MINISTRY OF AGRICULTURE, FISHERIES AND FOOD
FISHERIES LABORATORY, LOWESTOFT, SUFFOLK, ENGLAND

1993 RESEARCH VESSEL PROGRAMME

REPORT: RV CIROLANA: CRUISE 5

STAFF:

J H Nichols	
L E Woolner	
D K Mills (RV LOUGH FOYLE, 24-26 May)	
B F Riches	
G M Haynes	
A J Winpenny	
A Reeve	
R Head (PML)	to 19 May
P Tranter (PML)	to 19 May
S Kratzler (UCNW)	to 8 May and 19-27 May
P Tett (UCNW)	to 8 May
J W Read	to 8 May and 27-29 May
R Wilton (UCNW)	to 8 May
G Kennaway	from 8-27 May
K Ramsay	from 19 May
I Biegala	from 8-19 May

DURATION: 4 May-2 June

LOCATION: Irish Sea

AIMS:

1. To deploy a moored current meter rig at 53°51'N 05°34'W to monitor continuously near-surface chlorophyll 'a' fluorescence, nitrate, salinity and light. To monitor temperature throughout the water column and near-surface/near-bottom current speed and direction.

2. To measure daily primary production at a number of sites within predetermined physical domains in the north-west Irish Sea.

3. To deploy and evaluate solar fluorometry as a measure of instantaneous primary production in conjunction with DANI.

4. To obtain estimates of zooplankton egg production in relation to both primary production and physical condition at the same sites as 2 above, and to collect copepod samples for ATC enzyme analysis.

5. To sample fish eggs and larvae in relation to physical domains in the north-west Irish Sea.

6. To estimate growth and condition of fish larvae in relation to temperature, food availability and physical domain.

7. To deploy a sediment trap for DANI at the moored rig site.

8. To take sediment samples and large volume surface seawater samples at 14 sites off the Cumbrian coast as part of the May Whitehaven survey (AEP 1).

NARRATIVE:

The ship sailed at 1830 h 4 May and after a good passage began plankton sampling in the Irish Sea at 1545 h 6 May. A moored instrument rig with sediment traps and two guard buoys was laid at 53°52.6'N 05°33.5'W by 0600 h 7 May. An hourly CTD sampling series at the mooring was completed at 0745 h on the following day, after which the ship steamed to Holyhead to exchange some staff. The UOR was then towed on a 40 n ml transect from west of Anglesey towards Dundrum Bay (Figure 1, grid points 22 to 7).

The first of three HSTN surveys on a 37-station grid (Figure 1) was started at 2240 h 8 May. This survey incorporated twice daily sampling of live copepods for egg production studies, concurrent measurements of primary production and continuous monitoring of surface temperature, salinity and chlorophyll 'a' fluorescence. The survey was completed at 0645 h 11 May, at grid point 37 where a full primary production incubation and live copepod collection was carried out. The ship then returned to the moored rig to take water samples from CTD rosette profiles for comparative observation with the moored sensors. An attempt to collect live fish larvae in the nominally stratified domain (grid point 6) was abandoned in poor weather at 2100 h. Work restarted at 0400 h 12 May off Dundalk Bay with larvae collection, live copepod collection and primary production incubation. Work continued in the coastal mixed water north to Dundrum Bay and included LHPR deployments. The ship steamed overnight to the nominally frontal domain (grid point 17) by 0500 h 13 May to repeat the previous day's pattern of sampling in this domain and in the eastern mixed area (grid point 21). Work was temporarily suspended from 1030 h to 1520 h while the ship steamed to Holyhead to pick up a new deckhand. The ship steamed overnight to a position in the middle of the eastern mixed domain, 53°50'N 4°10'W, to take samples for primary production incubation and to collect live copepods. The CTD rosette and solar fluorometer were then deployed on a line of five stations from the eastern mixed domain to the mooring (Figure 1). Water samples were taken at each station for chlorophyll 'a' and nutrient analysis. Live larvae collection tows and an LHPR deployment were carried out in deteriorating weather in the stratified domain (grid point 6), until 2145 h. Sampling in the coastal domain started at 0400 h 15 May and continued throughout the day. On completion at 0030 h 16 May, the UOR was towed on the transect from grid points 7 to 22. Samples for primary production incubation and live copepods were taken at the end of this transect.

The second coverage of the survey grid with the HSTN began at 0750 h, again incorporating additional sampling for primary production and live copepods. The survey continued in poor weather, towing the HSTN before the wind, until 2230 h 17 May when the SE severe gale forced a halt. The survey was restarted at 0620 h 18 May and completed at 2150 h. Grid points 30, 31 and 36 were not sampled. A final sample of live copepods was taken at 53°50'N 4°10'W after which the ship steamed to Barrow-in-Furness for the mid-cruise break, to change some staff and to pick up three current meter rigs for return to Lowestoft. The ship docked at 1000 h 19 May and sailed again at 0900 h 20 May.

The following fifteen hours were spent sampling sediment and taking large volume surface water samples at fourteen stations off the Cumbrian coast as part of the Marchon project (AEP 4). On completion at 2150 h, the samples and A Poole were transferred at sea to MV SOLWAY PROTECTOR off Whitehaven. The ship then returned to the site of the moored rig in the western Irish Sea arriving there at 0450 h 21 May.

At the mooring site CTD rosette and solar fluorometer profiles were taken. Water samples were taken for subsequent analysis of chlorophyll 'a' and nutrients. The remainder of the day was spent doing larvae collection and LHPR deployments in the stratified and coastal domains. The UOR was again towed overnight on a transect south-eastwards ending at grid point 22 at 0330 h 22 May. The line of five stations from the eastern mixed domain in the mooring, previously sampled on 14 May, was repeated. CTD rosette and solar fluorometer profiles were taken at each station. Further live larvae and LHPR samples were taken in the 'frontal' domain off Lambay Island (grid point 14), and in the 'mixed' domain east of the Kish Bank ending at 2250 h. The ship then returned to the mooring site at 0400 h 23 May to begin an hourly primary production sampling series with the CTD rosette and solar fluorometer. An *in situ* incubation rig was launched but, because of poor weather, this had to remain attached to the ship. The sampling series was completed at 0415 h 24 May. Because of strong easterly winds, the planned transfer at sea of D Mills to RV LOUGH FOYLE had to take place in the lee of the Isle of Man. Following the transfer, the weather further deteriorated and both vessels remained at anchor overnight.

RV CIROLANA left the anchorage at 0545 h 25 May and returned to the mooring site for a single CTD deployment. Further larvae collection tows were then made in the 'stratified' and 'coastal' domains until 2020 h when the final HSTN survey was started. This was halted at 0600 h on the following day by a NE gale off Rockabill. The ship slowly dodged north-eastwards eventually arriving at the anchorage off the Isle of Man at 1730 h 26 May. RV LOUGH FOYLE had remained there working over the previous 48 hours. D Mills returned to RV CIROLANA at 1830 h but because of a major switchgear failure in the engine room the ship remained there at anchor overnight. On completion of repairs the HSTN survey was restarted at 0545 h 27 May. A further five stations were completed before the ship steamed to Holyhead to pick up J W Read and to disembark two UCNW staff (1530 h to 1700 h). A further nine stations of the now modified HSTN survey were completed overnight, returning to the mooring site by 0600 h 28 May.

Dense fog with visibility < 50 m hampered the recovery of the instrument rig, sediment traps and guard buoys for servicing. This was completed at 1000 h after which the UOR was towed, on its only daylight transect, from grid point 7 to 22. On completion at 1540 h the ship returned to the mooring site to relay the rig. This was completed at 2030 h and after further larvae collection tows off Lambay and Kish Bank, the remainder of the HSTN survey stations were started at 0540 h 29 May. J Read was disembarked at Holyhead at 1930 h after which the last four HSTN stations were completed. The line of five CTD stations to the mooring was completed at 0700 h 30 May. The remainder of that day was spent sampling larvae and doing LHPR deployments in the 'stratified' domain and in the 'coastal' domain off Clogher Head and Dundalk Bay. This was completed at 1820 h. A final UOR transect from grid points 7 to 22 was started at 2000 h and completed at 2320 h. On completion, course was set for Lowestoft in a strong south-westerly wind. The weather slowly improved and after a calm passage through the English Channel RV CIROLANA docked in Lowestoft at 0730 h 2 June.

RESULTS

1. Moorings were deployed with a range of continuous recording instruments. An *in situ* analyser, recording fluorometer, recording transmissometer (UCNW), two light sensors (UCNW) and a current meter were deployed in the upper 20 m. A second current meter was placed above the sea bed. Separate moorings included a thermistor chain and two sediment traps (DANI). All instruments were recovered, serviced and redeployed except for the UCNW instruments which were retained on board ship for return to Lowestoft.

   Data were recovered on board from the fluorometer, current meters, thermistor chain and nitrate analyser. Initial inspection of the data was carried out on board. Current meter and thermister chain data will be processed in Lowestoft. Initial inspection of the nitrate data suggests that the instrument may have malfunctioned. Results from the fluorometer are shown in Figure 2. The uncalibrated output suggests that a number of blooms occurred during the initial study period.

   The experimental UCNW light meters are passive sensors that have been developed to measure downwelling irradiance at a number of wavelengths. The technique is being evaluated to determine the effectiveness of passive optical sensors as measures of phytoplankton pigment concentration and type. The sensors operate at the same wavelength as the satellite-borne SeaWhiffs sensors and will provide sea truth measures for algorithm development for satellite-based determinations of chlorophyll concentration.

2. Measurements of primary production and respiration were carried out on 10 occasions on samples collected at a number of locations. Water samples in glass bottles were incubated in the light and in the dark on board (simulated *in situ*) and on some occasions in the sea (*in situ*). The change in oxygen concentration in each sample was determined on board using a micro-processor controlled winkler titration system. Values for the photosynthetic efficiency (α) and light saturated rates of photosynthesis (Pbmax) were determined for each site by fitting randomly varying values of α and Pbmax to paired values of photosynthesis and irradiance and obtaining the best fit with a least squares fitting routine. From these values, together with respiration measures of submarine and surface irradiance, daily rates of water column primary productivity will be calculated. Joint measures of primary productivity were made on four occasions in collaboration with DANI personnel on board RV LOUGH FOYLE.

   Chlorophyll 'a' concentrations was determined in water samples collected by the rosette water sampler on each dip. Water samples were collected, filtered and extracted overnight in acetone. The concentration was determined fluorometrically on board. Levels ranged from < 1.0 mg m^{-3} to > 11.0 mg m^{-3} during the study period. Chlorophyll measures will be used to calibrate the CTD and moored fluorometers. On some occasions and at certain depths, water samples were size fractionated using membrane filters with pore sizes at 2.0 µm and 0.45 µm. Further water samples were also filtered for eventual determination of the chlorophyll:carotenoid ratio. This will be measured spectrophotometrically, on acetone extracts of frozen filters, in the laboratory.

   Plant nutrient levels were determined on the same water samples. The concentrations of dissolved nitrate, nitrite, phosphate and ammonia were measured on board. Silicate concentrations will be determined on samples returned to the laboratory.

3. An experimental instrument, the Biospherical Instruments Integrating Natural Fluorometer (INF300) was deployed at a number of sites during the cruise. This instrument measures upwelling light at 683 nm arising mainly from sunlight-induced chlorophyll fluorescence. The INF300 also records temperature, pressure, underwater scalar irradiance (PAR) and also has an external surface sensor for (PAR) irradiance. The results are being evaluated to determine the relationship between solar fluorescence and measured rates of primary productivity determined by the oxygen technique and also the ^{14}C method. The radiocarbon method was carried out by DANI staff on board the research vessel LOUGH FOYLE.

4. A total of 20 hauls were made with the double WP2-200 µm net at a haul rate of 0.5-1.0 m s^{-1}. Sampling was targetted at a wide geographical spread over the area with at least two sites within each of the physical domains. A CTD rosette cast was taken at most of the sites.

   Egg production experiments were carried out on individual female adults of *Acartia* and *Calanus* (where present) and other dominant copepod species including *Temora* and *Pseudocalanus*. Individual females were incubated at 10°C in 60 ml of 64 µm filtered sea water. Each incubation was terminated after 24 hours by the addition of 2 ml buffered formaldehyde solution.

   Samples of *Acartia* and *Calanus* (usually 10 adults/sample) were fixed in Bakers formol for subsequent histological examination.

   Samples for biomass and grazing rates were sieved into 2000-1000 µm, 1000-500 µm, and 500-200 µm size fractions in filtered sea water. Replicates from each sample were filtered on to 25 mm GF/F microfibre filters and 47 mm Sharkskin filters for biomass and grazing rate samples respectively.

   A bulk sample of mixed copepods was taken at each sampling site and fixed in liquid nitrogen for subsequent ATC enzyme analysis.

   All particulate samples were taken either from the CTD cast or from the non-toxic seawater supply at an inlet depth of 3-4 m. Water samples from the CTD were usually taken at 4 m, 10 m, 40 m and near bottom. Samples were filtered for the estimation of chlorophyll 'a', total chlorophyll and through 5 µm and 10 µm filters for size fractionated chlorophyll. Aliquots were also taken for estimates of total C, N. Water samples were also fixed in Lugols and in formaldehyde for phytoplankton species identification.

   All samples, with the exception of the ATC enzyme analyses, will be analysed at PML and completed within the next six months. The copepod egg incubation data will be used to validate and refine the copepod production model being developed at PML. ATC enzyme analyses will be carried out at UEA.

5. The plankton survey grid of 37 stations (Figure 1) was sampled three times, between 8-11 May; 16-18 May and 25-30 May. For logistical reasons, grid points 30, 31 and 36 were not sampled on the second and third surveys.

   Fish larvae were abundant in a band along the Irish coast from Dundrum Bay to Kish Bank. Their distribution extended from the 'coastal' domain into the 'stratified' area off Clogher Head and into the nomally frontal and mixed domains in the vicinity of Lambay Island and

Kish Bank respectively. The most abundant species were whiting, sprat and dab. Very few fish larvae and only a few fish eggs were noted in other parts of the survey area.

Profiles of salinity and temperature were obtained from the sampler CTD at most stations. However, these units, now 13 years old, were in need of frequent attention which resulted in some data loss. On the second and third surveys sub-surface seawater samples from the ship's non-toxic supply were analysed for nitrate + nitrite, nitrite, phosphate and ammonia levels using the Skalar continuous flow analyser and colorimetric technique. Salinity samples were also taken to calibrate the continuous and sampler CTDs. Samples for silicate have been stored and will be analysed on return to the laboratory.

The strong, often cold, east to north-east winds experienced for much of the cruise had a noticeable effect on the physical regime of the area. The strong stratification beginning to establish itself during the first plankton survey with values of over 50 J m^{-3} had been virtually destroyed in the nominally 'stratified' domain by the time of the third survey. Surface temperatures in this domain were also lower on the third survey. The CTD profiles of temperature, salinity and chlorophyll taken at the mooring on 7 May and on 30 May show the change most dramatically (Figure 3).

6. Sites to sample fish larvae for growth and condition were selected from a preliminary analysis of samples on the first plankton survey. Larvae collection tows using a 2 m diameter ring net and 800 µm mesh were made in each of the following domains:

'Coastal'	—	Dundalk Bay and Clogher Head; grid points 4 and 5 Dundrum Bay; grid point 2
'Frontal'	—	Lambay Island; grid point 14 Eastern front; grid point 17
'Mixed'	—	Kish Bank; grid point 13
'Stratified'	—	Off Clogher Head; grid point 6.

Dual LHPR deployments with coarse (270 µm) and fine (20 µm) mesh were also made at each station.

Large numbers of whiting and reasonable numbers of sprat and dab larvae were taken in the 2 m ring net at all the sites except t the eastern front. This site was only visited once and yielded just two larvae. A total of only 105 cod larvae were sampled. They were taken in all domains although the biggest sample, 30 larvae, was caught in the 'frontal' domain off Lambay Island on 30 May. A total of 7 haddock larvae were also sampled. Specimens of whiting, dab, sprat, cod and haddock were measured fresh and either deep-frozen or fixed in either IMS or formaldehyde solution for subsequent analysis of dry weight, age, growth and stomach contents.

The operation of the new dual LHPR system was a big disappointment. The dual system worked perfectly on deck but regularly failed in the water. Of the 14 deployments only 5 produced valid samples of coarse and fine together. Of the remainder, one series of coarse mesh samples and three of fine mesh samples were obtained. On the final sampling day the

system was deployed separately with coarse and fine boxes fitted on alternative hauls. This worked satisfactorily and in that way comparative samples were obtained in two areas.

It was concluded that the present design to operate two motors simultaneously does not provide sufficient power for underwater operation at 4.5 knots towing speed. Consideration will be given to a return to the system of operating the mechanism consecutively with a five second delay.

7. A member of the DANI staff from RV LOUGH FOYLE was on board to supervise the deployment of the sediment traps. They were successfully deployed as part of the moored array on the 7 May and recovered for servicing and redeployed on 28 May. Three samples were collected from the traps on 28 May and retained on board. They will be returned to DANI in Belfast for analysis.

8. Sediment samples and large-volume water samples were taken at the 14 stations allocated to RV CIROLANA as part of the Marchon survey. These were returned to shore for analysis. Samples for surface nutrient analysis were also taken. These samples, together with 70 samples collected by charter vessels and brought on board in Barrow, were analysed on board. Silicate samples were stored for subsequent analysis.

OTHER OBSERVATIONS

1. A total of 338 salinity samples were taken for CTD calibration. Due to problems of laboratory space during the first half of the cruise and generally poor weather conditions throughout, only a small proportion of these samples could be analysed on board. However, valuable experience on the siting and operation of the new Portasal salinometer, at sea, has been gained.

2. The MAFF UOR was deployed on a 37 nml transect (Figure 1) on 6 occasions during the cruise. The first deployment was in a NW direction, the remainder were towed to the SE. The second deployment had no data stored because of a battery failure. All other deployments provided temperature and chlorophyll 'a' data with few missing values. The salinity readings, however, cannot be relied upon. Only one transect was run in daylight and one partially in daylight. On both occasions the light sensors operated satisfactorily.

   The temperature structure for 4 transects spanning the cruise is shown in Figure 4. Thermal stratification was well established at the start of the cruise (8 May) but was broken up by gales over the period 11-18 May. During a period of relative calm from 19-23 May the structure began to be re-established only to be broken down again by the severe gales from 24-26 May.

   The corresponding transects for chlorophyll in mg m^{-3} are shown in Figure 5. These compare favourably with the values for phytoplankton biomass at the mooring (Figure 2) which was situated approximately 7 km from the NW end of the UOR transect.

3. Direct observations were made of the phytoplankton species composition in each of the 4 domains. Evidence of grazing by protozoa was recorded on video film. Water samples were taken and preserved in Lugol's iodine and in 2% gluteraldehyde for quantitative

estimates of species abundance and protozoan grazing pressure. At the mooring, samples were taken from the chlorophyll fluorescence maximum at the thermocline and at 40 m depth. At the front and in coastal water and mixed water regimes, samples were taken from 17 m depth only.

Due to adverse weather the spring bloom conditions at the mooring on 8 May were dispersed. By 21 May a second, smaller bloom was re-established with long chain diatoms (*R. delicatula; A. stolterfothii; E. zoodiacus; T. nordens-koldii*) forming the largest biomass. Unlike the earlier bloom, phytoflagellates and prymnesophytes were common in the bloom after 21 May.

4. Meteorological observations were collected daily during the cruise in order to drive 2 models simulating phytoplankton growth at the mooring location in the Irish Sea. The models included an original 2-layer version and an updated multi-layer 'turbulence closure' model. Both models were initialised with observations made at the mooring site at the beginning of the cruise. The models were run with daily updated met data in a predictive mode for comparison with observations at the mooring site.

J H Nichols
18 June 1993

SEEN IN DRAFT:

J R French (Master)
P Mackay (Senior Fishing Mate)

INITIALLED: JGS

DISTRIBUTION:

Basic list +
J H Nichols
L E Woolner
D K Mills
B F Riches
G M Haynes
A J Winpenny
A Reeve
E Head (PML)
P Tranter (PML)
S Kratzler (UCNW)
P Tett (UCNW)
J W Read
R Wilton (UCNW)
G Kennaway
K Ramsay
I Biegala
A Poole

Figure 1

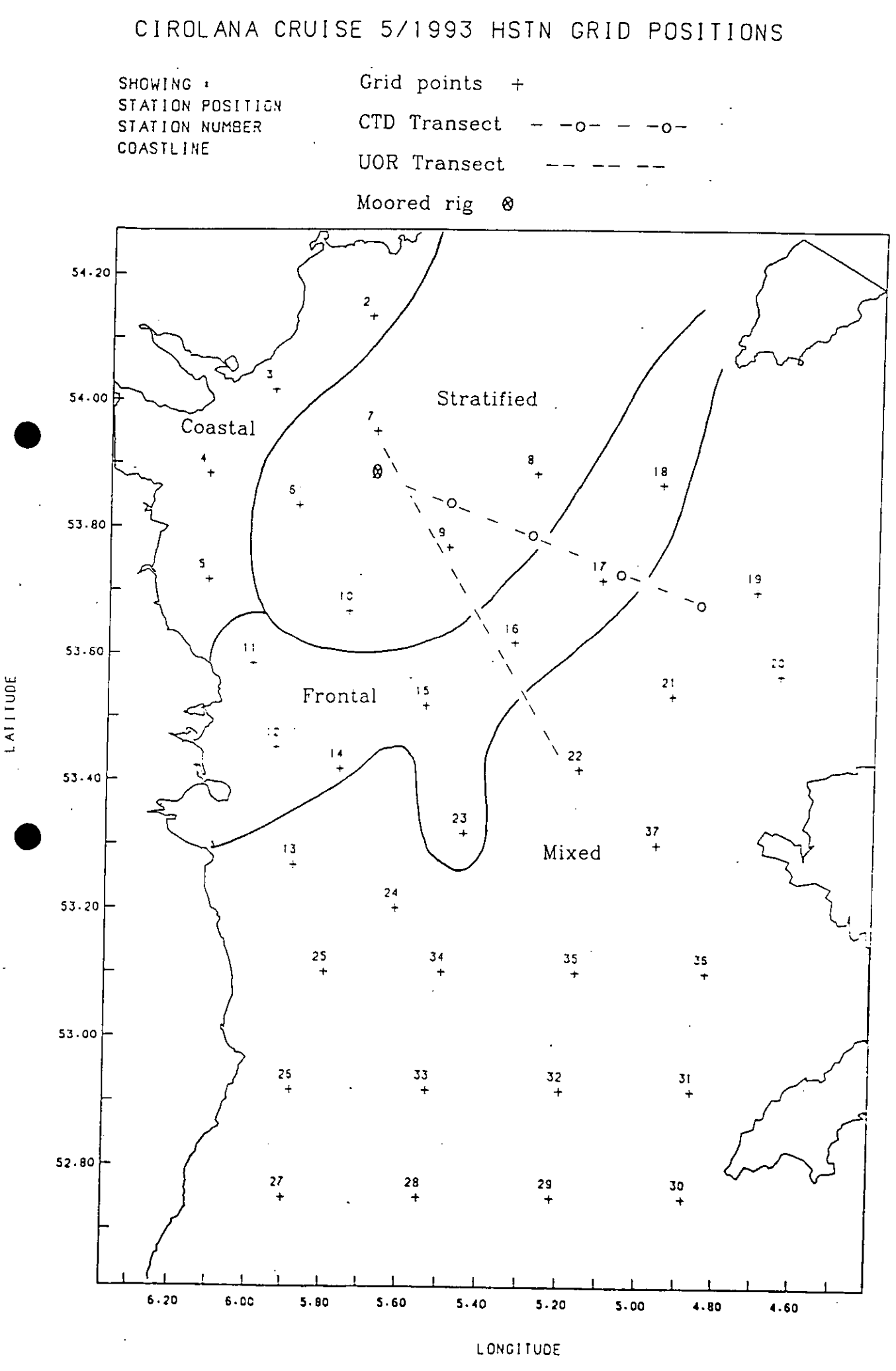

CIROLANA CRUISE 5/1993 HSTN GRID POSITIONS
SHOWING :
STATION POSITION
STATION NUMBER
COASTLINE
Grid points +
CTD Transect
UOR Transect
Moored rig
Coastal
Stratified
Frontal
Mixed
54.20
54.00
53.80
53.60
53.40
53.20
53.00
52.80
LATITUDE
6.20
6.00
5.80
5.60
5.40
5.20
5.00
4.80
4.60
LONGITUDE

Figure 2

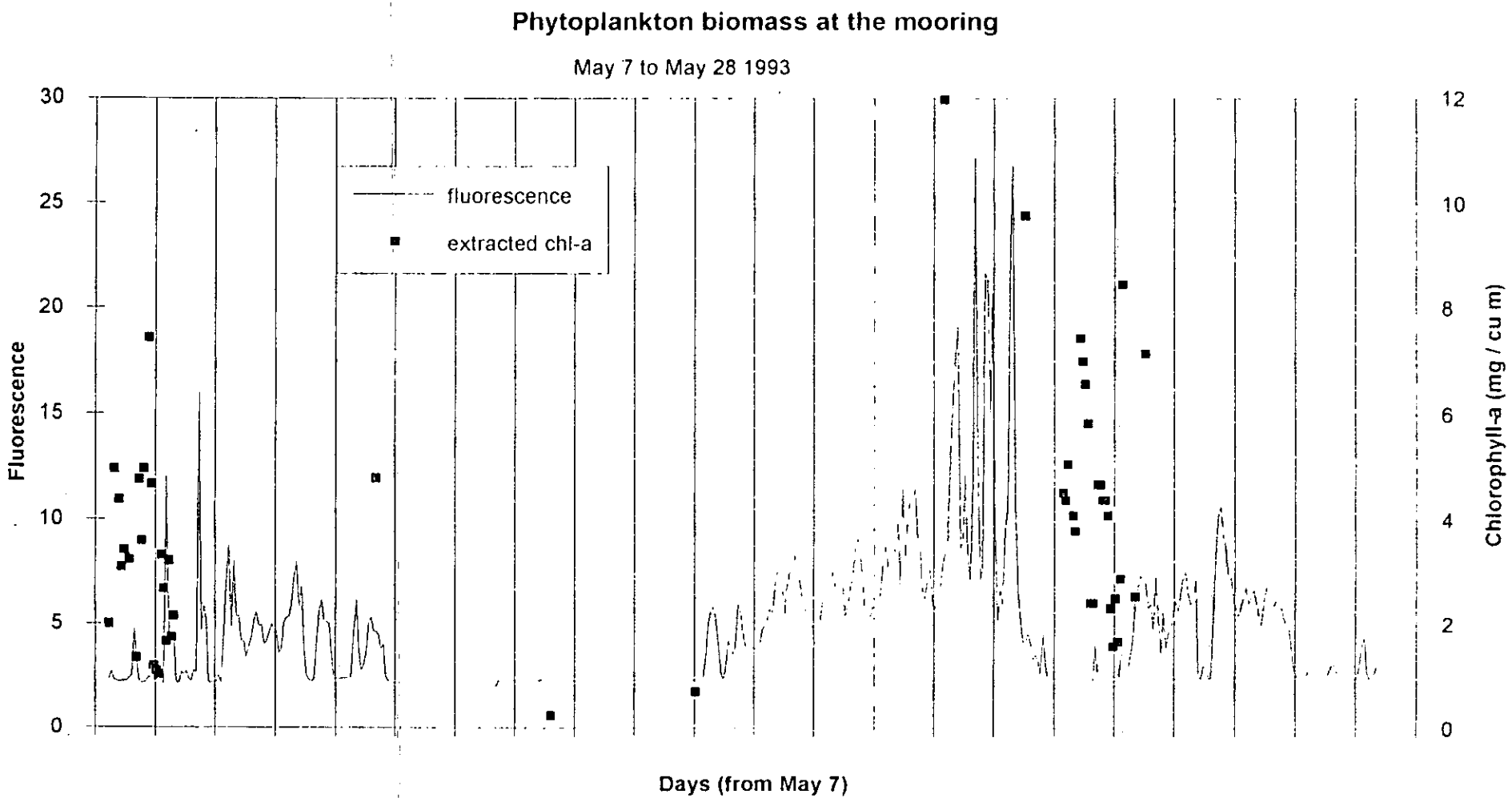
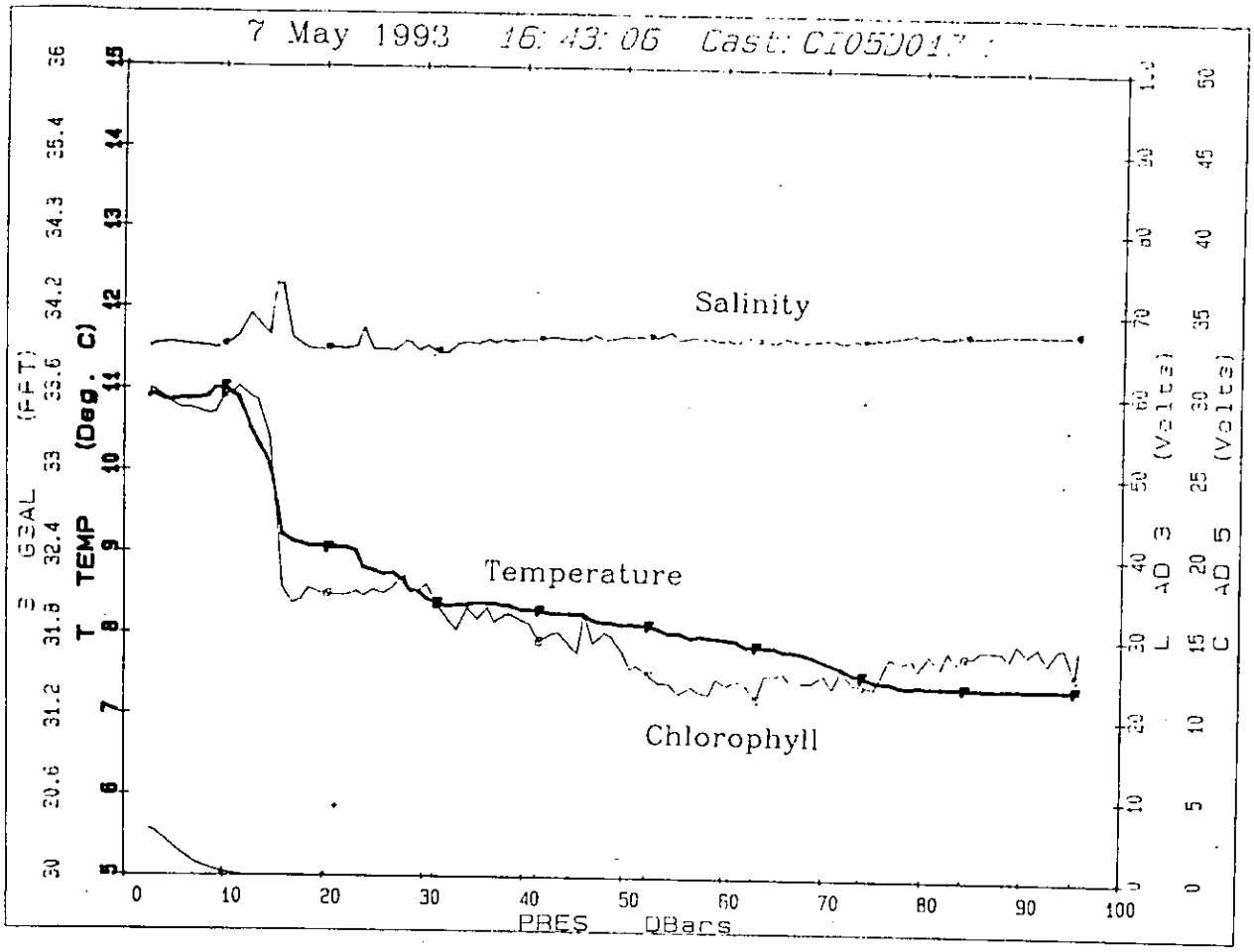

Phytoplankton biomass at the mooring
May 7 to May 28 1993
fluorescence
extracted chl-a
Fluorescence
Chlorophyll-a (mg / cu m)
Days (from May 7)
0
5
10
15
20
25
30
0
2
4
6
8
10
12

Figure 3


7 May 1993 16:43:06 Cast: CI05D01.?
Salinity
Temperature
Chlorophyll
PRES DBars

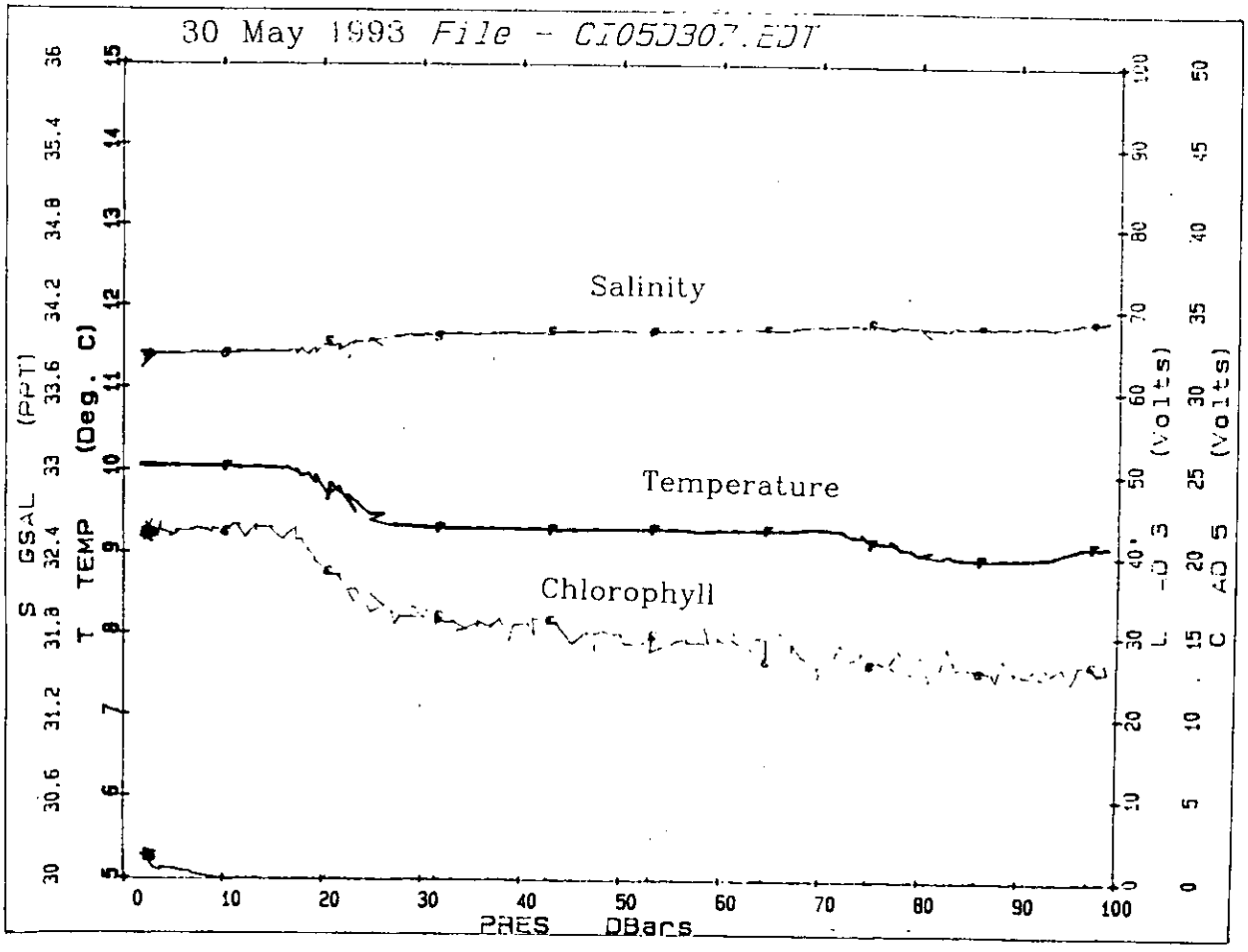
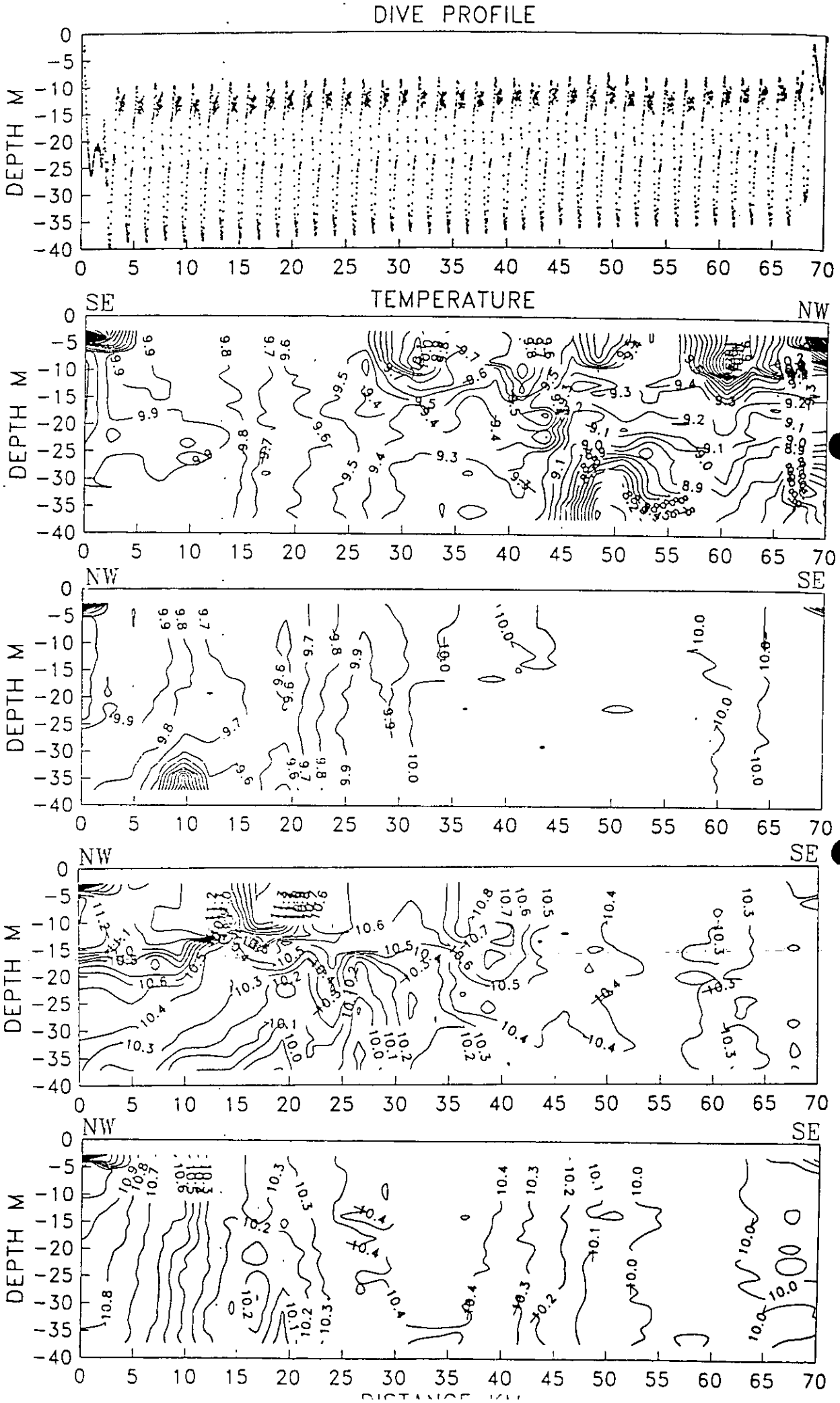

30 May 1993 File - CI05D30?.EDT
Salinity
Temperature
Chlorophyll
PRES DBars

Figure 4


DIVE PROFILE
DEPTH M
TEMPERATURE
SE
NW
8 May
16 May
22 May
28 May
DISTANCE KM

CI 5/93 UOR

Figure 5