Physical data report by station

Station n°135

LMD / UMR 8539 / Paris / France
LPO / UMR 6523 / Brest / France
IBENS / INSERM 1024 stations/ CNRS 8197 / Paris / France

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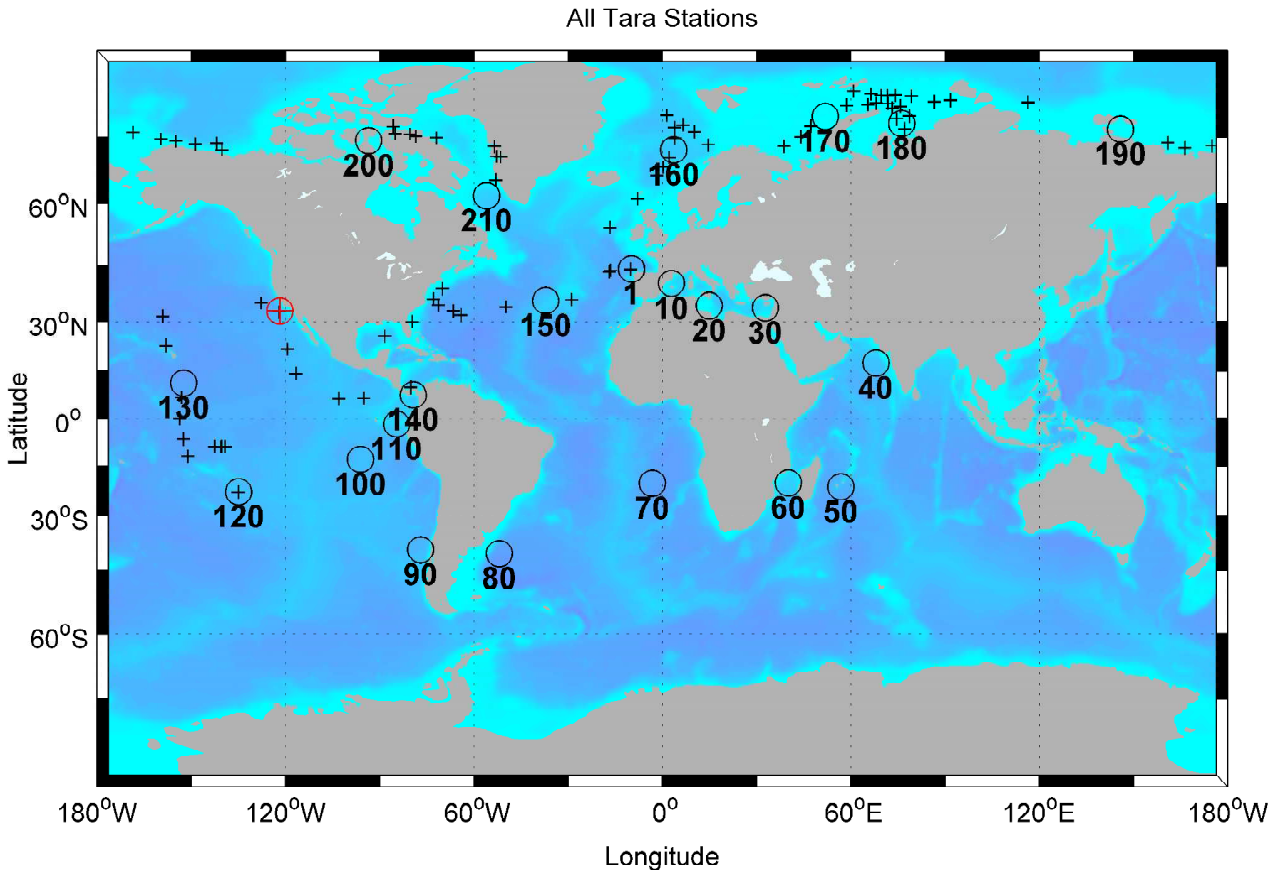

Contents

Station overview

We present here the geographical situation of the station and a quick overview of the physical data available. For more information please see the next sections. About availability in the table below, 1 means "available" and 0 "not available".

Station n°	135
Location	North Pacific Ocean
Date	23/10/2011
Mean Longitude	-121.386°
Mean Latitude	33.0171°
CTDs profiles	9

Availability:	
UV Satellite fields	1
SST Satellite fields	1
SSH Satellite fields	1
CHL1 Satellite fields	1
Argo floats	1

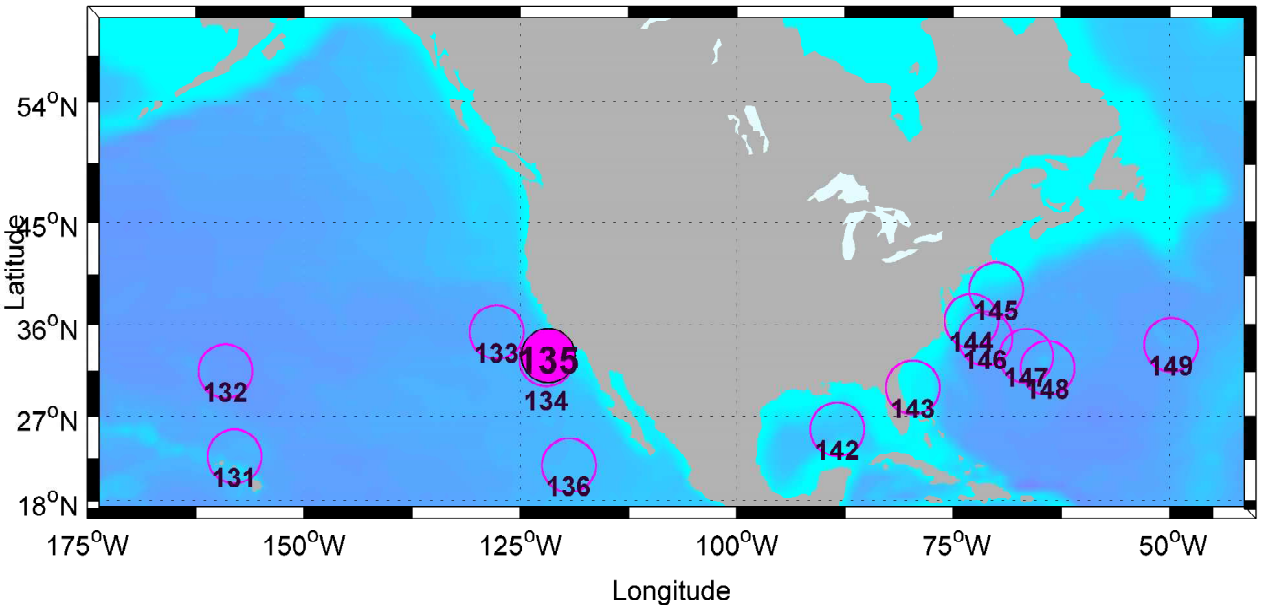

Figure 1: Filled magenta black circle indicate the station of this study.

1 Sea surface temperature, height and chlorophyll

1.1 Introduction

We present here several sea surface properties at the station position using satellite data (SSH $[m]$ in Fig.2 and Fig.3, the SST $[°C]$ in Fig.4 and Fig.5 and the CHL1 $[mg/m^3]$ in Fig.6 and Fig.7). We give definitions and information about these quantities below:

- Sea Surface Height (SSH): Maps of Absolute Dynamic Topography (MADT) from the global 1/4° (approx. $27km$) Daily Delayed Time Archiving Validation and Interpretation of Satellite Data in Oceanography (AVISO) field (Rio and Hernandez, 2004; Capet et al., 2014). The altimeter products were produced by Ssalto/Duacs and distributed by Aviso, with support from Cnes (`http://www.aviso.oceanobs.com/duacs/`).
- Sea Surface Temperature (SST): OSTIA uses satellite data provided by the GHRSST project, together with in-situ observations to determine the sea surface temperature. The analysis is performed using a variant of optimal interpolation (OI) described by Martin et al. (2007). The National Centre for Ocean Forecasting produces the analysis at a resolution of 1/20° (approx. $5km$). OSTIA data is provided in GHRSST netCDF format every day.
- Chlorophyll (CHL1): Weekly 1/10°Chlorophyll maps processed and distributed by ACRI-ST GlobColour service, supported by EU FP7 MyOcean & ESA GlobColour Projects, using ESA ENVISAT MERIS data, NASA MODIS and SeaWiFS data.

Legend In order to relieve figures we describe here their general legend:

- ● indicate the casts of Tara stations identified by their respective numbers.
- ○ are used to locate other Tara's stations around.
- □ refer to CTD profiles. When filled, each colour corresponds to a reference used in profiles plots (see CTD section) to make distinction between them.
- We indicate bathymetry by grey contours, horizontal geostrophic surface velocity field by dark arrows proportional to the current intensity, and SSH field by white contours.
- The ▼ is the nearest coast point (zlevel=0) of each ctd profile from etopo2 database
- When shown, ▽ represent Argo's data available around the mean longitude and latitude position of CTDs. We defined a box around the mean position with $\Delta X \pm 4°$ $lat - lon$ and $\Delta t \pm 15$ $julian\ days$. Argo's numbers are only an index.
- Date refers to the day when SST, SSH or Chlorophyll maps are available.

1.2 SSH maps

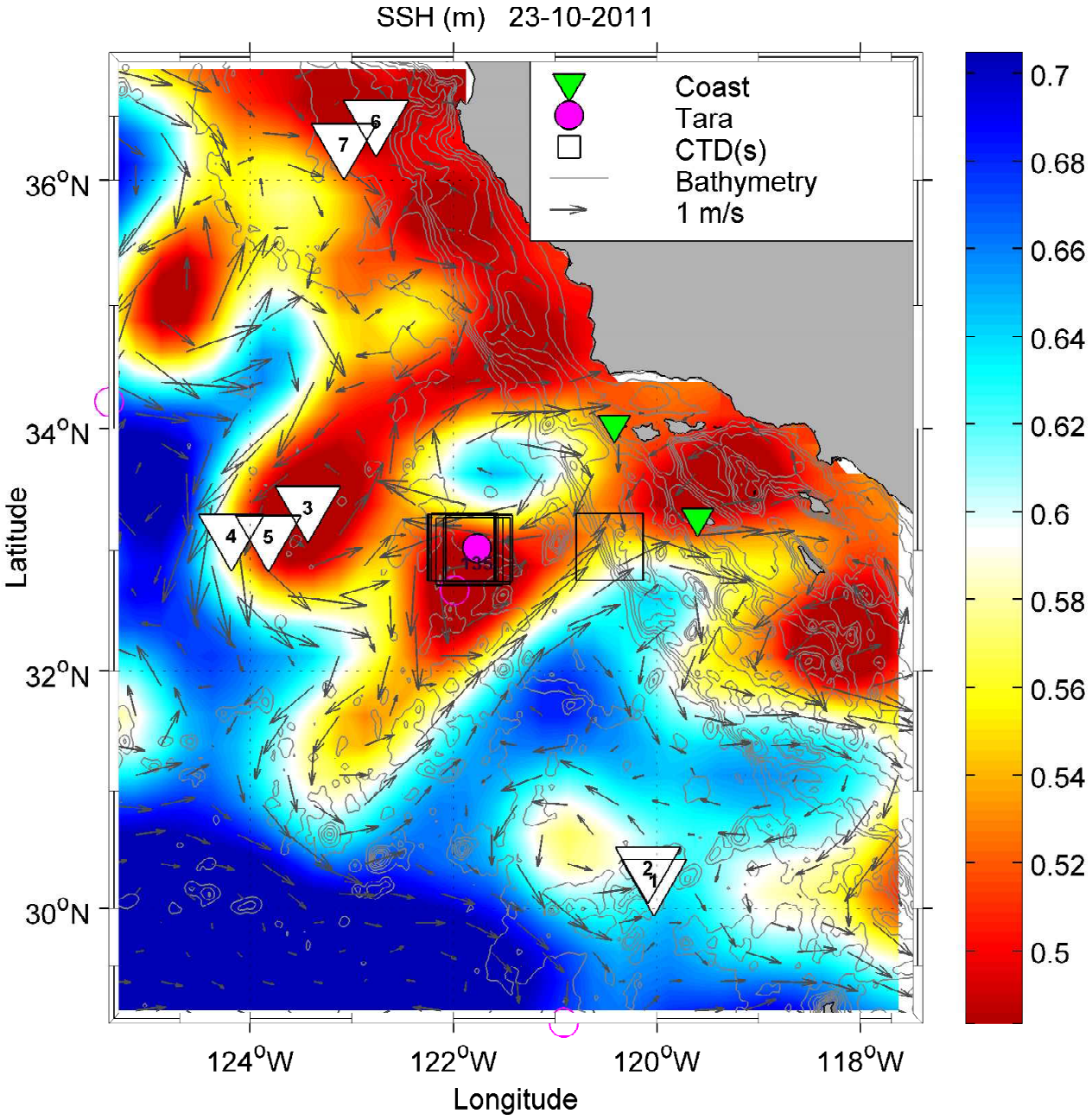

Figure 2: Description: see legend p. 14

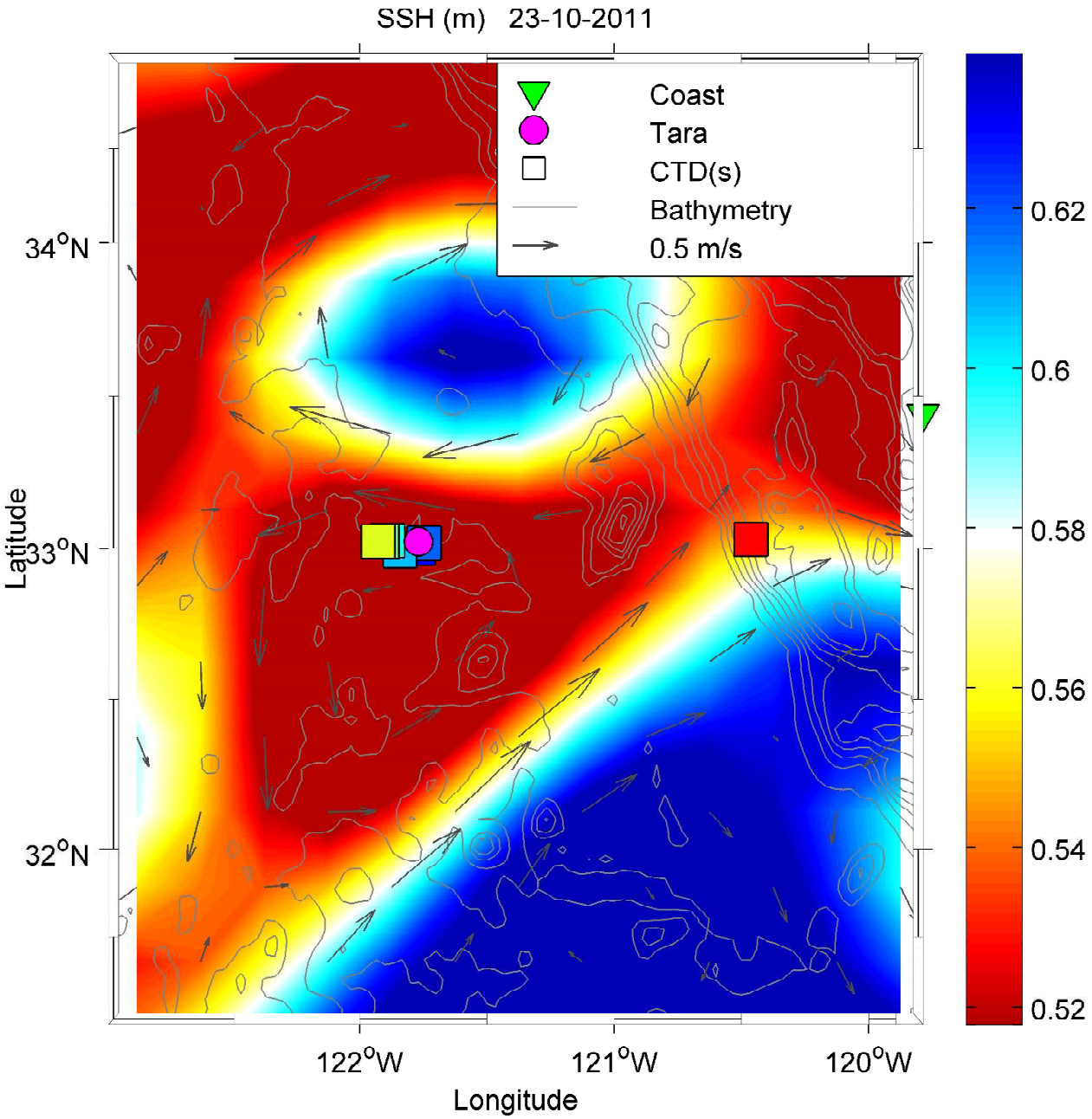

Figure 3: Description: see legend p. 14

1.3 SST maps

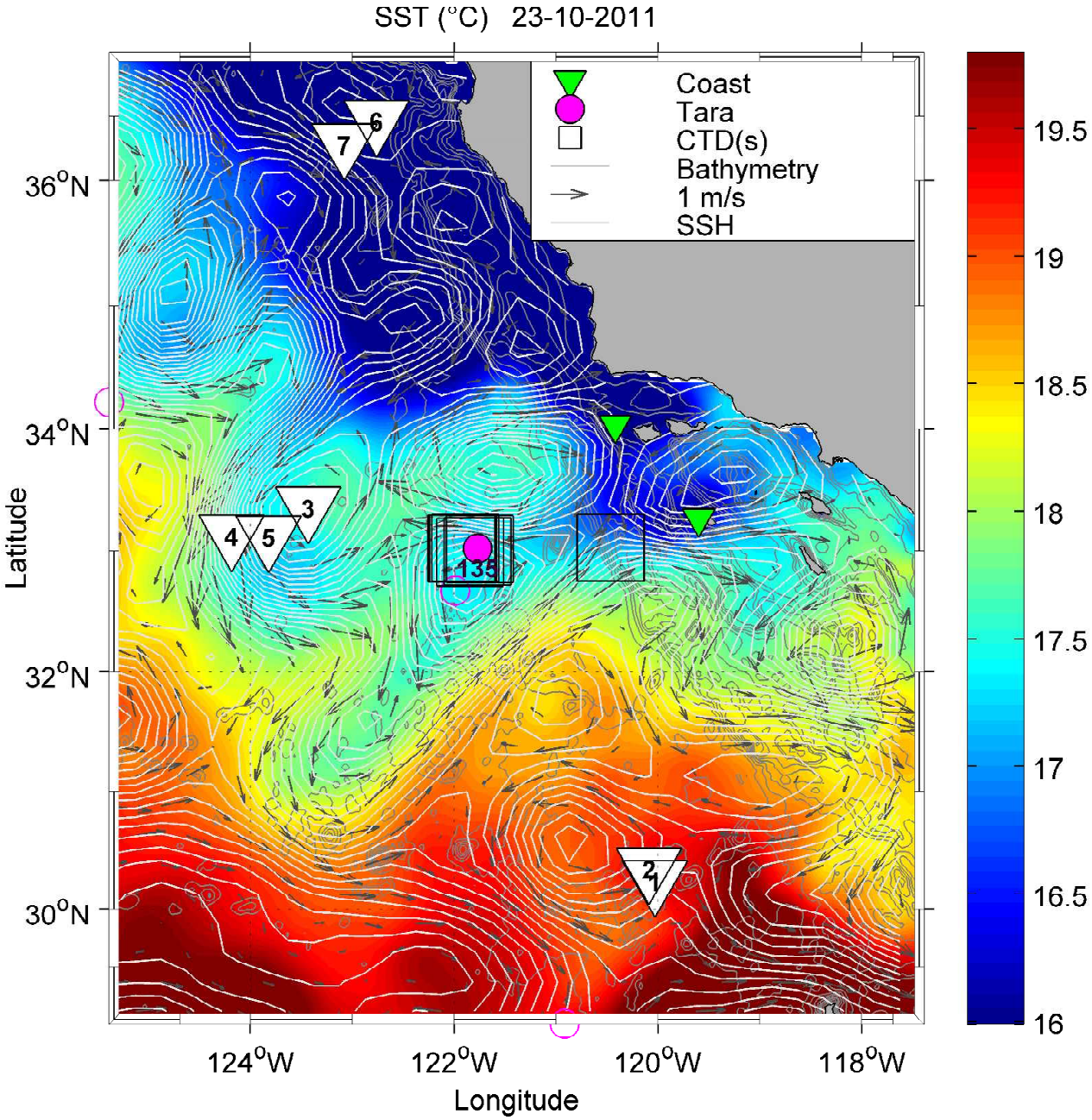

Figure 4: Description: see legend p. 14

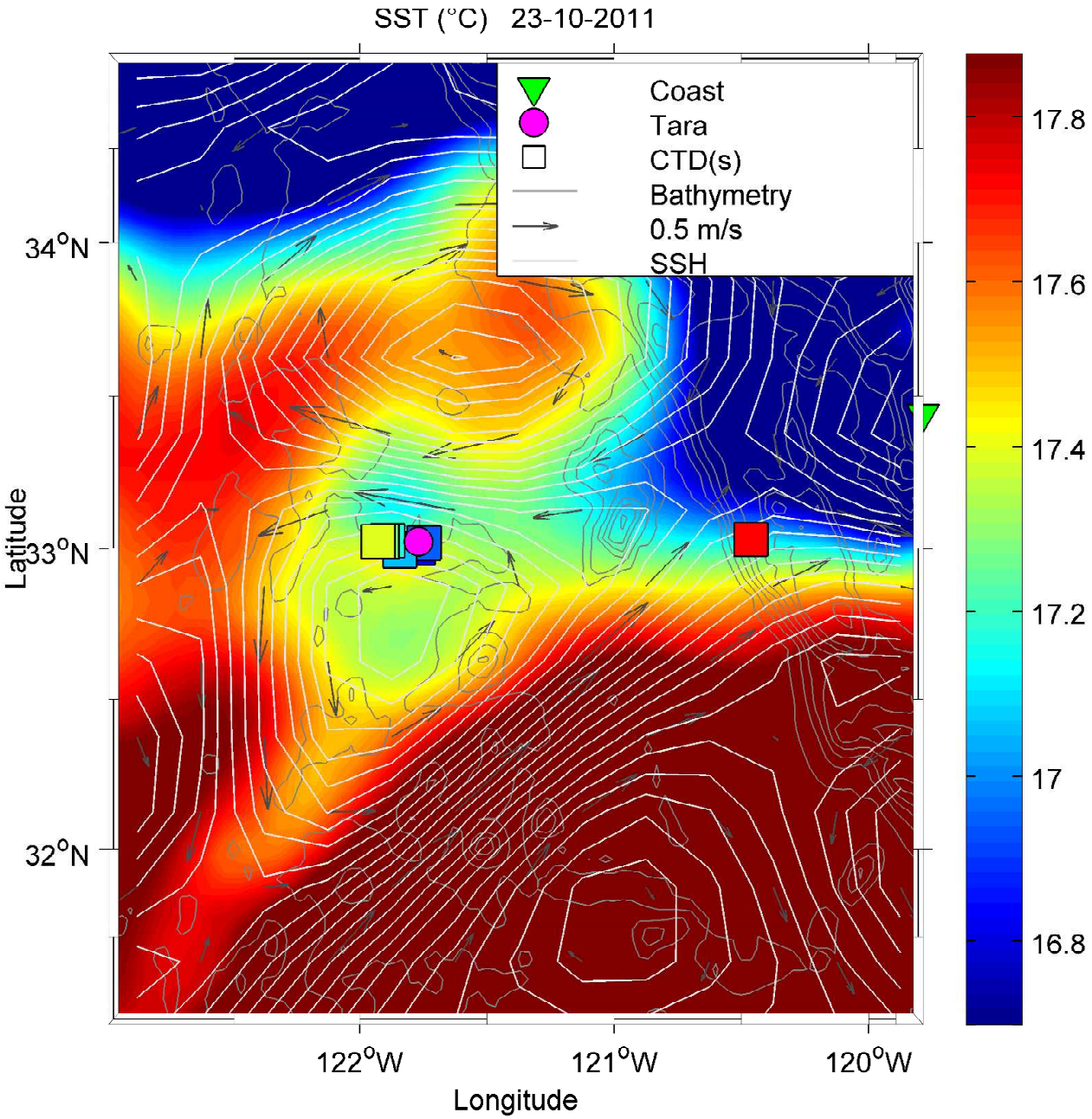

Figure 5: Description: see legend p. 14

1.4 Chlorophyl maps

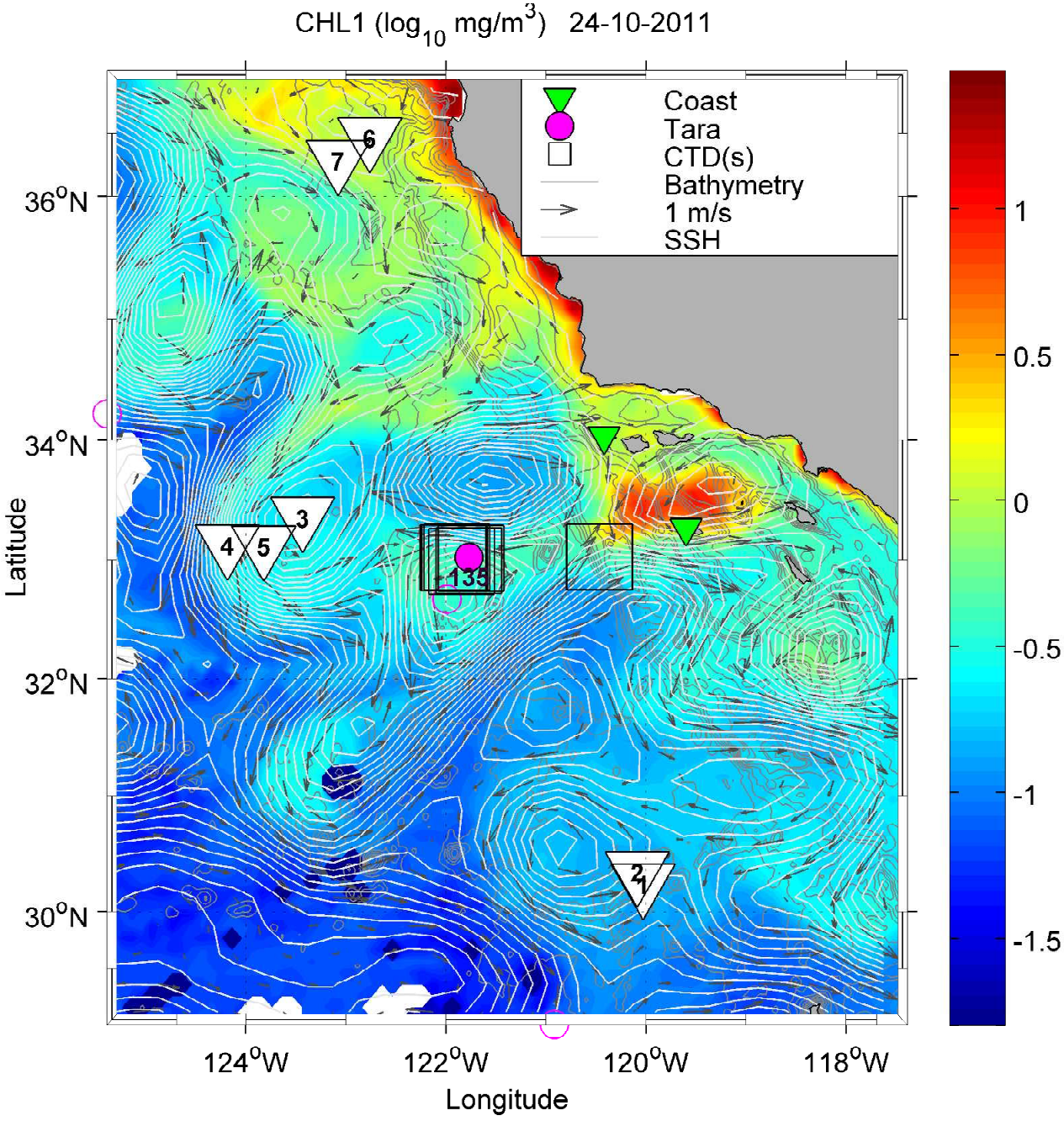

Figure 6: Description: see legend p. 14

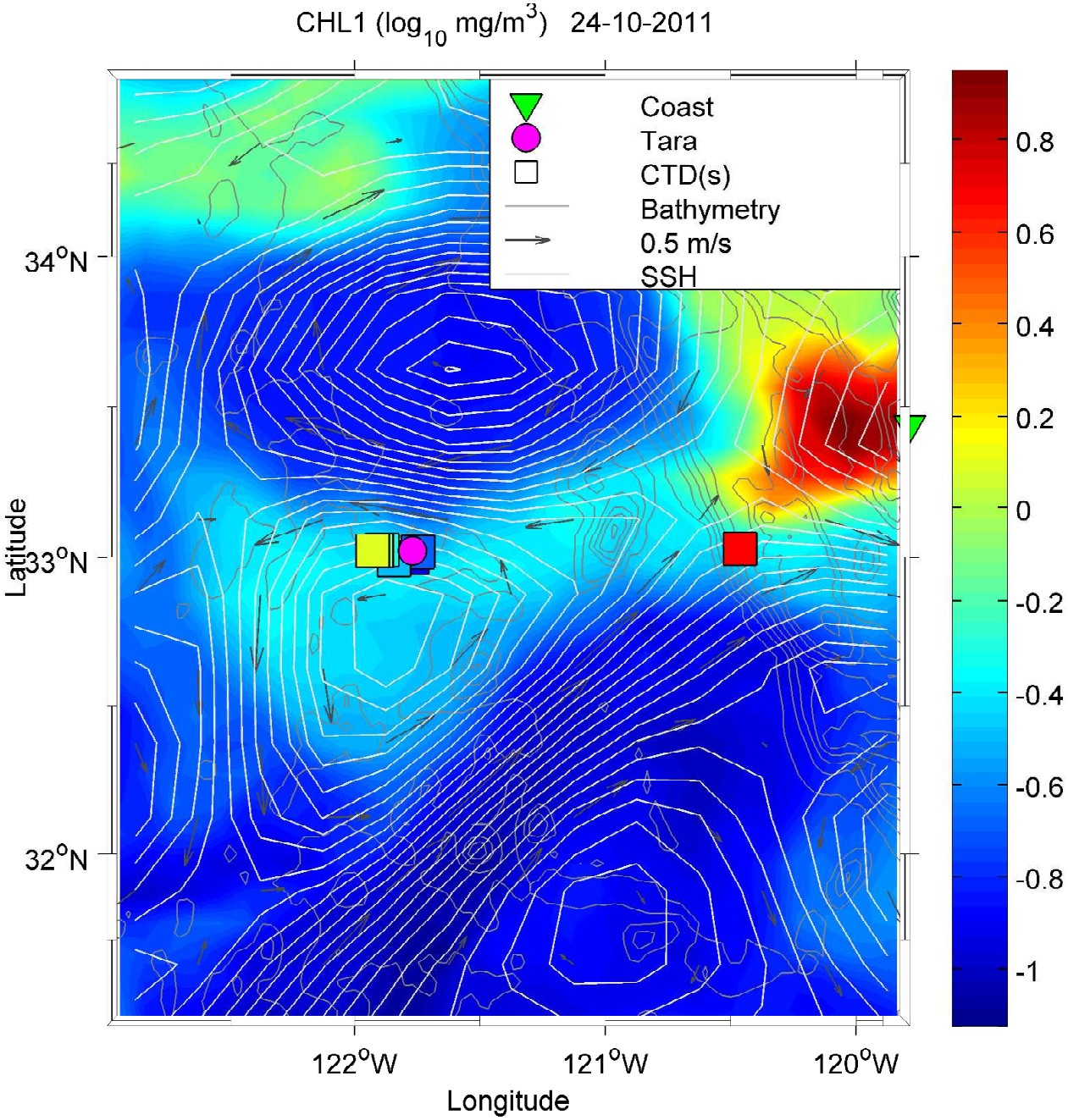

Figure 7: Description: see legend p. 14

2 TSG

2.1 Introduction

To complete the hydrological surface study, we use ThermoSalinoGraph (TSG) data measured by the Tara around the stations. Thermosalinographs are used to collect information about the sea surface, typically in flow-through systems operating continuously throughout a cruise.

We looked for the nearest TSG data available at $\Delta t \pm 15$ *julian days* around Tara stations. TSG data from the TARA OCEAN project (station 1 to 151) are validated but this is not the case of TSG data recorded during the TARA Porlar Cicle project that might present errors.24986 records satisfy these conditions. It is important to emphasize that TSG data are measure along the boat path whereas satellite data are snapshots.

TSG surface temperature is plotted over the Sea Surface Temperature measured by satellite and provided by OSTIA in figure 8.

TSG absolute salinity is plotted over the weekly Sea Surface Salinity data measured by Soil Moisture and Ocean Salinity (SMOS) mission in figure 9. The L3 SMOS data are available on the LOCEAN website (via a request form) but they still experience large biases and noise on various time and space scales. Nicolas KOLODZIEJCZYK work with a team at the LOCEAN to reduce these errors (see Hernandez et al. (2014), Kolodziejczyk et al. (2015b) and Kolodziejczyk et al. (2015a) for more information). These products are not perfect and large biases still exist but they are very promising. He gracefully gave us two types of corrected data for the context of this study:

- The most accurate set of data is composed of weekly map over the Atlantic (between 42N and 42S) with a resolution of 75 km for the period spanning from 2011 to 2013. Corrections are applied to reduce costal, large scale and seasonal orbit biases. An Optimal Interpolation using ISAS Argo interpolated products is performed.
- The other product is the 1/4 2days L3 SMOS data spanning from 30-Jun-2010 to 30-Aug-2014 on which a monthly filter and a systematic coastal bias correction are applied.

The Optimal interpolation product is not available for this station so the L3 band + coastal biais correction is ploted.

2.2 TSG Temperature maps

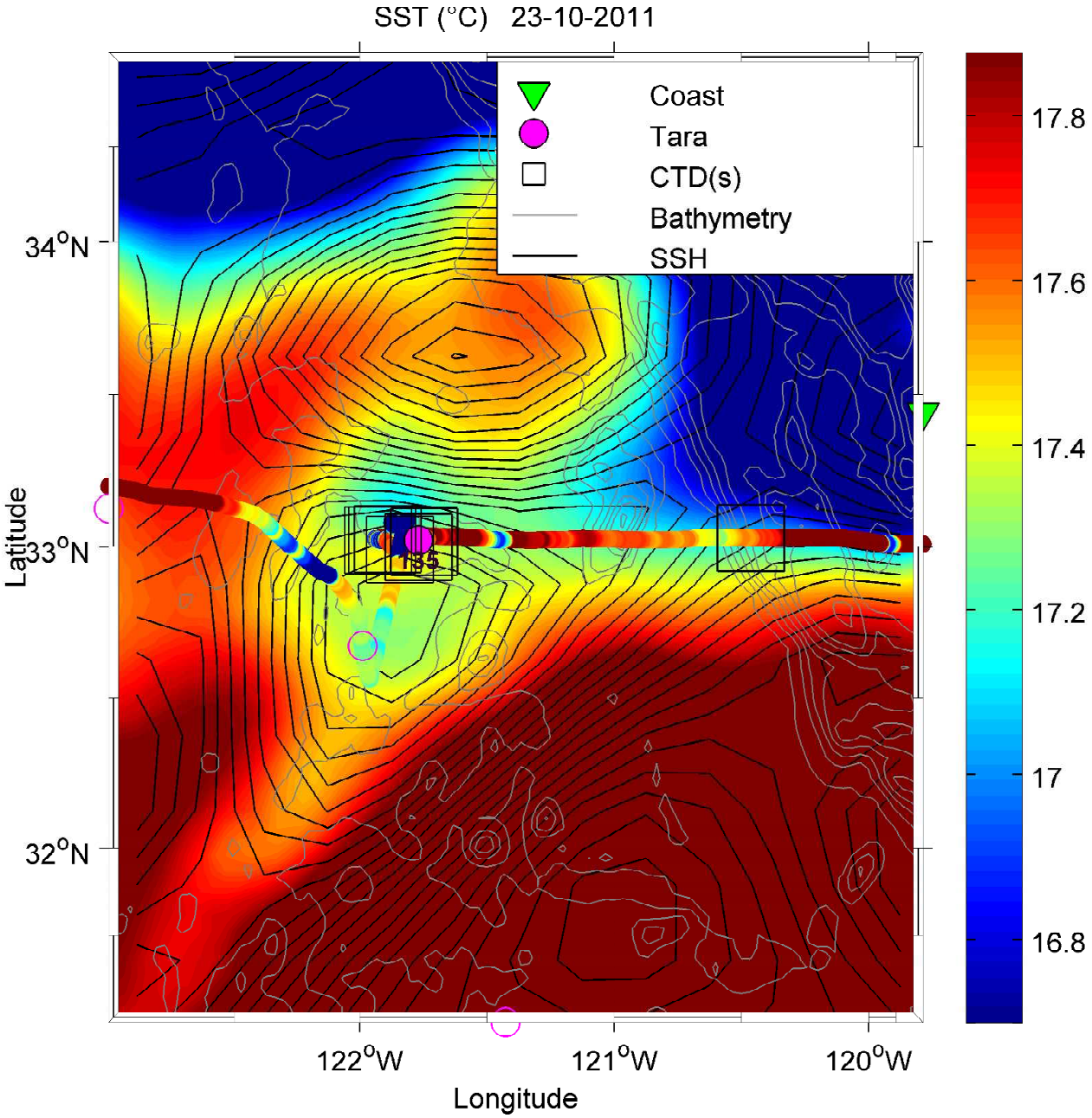

Figure 8: Description: see legend p. 14

2.3 TSG Salinity maps

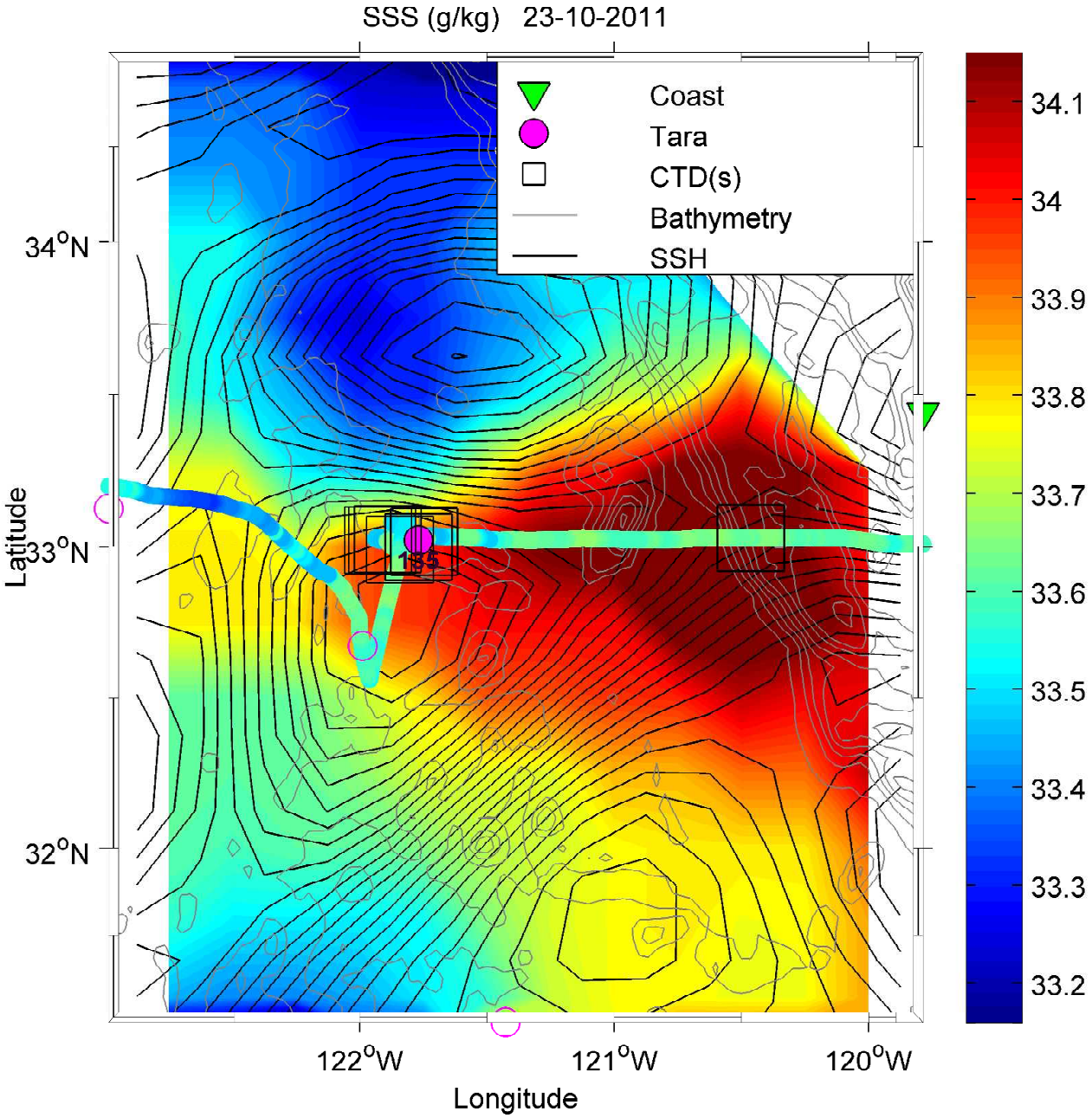

Figure 9: Description: see legend p. 14

3 Conductivity, Temperature and Depth (CTD) measurements

3.1 Introduction

In this study, CTD's measurements have been realized by a `Seabird vertical profiler`. The CTD profiles shown here are provided by the Villefranche Oceanographic Laboratory (LOV), Villefranche-Sur-Mer, France (http://www.obs-vlfr.fr/LOV/ZooPart/Portal/). Moreover, vertical profiles of Nitrate and Oxygen are provided. Additional quantities like salinity or density are then inferred using the Gibbs SeaWater (GSW) Oceanographic Toolbox (`http://www.teos-10.org/pubs/gsw/html/gsw_contents.html`).

For the Tara station n135, 9 CTD profiles are available. We calculate the potential density σ_0 referred to surface and the Brunt-Vaisala frequency (N^2). This one is a pulsation known as the "Brunt-Vaisala frequency" (s^{-2}), and given by:

$$N^2(z) = -\frac{g}{\rho_*}\frac{d\sigma}{dz} \tag{1}$$

where g is the vertical component of gravity, ρ_* a constant density value, d/dz the vertical derivative operator and σ the potential density (we use here σ_0). For more information please refer to Gerkema and Zimmerman (2008) (Eq. 3.18, p. 48 in the book). For each profile, $N^2(z)$ is calculated with a finite differences numerical scheme using $dz = 1m$. When calculated, $N^2(z)$ is averaged with a running median window on $30dbar$ (± 5 $dbar$, centred) to filter noise at small vertical scales (~ 1 m).

We calculate the depth of mixed layer using two definitions given by De Boyer Montégut et al. (2004) to determine the MLD (m). Given a potential temperature profile $\theta(z)$ or a potential density profile $\sigma(z)$, we calculate z for which:

$$|\theta(z) - \theta(10m)| \leq 0.2\ ^\circ C \tag{2}$$

$$|\sigma(z) - \sigma(10m)| \leq 0.03\ kg/m^3 \tag{3}$$

Profiles and $\theta - S$ diagrams are presented on Fig. 10 and 11. Colors are used to distinct each CTD profile (dark blue for the first to red for the last one, "jet colorbar-like": dark blue, blue, light blue, cyan, green, yellow, orange, dark orange, red, dark red). Filled circles represent the bottle depths. We give bottles depths, and we calculate the N^2 and fluorescence maximum depths. We give the values of N^2 at all these different depths. Results are given in the Tab. 1

Several indices were computed to describe the context of CTD sampling. A season flag and a position in the season are given for each ctd sample. 4 "submesoscale" structures indices were computed at each ctd location from Satellite data. The intensity of the STT gradient and the intensity of the geostrophic currents are directly understandable. Strain rate is linked to the derivative of geostrophic current [see Waugh et al. (2006)] and Lyapunov exponent (computed by F.D'Ovidio [see d'Ovidio et al. (2004)])is a measure of the presence of a transport front where values in excess of 0.1 day-1 are typically fronts.

Legend In order to relieve figures we describe here their general legend:

- For each CTD we give the Tara's cast's number, CTD number, the bottom depth inferred from `eTopo2` bathymetry product, the distance, azimuth and position of nearest coast point (also inferred from etopo).
- Time information are then presented by giving the date in classic and julian format. Two season indices are presented: the season and the position in this season
- We give the fluo value at Max_{Fluo} depth, and a simple sum of fluo along vertical profile (from 1 to 200m, when possible).
- "Submesoscale" indices computed from satellite data are then presented.

- Ctd properties are then computed at precise depths: MLD_θ, MLD_σ, Max_{Fluo}, Max_{N^2} and each bottle depth.

3.2 CTD profiles

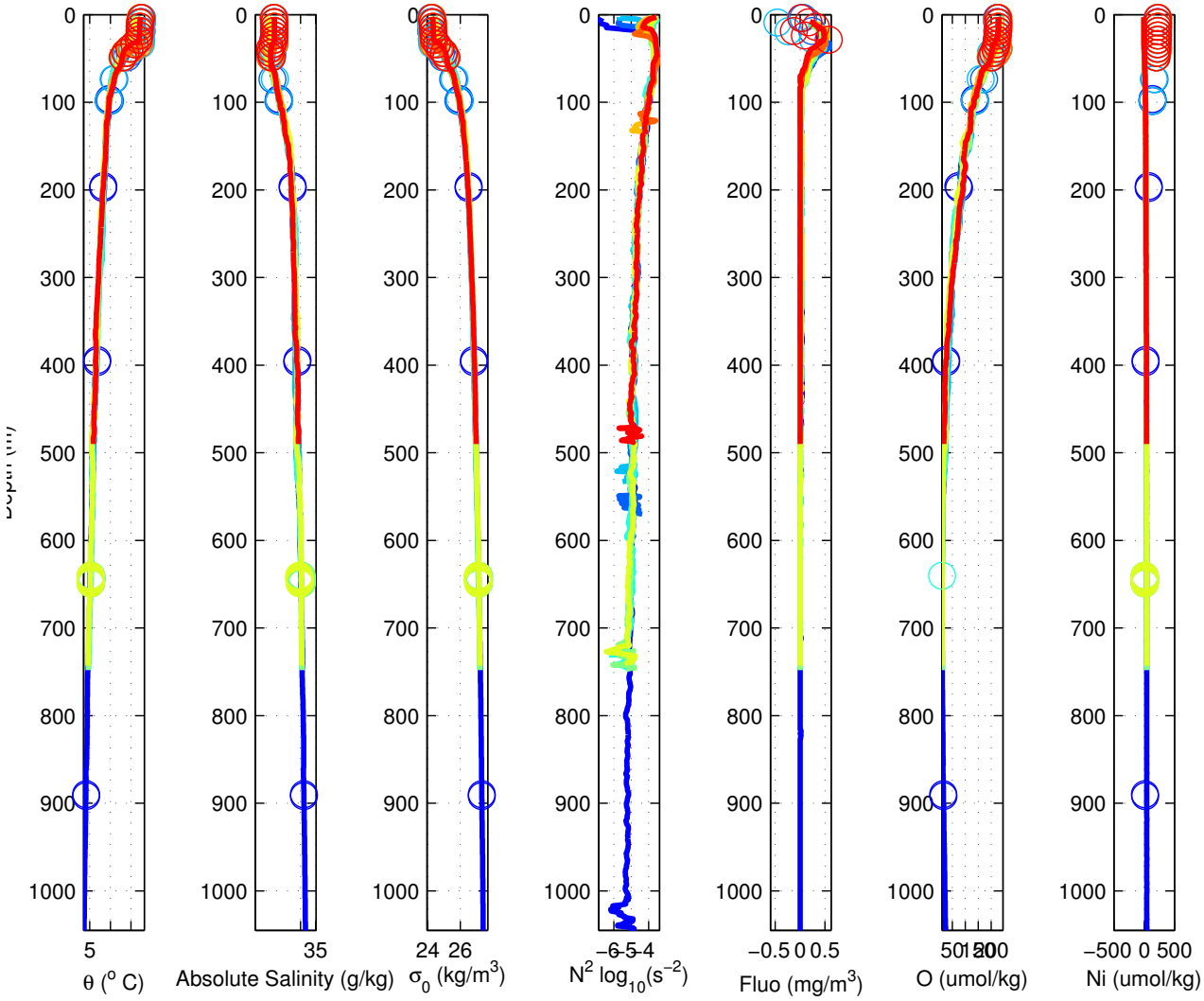

Figure 10: Description: see paragraph p. 14

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3.3 CTD $\theta - S$ diagrams

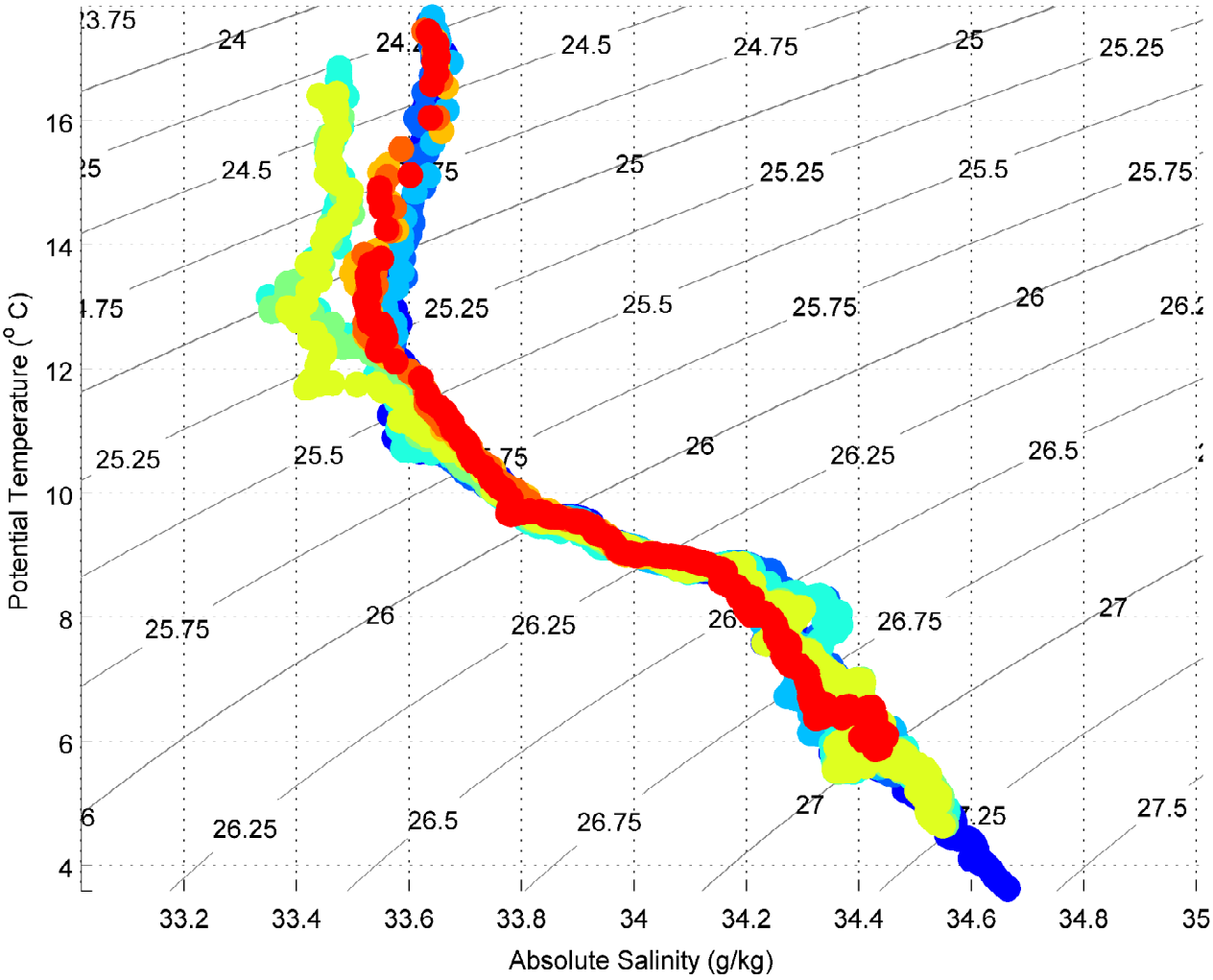

Figure 11: Description: see paragraph p. 14

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3.4 Water column characterization from CTD measurements

$Profil$	CTD	Lon	Lat	CTD Depth max (m)	Bathy (m)	Dist[km]/azimuth[°] coast	Lon coast	Lat coast
135	1	-121.7688	32.9982	1045	-4012	170/47	-120.4171	34.0333

Day	Month	Year	Julian day	Core biology Flag	Season	Season part (early-middle-late)
23	10	2011	2455858	1	Autumn	Middle

$Max_{Fluo}(mg/m^3)$	Depth (m)	Sum $Fluo$ $1-200m(mg/m^3)$
0.4095	33	57.841

Intensity SST Gradient $(°/100km)$	Intensity Geostrophic current (m/s)	Strain $rate$ (s^{-2})	Lyapunov exponent $(1/days)$
1.1531	0.2268	0.00011073	0.069856

	Depth (m)	T $(°C)$	AS (g/kg)	σ_0 (kg/m^3)	N^2 (s^{-2})	$Fluo$ (mg/m^3)	O $(\mu mol/kg)$	Ni $(\mu mol/kg)$
$10m$	10	17.4311	33.6487	24.2593	4.5098e-08	0.37184	226.6617	-1.8143
Max	1045	3.7109	34.6645	27.4274	NaN	0	23.5491	43.639
MLD_σ	33	17.3683	33.6504	24.2765	0.00043258	0.4095	219.5775	-1.0877
MLD_θ	33	17.3683	33.6504	24.2765	0.00043258	0.4095	219.5775	-1.0877
Max_{N2}	44	14.1613	33.5732	24.9349	0.00037229	0.40727	202.783	4.1768
Max_{Fluo}	33	17.3683	33.6504	24.2765	0.00043258	0.4095	219.5775	-1.0877
Max_O	14	17.4309	33.6488	24.2596	2.0684e-07	0.37252	226.3401	-0.86669
Min_O	679	5.0266	34.5348	27.1817	1.2309e-05	0	9.9215	41.9583
$Depth\ Nitro$	43	14.4179	33.5778	24.8845	0.00040752	0.43977	203.2457	2.2346
B i1	900	4.1193	34.6151	27.3459	3.3383e-06	0	16.1015	43.3116
B i2	898	4.1227	34.6144	27.3449	8.1383e-06	0	15.4212	44.0208
B i3	400	6.5483	34.3514	26.8475	8.9712e-06	0.028576	30.8151	37.0466
B i4	398	6.5792	34.3628	26.8523	9.6298e-06	0.012495	31.71	36.1473
B i5	200	8.3403	34.2488	26.5113	2.3291e-05	0.031618	79.7516	29.4303
B i6	198	8.3416	34.2471	26.5097	1.471e-05	0.031618	79.3884	28.8462
B i7	100	9.6587	33.8111	25.9608	6.2785e-05	0.024168	140.2123	21.2765
B i8	98	9.7283	33.8043	25.944	NaN	0.024168	140.4414	21.0581
B i9	10	17.4311	33.6487	24.2593	4.5098e-08	0.37184	226.6617	-1.8143
B i10	5	17.4268	33.6488	24.2602	2.0345e-07	NaN	225.8377	-1.1123

Table 1:

$Profil$	CTD	Lon	Lat	CTD Depth max (m)	Bathy (m)	Dist[km]/azimuth[°] coast	Lon coast	Lat coast
135	2	-121.7466	33.0159	571	-4001	167/47	-120.4171	34.0333

Day	Month	Year	Julian day	Core biology Flag	Season	Season part (early-middle-late)
23	10	2011	2455858	1	Autumn	Middle

$Max_{Fluo}(mg/m^3)$	Depth (m)	Sum $Fluo$ $1-200m(mg/m^3)$
0.56719	32	57.841

Intensity SST Gradient $(°/100km)$	Intensity Geostrophic current (m/s)	Strain $rate$ (s^{-2})	Lyapunov exponent $(1/days)$
1.4971	0.24598	9.6575e-05	0.069856

	Depth (m)	T $(°C)$	AS (g/kg)	σ_0 (kg/m^3)	N^2 (s^{-2})	$Fluo$ (mg/m^3)	O $(\mu mol/kg)$	Ni $(\mu mol/kg)$
$10m$	10	17.5904	33.6356	24.2111	3.1356e-06	0.39642	226.5443	-0.061926
Max	571	5.6287	34.5038	27.0854	NaN	0	11.2473	39.8838
MLD_σ	26	17.5009	33.6332	24.2315	9.9317e-05	0.44376	224.0742	-0.43376
MLD_θ	27	17.4554	33.6322	24.2416	0.0001485	0.44376	221.256	0.0035835
Max_{N2}	40	15.3983	33.6125	24.6997	0.00037802	0.5283	208.0494	3.0315
Max_{Fluo}	32	16.465	33.627	24.4701	0.0006084	0.56719	220.6078	0.94175
Max_O	14	17.5883	33.6356	24.2118	1.2878e-06	0.4202	225.4386	-0.064056
Min_O	568	5.6119	34.4875	27.0746	1.1036e-05	0	10.863	39.8452
$Depth\ Nitro$	568	5.6119	34.4875	27.0746	1.1036e-05	0	10.863	39.8452
B i1	100	9.6219	33.8231	25.9761	0.00011713	0	137.5907	22.9534
B i2	75	10.8808	33.6383	25.618	0.00022402	0.08125	165.7423	15.7048
B i3	50	13.7989	33.5896	25.0226	0.00051572	0.32296	196.3435	8.4294
B i4	45	14.3669	33.6064	24.9174	0.00037083	0.42097	202.1931	5.1746
B i5	40	15.3983	33.6125	24.6997	0.00037802	0.5283	208.0494	3.0315
B i6	35	15.9311	33.6212	24.5874	0.00016296	0.59126	217.1084	1.1232
B i7	30	17.0145	33.6426	24.3541	0.00055584	0.46901	221.1318	0.67259
B i8	20	17.5852	33.6356	24.2128	3.4387e-06	0.4307	224.8523	0.12927
B i9	10	17.5904	33.6356	24.2111	3.1356e-06	0.39642	226.5443	-0.061926
B i10	5	17.5948	33.6356	24.2099	9.2381e-07	NaN	225.4307	0.047228

Table 2:

$Profil$	CTD	Lon	Lat	CTD Depth max (m)	Bathy (m)	Dist[km]/azimuth[°] coast	Lon coast	Lat coast
135	3	-121.8421	32.99	534	-4049	176/48	-120.4171	34.0333

Day	Month	Year	Julian day	Core biology Flag	Season	Season part (early-middle-late)
24	10	2011	2455859	1	Autumn	Middle

$Max_{Fluo}(mg/m^3)$	Depth (m)	Sum $Fluo$ $1-200m(mg/m^3)$
0.45036	30	57.841

Intensity SST Gradient $(°/100km)$	Intensity Geostrophic current (m/s)	Strain $rate$ (s^{-2})	Lyapunov exponent $(1/days)$
0.69243	0.22456	0.00013823	0.069856

	Depth (m)	T $(°C)$	AS (g/kg)	σ_0 (kg/m^3)	N^2 (s^{-2})	$Fluo$ (mg/m^3)	O $(\mu mol/kg)$	Ni $(\mu mol/kg)$
$10m$	10	17.5881	33.6409	24.2158	0.00010353	0.33645	226.9186	-0.81063
Max	534	5.6452	34.4372	27.0305	NaN	0	15.5493	40.1233
MLD_σ	17	17.4956	33.6447	24.2411	3.9634e-05	0.39269	227.4907	-0.57108
MLD_θ	30	17.4162	33.6481	24.2632	NaN	0.45036	226.7712	-0.073954
Max_{N2}	43	13.8901	33.5798	24.9962	0.00013896	0.38924	202.182	6.2619
Max_{Fluo}	30	17.4162	33.6481	24.2632	NaN	0.45036	226.7712	-0.073954
Max_O	13	17.5363	33.6413	24.2286	2.4926e-05	0.34759	227.955	0.069034
Min_O	511	5.9927	34.4627	27.0076	2.3556e-06	0	14.9589	39.3011
$Depth\ Nitro$	38	14.8581	33.6101	24.8153	0.00054539	0.49862	209.0893	1.526
B i1	100	9.7005	33.8068	25.9505	5.1766e-05	0	139.4595	21.3794
B i2	75	10.7183	33.6865	25.6838	0.00031695	0.018509	157.5847	17.1291
B i3	50	13.1386	33.5534	25.1281	7.2153e-05	0.28847	193.6238	8.4432
B i4	45	13.5744	33.5869	25.0662	0.00045181	0.35683	198.1394	7.7346
B i5	40	14.2476	33.5829	24.9243	0.00028796	0.48332	202.2903	5.2702
B i6	35	16.1833	33.667	24.5654	0.0013349	0.49862	211.382	-0.2846
B i7	30	17.4162	33.6481	24.2632	NaN	0.45036	226.7712	-0.073954
B i8	20	17.4746	33.6459	24.2472	3.0744e-06	0.41952	228.4007	-0.63477
B i9	10	17.5881	33.6409	24.2158	0.00010353	0.33645	226.9186	-0.81063
B i10	5	17.6663	33.6411	24.1969	2.3211e-06	NaN	228.1851	-1.5329

Table 3:

$Profil$	CTD	Lon	Lat	CTD Depth max (m)	Bathy (m)	Dist[km]/azimuth[°] coast	Lon coast	Lat coast
135	4	-121.8896	33.0244	747	-3982	177/50	-120.4171	34.0333

Day	Month	Year	Julian day	Core biology Flag	Season	Season part (early-middle-late)
24	10	2011	2455859	1	Autumn	Middle

$Max_{Fluo}(mg/m^3)$	Depth (m)	Sum $Fluo$ $1-200m(mg/m^3)$
0.42523	20	57.841

Intensity SST Gradient $(°/100km)$	Intensity Geostrophic current (m/s)	Strain $rate$ (s^{-2})	Lyapunov exponent $(1/days)$
1.3893	0.25203	7.0786e-05	0.069856

	Depth (m)	T $(°C)$	AS (g/kg)	σ_0 (kg/m^3)	N^2 (s^{-2})	$Fluo$ (mg/m^3)	O $(\mu mol/kg)$	Ni $(\mu mol/kg)$
$10m$	10	16.104	33.4719	24.4332	0.00050482	0.20007	238.84	-0.11937
Max	747	4.7646	34.5361	27.2128	NaN	0	10.1299	42.7015
MLD_σ	10	16.104	33.4719	24.4332	0.00050482	0.20007	238.84	-0.11937
MLD_θ	11	15.908	33.4795	24.4834	0.00037741	0.20496	240.6472	-0.032332
Max_{N2}	6	16.6765	33.4743	24.3038	7.9105e-05	NaN	233.4198	-0.050828
Max_{Fluo}	20	15.3351	33.4598	24.5959	0.00012901	0.42523	240.8357	-1.1152
Max_O	14	15.5089	33.457	24.5553	6.5442e-05	0.34759	243.3663	-0.23752
Min_O	746	4.771	34.5367	27.2126	8.0142e-06	0	10.0309	43.4152
$Depth\ Nitro$	48	12.5455	33.5034	25.2057	0.0001502	0.22713	196.1066	7.3596
B i1	655	5.3382	34.5291	27.1409	6.6538e-06	0	10.2734	41.93
B i2	654	5.3389	34.5281	27.14	4.3645e-06	0	10.2915	41.7411
B i3	653	5.339	34.5284	27.1402	1.309e-06	0	10.3609	41.7003
B i4	652	5.3436	34.5288	27.14	1.1594e-06	0	10.4157	41.1349
B i5	651	5.3481	34.5292	27.1398	1.3363e-05	0	10.3267	41.3148
B i6	650	5.3657	34.5287	27.1372	1.6276e-05	0.0044541	10.3517	41.5464
B i7	649	5.3768	34.5293	27.1364	1.6454e-05	0	10.3157	40.8358
B i8	648	5.3862	34.5275	27.1339	2.6149e-05	0	10.4958	40.8526
B i9	647	5.3954	34.5254	27.1311	2.4886e-05	0	10.4289	41.7372
B i10	646	5.4018	34.5234	27.1288	2.2367e-05	0	10.3903	41.607

Table 4:

$Profil$	CTD	Lon	Lat	CTD Depth max (m)	Bathy (m)	Dist[km]/azimuth[°] coast	Lon coast	Lat coast
135	5	-121.9116	33.0205	748	-3958	179/50	-120.4171	34.0333

Day	Month	Year	Julian day	Core biology Flag	Season	Season part (early-middle-late)
24	10	2011	2455859	1	Autumn	Middle

$Max_{Fluo}(mg/m^3)$	Depth (m)	Sum $Fluo$ $1-200m(mg/m^3)$
0.4307	27	57.841

Intensity SST Gradient $(°/100km)$	Intensity Geostrophic current (m/s)	Strain $rate$ (s^{-2})	Lyapunov exponent $(1/days)$
1.2429	0.24154	8.878e-05	0.069856

	Depth (m)	T $(°C)$	AS (g/kg)	σ_0 (kg/m^3)	N^2 (s^{-2})	$Fluo$ (mg/m^3)	O $(\mu mol/kg)$	Ni $(\mu mol/kg)$
$10m$	10	15.5859	33.4628	24.5426	0.00011598	0.24335	240.0299	-2.6206
Max	748	4.7275	34.5551	27.232	NaN	0	10.2228	42.3066
MLD_σ	13	15.4529	33.4545	24.5657	9.04e-05	0.25801	239.5493	-2.5388
MLD_θ	14	15.4128	33.4556	24.5755	8.847e-05	0.27261	239.1654	-1.6776
Max_{N2}	59	12.3397	33.5443	25.277	0.00013116	0.19743	194.4764	7.464
Max_{Fluo}	27	15.0255	33.4711	24.6724	1.7054e-05	0.4307	235.9156	-2.0408
Max_O	13	15.4529	33.4545	24.5657	9.04e-05	0.25801	239.5493	-2.5388
Min_O	683	4.9947	34.5372	27.1873	2.6478e-06	0	9.8613	41.8159
$Depth\ Nitro$	69	11.3228	33.6032	25.5117	0.00020544	0.16578	176.0445	11.4602
B i1	655	5.2321	34.5428	27.1641	1.096e-05	0	10.044	40.1806
B i2	654	5.2398	34.5423	27.1628	2.1747e-05	0	9.9877	40.0842
B i3	653	5.2527	34.5402	27.1596	2.1891e-05	0	10.0645	40.3453
B i4	652	5.2591	34.5395	27.1583	7.9068e-06	0	10.054	40.9895
B i5	651	5.2612	34.5394	27.158	3.9674e-06	0	10.0747	40.607
B i6	650	5.2637	34.5392	27.1575	4.9996e-06	0	10.0764	40.8313
B i7	649	5.2662	34.5389	27.157	6.1405e-06	0.0038794	10.1223	40.5343
B i8	648	5.2732	34.539	27.1562	1.3763e-05	0.0038794	10.0117	40.5616
B i9	647	5.282	34.5377	27.1542	1.2622e-05	0.0038794	10.0743	40.5142
B i10	646	5.2835	34.5373	27.1537	3.8775e-06	0.0038794	10.0181	39.9804

Table 5:

$Profil$	CTD	Lon	Lat	CTD Depth max (m)	Bathy (m)	Dist[km]/azimuth[°] coast	Lon coast	Lat coast
135	6	-121.9276	33.021	743	-3938	180/51	-120.4171	34.0333

Day	Month	Year	Julian day	Core biology Flag	Season	Season part (early-middle-late)
24	10	2011	2455859	1	Autumn	Middle

$Max_{Fluo}(mg/m^3)$	Depth (m)	Sum $Fluo$ $1-200m(mg/m^3)$
0.50882	26	57.841

Intensity SST Gradient $(°/100km)$	Intensity Geostrophic current (m/s)	Strain $rate$ (s^{-2})	Lyapunov exponent $(1/days)$
1.1951	0.23738	0.00010053	0.069856

	Depth (m)	T $(°C)$	AS (g/kg)	σ_0 (kg/m^3)	N^2 (s^{-2})	$Fluo$ (mg/m^3)	O $(\mu mol/kg)$	Ni $(\mu mol/kg)$
$10m$	10	15.7642	33.4629	24.5029	0.00010467	0.27006	242.4174	0.11134
Max	743	4.709	34.5491	27.2293	NaN	0	10.3532	44.4191
MLD_σ	12	15.6276	33.4591	24.5305	0.00016259	0.28272	241.6506	-0.063498
MLD_θ	12	15.6276	33.4591	24.5305	0.00016259	0.28272	241.6506	-0.063498
Max_{N2}	5	16.409	33.44	24.3392	0.00022022	NaN	236.9916	0.55525
Max_{Fluo}	26	15.1001	33.4591	24.6469	0.00013976	0.50882	228.4717	-0.32114
Max_O	13	15.5458	33.4586	24.5483	0.00012867	0.33883	241.783	-0.44177
Min_O	692	4.8401	34.5262	27.1962	8.9553e-06	0	10.1177	43.8084
$Depth\ Nitro$	49	12.3968	33.4472	25.1909	0.000288	0.22713	207.5392	6.9943
B i1	655	5.2046	34.542	27.1667	3.3527e-06	0	10.3474	43.7534
B i2	654	5.204	34.5414	27.1663	3.2709e-06	0	10.1858	43.6792
B i3	653	5.1985	34.5403	27.166	5.8822e-06	0	10.1865	42.334
B i4	652	5.1964	34.5388	27.1651	9.488e-06	0	10.1571	43.4015
B i5	651	5.1914	34.5368	27.1641	9.3359e-06	0	10.2865	42.8361
B i6	650	5.188	34.5352	27.1631	5.5461e-06	0	10.2364	42.8746
B i7	649	5.1838	34.5343	27.1629	4.8206e-06	0	10.2181	43.3715
B i8	648	5.1808	34.5329	27.1622	5.8193e-06	0	10.1705	43.7835
B i9	647	5.1738	34.5294	27.1602	5.3314e-06	0	10.2173	44.0427
B i10	646	5.1551	34.5263	27.16	7.4463e-06	0	10.2926	42.4819

Table 6:

$Profil$	CTD	Lon	Lat	CTD Depth max (m)	Bathy (m)	Dist[km]/azimuth[°] coast	Lon coast	Lat coast
135	7	-120.4627	33.028	135	-1484	85/72	-119.5988	33.2667

Day	Month	Year	Julian day	Core biology Flag	Season	Season part (early-middle-late)
25	10	2011	2455860	1	Autumn	Middle

$Max_{Fluo}(mg/m^3)$	Depth (m)	Sum $Fluo$ $1-200m(mg/m^3)$
0.50939	17	57.841

Intensity SST Gradient $(°/100km)$	Intensity Geostrophic current (m/s)	Strain $rate$ (s^{-2})	Lyapunov exponent $(1/days)$
1.988	0.18686	0.00021115	0.069856

	Depth (m)	T $(°C)$	AS (g/kg)	σ_0 (kg/m^3)	N^2 (s^{-2})	$Fluo$ (mg/m^3)	O $(\mu mol/kg)$	Ni $(\mu mol/kg)$
$10m$	10	17.1023	33.6454	24.3349	2.2456e-05	0.31714	228.1837	-3.6626
Max	135	9.0049	34.0284	26.2357	NaN	0	112.5448	24.7241
MLD_σ	31	16.9904	33.6471	24.3634	3.7236e-05	0.44778	221.8451	-2.6064
MLD_θ	32	16.9635	33.6463	24.3691	0.00011699	0.44772	215.5782	-3.2157
Max_{N2}	42	13.7159	33.5051	24.9744	0.00019421	0.24256	213.5867	2.0542
Max_{Fluo}	17	17.0791	33.6486	24.3431	1.7326e-05	0.50939	228.5741	-2.7313
Max_O	14	17.0825	33.6481	24.3418	5.6297e-06	0.42283	228.9146	-2.5004
Min_O	132	9.01	34.0094	26.2201	1.0785e-05	0	111.7057	24.3108
$Depth\ Nitro$	36	15.2884	33.5612	24.6844	0.00032076	0.3911	223.9235	-2.3937
B i1	50	12.7528	33.5242	25.1816	8.5378e-05	0.14484	199.2115	5.924
B i2	45	13.1596	33.5256	25.1025	0.00024636	0.18803	198.6248	3.6805
B i3	40	14.2521	33.5774	24.919	0.00070437	0.31362	211.7044	1.5027
B i4	35	15.8447	33.6575	24.6343	0.0010128	0.39752	223.8355	-2.6689
B i5	30	17.0001	33.6477	24.3615	1.3722e-05	0.45057	226.5792	-2.4705
B i6	25	17.0473	33.648	24.3504	2.3077e-06	0.55388	227.7035	-2.3767
B i7	20	17.0564	33.6476	24.3478	4.7657e-06	0.55213	227.9945	-3.136
B i8	15	17.0815	33.6482	24.3421	2.3862e-06	0.45052	227.8654	-2.5004
B i9	10	17.1023	33.6454	24.3349	2.2456e-05	0.31714	228.1837	-3.6626
B i10	5	17.2575	33.6469	24.2991	9.6711e-05	NaN	228.26	-3.0605

Table 7:

$Profil$	CTD	Lon	Lat	CTD Depth max (m)	Bathy (m)	Dist[km]/azimuth[°] coast	Lon coast	Lat coast
135	8	-120.4626	33.028	126	-1483	85/71	-119.5988	33.2667

Day	Month	Year	Julian day	Core biology Flag	Season	Season part (early-middle-late)
25	10	2011	2455860	1	Autumn	Middle

$Max_{Fluo}(mg/m^3)$	Depth (m)	Sum $Fluo$ $1-200m(mg/m^3)$
0.49973	24	57.841

Intensity SST Gradient $(°/100km)$	Intensity Geostrophic current (m/s)	Strain $rate$ (s^{-2})	Lyapunov exponent $(1/days)$
1.988	0.18689	0.00021122	0.069856

	Depth (m)	T $(°C)$	AS (g/kg)	σ_0 (kg/m^3)	N^2 (s^{-2})	$Fluo$ (mg/m^3)	O $(\mu mol/kg)$	Ni $(\mu mol/kg)$
$10m$	10	17.1118	33.646	24.3331	1.3918e-05	0.28437	229.6874	-1.4044
Max	126	9.0764	33.9748	26.1825	NaN	0	121.1329	23.9409
MLD_σ	34	16.9981	33.6486	24.3628	1.69e-05	0.51124	227.1625	-1.5772
MLD_θ	38	16.9618	33.6471	24.3703	0.00038227	0.46283	216.4725	-2.0146
Max_{N2}	48	13.5768	33.5392	25.0291	0.00041559	0.187	202.2087	5.5049
Max_{Fluo}	24	17.0802	33.6498	24.344	7.0676e-06	0.49973	227.0522	-1.0838
Max_O	13	17.0873	33.6481	24.3406	1.3362e-05	0.34065	228.9406	-1.4209
Min_O	120	9.4063	33.9363	26.0996	0.00015024	0	120.7679	23.6699
$Depth\ Nitro$	65	11.6675	33.6291	25.4687	0.00054194	0.082856	168.7364	9.8874
B i1	50	13.2561	33.5262	25.0838	0.00015122	0.16578	200.828	5.7178
B i2	45	14.239	33.5657	24.9128	0.00057396	0.3095	208.5925	2.3414
B i3	40	16.0614	33.6501	24.5801	0.00098165	0.40437	215.6421	-0.84263
B i4	35	16.9879	33.647	24.364	8.8739e-06	0.48253	225.5188	-1.984
B i5	30	17.0192	33.648	24.3572	1.0523e-05	0.5117	227.5903	-2.5759
B i6	25	17.0774	33.6498	24.3447	2.323e-05	0.50258	227.0973	-0.94785
B i7	20	17.0843	33.6496	24.3428	3.3654e-07	0.47907	229.4109	-2.0126
B i8	15	17.0862	33.6488	24.3415	3.4956e-06	0.41161	228.3366	-1.617
B i9	10	17.1118	33.646	24.3331	1.3918e-05	0.28437	229.6874	-1.4044
B i10	5	17.2613	33.6481	24.2991	0.00027799	NaN	229.2698	-1.4771

Table 8:

$Profil$	CTD	Lon	Lat	CTD Depth max (m)	Bathy (m)	Dist[km]/azimuth[°] coast	Lon coast	Lat coast
135	9	-120.4624	33.028	490	-1481	85/71	-119.5988	33.2667

Day	Month	Year	Julian day	Core biology Flag	Season	Season part (early-middle-late)
25	10	2011	2455860	0	Autumn	Middle

$Max_{Fluo}(mg/m^3)$	Depth (m)	Sum $Fluo$ $1-200m(mg/m^3)$
0.47518	19	57.841

Intensity SST Gradient $(°/100km)$	Intensity Geostrophic current (m/s)	Strain $rate$ (s^{-2})	Lyapunov exponent $(1/days)$
1.988	0.18693	0.00021131	0.069856

	Depth (m)	T $(°C)$	AS (g/kg)	σ_0 (kg/m^3)	N^2 (s^{-2})	$Fluo$ (mg/m^3)	O $(\mu mol/kg)$	Ni $(\mu mol/kg)$
$10m$	10	17.1573	33.6479	24.3238	2.0883e-05	0.27115	228.8555	-1.3324
Max	490	5.9463	34.4378	26.9935	NaN	0	16.5647	39.1123
MLD_σ	21	17.0576	33.648	24.3478	4.274e-05	0.47643	226.3034	-1.4507
MLD_θ	27	16.9644	33.6446	24.3674	1.0796e-05	0.47518	223.5696	-1.2791
Max_{N^2}	39	13.6927	33.5312	24.9992	0.00017208	0.22458	204.3112	3.1386
Max_{Fluo}	19	17.076	33.6491	24.3443	2.9687e-05	0.47518	228.4969	-1.587
Max_O	13	17.1209	33.6479	24.3325	2.5777e-05	0.34759	228.9699	-1.0827
Min_O	490	5.9463	34.4378	26.9935	NaN	0	16.5647	39.1123
$Depth\ Nitro$	34	14.9221	33.5477	24.7536	0.00018458	0.36927	208.9293	-0.40552
B i1	50	12.8138	33.5293	25.1736	9.5904e-05	0.1385	196.8095	7.1151
B i2	45	13.041	33.5242	25.1249	9.6565e-05	0.16578	200.7323	9.7136
B i3	40	13.5189	33.5256	25.0302	0.00027531	0.20918	204.1327	3.7334
B i4	35	14.7637	33.5472	24.7873	0.00035257	0.32296	205.914	2.1515
B i5	30	16.7732	33.6489	24.4155	0.00035176	0.45387	215.3684	-1.2978
B i6	25	16.977	33.6464	24.3657	2.497e-05	0.48176	225.7324	-0.83002
B i7	20	17.0504	33.6506	24.3515	3.5159e-05	0.47643	227.3887	-1.5699
B i8	15	17.1055	33.6477	24.3361	1.8311e-05	0.37642	229.5631	-0.82794
B i9	10	17.1573	33.6479	24.3238	2.0883e-05	0.27115	228.8555	-1.3324
B i10	5	17.2435	33.649	24.304	0.00024787	NaN	229.1039	-1.2668

Table 9:

4 ARGO

4.1 Introduction

To complete the CTD study, we use ARGO data available around Tara's stations. ARGO is a global array of autonomous profiling floats that observe pressure, temperature and salinity in the upper $2000m$ of the ocean. These data were collected and made freely available by the International Argo Program and the national programs that contribute to it (http://www.argo.ucsd.edu, http://argo.jcommops.org).

The Argo Program is part of the Global Ocean Observing System. The ARGO profiles were downloaded on the Aviso ftp web site where only pressure (P), temperature (T), and salinity (S) data. However, some of these profiles were still suspicious so applied another analysis in the same way that Chaigneau et al. (2011) using the following conditions:

- Data flagged as good and probably good (Argo quality flag 1 and 2)
- The shallowest data above 15 dbar and the deepest data below 300m
- A difference of pressure level inferior than 25 dbar between 0-100dbar and inferior than 50 dbar between 100-300dbar

We looked for the nearest ARGO floats available in box defined by $\Delta X \pm 4°$ $lat-lon$ and $\Delta t \pm 15$ $julian\ days$ around Tara stations. For each CTD profile we search for the best matching ARGO profile. We computed distance dx, delay time dt, and radius $r = \sqrt{dx^2 + dt^2}$ between each ARGO and CTD profiles. We add correlations calculations between CTD-ARGO salinity and temperature. Correlations are calculated using the `corrcoef` function in `Matlab`. To make correlations calculation possible we interpolate ARGO profiles (defined on the 152 levels vertical grid) on a CTD-compatible 1 decibar vertical grid. We present the results in Tab. 11 with the ARGO profiles we kept after tests. We show the CTD and **all** ARGO profiles on Fig. 12, and a $\theta - S$ diagram on Fig. 13.

4.2 Correlations with CTD profiles

CTD	Argo	*Radius*	*dt* (*jul*)	*dx* (*km*)	θ correl.	S correl.	Lon Argo	Lat Argo
1	1	347.5174	5	347.4815	0.98866	0.97507	-120.028	30.251
1	2	334.4541	-6	334.4003	0.98725	0.98163	-120.087	30.357
1	3	160.341	5	160.263	0.99786	0.98707	-123.431	33.369
1	4	225.8277	-6	225.748	0.99712	0.99223	-124.183	33.138
1	5	192.5928	-16	191.927	0.99701	0.99282	-123.82	33.131
1	6	398.4967	4	398.4766	0.97178	0.97243	-122.76	36.484
1	7	386.6313	-7	386.5679	0.98118	0.97096	-123.077	36.3
2	1	348.2547	5	348.2188	0.98287	0.95581	-120.028	30.251
2	2	335.1876	-6	335.1339	0.98087	0.96866	-120.087	30.357
2	3	161.8348	5	161.7575	0.99627	0.97892	-123.431	33.369
2	4	227.7443	-6	227.6653	0.9941	0.98543	-124.183	33.138
2	5	194.4918	-16	193.8326	0.99603	0.99224	-123.82	33.131
2	6	397.0467	4	397.0266	0.95859	0.95181	-122.76	36.484
2	7	385.3939	-7	385.3303	0.97837	0.95263	-123.077	36.3
3	1	350.0836	6	350.0322	0.97928	0.95301	-120.028	30.251
3	2	337.0002	-5	336.9632	0.97863	0.96741	-120.087	30.357
3	3	154.0499	6	153.933	0.99881	0.98345	-123.431	33.369
3	4	219.0635	-5	219.0064	0.99344	0.98487	-124.183	33.138
3	5	185.8027	-15	185.1962	0.9939	0.9895	-123.82	33.131
3	6	397.9396	5	397.9082	0.95613	0.94983	-122.76	36.484
3	7	385.4722	-6	385.4255	0.97504	0.94726	-123.077	36.3
4	1	355.6235	6	355.5729	0.97817	0.93139	-120.028	30.251
4	2	342.5448	-5	342.5083	0.97932	0.94478	-120.087	30.357
4	3	148.7379	6	148.6168	0.99063	0.98427	-123.431	33.369
4	4	214.3413	-5	214.283	0.99177	0.9859	-124.183	33.138
4	5	181.0728	-15	180.4505	0.99046	0.98381	-123.82	33.131
4	6	393.288	5	393.2562	0.9812	0.97823	-122.76	36.484
4	7	380.5377	-6	380.4904	0.99108	0.98096	-123.077	36.3
5	1	356.2883	6	356.2378	0.99154	0.95016	-120.028	30.251
5	2	343.2146	-5	343.1781	0.99302	0.96292	-120.087	30.357
5	3	146.8827	6	146.7601	0.98884	0.98887	-123.431	33.369
5	4	212.3305	-5	212.2716	0.99608	0.9936	-124.183	33.138
5	5	179.0715	-15	178.4422	0.99384	0.98756	-123.82	33.131
5	6	393.3095	5	393.2777	0.98085	0.97399	-122.76	36.484
5	7	380.383	-6	380.3357	0.98735	0.97244	-123.077	36.3
6	1	357.0964	6	357.046	0.98895	0.92436	-120.028	30.251
6	2	344.026	-5	343.9897	0.98961	0.94003	-120.087	30.357
6	3	145.4298	6	145.306	0.99289	0.98827	-123.431	33.369
6	4	210.8346	-5	210.7753	0.99714	0.98721	-124.183	33.138
6	5	177.5808	-15	176.9461	0.99391	0.98631	-123.82	33.131
6	6	392.972	5	392.9402	0.98046	0.97866	-122.76	36.484
6	7	379.924	-6	379.8767	0.9881	0.97825	-123.077	36.3
7	1	311.9431	7	311.8646	0.95845	0.054195	-120.028	30.251
7	2	299.4806	-4	299.4539	0.97391	0.45031	-120.087	30.357
7	3	279.1665	7	279.0787	0.9967	0.94821	-123.431	33.369
7	4	347.2208	-4	347.1978	0.98961	0.91005	-124.183	33.138
7	5	313.6636	-14	313.351	0.9855	0.91933	-123.82	33.131
7	6	438.3573	6	438.3162	0.88828	0.83503	-122.76	36.484
7	7	435.8322	-5	435.8035	0.95009	0.83164	-123.077	36.3
8	1	311.9415	7	311.8629	0.97857	0.0017374	-120.028	30.251
8	2	299.4791	-4	299.4524	0.98568	0.35912	-120.087	30.357
8	3	279.1788	7	279.091	0.98576	0.89345	-123.431	33.369
8	4	347.2332	-4	347.2102	0.99478	0.84156	-124.183	33.138
8	5	313.676	-14	313.3634	0.99832	0.9126	-123.82	33.131
8	6	438.3631	6	438.3221	0.85358	0.77227	-122.76	36.484
8	7	435.8389	-5	435.8102	0.92605	0.77423	-123.077	36.3
9	1	311.9394	7	311.8608	0.98051	0.94465	-120.028	30.251
9	2	299.4772	-4	299.4505	0.98204	0.96368	-120.087	30.357
9	3	279.1941	7	279.1064	0.9968	0.98574	-123.431	33.369
9	4	347.2488	-4	347.2257	0.99189	0.988	-124.183	33.138

Table 10: Description: see paragraph p. 22

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CTD	Argo	*Radius*	dt (jul)	dx (km)	θ correl.	S correl.	Lon Argo	Lat Argo
9	5	313.6915	-14	313.379	0.99082	0.98492	-123.82	33.131
9	6	438.3704	6	438.3294	0.9601	0.9418	-122.76	36.484
9	7	435.8473	-5	435.8186	0.97897	0.9386	-123.077	36.3

Table 11: Description: see paragraph p. 22

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4.3 ARGO and CTD profiles

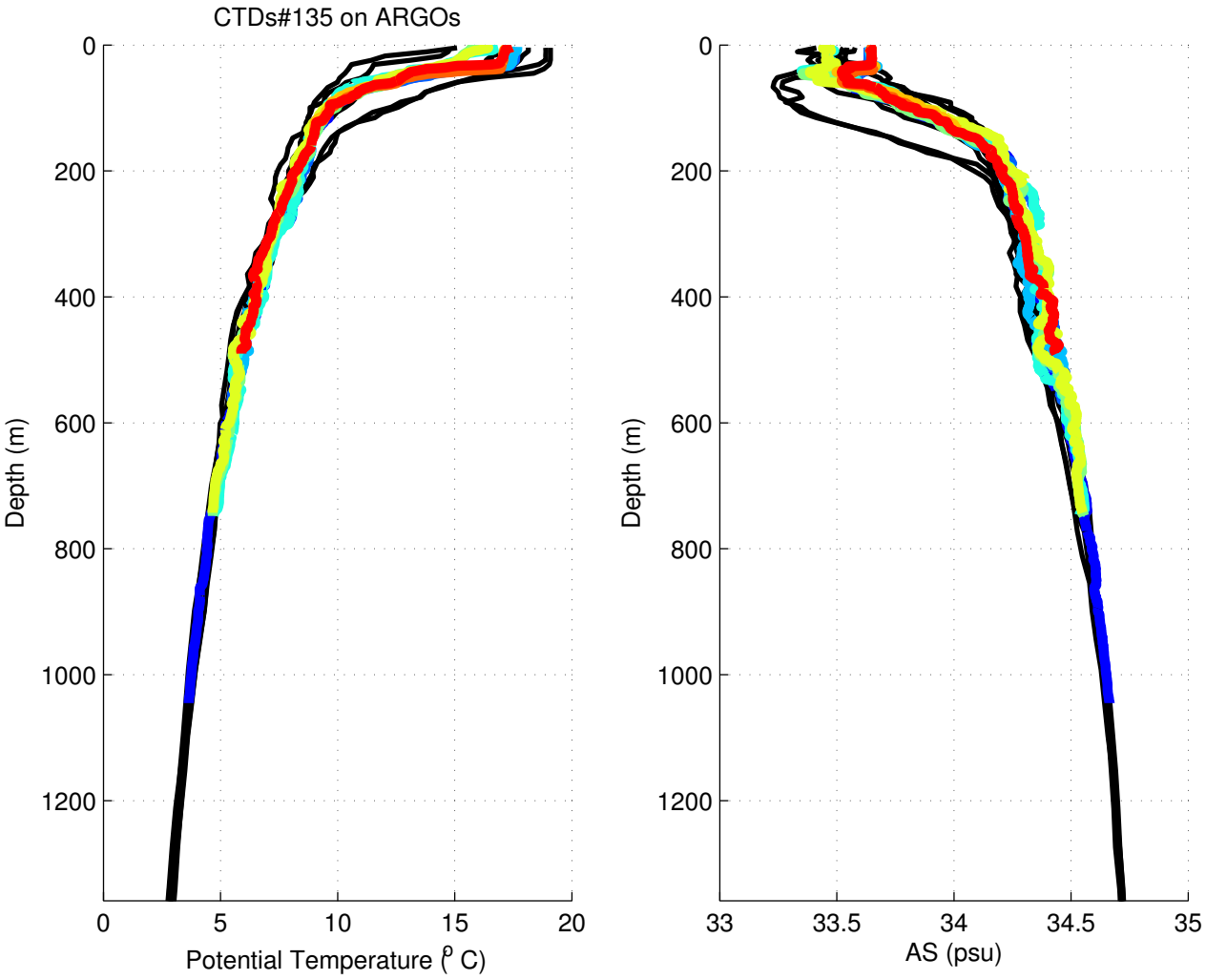

Figure 12: Description: see paragraph p. 22

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4.4 ARGO and CTD $\theta - S$ diagrams

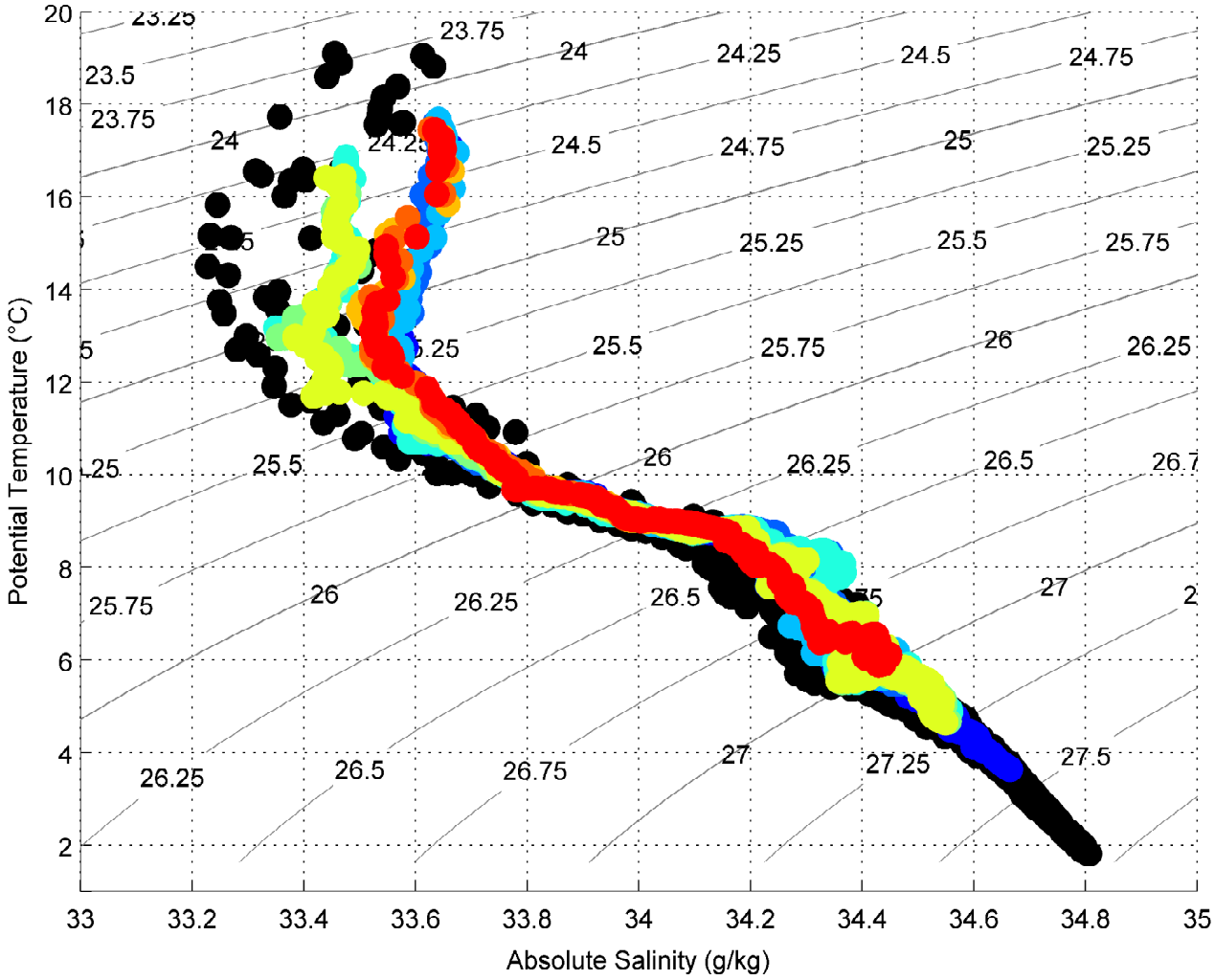

Figure 13: Description: see paragraph p. 22

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References

A Capet, E Mason, V Rossi, C Troupin, Y Faugère, I Pujol, and A Pascual. Implications of refined altimetry on estimates of mesoscale activity and eddydriven offshore transport in the eastern boundary upwelling systems. *Geophysical Research Letters*, 41(21):7602–7610, 2014. ISSN 1944-8007.

A Chaigneau, M Le Texier, G Eldin, C Grados, and O Pizarro. Vertical structure of mesoscale eddies in the eastern south pacific ocean: A composite analysis from altimetry and argo profiling floats. *Journal of Geophysical Research: Oceans*, 116(C11):n/a–n/a, 2011. ISSN 2156-2202. doi: 10.1029/2011JC007134.

C De Boyer Montégut, G Madec, A S Fischer, A Lazar, and D Iudicone. Mixed layer depth over the global ocean: An examination of profile data and a profilebased climatology. *Journal of Geophysical Research: Oceans (1978–2012)*, 109(C12), 2004. ISSN 2156-2202.

F d'Ovidio, V Fernández, E HernándezGarcía, and C López. Mixing structures in the mediterranean sea from finitesize lyapunov exponents. *Geophysical Research Letters*, 31(17), 2004. ISSN 1944-8007.

T Gerkema and JTF Zimmerman. An introduction to internal waves. *Lecture Notes, Royal NIOZ, Texel*, 2008.

O Hernandez, Jacqueline Boutin, Nicolas Kolodziejczyk, Gilles Reverdin, Nicolas Martin, Fabienne Gaillard, Nicolas Reul, and JL Vergely. Smos salinity in the subtropical north atlantic salinity maximum: 1. comparison with aquarius and in situ salinity. *Journal of Geophysical Research: Oceans*, 2014. ISSN 2169-9291.

N Kolodziejczyk, J Boutin, O Hernandez, A Sommer, G Reverdin, S Marchand, N Martin, J-L Vergely, and X Yin. Argo and smos sss combination helps monitoring sss variability from basin scale to mesoscale. 2015a.

Nicolas Kolodziejczyk, Olga Hernandez, Jacqueline Boutin, and Gilles Reverdin. Smos salinity in the subtropical north atlantic salinity maximum: 2. twodimensional horizontal thermohaline variability. *Journal of Geophysical Research: Oceans*, 2015b. ISSN 2169-9291.

MJ Martin, A Hines, and MJ Bell. Data assimilation in the foam operational shortrange ocean forecasting system: A description of the scheme and its impact. *Quarterly Journal of the Royal Meteorological Society*, 133(625):981–995, 2007. ISSN 1477-870X.

MH Rio and F Hernandez. A mean dynamic topography computed over the world ocean from altimetry, in situ measurements, and a geoid model. *Journal of Geophysical Research: Oceans (1978–2012)*, 109(C12), 2004. ISSN 2156-2202.

D W Waugh, E R Abraham, and M M Bowen. Spatial variations of stirring in the surface ocean: A case study of the tasman sea. *Journal of Physical Oceanography*, 36(3):526–542, 2006. ISSN 1520-0485.