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DEPARTEMENT MOBILITEIT EN OPENBARE WERKEN
WATERBOUWKUNDIG LABORATORIUM

Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing

Bestek 16EB/05/04

Deelrapport 2.32: Zout – en slibverdeling Deurganckdok Oktober 2008 – Maart 2009

Report 2.32: Salinity – Silt distribution October 2008 – March 2009

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TABLE OF CONTENTS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

1.1. The assignment

This report is part of the set of reports describing the results of the long-term measurements conducted in Deurganckdok aiming at the monitoring and analysis of silt accretion. This measurement campaign is an extension of the study "Extension of the study about density currents in the Beneden Zeeschelde" as part of the Long Term Vision for the Scheldt estuary. It is complementary to the study 'Field measurements high-concentration benthic suspensions (HCBS 2)'.

The terms of reference for this study were prepared by the 'Departement Mobiliteit en Openbare Werken van de Vlaamse Overheid, Afdeling Waterbouwkundig Laboratorium' (16EB/05/04). The repetition of this study was awarded to International Marine and Dredging Consultants NV in association with WL|Delft Hydraulics and Gems International on 10/01/2006. The project term was prolonged with an extra year from April 2007 till March 2008, 'Opvolging aanslibbing Deurganckdok'.

Waterbouwkundig Laboratorium– Cel Hydrometrie Schelde provided data on discharge, tide, salinity and turbidity along the river Scheldt and provided survey vessels for the long term and through tide measurements. Afdeling Maritieme Toegang provided maintenance dredging data. Agentschap voor Maritieme Dienstverlening en Kust – Afdeling Kust and Port of Antwerp provided depth sounding measurements.

The execution of the study involves a twofold assignment:

- Part 1: Setting up a sediment balance of Deurganckdok covering a period of two year, i.e. 04/2007 – 03/2009
- Part 2: An analysis of the parameters contributing to siltation in Deurganckdok

1.2. Purpose of the study

The Lower Sea Scheldt (Beneden Zeeschelde) is the stretch of the Scheldt estuary between the Belgium-Dutch border and Rupelmonde, where the entrance channels to the Antwerp sea locks are located. The navigation channel has a sandy bed, whereas the shallower areas (intertidal areas, mud flats, salt marshes) consist of sandy clay or even pure mud sometimes. This part of the Scheldt is characterized by large horizontal salinity gradients and the presence of a turbidity maximum with depth-averaged concentrations ranging from 50 to 500 mg/l at grain sizes of 60 - 100 μm. The salinity gradients generate significant density currents between the river and the entrance channels to the locks, causing large siltation rates. It is to be expected that in the near future also the Deurganckdok will suffer from such large siltation rates, which may double the amount of dredging material to be dumped in the Lower Sea Scheldt.

Results from the study may be interpreted by comparison with results from the HCBS and HCBS2 studies covering the whole Lower Sea Scheldt. These studies included through-tide measurement campaigns in the vicinity of Deurganckdok and long term measurements of turbidity and salinity in and near Deurganckdok.

The first part of the study focuses on obtaining a sediment balance of Deurganckdok. Aside from natural sedimentation, the sediment balance is influenced by the maintenance and capital dredging works. This involves sediment influx from capital dredging works in the Deurganckdok, and internal relocation and removal of sediment by maintenance dredging works. To compute a sediment balance an inventory of bathymetric data (depth soundings), density measurements of the

deposited material and detailed information of capital and maintenance dredging works will be made up.

The second part of the study is to gain insight in the mechanisms causing siltation in Deurganckdok, it is important to follow the evolution of the parameters involved, and this on a long and short term basis (long term & through-tide measurements). Previous research has shown the importance of water exchange at the entrance of Deurganckdok as essential for understanding sediment transport between the dock and the Scheldt river.

1.3. Overview of the Reports

1.3.1. Reports

Reports of the project 'Opvolging aanslibbing Deurganckdok' between April 2008 till March 2009 are summarized in Table 1-1. An overview of the HCBS2 and 'Opvolging aanslibbing Deurganckdok' (between April 2006 till March 2008) reports are given in Table 1-1.

This report 2.20, is one of a set of reports that gains insight in sediment and water transport between Deurganckdok and the river Scheldt, which belongs to the second part of this project.

Table 1-1: Overview of Deurganckdok Reports

Report	Description
Sediment Balance: Bathymetry surveys, Density measurements, Maintenance and construction dredging activities	
1.20	Sediment Balance: Three monthly report 1/4/2008 - 30/6/2008 (I/RA/11283/08.076/MSA)
1.21	Sediment Balance: Three monthly report 1/7/2008 – 30/9/2008 (I/RA/11283/08.077/MSA)
1.22	Sediment Balance: Three monthly report 1/10/2008 – 31/12/2008 (I/RA/11283/08.078/MSA)
1.23	Sediment Balance: Three monthly report 1/1/2009 – 31/03/2009 (I/RA/11283/08.079/MSA)
1.24	Annual Sediment Balance (I/RA/11283/08,080/MSA)
Factors contributing to salt and sediment distribution in Deurganckdok: Salt-Silt (OBS3A) & Frame measurements, Through tide measurements (SiltProfiling & ADCP) & Calibrations	
2.20	Through tide measurement Sediview DGD during average tide Spring 2008 – 19 June 2008 (I/RA/11283/08.081/MSA)
2.21	Through tide measurement Sediview DGD during average tide Spring 2008 –26 June 2008 (I/RA/11283/08.082/MSA)
2.22	Through tide measurement Sediview DGD during neap tide Summer 2008 – 24 September 2008 (I/RA/11283/08.083/MSA)
2.23	Through tide measurement Sediview DGD during spring tide Summer 2008 – 30 September 2008 (I/RA/11283/08.084/MSA)
2.24	Through tide measurement Sediview DGD during neap tide Autumn 2008 (I/RA/11283/08.085/MSA)
2.25	Through tide measurement Sediview DGD during spring tide Autumn 2008 (I/RA/11283/08.086/MSA)
2.26	Through tide measurement Sediview DGD during neap tide Winter 2009 (I/RA/11283/08.087/MSA)
2.27	Through tide measurement Sediview DGD during spring tide Winter 2009 (I/RA/11283/08.088/MSA)

Report	Description
2.28	Through tide measurement ADCP eddy DGD Summer 2008 – 1 October 2008 (I/RA/11283/08.089/MSA)
2.29	Through tide measurement Siltprofiler DGD Summer 2008 – 29 September 2008 (I/RA/11283/08.090/MSA)
2.30	Through tide measurement Siltprofiler DGD Winter 2009 (I/RA/11283/08.091/MSA)
2.31	Through tide measurement Salinity Profiling DGD Winter 2009 (I/RA/11283/08.092/MSA)
2.32	Salt-Silt distribution Deurganckdok: Six monthly report 1/4/2008 - 30/9/2008 (I/RA/11283/08.093/MSA)
2.33	Salt-Silt distribution Deurganckdok: Six monthly report 1/10/2008 – 31/3/2009 (I/RA/11283/08.094/MSA)
2.34	Calibration stationary & mobile equipment Autumn 2008 (I/RA/11283/08.095/MSA)
Boundary Conditions: Upriver Discharge, Salt concentration Scheldt, Bathymetric evolution in access channels, dredging activities in Lower Sea Scheldt and access channels	
3.20	Boundary conditions: Six monthly report 1/4/2008 – 30/09/2008 (I/RA/11283/08.096/MSA)
3.21	Boundary conditions: Six monthly report 1/10/2008 – 31/03/2009 (I/RA/11283/08.097/MSA)
Analysis	
4.20	Analysis of Siltation Processes and Factors 4/'06 – 3/'09 (I/RA/11283/08.098/MSA)

1.3.2. Measurement actions

Following measurements have been carried out during the course of this project:

1. Monitoring upstream discharge in the Scheldt river
2. Monitoring Salt and sediment concentration in the Lower Sea Scheldt taken from on permanent data acquisition sites at Lillo, Oosterweel and up- and downstream of the Deurganckdok.
3. Long term measurement of salt distribution in Deurganckdok.
4. Long term measurement of sediment concentration in Deurganckdok
5. Monitoring near-bed processes in the central trench in the dock, near the entrance as well as near the landward end: near-bed turbidity, near-bed current velocity and bed elevation variations are measured from a fixed frame placed on the dock's bed.
6. Measurement of current, salt and sediment transport at the entrance of Deurganckdok for which ADCP backscatter intensity over a full cross section are calibrated with the Sediview procedure and vertical sediment and salt profiles are recorded with the SiltProfiler equipment
7. Through tide measurements of vertical sediment concentration profiles -including near bed highly concentrated suspensions- with the SiltProfiler equipment. Executed over a grid of points near the entrance of Deurganckdok.
8. Monitoring dredging activities at entrance channels towards the Kallo, Zandvliet and Berendrecht locks
9. Monitoring dredging and dumping activities in the Lower Sea Scheldt

In situ calibrations were conducted on several dates to calibrate all turbidity and conductivity sensors, a description can be found in IMDC (2006a; 2007a; 2008f; 2008o; 2009c).

1.4. Structure of this report

This report is the factual data report for the Long term salt/silt measurements in the Deurganckdok: 01 October 2008 – 31 March 2009.

The first chapter comprises an introduction. The second chapter describes the project. Chapter 3 describes the measurement campaign, equipment and the course of the actual measurements. The measurement results and processed data are presented in Chapter 4, whereas chapter 5 gives a preliminary analysis of the data.

2. SEDIMENTATION IN DEURGANCKDOK

2.1. Project Area: Deurganckdok

Deurganckdok is a tidal dock situated at the left bank in the Lower Sea Scheldt, between Liefkenshoek and Doel. Deurganckdok has the following characteristics:

1. the dock has a total length of 2750 m and is 450 m wide at the Scheldt end and 400 m wide at the inward end of the dock
2. the bottom of Deurganckdok is provided at a depth of –17m TAW in the transition zones between the quay walls and the central trench and of –19m TAW in the central trench.
3. the quay walls reach up to +9m TAW

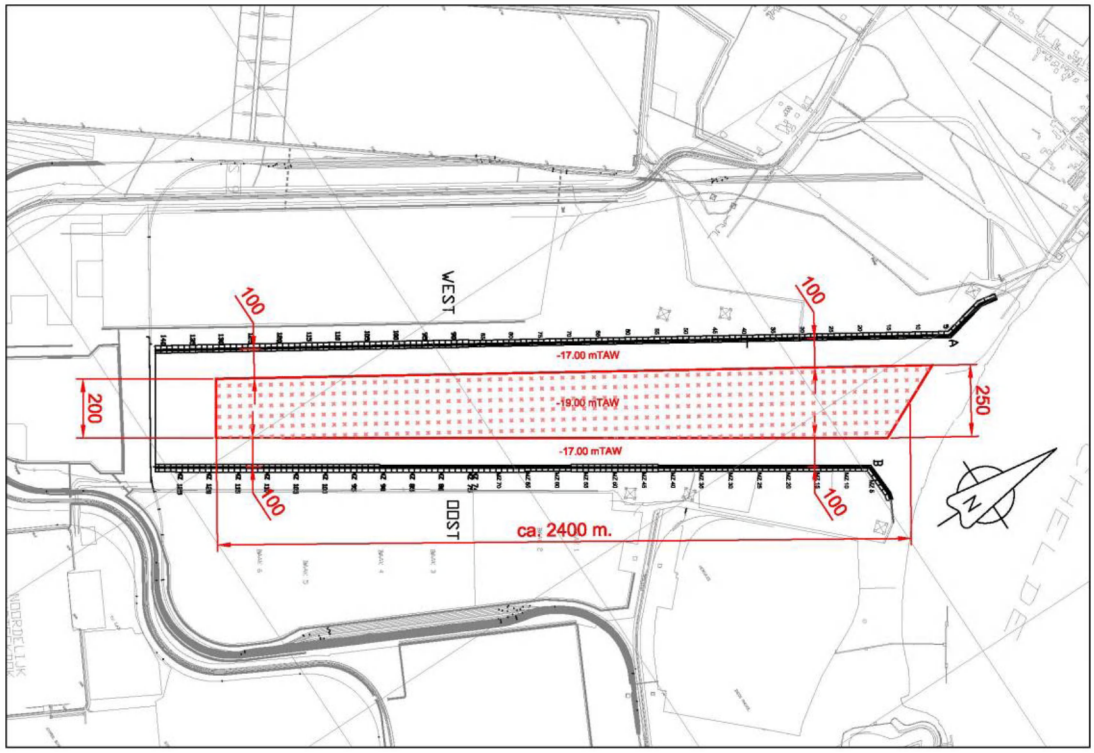

Figure 2-1: Overview of Deurganckdok

The dredging of the dock is performed in 3 phases. On 18 February 2005 the dike between the Scheldt and the Deurganckdok was breached. On 6 July 2005 Deurganckdok was officially opened. The second dredging phase was finalized a few weeks later. The first terminal operations have started since. In February 2007, the third dredging phase started and is finalised by February 2008.

2.2. Overview of the studied parameters

The first part of the study aims at determining a sediment balance of Deurganckdok and the net influx of sediment. The sediment balance comprises a number of sediment transport modes: deposition, influx from capital dredging works, internal replacement and removal of sediments due to maintenance dredging (Figure 2-2).

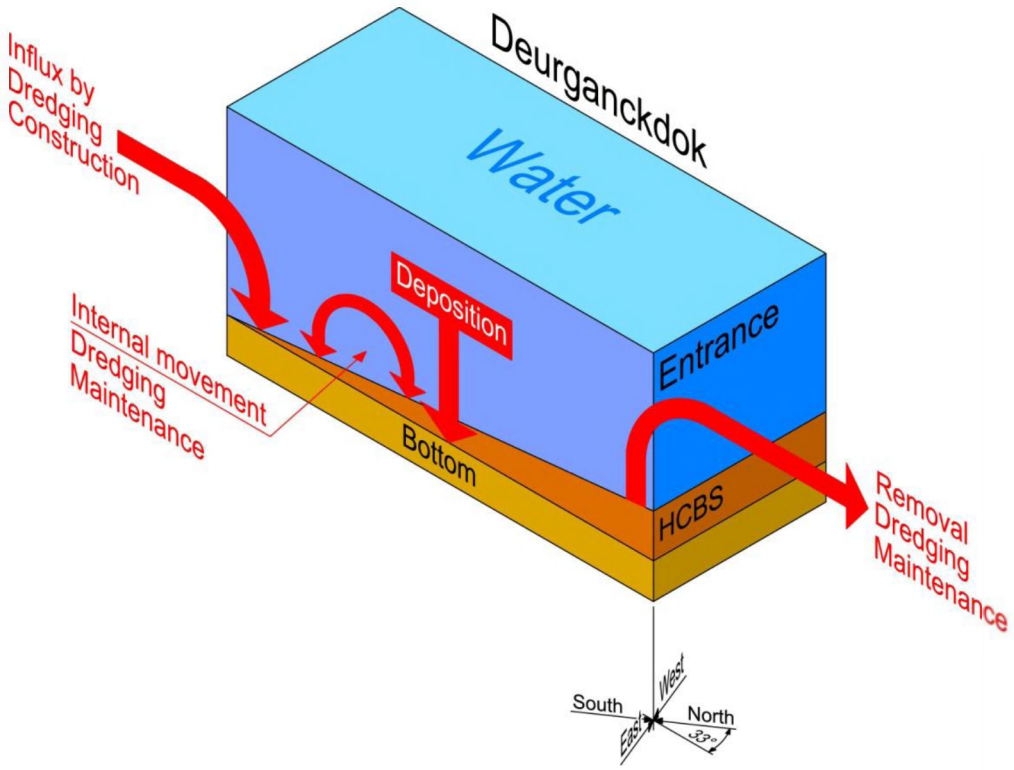

Figure 2-2: Elements of the sediment balance

A net deposition can be calculated from a comparison with a chosen initial condition t_0 (Figure 2-3). The mass of deposited sediment is determined from the integration of bed density profiles recorded at grid points covering the dock. Subtracting bed sediment mass at t_0 leads to the change in mass of sediments present in the dock (mass growth). Adding cumulated dry matter mass of dredged material removed since t_0 and subtracting any sediment influx due to capital dredging works leads to the total cumulated mass entered from the Scheldt river since t_0.

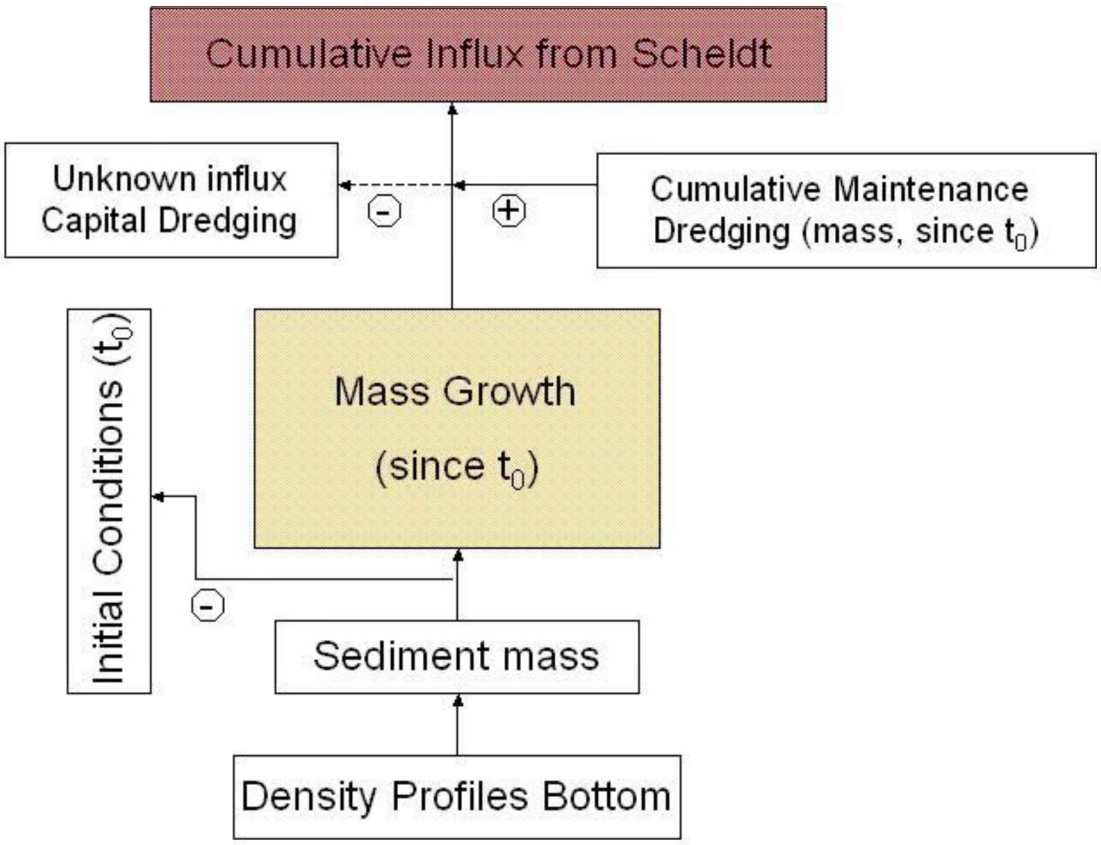

Figure 2-3: Determining a sediment balance

The main purpose of the second part of the study is to gain insight in the mechanisms causing siltation in Deurganckdok. The following mechanisms will be aimed at in this part of the study:

- Tidal prism, i.e. the extra volume in a water body due to high tide
- Vortex patterns due to passing tidal current
- Density currents due to salt gradient between the Scheldt river and the dock
- Density currents due to highly concentrated benthic suspensions

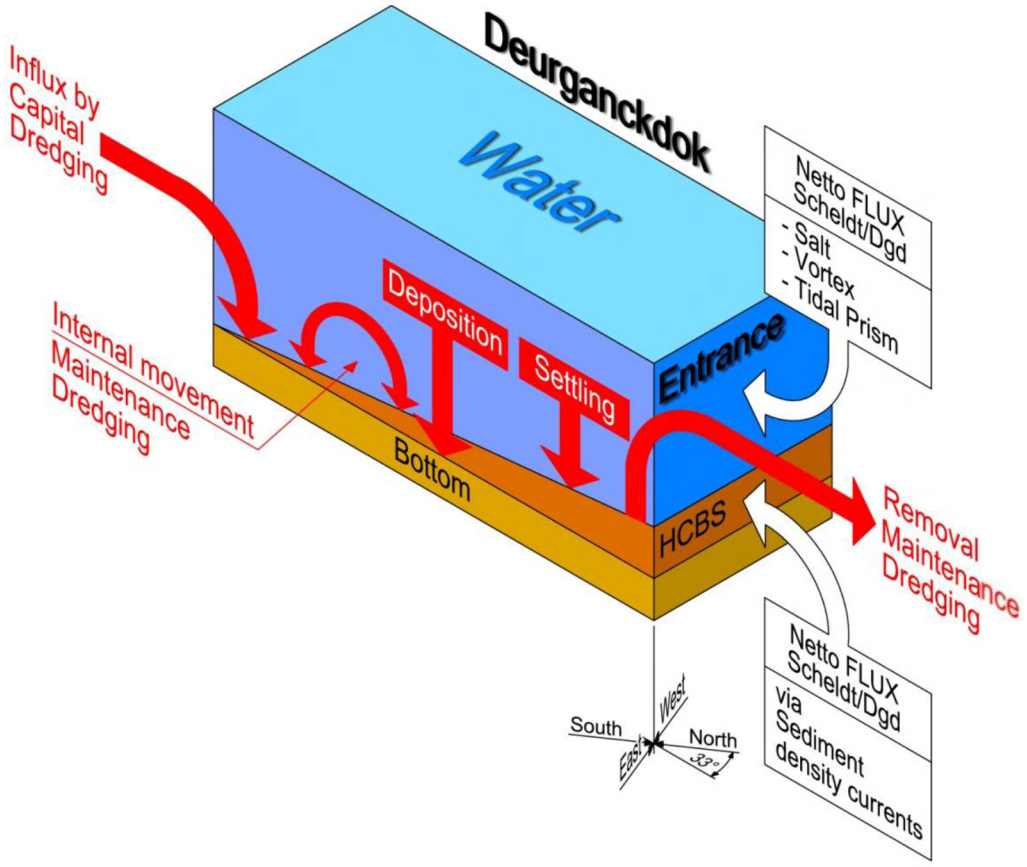

Figure 2-4: Transport mechanisms

These aspects of hydrodynamics and sediment transport have been landmark in determining the parameters to be measured during the project. Measurements will be focused on three types of time scales: one tidal cycle, one neap-spring cycle and seasonal variation within one year.

Following data are being collected to understand these mechanisms:

- Monitoring upstream discharge in the Scheldt river.
- Monitoring Salt and sediment concentration in the Lower Sea Scheldt at permanent measurement locations at Oosterweel, up- and downstream of the Deurganckdok.
- Long term measurement of salt and suspended sediment distribution in Deurganckdok.
- Monitoring near-bed processes (current velocity, turbidity, and bed elevation variations) in the central trench in the dock, near the entrance as well as near the current deflecting wall location.
- Dynamic measurements of current, salt and sediment transport at the entrance of Deurganckdok.
- Through tide measurements of vertical sediment concentration profiles -including near bed high concentrated benthic suspensions.
- Monitoring dredging activities at entrance channels towards the Kallo, Zandvliet and Berendrecht locks as well as dredging and dumping activities in the Lower Sea Scheldt.
- In situ calibrations were conducted on several dates to calibrate all turbidity and conductivity sensors.

2.3. Measurement objectives

2.3.1. Objective of the long term measurements near the quay walls

The goal of the survey is to monitor the spatial distribution of salt and silt in the Deurganckdok. Longitudinal, vertical and horizontal (from north to south quay) distribution is surveyed in this set up. The entrance of the dock is a favoured location because of the dynamics caused by the river-dock interaction. One deeper location in the dock is necessary to sample the longitudinal distribution of salt and silt along the dock.

3. THE MEASUREMENT CAMPAIGNS

3.1. Description of the long term suspended sediment-salinity measurements 01/10/2008 – 31/03/2009

3.1.1. Measurement location

During the period from 01/10/2008 till 31/03/2009, 8 multi parameter probes were placed on 4 fixed locations hanging from the quay wall in Deurganckdok at fixed depths.

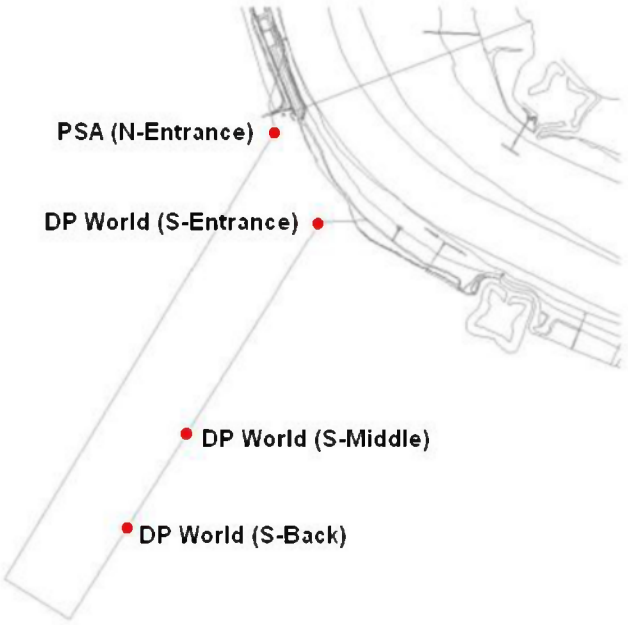

Figure 3-1: Map of the updated measurement locations for long term salt-silt measurements in Deurganckdok

Table 3-1: Measurement locations in UTM ED50

Location	*EASTING*	*NORTHING*	*Boulder*	*Operator*
DP World (S-back)	587760	5682449	Moot 101	DP World
DP World (S-middle)	588074	5682942	Moot 72	DP World
DP World (S-entrance)	588767	5684045	Moot 7	DP World
PSA (N-entrance)	588536	5684523	Moot 5 (boulder 286)	PSA HNN

Table 3-2: Deployment depths of all instruments for the measurement period

Salt Silt Measurements Deurganckdok				
Location	*Easting (UTM ED 50)*	*Northing (UTM ED 50)*	*Depth of instrument [m TAW]*	*Period*
S-back top	587760	5682449	-2.47	01/10/2008 – 31/03/2009
S-back bottom	587760	5682449	-12.37	01/10/2008 – 31/03/2009
S-middle top	588074	5682942	-2.34	01/10/2008 – 31/03/2009
S-middle bottom	588074	5682942	-12.23	01/10/2008 – 31/03/2009
S-entrance top	588767	5684045	-2.18	01/10/2008 – 31/03/2009
S-entrance bottom	588767	5684045	-13.51	01/10/2008 – 31/03/2009
N-entrance top	588536	5684523	-2.34	01/10/2008 – 31/03/2009
N-entrance bottom	588536	5684523	-12.26	01/10/2008 – 31/03/2009

3.1.2. The equipment

3.1.2.1. Quay Frame set up

A simple rectangular measurement frame was conceived for suspending the instruments from the quay wall down into the Deurganckdok. Two frames rest against the dock wall and are suspended by stainless steel cables hanging from a rawlplug, secured on top of the quay wall.

Using a guiding system and a winch, it was possible to recover these instruments without the help of a survey vessel.

Figure 3-2: Guiding system and chain suspended from the rawlplug (left), frame with RCM-9 and steel cables (right)

Figure 3-3: frame design

3.1.2.2. D& A Instruments OBS 3A

The D & A Instruments OBS 3A is a multiparameter instruments that consists of a CTD probe and a turbidity sensor. The instrument was set up to measure every ten minutes for a minute at a frequency of 1 Hz and output the average.

IMDC (2006a) gives more technical details on the OBS 3A.

3.1.3. Course of the measurements

After deployment on 28/04/2008, the instruments were recovered, cleaned and read out every two weeks. Table 3-3 lists the measurement periods and possible issues. Only OBS 3A instruments were deployed during this measurement period

Table 3-3: Overview of measurement periods and data gaps

S-BACK (DP World): -12.4 m TAW			
Period	*No data*	*Faulty data*	*Comments*
01-Oct-08			Start measurement period
22/10/2008 - 7/01/2009 24/03/2009 - 31/03/2009	X		Gaps in data

07/01/2009- 9/03/2009		X	faulty salinity values
31-Mar-09			End measurement period
S-BACK (DP World): -2.5 m TAW			
Period	*No data*	*Faulty data*	*Comments*
01-Oct-08			Start measurement period
22/10/2008 - 3/11/2008	X		Gaps in data
31-Mar-09			End measurement period
S-MIDDLE (DP World): -12.23 m TAW			
Period	*No data*	*Faulty data*	*Comments*
01-Oct-08			Start measurement period
1/10/2008 - 9/10/2008 22/10/2008 - 3/11/2008 24/03/2009 - 31/03/2009	X		Gaps in data
31-Mar-09			End measurement period
S-MIDDLE (DP World): -2.34 m TAW			
Period	*No data*	*Faulty data*	*Comments*
01-Oct-08			Start measurement period
1/10/2008 - 2/12/2008		X	low salinity values
22/10/2008 - 3/11/2008 22/11/2008 - 7/01/2009 24/03/2009 - 31/03/2009	X		Gaps in data
31-Mar-09			End measurement period
S-ENTRANCE (DP World): -13.51 m TAW			
Period	*No data*	*Faulty data*	*Comments*

01-Oct-08			Start measurement period
22/10/2008 - 1/12/2008	X		Gaps in data
12/02/2009 - 04/03/2009		X	Wrong salinity values
31-Mar-09			End measurement period
S-ENTRANCE (DP World): -2.18 m TAW			
Period	*No data*	*Faulty data*	*Comments*
01-Oct-08			Start measurement period
1/10/2008 - 22/10/2008		X	low salinity values
22/10/2008 - 3/11/2008	X		Gaps in data
31-Mar-09			End measurement period
N-ENTRANCE (PSA HNN): -12.26 m TAW			
Period	*No data*	*Faulty data*	*Comments*
01-Oct-08			Start measurement period
22/10/2008 - 1/12/2008 24/03/2009 - 31/03/2009	X		Gaps in data
31-Mar-09			End measurement period
N-ENTRANCE (PSA HNN): -2.34 m TAW			
Period	*No data*	*Faulty data*	*Comments*
01-Oct-08			Start measurement period
22/10/2008 - 3/11/2008	X		Gaps in data
31-Mar-09			End measurement period

4. PROCESSING OF DATASETS

4.1. Calibration of the sensors

A crucial aspect of the accuracy and reliability of the data concerns the calibration of the instruments before the measurement campaign. The calibration procedures and results are described in report 6.1 Winter calibration of the HCBS2 measurements (IMDC, 2006a), report 6.2 Summer calibration of the HCBS2 measurements (IMDC, 2007a), report 2.19 winter 2007 calibration of the Long Term Deurganckdok measurements (IMDC, 2008o) and report 2.34 autumn 2008 calibration of the stationary & mobile equipment (IMDC, 2009c).

4.1.1. Turbidity

Turbidity has been calibrated with the calibration coefficients derived on 28 October 2008 and described in report 2.34.

4.1.2. Conductivity

Conductivity of most sensors has been calibrated with the calibration coefficients derived on 28 October 2008 and described in report 2.34.

During this calibration, it appeared that the conductivity sensor from the OBS3A with serial number acted very differently compared to the other instruments. An offset from 5.11 was derived, while offsets of other sensors were much smaller. Because of this extremely high offset, it was decided not to deploy this instrument like it was calibrated, but to give the sensor first a full treatment. Therefore, the offset of 5.11 is only valid for the data measured before 28 October 2008.

The conductivity sensor of the OBS3A with serial number 247 has been cleaned completely just before the calibration of 28 October. Therefore, the calibration offset for serial number 247 is only valid for the data measured after 28 October 2008. The data between August 2008 and November 2008 has to be corrected with an offset of – 7.

4.2. Long term measurements near quay wall

The long term measurements executed at two depths (on average -2.3 m TAW and –12.6 m TAW) at four locations on the quay walls of Deurganckdok lasted from 1 October 2008 until 31 March 2009. Depth, temperature, salinity and suspended sediment concentration have been logged. All gathered time series have been converted to appropriate engineering units and combined to form series covering the complete period. During validation erroneous data due to mid term recovery, sensor malfunction and buried equipment has been removed. In this form the data is ready for processing.

4.2.1. Factual data: Weekseries

Measurements are visualized per instrument, location and per week in APPENDIX B.

- The title shows the week number followed by the year
- The first graph depicts the salinity and temperature
- The second and last graph shows the water level at the nearest tidal gauge and the suspended sediment concentration

Faulty data is omitted from these graphs.

4.2.2. Average tidal cycle of local parameters

For all parameters measured at one location data has been organised in separate series per tidal cycle (low water to next low water). High water moments were placed on a fixed position in the series, low water moments differ in time relative to high water due to variation in flood and ebb length with neap-spring phases. In this way a time series with time relative to high water is produced for each tide. When tidal elevation data showed substantial gaps data from pressure gauges was used to divide the long series into tidal series.

By defining average tidal amplitude A for neap, average and spring tides, it becomes possible to classify tidal cycles in three categories in the following way:

$$Neap: A \le \alpha(A_{neap} + A_{aver})$$
$$Spring: A \ge \alpha(A_{spring} + A_{aver})$$
$$Average: \alpha(A_{neap} + A_{aver}) < A < \alpha(A_{spring} + A_{aver})$$

where: A_{neap}, A_{aver} and A_{spring} are average amplitudes

α is a factor to decide where to distinguish between categories (here taken as 0.5)

Using such categorisation the tidal series can be grouped in neap, average and spring tides. Within these groups an average is made per parameter per tidal phase relative to high water (Figure 4-1). In this way an average neap tidal cycle, an average middle tidal cycle and an average spring tidal cycle is obtained for all parameters.

The same exercise is repeated for relative values, which are the measured values divided by the tidal average (the average parameter value for that particular tidal cycle). All three types are shown in one plot with a plot for salinity, sediment concentration and temperature per page in APPENDIX D1.

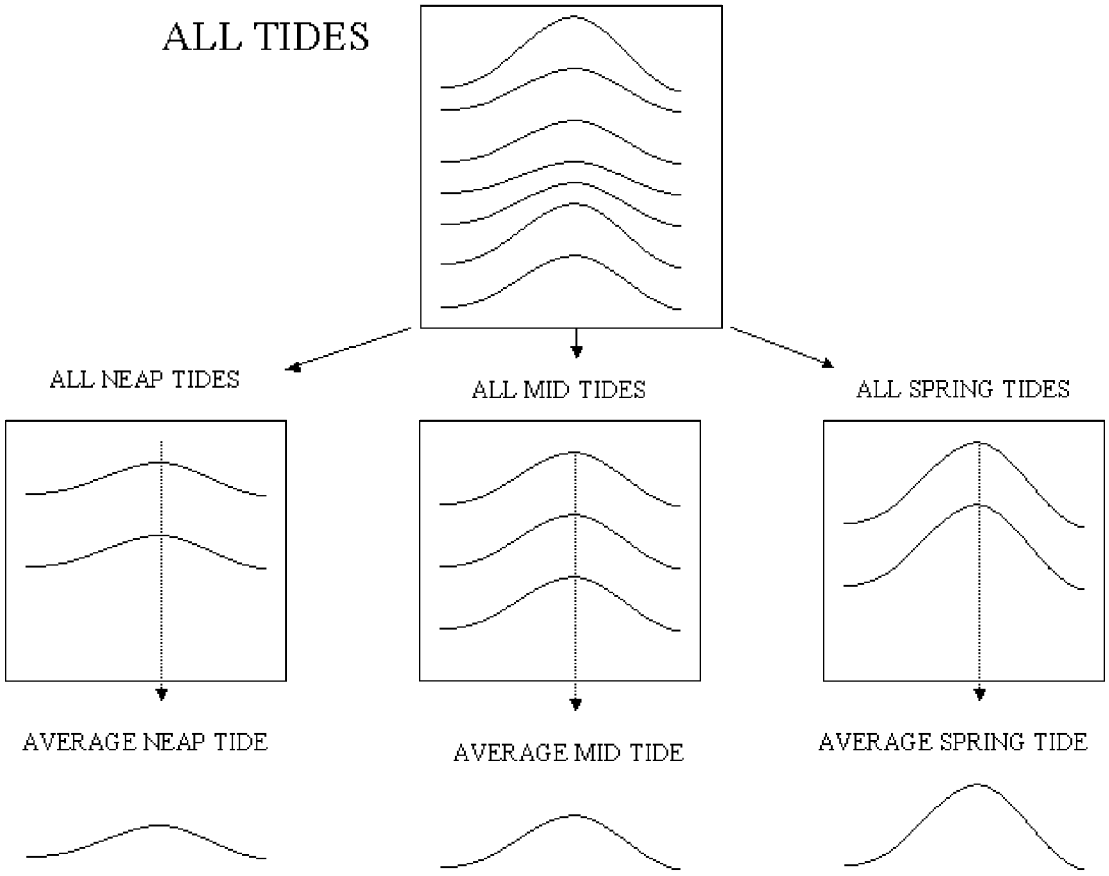

Figure 4-1: Categorisation of tidal tidal cycles

4.2.3. Average tidal cycle of gradients

For each of the three parameters being processed, four horizontal gradients (along dock's axis and cross dock, each at two depths) and four vertical gradients (one per location) have been calculated. The gradient along Deurganckdok was calculated over the full dock's length, and was obtained by the difference of measurements between-* S-BACK minus S-ENTRANCE. Further, the gradient across Deurganckdok was calculated as the difference between locations S-ENTRANCE and N-ENTRANCE; the distance between these locations measured 530.89 m. For each of the locations a vertical gradient has been calculated from the difference between the measurements at approximately –2.3 m TAW and the measurements at approximately –12.6 m TAW (-12.6 m data minus –2.3 m data).

The time series of gradients obtained as such have then been processed following exactly the same tidal separation technique as for the local parameters (described in §4.2.2). The results are shown in APPENDIX D2.

5. PRELIMINARY ANALYSIS

5.1. Long term salinity measurements 28/04/2008-10/10/2008

For each of the four locations salinity, sediment concentration and temperature have been logged at two depths. Apart from week series of every parameter, average tidal cycles have been determined for each parameter. This was done for absolute and relative values, as well as for horizontal gradients along and across the dock, and vertical gradients (APPENDIX D). All of these results are discussed below.

5.1.1. Week series

5.1.1.1. N-ENTRANCE

The water temperature close to the surface measured between 4 and 18 °C. From October to January, temperature decreased from 18°C in October to a value of 4°C in Janurary. From January to March, it started back to increase to a value of 10 °C. Near the bottom, temperatures varied in the same range of values.

Salinity measured between 14 ppt in October spring, to 3 ppt in March. Both near the top and near the bottom, tidal variation was noticed in the salinity values. The lowest salinity's were recorded after low water and the variation was more profound near the top, where lower salinity values were measured compared to the bottom.

With respect to suspended solids concentrations, low bottom concentrations were observed at low water (~50 mg/l). Instead, peaks of up to 1000 mg/l occurred during flooding. Near the surface, peaks generally were smaller, went up to 600 mg/l and occurred less frequent.

5.1.1.2. S-BACK

The water temperature is similar to the other locations (see 5.1.1.1).

Salinity near the bottom decreased from 13 ppt in October to 5 ppt in spring. Near the top, salinity has the same range, but a more profound variation in between the tides. In between a tide, salinity varied at both depths, with a minimum around 3 hours after LW.

Near the bottom, suspended solids concentrations between 100 and 200 mg/l were measured. Peaks were damped but concentrations may go up to 500 mg/l for very short times. Note also that there was a time delay in appearance, i.e. the peaks appeared after high water and later in time compared to N-ENTRANCE.

5.1.1.3. S-MIDDLE

The water temperature is similar to the other locations (see 5.1.1.1).

Salinity measured between 14 ppt in October spring, to 3 ppt in March. Both near the top and near the bottom, tidal variation was noticed in the salinity values. Top salinity is much higher in the period between 1/10/2008 and 23/11/2008. This is probably erroneous data due to pollution on the sensor, but data has not been removed.

The suspended solids concentrations were generally low (~6 mg/l) near the water surface with some peaks up to 400 mg/l. Close to the dock's bottom, concentration peaks of up to 800 mg/l could be seen.

5.1.1.4. S-ENTRANCE

The water temperature is similar to the other locations (see 5.1.1.1).

Salinity measured between 14 ppt in October spring, to 3 ppt in March. Both near the top and near the bottom, tidal variation was noticed in the salinity values. Tidal variation was measured with the lowest salinities around LW. Bottom salinity is too high in the period between 1/12/2008 and 31/03/2009. This is probably erroneous data due to pollution on the sensor, but data has not been removed.

Near the bottom, a 'background' suspended solids concentration of 25-50 mg/l was observed. Distinct peaks of up to 800 mg/l were seen at times of high water. Periods without any concentration peaks were also identified. Near the water surface, solids concentrations only peaked to values of up to 200-400 mg/l. A tidal variation was clearly present.

5.1.2. Average tidal cycles

Plots of averaged tidal cycles can be found in APPENDIX D.

5.1.2.1. Local Parameters

Water temperature did not show tidal variation and remained relatively constant.

In most locations salinity increased throughout the summer to maxima of 13-14 ppt and with variation over the tide.

No tidal variation of suspended solids concentration was observed for S-BACK and S-MIDDLE. The other locations, i.e. measurement locations near the dock entrance, showed a peak at high water during spring tide. Instead, this peak was more spread in time when neap tides occurred, i.e. solids concentration was less dependent on the water level. Results for an average tide were in between those of spring and neap tides. The observation of large suspended solids concentrations at high water was clearer near the bottom of the water column. There, values of up to 400 and 500 mg/l for S-ENTRANCE and N-ENTRANCE were detected.

5.1.2.2. Gradients

Cross-dock gradients from DP Worlds (S-ENTRANCE) towards PSA (N-ENTRANCE) have been calculated at both -2.3 m TAW and -12.3 m TAW. In general, calculated gradients were low and close to zero.
The cross-section gradient of salinity near the bottom increased during flood and decreases during ebb. Near the top, gradient was opposite due to the low measured salinities near the bottom of S-entrance.
With respect to suspended solids concentration, a maximum positive gradient appeared 0-2 hours after high water, indicating that the concentration at the south of the dock entrance is smaller than at the northern side. This positive gradient after HW is more profound near the bottom (4x) and during spring tide (0.5x).
Similarly as for solids concentration, a maximum positive gradient for temperature occurred around high water close to the water surface.

Along-dock gradients run from the entrance (S-ENTRANCE) towards the inland end (S-BACK) of the dock. Salinity gradients near the top are positive (lower salinities in the river) with the highest gradient around 4 hrs before HW. Only during a small period around HW, the gradient is positive (higher salinity in the dock). Near the bottom, salinity gradients are always negative (higher salinities in the river).
Calculated sediment concentrations always appeared negative both near the bottom and near the surface, i.e. the suspended solids concentration was larger near the dock entrance in comparison to locations inside the dock. A clear maximum in concentration gradient occurred around HW and is most profound during spring tide.
With respect to temperature gradients, a real trend could only be observed near the surface. There, maximal positive gradients were calculated during slack waters (both HW and LW) while

negative gradients were calculated in the periods in between LW and HW. For both surface and bottom, a clear impact of tidal magnitude was observed; the larger the tidal magnitude, the extremer (both positive and negative) the temperature gradient became.

Vertical gradients were computed between the bottom and top locations. Temperature gradients remain negative, while sediment concentration gradient and salinity gradient remain positive. A vertical gradient peak for suspended solids concentration occurred between 1 hour before and 2 hours after high water with the largest peak at spring tide.The same could be observed at S-ENTRANCE but the peak was less pronounced. The concentration gradient at N-ENTRANCE measured 3.5 mg/l/m whereas 1.0 mg/l/m was computed for S-ENTRANCE. Near S-BACK, no peak could be observed and contrary to the other locations, gradients are now larger during neap tides.

It could be concluded that no significant trend occurred for salinity when investigating the along-dock trend. For suspended solids concentration, vertical gradients remained positive for all. Whereas a gradient peak occurred near the entrance around HW, no real trend could be detected for the other locations in the dock. Also for the vertical temperature gradients, no tidal variation was observed, with always negative gradients.

5.1.3. Comparison with previous measurements

Because this measurement campaign occurred in spring and summer, its outcome is expected to be similar to the previous winter campaign from 2006 (IMCD, 2007q) and 2007 (IMDC, 2008m). The evolution of measured parameters is very similar. Peaks of suspended solids concentrations could be observed as well; the actual peaks at the different locations were similar. Tidal variations for both salinity and solids concentration occurred in both time series, i.e. the 2006 and 2007 measurements.

With respect to the cross-dock gradients, salinity gradients are positive during ebb, negative during flood. This conclusion was valid for both campaigns. When the horizontal top gradients are considered, same variation during the tidal cycle was observed for both salinity and temperature, with negative gradients during flood and opposite gradients during ebb.

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IMDC (2008y) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport 2.28: Through tide measurement ADCP eddy Summer 2008 – 1 October 2008 (I/RA/11283/08.089/MSA)

IMDC (2008z) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport 2.32: Salt-Silt distribution Deurganckdok: six monthly report 1/4/2008 – 30/9/2008 (I/RA/11283/08.093/MSA)

IMDC (2008aa) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport 3.20: Boundary conditions: Six monthly report 1/4/2008 – 30/09/2008 (I/RA/11283/08.096/MSA)

IMDC (2009a) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport 2.23: Through tide measurement Sediview during spring tide Summer 2008 – 30 September 2008 (I/RA/11283/08.084/MSA)

IMDC (2009b) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport 2.29: Through tide measurement SiltProfiler summer 2008 – 29 September 2008 (I/RA/11283/07.090/MSA)

IMDC (2009c) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport 2.34: Calibration stationary & mobile equipment autumn 2008 (I/RA/11283/08.095/MSA)

IMDC (2009d) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing Deelrapport 1.22: Sediment Balance: Three monthly report 1/10/2008 – 31/12/2008 (I/RA/11283/08.078/MSA)

IMDC (2009e) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport 2.24: Through tide measurement Sediview during neap tide Autumn 2008 (I/RA/11283/08.085/MSA)

IMDC (2009f) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport 2.25: Through tide measurement Sediview during spring tide Autumn 2008 (I/RA/11283/08.086/MSA)

IMDC (2009g) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing Deelrapport 1.23: Sediment Balance: Three monthly report 1/01/2009 – 31/03/2009 (I/RA/11283/08.079/MSA)

IMDC (2009h) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing Deelrapport 1.24: Annual Sediment Balance (I/RA/11283/08.080/MSA)

IMDC (2009i) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport 2.26: Through tide measurement Sediview during neap tide Winter 2009 (I/RA/11283/08.087/MSA)

IMDC (2009j) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport 2.30: Through tide measurement SiltProfiler winter 2009 (I/RA/11283/08.091/MSA)

IMDC (2009k) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport 2.31: Through tide measurement Salinity Profiling winter 2009 (I/RA/11283/08.092/MSA)

IMDC (2009l) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport 2.33: Salt-Silt distribution Deurganckdok: six monthly report 1/10/2008 – 31/3/2009 (I/RA/11283/08.094/MSA)

IMDC (2009m) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport 3.21: Boundary conditions: Six monthly report 1/10/2008 – 31/03/2009 (I/RA/11283/08.097/MSA)

IMDC (2009n) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport 2.27: Through tide measurement Sediview during spring tide Winter 2009 (I/RA/11283/08.088/MSA)

IMDC (2009o) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport 4.20: Analysis of siltation Processes and Factors (I/RA/11283/08.098/MSA)

TV SAM (2006a) Langdurige stationaire ADCP stroommetingen te Oosterweel dukdalf 01/2005-06/2005. 42SR S032PIB 2A.

TV SAM (2006b) Langdurige stationaire ADCP stroommetingen te Oosterweel dukdalf 07/2005-12/2005. 42SR S033PIB 2A.

TV SAM (2006c) Langdurige stationaire ADCP stroommetingen te Oosterweel dukdalf 01/2006-06/2006. 42SR S032PIB 2A.

Unesco (1983). Algorithms for computation of fundamental properties of seawater, UNESCO Technical Papers in Marine Science, 44. UNESCO, France.

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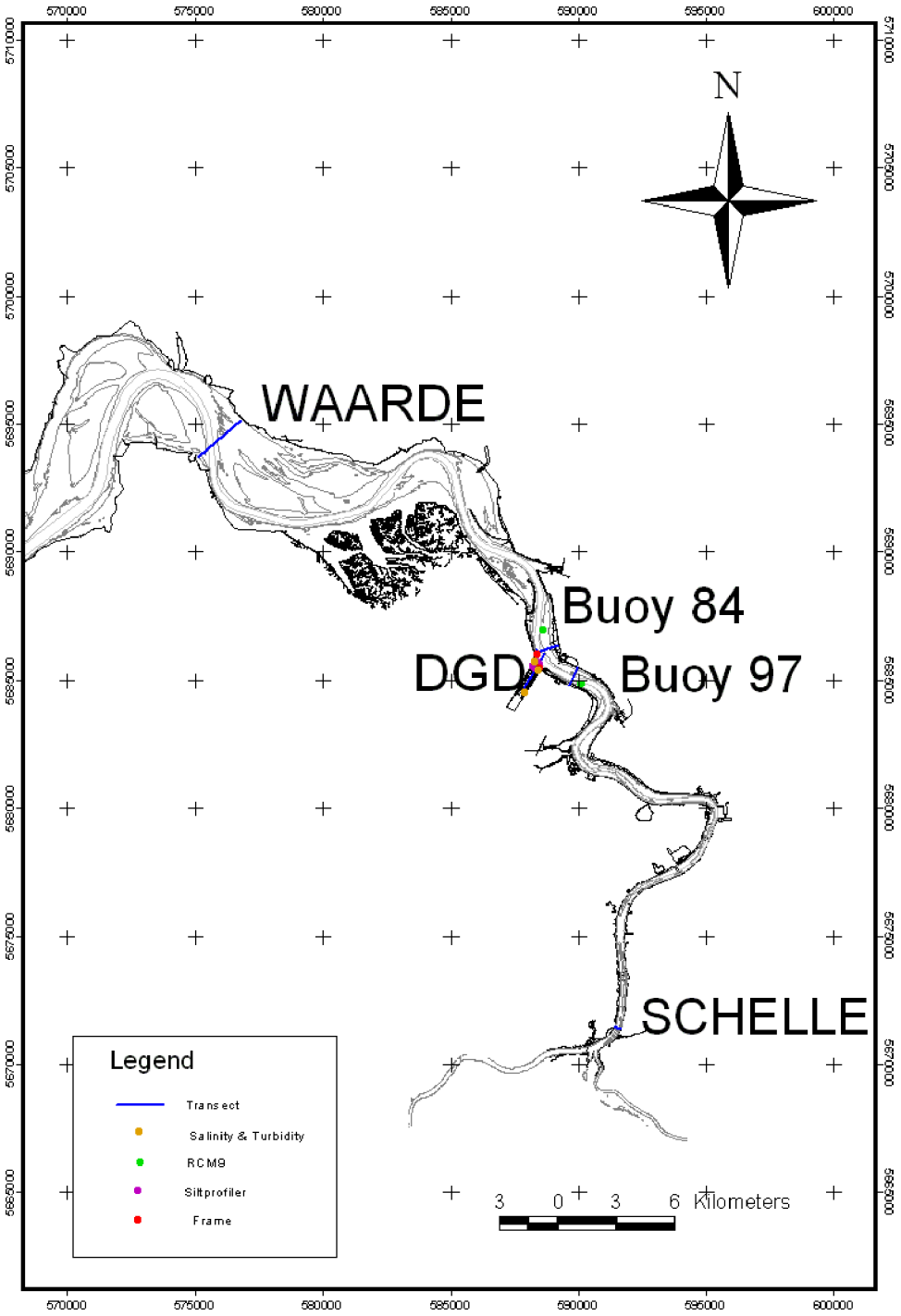
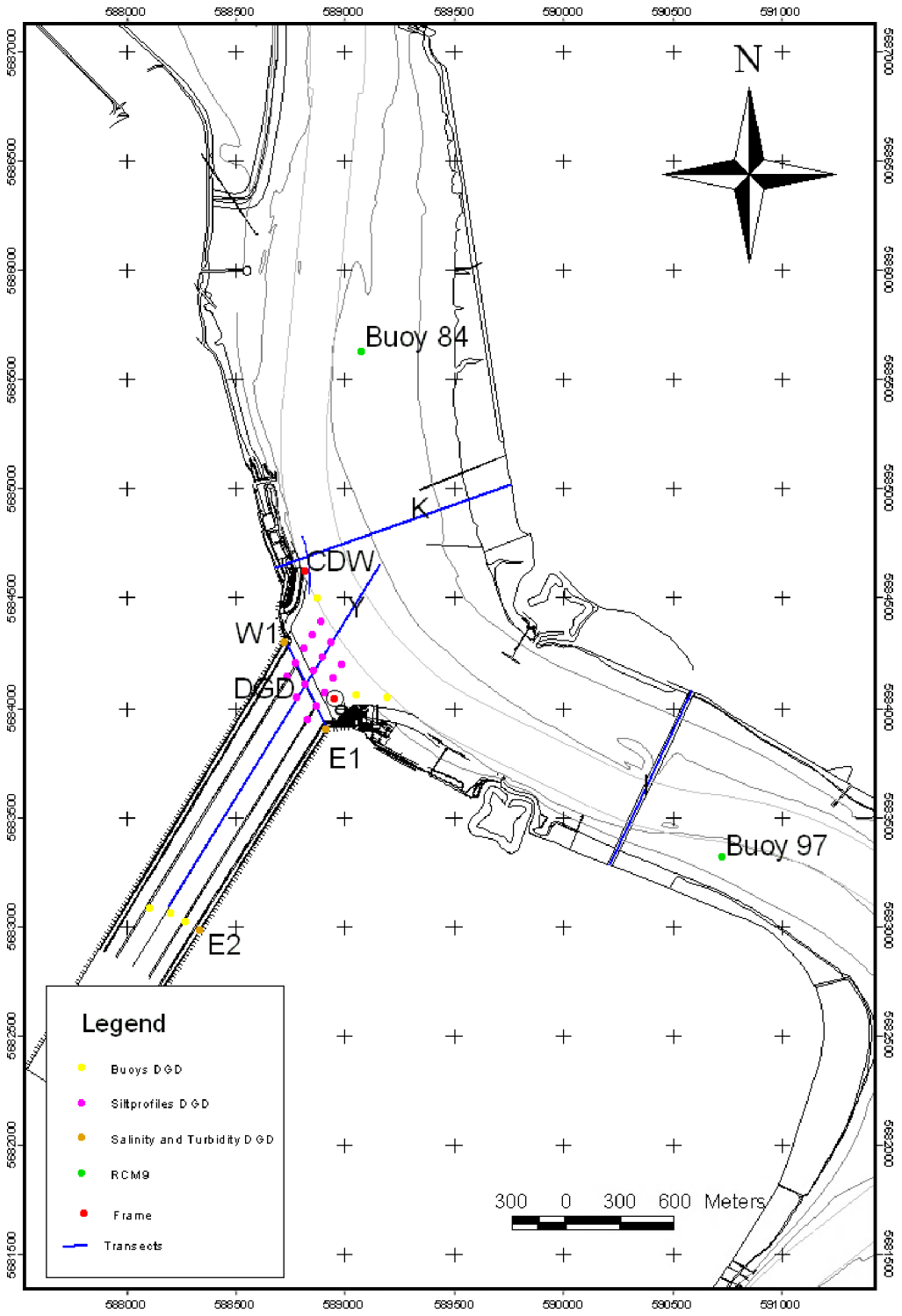
APPENDIX A.

OVERVIEW OF MEASUREMENTS

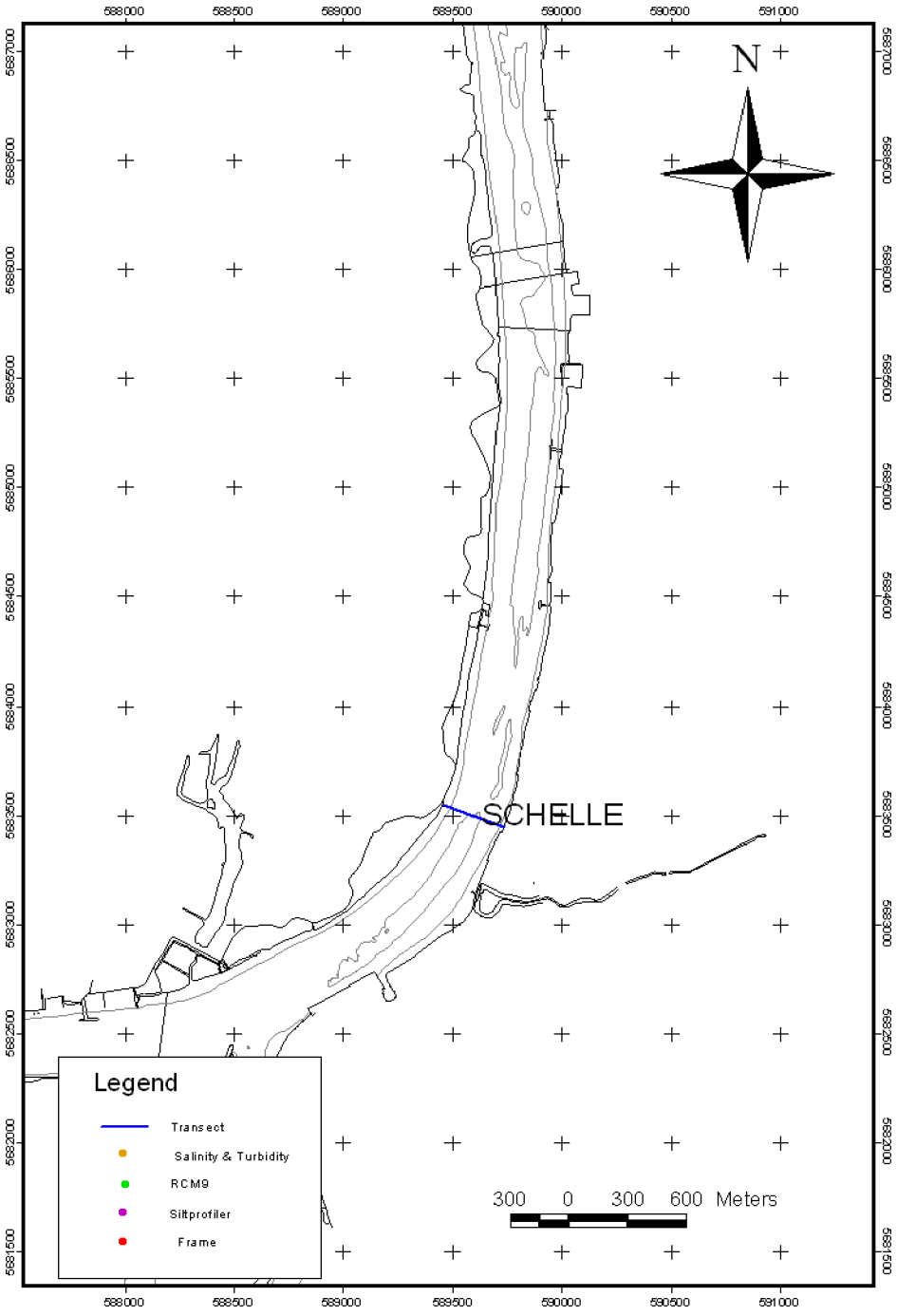
A.1 Overview of the measurement locations for the whole HCBS2 and Deurganckdok measurement campaigns



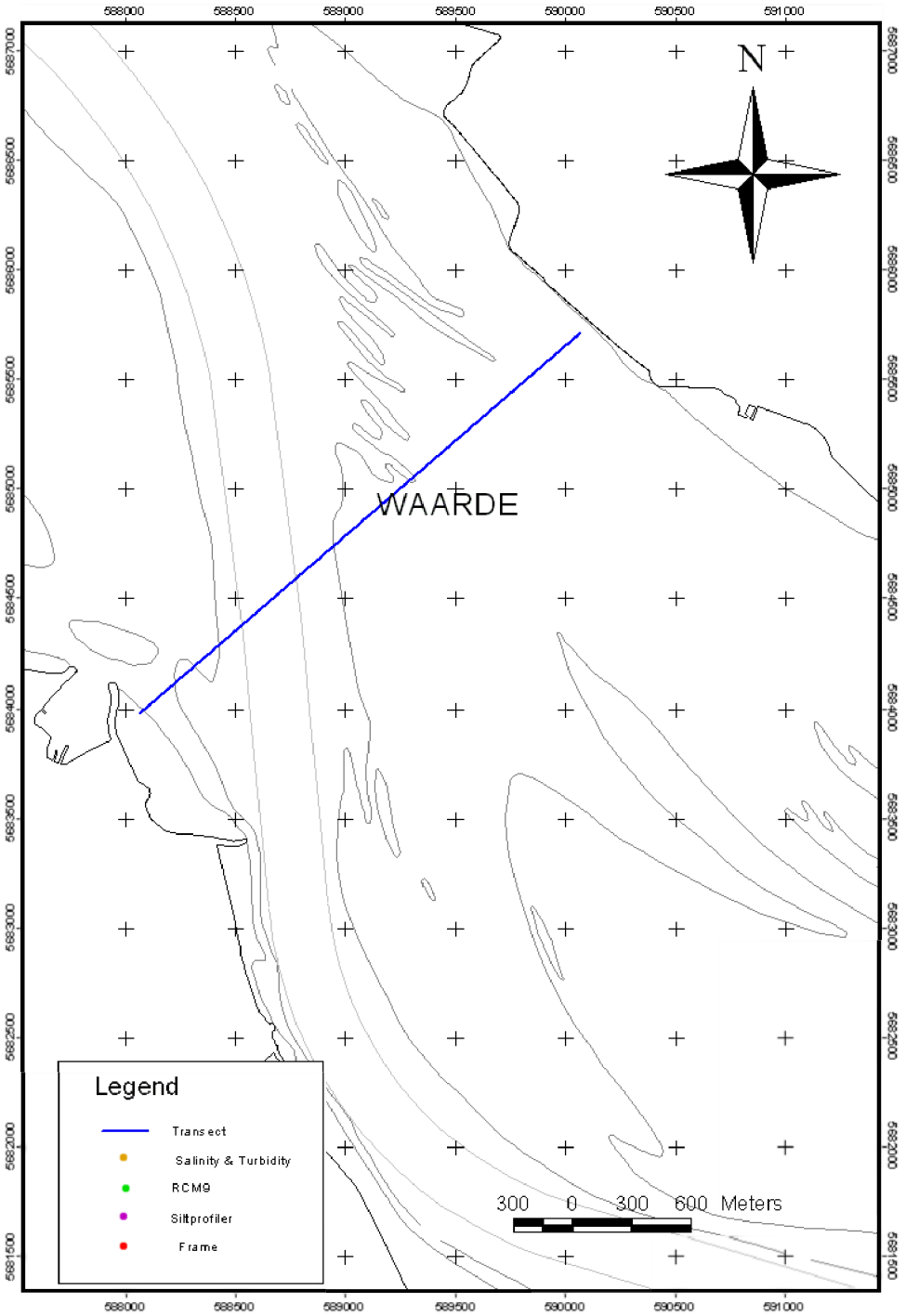
Annex Figure A-1: Overview of the measurement locations



Annex Figure A-2: Overview of the measurement locations at Deurganckdok



Annex Figure A-3: Transect S in Schelle



Annex Figure A-4: Transect W in Waarde

A.2 Overview of all measurement locations HCBS and Deurganckdok measurement campaigns

Annex Table A-1: coordinates of theoretical transects

Transect	Start Easting	Start Northing	End Easting	End Northing
I	590318.00	5683302.00	590771.00	5684257.00
K	588484.00	5684924.00	589775.00	5685384.00
SCHELLE	592645.07	5665794.06	592952.68	5665682.28
DGD	588764.88	5684056.49	588540.95	5684526.94
Y	589059.09	5684948.36	587898.76	5683076.56
WAARDE	573541.00	5696848.20	571318.00	5694932.90

Annex Table A-2: coordinates of SiltProfiler gauging locations

SP	EASTING	NORTHING
1	588737	5684638
2	588690	5684562
3	588643	5684486
4	588596	5684411
5	588549	5684335
6	588606	5684217
7	588653	5684293
8	588700	5684368
9	588747	5684444
10	588793	5684520
11	588850	5684402
12	588803	5684326
13	588756	5684250
14	588709	5684174
15	588662	5684099

A.3 Measurement overview at Transect DGD on 31/03/2009

Salt Silt measurements Deurganckdok			
Location	*Easting (UTM ED 50)*	*Northing (UTM ED 50)*	*Period*
P&O 1	588074	5682942	17/03/2006 – 28/04/2006
P&O 2	588767	5684045	17/03/2006 – 28/04/2006
PSA	588536	5684523	17/03/2006 – 28/04/2006
P&O 1	588074	5682942	20/07/2006 – 12/10/2006
P&O 2	588767	5684045	20/07/2006 – 12/10/2006
PSA	588536	5684523	20/07/2006 – 12/10/2006
P&O 1	588074	5682942	12/02/2007 – 27/03/2006
P&O 2	588767	5684045	12/02/2007 – 27/03/2006
PSA	588536	5684523	12/02/2007 – 27/03/2006
P&O 1	588074	5682942	18/09/2007 – 18/12/2006
P&O 2	588767	5684045	18/09/2007 – 18/12/2006
PSA	588536	5684523	18/09/2007 – 18/12/2006
DB Ports (S-back)	587760	5682449	28/02/2008 – 28/04/2008
DB Ports (S-middle)	588074	5682942	21/02/2008 – 28/04/2008
DB Ports (S-entrance)	588767	5684045	21/02/2008 – 28/04/2008
PSA (N-entrance)	588536	5684523	21/02/2008 – 28/04/2008
DP World (S-back)	587760	5682449	28/04/2008 – 31/03/2009
DP World (S-middle)	588074	5682942	28/04/2008 – 31/03/2009

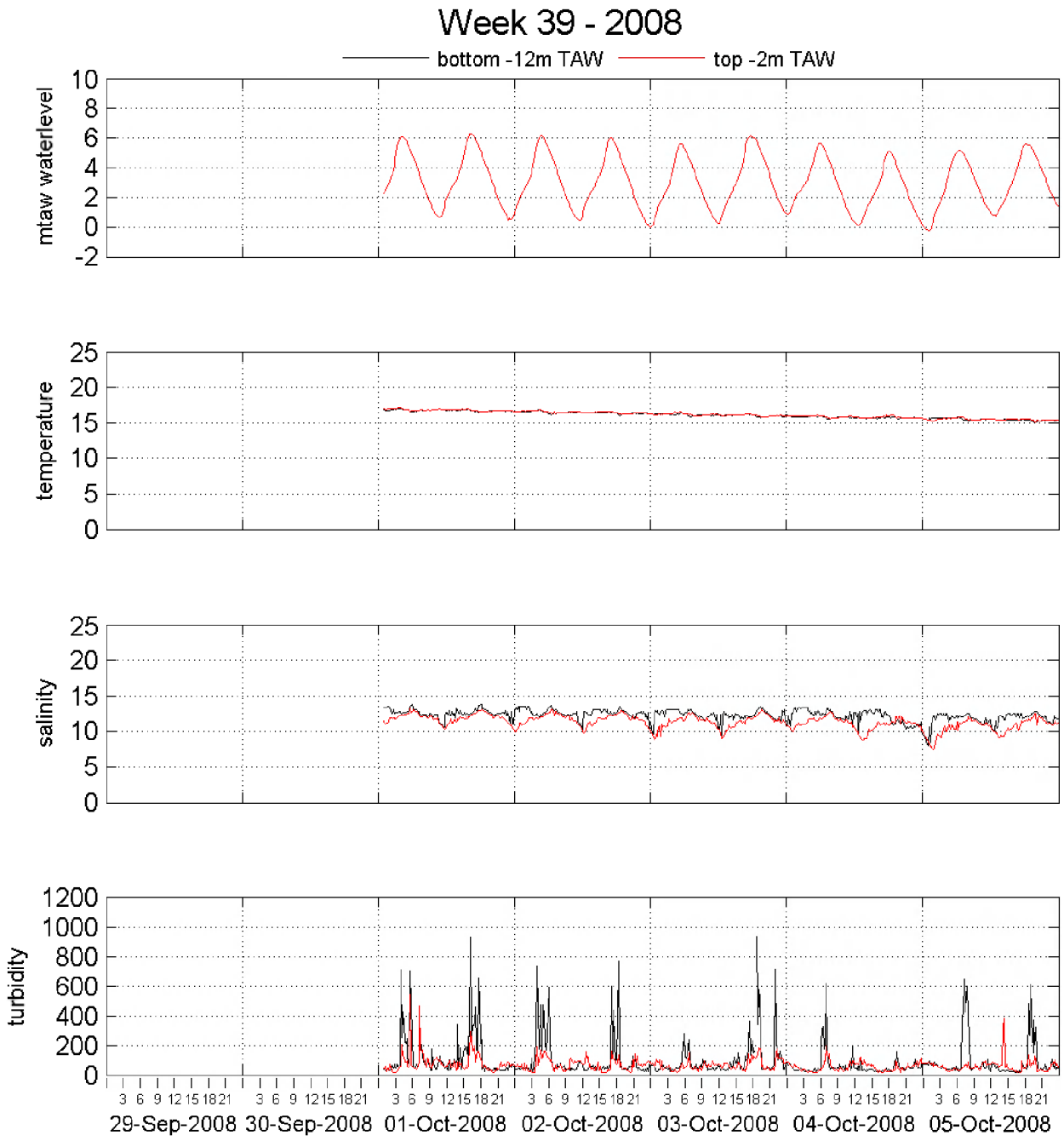
DP World (S-entrance)	588767	5684045	28/04/2008 – 31/03/2009
PSA (N-entrance)	588536	5684523	28/04/2008 – 31/03/2009

APPENDIX B.

WEEKSERIES SALT - SILT MEASUREMENTS DGD

B.1 N-ENTRANCE

11283



Week series of Salinity, Temperature, SS concentration and Tide

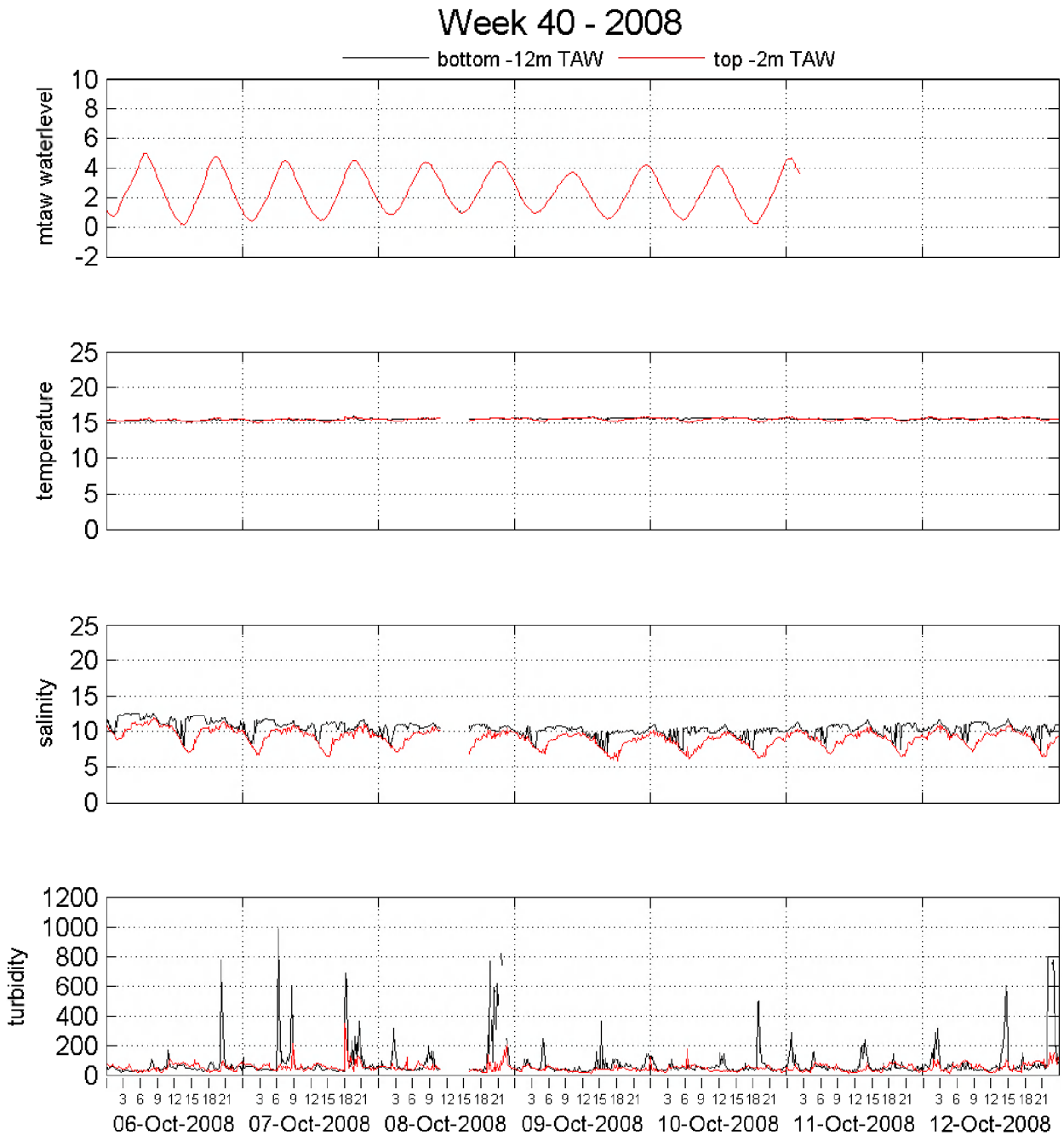
Processed

Location:

N entrance

I/RA/11283/08.094/MSA

11283



Week series of Salinity, Temperature, SS concentration and Tide

Processed

Location:

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I/RA/11283/08.094/MSA

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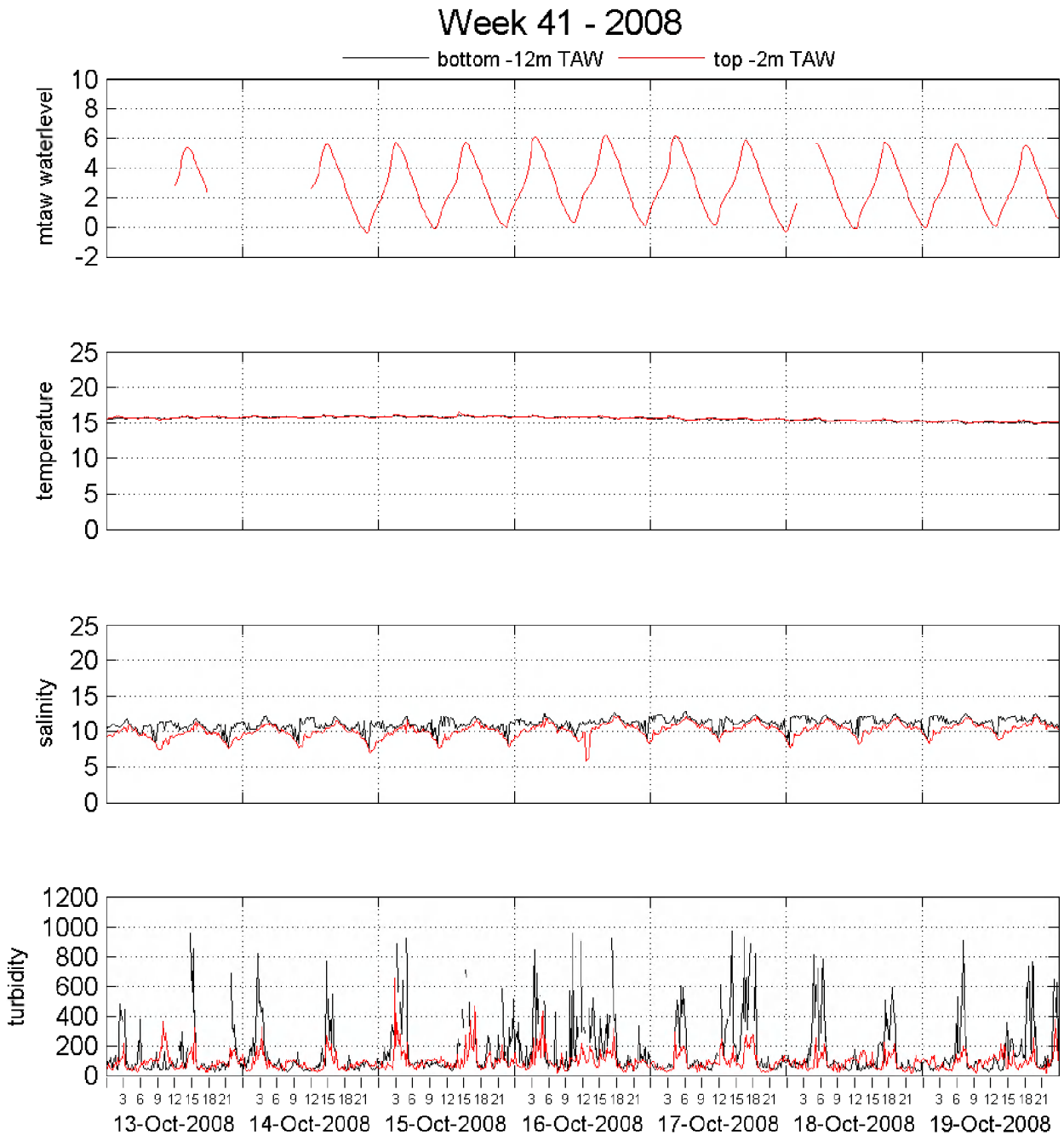

Week series of Salinity, Temperature, SS concentration and Tide

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Location:

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I/RA/11283/08.094/MSA

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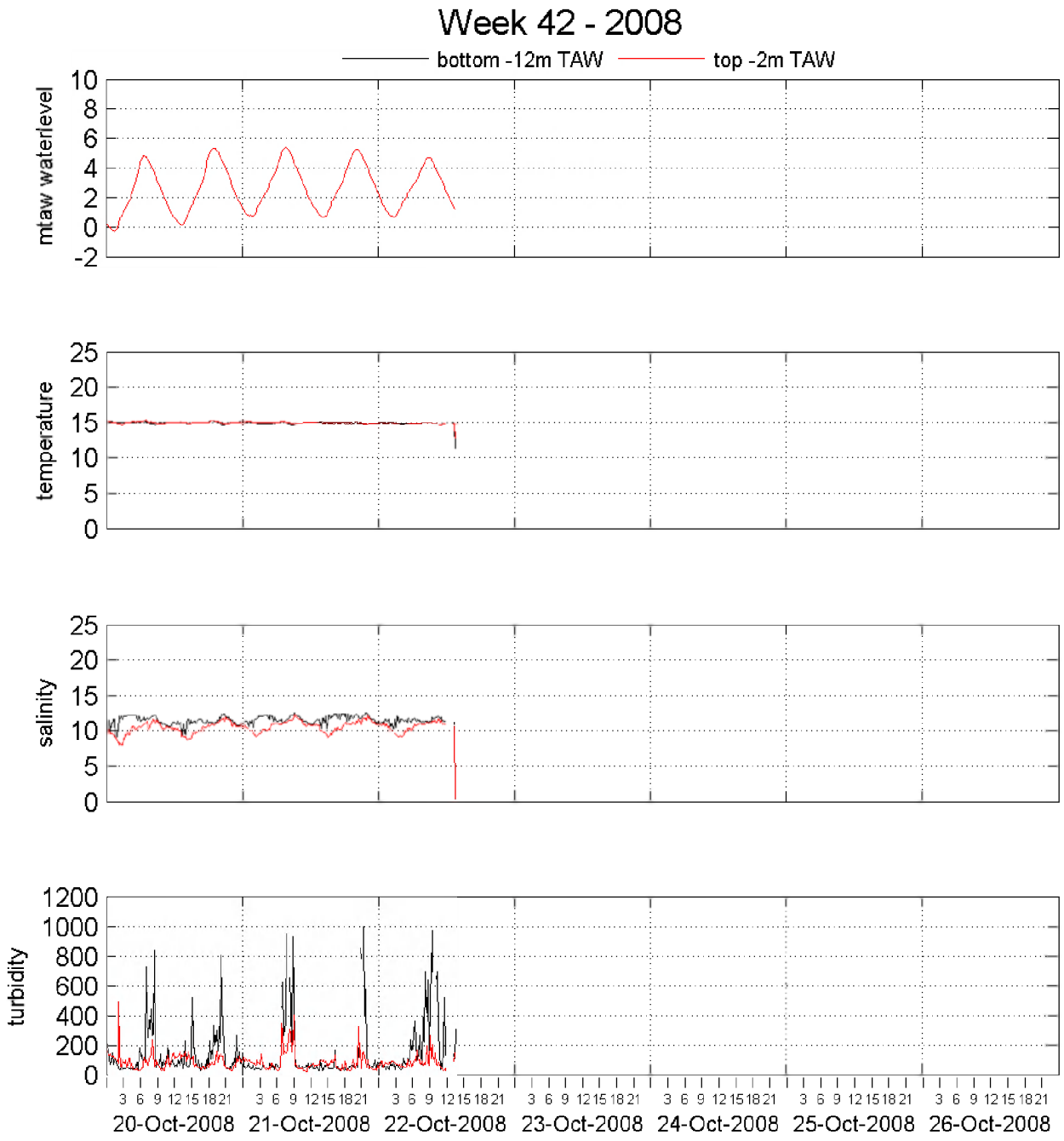

Week series of Salinity, Temperature, SS concentration and Tide

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Location:

N entrance

I/RA/11283/08.094/MSA

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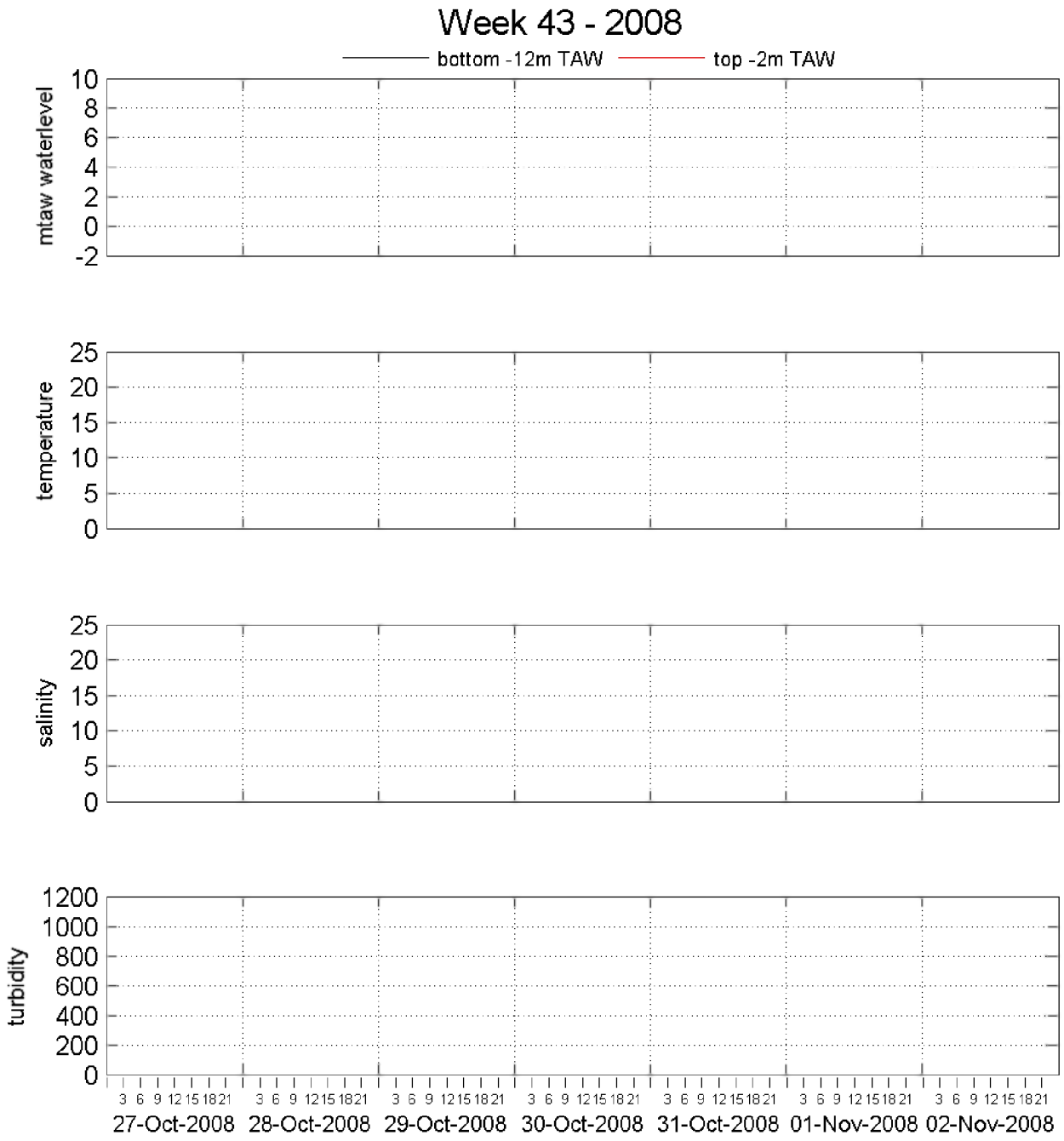

Week series of Salinity, Temperature, SS concentration and Tide

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IMDC

Location:

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I/RA/11283/08.094/MSA

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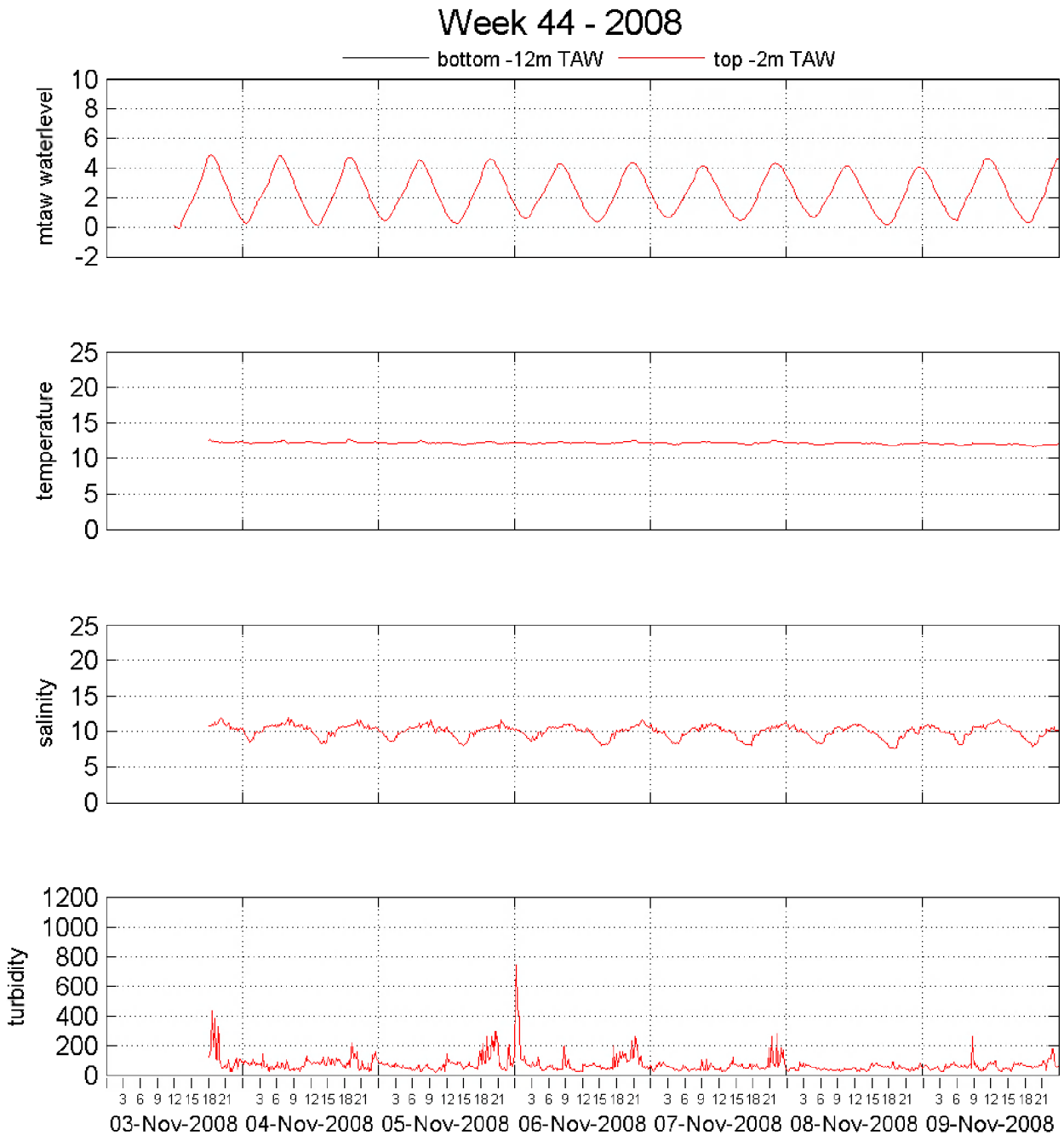

Week series of Salinity, Temperature, SS concentration and Tide

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Location:

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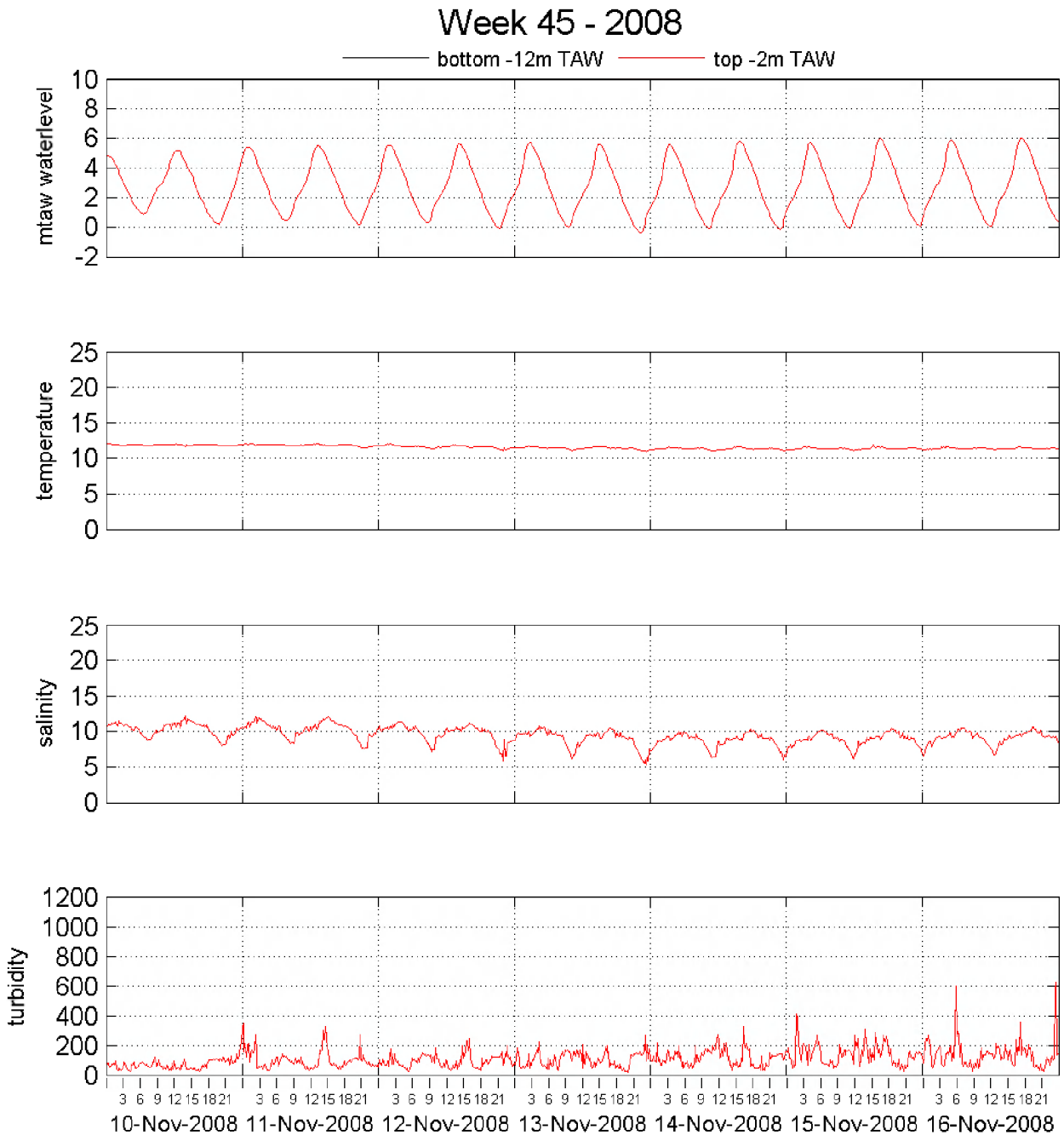

Week series of Salinity, Temperature, SS concentration and Tide

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Location:

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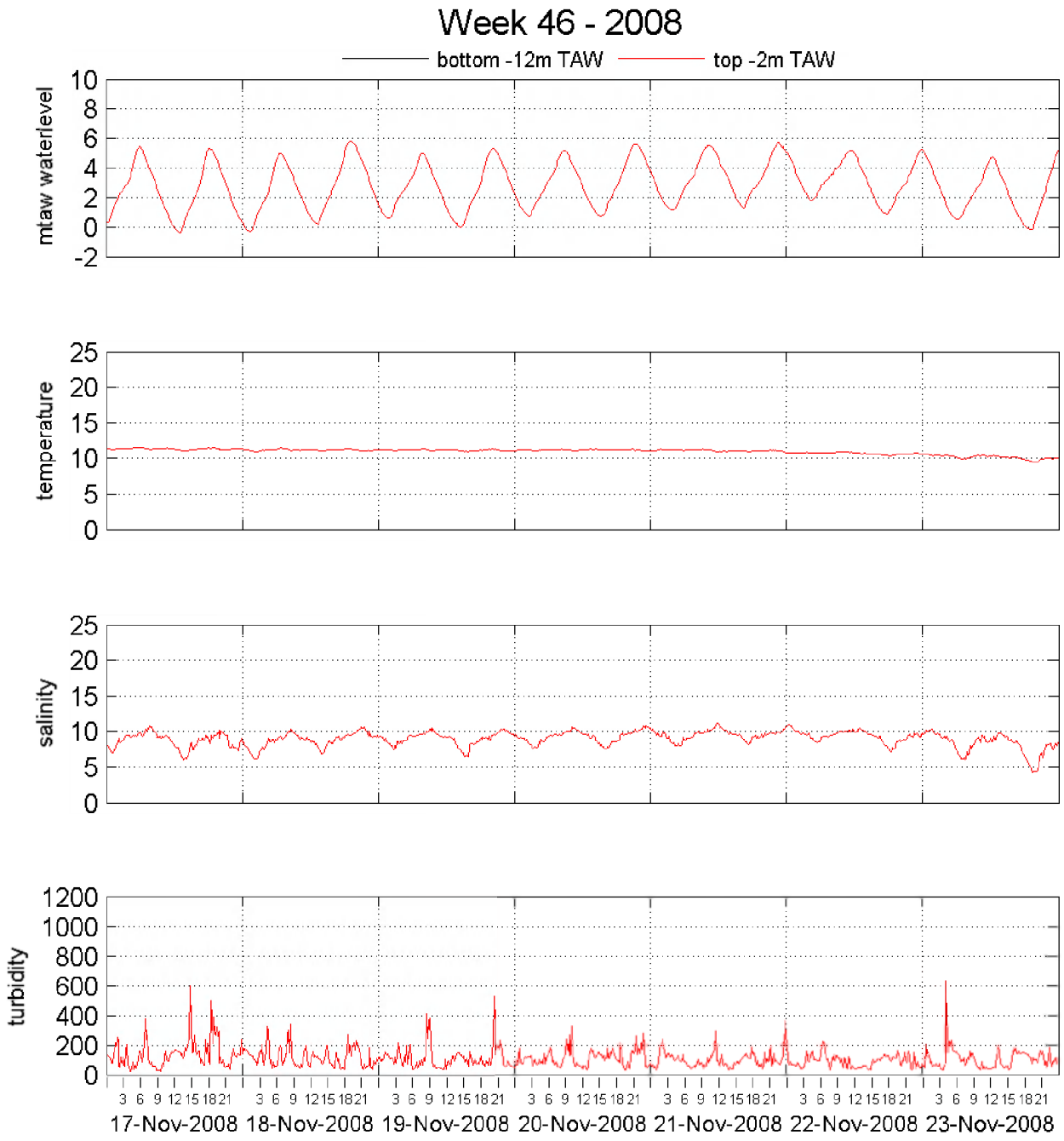

Week series of Salinity, Temperature, SS concentration and Tide

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Location:

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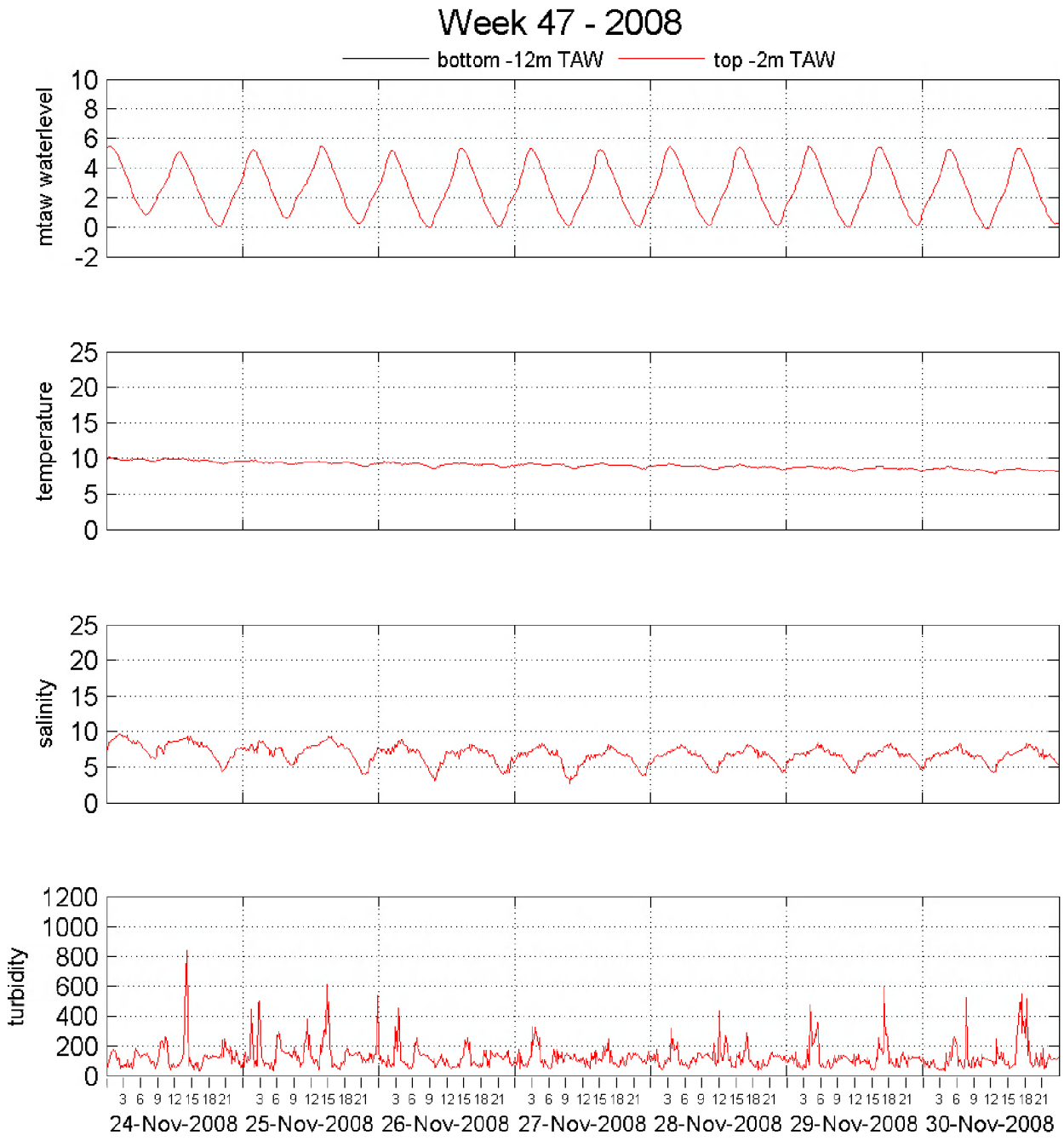

Week series of Salinity, Temperature, SS concentration and Tide

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Location:

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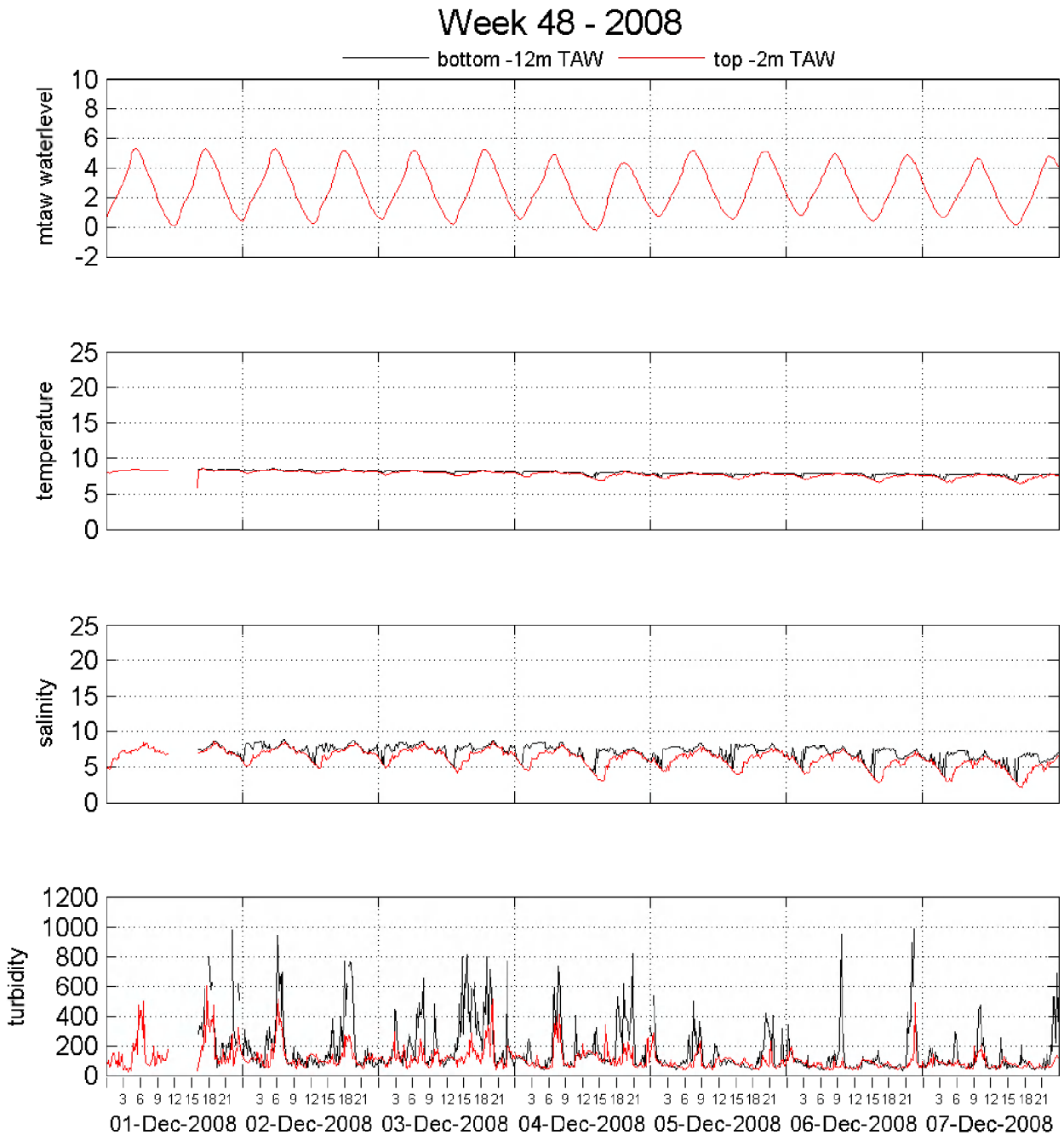

Week series of Salinity, Temperature, SS concentration and Tide

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Location:

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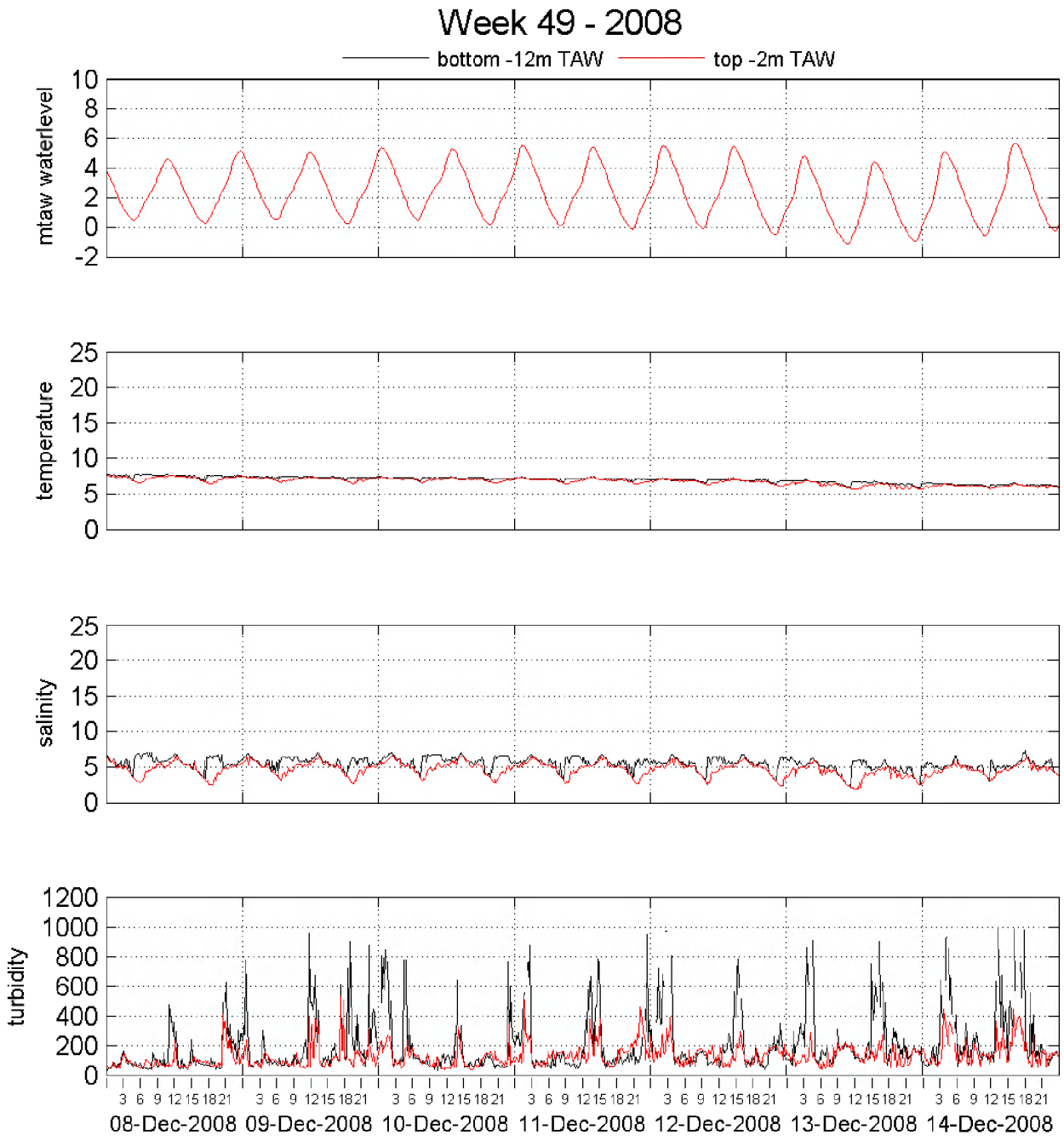

Week series of Salinity, Temperature, SS concentration and Tide

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Location:

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I/RA/11283/08.094/MSA

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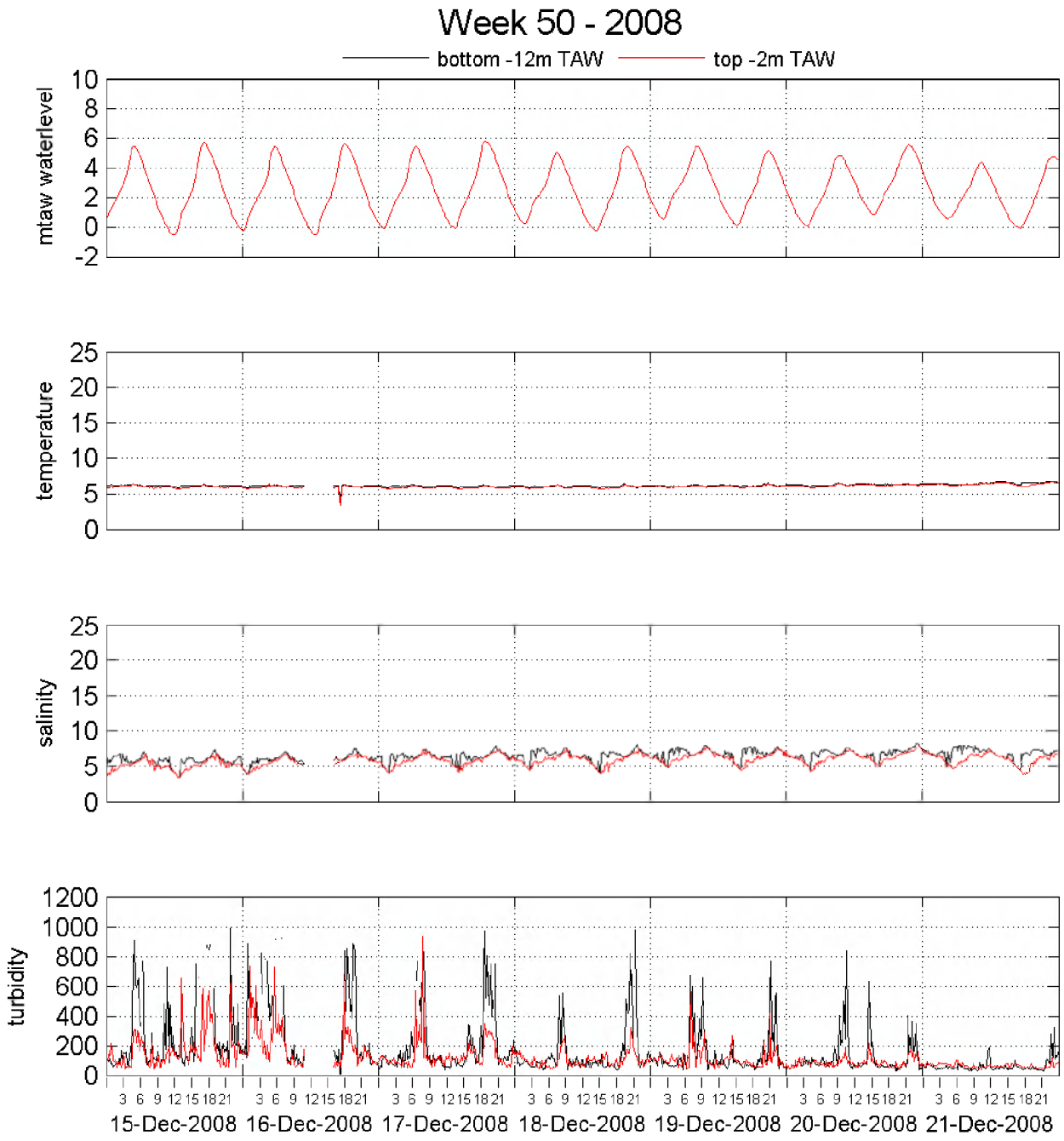

Week series of Salinity, Temperature, SS concentration and Tide

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Location:

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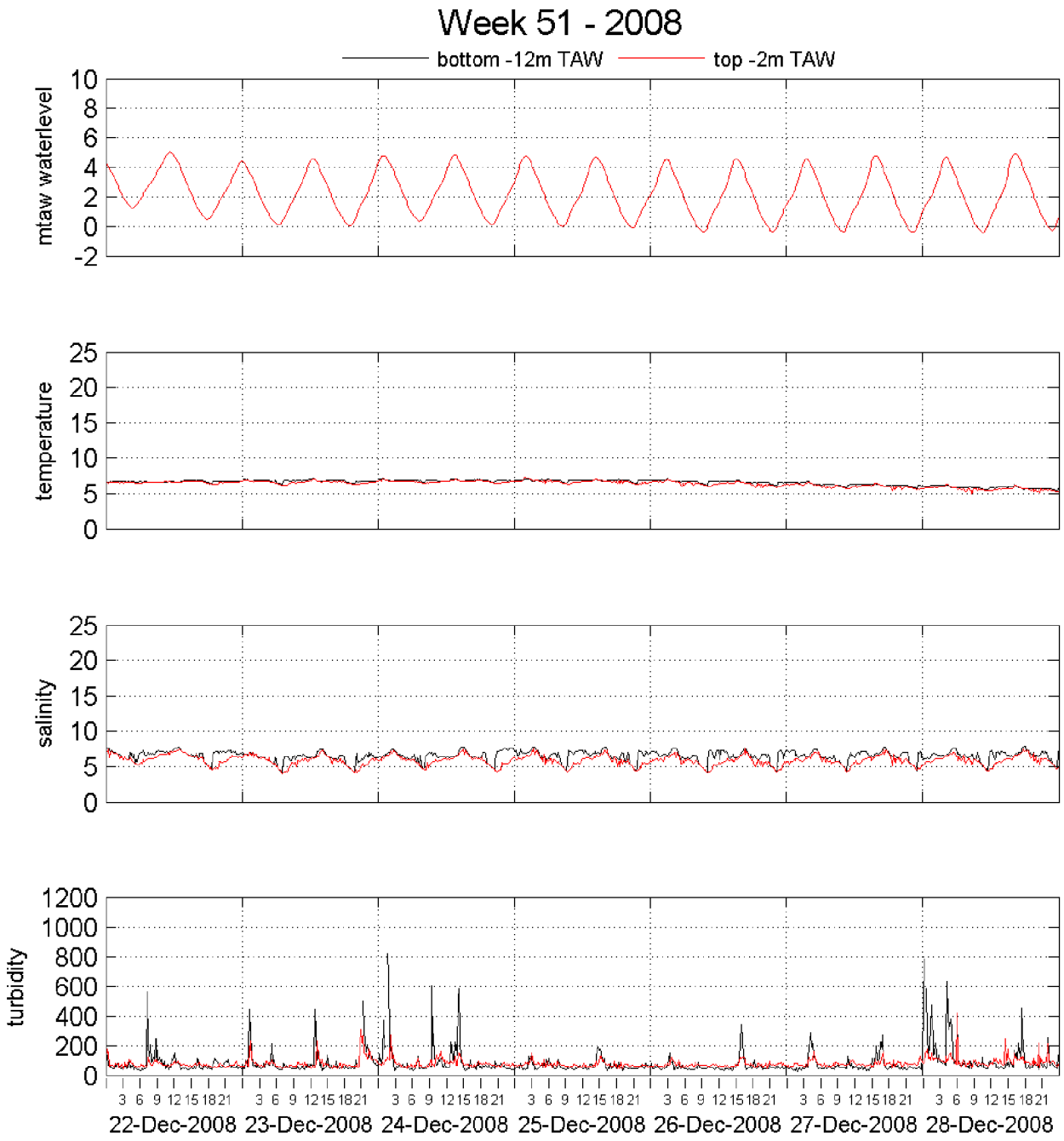

Week series of Salinity, Temperature, SS concentration and Tide

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Location:

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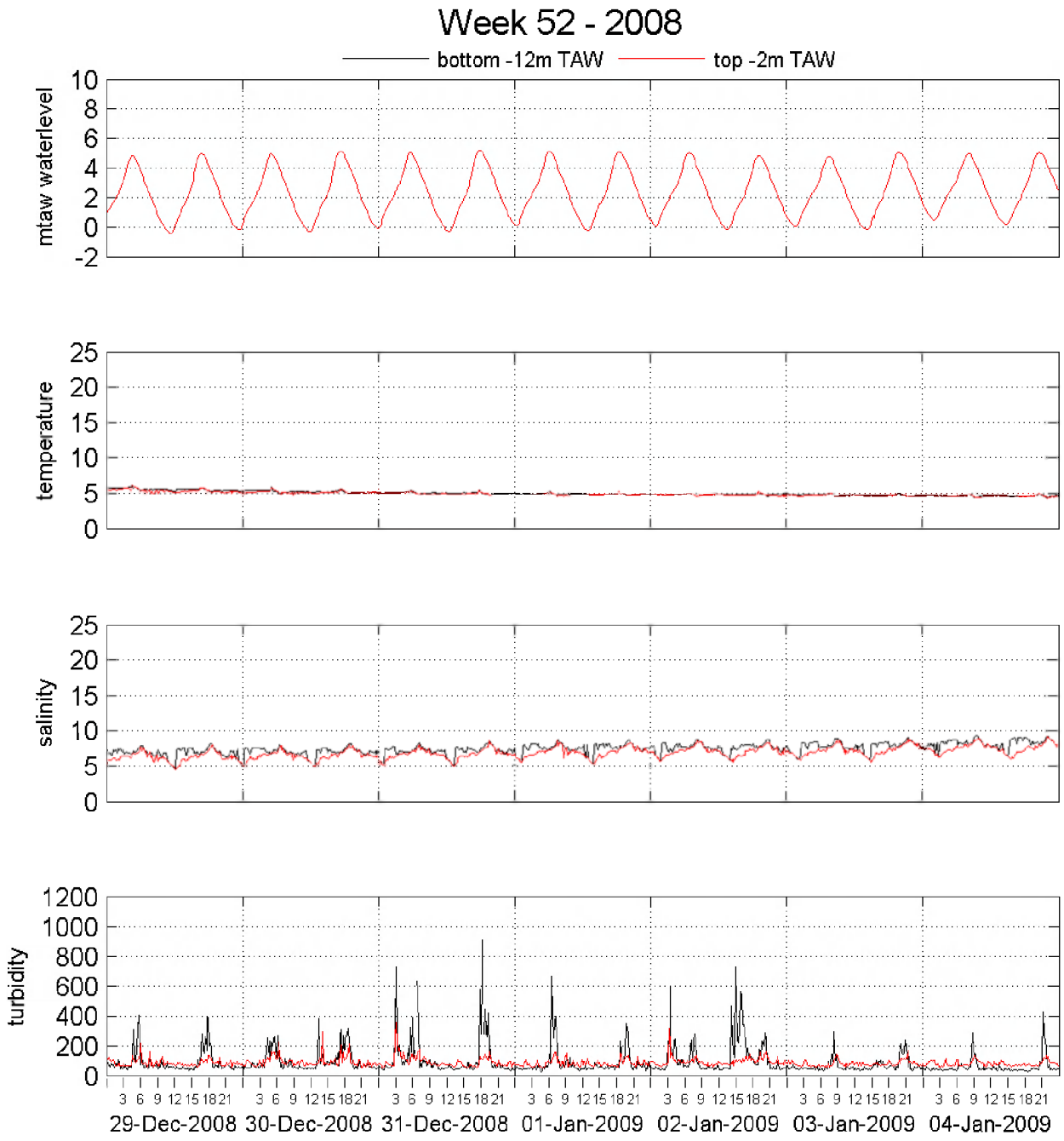

Week series of Salinity, Temperature, SS concentration and Tide

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Location:

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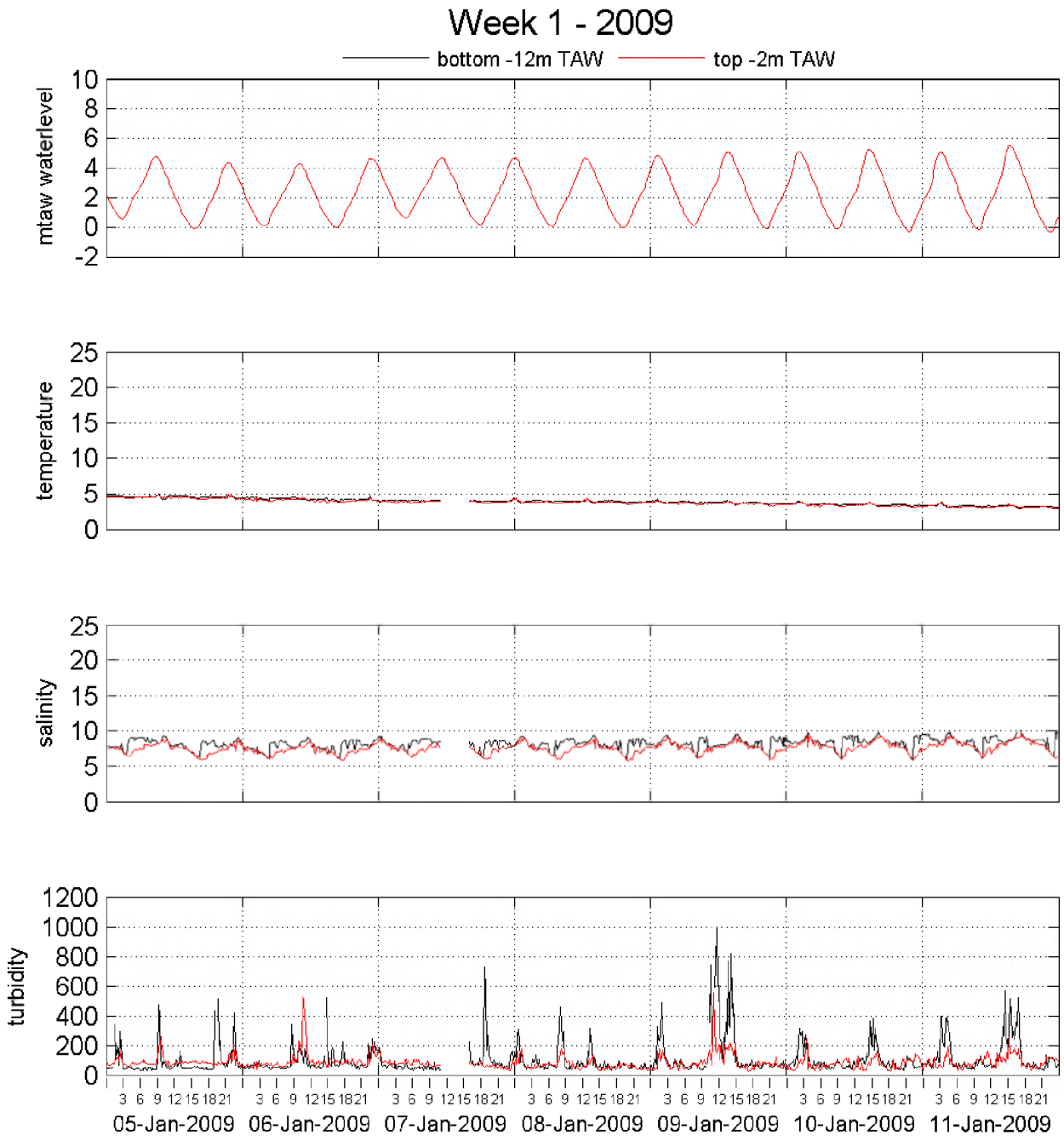

Week series of Salinity, Temperature, SS concentration and Tide

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Location:

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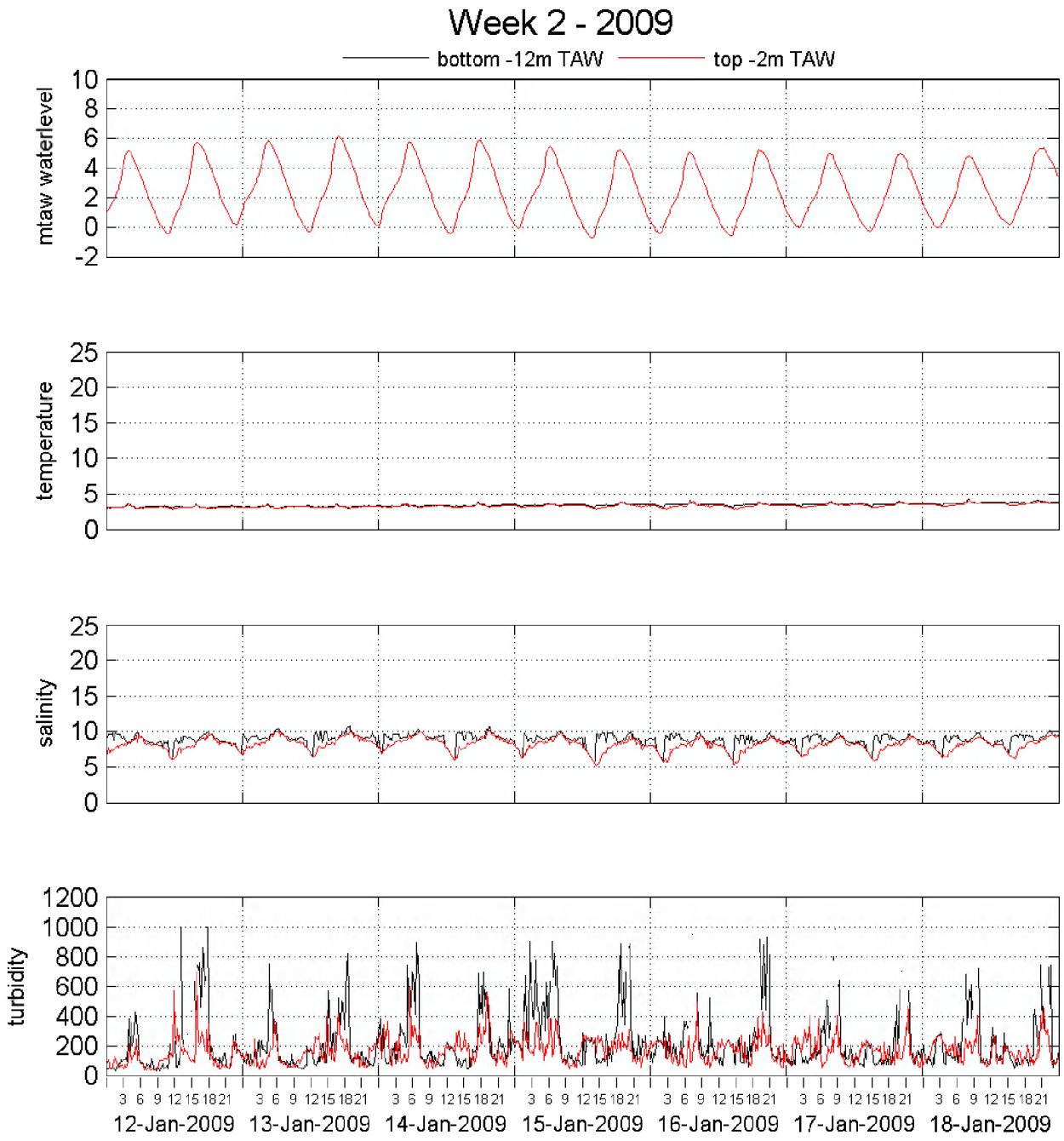

Week series of Salinity, Temperature, SS concentration and Tide

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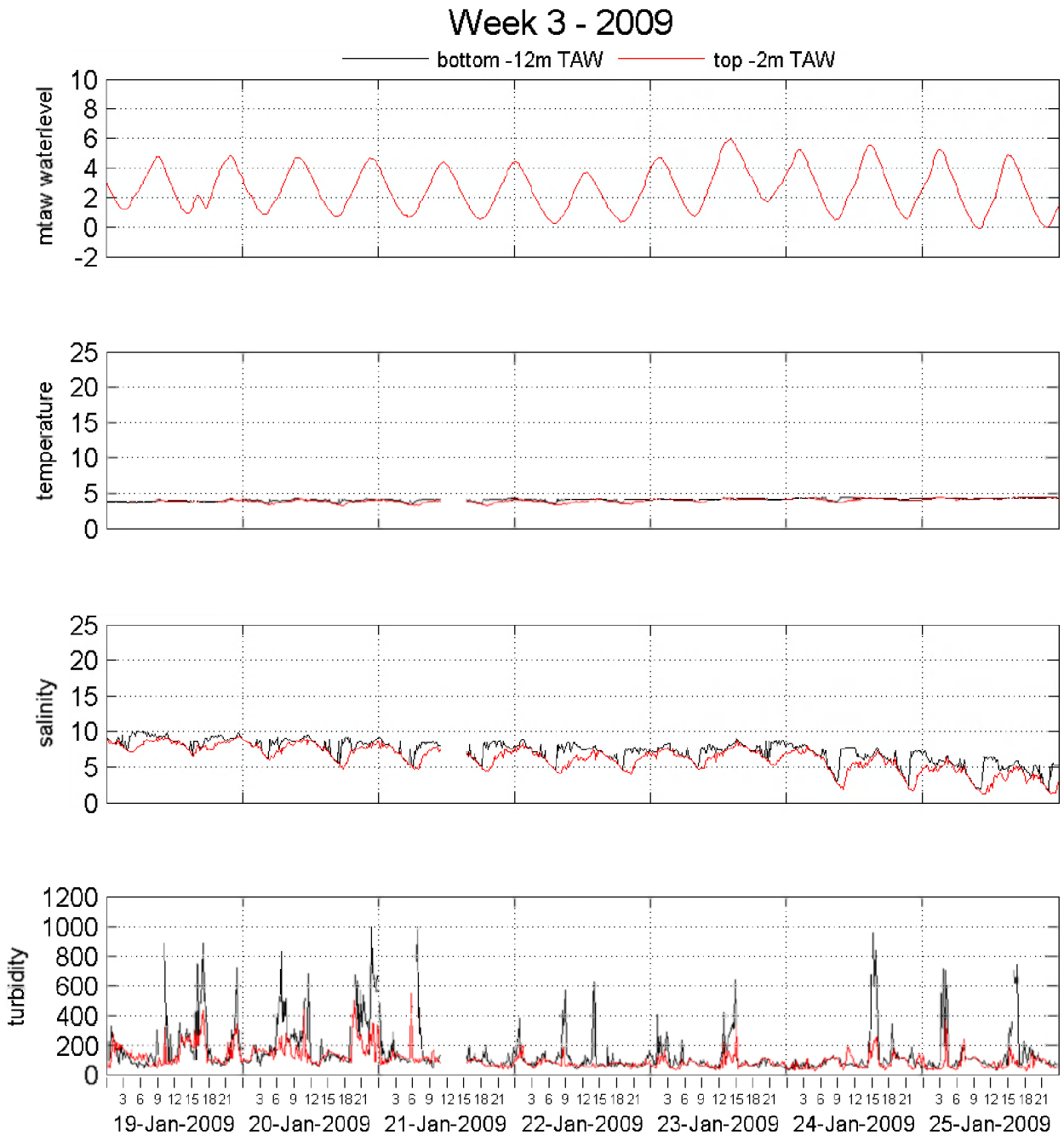

Week series of Salinity, Temperature, SS concentration and Tide

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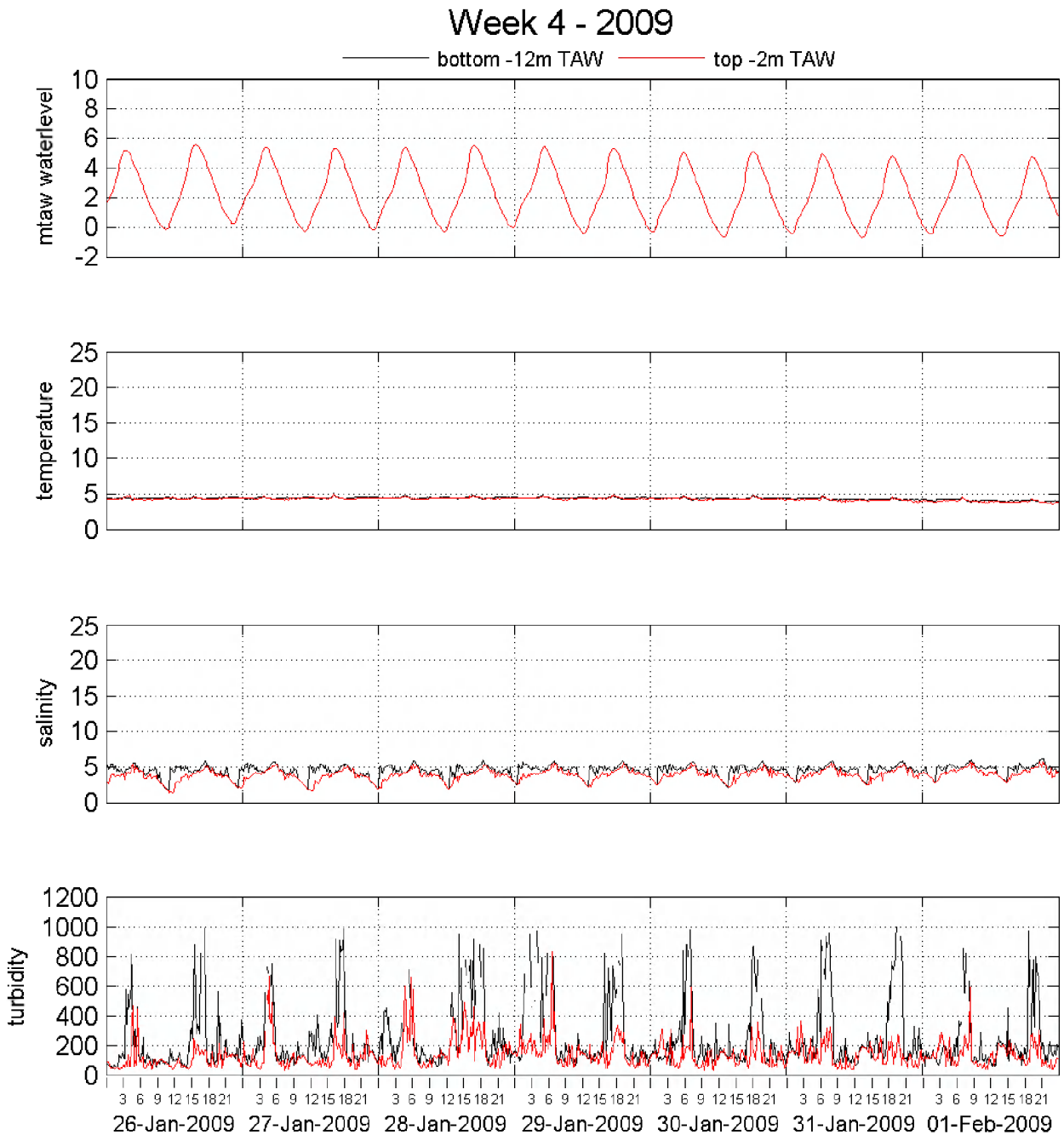

Week series of Salinity, Temperature, SS concentration and Tide

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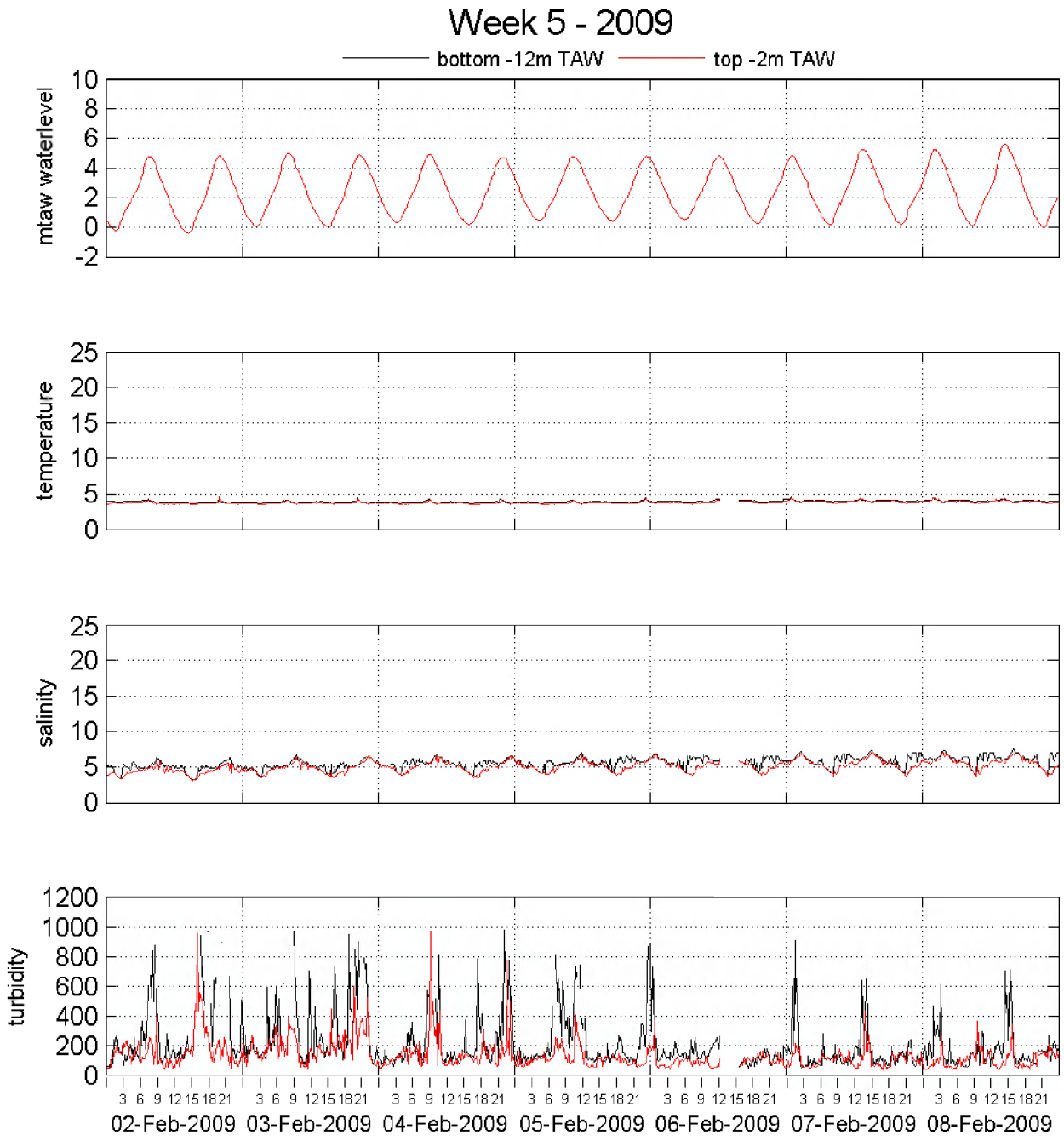

Week series of Salinity, Temperature, SS concentration and Tide

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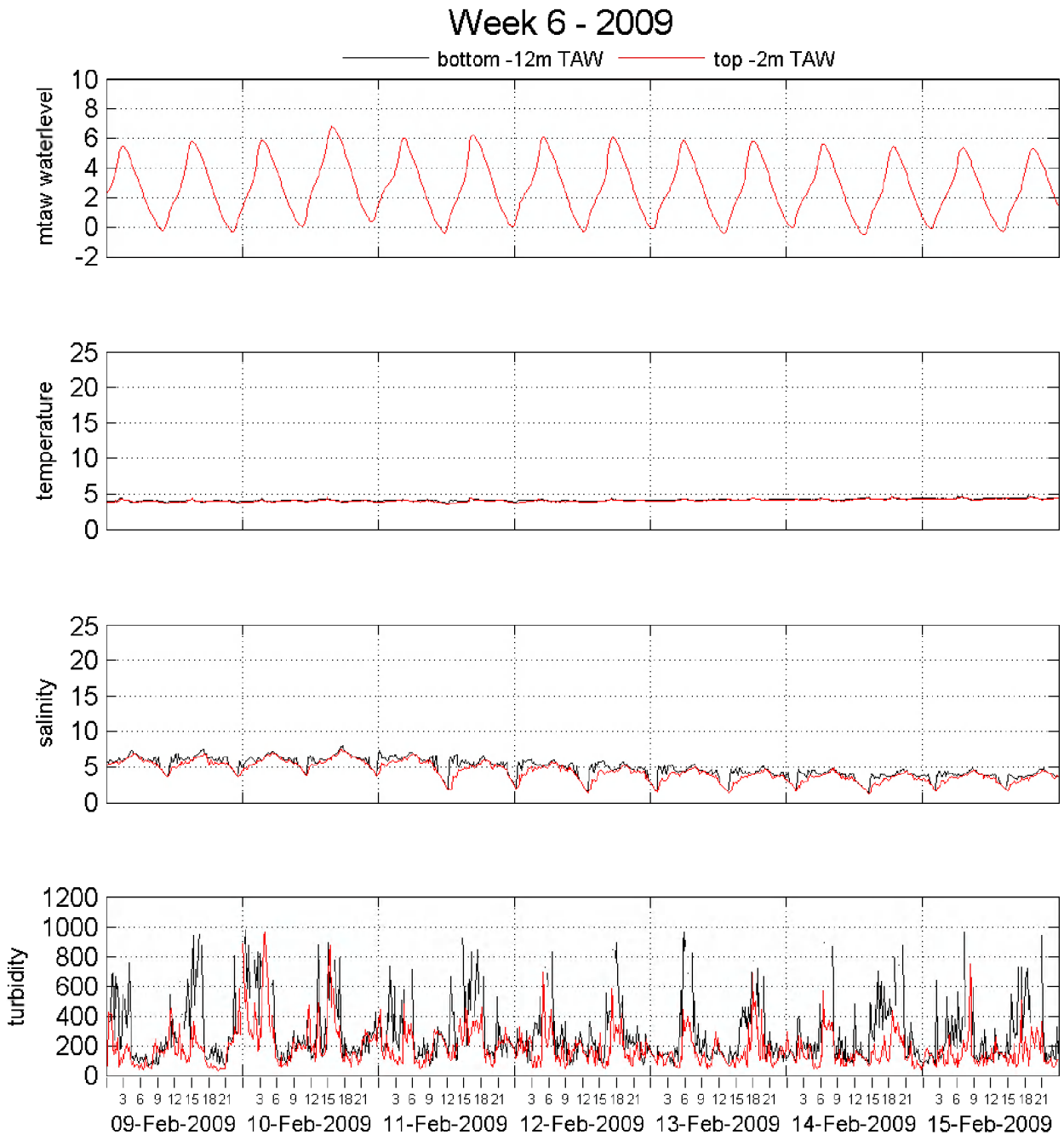

Week series of Salinity, Temperature, SS concentration and Tide

Processed

Location:

N entrance

I/RA/11283/08.094/MSA

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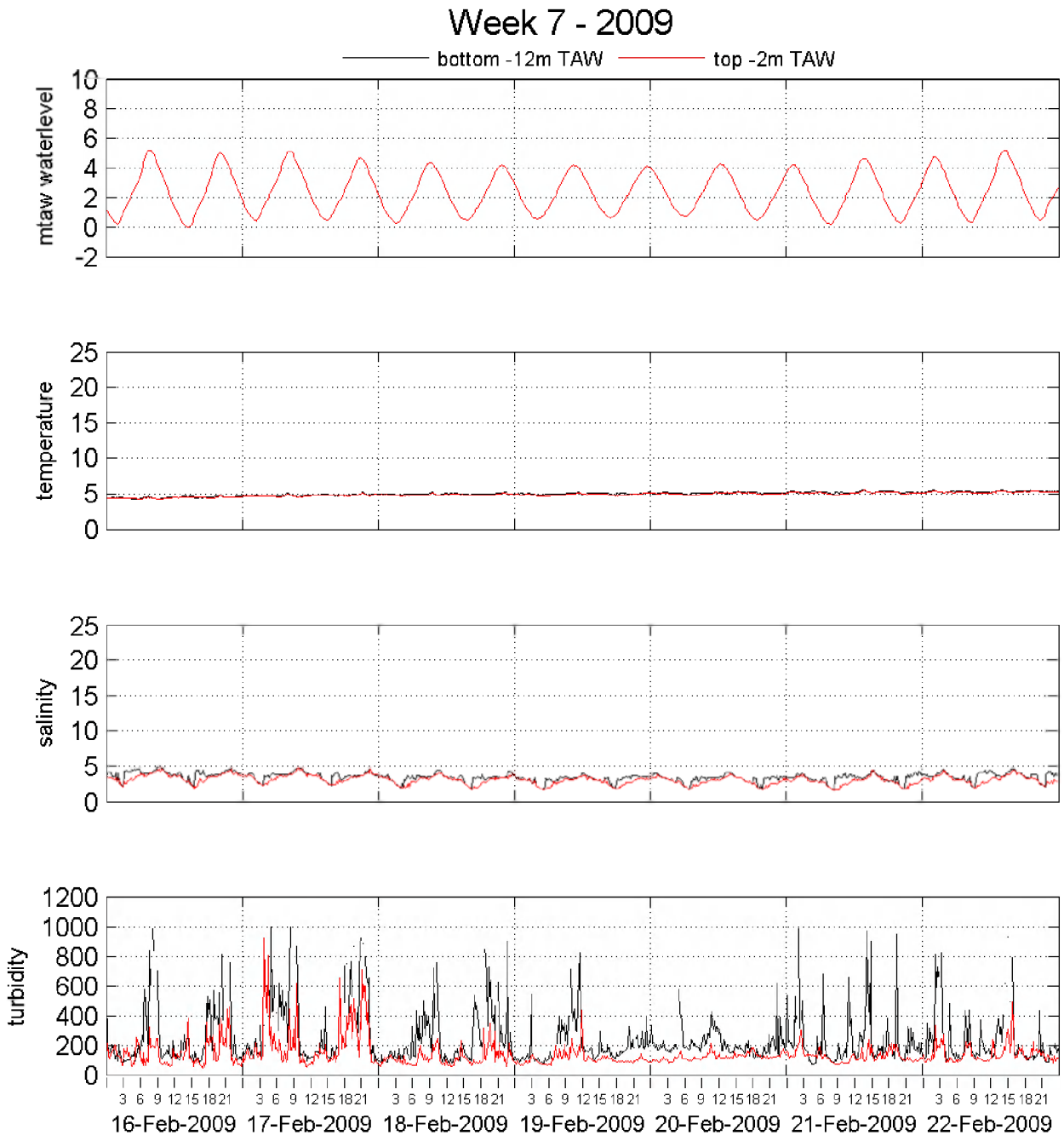

Week series of Salinity, Temperature, SS concentration and Tide

Processed

Location:

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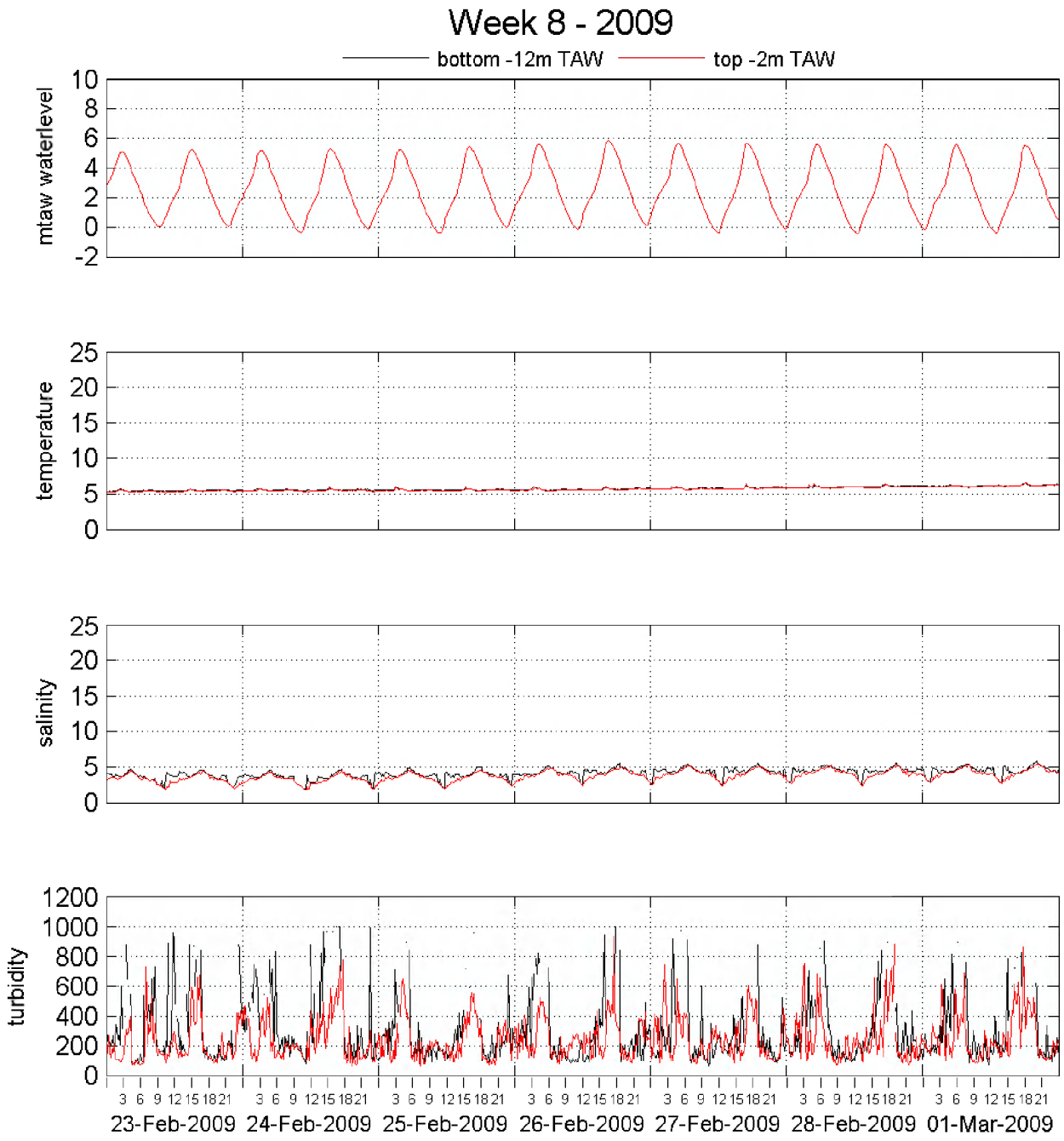

Week series of Salinity, Temperature, SS concentration and Tide

Processed

Location:

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I/RA/11283/08.094/MSA

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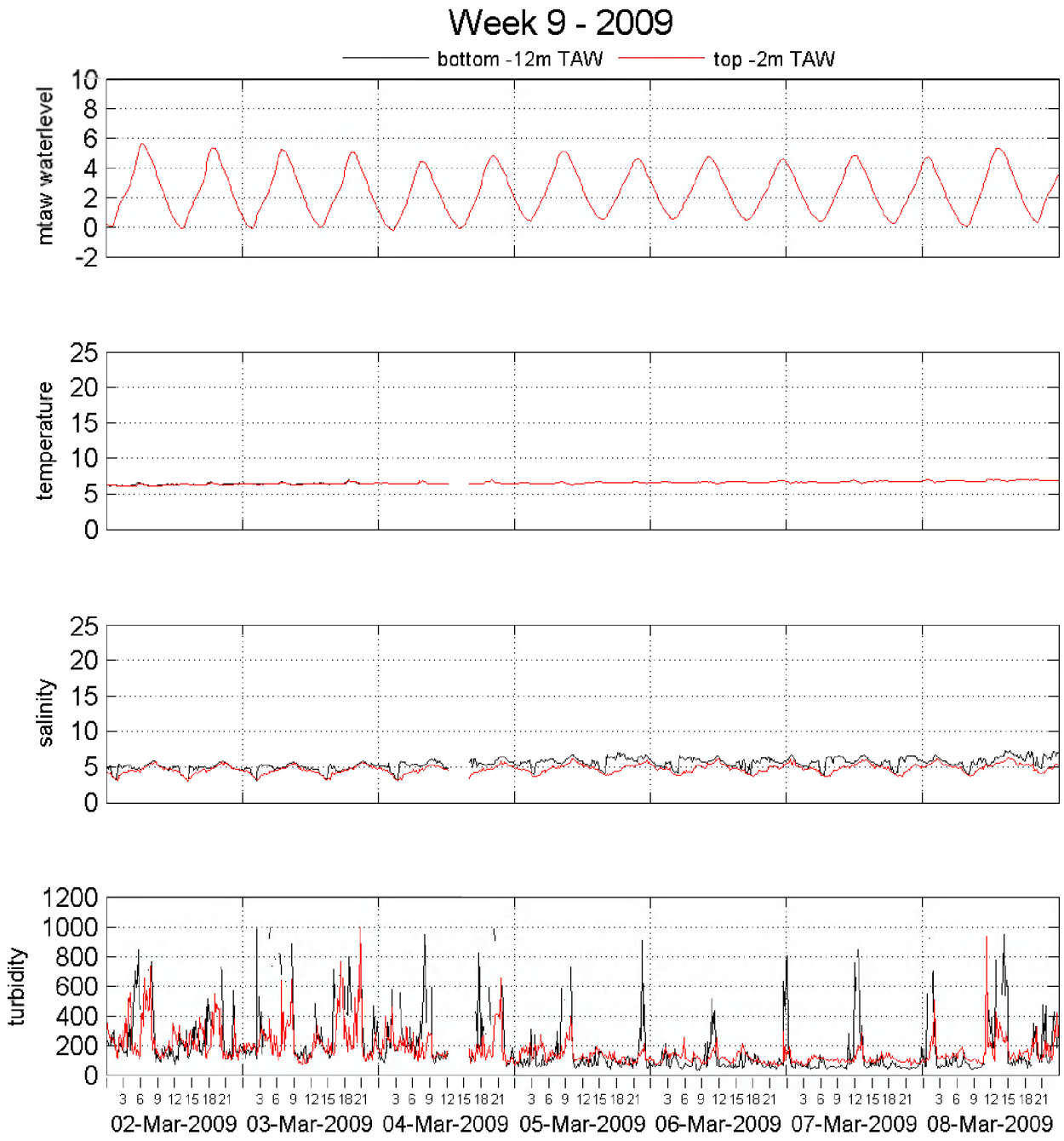

Week series of Salinity, Temperature, SS concentration and Tide

Processed

Location:

N entrance

I/RA/11283/08.094/MSA

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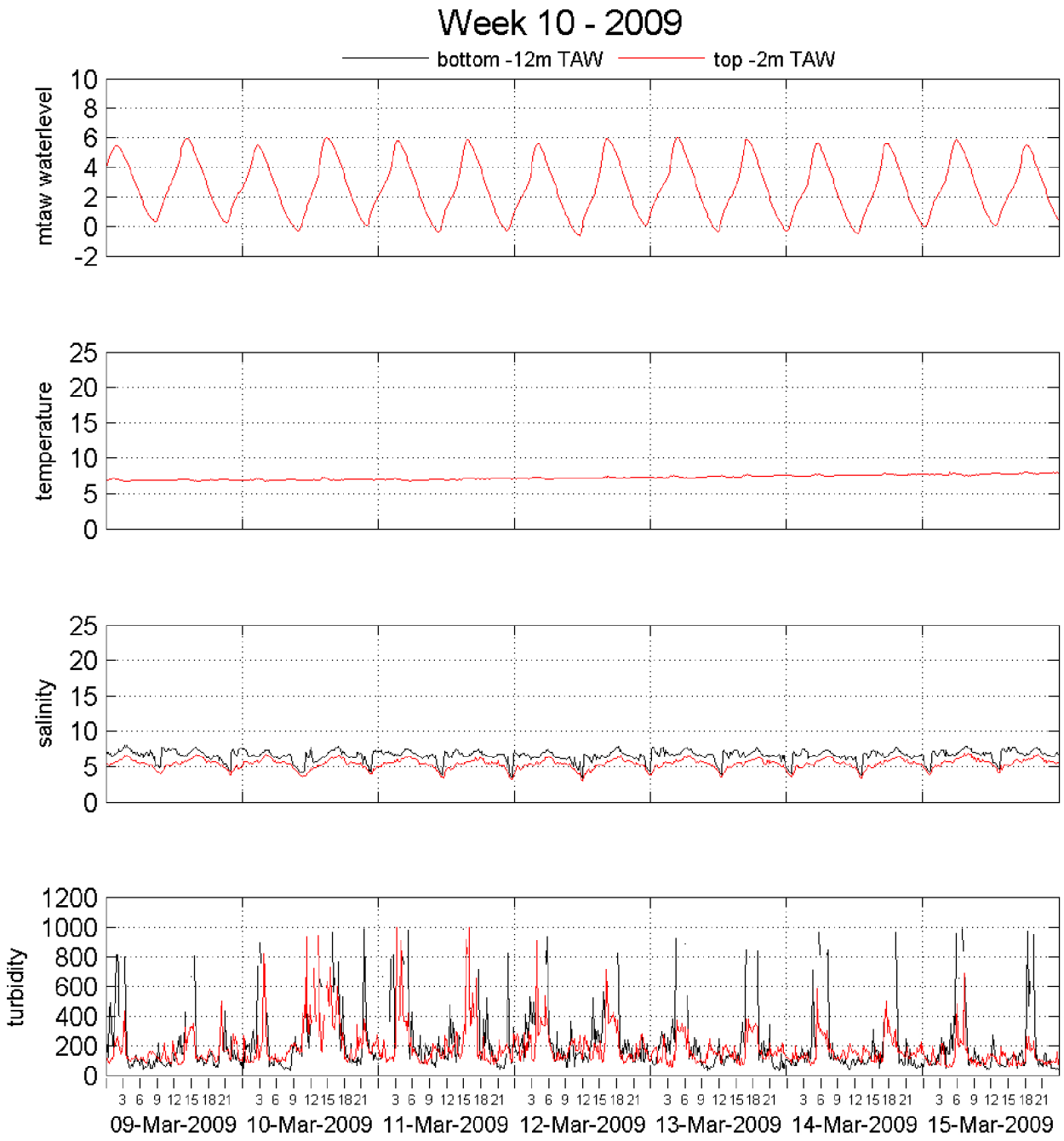


Week series of Salinity, Temperature, SS concentration and Tide

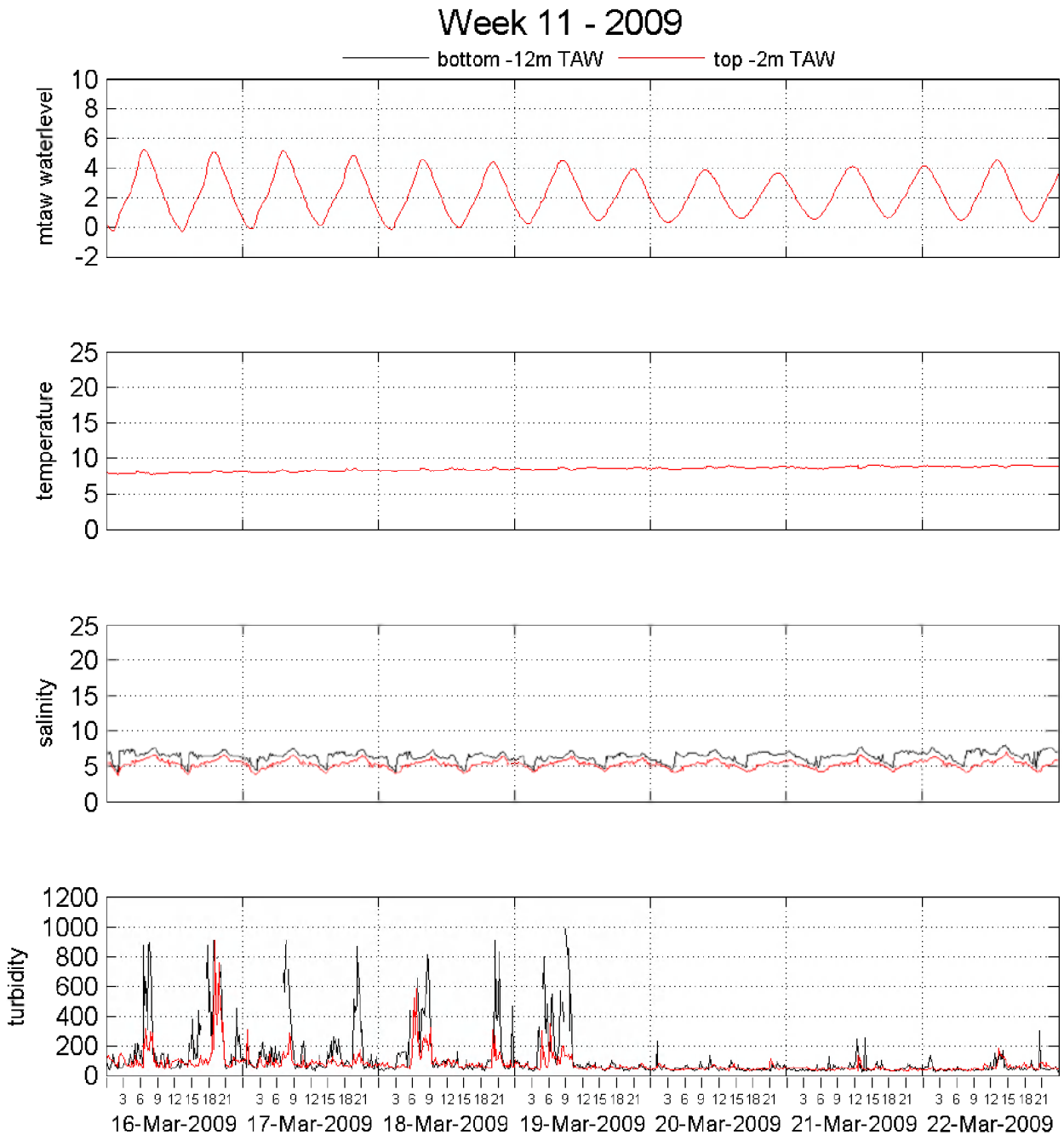
Processed

Location:

N entrance

I/RA/11283/08.094/MSA

11283



Week series of Salinity, Temperature, SS concentration and Tide

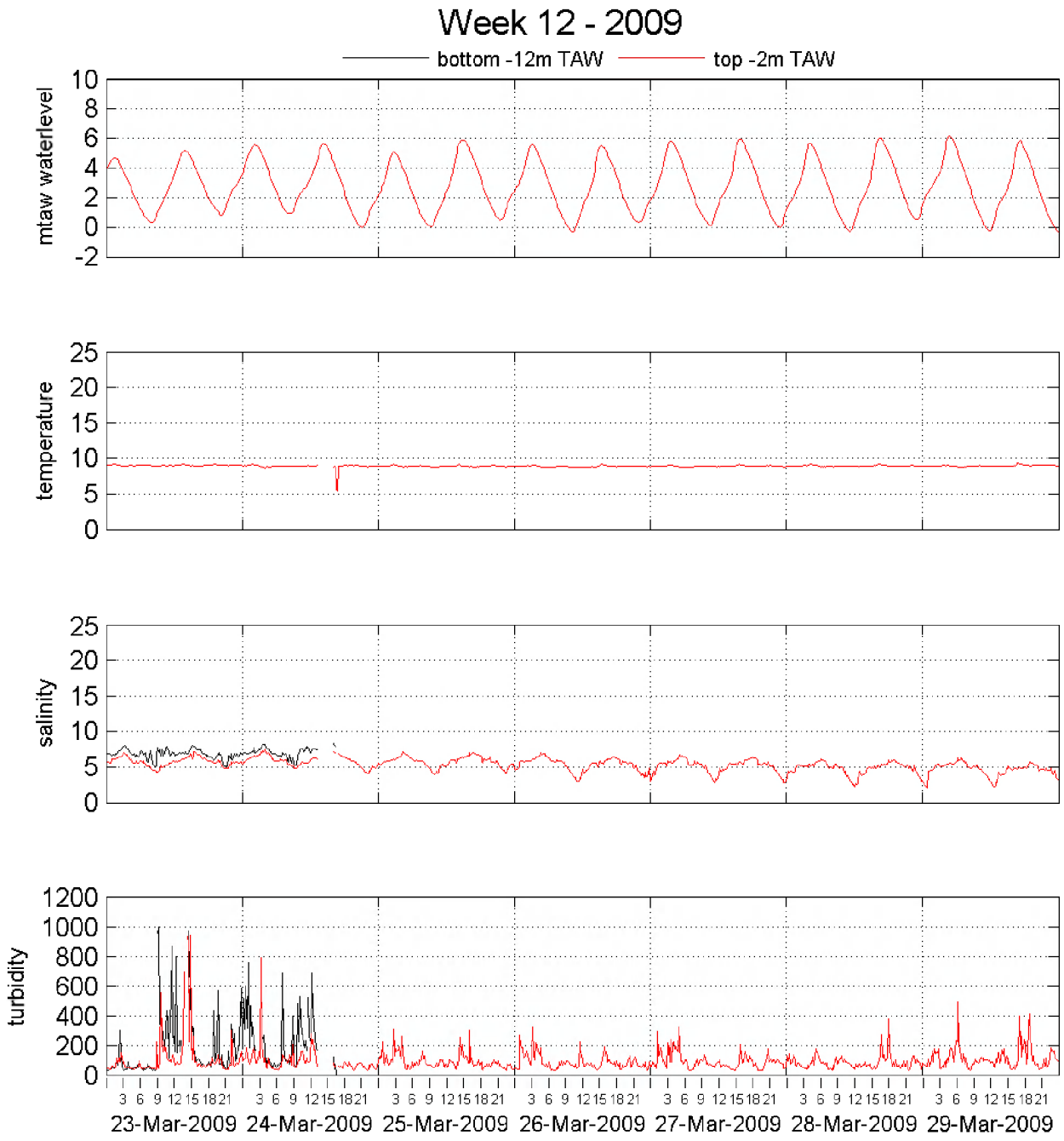
Processed

Location:

N entrance

I/RA/11283/08.094/MSA

11283



Week series of Salinity, Temperature, SS concentration and Tide

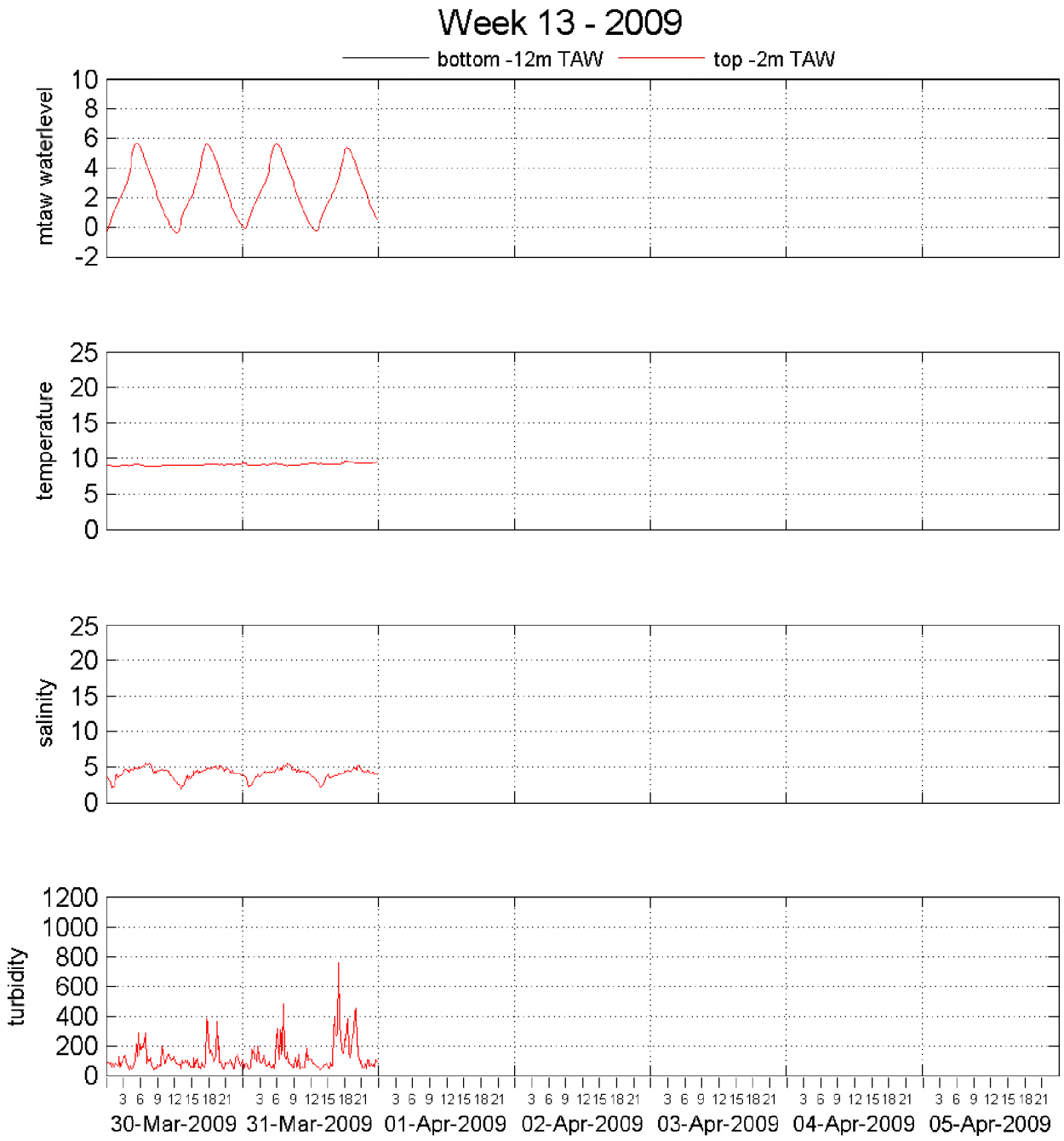
Processed

Location:

N entrance

I/RA/11283/08.094/MSA

11283



Week series of Salinity, Temperature, SS concentration and Tide

Processed

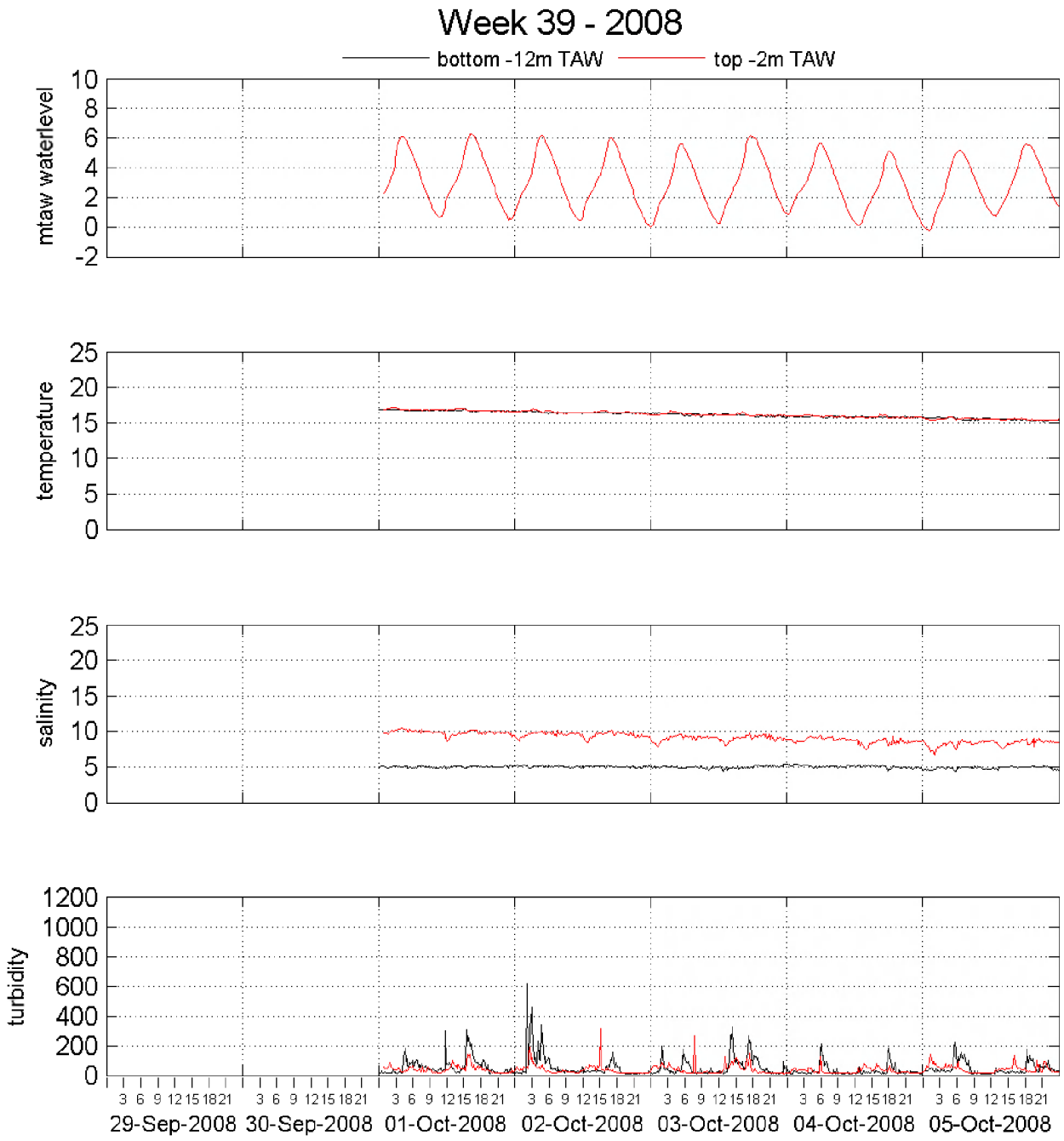
Location:

N entrance

I/RA/11283/08.094/MSA

B.2 S-ENTRANCE

11283



Week series of Salinity, Temperature, SS concentration and Tide

Processed

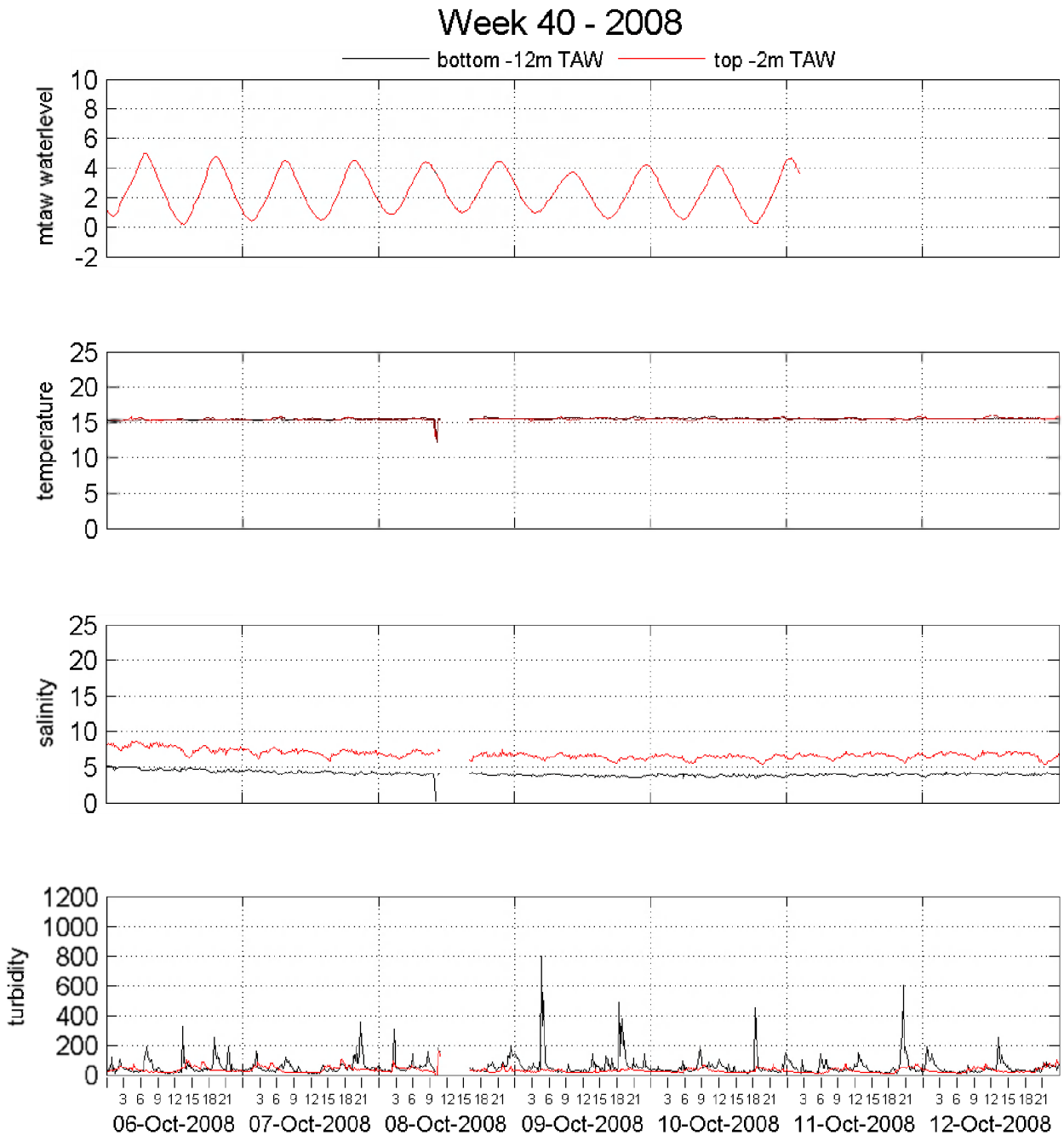
IMDC

Location:

S entrance

I/RA/11283/08.094/MSA

11283



Week series of Salinity, Temperature, SS concentration and Tide

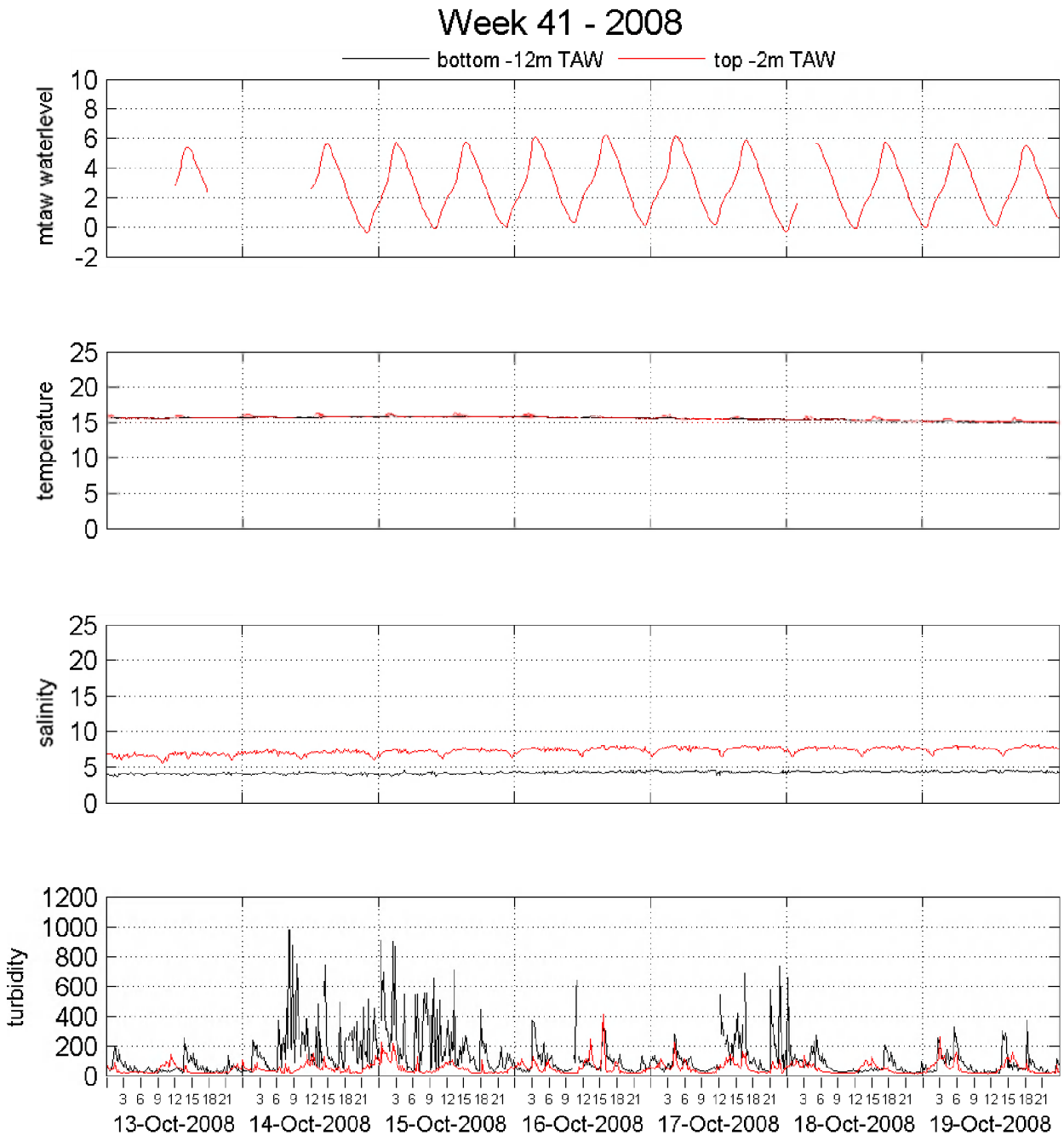
Processed

Location:

S entrance

I/RA/11283/08.094/MSA

11283



Week series of Salinity, Temperature, SS concentration and Tide

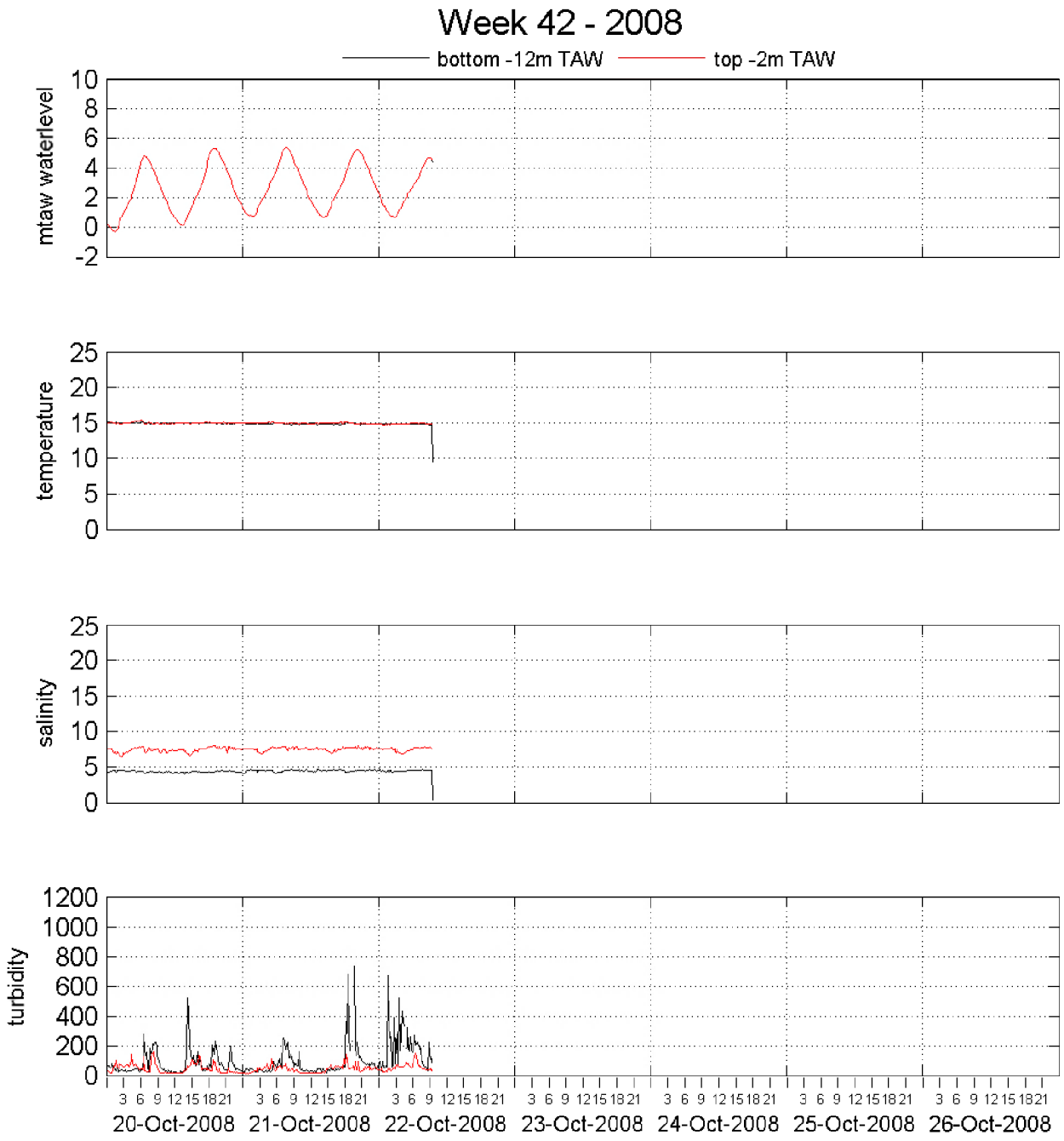
Processed

Location:

S entrance

I/RA/11283/08.094/MSA

11283



Week series of Salinity, Temperature, SS concentration and Tide

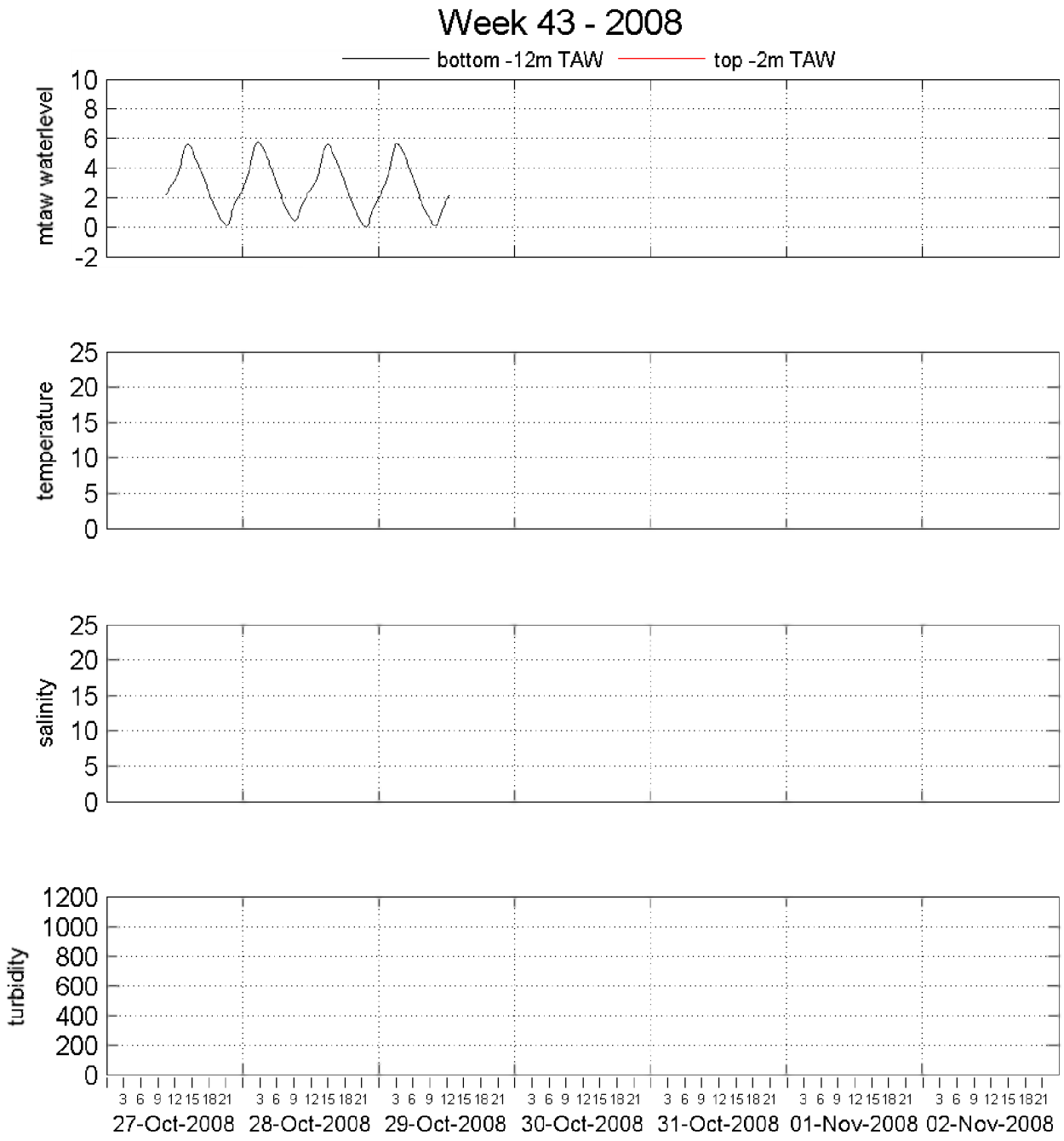
Processed

Location:

S entrance

I/RA/11283/08.094/MSA

11283



Week series of Salinity, Temperature, SS concentration and Tide

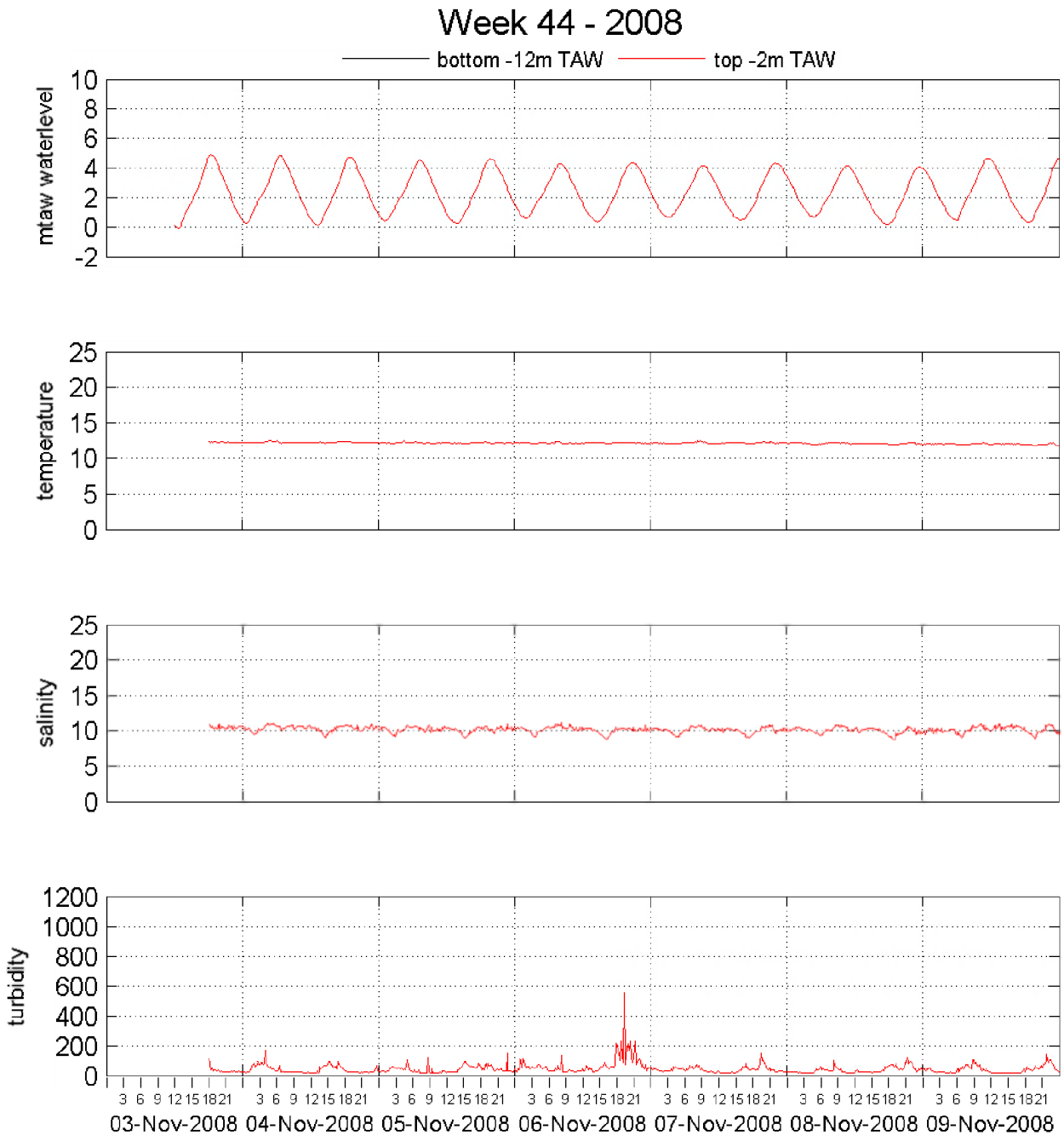
Processed

Location:

S entrance

I/RA/11283/08.094/MSA

11283



Week series of Salinity, Temperature, SS concentration and Tide

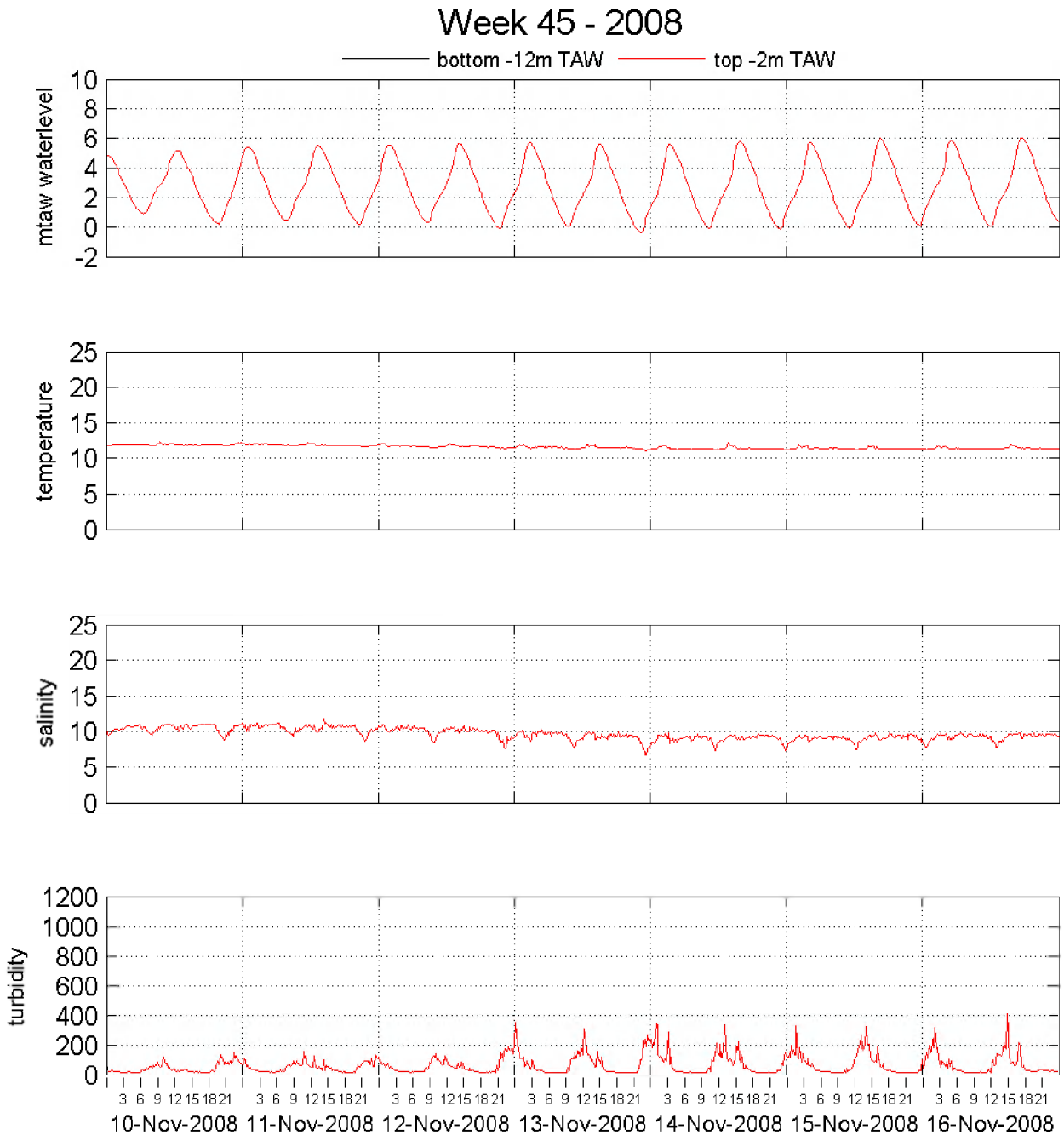
Processed

Location:

S entrance

I/RA/11283/08.094/MSA

11283



Week series of Salinity, Temperature, SS concentration and Tide

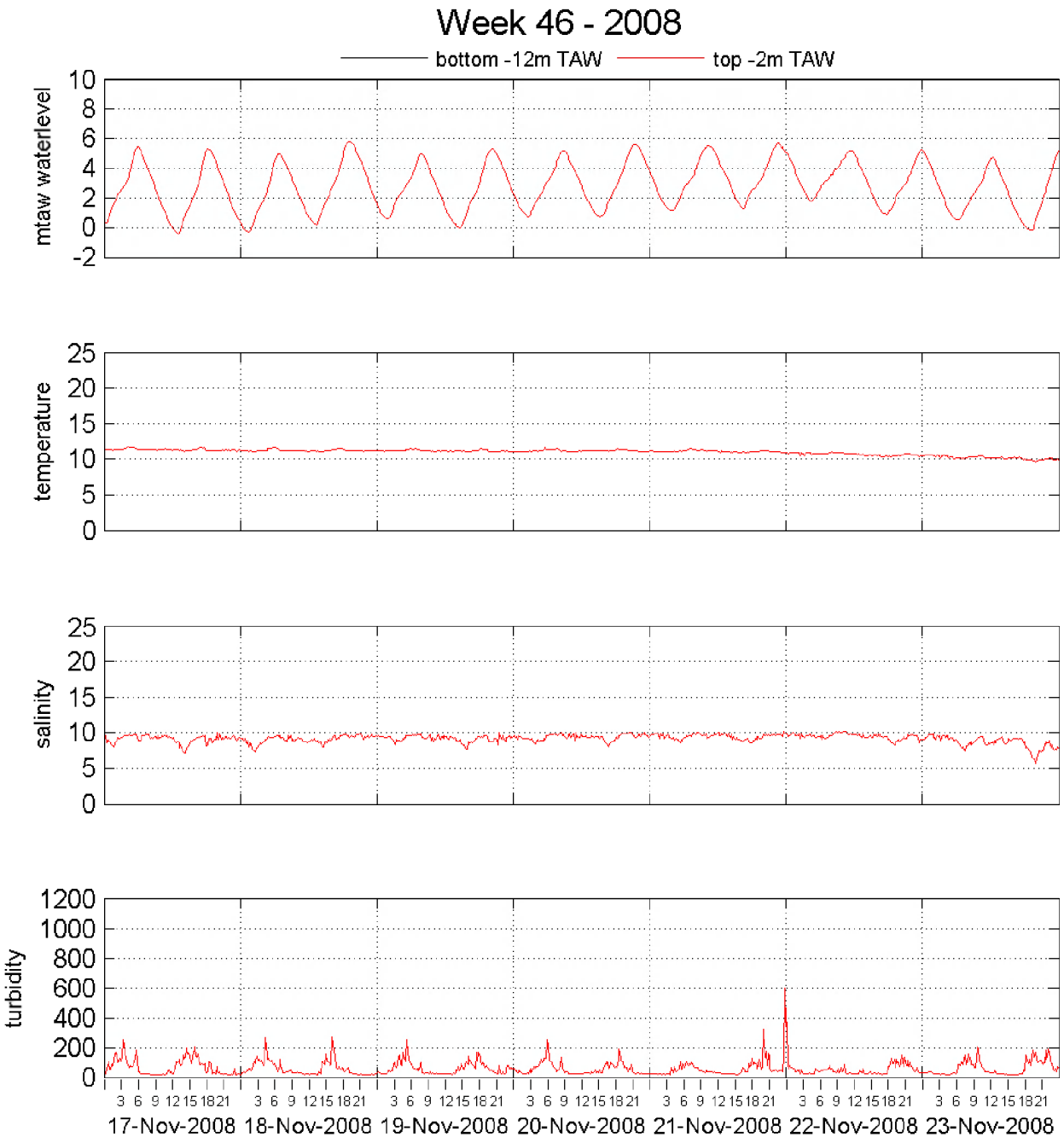
Processed

Location:

S entrance

I/RA/11283/08.094/MSA

11283



Week series of Salinity, Temperature, SS concentration and Tide

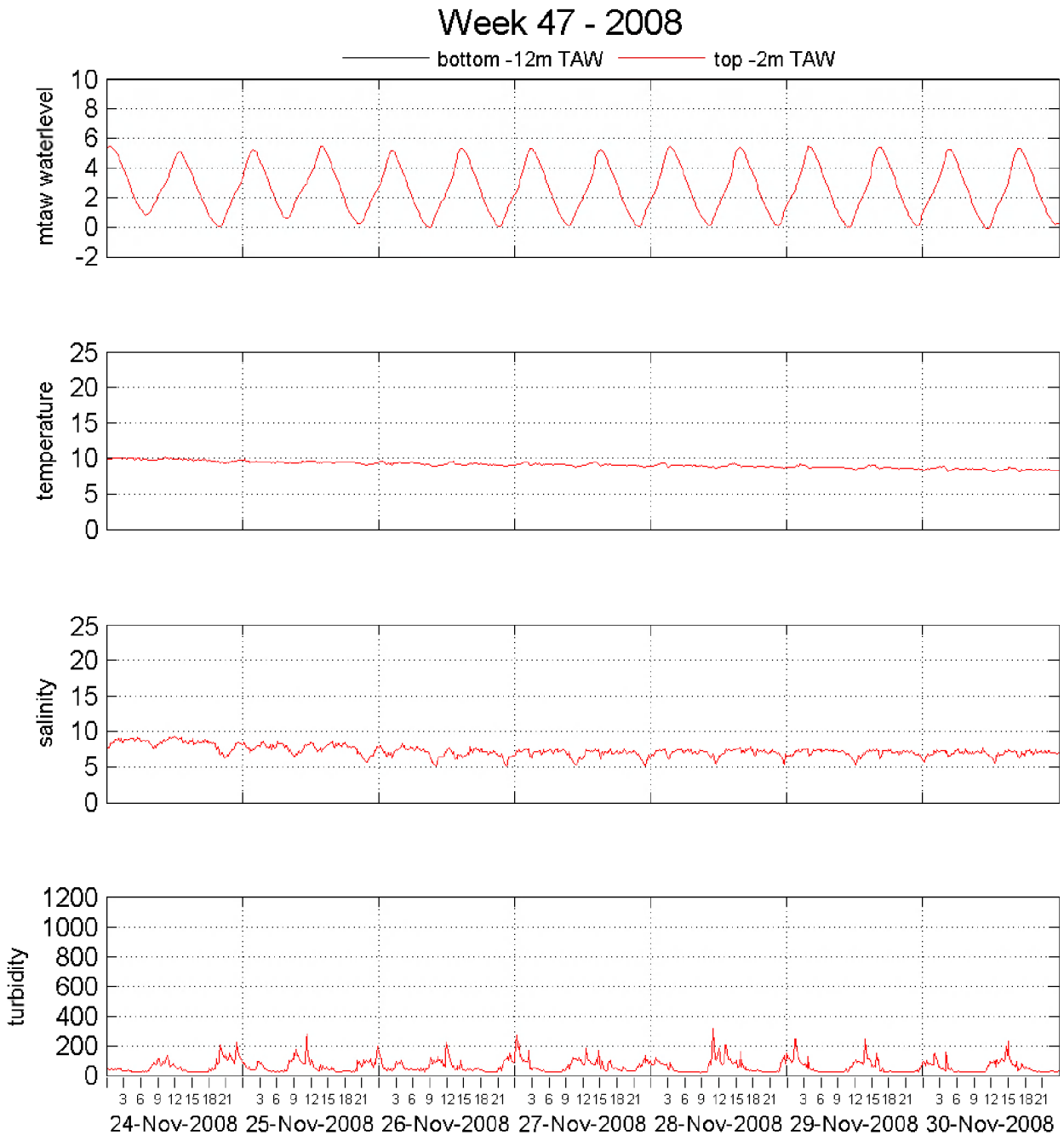
Processed

Location:

S entrance

I/RA/11283/08.094/MSA

11283



Week series of Salinity, Temperature, SS concentration and Tide

Processed

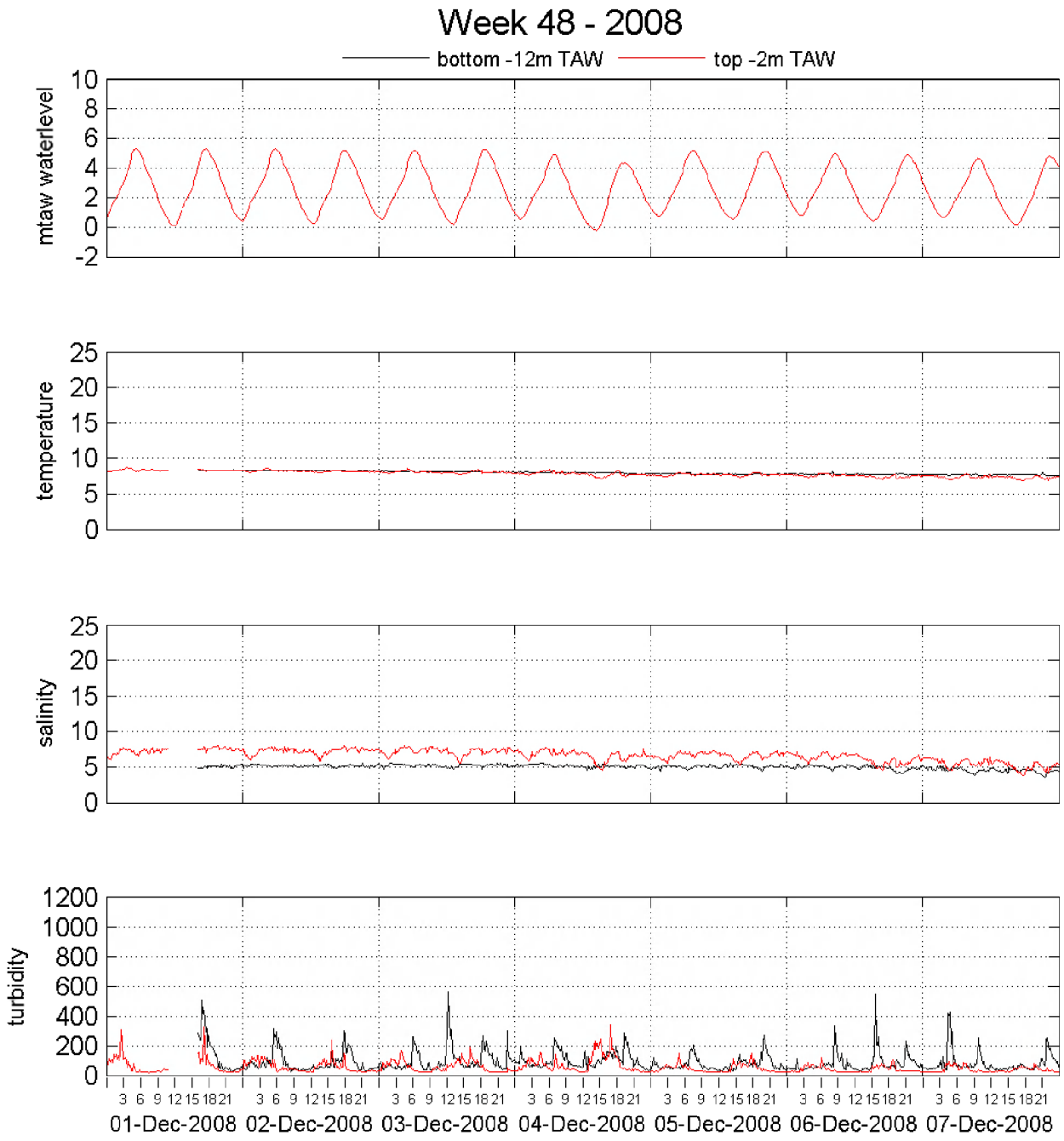
IMDC

Location:

S entrance

I/RA/11283/08.094/MSA

11283



Week series of Salinity, Temperature, SS concentration and Tide

Processed

Location:

S entrance

I/RA/11283/08.094/MSA

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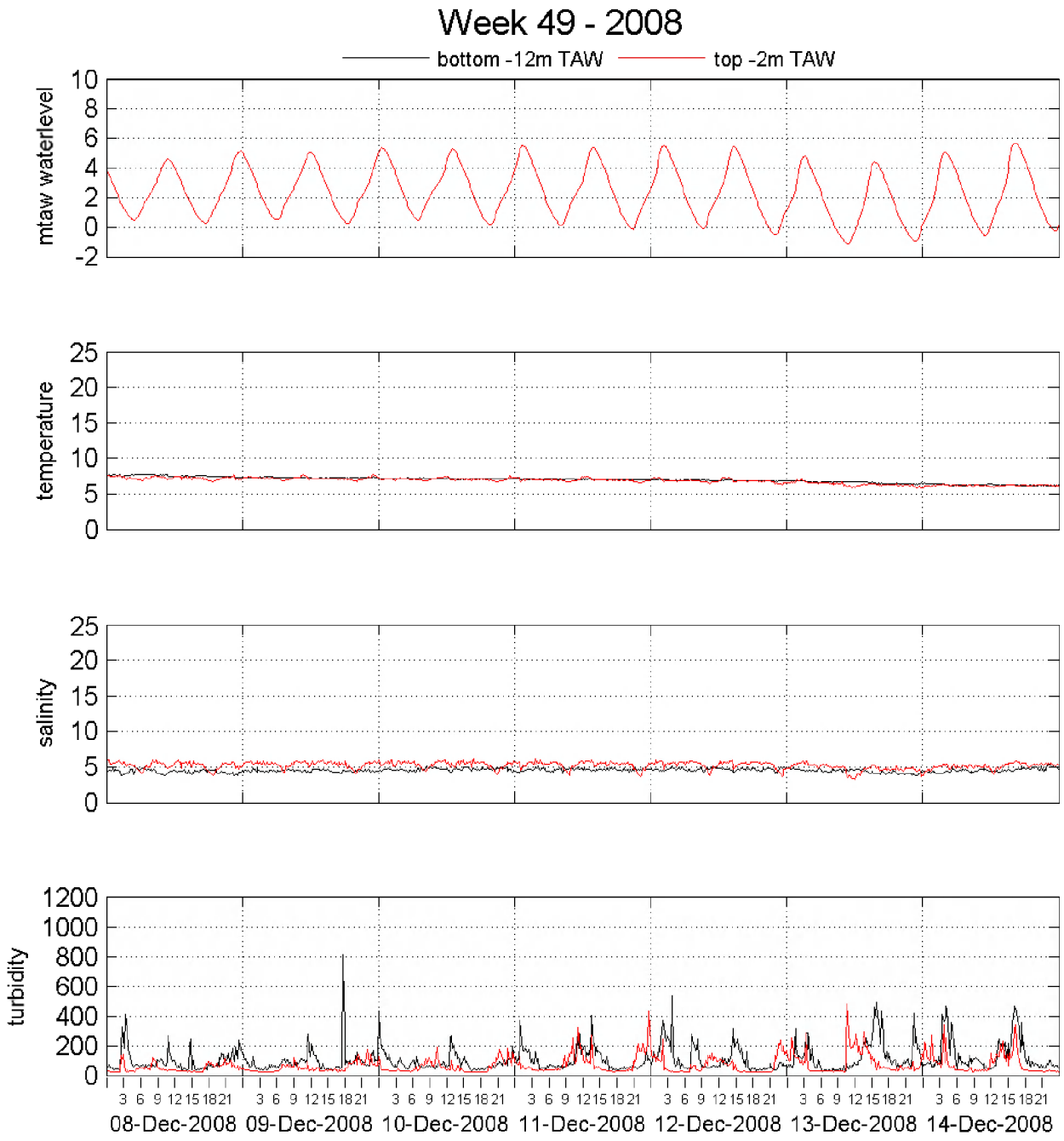

Week series of Salinity, Temperature, SS concentration and Tide

Processed

Location:

S entrance

I/RA/11283/08.094/MSA

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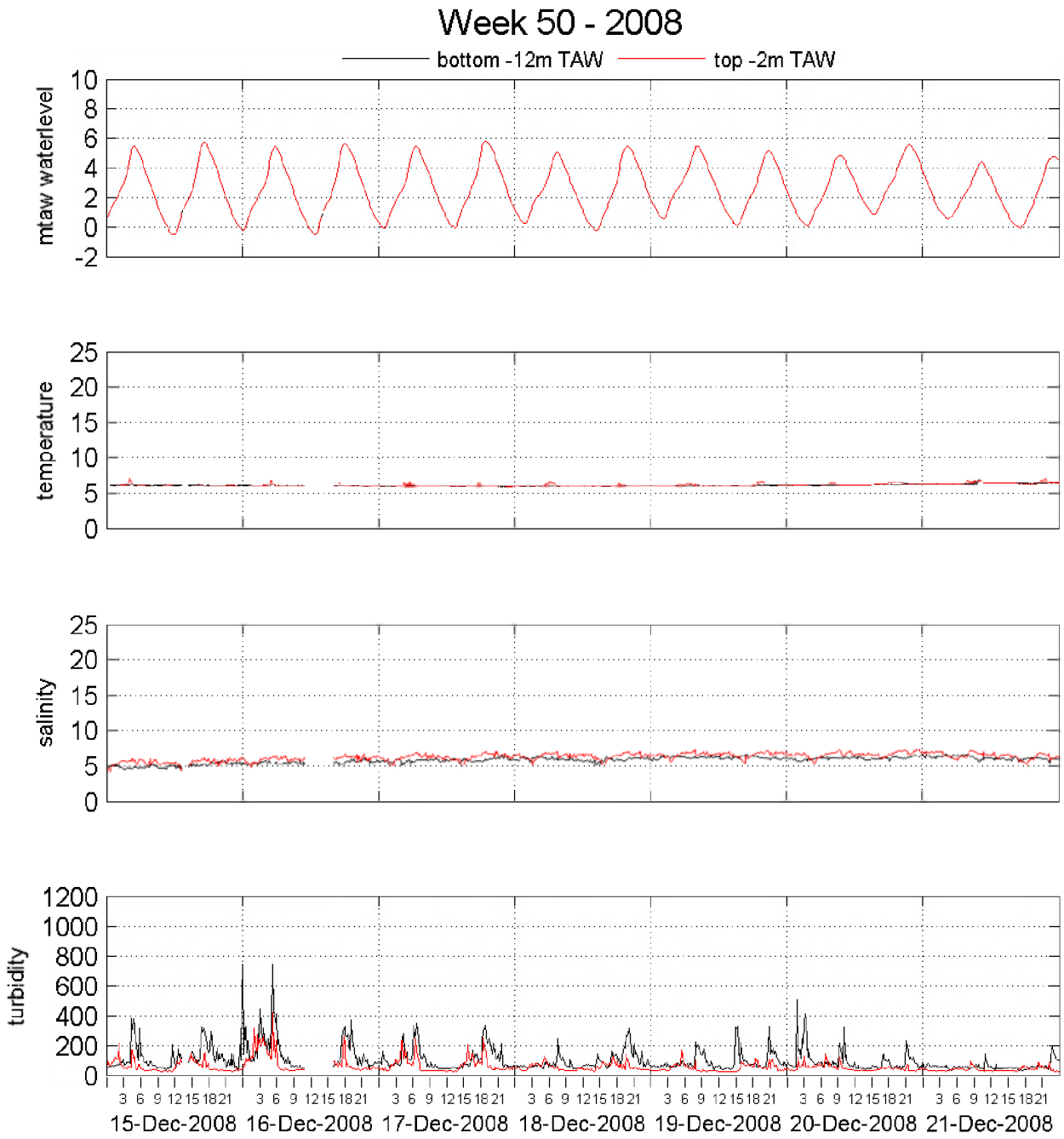

Week series of Salinity, Temperature, SS concentration and Tide

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Location:

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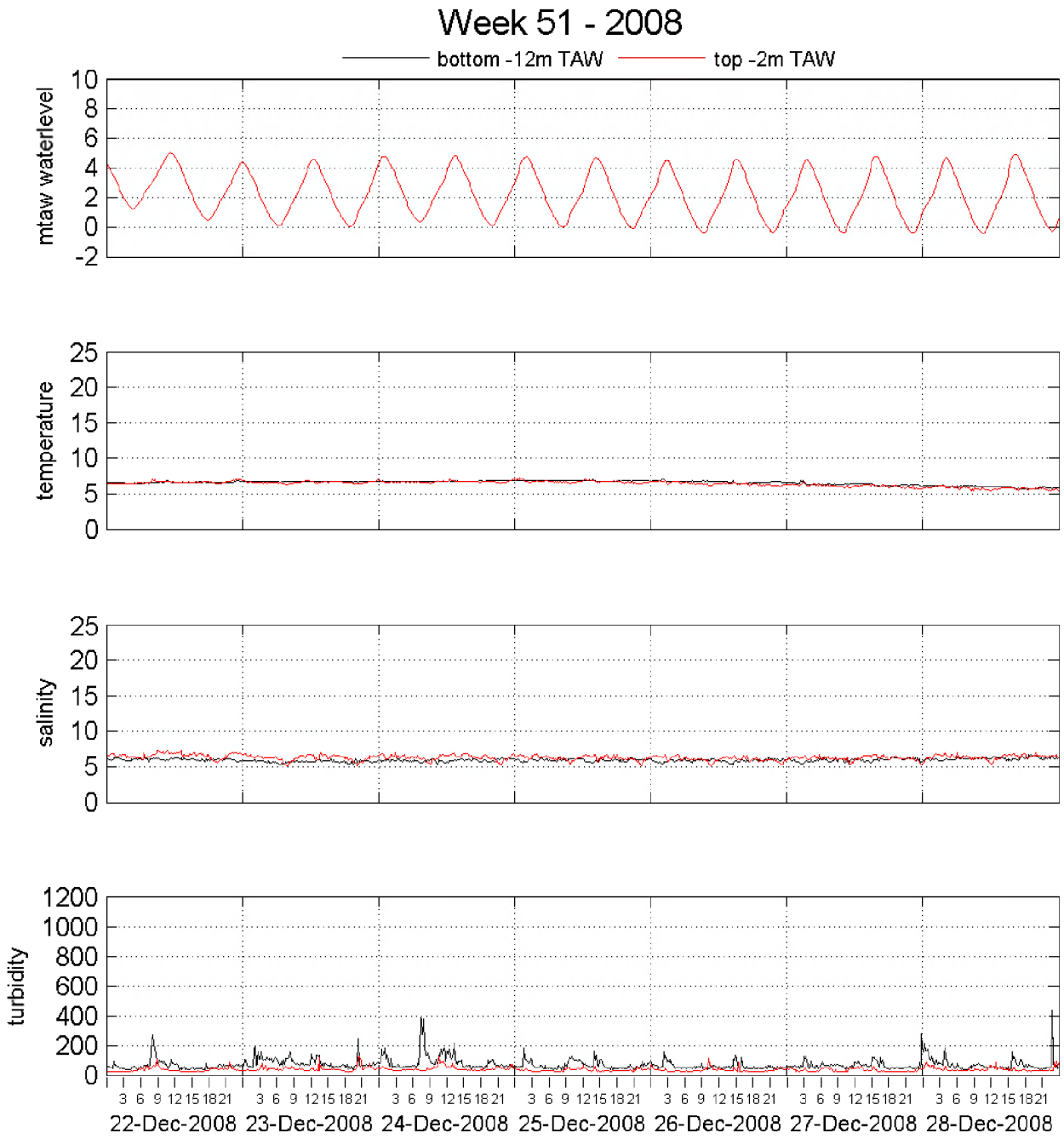

Week series of Salinity, Temperature, SS concentration and Tide

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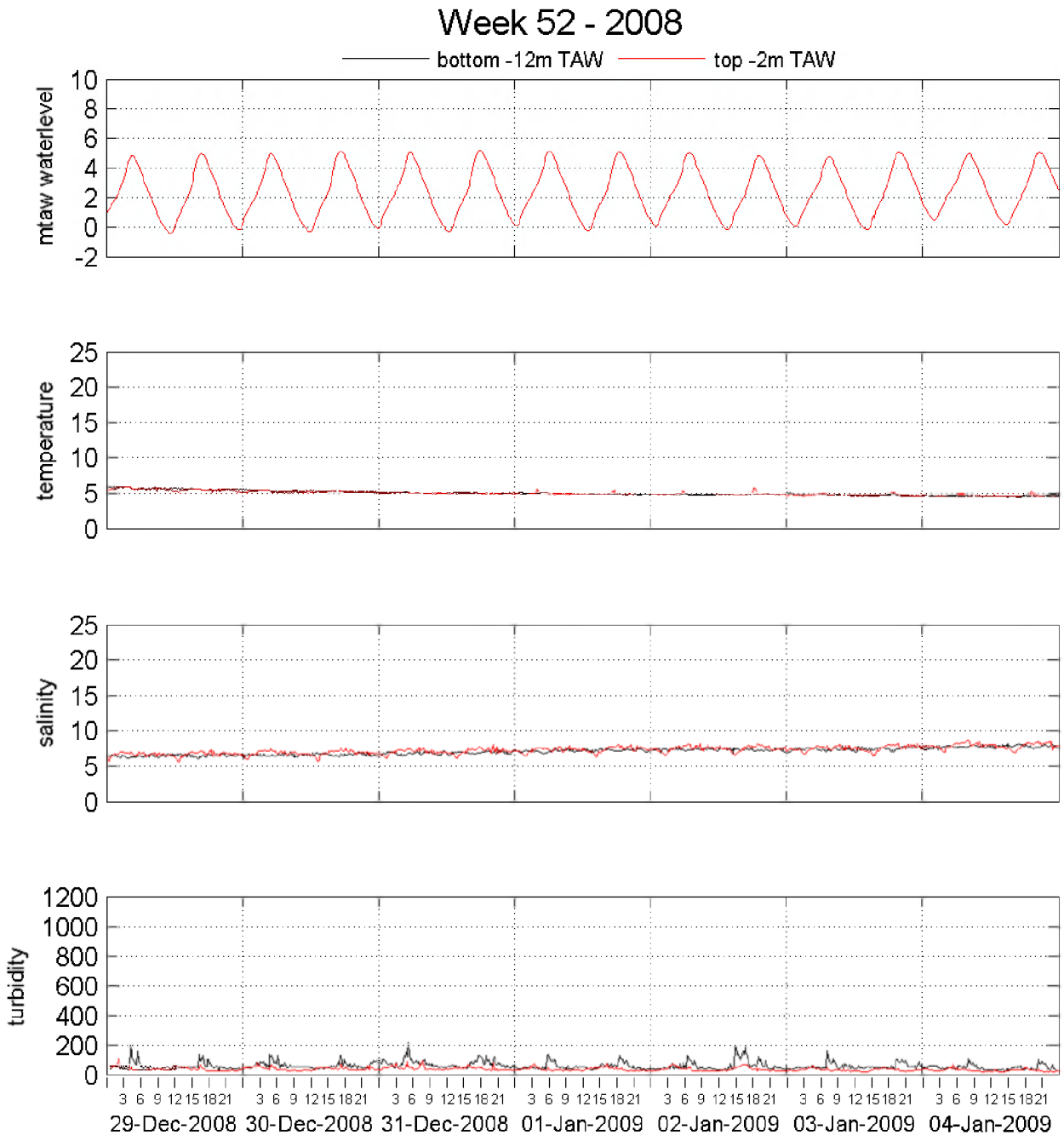

Week series of Salinity, Temperature, SS concentration and Tide

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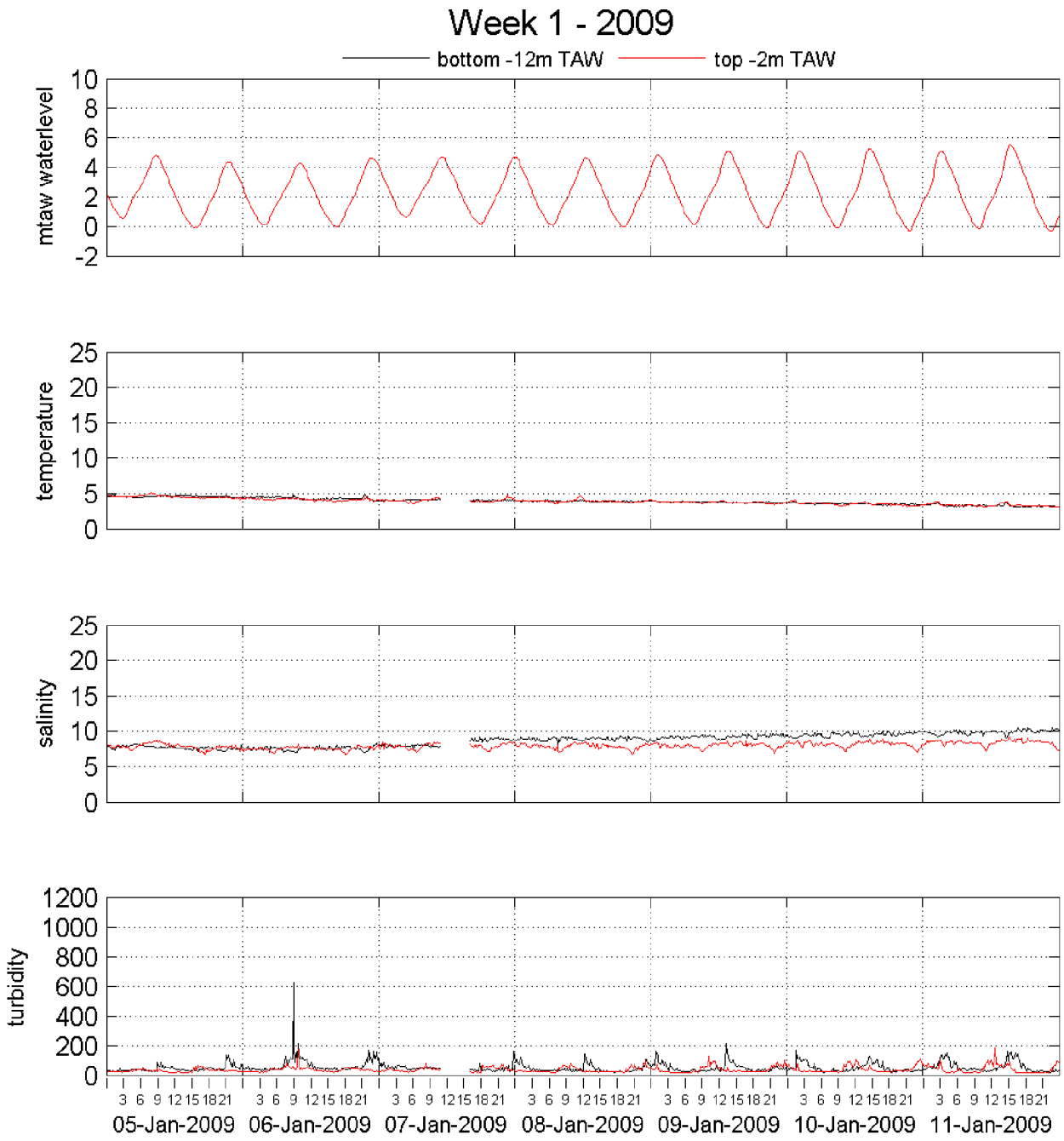
Location:

S entrance

I/RA/11283/08.094/MSA

11283



Week series of Salinity, Temperature, SS concentration and Tide

Processed

IMDC

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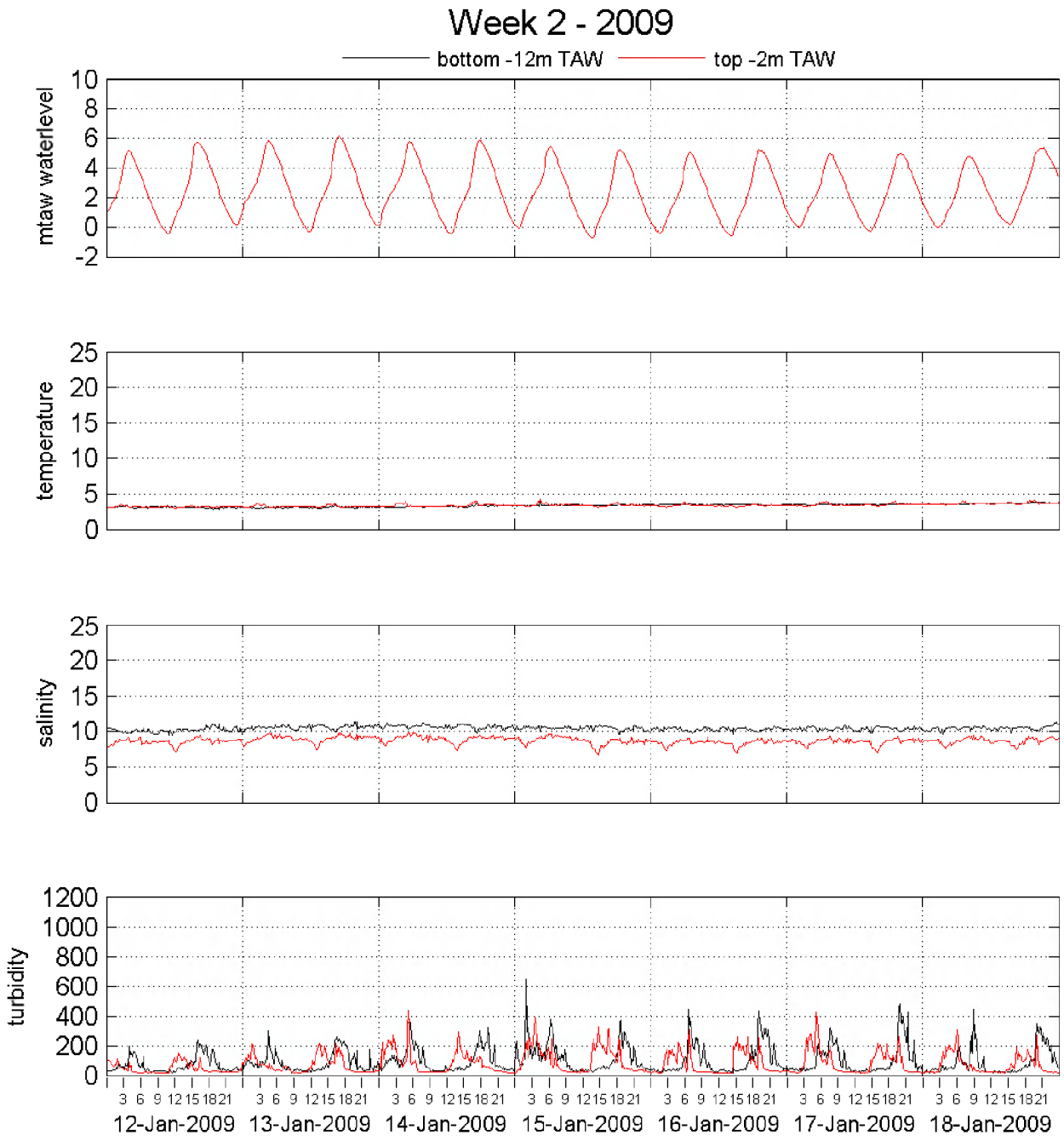
Location:

S entrance

I/RA/11283/08.094/MSA

11283



Week series of Salinity, Temperature, SS concentration and Tide

Processed

Location:

S entrance

I/RA/11283/08.094/MSA

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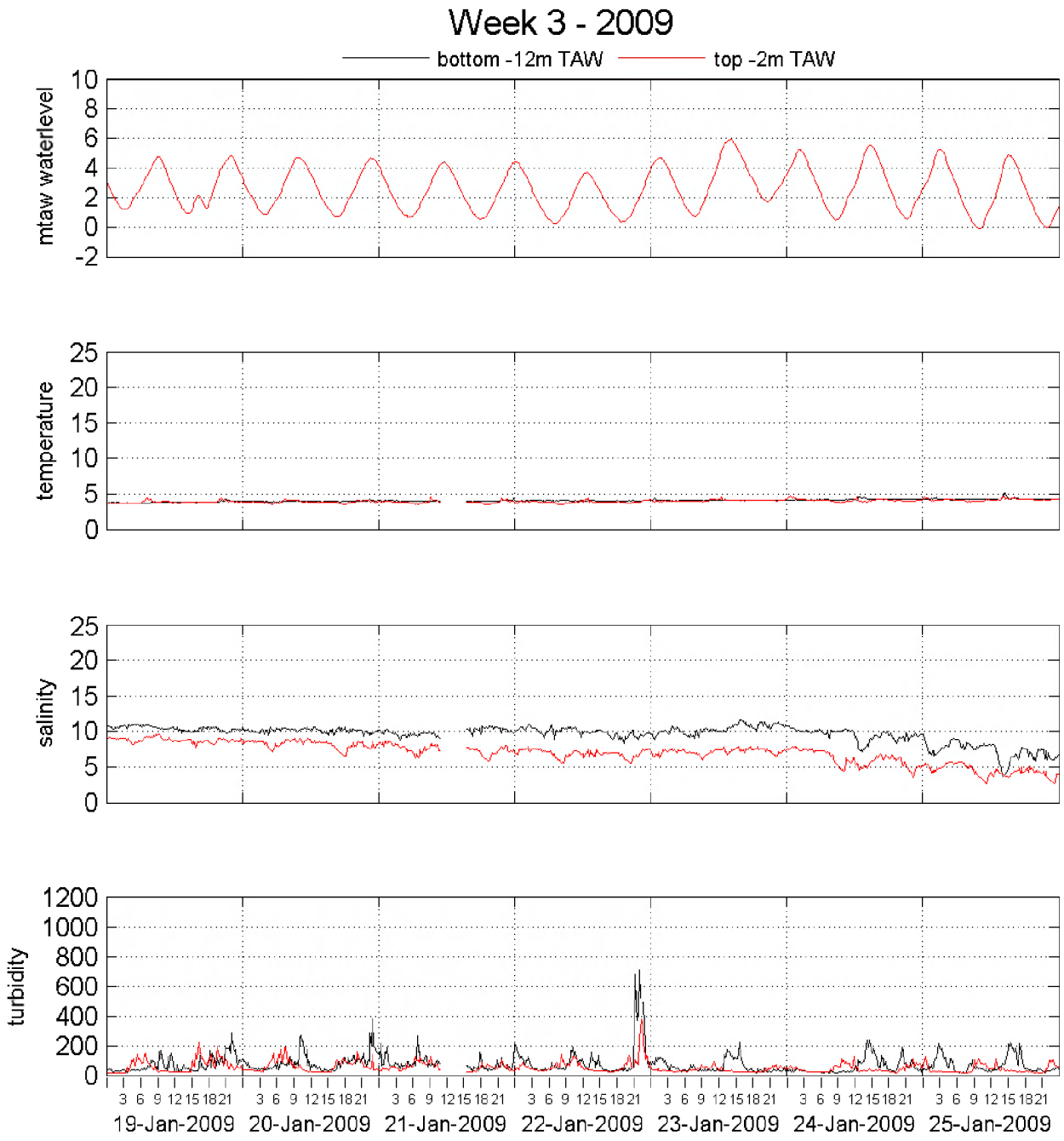

Week series of Salinity, Temperature, SS concentration and Tide

Processed

Location:

S entrance

I/RA/11283/08.094/MSA

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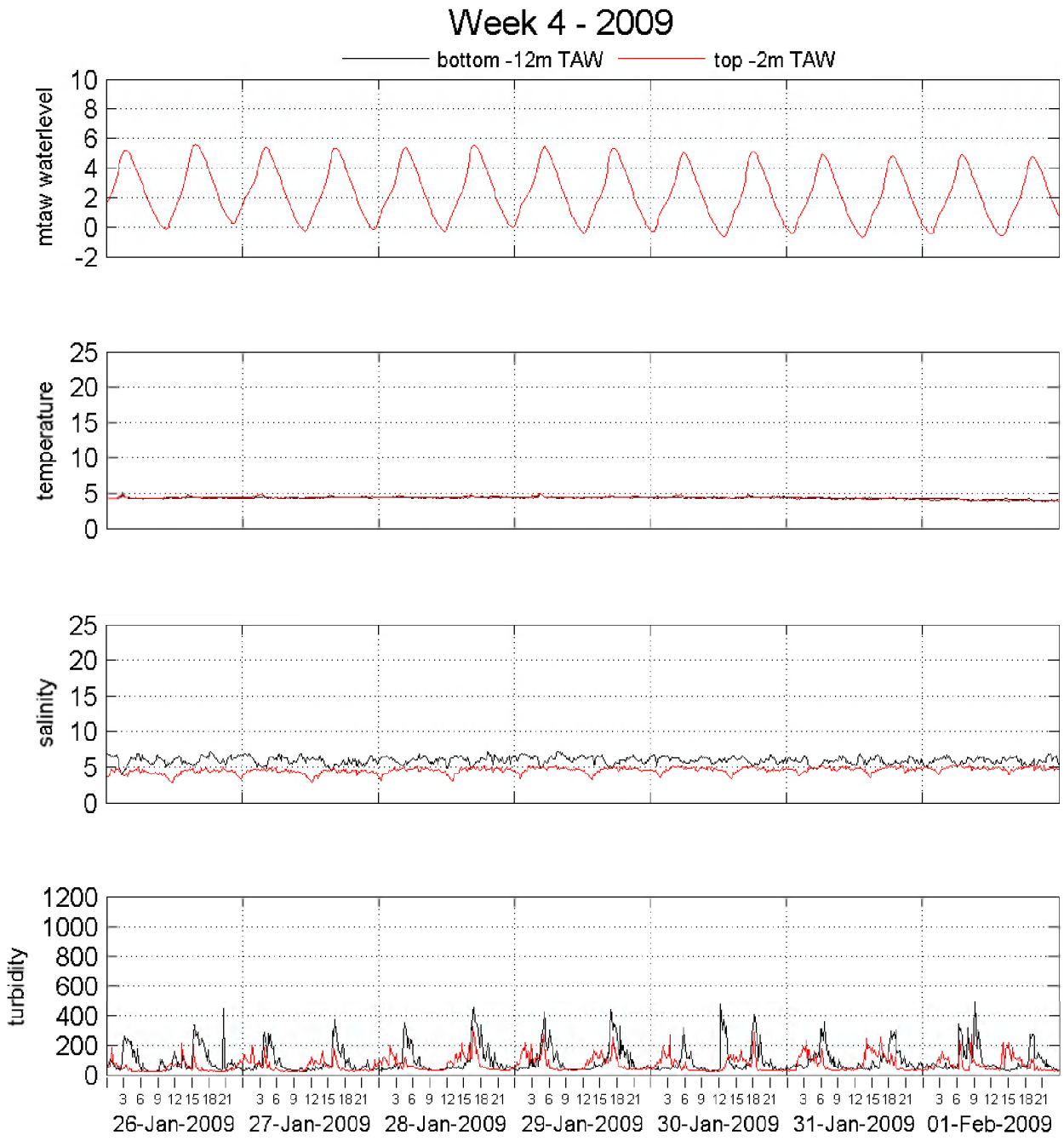


Week series of Salinity, Temperature, SS concentration and Tide

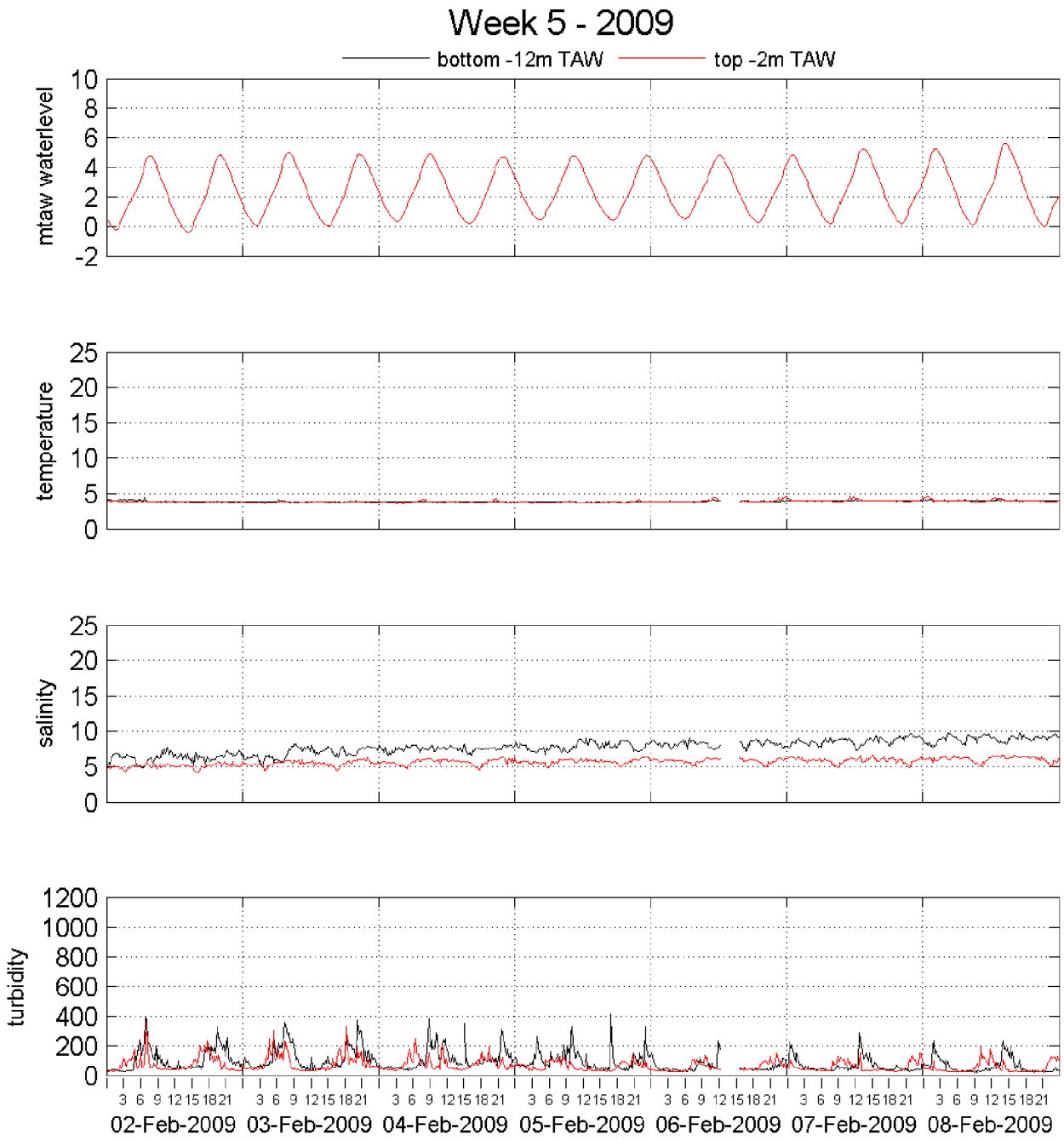
Processed

Location:

S entrance

I/RA/11283/08.094/MSA

11283



Week series of Salinity, Temperature, SS concentration and Tide

Processed

Location:

S entrance

I/RA/11283/08.094/MSA

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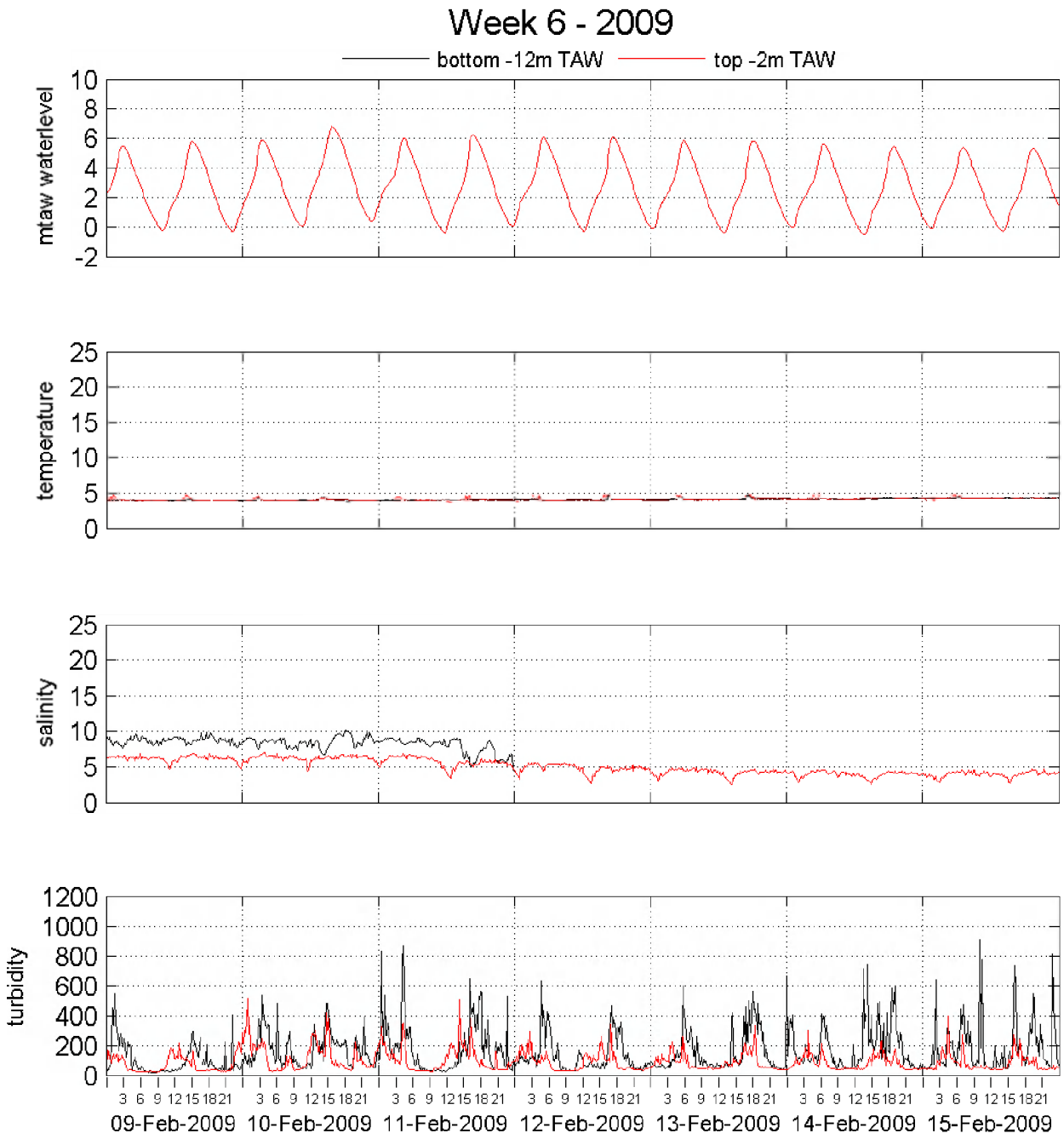

Week series of Salinity, Temperature, SS concentration and Tide

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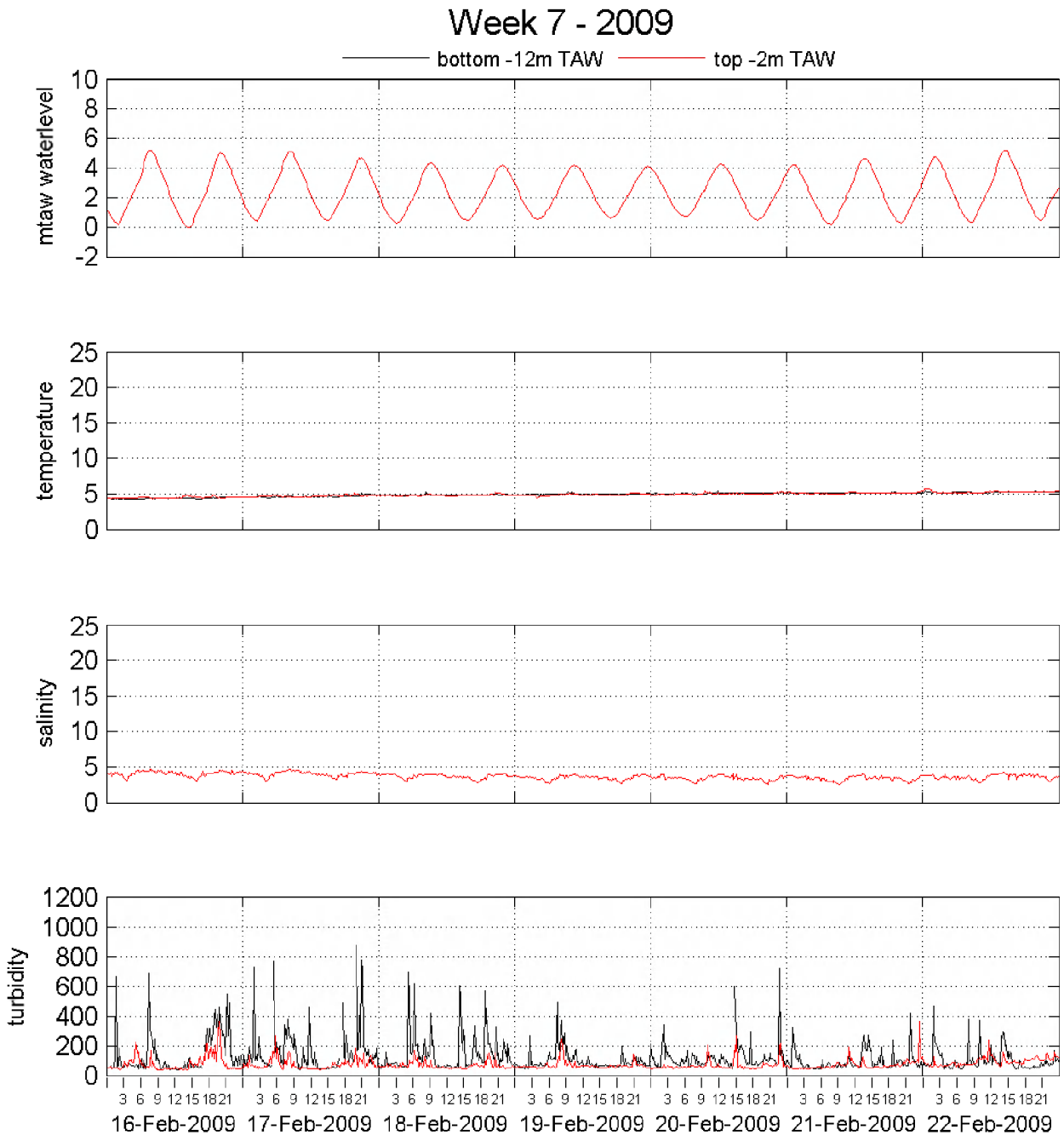
Location:

S entrance

I/RA/11283/08.094/MSA

11283



Week series of Salinity, Temperature, SS concentration and Tide

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Location:

S entrance

I/RA/11283/08.094/MSA

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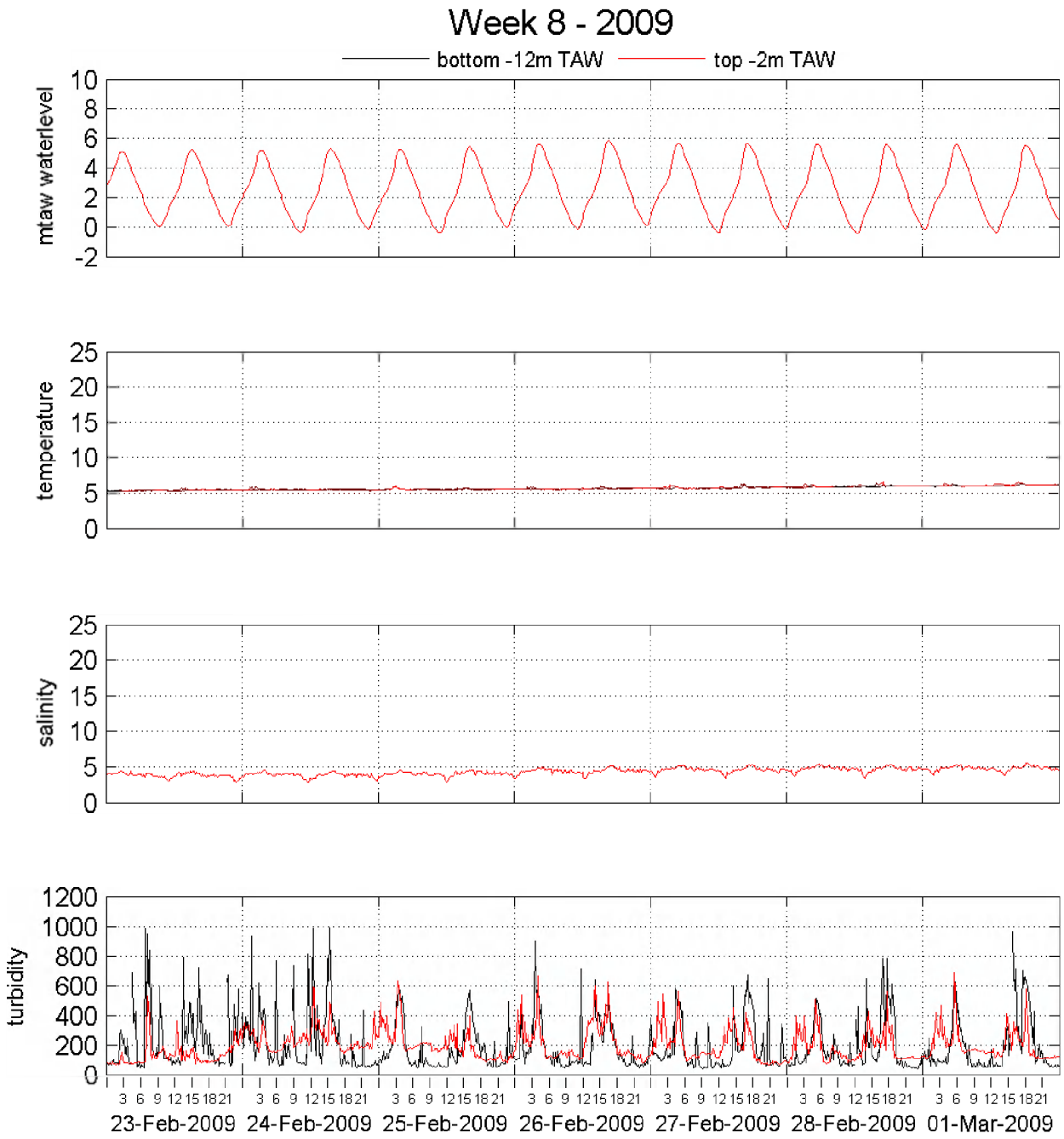

Week series of Salinity, Temperature, SS concentration and Tide

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Location:

S entrance

I/RA/11283/08.094/MSA

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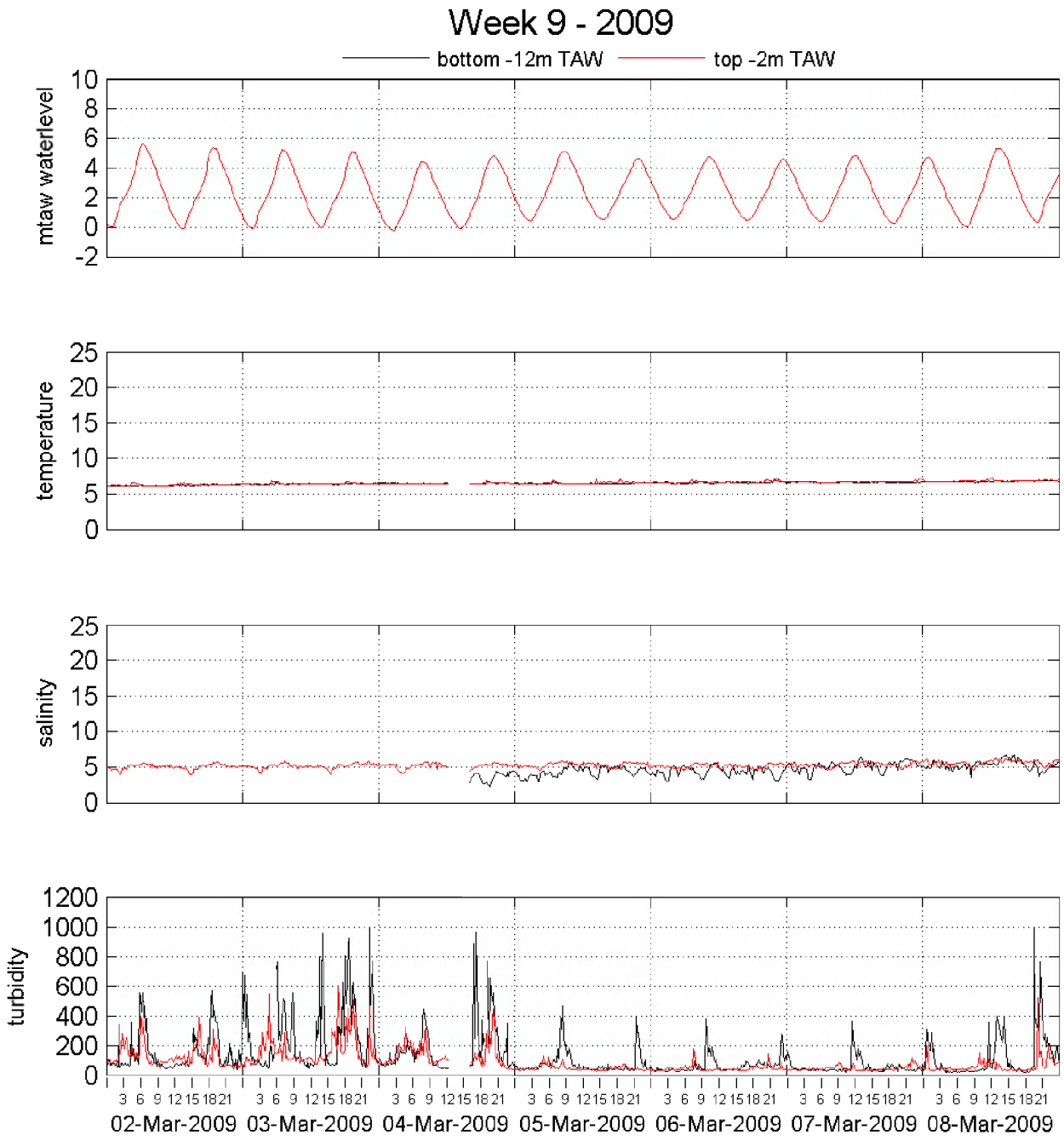

Week series of Salinity, Temperature, SS concentration and Tide

Processed

Location:

S entrance

I/RA/11283/08.094/MSA

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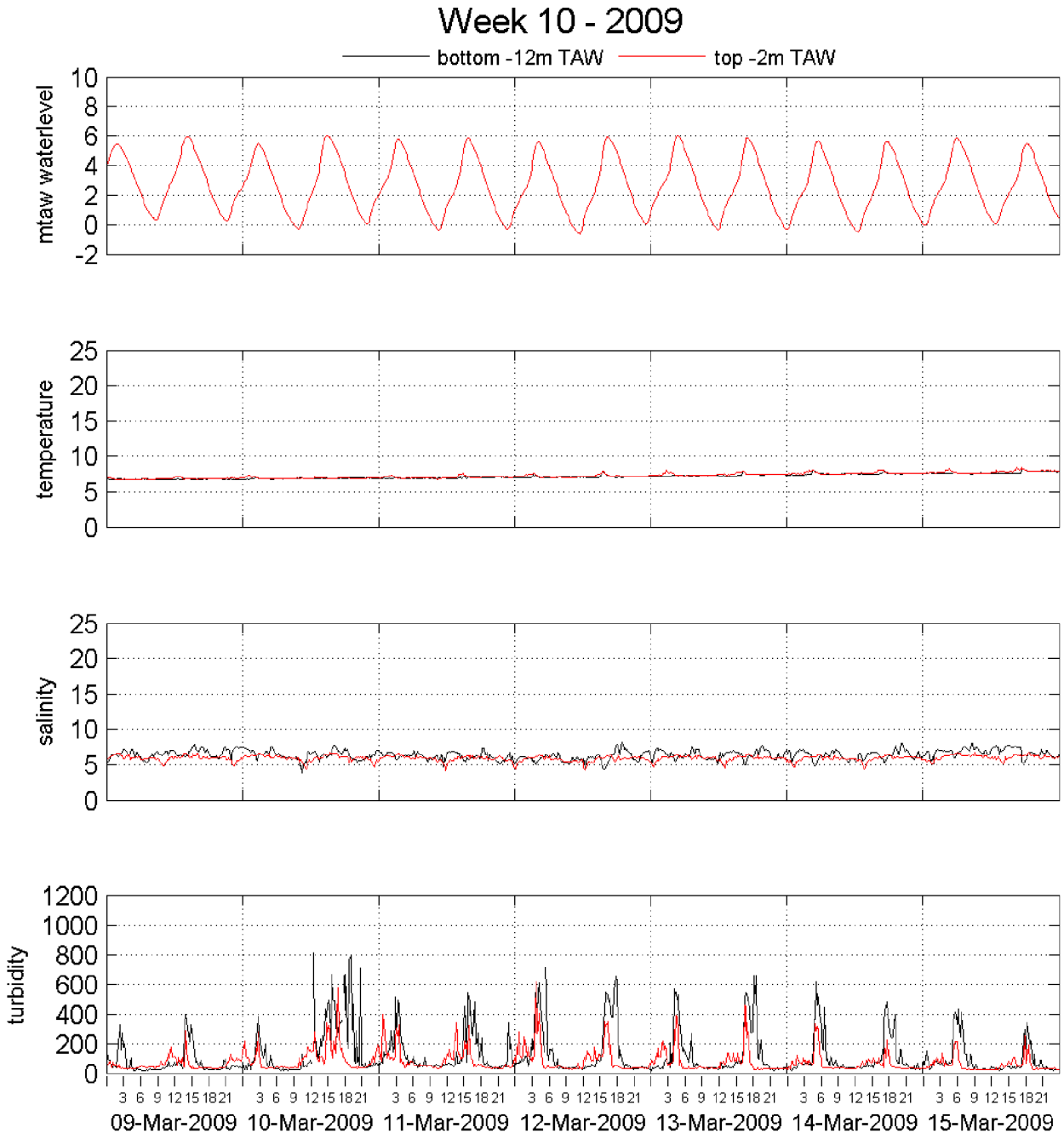

Week series of Salinity, Temperature, SS concentration and Tide

Processed

Location:

S entrance

I/RA/11283/08.094/MSA

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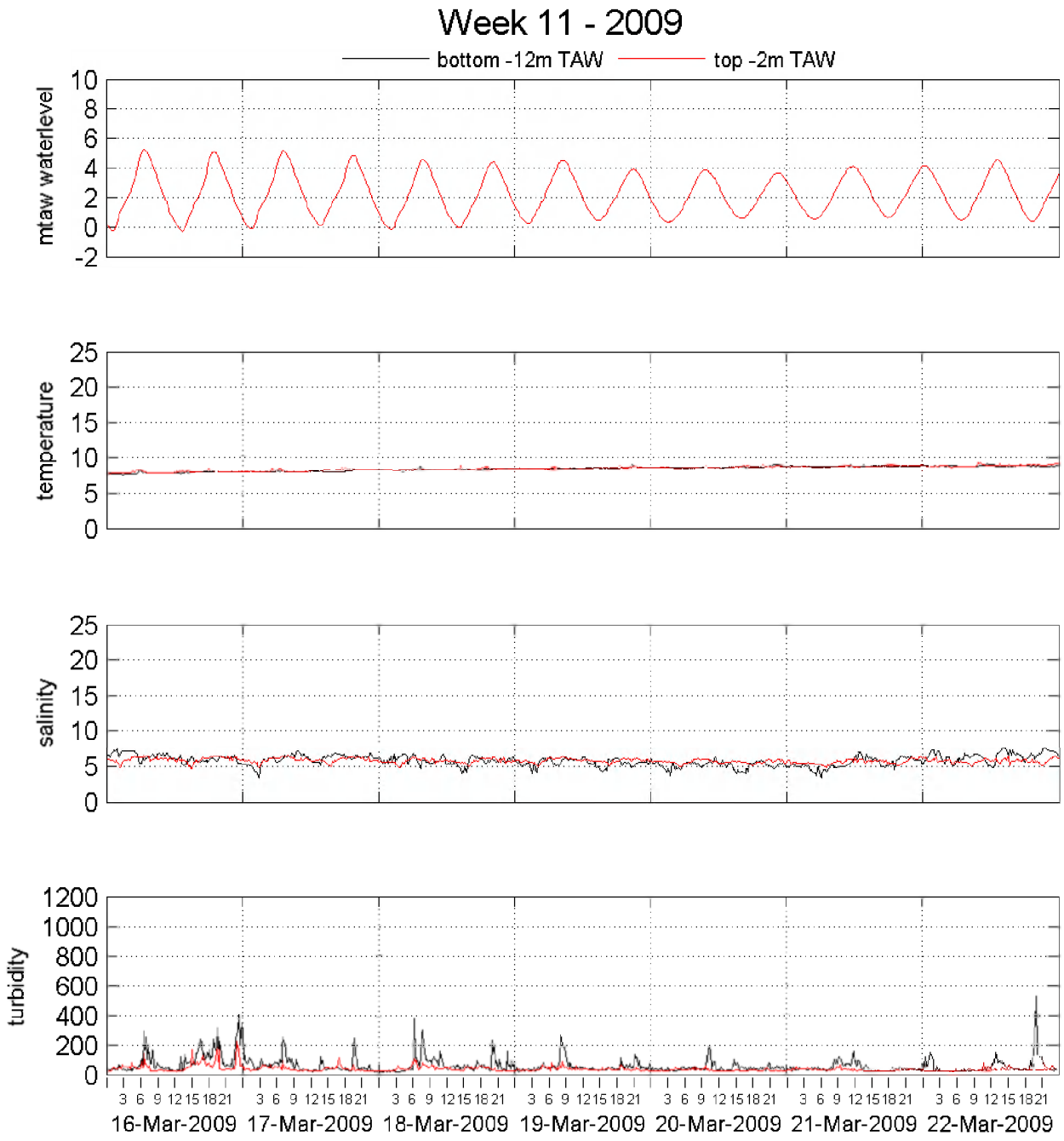

Week series of Salinity, Temperature, SS concentration and Tide

Processed

Location:

S entrance

I/RA/11283/08.094/MSA

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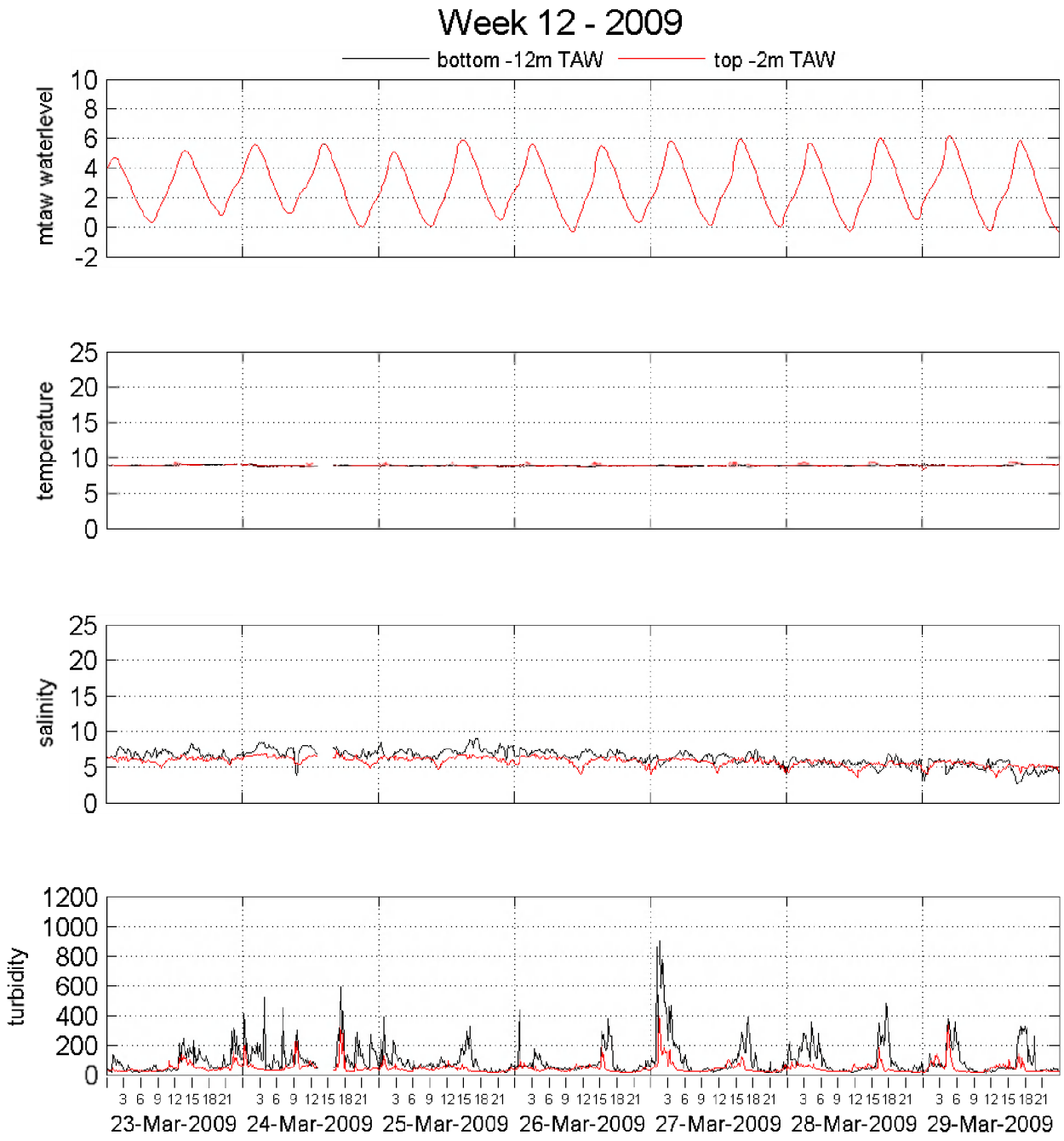

Week series of Salinity, Temperature, SS concentration and Tide

Processed

Location:

S entrance

I/RA/11283/08.094/MSA

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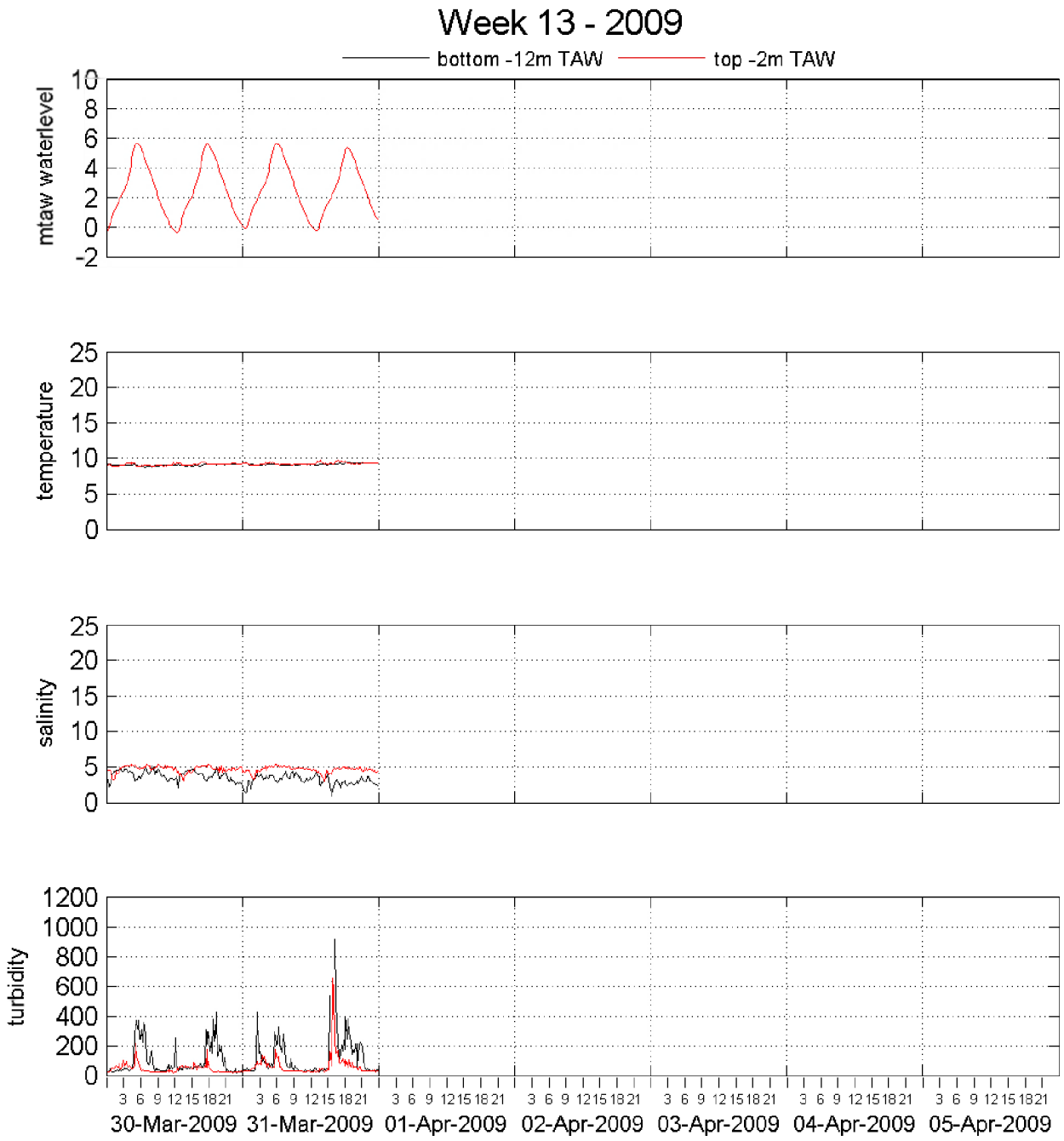


Week series of Salinity, Temperature, SS concentration and Tide

Processed

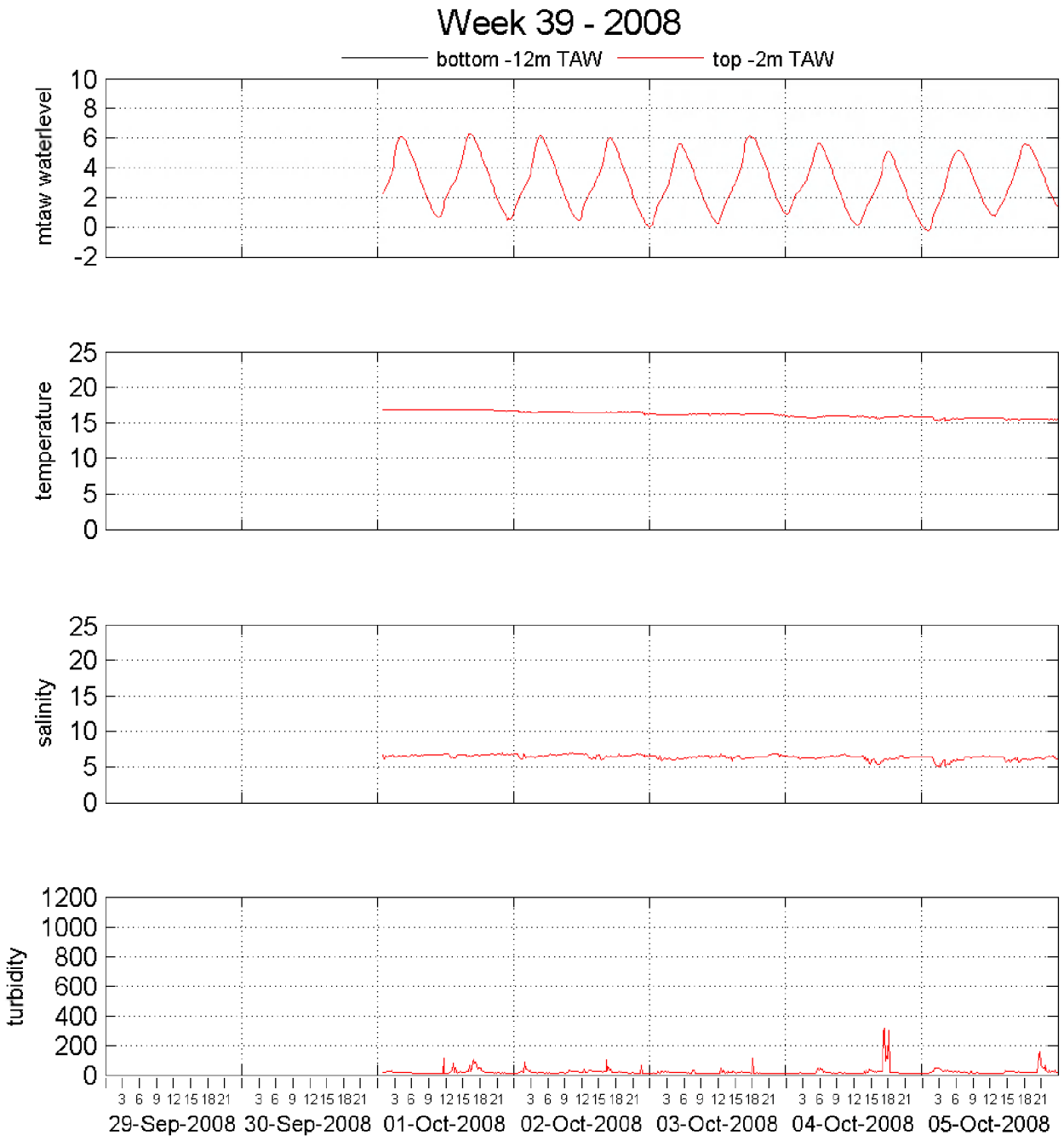
Location:

S entrance

I/RA/11283/08.094/MSA

B.3 S-MIDDLE

11283



Week series of Salinity, Temperature, SS concentration and Tide

Processed

Location:

S middle

I/RA/11283/08.094/MSA

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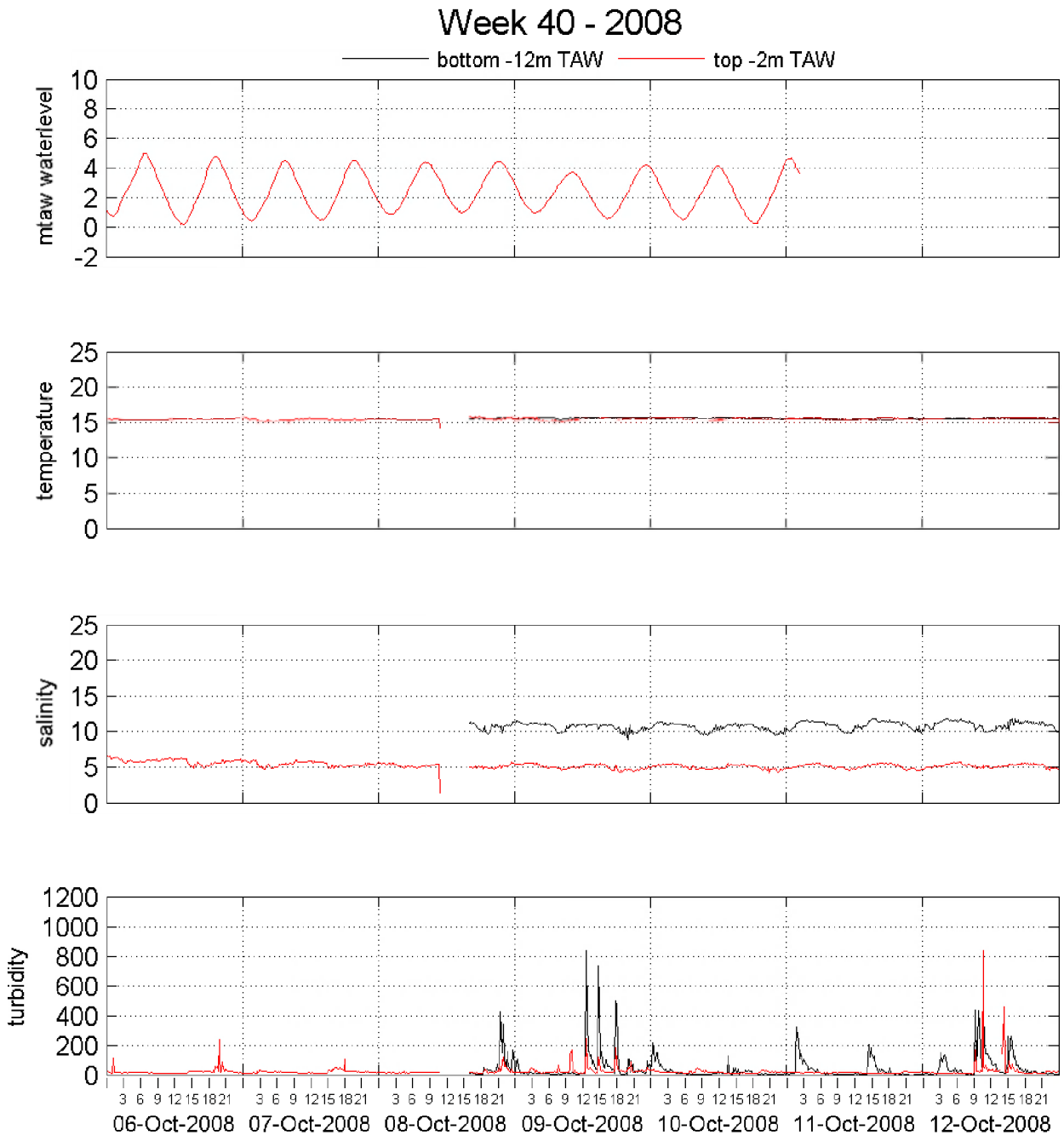

Week series of Salinity, Temperature, SS concentration and Tide

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Location:

S middle

I/RA/11283/08.094/MSA

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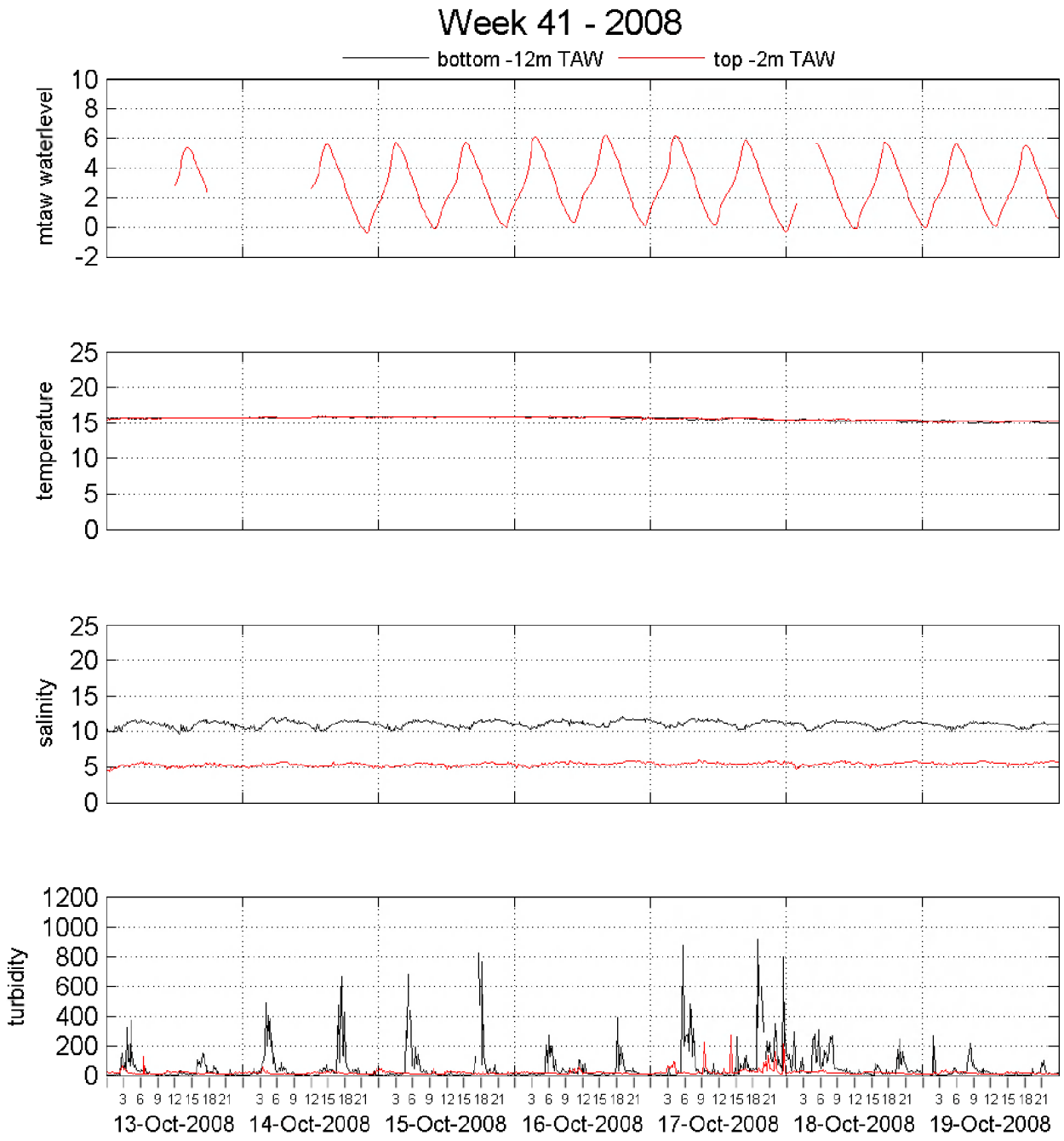

Week series of Salinity, Temperature, SS concentration and Tide

Processed

Location:

S middle

I/RA/11283/08.094/MSA

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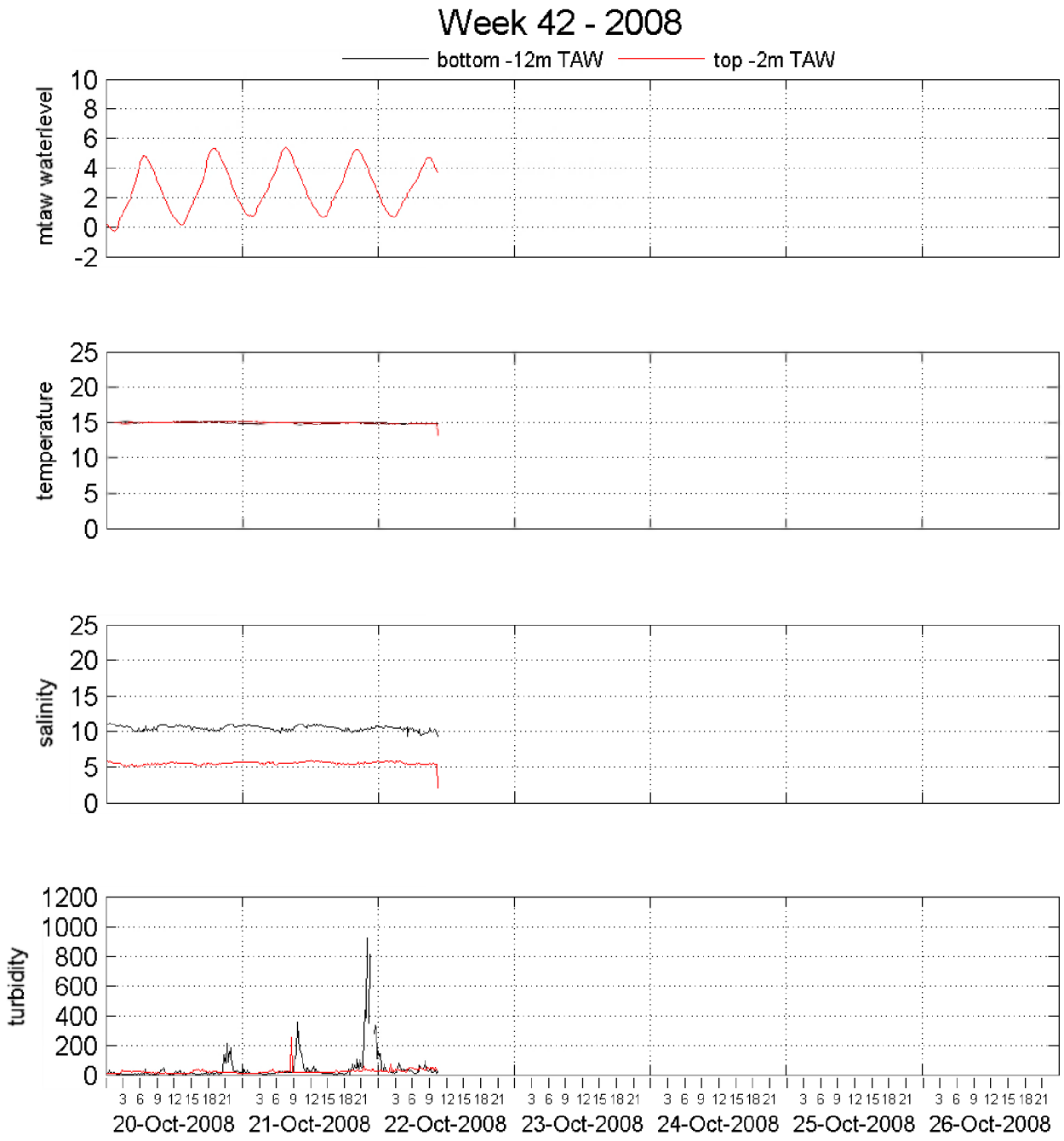

Week series of Salinity, Temperature, SS concentration and Tide

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Location:

S middle

I/RA/11283/08.094/MSA

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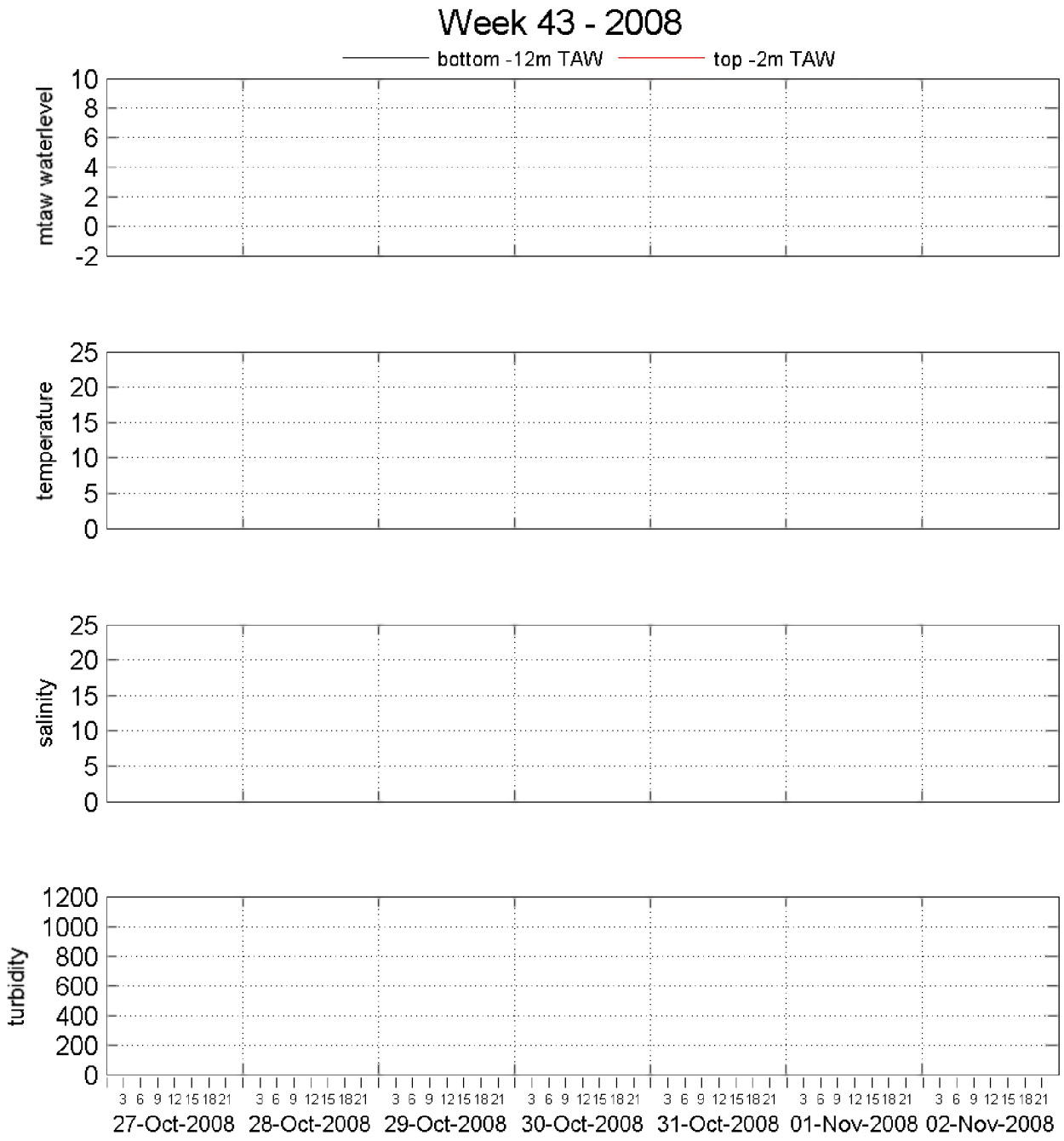


Week series of Salinity, Temperature, SS concentration and Tide

Processed

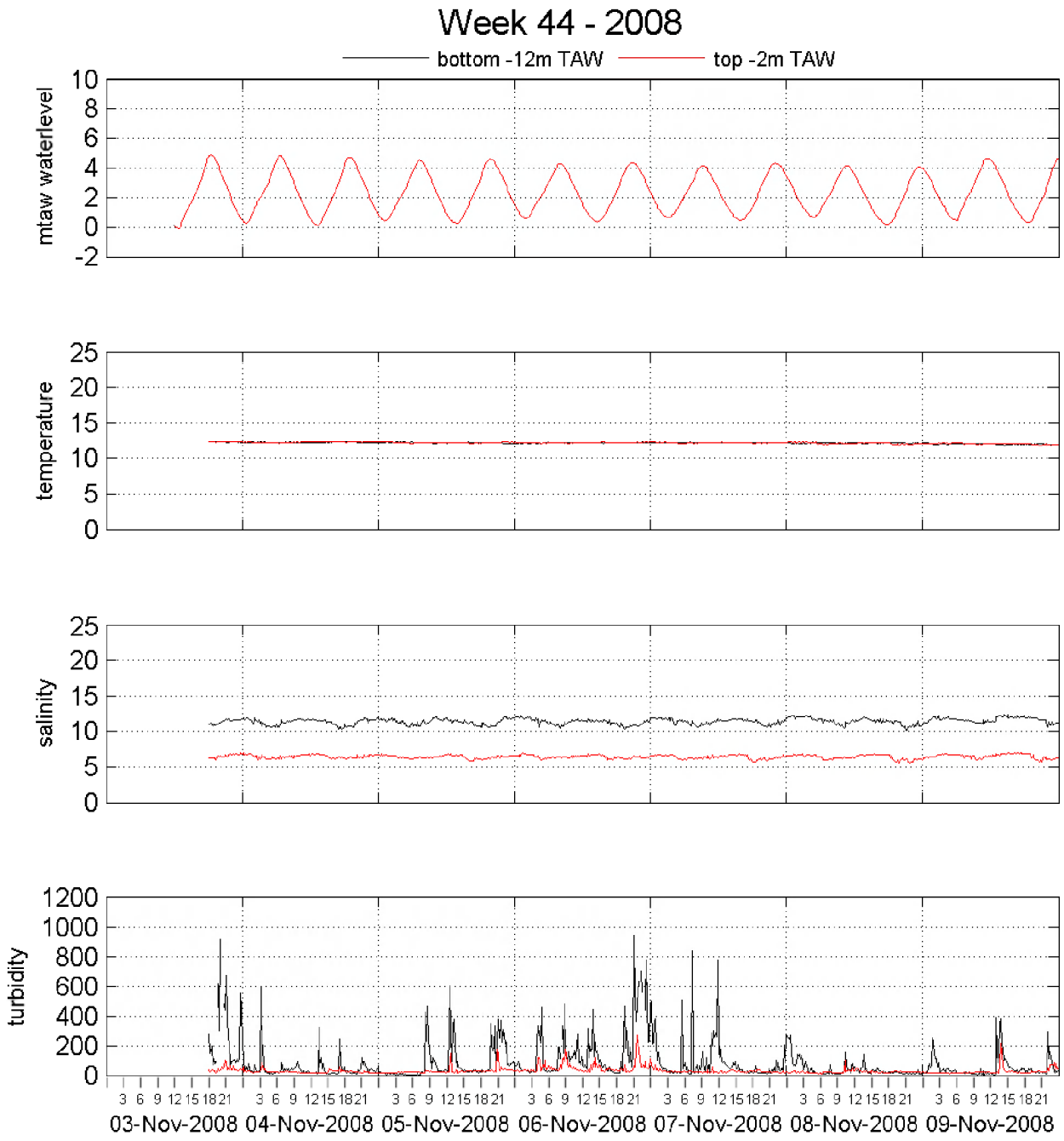
IMDC

Location:

S middle

I/RA/11283/08.094/MSA

11283



Week series of Salinity, Temperature, SS concentration and Tide

Processed

Location:

S middle

I/RA/11283/08.094/MSA

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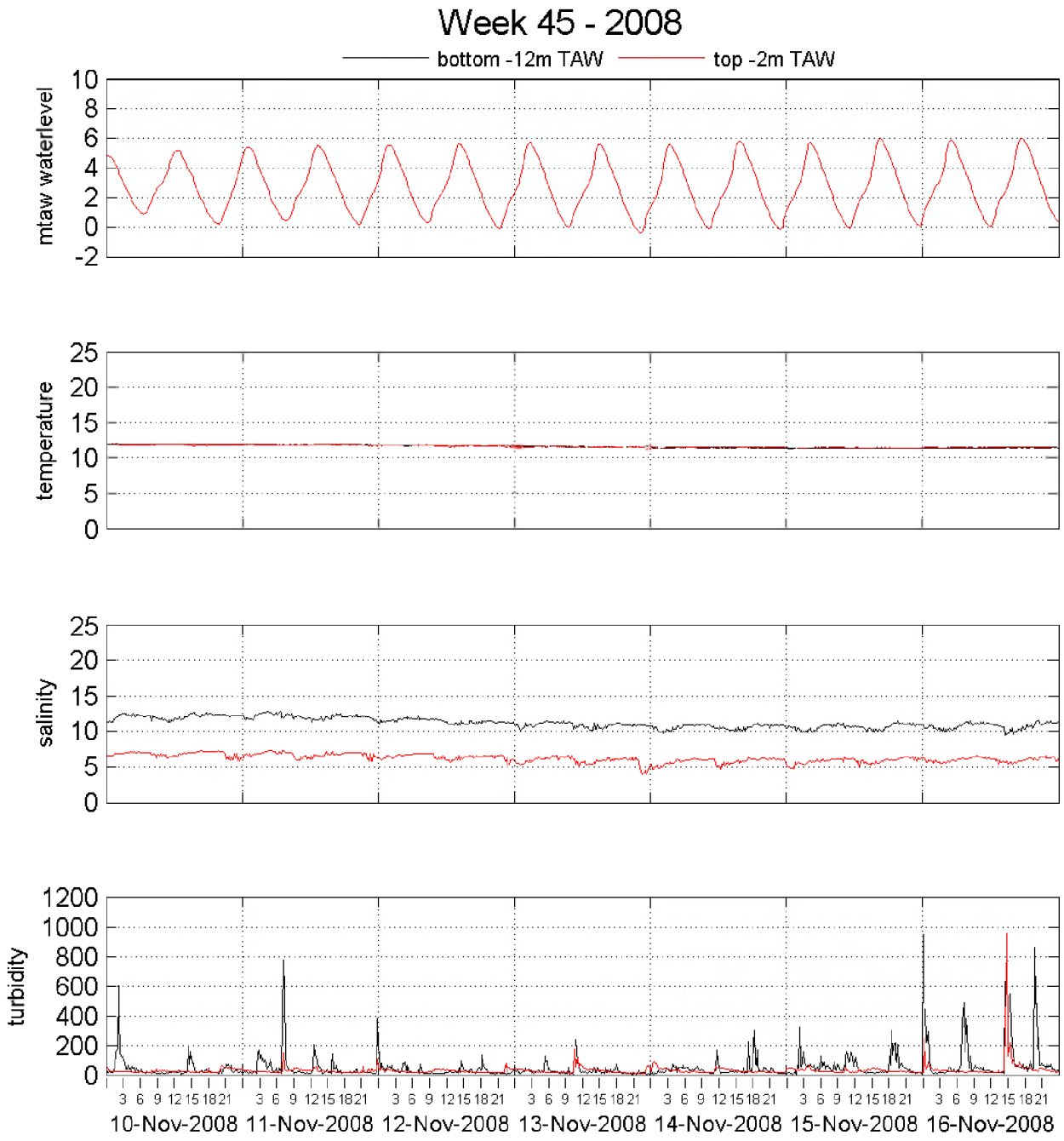

Week series of Salinity, Temperature, SS concentration and Tide

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Location:

S middle

I/RA/11283/08.094/MSA

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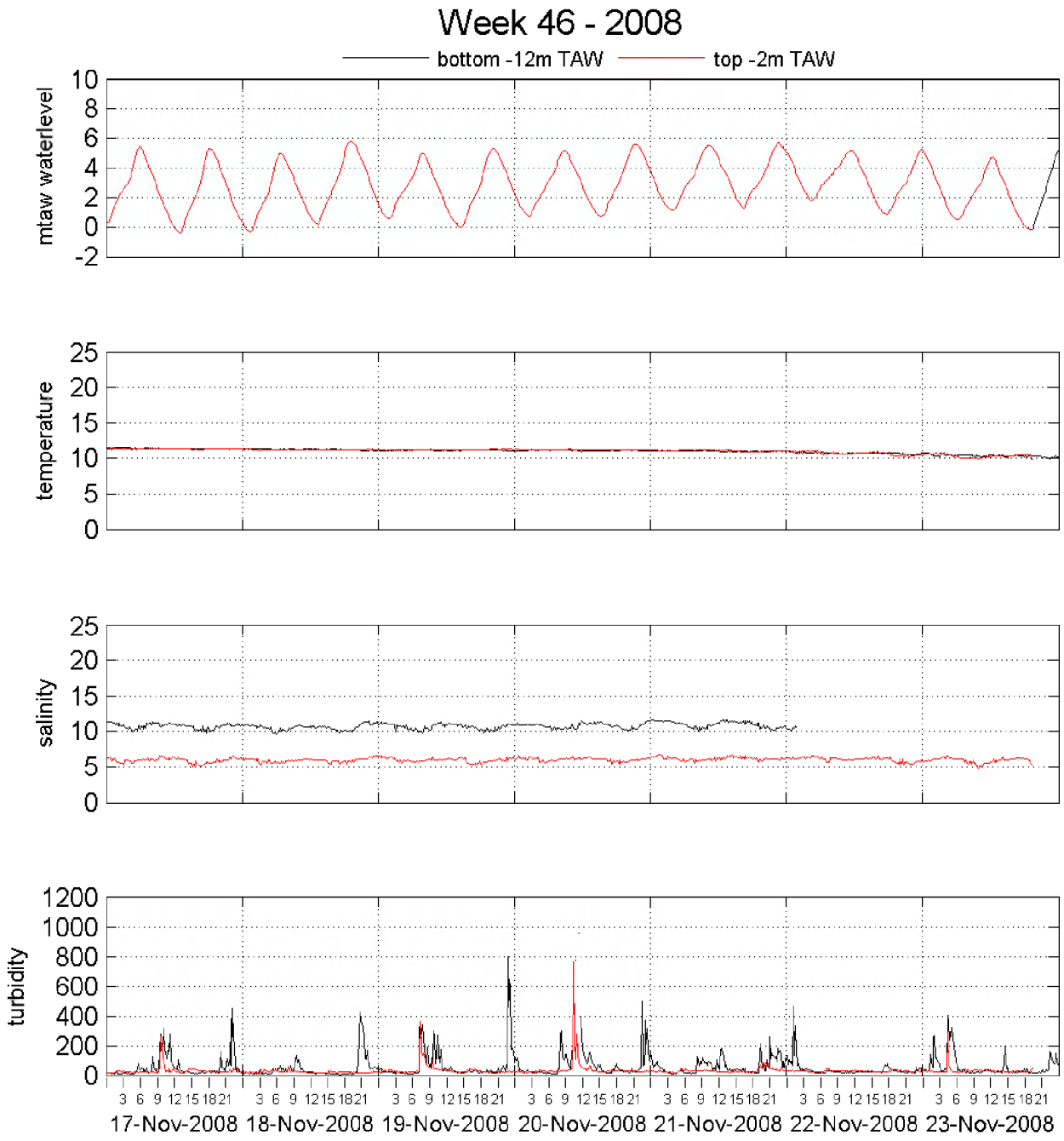

Week series of Salinity, Temperature, SS concentration and Tide

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Location:

S middle

I/RA/11283/08.094/MSA

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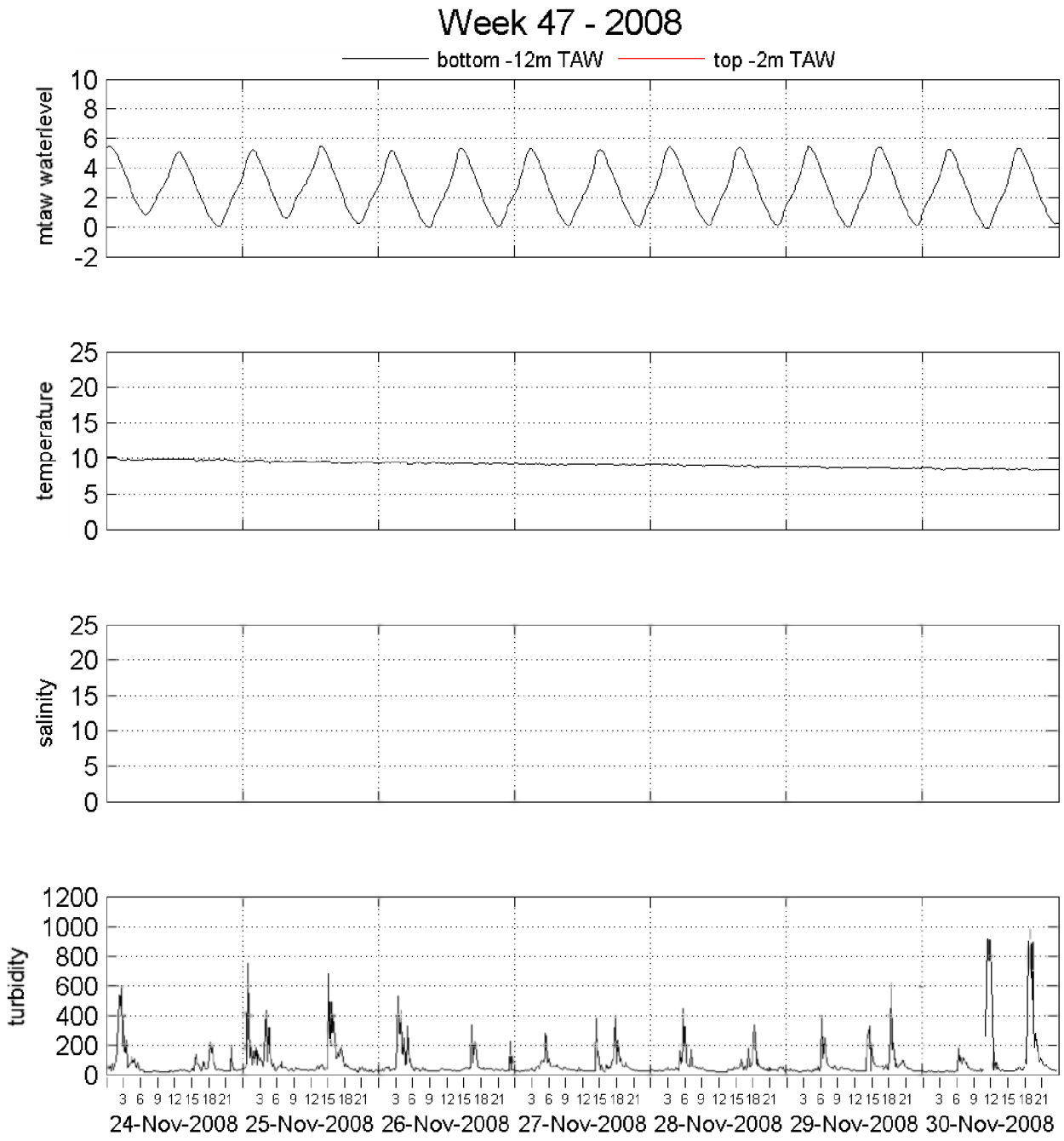

Week series of Salinity, Temperature, SS concentration and Tide

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Location:

S middle

I/RA/11283/08.094/MSA

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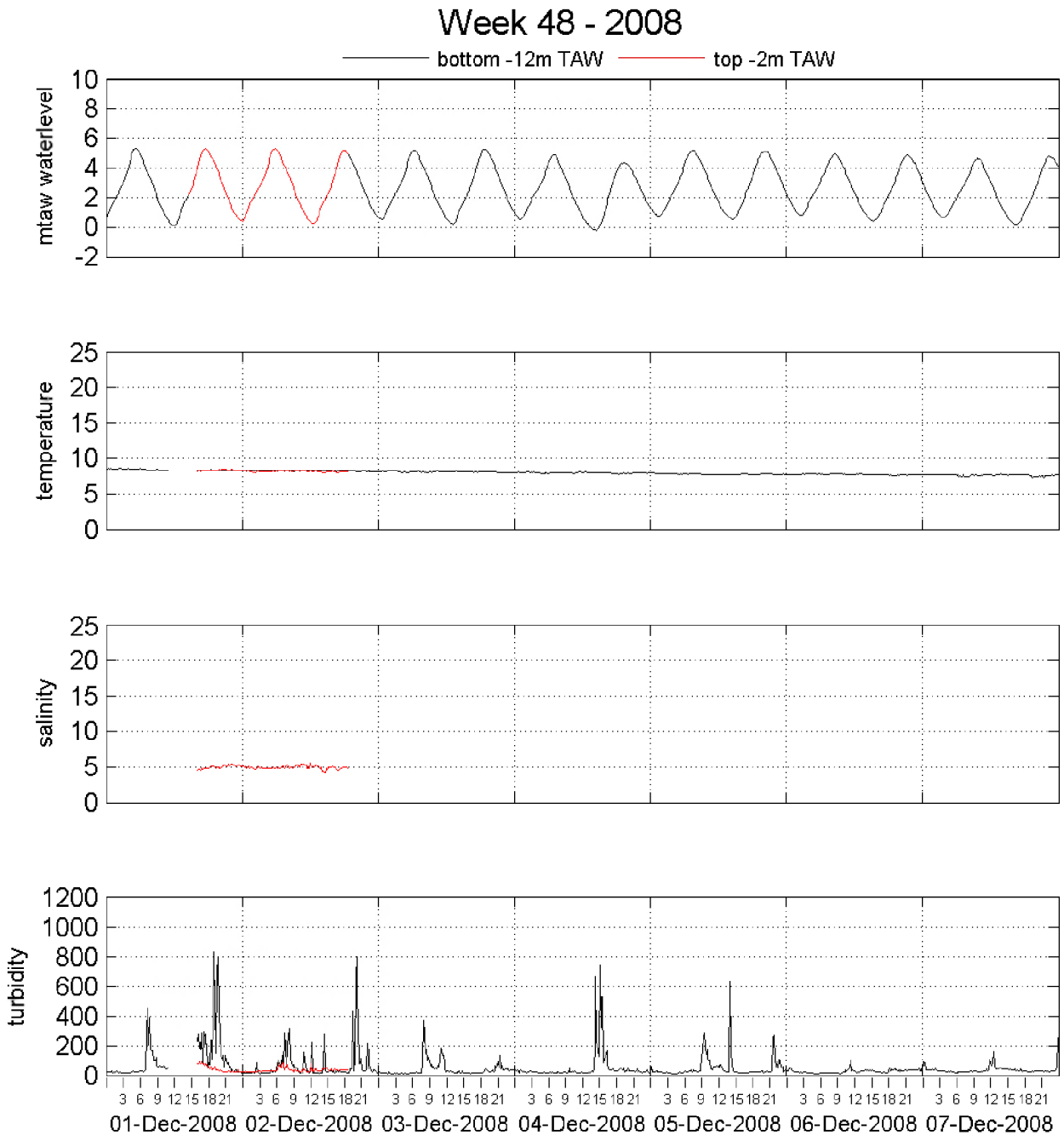

Week series of Salinity, Temperature, SS concentration and Tide

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Location:

S middle

I/RA/11283/08.094/MSA

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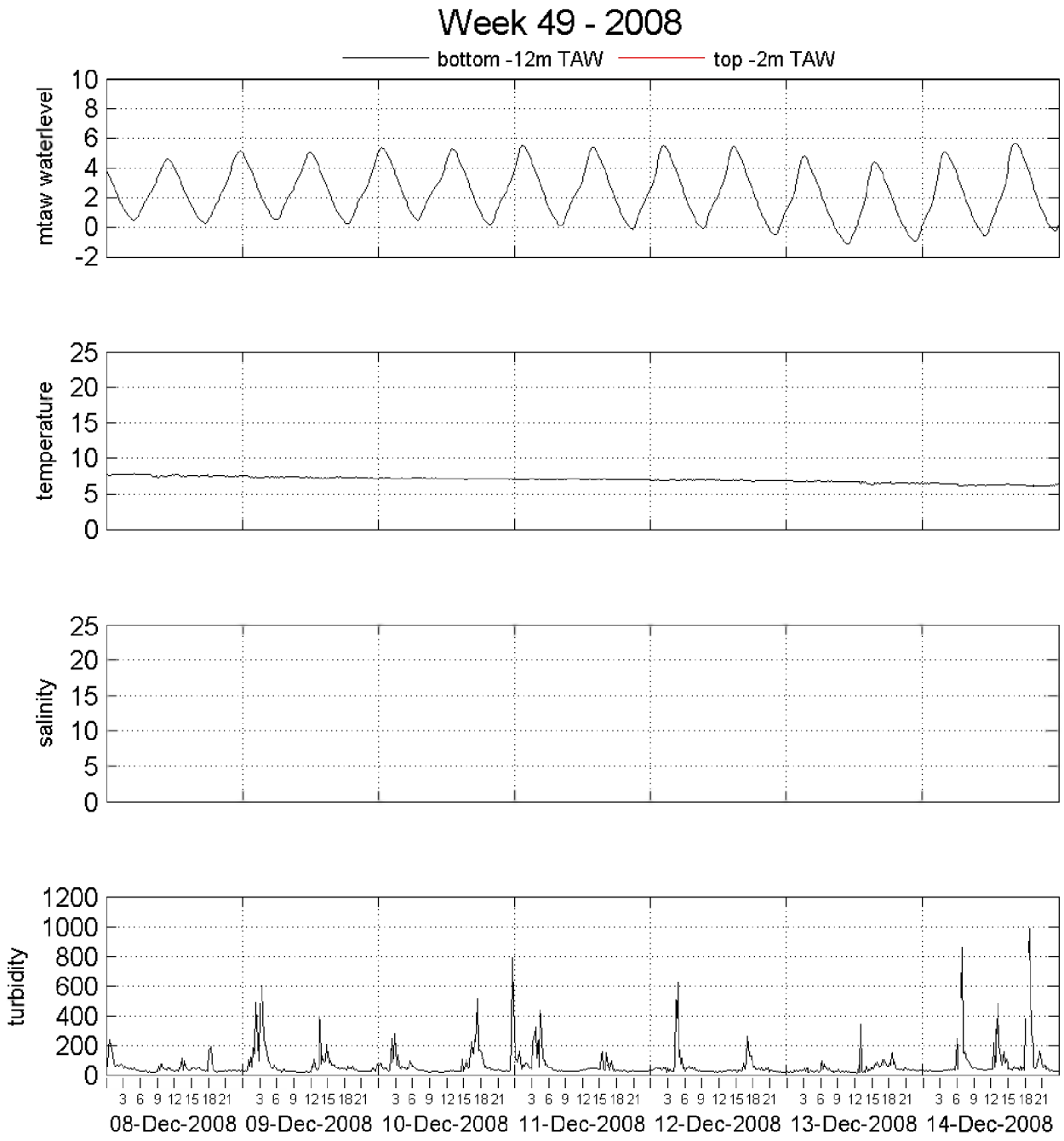

Week series of Salinity, Temperature, SS concentration and Tide

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Location:

S middle

I/RA/11283/08.094/MSA

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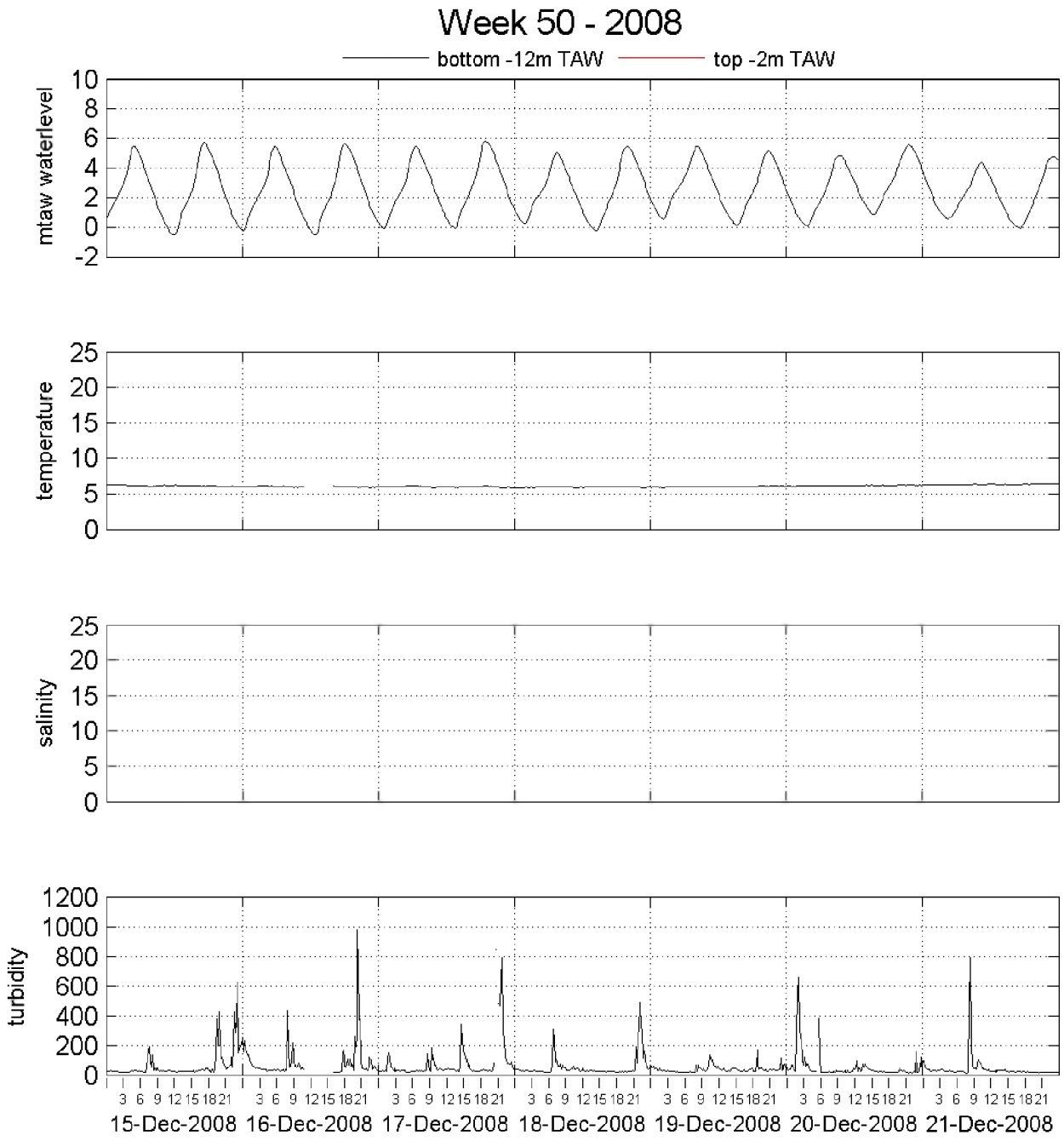

Week series of Salinity, Temperature, SS concentration and Tide

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Location:

S middle

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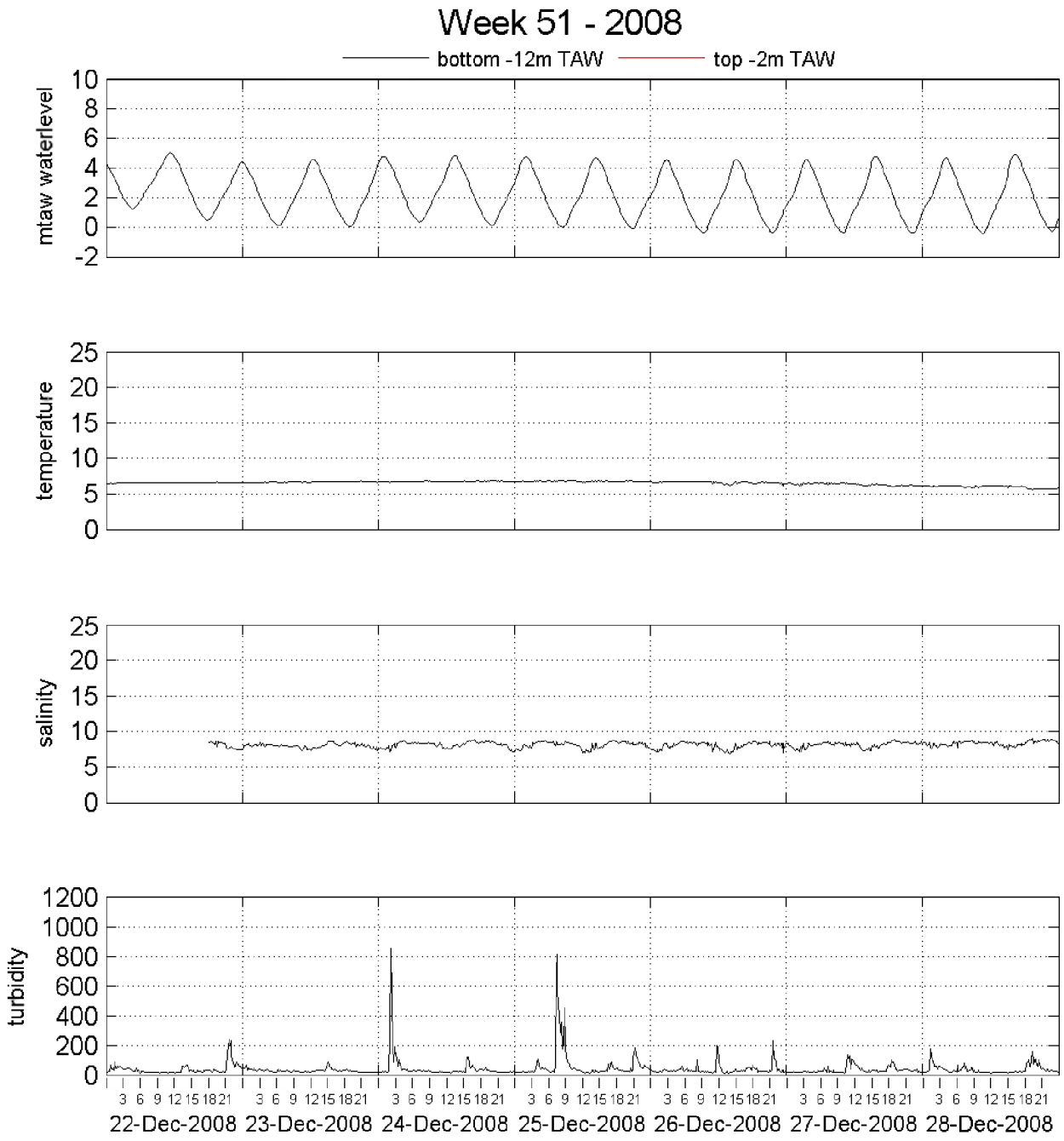

Week series of Salinity, Temperature, SS concentration and Tide

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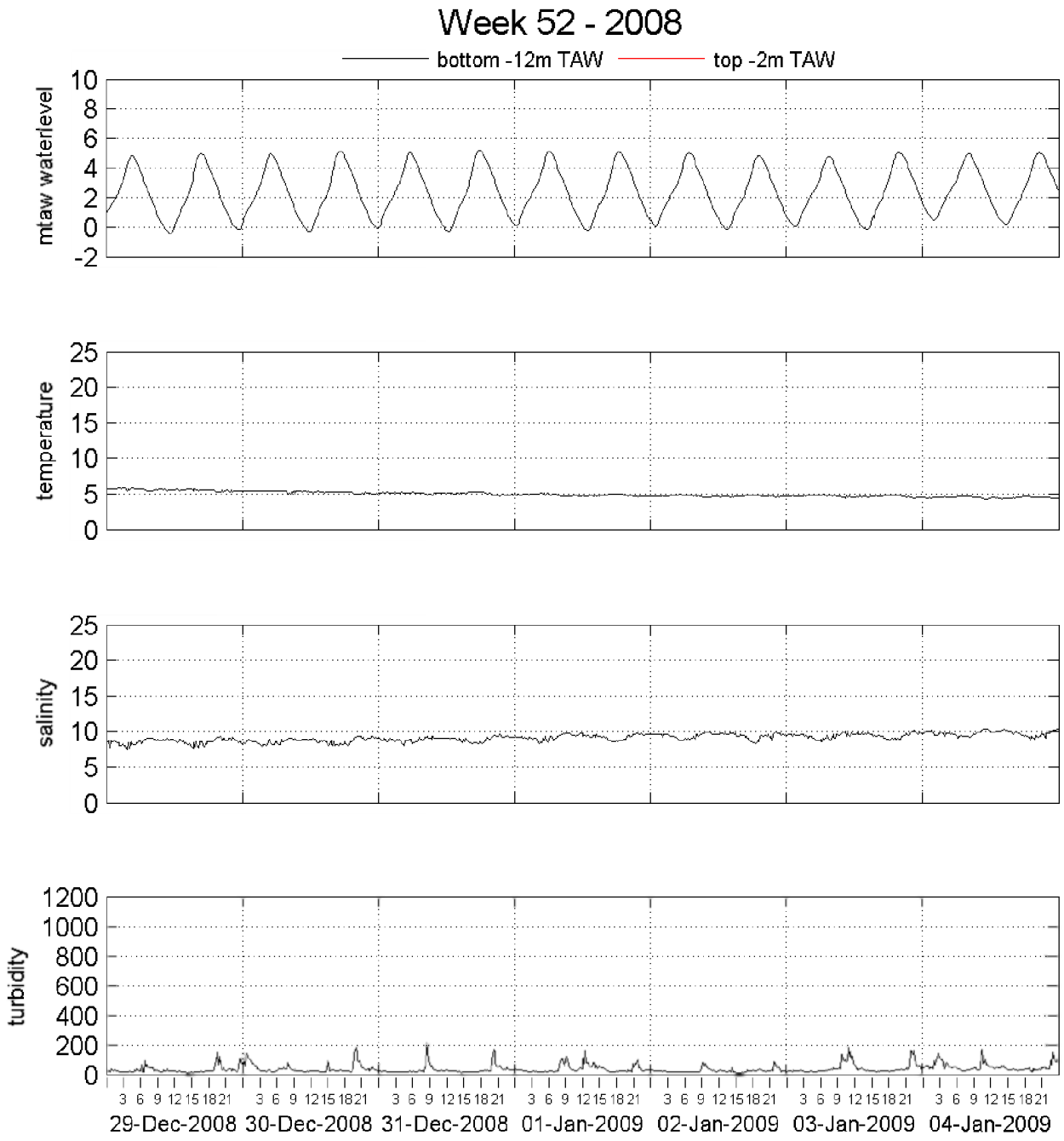

Week series of Salinity, Temperature, SS concentration and Tide

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Location:

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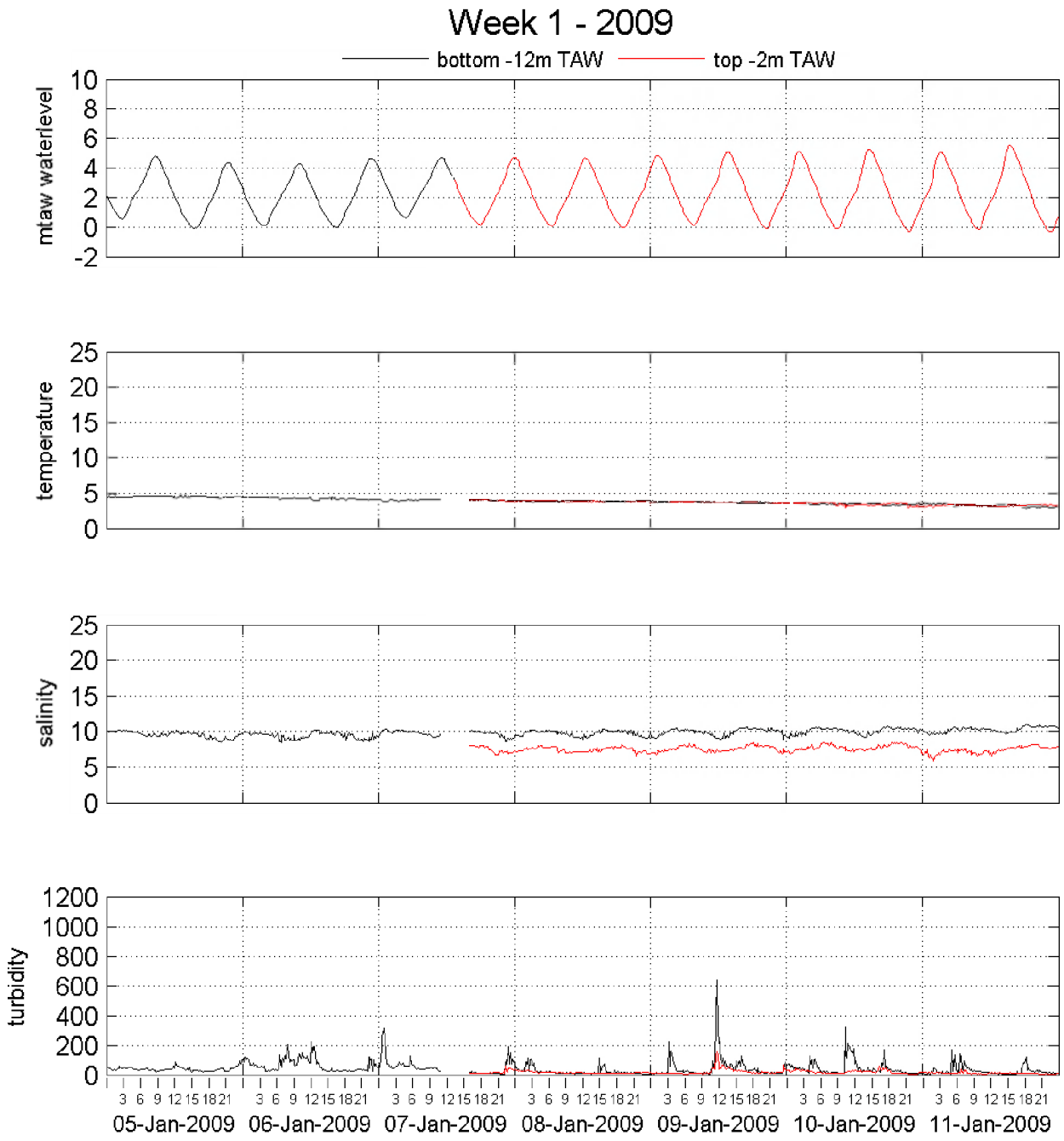

Week series of Salinity, Temperature, SS concentration and Tide

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Location:

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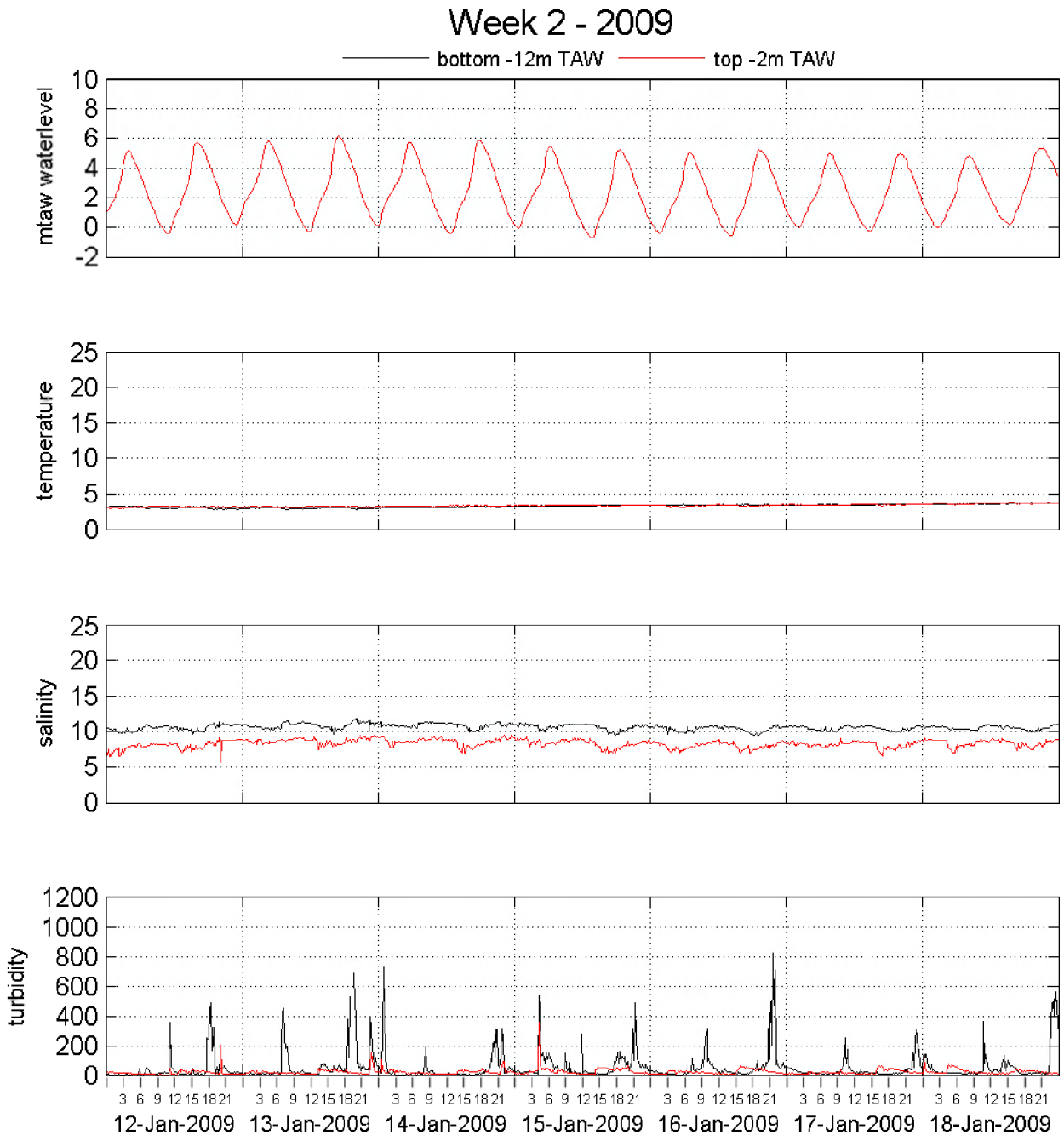

Week series of Salinity, Temperature, SS concentration and Tide

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Location:

S middle

I/RA/11283/08.094/MSA

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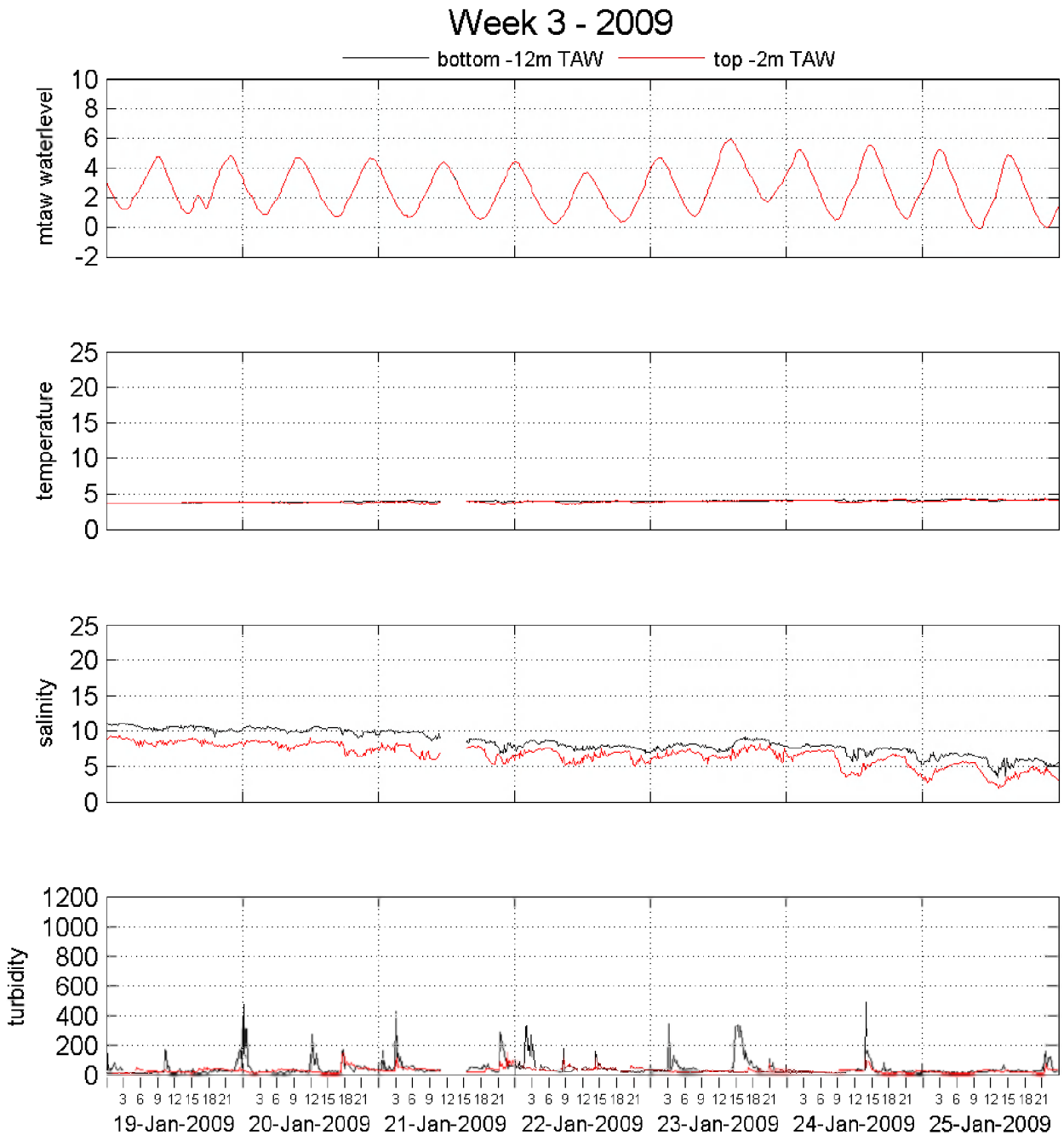

Week series of Salinity, Temperature, SS concentration and Tide

Processed

Location:

S middle

I/RA/11283/08.094/MSA

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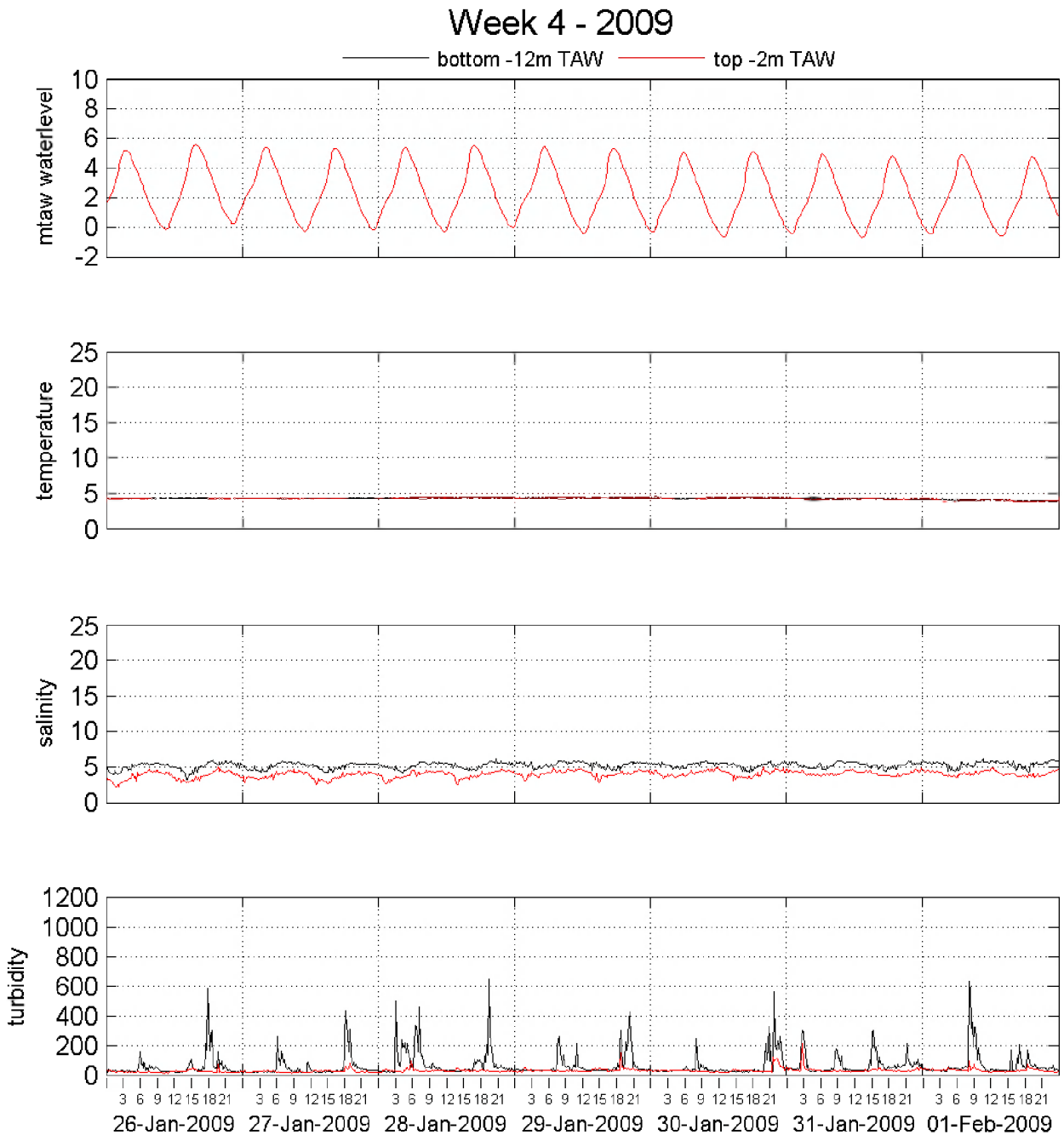

Week series of Salinity, Temperature, SS concentration and Tide

Processed

Location:

S middle

I/RA/11283/08.094/MSA

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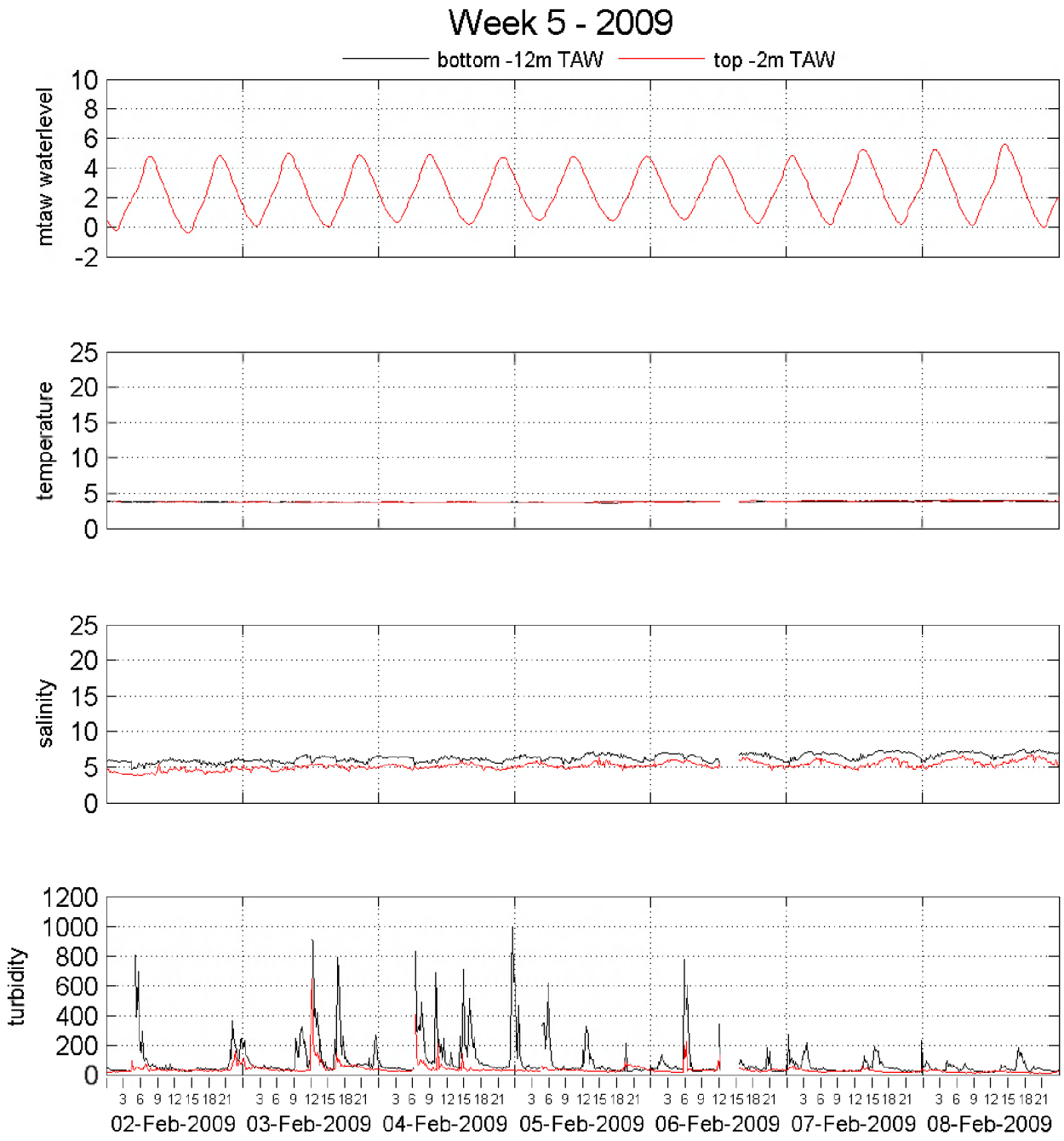

Week series of Salinity, Temperature, SS concentration and Tide

Processed

Location:

S middle

I/RA/11283/08.094/MSA

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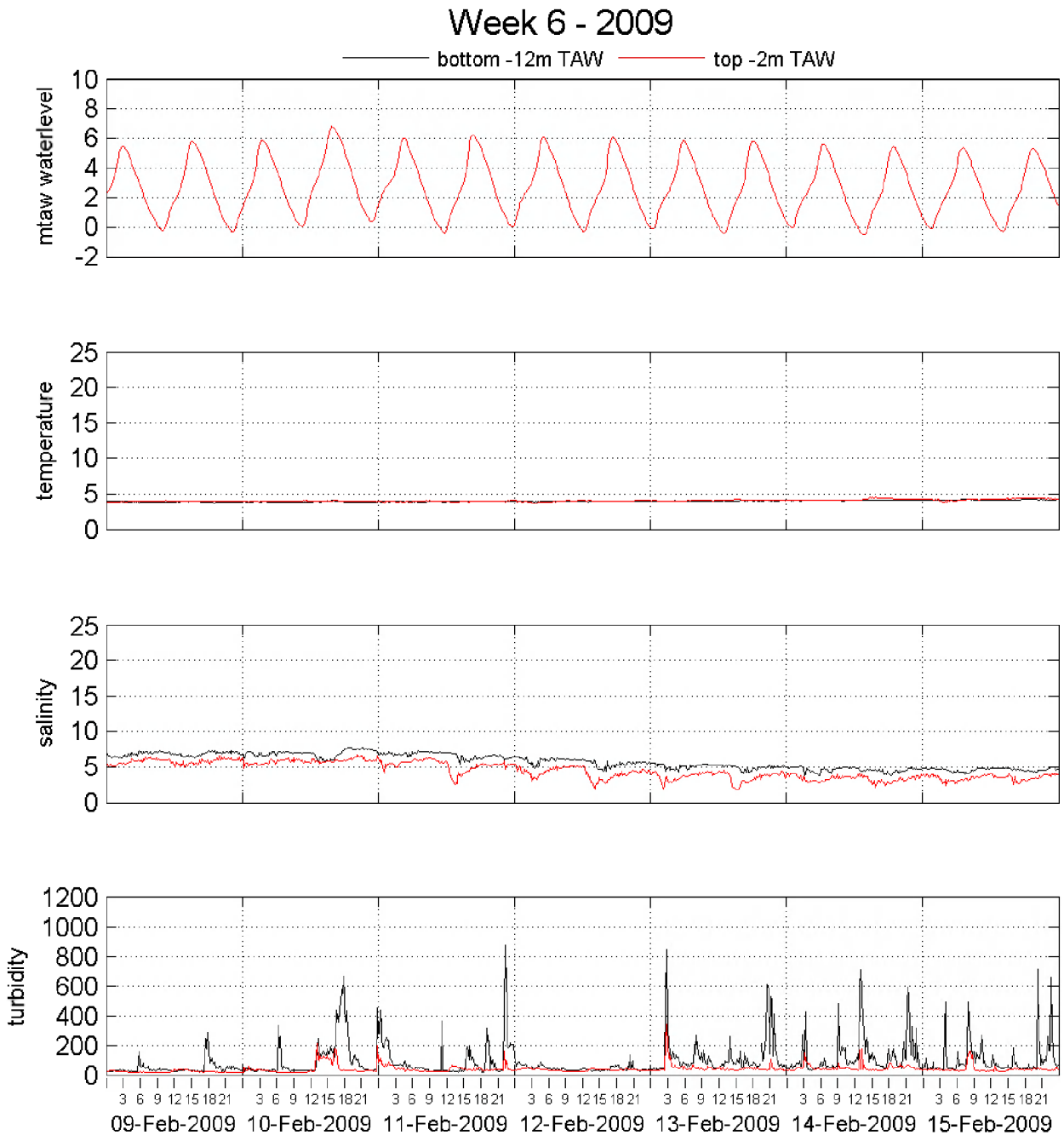

Week series of Salinity, Temperature, SS concentration and Tide

Processed

Location:

S middle

I/RA/11283/08.094/MSA

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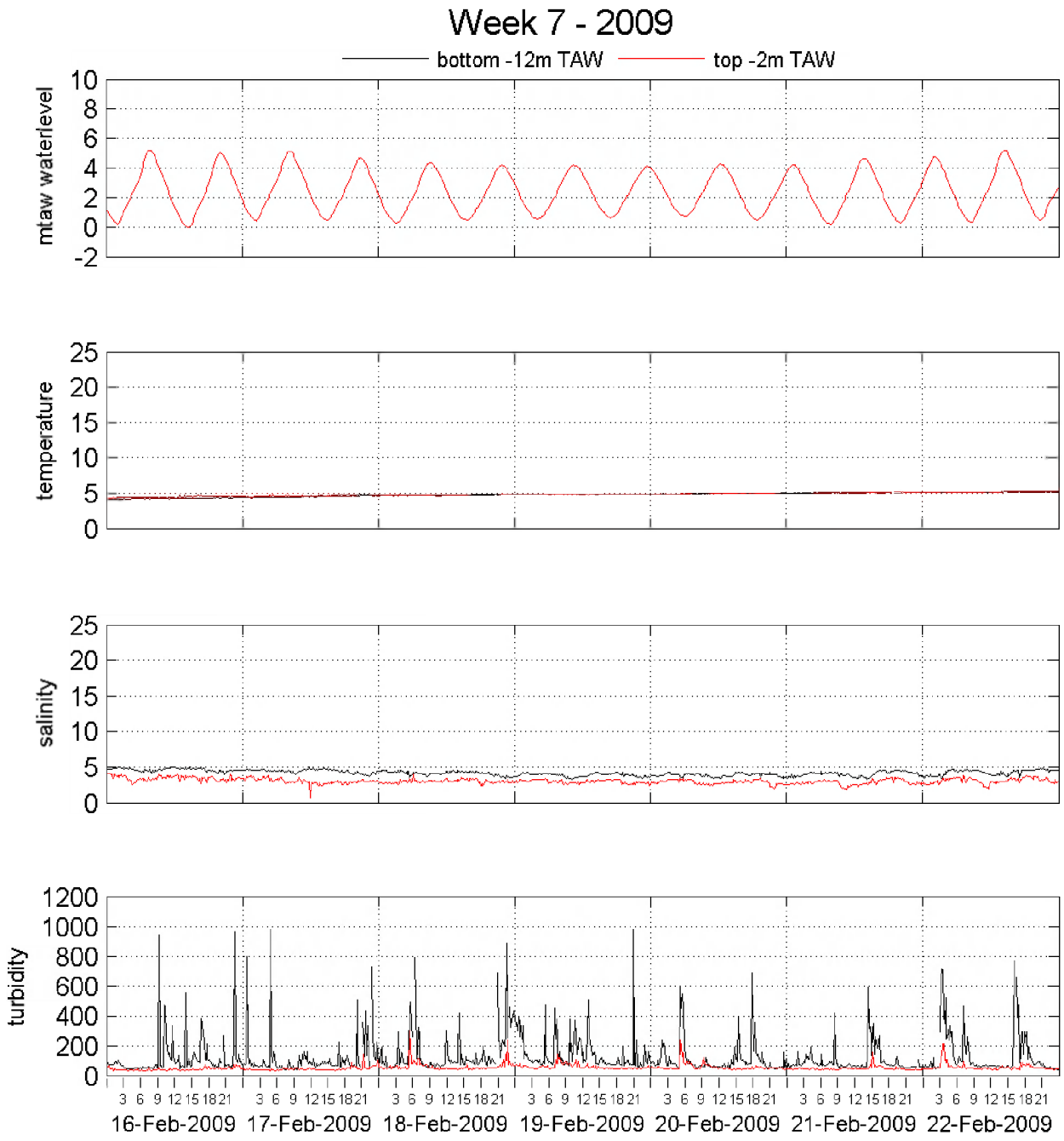

Week series of Salinity, Temperature, SS concentration and Tide

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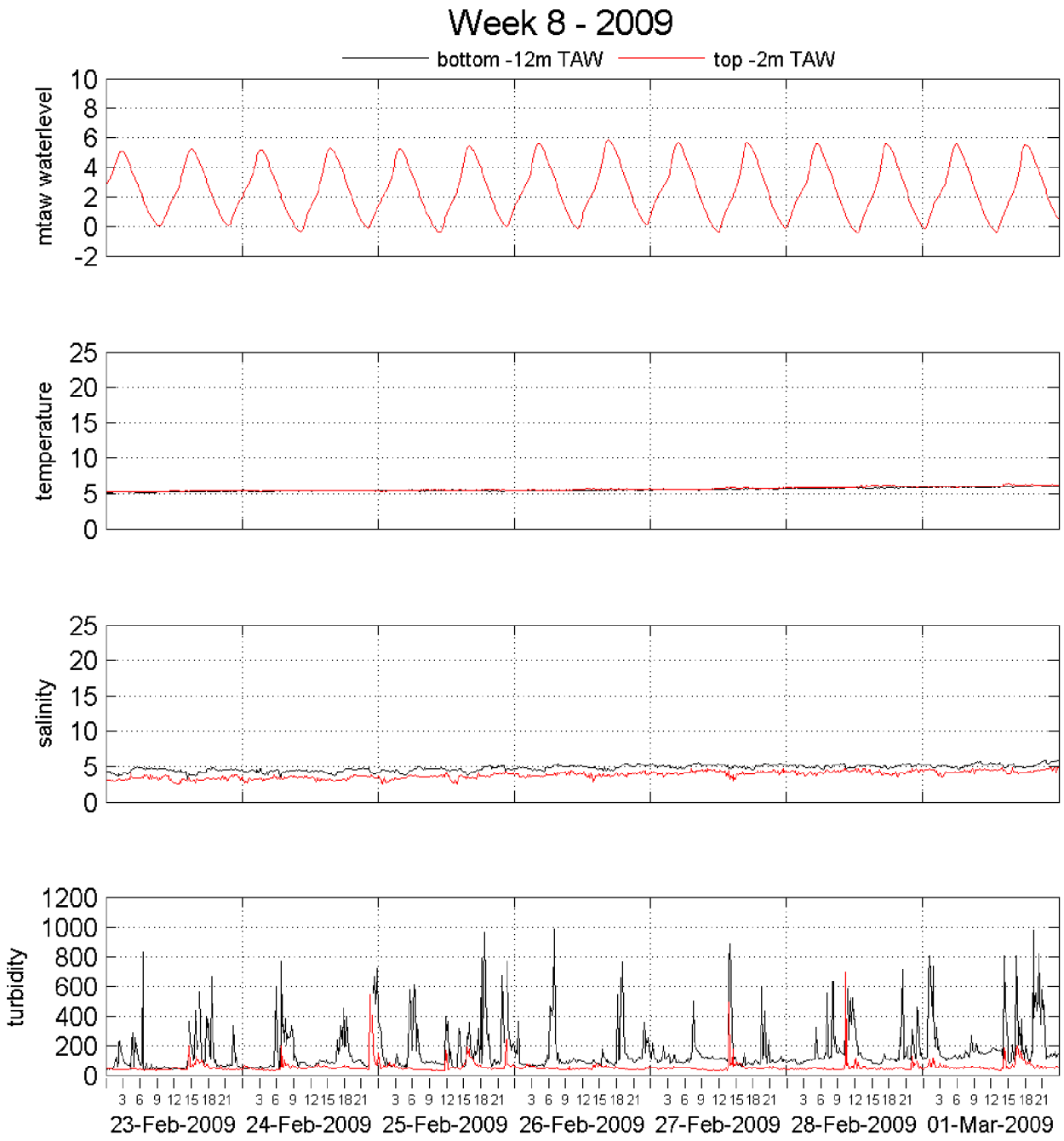
Location:

S middle

I/RA/11283/08.094/MSA

11283



Week series of Salinity, Temperature, SS concentration and Tide

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Location:

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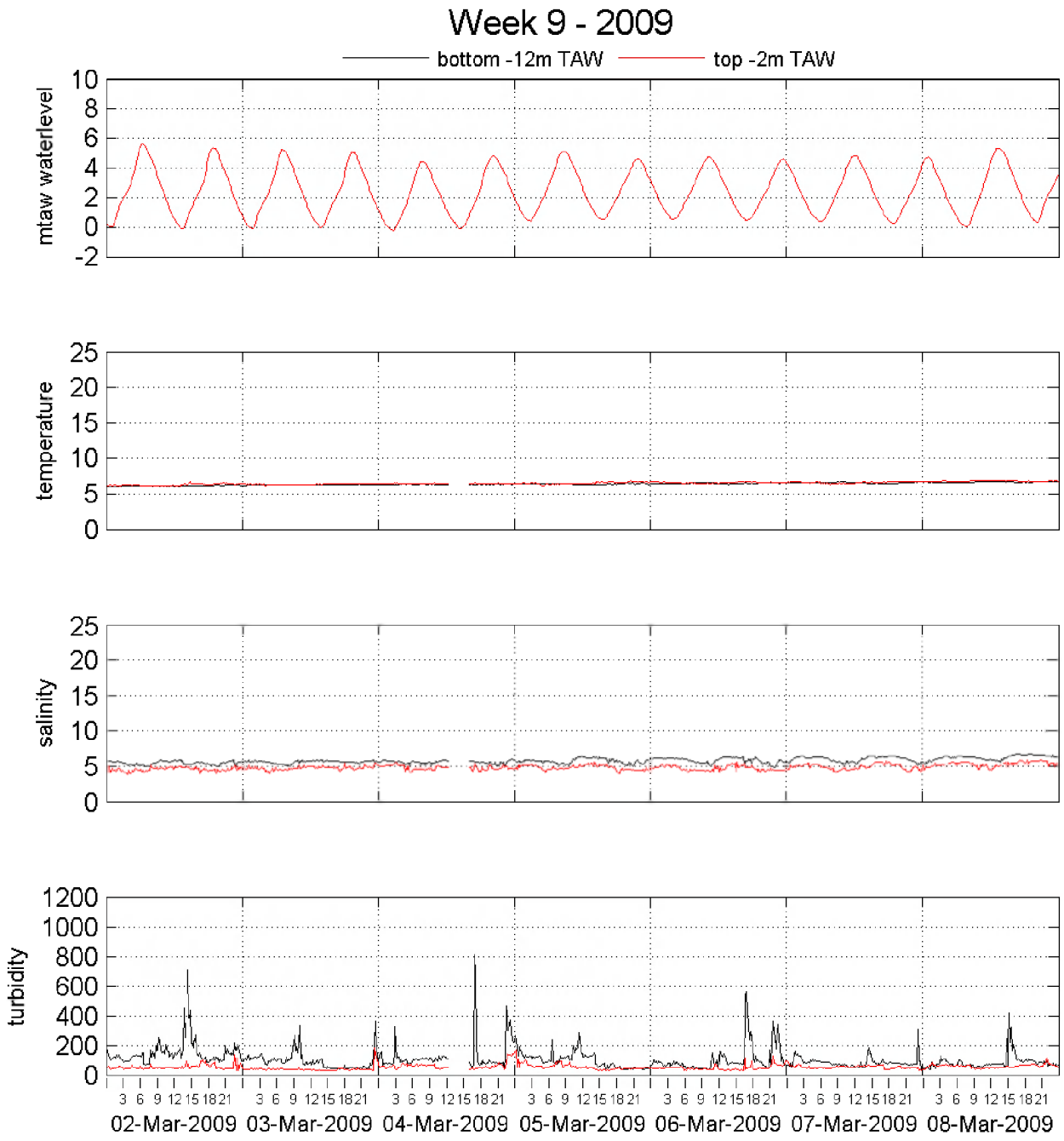

Week series of Salinity, Temperature, SS concentration and Tide

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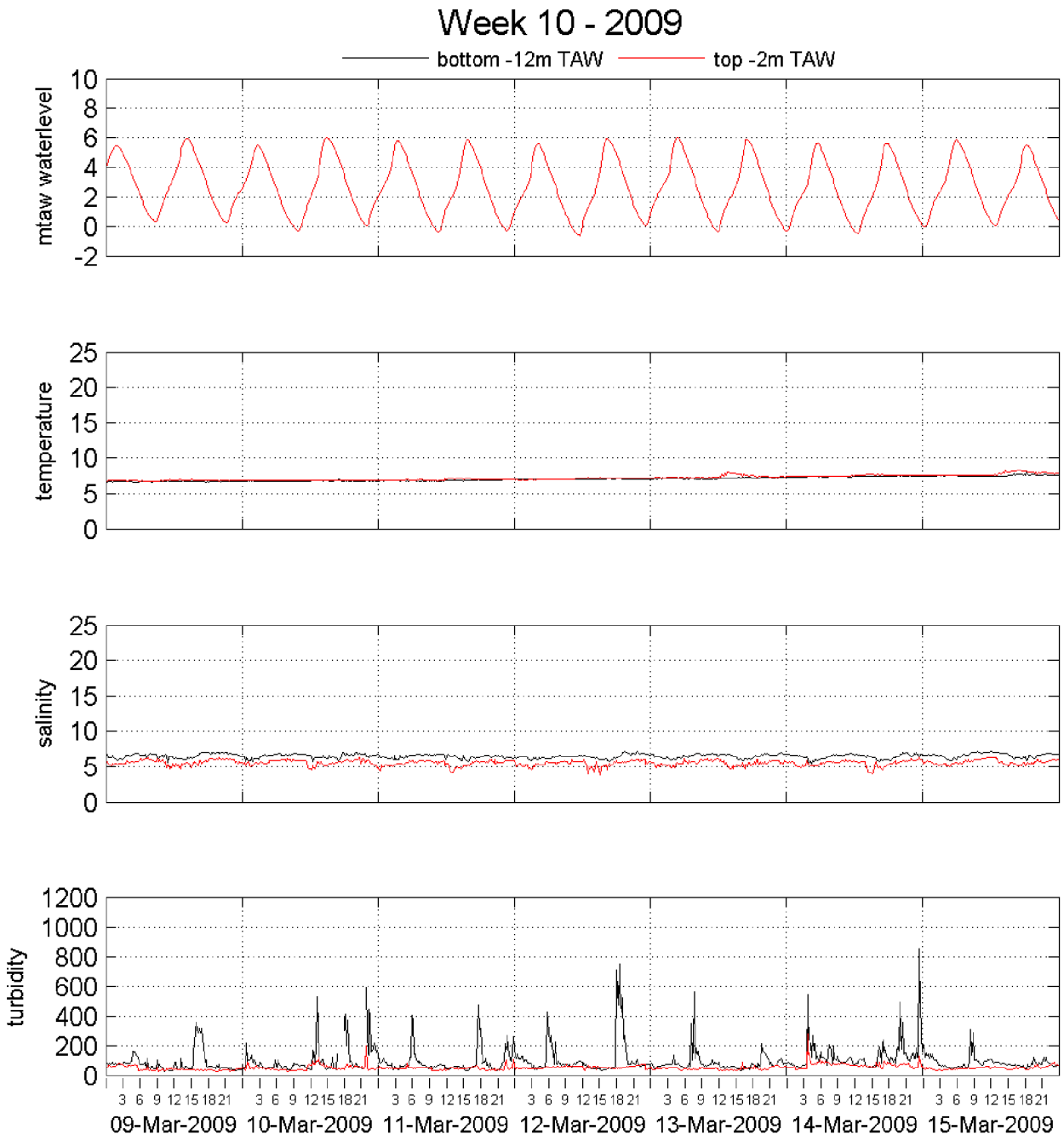

Week series of Salinity, Temperature, SS concentration and Tide

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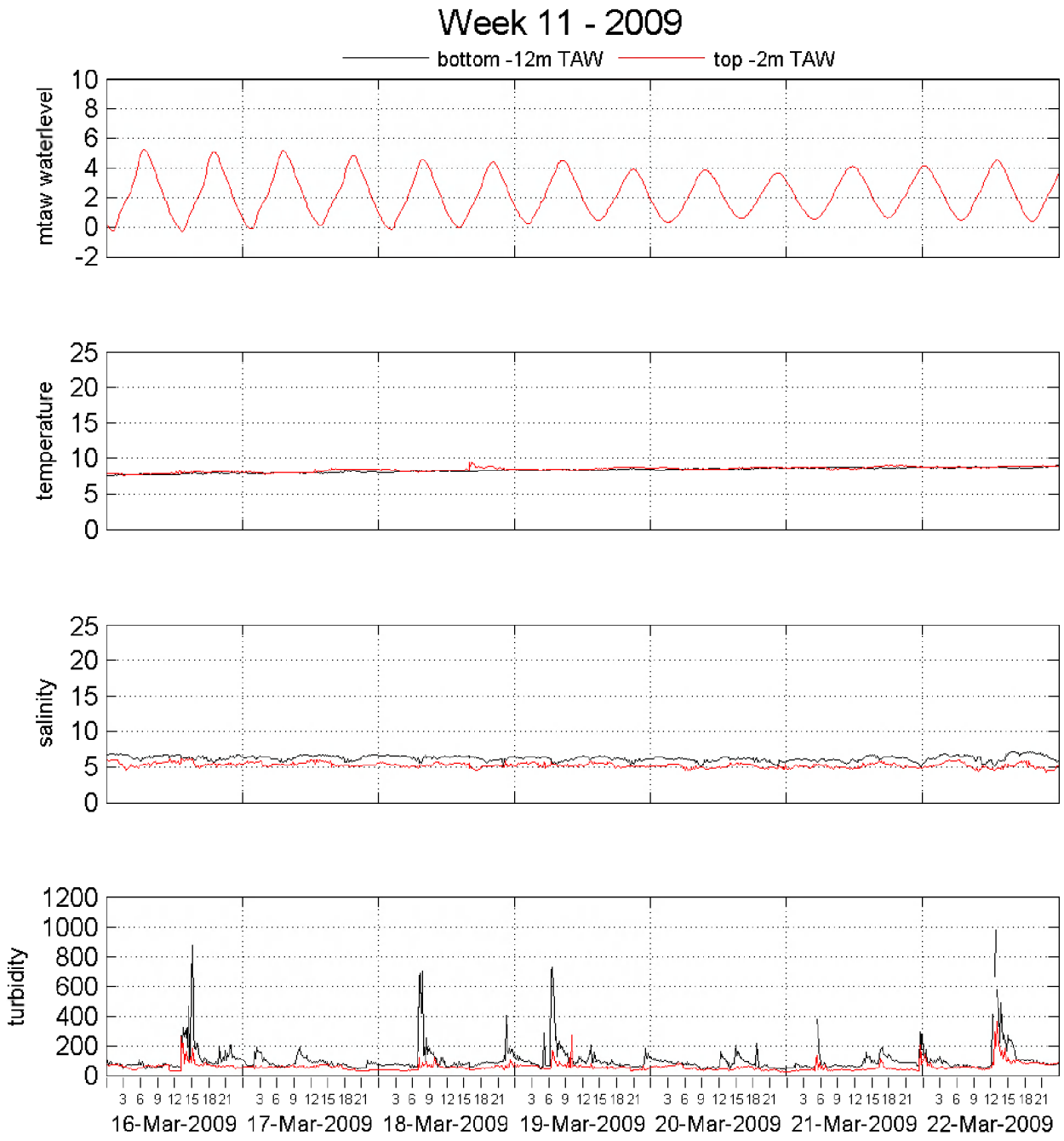

Week series of Salinity, Temperature, SS concentration and Tide

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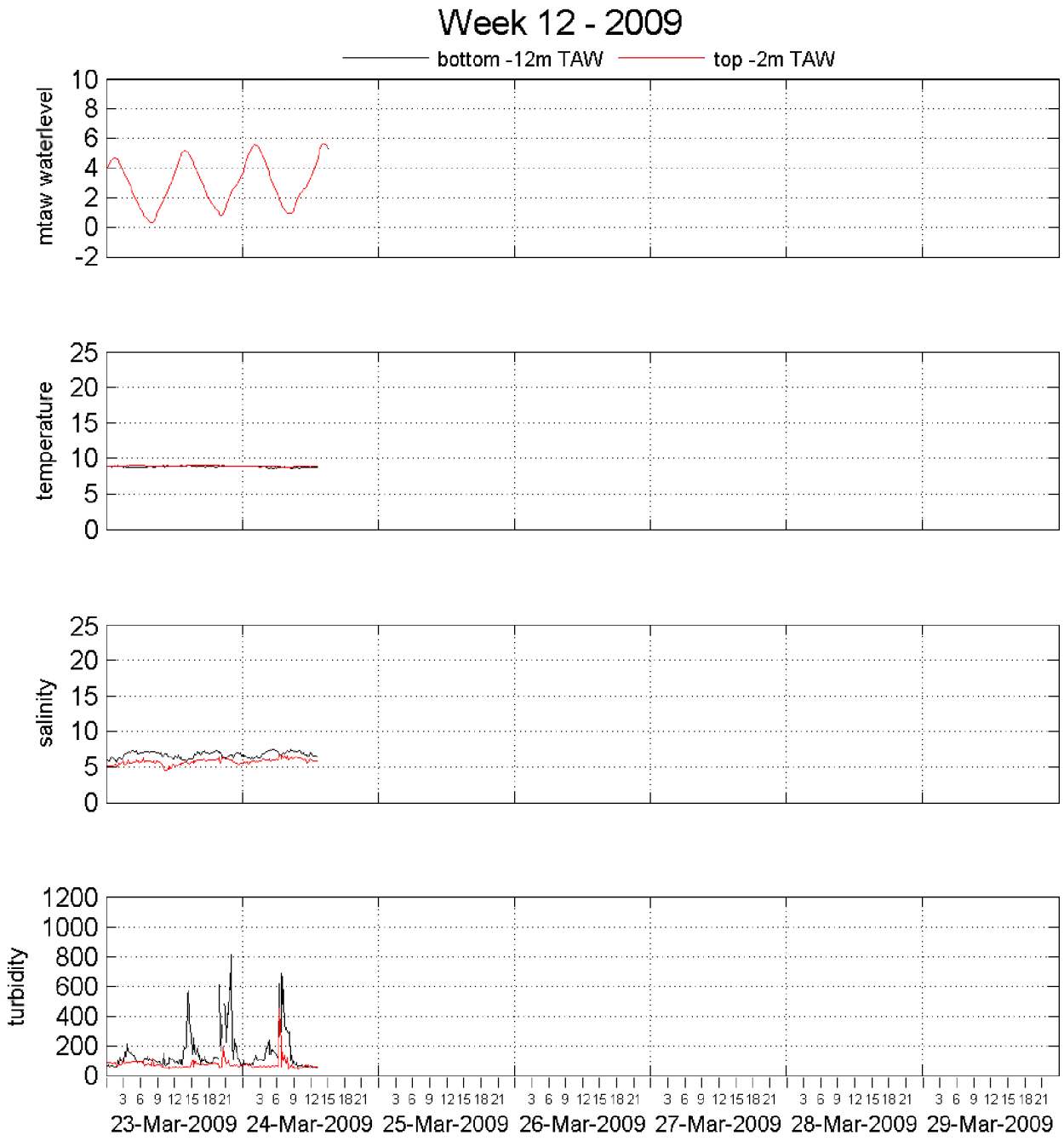

Week series of Salinity, Temperature, SS concentration and Tide

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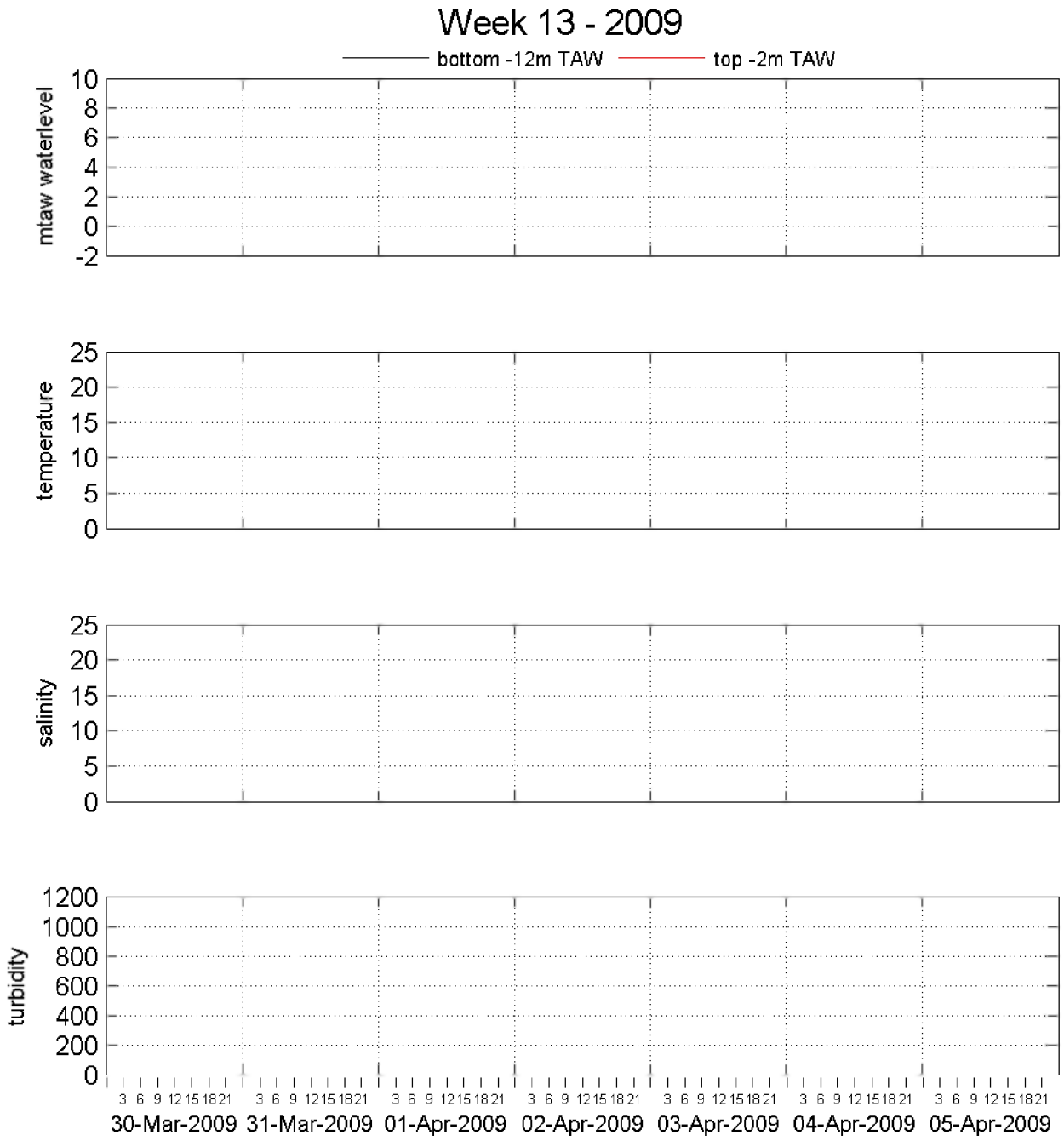

Week series of Salinity, Temperature, SS concentration and Tide

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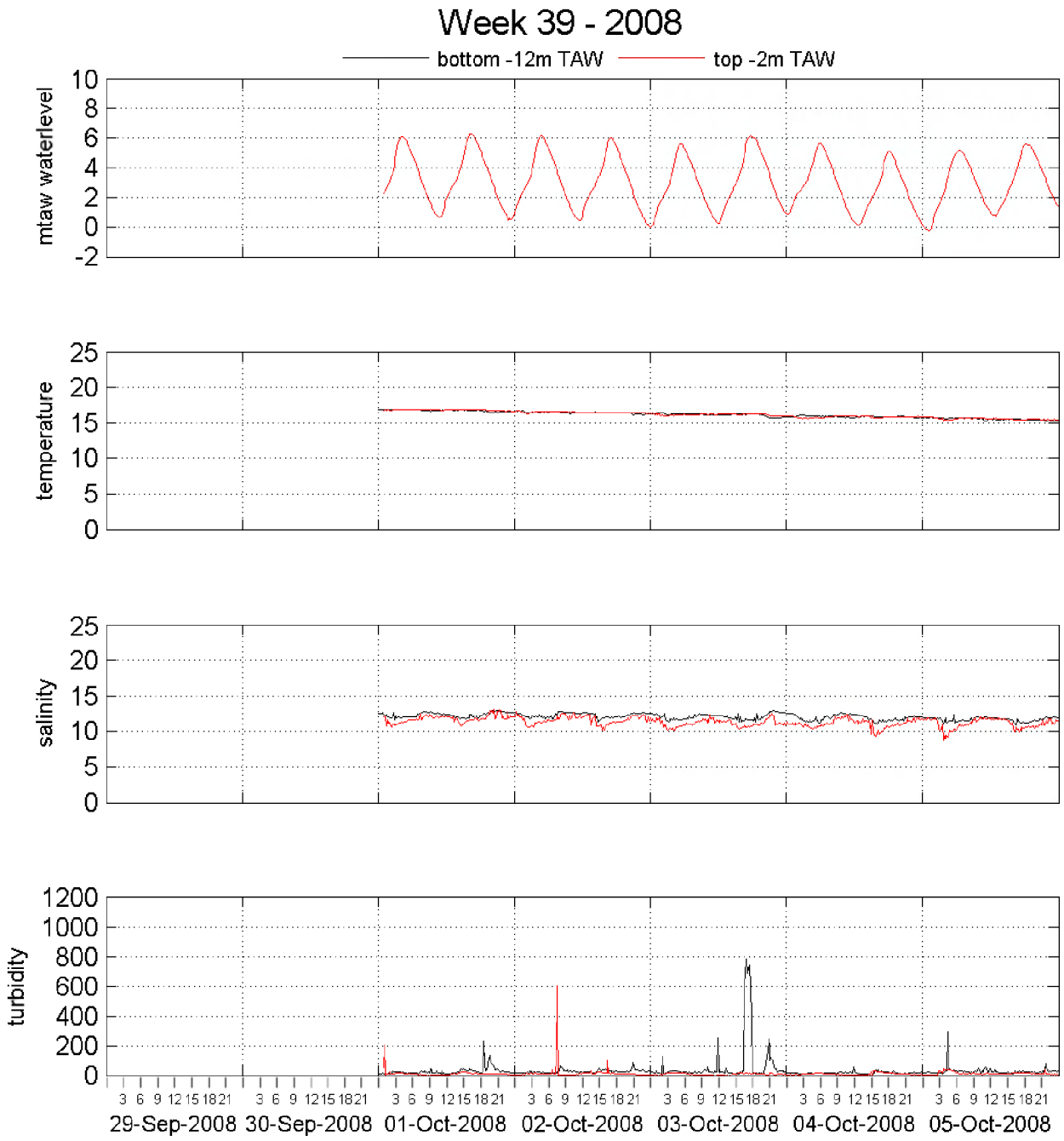

Week series of Salinity, Temperature, SS concentration and Tide

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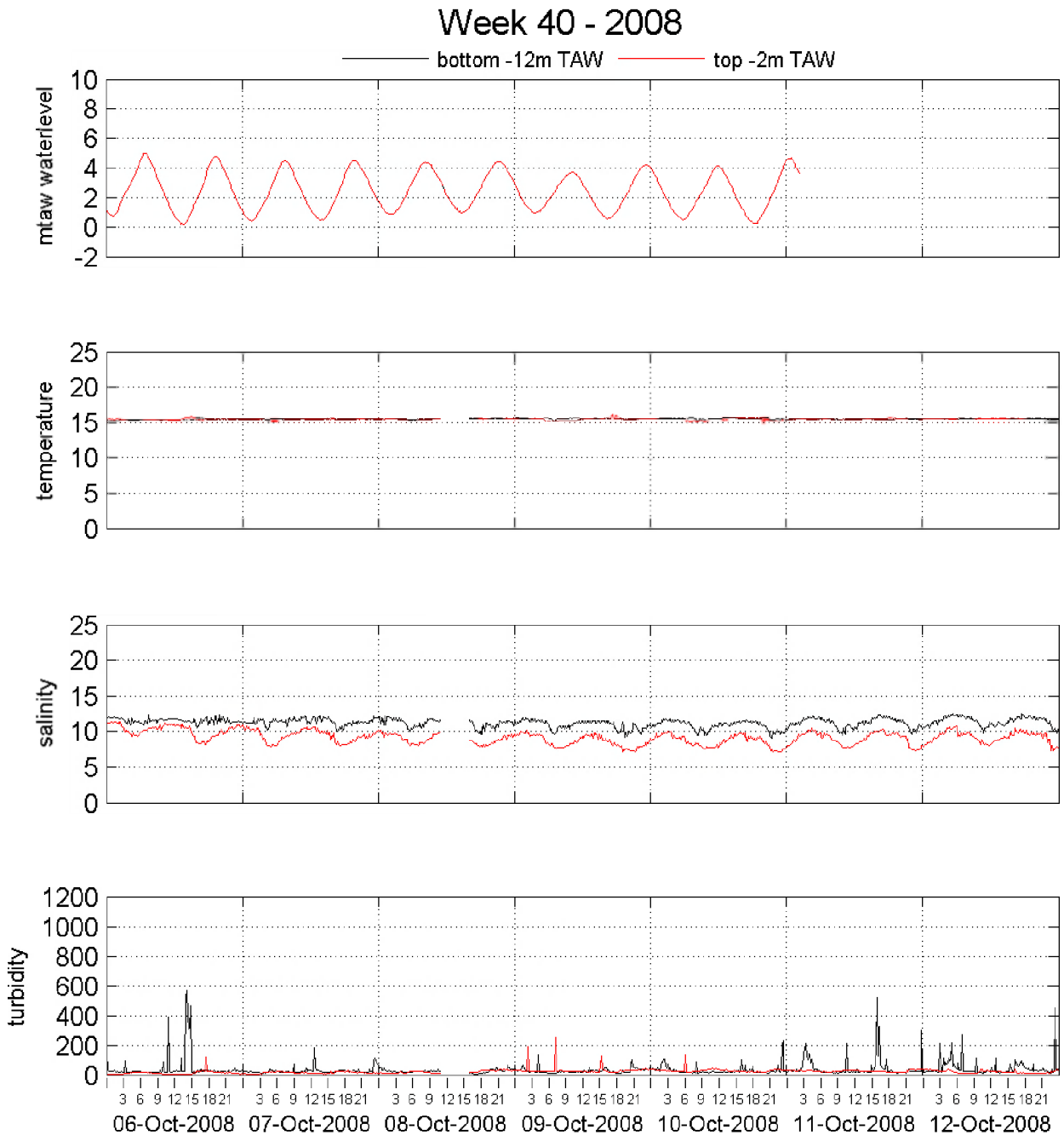

Week series of Salinity, Temperature, SS concentration and Tide

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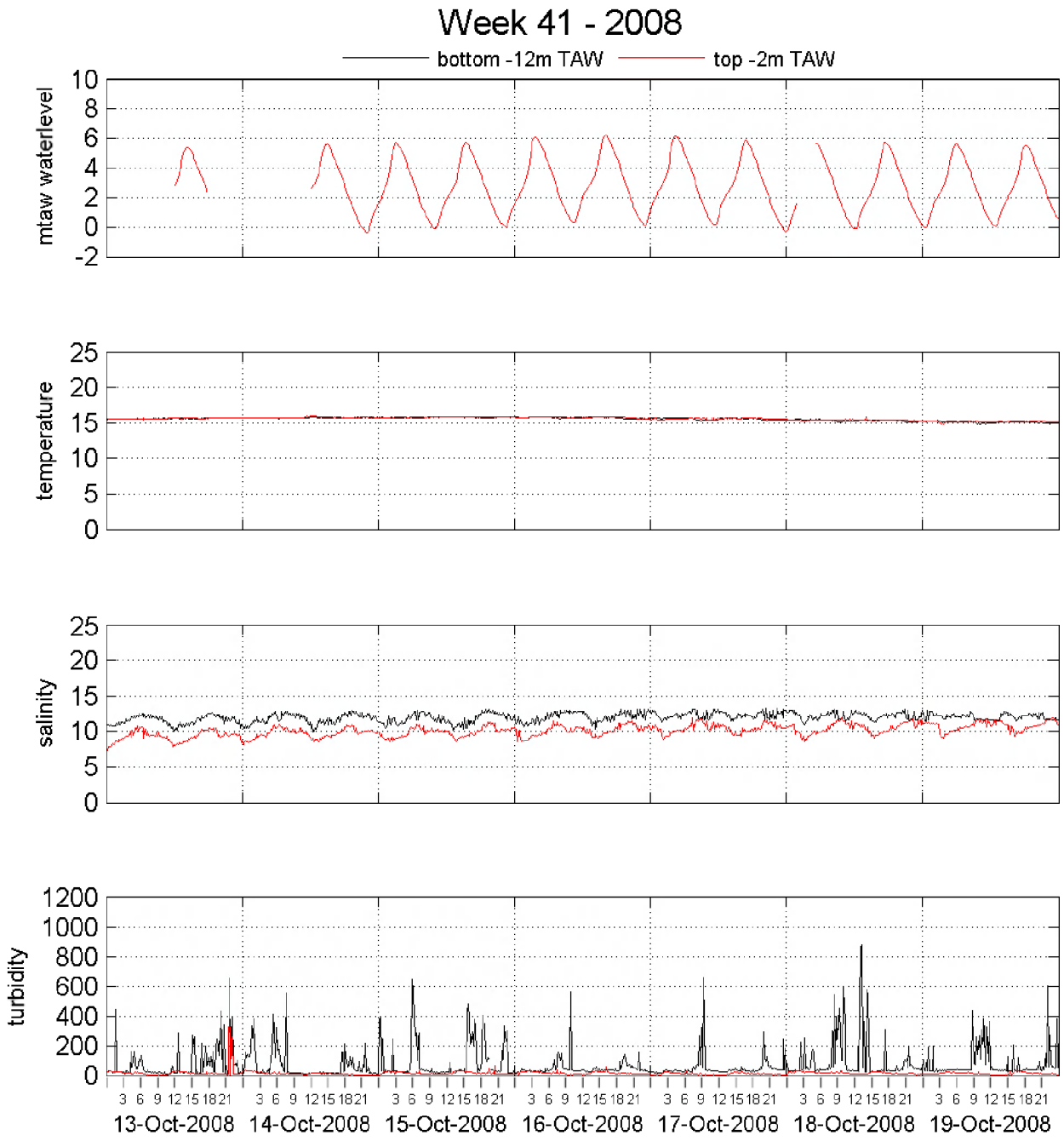

Week series of Salinity, Temperature, SS concentration and Tide

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Location:

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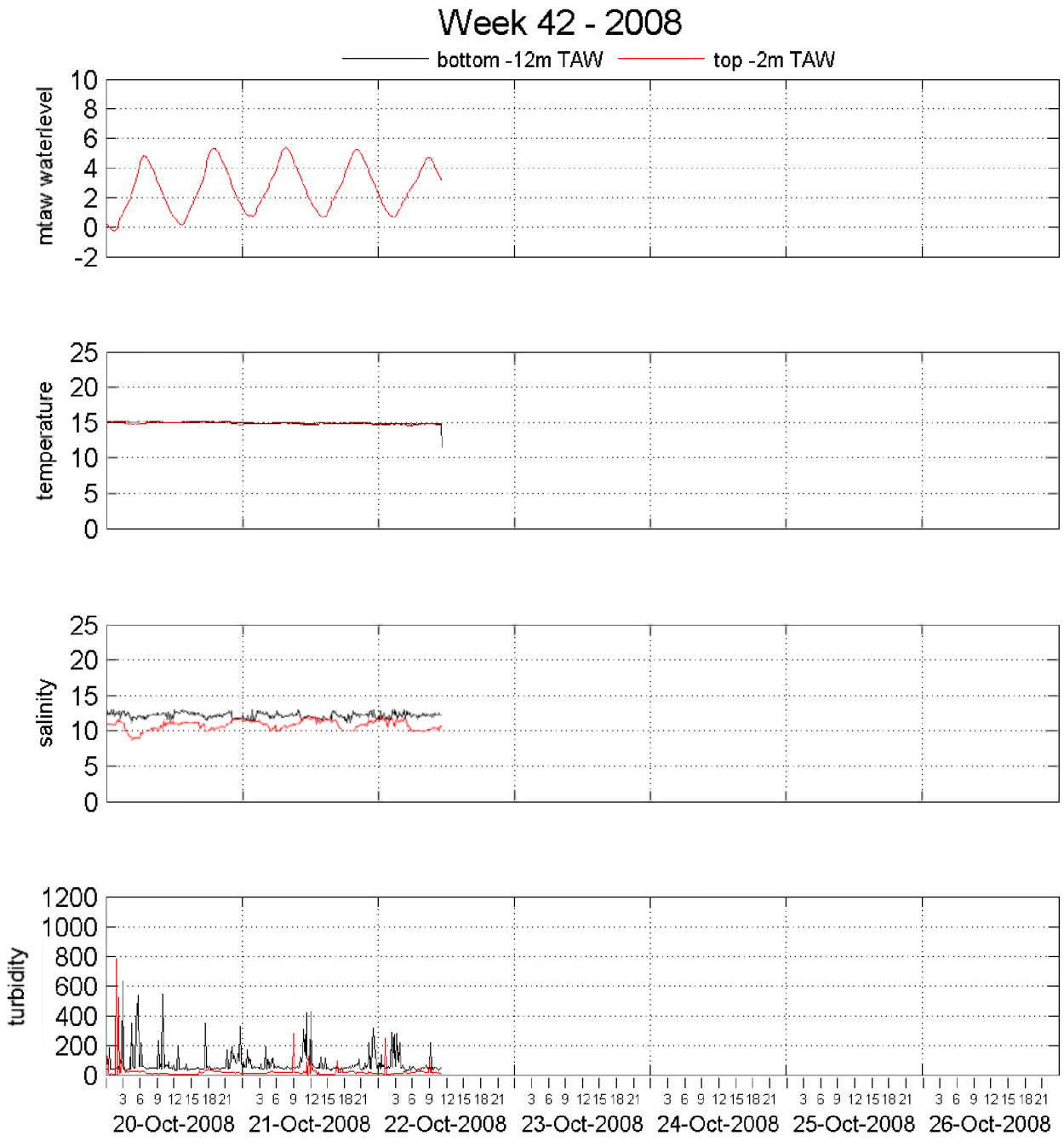

Week series of Salinity, Temperature, SS concentration and Tide

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Location:

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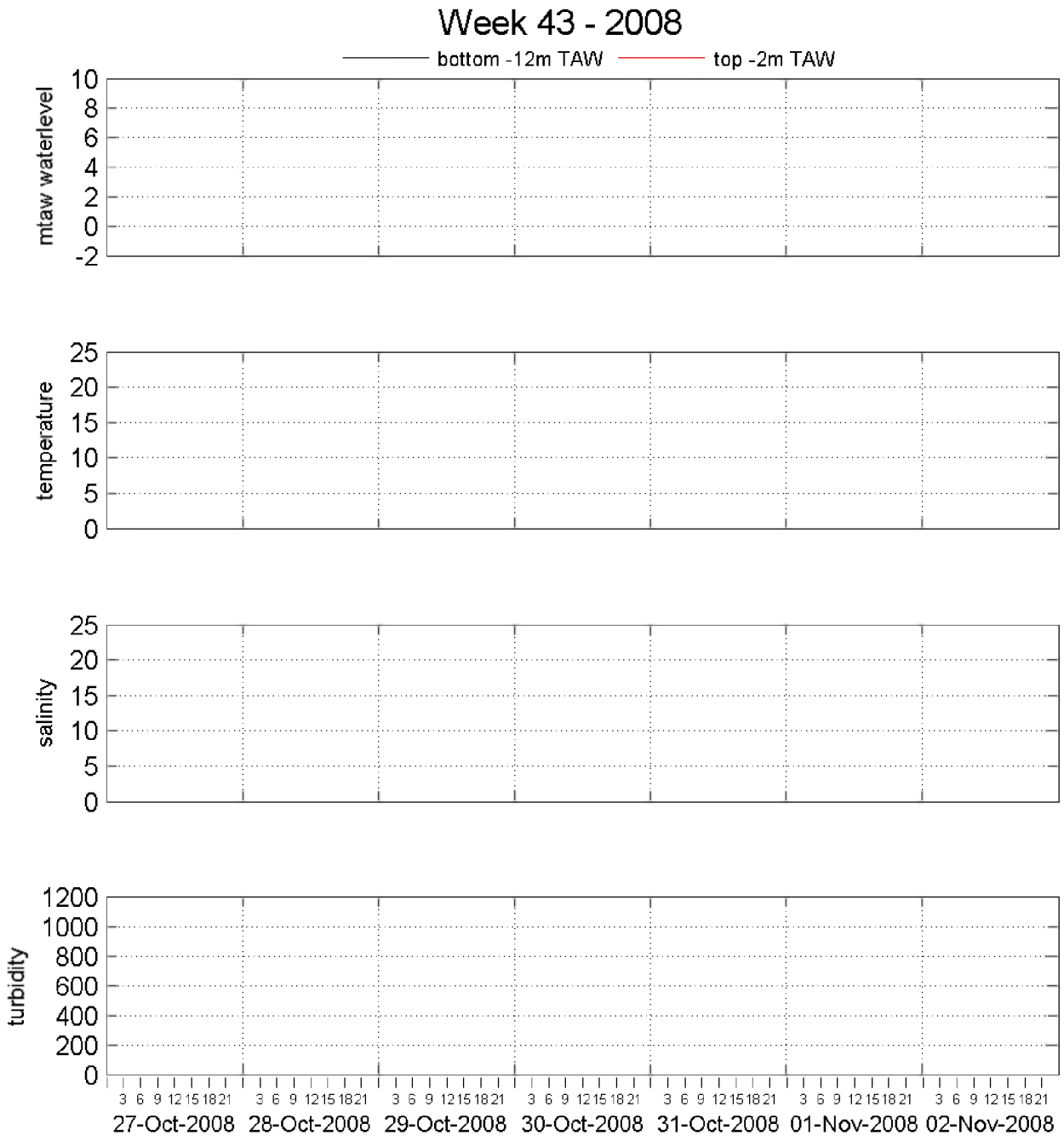

Week series of Salinity, Temperature, SS concentration and Tide

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Location:

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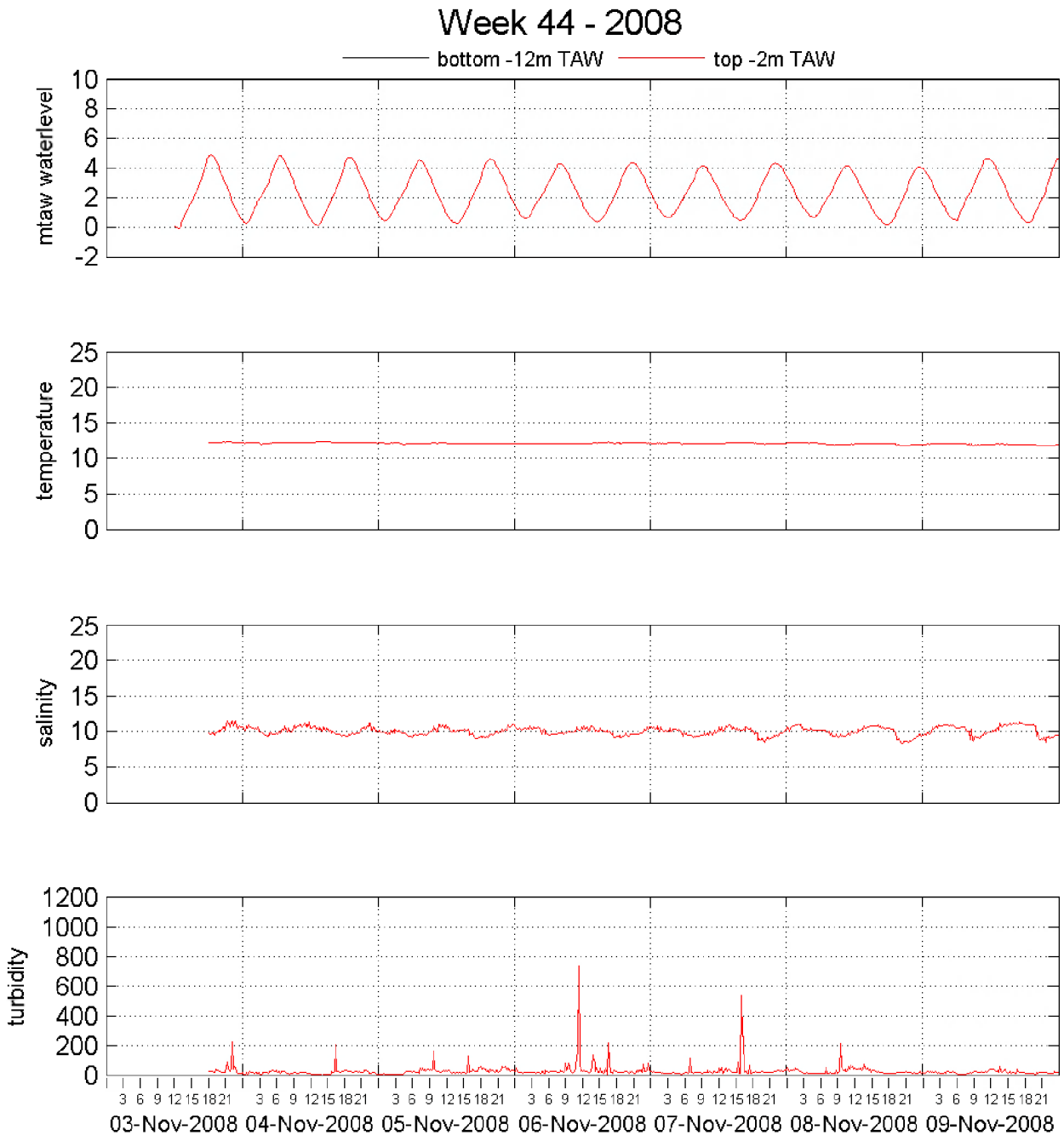

Week series of Salinity, Temperature, SS concentration and Tide

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Location:

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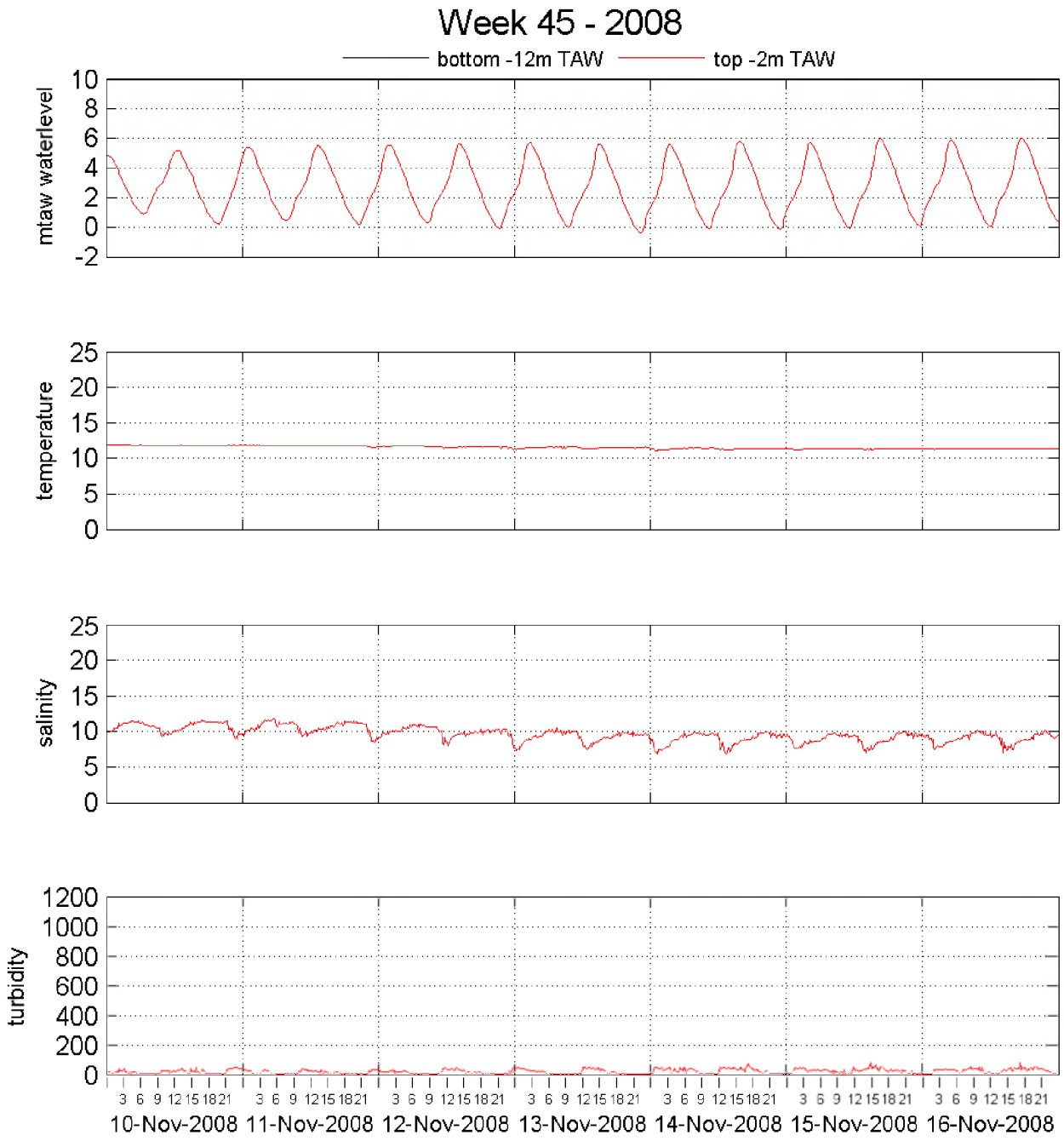

Week series of Salinity, Temperature, SS concentration and Tide

Processed

Location:

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I/RA/11283/08.094/MSA

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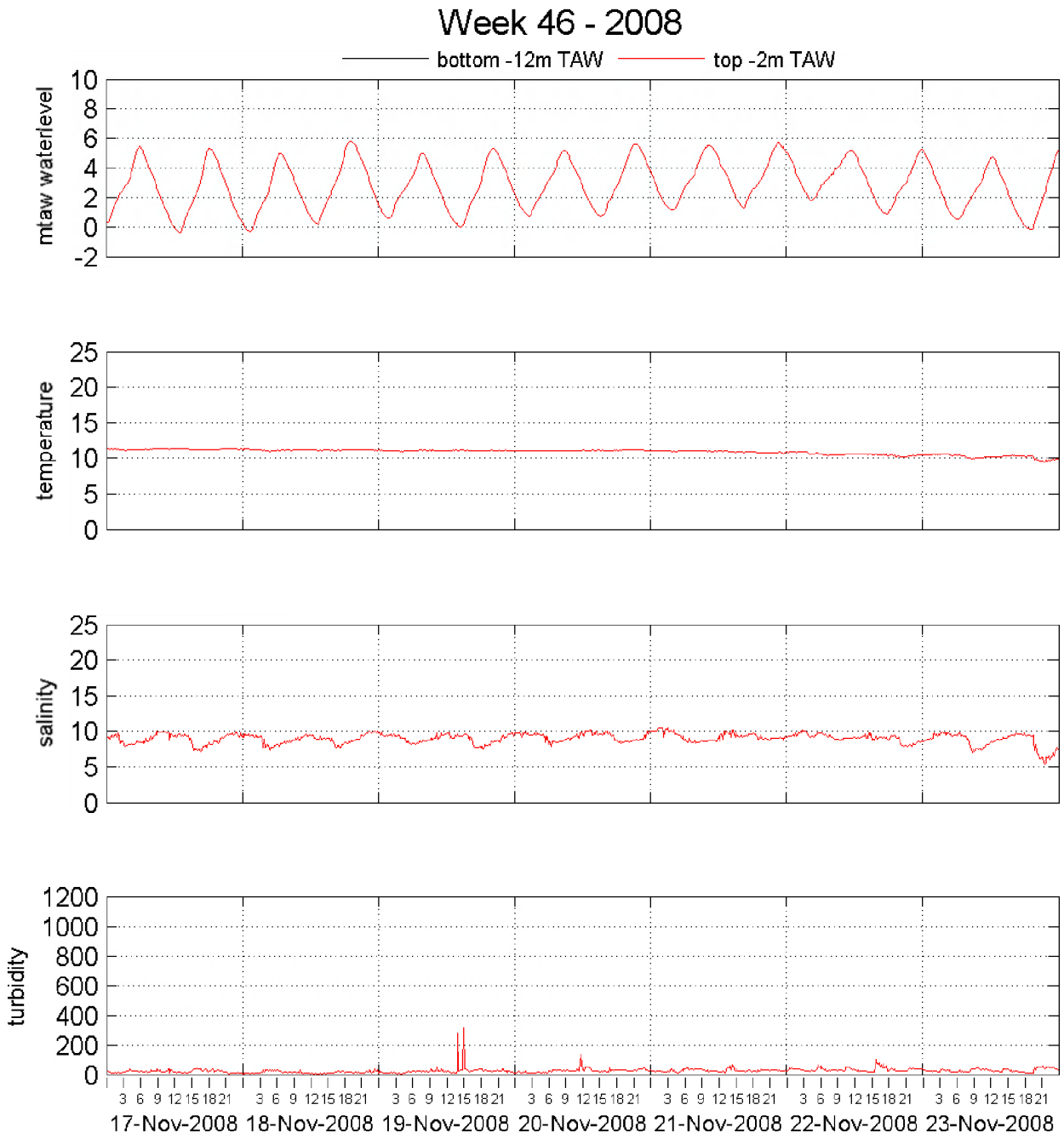

Week series of Salinity, Temperature, SS concentration and Tide

Processed

Location:

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I/RA/11283/08.094/MSA

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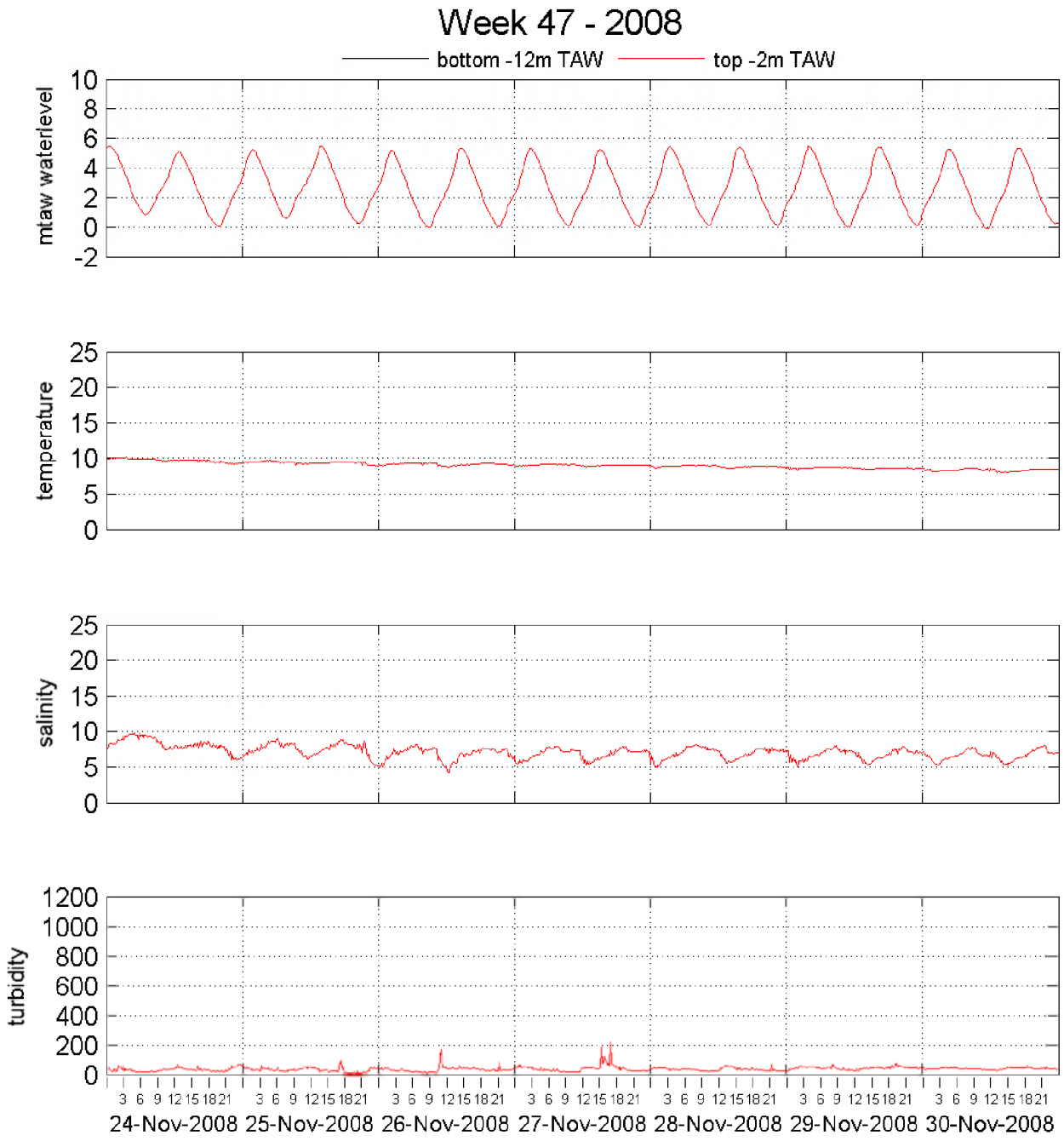

Week series of Salinity, Temperature, SS concentration and Tide

Processed

Location:

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I/RA/11283/08.094/MSA

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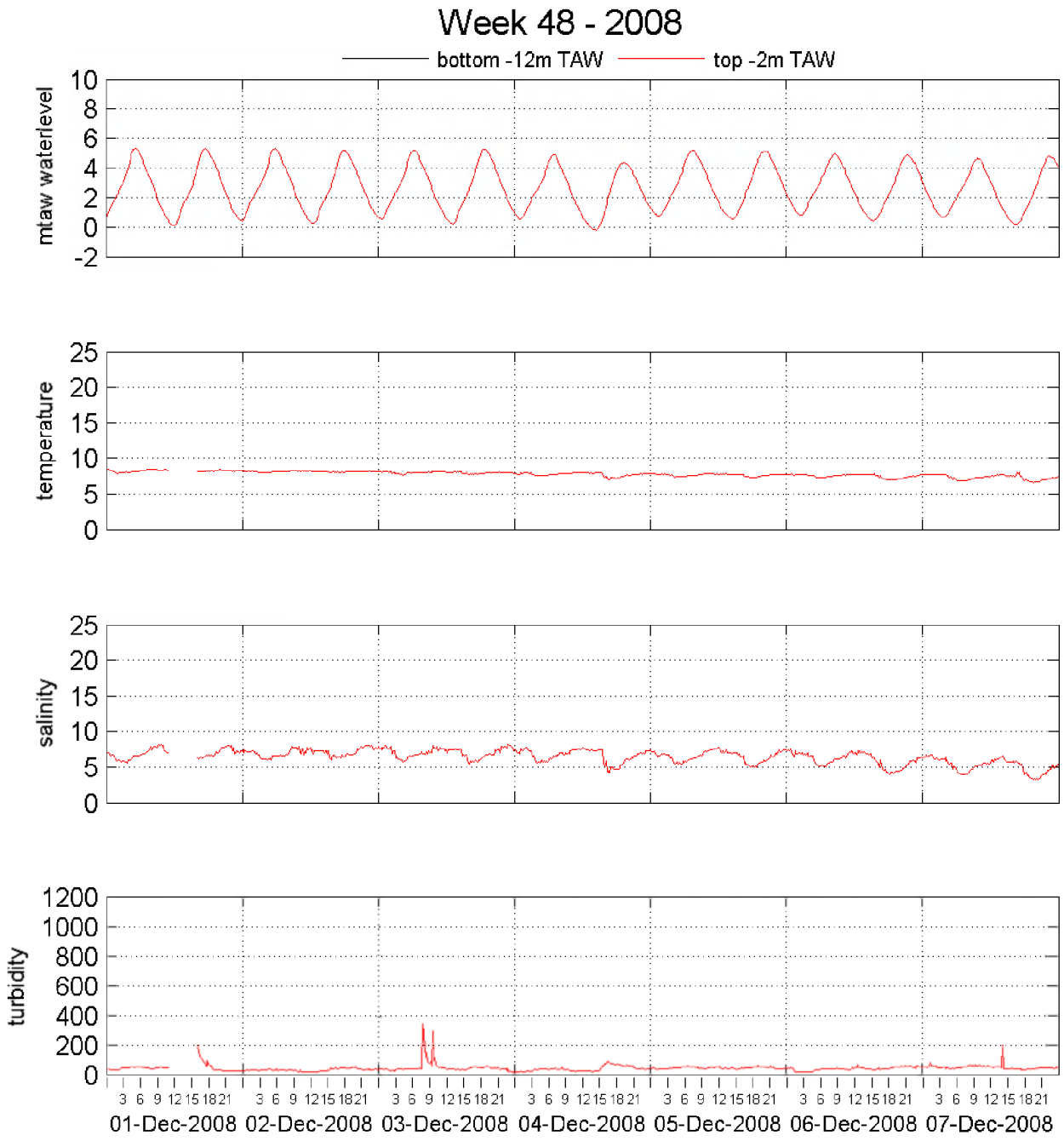

Week series of Salinity, Temperature, SS concentration and Tide

Processed

Location:

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I/RA/11283/08.094/MSA

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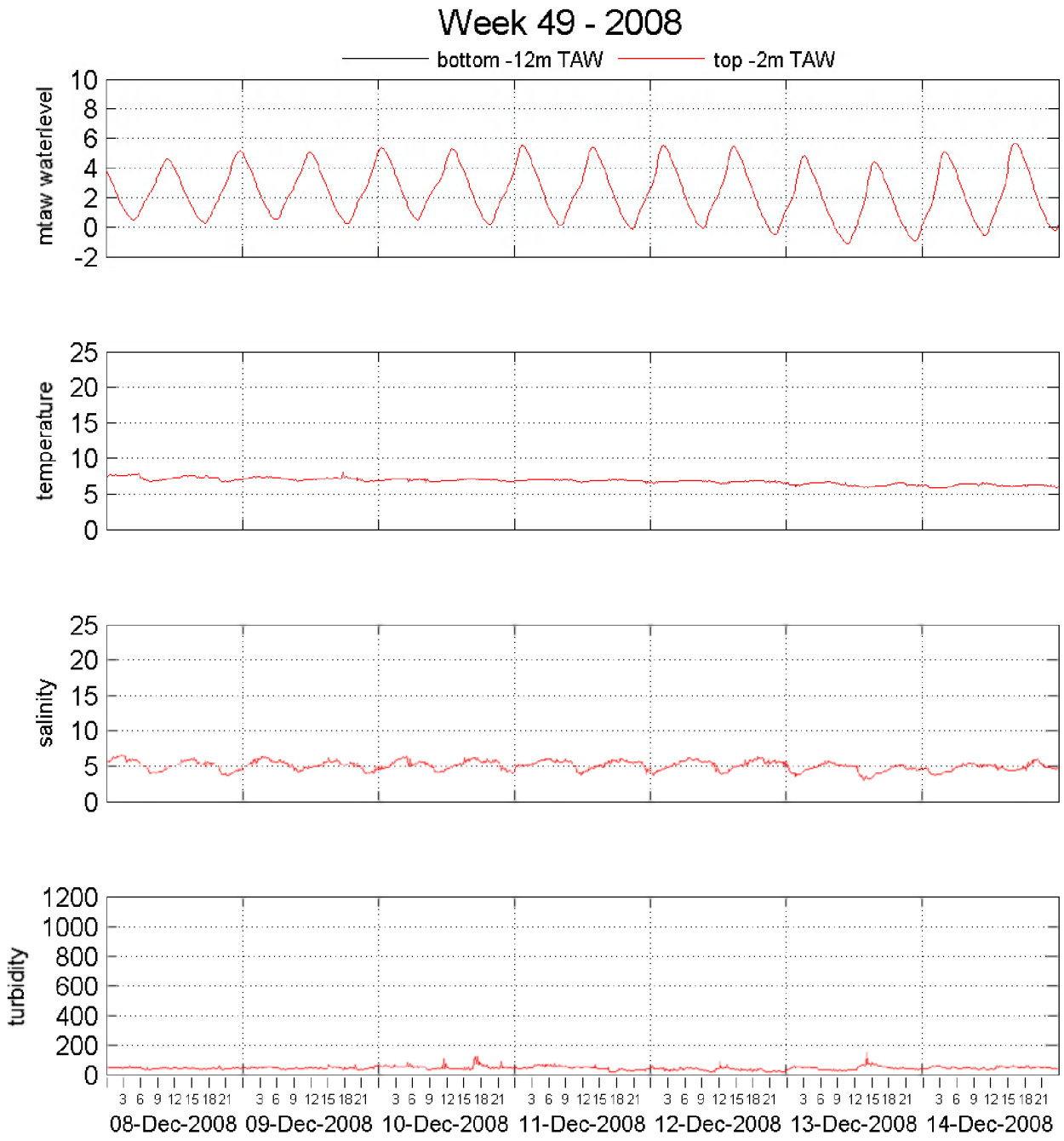

Week series of Salinity, Temperature, SS concentration and Tide

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Location:

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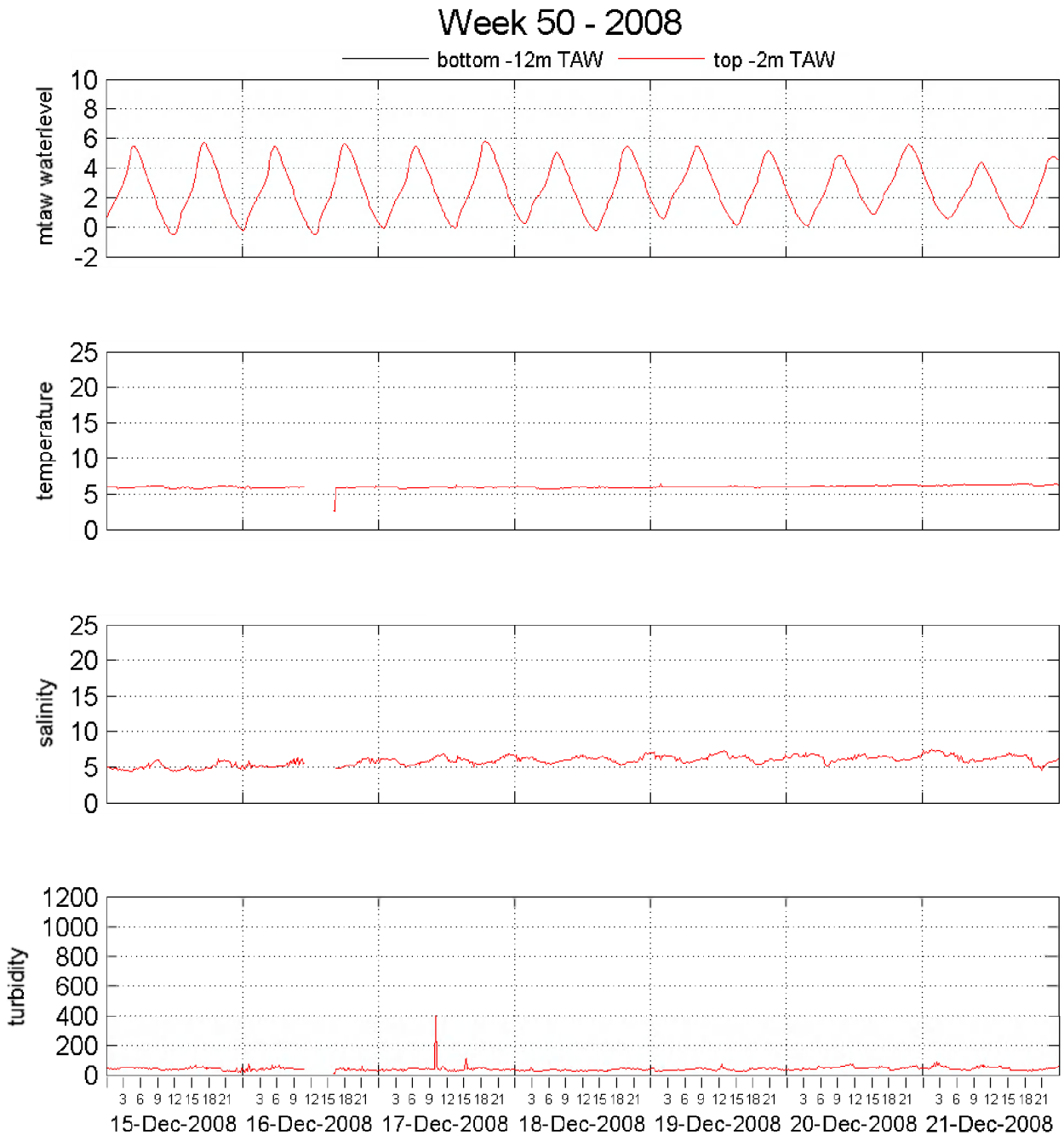

Week series of Salinity, Temperature, SS concentration and Tide

Processed

Location:

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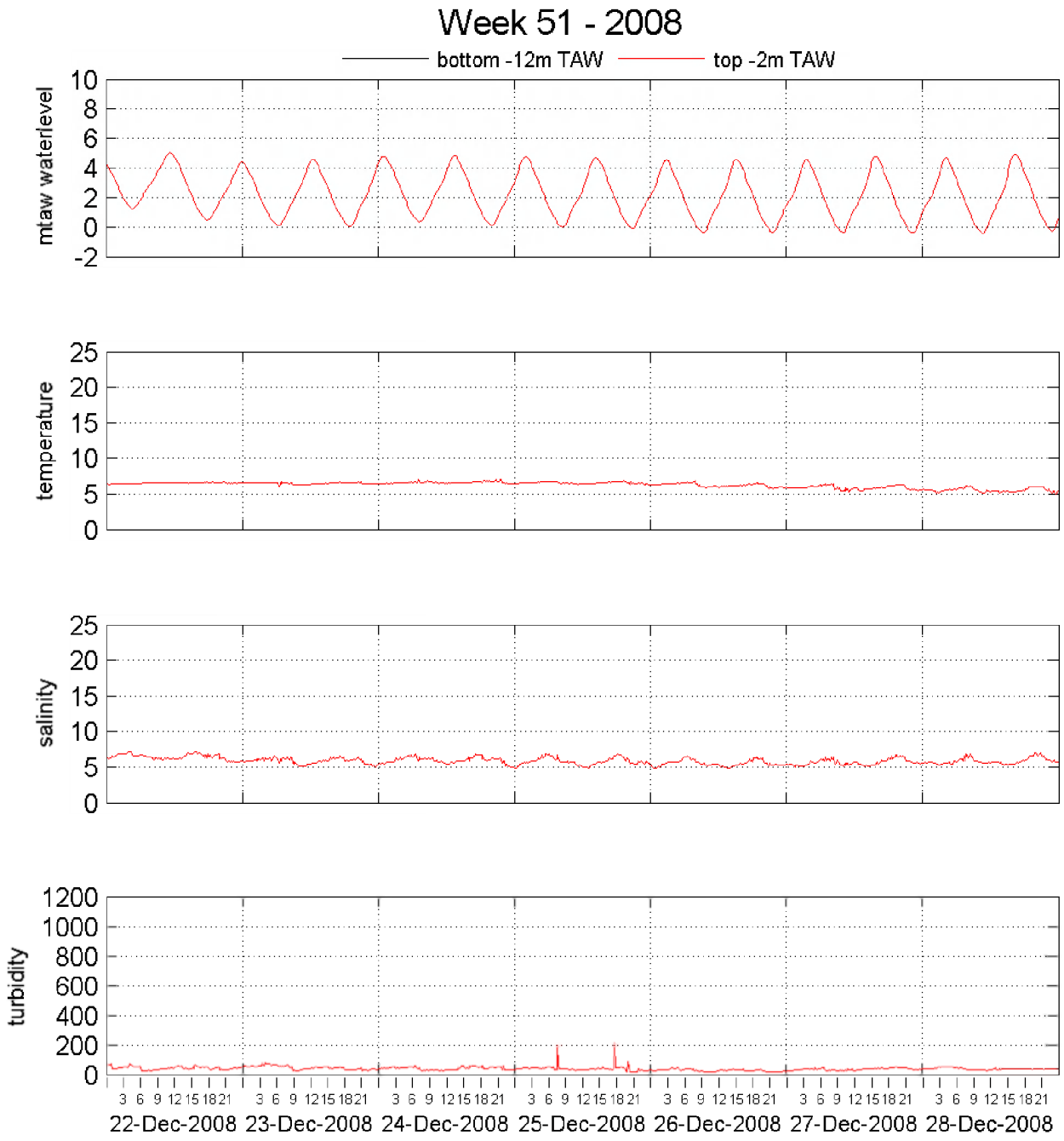

Week series of Salinity, Temperature, SS concentration and Tide

Processed

Location:

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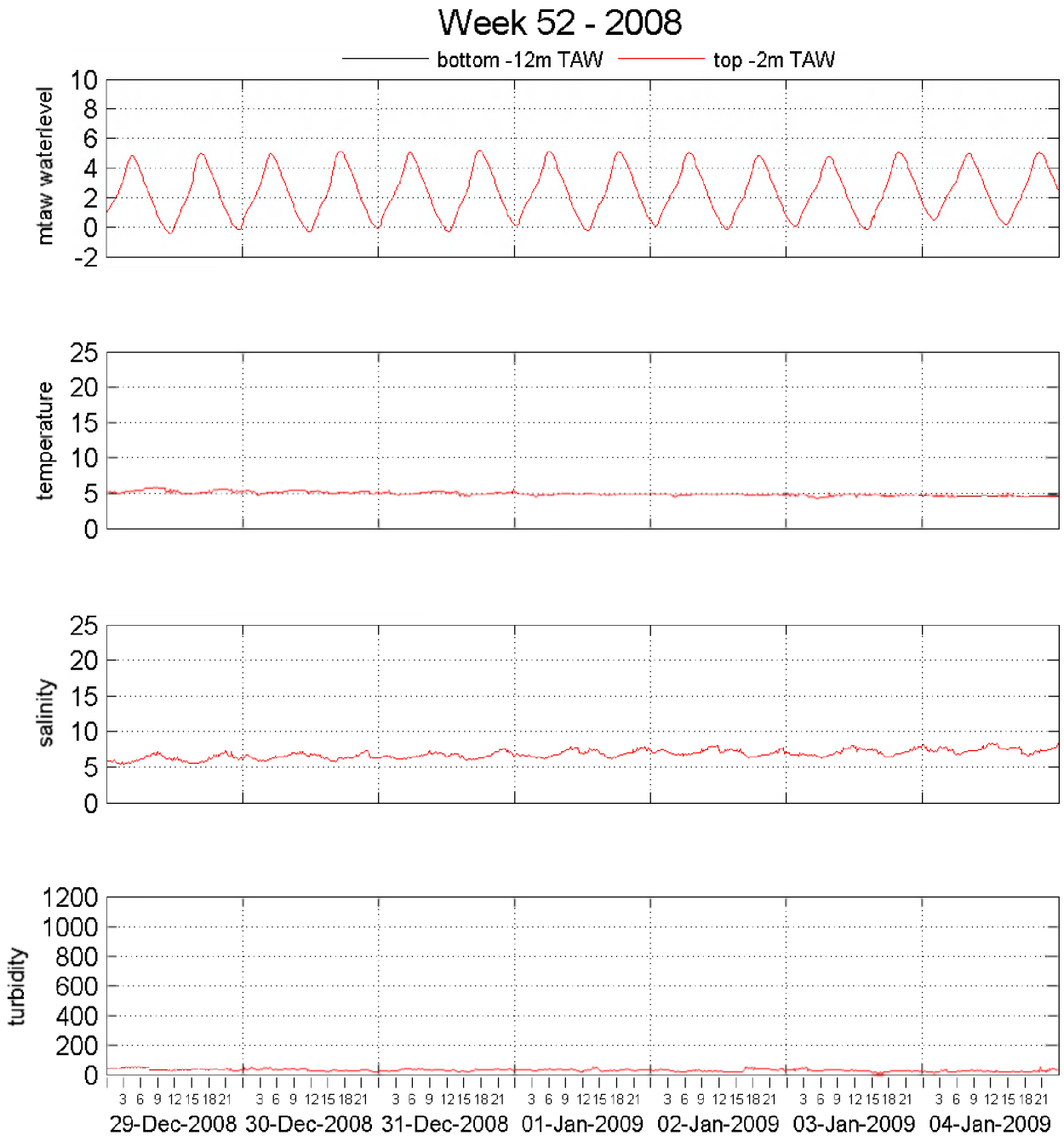

Week series of Salinity, Temperature, SS concentration and Tide

Processed

Location:

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I/RA/11283/08.094/MSA

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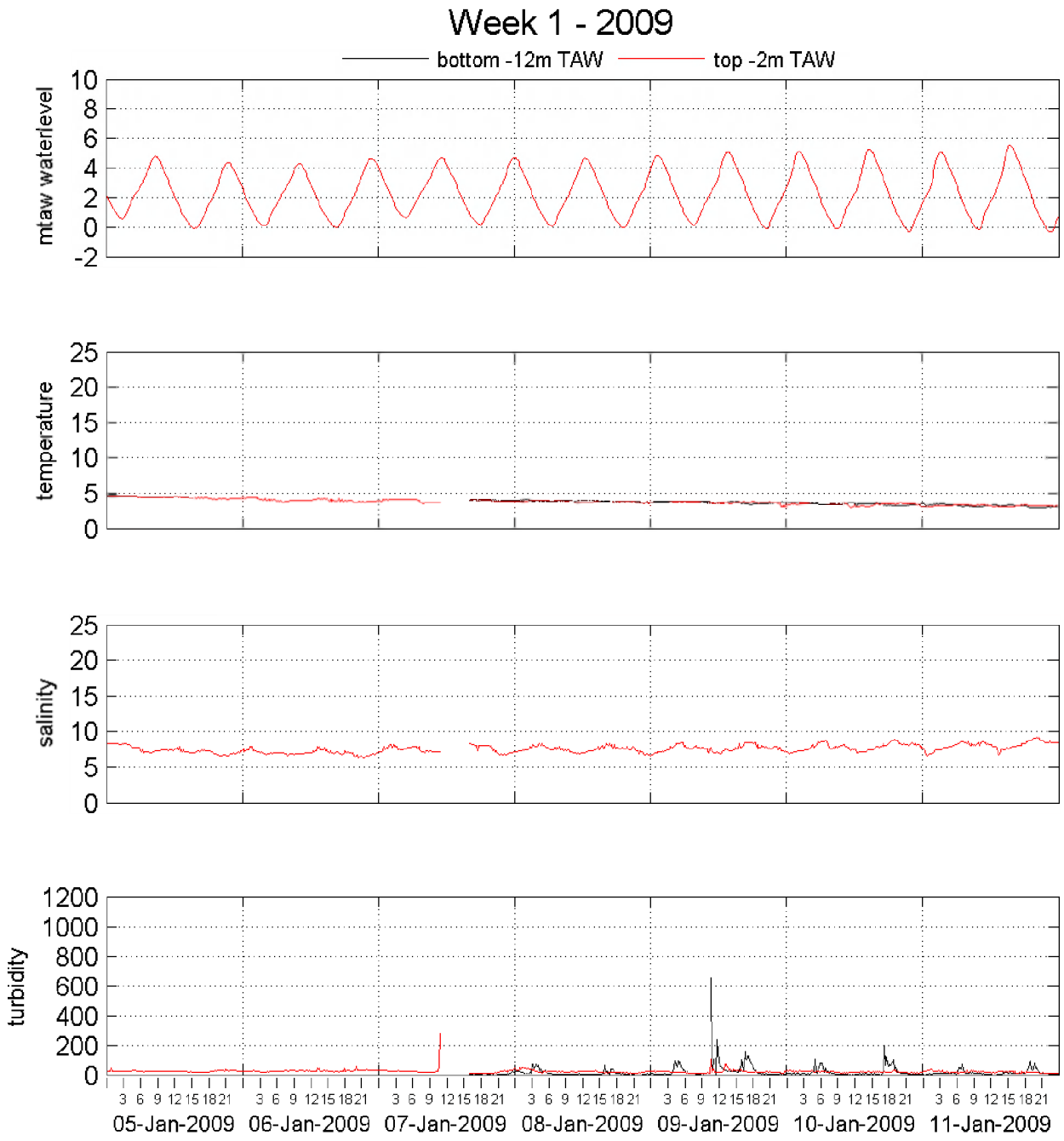

Week series of Salinity, Temperature, SS concentration and Tide

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Location:

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I/RA/11283/08.094/MSA

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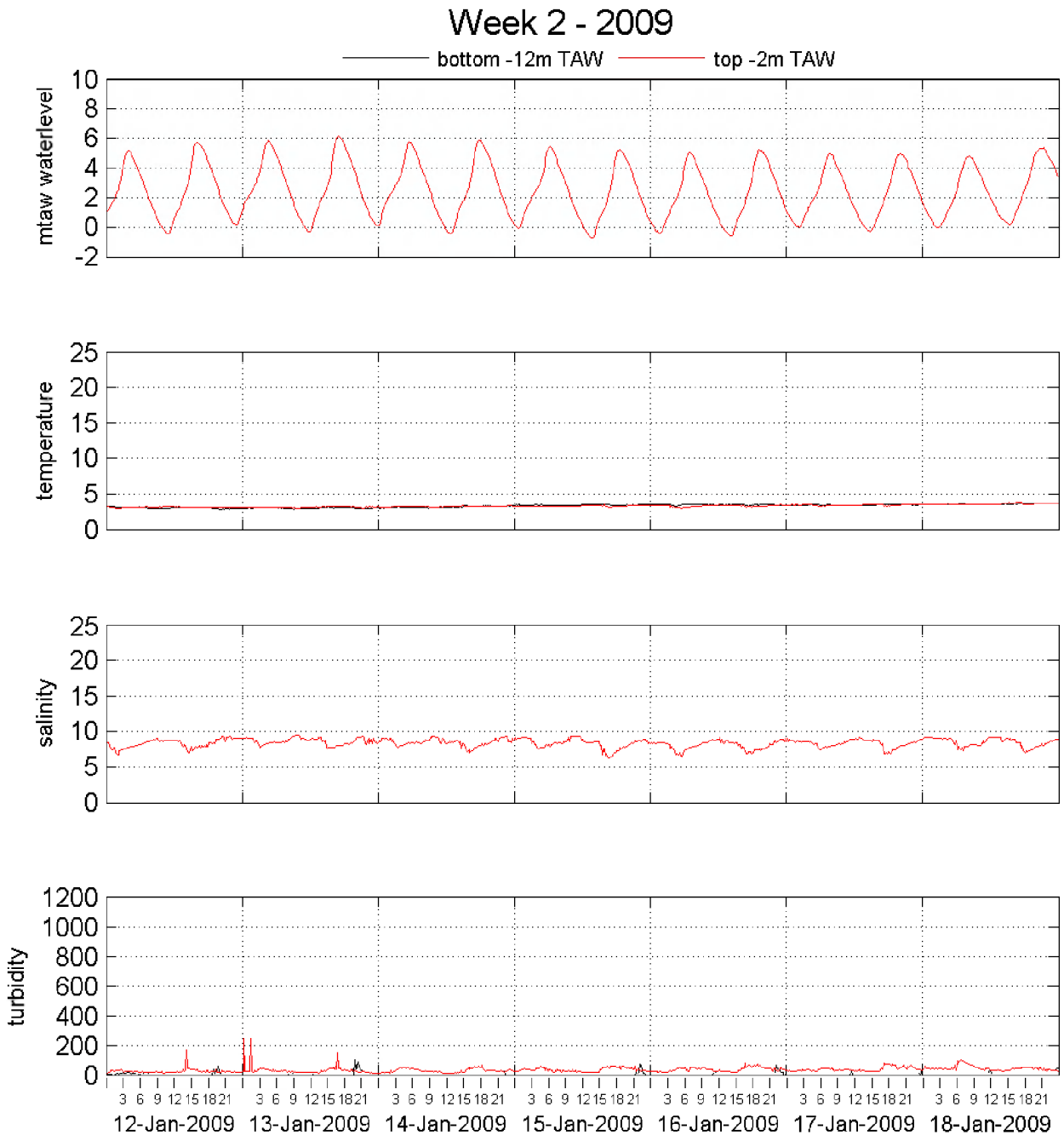

Week series of Salinity, Temperature, SS concentration and Tide

Processed

Location:

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I/RA/11283/08.094/MSA

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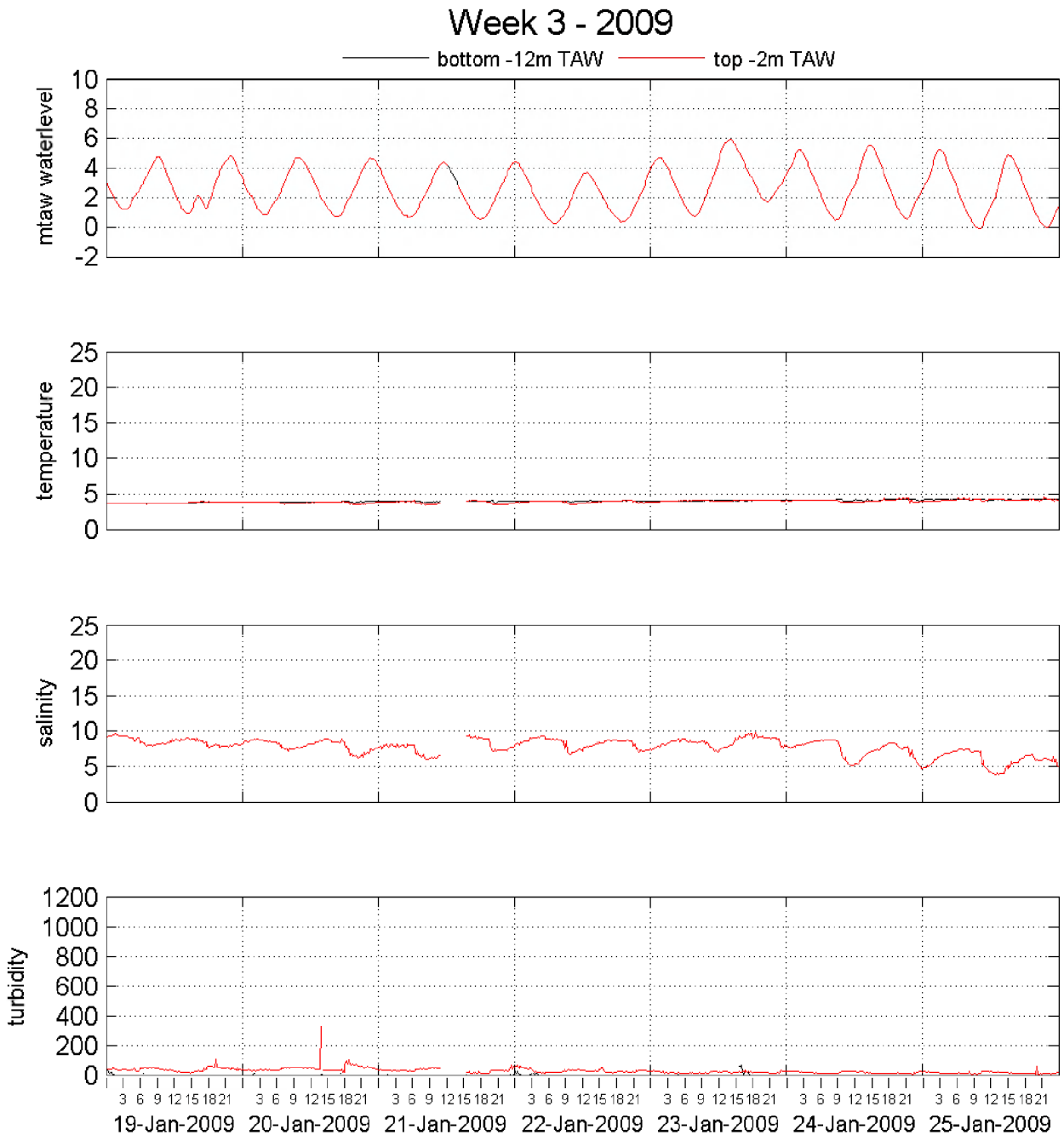

Week series of Salinity, Temperature, SS concentration and Tide

Processed

Location:

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I/RA/11283/08.094/MSA

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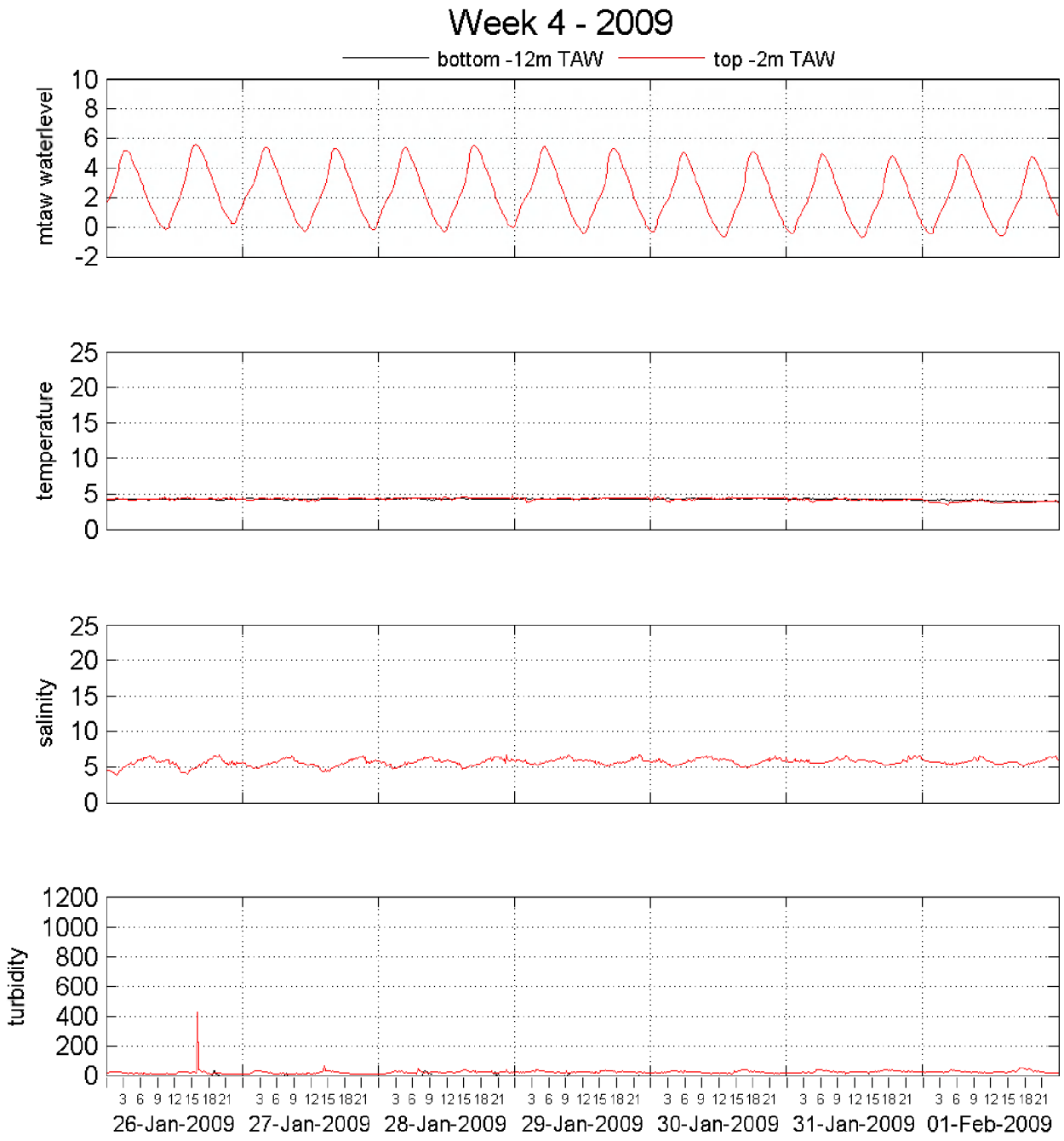

Week series of Salinity, Temperature, SS concentration and Tide

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Location:

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I/RA/11283/08.094/MSA

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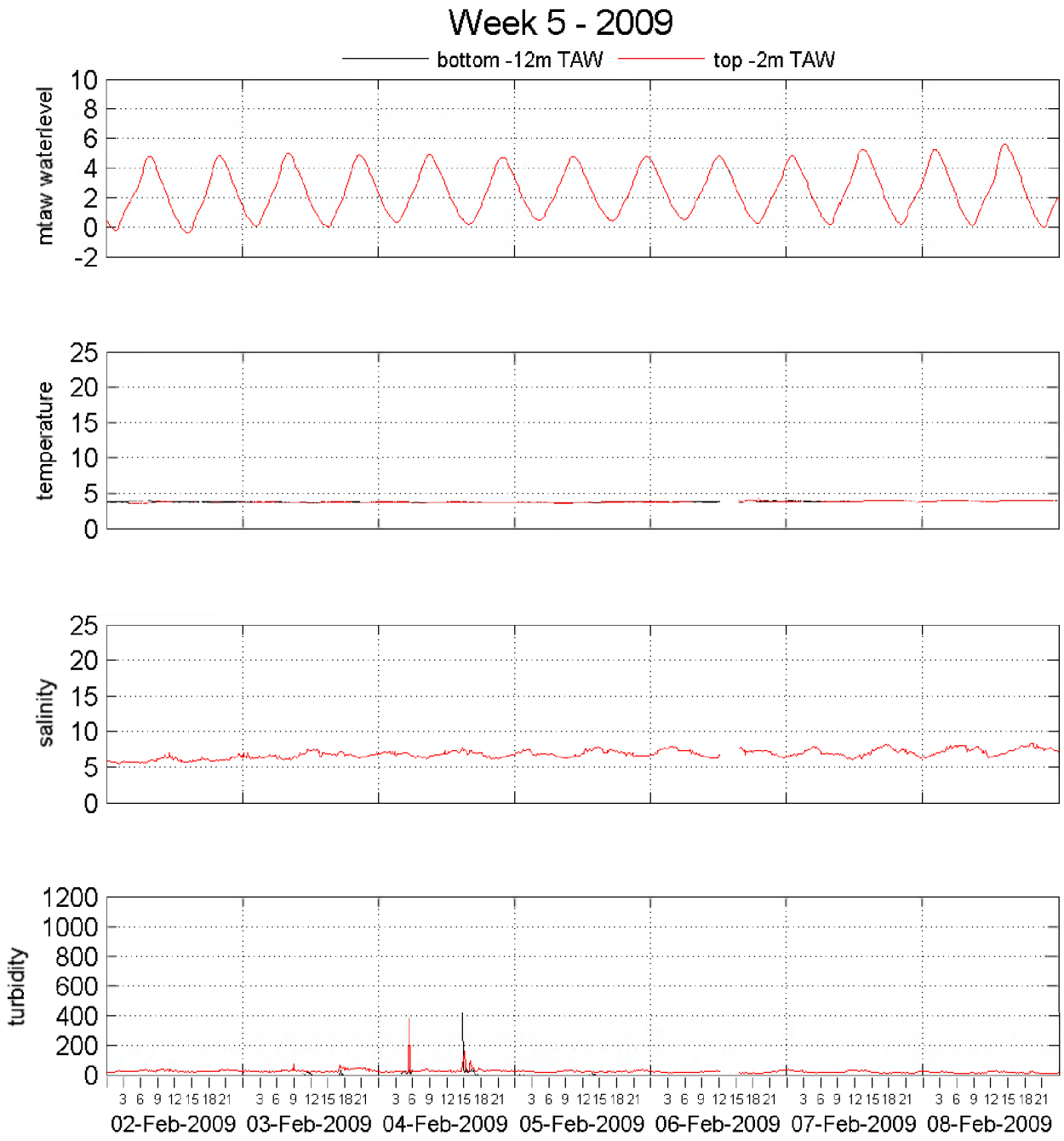

Week series of Salinity, Temperature, SS concentration and Tide

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Location:

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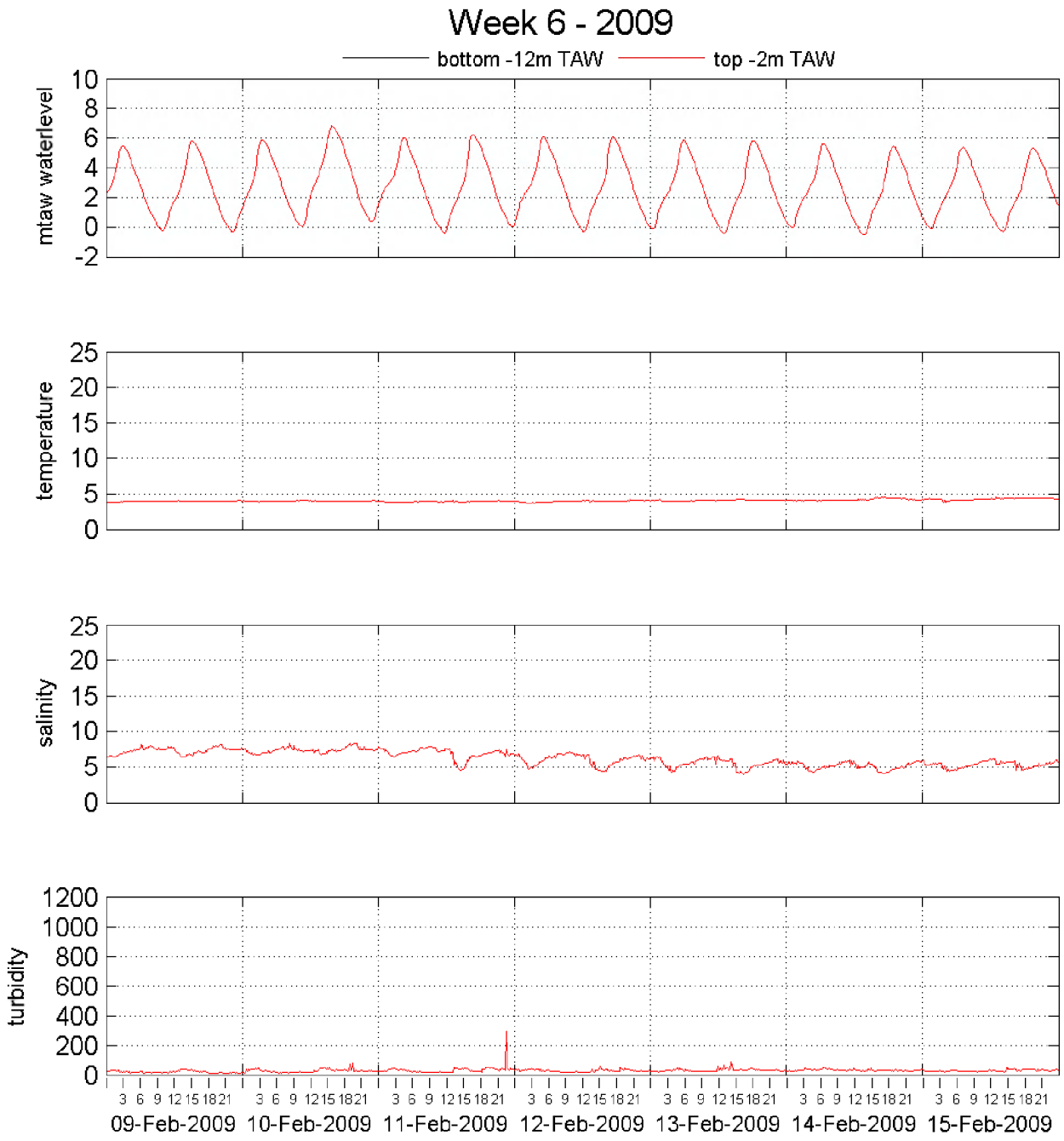

Week series of Salinity, Temperature, SS concentration and Tide

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Location:

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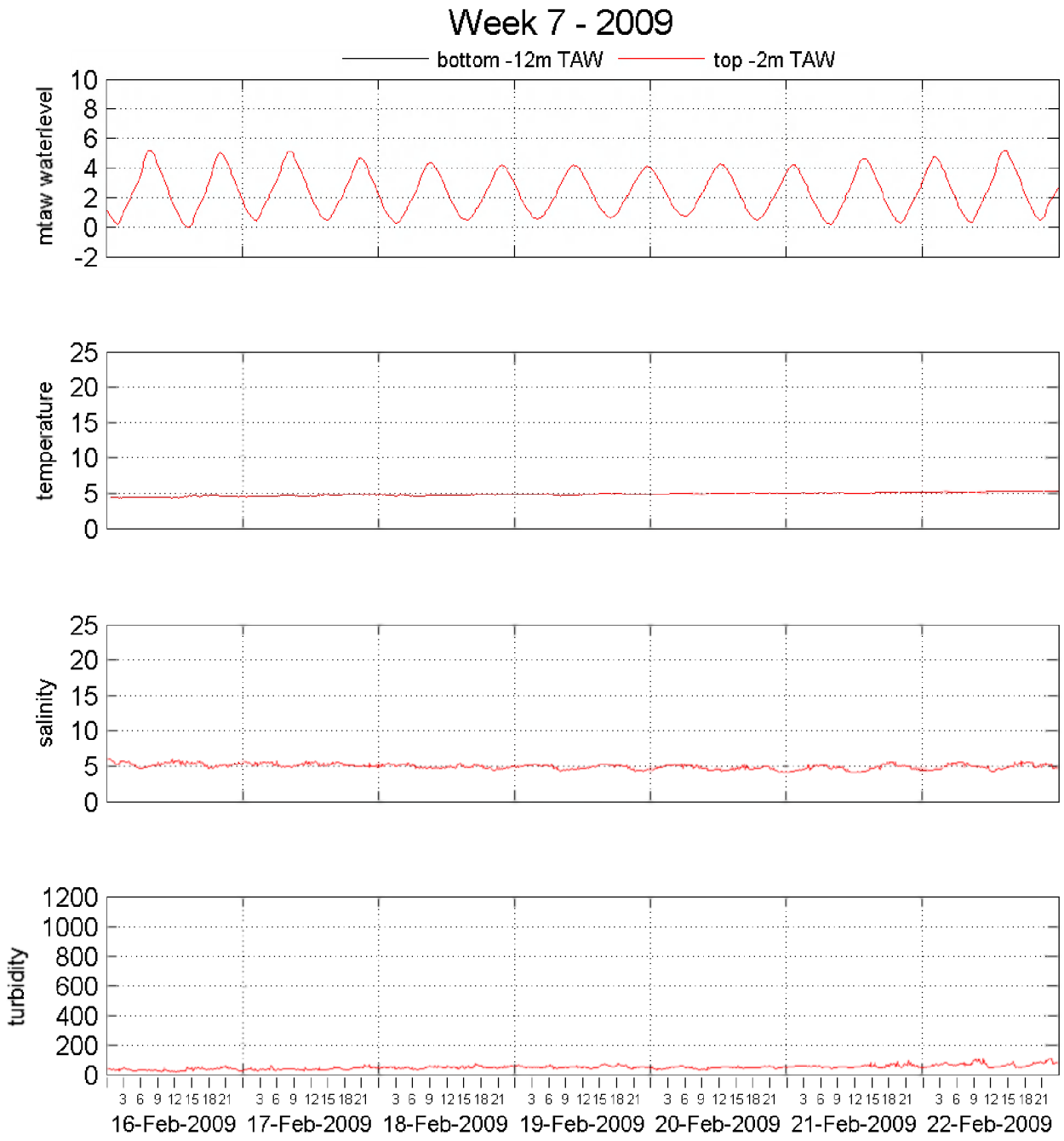

Week series of Salinity, Temperature, SS concentration and Tide

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Location:

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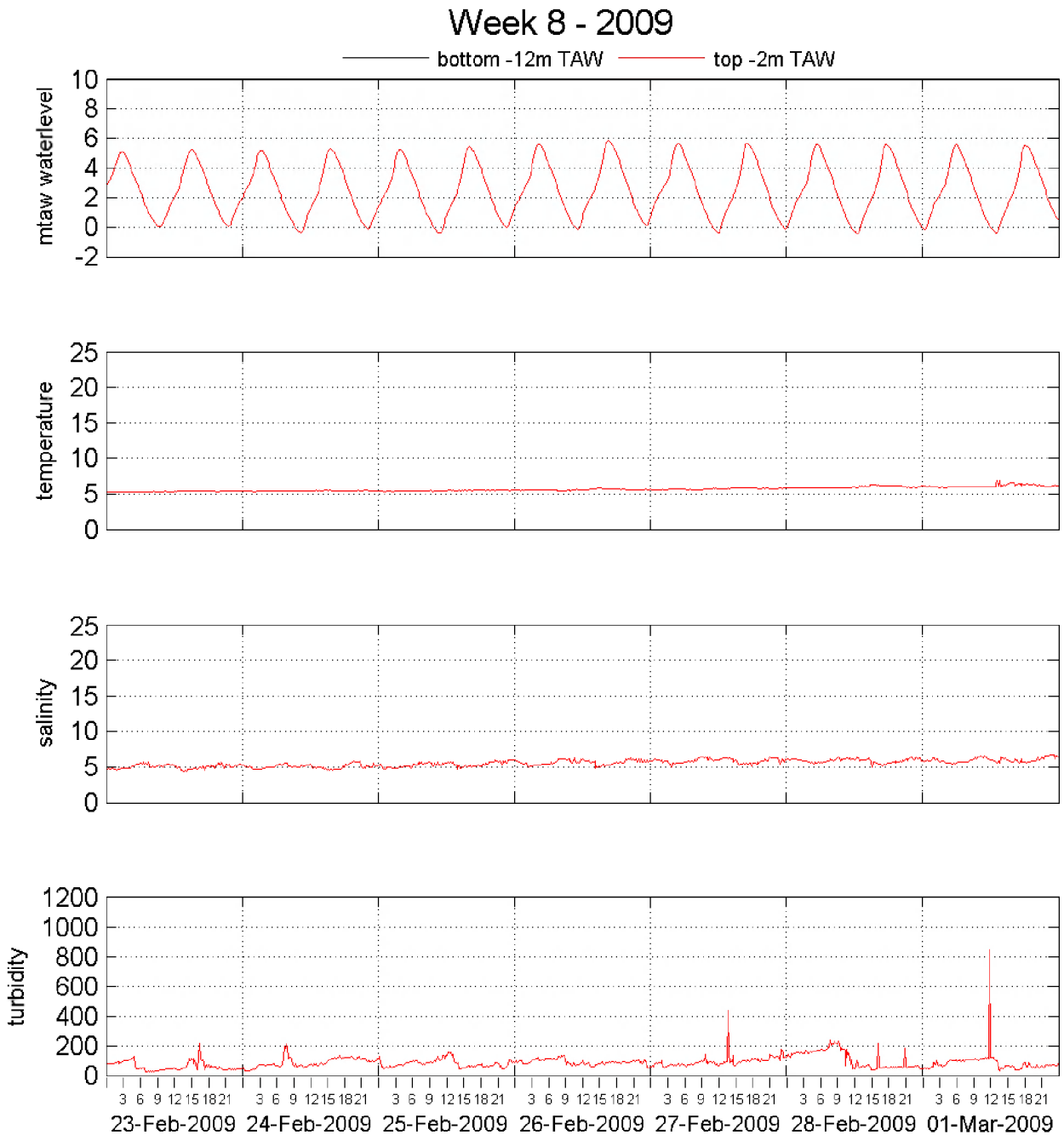

Week series of Salinity, Temperature, SS concentration and Tide

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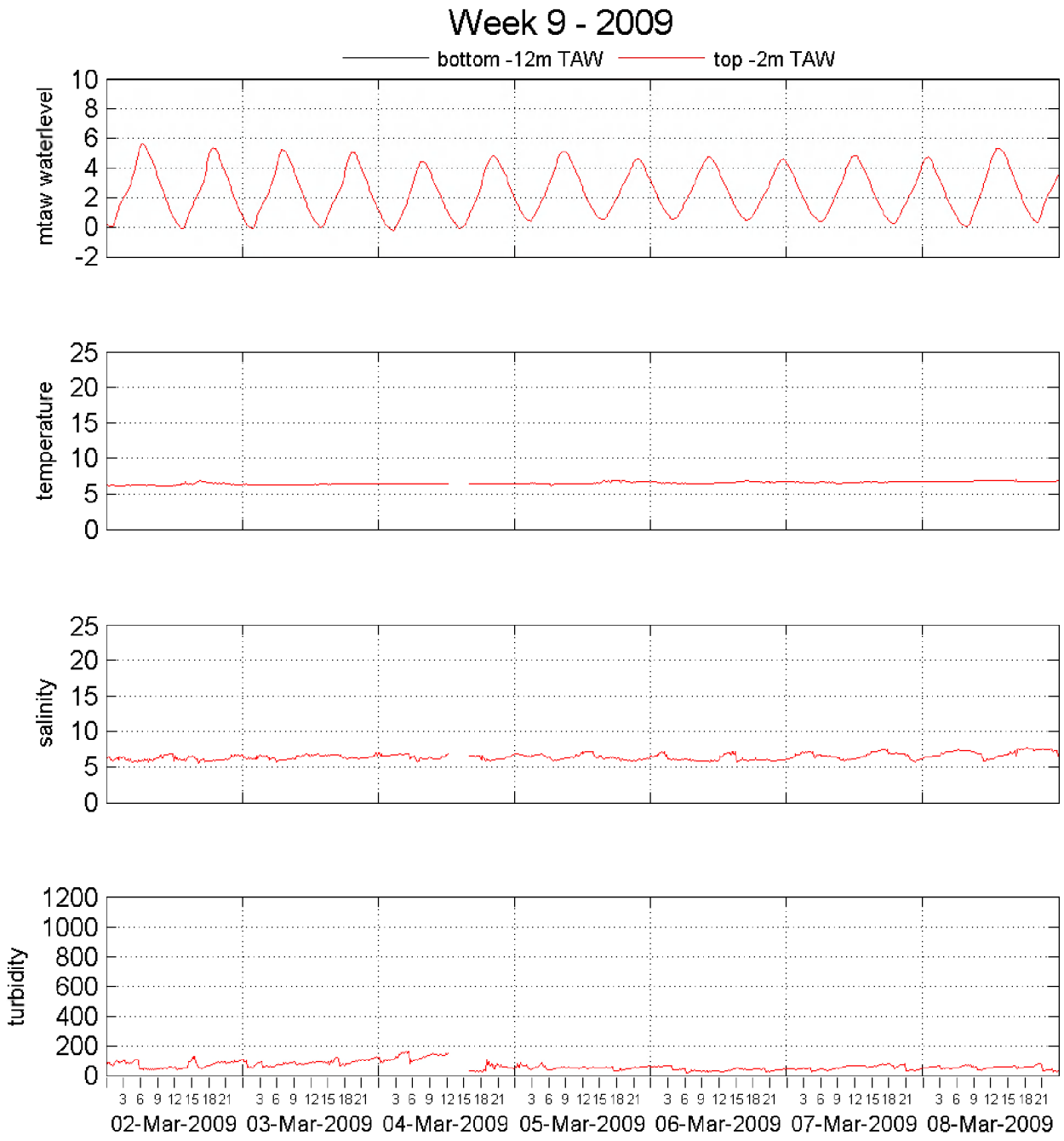

Week series of Salinity, Temperature, SS concentration and Tide

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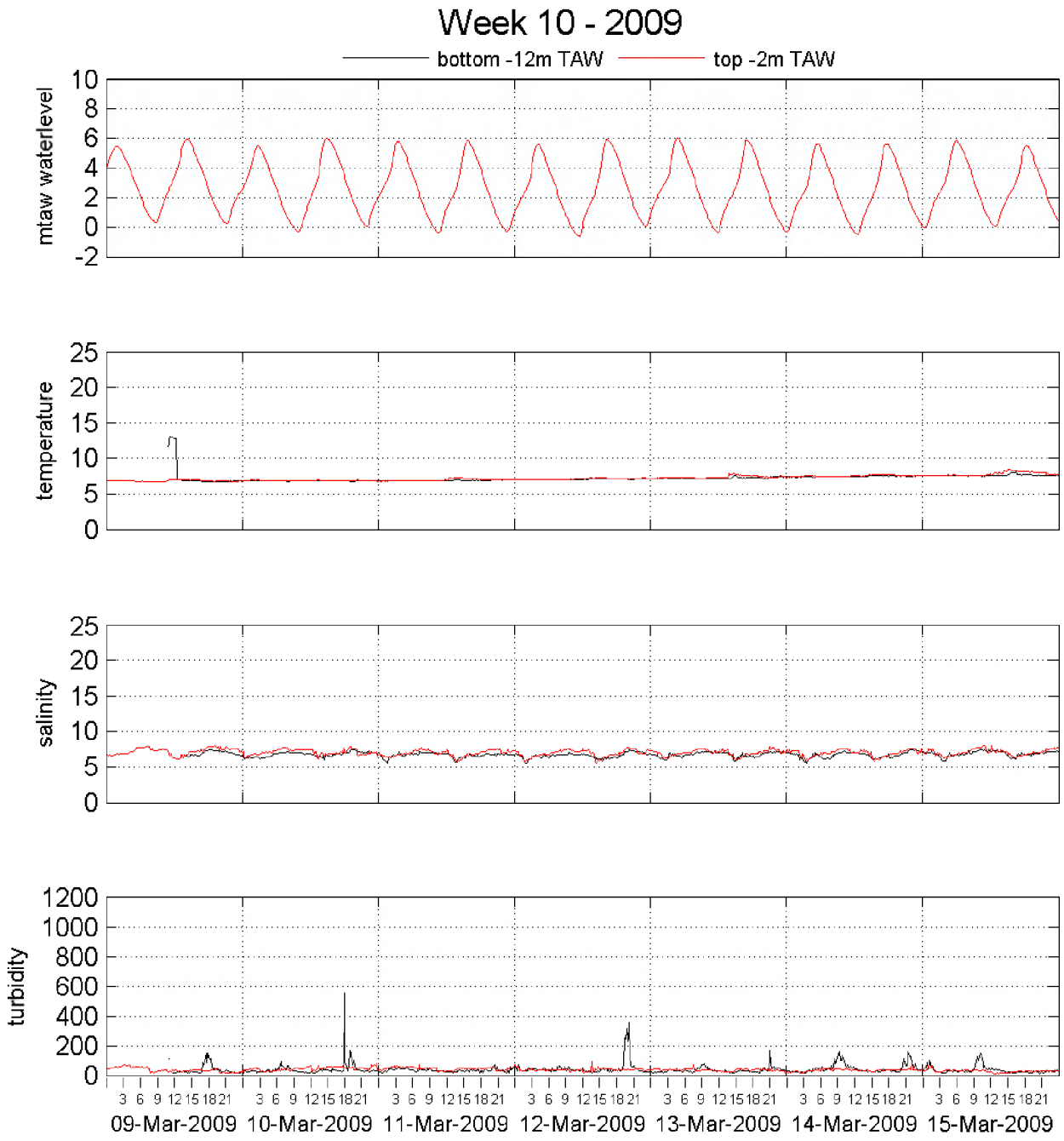

Week series of Salinity, Temperature, SS concentration and Tide

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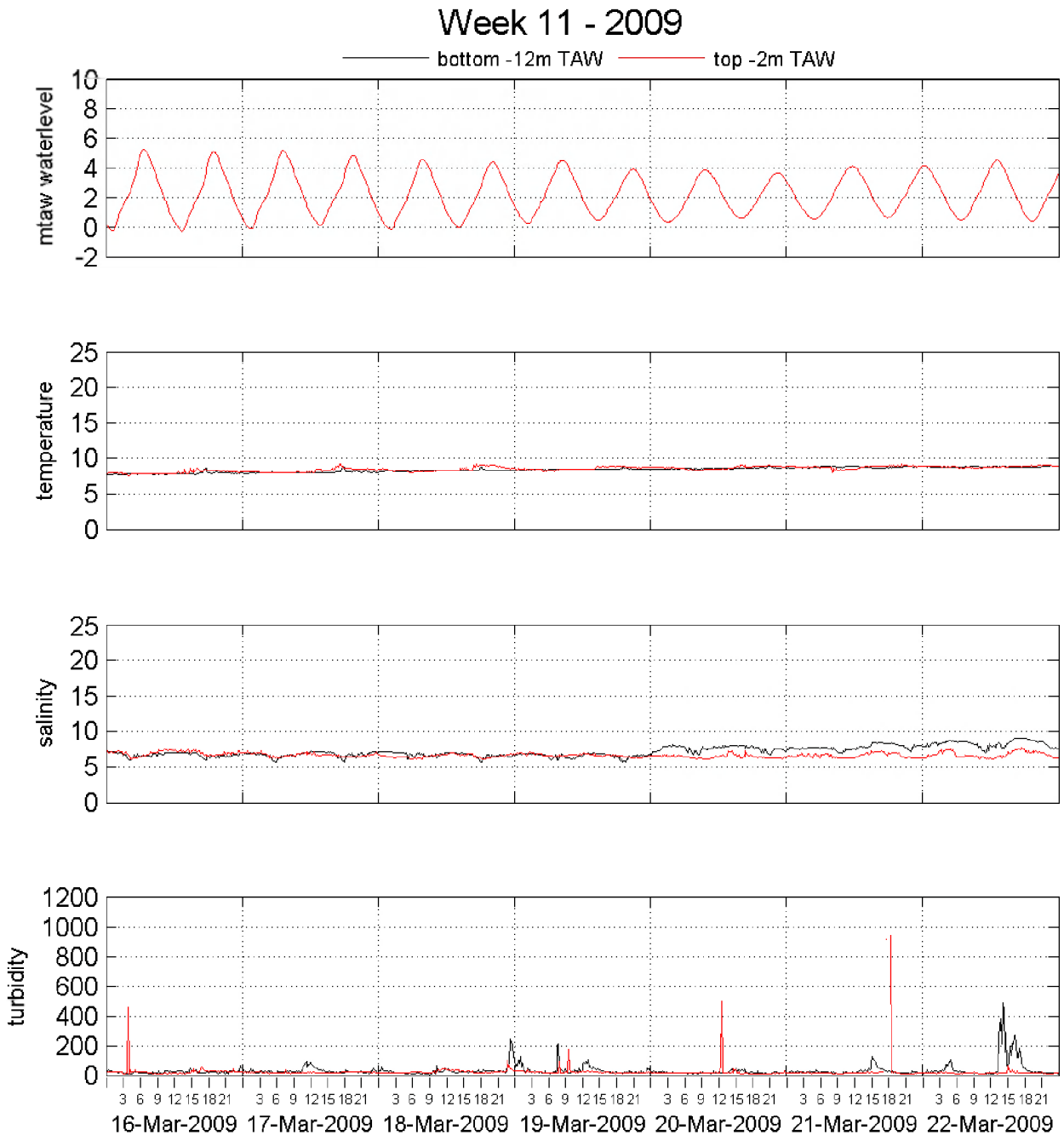

Week series of Salinity, Temperature, SS concentration and Tide

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Location:

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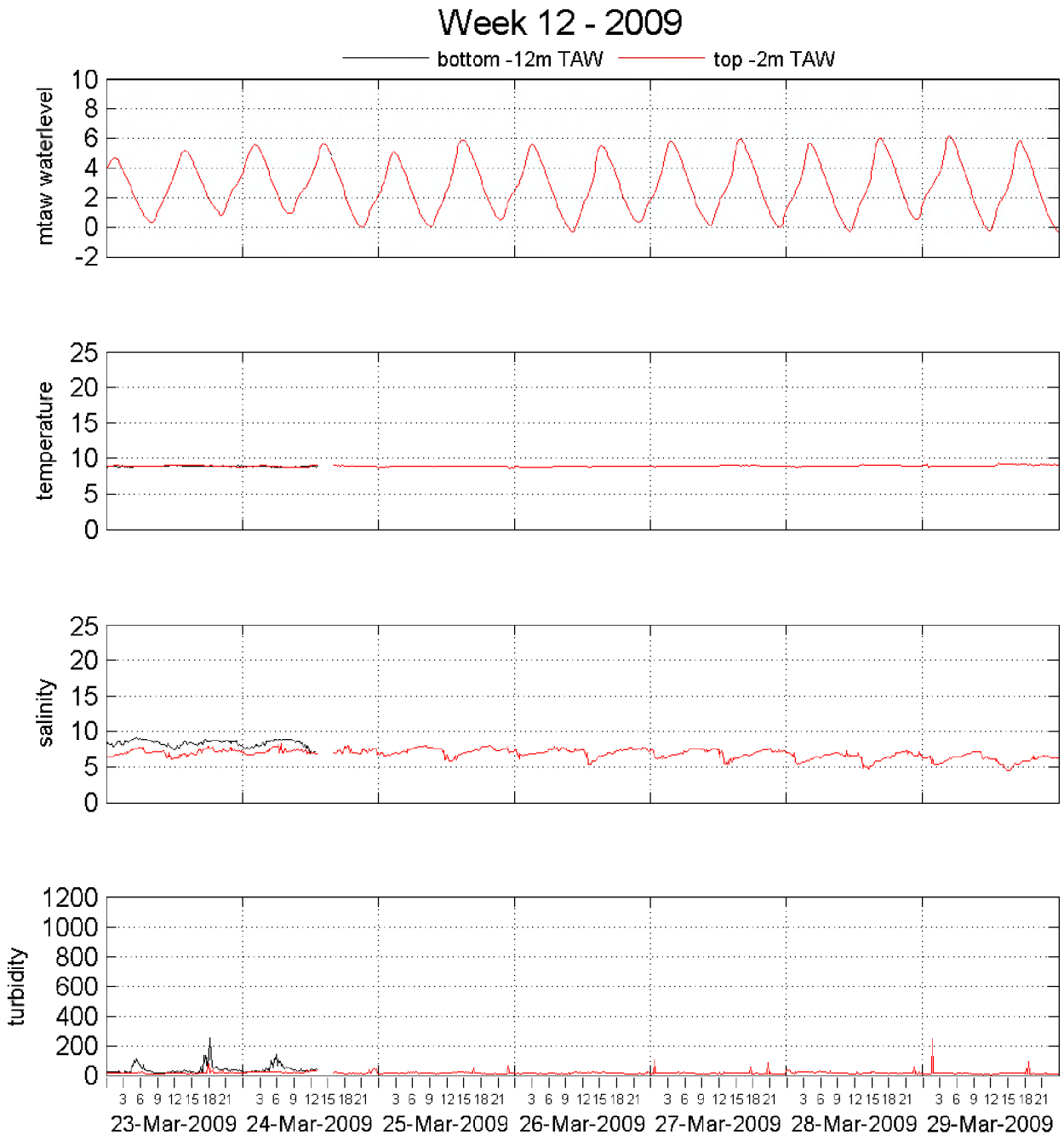

Week series of Salinity, Temperature, SS concentration and Tide

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Location:

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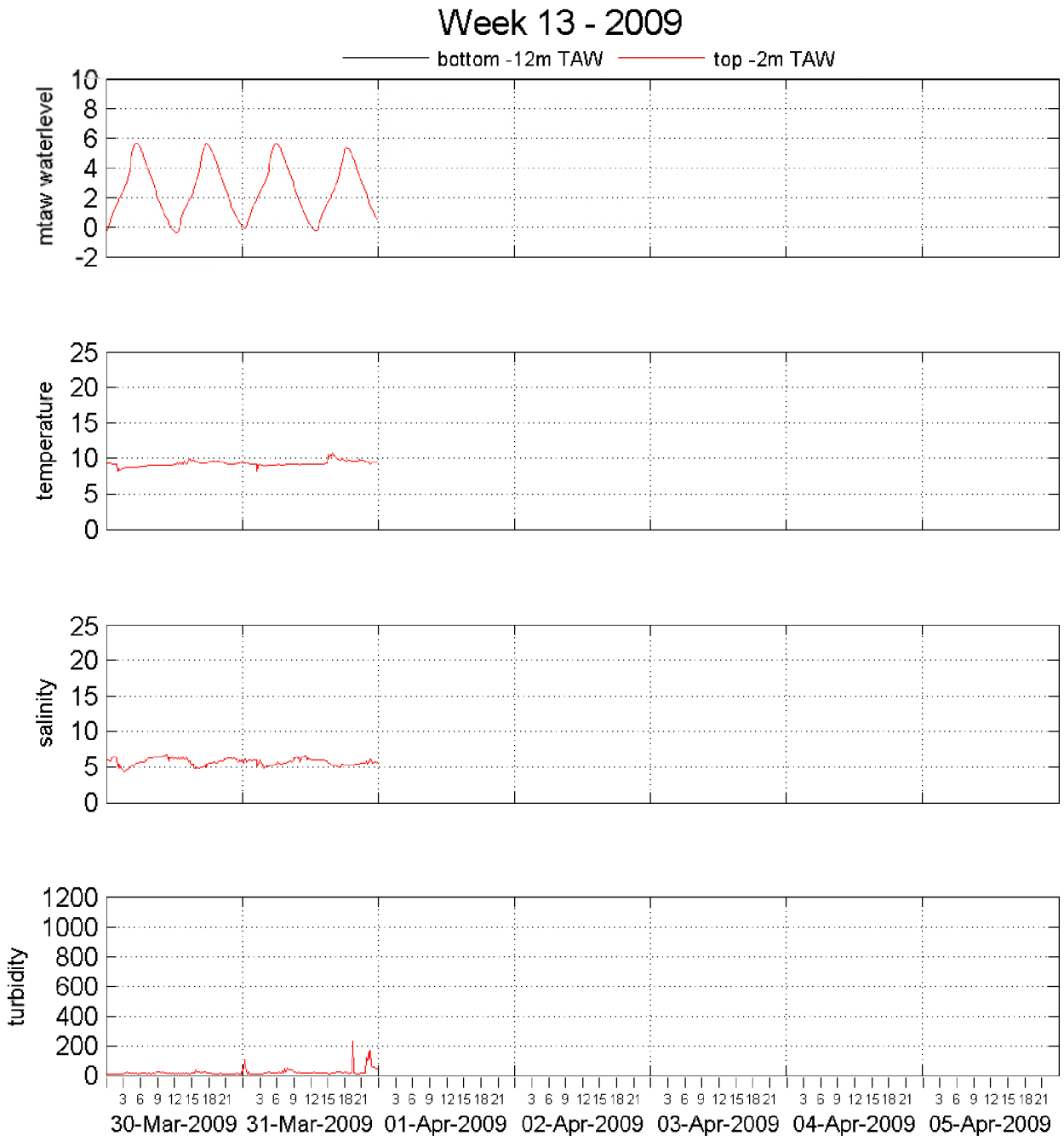


Week series of Salinity, Temperature, SS concentration and Tide

Processed

Location:

S Back

I/RA/11283/08.094/MSA

APPENDIX C.

OVERVIEW OF HCBS2 AND AANSLIBBING DEURGANCKDOK REPORTS

Report	Description of HCBS2
Ambient Conditions Lower Sea Scheldt	
5.3	Overview of ambient conditions in the river Scheldt – January-June 2006 (I/RA/11291/06.088/MSA)
5.4	Overview of ambient conditions in the river Scheldt – July-December 2006 (I/RA/11291/06.089/MSA)
5.5	Overview of ambient conditions in the river Scheldt : RCM-9 buoy 84 & 97 (1/1/2007 -31/3/2007) (I/RA/11291/06.090/MSA)
5.6	Analysis of ambient conditions during 2006 (I/RA/11291/06.091/MSA)
Calibration	
6.1	Winter Calibration (I/RA/11291/06.092/MSA)
6.2	Summer Calibration and Final Report (I/RA/11291/06.093/MSA)
Through tide Measurements Winter 2006	
7.1	21/3 Scheldewacht – Deurganckdok – Salinity Distribution (I/RA/11291/06.094/MSA)
7.2	22/3 Parel 2 – Deurganckdok (I/RA/11291/06.095/MSA)
7.3	22/3 Laure Marie – Liefkenshoek (I/RA/11291/06.096/MSA)
7.4	23/3 Parel 2 – Schelle (I/RA/11291/06.097/MSA)
7.5	23/3 Laure Marie – Deurganckdok (I/RA/11291/06.098/MSA)
7.6	23/3 Veremans Waarde (I/RA/11291/06.099/MSA)
HCBS Near bed continuous monitoring (Frames)	
8.1	Near bed continuous monitoring winter 2006 (I/RA/11291/06.100/MSA)
INSSEV	
9	Settling Velocity - INSSEV summer 2006 (I/RA/11291/06.102/MSA)
Cohesive Sediment	

10	Cohesive sediment properties summer 2006 (I/RA/11291/06.103/MSA)
Through tide Measurements Summer 2006	
11.1	Through Tide Measurement Sediview and Siltprofiler 27/9 Stream - Liefkenshoek (I/RA/11291/06.104/MSA)
11.2	Through Tide Measurement Sediview 27/9 Veremans - Raai K (I/RA/11291/06.105/MSA)
11.3	Through Tide Measurement Sediview and Siltprofiler 28/9 Stream - Raai K (I/RA/11291/06.106/MSA)
11.4	Through Tide Measurement Sediview 28/9 Veremans - Waarde(I/RA/11291/06.107/MSA)
11.5	Through Tide Measurements Sediview 28/9 Parel 2 - Schelle (I/RA/11291/06.108/MSA)
11.6	Through Tide measurement 26/9 Scheldewacht – Deurganckdok – Salinity Distribution (I/RA/11291/06.161/MSA)
Analysis	
12	Report concerning the presence of HCBS layers in the Scheldt river (I/RA/11291/06.109/MSA)

Report	Description of Opvolging aanslibbing Deurganckdok between April 2006 till March 2008
Sediment Balance: Bathymetry surveys, Density measurements, Maintenance and construction dredging activities	
1.1	Sediment Balance: Three monthly report 1/4/2006 – 30/06/2006 (I/RA/11283/06.113/MSA)
1.2	Sediment Balance: Three monthly report 1/7/2006 – 30/09/2006 (I/RA/11283/06.114/MSA)
1.3	Sediment Balance: Three monthly report 1/10/2006 – 31/12/2006 (I/RA/11283/06.115/MSA)
1.4	Sediment Balance: Three monthly report 1/1/2007 – 31/03/2007 (I/RA/11283/06.116/MSA)
1.5	Annual Sediment Balance (I/RA/11283/06.117/MSA)
1.6	Sediment balance Bathymetry: 2005 – 3/2006 (I/RA/11283/06.118/MSA)
1.10	Sediment Balance: Three monthly report 1/4/2007 - 30/06/2007 (I/RA/11283/07.081/MSA)
1.11	Sediment Balance: Three monthly report 1/7/2007 – 30/09/2007 (I/RA/11283/07.082/MSA)
1.12	Sediment Balance: Three monthly report 1/10/2007 – 31/12/2007 (I/RA/11283/07.083/MSA)
1.13	Sediment Balance: Three monthly report 1/1/2007 – 31/03/2007 (I/RA/11283/07.084/MSA)
1.14	Annual Sediment Balance (I/RA/11283/07.085/MSA)

Report	Description of Opvolging aanslibbing Deurganckdok between April 2006 till March 2008
Factors contributing to salt and sediment distribution in Deurganckdok: Salt-Silt (OBS3A) & Frame measurements, Through tide measurements (SiltProfiling & ADCP)	
2.1	Through tide measurement Siltprofiler 21/03/2006 Laure Marie (I/RA/11283/06.087/WGO)
2.2	Through tide measurement Siltprofiler 26/09/2006 Stream (I/RA/11283/06.068/MSA)
2.3	Through tide measurement Sediview spring tide 22/03/2006 Veremans (I/RA/11283/06.110/BDC)
2.4	Through tide measurement Sediview spring tide 27/09/2006 Parel 2 (I/RA/11283/06.119/MSA)
2.5	Through tide measurement Sediview average tide 24/10/2007 Parel 2 (I/RA/11283/06.120/MSA)
2.6	Salt-Silt distribution & Frame Measurements Deurganckdok 13/3/2006 – 31/05/2006 (I/RA/11283/06.121/MSA)
2.7	Salt-Silt distribution & Frame Measurements Deurganckdok 15/07/2006 – 31/10/2006 (I/RA/11283/06.122/MSA)
2.8	Salt-Silt distribution & Frame Measurements Deurganckdok 12/02/2007 – 18/04/2007 (I/RA/11283/06.123/MSA)
2.9	Calibration stationary equipment autumn (I/RA/11283/07.095/MSA)
2.10	Through tide measurement Siltprofiler 23 October 2007 (I/RA/11283/07.086/MSA)
2.11	Through tide measurement Salinity Profiling winter (I/RA/11283/07.087/MSA)
2.12	Through tide measurement Sediview winter 11 March 2008 Transect I (I/RA/11283/07.088/MSA)
2.13	Through tide measurement Sediview winter 11 March 2008 Transect K (I/RA/11283/07.089/MSA)
2.14	Through tide measurement Sediview winter 11 March 2008 Transect DGD (I/RA/11283/07.090/MSA)
2.15	Through tide measurement Siltprofiler 12 March 2008 (I/RA/11283/07.091/MSA)
2.16	Salt-Silt distribution Deurganckdok summer (21/6/2007 – 30/07/2007) (I/RA/11283/07.092/MSA)
2.17	Salt-Silt distribution & Frame Measurements Deurganckdok autumn (17/09/2007 - 10/12/2007) (I/RA/11283/07.093/MSA)
2.18	Salt-Silt distribution & Frame Measurements Deurganckdok winter (18/02/2008 - 31/3/2008) (I/RA/11283/07.094/MSA)
2.19	Calibration stationary & mobile equipment winter (I/RA/11283/07.096/MSA)

Report	Description of Opvolging aanslibbing Deurganckdok between April 2006 till March 2008
Boundary Conditions: Upriver Discharge, Salt concentration Scheldt, Bathymetric evolution in access channels, dredging activities in Lower Sea Scheldt and access channels	
3.1	Boundary conditions: Three monthly report 1/1/2007 – 31/03/2007 (I/RA/11283/06.127/MSA) including HCBS 2 report 5.5
~~3.2~~	~~Boundary condtions: Annual report (I/RA/11283/06.128/MSA)~~[1]
3.10	Boundary conditions: Three monthly report 1/4/2007 – 30/06/2007 (I/RA/11283/07.097/MSA)
3.11	Boundary conditions: Three monthly report 1/7/2007 – 30/09/2007 (I/RA/11283/07.098/MSA)
3.12	Boundary conditions: Three monthly report 1/10/2007 – 31/12/2007 (I/RA/11283/07.099/MSA)
3.13	Boundary conditions: Three monthly report 1/1/2008 – 31/03/2008 (I/RA/11283/07.100/MSA)
3.14	Boundary conditions: Annual report (I/RA/11283/07.101/MSA)
Analysis	
4.1	Analysis of Siltation Processes and Factors, 4/'06 – 3/'07 (I/RA/11283/06.129/MSA)
4.10	Analysis of Siltation Processes and Factors, 4/'07 – 3/'08 (I/RA/11283/07.102/MSA)

[1] considered in report 5.6 'Analysis of ambient conditions during 2006' (I/RA/11291/06.091/MSA) in the framework of the study 'Extension of the study about density currents in the Beneden Zeeschelde'

APPENDIX D. AVERAGE TIDAL CYCLES

D.1 Local parameters

Long Term Monitoring Siltation Deurganckdok

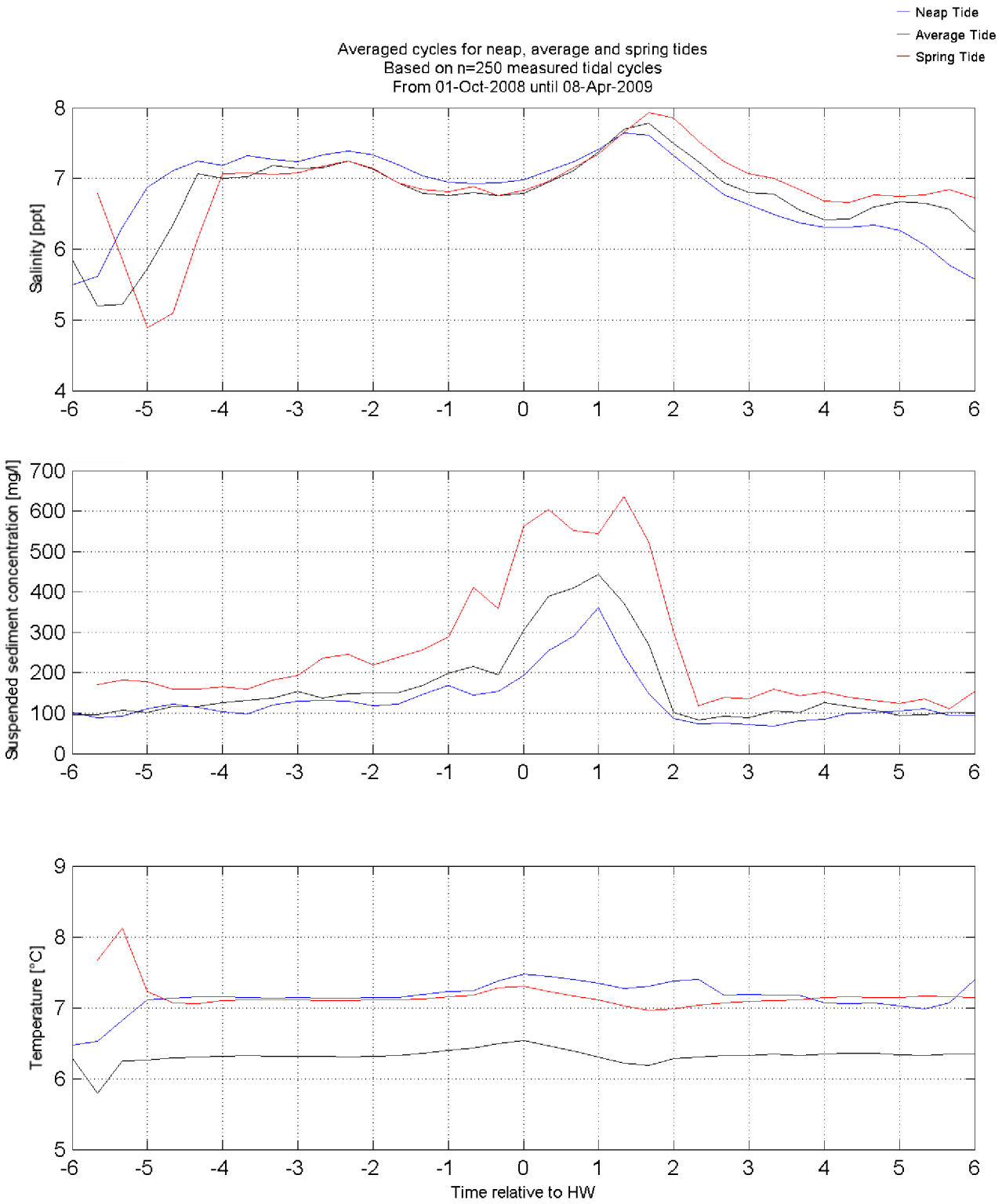
Autumn 2008

Equipment(s):

OBS-3A

Location:

N-ENTRANCE bottom



Absolute Parameters for averaged tidal cycle

Data Processed by:

In association with :

I/RA/11283/08.094/MSA

Long Term Monitoring Siltation Deurganckdok

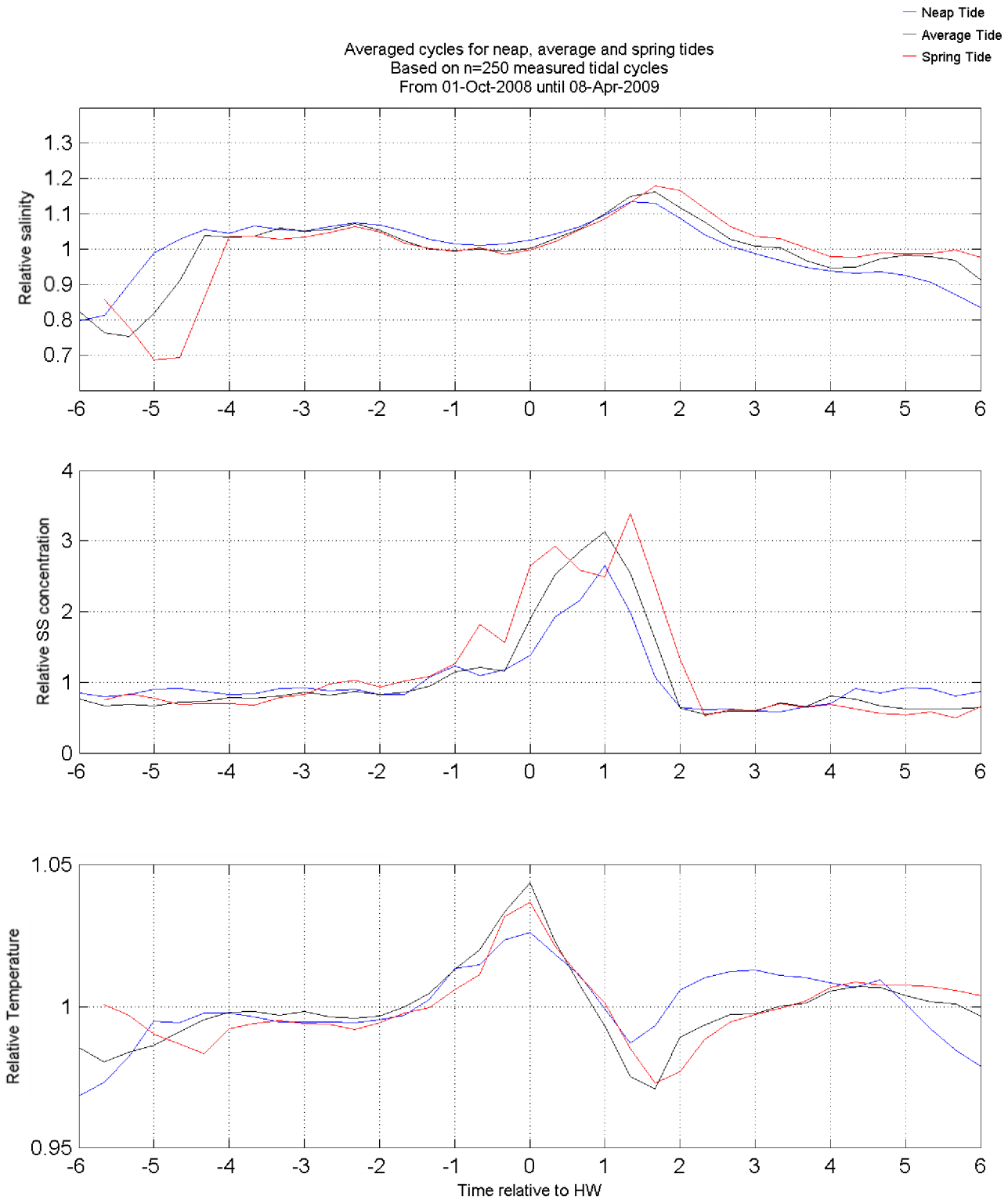
Autumn 2008

Equipment(s):

OBS-3A

Location:

N-ENTRANCE bottom



Relative Parameters for averaged tidal cycle

Data Processed by:

In association with :

I/RA/11283/08.094/MSA

Long Term Monitoring Siltation Deurganckdok

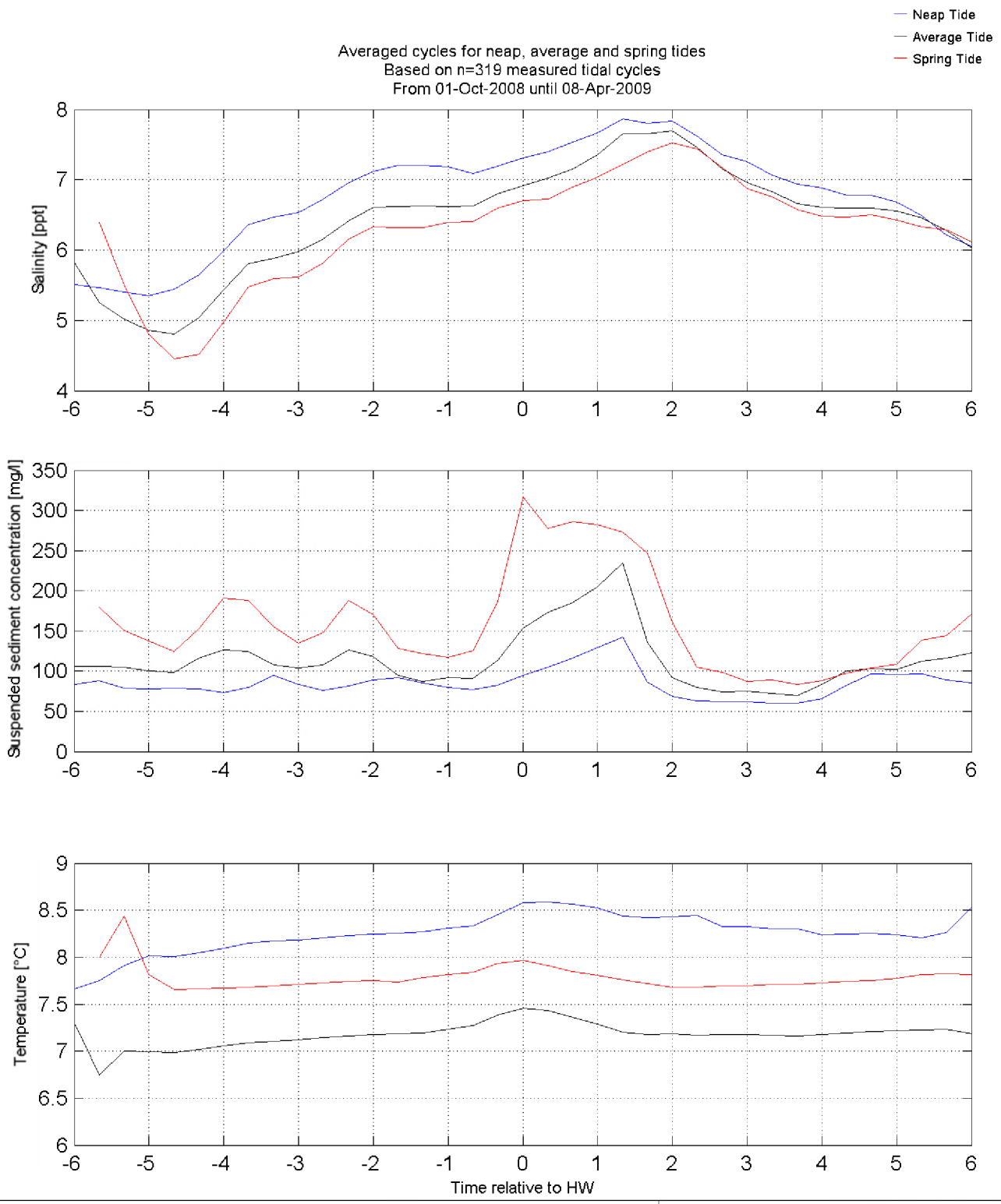
Autumn 2008

Equipment(s):

OBS-3A

Location:

N-ENTRANCE top



Absolute Parameters for averaged tidal cycle

Data Processed by:

In association with :

I/RA/11283/08.094/MSA

Long Term Monitoring Siltation Deurganckdok

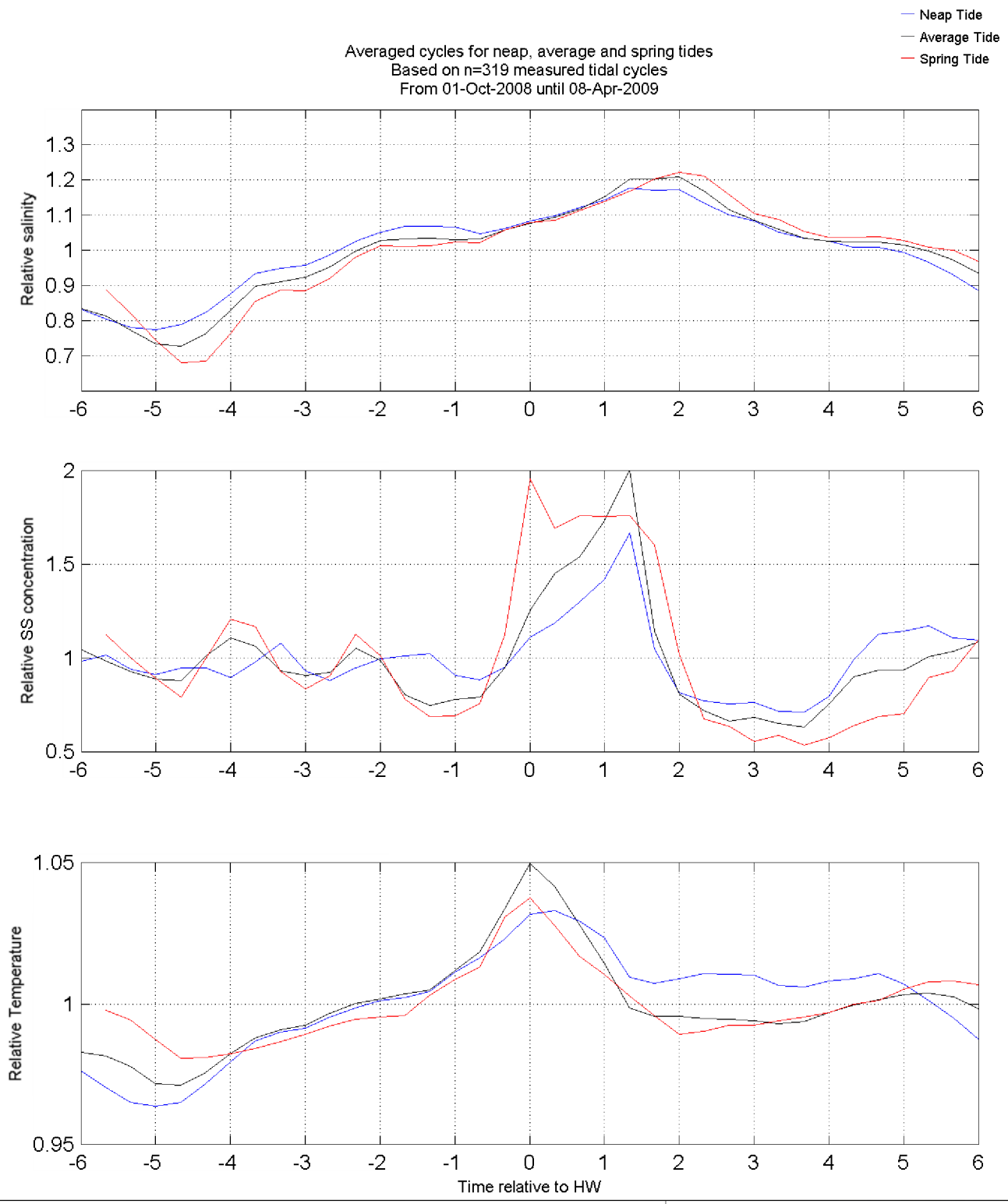
Autumn 2008

Equipment(s):

OBS-3A

Location:

N-ENTRANCE top



Relative Parameters for averaged tidal cycle

Data Processed by:

In association with :

I/RA/11283/08.094/MSA

Long Term Monitoring Siltation Deurganckdok

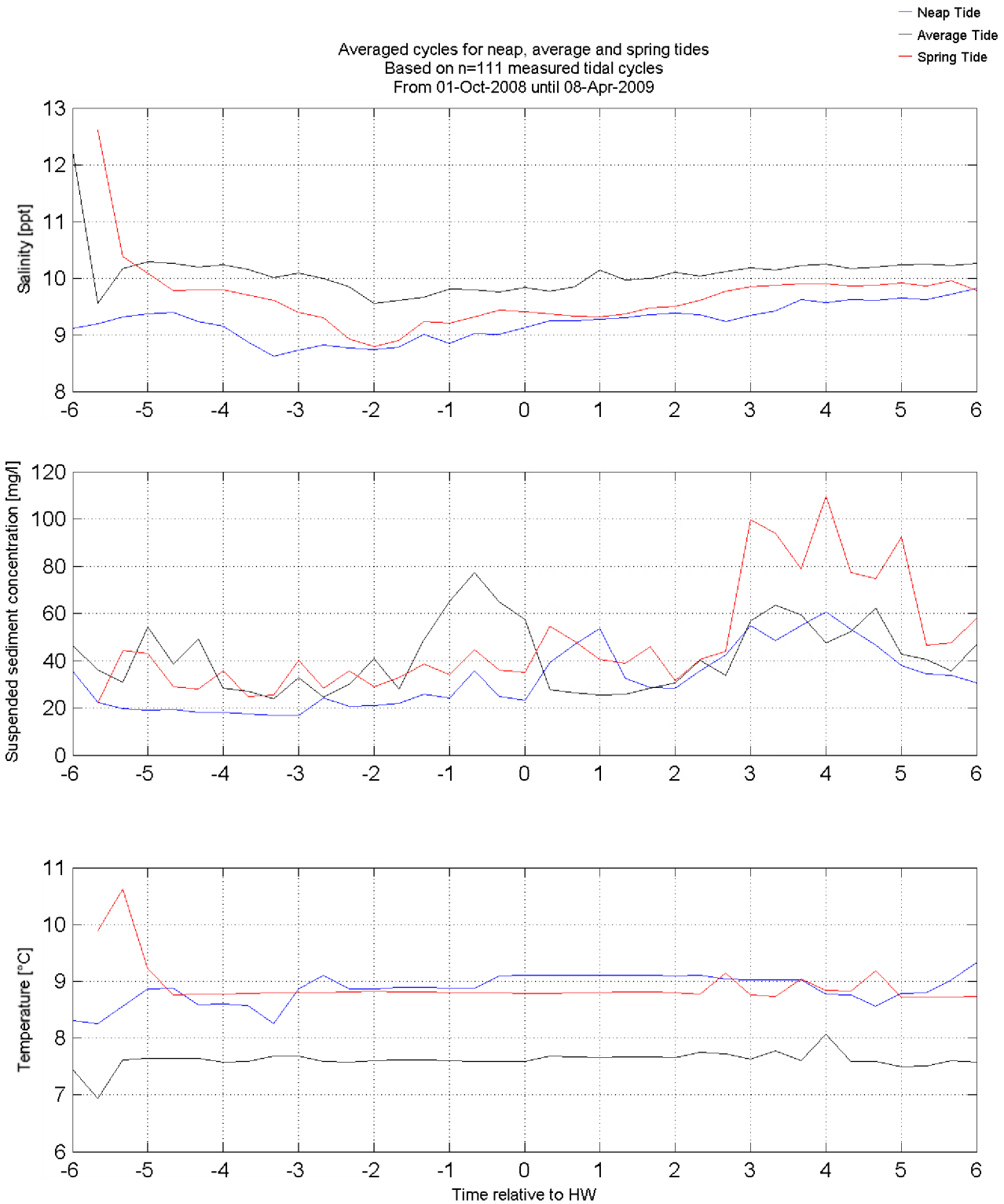
Autumn 2008

Equipment(s):

OBS-3A

Location:

S-BACK bottom



Absolute Parameters for averaged tidal cycle

Data Processed by:

In association with :

I/RA/11283/08.094/MSA

Long Term Monitoring Siltation Deurganckdok

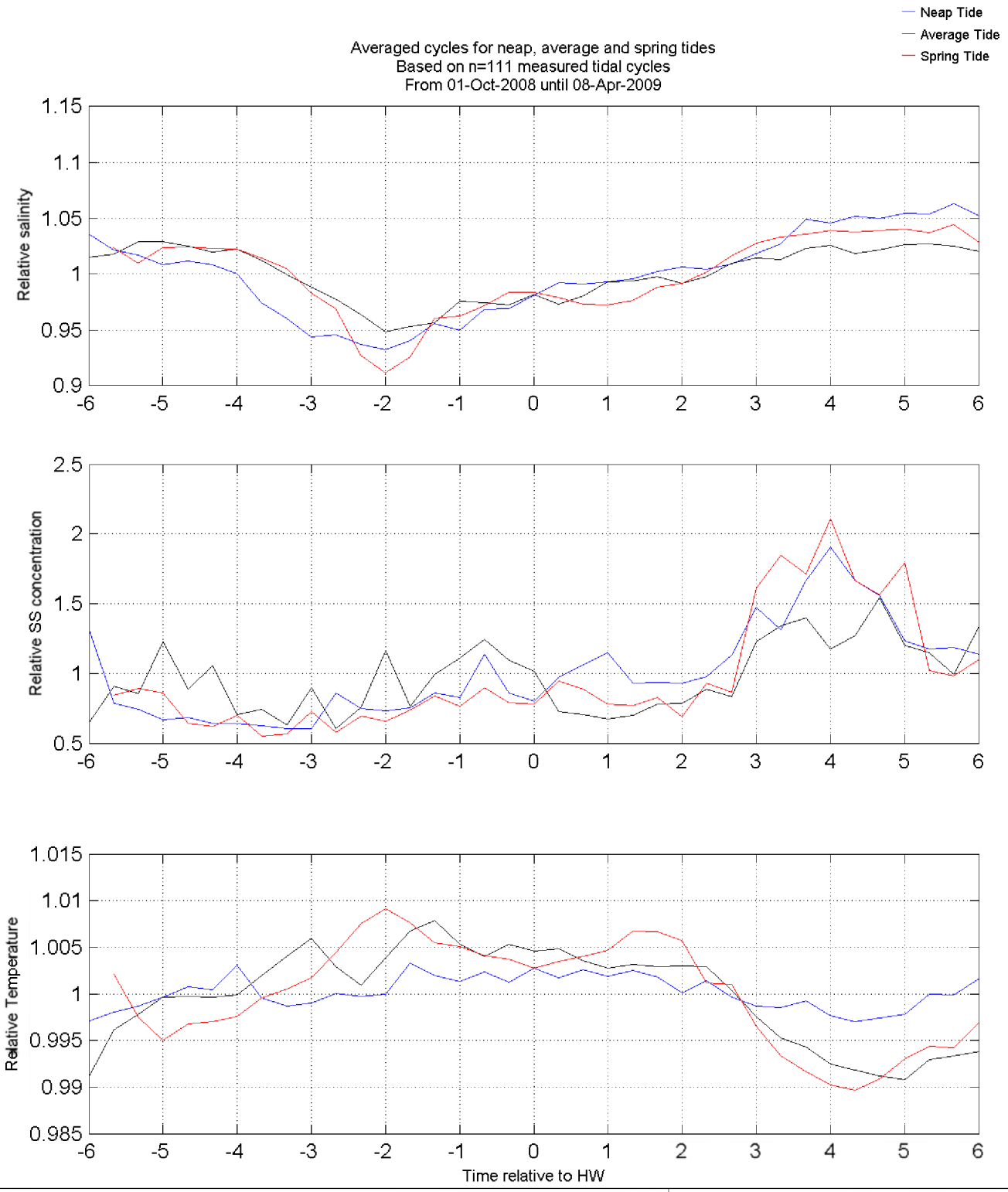
Autumn 2008

Equipment(s):

OBS-3A

Location:

S-BACK bottom



Relative Parameters for averaged tidal cycle

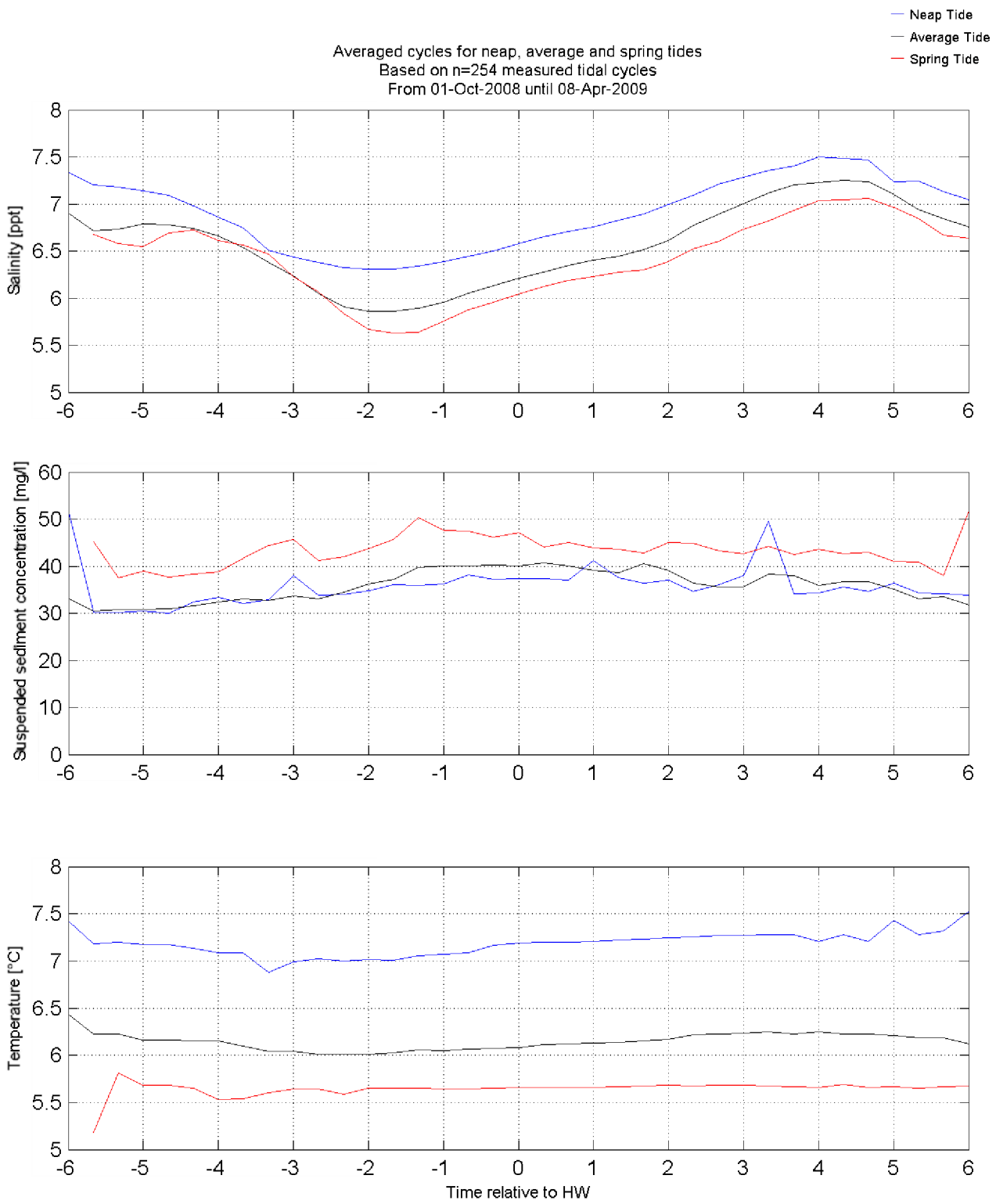
Data Processed by:

In association with :

I/RA/11283/08.094/MSA

Long Term Monitoring Siltation Deurganckdok

Autumn 2008	Equipment(s): OBS-3A
	Location: S-BACK top



Absolute Parameters for averaged tidal cycle

Data Processed by: IMDC

In association with : WL | delft hydraulics

I/RA/11283/08.094/MSA

Long Term Monitoring Siltation Deurganckdok

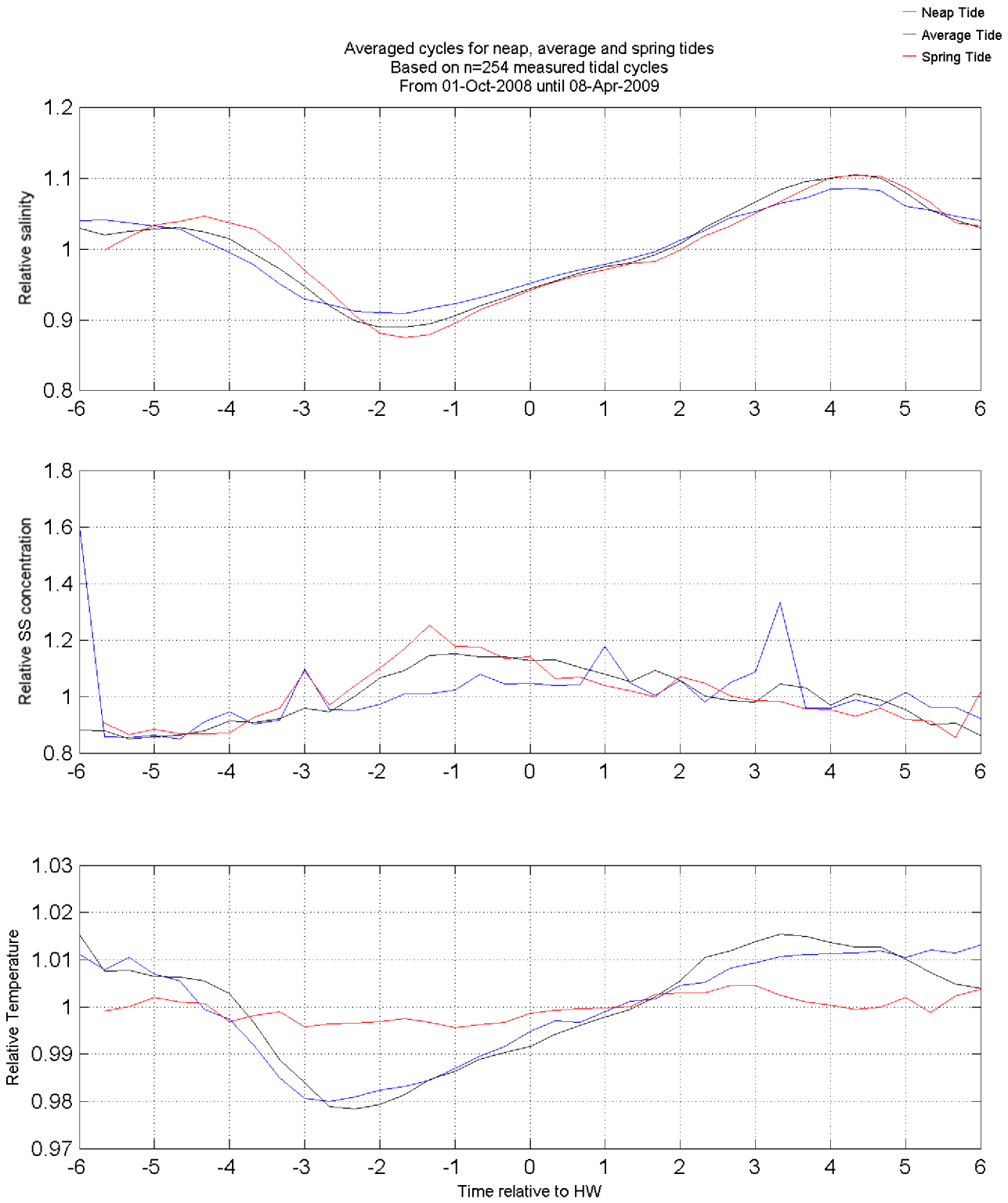
Autumn 2008

Equipment(s):

OBS-3A

Location:

S-BACK top



Relative Parameters for averaged tidal cycle

Data Processed by:

In association with :

I/RA/11283/08.094/MSA

Long Term Monitoring Siltation Deurganckdok

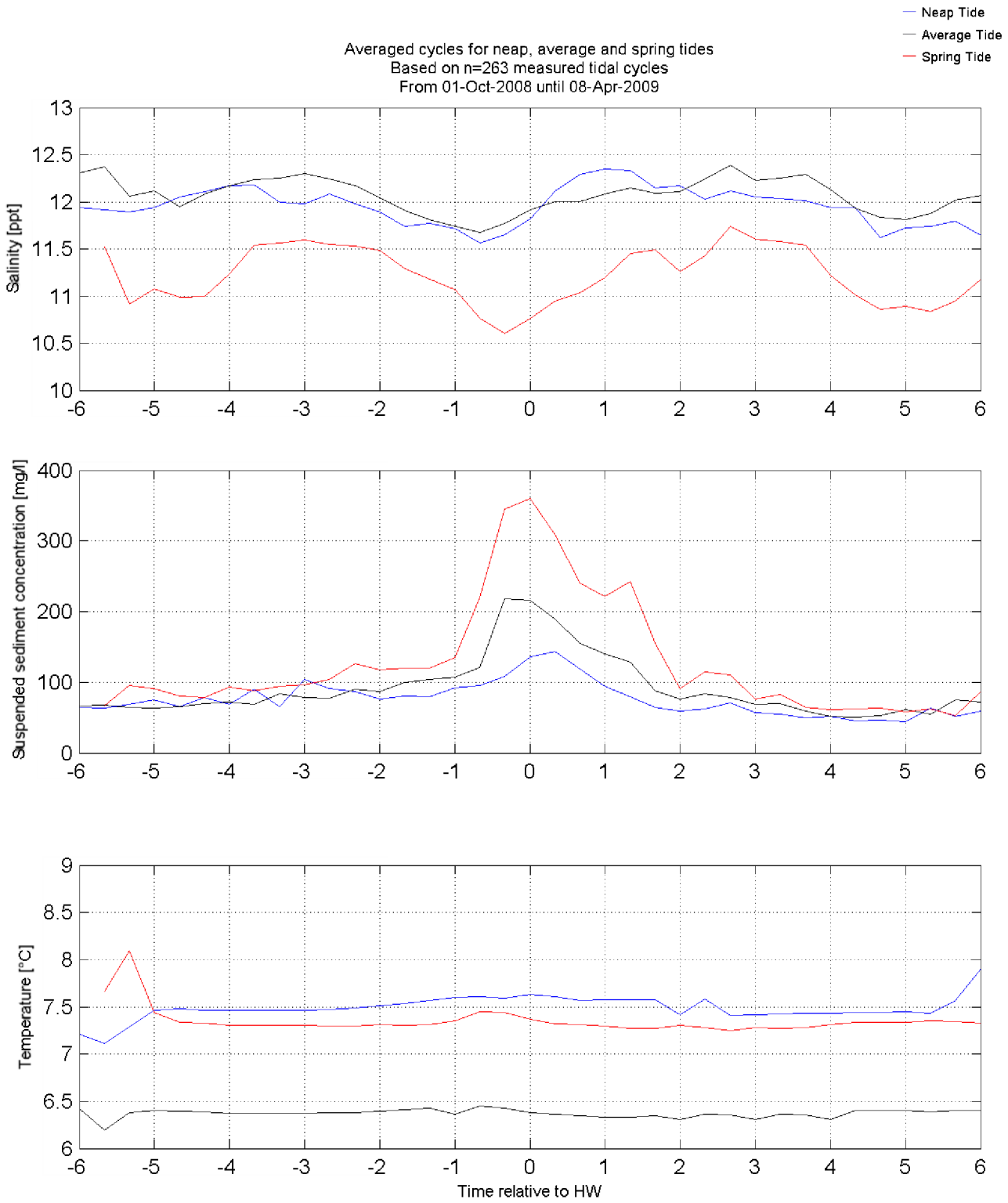
Autumn 2008

Equipment(s):

OBS-3A

Location:

S-ENTRANCE bottom



Absolute Parameters for averaged tidal cycle

Data Processed by:

In association with :

I/RA/11283/08.094/MSA

Long Term Monitoring Siltation Deurganckdok

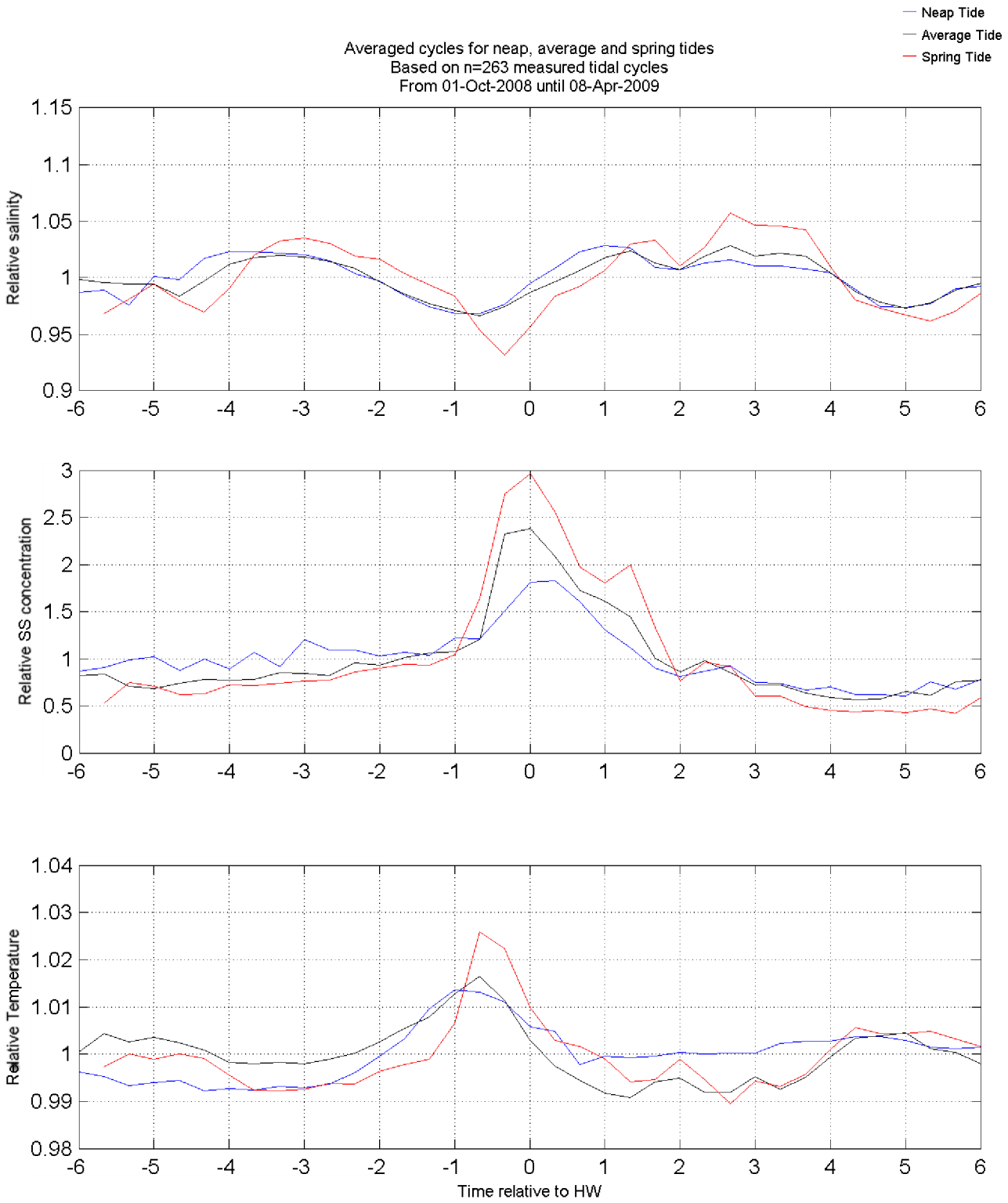
Autumn 2008

Equipment(s):

OBS-3A

Location:

S-ENTRANCE bottom



Relative Parameters for averaged tidal cycle

Data Processed by:

In association with :

I/RA/11283/08.094/MSA

Long Term Monitoring Siltation Deurganckdok

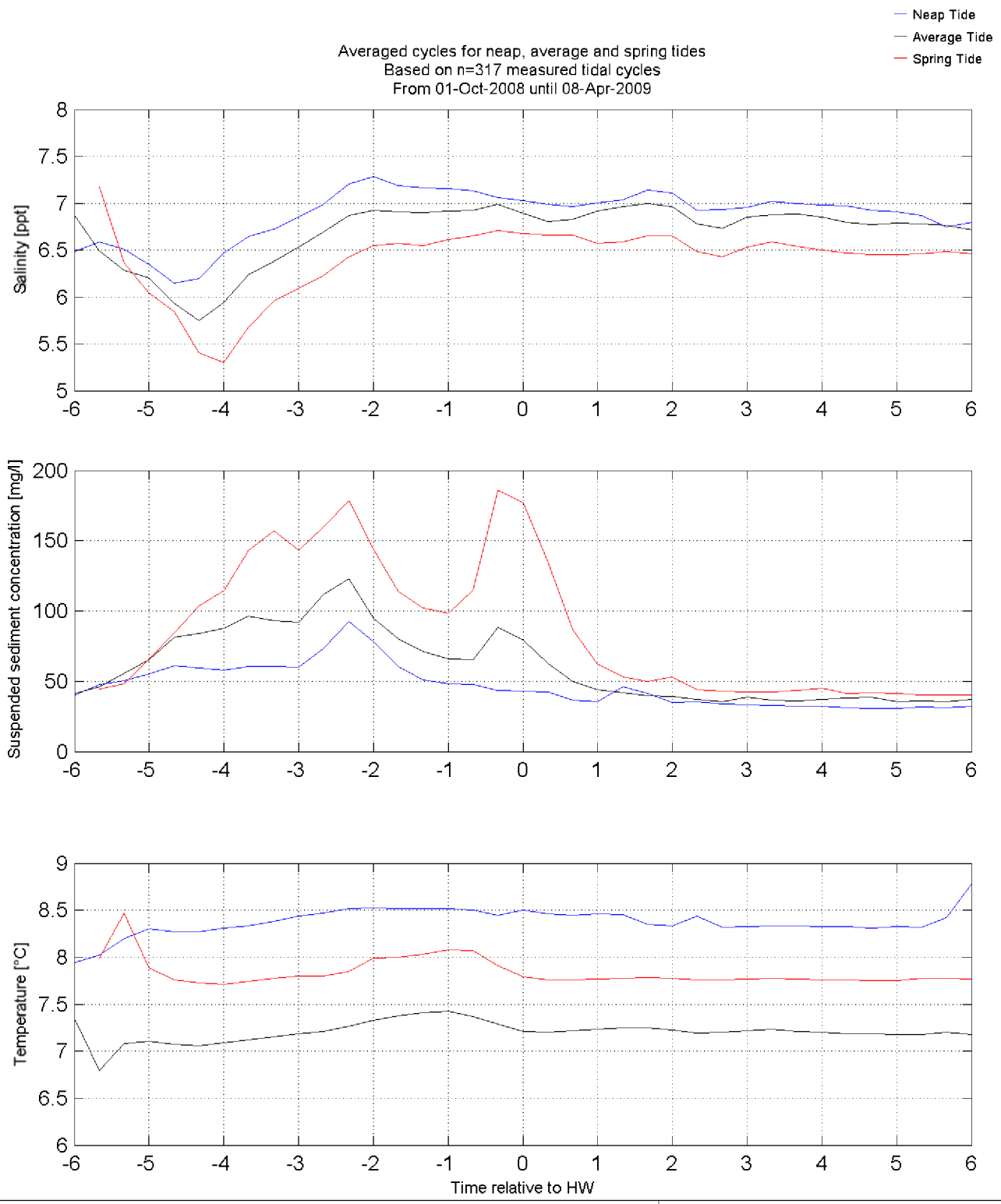
Autumn 2008

Equipment(s):

OBS-3A

Location:

S-ENTRANCE top



Absolute Parameters for averaged tidal cycle

Data Processed by:

In association with :

I/RA/11283/08.094/MSA

Long Term Monitoring Siltation Deurganckdok

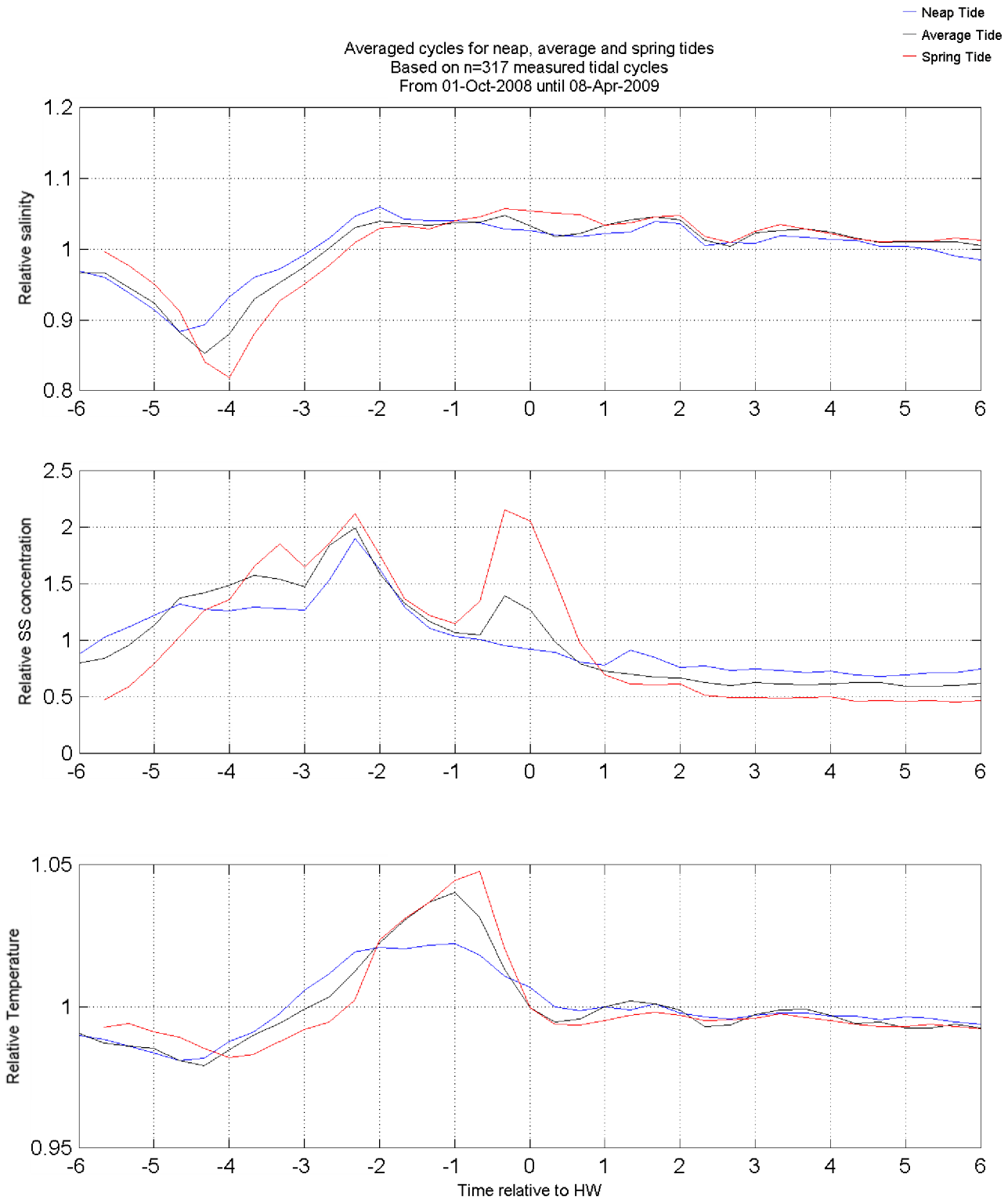
Autumn 2008

Equipment(s):

OBS-3A

Location:

S-ENTRANCE top



Relative Parameters for averaged tidal cycle

Data Processed by:

In association with :

I/RA/11283/08.094/MSA

Long Term Monitoring Siltation Deurganckdok

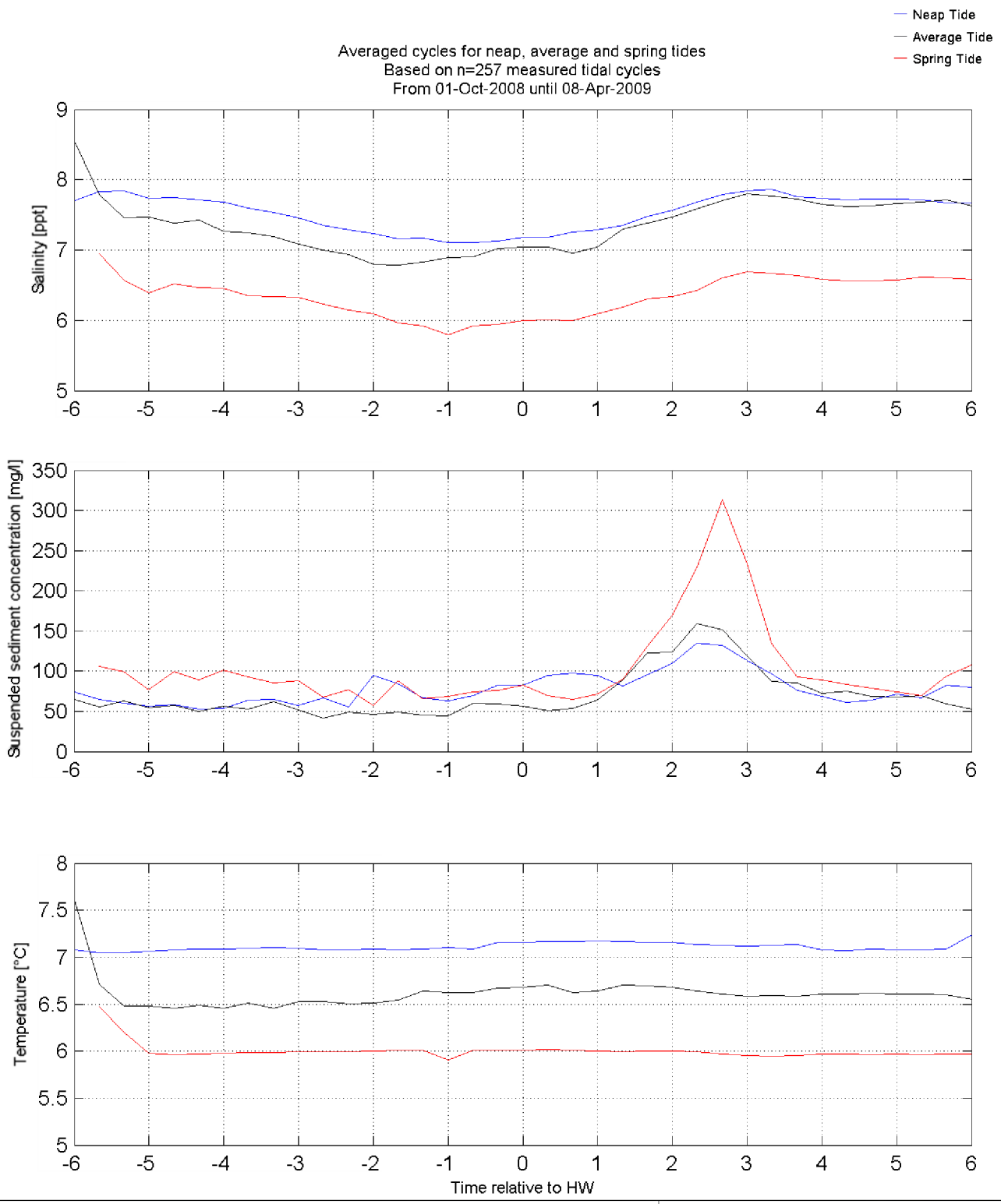
Autumn 2008

Equipment(s):

OBS-3A

Location:

S-MIDDLE bottom



Absolute Parameters for averaged tidal cycle

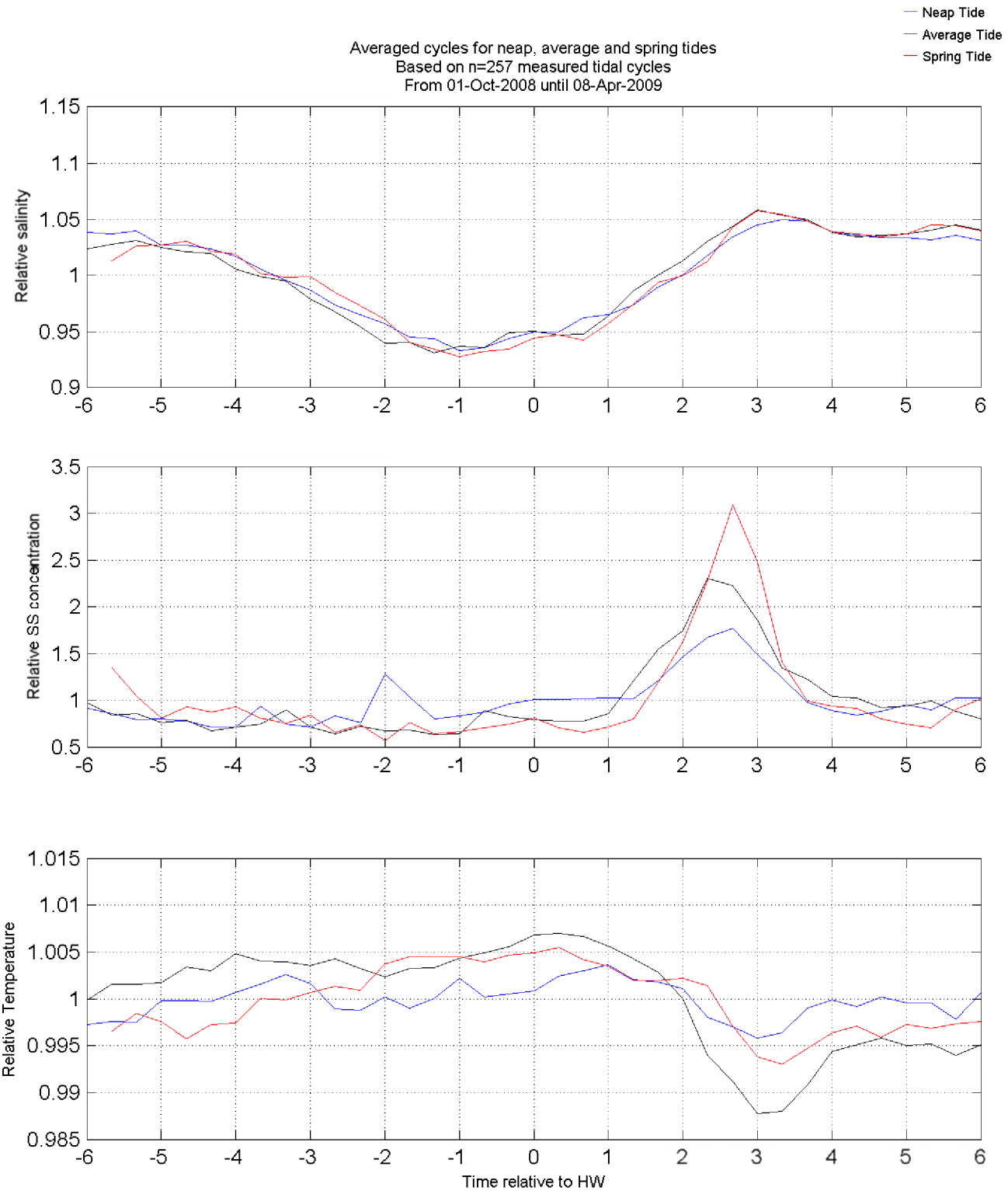
Data Processed by:

In association with :

I/RA/11283/08.094/MSA

Long Term Monitoring Siltation Deurganckdok

Autumn 2008	Equipment(s): OBS-3A
	Location: S-MIDDLE bottom



Relative Parameters for averaged tidal cycle

Data Processed by: IMDC

In association with : WL | delft hydraulics

I/RA/11283/08.094/MSA

Long Term Monitoring Siltation Deurganckdok

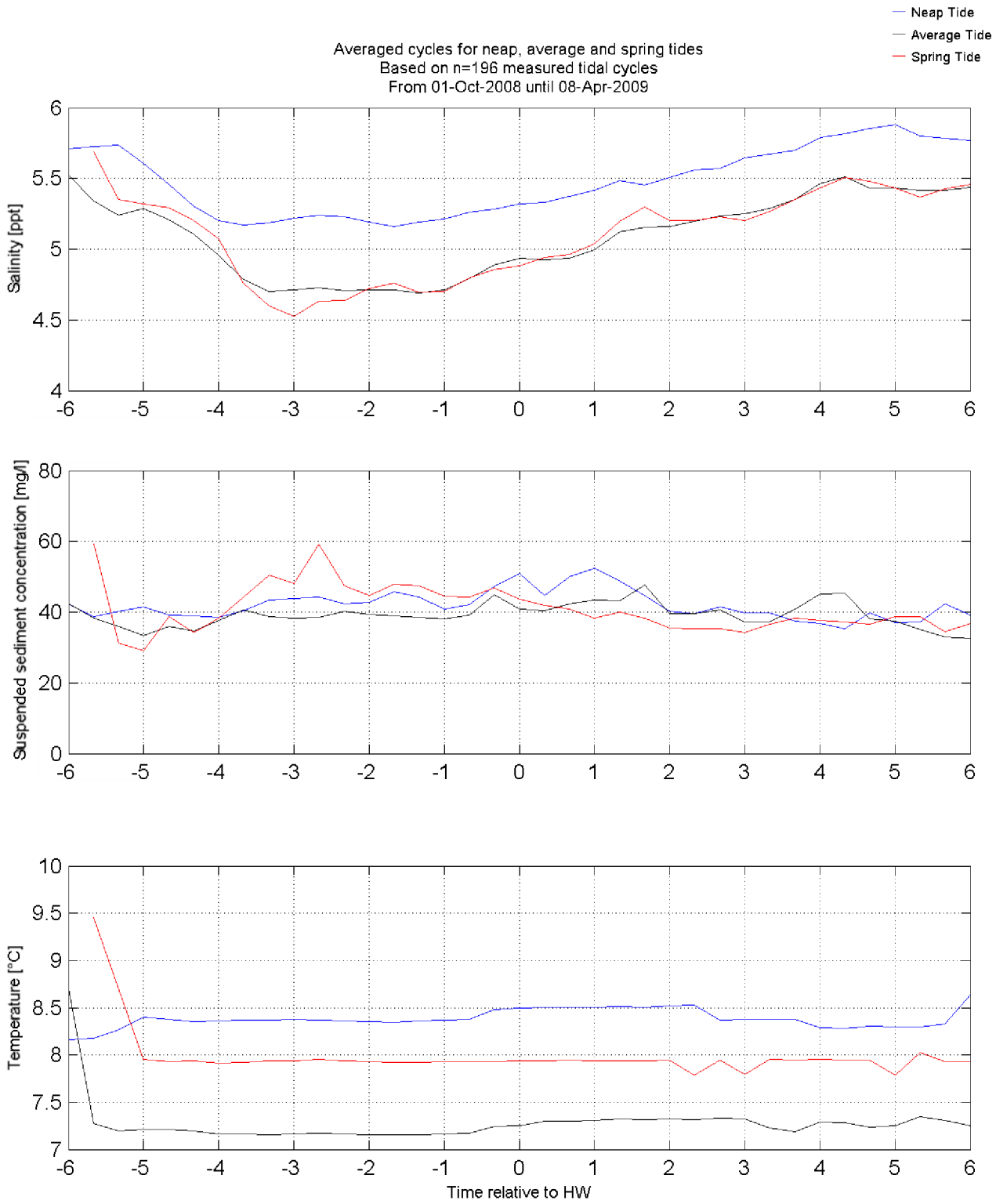
Autumn 2008

Equipment(s):

OBS-3A

Location:

S-MIDDLE top



Absolute Parameters for averaged tidal cycle

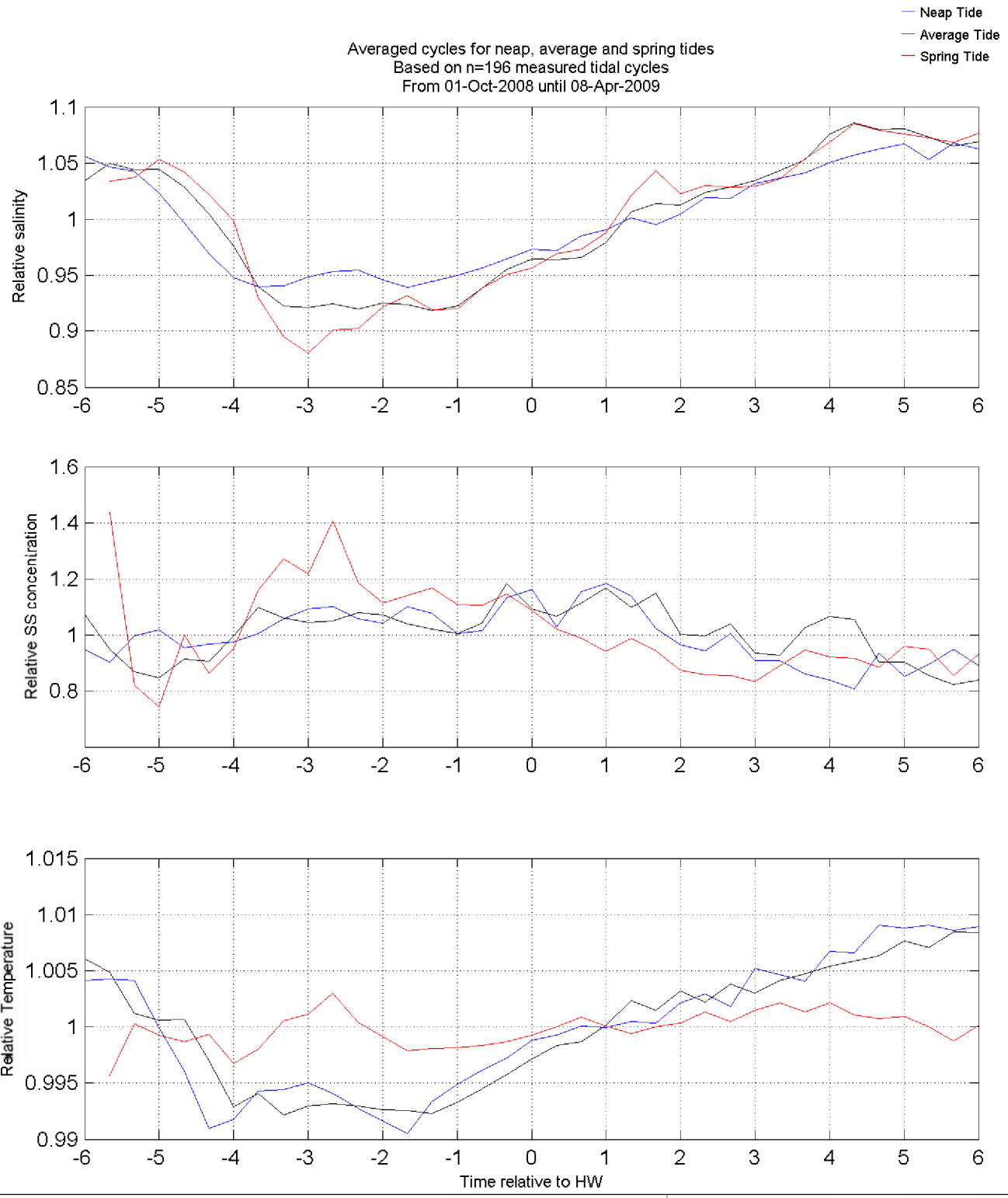
Data Processed by:

In association with :

I/RA/11283/08.094/MSA

Long Term Monitoring Siltation Deurganckdok

Autumn 2008	Equipment(s): OBS-3A
	Location: S-MIDDLE top



Relative Parameters for averaged tidal cycle

Data Processed by:

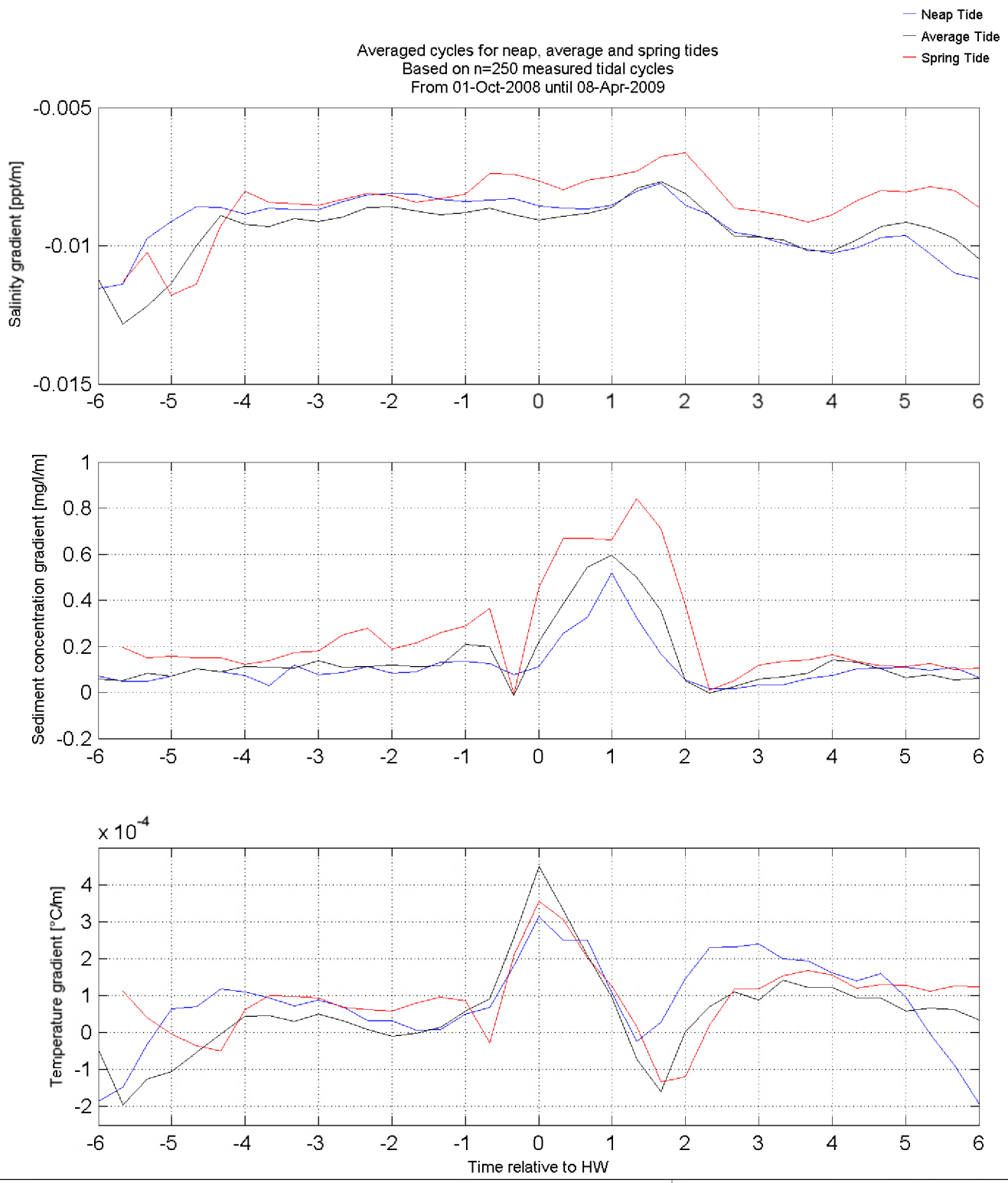
In association with :

I/RA/11283/08.094/MSA

D.2 Along-dock, cross-dock and vertical gradients

Long Term Monitoring Siltation Deurganckdok

Autumn 2008	Equipment(s): OBS 3A
	Location: DGD-entrance



Horizontal gradient at -12m TAW =(N-ENTRANCE - S-ENTRANCE)/Δx

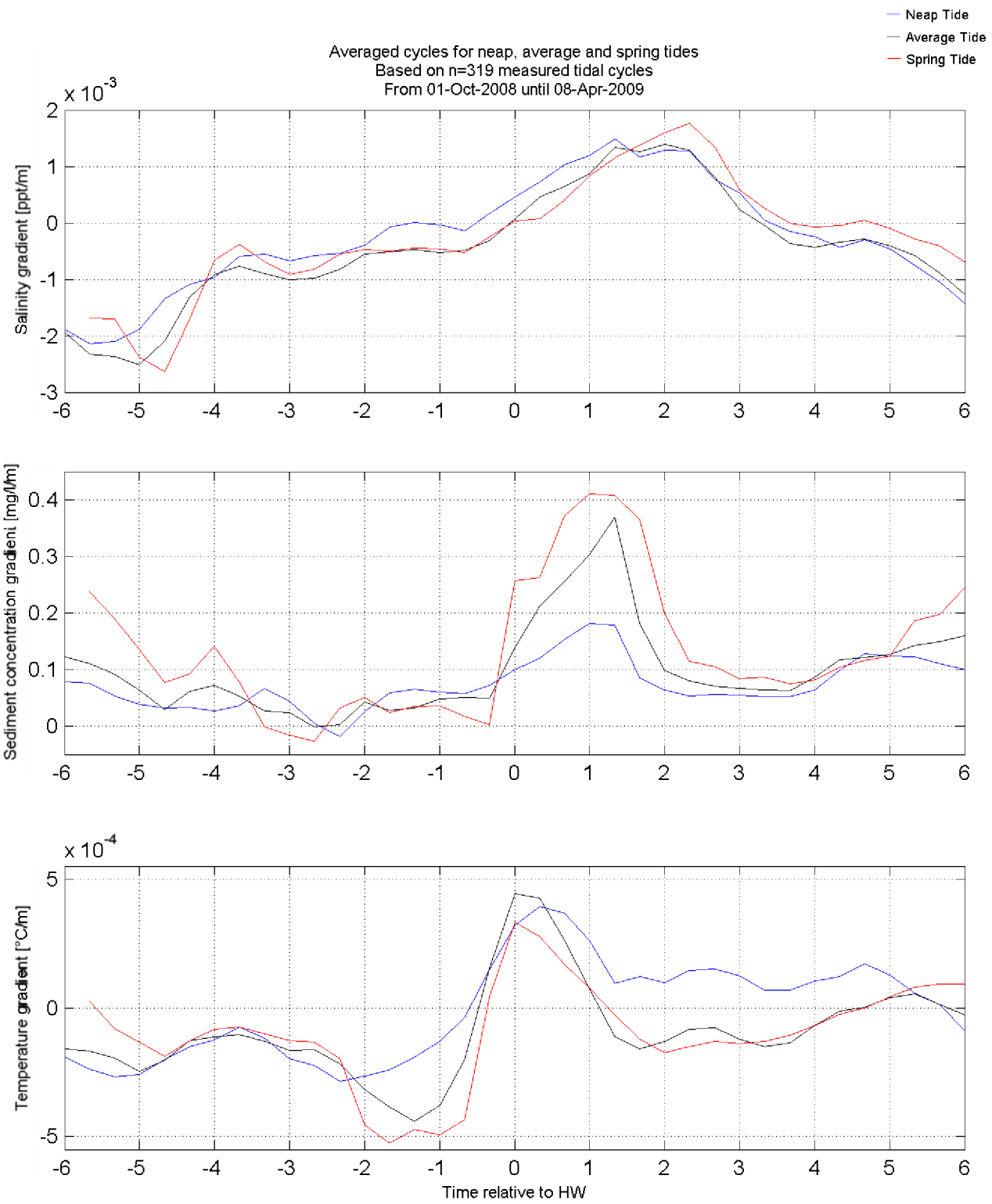
Data Processed by: IMDC

In association with :

I/RA/11283/08.094/MSA

Long Term Monitoring Siltation Deurganckdok

Autumn 2008	Equipment(s): OBS 3A
	Location: DGD-entrance



Horizontal gradient at -2.2m TAW =(N-ENTRANCE - S-ENTRANCE)/Δx

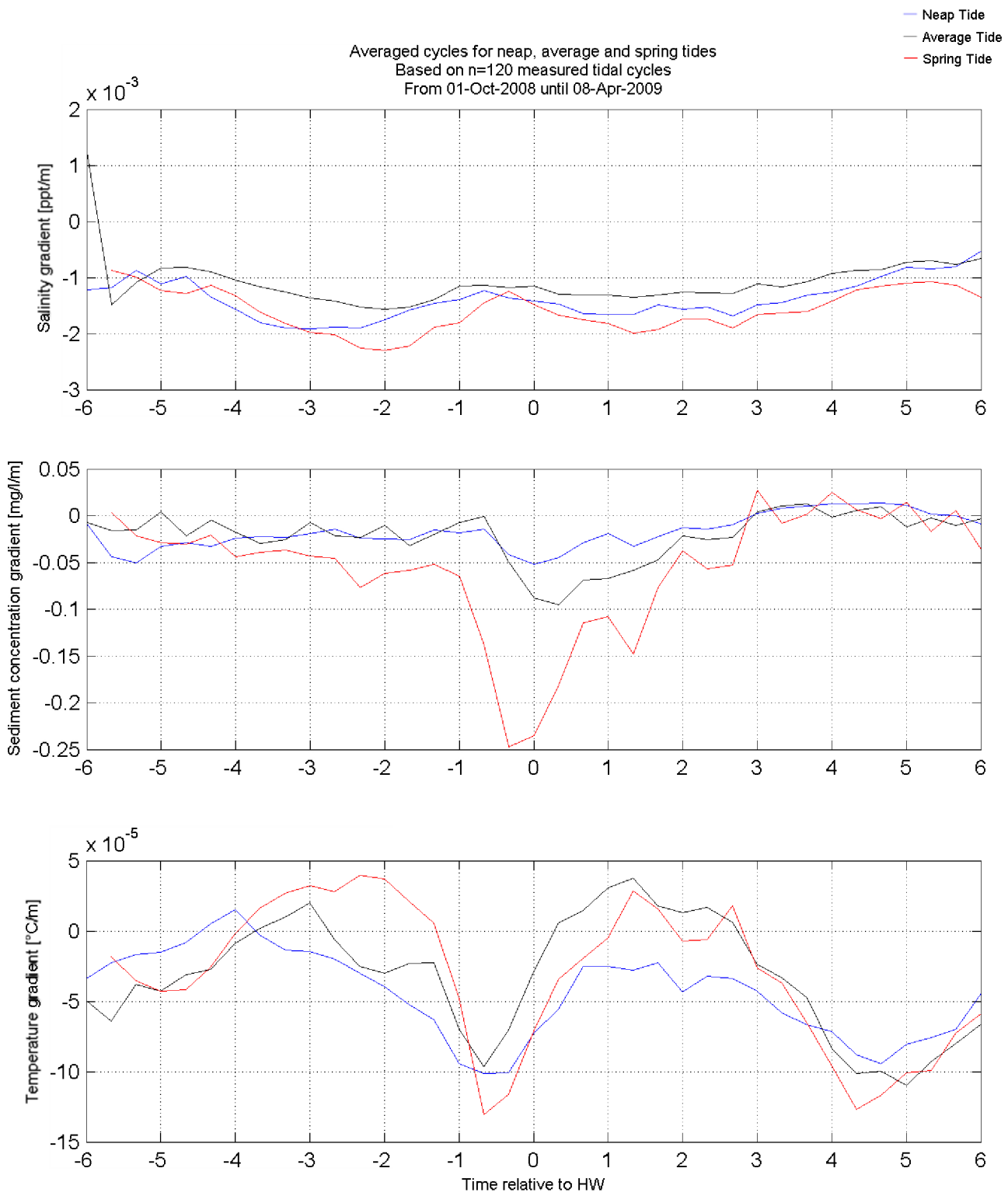
Data Processed by: IMDC

In association with :

I/RA/11283/08.094/MSA

Long Term Monitoring Siltation Deurganckdok

Autumn 2008	Equipment(s): OBS 3A
	Location: DGD-P&O (S)



Horizontal gradient at -12.6 m TAW =(S-BACK - S-ENTRANCE)/Δx

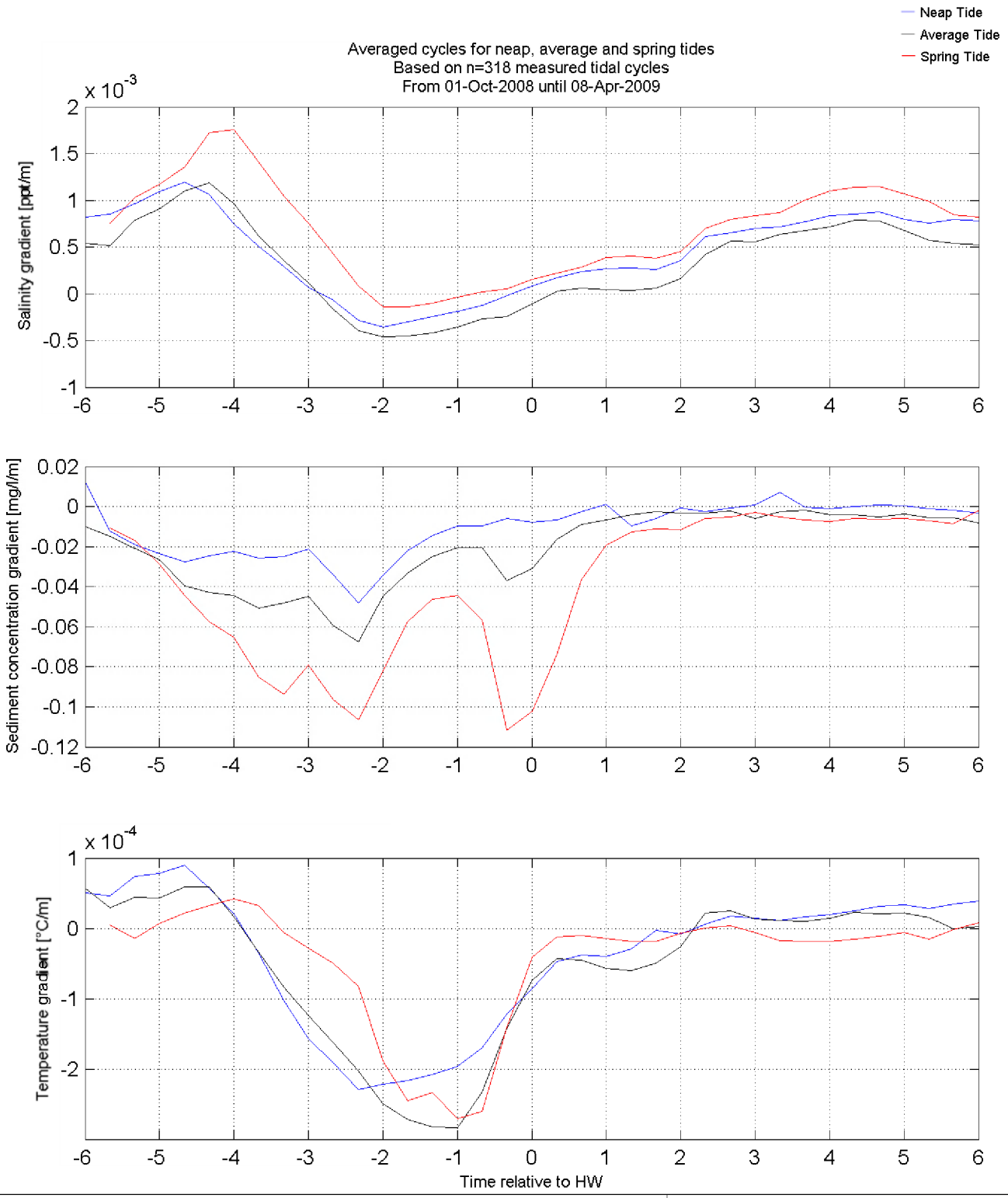
Data Processed by: IMDC

In association with :

I/RA/11283/08.094/MSA

Long Term Monitoring Siltation Deurganckdok

Autumn 2008	Equipment(s): OBS 3A
	Location: DGD-P&O (S)



Horizontal gradient at -2.4 m TAW =(S-BACK - S-ENTRANCE)/Δx

Data Processed by: IMDC

In association with : WL | delft hydraulics

I/RA/11283/08.094/MSA

Long Term Monitoring Siltation Deurganckdok

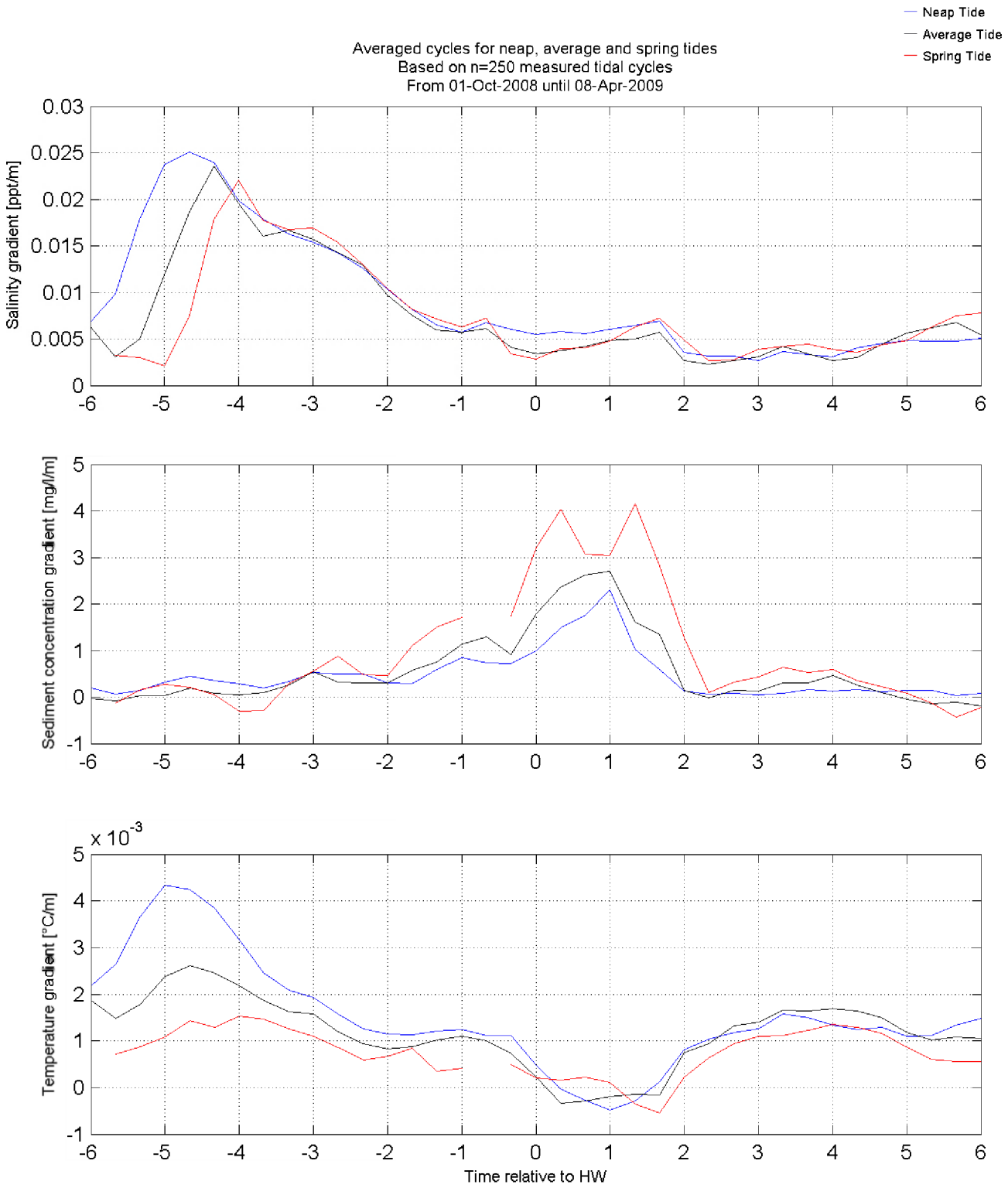
Autumn 2008

Equipment(s):

OBS 3A

Location:

DGD-PSA (N-entrance)



Vertical gradient at N-ENTRANCE =(data(-13m) - data(-2m))/Δz

Data Processed by:

In association with :

I/RA/11283/08.094/MSA

Long Term Monitoring Siltation Deurganckdok

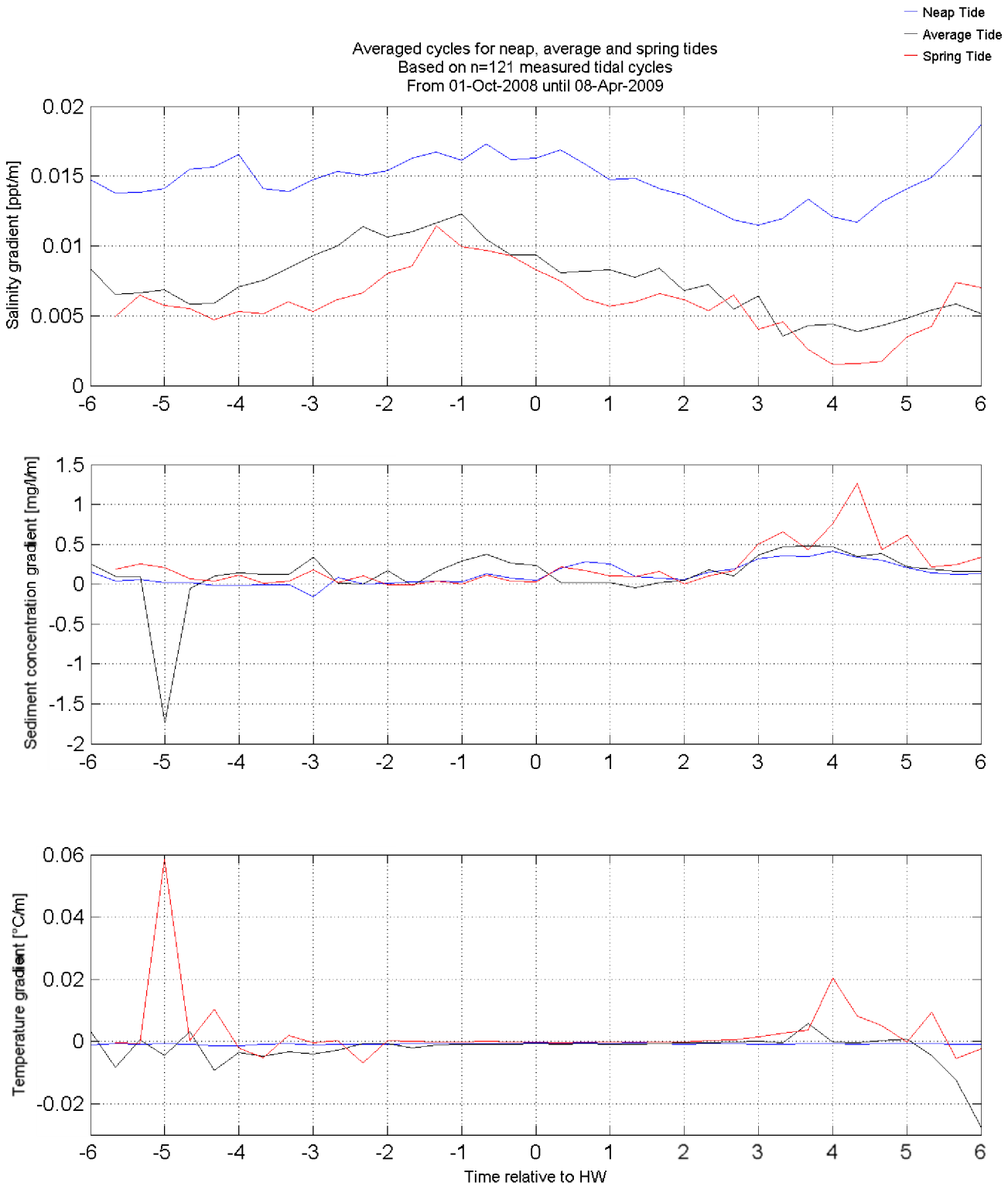
Autumn 2008

Equipment(s):

OBS 3A

Location:

DGD-P&O1 (S-back)



Vertical gradient at S-BACK =(data(-12m) - data(-2m))/Δz

Data Processed by:

In association with :

I/RA/11283/08.094/MSA

Long Term Monitoring Siltation Deurganckdok

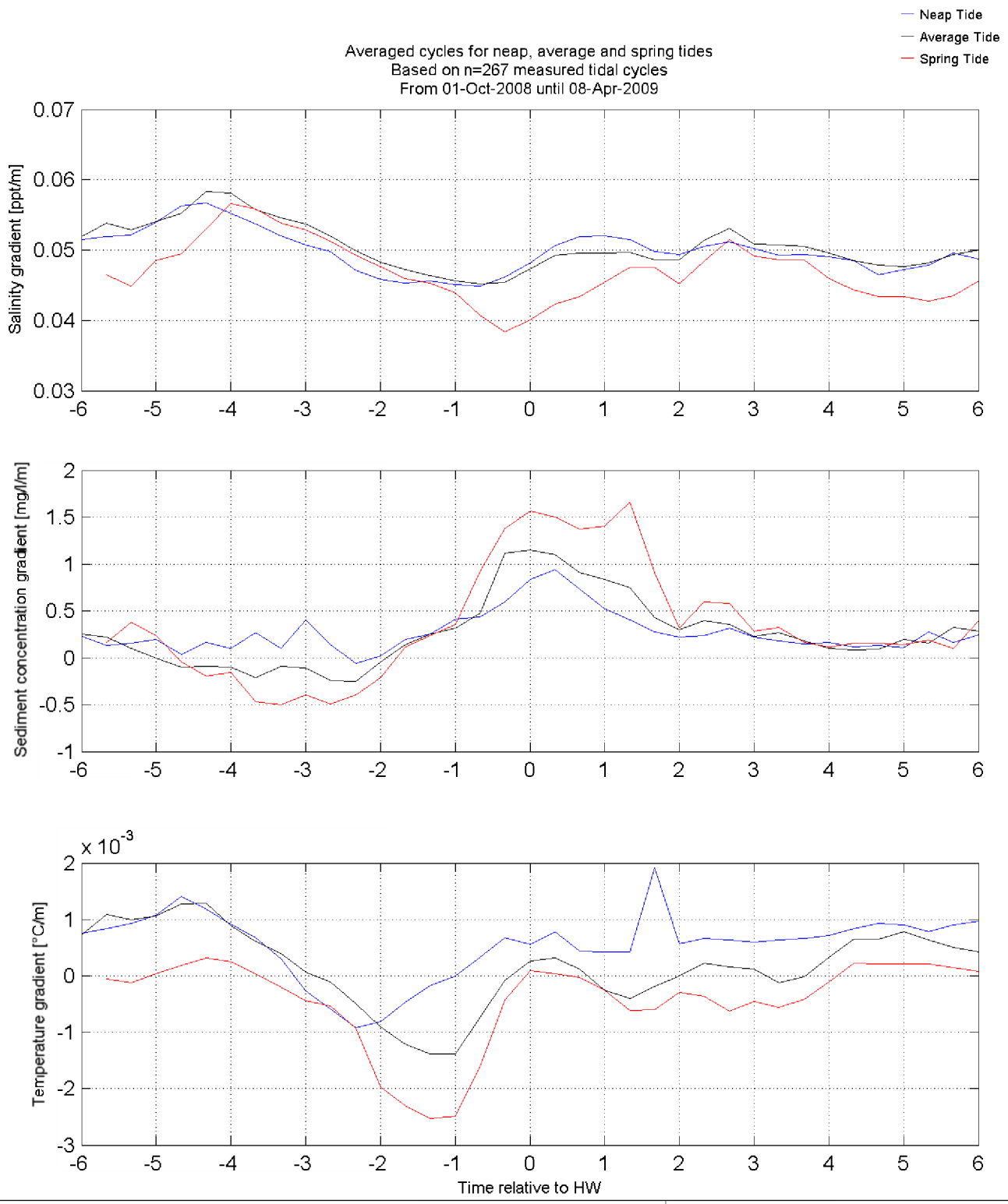
Autumn 2008

Equipment(s):

OBS 3A

Location:

DGD-P&O2 (S-entrance)



Vertical gradient at S-ENTRANCE =(data(-13m) - data(-2m))/Δz

Data Processed by:

In association with :

I/RA/11283/08.094/MSA

Long Term Monitoring Siltation Deurganckdok

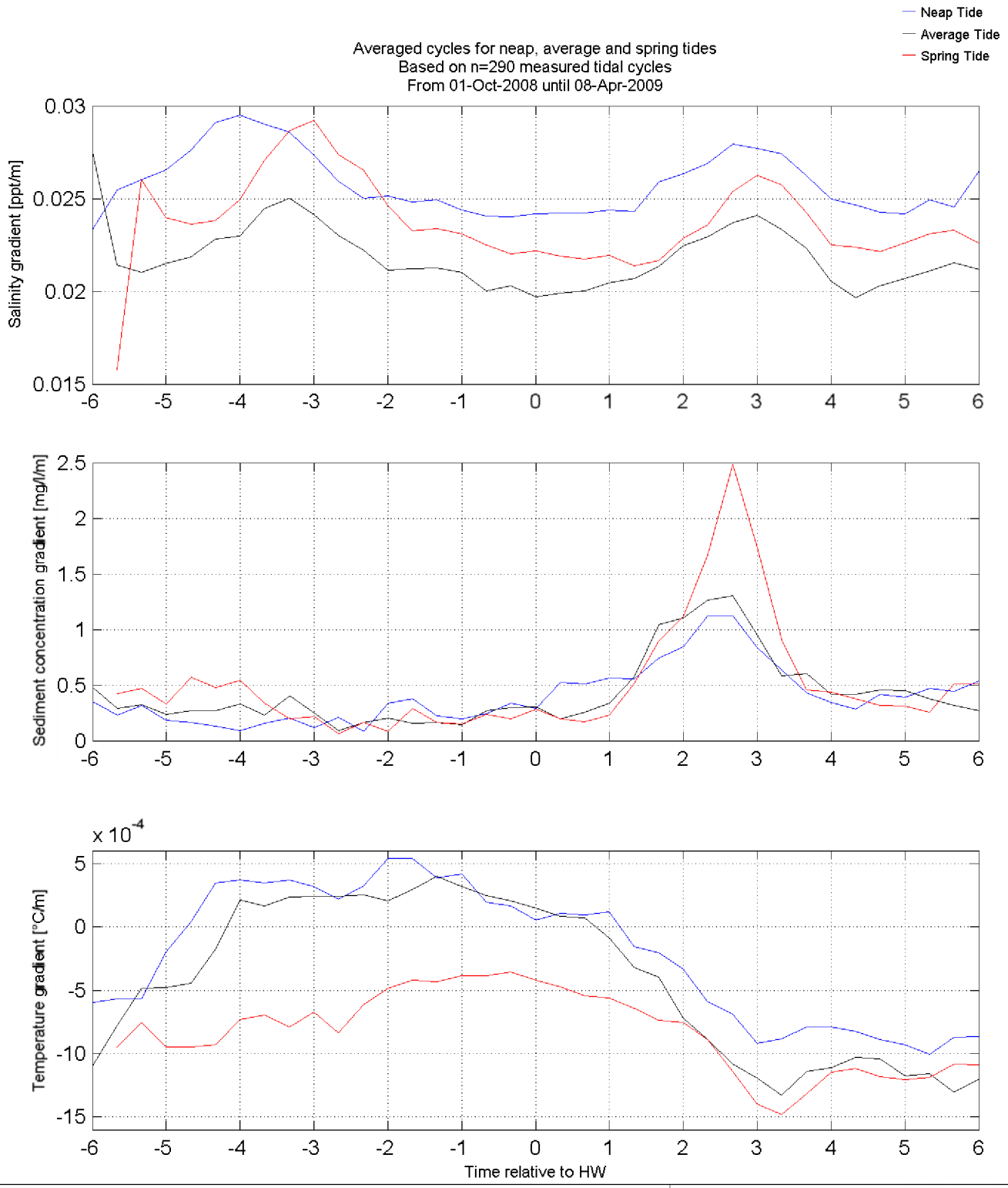
Autumn 2008

Equipment(s):

OBS 3A

Location:

DGD-DB Ports (S-middle)



Vertical gradient at S-MIDDLE =(data(-12.2m) - data(-2.3m))/Δz

Data Processed by:

In association with :

I/RA/11283/08.094/MSA