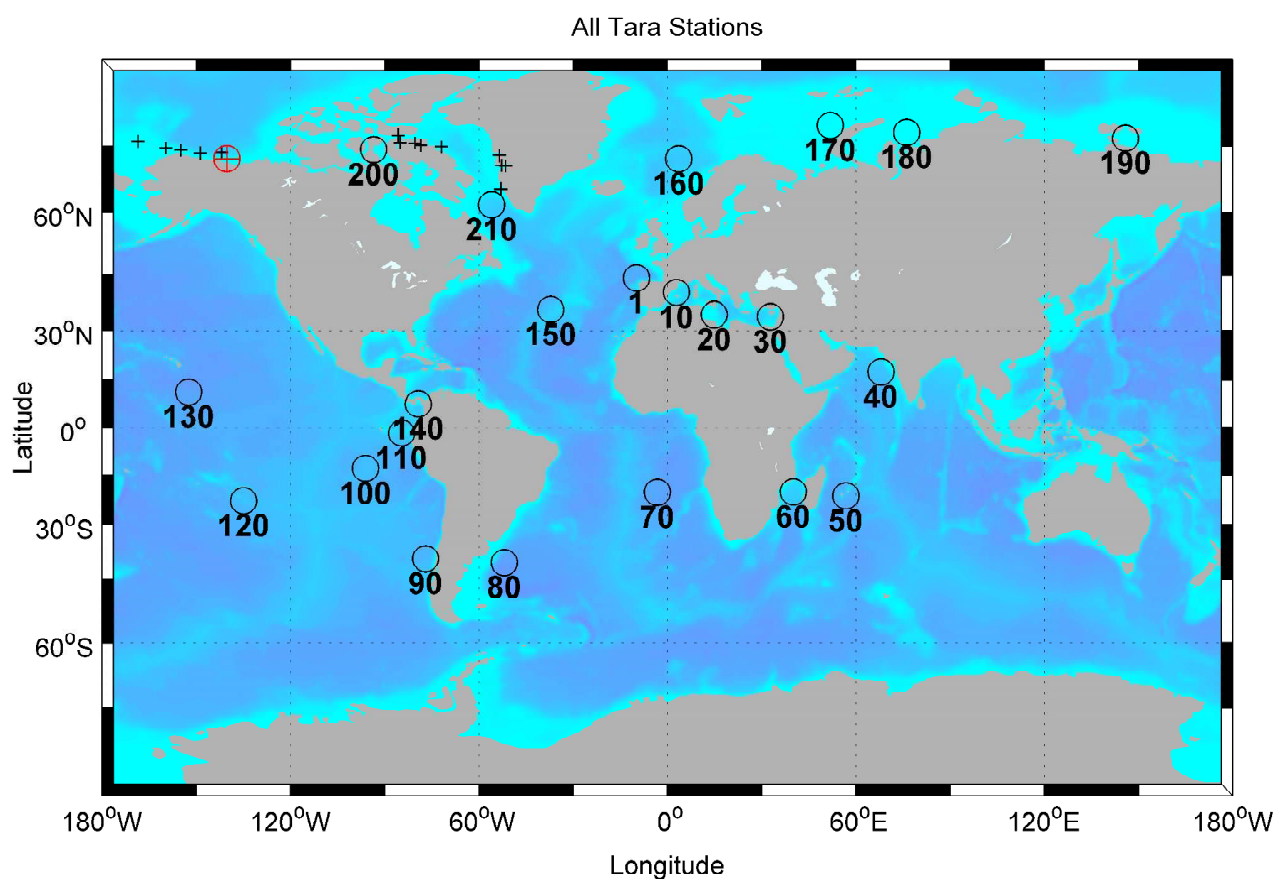


Physical data report by station

Station n°199

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

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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°	199
Location	Polar Circle
Date	17/9/2013
Mean Longitude	-140.2461°
Mean Latitude	70.3851°
CTDs profiles	1

Availability:	
UV Satellite fields	1
SST Satellite fields	1
SSS Satellite fields	1
SSH Satellite fields	1
CHL1 Satellite fields	1
Argo floats	0

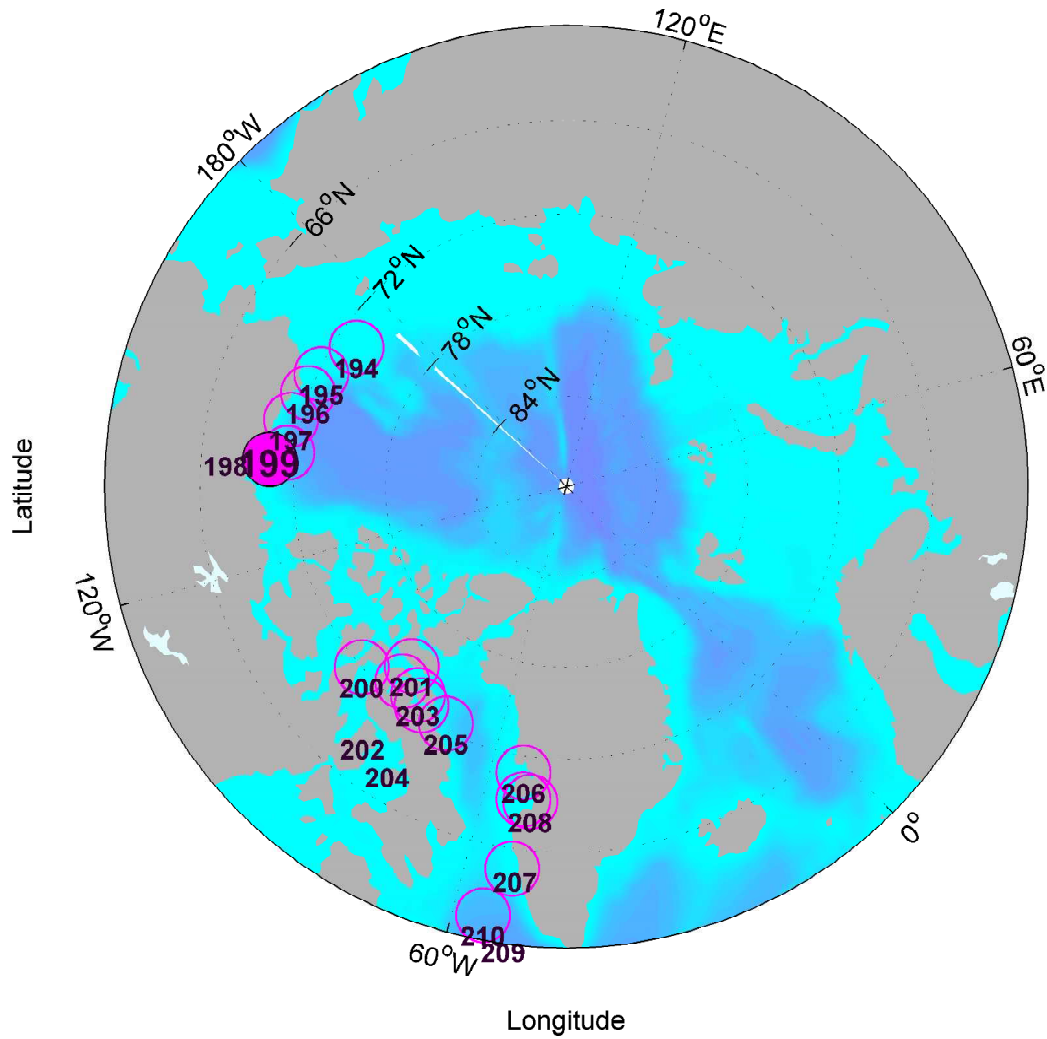


Figure 1: Filled magenta black circle indicate the station of this study.






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 [$^{\circ}C$] 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 $1/4^{\circ}$ (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 GHRSSST 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 $1/20^{\circ}$ (approx. $5km$). OSTIA data is provided in GHRSSST netCDF format every day.
- Chlorophyll (CHL1): Weekly $1/10^{\circ}$ 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 ($z_{level}=0$) 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 $\Delta X \pm 4^{\circ} lat - lon$ 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

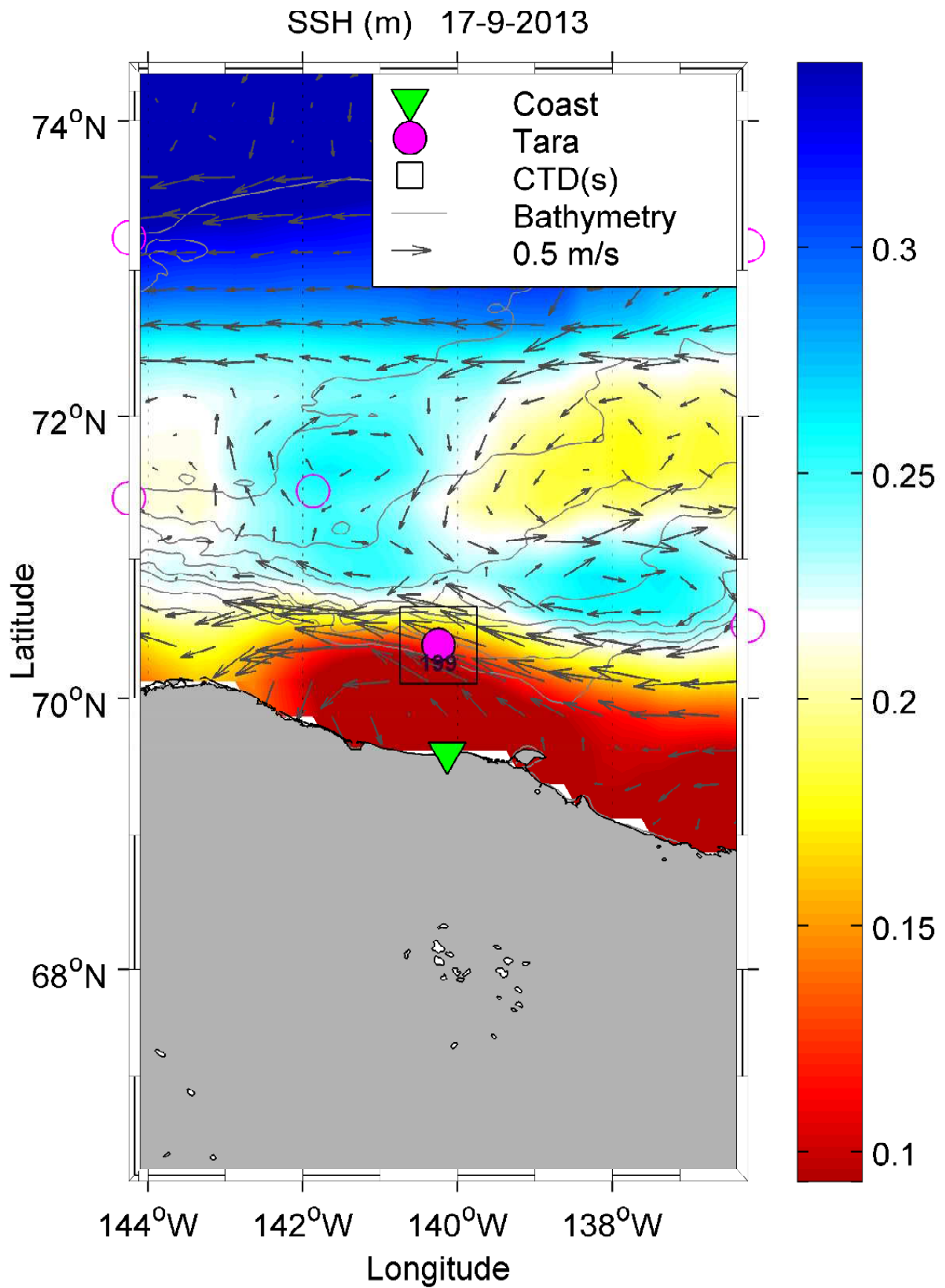


Figure 2: Description: see legend p. 14

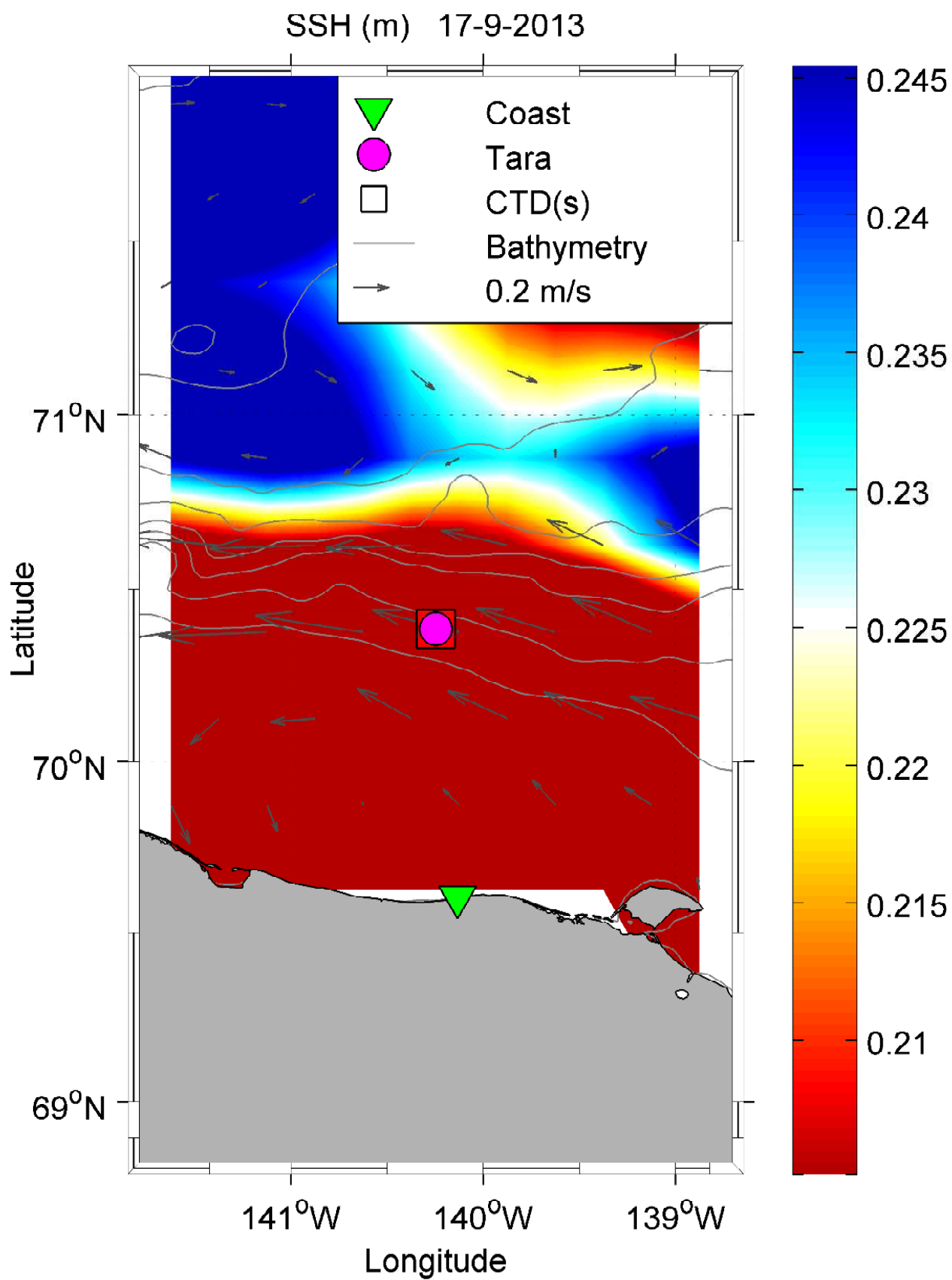
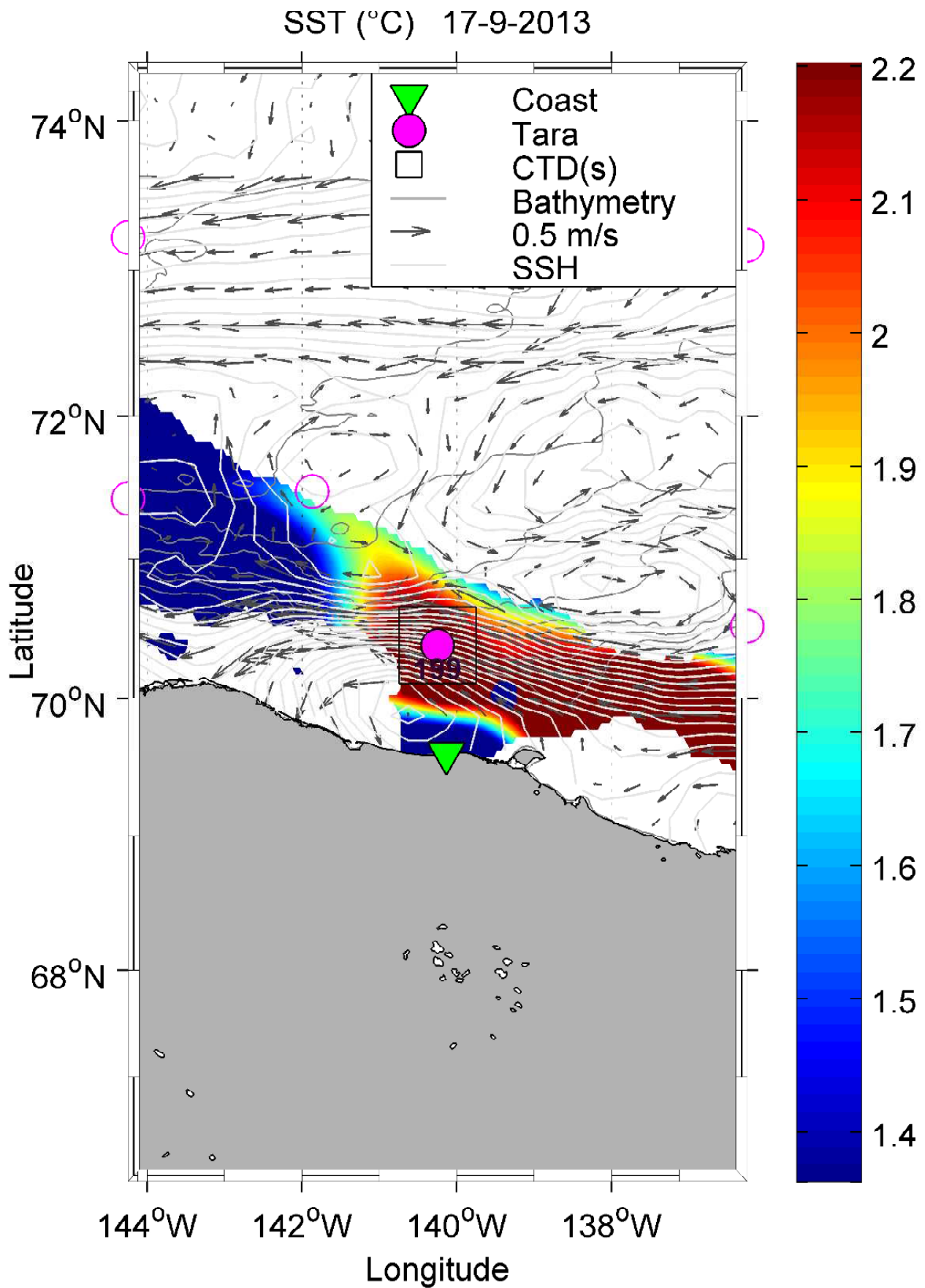


Figure 3: Description: see legend p. 14

1.3 SST maps



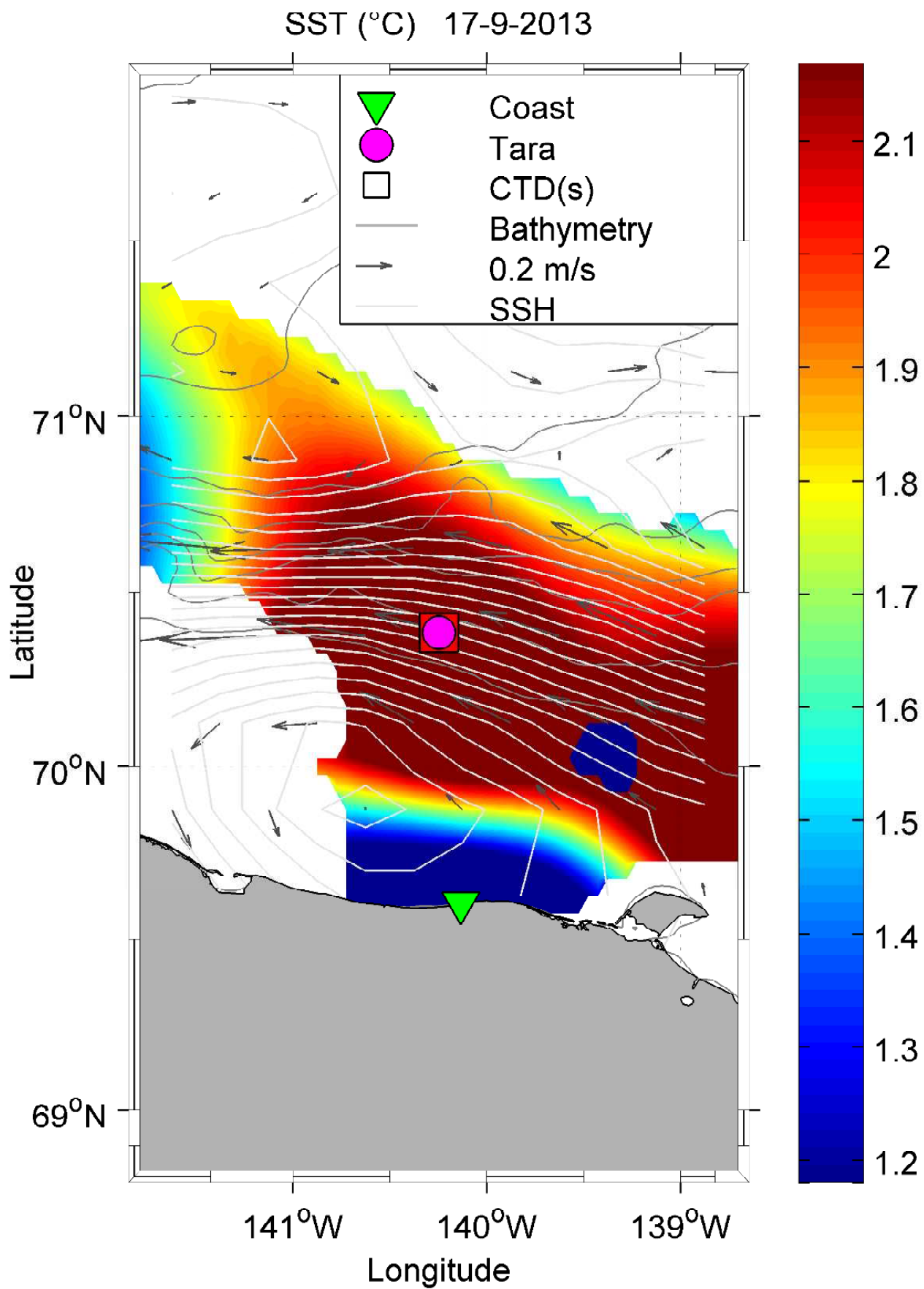


Figure 5: Description: see legend p. 14

1.4 Chlorophyll maps

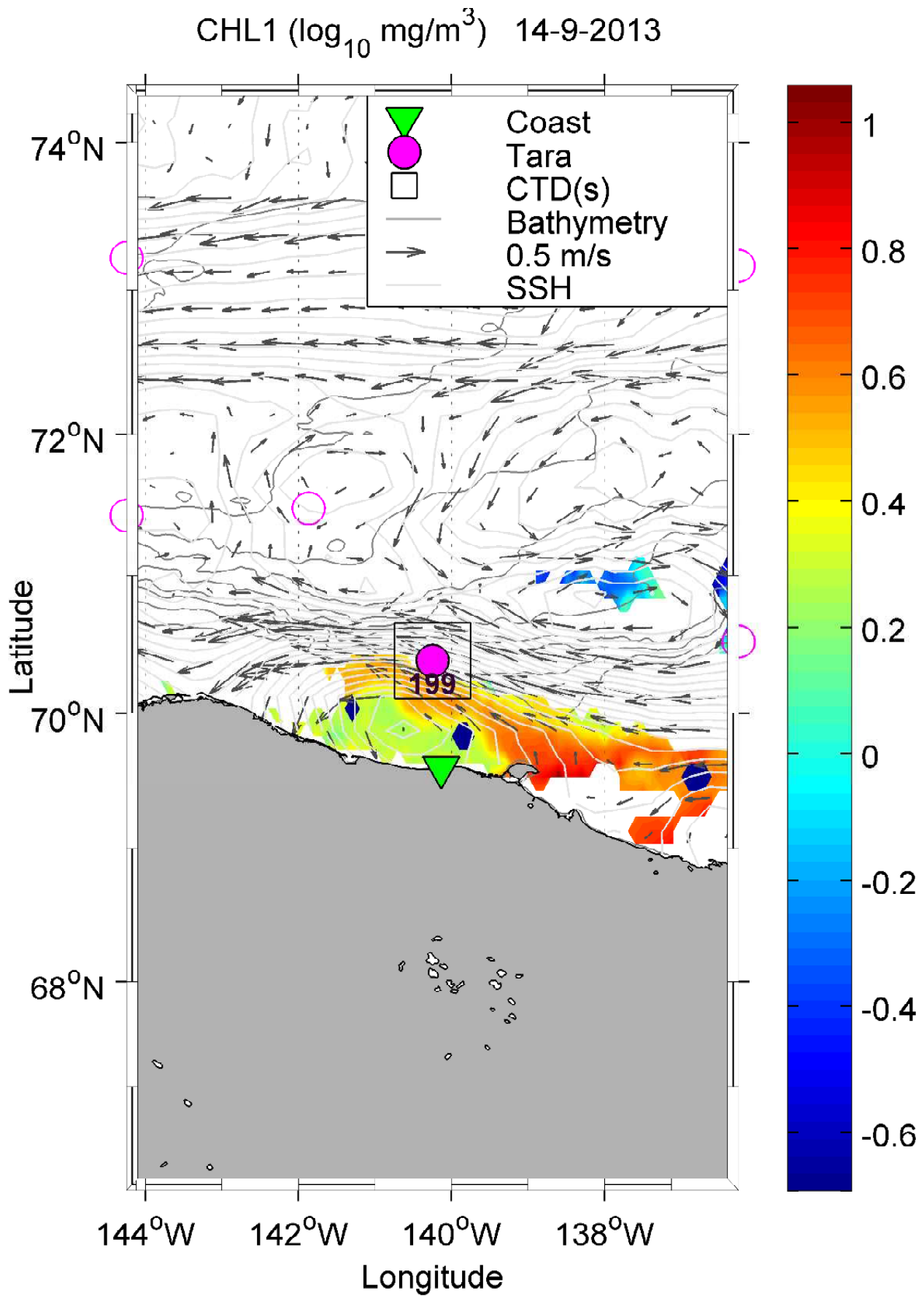


Figure 6: Description: see legend p. 14

CHL1 ($\log_{10} \text{mg/m}^3$) 14-9-2013

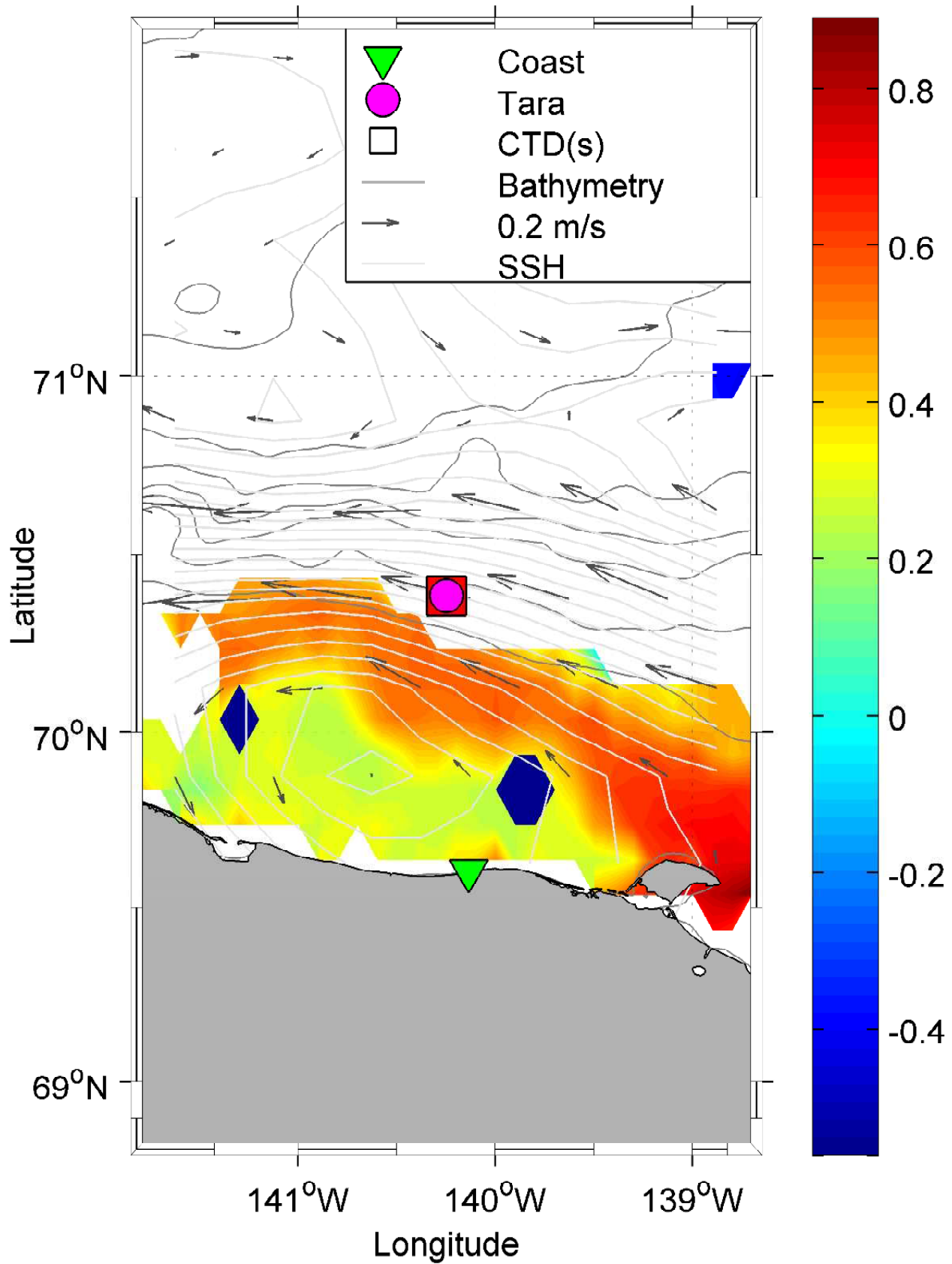


Figure 7: Description: see legend p. 14

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. 5841 records satisfy these conditions. It is important to emphasize that TSG data are measure along the boat path whereas satellite data are snapshots.

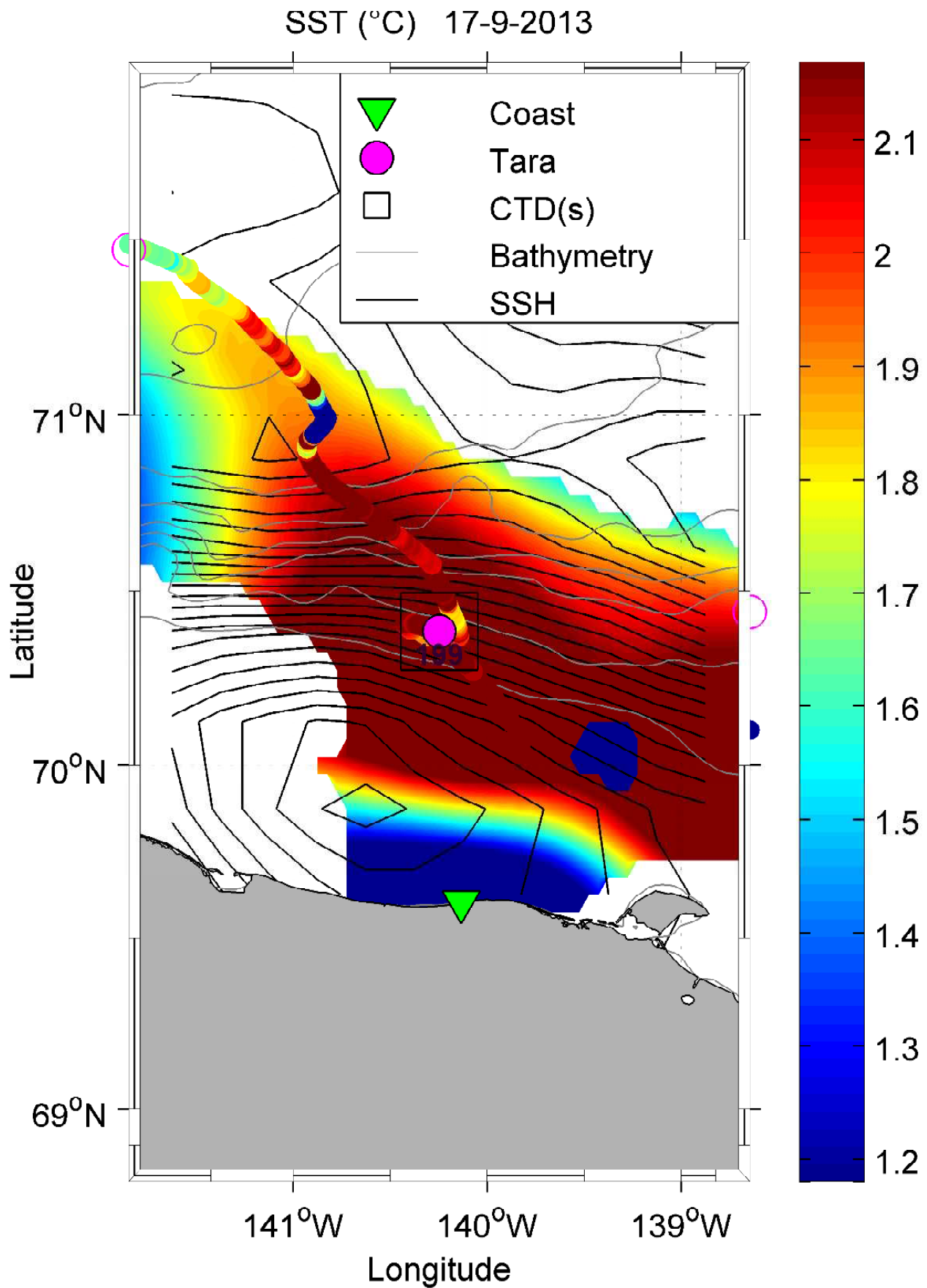
TSG surface temperature is plotted over the Sea Surface Temperature measured by satellite and provided by OSTIA in figure 8.

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 plotted.

2.2 TSG Temperature maps



2.3 TSG Salinity maps

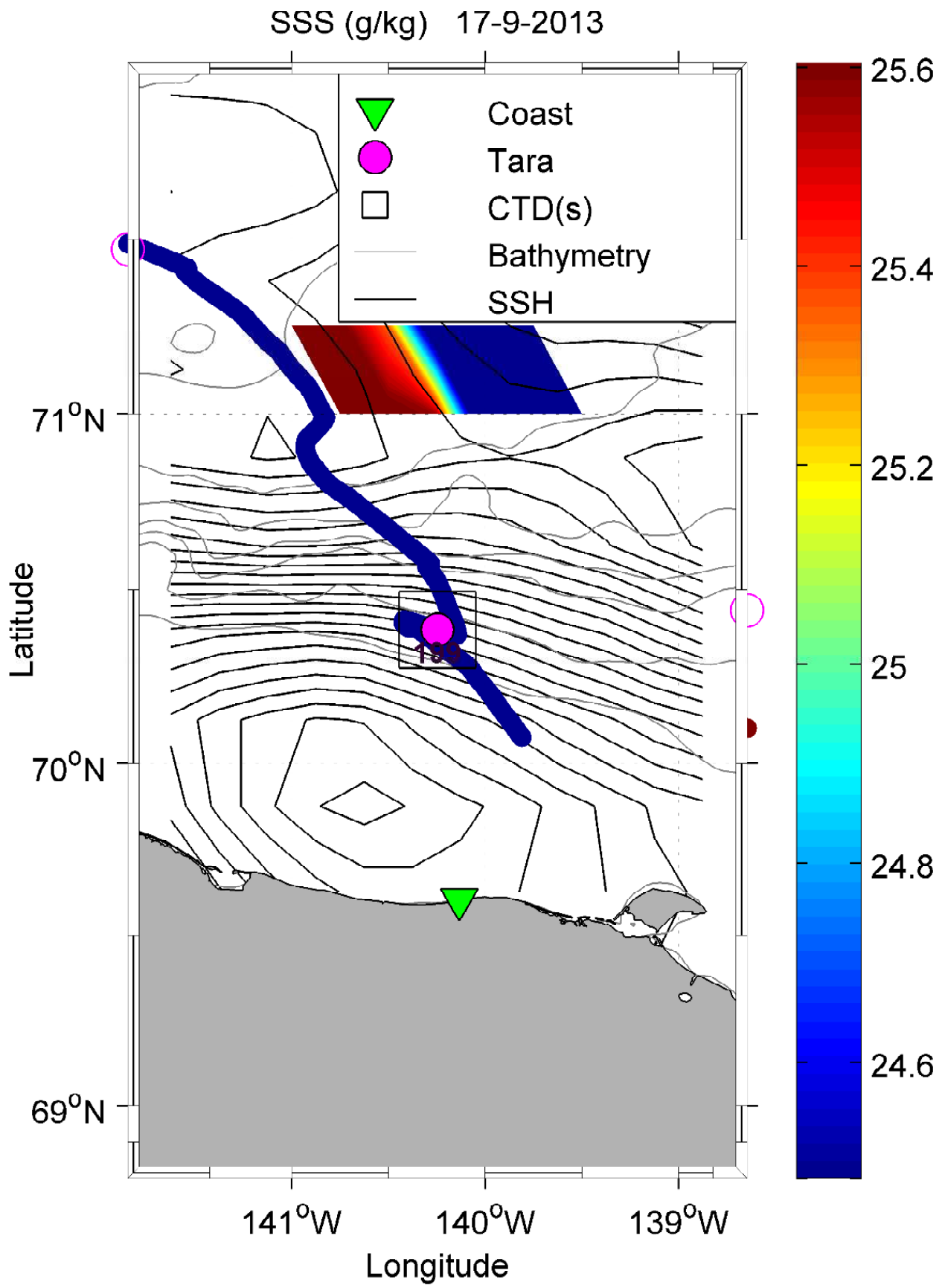


Figure 9: Description: see legend p. 14

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 n199, 1 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:

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

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:

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

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

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

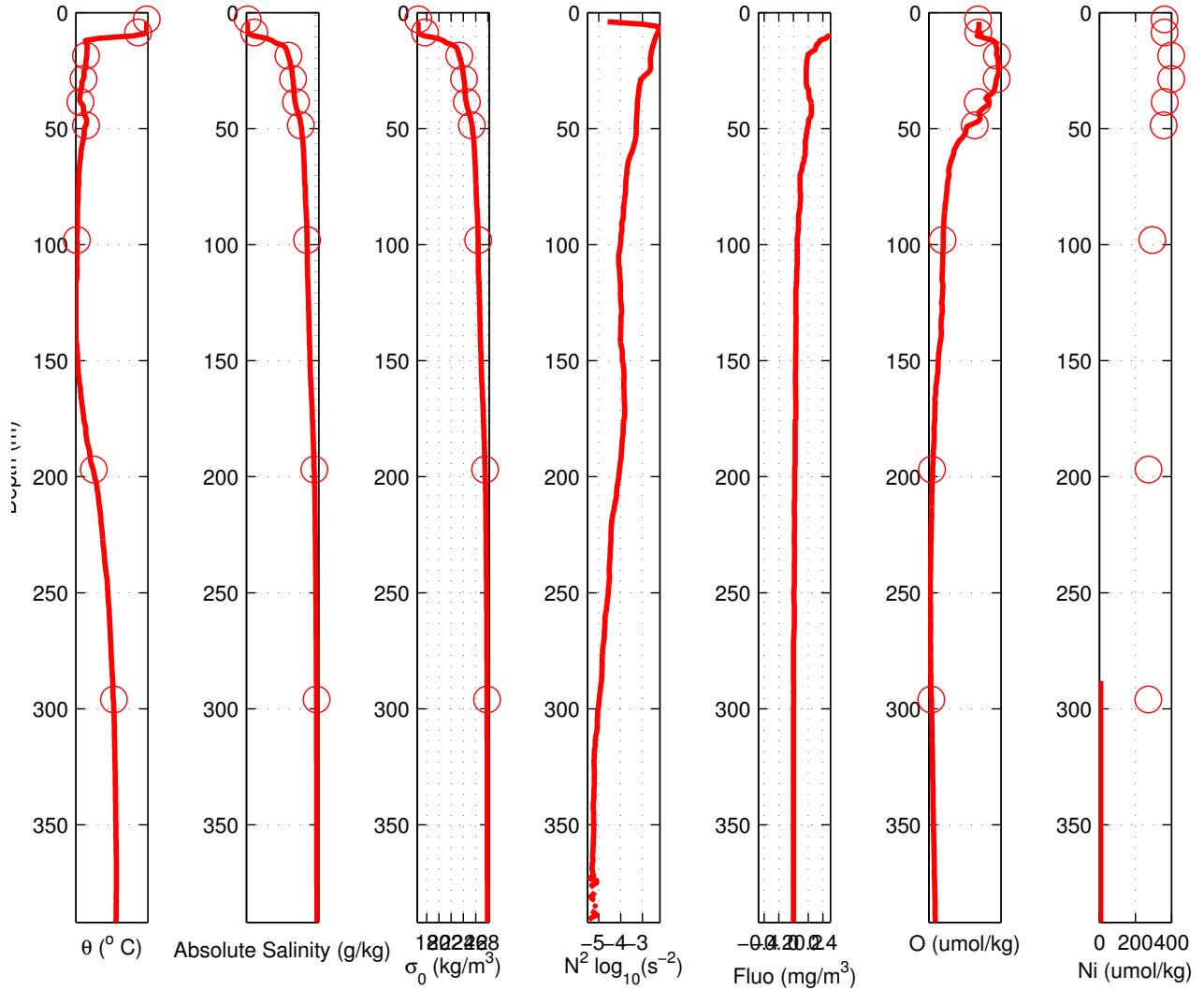


Figure 10: Description: see paragraph p. 14

3.3 CTD $\theta - S$ diagrams

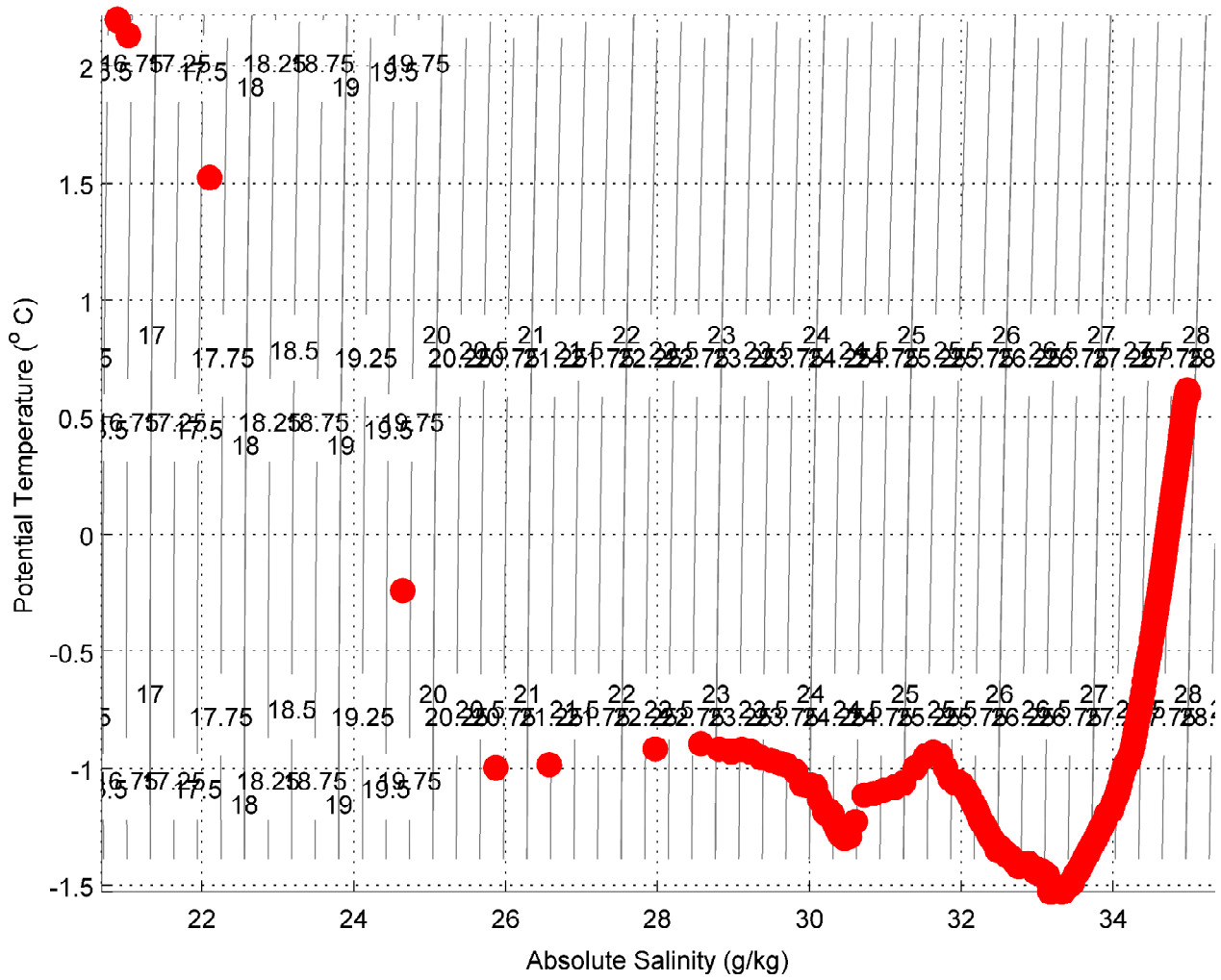


Figure 11: Description: see paragraph p. 14

3.4 Water column characterization from CTD measurements

<i>Profil</i>	CTD	Lon	Lat	CTD Depth max (m)	Bathy (m)	Dist[km]/azimuth[°]	coast	Lon coast	Lat coast
199	1	-140.2461	70.3851	392	-448	87/177		-140.1333	69.6037
Day	Month	Year	Julian day	Core biology Flag	Season	Season part (early-middle-late)			
17	9	2013	2456553	0	Summer	Late			
<i>MaxFluo</i> (mg/m ³)		Depth (m)		Sum <i>Fluo</i> 1 – 200m(mg/m ³)					
0.30928		14		57.841					
Intensity SST Gradient (°/100km)				Intensity Geostrophic current (m/s)		Strain rate (s ⁻²)		Lyapunov exponent (1/days)	
1.7563				0.19768		0.00021606		NaN	
	Depth (m)	<i>T</i> (°C)	<i>AS</i> (g/kg)	σ_0 (kg/m ³)	<i>N</i> ² (s ⁻²)	<i>Fluo</i> (mg/m ³)	<i>O</i> (μmol/kg)	<i>Ni</i> (μmol/kg)	
10m	10	1.5231	22.0998	17.5853	0.014468	0.47804	357.2114	NaN	
<i>Max</i>	392	0.6159	34.9901	27.932	NaN	0	278.4168	6.8477	
<i>MLD_σ</i>	10	1.5231	22.0998	17.5853	0.014468	0.47804	357.2114	NaN	
<i>MLD_θ</i>	10	1.5231	22.0998	17.5853	0.014468	0.47804	357.2114	NaN	
<i>Max_{N2}</i>	7	2.1953	20.8888	16.5976	4.6064e-05	NaN	360.5473	NaN	
<i>MaxFluo</i>	14	-0.91811	27.9679	22.3545	NaN	0.30928	392.8402	NaN	
<i>Max_O</i>	18	-0.91917	29.1092	23.2736	0.0010225	0.19856	394.4307	NaN	
<i>Min_O</i>	244	0.13464	34.7643	27.7787	3.9911e-05	0.0093329	268.998	NaN	
<i>Depth Nitro</i>	390	0.61705	34.9893	27.9313	4.5901e-06	0	278.1154	6.7101	
B i1	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	
B i2	300	0.49255	34.9104	27.8754	6.8525e-06	0	271.4049	6.4908	
B i3	200	-0.50976	34.4722	27.5761	0.00011192	0.017518	273.3558	NaN	
B i4	100	-1.4356	32.9896	26.4153	5.1507e-05	0.049868	293.2164	NaN	
B i5	50	-1.0458	31.8534	25.4876	0.00045066	0.18483	336.7913	NaN	
B i6	40	-1.1148	30.7181	24.5745	0.00092128	0.24308	376.8942	NaN	
B i7	30	-1.1907	30.202	24.1603	0.00046052	0.17538	393.3652	NaN	
B i8	20	-0.95581	29.3645	23.4801	0.0010473	0.18756	396.5636	NaN	
B i9	10	1.5231	22.0998	17.5853	0.014468	0.47804	357.2114	NaN	
B i10	4	2.1988	20.8844	16.594	NaN	NaN	361.1317	NaN	

Table 1:

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 $\Delta X \pm 4^\circ \text{ lat} - \text{lon}$ and $\Delta t \pm 15 \text{ julian days}$ around Tara stations, **but we did not find any ARGO data matching with this criteria.**

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.