HYDROGRAPHIC CRUISE REPORT

SAN DIEGO COASTAL EXPEDITION

R/V Melville 1209, 1217

Leg 1: 30 June – 10 July 2012

Leg 2: 8 December – 15 December 2012

Contents

INTRODUCTION

The data presented in this report were collected during cruises MV1209 and MV1217 of the San Diego Coastal Expedition (SDCE) program aboard the R/V Melville of Scripps Institution of Oceanography, University of California San Diego. The SDCE program was organized by doctoral students at Scripps to study the role of oxygen and carbonate chemistry in structuring benthic communities along the San Diego margin and slope, and to explore for methane seeps. Cruise time was funded by the UC Ship Funds program, an award that pays for sea time aboard Scripps research vessels to provide hands-on training for graduate and undergraduate students, postdoctoral researchers and early career faculty. Graduate student and postdoctoral researcher participants ranged in disciplines from biological oceanography and marine chemistry to physical oceanography. Any questions regarding datasets and data products can be directed to Christina Frieder, ctanner@ucsd.edu or christina.ann.frieder@gmail.com.

The main purposes of this report are to provide details on collection and processing of the hydrographic dataset, and to provide bottom water environmental data collected from the CTD-Rosette at the multicore stations to be used by all multicore users. The hydrographic dataset is unique in that it has extensive spatial and depth coverage of oxygen and carbonate chemistry conditions along and offshore of the San Diego margin.

PROGRAMS

Several programs produced data on this cruise series, and associated products from each of these programs are at varying stages of completion. These programs include:

1) *Hydrographic Surveys*: CTD and Rosette casts were conducted at multiple stations along three main lines during both cruises: Line D, Line L and Line P (Table 1 & 2). Line D extended southwest from the coastline of Del Mar, CA and was designed to correspond with inner stations of CalCOFI's Line 93. Line L extended west from Bird Rock, CA. Line P extended west from Point Loma, CA. Hydrographic data were collected with CTD and Rosette casts from the surface to near bottom depths. Standard procedures for collection of data are provided below, and data is publicly available. (Y. Takeshita ytakeshi@ucsd.edu)

2) *ADCP*: Continuous profiles of ocean currents and acoustic backscatter between 40 and 760 meters deep were measured along the ship track from a hull-mounted 75 kHz Acoustic Doppler Current Profiler (ADCP). Both broad-band and narrow-band ADCP data were averaged over 15-minute or 1-hour intervals. Thirty 25-meter depth bins were recorded. (S. Nam; sunam@ucsd.edu)

3) *CHIRPand Multibeam Surveys*: Multibeam and backscatter data were collected throughout the entire MV1209 cruise using the hull mounted Kongsberg EM122 system at 12 kHz (Fig. 1). CHIRP data were collected at targeted sites using the hull mounted Knudsen sub-bottom echosounder at both 3.5 kHZ and 12 kHz. (J. Maloney; jmmalone@ucsd.edu)

4) *Multicoring:* Sediment samples were collected at six stations along the margin and slope with a deep-sea multicorer with eight sample tubes 10 cm x 70 cm (Table 3). At least three drops were made at each station and tubes were divvied among multiple projects. Sediments were vertically-fractioned and processed with varying protocols depending on fate. The variety of projects included meiofauna and macrofauna community studies, protistan and microbial studies, and bulk sediment and porewater analyses. (C. Frieder; ctanner@ucsd.edu)

5) *Trawling and ROV Surveys*: Megafauna were sampled during both cruises with an otter trawl and observational data was gathered by ROV survey in December. Trawls were conducted at 100 and 300 m depths off Del Mar and 100, 300, and 400 m depths off La Jolla during both cruises. In addition, trawls were conducted at 100, 300, and 400 m depths off of Point Loma and at 400 m depth off Del Mar on MV1217. Recovered specimens were identified to lowest taxonomic level possible, enumerated, and a subset preserved in ethanol and formalin and will be made available to the Scripps Benthic Collections. ROV surveys (100-400 m depth) were conducted off of Del Mar and La Jolla on MV1217 and at Del Mar at 400 m depth on MV1209. (M. Navarro; monavarr@ucsd.edu)

6) *Seep Surveys*: Surveys of the Del Mar methane seep were conducted with the ROV and sediment collections were made with multicorer. Press release regarding identification of a methane seep off San Diego is available at https://scripps.ucsd.edu/news/1779. (B. Grupe; bgrupe@ucsd.edu)

STANDARD PROCEDURES FOR HYDROGRAPHIC DATA

CTD/Rosette Cast Data

A Sea-Bird Electronics, Inc., Conductivity-Temperature-Depth (CTD) instrument (SBE9) and dissolved oxygen sensor (Sea-Bird Electronics Sensor SBE43) with a rosette was deployed at each station on these cruises. The rosette was equipped with 24 ten-liter plastic (PVC) bottles. Each CTD/rosette cast usually sampled every 50 – 100 m with increased resolution in the upper 200 m of the water column. The sample spacing was designed to characterize near-bottom conditions, the structure of the OMZ, and the upper thermocline. Discrete samples were analyzed for oxygen, pH and total dissolved inorganic carbon (C_T), and salinity.

Salinity samples were collected from a subset of bottles and analyzed at the Ocean Data Facility using a Guildline Autosal 8400 salinometer. Samples were drawn into 200 ml borosilicate bottles that were rinsed three times with sample prior to filling. The salinometer was standardized before and after each group of samples with standardized seawater. Periodic checks on the conductivity of the standardized seawater were made by comparison with IAPSO Standard Seawater. The CTD-salinity values were corrected by applying a linear function based on discrete samples (Fig. 2). The offset (intercept) and gain (slope) are reported for CTD-salinity in Table 4.

Discrete samples for dissolved oxygen were collected and analyzed following standard procedures (Dickson 1996; Dickson et al. 2007). The endpoint was determined photometrically (Bryan 1976) using a custom titration cell described in Martz et al. 2011. A Milligat low flow M5 pump was used for titrant delivery. The concentration of the thiosulfate solution was determined directly prior and after each cruise using KIO_3 standard solutions prepared in house (Fisher, lot 105595); no detectable drift in titrant concentration was observed for either cruise. Duplicate samples were taken from two niskin bottles fired simultaneously at the same depth. Precision of the measurements was $\pm$ 0.75 and $\pm$ 0.31 µmol/kg for cruise MV1209 and MV1217, respectively. The accuracy of the measurements was estimated to be $\pm$ 0.5% based on Emerson et al. (1999) since KIO_3 standards were not recrystallized. The CTD-oxygen values were corrected by applying a linear function based on discrete samples (Fig. 2). The offset (intercept) and gain (slope) are reported for CTD-oxygen in Table 4.

Samples for C_T and pH were collected in 150 or 250 ml pyrex serum bottles (13 mm neck), and filled following standard procedures (Dickson et al., 2007), with a slight modification. The bottle was filled so no head space remained, and a gray butyl stopper was inserted to prevent gas exchange. Samples were typically analyzed within 4 hours of collection. Duplicate samples were taken from two niskin bottles that were simultaneously fired at the same depth for every cast.

C_T samples were analyzed using a system based on the design of O'Sullivan and Millero (1998). Briefly, a seawater sample is acidified, converting all C_T to $CO_{2(g)}$. The $CO_{2(g)}$ is then is extracted from the sample in a nitrogen gas stream and detected using a LiCOR 7000 NDIR gas analyzer. A Kloehn V6 syringe pump (5 mL syringe) was used to deliver 1 mL of sample to a custom stripping chamber, and subsequently 100 µL of 5% phosphoric acid was added. The acidified sample was bubbled with $N_{2(g)}$, and the resultant gas phase (now $N_{2(g)} + CO_{2(g)}$) was delivered to the LiCOR; the flow rate of the carrier gas was controlled using a mass flow controller. The $CO_{2(g)}$ stripped from the water sample results in a peak in the output of the LiCOR, and the C_T is proportional to the integral of this peak.

The C_T measurements were calibrated using Certified Reference Materials (CRMs), provided by the Dickson Lab at SIO (Batch 117 for MV1209, and a prototype batch of a high-CO_2 "CRM" (C_T = 2141.9 μmol/kg) for MV1217) by applying a gain correction (slope), and assuming an offset of zero (intercept). The CRMs were stored in CO_2 impermeable bags (3L Scholle DuraShield®), and were measured frequently throughout the cruise. Every day, a fresh bottle of CRM was opened to verify the stability of the CRM in the bag. No drift was observed. The gain calibration factor was interpolated to each sample. Precision of the measurements was estimated from duplicate samples for MV1209 and MV1217, and is ± 2.8 μmol/kg (n = 32) and ± 2.2 μmol/kg (n = 35), respectively. The accuracy of the measurements is estimated to be ± 3.5 μmol/kg.

pH samples were analyzed spectrophotometrically (Dickson et al. 2007; Clayton and Byrne, 1993), using an automated system described in Carter et al. 2013, except for the first 11 casts on MV1217 where measurements were made manually. For all measurements, a temperature controlled 10-cm cell was used. The temperature of the solution inside of the cell was not measured, but was assumed to be 20°C. Every sample was immersed in a temperature controlled water bath at 20°C for at least 25 minutes before analysis. The pH of the indicator dye (m-cresol purple, Acros, lot A0264321) solution (2 mM) was adjusted to be ~7.7 by adding a small amount of NaOH. Measurements of certified Tris buffer in artificial seawater (provided by the Dickson Lab) were used to apply an offset calibration to the pH measurements (0.035 and 0.025 pH units for MV1209 and MV1217, respectively). Precision of the measurements was estimated from duplicate samples for MV1209 and MV1217 to be ± 0.001 (n = 31) and ± 0.002 (n = 55), respectively. The accuracy of the measurements was estimated to be ± 0.02.

Pressures and temperatures assigned to the water sample data were derived from the CTD signals recorded just prior to the bottle trip. CTD temperatures reported with the bottle data have been rounded to the nearest hundredth of a degree Celsius.

Derived carbonate parameters are not included in the published dataset, but are available upon request. Nutrients were not measured on these cruises, however have been estimated through empirical relationships from NACP 2007 data based on the method described in Alin et al. (2012).

TABULATED HYDROGRAPHIC DATA

CTD/Rosette Cast Data

Data are provided as individual text files per cast. The time reported is the Coordinated Universal Time (UTC) at the beginning of the downcast. The sample files are numbered consecutively as they were conducted during the cruise. Header information within each file reports cruise number, station number, station name, cast number, time, latitude and longitude, and bottom depth. Bottom depths were determined acoustically. Only data for downcasts are included and are binned at 1-m intervals.

Discrete data for salinity, dissolved oxygen, C_T and pH are provided as individual text files per cruise formatted for Ocean Data View (ODV). Missing value indicator is -999. Flags are reported for CTD pressure, CTD salinity, CTD temperature, CTD oxygen, bottle pH, temperature of pH measurement, C_T, bottle oxygen, and bottle salinity. Flag numbers represent 1= good data, 2= probably good, 3 = probably bad, 4 = bad, 6 = averaged data, 8 = lost sample, 9 = not sampled. All pH measurements are reported at the measurement temperature (20 °C) and pressure of 0 dbar.

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TABLES

Table 1. MV1209 (July 2012) CTD/Rosette station numbers, names, cast number, time, location and bottom depth.

Station No.	Station Name	Cast No.	Time (GMT)	Latitude	Longitude	Bottom Depth (m)
1	'D4'	1	7/1/2012 14:40	32.9391	-117.3449	390
2	'D3'	1	7/1/2012 19:15	32.9504	-117.3269	350
3	'D2'	1	7/1/2012 21:14	32.9445	-117.3079	67
4	'D1'	1	7/2/2012 3:22	32.9674	-117.2928	32
5	'D5'	1	7/2/2012 4:30	32.9291	-117.3649	480
6	'D6'	1	7/2/2012 6:39	32.9097	-117.4059	644
7	'L9'	1	7/2/2012 9:44	32.8095	-117.5019	800
8	'D7'	1	7/2/2012 15:19	32.8500	-117.5318	850
9	'L8'	1	7/3/2012 18:17	32.8100	-117.4658	705
10	'L7'	1	7/3/2012 20:53	32.8100	-117.4166	523
11	'L2'	1	7/4/2012 18:52	32.8098	-117.2985	25
12	'L3'	1	7/4/2012 19:26	32.8107	-117.3099	40
13	'L4'	1	7/4/2012 20:05	32.8099	-117.3242	68
14	'L5'	1	7/5/2012 15:36	32.8100	-117.3498	92
15	'L6'	1	7/5/2012 16:56	32.8101	-117.3758	232
16	'L6b'	1	7/5/2012 18:37	32.8101	-117.3849	300
17	'D9'	1	7/5/2012 22:40	32.7021	-117.8600	650
18	'D8'	1	7/6/2012 1:26	32.7789	-117.6783	1050
19	'SDT'	1	7/6/2012 15:30	32.6333	-117.4999	1050
20	'SDT2'	1	7/9/2012 0:00	32.6905	-117.5307	1115
21	'P10'	1	7/7/2012 2:38	32.6910	-117.6129	1140
22	'SDT9'	1	7/7/2012 5:02	32.6898	-117.6809	1152
23	'D8b'	1	7/7/2012 7:00	32.7305	-117.7818	275
24	'SDT8'	1	7/7/2012 8:40	32.7552	-117.7163	1104
25	'P5'	1	7/7/2012 12:20	32.6900	-117.3369	130
26	'P4'	1	7/7/2012 13:25	32.6896	-117.3162	84
27	'P3'	1	7/7/2012 14:18	32.6896	-117.2963	69
28	'P2'	1	7/7/2012 15:12	32.6901	-117.2794	52
29	'P1'	1	7/7/2012 15:53	32.6899	-117.2721	30
30	'L6b'	2	7/8/2012 15:14	32.8100	-117.3847	300
31	'DM'	1	7/8/2012 21:14	32.9286	-117.3168	115
32	'D8'	2	7/9/2012 0:13	32.7788	-117.6782	1055
33	'D8'	3	7/9/2012 4:00	32.7788	-117.6827	1050
34	'P8'	1	7/9/2012 15:45	32.6900	-117.4454	502
35	'P7'	1	7/9/2012 17:55	32.6901	-117.3933	358
36	'P6'	1	7/9/2012 19:44	32.6900	-117.3678	268
37	'SDT6b'	1	7/9/2012 23:50	32.9033	-117.7825	1030
38	'SDT4'	1	7/10/2012 8:09	32.8095	-117.6240	985

Table 2. MV1217 (December 2012) CTD/Rosette station numbers, names, cast number, time, location and bottom depth.

Station No.	Station Name	Cast No.	Date	Latitude	Longitude	Bottom Depth (m)
1	'SDT2'	1	12/8/2012 20:43	32.6901	-117.5306	1102
2	'SDT4'	1	12/8/2012 23:47	32.8093	-117.6240	978
3	'L7'	1	12/9/2012 5:22	32.8100	-117.4166	522
4	'D1'	1	12/10/2012 2:22	32.9675	-117.2930	35
5	'D2b'	1	12/10/2012 3:26	32.9597	-117.3099	74
6	'DM'	1	12/10/2012 4:42	32.9275	-117.3169	110
7	'D3'	1	12/10/2012 6:10	32.9504	-117.3269	346
8	'D5'	1	12/10/2012 7:49	32.9291	-117.3650	475
9	'D6'	1	12/10/2012 9:43	32.9097	-117.4059	640
10	'DL300'	1	12/10/2012 12:04	32.8628	-117.3607	282
11	'DL100'	1	12/10/2012 13:09	32.8626	-117.3340	99
12	'L6b'	1	12/11/2012 8:42	32.8101	-117.3848	299
13	'L5'	1	12/11/2012 10:10	32.8099	-117.3498	90
14	'L4'	1	12/11/2012 11:08	32.8099	-117.3242	59
15	'L2'	1	12/11/2012 11:51	32.8098	-117.2985	24
16	'SDT6b'	1	12/11/2012 15:20	32.9033	-117.7825	1023
17	'SDT8'	1	12/12/2012 4:42	32.7550	-117.7163	1093
18	'D7'	1	12/12/2012 7:14	32.8494	-117.5320	841
19	'L8'	1	12/13/2012 5:59	32.8100	-117.4659	695
20	'SDT9'	1	12/13/2012 8:45	32.6898	-117.6806	1141
21	'D9'	1	12/13/2012 11:02	32.7025	-117.8599	643
22	'SDT'	1	12/14/2012 4:42	32.6333	-117.5000	1170
23	'P8'	1	12/14/2012 11:24	32.6900	-117.4454	481
24	'L9'	1	12/15/2012 1:15	32.8095	-117.5019	781
25	'P4'	1	12/15/2012 8:21	32.6896	-117.3162	85
26	'P2b'	1	12/15/2012 9:11	32.8095	-117.5019	60
27	'P7'	1	12/15/2012 11:07	32.6901	-117.3933	350
28	'P9b'	1	12/15/2012 15:15	32.6932	-117.5721	1100
29	'P10'	1	12/15/2012 16:31	32.6916	-117.6130	1100

Table 3. Multicore site locations and depth and measurements of temperature, salinity, dissolved oxygen (both µmol/kg and ml/l), pH (total scale; in-situ temperature and pressure), and total dissolved inorganic carbon (DIC). Alkalinity, pCO_2, saturation state of aragone and calcite (Ω_{Ar} and Ω_{Ca}, respectively) were calculated from DIC and pH at in-situ temperature and pressure using CO2SYS.

Cruise	CTD Stn.	Depth (m)	Latitude (N)	Longitude (W)	Temp (°C)	Salinity	$[O_2]$ (µmol/kg)	DO (ml/l)	pH_T	DIC (µmol/kg)	Alkalinity (µmol/kg)	pCO_2 (uatm)	ΩAr	ΩCa
MV1209	L6b	300	32 48.601	117 28.086	9.2597	34.297	38.1	0.83	7.593	2260.6	2283.7	1220.1	0.714	1.121
MV1209	L7	528	32 48.602	117 24.995	6.8180	34.306	17.4	0.38	7.551	2304.7	2308.2	1313.7	0.583	0.916
MV1209	L8	700	32 48.598	117 27.058	5.7354	34.360	10.6	0.23	7.545	2326.4	2326.2	1306.9	0.544	0.855
MV1209	L9	806	32 48.571	117 30.416	5.0896	34.407	11.0	0.24	7.552	2342.2	2342.7	1274.2	0.537	0.843
MV1209	SDT6b	1040	32 54.110	117 46.964	4.0297	34.479	20.3	0.44	7.583	2357.0	2362.3	1129.0	0.550	0.862
MV1209	SDT	1175	32 38.000	117 29.993	3.6724	34.468	31.1	0.67	7.596	2372.6	2385.9	1105.1	0.541	0.847
MV1217	L6b	300	32 48.601	117 28.086	8.6137	34.145	70.9	1.54	7.654	2230.6	2268.5	1045.1	0.789	1.241
MV1217	L7	528	32 48.602	117 24.995	6.6217	34.313	16.2	0.35	7.566	2303.9	2311.4	1265.3	0.598	0.940
MV1217	L8	700	32 48.598	117 27.058	5.8975	34.348	11.9	0.26	7.555	2325.0	2326.7	1285.3	0.563	0.884
MV1217	L9	806	32 48.571	117 30.416	5.0491	34.405	13.5	0.29	7.561	2342.7	2345.8	1250.2	0.547	0.859
MV1217	SDT6b	1040	32 54.110	117 46.964	4.1685	34.476	20.3	0.44	7.581	2361.0	2369.3	1164.2	0.542	0.850
MV1217	SDT	1175	32 38.000	117 29.993	3.8231	34.501	26.6	0.58	7.591	2360.0	2371.7	1121.9	0.543	0.850

Table 4. Correction factors that have been applied to CTD data for dissolved oxygen (DO; μmol kg^{-1}) and salinity.

Cruise	Parameter	Correction
MV1209	Salinity	$sal_{corr} = 0.6146 \times sal_{CTD} + 0.9824$
	DO	$DO_{corr} = 0.335 \times DO_{CTD} + 1.0148$
MV1217	Salinity	$sal_{corr} = 0.1916 \times sal_{CTD} + 0.9945$
	DO	$DO_{corr} = 1.890 \times DO_{CTD} + 1.0660$

FIGURES

Figure1. Bathymetric data collected during MV1209.

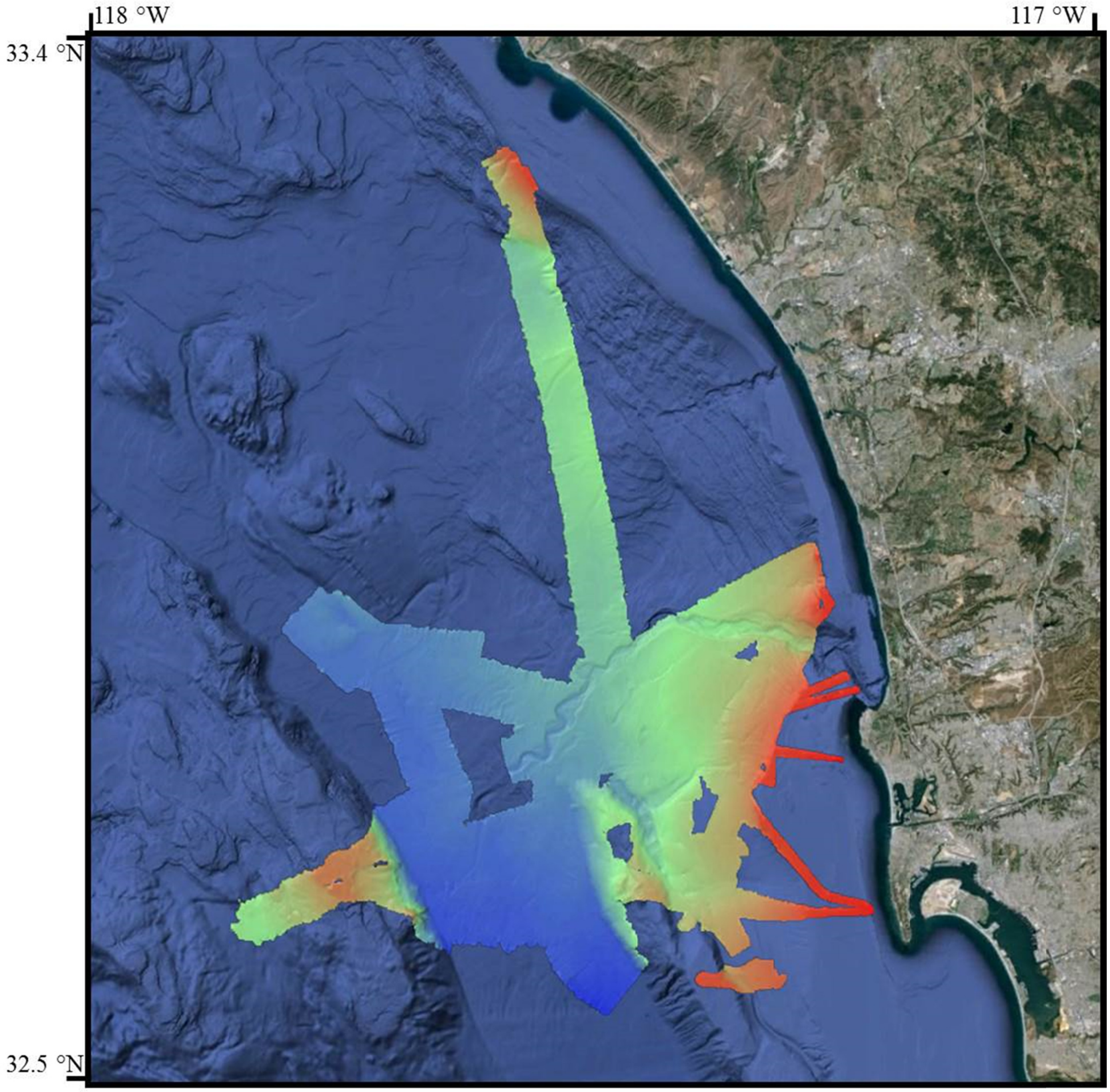

Figure 2. Map of CTD stations, D-line, L-line and P-line from MV1209 and MV1217.

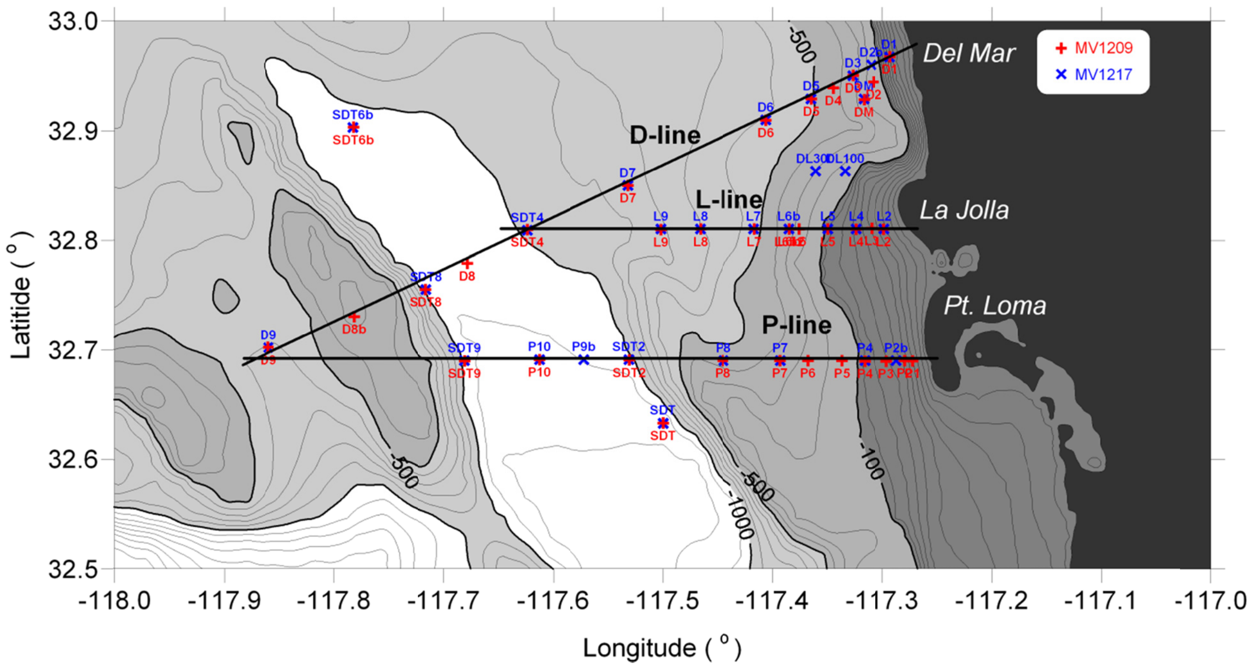

Figure 3. CTD salinity correction plots for (a) MV1209 and (b) MV1217. CTD dissolved oxygen correction plots for (c) MV1209 and (d) MV1217. The RMSE of the linear correction for oxygen during MV1209 and MV1217 was 2.6 (n = 246) and 2.2 (n = 327) µmol/kg, respectively.

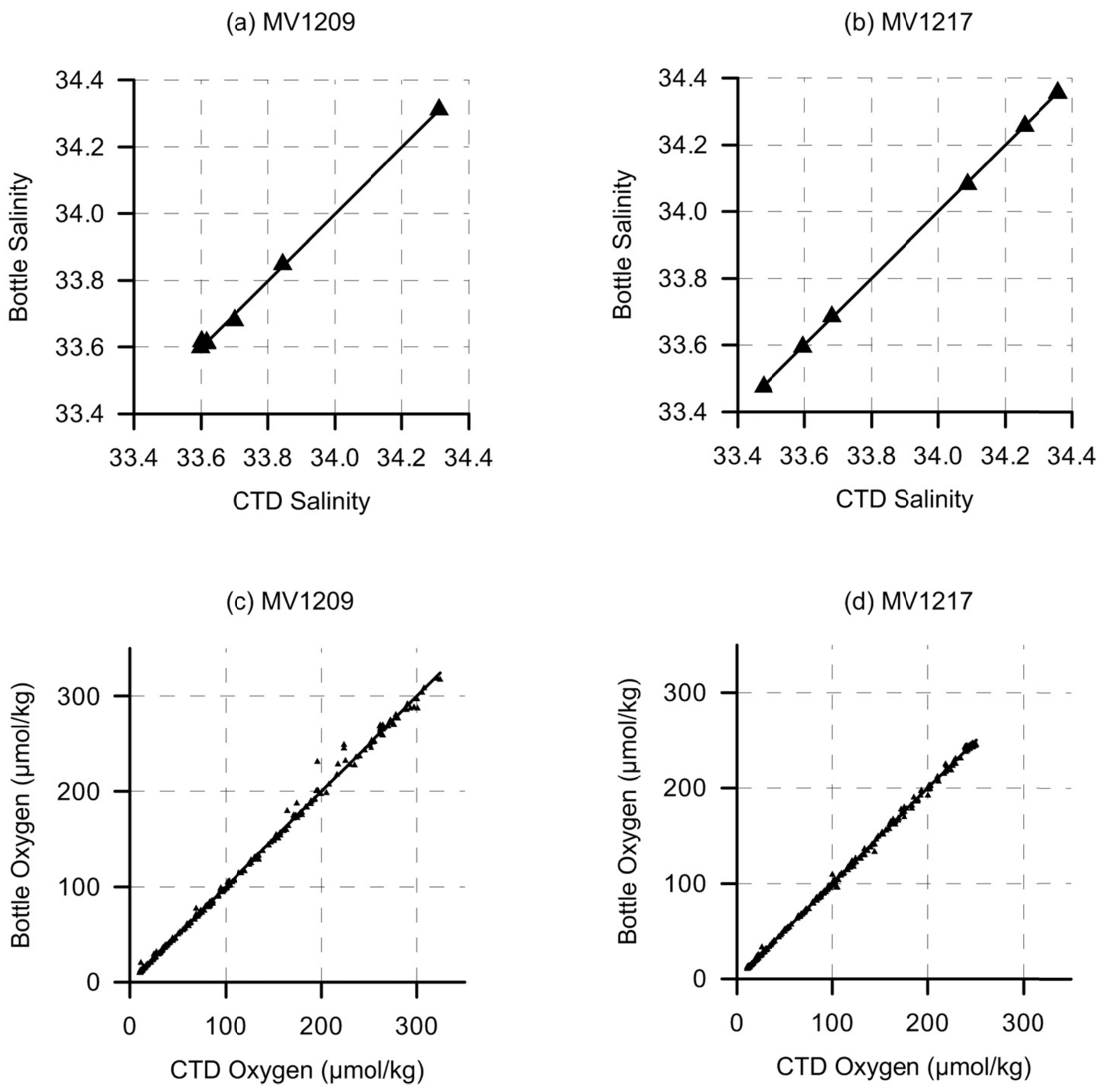

Figure 4. Alongshore current structure (positive is poleward) during MV1209 (July 2012).

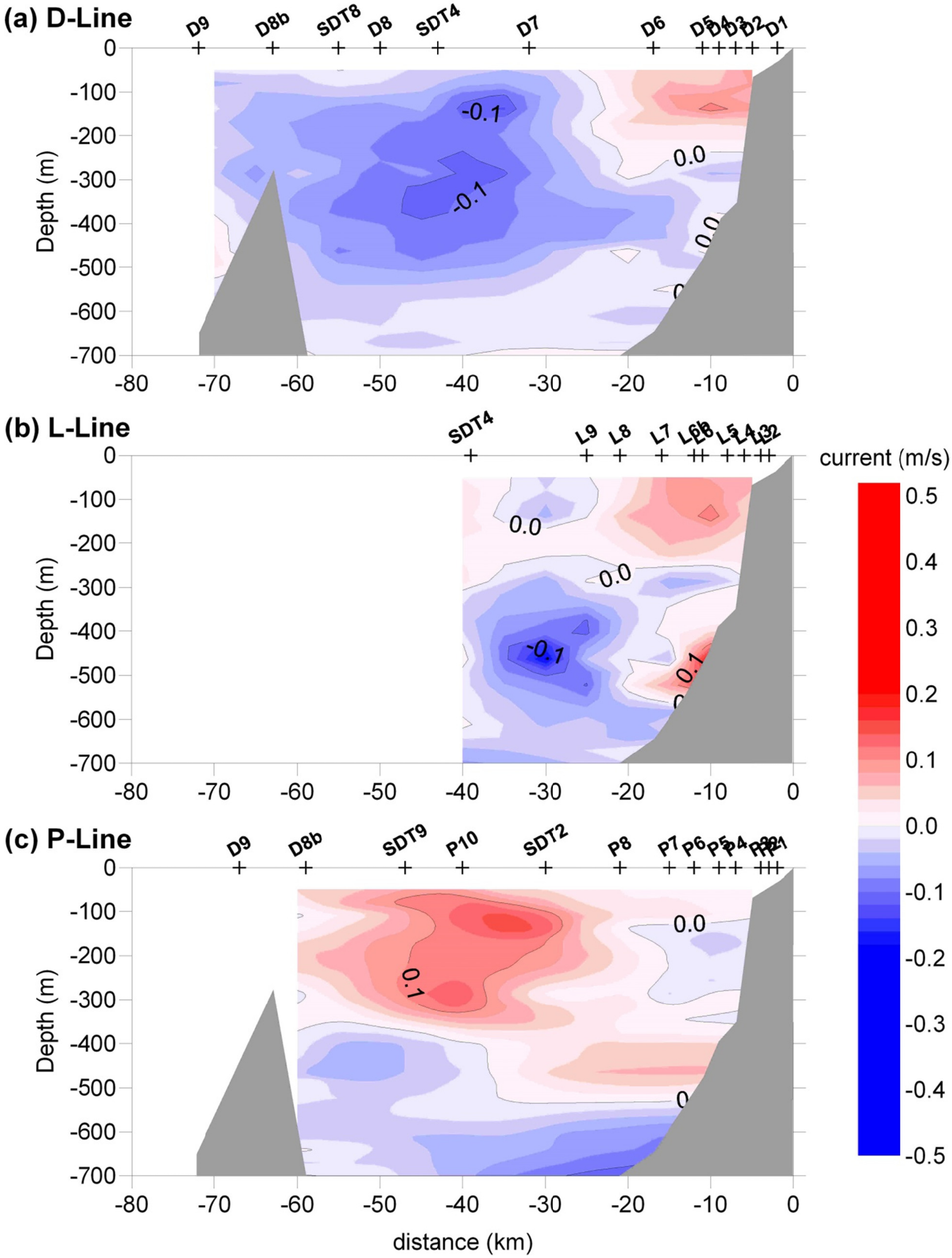

Figure 5. Alongshore current structure (positive is poleward) during MV1217 (December 2012).

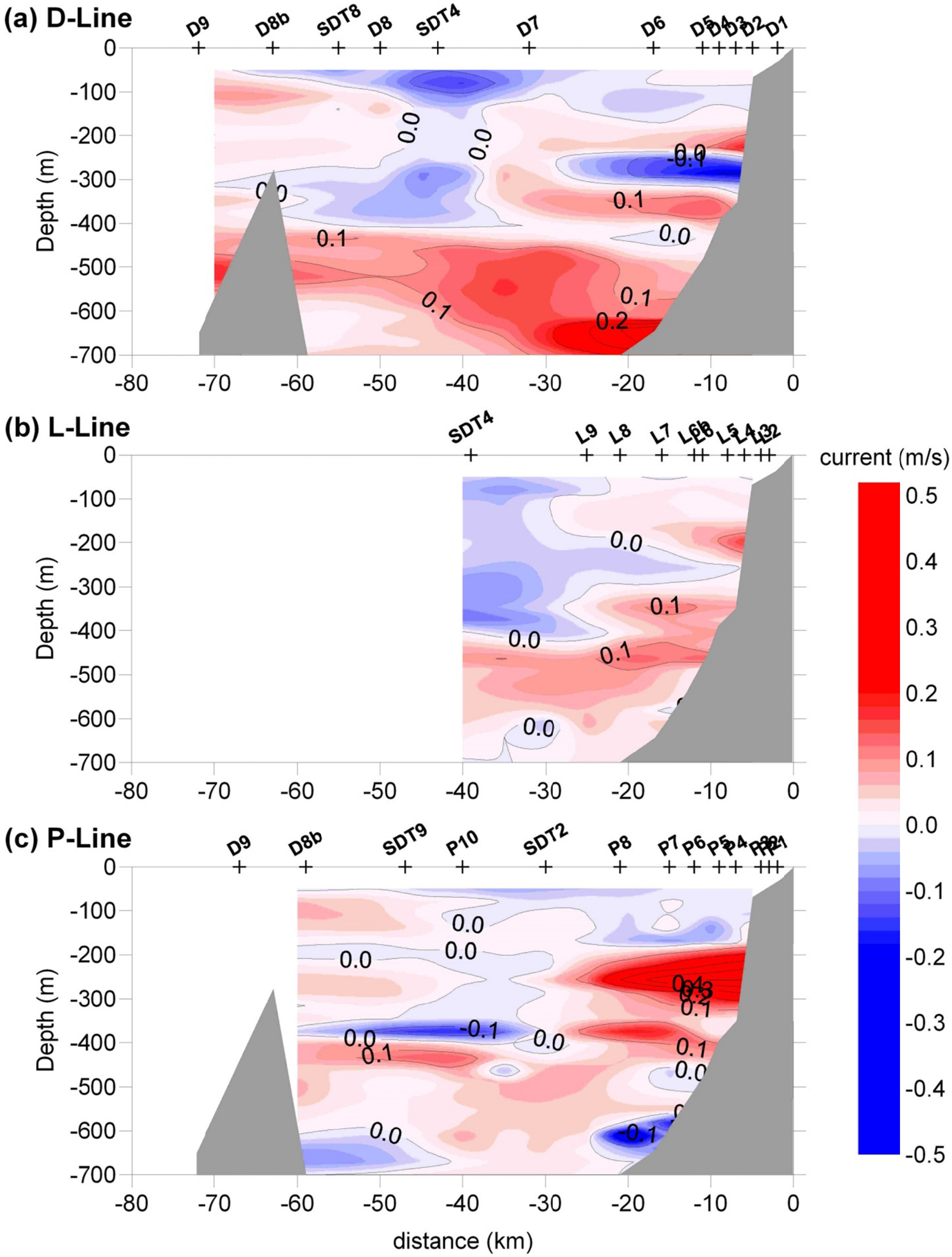

Figure 6. Cross-sections of potential density during MV1209 (July 2012).

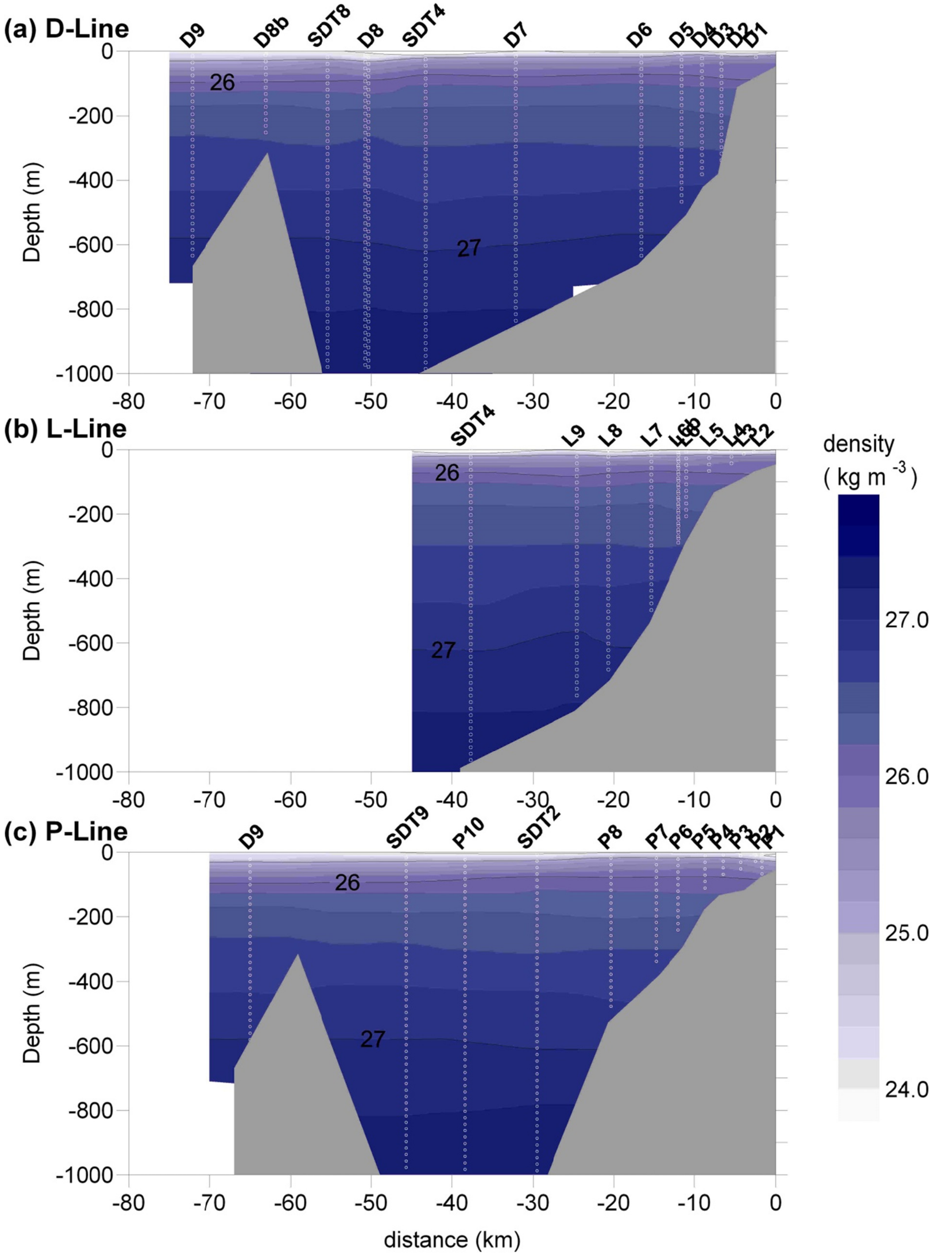

Figure 7. Cross-sections of potential density during MV1217 (December 2012).

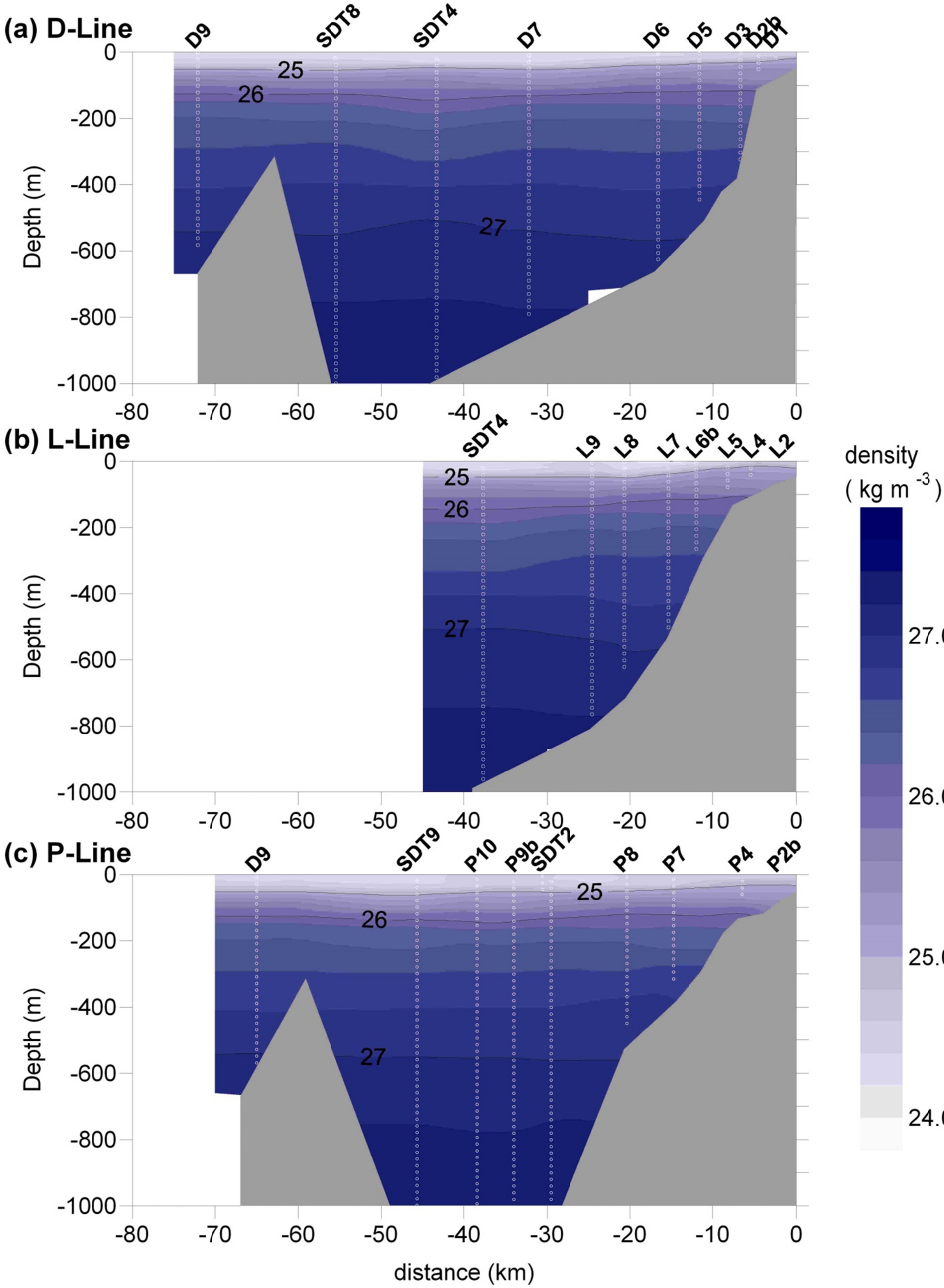

Figure 8. Cross-sections of dissolved oxygen (μmol/kg) during MV1209 (July 2012).

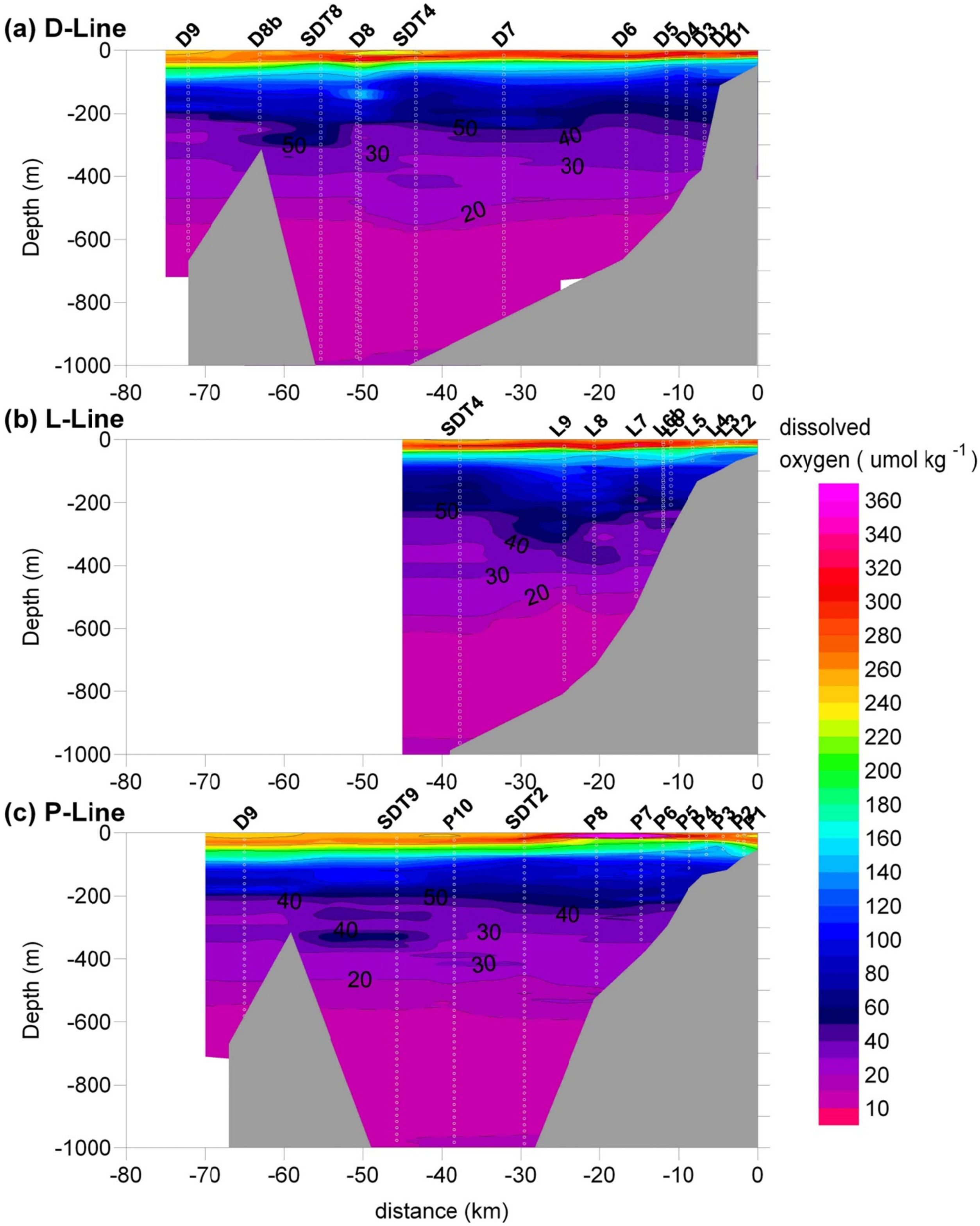

Figure 9. Cross-sections of dissolved oxygen (μmol/kg) during MV1217 (December 2012).

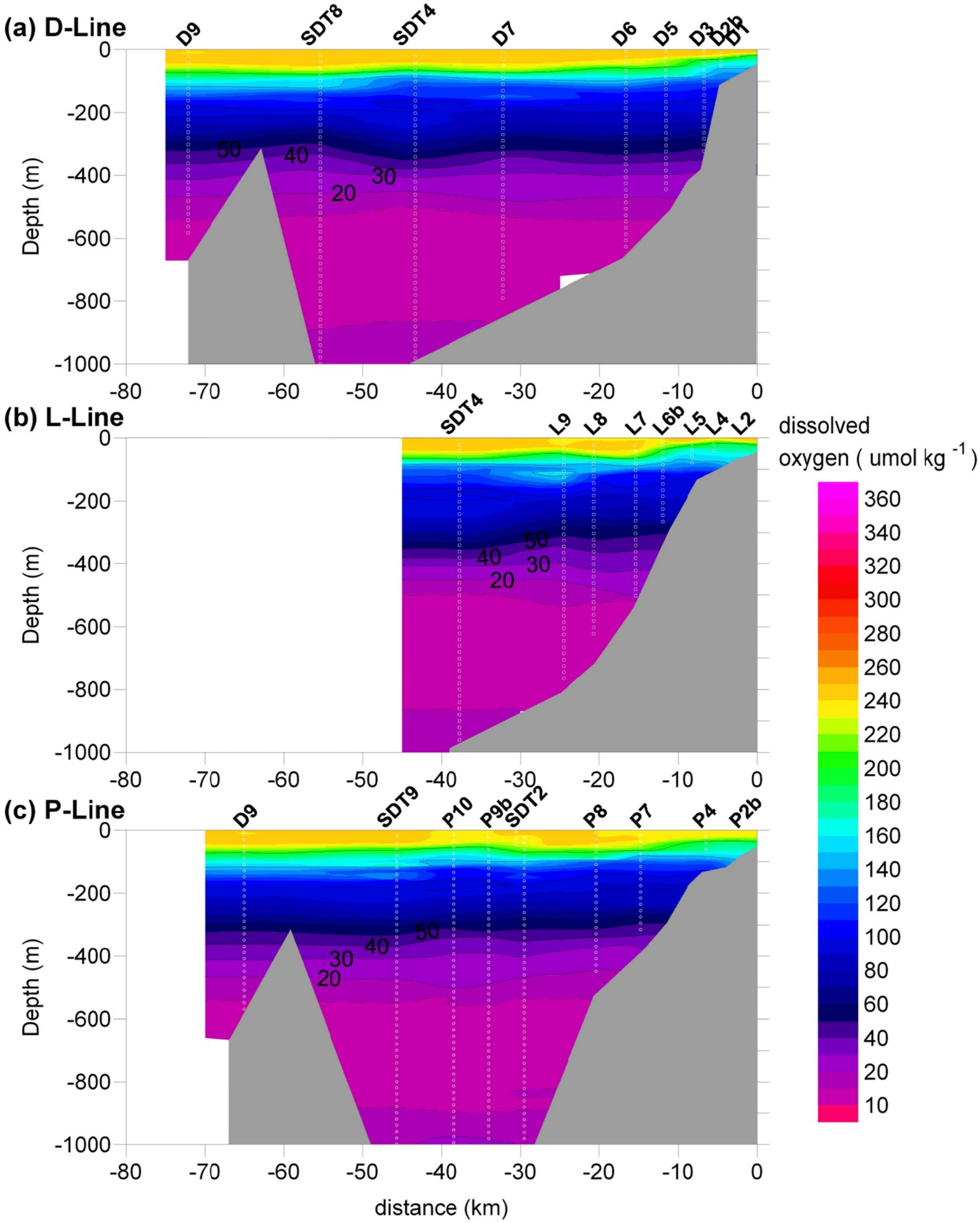

Figure 10. Cross-sections of pH (total scale; in-situ) during MV1209 (July 2012).

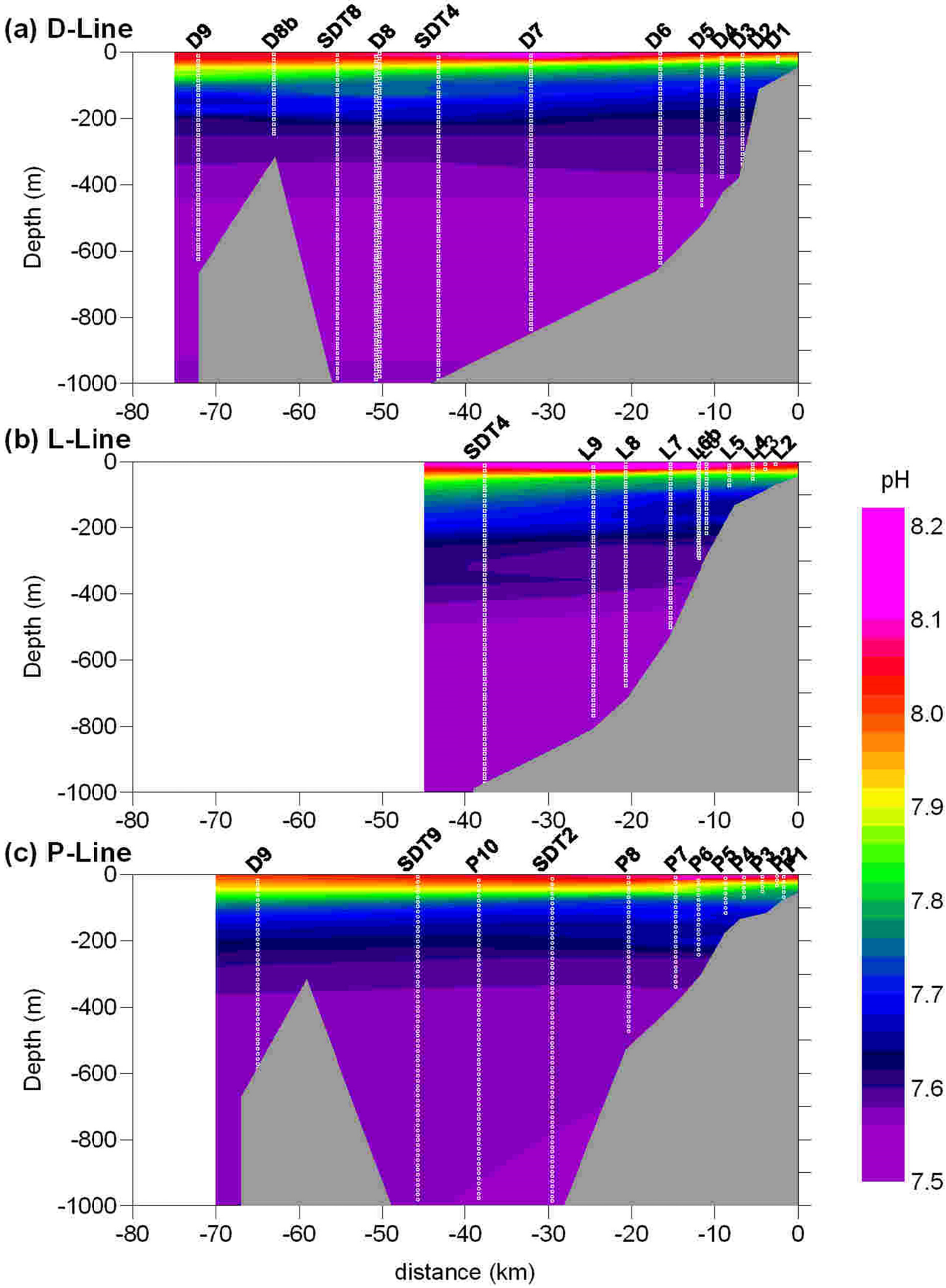

Figure 11. Cross-sections of pH (total scale; in-situ) during MV1217 (December 2012).

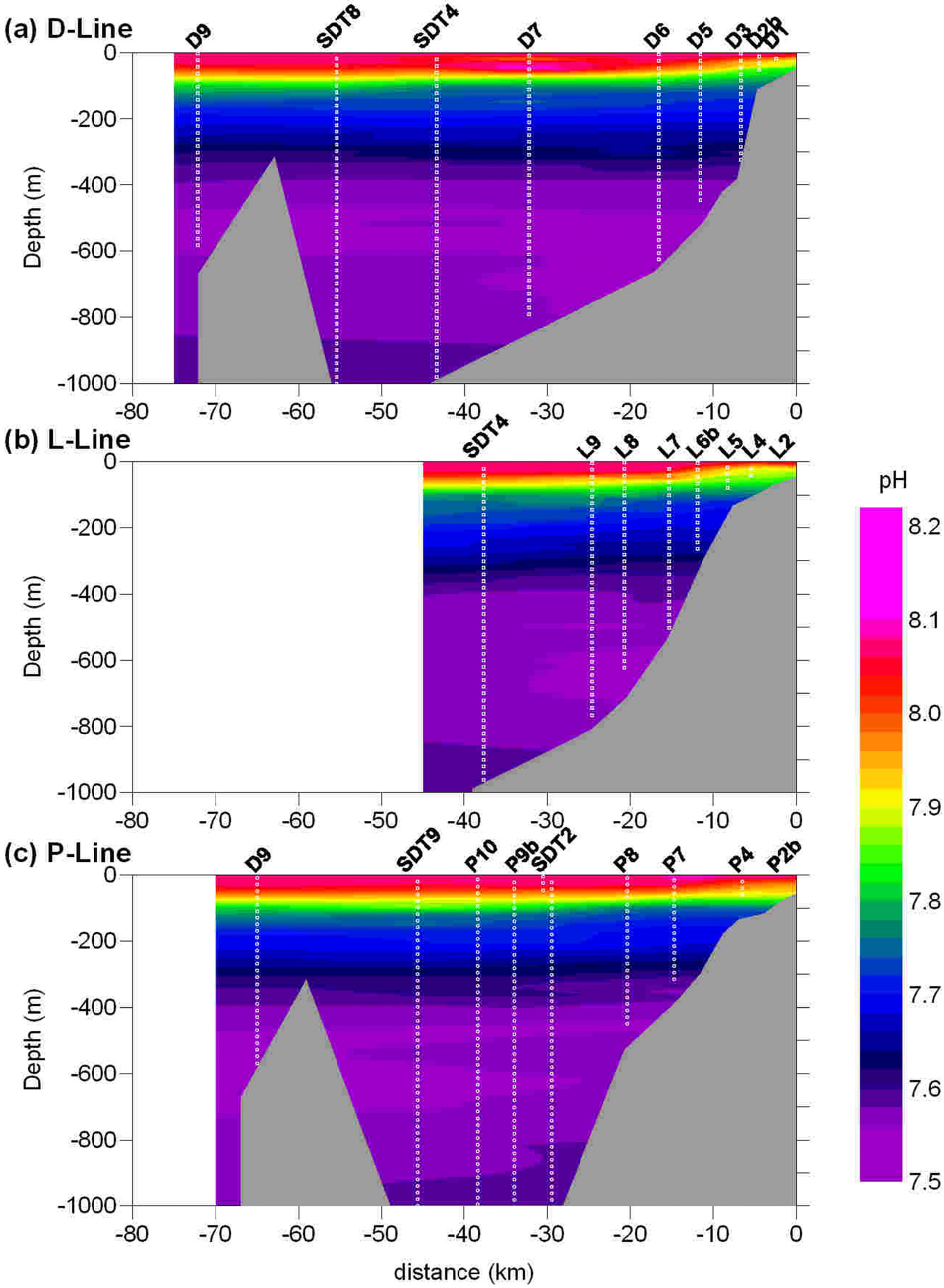

Figure 12. Cross-sections of pCO_2 (μatm; in-situ) during MV1209 (July 2012).

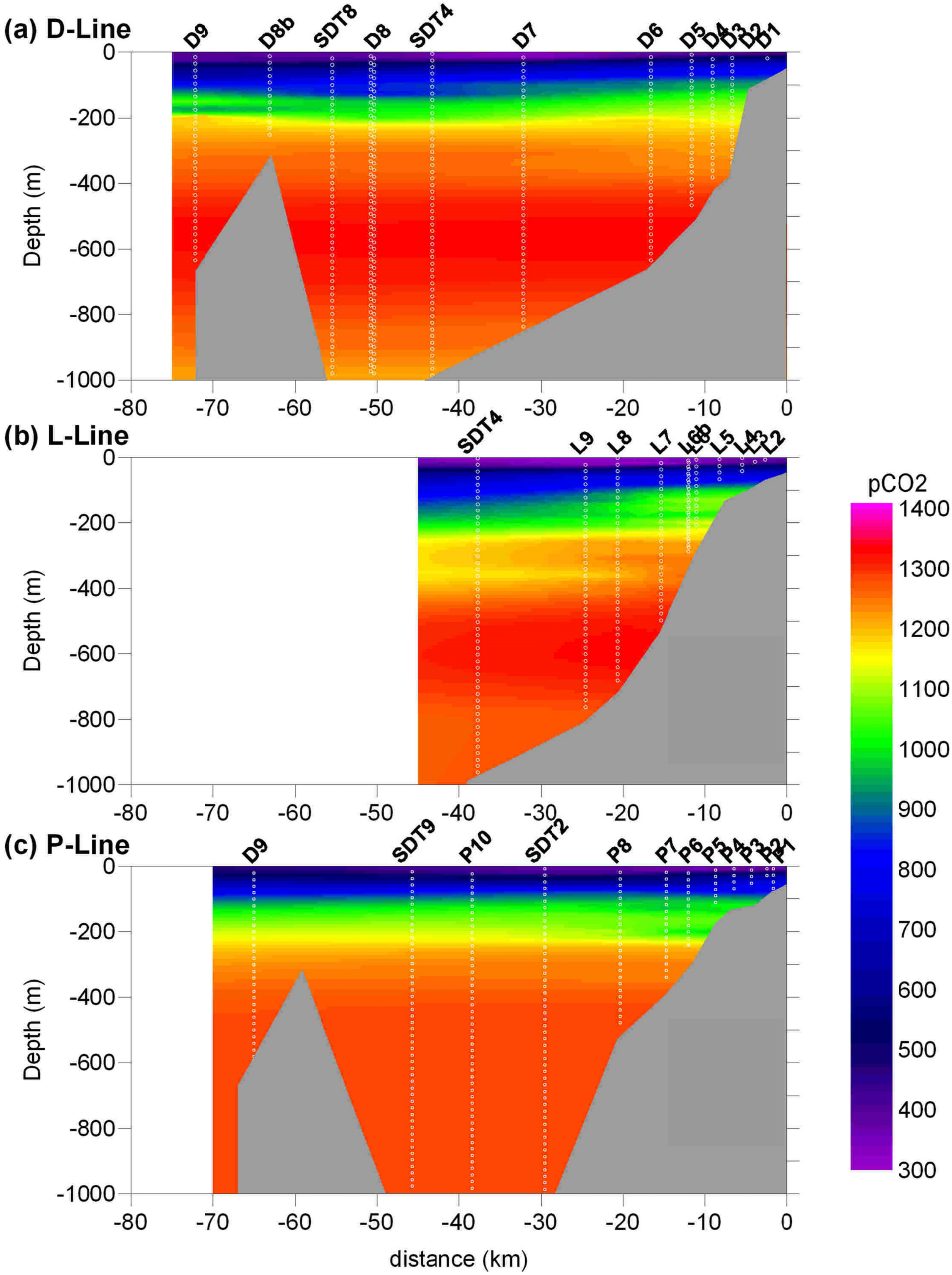

Figure 13. Cross-sections of pCO_2 (μatm; in-situ) during MV1217 (December 2012).

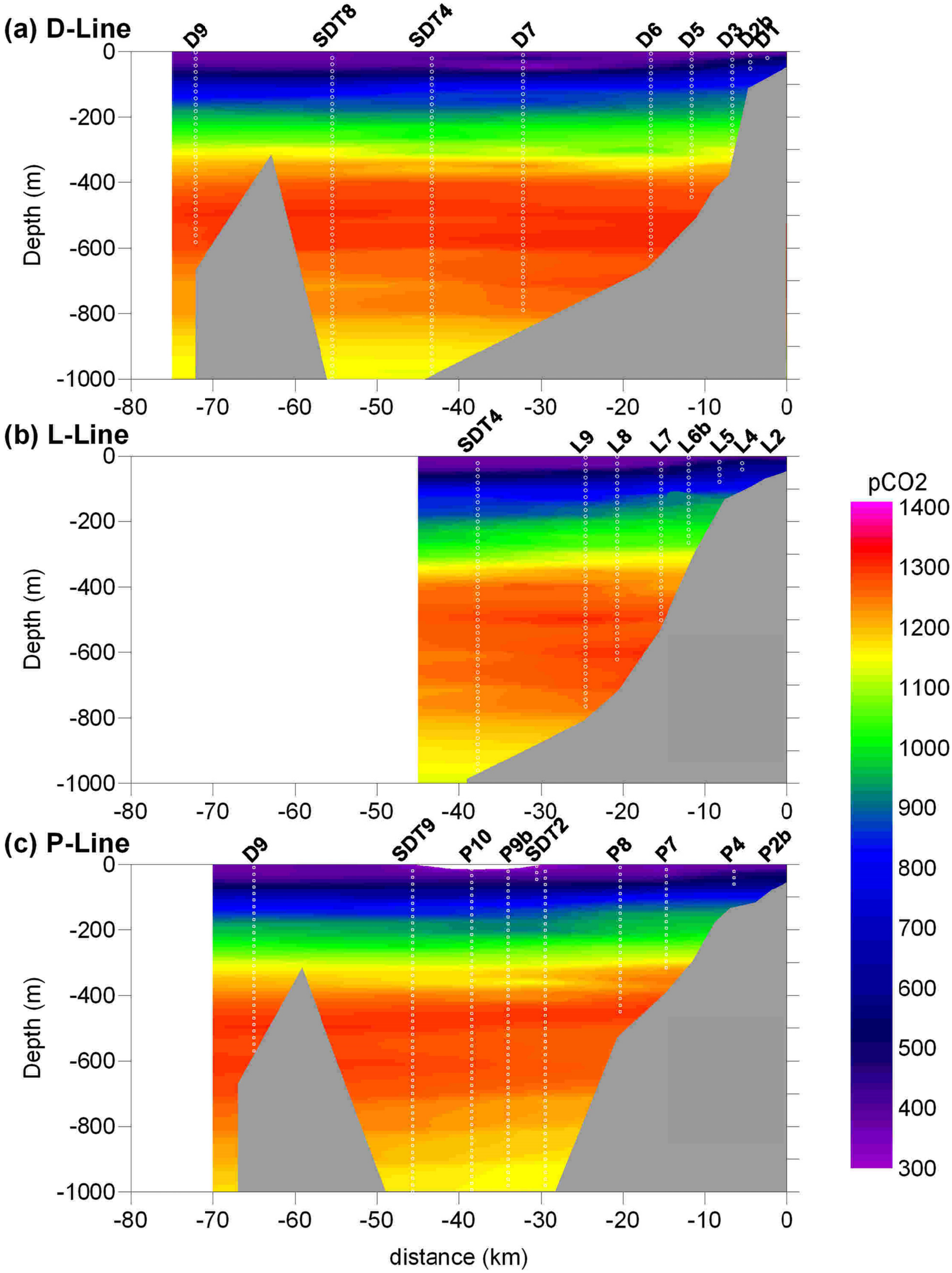

Figure 14. Cross-sections of Ω(aragonite; in-situ) during MV1209 (July 2012).

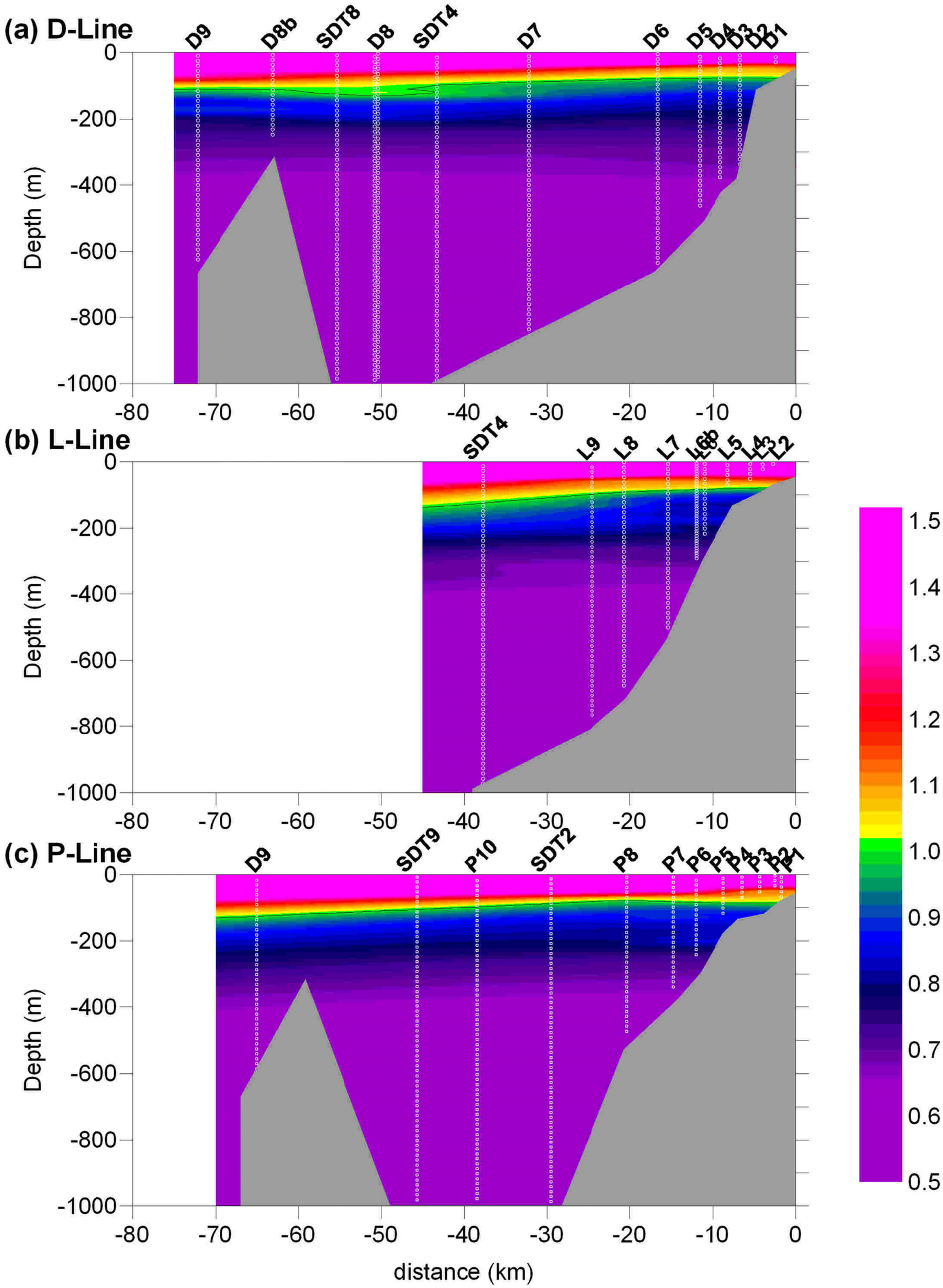

Figure 15. Cross-sections of Ω(aragonite; in-situ) during MV1217 (December 2012).