HOTEC- 2

Ship: M/V NOI'I

Station: 19°55'N, 156°08'W

Sample Number:	1	2	3	4*	5
Date:	4-12-79	4-12-79	4-12-79	4-12-79	4-12-79
Time Start (Local):	1142	1330	1455	1900	2030
Net Diameter (m):	0.75	0.75	0.75	0.75	0.75
Mesh Size (μ):	202	202	202	202	202
Tow Type:	Oblique	Oblique	Horizontal	Oblique	Horizontal
Depth Covered (m):	1200-0	400-0	25	480-0	25
Wire Out (m):	1550	1300	35	1300	35
Wire Angle (o):	30-40	50	45	50	45
Flowmeter Revs.:	90605	91086	11693	84485	10729
Volume Filtered (m^3):	2025	2036	261	1888	240
Length of Tow (min):	98	73	10	80	10

*Sample #4 - LBL Check Sample

Appendix Table D-3. Zooplankton tow data summary for HOTEC 3.

Cruise: HOTEC- 3

Ship: M/V EL GRECO

Station: 19°55'N, 156°09'W

Sample Number:	1	2	3	4	5*	6
Date:	6-17-79	6-17-79	6-17-79	6-17-79	6-17-79	6-18-79
Time Start (Local):	1430	1500	-	-	1730	0040
Net Diameter (m):	0.75	0.75	0.5	0.5	0.5	0.5
Mesh Size (μ):	202	202	202	202	202	202
Tow Type:	Oblique	Oblique	Oblique	Horizontal	Oblique	Horizontal
Depth Covered (m):	1000-800	800-200	200-0	25	1000-0	25
Wire Out (m):	-	-	-	35	-	35
Wire Angle (o):	-	-	-	45	-	45
Flowmeter Revs.:	30276	21403	10114	29219	59789	30347
Volume Filtered (m^3):	357	252	53	153	313	159
Length of Tow (min):	-	-	-	10	30	10

*Sample #5 - LBL Check Sample

Appendix Table D-4. Zooplankton tow data summary for HOTEC 4.

Cruise: HOTEC- 4

Ship: R/V KANA KEOKI

Station: 19°56'N, 156°08'W

Sample Number:	1	2	3	4	5	6
Date:	7-29-79	7-29-79	7-29-79	7-29-79	7-29-79	7-29-79
Time Start (Local):	1413	1436	1452	1517	1558	1616
Net Diameter (m):	0.5	0.5	0.5	0.5	0.5	0.5
Mesh Size (μ):	202	202	202	202	202	202
Tow Type:	Horizontal	Horizontal	Oblique	Oblique	Oblique	Oblique
Depth Covered (m):	25	25	25-0	25-0	200-0	200-0
Wire Out (m):	35	35	35	35	300	300
Wire Angle (o):	45	45	45	45	45	45
Flowmeter Revs.:	15443	13626	11336	11376	7326	7541
Volume Filtered (m^3):	81	72	60	60	39	40
Length of Tow (min):	12	12	17	12	11	16

Table D-4 (cont.)

Cruise: HOTEC- 4

Ship: R/V KANA KEOKI

Station: 19°56'N, 156°08'W

Sample Number:	7	8	9*	10	11	12	13
Date:	7-29-79	7-29-79	7-29-79	7-29-79	7-29-79	7-29-79	7-29-79
Time Start (Local):	1642	1728	2005	2059	2115	2136	2156
Net Diameter (m):	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Mesh Size (μ):	202	202	202	202	202	202	202
Tow Type:	Oblique	Oblique	Oblique	Horizontal	Horizontal	Oblique	Oblique
Depth Covered (m):	800-200	800-200	1000-0	25	25	25-0	25-0
Wire Out (m):	1150	1150	1400	35	35	35	35
Wire Angle (o):	45	45	45	45	45	45	45
Flowmeter Revs.:	25448	42328	60468	18566	13694	11908	11344
Volume Filtered (m^3):	34	223	319	98	72	63	60
Length of Tow (min):	32	40	40	10	12	12	12

*Sample #9 - LBL Check Sample

Appendix Table D-5. Zooplankton tow data summary for HOTEC 5.

Cruise: HOTEC- 5

Ship: R/V KANA KEOKI

Station: 19°56'N, 156°08'W

Sample Number:	6	7	8	9	10*	11	12
Date:	10-2-79	10-2-79	10-3-79	10-3-79	10-3-79	10-3-79	10-3-79
Time Start (Local):	2252	2330	0007	0021	0047	0810	0855
Net Diameter(m):	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Mesh Size (μ):	202	202	202	202	202	202	202
Tow Type:	Oblique	Oblique	Oblique	Oblique	Oblique	Oblique	Oblique
Depth Covered (m):	200-25	200-25	25-0	25-0	1000-0	600-200	600-200
Wire Out (m):	250	250	30	30	1200	700	700
Wire Angle (o):	40	40	30	30	30	30	30
Flowmeter Revs.:	38757	37095	10079	9332	81064	56846	50814
Volume Filtered (m^3):	455	435	119	110	953	669	594
Length of Tow (min):	26	29	9	9	40	40	27

Samples 1-5 Unsuccessful - Faulty Trip Mechanism
Sample #10 - LBL Check Sample

Table D-5 (cont.)

Cruise: HOTEC- 5

Ship: R/V KANA KEOKI

Station: 19°56'N, 156°08'W

Sample Number:	13	14	15	16	17	18
Date:	10-3-79	10-3-79	10-3-79	10-3-79	10-4-79	10-4-79
Time State (Local):	0937	1008	1346	1358	0138	0237
Net Diameter (m):	0.75	0.75	0.75	0.75	0.75	0.75
Mesh Size (μ):	202	202	202	202	202	202
Tow Type:	Oblique	Oblique	Oblique	Oblique	Oblique	Oblique
Depth Covered (m):	200-25	200-25	25-0	25-0	600-200	600-200
Wire Out (m):	250	250	30	30	700	700
Wire Angle (o):	30	30	30	30	30	30
Flowmeter Revs.:	29233	27236	18039	7043	90407	59218
Volume Filtered (m^3):	343	321	211	83	1060	695
Length of Tow (min):	22	23	8	6	47	45

Appendix Table D-6. Zooplankton tow data summary for HOTEC 6

Cruise: HOTEC- 6

Ship: R/V NOI'I

Station: 19°56'N, 156°08'W

Sample Number:	1	2	3	4	5	6
Date:	12-7-79	12-7-79	12-7-79	12-7-79	12-7-79	12-7-79
Time Start (Local):	1350	1410	1426	1512	1557	1658
Net Diameter (m):	0.75	0.75	0.75	0.75	0.75	0.75
Mesh Size (μ):	202	202	202	202	202	202
Tow Type:	Oblique	Oblique	Oblique	Oblique	Oblique	Oblique
Depth Covered:	0-25-0	0-25-0	25-200-25	25-200-25	200-600-200	200-600-200
Wire Out (m):	35	35	285	285	850	850
Wire Angle (o):	45	45	45	45	45	45
Flowmeter Revs.:	7130	16388	27468	31458	74467	66190
Volume Filtered (m^3):	84	193	323	370	875	778
Length of Tow (min):	8	9	38	39	56	53

Table D-6 (cont.)

Cruise: HOTEC- 6

Ship: R/V NOI'I

Station: 19°56'N, 156°08'W

Sample Number:	7	8	9	10	11	12	13*
Date:	12-7-79	12-7-79	12-7-79	12-7-79	12-7-79	12-7-79	12-8-79
Time Start (Local):	1937	1947	2003	2034	2116	2245	0158
Net Diameter (m):	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Mesh Size (μ):	202	202	202	202	202	202	202
Tow Type:	Oblique	Oblique	Oblique	Oblique	Oblique	Oblique	Oblique
Depth Covered:	0-25-0	0-25-0	25-200-25	25-200-25	200-600-200	200-600-200	0-1000-0
Wire Out (m):	35	35	285	285	850	850	1400
Wire Angle (o):	45	45	45	45	45	45	45
Flowmeter Revs.:	11633	10184	38082	39465	93378	98007	36925
Volume Filtered (m^3):	137	120	448	464	1097	1152	434
Length of Tow (min):	6	6	24	25	78	63	46

* Sample #13: LBL Check Sample

Appendix Table D-7. Dry weight, ash-free dry weight, and per cent organic content for the zooplankton samples from HOTEC 1, 2, and 3. Weights in (mg/m^3).

	Dry weight	Ash-free dry weight	Per cent organic
HOTEC 1			
800-0 m vertical			
Macro	.28	.25	89.3
Micro	.25	.20	80.0
25 m horizontal day			
Macro	1.63	1.43	87.7
Micro	.53	.45	86.5
25 m horizontal night			
Macro	1.54	1.38	89.6
Micro	1.46	.91	62.3
HOTEC 2			
1200-0 m oblique			
Macro	.96	.84	87.5
Micro	.32	.29	90.6
400-0 m oblique			
Macro	1.14	1.01	88.6
Micro	.39	.34	87.2
25 m horizontal day			
Macro	.96	.84	88.5
Micro	3.83	3.54	92.4
25 m horizontal night			
Macro	1.51	1.26	83.4
Micro	.83	.69	83.1

Table D-7 (cont.)

HOTEC 3			
800-200 m vertical			
Macro	.37	.31	83.8
Micro	.26	.22	84.6
200-0 m vertical			
Macro	3.00	2.19	73.0
Micro	2.19	1.78	81.3
25 m horizontal day			
Macro	.94	.85	90.4
Micro	1.09	.88	80.7
25 m horizontal night			
Macro	1.31	.98	74.8
Micro	1.33	1.18	88.7

Appendix Table D-8. Dry weight, ash-free dry weight, and per cent organic content for the zooplankton samples from HOTEC 4. Weight in (mg/m^3).

Sample #	Depth	Time	Size*	Dry Weight mg/m^3	Ash Free Dry Weight mg/m^3	% Organic
1	25	Day	Macro	5.62	4.79	85.2
			Meso	2.20	1.79	81.4
2	25	Day	Macro	3.92	3.09	78.8
			Meso	2.67	1.97	73.8
3	0-25-0	Day	Macro	2.93	2.53	86.3
			Meso	1.90	1.60	84.2
4	0-25-0	Day	Macro	1.77	1.33	75.1
			Meso	1.70	1.30	76.4
5	0-200-0	Day	Macro	2.12	1.71	80.7
			Meso	1.60	1.40	87.5
6	0-200-0	Day	Macro	1.51	1.31	86.7
			Meso	1.66	1.46	87.9
7	200-800-200	Day	Macro	.85	.72	84.7
			Meso	.30	.25	83.3
8	800-1000-800	Day	Macro	.21	.15	71.4
			Meso	.09	.07	77.8
10	25	Night	Macro	2.24	2.00	89.3
			Meso	1.65	1.49	90.3
11	25	Night	Macro	4.00	3.39	84.8
			Meso	2.03	1.81	89.2
12	0-25-0	Night	Macro	4.51	3.90	86.5
			Meso	2.92	2.57	88.0
13	0-25-0	Night	Macro	5.23	4.60	87.9
			Meso	3.27	2.77	84.7

* Macro Fraction - Retained on 500 μ mesh
Meso Fraction - Passes 500 μ mesh, retained on 200 μ mesh

Appendix Table D-9. Dry weight, ash-free dry weight, and per cent organic content for the zooplankton samples from HOTEC 5. Weight in (mg/m^3).

Sample #	Depth	Time	Size*	Dry Weight mg/m^3	Ash Free Dry Weight	% Organic
15	0-25-0	Day	Macro	.68	.49	72.1
			Meso	.80	.59	73.7
16	0-25-0	Day	Macro	.82	.67	81.7
			Meso	.82	.67	81.7
13	200-25	Day	Macro	1.26	1.00	79.4
			Meso	.87	.65	74.7
14	200-25	Day	Macro	1.07	.83	77.6
			Meso	1.02	.79	77.4
11	600-200	Day	Macro	.69	.56	81.2
			Meso	.44	.32	72.7
12	600-200	Day	Macro	.75	.64	85.3
			Meso	.46	.38	82.6
8	0-25-0	Night	Macro	3.76	1.75	46.5
			Meso	1.92	1.45	75.5
9	0-25-0	Night	Macro	3.67	2.51	68.4
			Meso	2.00	1.38	69.0
6	200-25	Night	Macro	2.12	1.43	67.4
			Meso	1.03	.79	76.7
7	200-25	Night	Macro	1.85	1.31	70.8
			Meso	.87	.67	77.0
17	600-200	Night	Macro	.14	.13	92.9
			Meso	.05	.04	80.0
18	600-200	Night	Macro	.04	.037	92.5
			Meso	.02	.014	70.0

* Macro Fraction - Retained on 500 μ mesh
Meso Fraction - Passes 500 μ mesh, retained on 200 μ mesh

Appendix Table D-10. Dry weight, ash-free dry weight, and per cent organic content for the zooplankton samples from HOTEC 6. Weight in (mg/m^3).

Sample #	Depth	Time	Size*	Dry Weight mg/m^3	Ash Free Dry Weight	% Organic
1	0-25-0	Day	Macro	3.24	2.33	71.9
			Meso	2.52	1.67	66.3
2	0-25-0	Day	Macro	3.77	3.38	89.7
			Meso	1.66	1.22	73.5
3	25-200-25	Day	Macro	1.50	1.20	80.0
			Meso	1.98	1.25	63.1
4	25-200-25	Day	Macro	2.28	1.88	82.5
			Meso	1.86	1.23	66.1
5	200-600-200	Day	Macro	0.65	0.51	78.5
			Meso	0.37	0.24	64.9
6	200-600-200	Day	Macro	0.54	0.47	87.0
			Meso	0.31	0.22	71.0
7	0-25-0	Night	Macro	3.74	3.07	82.1
			Meso	2.13	1.34	62.9
8	0-25-0	Night	Macro	4.77	4.13	86.6
			Meso	4.57	2.50	54.7
9	25-200-25	Night	Macro	2.29	2.01	87.8
			Meso	1.00	0.78	78.0
10	25-200-25	Night	Macro	2.74	2.40	87.6
			Meso	0.99	0.79	79.8
11	200-600-200	Night	Macro	-	-	-
			Meso	-	-	-
12	200-600-200	Night	Macro	0.83	0.74	89.2
			Meso	0.62	0.40	64.5

Appendix Table D-11. Zooplankton abundance (number/m^3) for HOTEC 1.

	1 800-0 m Vertical Day	2 800-0 m Vertical Day	3 25 m Horizontal Day	4 25 m Horizontal Night
Nannocalanus minor	.19		1.49	
Neocalanus gracilis	1.03	.33	1.82	1.14
N. robustior		.54	.71	.07
Undinula vulgaris	.33	.04	.78	5.55
Eucalanus mucronatus	.01	.08	.26	.02
E. elongatus				
E. crassus	.13	.03		
Acrocalanus monachus	1.02	.04		.91
Calocalanus ovalis	.38		3.53	1.83
C. sp. A		.33		.02
M cynocera clausi	2.38	1.52	4.65	3.02
Clausocalanus arcuicornis				
Euaetideus giesbrechti				
Gaetanus sp. A				
Valdeviella brevicornis				
Euchaeta marina	.74	1.00	3.35	4.46
Phaenna spinifera				.05
Scolecithrix danae	.19	.22	1.53	2.33
S. bradyi	.02	.01	.07	
Scottocalanus thomasi	.01	.01		
Lophothrix latipes	.01	.05		
Pleuromamma xiphias	.10	.08		
P. abdominalis	.27	.66		2.22
P. piseki	.34	.38	.37	1.58
P. quadrangulata				
Centropages violacaeus	.85	.06	1.15	1.71
C. calaninus				.02
C. bradyi				.02
Lucicutia flavicornis	2.39	.41		2.79
L. clausi				
Haloptilis oxycephalis				.02
Euaugaptilis rigidus?	.74	1.38		
Paracandacia truncata				.05
Candacia bipinnata	.04	.03		.11
C. varicans	.88	.21	.07	.25
C. paenelongimana	.01			.02
Pontellina plumata	.02	.01	.22	.02
Labidocera sp. A	.01			
Neopontella sp. A				
Parundinella sp. A	.01			
Acartia danae	.02			
A. negligens	1.44	1.44	7.85	5.71
Mormonilla phasma				

Table D-11 (cont.)

	1	2	3	4
Oithona setigera linerais	12.80	10.44	33.82	34.29
Oncaea venusta	2.22	1.23	1.60	8.85
O. mediterranea	2.48	3.08	1.71	.85
O. conifera	.25			.23
Conaea gracilis				3.89
Lubbockia squillimana	.01			.05
Sapphirina metallina	.02			
S. nigromaculata		.04	.07	.18
S. ovatolanceolata				
S. sp. A	.01		.07	
Copilia mirabilis	.04	.04	.04	.18
Corycaeus speciosus	2.59	1.21	5.02	2.70
C. clausi	.39	.33	.15	1.65
C. lautus	.33	.22	.74	.85
C. typicus	.38	.22		.16
C. limbatus				16.00
Farranula gracilis	.42		.74	.07
Clytemnestra scutellata	.04	.01		.23
Macrosetella gracilis	.66	.12	1.49	.46
Microsetella rosea	.02			.02
Euterpina acutifrons	.05			
Miracia efferata				
Microcalanoid	7.14	5.50	32.60	4.22
Pleuromamma copepodite				7.77
Candacia copepodite			1.75	.91
Calanoid nauplius	1.30	1.65	.15	
Calanoid copepodite				
Oncaea copepodite				
Corycaeus copepodite			.78	1.60
Unidentified copepod	.05	.19	.19	.46
Ostracod	2.04	2.90	.22	3.79
Hypediid amphipod	.13	.08	.74	.32
Euphausiid juvenile	.08	.09	.29	.48
Euphausiid zoea	.02	.05		
Euphausiid nauplius	.13		.93	
Decapod zoea	.02	.04	.19	.02
Brachyuran zoea		.11		
Penaeid zoea				1.76
Mysid				
Lucifer sp.	.18		.19	.11
Radiolarians	.38			
Foraminifera				
Siphonophore	.05	.08	.04	.05
Hydromedusae		.14		.05
Polychaetes	.46	.08	.74	.55
Gastropod		.67		.14
Bivalve				39.63
Heteropod				.18
Pteropod		.22	.07	.07
Echinoderm larva				
Salp		.27	.56	.66
Doliolid	.19	.25	.67	.48
Larvacean	3.64	3.28	1.97	2.15
Chaetognath	1.19	1.30	3.53	4.16

Appendix Table D-12. Zooplankton abundance (number/m^3) for HOTEC 2.

	1 1200-0 m Oblique Day	2 400-0 m Oblique Day	3 25 m Horizontal Day	4 25 m Horizontal Night
Nannocalanus minor	.13	.21	.06	.37
Neocalanus gracilis	.22	.21	1.86	1.11
N. robustior	.02	.05	.19	.24
Undinula vulgaris	.02	.02		.03
Eucalanus mucronatus	.05	.03		
E. elongatus	.02	.02		
E. crassus		.08		
Acrocalanus monachus			1.33	.40
Calocalanus ovalis	.80	.33	.62	.34
C. sp. A				
M cynocera clausi	.69	.33	1.24	1.05
Clausocalanus arcuicornis				
Euaetideus giesbrechti		.02		
Gaetanus sp. A		.02		
Valdeviella brevicornis	.02			
Euchaeta marina	1.39	1.22	1.08	5.30
Phaenna spinifera				
Scolecithrix danae	.05	.65	.16	.14
S. bradyi				
Scottocalanus thomasi		.03		
Lophothrix latipes				
Pleuromamma xiphias	.10			
P. abdominalis	.11	1.26	.03	.17
P. piseki	.67	3.34	.03	7.46
P. quadrangulata	.05	.02		
Centropages violacaeus	.08	.64	2.91	.84
C. calaninus				
C. bradyi				
Lucicutia flavicornis	2.75	.54		3.00
L. clausi		1.50		
Haloptilis oxycephalis		.02		
Euaugaptilis rigidus?	.85	.83		.07
Paracandacia truncata				
Candacia bipinnata	.02	.08		
C. varicans		.05		.27
C. paenelongimana			.06	.03
Pontellina plumata	.02	.02	.68	.10
Labidocera sp. A				
Neopontella sp. A			.03	
Parundinella sp. A	.02			
Acartia danae	.40	.51		
A. negligens	4.16	1.73	10.60	23.83
Mormonilla phasma	.96	.16	6.85	3.38

Table D-12 (cont.)

	1	2	3	4
Oithona setigera linerais	7.71	4.96	28.22	8.64
Oncaea venusta	.30	.02	1.27	.67
O. mediterranea	2.93	2.59		1.01
O. conifera	.80	.65		
Conaea gracilis	.82	.05	.62	
Lubbockia squillimana	.24		.62	.03
Sapphirina metallina				.07
S. nigromaculata	.02		.19	.37
S. ovatolanceolata		.02		
S. sp. A			.03	
Copilia mirabilis	.08	.05	.19	.17
Corycaeus speciosus	.26	.41	3.07	4.15
C. clausi	.05		.62	.17
C. lautus	.26	.13	1.52	1.11
C. typicus				.47
C. limbatus	1.28	.48	26.08	27.92
Farranula gracilis	.24			
Clytemnestra scutellata				
Macrosetella gracilis	.02	.06		
Microsetella rosea				
Euterpina acutifrons	.02	.02		.03
Miracia efferata				.03
Microcalanoid	20.39	9.47	548.37	39.32
Pleuromamma copepodite	1.63	3.24	1.98	.33
Candacia copepodite	.35	.84	1.86	1.80
Calanoid nauplius		.32		.67
Calanoid copepodite				
Oncaea copepodite	1.33	2.39		4.79
Corycaeus copepodite	3.76	1.14	8.49	5.27
Unidentified copepod	.05			
Ostracod	5.07	3.69		2.80
Hypediid amphipod	.16	.10	.22	.51
Euphausiid juvenile	.22		.12	1.35
Euphausiid zoea		.92		
Euphausiid nauplius	.40	.22	1.24	
Decapod zoea	.14	.11	.16	.24
Brachyuran zoea		.19		.03
Penaeid zoea	.06	.02		
Mysid		.02	.03	.07
Lucifer sp.				.07
Radiolarians		.16		
Foraminifera	.08	.16		
Siphonophore	.10	.30	.62	.61
Hydromedusae				.07
Polychaetes	.02	.05	.06	.14
Gastropod	.59	.25	.06	4.93
Bivalve	.50			.37
Heteropod			.03	.07
Pteropod	.16	.22		.64
Echinoderm larva	.08		2.76	2.26
Salp	.05	.03	.12	
Doliolid	.03	.10	.16	.24
Larvacean	.64	.17	10.57	4.52
Chaetognath	.85	1.83	7.38	5.87

Appendix Table D-13. Zooplankton abundance (number/m^3) for HOTEC 3.

	1	2	3	4	5
	1200-0 m Vertical Day	800-0 m Vertical Day	200-0 m Vertical Day	25 m Horizontal Day	25 m Horizontal Night
Nannocalanus minor		.02	.10	.09	
Neocalanus gracilis		.02	2.03	.26	.09
N. robustior			.20	.09	
Undinula vulgaris		.02	2.03	1.71	11.43
Eucalanus mucronatus		.06	.30		
E. elongatus		.03		.17	.60
E. crassus					
Acrocalanus monachus	.07	.08	.92	2.05	.77
Calocalanus ovalis			4.27	3.84	3.93
C. sp. A					
M cynocera clausi		.09	8.14	3.84	6.23
Clausocalanus arcuicornis			10.08		
Euaetideus giesbrechti					
Gaetanus sp. A		.10			
Valdeviella brevicornis					
Euchaeta marina		.47	3.36	1.96	5.37
Phaenna spinifera		.02	.36		
Scolecithrix danae	.02	.02	1.63	.60	3.58
S. bradyi				.09	
Scottocalanus thomasi				.43	
Lophothrix latipes		.03			
Pleuromamma xiphias	.02	.14			
P. abdominalis	.02	.06	.10		.94
P. piseki		1.71	.41		9.90
P. quadrangulata					.09
Centropages violacaeus			1.22	1.88	1.19
C. calaninus					
C. bradyi					
Lucicutia flavicornis	.43	.89	8.24		7.85
L. clausi					
Haloptilis oxycephalis					
Euaugaptilis rigidus?	.11	.89	2.34	.34	
Paracandacia truncata			.51		.09
Candacia bipinnata			.51	.26	
C. varicans			1.63		.77
C. paenelongimana			.10	1.28	
Pontellina plumata			.92	.17	
Labidocera sp. A					.09
Neopontella sp. A					
Parundinella sp. A					
Acartia danae		.02			
A. negligens		.24	20.87	16.89	19.20
Mormonilla phasma	.57	1.58	.81	.34	.77

Table D-13 (cont.)

	1	2	3	4	5
Oithona setigera linerais	.02	2.96	81.63	13.56	20.99
Oncaea venusta	.09	1.49	10.89	9.81	12.97
O. mediterranea	.05	5.89	10.69	2.30	1.71
O. conifera		.72			.68
Conaea gracilis	.05	.26	.81		
Lubbockia squillimana		.18	2.54		1.62
Sapphirina metallina					
S. nigromaculata					
S. ovatolanceolata					
S. sp. A		.06	1.12	.34	.34
Copilia mirabilis				.34	.43
Corycaeus speciosus		.20	2.85	3.24	3.16
C. clausi	.02		1.32	1.02	1.02
C. lautus			2.14	2.06	1.79
C. typicus		.03			
C. limbatus	.05	.36	4.48	11.77	17.92
Farranula gracilis					
Clytemnestra scutellata	.02				
Macrosetella gracilis				.34	
Microsetella rosea				.34	
Euterpina acutifrons	.05	.06			
Miracia efferata					
Microcalanoid	.36	9.81	138.02	101.08	135.44
Pleuromamma copepodite	.07	3.01	3.66	.09	1.11
Candacia copepodite		.27	1.63	3.16	4.35
Calanoid nauplius	.02		4.17		2.05
Calanoid copepodite		.06	.81		
Oncaea copepodite	.29	1.36	29.41	4.78	32.18
Corycaeus copepodite	.02	.05	5.70	2.05	3.58
Unidentified copepod	.32	.54	2.85		
Ostracod	.07	1.89	3.16	.09	12.80
Hypediid amphipod		.06	.61	.43	2.05
Euphausiid juvenile		.23	.10	.17	1.79
Euphausiid zoea		.11	2.54	6.56	1.37
Euphausiid nauplius		.09	2.65	7.68	4.86
Decapod zoea		.02	.30	.26	.26
Brachyuran zoea					
Penaeid zoea				.09	
Mysid					.09
Lucifer sp.					
Radiolarians		.42	6.21	4.95	9.13
Foraminifera		.12	.10		
Siphonophore		.03			.26
Hydromedusae			.20	.17	.17
Polychaetes		.03	2.75	.34	1.11
Gastropod	.02	.91	7.43	10.49	13.23
Bivalve		.24	3.56	3.93	10.93
Heteropod					
Pteropod		.05			1.11
Echinoderm larva			1.32	.85	.51
Salp				.60	
Doliolid		.02	.20	.09	.43
Larvacean		.03	77.76	41.62	47.79
Chaetognath	.05	.72	11.09	3.66	7.93

Appendix Table D-14. Taxonomic summary for HOTEC 1. Number/m^3

Sample Number:	1	2	3	4
	800-0 m Vertical Day	800-0 m Vertical Day	25 m Horizontal Day	25 m Horizontal Night
Calanoid copepod	9.78	6.97	19.67	28.14
Microcalanoid copepod	11.84	9.04	42.68	18.68
Cyclopoid copepod	21.95	16.81	43.96	69.95
Harpacticoid copepod	.77	.13	1.49	.71
Ostracod	2.04	2.90	.22	3.79
Amphipod	.13	.08	.74	.32
Euphausiid	.23	.14	1.22	.48
Decapod	.20	.15	.38	1.89
Radiolarian	.38			
Foraminifera				
Siphonophore	.05	.08	.04	.05
Hydromedusa		.15		.05
Polychaete	.46	.08	.74	.55
Gastropod		.67		.14
Bivalve				39.63
Heteropod				.18
Pteropod		.22	.07	.07
Salp		.27	.56	.66
Doliolid	.19	.25	.67	.48
Larvacean	3.64	3.28	1.97	2.15
Chaetognath	1.19	1.30	3.53	4.16

Appendix Table D-15. Taxonomic summary for HOTEC 2. Number /m^3

Sample Number:	1	2	3	4
	1000-0 m Oblique Day	400-0 m Oblique Day	25 m Horizontal Day	25 m Horizontal Night
Calanoid copepod	12.11	13.27	24.25	46.34
Microcalanoid copepod	23.86	14.53	591.40	43.91
Cyclopoid copepod	20.08	12.89	70.92	54.84
Harpacticoid copepod	.04	.06		.08
Ostracod	5.07	3.69		2.80
Amphipod	.16	.10	.22	.51
Euphausiid	.64	1.14	1.36	1.35
Decapod	.20	.34	.19	.41
Radiolarian		.16		
Foraminifera	.08	.16		
Siphonophore	.10	.30	.62	.61
Hydromedusa				.07
Polychaete	.02	.05	.06	.15
Gastropod	.59	.25	.06	4.93
Bivalve	.50			.37
Heteropod			.03	.07
Pteropod	.16	.22		.64
Salp	.05	.03	.12	
Doliolid	.03	.10	.16	.24
Larvacean	.64	.17	10.57	4.52
Chaetognath	.85	1.83	7.38	5.87

Appendix Table D-16. Taxonomic summary for HOTEC 3. Number/m^3

Sample Number:	1	2	3	4	5
	1000-800 m Vertical Day	800-200 m Vertical Day	200-0 m Vertical Day	25 m Horizontal Day	25 m Horizontal Night
Calanoid copepod	1.17	6.36	47.91	26.56	61.96
Microcalanoid copepod	.52	13.32	171.60	114.06	153.88
Cyclopoid copepod	.59	13.56	153.58	51.27	98.39
Harpacticoid copepod	.07	.06		.68	
Ostracod	.07	1.89	3.16	.09	12.80
Amphipod		.06	.61	.43	2.05
Euphausiid		.43	5.29	14.41	8.02
Decapod		.02	.30	.35	.35
Radiolarian		.42	6.21	4.95	9.13
Foraminifera		.12	.10		
Siphonophore		.03			.26
Hydromedusa			.20	.17	.17
Polychaete		.03	2.75	.34	1.11
Gastropod	.02	.91	7.43	10.49	13.23
Bivalve		.24	3.56	3.93	10.93
Heteropod					
Pteropod		.05			1.11
Salp				.60	
Doliolid		.02	.20	.09	.43
Larvacean		.03	77.76	41.62	47.79
Chaetognath	.05	.72	11.09	3.66	7.93

Appendix Table D-17. Taxonomic summary for HOTEC 4. Number/m^3

Sample Number:	1	2	3	4	5	6
	25 m Horizontal Day	25 m Horizontal Day	25–0 m Oblique Day	25–0 m Oblique Day	0–200–0 m Oblique Day	0–200–0 m Oblique Day
Calanoid copepod	104.05	47.62	36.27	28.80	22.74	18.89
Microcalanoid copepod	225.77	256.36	182.40	172.80	142.22	146.33
Cyclopoid copepod	58.90	90.79	103.47	73.07	144.70	145.93
Harpacticoid copepod						
Ostracod	2.36				9.10	14.07
Amphipod					.41	
Euphausiid	.78	1.78	1.07	.53	.41	3.22
Decapod	.39	.89		.53		.80
Radiolarian	4.32	9.35	9.60	11.73	7.44	2.81
Foraminifera	1.57	1.78				
Siphonophore				1.06	2.48	4.02
Hydromedusa	.78				.41	1.21
Polychaete	.39		1.60	.53	1.65	.40
Gastropod	4.32	3.56	3.73	4.80	4.96	5.63
Bivalve	1.57	2.23	2.67	3.73	.83	2.41
Heteropod						1.61
Pteropod			.53			.40
Salp	.78	2.23	2.67	3.20	.83	
Doliolid	1.57	2.23	3.20		3.31	6.43
Larvacean	179.83	162.00	208.53	224.00	195.55	225.13
Chaetognath	1.96	5.34	6.93	2.67	8.68	5.23
Cladoceran			1.07	1.60	.41	.40
Echinoderm larvae			.53		.41	.80

Table D-17 (cont.)

Sample Number:	7	8	10	11	12	13
	200-800-200 m Oblique Day	800-1200-800 m Oblique Day	25 m Horizontal Night	25 m Horizontal Night	25-0 m Oblique Night	25-0 m Oblique Night
Calanoid copepod	6.93	1.08	21.88	33.78	30.98	26.13
Microcalanoid copepod	27.58	3.80	115.92	110.67	229.08	272.00
Cyclopoid copepod	25.19	3.37	135.18	132.89	163.05	138.67
Harpacticoid copepod	.24		.65			.53
Ostracod	3.46	.22	8.49	11.11	4.57	4.27
Amphipod	.12	.14	1.96	1.78	.50	
Euphausiid	.72	.11	13.06	4.44	5.08	4.80
Decapod					.50	
Radiolarian	.72	.11	2.29	2.67	6.09	1.60
Foraminifera						
Siphonophore	.48		.65	4.44	6.09	4.27
Hydromedusa		.04	.33	.44	.50	3.73
Polychaete			.65			2.13
Gastropod	.72	.14	1.63	1.33	16.76	18.67
Bivalve	.12		3.27	3.11	10.67	5.33
Heteropod			.33	.44		
Pteropod			.65		1.52	.53
Salp					.50	
Doliolid			1.63	.89		
Larvacean	36.06	6.35	134.53	176.89	174.22	200.00
Chaetognath	.84	.04	3.59	2.22	9.65	9.07
Cladoceran					1.52	1.06
Echinoderm larvae	.24	.07				.53

Appendix Table D-18. Taxonomic summary for HOTEC 5. Number/m^3

Sample Number:	6	7	8	9
	200–25 m Oblique Night	200–25 m Oblique Night	25–0 m Oblique Night	25–0 m Oblique Night
Calanoid copepod	17.82	12.36	22.23	26.37
Microcalanoid copepod	72.96	65.32	126.92	122.57
Cyclopoid copepod	61.14	52.38	84.97	106.28
Harpacticoid copepod	.18	.20	1.79	1.16
Ostracod	11.44	11.57	5.02	5.43
Amphipod	.56	.20	-	.78
Euphausiid	1.31	1.57	1.43	.78
Decapod	.75	.20	-	.39
Radiolarian	2.44	.59	2.15	4.27
Foraminifera	-	-	-	-
Siphonophore	1.69	1.77	.36	1.55
Hydromedusa	.18	.59	.72	1.55
Polychaete	.56	.98	.72	1.94
Gastropod	4.50	6.87	8.96	11.25
Bivalve	8.06	6.67	24.74	24.05
Heteropod	.18	-	.36	.39
Pteropod	-	.98	.36	1.16
Salp	.36	-	-	.39
Doliolid	.56	.59	.36	1.55
Larvacean	27.38	22.56	48.40	40.34
Chaetognath	5.81	2.75	16.49	14.74
Cladoceran	-	-	-	-
Echinoderm larvae	.94	.59	.72	.39

Table D-18 (cont.)

Sample Number:	11	12	13	14
	600-200 m Oblique Day	600-200 m Oblique Day	200-25 m Oblique Day	200-25 m Oblique Day
Calanoid copepod	5.36	6.39	8.46	7.71
Microcalanoid copepod	35.59	34.98	74.39	82.41
Cyclopoid copepod	24.04	25.79	54.98	60.61
Harpacticoid copepod	.06	.50	.25	.80
Ostracod	4.78	4.60	12.69	8.11
Amphipod	.38	.14	.87	.53
Euphausiid	.32	.65	1.12	.40
Decapod	-	-	.50	.13
Radiolarian	1.02	.72	4.10	5.45
Foraminifera	-	-	-	1.60
Siphonophore	.38	.36	2.11	1.20
Hydromedusa	-	-	.25	.93
Polychaete	.13	-	.62	.13
Gastropod	1.98	1.44	2.61	8.11
Bivalve	2.74	2.23	4.23	23.66
Heteropod	-	-	-	-
Pteropod	.06	.07	-	.13
Salp	-	-	.62	-
Doliolid	.19	.14	1.74	.93
Larvacean	7.21	4.81	24.51	34.56
Chaetognath	2.74	2.44	7.09	5.72
Cladoceran	.06	-	-	-
Echinoderm larvae	.13	.14	.25	.53

Table D-18 (cont.)

Sample Number:	15	16	17	18
	25-0 m Oblique Day	25-0 m Oblique Day	600-200 m Oblique Night	600-200 m Oblique Night
Calanoid copepod	3.64	6.17	1.35	.36
Microcalanoid copepod	52.78	50.38	3.22	.48
Cyclopoid copepod	41.05	51.92	3.40	.74
Harpacticoid copepod	1.01	1.03	.02	-
Ostracod	.40	-	1.03	.12
Amphipod	-	.51	.02	-
Euphausiid	.20	-	.04	.02
Decapod	-	-	.02	.01
Radiolarian	5.26	5.14	.14	.01
Foraminifera	.61	.51	-	-
Siphonophore	.20	1.54	-	-
Hydromedusa	-	-	-	.01
Polychaete	.20	-	-	-
Gastropod	2.83	2.06	.06	.01
Bivalve	8.29	10.28	.04	.01
Heteropod	-	-	-	-
Pteropod	.20	-	.02	-
Salp	-	-	-	-
Doliolid	.81	-	-	.01
Larvacean	24.27	57.06	.52	.07
Chaetognath	4.85	3.08	.42	.09
Cladoceran	-	-	-	-
Echinoderm larvae	.61	-	-	-

Appendix Table D-19. Taxonomic summary for HOTEC 6. Number/m^3

Sample Number:	1	2	3	4
	0-25-0 m Oblique Day	0-25-0 m Oblique Day	25-200-25 m Oblique Day	25-200-25 m Oblique Day
Calanoid copepod	33.02	48.64	18.60	22.14
Microcalanoid copepod	101.59	119.38	118.69	111.16
Cyclopoid copepod	85.33	67.21	67.55	62.27
Harpactiloid copepod	2.03	1.77	1.09	.46
Ostracod			4.65	5.30
Amphipod		.44		.46
Euphausiid	.51			.46
Decapod	2.54	1.33	.55	.46
Radiolarian	.51	1.77	13.40	21.91
Foraminifera	.51	1.77		1.61
Siphonophore				.69
Hydromedusa				
Polychaete	2.03	1.33	1.09	.46
Gastropod	33.52	28.74	15.31	3.23
Bivalve	7.11	10.17	74.93	33.44
Heteropod				
Pteropod				
Salp				.46
Doliolid		.44	2.18	1.38
Larvacean	1.01	9.73	10.94	15.45
Chaetognath	9.14	15.03	4.65	8.99
Echinoderm Larvae				.92

Table D-19 (cont.)

Sample Number:	5	6	7	8
	200-600-200 m Oblique Day	200-600-200 m Oblique Day	0-25-0 m Oblique Night	0-25-0 m Oblique Night
Calanoid copepod	8.58	5.04	59.80	86.76
Microcalanoid copepod	20.97	17.55	127.07	210.49
Cyclopoid copepod	13.46	11.41	61.66	83.20
Harpactiloid copepod	.39	.22	4.98	4.27
Ostracod	4.29	4.28	9.34	11.38
Amphipod	.20	.11	.62	2.13
Euphausiid	.78	.44		2.13
Decapod		.11	.62	1.42
Radiolarian	1.46	1.75	1.87	.71
Foraminifera				
Siphonophore			1.25	
Hydromedusa				.71
Polychaete			1.87	.71
Gastropod	.78	.99	8.72	24.18
Bivalve	3.02	4.50	62.91	131.55
Heteropod				
Pteropod			.62	
Salp				
Doliolid	.20	.11	.62	2.13
Larvacean	1.17	.33	15.57	41.96
Chaetognath	1.56	1.43	2.49	10.67
Echinoderm Larvae		.11	.62	1.42

Table D-19 (cont.)

Sample Number:	9	10	11*	12
	25-200-25 m Oblique Night	25-200-25 m Oblique Night		200-600-200 m Oblique Night
Calanoid copepod	21.14	22.62		11.11
Microcalanoid copepod	57.71	58.67		31.48
Cyclopoid copepod	53.14	53.33		29.26
Harpactiloid copepod		.37		.22
Ostracod	6.48	6.25		3.70
Amphipod	.76	.55		.30
Euphausiid	2.48	2.21		.67
Decapod	.57	.37		.22
Radiolarian	4.57	4.78		.74
Foraminifera				
Siphonophore	.57	.74		.15
Hydromedusa				.22
Polychaete	1.33	1.29		.52
Gastropod	5.90	6.07		1.04
Bivalve	14.48	15.45		10.52
Heteropod	.38	.37		
Pteropod	.38	.55		
Salp				
Doliolid	1.14	1.29		.67
Larvacean	11.42	10.67		6.22
Chaetognath	2.48	2.39		2.07
Echinoderm Larvae	.57	.37		.30

*Sample lost in processing

Appendix Table D-20. Larval fish taken during HOTEC 3. Number/sample.

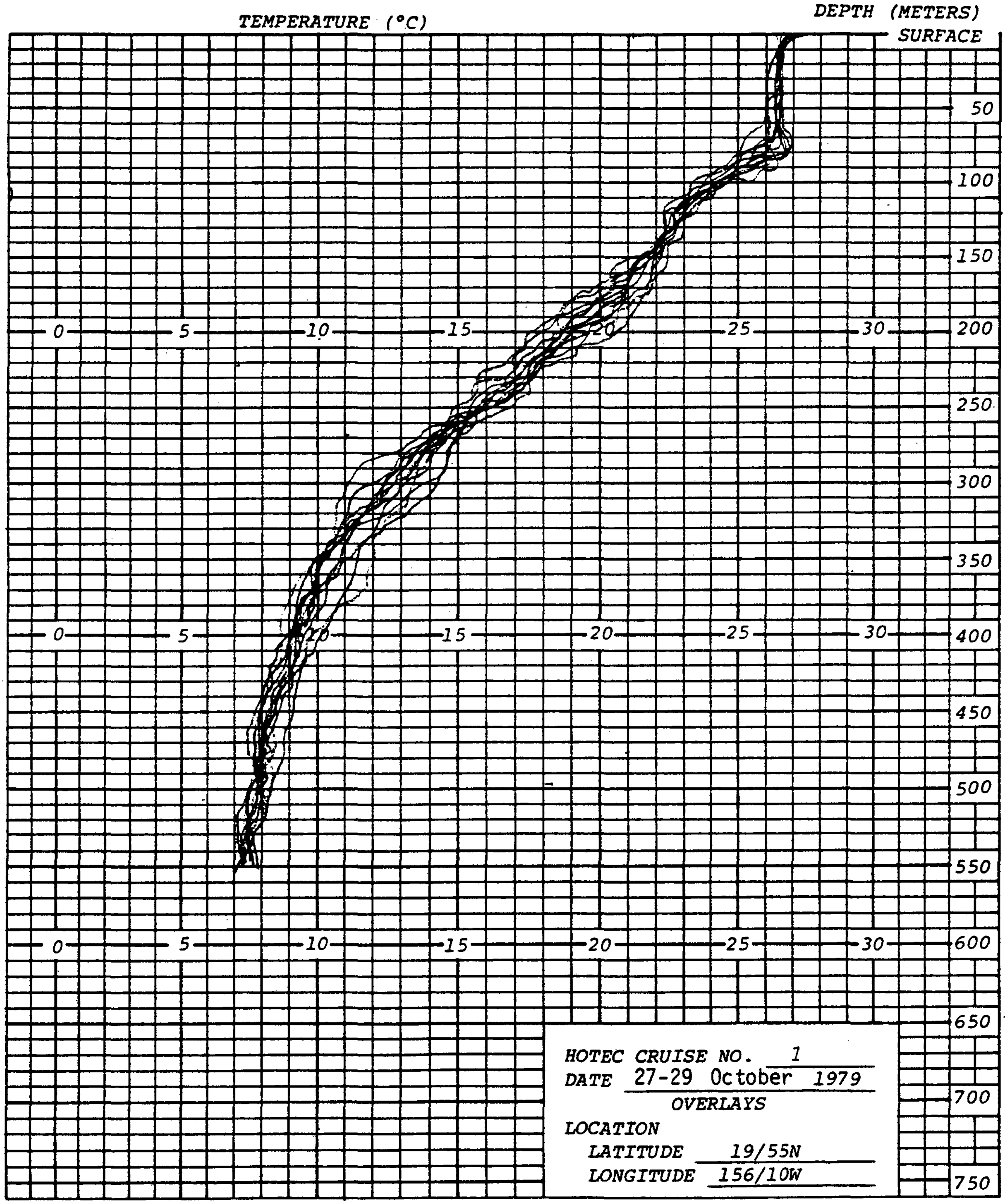
	Oblique #1 1200 - 800 m	Oblique #2 800 - 200 m	Oblique #3 200 - 0 m	Horizontal #1 25 m day	Horizontal #2 25 m night
Blennidae					
Enchelyurus brunneolus	1				
Carangidae					
Megalaspis cordyla		1			
Exoctidae			1		
Gempylidae					
Cempylus serpens					1
Gonostomatidae					
Cyclothone sp.	1	16	1	2	7
Diplophos taenia		1		1	1
Gonostoma sp.	1	1			
Iniomidae		1			
Melamphaeidae					
Melamphes danae	1				
Melamphes sp.	1				
Melanocoetidae					
Melanocoetus johnsoni			1	1	
Melanostomiatidae					
Melanostomias biseriatus		1			
Molidae					
Ranzania levis		1	1	2	1
Mycotophidae					
Benthosema fibulatum					1
Benthosema sp.	2	4			
Bolinichthys sp.					1
Ceratoscopelus warmingi	3	5	11	38	4
Ceratoscopelus sp.					4
Diaphus theta	1				
Diaphus sp.	1		5		4
Diogenichythys atlanticus	2				
Diogenichythys sp.			1		
Hypogophum proximum	4	1			
Hypogophum reinhardti	3				
Lampanyctus nobilis					1

Table D-20 (contd.)

	Oblique #1 1200-800 m	Oblique #2 800-200 m	Oblique #3 200-0 m	Horizontal #1 25 m day	Horizontal #2 25 m night
Mycotophidae (cont.)					
Lanpanyctus sp.	1	1	3		
Lampadena luminosa					2
Lampadena sp.					4
Symbolophorus californiensis	1		4		
Unidentified myctophid	4	4			3
Notosudidae					
Scopelosaurus sp.	1				
Phatichthiidae					
Valencienellus tripunctulatus			2		
Serranidae			1		
Sternoptychidae					
Argyropelecus aculeatus		1			
Unidentified leptocephalus					1
Unidentified yolk sac	1	1	1	2	2
Unidentified damaged	19	10	6	1	3
Unidentified	11	10	1	6	4

APPENDIX E

XBT Data For HOTEC 1-6 Cruises



TEMPERATURE (°C)
DEPTH (METERS)
SURFACE
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100
150
200
250
300
350
400
450
500
550
600
650
700
750
0
5
10
15
20
25
30
HOTEC CRUISE NO. 1
DATE 27-29 October 1979
OVERLAYS
LOCATION
LATITUDE 19/55N
LONGITUDE 156/10W

ISOTHERM DEPTHS (M)

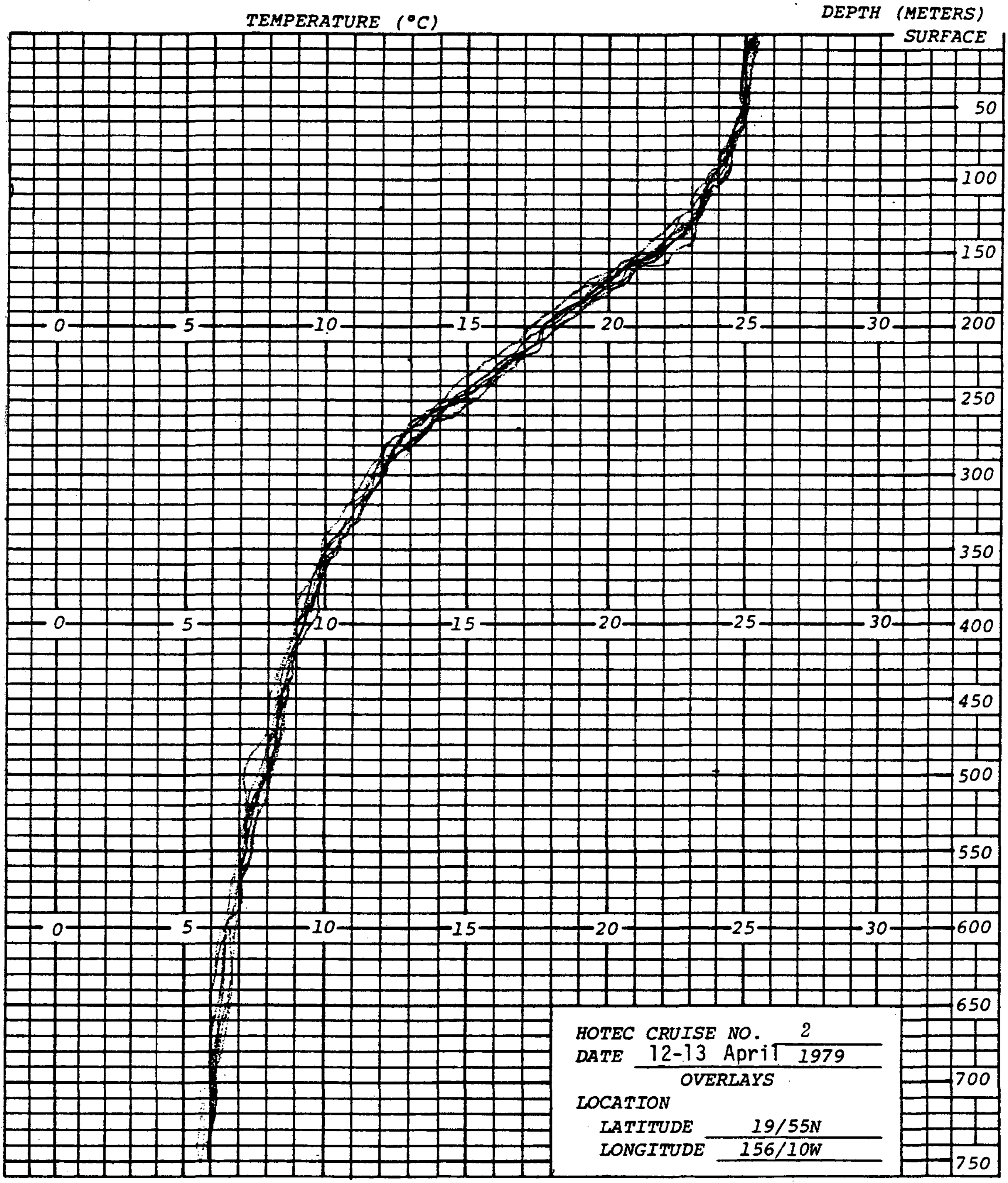
HOTEC CRUISE # 1 SHIP: M/V HoLoHoLo

XBT no.	1	2	3	4	5	6	
LATITUDE °	20	19	20	19	19	19	
′	05	59	01	56	58	59	
LONGITUDE °	156	156	156	156	156	156	
′	02	08	05	16	12	08	
DATE (GMT)	10/27/78	10/28/78	10/28/78	10/28/78	10/28/78	10/28/78	
TIME (GMT)	2115	0300	0450	0700	0845	1145	
TIME (LOCAL)	1115	1700	1850	2100	2245	0145	
SURF. T (°C)	27.7	27.6	27.0	26.8	26.9	26.5	
29							
28							
27	02	03					
26	64	76	75	91	84	88	
25	91	91	91	104	94	91	
24	100	107	102	116	108	104	
23	134	119	128	139	136	122	
22	152	149	142	171	162	149	
21	168	172	168	185	195	175	
20	175	190	178	198	201	197	
19	198	198	192	210	213	211	
18	213	216	223	225	226	218	
17	238	245	235	236	238	238	
16	248	256	247	250	248	253	
15	259	259	253	256	259	268	
14	274	277	268	264	268	296	
13	290	297	277	277	290	309	
12	314	335	308	300	311	320	
11	332	369	338	328	331	335	
10	347	396	379	366	355	372	
9	396	441	425	408	396	421	
8	442	491	469	442	440	472	
7							
6							

ISOTHERM DEPTHS (M)

HOTEC CRUISE # 1 SHIP: M/V HoLoHoLo

XBT no.	7	8	9	10	11	12	
LATITUDE °	19	19	20	19	19	20	
′	59	59	00	59	59	05	
LONGITUDE °	156	156	156	156	156	156	
′	08	12	12	08	05	04	
DATE (GMT)	10/28/78	10/28/78	10/28/78	10/29/78	10/29/78	10/29/78	
TIME (GMT)	1330	1545	2000	0050	1745	2100	
TIME (LOCAL)	0330	0545	1000	1450	0745	1100	
SURF. T (°C)	25.6	26.5	27.3	27.7	27.0	27.1	
29							
28							
27			08	03		03	
26		79	84	79	98	91	
25	75	85	101	93	101	104	
24	81	98	114	104	107	114	
23	94	114	122	128	125	140	
22	108	128	152	145	145	160	
21	142	157	175	168	152	172	
20	165	166	189	174	180	198	
19	186	175	204	183	191	210	
18	195	187	219	213	201	219	
17	206	213	236	226	229	244	
16	226	226	244	248	232	250	
15	244	247	259	270	256	253	
14	267	280	271	285	274	271	
13	305	297	303	317	290	274	
12	320	309	320	344	314	282	
11	328	320	335	378	343	309	
10	338	347	358	394	381	351	
9	366	393	389	426	421	378	
8	408	442	457	495	488	462	
7	465						
6							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DEPTH (METERS)
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350
0
5
10
15
20
25
30
400
450
500
550
0
5
10
15
20
25
30
600
650
700
750
HOTEC CRUISE NO. 2
DATE 12-13 April 1979
OVERLAYS
LOCATION
LATITUDE 19/55N
LONGITUDE 156/10W

ISOTHERM DEPTHS (M)

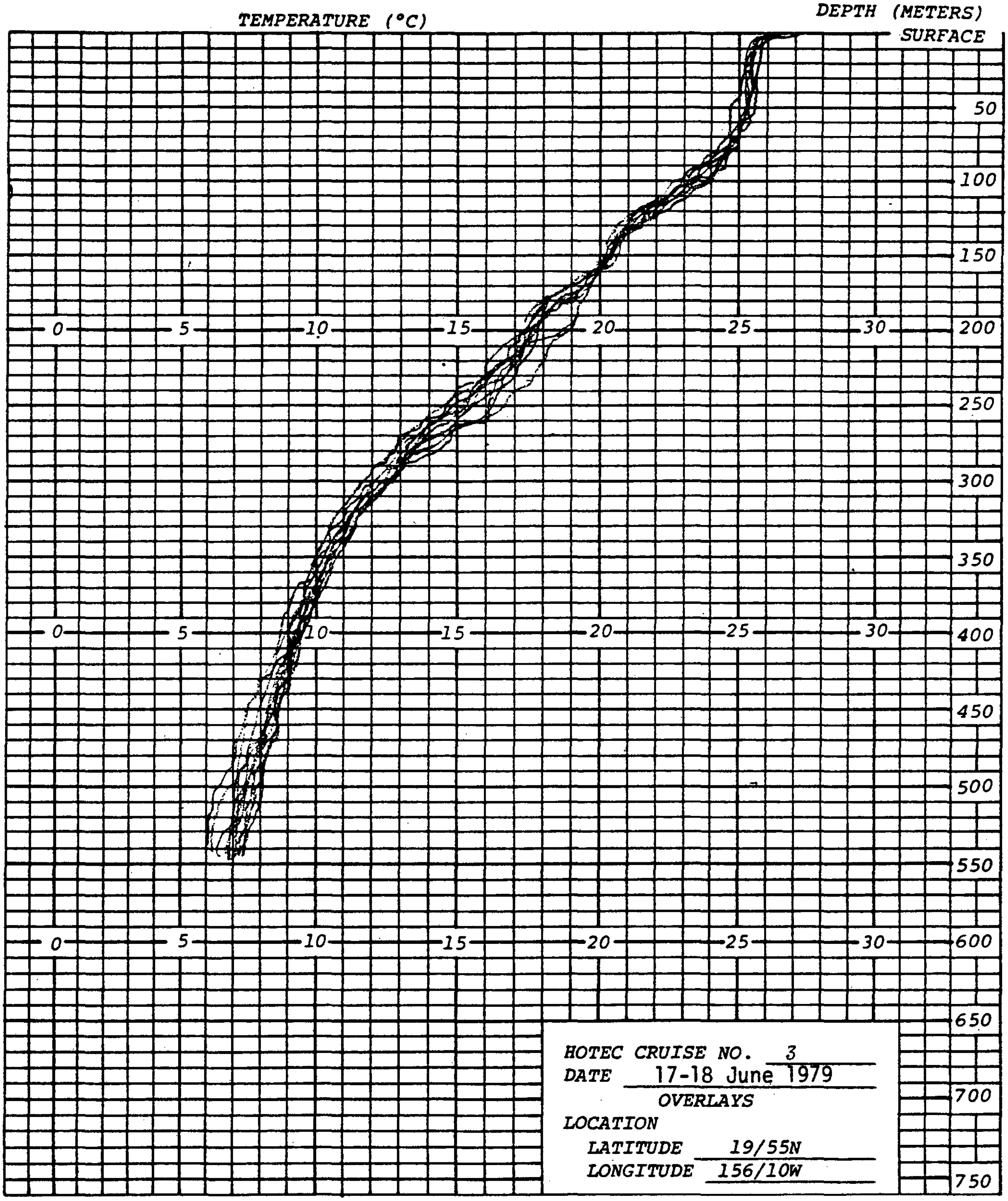
HOTEC CRUISE # 2   SHIP: M/V Noi'i

XBT no.	1	2	3	4	5	6	
LATITUDE °	19	19	19	19	19	19	
'	55	55	55	55	56	56	
LONGITUDE °	156	156	156	156	156	156	
'	09	09	10	09	08	08	
DATE (GMT)	4/12/79	4/12/79	4/13/79	4/13/79	4/13/79	4/13/79	
TIME (GMT)	2045	2159	0001	0202	0401	0600	
TIME (LOCAL)	1025	1159	1401	1602	1801	2000	
SURF. T (°C)	24.8	25.2	25.2	25.0	25.0	24.8	
29							
28							
27							
26							
25			05				
24	93	91	90	85	105	88	
23	128	123	121	121	125	125	
22	145	138	140	138	145	144	
21	152	156	160	163	152	159	
20	165	160	175	172	165	170	
19	180	180	183	183	183	190	
18	196	193	195	195	192	200	
17	205	222	218	221	215	218	
16	220	228	230	238	235	234	
15	235	242	246	251	248	248	
14	250	257	260	263	255	259	
13	267	277	278	275	268	268	
12	285	294	293	288	290	287	
11	320	320	323	318	320	313	
10	353	351	358	350	361	365	
9	388	407	404	385	407	424	
8	452	460	477	452	465	481	
7	530	523	551	520	550	540	
6	600	620	665	650	650	660	

ISOTHERM DEPTHS (M)

HOTEC CRUISE # 2 SHIP: M/V Noi'i

XBT no.	7	8	9	10	11	12	
LATITUDE °	19	19	19	19	19	19	
'	55	54	55	56	55	56	
LONGITUDE °	156	156	156	156	156	156	
'	09	11	10	09	03	02	
DATE (GMT)	4/13/79	4/13/79	4/13/79	4/13/79	4/13/79	4/13/79	
TIME (GMT)	0301	1000	1200	1400	1608	1800	
TIME (LOCAL)	2201	0000	0200	0400	0608	0800	
SURF. T (°C)	24.8	25.0	24.9	24.8	24.8	24.8	
29							
28							
27							
26							
25							
24	91	90	90	90	100	100	
23	130	128	133	121	133	130	
22	145	145	156	148	137	136	
21	156	156	161	152	150	149	
20	166	167	173	170	170	167	
19	176	177	182	184	193	183	
18	191	186	201	200	197	196	
17	201	206	217	215	217	218	
16	221	223	233	229	230	224	
15	235	238	242	244	235	234	
14	258	259	259	258	249	243	
13	278	277	276	275	266	266	
12	290	292	295	295	290	290	
11	313	320	319	315	330	332	
10	342	350	345	367	355	353	
9	404	400	390	400	380	372	
8	460	466	475	440	bottom	bottom	
7	523	545	540	540			
6	612	670	640	640			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DEPTH (METERS)
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400
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500
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600
650
700
750
0
5
10
15
20
25
30
HOTEC CRUISE NO. 3
DATE 17-18 June 1979
OVERLAYS
LOCATION
LATITUDE 19/55N
LONGITUDE 156/10W

ISOTHERM DEPTHS (M)

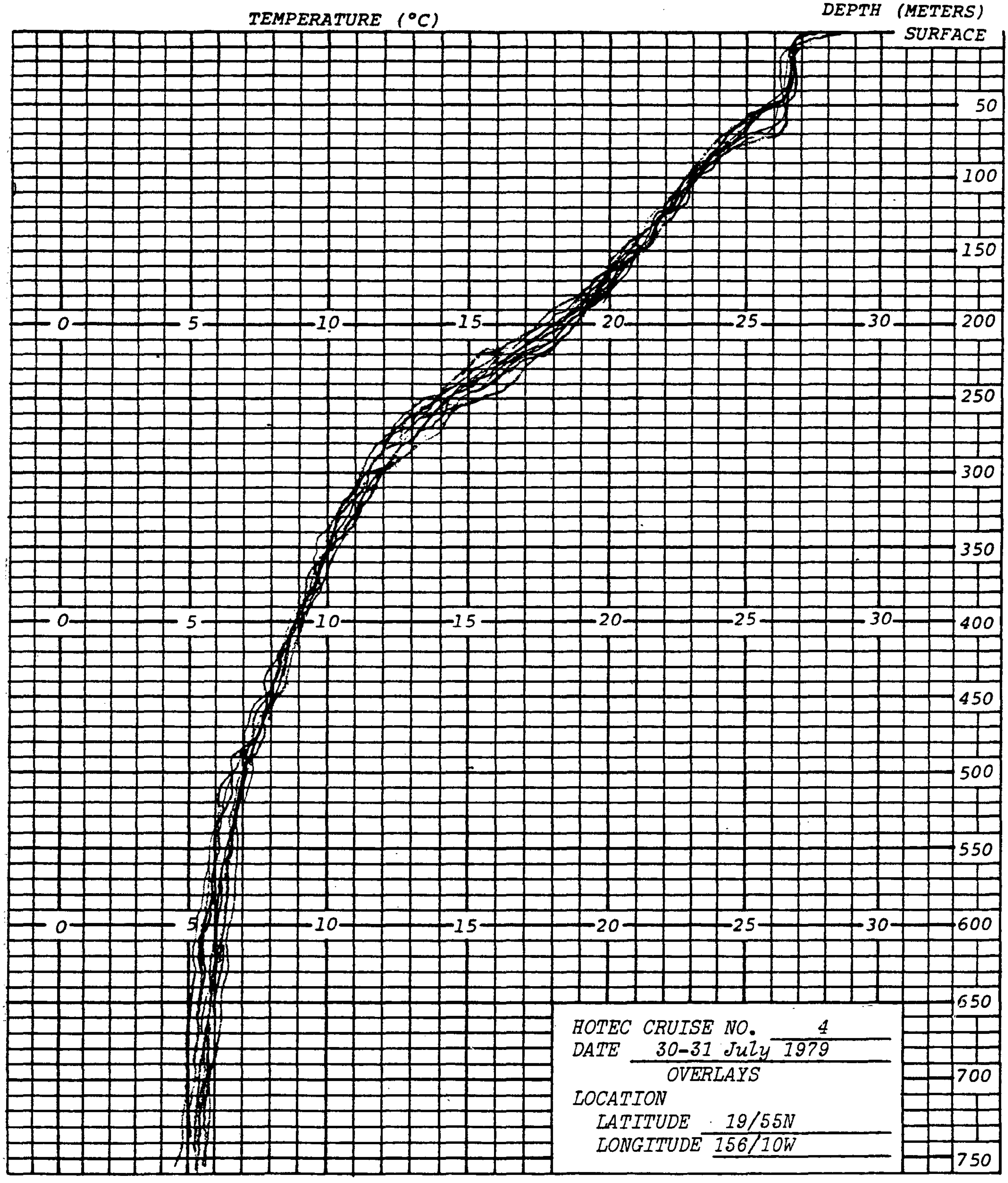
HOTEC CRUISE # 3 SHIP: M/V EL Greco

XBT no.	1	2	3	4	5		
LATITUDE °	19	19	19	19	19		
′	55	56	56	56	54		
LONGITUDE °	156	156	156	156	156		
′	09	09	09	09	09		
DATE (GMT)	6/17/79	6/18/79	6/18/79	6/18/79	6/18/79		
TIME (GMT)	2200	0010	0200	0405	0750		
TIME (LOCAL)	1200	1410	1600	1805	2150		
SURF. T (°C)	25.8	26.4	27.2	27.1	25.8		
29							
28							
27			01	01			
26		02	04	02			
25	53	45	56	65	56		
24	95	83	86	88	81		
23	112	103	100	110	98		
22	123	116	119	114	114		
21	134	134	132	127	133		
20	164	163	150	154	153		
19	180	182	165	170	179		
18	193	194	180	182	198		
17	227	225	214	207	214		
16	246	237	227	230	260		
15	263	250	250	253	263		
14	273	258	266	263	271		
13	290	270	285	280	285		
12	316	295	308	310	303		
11	338	320	330	335	328		
10	370	350	363	370	365		
9	420	413	408	410	401		
8	440	470	470	450	450		
7	495	530	530	515	521		
6							

ISOTHERM DEPTHS (M)

HOTEC CRUISE # 3 SHIP: M/V EL Greco

XBT no.	6	7	8	9	10		
LATITUDE °	19	19	19	19	19		
'	56	55	55	55	56		
LONGITUDE °	156	156	156	156	156		
'	08	09	09	09	09		
DATE (GMT)	6/18/79	6/18/79	6/18/79	6/18/79	6/18/79		
TIME (GMT)	1029	1203	1400	1600	1800		
TIME (LOCAL)	0029	0203	0400	0600	0800		
SURF. T (°C)	25.6	25.6	25.4	25.4	25.4		
29							
28							
27							
26							
25	64	70	60	55	69		
24	95	91	87	83	90		
23	108	112	107	101	104		
22	111	120	112	110	120		
21	120	133	123	130	132		
20	152	155	153	158	163		
19	189	178	175	172	180		
18	205	190	187	199	195		
17	234	210	208	215	215		
16	255	225	235	234	240		
15	265	248	245	242	260		
14	280	260	257	266	285		
13	285	280	277	287	303		
12	300	300	297	310	310		
11	321	333	224	343	340		
10	358	372	262	370	369		
9	410	419	396	415	395		
8	466	480	469	473	446		
7	540	536	535		520		
6							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DEPTH (METERS)
SURFACE
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100
150
200
250
300
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400
450
500
550
600
650
700
750
0
5
10
15
20
25
30
HOTEC CRUISE NO. 4
DATE 30-31 July 1979
OVERLAYS
LOCATION
LATITUDE 19/55N
LONGITUDE 156/10W

ISOTHERM DEPTHS (M)

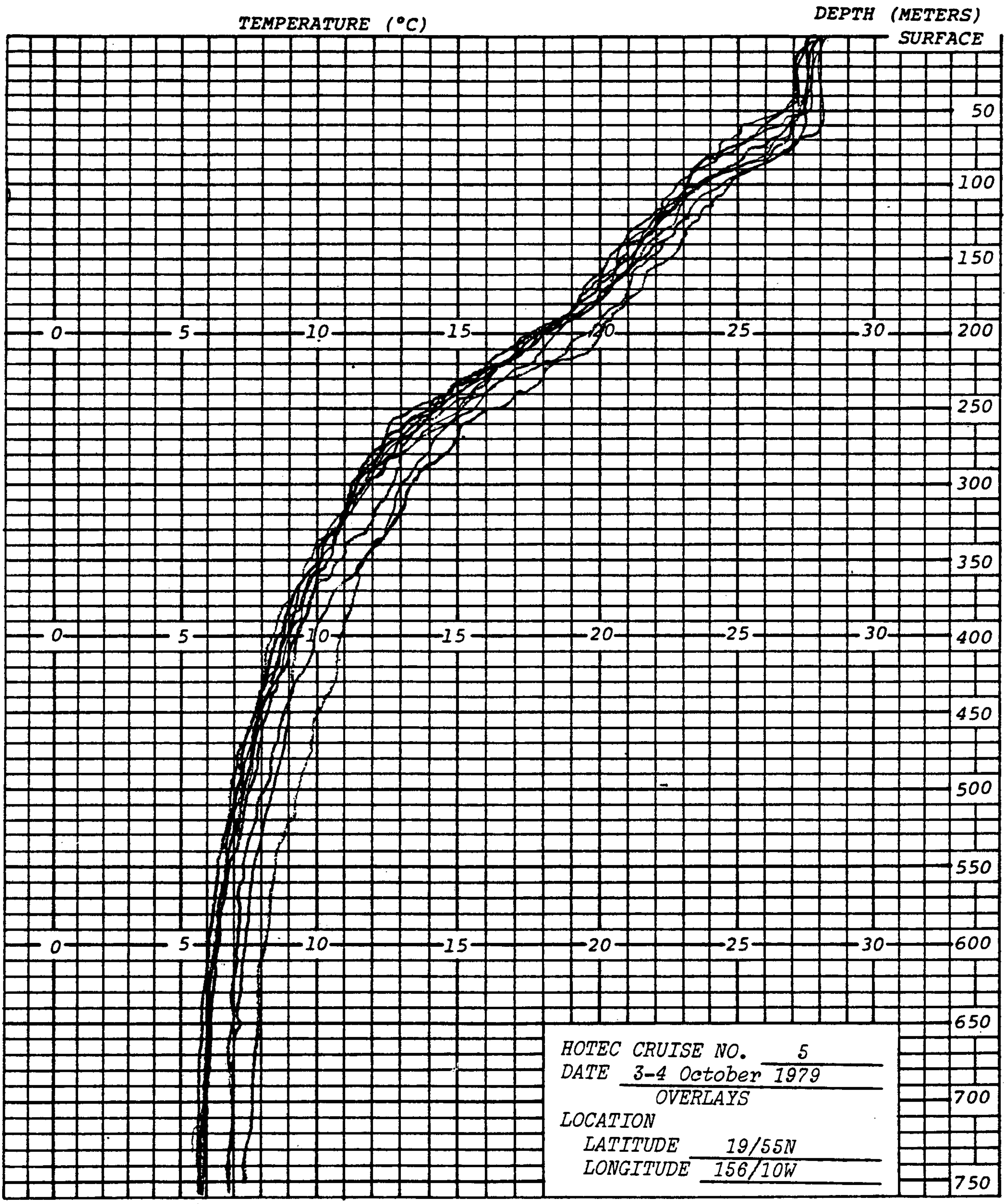
HOTEC CRUISE # 4 SHIP: R/V Kana Keoki

XBT NO.	1	2	4	5	6	7	8
LATITUDE °	19	19	19	19	19	19	19
'	56	56	55	56	56	56	57
LONGITUDE °	156	156	156	156	156	156	156
'	09	09	09	09	08	09	05
DATE (GMT)	7/30/79	7/30/79	7/30/79	7/30/79	7/30/79	7/30/79	7/31/79
TIME (GMT)	0200	0600	1015	1445	1800	2200	0200
TIME (LOCAL)	1600	2000	0015	0445	0800	1200	1600
SURF T (°C)	28.6	28.4	27.1	26.7	26.8	27.3	27.6
29							
28	1	1					
27	15	3	0.5			6	4
26	50	50	41	50	49	49	62
25	65	63	58	66	55	59	68
24	85	86	79	85	75	75	75
23	109	102	91	100	98	99	100
22	123	121	116	120	115	120	125
21	150	145	139	140	140	148	150
20	170	164	160	165	158	168	168
19	192	190	183	185	185	182	190
18	215	200	190	199	204	197	213
17	223	213	200	212	218	205	230
16	240	234	215	226	232	232	245
15	248	242	223	240	245	238	255
14	268	268	242	251	258	248	258
13	289	280	258	272	270	258	272
12	295	308	283	295	289	283	299
11	314	340	309	320	315	310	329
10	350	360	355	350	340	350	360
9	400	410	400	390	403	410	420
8	435	455	450	440	442	460	448
7	500	490	500	470	485	500	475
6	585	561	580	580	550	600	555

ISOTHERM DEPTHS (M)

HOTEC CRUISE # 4 SHIP: R/V Kana Keoki

XBT no.	9	10	11	12	13
LATITUDE °	19	19	19	19	19
'	52	57	54	54	54
LONGITUDE °	156	156	156	156	156
'	12	10	09	10	08
DATE (GMT)	7/31/79	7/31/79	7/31/79	7/31/79	7/31/79
TIME (GMT)	0600	1000	1400	1800	2200
TIME (LOCAL)	2000	2400	0400	0800	1200
SURF. T (°C)	27.1	26.8	26.7	26.6	27.0
29					
28					
27	3				
26	72	51	69	65	70
25	78	71	72	80	82
24	89	83	86	91	93
23	104	100	102	102	110
22	125	130	136	125	127
21	149	151	155	146	151
20	165	170	175	167	165
19	188	194	199	183	188
18	209	208	218	212	210
17	225	228	231	227	218
16	235	235	240	235	232
15	252	250	250	250	243
14	265	265	268	261	252
13	285	283	280	278	269
12	302	306	298	298	295
11	320	329	320	334	316
10	348	370	356	369	360
9	400	420	390	408	404
8	450	475	445	459	444
7	506	528	484	496	478
6	590	600	590	610	590



TEMPERATURE (°C)
DEPTH (METERS)
SURFACE
0 5 10 15 20 25 30
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
HOTEC CRUISE NO. 5
DATE 3-4 October 1979
OVERLAYS
LOCATION
LATITUDE 19/55N
LONGITUDE 156/10W

ISOTHERM DEPTHS (M)

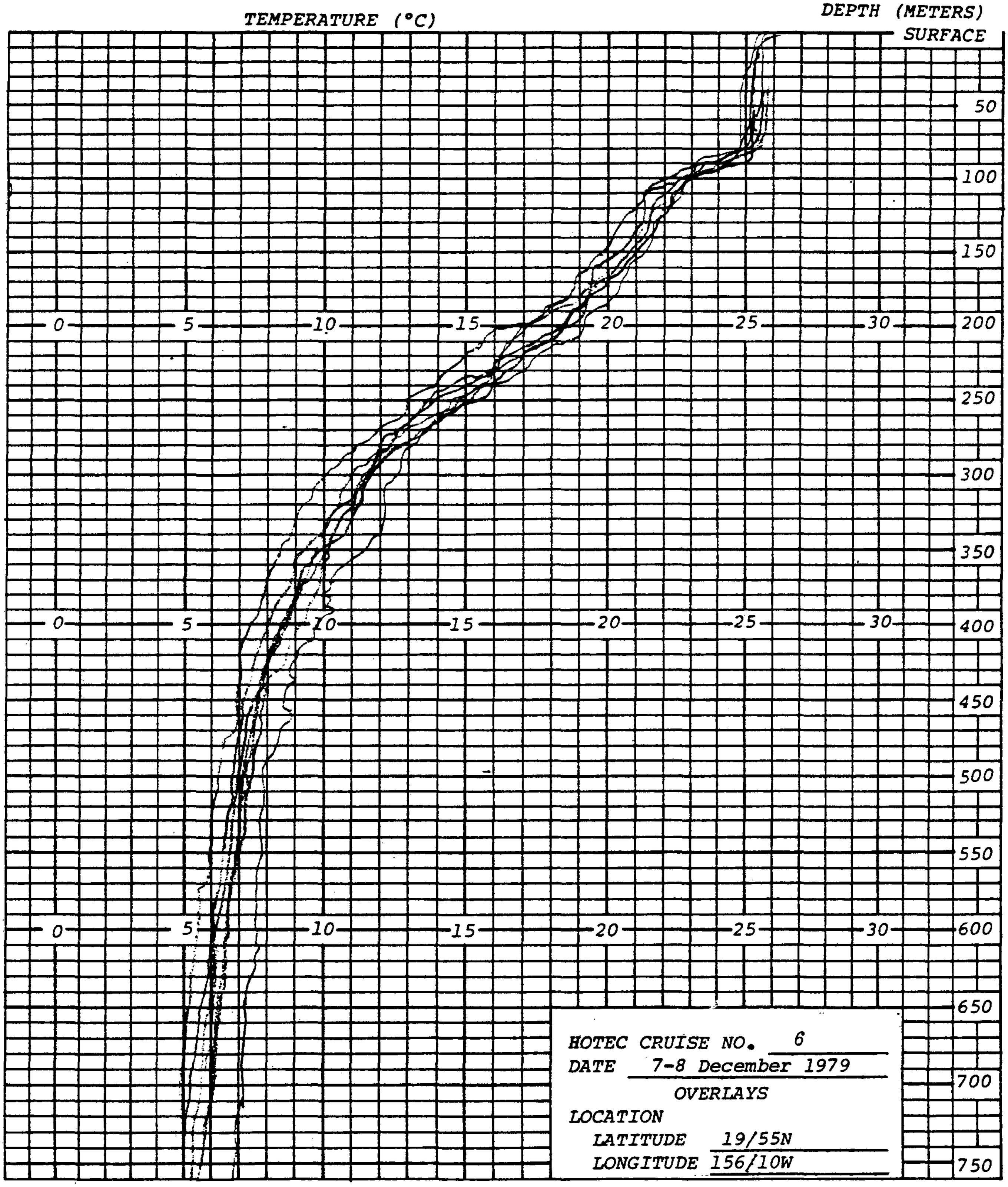
HOTEC CRUISE # 5 SHIP: R/V Kana Keoki

XBT NO.	1	3	4	5	6	7	8
LATITUDE °	19	19	19	19	19	19	19
'	56	55	54	56	55	56	51
LONGITUDE °	156	156	156	156	156	156	156
'	09	15	10	08	11	10	09
DATE (GMT)	10/3/79	10/3/79	10/3/79	10/3/79	10/3/79	10/4/79	10/4/79
TIME (GMT)	0232	1000	1400	1758	2200	0208	0600
TIME (LOCAL)	1632	2400	0400	0758	1200	1608	2000
SURF T (°C)	27.8	27.0	27.0	27.1	27.2	27.6	27.7
29							
28							
27	50	0	0	10	25	59	40
26	70	53	80	81	54	80	70
25	85	65	90	88	60	91	83
24	92	73	93	93	84	112	98
23	102	83	110	109	97	135	110
22	119	103	132	124	115	155	133
21	140	120	149	138	137	175	151
20	160	157	165	166	163	195	170
19	178	171	180	188	180	218	183
18	191	190	196	200	200	222	199
17	210	209	201	212	210	243	210
16	220	226	220	225	229	253	230
15	231	237	235	231	240	261	245
14	242	255	250	244	251	286	260
13	263	270	258	251	265	303	268
12	283	298	300	278	282	338	289
11	296	340	332	311	304	377	320
10	345	363	350	340	340	448	348
9	390	386	372	370	370	500	385
8	435	427	450	420	435	560	425
7	505	505	510	485	500		510
6	580	600	650	570	595		610

ISOTHERM DEPTHS (M)

HOTEC CRUISE # 5 SHIP: R/V Kana Keoki

XBT no.	9	11	12
LATITUDE °	19	19	19
′	48	56	56
LONGITUDE °	156	156	156
′	10	09	10
DATE (GMT)	10/4/79	10/4/79	10/4/79
TIME (GMT)	1000	1800	2200
TIME (LOCAL)	0000	0800	1200
SURF. T (°C)	27.6	27.6	27.7
29			
28			
27	48	40	50
26	74	57	54
25	84	73	72
24	90	80	86
23	115	100	103
22	135	118	135
21	156	135	158
20	185	163	184
19	203	184	210
18	218	195	220
17	228	210	238
16	236	220	251
15	252	232	262
14	263	248	291
13	273	255	300
12	288	283	315
11	307	320	342
10	340	338	365
9	373	376	395
8	432	410	438
7	490	479	517
6	570	600	630


TEMPERATURE (°C)
DEPTH (METERS)
SURFACE
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
0
5
10
15
20
25
30
HOTEC CRUISE NO. 6
DATE 7-8 December 1979
OVERLAYS
LOCATION
LATITUDE 19/55N
LONGITUDE 156/10W

ISOTHERM DEPTHS (M)

HOTEC CRUISE # 6 SHIP: M/V Noi'i

XBT no.	3	4	5	6
LATITUDE °	19	19	19	19
'	55.4	54.2	55.7	57.0
LONGITUDE °	156	156	156	156
'	8.5	10.6	9.1	9.6
DATE (GMT)	12/8/79	12/8/79	12/8/79	12/8/79
TIME (GMT)	0015	0200	0355	0600
TIME (LOCAL)	1415	1600	1755	2000
SURF. T (°C)	25.8	25.9	25.6	25.3
29				
28				
27				
26				
25	86	80	80	70
24	92	88	85	90
23	98	100	98	93
22	122	119	115	103
21	149	152	145	135
20	165	182	170	155
19	185	203	190	194
18	205	211	213	205
17	214	228	223	215
16	232	235	235	223
15	248	243	245	234
14	255	263	250	242
13	272	279	269	260
12	285	337	290	276
11	321	352	320	308
10	340	392	340	348
9	373	419	360	374
8	415	488	408	414
7	470	680	470	480
6	590		595	610

ISOTHERM DEPTHS (M)

HOTEC CRUISE # 6 SHIP: M/V Noi'i

XBT no.	10	11	12
LATITUDE °	19	19	19
′	56.9	54.6	54.8
LONGITUDE °	156	156	156
′	10.1	11.2	07.5
DATE (GMT)	12/8/79	12/8/79	12/8/79
TIME (GMT)	0845	1150	1680
TIME (LOCAL)	2245	0150	0680
SURF. T (°C)	25.2	25.2	25.5
29			
28			
27			
26			
25	70	81	30
24	85	89	93
23	93	97	100
22	105	115	108
21	125	130	121
20	143	153	150
19	165	177	169
18	180	185	190
17	190	200	203
16	219	218	208
15	238	245	225
14	250	259	245
13	263	268	252
12	277	280	274
11	305	296	290
10	325	327	306
9	380	370	340
8	420	415	382
7	485	492	450
6	620	605	575

APPENDIX F

Meteorological Data For HOTEC 2-6 Cruises

METEOROLOGICAL DATA

HOTEC CRUISE NO. 2 SHIP: M/V NOI'I

OBSERVATION NO.	1	2	3	4	5	6	7	8
DATE (GMT)	4/12/79	4/13/79	4/13/79	4/13/79	4/13/79	4/13/79		
DATE (LOCAL)	4/12/79	4/12/79	4/12/79	4/13/79	4/13/79	4/13/79		
TIME (GMT)	2200	0200	0600	1000	1400	1800		
TIME (LOCAL)	1200	1600	2000	0000	0400	0800		
LATITUDE	19°55'	19°55'	19°56'	19°54'	19°56'	19°56'		
LONGITUDE	156°09'	156°09'	156°08'	156°11'	156°09'	156°02'		
BAROMETRIC PRESSURE (In.Hg)	30.18	30.14	30.14	30.15	30.11	30.16		
CLOUD COVER (%)	60	60	70	95	100	80		
VISIBILITY (NM)	25	30	30	25	20	30		
WIND SPEED (Knots)	6	9	CALM	5	CALM	CALM		
*WIND DIRECTION (°M)	240	230	240	310	160	0		
SEA STATE (Beaufort)	2	3	2	2	3	2		
WAVE HEIGHT (Ft)	1	2	1	1	2	2		
*WAVE DIRECTION (°M)	180	180	180	160	160	230		
WAVE PERIOD (Sec)	5	5	-	-	5	5		
RELATIVE HUMIDITY (%)	78.5	78.5	86	91	91	86		
TEMPERATURE (°C)	25	25	23.9	23.3	23.3	24.4		

*DIRECTION FROM WHICH WIND AND WAVES APPROACH

METEOROLOGICAL DATA

HOTEC CRUISE NO. 3 SHIP: M/V EL GRECO

OBSERVATION NO.	1	2	3	4	5	6	7	8
DATE (GMT)	6/17/79	6/18/79	6/18/79	6/18/79	6/18/79	6/18/79	6/18/79	
DATE (LOCAL)	6/17/79	6/17/79	6/17/79	6/18/79	6/18/79	6/18/79	6/18/79	
TIME (GMT)	2200	0200	0600	1034	1413	1807	2220	
TIME (LOCAL)	1200	1600	2000	0034	0413	0807	1220	
LATITUDE	19°55'	19°56'	19°56'	19°56'	19°56'	19°56'	19°55'	
LONGITUDE	156°09'	156°09'	156°09'	156°08'	156°09'	156°08'	156°08'	
BAROMETRIC PRESSURE (In.Hg)	30.26	30.24	30.28	30.30	30.28	30.30	30.30	
CLOUD COVER (%)	25	25	NIGHT	NIGHT	15	40	50	
VISIBILITY (NM)	30+	40+	40+	40+	40+	40+	30+	
WIND SPEED (Knots)	5	CALM	CALM	5	6	CALM	4	
*WIND DIRECTION (°M)	220	-	-	182	170	-	158	
SEA STATE (Beaufort)	1	1	1	1	1	1	1	
WAVE HEIGHT (Ft)	3-4	3-4	3-4	3-4	3-4	2-3	2-3	
*WAVE DIRECTION (°M)	345	350	-	-	-	355	355	
WAVE PERIOD (Sec)	5	4.5	-	-	-	5	5	
RELATIVE HUMIDITY (%)	72	67	75	79	71	72	72	
TEMPERATURE (°C)	27.8	30.6	27.2	25.6	25	26.7	26.7	

*DIRECTION FROM WHICH WIND AND WAVES APPROACH

METEOROLOGICAL DATA

HOTEC CRUISE NO. 4 SHIP: R/V KANA KEOKI

OBSERVATION NO.	1	2	3	4	5	6	7	8
DATE (GMT)	7/30/79	7/30/79	7/30/79	7/30/79	7/30/79	7/30/79	7/31/79	7/31/79
DATE (LOCAL)	7/29/79	7/29/79	7/30/79	7/30/79	7/30/79	7/30/79	7/30/79	7/30/79
TIME (GMT)	0200	0600	1000	1445	1815	2200	0230	0600
TIME (LOCAL)	1600	2000	0000	0445	0815	1200	1630	2000
LATITUDE	19°56'	19°56'	19°55'	19°55'	19°56'	19°56'	19°57'	19°52'
LONGITUDE	156°09'	156°09'	156°10'	156°09'	156°08'	156°09'	156°06'	156°12'
BAROMETRIC PRESSURE (In.Hg)	30.02	30.05	30.06	30.02	30.04	30.05	30.00	30.02
CLOUD COVER (%)	20	30	10	10	10	5	20	30
VISIBILITY (NM)	25	30	25	25	30	30	25	25
WIND SPEED (Knots)	3	4	4	8	4	5	0	4.5
*WIND DIRECTION (°T)	350	160	95	325	350	63	-	180
SEA STATE (Beaufort)	1	1	1	1	1	2	1	2
WAVE HEIGHT (Ft)	2	2	2	2	2	2	2	2
*WAVE DIRECTION (°T)	20	25	20	60	10	25	15	5
WAVE PERIOD (Sec)	5	6	5	5	5	6	6	5
RELATIVE HUMIDITY (%)	69	74	64	72	64	72	62	72
TEMPERATURE (°C)	24.4	23.9	21.7	22.8	22.2	23.3	30.0	27.2

*DIRECTION FROM WHICH WIND AND WAVES APPROACH

METEOROLOGICAL DATA

HOTEC CRUISE NO. 4 SHIP: R/V KANA KEOKI

OBSERVATION NO.	9	10	11	12	13	14**	15	16
DATE (GMT)	7/31/79	7/31/79	7/31/79	7/31/79	8/01/79	8/01/79	8/01/79	8/01/79
DATE (LOCAL)	7/31/79	7/31/79	7/31/79	7/31/79	7/31/79	7/31/79	8/01/79	8/01/79
TIME (GMT)	1000	1430	1800	2210	0200	0600	1000	1415
TIME (LOCAL)	0000	0430	0800	1210	1600	2000	0000	0415
LATITUDE	19°57'	19°55'	19°54'	19°54'	19°54'	19°51'	19°55'	19°56'
LONGITUDE	156°10'	156°09'	156°10'	156°08'	156°07'	155°57'	156°08'	156°09'
BAROMETRIC PRESSURE (In.Hg)	30.04	30.00	30.02	30.00	29.94	29.96	29.98	29.95
CLOUD COVER (%)	20	-	35	1	5	20	20	10
VISIBILITY (NM)	25	25	25	25	25	25	25	25
WIND SPEED (Knots)	18	0	0	8	12	12	8	5
*WIND DIRECTION (°T)	117	-	-	270	10	5	-	220
SEA STATE (Beaufort)	3	1	1	1	3	2	2	2
WAVE HEIGHT (Ft)	2	2	2.5	1	3	1.5	2	2
*WAVE DIRECTION (°T)	90	100	350	30	0	20	10	20
WAVE PERIOD (Sec)	4.5	5	4	4	4	4	5	4.5
RELATIVE HUMIDITY (%)	72	75	65	65	73	68	71	74
TEMPERATURE (°C)	26.1	25.6	27.8	28.3	28.3	26.7	25.6	25.0

*DIRECTION FROM WHICH WIND AND WAVES APPROACH

**Anchored in Kiholo Bay

METEOROLOGICAL DATA

HOTEC CRUISE NO. 5 SHIP: R/V KANA KEOKI

OBSERVATION NO.	1	2	3	4	5	6	7	8
DATE (GMT)	10/3/79	10/3/79	10/3/79	10/3/79	10/4/79	10/4/79	10/4/79	10/4/79
DATE (LOCAL)	10/2/79	10/3/79	10/3/79	10/3/79	10/3/79	10/3/79	10/4/79	10/4/79
TIME (GMT)	0600	1000	1400	1800	0200	0600	1000	1400
TIME (LOCAL)	2000	0000	0400	0800	1600	2000	0000	0400
LATITUDE	19°57'	19°58'	19°56'	19°57'	19°57'	19°53'	19°50'	19°55'
LONGITUDE	156°10'	156°12'	156°09'	156°08'	156°09'	156°08'	156°08'	156°08'
BAROMETRIC PRESSURE (In.Hg)	29.85	29.85	29.88	29.88	29.85	29.88	29.90	29.91
CLOUD COVER (%)	90	90	90	20	60	60	30	10
VISIBILITY (NM)	15	15	15	15	15	15	15	15
WIND SPEED (Knots)	10	12	6	6	0	6	6	6
*WIND DIRECTION (°T)	340	-	70	240	-	170	138	140
SEA STATE (Beaufort)	0	1	0	0	0	0	0	0
WAVE HEIGHT (Ft)	1	1	1	0	2	1-2	1	2
*WAVE DIRECTION (°T)	20	20	20	20	60	40	120	90
WAVE PERIOD (Sec)	10	3	3	3	3	3	3	3
RELATIVE HUMIDITY (%)	75.5	83	82.7	72.5	72.5	79	75.5	61.5
TEMPERATURE (°C)	27.7	26.6	25.6	27.7	27.8	26.6	27.7	27.8

*DIRECTION FROM WHICH WIND AND WAVES APPROACH

METEOROLOGICAL DATA

HOTEC CRUISE NO. 5 SHIP: R/V KANA KEOKI

OBSERVATION NO.	9	10	11	12	13	14	15	16
DATE (GMT)	10/4/79	10/4/79	10/5/79	10/5/79	10/5/79	10/5/79	10/5/79	10/6/79
DATE (LOCAL)	10/4/79	10/4/79	10/4/79	10/4/79	10/5/79	10/5/79	10/5/79	10/5/79
TIME (GMT)	1800	2200	0200	0600	1000	1400	2200	0200
TIME (LOCAL)	0800	1200	1600	2000	0000	0400	1200	1600
LATITUDE	19°58'	19°58'	20°00'	20°02'	19°57'	19°56'	20°00'	20°02'
LONGITUDE	156°08'	156°08'	156°06'	156°03'	156°07'	156°08'	156°06'	156°03'
BAROMETRIC PRESSURE (In.Hg)	29.94	29.94	29.93	29.92	29.94	29.91	29.94	29.93
CLOUD COVER (%)	10	10	10	40	10	40	100	90
VISIBILITY (NM)	15	15	15	15	15	15	15	15
WIND SPEED (Knots)	12	5	6	4	2	0	1	4
*WIND DIRECTION (°T)	174	-	270	255	130	-	300	305
SEA STATE (Beaufort)	0	0	0	0	0	0	0	0
WAVE HEIGHT (Ft)	1	1	2	1	1	1	1	1
*WAVE DIRECTION (°T)	CONFUSED	30	250	350	350	350	350	350
WAVE PERIOD (Sec)	-	3	3.5	3	3	3	3	3
RELATIVE HUMIDITY (%)	72.5	79	79	83	79	75	75.2	83
TEMPERATURE (°C)	27.8	26.6	27.2	26.6	26.6	26.7	27.3	26.7

*DIRECTION FROM WHICH WIND AND WAVES APPROACH

METEOROLOGICAL DATA

HOTEC CRUISE NO. 6 SHIP: M/V NOI'I

OBSERVATION NO.	1	2	3	4	5	6	7	8
DATE (GMT)	12/7/79	12/8/79	12/8/79	12/8/79	12/8/79	12/8/79		
DATE (LOCAL)	12/7/79	12/7/79	12/7/79	12/8/79	12/8/79	12/8/79		
TIME (GMT)	2200	0200	0600	1200	1700	2200		
TIME (LOCAL)	1200	1600	2000	0200	0700	1200		
LATITUDE	19°55.9'	19°51.9'	19°57.0'	19°54.5'	19°54.8'	19°55.6'		
LONGITUDE	156°8.2'	156°8.6'	156°9.6'	156°11.2'	156°7.5'	156°5.9'		
BAROMETRIC PRESSURE (In.Hg)	30.20	30.16	30.22	30.19	30.18	30.15		
CLOUD COVER (%)	5	5	-	30	5	5		
VISIBILITY (NM)	30	30	30	30	30	30		
WIND SPEED (Knots)	3	0	5	0	1	0		
*WIND DIRECTION (°M)	235	-	180	-	-	-		
SEA STATE (Beaufort)	1	1	1	1	1	1		
WAVE HEIGHT (Ft)	4	2	3	2	2	1		
*WAVE DIRECTION (°M)	000	000	000	000	000	000		
WAVE PERIOD (Sec)	5	5	5	5	5	5		
RELATIVE HUMIDITY (%)	79	72	79	83	83	85		
TEMPERATURE (°C)	26.1	27.8	26.1	25.6	25.6	26.9		

*DIRECTION FROM WHICH WIND AND WAVES APPROACH

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BERKELEY, CALIFORNIA 94720