Physical data report by station

Station n°194

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

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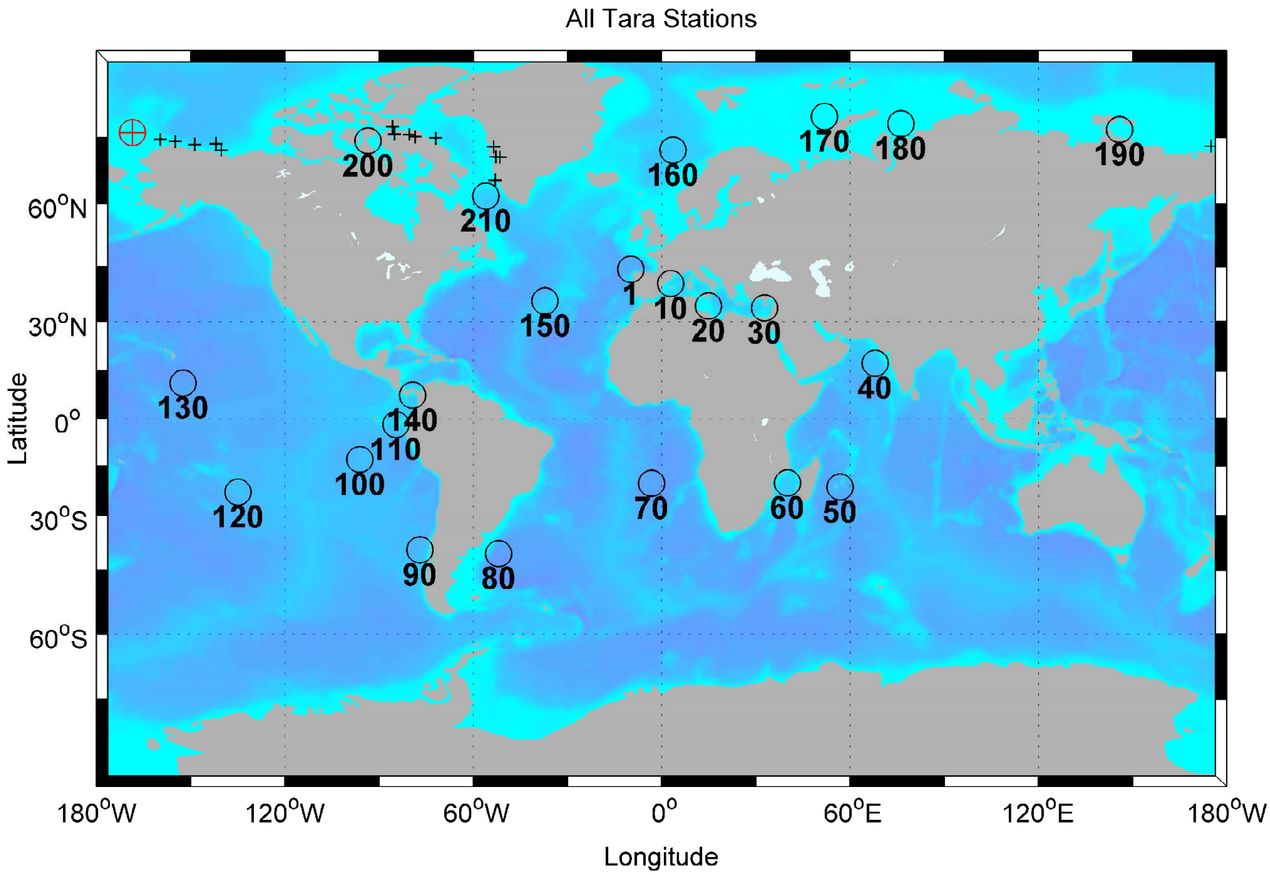


Contents

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°	194
Location	Polar Circle
Date	11/9/2013
Mean Longitude	-168.4486°
Mean Latitude	73.3509°
CTDs profiles	3

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

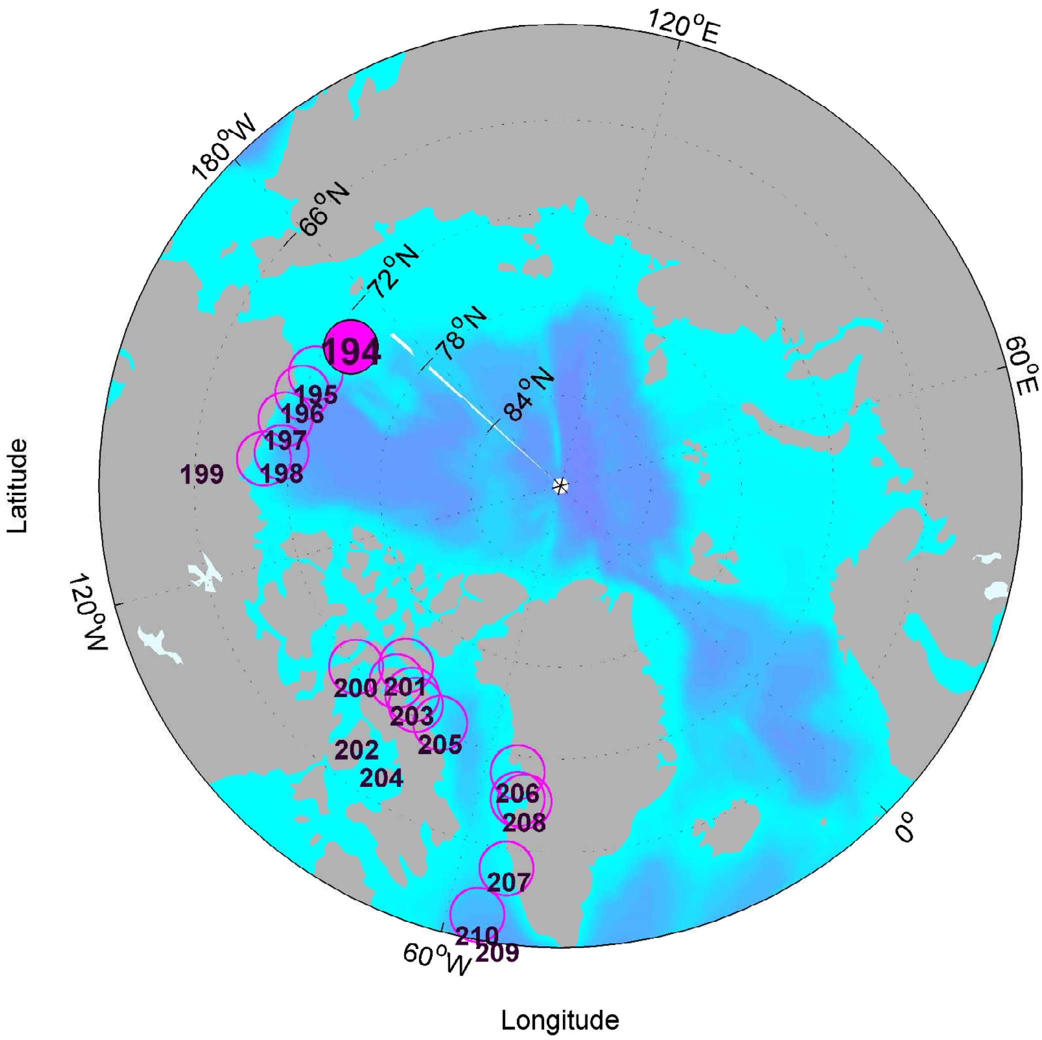


Figure 1: Filled magenta black circle indicate the station of this study.

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 $[°C]$ 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, $\bigtriangledown$ 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

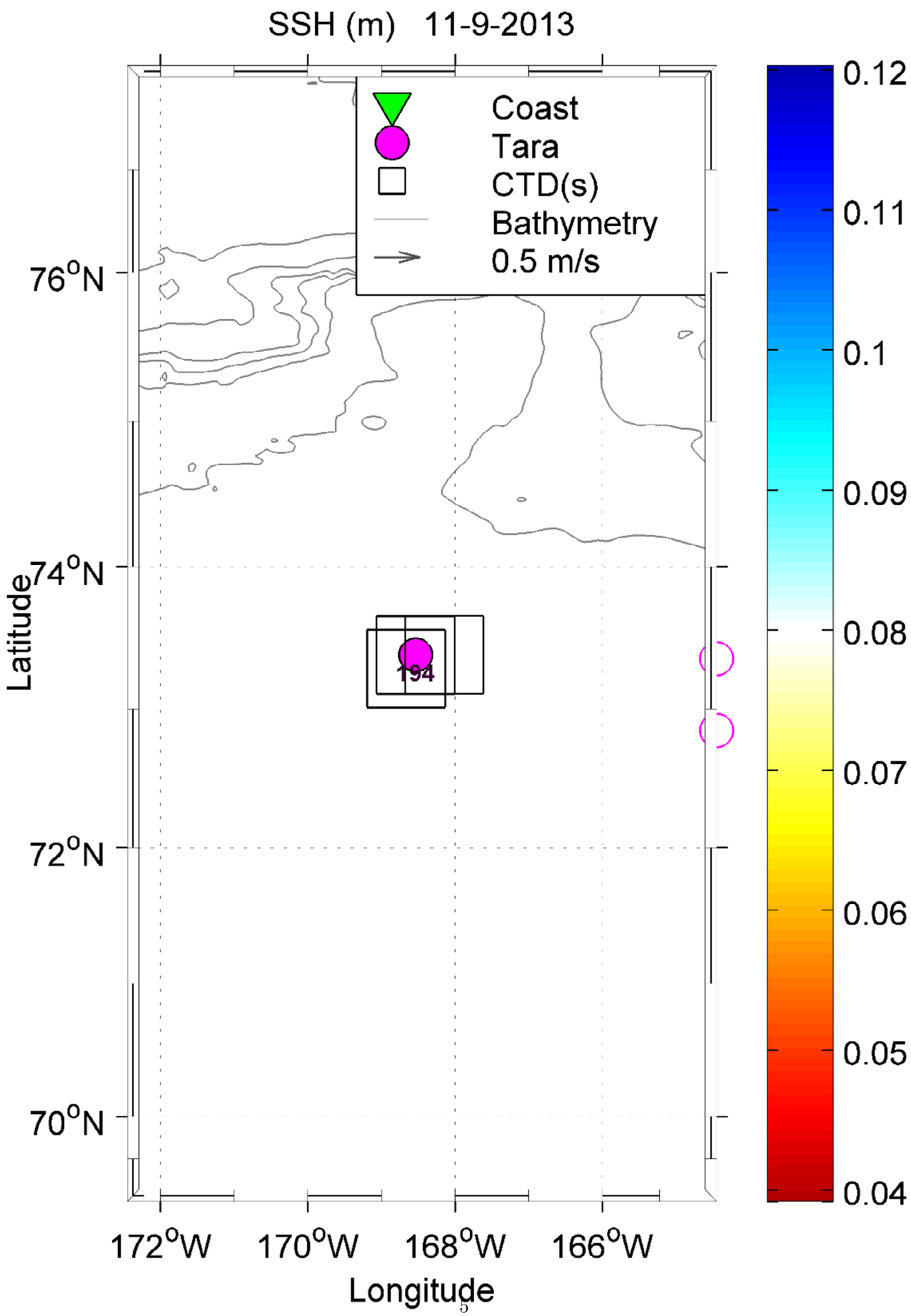


Figure 2: Description: see legend p. 14

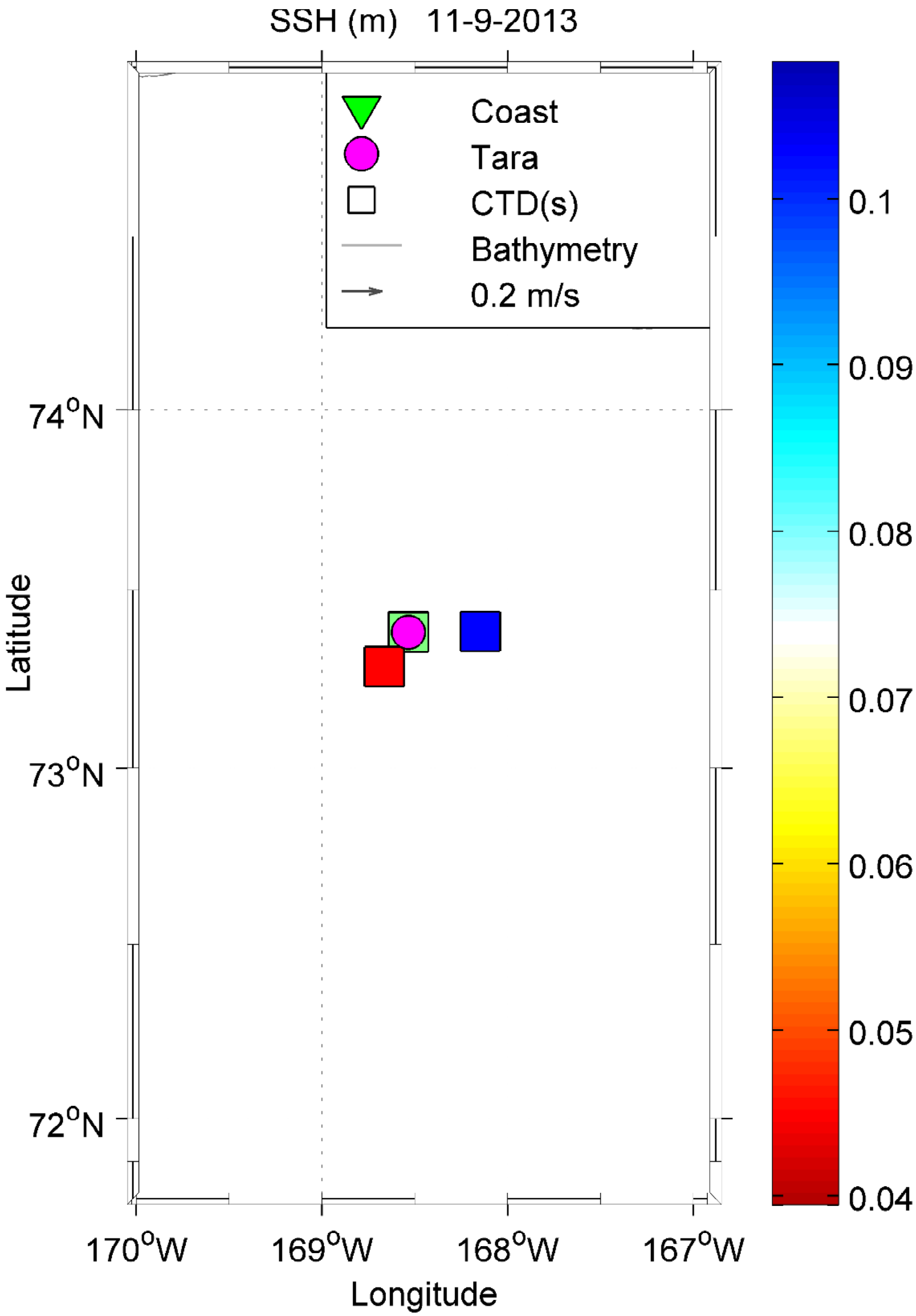
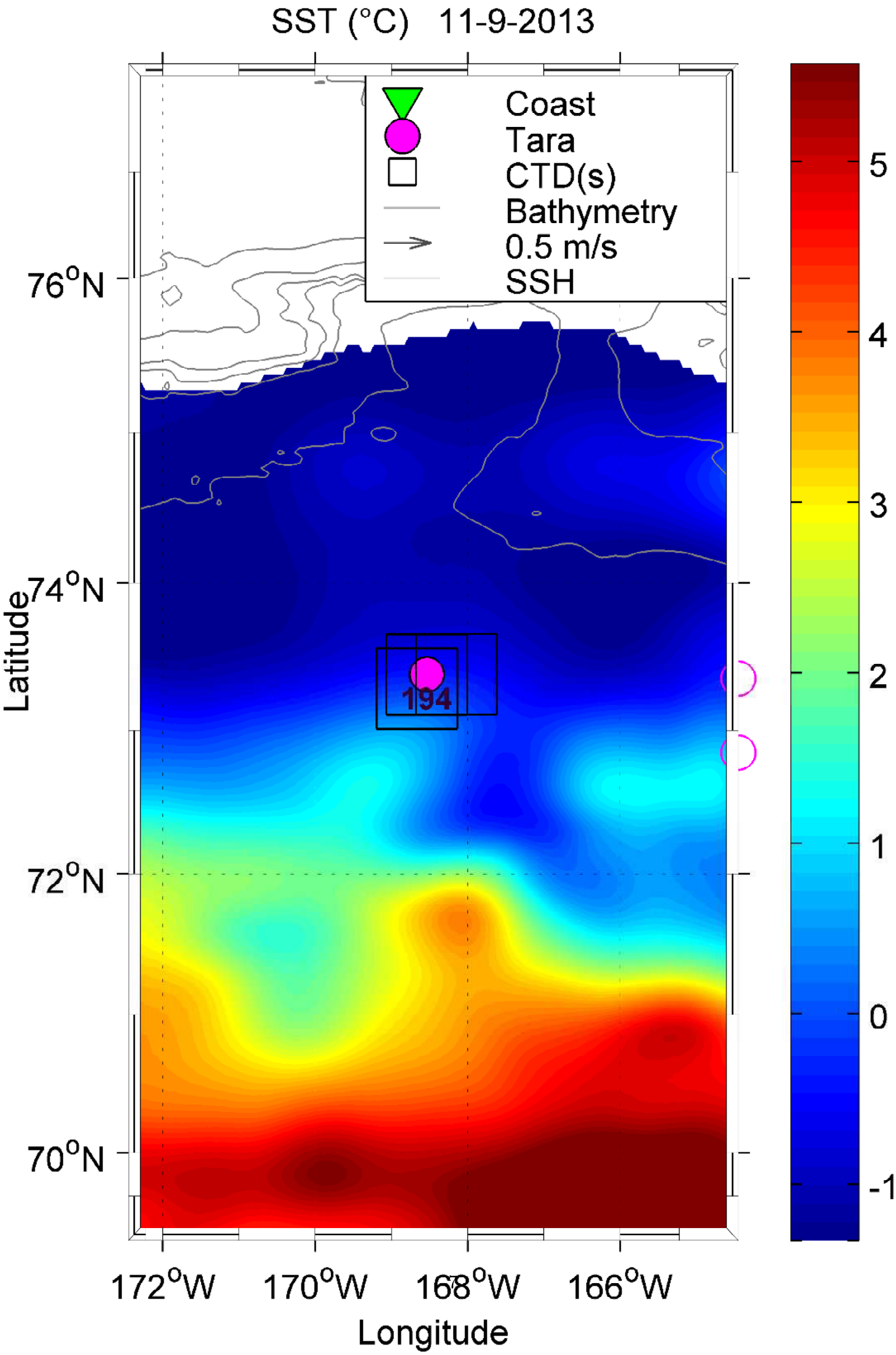


Figure 3: Description: see legend p. 14

1.3 SST maps



SST (°C) 11-9-2013
Coast
Tara
CTD(s)
Bathymetry
0.5 m/s
SSH
194
76°N
74°N
72°N
70°N
Latitude
172°W
170°W
168°W
166°W
Longitude
5
4
3
2
1
0
-1

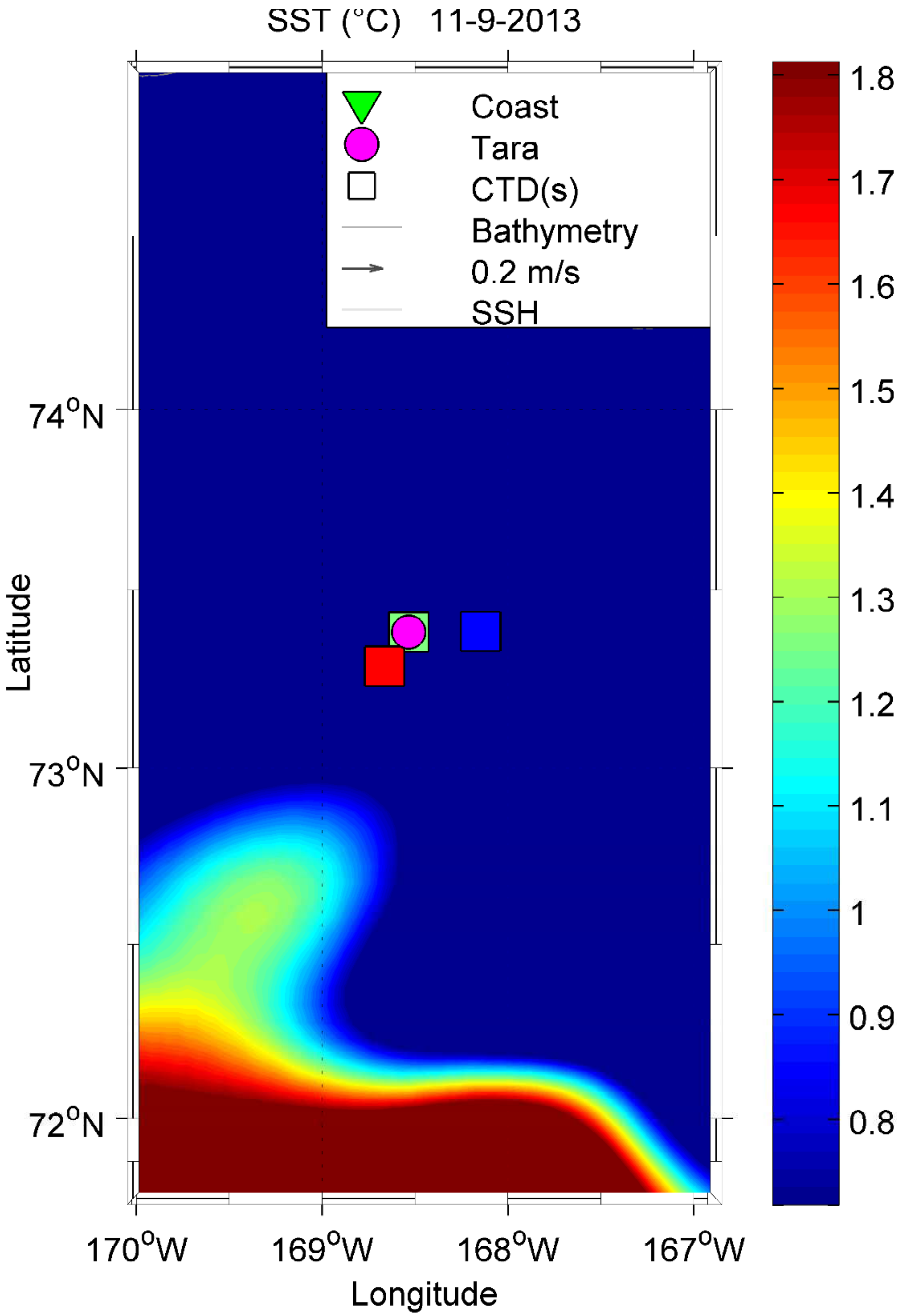


Figure 5: Description: see legend p. 14

1.4 Chlorophyl maps

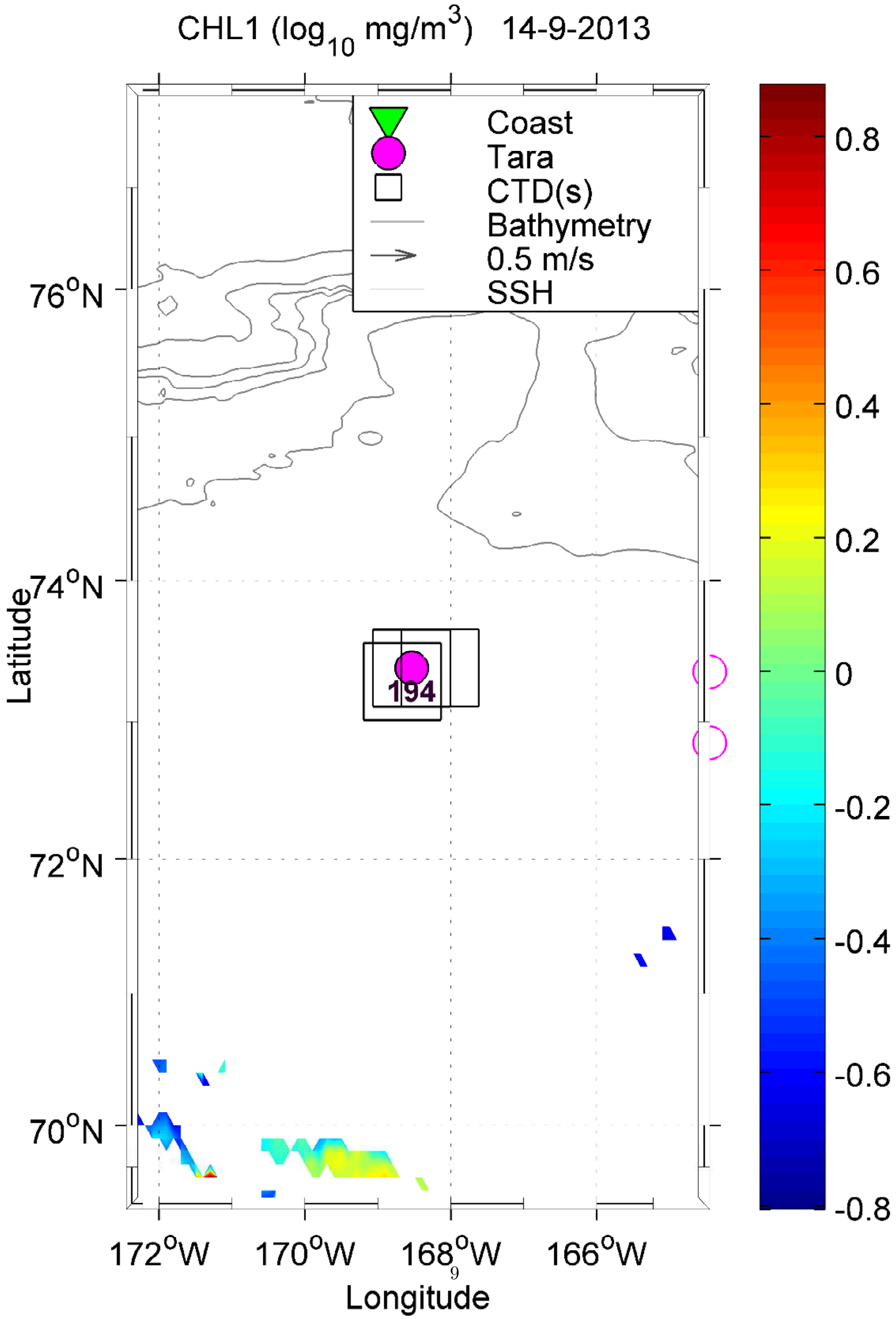


Figure 6: Description: see legend p. 14

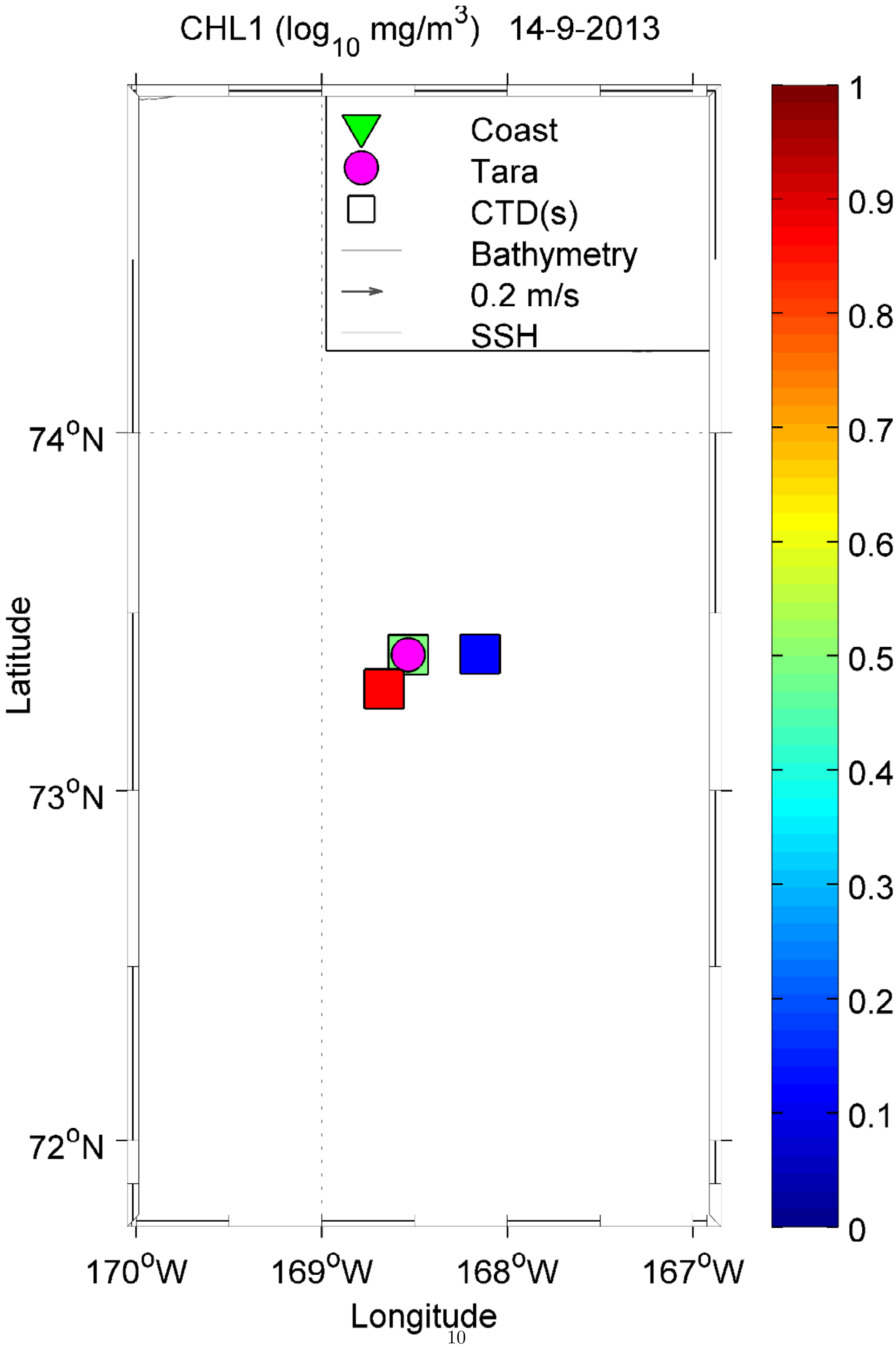


Figure 7: Description: see legend p. 14

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.6300 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

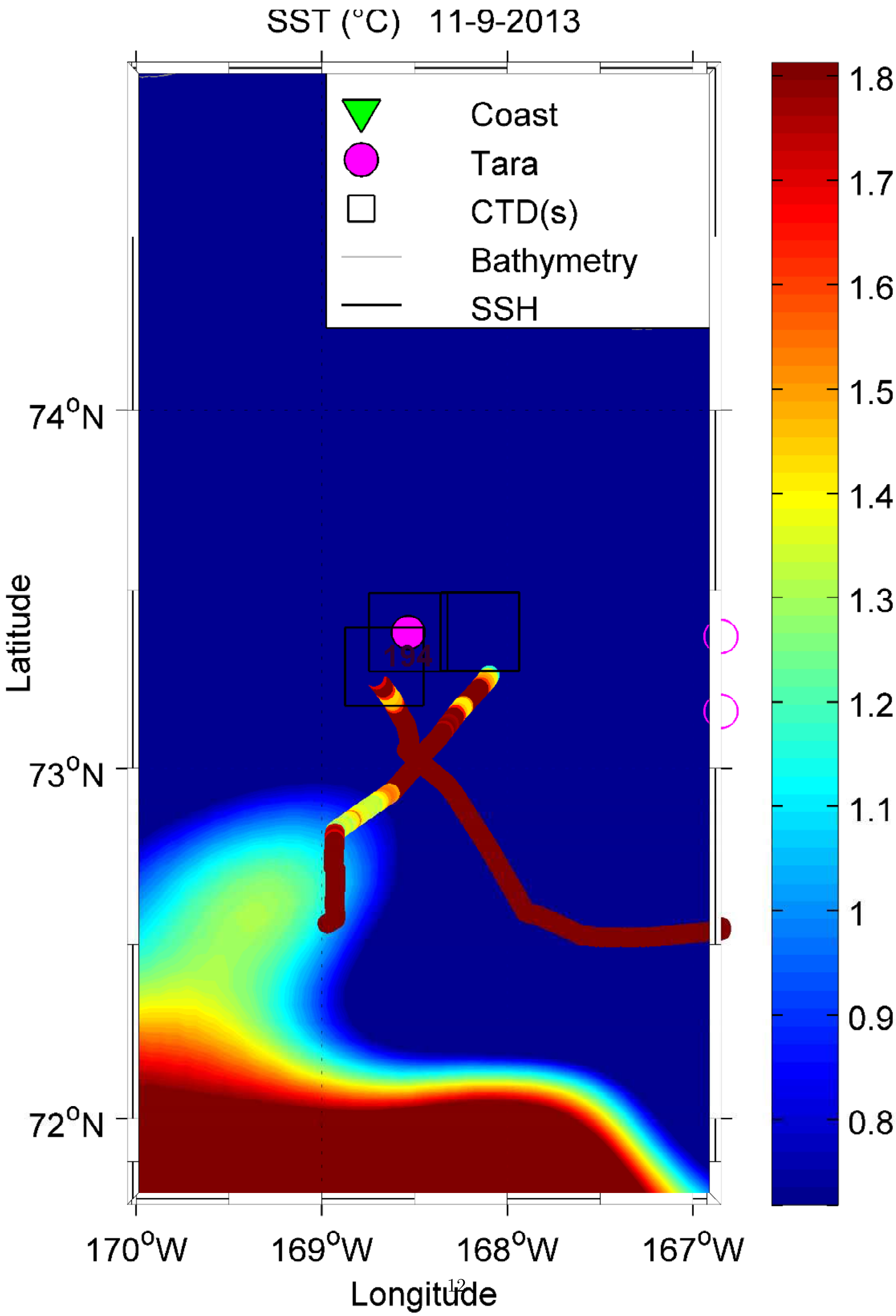


Figure 8: Description: see legend p. 14

2.3 TSG Salinity maps

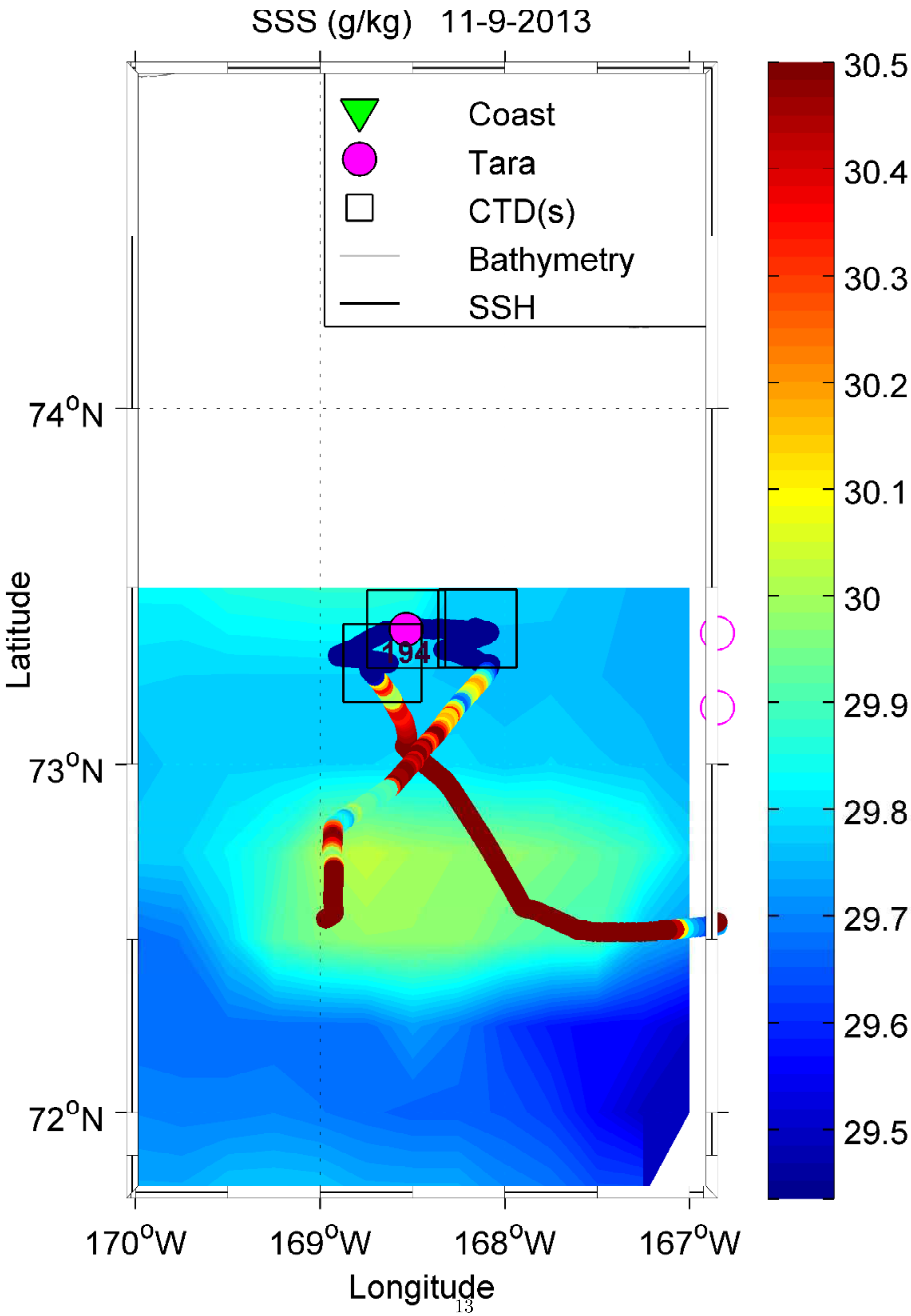


Figure 9: Description: see legend p. 14

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 n194, 3 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 $30dbar$ ($\pm 5\ dbar$, centred) to filter noise at small vertical scales ($\sim 1\ m$).

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:

$$|\theta(z) - \theta(10m)| \leq 0.2\ °C \quad (2)$$

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

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

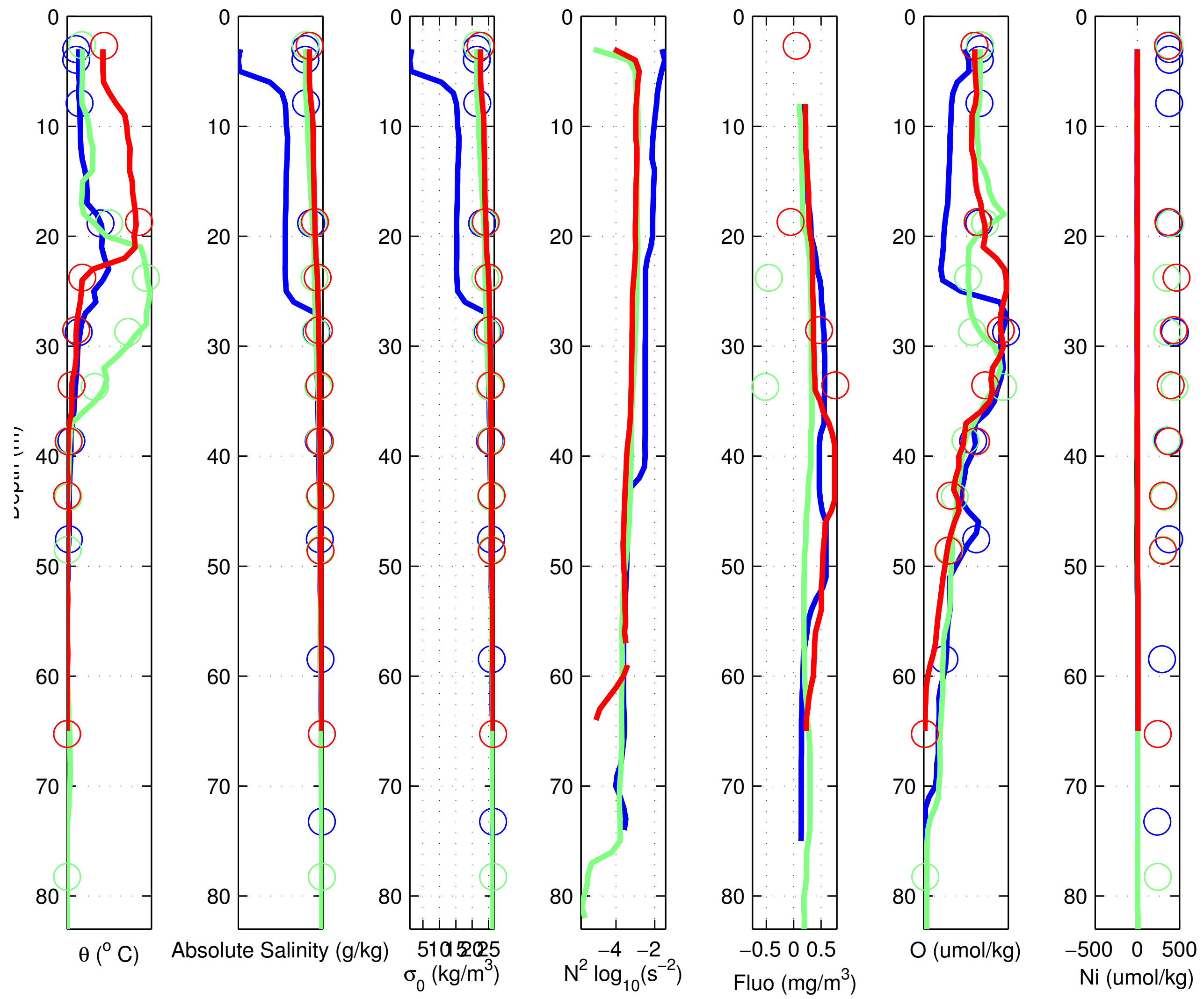


Figure 10: Description: see paragraph p. 14

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3.3 CTD $\theta - S$ diagrams

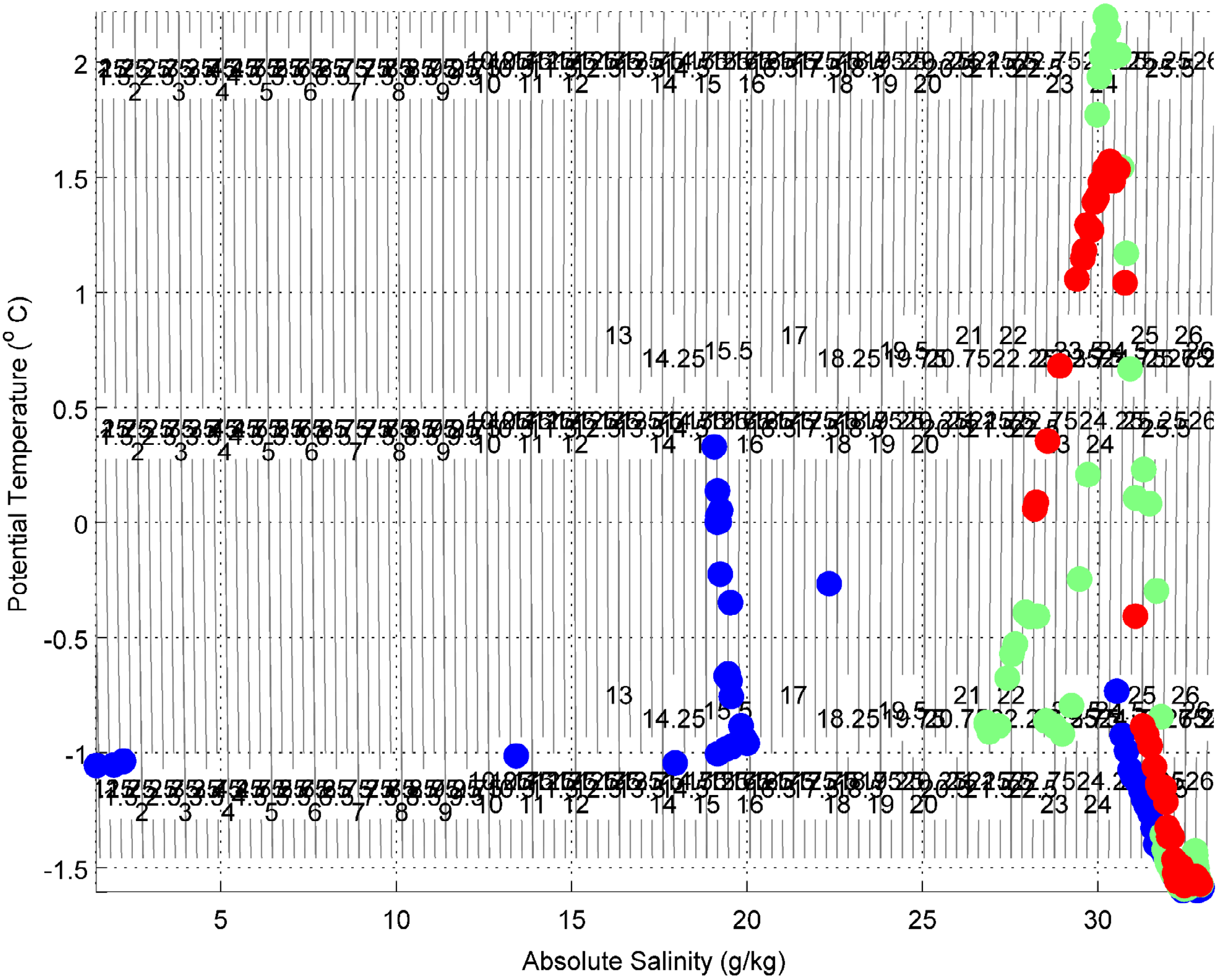

Figure 11: Description: see paragraph p. 14

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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
194	1	-168.1473	73.3842	75	-105	395/238	-177.5	71.2543

Day	Month	Year	Julian day	Core biology Flag	Season	Season part (early-middle-late)
11	9	2013	2456547	1	Summer	Late

$Max_{Fluo}(mg/m^3)$	Depth (m)	Sum $Fluo$ $1-200m(mg/m^3)$
0.46626	41	57.841

Intensity SST Gradient $(°/100km)$	Intensity Geostrophic current (m/s)	Strain $rate$ (s^{-2})	Lyapunov exponent $(1/days)$
1.8125	NaN	NaN	NaN

	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	-0.97426	19.5569	15.5827	1.818e-05	0.15884	303.3965	-3.7262
Max	75	-1.5854	32.9629	26.3977	NaN	0.13453	243.1197	4.7172
MLD_σ	25	-0.34895	19.5226	15.5582	0.0095466	0.50161	328.1909	-4.4742
MLD_θ	33	-1.1657	31.2251	24.9846	0.00078846	0.56304	425.2699	-4.0162
Max_{N^2}	4	-1.0563	1.4505	0.95076	0.0030892	NaN	347.5101	-4.8011
Max_{Fluo}	41	-1.4255	31.8308	25.4797	0.00063644	0.46626	340.2914	-2.1438
Max_O	26	-0.26652	22.3339	17.8191	0.041527	0.50834	422.9028	-4.4715
Min_O	74	-1.5912	32.9397	26.3792	0.00026892	0.13836	239.9132	5.3254
$Depth$ $Nitro$	61	-1.5782	32.5218	26.0413	0.00036618	0.16454	278.9795	2.8186
B i1	75	-1.5854	32.9629	26.3977	NaN	0.13453	243.1197	4.7172
B i2	75	-1.5854	32.9629	26.3977	NaN	0.13453	243.1197	4.7172
B i3	60	-1.5887	32.4756	26.0042	0.00032321	0.16794	286.2838	2.3822
B i4	49	-1.5354	32.1723	25.758	0.00024622	0.58741	330.2782	-1.9122
B i5	40	-1.3941	31.7575	25.4198	0.00046979	0.46626	353.2198	-2.4385
B i6	30	-1.0738	30.9125	24.7302	0.00071913	0.55767	425.5699	-4.026
B i7	20	0.0283	19.1608	15.2674	0.00015209	0.31676	286.7654	-3.9616
B i8	9	-0.98438	19.3993	15.4557	0.00036569	0.13947	304.2909	-3.3652
B i9	5	-1.0539	1.947	1.3534	0.045475	NaN	348.044	-4.6384
B i10	3	-1.0375	2.2219	1.5812	NaN	NaN	338.4567	-4.0093

Table 1:

$Profil$	CTD	Lon	Lat	CTD Depth max (m)	Bathy (m)	Dist[km]/azimuth[°] coast	Lon coast	Lat coast
194	2	-168.5345	73.3824	83	-107	384/236	-177.5	71.2543

Day	Month	Year	Julian day	Core biology Flag	Season	Season part (early-middle-late)
12	9	2013	2456548	1	Summer	Late

$Max_{Fluo}(mg/m^3)$	Depth (m)	Sum $Fluo$ $1-200m(mg/m^3)$
0.31944	30	57.841

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

	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	-0.57169	27.5465	22.0082	0.00089006	0.13327	367.5526	-0.92029
Max	83	-1.571	32.9374	26.3767	NaN	0.19068	244.886	6.7657
MLD_σ	10	-0.57169	27.5465	22.0082	0.00089006	0.13327	367.5526	-0.92029
MLD_θ	14	-0.40655	28.2691	22.5848	0.0018771	0.15456	384.5499	-1.8465
Max_{N^2}	10	-0.57169	27.5465	22.0082	0.00089006	0.13327	367.5526	-0.92029
Max_{Fluo}	30	1.1702	30.8051	24.5499	0.0011787	0.31944	409.0689	-0.74839
Max_O	25	2.1992	30.2098	24.0105	0.00052357	0.31356	349.0165	-2.045
Min_O	81	-1.571	32.9367	26.3762	1.7255e-06	0.18766	244.8784	6.5229
$Depth$ $Nitro$	39	-1.4597	31.9485	25.5755	0.00041291	0.30974	335.0931	-0.23768
B i1	85	NaN	NaN	NaN	NaN	NaN	NaN	NaN
B i2	80	-1.5711	32.9365	26.3761	2.2505e-06	0.18766	244.9001	6.1997
B i3	50	-1.5484	32.2631	25.8317	0.00016569	0.19356	305.1118	3.741
B i4	45	-1.5229	32.1237	25.7185	0.00028005	0.24021	315.7616	3.0488
B i5	40	-1.4801	31.9887	25.6084	0.00025293	0.30974	331.6827	1.149
B i6	35	-0.29638	31.6657	25.3102	0.0014678	0.33232	388.6812	-2.0271
B i7	30	1.1702	30.8051	24.5499	0.0011787	0.31944	409.0689	-0.74839
B i8	25	2.1992	30.2098	24.0105	0.00052357	0.31356	349.0165	-2.045
B i9	20	0.2077	29.7105	23.7166	0.0014905	0.24539	367.2957	-1.5462
B i10	3	-0.8692	26.8151	21.4256	NaN	NaN	375.7068	-1.5148

Table 2:

$Profil$	CTD	Lon	Lat	CTD Depth max (m)	Bathy (m)	Dist[km]/azimuth[°] coast	Lon coast	Lat coast
194	3	-168.6642	73.2862	65	-100	375/237	-177.5	71.2543

Day	Month	Year	Julian day	Core biology Flag	Season	Season part (early-middle-late)
12	9	2013	2456548	1	Summer	Late

$Max_{Fluo}(mg/m^3)$	Depth (m)	Sum $Fluo$ $1-200m(mg/m^3)$
0.64009	37	57.841

Intensity SST Gradient $(°/100km)$	Intensity Geostrophic current (m/s)	Strain $rate$ (s^{-2})	Lyapunov exponent $(1/days)$
3.0779	NaN	NaN	NaN

	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	1.1488	29.5654	23.5607	0.00081375	0.2178	355.3235	0.94026
Max	65	-1.5693	32.9159	26.3594	NaN	0.22573	240.5781	8.388
MLD_σ	10	1.1488	29.5654	23.5607	0.00081375	0.2178	355.3235	0.94026
MLD_θ	22	1.0421	30.7676	24.5233	0.0024145	0.33651	414.6675	0.78253
Max_{N^2}	5	0.059598	28.1978	22.5134	0.00015854	NaN	363.0256	0.2306
Max_{Fluo}	37	-1.4645	32.1655	25.7508	0.00030856	0.64009	340.6268	0.92051
Max_O	22	1.0421	30.7676	24.5233	0.0024145	0.33651	414.6675	0.78253
Min_O	65	-1.5693	32.9159	26.3594	NaN	0.22573	240.5781	8.388
$Depth\ Nitro$	38	-1.5233	32.1843	25.7675	0.00017904	0.70572	337.1235	1.6899
B i1	67	NaN	NaN	NaN	NaN	NaN	NaN	NaN
B i2	80	NaN	NaN	NaN	NaN	NaN	NaN	NaN
B i3	50	-1.5678	32.4925	26.0174	0.00022842	0.52622	289.2129	5.7189
B i4	45	-1.4909	32.3287	25.8832	0.0002812	0.68721	323.5726	5.4611
B i5	40	-1.5487	32.2316	25.8062	0.00016778	0.74766	323.5777	3.0091
B i6	35	-1.3564	32.0663	25.668	0.00038446	0.48164	398.7585	0.68822
B i7	30	-1.1535	31.8171	25.4615	0.00052726	0.36686	431.6605	0.88407
B i8	25	-0.92316	31.3855	25.107	0.00084464	0.34512	438.9123	0.916
B i9	20	1.4849	30.4313	24.233	0.00089644	0.30473	387.3155	0.618
B i10	3	0.060364	28.1976	22.5132	NaN	NaN	362.1313	0.44262

Table 3:

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

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