Description of currents based on Acoustic Doppler Current Profiler (ADCP) data from T-ECHO cruises

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SUMMARY : During T-ECHO project, ADCP profiles were acquired for each transect. Data for three of the T-ECHO cruises (GICS-2, GICS-3 and GIAS-2) are presented. High variability on the continental shelf is one of the characteristics that determine general circulation. Some trends of this circulation are identified. General anticyclonic circulation over the shelf and a predominant south component current can be noticed. A weak countercurrent following the coast is also present. Shelf circulation reflects the effect of wind and riverine discharge. Also some intrusion from oceanic frontal waters has been detected. In Adriatic Sea the analysis of only one cruise demonstrates the intense impact of river and wind on the variability of the north basin. Geostrophic circulation was detected in the southern part of this area, following the general circulation. Also in the northern part, this coastal south current is typical for summer period, with strong stratification as observed during GIAS-2.

INTRODUCTION

The use of the acoustic doppler effect currentmeter (ADCP) for the measuring of currents has some positive aspects and some negative ones. The fact of time shifting through specific transects, as it is the case in the T-ECHO project, makes it all the more difficult the interpretation of data. However, if the scale of time and space is sufficiently small, this problem may be avoided. Moreover, if our aim is to describe the dynamic of the water masses in a specific cruise, we may encounter data not comparable among themselves. The ADCP data can not stand alone; they must be accompanied with the corresponding hydrographical data (temperature, salinity, sigma-t) obtained through the CTD casts, with an adequate grid sampling strategy.

On the other hand, the amount of information and the fact of the sampling being carried out between stations, permits us to obtain a dynamic view of the actual currents.

Circulation in the continental shelf is highly variable. The warming/cooling of water and the wind cause short term changes in circulation. However it is where the ADCP better works, since it can measure the relative speed over the bottom in respect to the vessel, thus obtaining absolute currents. Instead, out of the shelf the ADCP looses the bottom and currents must be estimated by calculating the geostrophic currents from the CTD data or either, taking as a reference the current of a depth level as deep as possible. General circulation, in oceanic waters, makes it that variability or at least, that the circulation pattern be more uniform.

On analysing the data from the GICS and GIAS cruises we must bear in mind the general frame in which we are, since many of the singularities that we may encounter should be explained either through the above mentioned processes, such as evaporation, wind strain or warming/cooling, or through the general circulation enveloping the surveyed zone.

The shelf of Ebro's delta is an expansion of the Iberian shelf formed by the contribution of fluvial sediments. It is the widest part of the shelf in the Spanish Mediterranean. It receives, particularly in spring and in autumn, the important contribution of continental waters, mainly from the river Ebro, but also from other tributaries. This shelf has a very moderate inclination, the 100-150 metres isobathe setting the beginning of the slope, which then is descending down to a depth between 1400 and 1600 metres. Three zones can be distinguished:

(i) The northern part, where the shelf widens out, reaching thirtyfive miles and coinciding with the mouth of the delta,
(ii) the central part, where these 30 miles are maintained until reaching
(iii) the southern area, where it narrows again, this time very significantly.

The two limits are, then, the widening and the narrowing of the continental shelf.

These two features produce an effect in the general circulation. The general circulation is mainly constituted by the slope current (*Font et al.*, 1990; Castellón *et al.*, 1990), which follows the slope in a southwestern direction. On finding, in the North, a stretching of the shelf, this current lightly wells up the shelf, shifting again to follow the slope in a depth of some 400 metres (obviously, it is difficult to define a "depth of the front" when this front is over the incline of the slope). After crossing in a southwestern direction the total of the deltaic shelf, it meets an abrupt narrowing where, this time, the current leaves the shelf. Due to this circulation, the eddies over the shelf must follow an anticyclonic course (Font *et al.*, 1990).

The variability in this general frame shall be determined, as it has been already mentioned, by the warming/cooling, by the evaporation and by the wind strain. The Ebro depression is a pass along which the northwestern winds swiftly move, then provoking gales in the Golf of Sant Jordi, which is actually the one formed by the shelf widening North of the river mouth. As will be shown farther on, the effects of this wind on the circulation and on the characteristics of the water masses are evident; the wind causes anticyclonic rotation.

With regard to the cruises in the Adriatic Sea it must be pointed out that the investigation area was limited to the Northern fraction, which occupies a third of the North of this Sea. Its bottom is slighlty inclined from the 100 metres isobathe in the South to an average of 30-40 metres in the less deep area in the North. As its most important characteristics must be mentioned the presence of the Po delta, which represents the most important contribution of fresh water and nutrients to this zone and to the whole Sea in general, and the effect of the "Bora", the wind of Northeastern component which blows specially in this northern part of the Adriatic.

The general circulation of this fraction is precisely affected by these two facts, riverine inflow and wind (Fonda Umani *et al.*, 1990). The heat flow and the huge amounts of fresh water are the determining factors on the circulation. Through winter, the continental waters of the Po, rich of nutrients, are caught in a coastal stripe and the current has a southern component. Through summer, with the strong stratification, the fresh water discharges of the Po extend southward on the surface layers to the whole region, until a gale increases the height of the mixing layer, destroying the stratification, at least during the wind stress period. As it will seen later, (i.e. GIAS-2 cruise), in the southern part of the study area, with increasing depth, the geostrophic circulation gets more important.

MATERIAL AND METHODS

The ADCP is an equipment made by RD Instruments, model VM-150, operating at 153 kHz frequency. The transducers are mounted on the hull. The installation was done during 1989 on board R/V García del Cid.

The ADCP is connected to a gyrocompass through a synchro (1:1) interface. Data acquisition was made with a PC 486 processor using RDI Transect software. GPS NMEA183 position information was entered through serial port and ADCP was connected through GPIB interface board. The general settings of the instrument are shown in tables 1 and 2.

Processed data files from Transect were analysed. Processed data correspond to ensembles of ADCP current measurement. Ensembles are averaged data from successive profiles of measured current obtained by pinging.

The ADCP can measure the current by measuring the Doppler shift of a returned echo. If the Doppler shift of the bottom echo is also measured, then the absolute current measuring is possible. This process is called Bottom Tracking. Because the T-ECHO project has the continental shelf as objective area, only Bottom Tracking ensembles were used. During sampling, only Processed files were recorded.

Bin length and sampling interval were chosen following the RD ADCP manual instructions. Reducing bin length or reducing sampling interval will increase the short term error. During T-ECHO cruises 4 bin length and 5 minutes ensemble interval were selected, providing a reasonable resolution (short term error=1.107 cm/s) for a 150 kHz instrument.

Data obtained were then introduced into TECHO_VIEWER database and plotted. No filtering was done and all the information presented in this paper are based on the raw data obtained. The only filter used was bottom track limit (350 m).

Table 1. ADCP instrument parameters

Transducer depth	4 m
Echo Intensity scale	0.43 dB/cts
Absorption coef.	0.039 dB/m
Salinity	37 %o
Speed of sound correction	1500

Table 2. General instrument settings for ADCP during cruises GICS-2, GIAS-2 and GICS-3).

Cruise	Bin Length	Blank distance	Number of Bins	Sampling Interval
GICS_2	4 m	6 m	100	300 s
GIAS_2	4 m	6 m	24	300 s
GICS_3	4 m	6 m	24	300 s

ADCP sampling was performed only during first coverage of GICS cruises because of some acoustic interference with the multibeam Sonar. In GIAS cruises, sampling was performed during the whole surveys.

ADCP tracks are then coincident with echointegration tracks. The sampling interval (ensemble interval: time of averaging) was set to 5 minutes (300 s). Depending on boat speed this sampling rate is equivalent to 0.62 nautical miles (nm) for 7.5 knots. Because sampling interval was set in time and not in distance, data from ADCP could be referenced to echointegration data but with a resolution of 0.6 to 0.7 miles.

ADCP equipment also provides data corresponding to Echo Intensity, and were stored into files. Echo intensity is a coefficient of backscattering obtained from ADCP signal. Voltage from echo signal is integrated for the corresponding bin and then corrected for depth (TVG). The Transect software outputs this value as "counts". A prefixed constant for each instrument is facilitated by RD Instruments; in the present case it is 0.43 dB per count. No calibration of this parameter of the instruments echo intensity output was done. Values are relative and comparision between cruises must assume no drift of instrument features.

In this paper are presented the results of the cruises GICS-2 and GICS-3 (carried out during May of 1994 and 1995, respectively) in the Catalan Sea, and cruise GIAS-2 (September 1994) performed in the northern Adriatic Sea. Results of cruises GICS-1 and GIAS-3 are not presented due to some problems on the gyrocompass synchro interface, data file need extra filtering.

RESULTS AND CONCLUSIONS

GICS-2 cruise

Figures 1 to 4 show the horizontal stick plot maps for depths of 14, 22, 50, and 82 m. A general trend with SW direction is manifested. The figure 10 shows a polar plot of magnitude of current for all depth levels categorised by bottom depth (<50, 50 to 75, 75 to 100, 100 to 200 and 200 to 350) and by latitude (<40° 00' N, 40° to 40° 30', 40° 30' to 41° 00' and > 41° 00'). It can be observed that the general trend is towards SW, the average (tables 3 to 6) also showing this fact. North components are found in the countercurrent close to the coast.

The frequency distributions of currents (figs. 8, 9 and 11) show a normal distribution as expected, with no high values (average for 14 metres depth 9.47 cm/s). In figures 5 to 7 the current sticks have been plotted over the density (sigma-t) contour map for the same depth. No particular geostrophic currents were observed, and the general countercurrent is well correlated with density isolines close to the coast.

Higher velocities are centred in the middle of the continental shelf, the weaker ones being close to the coast. Therefore it seems clear the existence of a general anitcyclonic circulation: the river waters gently descend within the region (Salat *et al.*, 1997), whilst still more gently, a coastal current is heading to the North.

Nevertheless, and as it will be seen later in GICS-3 cruise, this structure is highly variable depending on the wind strain as well as on the river discharges.

Table 3. Statistics for 14m depth bin (cm/s), GICS-2.

	Magn.	E-W Comp.	N-S Comp.
SUM	5985.08	-339.50	-1480.70
MIN	0.36	-31.10	-45.40
MAX	48.33	31.90	40.30
CNT	632	632	632
AVG	9.47	-0.54	-2.34

Table 4. Statistics for 22m depth bin (cm/s), GICS-2.

	Magn.	E-W Comp.	N-S Comp
SUM	5434.18	-779.60	-1824.70
MIN	0.20	-23.50	-40.90
MAX	45.68	37.40	44.30
CNT	636	636	636
AVG	8.54	-1.23	-2.87

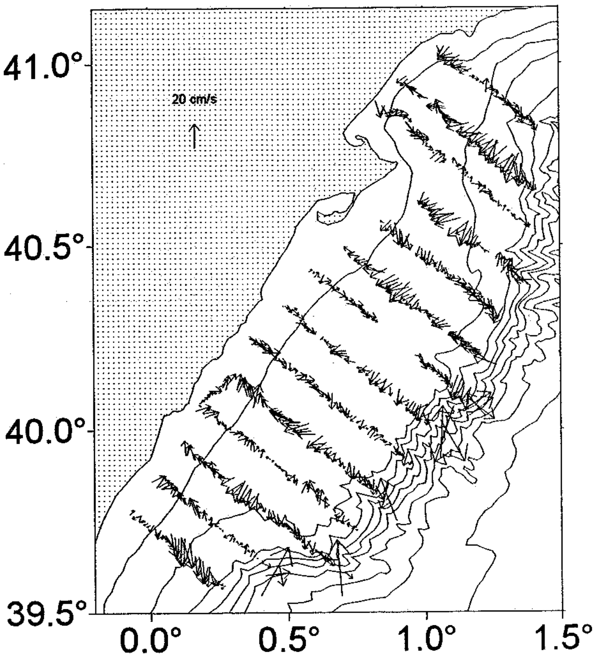

FIG. 1. - Stick plots of currents for 14 metres level during GICS-2 cruise.

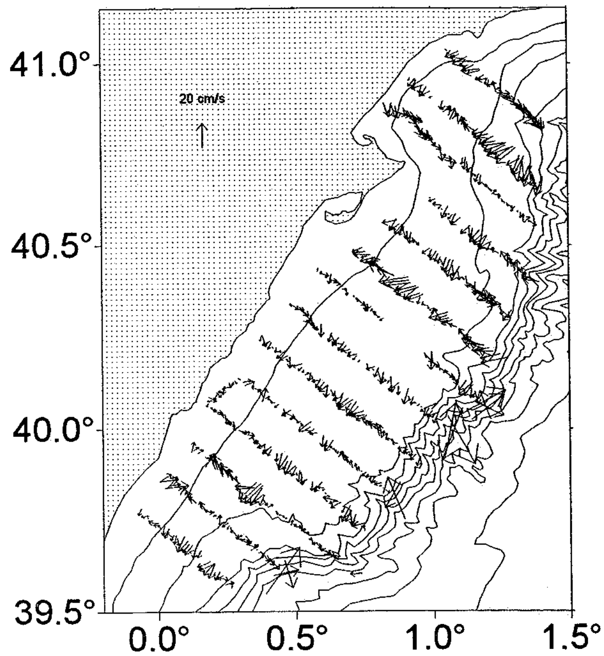

FIG. 2. - Stick plots of currents for 22 metres level during GICS-2 cruise.

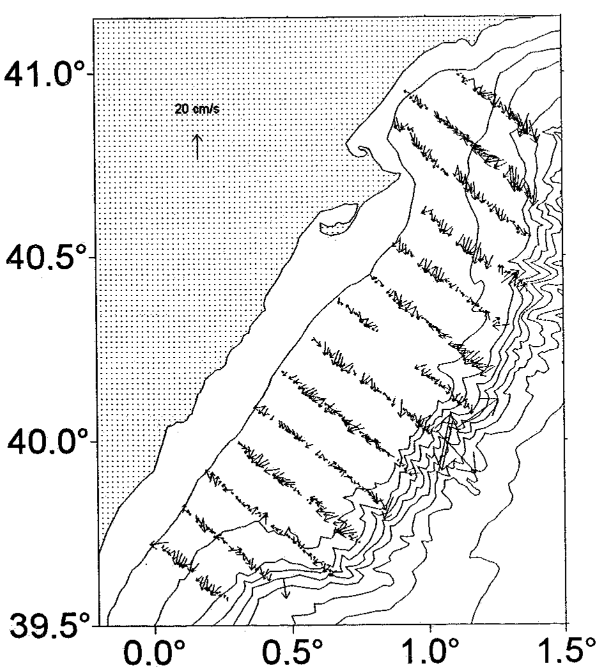

FIG. 3. - Stick plots of currents for 50 metres level during GICS-2 cruise.

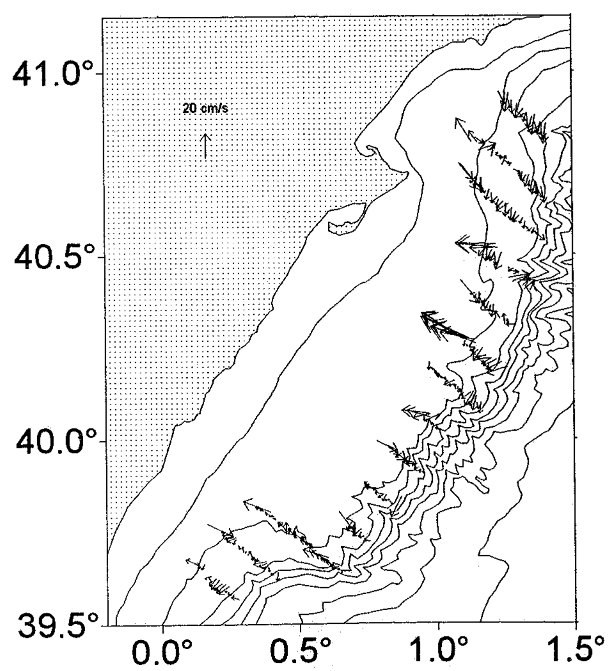

FIG. 4. - Stick plots of currents for 82 metres level during GICS-2 cruise.

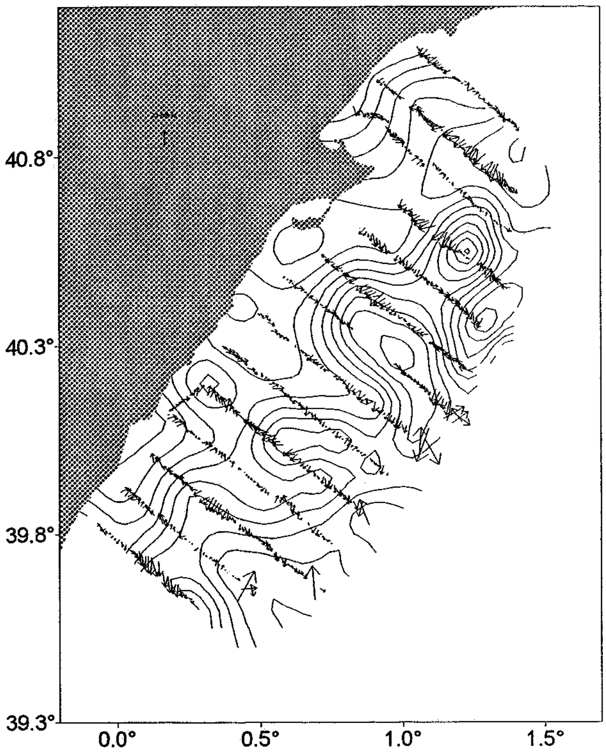

FIG. 5. - Currents and density distribution during GICS-2 for 14 metres depth.

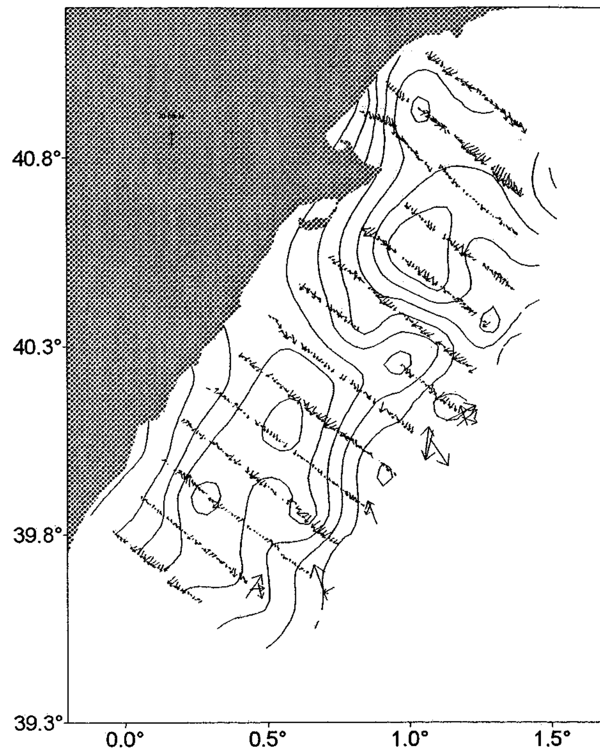

FIG. 6. - Currents and density distribution during GICS-2 for 30 metres depth.

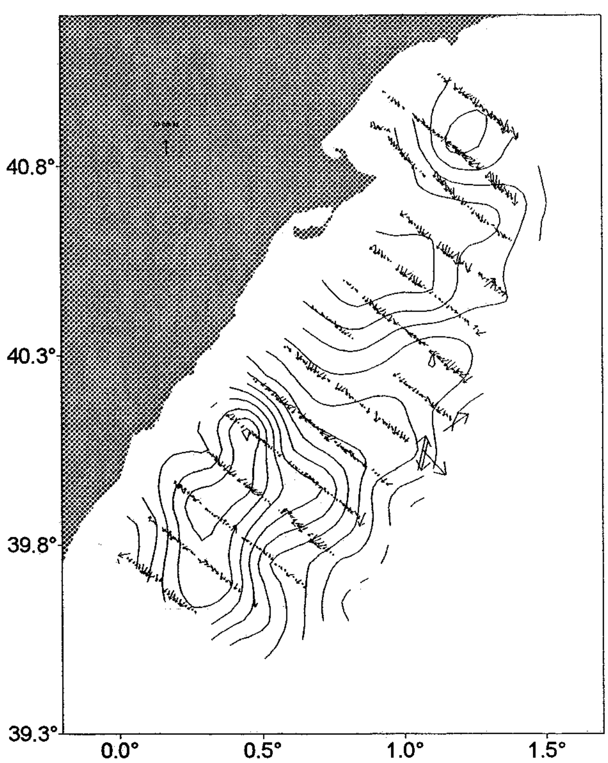

FIG. 7. - Currents and density distribution during GICS-2 for 50 metres depth.

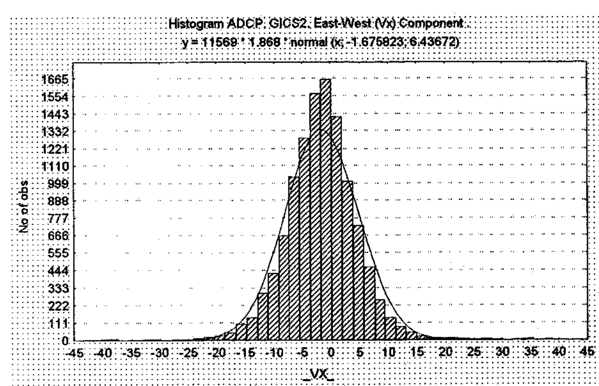

FIG. 8. - Frequency distribution of East-West (Vx) component for GICS-2 (cm/s).

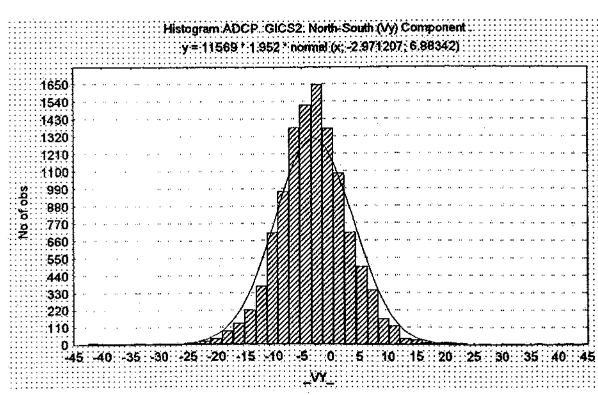

FIG. 9. - Frequency distribution of North-South (Vy) component for GICS-2 (cm/s).

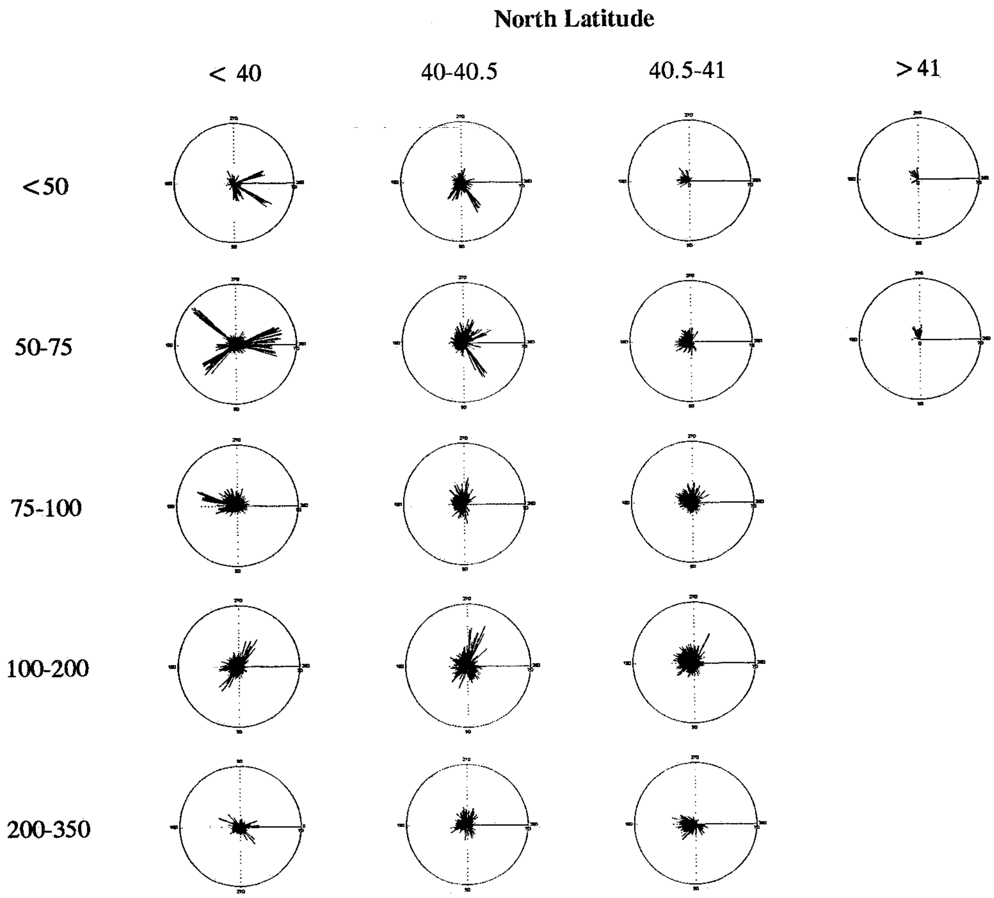

FIG. 10. - Polar plots of GICS-2 currents categorized by depth and latitude. North is on the right and East at the bottom.

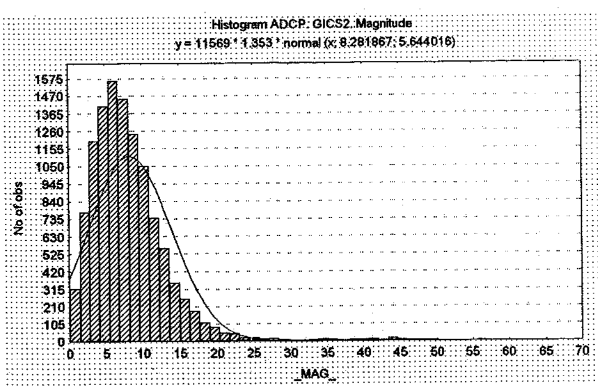

FIG. 11. - Frequency distribution of current magnitude for GICS-2 (cm/s).

Table 5. Statistics for 50m depth bin (cm/s), GICS-2.

	Magn.	E-W Comp.	N-S Comp
SUM	4074.86	-1186.00	-1956.70
MIN	0.63	-16.70	-39.80
MAX	46.13	33.60	45.10
CNT	533	533	533
AVG	7.65	-2.23	-3.67

Table 6. Statistics for 82m depth bin (cm/s), GICS-2.

	Magn.	E-W Comp.	N-S Comp.
SUM	2308.91	-710.60	-777.00
MIN	0.30	-36.80	-21.70
MAX	40.41	20.70	18.80
CNT	253	253	253
AVG	9.13	-2.81	-3.07

GICS-3 cruise

During this cruise currents are more intense than in the previous one. The average for the first depths reaches 12 cm/s. Although we can not talk of a trend, since eddies were many, we can say that in the average, the transport is Northeast. Two eddies are clearly observable, one in the south of the surveyed area and the other one Southeast of the mouth of the river Ebro. In figures13 to 15 appear these two eddies, and the effect of the slope current, rather well visible particularly in the southermost eddy. It must be noted that this cruise suffered the effects of a strong gale possibly affecting the circulation, but mainly the physical characteristics of the water column (Salat *et al.*, 1997).

The cruise started on May 10th and was interrupted on the 11th coinciding with the 3rd radial. It was pursued on the 14th on radial 4; this should be considered when looking at the data and especially in figures 16 to 18, where the stick plots have been plotted over the density contour.

In this cruise were detected stronger currents and quite significant eddies, although their origin is difficult to determine. The frequency distribution shows a wider range than in the previous cruise. The average of the currents is higher (12 cm/s) and the general trend is North. If we observe the polar plots we shall appreciate too the North trend of the countercurrent and, just as in GICS-2, the currents in the northern zone are very weak, specially near the coast. In comparison with the density field during the cruise we appreciate a certain agreement in the north and the south eddy. The origin of the current towards North in the South of the area seems to be from shelf waters, since no other origin -as e.g. Atlantic water, which appears, in other occasions, entering through the Ibiza channel- is appreciated in the TS diagrams (Salat *et al.*, 1997).

Table 7. Statistics for 14 m depth bin (cm/s).

	Magn.	E-W Comp.	N-S Comp.
SUM	8865.87	902.90	503.80
MIN	0.30	-28.10	-44.40
MAX	48.65	45.40	30.50
CNT	694	694	694
AVG	12.78	1.30	0.73

Table 8. Statistics for 22 m depth bin (cm/s).

	Magn.	E-W Comp.	N-S Comp.
SUM	8778.00	623.60	775.40
MIN	0.50	-26.50	-22.30
MAX	43.35	43.10	27.70
CNT	677	677	677
AVG	12.97	0.92	1.15

Table 9. Statistics for 50 m depth bin (cm/s).

	Magn.	E-W Comp.	N-S Comp.
SUM	5015.57	1170.40	694.70
MIN	0.20	-20.90	-16.10
MAX	26.16	25.80	19.00
CNT	584	584	584
AVG	8.59	2.00	1.19

What is apparently evident is that a water bag of lower density remains retained, possibly water from the slope current or foreign water having entered. The eddy may have its remote origin in the gale above mentioned, although it is difficult to ascertain it.

According to Salat *et al.* (1997), it can be appreciated that both eddies correspond with a water intrusion from a foreign origin (oceanic) with a higher salinity, the eddies reaching at least a depth of 50 metres, where they become weaker and disappear.

These 3-D phenomena are easily visualized in the transect figures, comparing the corresponding transect sections from ADCP and echointegration (Castellón *et al.*, 1997).

All this area is characterised by a coincidence of the backscattering with the currents structures (specially in transects 10 to 14). A more extended analysis of this relation needs to be done.

On the other hand, it is normal that a more intense current, or a conspicuous singularity, affects the mesoscale structure of the back-scattering distribution and therefore of the schools and their composition. As an example, when comparing Transect 3, Fig. 40 from GICS-3 echointegration (Castellón, *et al.*, 1997), and Fig. 33 from ADCP echo intensity measurements, and also with the corresponding image of the East-West current, Fig. 32, it appears evident that, at least in the areas of strong current gradients (eddies or fronts), the concentrations of echoes follow the same structure, although it is difficult to separate from the effect of diel migration.

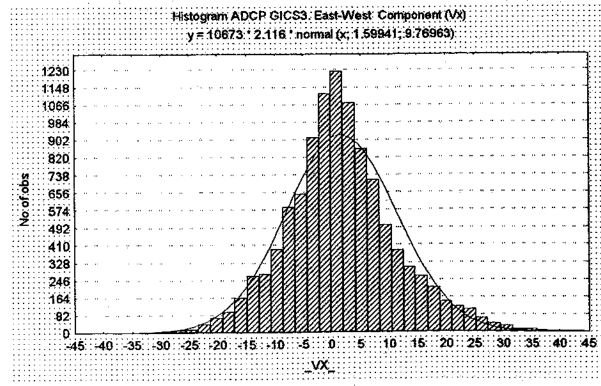

FIG. 12. - Frequency distribution of East-West (Vx) component for GICS-3 (cm/s).

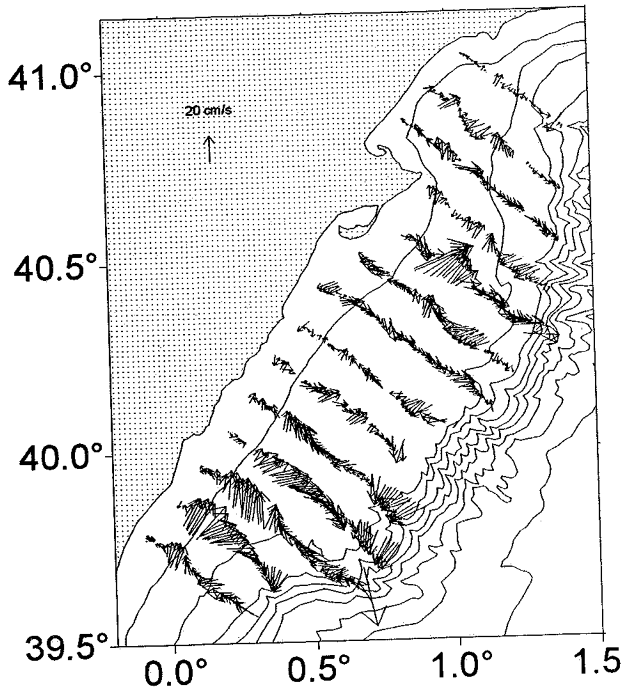

FIG. 13. - Stick plots of currents for 14 metres level during GICS-3 cruise.

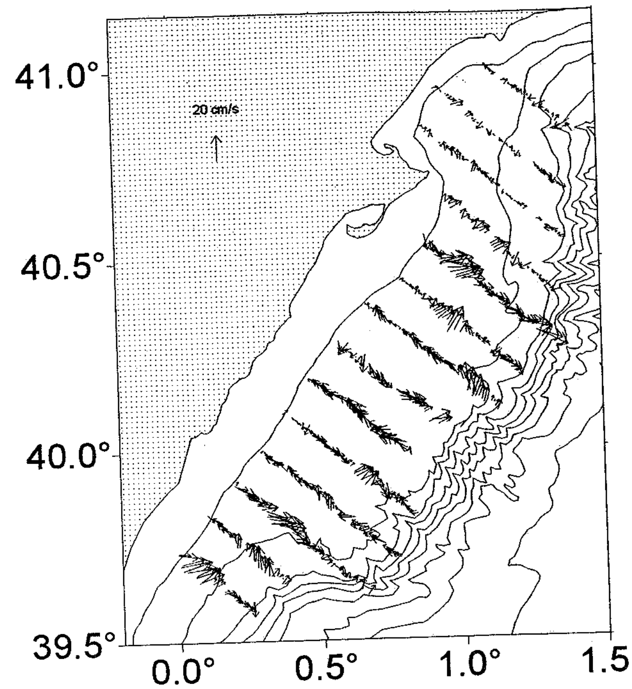

FIG. 14. - Stick plots of currents for 50 metres level during GICS-3 cruise.

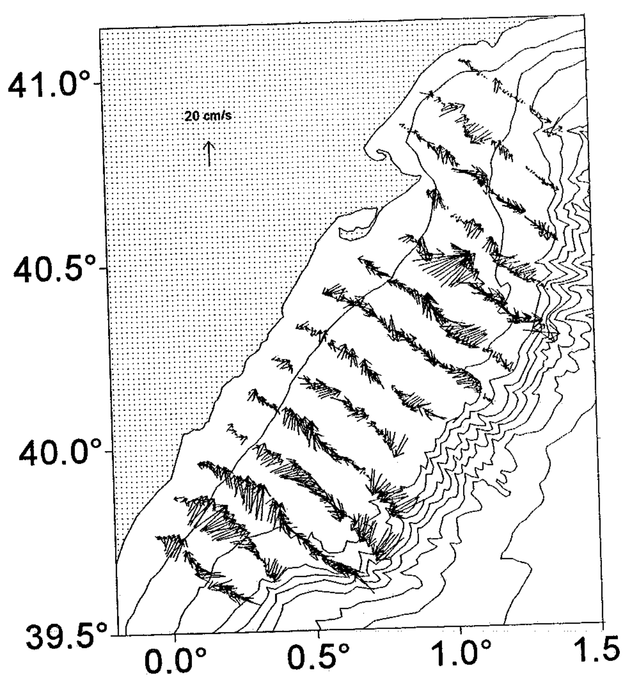

FIG. 15. - Stick plots of currents for 22 metres level during GICS-3 cruise.

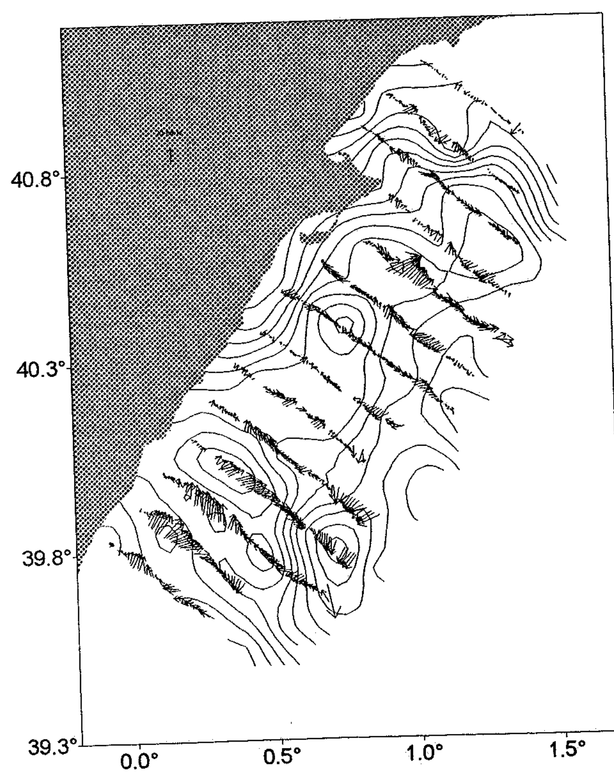

FIG. 16. - Currents and density distribution during GICS-3 for 14 metres depth.

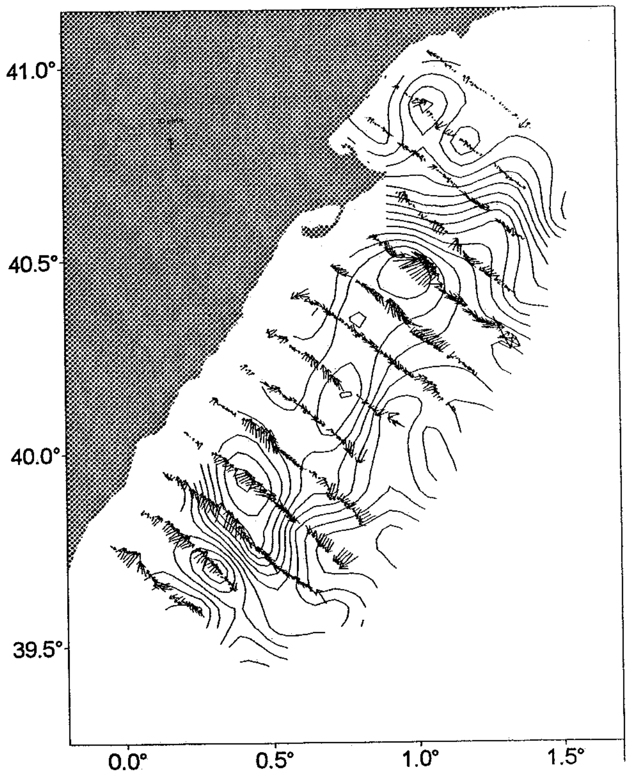

FIG. 17. - Currents and density distribution during GICS-3 for 30 metres depth.

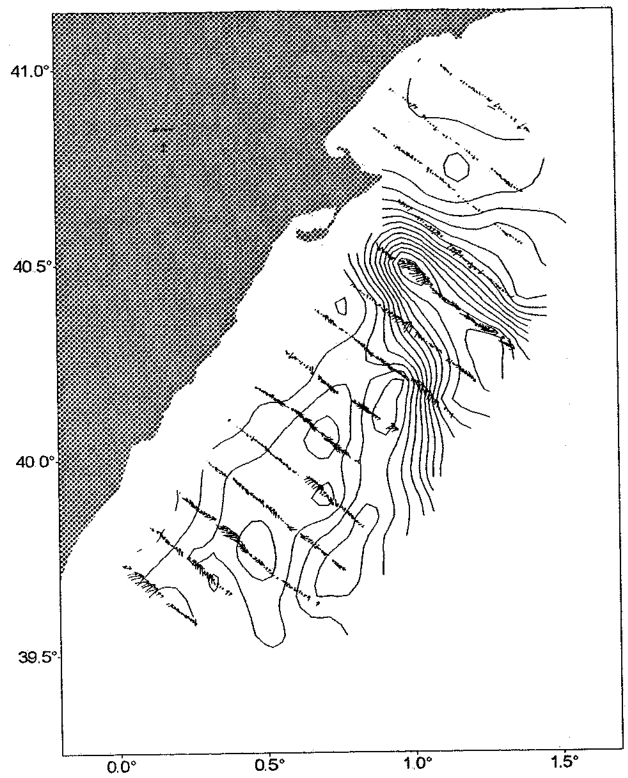

FIG. 18. - Currents and density distribution during GICS-3 for 50 metres depth.

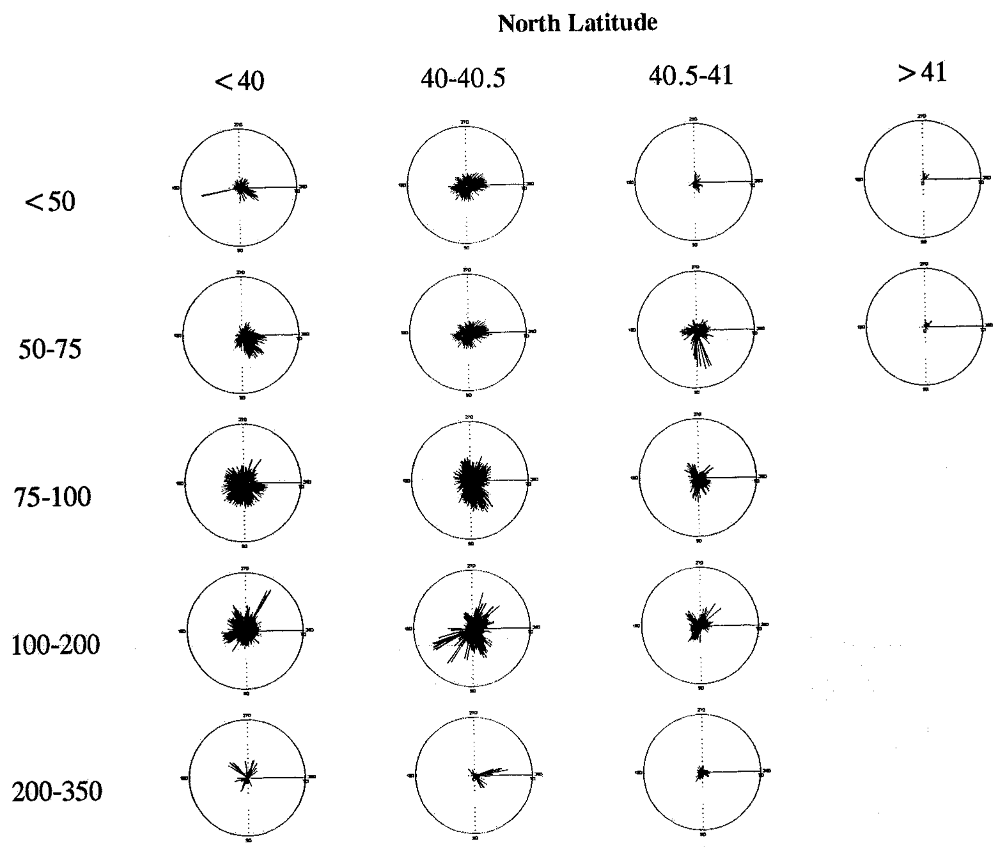

FIG. 19. - Polar plots of GICS-3 currents categorized by depth and latitude. North is on the right and East at the bottom.

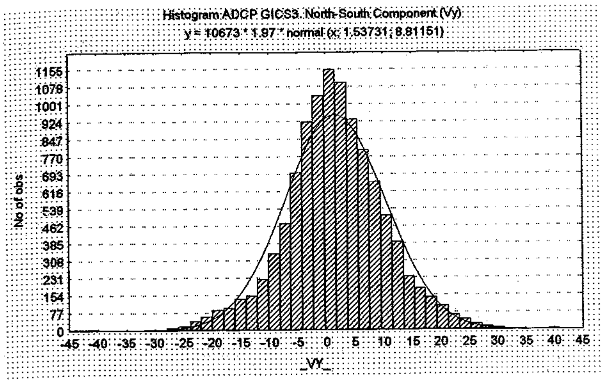

FIG. 20. - Frequency distribution of North-South (Vy) component for GICS-3 (cm/s).

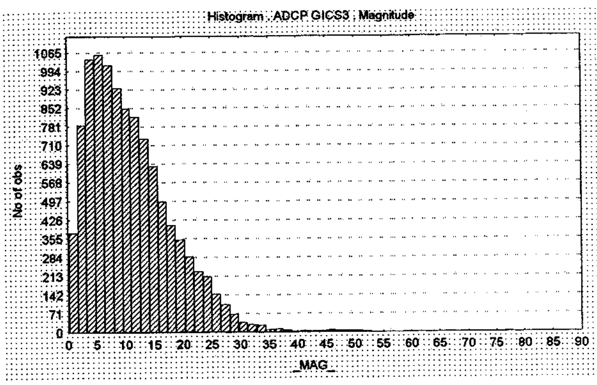

FIG. 21. - Frequency distribution of current Magnitude for GICS-3 (cm/s).

GIAS-2 cruise

The GIAS-2 cruise also had a particular development. It was only sampled the northern Adriatic until parallel 43°, but the conditions were not homogeneous as two storms changed the system, at least increasing the height of the mixing layer; particularly, the three southern most radials, were carried out after a strong gale.

The peculiarities of the Adriatic in comparison with the rest of the Mediterranean have been outlined by many authors (a classic approach being Buljan & Zore-Armanda, 1976). The general trends could be summarized as: the bathymetry is less than 80 metres in the northern half, and the warming-cooling and evaporation as well as the wind have a still more considerable effect on the circulation. General geostrophic circulation in prewinter has a SE component in the Italian coast and a Northwest one towards the centre of the basin. This circulation is clearly observed in the three mentioned radials, which are the three deepest radials.

Table 10. Statistics for 10 metres depth bin (cm/s).

	Magn.	E-W. comp	N-S. comp
SUM	6123.39	144.00	-2360.80
MIN	0.72	-22.70	-36.40
MAX	38.58	22.90	21.80
CNT	562	562	562
AVG	10.90	0.26	-4.20

Table 11. Statistics for 30 metres depth bin (cm/s).

	Magn.	E-W. comp	N-S. comp
SUM	3421.10	206.40	-1516.90
MIN	0.50	-16.30	-36.10
MAX	39.28	19.10	19.40
CNT	282	282	282
AVG	12.13	0.73	-5.38

Table 12. Statistics for 42 metres depth bin (cm/s).

	Magn.	E-W.comp	N-S. comp
SUM	2165.62	201.90	-1088.00
MIN	0.42	-13.30	-32.40
MAX	36.58	17.00	15.80
CNT	219	219	219
AVG	9.89	0.92	-4.97

Table 13. Statistics for 50 metres depth bin (cm/s).

	Magn.	E-W. comp	N-S. comp
SUM	1598.12	99.20	-851.50
MIN	1.00	-12.20	-23.10
MAX	26.60	16.40	11.50
CNT	179	179	179
AVG	8.93	0.55	-4.76

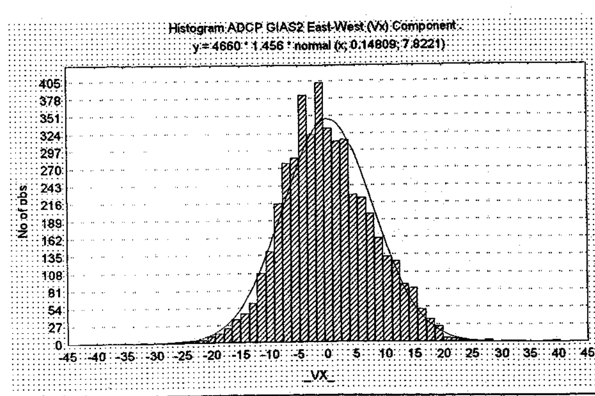

FIG. 22. - Frequency Distribution of East-West (Vx) component for GIAS-2 (cm/s).

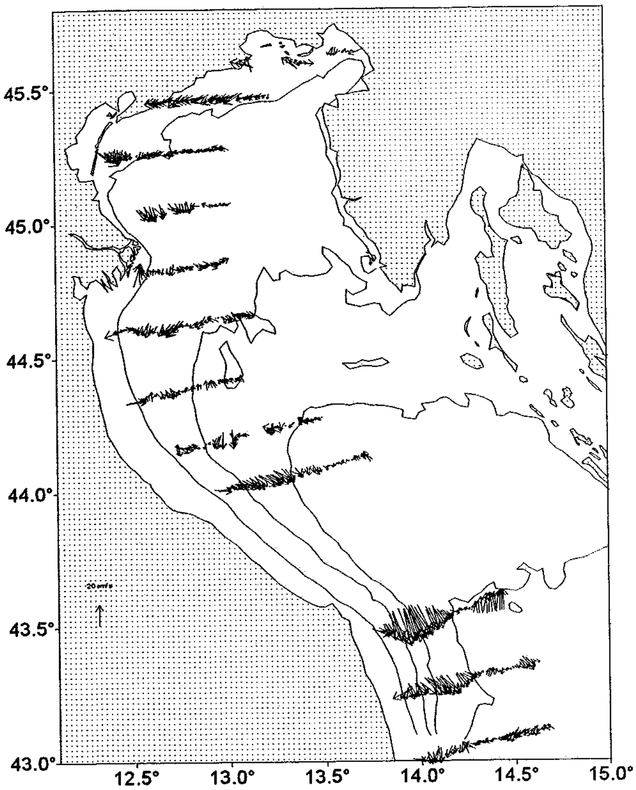

FIG. 23. - Stick plots of currents for 10 metres level during GIAS-2 cruise.

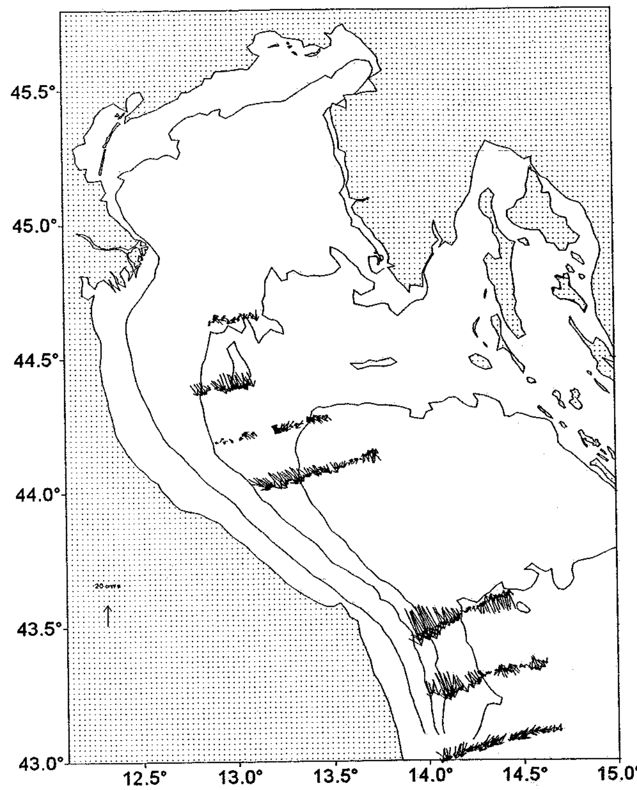

FIG. 24. - Stick plots of currents for 30 metres level during GIAS-2 cruise.

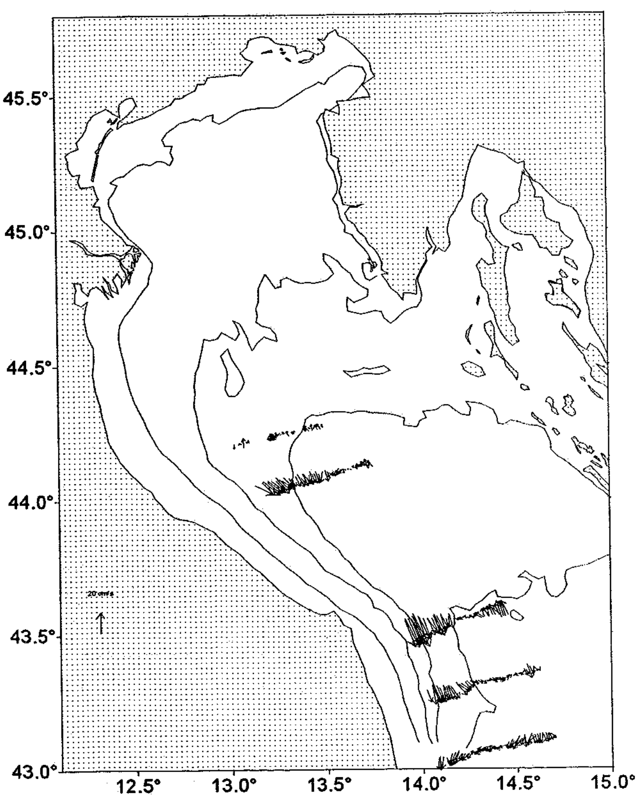

FIG. 25. - Stick plots of currents for 42 metres level during GIAS-2 cruise.

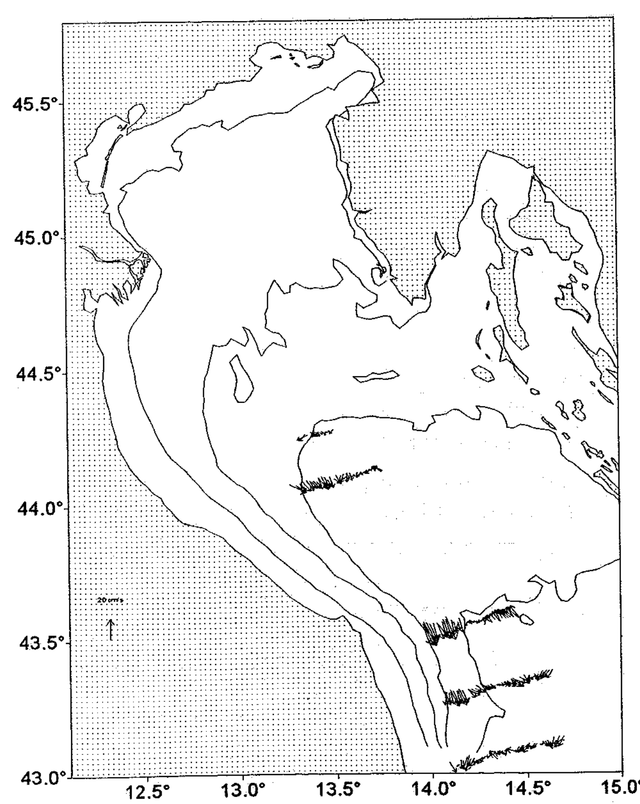

FIG. 26. - Stick plots of currents for 50 metres level during GIAS-2 cruise.

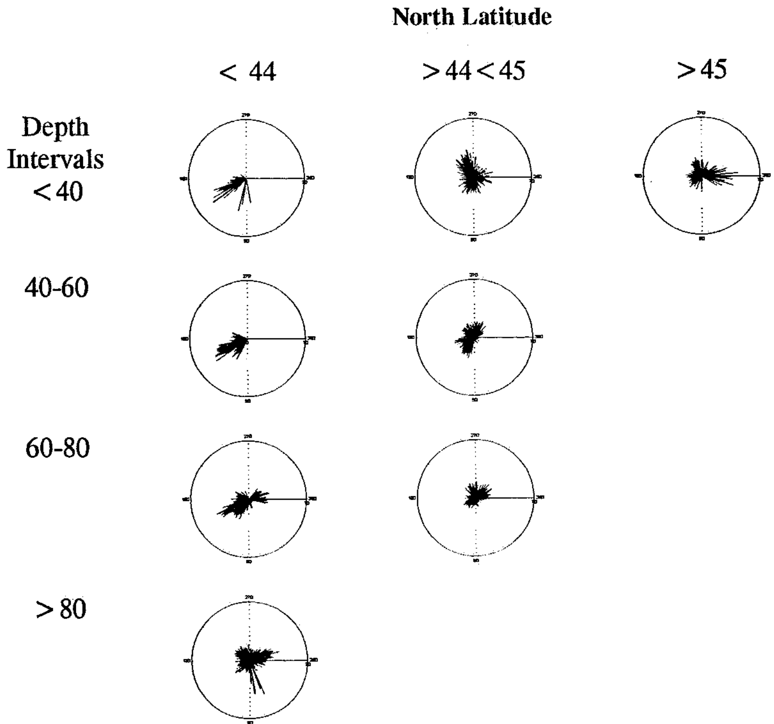

FIG. 27. - Polar plots of GIAS-2 currents categorized by depth and latitude. North is on the right and East at the bottom.

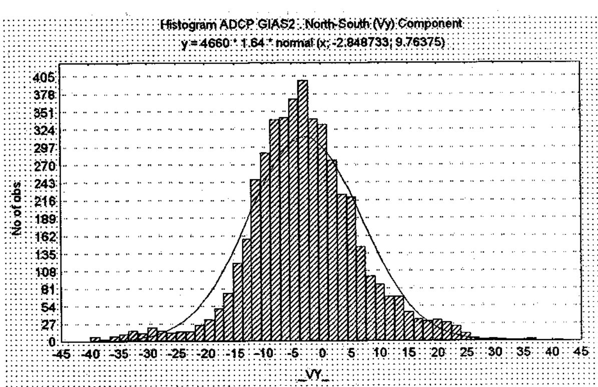

FIG. 28. - Frequency Distribution of North -South component (Vy) for GIAS-2 (cm/s).

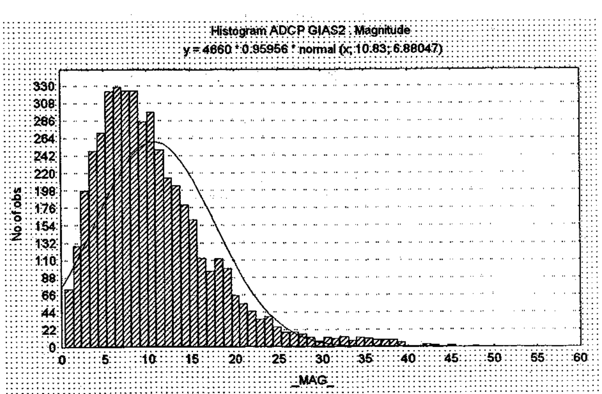

FIG. 29. - Frequency Distribution of current Magnitude for GIAS-2 (cm/s).

The average of currents for this cruise is between 9.89 cm/s at 42 metres depth and 10.9 at 10 metres, reaching the maximum at 22 metres with 12.36 cm/s. The trend, as previously said, is Southeast and it can be appreciated in the polar plots (fig. 27), specially in the southern part.

Transects

In figures 30 to 35 are presented the grafics of the transects for the North-South and West-East current components of the three cruises analyzed. GICS-2 transects are plotted in figures 30 (East/West component) and 31 (North/South component); GICS-3 transects are plotted in figures 32 (East/West component) and 33 (North/South Component). GIAS-2 cruise transects are in figures 34 (East/West component) and 35 (North/South component).

This presentation mode helps data visualization, as the general context of the sampled system is easily appraised.

Moreover, as the same presentation mode was chosen for the echo-integration results from the BioSonics vertical echosounder, and data was gathered simultaneously (that is, the spatiotemporal coordinates are coincident) ADCP data (environment side) could be directly compared with echointegration (biological side).

On the other hand, ADCP Transect soft provides an extra data set with interest on the biological side: echo-intensity, being a back-scattering coefficient.

Units used for echo-intensity in this paper are not dB, but "counts", being the digital output of the instrument. The results are not comparable between cruises, but the relation between these data and those of the echo-integration should be considered within each cruise. The results are presented in "transect" map projection in figures 36, 37 and 38, respectively cruises GICS-2, GICS-3 and GIAS-2.

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Miguel A. Gallego kindly reviewed the English version manuscript.

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FIG. 30. - Cruise GICS-2, 1st coverage (May 1994)

Velocity distribution of E/W component of currents - Catalan Sea

Vertical axis: depth (meters); horizontal axis: distance (nautical miles) from/to reference point; colour scale: E/W component of the current (cm/s). Transect naming convention: ck_lnnVX: c for Catalan sea cruise, k is cruise number, l is Leg identifier label, nn is leg (transect) number, and VX is velocity current component label on East/West axis.

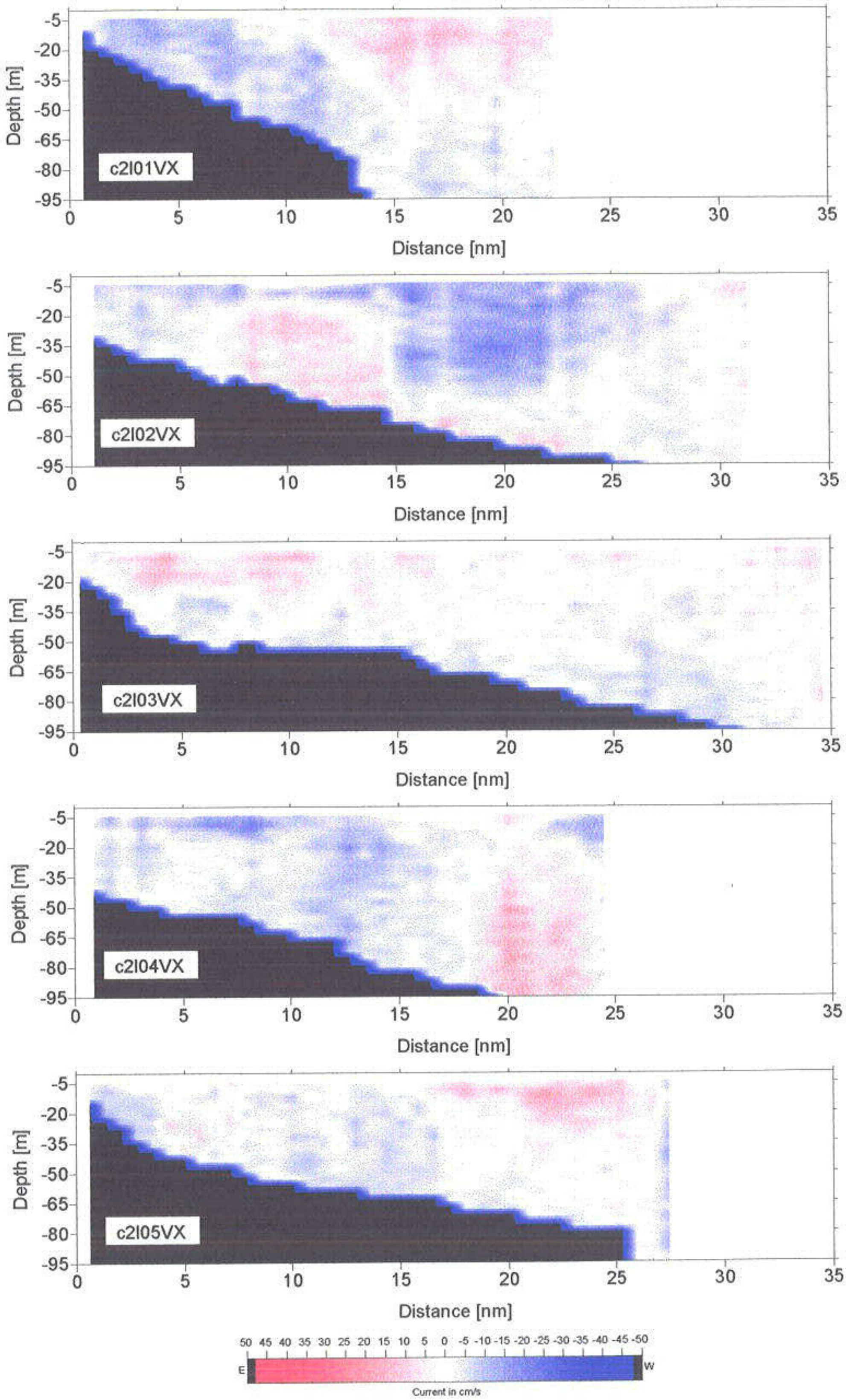


FIG. 30 (cont.). - Cruise GICS-2, 1st coverage (May 1994)

Velocity distribution of E/W component of currents - Catalan Sea

Vertical axis: depth (meters); horizontal axis: distance (nautical miles) from/to reference point; colour scale: E/W component of the current (cm/s). Transect naming convention: ck_lnnVX: c for Catalan sea cruise, k is cruise number, l is Leg identifier label, nn is leg (transect) number, and VX is velocity current component label on East/West axis.

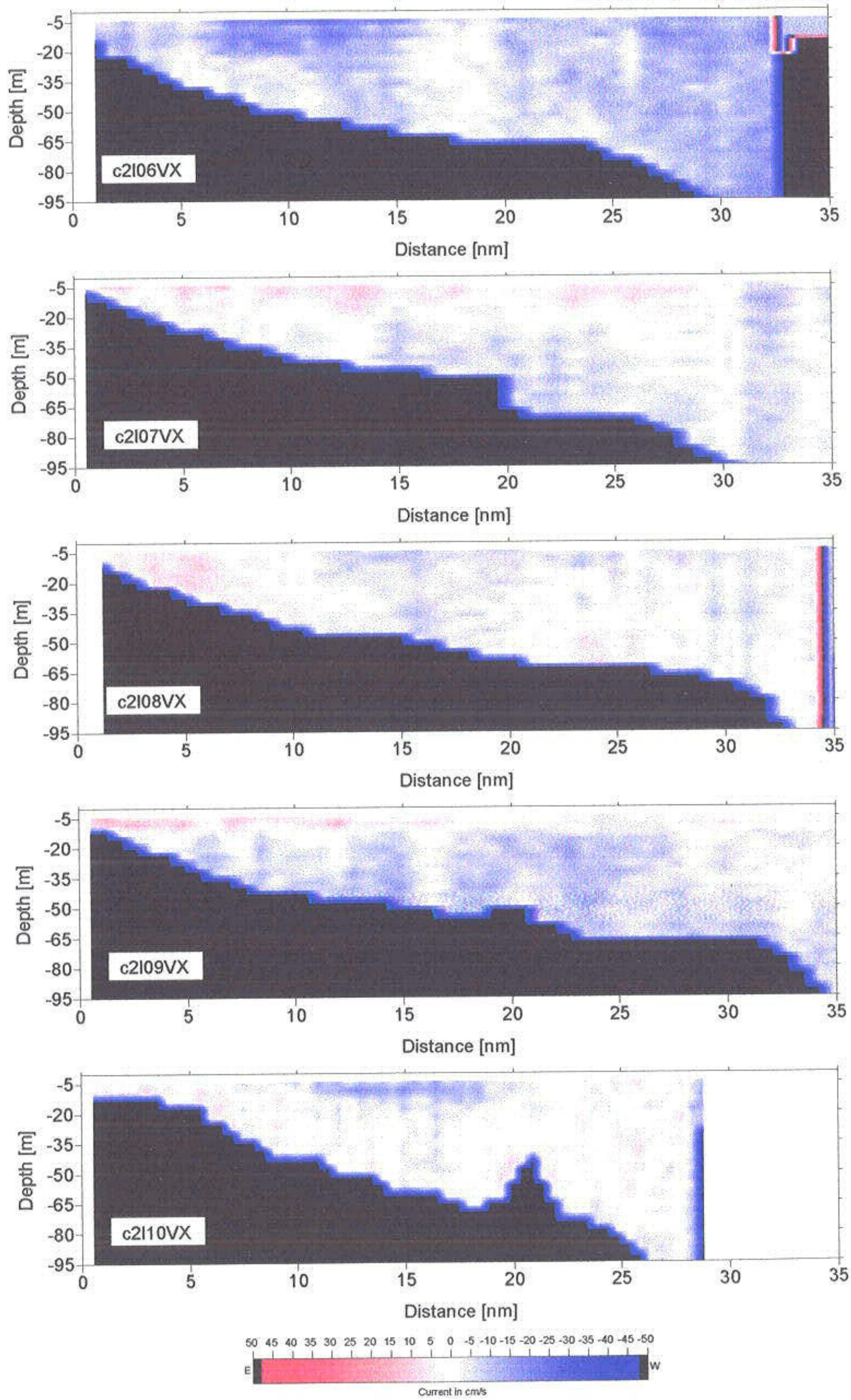


FIG. 30 (cont.). - Cruise GICS-2, 1st coverage (May 1994)

Velocity distribution of E/W component of currents - Catalan Sea

Vertical axis: depth (meters); horizontal axis: distance (nautical miles) from/to reference point; colour scale: E/W component of the current (cm/s). Transect naming convention: ck_lnnVX: c for Catalan sea cruise, k is cruise number, l is Leg identifier label, nn is leg (transect) number, and VX is velocity current component label on East/West axis.

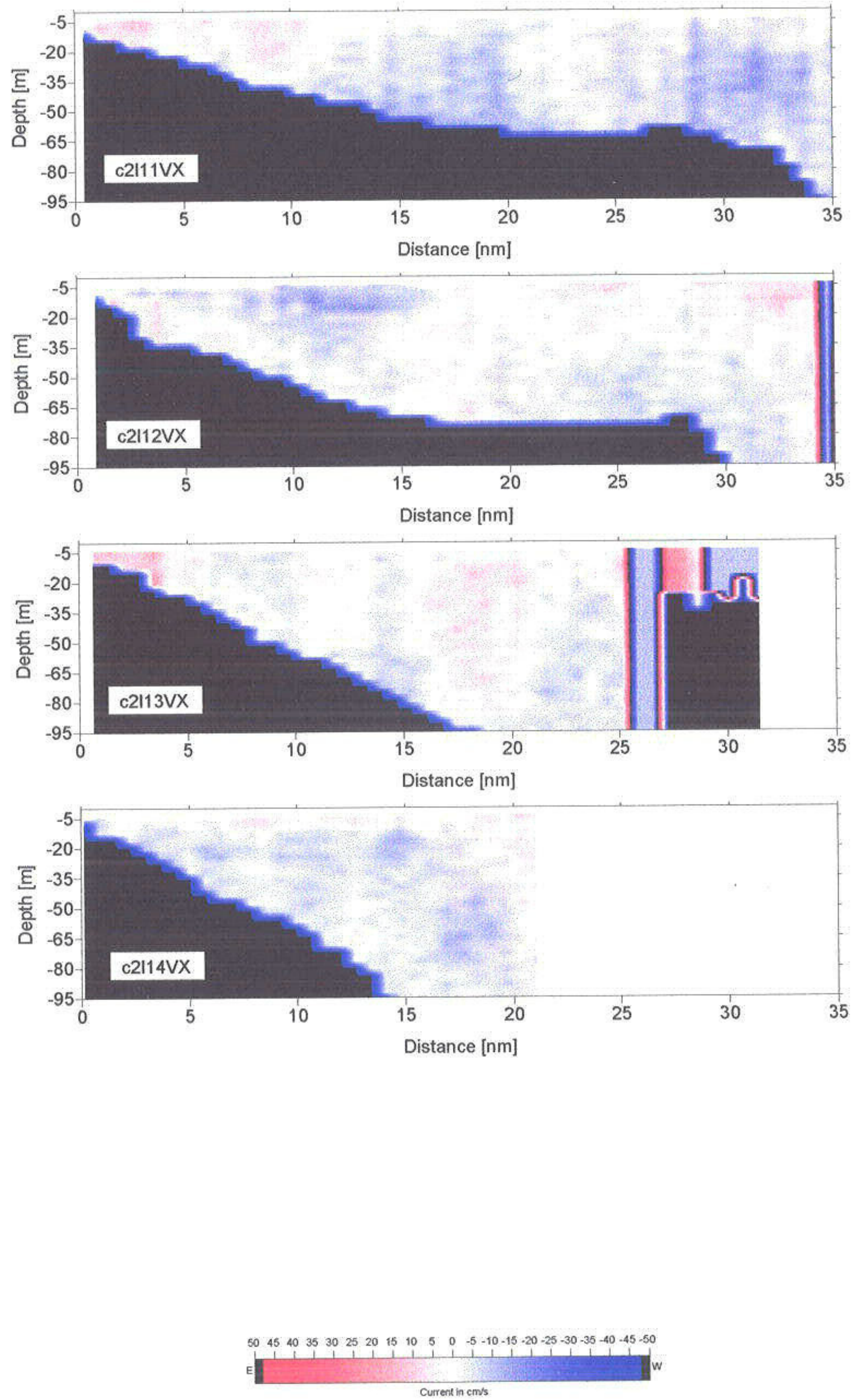


FIG. 31. - Cruise GICS-2, 1st coverage (May 1994)

Velocity distribution of N/S component of currents - Catalan Sea

Vertical axis: depth (meters); horizontal axis: distance (nautical miles) from/to reference point; colour scale: N/S component of the current (cm/s). Transect naming convention: ck_lnnVY: c for Catalan sea cruise, k is cruise number, l is Leg identifier label, nn is leg (transect) number, and VY is velocity current component label on North/South axis.

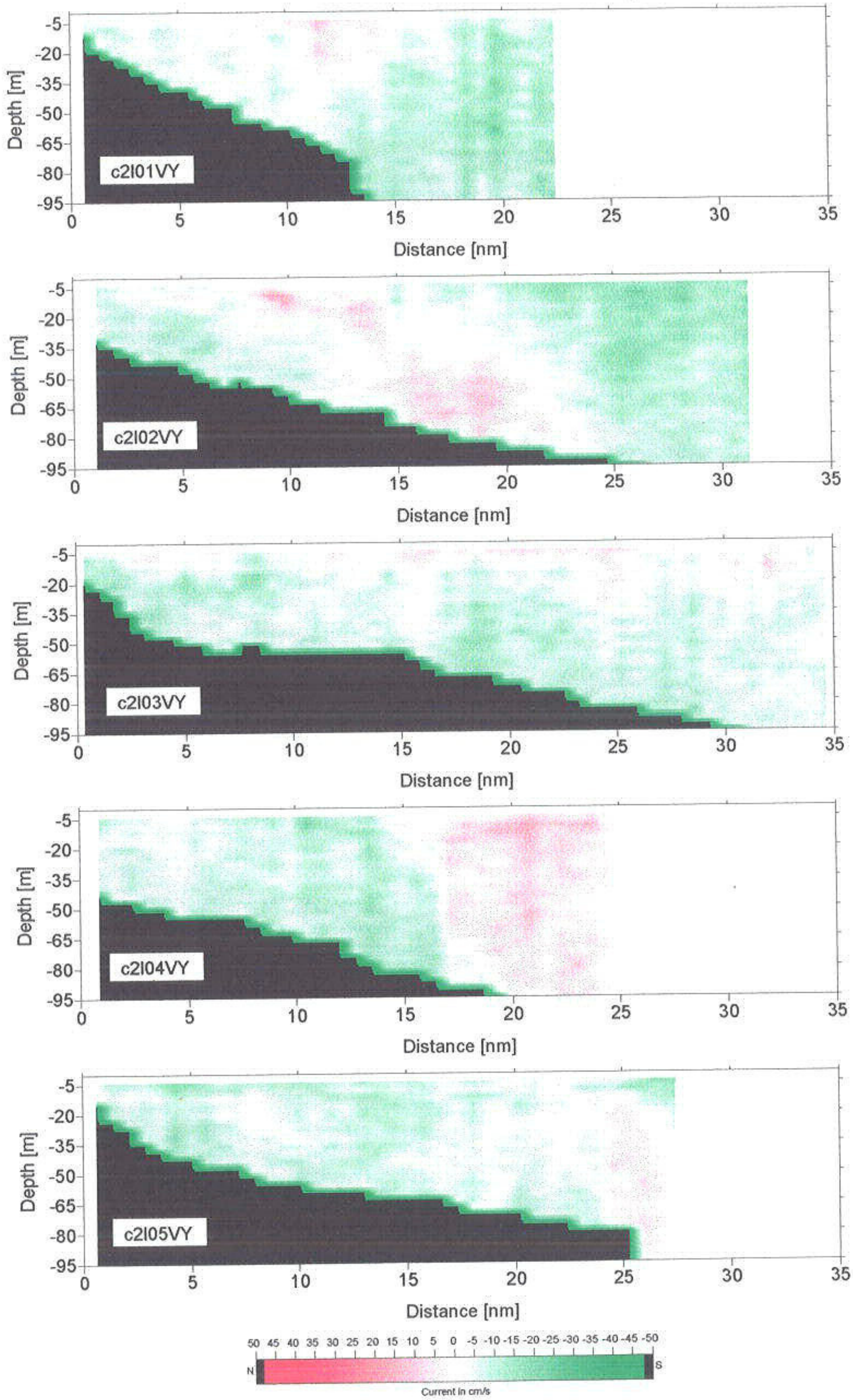


FIG. 31. (cont.) - Cruise GICS-2, 1st coverage (May 1994)

Velocity distribution of N/S component of currents - Catalan Sea

Vertical axis: depth (meters); horizontal axis: distance (nautical miles) from/to reference point; colour scale: N/S component of the current (cm/s). Transect naming convention: ck_lnnVY: c for Catalan sea cruise, k is cruise number, l is Leg identifier label, nn is leg (transect) number, and VY is velocity current component label on North/South axis.

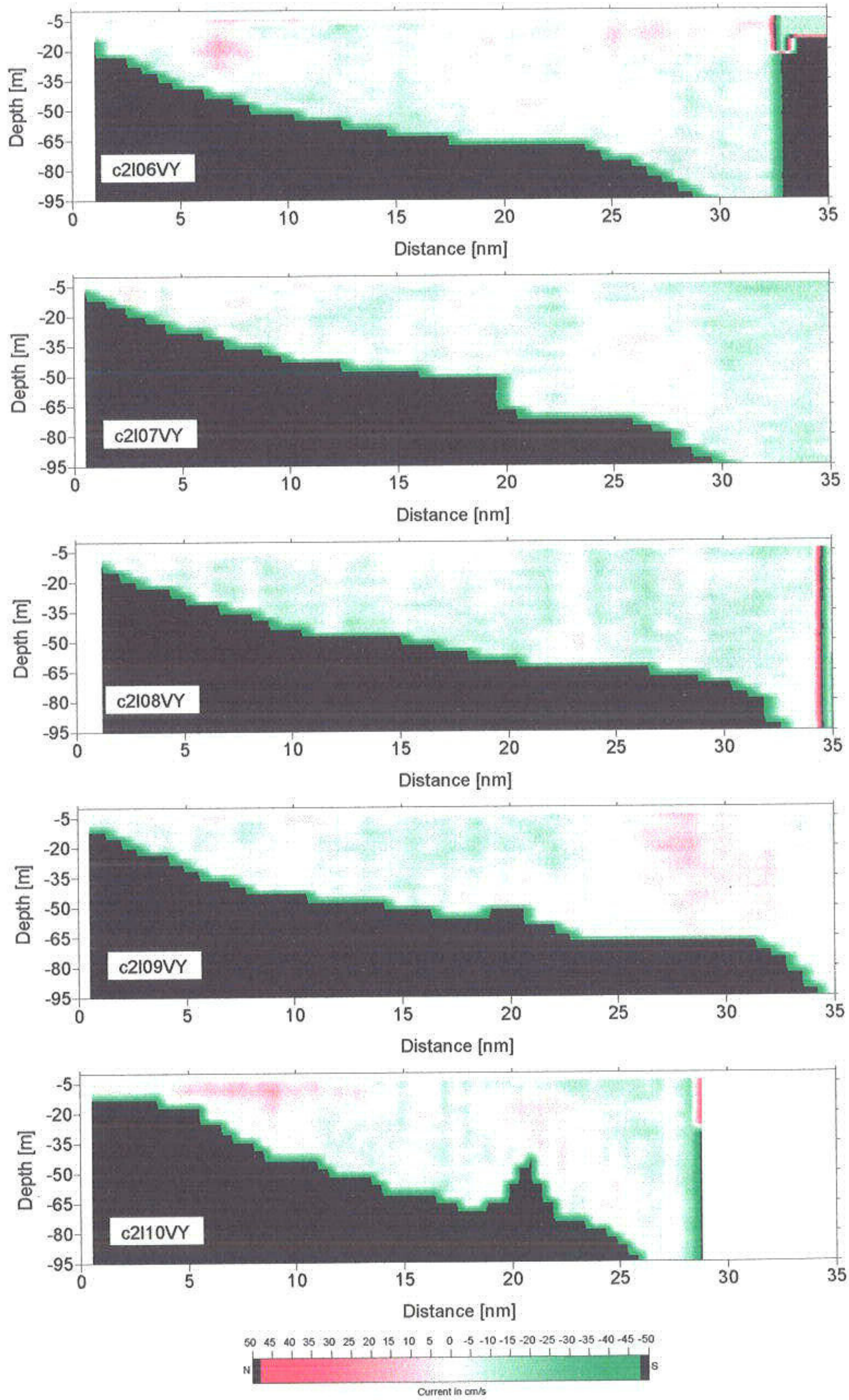


FIG. 31. (cont.) - Cruise GICS-2, 1st coverage (May 1994)

Velocity distribution of N/S component of currents - Catalan Sea

Vertical axis: depth (meters); horizontal axis: distance (nautical miles) from/to reference point; colour scale: N/S component of the current (cm/s). Transect naming convention: ck_lnnVY: c for Catalan sea cruise, k is cruise number, l is Leg identifier label, nn is leg (transect) number, and VY is velocity current component label on North/South axis.

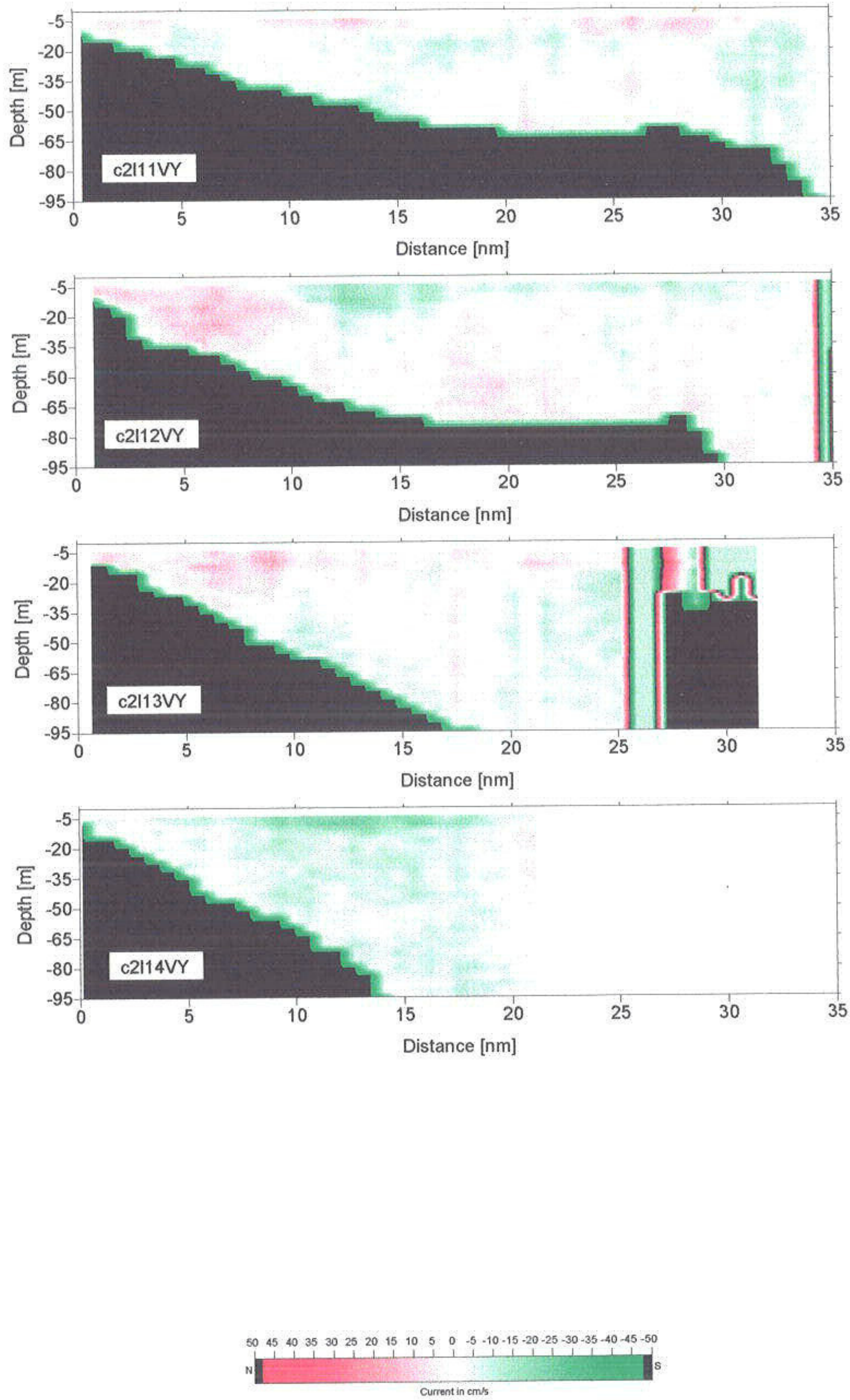


FIG. 32. - Cruise GICS-3, 1st coverage (May 1995)

Velocity distribution of E/W component of currents - Catalan Sea

Vertical axis: depth (meters); horizontal axis: distance (nautical miles) from/to reference point; colour scale: E/W component of the current (cm/s). Transect naming convention: ck_lnnVX: c for Catalan sea cruise, k is cruise number, l is Leg identifier label, nn is leg (transect) number, and VX is velocity current component label on East/West axis.

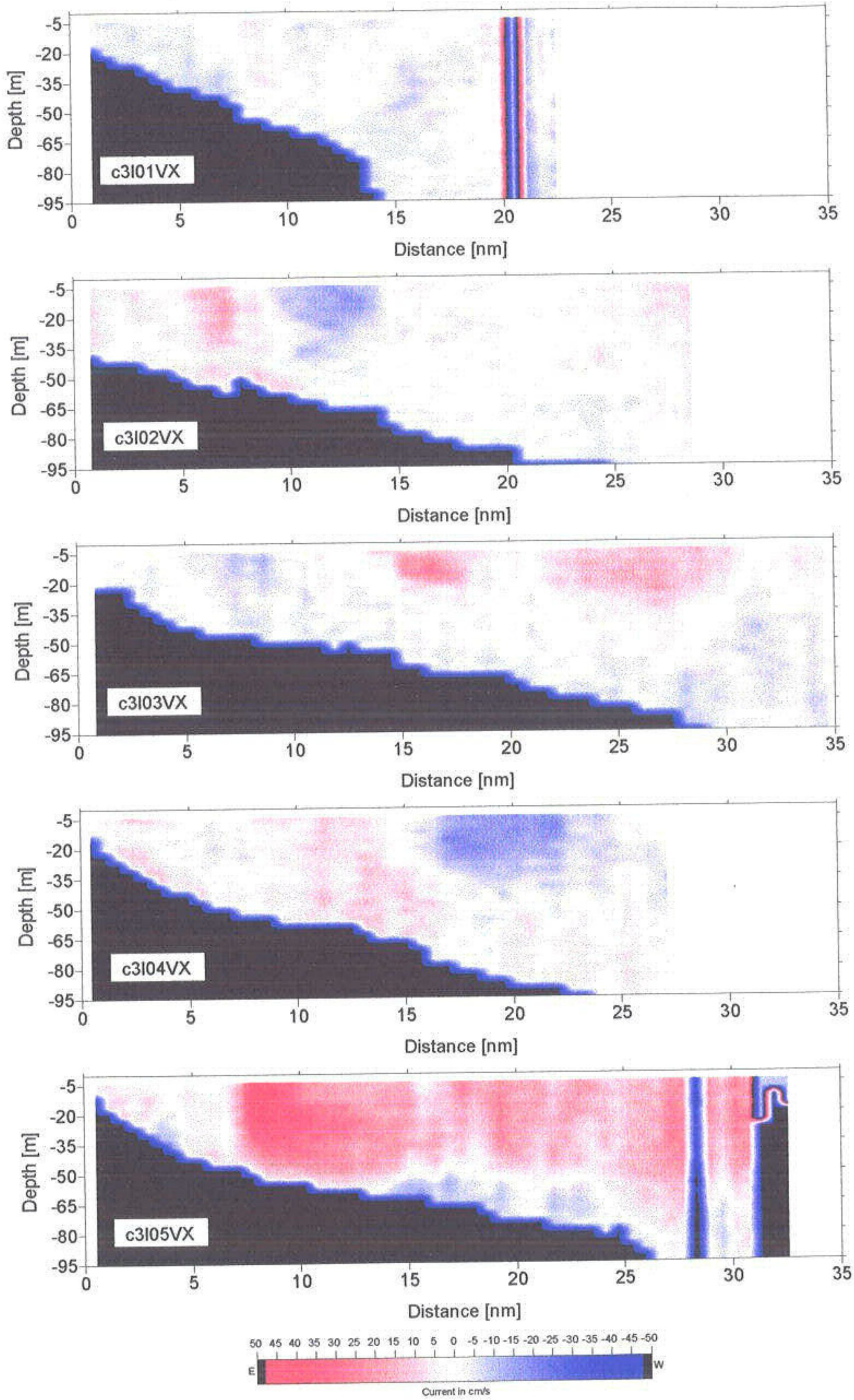


FIG. 32 (cont.). - Cruise GICS-3, 1st coverage (May 1995)

Velocity distribution of E/W component of currents - Catalan Sea

Vertical axis: depth (meters); horizontal axis: distance (nautical miles) from/to reference point; colour scale: E/W component of the current (cm/s). Transect naming convention: ck_lnnVX: c for Catalan sea cruise, k is cruise number, l is Leg identifier label, nn is leg (transect) number, and VX is velocity current component label on East/West axis.

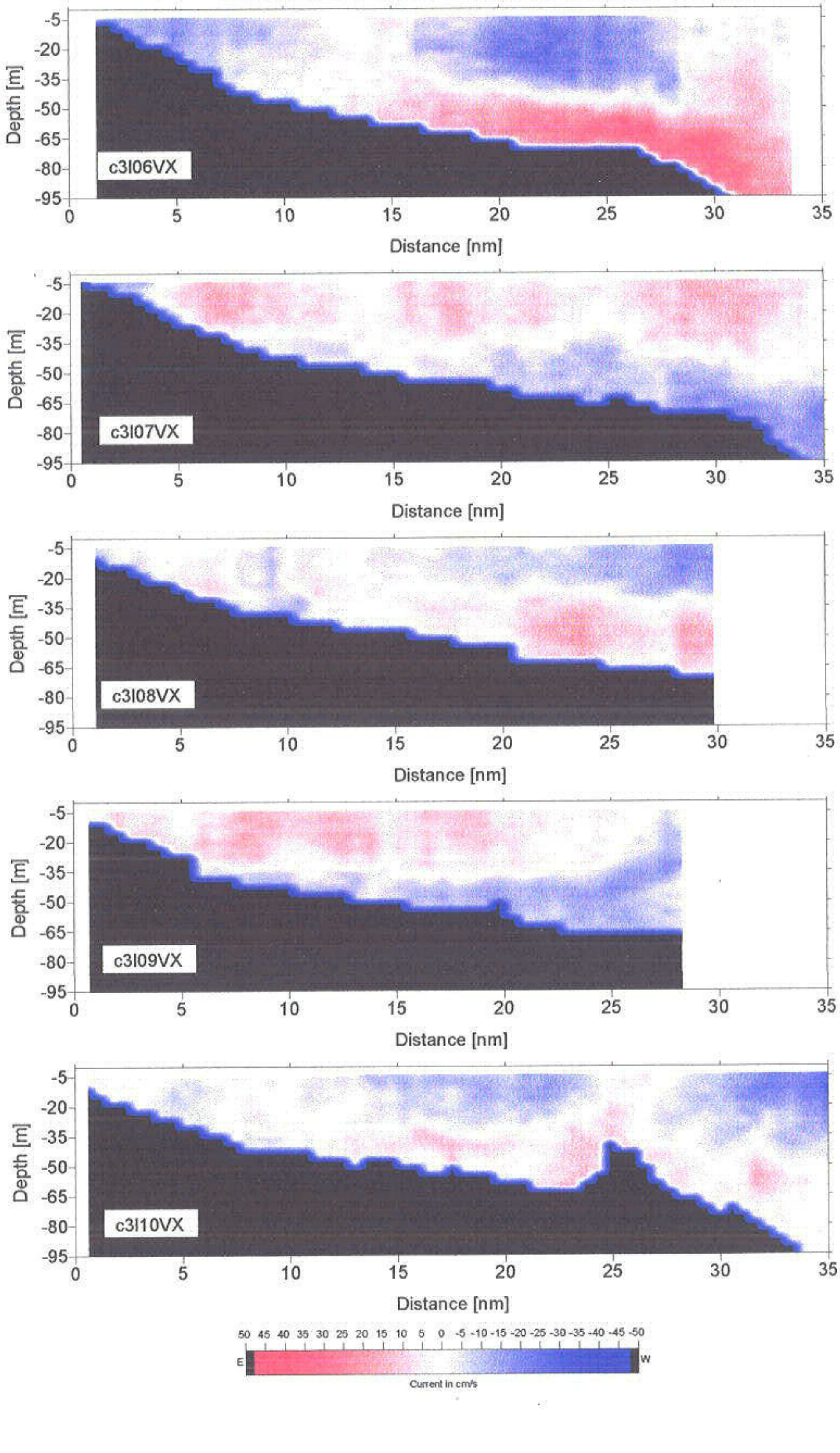


FIG. 32 (cont.). - Cruise GICS-3, 1st coverage (May 1995)

Velocity distribution of E/W component of currents - Catalan Sea

Vertical axis: depth (meters); horizontal axis: distance (nautical miles) from/to reference point; colour scale: E/W component of the current (cm/s). Transect naming convention: ck_lnnVX: c for Catalan sea cruise, k is cruise number, l is Leg identifier label, nn is leg (transect) number, and VX is velocity current component label on East/West axis.

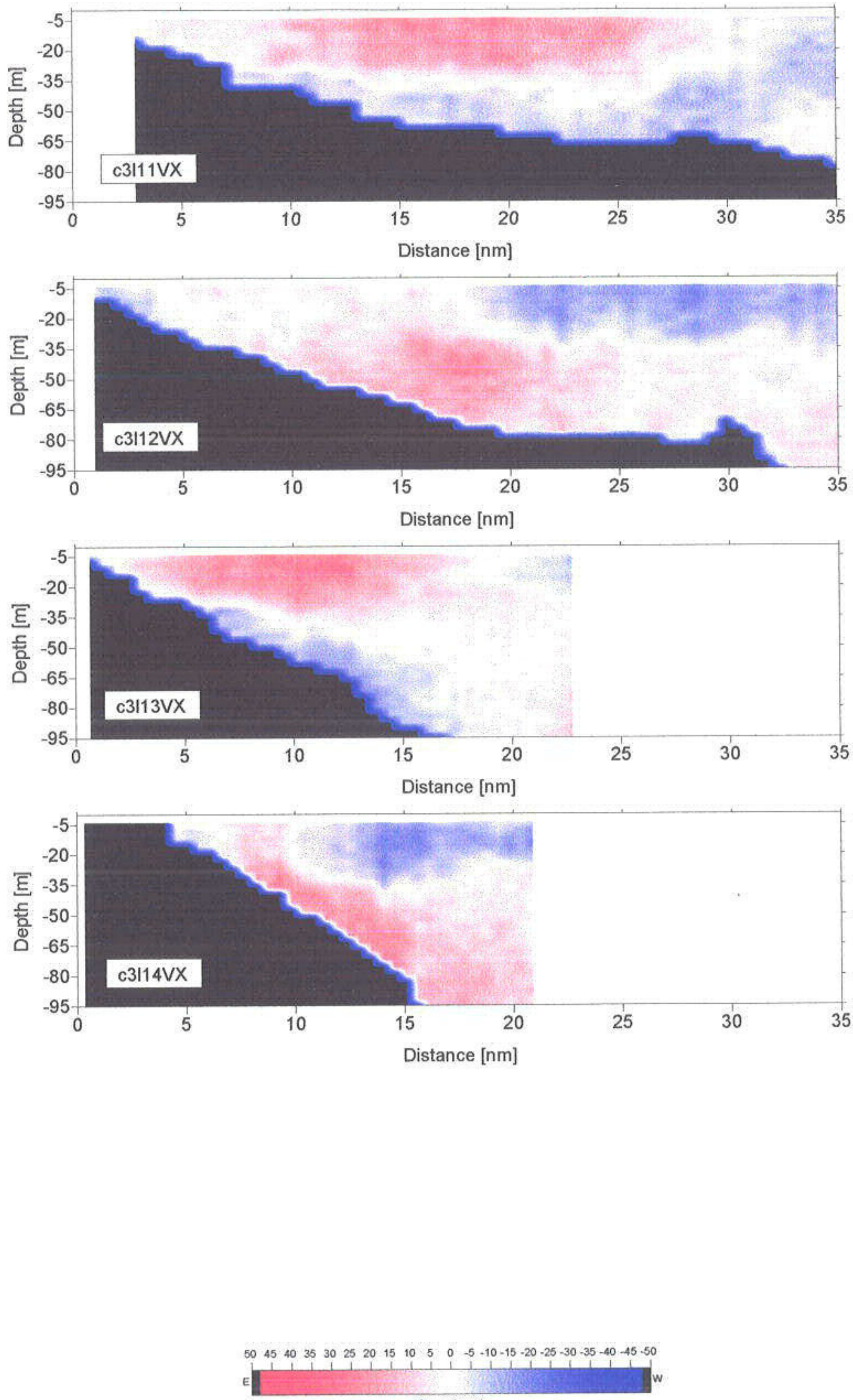


FIG. 33. - Cruise GICS-3, 1[st] coverage (May 1995)

Velocity distribution of N/S component of currents - Catalan Sea

Vertical axis: depth (meters); horizontal axis: distance (nautical miles) from/to reference point; colour scale: N/S component of the current (cm/s). Transect naming convention: ck_lnnVY: c for Catalan sea cruise, k is cruise number, l is Leg identifier label, nn is leg (transect) number, and VY is velocity current component label on North/South axis.

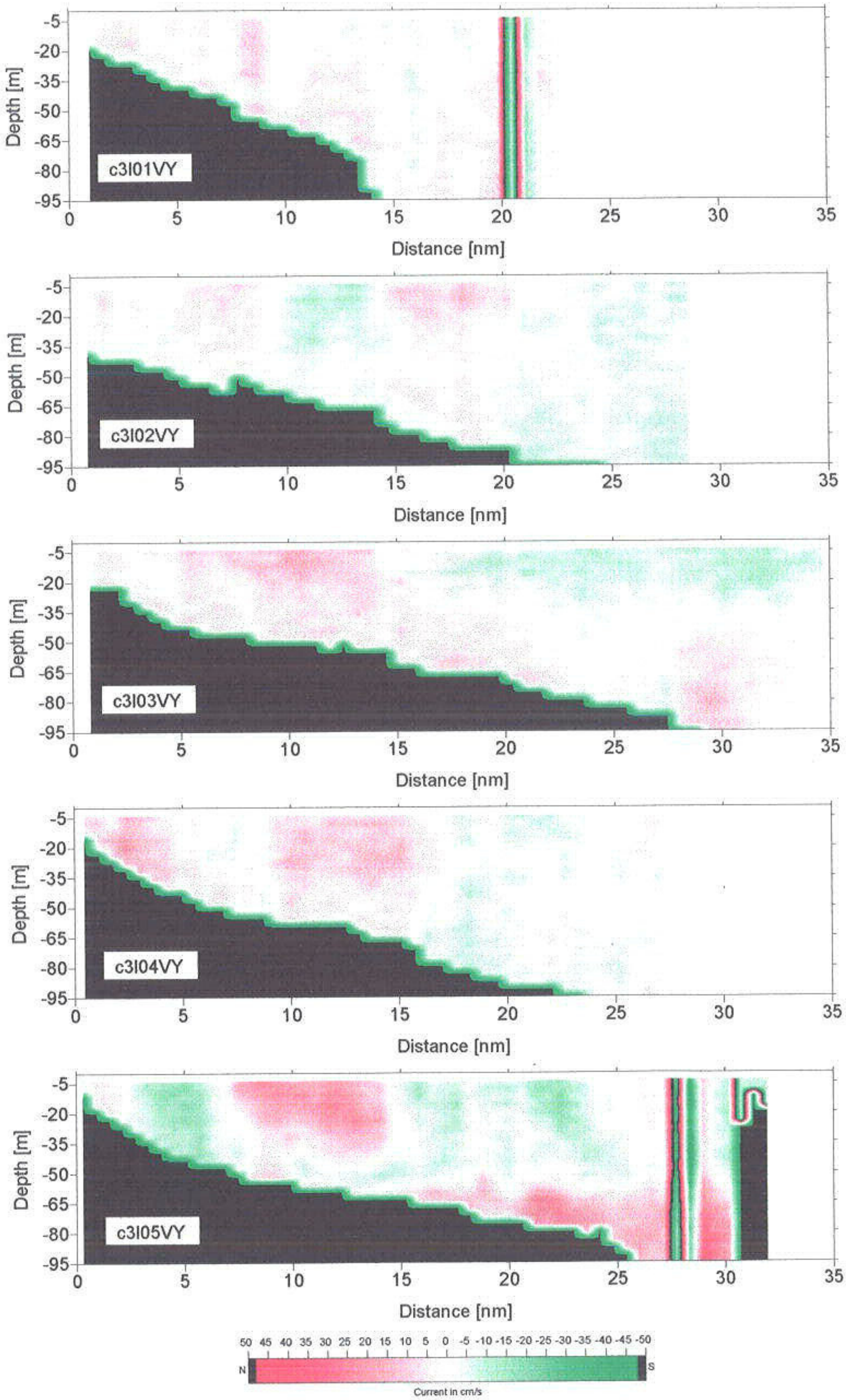


FIG. 33. (cont.) - Cruise GICS-3, 1st coverage (May 1995)

Velocity distribution of N/S component of currents - Catalan Sea

Vertical axis: depth (meters); horizontal axis: distance (nautical miles) from/to reference point; colour scale: N/S component of the current (cm/s). Transect naming convention: ck_lnnVY: c for Catalan sea cruise, k is cruise number, l is Leg identifier label, nn is leg (transect) number, and VY is velocity current component label on North/South axis.

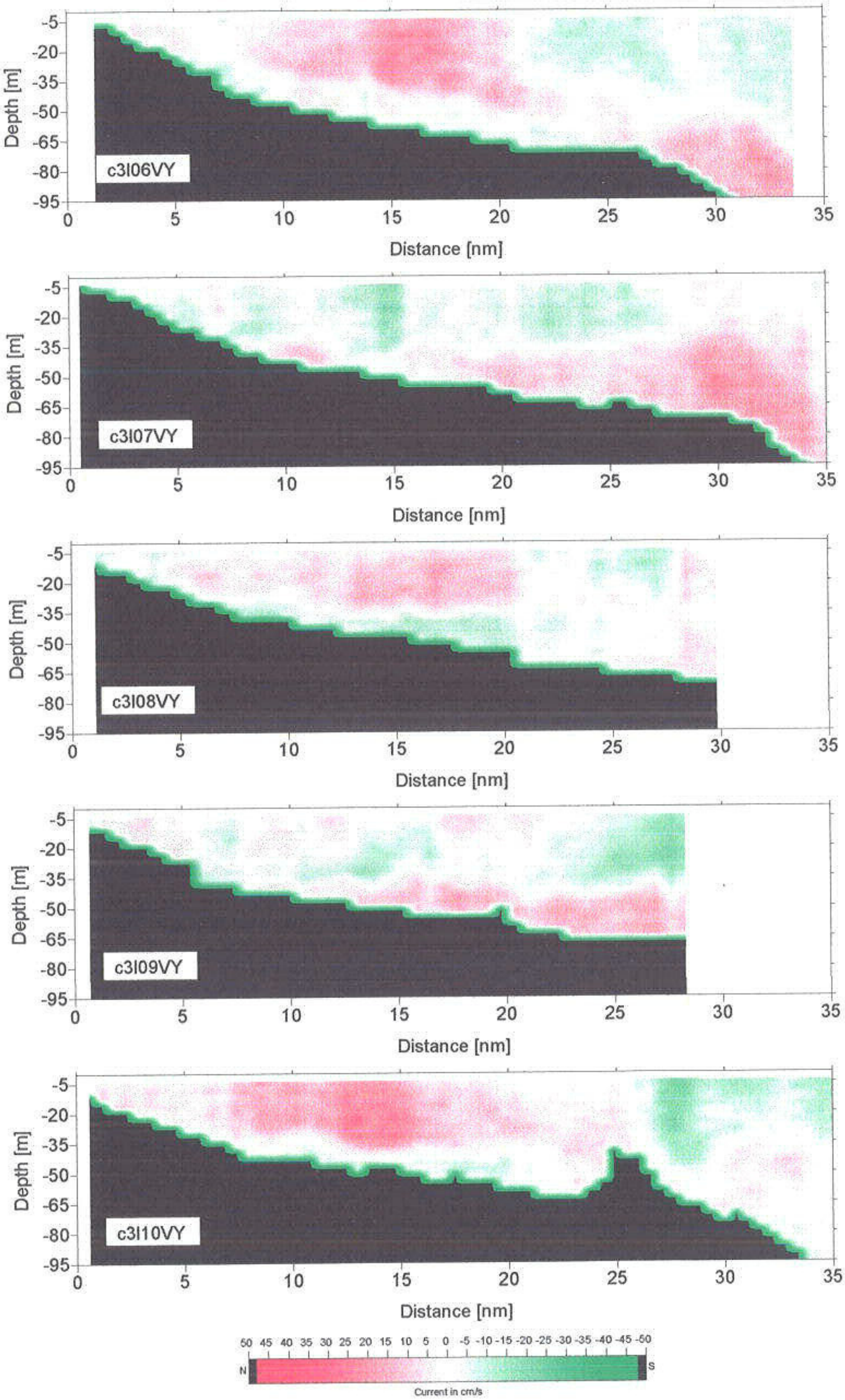


FIG. 33. (cont.) - Cruise GICS-3, 1st coverage (May 1995)

Velocity distribution of N/S component of currents - Catalan Sea

Vertical axis: depth (meters); horizontal axis: distance (nautical miles) from/to reference point; colour scale: N/S component of the current (cm/s). Transect naming convention: ck_lnnVY: c for Catalan sea cruise, k is cruise number, l is Leg identifier label, nn is leg (transect) number, and VY is velocity current component label on North/South axis.

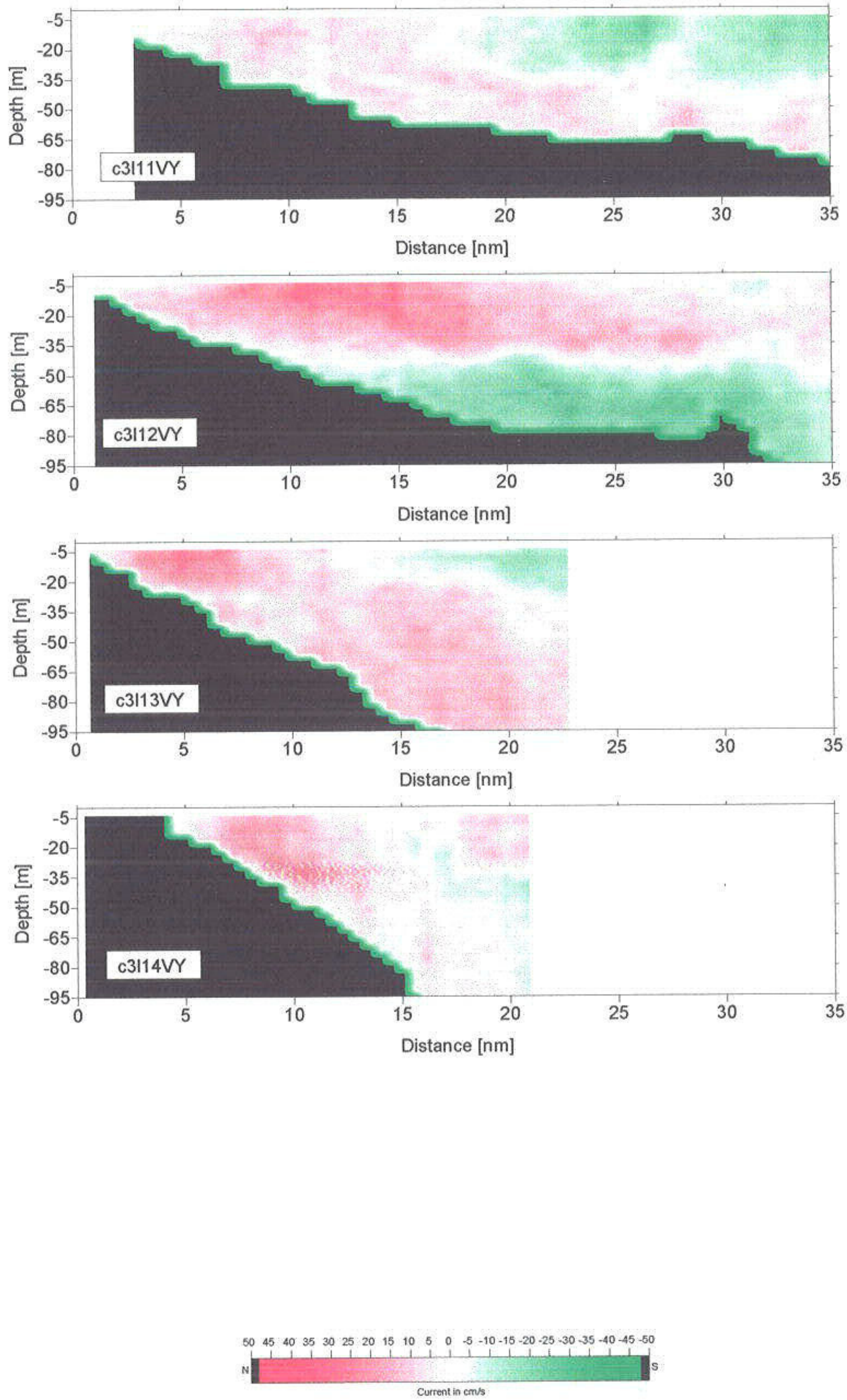


FIG. 34. - Cruise GIAS-2 (September 1994)

Velocity distribution of E/W component of currents - Adriatic Sea

Vertical axis: depth (meters); horizontal axis: distance (nautical miles) from/to reference point; colour scale: E/W component of the current (cm/s). Transect naming convention: ak_lnnVX: a for Adriatic sea cruise, k is cruise number, l is Leg identifier label, nn is leg (transect) number, and VX is velocity current component label on East/West axis.

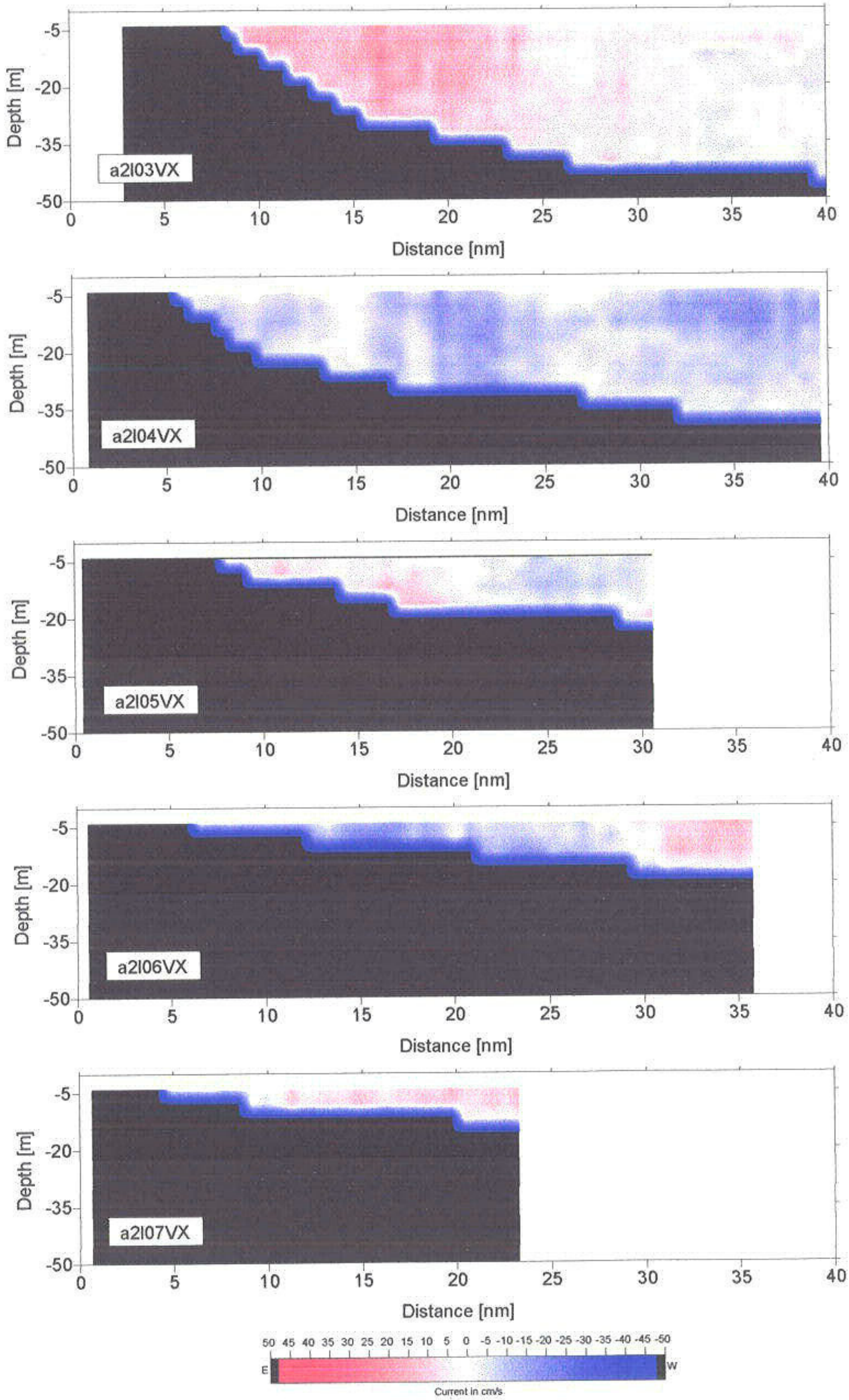


FIG. 34 (cont.). - Cruise GIAS-2 (September 1994)

Velocity distribution of E/W component of currents - Adriatic Sea

Vertical axis: depth (meters); horizontal axis: distance (nautical miles) from/to reference point; colour scale: E/W component of the current (cm/s). Transect naming convention: ak_lnnVX: a for Adriatic sea cruise, k is cruise number, l is Leg identifier label, nn is leg (transect) number, and VX is velocity current component label on East/West axis.

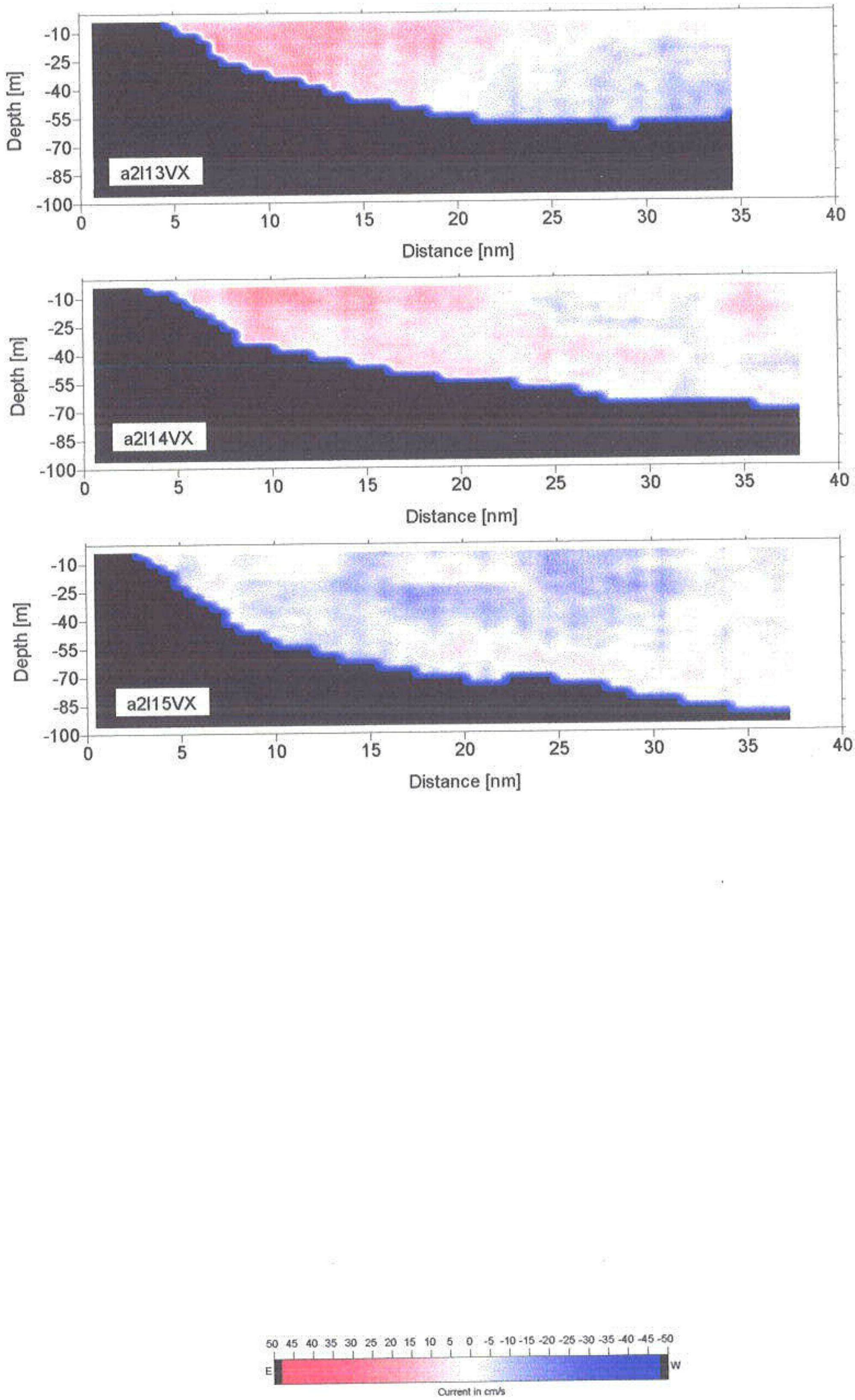


FIG. 35. - Cruise GIAS-2 (September 1994)

Velocity distribution of N/S component of currents - Adriatic Sea

Vertical axis: depth (meters); horizontal axis: distance (nautical miles) from/to reference point; colour scale: N/S component of the current (cm/s). Transect naming convention: ak_lnnVY: a for Adriatic sea cruise, k is cruise number, l is Leg identifier label, nn is leg (transect) number, and VY is velocity current component label on North/South axis.

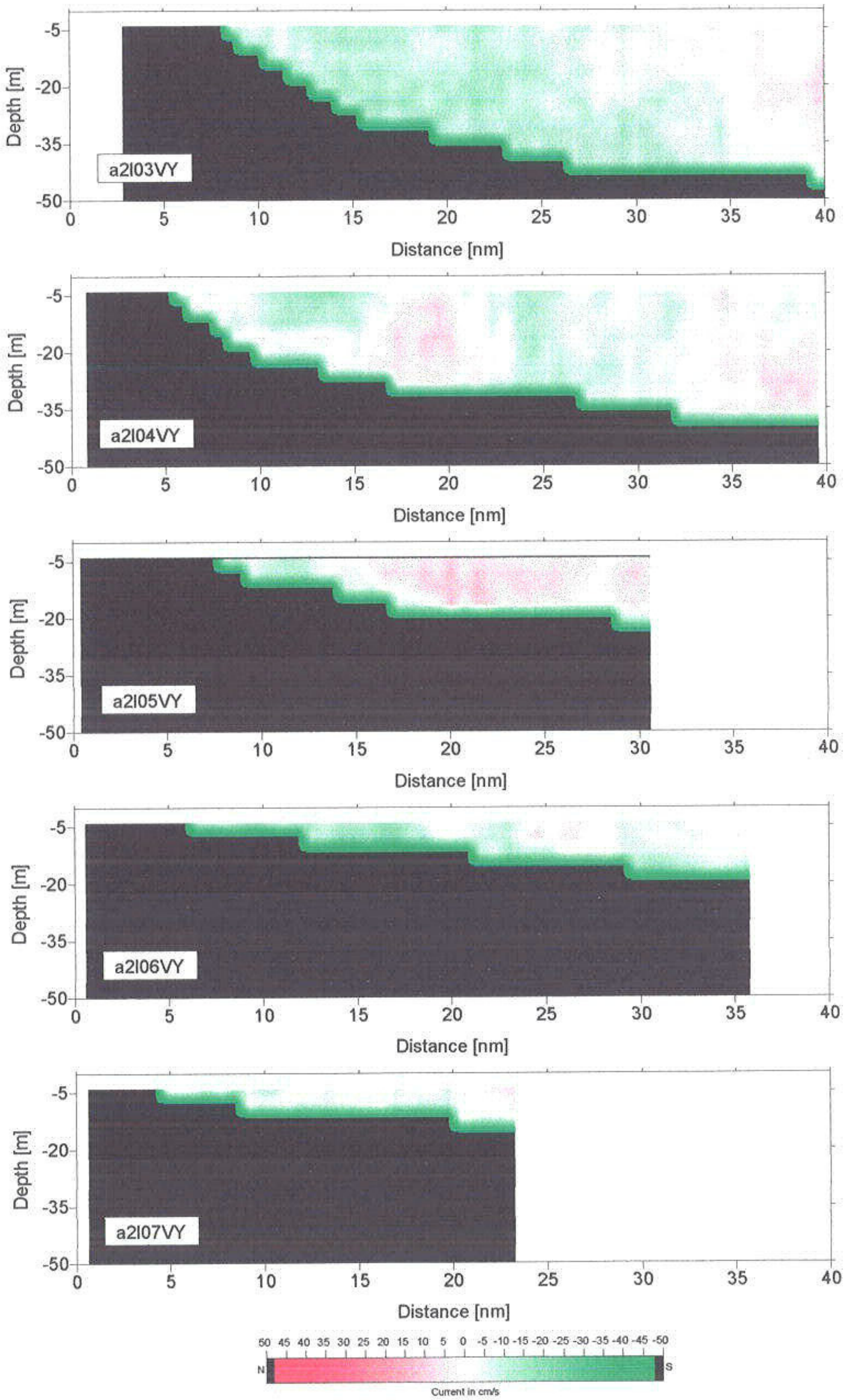
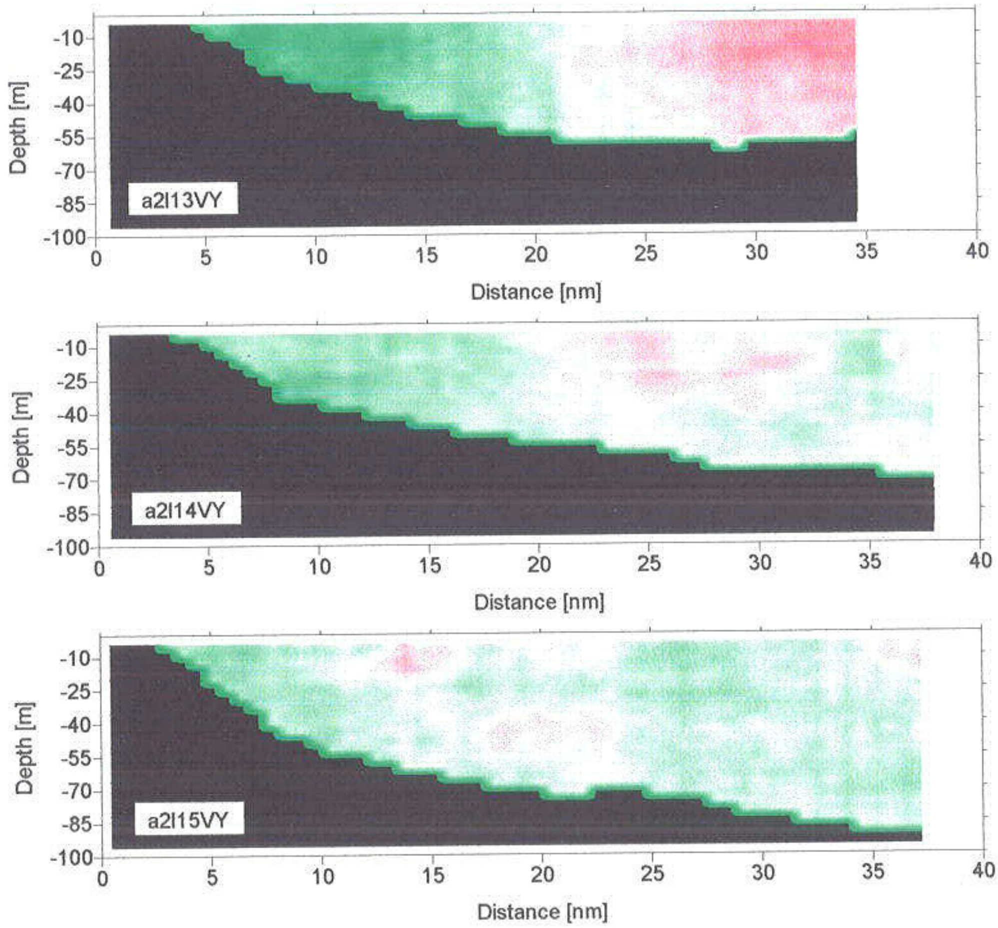


FIG. 35 (cont.). - Cruise GIAS-2 (September 1994)

Velocity distribution of N/S component of currents - Adriatic Sea

Vertical axis: depth (meters); horizontal axis: distance (nautical miles) from/to reference point; colour scale: N/S component of the current (cm/s). Transect naming convention: ak_lnnVY: a for Adriatic sea cruise, k is cruise number, l is Leg identifier label, nn is leg (transect) number, and VY is velocity current component label on North/South axis.



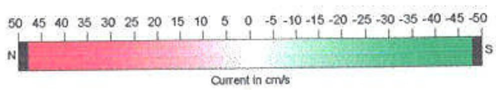


FIG. 36. - Cruise GICS-2, 1st coverage (May 1994)

Echo intensity distribution - Catalan Sea

Vertical axis: depth (meters); horizontal axis: distance (nautical miles) from/to reference point; colour scale: echo intensity (counts), see text for details. Transect naming convention: ck_lnnA2: c for Catalan sea cruise, k is cruise number, l is Leg identifier label, nn is leg (transect) number, and A2 is label identifier for echo instensity from Doppler .

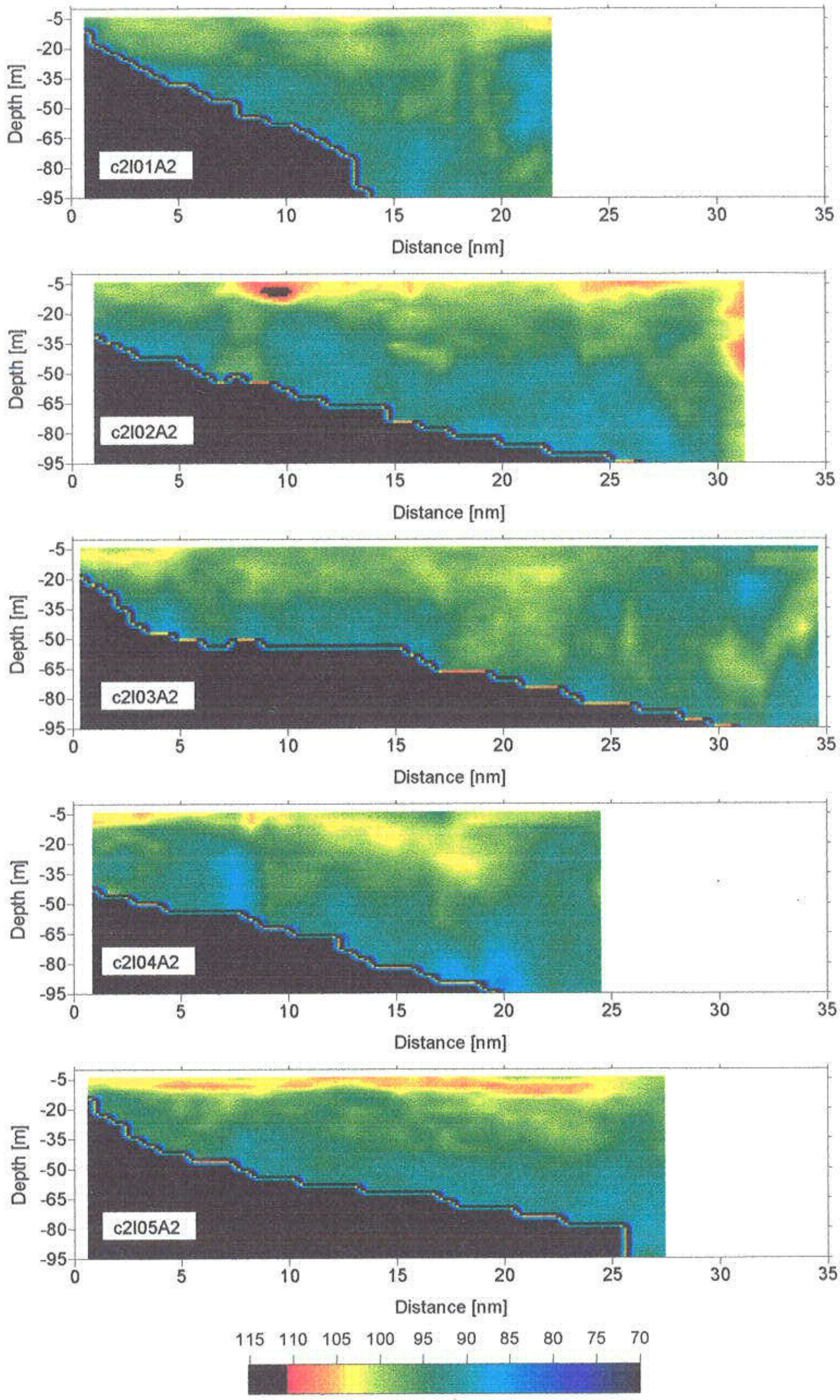


FIG. 36 (cont.). - Cruise GICS-2, 1st coverage (May 1994)

Echo intensity distribution - Catalan Sea

Vertical axis: depth (meters); horizontal axis: distance (nautical miles) from/to reference point; colour scale: echo intensity (counts), see text for details. Transect naming convention: ck_lnnA2: c for Catalan sea cruise, k is cruise number, l is Leg identifier label, nn is leg (transect) number, and A2 is label identifier for echo instensity from Doppler .

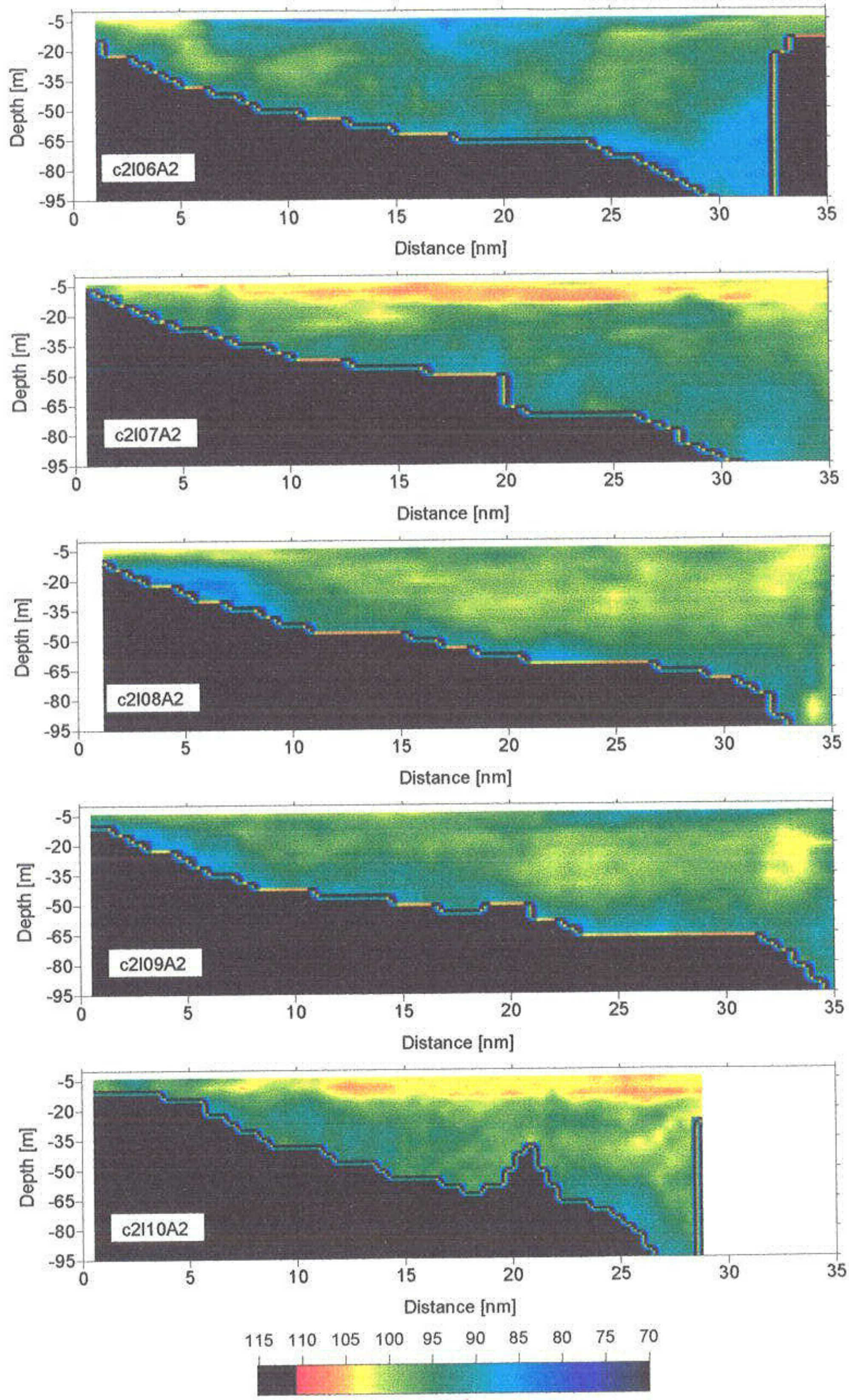


FIG. 36 (cont.). - Cruise GICS-2, 1st coverage (May 1994)

Echo intensity distribution - Catalan Sea

Vertical axis: depth (meters); horizontal axis: distance (nautical miles) from/to reference point; colour scale: echo intensity (counts), see text for details. Transect naming convention: ck_lnnA2: c for Catalan sea cruise, k is cruise number, l is Leg identifier label, nn is leg (transect) number, and A2 is label identifier for echo instensity from Doppler .

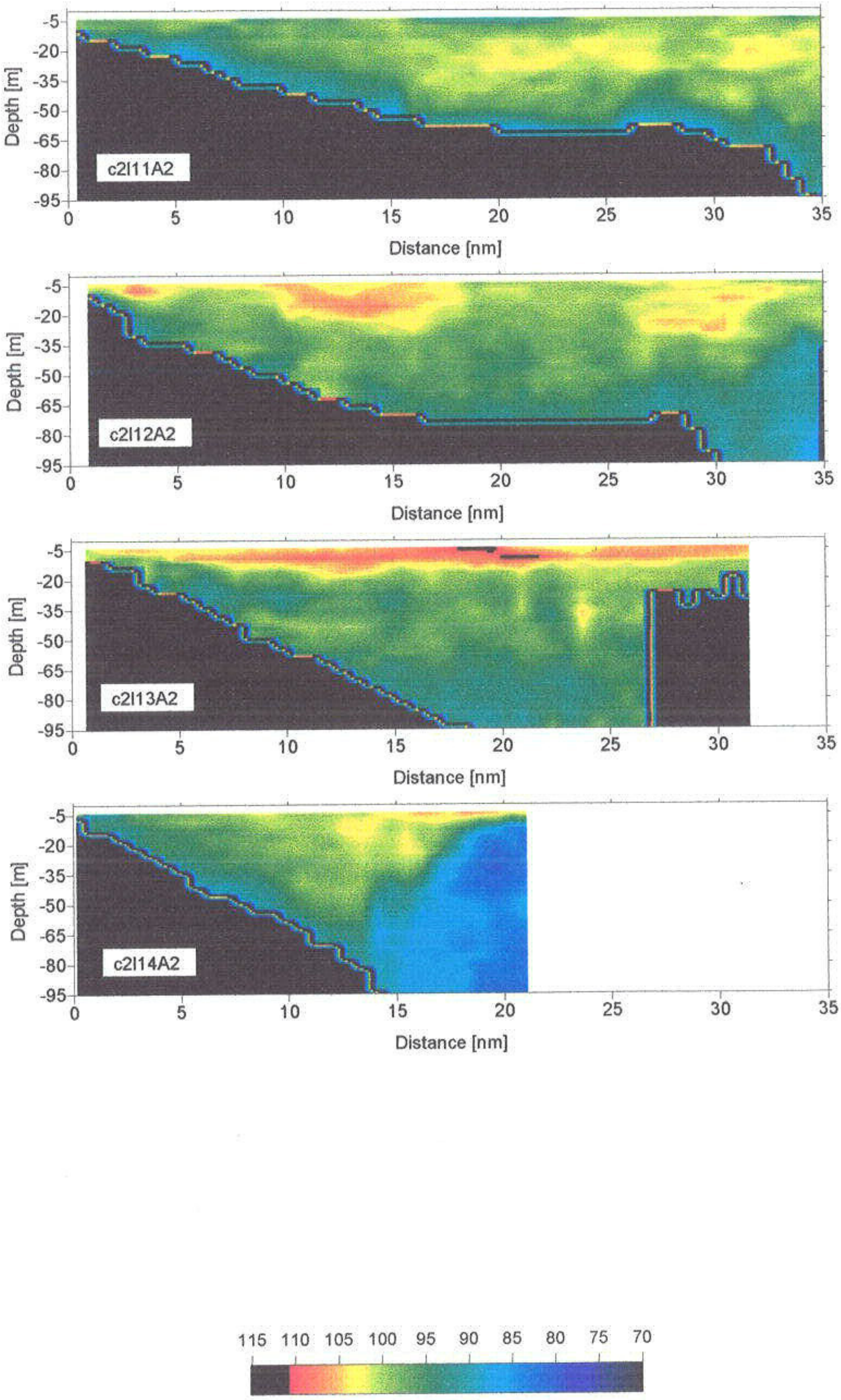


FIG. 37. - Cruise GICS-3, 1st coverage (May 1995)

Echo intensity distribution - Catalan Sea

Vertical axis: depth (meters); horizontal axis: distance (nautical miles) from/to reference point; colour scale: echo intensity (counts), see text for details. Transect naming convention: ck_lnnA2: c for Catalan sea cruise, k is cruise number, l is Leg identifier label, nn is leg (transect) number, and A2 is label identifier for echo instensity from Doppler.

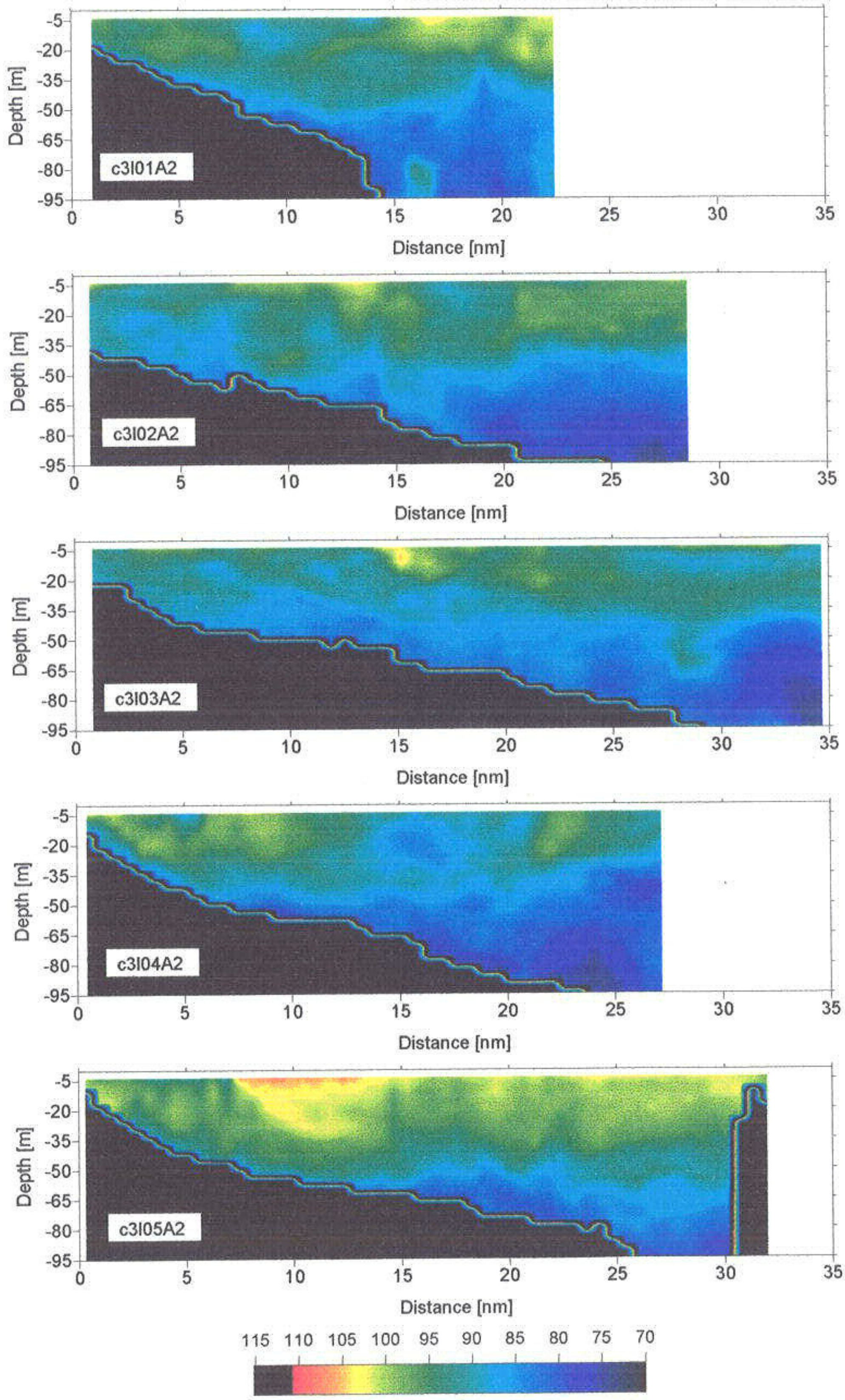


FIG. 37. (cont.) - Cruise GICS-3, 1[st] coverage (May 1995)

Echo intensity distribution - Catalan Sea

Vertical axis: depth (meters); horizontal axis: distance (nautical miles) from/to reference point; colour scale: echo intensity (counts), see text for details. Transect naming convention: ck_lnnA2: c for Catalan sea cruise, k is cruise number, l is Leg identifier label, nn is leg (transect) number, and A2 is label identifier for echo instensity from Doppler.

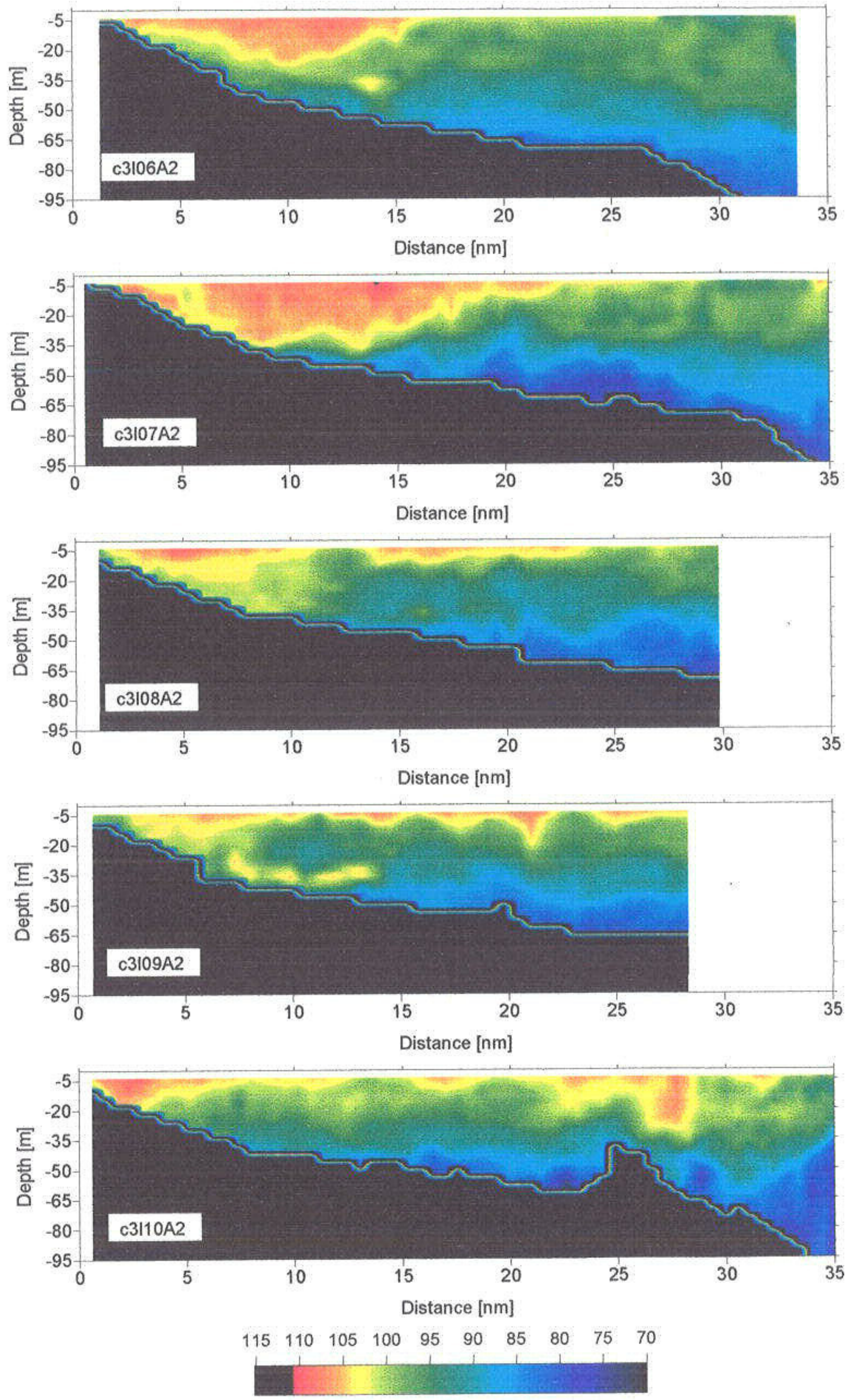


FIG. 37. (cont.) - Cruise GICS-3, 1st coverage (May 1995)

Echo intensity distribution - Catalan Sea

Vertical axis: depth (meters); horizontal axis: distance (nautical miles) from/to reference point; colour scale: echo intensity (counts), see text for details. Transect naming convention: ck_lnnA2: c for Catalan sea cruise, k is cruise number, l is Leg identifier label, nn is leg (transect) number, and A2 is label identifier for echo instensity from Doppler.

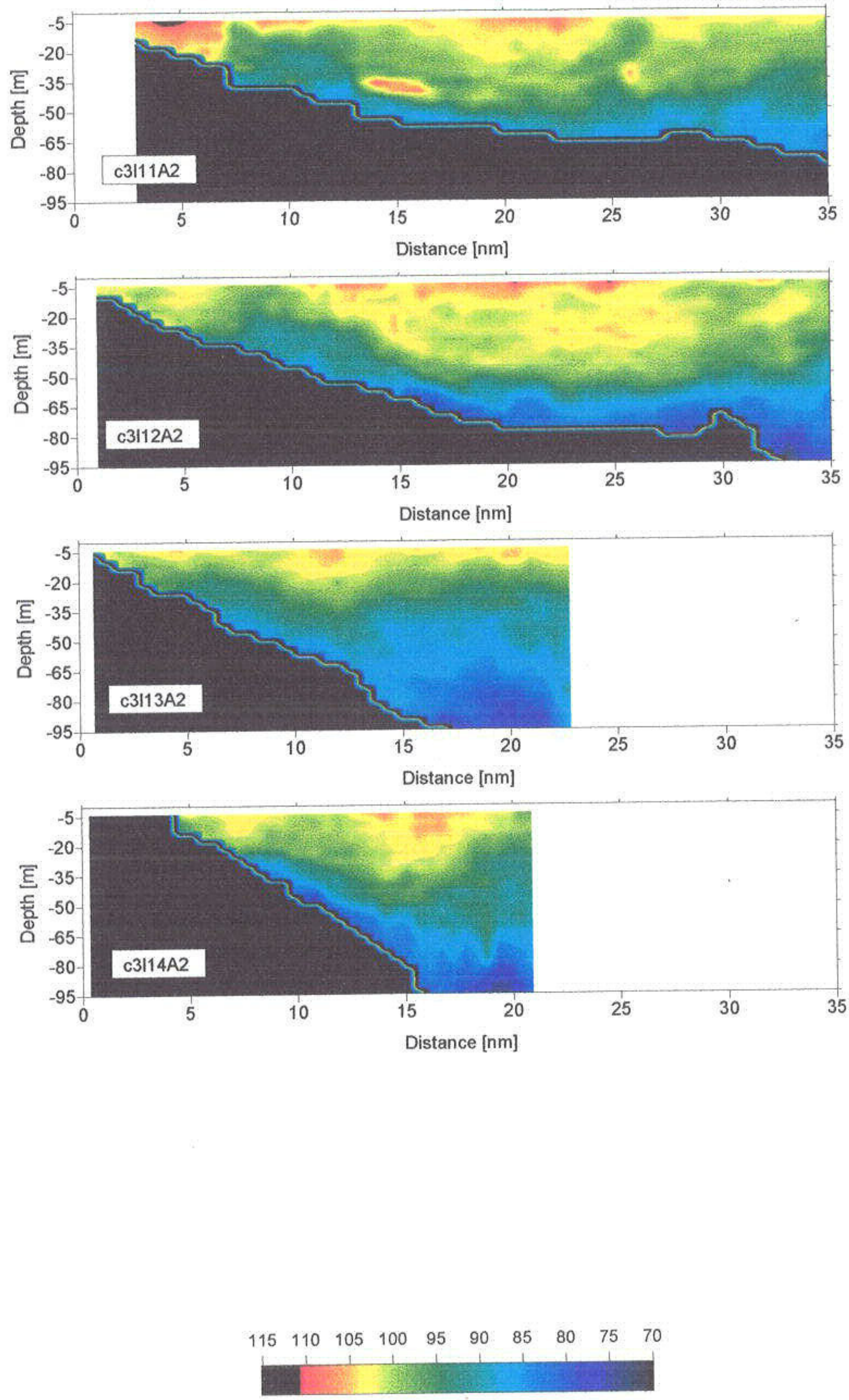


FIG. 38. - Cruise GIAS-2 (September 1994)

Echo intensity distribution - Adriatic Sea

Vertical axis: depth (meters); horizontal axis: distance (nautical miles) from/to reference point; colour scale: echo intensity (counts), see text for details. Transect naming convention: ak_lnnA2: a for Adriatic sea cruise, k is cruise number, l is Leg identifier label, nn is leg (transect) number, and A2 is label identifier for echo instensity from Doppler.

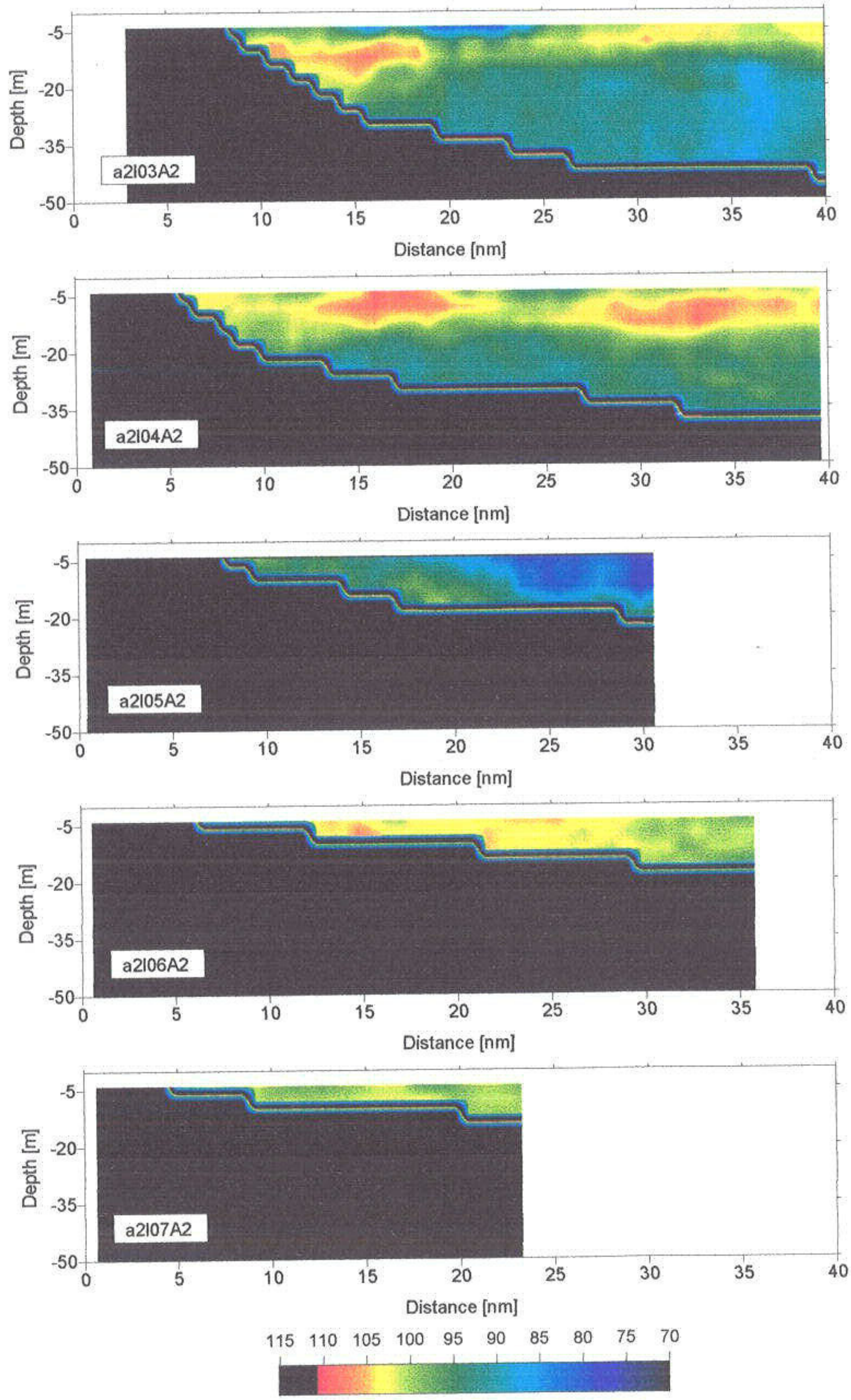


FIG. 38 (cont.). - Cruise GIAS-2 (September 1994)

Echo intensity distribution - Adriatic Sea

Vertical axis: depth (meters); horizontal axis: distance (nautical miles) from/to reference point; colour scale: echo intensity (counts), see text for details. Transect naming convention: ak_lnnA2: a for Adriatic sea cruise, k is cruise number, l is Leg identifier label, nn is leg (transect) number, and A2 is label identifier for echo instensity from Doppler.