RESEARCH SUMMARY

Cruise FR 1/95

INTERNAL TIDAL EVOLUTION ON THE NORTHWEST SHELF

Itinerary

Sailed Fremantle 0001 10 Jan 1995

Arrived Dampier 0800 24 Jan 1995

Principal Investigators

Dr Peter Holloway

Australian Defence Force Academy

Dr Peter Craig

CSIRO Division of Oceanography

Dr Miles Furnas

Australian Institute of Marine Science

February 1995

FRANKLIN

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Dr P Craig	CSIRO Division of Oceanography
Dr M Furnas	Australian Institute of Marine Science

Scientific Program

The project aims to measure and describe the temporal and spatial evolution of tidally forced internal waves as they are generated and propagate across a shelf and slope region on the North West Shelf and also to measure the associated formation of high frequency internal wave trains. The project also aims to measure the variability in the primary production in this region and to attempt to relate this to the internal wave dynamics.

The aims are to be met through the deployment of 10 moorings containing 19 current meters, 3 thermistor strings, 3 Acoustic Doppler Current Profilers (ADCP's) and 2 water level recorders. These moorings are to be recovered on cruise FR 4/95. In addition, repeated CTD (and ADCP) stations are to be occupied along two cross-shelf/slope transects.

Cruise Narrative

The ship departed Fremantle on time but immediately encountered problems with the gyro and auto pilot. We were forced to wait 2 miles off Fremantle that night until the problem could be fixed the next morning by contractors from Fremantle. We continued on from Fremantle at 1500 on Tuesday 10 January, 15 hours behind schedule. We then steamed towards the North West Shelf for the first mooring site, approximately 82 hours away. The next two days were spent preparing moorings and instruments and fine tuning the CTD and nutrient sampling strategies. We made up some lost time in good sailing conditions over the Wednesday and Thursday.

On Thursday (12/1/95) it was discovered that two of the ADCP's were shipped without batteries and arrangements were made to have these flown from Hobart to Karratha. Woodside Offshore Petroleum agreed to fly the batteries out to the North Rankin platform on a regular helicopter flight, to be collected from their standby vessel on Tuesday (17/1/95). Later that day there was a failure of the main generator and about 1 hour was lost investigating the extent of the damage. Although power was down on the bow and stern thrusters, the cruise continued as planned.

We arrived at the first mooring site (M1), approximately 240 km offshore of Dampier, at around 1500 on Friday (13/1/95) after spending about 1 hour steaming offshore of the estimated mooring location so as to gain the correct water depth (750 m). At this point we were only 5 hours behind the initial schedule. The mooring was laid in about an hour. We then steamed to the second mooring site and deployed M2 in 300 m depth, completing the task by 1830.

Not wishing to deploy further moorings in the dark, we steamed back to CTD station C11, mid-way between moorings M1 and M2, and completed 13 CTD stations, one every hour, finishing at 0915 Saturday (14/1/95). We were pleased to see some vertical movement in profiles of temperature, salinity and fluorescence, at least 40 m over the 13 hours, indicative of the internal waves we are searching for.

Back in daylight hours we steamed 20 nm to mooring site M3/M3A to deploy a thermistor chain and ADCP in separate moorings. The thermistor mooring was deployed at 1200, taking about 1 hour and the ADCP mooring by 1315. An hour's further steaming took us to mooring site M4/M4A/M4B about 2nm from the North Rankin A gas production platform. Two moorings were laid here, a "U" current meter mooring (4B) and a thermistor chain (4A), finishing by 1730. Mooring 4B was additional to the initially proposed project and consisted of 5 acoustic current meters

loaned by Woodside Offshore Petroleum, with the mooring components and construction provided by Steedman Science and Engineering. The intention is to allow a comparison of conventional current meters to ADCP current records. The current meters also record at a higher frequency than the ADCP and thermistor chains. The M4/M4A/M4B, as well as CTD site C5, are within a 5 nm protected zone around the North Rankin Platform. Permission was granted by Woodside to enter the zone and to deploy the instruments. This provides some added protection to the moorings from potential hazards such as trawlers as well as providing information from a location of engineering significance to Woodside.

From mooring site M4 we steamed back offshore to CTD site C7 and commenced stations at 1830 on Saturday, repeated every half hour for 13 hours, finishing at 0745 on Sunday (15/1/95). From here we steamed to mooring site M5 carrying out a single CTD cast at 0900 for biological productivity studies. The thermistor chain was then deployed at this site followed by a current meter mooring at M6 in 67 m water depth, completed by 1200. The M5 thermistor chain was loaned for the experiment by Steedman Science and Engineering. From here we steamed to site C1 our innermost CTD station commencing a 12 hour sequence of half hourly CTD casts at 1300, finishing at 0115 Monday (16/1/95).

The sequence of 13 hour CTD stations continued, completing C2 and C3 and then moving to C6(M4), the North Rankin site. During this 13 hour cycle, starting at 0730 on Tuesday (17/1/95), our ADCP battery packs, along with two other boxes of freight, were delivered by helicopter to the North Rankin platform, transferred to a rig tender vessel and then sent to Franklin by the tender vessel's rescue boat. The transfer to Franklin was completed by 1015, between two half-hourly CTD casts. The ADCP mooring for the M4 site was then assembled during the day while CTD casts were being carried out and the mooring deployed between the 1500 and 1530 CTD casts.

On Tuesday evening the C4 CTD site was started and completed at 1100 on Wednesday (18/1/95) immediately followed by the final mooring deployment of an ADCP at this location (M5). From here on, 13 to 14 hour CTD stations were carried out moving out along the line in an offshore direction. At deeper locations, the CTD casts were increased to hourly and then to every 1.5 hours at C13.

On all CTD casts 2 bottles were sampled for salinity calibration and one pair of reversing thermometers used at one depth. At every second location, between 7 and 11 additional bottle samples were taken approximately every 2 hours over the 13 hour cycle, for nutrient analysis and for filtering for chlorophyll. In addition, on most

mornings at around 0900, water samples were taken for the biological productivity studies.

The deeper CTD stations (C12 and C13) showed a much weaker internal tide signal than seen in the shallower water. Therefore the deep CTD locations (C14 and C15) were not carried out and, instead, 2 shallower stations on the second transect line (C18, C19) were sampled over complete 13 hour cycles and finally C20 was sampled over 10 hours. It was necessary to finish sampling at 0100 on Tuesday (24/1/95) allowing 7 hours to steam to Dampier and arriving at 0800. Because sampling continued up until so close to the end of the cruise, salinity samples were not taken at the last station.

For most of the cruise we experienced moderate to weak winds and slight seas, and the weather did not hamper any of the work.

Preliminary Results

By the end of the cruise some preliminary plotting of the CTD data was completed. Figures 2, 3 and 4 show some example results of time/depth sections of sigma-t and fluorescence from 3 different locations. The isopycnals show strong internal wave signals with a combination of short period (solitary) waves as well as the longer 12 hour period internal tide. Wave heights of between 30 and 60 m are seen, representing displacements of around half the water depth. The waves are strongly non-linear.

The contoured distributions of fluorescence look very similar to the isopycnal displacements. In particular the maxima in the fluorescence undergo large and rapid vertical excursions, acting as a passive tracer over these short time scales, and following the vertical water movements. The fluorescence gives a measure of the biomass of phytoplankton and these rely on both light and nutrients for growth. The light levels available to the phytoplankton will change dramatically as they are moved vertically by the internal waves.

A time sequence of the depth distribution of nitrate and phosphate from the C6 location are shown in Figure 5 and can be compared to the vertical displacements associated with the internal wave motion seen at this location (Figure 4). It is clear that the nutrients are being raised vertically, by the internal waves, up to 60 m from 100 to 40 m depth and from a region of very low to moderate light levels.

Summary

Although much of the project relies on the results from the moored instruments, we have been successful in gaining excellent data on the variability and structure of internal waves in the region from the repeated CTD casts. In addition the nutrient and chlorophyll measurements will allow us to investigate the importance of these waves on the biological productivity.

Some time was lost due to problems with the ship's gyro, from having to get instrument batteries brought from Hobart to the North Rankin platform, and from a slight underestimate of the time required to deploy the moorings. However, we still had sufficient time to complete all of the moorings and most of our planned CTD stations. In all, we deployed 10 moorings and completed 366 CTD stations.

Acknowledgments

The expert and willing assistance of the Master, Ian Sneddon, and crew of Franklin is greatly appreciated. We wish to acknowledge the assistance and cooperation of Woodside Offshore Petroleum, and in particular Mr. Dave Brennan, for allowing for freight to be transferred from Karratha to Franklin via the North Rankin platform and for giving permission to moor instruments and operate within the 5 nm protected zone around the North Rankin platform. Woodside also provided the 5 acoustic current meters for mooring M4B. We also acknowledge the generosity of Steedman Science and Engineering (particularly Mr Stephen Buchan and Mr Stan Stroud) for suggesting and constructing the M4B mooring, and for the loan of their thermistor chain for mooring M5A.

Scientific Personnel

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Stephen Walker	CSIRO, Division of Oceanography	
Fred Boland	CSIRO, Division of Oceanography	
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Alan Mitchell	Australian Institute of Marine Science	
David Vaudrey	CSIRO, ORV	(Cruise Manager)
Erik Madsen	CSIRO, ORV	
Ron Plaschke	CSIRO, ORV	

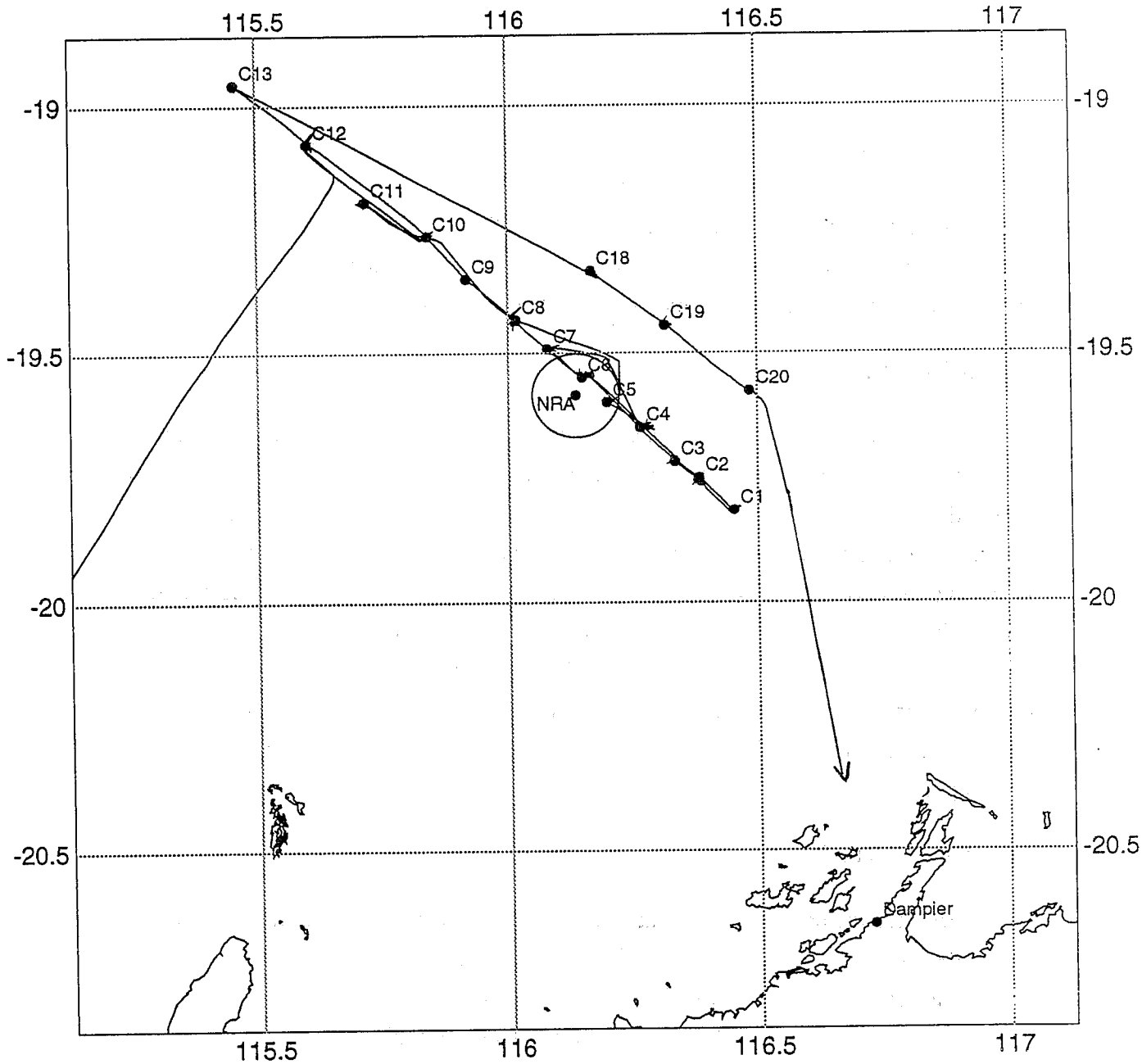

Figure 1 Cruise track of FR95/01, excluding transit from Fremantle. Mooring and CTD locations are shown. The circle shows the 5 nm protected zone around the North Rankin platform (NRA).

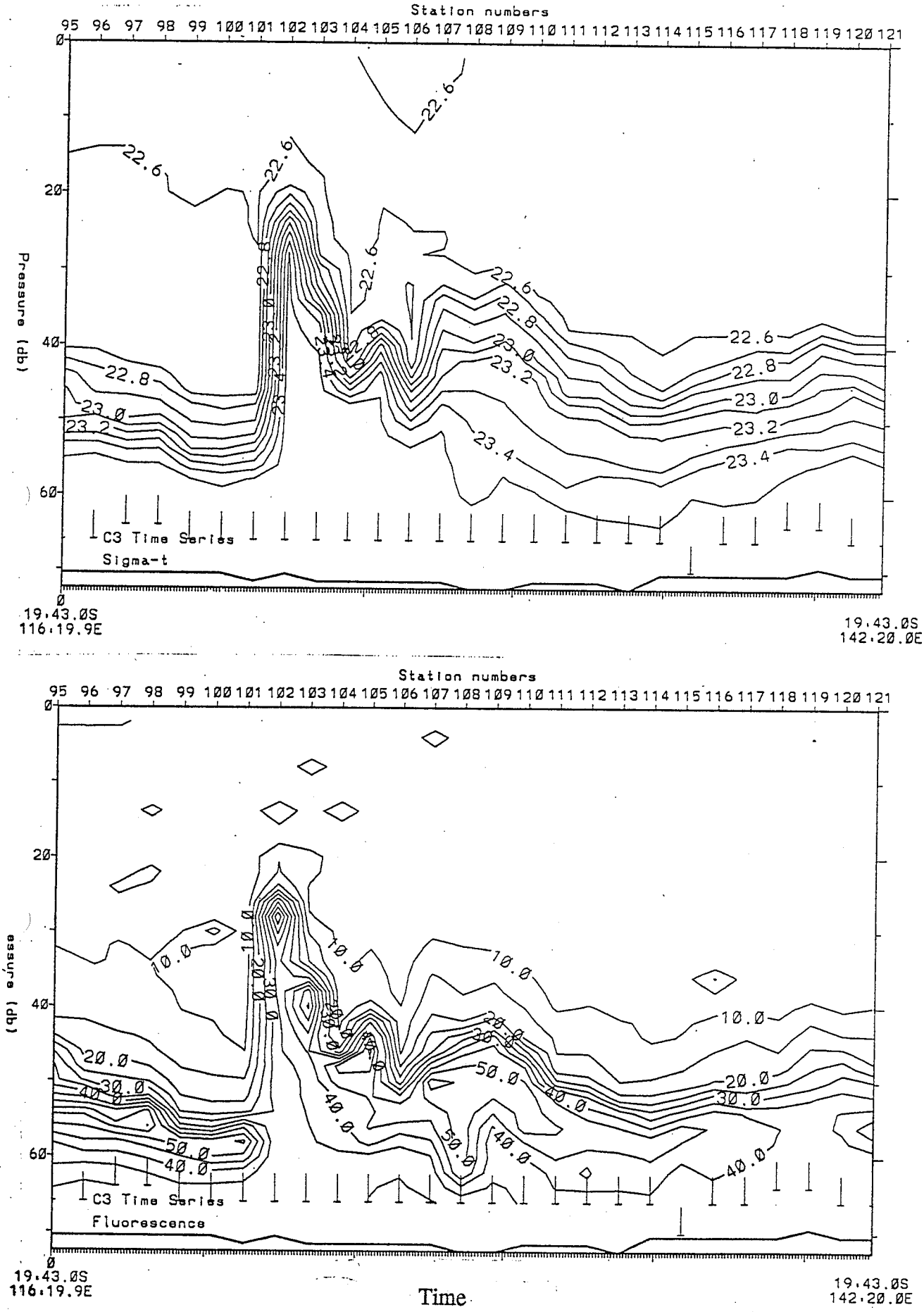

Figure 2 Time-depth sections of sigma-t and fluorescence over a 13 hour period at location C3 in 70 m water depth. CTD casts are every 30 minutes.

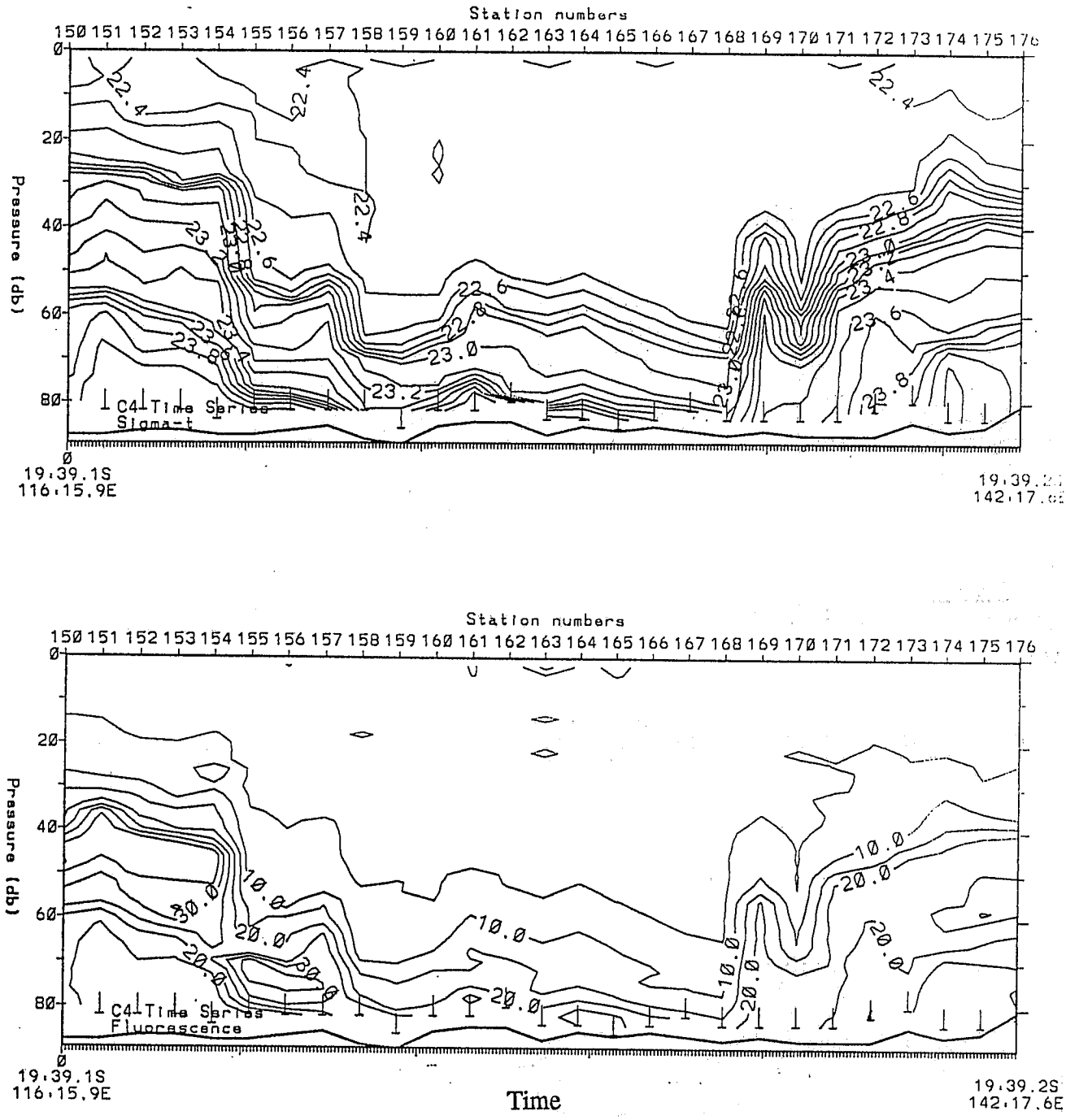

Figure 3 Time-depth sections of sigma-t and fluorescence over a 13 hour period at location C4 in 85 m water depth. CTD casts are every 30 minutes.

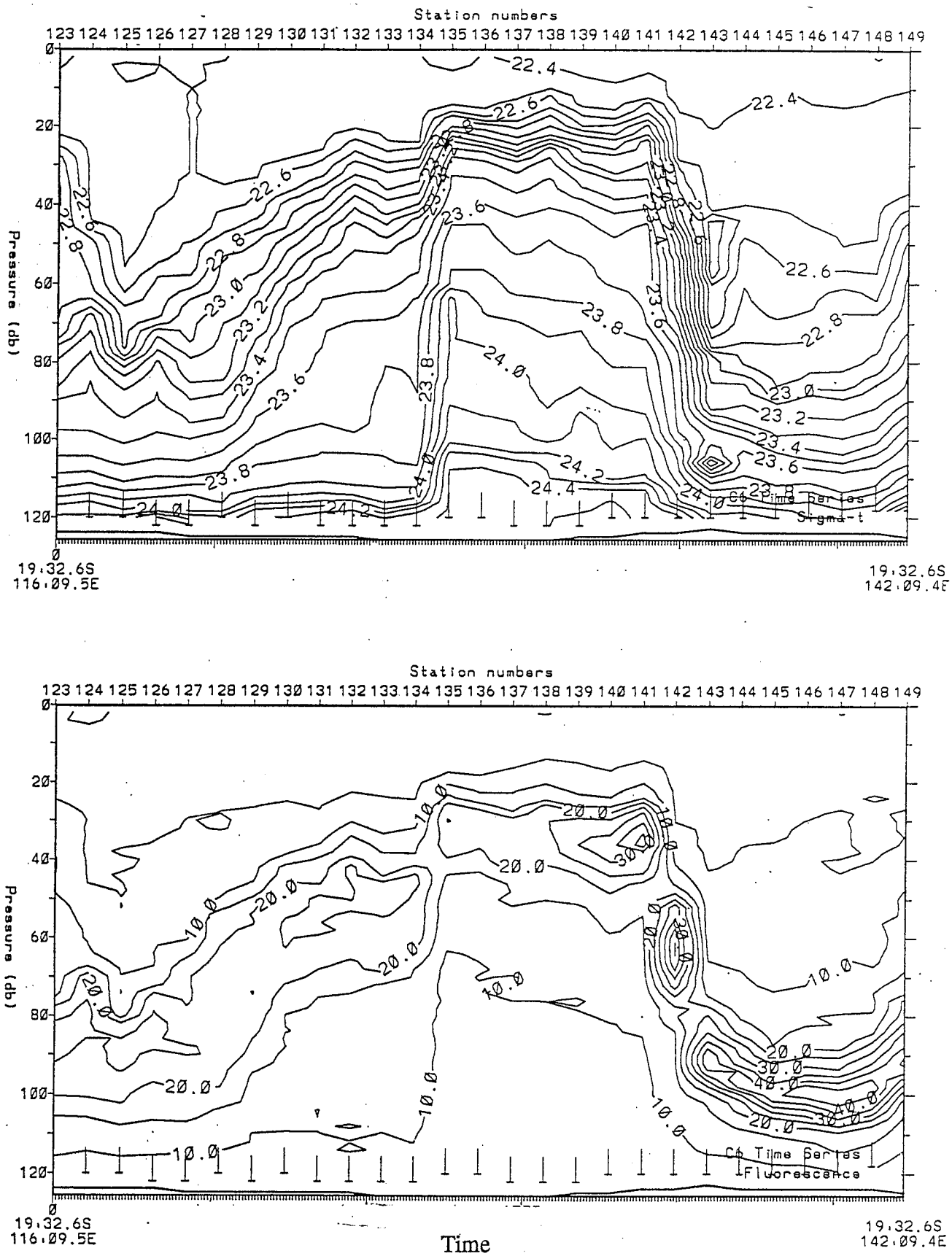

Figure 4 Time-depth sections of sigma-t and fluorescence over a 13 hour period at location C6 in 125 m water depth. CTD casts are every 30 minutes.

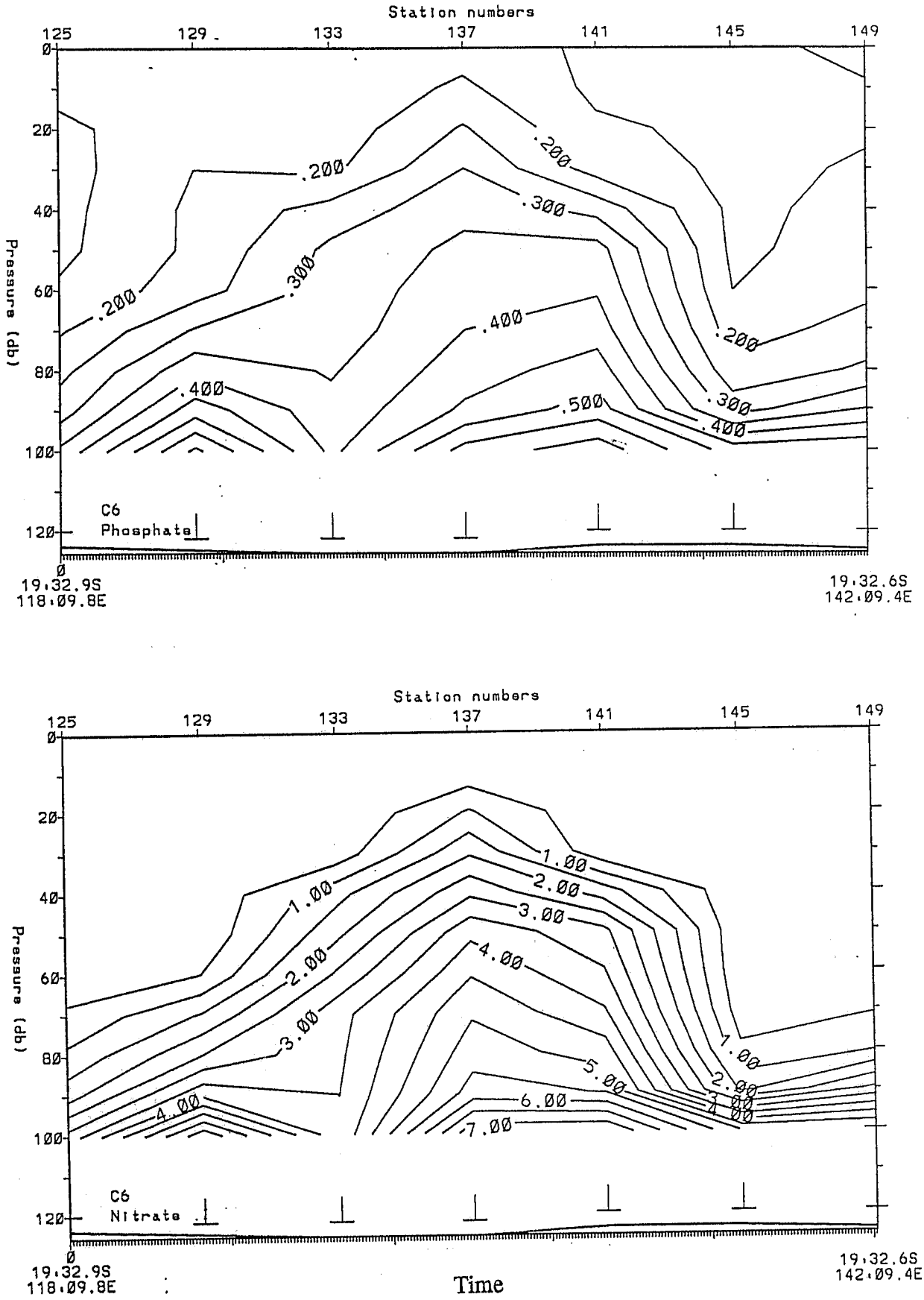

Figure 5 Time-depth sections of nitrate and phosphate over a 12 hour period at location C6 in 125 m water depth. Measurements are very 2 hours.