SOCIB

CRUISE REPORT

SOCIB ALMO November15

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Summary

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ABSTRACT:
The ALMO cruise was designed to investigate the connection, in terms of circulation and water masses variability, between the Ibiza Channel (IC), a 'choke' point in the basin scale circulation, and the Almería-Oran frontal system in the Alborán Sea. The IC is a narrow (80 km) channel between mainland Spain and Ibiza Island that exerts a controlling influence on an important North/South exchange of different water masses and are known to affect local ecosystems (Alameney et al. 2010). The Northern Current (NC) flows southward through the channel, seasonally strengthening, and carrying more saline waters of longer residence in the Mediterranean south. Less saline waters of more recent Atlantic origin intermittently flow northward. In addition, mesoscale eddies arrive to the channel and can impede or bock this exchange. Variability in this exchange is high, with changes in transport of watermass north and south, of the same order as the seasonal signal occurring over periods of days to weeks (Heslop et al. 2012). The Almería-Oran front, located south of the IC in the Alborán Sea, is generally viewed as the interface between Mediterranean and Atlantic Waters, it forms a steep gradient in salinity as fresher Atlantic Water (AW), from inflow through the Gibraltar Strait and forming the west flowing Atlantic Jet meets the more saline surface waters of the Mediterranean (Modified Atlantic Water, MAW). The connection, between these two important governing points of the Mediterranean basin scale circulation system, is however little studied. The ALMO cruise sampled 5 transects along the path of the NC, from south of the IC to the Almeria-Oran front, in order to investigate this interconnection. Is the Almeria-Oran front dominant driver in the Alborán Sea? Does a stronger density gradient form if cold fresh winter mode water (WIW) is carried to the frontal region? Does a strong Almeria-Oran front lead to a short circuit for the fresher Atlantic inflows through the IC? The understanding of this interconnection is important for our understanding of high frequency (weeks to months) variability in the Mediterranean circulation and so for improving model forecasting.

KEYWORDS: Mediterranean, circulation, Ibiza Channel, Almería-Oran front, mesoscale variability.

ISSUING ORGANISATION: SOCIB (Balearic Islands Coastal Ocean Observing and Forecasting System).

A PDF of this report is available for download at:

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Carlos Velon	Marinero
Altair García Gandiá	Segunda de Maquinas

3. INTRODUCTION

SOCIB is committed to supporting the IEO GIFT cruise/mooring in the Strait of Gibraltar (Emma Huertas, del CSIC, Instituto de Ciencias Marinas de Andalucía). The ALMO cruise was conceived to increase our knowledge of the connection between the Ibiza Channel circulation 'choke' point and the Almería-Oran front in the Alboran Sea, by taking advantage of the transit route, and through this also expand SOCIB monitoring capacity.

The idea (discussed originally between Emma, John, Benja and Carlos) is to undertake a series of transects to investigate the interface between the NC and the Almeria Oran front. The cruise plan developed from this was to undertake 5 of transects across the Northern Current (NC), over 5 days, the final transect sampling across the Almeria-Oran Front in the Alborán Sea. in order to look at the role of the Ibiza Channel (IC) and the impact of the seasonality/high frequency changes we see in circulation in the IC on the Almería-Oran front/eastern Alborán Sea region (see hypotheses below). With simultaneous glider sampling in the IC, managed by SOCIB Glider Facility (Marc Torner). In addition 4 drifters and 1 Argo float will be deployed, to provide further information and satellite information (altimetry, ocean colour and SST) will be used real-time to check the location of the Almeria-Oran front and adjust the location of the final transect.

The Almería-Oran front viewed as the interface between Mediterranean and Atlantic Waters, although generally south of Cabo de Gata its precise its location varies from close to the Algerian coast to close to the Spanish mainland coast, and from east and west.

Advantage of using ship time for this activity: synchronous observations across a broad geographical scale, deep profiles and accuracy, enhanced biogeochemical sampling.

3.1 Hypotheses:

- The Almeria-Oran front and the IC region show some sympathy
- The Almeria-Oran front dominant driver is gyre dynamics in the Alborán Sea.
- There will be a stronger density gradient during the arrival of winter mode waters at the front region from the IC, implies a delay time for teleconnection in the region
- A strong Almeria-Oran front leads to short-circuit for Atlantic inflows through the IC

3.2 Summary of objectives:

ALMO cruise general:

- Add to the knowledge of Mediterranean circulation, through investigating the connection between the IC and the Almeria-Oran Front.
- Extending the range of SOCIB monitoring activity, by taking a range of both physical and biogeochemical samples in a generally under sampled region
- Incorporate data from ship, gliders, drifters and Argo, in a multi platform study

ALMO Nov15 specific:

- Sample 5 transects across the NC, from below IC to the Almería-Oran front (Denia to

Cabo de Gata), the final transect crossing the Almería-Oran front

- Launch 4 drifters in the NC
- Launch 1 Argo float southwest of Ibiza Island

3.3 Station Plan

See below for planned and actual transects. Annex 1 has details of planed sections.

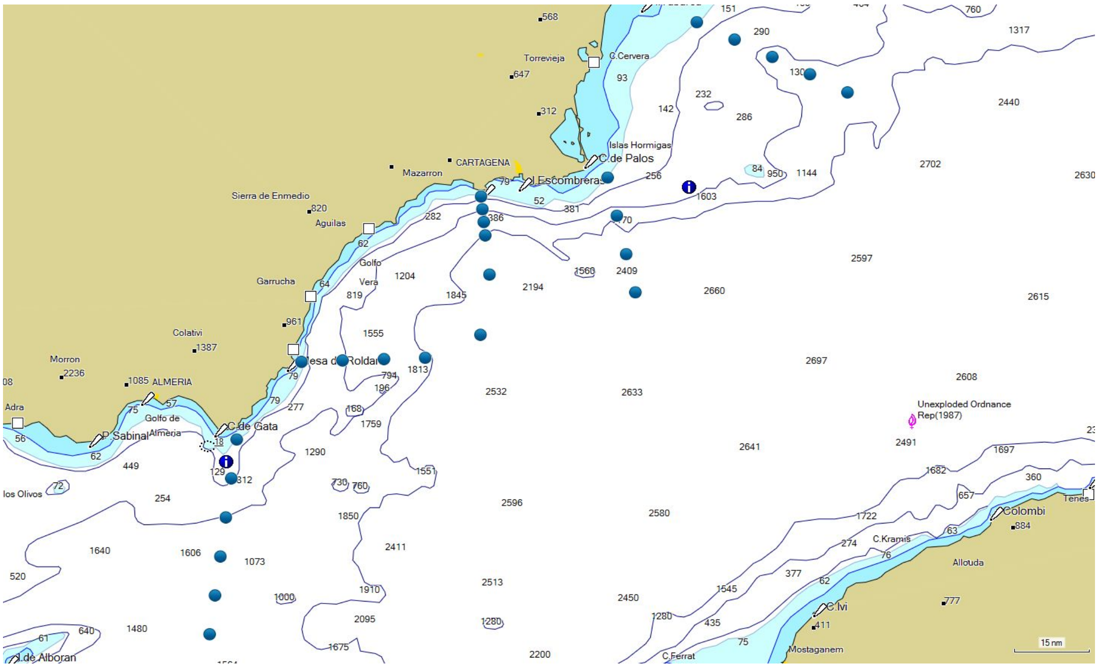


Fig 3.3.1. Pre-mission plan of ALMO stations

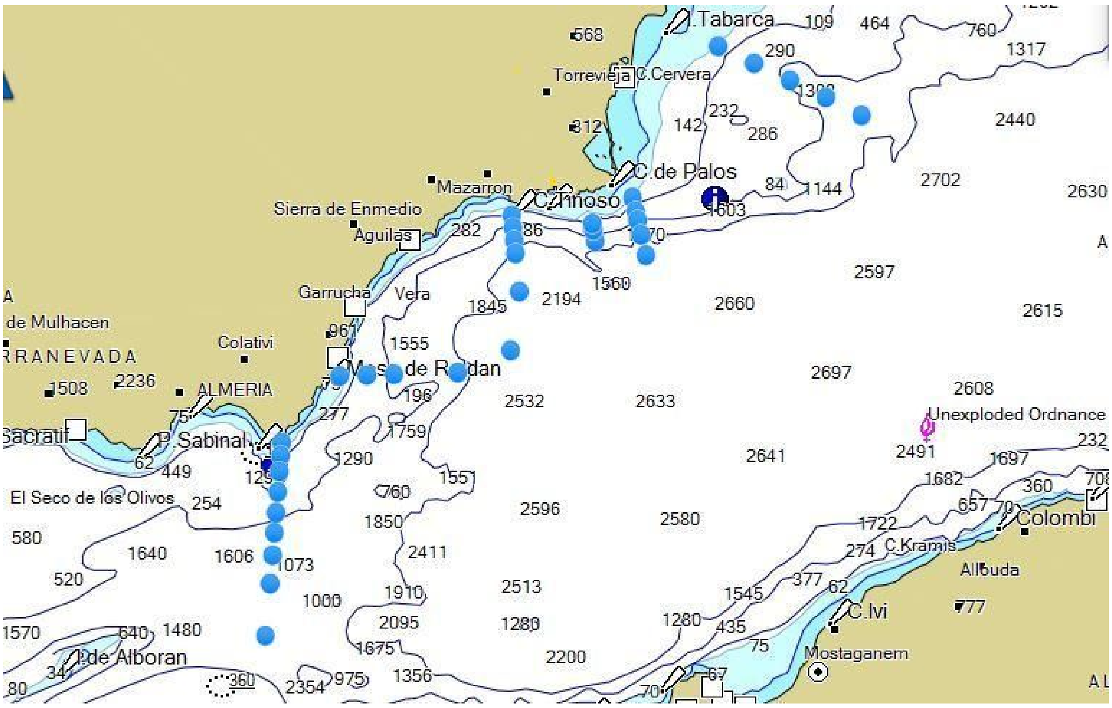


Fig 3.3.2. ALMO stations actual

4. Diary

Abbreviations:

IC – Ibiza Channel

MC – Mallorca Channel

NC – Northern Current

AW – Atlantic Water

27/11/2015 - DAY 1 ALMO Cruise- Transit to Alicante

B/O SOCIB departed Palma at 04:00 GMT, in order to arrive mid evening to Alicante, transit time 18 h at 12 knots. Prediction - 2 – 2.5 m seas in the Mallorca and Ibiza Channels (hereafter IC and MC), the real-time data from SOCIB Ibiza Channel buoy showing sig. wave heights of 2.4 – 2.7 m.

Out of lee of Mallorca Island, swell 2 – 2.5 m, from NE, however long distance between waves and direction of travel meant that swell to rear of vessel on port side and so not uncomfortable. Captain maintained 12 knots speed.

At 08:30 GMT instruments switched on, generally functioning, but some issues, see notes in Section 7.

At 11:30 GMT discuss where to launch Argo Float. Options IC or end Day 1 (Alicante) transect, decide IC as 1) likely to deliver more interesting results 2) 2 x Argo to south already. Launch position selected as en route with sufficient depth, mid channel in the IC with 800 m depth - 38º 38.263’, 00º 45.123’. At same location will test CTD to check new cable termination.

12.20 GMT coming off the Ibiza platform northward flowing surface current visible in ADCP, 25 – 30 cms-1 to 40 m then deepening to 75 m. ADCP data not extending below 125 m depth, John not surprised given seas (2 m swell) and speed (12 knots). Out of the lee of Ibiza, we experienced swell 2 – 2.5 m, in line with sig. wave height from the IC buoy, but with long wavelength and astern, so not uncomfortable for passage.

13:15 GMT - 38 º 37.910’, 00 º 45.322’ – CTD test and Argo launch: 13:21 GMT CTD Rosette lowered, thermocline 40 – 80 m, no problems apparent with CTD, to approx. 800 m depth. Bottle number 10 did not fire, there have been consistent problems with this bottle, this will not be used for the mission. At 13.44 GMT SCB-APEX006 (s/n: 6917; Argos ID: 881692767961; WMO: 6901244), launched at 38º 37.818’, 00º 45.319’. Data Centre had been receiving data from the float since after lunch. Argo float launched in area with weak southward flowing currents, soon after commencing passage the current became southward flowing, will be interesting to see direction float takes.

16:50 weak south flowing currents visible across approx. half of IC, continue on to the shelf and then on shelf revert to northward flow.

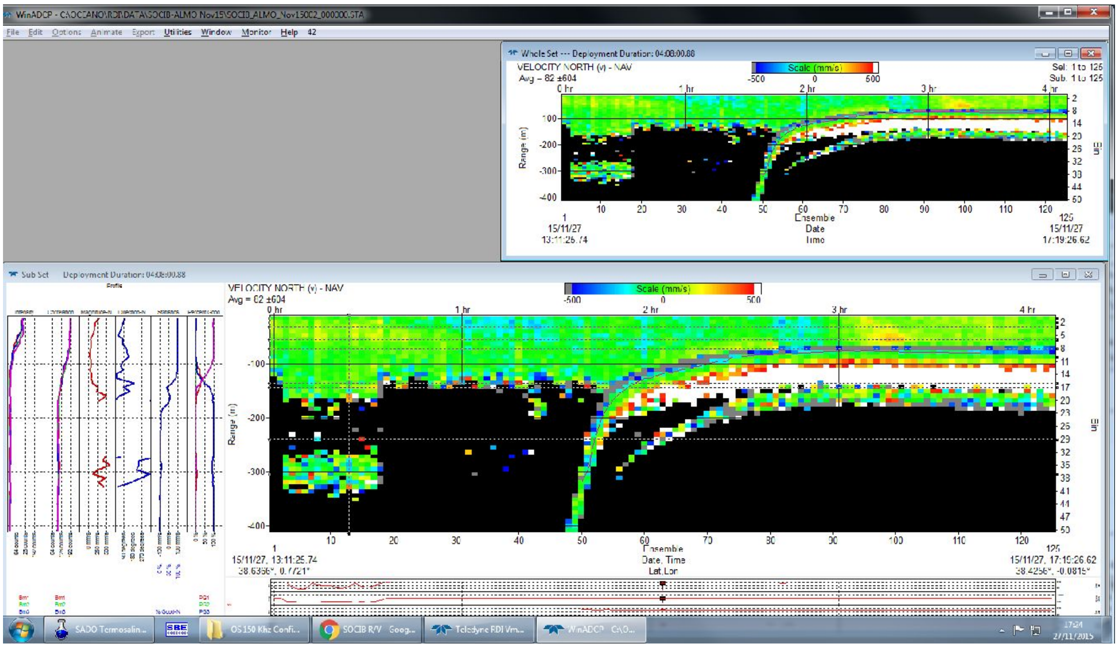


Fig 4.1. ADCP: 27/11/2015 screen shot to show dead-zone/band in ADCP data. Underway see ADCP penetration to 125 m, on station a gap (dead zone) is visible, below which there is data (240 m to 330 m). This gap is due to lack of life/particles for ADCP refection, John has seen before in the Mediterranean many times and it is related to migration, the deep band containing small fish and larger zooplankton that migrate out of the photic zone in the day.

28/11/2015 - DAY 2 ALMO Cruise - Transect 1 (TR1) Alicante

B/O SOCIB departed Almeria at 07:00 GMT, seas calm, slight swell and skies clear. One change from cruise plan, discussed by the team the previous evening, is to launch all the drifters today at different bathymetries, e.g. 100 m, 200 m, 300 m and 400 m. To see if we gain some idea of the flow structure and how closely the current follows f/h. Previous day the start of the NC was at approx.. 38.6119 (38º 36.71’ N), 0.6762 (00º 40.57 E) along track, with 650m bathymetry, just after where launched the Argo float, and ended 38.5024 (38º 0.144’ N), 0.2186 (00º 13.11 E) with 80m bathymetry.

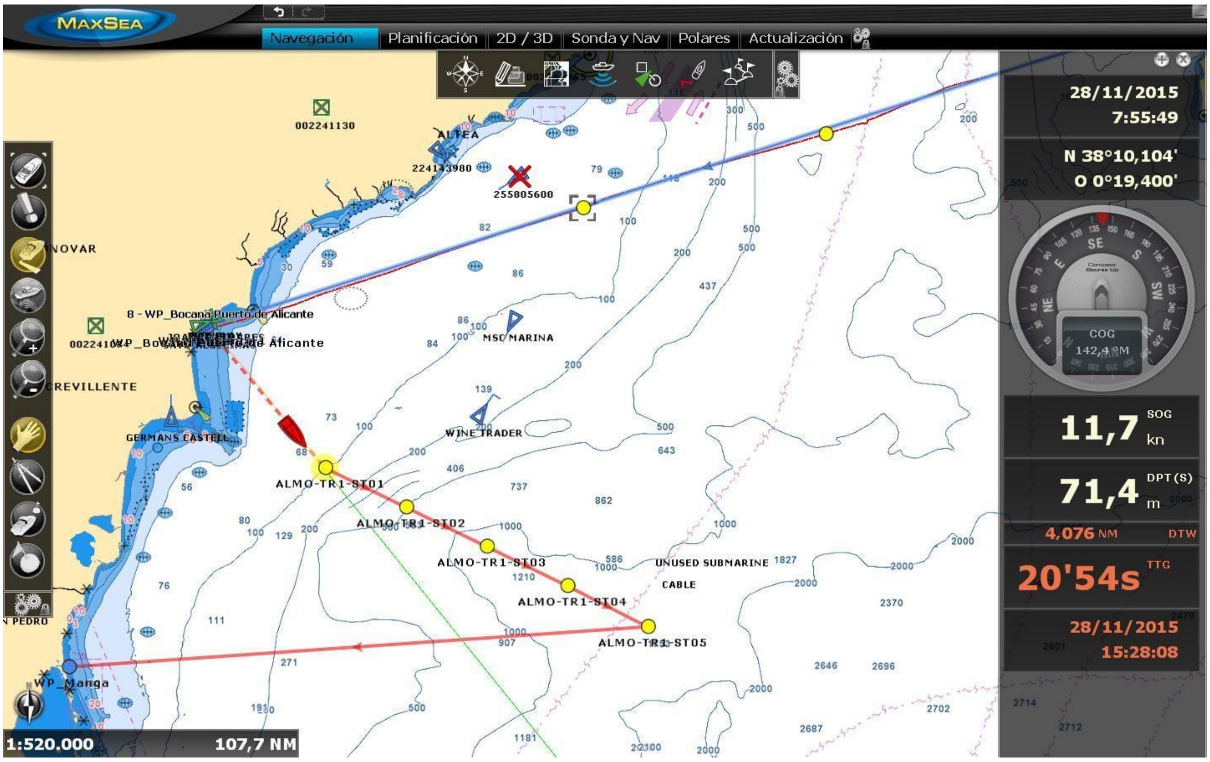


Fig 4.2. Track and start end of NC over plotted.

08:09 GMT - 38º 07.936' N, 00º 17.270' E – 80 m bathymetry, weak southward flows in ADCP (NC) 20 cm s-1 – consistent with yesterday.

08:16 GMT – arrive to first station **ALMO-TR1-ST01 - 38º 06.991' N, 00º 16.049' E** – 100 m depth, in water 08:19 GMT. Water column still quite stratified, narrow bands of sub-surface low salinity but no WIW. 08:16 GMT – launch first drifter **SCB-SVP024** (s/n y Argos ID: 152146) **- 38º 06.927' N, 00º 15.926' E – 100 m** (this and the second drifters have the straps tying the drogue together still attached – do they take time to dissolve?).

08:44 GMT – launch second drifter **SCB-SVP025** (s/n y Argos ID: 152147) **- 38º 05.302' N, 00º 11.963' E – 200 m** (this drifter had the straps tying the drogue together in place)

08:59 GMT – launch third drifter **SCB-SVP026** (s/n y Argos ID: 152148) **- 38º 05.302' N, 00º 11.963' E – 400 m** (this drifter had the straps tying the drogue together removed).

09:07 GMT – arrive to second station **ALMO-TR1-ST02 - 38º 03.484' N, 00º 06.900' E** – 484 m depth. Here the ADCP shows northward flows diminished, however looking at the E/W flows we see increased westward flow. Although we chose this transect to run out through a canyon, it's a canyon indicated by the 1000 m contour, while the 500 m contour in fact turns westward after the transect and there is a 'C' shaped bend in the contour to the west. This is possibly the reason that we see this westward flow (in the NC) following the 500 m bathymetry. Decide to launch 4th buoy on return transect, probably at 300 m. **Implemented surface sampling of S with a '2 min' stop for sensors to stabilize before bottles fired to improve sampling for salinity corrections.**

10:10 GMT – arrive to third station **ALMO-TR1-ST03 - 37º 59.972' N, 00º 02.214' E** – 1120 m depth, in water 10:13 GMT. Reappearance in the ADCP of the 'dead zone' of no particles this time slightly deeper at 175 m, maybe due to increased light levels. Gentle swell, 1 m.

11:32 GMT – arrive to fourth station **ALMO-TR1-ST04 - 37º 56.451' N, 00º 11.362' E** – 1383 m depth, in water 11:34 GMT. Completed 12:24 GMT 37º 56.444' N, 00º 11.704' E. Some northward flow in ADCP.

13:07 GMT – arrive to station **ALMO-TR1-ST05 - 37º 52.764' N, 00º 20.488' E** – 1633 m depth, sea conditions 1 m gentle swell. Completed 14:15 GMT 37º 52.822' N, 00º 20.529' E. In ADCP the 'dead zone' has disappeared and also in surface salinity we just see tip of lower salinity water 36.7/36.8, suggesting more recent AW. Discussed with Benjamin/John changing the stations for tomorrow as we have few over a steep gradient, first station 100 m and second at 1500 m, all agreed to sample more densely (similar to DAY 3) and John suggested adding some additional stations across the flow on the transect back. The new plan, in Section 3, figure 3.3.2, with more stations where we have observed the southward flows of NC in ADCP data, then extending out to 2000 m and with an extra 3 stations perpendicular to the bathymetry between 100 and 1000 m on the return to Cartagena.

15:51 GMT southward transports start to be visible in ADCP coincident with 500 m bathymetry, 25 – 30 cm s-1 – (37.863043 N/0.02283 E) 37º 51.78' N, 00º 1.34' E. Later the current becomes very weak/disappears.

16:58 GMT – launched final (4th) drifter **SCB-SVP028** (s/n y Argos ID: 152150) **- 37º 50.584' N, 00º 19.697' E – 300 m** (straps tying the drogue together were removed prior to launch). In ADCP appears to be southward flow and as leaving deployment point this increases.

29/11/2015 - DAY 3 ALMO Cruise - Transect 2 (TR2) Palos

06:45 GMT (approx.) depart Mar Menor (San Pedro de Pinatar, a tuna fishing port). The new sampling plan for DAY 2, Section 3, follows the same bearing as planned transect, however with more stations across the slope and fewer deep stations. The additional stations are close to the end of the shipping channel. Martín a little concerned, however Maritimo had been informed, the stations were not in the channel and the relevant coastal station had issued a notice about our work in the area. Furthermore it was clear day with excellent visibility and the stations were not deep, 200 - 500 m. In the event the passage of the ships was such that there were no problems.

Arrived 1st station DAY 3, **ALMO_TR2_ST06 at 08:01 GMT, 37º 35.372' N, 0º 37.593' W – 95.8 m.** Temperature a little spiky, small scale interleaving in the surface, small lenses of warmer water.

Arrived 2nd station, **ALMO_TR2_ST07 at 08:27 GMT, 37º 32.446' N, 0º 36.736' W – 213 m.** Echo sounder response too shallow, had to refocus below 150 m to pick up the bottom, without confusing with signals from the slope etc. In ADCP southward flow of approx. 25 cm s-1 full depth, with westward flow only registering below 50 m. Some disconnection between flows above and below the thermocline, which we have seen in the IC glider data. In T/S see a small T min. associated with a thin low temperature layer. CTD recovered safely at approx. 08:43 GMT.

Arrived 3rd station, **ALMO_TR2_ST08 at 08:27 GMT, 37º 30.502' N, 0º 36.140' W – 792 – 870 m.** Bathymetry dropped off quickly (station planned for approx. 500 m) and ship drifting off station with currents and bathymetry deepening rapidly. In T/S again appears again a T min., associated with a thin low temperature layer, and in ADCP strong westward flow below the thermocline of order 25 - 30 cm s-1. Vessel drifts (approx. 600 m on downcast) on station such that final depth of cast was 870 m, total drift 1 km, ETD team do well in judging the final depth, the altimeter was not registering the bottom (angle) only had the echo sounder. At the next station use dynamic positioning. Some question about quality of backscatter/turbidity sensor sampling. CTD recovered safely at approx. 09:43 GMT.

Arrived 4th station, **ALMO_TR2_ST09** at 09:58 GMT**,** CTD in water at **10:10 GMT 37º 27.428' N, 0º 35.401' W – 1500 m.** In ADCP westward flow now confined to the surface 200 m, less weaker above the thermocline 0 – 50 m have southward flow at surface, which weaken with depth and still significant westward flow but some indication that we are at the end of the current, some suggestion of eastward flow below 180 m. The angle of the turbidity sensor was changed by about 5 deg. and the signal looks to be improved and dynamic positioning used. CTD recovered safely at approx. 11:05 GMT.

Arrived 5th station, **ALMO_TR2_ST10** at 11.36 GMT**,** CTD in water at **11:40 GMT 37º 25.254' N, 0º 34.000' W – 2375 m.** T/S profile has no T min water mass. CTD recovered safely at approx. 12:26 GMT. Dolphins on transit.

At 14.00 GMT arrived at **ALMO_TR2_ST11,** 1st of 3 stations taking a short x-slope transect on return to port, **CTD in water at 14:03 GMT, 37º 26.195' N, 0º 47.044' W – 950 m.** At this station we see.as before a T min. in T/S profile – could look at using this signature in T/S to track waters from the north/NC. Ship drifts to SW, bathymetry changes to 1054 m. In ADCP stronger westward flow to 150 m approx. 30 cm s-1, at ALMO_TR2_ST08, had flows to 200 m after not until now, now have flows westward to 300 m. ADCP has some pattern that may or may not be believable, a 0 – 30 m westward surface flow, a 'gap' and then below the thermocline flows west from 70 – 120 m. CTD recovered safely at approx. 14:41 GMT.

At 15.11 GMT arrived at **ALMO_TR2_ST12,** 2nd of 3 stations taking a short x-slope transect (E-W) on return to port (Cartegena), **CTD in water at 14:03 GMT, 37º 28.546' N, 0º 47.537' W – 425 m.** As before a T min. in the T/S profile at approx. 50 m depth, ship drifts SW again however as using dynamic positioning only 50 m. CTD recovered safely at 15:27 GMT.

At 15.11 GMT arrived at **ALMO_TR2_ST13,** last of 3 stations taking a short x-slope transect on return to port (Cartegena), **CTD in water at 14:03 GMT, 37º 29.873' N, 0º 47.724' W – 97 m.** Again a T min. in the T/S profile at approx. 50 m depth. CTD recovered safely at 15:59 GMT. The ADCP appears to show a strengthening of the westward flow close to the shelf edge and current to full depth (at approx. 37.442/-0.7394) a subsurface core of along shelf eastward flow visible below the main current, at 150 to 300 m, from 37.436/-0.785 to western shelf slope. Such subsurface counter flows are also visible in the glider data, some sort of transitory feature? On shelf we see an attenuation of the westward flow (to approx.

37.4245/-0.5802) and an on-shelf eastward flow.

Arrive to Cartagena at approx. 16:52 GMT. Prediction good for the next 3 days, maximum 1 – 1.5 m waves in forecast.

The drifters launched yesterday are already in the Argos system (see fig. 4.3), the three launched on the transect out are following the contours south, the 4th launched at 300 m isobaths but on the return transect close in weak southward flows but just outside the detected southward flows if anything is heading N.

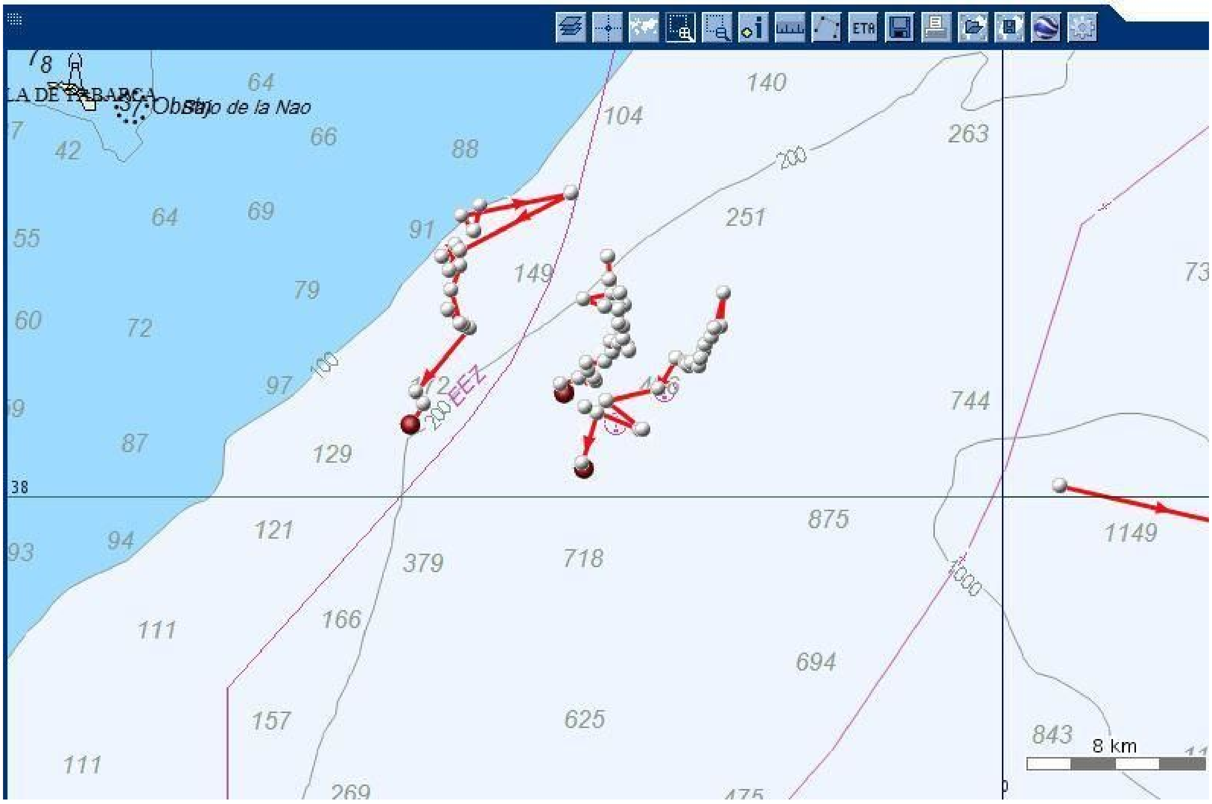


Fig 4.3. First 3 drifters, tracking surface flows (drogue at 15 m) from deployment along the transect T1 (28/11/2015), at 100 m, 200 m and 400 m isobaths (from ARGOS). Looks like some initial location 'spikes' in drifter 1st and 3rd drifter.

30/11/2015 - DAY 4 ALMO Cruise - Transect 3 (TR3) Cartagena

Depart Cartagena 07:00 GMT approx., seas calm and skies clear.

Arrived 1st station **ALMO_TR3_ST14** at 07:35 GMT approx. Slight swell from the W, 0.5 m. **CTD in water at 07:35 GMT, 37º 31.432' N, 1º 2.232' W – 79 m.** Not much sign W current in ADCP. CTD recovered safely 07:43. Next station at 1000 m. At approx. 230 m depth see signal of W flowing current in ADCP, subsurface approx. 50 m, this signal strengthens as we travel to next way point expanding to 0 – 175 m west flowing signal of 30 – 35 cm s-1.

The slope is steep here, we will learn in the analysis of the data, whether a strategy of bathymetry dependent sampling might be considered for the future 80, 200, 400, 600, 1000, 2000 m (?). It will be important to try and find a way to integrate the CTD and ADCP data – we have not yet done this at SOCIC, however it is complex work and will require careful (non trivial) QC of ADCP data as discussed with John and Krissy.

Arrive 2nd station, **ALMO_TR3_ST15, CTD in water at 08:06 GMT, 37º 28.752' N, 1º 7.884' W – 1200 m.** We drift a SW before starting sampling and the bathymetry changes (perhaps we need to be a little more accurate when on steep slopes to capture what we want). Ship drifts on station SW, however bathymetry does not change much, we are drifting along the contour. ADCP suggests W flow, no S component, strong at the surface 100 m and weaker to 150 m (is there a strange low vel. band concurrent with thermocline?). Drift 350 m when complete station and depth 1175 m. No sign of any low T minima. CTD recovered safely 08:55 GMT.

Arrive 3rd station 09:17 GMT, **ALMO_TR3_ST16, CTD in water at 09:22 GMT, 37º 26.237' N, 1º 7.542' W – 1880 m.** ADCP suggests westward flow, 0 – 100 m, in T/S a T min. at approx. 50 - 56 m, looks similar to what seen in DAY 2 and DAY 3. CTD recovered safely.

Arrive 4th station 11:00 GMT, **ALMO_TR3_ST17, CTD in water at 11:03 GMT, 37º 26.237' N, 1º 7.542' W – 2219 m.** ADCP suggests continuous W ward flow, 0 – 100 m, however now stronger, 40cm s-1. In T/S a T min. at approx. 50 m. CTD recovered safely at 12:26 GMT.

DAY 3 and DAY 4 should allow us to 'close' the box and biogeochemical samples will hopefully add to what we know about the different water mass in T and S, however I am not sure based on what we see on cruise that sampling at depths greater than 1500 m is useful for the problem of tele-connection.

Arrive 5th and final station 13:08 GMT, **ALMO_TR3_ST18, CTD in water at 13:11 GMT, 37º 15.557' N, 1º 6.127' W – 2430 m.** In ADCP data we have just reached the end of what has been a continuous 0 – 100 m westward flow, the offshore section appearing stronger than the inshore section, 40 cm s-1 vs. 30 cm s-1. The end of this broad southward flow appears to attenuate to approx. 37.4359/-1.12929. No T min. in T/S at this station, but a new feature a small S max., 360 – 380 m, on the 'subsurface' S maximum, suggesting a different water mass. There is also a different signal in the beam transmission. CTD recovered safely at 14:48 GMT.

In ADCP the broad southward flow (0 – 100/150 m) shows a general weak northward component up until the final section between ST17 and ST18 where it changes to a southward component. This fits with the bathymetry, which from Cabo de Palos turns northward (back towards the coast) past Cartagena, however out at the final station ST18 we are some distance past the 2000 m contour closer to the SW-NE side of the Golfo de Vera, a bathymetry steered current could be turning south at its end point.

As turn and make transit to port (Garrucha) the ADCP continues to show weak southward flows, stronger surface southward flows (0 – 200 m) at approx. 37.2628/-1.1195, strongest in the surface 50 m.

Arrive Garrucha port approx. 17:32 GMT.

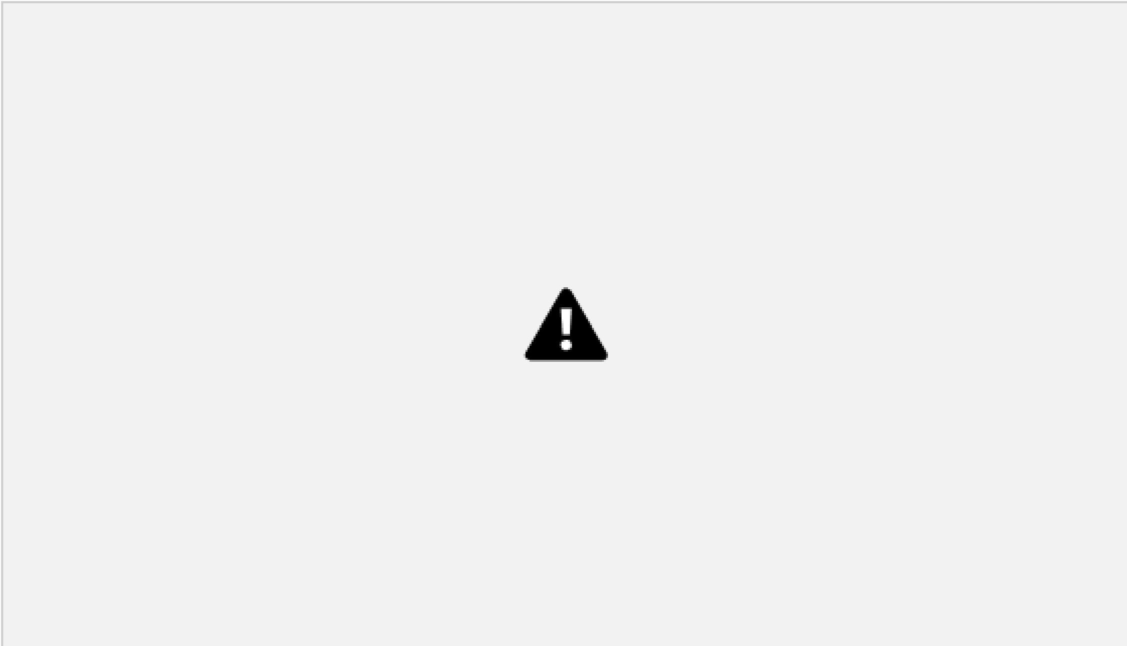


Fig 4.4. Drifters now in DAPP 30/11/2015, 1st deployed (y) has perhaps been captured, 2nd deployed (r) following the current approx. SW, 3rd deployed (b) following the current SW, the 4th deployed.

Planning for the DAY 5 Almeria-Oran front underway, preliminary idea overlain over SST (fig. 4.5). This samples a little inshore of the earlier drifter path (OGS002), then offshore crossing an apparent filament feature in SST and the earlier drifter path. Feedback received (John, Joaquín and Charles) - ‘‘Interestingly, on some of the satellite images you can see filaments of colder water between the two water masses, largely in line with the drifter trajectory and we suspect these are being advected along the Almeria Oran front too. So they also may indicate the position of the surface of the front. Don't forget however, that the front will be further south and west with depth, and probably most clear in horizontal salinity gradient (jump!).’’

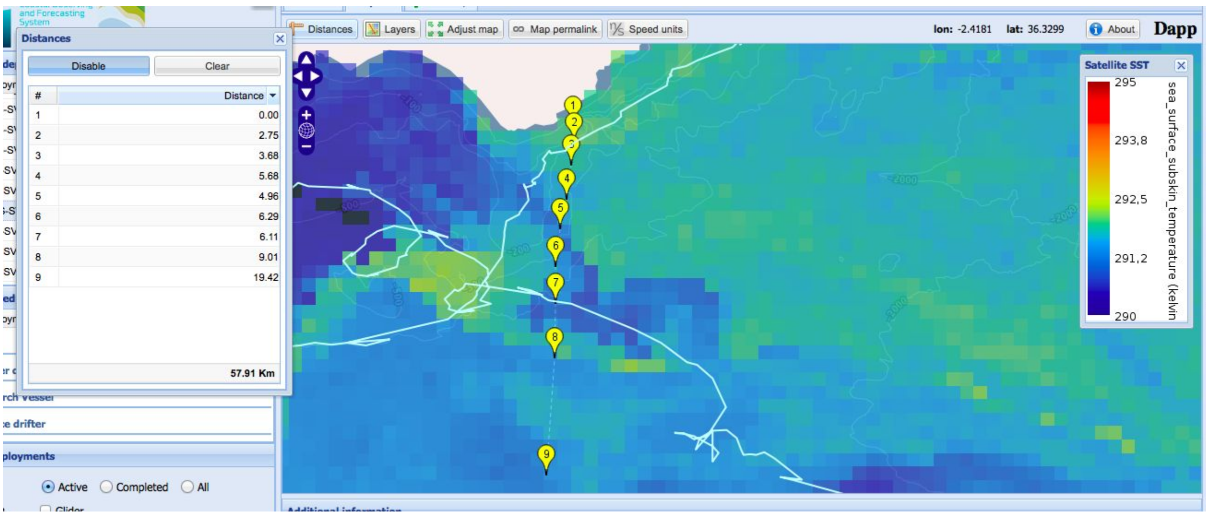
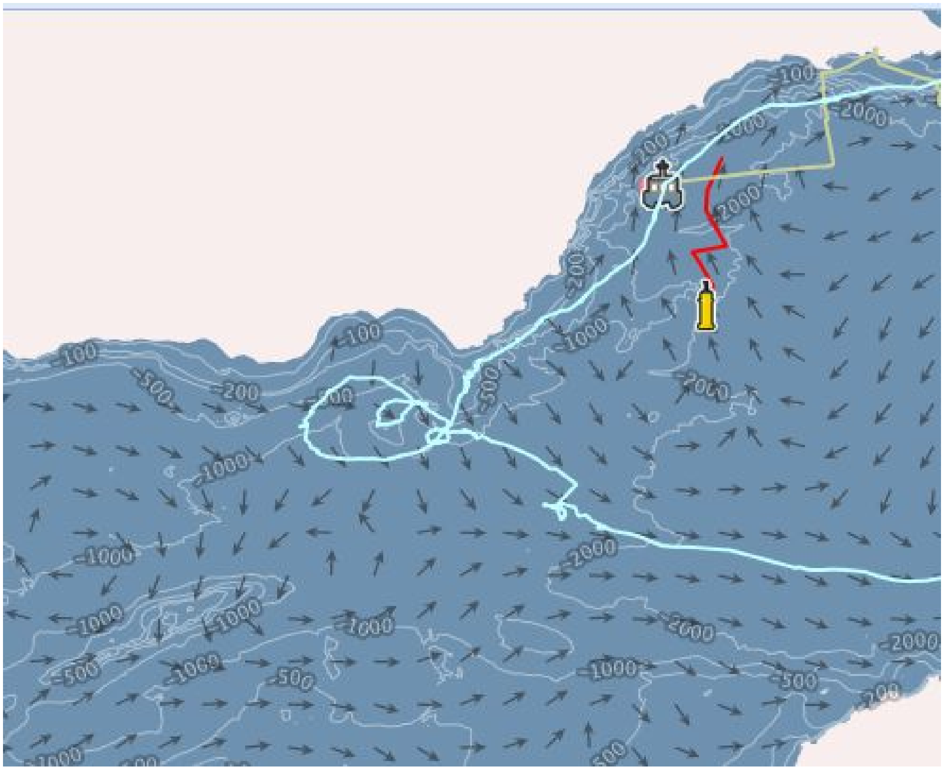


Fig. 4.5. Station planning with SST and drifter path

01/12/2015 DAY 5 ALMO Cruise: Transect 4 (TR4) Carbonnera

Depart Garrucha at 06:45 GMT approx., salmon sky and a cool breeze, feels like winter.

Revised plan for DAY 6 (fig. 4.6), Almería-Oran front transect. There are now 9 stations, originally planned 6, however we are want to sample across the NC and across Almería-Oran frontal zone and the location of this is not clear.



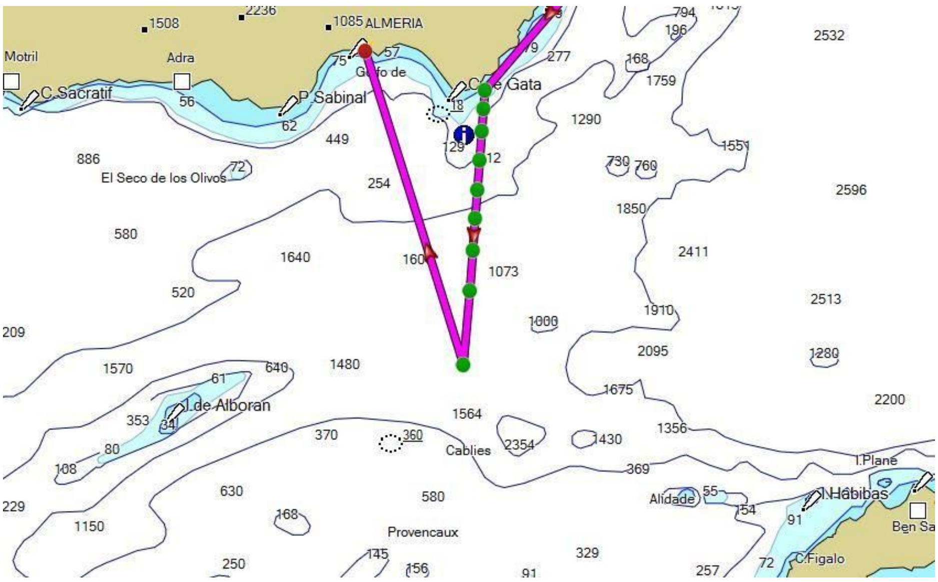


Fig. 4.6. Revision of stations fro DAY 6

The new transect crosses the earlier drifter path inshore (NC indicator) and then crosses drifter path offshore and the convergence zone of south and west flow in altimetry (frontal zone indicator) The stations are at 100, 220, 400, 600, 1000, 1100, 1300, 1700 and 1900 m. A long day tomorrow, especially for biogeochemistry, we spend the night again in la Garrucha. Tomorrow early depart early and faster transit speeds (16 – 20 knots), estimated arrival to Almería port 21:00 – 22:00.

Changed the station locations slightly en route to first station, bringing the 2nd station to 500 m (same transect bearing) and 3rd to 1200 m (first 3 stations now approx. 5.5 km apart), to increase the density of the inshore sampling as done on previous transects (see Section 1).

Arrived 1st station DAY 5, **ALMO_TR4_ST19**, at 07:57 GMT. **CTD in water at 07:57 GMT, 36º 57.00' N, 1º 51.564' W – 103 m.** Not much sign of current in ADCP, although as travel S in transit a southward current was showing. T/S profile is a clear mixing line from LIW to surface. CTD recovered safely 08:04. Leaving this station southward flow appears in upper 70 m (approx. 36.958/-1.828), fairly strong, which as we move east extends to deeper depths with a weaker signal.

Arrived 2nd station **ALMO_TR4_ST20** at 08:36 GMT, 0.5 m waves from the NE and cool breeze. **CTD in water at 08:38 GMT, 36º 57.920' N, 1º 44.680' W – 538 m.** T/S profile is a clear mixing line from LIW to surface, no indication the T min. layer seen in transects of previous day. In ADCP flows are to S and with some easting to 200 m and strongest in surface 50 m, 40 cm s-1. Interestingly we already see some westward flow appearing at this station around 200 m depth, as move out cross shelf flow becomes more strongly westward, offshore at 1000m a more general SW direction following general shape of the gulf. In vertical this would look like a shear, shift from SSE at surface to SSW below 200 m. Also see return of the 'dead zone' 150 – 200 m. CTD recovered safely 08:04.

Arrived 3rd station **ALMO_TR4_ST21** at 09:35 GMT, 0.5 m waves from the NE and cool breeze, with sunshine. **CTD in water at 09:36 GMT, 36º 58.148' N, 1º 37.784' W – 1270 m.** T/S profile is a clear mixing line from LIW to surface, no indication the T min. layer seen in previous days. In ADCP flows are to S but southward component is reducing and the westward component strengthening, the eastward component had become more surface (upper 50 m) finally ending just before station. Low flows in the surface to 50 m, then predominantly westward to 200 m. This seems to be matching the inshore offshore shape of the contours. Between stations in ADCP flows are to still to the S but this is reducing and becoming more surface and the westward component strengthening, the flows become predominantly westward from 0 – 200 m towards the 4th station. The team discussed and developed sampling strategy for DAY 5. CTD recovered safely 10:29 GMT.

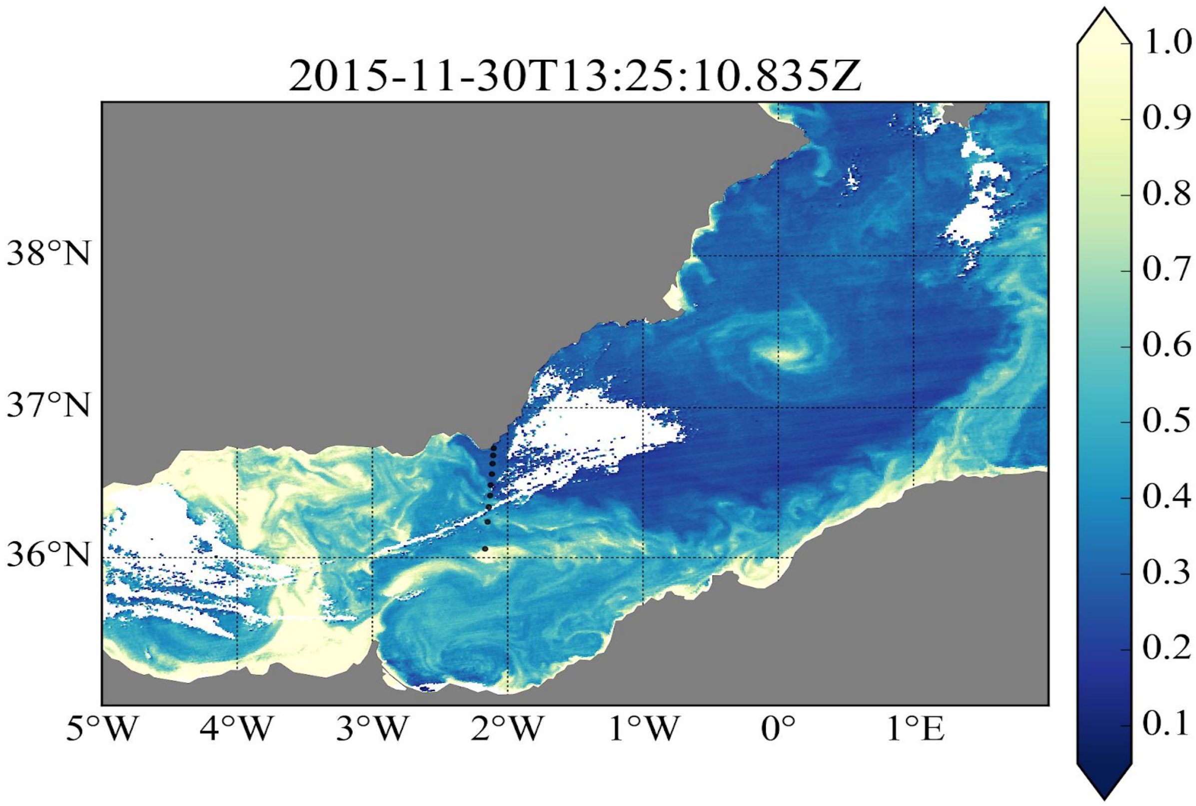
Arrived 4th station **ALMO_TR4_ST22** at 14:00 GMT. **CTD in water at 14:02 GMT, 37º 03.388' N, 1º 8.329' W – 2390 m.** In T/S profile there is now an indication of a T min layer at approx. 50 m (with a signal in fluorescence and beam transmission). In ADCP the flow has a strong westward component (30 cm s-1) to 200 m is strong. CTD recovered safely 12:54 GMT. Following station is further to the N to enable 'close the box' calculation with the N-S transect of the previous day. Between stations the west component reduces to 10 – 15 cm s-1 and above 50 m there is northward flow at this station and through to next.

Arrived final station DAY 5, **ALMO_TR4_ST23**, at 11:42 GMT. **CTD in water at 11:43 GMT, 36º 58.568' N, 1º 21.683' W – 2076 m.** In T/S profile there is a small T min. indication, some small spikes in S fairly consistent with spikes in fluorescence at around 50 m. In ADCP the northward flow in the surface 0 – 50 m ended a little before the station, on station the flows generally to the W, 10 – 15 cm s-1 and more consistent from 50 m to 200 m, flow direction appears to be WSW. CTD recovered safely 15:25 GMT.

Quite a change in direction of flow occurred between station 21 and 22 from SSE to WSW, with some interesting changes at different depths, flow does not change uniformly in the water column. As more east along the transect the westerly component starts deep, at around 200 m an, the flow is then more uniformly SW around station 20 and between 50 and 200 m. Further east the flow has a stronger westerly component and becomes WSW from 0 – 200 m. The flow is strongest between stations 21 and 22 and to just before station 23, when there is a weakening of the westward flow (10 – 15 cm s-1) between 50 m to 200 m. From station 22 to just before station 23 there appears to be some surface northward flow between 0 to 50 m, the boundary is coincident with the thermocline, and as seen in previous days (and in glider data). The surface waters also look like they change in salinity between station 22 and 23 from the salinometer data and in ADCP it appears that we move out of a higher flow area (WSW) into a lower velocity flows. Visibility reduced and skies clouded.

02/12/2015 DAY 6 ALMO Cruise: Transect 5 (TR5) Almeria-Oran

Depart la Garrucha at 05:48 GMT approx., skies clear (stars) and seas calm, calmer than prediction of 1 m. Ship at 17 knots. Ocean Combining Ocean Colour and altimetry from Charles, there are perhaps two zones of interest, one the interface between low and higher chlorophyll that is similar to the earlier drifter track and appears to mark a boundary and further to the south an eastward flow in the geostrophic velocity derived from altimetry. The Almería-Oran transect developed yesterday crosses the first boundary (approx. ST 29 and ST 30) and the final station is placed to just be within the altimetry indicated eastward flow, which is also visible as a high chlorophyll plume 30/11/2015.


2015-11-30T13:25:10.835Z
38°N
37°N
36°N
5°W
4°W
3°W
2°W
1°W
0°
1°E
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

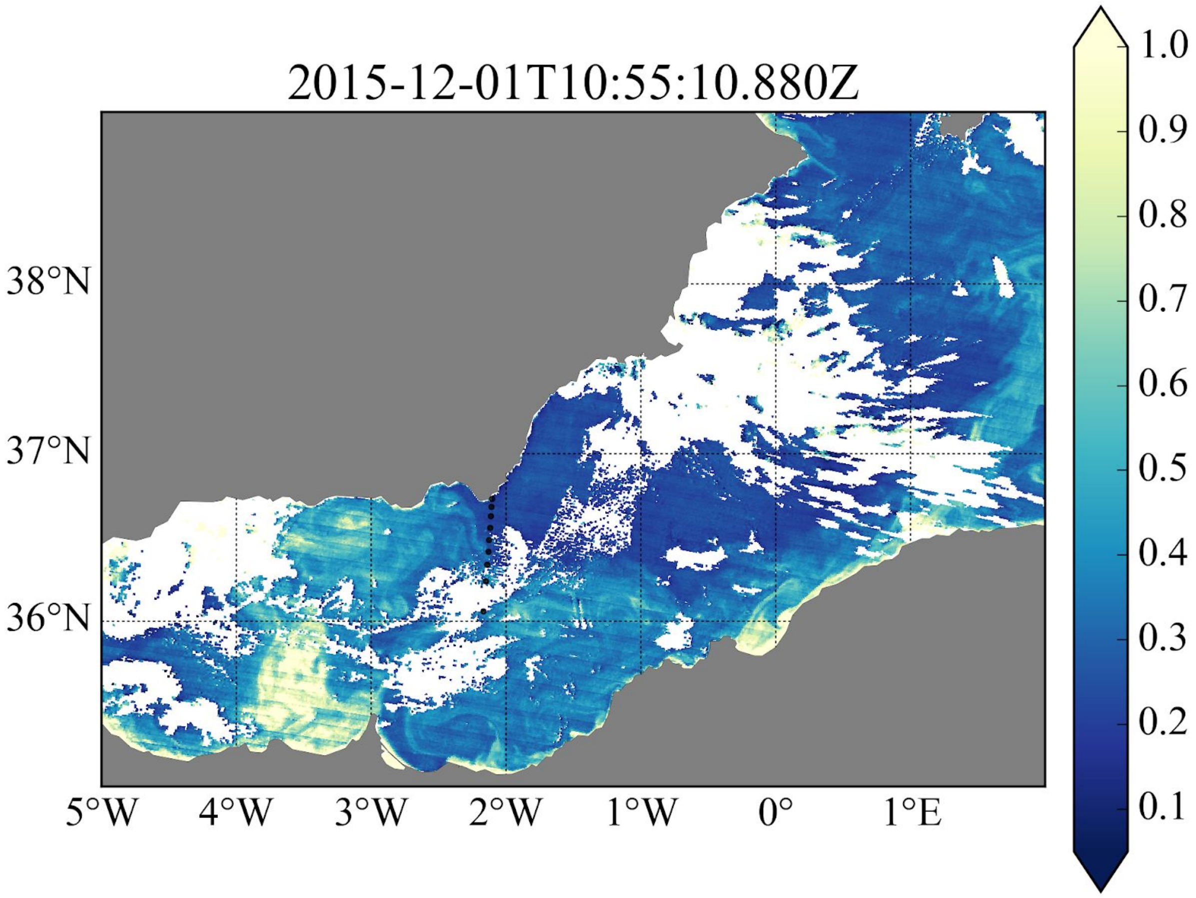

2015-12-01T10:55:10.880Z
38°N
37°N
36°N
5°W
4°W
3°W
2°W
1°W
0°
1°E
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

Fig 4.7. (Upper) Fig 4.7. Colour image from 01/12/2015, produced by Charles with TR5 over plotted, (Lower) 30/11/2015

Arrived 1st station DAY 6, **ALMO_TR5_ST24,** at 17:45 GMT. **CTD in water at 07:47 GMT, 36º 43.769' N, 2º 6.198' W – 70 m.** A quick dip, surface salinity 37.6, CTD recovered safely 07:51 GMT.

Arrived 2nd station **ALMO_TR5_ST25,** at 08:09 GMT. **CTD in water at 08:10 GMT, 36º 41.658' N, 2º 6.406' W – 224 m.** Surface salinity 37.6, thermocline at 50 m. ADCP swing some flow south and west. Entering southward flow between the stations 0 – 125 m, with west component 50 – 125 m, of order 20 cm s-1. CTD recovered safely 08:23 GMT.

Arrived 3rd station **ALMO_TR5_ST26,** at 08:44 GMT. **CTD in water at 08:45 GMT, 36º 37.735 N, 2º 6.760' W – 423 m.** Surface salinity 37.6, halocline 50 m to 125 m, thermocline at 50 m to 125 m. ADCP indicating southward flow. CTD recovered safely 09:03 GMT.

Arrived 4th station **ALMO_TR5_ST27,** at 09:26 GMT. **CTD in water at 09:30 GMT, 36º 33.481 N, 2º 7.132' W – 517 m.** Surface salinity 37.55, thermocline at 50 m to 150 m, we are just at the end of the 500 m contour outcrop around Cabo de Gata. ADCP indicating southward flow to 150 m. CTD recovered safely 09:52 GMT. ADCP show velocities much more in the surface than expected, southward flow strong but some rotation sheer in the velocity around the thermocline.

Arrived 5th station **ALMO_TR5_ST28,** at 10.20 GMT. **CTD in water at 10:21 GMT, 36º 29.154 N, 2º 7.546' W – 928 m.** Surface salinity 37.6, thermocline at 50 m to 100 m. ADCP indicating southward flow strongest in surface 100 m, south and west. Ship drifts west on station. CTD recovered safely 10:57 GMT.

Arrived 6th station **ALMO_TR5_ST29,** at 11:25 GMT, **CTD in water at 11:26 GMT, 36º 25.013 N, 2º 7.918' W – 1206 m.** Now in the zone when we might see a change water mass properties, as around the frontal region indicated by Ocean Colour images. However surface salinity is 37.55 and no change at depth, in T/S a lower T min. bump is visible at approx. 60 m. ADCP indicating southward flow to 200 m, no west in surface however more east. CTD recovered safely 12:09 GMT. Seas are flat and glassy, many meduzas (Nautoluki). In between stations have eastward flowing currents (crossing filaments?) it will be interesting to see what the biogeochemistry shows, as in the ADCP the velocities are not showing a clear story yet. We have not encountered the front here, if we are in the area delineated by chlorophyll and not encountered the front may lie in the zone of the strong eastward flowing currents, seen in altimetry, that the final station is designed to just reach.

Arrived 7th station **ALMO_TR5_ST30,** at 12:40 GMT, **CTD in water at 12:44 GMT, 36º 20.339 N, 2º 8.334' W – 1381 m.** Surface salinity is 37.6, in T/S there lower bump visible, approx. 60 m. ADCP now indicating westward flows below the thermocline and to 200 m, these look in terms of depths and strength more like the westward flows of the previous day. CTD recovered safely 13:38 GMT. Perhaps the interchanging currents to the north have been filaments and mesoscale features, in ADCP the interfaces between these east and west flows looks to be shoaling to the south.

Arrived 8th station **ALMO_TR5_ST31,** at 14:10 GMT, **CTD in water at 14:17 GMT, 36º 14.419 N, 2º 8.885' W – 1850 m.** Surface salinity is 37.1 and between 20 – 40 m there appears to be some interleaving layers in salinity, different T/S profile in the surface however no change in the salinity profile at depth. ADCP indicates the flows are relatively strong and to the W with little or no southward component in the flow and they are below the thermocline. If this change is indeed an indication of the path of the NC flowing south then it will perhaps be interesting to look at the difference in biogeochemistry between ST29 and ST30. In ADCP the flows look more like the west flowing currents from yesterday. CTD recovered safely 15:25 GMT.

As we move south along the transect the salinities in the salinometer fall and before arriving to the final station we reach a 'wall' of eastward flows (in ADCP) at 36.1932/-2.1547, where the westward 20 – 25 cm s-1 flow between 50 – 200 m ends and eastward flow from 0 – depth of ADCP coverage of 40 cm s-1 starts, the interface is vertical. The surface salinities in the salinometer are now of order 36.7 to 36.6 (even 36.5), which indicates AW, we are obviously close to the frontal zone. However this band of eastward current just as suddenly ends before we arrive to the final station.

The 9th station, at the original location of the final station the CTD is in the water when we detect some strong surface flows in the ADCP and decide to sample further south to see if we can locate the actual front. For some minutes no further eastward flow is detected and then the signature of eastward flows strengthen and deepen in the ADCP. The eastward flows are of order 80 cm s-1 and the surface salinities are consistently 36.6, this is the start of the Almería-Oran front and we decide place the station **ALMO_TR5_ST31, CTD in water at 16:47 GMT, 36º 0.888 N, 2º 8.845' W – 1887 m.** Salinity at the surface is 36.6 and the ADCP shows strong easterly velocities 80 m. The AW salinities are not deep, below the zone of the current they return to more typical MW salinities. However this is the start of the interface between the flows from the north and the Almería-Oran AW front. CTD recovered safely 17:49 GMT. In ADCP the change is abrupt and it would appear that the northern flows are running due W, below the 50 m thermocline with velocities of order of 20 – 25 cm s-1, while frontal waters flow due E, from the surface to an unknown depth, at 80 cm s -1, and that this change occurs over a short area of order 10 km (5 nm). The ideal would be to sample further across the front, however we encountered the interface and that is sufficient - next time.

Arrive Almería port approx. 21:00 GMT.

5. Technical Operations Report

5.1 CTD Report

5.1.1 Instrument description

Manufacturer:	SeaBird
Model:	SBE911+
S/N:	1031
SOCIB Inventory:	SCB-SBE9002
Sensors	

Sensor:		S/N	Calibration Date
Temperature	SBE 3P	03P5427	2013/12/19
Temperature 2	SBE 3P	03P5449	2013/12/19
Conductivity	SBE4C	043872	2014/01/14
Conductivity 2	SBE4C	043877	2014/01/14
Pressure		119076	2014/02/03
Oxygen	SBE 43	432117	2014/01/18
Transmisiometer	WET Labs C-Star 25-650	CST-1413 DR	2014/03/05
Turbidity	STM Sea Point	12181	2014/01/23
Fluorometer	Seapoint 6000m	3258	2014/01/23
Irradiance	PAR Biospherical QCP-2300L-HP	70363	2011/03/25
Surface Irradiance	SPAR Superficie Biospherical QCR2200	20395	2011/03/28

	Altímeter	Datasonics PSA-916D	52712	

Configuration file: **2014-10-23_1031_SOCIB.XMLCON**

5.1.2 Background:

In the former cruise had been discussed to cut the last 10 meters and renew the connection because of upcoming oxidation in these last meters. The end of the "Cable of Communications" had been cut and the connection renewed. Furthermore had been changed the plastic holders of the "tire drop". Additionally, one day before the ALMO-NOV-15 cruise on 26 of November 2015 had been realized a test at going down up to 67m in the bay of Palma.

Since former cruises had been notified problems with the bottle 10. Before this cruise had been realized and special cleaning and maintenance of the upper part of the Rosette. It had been dismounted and analysed the hook-system, the revision was satisfying and all parts are working correct. In the test on deck (dry test) all bottles closed correctly. As recommended, during this campaign had been taken special attention on the functionality of this bottle before using it to collect samples.

5.1.3 Observations:

Due to noisy signals from the Turbidity-Sensor mounted in the lower part of the rosette had been changed its position on the second day of the cruise. The first change was turning it a few degrees. The obtained results in the following cast were clearer but jumped constant 80 FTU. For the next cast, the second change consists in removing it from its horizontal position of origin, mounted parallel to the CTD in a horizontal position near to the cage. The obtained results in the following cast went back similar to the scale before the first change. The signal now has less noise, but there can still be observed a little difference of "more noise" in the downcast in comparison to the upcast.

5.1.4 CTD-Profiles

Transect 1. ALICANTE

ALMO-TR1-ST01	**Operator:**	ILE, NCW	28/11/2015
Ini. Lat:	38º06.990'N	**Ini. Lon:**	0º16.040'W
Depth (sonde):	99m	**Max. CTD depth:**	89m
Observations:	In the upcast it had been stopped at 32m and went down again up to take the samples at 35m.		

Bottles:

Btl. #1:	Botto m	**Btl. #4:**	3 5	**Btl. #7:**	5	**Btl. #10:**	
Btl. #2:	Botto m	**Btl. #5:**	3 5	**Btl. #8:**		**Btl. #11:**	
Btl. #3	50	**Btl. #6:**	5	**Btl. #9:**		**Btl. #12:**	

ALMO-TR1-ST 02	**Operator:**	ILE, NCW	28/11/2015
Ini. Lat:	38º03.475'N	**Ini. Lon:**	0º06.886'W
Depth (sonde):	485m	**Max. CTD depth:**	478m
Observations:	It had been stopped in the upcast at 5 and waited 2 min to stabilize the two sensor of salinity. It had been launched the Drifter SCB-SVP026 at N 38º04.212' W 0º08.736'.		

Bottles:

Btl. #1:	Bottom	**Btl. #4:**	150	**Btl. #7:**	4 0	**Btl. #10:**	cerrado
Btl. #2:	Bottom	**Btl. #5:**	100	**Btl. #8:**	2 5	**Btl. #11:**	
Btl. #3	200	**Btl. #6:**	40	**Btl. #9:**	5	**Btl. #12:**	

ALMO-TR1-ST03	**Operator:**	ILE, BCP	28/11/2015

Ini. Lat:	37º59.574'N	**Ini. Lon:**	0º02.210'E
Depth (sonde):	1121m	**Max. CTD depth:**	1119m
Observations:			

Bottles:

Btl. #1:	Bottom	**Btl. #4:**	500	**Btl. #7:**	100	**Btl. #10:**	closed
Btl. #2:	Bottom	**Btl. #5:**	200	**Btl. #8:**	45	**Btl. #11:**	25
Btl. #3	1000	**Btl. #6:**	150	**Btl. #9:**	45	**Btl. #12:**	5

ALMO-TR1-ST04	**Operator:**	ILE, BCP	28/11/2015
Ini. Lat:	37º56.448'N	**Ini. Lon:**	0º11.399'E
Depth (sonde):	1384m	**Max. CTD depth:**	
Observations:	stopped at 5m waiting 1 min until close the bottle		

Bottles:

Btl. #1:	Bottom	**Btl. #4:**	500	**Btl. #7:**	100	**Btl. #10:**	closed
Btl. #2:	Bottom	**Btl. #5:**	200	**Btl. #8:**	45	**Btl. #11:**	25
Btl. #3	1000	**Btl. #6:**	150	**Btl. #9:**	45	**Btl. #12:**	5

ALMO-TR1-ST05	Operator:	ILE	28/11/2015
Ini. Lat:	37º52.766'N	Ini. Lon:	0º20.487'E
Depth (sonde):	1631m	Max. CTD depth:	1640m
Observations:			

Bottles:							
Btl. #1:	Bottom	Btl. #4:	500	Btl. #7:	100	Btl. #10:	closed
Btl. #2:	Bottom	Btl. #5:	200	Btl. #8:	53	Btl. #11:	25
Btl. #3	1019	Btl. #6:	150	Btl. #9:	53	Btl. #12:	5

Transect 2. PALOS

ALMO-TR2ST06	Operator:	ILE, NCW	29/11/2015
Ini. Lat:	37º35.386'N	Ini. Lon:	0º37.592'W
Depth (sonde):	97m	Max. CTD depth:	86m
Observations:			

Bottles:							
Btl. #1:	Bottom	Btl. #4:	50	Btl. #7:	5	Btl. #10:	
Btl. #2:	Bottom	Btl. #5:	25	Btl. #8:		Btl. #11:	

Btl. #3	50	**Btl. #6:**	5	**Btl. #9:**		**Btl. #12:**	

ALMO-TR2ST07	**Operator:**	ILE, BCP	29/11/2015
Ini. Lat:	37º32.282'N	**Ini. Lon:**	0º36.688'W
Depth (sonde):	215m	**Max. CTD depth:**	223m
Observations:	Drifting, sounder depth 234m, Bottle 5 did not close properly		

Bottles:

Btl. #1:	Bottom	**Btl. #4:**	100	**Btl. #7:**	25	**Btl. #10:**	closed
Btl. #2:	Bottom	**Btl. #5:**	50	**Btl. #8:**	5	**Btl. #11:**	
Btl. #3	150	**Btl. #6:**	50	**Btl. #9:**	5	**Btl. #12:**	

ALMO-TR2ST08	**Operator:**	ILE, NCW	29/11/2015
Ini. Lat:	37º30.502'N	**Ini. Lon:**	0º36.142'W
Depth (sonde):	798m	**Max. CTD depth:**	870m
Observations:	Drifting, sounder depth changed from 798 to 900. Stopped in 870m without signal from the altimeter.		

Bottles:

Btl. #1:	Bottom	**Btl. #4:**	200	**Btl. #7:**	50	**Btl. #10:**	not closed
Btl. #2:	Bottom	**Btl. #5:**	150	**Btl. #8:**	50	**Btl. #11:**	5
Btl. #3	500	**Btl. #6:**	100	**Btl. #9:**	25	**Btl. #12:**	5

ALMO-TR2ST09	**Operator:**	ILE, NCW	29/11/2015
Ini. Lat:	37º27.427'N	**Ini. Lon:**	0º35.400'W
Depth (sonde):	1499m	**Max. CTD depth:**	1500m
Observations:	Drifting, Sounder depth 1550m. It had been modified (Turned 5º down) the position of the Turbidity-Sensor.		

Bottles:

Btl. #1:	Bottom	**Btl. #4:**	500	**Btl. #7:**	100	**Btl. #10:**	closed
Btl. #2:	Bottom	**Btl. #5:**	200	**Btl. #8:**	41	**Btl. #11:**	25
Btl. #3	1000	**Btl. #6:**	150	**Btl. #9:**	41	**Btl. #12:**	5

ALMO-TR2ST10	**Operator:**	ILE, NCW, BCP	29/11/2015
Ini. Lat:	37º 23. 30'N	**Ini. Lon:**	0º24.05'W
Depth (sonde):	2240m	**Max. CTD depth:**	2289m

Observations:	Rosette came on board before taking the 5m sample, put back in the water to get them.

Bottles:

Btl. #1:	Bottom	**Btl. #4:**	500	**Btl. #7:**	100	**Btl. #10:**	not closed
Btl. #2:	Bottom	**Btl. #5:**	200	**Btl. #8:**	50	**Btl. #11:**	32
Btl. #3	1000	**Btl. #6:**	150	**Btl. #9:**	32	**Btl. #12:**	5

TRANSECT 2B. PALOSB

ALMO-TR2B ST11	**Operator:**	ILE, NCW	29/11/2015
Ini. Lat:	37º26.129'N	**Ini. Lon:**	0º47.130'W
Depth (sonde):	961m	**Max. CTD depth:**	1051m
Observations:	It had been changed the position of the Turbidity-Sensor from its horizontal position into vertical, fixed on a mettal tube form the Rosette. It had been stopped in the upcast at 20m and went down up to 25 to take the sample		

Bottles:

Btl. #1:	Bottom	**Btl. #4:**	200	**Btl. #7:**	60	**Btl. #10:**	closed
Btl. #2:	Bottom	**Btl. #5:**	150	**Btl. #8:**	60	**Btl. #11:**	5
Btl. #3	500	**Btl. #6:**	100	**Btl. #9:**	25	**Btl. #12:**	5

ALMO-TR2BST12	Operator:	ILE, BCP	29/11/2015
Ini. Lat:	37º 28. 55'N	Ini. Lon:	0º 47. 49'W
Depth (sonde):	455m	Max. CTD depth:	412m
Observations:	Drifting, sounder depth changed to 400m		

Bottles:

Btl. #1:	Bottom	Btl. #4:	150	Btl. #7:	50	Btl. #10:	closed
Btl. #2:	Bottom	Btl. #5:	100	Btl. #8:	25	Btl. #11:	5
Btl. #3	200	Btl. #6:	50	Btl. #9:	5	Btl. #12:	

ALMO-TR2BST13	Operator:	ILE, NCW	29/11/2015
Ini. Lat:	37º29.856'N	Ini. Lon:	0º47.741'W
Depth (sonde):	93m	Max. CTD depth:	83m
Observations:			

Bottles:

Btl. #1:	Bottom	Btl. #4:	50	Btl. #7:	5	Btl. #10:	
Btl. #2:	Bottom	Btl. #5:	22	Btl. #8:		Btl. #11:	
Btl. #3	50	Btl. #6:	5	Btl. #9:		Btl. #12:	

Transect 3. TIÑOSO

ALMO-TR3-ST14	Operator:	NCW, ILE	30/11/2015
Ini. Lat:	37º31.438'N	Ini. Lon:	1º08.232'W
Depth (sonde):	78m	Max. CTD depth:	68m
Observations:			

Bottles:

Btl. #1:	Bottom	Btl. #4:	50	Btl. #7:	5	Btl. #10:	
Btl. #2:	Bottom	Btl. #5:	25	Btl. #8:		Btl. #11:	
Btl. #3	50	Btl. #6:	5	Btl. #9:		Btl. #12:	

ALMO-TR3-ST 15	Operator:	NCW, ILE	30/11/2015
Ini. Lat:	37º28.753'N	Ini. Lon:	1º07.884'W
Depth (sonde):	1234m	Max. CTD depth:	1175m
Observations:	Drifting 350m, sounder depth 1170, stopped in 1175 without signals from the altimeter.		

Bottles:

Btl. #1:	Bottom	Btl. #4:	200	Btl. #7:	55	Btl. #10:	closed

Btl. #2:	Bottom	**Btl. #5:**	150	**Btl. #8:**	5 5	**Btl. #11:**	5
Btl. #3	500	**Btl. #6:**	100	**Btl. #9:**	2 5	**Btl. #12:**	5

ALMO-TR3-ST16	**Operator:**	NCW, ILE	30/11/2015
Ini. Lat:	37º26.238'N	**Ini. Lon:**	1º07.543'W
Depth (sonde):	1875m	**Max. CTD depth:**	1924m
Observations:	Drifting 200m, sounder depth 1937m.		

Bottles:

Btl. #1:	Bottom	**Btl. #4:**	500	**Btl. #7:**	100	**Btl. #10:**	close d
Btl. #2:	Bottom	**Btl. #5:**	200	**Btl. #8:**	53	**Btl. #11:**	25
Btl. #3	1000	**Btl. #6:**	150	**Btl. #9:**	53	**Btl. #12:**	5

ALMO-TR3-ST 17	**Operator:**	NCW, ILE	30/11/2015
Ini. Lat:	37º23.549'N	**Ini. Lon:**	01º07.164'W
Depth (sonde):	2218m	**Max. CTD depth:**	2290m
Observations:	Little drifting, good altimeter signal, stopped in 2290m with a sounder depth of 2253m.		

Bottles:							
Btl. #1:	Bottom	Btl. #4:	500	Btl. #7:	100	Btl. #10:	Closed
Btl. #2:	1500	Btl. #5:	200	Btl. #8:	60	Btl. #11:	25
Btl. #3	1000	Btl. #6:	150	Btl. #9:	60	Btl. #12:	5

ALMO-TR3-ST18	Operator:	BCP, NCW	30/11/2015
Ini. Lat:	N 37º15.562’	Ini. Lon:	W 1º06.104’
Depth (sonde):	2431m	Max. CTD depth:	2460m
Observations:	Good altimeter signal, stopped at 2460m with a sounder depth of 2430m.		

Bottles:							
Btl. #1:	Bottom	Btl. #4:	500m	Btl. #7:	100m	Btl. #10:	closed
Btl. #2:	1250m	Btl. #5:	200m	Btl. #8:	50m	Btl. #11:	25m
Btl. #3	1000m	Btl. #6:	140m	Btl. #9:	50m	Btl. #12:	5m

Transect 4. CARBONERA

ALMO-TR4-ST19	Operator:	ILE, NCW	01/12/2015
Ini. Lat:	36º57.753’N	Ini. Lon:	1º51.562’W
Depth (sonde):	102m	Max. CTD depth:	93m
Observations:			

Bottles:

Btl. #1:	Bottom	Btl. #4:	25	Btl. #7:		Btl. #10:	
Btl. #2:	Bottom	Btl. #5:	5	Btl. #8:		Btl. #11:	
Btl. #3	50	Btl. #6:	5	Btl. #9:		Btl. #12:	

ALMO-TR4-ST20	Operator:	ILE, BCP	01/12/2015
Ini. Lat:	36º57.885'N	Ini. Lon:	1º44.683'W
Depth (sonde):	532m	Max. CTD depth:	520m
Observations:			

Bottles:

Btl. #1:	Bottom	Btl. #4:	150	Btl. #7:	57	Btl. #10:	
Btl. #2:	Bottom	Btl. #5:	100	Btl. #8:	25	Btl. #11:	
Btl. #3	200	Btl. #6:	57	Btl. #9:	5	Btl. #12:	

ALMO-TR4-ST21	Operator:	LPB, NCW	01/12/2015
Ini. Lat:	36º58.157'N	Ini. Lon:	1º37.793' W
Depth (sonde):	1265m	Max. CTD depth:	1240m

Observations:	Drifting 500m, sounder depth 1235m. Good altimeter signal, stopped at 1240m. Total drifting 1000m Bottle 11 hasn´t closed acurate.

Bottles:

Btl. #1:	Bottom	**Btl. #4:**	500m	**Btl. #7:**	100m	**Btl. #10:**	close d
Btl. #2:	Bottom	**Btl. #5:**	200m	**Btl. #8:**	50m	**Btl. #11:**	X
Btl. #3	1000m	**Btl. #6:**	140m	**Btl. #9:**	50m	**Btl. #12:**	5m

ALMO-TR4-ST22	**Operator:**	ILE, BCP	01/12/2015
Ini. Lat:	36º58.613'N	**Ini. Lon:**	1º21.624'W
Depth (sonde):	2075m	**Max. CTD depth:**	2095m
Observations:	Drifting 600m		

Bottles:

Btl. #1:	Bottom	**Btl. #4:**	1000m	**Btl. #7:**	150m	**Btl. #10:**	50
Btl. #2:	Bottom	**Btl. #5:**	500m	**Btl. #8:**	100m	**Btl. #11:**	25m
Btl. #3	1500m	**Btl. #6:**	250m	**Btl. #9:**	50m	**Btl. #12:**	5m

ALMO-TR4-ST23	**Operator:**	NCW, BCP	01/12/2015

Ini. Lat:	37º03.307'N	**Ini. Lon:**	1º08.282'W
Depth (sonde):	2435	**Max. CTD depth:**	2406m
Observations:	Drifting 600m WSW		

Bottles:

Btl. #1:	Bottom	**Btl. #4:**	1500m	**Btl. #7:**	150m	**Btl. #10:**	50m
Btl. #2:	Bottom	**Btl. #5:**	500m	**Btl. #8:**	100m	**Btl. #11:**	25m
Btl. #3	1000m	**Btl. #6:**	200m	**Btl. #9:**	50m	**Btl. #12:**	5m

Transect 5. CABO DE GATA

ALMO-TR5-ST24	**Operator:**	NCW, ILE	02/12/2015
Ini. Lat:	36º 43.778' N	**Ini. Lon:**	2º 6.193' W
Depth (sonde):	70m	**Max. CTD depth:**	62m
Observations:			

Bottles:

Btl. #1:	Bottom	**Btl. #4:**	45m	**Btl. #7:**	5 m	**Btl. #10:**	m
Btl. #2:	Bottom	**Btl. #5:**	25m	**Btl. #8:**	5 m	**Btl. #11:**	m
Btl. #3	45m	**Btl. #6:**	25m	**Btl. #9:**	m	**Btl. #12:**	m

ALMO-TR5-ST25	Operator:	NCW, BCP	02/12/2015
Ini. Lat:	36º 41.071’ N	Ini. Lon:	2º 6.422’ W
Depth (sonde):	223m	Max. CTD depth:	221m
Observations:			

Bottles:

Btl. #1:	Bottom	Btl. #4:	100m	Btl. #7:	25m	Btl. #10:	5 m
Btl. #2:	Bottom	Btl. #5:	55m	Btl. #8:	25m	Btl. #11:	m
Btl. #3	150m	Btl. #6:	55m	Btl. #9:	5m	Btl. #12:	m

ALMO-TR5-ST26	Operator:	BCP, NCW	02/12/2015
Ini. Lat:	36º 37.739’ N	Ini. Lon:	2º 6.760’ W
Depth (sonde):	425m	Max. CTD depth:	424m
Observations:			

Bottles:

Btl. #1:	Bottom	Btl. #4:	150m	Btl. #7:	62m	Btl. #10:	5 m
Btl. #2:	Bottom	Btl. #5:	100m	Btl. #8:	25m	Btl. #11:	5 m
Btl. #3	200m	Btl. #6:	62m	Btl. #9:	25m	Btl. #12:	m

ALMO-TR5-ST27		Operator:	ILE, BCP		02/12/2015
Ini. Lat:		36º 33.481' N	Ini. Lon:		2º 7.133' W
Depth (sonde):		516m	Max. CTD depth:		518m
Observations:		Bottle 1 has not closed acurate.			

Bottles:

Btl. #1:	Bottom	Btl. #4:	200m	Btl. #7:	58m	Btl. #10:	25m
Btl. #2:	Bottom	Btl. #5:	150m	Btl. #8:	58m	Btl. #11:	5m
Btl. #3	400m	Btl. #6:	100m	Btl. #9:	25m	Btl. #12:	5m

ALMO-TR5-ST28		Operator:	NCW, BCP		02/12/2015
Ini. Lat:		36º 29.156' N	Ini. Lon:		2º 07.542' W
Depth (sonde):		937 m	Max. CTD depth:		916 m
Observations:		No signal from altimeter. Sounder depth 923m. Drifting 300m W			

Bottles:

Btl. #1:	Bottom	Btl. #4:	200m	Btl. #7:	56m	Btl. #10:	25m
Btl. #2:	Bottom	Btl. #5:	150m	Btl. #8:	56m	Btl. #11:	5m

Btl. #3	450m	**Btl. #6:**	100m	**Btl. #9:**	25m	**Btl. #12:**	5m

ALMO-TR5-ST29	**Operator:**	NCW, BCP, ILE	02/12/2015
Ini. Lat:	36º 24.998' N	**Ini. Lon:**	2º 7.913' W
Depth (sonde):	1207m	**Max. CTD depth:**	1206m
Observations:	Altimeter: 10m to bottom		

Bottles:

Btl. #1:	Bottom	**Btl. #4:**	200m	**Btl. #7:**	58m	**Btl. #10:**	25m
Btl. #2:	Bottom	**Btl. #5:**	150m	**Btl. #8:**	58m	**Btl. #11:**	5m
Btl. #3	500m	**Btl. #6:**	100m	**Btl. #9:**	25m	**Btl. #12:**	5m

ALMO-TR5-ST30	**Operator:**	NCW, ILE	02/12/2015
Ini. Lat:	36º 20.340' N	**Ini. Lon:**	2º 8.346' W
Depth (sonde):	1382m	**Max. CTD depth:**	1382m
Observations:	Altimeter: 9,8m to bottom		

Bottles:

Btl. #1:	Bottom	**Btl. #4:**	1000m	**Btl. #7:**	150m	**Btl. #10:**	58m

Btl. #2:	Bottom	**Btl. #5:**	500m	**Btl. #8:**	100m	**Btl. #11:**	25m
Btl. #3	1200m	**Btl. #6:**	200m	**Btl. #9:**	58m	**Btl. #12:**	5m

ALMO-TR5-ST31	**Operator:**	NCW, BCP	02/12/2015
Ini. Lat:	36º 14.435' N	**Ini. Lon:**	W 2º 8.887' W
Depth (sonde):	1845m	**Max. CTD depth:**	1859m
Observations:	Good Altimeter signal. Stopped at 9 meter to bottom.		

Bottles:

Btl. #1:	Bottom	**Btl. #4:**	1000m	**Btl. #7:**	150m	**Btl. #10:**	40m
Btl. #2:	Bottom	**Btl. #5:**	500m	**Btl. #8:**	100m	**Btl. #11:**	25m
Btl. #3	1500m	**Btl. #6:**	200m	**Btl. #9:**	40m	**Btl. #12:**	5m

ALMO-TR5-ST 32	**Operator:**	NCW, BCP	02/12/2015
Ini. Lat:	36º 0.893' N	**Ini. Lon:**	2º 8.850' W
Depth (sonde):	1889m	**Max. CTD depth:**	1881m
Observations:	Stopped at 1881m, 9m to bottom igual to sounder depth of 1890m. Its recomended to adapt for each cruise the settings of the sounder acording to the sea conditions.		

Bottles:							
Btl. #1:	Bottom	**Btl. #4:**	1000m	**Btl. #7:**	150m	**Btl. #10:**	56m
Btl. #2:	Bottom	**Btl. #5:**	500m	**Btl. #8:**	100m	**Btl. #11:**	25m
Btl. #3	1500m	**Btl. #6:**	200m	**Btl. #9:**	56m	**Btl. #12:**	5m

5.2 Drifter Report

An essential part of the campaign ALMO-NOV-15 are the data collected from drifter buoys. Therefore had been prepared in total 9 buoys, 5 SVP drifter and 4 ODI drifter. During the 28 of November 2015 had been launched 4 SVP-Drifter:

SCB-SVP024	***S/N & Argos ID:*** 152146
Date: 28 de Noviembre de 2015	***Hour:*** 8:25 UTC
Lat: 38º06.928'N	***Lon:*** 0º15. 938'W

SCB-SVP025	***S/N & Argos ID:*** 152147
Date: 28 de Noviembre de 2015	***Hour:*** 8:44 UTC
Lat: 38º05.302'N	***Lon:*** 0º11. 963'W

SCB-SVP026	***S/N & Argos ID:*** 152148
Date: 28 de Noviembre de 2015	***Hour:*** 8:59 UTC
Lat: 38º04.212'N	***Lon:*** 0º08. 736'W

SCB-SVP028	***S/N & Argos ID:*** 152150
Date: 28 de Noviembre de 2015	***Hour:*** 16:58 UTC
Lat: 37º 50.578'N	***Lon:*** 0º 19. 713'W

During the 03 of December 2015 had been launched ……

SCB-SVP023	***S/N & Argos ID:*** 137376
Date: 04 de Diciembre de 2015	***Hour:*** 10:15 UTC
Lat: 35º 59.244 'N	***Lon:*** 05º 22.153 'W

SCB-ODI008

S/N: 051	***IMEI:*** 300234062844920
Date: 04 de Diciembre de 2015	***Hour:*** 10:15 UTC
Lat: 35º 59.244 ’N	***Lon:*** 05º 22.153 ’W

SCB-ODI009	
S/N: 052	***IMEI:*** 300234062747140
Date: 04 de Diciembre de 2015	***Hour:*** 10:15 UTC
Lat: 35º 59.244 ’N	***Lon:*** 05º 22.153 ’W

SCB-ODI010	
S/N: 053	***IMEI:*** 300234062845920
Date: 04 de Diciembre de 2015	***Hour:*** 10:15 UTC
Lat: 35º 59.244 ’N	***Lon:*** 05º22.153 ’W

SCB-ODI011	
S/N: 054	***IMEI:*** 300234062746150
Date: 04 de Diciembre de 2015	***Hour:*** 10:15 UTC
Lat: 35º 59.244 ’N	***Lon:*** 05º22.153 ’W

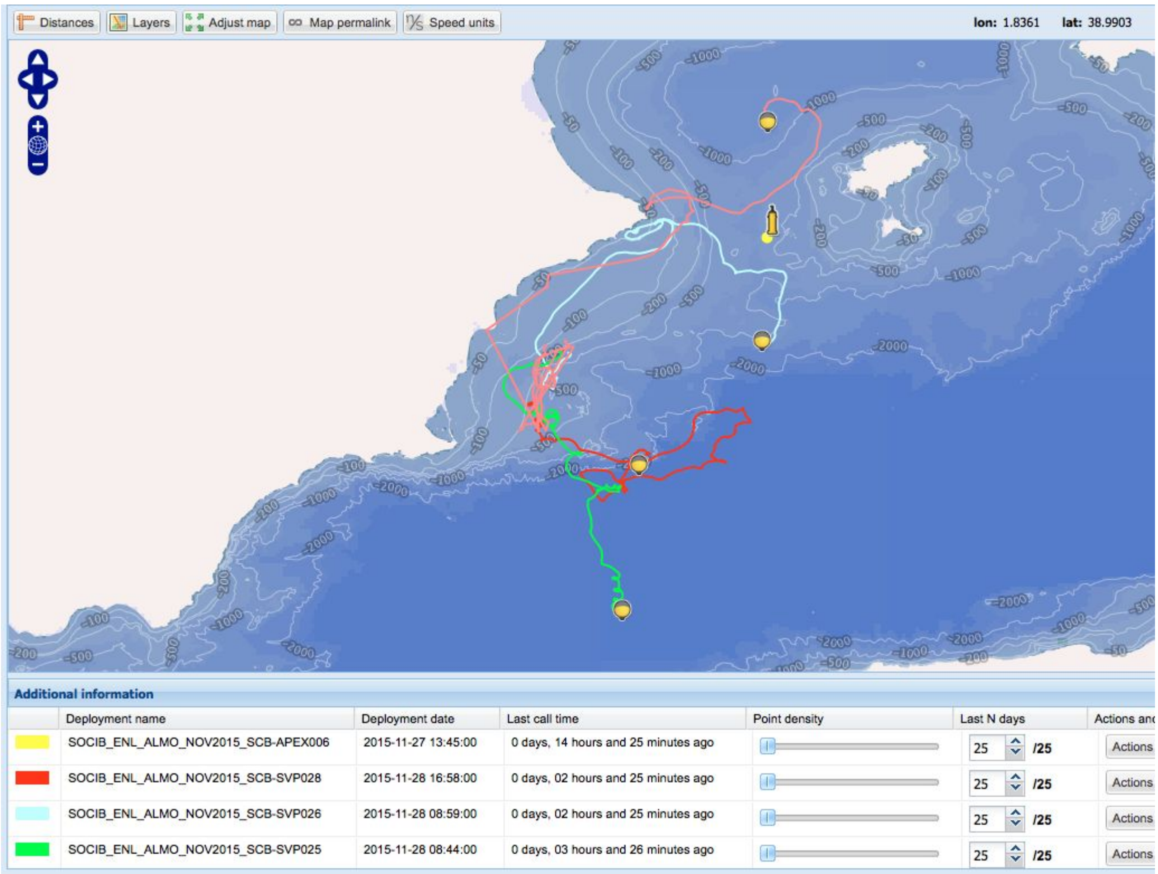


Figure 5.1: Update from DAPP 22/12/2015: Surface Drifters and Argo float launched in during ALMO campaign.

6 Scientific reports and preliminary data

6.1 Biogeochemical Sampling Report

6.1.1 Biogeochemical team

PI: Emma Heslop
Participants: John Allen (SOCIB), Eva Alou (SOCIB)*, Ana Massanet (IMEDEA), Krissy Reeves (SOCIB) and with the help of Laura Pereda (UIB-IMEDEA). Author (*).

6.1.2 Introduction

We focused on the comparison of CTD sensor measurements (SBE-911*plus* CTD probe, Sea-Bird Electronics) against *in situ* discrete water samples of the following parameters: salinity, dissolved oxygen and chlorophyll (chl *a*) concentration. In addition to this and following the general hypothesis of the SOCIB-ALMO Dec15 project, we focused on how physical processes influenced biogeochemical processes within the Almeria and Oran front (ALMO front), in the eastern Alboran Sea.

6.1.3 Objectives

Primary objectives

1. To compare the CTD sensors against the *in situ* discrete water samples of the parameters mentioned above.

Secondary field objectives

1. To estimate chl *a* concentration and distribution (as a proxy for phytoplankton biomass).

2. To assess nutrient concentration distribution: Nitrate (NO_3^-), nitrite (NO_2^-), silicate (SiO_2) and phosphate (PO_4^{3-}).

3. To study phytoplankton community composition.

6.1.4 Sampling program

The sampling was carried out on 5 days from November the 28th (Alicante) to December the 2nd (Almería). Water samples were taken at each station with the rosette on board.

1. Salinity

Samples were taken with 200 ml bottles at 1 to 3 depths (see table 6.1.1). Further analysis with an auto-salinometer (GILDLINE PORTASAL 8410A) will be carried out at the IMEDEA.

2. Dissolved oxygen

Samples for comparison between the dissolved oxygen CTD sensor (SBE-43) and *in situ* water samples (Winkler's method, Langdon 2010) were taken at 3 stations along each transect. We chose depths of varying oxygen concentrations (in order to sample the full spectrum of possible oxygen concentrations within the region) and made replicates at random stations (see Table 6.1.1).

Samples were analyzed on board after an 8-12 h period in darkness with a titration procedure with potentiometric endpoint detection (Metrohm 888 Titrator).

The final dissolved oxygen dataset will be produced post-cruise following the analysis of the data.

3. Nutrients

Samples for inorganic nutrients were taken at all stations at a maximum of 10 depths (see table 6.1.1). Three replicates were taken for each depth using 5 ml tubes and kept frozen on board (-20 ºC) until further laboratory analyses.

4. Chlorophyll a concentration

Satellite images of chl *a* were used during the cruise to estimate the position of the Almeria-Oran Front, distinguish the front structure and identify differences between Atlantic and Mediterranean water masses.

Discrete water samples were taken on each station at 4 depths (Table 6.1.1). For each sample, a volume of 1L was filtered through 45 mm Whatman GF/F filters and immediately placed in plastic vials and stored in a freezer onboard (-20 ºC). Chl *a* determination will be carried out at the IMEDEA by fluorometry (using a Turner Trilogy fluorometer).

5. Phytoplankton community composition

Samples were taken on each station at the deep chlorophyll maximum (DCM) for general cell identification (cells fixed in Lugol's solution, Utermöhl 1958). Samples for microscopy will be analyzed post-cruise at the IMEDEA.

Samples for High Performance Liquid Chromatography (HPLC) analyses were taken on each station at 2 depths (surface and DCM). The total fraction was collected and a volume of 2 L filtered through a GF/F filter (retaining microorganisms larger than the nominal pore size of 0.7 μm). Samples were stored on board the R/V SOCIV in a liquid nitrogen dry-shipper.

Table 6.1.1. List of sampled stations, variables sampled and depths (in meters), replicates are noted by an asterisk.

Station	Date	Salinity	Oxygen*	Nutrients*	Chl *a*	HPLC	Phytoplankton Lugol	Remarks
TR1-ST01	28/11/15	Bottom	None	5, 35, 50, bottom	5, 35, 50, bottom	5, 35	35	DCM aprox. 0.5 mg/m^3
TR1-ST02	28/11/15	5, bottom	25, 200, bottom.	5, 25, 40, 100,150, 200, bottom	5, 25, 40, 100	5, 40	40	The CTD stopped 2min before closing bottle for quality sampling.
TR1-ST03	28/11/15	5, 500	25*, 200, 500, bottom*	5, 25, 45, 100, 150 200, 500, 1000, bottom	5, 25, 45, 100	5, 45	45	
TR1-ST04	28/11/15	5, 1000	25*, 200, 1000, bottom*	5, 25, 45, 100, 150, 200, 500, 1000, bottom	5, 25, 45, 100	5, 45	45	The CTD stopped 2 min before closing bottle for quality sampling.
TR1-ST05	28/11/15	5, 500, bottom	none	5, 25, 53, 100, 150, 200, 500, 1000, bottom	5, 25, 53, 100	5, 53	53	
TR2-ST06	29/11/15	5, bottom	none	5, 25, 50, bottom	5, 25, 50, bottom	5, 50	50	TR2B is added to this t 2 min at 5 m for salinity
TR2-ST07	29/11/15	5, bottom	none	5, 25, 50, 100, 150, bottom	5, 25, 50, 100	5, 50	50	DCM at 50 m taken fro 6, bottle 5 did not close
TR2-ST08	29/11/15	5, 500	25*, 200, bottom*	5, 25, 50 100 150, 200, bottom	5, 25, 50, 100	5, 50	50	Copepods in the DCM. filters are brownish.

TR2-ST09	29/11/15	5, 1000	25*, 200, bottom*	5, 25, 40, 100, 150, 200, 500, 1000, bottom	5, 25, 40, 100	5, 40	40	Lots of copepods, brow
TR2-ST10	29/11/15	5, bottom	50, 200, bottom	5, 34, 50, 100, 150, 200, 500, 1000, bottom	5, 34, 50, 100	5, 34	34	Bottle 9 (5 m) did not cl was down again and th bottle. DCM @ 34m. C taken at 50 m because at 34m. HPLC filtrated volume=1710ml. Turbic sensor changed positio changed scale, lots of v
TR2B-ST11	29/11/15	5, bottom	none	5, 25, 60, 100, 150, 200, 500, bottom	5, 25, 60, 100	5, 60	60	
TR2B-ST12	29/11/15	5, bottom	200, bottom	5, 50, 100, 150, 200, 500, bottom	5, 25, 50, 100	none	50	Bottle @ 25m did not cl Oxygen & nutrients not HPLC not sampled, lab process.
TR2B-ST13	29/11/15	5, bottom	none	5, 25, 50, bottom	5, 25, 50, bottom	5, 50	50	
TR3-ST14	30/11/15	5, 25m	none	5, 25, 50, bottom	5, 25, 50, bottom	5, 50	50	There is no clear DCM
TR3-ST15	30/11/15	5, 500	25*, 200, 500, bottom*	5, 25, 55, 100, 150, 200, 500, bottom	5, 25, 55, bottom	5, 55	55	

TR3-ST16	30/11/15	5, 1000	25, 200, 1000, bottom	5, 25, 53, 100, 150, 200, 500, 1000, bottom	5, 25, 53, 100	5, 53	53	
TR3-ST17	30/11/15	5, bottom	25*, 200, 1000, bottom*	5, 25, 60, 100, 150, 200, 500, 1000, 1200, bottom	5, 25, 60, 100	5, 60	60	
TR3-ST18	30/11/15	5, bottom	none	5, 25, 50, 100, 150, 200, 500, 1000, 1250, bottom	5, 25, 50, 100	5, 50	50	Snapshot of the profile, DCM, green filters
TR4-ST19	1/12/15	5, 25	none	5, 25, 50, bottom	5, 25, 50, 100	5, 50	50	
TR4-ST20	1/12/15	5, bottom	25*, 200, bottom*	5, 25, 57, 100, 150, 200, bottom	5, 25, 50, 100	5, 57	57	
TR4-ST21	1/12/15	1000, bottom	200, 500, bottom	5, 50, 100, 150, 200, bottom	5, 25, 50, 100	5, 50	50	Bottle @ 5 m did not cl Bottom taken from bott
TR4-ST22	1/12/15	5, 1500, bottom	25*, 200, 1000, bottom*	5, 25, 50, 100, 150, 200, 500, 1000, 1500, bottom	5, 25, 50, 100	5, 50	50	

TR4-ST23	1/12/15	5, bottom	none	5, 25, 50, 100, 150, 200, 500, 1000, 1500, bottom	5, 25, 50, 100	5, 50	50	
TR5-ST24	2/12/15	5, 25	none	5, 25, 45, bottom	5, 25, 50, 100	none	45	From this station to the they added a B after nu
TR5-ST25	2/12/15	none	none	5, 25, 50, 100, 150, bottom	5, 25, 50, 100	5, 50	50	
TR5-ST26	2/12/15	5, 100	25, 200, bottom	5, 25, 62, 100,150, 200, bottom	5, 25, 62, 100	5, 62	62	Gelatinous
TR5-ST27	2/12/15	none	none	5, 25, 58, 100, 130, 200, 400, bottom	5, 25, 58, 100	5, 58	none	
TR5-ST28	2/12/15	5, 450	25, 200, 450, bottom	5, 25, 58, 100, 150, 200, 450, bottom	5, 25, 58, 100	5, 58	58	
TR5-ST29	2/12/15	none	none	5, 25, 50, 100, 150, 200, 500, bottom	5, 25, 50, 100	5, 50	50	*Pelagia noctiluca,* salps

TR5-ST30	2/12/15	5, bottom	25, 200, bottom	5, 25, 40, 100, 150, 200, 500, bottom	5, 25, 40, 100	5, 40	40	
TR5-ST31	2/12/15	none	none	5, 25, 50, 100, 150, 200, 500, 1000, 1500, bottom	5, 25, 50, 100	5, 50	none	
TR5-ST32	2/12/15	5, 1000, bottom	none	5, 25, 50, 100, 150, 200, 500, 1000, 1500, bottom	5, 25, 50, 100	5, 50	50	Convergence NC & AL

6.1.5 Preliminary results:

The final biogeochemical dataset will be produced in due course following post-cruise analysis of the data. Below we present some preliminary results obtained with the CTD sensors for salinity (Sea-Bird SBE-911*plus*), dissolved oxygen (Sea-Bird SBE43) and *in vivo* fluorescence (SeaPoint Chlrophyll Fluorometer) distribution on transect TR1.

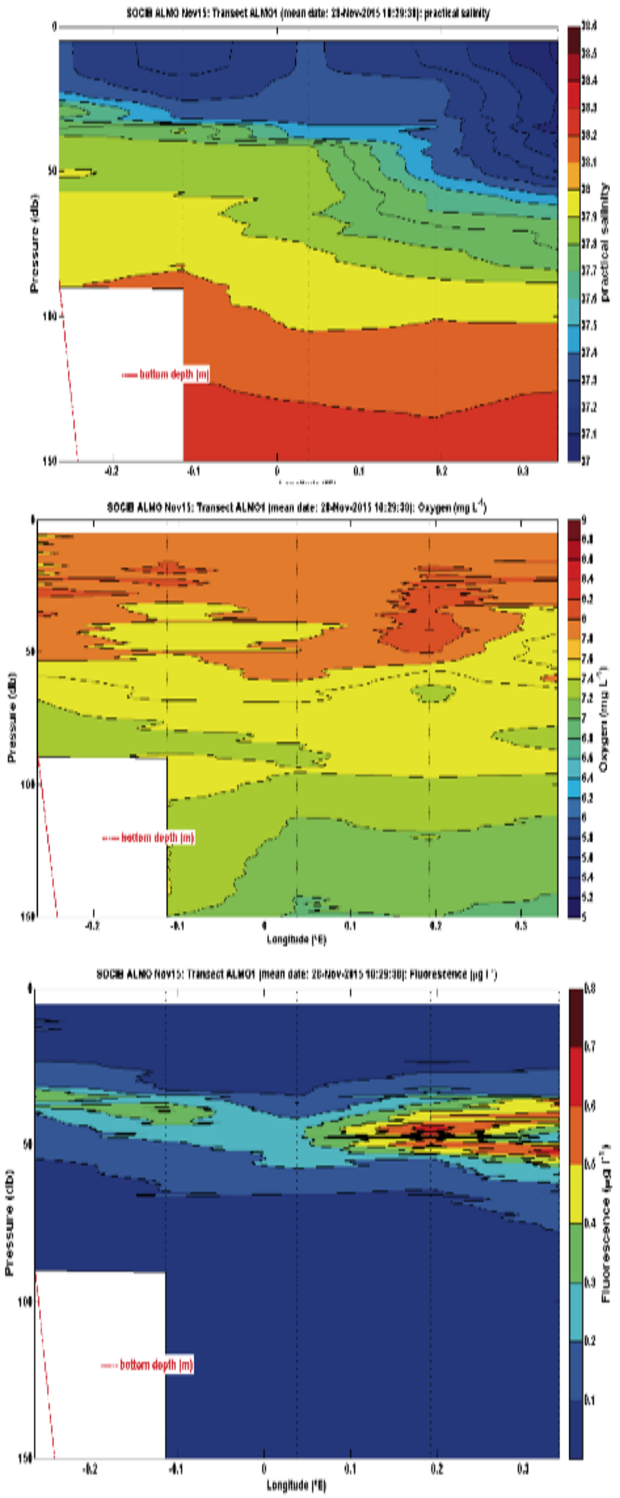


Fig. 6.1.1. Initial figure for salinity, dissolved oxygen and fluorescence distribution obtained during transect 1 of the cruise (CTD sensor measurements, SBE-911*plus* CTD probe, Sea-Bird Electronics).

6.1.6 References:

Langdon C. (2010) Determination of dissolved oxygen in seawater by Winkler titration using *the amperometric technique. In: Sloyan B.M., Sabine C. (Eds). GO_SHIP repeat hydrography manual: A Collection of Expert Reports and guidelines. IOC/ IOCCP. Paris.*

Utermöhl H. (1958) Zur Vervollkommung der quantitativen Phytoplankton Methodik. Mitt Int Ver Theor Angew Lim- nol 9:1–38.

6.2 Physical Data Report – ADCP and CTD

6.2.1 Introduction

The following report contains an overview of the physical data collected from the CTD and the VM-ADCP on board the R/V SOCIB catamaran from the 27th November to the 2nd December 2015. The methods section will be split into two sections. Firstly, a technical description of the VM-ADCP and the resulting calibration report are provided, while the second section briefly outlines the steps followed in order to process the data to provide initial results as shown in the results section. Scientific interpretation is not included in this report.

Aim: Teleconnections of the Northern Current: How does the Northern Current evolve as it flows toward the Almerìa-Oran Front and what role does it play on the transfer of water masses?

Objective: to undertake 5 sections perpendicular to the coastline of mainland Spain, crossing the Northern Current as it traverses south and westwards towards the Strait of Gibraltar. The aim of the final section is to locate the Almerìa-Oran Front and sample both the northern Mediterranean side and the southern Atlantic side of the front.

6.2.2 Methods

Each section consists of CTD stations with the following sensor measurements: temperature, conductivity (and therefore practical salinity), turbidity, fluorescence and oxygen. Water samples were taken for biogeochemical purposes as well as calibration purposes for both salinity and oxygen. Throughout the entire cruise (i.e. both during sections and during transits), a VM-ADCP was recording data about the movement of the upper water column, while a thermosalinograph recorded surface temperature and salinity.

6.2.2.1 On board data processing VM-ADCP

The R/V SOCIB is equipped with a 150 kHz, RDI Ocean Surveyor, VM-ADCP (vessel-mounted Acoustic Doppler Current Profiler) transducer located in the port hull just forward of the accommodation bulkhead in front of the fuel tanks. Data is recorded and displayed real-time using the RDI developed software VmDas (RDI's data acquisition and playback software) and WinADCP (RDI's visualisation software).

Processing VM-ADCP data is a complex procedure, but SOCIB has begun making this a routine non specialist task. Here, the data are left in its basic processed state with no quality control procedures to remove spurious data. In the results section, three types of plots are presented. Here, the process of creating these figures are briefly described.

The basic data processing was carried out to SOCIB's VM-ADCP standard operating procedures (SOPs) within VM-DAS and WinADCP. This applied the following steps:

Step 1: Replace velocity 'data' with an absent value or flag if variable "2+bmbad" is greater than 25% (% of pings where >1 beam return echo is bad and therefore no velocity computed).

Step 2: Align vector components to 3D-GPS heading data..

Step 3: Apply the calibration misalignment angle, ø, and scaling factor, A. This should be checked on every science cruise, as discussed in the SOPs, if at all possible.

Step 4: Subtract the vessel velocity from the adcp data. The end product is the absolute velocity of the water.

Step 5: Real-time WinADCP visualisation was generally used to monitor the .STA (short term average) data files, using a monitoring time interval of 120 seconds. When not in 'monitor' mode, WinADCP was used to output current profile data and ancillary data (e.g. bottom tracking) in either ascii or MatLab format.

Throughout the duration of the cruise, the initiation files for both bottom-tracking and water-tracking mode included the following settings:

- Transducer depth = 2 metres
- Blank distance = 8 metres
- Number of Bins = 50
- Bin thickness = 8 metres
- Max range for bottom tracking = 400 metres
- STA files (short term averaging): 120 seconds
- LTA files (long term averaging): 600 seconds

The EA Heading alignment was set to -45.5^o while the velocity scale factor for profile velocities was set to 1.0080, in accordance with previous cruises. These values correct for misalignment between the VM-ADCP instrument and the ship. Throughout the cruise, a total of 5 transects were carried out in bottom-tracking mode for the purpose of misalignment calibration checks (as described in the SOPs). The bottom track STA files were read into excel and sections of data were then copied into a VM-ADCP calibration spreadsheet. These data sections were subjectively chosen on the basis of relatively constant ship velocity, heading and bottom depth. The calibration spreadsheet follows the standard theory for VM-ADCP installation calibration from bottom track information as described in Joyce (1989) and Pollard and Reed (1989). The resulting calibrations of the five bottom-track sections are provided in table 6.2.1. The mean misalignment angle varies from about -0.007^o to about 0.012^o, with no statistical significance. The mean amplitude factor varies from about 1.0003 to 1.0035. By multiplying the mean amplitude factor with the presently used velocity scale factor (1.0080), a recommended velocity scale factor is calculated. The calibrations suggest that the velocity scale factor could be increased from the present 1.0080 to as much as 1.0115, with statistical significance. However, this extreme value comes from a short data transect and the calibration is based on just 10 data points, with slightly more varied bottom depth and ship velocity in comparison to the other calibration files, and therefore it is recommended to treat this calibration as an outlier. All other calibrations suggest an increase in the velocity scale factor to between 1.0090 and 1.0099, but with little or no statistical significance. Therefore the heading alignment and velocity scale factor both remained at -45.5^{o} and 1.0080 respectively during the cruise.

Since the VM-ADCP is running constantly, it is sometimes difficult to distinguish at which point in the contour plots, provided by WinADCP, the ship is stationary during station sampling, and when the ship is in transit between stations (i.e. each data file provides continuous measurement that does not distinguish between station and transit times). The two-minute short-term-averaged data (.STA) are therefore exported from WinADCP and the contour plots are recreated in MATLAB, with a corresponding subplot which shows the distance between the mid-points of each ensemble. Thus, when the ship is on station, the distance between each ensemble decreases to more or less 0, and when the ship is in transit, the distance typically increases to above 0.4 km. This allows for the creation of the final type of contour plot provided by the VM-ADCP .STA data, where all ensembles measured when the ship is on station are removed from the contour plots, in order to focus on ship transects, which is more representative of the spatial variation in water velocity. These were created by removing all ensemble data points where the distance between data points is less than 0.4 km. This value was fairly arbitrarily chosen and other values could be found necessary on other cruises. By using the largest distance possible without losing obvious sections of data measured while the ship is moving, we remove as much as possible of the ensemble data points measured when the ship is accelerating/decelerating as it approaches/leaves a station. Note these plots have no quality control processing and are essentially a quick method of visualising the VM-ADCP data. Post-cruise processing will introduce further data-quality procedures in the near future.

Table 6.2.1: VM-ADCP Calibration summary.

Date	File	No. of data points	Mean Phi (misalignement)	Std Phi	Statistically significant?	Mean Amplitude Factor	Std Amplitude Factor	Recommended Velocity scale factor
27/11/15	15001	45	-0.00699	0.2818	No	-1.00187	0.0077	1.0099
27/11/15	15002	59	-0.0388	0.2440	No	-1.00170	0.0055	1.0097
29/11/15	15004	16	-0.0594	0.1701	No	-1.00096	0.0026	1.0090
30/11/15	15007	10	-0.0079	0.0813	No	-1.00349	0.0011	1.0115
02/12/15	15010	21	0.0121	0.1361	No	-1.00112	0.0013	1.0091

6.2.2.2 On board data Processing: CTD

On board the R/V SOCIB is a Seabird SBE911 Plus CTD fixed onto a stainless steel Rosette frame fitted with twelve Niskin-bottles, and is equipped with the following sensors:

- Temperature x 2
- Salinity (conductivity) x 2
- Fluorescence
- Transmittance
- Turbidity
- Chlorophyll
- Surface PAR
- PAR
- Oxygen

CTD casts were carried out at a total of 32 stations, taking place along 6 transects (one transect consists of just three stations and had been labelled in the CTD data as transect 2B and is considered a sub-section due to its close proximity to transect 2). At each station, the biogeochemistry team on board took samples for biogeochemical studies of the upper water column to determine the influence of the Northern Current on the spatial distribution and concentration of nutrients, chlorophyll and dissolved oxygen; as well as for the validation/calibration of the salinity and oxygen sensors, all of which will be carried out post cruise.

For further details regarding the methodology regarding the tech specs of the CTD stations and also of the water sampling, refer to the ETD technical report and the biogeochemical report respectively.

While on board, the CTD data were processed using Seabird Data Processing Version 7.23.2. The processing is outlined as follows:

1. ***Data Conversion***: converts raw data from engineering units to binary .cnv files; .ros files are also produced. The following variables were exported (note where there are two sensors available, the sensors are labelled as 0 and 1 (e.g. t090C and t190C, and c0mS/cm and c1mS/cm):

   # name 0 = latitude: Latitude [deg]

   # name 1 = longitude: Longitude [deg]

   # name 2 = depSM: Depth [salt water, m]

   # name 3 = prDM: Pressure, Digiquartz [db]

   # name 4 = t090C: Temperature [ITS-90, deg C]

   # name 5 = t190C: Temperature, 2 [ITS-90, deg C]

   # name 6 = T2-T190C: Temperature Difference, 2 - 1 [ITS-90, deg C]

name 7 = c0mS/cm: Conductivity [mS/cm]

name 8 = c1mS/cm: Conductivity, 2 [mS/cm]

name 9 = C2-C1mS/cm: Conductivity Difference, 2 - 1 [mS/cm]

name 10 = sal00: Salinity, Practical [PSU]

name 11 = sal11: Salinity, Practical, 2 [PSU]

name 12 = secS-priS: Salinity, Practical, Difference, 2 - 1 [PSU]

name 13 = density00: Density [density, kg/m^3]

name 14 = density11: Density, 2 [density, kg/m^3]

name 15 = D2-D1,d: Density Difference, 2 - 1 [density, kg/m^3]

name 16 = sbeox0Mg/L: Oxygen, SBE 43 [mg/l]

name 17 = spar: SPAR/Surface Irradiance

name 18 = par: PAR/Irradiance, Biospherical/Licor

name 19 = flSP: Fluorescence, Seapoint

name 20 = seaTurbMtr: Turbidity, Seapoint [FTU]

name 21 = flag: 0.000e+00

2. ***Filter*** applied a low-pass filter (value of 0.15s) on the pressure and depth data, which smoothed the high frequency (rapidly changing) data.
3. ***AlignCTD*** compensates for sensor time-lag between the pressure, temperature and conductivity sensors. Advance primary (and secondary) conductivity = 0.073 seconds
4. ***Cell Thermal Mass*** applied a filter to remove conductivity cell thermal mass effects from the measured conductivity.
5. ***Derive***, densities sigma-theta (kg/m3) for T/C sensor pair 2, salinities (psu) for both T/C sensor pairs and depth(m) were calculated.
6. ***ASCII Out*** converted data from binary to ASCII format by the module. The data had been kept in binary format up to this stage to avoid any loss in precision that could occur when converting to Ascii.
7. ***BottleSum*** created the ASCII bottle files (.btl) from the .ros files for each bottle fired within a single cast. These files consist of the mean, standard deviation, maximum and minimum values for all variables scanned over a 5 second period.
8. ***BinAve*** provided averages for all variables over 0.5 metre bins. (in ASCII format thanks to ***ASCII Out***).

Once CTD data were processed using the SeaBird software, the BIN_AVE .cnv files are read into MATLAB (version R2013a) and converted into a MATLAB structured array, grouped together according to transect number. The structured array does not include up casts; down casts are assumed to be steadier due to the fall rate of the CTD versus the heave of the ship during an upcast. Contour plots of all sections are created for each variable and shown in the following results section. Note the resolution of the sections by noting the station locations as marked by the vertical black dotted lines in each contour plot. Additionally, T/S Diagrams and temperature-pressure and salinity-pressure profiles are also plotted. For this report, the figures provided for potential temperature and salinity are derived from the secondary sensor, t190C and sal11 respectively. Upon availability of the in situ salinity bottle sample data, calibration of both conductivity (and thus salinity) sensors can be carried out, and the sensor providing the most accurate results (according to the bottle sample data) will be provided and plotted in a future processed data post cruise report.

6.2.3 Results

This section is structured as follows: firstly, vector plots showing current water velocity from the entirety of the cruise are shown. The remainder of the figures are presented in order of day/section.

6.2.3.1 Velocity Vector Maps

Figures 6.2.1.1 to 6.2.1.4 show velocity vectors averaged into 4 km bins mapped over bottom water bathymetry at 24, 56, 64 and 72 metres respectively. The magnitude of the velocity decreases with increasing depth, and all three plots show the direction of the flow generally following the bathymetry contours. In the latter two plots, the direction of flow switches by about 180º from a predominantly westward direction north of about 36.2 ºN to a predominantly eastward direction south of this apparent frontal region. This could be representative of the Almerìan-Oran Front, which will be investigated further upon assessment of the ADCP contour plots shown in section 6.2.3.2. While the flow is predominantly south and south-westwards, following the coast towards the Strait of Gibraltar, there are a small number of vectors hugging the coastline that shows a reverse flow. It may be that a coastal counter current flows along the coastline where bottom depth is less than 100 m (i.e. the lightest blue, lowest contour colour in figures 6.2.1.1-4).

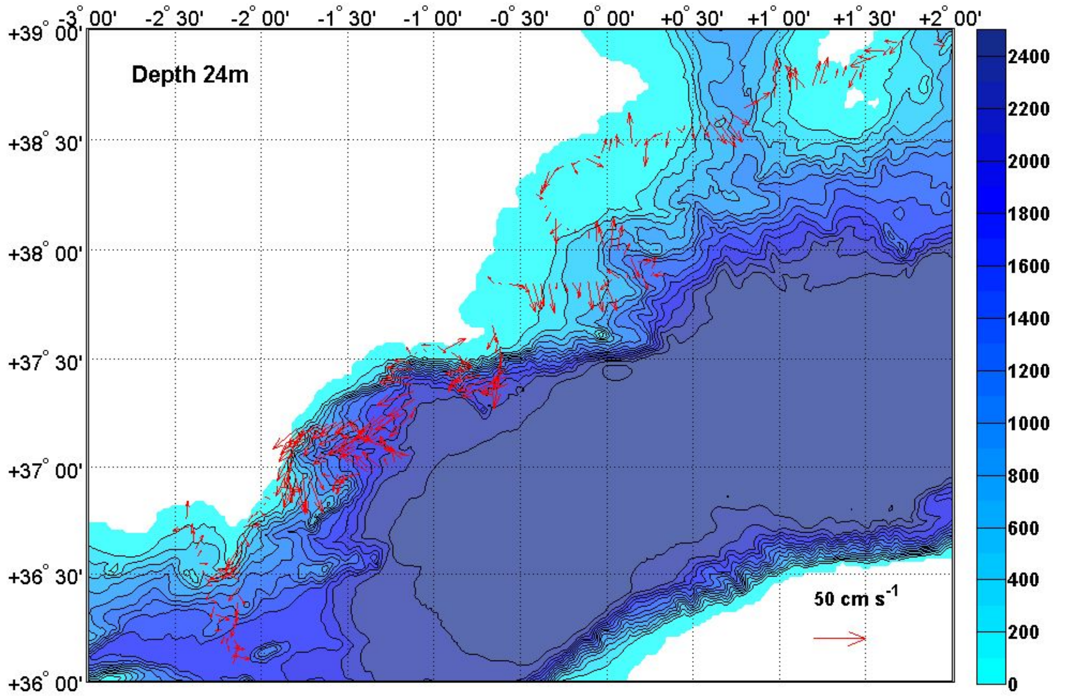


Fig. 6.2.1.1. 4 km averaged velocity vectors (cm s^{-1}) at 24 metres over bottom bathymetry (m) from VM-ADCP.

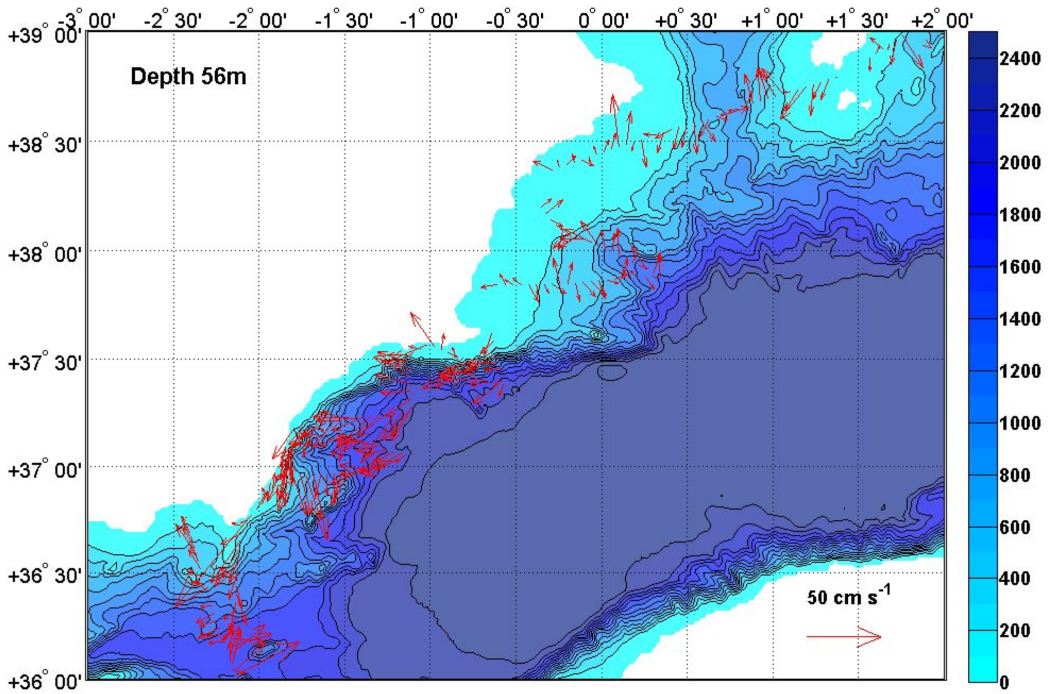


Fig. 6.2.1.2. 4 km averaged velocity vectors (cm s^{-1}) at 56 metres over bottom bathymetry (m) from VM-ADCP.

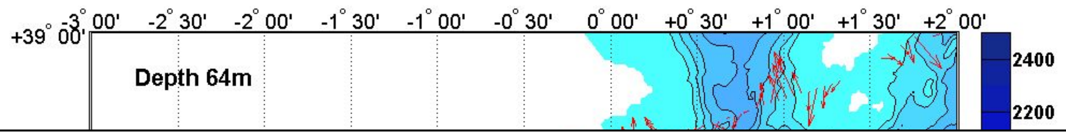


Fig. 6.2.1.3. 4 km averaged velocity vectors (cm s^{-1}) at 64 metres over bottom bathymetry (m) from VM-ADCP.

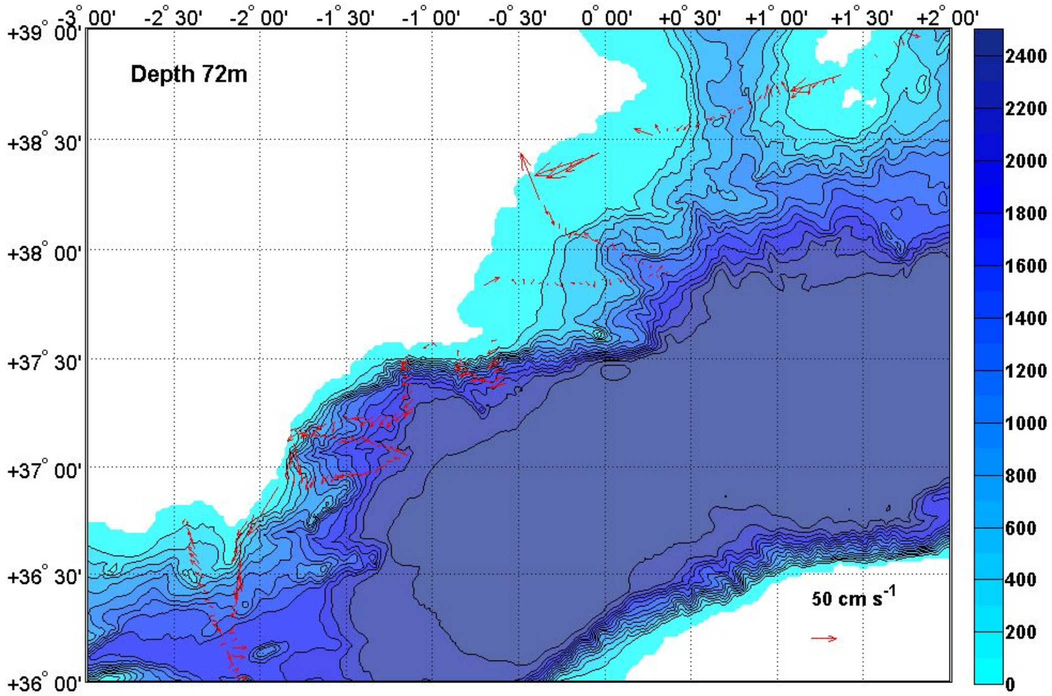


Fig. 6.2.1.4. 4 km averaged velocity vectors (cm s^{-1}) at 72 metres over bottom bathymetry (m) from VM-ADCP.

6.2.3.2 VM-ADCP velocity contour plots and CTD sections

The following section is laid out as follows. Each sub-section shows results based on a different transect of the cruise. The first sub-section shows ADCP results only as no CTD sections were carried out on this day (27/11/2015; with the exception of a test station in the deepest part of the Ibiza Channel to test a new cable for the CTD). For the remaining sub-sections, the figures are presented as follows:

1. VM-ADCP contour whole: shows the u (East/West) and v (North/South) velocity as a function of ensemble number, while the third plot shows the distance between the mid-points of each ensemble bin, to highlight the moments when the ship is on station (distance will be close to 0 km) and when the ship is in transit (distance will be more than 0.4 km).
2. VM-ADCP with stations removed: shows the u (East/West) and v (North/South) velocity as a function of cumulative distance between ensemble mid-points, where all ensemble points where the distance between cumulative ensemble bins is less than 0.4 km are removed to show only data from when the ship is moving.
3. CTD sections: top 300 m
    3.1. Potential temperature (ºC)
    3.2. Salinity
    3.3. Sigma potential density (kg m^{-3})
    3.4. Oxygen (mg L^{-1})
    3.5. Fluorescence (µg L^{-1})
    3.6. Turbidity (FTU)
4. CTD sections: to 2500 m
    4.1. Potential temperature (ºC)
    4.2. Salinity
    4.3. Sigma potential density (kg m^{-3})
    4.4. Oxygen (mg L^{-1})

Most transects include one ADCP section; with the exception of day one and of day 6 where two sections covering significant distances are available.

T/S diagrams are presented together in the following section 6.2.3.3.

<u>27/11/2015: Transit from Palma de Mallorca to Port of Alicante</u>

VM-ADCP was run in bottom-tracking mode for the entire day for calibration purposes. There are two VM-ADCP files, 15001 (Fig. 2.1.1) begins on transit from the bay of Palma de Mallorca, and file 15002 (Fig. 2.1.2) begins at the deepest part of Ibiza channel at 38.6366º N, 0.7721º E, when a test CTD cast was carried out, to the port of Alicante. The figures show contour plots of velocity in the east/west (a) and north/south (b) direction, and a plot of ensemble number as a function of distance between the mid-points of each ensemble (c). Thus, where the distance is almost 0 km, the ship is on station.   .

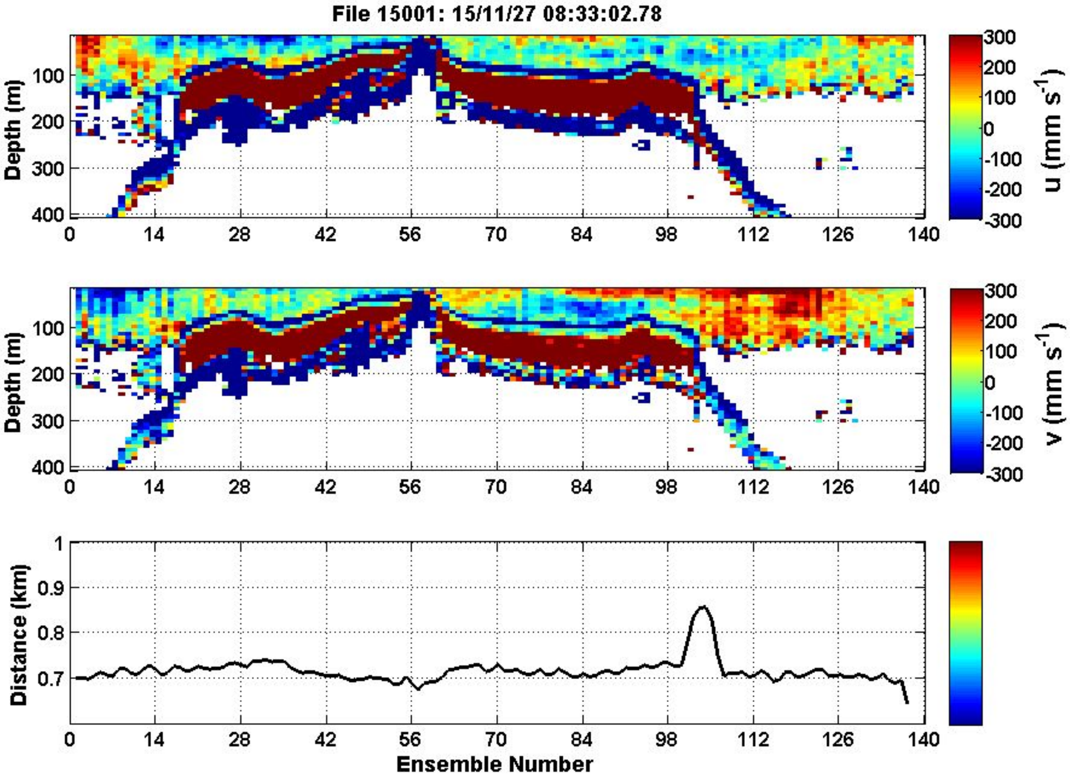


Fig. 2.1.1 VM-ADCP current velocity in the East/West direction (a) and in the North/South direction (b) and the distance between the mid-points of each ensemble bin number (c). Ensemble 1 begins in Palma Bay while ensemble 140 ends in the deepest part of the Ibiza Channel.

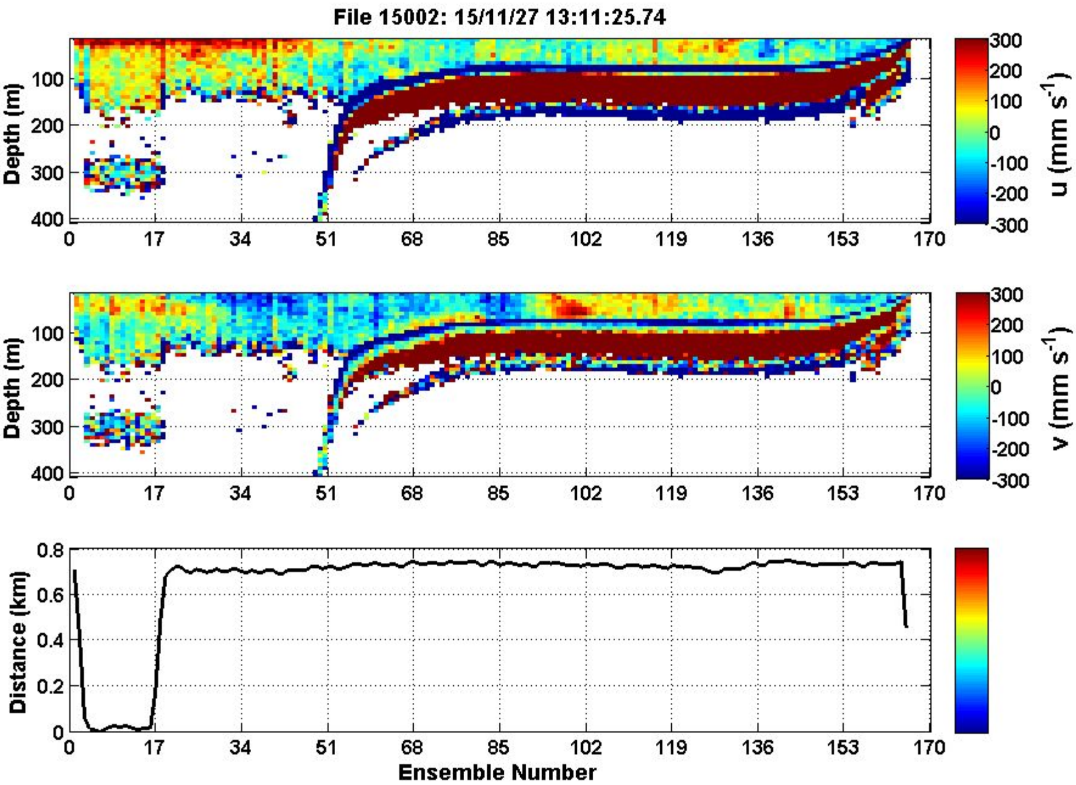


Fig. 2.1.2. VM-ADCP current velocity in the East/West direction (a) and in the North/South direction (b) and the distance between the mid-points of each ensemble bin number (c). Ensemble 1 begins in the deepest part of the Ibiza Channel while ensemble 166 ends while approaching the Port of Alicante.

Day 1 (28/11/2015): Section 1

Transect: from the port of Alicante at 38º 19.806 N, 0º 29.452 W to final station 5 at 37.8794º N, 0.3425º E, and then to port of Manga at 37º 44.231 N, 0º 42.795 W.

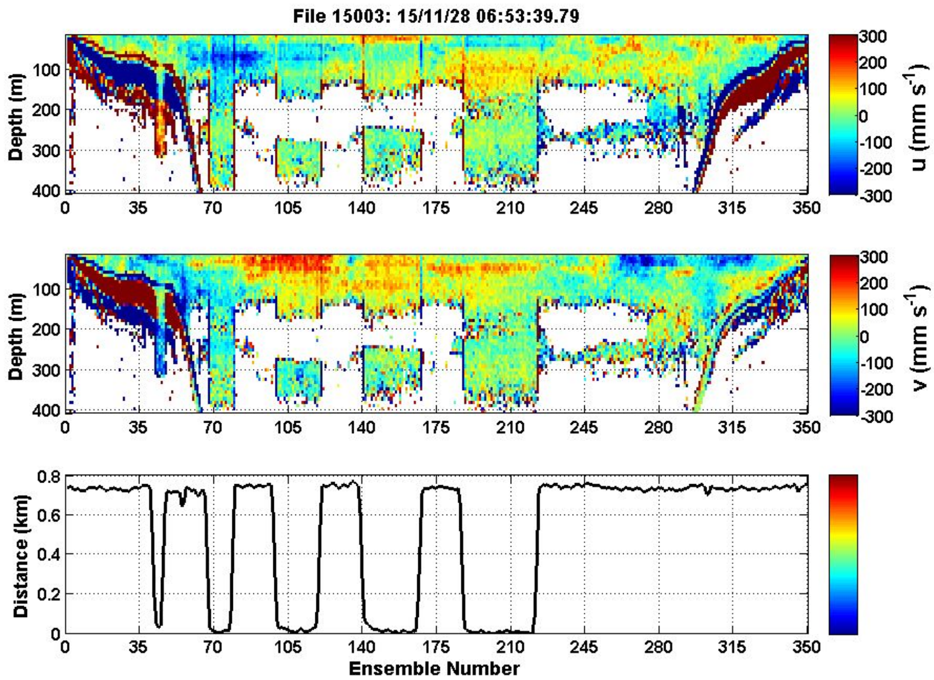


Fig 3.1. VM-ADCP current velocity in the East/West direction (a) and in the North/South direction (b) and the distance between the mid-points of each ensemble bin number (km). Ensemble 1 begins at 38.3242° N, 0.4891° W and ensemble 352 ends at 37.8269° N, 0.7274° W. The ship turning point occurs at ensemble 220.

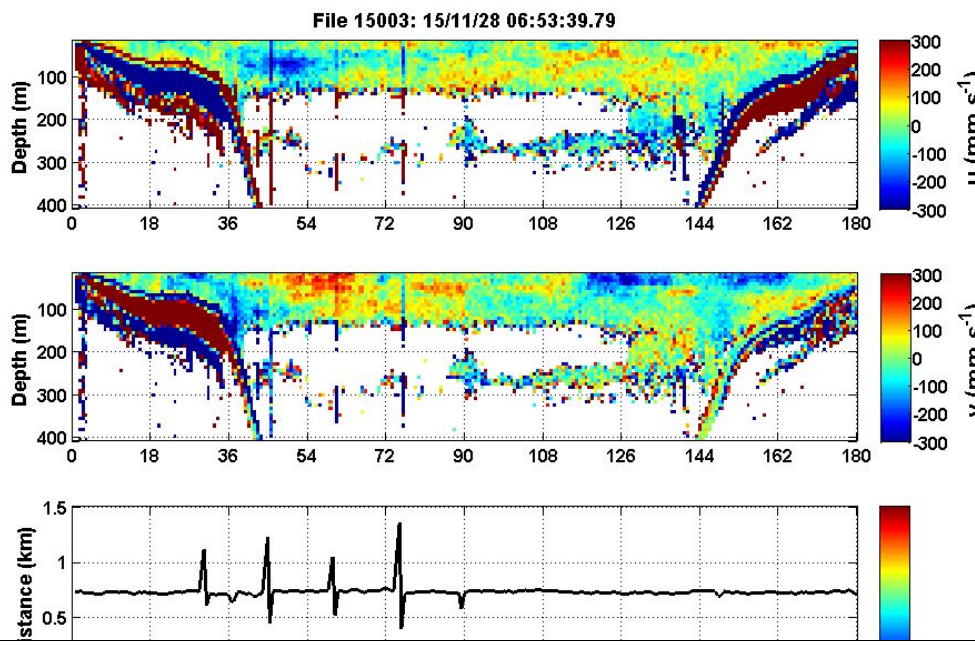


Fig. 3.2 VM-ADCP current velocity in the East/West direction (a) and in the North/South direction (b) and the distance between the mid-points of each ensemble bin number (km) as a function of cumulative distance between ensemble bins, with station data removed. The spikes in Fig. c indicate where station data have been removed. Ensemble 1 begins at 38.3242° N, 0.4891° W and a after a transit of 180 km ends at 37.8269° N, 0.7274° W. The ship turning point occurs at ensemble 220, 90 km.

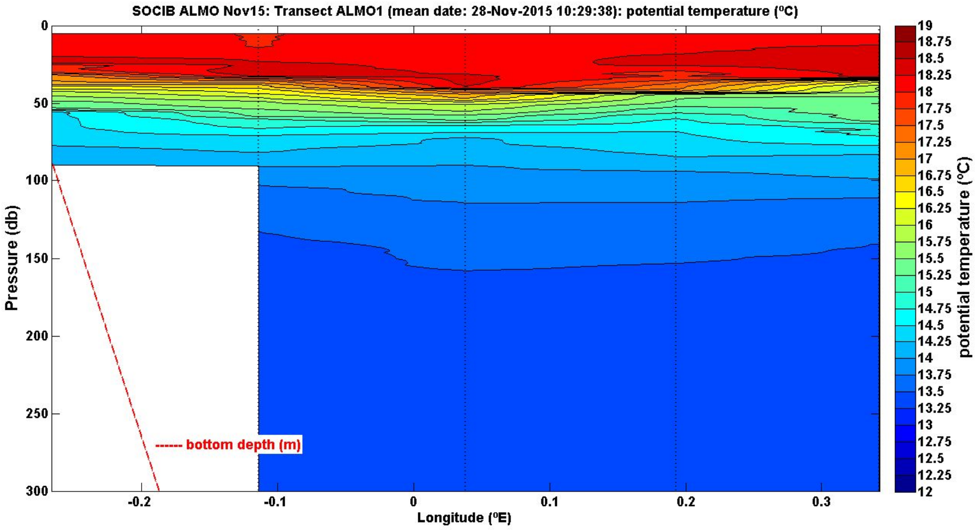


Fig. 3.3.1. Potential Temperature (ºC) contour section of the top 300 m. Station locations are indicated by black dotted vertical lines.

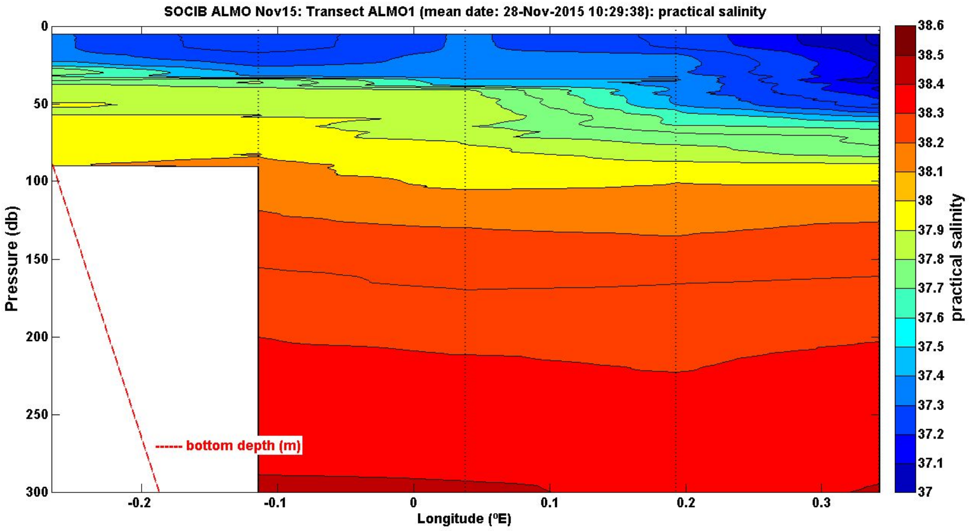


Fig. 3.3.2. Practical Salinity contour section of the top 300 m. Station locations are indicated by black dotted vertical lines.

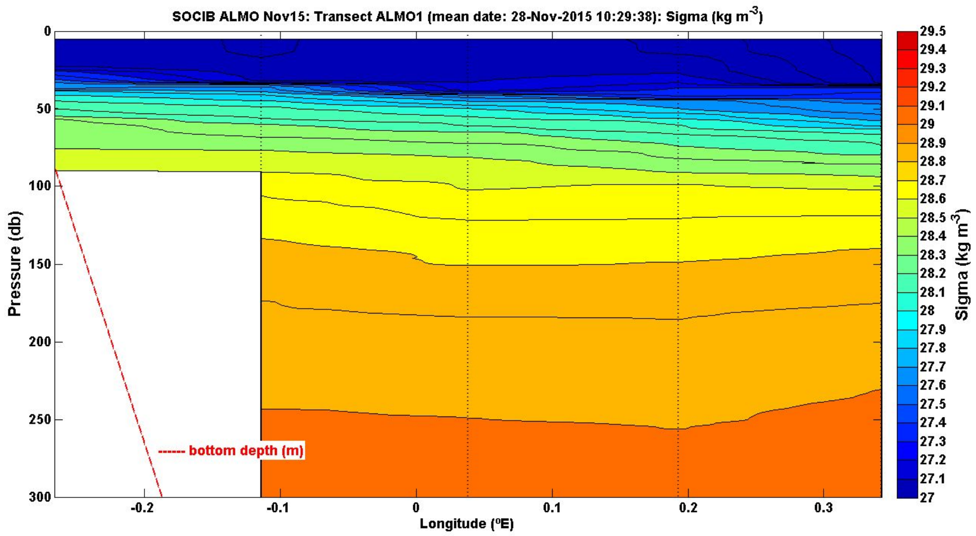


Fig. 3.3.3. Sigma (kg m^{-3}) contour section of the top 300 m. Station locations are indicated by black dotted vertical lines.

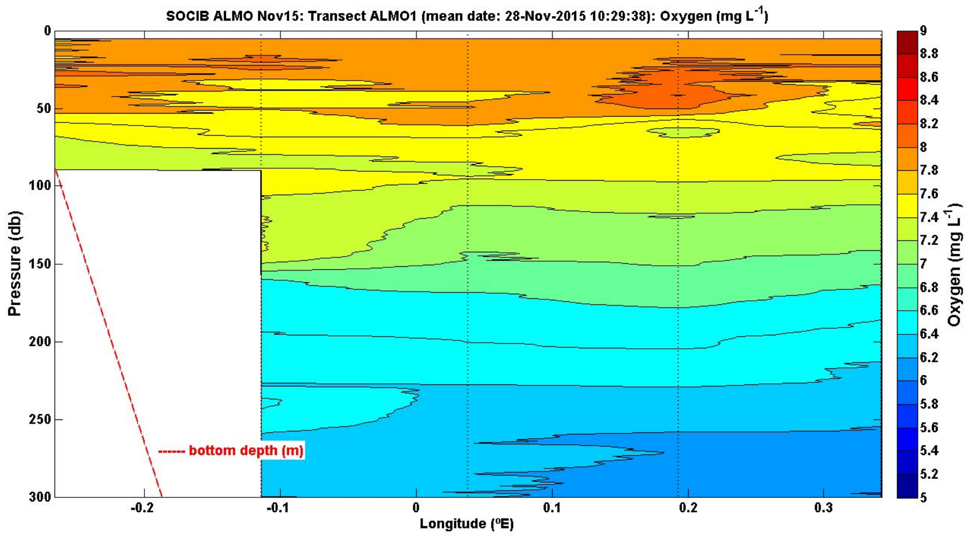


Fig. 3.3.4. Oxygen (mg L^{-1}) contour section of the top 300 m. Station locations are indicated by black dotted vertical lines.

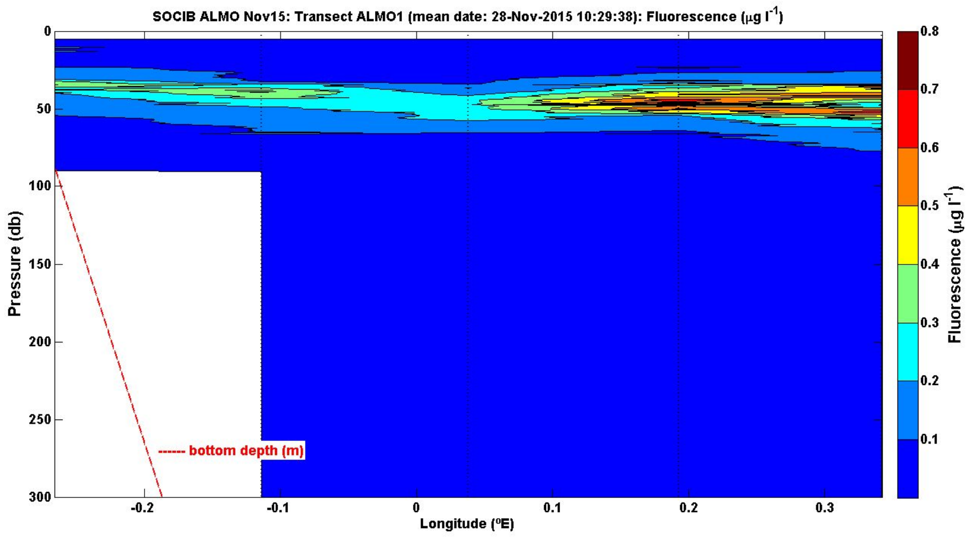


Fig. 3.3.5. Fluorescence (μg L^{-1}) contour section of the top 300 m. Station locations are indicated by black dotted vertical lines.

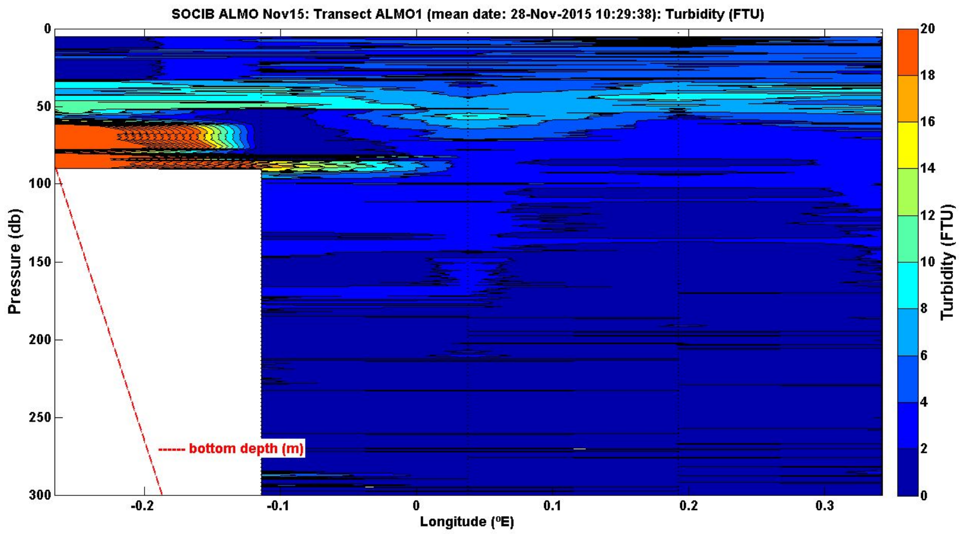


Fig. 3.3.6. Turbidity (FTU) contour section of the top 300 m. Station locations are indicated by black dotted vertical lines.

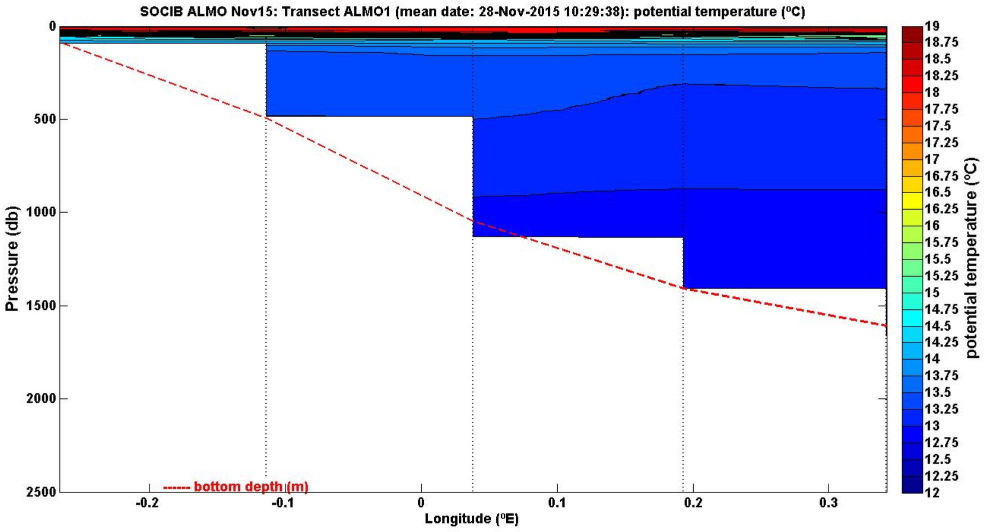


Fig. 3.4.1. Potential Temperature (ºC) contour section of the whole 2500 m. Station locations are indicated by black dotted vertical lines.

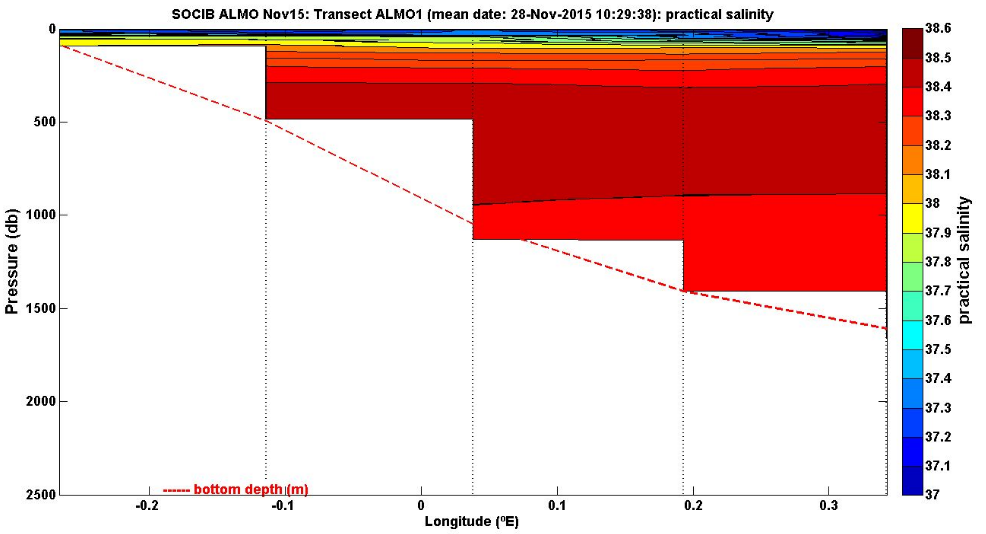


Fig. 3.4.2. Practical Salinity contour section of the whole 2500 m. Station locations are indicated by black dotted vertical lines.

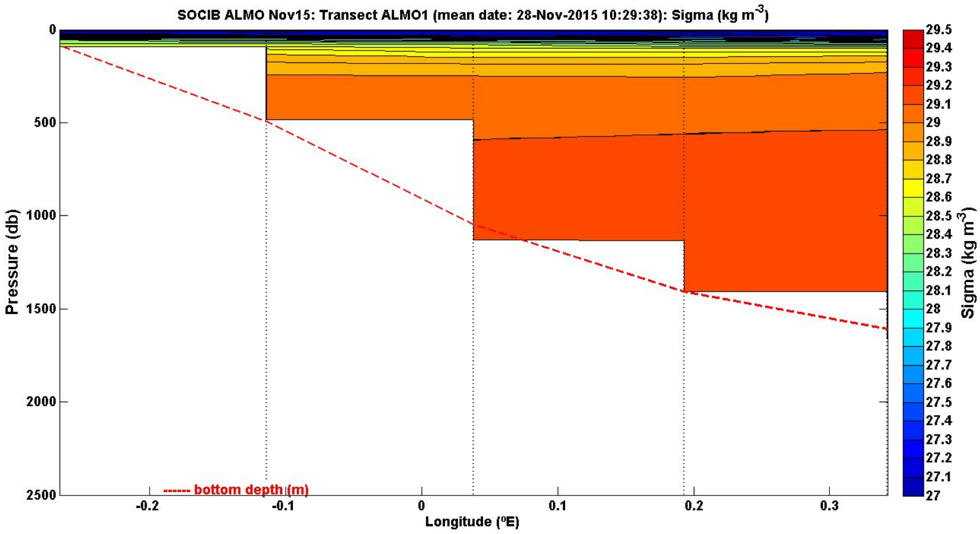


Fig. 3.4.3. Sigma (kg m^{-3}) contour section of the whole 2500 m. Station locations are indicated by black dotted vertical lines.

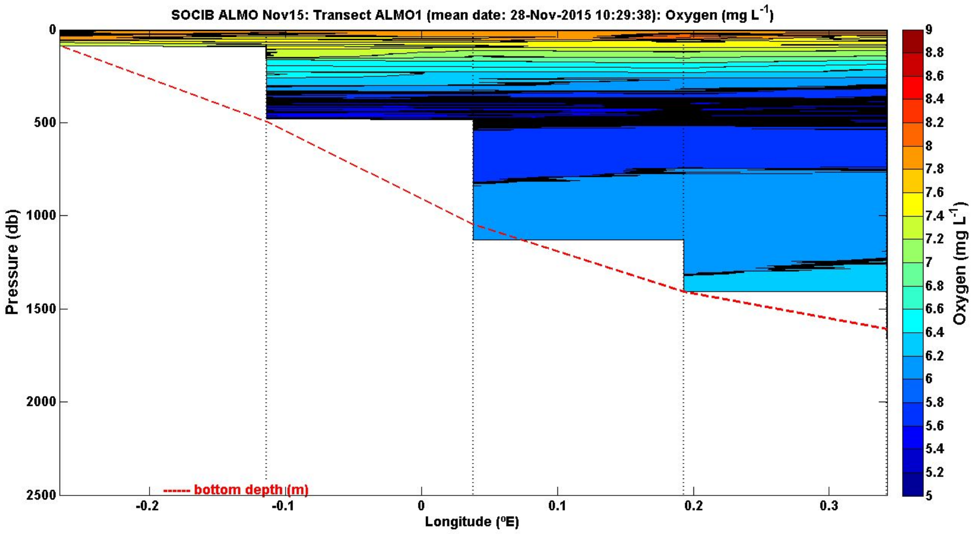


Fig. 3.4.4. Oxygen (mg L^{-1}) contour section of the whole 2500 m. Station locations are indicated by black dotted vertical lines.

Day 2 (29/11/2015): Section 2

Transect: from the port of Manga at 37º 44.231 N, 0º 42.795 W to station 10 at 37.3821º N, 0.5735º W and then to port of Bocana Cartagena. During the return route, transect 2B consisting of three stations was carried out (see section 3.2.4).

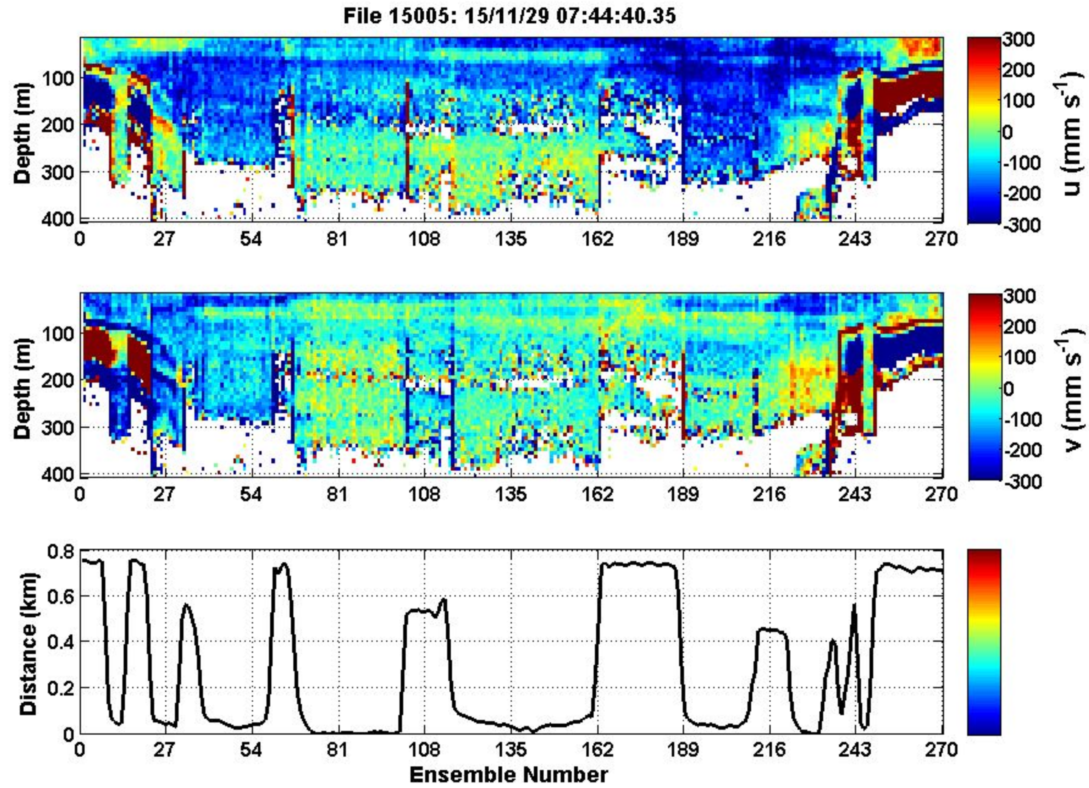


Fig 4.1. VM-ADCP current velocity in the East/West direction (a) and in the North/South direction (b) and the distance between the mid-points of each ensemble bin number (km). Ensemble 1 begins at 37.6398° N, 0.6542° W and ensemble 163 shows the ships southern-most extent at 37.372° N, 0.59° W, and the final ensemble 273 ends at 37.5583° N, 0.979° W. Note this transect incorporates section 2 between ensemble 1 and 163, and section 2B between ensemble 189 and the end ensemble.

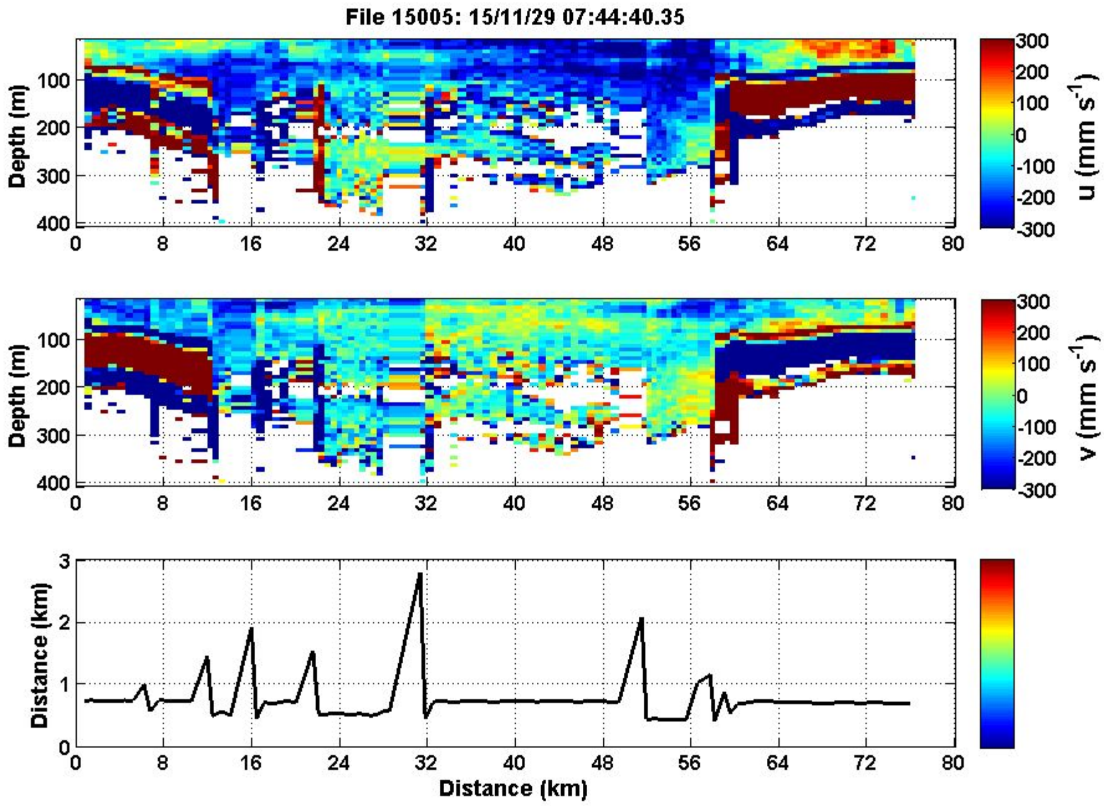


Fig. 4.2 VM-ADCP current velocity in the East/West direction (a) and in the North/South direction (b) and the distance between the mid-points of each ensemble bin number (km) as a function of cumulative distance between ensemble bins, with station data removed. The spikes in Fig. c indicate where station data have been removed. The ship begins its return northward transect after 32 km of steaming south, travelling in a north-westward direction until 50 km into the distance travelled, after which the ship steamed northwards in order to cast stations for section 2B.

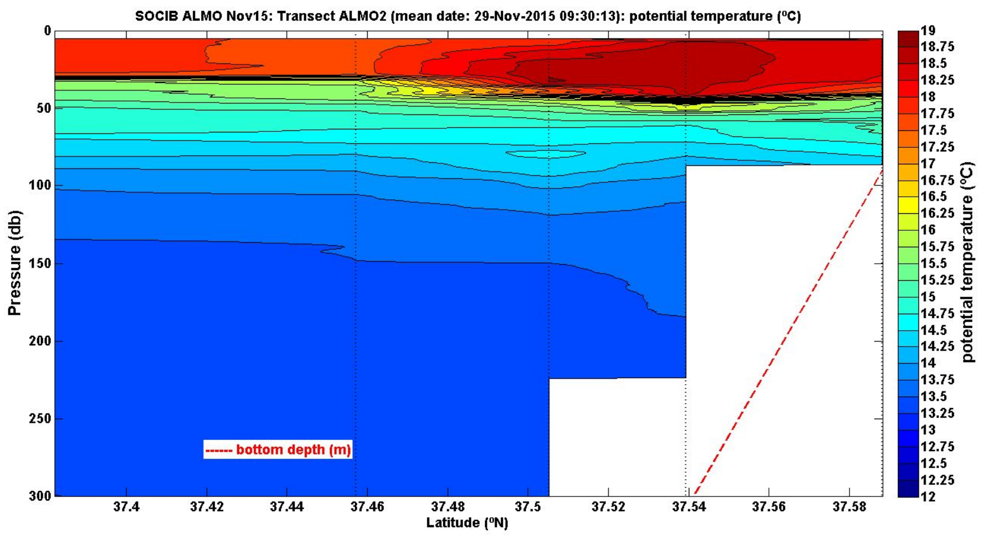


Fig. 4.3.1. Potential Temperature (ºC) contour section of the top 300 m. Station locations are indicated by black dotted vertical lines.

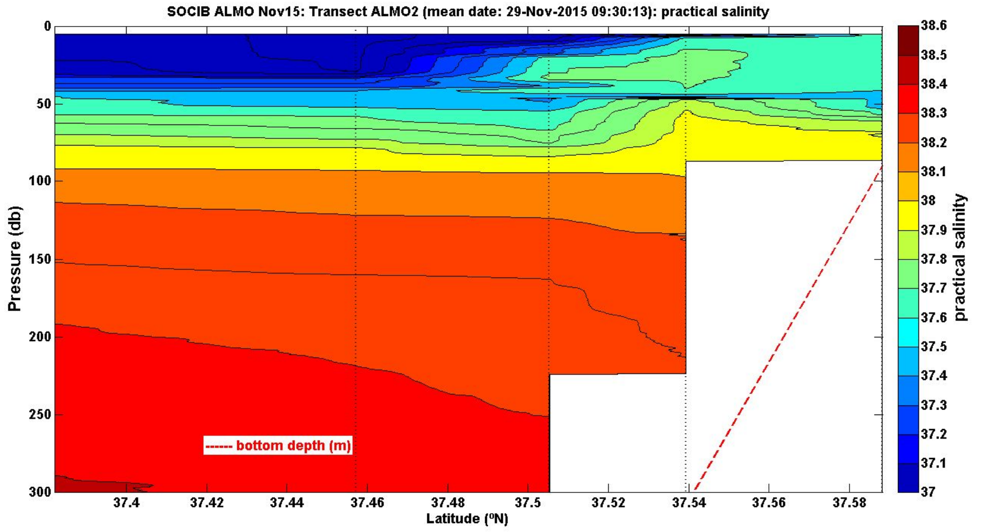


Fig. 4.3.2. Practical Salinity contour section of the top 300 m. Station locations are indicated by black dotted vertical lines.

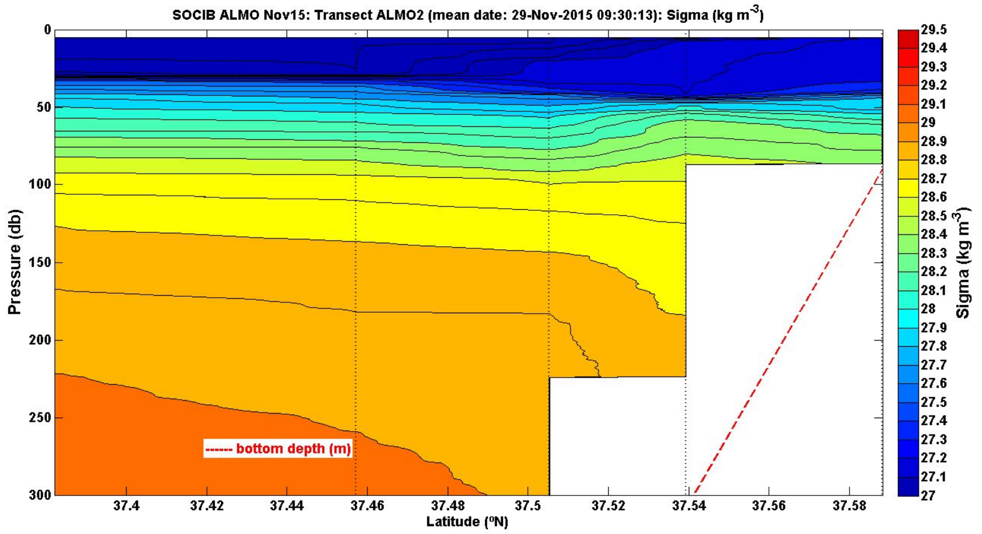


Fig. 4.3.3. Sigma (kg m^{-3}) contour section of the top 300 m. Station locations are indicated by black dotted vertical lines.

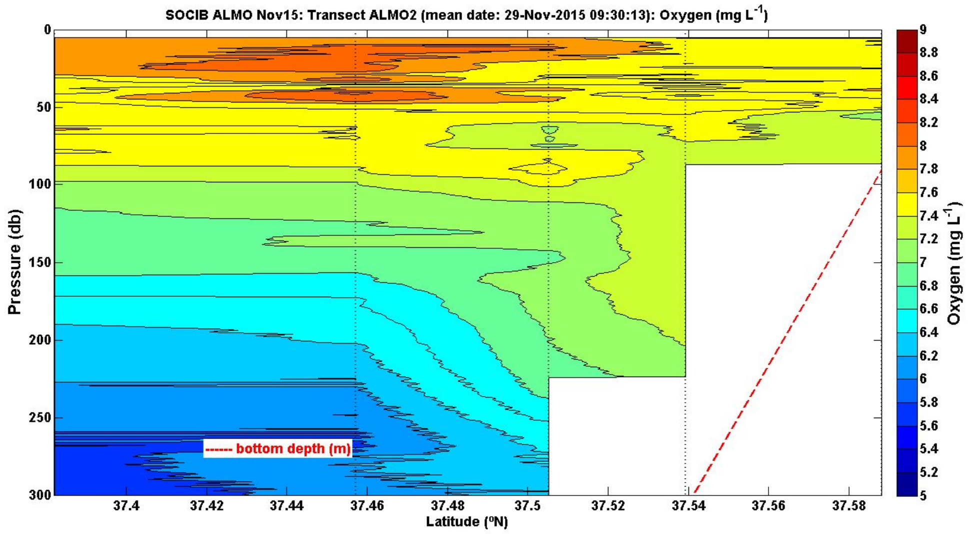


Fig. 4.3.4. Oxygen (mg L^{-1}) contour section of the top 300 m. Station locations are indicated by black dotted vertical lines.

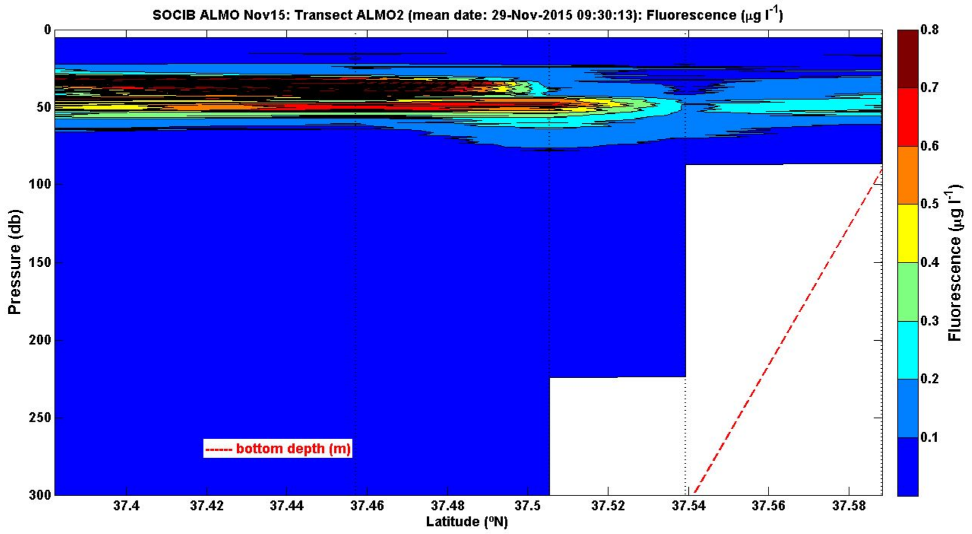


Fig. 4.3.5. Fluorescence (µg L^{-1}) contour section of the top 300 m. Station locations are indicated by black dotted vertical lines.

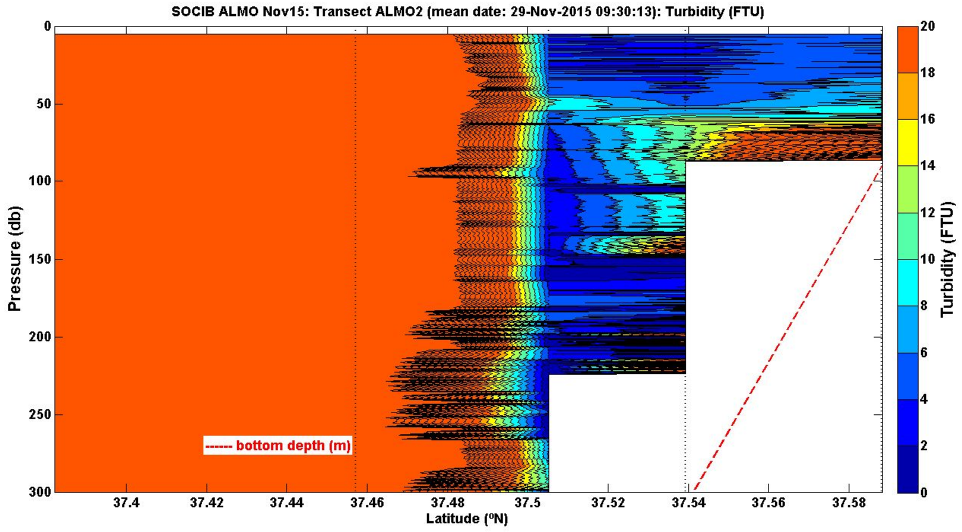


Fig. 4.3.6. Turbidity (FTU) contour section of the top 300 m. Station locations are indicated by black dotted vertical lines. For stations 9 and 10 there appears to be a problem with the turbidity sensor.

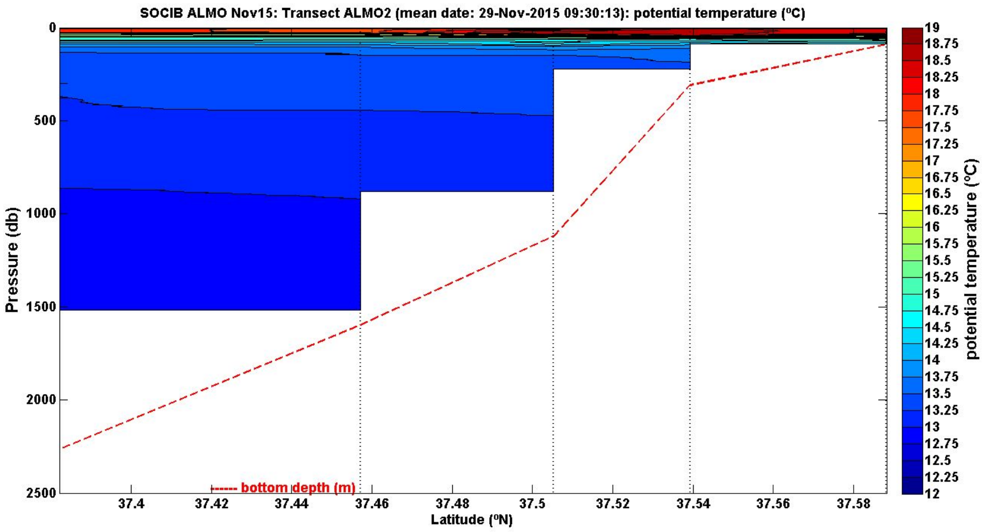


Fig. 4.4.1. Potential Temperature (ºC) contour section of the whole 2500 m. Station locations are indicated by black dotted vertical lines.

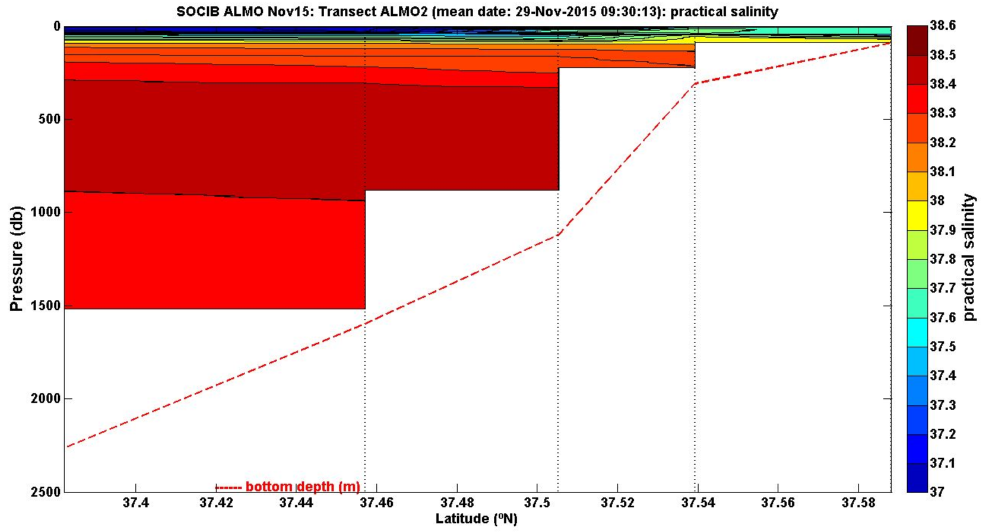


Fig. 4.4.2. Practical Salinity contour section of the whole 2500 m. Station locations are indicated by black dotted vertical lines.

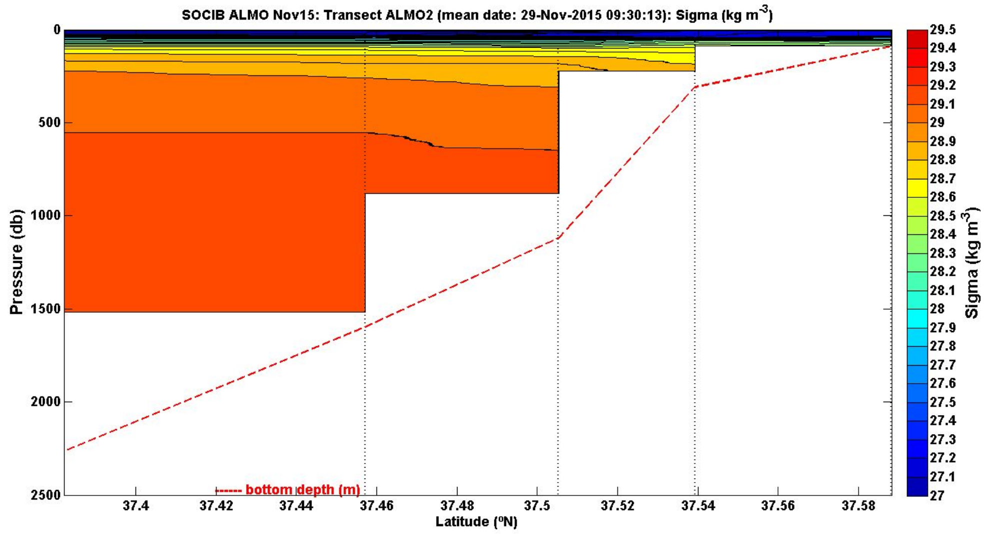


Fig. 4.4.3. Sigma (kg m^{-3}) contour section of the whole 2500 m. Station locations are indicated by black dotted vertical lines.

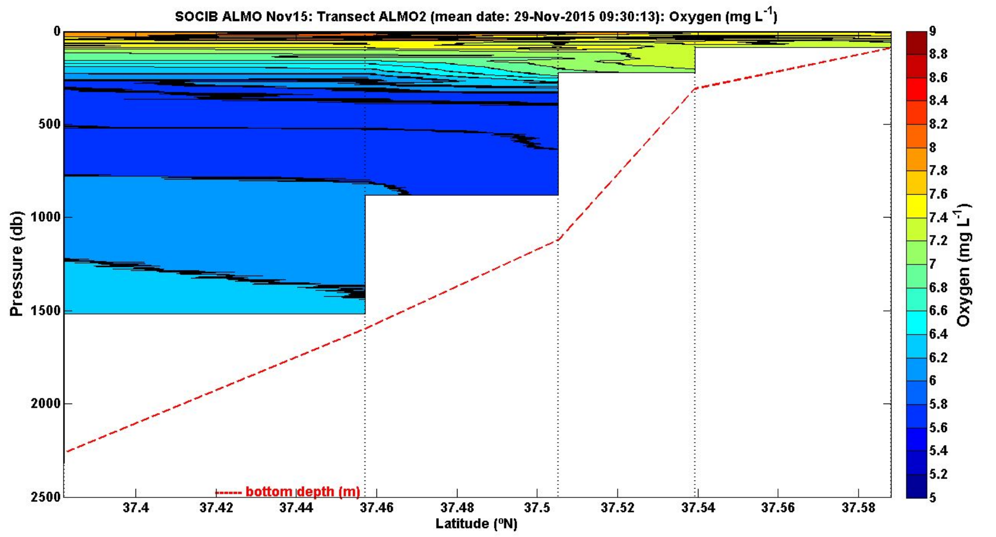


Fig. 4.4.4. Oxygen (mg L^{-1}) contour section of the whole 2500 m. Station locations are indicated by black dotted vertical lines.

__Day 2 (29/11/2015): Section 2B__

Transect: This section covers a small segment of steep bathymetric gradient from station 11 at 37.4343° N, 0.7873° W to station 13 at 37.4979° N, 0.7956° W.

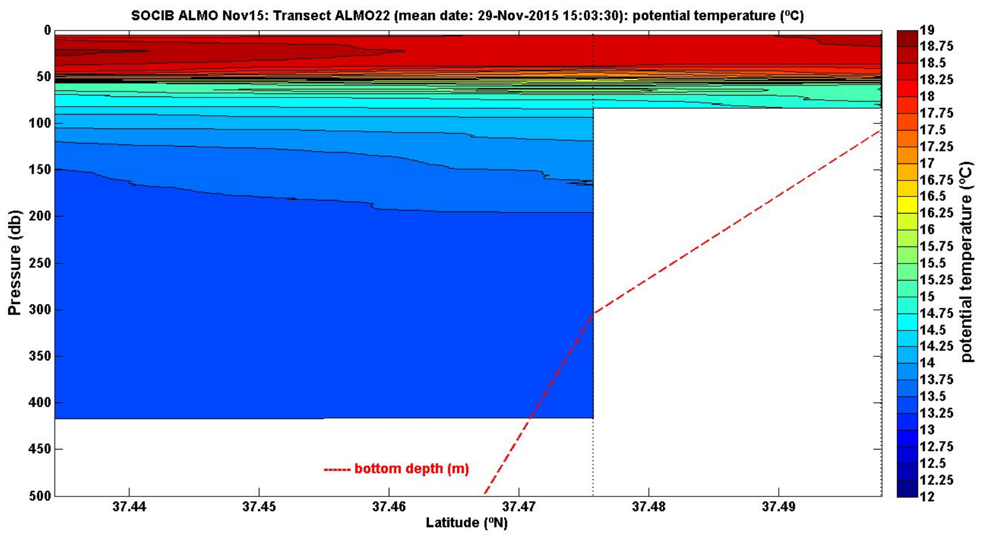


Fig. 5.3.1. Potential Temperature (ºC) contour section of 500 m. Station locations are indicated by black dotted vertical lines.

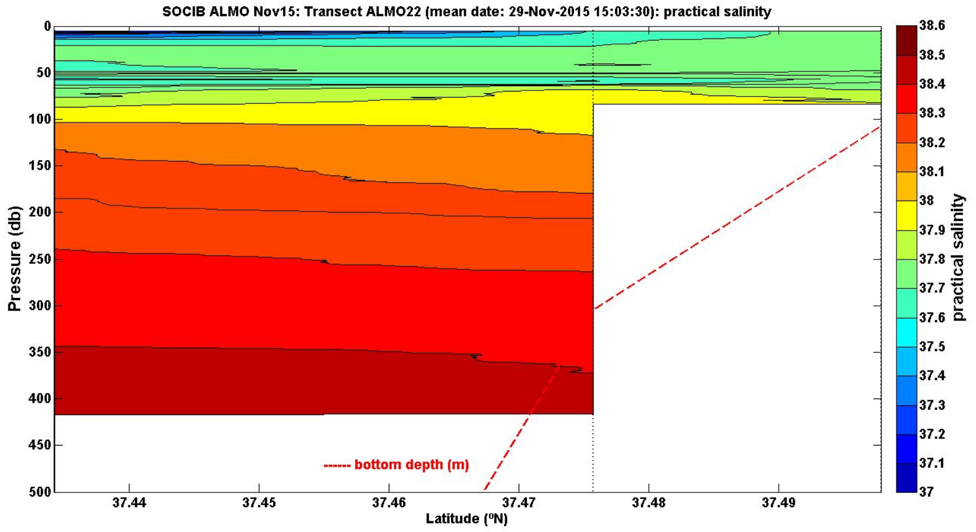


Fig. 5.3.2. Practical Salinity contour section of the top 500 m. Station locations are indicated by black dotted vertical lines.

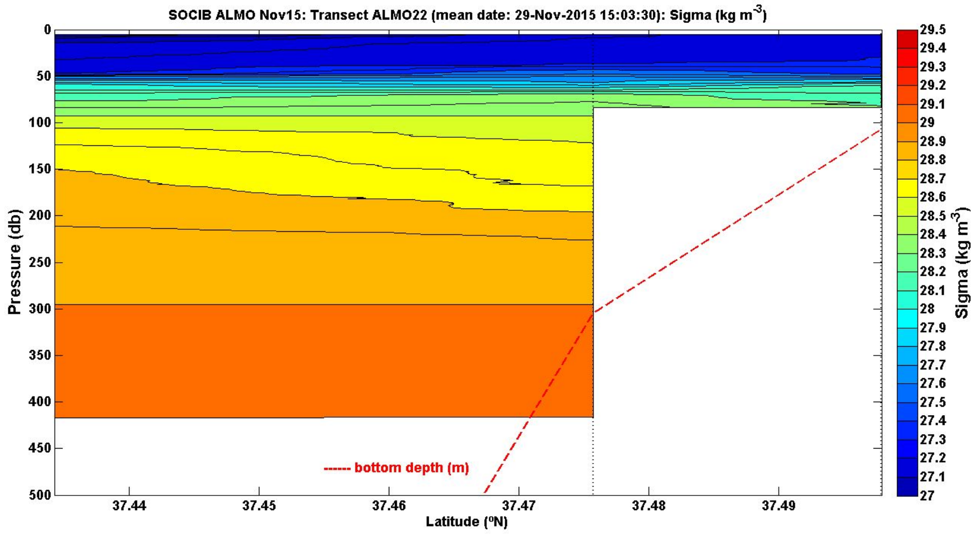


Fig. 5.3.3. Sigma (kg m^{-3}) contour section of the top 500 m. Station locations are indicated by black dotted vertical lines.

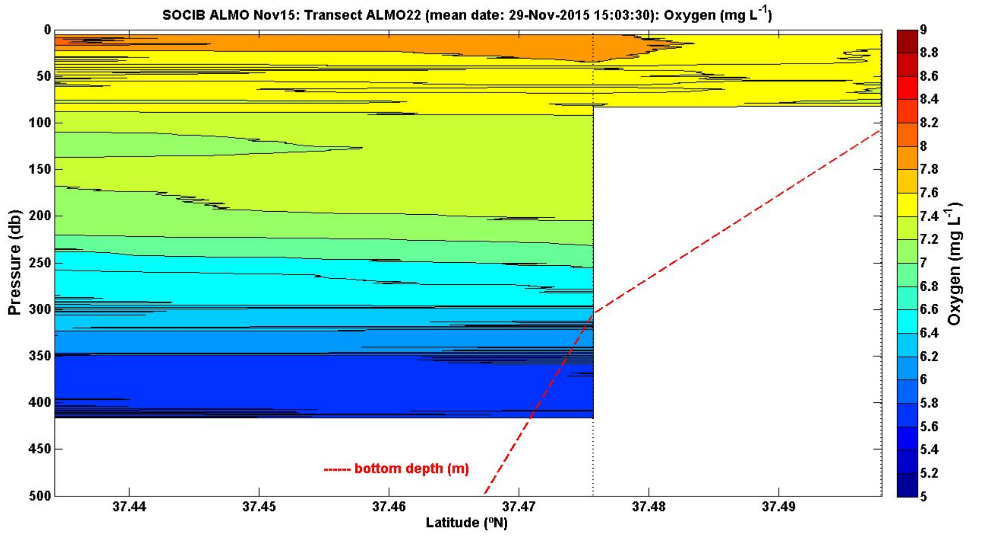


Fig. 5.3.4. Oxygen (mg L^{-1}) contour section of the top 500 m. Station locations are indicated by black dotted vertical lines.

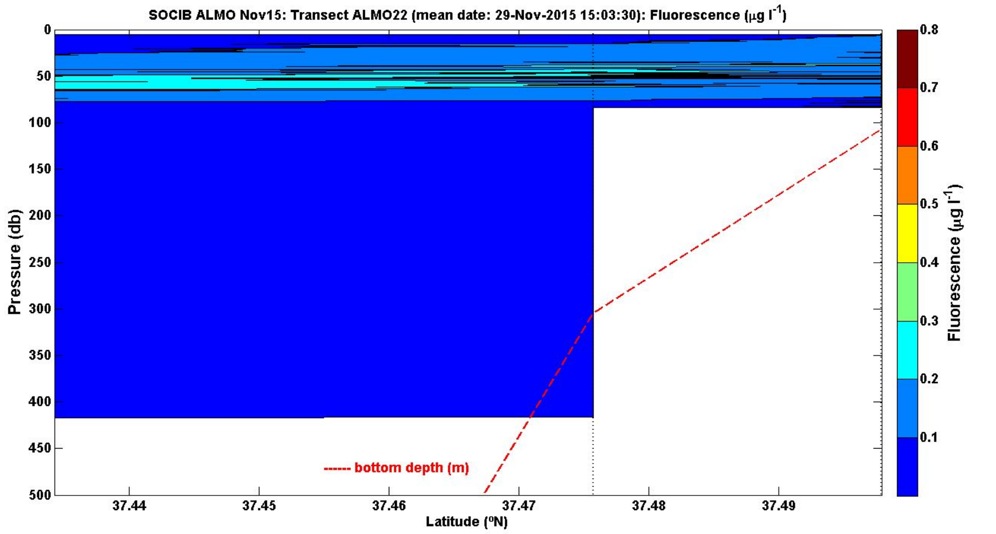


Fig. 5.3.5. Fluorescence (µg L^{-1}) contour section of the top 500 m. Station locations are indicated by black dotted vertical lines.

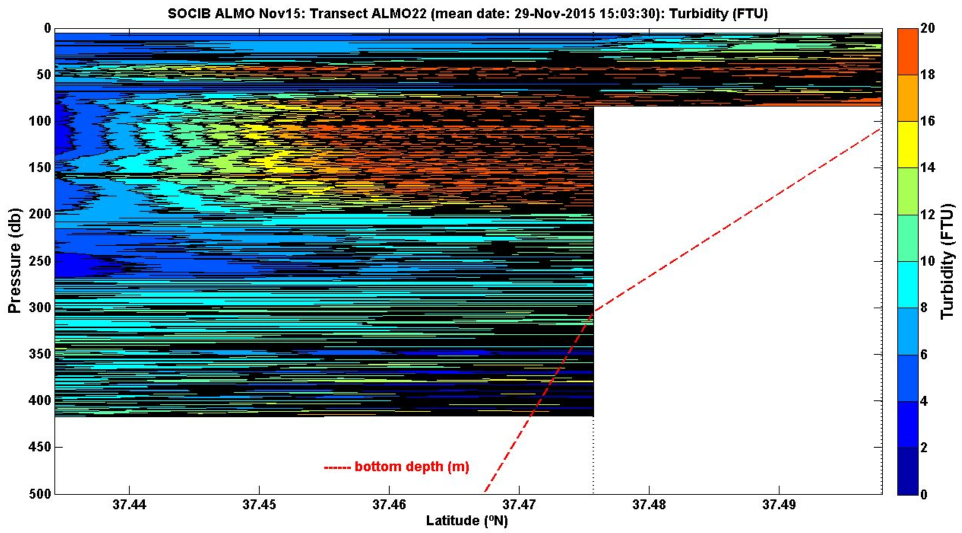


Fig. 5.3.6. Turbidity (FTU) contour section of the whole 500 m. Station locations are indicated by black dotted vertical lines.

Day 4 (30/11/2015): Section 3

Transect: After leaving the port of Bocana Cartegana and steaming south-west out of the bay the ship steamed southwards to sample stations 14 (37.5237° N, 1.1375° W) to 18, (37.2573° N, 1.1082° W). The ship then had a long transit period westwards to the port of Bocana Carboneras.

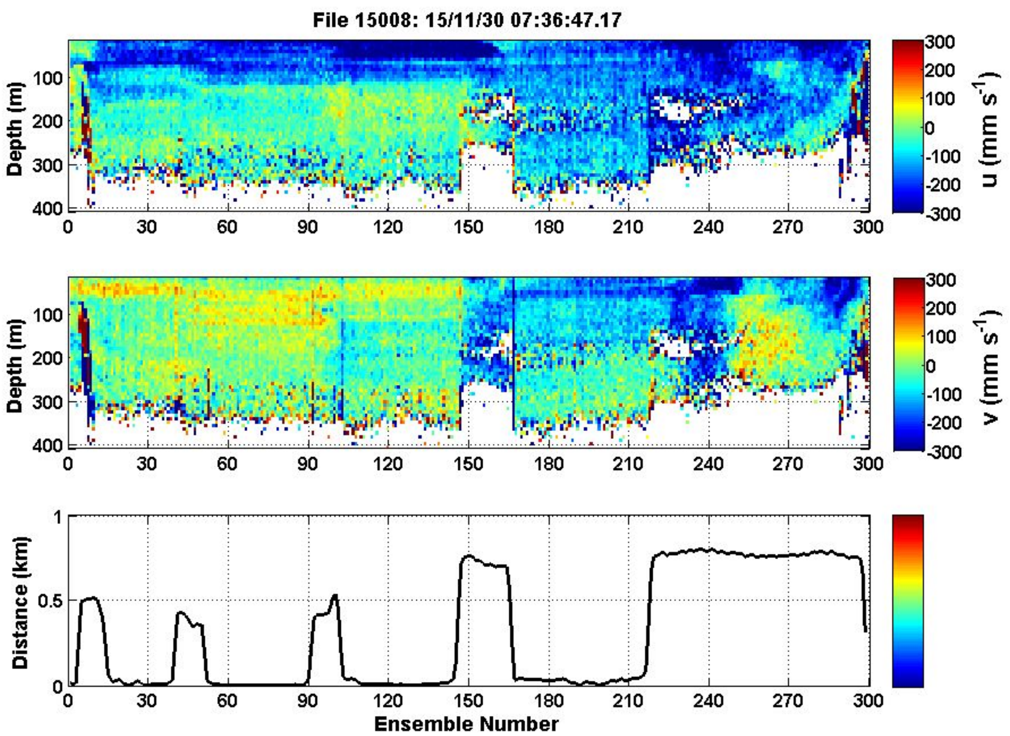


Fig 6.1. VM-ADCP current velocity in the East/West direction (a) and in the North/South direction (b) and the distance between the mid-points of each ensemble bin number (km). Ensemble 1 begins at 37.5239° N, 1.1371° W (station 14); the ship steams southwards to station 18 up until ensemble 218, and then steams westwards towards the coast; ensemble 299 ends at 37.1773° N, 1.8158° W.

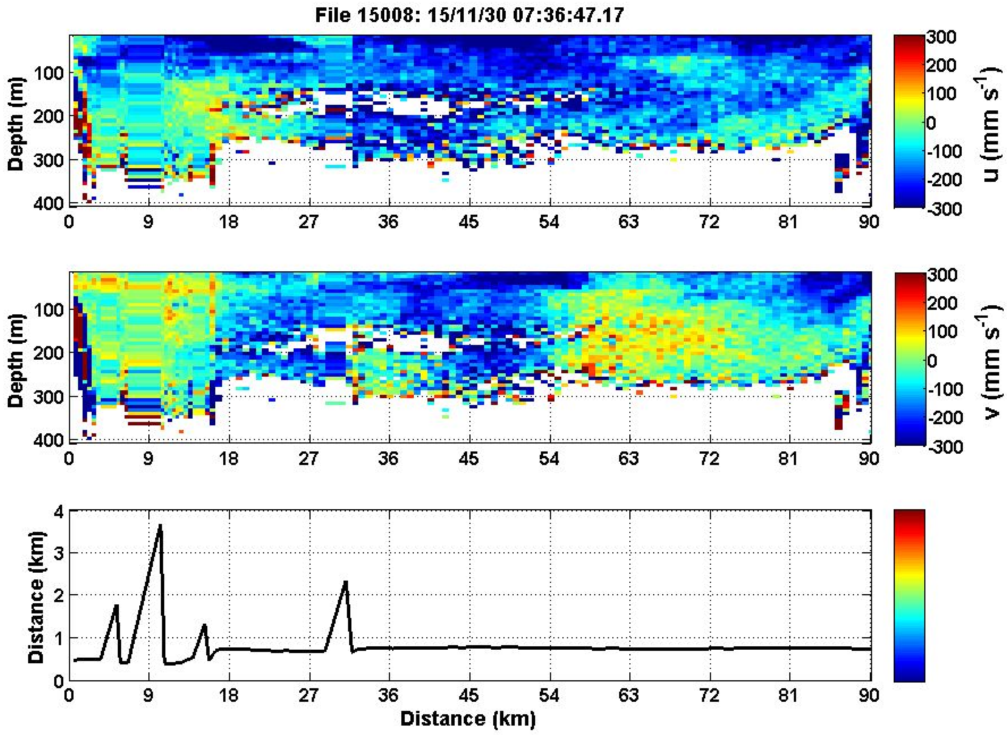


Fig. 6.2 VM-ADCP current velocity in the East/West direction (a) and in the North/South direction (b) and the distance between the mid-points of each ensemble bin number (km) as a function of cumulative distance between ensemble bins, with station data removed. The spikes in Fig. c indicate where station data have been removed. For the first 30 km, the ship is steaming southwards, during sampling of stations 14 to 18. After 30 km, the ship steams ~60 km westwards towards the coast.

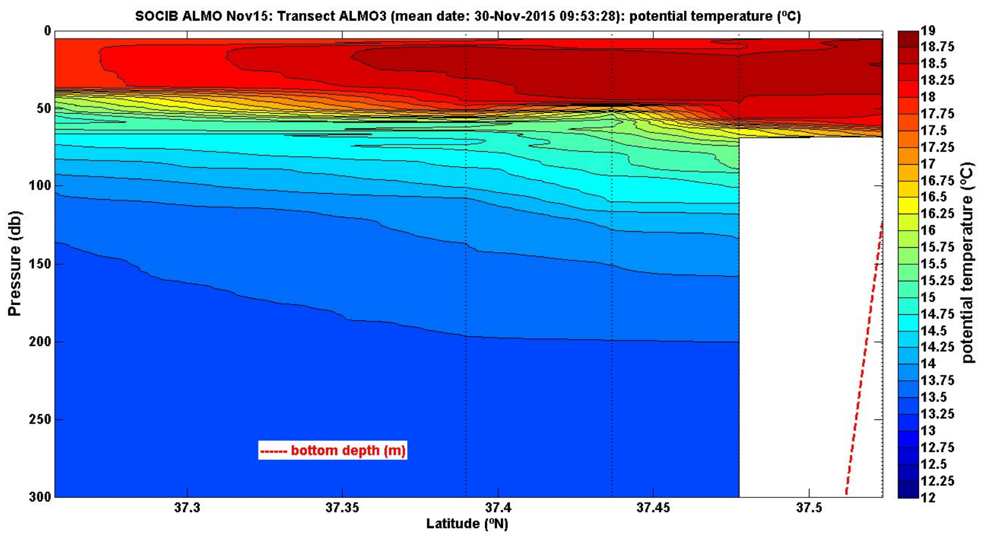


Fig. 6.3.1. Potential Temperature (ºC) contour section of the top 300 m. Station locations are indicated by black dotted vertical lines.

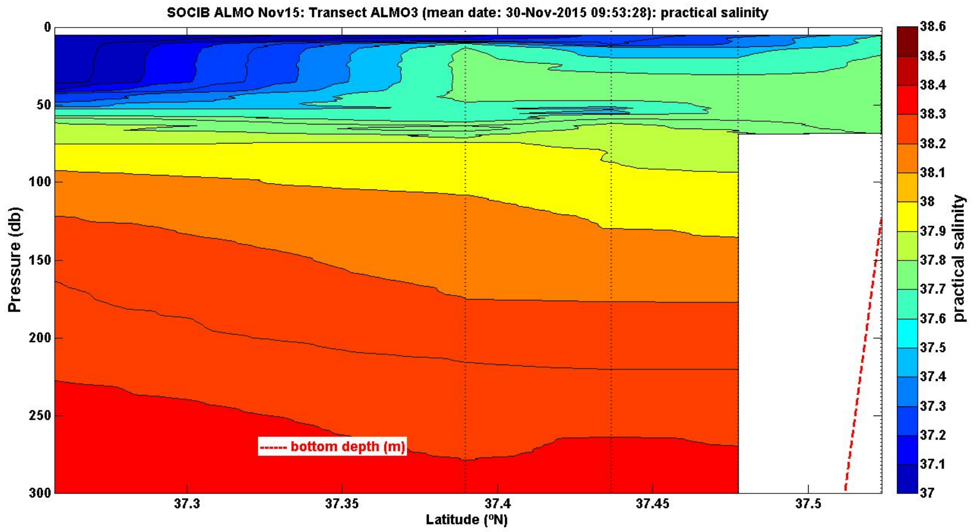


Fig. 6.3.2. Practical Salinity contour section of the top 300 m. Station locations are indicated by black dotted vertical lines.

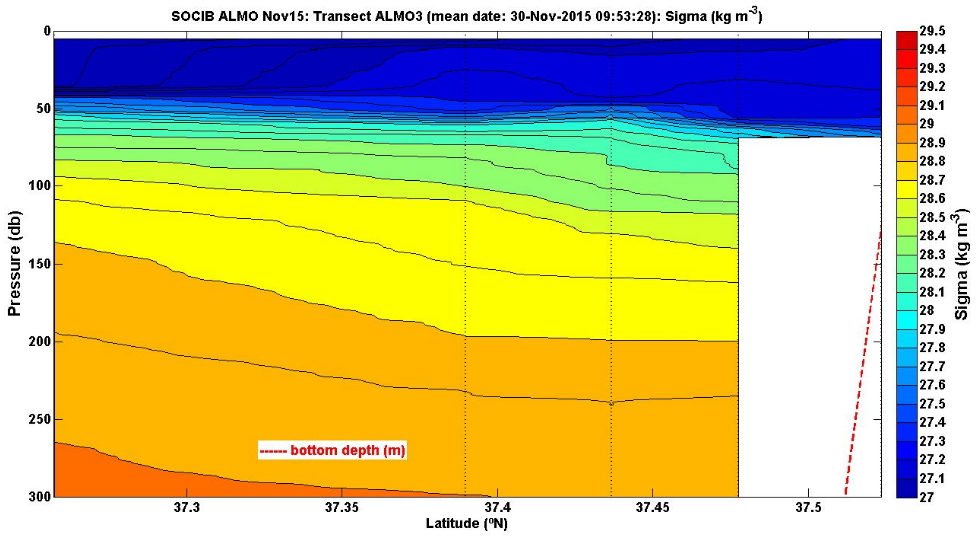


Fig. 6.3.3. Sigma (kg m^{-3}) contour section of the top 300 m. Station locations are indicated by black dotted vertical lines.

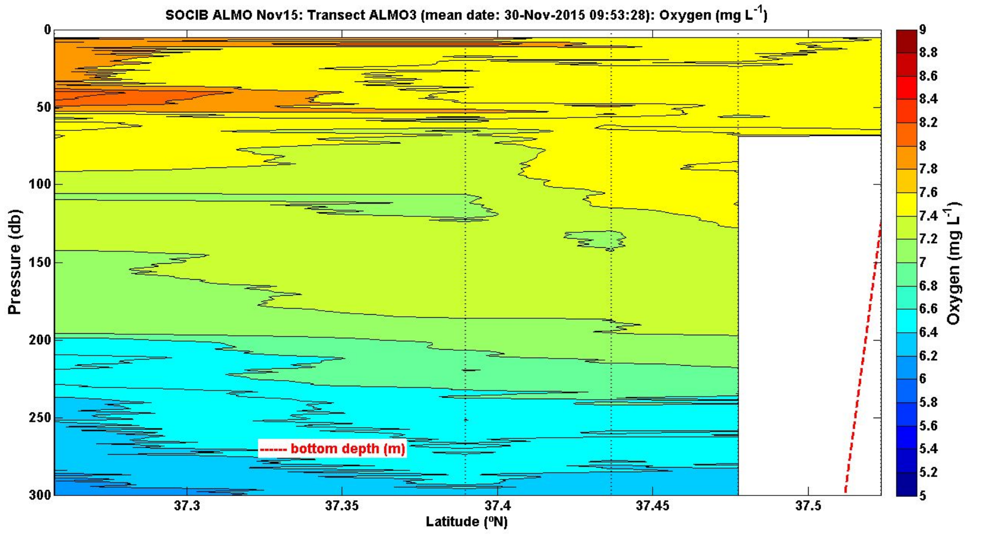


Fig. 6.3.4. Oxygen (mg L^{-1}) contour section of the top 300 m. Station locations are indicated by black dotted vertical lines.

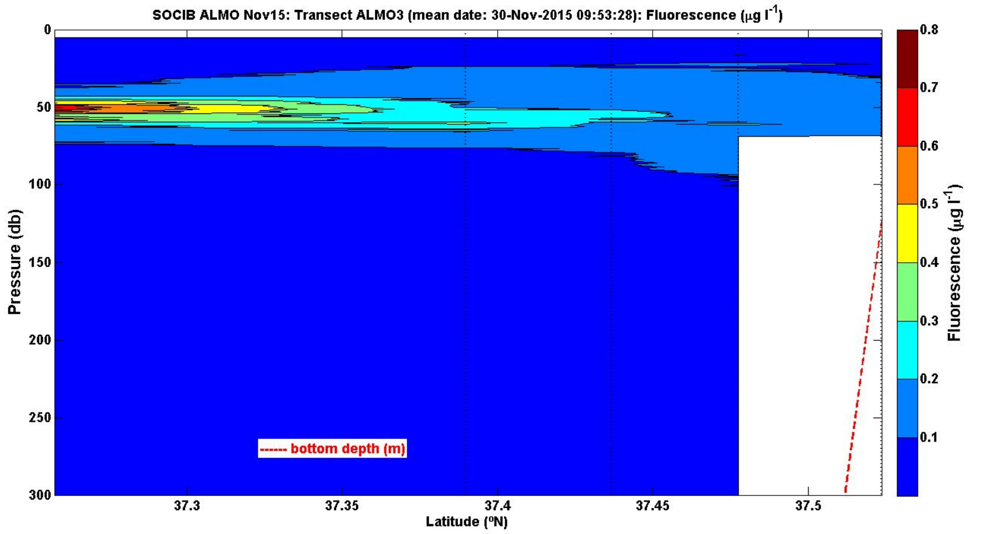


Fig. 6.3.5. Fluorescence (µg L^{-1}) contour section of the top 300 m. Station locations are indicated by black dotted vertical lines.

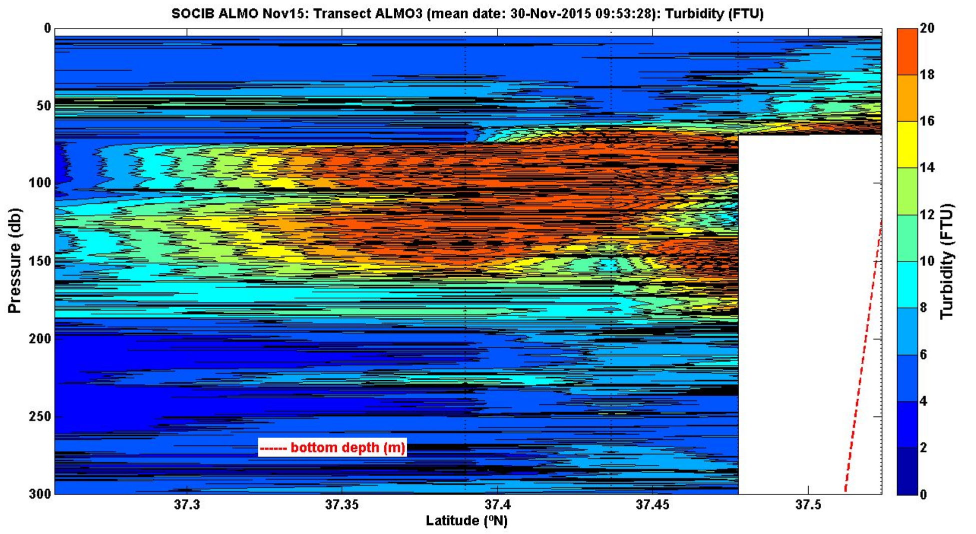


Fig. 6.3.6. Turbidity (FTU) contour section of the top 300 m. Station locations are indicated by black dotted vertical lines.

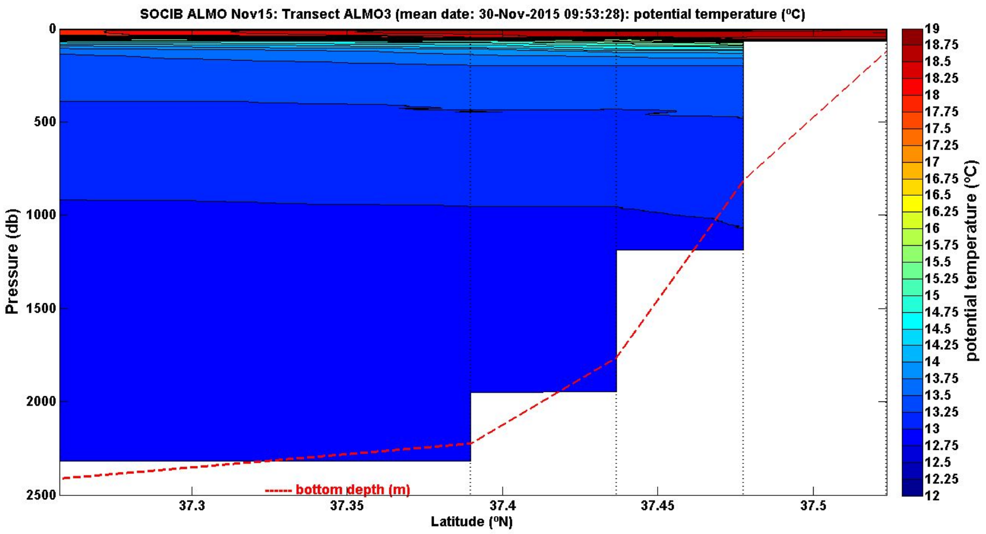


Fig. 6.4.1. Potential Temperature (ºC) contour section of the whole 2500 m. Station locations are indicated by black dotted vertical lines.

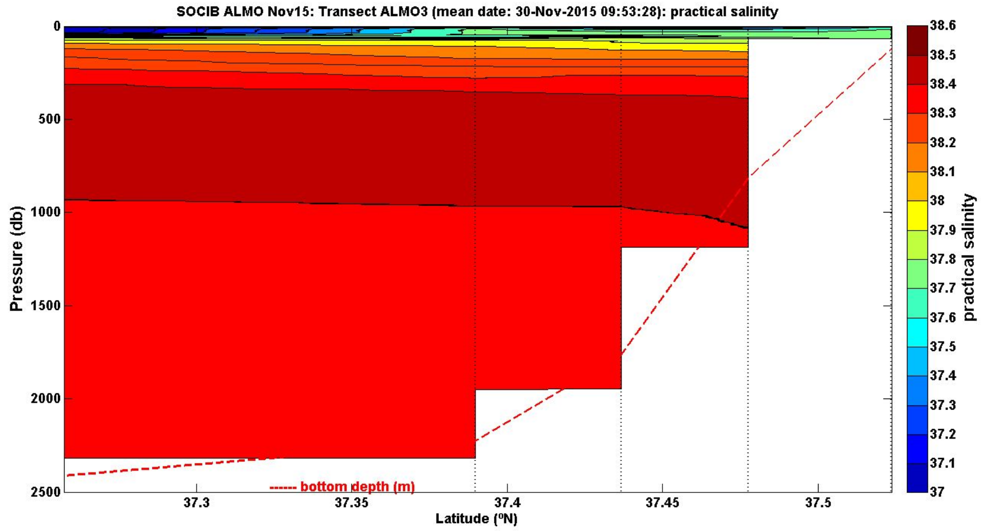


Fig. 6.4.2. Practical Salinity contour section of the whole 2500 m. Station locations are indicated by black dotted vertical lines.

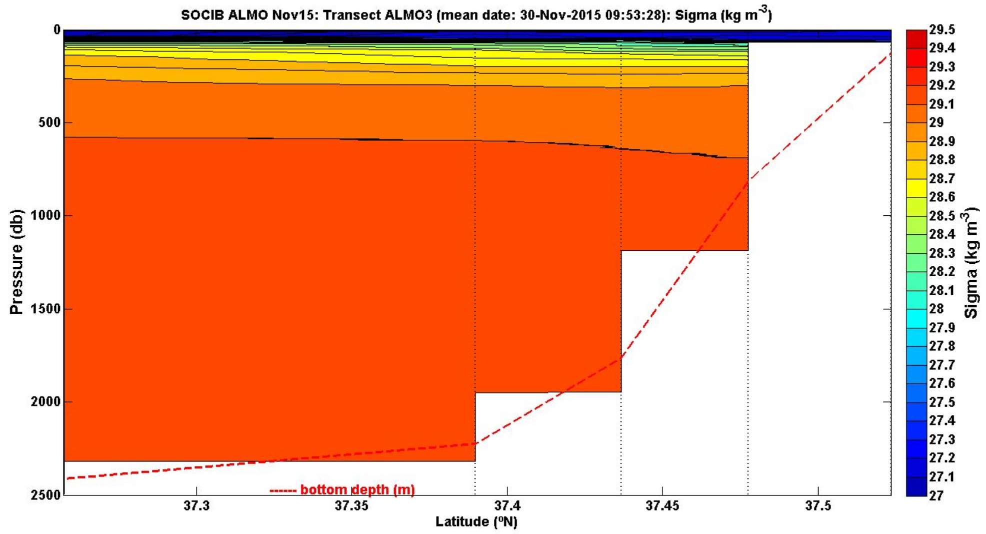


Fig. 6.4.3. Sigma (kg m^{-3}) contour section of the whole 2500 m. Station locations are indicated by black dotted vertical lines.

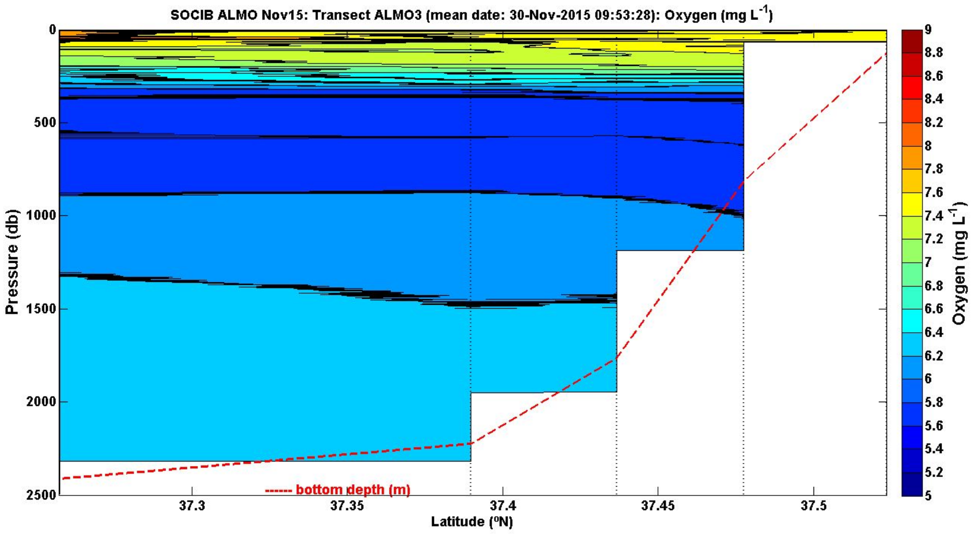


Fig. 6.4.4. Oxygen (mg L^{-1}) contour section of the whole 2500 m. Station locations are indicated by black dotted vertical lines.

Day 5 (01/12/2015): Section 4

Transect: The ship left the port of Bocana Carboneras and steamed eastwards carrying out 5 stations to the eastern-most station at 37.0546° N, 1.1426° W, before steaming south-westwards to the port of Bocana San José.

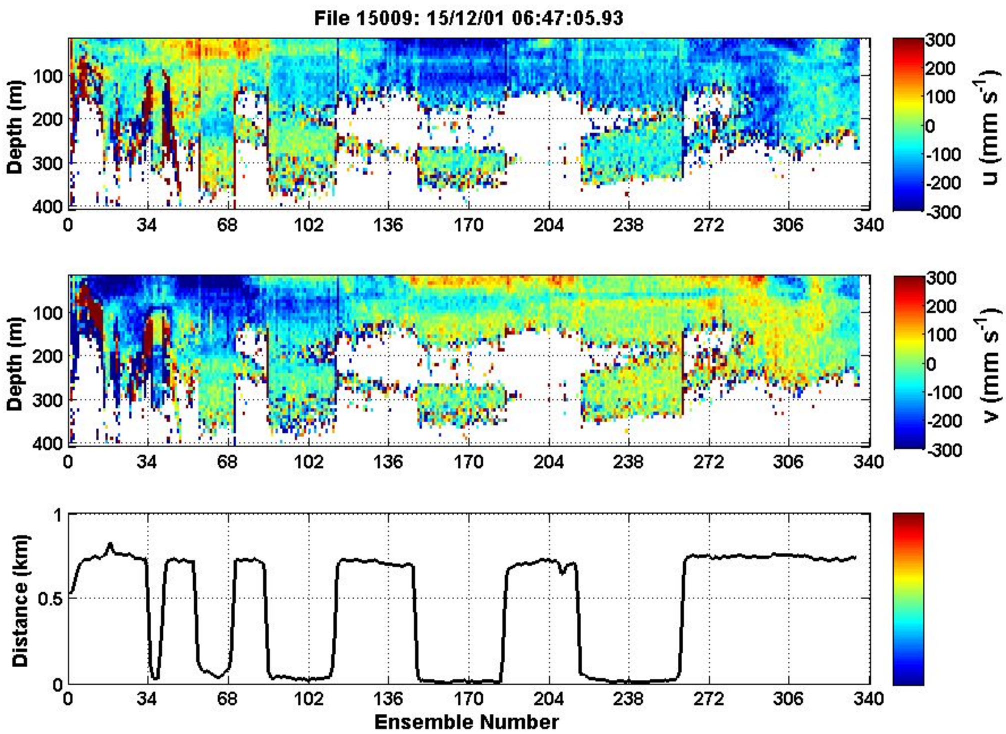


Fig 7.1. VM-ADCP current velocity in the East/West direction (a) and in the North/South direction (b) and the distance between the mid-points of each ensemble bin number (km). Ensemble 1 begins at

37.1777° N, 1.8172° W and ensemble 336 ends at 37.1610° N, 1.7556° W. The ship steamed eastwards from ensemble 1 to station 22 (36.9758° N, 1.3618° W) at ensembles 148-183 then north-eastwards to station 23 (37.0546° N, 1.1426° W), ensembles 216-260. From the end of station 23 (ensemble 261), the ship steamed south-westwards towards the port of Bocana San José.

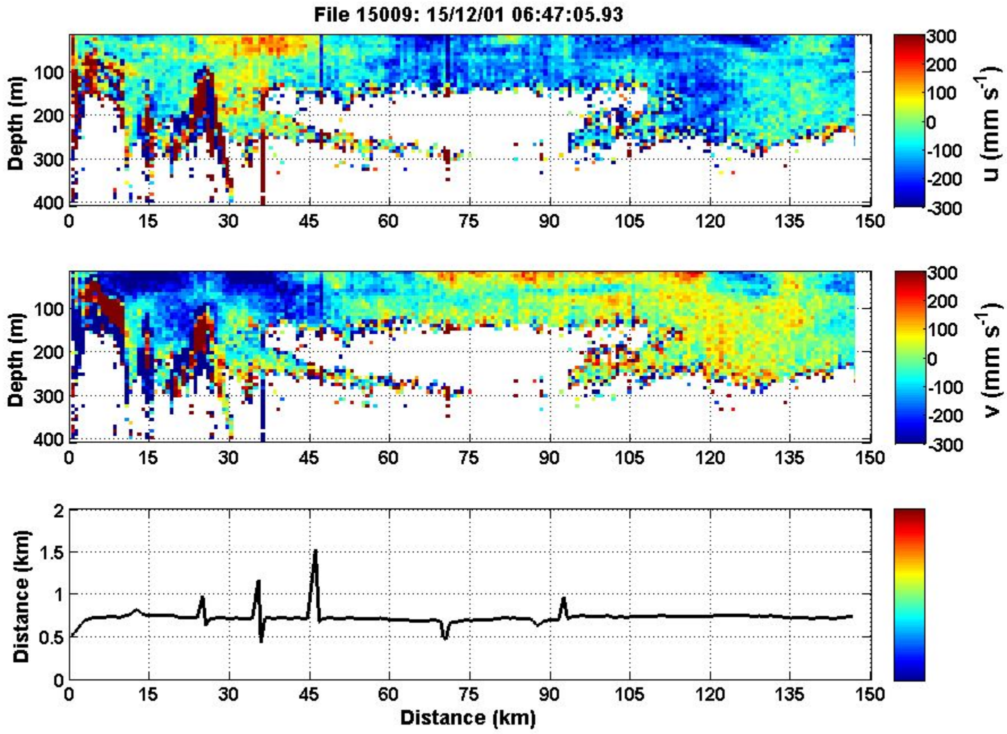



Fig. 7.2 VM-ADCP current velocity in the East/West direction (a) and in the North/South direction (b) and the distance between the mid-points of each ensemble bin number (km) as a function of cumulative distance between ensemble bins, with station data removed. The spikes in Fig. c indicate where station data have been removed. For the first ~92 km the ship steamed in a predominantly eastward direction (with a northern component between ~70 and ~92 km). After ~92 km, the ship steamed south westwards in it its return to the coast.

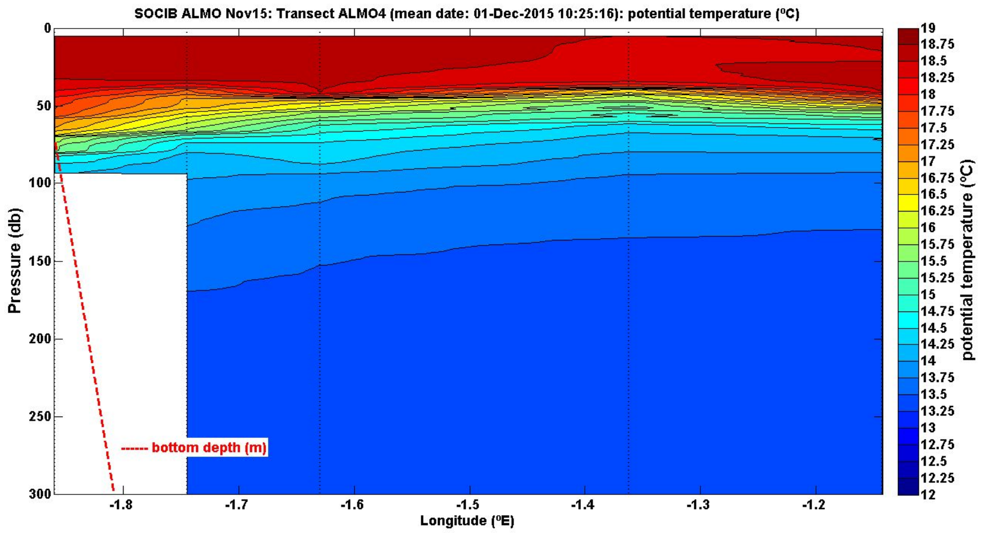


Fig. 7.3.1. Potential Temperature (ºC) contour section of the top 300 m. Station locations are indicated by black dotted vertical lines.

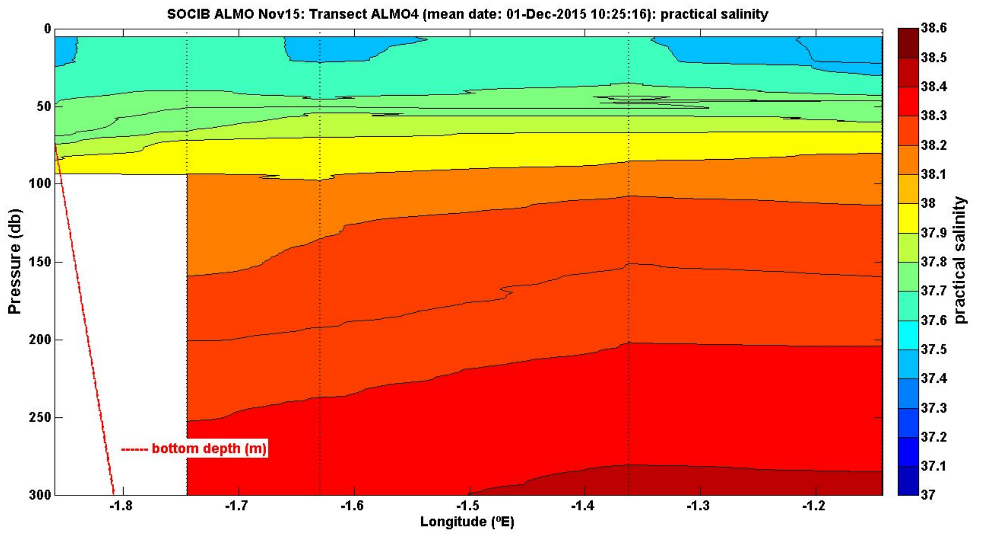


Fig. 7.3.2. Practical Salinity contour section of the top 300 m. Station locations are indicated by black dotted vertical lines.

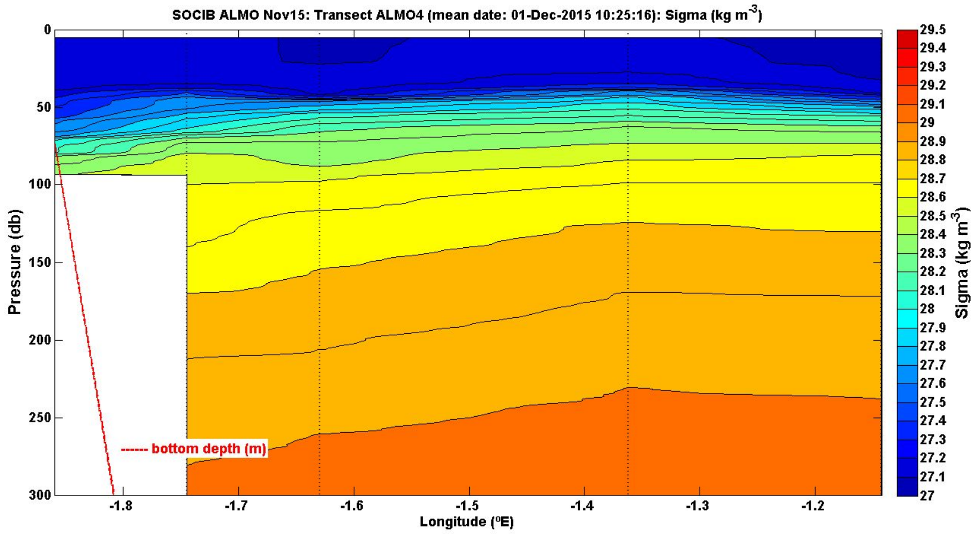


Fig. 7.3.3. Sigma (kg m^{-3}) contour section of the top 300 m. Station locations are indicated by black dotted vertical lines.

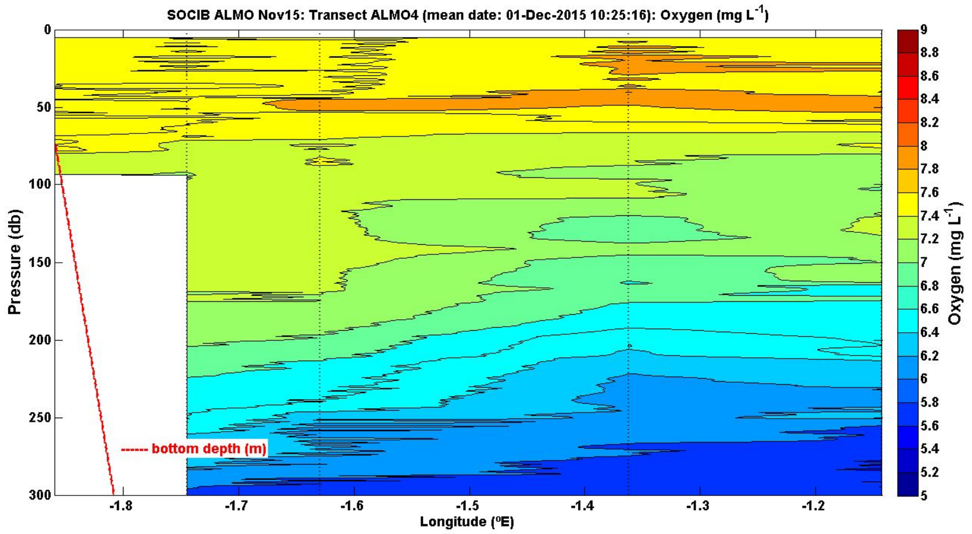


Fig. 7.3.4. Oxygen (mg L^{-1}) contour section of the top 300 m. Station locations are indicated by black dotted vertical lines.

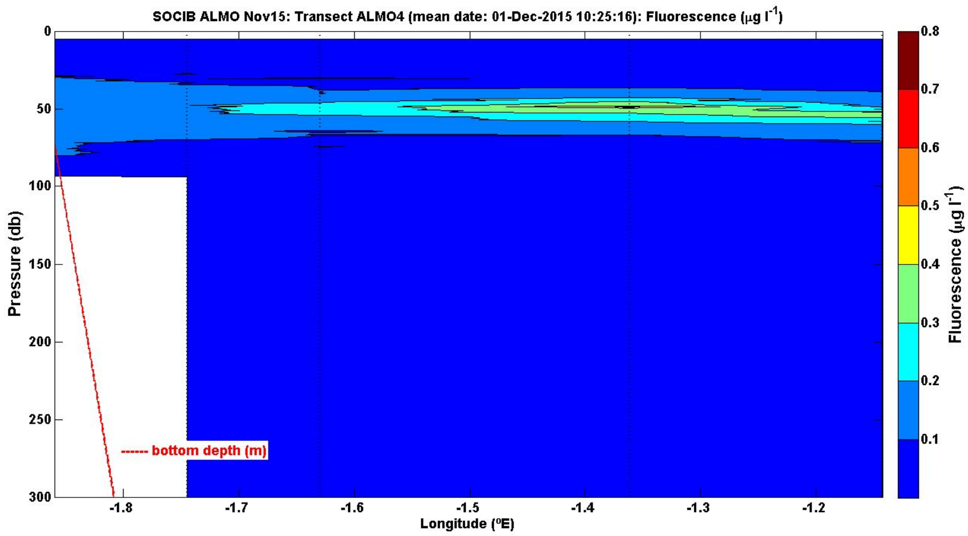


Fig. 7.3.5. Fluorescence (μg L^{-1}) contour section of the top 300 m. Station locations are indicated by black dotted vertical lines.

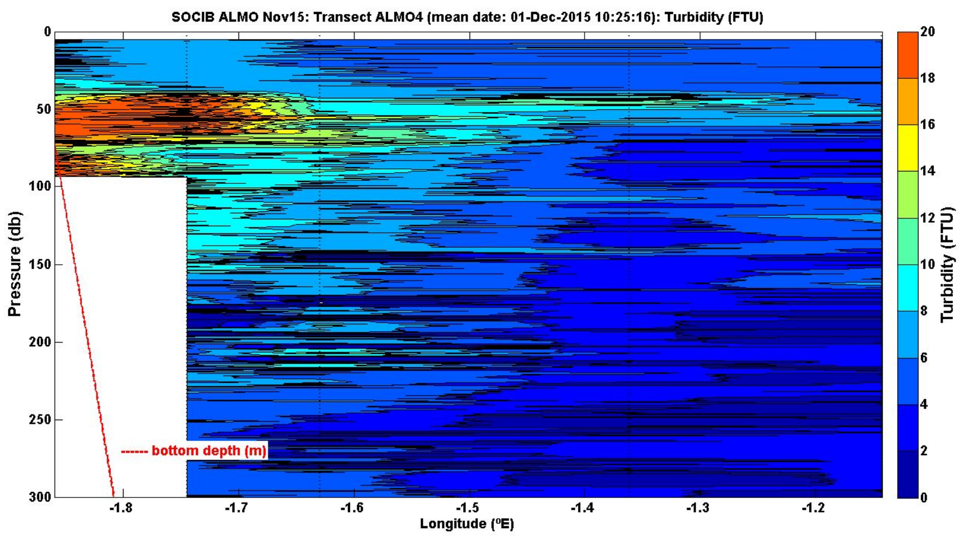


Fig. 7.3.6. Turbidity (FTU) contour section of the top 300 m. Station locations are indicated by black dotted vertical lines.

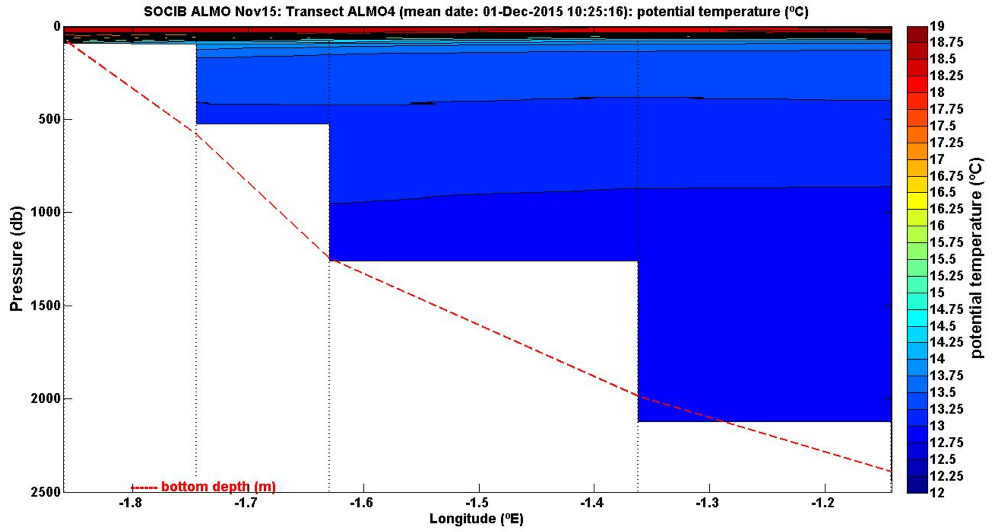


Fig. 7.4.1. Potential Temperature (ºC) contour section of the whole 2500 m. Station locations are indicated by black dotted vertical lines.

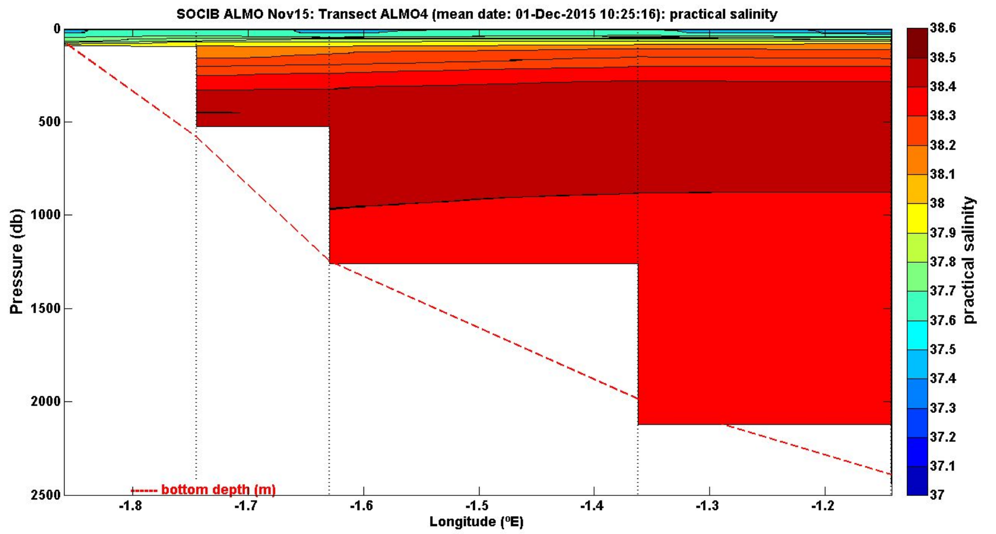


Fig. 7.4.2. Practical Salinity contour section of the whole 2500 m. Station locations are indicated by black dotted vertical lines.

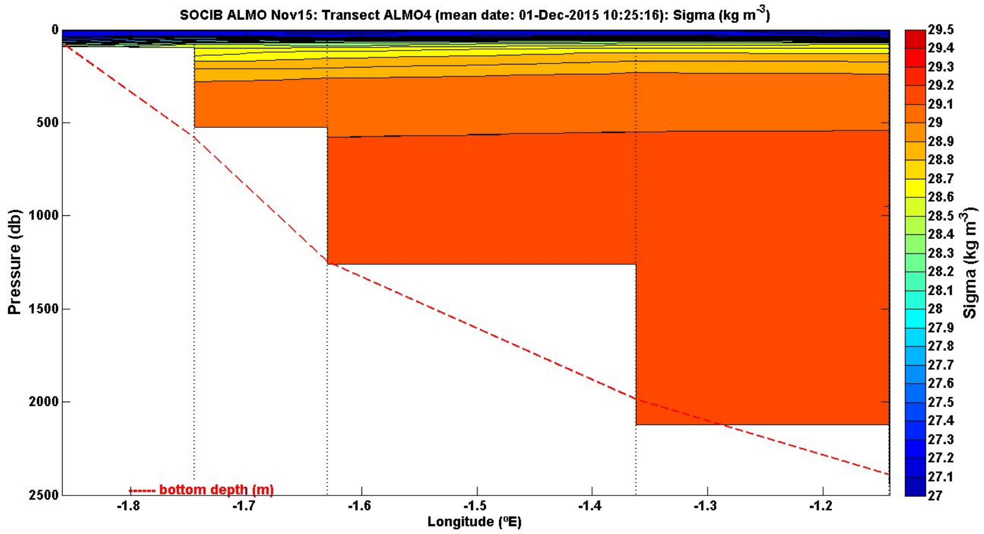


Fig. 7.4.3. Sigma (kg m^{-3}) contour section of the whole 2500 m. Station locations are indicated by black dotted vertical lines.

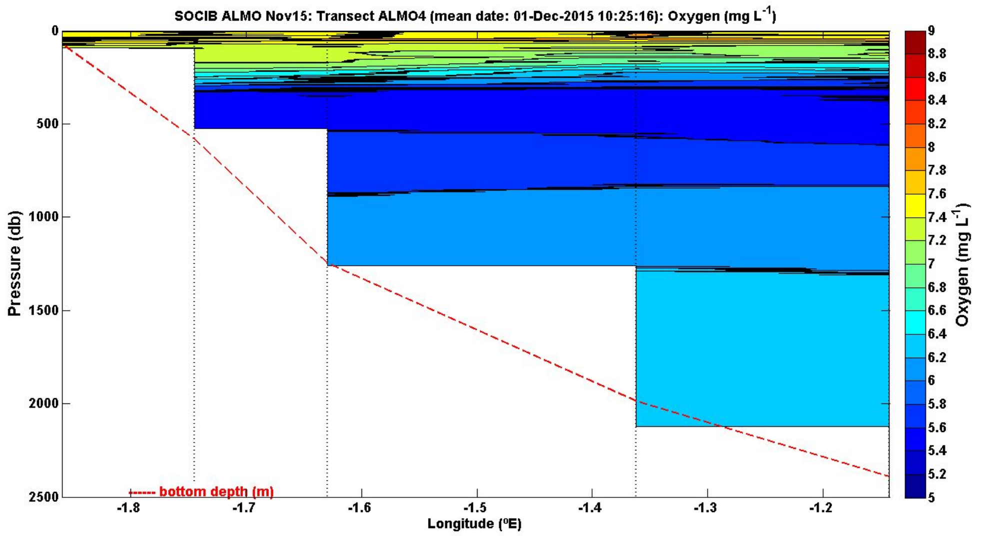


Fig. 7.4.4. Oxygen (mg L^{-1}) contour section of the whole 2500 m. Station locations are indicated by black dotted vertical lines.

Day 6 (02/12/2015): Section 5

Transect: The ship steamed south-westwards along the coast to station 24 at 36.7295º N, 2.1033º W, and then steamed southwards, sampling 9 stations until the final station at 36.0156º N, 2.1423º W, before steaming northwards to the port of Almería. There are two VM-ADCP transects presented for this day; file 15010 in Fig. 8.1.1 covers the transit from the port of Bocana Carboneras at 36º 58.148 N, 1º 53.529 W to just before reaching the first station (at 36.7622º N, 2.0564º W), while file 15011 in Fig. 8.1.2 and 8.2.2 covers the section and the return journey to the port of Almería.

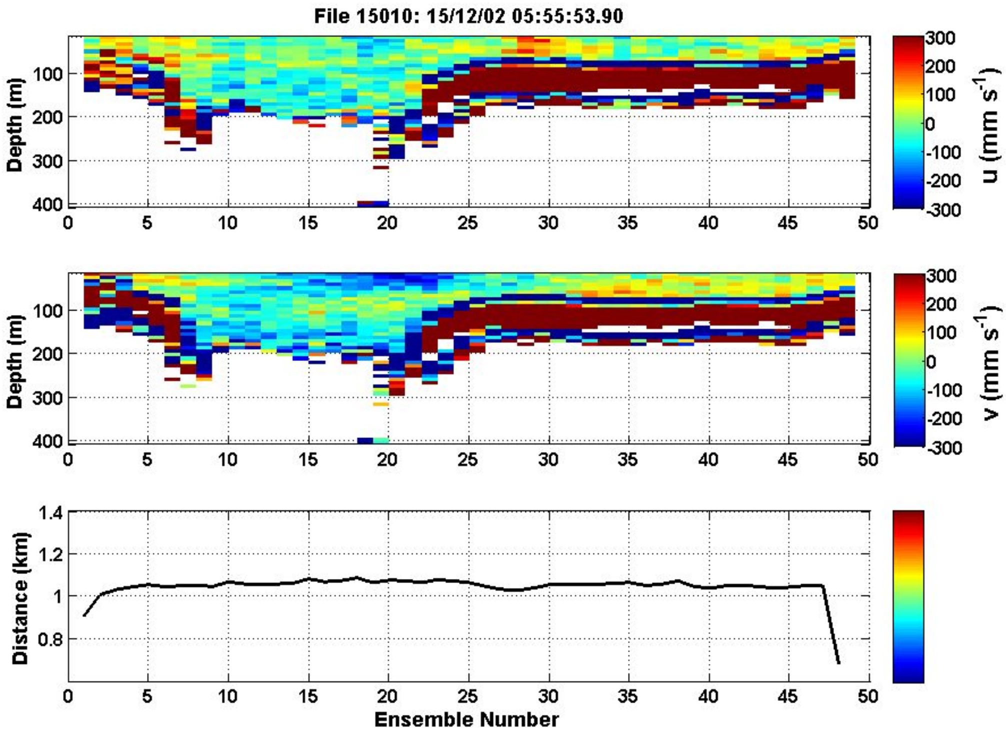


Fig 8.1.1. VM-ADCP current velocity in the East/West direction (a) and in the North/South direction (b) and the distance between the mid-points of each ensemble bin number (km).). Ensemble 1 begins at 37.1557º N, 1.8128º W; the ship steamed south-westwards along the coast to the sections first station and ends just before reaching the station; ensemble 49 ends at 37.1610º N, 1.7556º W.

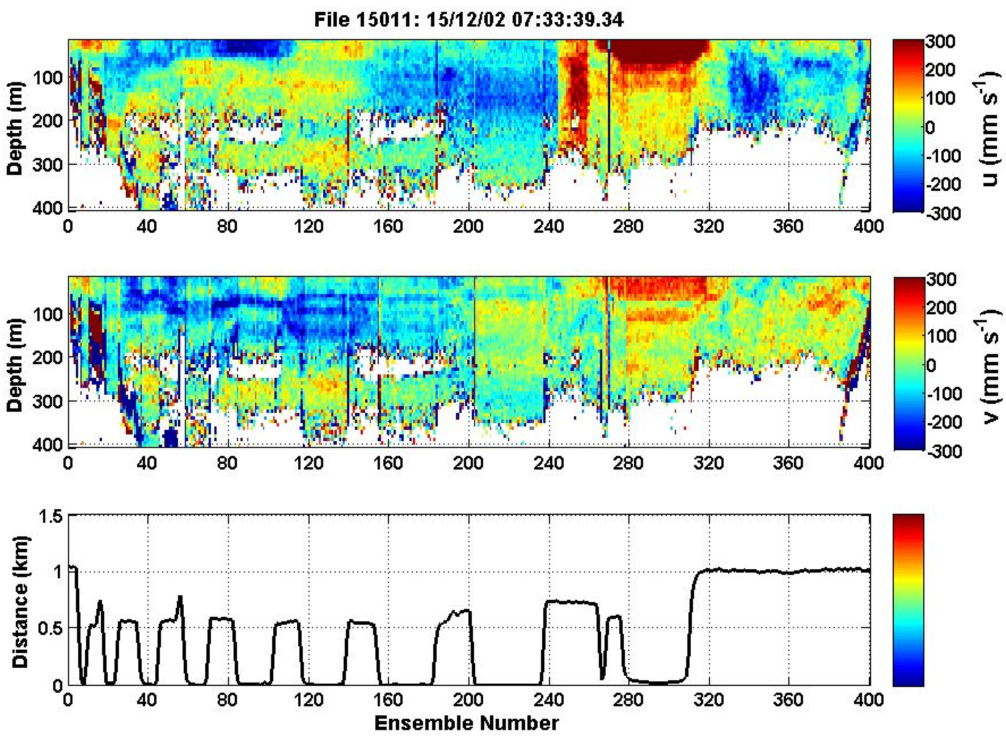


Fig 8.1.2. VM-ADCP current velocity in the East/West direction (a) and in the North/South direction (b) and the distance between the mid-points of each ensemble bin number (km). Ensemble 1 starts just before reaching station 24, at 37.7622° N, 2.0564° W, after which the ship steamed southwards to the southernmost point at station 32, ensembles 278 to ~310, 36.0156° N, 2.1423° W. The ship then returned northwards to the coast from ensembles ~320 to 400.

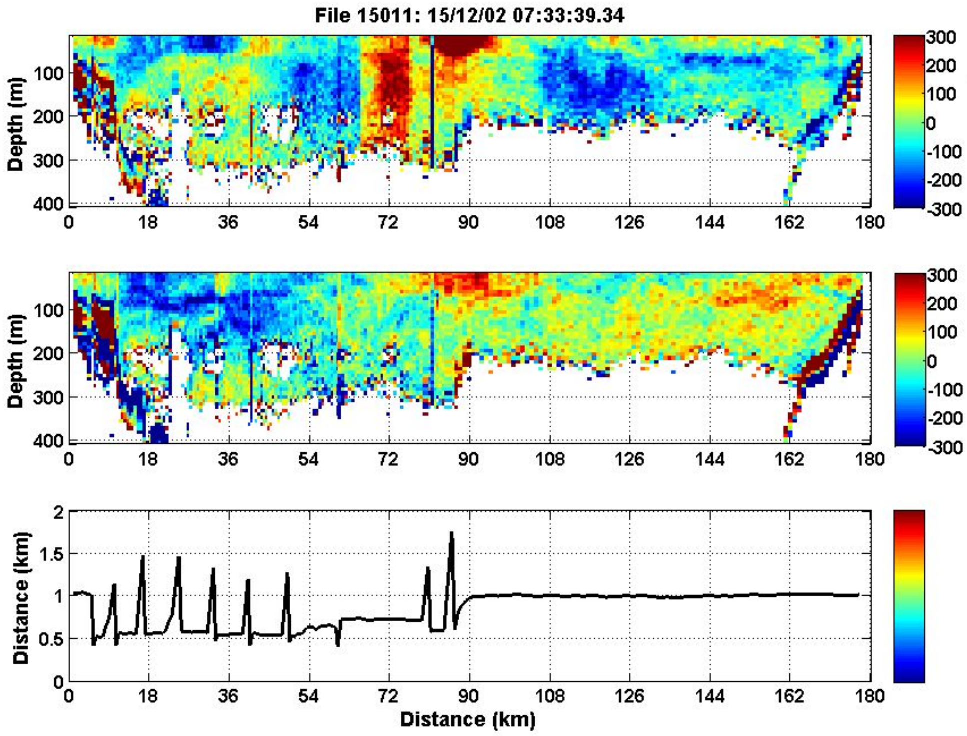


Fig. 8.2.2 VM-ADCP current velocity in the East/West direction (a) and in the North/South direction (b) and the distance between the mid-points of each ensemble bin number (km) as a function of cumulative distance between ensemble bins, with station data removed. The spikes in Fig. c indicate where station data have been removed. The ship steamed southwards for just under 90 km to the final station before steaming northwards to the coast.

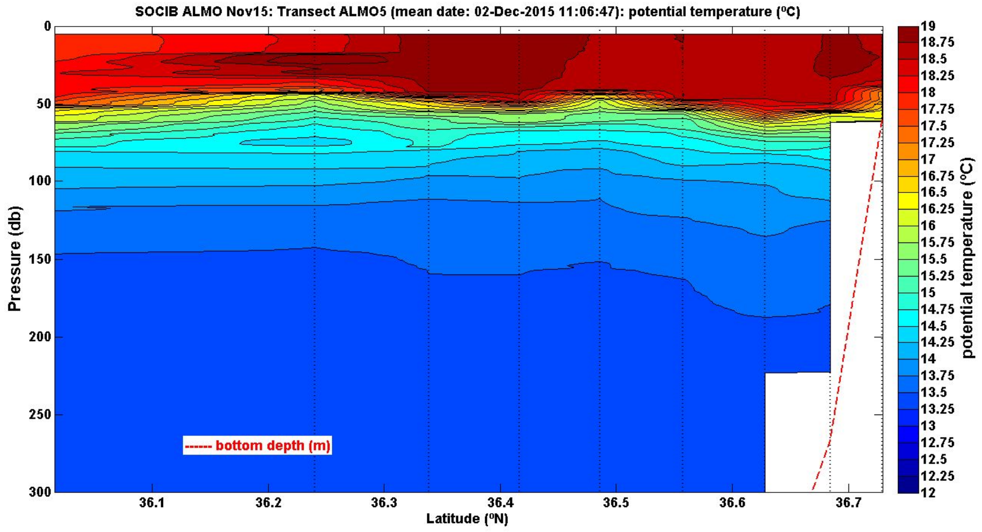


Fig. 8.3.1. Potential Temperature (ºC) contour section of the top 300 m. Station locations are indicated by black dotted vertical lines.

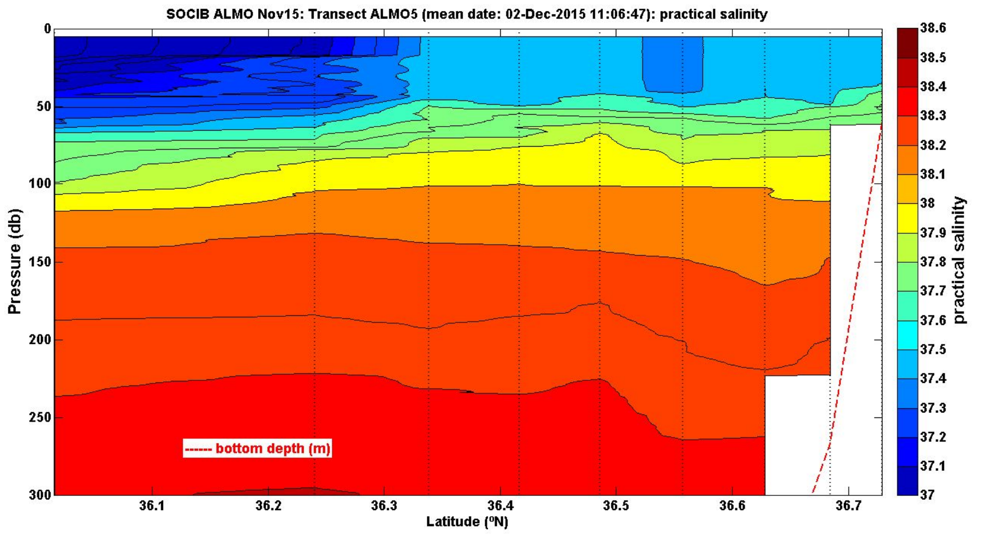


Fig. 8.3.2. Practical Salinity contour section of the top 300 m. Station locations are indicated by black dotted vertical lines.

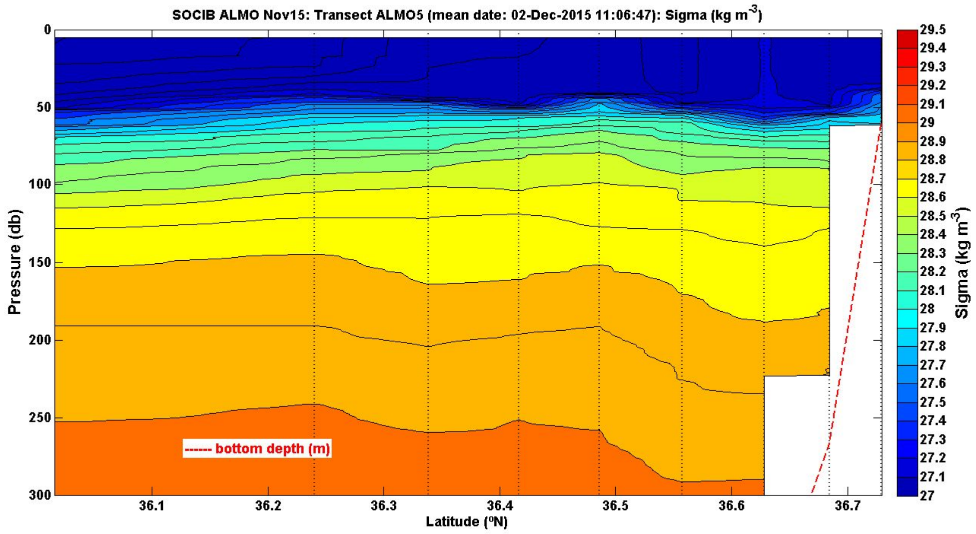


Fig. 8.3.3. Sigma (kg m^{-3}) contour section of the top 300 m. Station locations are indicated by black dotted vertical lines.

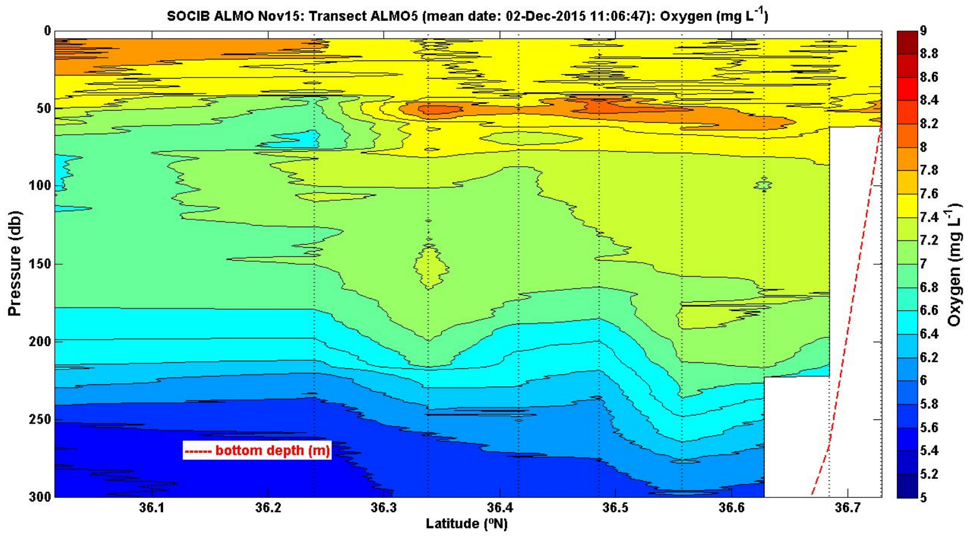


Fig. 8.3.4. Oxygen (mg L^{-1}) contour section of the top 300 m. Station locations are indicated by black dotted vertical lines.

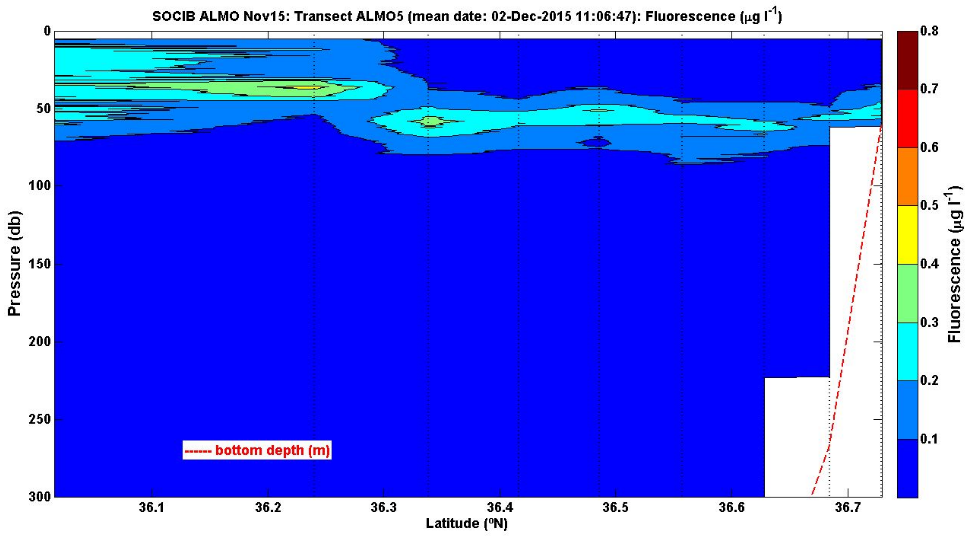


Fig. 8.3.5. Fluorescence (µg L^{-1}) contour section of the top 300 m. Station locations are indicated by black dotted vertical lines.

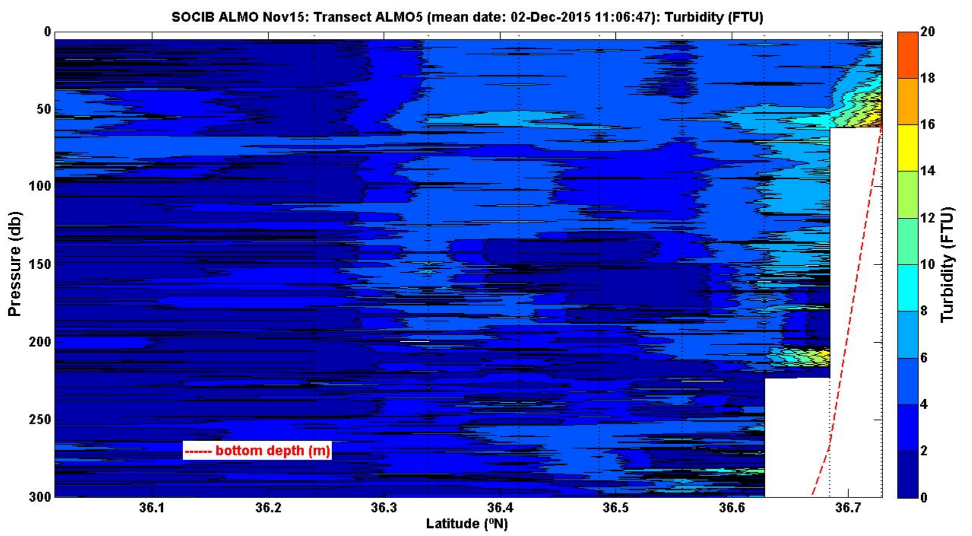


Fig. 8.3.6. Turbidity (FTU) contour section of the top 300 m. Station locations are indicated by black dotted vertical lines.

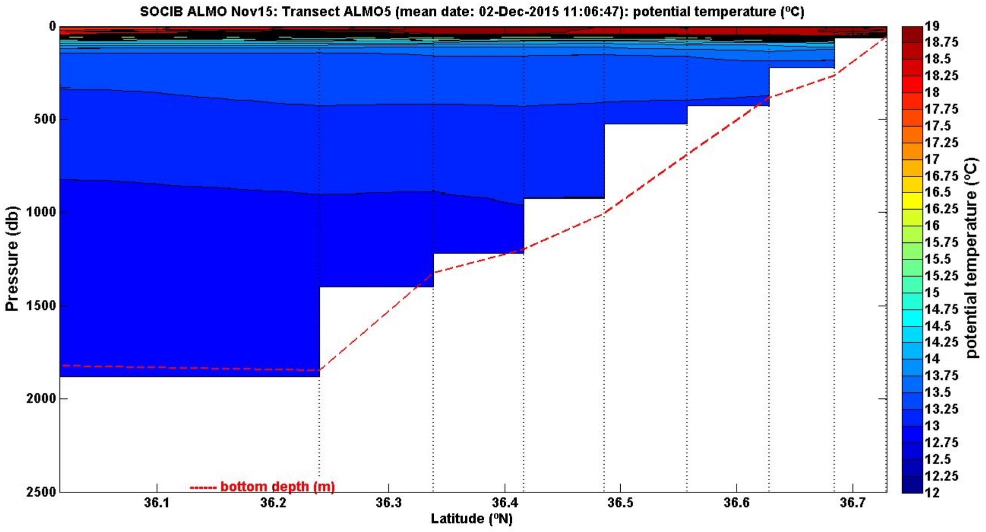


Fig. 8.4.1. Potential Temperature (ºC) contour section of the whole 2500 m. Station locations are indicated by black dotted vertical lines.

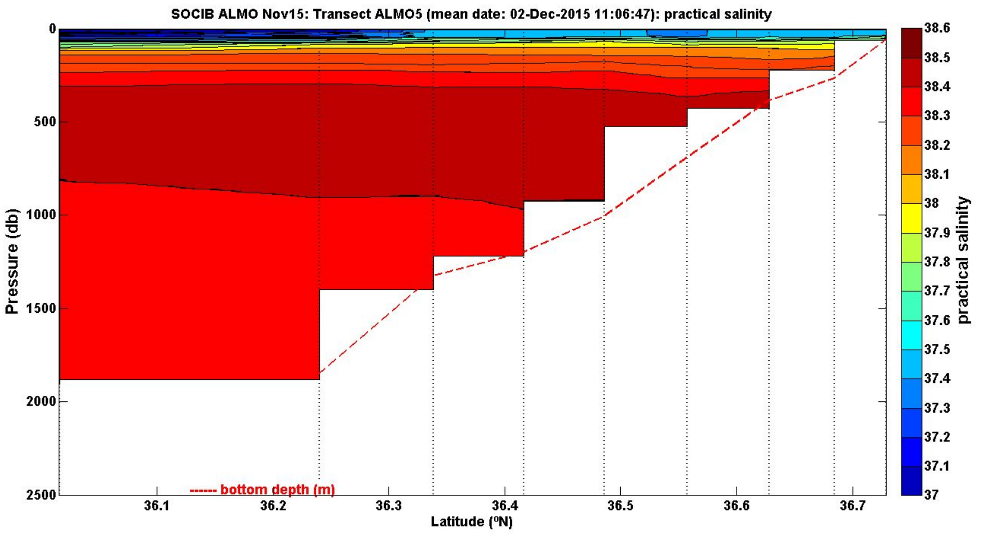


Fig. 8.4.2. Practical Salinity contour section of the whole 2500 m. Station locations are indicated by black dotted vertical lines.

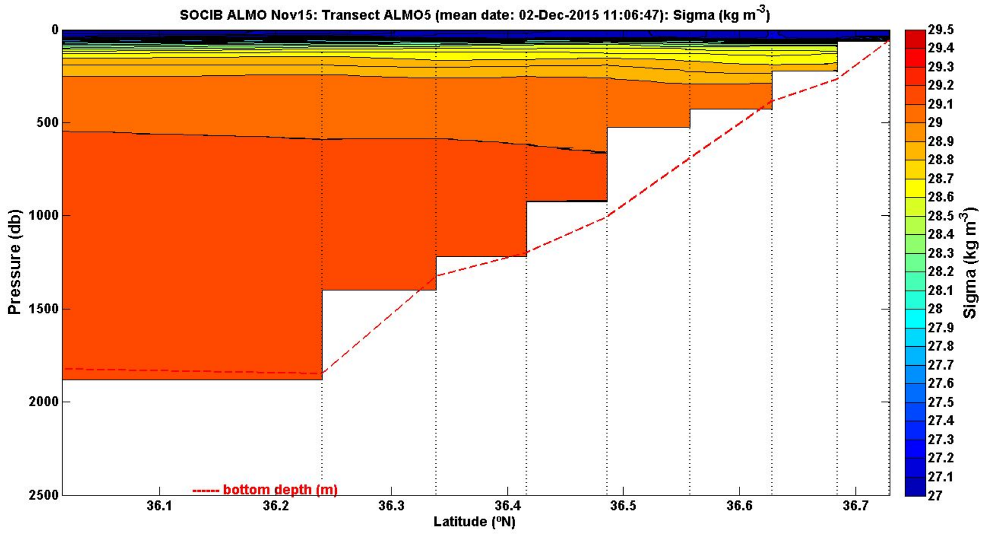


Fig. 8.4.3. Sigma (kg m^{-3}) contour section of the whole 2500 m. Station locations are indicated by black dotted vertical lines.

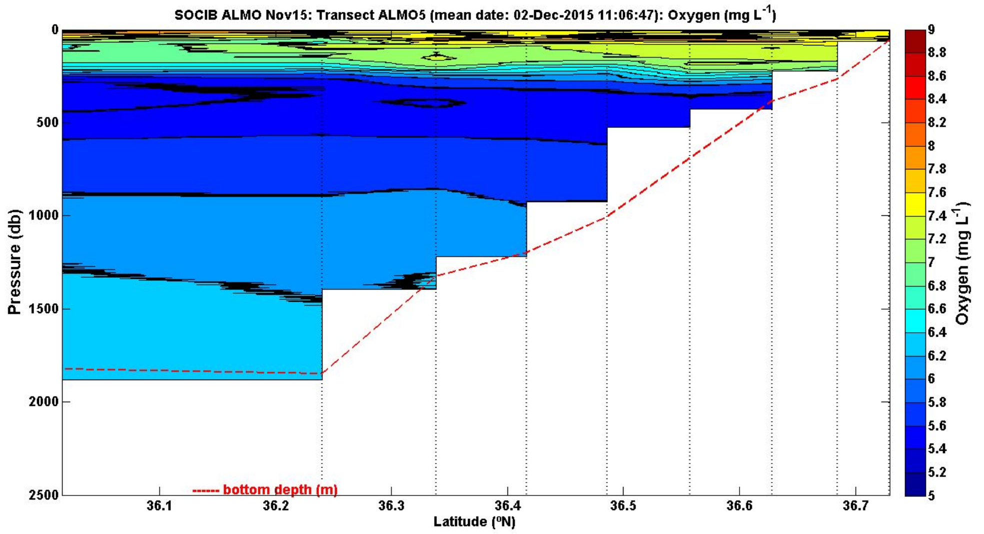


Fig. 8.4.4. Oxygen (mg L^{-1}) contour section of the whole 2500 m. Station locations are indicated by black dotted vertical lines.

6.2.3.3 T/S Diagrams of all stations

This section shows the T/S diagrams of each section, with the T/S data from all 32 stations in grey in the background. The stations of each section are coloured from light to dark, representing close to the coast to the deepest station.

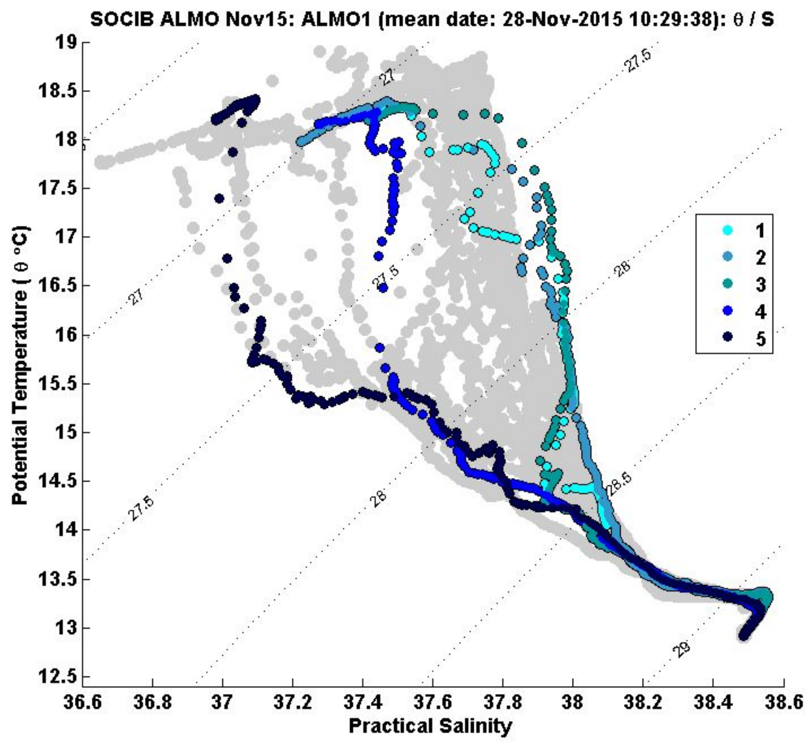


Fig. 9.1. T/S Diagram of stations 1 to 5, of section 1. The lightest colours indicate stations closest to the coast while colours darken with increasing distance from the coast. The grey dots shows the spread of T/S values from all stations of the entire cruise.

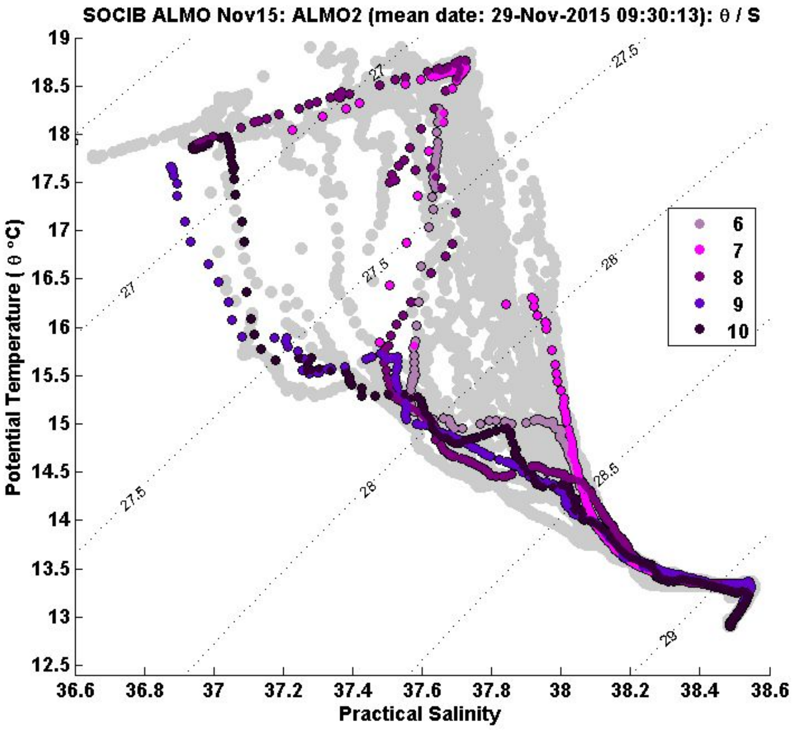


Fig. 9.2. T/S Diagram of stations 6 to 10, of section 2 The lightest colours indicate stations closest to the coast while colours darken with increasing distance from the coast. The grey dots shows the spread of T/S values from all stations of the entire cruise.

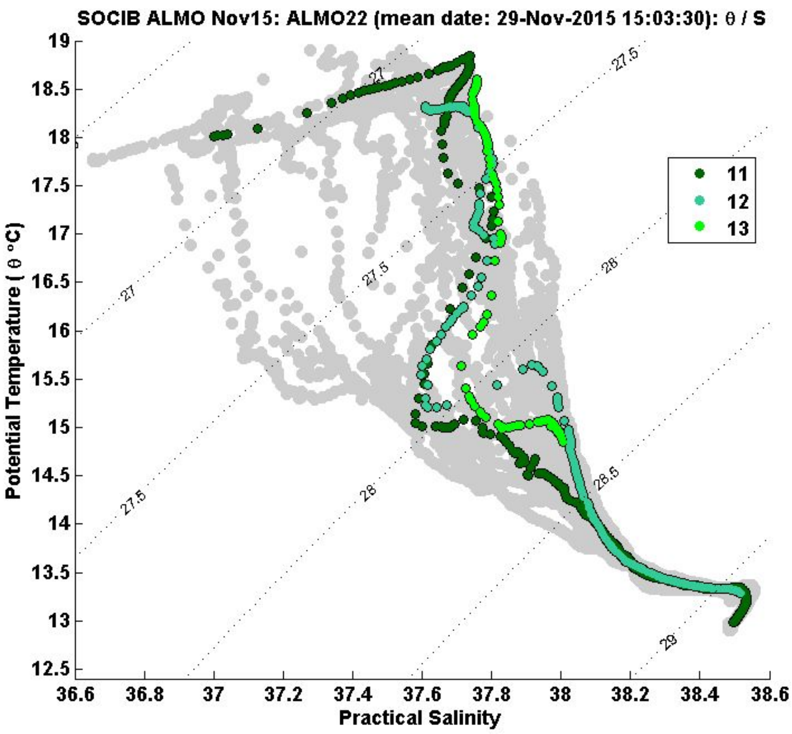


Fig. 9.3. T/S Diagram of stations 11 to 13, of section 2B. The lightest colours indicate stations closest to the coast while colours darken with increasing distance from the coast. The grey dots shows the spread of T/S values from all stations of the entire cruise.

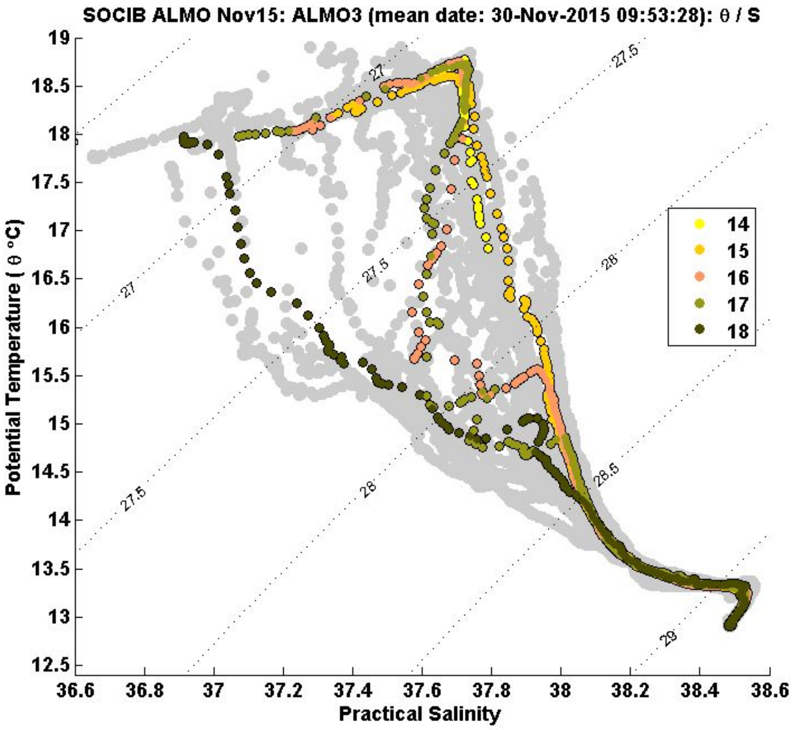



Fig. 9.4. T/S Diagram of stations 14 to 18, of section 3. The lightest colours indicate stations closest to the coast while colours darken with increasing distance from the coast. The grey dots shows the spread of T/S values from all stations of the entire cruise.

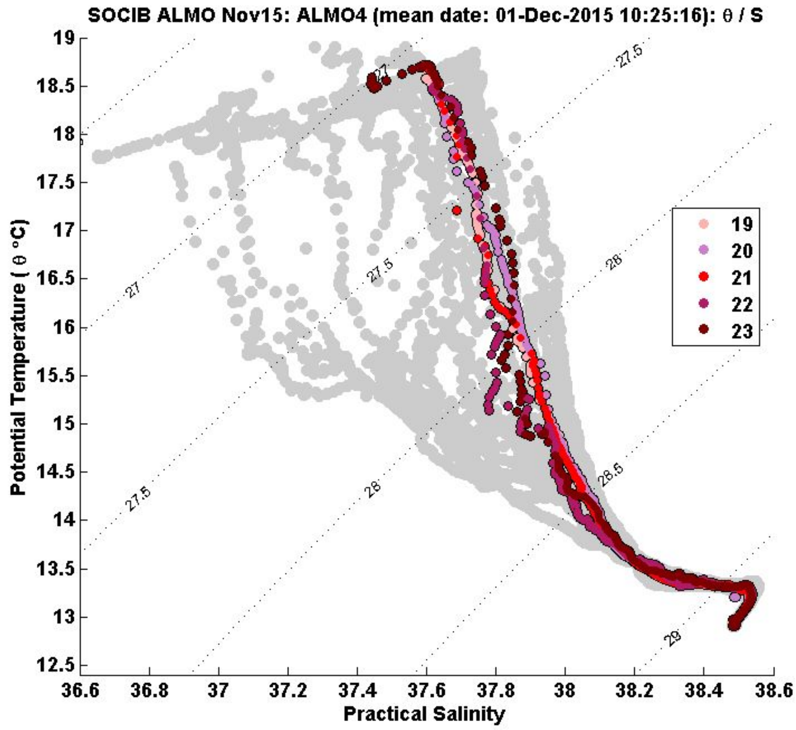


Fig. 9.5. T/S Diagram of stations 19 to 23, of section 4. The lightest colours indicate stations closest to the coast while colours darken with increasing distance from the coast. The grey dots shows the spread of T/S values from all stations of the entire cruise.

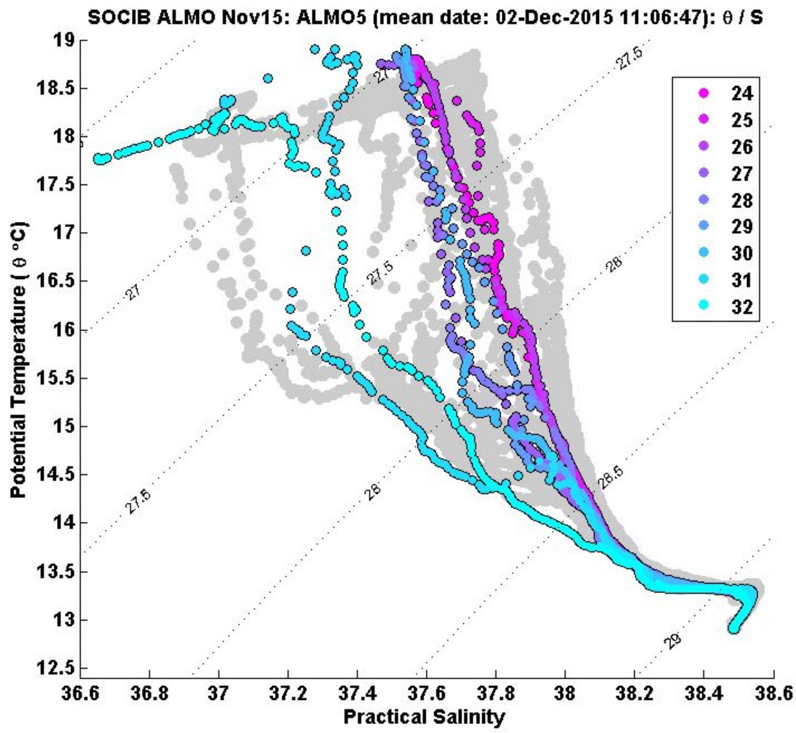


Fig. 9.6. T/S Diagram of stations 24 to 32, of section 5. The lightest colours indicate stations closest to the coast while colours darken with increasing distance from the coast. The grey dots shows the spread of T/S values from all stations of the entire cruise.

6.2.4 Discussion: Summary of key features

1. Flow follows the bathymetry southwards and westwards, weakening below 65 m. Possibility of a shallow coastal counter current is sometimes suggested.
2. Contours of CTD sections generally deepen towards coast
3. Fluorescence and Oxygen maximums occur at the base of the thermocline.
4. The deep stations show different T/S properties to shallower stations (stations 5, 9, 10, 18, 31 and 32) – a shallower gradient of the mixing line between surface and sub-surface waters.
5. Striking temporary jet feature in the final section 5 (Figs. 8.1.2 and 8.2.2), just north of the Almería-Oran Front at about 36.1737° N, 2.1569° W to 36.0955° N, 2.1651° W (ensembles 248 to 260). North of this section the current has a strong westward flowing component below about 70 m (ranging from ~12 to 20 cm s^{-1}), and suddenly changes to a strong eastward flow of about 25 to 32 cm s^{-1} throughout the entire upper water column (albeit with a flow of less than 20 cm s^{-1} in the upper 40 m). This feature is about 9 km thick. Upon the return transit, as the ship passes through this latitude band (ensembles 320-329), just 0.5 km west of the location and two hours later, the velocity, while still eastward, has reduced to about 5 to 15 cm s^{-1}. There is still present a sharp transition back into westward flow at about 36.189° N (ensemble 330).
6. Beginning of Almeria-Oran Front detected at ensemble 262 (36.0825° N, 2.1663° W); in the top 40 m there is a strong eastward flow of 30-40 cm s^{-1}. This region of strong eastward flow deepens to about 90 m at ensemble 279 (36.150° N, 2.1452° W), with eastward velocities at about 80 cm s^{-1} at the surface which reduces to about 21 cm s^{-1} at 80 m. In Fig. 8.2.2 note the apparent east/west banded structure after removal of station ensembles, with a slight southern component on the outward journey and a slight northern component on the return transit.

6.3 Glider Report

See link for the full SOCIB_CANALES_NOV2015 glider mission report.

https://repository.socib.es:8643/repository/entry/get/GF-MR-0041_MSR_U184_CanalesNOV2015.pdf?entryid=56e1a146-56db-41b2-8b26-6973384d59cb

With a summary below.

Mission Name	*SOCIB_CANALES_NOV2015 (GF-MR-0041)*
Platform Model	*Slocum 1000 G1*
Platform ID / Name / WMO Code	*U184 / IDEEP00 / 68452*
Related Platforms / Missions	• *SOCIB-R/V (Canales-Autumn & ALMO missions)* • *IMEDEA glider IDEEP00 (SOCIB GF-MR-0041 mission)*
Start Date	*2015-11-03*

End Date		*2015-12-21*	
Total Days	*49*	**Total distance (Km / Nm)**	*1099 / 594*
Survey Area		*Mallorca and Eïvissa Channels (Western Mediterranean Sea)*	
Objective(s)	• *Establishing the variability of the N/S exchange of water masses that occur through the Ibiza Channel(IC). Sampling standard transects across the Ibiza Channel several times using physical and biogeochemical sensors. No greater than 1 month gap in between consecutive iterations. The Mallorca Channel is also sampled when operationally practical.* • *Synoptic contribution to ALMO cruise by SOCIB-R/V and its main objective:Transects across the Northern Current (NC) and sampling across the Almeria-Oran front, in order to look at the role of the IC and the impact of the seasonality/high frequency changes seen in circulation in IC on the Almeria-Oran front/eastern Alboran Sea*		

6.4 Other platforms contemporaneous to campaign

- The following additional platforms were active in the sampling region before, during and after the ALMO campaign:
- SCB_ARVORI001_SOCIB_ENL_Canales_Nov2014
- SCB_SVP018_SOCIB_ENL_Canales_Jul2015
- OGS_SVP002_PRESEUS_EPR_ALBOREX_May2014

In particular during the campaign the SVP float - SCB_SVP018 - was used to analyse the location of the Almería-Oran front for the final (DAY 6) transect.

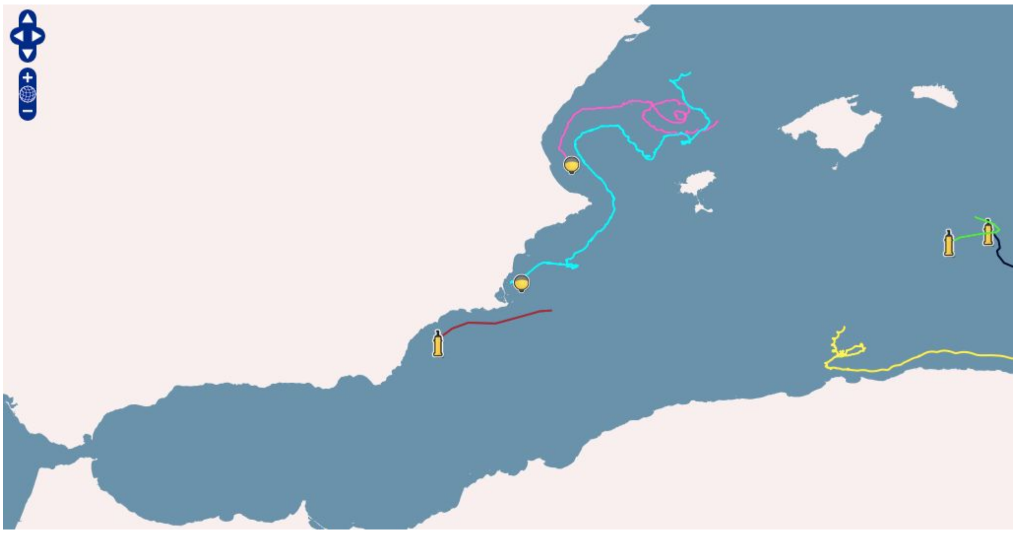


Figure x: From DAPP 03/11/2015: Drifters and Argo currently following the path of the Northern Current, in the region that ALMO sampled at the end of Nov.

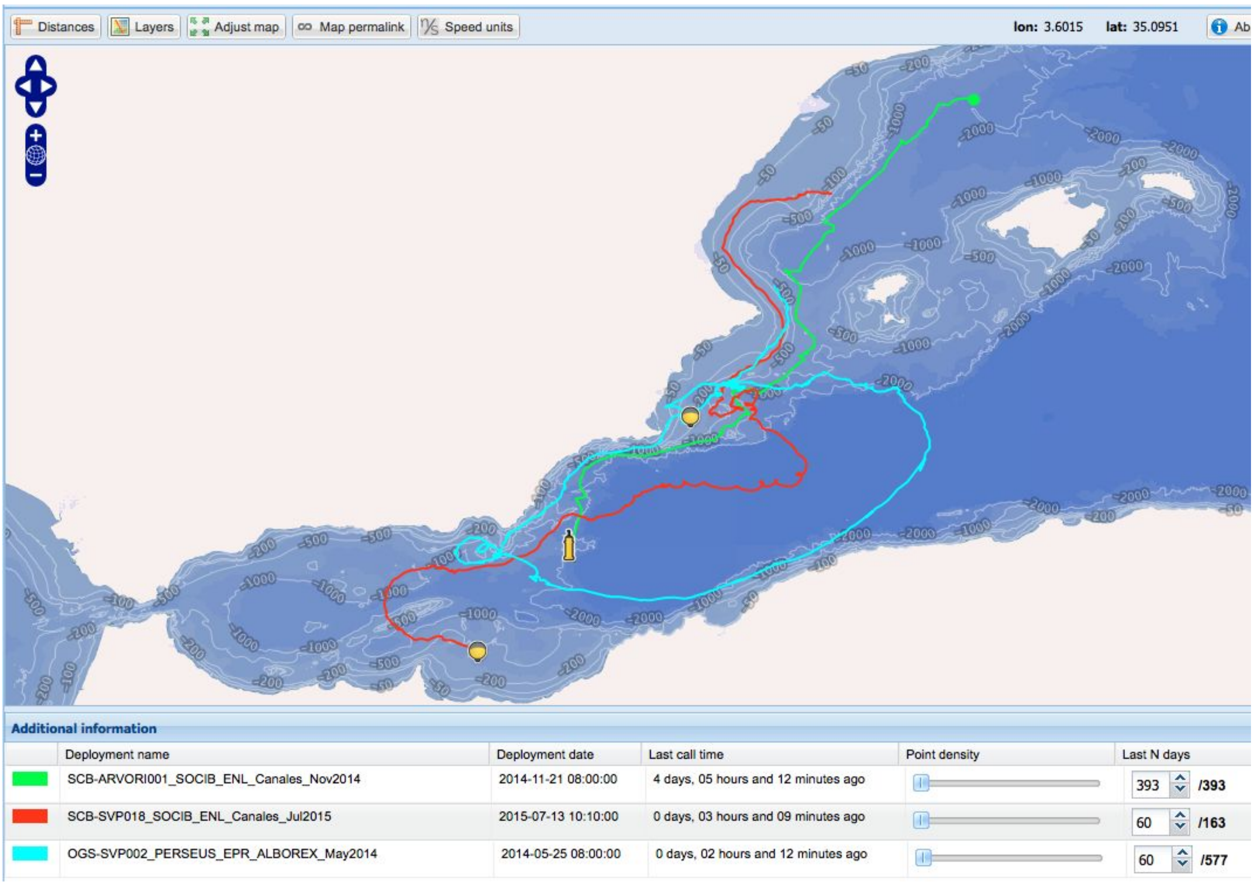


Figure x: Update from DAPP 22/12/2015: Drifters and Argo currently following the path of the Northern Current, in the region that ALMO sampled at the end of Nov.

7 Operational notes – issues to be discussed/resolved

7.1 Data/instrument display

Several data issues with the vessel that should be addressed, not urgent, but for discussion decision and action:

Seaboard – onboard:

- Fluorescence (V) from the salinometer not functioning – should be addressed if we want to capture this underway data (importance?) – UTM installed – this would be have been a good tool for the Almeria Oran front – so should be fixed

- Wind from meteo instruments is not calculated correctly – we should not display this data (web?) if it is not correct, this should be addressed

- Salinograph plot cannot cope with change from E/W, plus cannot set the ability to set the scale installed – this would be have been a good tool for the Almeria Oran front and other days on this cruise – so should be fixed (we did try to fake it!)

- Ships position plotted in DAPP same problem - UTM installed - Incorrect data should not be streamed

Possible solution - Jan-Feb 2016 organise a review of ship data systems to get things functioning correctly for 2016 campaigns, coordination between ETD, Data Centre, IT, UTM?

Data we collect but that are not made visible:

- ADCP data not viewable in SOCIB web – we not have good dataset, this should be viewable in some way – John, Krissy and Emma discussed on board for 2016, some initial ideas/results visible in this report. If we do not give visibility to datasets that we work hard to collect, then the work has no visibility.

- Same comment for biogeochemical data

In 2016 a plan could be developed for the new web on how to show these data sets post mission.

Iridium Argo:

SOCIB cannot yet data from Iridium Argo, will need to get data from Coriolis.

7.2 Biogeochemical sampling on SOCIB ship missions

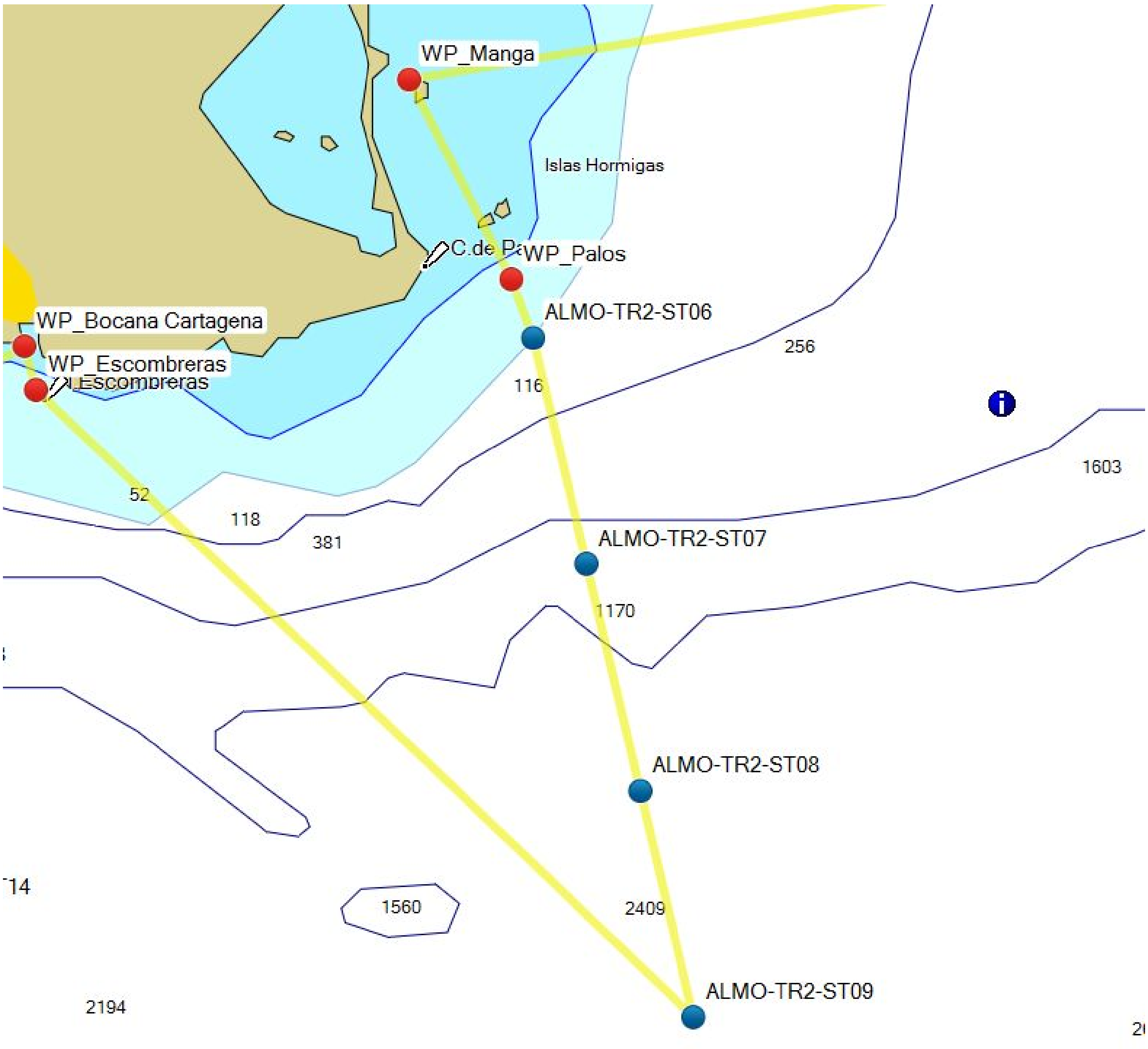
Evening discussions covered the sampling of S and O2 and how to make ‘canales’ more workable; the amount of O2 samples is too great a burden, can we do with less now we have calibrated a number of missions. John was keen on more S and less O2 and then suggested that we could take fewer samples but increase the accuracy, by stopping the rosette on ascent for approx. 2 mins (or however long it takes for the sensors to stabilize) and then firing the bottles for samples of S and O2, whilst maintaining the ‘on the fly’ approach for the biogeochemistry. This approach was tested on the ALMO cruise.

ANNEX 1: Transect Plan day by day

Day 1: Alicante - Mar Menor

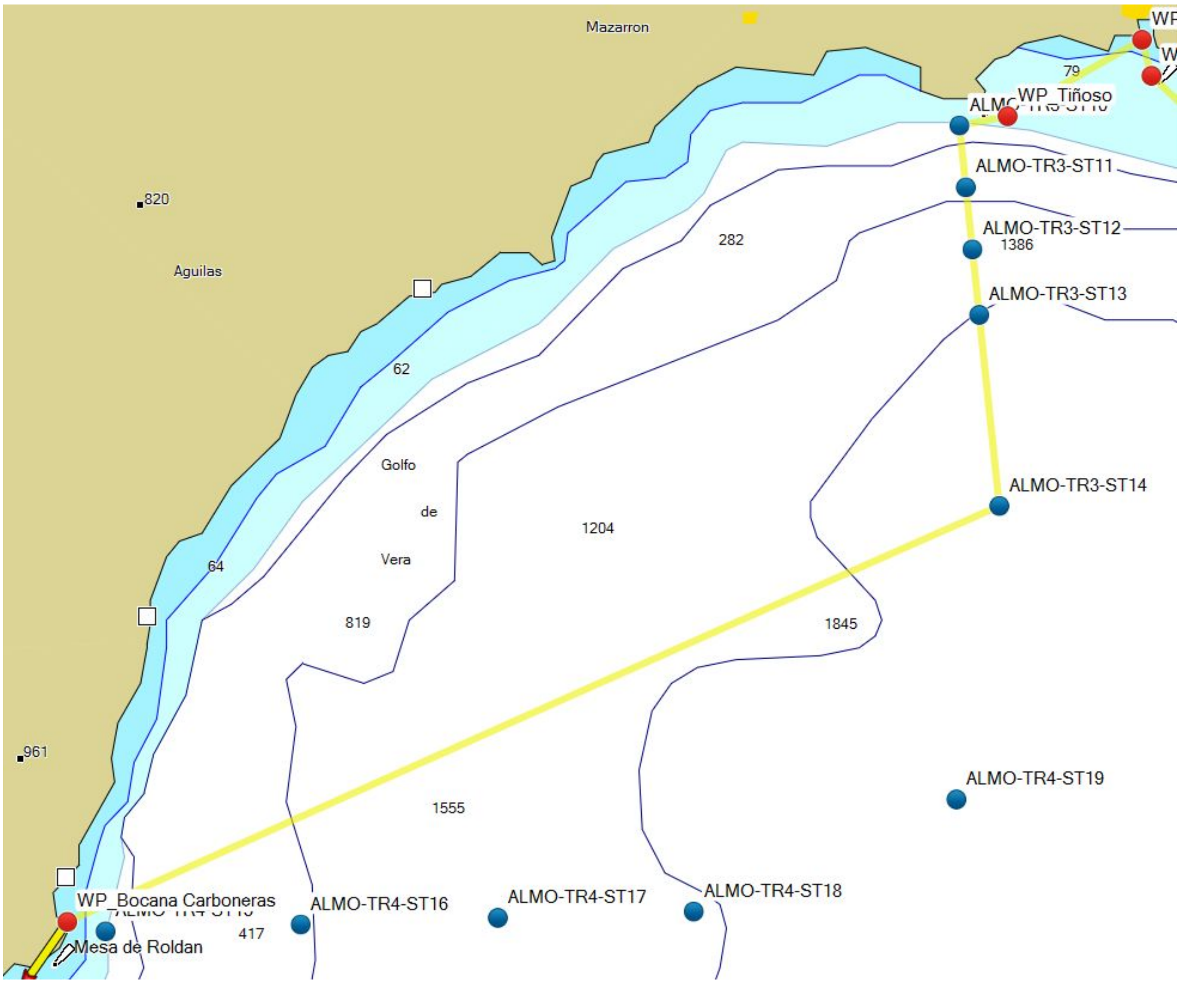
Nombre	Posición	Hora de llegada	Escala	Hora de salida	Distancia total	Tiempo total	Profundidad
WP_PAlicante 1	N38 19.806 W0 29.452			**27/11/2015 8:00**	0 m	0 s	
ALMO-TR1-ST01	N38 06.991 W0 16.061	27/11/2015 9:27	10 min	**27/11/2015 9:37**	16.6 nm	1 h, 27 min	100 m
ALMO-TR1-ST02	N38 03.475 W0 06.906	27/11/2015 10:19	30 min	**27/11/2015 10:49**	24.6 nm	2 h, 8 min	500 m
ALMO-TR1-ST03	N37 59.964 E0 02.220	27/11/2015 11:31	1 h, 0 min	**27/11/2015 12:31**	32.6 nm	2 h, 50 min	1200 m
ALMO-TR1-ST04	N37 56.443 E0 11.341	27/11/2015 13:12	1 h, 10 min	**27/11/2015 14:22**	40.7 nm	3 h, 32 min	1400 m
ALMO-TR1-ST05	N37 52.776 E0 20.442	27/11/2015 15:05	1 h, 20 min	**27/11/2015 16:25**	48.7 nm	4 h, 14 min	1550 m
WP_Manga	N37 44.231 W0 42.795	27/11/2015 20:50			100 nm	8 h, 39 min	

Day 2: Mar Menor - Cartagena



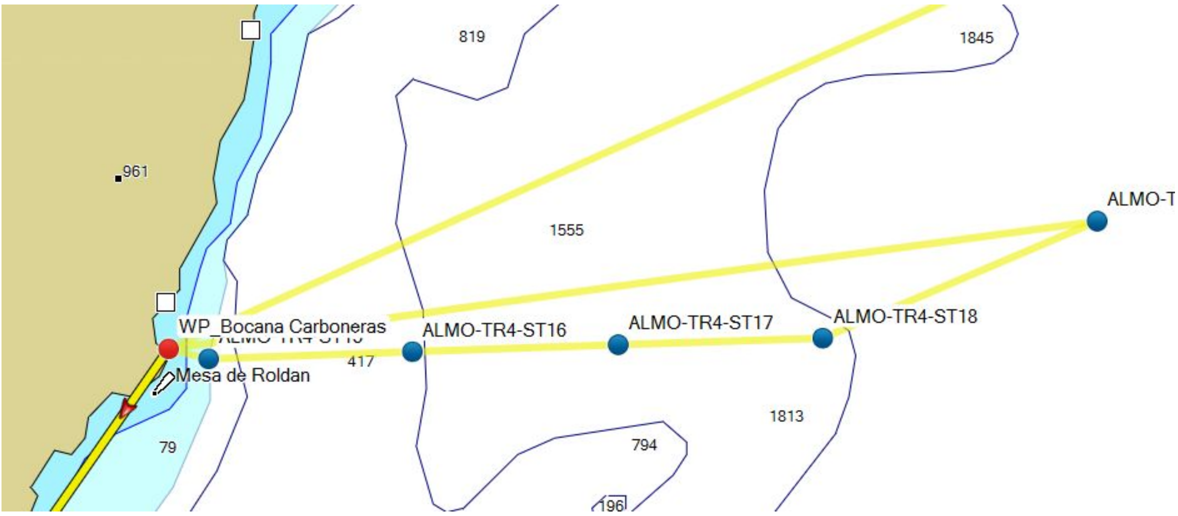
Nombre	Posición	Hora de llegada	Escala	Hora de salida	Distancia total	Tiempo total	Profundidad
WP_Manga	N37 44.231 W0 42.795			**28/11/2015 8:00**	0 m	0 s	
WP_Palos	N37 37.377 W0 38.491	28/11/2015 8:40		28/11/2015 8:40	7.7 nm	40 min	30.0 m
ALMO-TR2-ST06	N37 35.365 W0 37.578	28/11/2015 8:51	10 min	**28/11/2015 9:01**	9.8 nm	51 min	100 m
ALMO-TR2-ST07	N37 27.599 W0 35.315	28/11/2015 9:42	1 h, 20 min	**28/11/2015 11:02**	17.8 nm	1 h, 33 min	1500 m
ALMO-TR2-ST08	N37 19.795 W0 33.042	28/11/2015 11:44	2 h, 15 min	**28/11/2015 13:59**	25.8 nm	2 h, 15 min	2400 m
ALMO-TR2-ST09	N37 12.031 W0 30.796	28/11/2015 14:41	2 h, 30 min	**28/11/2015 17:11**	33.8 nm	2 h, 56 min	2600 m
WP_Escombreras	N37 33.539 W0 58.422	28/11/2015 19:51		28/11/2015 19:51	64.6 nm	5 h, 37 min	30.0 m
WP_Bocana Cartagena	N37 35.043 W0 58.909	28/11/2015 20:00			66.1 nm	5 h, 45 min	

Day 3: Cartagena - Carboneras



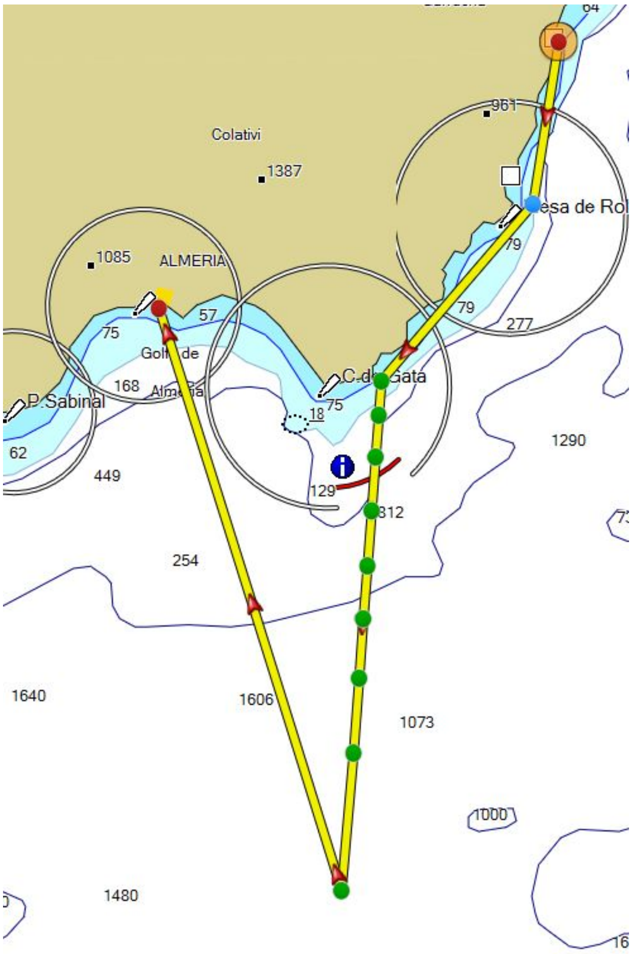
Nombre	Posición	Hora de llegada	Escala	Hora de salida	Distancia total	Tiempo total	Profundidad
WP_Bocana Cartagena	N37 35.043 W0 58.909			**29/11/2015 8:00**	0 m	0 s	
WP_Tiñoso	N37 31.840 W1 05.742	29/11/2015 8:33		29/11/2015 8:33	6.3 nm	33 min	
ALMO-TR3-ST10	N37 31.451 W1 08.196	29/11/2015 8:43	10 min	**29/11/2015 8:53**	8.3 nm	43 min	100 m
ALMO-TR3-ST11	N37 28.867 W1 07.858	29/11/2015 9:07	1 h, 0 min	**29/11/2015 10:07**	10.9 nm	57 min	1000 m
ALMO-TR3-ST12	N37 26.278 W1 07.521	29/11/2015 10:20	1 h, 40 min	**29/11/2015 12:00**	13.5 nm	1 h, 10 min	1600 m
ALMO-TR3-ST13	N37 23.550 W1 07.166	29/11/2015 12:15	1 h, 50 min	**29/11/2015 14:05**	16.3 nm	1 h, 25 min	2200 m
ALMO-TR3-ST14	N37 15.583 W1 06.122	29/11/2015 14:47	2 h, 0 min	**29/11/2015 16:47**	24.3 nm	2 h, 7 min	2300 m
WP_Bocana Carboneras	N36 58.148 W1 53.529	29/11/2015 20:24			66.0 nm	5 h, 44 min	

Day 4: Carboneras - Carboneras



Nombre	Posición	Hora de llegada	Escala	Hora de salida	Distancia total	Tiempo total	Profundidad
WP_Bocana Carboneras	N36 58.148 W1 53.529			**30/11/2015 8:00**	0 m	0 s	
ALMO-TR4-ST15	N36 57.753 W1 51.581	30/11/2015 8:08	10 min	**30/11/2015 8:18**	1.6 nm	8 min	
ALMO-TR4-ST16	N36 58.058 W1 41.645	30/11/2015 9:00	1 h, 0 min	**30/11/2015 10:00**	9.6 nm	50 min	
ALMO-TR4-ST17	N36 58.354 W1 31.611	30/11/2015 10:42	1 h, 30 min	**30/11/2015 12:12**	17.6 nm	1 h, 32 min	
ALMO-TR4-ST18	N36 58.634 W1 21.642	30/11/2015 12:53	1 h, 0 min	**30/11/2015 13:53**	25.6 nm	2 h, 14 min	
ALMO-TR4-ST19	N37 03.332 W1 08.273	30/11/2015 14:54	2 h, 1 min	**30/11/2015 16:55**	37.3 nm	3 h, 14 min	
WP_Bocana Carboneras	N36 58.148 W1 53.529	30/11/2015 20:06			73.9 nm	6 h, 26 min	

Day 5: Carboneras - Almería



Nombre	Posición	Hora de llegada	Escala	Hora de salida	Distancia total	Tiempo total	Profundidad
WP_Bocana_Garrucha	N37 10.554 W1 49.109			**30/11/2015 7:00**	0 ft	0 s	10.0 m
ALMO-TR4-ST19	N36 57.753 W1 51.581	30/11/2015 8:08		30/11/2015 8:08	12.9 nm	1 h, 7 min	
ALMO-TR5-ST24_B	N36 43.785 W2 06.195	30/11/2015 9:43	10 min	**30/11/2015 9:53**	31.2 nm	2 h, 43 min	75.0 m
ALMO-TR5-ST25_B	N36 41.085 W2 06.443	30/11/2015 10:07	20 min	**30/11/2015 10:27**	33.9 nm	2 h, 57 min	250 m
ALMO-TR5-ST26_B	N36 37.793 W2 06.750	30/11/2015 10:44	25 min	**30/11/2015 11:09**	37.2 nm	3 h, 14 min	400 m
ALMO-TR5-ST27_B	N36 33.548 W2 07.131	30/11/2015 11:32	30 min	**30/11/2015 12:02**	41.4 nm	3 h, 36 min	600 m
ALMO-TR5-ST28_B	N36 29.196 W2 07.533	30/11/2015 12:24	50 min	**30/11/2015 13:14**	45.8 nm	3 h, 59 min	1000 m
ALMO-TR5-ST29_B	N36 25.019 W2 07.941	30/11/2015 13:36	50 min	**30/11/2015 14:26**	50.0 nm	4 h, 21 min	1100 m
ALMO-TR5-ST30_B	N36 20.330 W2 08.339	30/11/2015 14:51	1 h, 0 min	**30/11/2015 15:51**	54.7 nm	4 h, 46 min	1300 m
ALMO-TR5-ST31_B	N36 14.414 W2 08.879	30/11/2015 16:22	1 h, 20 min	**30/11/2015 17:42**	60.7 nm	5 h, 17 min	1700 m
ALMO-TR5-ST32_B	N36 03.561 W2 10.043	30/11/2015 18:39	1 h, 45 min	**30/11/2015 20:24**	71.5 nm	6 h, 13 min	1900 m
WP_Bocana Almería	N36 49.521 W2 27.635	01/12/2015 0:34			120 nm	10 h, 24 min	10.0 m