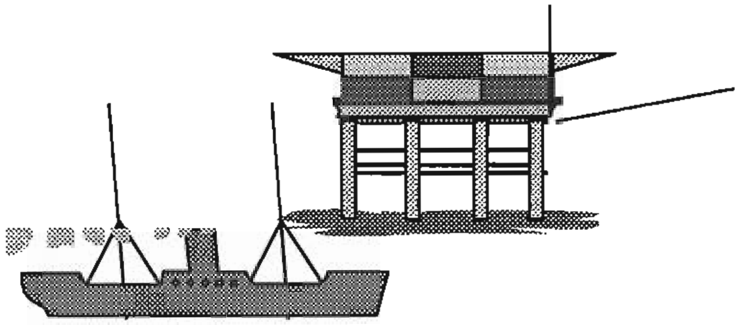
NERC CRUISE REPORT : *Challenger* # 129



The ASGAMAGE experiment, 16 October- 1st November 1996:

Gas transfer velocities and biogenic gas fluxes in the southern North Sea.

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Introduction :

Cruise # 129 of RRS *Challenger* formed the U.K. component of ASGAMAGE[1], a joint European contribution to the MAGE[2] core science activity of IGAC[3]. Seatime funds were provided from the NERC ACSOE[4] programme, with on-board science activities funded in part by the EU under MAST-III. The central aim of ASGAMAGE was to compare directly for the first time under a range of field conditions, a comprehensive suite of geophysical forcings which influence sea-air gas transfer. This was achieved through two simultaneous co-ordinated studies, on board *Challenger* and on *Meetpost Noordwijk,* a manned meteorological platform 8 km off the Dutch coast (52° 17 N; 004° 18 E) operated by the Royal Netherlands Meteorological Institute, KNMI (Figure 1).

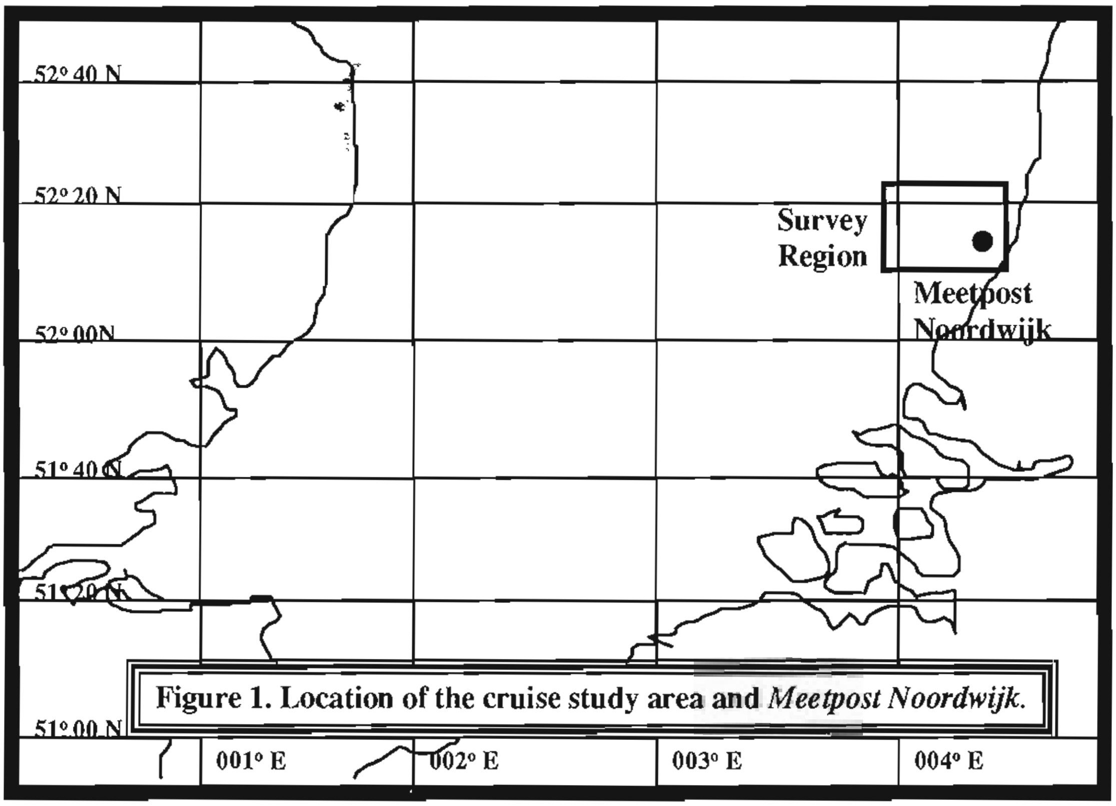

Figure 1. Location of the cruise study area and *Meetpost Noordwijk*.

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1 A corruption of a previous experimental campaign, ASGASEX '96 [1], by MAGE.
2 Marine Aerosol and Gas Exchange.
3 International Global Atmospheric Chemistry, a core component of the International Geosphere-Biosphere Programme (IGBP).
4 Atmospheric Chemistry Studies in the Oceanic Environment.

Scientific Background :

Air-sea gas transfer exerts important controls on global biogeochemical processes, for example the inter-reservoir exchange of greenhouse gases [2,3] and the contribution from volatile ocean sulphur to acid rain and climate regulation [4,5].
Calculations of air-sea gas exchange require an independant estimate of the water-side gas transfer velocity, k_w, a variable quantity which is influenced by a range of geophysical forcings including wind speed, wave geometry and fetch, boundary layer stability and the presence of surfactants and bubbles [6-10]. The complex interaction of these processes is a major barrier to understanding the functionality of gas transfer, and can lead to significant errors in gas budgeting calculations [11]. To date, most seagoing work in this research area has focused on the relationship between k_w and wind speed [11-17]. This is in part a consequence of the highly specialised nature of some of the other measurements, compared with the ease with which wind speed can be routinely monitored from ships. However, when plots of k_w vs wind speed from different measurement programmes are compared, the data show substantial discrepancies which cannot be ascribed to experimental precisions alone, a conclusion which highlights the important additional controls on k_w exerted by other geophysical variables.

Because of its location and well characterised flow distortion characteristics, *Meetpost Noordwijk* is one of few structures in the world ideally suited to the simultaneous measurement of a suite of geophysical variables thought to influence air-sea gas exchange [1], and it is in a region previously used by us to characterise gas transfer velocities and biogas fluxes using established techniques [14,18]. By co-ordinating these complementary shipboard and *Meetpost* based activities for the first time in a structured experimental campaign, ASGAMAGE provided an unique opportunity to make fundamental advances in our understanding of the air-sea gas exchange process.

The *Meetpost* programme involved micrometeorological estimates of CO_2 transfer velocities (eddy correlation, eddy dissipation and gradient methods) and measurements of wave geometry, bubble fluxes and spectra, fluxes of heat, momentum and biogases (including CO_2, CH_4 and N_2O) and meteorological variables. The results from this programme will be presented in a separate report.

Specific Cruise Objectives :

Although strongly linked to the *Meetpost* based activities, *Challenger* 129 was conceived as an independent study with well defined objectives of its own:

(1) *To measure rates of gas transfer across the sea -air interface as functions of windspeed and associated geophysical variables by the release of volatile (helium-3 and sulphur hexafluoride) and conservative (* bacillus globigii *spores and rhodamines WT and sulpho-G) tracers into moderately productive waters of the southern North Sea, about 20 km west of the marine meteorological platform "Meetpost Noordwijk".*

(2) *Simultaneously to investigate the marine biological sources and sinks of* CH_4, N_2O, *non-methane hydrocarbons, CO and* O_2 *and to combine concentration measurements with the results from* **(1)** *in order to accurately constrain the sea-air fluxes of these important biogases.*

(3) *To monitor changes in algal biomass and speciation and to determine their relationship with water column mixing and turbulence using a Lagrangian approach.*

(4) *To co-ordinate activities* (1) *and* (2) *with simultaneous measurements of wave geometry, bubble fluxes and spectra, micrometeorological estimates of CO_2 transfer velocities and measurements of biogas, heat and momentum fluxes made onboard "Meetpost Noordwijk", by collaborating scientisits.*
(5) *Using* (1) *to* (4), *to compare directly different techniques for estimating gas transfer velocities at sea, to evaluate the importance of a suite of geophysical forcings on gas transfer and to construct detailed predictive models of the air-sea gas exchange process.*

Methods :

1. Tracer-measurements of air-sea gas transfer velocities

Gas transfer velocities can be routinely measured at sea by simultaneously releasing two tracers, one of which is volatile and the other conservative. Concentration measurements for the volatile tracer are used to assess k_w, with corrections for dispersive dilution determined with the conservative tracer. However, at the time of our first seagoing measurements of k_w in 1989 (*Challenger* cruise # 48 [19]), an "acceptable" conservative tracer, i.e. one that was non-toxic, non-radioactive and detectable in trace quantities, had not been identified. Although conservative tracers such as rhodamine-B had been developed for tidal dispersion studies [20], quoted limits of detection were impractical for our purposes (rhodamine-B is also designated a class 1 carcinogen). We therefore developed an alternative "dual tracer technique" [14], in which two volatile tracers with a large diffusivity contrast, in this case ^3He and SF_6, were released to seawater and their concentrations monitored with time as they escaped to the atmosphere at different rates. The *difference* in the transfer velocities of the two gases was measured initially and subsequently converted to absolute values of k_w using assumed physical relationships.

Recently, conservative tracers more suited to our purposes (spores of the microbe *Bacillus globigii* and the rhodamines WT and Sulpho-G) have become available. Microbial tracer technology is not new, having been used previously to evaluate sewage dispersion in coastal waters [21] and the migration of contaminating microbes in groundwater [22]. Bacterial spores are ideally suited to such studies because they persist in the environment in a metabolically inactive state and have better detection limits than commonly used chemical tracers. Also they are innocuous in use, incapable of growth in the environment and unlikely to interfere with natural microbial populations [23]. These characteristics suggested to us that bacterial spores might be an ideal conservative tracer for use in gas exchange studies in open seawater and we first used them in this context during *Challenger* Cruise 99A in 1993 [24]. Data obtained on that cruise facilitated the direct calculation of k_w for SF_6 and ^3He independently of eachother and allowed us to determine the Schmidt number dependence of gas transfer, a significant advance on our previous capabilities [25]. During *Challenger* 129 our aim was to improve on our first results by using a higher initial spore concentration, minimising sample storage and handling and carrying out experiments to investigate whether spores are truely conservative with respect to light exposure and microzooplankton grazing.

Rhodamines WT and Sulpho-G are representative of a new generation of non-toxic tracer "dyes" which can be analysed at high dilution using improved techniques of analysis [26]. Rhodamine WT is susceptible to mild photodegradation and as such is not strictly conservative. However, by measuring its ratio to conservative rhodamine sulpho-G, any non-conservatism can be corrected for. By deploying these compounds in conjunction with the other three tracers, we aimed to generate additional sets of estimates of k_w for SF_6 and ^3He. Thus it would be possible for the first time to compare directly k_w determined with three different combinations of tracers.

Tracer preparation

Tracer preparation took place ~ 25 km to the northwest of the designated release site, in order to avoid accidental spillages of concentrated tracers in the release area.

The release of SF_6 and ^3He to seawater is complicated by their low solubilities, ca. 1.8×10^{-4} and 3.9×10^{-4} mol dm^{-3} at 25 °C respectively. Because this work requires the injected tracer masses to be accurately known, they were first dissolved in water in a gas-tight steel tank of 2250 dm^3 capacity. The tank was first filled with freshwater to which common salt was added to adjust its density to that of ambient seawater. Eight units of Biotrace (International Biochemicals Ltd., Eire), each containing 10^{14} spores of *Bacillus globigii var Niger (BG)* were then dissolved in the tank water (cf. 2 units in 1993 [24]) and the tank sealed to leave a small headspace ~ 0.5 dm^3. Pure SF_6 and ^3He were then added to the headspace, with pumped recirculation through the tank water via a steel frit. Dissolved gas concentrations in the tank water were monitored by thermal conductivity gas chromatography. When the theoretical saturation values for SF_6 and ^3He were reached a further sample of tank water was withdrawn for spore analysis and the tank sealed.

Because rhodamines WT and sulpho-G have unique preparation requirements which interfere with the gas saturation procedure, they were prepared separately. 25 kg of rhodamine WT (20% solution) was added to 50 kg of tapwater in a 1000 dm^3 steel tank, with continuous stirring via a submersible recirculation pump. 75 dm^3 of CH_3OH and 10 kg of rhodamine sulpho-G powder were then added and the tank filled to volume with ambient seawater and sealed.

Following these activities, the afterdeck, tank exteriors and all tracer preparation materials were thoroughly flushed with the seawater fire hoses to remove gross tracer contamination. The tanks remained sealed en-route to the release site.

Tracer Release

Prior to tracer release, a series of CTD casts were made along the axis of the designated release site (52° 16 N, 004° 02 E - 52° 20 N, 004° 05 E) in order to establish ambient tracer backgrounds and provide a further check on tracer contamination by the ship. They also ensured that the water column was unstratified; significant stratification complicates the subsequent interpretation of tracer distributions. In addition to being conveniently close to *Meetpost Noordwijk* for comparative studies, the release site is the one used by us previously [14,19,24], having been selected for its relatively uniform seabed, which simplifies the calculation of k_w based on volatile tracers.

Tracer release was initiated at the end of high water slacks and continued during the six hour cycle to low water slacks. *Challenger* held station along the tidal axis with her stern "downtide" and the tracers were deployed by displacement with water pumped into header tanks. This procedure minimised the loss of SF_6 and ^3He to the atmosphere and maintained the integrity of the SF_6 / ^3He ratio throughout the release. Deployment was through two subsurface hoses at 10 m depth with in-line flowmeters for the coordination of tank water flowrates. These were increased at intervals in order to compensate for continual tracer dilution in the tanks. The tracer-tagged water streamed away in the tide in a northeasterly direction, producing a line release roughly the length of the tidal ellipse, ~8 km. Three drogued surface drifting buoys were deployed at equal intervals along the tracer axis. The "middle" buoy had an attached incubation rig designed to evaluate the effects of light exposure on *Bacillus globigii* spores. The buoys were tracked with the Argos satellite network and with direction finding receivers.

Initial calculations based on tank water flowrates indicated that > 88 % of the tracers had been released over the 5.5 hr duration of the deployment. Samples were collected from the water left in the 2250 dm^3 tank at the end of the deployment (prior to cleaning out the tanks) for determination of the total number of spores deployed.

Following deployment *Challenger* returned to the initial tracer preparation area where the tanks were thoroughly cleaned using the seawater fire hoses. All tubing and ancillary equipment used in the release was sealed inside the tanks and the tank exteriors and afterdeck were thoroughly washed down.

Tracer Analysis

The tracer patch was continuously surveyed for SF_6 using a custom-built, fully automated gas chromatographic system. The instrument analysed a continuous seawater flow delivered from an overside pump. SF_6 was purged from seawater with N_2 gas, dried over Nafion and trapped cryogenically on Porapak-Q. Subsequent thermal desorption was followed by injection into an electron capture gas chromatograph, with separation of SF_6 from O_2 on molecular sieve 5A. Backflushing of the column facilitated a continuous sequence of analyses with a 3 minute repeat time. Individual chromatograms were automatically "fingerprinted" by matching them with time and position coordinates obtained from a GPS, and the data output to a P.C. for processing. P.C. output was in the form of a "map" of the tracer patch which was automatically updated after every analysis. This was used as an aid to navigation around the patch. At the patch "centre", as identified from the surveys, seawater samples were collected with the CTD from 3 or 4 depths, using 10 litre stainless steel sprung Niskin bottles. Subsamples were then removed for the analysis of tracers and other biogeochemical quantities.

One litre samples collected for SF_6 (~ 400 in total) were analysed immediately using a "discrete" version of the continuous mapping system. For ^3He analysis 74 samples, each of volume ~ 40 cm^3, were collected in copper tubes and sealed by pinch-off clamps at each end. These were stored for later ^3He analysis in the noble gas facility at the Lamont-Doherty Earth Observatory (Columbia University). Subsequent sample processing will involve initial vacuum extraction of seawater volatiles into glass ampoules containing activated charcoal, with separation and purification of ^3He on a series of cold traps. Analyses will be on a VG-5400 helium isotope mass spectrometer; ^4He will be measured with a Faraday Cup and ^3He with a Johnston-MM1 electron multiplier [27]. Samples for the analysis of rhodamines WT and sulpho-G (140 in total, each of volume 400 cm^3) were collected in replicate in opaque glass 500 cm^3 screw cap bottles. These were stored in "dark boxes" for subsequent analysis at the Netherlands National Institute of Sea Research (NIOZ), using techniques developed there [26]. We anticipate that the ^3He and rhodamine data will become available during March 1997.

Samples for spores analysis were collected from the CTD rosette and from the over-side pump supply into sterile 1.3 litre polystyrene roller bottles, and analysed immediately or after storage for up to 12 hours in the ship's constant temperature laboratory at ambient seawater temperature (~ 15° C). Suites of replicates were returned to UEA to test for the effect of storage on spore counts. In all 598 individual spore analyses were carried out, following an established procedure [21]. For CTD and pump samples 10 replicate samples of between 100 cm^3 and 500 cm^3 were dispensed into sterile containers using sterile measuring cylinders. For experiments 5 replicate samples of 25 cm^3 to 30 cm^3 were collected for analysis. Our original intention had been that glass and plasticware would be used once only to prevent sample cross-contamination. However, the spore concentration decreased more rapidly than had been anticipated and it was necessary to wash and reuse the larger volume bottles. All sample aliquots were heated at 63°C for 30 minutes in a water bath to induce full spore germination and reduce the background bacterial flora. Temperature was monitored using a digital thermometer placed in a control bottle containing water at the same temperature as the samples. The heated samples were then filtered through sterile 0.45 μm gridded cellulose nitrate filters (47mm diameter) mounted in disposable holders. In order to ensure complete removal of spores from the bottles, they were rinsed with autoclaved seawater which was also filtered. The filters were removed using sterile forceps and incubated on Petri-Pads soaked in sterile recovery medium containing tryptone. The petri dishes were iuncubated in the dark at 30°C for 18 to 20 hours prior to counting of the orange/brown pigmented colonies characteristic of *Bacillus globigii*. Counts were repeated after a further 6 to 10 hours. Residual analyses of stored spores samples should be completed by the end of 1996. Further data analysis will be carried out when data for the other tracers become available.

2. Wind Data

Wind speed and direction data were logged continuously by the *Challenger* met. pack. The data are output in a form which is automatically corrected for the ships speed and direction of movement. Wind speeds were also logged on ship using a sonic anemometer provided by Peter Taylor (Southampton), however this instrument ceased logging late on in the cruise (see below). Additional windspeed data are also available from *Meetpost Noordwijk* and from two other platforms operated by KNMI, *Europlatform* and *Goeree*. These are located about 20 km to the south of *Meetpost Noordwijk*. During the cruise, two wind speed intercalibration exercises were carried out in conjunction with *Meetpost Noordwijk*. In these, *Challenger* held station for periods of several hours in the vicinity of the *Meetpost,* alternately upwind and downwind of it. It was during the second of these exercises that the sonic anemometer unfortunately failed. Nevertheless, when they become available the wind speed data from all of these sources should facilitate detailed evaluation of the performance of the *Challenger* Metpack, particularly during the frequent and rapid manoeuvres characteristic of the tracer surveys.

3. Associated Studies

1. Carbon monoxide in surface seawater and air.

Underway measurements for CO were taken continously from the non-toxic supply and analysed directly by gas chromatography/atomic absorption. Seawater was pumped at a rate of 0.7 litre min^{-1} to an equilibrator with a 4:1 volume ratio of water to gas. A Martin steel bellows pump was used to recirculate the air through the equilibrator. Hopcalite was used to clean up the carrier gas (zero grade air). Equilibrium was reached in 8 minutes. A 1 ml gas sample was then injected through a precolumn (Unibead, 60-80 mesh) and a 1m molecular-sieve 13X (80-100 mesh) column to a Reduction Gas Detector. In the detector CO is carried over a mercuric-oxide bed which reacts on a mole-to-mole basis to produce carbon dioxide and elemental mercury. An ultraviolet lamp subsequently detects elemental mercury which is recorded on a Spectra-Physics integrator. Individual water samples were analysed in 12 min. and air samples in 2.5min. The whole run is automated and is controlled via a laptop computer. Atmospheric samples were taken every 1.5 hours from the bow to avoid possible contamination from the ships exhausts.

CO concentrations reached a maximum in the mid-afternoon, *ca* 3hrs after midday, and decreased at a steady rate to constant levels *ca* 5hrs after sunset. Figure 2 shows a typical diurnal cycle for CO. Photolysis of dissolved organic carbon (DOC) has been identified as the main mode of CO production. Preliminary analysis of the data collected during the cruise seems to confirm this theory: during days of low insolation CO levels also remained low throughout the day.

Evasion to the atmosphere is the largest loss mechanism for oceanic CO. Further research is needed to quantify sea-air fluxes and microbial consumption of CO. Atmospheric levels showed a high degree of CO variability, possibly due to air masses with high CO content blowing in from eastern Europe. Closer examination of the data is needed to test this hypotheses.

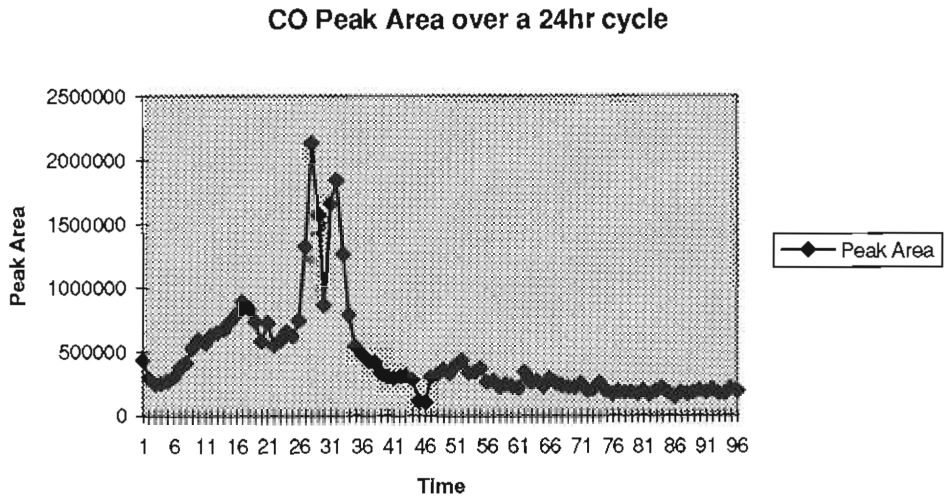

Figure 2. A typical diurnal cycle of dissolved CO in surface seawater, as observed during the cruise.

2. Nitrous oxide and methane in seawater and air.

Partial pressures of N_2O and CH_4 were measured in samples of seawater and air by gas chromatography, with electron capture detection (ECD) for N_2O and flame ionisation detection (FID) for CH_4, following a fully automated headspace equilibration technique [28]. One litre volume seawater samples were collected from a total of 26 CTD stations and compared with analyses of ambient air. Unfortunately, because of an unforseen technical problem involving the co-elution of SF_6 with N_2O on the ECD, N_2O sample peaks were swamped by high concentrations of the tracer and these measurements had to be abandoned. The results for CH_4 were unaffected. These data are currently in an unprocessed form and require solubility corrections based on ambient salinity and temperature data from the CTD which require further calibration. Nevertheless, some preliminary observations are possible. Firstly, all seawater samples showed significant CH_4 supersaturations relative to ambient air, with the highest values in coastal regions affected by freshwater inputs such as the Rhine plume. Secondly, overall CH_4 supersaturations were significantly depressed immediately following the passage of a severe storm (Force 11) on 27-29/10. This is most likely a consequence of enhanced gas transfer relative to the rate of water column CH_4 synthesis. More detailed insight into the rate processes involved will be possible when the results from the tracer experiments are processed.

3. Non-methane hydrocarbons in seawater and air.

Non-methane hydrocarbons (NMHC's) are important reactive gases in the atmosphere. They are a sink for hydroxyl radical (OH) and are key players in the production and destruction of ozone in the troposphere. The importance of anthropogenic emissions of NMHC's and biogenic emissions of monoterpenes and isoprene (2-

methyl 1,3-butadiene) from the terrestrial biosphere has long been recognised and extensively studied. However, the ocean as a source of reactive species such as isoprene has only recently been identified. The emission of isoprene and other NMHC's from the ocean may provide a significant source of reactive organics to the atmosphere over the remote oceans. The mechanism of production of these gases in seawater is poorly understood. It is believed to be a combination of both photochemistry and emission of NMHC's or their precursors from phytoplankton.

Seawater and air samples were collected throughout the cruise and analysed *in situ* by gas chromatography with flame ionisation detection (GC-FID). 1.5 litre seawater samples were purged with CP nitrogen at 60 ml min^{-1} for 30 mins to remove the trace gases, which then passed through a water droplet trap and a nafion dryer before being cryogenically concentrated in a 1/8" stainless steel trap containing 80 mesh glass beads held at -185°C by a headspace of liquid N_2. This temperature trapped all trace gases of interest whilst allowing the free passage of N_2 and O_2. The sample loop was heated at 95°C to inject the sample into the GC where the components were separated on an Al_2O_3 PLOT column. The method is described elsewhere [29]. Air samples were preconcentrated in the same way. Approximately 30 aliphatic C_2 - C_7 NMHC's were separated and quantitatively analysed for each sample. DMS was also observed, but the analytical conditions were not optimised for this compound so it was not quantified.

Air samples were collected once per day from stainless steel and aluminium 1/4" tubing mounted forward of the bridge on the raft deck. A battery operated metal bellows pump was used to fill a 3.2 l stainless steel canister to ca. 30 psig. Seawater samples were collected from both the CTD and the ship's underway seawater supply. The underway samples were collected via a silicon tube immersed in the on-deck box containing the flow-through transmissometer. This supply was directly connected to the underway fluorometer. Samples were also collected from the SF_6 intake (over-the-side "shoe") but these samples contained anthropogenic contaminants which were not observed in simultaneously collected samples from the ship's underway seawater supply.

With each NMHC seawater sample water was also collected for analysis of the following supporting biological parameters. 100 - 200 ml of water was filtered onto 25 mm Whatman GF/F filters and flash-frozen in liquid nitrogen for fluorometric analysis of chlorophyll at UEA [30]. 150 ml sample aliquots were treated with lugol's iodine and further 150 ml aliquots were treated with formalin for the preservation of phytoplankton and zooplankton. These samples will analysed subsequently in Southampton. Samples were collected routinely between ca. 0800 and 2100.

A 24 hour Lagrangian study was carried out in the patch from 0300 on JD 299(25/10/96) to 0200 on JD 300. An initial inspection of the data shows very little change in the NMHC concentrations (in particular isoprene) over this period. The sampling record is shown in Tables 1 and 2. 96 seawater samples were collected and analysed for NMHCs, chlorophyll and phytoplankton taxonomy. 13 air samples were collected.

Table 1 NMHC CTD samples

OID	CTD#	DEPTH	COMMENT	OTHER CO-DETERMINANTS
S2-12	CTD04	5		Chlorophyll, phytoplankton
S3-01	CTD07	10		Chlorophyll, phytoplankton
S5-03	CTD07	5		Chlorophyll, phytoplankton
S2-15	CTD08	15		Chlorophyll, phytoplankton
S3-02	CTD08	5		Chlorophyll, phytoplankton
-	CTD08	10	No HC	Phytoplankton

			sample	
S5-04	CTD09	5		Chlorophyll, phytoplankton
S2-20	CTD11	17		Chlorophyll, phytoplankton
S3-03	CTD11	10		Chlorophyll, phytoplankton
S5-05	CTD11	5		Chlorophyll, phytoplankton
S2-21	CTD12	14		Chlorophyll, phytoplankton
S3-04	CTD12	8		Chlorophyll, phytoplankton
S5-06	CTD12	4		Chlorophyll, phytoplankton
S2-22	CTD13	5		Chlorophyll, phytoplankton
S2-28	CTD16	15		Chlorophyll, phytoplankton
S3-05	CTD16	11		Chlorophyll, phytoplankton
S5-08	CTD16	5		Chlorophyll, phytoplankton
S2-30	CTD17	15		Chlorophyll, phytoplankton
S3-06	CTD17	10		Chlorophyll, phytoplankton
S5-09	CTD17	5		Chlorophyll, phytoplankton
S2-35	CTD19	16		Chlorophyll, phytoplankton
S3-08	CTD19	9		Chlorophyll, phytoplankton
S5-10	CTD19	5		Chlorophyll, phytoplankton
S3-09	CTD21	5		Chlorophyll, phytoplankton
S5-11	CTD22	5		Chlorophyll, phytoplankton
S2-36	CTD24	14		Chlorophyll, phytoplankton
S3-10	CTD24	9		Chlorophyll, phytoplankton
S5-12	CTD24	6		Chlorophyll, phytoplankton
S2-37	CTD26	5		Chlorophyll, phytoplankton
S5-14	CTD28	5		Chlorophyll, phytoplankton
S2-38	CTD29	5		Chlorophyll, phytoplankton
S3-12	CTD30	9		Chlorophyll, phytoplankton
S5-15	CTD30	5		Chlorophyll, phytoplankton
S2-39	CTD31	5		Chlorophyll, phytoplankton
S5-18	CTD32	5		Chlorophyll, phytoplankton
S2-40	CTD33	14		Chlorophyll, phytoplankton
S3-15	CTD33	9		Chlorophyll, phytoplankton
S5-19	CTD33	5		Chlorophyll, phytoplankton
S3-16	CTD34	5		Chlorophyll, phytoplankton
S2-49	CTD35	30		Chlorophyll, phytoplankton
S3-20	CTD35	17		Chlorophyll, phytoplankton
S5-20	CTD35	7		Chlorophyll, phytoplankton
S5-22	CTD36	5		Chlorophyll, phytoplankton
S2-51	CTD37	17		Chlorophyll, phytoplankton
S3-21	CTD37	10		Chlorophyll, phytoplankton
S5-23	CTD37	5		Chlorophyll, phytoplankton

Table 2 - NMHC Underway samples

OID	TBEGNS	GCODE	COMMENT	OTHER CO-DETERMINANTS
S2-01	17/10/96 11:35	GPUMP	Sample lost	Chlorophyll, phytoplankton
S2-02	17/10/96 15:17	GPUMP		Chlorophyll, phytoplankton
S2-03	18/10/96 07:30	GPUMP		Chlorophyll, phytoplankton
S2-04	18/10/96 11:45	GPUMP		Chlorophyll, phytoplankton
A1-01	18/10/96 13:47	AIRBOT		
S2-05	18/10/96 15:45	GPUMP		Chlorophyll, phytoplankton

S5-01	18/10/96 15:45	GPUMP		Chlorophyll
S2-06	18/10/96 19:47	GPUMP		Chlorophyll, phytoplankton
S2-07	19/10/96 08:00	GPUMP		Chlorophyll, phytoplankton
S2-08	19/10/96 10:00	GPUMP		Chlorophyll, phytoplankton
S2-09	19/10/96 12:22	GPUMP		Chlorophyll, phytoplankton
S2-10	19/10/96 14:58	GPUMP		Chlorophyll, phytoplankton
S2-11	19/10/96 16:01	GPUMP		Chlorophyll, phytoplankton
S5-02	19/10/96 16:02	CPUMP	Teflon tube	Chlorophyll
A1-02	19/10/96 18:07	AIRBOT		
S2-13	20/10/96 08:48	GPUMP		Chlorophyll, phytoplankton
S2-14	20/10/96 11:36	CPUMP		Chlorophyll
A1-03	20/10/96 15:12	GPUMP		
S2-16	21/10/96 08:12	GPUMP		Chlorophyll, phytoplankton
A1-04	21/10/96 10:04	AIRBOT		
A5-01	21/10/96 10:20	AIRBOT		
S2-17	21/10/96 12:05	GPUMP		Chlorophyll, phytoplankton
S2-18	21/10/96 14:25	GPUMP		Chlorophyll, phytoplankton
S2-19	21/10/95 14:25	GPUMP		Chlorophyll, phytoplankton
S5-07	22/10/96 11:58	GPUMP		Chlorophyll, phytoplankton
S2-23	22/10/96 16:00	GPUMP		Chlorophyll, phytoplankton
S2-24	22/10/96 17:40	GPUMP		Chlorophyll, phytoplankton
A5-02	22/10/96 19:00	AIRBOT		
S2-25	23/10/96 12:05	GPUMP		Chlorophyll, phytoplankton
S2-26	23/10/96 14:45	GPUMP		Chlorophyll, phytoplankton
S2-27	23/10/96 16:04	GPUMP		Chlorophyll, phytoplankton
S2-29	23/10/96 20:05	GPUMP		Chlorophyll, phytoplankton
A1-05	24/10/96 08:52	AIRBOT		
S3-07	24/10/96 12:12	GPUMP		Chlorophyll, phytoplankton
S2-31	24/10/96 14:42	GPUMP		Chlorophyll, phytoplankton
S2-32	24/10/96 15:47	GPUMP		Chlorophyll, phytoplankton
S2-33	25/10/96 03:14	GPUMP		Chlorophyll, phytoplankton
S2-34	25/10/96 04:12	GPUMP		Chlorophyll, phytoplankton
A5-03	25/10/96 09:17	AIRBOT		
S3-13	25/10/96 20:04	GPUMP		Chlorophyll, phytoplankton
S5-16	25/10/96 22:02	GPUMP		Chlorophyll, phytoplankton
S5-17	26/10/96 00:05	GPUMP		Chlorophyll, phytoplankton
S3-14	26/10/96 01:47	GPUMP		Chlorophyll, phytoplankton
A1-06	26/10/96 15:25	AIRBOT		Chlorophyll, phytoplankton
S3-16	26/10/96 16:20	GPUMP		Chlorophyll, phytoplankton
S2-41	26/10/96 19:25	GPUMP		Chlorophyll, phytoplankton
S2-42	27/10/96 09:50	GPUMP		Chlorophyll, phytoplankton
S3-17	27/10/96 11:00	GPUMP		Chlorophyll, phytoplankton
S2-43	27/10/96 12:13	CPUMP		Chlorophyll, phytoplankton
S3-18	27/10/96 14:25	CPUMP		Chlorophyll, phytoplankton
A5-04	27/10/96 15:07	AIRBOT		
S2-44	28/10/96 13:10	CPUMP		Chlorophyll, phytoplankton
S2-45	28/10/96 15:45	CPUMP		Chlorophyll, phytoplankton
S3-19	28/10/96 18:58	CPUMP		Chlorophyll, phytoplankton
A1-07	28/10/96 19:30	AIRBOT		
S2-46	28/10/96 19:48	CPUMP		Chlorophyll, phytoplankton
S2-47	29/10/96 13:22	GPUMP		Chlorophyll, phytoplankton
S2-48	29/10/96 15:00	GPUMP		Chlorophyll, phytoplankton

A5-05	29/10/96 16:27	AIRBOT		
S5-21	29/10/96 20:00	GPUMP		Chlorophyll, phytoplankton
S2--50	30/10/96 10:25	GPUMP		Chlorophyll, phytoplankton
S3-22	30/10/96 16:25	GPUMP		Chlorophyll, phytoplankton
A1-08	30/10/96 17:25	AIRBOT		

4. Changes in algal biomass and speciation determined with a Lagrangian approach: comparison with mixing and turbulence in the water column.

Routine water sampling took place four times daily from the non-toxic seawater supply for calibration of the transmissometer, fluorometer and oxygen sensors in the deck-flow box. Samples were also collected from each CTD cast to calibrate the attached sensors.

Samples were collected for the analysis of nutrients (NO_2^-, NO_3^-, NH_4^+ PO_4^{3-} and Si), chlorophyll-a, organic and inorganic fractions of suspended particulate matter (SPM) and dissolved O_2, and for the identification and enumeration of phytoplankton. The sampling strategy was coordinated with that for the NMHC's (see 3, above) in order to ensure full compatibility of the biological measurements with these trace gas data.

Nutrient samples, collected daily, were GF/F filtered and stored in a refrigerator for subsequent analysis in Southampton. Samples for SPM and O_2 were also stored for post-cruise analysis. Chlorophyll was determined during the cruise, with concentrations ranging from 0.7 - 2.0 mg m^{-3}. Phytoplankton samples were counted live or preserved in Lugol`s solution. Microscopic examination showed that diatoms were common with a small chain-forming species (yet to be identified) most abundant in the majority of samples. Other diatom species such as *Biddulphia spp.*, *Asterionella spp.*, and *Chaetoceros spp.* were also observed. A few dinoflagellates were also counted.

ADCP (Acoustic Doppler Current Profiler) data were recorded routinely during the cruise. The vessel mounted ADCP (150kHz) collected data every two minutes with a bin depth of 1m.

In a Lagrangian experiment on 25-26/10/96, a discrete water "parcel" within the tracer patch was "tracked" by following an Argos buoy (initial co-ordinates 52° 22.9 N; 004° 11.5 E). The water column at this location was ~ 20 m deep and remained generally well mixed throughout the cruise. Nevertheless, a weak salinity structure was observed between 1015 and 1320 GMT on 25/10 with lower salinity surface water (~31 psu) overlying more saline water (~33 psu). Hourly CTD`s were collected over a 12 hr period from approximate local sunrise (0500 GMT), with additional samples collected hourly from the non-toxic seawater supply from 0300 GMT on 25/10 to 0100 GMT on 26/10. The experiment took place two days before maximum spring tides, with a predicted tidal range of 1.8m, and immediately followed a period of mild weather from 22/10. Low waters were at 0729 and 1956 GMT, with high waters at 0207 and 1426 GMT, indicating an extended period of low water. Double low waters are common in this region but the tide tables only indicate the time of the first low water. Phytoplankton cell counts were made on all CTD casts. Early morning counts showed samples to have similar species distributions to samples identified earlier in the cruise. During the day however, many large diatom chains ~ 2mm were clearly visible. The main chain formers were *Biddulphia spp.* and the unidentified smaller diatom noted previously. Between 1015 and 1420 GMT cell and species numbers increased and a new organism was observed which had not been present in previous water samples. This was a large chain-forming *Rhizosolenia spp.* with a maximum chain length ~ 3mm. When the water column became well mixed at ~1400 GMT, species diversity decreased and there was a return to an abundance of smaller diatom chains. Numerous zooplankton species were observed (as in the rest of the cruise), with copepods the most common. The hydrozoan *Obelia spp.* was also abundant, usually in the free-swimming medusoid stage, but also as a hydroid colony. Other filter feeders such as the larvacean *Oikopleura spp.* were also counted. Measurements of current velocity and direction, and shear structure (cm s^{-1}) will be used subsequently to evaluate the physical constraints on biology which operated during the survey. Richardson numbers will be calculated as measures of water column turbulence, which has important implications for phytoplankton parameters including vertical species distributions, chain lengths and carbon biomass. Recorded beam intensities will be used to provide relative estimates of SPM comparable to the transmissometer data.

BODC Shipboard Data Management :

BODC was contracted to undertake primary shipboard data management for *Challenger* 129. There were two primary objectives. The first was to construct a comprehensive, centralised inventory of all samples collected and measurements made. This inventory forms the basis of the database framework for the collected data. It will be supplied to BADC to assist with their data tracking and subsequently disseminated to the scientific party for reference. The second objective of BODC is the processing, quality assurance and calibration of the underway and CTD profile data. The underway data (navigation, fluorometer, thermosalinograph, oxygen sensor, transmissometer, bathymetry and meteorological measurements) will be worked through BODC's standard quality assurance procedures. The fully processed data will be reformatted into Ames and submitted to BADC. The data will also be available at BODC. Likewise, the CTD profiles will be processed at BODC. Production of a report entitled 'Data collection on CH129' is anticipated during early 1997 and it will be distributed to all cruise participants.

Equipment Deployed, Recovered And Lost :

Three drogued surface drifting buoys, tracked by the Argos satellite network and on-board direction finding receivers, were deployed on 18/10/96 as follows:

Time	Position	Buoy #
17-00 GMT	52° 16.6 N; 004° 01.5 E	Buoy # 8.
19-12 GMT	52° 16.6 N; 004° 01.4 E	Buoy # 2*
21-16 GMT	52° 16.5 N; 004° 01.4 E	Buoy # 1

* Deployed with an attached incubation rig containing experiments with *Bacillus globigii* spores.

Buoy # 1 stopped transmitting early on in the cruise and visual contact was lost for the last time on 27/10. Following the passage of a severe storm (Force 11) on 27-29/10, all three buoys were displaced several km to the north east of their earlier positions. Buoy # 2 and the attached incubation rig were recovered at 52° 37.6 N; 004° 27.0 E on 30/10/96, following an extensive search. Unfortunately, because of severe time constraints the search for buoys # 1 and # 8 had to be abandoned and they were not recovered during the cruise.

Points for the Attention of RVS :

Minor problems were encountered in two areas. Firstly, raw data from the ADCP were not successfully archived by the software. Consequently, only the processed data are available for retrieval. Secondly, the sonic anemometer ceased logging on 27/10. These problems only came to light at the end of the cruise. With these exceptions, all of the remaining RVS equipment functioned correctly.

One additional comment is that the output from the ship's met. package is currently only available on-screen in the plot room. A second screen displaying these data in the main laboratory would be an extremely valuable aid to scientific decision making during steaming.

Condensed Scientific Log :

14/15 Oct. Arrival of Scientific Personnel and loading of equipment onto RRS *Challenger* in Portland. Scientific equipment assembled in the main, wet and fish labs. Installation of 2250 l and 1000 l steel tracer tanks on the aft deck. RVS equipment installation and testing.

16 Oct:

16 Oct:		Completion of RVS equipment installation and testing.	
	15-00 GMT	Departed from Portland quay and commenced steaming for tracer release site. Work continuing to bring continuous and discrete SF_6 analytical systems "on-line".	
17 Oct:	09-00 GMT	Work continuing to make ready underway tracer system.	
	12-00 GMT	Commenced preparation of gaseous and conservative tracers underway : 25 kg Rhodamine WT (20% solution), 10 kg Rhodamine sulpho-G powder dissolved in 75 l MeOH, 900 l seawater (1000 l tank), tank topped up with further seawater and sealed; 5 l *bacillus globigii* bacterial spores (10^8 individuals) dissolved in saltwater (2250 l tank). SF_6 and ^3He dissolved in 2250 l tank by bubbling and tank sealed. Afterdeck/ tank exteriors thoroughly flushed with seawater fire hoses to remove gross tracer contamination. Argos buoys readied for deployment.	
	18-10 GMT	52° 12.0 N; 003° 11.6 E	Commenced calibration survey for ADCP.
	19-10 GMT	52° 17.9 N; 003° 18.4 E	Completed calibration survey for ADCP.
	22-12 GMT	52° 19.9 N; 004° 05.0 E	Arrived tracer release site and hove to for morning CTD.
18 Oct:	07-15 GMT	52° 16.6 N; 004° 01.6 E	CTD (# 01) for tracer "backgrounds" and biological parameters along tracer release axis (tracer survey #1).
	07-45 GMT	52° 16.5 N; 004° 01.6 E	Hove to for repairs to CTD winch
	09-36 GMT	52° 16.1 N; 004° 01.7 E	Winch repairs completed. Proceeding to next CTD station.
	10-10 GMT	52° 18.5 N; 004° 03.6 E	CTD (# 02) for tracer "backgrounds" and biological parameters along tracer release axis .
	11-55 GMT	52° 19.7 N; 004° 05.1 E	CTD (# 03) for tracer "backgrounds" and biological parameters along tracer release axis (end of survey #1)..
	12-07 GMT	52° 19.8 N; 004° 05.1 E	Deployment of overside pump, testing and connection to continuous SF_6 analysis system.
	13-52 GMT	52° 15.2 N; 003° 59.1 E	Hove to for test of CTD operating system.
	16-38 GMT	52° 16.6 N; 004° 01.4 E	Commenced tracer deployments at end of high water slacks with vessel aligned stern downtide. Tracers released over stern at nominal 10 m depth.
	17-00 GMT	52° 16.6 N; 004° 01.5 E	Argos buoy # 8 deployed. Tracer release continuing.
	19-12 GMT	52° 16.6 N; 004° 01.4 E	Argos buoy # 2 deployed with attached incubation rig for *bacillus globigii* spores. Tracer release continuing.

	21-16 GMT	52° 16.5 N; 004° 01.4 E	Argos buoy # 1 deployed. Tracer release continuing.
	22-20 GMT	52° 16.5 N; 004° 01.2 E	Tracer release completed. Commenced steaming to ~10 km NW of release site for cleaning of tracer tanks.
19 Oct:	07-20 GMT	52° 21.9 N; 003° 43.4 E	Commenced flushing of tracer tanks with seawater hoses. Tracer deployment equipment sealed inside tanks and decks, tanks and CTD thoroughly hosed down.
	13-25 GMT	52° 21.7 N; 003° 44.0 E	Completed tank and ship cleaning. En-route to tracer release site.
	17-15 GMT	52° 15.9 N; 004° 03.6 E	Commenced D-F survey for Argos buoy # 1.
	18-10 GMT	52° 14.5 N; 004° 03.8 E	In vicinity of Argos buoy # 1. Commenced tracer survey #2.
	19-17 GMT	52° 15.6 N; 004° 02.9 E	CTD (# 04) for all tracers, and biological parameters
19 Oct:	21-38 GMT	52° 18.4 N; 004° 03.3 E	CTD (# 05) for all tracers, and biological parameters
	23-15 GMT	52° 20.8 N; 004° 04.7 E	CTD (# 06) for all tracers, and biological parameters. Hove to overnight.
20 Oct:	07-35 GMT	52° 20.9 N; 004° 12.8 E	Commenced tracer survey. Tide running to the NNE.
	11-31 GMT	52° 20.9 N; 004° 04.5 E	CTD (# 07) for all tracers and biological parameters
	13-43 GMT	52° 24.9 N; 004° 09.8 E	Proceeding towards *Meetpost Noordwijk.*
	15-58 GMT	52° 16.2 N; 004° 18.6 E	VHF contact with *Meetpost Noordwijk.* CTD (# 08) for SF_6 and biological parameters offshore of *Meetpost Noordwijk..*
	17-13 GMT	52° 14.7 N; 004° 21.1 E	CTD (# 09) for biological parameters inshore of *Meetpost Noordwijk.* Tracer survey #2 terminated.
	18-22 GMT	52° 16.1 N; 004° 17.2 E	CTD (# 10) for SF_6, O_2 and phytoplankton upwind of *Meetpost Noordwijk..*
	20-10 GMT	52° 17.8 N; 004° 19.3 E	Stationed downwind of *Meetpost* for intercalibration of meteorological package.
21 Oct:	03-00 GMT	52° 17.2 N; 004° 17.5 E	End of calibration. Proceeding to tracer release site.
	06-47 GMT	52° 15.4 N; 004° 08.0 E	Start of tracer survey # 3
	09-40 GMT	52° 21.8 N; 004° 06.7 E	Weather too rough for CTD. Hove to for underway sampling for all tracers (sample u/w #01).
	10-55 GMT	52° 25.0 N; 004° 01.9 E	Underway "backgrounds" for SF_6 at patch periphery.
	18-40 GMT	52° 18.5 N; 004° 05.1 E	CTD (#11) for all tracers and biological parameters. Resumed tracer survey.
22 Oct:	09-32 GMT	52° 18.5 N; 004° 03.7 E	CTD (#12) for all tracers and biological parameters. Resumed tracer survey.
	11-50 GMT	52° 21.9 N; 004° 05.3 E	CTD (#13) for all tracers and biological parameters. Resumed tracer survey.
	21-15 GMT	52° 20.8 N; 004° 04.0 E	CTD (#14) for all tracers and biological parameters. Resumed tracer survey.
23 Oct:	02-03 GMT	52° 19.7 N; 004° 00.9 E	Stopped for underway sample (u/w #02) for SF_6, ^3He and Rhodamines. Resumed tracer survey.
	07-20 GMT	52° 22.7 N; 004° 03.6 E	CTD (#15) for all tracers and NMHC. Resumed survey.
	17-36 GMT	52° 22.6 N; 004° 09.6 E	CTD (#16) for all tracers and biological parameters. Resumed survey.

24 Oct:	03-06 GMT	52° 15.2 N; 004° 09.6 E	Stopped for underway sample (u/w #03) for all tracers. Resumed tracer survey.
	09-21 GMT	52° 14.5 N; 003° 59.3 E	CTD (#17) for all tracers and biological parameters. Resumed survey.
	19-35 GMT	52° 19.9 N; 004° 07.1 E	CTD (#18) for all tracers and biological parameters. Resumed survey.
25 Oct:	03-00 GMT	52° 22.4 N; 004° 11.4 E	Hove to at Argos buoy # 1 for start of 12 hour CTD survey.
	03-45 GMT	52° 22.5 N; 003° 11.4 E	Underway sample (#04) for SF_6 in vicinity of buoy # 1.
	04-08 GMT	52° 23.0 N; 004° 11.1 E	Underway sample (#05) for SF_6 in vicinity of buoy # 1.
	04-22 GMT	52° 23.5 N; 004° 10.9 E	Underway sample (#06) for SF_6 in vicinity of buoy # 1.
25 Oct:	04-33 GMT	52° 24.2 N; 004° 10.8 E	Underway sample (#07) for SF_6 in vicinity of buoy # 1.
	04-58 GMT	52° 23.8 N; 004° 11.5 E	Underway sample (#08) for SF_6 in vicinity of buoy # 1.
	05-13 GMT	52° 23.7 N; 004° 11.4 E	Underway sample (#09) for SF_6. CTD (#19) for all tracers and biological parameters in vicinity of buoy # 1.
	06-22 GMT	52° 22.9 N; 004° 11.5 E	CTD (#20) for phytoplankton in vicinity of buoy # 1.
	07-23 GMT	52° 21.8 N; 004° 10.8 E	CTD (#21) for phytoplankton, Chl-a and NMHC, buoy # 1.
	08-26 GMT	52° 21.1 N; 004° 10.1 E	CTD (#22) for phytoplankton and CH_4, buoy # 1.
	09-27 GMT	52° 20.3 N; 004° 09.4 E	CTD (#23) for phytoplankton and Chl-a, buoy # 1.
	10-17 GMT	52° 19.8 N; 004° 09.6 E	CTD (#24) for SF_6 and biological parameters, buoy # 1.
	11-17 GMT	52° 19.7 N; 004° 09.6 E	CTD (#25) for SF_6 and biological parameters, buoy # 1.
	12-20 GMT	52° 20.4 N; 004° 10.7 E	CTD (#26) for SF_6 and biological parameters, buoy # 1.
	13-20 GMT	52° 21.7 N; 004° 12.0 E	CTD (#27) for all tracers and biological parameters, buoy # 1.
	14-24 GMT	52° 23.0 N; 004° 12.6 E	CTD (#28) for SF_6, Rhodamine, biological parameters, buoy # 1.
	15-26 GMT	52° 24.7 N; 004° 13.4 E	CTD (#29) for SF_6 and biological parameters, buoy # 1.
	16-23 GMT	52° 25.0 N; 004° 12.7 E	CTD (#30) for SF_6 and biological parameters, buoy # 1.
	17-28 GMT	52° 25.6 N; 004° 13.5 E	CTD (#31) for all tracers and biological parameters, buoy # 1.
26 Oct:	07-51 GMT	52° 26.4 N; 004° 15.2 E	CTD (#32) for all tracers and biological parameters, buoy # 1.
	12-17 GMT	52° 23.1 N; 004° 12.2 E	CTD (#33) for biological parameters, buoy # 1.
	15-09 GMT	52° 28.1 N; 004° 16.3 E	CTD (#34) for all tracers and biological parameters, buoy # 1.
27 Oct:	05-00 GMT	52° 29.2 N; 004° 17.1 E	Manoeuvre to avoid shipping. Loss of contact with buoy # 1.
	07-40 GMT	52° 24.9 N; 004° 17.4 E	Resumed tracer survey.
	11-48 GMT	52° 26.6 N; 004° 18.3 E	Hove to for underway sample (#20) for all tracers.
	13-00 GMT	52° 25.4 N; 004° 14.7 E	Cessation of deck operations due to adverse weather conditions: wind heading 220° , windspeed 40 kts. Heading for shelter off Suffolk coast.
	18-00 GMT	52° 25.9 N; 004° 01.3 E	Underway sample (#21) for SF_6, ^3He and Rhodamines. Suspension of scientific operations.
28 Oct:	00-00 GMT	52° 22.2 N; 003° 29.1 E	Continued making for shelter off U.K. coast: wind heading 240° , windspeed 22-27 kts.

	06-00 GMT	52° 24.9 N; 003° 26.8 E	Wind heading 235°, windspeed 25-30 kts.
	08-00 GMT	52° 23.1 N; 002° 53.8 E	Wind heading 230°, windspeed 27-35 kts, 1001.0 mbar.
	13-00 GMT	52° 14.5 N; 002° 41.1 E	Wind heading 230°, windspeed 30-35 kts, 997.0 mbar.
	19-00 GMT	52° 14.4 N; 002° 21.1 E	Wind heading 230°, windspeed 40-50 kts.
	13-00 GMT	52° 14.5 N; 002° 41.1 E	Wind heading 230°, windspeed 30-35 kts, 997.0 mbar.
	19-00 GMT	52° 14.4 N; 002° 21.1 E	Wind heading 230°, windspeed 40-50 kts.
29 Oct:	06-00 GMT	52° 21.2 N; 001° 48.1 E	Sheltering off East Anglia: wind heading 230°, windspeed 25 kts.
	14-00 GMT	52° 15.8 N; 001° 44.5 E	Leaving shelter to return to tracer deployment site.
	15-27 GMT	52° 16.9 N; 002° 00.2 E	Failure of overside pump. Hove to for retrieval and repairs.
	15-52 GMT	52° 18.1 N; 002° 00.2 E	Overside pump redeployed. Resumed course.
29 Oct:	16-26 GMT	52° 19.0 N; 002° 01.7 E	Overside pump failure. Pump retrieved and spare substituted.
	17-18 GMT	52° 21.4 N; 002° 02.1 E	CTD (#35) for all tracers (backgrounds) and biological parameters.
	17-24 GMT	52° 21.7 N; 002° 02.0 E	Resumed course for tracer deployment site..
30 Oct:	08-15 GMT	52° 25.1 N; 004° 15.1 E	Arrival at anticipated tracer site, to NNE of earlier surveys.
	11-00 GMT	52° 35.5 N; 004° 09.6 E	Trace relocated: hove to for CTD.
	11-12 GMT	52° 35.4 N; 004° 09.7 E	CTD (#36) for all tracers and biological parameters. Resuming tracer survey.
	12-55 GMT	52° 36.1 N; 004° 13.4 E	CTD (#37) for all tracers and biological parameters.
	13-06 GMT	52° 36.0 N; 002° 13.1 E	Proceeding to last update position and initiate search for Argos buoy # 2.
	15-43 GMT	52° 37.6 N; 004° 27.0 E	Argos buoy and *bacillus globigii* rig recovered.
	16-05 GMT	52° 37.5 N; 004° 26.8 E	Overside pump retrieved. Mounting dismantled and secured. Proceeding to *Meetpost Noordwijk* for wind calibration.
	20-00 GMT	52° 16.2 N; 004° 15.4 E	Hove to off *Meetpost Noordwijk* for wind calibration.
31 Oct:	00-00 GMT	52° 14.7 N; 004° 11.3 E	Leaving *Meetpost Noordwijk* for return to port in Gt. Yarmouth.
	08-00 GMT	52° 34.7 N; 002° 49.2 E	En-route to Corton buoy, approach to Gt. Yarmouth
	14-30 GMT	52° 31.4 N; 001° 53.3 E	Awaiting Pilot and tide off Corton buoy. End of science.
	20-30 GMT		Docking at south quay: P.S.O's R.P.C. and then off to "The Gallon Can" !

List of CTD Stations :

Temperature, pressure, salinity and upwelling and downwelling irradiances were monitored routinely on each cast using standard RVS sensors on the CTD. Tracers and other biogeochemical samples obtained from the CTD bottle rosette, are summarised below:

SF_6 = Sulphur hexafluoride
^3He = Helium-3
Sp = *Bacillus globigii* spores
Rh = Rhodamines WT and G
Chl = Chlorophyll - a
Phy = Phytoplankton
SPM = Suspended particulate matter
O_2 = Dissolved Oxygen
HC = Non-methane hydrocarbons
CH_4 = Dissolved Methane
Nut = Dissolved Nutrients
Sal = Salinity calibration samples

Date	Time GMT	Position	CTD / Depth		SF_6	^3He	Sp	Rh	Chl	Phy	SPM	O_2	HC	CH_4	Nut	Sal
18 Oct:	07-15	52° 16.6 N; 04° 01.6 E	01	18		●		●	●	●				●		
				10		●			●	●	●			●		
				05		●		●	●	●	●			●		
	10-10	52° 18.5 N; 04° 03.6 E	02	19			●							●		
				10			●							●		
				05			●							●		
	11-55	52° 19.7 N; 04° 05.1 E	03	18		●		●		●				●		
				10										●		
				06		●		●						●		
	19-17	52° 15.6 N; 04° 02.9 E	04	18	●	●	●	●			●	●		●	●	
				10	●	●	●	●	●			●		●	●	
				05	●	●	●	●	●	●		●	●	●	●	
	21-38	52° 18.4 N; 04° 03.3 E	05	18	●	●	●	●		●					●	
				10	●	●	●	●		●						
				05	●	●	●	●		●					●	
	23-15	52° 20.8 N; 04° 04.7 E	06	10	●	●		●		●						
				18	●	●		●		●						
20 Oct:	11-31	52° 20.9 N; 04° 04.5 E	07	18	●	●	●	●		●		●				●
				10	●	●	●	●	●	●			●	●		
				05	●	●	●	●	●	●			●	●		
	15-58	52° 16.2 N; 04° 18.6 E	08	15						●			●	●		●
				10	●					●				●		
				05						●			●	●		
	17-13	52° 14.7 N; 04° 21.1 E	09	15						●				●	●	
				08						●					●	
				05					●	●			●	●	●	
	18-22	52° 16.1 N; 04° 17.2 E	10	13	●					●						
				09	●					●		●				
				05	●					●						
	18-40	52° 18.5 N; 04° 05.1 E	11	17	●	●	●	●		●			●	●		
				10	●	●	●	●		●	●		●	●	●	
				05	●	●	●	●		●		●	●	●	●	

22 Oct:	09-32	52° 18.5 N; 04° 03.7 E	12	14 08 04	● ● ●	● ● ●	● ● ●	● ● ●	● ● ●	● ● ●	●	●	● ● ●	● ● ●	● ● ●	
	11-50	52° 21.9 N; 04° 05.3 E	13	15 11 05	● ● ●	● ● ●	● ● ●	● ● ●	●	● ● ●			●			●
	21-15	52° 20.8 N; 04° 04.0 E	14	15 11 09 06 04	● ● ● ● ●	● ● ● ● ●	●	● ● ● ● ●						● ●		
23 Oct:	07-20	52° 22.7 N; 04° 03.6 E	15	15 13 09 04	● ● ● ●	● ● ● ●	●	● ● ● ●								
	17-36	52° 22.6 N; 04° 09.6 E	16	15 11 05	● ● ●	● ● ●	●	● ● ●	● ● ●	● ● ●	●	●	● ● ●	● ●	● ● ●	
24 Oct:	09-21	52° 14.5 N; 03° 59.3 E	17	15 10 05	● ● ●	● ● ●	●	● ● ●	● ● ●	● ● ●	●	●	● ● ●	●	● ● ●	
	19-35	52° 19.9 N; 04° 07.1 E	18	14 10 05	● ● ●	● ● ●	●	● ● ●		● ● ●	●					
25 Oct:	05-13	52° 23.7 N; 04° 11.4 E	19	16 09 05	● ● ●	● ● ●	●	● ● ●	● ● ●	● ● ●	●	●	● ● ●	●	● ● ●	
	06-22	52° 22.9 N; 04° 11.5 E	20	15 09 05						● ● ●						
	07-23	52° 21.8 N; 04° 10.8 E	21	14 08 05					●	● ● ●			●			
	08-26	52° 21.1 N; 04° 10.1 E	22	15 09 05						● ● ●				●		
	09-27	52° 20.3 N; 04° 09.4 E	23	14 09 05					●	● ● ●						
	10-17	52° 19.8 N; 04° 09.6 E	24	14 09 06	● ● ●				● ● ●	● ● ●			● ● ●	●		
	11-17	52° 19.7 N; 04° 09.6 E	25	15 09 05	● ● ●					● ● ●						●
	12-20	52° 20.4 N; 04° 10.7 E	26	15 10 06					●	● ● ●			●	●		

	13-20	52° 21.7 N; 04° 12.0 E	27	15	●	●		●		●						
				09	●	●		●		●						
				05	●	●	●	●		●						
	14-24	52° 23.0 N; 04° 12.6 E	28	14	●					●						
				10	●					●						
				05	●				●	●			●	●		
	15-26	52° 24.7 N; 04° 13.4 E	29	14	●					●						●
				09	●					●						
				05	●				●	●			●	●		
	16-23	52° 25.0 N; 04° 12.7 E	30	14	●					●						
				09	●				●	●			●			
				05	●				●	●			●	●		
	17-28	52° 25.6 N; 04° 13.5 E	31	16	●	●		●		●		●			●	
				09	●	●	●	●		●					●	
				05	●	●		●	●	●	●		●		●	
26 Oct:	07-51	52° 26.4 N; 04° 15.2 E	32	14	●	●		●		●	●				●	
				09	●	●	●	●	●	●		●			●	
				05	●	●		●	●	●			●		●	
	12-17	52° 23.1 N; 04° 12.2 E	33	14					●	●			●			
				09					●	●	●		●			
				05					●	●			●	●		
	15-09	52° 28.1 N; 04° 16.3 E	34	15	●	●		●		●						
				09	●	●	●	●		●						
				05	●	●		●	●	●			●	●		
	17-18	52° 21.4 N; 02° 02.1 E	35	30	●	●		●	●	●		●	●		●	●
				17	●	●	●	●	●	●	●		●		●	
				07	●	●		●	●	●		●	●	●	●	
30 Oct:	11-12	52° 35.4 N; 04° 09.7 E	36	18	●	●		●	●	●	●	●			●	●
				10	●	●	●	●	●	●					●	
				05	●	●		●	●	●		●	●	●	●	
	12-55	52° 36.1 N; 04° 13.4 E	37	17	●	●		●	●	●	●		●			●
				10	●	●	●	●	●	●	●	●	●			
				05	●	●		●	●	●			●	●		

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Contents

Challenger CH129
CTD and Underway Data Report

Introduction.

The Challenger cruise CH129 formed the UK component of ASGAMAGE with seatime funds provided from the NERC ACSOE programme.

The cruise started on 16th October 1996 from Portland Harbour and sailed to the position 52.277°N, 4.026°E where the first of 3 background CTD casts was obtained. Tracer release was initiated at 16:38Z on the 18th October and continued to 22:20 on the same evening along the axis 52.266°N, 4.003°E ↔ 52.333°N, 4.083°E. Sampling of the tracer patch (underway and CTD casts) continued from the 19th October to 27th October when scientific operations were suspended at 18:00Z due to deteriorating weather conditions. A met. instrument intercalibration exercise was carried out on the 20th October in the vicinity of the *Meetpost Noordwijk* (52.283 °N, 4.300 °E).

The Challenger made shelter off East Anglia on the 28th October before returning to the tracer patch on the 29th. A further intercalibration exercise was attempted at the *Meetpost Noordwijk* on the 30th between 20:00 and 23:55Z.

Cruise CH129 ended at Great Yarmouth on the 31st October at 20:30Z. Further details of the scientific background and methods used during the cruise are given in the *NERC Cruise Report : Challenger#129*.

BODC was charged with working up the oceanographic data on behalf of ACSOE. Primary shipboard data management was undertaken by BODC with the construction of a comprehensive, centralised inventory of all samples collected and measurements made. On disembarking Challenger, RVS supplied BODC with the automatically logged CTD, underway oceanographic and meteorological data. This raw data set has since been calibrated, quality controlled and documented.

The following sections of this report include the documentation for the CTD and underway post-cruise data processing and the comprehensive inventory of sampling. In addition, co-parameters (salinity, temperature, meteorology, etc) have been extracted from the underway and CTD data and merged with scientists discrete samples to aid analysis. Plots of the CTD profiles are also included.

Shipboard Data Management.

A comprehensive inventory of samples taken and measurements made was produced and continuously updated during the cruise. These were normally in the form of spreadsheets. These have since been updated with logged positions and water depths. Figure 1 gives a list of CTD casts and the depths at which bottles were actually fired after pressure correction of the CTD.

Figure 1 : CTD cast positions and times.

OID	Latitude	Longitude	W.depth m	Start Time / GMT	End Time / GMT	Bottle depths / m
CTD01	52.27609	4.02725	22.2	18/10/96 07:22	18/10/96 07:35	1.8, 7.1, 14.5
CTD02	52.30901	4.06068	21.9	18/10/96 10:10	18/10/96 10:28	3, 8, 16.2
CTD03	52.32697	4.08488	20.3	18/10/96 11:58	18/10/96 12:07	3.1, 7.9, 15.1
CTD04	52.25782	4.04907	23.4	19/10/96 19:18	19/10/96 19:30	0.8, 7.5, 14.8
CTD05	52.30580	4.05341	22.0	19/10/96 21:40	19/10/96 21:48	3.2, 7.9, 15.2
CTD06	52.32070	4.12149	21.5	19/10/96 23:16	20/10/96 11:39	0.7, 7.9, 15.2
CTD07	52.35004	4.17818	20.2	20/10/96 11:31	20/10/96 16:04	2.6, 7.6, 14.9
CTD08	52.25266	4.33882	17.0	20/10/96 15:58	20/10/96 17:23	3.2, 8.1, 12.4
CTD09	52.24454	4.35151	17.7	20/10/96 17:13	20/10/96 17:23	2.6, 5.2, 12.4
CTD10	52.26894	4.28727	17.9	20/10/96 18:23	20/10/96 18:33	2.3, 6.2, 10.5
CTD11	52.30877	4.08463	20.1	21/10/96 18:40	21/10/96 18:50	1.8, 7.5, 14.6
CTD12	52.30806	4.06519	22.2	22/10/96 09:32	22/10/96 09:41	1.7, 5.7, 11.1
CTD13	52.36653	4.08818	22.1	22/10/96 11:50	22/10/96 11:59	2.6, 8, 12.3
CTD14	52.34550	4.06669	22.0	22/10/96 21:15	22/10/96 21:25	1.5, 3.3, 6.3, 8.2, 12.8
CTD15	52.37741	4.05764	21.7	23/10/96 07:20	23/10/96 07:31	1.4, 6.3, 10.2, 13
CTD16	52.37545	4.15878	19.8	23/10/96 17:36	23/10/96 17:45	2.3, 8.2, 12.4
CTD17	52.24067	3.98953	21.8	24/10/96 09:21	23/10/96 09:31	2.8, 7.7, 12.5
CTD18	52.32805	4.13049	20.1	24/10/96 19:48	24/10/96 19:56	1.8, 6.9, 11.4
CTD19	52.39407	4.19047	22.1	25/10/96 05:15	25/10/96 05:28	2.6, 6.4, 13.7
CTD20	52.38054	4.19095	20.0	25/10/96 06:22	25/10/96 06:29	2.7, 6.7, 12.1
CTD21	52.36462	4.17958	20.2	25/10/96 07:23	25/10/96 07:31	2.1, 5, 10.8
CTD22	52.35186	4.16890	20.0	25/10/96 08:18	25/10/96 08:29	2.1, 6, 11.9
CTD23	52.33868	4.16074	20.6	25/10/96 09:18	25/10/96 09:29	2.9, 6.7, 11.4
CTD24	52.33035	4.15647	19.8	25/10/96 10:17	25/10/96 10:26	2.8, 5.8, 10.7
CTD25	52.32813	4.15940	20.8	25/10/96 11:18	25/10/96 11:27	1.9, 6.7, 12.4
CTD26	52.33935	4.17763	20.6	25/10/96 12:17	25/10/96 12:18	2.9, 6.8, 12.3
CTD27	52.36196	4.19916	20.9	25/10/96 13:15	25/10/96 13:25	2.5, 6.4, 11.9
CTD28	52.38216	4.20996	21.0	25/10/96 14:15	25/10/96 14:25	2.1, 7, 11.1
CTD29	52.40899	4.22100	20.5	25/10/96 15:16	25/10/96 15:26	2.8, 6.7, 10.9
CTD30	52.41610	4.21347	19.3	25/10/96 16:13	25/10/96 16:24	2.7, 6.6, 11.6
CTD31	52.42681	4.22489	20.8	25/10/96 17:17	25/10/96 17:28	2.8, 6.7, 12.9
CTD32	52.43800	4.25079	19.1	26/10/96 07:53	26/10/96 08:02	2.8, 6.4, 11.4
CTD33	52.38621	4.20281	20.8	26/10/96 12:18	26/10/96 12:25	2.2, 6.2, 10.6
CTD34	52.46859	4.27204	19.2	26/10/96 16:09	26/10/96 16:20	2.2, 6.3, 12.4
CTD35	52.35122	2.03610	39.0	29/10/96 17:04	29/10/96 17:18	4.8, 14.3, 28.4
CTD36	52.58849	4.15872	25.3	30/10/96 11:12	30/10/96 11:23	2.9, 8.1, 15.7
CTD37	52.60070	4.22060	22.1	30/10/96 12:56	30/10/96 13:05	2.4, 7.6, 14.6

An inventory of all samples taken from the CTD bottles for analysis are given in Figure 2. The identification of each sample is given by the CTD number and the nominal depth of the bottle firing. Actual depths of the bottle firings may be extracted from Figure 1.

Figure 2 : CTD Bottle Sampling.

CTD-Bottle Depth	SF6	3He	Spores	Rhodomene	NMHC	Methane	Oxygen	Phytoplankton	Chlorophyll	Nutrients	SPM	Salinity
01-18		■		■		■		■	■	■		■
01-10						■		■	■	■	■	
01-05		■		■		■		■	■	■	■	
02-19			■			■		■				■
02-10			■			■		■				
02-05			■			■		■				
03-18		■		■		■		■	■			■
03-10						■		■				
03-06		■		■		■		■				
04-18	■	■	■	■		■		■			■	■
04-10	■	■	■	■		■	■	■	■			
04-05	■	■	■	■	■	■		■	■			
05-18	■	■	■	■				■		■		■
05-10	■	■	■	■				■				
05-05	■	■	■	■				■		■		
06-10	■	■		■				■				
06-18								■				■
07-18	■	■	■	■			■	■				■
07-10	■	■	■	■	■	■		■	■		■	
07-05	■	■	■	■	■	■		■	■			
08-15					■	■		■	■			■
08-10	■					■	■	■				
08-05					■	■		■	■			
09-15						■		■		■		■
09-08								■		■		
09-05					■	■		■	■	■		
10-13	■							■				■
10-09	■						■	■				

CTD-Bottle Depth	SF6	3He	Spores	Rhodomene	NMHC	Methane	Oxygen	Phytoplankton	Chlorophyll	Nutrients	SPM	Salinity
10-05	■							■				
11-17	■	■	■	■	■	■		■	■			■
11-10	■	■	■	■	■	■		■	■	■	■	
11-05	■	■	■	■	■	■	■	■	■	■		
12-14	■	■	■	■	■	■		■	■	■		■
12-08	■	■	■	■	■	■	■	■	■	■		
12-04	■	■	■	■	■	■		■	■	■	■	
13-15	■	■	■	■				■				■
13-11	■	■	■	■	■			■				
13-05	■	■	■	■	■			■	■			
14-15	■	■		■		■		■				■
14-11	■	■		■		■		■				
14-09	■	■		■				■				
14-06	■	■		■				■				
14-04	■	■	■	■				■				
15-16	■	■		■				■	■			■
15-13	■	■		■				■	■			
15-09	■	■	■	■				■	■			
15-04	■	■		■				■	■			
16-15	■	■		■	■	■		■	■	■		■
16-11	■	■	■	■	■	■		■	■	■	■	
16-05	■	■		■	■		■	■	■	■		
17-15	■	■		■	■	■		■	■	■	■	■
17-10	■	■	■	■	■			■	■	■		
17-05	■	■	■	■	■		■	■	■	■		
18-14	■	■		■			■	■				■
18-10	■	■	■	■				■			■	
18-05	■	■		■				■				

Figure 2 : CTD Bottle Sampling (continued)

CTD-Bottle Depth	SF6	3He	Spores	Rhodomene	NMHC	Methane	Oxygen	Phytoplankton	Chlorophyll	Nutrients	SPM	Salinity
19-16	■	■		■	■		■	■	■	■		■
19-09	■	■	■	■	■			■	■	■	■	
19-05	■	■		■	■	■		■	■	■		
20-15								■				■
20-09								■				
20-05								■				
21-14								■				■
21-08								■				
21-05					■			■	■			
22-15								■				■
22-09								■				
22-05						■		■				
23-14								■				■
23-09								■				
23-05								■	■			
24-14	■				■			■	■			■
24-09	■				■			■	■			
24-06	■				■	■		■	■			
25-15	■							■				■
25-09	■							■				
25-05	■							■				
26-15								■				■
26-10								■				
26-06					■	■		■	■			
27-15	■	■		■				■				
27-09	■	■	■	■				■				
27-05	■	■		■				■				
28-14	■							■				■
28-10	■							■				

CTD-Bottle Depth	SF6	3He	Spores	Rhodomene	NMHC	Methane	Oxygen	Phytoplankton	Chlorophyll	Nutrients	SPM	Salinity
28-05	■				■	■		■	■			
29-14	■							■				■
29-09	■							■				
29-05	■				■	■		■	■			
30-14	■							■				■
30-09	■				■			■	■			
30-05	■				■	■		■	■			
31-16	■	■		■						■		■
31-09	■	■	■	■						■		
31-05	■	■		■	■				■	■	■	
32-14	■	■		■				■		■	■	■
32-09	■	■	■	■			■	■	■	■		
32-05	■	■		■	■			■	■	■		
33-14					■			■	■			■
33-09					■			■	■		■	
33-05					■	■		■	■			
34-15	■	■		■				■				■
34-09	■	■	■	■				■				
34-05	■	■		■	■	■		■	■			
35-30	■	■		■	■		■	■	■	■		■
35-17	■	■	■	■	■			■	■	■	■	
35-07	■	■		■	■	■	■	■	■	■		
36-18	■	■		■			■	■	■	■	■	■
36-10	■	■	■	■				■		■		
36-05	■	■		■	■	■	■	■	■	■		
37-17	■	■		■	■			■	■		■	■
37-10	■	■	■	■	■		■	■	■		■	
37-05	■	■		■	■	■		■	■			

Figure 3 contains a list of times and positions of non-toxic supply samples taken for nutrient, oxygen, spm and phaeopigment and chlorophyll analyses. Further non-toxic supply samples were taken for salinity, NMHC, methane and carbon dioxide determinations but are not included here.

Figure 3 : Underway non-toxic supply sampling.

OID	Date & Time (GMT)	Latitude (degrees)	Longitude (degrees)	DETERMINANTS
NT002	17/10/96 12:12	51.3080	2.1200	Oxygen
NT003	17/10/96 14:45	51.6795	2.4816	Chlorophyll
NT005	17/10/96 18:17	52.2190	3.1934	SPM
NT008	18/10/96 07:29	52.2761	4.0272	Chlorophyll
NT009	18/10/96 07:37	52.2758	4.0271	Oxygen
NT011	18/10/96 11:45	52.3318	4.0858	Chlorophyll
NT013	18/10/96 15:45	52.2776	4.0246	Chlorophyll
NT015	18/10/96 18:15	52.2762	4.0245	Chlorophyll
NT016	18/10/96 19:45	52.2759	4.0263	Nutrients, SPM, Oxygen
NT017	18/10/96 19:47	52.2759	4.0257	Chlorophyll
NT020	19/10/96 08:00	52.3643	3.7046	Nutrients, Chlorophyll, SPM, Oxygen
NT022	19/10/96 12:22	52.3586	3.7531	Chlorophyll
NT024	19/10/96 16:00	52.2559	4.0596	Chlorophyll
NT028	20/10/96 08:40	52.3044	4.0984	Oxygen
NT029	20/10/96 08:48	52.2968	4.0813	Nutrients
NT031	20/10/96 11:50	52.3516	4.0902	Chlorophyll
NT033	20/10/96 18:58	52.2895	4.2678	SPM
NT036	21/10/96 08:12	52.3064	4.0560	Chlorophyll, SPM, Oxygen, Nutrients
NT038	21/10/96 12:05	52.4174	4.2786	Chlorophyll
NT039	21/10/96 16:20	52.2240	3.9493	Chlorophyll
NT042	21/10/96 23:02	52.2923	4.0484	Chlorophyll
NT044	22/10/96 03:00	52.4584	4.0508	Chlorophyll
NT047	22/10/96 08:00	52.3556	4.1161	Chlorophyll
NT048	22/10/96 09:10	52.3084	4.0600	SPM
NT049	22/10/96 11:58	52.3675	4.0882	Chlorophyll
NT050	22/10/96 16:00	52.3804	4.1377	Chlorophyll, Oxygen
NT052	22/10/96 20:08	52.3516	4.0547	Oxygen
NT054	22/10/96 23:20	52.2919	4.0066	Chlorophyll
NT056	23/10/96 03:00	52.3313	4.0760	Chlorophyll
NT058	23/10/96 07:00	52.3825	4.0615	Chlorophyll
NT059	23/10/96 09:53	52.3203	3.9883	SPM, Oxygen
NT060	23/10/96 12:04	52.3899	4.0619	Chlorophyll, Nutrients
NT062	23/10/96 16:15	52.4489	4.2372	Chlorophyll
NT063	23/10/96 20:05	52.2388	4.0584	Chlorophyll, Oxygen
NT064	23/10/96 23:10	52.3375	4.2285	Chlorophyll
NT067	24/10/96 03:55	52.2396	4.1684	Chlorophyll
NT068	24/10/96 07:00	52.3935	4.1549	Chlorophyll
NT071	24/10/96 12:12	52.3309	4.0170	Chlorophyll
NT120	24/12/96 15:47	52.3705	4.1601	Chlorophyll
NT121	24/12/96 19:50	52.3284	4.1302	Chlorophyll
NT074	25/10/96 01:41	52.3661	4.1118	Chlorophyll

Figure 3 : Underway non-toxic supply sampling (continued):-

OID	Date & Time (GMT)	Latitude (degrees)	Longitude (degrees)	DETERMINANTS
NT075	25/10/96 03:14	52.3775	4.1919	Oxygen, Nutrients
NT076	25/10/96 05:14	52.3947	4.1904	Chlorophyll
NT079	25/10/96 15:20	52.4086	4.2207	Oxygen
NT081	25/10/96 20:04	52.4083	4.2102	Chlorophyll, SPM, Oxygen
NT082	25/10/96 22:02	52.3852	4.1996	Chlorophyll, SPM
NT083	26/10/96 00:05	52.3616	4.1942	Chlorophyll, Oxygen
NT085	26/10/96 09:02	52.4312	4.2450	Nutrients
NT088	26/10/96 19:25	52.4612	4.2695	Oxygen
NT089	26/10/96 19:29	52.4594	4.2681	Chlorophyll
NT093	27/10/96 09:50	52.3740	4.2159	Chlorophyll, Oxygen
NT098	28/10/96 13:10	52.2435	2.7684	Oxygen
NT101	28/10/96 19:48	52.2235	2.2875	Chlorophyll, SPM
NT105	29/10/96 13:22	52.2240	1.7178	Chlorophyll, SPM, Oxygen
NT107	29/10/96 15:00	52.2779	1.9233	SPM, Nutrients
NT108	29/10/96 20:00	52.3572	2.4235	Chlorophyll, SPM, Oxygen
NT113	30/10/96 16:25	52.6263	4.4265	Chlorophyll, SPM, Oxygen, Nutrients
NT117	31/10/96 10:25	52.5709	2.6326	Oxygen, Nutrients

Figures 4 and 5 give the samples taken from underway and CTD bottles samples respectively. Salinity, water temperature, wind velocity and atmospheric pressure have been extracted from the underway (or CTD) profiles and merged with the sample data.

Similarly, Figures 6 and 7 contain sample information for NMHC analyses carried out on CTD bottle samples, and general and clean pump samples. Air bottle samples are included in Figure 7.

Merged sample data for carbon dioxide data are not included in this report due to the large number of samples. However, sample data has been merged with corresponding water chemistry and meteorological measurements.

Please refer to the underway and CTD processing documentation when using the merged data e.g. fluorometer chlorophyll calibration details, etc.

Figure 4 : Underway samples for methane analysis.

OID	Date / Time	Latitude	Longitude	Salinity	Temperature	Wind Direction	Wind Speed	Air Pressure
	(GMT)	(decimal degrees)		(PSU)	(°C)	(degrees)	(Knots)	(mbars)
19-UW	25/10/96 05:15	52.3946	4.1903	33.5576	13.9095	149.7	18.71	1015.66
22-UW	25/10/96 08:18	52.3530	4.1704	33.4535	13.8041	169.6	16.21	1016.09
24-UW	25/10/96 10:17	52.3308	4.1568	33.1249	13.7871	177.2	12.82	1016.08
26-UW	25/10/96 12:17	52.3392	4.1774	32.4197	13.7391	202.4	14.85	1016.74
28-UW	25/10/96 14:15	52.3806	4.2089	33.2201	13.8781	253.1	14.36	1017.37
29-UW	25/10/96 15:16	52.4068	4.2196	33.3219	13.8824	222.6	7.94	1017.65
30-UW	25/10/96 16:13	52.4152	4.2147	33.3694	13.8612	206.9	14.40	1017.70
UW-UW1	29/10/96 11:05	52.3271	1.7775	34.3498	13.3833	301.8	20.11	1008.44

Figure 5 : CTD bottle samples for methane analyses.

CTD #	Bottle Depth (m)	Salinity (PSU)	Water Temperature. (°C)	Wind Direction (Degrees)	Wind Speed (Knots)	Air Pressure (mbars)
CTD01	1.8	33.803	14.553	21.48	182.08	1009.55
CTD01	7.1	33.807	14.553	21.48	182.08	1009.55
CTD01	14.5	33.828	14.561	21.48	182.08	1009.55
CTD02	3	33.596	14.539	24.27	167.86	1009.66
CTD02	8	33.596	14.538	24.27	167.86	1009.66
CTD02	16.2	33.625	14.544	24.27	167.86	1009.66
CTD03	3.1	33.746	14.516	24.77	189.93	1008.18
CTD03	7.9	33.756	14.517	24.77	189.93	1008.18
CTD03	15.1	33.771	14.518	24.77	189.93	1008.18
CTD04	0.8	33.959	14.42	19.11	246.30	1019.51
CTD04	7.5	33.961	14.427	19.11	246.30	1019.51
CTD04	14.8	33.964	14.429	19.11	246.30	1019.51
CTD07	2.6	33.739	14.384	20.76	235.22	1016.02
CTD07	7.6	33.74	14.381	20.76	235.22	1016.02
CTD07	14.9	33.74	14.382	20.76	235.22	1016.02
CTD08	3.2	31.525	14.222	19.76	215.97	1016.10
CTD08	8.1	31.867	14.255	19.76	215.97	1016.10
CTD08	12.4	32.1	14.273	19.76	215.97	1016.10
CTD09	2.6	31.414	14.219	19.76	215.97	1016.10
CTD09	12.4	31.432	14.222	19.76	215.97	1016.10
CTD11	1.8	33.774	14.362	22.30	301.00	1022.12
CTD11	7.5	33.777	14.365	22.30	301.00	1022.12
CTD11	14.6	33.787	14.363	22.30	301.00	1022.12
CTD12	1.7	34.074	14.318	9.42	194.00	1025.52
CTD12	5.7	34.077	14.318	9.42	194.00	1025.52
CTD12	11.1	34.085	14.316	9.42	194.00	1025.52
CTD14	8.2	33.396	14.274	15.86	160.68	1025.20
CTD14	12.8	33.649	14.323	15.86	160.68	1025.20
CTD16	8.2	33.792	14.216	18.64	118.78	1023.33
CTD16	12.4	33.801	14.217	18.64	118.78	1023.33
CTD17	2.8	33.534	14.038	15.63	134.36	1021.10
CTD19	2.6	33.545	13.913	19.08	161.79	1015.67
CTD22	2.1	33.44	13.873	16.99	168.06	1016.06
CTD24	2.8	33.098	13.846	13.16	186.09	1016.14
CTD26	2.9	32.311	13.802	16.97	210.36	1016.95
CTD28	2.1	33.202	13.865	12.11	257.94	1017.25
CTD29	2.8	33.313	13.882	12.44	218.17	1017.72
CTD30	2.7	33.371	13.9	14.97	207.54	1017.68
CTD33	2.2	32.806	13.743	21.79	217.68	1019.69
CTD34	2.2	32.707	13.747	20.46	262.84	1019.91
CTD35	4.8	34.604	13.76	26.23	296.22	1015.81
CTD36	2.9	34.344	13.505	21.12	257.13	1022.11
CTD37	2.4	34.34	13.46	26.11	270.85	1021.36

Figure 6 : CTD Bottle samples for NMHC analyses.

OID	CTD#	DEPTH (m)	Salinity (PSU)	Temperature (°C)	WSpeed (Knots)	Wind Dir. (degrees)	Chlorophyll (mg m⁻³)	Dry Bulb (°C)	Wet Bulb (°C)	Air Press (mbars)
S2-12	CTD04	7.5	33.961	14.427	19.112	246.3011	1.3257	14.3263	11.2134	1019.507
S3-01	CTD07	7.6	33.74	14.381	20.7627	235.2248	0.9855	14.3389	13.6047	1016.017
S5-03	CTD07	2.6	33.739	14.384	20.7627	235.2248	0.9855	14.3389	13.6047	1016.017
S2-15	CTD08	12.4	32.1	14.273	19.7567	215.9719	1.1245	13.9652	13.2324	1016.098
S3-02	CTD08	3.2	31.525	14.222	19.7567	215.9719	1.1245	13.9652	13.2324	1016.098
-	CTD08	8.1	31.867	14.255	19.7567	215.9719	1.1245	13.9652	13.2324	1016.098
S5-04	CTD09	2.6	31.414	14.219	19.7567	215.9719	1.1245	13.9652	13.2324	1016.098
S2-20	CTD11	14.6	33.787	14.363	22.3036	252.3032	1.0037	13.1315	10.5956	1022.12
S3-03	CTD11	7.5	33.777	14.365	22.3036	252.3032	1.0037	13.1315	10.5956	1022.12
S5-05	CTD11	1.8	33.774	14.362	22.3036	252.3032	1.0037	13.1315	10.5956	1022.12
S2-21	CTD12	11.1	34.085	14.316	9.4235	250.7192	1.788	13.3195	12.4528	1025.522
S3-04	CTD12	5.7	34.077	14.318	9.4235	250.7192	1.788	13.3195	12.4528	1025.522
S5-06	CTD12	1.7	34.074	14.318	9.4235	250.7192	1.788	13.3195	12.4528	1025.522
S2-22	CTD13	2.6	34.005	14.328	3.9958	201.9844	1.664	13.7547	11.1962	1025.665
S2-28	CTD16	12.4	33.801	14.217	18.6353	118.7807	1.4774	13.0371	10.0851	1023.33
S3-05	CTD16	8.2	33.792	14.216	18.6353	118.7807	1.4774	13.0371	10.0851	1023.33
S5-08	CTD16	2.3	33.777	14.208	18.6353	118.7807	1.4774	13.0371	10.0851	1023.33
S2-30	CTD17	12.5	33.746	14.106	15.6279	134.3605	1.2882	10.6013	8.5567	1021.1
S3-06	CTD17	7.7	33.568	14.056	15.6279	134.3605	1.2882	10.6013	8.5567	1021.1
S5-09	CTD17	2.8	33.534	14.038	15.6279	134.3605	1.2882	10.6013	8.5567	1021.1
S2-35	CTD19	13.7	33.552	13.931	19.0828	161.7925	1.2003	10.6229	8.9875	1015.667
S3-08	CTD19	6.4	33.546	13.92	19.0828	161.7925	1.2003	10.6229	8.9875	1015.667
S5-10	CTD19	2.6	33.545	13.913	19.0828	161.7925	1.2003	10.6229	8.9875	1015.667
S3-09	CTD21	2.1	33.449	13.87	18.6677	176.3116	1.0631	10.1563	8.8533	1016.088
S5-11	CTD22	2.1	33.44	13.873	16.9877	168.0622	1.1467	10.7142	9.3836	1016.065
S2-36	CTD24	10.7	33.402	13.875	13.1648	186.0883	1.8716	12.0174	10.5524	1016.135
S3-10	CTD24	5.8	33.162	13.851	13.1648	186.0883	1.8716	12.0174	10.5524	1016.135
S5-12	CTD24	2.8	33.098	13.846	13.1648	186.0883	1.8716	12.0174	10.5524	1016.135
S2-37	CTD26	2.9	32.311	13.802	16.9711	210.355	1.5467	12.9865	12.0659	1016.947
S5-14	CTD28	2.1	33.202	13.865	12.1099	257.9375	1.3786	13.4883	12.6956	1017.252
S2-38	CTD29	2.8	33.313	13.882	12.4431	218.1682	1.2451	13.5478	12.4245	1017.717
S3-12	CTD30	6.6	33.386	13.903	14.9723	207.5438	1.359	13.6813	12.7066	1017.675
S5-15	CTD30	2.7	33.371	13.9	14.9723	207.5438	1.359	13.6813	12.7066	1017.675
S2-39	CTD31	2.8	33.328	13.881	15.9141	201.8942	1.3896	-	13.5242	1018.098
S5-18	CTD32	2.8	32.84	13.751	19.5812	240.5099	1.2194	13.234	9.5345	1018.632
S2-40	CTD33	10.5	32.86	13.752	21.786	217.6785	1.3153	13.2338	11.1647	1019.688
S3-15	CTD33	6.2	32.855	13.75	21.786	217.6785	1.3153	13.2338	11.1647	1019.688
S5-19	CTD33	2.2	32.806	13.743	21.786	217.6785	1.3153	13.2338	11.1647	1019.688
S3-16	CTD34	2.2	32.707	13.747	20.4616	262.835	1.1393	13.3615	10.0944	1019.912
S2-49	CTD35	28.4	34.601	13.785	26.2325	296.2234	0.5768	9.7374	6.5056	1015.808
S3-20	CTD35	14.3	34.603	13.765	26.2325	296.2234	0.5768	9.7374	6.5056	1015.808
S5-20	CTD35	4.8	34.604	13.76	26.2325	296.2234	0.5768	9.7374	6.5056	1015.808
S5-22	CTD36	2.9	34.344	13.505	21.1234	257.127	1.0969	10.6882	8.2123	1022.105
S2-51	CTD37	14.6	34.344	13.468	26.1113	270.8512	0.9946	11.3405	8.8847	1021.362
S3-21	CTD37	7.6	34.342	13.466	26.1113	270.8512	0.9946	11.3405	8.8847	1021.362
S5-23	CTD37	2.4	34.34	13.46	26.1113	270.8512	0.9946	11.3405	8.8847	1021.362

Figure 7 : Underway sampling for NMHC.

Originators ID.	Date/Time GMT	Latitude decimal°	Longitude decimal°	Water Depth metres	Gear-code	Sea Temp. °C	Salinity PSU	Chlorophyll mg m⁻³	Wind Speed Knots	Wind Direction degrees	Dry Bulb Temp. °C	Wet Bulb Temp. °C	Atmos. Pressure mbars
S2-01	17/10/96 11:35	51.23195	2.04178	36.2	GPUMP	15.16	34.935	0.934	4.896	202.459	11.630	9.778	1007.682
S2-02	17/10/96 15:17	51.75878	2.58981	38.4	GPUMP	15.04	34.932	1.151	7.801	201.724	11.538	9.464	1008.151
S2-03	18/10/96 07:30	52.27607	4.02723	22.2	GPUMP	14.57	33.810	1.314	20.230	176.470	10.379	9.623	1009.689
S2-04	18/10/96 11:46	52.33179	4.08575	21.3	GPUMP	14.50	33.773	1.457	24.690	188.631	11.681	9.758	1008.470
A1-01	18/10/96 13:47	52.25585	3.98924	23.1	AIRBOT	14.61	33.578	1.318	28.209	178.653	12.928	10.178	1006.717
S2-05	18/10/96 15:45	52.27755	4.02455	21.4	GPUMP	14.54	33.821	1.366	30.176	175.267	11.786	10.211	1006.085
S5-01	18/10/96 15:45	52.27755	4.02455	21.4	GPUMP	14.54	33.821	1.366	30.176	175.267	11.786	10.211	1006.085
S2-06	18/10/96 19:47	52.27592	4.02572	22.4	GPUMP	14.32	34.217	1.561	29.589	196.848	12.056	10.925	1005.476
S2-07	19/10/96 08:00	52.36429	3.70461	25.6	GPUMP	14.57	35.043	1.597	22.741	290.652	12.981	10.726	1011.784
S2-08	19/10/96 10:00	52.36248	3.74485	27.1	GPUMP	14.40	34.981	1.560	23.067	283.515	0.000	10.676	1013.844
S2-09	19/10/96 12:22	52.35857	3.75312	28.7	GPUMP	14.40	35.019	1.681	20.785	285.336	13.392	10.401	1016.134
S2-10	19/10/96 14:58	52.30407	3.93771	21.9	GPUMP	14.46	34.258	1.444	21.477	258.421	13.507	11.139	1017.628
S2-11	19/10/96 16:01	52.25447	4.05963	22.3	GPUMP	14.31	33.498	1.552	19.723	263.990	13.660	11.148	1017.748
S5-02	19/10/96 16:02	52.25299	4.05968	22.3	CPUMP	14.30	33.509	1.542	19.972	263.651	13.670	11.118	1017.744
A1-02	19/10/96 18:07	52.24065	4.06293	23.1	AIRBOT	14.32	33.874	1.462	17.447	257.028	14.052	11.513	1019.411
S2-13	20/10/96 08:48	52.29680	4.08127	22.6	GPUMP	14.33	33.462	1.581	17.207	258.943	14.623	13.617	1017.933
S2-14	20/10/96 11:36	52.34935	4.07597	22.3	CPUMP	14.41	33.749	1.264	23.768	261.989	14.572	13.485	1017.919
A1-03	20/10/96 15:12	52.27340	4.31677	16.9	GPUMP	14.25	31.736	1.016	21.103	240.621	14.555	13.799	1016.495
S2-16	21/10/96 08:12	52.30644	4.05599	21.5	GPUMP	14.30	33.598	1.216	28.341	316.358	13.568	11.286	1014.289
A1-04	21/10/96 10:04	52.36714	4.10831	22.9	AIRBOT	14.23	33.876	1.224	22.641	315.942	13.644	11.447	1016.882
A5-01	21/10/96 10:20	52.38337	4.08688	21.6	AIRBOT	14.30	34.009	1.289	25.507	315.248	13.597	11.230	1017.072
S2-17	21/10/96 12:05	52.41740	4.27861	19.2	GPUMP	14.13	31.698	0.956	22.709	313.453	13.672	11.392	1017.887
S2-18	21/10/96 14:25	52.33032	4.05058	22.2	GPUMP	14.25	33.731	1.157	22.334	324.834	13.364	11.075	1019.810
S2-19	21/10/95 14:25	52.33032	4.05058	22.2	GPUMP	14.25	33.731	1.157	22.334	324.834	13.364	11.075	1019.810
S6-07	22/10/96 11:58	52.36747	4.08818	21.8	GPUMP	14.31	34.023	1.358	13.893	215.422	13.611	11.759	1025.565
S2-23	22/10/96 16:00	52.38044	4.13768	20.0	GPUMP	14.29	33.605	1.826	9.780	199.054	13.323	11.642	1024.830
S2-24	22/10/96 17:40	52.48003	4.09983	23.1	GPUMP	14.24	33.737	1.556	11.278	186.551	13.371	11.505	1024.954
A5-02	22/10/96 19:00	52.36752	4.09512	20.4	AIRBOT	14.25	33.153	1.047	10.443	181.463	13.496	11.228	1025.362
S2-25	23/10/96 12:05	52.38998	4.06485	23.3	GPUMP	14.22	33.502	1.507	15.390	140.118	12.858	9.826	1024.822
S2-26	23/10/96 14:45	52.41595	4.02812	23.0	GPUMP	14.28	34.199	1.457	17.461	124.885	13.788	10.304	1023.603
S2-27	23/10/96 16:04	52.45210	4.22455	20.8	GPUMP	14.10	32.158	1.022	18.290	128.505	13.560	10.197	1023.952
S2-29	23/10/96 20:05	52.23883	4.05843	20.9	GPUMP	14.12	33.454	1.351	21.025	121.164	11.953	9.752	1022.485
A1-05	24/10/96 08:52	52.26851	3.99942	21.7	AIRBOT	14.01	33.738	1.090	16.764	144.484	10.559	8.485	1021.058
S3-07	24/10/96 12:12	52.33093	4.01701	22.5	GPUMP	14.08	34.193	1.328	14.418	137.879	12.722	9.546	1019.626
S2-31	24/10/96 14:42	52.35066	4.29016	18.2	GPUMP	13.68	29.870	1.600	11.893	129.891	13.160	10.559	1018.866
S2-32	24/10/96 15:47	52.37054	4.16014	20.3	GPUMP	14.05	33.564	1.272	14.287	129.485	13.300	10.520	1018.753
S2-33	25/10/96 03:14	52.37746	4.19187	19.2	GPUMP	13.91	33.460	1.080	20.332	148.506	10.839	8.944	1015.983
S2-34	25/10/96 04:12	52.39783	4.18148	21.5	GPUMP	13.89	33.635	1.183	19.601	163.151	11.010	9.211	1015.505
A5-03	25/10/96 09:17	52.34026	4.16088	20.5	AIRBOT	13.80	33.337	1.336	14.050	170.515	11.278	9.815	1015.783
S3-13	25/10/96 20:04	52.40830	4.21015	20.5	GPUMP	13.80	33.268	1.234	19.501	205.214	13.829	12.934	1018.318
S5-16	25/10/96 22:02	52.38523	4.19962	18.0	GPUMP	13.73	32.380	0.955	18.943	196.193	13.905	12.417	1018.559
S5-17	26/10/96 00:05	52.36164	4.19423	19.0	GPUMP	13.72	32.401	0.893	18.048	181.397	13.207	12.024	1018.677

Originators ID.	Date/Time GMT	Latitude decimal °	Longitude decimal °	Water Depth metres	Gear-code	Sea Temp. °C	Salinity PSU	Chlorophyll mg m^{-3}	Wind Speed Knots	Wind Direction degrees	Dry Bulb Temp. °C	Wet Bulb Temp. °C	Atmos. Pressure mbars
S3-14	26/10/96 01:47	52.39671	4.23334	22.0	GPUMP	13.70	32.371	0.902	20.409	181.678	12.668	11.997	1017.912
A1-06	26/10/96 15:25	52.45202	4.26073	20.2	AIRBOT	13.76	32.791	1.108	23.606	240.067	13.471	10.237	1019.628
S3-16	26/10/96 16:20	52.46964	4.27185	19.1	GPUMP	13.76	32.716	1.105	21.593	250.040	13.366	10.192	1019.966
S2-41	26/10/96 19:25	52.46124	4.26947	18.3	GPUMP	13.73	32.872	1.049	18.499	222.682	13.674	10.951	1020.498
S2-42	27/10/96 09:50	52.37400	4.21594	18.6	GPUMP	13.76	32.695	1.002	31.184	195.887	11.918	10.678	1012.133
S3-17	27/10/96 11:00	52.39854	4.25297	18.8	GPUMP	13.70	32.739	1.066	36.888	196.434	12.171	11.098	1009.697
S2-43	27/10/96 12:13	52.43687	4.28860	17.8	GPUMP	13.68	32.081	0.934	36.000	200.207	11.797	11.644	1008.621
S3-18	27/10/96 14:25	52.42915	4.19645	20.8	GPUMP	13.80	33.778	1.172	39.927	223.156	13.009	12.778	1006.478
A5-04	27/10/96 15:07	52.43504	4.15824	22.0	AIRBOT	13.83	33.976	1.230	38.315	225.284	13.652	13.437	1006.498
S2-44	28/10/96 13:10	52.24349	2.76839	48.9	GPUMP	14.34	34.979	0.852	31.547	219.917	15.237	12.915	996.691
S2-45	28/10/96 15:45	52.28899	2.55470	42.9	GPUMP	14.35	35.021	0.905	33.819	220.505	14.796	11.958	995.611
S3-19	28/10/96 18:58	52.23996	2.35463	41.2	GPUMP	14.34	35.011	0.786	41.323	217.080	14.181	11.100	991.900
A1-07	28/10/96 19:30	52.22797	2.31525	55.0	AIRBOT	14.29	34.986	0.793	40.132	211.476	14.250	10.827	990.476
S2-46	28/10/96 19:48	52.22349	2.28749	54.9	GPUMP	14.26	35.020	0.871	38.671	211.146	14.325	10.816	989.850
S2-47	29/10/96 13:22	52.22401	1.71780	24.4	GPUMP	13.43	34.476	0.831	26.168	298.791	9.302	6.483	1011.800
S2-48	29/10/96 15:00	52.27792	1.92326	27.2	GPUMP	13.67	34.553	0.668	26.360	308.523	9.648	6.374	1013.432
A5-05	29/10/96 16:27	52.31676	2.02865	36.2	AIRBOT	13.68	34.631	0.599	28.906	293.652	9.397	5.957	1015.257
S5-21	29/10/96 20:00	52.35721	2.42353	42.2	GPUMP	14.00	34.929	0.553	23.306	296.850	9.984	6.962	1017.200
S2-50	30/10/96 10:25	52.55391	4.16829	24.2	GPUMP	13.64	34.510	1.081	24.078	279.194	10.815	8.247	1021.547
S3-22	30/10/96 16:25	52.62634	4.42646	18.7	GPUMP	13.20	31.946	1.045	24.355	260.674	11.550	9.065	1021.811
A1-08	30/10/96 17:25	52.56929	4.30144	18.1	AIRBOT	13.34	33.428	0.920	25.212	264.732	11.672	9.033	1021.832

Challenger Cruise CH129 (16 - 31 October 1996)
CTD Data Documentation

1) Instrumentation

The CTD profiles were taken with an RVS Neil Brown Systems Mk3B CTD (s/n 1195) incorporating a pressure sensor (s/n 99488), conductivity cell (s/n 15701), platinum resistance thermometer (s/n 15701) and a Beckman dissolved oxygen sensor (s/n 0-5-18). The CTD unit was mounted vertically in the centre of a protective cage approximately 1.5 m square. Attached to the bars of the frame was a Chelsea Instruments Mk II Aquatracka fluorometer (s/n 229) and a SeaTech red light (661 nm) transmissometer with a 25 cm path length (s/n 104-D).

A General Oceanics rosette sampler capable of holding 12, 10 litre Niskin or Go/Flo bottles was mounted above the frame. The bases of the bottles were 0.75 m above the pressure head with their tops 1.55 m above it. One of the bottles was fitted with a holder for up to three digital reversing thermometers mounted 1.38 m above the CTD temperature sensor. Two out of three available reversing thermometers (s/n T179, T220, T238) were used on each cast.

Below the rosette sampler and fitted to the bottom of the cage was a PML 2-pi PAR (photo synthetically available radiation) sensor pointing downwards to measure upwelling irradiance (s/n 8). A second such sensor (s/n 10) was fitted above the rosette pointing upwards to measure downwelling irradiance. Both sensors were pressure hardened to 1000 db, however, this posed no problems on this cruise. It should be noted that the PAR sensors were vertically separated by approximately 2m.

Lowering rates were generally in the range of 0.5-1.0 m/sec but could be up to 1.5 m/sec. Bottle samples and reversing thermometer measurements were acquired on the ascent of all 37 casts.

2) Data Acquisition

CTD data were sampled at a frequency of 32 Hz. Data reduction was in real time, converting the 32 Hz data to a 1-second time series (done by the RVS Level A system) which was then passed through an Analogue-Digital Converter and logged as digital counts on the Level C.

3) On-Board Data Processing

RVS software on the Level C (a SUN workstation) was used to convert the raw counts into engineering units (Volts for transmissometer and fluorometer, ml/l for oxygen, mmho cm^{-1} for conductivity and for temperature, °C). A nominal calibration, a simple antilog, was also applied to the chlorophyll channel at this stage.

Salinity (Practical Salinity Units, as defined by the Practical Salinity Scale (Fofonoff and Millard 1982)) was calculated from the conductivity ratios (conductivity / 42.914) and a time lagged temperature using the function described in UNESCO Report 37 (1981).

Data were written onto a Quarter Inch Cartridge tape in RVS internal format and submitted to BODC for post-cruise processing and data-banking.

4.1) Reformatting

The data were converted into the BODC internal format (PXF) to allow the use of in-house software tools, notably the workstation graphics editor. In addition to reformatting, the transfer program applied the following modifications to the data:

The nominal calibration to the fluorometer was removed.

Dissolved oxygen was converted from ml dm^{-3} to µM by multiplying the values by 44.66.

The raw transmissometer voltages were corrected for light source decay using a correction ratio computed from a light reading in air taken during the cruise (4.724 V) and the manufacturer's figure for the new instrument calibrated 26/05/1994 (4.746 V).

Transmissometer voltages were converted to percentage transmission by multiplying them by 20 and then to attenuance using the algorithm:-

$$\text{attenuance} = -4 * \log (\% \text{ transmission} / 100)$$

The 2-pi PAR voltages were converted to W/m2 using the equations derived from sensor calibrations of August 1994:

Downwelling:	PAR = exp (-4.980 * V + 6.565)
Upwelling:	PAR = exp (-4.970 * V + 6.426)

4.2) Editing

Reformatted CTD data were transferred onto a high speed graphics workstation. Using custom in-house graphics editors, downcast and upcast were differentiated and the limits of the downcasts and upcasts were manually flagged.

In addition, spikes on all the downcast channels were manually flagged 'suspect' by modification of the associated quality control flag. In this way none of the original data values were edited or deleted.

The pressure ranges over which the bottle samples were being collected were logged by manual interaction with the software. Usually, the marked reaction of the oxygen sensor to the bottle firing sequence was used to determine this. These pressure ranges were subsequently used, in conjunction with a geometrical correction for the position of the water bottles with respect to the CTD pressure transducer, to determine the pressure range of data to be averaged for calibration values.

4.3) Calibration

With the exception of pressure, calibrations were done by comparison of CTD data against measurements made on water bottle samples or from the reversing thermometers mounted on the water bottles as in the case of temperature. In general, values were averaged from the CTD downcasts but where inspection on a graphics workstation showed significant hysteresis, values were manually extracted from the CTD upcasts.

All calibrations described here have been applied to the data.

4.3.1) Pressure

The pressure offset was determined by looking at the pressures recorded when the CTD was clearly logging in air (readily apparent from the conductivity channel). The PAR sensors entering the water also acted as a check. A consistent value was observed throughout the cruise thus:

$$P_{corrected} = P_{observed} - 1.68$$

4.3.2) Temperature

Neil Brown Mk III thermometer readings were calibrated against digital reversing thermometer readings. The calibration showed the mean difference as -0.0084 (standard deviation 0.0062). This was not deemed significant so no post-cruise back calibration has been applied to temperature.

4.3.3) Salinity

On every cast a salinity sample was taken from the deepest bottle fired. Samples were collected in glass bottles filled to just below the neck and sealed with plastic stoppers. Batches of samples were left for at least 24 hours to reach thermal equilibrium in the constant temperature laboratory containing the salinometer before analysis.

The bottle salinities for CTD01-CTD16 were measured during the cruise on a Guidline Autosal bench salinometer. Due to a problem with the Autosal onboard, the remaining bottles were stored for later analysis, but subsequently no data has been provided to BODC on these samples. The calibration using the 16 available salinity values gave a mean correction of 0.040 PSU (standard deviation 0.023).

4.3.4) Oxygen

The dissolved oxygen sensor is not calibrated awaiting the results from Winkler titrations.

4.3.5) Chlorophyll

An attempt was made to calibrate the fluorometer against water bottle samples. Acetone extracted chlorophyll samples were measured fluorometrically by SOC. However, due to a large drift of the instrument throughout the cruise it was not possible to apply a satisfactory calibration. As the water column appears well mixed with respect to chlorophyll, the CTD fluorometer will be intercalibrated against the underway fluorometer in an attempt to salvage the CTD data.

4.3.6) Attenuance and Total Suspended Matter

Attenuance was regressed against total suspended matter determinations to allow attenuance to be expressed in terms of suspended matter. Fifteen samples for SPM determination were taken on various casts and different depths during the cruise. The sediment loading was very similar for the majority of the casts and this resulted in a large scatter of the spm values for essentially the same attenuance. A sample taken on cast CTD35 off the East Anglian coast had a very high SPM concentration compared to the other casts. A separate calibration was deduced using samples taken on CTD33-37 for CTD35. The sample taken from CTD35 was omitted from the 'low-range' calibration for the other casts.

The following calibrations have been applied:-

For casts CTD01-CTD34, CTD36 and CTD37
Total suspended matter (mg/l) = (Attenuance-6.27731)/14.13677 (r^2 = 91.3 %)

For cast CTD35
Total suspended matter (mg/l) = (Attenuance-0.83382)/9.695966 (r^2 = 99.5 %)

Worst error is estimated as being ±3 mg/l.

5) Data Warnings

The fluorometer is uncalibrated due to significant baseline drift over the duration of the cruise. It is hoped to salvage this data by intercalibration with the underway fluorometer. Oxygen is uncalibrated.

6) Bibliography

Fofonoff, N.P. and Millard R.C. 1982. Algorithms for computation of fundamental properties of seawater. *UNESCO Technical Papers in Marine Science.* 44.

Challenger Cruise CH129 (16 - 31 October 1996)
Underway Data Documentation

1) Components of the Underway Data Set

The underway data set for Challenger CH129 contains the following data channels. The single character following each channel in parentheses is the corresponding channel identifier in the binary merge file.

Navigation:	Latitude (degrees +ve N) (A) Longitude (degrees +ve E) (B) Bathymetric depth (m) (J)
Meteorology:	Photosynthetically available radiance (W/m^2) (t) Solar radiation (W/m^2) (O) Dry bulb air temperature (°C) (n) Wet bulb air temperature (°C) (o) Wind speed (knots) (Y) Wind direction (degrees blowing from) (V) Barometric pressure (mb) (z)
Physics:	Sea surface temperature (°C) (C) Salinity (PSU) (F) Optical attenuance (per m) (I) Total suspended matter from transmissometer (mg/l) (W)
Biology:	Aquatracka chlorophyll (mg/m^3) (G) Oxygen concentration at in-situ salinity and temperature (μM) (Q)

2) Methodology Overview

2.1) Plumbing

The ship is fitted with a non-toxic pumped sea water supply with water drawn from an inlet approximately 4 m below the surface. All ships discharges are to port to minimise risk of contamination.

The thermosalinograph was fed from the non-toxic supply via a small header tank to remove bubbles. Tests on previous Challenger cruises have shown that the residence time from the inlet to the instrument housing is of the order of 50 seconds.

The underway transmissometer, fluorometer and oxygen sensor were housed in a large plastic tank on the starboard deck connected directly to the non-toxic manifold with internal baffles to regulate the flow of water over the instruments.

2.2) Data Acquisition

Data logging and initial processing was handled by the RVS ABC system. The Level A sampling microcomputer digitises an input voltage, applies a time stamp from the scientific master clock and transfers the data via the Level B disk buffer onto the Level C where the Level A messages are assembled into data files. Sampling rates varied from 10-30 seconds.

The Level C includes a suite of calibration software which was used to apply initial calibration to convert raw ADC counts into engineering units. At the end of the cruise, the Level C disk base was transferred to BODC for further processing.

The YSI oxygen sensor had its own in-built logger. Data was logged at 5 minute intervals and was downloaded to diskette for merging into the underway data set at BODC.

2.3) BODC Data Processing Procedures

Data from the Level C files were merged into a common file (the binary merge file) on a 30 second time base, using time as the primary linking key. The time channel supplied was GMT. Data values sampled more frequently than one minute were reduced by averaging. Data logged as voltages (e.g. PAR) were converted to engineering units. Wind velocity was corrected for ship's motion and heading.

Each data channel was inspected on a graphics workstation and any spikes or periods of dubious data were flagged. The power of the workstation software was used to undertake all possible comparative screening checks between channels by overlaying parameter plots (e.g. to ensure corrected wind velocity data are not influenced by changes in ship's heading). The screening system was also capable of simultaneously displaying the data and ship's position on a map to enable data screening to take oceanographic climatology into account.

3) Methodology and calibration procedures

3.1) Navigation and bathymetry

GPS was the primary navigation system used on this cruise. When no GPS fixes were available the ship's position was determined by dead reckoning based upon the ship's gyro and EM log. Once a fix was obtained after a period of dead reckoning, the surface drift velocity was computed. If this exceeded four knots, the data were automatically flagged suspect. The positional error due to surface drift was then retrospectively applied over the period of dead reckoning.

At BODC a program was run which locates any null values in the latitude and longitude channels and checks to ensure that the ship's speed over the ground does not exceed 15 knots. A total of 17 speed check fails were encountered. Spikes causing these were identified and replaced by interpolated values. There were no gaps in the navigation.

A SimRad EA500 deep echo sounder was operated throughout the cruise using a hull transducer. The instrument was sampled every 30 seconds by the level A and a correction

(4 m) for sensor depth below sea surface applied. Carter's Table corrections for variation of sound velocity in sea water were applied by the level C software. The resulting channel was examined on a graphics workstation and very few values were flagged suspect.

3.2) Meteorology

Radiation

Challenger was equipped for this cruise with four radiation sensors. Kipp and Zonen solar radiation meters were mounted in gimballed housings on the port and starboard side of the 'Monkey Island' above the scientific bridge. The starboard location is far from ideal due to a large satellite communication raydome which frequently shades the instruments. Two planar PAR radiance sensors were mounted on the meteorological package platform on the port and starboard sides of the formast.

The Kipp and Zonen instruments have been in operation since 1988 but were overhauled and recalibrated in July 1995. The PAR radiance sensors were installed in May 1996.

The Kipp and Zonen instruments on Challenger are unique in as much as they are connected to a data integrator. This converts the instrument voltages into W m^{-2} and integrates the values producing 10 minute and running total integrations in kJ m^{-2}. The output from the integrator is logged by the level A at the end of each integration period.

At BODC, the 10 minute integrations are merged into the underway file by a custom program that divides the integrated energy by the integration interval to give an averaged radiance value. The time stamp is also adjusted to the mid-point of the averaging interval by subtracting five minutes. A problem with the integrator calibrations has resulted in the values being much lower than expected - this requires further investigation.

The planar sensors were logged every 5 seconds as a voltage by the meteorological package PC level A. The voltages were converted to W/m^2 from volts at BODC using the following manufacturer's calibrations:

Port (s/n 2273)	W/m^2 = (V*1000*1000)/16.30
Starboard (s/n 2274)	W/m^2 = (V*1000*1000)/16.75

A merged PAR channel was then produced by taking the maximum port and starboard values to eliminate sensor shading effects.

Barometric pressure

The meteorological package included a Vaisala aneroid barometer mounted on the formast platform. The instrument output data in millibars which was logged every 5 seconds by the PC level A. These data were reduced by averaging to 30 second sampling at BODC and examined on a graphics workstation. No flagging was required.

Air temperature

The Metpac fitted to Challenger for this cruise included two vector instruments psychrometers fitted to the port and starboard sides of the formast. The sensors were new in may 1996. The psychrometers output voltages which were converted to temperatures using the manufacturer's calibrations thus:

Port instrument (s/n 2003)

$$\text{Dry bulb} = 7.648506E\text{-}11(mV)^3 + 1.839413E\text{-}6(mV)^2 + 0.0384022(mV) - 10.36550$$
$$\text{Wet bulb} = 1.303252E\text{-}10(mV)^3 + 1.630955E\text{-}6(mV)^2 + 0.0386373(mV) - 10.19036$$

Starboard instrument (s/n 2004)

$$\text{Dry bulb} = 1.305221E\text{-}10(mV)^3 + 1.721910E\text{-}6(mV)^2 + 0.0384830(mV) - 10.39138$$
$$\text{Wet bulb} = 2.793227E\text{-}10(mV)^3 + 1.400990E\text{-}6(mV)^2 + 0.0387425(mV) - 10.19036$$

The data were logged on a PC level A every 5 seconds. The data were averaged at 30 second intervals and merged into the underway file where the above calibrations were applied.

A first pass inspection on a graphics workstation was done to flag out any obvious problems affecting one of the psychrometers but not the other. in general, the agreement between the temperature sensors was very good, usually within 0.1°C.

Combined dry and wet bulb temperature channels were generated by averaging the data from the port and starboard sensors. The merged channels were then inspected on a graphics workstation. A number of noisy high temperature events affecting all sensors were identified in the record. Where these correlated with wind on the stern (relative wind direction between 45 and 135 for the way the conventional anemometer was mounted on Challenger) or changes in ship's course they were attributed to stack thermal pollution and flagged suspect.

Wind velocity

A Vaisala conventional cup and vane anemometer were mounted on the meteorological package platform on the formast (approximately 12 m above sea level) with the cup to port and vane to starboard.

The cup anemometer generated relative windspeed in m/s and relative wind direction in degrees. These were logged every 5 seconds by the PC level A. At BODC the windspeed was reduced to 30 second sampling by averaging and spot wind direction values were taken every 30 seconds from the 5 second stream. the windspeed was converted to knots by multipying by 1.94. The merged file also included ship's heading and ship's velocity logged at 30 second intervals. All these data channels were examined on a graphics workstation and suspect values flagged.

The ship's heading was added to the relative wind direction an 260 degrees subtracted to correct for the vane orientation. The resulting value was constrained to the range 0-359 by adding or subtracting 360 as appropriate. The ship's velocity over the ground was then subtracted from the relative wind velocity to give absolute wind velocity. Note that as the two velocities have opposite sign conventions, this is effectively an addition of the velocities converted to uniform sign convention.

The data were again screened on a workstation. Comparative screening checks were made to ensure that the absolute wind velocity was truly independent of the ship's velocity and heading. This proved to be the case except for spikes (usually in absolute direction but occasionally in speed as well) coinciding with times when the ship was accelerating or decelerating. These have been attributed to the mismatch in the sampling rates of navigation and meteorology and have been flagged suspect. Finally, the data was checked against entries in the bridge logs.

3.3) Physics

Temperature and salinity

Temperature and salinity were measured using an ODEC (Ocean Data Equipment Corporation) model TSG-103 thermosalinograph, incorporating a remote temperature sensor (thermolinear thermistor) and an inductive type conductivity cell mounted next to a second thermistor.

The remote temperature sensor was supplied by water from the intake side of the non-toxic supply i.e. the sea surface temperature was measured at near-ambient temperature free from any warming effects induced by the pumping system. The conductivity cell and housing temperature thermistor were supplied from a flow-through system from the non-toxic supply.

The raw ADC counts were calibrated to give conductivity and two temperature channels based upon laboratory calibrations undertaken by RVS. Salinity was computed from the housing temperature and conductivity using the UNESCO 1978 Practical Salinity Scale (Fofonoff and Millard, 1982).

The data were sampled every 30 seconds and merged into the underway data file. The temperature and salinity streams were inspected on a graphics workstation and all suspect values flagged. There were a large number of spikes flagged suspect. There are two large gaps on the 21/10/96 between 14:35 and 15:03 and 15:14 and 16:11Z which are also flagged suspect coinciding with pump maintenance.

Salinity was back calibrated using a set of discrete salinity measurements taken from the non-toxic supply. Samples were collected in glass bottles to just below the neck and sealed with plastic stoppers. Batches of samples were left for at least 24 hours to reach thermal equilibrium in the constant temperature laboratory containing the salinometer before analysis.

Thirty-one samples collected between 16/10/1996 and 24/10/1996 were analysed during the cruise on a Guideline Autosal bench salinometer. Due to a problem with the autosal onboard, the remaining 31 samples (covering the period 24/10/96 to 31/10/1996) were stored for later analysis, but subsequently no data has been provided to BODC on these samples. In order to supplement the calibration data set, calibrated surface (4 m) CTD data has been used (37 salinities).

Analysis of the differences between thermosalinograph and bottle salinities/CTD thermosalinograph revealed that the instrument drifted at the start of the cruise. This was complicated by additional jumps in the signal where segments of the signal appear offset from adjacent segments.

The salinity calibration was modelled by the equation:

Corrected salinity = Raw salinity + (Cycle_number * Slope) + Offset

This correction model has been applied to the data with the following coefficients.

Start date	End date	Slope	Offset
16/10/1996 16:00	17/10/1996 21:56	-0.00013	0.493929
17/10/1996 21:57	28/10/1996 10:31	0.00000	0.027
28/10/1996 10:32	31/10/1996 17:46	0.00000	0.117

After calibration, the period before 17/10/1996 02:20 was still thought to be low for the English Channel, and in the absence of further calibration data could not be corrected and has therefore been flagged as suspect.

The remote (i.e. sea surface) temperature was back calibrated against readings from the Neil Brown Mk3B CTD which was held at the non-toxic inlet depth on each cast whilst the thermosalinograph was being logged. This showed that the thermosalinograph temperature was a function of temperature and was further complicated by jumps and drops in the signal where segments of the signal appear offset from adjacent segments.

The temperature calibration was modelled by the following equation:

Corrected temperature = (Raw temperature * Slope) + Offset

This correction model has been applied to the data with the following coefficients:

Start date	End date	Slope	Offset
16/10/1996 16:00	20/10/1996 12:35	0.7087	2.9308
20/10/1996 12:36	20/10/1996 17:20	0.7087	3.0308
20/10/1996 17:21	20/10/1996 17:38	0.7087	3.0008
20/10/1996 17:39	24/10/1996 07:11	0.7087	2.9308
24/10/1996 07:12	25/10/1996 07:26	0.7087	2.8108
25/10/1996 07:27	25/10/1996 12:31	0.7087	2.8308
25/10/1996 12:32	31/10/1996 17:46	0.6448	0.117

Optical Attenuance and Total Particulate Matter

Optical attenuance was measured using a SeaTech 660 nm (red) 25 cm pathlength transmissometer (s/n 116D) contained in a plastic water bath continuously flushed by the non-toxic supply. The data were logged as voltages every 30 seconds and merged into the underway data file.

The data were corrected for light source decay by multiplying the voltages by a factor of 1.0111. This was based on an air reading of 4.756V taken on 16/10/1996 and the manufacturers air reading of 4.810 (23/07/1991) and blocked path readings of 0.000V and 0.0001V respectively.

Voltages were converted to percentage transmission by multiplying by 20. Any values outside the operational limits of the instrument (1-91.3%) were automatically flagged suspect.

The percentage transmission was converted to attenuance using the equation:

Attenuance = -4.0 log(% Transmission/100)

Inspection of the data using a graphics workstation showed the data set to be extremely noisy at times due to bubbles forming in the non-toxic system during rough weather. These have been flagged out.

Attenuance was regressed against total suspended matter determinations to derive the equation below to allow attenuance to be expressed as suspended matter.

Total Suspended Matter = (Attenuance * 0.401906) - 1.0256

The R_2 for the regression was 97.7 % with a standard error of 0.84. The calibration covered the range 0 to 59 mg/l, values above this in the underway file were automatically flagged 'U' - uncalibrated.

3.4) Biology

Chlorophyll

Chlorophyll was measured by a Chelsea Instruments Mk2 Aquatracka fluorometer (s/n 246), mounted in the same tank as the transmissometer. The data were logged as voltages every 30 seconds. The data were examined graphically and any suspect data flagged. Very little data required flagging other than the odd spike.

A data set of 26 fluorometrically assayed extracted chlorophyll samples analysed onboard by SOC were made available for the fluorometer calibration. Calibration was achieved by regression of the log of the extracted chlorophyll value against the raw fluorometer voltage. The cruise data were treated as a single population.

chlorophyll (mg/m^3) = exp (-1.97141 + 1.070103 * raw_voltage)

The adjusted R^2 for this regression was 68 %. The mean error was essentially zero with a standard deviation of 0.11.

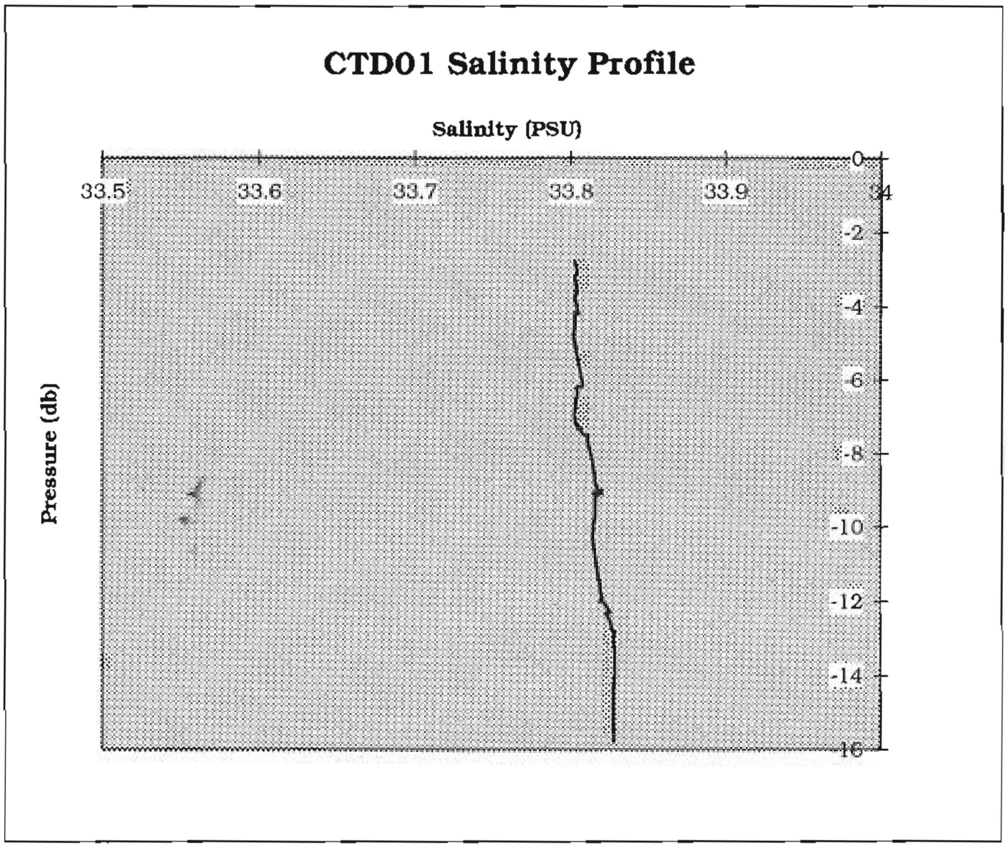
Oxygen sensor

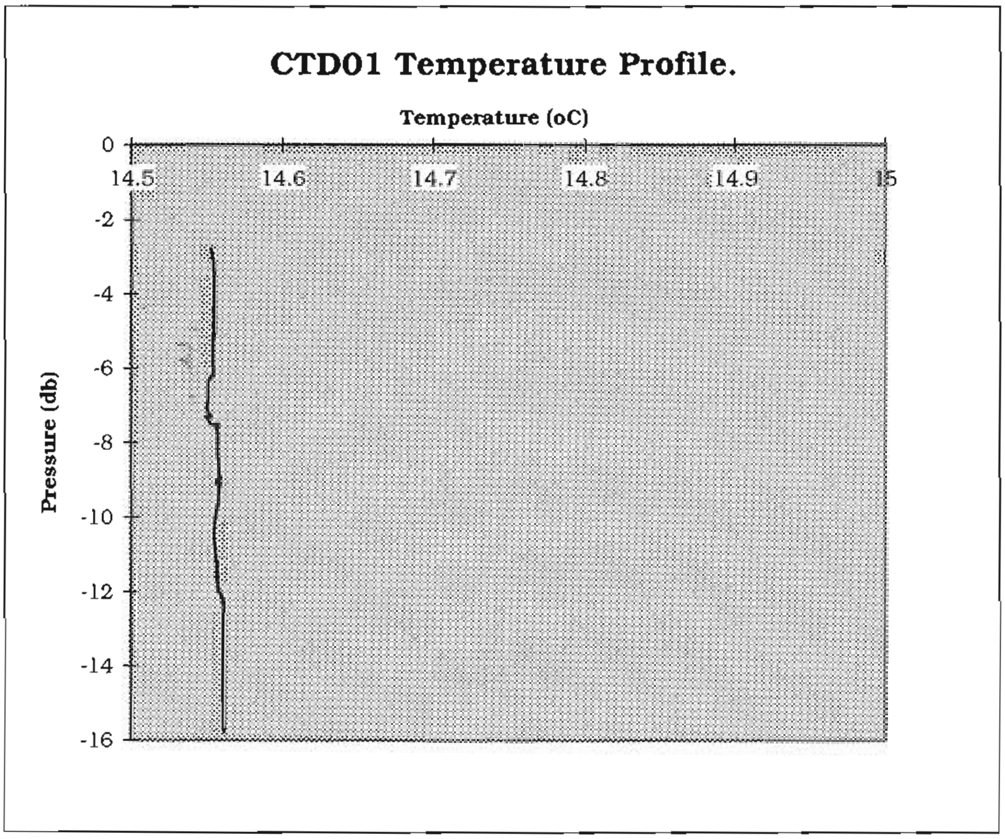
A YSI 6000 oxygen sensor (s/n 94E18708) was operated by SOC. Data has been merged into the underway data file and screened on a graphical workstation. The channel will be calibrated against Winkler titration assays on receipt of the discrete data.

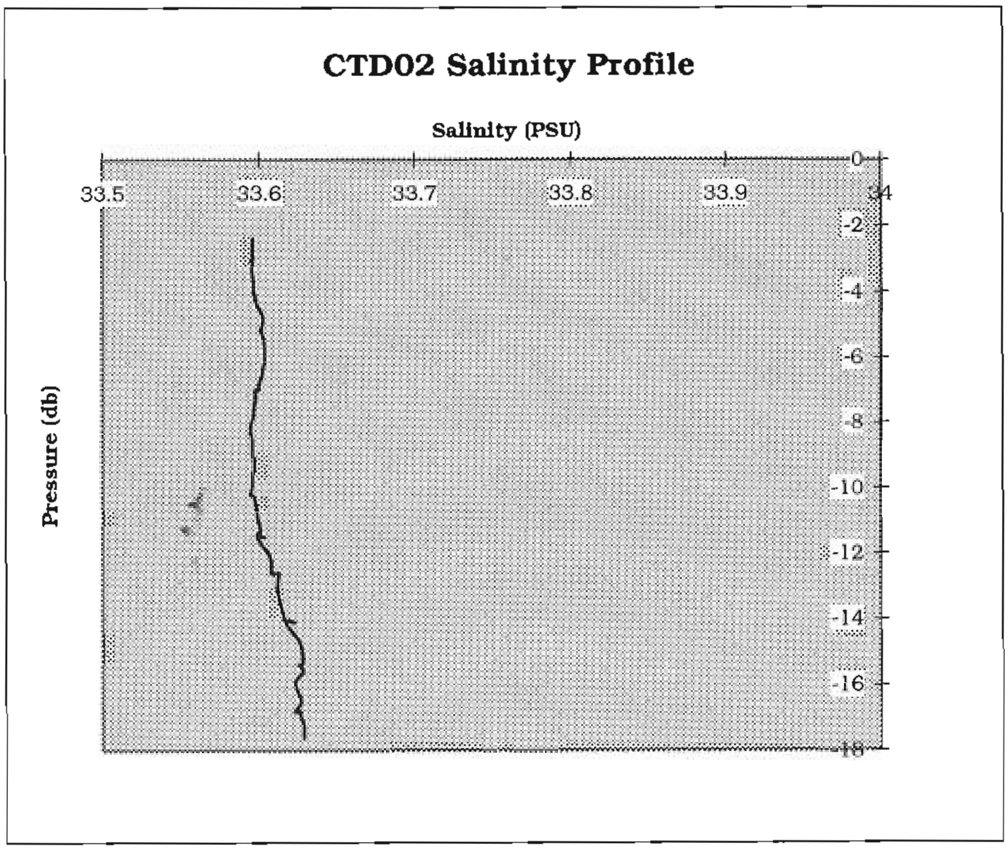
4) References

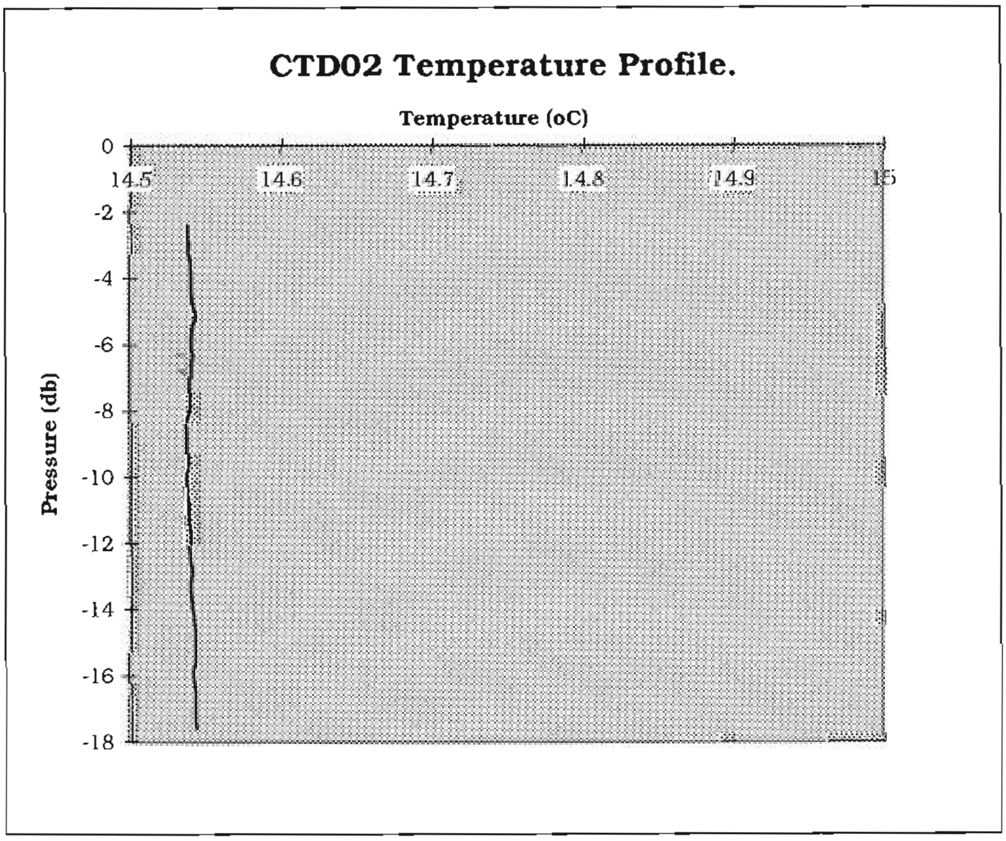
Fofonoff, N.P., Millard Jr., R.C. (1983). Algorithms for computation of fundamental properties of seawater. ***UNESCO Technical Papers in Marine Science*** 44.

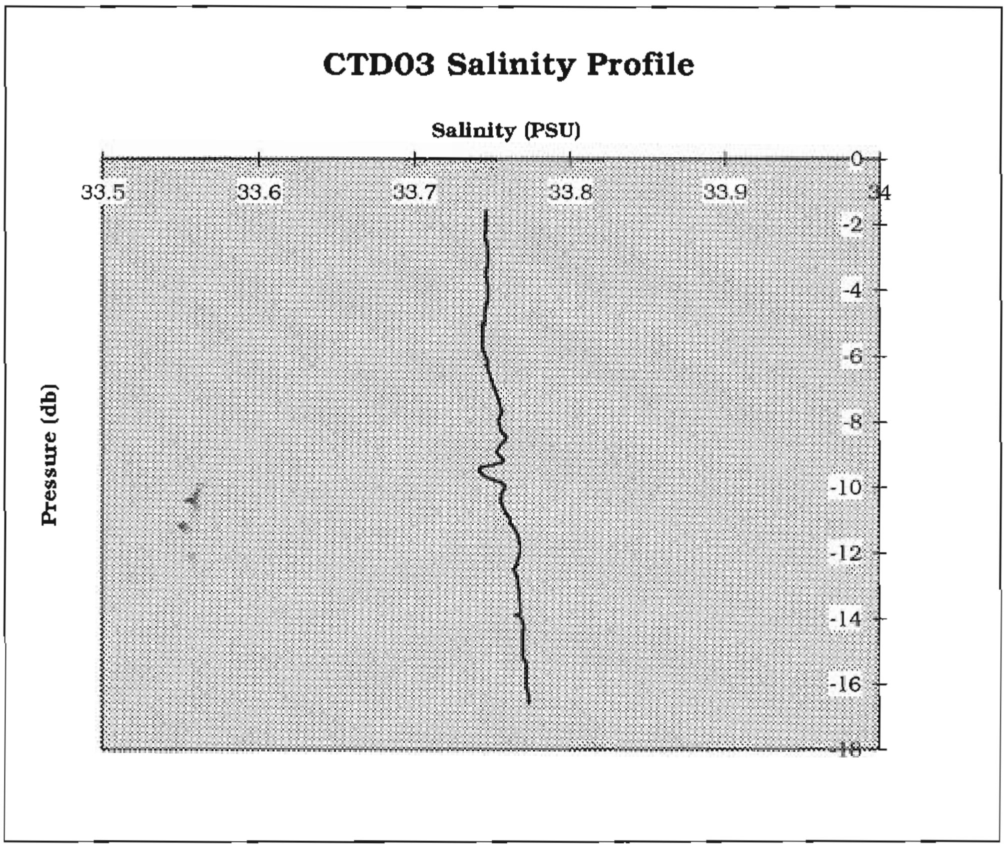
Strickland, J.D.H., Parsons, T.R. (1975). A practical handbook of seawater analysis. ***Fish. Res. Bd. Can.*** pp.167-311.

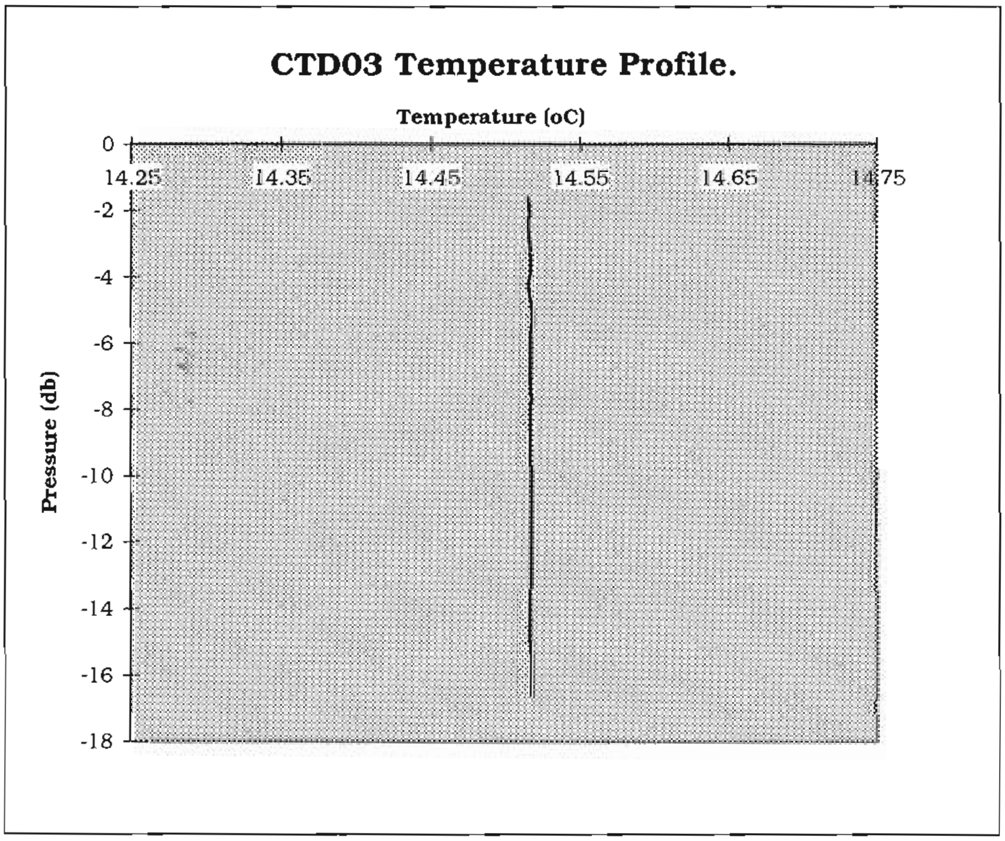

CTD01 Salinity Profile
Salinity (PSU)
33.5
33.6
33.7
33.8
33.9
34
0
-2
-4
-6
-8
-10
-12
-14
-16
Pressure (db)

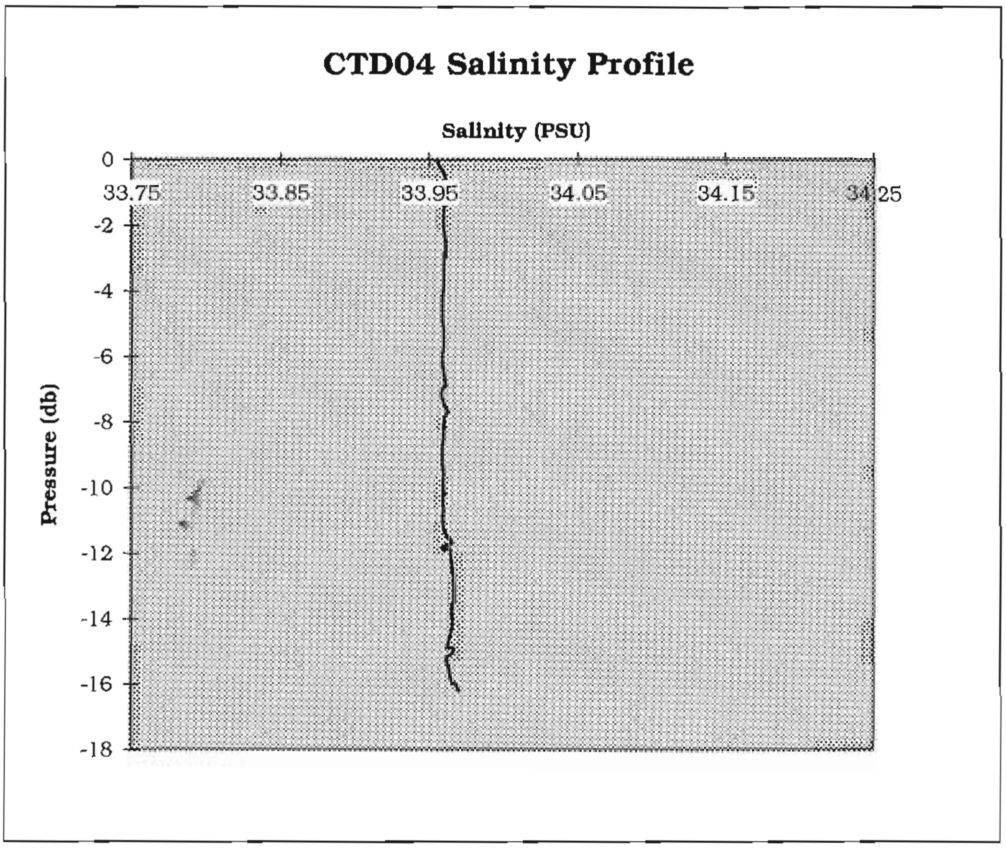

CTD01 Temperature Profile.
Temperature (oC)
14.5
14.6
14.7
14.8
14.9
15
0
-2
-4
-6
-8
-10
-12
-14
-16
Pressure (db)

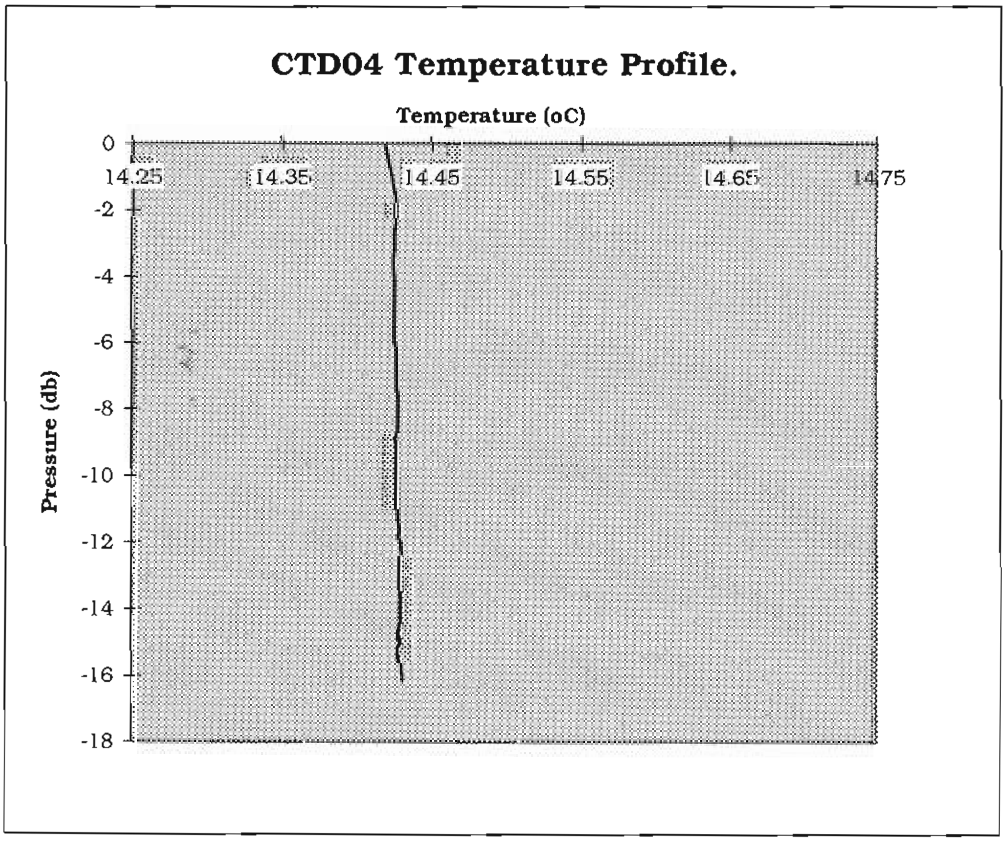

CTD02 Salinity Profile
Salinity (PSU)
33.5
33.6
33.7
33.8
33.9
34
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
Pressure (db)

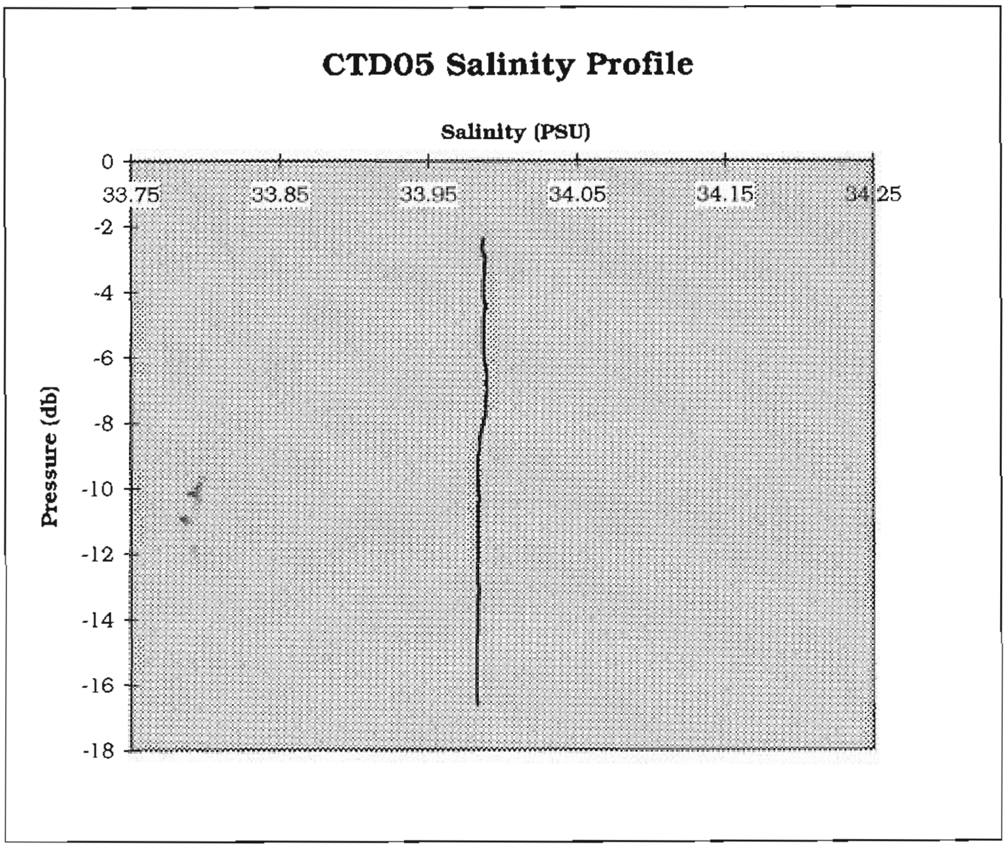

CTD02 Temperature Profile.
Temperature (oC)
14.5
14.6
14.7
14.8
14.9
15
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
Pressure (db)

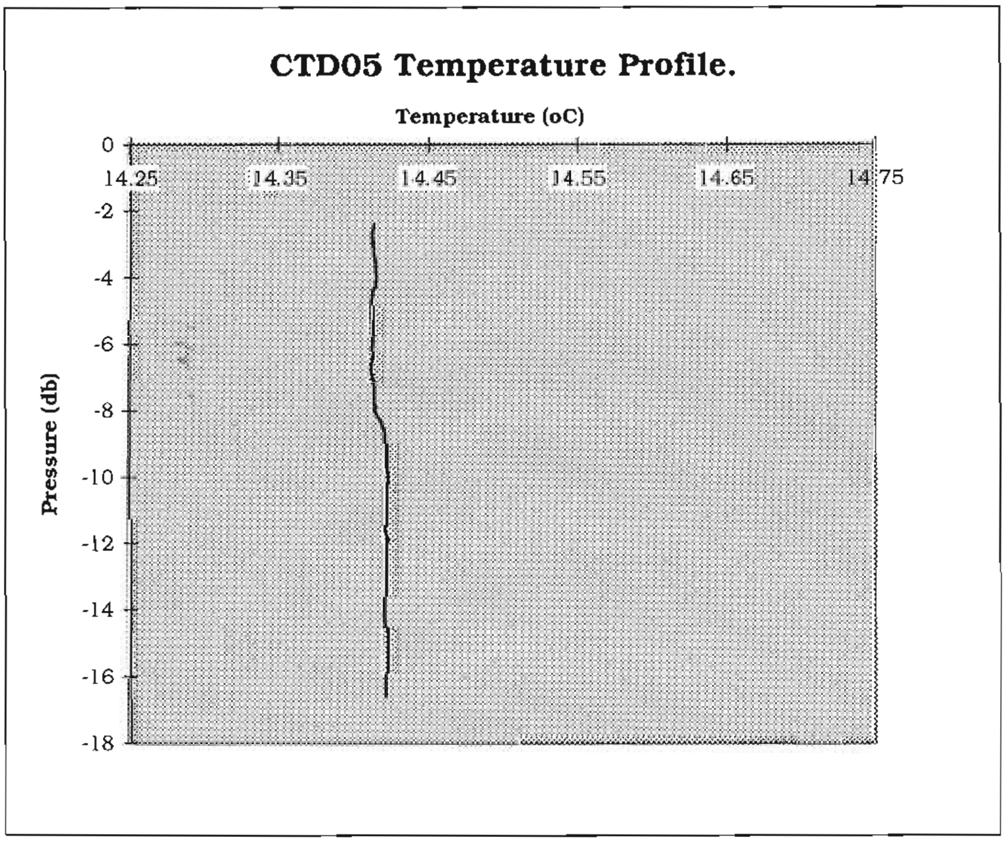

CTD03 Salinity Profile
Salinity (PSU)
33.5
33.6
33.7
33.8
33.9
34
Pressure (db)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18

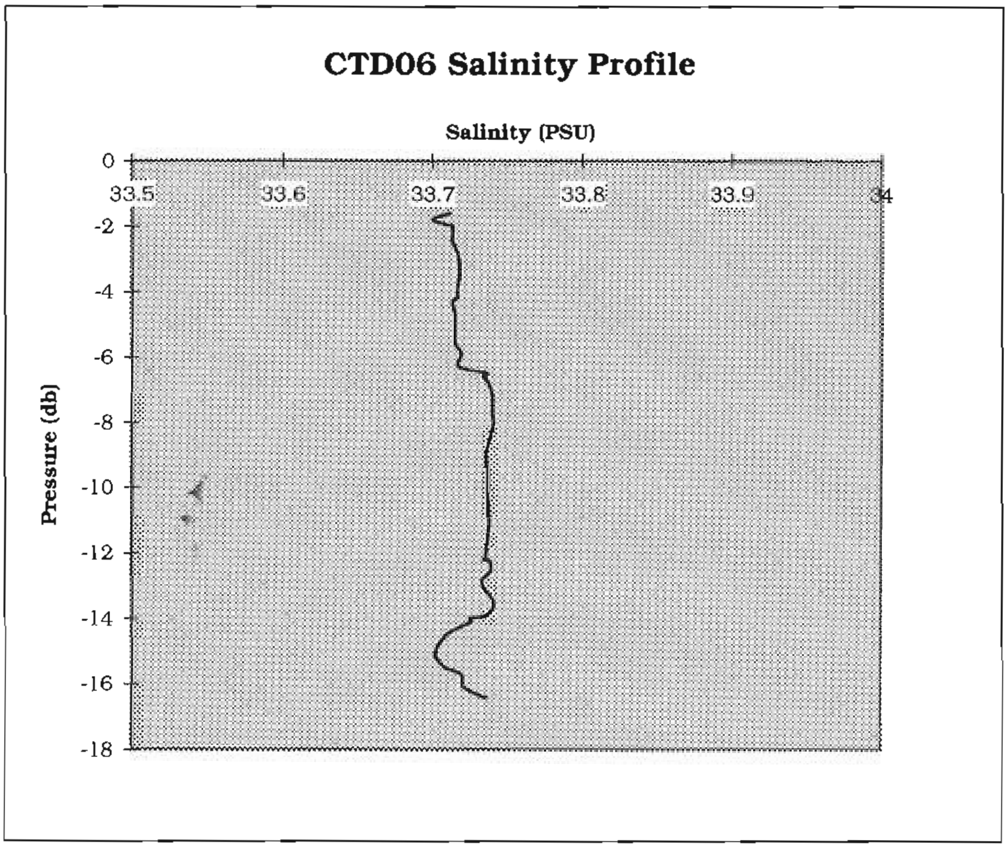

CTD03 Temperature Profile.
Temperature (oC)
14.25
14.35
14.45
14.55
14.65
14.75
Pressure (db)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18

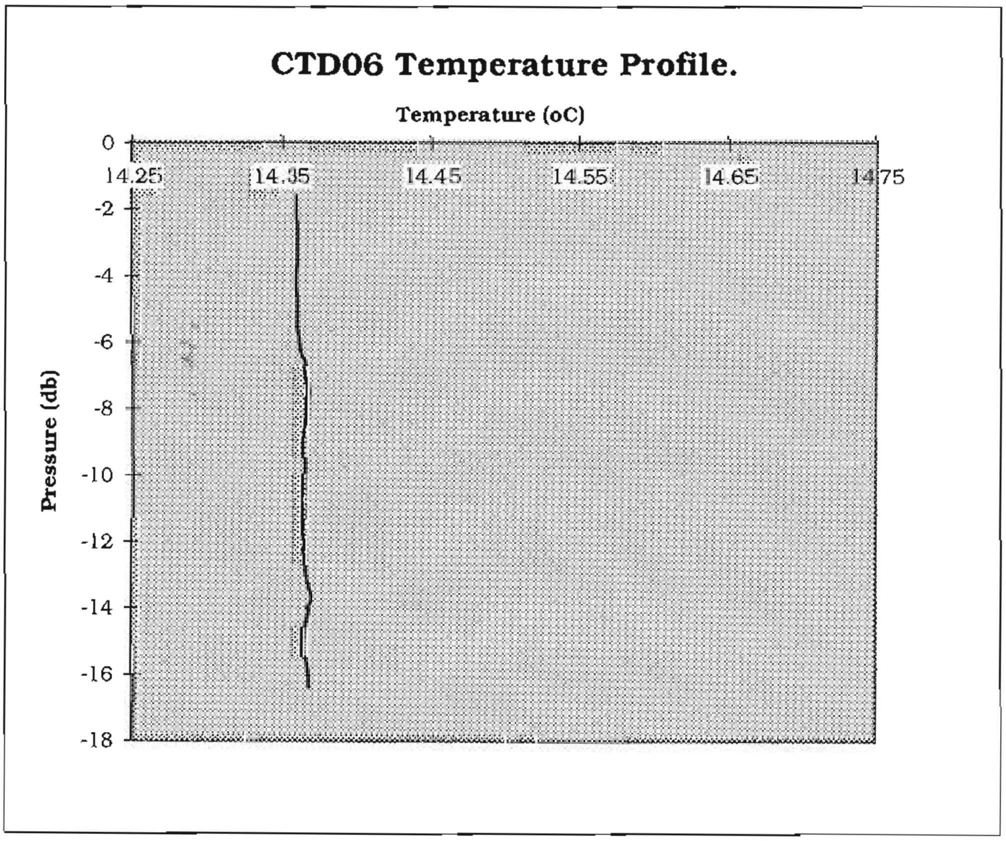

CTD04 Salinity Profile
Salinity (PSU)
33.75
33.85
33.95
34.05
34.15
34.25
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
Pressure (db)

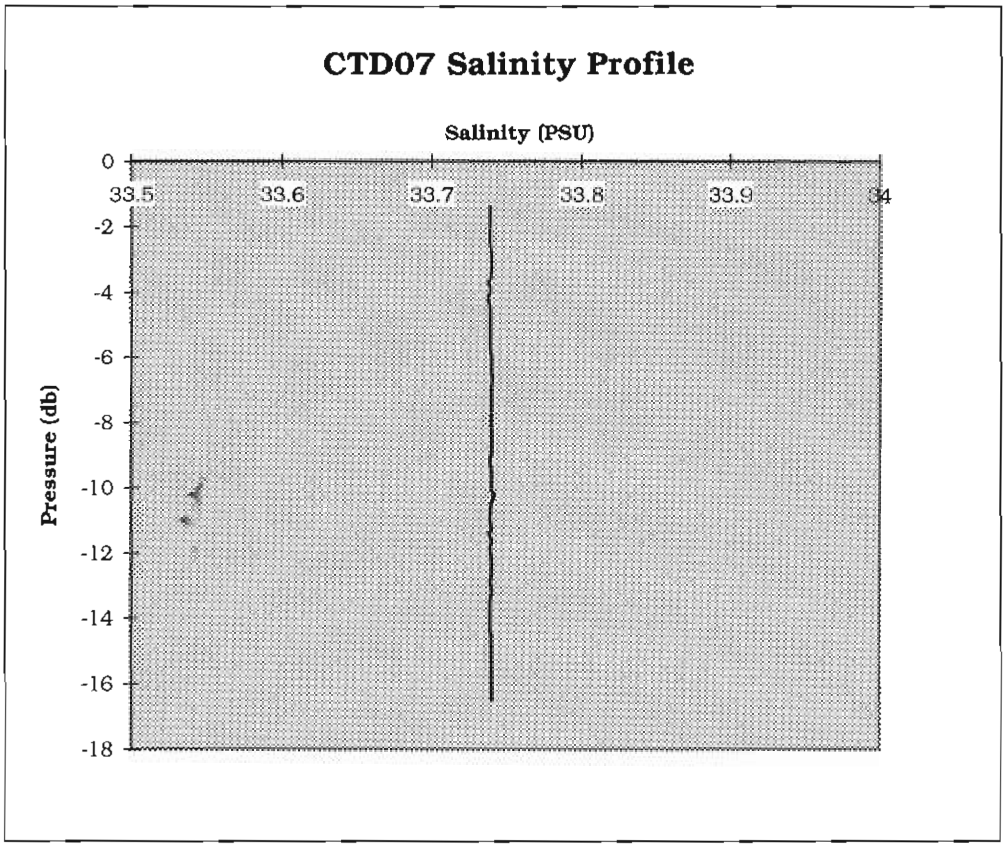

CTD04 Temperature Profile.
Temperature (oC)
14.25
14.35
14.45
14.55
14.65
14.75
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
Pressure (db)

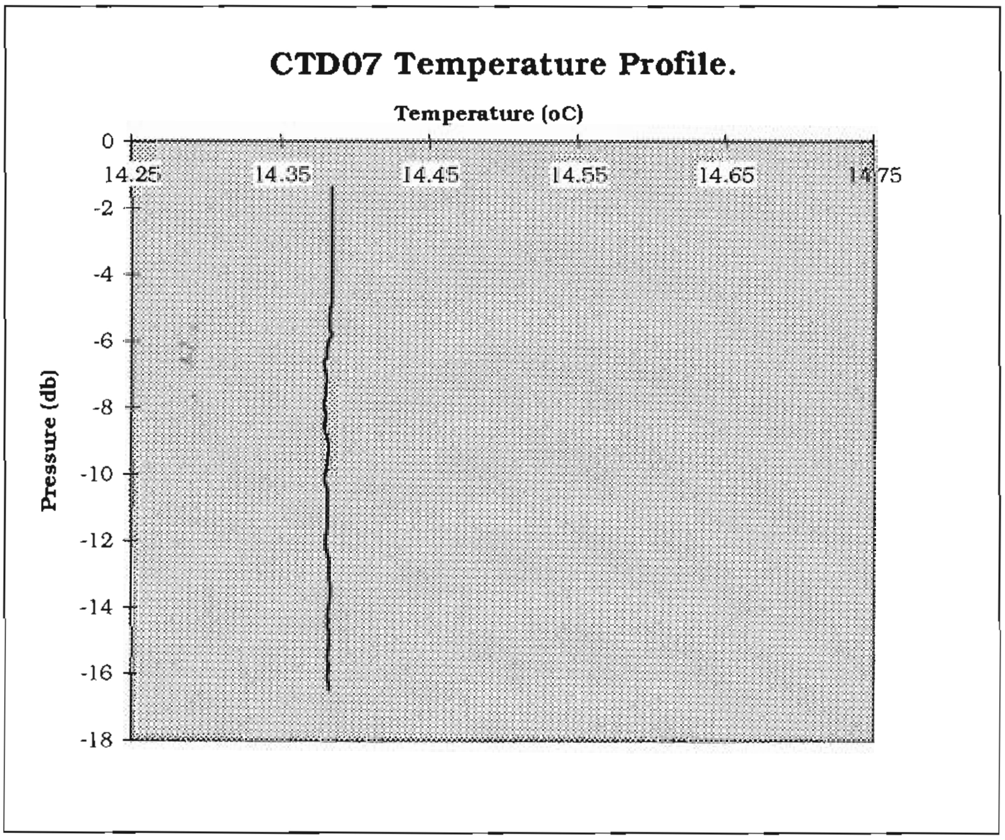

CTD05 Salinity Profile
Salinity (PSU)
Pressure (db)
33.75
33.85
33.95
34.05
34.15
34.25
0
-2
-4
-6
-8
-10
-12
-14
-16
-18

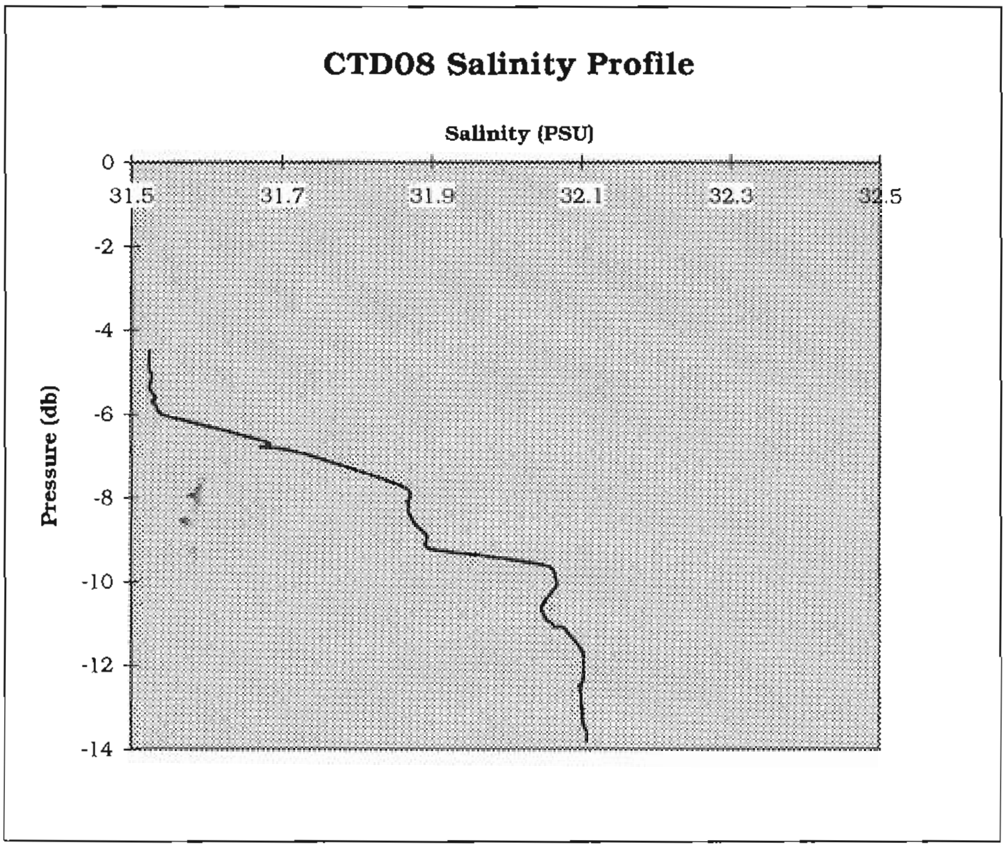

CTD05 Temperature Profile.
Temperature (oC)
Pressure (db)
14.25
14.35
14.45
14.55
14.65
14.75
0
-2
-4
-6
-8
-10
-12
-14
-16
-18

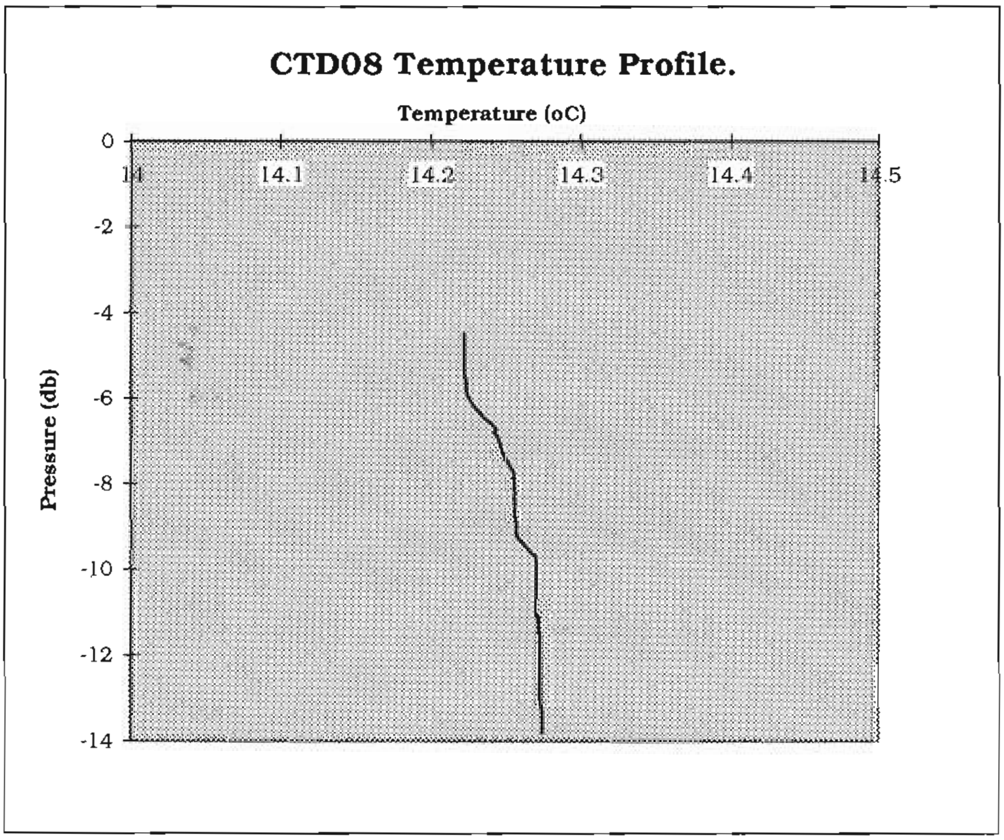

CTD06 Salinity Profile
Salinity (PSU)
33.5
33.6
33.7
33.8
33.9
34
Pressure (db)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18

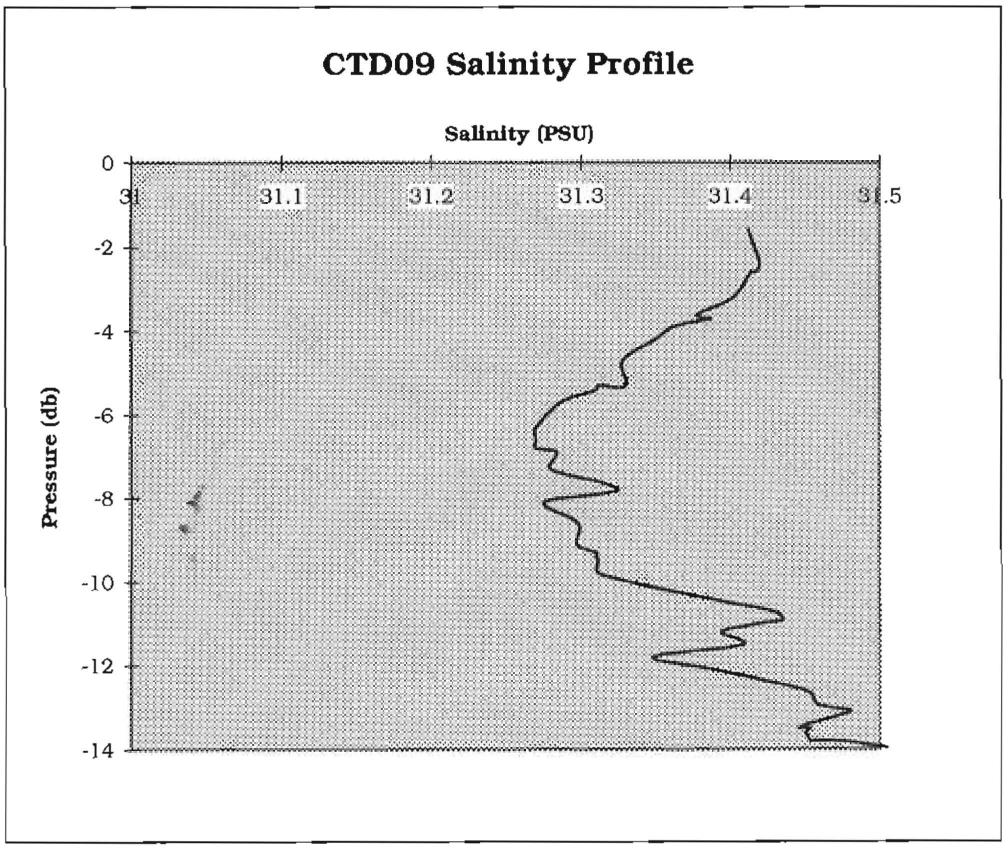

CTD06 Temperature Profile.
Temperature (oC)
14.25
14.35
14.45
14.55
14.65
14.75
Pressure (db)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18

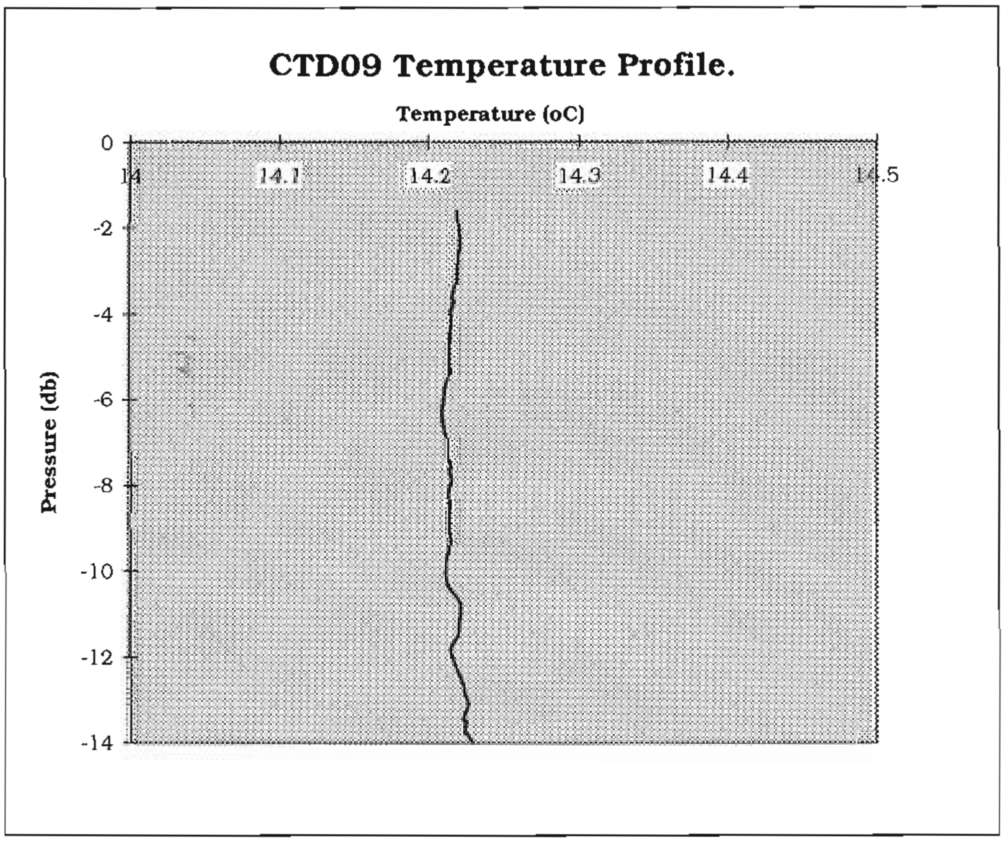

CTD07 Salinity Profile
Salinity (PSU)
Pressure (db)
33.5
33.6
33.7
33.8
33.9
34
0
-2
-4
-6
-8
-10
-12
-14
-16
-18

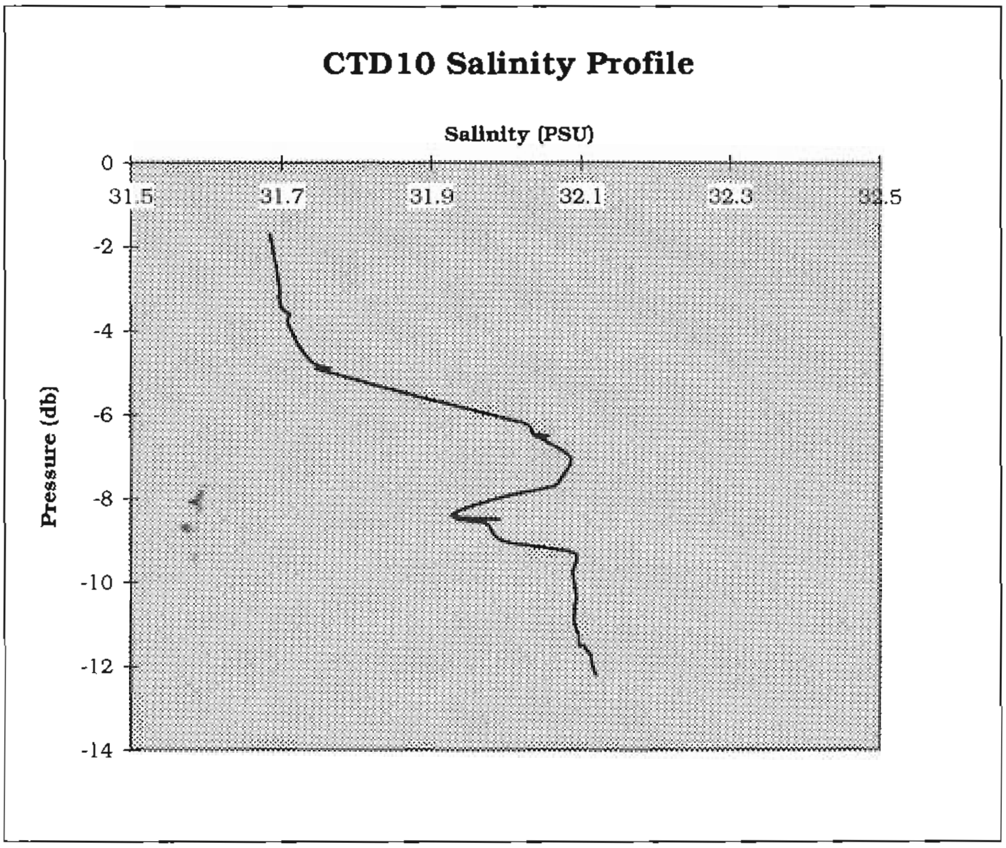

CTD07 Temperature Profile.
Temperature (oC)
Pressure (db)
14.25
14.35
14.45
14.55
14.65
14.75
0
-2
-4
-6
-8
-10
-12
-14
-16
-18

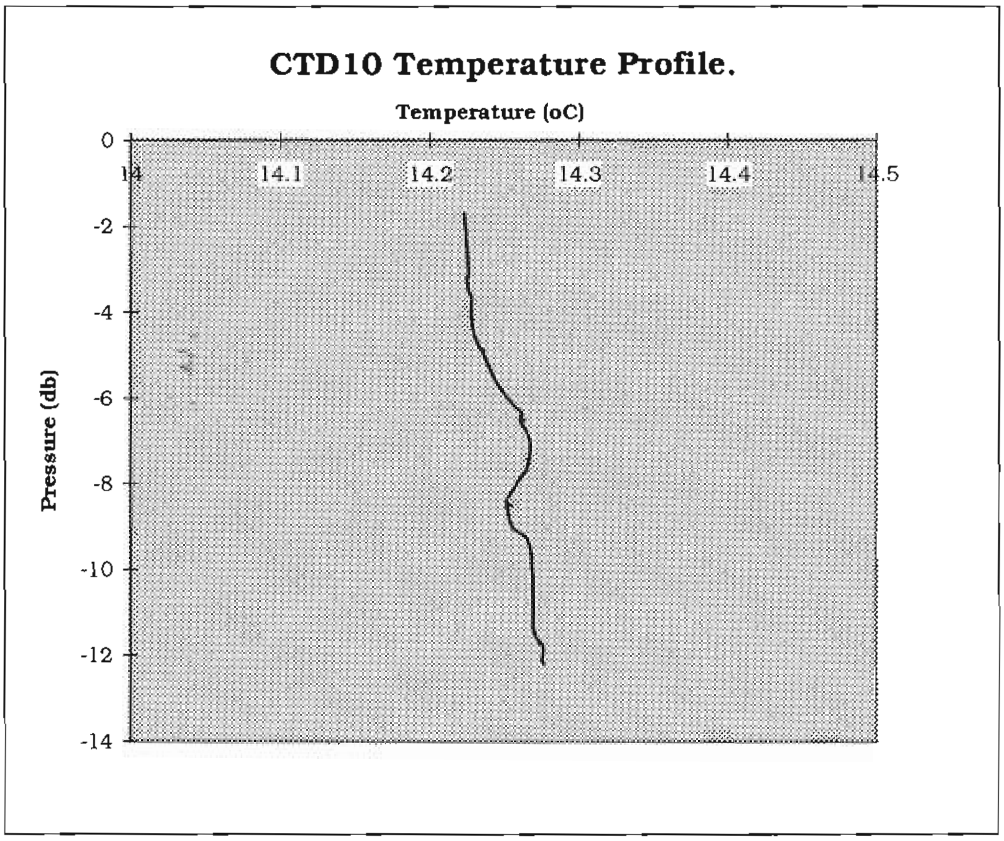

CTD08 Salinity Profile
Salinity (PSU)
Pressure (db)
0
-2
-4
-6
-8
-10
-12
-14
31.5
31.7
31.9
32.1
32.3
32.5

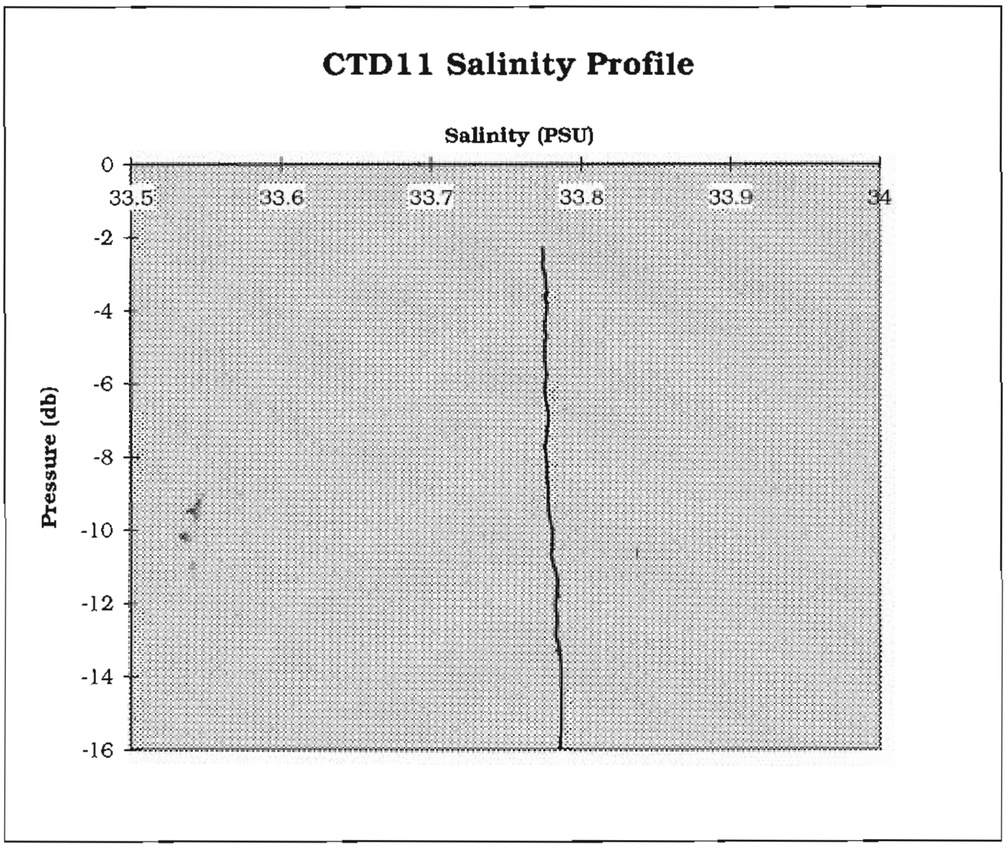

CTD08 Temperature Profile.
Temperature (oC)
Pressure (db)
0
-2
-4
-6
-8
-10
-12
-14
14
14.1
14.2
14.3
14.4
14.5

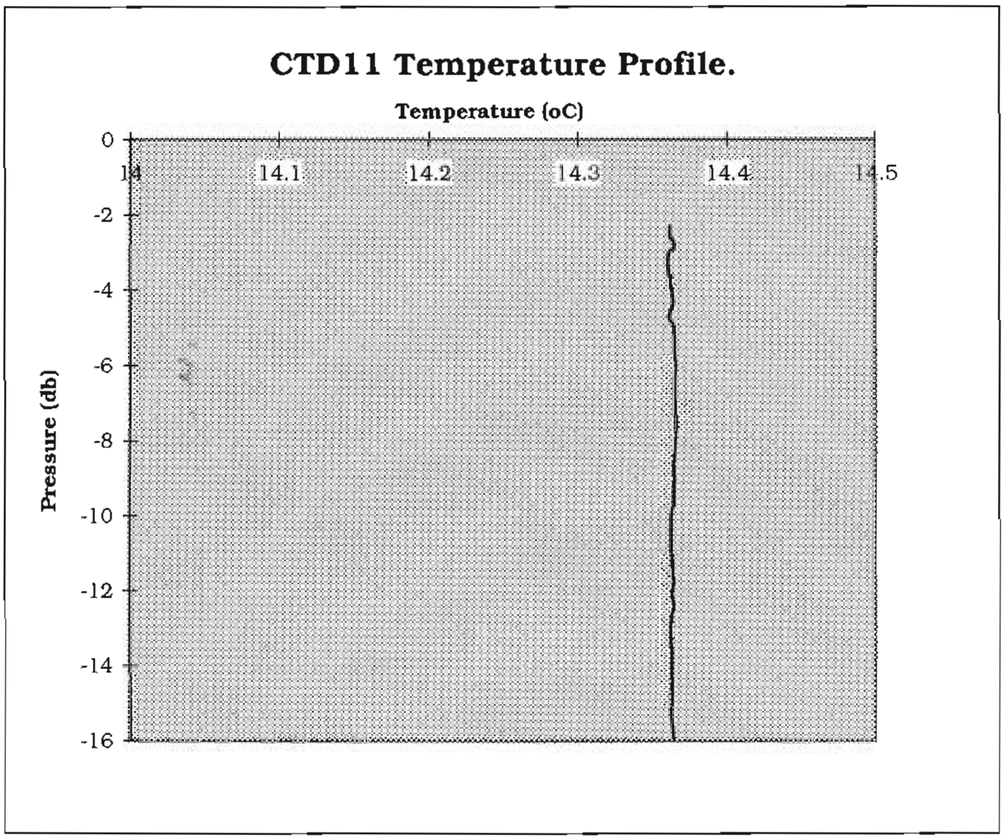

CTD09 Salinity Profile
Salinity (PSU)
31
31.1
31.2
31.3
31.4
31.5
Pressure (db)
0
-2
-4
-6
-8
-10
-12
-14

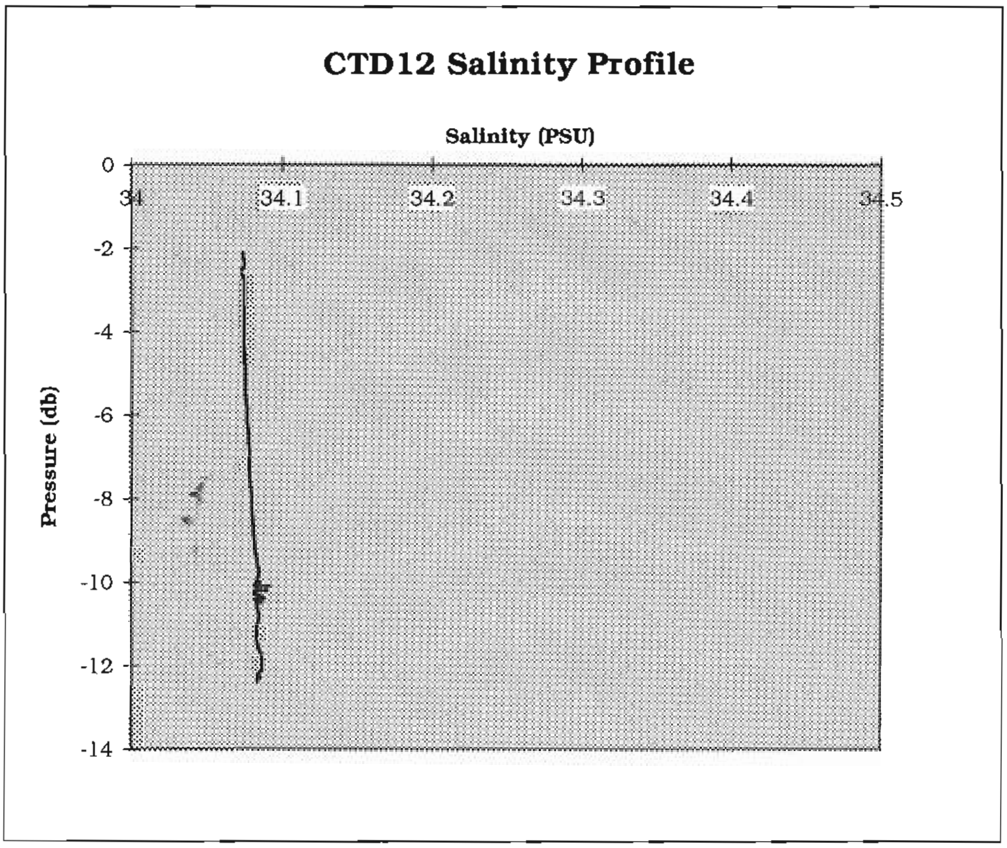

CTD09 Temperature Profile.
Temperature (oC)
14
14.1
14.2
14.3
14.4
14.5
Pressure (db)
0
-2
-4
-6
-8
-10
-12
-14

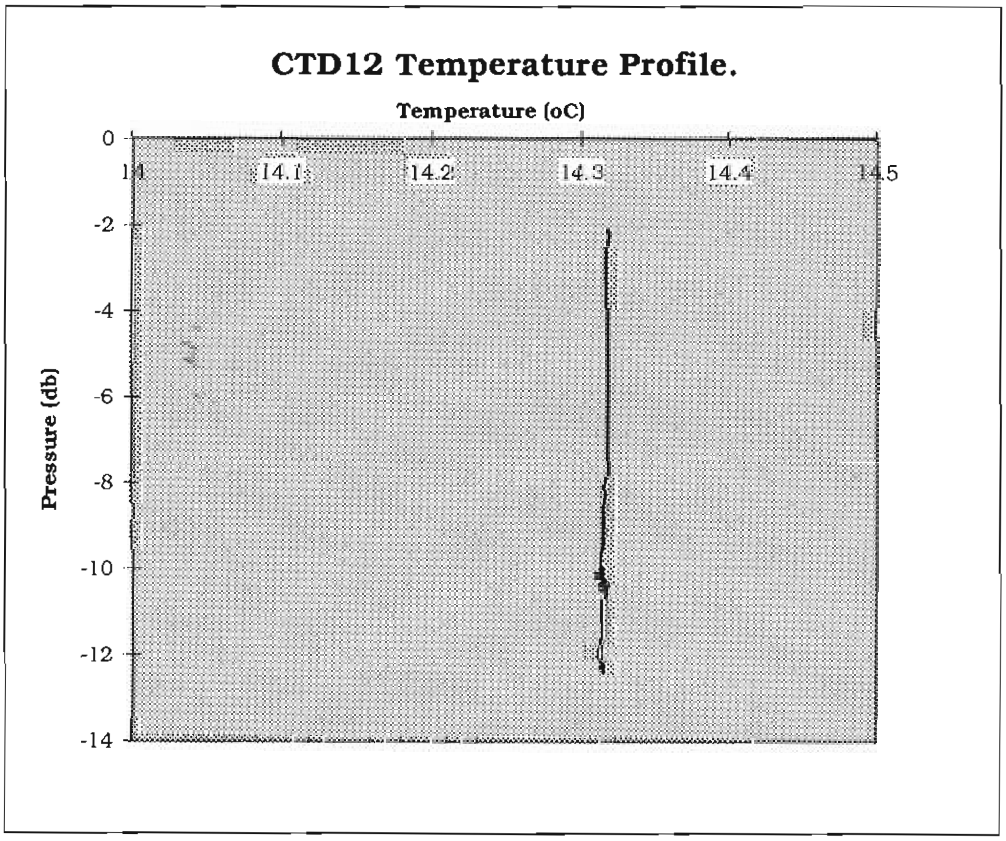

CTD10 Salinity Profile
Salinity (PSU)
31.5
31.7
31.9
32.1
32.3
32.5
0
-2
-4
-6
-8
-10
-12
-14
Pressure (db)

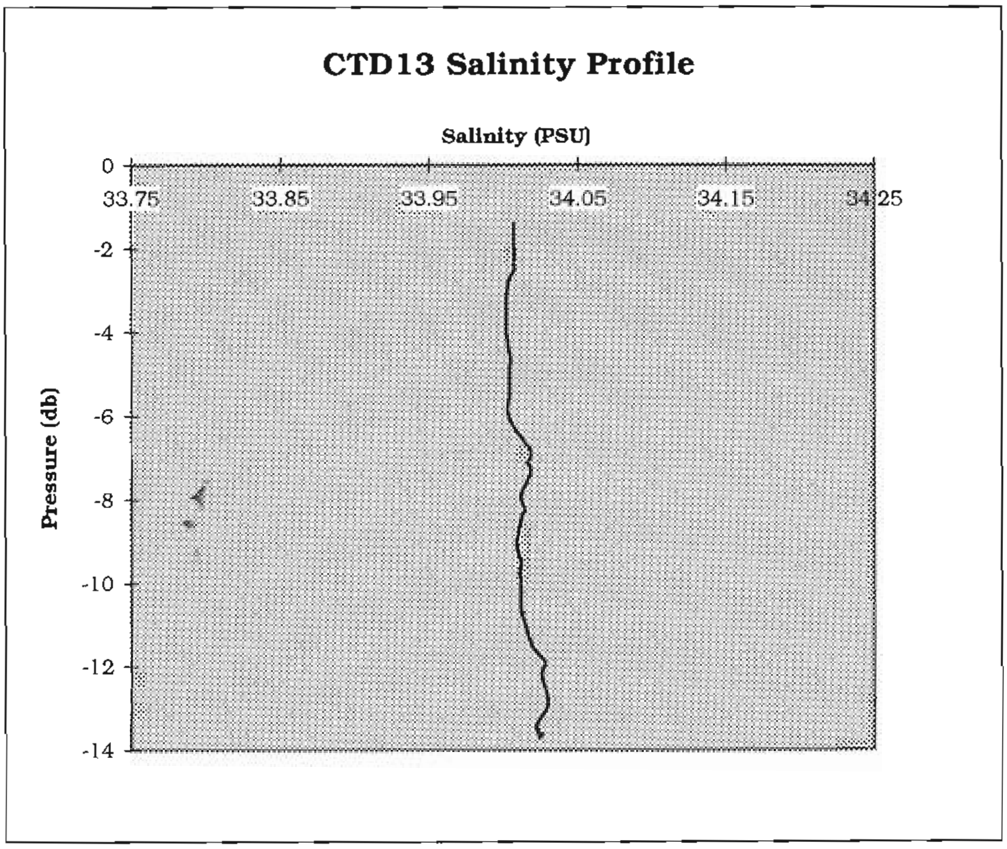

CTD10 Temperature Profile.
Temperature (oC)
14
14.1
14.2
14.3
14.4
14.5
0
-2
-4
-6
-8
-10
-12
-14
Pressure (db)

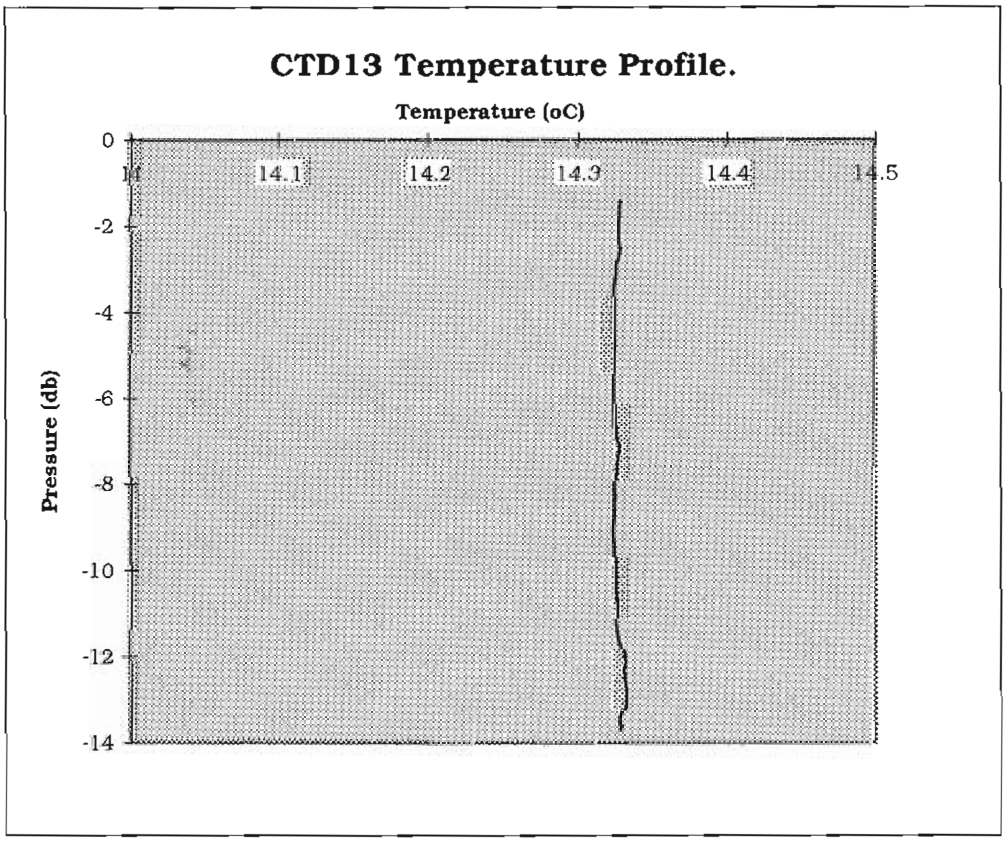

CTD11 Salinity Profile
Salinity (PSU)
0
33.5
33.6
33.7
33.8
33.9
34
-2
-4
-6
-8
-10
-12
-14
-16
Pressure (db)

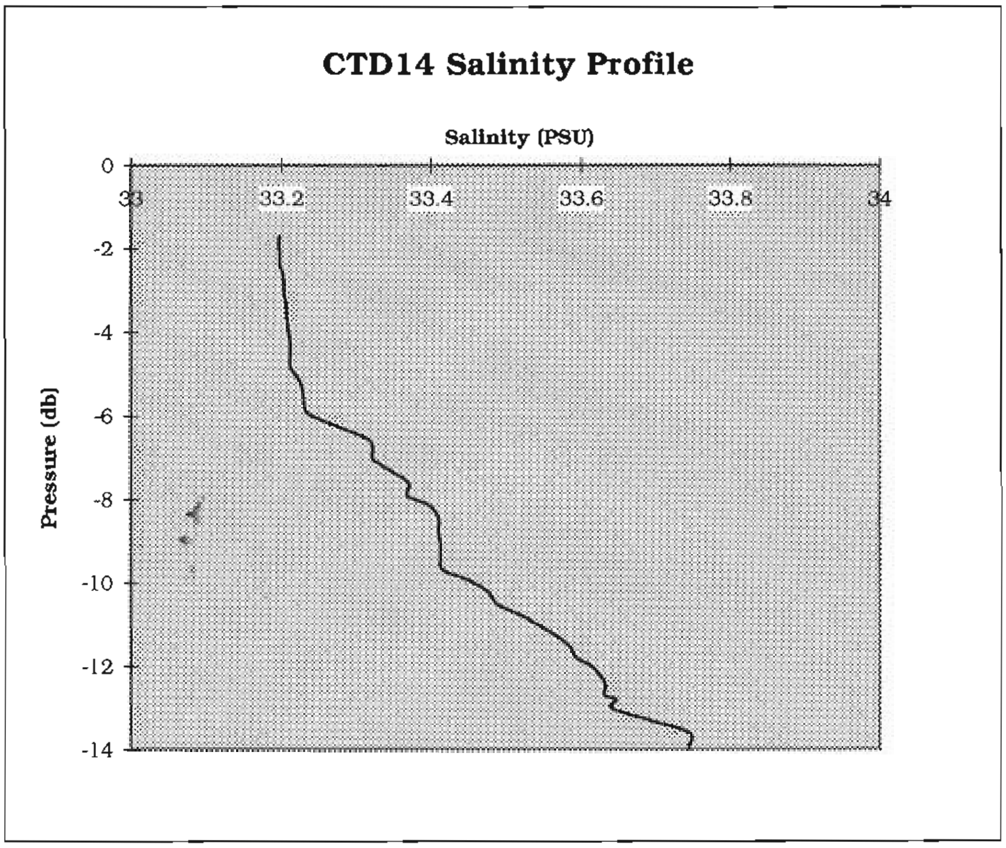

CTD11 Temperature Profile.
Temperature (oC)
0
14
14.1
14.2
14.3
14.4
14.5
-2
-4
-6
-8
-10
-12
-14
-16
Pressure (db)

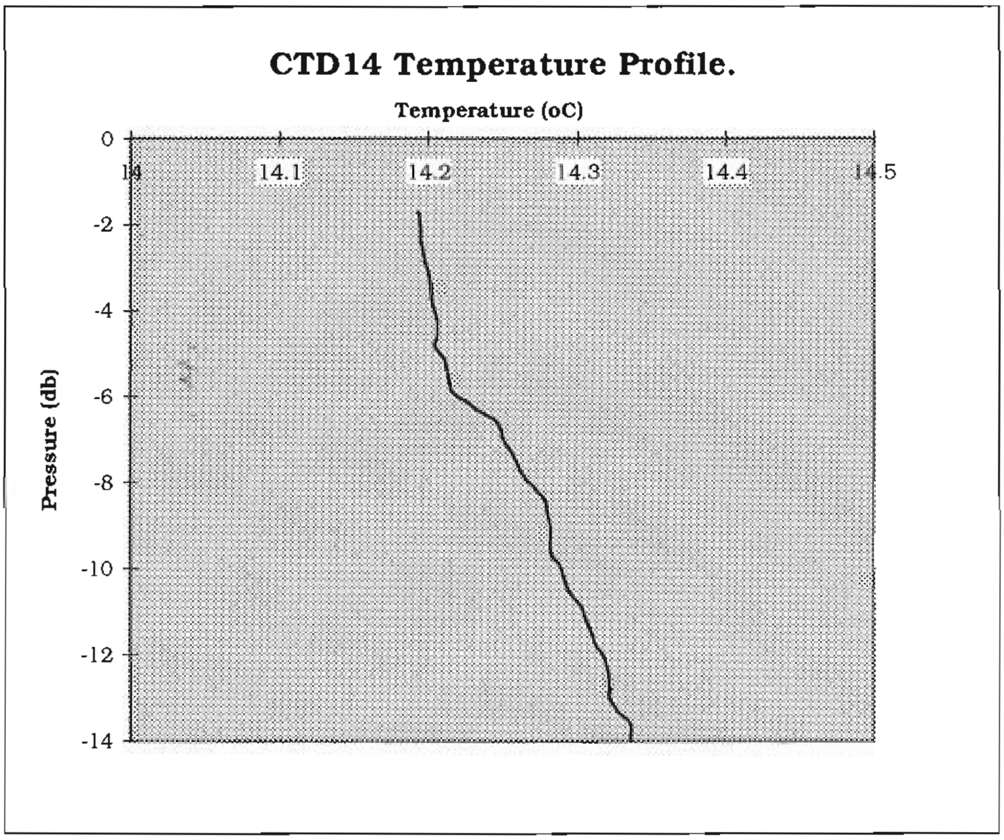

CTD12 Salinity Profile
Salinity (PSU)
Pressure (db)
0
-2
-4
-6
-8
-10
-12
-14
34
34.1
34.2
34.3
34.4
34.5

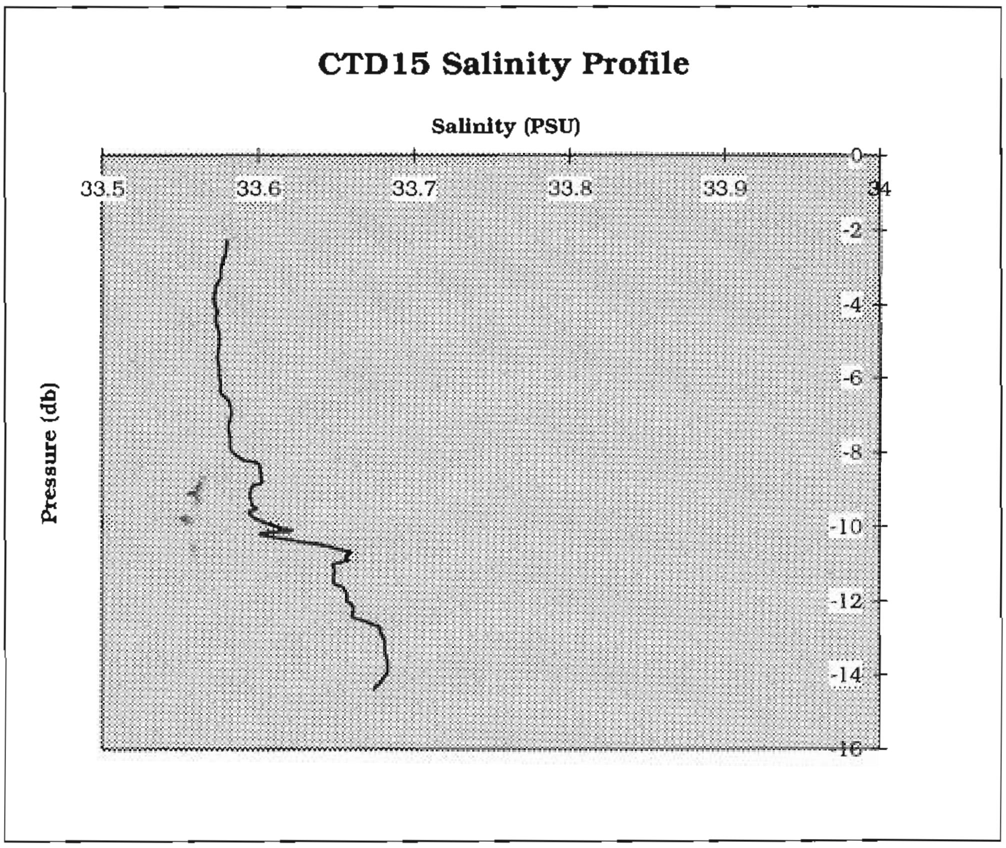

CTD12 Temperature Profile.
Temperature (oC)
Pressure (db)
0
-2
-4
-6
-8
-10
-12
-14
14
14.1
14.2
14.3
14.4
14.5

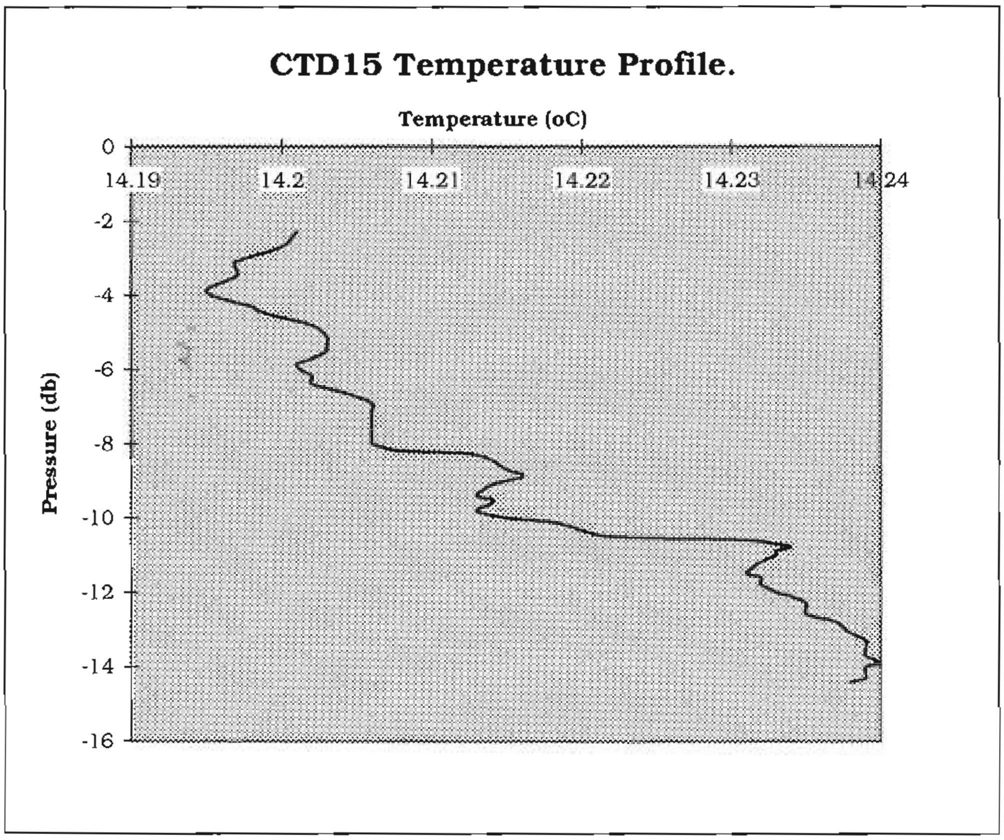

CTD13 Salinity Profile
Salinity (PSU)
0
33.75
33.85
33.95
34.05
34.15
34.25
-2
-4
-6
-8
-10
-12
-14
Pressure (db)

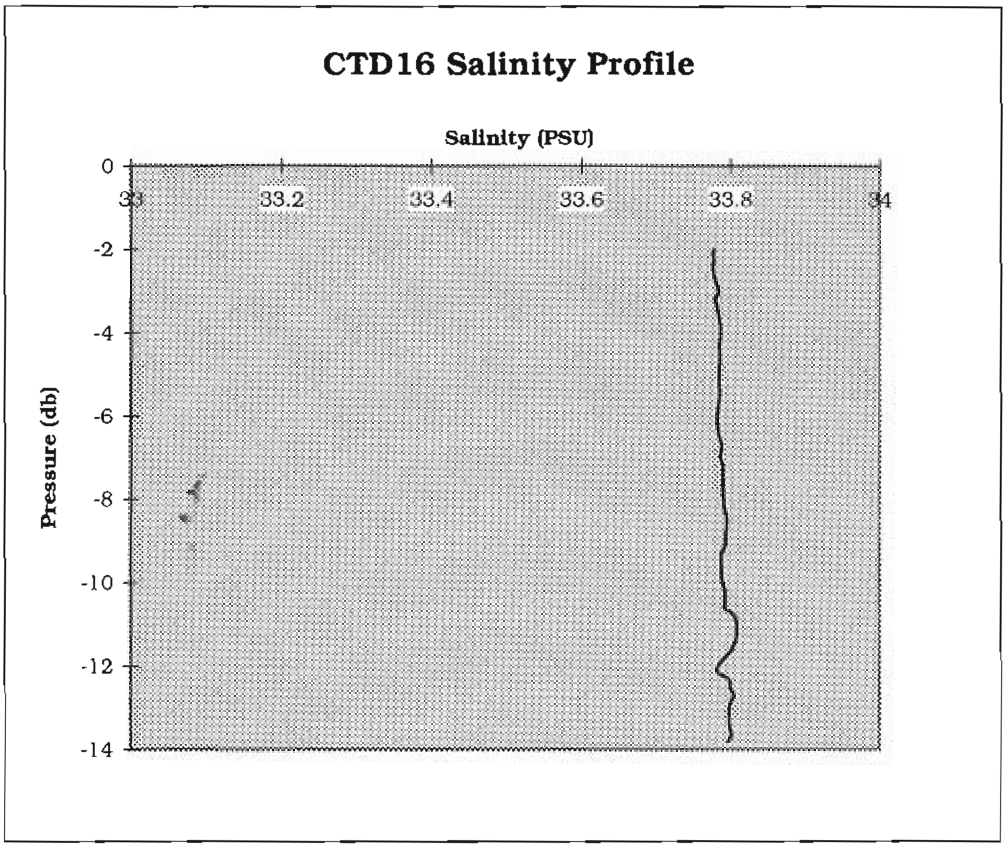

CTD13 Temperature Profile.
Temperature (oC)
0
14.1
14.2
14.3
14.4
14.5
-2
-4
-6
-8
-10
-12
-14
Pressure (db)

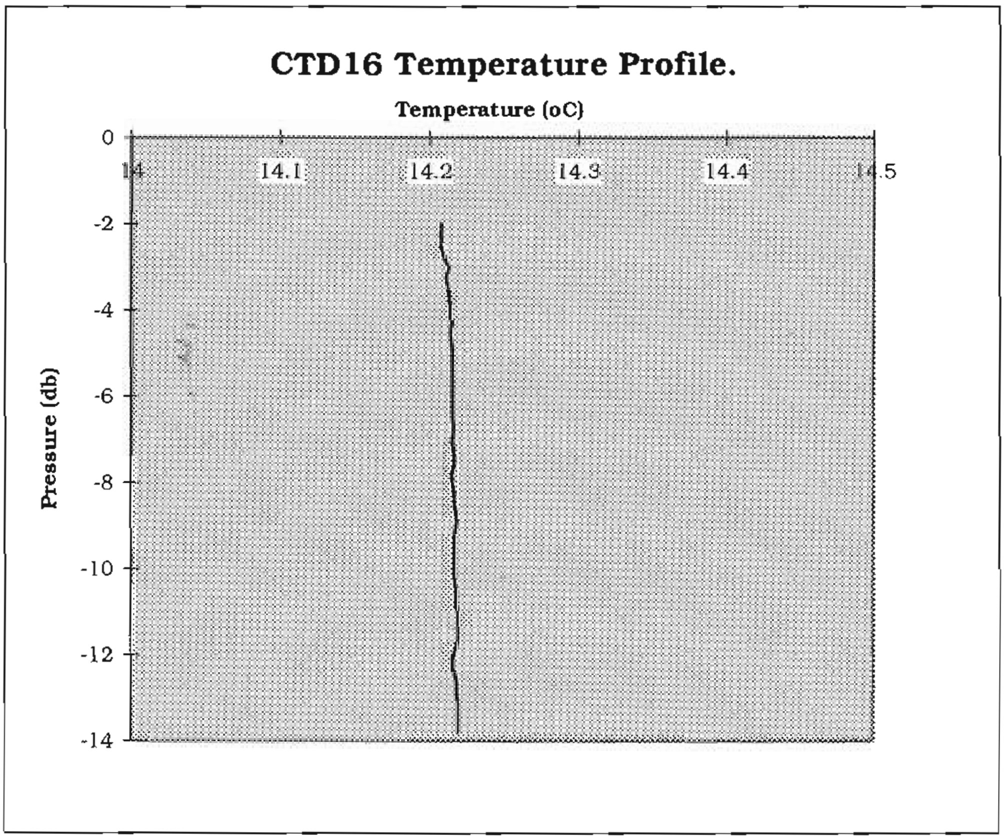

CTD14 Salinity Profile
Salinity (PSU)
33
33.2
33.4
33.6
33.8
34
Pressure (db)
0
-2
-4
-6
-8
-10
-12
-14

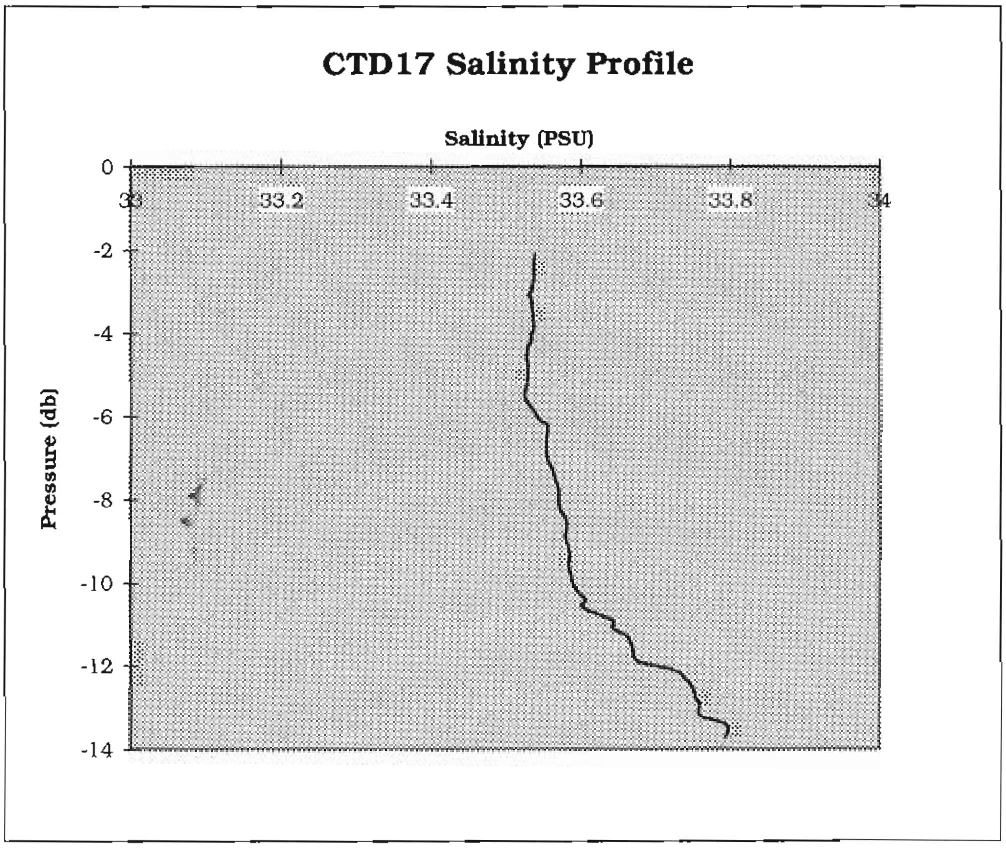

CTD14 Temperature Profile.
Temperature (oC)
14
14.1
14.2
14.3
14.4
14.5
Pressure (db)
0
-2
-4
-6
-8
-10
-12
-14

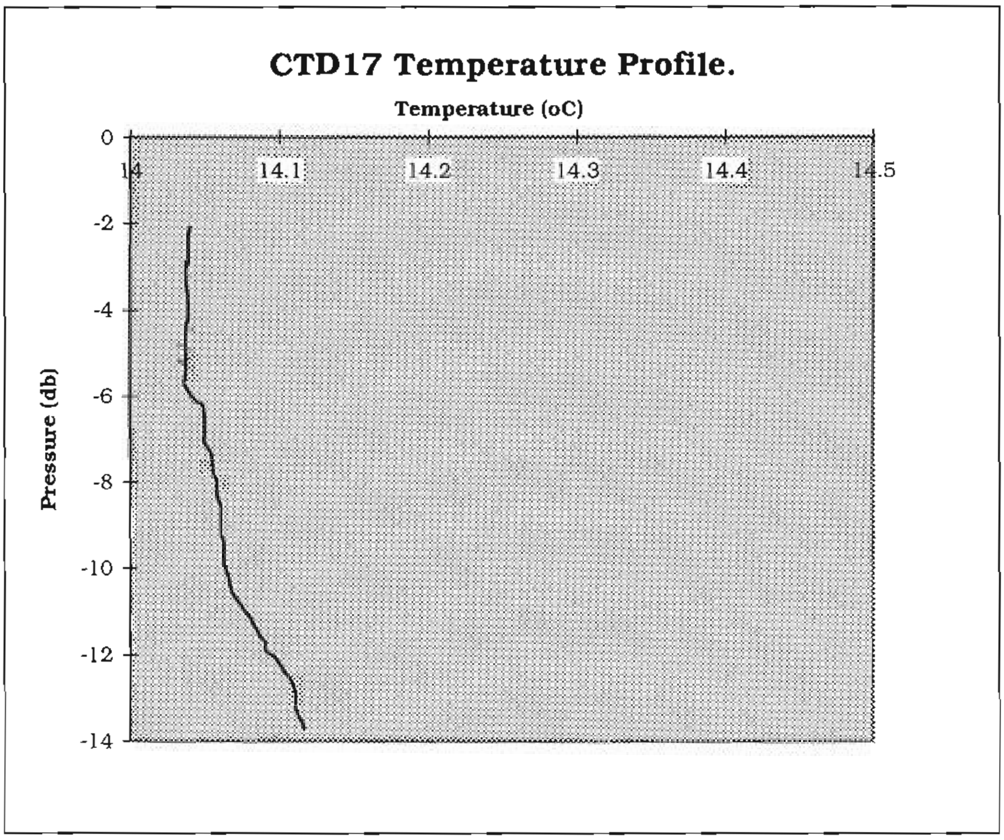

CTD15 Salinity Profile
Salinity (PSU)
33.5
33.6
33.7
33.8
33.9
34
0
-2
-4
-6
-8
-10
-12
-14
-16
Pressure (db)

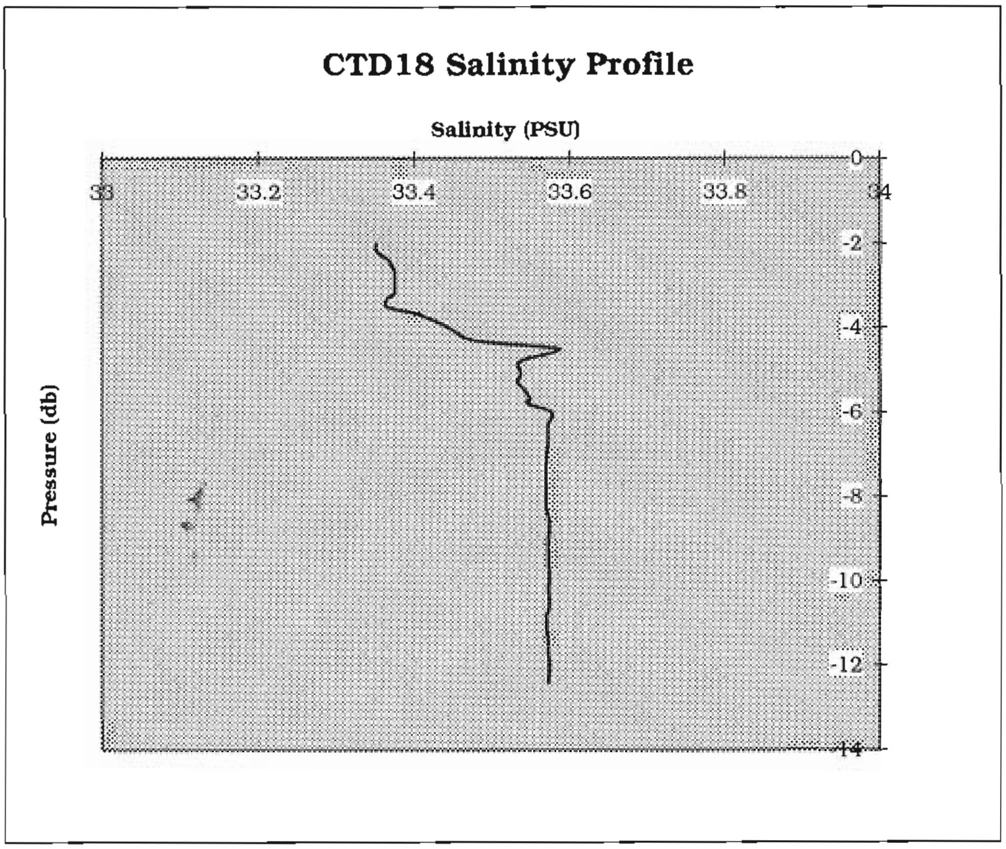

CTD15 Temperature Profile.
Temperature (oC)
14.19
14.2
14.21
14.22
14.23
14.24
0
-2
-4
-6
-8
-10
-12
-14
-16
Pressure (db)

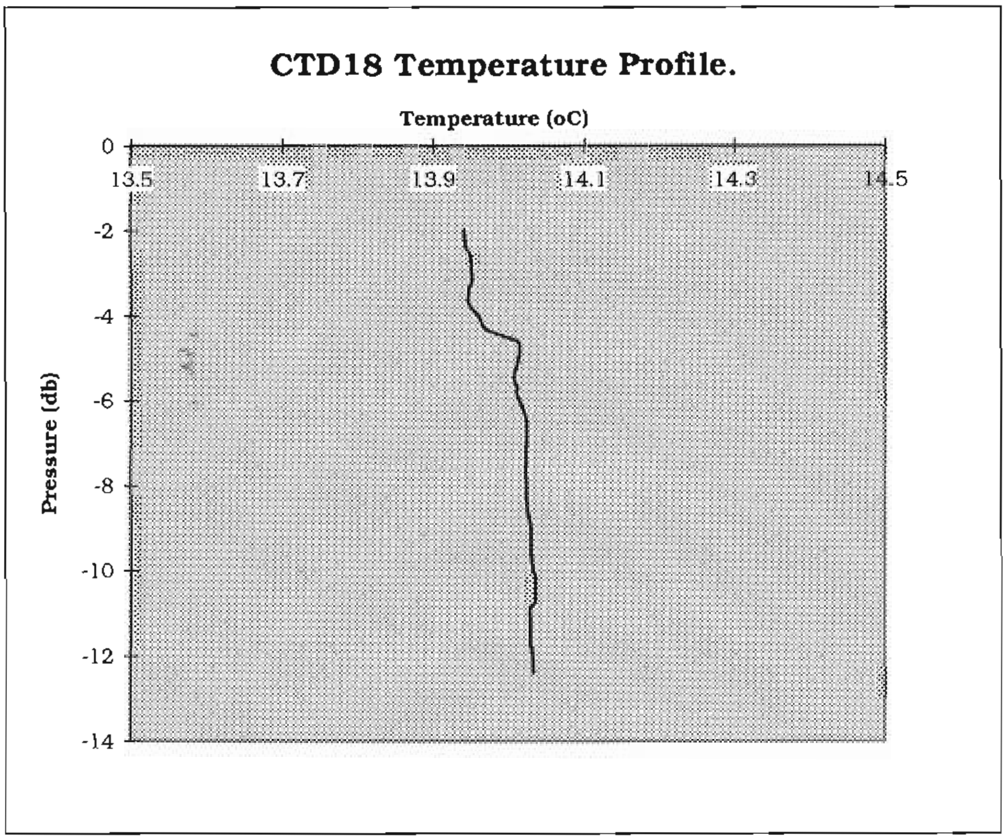

CTD16 Salinity Profile
Salinity (PSU)
0
33
33.2
33.4
33.6
33.8
34
-2
-4
-6
-8
-10
-12
-14
Pressure (db)

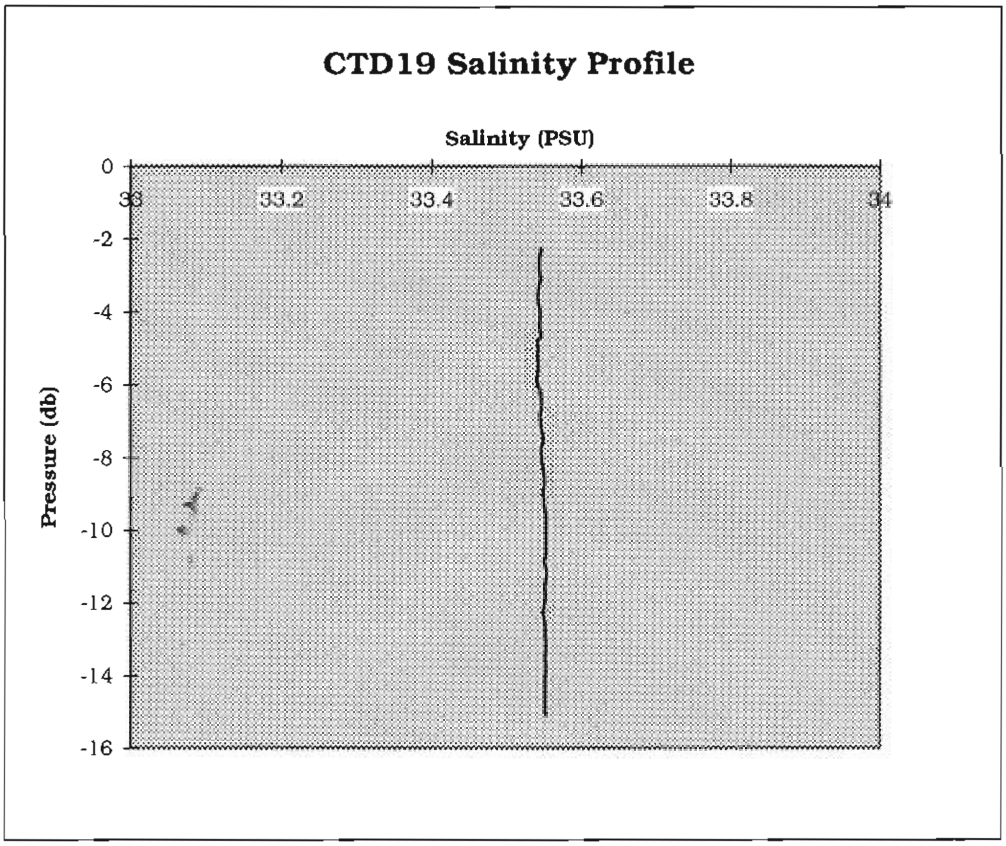

CTD16 Temperature Profile.
Temperature (oC)
0
14
14.1
14.2
14.3
14.4
14.5
-2
-4
-6
-8
-10
-12
-14
Pressure (db)

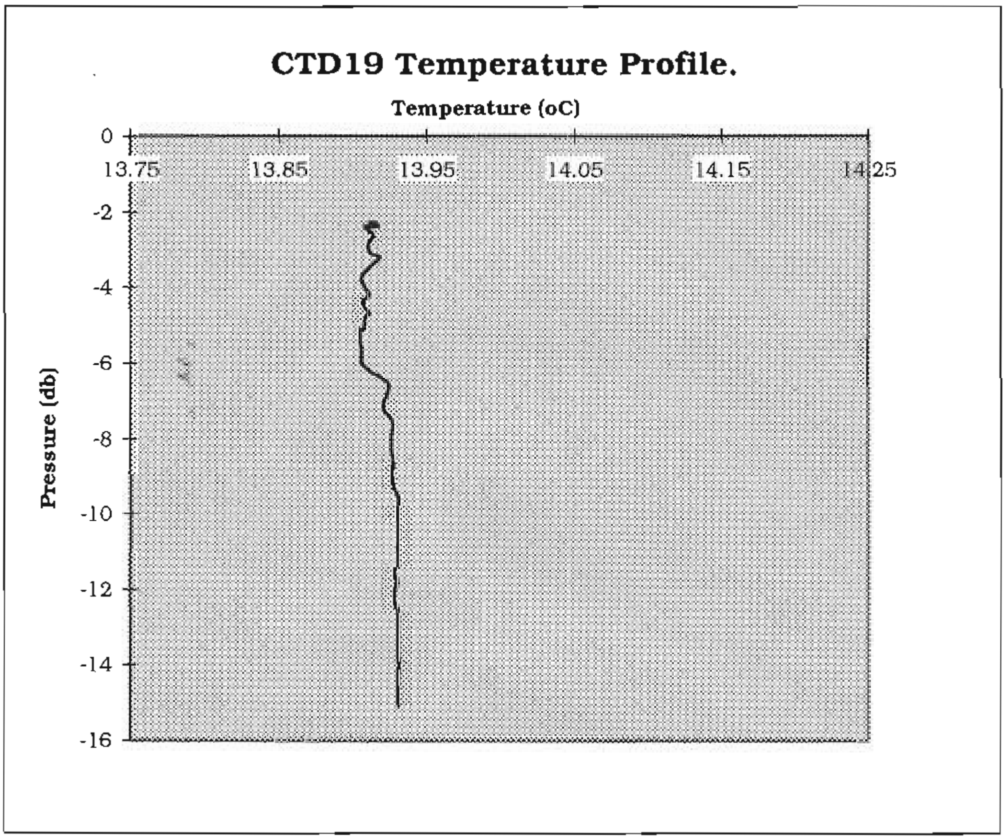

CTD17 Salinity Profile
Salinity (PSU)
Pressure (db)
33
33.2
33.4
33.6
33.8
34
0
-2
-4
-6
-8
-10
-12
-14

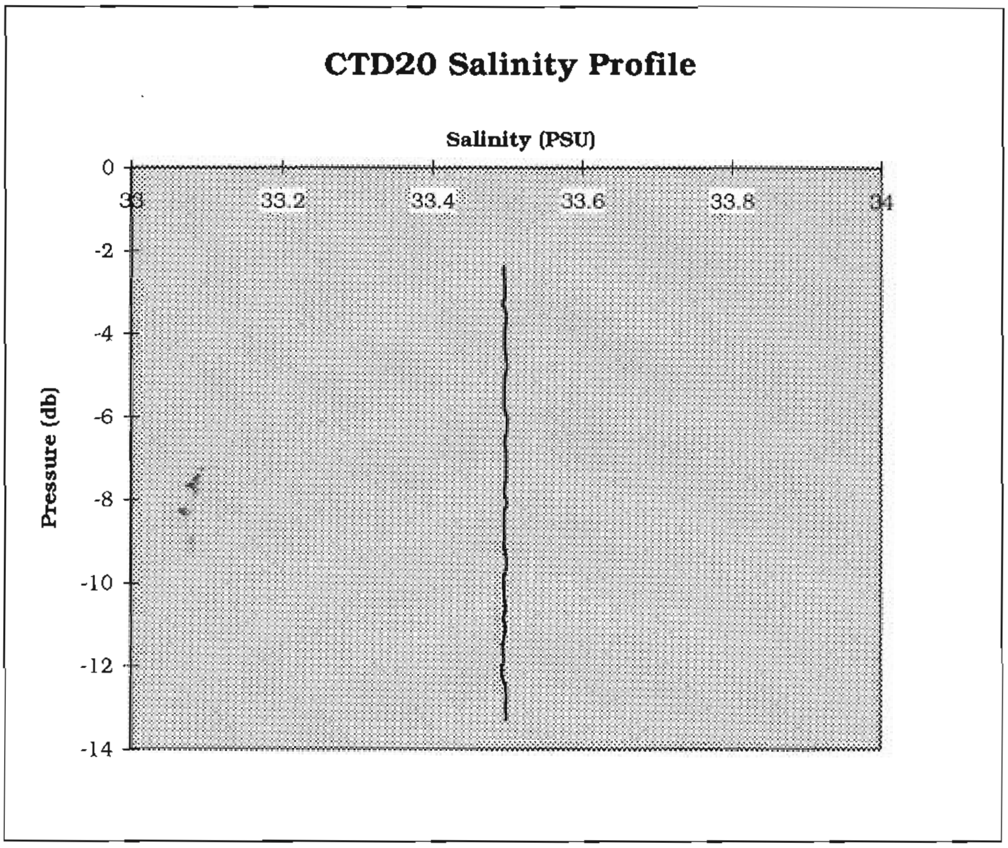

CTD17 Temperature Profile.
Temperature (oC)
Pressure (db)
14
14.1
14.2
14.3
14.4
14.5
0
-2
-4
-6
-8
-10
-12
-14

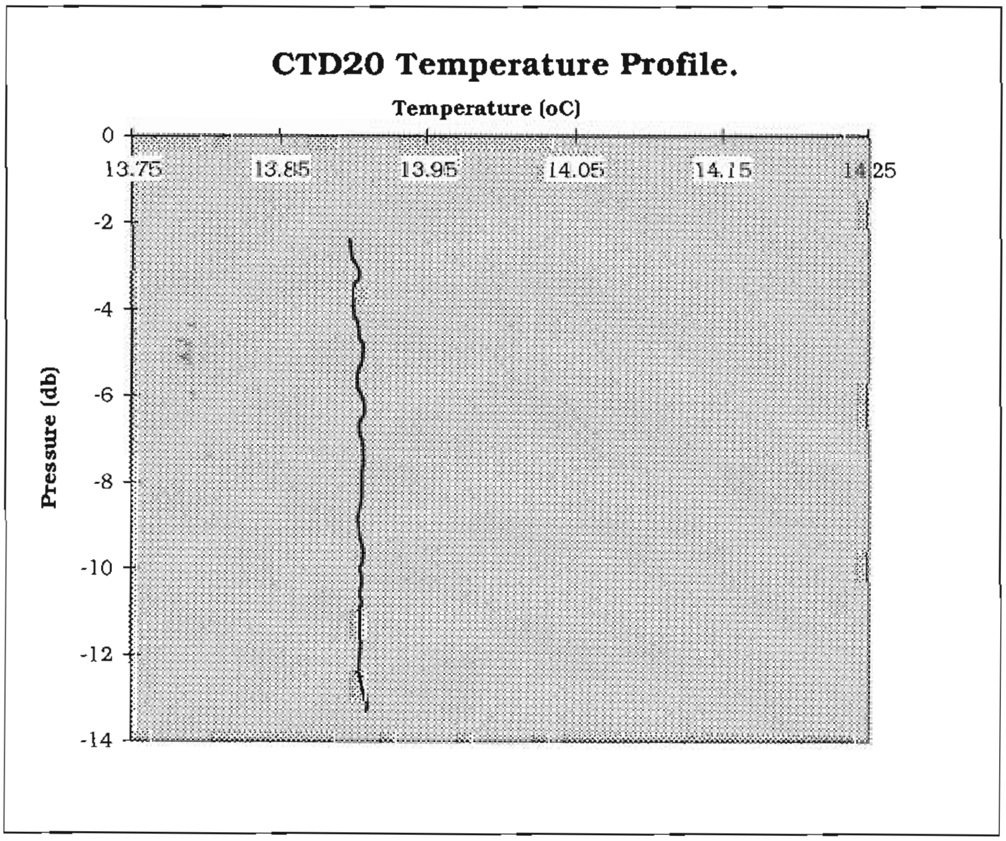

CTD18 Salinity Profile
Salinity (PSU)
33
33.2
33.4
33.6
33.8
34
0
-2
-4
-6
-8
-10
-12
-14
Pressure (db)

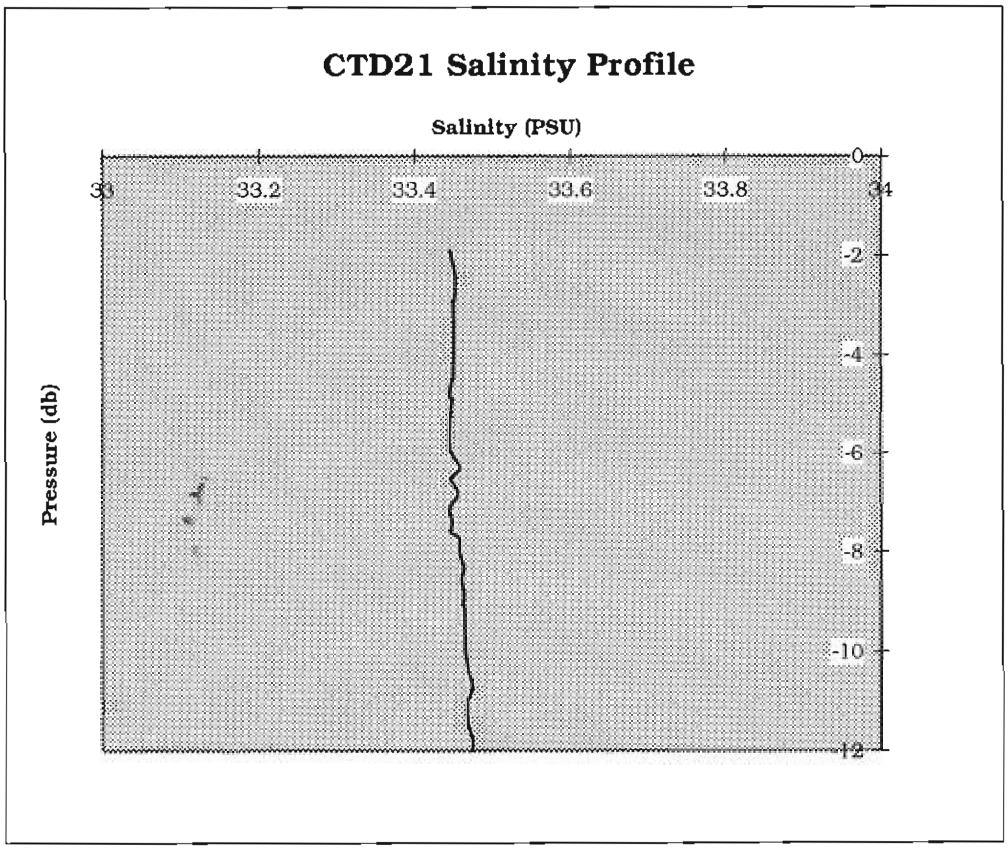

CTD18 Temperature Profile.
Temperature (oC)
13.5
13.7
13.9
14.1
14.3
14.5
0
-2
-4
-6
-8
-10
-12
-14
Pressure (db)

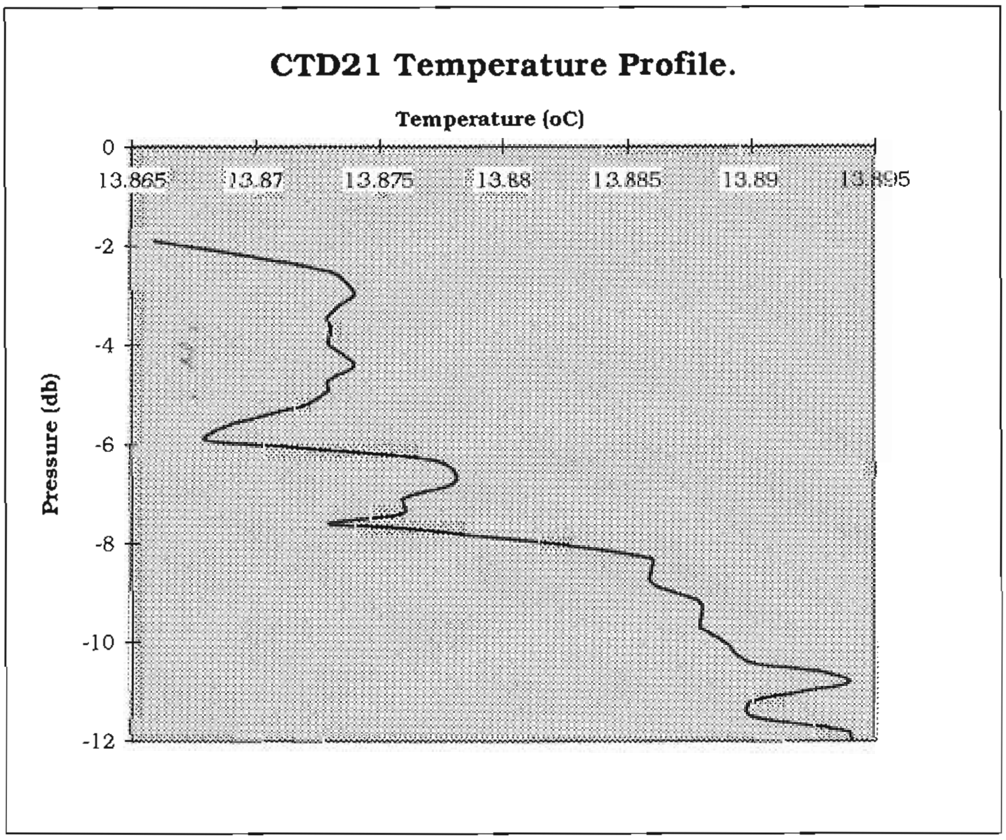

CTD19 Salinity Profile
Salinity (PSU)
33
33.2
33.4
33.6
33.8
34
0
-2
-4
-6
-8
-10
-12
-14
-16
Pressure (db)

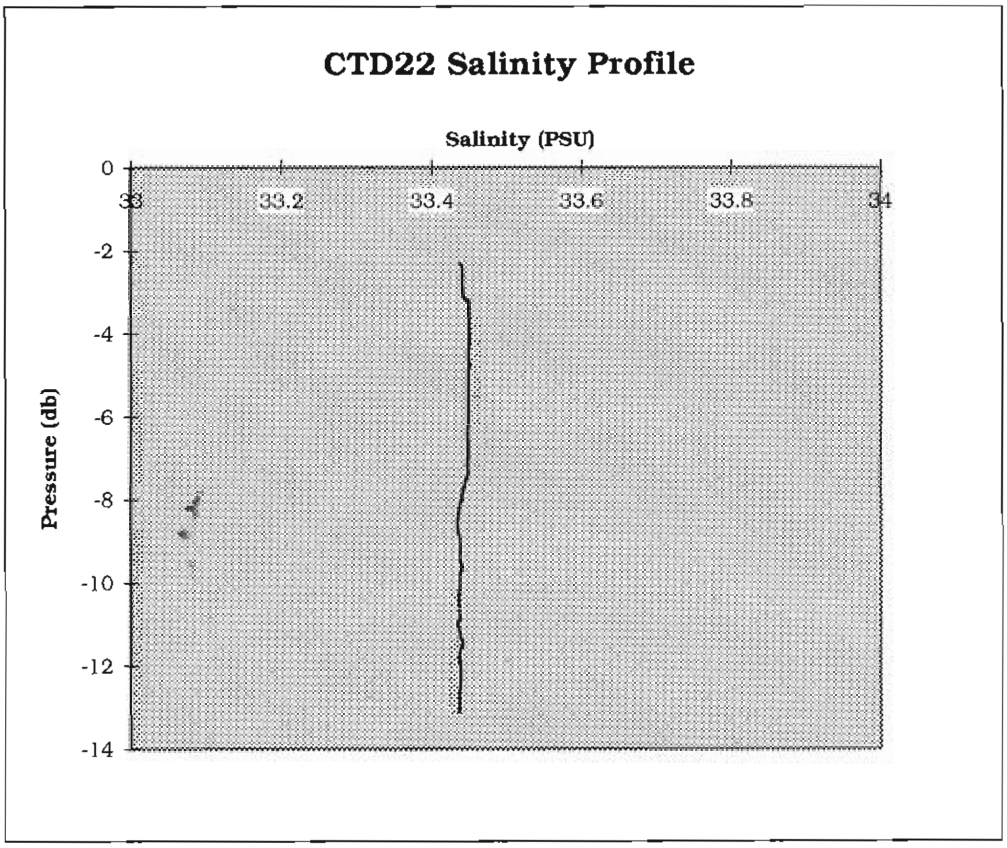

CTD19 Temperature Profile.
Temperature (oC)
13.75
13.85
13.95
14.05
14.15
14.25
0
-2
-4
-6
-8
-10
-12
-14
-16
Pressure (db)

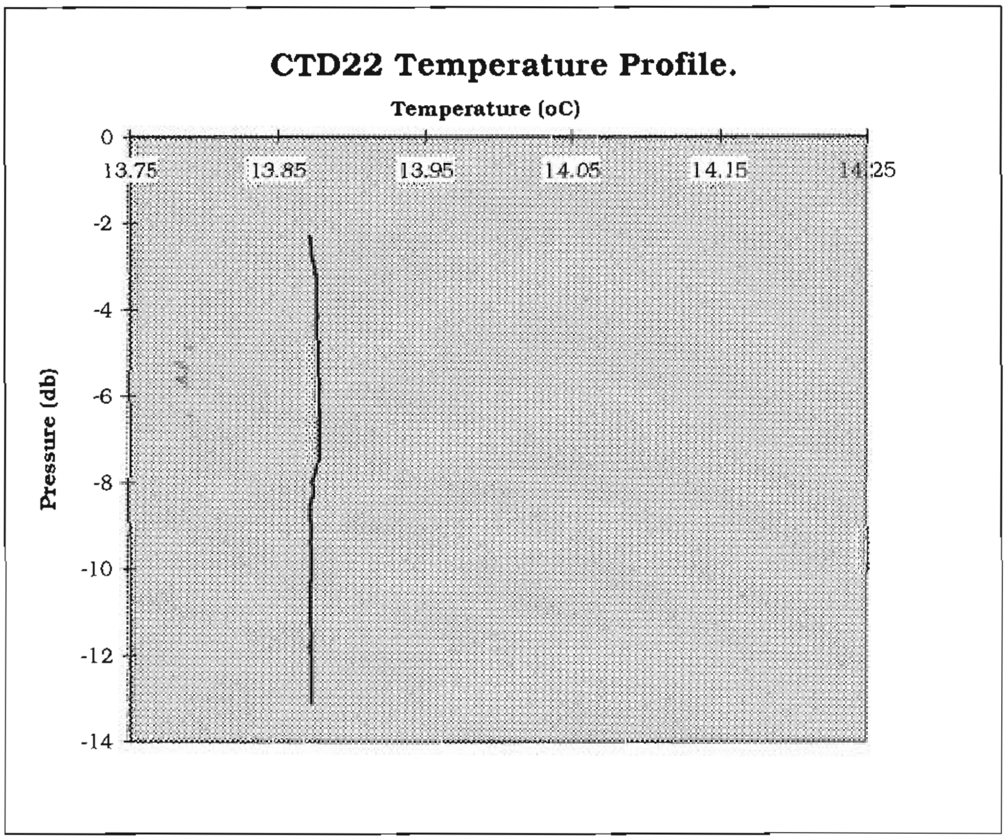

CTD20 Salinity Profile
Salinity (PSU)
33
33.2
33.4
33.6
33.8
34
Pressure (db)
0
-2
-4
-6
-8
-10
-12
-14

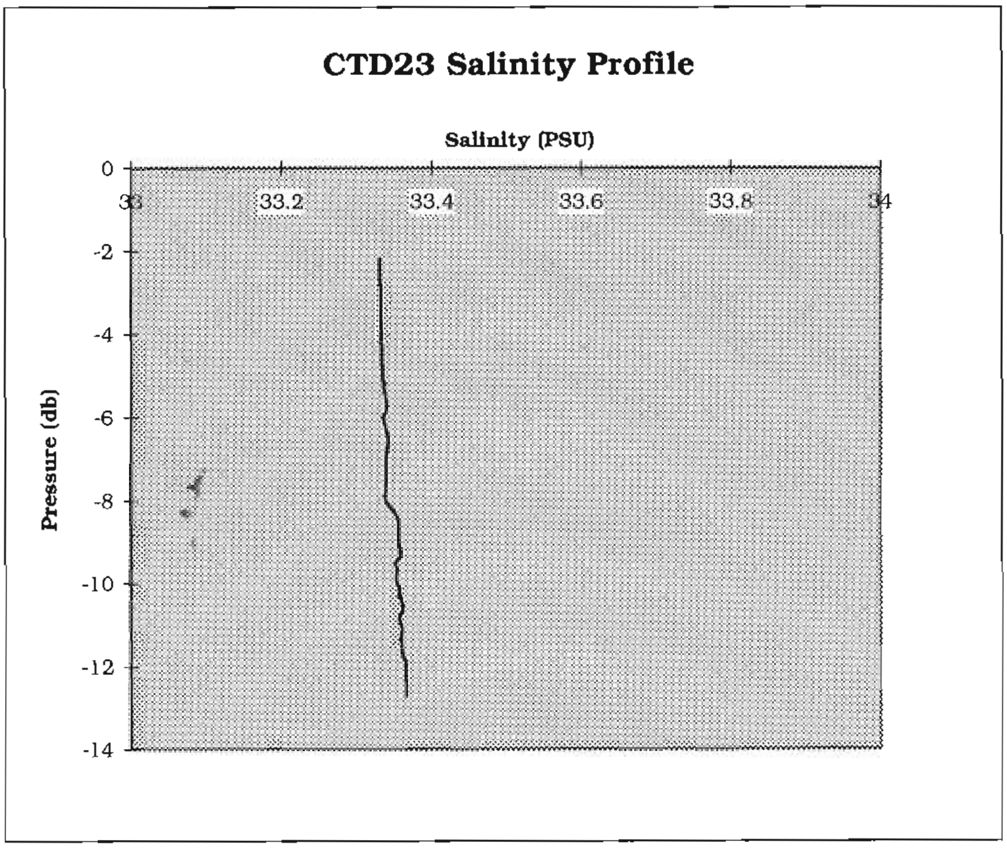

CTD20 Temperature Profile.
Temperature (oC)
13.75
13.85
13.95
14.05
14.15
14.25
Pressure (db)
0
-2
-4
-6
-8
-10
-12
-14

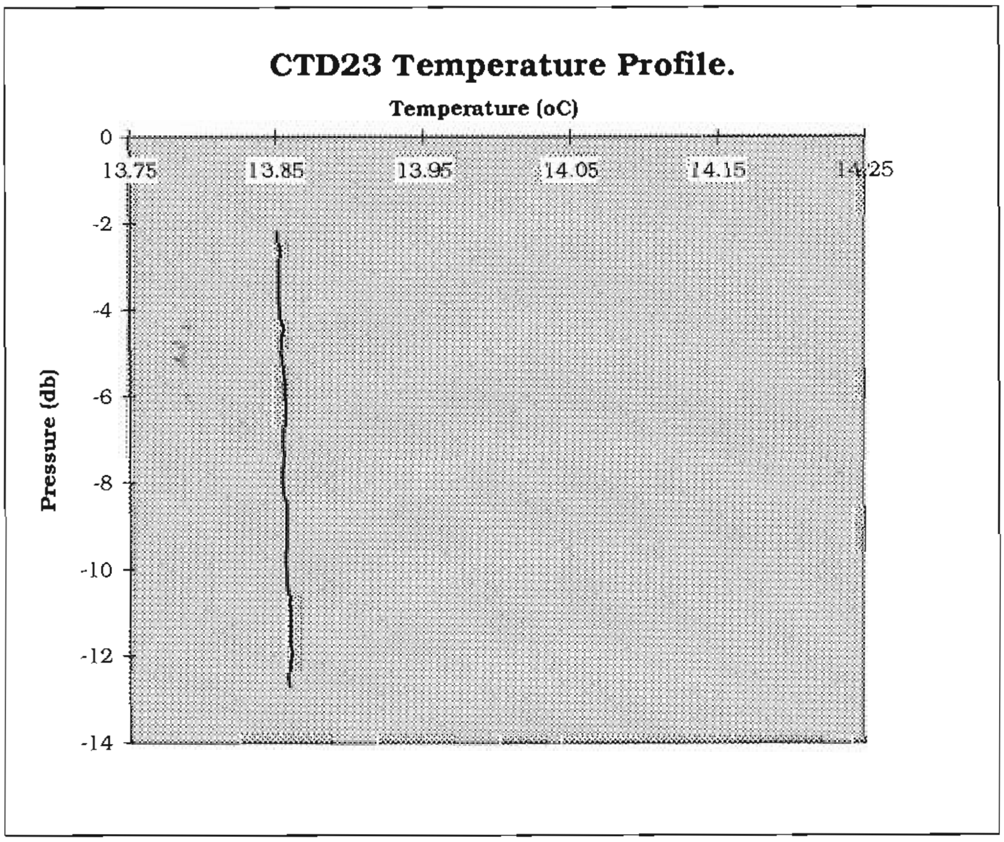

CTD21 Salinity Profile
Salinity (PSU)
33
33.2
33.4
33.6
33.8
34
0
-2
-4
-6
-8
-10
-12
Pressure (db)

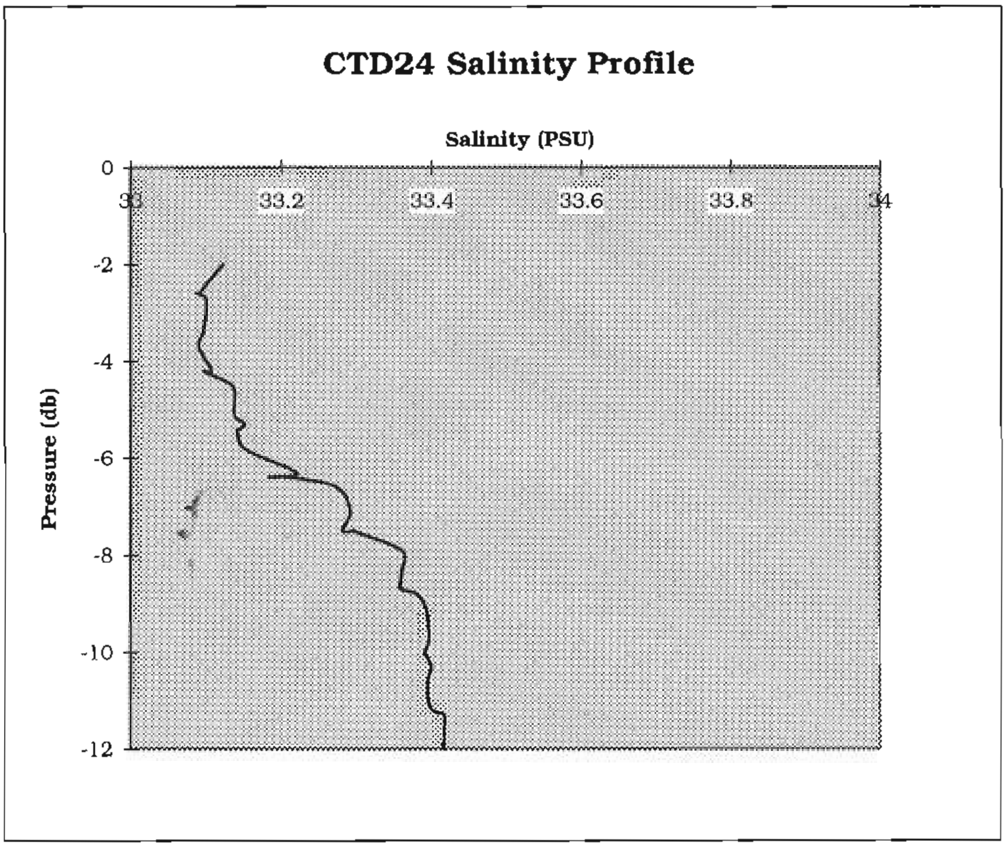

CTD21 Temperature Profile.
Temperature (oC)
13.865
13.87
13.875
13.88
13.885
13.89
13.895
0
-2
-4
-6
-8
-10
-12
Pressure (db)

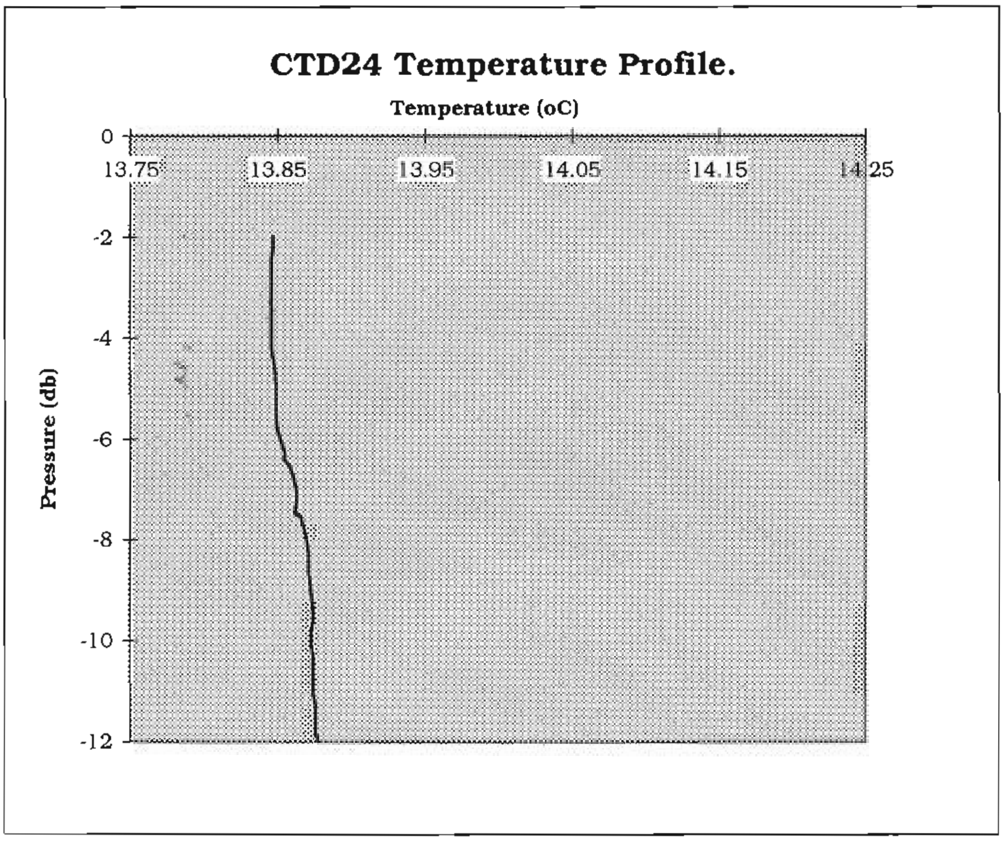

CTD22 Salinity Profile
Salinity (PSU)
Pressure (db)
0
-2
-4
-6
-8
-10
-12
-14
33
33.2
33.4
33.6
33.8
34

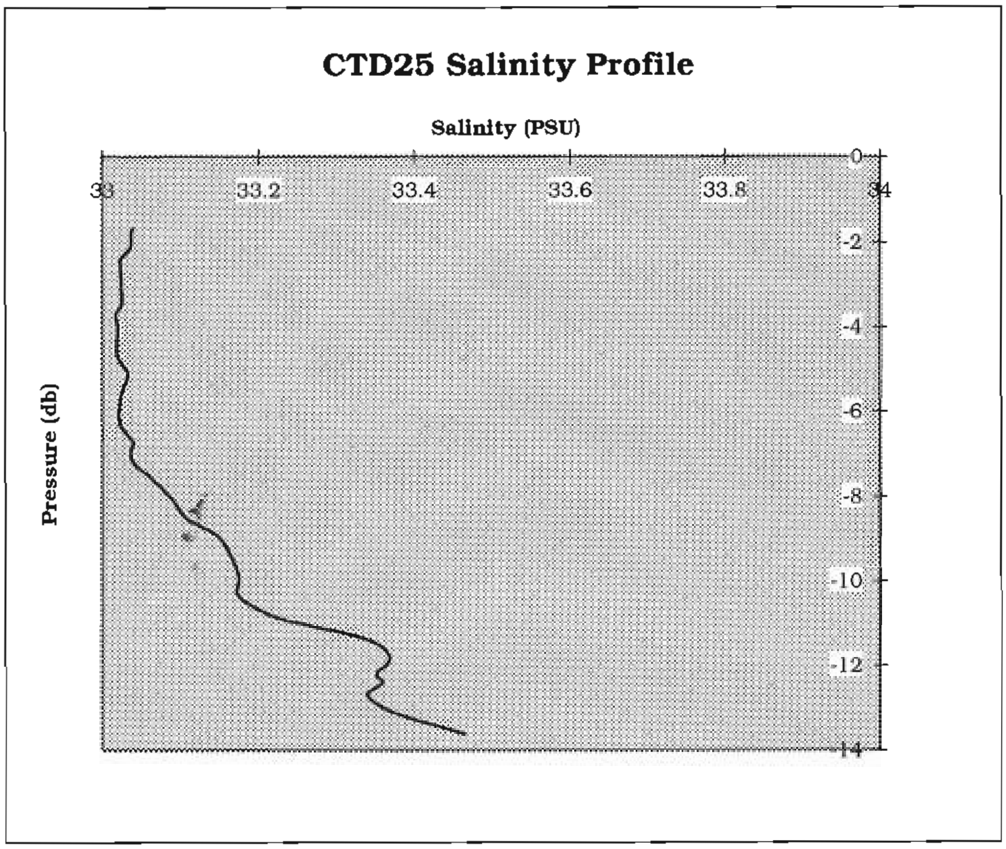

CTD22 Temperature Profile.
Temperature (oC)
Pressure (db)
0
-2
-4
-6
-8
-10
-12
-14
13.75
13.85
13.95
14.05
14.15
14.25

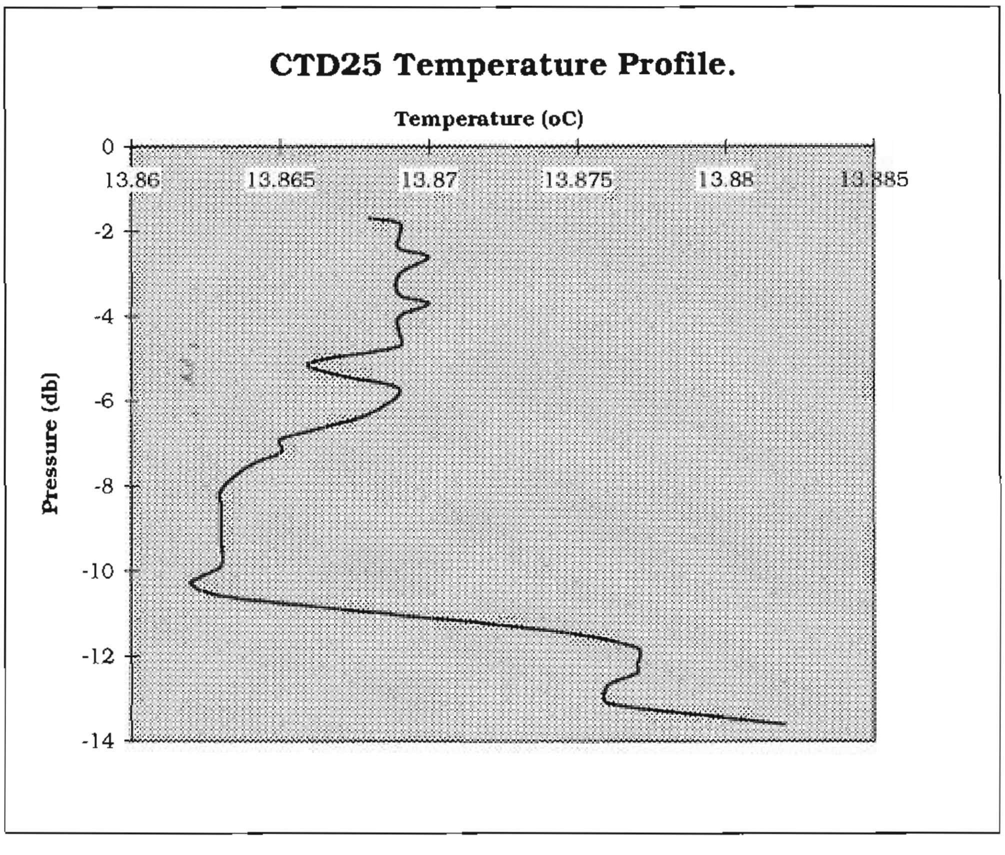

CTD23 Salinity Profile
Salinity (PSU)
33
33.2
33.4
33.6
33.8
34
Pressure (db)
0
-2
-4
-6
-8
-10
-12
-14

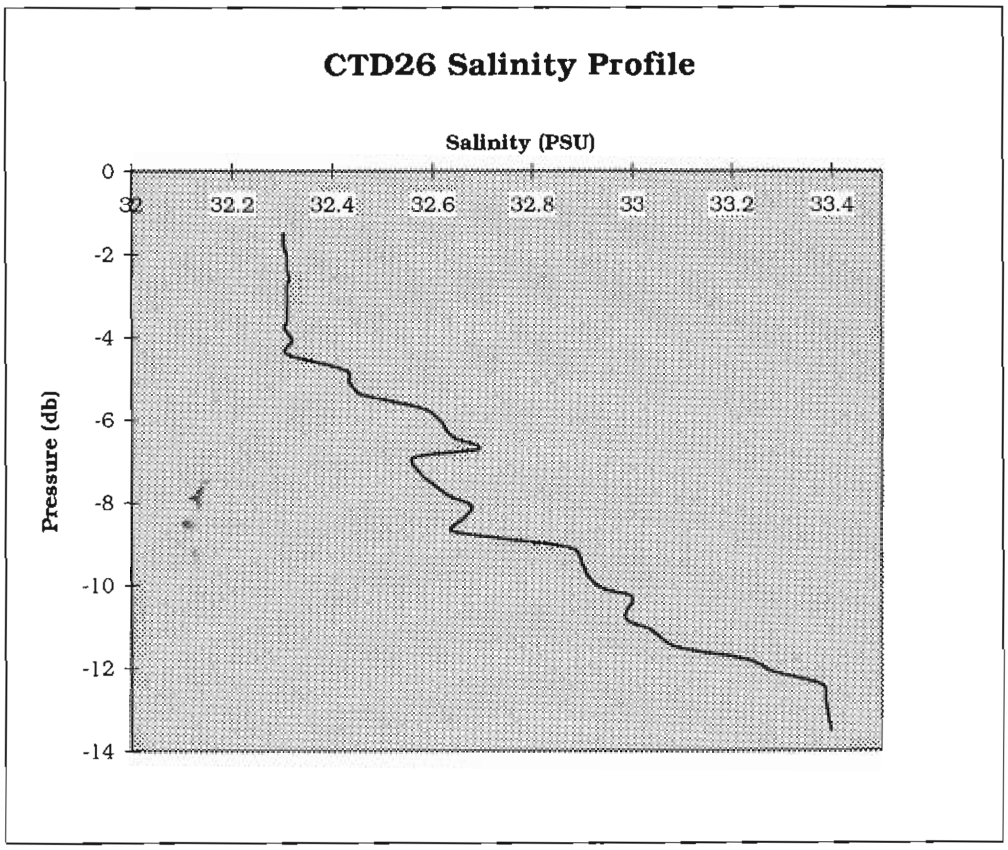

CTD23 Temperature Profile.
Temperature (oC)
13.75
13.85
13.95
14.05
14.15
14.25
Pressure (db)
0
-2
-4
-6
-8
-10
-12
-14

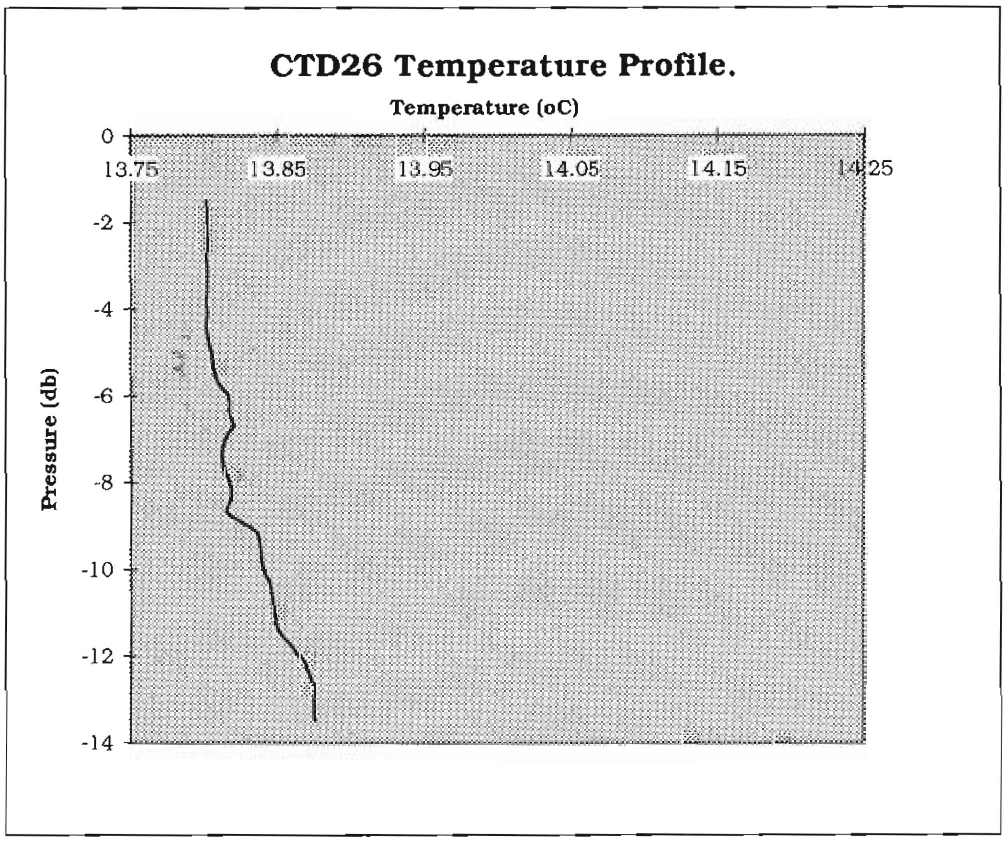

CTD24 Salinity Profile
Salinity (PSU)
33
33.2
33.4
33.6
33.8
34
0
-2
-4
-6
-8
-10
-12
Pressure (db)

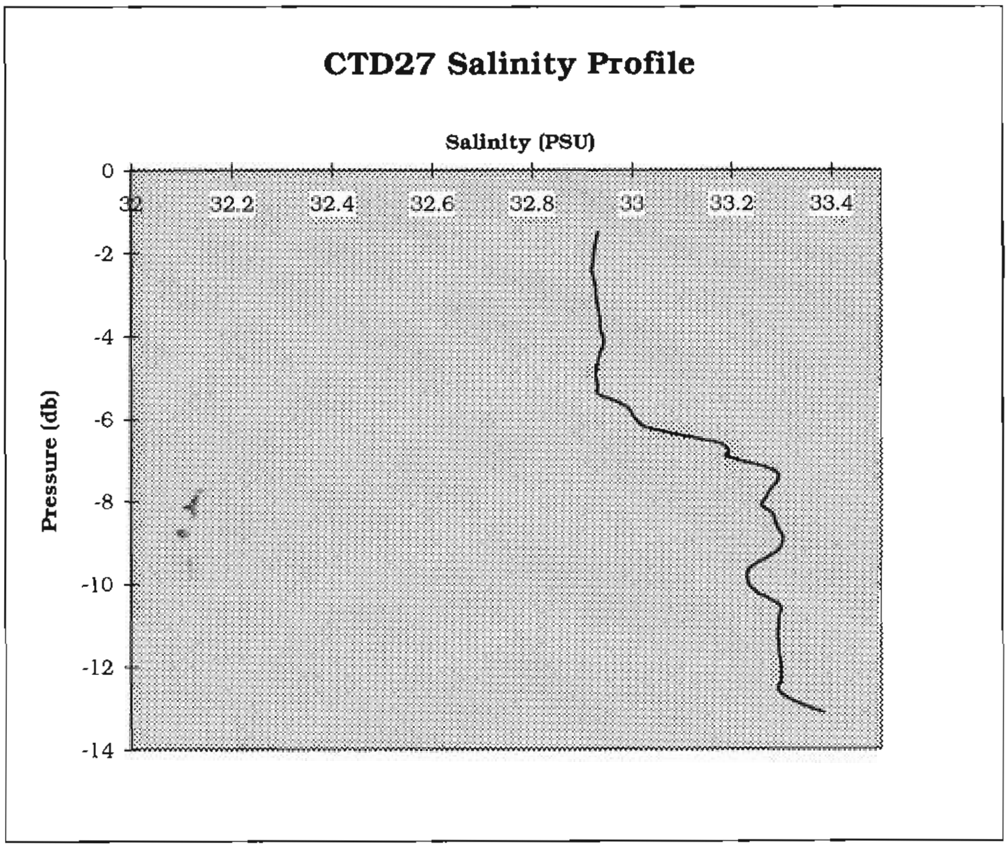

CTD24 Temperature Profile.
Temperature (oC)
13.75
13.85
13.95
14.05
14.15
14.25
0
-2
-4
-6
-8
-10
-12
Pressure (db)

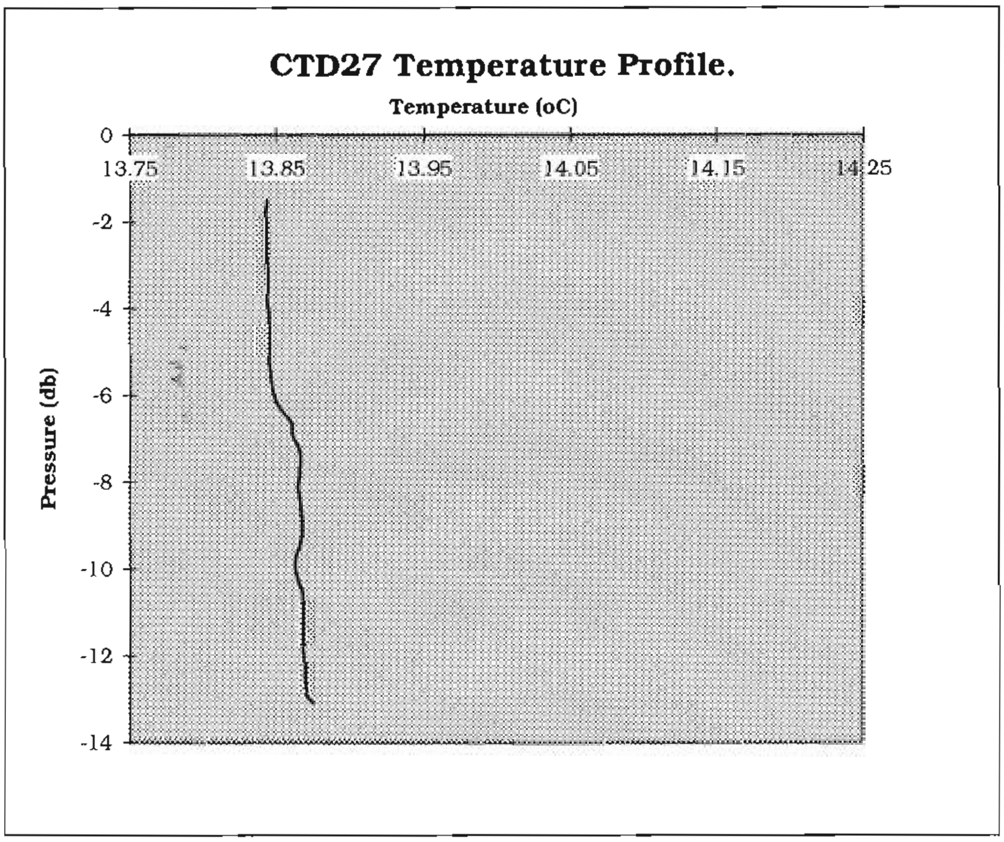

CTD25 Salinity Profile
Salinity (PSU)
33
33.2
33.4
33.6
33.8
34
0
-2
-4
-6
-8
-10
-12
-14
Pressure (db)

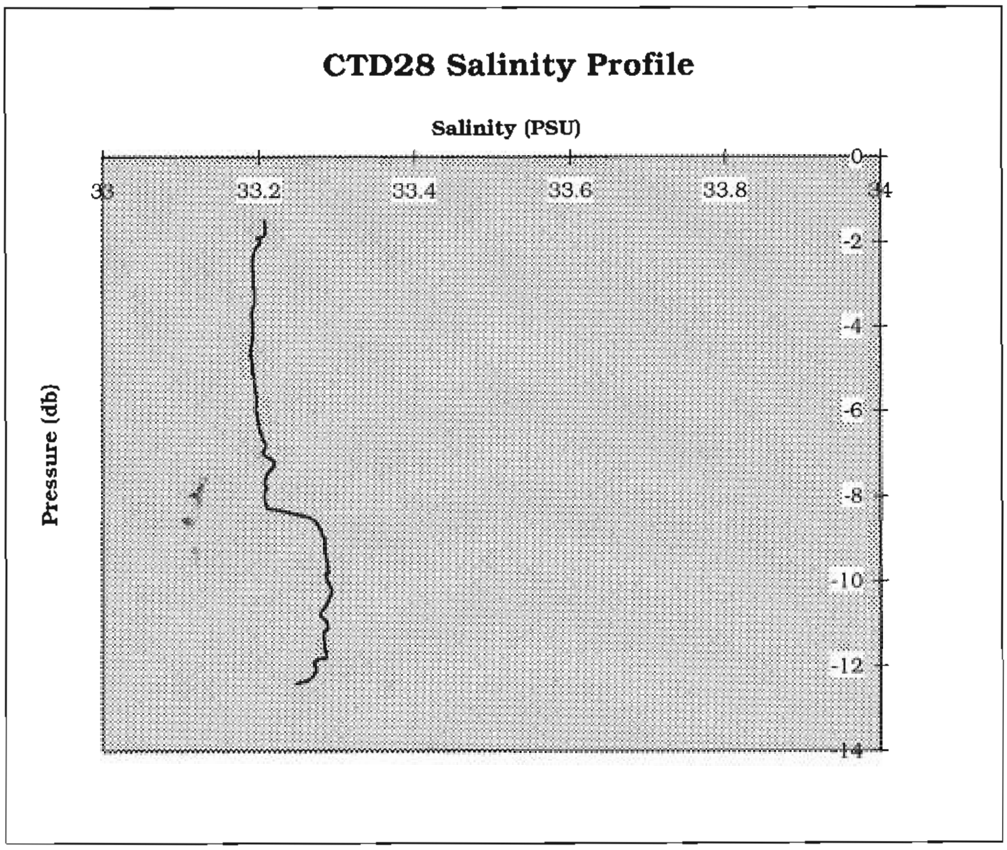

CTD25 Temperature Profile.
Temperature (oC)
13.86
13.865
13.87
13.875
13.88
13.885
0
-2
-4
-6
-8
-10
-12
-14
Pressure (db)

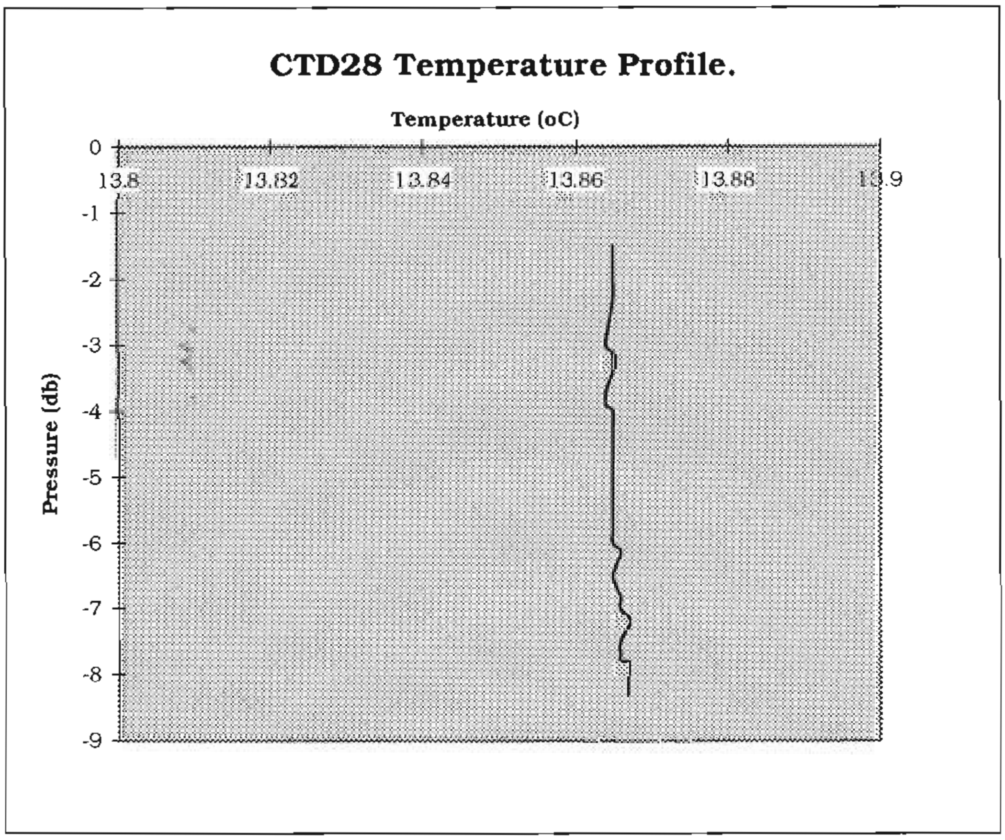

CTD26 Salinity Profile
Salinity (PSU)
Pressure (db)
0
-2
-4
-6
-8
-10
-12
-14
32
32.2
32.4
32.6
32.8
33
33.2
33.4

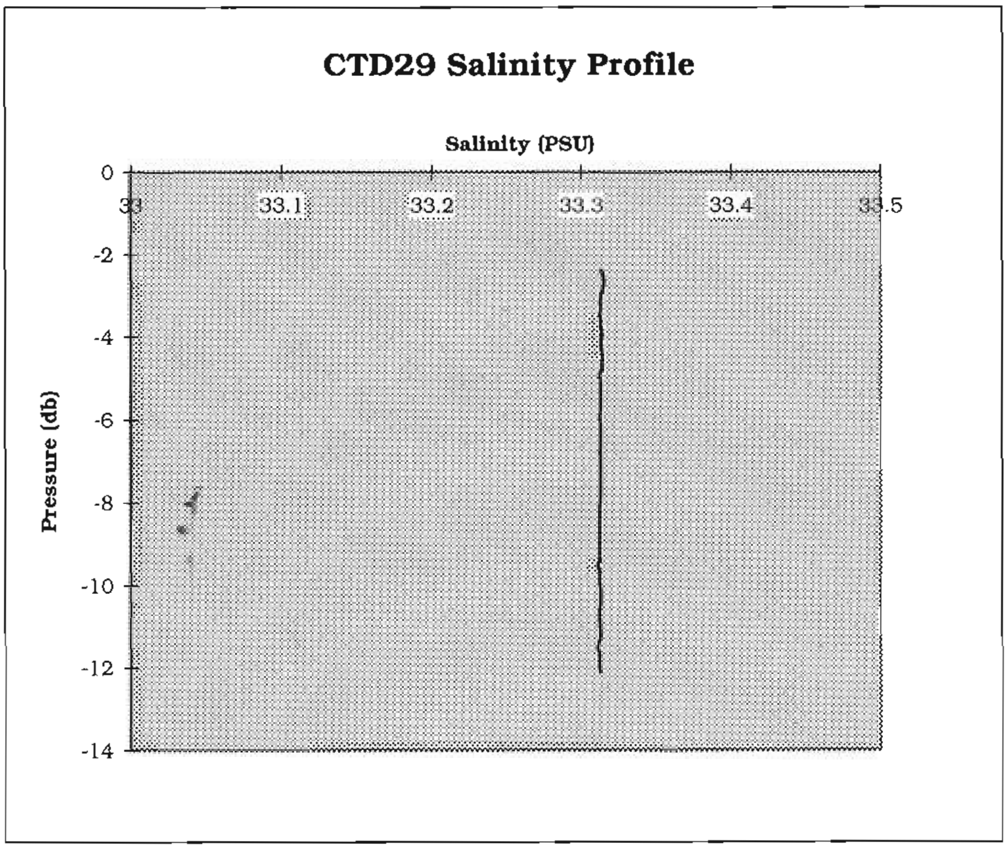

CTD26 Temperature Profile.
Temperature (oC)
Pressure (db)
0
-2
-4
-6
-8
-10
-12
-14
13.75
13.85
13.95
14.05
14.15
14.25

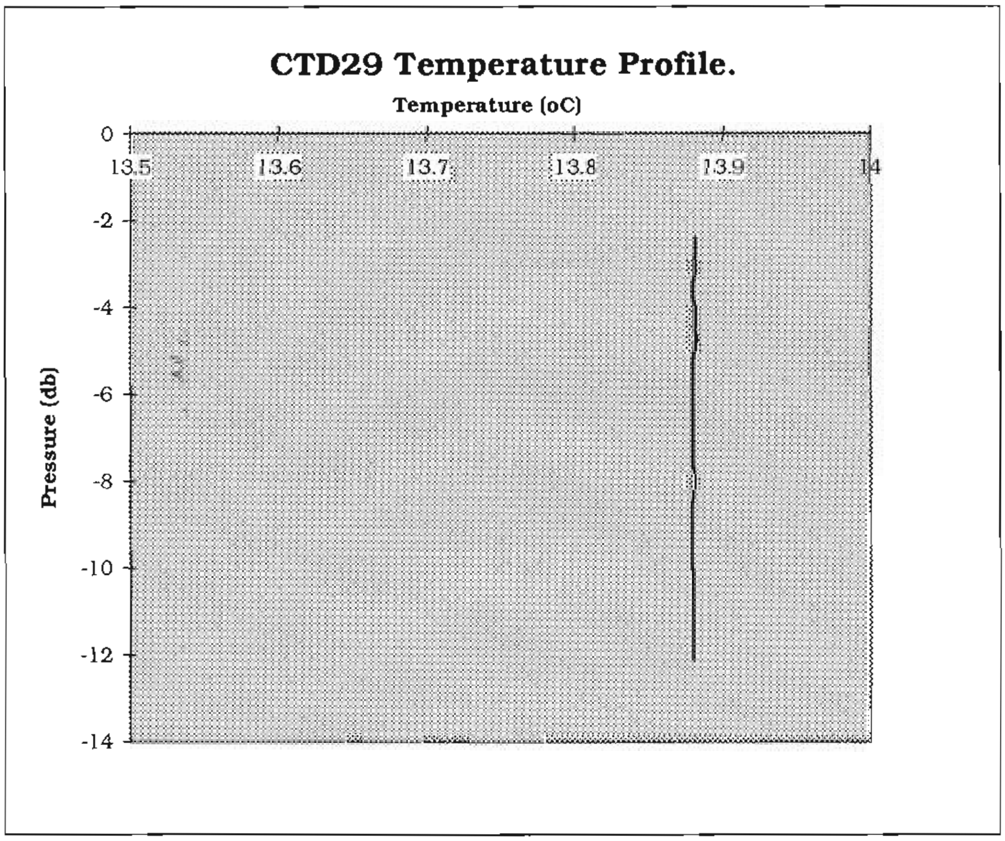

CTD27 Salinity Profile
Salinity (PSU)
32
32.2
32.4
32.6
32.8
33
33.2
33.4
Pressure (db)
0
-2
-4
-6
-8
-10
-12
-14

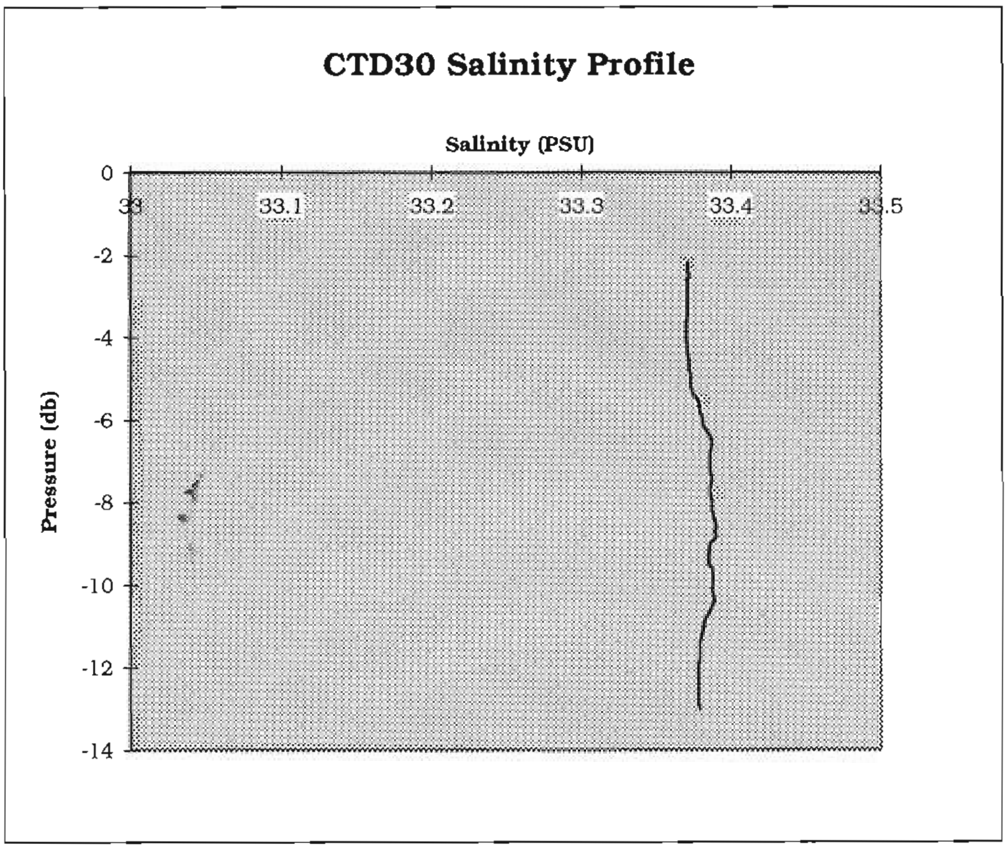

CTD27 Temperature Profile.
Temperature (oC)
13.75
13.85
13.95
14.05
14.15
14.25
Pressure (db)
0
-2
-4
-6
-8
-10
-12
-14

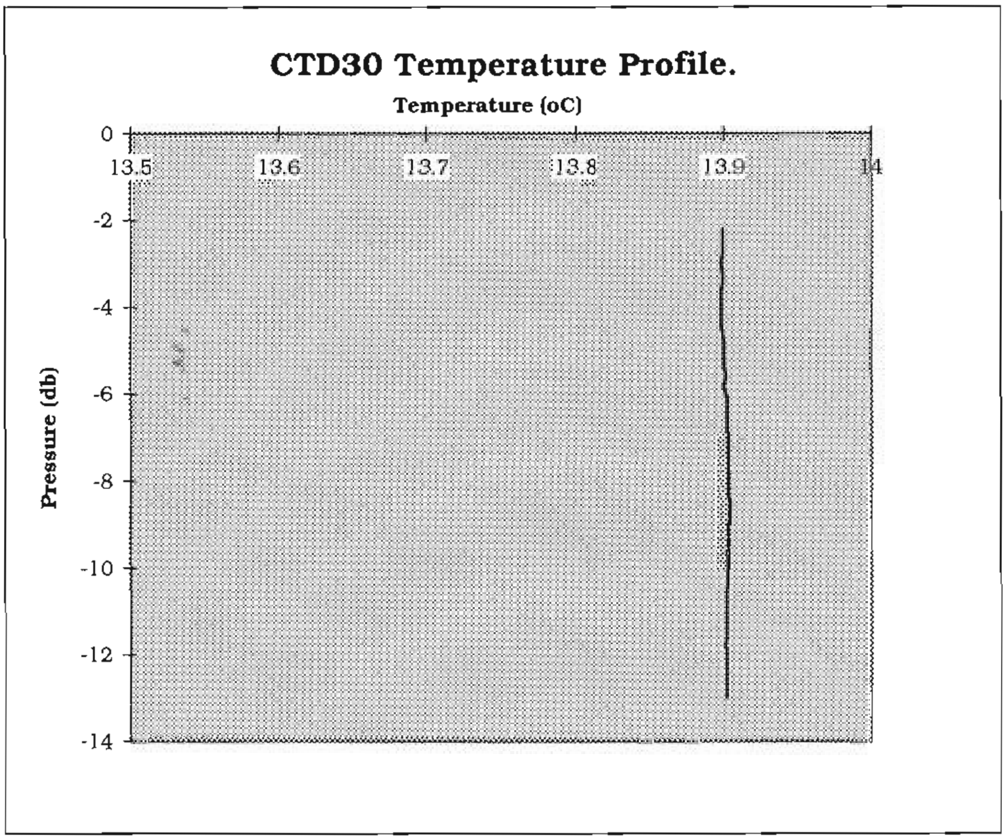

CTD28 Salinity Profile
Salinity (PSU)
33
33.2
33.4
33.6
33.8
34
0
-2
-4
-6
-8
-10
-12
-14
Pressure (db)

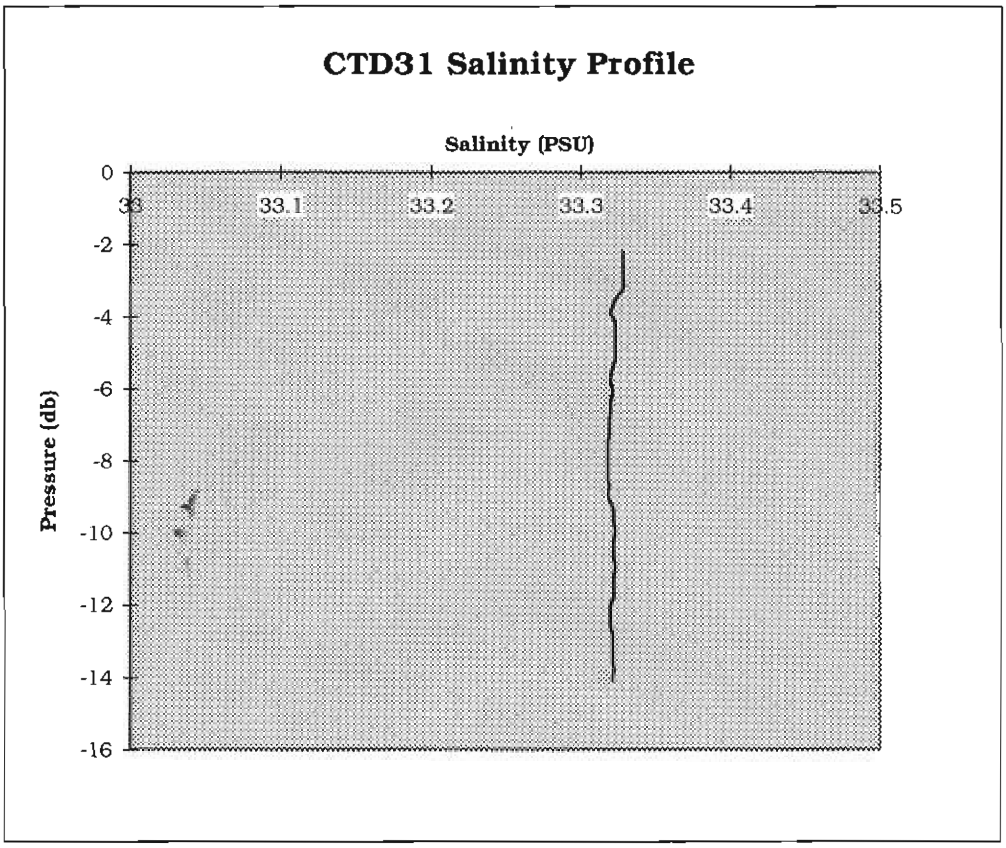

CTD28 Temperature Profile.
Temperature (oC)
13.8
13.82
13.84
13.86
13.88
13.9
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
Pressure (db)

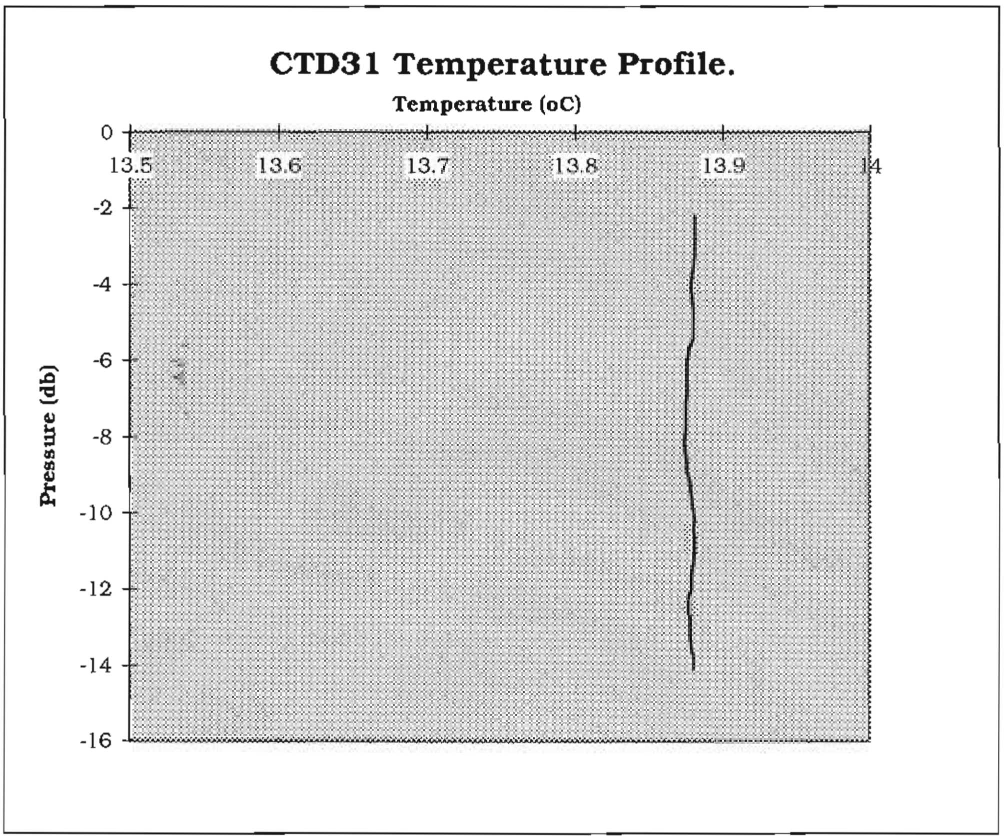

CTD29 Salinity Profile
Salinity (PSU)
Pressure (db)
0
-2
-4
-6
-8
-10
-12
-14
33
33.1
33.2
33.3
33.4
33.5

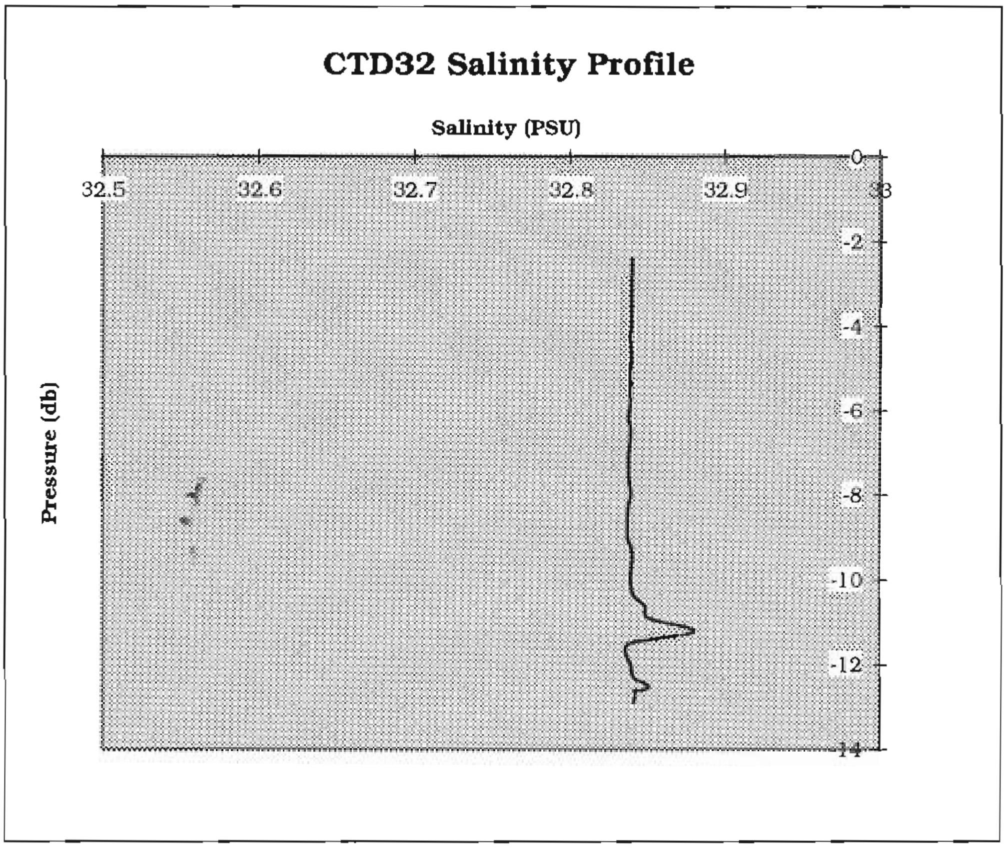

CTD29 Temperature Profile.
Temperature (oC)
Pressure (db)
0
-2
-4
-6
-8
-10
-12
-14
13.5
13.6
13.7
13.8
13.9
14

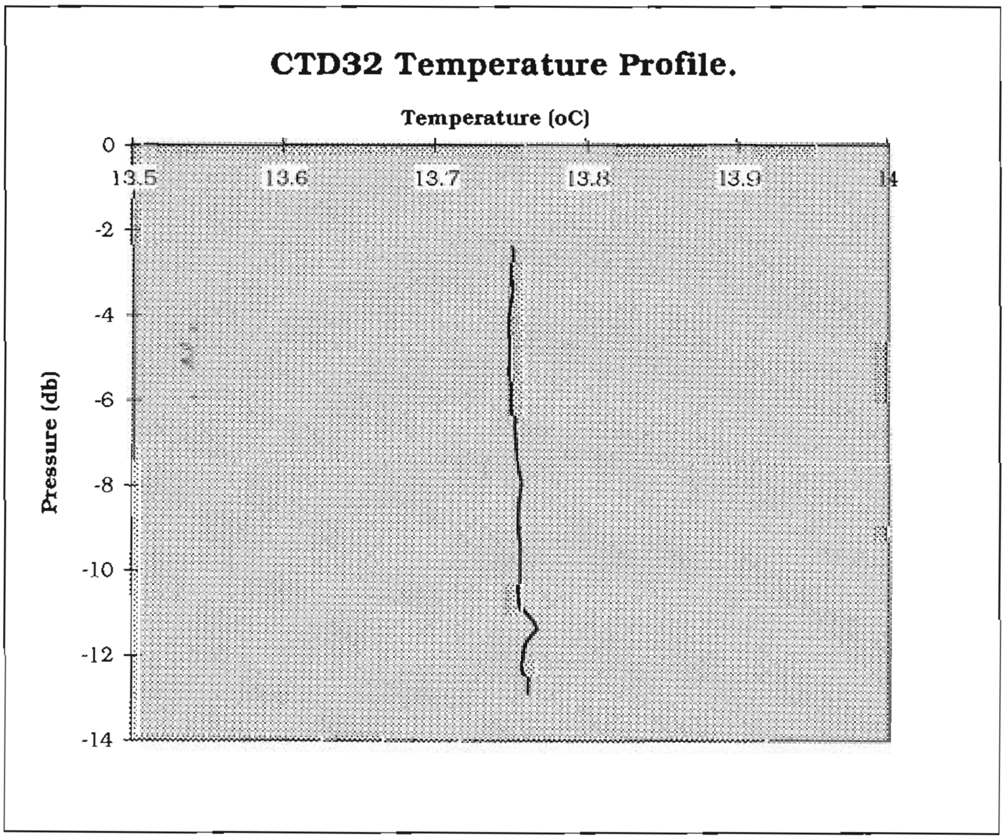

CTD30 Salinity Profile
Salinity (PSU)
33
33.1
33.2
33.3
33.4
33.5
0
-2
-4
-6
-8
-10
-12
-14
Pressure (db)

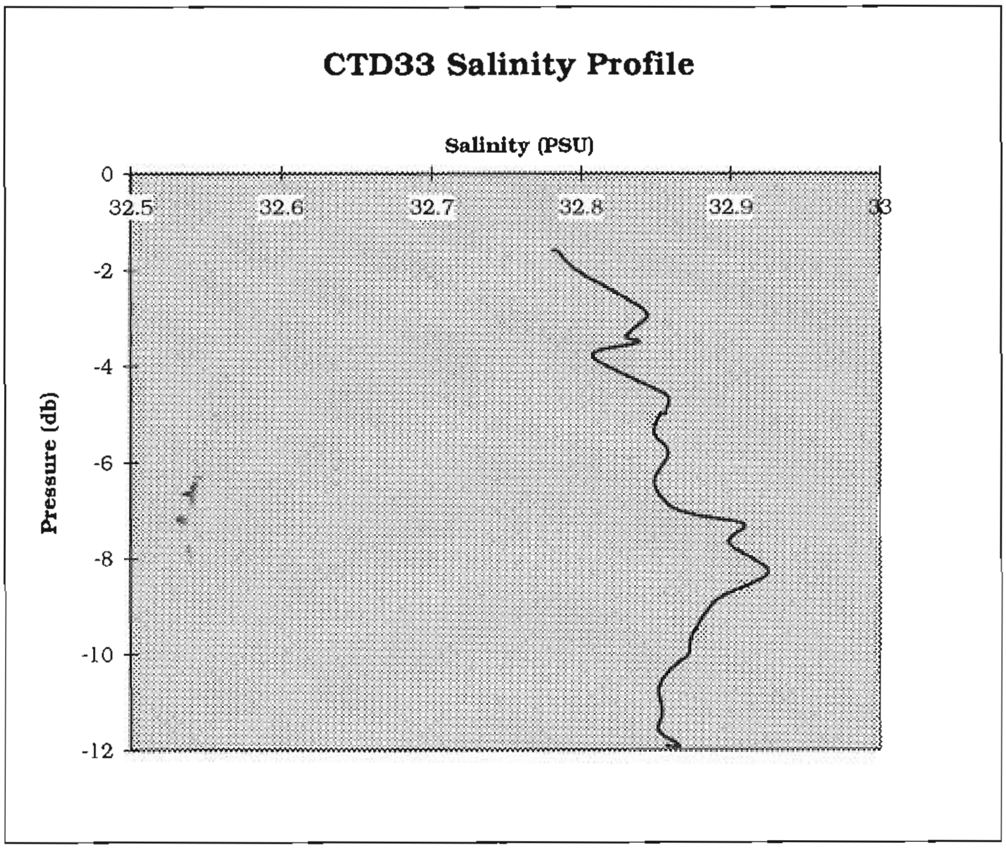

CTD30 Temperature Profile.
Temperature (oC)
13.5
13.6
13.7
13.8
13.9
14
0
-2
-4
-6
-8
-10
-12
-14
Pressure (db)

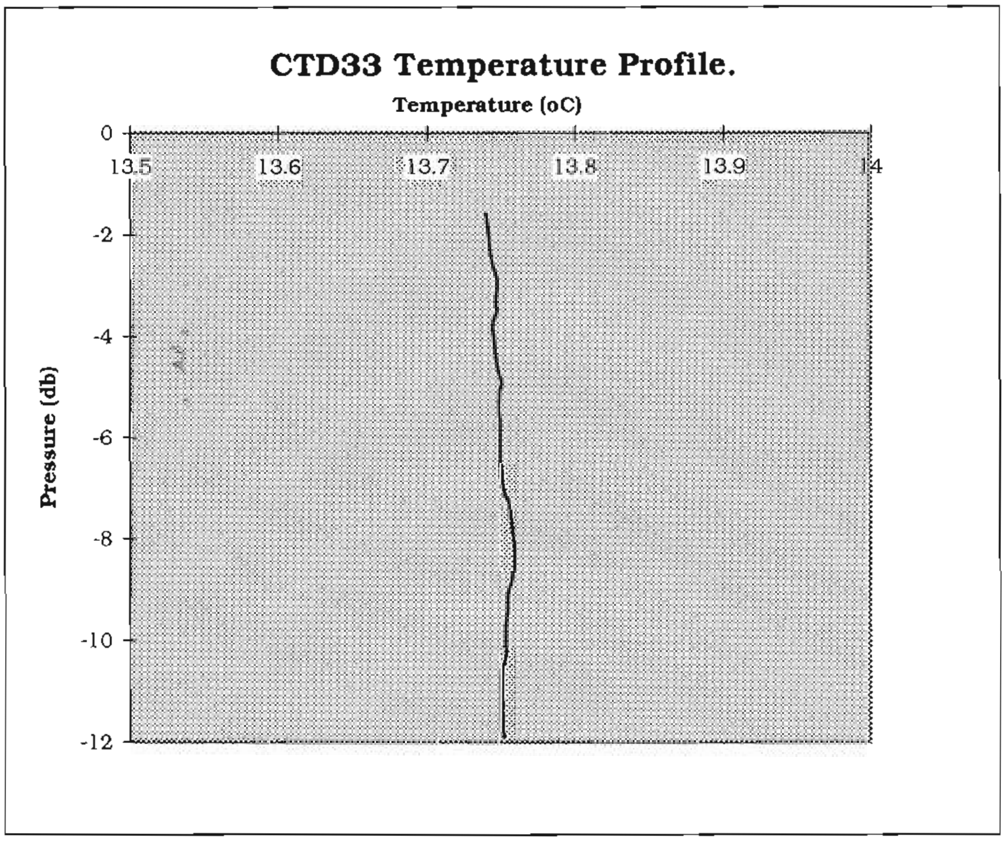

CTD31 Salinity Profile
Salinity (PSU)
33
33.1
33.2
33.3
33.4
33.5
0
-2
-4
-6
-8
-10
-12
-14
-16
Pressure (db)


CTD31 Temperature Profile.
Temperature (oC)
13.5
13.6
13.7
13.8
13.9
14
0
-2
-4
-6
-8
-10
-12
-14
-16
Pressure (db)

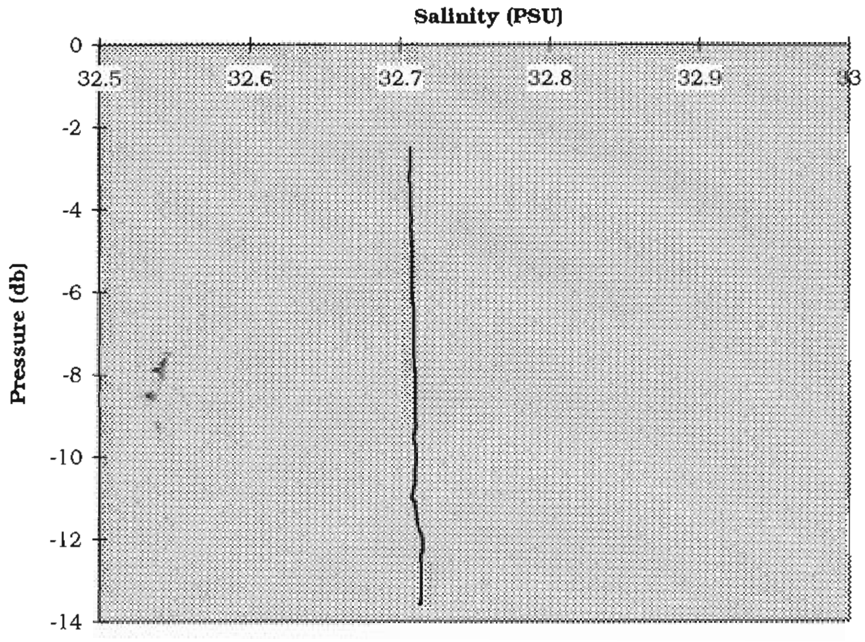

CTD32 Salinity Profile
Salinity (PSU)
32.5
32.6
32.7
32.8
32.9
33
0
-2
-4
-6
-8
-10
-12
-14
Pressure (db)


CTD32 Temperature Profile.
Temperature (oC)
13.5
13.6
13.7
13.8
13.9
14
0
-2
-4
-6
-8
-10
-12
-14
Pressure (db)

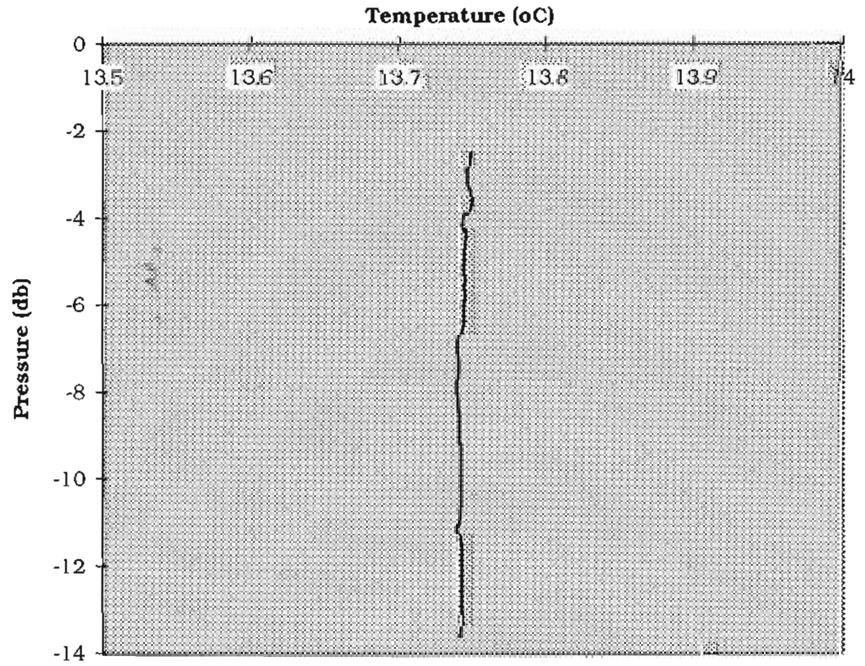

CTD33 Salinity Profile
Salinity (PSU)
32.5
32.6
32.7
32.8
32.9
33
0
-2
-4
-6
-8
-10
-12
Pressure (db)

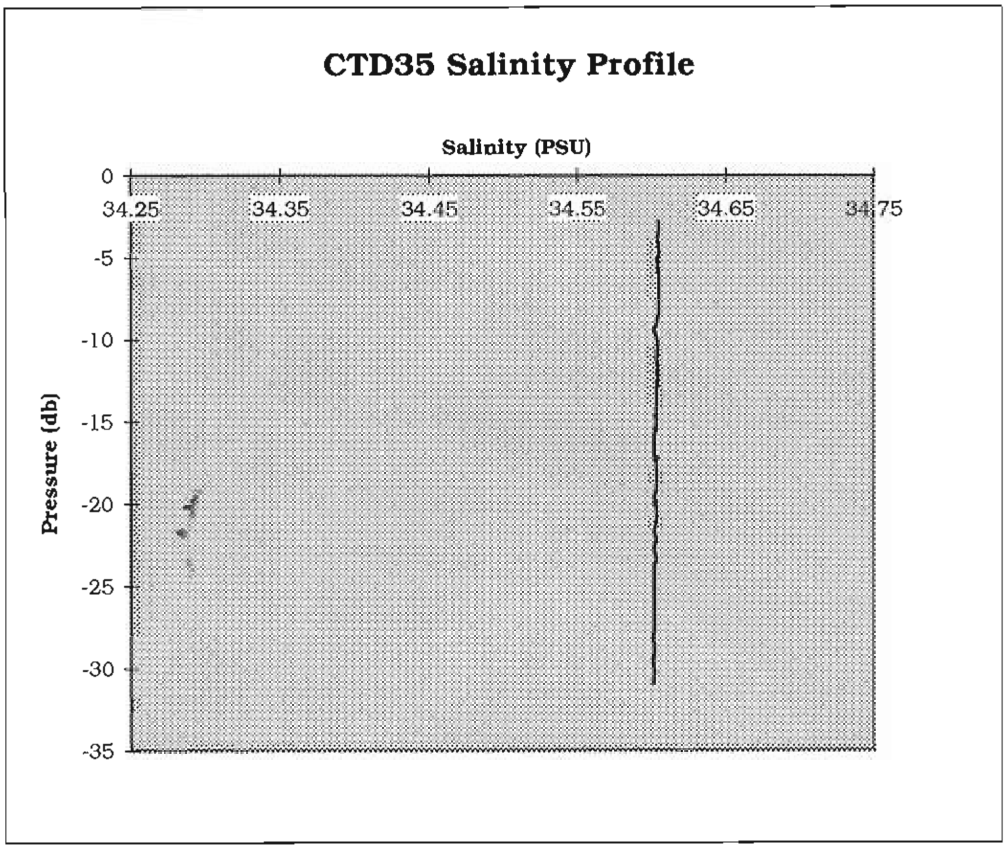

CTD33 Temperature Profile.
Temperature (oC)
13.5
13.6
13.7
13.8
13.9
14
0
-2
-4
-6
-8
-10
-12
Pressure (db)

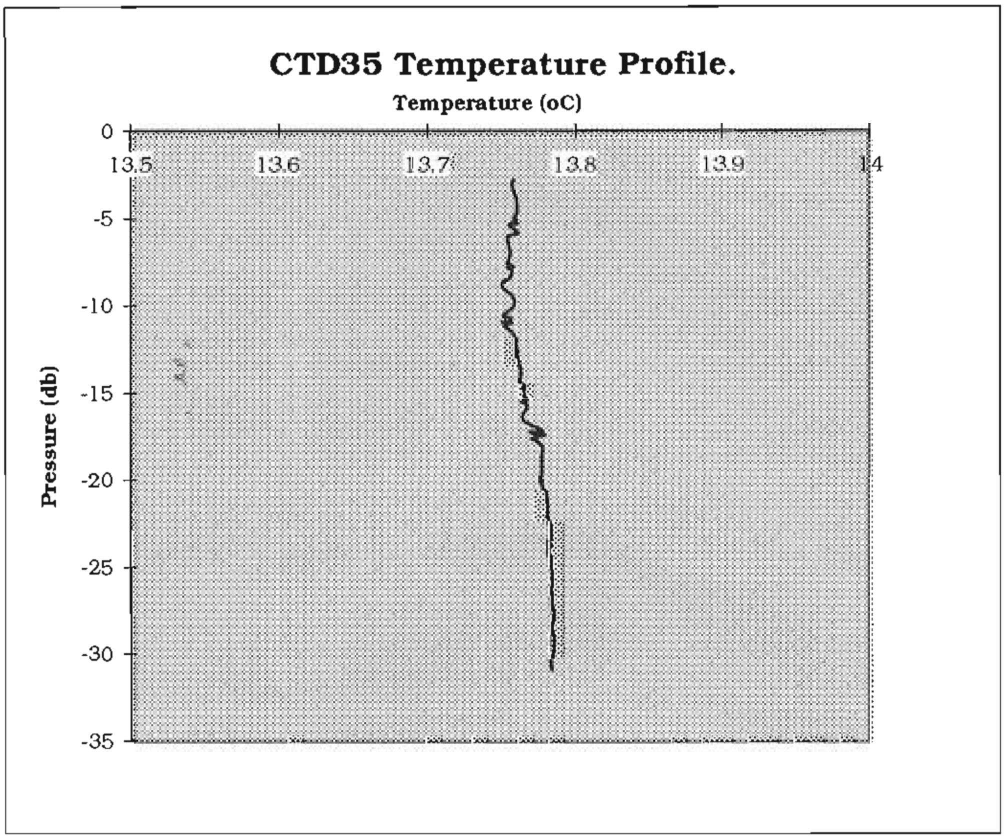
CTD34 Salinity Profile

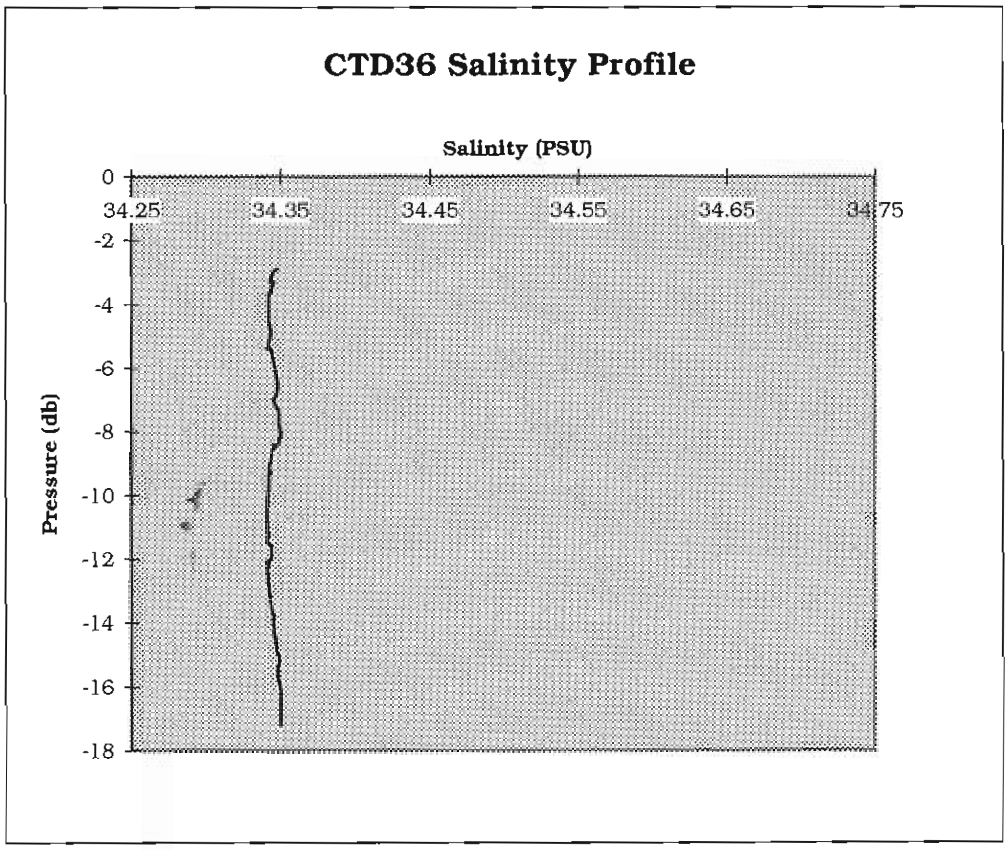


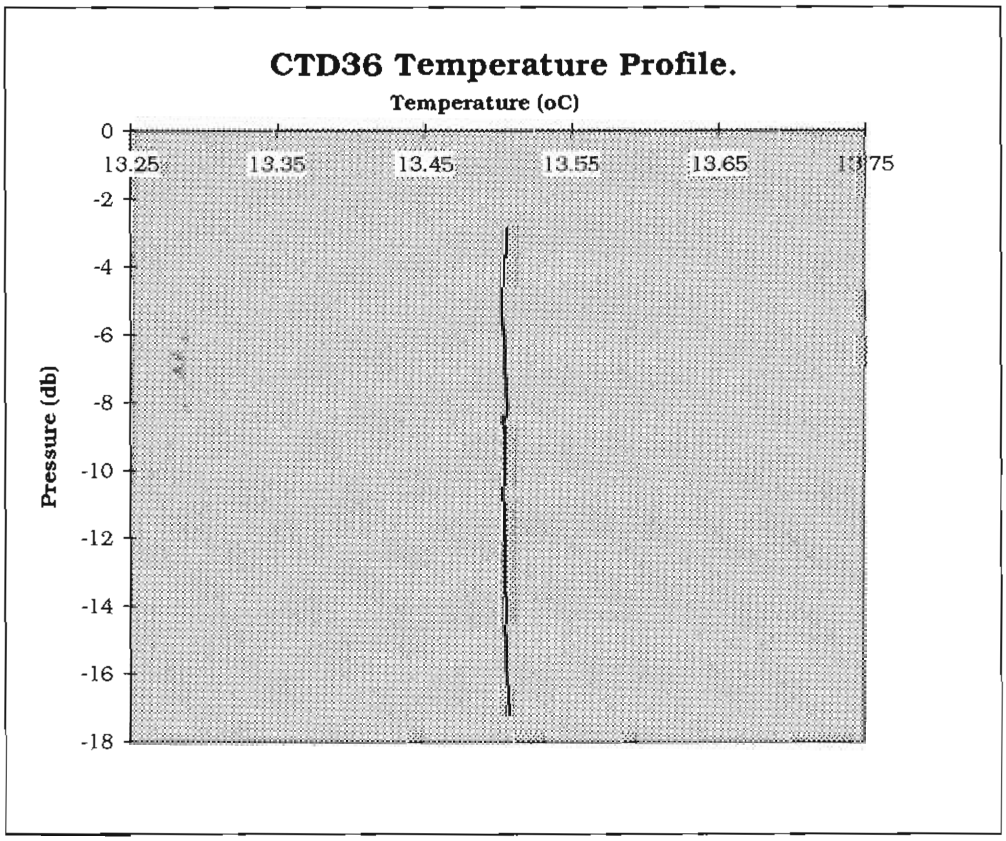
CTD34 Temperature Profile.

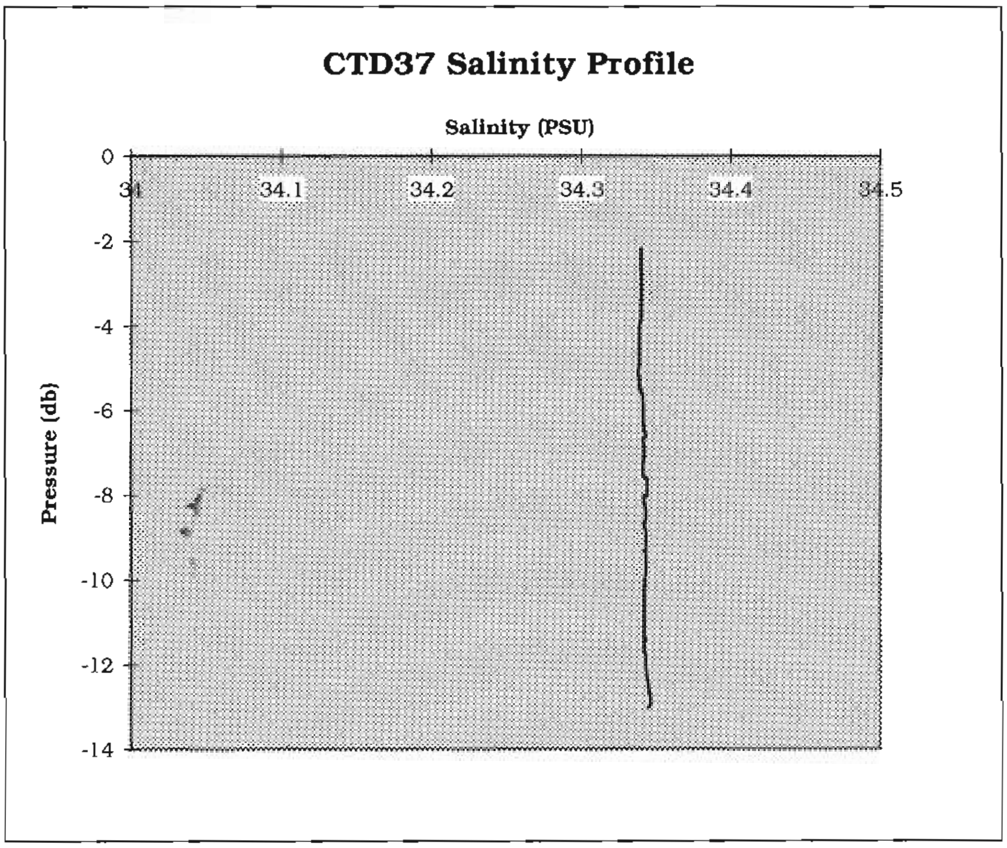


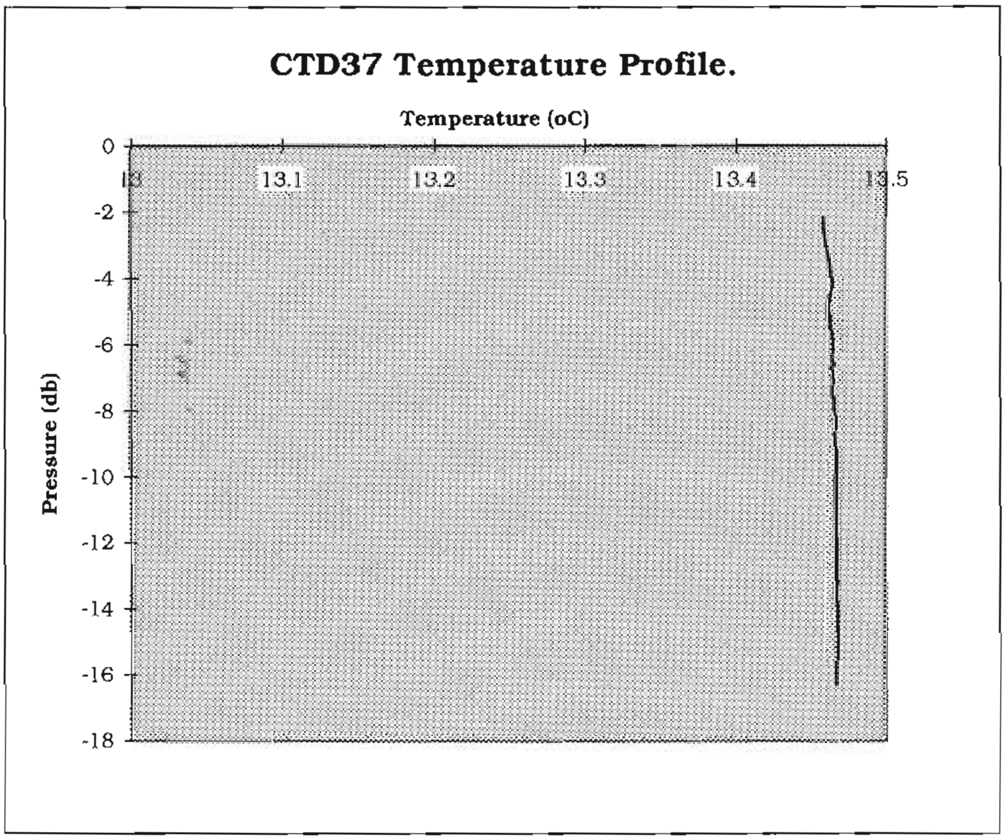

CTD35 Salinity Profile
Salinity (PSU)
34.25
34.35
34.45
34.55
34.65
34.75
Pressure (db)
0
-5
-10
-15
-20
-25
-30
-35

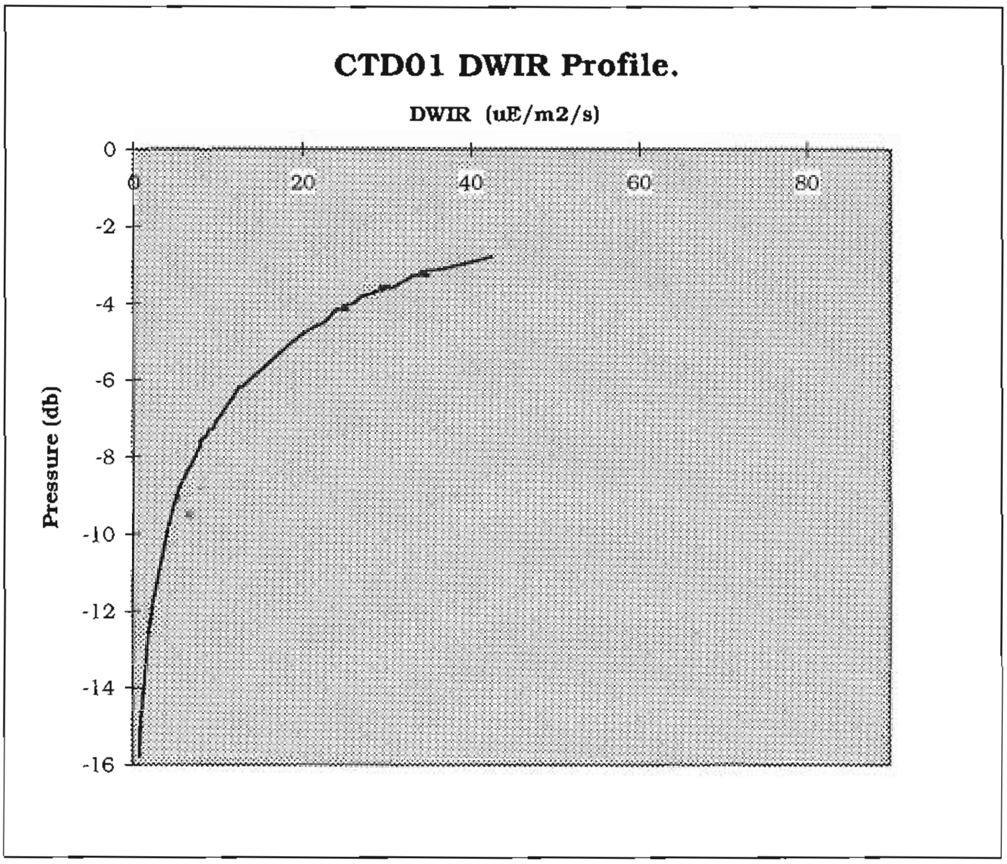

CTD35 Temperature Profile.
Temperature (oC)
13.5
13.6
13.7
13.8
13.9
14
Pressure (db)
0
-5
-10
-15
-20
-25
-30
-35

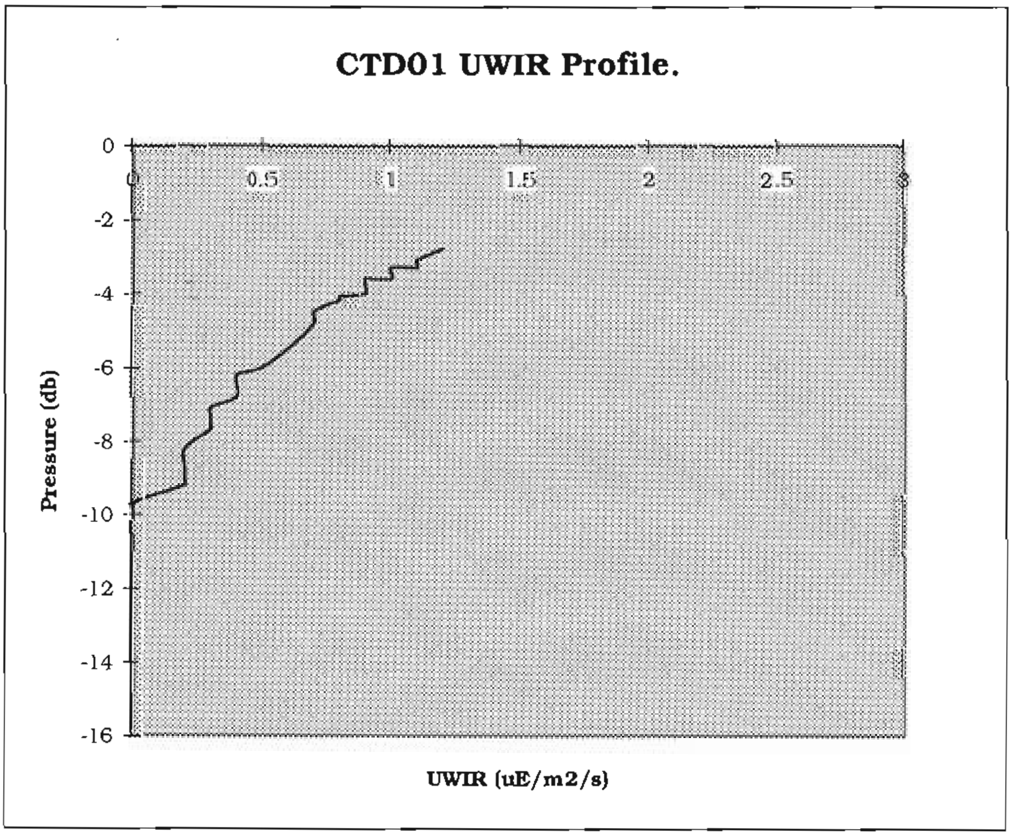

CTD36 Salinity Profile
Salinity (PSU)
Pressure (db)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
34.25
34.35
34.45
34.55
34.65
34.75

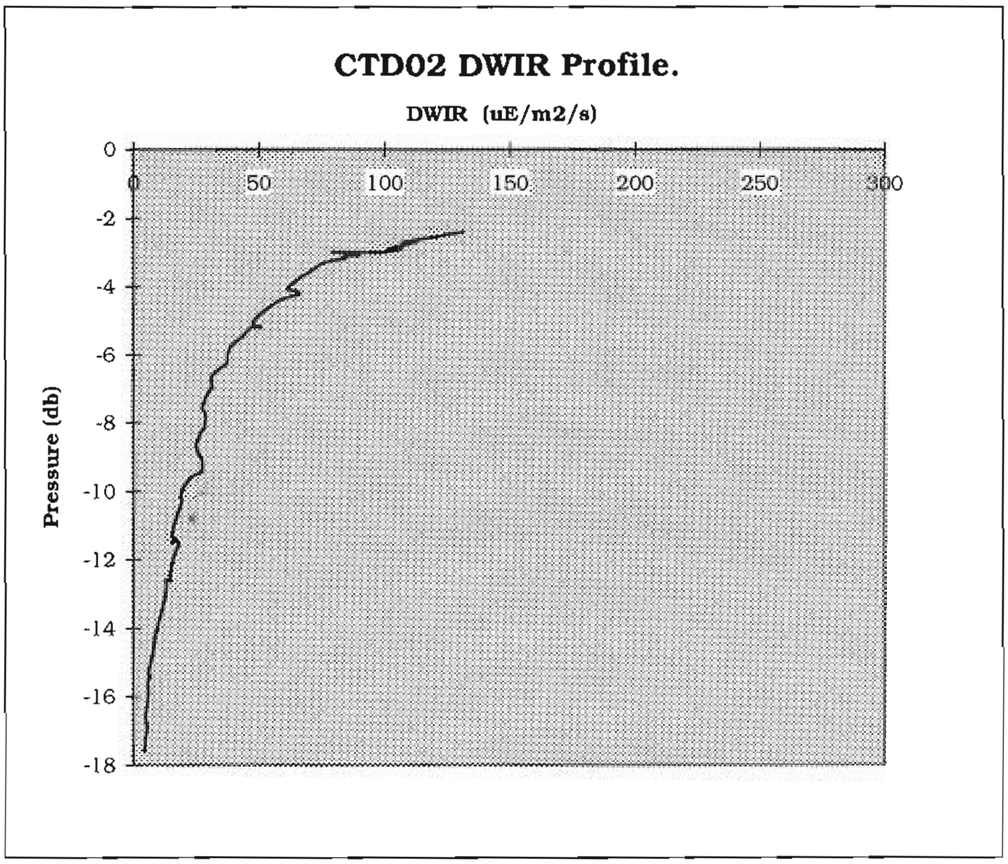

CTD36 Temperature Profile.
Temperature (oC)
Pressure (db)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
13.25
13.35
13.45
13.55
13.65
13.75

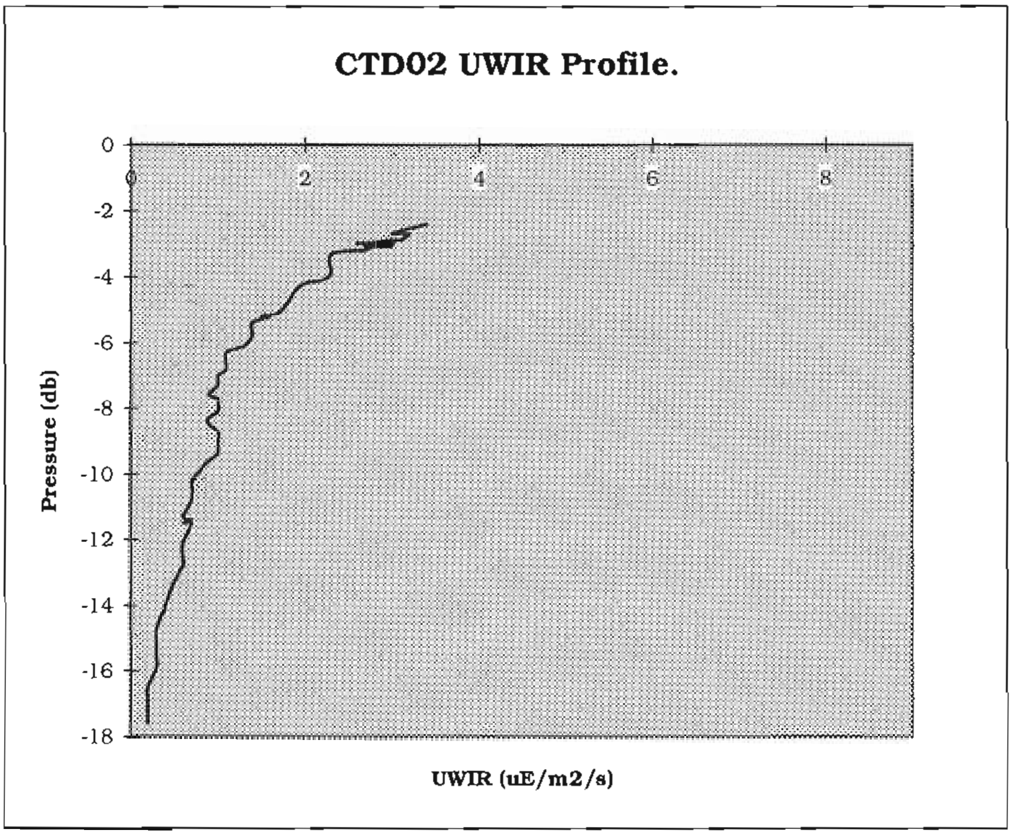

CTD37 Salinity Profile
Salinity (PSU)
34
34.1
34.2
34.3
34.4
34.5
0
-2
-4
-6
-8
-10
-12
-14
Pressure (db)

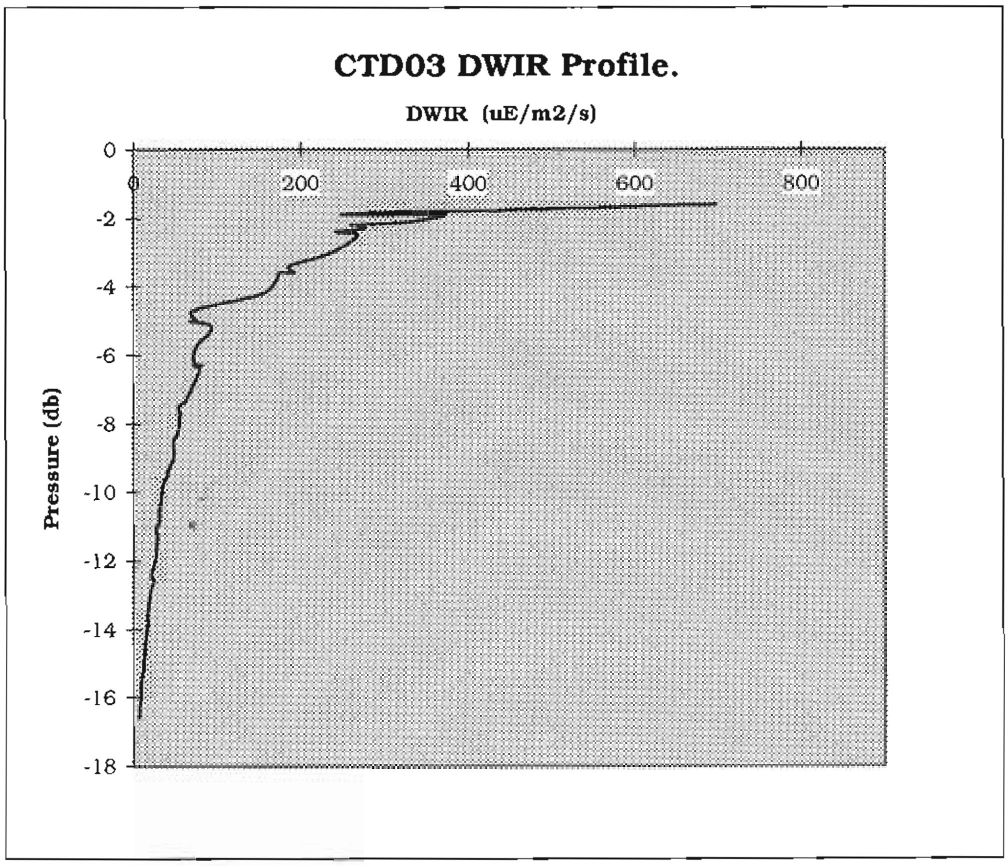

CTD37 Temperature Profile.
Temperature (oC)
13
13.1
13.2
13.3
13.4
13.5
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
Pressure (db)

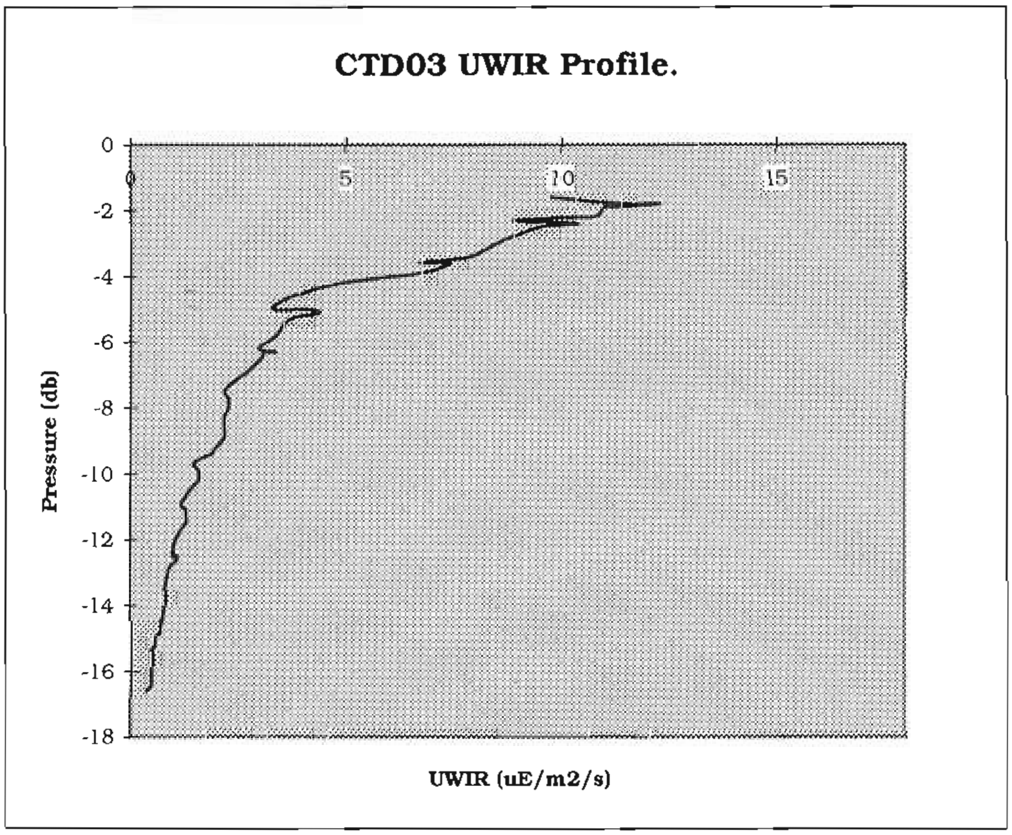

CTD01 DWIR Profile.
DWIR (uE/m2/s)
0
20
40
60
80
0
-2
-4
-6
-8
-10
-12
-14
-16
Pressure (db)

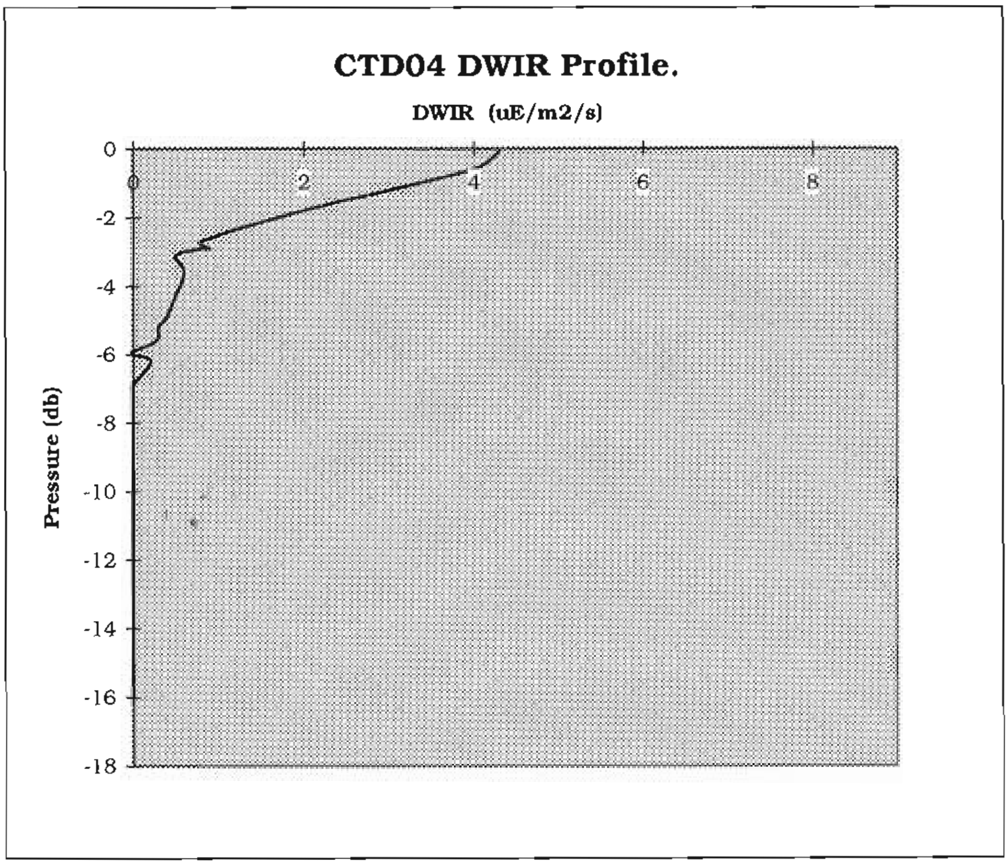

CTD01 UWIR Profile.
0
0.5
1
1.5
2
2.5
3
0
-2
-4
-6
-8
-10
-12
-14
-16
Pressure (db)
UWIR (uE/m2/s)

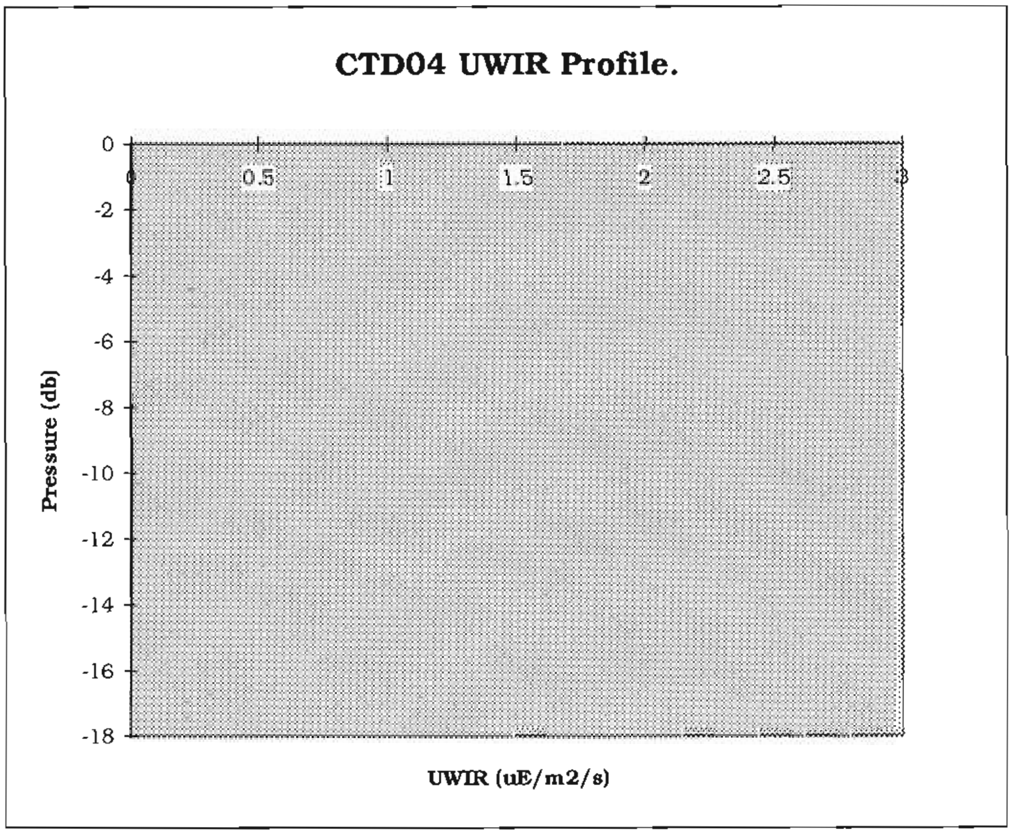

CTD02 DWIR Profile.
DWIR (uE/m2/s)
0
50
100
150
200
250
300
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
Pressure (db)

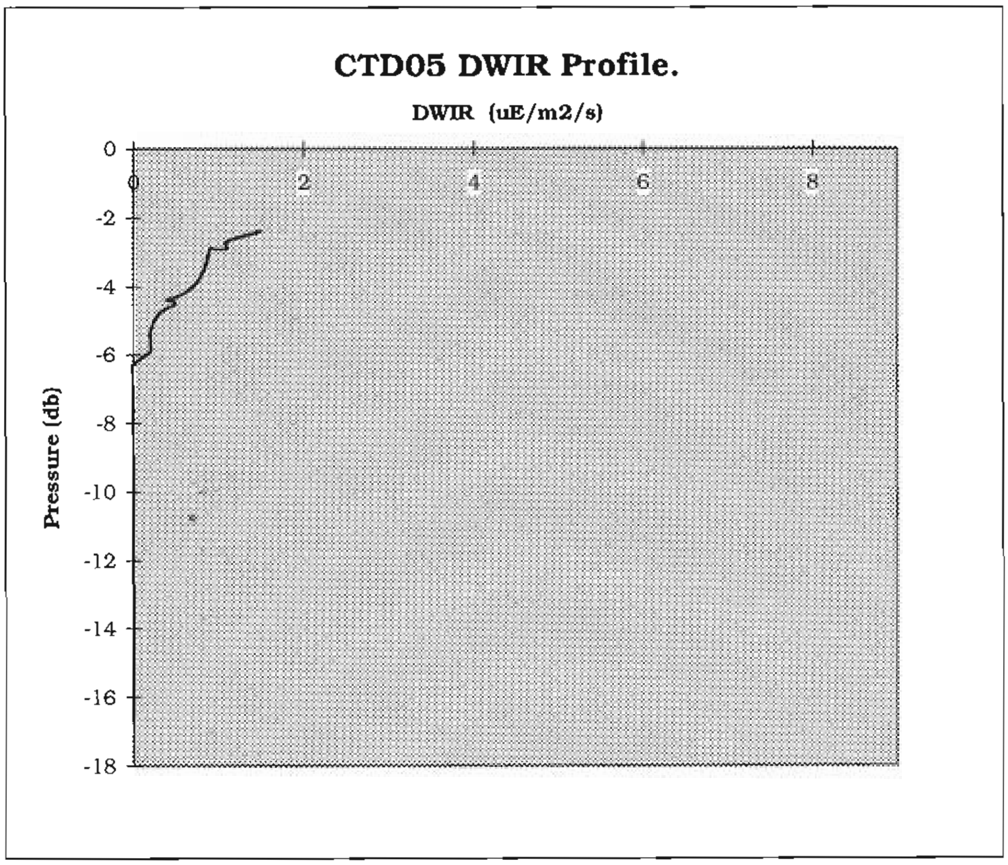

CTD02 UWIR Profile.
0
2
4
6
8
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
Pressure (db)
UWIR (uE/m2/s)

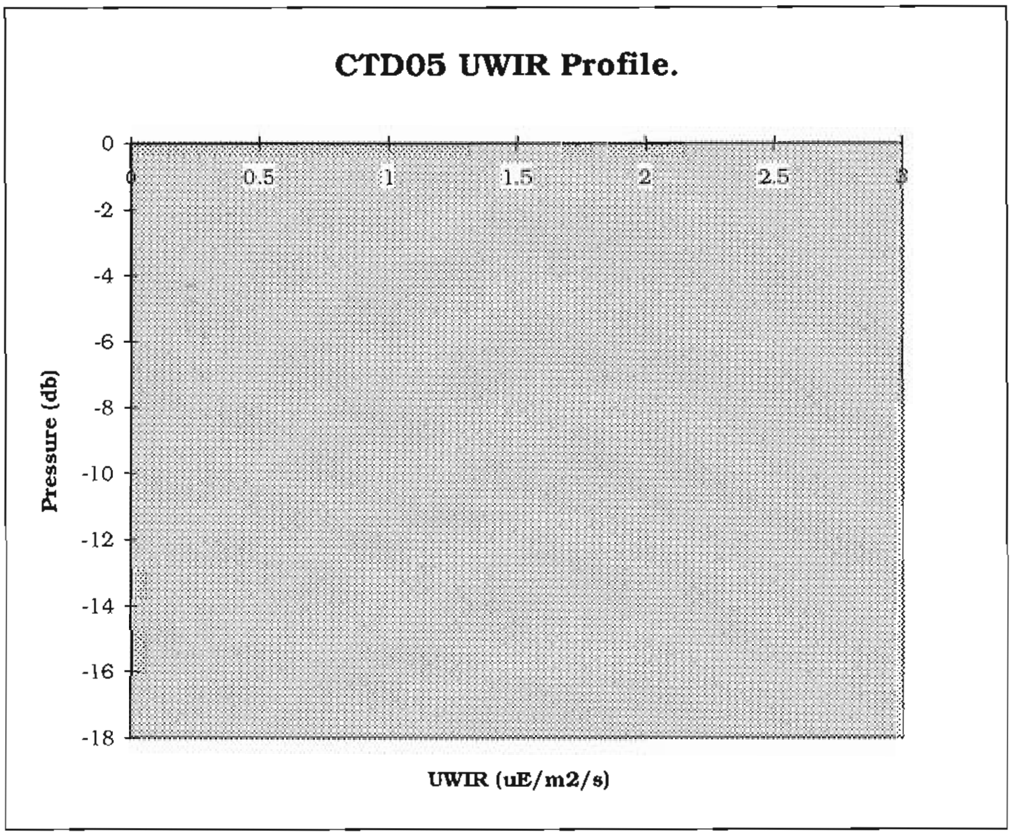

CTD03 DWIR Profile.
DWIR (uE/m2/s)
0
200
400
600
800
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
Pressure (db)

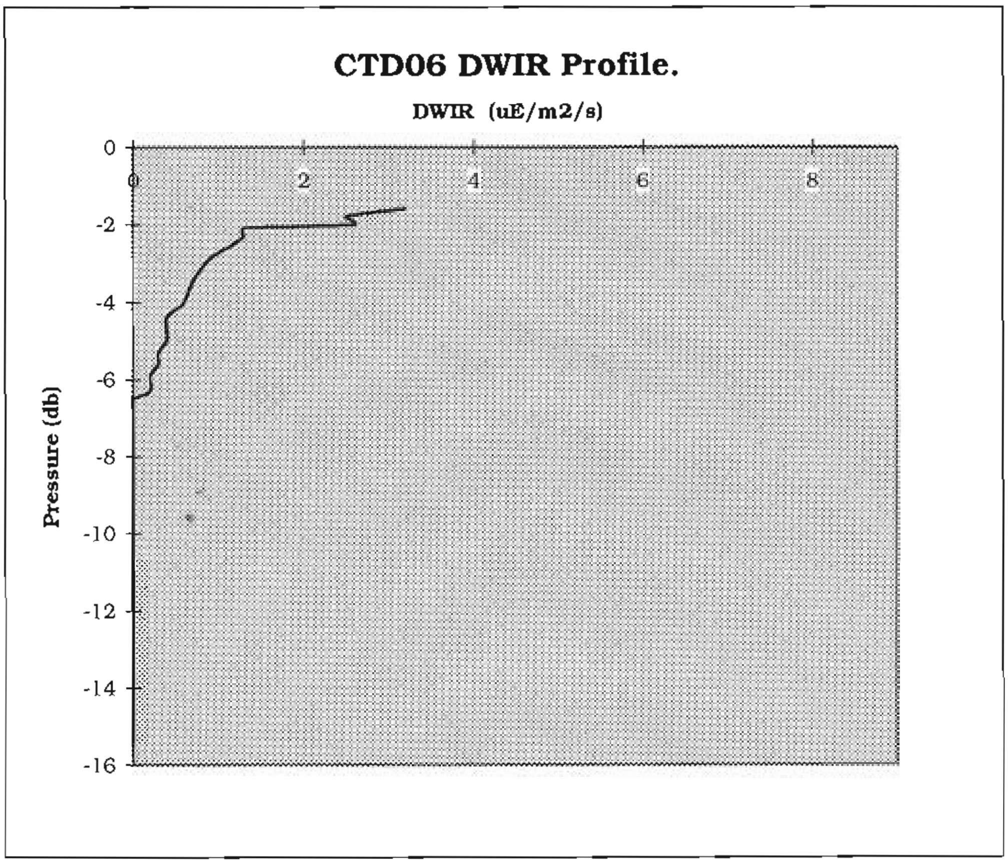

CTD03 UWIR Profile.
0
5
10
15
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
Pressure (db)
UWIR (uE/m2/s)

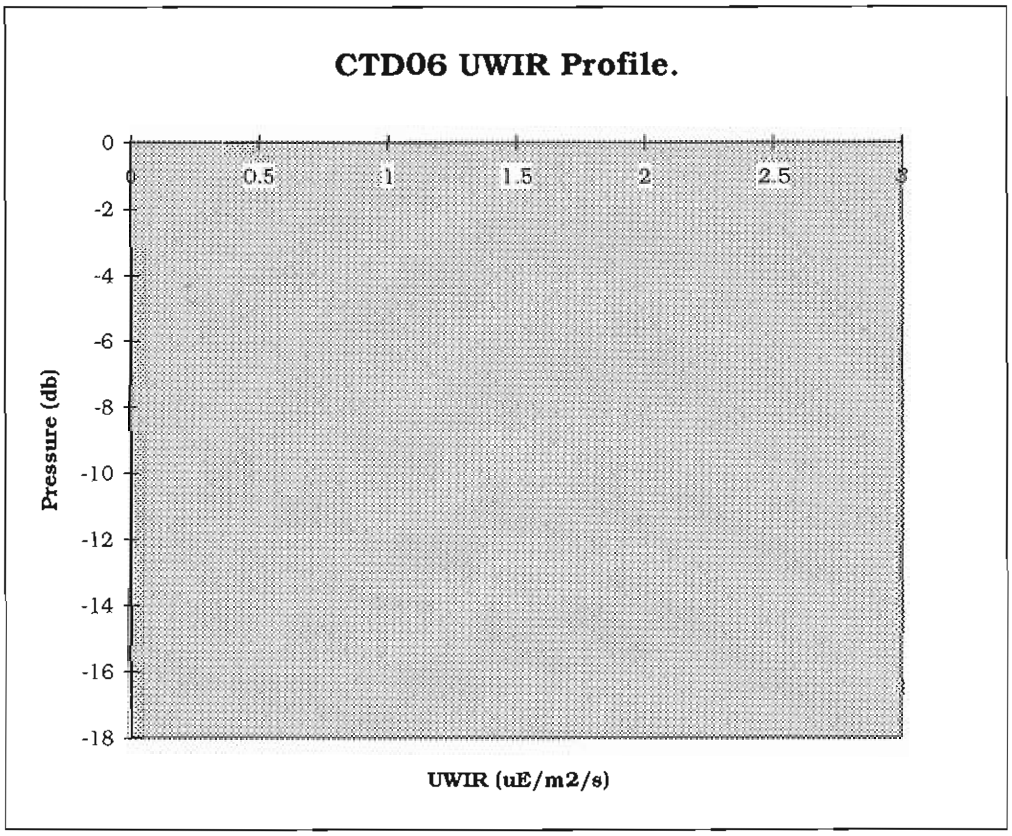

CTD04 DWIR Profile.
DWIR (uE/m2/s)
0
2
4
6
8
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
Pressure (db)

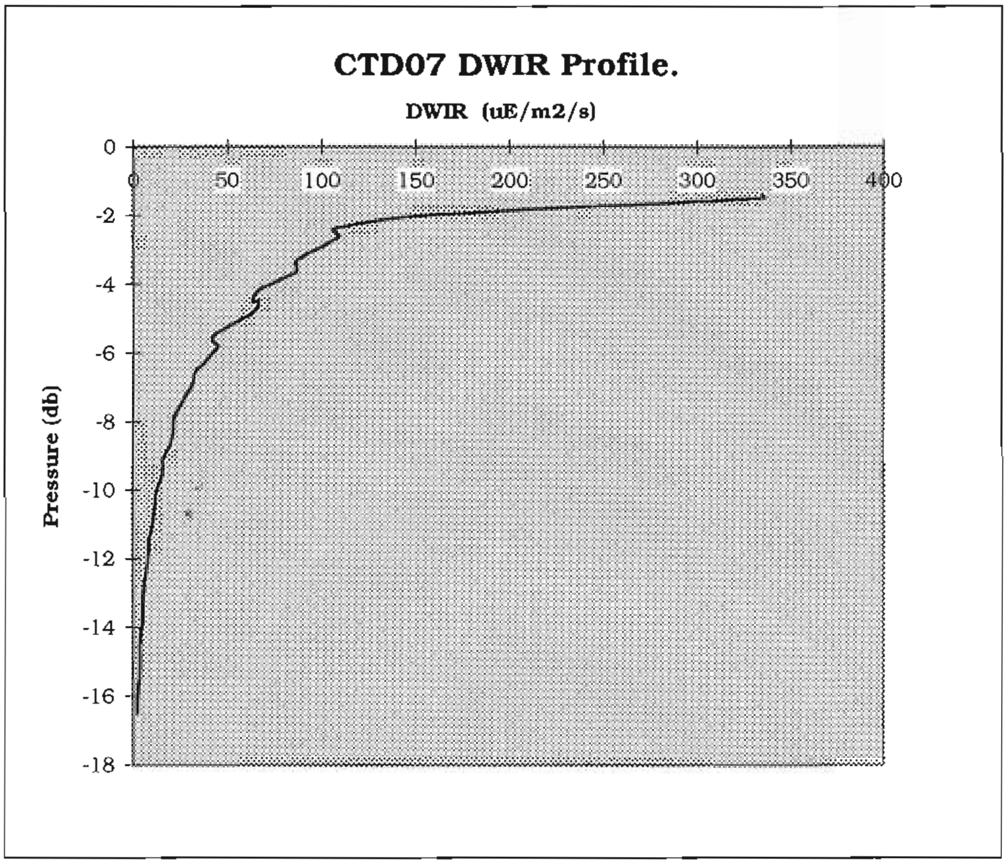

CTD04 UWIR Profile.
0
0.5
1
1.5
2
2.5
3
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
Pressure (db)
UWIR (uE/m2/s)

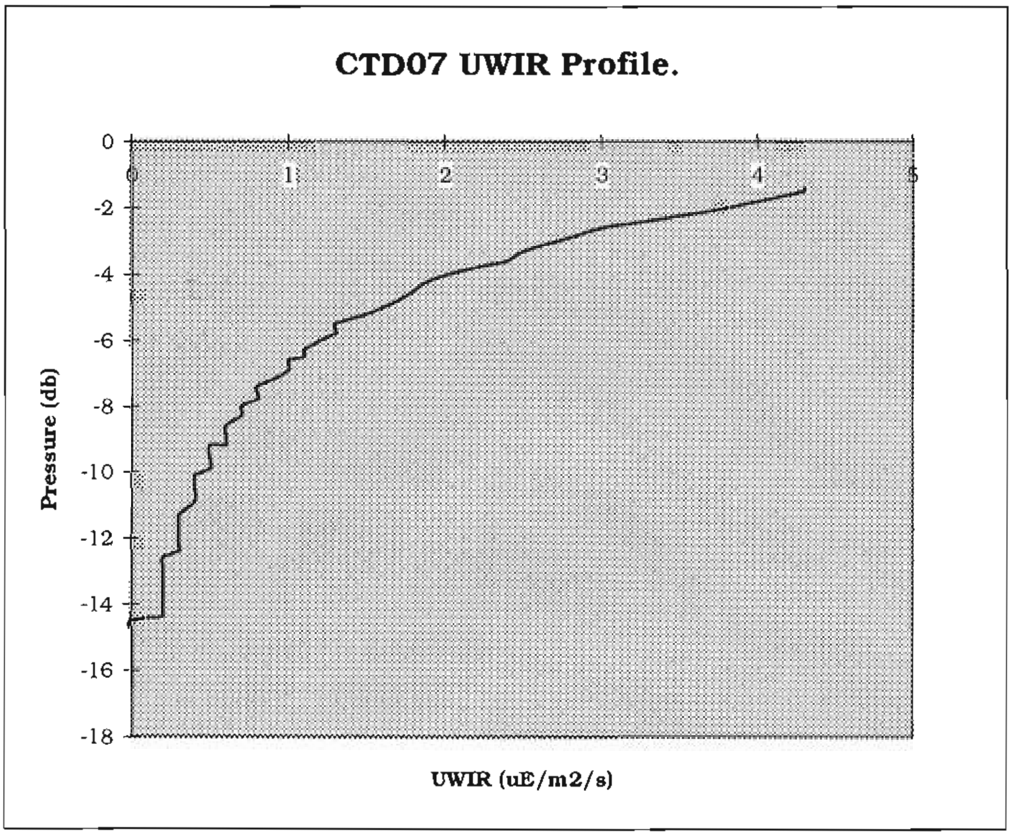

CTD05 DWIR Profile.
DWIR (uE/m2/s)
0
2
4
6
8
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
Pressure (db)

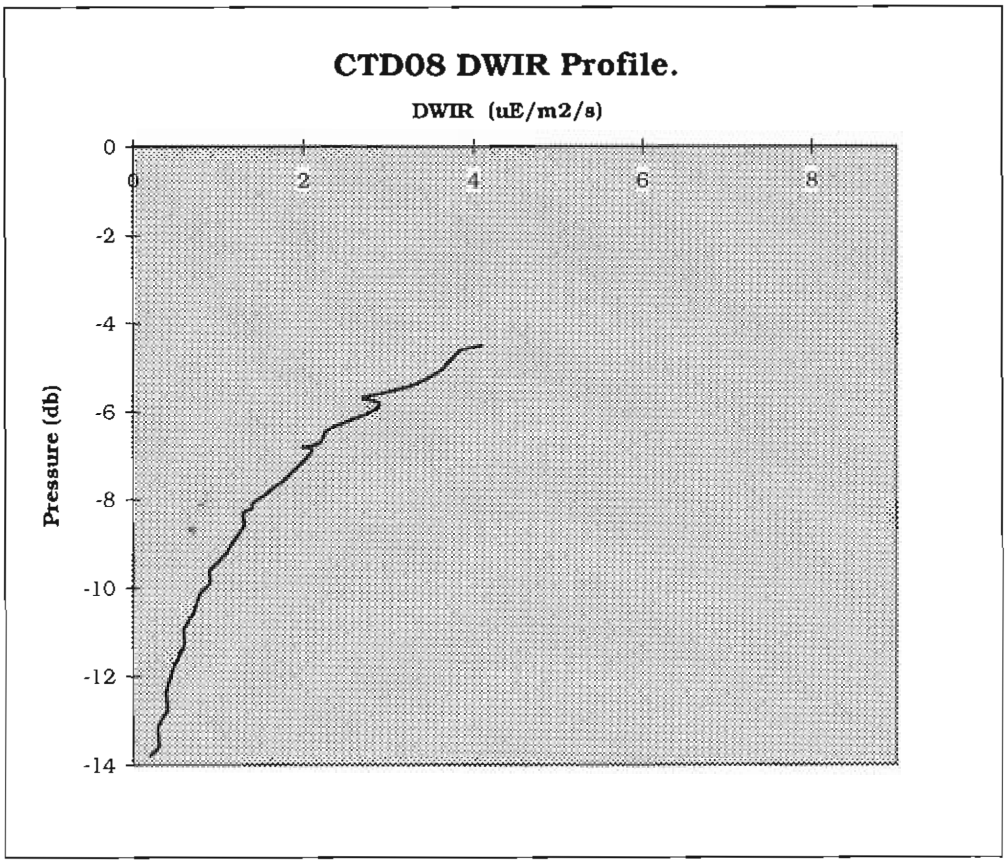

CTD05 UWIR Profile.
0
0.5
1
1.5
2
2.5
3
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
Pressure (db)
UWIR (uE/m2/s)

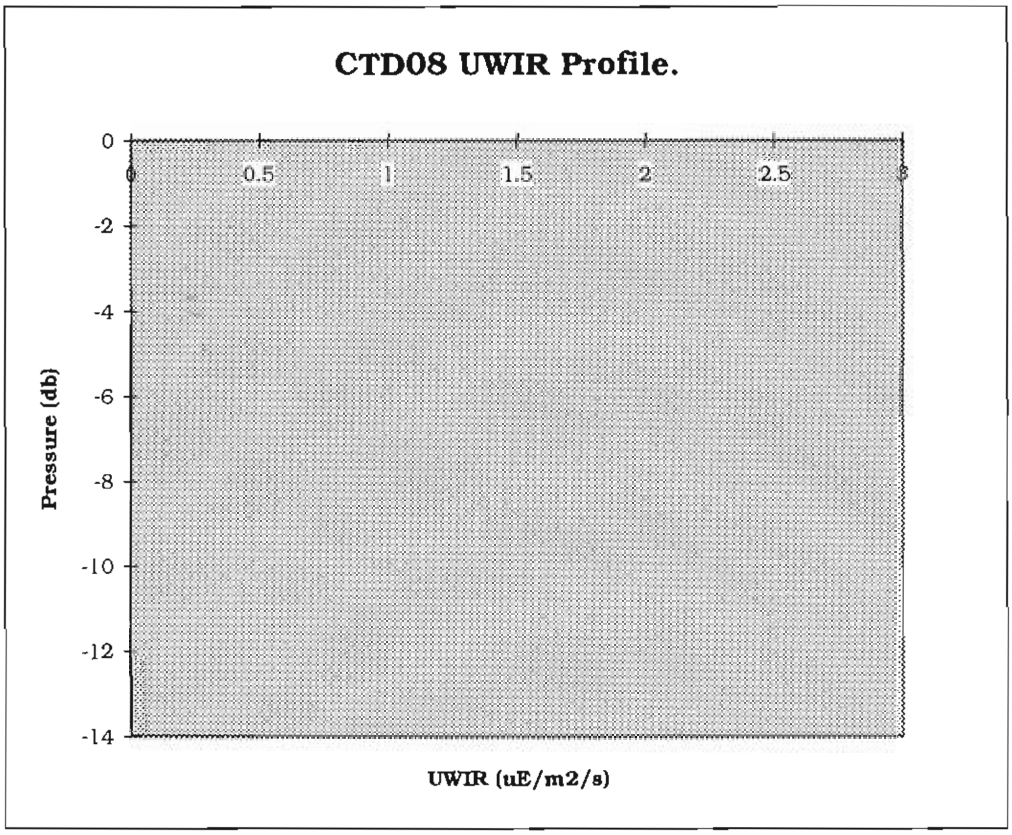

CTD06 DWIR Profile.
DWIR (uE/m2/s)
0
2
4
6
8
0
-2
-4
-6
-8
-10
-12
-14
-16
Pressure (db)

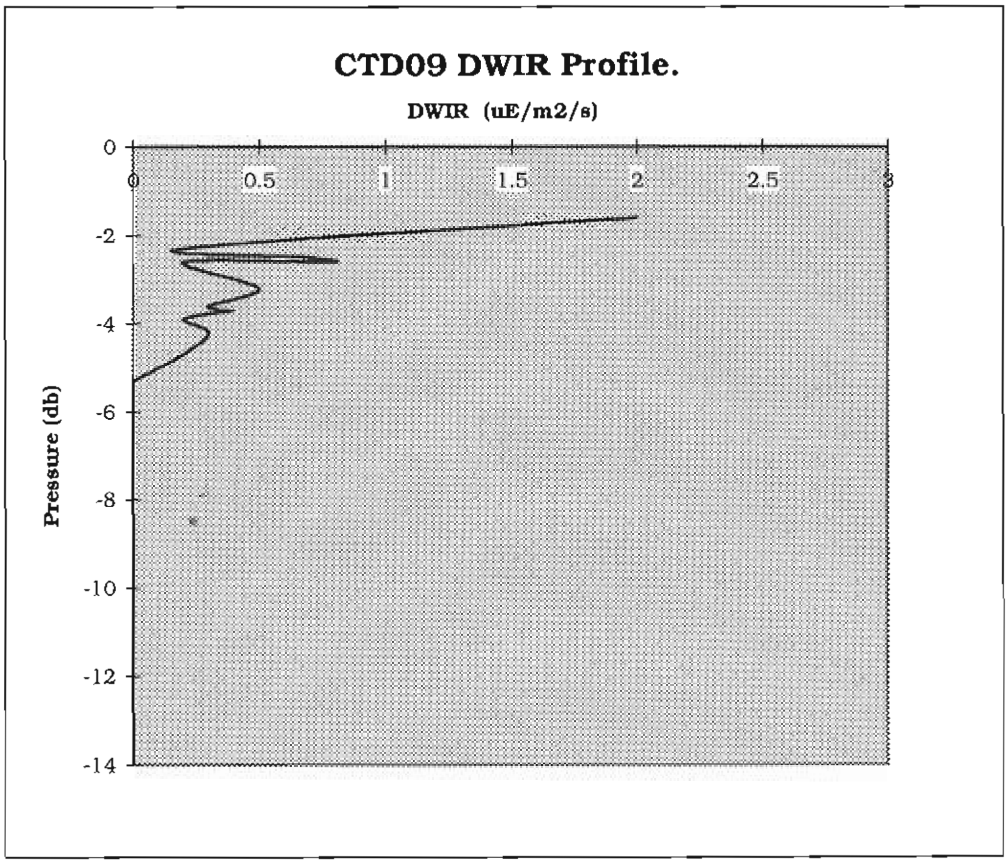

CTD06 UWIR Profile.
0
0.5
1
1.5
2
2.5
3
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
Pressure (db)
UWIR (uE/m2/s)

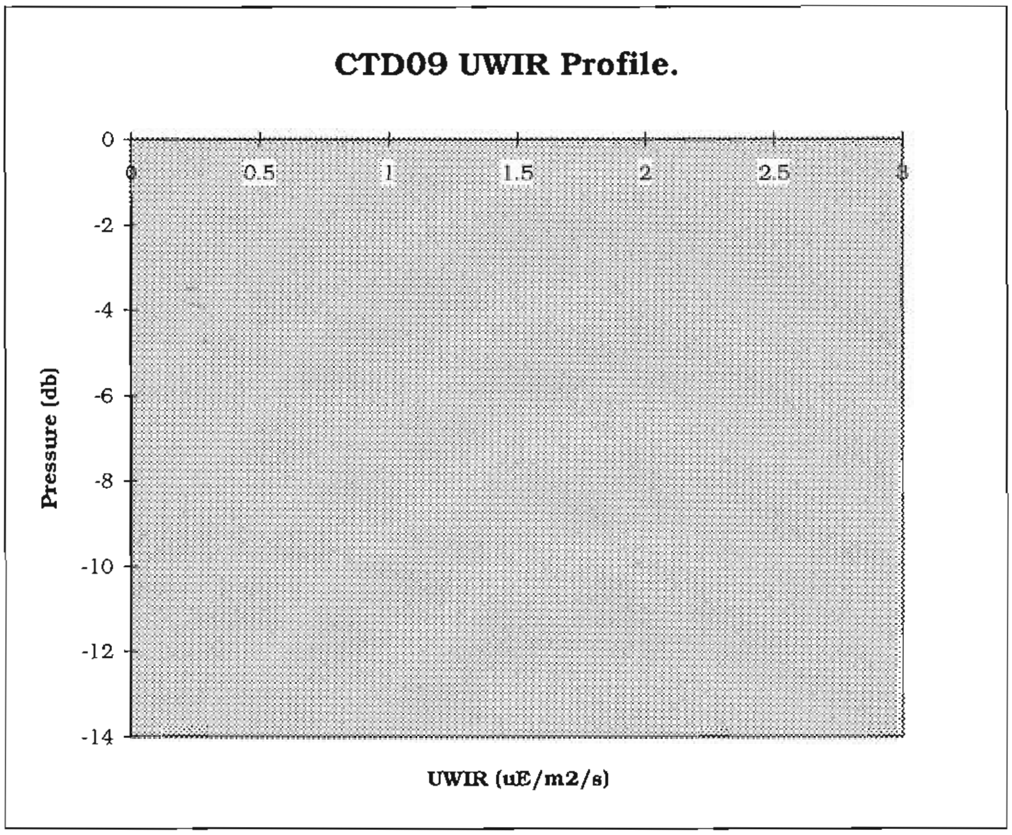

CTD07 DWIR Profile.
DWIR (uE/m2/s)
0
50
100
150
200
250
300
350
400
-2
-4
-6
-8
-10
-12
-14
-16
-18
Pressure (db)

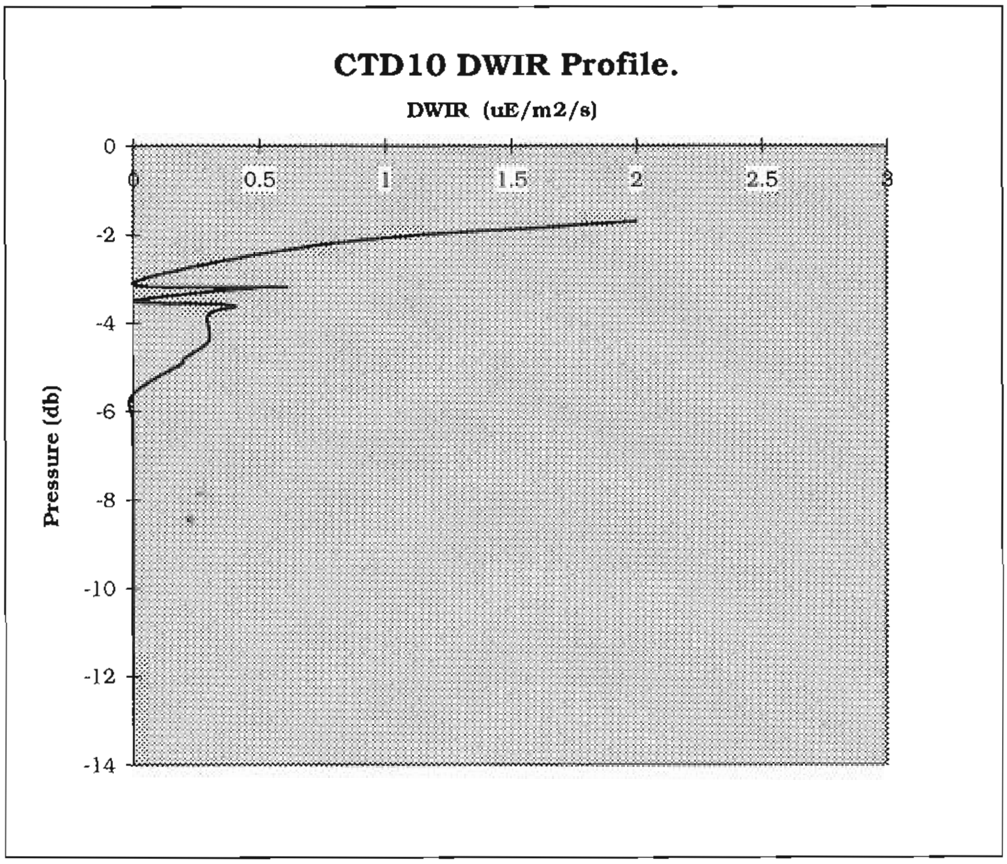

CTD07 UWIR Profile.
0
1
2
3
4
5
-2
-4
-6
-8
-10
-12
-14
-16
-18
Pressure (db)
UWIR (uE/m2/s)

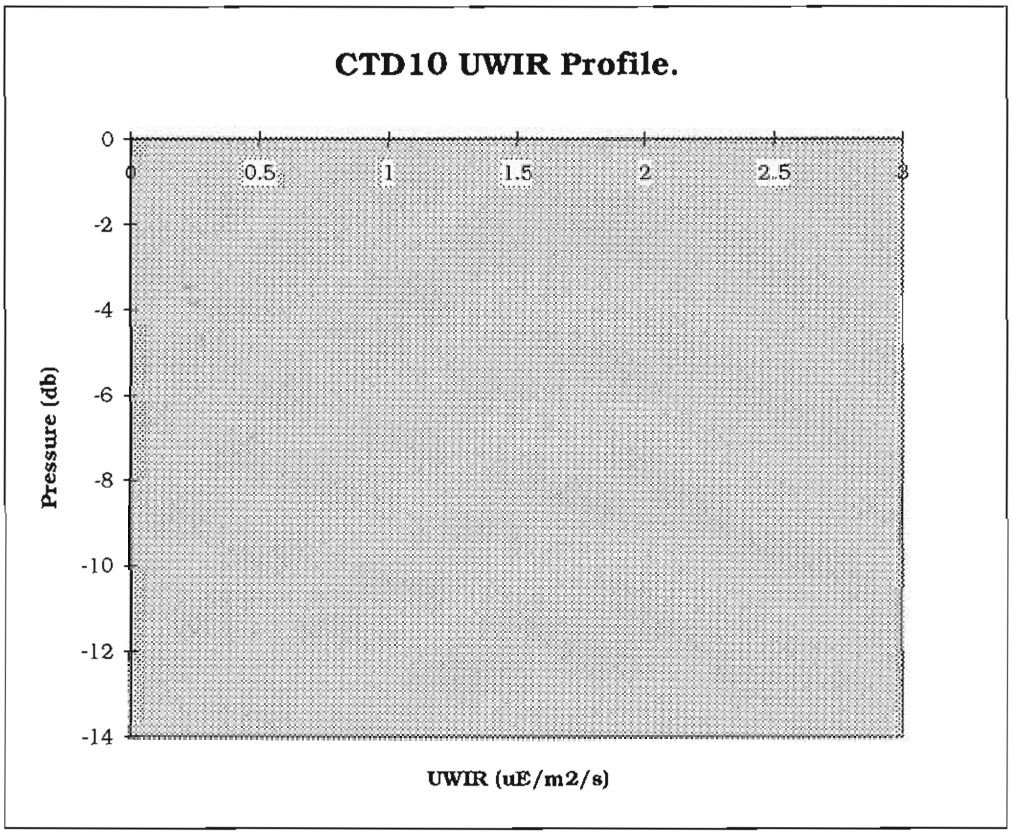

CTD08 DWIR Profile.
DWIR (uE/m2/s)
0
2
4
6
8
0
-2
-4
-6
-8
-10
-12
-14
Pressure (db)

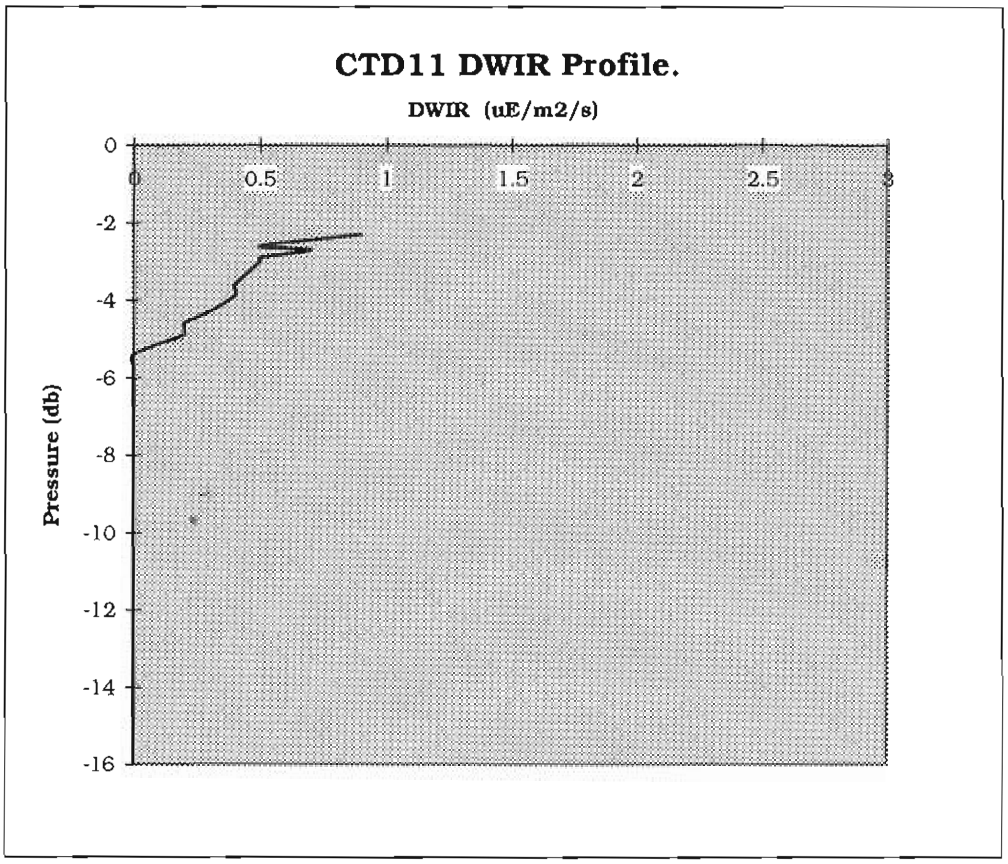

CTD08 UWIR Profile.
0
0.5
1
1.5
2
2.5
3
0
-2
-4
-6
-8
-10
-12
-14
Pressure (db)
UWIR (uE/m2/s)

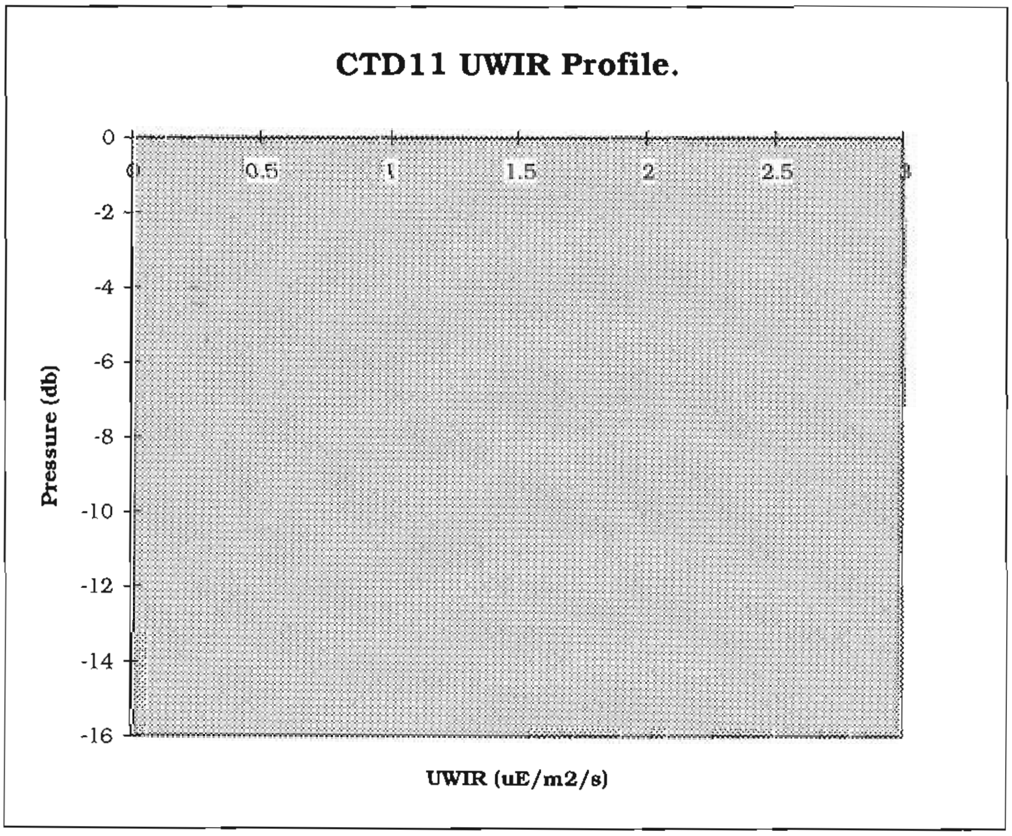

CTD09 DWIR Profile.
DWIR (uE/m2/s)
0
0.5
1
1.5
2
2.5
3
-2
-4
-6
-8
-10
-12
-14
Pressure (db)

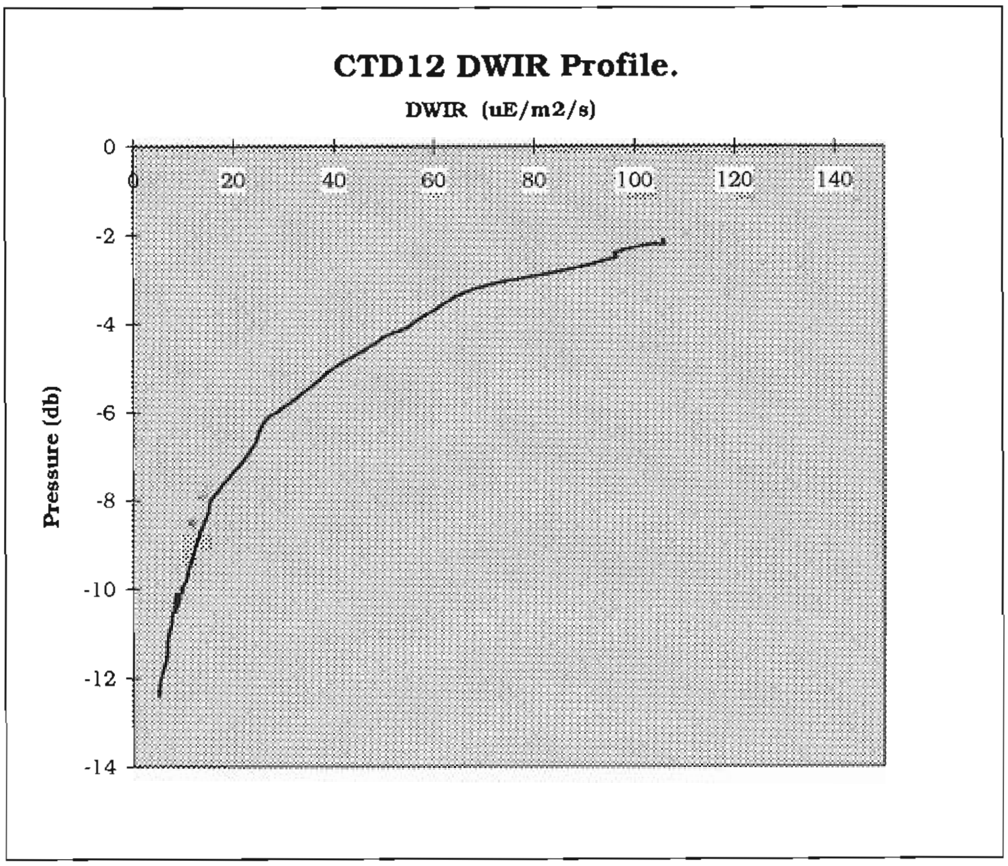

CTD09 UWIR Profile.
0
0.5
1
1.5
2
2.5
3
-2
-4
-6
-8
-10
-12
-14
Pressure (db)
UWIR (uE/m2/s)

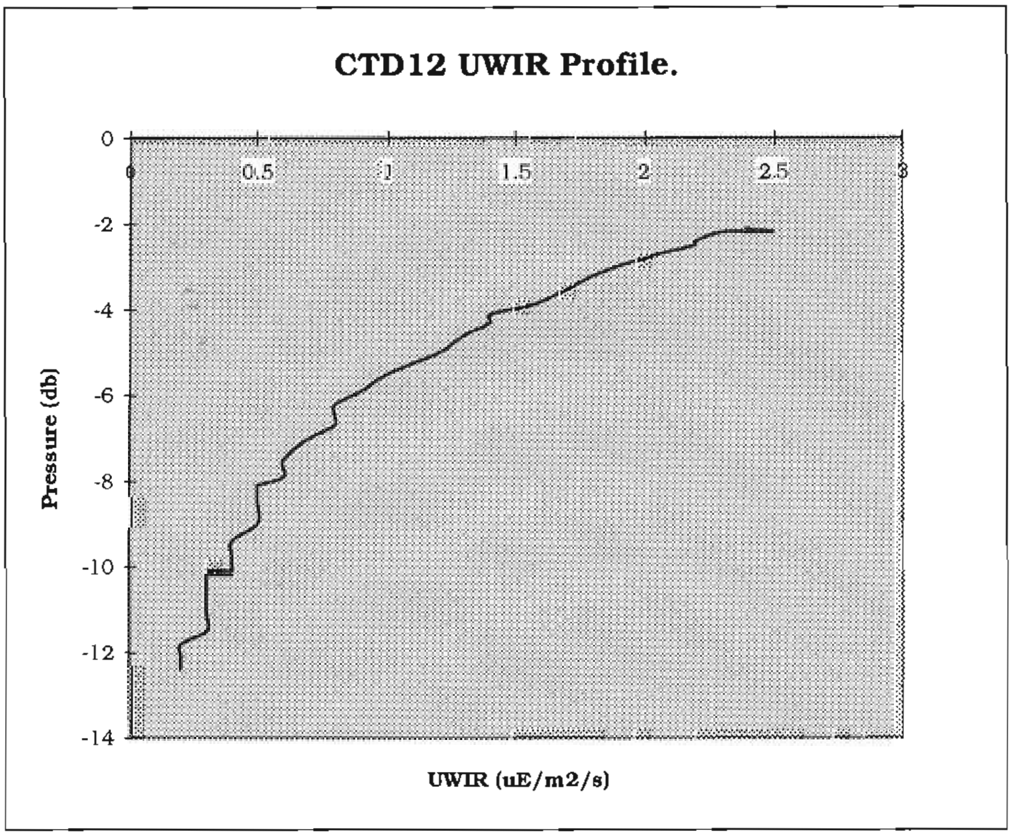

CTD10 DWIR Profile.
DWIR (uE/m2/s)
Pressure (db)
0
0.5
1
1.5
2
2.5
3
0
-2
-4
-6
-8
-10
-12
-14

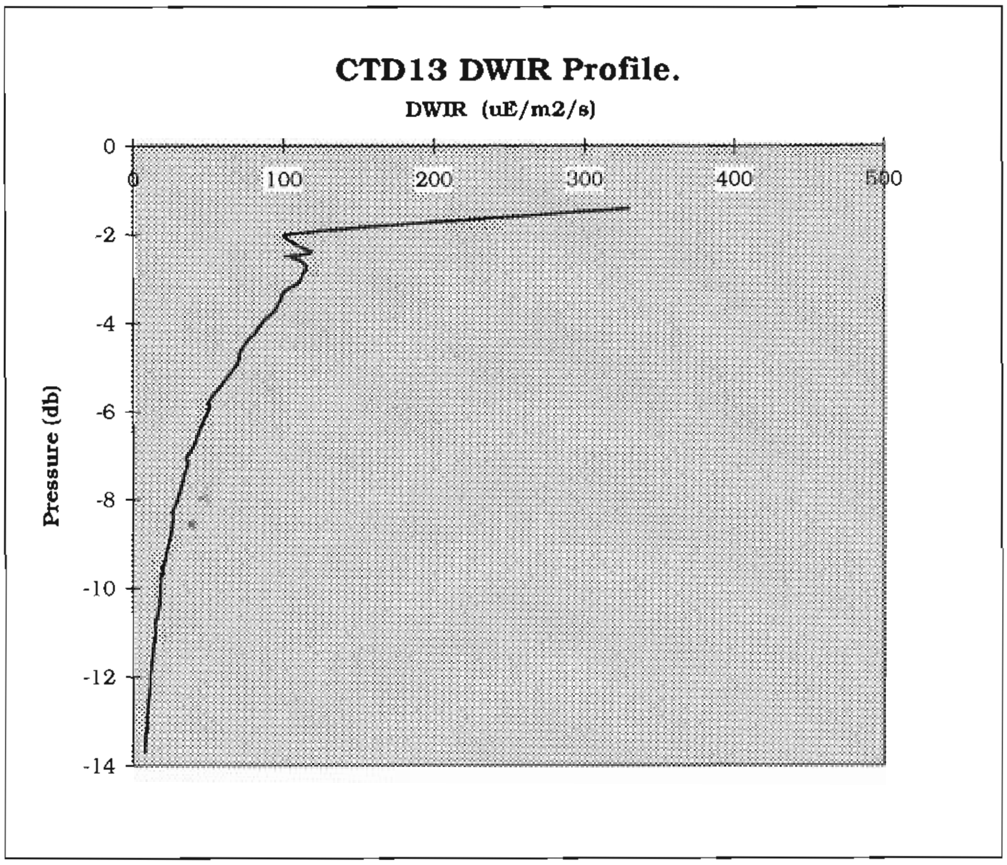

CTD10 UWIR Profile.
0
0.5
1
1.5
2
2.5
3
0
-2
-4
-6
-8
-10
-12
-14
Pressure (db)
UWIR (uE/m2/s)

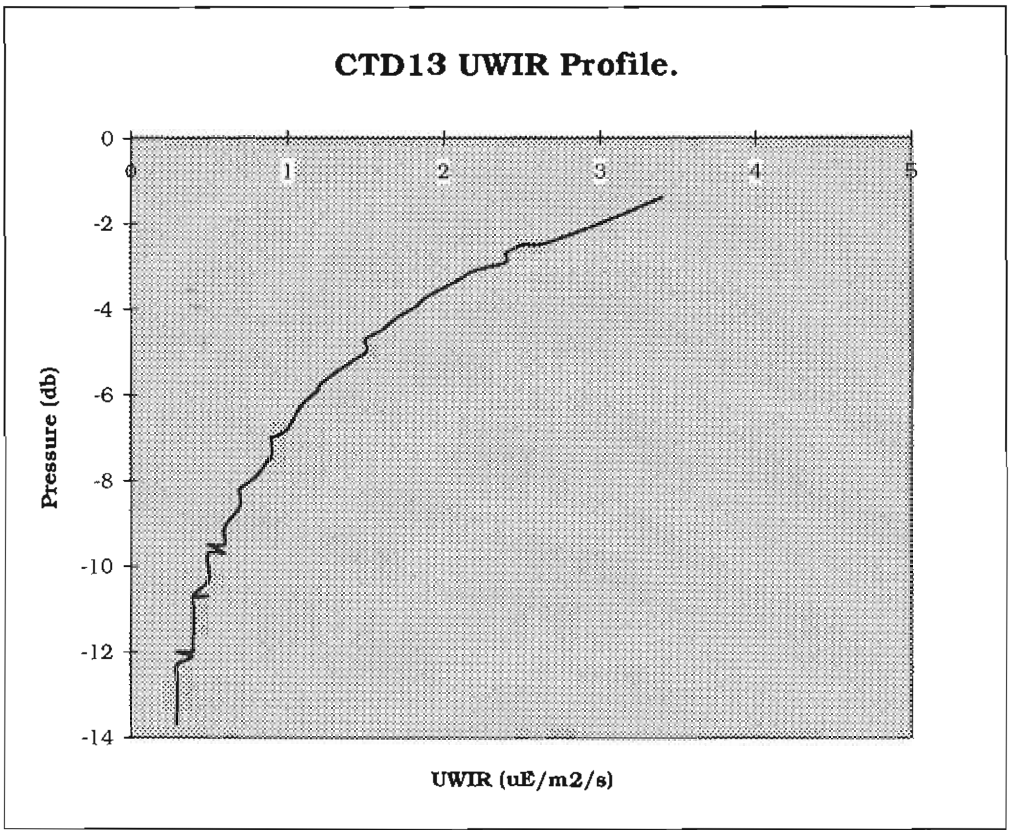

CTD11 DWIR Profile.
DWIR (uE/m2/s)
0
0.5
1
1.5
2
2.5
3
-2
-4
-6
-8
-10
-12
-14
-16
Pressure (db)

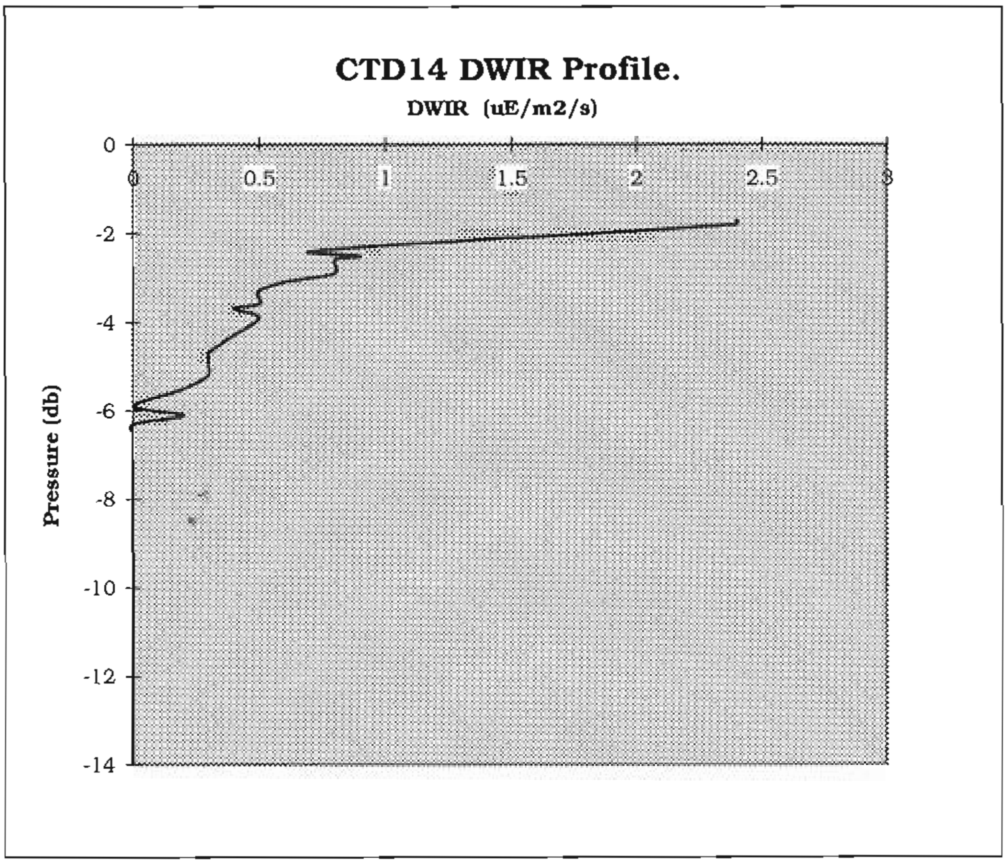

CTD11 UWIR Profile.
0
0.5
1
1.5
2
2.5
3
-2
-4
-6
-8
-10
-12
-14
-16
Pressure (db)
UWIR (uE/m2/s)

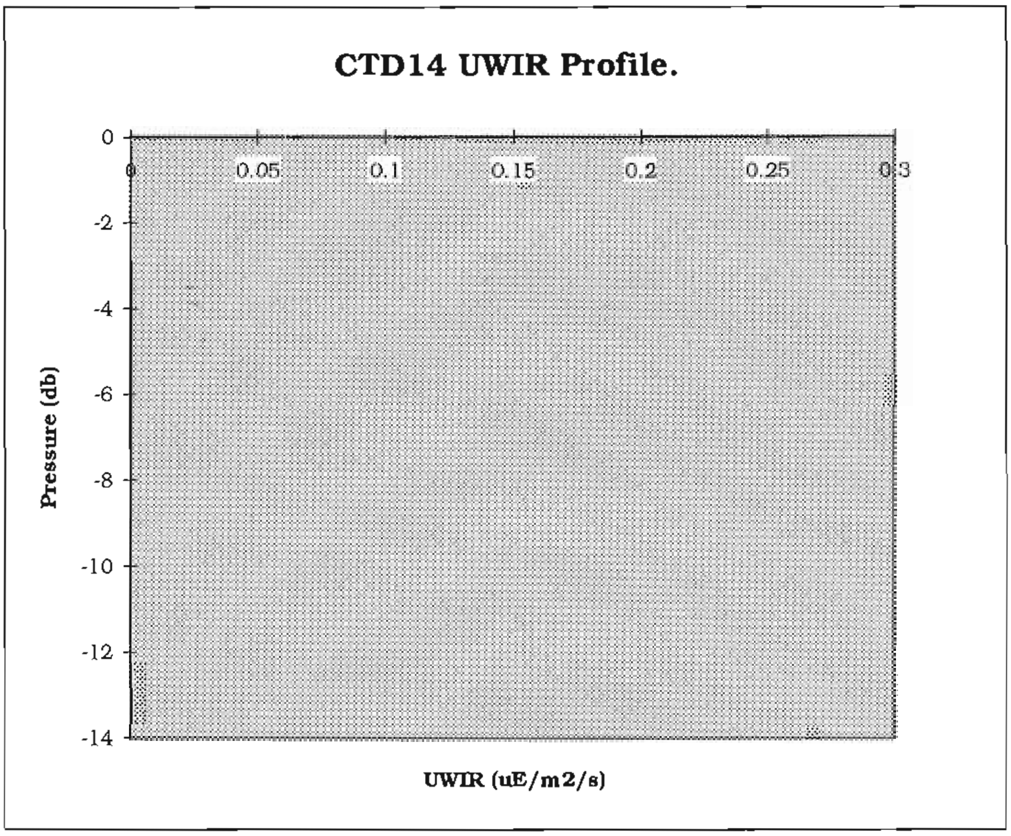

CTD12 DWIR Profile.
DWIR (uE/m2/s)
Pressure (db)
0
20
40
60
80
100
120
140
0
-2
-4
-6
-8
-10
-12
-14

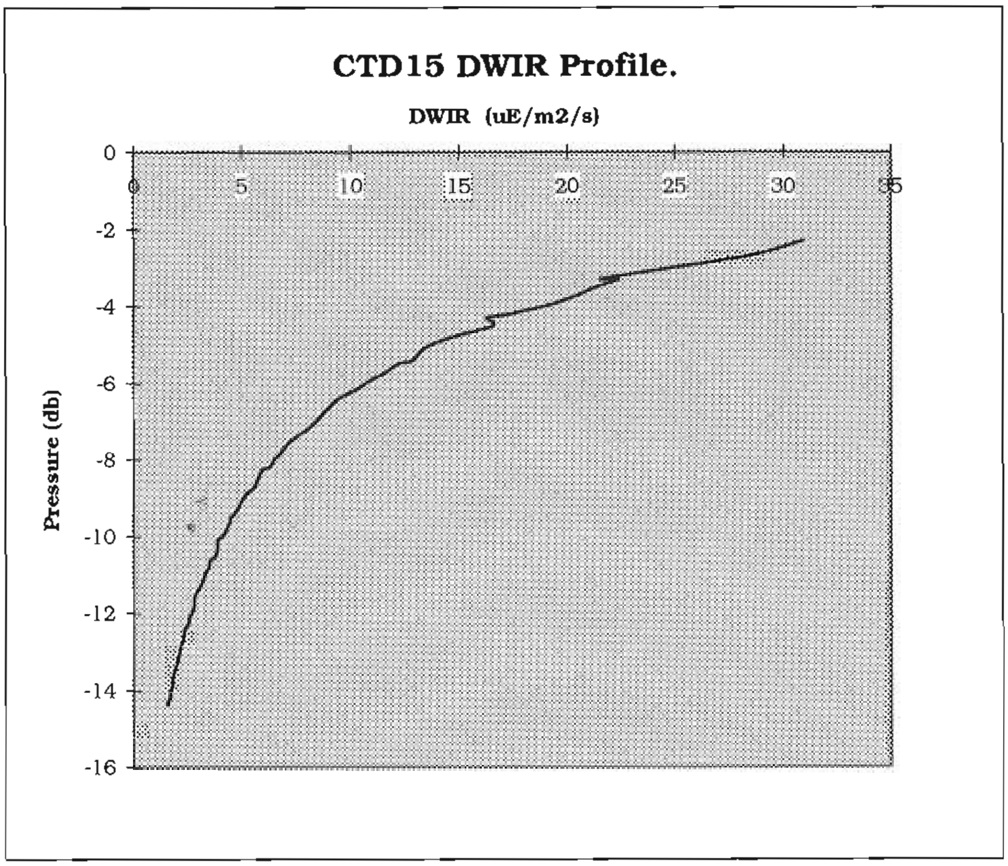

CTD12 UWIR Profile.
Pressure (db)
UWIR (uE/m2/s)
0
0.5
1
1.5
2
2.5
3
0
-2
-4
-6
-8
-10
-12
-14

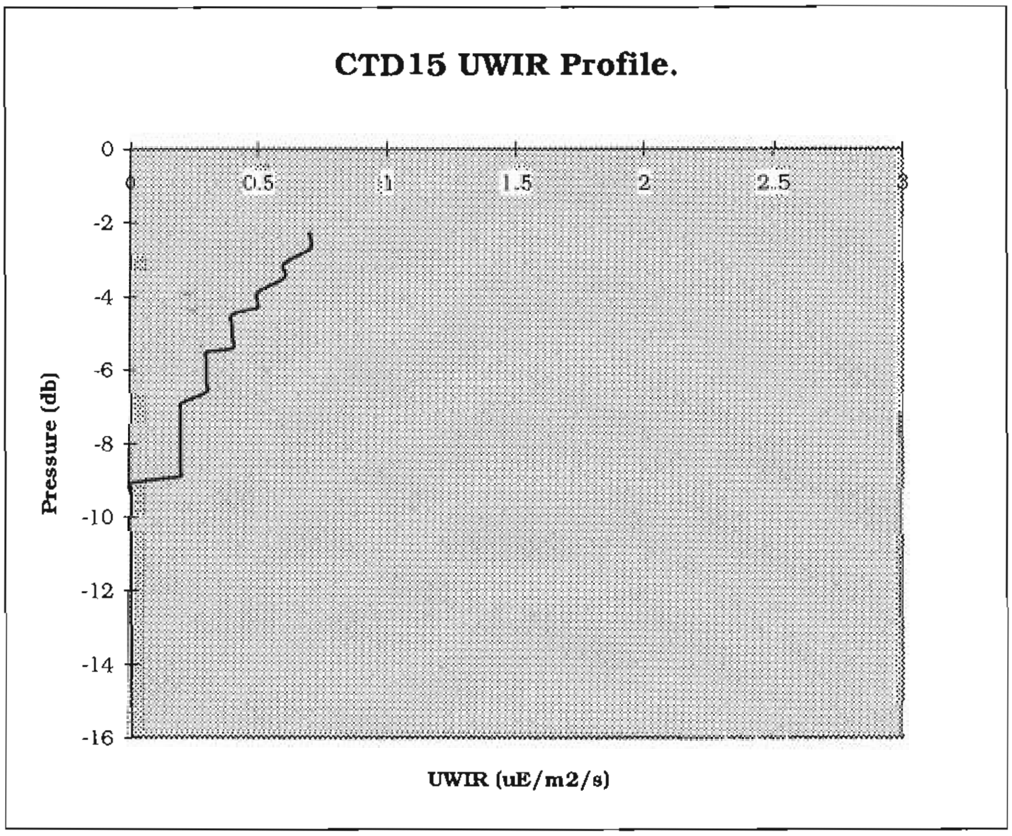

CTD13 DWIR Profile.
DWIR (uE/m2/s)
0
100
200
300
400
500
-2
-4
-6
-8
-10
-12
-14
Pressure (db)

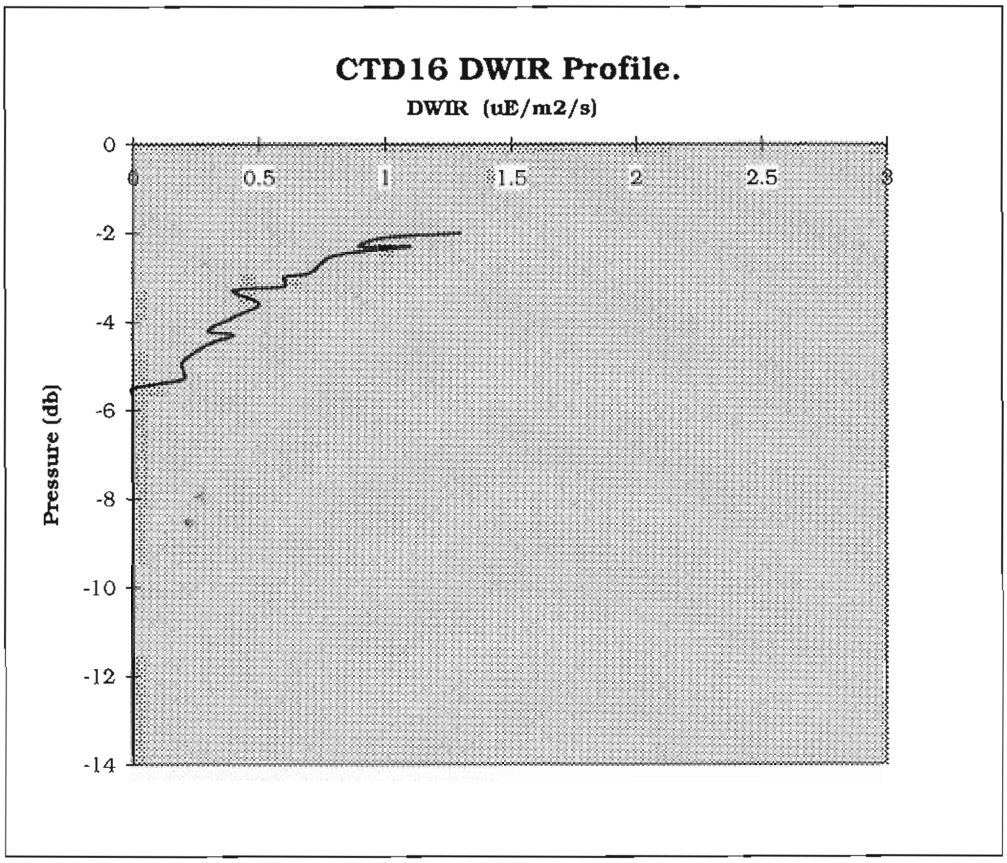

CTD13 UWIR Profile.
0
1
2
3
4
5
-2
-4
-6
-8
-10
-12
-14
Pressure (db)
UWIR (uE/m2/s)

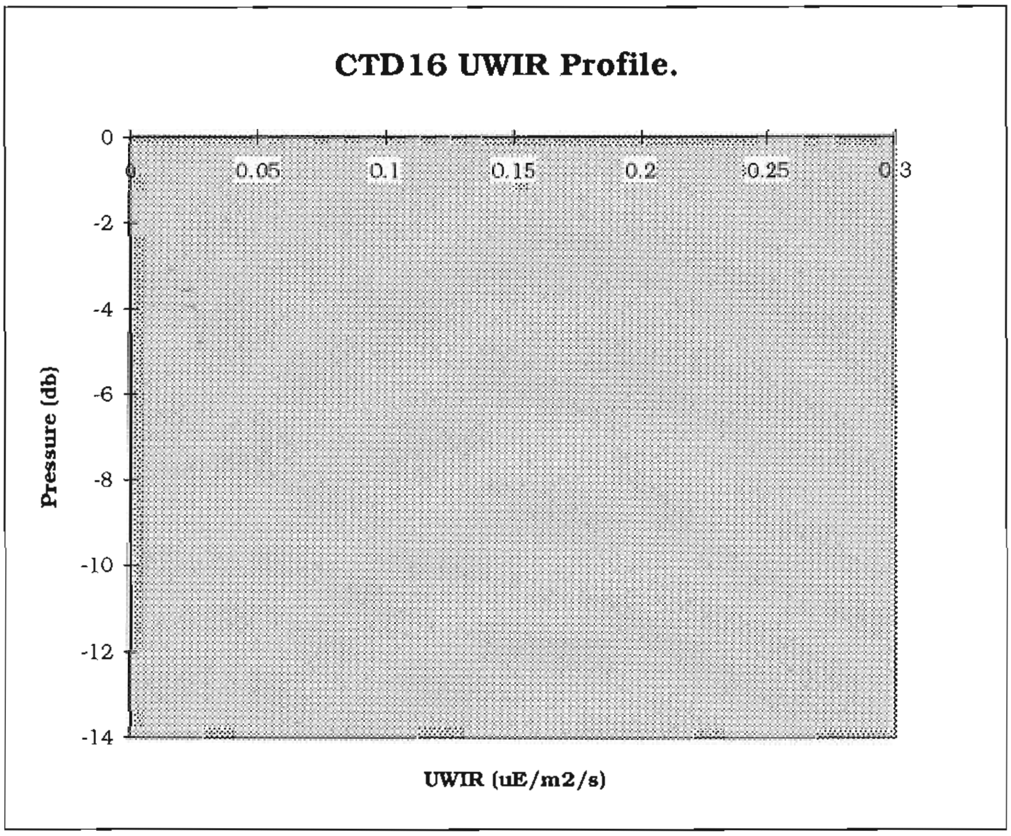

CTD14 DWIR Profile.
DWIR (uE/m2/s)
0
0.5
1
1.5
2
2.5
3
-2
-4
-6
-8
-10
-12
-14
Pressure (db)

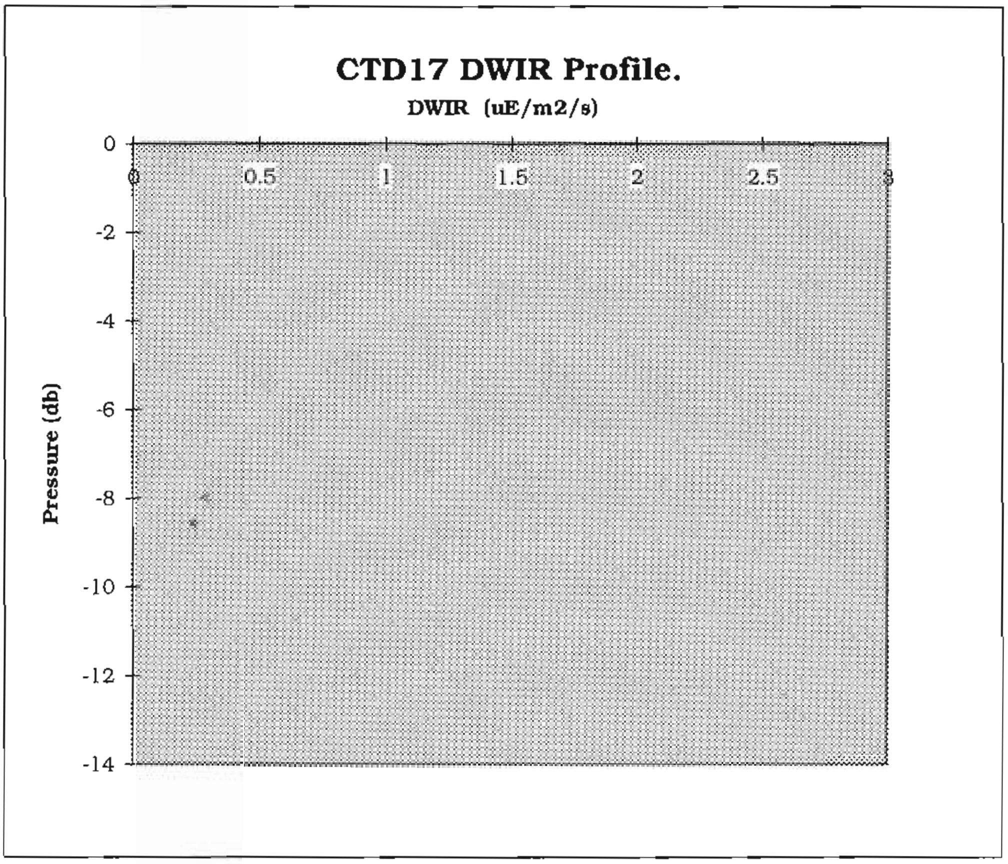

CTD14 UWIR Profile.
0
0.05
0.1
0.15
0.2
0.25
0.3
-2
-4
-6
-8
-10
-12
-14
Pressure (db)
UWIR (uE/m2/s)

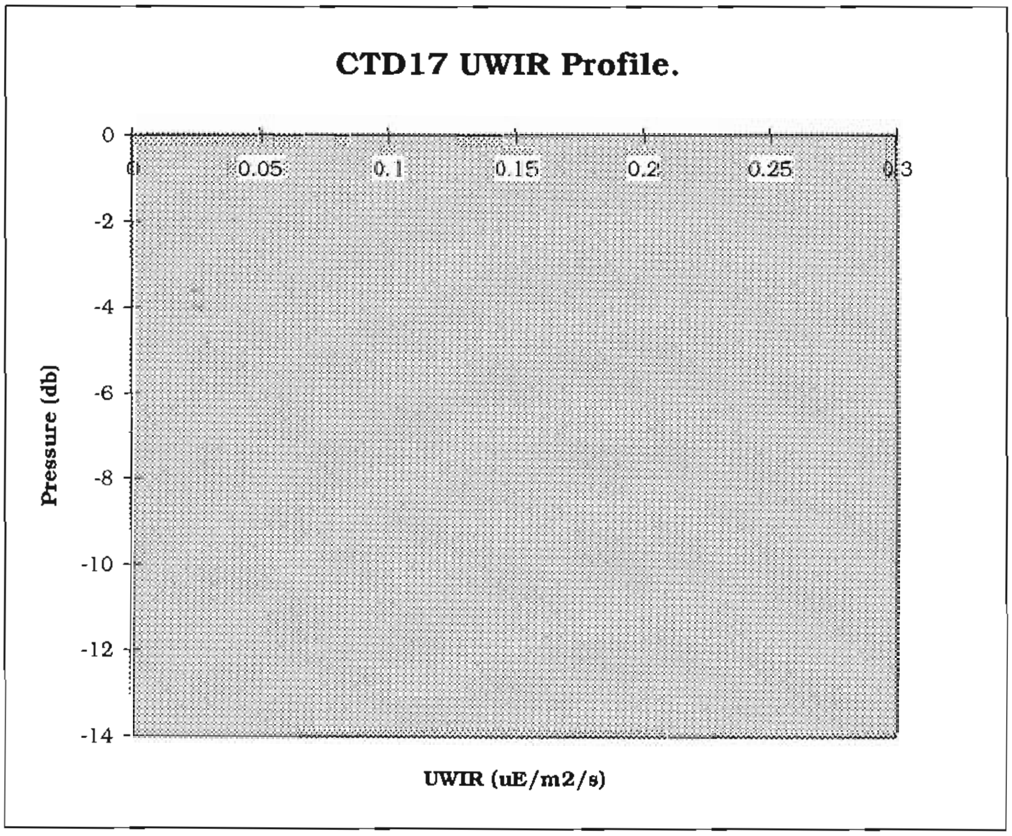

CTD15 DWIR Profile.
DWIR (uE/m2/s)
Pressure (db)
0
5
10
15
20
25
30
35
-2
-4
-6
-8
-10
-12
-14
-16

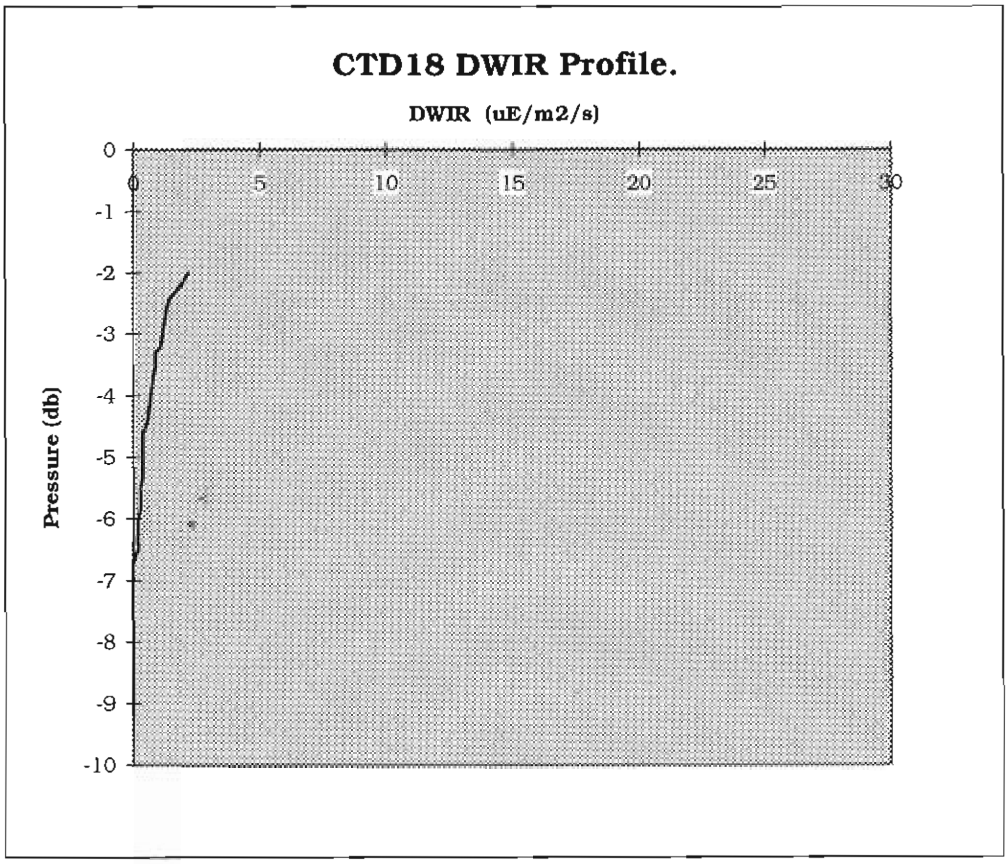

CTD15 UWIR Profile.
Pressure (db)
UWIR (uE/m2/s)
0
0.5
1
1.5
2
2.5
3
-2
-4
-6
-8
-10
-12
-14
-16

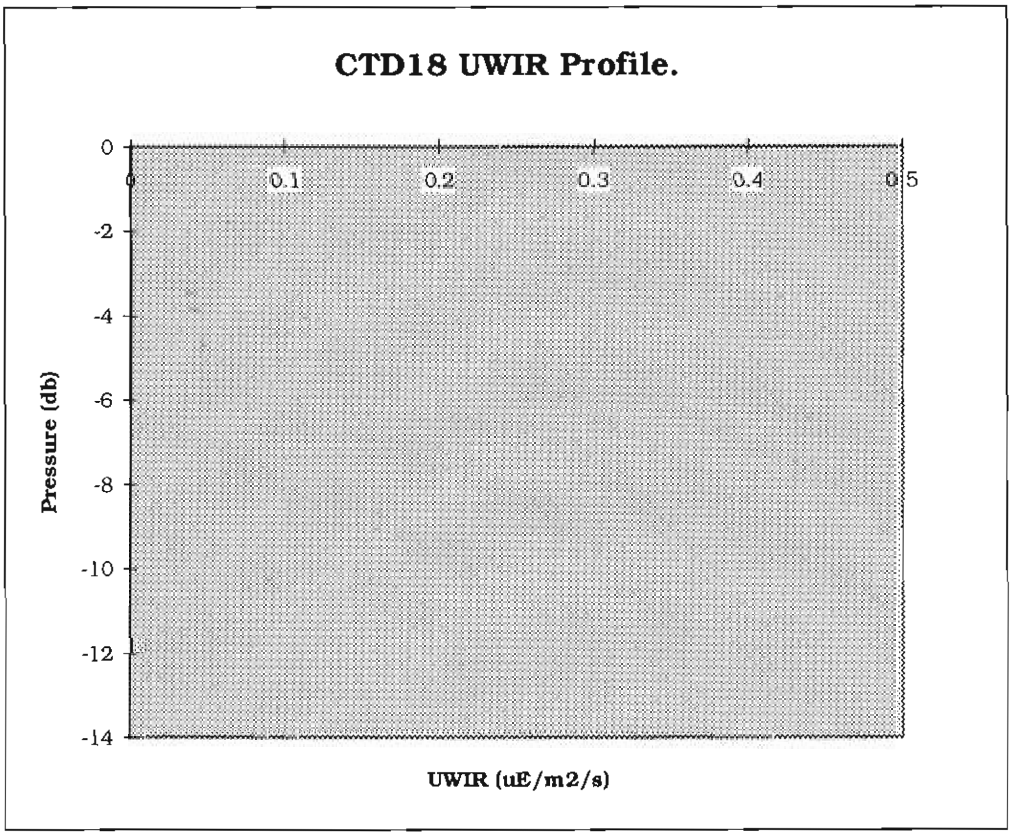

CTD16 DWIR Profile.
DWIR (uE/m2/s)
0
0.5
1
1.5
2
2.5
3
-2
-4
-6
-8
-10
-12
-14
Pressure (db)

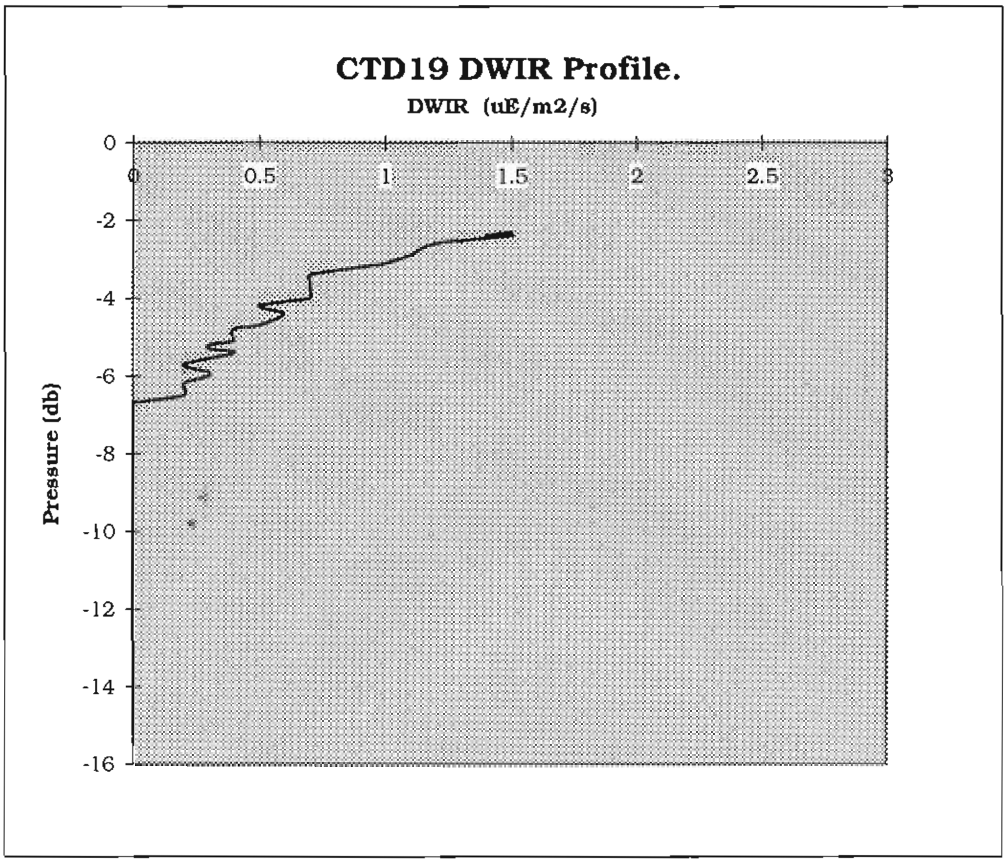

CTD16 UWIR Profile.
0
0.05
0.1
0.15
0.2
0.25
0.3
-2
-4
-6
-8
-10
-12
-14
Pressure (db)
UWIR (uE/m2/s)

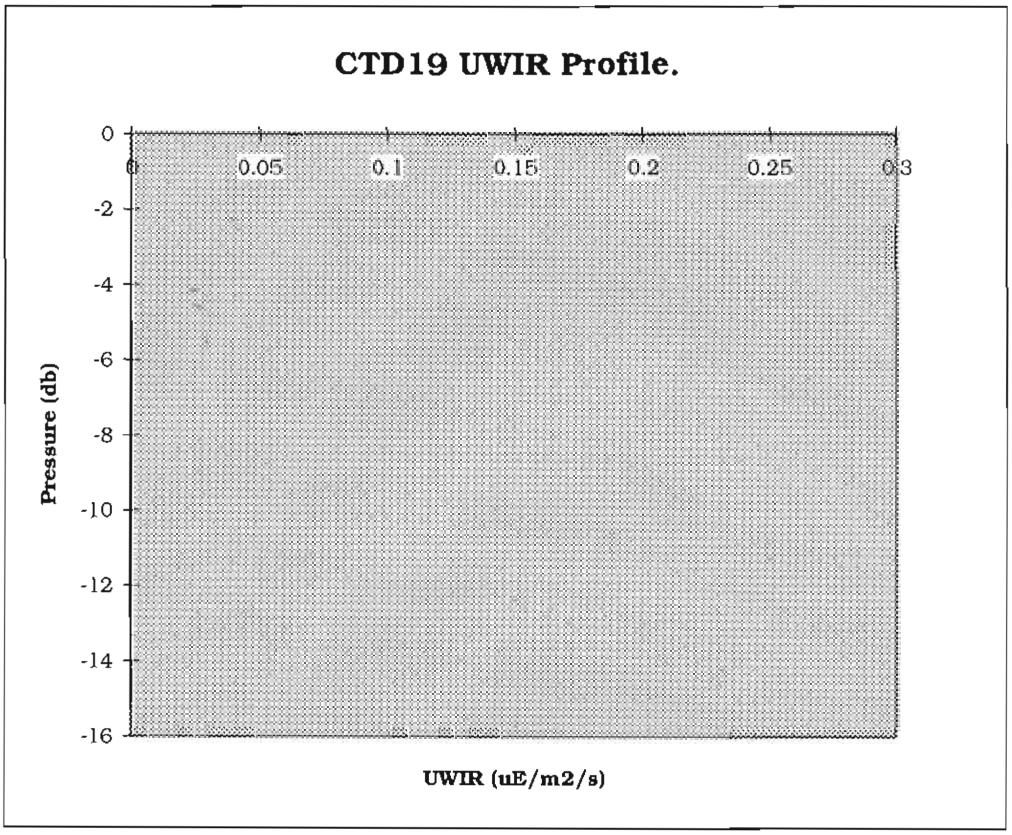

CTD17 DWIR Profile.
DWIR (uE/m2/s)
0
0.5
1
1.5
2
2.5
3
-2
-4
-6
-8
-10
-12
-14
Pressure (db)

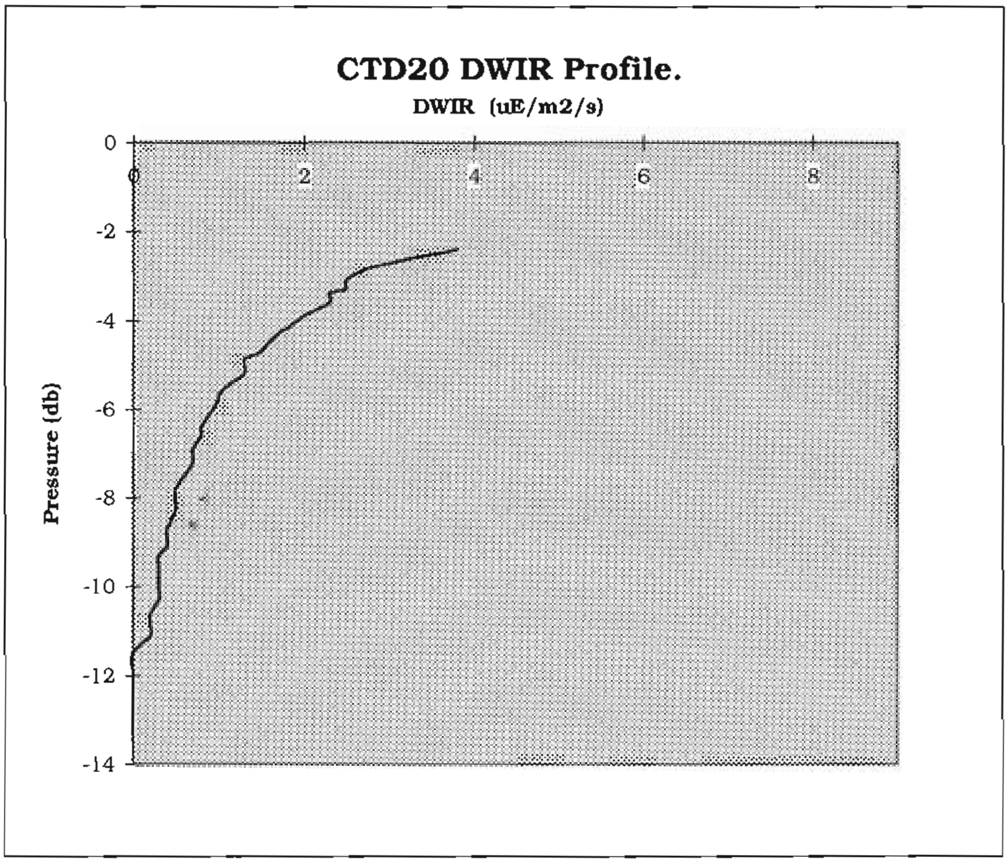

CTD17 UWIR Profile.
0
0.05
0.1
0.15
0.2
0.25
0.3
-2
-4
-6
-8
-10
-12
-14
Pressure (db)
UWIR (uE/m2/s)

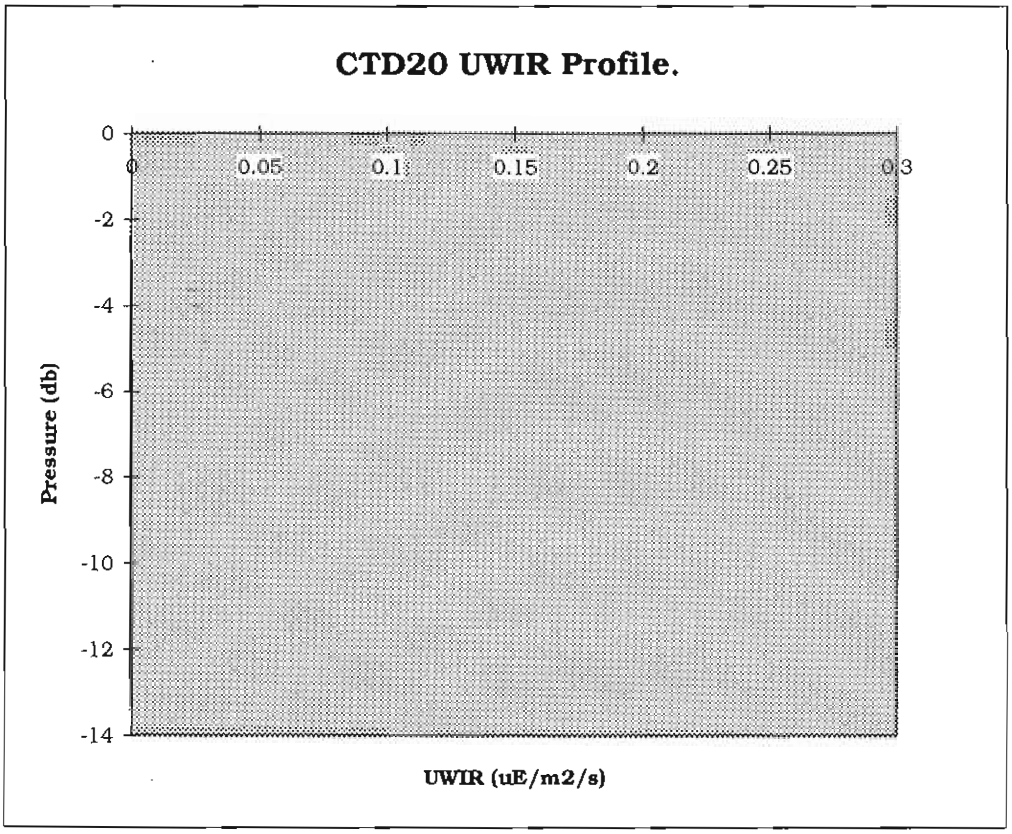

CTD18 DWIR Profile.
DWIR (uE/m2/s)
0
5
10
15
20
25
30
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
Pressure (db)

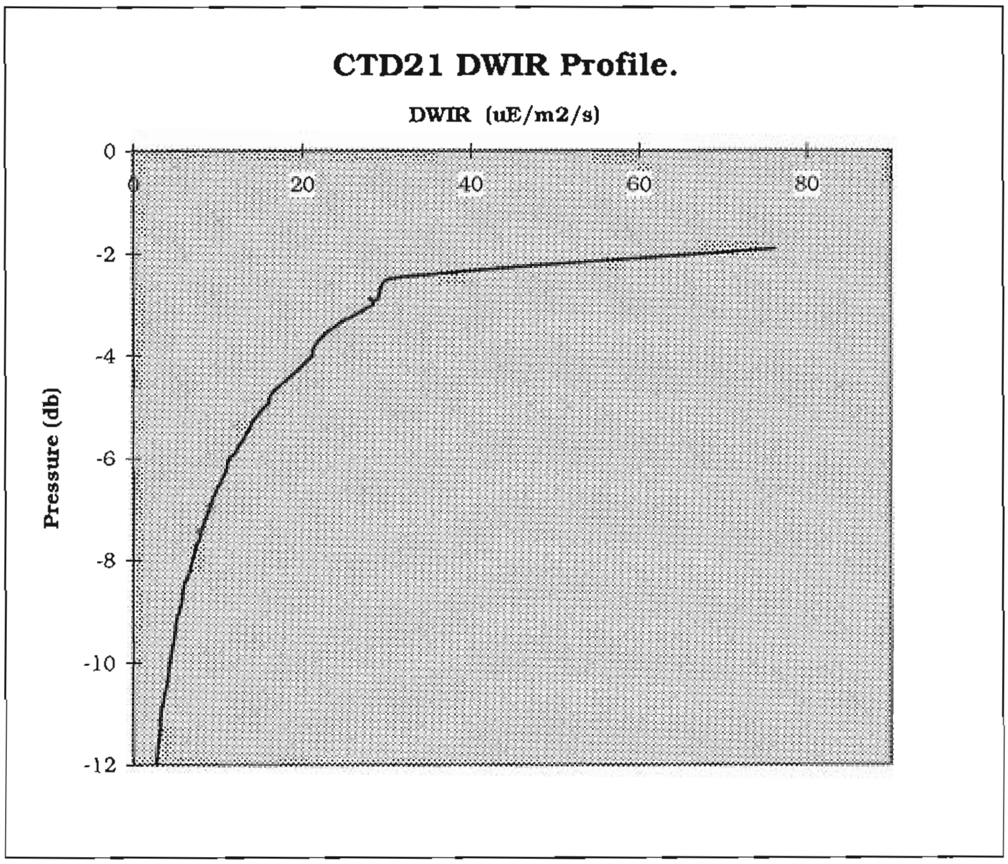

CTD18 UWIR Profile.
0
0.1
0.2
0.3
0.4
0.5
0
-2
-4
-6
-8
-10
-12
-14
Pressure (db)
UWIR (uE/m2/s)

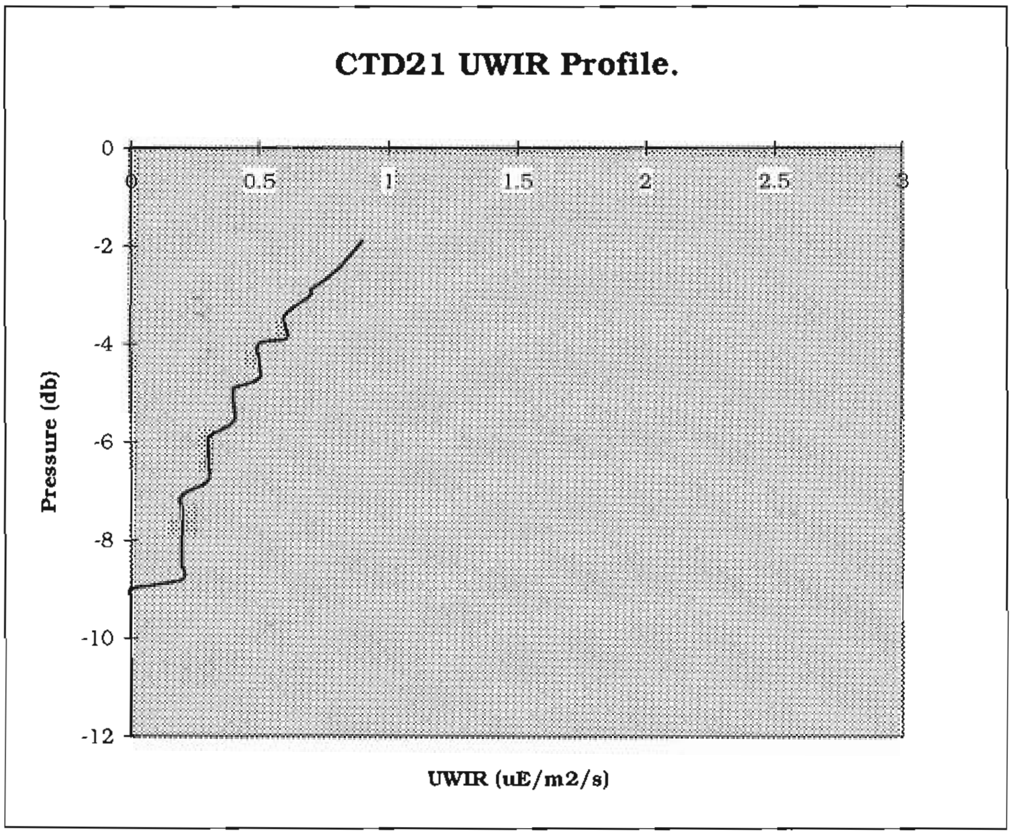

CTD19 DWIR Profile.
DWIR (uE/m2/s)
0
0.5
1
1.5
2
2.5
3
-2
-4
-6
-8
-10
-12
-14
-16
Pressure (db)

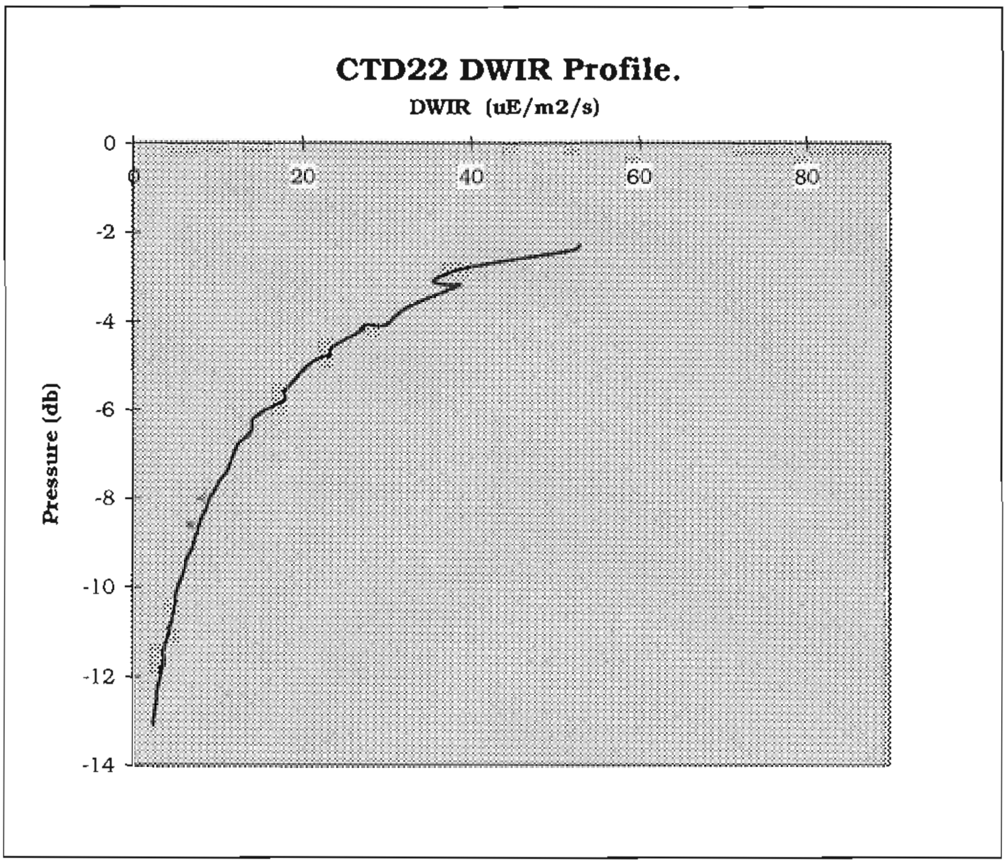

CTD19 UWIR Profile.
0
0.05
0.1
0.15
0.2
0.25
0.3
-2
-4
-6
-8
-10
-12
-14
-16
Pressure (db)
UWIR (uE/m2/s)

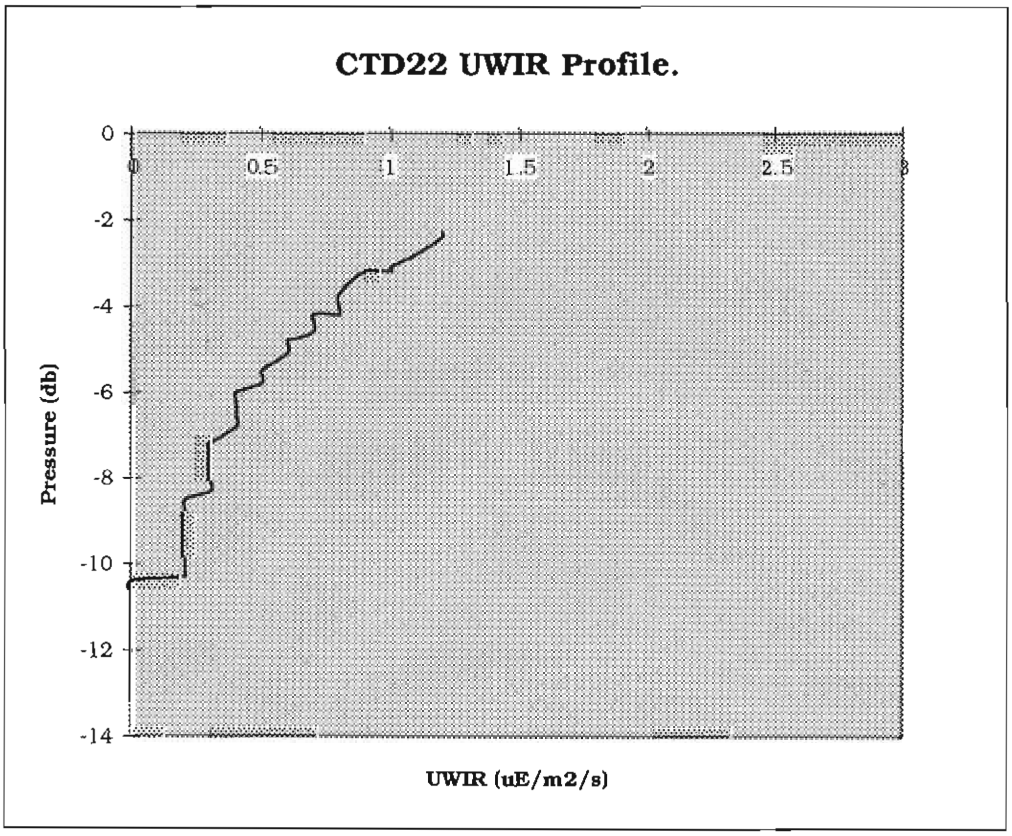

CTD20 DWIR Profile.
DWIR (uE/m2/s)
0
2
4
6
8
0
-2
-4
-6
-8
-10
-12
-14
Pressure (db)

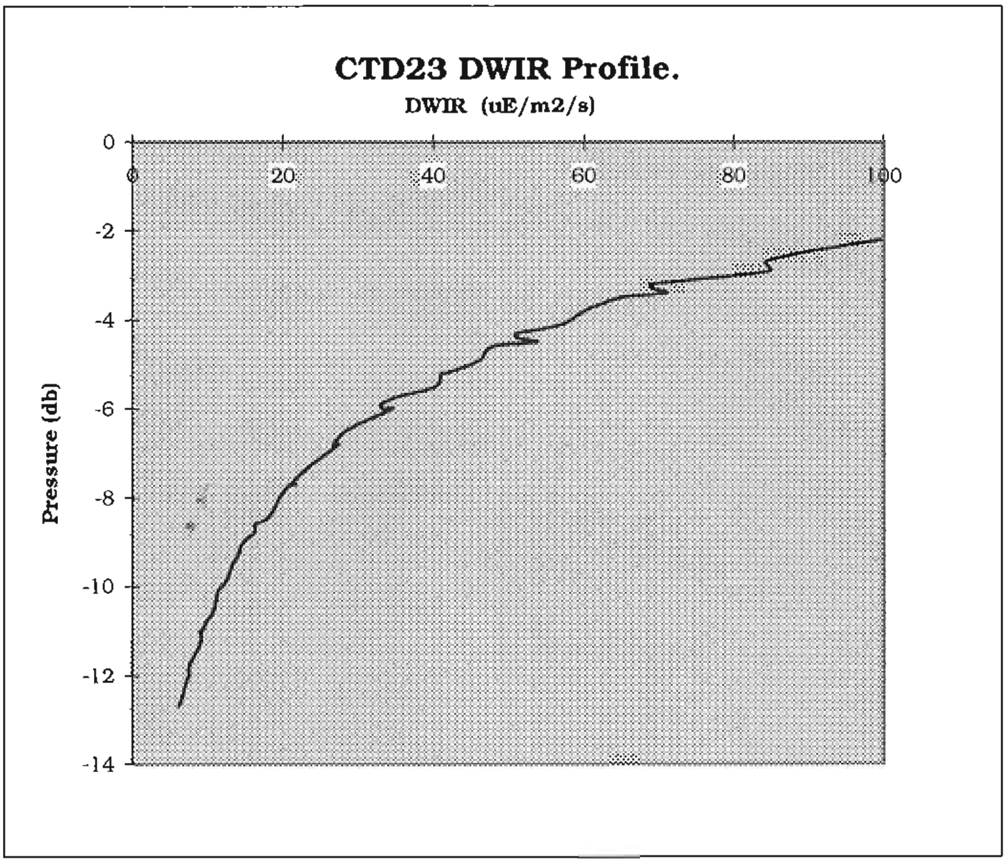

CTD20 UWIR Profile.
0
0.05
0.1
0.15
0.2
0.25
0.3
0
-2
-4
-6
-8
-10
-12
-14
Pressure (db)
UWIR (uE/m2/s)


CTD21 DWIR Profile.
DWIR (uE/m2/s)
0
20
40
60
80
0
-2
-4
-6
-8
-10
-12
Pressure (db)

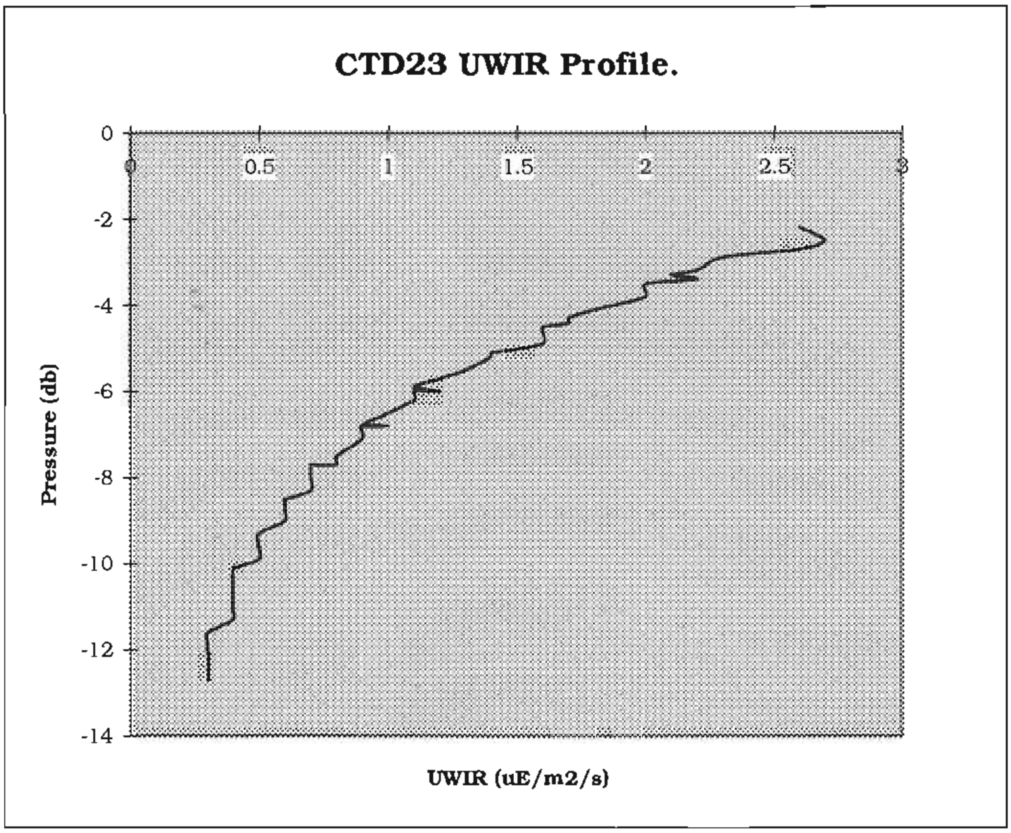

CTD21 UWIR Profile.
0
0.5
1
1.5
2
2.5
3
0
-2
-4
-6
-8
-10
-12
Pressure (db)
UWIR (uE/m2/s)


CTD22 DWIR Profile.
DWIR (uE/m2/s)
0
20
40
60
80
0
-2
-4
-6
-8
-10
-12
-14
Pressure (db)

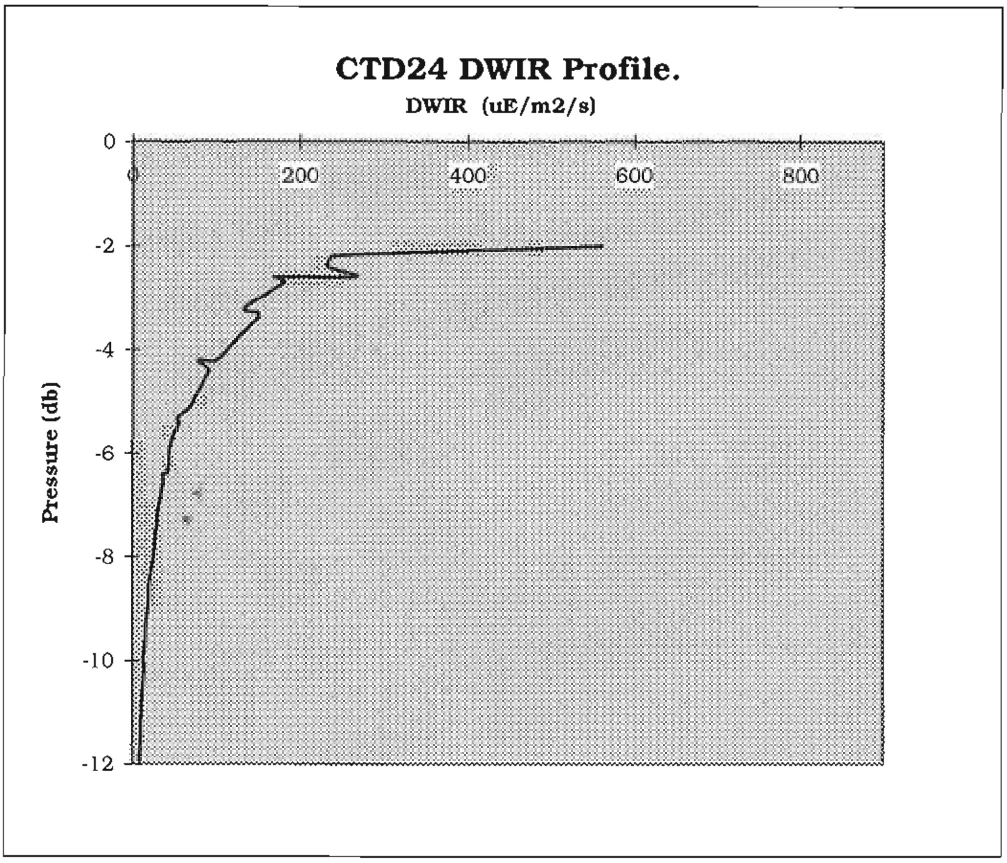

CTD22 UWIR Profile.
0
0.5
1
1.5
2
2.5
3
0
-2
-4
-6
-8
-10
-12
-14
Pressure (db)
UWIR (uE/m2/s)

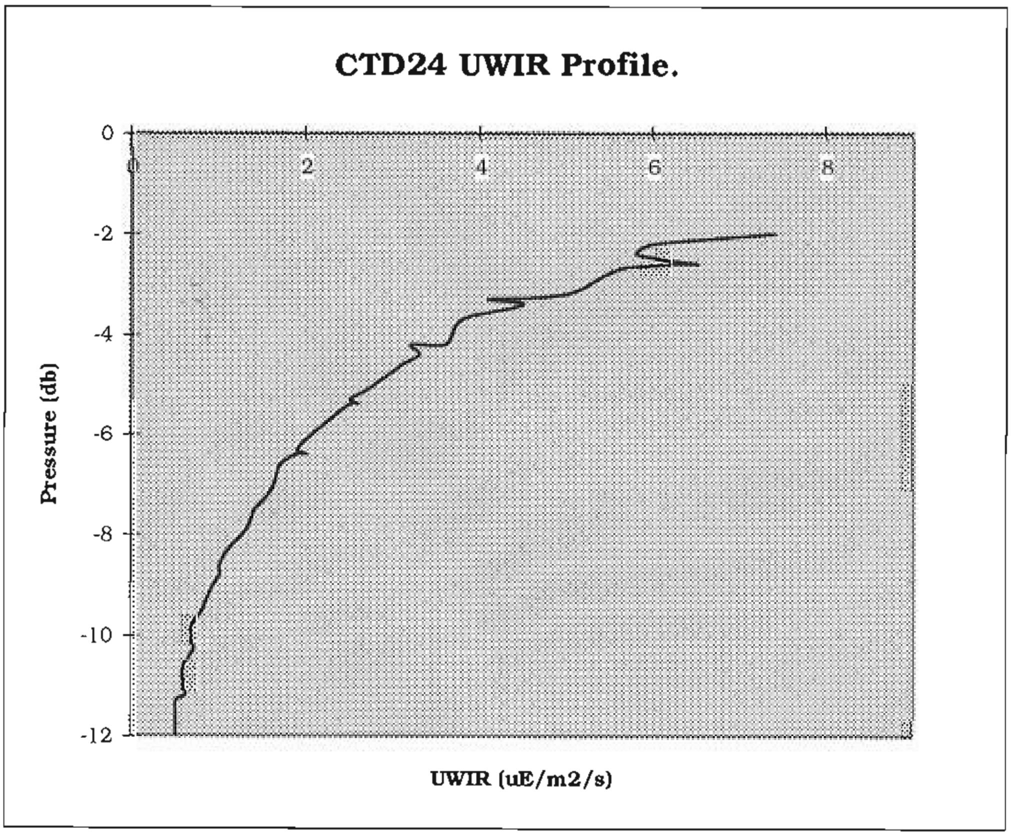


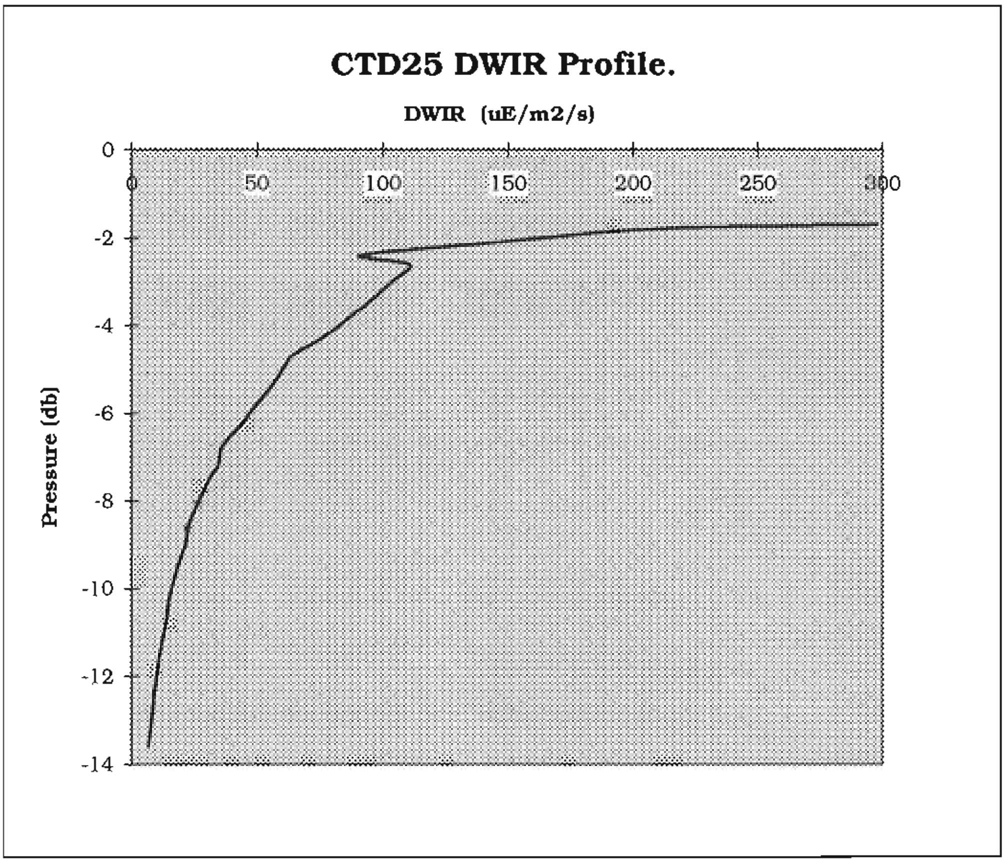
CTD23 DWIR Profile.
DWIR (uE/m2/s)
0
20
40
60
80
100
0
-2
-4
-6
-8
-10
-12
-14
Pressure (db)

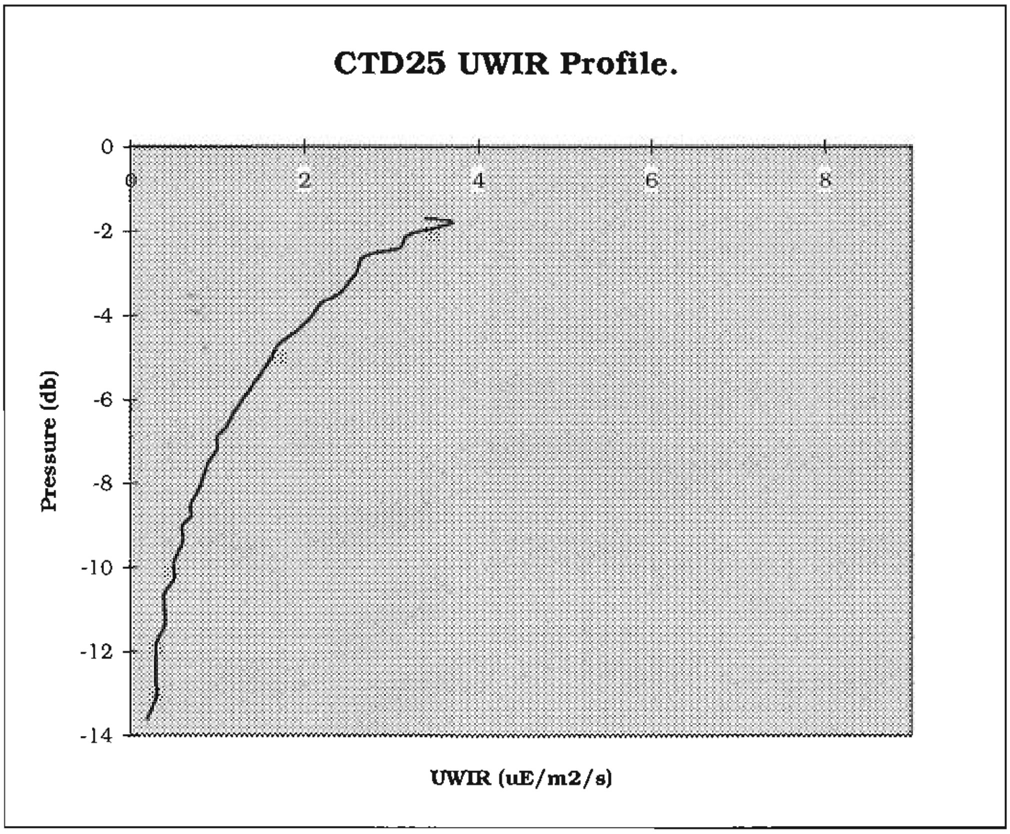


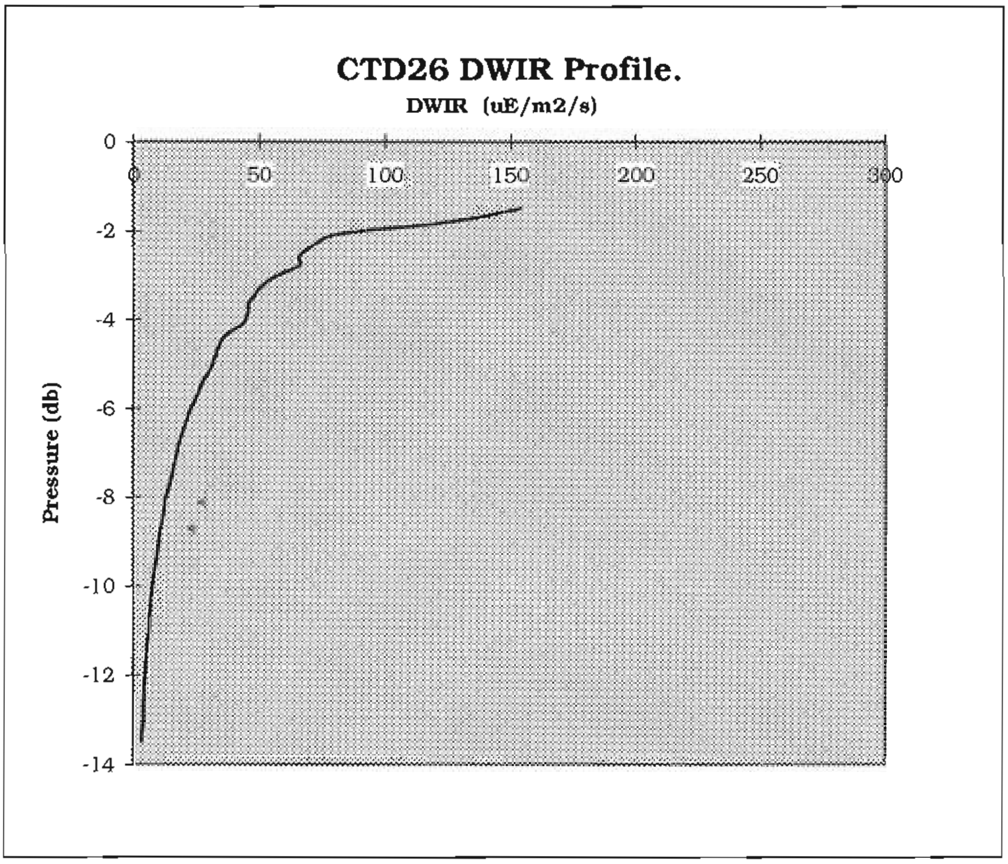
CTD23 UWIR Profile.
0
0.5
1
1.5
2
2.5
3
0
-2
-4
-6
-8
-10
-12
-14
Pressure (db)
UWIR (uE/m2/s)

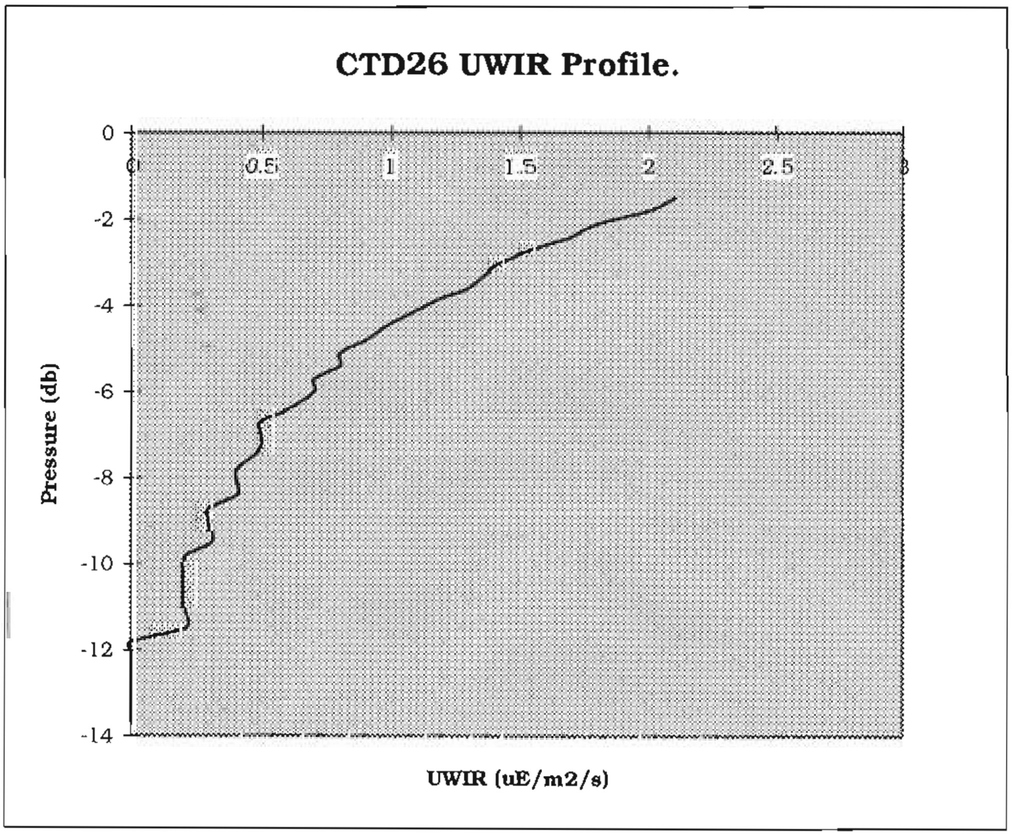

CTD24 DWIR Profile.
DWIR (uE/m2/s)
0
200
400
600
800
0
-2
-4
-6
-8
-10
-12
Pressure (db)

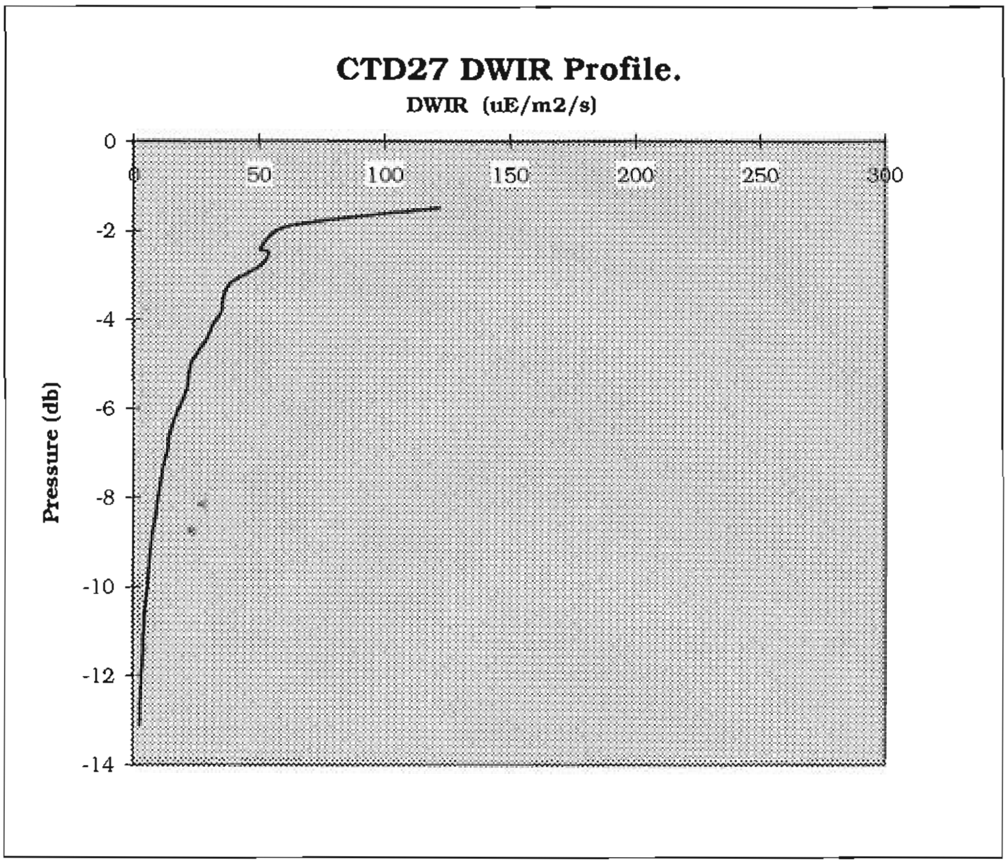

CTD24 UWIR Profile.
0
2
4
6
8
0
-2
-4
-6
-8
-10
-12
Pressure (db)
UWIR (uE/m2/s)

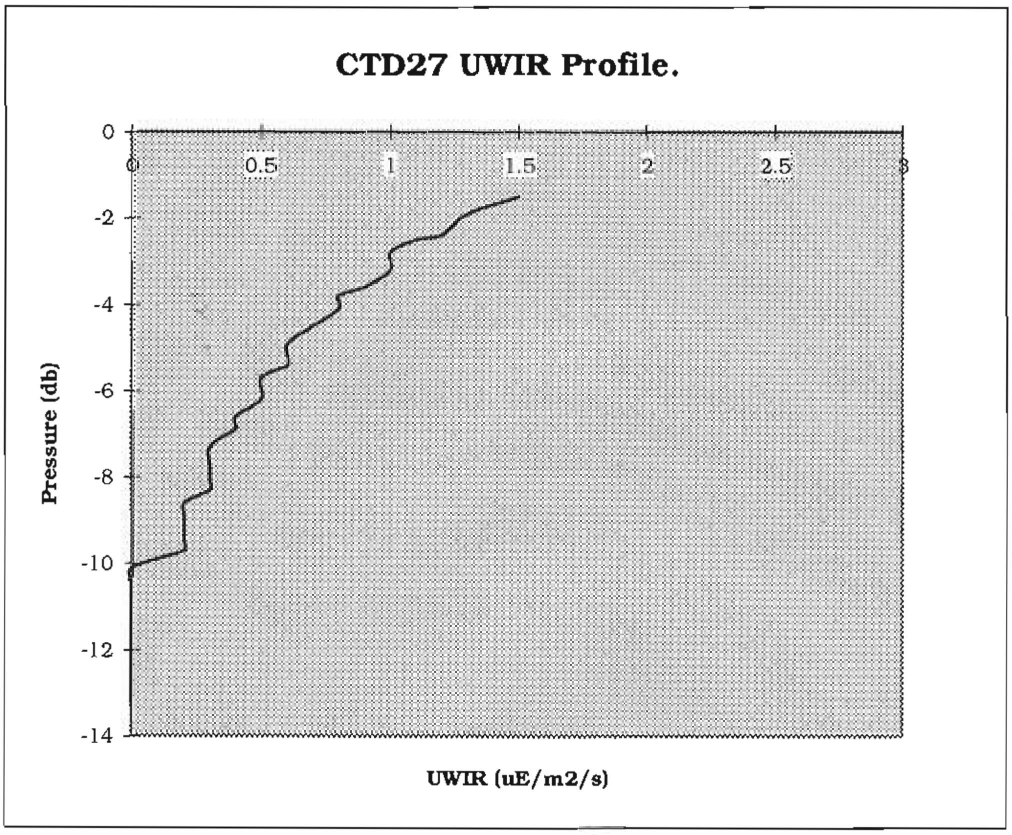

CTD25 DWIR Profile.
DWIR (uE/m2/s)
0
50
100
150
200
250
300
-2
-4
-6
-8
-10
-12
-14
Pressure (db)

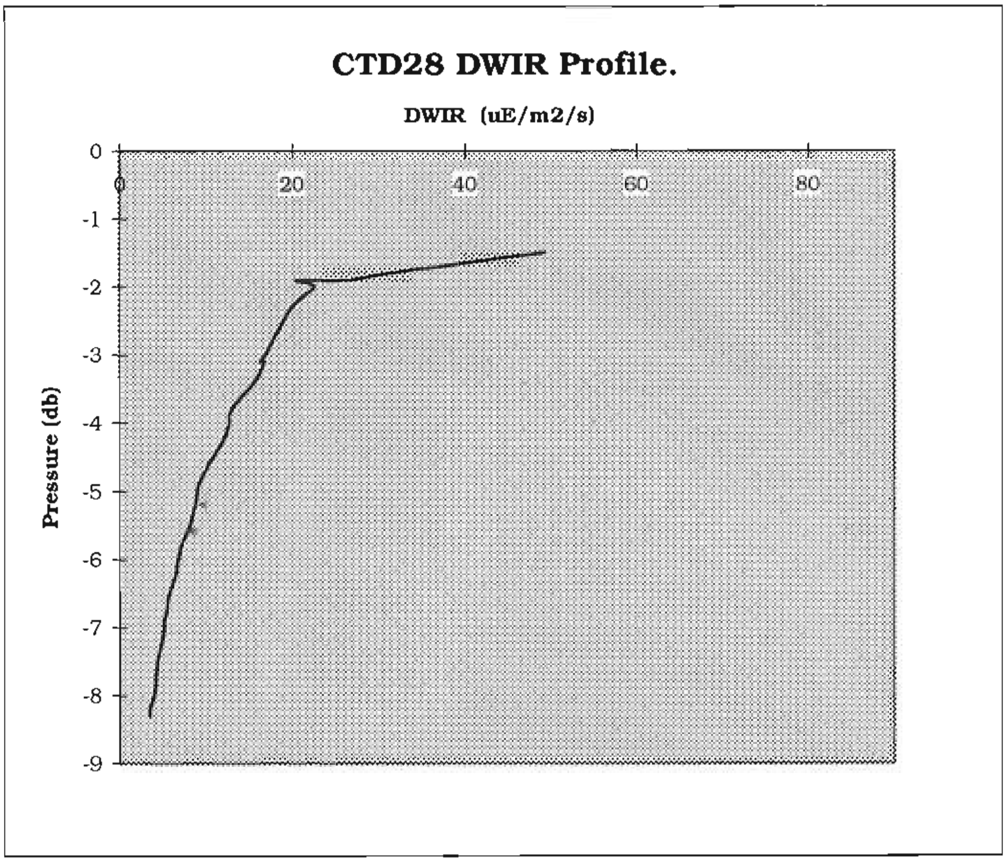

CTD25 UWIR Profile.
0
2
4
6
8
-2
-4
-6
-8
-10
-12
-14
Pressure (db)
UWIR (uE/m2/s)

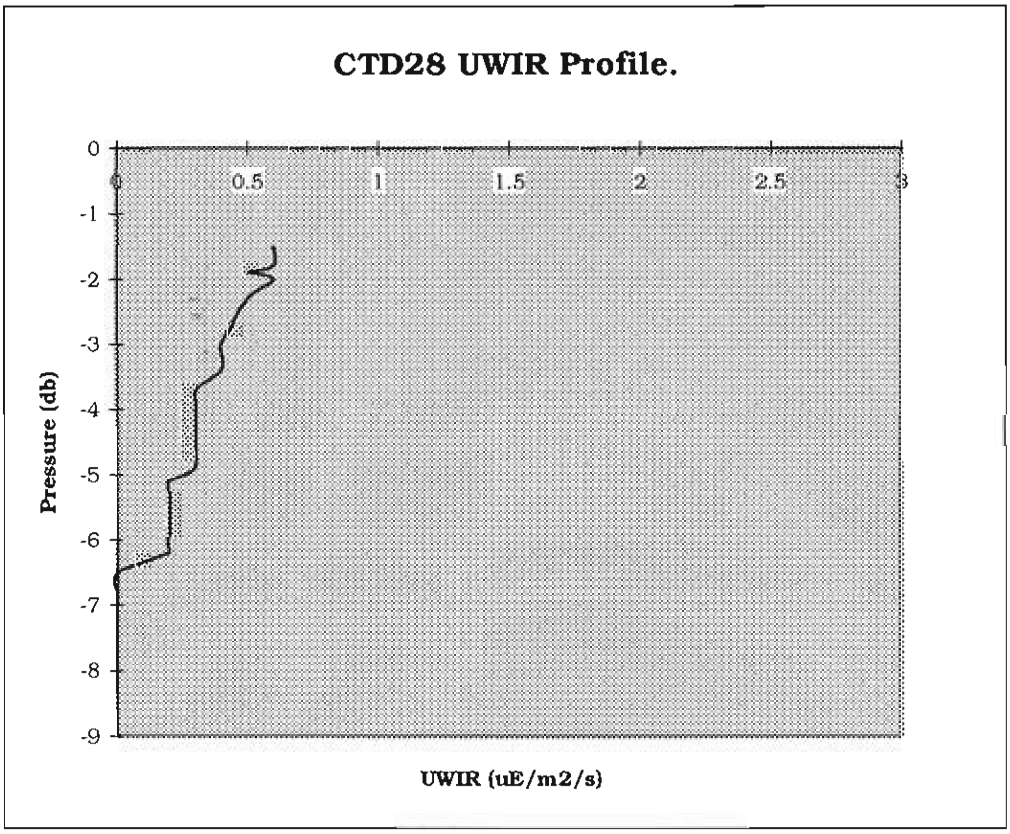

CTD26 DWIR Profile.
DWIR (uE/m2/s)
0
50
100
150
200
250
300
0
-2
-4
-6
-8
-10
-12
-14
Pressure (db)

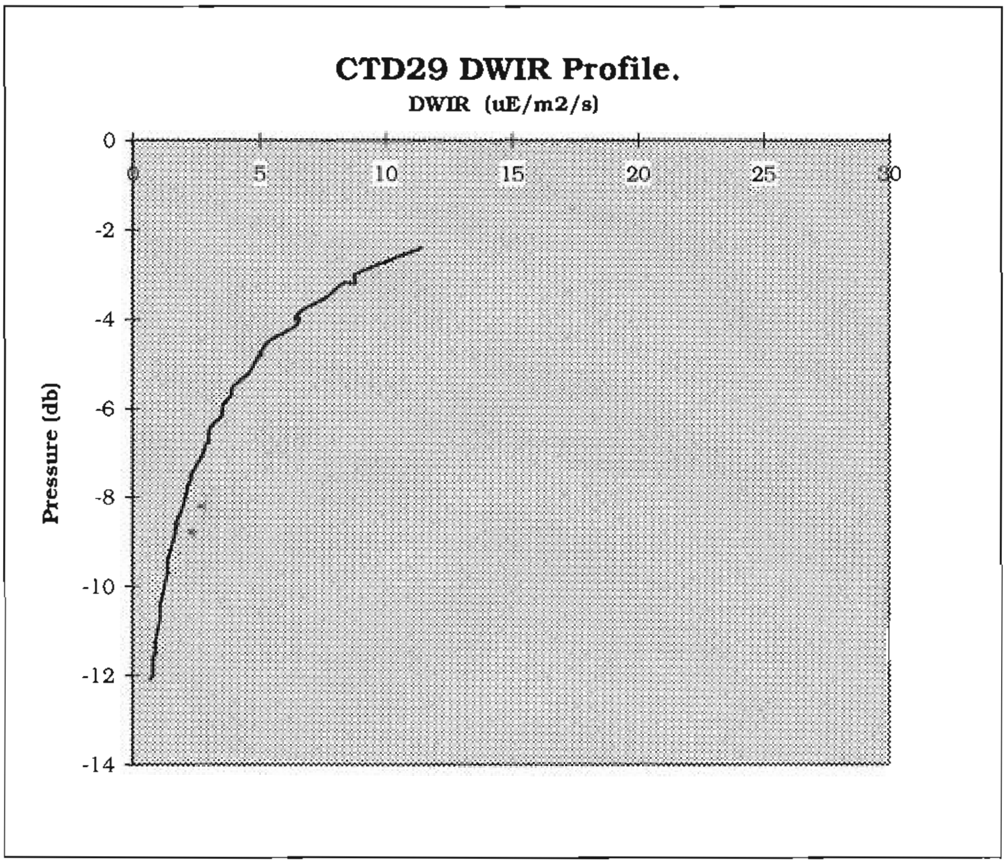

CTD26 UWIR Profile.
0
0.5
1
1.5
2
2.5
3
0
-2
-4
-6
-8
-10
-12
-14
Pressure (db)
UWIR (uE/m2/s)

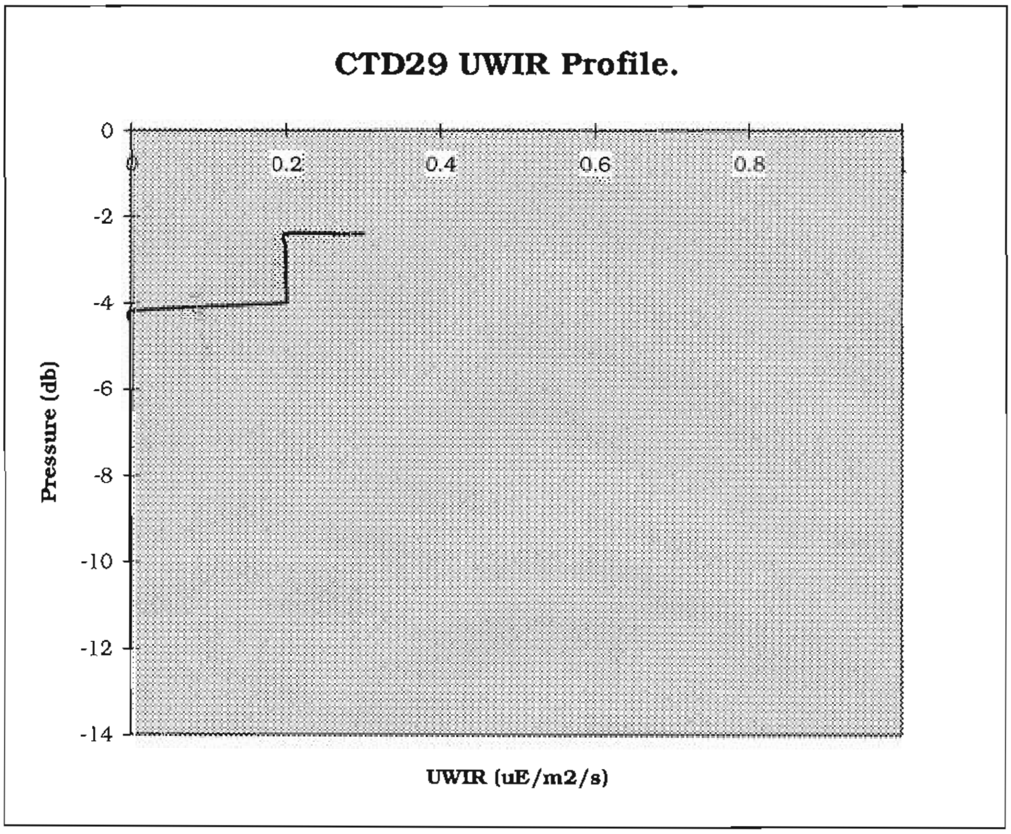

CTD27 DWIR Profile.
DWIR (uE/m2/s)
0
50
100
150
200
250
300
0
-2
-4
-6
-8
-10
-12
-14
Pressure (db)

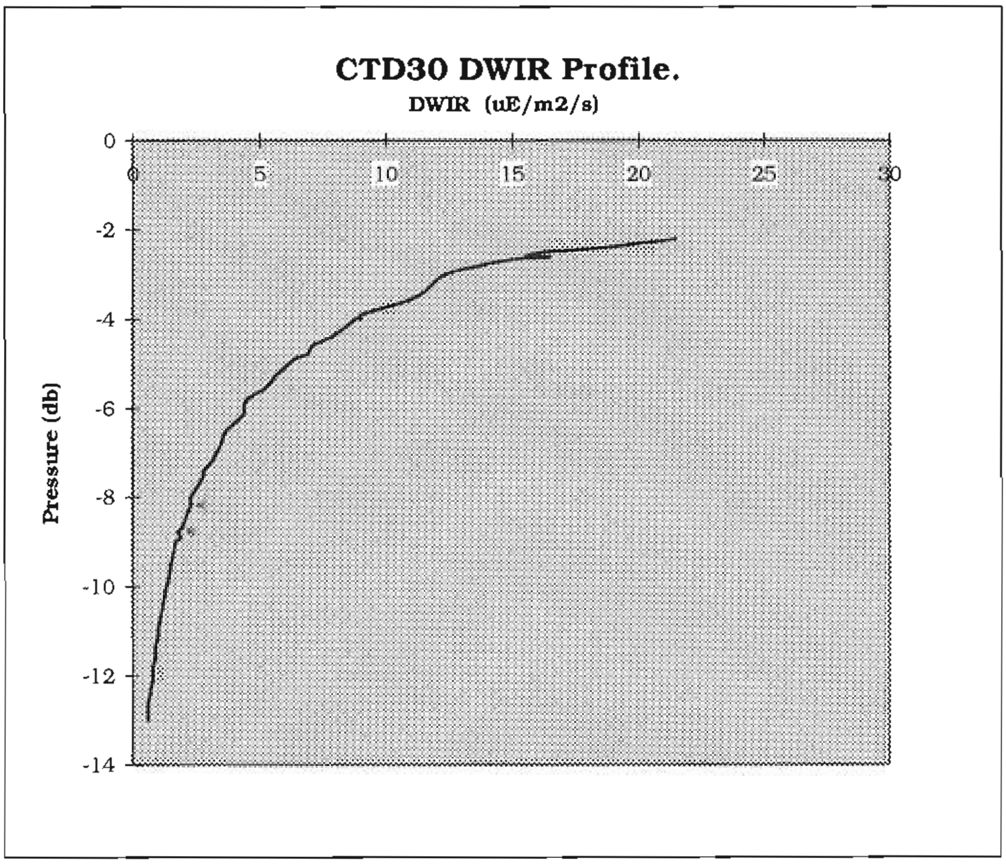

CTD27 UWIR Profile.
0
0.5
1
1.5
2
2.5
3
0
-2
-4
-6
-8
-10
-12
-14
Pressure (db)
UWIR (uE/m2/s)

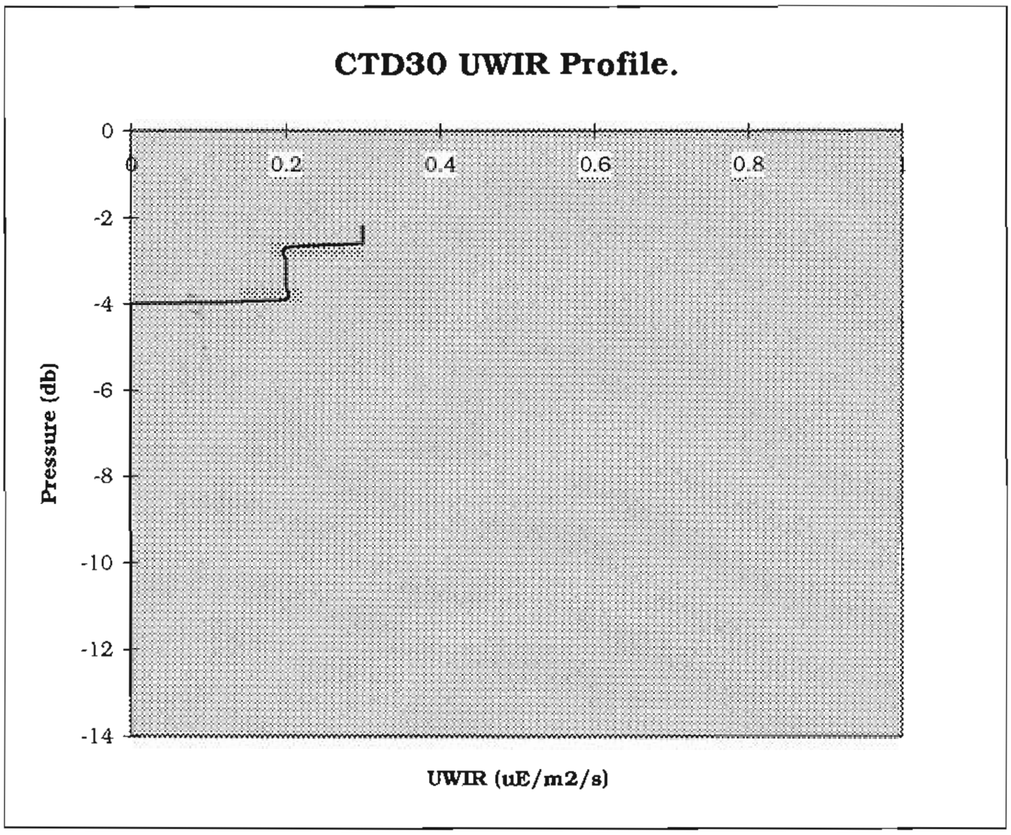

CTD28 DWIR Profile.
DWIR (uE/m2/s)
0
20
40
60
80
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
Pressure (db)

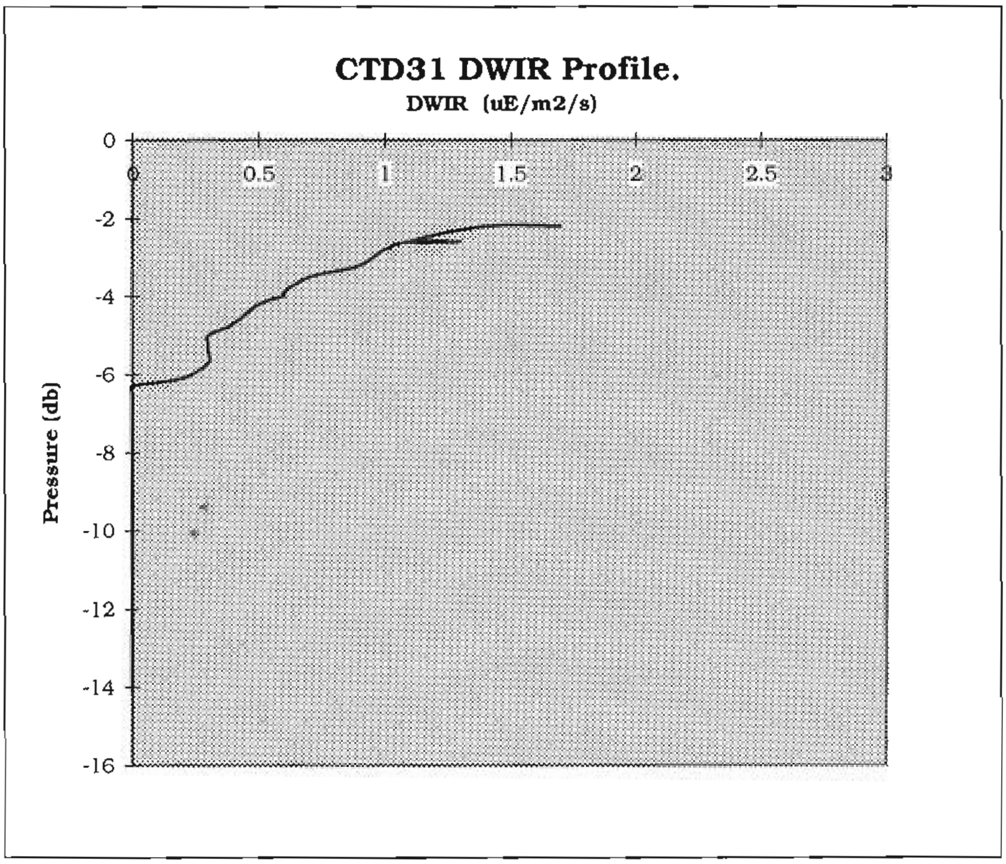

CTD28 UWIR Profile.
0
0.5
1
1.5
2
2.5
3
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
Pressure (db)
UWIR (uE/m2/s)

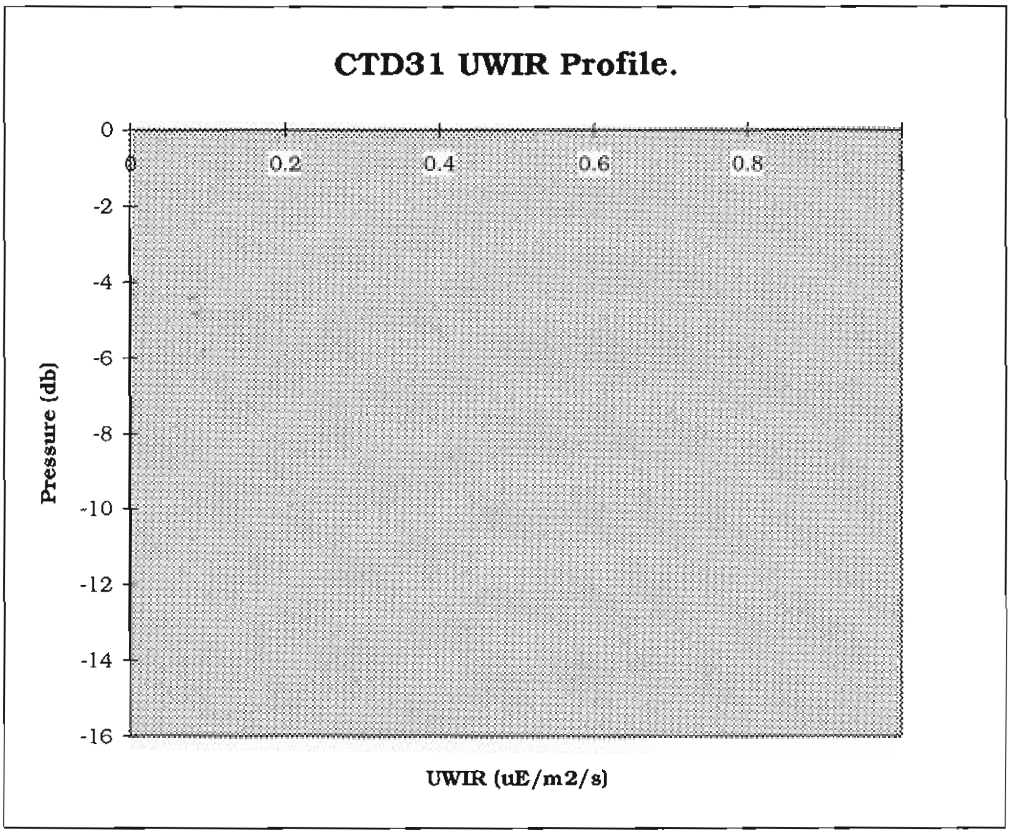

CTD29 DWIR Profile.
DWIR (uE/m2/s)
0
5
10
15
20
25
30
0
-2
-4
-6
-8
-10
-12
-14
Pressure (db)

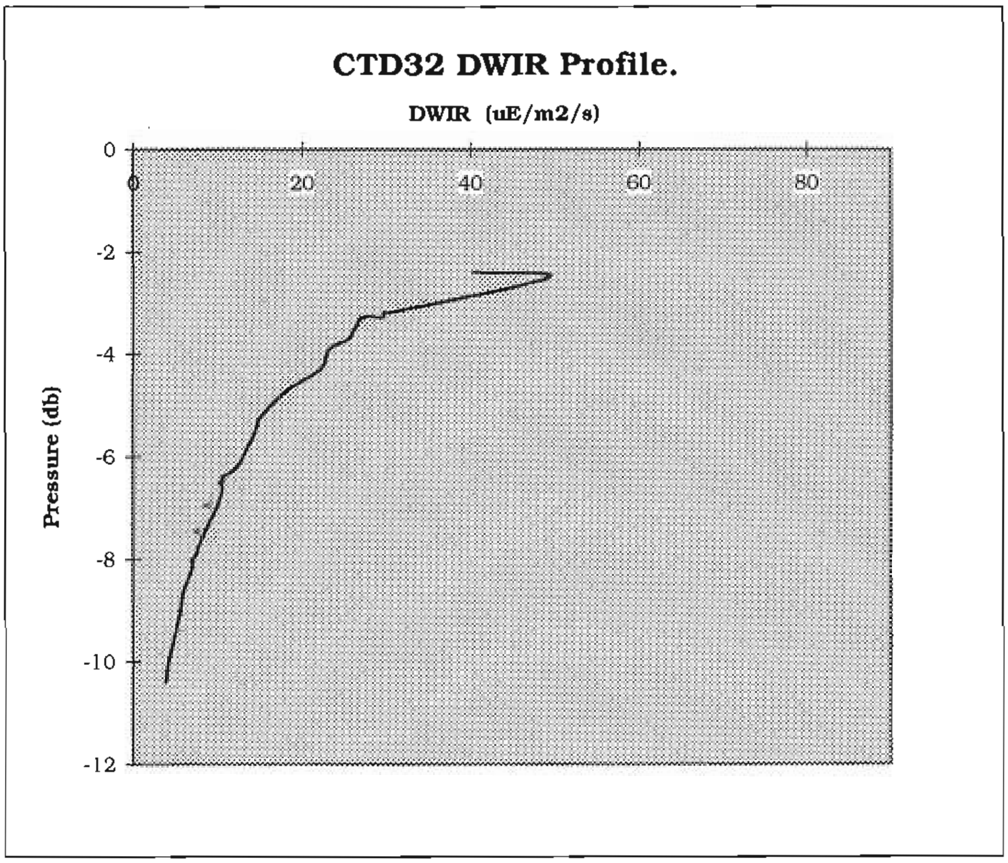

CTD29 UWIR Profile.
0
0.2
0.4
0.6
0.8
1
0
-2
-4
-6
-8
-10
-12
-14
Pressure (db)
UWIR (uE/m2/s)

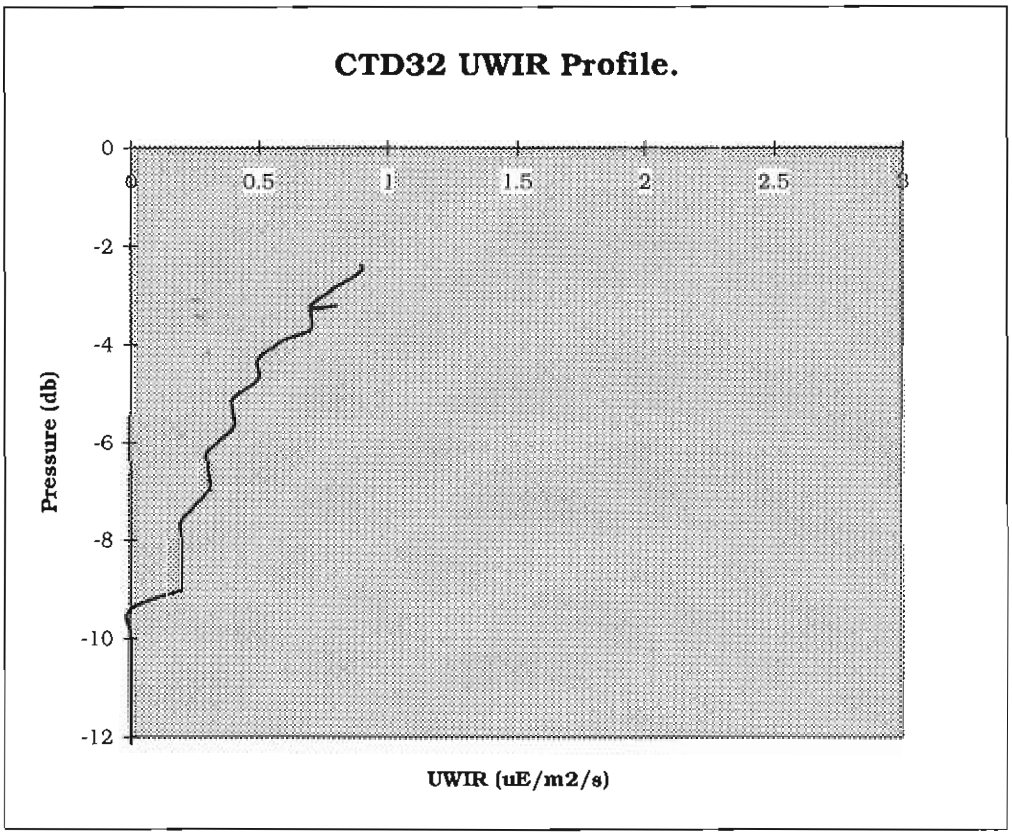

CTD30 DWIR Profile.
DWIR (uE/m2/s)
Pressure (db)
0
-2
-4
-6
-8
-10
-12
-14
0
5
10
15
20
25
30

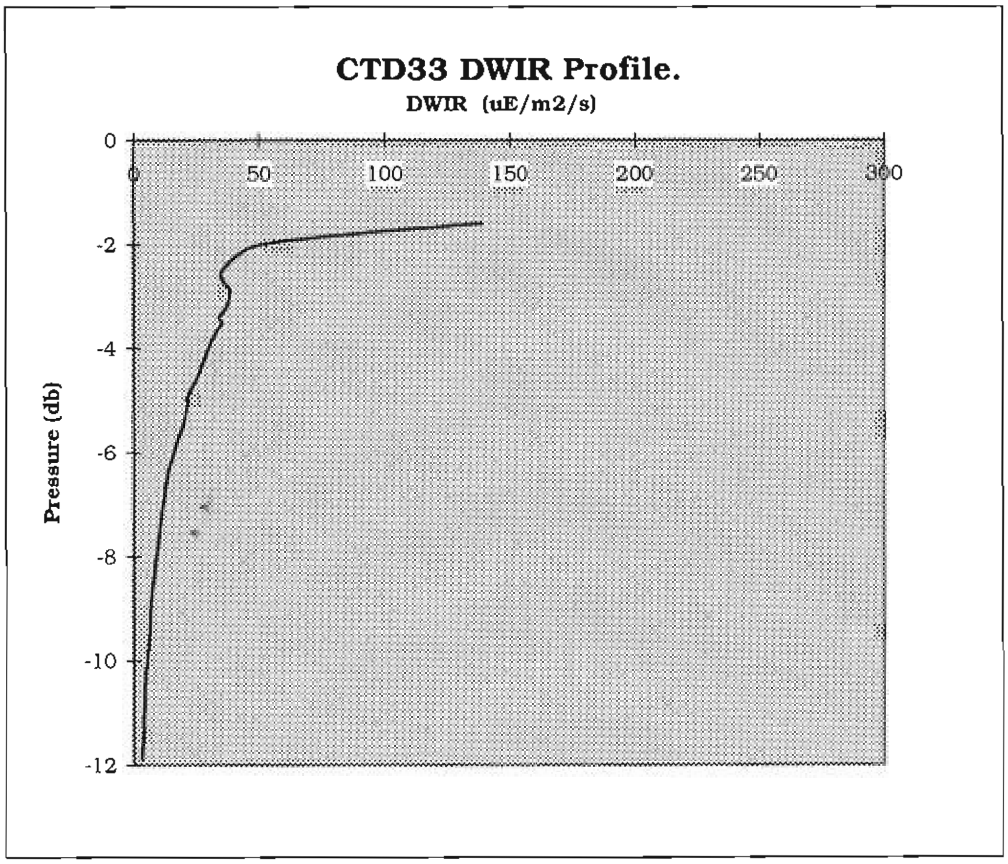

CTD30 UWIR Profile.
Pressure (db)
UWIR (uE/m2/s)
0
-2
-4
-6
-8
-10
-12
-14
0
0.2
0.4
0.6
0.8
1

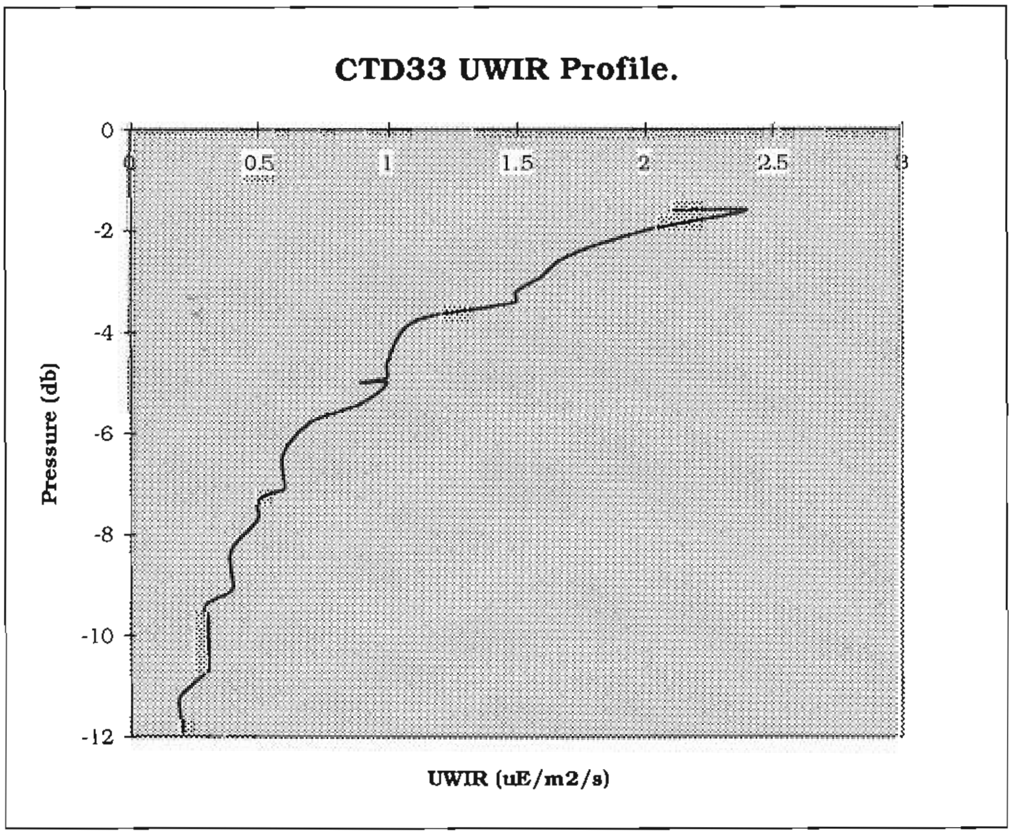

CTD31 DWIR Profile.
DWIR (uE/m2/s)
0
0.5
1
1.5
2
2.5
3
-2
-4
-6
-8
-10
-12
-14
-16
Pressure (db)

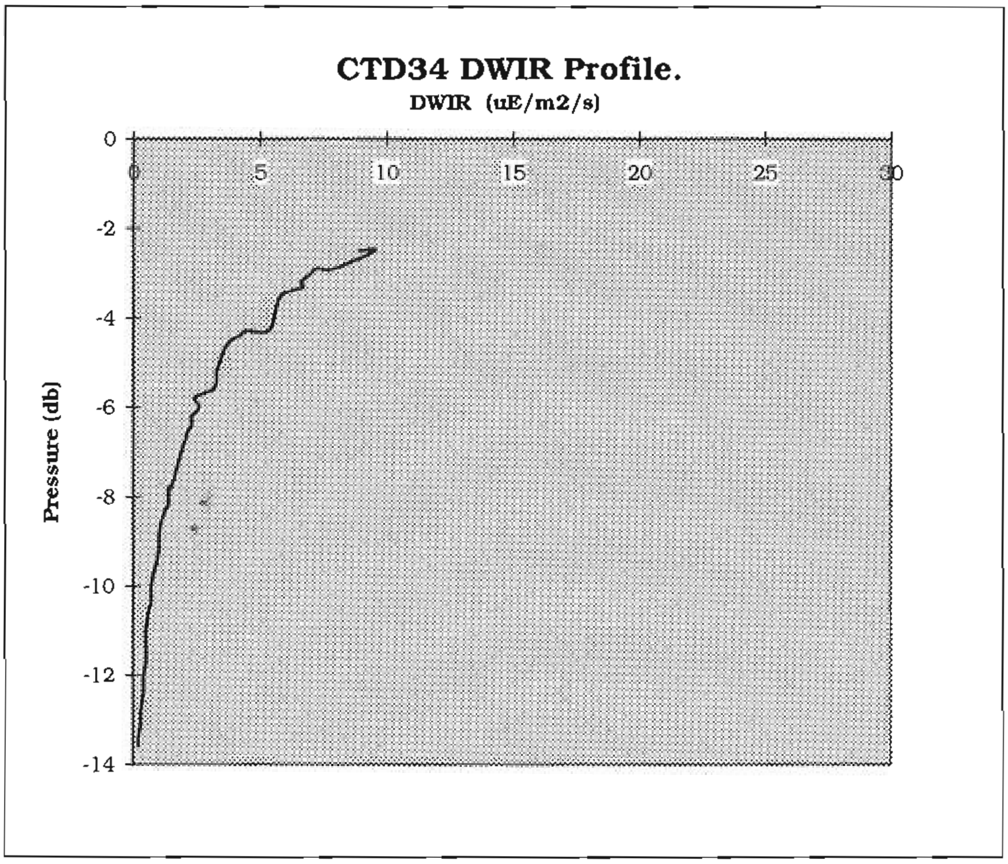

CTD31 UWIR Profile.
0
0.2
0.4
0.6
0.8
1
-2
-4
-6
-8
-10
-12
-14
-16
Pressure (db)
UWIR (uE/m2/s)

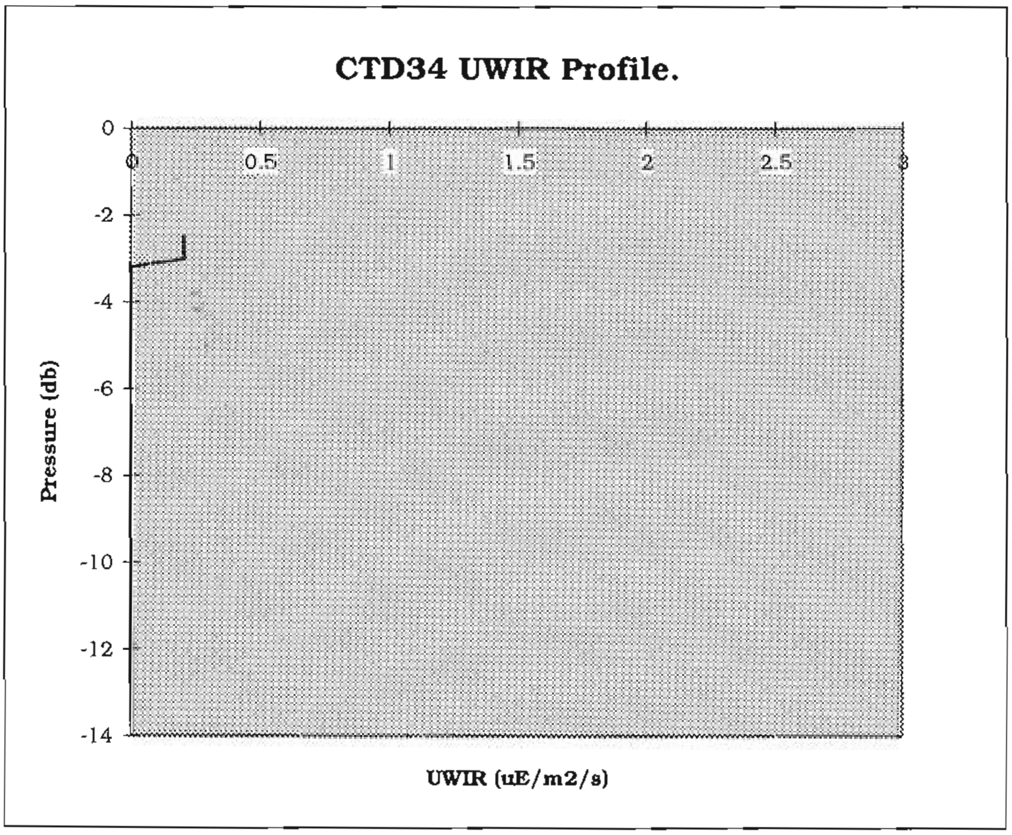

CTD32 DWIR Profile.
DWIR (uE/m2/s)
0
20
40
60
80
0
-2
-4
-6
-8
-10
-12
Pressure (db)

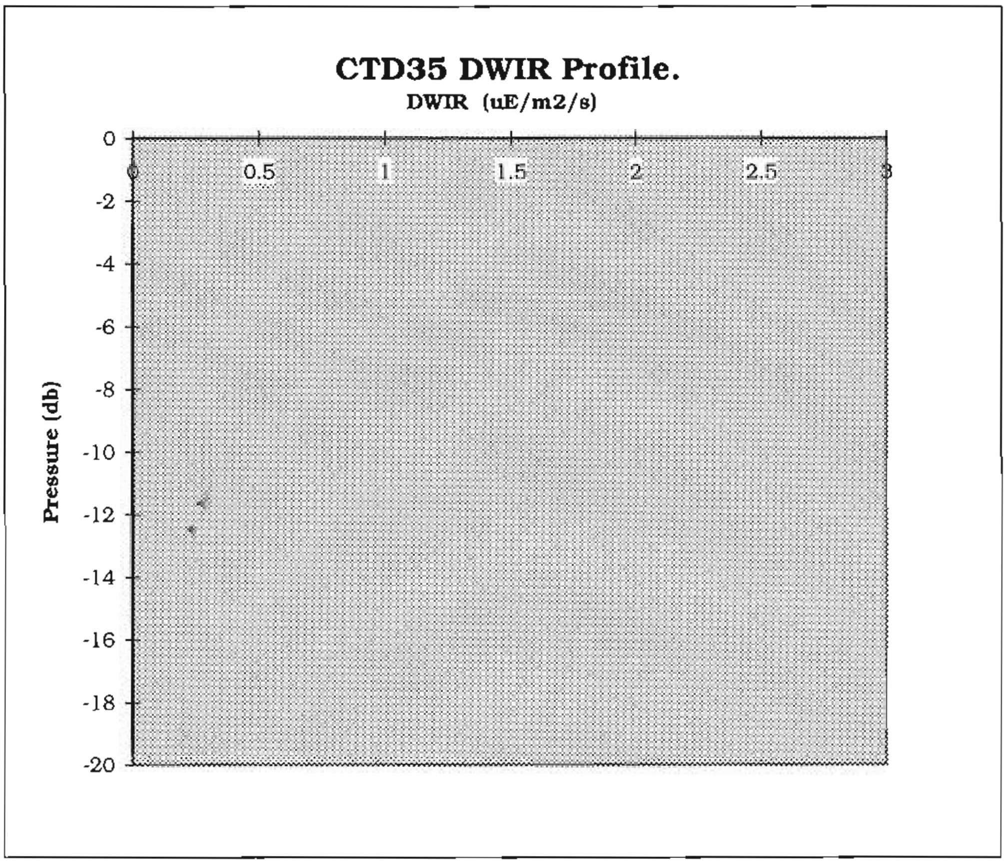

CTD32 UWIR Profile.
0
0.5
1
1.5
2
2.5
3
0
-2
-4
-6
-8
-10
-12
Pressure (db)
UWIR (uE/m2/s)


CTD33 DWIR Profile.
DWIR (uE/m2/s)
0
50
100
150
200
250
300
0
-2
-4
-6
-8
-10
-12
Pressure (db)

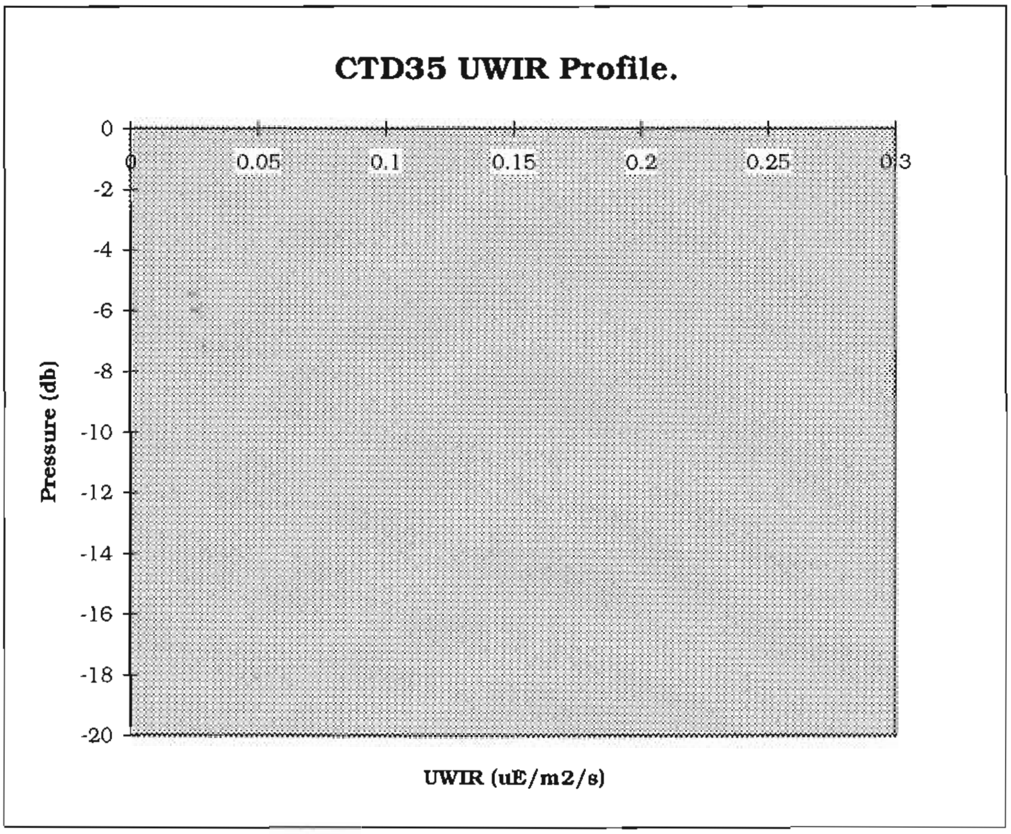

CTD33 UWIR Profile.
0
0.5
1
1.5
2
2.5
3
0
-2
-4
-6
-8
-10
-12
Pressure (db)
UWIR (uE/m2/s)


CTD34 DWIR Profile.
DWIR (uE/m2/s)
0
5
10
15
20
25
30
0
-2
-4
-6
-8
-10
-12
-14
Pressure (db)

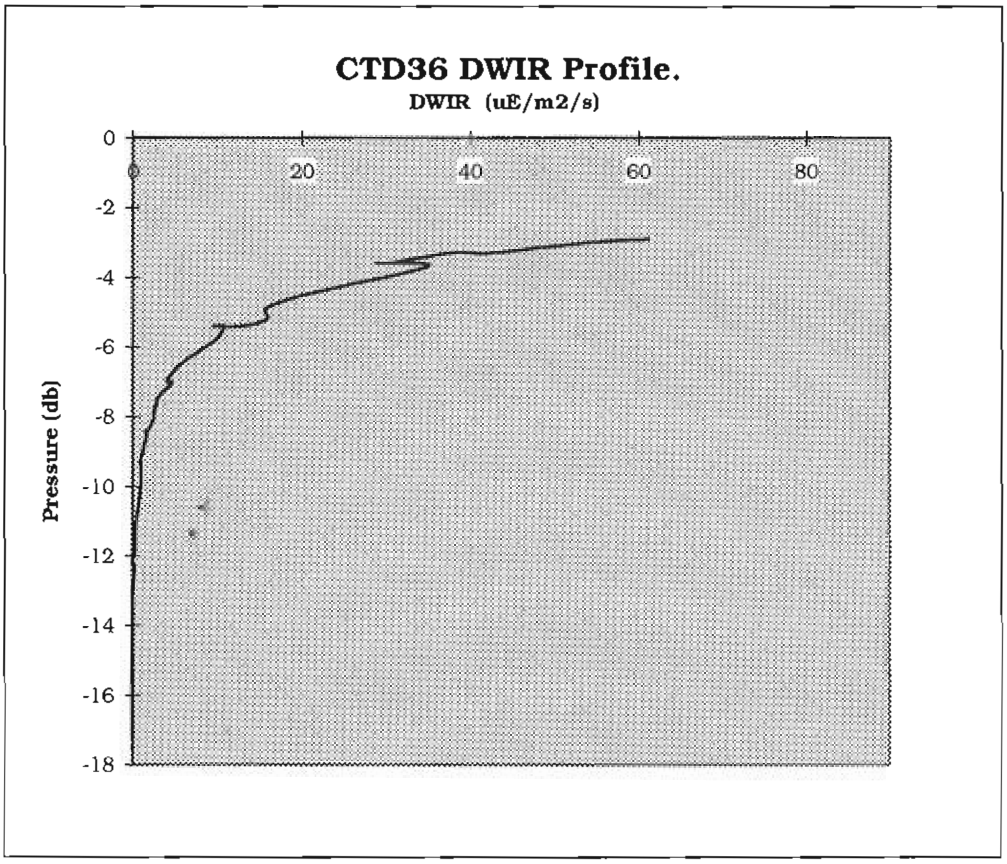

CTD34 UWIR Profile.
0
0.5
1
1.5
2
2.5
3
0
-2
-4
-6
-8
-10
-12
-14
Pressure (db)
UWIR (uE/m2/s)

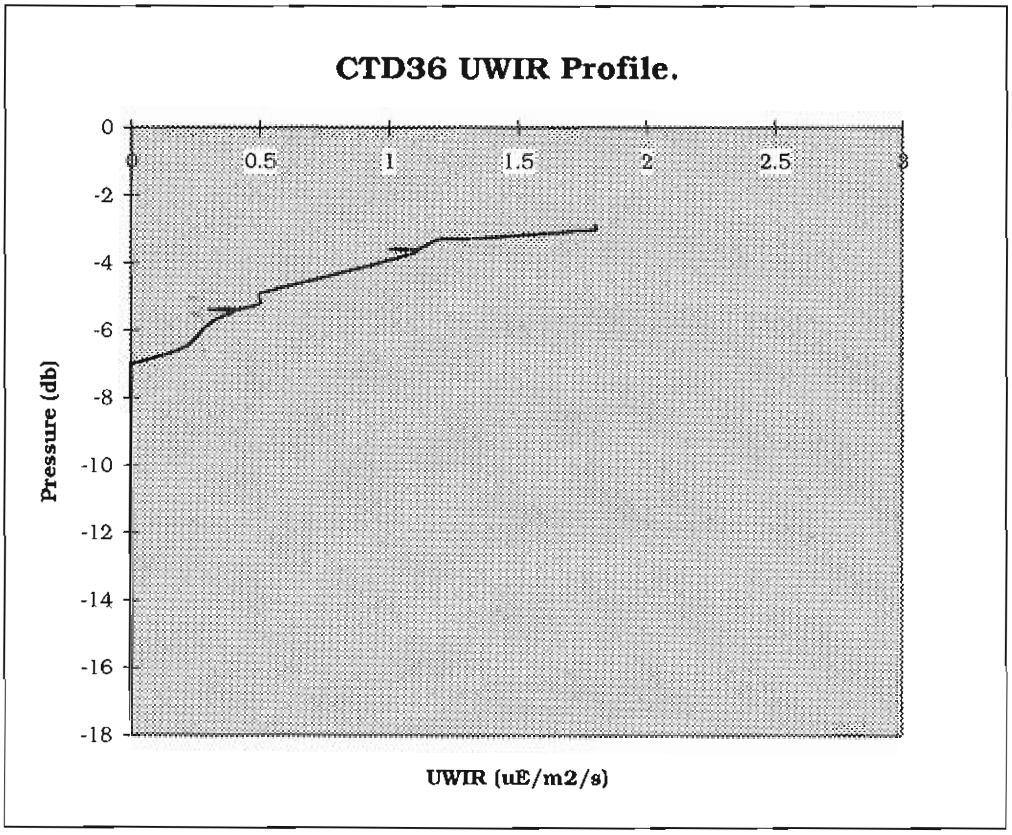


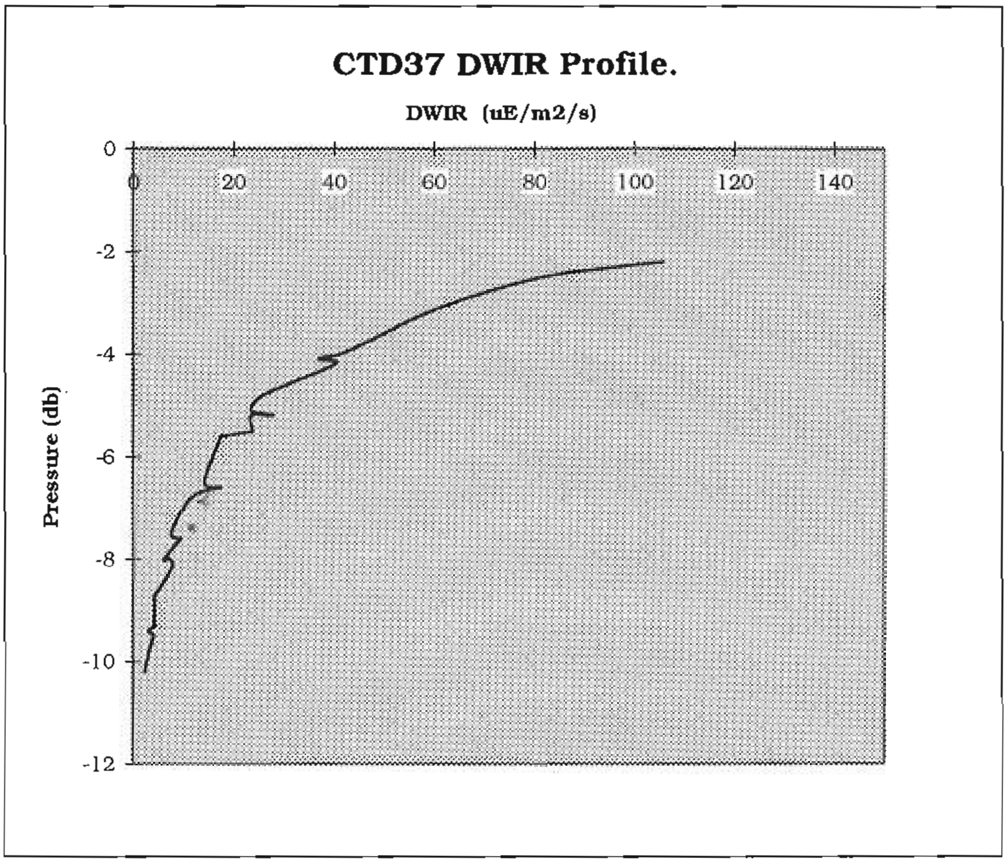
CTD35 DWIR Profile.
DWIR (uE/m2/s)
0
0.5
1
1.5
2
2.5
3
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
Pressure (db)

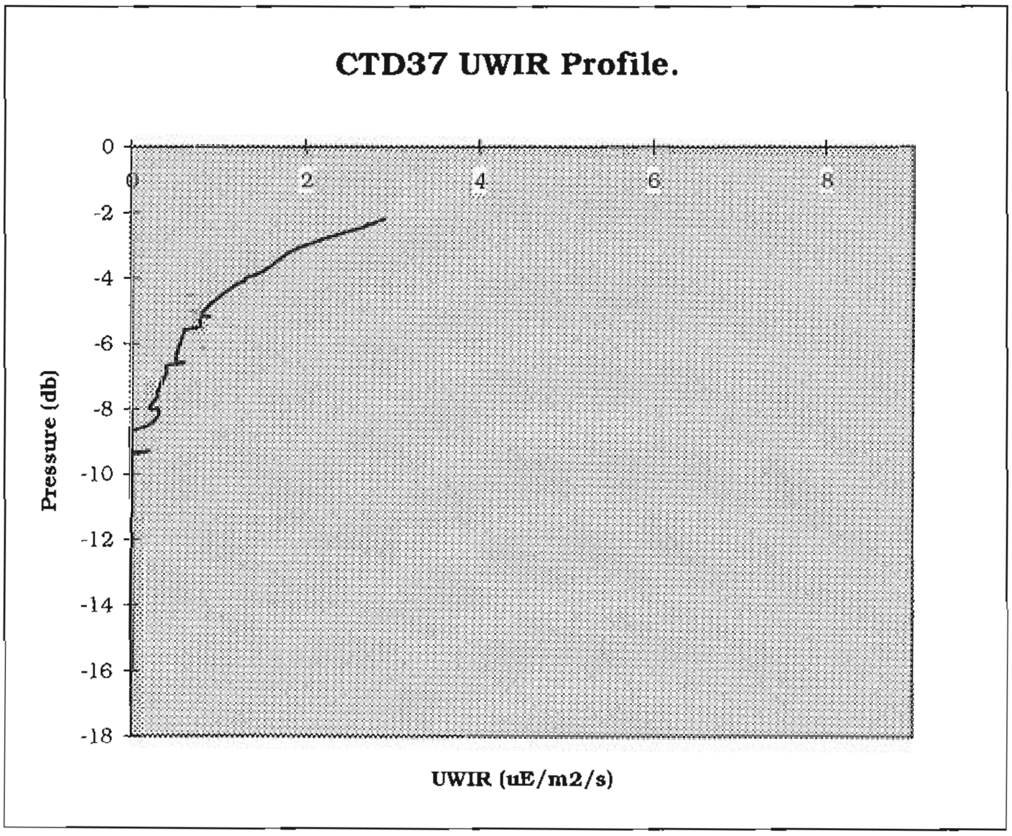


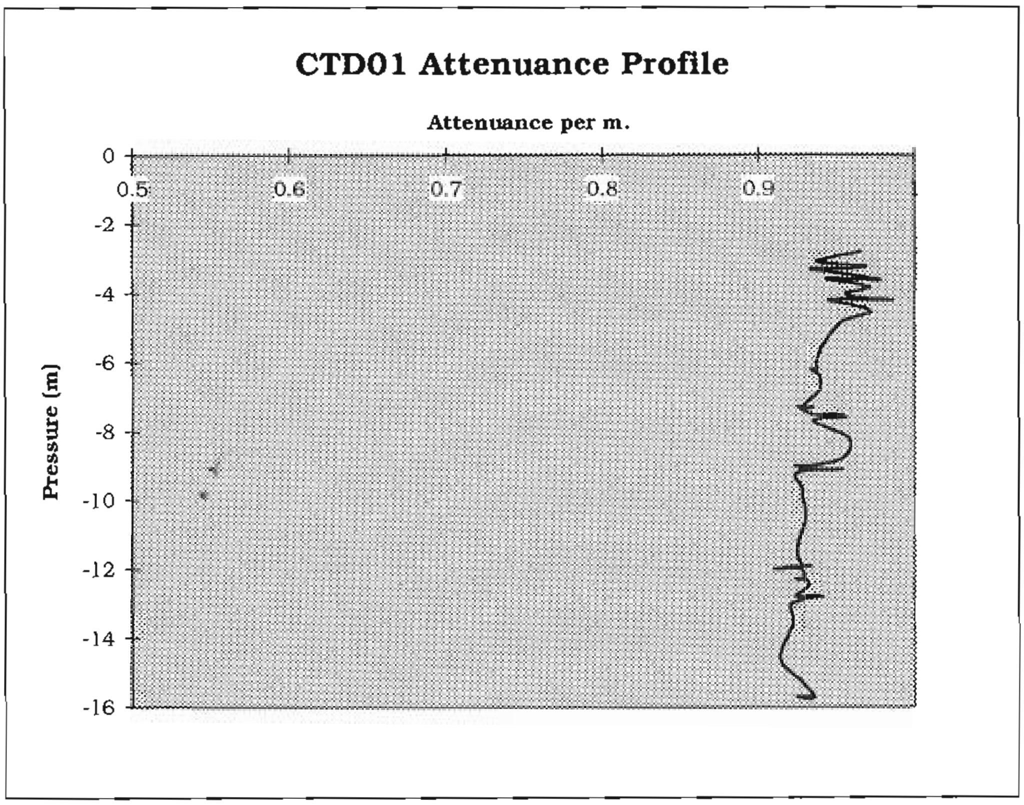
CTD35 UWIR Profile.
0
0.05
0.1
0.15
0.2
0.25
0.3
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
Pressure (db)
UWIR (uE/m2/s)

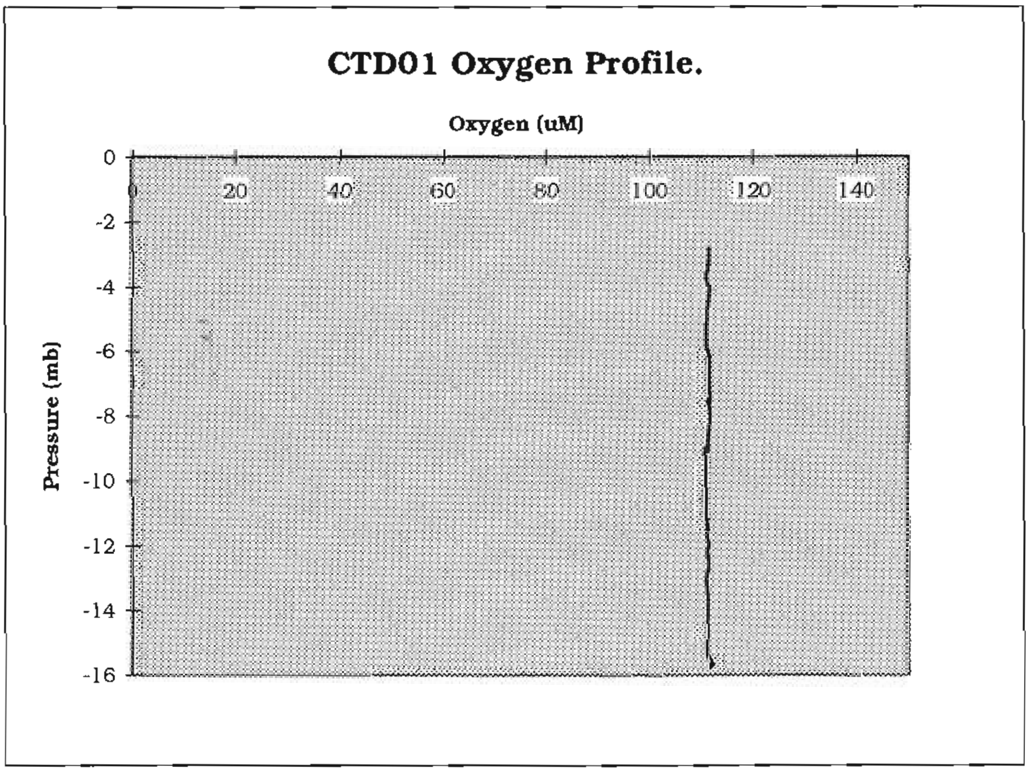

CTD36 DWIR Profile.
DWIR (uE/m2/s)
Pressure (db)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
0
20
40
60
80

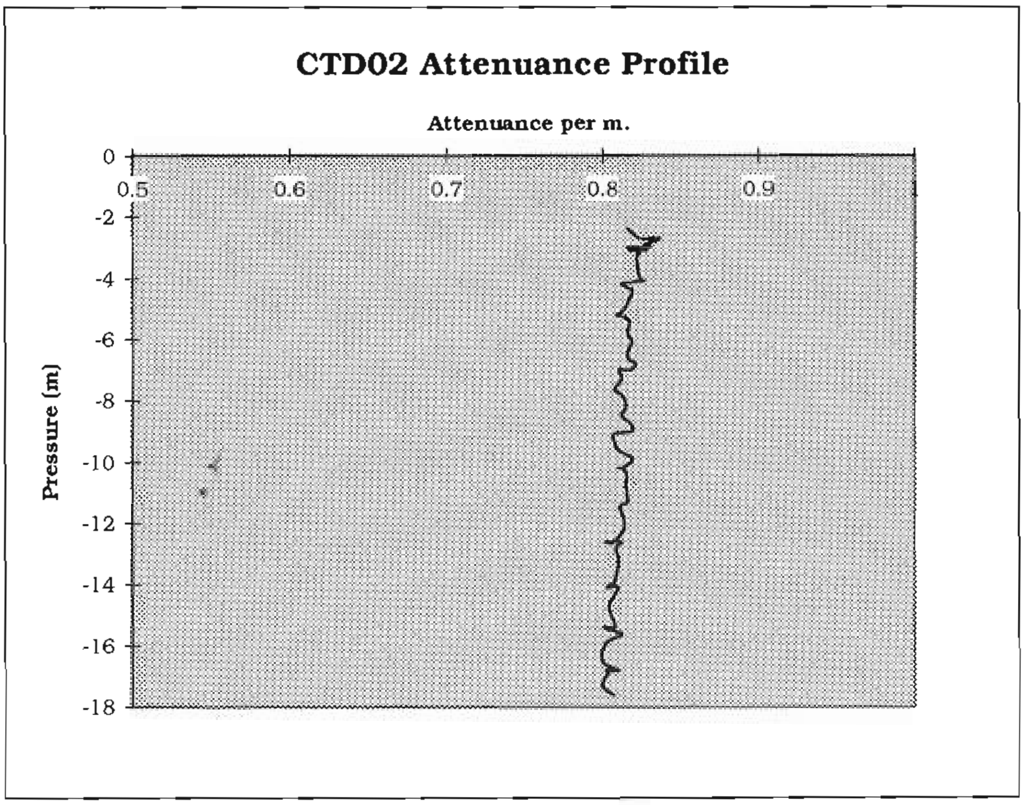

CTD36 UWIR Profile.
Pressure (db)
UWIR (uE/m2/s)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
0
0.5
1
1.5
2
2.5
3

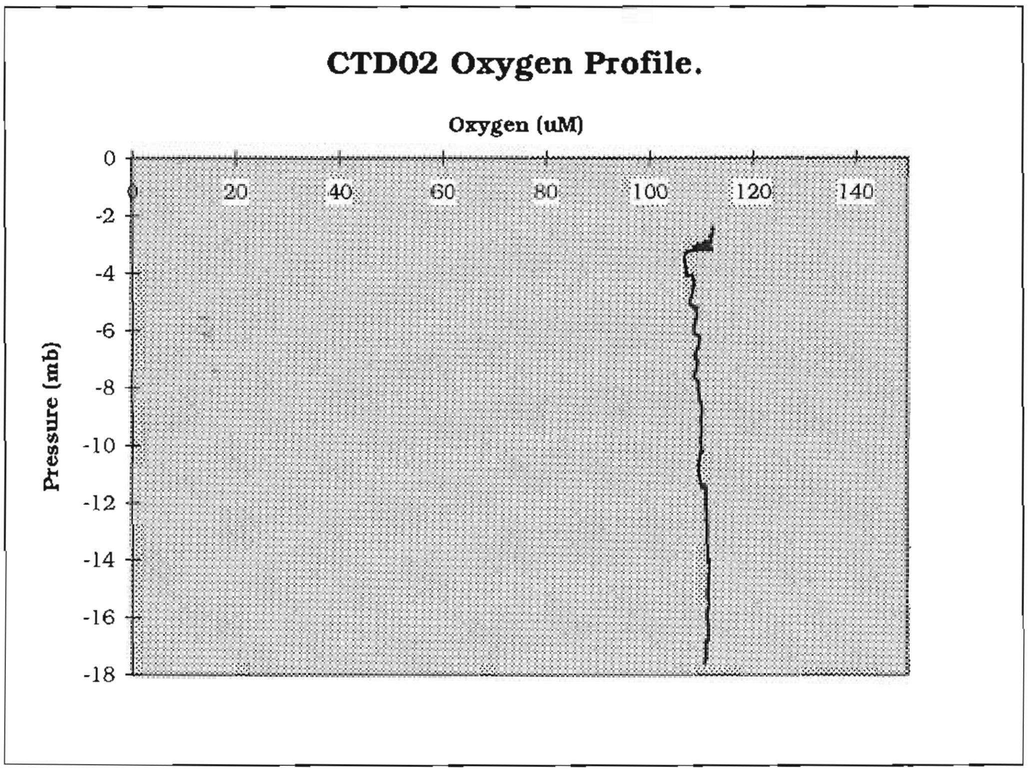

CTD37 DWIR Profile.
DWIR (uE/m2/s)
0
20
40
60
80
100
120
140
0
-2
-4
-6
-8
-10
-12
Pressure (db)

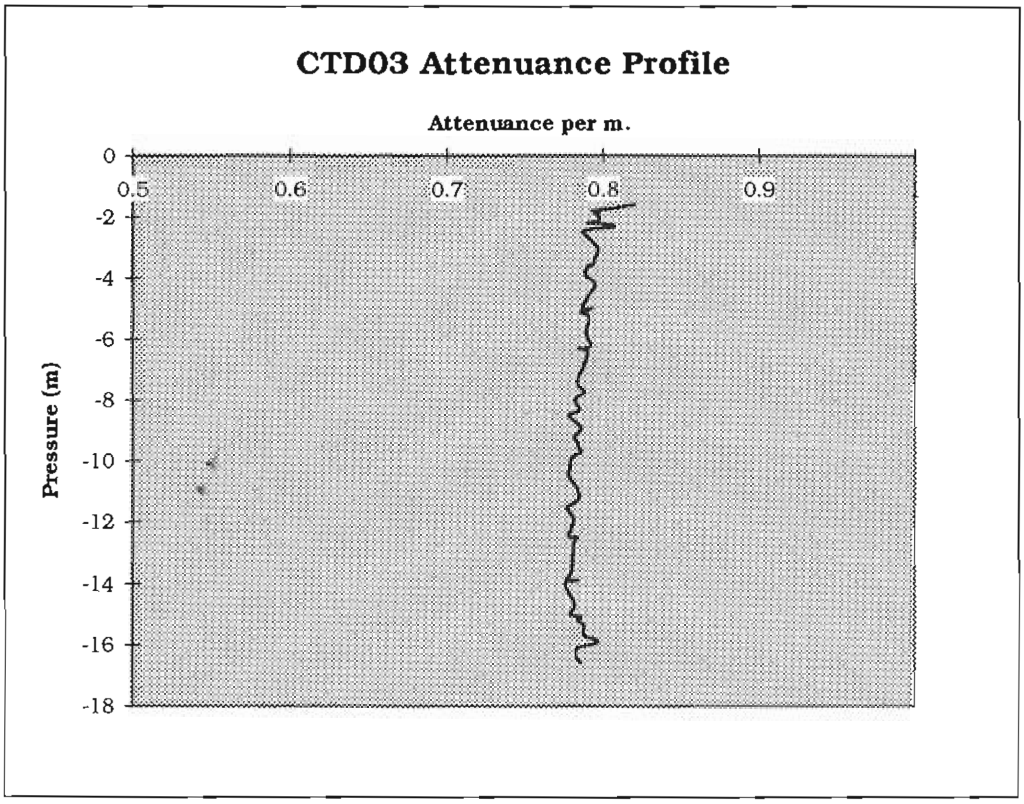

CTD37 UWIR Profile.
0
2
4
6
8
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
Pressure (db)
UWIR (uE/m2/s)

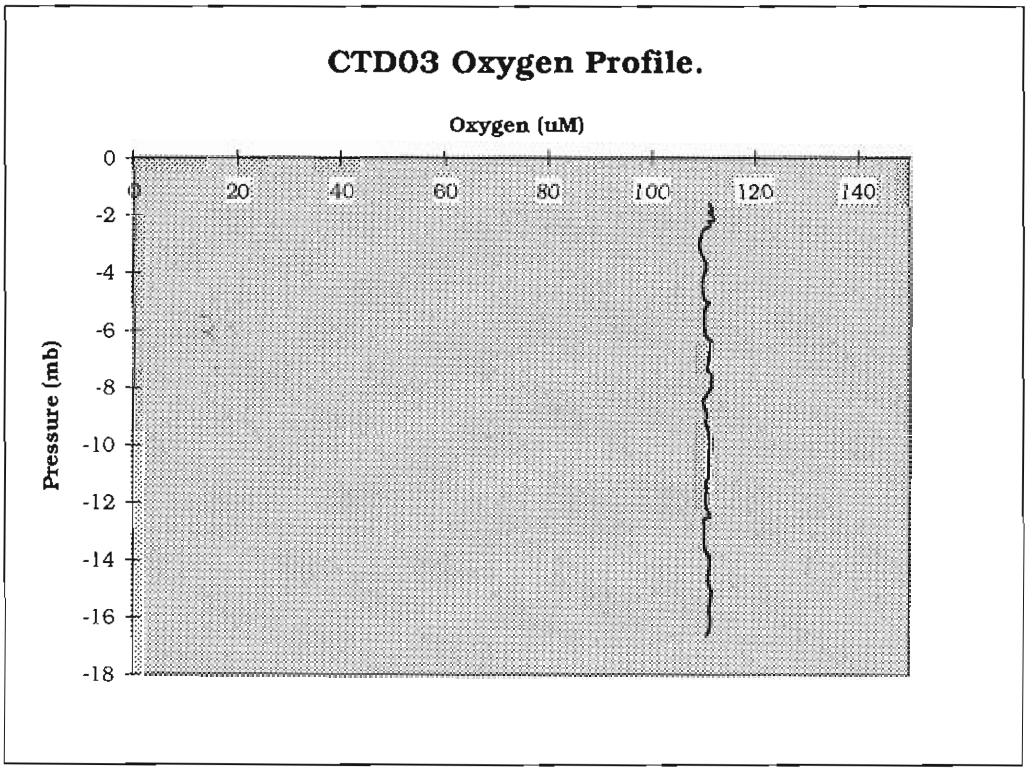

CTD01 Attenuance Profile
Attenuance per m.
0.5
0.6
0.7
0.8
0.9
1
0
-2
-4
-6
-8
-10
-12
-14
-16
Pressure (m)

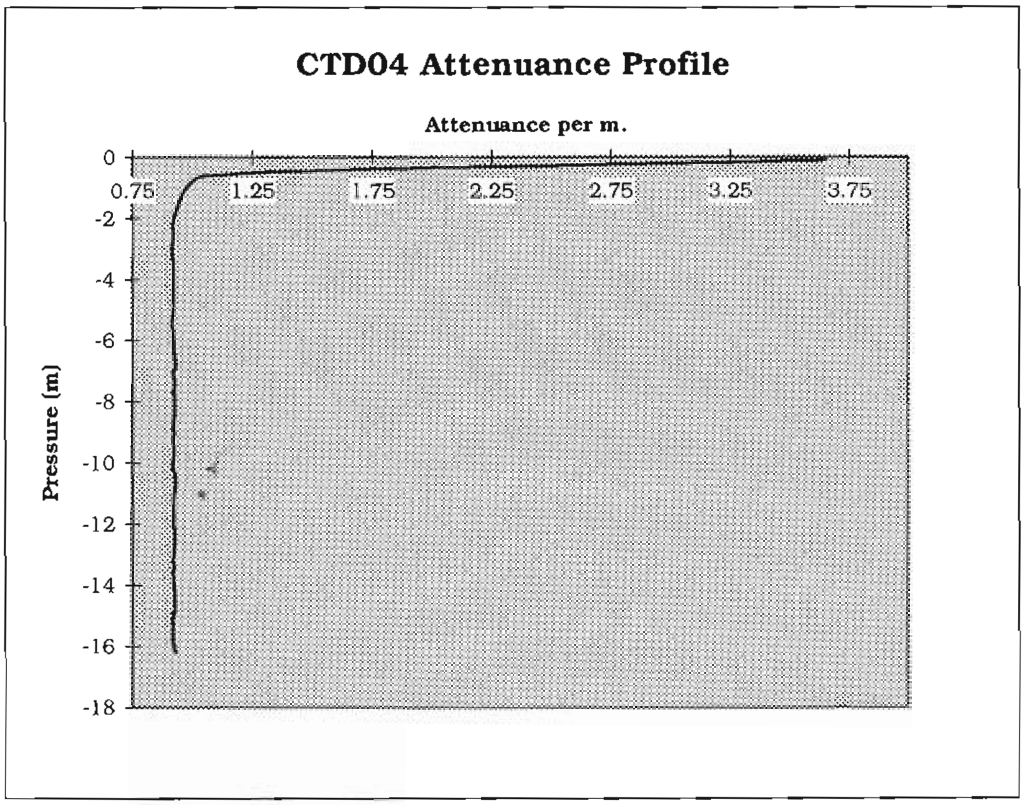

CTD01 Oxygen Profile.
Oxygen (uM)
0
20
40
60
80
100
120
140
0
-2
-4
-6
-8
-10
-12
-14
-16
Pressure (mb)

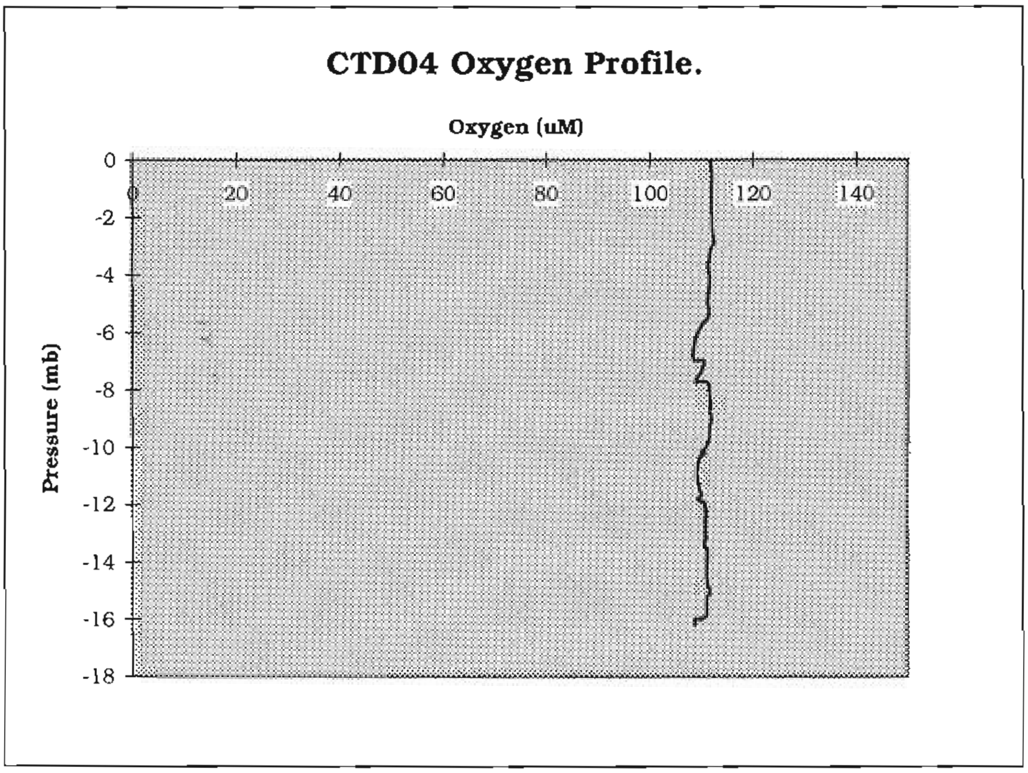

CTD02 Attenuance Profile
Attenuance per m.
Pressure (m)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
0.5
0.6
0.7
0.8
0.9
1

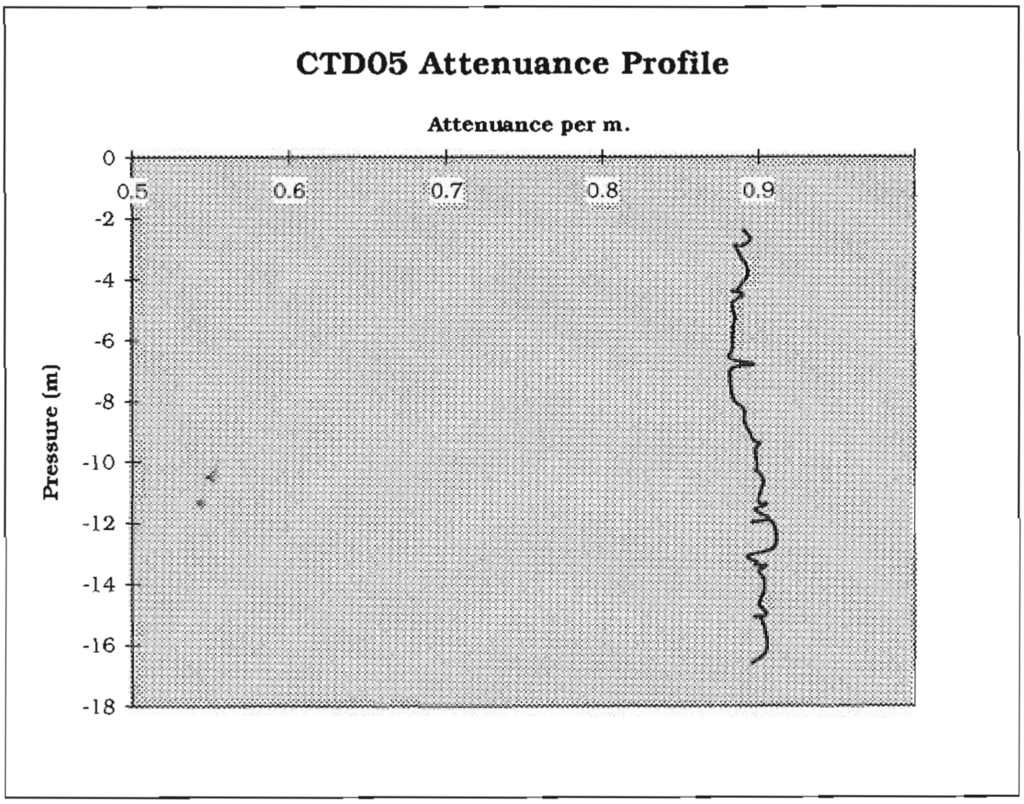

CTD02 Oxygen Profile.
Oxygen (uM)
Pressure (mb)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
0
20
40
60
80
100
120
140

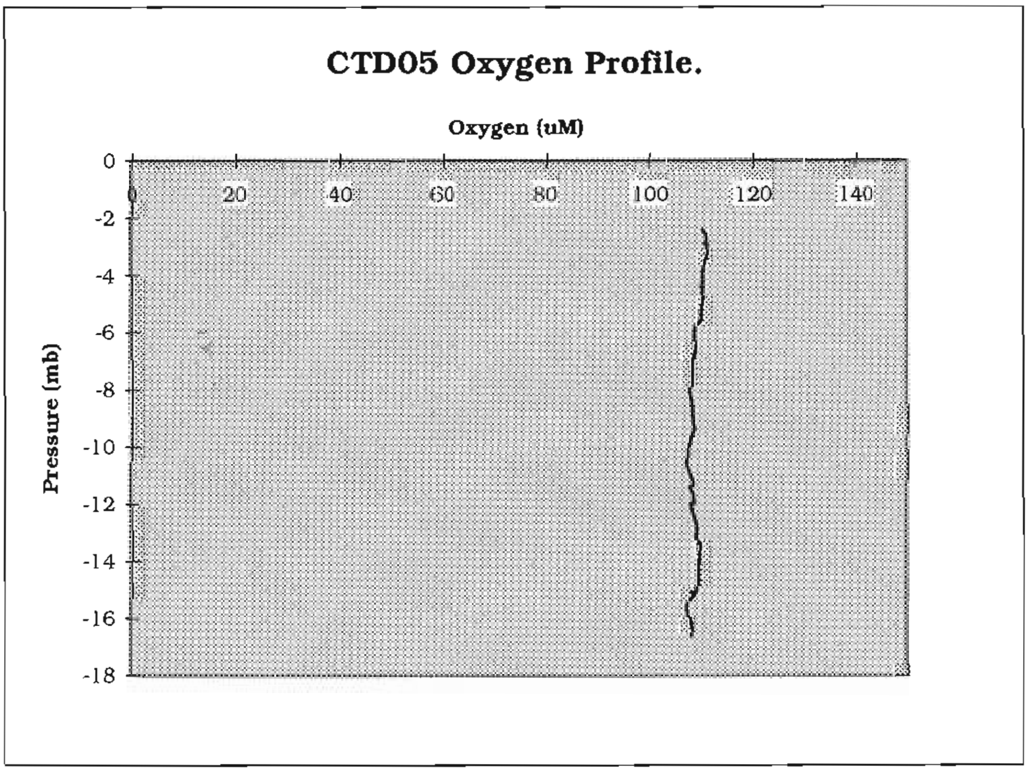

CTD03 Attenuance Profile
Attenuance per m.
0.5
0.6
0.7
0.8
0.9
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
Pressure (m)

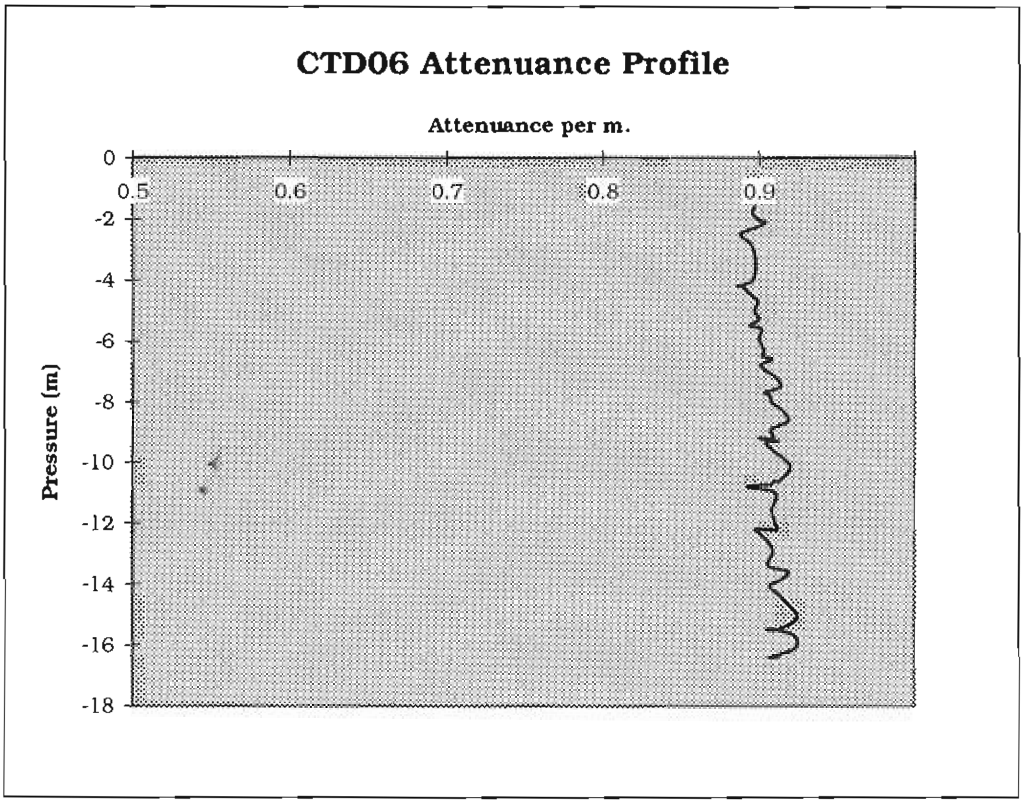

CTD03 Oxygen Profile.
Oxygen (uM)
0
20
40
60
80
100
120
140
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
Pressure (mb)

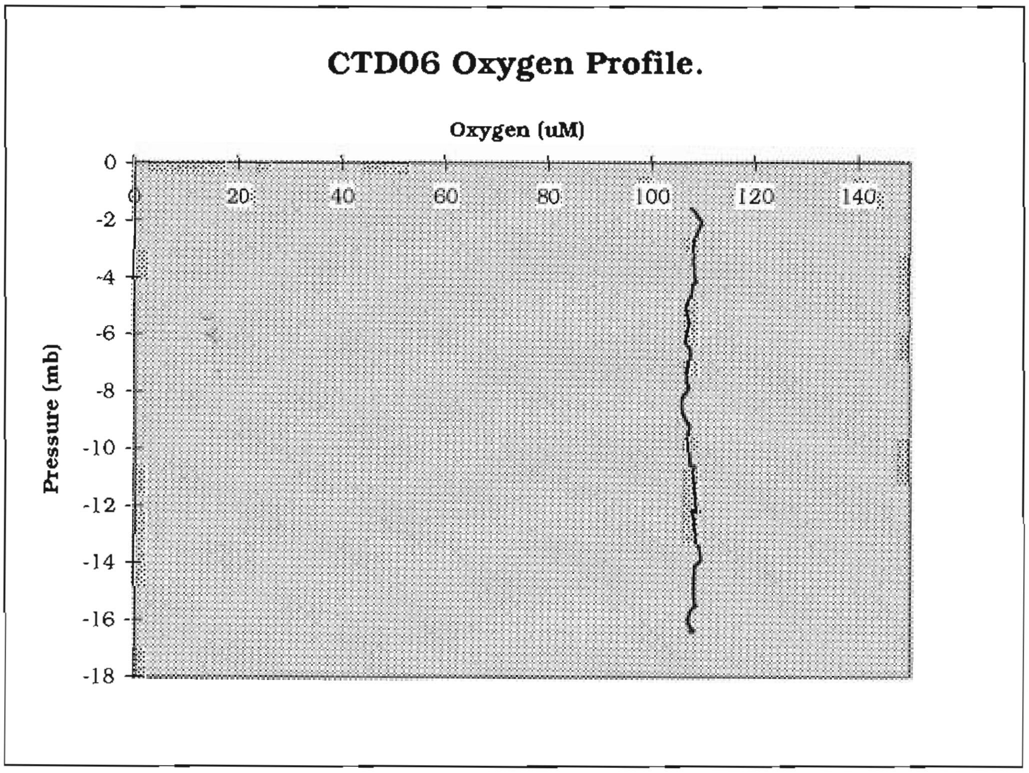

CTD04 Attenuance Profile
Attenuance per m.
0.75
1.25
1.75
2.25
2.75
3.25
3.75
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
Pressure (m)

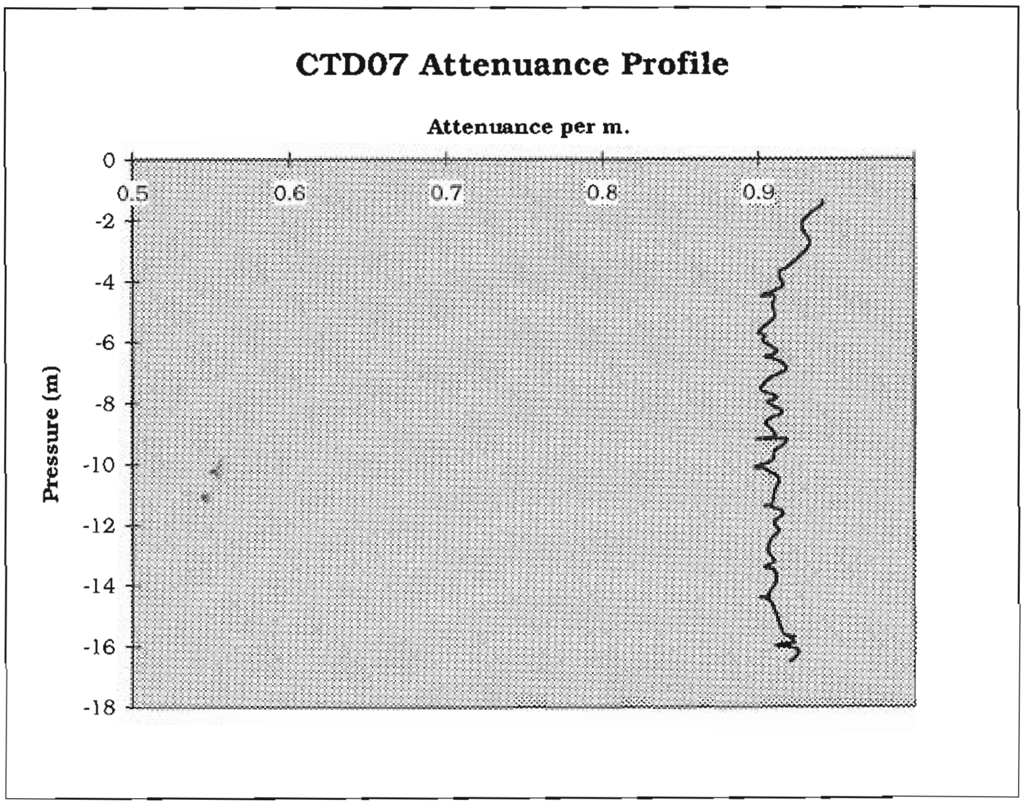

CTD04 Oxygen Profile.
Oxygen (uM)
0
20
40
60
80
100
120
140
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
Pressure (mb)

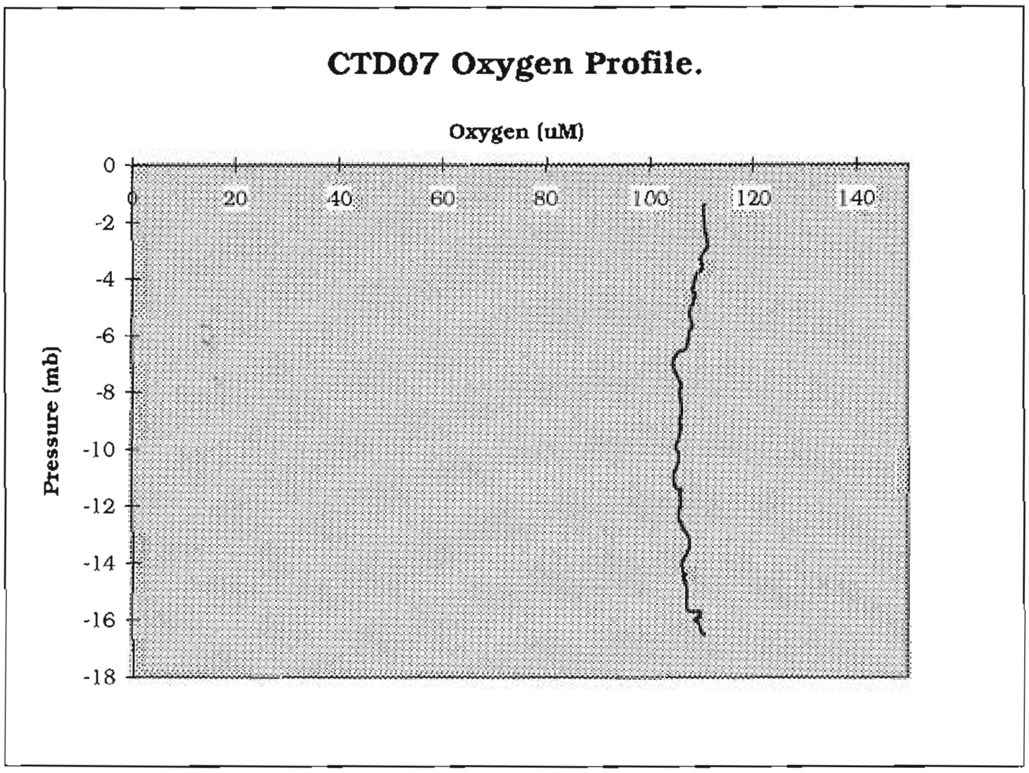

CTD05 Attenuance Profile
Attenuance per m.
0.5
0.6
0.7
0.8
0.9
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
Pressure (m)

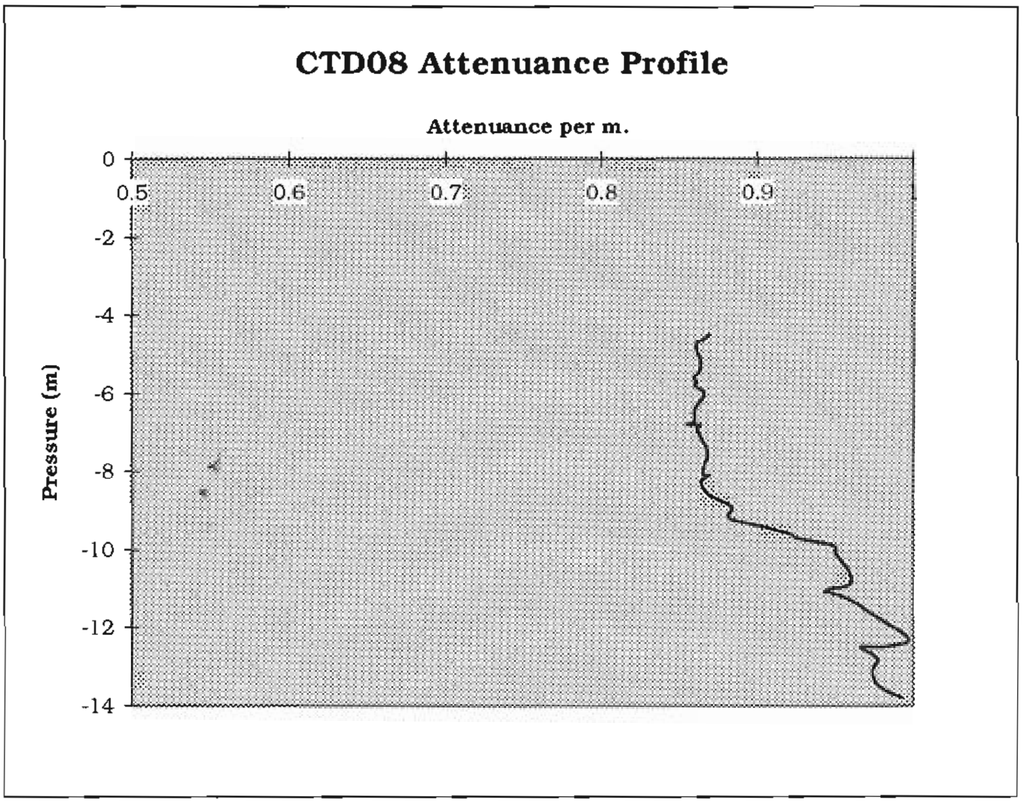

CTD05 Oxygen Profile.
Oxygen (uM)
0
20
40
60
80
100
120
140
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
Pressure (mb)

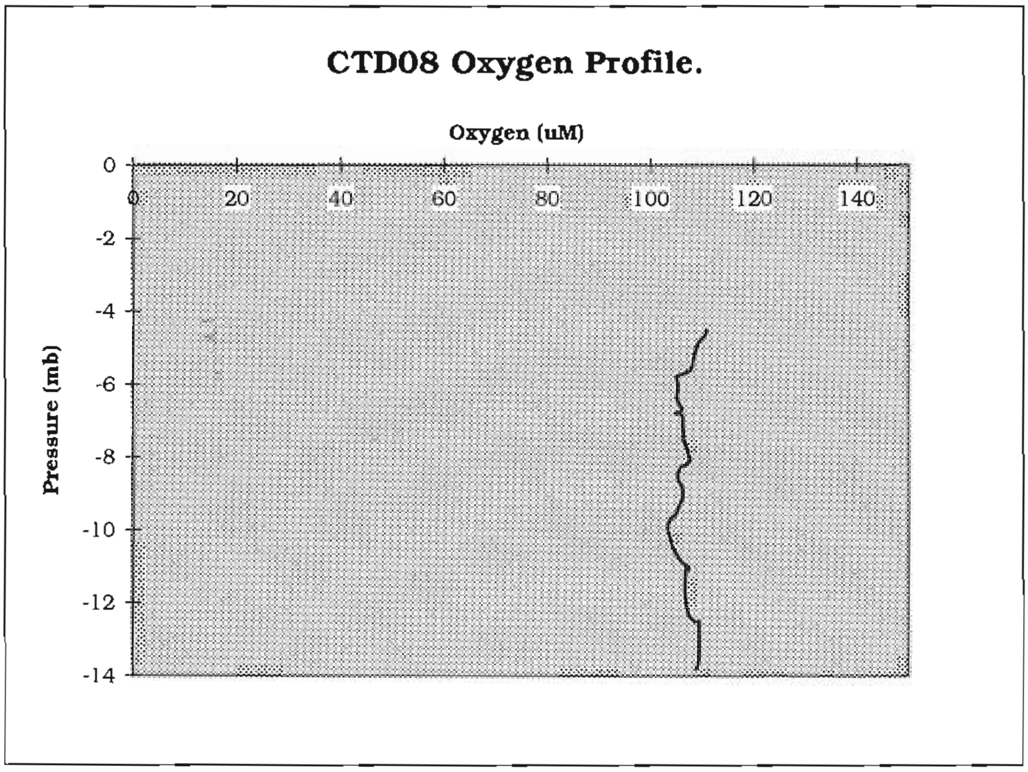

CTD06 Attenuance Profile
Attenuance per m.
0.5
0.6
0.7
0.8
0.9
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
Pressure (m)

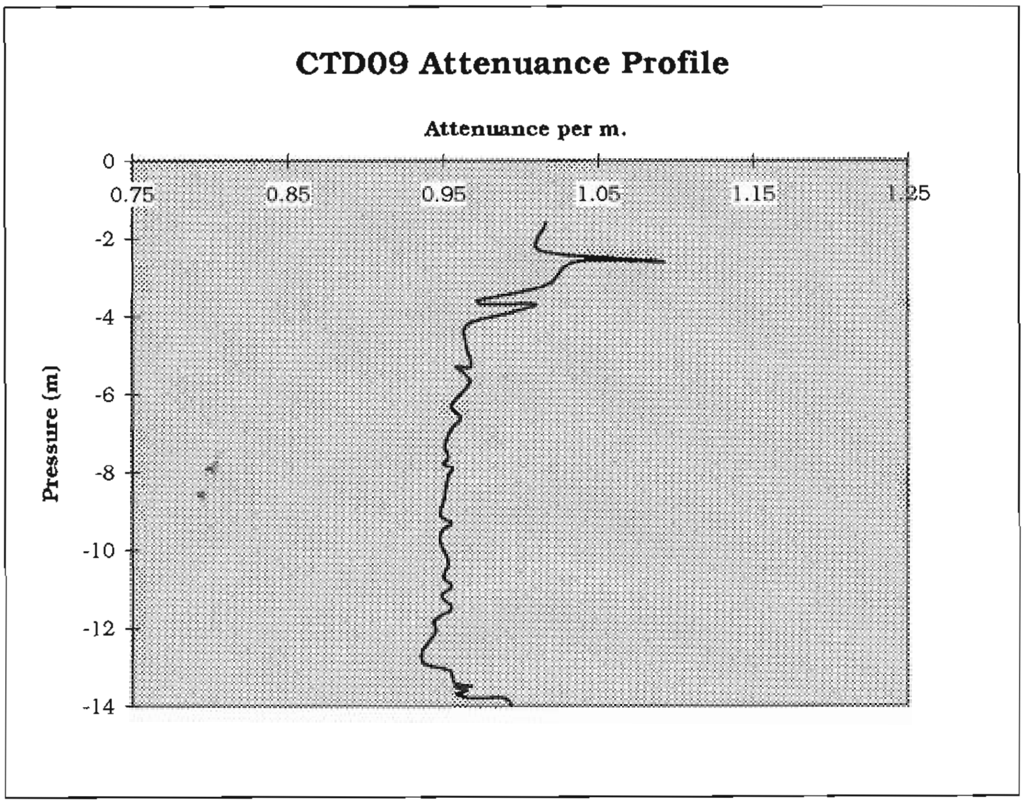

CTD06 Oxygen Profile.
Oxygen (uM)
0
20
40
60
80
100
120
140
-2
-4
-6
-8
-10
-12
-14
-16
-18
Pressure (mb)

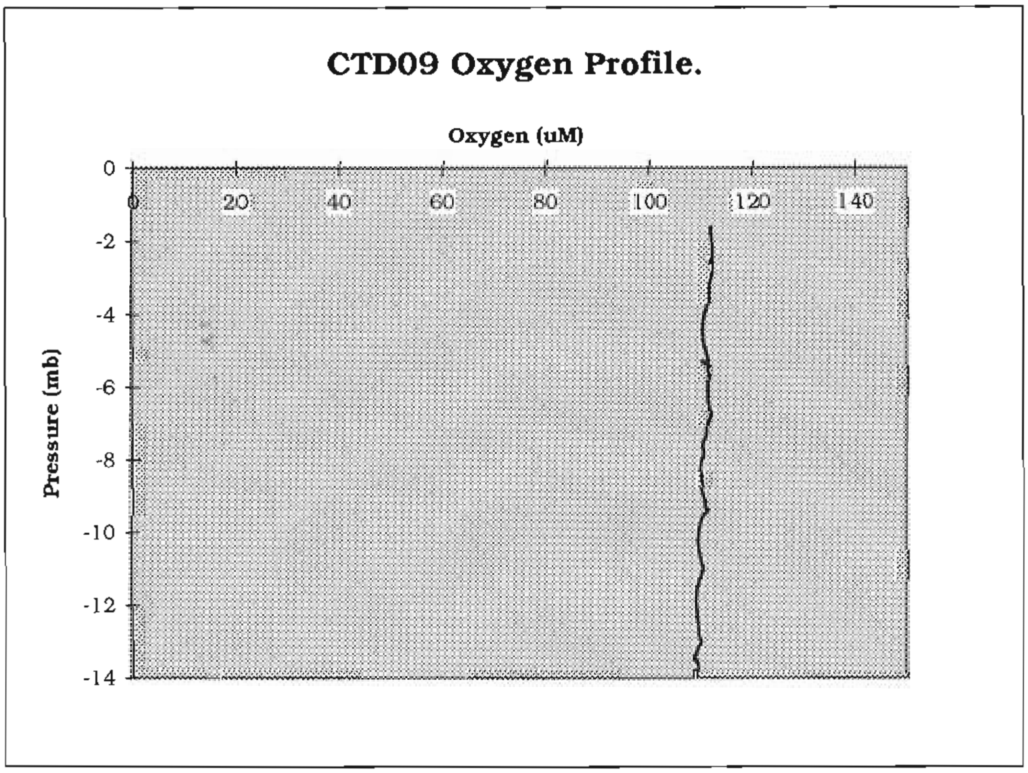

CTD07 Attenuance Profile
Attenuance per m.
0.5
0.6
0.7
0.8
0.9
1
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
Pressure (m)

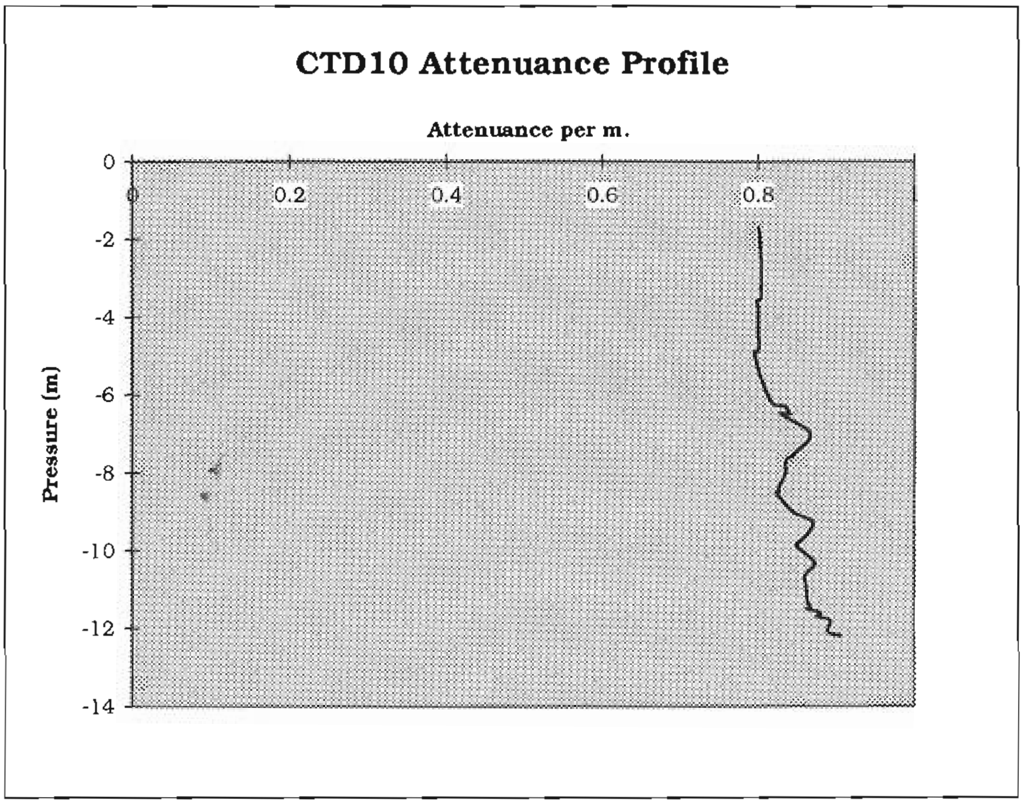

CTD07 Oxygen Profile.
Oxygen (uM)
0
20
40
60
80
100
120
140
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
Pressure (mb)

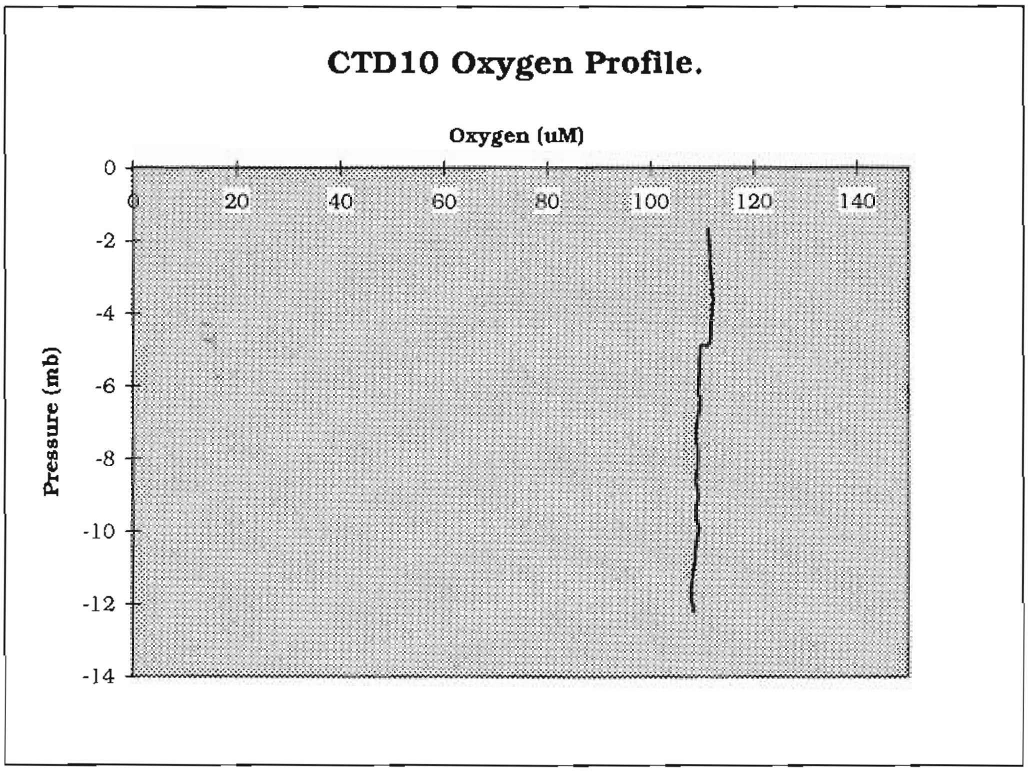

CTD08 Attenuance Profile
Attenuance per m.
Pressure (m)
0
-2
-4
-6
-8
-10
-12
-14
0.5
0.6
0.7
0.8
0.9
1

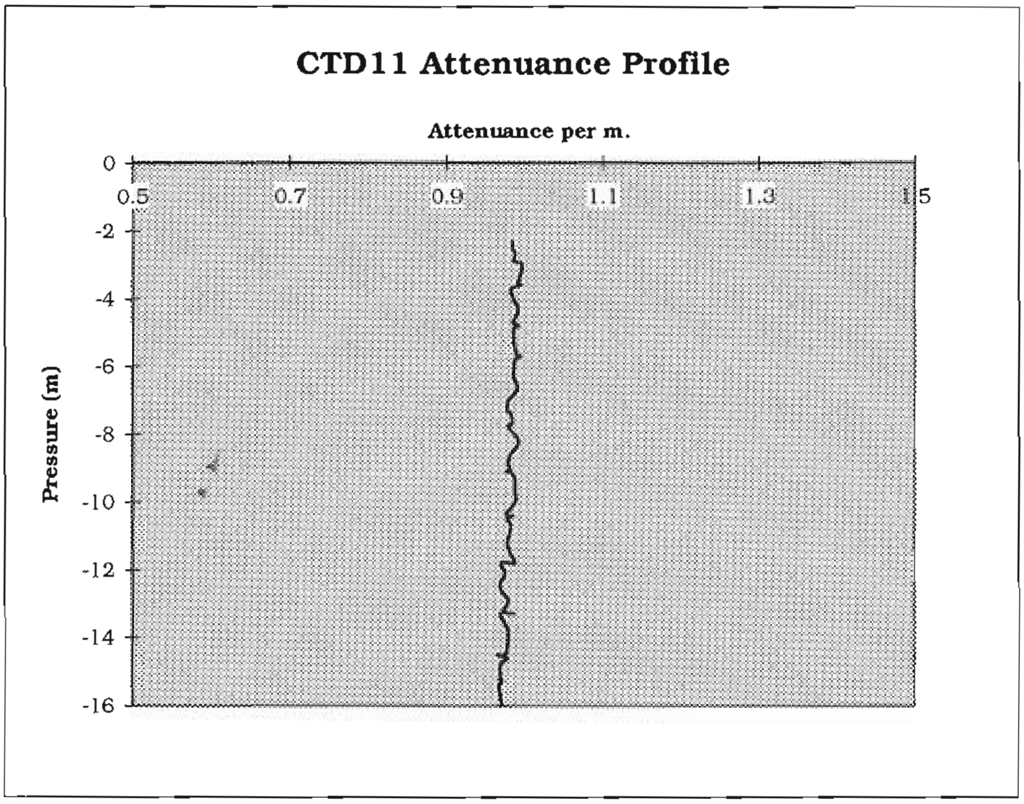

CTD08 Oxygen Profile.
Oxygen (uM)
Pressure (mb)
0
-2
-4
-6
-8
-10
-12
-14
0
20
40
60
80
100
120
140

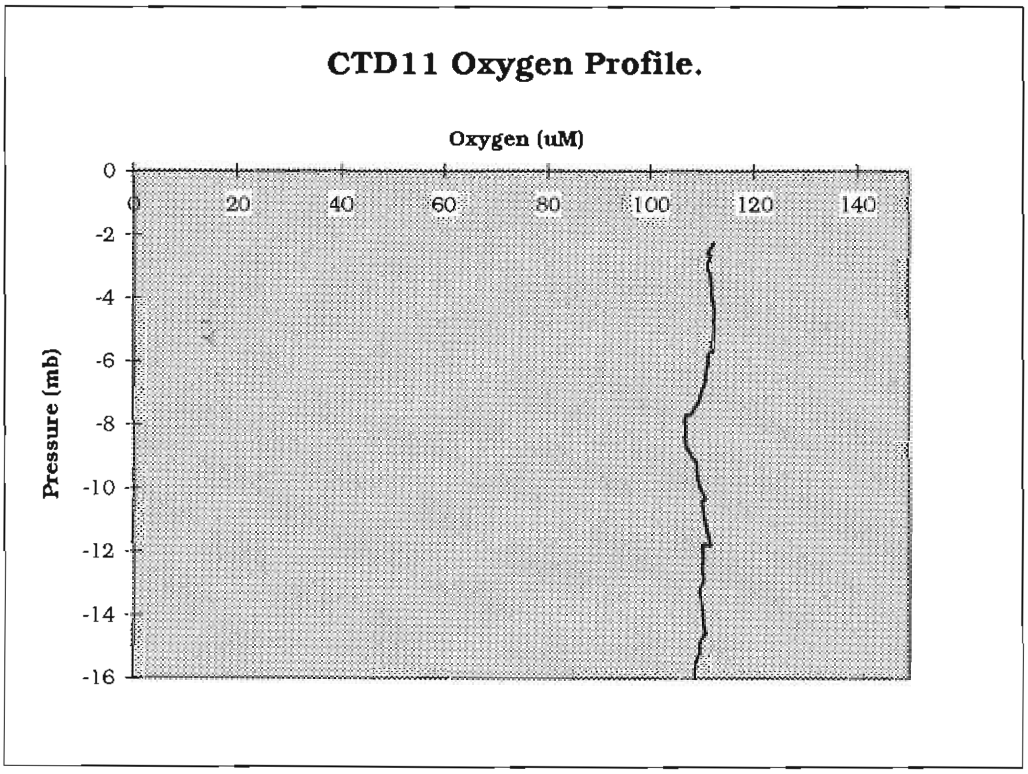

CTD09 Attenuance Profile
Attenuance per m.
0.75
0.85
0.95
1.05
1.15
1.25
0
-2
-4
-6
-8
-10
-12
-14
Pressure (m)

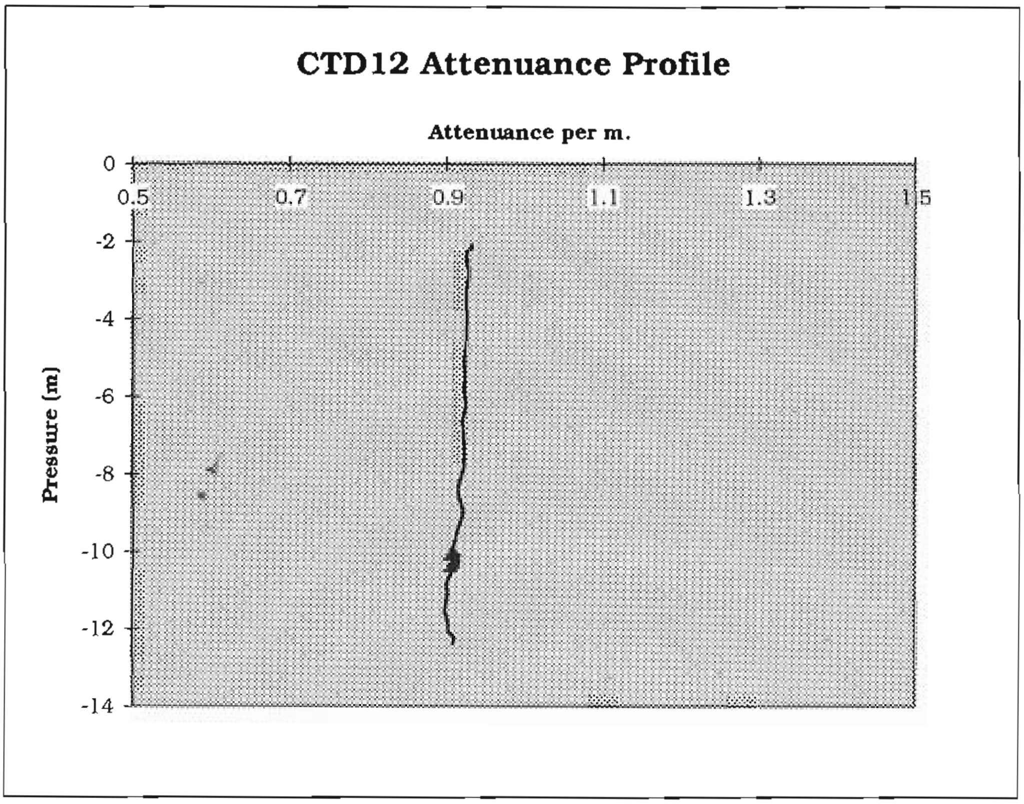

CTD09 Oxygen Profile.
Oxygen (uM)
0
20
40
60
80
100
120
140
0
-2
-4
-6
-8
-10
-12
-14
Pressure (mb)

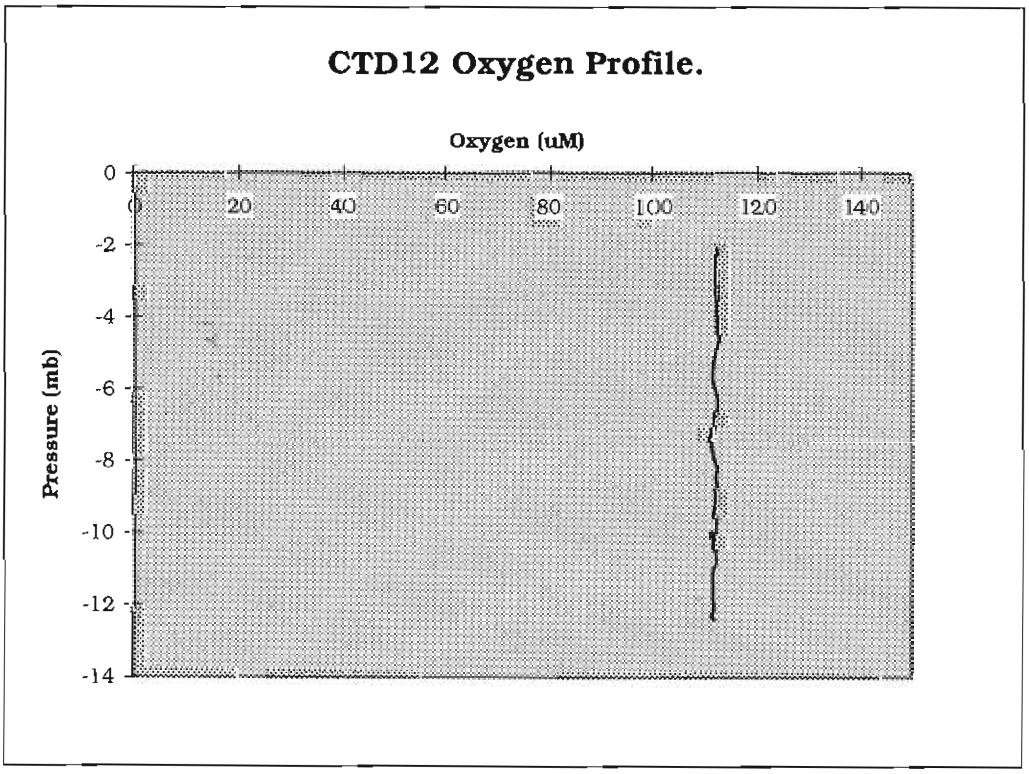

CTD10 Attenuance Profile
Attenuance per m.
0
0.2
0.4
0.6
0.8
1
0
-2
-4
-6
-8
-10
-12
-14
Pressure (m)

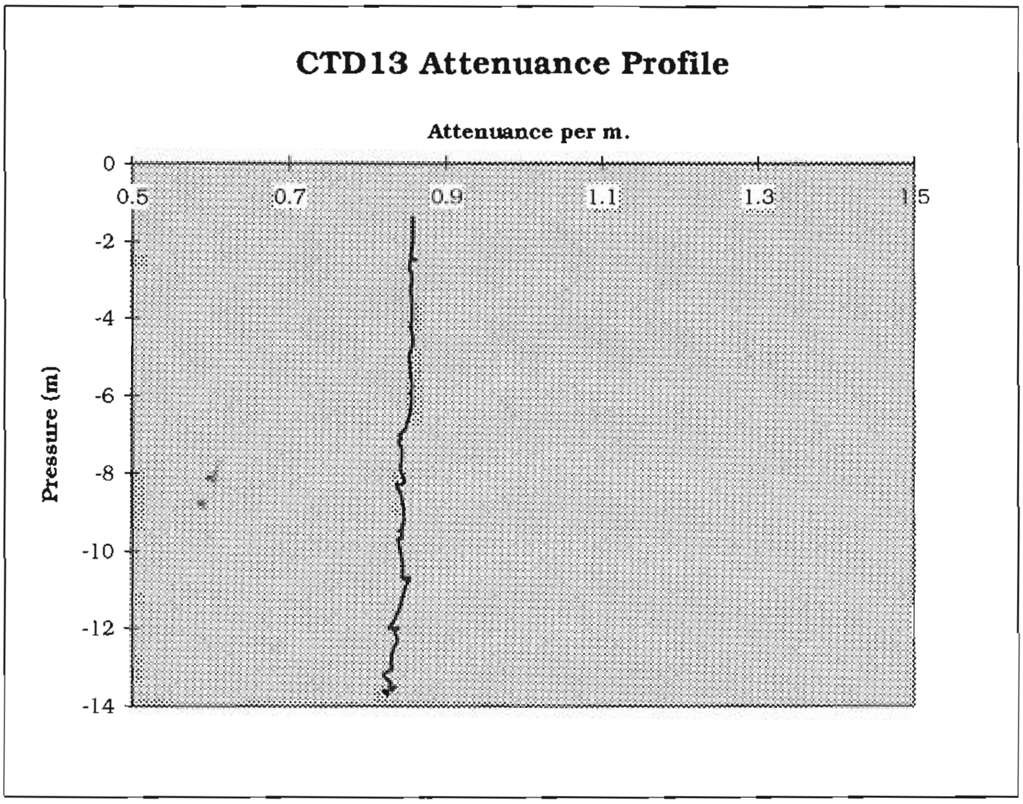

CTD10 Oxygen Profile.
Oxygen (uM)
0
20
40
60
80
100
120
140
0
-2
-4
-6
-8
-10
-12
-14
Pressure (mb)

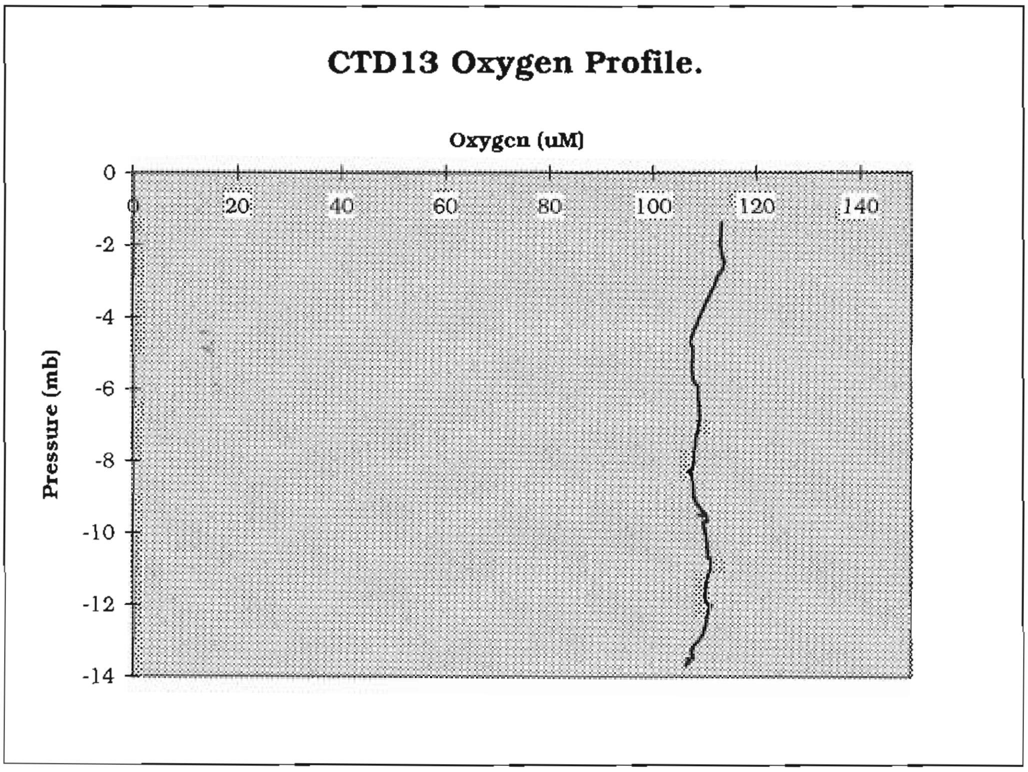

CTD11 Attenuance Profile
Attenuance per m.
Pressure (m)
0.5
0.7
0.9
1.1
1.3
1.5
0
-2
-4
-6
-8
-10
-12
-14
-16

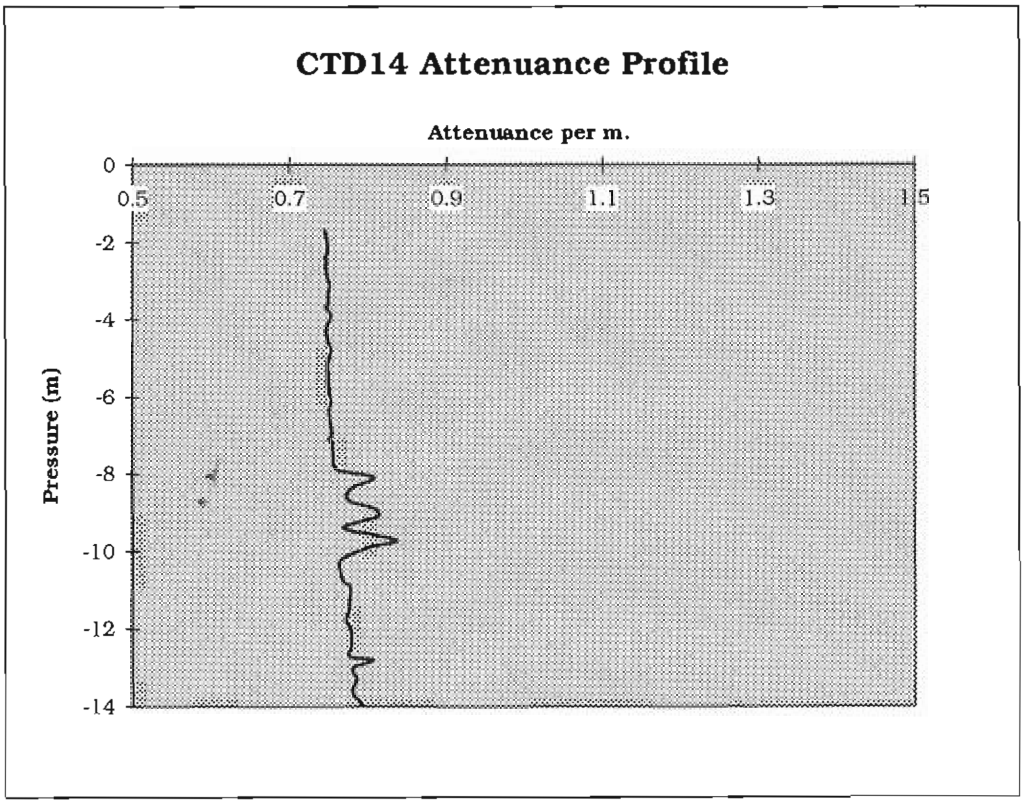

CTD11 Oxygen Profile.
Oxygen (uM)
Pressure (mb)
0
20
40
60
80
100
120
140
0
-2
-4
-6
-8
-10
-12
-14
-16

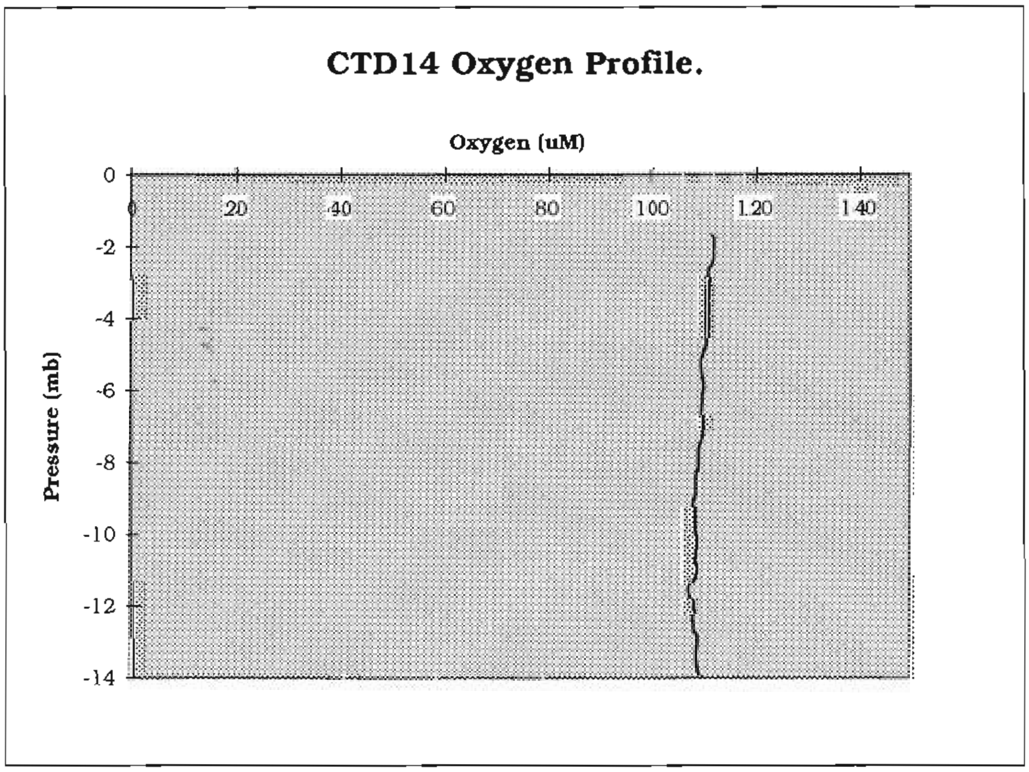

CTD12 Attenuance Profile
Attenuance per m.
Pressure (m)
0
-2
-4
-6
-8
-10
-12
-14
0.5
0.7
0.9
1.1
1.3
1.5

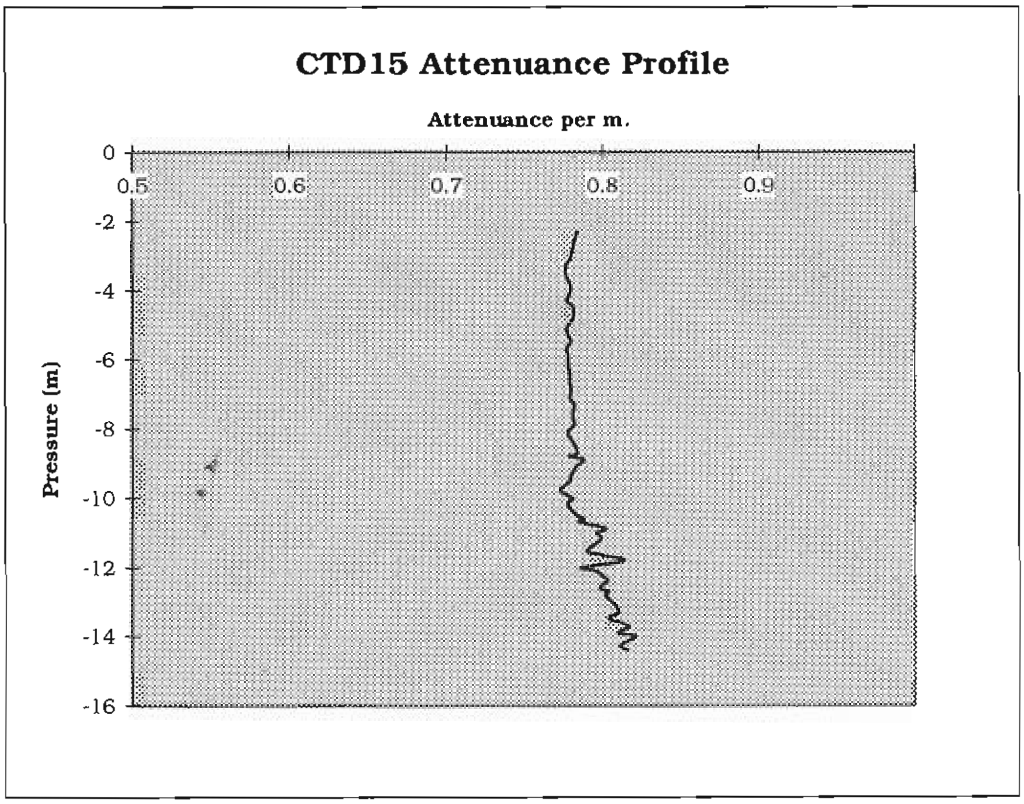

CTD12 Oxygen Profile.
Oxygen (uM)
Pressure (mb)
0
-2
-4
-6
-8
-10
-12
-14
0
20
40
60
80
100
120
140

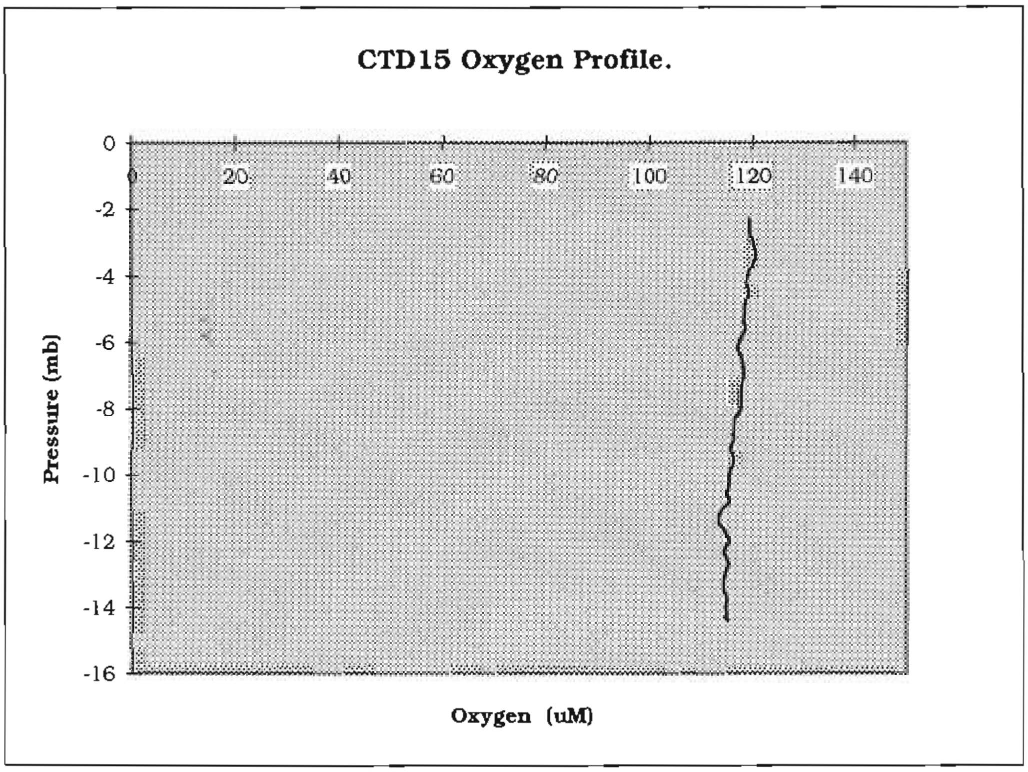

CTD13 Attenuance Profile
Attenuance per m.
Pressure (m)
0.5
0.7
0.9
1.1
1.3
1.5
0
-2
-4
-6
-8
-10
-12
-14

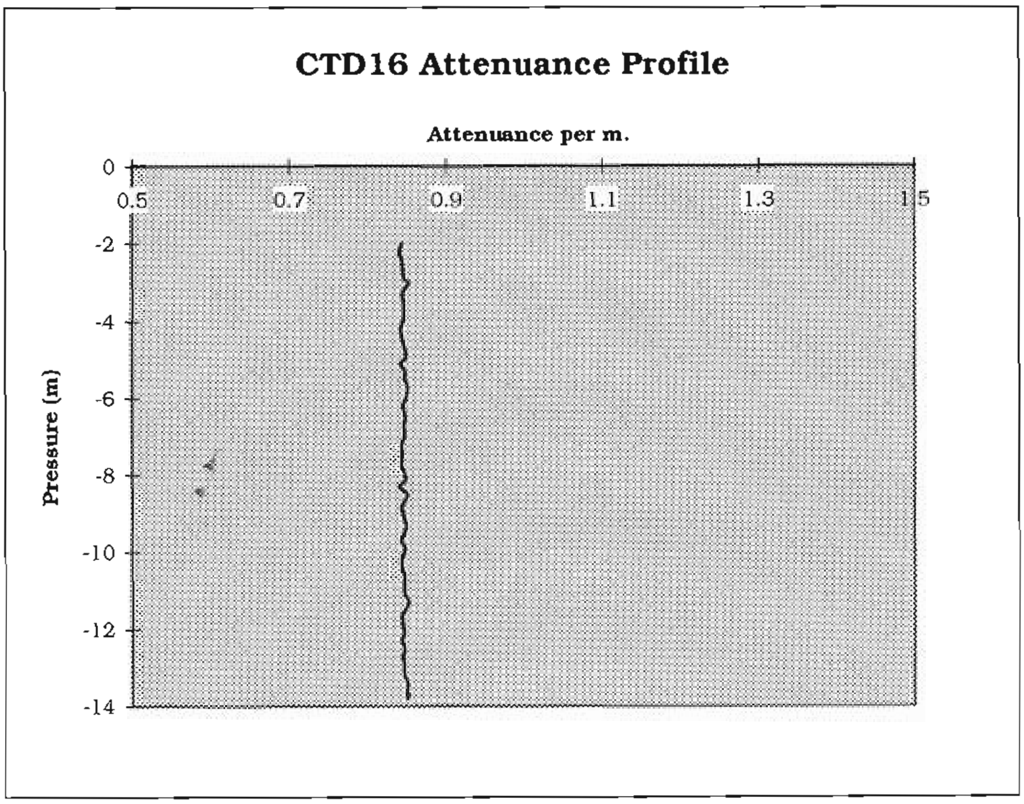

CTD13 Oxygen Profile.
Oxygen (uM)
Pressure (mb)
0
20
40
60
80
100
120
140
0
-2
-4
-6
-8
-10
-12
-14

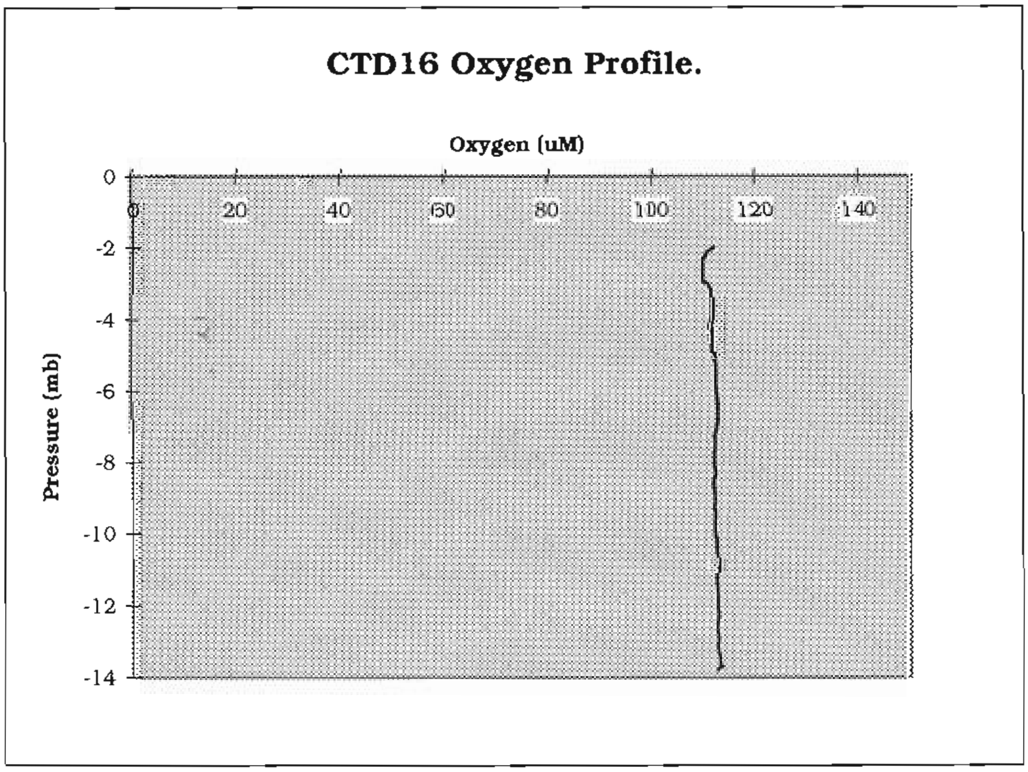

CTD14 Attenuance Profile
Attenuance per m.
Pressure (m)
0
-2
-4
-6
-8
-10
-12
-14
0.5
0.7
0.9
1.1
1.3
1.5

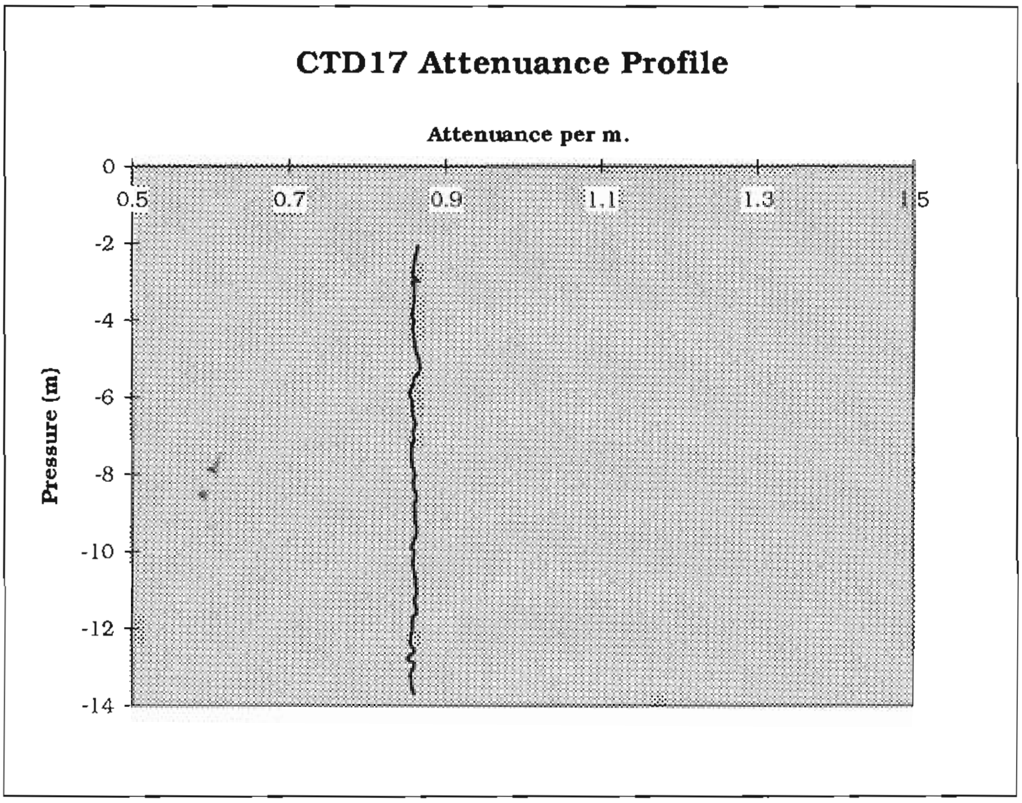

CTD14 Oxygen Profile.
Oxygen (uM)
Pressure (mb)
0
-2
-4
-6
-8
-10
-12
-14
0
20
40
60
80
100
120
140

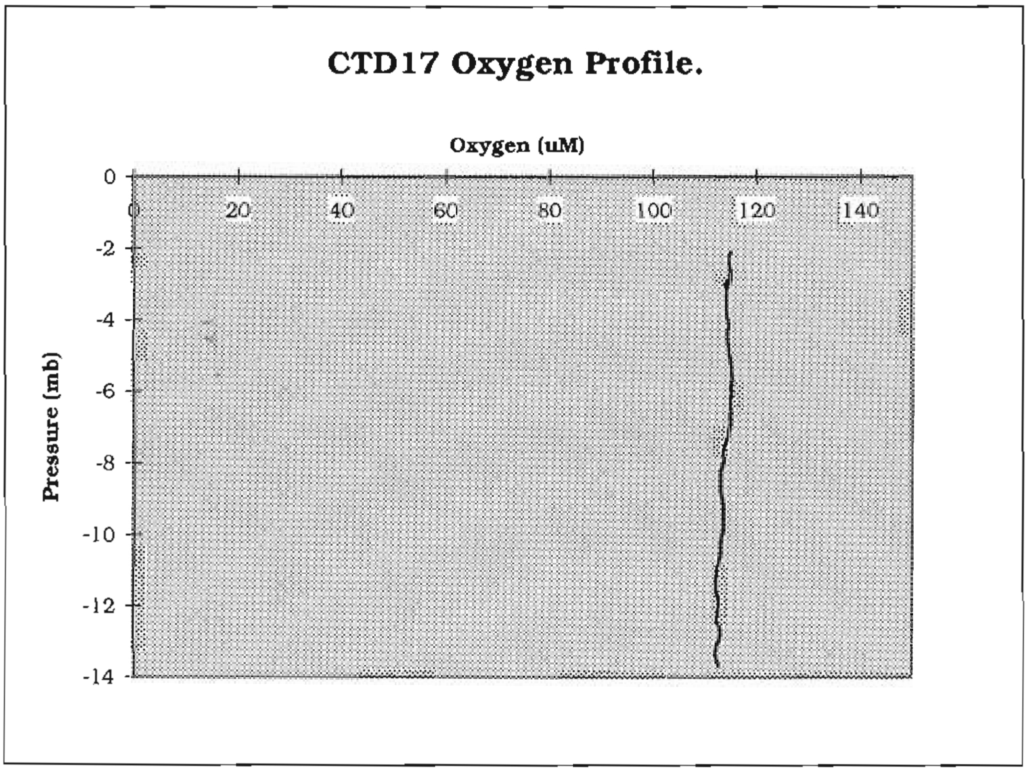

CTD15 Attenuance Profile
Attenuance per m.
0
0.5
0.6
0.7
0.8
0.9
-2
-4
-6
-8
-10
-12
-14
-16
Pressure (m)

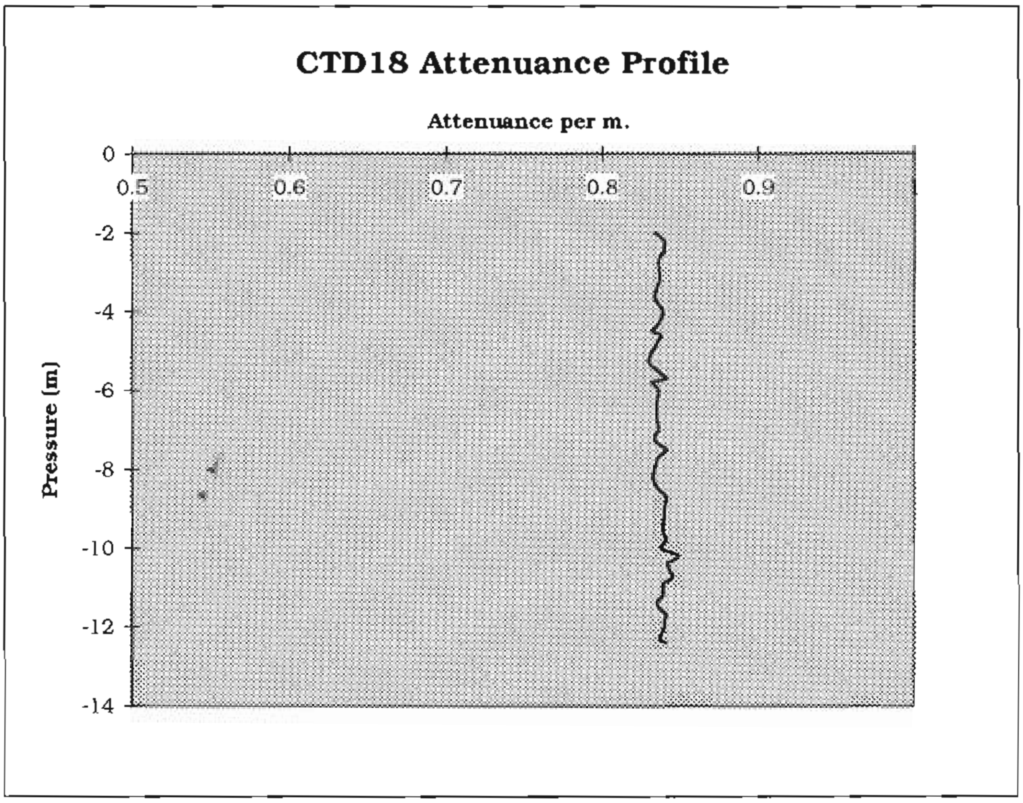

CTD15 Oxygen Profile.
0
20
40
60
80
100
120
140
-2
-4
-6
-8
-10
-12
-14
-16
Pressure (mb)
Oxygen (uM)

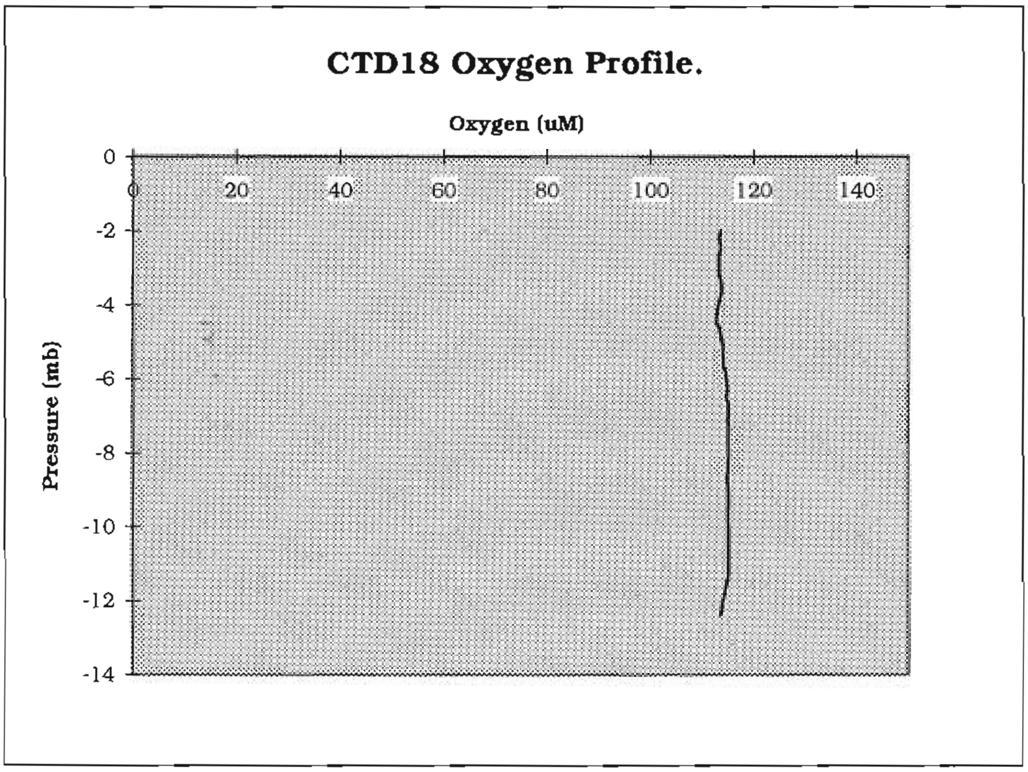

CTD16 Attenuance Profile
Attenuance per m.
0.5
0.7
0.9
1.1
1.3
1.5
0
-2
-4
-6
-8
-10
-12
-14
Pressure (m)

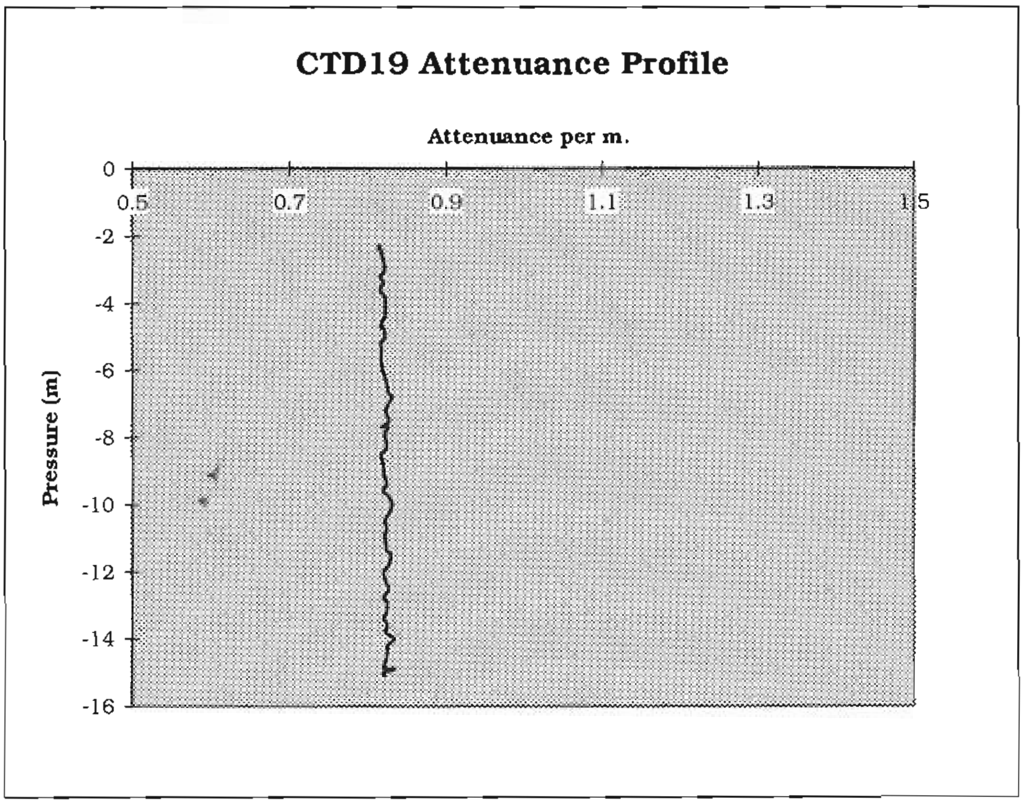

CTD16 Oxygen Profile.
Oxygen (uM)
0
20
40
60
80
100
120
140
0
-2
-4
-6
-8
-10
-12
-14
Pressure (mb)

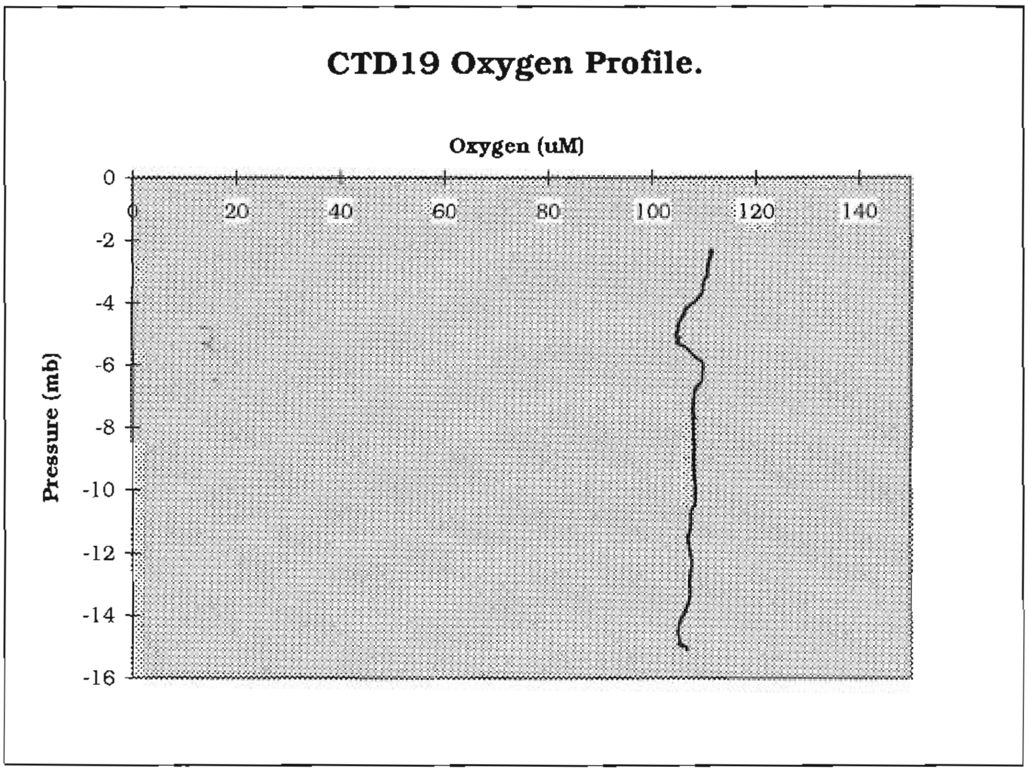

CTD17 Attenuance Profile
Attenuance per m.
0
0.5
0.7
0.9
1.1
1.3
1.5
-2
-4
-6
-8
-10
-12
-14
Pressure (m)

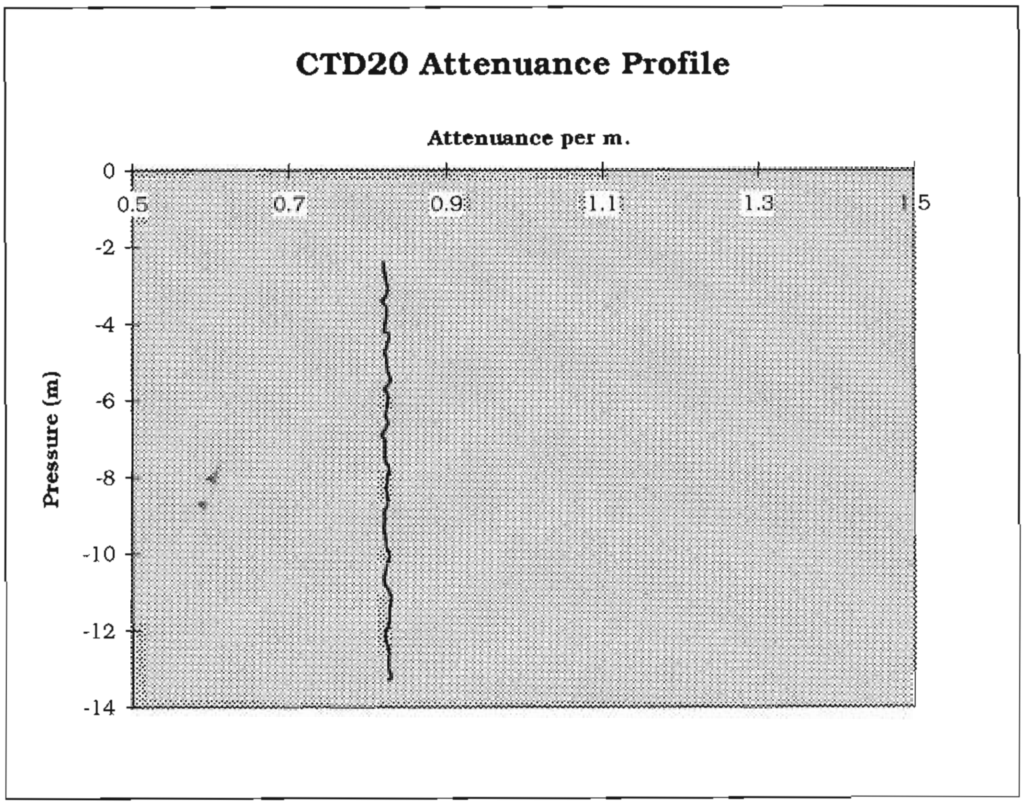

CTD17 Oxygen Profile.
Oxygen (uM)
0
20
40
60
80
100
120
140
-2
-4
-6
-8
-10
-12
-14
Pressure (mb)

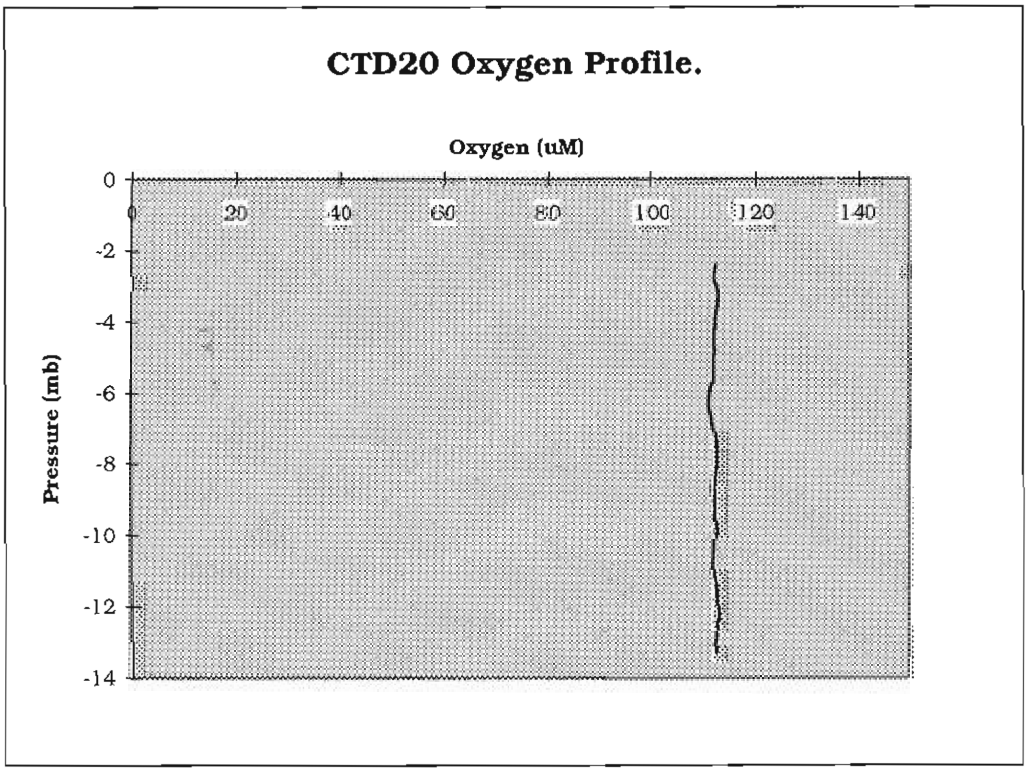

CTD18 Attenuance Profile
Attenuance per m.
Pressure (m)
0
0.5
0.6
0.7
0.8
0.9
1
-2
-4
-6
-8
-10
-12
-14

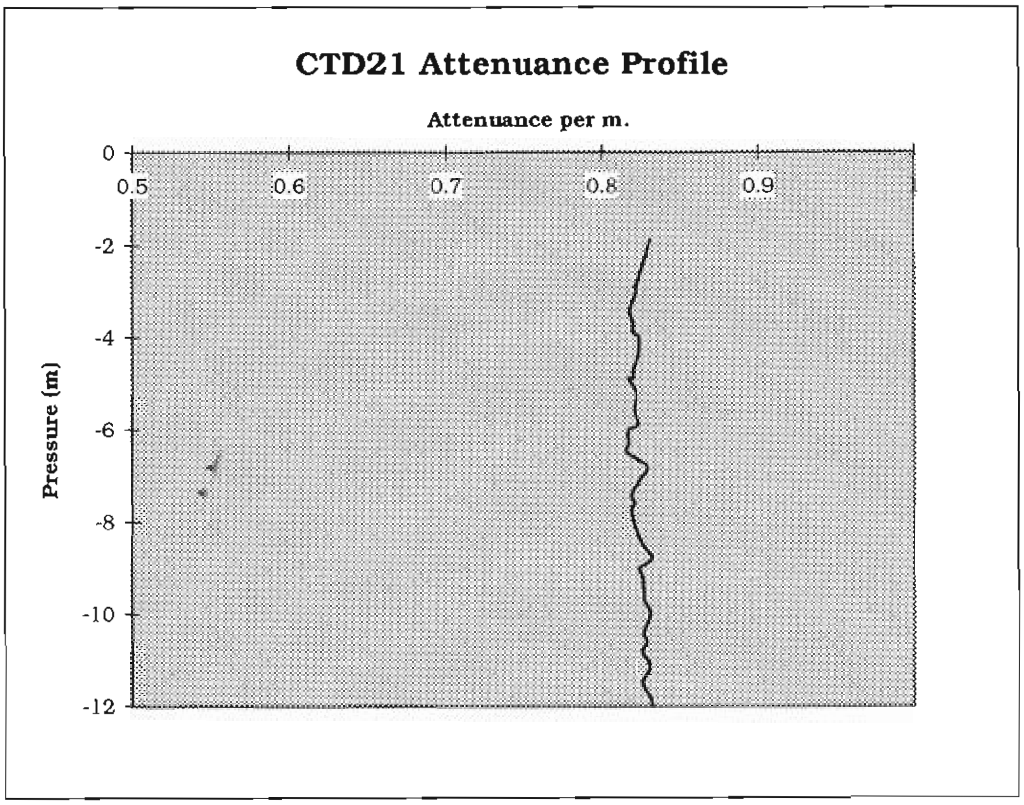

CTD18 Oxygen Profile.
Oxygen (uM)
Pressure (mb)
0
20
40
60
80
100
120
140
-2
-4
-6
-8
-10
-12
-14

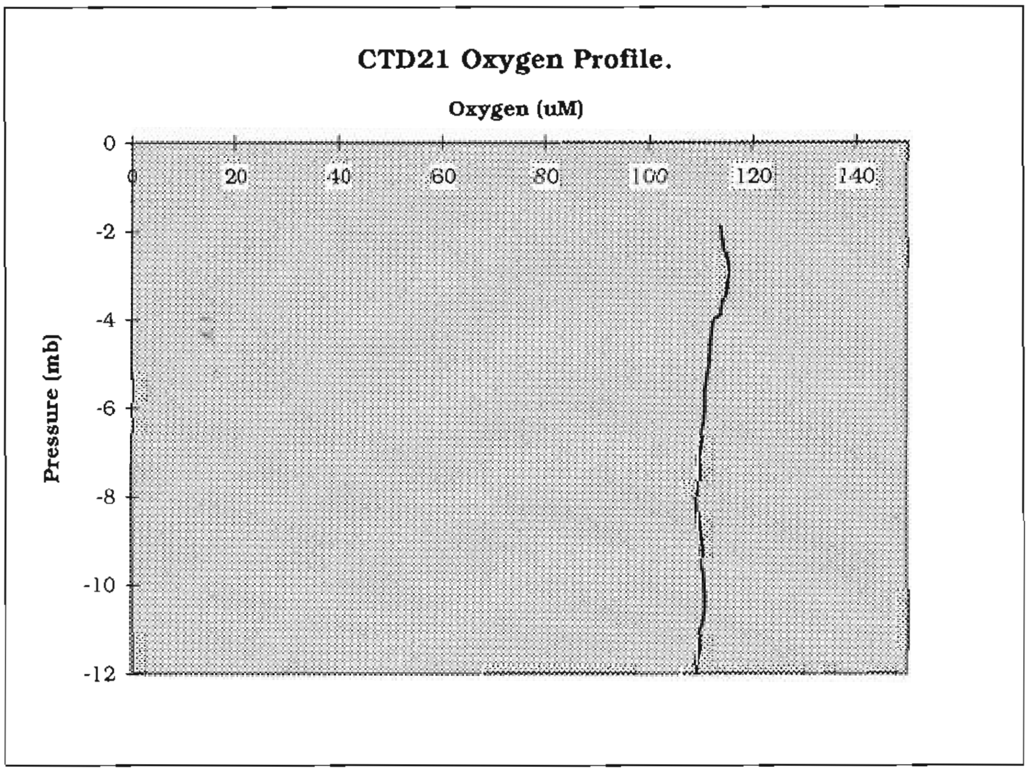

CTD19 Attenuance Profile
Attenuance per m.
Pressure (m)
0
-2
-4
-6
-8
-10
-12
-14
-16
0.5
0.7
0.9
1.1
1.3
1.5

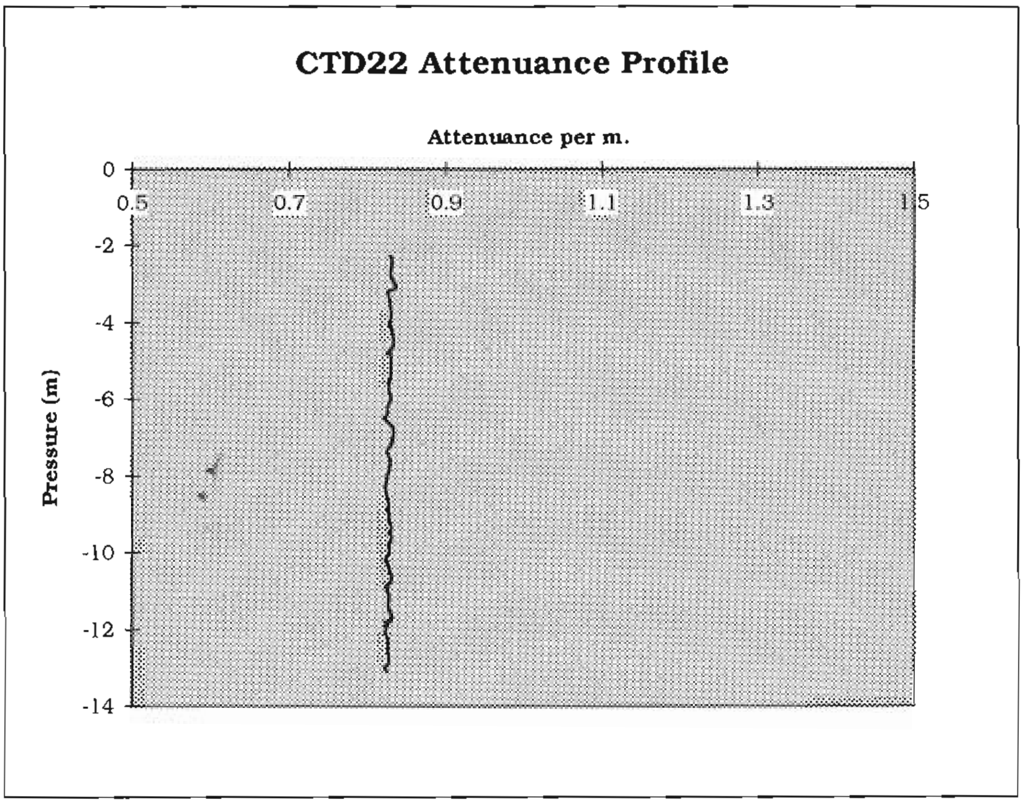

CTD19 Oxygen Profile.
Oxygen (uM)
Pressure (mb)
0
-2
-4
-6
-8
-10
-12
-14
-16
0
20
40
60
80
100
120
140

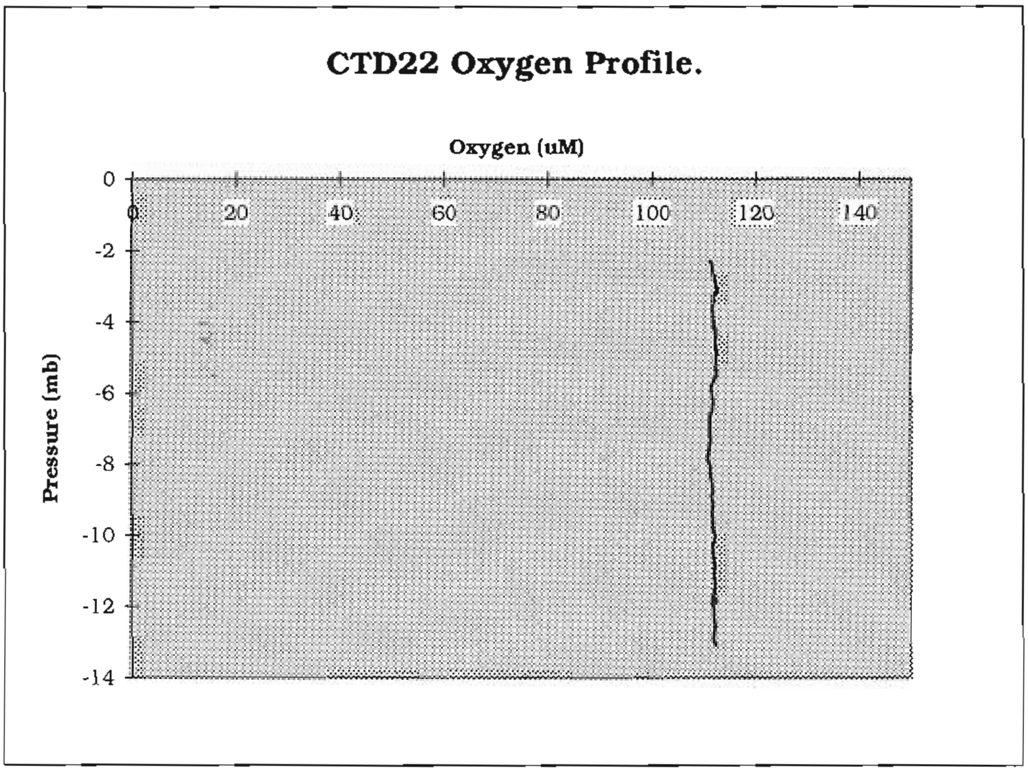

CTD20 Attenuance Profile
Attenuance per m.
0.5
0.7
0.9
1.1
1.3
1.5
0
-2
-4
-6
-8
-10
-12
-14
Pressure (m)

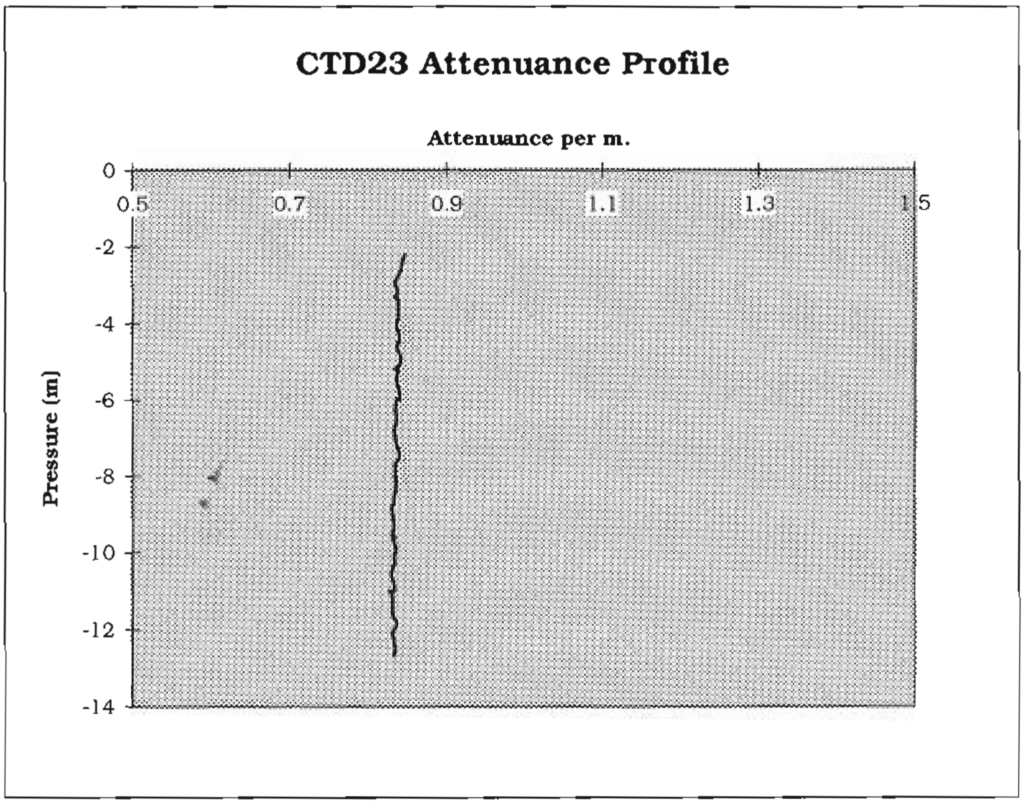

CTD20 Oxygen Profile.
Oxygen (uM)
0
20
40
60
80
100
120
140
0
-2
-4
-6
-8
-10
-12
-14
Pressure (mb)

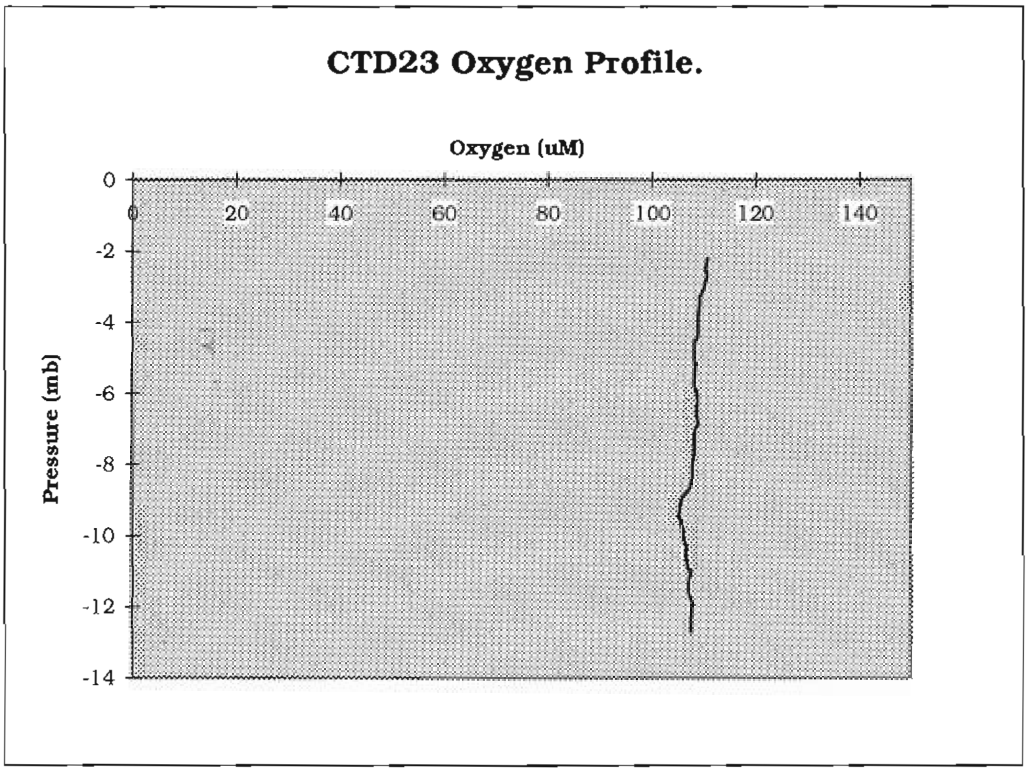

CTD21 Attenuance Profile
Attenuance per m.
0.5
0.6
0.7
0.8
0.9
1
0
-2
-4
-6
-8
-10
-12
Pressure (m)

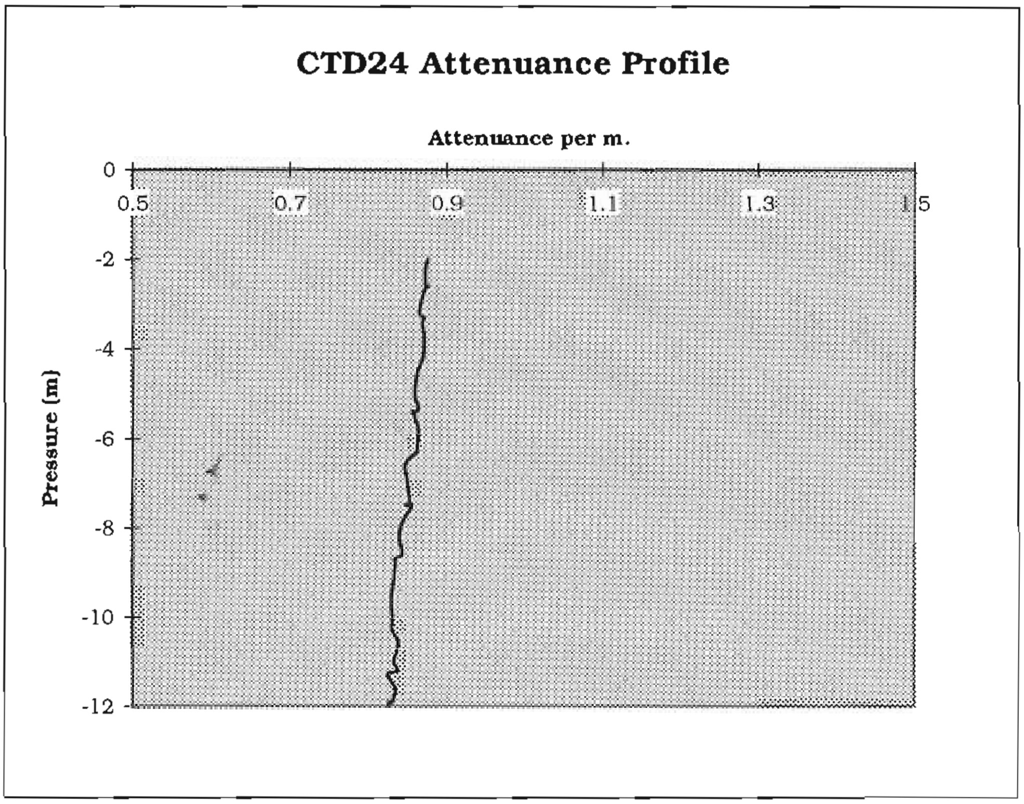

CTD21 Oxygen Profile.
Oxygen (uM)
0
20
40
60
80
100
120
140
0
-2
-4
-6
-8
-10
-12
Pressure (mb)

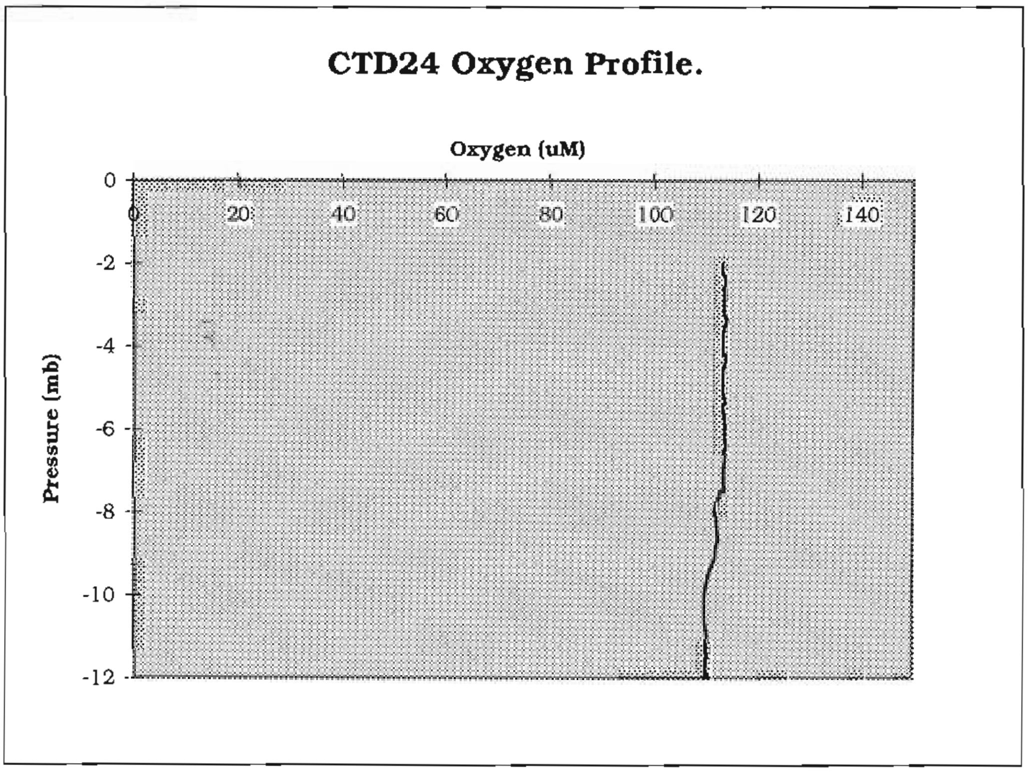

CTD22 Attenuance Profile
Attenuance per m.
0
0.5
0.7
0.9
1.1
1.3
1.5
-2
-4
-6
-8
-10
-12
-14
Pressure (m)

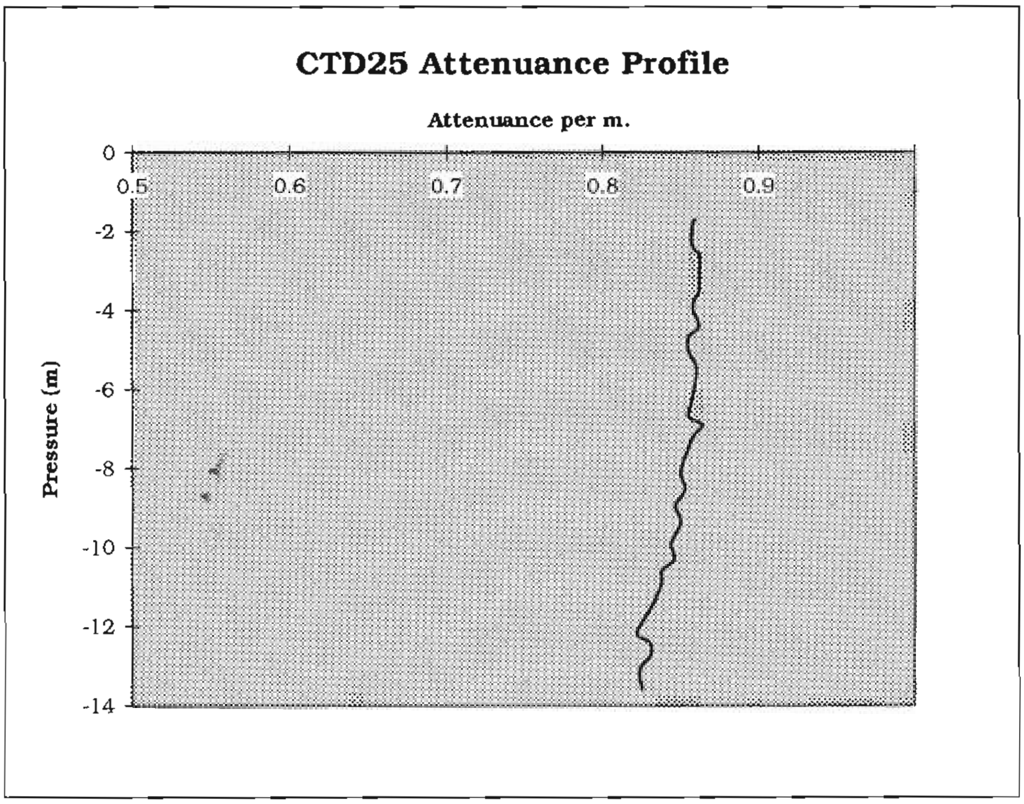

CTD22 Oxygen Profile.
Oxygen (uM)
0
20
40
60
80
100
120
140
-2
-4
-6
-8
-10
-12
-14
Pressure (mb)

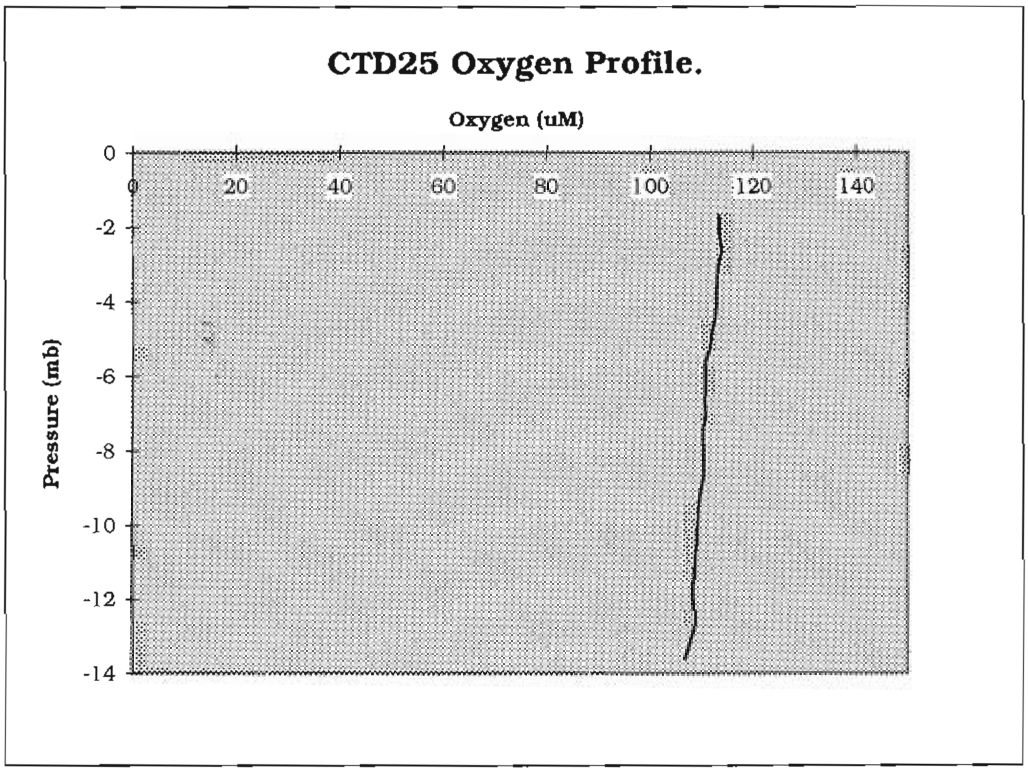

CTD23 Attenuance Profile
Attenuance per m.
0.5
0.7
0.9
1.1
1.3
1.5
0
-2
-4
-6
-8
-10
-12
-14
Pressure (m)

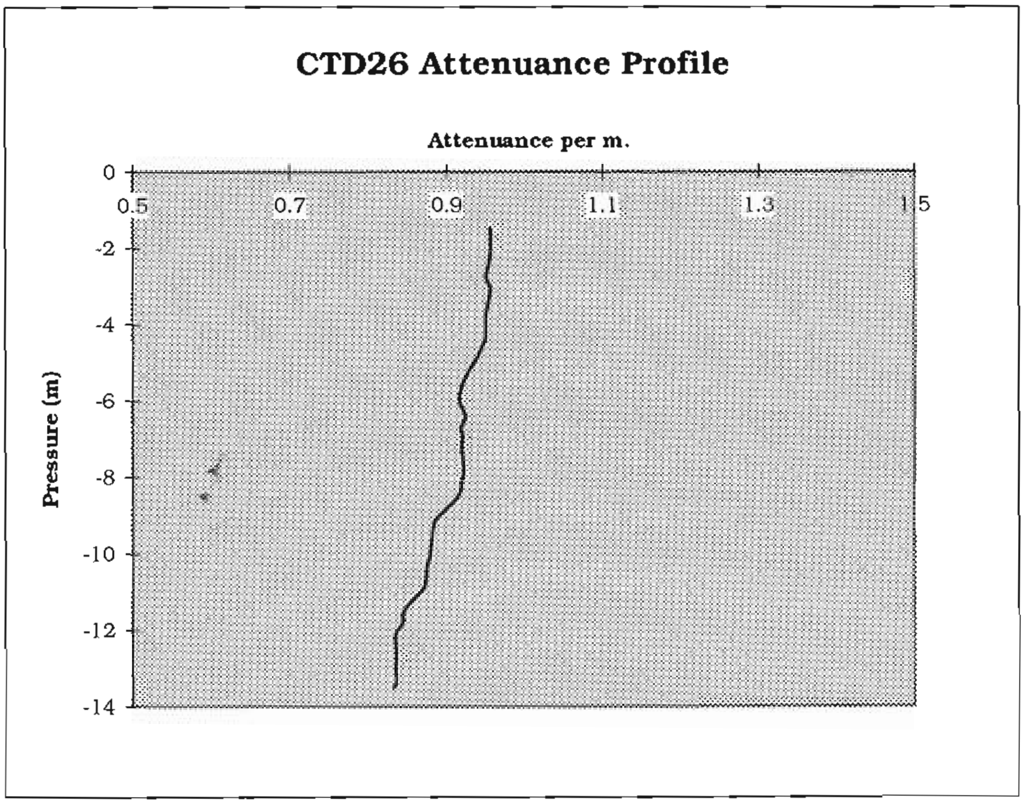

CTD23 Oxygen Profile.
Oxygen (uM)
0
20
40
60
80
100
120
140
0
-2
-4
-6
-8
-10
-12
-14
Pressure (mb)

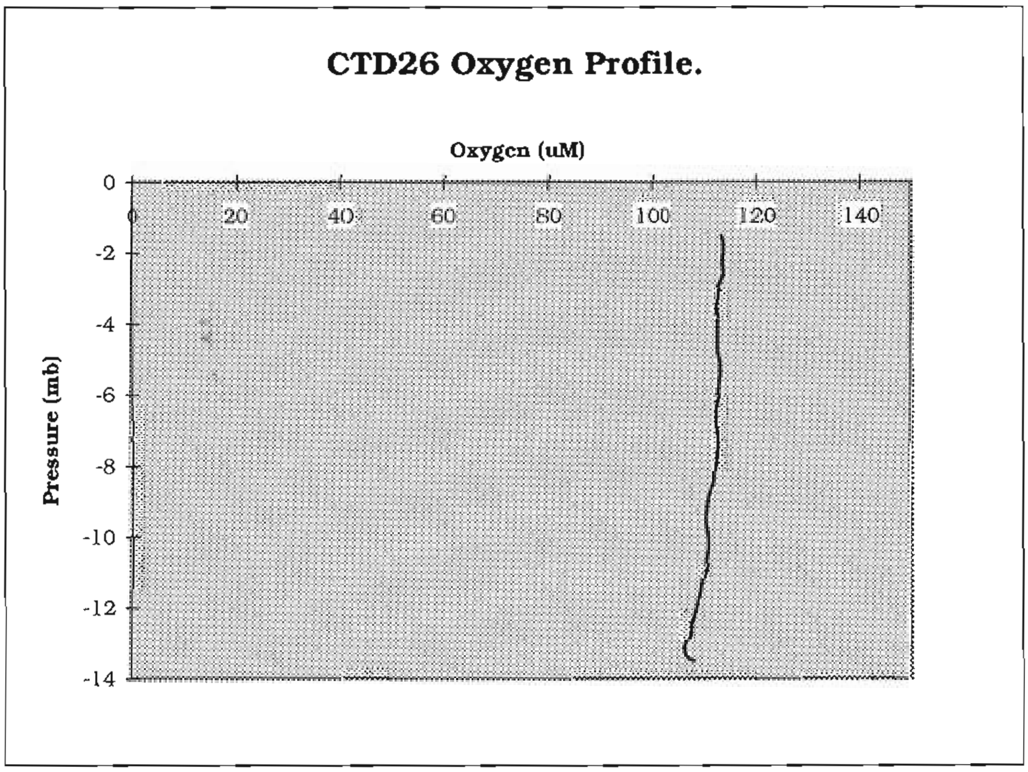

CTD24 Attenuance Profile
Attenuance per m.
0.5
0.7
0.9
1.1
1.3
1.5
0
-2
-4
-6
-8
-10
-12
Pressure (m)

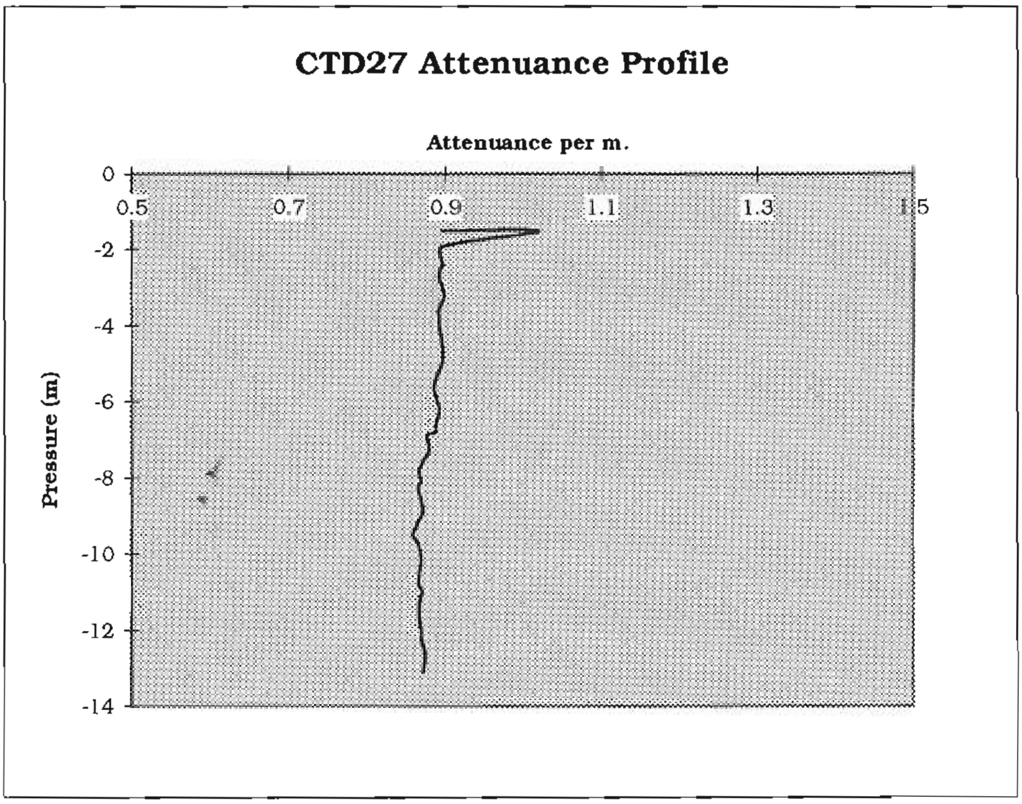

CTD24 Oxygen Profile.
Oxygen (uM)
0
20
40
60
80
100
120
140
0
-2
-4
-6
-8
-10
-12
Pressure (mb)

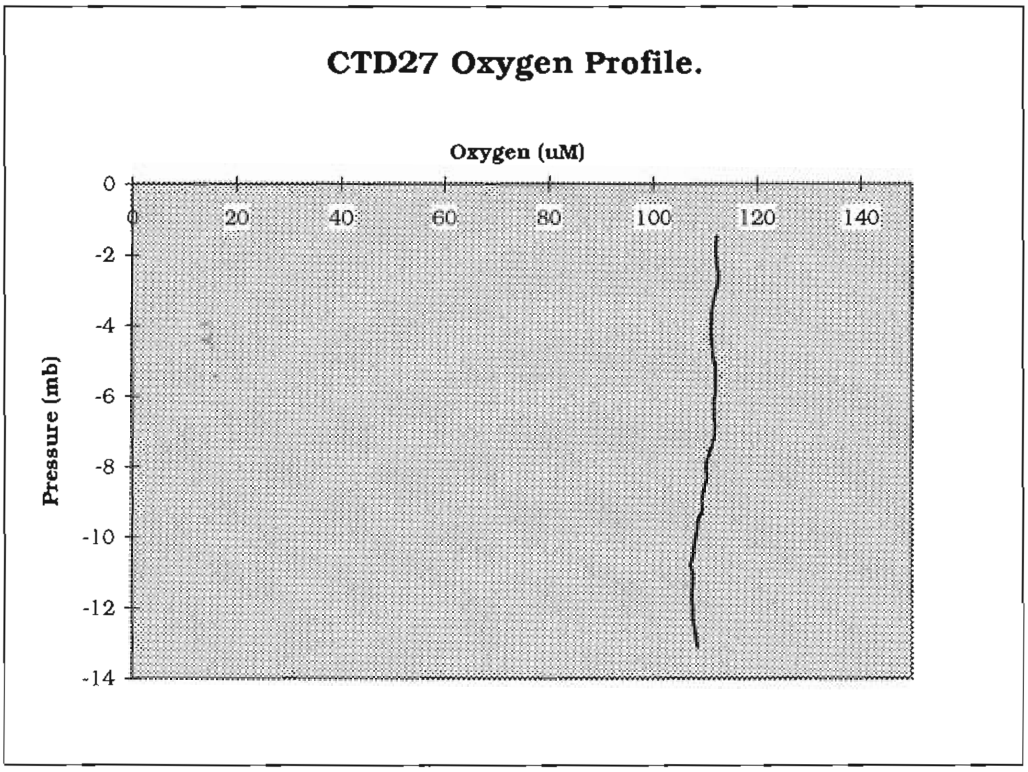

CTD25 Attenuance Profile
Attenuance per m.
0
0.5
0.6
0.7
0.8
0.9
-2
-4
-6
-8
-10
-12
-14
Pressure (m)

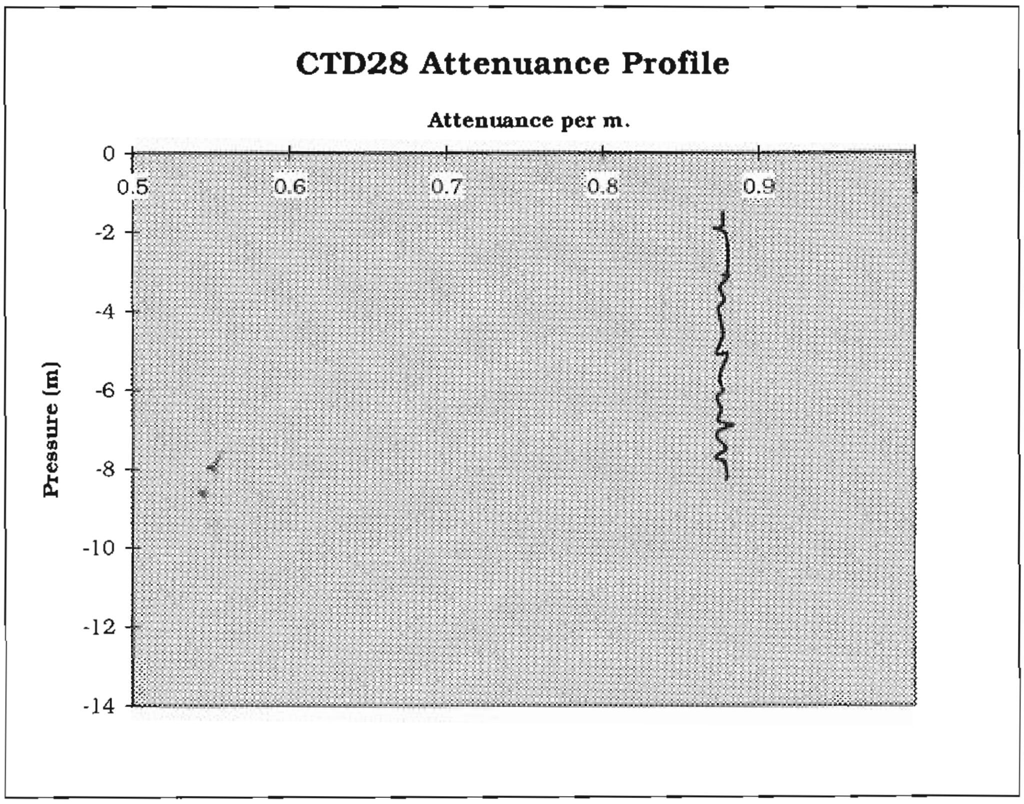

CTD25 Oxygen Profile.
Oxygen (uM)
0
20
40
60
80
100
120
140
-2
-4
-6
-8
-10
-12
-14
Pressure (mb)

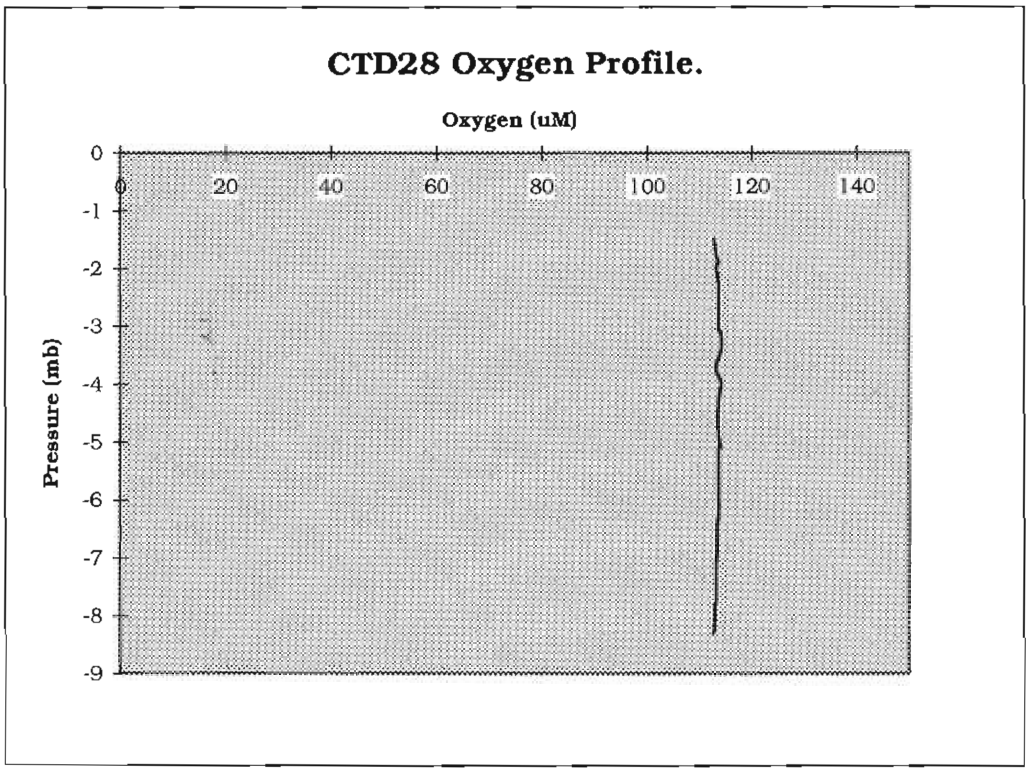

CTD26 Attenuance Profile
Attenuance per m.
0
0.5
0.7
0.9
1.1
1.3
1.5
-2
-4
-6
-8
-10
-12
-14
Pressure (m)

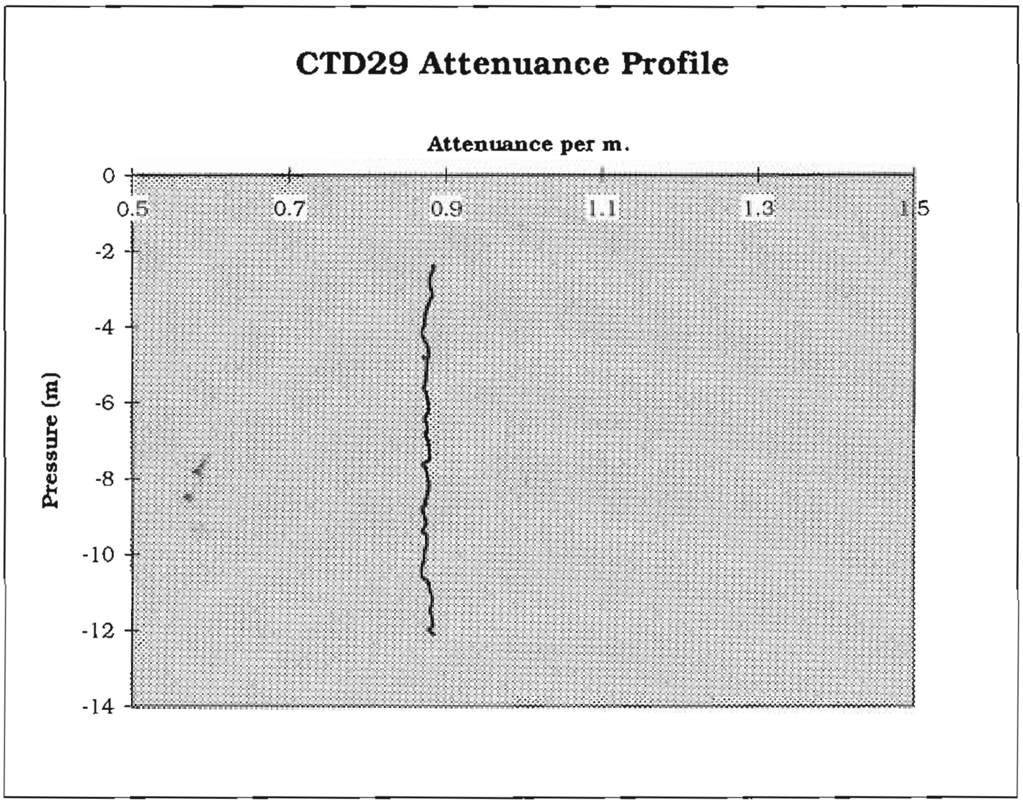

CTD26 Oxygen Profile.
Oxygen (uM)
0
20
40
60
80
100
120
140
-2
-4
-6
-8
-10
-12
-14
Pressure (mb)

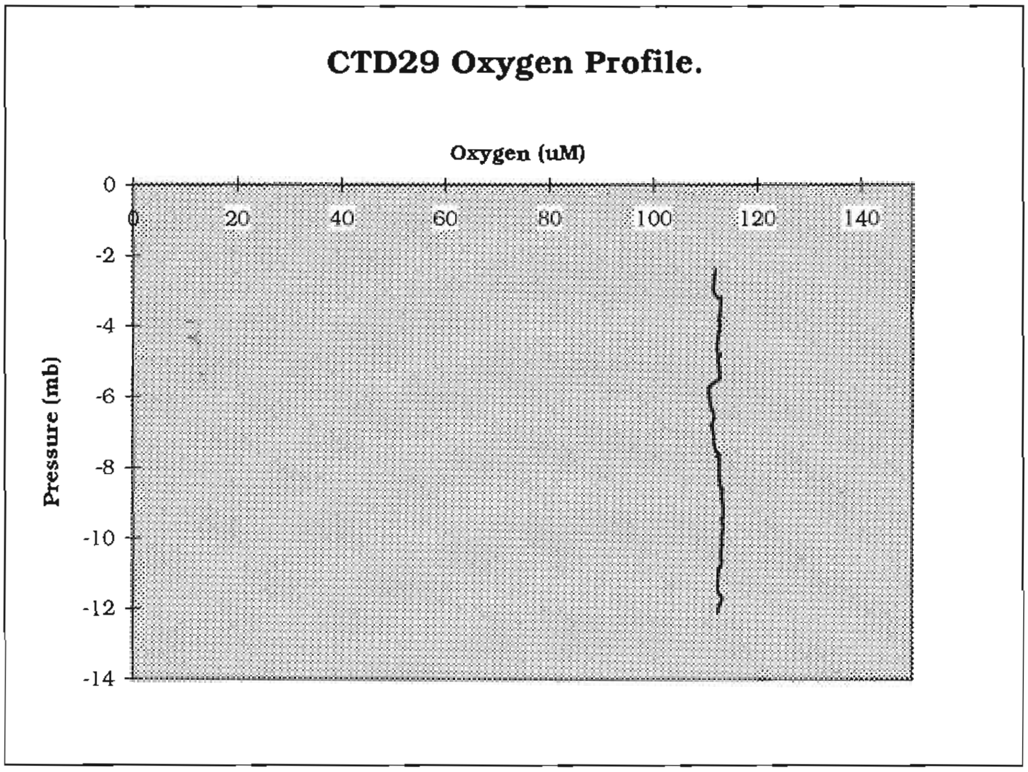

CTD27 Attenuance Profile
Attenuance per m.
0.5
0.7
0.9
1.1
1.3
1.5
0
-2
-4
-6
-8
-10
-12
-14
Pressure (m)

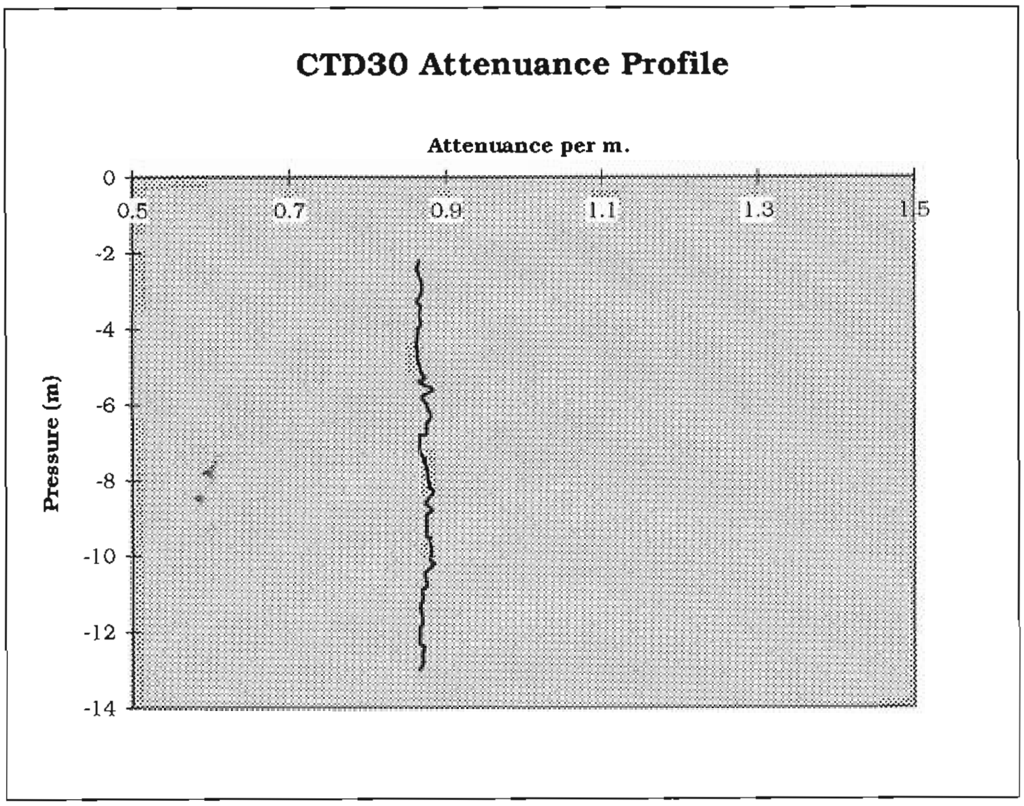

CTD27 Oxygen Profile.
Oxygen (uM)
0
20
40
60
80
100
120
140
0
-2
-4
-6
-8
-10
-12
-14
Pressure (mb)

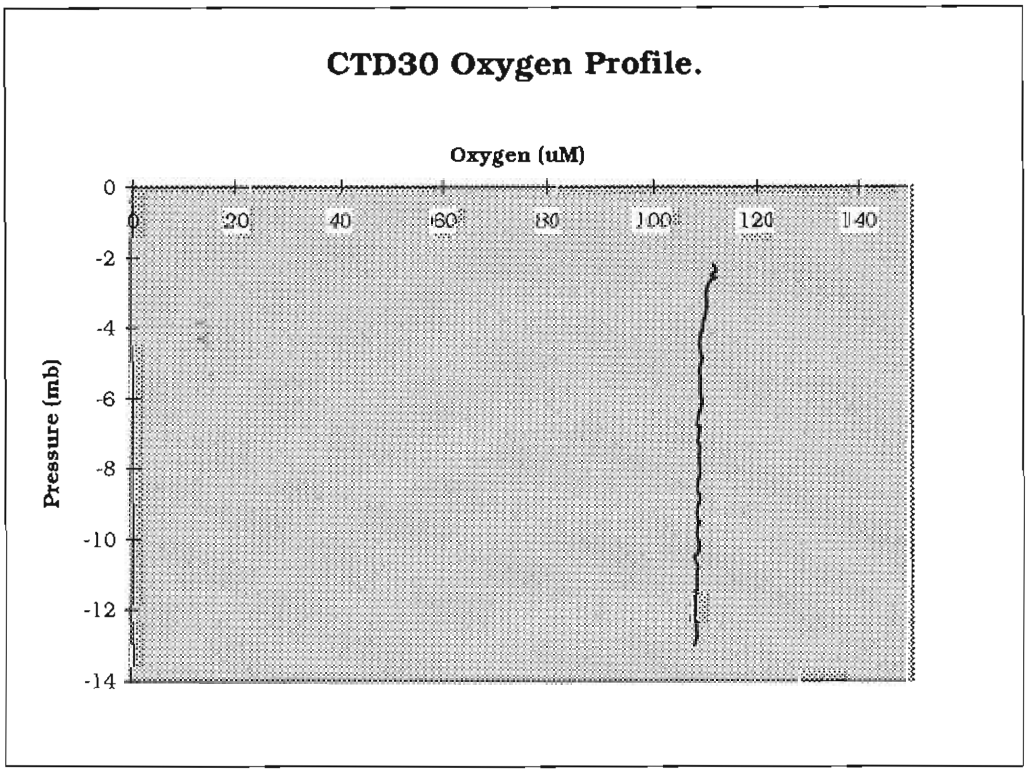

CTD28 Attenuance Profile
Attenuance per m.
0.5
0.6
0.7
0.8
0.9
1
0
-2
-4
-6
-8
-10
-12
-14
Pressure (m)

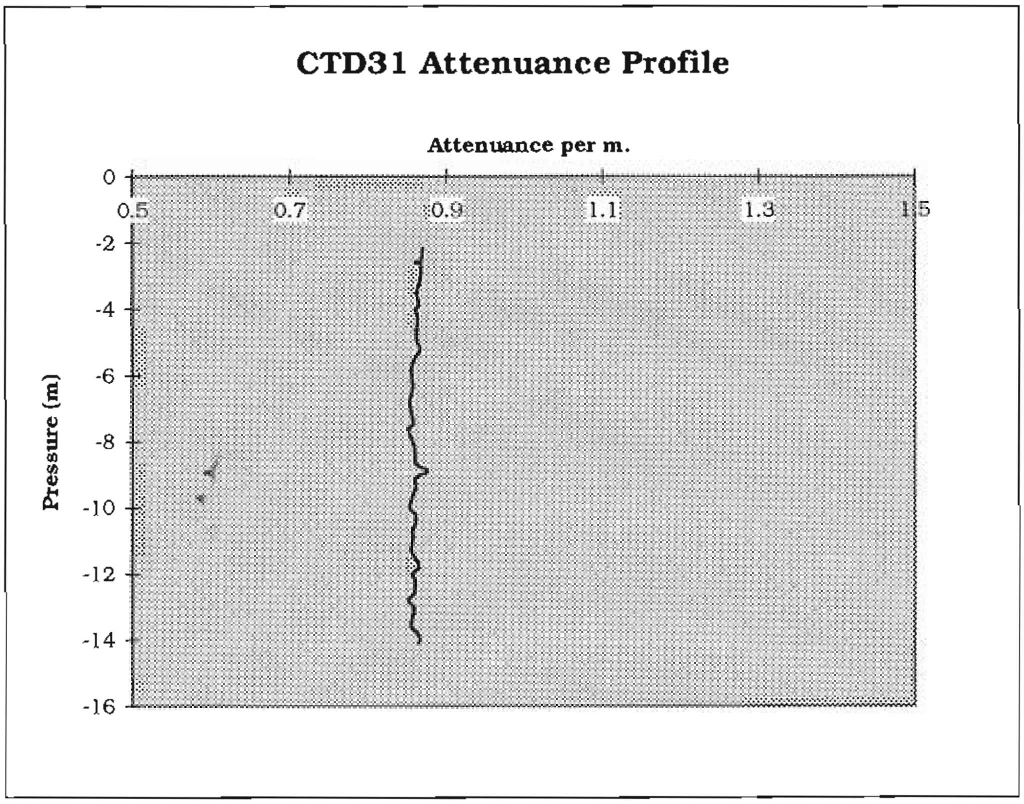

CTD28 Oxygen Profile.
Oxygen (uM)
0
20
40
60
80
100
120
140
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
Pressure (mb)

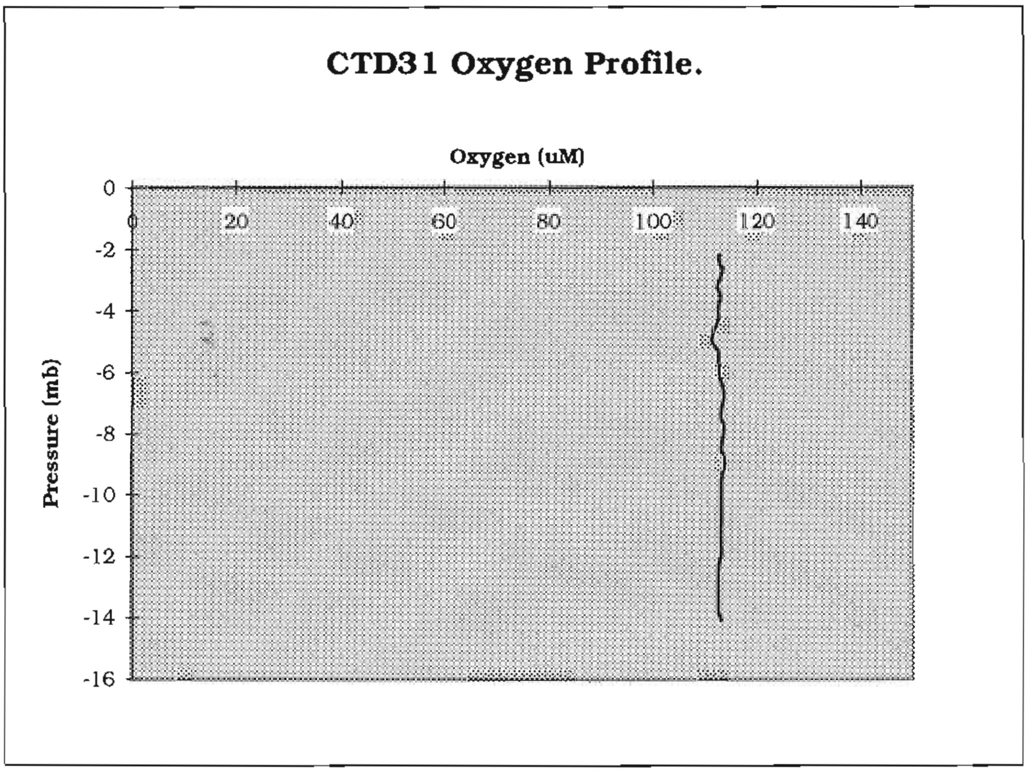

CTD29 Attenuance Profile
Attenuance per m.
0.5
0.7
0.9
1.1
1.3
1.5
0
-2
-4
-6
-8
-10
-12
-14
Pressure (m)

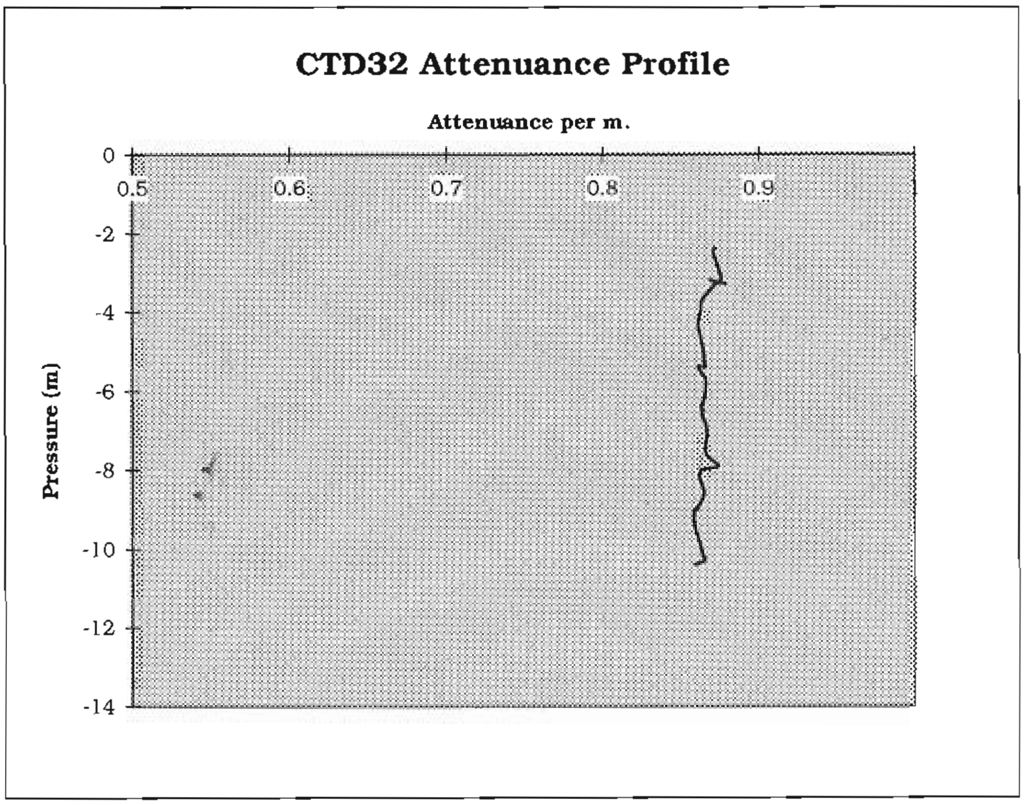

CTD29 Oxygen Profile.
Oxygen (uM)
0
20
40
60
80
100
120
140
0
-2
-4
-6
-8
-10
-12
-14
Pressure (mb)

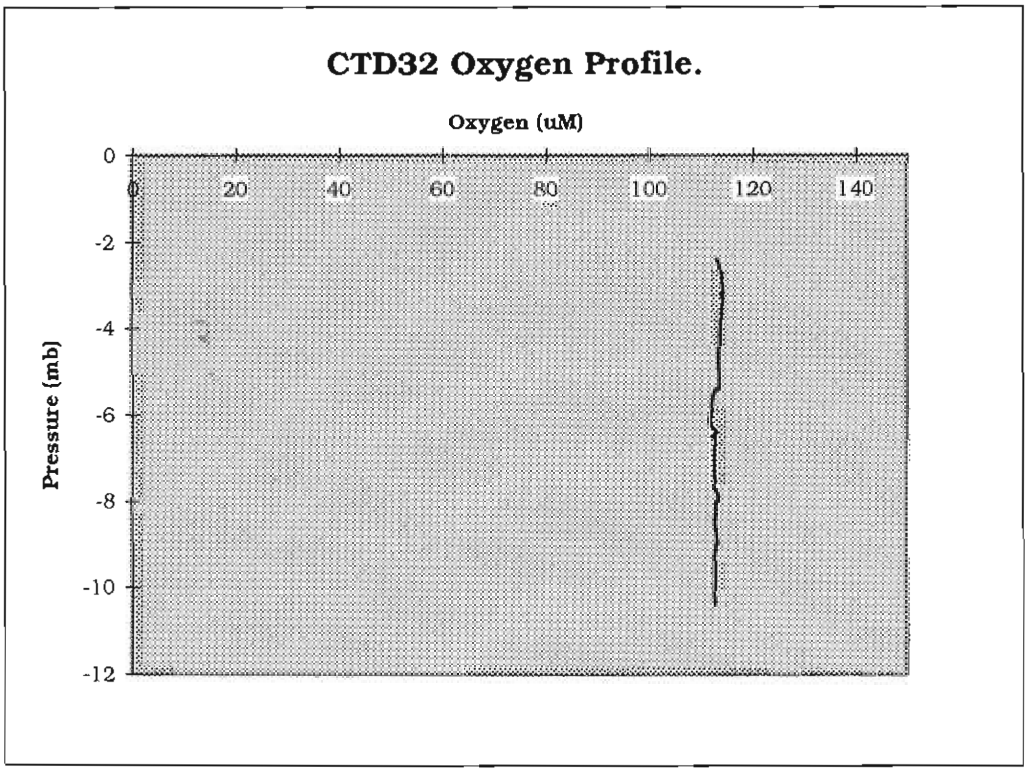

CTD30 Attenuance Profile
Attenuance per m.
Pressure (m)
0.5
0.7
0.9
1.1
1.3
1.5
0
-2
-4
-6
-8
-10
-12
-14

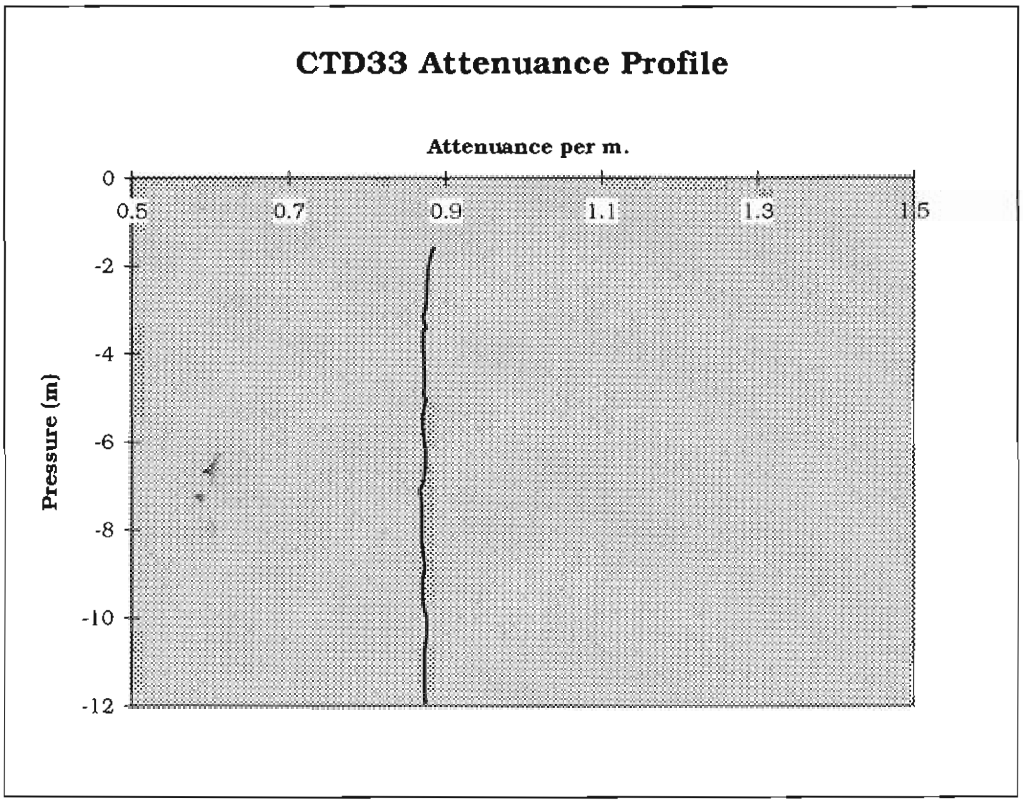

CTD30 Oxygen Profile.
Oxygen (uM)
Pressure (mb)
0
20
40
60
80
100
120
140
0
-2
-4
-6
-8
-10
-12
-14

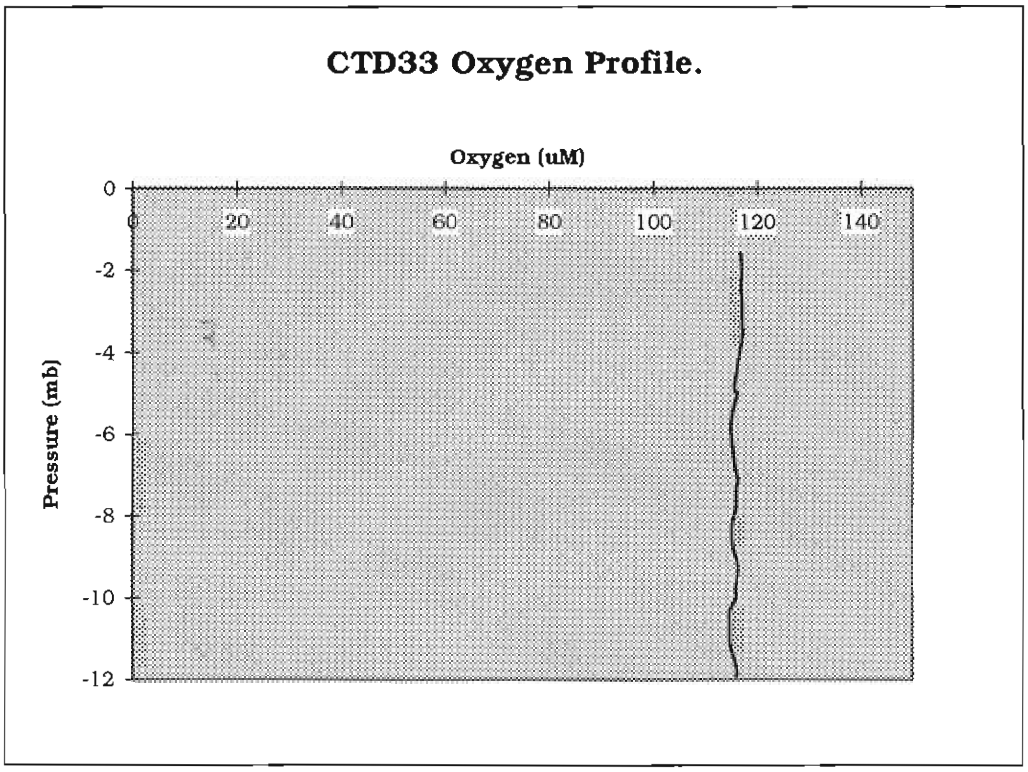

CTD31 Attenuance Profile
Attenuance per m.
0.5
0.7
0.9
1.1
1.3
1.5
0
-2
-4
-6
-8
-10
-12
-14
-16
Pressure (m)

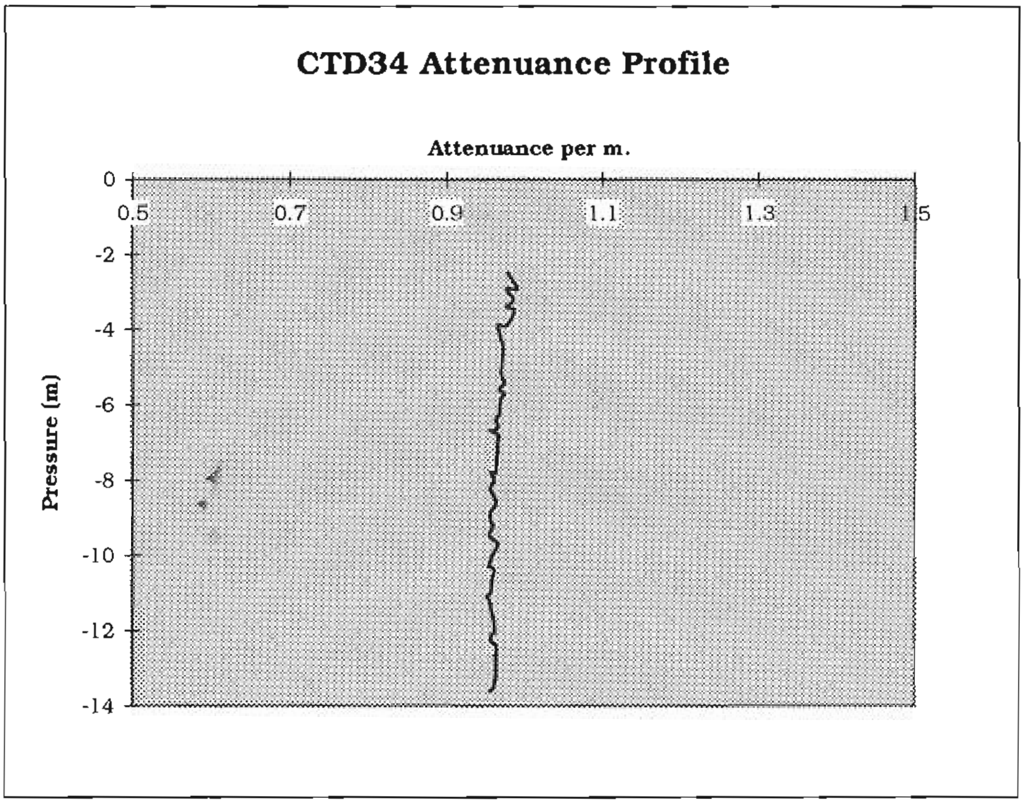

CTD31 Oxygen Profile.
Oxygen (uM)
0
20
40
60
80
100
120
140
0
-2
-4
-6
-8
-10
-12
-14
-16
Pressure (mb)

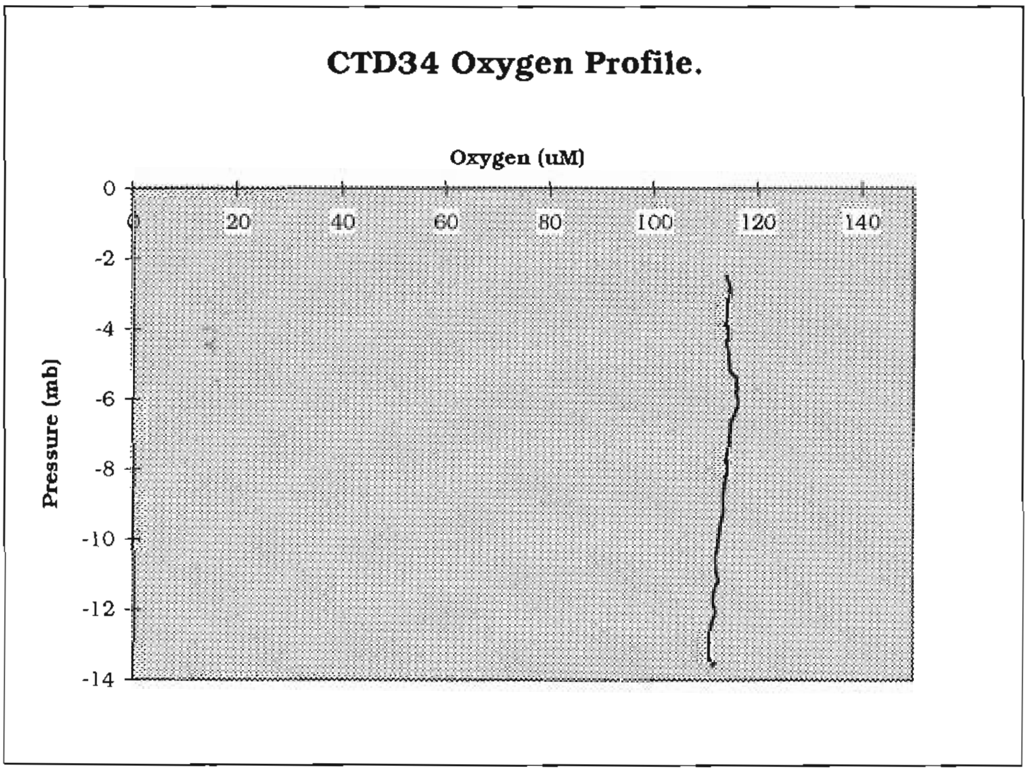

CTD32 Attenuance Profile
Attenuance per m.
0.5
0.6
0.7
0.8
0.9
0
-2
-4
-6
-8
-10
-12
-14
Pressure (m)

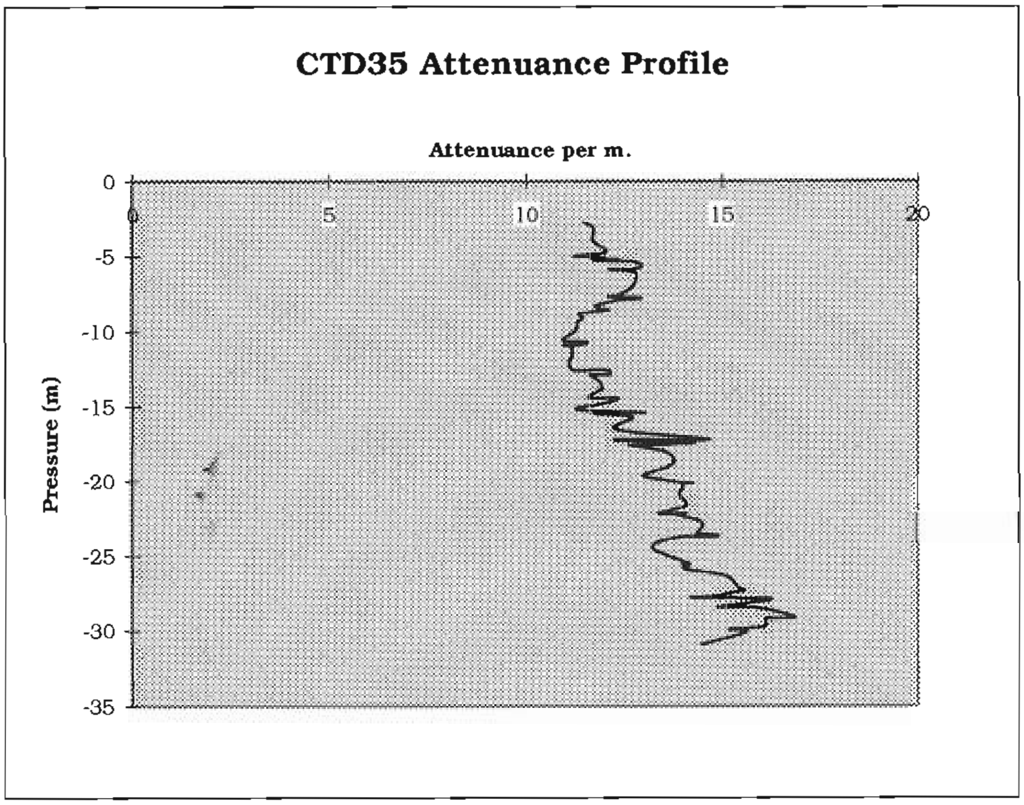

CTD32 Oxygen Profile.
Oxygen (uM)
0
20
40
60
80
100
120
140
0
-2
-4
-6
-8
-10
-12
Pressure (mb)

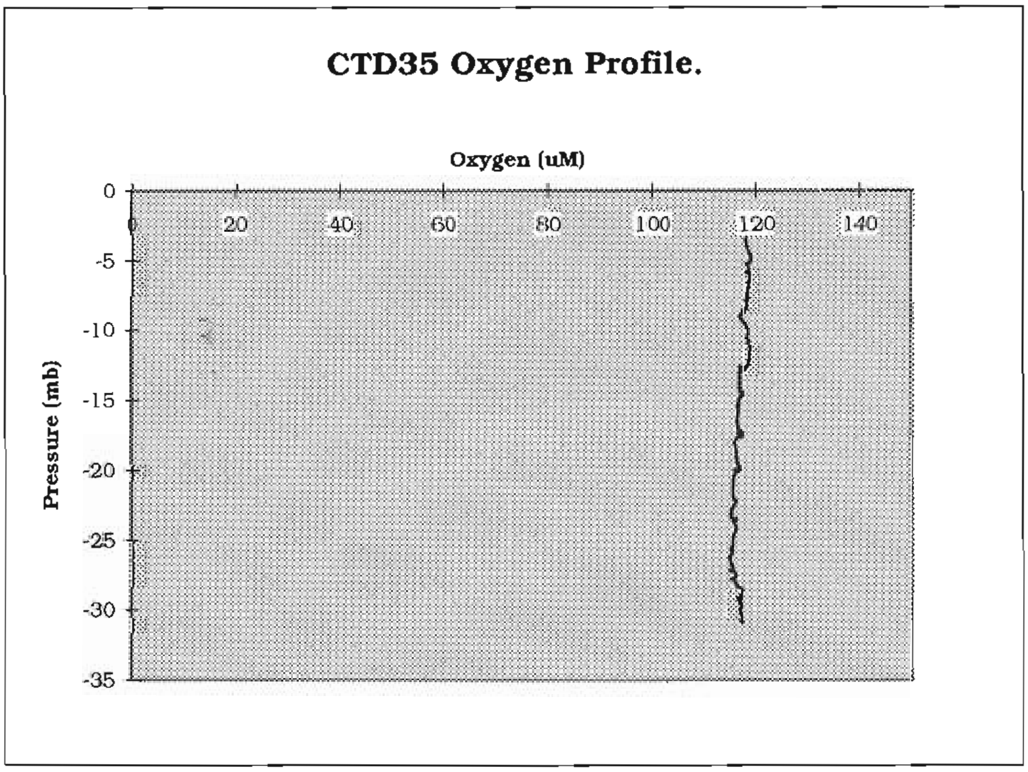

CTD33 Attenuance Profile
Attenuance per m.
0.5
0.7
0.9
1.1
1.3
1.5
Pressure (m)
0
-2
-4
-6
-8
-10
-12

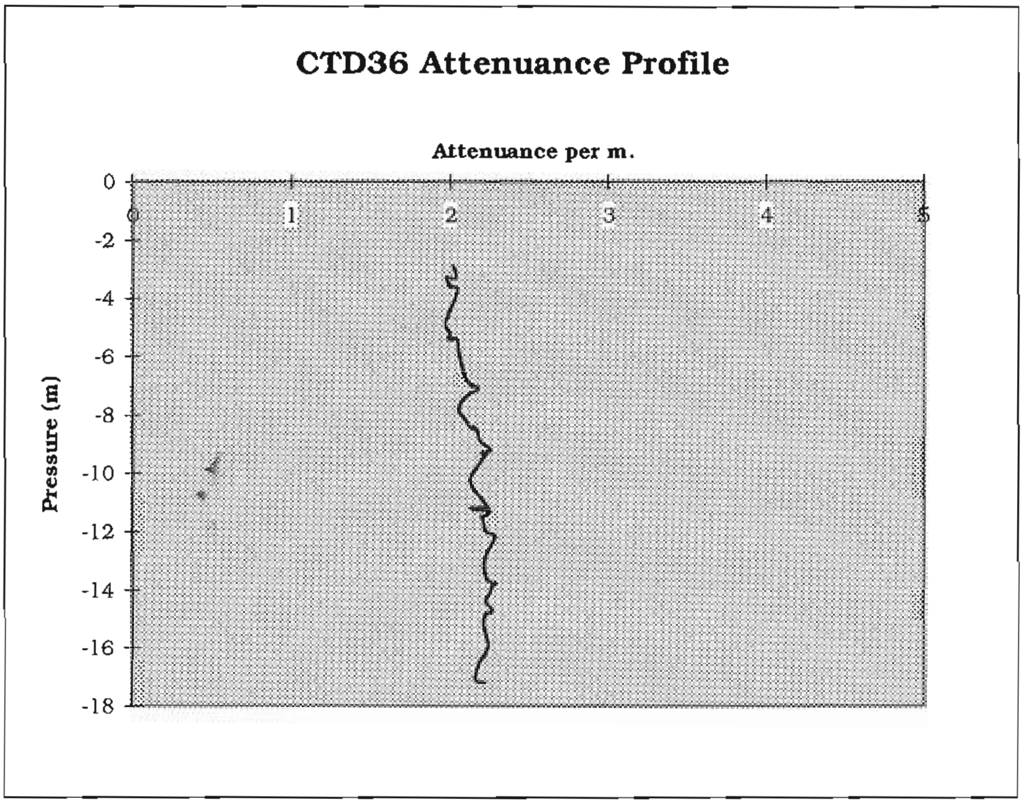

CTD33 Oxygen Profile.
Oxygen (uM)
0
20
40
60
80
100
120
140
Pressure (mb)
0
-2
-4
-6
-8
-10
-12

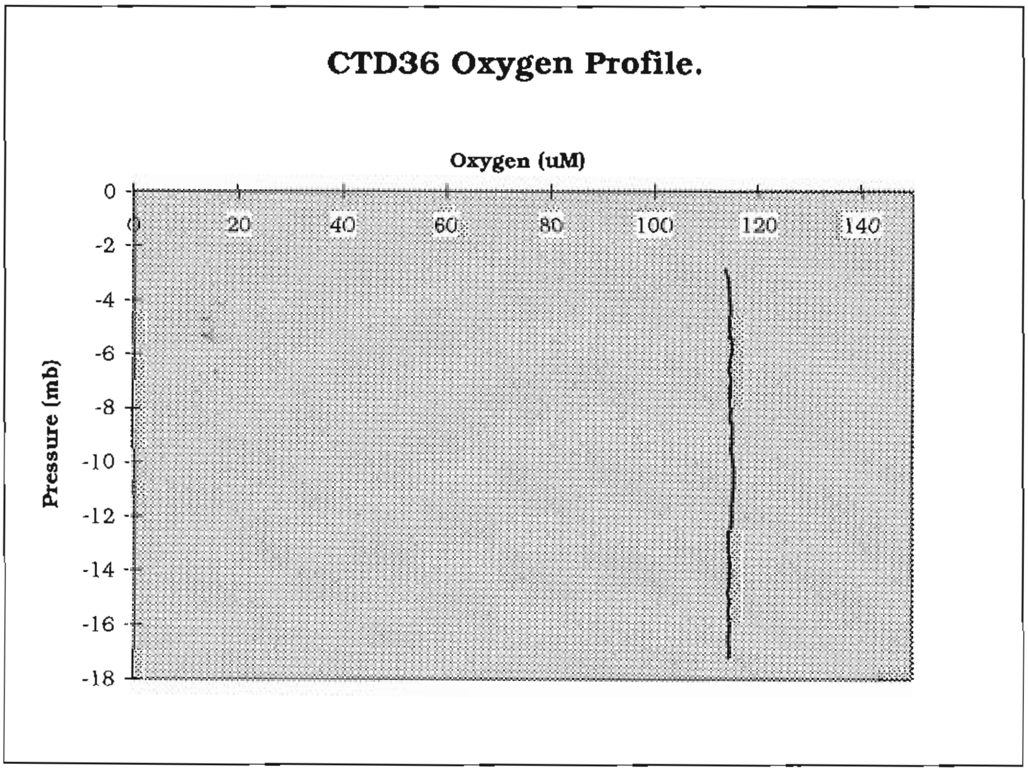

CTD34 Attenuance Profile
Attenuance per m.
Pressure (m)
0
-2
-4
-6
-8
-10
-12
-14
0.5
0.7
0.9
1.1
1.3
1.5

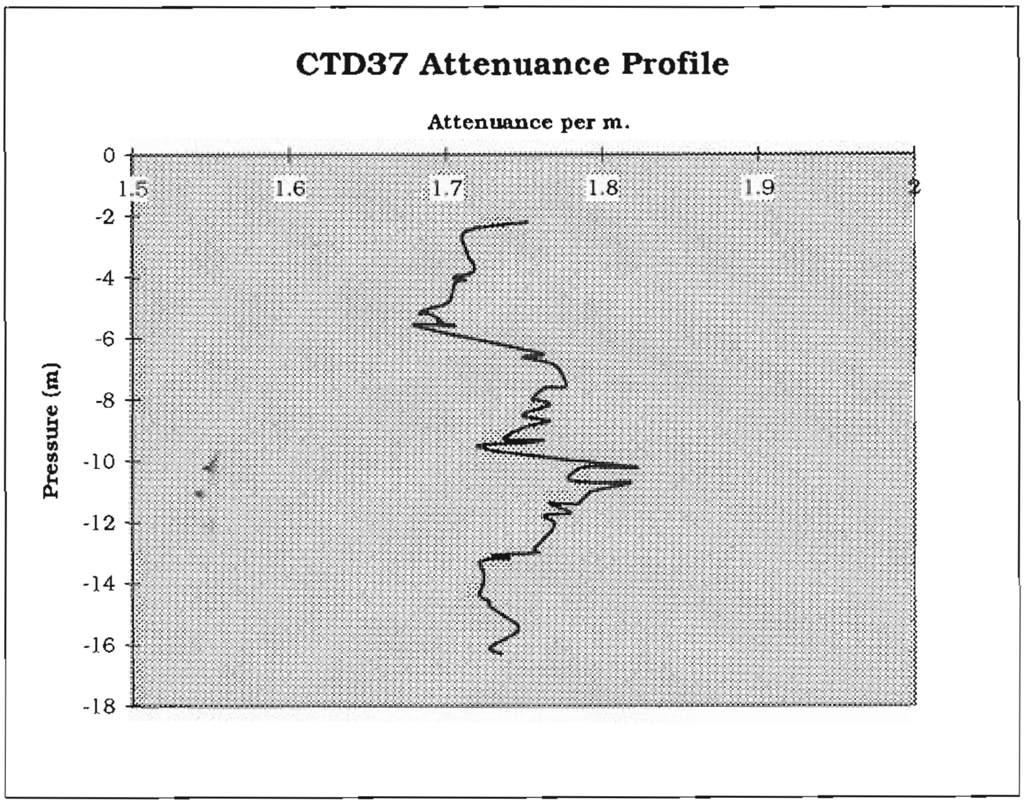

CTD34 Oxygen Profile.
Oxygen (uM)
Pressure (mb)
0
-2
-4
-6
-8
-10
-12
-14
0
20
40
60
80
100
120
140

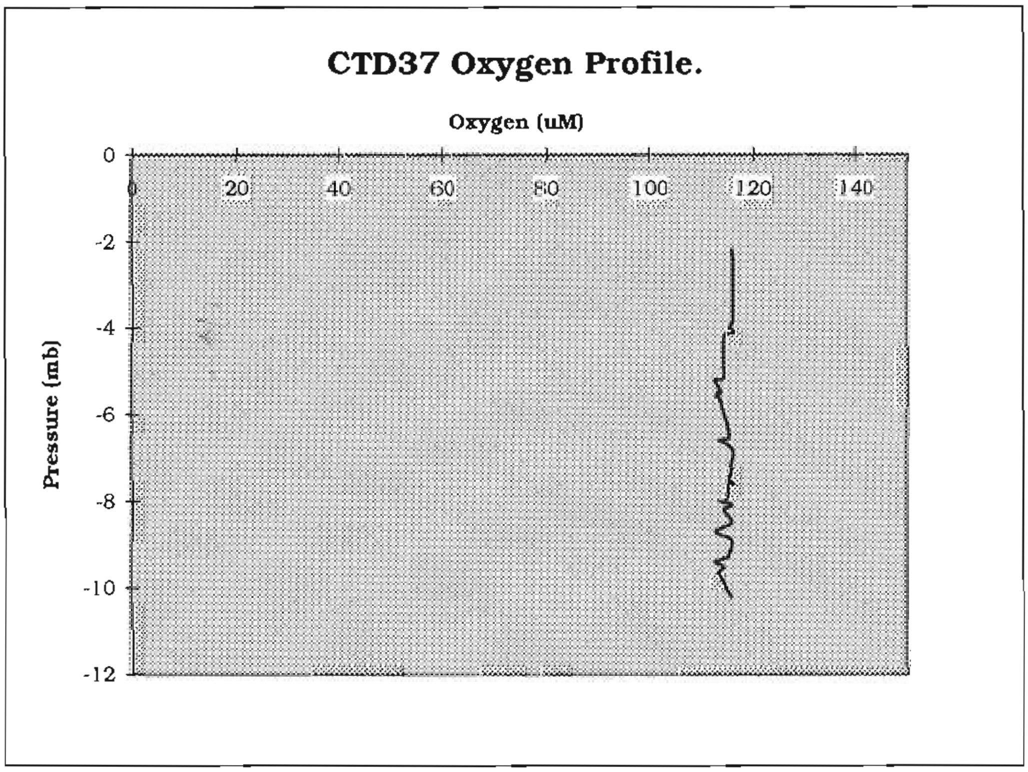

CTD35 Attenuance Profile
Attenuance per m.
0
5
10
15
20
0
-5
-10
-15
-20
-25
-30
-35
Pressure (m)


CTD35 Oxygen Profile.
Oxygen (uM)
0
20
40
60
80
100
120
140
0
-5
-10
-15
-20
-25
-30
-35
Pressure (mb)


CTD36 Attenuance Profile
Attenuance per m.
0
1
2
3
4
5
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
Pressure (m)


CTD36 Oxygen Profile.
Oxygen (uM)
0
20
40
60
80
100
120
140
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
Pressure (mb)


CTD37 Attenuance Profile
Attenuance per m.
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
1.5
1.6
1.7
1.8
1.9
2
Pressure (m)


CTD37 Oxygen Profile.
Oxygen (uM)
0
-2
-4
-6
-8
-10
-12
0
20
40
60
80
100
120
140
Pressure (mb)