REPORT

Flemish Government - Department of Mobility and Public Works

Maritime Access Division

Evaluation of the external effects on the siltation in Deurganckdok (2012 - 2014)

Report 1.13: Analysis of the boundary conditions in survey years 3 and 4: 01/04/2008 – 31/03/2010

31 October 2014 - version 3.0

International Marine & Dredging Consultants

in collaboration with

Deltares

Enabling Delta Life

Colophon

International Marine & Dredging Consultants

Address: Coveliersstraat 15, 2600 Antwerp, Belgium

☎: + 32 3 270 92 95

Fax: + 32 3 235 67 11

Email: info@imdc.be

Website: www.imdc.be

Document Identification

Title	Report 1.13: Analysis of the boundary conditions in survey years 3 and 4: 01/04/2008 – 31/03/2010
Project	Evaluation of the external effects on the siltation in Deurganckdok (2012 - 2014)
Client	Flemish Government - Department of Mobility and Public Works - Maritime Access Division
Tender	16EF/2011/28
Document ref	I/RA/11406/13.054/MGO
Document name	K:\PROJECTS\11\11406 - Evaluatie externe effecten aanslibbing DGD II\10-Rap\1.13_RA13054_Analyse_omgevingscondities_2008-2010\RA13054_omgevingscond_annual _report_200804_201003_v3.0.docx

Revision

Version	Date	Description	Author	Checked	Approved
1.0	07/06/13	Concept	MGO/CCA	JCA	GVH
2.0	26/08/13	Concept	CCA/JCA	BDC	GVH
3.0	31/10/14	Final	MGO	JCA	KDW

Contact within IMDC

Name	Jan Claus
Phone number	+32 3 287 25 26
Email	jan.claus@imdc.be

Distribution List

3	Hard copy	Mr. Roose (Maritime Access Division)
3	Hard copy	Mr. Vanlede (Flanders Hydraulics Research)

Table of Contents

Annexes

List of Tables

List of Figures

0. SUMMARY

This report presents the data analysis of long-term stationary measurements in the Lower Sea Scheldt for the survey years 3 and 4 or between 01/04/2008 and 31/03/2010. In particular, it aims to provide as much insight as possible into the 2-yearly evolution in discharge, current velocities, temperature, salinity and suspended sediment concentrations in the River Scheldt. Because of their long duration, it will be possible to study the variations of the measured variables according to different times scales (ebb/flood, spring tide/average tide/ neap tide, seasons). Due to the importance of external effects on siltation in Deurganckdok the report will focus more on sediment transport into the Lower Sea Scheldt.

1. INTRODUCTION

1.1 THE ASSIGNMENT

This report is part of a set of reports concerning the project 'Evaluation of the external effects on the siltation in Deurganckdok (2012 - 2014)'. The terms of reference were prepared by 'Department of Mobility and Public Works of the Flemish Government, Maritime Access Division (16EF/2011/28). Part 1 of the study was awarded to International Marine and Dredging Consultants NV in association with Deltares on February 3rd 2012.

This study is a follow-up study on the study 'Evaluation of the external effects on the siltation in Deurganckdok' (2009 - 2012) and the study 'Siltation Deurganckdok (2006 -2009)'.

The data and information that are used in this project are carried out or collected by Flanders Hydraulics Research, Maritime Access Division and the Agency for Maritime Services and Coast. Flanders Hydraulics Research provided data on discharge, tide, salinity and turbidity along the river Scheldt. Maritime Access Division provided maintenance dredging data. Agency for Maritime Services and Coast – Coast Division provided depth sounding and density profile measurements.

1.2 AIM OF THE STUDY

The purpose of this study entails evaluating the external effects on the siltation in the Deurganckdok (DGD). External effects are those effects caused by recent or near-future human operations in the vicinity of Deurganckdok:

- The deepening and widening of the navigational channel in the Lower Sea Scheldt between the entrance of the Deurganckdok and the access channels to the locks of Zandvliet-Berendrecht (2008 - 2010);
- The deepening of the entrance to the Deurganckdok by removing the sill at the entrance (2009 - 2010);
- The construction of the Current Deflecting Wall downstream to the entrance of the Deurganckdok (2010 - 2011);
- The change in maintenance depth or strategy;
- Construction of the second Waaslandlock at the landward end of DGD (started in 2011)

1.3 OVERVIEW OF THE STUDY

This study is composed of 2 parts:

- Reporting and analysis of existing documents and delivered measurement data.
- Execution of specific measurement campaign to determine the siltation and salinity rates at the entrance of DGD.

Reports of the project 'Evaluation of the external effects on the siltation in the Deurganckdok (2009 - 2012)' are summarized in Table 1-1. The numbering of the reports follows the previous project that ran between 2009 and 2012 (IMDC, 2010a – IMDC, 2013a; Annex A).

This report is a continuation of the set analysis of boundary conditions reports (IMDC, 2007; IMDC, 2008a) which were made in the previous projects: Uitbreiding studie densiteitsstromingen in de Beneden Zeeschelde in het kader van LTV Meetcampagne naar hooggeconcentreerde slibsuspensies and Aanslibbing Deurganckdok (2006 - 2009).

Table 1-1: Overview of the project 'Evaluation of the external effects on the siltation in Deurganckdok (2012 - 2014)'.

Report	Description
I.	**Analysis and Reporting**
I.1 Annual Sediment Balance: Bathymetry surveys, Density measurements, Maintenance and construction dredging activities	
1.09	Annual Sediment Balance in survey year 7: 01/04/2012-31/03/2013 (I/RA/11406/13.143/JCA)
1.10	Annual Sediment Balance in survey year 8: 01/04/2013-31/03/2014 (I/RA/11406/13.144/JCA)
I.2 Boundary Conditions: Upriver Discharge, Salt concentration Scheldt, Bathymetric evolution in access channels, dredging activities in Lower Sea Scheldt and access channels	
1.11	Boundary Conditions in survey year 7: 01/04/2012 – 31/03/2013 (I/RA/11406/13.145/JCA)
1.12	Boundary Conditions in survey year 8: 01/04/2013 – 31/03/2014 (I/RA/11406/13.146/JCA)
I.3 Analysis of the boundary conditions	
1.13	***Analysis of the boundary conditions in survey years 3 and 4: 01/04/2008 – 31/03/201 (I/RA/11406/13.054/MGO)***
1.14	Analysis of the boundary conditions in survey years 5 and 6: 01/04/2010 - 31/03/2012 (I/RA/11406/13.062/MGO)
1.15	Analysis of the boundary conditions in survey years 7 and 8: 01/04/2012 – 31/03/2014 (I/RA/11406/13.147/JCA)
I.4 Analysis: evaluation of external effects on siltation in Deurganckdok	
1.16	Analysis of external effects on siltation processes and factors (I/RA/11406/13.147/JCA)
II.	**Longterm salinity and turbidity measurement campaign at the entrance Deurganckdok**
II.1 Salinity Siltation Distribution at the entrance of Deurganckdok	
2.14	Salinity-Siltation distribution Deurganckdok in survey year 7: 01/04/2012 - 31/03/2013
2.15	Salinity-Siltation distribution Deurganckdok in survey year 8: 01/04/2013 – 31/03/2014
II.5 Quality Control instruments	
2.16	Calibration stationary equipment 2012
2.17	Calibration stationary equipment 2013

1.4 STRUCTURE OF THE REPORT

Chapter 2 will provide a general summarizing description of the project, with a description of the processing method. Chapter 3 describes the boundary conditions (tide, discharge) for the analysis.

In the following chapters, an analysis will be given of the variable variations that influence the sediment transport or that might explain the variations thereof. The variations of the influencing variables will be processed according to different time scales (tide, months, neap tide – spring tide cycle, semester, seasons). Chapter 4 will deal with the velocity measurements, Chapter 5 will treat the salinity and Chapter 6 will treat temperature.

A similar analysis will be carried out in Chapter 7 regarding the variations shown on different time scales in relation to the sediment transport. Additionally, these variations of the sediment transport will be put into relation with the evolution of the influencing variables as described in the previous chapters.

Conclusions are drawn in Chapter 8.

2. SEDIMENTATION IN DEURGANCKDOK

2.1 PROJECT AREA: DEURGANCKDOK

Deurganckdok is a tidal dock situated between Liefkenshoek and Doel on the left bank in the Lower Sea Scheldt. 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 located at a depth of –17 mTAW in the transition zones between the quay walls and the central trench and of –19 m TAW in the central trench.
3. The quay walls reach up to +9 m TAW.

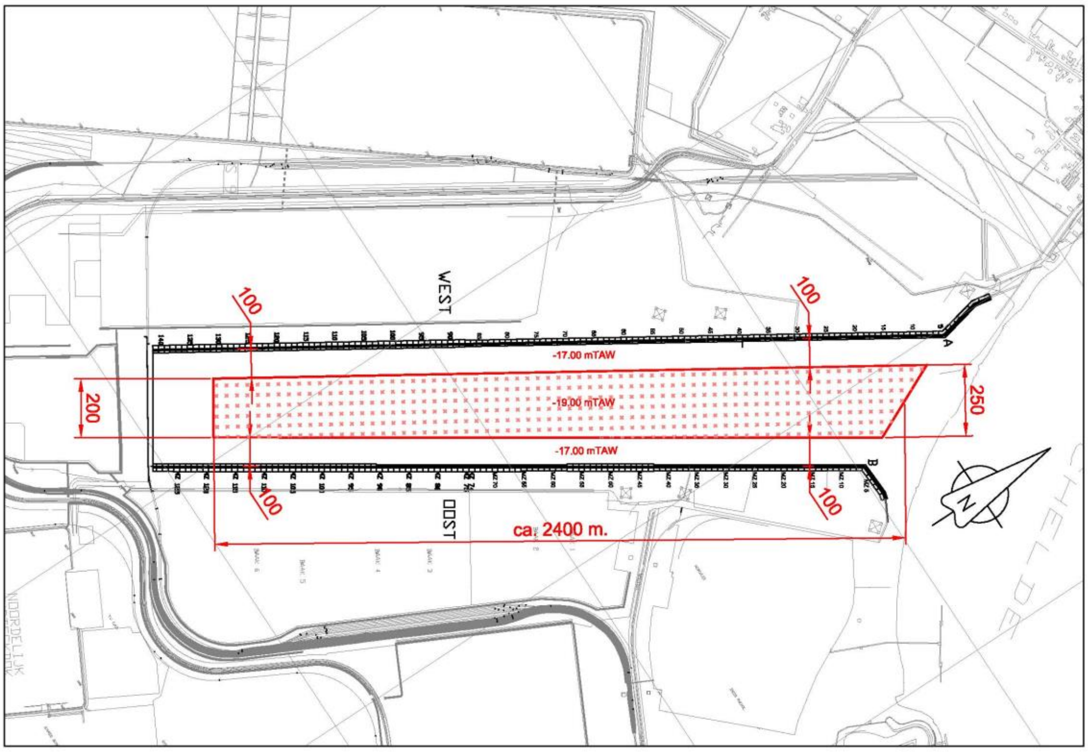


Figure 2-1: Overview of Deurganckdok

The dredging of the dock was performed in 3 phases, namely, between the start on February 2005 and finalization in February 2008. A Current Deflecting Wall (CDW) was constructed at the entrance of Deurganckdok in 2010-2011 with the objective of reducing the yearly sedimentation in the dock. The CDW was completed in August 2011.

Other main construction works which have been carried out near the dock since the opening of Deurganckdok are summarized in Table 2-1.

Table 2-1: Overview of construction works carried out since the opening of Deurganckdok.

Date	Description
18th February 2005	Deurganckdok dike between the Scheldt and the dock was opened
18th Feb 2005 – 1st Aug 2005	Dredging Phase 2 (end)
Feb 2007 – Feb 2008	Dredging Phase 3, dock extended from 1500 to 2500 m
Jul 2008 – Aug 2010	Deepening and widening of the Scheldt navigation channel in Belgium (spread over a long period, exact timing not known)
Nov 2009 – Jun 2010	Dredging of the entrance sill
Apr 2010 – Aug 2011	Construction of the Current Deflecting Wall (CDW)
> Mar 2011	Change of maintenance depth -15.9 m / -17.5 m / -15.2 m in quays / trench / entrance (included in maintenance dredging)
> Nov 2011	Construction of the 2nd Waaslandlock at the landward end of DGD

2.2 OVERVIEW OF THE STUDIED PARAMETERS

The purpose of this study entails evaluating the external effects on siltation in the Deurganckdok (DGD) and is based on the analysis and reporting of measurement data. The analysis of the measurement data contains two main components: the derivation of a yearly mass balance of the dock and the analysis of sediment exchange mechanisms, including a conceptual sedimentation model, which uses results from the mass balance, boundary conditions and measurement data at the entrance of Deurganckdock. Analysis and reporting of the natural and human conditions in the Lower Sea Scheldt would provide more insight into the mechanisms causing the siltation in Deurganckdok.

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).

A net deposition can be calculated from a comparison with a chosen initial condition t0 (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 t0 leads to the change in mass of sediments present in the dock (mass growth). Adding cumulated dry matter mass of dredged material removed since t0 and subtracting any sediment influx due to capital dredging works leads to the total cumulated mass entered from the river Scheldt since t0.

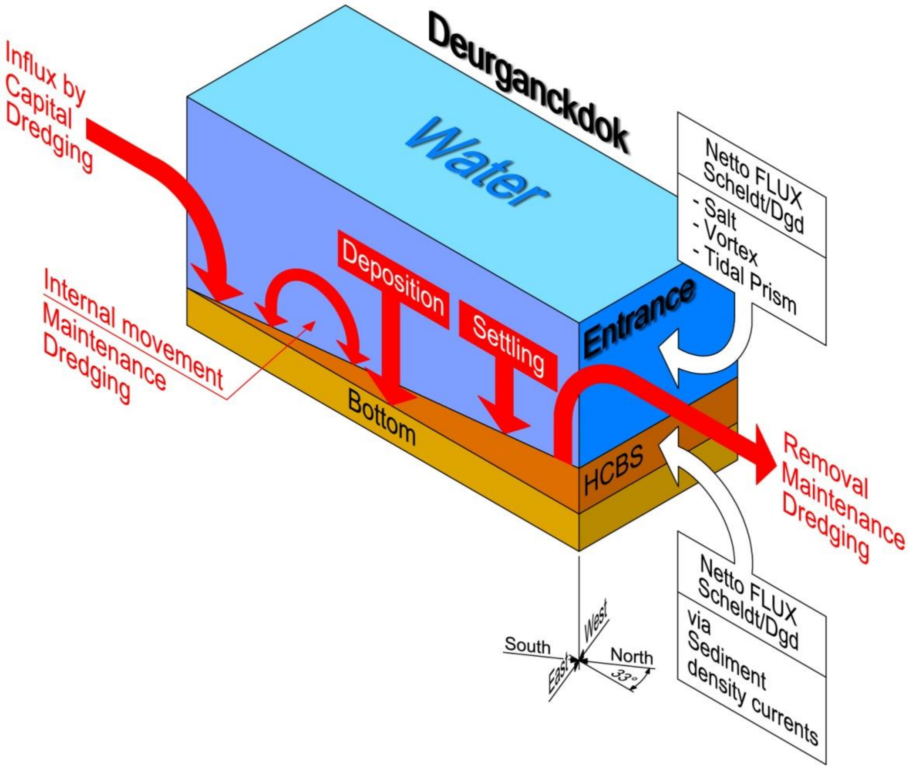


Figure 2-2: Elements of the sediment balance and transport mechanisms

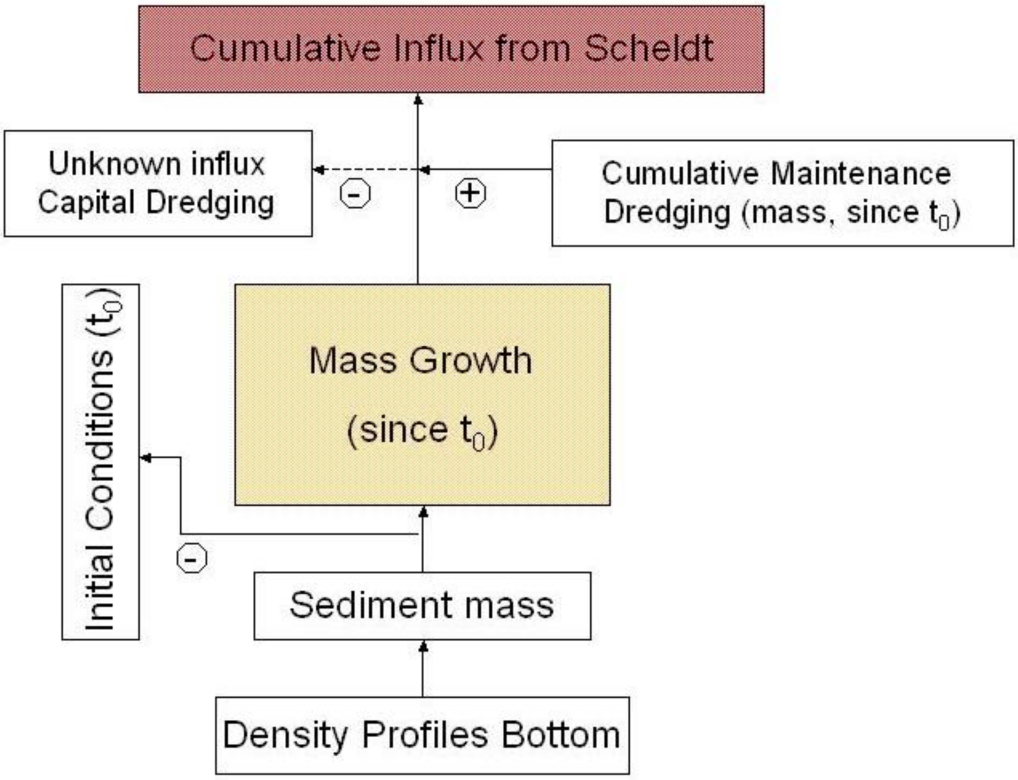


Figure 2-3: Determining a sediment balance

The following mechanisms concerning sediment exchange will form the objective of this 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 salinity gradient between the River Scheldt and the dock
- Density currents due to highly concentrated benthic suspensions

These aspects of hydrodynamics and sediment transport have been the landmarks in determining the parameters to be measured during the project. Measurements have focused on three types of timescales: 1/ one tidal cycle 2/ one neap-spring cycle 3/ seasonal variation within one year.

The following data have been collected to understand these mechanisms:

- Monitoring upstream discharge in the River Scheldt.
- Monitoring Salinity and sediment concentration in the Lower Sea Scheldt at permanent measurement locations at Oosterweel, up- and downstream of the Deurganckdok.
- Long term measurements of salinity and suspended sediment distribution at the entrance of Deurganckdok.
- 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 OBJECTIVES OF THE REPORT

This report will deal with the long-term stationary measurements to determine the environmental conditions in the Lower Sea Scheldt between April 2008 and March 2010. It will describe the results of the analysis of the long-term measurements in the Lower Sea Scheldt. Because of their long duration, it will be possible to study the variations of the measured variables on different time scales (ebb/flood, tide, spring tide/average tide/neap tide, and seasons). The factual data reports of these data are recorded in reports: IMDC (2008b), IMDC (2009d) and IMDC (2011c).

3. TIDE AND DISCHARGE

This chapter will provide a detailed description of the analysis' general framework. Firstly, the execution of the measurement campaign will be summarized. A description is then given of the measurement data processing used to carry out the analysis and finally the boundary conditions of the aforementioned analysis (tide, discharge and precipitation) will be presented.

3.1 DESCRIPTION OF THE MEASUREMENT CAMPAIGN

Long-term measurements near Buoy 84 and 97 were carried out by IMDC in the Lower Sea Scheldt. Since July 2008, Flanders Hydraulics Research has been integrating the measurements taken near Buoy 84 into their permanent monitoring system of the Lower Sea Scheldt. All the permanent measurement locations upstream of Antwerp were used in this report between 01/04/2008 until 31/03/2010: Prosperpolder, Buoy 84, Liefkenshoek, Buoy 97 and Oosterweel. Measurements at the location of Buoy 97 stopped on 2/07/2008 and were replaced by the measurement location at Liefkenshoek. Measurements at the Liefkenshoek site started on 31/07/2009. With the exception of Liekenshoek, we also refer to the factual data reports: IMDC (2008b); IMDC (2009d) and IMDC (2011c) in which the measured data are presented in detail. Liefkenshoek factual data is reported as part of this project in report 2.11.

The measurement locations: Buoy 84 and 97, and the stations in Oosterweel, Prosperpolder and Liefkenshoek provide the data for the following analysis. At Buoy 84 and 97, and at Oosterweel, measurements have been carried out at two different depths. The location, depth and measurement period for each instrument is given in Table 3-1. Reference is made to the data reports for a description of periods for which no data or incorrect data have been logged.

Table 3-1 UTM Coordinates of the locations and depth of the instruments (downstream top)

Location	Easting [UTM ED50]	Northing [UTM ED50]	Period	[m] above bottom	Elevation [m TAW]
Prosperpolder	586 307	5 689 501	Apr2008 – Mar2010	2.5	-1.5
Buoy 84	588 971	5 686 097	Apr2008 – Mar2010	3.3	-5.6
				0.8	-8.1
Liefkenshoek	589 731	5 683 787	Aug2009 – Mar 2010	2.0	-1.5
Buoy 97	590 932	5 683 350	Apr2008 – Jun2008	3.3	-5.3
				0.8	-7.8
Oosterweel	595 574	5 677 278	Apr2008 – Mar2010	4,5	-2.3
				1.0	-5.8

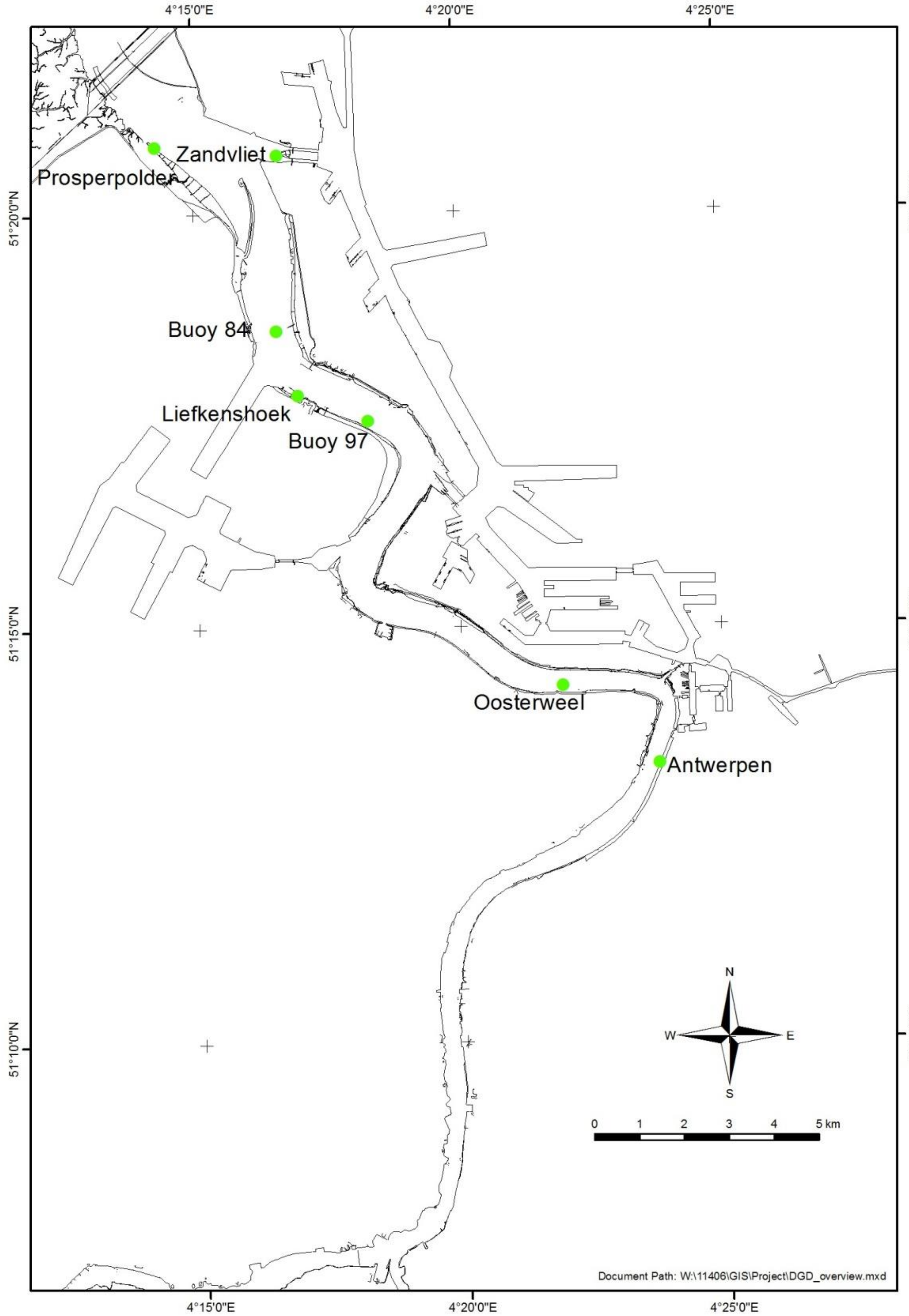


Figure 3-1 Overview of the measurement locations on the Sea Scheldt

Anderaa RCM9 and Anderaa SeaGuard instruments were used to measure the flow velocity and direction, temperature, pressure, conductivity and turbidity. A CTD instrument manufactured by Valeport Ltd, was used at Liefkenshoek. The measurement frequency was 10 minutes.

The analyzed variables in this report (and presented in the data reports) are: flow velocity and direction, salinity, temperature and sediment concentration. Salinity is derived from the pressure, conductivity and the temperature. Sediment concentration is derived from the calibration of the turbidity meter (see Chapter 7). No velocity data is recorded at Prosperpolder and Liefkenshoek.

Tidal data were provided by Flanders Hydraulics Research in the form of water levels taken every 10 minutes in Prosperpolder, Liefkenshoek and Antwerp. Prosperpolder was used as a tidal station for the measurement location Prosperpolder; Liefkenshoek for Buoy 84 & 97 and measurement location Liefkenshoek; and Antwerp for the measurement location Oosterweel.

3.2 DATA PROCESSING

Due to the different measurement times for the various instruments, the data were interpolated at fixed times before being analyzed. These interpolated times correspond with the times of the 10 minute tide data of Flanders Hydraulics Research.

In order to reach a conclusion regarding the variations on the various time scales, the data were sorted out and grouped per tide, ebb or flood. The aim was to be able to calculate minimum/maximum values, amplitude, and average values for the variables per episode (tide, ebb, flood). It has to be underlined that the term amplitude as used here means the difference between a variable maximum and minimum within an episode. The tides were then classified as neap tide, average tide and spring tide in order to prepare the average tidal curves.

3.2.1 Tide, ebb, flood and slack water

In order to be able to calculate the average or extreme values for ebb, flood and tidal periods the limits of these episodes have to be determined first. The approach was that a tide, an ebb, a flood, is time-delimited by the moments of slack water. These have been defined as the minimal values in flow velocity in pre-determined time intervals. These intervals were determined using a series of average times of high and low tide in an astronomical model of the tidal water level times in Antwerp. The aim is to produce a series of time intervals wide enough (about half a tide) and approximately centered on a moment of low or high tide in order to seek the minimum velocity within this interval, determining the moment of the corresponding low or high slack water. Because of the measurement frequency, the time tags of slack water were determined with an accuracy of 10 minutes.

Once the slack water time tags were known, the measurement data were classified per flood (from time of low water slack – LWS – to high water slack– HWS), per ebb (from HWS to LWS) and tide (flood and ebb, LWS1 – LWS2) and calculations were made for the maximum, minimum, amplitude (max-min), and the average value per episode and per analyzed variable. Note that at Prosperpolder and Liefkenshoek, where no velocity data were measured, the classification of the data occurred using the salinity instead of the water level data.

3.2.2 Neap tide - Spring tide cycle

Spring tide is defined as the first tide immediately following the fifth moon passage at Ukkel, and should be calculated from the time of new or full moon. Neap tide is determined in the same way, from the time of the first and the last quarter (FHR, 2009).

In order to avoid having to use an astronomic model, an approach was used in which the difference between the various tidal types is calculated using the measured tidal characteristics. This approach is based on the fact that a spring tide is characterized by a larger – and neap tide by a smaller – amplitude than an average tide. That is why in the analysis the tides observed with the largest amplitudes are considered spring tides and those with the smallest amplitudes are considered neap tides. If Δh_{neap} stands for the tidal difference of an average neap tide, Δh_{spring} for the tidal range of an average spring tide and Δh_{aver} for the tidal difference of an average tide, then a neap, spring and average tide will be defined as follows (Δh is the measured tidal range for a particular tide):

- Neap tide: $\Delta h \leq 0.5\ (\Delta h_{neap} + \Delta h_{aver})$
- Spring tide: $\Delta h \geq 0.5\ (\Delta h_{spring} + \Delta h_{aver})$
- Average tide: $0.5\ (\Delta h_{neap} + \Delta h_{aver}) < \Delta h < 0.5\ (\Delta h_{spring} + \Delta h_{aver})$

The coefficients Δh_{neap}, Δh_{aver} and Δh_{spring} were determined in every tidal location by multiplying the average amplitude of a neap, average and spring tide for the decade 1991-2000 respectively in Prosperpolder, Zandvliet, Liefkenshoek and Antwerp (see §3.3.1.2) with a correction factor, representing the relation of the average tidal difference in the tidal location during the previous decade and the average tidal difference observed during the period studied in this report.

The limits resulting from this between a neap tide, an average tide and a spring tide, are illustrated in Table 3-2. In Liefkenshoek for example, a tide with an amplitude smaller than 4.68 m is regarded as a neap tide, with an amplitude higher than 5.47 m as a spring tide. The tides in between are regarded as average tides.

Table 3-2: Considered amplitude limit [m] between a neap, an average and a spring tide in Prosperpolder, Liefkenshoek and Antwerp.

	Prosperpolder	Liefkenshoek	Antwerp
Neap – Average Limit	4.60	4.68	4.86
Spring – Average Limit	5.38	5.47	5.51

Table 3-3 gives the number of neap, average and spring tides recorded during the measurement period according to the above classification for the available tidal locations. The difference in number of tides observed between the various locations is caused by the fact that sometimes data are missing in the tide data received. It can be observed that classification follows a relation of 25 % neap tide, 40 % average tide and 35 % spring tide.

Once the various tides have been classified per category, the average tidal curves are calculated for all variables. These were obtained by classification for each tide from a certain type of all available values per time tag (that is every 10 minutes) compared with HW. Then an average value is calculated for each time tag related to HW.

Additionally, the measurements are classified per trimester and per summer, winter of a year. Here winter is defined as the period between October and March, and summer the period between April and September by analogy with analyses of similar long-term measurement campaigns.

Table 3-3: Amount of neap, average, and spring tides measured during considered period.

2008-2009		**Apr-Jun**	**Jul-Sep**	**Oct-Dec**	**Jan-Mar**	**Summer**	**Winter**	**Year 1**	**Total Period**
Prosperpolder	Neap	-	-	-	-	-	-	-	149
	Avg	-	-	-	-	-	-	-	243
	Spring	-	-	-	-	-	-	-	211
	All	-	-	-	-	-	-	-	603
Liefkenshoek	Neap	34	43	43	47	77	90	167	266
	Avg	84	58	73	53	142	126	268	429
	Spring	52	73	41	69	127	110	235	380
	All	170	174	157	169	346	326	670	1075
Antwerp	Neap	28	35	48	53	63	101	164	214
	Avg	93	63	68	49	157	117	273	386
	Spring	49	72	38	67	122	105	226	309
	All	170	170	154	169	342	323	663	909
2009-2010		**Apr-Jun**	**Jul-Sep**	**Oct-Dec**	**Jan-Mar**	**Summer**	**Winter**	**Year 2**	**Total Period**
Prosperpolder	Neap	28	44	39	38	72	77	149	149
	Avg	69	53	77	44	124	121	243	243
	Spring	53	43	52	63	96	115	211	211
	All	150	140	168	145	292	313	603	603
Liefkenshoek	Neap	27	38	20	14	65	34	99	266
	Avg	75	50	26	10	127	36	161	429
	Spring	59	61	25	1	120	25	145	380
	All	161	149	71	24	312	95	405	1075
Antwerp	Neap	25	25	-	-	50	-	50	214
	Avg	66	47	-	-	113	-	113	386
	Spring	47	36	-	-	83	-	83	309
	All	138	108	-	-	246	-	246	909

3.3 BOUNDARY CONDITIONS OF THE ANALYSIS

3.3.1 Tidal variations

3.3.1.1 Tide measurements during the measurement campaign

The digitalized tidal series, with a measurement frequency of 10 minutes in Prosperpolder, Liefkenshoek and Antwerp, was provided by Flanders Hydraulic Research. The accuracy thereof is indicated with 2 cm for height and 2 minutes for time (FHR, 2009).

In Annex-Figure B-1 to Annex-Figure B-3 the course of HW, LW and the tidal amplitude per tide over the measurement period is presented for the various tidal locations. The periodic cycles between tides with a large amplitude (regarded as spring tide) and with a low amplitude (regarded as neap tide) are very clear.

3.3.1.2 Average tidal curves during the measurement campaign

The average tidal curves were calculated for the tide gauges on the basis of the tidal data provided by Flanders Hydraulics Research (Annex-Figure B-4 to Annex-Figure B-6).

The averages for HW & LW levels, tidal amplitude, and the duration of rise and fall could all be determined from these curves (Table 3-4 and Table 3-5). Since Flanders Hydraulics Research provided the data on the basis of 10 minute intervals the level of precision – when determining the duration calculated for rising, falling and tide – amounts to 20 minutes.

Table 3-4 Average HW, LW [m TAW] and tidal amplitude [m] for a neap, an average and a spring tide at Prosperpolder, Liefkenshoek and Antwerp, April 2008 – March 2010.

Survey 2008-2010	Neap tide			Average tide			Spring tide		
	HW	LW	Amp	HW	LW	Amp	HW	LW	Amp
Prosperpolder	4.34	0.12	4.22	4.87	-0.25	5.11	5.34	-0.48	5.83
Liefkenshoek	4.67	0.35	4.32	5.20	-0.04	5.24	5.66	-0.30	5.96
Antwerp	4.79	0.32	4.48	5.25	-0.06	5.31	5.68	-0.31	6.00

Table 3-5: Average duration [h:mm] of rising and falling for an averaged neap, average and spring tide at Prosperpolder, Liefkenshoek and Antwerp, April 2008 – March 2010.

Survey 2008-2010	Neap tide			Average tide			Spring tide		
	Flood	Ebb	Tide	Flood	Ebb	Tide	Flood	Ebb	Tide
Prosperpolder	06:10	06:20	12:30	05:50	06:40	12:30	05:40	06:50	12:30
Liefkenshoek	06:00	06:40	12:40	05:40	06:40	12:20	05:20	06:50	12:10
Antwerp	05:50	06:40	12:30	05:30	06:50	12:20	05:10	07:10	12:20

3.3.1.3 Comparison with the decade values and previous investigation

The average water levels and duration regarding neap, average and spring tide recorded during the period 1991-2000 in the tidal gauges of Zandvliet, Prosperpolder, Liefkenshoek and Antwerp, were reported in FHR (2009) and are shown in Table 3-7 and Table 3-9. When comparing these tables with Table 3-4 and Table 3-5, we find that on the basis of amplitude the classification of tides in various categories delivers results that are sufficiently close to the astronomical reality in terms of high & low water levels, amplitude and duration of the episodes. The values for Zandvliet and Prosperpolder are comparable since these measurement locations are situated on opposite banks of the River Scheldt, for instance; the values recorded for Zandvliet are used in this analysis.

A comparison of the present results with those from the previous report IMDC (2008a) (Table 3-6 and Table 3-8) shows that the tidal parameters are comparable. However, some differences are observed, mainly in the amplification of the tidal amplitude between Liefkenshoek and Antwerp. In both analyses, conducted in 2007-2008 and 1991-2000, an amplification of the tidal amplitude of 14 to 27 cm is seen between these two stations, while in the 2008-2010 analysis an increase of 7 cm (average tide) and 4 cm (spring tide) is found.

Table 3-6: Averaged HW, LW [m TAW] and tidal amplitude [m] for a neap, an average and a spring tide at Prosperpolder, Liefkenshoek and Antwerp for April 2007 – March 2008 (IMDC, 2008a).

Survey 2007 - 2008	Neap tide			Average tide			Spring tide		
	HW	LW	Amp	HW	LW	Amp	HW	LW	Amp
Zandvliet	4.52	0.43	4.09	5.09	0.04	5.05	5.54	-0.30	5.84
Liefkenshoek	4.62	0.38	4.24	5.22	-0.03	5.25	5.68	-0.18	5.86
Antwerp	4.72	0.34	4.38	5.29	-0.13	5.42	5.72	-0.41	6.13

Table 3-7: Averaged HW, LW [m TAW] and tidal amplitude [m] for a neap, an average and a spring tide at Prosperpolder, Liefkenshoek and Antwerp for the decade 1991 – 2000 (FHR, 2009).

Survey 1991 - 2000	Neap tide			Average tide			Spring tide		
	HW	LW	Amp	HW	LW	Amp	HW	LW	Amp
Prosperpolder	4.56	0.41	4.15	5.12	0.08	5.04	5.55	-0.16	5.71
Zandvliet	4.59	0.43	4.16	5.14	0.09	5.06	5.58	-0.14	5.72
Liefkenshoek	4.63	0.39	4.24	5.19	0.06	5.13	5.63	-0.18	5.81
Antwerp	4.77	0.34	4.43	5.29	0.00	5.29	5.72	-0.23	5.95

Table 3-8: Average duration [h:mm] of rising and filling for an averaged neap, average and spring tide at Prosperpolder, Liefkenshoek and Antwerp for April 2007 to March 2008 (IMDC, 2008a)

Survey 2007 - 2008	Neap tide			Average tide			Spring tide		
	Flood	Ebb	Tide	Flood	Ebb	Tide	Flood	Ebb	Tide
Zandvliet	5:50	6:40	12:30	5:40	6:50	12:30	5:20	7:10	12:30
Liefkenshoek	5:50	6:50	12:40	5:30	7:10	12:40	5:10	7:00	12:10
Antwerp	5:50	6:50	12:40	5:20	7:10	12:30	5:00	7:10	12:10

Table 3-9: Average duration [h:mm] of rising and falling for an averaged neap, average and spring tide at Prosperpolder, Liefkenshoek and Antwerp for the decade 1991-2000 (FHR, 2009)

Survey 1991 - 2000	Neap tide			Average tide			Spring tide		
	Flood	Ebb	Tide	Flood	Ebb	Tide	Flood	Ebb	Tide
Zandvliet	6:04	6:36	12:40	5:42	6:43	12:25	5:27	6:51	12:18
Liefkenshoek	6:03	6:37	12:40	5:41	6:44	12:25	5:27	6:52	12:19
Antwerp	6:00	6:40	12:40	5:34	6:51	12:25	5:17	7:02	12:19

3.3.1.4 Tidal effects

The Scheldt is ‘macrotidal’, it is an estuary with a tidal amplitude larger than 4 m. The tidal amplitude determines the potential to mix fresh water with salt water which has his influence on the sediment transport. Therefore, it is important to know the general effects of the tide in the Scheldt.

On the one hand, the tidal wave in estuaries is significantly changed due to the side effects from bottom friction of the flow, and on the other hand through the narrowing of the estuaries in the upstream direction (convergence). Dyer (1995) states that on the one hand, convergence causes a partial reflection of the tidal wave and on the other hand the compression thereof, in an increasingly smaller cross section, which results in an increase of the tidal amplitude. Bottom friction has the opposite effect; it will increase with the decreasing water depth and increasing flow velocity due to which energy will be extracted from the tidal wave and the amplitude thereof will decrease. In the Lower Sea Scheldt and the Western Scheldt the convergence effects are larger than the friction effects, which is proven by the fact that the tidal amplitude increases starting from the estuary (Vlissingen) to Schelle and then decreases upstream of Schelle. This phenomenon is indicated as ‘hyper synchronous’ (see Dyer, 1995). Table 3-10 provide information about some tidal gauges from the Scheldt basin regarding the average tidal amplitudes. The values of the tidal amplitudes also allow the Scheldt to be split into two parts; that means to say, the downstream part from the estuary to somewhere next to Schelle, and an upstream part from Schelle to Gentbrugge. This report will deal extensively with the downstream part of the river.

Tidal amplitude in the Lower Sea Scheldt is relatively large when compared to the water depth; the relation between both variables is about 0.3. For estuaries with a relatively large relation between tidal amplitude and water depth (> 0.3) there is an important asymmetry in the tide (see Annex-Figure B-4– Annex-Figure B-6) and in the flow velocity curves (see Chapter 3). The largest flow velocities appear during flood. This asymmetry in the tidal curve is due to the fact that during the beginning of the flood, the friction effects are greater than at the end of the flood when the water is deeper. In the Lower Sea Scheldt the convergence effect on the tidal amplitude is greater than the effect of the friction, and that is why the propagation velocity of the tidal wave increases (Savenije & Veling E, 2005), see Table 3-10, giving an indication of the average delay of the moment of HW compared to Vlissingen and the average propagation velocity of the HW. The increasing propagation velocity of the tidal wave (as far as Antwerp) causes the high water to propagate increasingly faster from the estuary, while the low waters stay behind. The result thereof is a decreased flood duration, an increased ebb duration and, increasingly, a more asymmetric velocity course and the tidal flow with a typical flood-dominating character. The flood-dominating character of the flow is most distinct for spring tides. For a neap tide, the low waters are higher and the high waters are lower, hence the friction effects are somewhat less important at the beginning of the flood and somewhat more important at the end in comparison to spring tide.

Table 3-10: Tidal amplitude [m] for an averaged spring, average and neap tide, duration [h:mm] rising and falling, delay of HW compared to Vlissingen, distance to mouth [km] and propagation velocity of HW [km/h] at several tidal gauges of the Scheldt for the decade 1991-2000 (FHR, 2009).

	Aver. Tidal amplitude.			Average Duration		Decelaration HW with respect to Vlissingen (hh.min)	Distance to mouth (km)	Propagation velocity HW (km/h)
	neap tide (m)	aver tide (m)	spring tide (m)	rising (hh.min)	falling (hh.min)			
Vlissingen	3.06	3.89	4.53	5:57	6:28	0:00	2.00	-
Hansweert	3.68	4.49	5.09	6:02	6:23	0:56	35.80	36.21
Prosperpolder	4.15	5.04	5.71	5:42	6:43	1:25	55.98	41.75
Antwerpen	4.43	5.29	5.95	5:25	7:01	1:45	77.60	64.86
Schelle	4.61	5.42	6.01	5:30	6:55	2:23	91.23	21.52
St. Amands	4.05	5.11	5.59	4:59	7:26	2:53	108.77	35.08
Dendermonde	3.72	4.14	4.43	4:51	7:34	3:31	121.77	20.53
Melle	2.23	2.38	2.52	4:18	8:08	5:14	150.79	16.90

3.3.2 Fresh water discharge and precipitation

Flanders Hydraulics Research has collected discharge data in a number of gauging stations situated outside the tidal influence. These discharges are then converted into discharge at the mouth of the various tributaries and into a total upstream discharge on the Scheldt at Schelle, see AZ (1974).

The stations are located at Melle (Scheldt), Appels (Dender), Eppegem (Zenne), Wilsele-Wijgmaal (Dijle), Hulshout (Grote Nete) and Grobbendonk (Kleine Nete). The discharge at Melle and Dendermonde is measured by means of an acoustic discharge meter, while in the other stations the water height is measured and the discharge is then calculated on the basis of the calibrated relation with the water height.

Discharge at the mouths of the rivers is determined from the discharge monitored at the stations by comparing the surface of the hydrographic basin at the mouth and the one at the station, assuming thereby that the flow is proportional to the surface. In terms of multiplication factors, the following results are obtained from the discharge monitored at the station: for the Zenne 1.13, for the Dijle 1.08, for the Kleine Nete 1.46 and for the Grote Nete 1.35. The surplus flow produced by the Durme, the Beneden Nete, the Rupel and the side discharge from the Scheldt located between Melle and Schelle, are calculated by comparing their basin with the surface of the hydrographic basin, of the rivers measured, showing that the sum of the flows may be obtained by dividing the total discharge – of the rivers monitored – by 5.05. The total discharge at Schelle can now be found by adding up all flows. By computing the total discharge in this manner, it is assumed that the concentration time is equal in all rivers, that there is no phase shift between the flow at the mouth of a tributary and the discharge at Schelle and that the precipitation is equally distributed over the complete hydrographic basin of the Scheldt.

During the measurement period (April 2008 – March 2010), the average fresh water discharge at Schelle was 102 m³/s, which is in between the extreme decade-average values, specifically, between 26 m³/s and 543 m³/s. These data compare well with the data obtained from April 2007 to March 2008 (IMDC, 2008a) where the average upper discharge at Schelle was 118 m³/s, with extreme decade average values between 37 m³/s and 539 m³/s. The monthly statistics compiled from the fresh water discharge recorded in period April 2008 – March 2010, are shown in Table 3-11 and Table 3-12. A comparison of the monthly average discharge with the long-term average discharge per decade shows that the fresh water discharge in the Scheldt indeed displayed average characteristics in the current measurement period. (See Annex-Figure B-7)

Table 3-11: Statistics of the monthly fresh water discharge [m³/s] at Schelle period April 2008 – March 2009.

	April 2010	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	January 2011	Feb	Mar	Year
Min.	71	51	48	42	40	38	47	72	62	57	104	78	38
Max.	201	182	269	139	288	129	262	274	364	529	543	270	543
Avg.	120	82	113	67	84	58	90	129	146	151	191	131	113.15
Std.	38	32	58	24	55	20	49	61	73	112	116	60	31

Table 3-12: Statistics of the monthly fresh water discharge [m³/s] at Schelle period April 2009 – March 2010.

	April 2010	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	January 2011	Feb	Mar	Year
Min.	61	39	37	39	30	26	28	54	59	74	80	79	26
Max.	159	206	157	142	72	59	245	255	314	228	224	506	506
Avg.	93	70	62	59	39	35	62	107	144	126	172	147	93
Std.	23	34	30	22	10	8	43	58	75	48	40	86	24.14

4. FLOW VELOCITY AND DIRECTION

The flow velocity is one of the determining factors for the suspended sediment transport and a high degree of correlation is expected between these two variables. In this chapter first of all flow measurements will be analyzed in terms of average flow direction, as well as maximum and average flow velocity. Then, the average flow velocity curves will be presented and analyzed in terms of moments of maximum flow velocity and of slack water.

4.1 MAXIMUM AND AVERAGE VALUES PER EBB/FLOOD

Table 4-1 and Table 4-2 display the monthly averages of the maximum ebb and flood flow velocities for neap tide, average tide and spring tide conditions in the various measurement locations. Table 4-3 and Table 4-4 display the monthly averages of the average flow velocities and directions per ebb and Table 4-5 and Table 4-6 display the monthly averages of the average flow velocities and directions per flood and for an average neap tide, an average tide and an average spring tide. Whenever there is a dash (-) in the table, there was no or only bad quality data available.

The maximum and average flow velocities for ebb and flood and the flow direction for the maximum ebb and flood velocities for the complete measurement period are given in Annex-Figure C-1 to Annex-Figure C-13.

A comparison of the present data, with that of the data for the period April 2007 – March 2008 (IMDC 2008a) shows that the velocity data during both periods show very similar characteristics. As can be expected, assuming a logarithmic velocity profile, for both datasets the velocity measured by the top instrument is larger than the one measured by the bottom instrument. Annex-Figure C-31 to Annex-Figure C-33 establish these assumptions.

Both datasets also indicate a strong connection between the tidal amplitude and the velocity course. The tables indicate that in both datasets the maximum and average velocities increase from neap tide to spring tide.

Table 4-1: Maximal ebb phase velocity [m/s] for each month and measurement station.

		Apr 2008	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2009	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2010	Feb	Mar	Total Period
Buoy 84 (-8.1 m TAW)	Neap tide	0.55	0.57	0.64	0.56	0.54	0.51	0.56	0.54	0.57	0.58	0.55	0.55	0.53	0.54	0.55	0.53	0.55	0.53	0.54	0.54	0.60	0.60	0.55	0.53	0.55
	Avg tide	0.64	0.63	0.62	0.64	0.62	0.61	0.65	0.62	0.62	0.60	0.62	0.60	0.62	0.60	0.59	0.61	0.63	0.61	0.59	0.59	0.66	0.65	0.60	0.60	0.62
	Spring tide	0.69	0.63	0.68	0.67	0.65	0.61	0.68	0.64	0.63	0.66	0.67	0.65	0.63	0.61	0.63	0.64	0.64	0.65	0.65	0.60	-	0.66	0.64	0.63	0.65
Buoy 84 (-5.6 m TAW)	Neap tide	0.64	0.65	0.77	0.66	0.65	0.62	0.65	0.66	0.65	0.69	0.67	0.63	0.62	-	0.59	0.57	0.57	0.63	0.62	0.63	0.67	0.69	0.63	0.61	0.64
	Avg tide	0.75	0.74	0.74	0.72	0.75	0.72	0.76	0.72	0.70	0.70	0.77	0.71	0.70	-	0.62	0.64	0.71	-	0.67	0.65	0.74	0.75	0.69	0.69	0.71
	Spring tide	0.84	0.82	0.86	0.78	0.79	0.77	0.78	0.77	0.76	0.77	0.82	0.79	0.74	-	0.70	0.71	0.74	-	0.74	0.68	-	0.75	0.76	0.73	0.77
Buoy 97 (-7.8 m TAW)	Neap tide	0.53	0.58	0.57	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.55
	Avg tide	0.62	0.62	0.59	0.59	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.60
	Spring tide	0.65	0.63	0.67	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.65
Buoy 97 (-5.3 m TAW)	Neap tide	0.66	0.72	0.71	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.69
	Avg tide	0.75	0.81	0.74	0.77	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.77
	Spring tide	0.81	0.87	0.86	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.84
Oosterweel (- 5.8 m TAW)	Neap tide	0.61	0.62	0.66	0.64	0.62	0.65	0.62	0.69	0.63	0.69	0.64	0.68	0.71	0.71	0.75	0.70	0.68	0.73	-	-	-	-	-	-	0.66
	Avg tide	0.66	0.67	0.66	0.67	0.70	0.70	0.72	0.74	0.69	0.72	0.69	0.73	0.75	0.75	0.77	0.72	0.78	0.75	-	-	-	-	-	-	0.71
	Spring tide	0.70	0.70	0.69	0.69	0.71	0.73	0.76	0.79	0.69	0.75	0.72	0.76	0.77	0.78	0.78	0.77	0.82	-	-	-	-	-	-	-	0.74
Oosterweel (- 2.3 m TAW)	Neap tide	0.82	0.87	0.87	0.89	0.84	0.85	0.88	0.90	0.89	0.95	0.83	0.87	0.88	0.89	0.95	0.91	-	-	-	-	-	-	-	-	0.88
	Avg tide	0.89	0.93	0.89	0.92	0.93	0.98	0.99	0.99	0.96	0.98	0.90	0.95	0.94	0.96	0.96	0.92	-	-	-	-	-	-	-	-	0.94
	Spring tide	0.92	0.95	0.96	0.96	0.95	1.00	1.05	1.06	0.95	1.02	0.95	0.97	0.96	0.98	1.00	0.91	-	-	-	-	-	-	-	-	0.97

*Prosperpolder and Liefkenshoek have no velocity data available.

Table 4-2: Maximal flood phase velocity [m/s] for each month and measurement station.

		Apr 2008	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2009	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2010	Feb	Mar	Total period
Buoy 84 (-8.1 m TAW)	Neap tide	0.76	0.79	0.75	0.74	0.72	0.72	0.75	0.74	0.78	0.74	0.71	0.74	0.70	0.75	0.79	0.77	0.72	0.69	0.70	0.75	0.85	0.86	0.79	0.68	0.74
	Avg tide	0.94	0.92	0.85	0.86	0.87	0.87	0.98	0.94	0.95	0.95	0.94	0.97	0.98	0.82	0.93	0.91	0.91	0.91	0.91	0.97	0.94	0.99	1.04	0.95	0.92
	Spring tide	1.08	1.08	0.92	0.91	0.95	0.89	1.01	1.09	1.16	1.13	1.10	1.13	1.15	0.81	1.10	1.09	1.08	1.12	1.06	1.14	-	1.13	1.07	1.09	1.05
Buoy 84 (-5.6 m TAW)	Neap tide	0.85	0.87	0.83	0.79	0.81	0.79	0.81	0.79	0.86	0.84	0.81	0.82	0.79	-	0.82	0.80	0.77	0.78	0.76	0.83	0.87	0.92	0.84	0.75	0.82
	Avg tide	1.06	1.00	1.01	1.00	0.95	0.97	1.07	1.04	1.07	1.08	1.06	1.07	1.05	-	0.95	0.94	0.93	-	0.93	1.02	1.03	1.10	1.12	1.02	1.02
	Spring tide	1.26	1.26	1.15	1.09	1.14	1.13	1.18	1.20	1.38	1.33	1.32	1.24	1.25	-	1.15	1.12	1.25	-	1.17	1.17	-	1.28	1.20	1.18	1.21
Buoy 97 (-7.8 m TAW)	Neap tide	0.72	0.85	0.83	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.78
	Avg tide	0.90	0.95	0.93	0.96	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.93
	Spring tide	1.07	1.15	1.12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.10
Buoy 97 (-5.3 m TAW)	Neap tide	0.90	0.95	0.95	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.93
	Avg tide	1.15	1.10	1.09	1.15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.11
	Spring tide	1.37	1.37	1.24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.33
Oosterweel (- 5.8 m TAW)	Neap tide	0.69	0.74	0.73	0.66	0.65	0.64	0.65	0.73	0.76	0.71	0.71	0.71	0.68	0.78	0.74	0.74	0.68	0.78	-	-	-	-	-	-	0.71
	Avg tide	0.87	0.86	0.84	0.85	0.87	0.85	0.90	0.91	0.85	0.85	0.90	0.93	0.91	0.87	0.85	0.88	0.89	0.91	-	-	-	-	-	-	0.87
	Spring tide	1.06	1.06	0.96	0.96	1.01	0.99	0.99	1.09	1.04	1.05	1.13	1.06	1.04	1.02	0.98	1.02	1.01	-	-	-	-	-	-	-	1.03
Oosterweel (- 2.3 m TAW)	Neap tide	0.78	0.86	0.84	0.79	0.78	0.75	0.78	0.81	0.86	0.83	0.84	0.79	0.74	0.84	0.80	0.87	-	-	-	-	-	-	-	-	0.81
	Avg tide	0.99	0.96	0.93	0.96	0.99	0.97	1.00	1.00	0.98	1.03	1.05	1.06	0.96	0.95	0.92	1.00	-	-	-	-	-	-	-	-	0.98
	Spring tide	1.24	1.22	1.05	1.07	1.16	1.10	1.12	1.21	1.24	1.22	1.29	1.21	1.10	1.10	1.07	1.02	-	-	-	-	-	-	-	-	1.16

*Prosperpolder and Liefkenshoek have no velocity data available.

Table 4-3: Averaged ebb phase velocity [m/s] for each month and measurement station.

		Apr 2008	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2009	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2010	Feb	Mar	Total Period
Buoy 84 (-8.1 m TAW)	Neap tide	0.29	0.33	0.35	0.31	0.29	0.26	0.29	0.29	0.29	0.29	0.31	0.29	0.29	0.29	0.31	0.29	0.30	0.29	0.29	0.27	0.32	0.34	0.32	0.30	0.30
	Avg tide	0.33	0.36	0.36	0.35	0.33	0.29	0.33	0.32	0.31	0.31	0.33	0.32	0.32	0.34	0.32	0.33	0.34	0.34	0.32	0.30	0.35	0.39	0.35	0.35	0.33
	Spring tide	0.36	0.37	0.39	0.36	0.35	0.31	0.35	0.34	0.32	0.34	0.37	0.34	0.34	0.37	0.35	0.36	0.35	0.36	0.35	0.31	-	0.37	0.37	0.37	0.35
Buoy 84 (-5.6 m TAW)	Neap tide	0.37	0.39	0.46	0.37	0.37	0.35	0.39	0.38	0.38	0.37	0.41	0.36	0.37	-	0.36	0.35	0.34	0.38	0.36	0.34	0.39	0.43	0.40	0.37	0.38
	Avg tide	0.41	0.44	0.46	0.42	0.42	0.39	0.43	0.42	0.40	0.40	0.44	0.42	0.40	-	0.38	0.37	0.39	-	0.38	0.37	0.42	0.48	0.44	0.43	0.42
	Spring tide	0.48	0.48	0.50	0.45	0.45	0.43	0.46	0.44	0.43	0.44	0.49	0.45	0.44	-	0.42	0.41	0.44	-	0.44	0.39	-	0.47	0.48	0.46	0.45
Buoy 97 (-7.8 m TAW)	Neap tide	0.32	0.35	0.34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.33
	Avg tide	0.37	0.40	0.37	0.37	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.37
	Spring tide	0.40	0.43	0.42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.41
Buoy 97 (-5.3 m TAW)	Neap tide	0.42	0.47	0.45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.44
	Avg tide	0.48	0.53	0.48	0.49	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.50
	Spring tide	0.52	0.59	0.55	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.55
Oosterweel (- 5.8 m TAW)	Neap tide	0.43	0.42	0.47	0.45	0.42	0.45	0.40	0.47	0.43	0.45	0.43	0.46	0.48	0.48	0.52	0.47	0.46	0.49	-	-	-	-	-	-	0.45
	Avg tide	0.48	0.47	0.48	0.48	0.48	0.50	0.49	0.52	0.49	0.50	0.49	0.52	0.56	0.53	0.55	0.50	0.56	0.53	-	-	-	-	-	-	0.50
	Spring tide	0.53	0.51	0.50	0.51	0.51	0.53	0.53	0.56	0.51	0.53	0.52	0.56	0.58	0.56	0.59	0.55	0.60	-	-	-	-	-	-	-	0.54
Oosterweel (- 2.3 m TAW)	Neap tide	0.57	0.61	0.61	0.61	0.57	0.58	0.59	0.62	0.61	0.63	0.57	0.60	0.60	0.61	0.65	0.64	-	-	-	-	-	-	-	-	0.60
	Avg tide	0.63	0.66	0.65	0.67	0.67	0.70	0.70	0.69	0.70	0.68	0.65	0.69	0.70	0.67	0.70	0.66	-	-	-	-	-	-	-	-	0.68
	Spring tide	0.68	0.70	0.71	0.70	0.71	0.74	0.75	0.74	0.71	0.73	0.69	0.71	0.74	0.71	0.75	0.69	-	-	-	-	-	-	-	-	0.71

*Prosperpolder and Liefkenshoek have no velocity data available.

Table 4-4: Average flood phase velocity [m/s] for each month and measurement station.

		Apr 2008	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2009	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2010	Feb	Mar	Total Period
Buoy 84 (-8.1 m TAW)	Neap tide	0.48	0.50	0.50	0.47	0.45	0.45	0.45	0.47	0.49	0.47	0.46	0.47	0.44	0.47	0.49	0.48	0.46	0.43	0.45	0.47	0.53	0.54	0.49	0.45	0.47
	Avg tide	0.56	0.55	0.54	0.55	0.52	0.53	0.56	0.55	0.55	0.55	0.55	0.56	0.56	0.52	0.55	0.54	0.54	0.54	0.53	0.56	0.55	0.56	0.57	0.56	0.55
	Spring tide	0.61	0.62	0.57	0.57	0.57	0.55	0.58	0.60	0.61	0.58	0.59	0.59	0.61	0.53	0.60	0.61	0.59	0.59	0.59	0.60	-	0.57	0.51	0.60	0.59
Buoy 84 (-5.6 m TAW)	Neap tide	0.53	0.56	0.53	0.51	0.50	0.50	0.50	0.51	0.53	0.53	0.51	0.51	0.50	-	0.53	0.53	0.50	0.51	0.49	0.51	0.55	0.57	0.52	0.48	0.52
	Avg tide	0.64	0.62	0.62	0.62	0.59	0.59	0.61	0.61	0.62	0.63	0.63	0.62	0.61	-	0.58	0.57	0.57	-	0.56	0.60	0.61	0.63	0.62	0.60	0.61
	Spring tide	0.71	0.71	0.67	0.65	0.65	0.65	0.66	0.66	0.70	0.69	0.69	0.67	0.67	-	0.64	0.64	0.66	-	0.64	0.62	-	0.66	0.58	0.64	0.67
Buoy 97 (-7.8 m TAW)	Neap tide	0.46	0.56	0.54	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.51
	Avg tide	0.52	0.61	0.60	0.62	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.58
	Spring tide	0.59	0.68	0.65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.62
Buoy 97 (-5.3 m TAW)	Neap tide	0.59	0.65	0.65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.63
	Avg tide	0.70	0.72	0.70	0.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.71
	Spring tide	0.77	0.81	0.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.78
Oosterweel (- 5.8 m TAW)	Neap tide	0.47	0.48	0.49	0.45	0.43	0.44	0.44	0.47	0.51	0.46	0.47	0.48	0.47	0.50	0.51	0.49	0.47	0.52	-	-	-	-	-	-	0.47
	Avg tide	0.54	0.53	0.53	0.53	0.53	0.53	0.54	0.56	0.53	0.53	0.56	0.56	0.57	0.55	0.55	0.55	0.56	0.56	-	-	-	-	-	-	0.54
	Spring tide	0.59	0.59	0.56	0.56	0.57	0.56	0.56	0.62	0.59	0.59	0.61	0.60	0.61	0.59	0.59	0.59	0.60	-	-	-	-	-	-	-	0.59
Oosterweel (- 2.3 m TAW)	Neap tide	0.54	0.57	0.58	0.55	0.53	0.52	0.54	0.55	0.59	0.56	0.57	0.55	0.53	0.56	0.57	0.58	-	-	-	-	-	-	-	-	0.56
	Avg tide	0.62	0.61	0.61	0.62	0.63	0.62	0.64	0.64	0.63	0.65	0.66	0.66	0.62	0.61	0.60	0.62	-	-	-	-	-	-	-	-	0.62
	Spring tide	0.69	0.69	0.64	0.65	0.67	0.66	0.66	0.70	0.70	0.70	0.71	0.69	0.67	0.65	0.65	0.62	-	-	-	-	-	-	-	-	0.68

*Prosperpolder and Liefkenshoek have no velocity data available.

Table 4-5: Averaged ebb phase direction [deg] for each month and measurement station.

		Apr 2008	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2009	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2010	Feb	Mar	Total Period
Buoy 84 (-8.1 m TAW)	Neap tide	**354**	**353**	**357**	**357**	**353**	**350**	**351**	**356**	**353**	**355**	**351**	**352**	**353**	**354**	**358**	**352**	**356**	**352**	**351**	**350**	**355**	**1**	**355**	**354**	**353**
	Avg tide	357	356	358	358	357	354	358	3	360	1	358	356	358	359	358	354	359	359	356	358	359	3	360	357	358
	Spring tide	359	360	357	1	357	353	355	3	353	2	358	356	355	1	357	357	0	359	359	357	-	2	0	355	358
Buoy 84 (-5.6 m TAW)	Neap tide	355	351	350	348	355	357	358	2	358	359	349	1	1	-	2	359	3	1	354	1	5	7	2	360	358
	Avg tide	354	357	352	353	353	358	360	2	1	1	353	0	1	-	1	359	359	-	352	3	2	7	2	359	358
	Spring tide	356	359	353	353	354	359	359	360	1	358	354	1	2	-	3	1	1	-	357	1	-	8	5	2	358
Buoy 97 (-7.8 m TAW)	Neap tide	296	298	303	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	298
	Avg tide	295	296	300	299	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	298
	Spring tide	296	292	299	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	296
Buoy 97 (-5.3 m TAW)	Neap tide	285	287	288	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	286
	Avg tide	285	287	287	287	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	287
	Spring tide	287	285	287	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	286
Oosterweel (- 5.8 m TAW)	Neap tide	272	275	274	270	271	271	275	272	272	269	268	271	272	272	272	273	274	272	-	-	-	-	-	-	272
	Avg tide	270	273	272	272	271	272	272	272	271	269	268	269	272	272	272	272	273	272	-	-	-	-	-	-	272
	Spring tide	269	273	274	272	271	272	273	271	272	269	269	269	272	271	272	272	273	-	-	-	-	-	-	-	271
Oosterweel (- 2.3 m TAW)	Neap tide	263	262	260	263	261	264	263	262	264	264	261	262	264	260	266	264	-	-	-	-	-	-	-	-	263
	Avg tide	262	262	260	261	261	263	263	262	264	262	260	262	263	262	262	264	-	-	-	-	-	-	-	-	262
	Spring tide	262	264	259	261	260	262	261	261	264	262	261	261	264	261	264	264	-	-	-	-	-	-	-	-	262

*Prosperpolder and Liefkenshoek have no velocity data available.

Table 4-6: Average flood phase direction [deg] for each month and measurement station.

		Apr 2008	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2009	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2010	Feb	Mar	Total Period
Buoy 84 (-8.1 m TAW)	Neap tide	**188**	**188**	**186**	**187**	**190**	**187**	**187**	**184**	**186**	**184**	**188**	**191**	**187**	**190**	**184**	**186**	**189**	**188**	**187**	**190**	**186**	**186**	**190**	**192**	**188**
	Avg tide	181	183	184	183	187	182	181	180	181	180	181	183	179	185	182	183	186	183	185	182	179	182	182	184	182
	Spring tide	178	180	176	178	185	179	177	178	178	178	179	180	178	179	180	181	182	179	180	180	-	180	179	183	180
Buoy 84 (-5.6 m TAW)	Neap tide	184	184	188	184	181	181	179	181	185	184	185	189	187	-	186	187	188	187	184	190	191	187	187	189	185
	Avg tide	181	178	183	179	175	179	175	180	180	180	179	184	183	-	184	186	187	-	180	183	181	183	181	186	181
	Spring tide	177	172	182	178	173	177	174	177	178	178	178	183	181	-	183	183	182	-	175	181		181	182	184	178
Buoy 97 (-7.8 m TAW)	Neap tide	93	104	111	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100
	Avg tide	93	106	115	116	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	108
	Spring tide	106	87	108	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	103
Buoy 97 (-5.3 m TAW)	Neap tide	118	116	115	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	116
	Avg tide	117	116	116	116	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	117
	Spring tide	115	118	115	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	116
Oosterweel (- 5.8 m TAW)	Neap tide	97	95	95	95	95	96	94	101	96	95	96	97	100	94	100	96	95	95	-	-	-	-	-	-	96
	Avg tide	98	95	97	96	94	97	96	99	95	95	97	96	99	95	98	97	95	97	-	-	-	-	-	-	96
	Spring tide	99	93	97	95	94	95	95	99	94	96	97	96	99	95	99	98	96	-	-	-	-	-	-	-	96
Oosterweel (- 2.3 m TAW)	Neap tide	93	96	95	96	96	98	97	95	94	96	98	97	97	97	95	94	-	-	-	-	-	-	-	-	96
	Avg tide	95	95	97	97	96	97	96	96	95	96	98	97	97	95	96	92	-	-	-	-	-	-	-	-	96
	Spring tide	93	93	99	96	96	97	97	96	92	97	98	97	96	94	95	90	-	-	-	-	-	-	-	-	96

*Prosperpolder and Liefkenshoek have no velocity data available.

4.2 TIDAL AVERAGE VELOCITY CURVES

The tidal-average velocity curve has been calculated for each measurement location. The tidal-average velocity course is presented in those curves depending upon the time related to HW, and for an average neap tide, an average tide and an average spring tide, see Annex-Figure C-19 to Annex-Figure C-24. These figures clearly show the asymmetric character of the velocities (see §3.3.1.4). Besides the asymmetry, which is the result of the convergence and friction effects in the estuary, the velocity curves in the measurement locations are influenced by local effects. All locations are situated at the edge or outside the navigation channel (ebb channel), and hence the local geometry and bathymetry dominate the velocity curve especially during the flood (whirlpool formation, embankments, vertical constructions).

The tidal-average curves allow the average values and the time of maximum flow velocity during ebb and flood for an average neap tide, an average tide and an average spring tide to be determined (Table 4-7). The maximum flow velocity during ebb and flood is larger during a spring tide than during a neap tide and in addition to this the increase in maximum flow velocity is larger during flood than during ebb. Maximum flood velocity during a spring tide in the measurement locations is 36.67% larger than during a neap tide, while the maximum ebb velocity is only 9.5% larger during a spring tide than during a neap tide.

These results can be compared to the data from April 2008 – March 2010 (IMDC 2013b). For this series, the results obtained show a similar trend since; the maximum flow velocity (for ebb and flood) is larger during a spring than during a neap tide and the maximum velocities are also larger during flood. Moreover, the comparison between maximum velocities during spring and a neap tide show the following values: 35.5% (Flood) and 9.67% (Ebb). It can be concluded therefore that the behavior for both periods are similar.

Maximum velocity data taken at all measurement locations is always observed during flood. This maximum in the flood flow is always observed approximately 1 hour before HW. During a neap tide the maximum flood flow is generally observed earlier (about 1h20 before HW) than during spring tide (about 0h45-0h50 before HW). At ebb, the course is more regular (less distinct peaks). In the locations furthest downstream (Buoys 84&97) the maximum at ebb is generally observed at 2h40 after HW, independently of the tidal strength. Further upstream in Oosterweel the maximum ebb values are spread from 3h40 to 4h00 after HW.

Table 4-7: Average tidal curve for the flow velocity. Value [m/s] and time to HW [h:min] of the maximum velocity for the flood and the ebb phase for an averaged neap, average and spring tide, April 2008 – March 2010.

Location	Instrument depth	Tidal phase	Velocity		Time to HW	
			Flood	Ebb	Flood	Ebb
Buoy 84	-5.6 m TAW	Neap	0.75	0.61	-1:20	02:40
		Average	0.98	0.66	-0:50	02:30
		Spring	1.18	0.72	-0:50	02:40
Buoy 84	-8.1 m TAW	Neap	0.68	0.51	-1:20	02:40
		Average	0.89	0.57	-0:50	02:40
		Spring	1.01	0.60	-0:50	02:40
Buoy 97	-5.3 m TAW	Neap	0.89	0.67	-1:10	02:30
		Average	1.08	0.74	-1:00	02:40
		Spring	1.29	0.81	-0:40	02:30
Buoy 97	-7.8 m TAW	Neap	0.73	0.54	-1:30	02:30
		Average	0.90	0.57	-1:00	02:40
		Spring	1.07	0.62	-0:50	02:30
Oosterweel	-5.8 m TAW	Neap	0.67	0.62	-1:20	03:50
		Average	0.84	0.67	-0:50	04:00
		Spring	1.01	0.69	-0:40	04:10
Oosterweel	-2.3 m TAW	Neap	0.78	0.84	-1:10	03:50
		Average	0.95	0.90	-0:50	04:00
		Spring	1.14	0.92	-0:40	04:10

Slack water means to say the moment when the ebb flow changes into flood flow. In theory, this is the moment when the velocity equals zero. Due to the appearance of among others things, whirlpools, secondary flows, horizontal and vertical salinity gradients, the flow velocity never equals zero, and hence the moment of slack water in the measurement data is taken as the moment of minimum velocity. The velocity data indicate that both low and high water slack generally appear earlier during neap tide than during spring tide, see Table 4-8.

The tidal averaged flow directions are shown in Annex-Figure C-25 to Annex-Figure C-30. Note: no standard deviations are plotted in this figure, as they are not adequately defined for directional data. These figures indicate that the flow gradually changes its direction at Buoy 84, between 1 and 2 hours after HW, where at the bottom sensor the direction turns through South and at the top sensor directly towards the ebb direction. After that, the flow direction moves to ebb for 4 hours. Similar behavior is observed at buoy 97 where at the bottom the flow turns over the opposite direction to ebb compared to the top sensor depth. At Oosterweel, the transition at high slack water is rather fast, whereas the low water slack tide shows a more gradual transition. Earlier through-tide measurements indicate that the low water slack commences at a different moment depending on the location of the measurement point in the cross section. The flow direction in the measurement points located in shallower regions changes earlier than in the measurement points located in the navigation channel. This phase shifting in low water slack over a cross section can take about 1 hour. High water slack is more synchronic along the width of the river. These differences in the slack time period are due to the fact that the ebb flow principally follows the main channel while the flood flow spreads more over the entirety of the sections and reaches its maximum in the regions close to the banks.

Other effects influencing the moment of slack are the vertical and horizontal salinity gradients. The Scheldt is known to be a well-mixed estuary, but even small vertical salinity gradients can have an important influence on the flow pattern (Winterwerp et al., 2006).

Table 4-8: Average tidal curve for the flow velocity. Time in relation to HW of the low (LSW) and high (HSW) slack water and according to the duration of the rise and fall of the tide for an averaged neap, average and spring tide (April 2008 – March 2010).

Location	Instrument depth	Tidal phase	*LSW 1*	*HSW*	*LSW 2*	*LSW 1 to HSW*	*HSW to LSW 2*	*Total*
Buoy 84	-8.1 m TAW	Neap	-6:10	00:50	06:30	07:00	05:40	12:40
		Average	-5:40	01:00	06:40	06:40	05:40	12:20
		Spring	-5:30	01:00	07:00	06:30	06:00	12:30
Buoy 84	-5.8 m TAW	Neap	-5:50	01:00	06:50	06:50	05:50	12:40
		Average	-5:30	01:00	06:50	06:30	05:50	12:20
		Spring	-5:20	01:00	07:00	06:20	06:00	12:20
Buoy 97	-7.5 m TAW	Neap	-5:40	01:00	07:00	06:40	06:00	12:40
		Average	-5:20	01:00	07:10	06:20	06:10	12:30
		Spring	-5:10	01:10	07:10	06:20	06:00	12:20
Buoy 97	-5.1 m TAW	Neap	-5:20	01:00	07:20	06:20	06:20	12:40
		Average	-5:00	01:10	07:20	06:10	06:10	12:20
		Spring	-5:00	01:10	07:30	06:10	06:20	12:30
Oosterweel	-5.8 m TAW	Neap	-5:20	00:50	07:10	06:10	06:20	12:30
		Average	-5:00	01:00	07:20	06:00	06:20	12:20
		Spring	-4:50	01:10	07:40	06:00	06:30	12:30
Oosterweel	-2.1 m TAW	Neap	-5:10	00:50	07:20	06:00	06:30	12:30
		Average	-5:00	01:00	07:20	06:00	06:20	12:20
		Spring	-4:40	01:10	07:40	05:50	06:30	12:20

4.3 CONCLUSION

In general, the velocity data recorded from April 2008 to March 2010 corresponds to the data measured from April 2007 to March 2008. This conclusion is established by Annex-Figure C-31 to Annex-Figure C-33 presenting the monthly average current velocity of the both reporting period. This was expected because tide and discharge exert significant influence on flow velocity, and both show similar characteristics in the measurement periods compared.

5. SALINITY

Salt concentration or salinity is used as a seawater indicator and is also analyzed in this sense. It is assumed that the interaction and exchange processes between salt and fresh water is one of the determining factors for the sediment transport. To start, this chapter presents the maximum, minimum and average values, paying attention to the identification of salt and fresh water and mixtures thereof. The salinity amplitude will then be analyzed, stressing the various regimes of interaction between tidal-related and discharge-related flow processes and the location of the salt penetration front. The tidal-average salinity curves and the analysis of these in terms of time and duration of slack follow. Finally, high salinity gradients, which might cause density currents, will be tracked.

5.1 MINIMUM, MAXIMUM AND AVERAGE VALUES

Table 5-1 to Table 5-3 indicate maximum, minimum and average monthly salinity for the various measurement locations during the period April 2008 – March 2010. Also see Annex-Figure D-1 to Annex-Figure D-10.

The average salinity during the measurement period is the highest at Prosperpolder (situated furthest downstream) and the lowest at Oosterweel top sensor (situated furthest upstream) and is gradually decreases in an upstream direction. Compared to the rest of the year, higher levels of salinity are found in all locations during July to November. The highest value (20.39) was measured in Prosperpolder in October 2009 and in Buoy 84 in October 2009. The lowest value was measured at Oosterweel (0.07) in March 2010.

The monthly averaged salinities for most of these instruments show that the salinities at the upper and lower instrument are very similar (they are slightly lower at the upper instrument), which means that stratification is not important and that the Scheldt estuary can be classified as well-mixed (Dyer, 1995). No attempt was made to compare the minimum and maximum monthly salinities of the upper and lower instruments, as these are very sensitive to missing data.

It can be observed that the average salinity response to wet and dry periods is quite different in the Lower Sea Scheldt. At all locations except for Oosterweel Top, the average salinity increases with the same rate during dry periods (Annex-Figure D-18). The salinity increase is due to dispersion of salt from downstream and shows a rate of about 1.5 psu per month for all of these stations.

In contrast, the response of fresh water discharge peaks (fall and winter) is much sharper. The response time near Deurganckdok was previously determined at about 7 days by IMDC (2010c).

Table 5-1: Monthly maximal salinity [psu] for each measurement station.

Location	Apr 2008	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2009	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2010	Feb	Mar	Total Period
Buoy 84 (-8.1 m TAW)	8.08	10.32	11.12	12.58	12.95	15.74	15.59	14.26	10.4	12.78	9.59	9.02	10.44	12.81	14.7	15.27	17.64	19.07	20.03	19.62	14.03	11.56	10.49	9.71	20.03
Buoy 84 (-5.6 m TAW)	8.40	10.57	11.54	10.67	-	-	-	-	-	-	-	-	9.41	-	-	-	13.89	13.34	16.52	16.81	12.12	9.95	9.05	8.41	16.81
Buoy 97 (-7.8 m TAW)	6.49	8.61	9.48	9.86	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9.86
Buoy 97 (-5.3 m TAW)	6.46	8.61	9.48	9.85	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9.85
Oosterweel (- 5.8 m TAW)	4.54	6.27	7.24	8.35	8.79	11.02	11.18	9.46	5.98	8.01	5.33	5.14	6.28	7.99	9.8	10.73	12.17	13.31	14.06	13.26	8.05	6.58	5.72	4.98	14.06
Oosterweel (- 2.3 m TAW)	4.58	6.31	7.24	8.32	8.78	11.06	11.24	9.39	5.98	8.02	5.26	5.08	6.31	8.00	9.83	10.16	-	13.05	14.12	12.34	8.02	6.58	5.72	4.97	14.12
Prosperpolder (- 1.5 m TAW)	9.81	11.41	12.42	13.98	13.81	15.8	16.89	15.85	11.94	14.23	12.19	10.86	11.91	13.46	14.89	16.45	17.78	18.62	20.39	19.32	15.06	12.22	11.19	10.30	20.39
Liefkenshoek	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12.08	13.26	14.45	15.27	15.17	9.4	7.57	7.04	6.11	15.27

Table 5-2: Monthly minimal salinity [psu] for each measurement station.

Location	Apr 2008	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2009	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2010	Feb	Mar	Total Period
Buoy 84 (-8.1 m TAW)	1.35	4.58	5.73	7.42	7.02	9.22	8.38	6.03	3.75	3.07	2.56	3.8	2.51	6.89	8.92	10.03	11.71	13.43	13.18	9.27	5.36	4.96	4.4	2.84	1.35
Buoy 84 (-5.6 m TAW)	1.39	4.60	5.71	7.35	-	-	-	-	-	-	-	-	3.35	-	-	-	9.94	10.7	11.24	7.97	4.29	4.08	3.64	2.23	1.39
Buoy 97 (-7.8 m TAW)	0.48	3.13	3.22	6.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.48
Buoy 97 (-5.3 m TAW)	0.65	2.83	3.09	5.79	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.65
Oosterweel (- 5.8 m TAW)	0.26	0.55	0.45	1.23	0.64	1.34	0.75	0.43	0.14	0.23	0.23	0.31	0.4	0.71	1.03	1.73	2.75	3.71	2.01	0.68	0.42	0.42	0.4	0.4	0.14
Oosterweel (- 2.3 m TAW)	0.26	0.51	0.41	1.21	0.64	1.28	0.75	0.43	0.00	0.03	0.25	0.31	0.17	0.72	1.03	1.64	-	5.05	1.88	0.59	0.37	0.36	0.37	0.07	0.00
Prosperpolder (- 1.5 m TAW)	2.02	5.52	6.28	7.94	7.66	9.00	9.95	6.85	5.47	4.09	3.32	4.59	4.55	7.50	9.30	10.55	10.73	11.29	13.71	10.12	6.27	5.88	5.02	3.67	2.02
Liefkenshoek	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10.55	8.6	10.01	8.85	5.76	2.67	2.31	2.71	3.49	2.31

Table 5-3: Monthly averaged salinity [psu] for each measurement station.

Location	Apr 2008	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2009	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2010	Feb	Mar	Total Period
Buoy 84 (- 8.1 m TAW)	4.69	7.77	8.32	9.99	9.94	11.76	11.95	10.76	7.28	8.33	5.39	6.46	6.79	9.48	11.35	12.59	14.47	15.88	16.63	15.82	9.92	8.24	7.34	6.02	9.84
Buoy 84 (- 5.6 m TAW)	4.84	7.94	8.35	9.05	-	-	-	-	-	-	-	-	5.97	-	-	-	11.86	12.03	14.04	13.52	8.54	6.98	6.18	5.13	8.23
Buoy 97 (- 7.8 m TAW)	3.60	6.25	6.82	8.08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.48
Buoy 97 (- 5.3 m TAW)	3.55	6.25	6.68	7.98	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.54
Oosterweel (- 5.8 m TAW)	1.58	3.23	3.07	4.81	4.48	5.84	5.16	3.99	2.20	2.82	1.48	2.15	2.41	4.02	5.15	6.68	7.96	8.97	8.40	7.04	3.21	2.60	2.18	1.92	4.21
Oosterweel (- 2.3 m TAW)	1.56	3.20	3.04	4.76	4.42	5.76	5.09	3.94	2.18	2.83	1.47	2.13	2.36	3.98	5.12	6.36	-	9.35	8.33	6.47	3.16	2.56	2.15	1.75	3.65
Prosperpolder (- 1.5 m TAW)	5.71	8.39	8.78	10.55	10.20	12.09	12.76	11.83	8.50	9.26	6.37	7.36	7.76	10.02	11.70	13.34	14.13	15.01	16.72	15.00	9.90	8.51	7.43	6.43	10.36
Liefkenshoek	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11.48	11.11	12.09	12.57	11.55	6.84	5.67	4.80	4.98	9.46

Table 5-4: Classification of the homoiohaline waters (Dahl, 1956).

Classification			*Salinity content in psu*
Fresh water			0.0-0.5
Brackish water	Oligohaline	Slightly brackish water	0.5-5.0
	Mesohaline	Moderately brackish water	5.0-18.0
	Polyhaline	Very brackish water	18.0-30.0
Salt water	Euhaline		30.0-35
	Metahaline		36-40

5.2 AVERAGE TIDAL CYCLES OF SALINITY

A tidal salinity curve was drawn up for each measurement location. The course of the tide with which the variation in salinity is expressed in relation to the time compared to high tide for reap tide, average tide and spring tide (Annex-Figure D-19 to Annex-Figure D-42). With these curves, the average time tags of maximum and minimum salinity may be determined in function of the tidal amplitude (Table 5-5). Because the data have been measured with a frequency of 10 minutes, there is an inaccuracy in the time tags calculated which amounts to 10 minutes at most. A graph is presented for each location displaying neap, mid and spring tides. In each of these graphs, five plots are shown: one plot showing the average tidal cycles for the four seasons together, and four plots showing average and 5+95 percentiles tidal cycles separately per season. Summer is defined as July-August-September, the consecutive seasons per three months starting from October.

Extreme values in salinity may also be used to calculate the times of slack water. The moment of low and high water slack will then be defined as respectively the moment of minimum and maximum salinity.

Table 5-5 Average tidal curve for the relative salinity. Time to HW of the moments of minimum (Min1 & Min2) and maximum (Max) salinity and duration of the rising, falling and for the tide for an averaged neap, average and spring tide, April 2008 – March 2010.

Location	Instrument depth	Tidal phase	*Min 1*	*Max*	*Min 2*	*Min 1 to Max*	*Max to Min 2*	*Total Duration*
Prosperpolder	-1.5 m TAW	Neap	-4:50	00:30	07:50	05:20	07:20	12:40
		Average	-4:40	00:30	07:40	05:10	07:10	12:20
		Spring	-4:30	00:30	08:00	05:00	07:30	12:30
Buoy 84	-8.1 m TAW	Neap	-4:30	00:20	08:00	04:50	07:40	12:30
		Average	-4:30	00:40	08:00	05:10	07:20	12:30
		Spring	-4:20	00:50	08:00	05:10	07:10	12:20
Buoy 84	-5.8 m TAW	Neap	-4:50	00:20	07:50	05:10	07:30	12:40
		Average	-4:30	00:40	07:50	05:10	07:10	12:20
		Spring	-4:30	00:40	08:00	05:10	07:20	12:30
Liefkenshoek	-1.5 m TAW	Neap	-4:50	01:20	07:50	06:10	06:30	12:40
		Average	-4:40	01:30	07:50	06:10	06:20	12:30
		Spring	-4:20	01:40	08:00	06:00	06:20	12:20
Buoy 97	-7.5 m TAW	Neap	-5:0	00:50	07:30	05:50	06:40	12:30
		Average	-4:50	01:00	07:30	05:50	06:30	12:20
		Spring	-4:50	01:20	07:40	06:10	06:20	12:30
Buoy 97	-5.1 m TAW	Neap	-5:0	00:50	07:30	05:50	06:40	12:30
		Average	-4:50	00:50	07:30	05:40	06:40	12:20

Location	Instrument depth	Tidal phase	*Min 1*	*Max*	*Min 2*	*Min 1 to Max*	*Max to Min 2*	*Total Duration*
		Spring	-5:0	01:00	07:30	06:00	06:30	12:30
Oosterweel	-5.7 m TAW	Neap	-5:30	00:40	07:10	06:10	06:30	12:40
		Average	-5:00	00:50	07:20	05:50	06:30	12:20
		Spring	-4:40	01:00	07:50	05:40	06:50	12:30
Oosterweel	-2.3 m TAW	Neap	-5:20	00:40	07:10	06:00	06:30	12:30
		Average	-4:50	00:50	07:30	05:40	06:40	12:20
		Spring	-4:40	01:10	07:40	05:50	06:30	12:20

In general, we note that both the moments of minimum and maximum salinity appear earlier during neap tide than during spring tide. That is why a “flood” takes longer and an “ebb” less long at neap tide than at spring tide.

The time tags of minimum and maximum salinity, used to determine moments of slack water and mentioned in Table 5-5, can only be applied locally. The measurement locations are only situated at one point, vertically and close to the river bank. The effects of vertical stratification (the vertical salinity gradient is the largest around slack water), of horizontal stratification (over the cross section), of two-layered flows (especially around LW-slack) and of local flow phenomena (whirlpool formation, access channels, secondary flows, etc.) can have a strong influence on the moment of slack water.

5.3 SALINITY AMPLITUDE

Annex-Table D-1 and Annex-Table D-2 display the average difference between minimum & maximum salinity per tide (salinity amplitude) and per measurement location for an average neap tide, an average tide and an average spring tide over various periods, see also Annex-Figure D-11 to Annex-Figure D-18. It is important to know the salinity amplitude and its variations because these are the main reason density flows arise. Density flows cause an increased water exchange between the access channels or the Deurganckdok and the river. Hence, they can be responsible for an important part of the important sediment transports.

The various figures and tables (especially Annex-Table D-1, Annex-Figure D-8) show that the salinity amplitude is determined by the relative strength of the two flow mechanisms mentioned above: on the one hand, tide-related flow mechanism of which the strength is influenced by the neap tide/spring tide cycles and by storms, and for which the tidal amplitude can constitute a good indicator of the strength, and on the other hand, discharge-related flow mechanisms of which the strength is influenced by precipitation, and for which the absolute salinity constitutes a good indicator of the strength. It goes without saying that the distance to the estuary mouth also plays an important role in the interaction between both mechanisms.

In a normal situation (that is to say without extreme precipitation), the tidal amplitude seems to have a dominant effect on the salinity amplitude in the measurement locations downstream, while the salinity of the discharge water has an important effect on the salinity amplitude in the measurement locations upstream. When extreme precipitation occurs, the salinity drops quickly and takes a long time to recover and return to the normal salinity level (Annex-Figure D-1 to Annex-Figure D-8).

When discharge increases, the fresh water head pushes the salinity front downstream. At one point the salinity minimum at low tide will reach the fresh water threshold more easily in periods with high precipitation. When a certain “critical” discharge history is exceeded the salinity front is pushed so far downstream that it causes the tidal salinity amplitude at that location to drop near to zero. At the other end at the mouth, the fresh water is fully diffused in the seawater, so that no front is observed and both the minimum & maximum salt concentrations during a tide are close to the seawater threshold.

Hence, the variations in discharge cause the longitudinal salt profile to undergo constant change. The variations due to the discharge are not symmetric. For a high discharge, the salinity will very suddenly decrease, while a decreasing discharge will cause the salinity to slowly increase. The salinity front will slowly but continuously propagate due to diffusion and vertical flow velocity gradients (dispersion), as a result of which high salinity values may also be measured in the upstream locations, until the discharge is sufficiently high to push the salinity front downstream (backflow).

The effect of the absolute salinity value (as an indicator of the relative strength of the upper discharge) on the salinity amplitude may also be observed in the measurement locations upstream (i.e. Oosterweel) where the salinity strongly decreases just after the discharge peaks.

The tidal effects work on a shorter time scale (one or several tides, neap spring variation) compared to the effect of a high discharge (wet & dry periods, seasons) but can be felt with decreasing force from downstream to upstream at all locations.

Due to the interaction between these two kinds of mechanisms, and on the basis of the salinity amplitude, several regimes were distinguished, each one with a different grade of correlation between tidal and salinity amplitude. The correlation can be illustrated by studying the magnitude of the cross-correlation coefficient of tidal and salinity amplitude (Annex-Figure D-11 to Annex-Figure D-16). In these correlation plots, it is indeed possible to observe that there is limited variation in the position of the fitted line for Buoy 84, Buoy 97 and Liefkenshoek. For Oosterweel, the effect of another factor on salinity amplitude, namely the upstream discharge, is clearly visible.

- Saline regime: This is the regime that dominates in the location furthest downstream in normal situations where the effect of diffusion – backflow is hardly felt. There is insufficient fresh water to form a contrast with the salt water. Both the minimum & maximum values in salinity are high, which results in the salinity amplitude remaining moderate and fairly constant.
- Greatly brackish regime: For this regime, the two types of mechanisms are in balance. The contrast between minimum & maximum salinity values depends both on tidal amplitude and on discharge, which also determines the average value. When compared to the other two regimes the salinity amplitude is largest.

- Slightly brackish regime: This regime occurs when discharge is strong enough and the location upstream is enough to keep the salt penetration front downstream of the measurement location during the lower part of the tide. In this sense, the effects of diffusion and back-flow become more important than the tidal effects. The maximum salinity values will decrease compared with the above described regime, while the minimum values equal the fresh water threshold, as a result of which the values of the salinity amplitude and the connection with the tidal force will decrease.
- Fresh water regime: This regime occurs when the discharge is so large in comparison with the tidal amplitude that the saline front will remain in the downstream location during the whole tide. The tidal effect will only be felt by the propagation of the water wave. The salinity will strive to reach a constant value with an amplitude nearing zero. This regime occurs at Oosterweel during winter when the fresh water discharge is abundant.

Although the denomination was inspired by the Dahl classification (1956), it has to be noted that the salinity values dominating per regime do not correspond with the values in Table 5-4.

At Buoy 84 and Prosperpolder, the saline regime dominates in summer conditions. In high discharge conditions, Buoy 84 and in some years even Prosperpolder can experience greatly brackish conditions. At buoy 84 (and Deurganckdok) slightly brackish conditions occur in years with high river runoff. At Buoy 97 and Liefkenshoek the greatly brackish regime dominates, although in periods of high discharge coupled with low amplitudes, a slightly brackish or even a fresh water regime can occur. In Oosterweel, both the greatly brackish and the slightly brackish regimes occur. For the period 2008-2010 considered in this report, these findings for Buoy 97 and Liefkenshoek cannot be fully confirmed due to the lack of data.

For a greatly brackish regime, the salinity amplitudes reach their highest values.

In more upstream locations and/or for higher flows compared to the tidal amplitude, the slightly brackish regime dominates. The salinity amplitude for this regime is smaller but due to the fact that the saline front is shifting to, and from along, the location during the tide, high longitudinal gradients in salinity and therefore high sediment concentrations may be expected.

5.4 LONGITUDINAL GRADIENTS

High longitudinal gradients of salinity may cause density flows and hence sediment transport. Longitudinal gradients will be assessed here by using an estimate formula:

$$\partial S / \partial x = \left(dS / dt \right) 1 / V = \frac{S_{i+1} - S_i}{t_{i+1} - t_i} \frac{1}{\overline{V_{i,i+1}}}$$

with S_i the salinity at time i, t_i the time i, $\overline{V_{i,i+1}}$ the average flow velocity between time tags i and i+1.

The data show that for the station Buoy 84 (Top and Bottom), the gradients are larger during ebb than during flood (Table 5-7 and Table 5-8). Whereas for Oosterweel the gradients are slightly larger during flood. This observation is not in line with earlier findings of IMDC (2008), which shows larger gradients during flood than during ebb for Buoy 84, and larger gradients during ebb for the Oosterweel measurement stations. On the other hand, no clear relation can be derived between the gradients and the tidal amplitude. In general, the largest gradients are in for the greatly brackish regime and the smallest for the fresh water regime. Intermediate values are obtained for a slightly brackish regime. The differences between ebb and flood salinity gradients might be caused by the difference in flow velocity between the left and right bank. The velocities measured at the measurement stations might therefore not be fully representative of the propagation velocity for the complete salt wedge.

The above formula is calculated for each measurement time (every 10 minutes). Per episode (tide, ebb, flood), the monthly average value has been calculated. Table 5-7 and Table 5-8 give the monthly average gradients for ebb and flood, as well as the dominating regimes. Table 5-6 displays the average values per trimester for the tidal averages.

Since the greatly brackish regime is also characterized by a high salinity, the regime goes hand in hand with the highest spatial variations in salinity of all, and hence represents the critical condition in terms of sediment transport caused by salt and fresh water exchanges and mixing processes.

Table 5-6: Quarterly average value of the tide-averaged horizontal salinity gradient [psu/km] and flow regime of each measurement station.

		Apr-Jun 2008	Jul-Sep 2008	Oct-Dec 2008	Jan-Mar 2009	Apr-Jun 2009	Jul-Sep 2009	Oct-Dec 2009	Jan-Mar 2010
Buoy 84 (-8.1 m TAW)	Neap tide	0.40	0.53	0.59	0.47	0.42	0.50	0.60	0.46
	Avg tide	0.44	0.50	0.58	0.48	0.44	0.53	0.64	0.48
	Spring tide	0.47	0.60	0.59	0.53	0.50	0.55	0.66	0.57
Buoy 84 (-5.6 m TAW)	Neap tide	0.38	-	-	-	0.34	0.35	0.48	0.38
	Avg tide	0.42	0.37	-	-	0.36	0.34	0.54	0.39
	Spring tide	0.44	-	-	-	0.43	0.40	0.53	0.46
-Buoy 97 (-7.8 m TAW)	Neap tide	0.43	-	-	-	-	-	-	-
	Avg tide	0.45	0.41	-	-	-	-	-	-
	Spring tide	0.44	-	-	-	-	-	-	-
Buoy 97 (-5.3 m TAW)	Neap tide	0.33	-	-	-	-	-	-	-
	Avg tide	0.34	0.35	-	-	-	-	-	-
	Spring tide	0.31	-	-	-	-	-	-	-
Oosterweel (- 5.8 m TAW)	Neap tide	0.32	0.57	0.52	0.30	0.45	0.66	-	-
	Avg tide	0.37	0.55	0.45	0.31	0.49	0.64	-	-

		Apr-Jun 2008	Jul-Sep 2008	Oct-Dec 2008	Jan-Mar 2009	Apr-Jun 2009	Jul-Sep 2009	Oct-Dec 2009	Jan-Mar 2010
	Spring tide	0.32	0.54	0.51	0.30	0.47	0.60	--	-
Oosterweel (- 2.3 m TAW)	Neap tide	0.27	0.44	0.42	0.26	0.37	0.52	-	-
	Avg tide	0.31	0.43	0.37	0.26	0.42	0.51	-	-
	Spring tide	0.27	0.43	0.42	0.25	0.41	0.49	-	-

5.5 LONG-TERM VARIATIONS

By using a monthly running-average filter (a low pass filter) the salinity data will be smoothed out and prolonged variations will be more visible. In the long-term, the average salinity in Annex-Figure D-43 to Annex-Figure D-46 show a seasonal cycle. During spring the salinity is at its lowest, due to a higher fresh water discharge and more runoff due to the increased saturation levels of soil at the end of winter. These seasonal variations can be seen in the data of all measurement stations taken into consideration: Prosperpolder, Buoy 84, Buoy 97, Liefkenshoek and Oosterweel, and in the data from both bottom and top sensors. As a result of a lower influence of the fresh water inflow the measurement stations located in more downstream positions register the highest salinity levels during the summer period (more than 15 psu). In the measurement stations situated in a more upstream location, the peak salinities are lower, at around 10 psu. Annex-Figure D-47 shows that the summer salinities recorded for 2006 and 2009 are high in comparison with the summer salinity of 2007 and 2008. This is possibly caused by a higher summer discharge during these years. The summer salinity of 2009 is extremely high compared to the previous years (Annex-Figure D-43 to Annex-Figure D-46).

Table 5-7: Monthly average value of the ebb phase averaged horizontal salinity gradient [psu/km] and flow regime for each measurement station.

		Apr 2008	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2009	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2010	Feb	Mar	Total period
Buoy 84 (-8.1 m TAW)	Neap tide	0.47	0.54	0.50	0.63	0.54	0.78	0.83	0.69	0.65	0.74	0.49	0.58	0.49	0.54	0.59	0.71	0.55	0.59	0.68	0.80	0.62	0.55	0.56	0.57	0.61
	Avg tide	0.44	0.54	0.54	0.54	0.66	0.75	0.75	0.76	0.68	0.64	0.52	0.53	0.49	0.53	0.54	0.66	0.58	0.58	0.80	0.79	0.74	0.59	0.55	0.53	0.61
	Spring tide	0.46	0.63	0.60	0.62	0.71	0.80	0.73	0.68	0.70	0.73	0.57	0.60	0.62	0.52	0.65	0.66	0.58	0.67	0.81	0.80	-	0.84	0.60	0.60	0.65
Buoy 84 (-5.6 m TAW)	Neap tide	0.43	0.45	0.47	-	-	-	-	-	-	-	-	-	0.39	-	-	-	0.38	0.38	0.58	0.60	0.59	0.41	0.49	0.47	0.47
	Avg tide	0.42	0.51	0.46	0.38	-	-	-	-	-	-	-	-	0.39	-	-	-	0.34	-	0.86	0.52	0.60	0.45	0.45	0.42	0.49
	Spring tide	0.46	0.55	0.56	-	-	-	-	-	-	-	-	-	0.48	-	-	-	0.38	-	0.62	0.59	-	0.51	0.61	0.50	0.50
Buoy 97 (-7.8 m TAW)	Neap tide	0.43	0.52	0.61	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.50
	Avg tide	0.46	0.46	0.54	0.44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.50
	Spring tide	0.52	0.41	0.59	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.52
Buoy 97 (-5.3 m TAW)	Neap tide	0.31	0.38	0.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.39
	Avg tide	0.32	0.37	0.47	0.43	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.40
	Spring tide	0.33	0.32	0.47	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.36
Oosterweel (- 5.8 m TAW)	Neap tide	0.24	0.39	0.43	0.53	0.53	0.60	0.73	0.61	0.35	0.42	0.22	0.30	0.38	0.45	0.49	0.66	0.61	0.61	-	-	-	-	-	-	0.46
	Avg tide	0.21	0.41	0.42	0.53	0.52	0.58	0.65	0.48	0.35	0.35	0.26	0.31	0.35	0.44	0.51	0.62	0.57	0.62	-	-	-	-	-	-	0.45
	Spring tide	0.20	0.35	0.46	0.51	0.53	0.54	0.63	0.51	0.30	0.39	0.28	0.27	0.34	0.46	0.53	0.57	0.56	-	-	-	-	-	-	-	0.44
Oosterweel (- 2.3 m TAW)	Neap tide	0.21	0.29	0.32	0.40	0.39	0.47	0.46	0.49	0.25	0.32	0.16	0.26	0.25	0.35	0.41	0.47	-	-	-	-	-	-	-	-	0.33
	Avg tide	0.17	0.30	0.31	0.38	0.40	0.41	0.46	0.37	0.27	0.28	0.19	0.23	0.25	0.35	0.41	0.46	-	-	-	-	-	-	-	-	0.33
	Spring tide	0.16	0.28	0.32	0.39	0.38	0.41	0.48	0.40	0.24	0.32	0.18	0.23	0.29	0.37	0.44	0.46	-	-	-	-	-	-	-	-	0.32

Table 5-8: Monthly average value of the flood phase averaged horizontal salinity gradient [psu/km] and flow regime for each measurement station.

		Apr 2008	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2009	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2010	Feb	Mar	Total period
Buoy 84 (-8.1 m TAW)	Neap tide	0.28	0.35	0.35	0.51	0.46	0.40	0.66	0.45	0.42	0.50	0.33	0.34	0.31	0.36	0.33	0.40	0.35	0.40	0.51	0.61	0.43	0.44	0.38	0.32	0.41
	Avg tide	0.30	0.37	0.39	0.36	0.44	0.43	0.50	0.51	0.39	0.44	0.35	0.38	0.39	0.39	0.35	0.46	0.38	0.43	0.63	0.49	0.49	0.42	0.41	0.39	0.42
	Spring tide	0.36	0.43	0.49	0.42	0.50	0.52	0.50	0.51	0.43	0.50	0.41	0.42	0.40	0.45	0.46	0.43	0.49	0.48	0.55	0.49	-	0.50	0.43	0.50	0.46
Buoy 84 (-5.6 m TAW)	Neap tide	0.31	0.31	0.38	-	-	-	-	-	-	-	-	-	0.29	-	-	-	0.32	0.30	0.40	0.41	0.34	0.36	0.30	0.27	0.33
	Avg tide	0.31	0.38	0.40	0.38	-	-	-	-	-	-	-	-	0.33	-	-	-	0.34	-	0.49	0.41	0.45	0.36	0.35	0.30	0.38
	Spring tide	0.33	0.41	0.41	-	-	-	-	-	-	-	-	-	0.39	-	-	-	0.42	-	0.51	0.41	-	0.39	0.33	0.42	0.40
Buoy 97 (-7.8 m TAW)	Neap tide	0.30	0.33	0.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.36
	Avg tide	0.41	0.31	0.44	0.37	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.40
	Spring tide	0.33	0.31	0.39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.34
Buoy 97 (-5.3 m TAW)	Neap tide	0.23	0.29	0.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.28
	Avg tide	0.21	0.27	0.34	0.28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.29
	Spring tide	0.22	0.24	0.30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.25
Oosterweel (- 5.8 m TAW)	Neap tide	0.25	0.40	0.41	0.57	0.56	0.66	0.63	0.60	0.33	0.46	0.21	0.31	0.32	0.46	0.52	0.71	0.71	0.62	-	-	-	-	-	-	0.47
	Avg tide	0.21	0.40	0.42	0.53	0.55	0.60	0.67	0.48	0.36	0.37	0.25	0.32	0.36	0.47	0.55	0.70	0.62	0.69	-	-	-	-	-	-	0.47
	Spring tide	0.21	0.37	0.44	0.53	0.53	0.60	0.66	0.50	0.31	0.38	0.24	0.31	0.38	0.48	0.57	0.63	0.62	-	-	-	-	-	-	-	0.46
Oosterweel (- 2.3 m TAW)	Neap tide	0.23	0.34	0.41	0.49	0.45	0.51	0.52	0.55	0.28	0.38	0.17	0.29	0.26	0.41	0.50	0.57	-	-	-	-	-	-	-	-	0.38
	Avg tide	0.18	0.36	0.38	0.45	0.49	0.51	0.55	0.45	0.33	0.31	0.20	0.26	0.32	0.42	0.52	0.55	-	-	-	-	-	-	-	-	0.40
	Spring tide	0.18	0.31	0.39	0.46	0.46	0.51	0.59	0.47	0.27	0.35	0.20	0.25	0.34	0.44	0.56	0.53	-	-	-	-	-	-	-	-	0.38

6. TEMPERATURE

The aim of this chapter is to determine whether the seasonal cycle has an influence on the sediment transport. Indeed, the quantities of available sediments might be influenced by temperature and light-related processes (biological activity, increase of flocculation, etc). The temperature course has been taken in this sense. First we will present the monthly minimum, maximum and average values. Then, we will study the evolution of the temperature amplitude. Finally, we will present the tidal-averaged temperature curves.

6.1 MINIMUM, MAXIMUM AND AVERAGE VALUES

Table 6-1 and Table 6-2 display the monthly minimum & maximum temperatures for the various measurement locations, see also Annex-Figure E-1a, Annex-Figure E-8a and Annex-Figure E-9. Table 6-3 shows the average monthly temperature. The Annex-Figure E-19 to Annex-Figure E-22 presents the monthly average curve compared with the previous reporting period.

The warmest water temperature recorded during the measurement period was registered in July 2009 (up to 24.22 °C at Buoy 84). The coldest water temperatures were measured in January 2009 (1.2 °C in Oosterweel). The maximum water temperature is slightly higher than recorded from April 2007 to March 2008 (IMDC, 2008t), when water temperatures up to 22.3 °C were measured. The lowest temperature measured from April 2007 to March 2008 was 3.6 °C. The winter temperatures of this reporting period were colder than the previous years and the summer temperatures were similar.

6.2 TEMPERATURE AMPLITUDE

Annex-Figure E-1b to Annex-Figure E-8b, and Annex-Figure E-10, display the average difference between minimum & maximum temperatures per tide (temperature amplitude) and per measurement location for an average neap tide, an average tide and an average spring tide, and for various periods, see also Annex-Figure E-1. The table shows that the temperature amplitude is somewhat influenced both by seasons (absolute water temperature) and by the tidal amplitude. Furthermore, the location of the measurement point is important.

The most important factor determining the size of the temperature amplitude is the seasonal variation at Buoy 84. Here, the larger temperature differences per tide occur during winter; during summer these differences are smaller. No seasonal variation in the temperature amplitude is present at the other locations. The influence of the tidal amplitude is of minor importance. In general, the temperature amplitude is larger in the upstream measurement locations; it is approximately 0.8 °C upstream and about 0.4 °C downstream. In the downstream location (Buoy 84) there is very little mixing of fresh with salt water, resulting in an almost constant temperature and a small temperature amplitude. However, at Prosperpolder, large temperature amplitudes exist, probably as a result of local effects. An analogous phenomena probably occurs at the upstream end, where there is too little salt water with which to create a temperature difference. The brackish regions, such as at Buoy 97 and Oosterweel, where there is an important interaction between the upstream and downstream processes, present larger differences than at Buoy 84.

Table 6-1: Monthly maximal temperature [°C] for each measurement station.

	Apr 2008	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2009	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2010	Feb	Mar	Total period
Buoy 84 (-8.1 m TAW)	13.12	18.46	20.36	22.52	22.6	20.38	17.1	12.91	8.48	5.15	6.43	9.53	15.12	18.37	21.97	23.09	23.12	21.47	18.9	14.32	10.27	4.4	5.46	10.25	23.12
Buoy 84 (-5.6 m TAW)	13.09	18.49	20.4	22.25	22.91	20.2	16.91	12.85	8.42	5.04	6.29	9.23	14.8	-	22.00	24.22	23	21.52	17.81	14.3	10.28	4.38	5.43	10.27	24.22
Buoy 97 (-7.8 m TAW)	13.15	18.5	20.6	20.79	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20.79
Buoy 97 (-5.3 m TAW)	13.16	18.47	20.67	20.76	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20.76
Oosterweel (- 5.8 m TAW)	13.91	18.87	20.12	22.02	22.31	20.12	16.97	12.65	8.15	5.04	6.17	9.33	15.51	18.39	21.89	23.19	22.99	21.43	18.87	14.17	10.18	4.22	6.24	10.87	23.19
Oosterweel (- 2.3 m TAW)	13.95	18.87	20.12	22.01	22.27	20.1	16.98	12.63	8.13	5.05	6.17	9.34	15.48	18.4	21.94	23.19	-	19.1	18.88	11.94	10.17	4.25	6.26	10.89	23.19
Prosperpolder (- 1.5 m TAW)	13.73	18.56	20.89	22.85	22.89	20.12	17.13	13.36	8.98	5.93	6.56	10.51	15.51	20.02	22.47	23.84	23.08	21.38	18.8	14.54	10.69	4.9	7.04	10.8	23.84
Liefkenshoek	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	21.5	23.32	21.79	19.09	14.57	10.65	4.84	5.14	10.48	23.32

Table 6-2: Monthly minimal temperature [°C] for each measurement station.

	Apr 2008	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2009	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2010	Feb	Mar	Total Period
Buoy 84 (-8.1 m TAW)	8.16	12.62	17.92	18.58	19.19	16.43	12.43	8.16	4.49	2.58	3.4	5.72	9.05	14.63	17.44	20.57	20.73	18.2	13.78	10.06	4.13	2.31	2.84	4.88	2.31
Buoy 84 (-5.6 m TAW)	8.1	12.61	17.89	18.75	19.19	16.91	12.4	8.13	4.46	2.56	3.38	5.66	9.05	-	17.46	20.53	20.76	20.53	13.79	10.06	4.1	2.35	2.87	4.87	2.35
Buoy 97 (-7.8 m TAW)	7.84	12.77	18.01	19.96	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.84
Buoy 97 (-5.3 m TAW)	7.82	12.79	18.02	19.94	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.82
Oosterweel (- 5.8 m TAW)	7.87	12.97	17.94	18.68	19.06	15.87	11.29	6.25	4.07	1.26	2.79	5.98	9.04	14.96	17.79	20.95	20.98	17.89	12.77	9.52	3.05	1.57	2.66	4.69	1.26
Oosterweel (- 2.3 m TAW)	7.87	12.98	17.91	18.7	19.07	15.88	11.28	6.22	4.05	1.2	2.77	5.97	9.05	14.97	17.79	21.21	-	17.98	12.92	9.53	3.06	1.57	2.63	4.22	1.2
Prosperpolder (- 1.5 m TAW)	8.47	12.48	17.74	18.4	18.97	16.16	12.15	7.96	6.72	2.19	3.09	5.43	8.83	14.46	17.23	20.35	20.54	17.9	13.55	9.93	4.23	2.09	2.55	4.65	2.09
Liefkenshoek	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	21.16	21	18.52	13.92	10.01	3.71	2.54	3.53	9.56	2.54

Table 6-3: Monthly averaged temperature [°C] for each measurement station.

	Apr 2008	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2009	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2010	Feb	Mar	Total period
Buoy 84 (-8.1 m TAW)	10.44	16.30	19.00	20.14	20.80	18.28	15.28	11.01	6.67	3.95	4.56	7.82	12.57	16.18	19.04	21.58	21.86	19.33	15.81	11.97	7.28	3.41	3.94	6.91	13.00
Buoy 84 (-5.6 m TAW)	10.41	16.30	19.05	20.15	20.80	18.41	15.25	10.98	6.63	3.92	4.53	7.53	12.48		19.05	21.64	22.07	21.07	15.30	11.98	7.28	3.40	3.94	6.91	12.21
Buoy 97 (-7.8 m TAW)	10.49	16.14	19.09	20.36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15.19
Buoy 97 (-5.3 m TAW)	10.49	16.42	19.10	20.34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15.43
Oosterweel (- 5.8 m TAW)	10.54	16.78	18.97	20.07	20.77	17.99	14.68	10.23	5.76	3.43	4.33	7.82	12.73	16.23	18.95	21.73	21.90	19.22	15.44	11.54	6.79	3.16	3.77	6.84	12.86
Oosterweel (- 2.3 m TAW)	10.55	16.79	18.97	20.06	20.76	18.21	14.68	10.21	5.75	3.41	4.33	7.83	12.73	16.24	18.95	22.11	-	18.60	15.61	10.93	6.78	3.15	3.76	6.84	11.97
Prosperpolder (- 1.5 m TAW)	10.39	16.26	18.93	20.06	20.69	18.20	15.30	10.94	7.72	3.81	4.50	7.74	12.55	16.14	18.94	21.47	21.74	19.19	15.68	11.88	7.20	3.33	4.03	6.90	13.38
Liefkenshoek	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	21.34	22.07	19.50	16.03	12.03	7.29	3.46	4.07	9.93	12.71

6.3 TIDAL AVERAGE TEMPERATURE CURVES

Hence, the tidal temperature difference is limited and will almost never be greater than 2°C. However, it is interesting to note the temperature course recorded during a tide at the different measurement locations. This tidal course of the temperature is represented in the tidal-averaged temperature curves, which were drawn up for each of the measurement locations.

The course of these tidal-averaged temperatures is measured on the basis of time in relation to high water and this for neap tide, average tide and spring tide, see Annex-Figure E-11 to Annex-Figure E-18 Analysis of the heat exchange between seawater and fresh water in the estuary is not as simple as de analysis of the salt exchange, for which seawater (high salinity) and fresh water (low salinity) are easily tracked. To be able to analyze the effects of the interaction on both water masses with their own seasonal variations of temperature and to explain the shape of the tidal temperature curves in each measurement location, one should first be able to determine the boundary conditions (temperature in the deep sea and far enough upstream) in order to separate the periods during which the sea is warmer – than de Upper Scheldt – from the periods when the sea is colder.

6.4 LONG-TERM VARIATIONS

Figures of the monthly average temperatures (Annex-Figure E-19 to Annex-Figure E-22) as well as multi-year variations of temperature (Annex-Figure E-23) at the different measurement stations can be found in the appendix.

7. SEDIMENT CONCENTRATION

The fine fraction of suspended material (sediment) is of great importance in an estuary. Due to the estuarine processes (tidal movement, salinity, residual flow, etc.) the concentration varies greatly with respect to time and place and affects the deposition, erosion and transport processes of the sediment. In this sense, the aim of the present study is to provide better insight into the processes and their influencing factors (flow velocity, salinity, temperature). This knowledge forms the basis when determining the strategies for dredging and relocation, both in the framework of productive and cost-effective working methods, and of developing sustainable relocation options.

The intended purpose of the measurements presented here is to quantify the variation of sediment in suspension on the basis of different time scales and with respect to space. Due to the high variability of the sediment concentration in the water column and especially near the bottom, it is often very difficult to distinguish the effects of local erosion and sedimentation from the general sediment transport, hence it is also very difficult to see the correlations between the measured concentrations in the different measurement locations. In the past, different calibration curves and instruments were used for the same measurement locations (IMDC, 2013).

To provide a decent and comparable set of figures and tables over all of the projects, the raw turbidity data used for this report was first re-calibrated for the different instruments using the calibration curves delivered by Flanders Hydraulics Research (see IMDC, 2012o), before conducting further processing. The sediment concentration values could therefore be different compared to the factual data reports (IMDC, 2008b; 2009d; 2011c.).

At Buoy 84 (top), the Aanderaa RCM-9 was replaced by Aanderaa SeaGuard in 2009, which has its own influence on the turbidity data. Since installing the SeaGuard the turbidity sensor’s maximum level of 500 FTU was reached on several occasions. Based on the calibration curves (IMDC, 2012o), the maximum sediment concentration that could be measured by Aanderaa SeaGuard at Buoy84 is about 828 mg/. While the Aanderaa RCM-9 measures sediment concentration values of up to 2300 mg/l. If the maximal sediment concentrations exceed this value the actual maximum will remain unknown and the calculated average sediment concentration will be shown at a lower level than it actually is. The phenomena could be noticed in Annex-Figure F-1a.

In the first part of this chapter, the different behavioral patterns of the sediment transport between the ebb and flood phases will be studied with regard to the maximum and average values for both phases. Attention will then be paid to the different time scales governing the variations in sediment concentration. Afterwards, the focus will be put on the general course of the concentration along the tide. In a third part, the variations along the neap/spring tide cycle, as well as the correlation between flow velocity and sediment concentration will be analyzed. Finally, a fourth part will provide an introduction to the analysis of the long-term variations of the suspended sediment concentration.

7.1 EBB AND FLOOD VARIATIONS

Previous long-term ADCP flow measurements (TV Sam, 2006a-c), 13-hour measurements, and the tidal velocity curves show that the flow patterns differ substantially between ebb and flood. This leads to asymmetric sediment transport, and the so-called tidal pumping effect.

The minimum, maximum and average sediment concentrations at ebb and flood have been shown in Annex-Figure F-1 to Annex-Figure F-14. Table 7-1 and Table 7-2 provide the monthly maximum recorded values of the sediment concentration at ebb and flood for the measurement locations and for an average neap tide, average tide and average spring tide.

Table 7-3 and Table 7-4 show the monthly average ebb and flood sediment concentrations for an average neap tide, average tide and average spring tide, each time mentioning the flow regimes as defined in Section 4. Annex-Figure F-1 and Annex-Figure F-3 provide the average sediment concentrations per ebb, per flood and per tide and this per trimester, per summer, per winter and per year and for an average neap tide, average tide and average spring tide.

The average sediment concentrations in Buoy 84 and 97 are higher during ebb than during flood, with the largest peak recorded by the lowest instruments and during flood. At Oosterweel, the average sediment concentration is slightly higher at flood, and it is during this period that the largest peaks occur, again for the lowest station. In contrast to what was found in IMDC 2008t, there is no clear correlation between the flow regime and the sediment concentrations. The tables and figures mainly indicate that the variations in sediment concentration are governed by phenomena working in accordance with different time scales:

- When a consolidated layer is suddenly brought back to suspension, peaks occur in the course of the maximum values. Although this increase is almost instantaneous, it is also the result of lengthy sedimentation and consolidation processes.
- Within one tide, and due to the nature of the velocity course itself, the variations in suspended sediment concentration are very high.
- Flow velocity is a determining factor for the bringing and keeping of sediment in suspension. In Section 3, a clear relation has been indicated between average flow velocity and tidal amplitude, as a result of this, variations in sediment concentration are expected along the neap tide/spring tide cycles.
- Variations on a more prolonged time scale may occur. The availability of the sediments may change through the seasonal cycles. In Section 4 we also noted that the interaction between tidal flow and discharge (and hence between precipitation, wet and dry seasons) and the relation between the force of these two mechanisms, leads to the shifting of zones with high spatial salinity gradients (greatly brackish) and zones with important mixing processes (saline front, slightly brackish), which are able to strongly influence the suspension.

These factors cannot be separated from each other, thus making it difficult to analyze them and to draw general conclusions. The high variability of the sediment concentration in the water column and especially near the bottom, and the turbulent variations in the flow, combined with the point character of the measurements as well as interventions in the sediment balance created by dredging and relocation, place many obstacles in the way of a general understanding. A typical problem is making a distinction between the effects of local erosion and sedimentation and the general sediment transport (advection) on the Scheldt. Nevertheless, this analysis will try to isolate the various phenomena and clarify them hereinafter.

Table 7-1: Maximal ebb phase suspended sediment concentration (mg/l) for an averaged neap, average and spring tide.

		Apr 2008	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2009	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2010	Feb	Mar	Total Period
Buoy 84 (-8.1 m TAW)	Neap tide	423	868	572	675	740	577	483	520	528	457	766	615	439	740	312	799	610	505	717	531	778	1007	658	684	619
	Avg tide	720	1027	601	717	1114	835	730	764	641	516	817	883	626	769	407	892	618	693	932	652	1124	1072	768	953	759
	Spring tide	814	1077	831	839	981	1076	864	768	1051	685	941	953	777	759	485	1158	588	857	1003	761	-	1075	962	949	872
Buoy 84 (-5.6 m TAW)	Neap tide	230	459	292	322	294	278	246	335	364	370	526	377	224	-	176	445	182	172	586	410	489	750	523	496	373
	Avg tide	341	529	334	377	492	443	406	531	429	412	642	648	374	-	184	636	345	-	768	500	730	751	649	655	478
	Spring tide	525	674	525	574	593	755	454	561	879	598	897	821	475	-	310	809	466	-	810	538	-	710	809	685	630
Buoy 97 (-7.8 m TAW)	Neap tide	444	653	814	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	501
	Avg tide	575	769	767	963	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	706
	Spring tide	746	779	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	754
Buoy 97 (-5.3 m TAW)	Neap tide	351	867	551	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	564
	Avg tide	491	989	610	645	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	730
	Spring tide	699	911	856	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	796
Oosterweel (- 5.8 m TAW)	Neap tide	343	535	275	421	340	237	444	365	361	232	599	389	181	394	146	451	286	315	-	-	-	-	-	-	362
	Avg tide	321	599	326	431	503	327	392	474	362	339	628	410	280	456	218	506	334	382	-	-	-	-	-	-	408
	Spring tide	319	531	397	516	472	358	408	485	500	465	663	435	323	486	244	603	307	-	-	-	-	-	-	-	446
Oosterweel (- 2.3 m TAW)	Neap tide	170	368	246	312	240	187	315	290	368	325	387	276	144	287	119	152	-	-	-	-	-	-	-	-	285
	Avg tide	288	413	248	318	351	258	297	384	298	322	511	333	236	343	170	338	-	-	-	-	-	-	-	-	316
	Spring tide	313	373	280	368	350	273	327	428	568	428	486	346	269	370	192	392	-	-	-	-	-	-	-	-	356

Table 7-2: Maximal flood phase suspended sediment concentration (mg/l) for an averaged neap, average and spring tide.

		Apr 2008	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2009	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2010	Feb	Mar	Total period
Buoy 84 (-8.1 m TAW)	Neap tide	337	703	558	571	481	421	316	417	430	421	575	499	292	444	254	459	357	383	462	347	585	943	458	394	459
	Avg tide	528	878	624	687	681	605	688	682	538	570	749	654	468	607	319	699	518	570	755	550	1009	1040	577	670	643
	Spring tide	735	906	909	900	743	886	737	573	779	711	961	765	557	669	386	808	527	838	858	576		863	624	856	751
Buoy 84 (-5.6 m TAW)	Neap tide	165	197	156	203	158	143	143	203	200	218	222	225	143		91	145	129	136	184	159	285	532	304	226	200
	Avg tide	254	250	197	257	226	233	254	279	251	255	318	369	237		109	246	195		308	231	470	620	389	377	266
	Spring tide	357	349	284	345	317	339	305	334	437	375	513	565	305		136	363	300		458	267		589	406	501	361
Buoy 97 (-7.8 m TAW)	Neap tide	401	643	648	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	452
	Avg tide	639	751	717	834	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	693
	Spring tide	689	893	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	739
Buoy 97 (-5.3 m TAW)	Neap tide	251	363	294	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	299
	Avg tide	353	476	374	403	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	410
	Spring tide	451	540	497	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	487
Oosterweel (- 5.8 m TAW)	Neap tide	302	488	300	375	359	279	418	409	334	224	416	330	166	414	184	512	268	316	-	-	-	-	-	-	343
	Avg tide	215	477	315	425	505	361	458	506	346	355	472	360	262	450	281	567	372	384	-	-	-	-	-	-	399
	Spring tide	223	422	390	478	510	391	439	534	481	428	515	373	298	494	232	702	320	-	-	-	-	-	-	-	429
Oosterweel (- 2.3 m TAW)	Neap tide	196	447	292	367	320	250	390	358	309	367	409	301	152	377	166	219	-	-	-	-	-	-	-	-	323
	Avg tide	294	430	278	382	449	319	389	462	335	339	419	315	231	412	255	441	-	-	-	-	-	-	-	-	361
	Spring tide	250	390	342	428	459	332	406	506	455	464	464	345	277	445	225	530	-	-	-	-	-	-	-	-	390

Table 7-3: Average ebb phase suspended sediment concentration (mg/l) for an averaged neap, average and spring tide.

		Apr 2008	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2009	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2010	Feb	Mar	Total Period
Buoy 84 (-8.1 m TAW)	Neap tide	183	381	248	271	283	216	187	243	257	235	390	271	221	277	151	297	250	210	335	243	388	653	362	327	278
	Avg tide	294	464	278	310	490	353	339	433	327	322	502	479	318	320	168	395	304	325	464	338	680	720	479	572	380
	Spring tide	386	566	427	434	497	492	378	457	603	480	646	561	389	346	232	571	313	471	604	398	-	753	598	636	470
Buoy 84 (-5.6 m TAW)	Neap tide	114	167	143	130	120	121	117	179	189	197	253	155	118	-	78	140	77	78	245	179	253	466	256	217	176
	Avg tide	162	201	144	156	196	194	200	295	226	241	334	301	171	-	89	215	125	-	366	242	434	504	353	345	231
	Spring tide	238	275	238	237	239	307	221	322	437	372	476	443	212	-	132	337	194	-	487	271	-	524	461	424	304
Buoy 97 (-7.8 m TAW)	Neap tide	244	405	425	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	278
	Avg tide	348	529	404	535	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	397
	Spring tide	412	568	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	450
Buoy 97 (-5.3 m TAW)	Neap tide	203	403	293	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	292
	Avg tide	281	463	295	320	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	356
	Spring tide	338	472	434	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	399
Oosterweel (- 5.8 m TAW)	Neap tide	115	278	158	225	194	155	259	247	235	152	316	201	91	190	91	262	160	172	-	-	-	-	-	-	202
	Avg tide	150	303	171	233	297	205	273	315	233	207	358	241	140	243	127	304	202	214	-	-	-	-	-	-	234
	Spring tide	165	285	209	282	280	228	266	334	349	307	404	260	161	267	122	338	171	-	-	-	-	-	-	-	262
Oosterweel (- 2.3 m TAW)	Neap tide	80	205	124	179	148	128	203	201	207	197	247	152	74	148	70	91	-	-	-	-	-	-	-	-	169
	Avg tide	116	232	135	186	221	170	213	266	199	220	302	195	114	196	103	221	-	-	-	-	-	-	-	-	191
	Spring tide	133	220	170	223	229	184	226	291	338	288	330	224	139	210	101	277	-	-	-	-	-	-	-	-	220

Table 7-4: Average flood phase suspended sediment concentration (mg/l) for an averaged neap, average and spring tide.

		Apr 2008	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2009	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2010	Feb	Mar	Total Period
Buoy 84 (-8.1 m TAW)	Neap tide	132	197	166	161	151	132	107	154	165	176	217	191	134	140	81	135	106	110	169	145	240	447	265	201	167
	Avg tide	233	264	213	238	259	238	247	268	222	244	345	324	223	218	119	219	183	209	266	215	393	557	343	357	252
	Spring tide	304	343	359	351	315	339	272	315	388	361	504	400	276	252	150	307	212	321	356	239	-	538	352	455	326
Buoy 84 (-5.6 m TAW)	Neap tide	93	112	87	92	78	77	79	115	125	137	146	111	86	-	48	66	55	50	97	94	143	304	180	124	112
	Avg tide	141	139	108	145	128	131	162	191	165	171	221	202	138	-	67	110	89	-	154	137	251	405	253	226	158
	Spring tide	197	197	166	196	173	196	174	234	283	268	338	296	172	-	83	183	128	-	244	150	-	412	238	324	211
Buoy 97 (-7.8 m TAW)	Neap tide	204	270	279	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	219
	Avg tide	328	350	318	392	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	327
	Spring tide	388	432	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	399
Buoy 97 (-5.3 m TAW)	Neap tide	129	186	148	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	152
	Avg tide	176	235	164	196	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	195
	Spring tide	230	267	248	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	244
Oosterweel (- 5.8 m TAW)	Neap tide	114	318	176	258	238	189	273	269	213	147	257	197	93	234	117	323	186	219	-	-	-	-	-	-	214
	Avg tide	129	310	190	271	340	232	297	320	224	182	303	227	148	277	172	379	248	256	-	-	-	-	-	-	252
	Spring tide	143	287	246	324	336	260	291	346	326	291	334	242	183	317	154	438	224	-	-	-	-	-	-	-	281
Oosterweel (- 2.3 m TAW)	Neap tide	95	275	158	232	204	166	248	230	187	208	232	162	82	207	101	144	-	-	-	-	-	-	-	-	191
	Avg tide	122	274	168	234	292	206	247	287	202	208	271	195	127	249	150	311	-	-	-	-	-	-	-	-	221
	Spring tide	126	263	211	283	294	219	269	318	304	301	290	218	165	281	136	375	-	-	-	-	-	-	-	-	248

7.2 TIDAL VARIATIONS

The factual data reports compiled on the basis of the measurement campaign (IMDC, 2008b; 2009d; 2011c) show the 10 minute evolution on week plots for all variables, this includes sediment concentration. Several peaks can be found per tide. The variations between the tides based on the tidal difference are clearly visible too.

The course of the flow velocity along one tide (as developed in §4.2), put in parallel with erosion and sedimentation processes may explain the occurrence of some of the peaks in the concentration course. The flow pattern and the erosion – sedimentation processes could explain three different peaks during an episode (ebb or flood):

- The sediment layer formed during slack will have a lower density and will easily erode when the flow velocity increases just after the slack, resulting in a first possible concentration peak.
- In section §4.1, we saw that the average velocity values were following the neap and spring tide cycle, with high amplitude tides showing higher velocities. Along this cycle, during the periods with the smallest amplitudes (neap tides) sedimentation would prevail, allowing the consolidation of layers of settled sediments. During the phases of the cycle with higher velocity (spring tides and, to a lesser degree, average tides), (part of) the consolidated layers can be eroded and brought back into suspension. Consolidation and erosion cycles of this type can also be imagined in relation to longer time scales (for instance, seasonal, dry-humid periods). The resistance to erosion of those layers, consolidated on various time scales, is higher than the settled layers during slack. Erosion of those layers only occurs when the flow velocity (and thus the bed shear stress) is higher than a certain threshold. During the phase of increasing flow velocity, and during the erosion phase of the consolidation-erosion cycle (i.e. during spring tide, and to a lesser degree average tide for the tidal amplitude cycle), this threshold can be exceeded, causing the erosion of all or a part of a consolidated layer which can be brought into suspension, leading to the apparition of a second peak.
- A third peak in the concentration during increasing velocity phase will coincide with the maximum flood velocity, which is in general more distinct during a spring tide than during a neap tide. During ebb, the velocity course shows a more uniformed pattern than during flood, for which more peaks are recorded. Hence, the appearance of a maximum velocity concentration peak should be less frequent during ebb than during flood.
- Since the ebb and flood currents follow different paths in the Scheldt estuary, the position of the measurement station has a big influence on the sediment concentration data registered.
- The settlement of the suspended sediment during slack leads to a higher suspended sediment concentration near the bottom of the riverbed. The bottom station will register higher sediment concentrations during this period.

Long-term variations of tidal extrema in relation to fresh water discharge and tidal amplitude are shown in Annex-Figure F-1 to Annex-Figure F-14.

7.3 TIDAL-AVERAGED SEDIMENT CONCENTRATION CURVES

A tidal-averaged sediment concentration curve has been drawn for each of the measurement locations. The course of this sediment concentration curve is determined as a function of the time in relation to high water and this for neap tide, average tide and spring tide, see Annex-Figure F-15 to Annex-Figure F-32. These curves allow us to determine the average time tags of the peaks in sediment concentration as a function of the tidal amplitude (see also Table 7-5). Because the data have been measured with a frequency of 10 minutes, there is an inaccuracy in the time tags calculated which amounts to 10 minutes at most. In general, the time tags in this table show a reasonable agreement with the time tags found in the data from April 2007 to March 2008 (IMDC 2008t), which indicates that the tidally-averaged sediment concentration curves are qualitatively similar to those from April 2007 to March 2008. This is confirmed by a visual comparison of the graphs.

- **Buoy 84**: <u>During flood</u> (considered here as going from low water slack to high water slack), a first small concentration peak can be observed at the bottom station about 4h to HW. This peak is the reflection of a small velocity peak that is also only observed at the bottom location. From that time the concentration stays high until HW slack in the top sensor. In the bottom sensor, the concentration drops slightly and another concentration peak occurs together with the velocity peak about 1h00 to HW. <u>During ebb</u> (from HWS to LWS), a first concentration peak occurs about 2h00 after HW, half an hour before the first ebb velocity peak, which is very weak during neap tide conditions. This first ebb peak can thus only be explained by the erosion of the layer that settled during high water slack. The velocity peak at about 2h30 after HW, which is also the maximal ebb velocity, does not find any reflected image in the concentration course. The second velocity peak about 4h00 is well reflected in the concentration. The peak in the concentrations at the upper measurement instrument is the most pronounced of all. As can be observed by comparing both curves, the velocity course is far from being perfectly reflected in the concentration course. Some of the velocity peaks (even the biggest ones) do not create any concentration peaks Furthermore, in general it can be observed that while the velocity pattern is clearly flood-oriented, the biggest concentration values are recorded during ebb (especially at the location of the upper measurement instrument). This shows that the concentration at one point of the estuary is not the consequence of local erosion-sedimentation processes but rather the result of global sediment transport in the river, which is itself the consequence of multiple local processes. In this way, the higher concentrations during ebb can be explained by the fact that in this location the ebb flow is loaded with more sediment than the flood flow “coming” from the sandy environment located at the Plaat van Doel).

Table 7-5: Average tidal curves of the sediment concentration, time to HW of the minimal (around slack waters) and maximal (during flood and ebb phase, max value of both in bold characters) concentration for an average neap, average and spring tide. April 2008 – March 2010.

			Min Around LSW 1	*Max during flood*	*Min around HSW*	*Max during ebb*	*Min around LSW 2*	*Tide duration*
Buoy 84	-8.1 m TAW	Neap	-5:40	-3:50	01:10	04:10	07:10	12:50
		Average	-5:30	-3:40	01:20	04:10	07:00	12:30
		Spring	-5:10	-3:40	01:30	04:00	07:10	12:20
Buoy 84	-5.8 m TAW	Neap	-4:30	-1:30	01:20	04:00	08:00	12:30
		Average	-4:20	-1:30	01:30	04:00	08:00	12:20
		Spring	-4:20	-0:50	01:30	03:50	08:00	12:20
Buoy 97	-7.5 m TAW	Neap	-5:20	-4:00	01:20	03:40	07:30	12:50
		Average	-5:10	-4:00	01:20	03:30	07:20	12:30
		Spring	-4:50	-4:10	01:20	02:20	07:20	12:10
Buoy 97	-5.1 m TAW	Neap	-4:40	-2:10	01:30	03:30	07:50	12:30
		Average	-4:40	-0:30	01:30	03:30	07:50	12:30
		Spring	-4:30	-0:30	01:40	03:20	08:00	12:30
Oosterweel	-5.7 m TAW	Neap	-5:10	-2:00	01:00	02:10	07:10	12:20
		Average	-5:10	-2:10	01:00	02:10	07:20	12:30
		Spring	-4:50	-2:10	01:10	02:20	07:40	12:30
Oosterweel	-2.3 m TAW	Neap	-4:50	-1:20	01:20	02:10	07:40	12:30
		Average	-4:40	-2:10	01:30	02:10	07:40	12:20
		Spring	-4:30	-2:10	01:30	02:20	08:00	12:30

- **Buoy 97**: Although data is only available for about two months in spring, an analysis is made. The first concentration peaks during ebb (between 4h30 and 4h00 to HW, principally in the bottom station and for average and spring tides) and flood (2h30 after HW) occur during the increasing velocity phase after the slacks and is due to the erosion of the layers settled during slack. The first velocity peak for both phases (-3h40 for flood and +2h40 for ebb) does not generate any peak in the concentration course. After the erosion peak, the two other peaks during flood (-2h00 and -0h30) can be correlated with velocity peaks (about -2h00 and -0h50). In the top station, there is some delay between the velocity and the concentration peaks, which can be explained by the time needed for the sediment to spread vertically. During ebb, a second peak (+3h30), which is the maximum concentration for the whole tidal course, occurs half an hour before the maximum ebb velocity value (+4h00) and has to be explained by the global transport on the river. A third and last peak during ebb occurs at +6h00 together with a velocity peak. Here also, the global concentration pattern is ebb-oriented while the biggest velocities are recorded during flood.

- **Oosterweel**: The velocity curve shows a double peak pattern (-3h30 and –1h00, the second one dominant) during flood and a quite continuous pattern during ebb with peaking values between +2h00 and +4h00. Note that this peak is more pronounced than the one found in the data from September 2005 to March 2007 (IMDC 2008a). During flood, the first velocity peak generates a small bump in the concentration, most visible for the bottom station and during average or spring tide. The biggest flood concentration peaks occurs between the two velocity peaks and is probably due to the erosion of the settled layers. During ebb, a first concentration peak occurs during the increase of the velocity after slack by erosion of the settled layers, a second, peak is synchronous with the velocity maximum. At this location there is a better correspondence between the ebb-flood proportions of the velocity and the concentration course.
- **Prosperpolder and Liefkenshoek**: No measurements available.

7.4 NEAP TIDE – SPRING TIDE VARIATIONS AND INFLUENCE OF FLOW VELOCITY

The velocity course during a neap tide is different from the one during a spring tide. The flow during flood is also qualitatively different for a spring tide and a neap tide. During a spring tide the flood velocities are more asymmetric and they display a distinct double peak. During a neap tide the flood course of the velocity occurs more gradually. This means that along the neap and spring tide cycle the peak flood velocities show relative increases in a more pronounced way than the peak ebb velocities, hence resulting in a relatively higher erosion of sediment during a spring tide flood than during a neap tide flood.

For instance, in Buoy 84 the average sediment concentration during a spring tide (Annex-Table F-1 and Annex-Table F-3) at the lower and upper measurement instruments is 87% and 101% higher respectively than during a neap tide and the increase can mainly be felt during flood (102% and 112%) rather than during ebb (93% and 92% respectively). Similar percentages (but slightly higher) were found for the period from September 2005 to March 2007.

In Buoy 97, the increase between neap and spring tide is also larger at flood than at ebb but in a less distinct way (100% and 74% for the lower and upper instrument, 107% and 94% during flood and 93% and 64% for ebb). In Oosterweel, (68% and 99% increase between neap and spring tide for the lower and upper instrument) the flood flow does not really overrule the ebb-oriented character and the increase (62% and 82% for flood; 72% and 116% for ebb) occurs mainly during ebb, in contrast to what was found from September 2005 to March 2007, where it was determined that the increase between neap and spring tide was lower (40%) and was spread evenly between ebb and flood.

It should also be noted that the increase in sediment transport between neap tide and spring is felt in a more pronounced way at the bottom stations during the winter. In summer, the increase along the cycle is identical for the lower and higher stations.

In the upstream direction, the influence of the tidal amplitude on the flow velocity is less obvious and the flow is mainly ebb-oriented. However, it is difficult to draw any conclusions or to observe any trends for the sediment transport on account of the configuration at each of the measurement locations being different (depth, distance to water channel, quay-walls, banks and other constructions which might influence the sediment transport).

Flow velocity is one of the things that determines transport. The relation between tidal amplitude and flow velocity found in Section §4.1, explains the variations of concentrations in the neap tide and spring tide cycle. In Annex-Figure F-33 to Annex-Figure F-38, the ebb, respectively flood average sediment concentration has been correlated with the ebb, respectively flood average flow velocity. The figures clearly indicate that the average sediment concentration is in significant correlation with the average flow velocity. For Buoy 84 and 97, the correlation factor is mediocre (0.28-0.58) both for ebb and flood. In Oosterweel, it seems that the sediment concentration can only be correlated with the velocity at flood (0.31-0.33). At ebb, the correlation factors are fairly low (especially at the lower instrument) and the significance is fairly high, indicating that there is no relation between both variables here. One of the ways this might be explained is by the fact that in Oosterweel the flow is more ebb-oriented and this is hence more concentrated in the navigation channel. Since the instrument is located outside the channel, it is quite possibly the cause of the lack of correlation between both variables.

A correlation of velocity and sediment concentration was found here, but the flow velocity is far from being the sole factor influencing the sediment concentration, and the relation with the tidal amplitude of Section §4.1 only forms a partial explanation for the development in the neap and spring tide cycle.

The correlation found at Buoy 84 shows that the angle of the fitted lines is steeper for autumn and winter than for spring and summer. It is known that during summer algae layers on top of intertidal areas increase the critical shear stress. It can therefore be the reason why certain flow velocities correlate with higher concentrations in winter compared to summer.

Another process that might form the basis of the development of sediment concentrations is the occurrence of high salinity amplitudes and hence of gradients causing density flows. We have seen that these also depend on the tidal amplitude and hence the neap and spring tide cycle, but also on the flow regime and hence on the interaction between tidal amplitude and discharge. The sediment availability also forms an important factor. This will be discussed below.

In Figures F-45 to F-50, it can be observed that the mean sediment concentration can be correlated well with the tidal variation in sediment concentration.

7.5 PROLONGED VARIATIONS

The variations of the sediment concentrations observed on a long time scale may be caused by different, although not always independent, influence factors. For example:

- Fresh water discharge (shifting of zones with high salinity gradients and intense mixing processes of salt and fresh water, larger sediment input from the non-tidal related part of the basin)
- Temperature (biological activity, climate factors, organic material in suspension and aggregation / flocculation of sediment particles)
- Storm surges
- Land erosion (terrestrial input of fine sediments)
- Human activities,

Hereinafter, we will first discuss the evolutions along the seasonal cycle, then the influence of the interaction between discharge and tidal effects and lastly the long-term evolution of the suspended sediment concentration at the measurement locations.

7.5.1 Seasonal cycle

Temperature is a variable, which is clearly related to the seasons. That is why temperature may be used to show the season-related variation of the sediment concentration. Annex-Figure F-39 to Annex-Figure F-44 display the tidal average sediment concentration based on the tidal average water temperature for the measurement stations. The coefficients of Buoy 84 and Oosterweel are all negative and between –0.07 and –0.49, meaning that periods with a low water temperature (winter) correspond with periods with a higher sediment concentration more than in periods with higher temperatures (summer) and that both variables are correlated in a comparable way as the correlation with the velocity. This corroborates with the seasonal influences that are clearly visible in Annex-Table F-1 to Annex-Table F-3, which show on average 25 % higher concentrations in winter than in summer, with maximum differences of 60 %. The values of the coefficients at buoy 97 are slightly positive, probably due to the low number of data points. Care must be taken in interpreting these results, because (as can be seen in Section §6.1) the temperatures that occur are mostly around 8 and 20°C, and hence the temperature data used in the correlation analysis is not homogeneously distributed. This explains the peaks in the sediment concentrations around these temperatures, because any extreme event leading to a high sediment concentration is more likely to occur at one of these temperatures, because they occur most frequently.

The correlation results for Buoy 97 are poor, this is due to the limited availability of data for this station.

7.5.2 Interaction tide - discharge

Table 7-2 to Table 7-4 indicate the ebb and flood maximum and average sediment concentration of the different flow regimes discussed in Chapter 4.

According to the literature (see for example Dyer, 1995) in mesotidal and macrotidal estuaries (i.e. estuaries with average large tidal amplitudes at top), there is one zone with higher sediment concentrations than elsewhere. The turbidity maximum is usually found at the upstream end of the salt penetration front, that is a zone with a salinity of 1 to 5 psu. The inter-tidal saline regime contains this saline front for each tide thereby explaining the higher concentration values. In the present dataset the maximum sediment concentrations occur at Buoy 97 confirming that the turbidity maximum is indeed occurring in the studied area.

For example, in Annex-Figure F-3 it is clear that in the long-term the tidal minimal sediment concentration correlates well with the fresh water discharge at Buoy 84. In the following figures the same can be observed for Oosterweel. The causality might be direct or indirect. High discharge occurs in winter, when, sediments are also eroded more easily due to the absence, among other things, of algae on intertidal areas and a higher frequency of storms.

7.5.3 Evolution

The long-term evolution of the suspended sediment concentration at Buoy 84 and Buoy 97 does not show any obvious trends. However, there is a slight increase during the considered period. At both Buoy 84 and Oosterweel measurement stations, the suspended sediment concentration starts to increase faster from the summer of 2009 onwards. It is known that the lunar nodal tide variations (18.6 year cycle) have an influence on tidal range and thus sediment concentration (E.g. Wang and Townend, 2011). The nodal factor was rising in the period 2007-2010 and could be partially responsible for rising trends during that period.

At Buoy 84 and Buoy 97 there is a seasonal cycle that shows higher sediment concentrations during summer periods and lower sediment concentrations during winter periods (Annex-Figure F-51 & Annex-Figure F-52). At the Oosterweel measurement location there is a long-term trend of rising sediment concentrations in both bottom and top measurement data (Annex-Figure F-53 & Annex-Figure F-54). However, the seasonal trend is less clear. In IMDC (2013b) is proved that the dredging/dumping activities are partially responsible for the increasing trends in the Lower Sea Scheldt, especially at station Oosterweel. Increased dredging activities for the maintenance of Deurganckdok and the deepening and widening of the fairway took place during this reporting period

8. CONCLUSION

The analysis of the measurements has clearly proven that the variables measured vary in a very complex way with the tide, along with neap and spring tide cycles and in accordance with the seasons. The tide-related and the neap and spring tide variations can be explained by the hydrodynamics of the estuary. The seasonal-related variations are caused by climate, physical, chemical and biological processes.

Flow velocity, salinity, sediment concentration and temperature clearly vary with the tide. Furthermore, sediment concentration, salinity and temperature display prolonged variations (seasonal). The influence of seasons is in direct relation to the climatological cycle. However, the influence on the sediment concentration and salinity is indirectly related due to variations in discharge and biological activity.

Nevertheless, the data in the current measurement period, which ranges from April 2007 to March 2008, compares well with the data measured between September 2005 and March 2007 (IMDC 2008t). For the flow velocity data this could be expected, as these are mainly determined by the astronomical tide, which does not show much variation across the years, and because the fresh water flow discharge in the River Scheldt showed very similar statistics for both periods. However, a clear long-term concentration trend can be observed in the Oosterweel sediment concentration data. Average concentrations gradually rose from about 150 mg/l in 2006 to about 250 mg/l in 2009. Increased dredging activities for the maintenance of Deurganckdok and the deepening and widening of the fairway took place during this period. These activities are probably the main explanation of the increase (IMDC, 2013b) and partially in combination with lunar nodal tide variation.

9. REFERENCES

AZ (1974). Debieten van het Scheldebekken periode 1959 – 1972. *Ministerie van Openbare werken, Antwerpse Zeehavendienst.*

Dahl, E. (1956). Ecological salinity boundaries in poikilohaline waters. Oikos, 7(I): 1–21

Dyer K.R. (1995). Sediment transport processes in estuaries. *Geomorphology and Sedimentology of Estuaries. Developments in Sedimentology*, 53 (ed. G.M.E. Perillo), 423-449

Flanders Hydraulics Research, (2009), Overzicht van de tijwaarnemingen in het Zeescheldebekken gedurende het deccenium 1991-2000: T.O. tijwaarnemingen Zeescheldebekken 1991-2000, versie 2.0. WL rapport 833_01.

IMDC (2007). Uitbreiding studie densiteitsstromingen in de Beneden Zeeschelde in het kader van LTV Meetcampagne naar hooggeconcentreerde slibsuspensies Deelrapport 5.6 Deelrapport 5.6: Analyse omgevingscondities: september 2005 – maart 2007 (I/RA/11291/06.091/MSA), in opdracht van AWZ.

IMDC (2008a) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport 3.14: Boundary conditions: Annual report (I/RA/11283/07.101/MSA)

IMDC (2008b) 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 (2009d) 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 (2010a) Evaluatie externe effecten aanslibbing Deurganckdok. Deelrapport 2.5 Through Tide measurement: eddy currents DGD 02/03/2010 (I/RA/11283/10.051/MSA)

IMDC (2010b) Evaluatie externe effecten aanslibbing Deurganckdok. Deelrapport 2.8 Sal-Silt distribution Deurganckdok 01/04/2009 – 31/03/2010 (I/RA/11354/10.068/NZI)

IMDC (2010c) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport 4.20: Analysis of siltation Processes and Factors (I/RA/11283/08.098/MSA)

IMDC (2011a) Evaluatie externe effecten aanslibbing Deurganckdok. Deelrapport 1.1 Annual Sediment Balance year 1: 1/04/2009 – 31/03/2010 (I/RA/11354/10.067/NZI)

IMDC (2011b) Evaluatie externe effecten aanslibbing Deurganckdok. Deelrapport 1.2 Annual Sediment Balance year 2: 1/04/2009 – 31/03/2010 (I/RA/11354/10.100/MBO/ANF)

IMDC (2011c) Evaluatie externe effecten aanslibbing Deurganckdok. Deelrapport 1.4 Boundary Conditions year 1: 01/04/2009 – 31/03/2010 (I/RA/11354/10.102/MBO/ANF)

IMDC (2011d) Evaluatie externe effecten aanslibbing Deurganckdok. Deelrapport 1.7 Synthesis report of research on Current Deflecting Wall (I/RA/11354/10.063/MBO)

IMDC (2012a) Evaluatie externe effecten aanslibbing Deurganckdok. Deelrapport 2.1 Through Tide Sediview measurement: entrance DGD during spring tide in Autumn 2011 (I/RA/11354/10.106/MBO/ANF)

IMDC (2012b) Evaluatie externe effecten aanslibbing Deurganckdok. Deelrapport 2.2 Through Tide Sediview measurement: entrance DGD during neap tide in Autumn 2011 (I/RA/11354/10.107/MBO/ANF)

IMDC (2012c) Evaluatie externe effecten aanslibbing Deurganckdok. Deelrapport 2.6 Through Tide measurement: eddy currents DGD Autumn 2011 (I/RA/11354/10.110/MBO/ANF)

IMDC (2012d) Evaluatie externe effecten aanslibbing Deurganckdok. Deelrapport 2.10 Salt-Silt & Current Distribution entrance Deurganckdok: Frame measurements and through-tide measurements: Autumn 2011 (I/RA/11354/11.131/BQU)

IMDC (2012e) Evaluatie externe effecten aanslibbing Deurganckdok. Deelrapport 2.12 Calibration stationary & mobile equipment 16/03/2011 (I/RA/11354/11.113/MBO/ANF)

IMDC (2012f) Evaluatie externe effecten aanslibbing Deurganckdok. Deelrapport 1.5 Boundary conditions year 2: 01/04/2010 – 31/03/2011 (I/RA/11354/11.103/MBO/ANF)

IMDC (2012g) Evaluatie externe effecten aanslibbing Deurganckdok. Deelrapport 2.3 Through Tide Sediview measurement: entrance DGD during spring tide in Winter 2012 (I/RA/11354/10.108/MBO/ANF)

IMDC (2012h) Evaluatie externe effecten aanslibbing Deurganckdok. Deelrapport 2.4 Through Tide Sediview measurement: entrance DGD during neap tide in Winter 2012 (I/RA/11354/10.109/MBO/ANF)

IMDC (2012k) Evaluatie externe effecten aanslibbing Deurganckdok. Deelrapport 2.7 Through Tide measurement: eddy currents DGD Winter 2012 (I/RA/11354/10.111/MBO/ANF)

IMDC (2012l) Evaluatie externe effecten aanslibbing Deurganckdok Deelrapport 2.11 Salt-Silt & Current Distribution entrance Deurganckdok: Frame measurements and through-tide measurements: Winter 2012 (I/RA/11354/11.114/MBO/ANF)

IMDC (2012m) Evaluatie externe effecten aanslibbing Deurganckdok. Deelrapport 1.3 Annual Sediment Balance year 3: 1/04/2011 – 31/03/2012 (I/RA/11354/10.101/MBO/ANF)

IMDC (2012n) Evaluatie externe effecten aanslibbing Deurganckdok. Deelrapport 2.9 Sal-Silt distribution Deurganckdok 01/04/2009 – 31/05/2010 (I/RA/11354/10.112/MBO/ANF)

IMDC (2012o) Evaluatie externe effecten aanslibbing Deurganckdok. Deelrapport 2.13 Calibration stationary & mobile equipment 01/06/2012 (I/RA/11354/12.011/JCA)

IMDC (2012p) Evaluatie externe effecten aanslibbing Deurganckdok. Deelrapport 1.6 Boundary conditions year 3: 01/04/2011 – 31/03/2012 (I/RA/11354/11.104/MBO/ANF)

IMDC (2013a) Evaluatie externe effecten aanslibbing Deurganckdok. Deelrapport 1.8 Analysis of external effects on siltation processes and factors (I/RA/11354/10.105/MBO/ANF)

IMDC (2013b) Monitoringsprogramma Flexibel storten. Deelopdracht 1: Analyse slibconcentratiemetingen in de Zeeschelde (I/RA/11353/13.169/DPP)

Savenije, H. & Veling EJM (2005). Relation between tidal damping and wave celerity in estuaries. Journal o geophysical research, 110.

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.

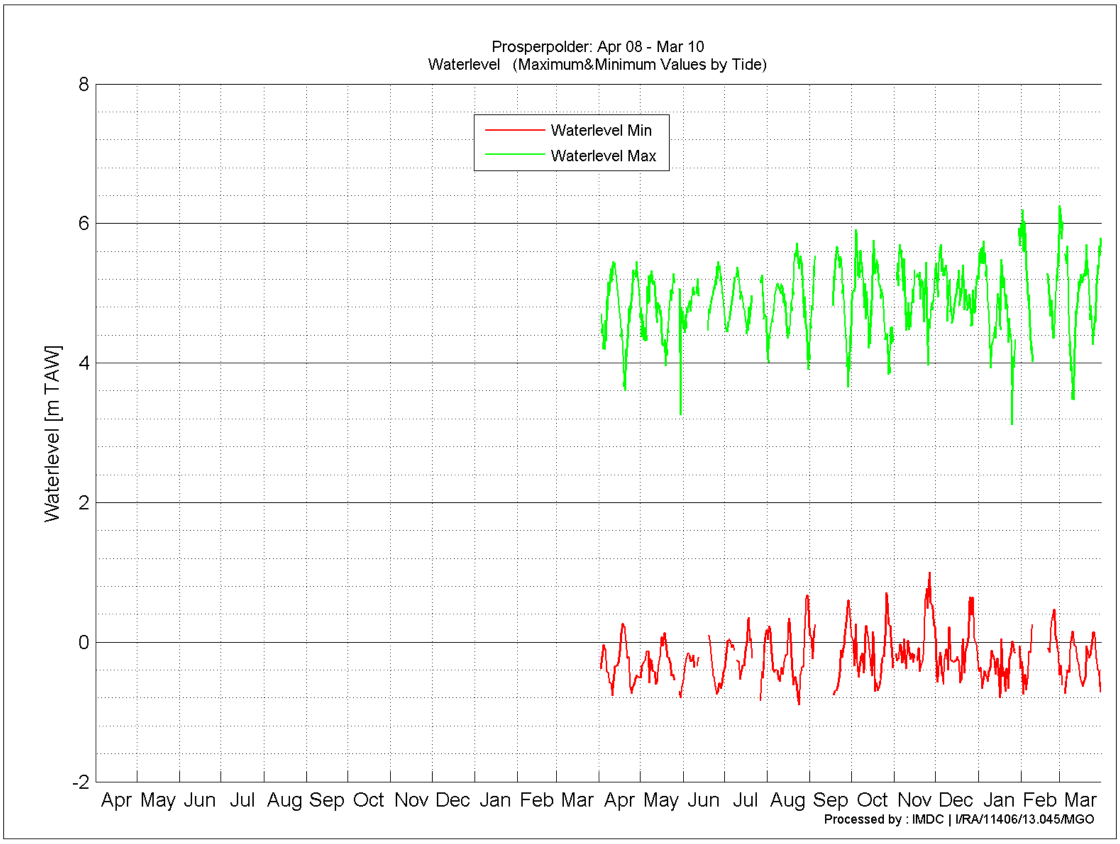
Wang, Z.B. and Townend I.H (2011). Influence of the nodal tide on the morphological response of estuaries. Marine Geology 291-294, pp.73-82.

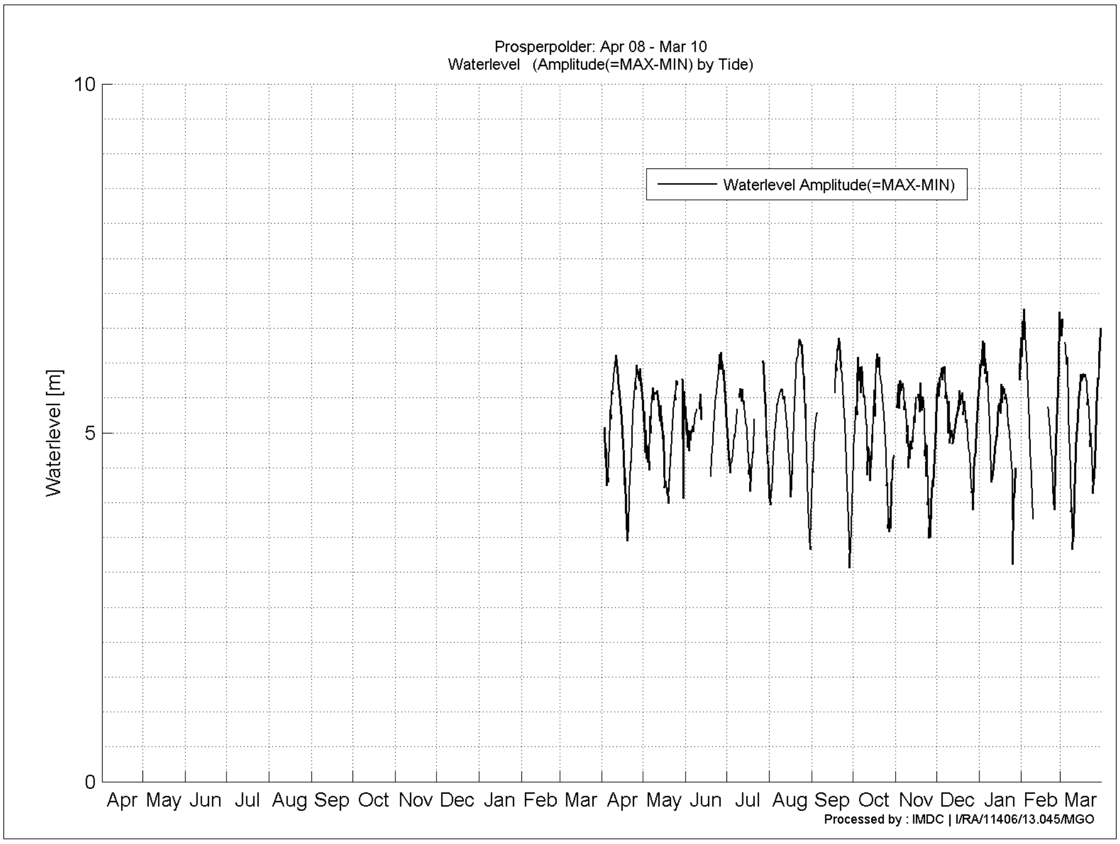
Winterwerp, J., Wang, Z., van der Kaaij, T., Verelst, K., Bijlsma, A., Meersschaut, Y. & Sas, M. (2006). Flow velocity profiles in the lower Scheldt estuary. *Ocean dynamics*, *56*, pp. 284- 294.

Annex A Overview of the reports from the previous project: External effects siltation Deurganckdok (2009-2012)

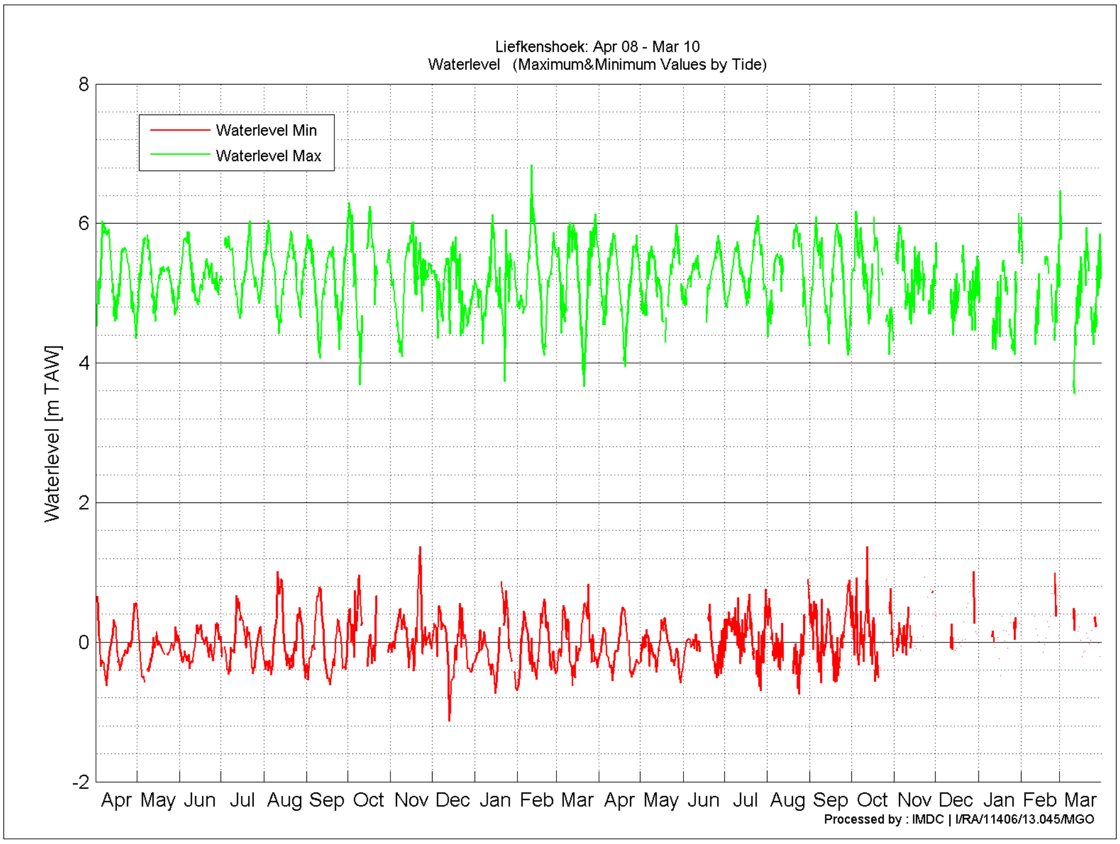
Report	Description
1.	**Reporting**
I.1 Annual Sediment Balance: Bathymetry surveys, Density measurements, Maintenance and construction dredging activities	
1.1	Annual Sediment Balance: year 1: 1/4/2009-31/3/2010 (I/RA/11354/10.067/NZI)
1.2	Annual Sediment Balance: year 2: 1/4/2010-31/3/2011 (I/RA/11354/10.100/MBO/ANF)
1.3	Annual Sediment Balance: year 3: 1/4/2011-31/3/2012 (I/RA/11354/10.101/MBO/ANF)
I.2 Boundary Conditions: Upriver Discharge, Salt concentration Scheldt, Bathymetric evolution in access channels, dredging activities in Lower Sea Scheldt and access channels	
1.4	Boundary Conditions year 1: 01/04/2009 – 31/3/2010 (I/RA/11354/10.102/MBO/ANF)
1.5	Boundary Conditions year 2: 01/04/2010 – 31/3/2011 (I/RA/11354/10.103/MBO/ANF)
1.6	Boundary Conditions year 3: 01/04/2011 – 31/3/2012 (I/RA/11354/10.104/MBO/ANF)
I.3 Synthesis of CDW research	
1.7	Synthesis report of research on Current Deflecting Wall (I/RA/11354/10.063/MBO)
I.4 Analysis: evaluation of external effects on siltation in Deurganckdok	
1.8	Analysis of external effects on siltation processes and factors (I/RA/11354/10.105/MBO/ANF)
2.	**Measurement campaigns: Factors contributing to salt and sediment distribution in Deurganckdok: Salt-Silt (OBS3A) & Frame measurements, Through-tide measurements (Silt Profiling & ADCP) & Calibrations**
II.1 Through tide measurements fixed transects	
2.1	Through tide Sediview measurement: Entrance DGD during spring tide Autumn 2011 (I/RA/11354/10.106/MBO/ANF)
2.2	Through tide Sediview measurement: Entrance DGD during neap tide Autumn 2011 (I/RA/11354/10.107/MBO/ANF)
2.3	Through tide Sediview measurement: Entrance DGD during spring tide Winter 2012 (I/RA/11354/10.108/MBO/ANF)
2.4	Through tide Sediview measurement: Entrance DGD during neap tide Winter 2012 (I/RA/11354/10.109/MBO/ANF)
II.2 Through tide measurements eddy currents	
2.5[2]	Through tide measurements: Eddy Currents DGD 02/03/2010 (I/RA/11283/10.051/MSA)
2.6	Through tide measurements: Eddy Currents DGD Autumn I/RA/11354/10.110/MBO/ANF)
2.7	Through tide measurements: Eddy Currents DGD Spring 2012 (I/RA/11354/10.111/MBO/ANF)
II.3 Salt Silt Distribution entrance Deurganckdok	
2.8[3]	Salt-Silt distribution Deurganckdok 1/4/2009-31/3/2010 (I/RA/11354/10.068/NZI)
2.9	Sal-Silt distribution Deurganckdok 1/6/2011-30/05/2012 (I/RA/11354/10.112/MBO/ANF)
II.4 Current Salt Silt Distribution CDW Deurganckdok	
2.10	Salt Silt & Current Distribution entrance Deurganckdok: frame measurements and through tide measurements: Autumn 2011 (I/RA/11354/11.131/BQU)
2.11	Salt Silt & Current Distribution entrance Deurganckdok: frame measurements and through tide measurements: Winter 2012 (I/RA/11354/10.114/MBO/ANF)
II.5 Quality Control instruments	
2.12	Calibration stationary & mobile equipment 16/03/2011 (I/RA/11354/10.113/MBO/ANF)
2.13	Calibration stationary equipment 2012 (I/RA/11354/12.011/JCA)

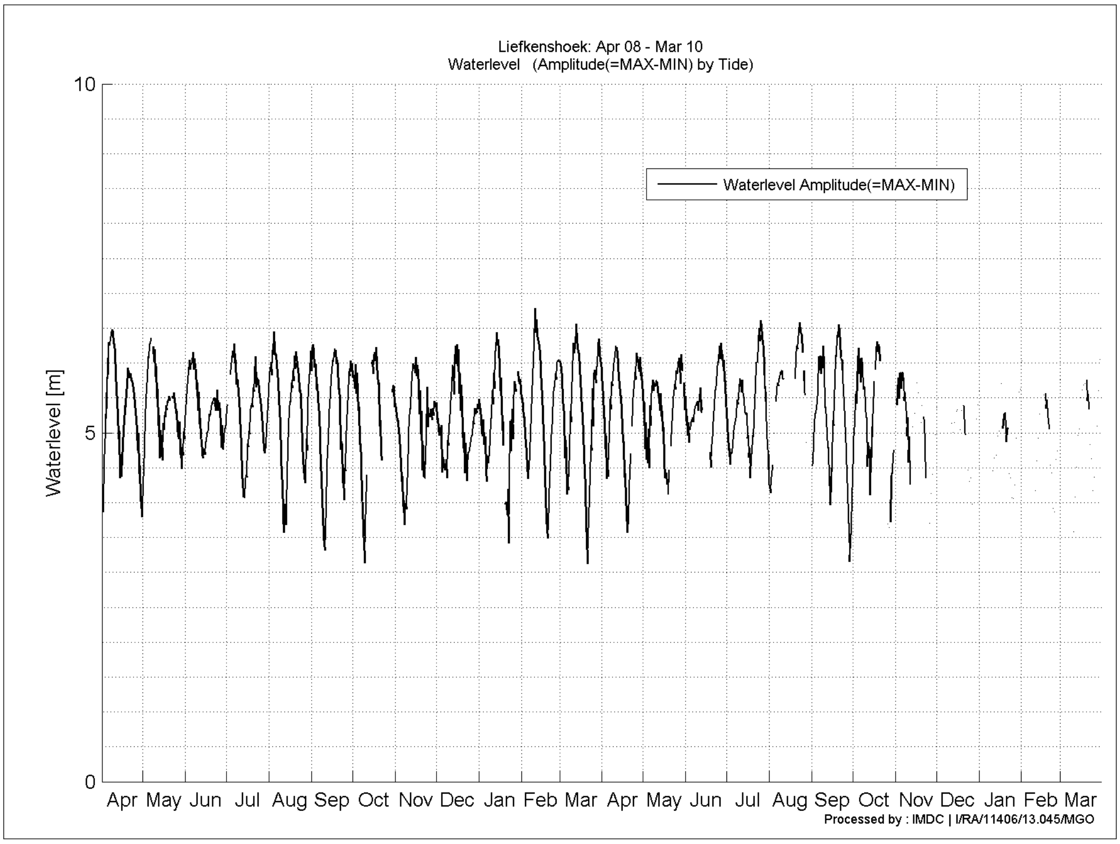
Annex B Figures for tide and discharge



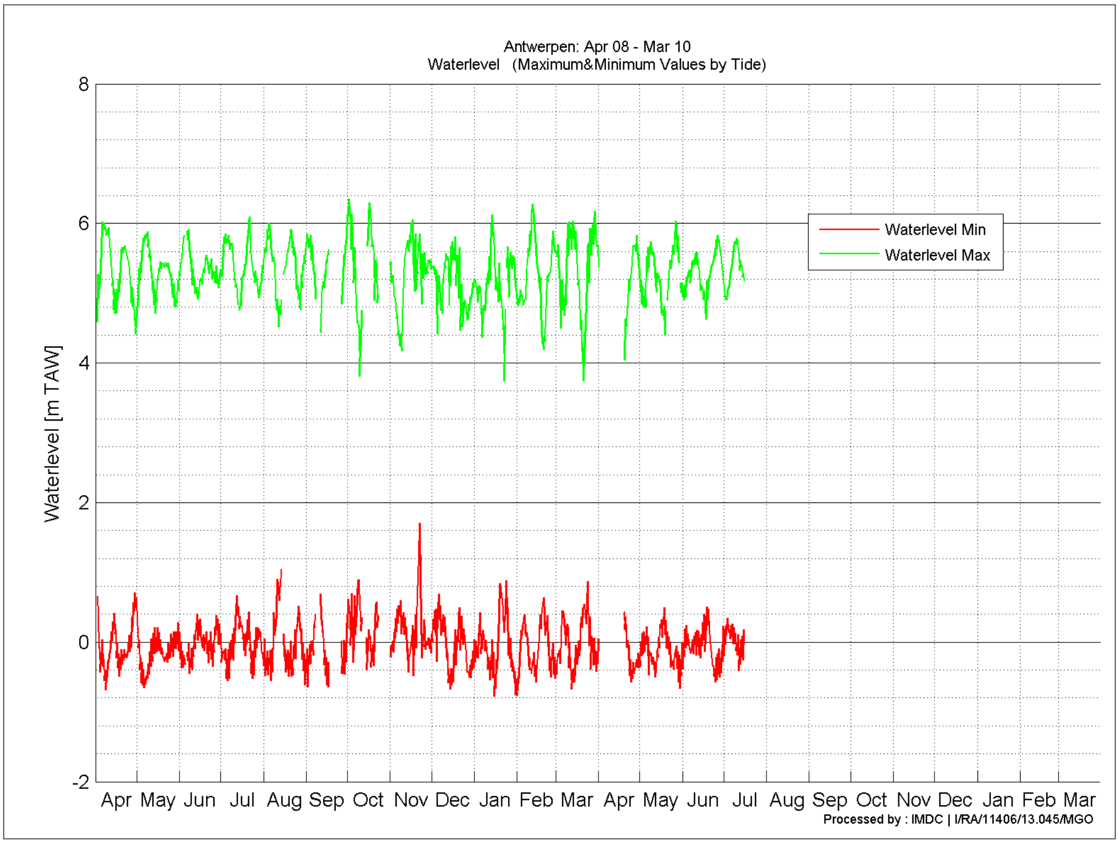


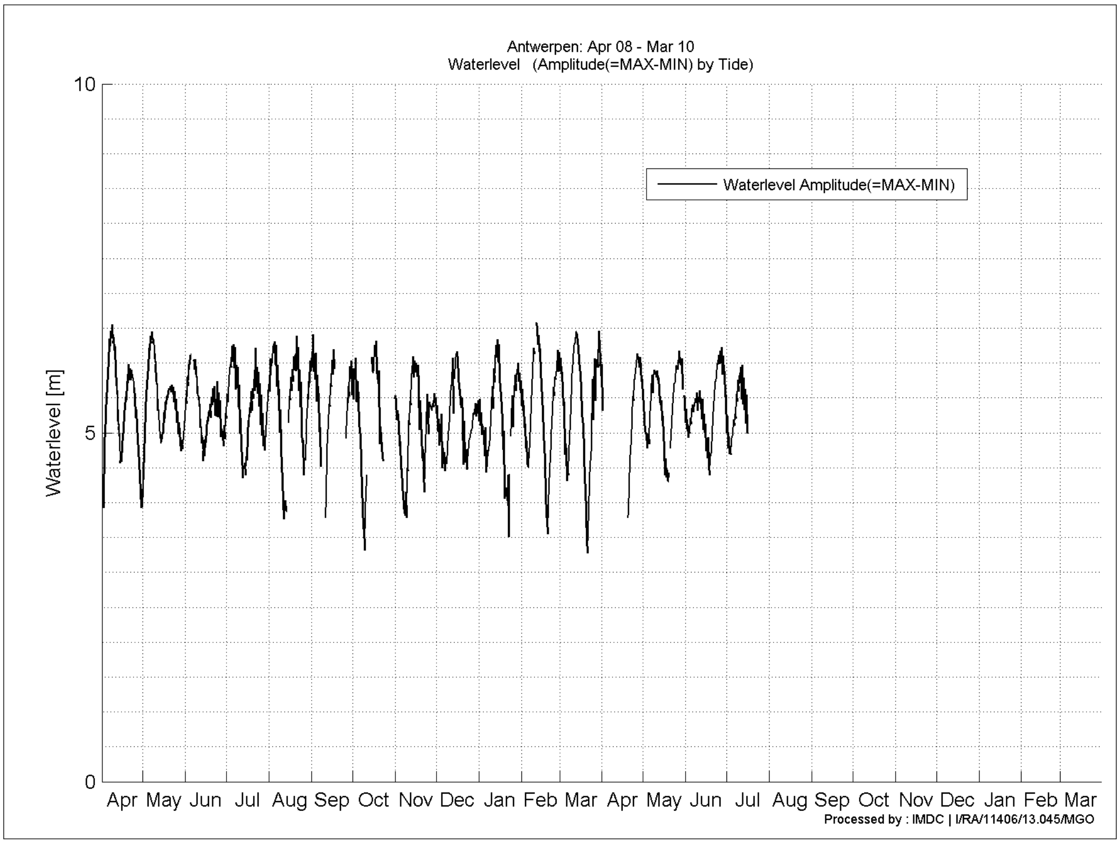
Annex-Figure B-1: Prosperpolder. April 2008 – March 2010. (a) HW and LW (b) Tidal Amplitude.



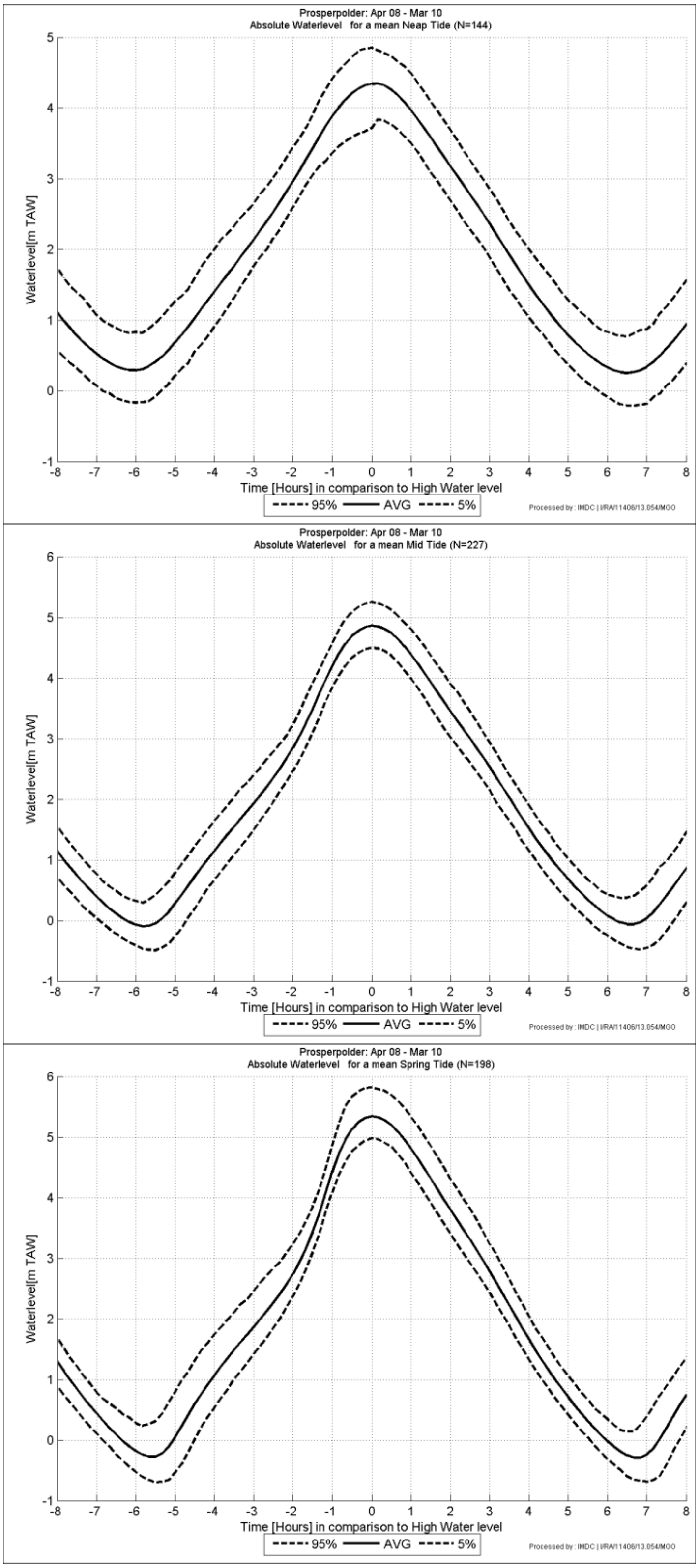


Annex-Figure B-2: Liefkenshoek. April 2008 – March 2010. (a) HW and LW (b) Tidal Amplitude.

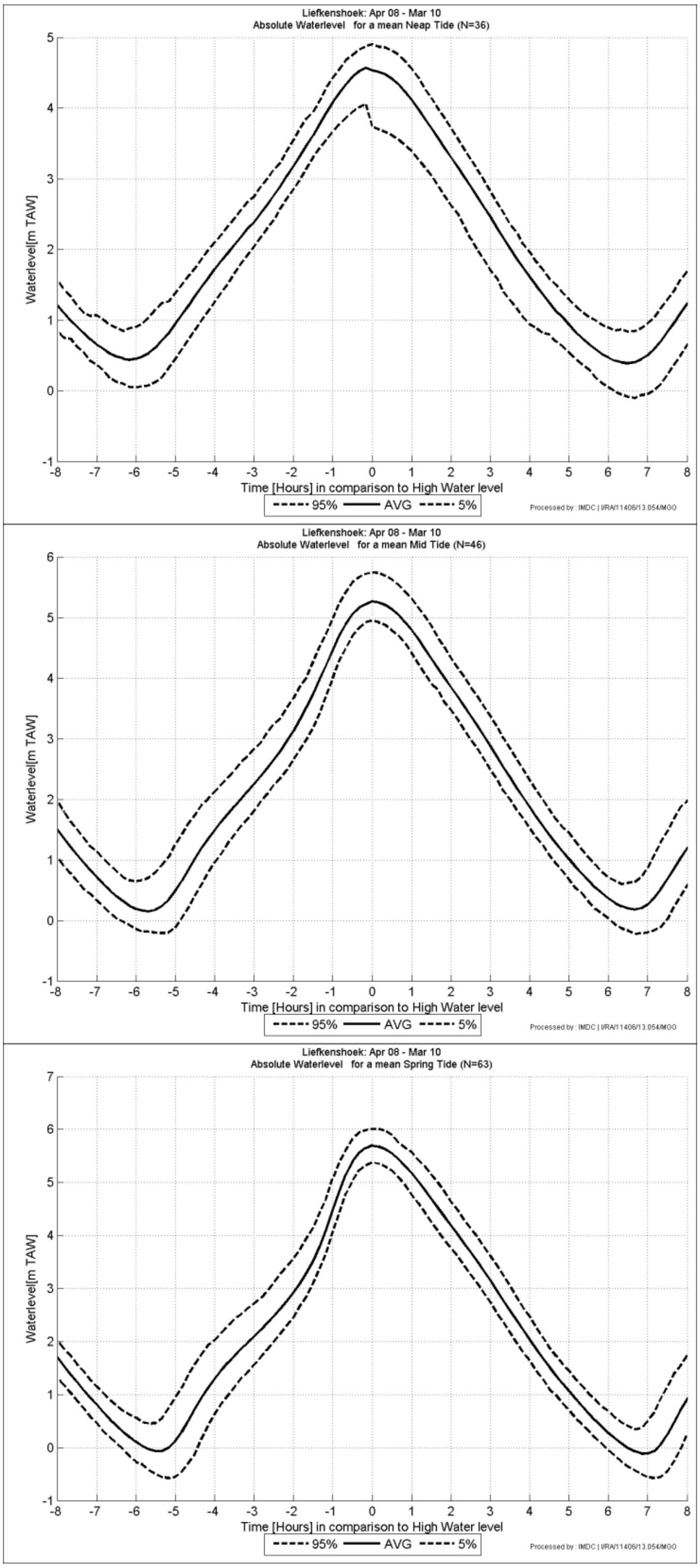




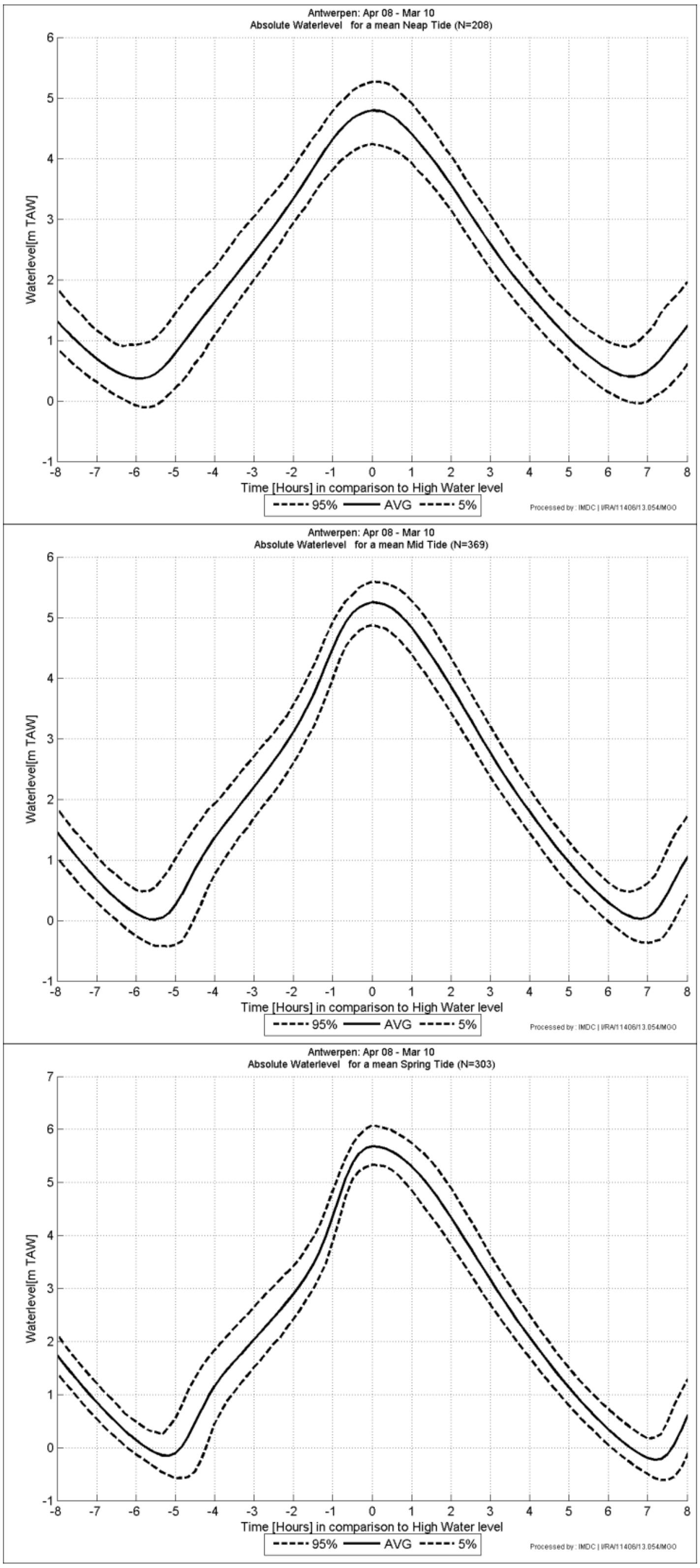
Annex-Figure B-3: Oosterweel. April 2008 – March 2010. (a) HW and LW (b) Tidal Amplitude.



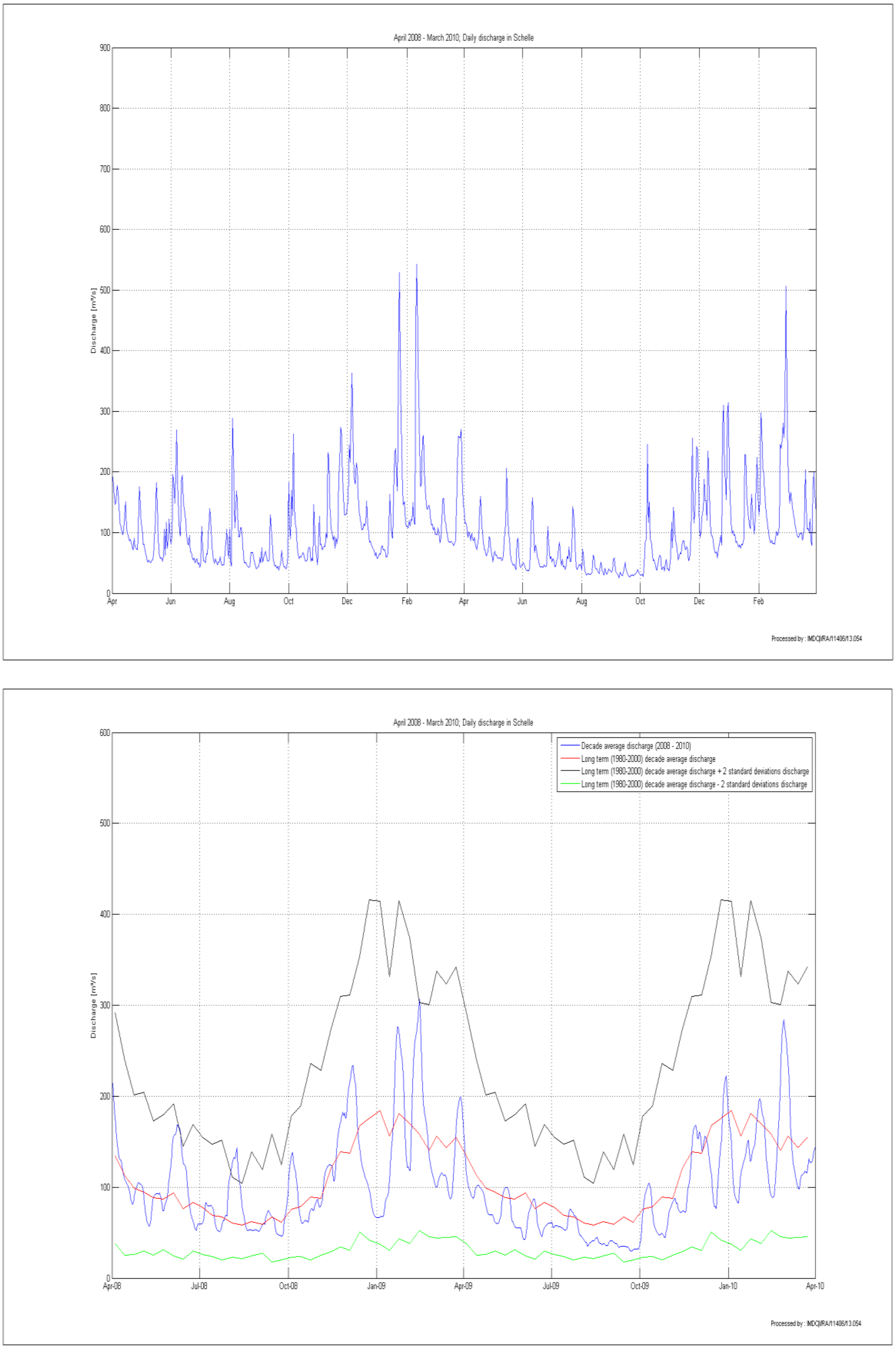
Annex-Figure B-4: Prosperpolder. Averaged (a) neap tide, (b) average tide and (c) spring tide curve, April 2008 – March 2010.



Annex-Figure B-5: Liefkenshoek. Averaged (a) neap tide, (b) average tide and (c) spring tide curve, April 2008 – March 2010.

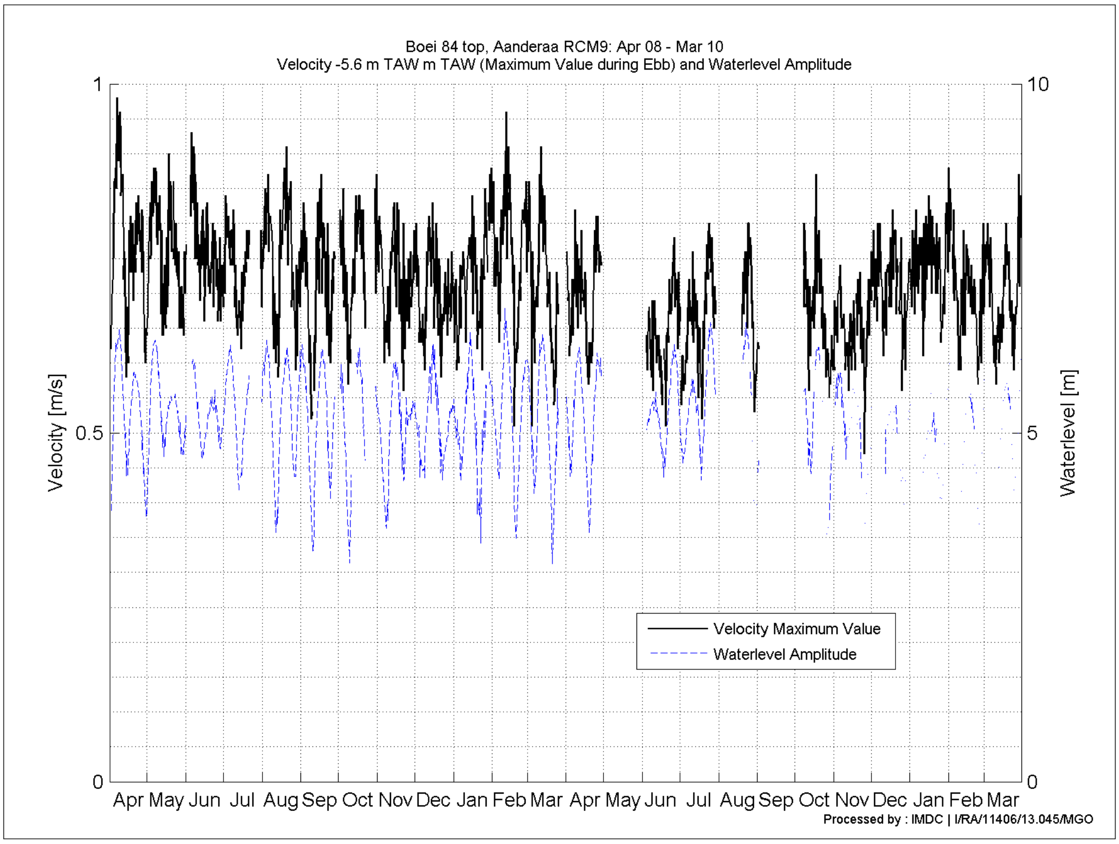


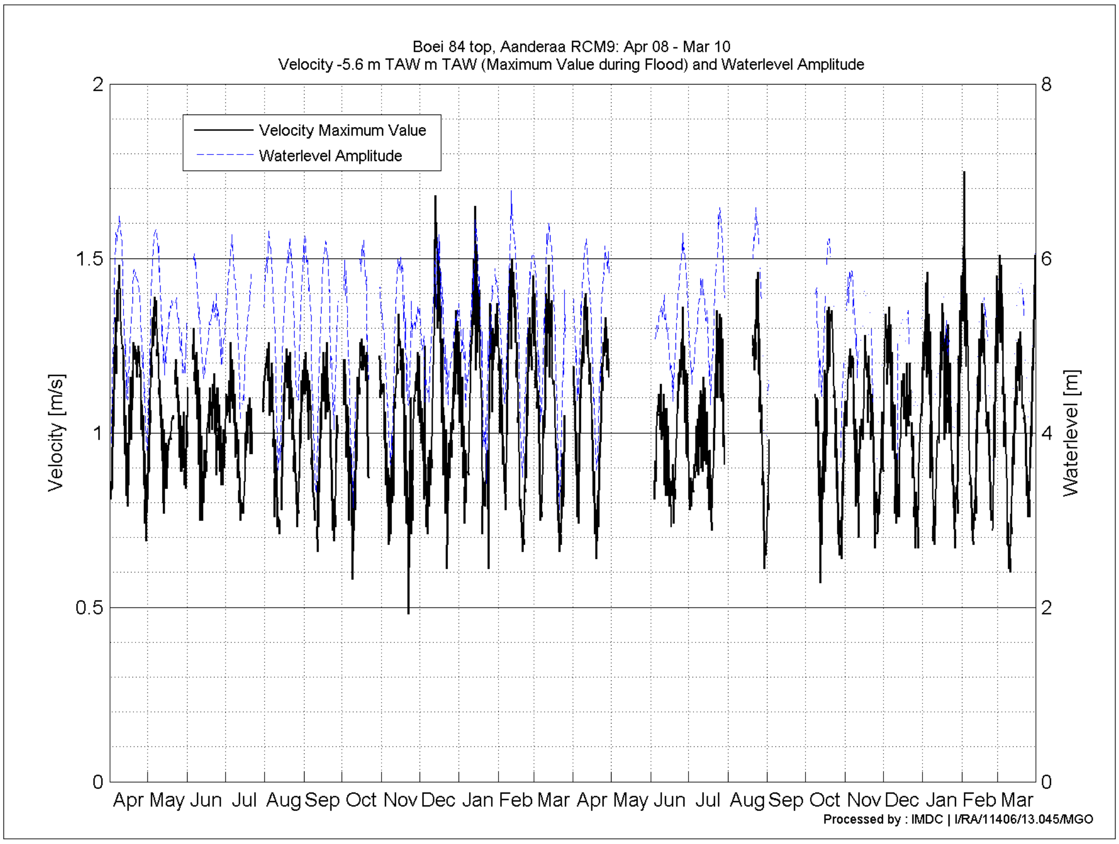
Annex-Figure B-6: Oosterweel. Averaged (a) neap tide, (b) average tide and (c) spring tide curve, April 2008 – March 2010.



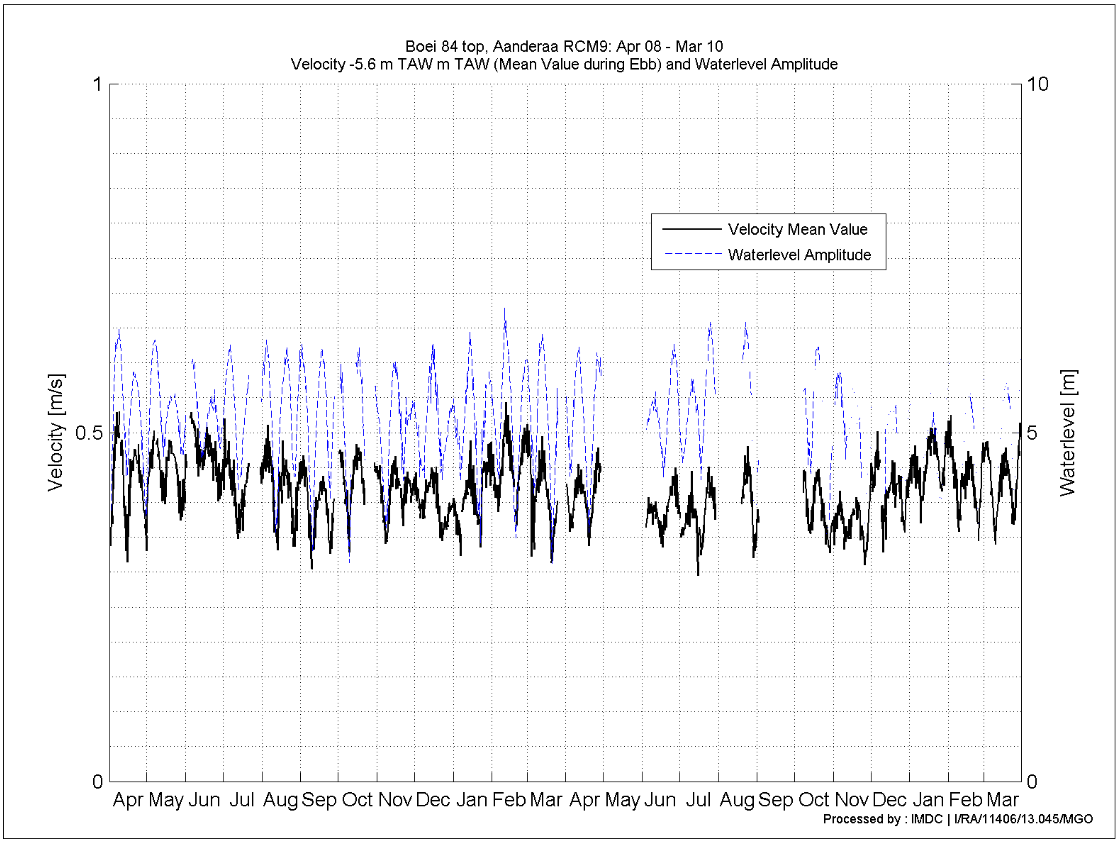
Annex-Figure B-7: (a) Day-averaged and (b) Decade-averaged Scheldt discharge at Schelle.

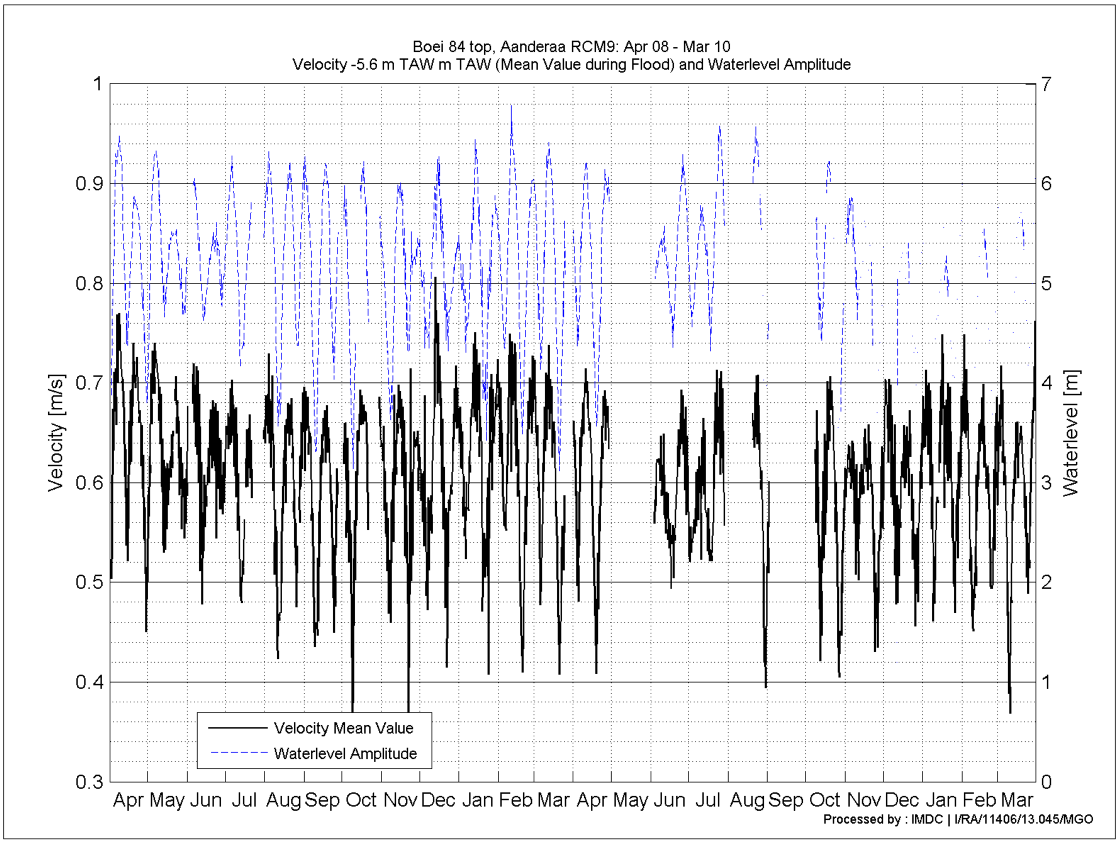
Annex C Figures for flow velocity and direction



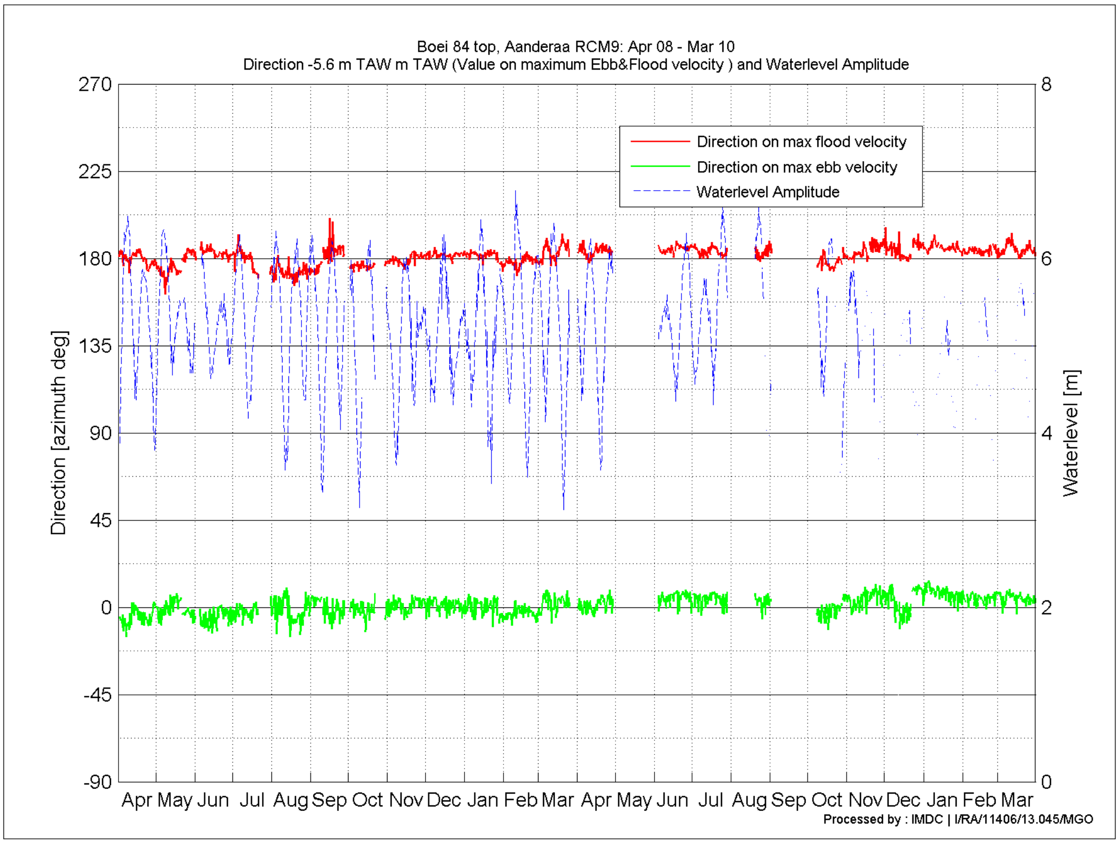


Annex-Figure C-1: Buoy 84 Top (-5.6 m TAW). Maximum (a) ebb & (b) flood phase velocity and tidal amplitude at Liefkenshoek, April 2008 – March 2010.

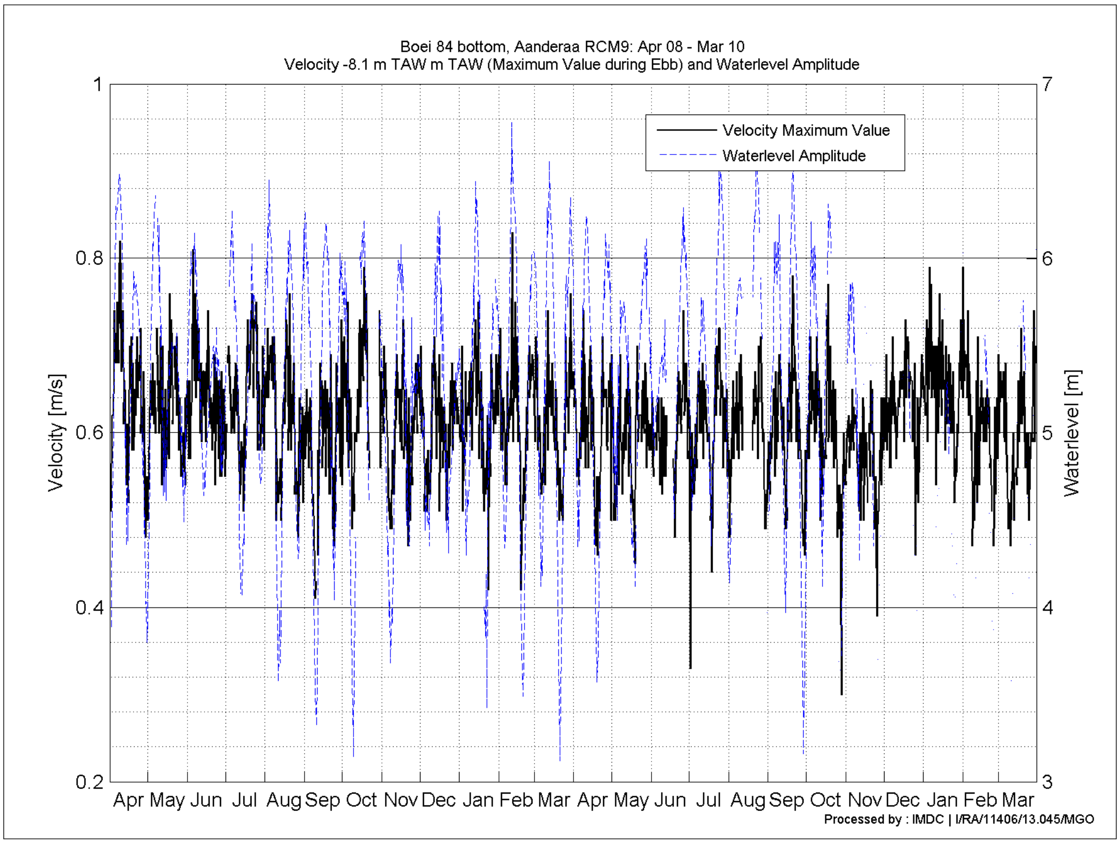


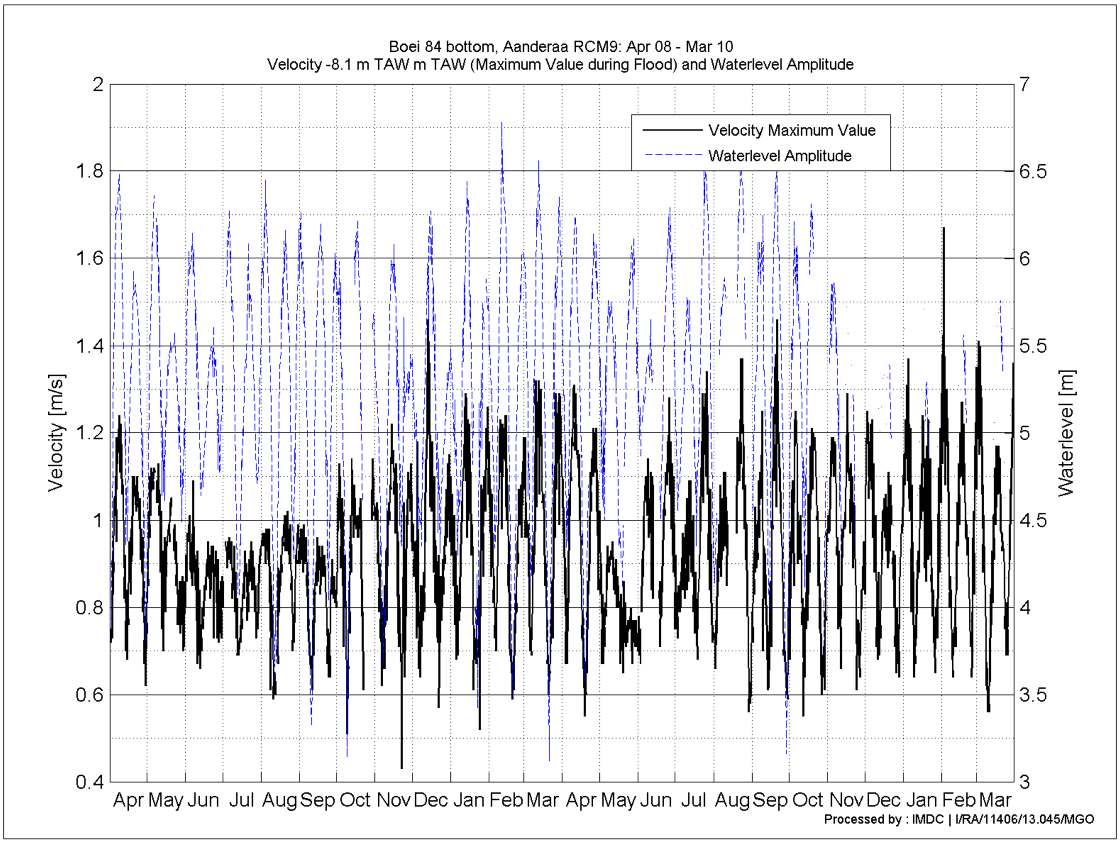


Annex-Figure C-2: Buoy 84 Top (-5.6 m TAW). Mean (a) ebb & (b) flood phase velocity and tidal amplitude at Liefkenshoek, April 2008 – March 2010.

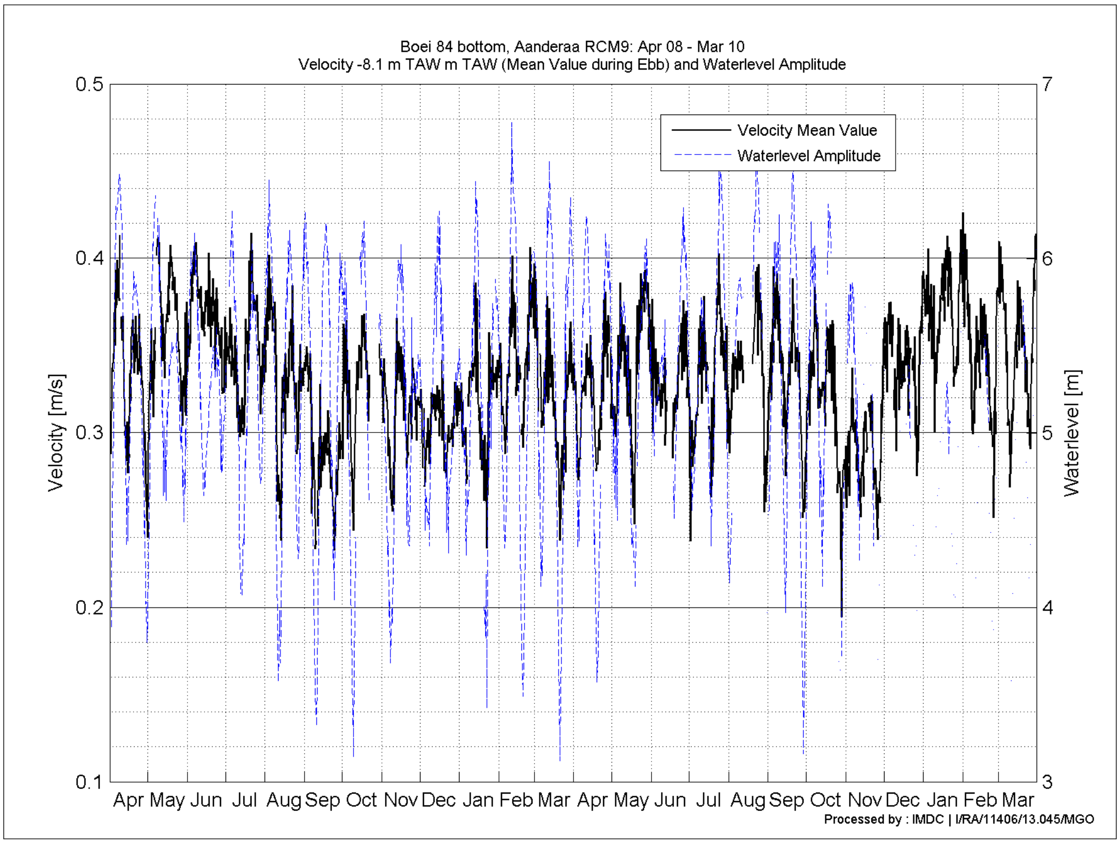


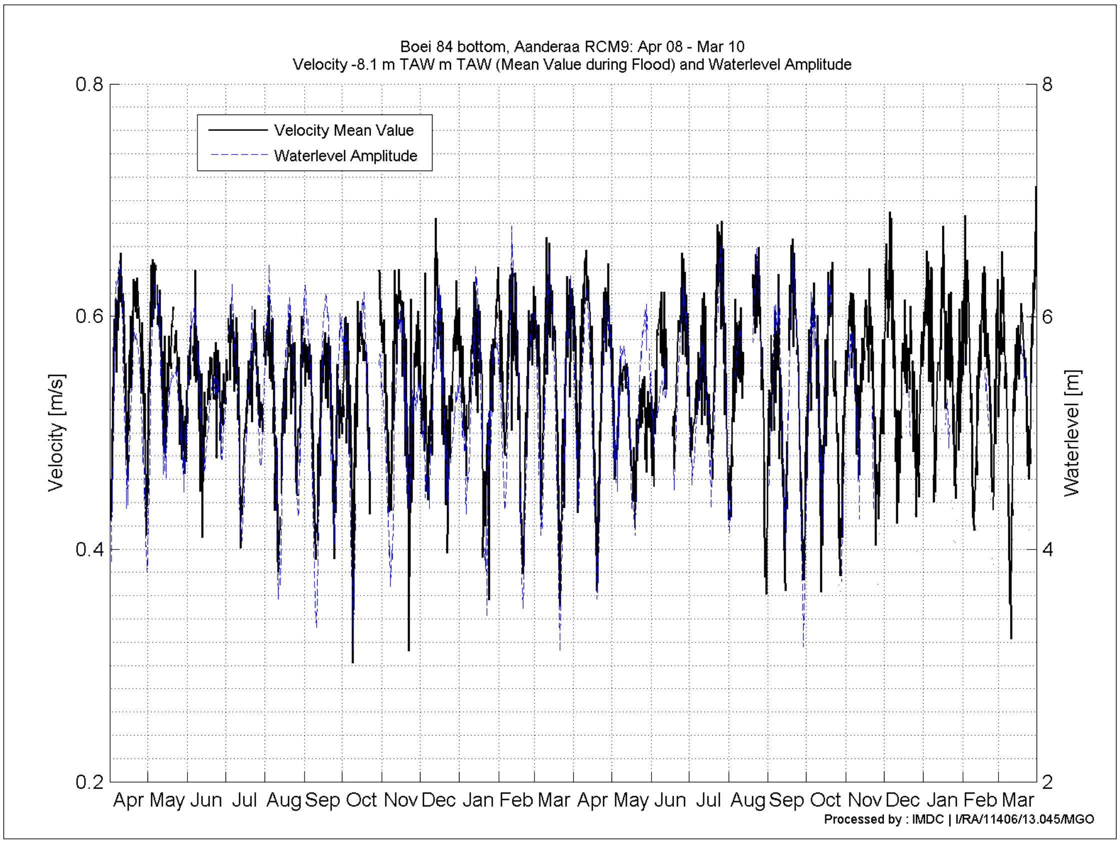
Annex-Figure C-3: Buoy 84 Top (-5.6 m TAW). Flow direction based on maximal ebb and flood phase velocity, and water level amplitude, April 2008 – March 2010.



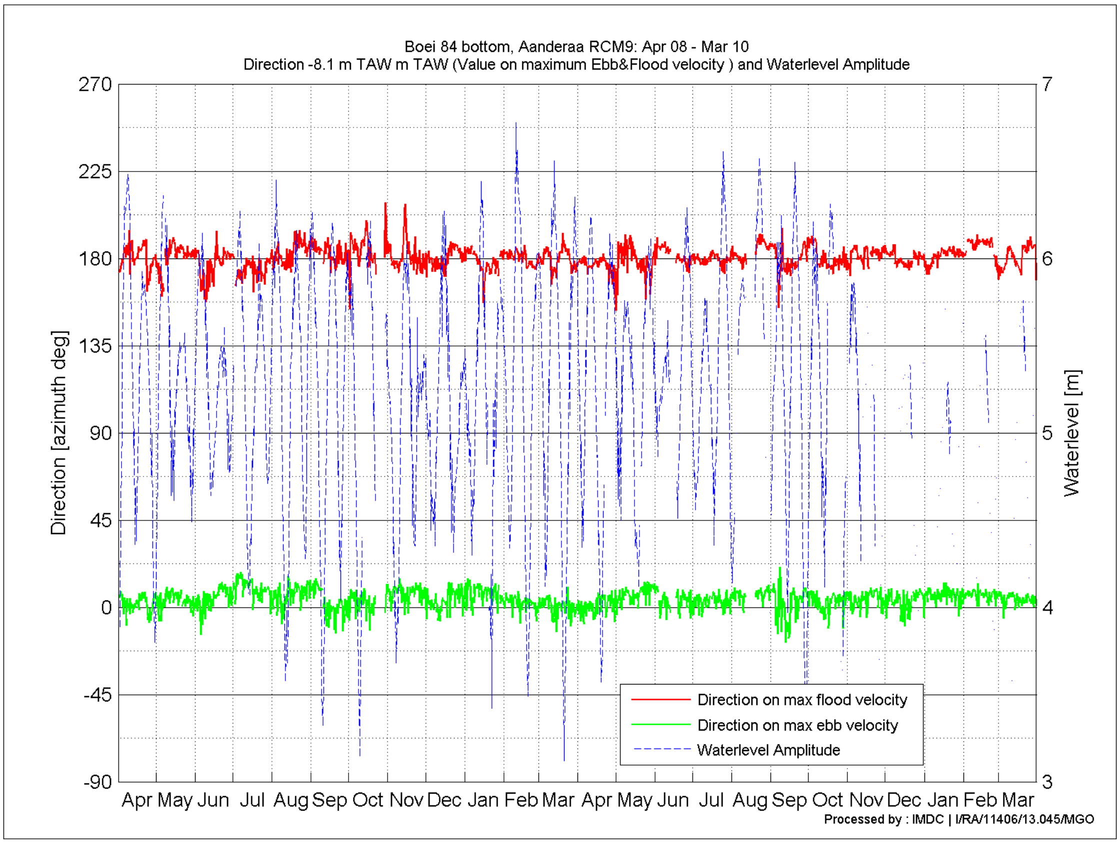


Annex-Figure C-4: Buoy 84 Bottom (-8.1 m TAW). Maximal (a) ebb & (b) flood phase velocity and tidal amplitude at Liefkenshoek, April 2008 – March 2010.

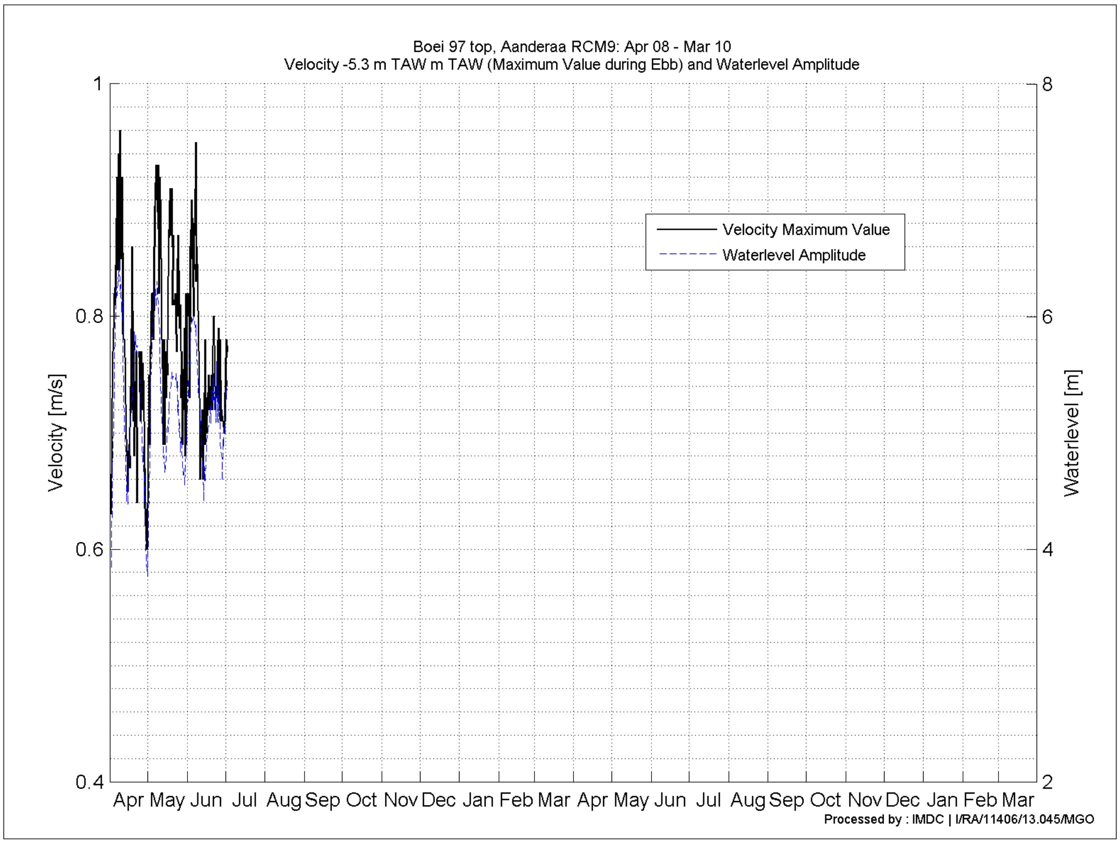


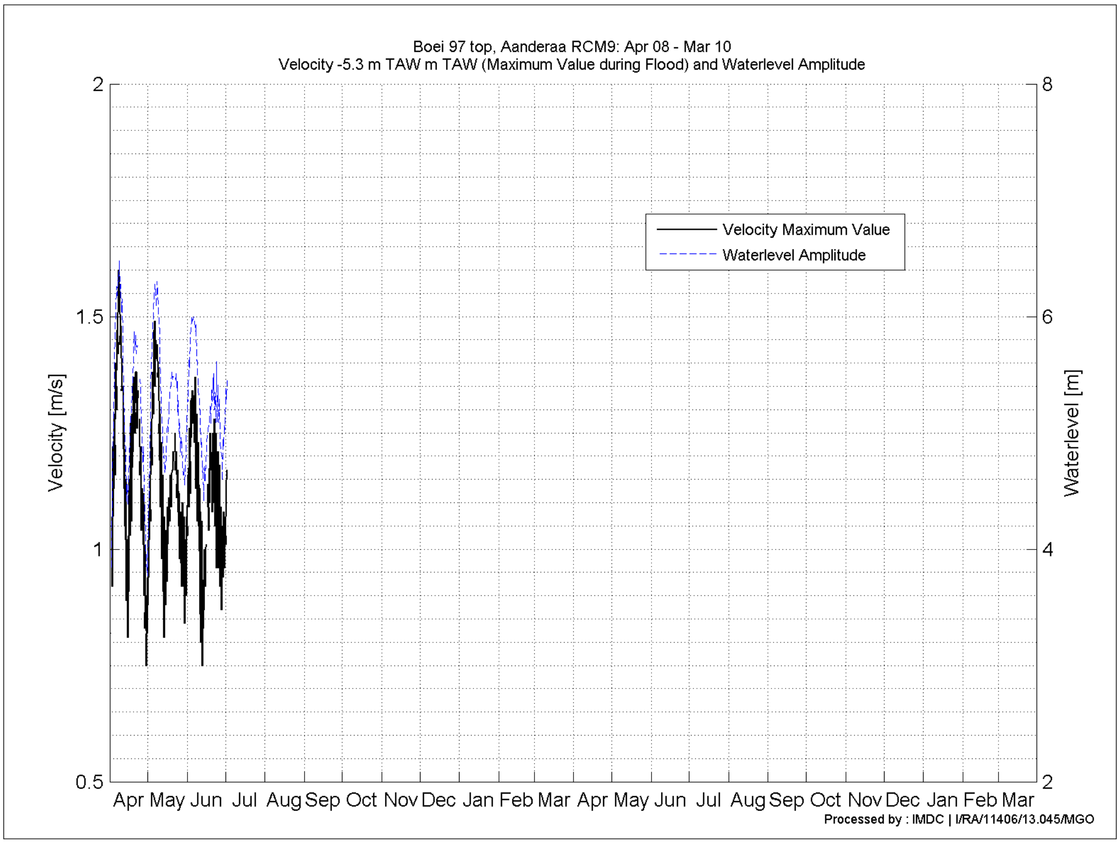


Annex-Figure C-5: Buoy 84 Bottom (-8.1 m TAW). Averaged (a) ebb & (b) flood phase velocity and tidal amplitude at Liefkenshoek, April 2008 – March 2010.

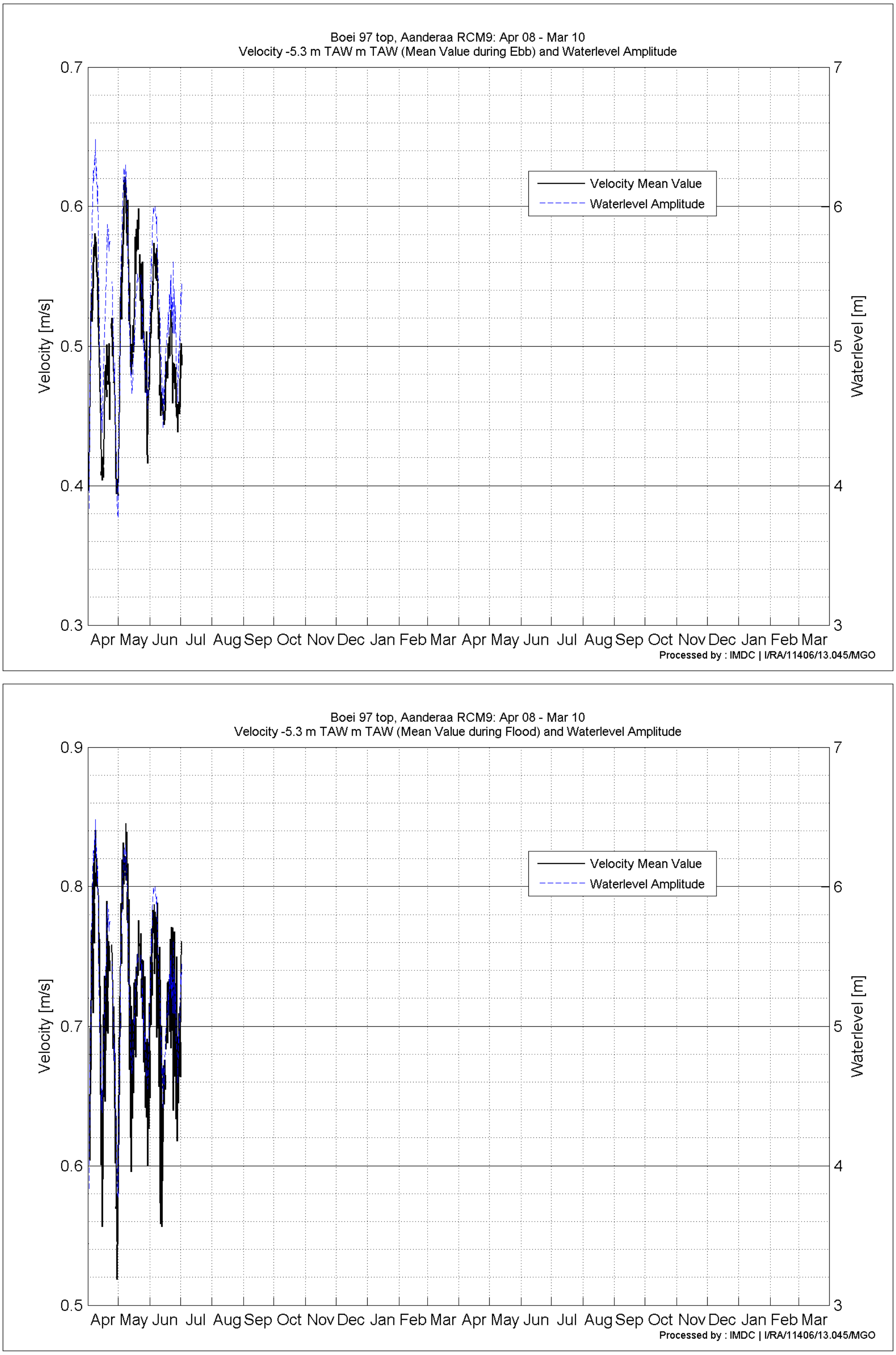


Annex-Figure C-6: Buoy 84 (-8.1 m TAW), Flow direction based on maximal ebb phase and flood phase velocity and water level amplitude, April 2008 – March 2010.

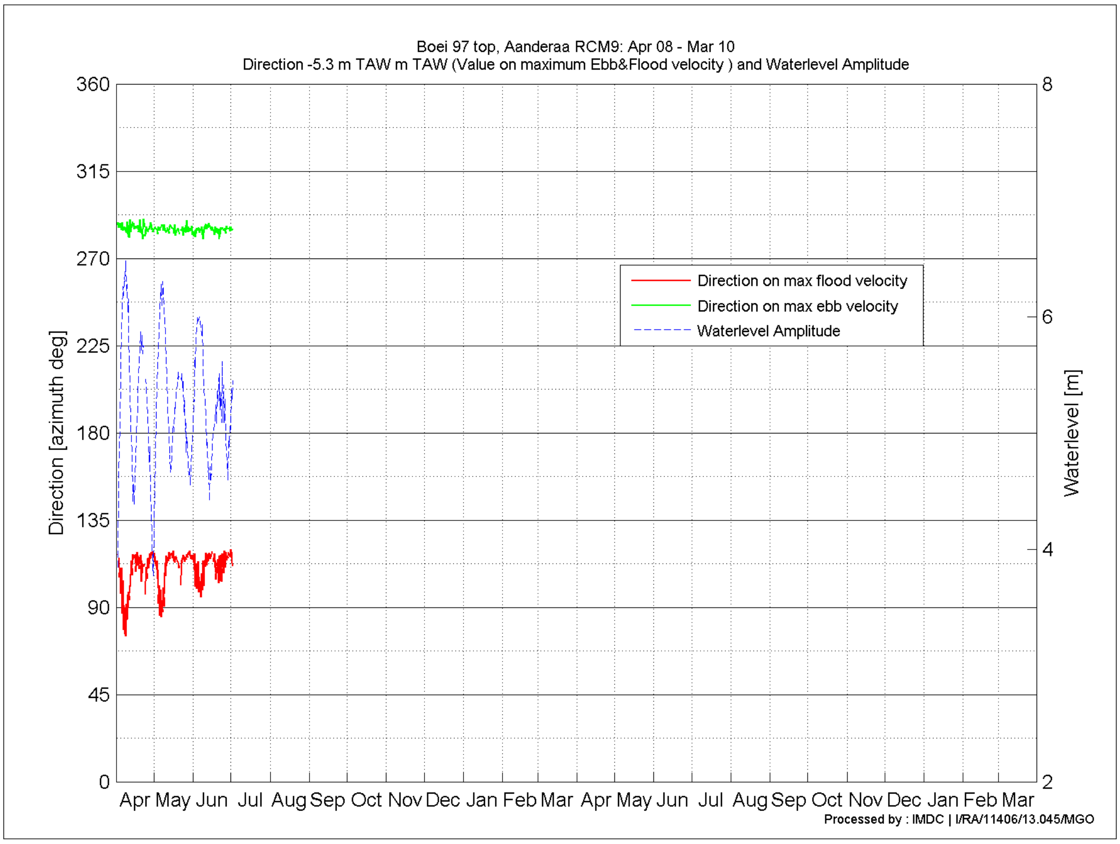




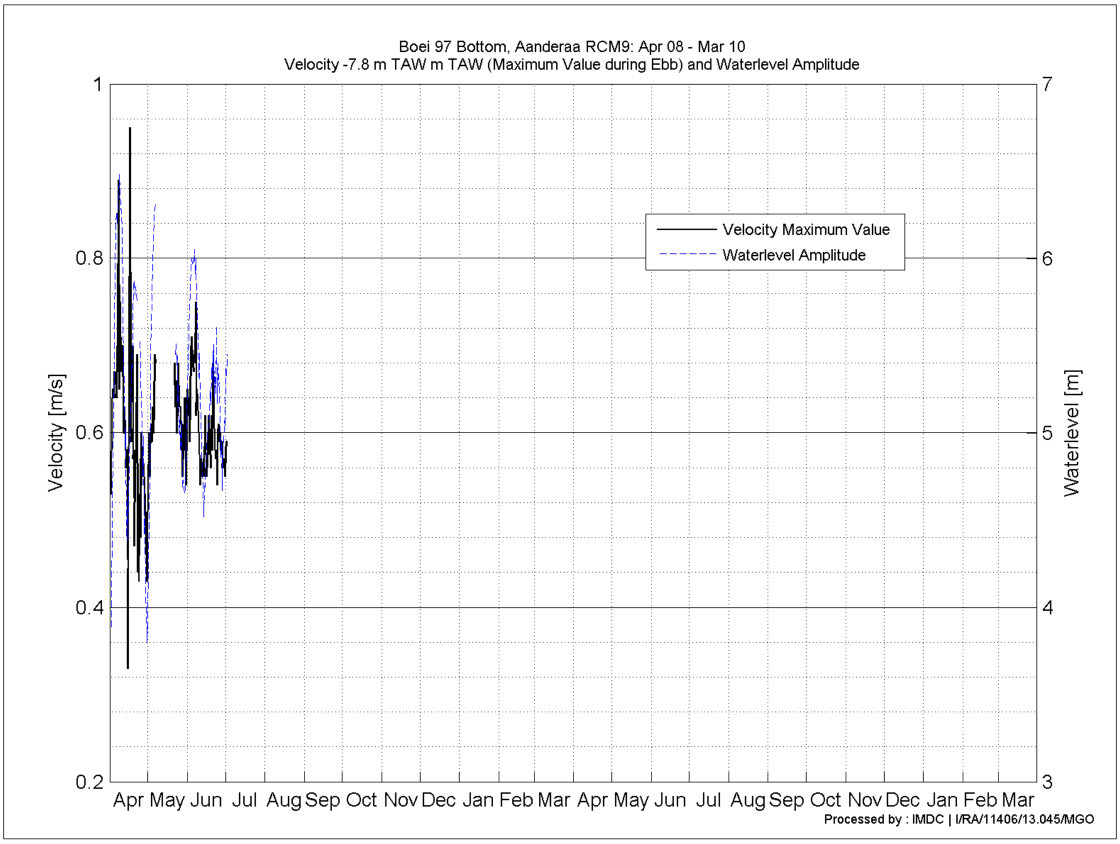
Annex-Figure C-7: Buoy 97 Top (-5.3 m TAW). Maximal (a) ebb & (b) flood phase velocity and tidal amplitude at Liefkenshoek, April 2008 – March 2010.

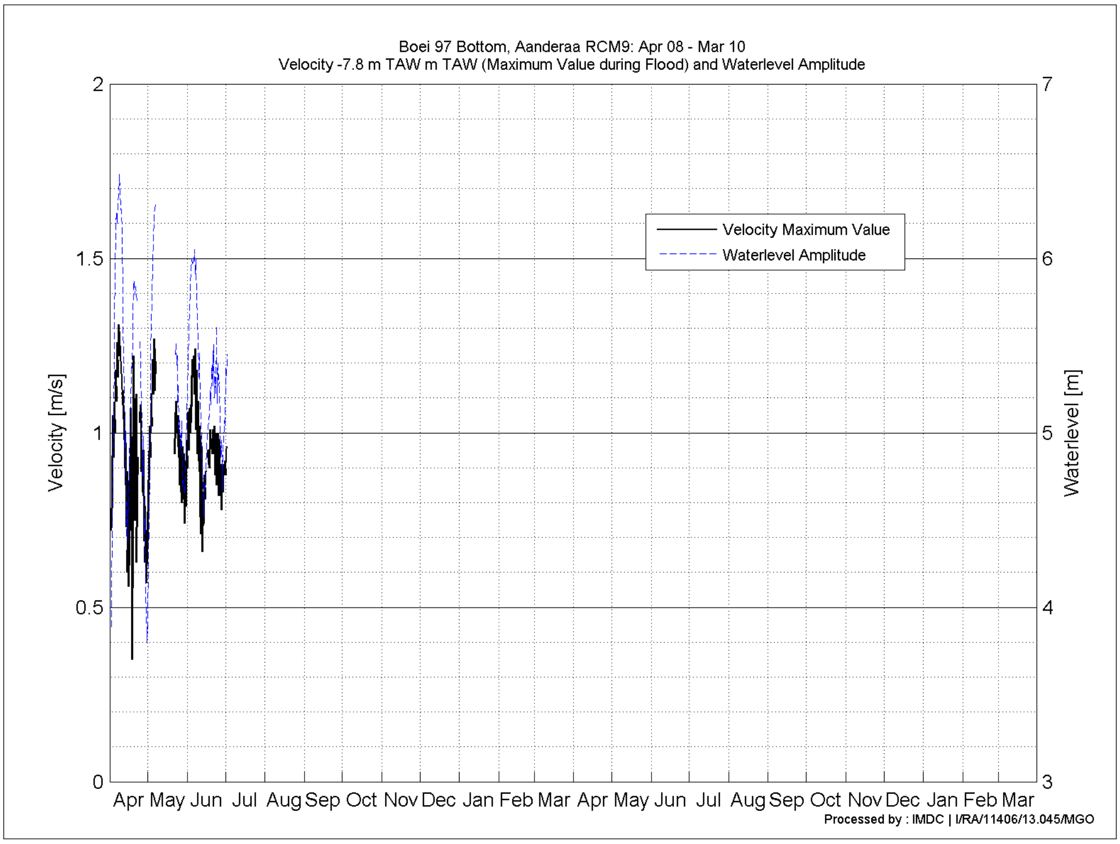


Annex-Figure C-8: Buoy 97 Top (-5.3 m TAW). Mean (a) ebb & (b) flood phase velocity and tidal amplitude at Liefkenshoek, April 2008 – March 2010.

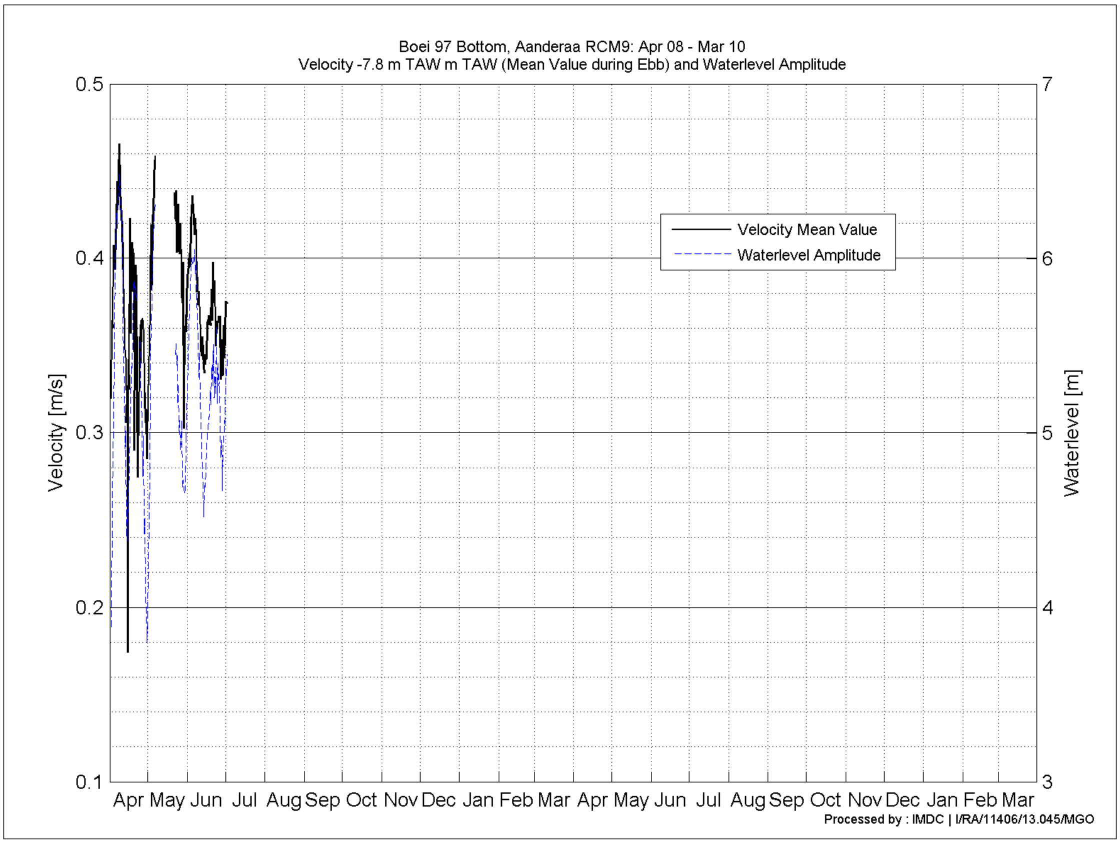


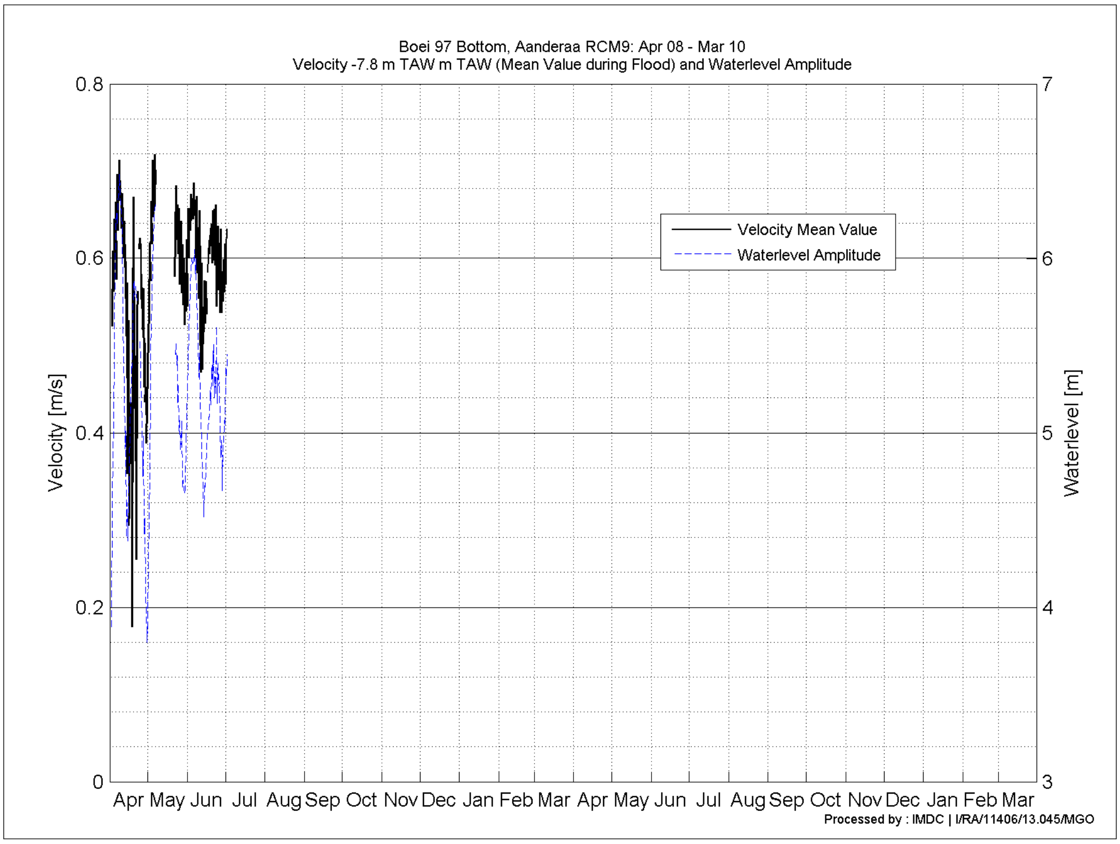
Annex-Figure C-9: Buoy 97 Top (-5.3 m TAW). Flow direction on maximal ebb phase and flood phase velocity and water level amplitude, April 2008 – March 2010.



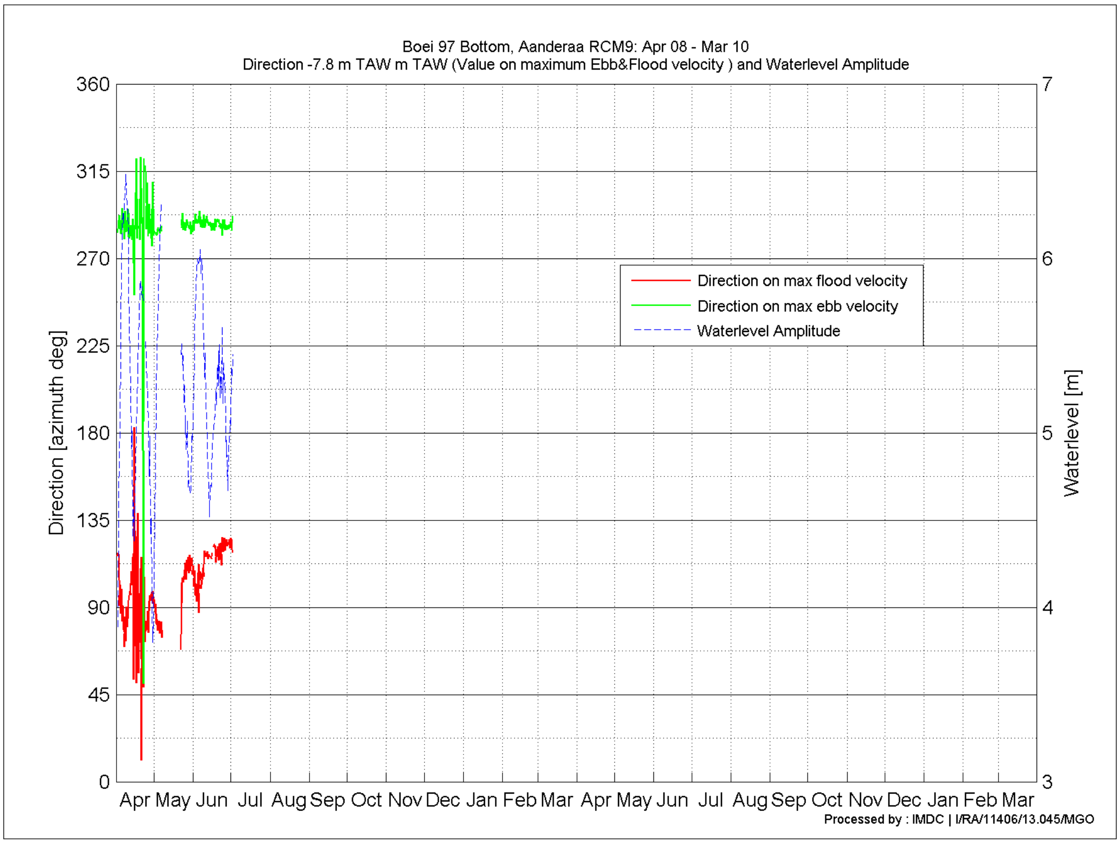


Annex-Figure C-10: Buoy 97 Bottom (-7.8 m TAW). Maximal (a) ebb & (b) flood phase velocity and tidal amplitude at Liefkenshoek, April 2008 – March 2010.

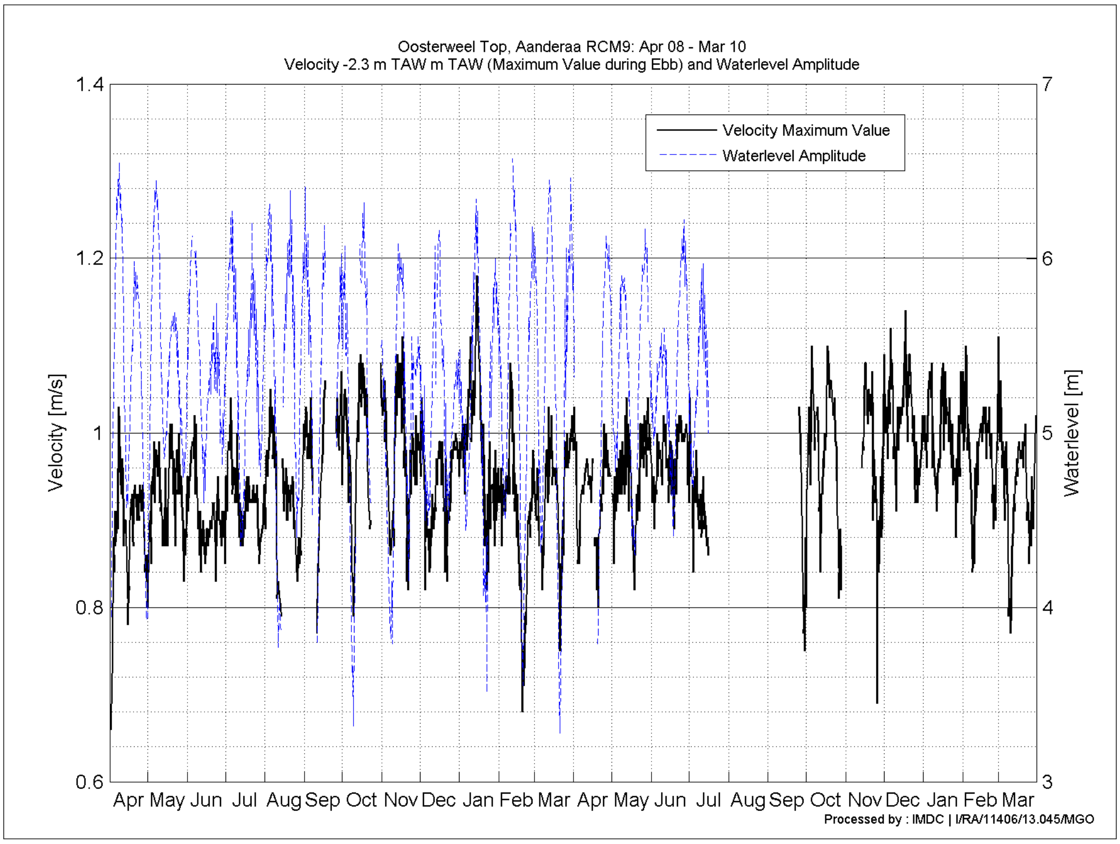


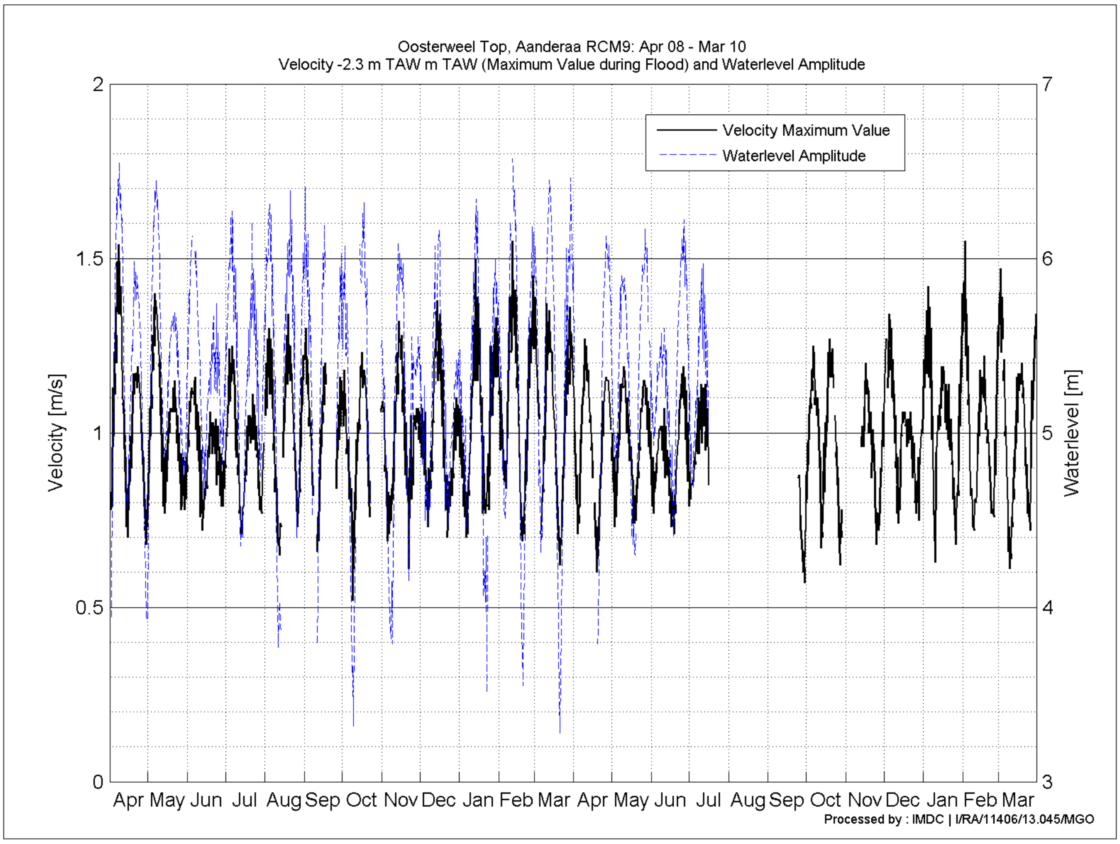


Annex-Figure C-11: Buoy 97 Bottom (-7.8 m TAW). Mean (a) ebb & (b) flood phase velocity and tidal amplitude at Liefkenshoek, April 2008 – March 2010.

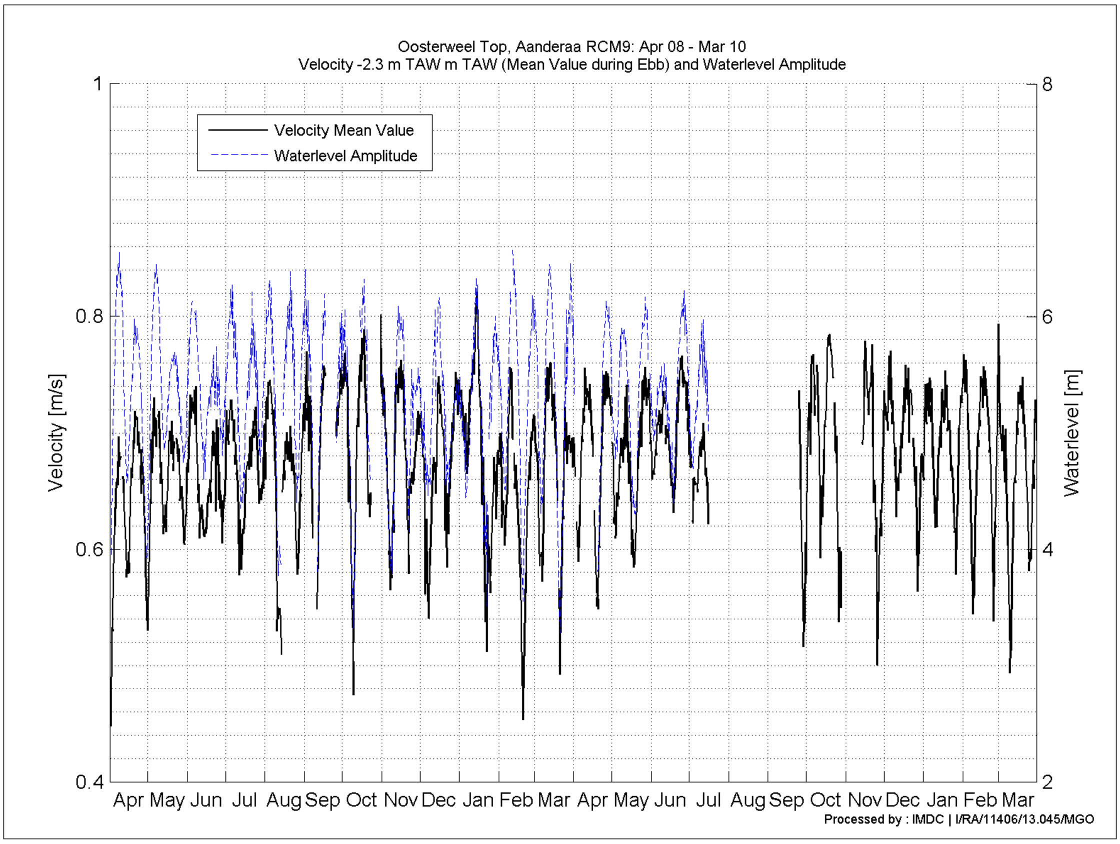


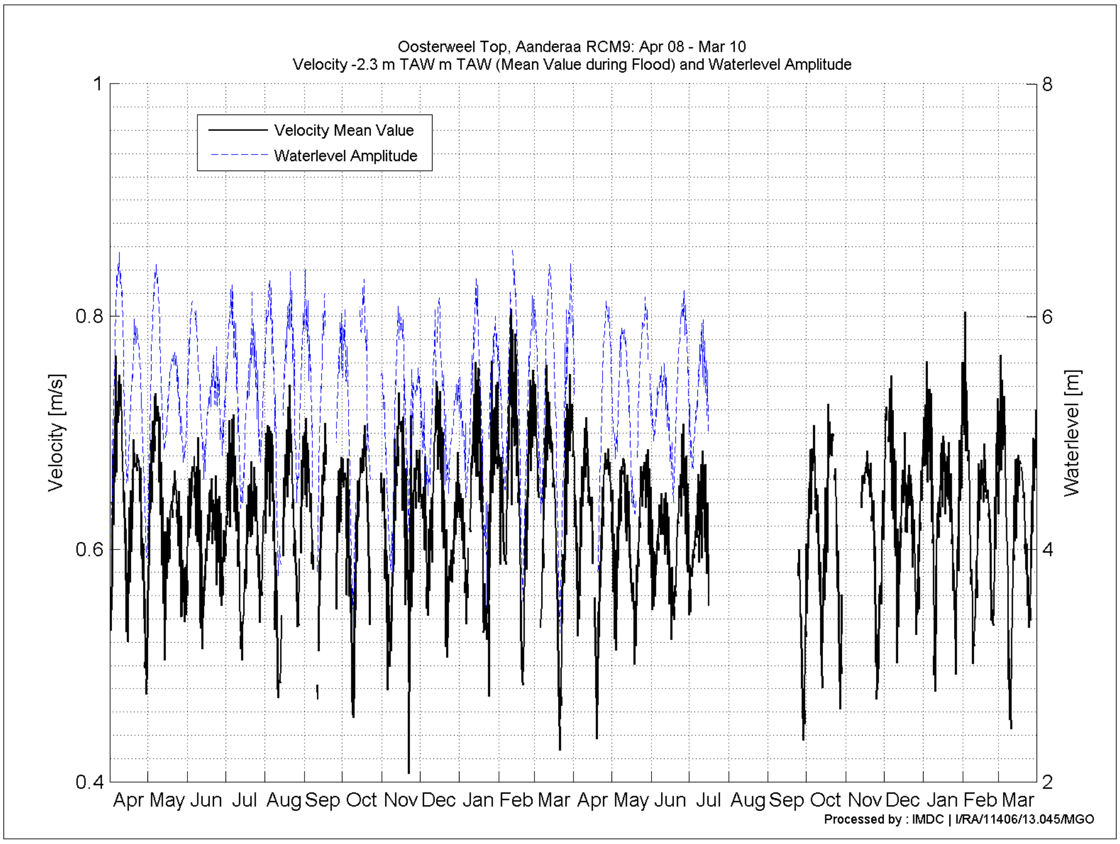
Annex-Figure C-12: Buoy 97 Bottom (-7.8 m TAW). Flow direction based on maximal ebb phase and flood phase velocity and water level amplitude, April 2008 – March 2010.



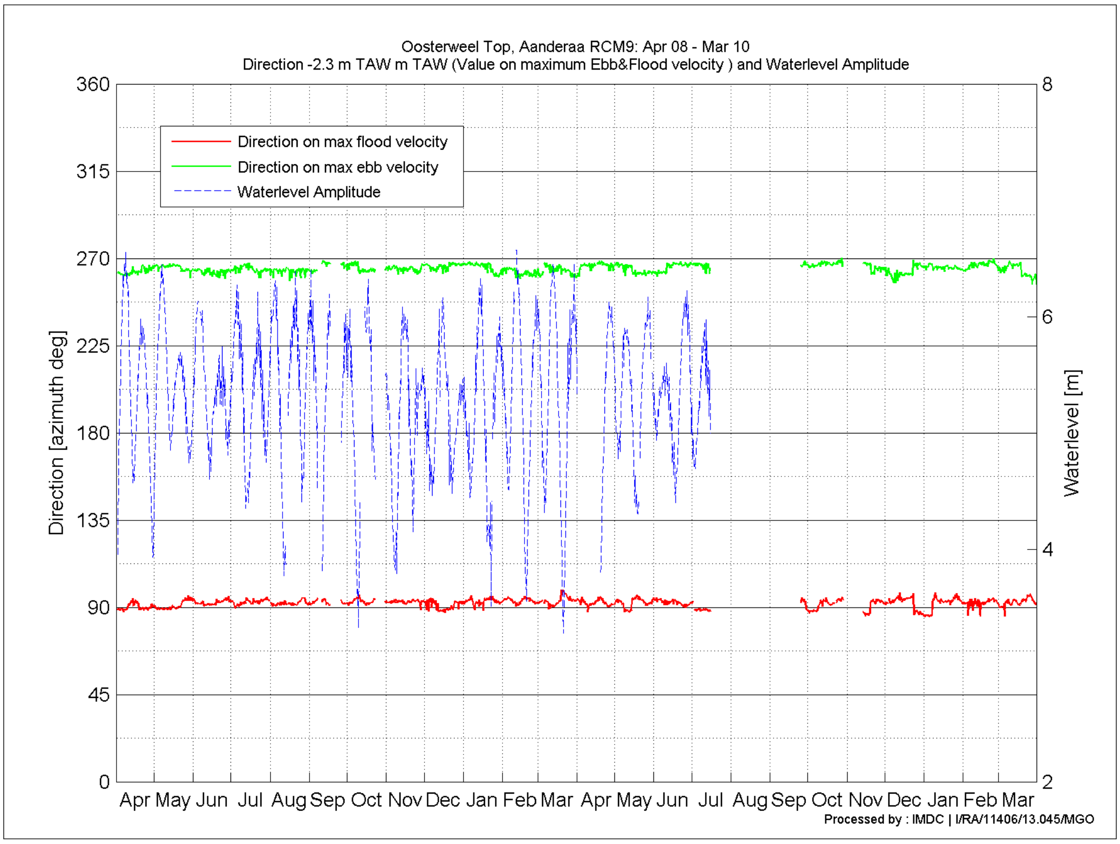


Annex-Figure C-13: Oosterweel Top (-2.3 m TAW). Maximal (a) ebb & (b) flood phase velocity and tidal amplitude at Oosterweel, April 2008 – March 2010.

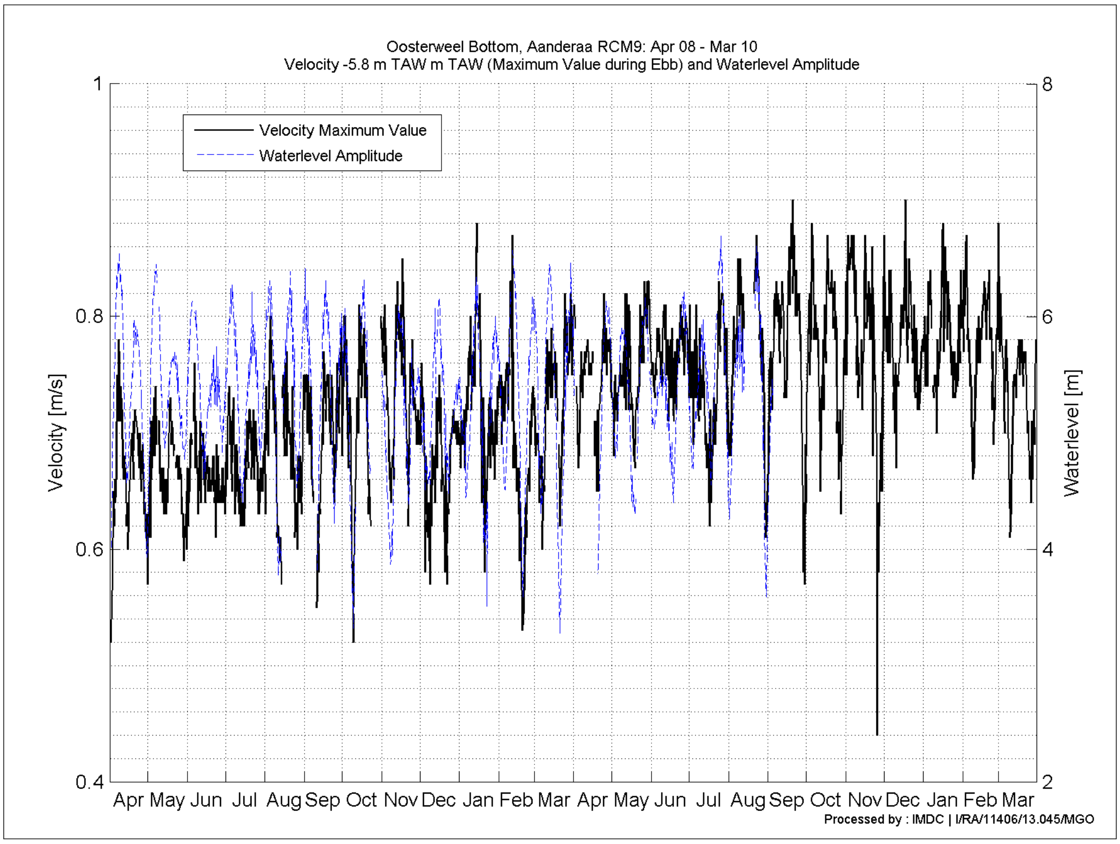


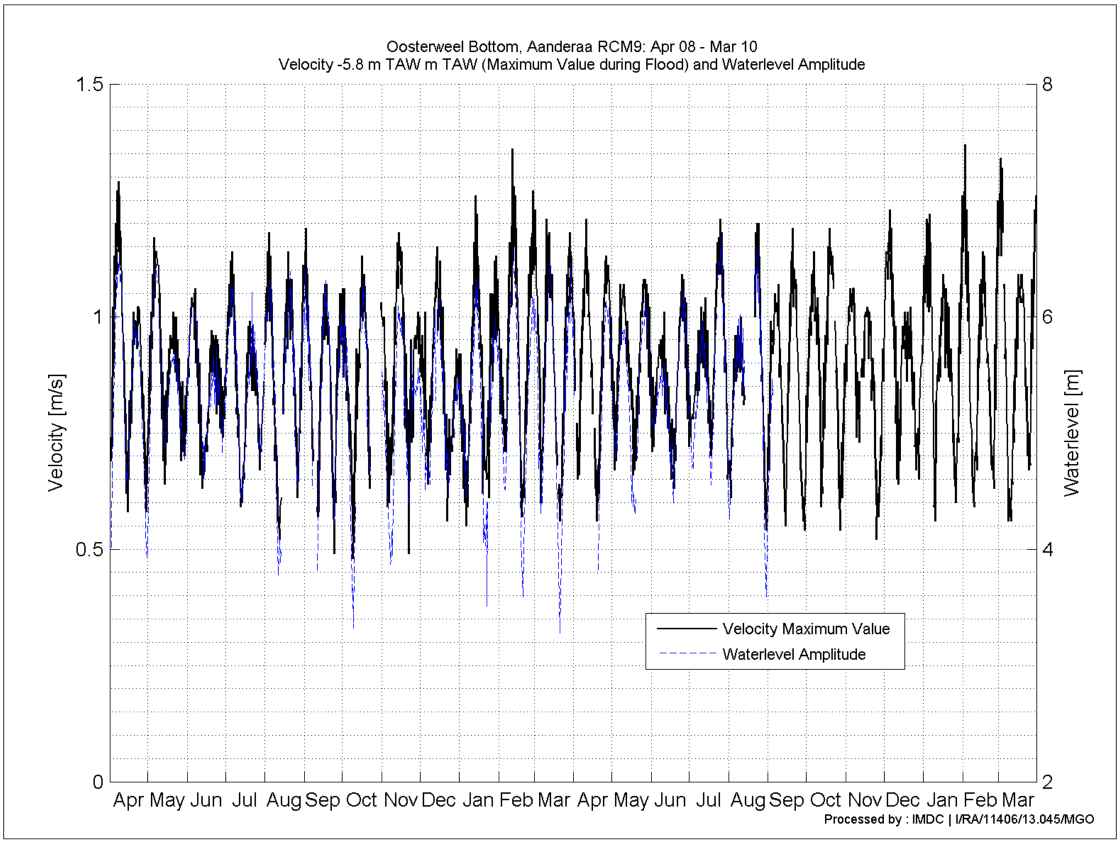


Annex-Figure C-14: Oosterweel Top (-2.3 m TAW). Mean (a) ebb & (b) flood phase velocity and tidal amplitude at Oosterweel, April 2008 – March 2010.

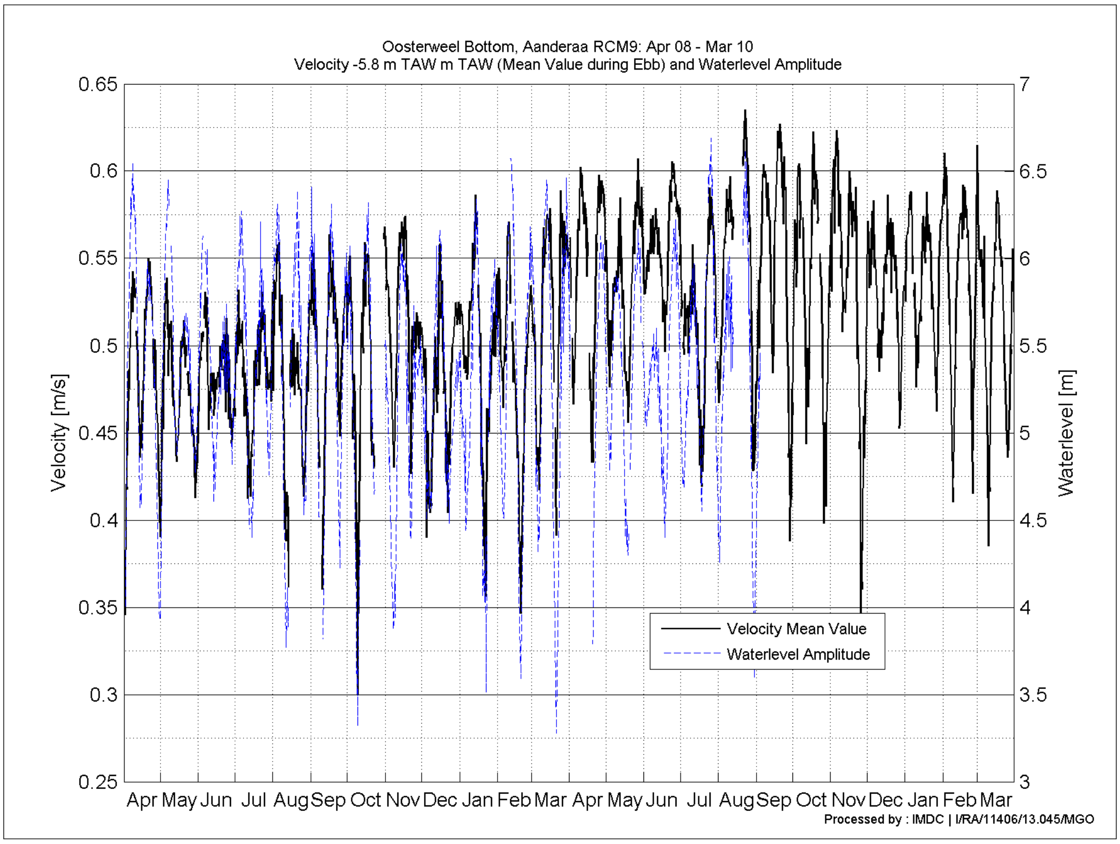


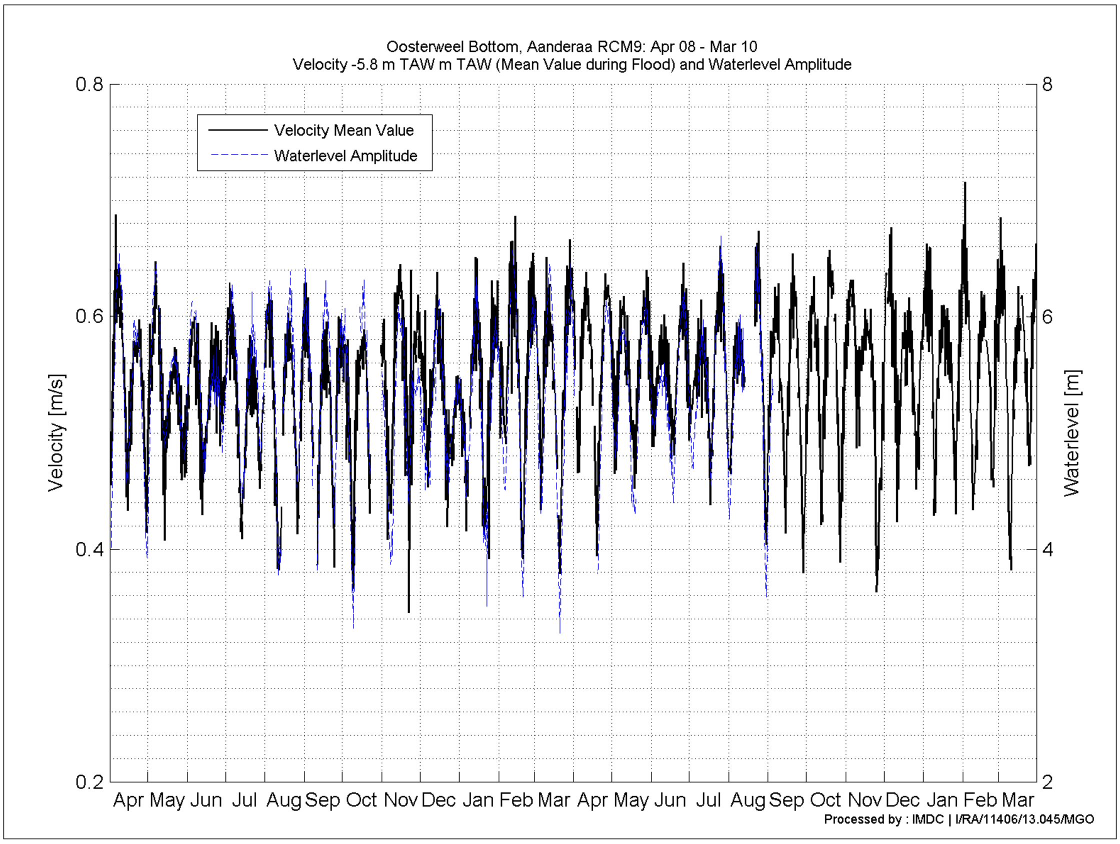
Annex-Figure C-15: Oosterweel Top (-2.3 m TAW). Flow direction on maximal ebb phase and flood phase velocity and water level amplitude, April 2008 – March 2010.



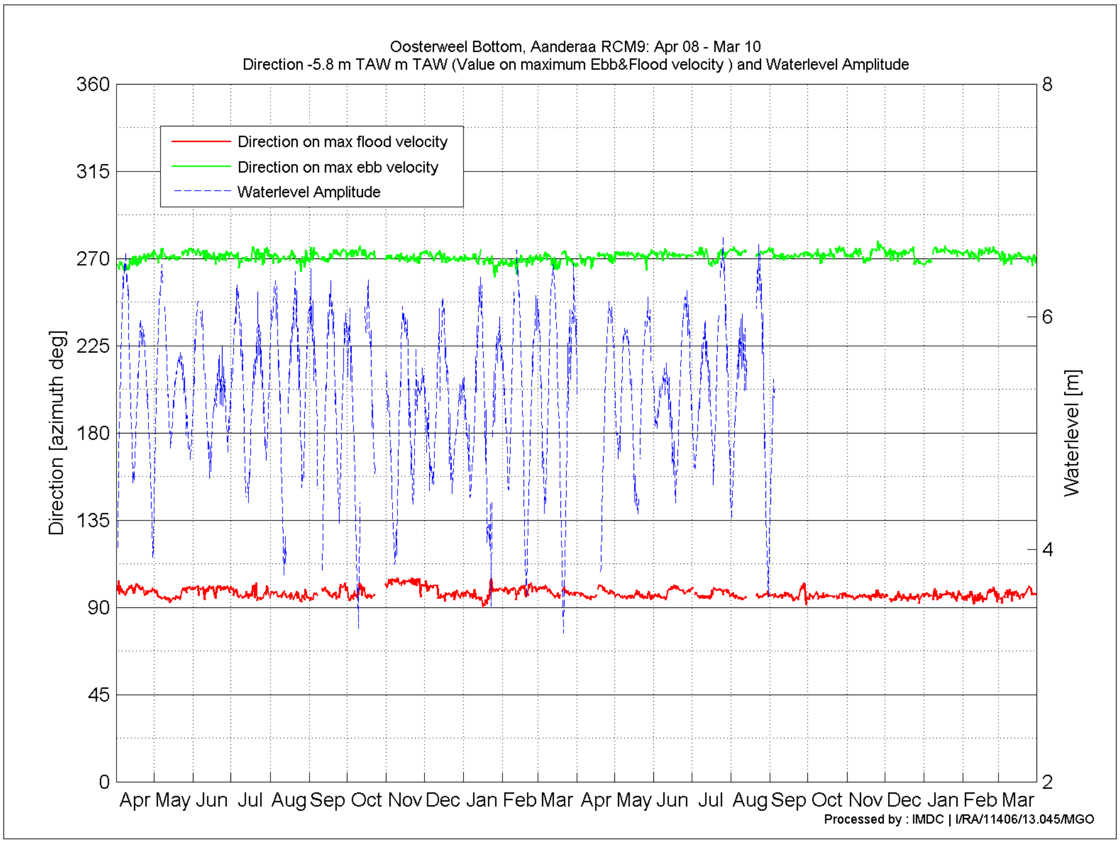


Annex-Figure C-16: Oosterweel Bottom (-5.8 m TAW). Maximal (a) ebb & (b) flood phase velocity and tidal amplitude at Oosterweel, April 2008 – March 2010.

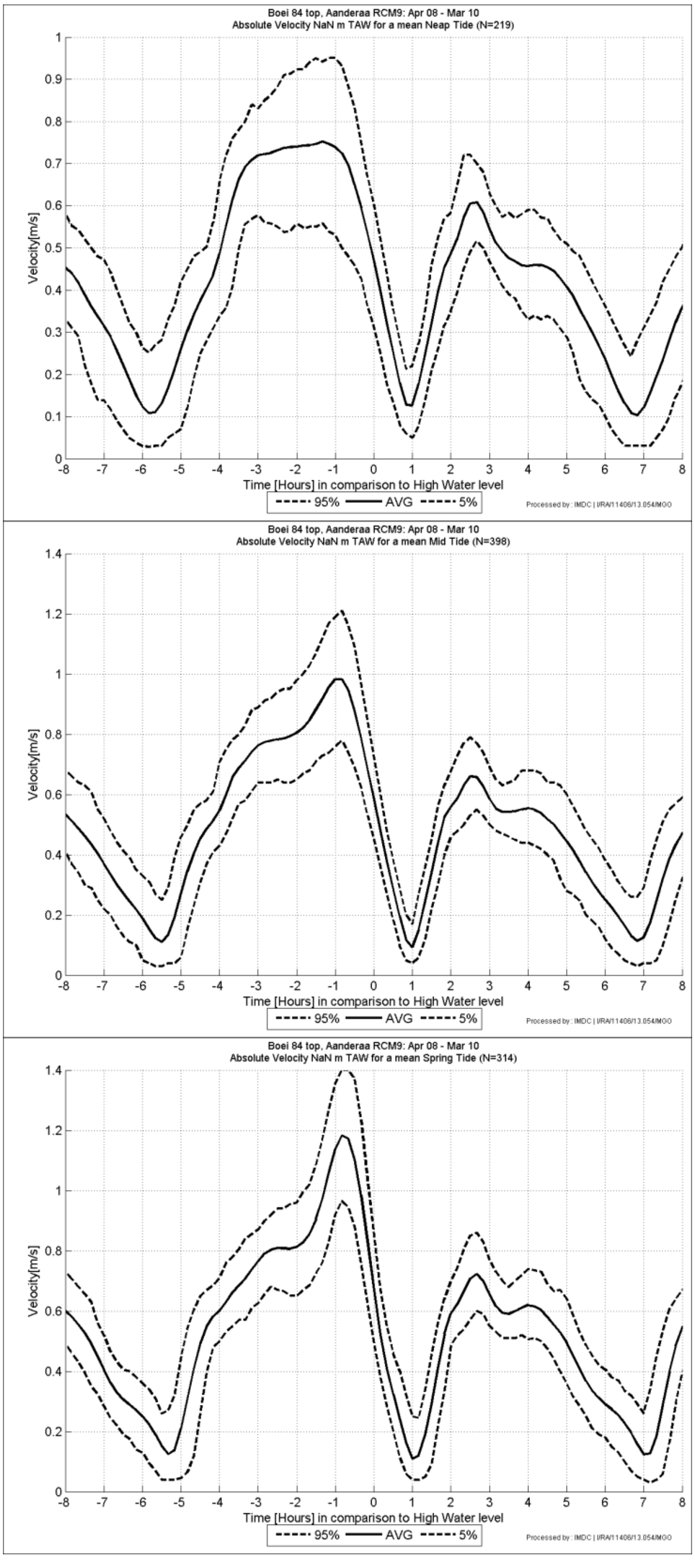




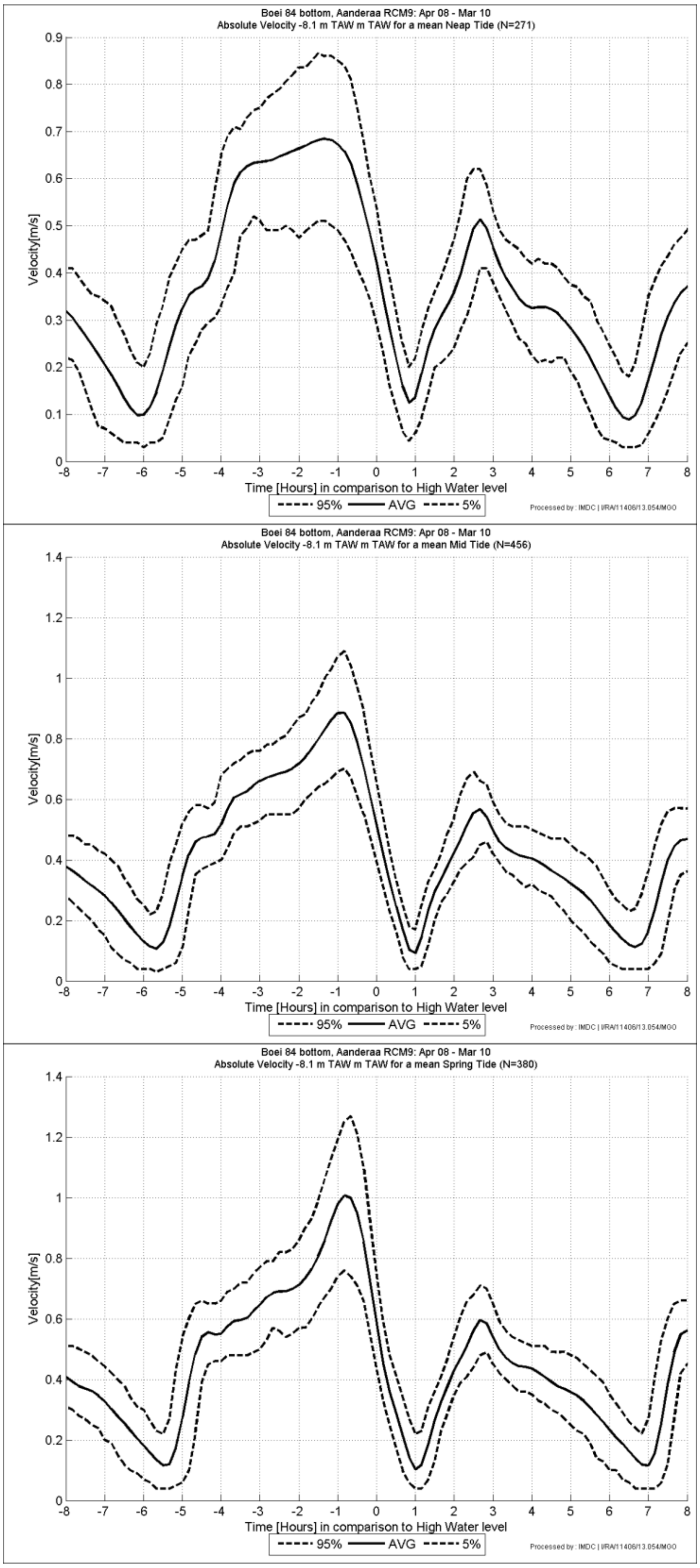
Annex-Figure C-17: Oosterweel Bottom (-5.8 m TAW). Mean (a) ebb & (b) flood phase velocity and tidal amplitude at Oosterweel, April 2008 – March 2010.



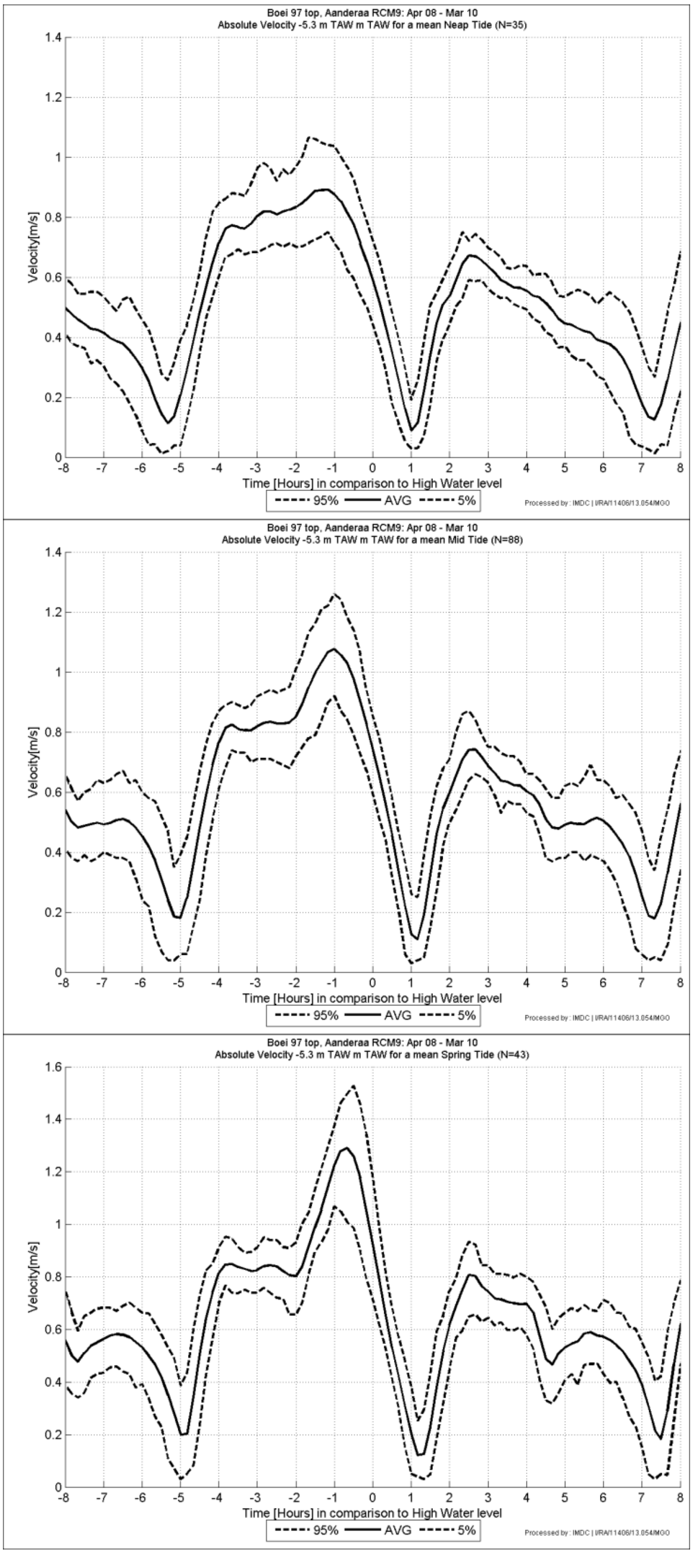
Annex-Figure C-18: Oosterweel Bottom (-5.8 m TAW). Flow direction on maximal ebb phase and flood phase velocity and water level amplitude, April 2008 – March 2010.



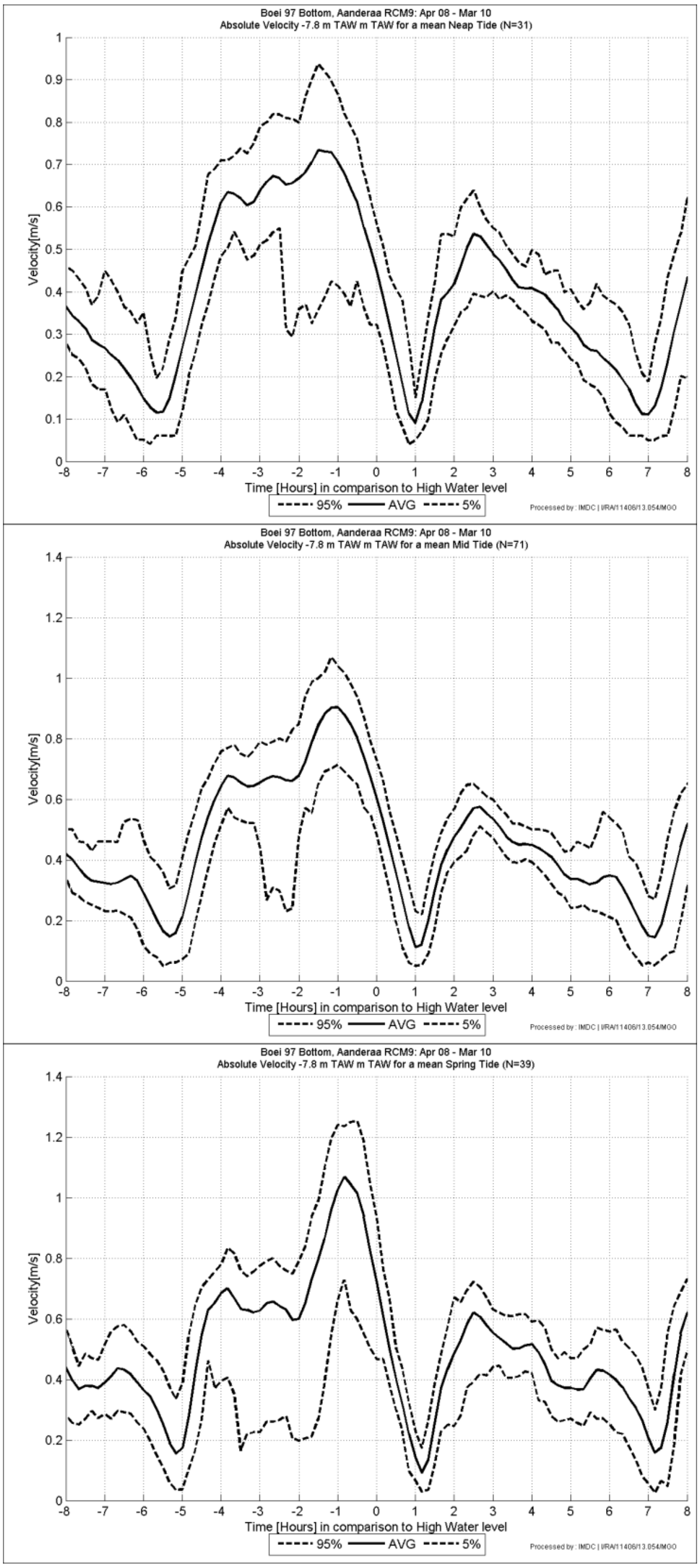
Annex-Figure C-19: Buoy 84 (-5.6 m TAW). Averaged tidal curve of the flow velocity for (a) a neap, (b) an average and (c) a spring tide, April 2008 – March 2010.



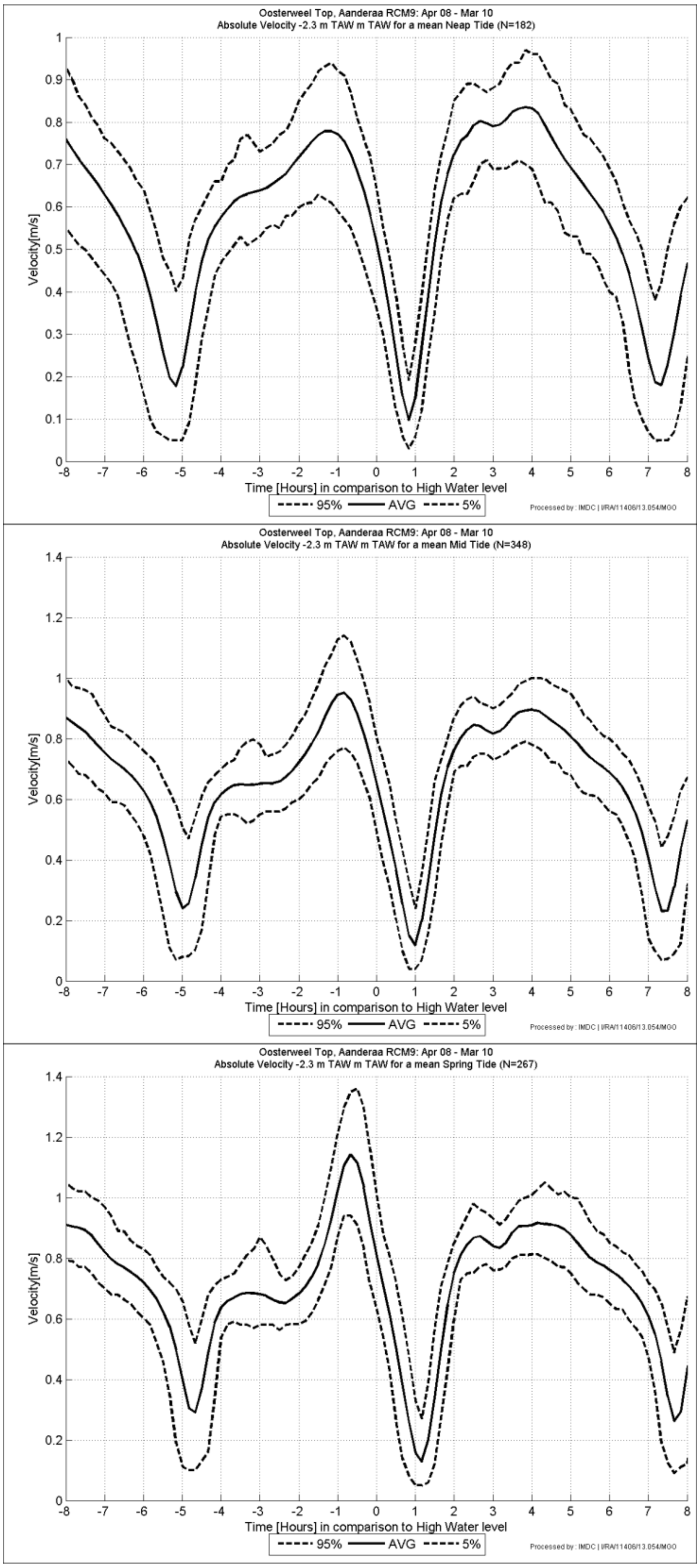
Annex-Figure C-20: Buoy 84 (-8.1m TAW). Averaged tidal curve of the flow velocity for (a) a neap, (b) an average and (c) a spring tide, April 2008 – March 2010.



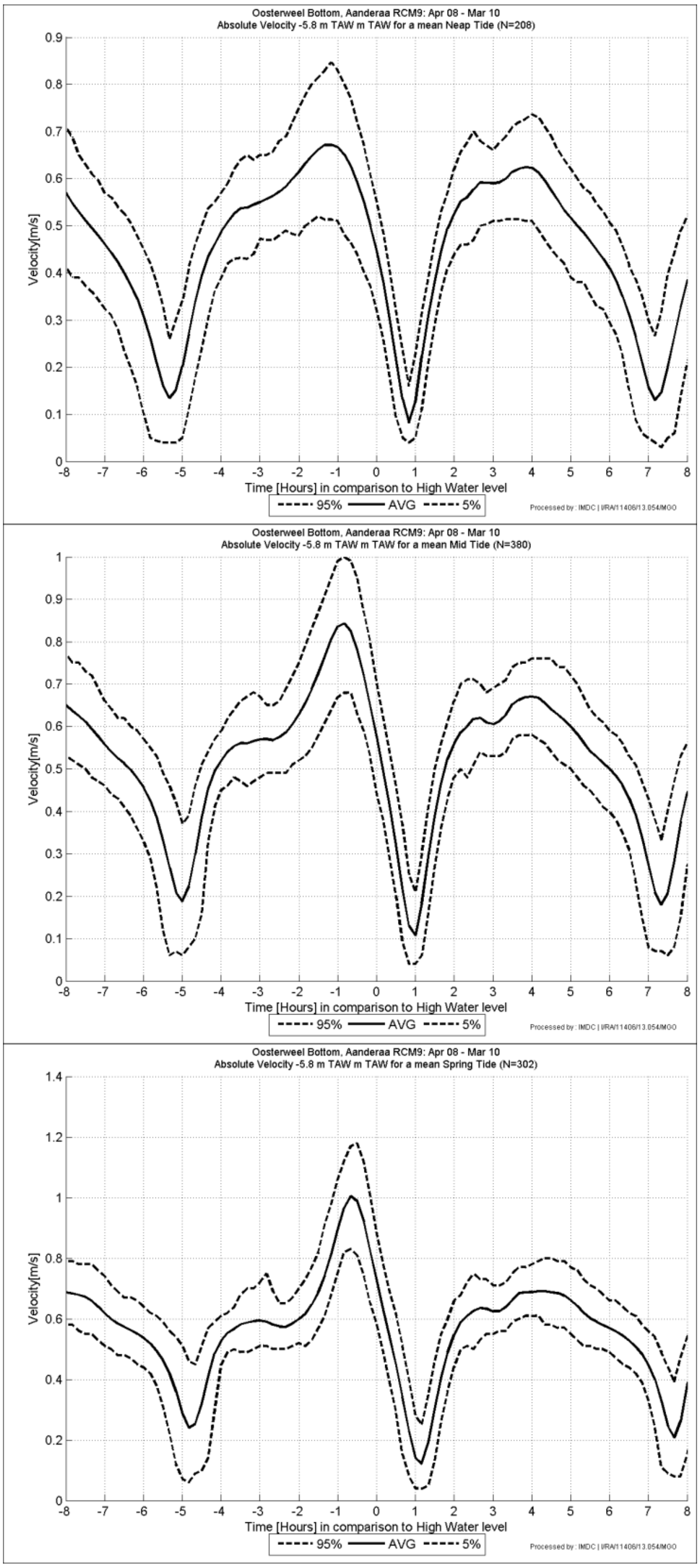
Annex-Figure C-21: Buoy 97 (-5.3m TAW). Averaged tidal curve of the flow velocity for (a) a neap, (b) an average and (c) a spring tide, April 2008 – March 2010.



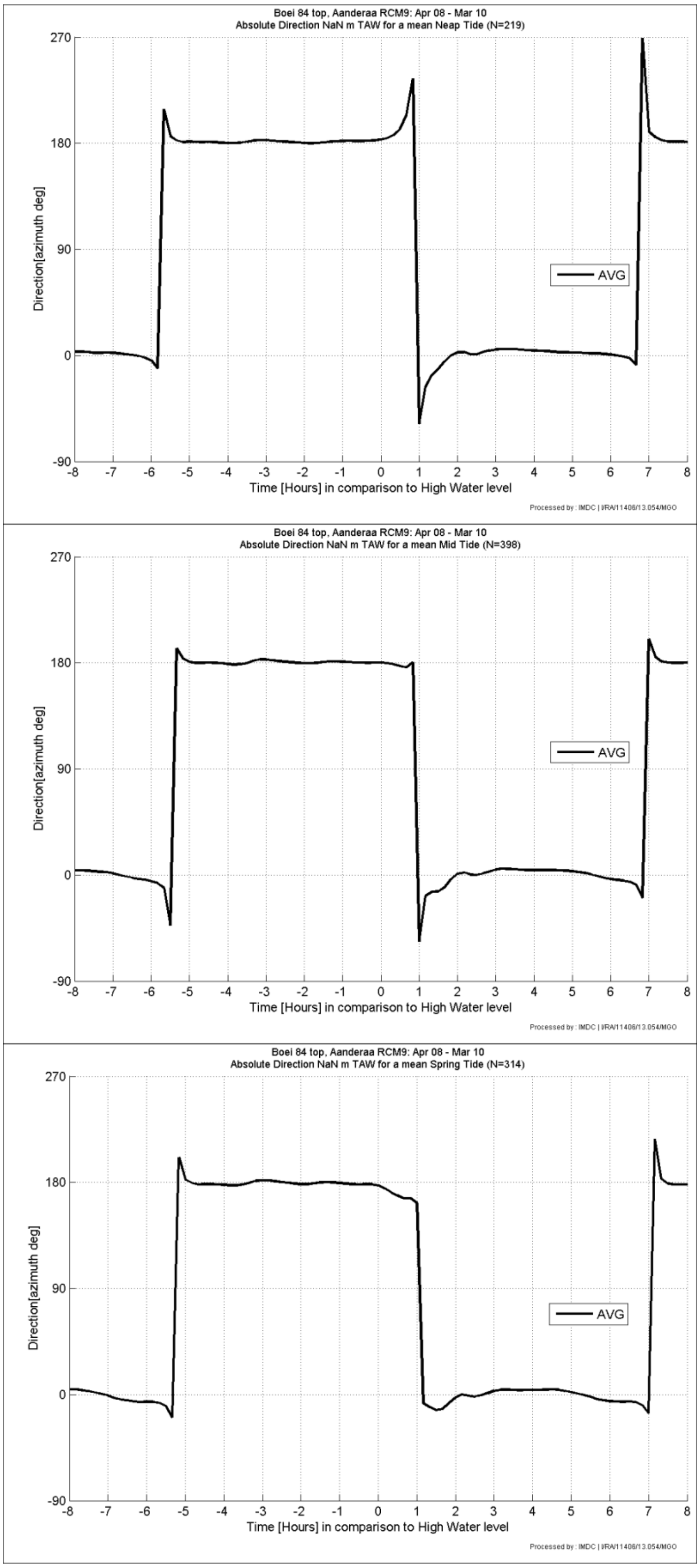
Annex-Figure C-22: Buoy 97 (-7.8m TAW). Averaged tidal curve of the flow velocity for (a) a neap, (b) an average and (c) a spring tide, April 2008 – March 2010.



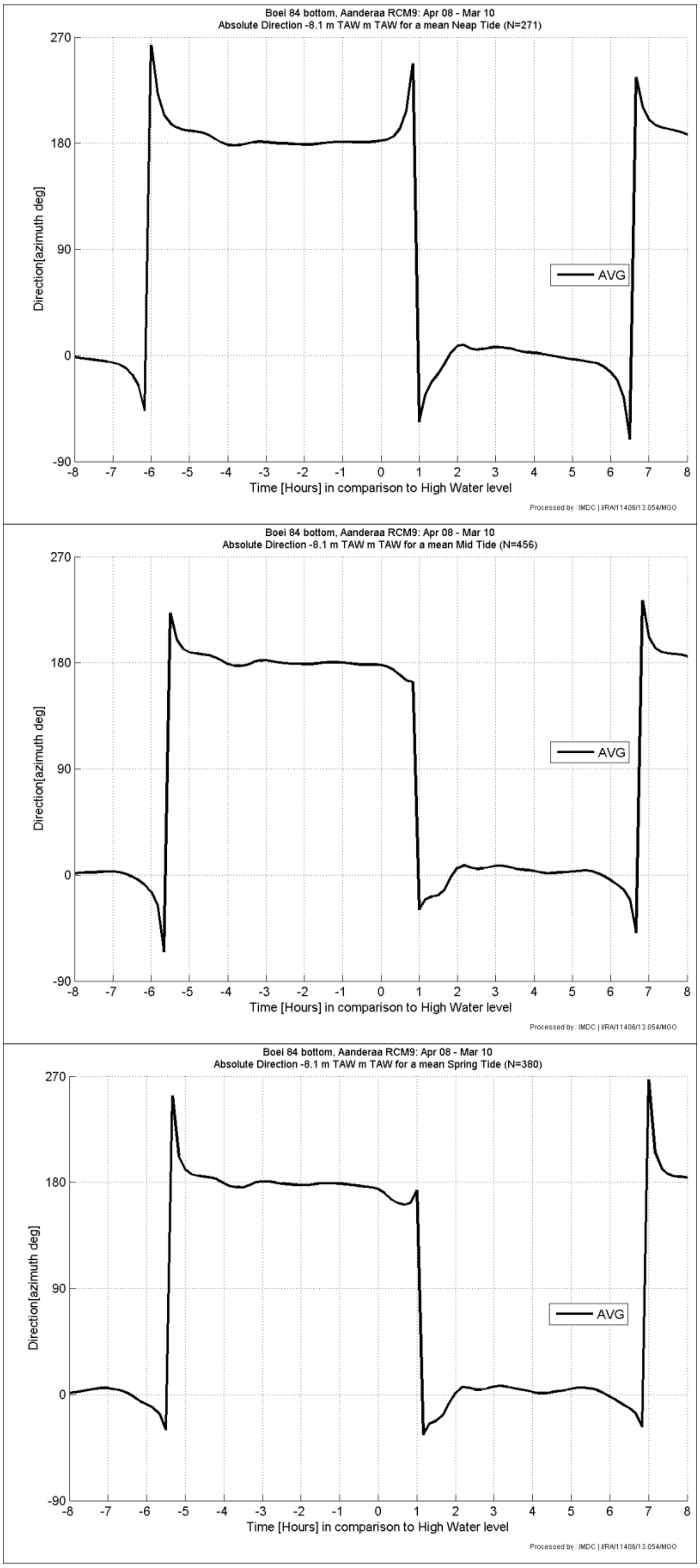
Annex-Figure C-23: Oosterweel Top (-2.3m TAW). Averaged tidal curve of the flow velocity for (a) a neap, (b) an average and (c) a spring tide, April 2008 – March 2010.



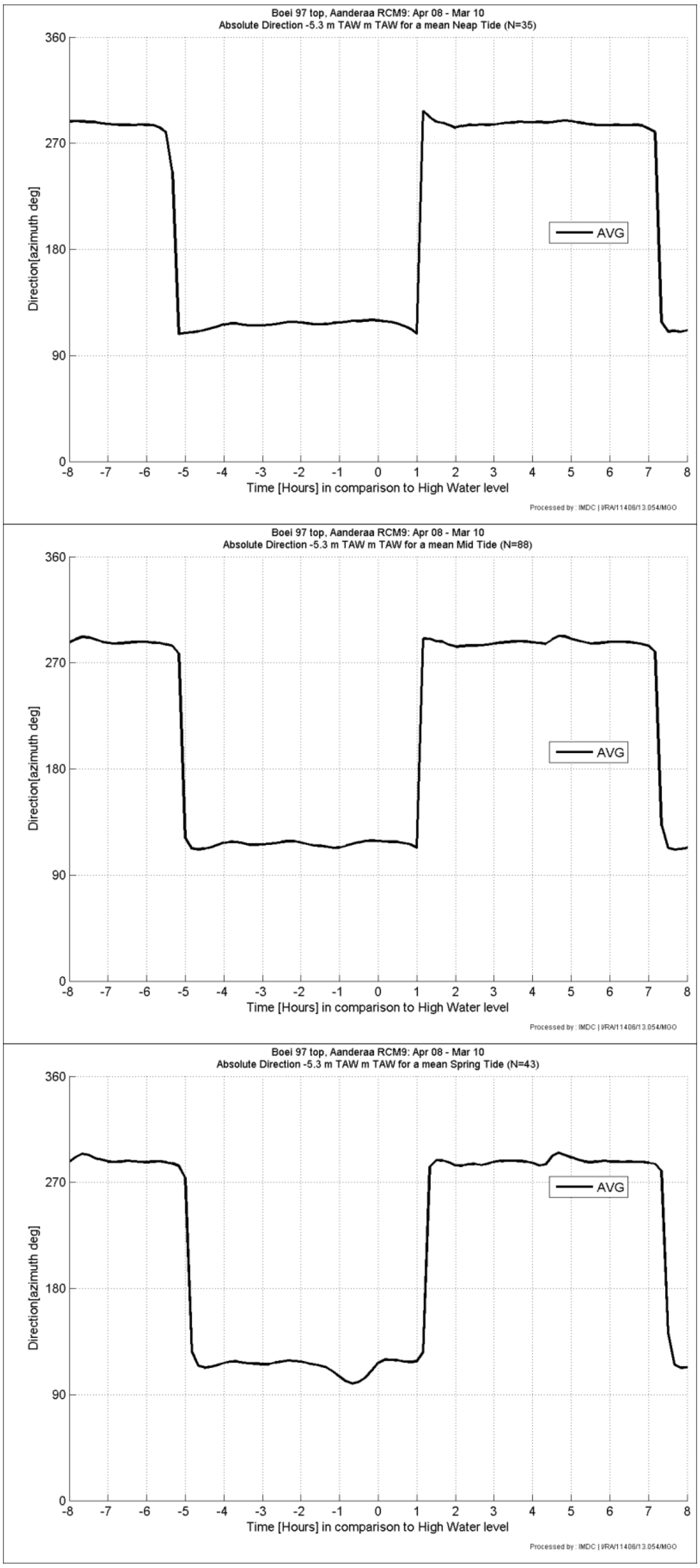
Annex-Figure C-24: Oosterweel Bottom (-5.8m TAW). Averaged tidal curve of the flow velocity for (a) a neap, (b) an average and (c) a spring tide, April 2008 – March 2010.



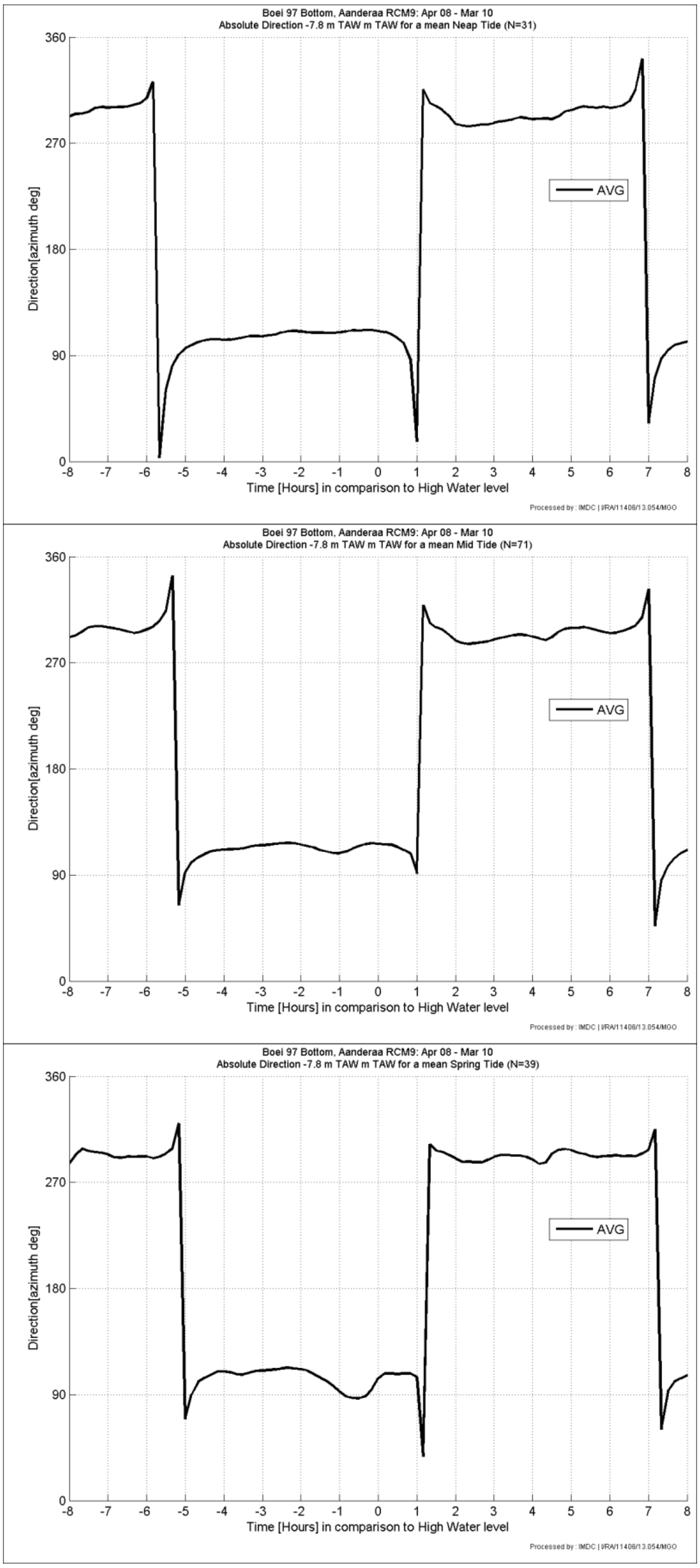
Annex-Figure C-25: Buoy 84 (-5.6m TAW). Averaged tidal curve of the flow direction for (a) a neap, (b) an average and (c) a spring tide, April 2008 – March 2010.



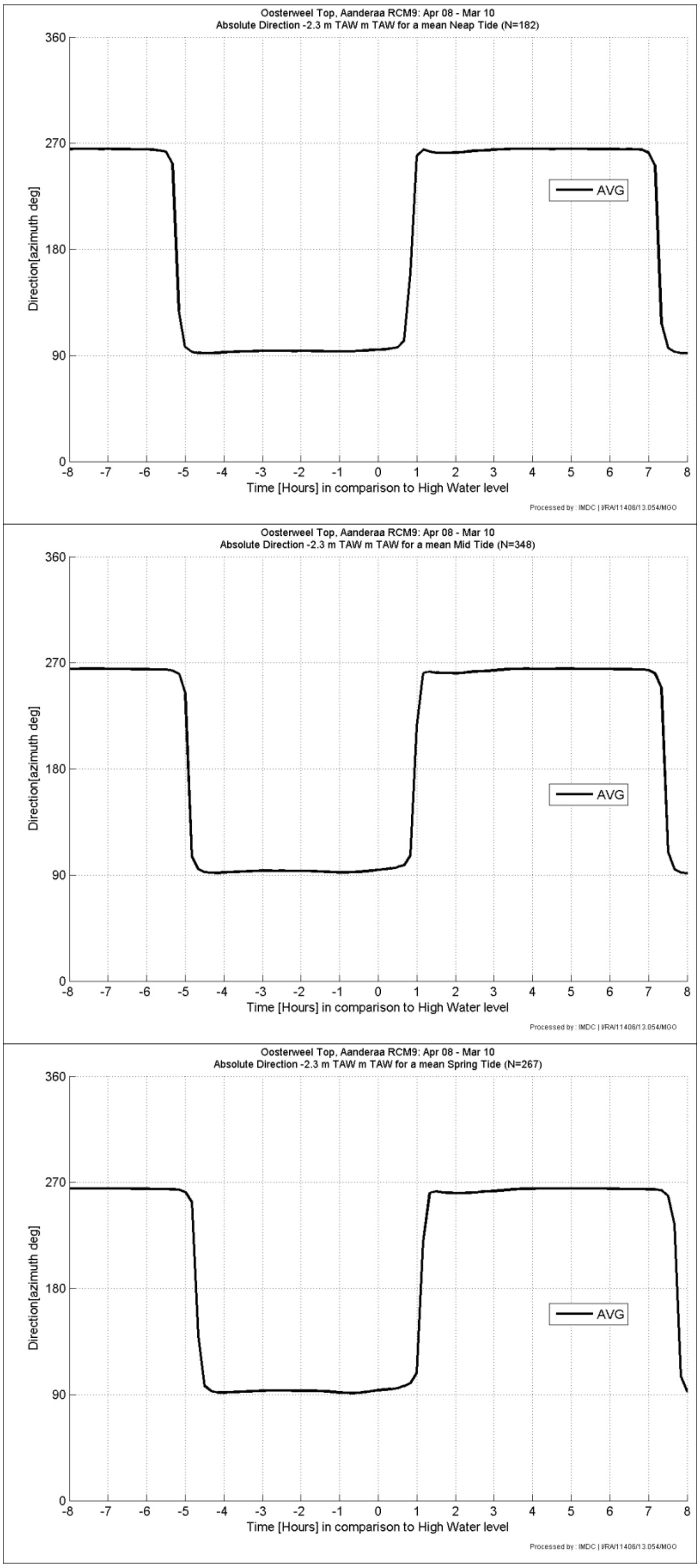
Annex-Figure C-26: Buoy 84 (-8.1m TAW). Averaged tidal curve of the flow direction for (a) a neap, (b) an average and (c) a spring tide, April 2008 – March 2010.



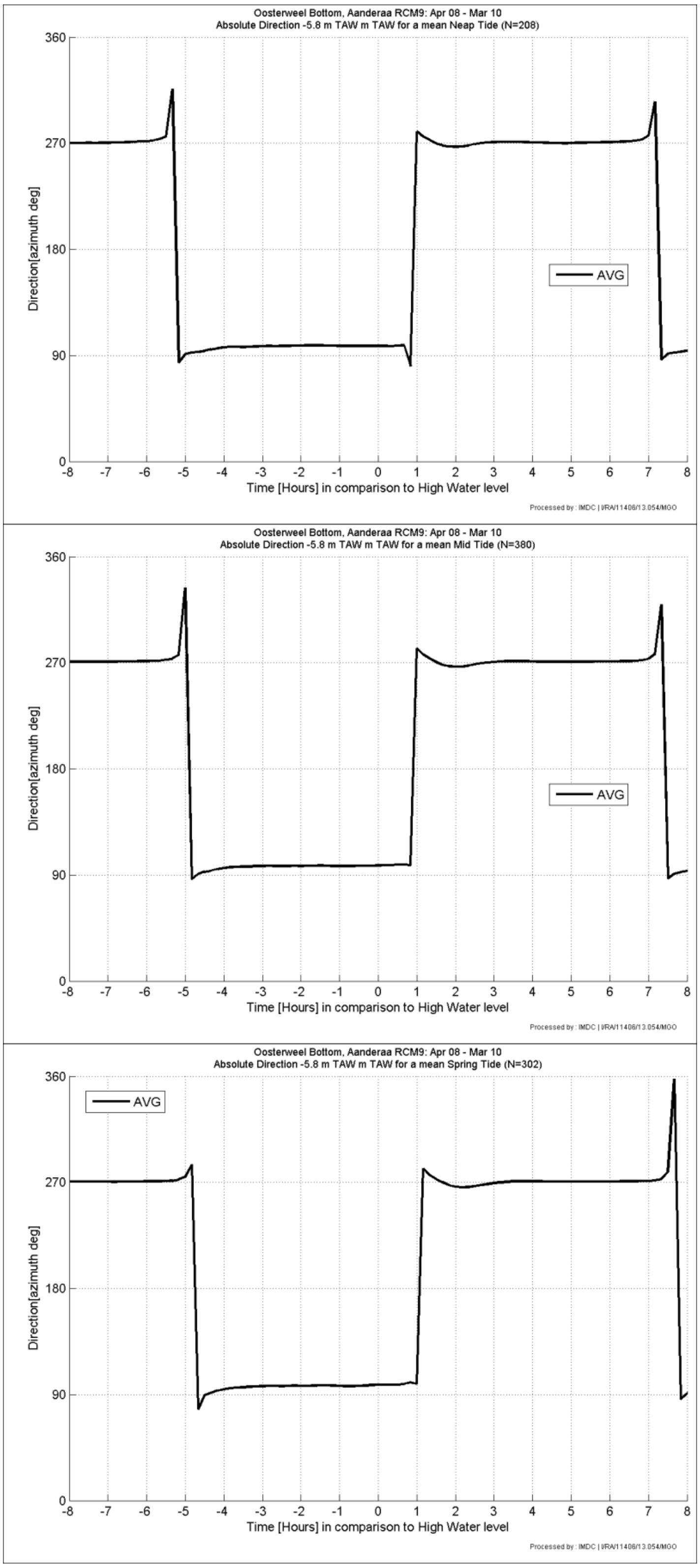
Annex-Figure C-27: Buoy 97 (-5.3m TAW). Averaged tidal curve of the flow direction for (a) a neap, (b) an average and (c) a spring tide, April 2008 – March 2010.



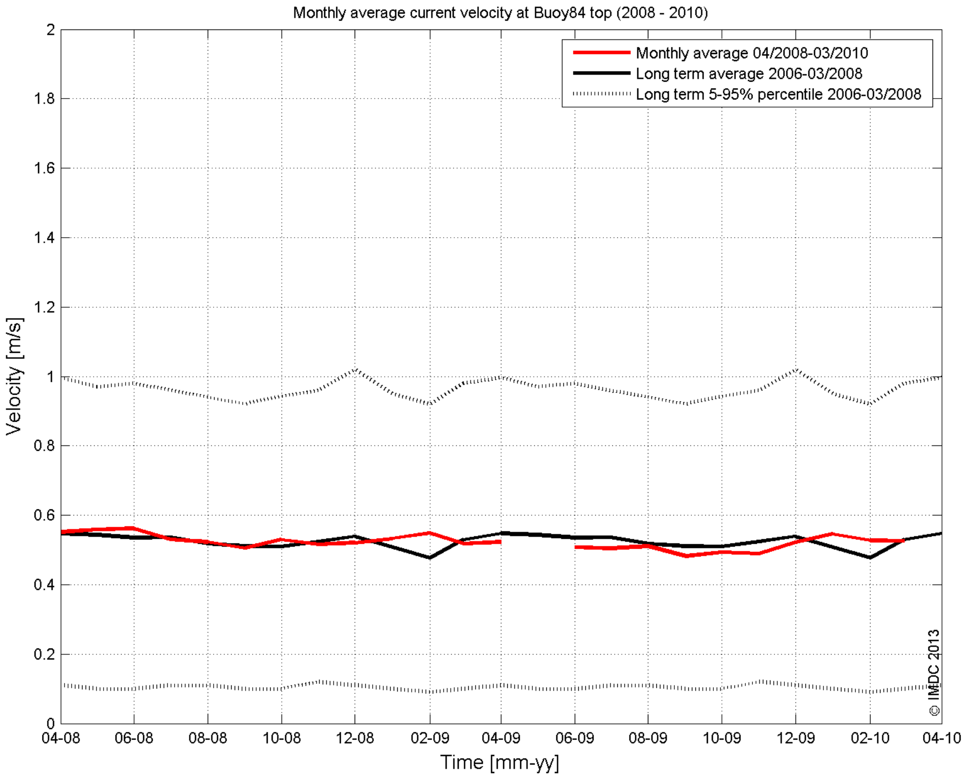
Annex-Figure C-28: Buoy 97 (-7.8m TAW). Averaged tidal curve of the flow direction for (a) a neap, (b) an average and (c) a spring tide, April 2008 – March 2010.

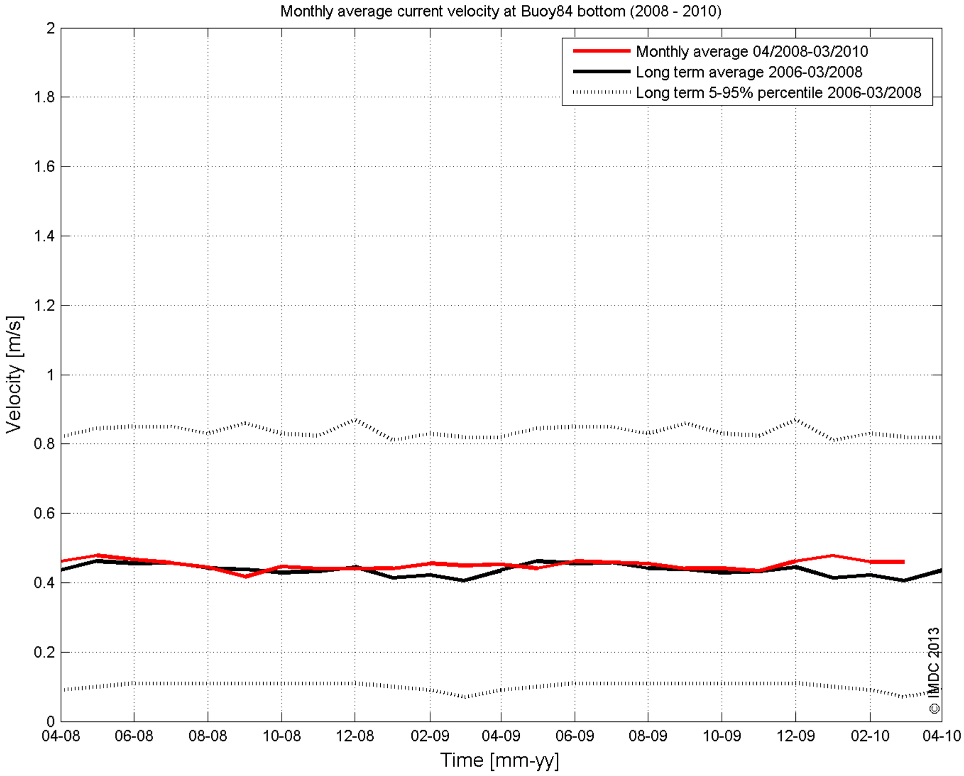


Annex-Figure C-29: Oosterweel Top (-2.3m TAW). Averaged tidal curve of the flow direction for (a) a neap, (b) an average and (c) a spring tide, April 2008 – March 2010.

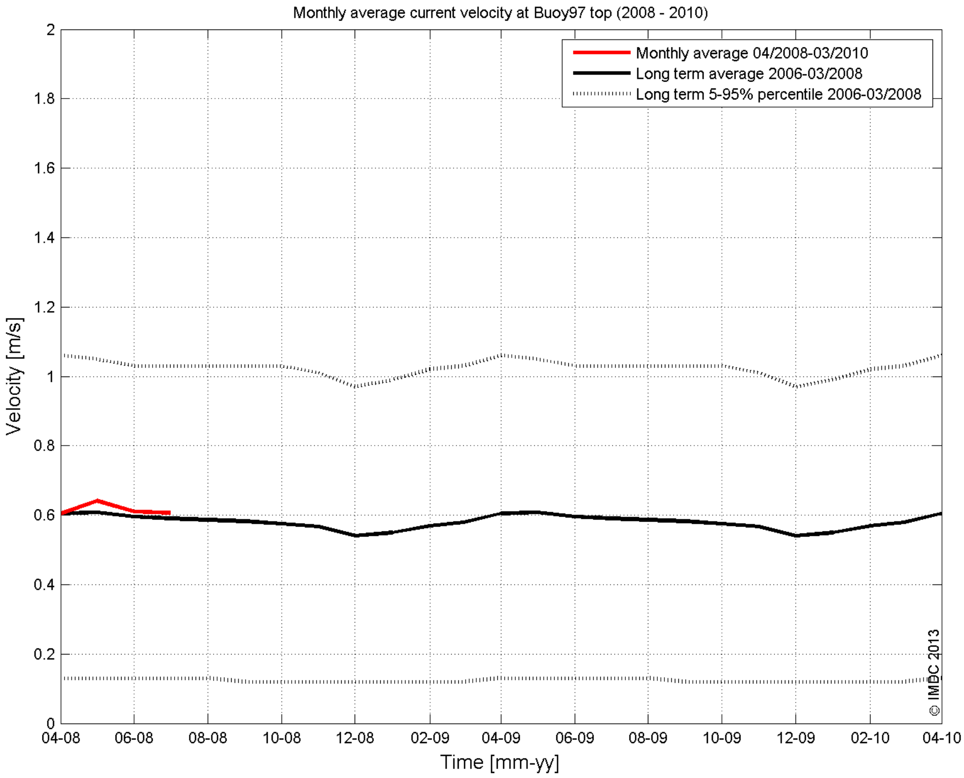


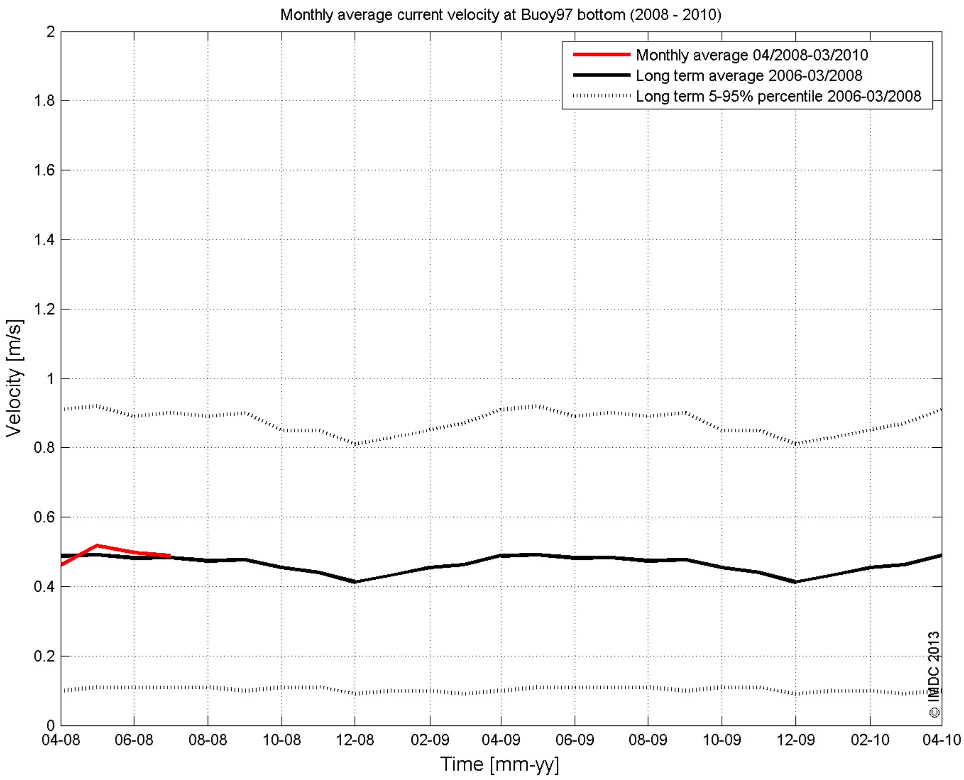
Annex-Figure C-30: Oosterweel Bottom (-5.8m TAW). Averaged tidal curve of the flow direction for (a) a neap, (b) an average and (c) a spring tide, April 2008 – March 2010.



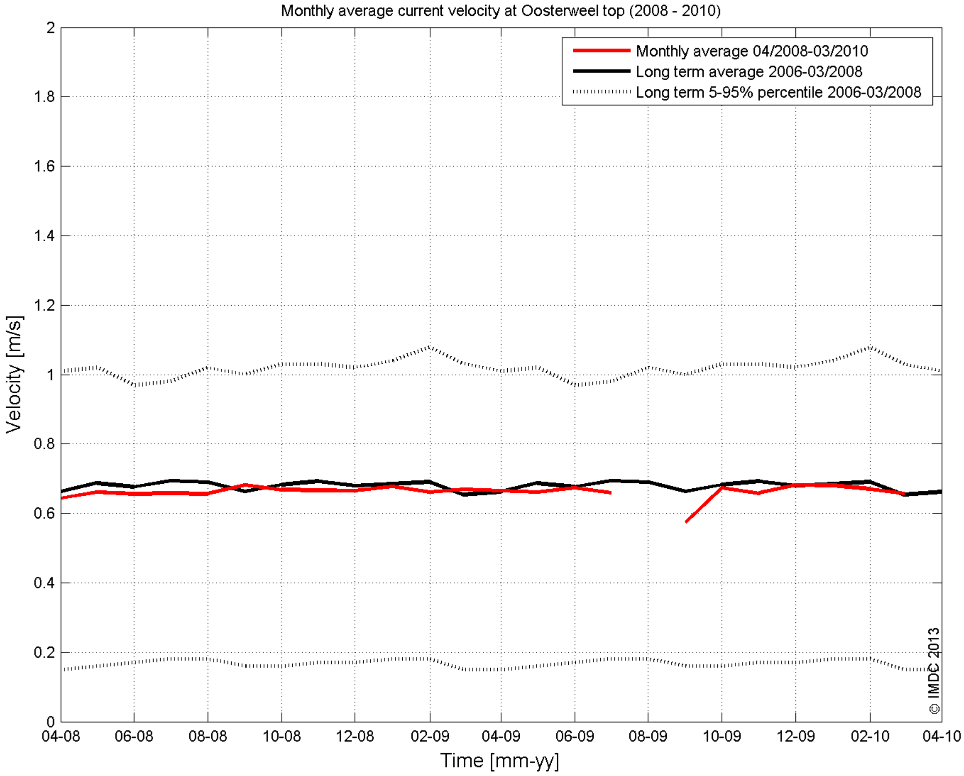


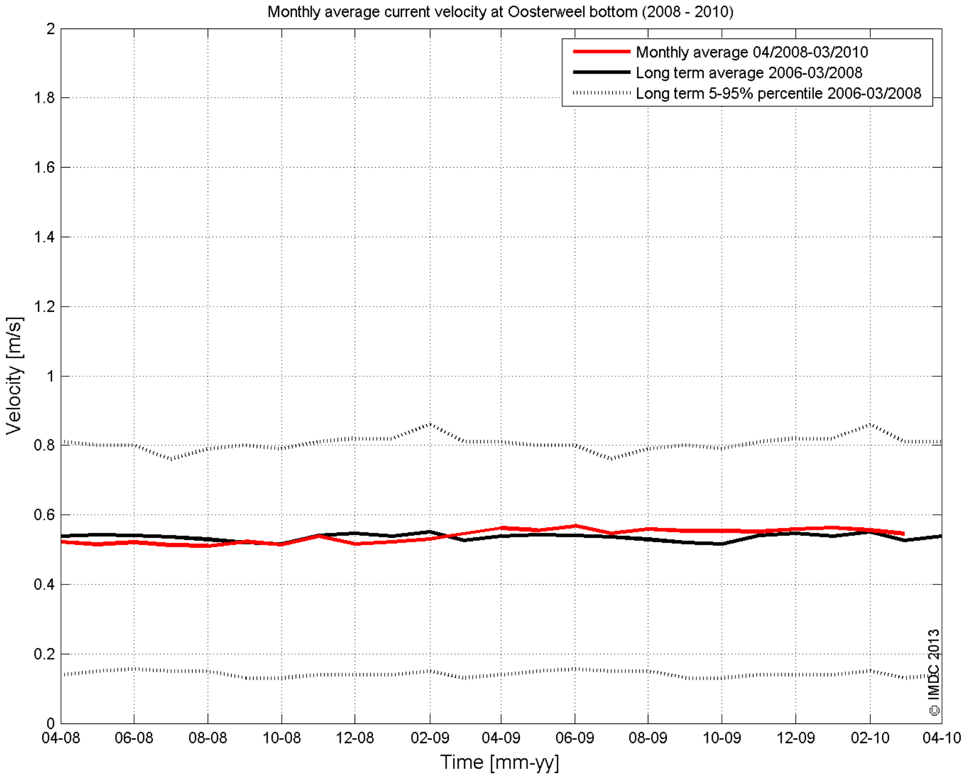
Annex-Figure C-31: The monthly average current velocity curves of Buoy 84 top (a) and bottom (b) between April 2008 – March 2010 and 2006 – March 2008 including the monthly 5/95% percentiles.





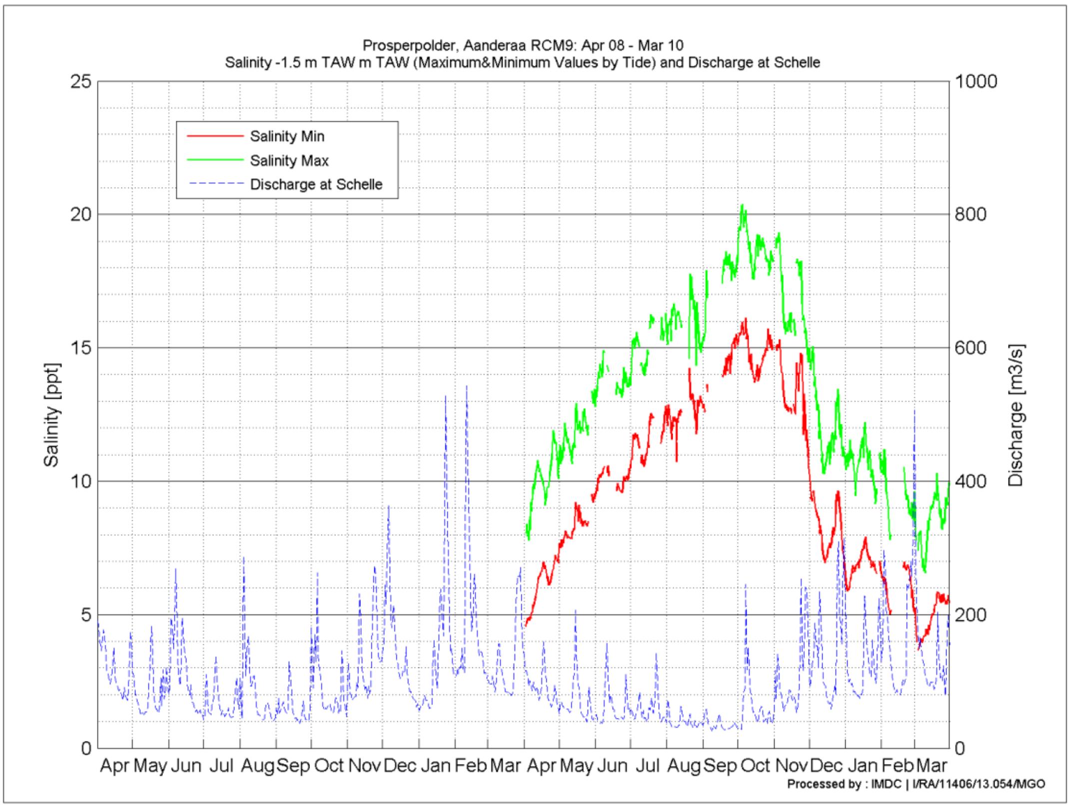
Annex-Figure C-32: The monthly average current velocity curves of Buoy 97 top (a) and bottom (b) between April 2008 – March 2010 and 2006 – March 2008 including the monthly 5/95% percentiles.

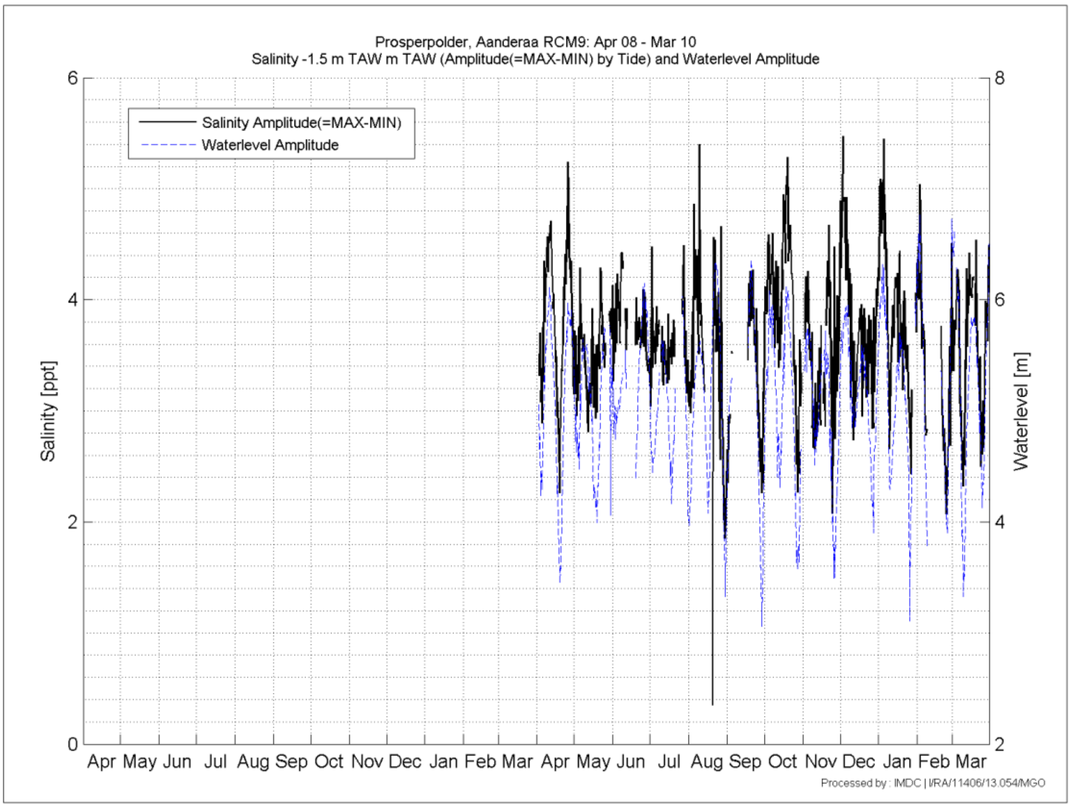




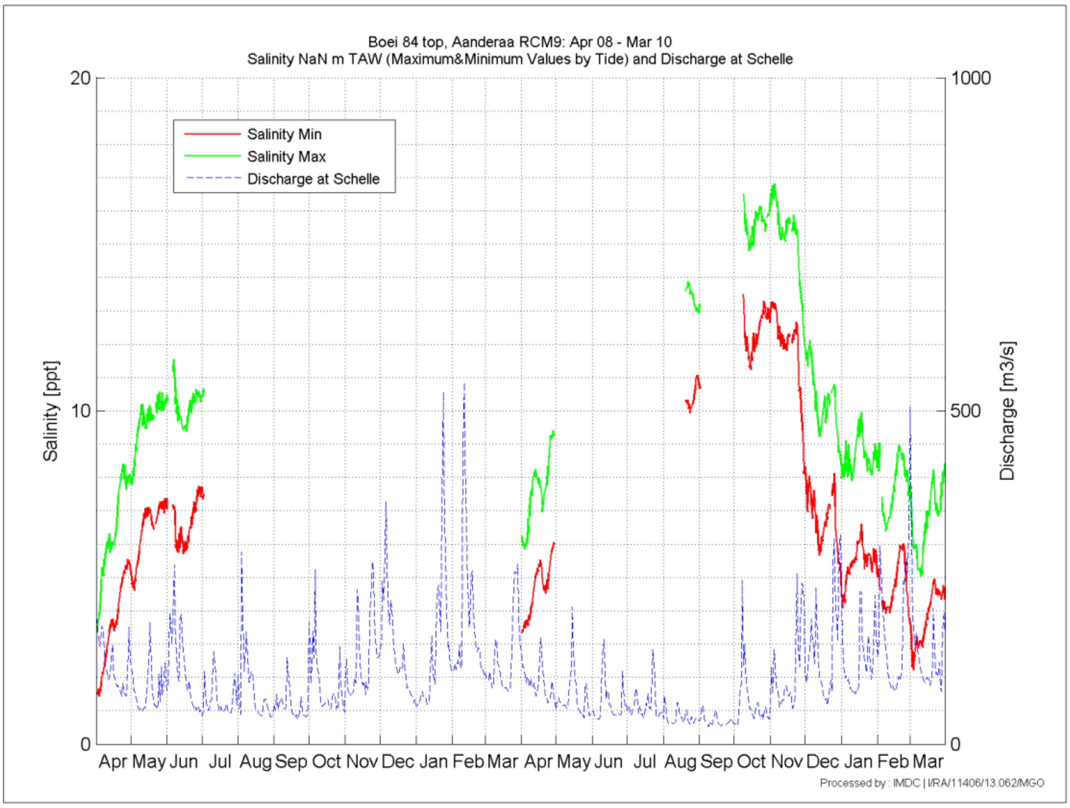
Annex-Figure C-33: The monthly average current velocity curves of Oosterweel top (a) and bottom (b) between April 2008 – March 2010 and 2006 – March 2008 including the monthly 5/95% percentiles.

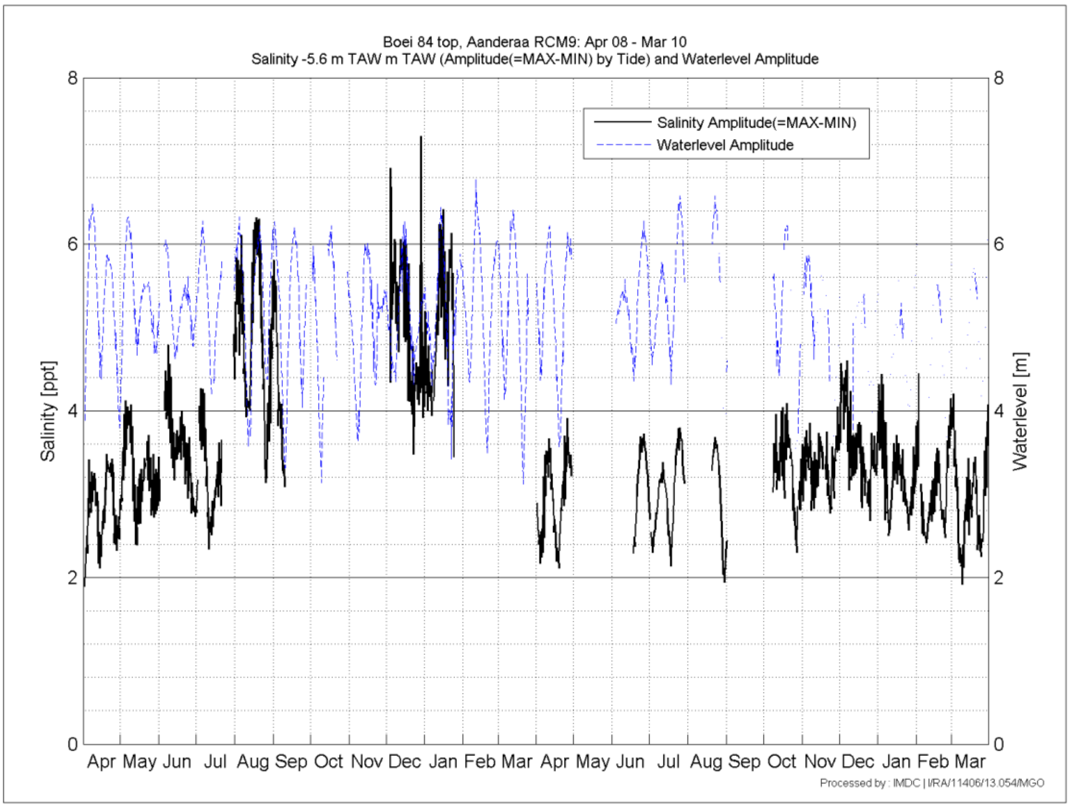
Annex D Figures for salinity



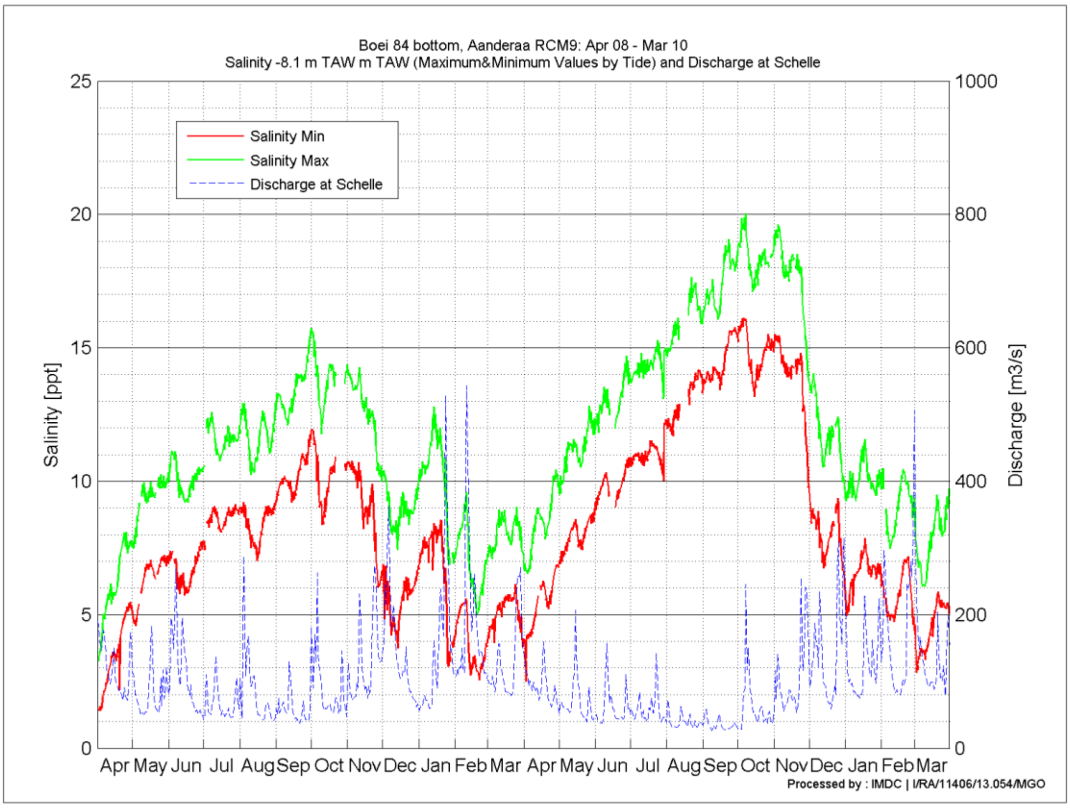


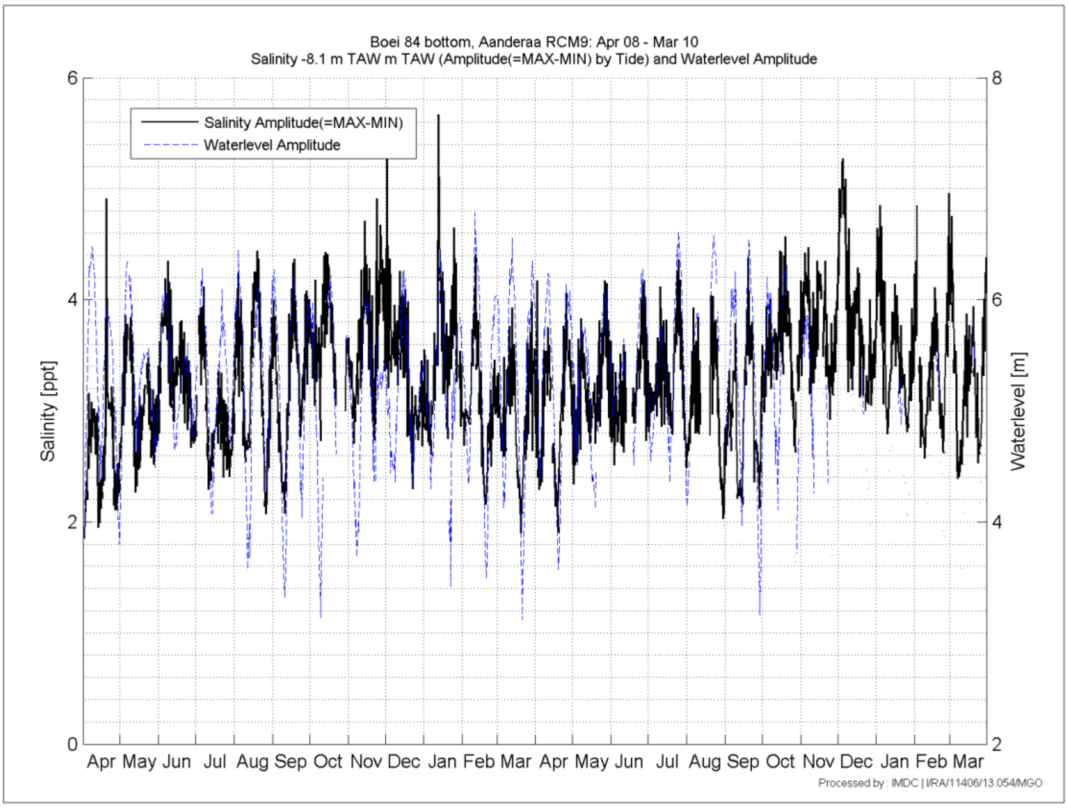
Annex-Figure D-1: Prosperpolder (-1.5m TAW), April 2008 – March 2010. (a) Tidal min & max salinity and discharge of the River Scheldt at Schelle (b) Tidal salinity and water level amplitude.



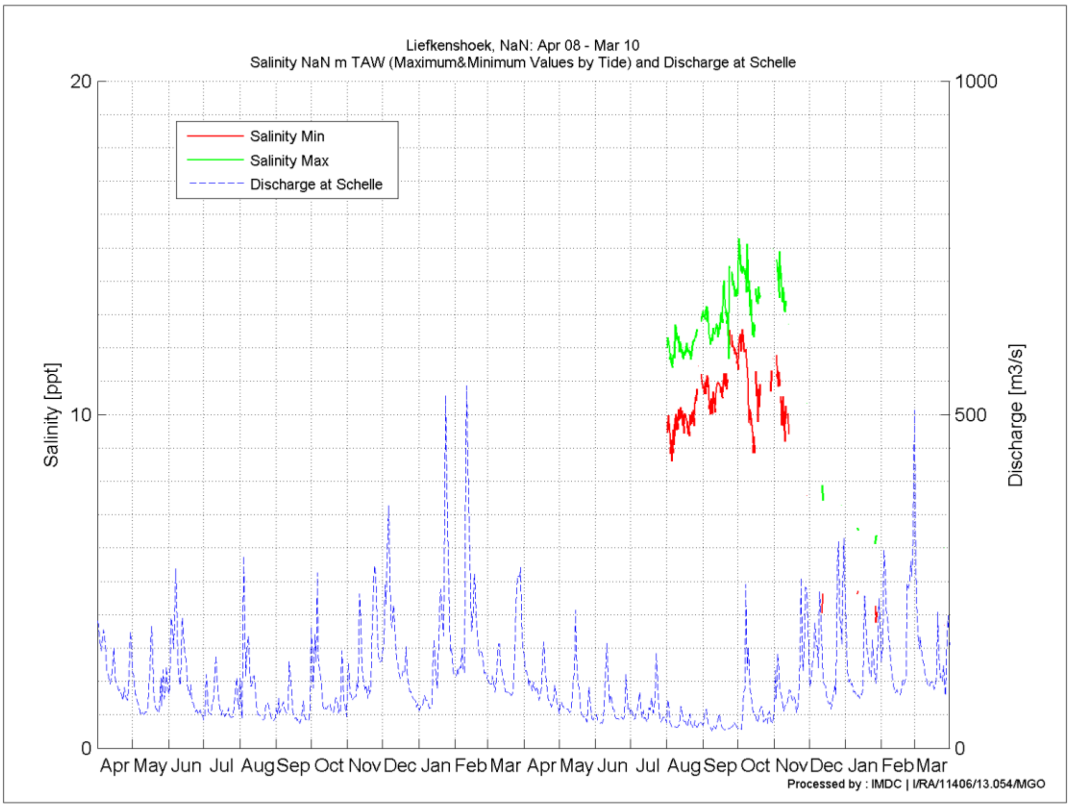


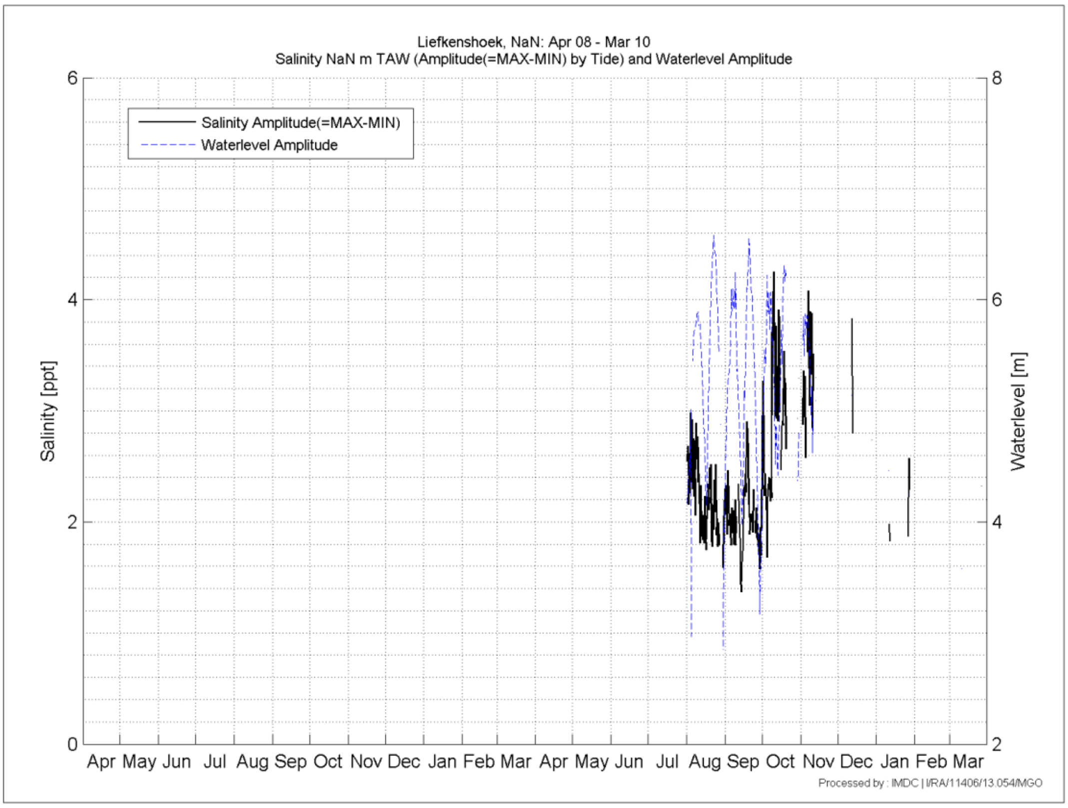
Annex-Figure D-2: Buoy 84 (-5.6m TAW), April 2008 – March 2010. (a)Tidal min & max salinity and discharge of the River Scheldt at Schelle (b) Tidal salinity and water level amplitude.



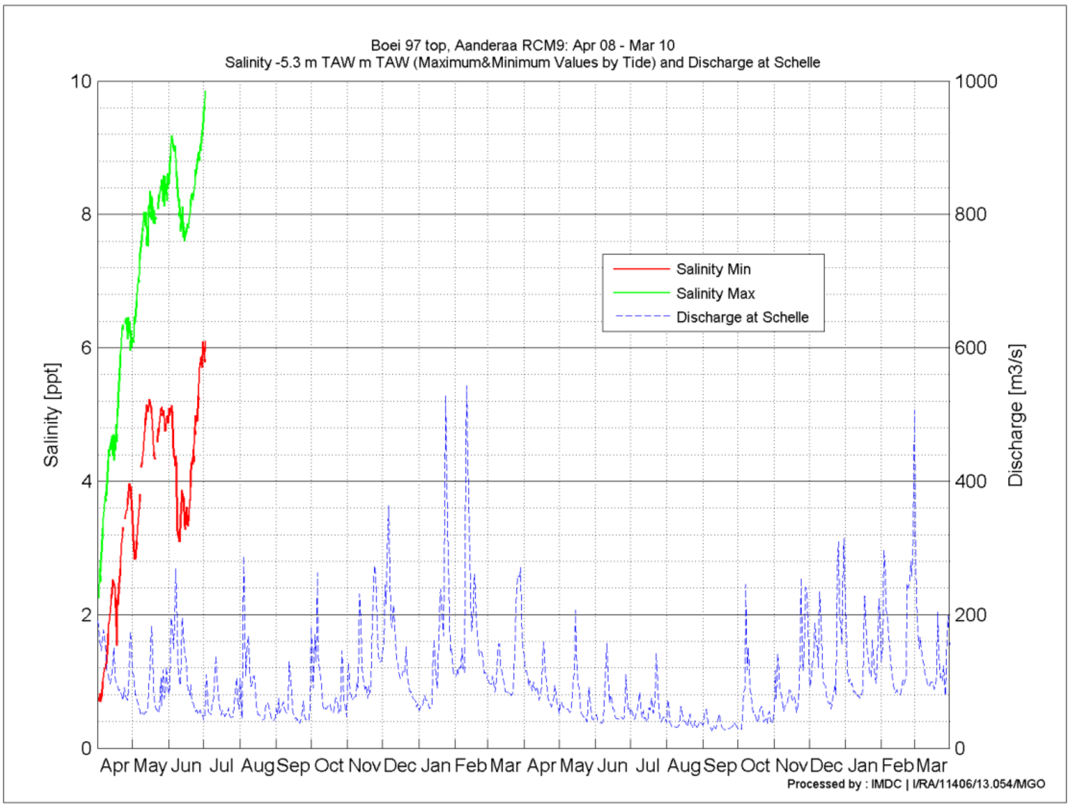


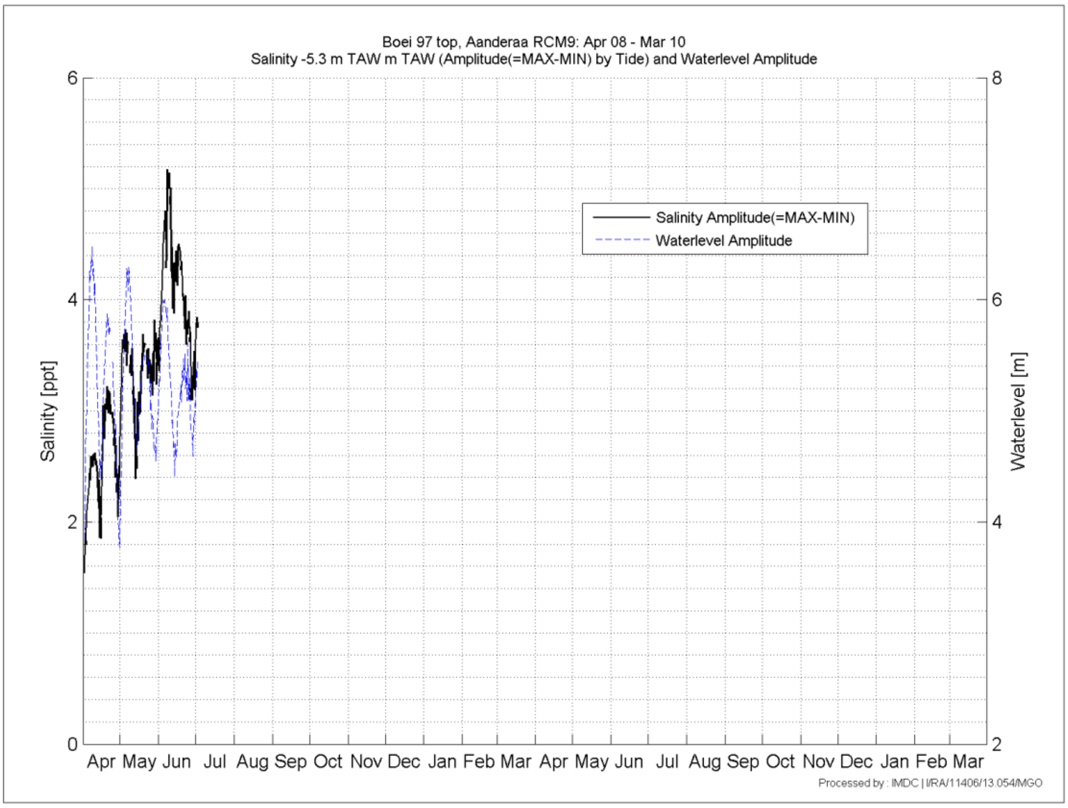
Annex-Figure D-3: Buoy 84 (-8.1m TAW), April 2008 – March 2010. (a) Tidal min & max salinity and discharge of the River Scheldt at Schelle (b) Tidal salinity and water level amplitude.



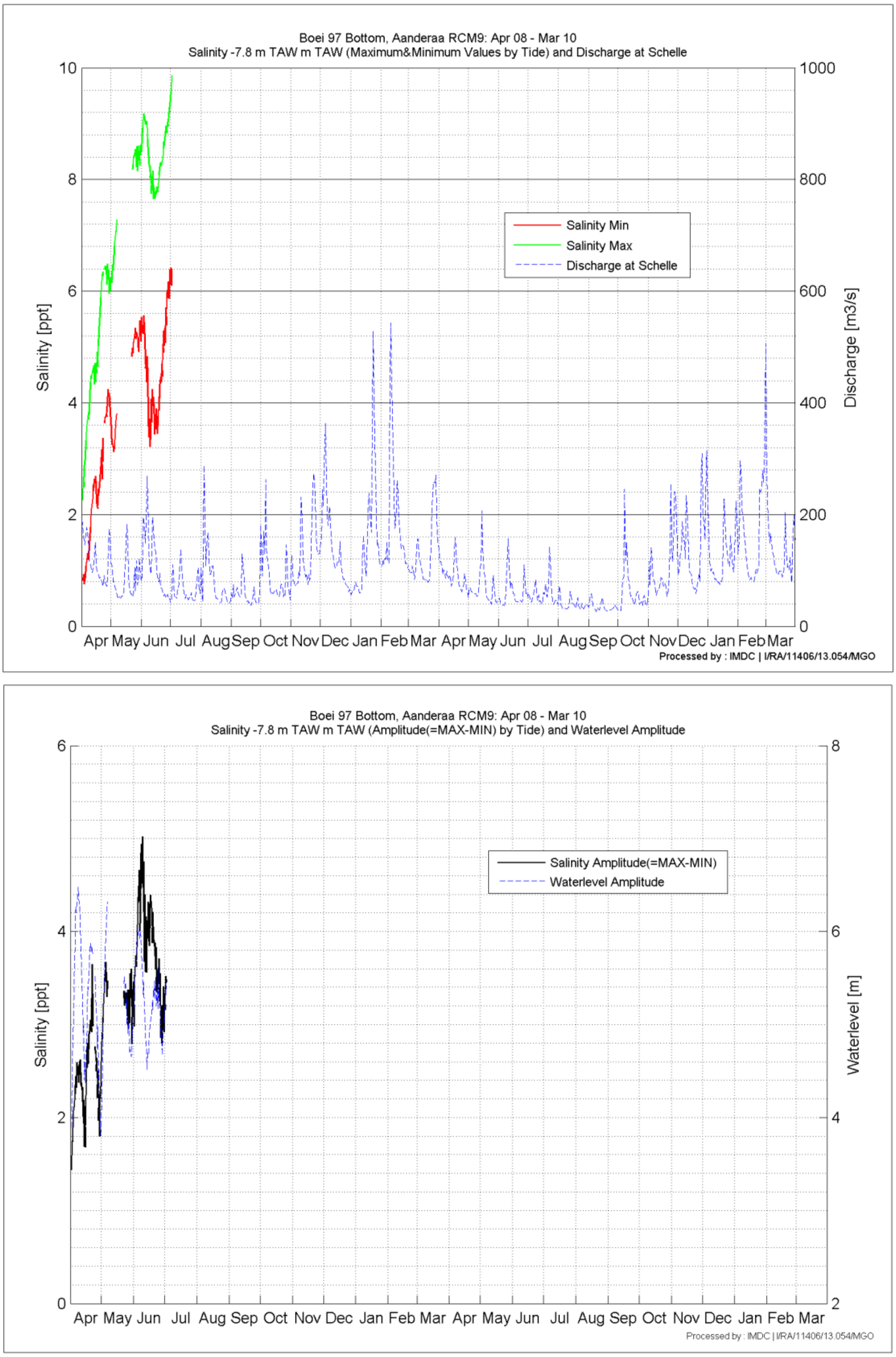


Annex-Figure D-4: Liefkenshoek, April 2008 – March 2010. (a) Tidal min & max salinity and discharge of the River Scheldt at Schelle (b) Tidal salinity and water level amplitude.

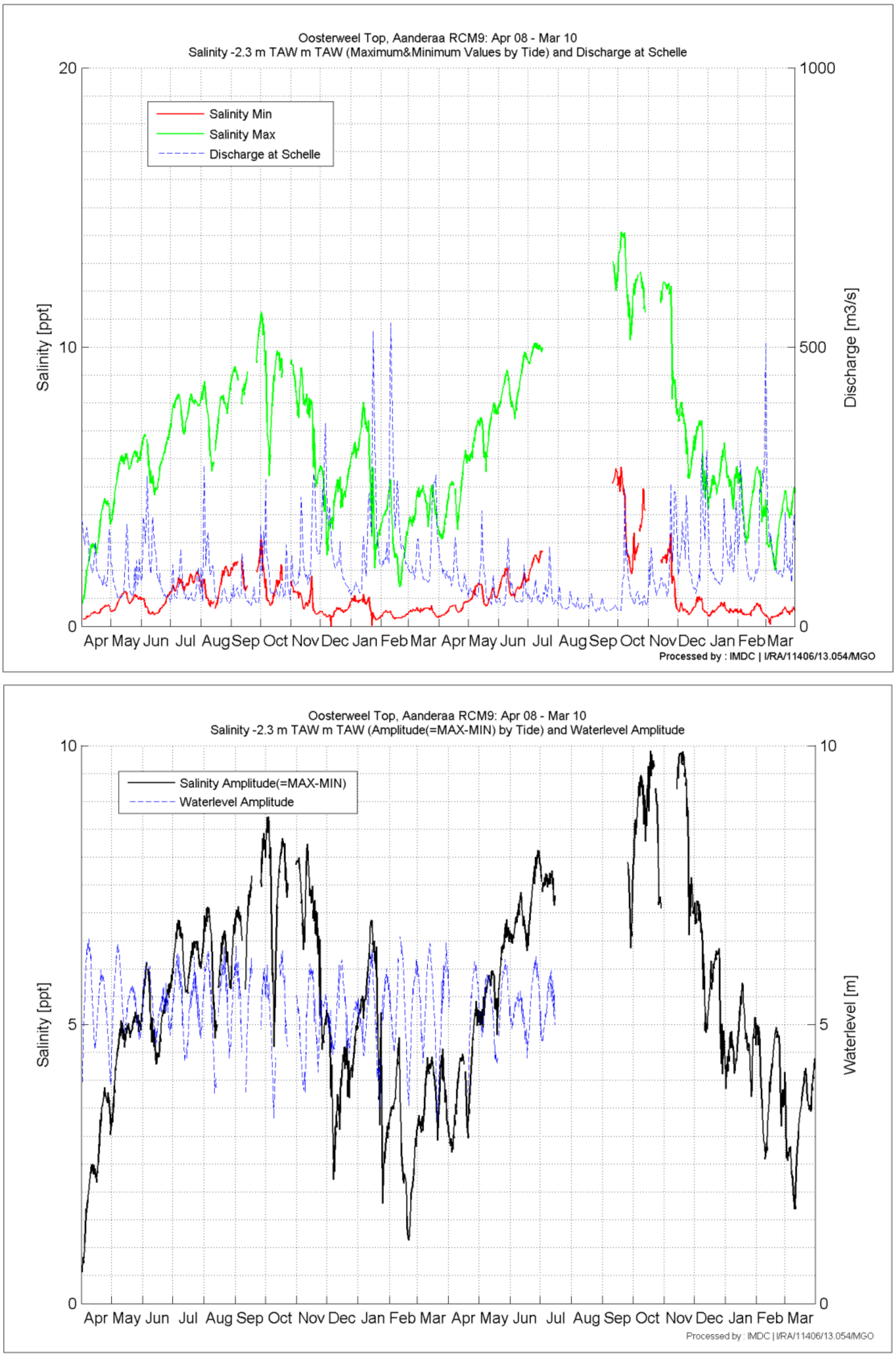




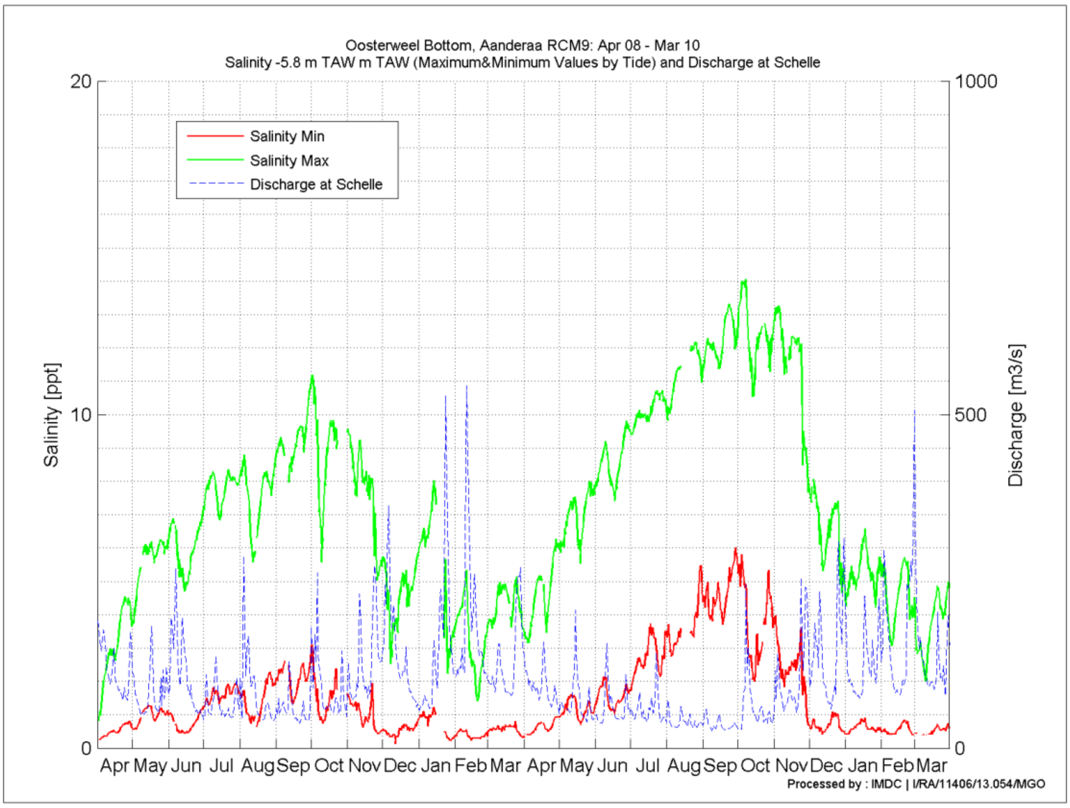
Annex-Figure D-5: Buoy 97 (-5.3m TAW), April 2008 – March 2010. (a) Tidal min & max salinity and discharge of the River Scheldt at Schelle (b) Tidal salinity and water level amplitude.

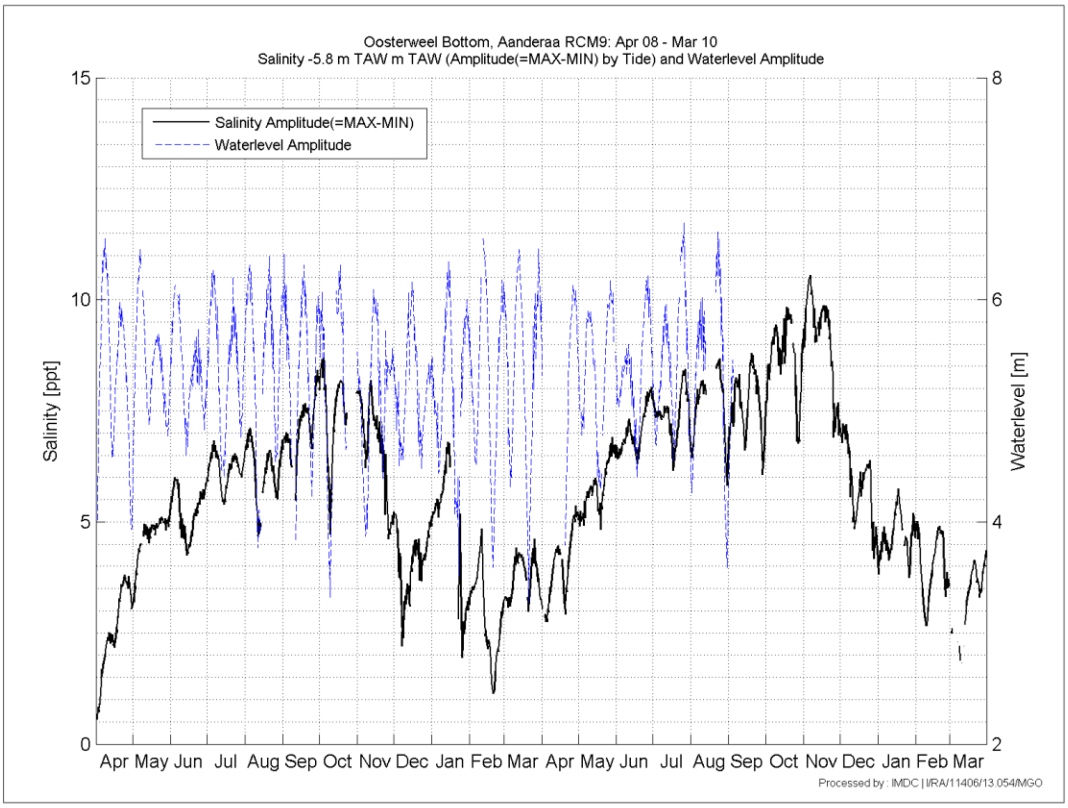


Annex-Figure D-6: Buoy 97 (-7.8m TAW), April 2008 – March 2010. (a) Tidal min & max salinity and discharge of the River Scheldt at Schelle (b) Tidal salinity and water level amplitude.

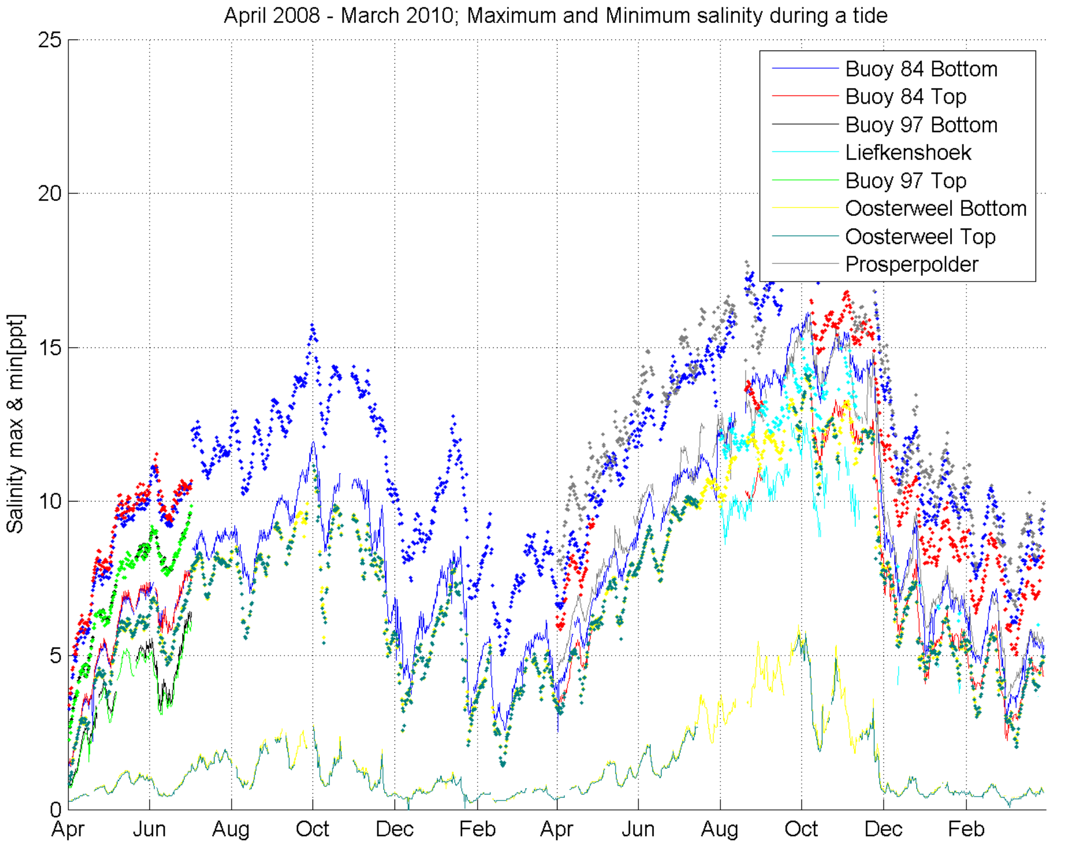


Annex-Figure D-7: Oosterweel Top (-2.3m TAW), April 2008 – March 2010. (a) Tidal min & max salinity and discharge of the River Scheldt at Schelle (b) Tidal salinity and water level amplitude.

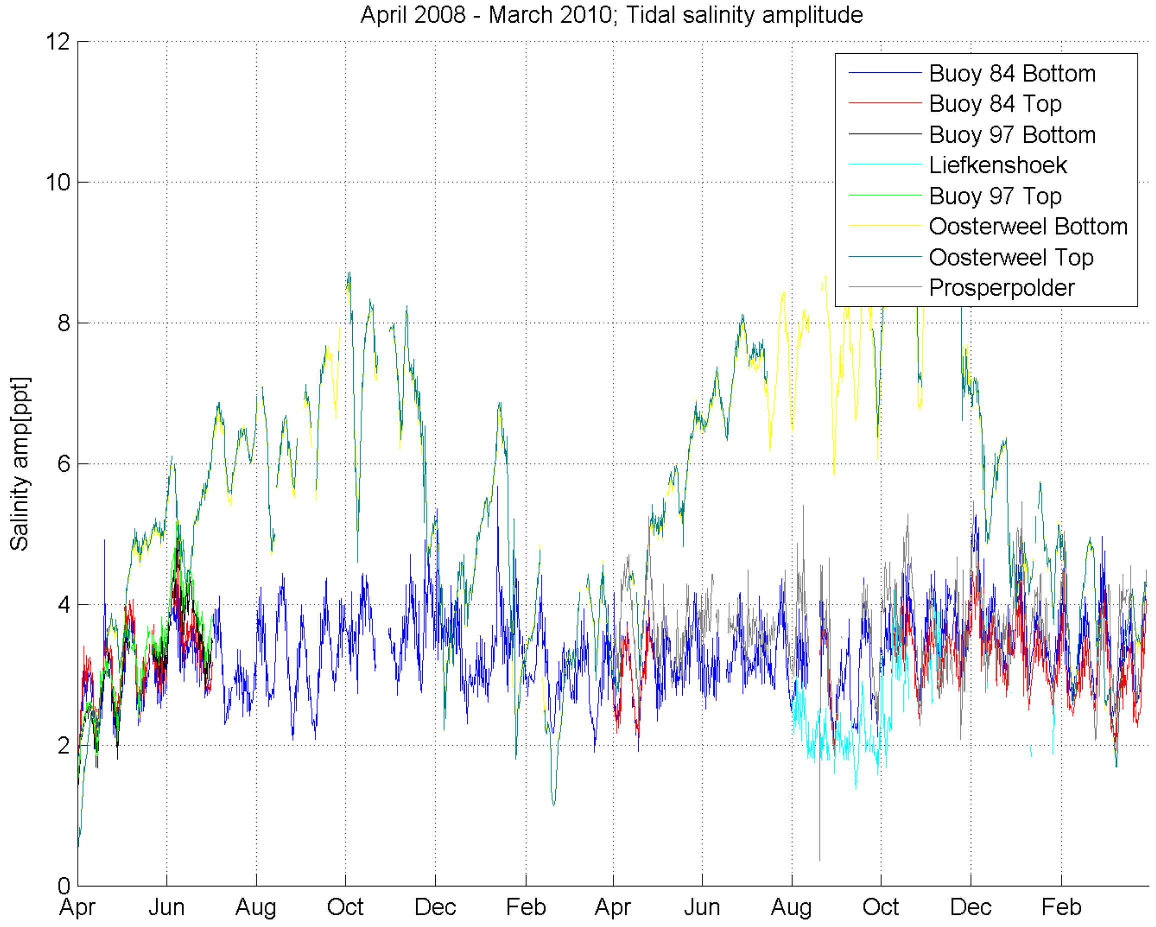




Annex-Figure D-8: Oosterweel Bottom (-5.8m TAW), April 2008 – March 2010. (a) Tidal min & max salinity and discharge of the River Scheldt at Schelle (b) Tidal salinity and water level amplitude.



Annex-Figure D-9: Maximal (…) and minimal (-) tidal salinity for all measurement stations.



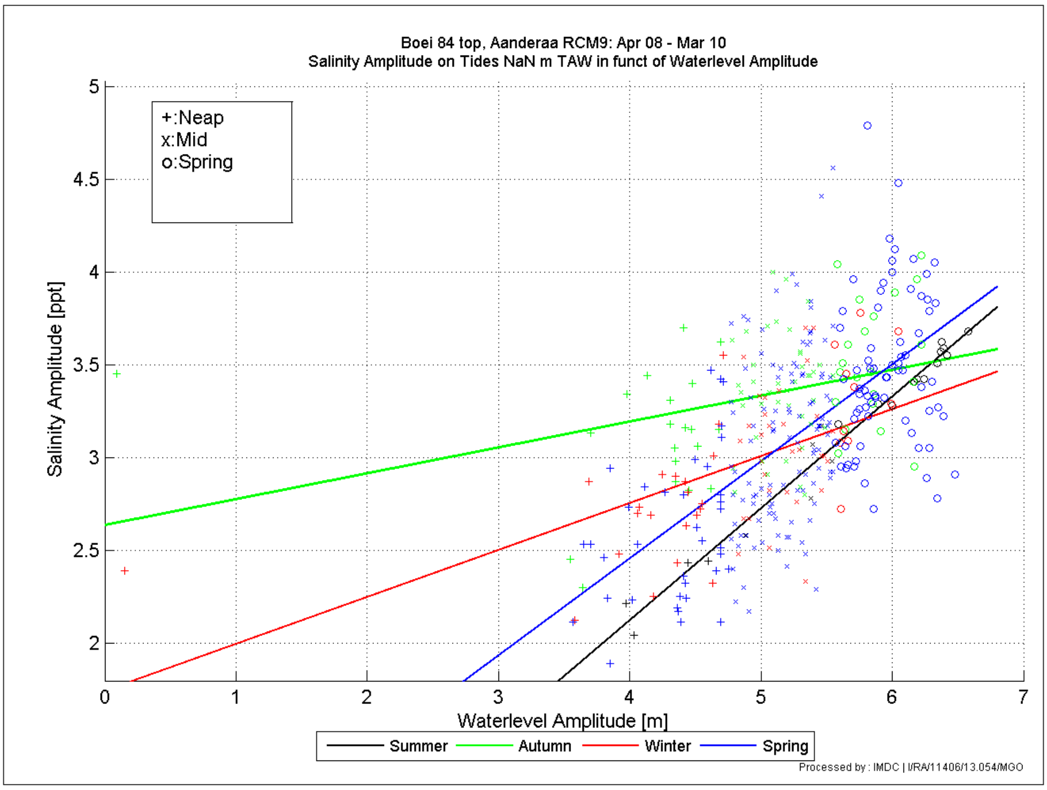
Annex-Figure D-10: Tidal amplitude of the salinity for all measurement stations.

Annex-Table D-1: Averaged tidal salinity amplitude [psu] (ΔS), standard deviation (σ), and amount of tide in the sample (N) for every measurement station during the period dealt with (April 2008 – March 2010) – year 1 (April 2008 – March 2009). Summer = April to September, Winter = October to March.

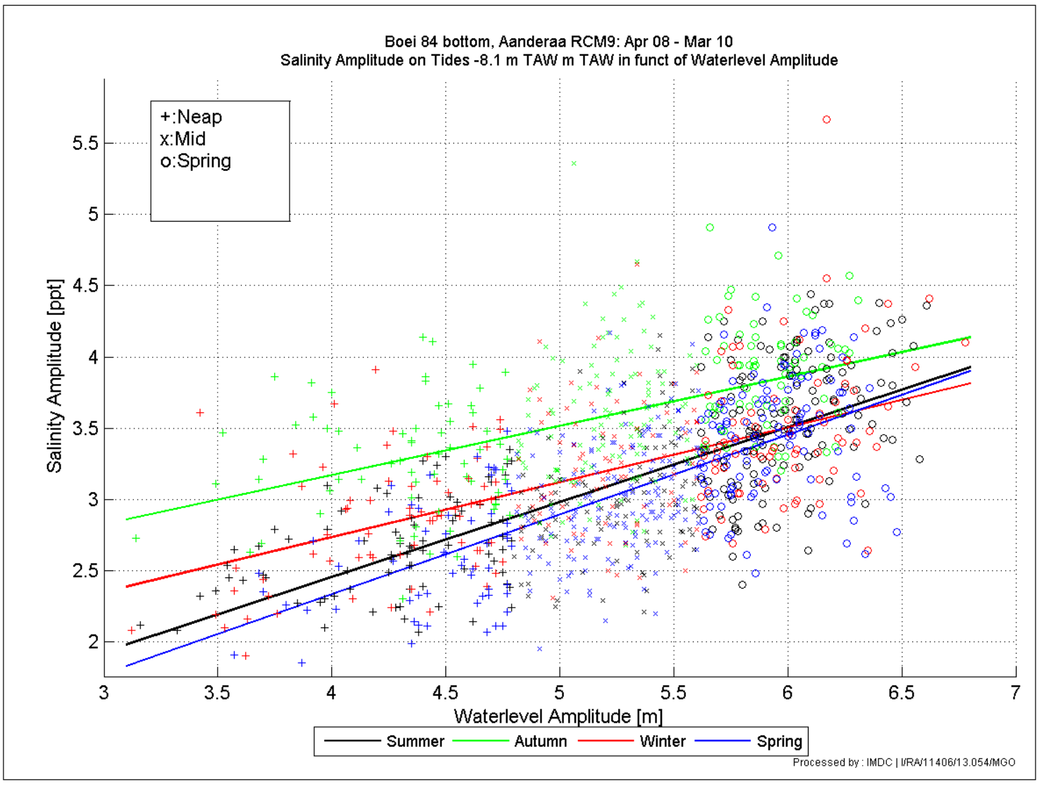
			Apr-Jun			Jul-Sep			Oct-Dec			Jan-Mar			Summer			Winter			Year 1			Total period		
			ΔS	σ	N	ΔS	σ	N	ΔS	σ	N	ΔS	σ	N	ΔS	σ	N	ΔS	σ	N	ΔS	σ	N	ΔS	σ	N
Buoy 84	**-8.1 m TAW**	Neap	2.6	0.4	34.0	2.6	0.3	44.0	3.2	0.4	44.0	2.8	0.5	47.0	2.6	0.4	78.0	2.9	0.5	108.0	2.8	0.5	169.0	2.8	0.5	277.0
		Avg	3.0	0.4	85.0	3.0	0.4	56.0	3.5	0.5	72.0	3.1	0.5	54.0	3.0	0.4	141.0	3.3	0.5	141.0	3.2	0.5	267.0	3.2	0.5	469.0
		Spring	3.4	0.5	51.0	3.6	0.4	74.0	3.9	0.4	40.0	3.5	0.5	69.0	3.5	0.5	127.0	3.6	0.5	135.0	3.6	0.5	234.0	3.6	0.5	389.0
		All	3.0	0.5	170.0	3.2	0.6	174.0	3.5	0.5	156.0	3.2	0.6	170.0	3.1	0.6	346.0	3.3	0.6	384.0	3.2	0.6	670.0	3.2	0.5	1135.0
	-5.6 m TAW	Neap	2.7	0.4	23.0	-	-	1.0	-	-	1.0	-	-	1.0	2.7	0.4	23.0	-	-	1.0	2.7	0.4	23.0	2.7	0.4	82.0
		Avg	3.2	0.5	95.0	3.1	0.1	2.0	-	-	1.0	-	-	1.0	3.2	0.5	97.0	-	-	1.0	3.2	0.5	97.0	3.1	0.4	190.0
		Spring	3.5	0.5	48.0	-	-	1.0	-	-	1.0	-	-	1.0	3.5	0.5	48.0	-	-	1.0	3.5	0.5	48.0	3.5	0.4	114.0
		All	3.2	0.5	166.0	3.1	0.1	2.0	-	-	1.0	-	-	1.0	3.2	0.5	168.0	-	-	1.0	3.2	0.5	168.0	3.2	0.5	386.0
Buoy 97	**-7.8 m TAW**	Neap	2.8	0.9	32.0	-	-	1.0	-	-	1.0	-	-	1.0	2.8	0.9	32.0	-	-	1.0	2.8	0.9	32.0	2.8	0.9	32.0
		Avg	3.3	0.7	71.0	3.5	0.0	2.0	-	-	1.0	-	-	1.0	3.3	0.6	73.0	-	-	1.0	3.3	0.6	73.0	3.3	0.6	73.0
		Spring	3.3	0.8	39.0	-	-	1.0	-	-	1.0	-	-	1.0	3.3	0.8	39.0	-	-	1.0	3.3	0.8	39.0	3.3	0.8	39.0
		All	3.2	0.8	142.0	3.5	0.0	2.0	-	-	1.0	-	-	1.0	3.2	0.8	144.0	-	-	1.0	3.2	0.8	144.0	3.2	0.8	144.0
	-5.3 m TAW	Neap	3.0	0.8	36.0	-	-	1.0	-	-	1.0	-	-	1.0	3.0	0.8	36.0	-	-	1.0	3.0	0.8	36.0	3.0	0.8	36.0
		Avg	3.5	0.6	88.0	3.8	0.1	2.0	-	-	1.0	-	-	1.0	3.5	0.6	90.0	-	-	1.0	3.5	0.6	90.0	3.5	0.6	90.0
		Spring	3.4	0.8	46.0	-	-	1.0	-	-	1.0	-	-	1.0	3.4	0.8	46.0	-	-	1.0	3.4	0.8	46.0	3.4	0.8	46.0
		All	3.3	0.8	170.0	3.8	0.1	2.0	-	-	1.0	-	-	1.0	3.4	0.8	172.0	-	-	1.0	3.4	0.8	172.0	3.4	0.8	172.0
Oosterweel	**- 5.8 m TAW**	Neap	3.6	1.2	21.0	5.8	0.7	33.0	5.5	1.6	48.0	3.3	1.3	45.0	4.9	1.4	54.0	4.7	1.8	104.0	4.6	1.7	147.0	5.0	1.7	196.0
		Avg	4.5	1.2	93.0	6.4	0.5	58.0	5.7	1.6	69.0	3.8	1.2	46.0	5.2	1.4	151.0	5.2	1.7	130.0	5.1	1.5	266.0	5.6	1.6	378.0
		Spring	4.0	1.4	50.0	6.8	0.5	59.0	6.8	1.8	38.0	3.8	1.3	57.0	5.5	1.7	110.0	5.4	2.1	112.0	5.3	1.9	204.0	5.8	1.9	287.0
		All	4.2	1.3	164.0	6.4	0.6	150.0	5.9	1.7	155.0	3.7	1.3	148.0	5.3	1.5	315.0	5.1	1.9	346.0	5.0	1.7	617.0	5.5	1.7	861.0
	- 2.3 m TAW	Neap	3.6	1.2	21.0	5.6	0.4	27.0	5.6	1.6	47.0	3.5	1.3	50.0	4.7	1.3	48.0	4.6	1.8	101.0	4.6	1.6	145.0	4.7	1.6	171.0
		Avg	4.5	1.2	91.0	6.4	0.4	53.0	5.7	1.6	71.0	4.0	1.4	53.0	5.2	1.3	144.0	5.1	1.8	135.0	5.1	1.5	268.0	5.4	1.6	352.0
		Spring	4.1	1.4	54.0	6.7	0.4	50.0	6.7	1.8	37.0	4.0	1.4	57.0	5.4	1.7	105.0	5.3	2.1	104.0	5.2	1.9	198.0	5.5	1.8	250.0
		All	4.3	1.3	166.0	6.3	0.6	130.0	5.9	1.7	155.0	3.8	1.4	160.0	5.2	1.5	297.0	5.0	1.9	340.0	5.0	1.7	611.0	5.3	1.7	773.0

Annex-Table D-2: Averaged tidal salinity amplitude [psu] (ΔS), standard deviation (σ), and amount of tide in the sample (N) for every measurement station during the considered period (April 2008 – March 2010) – year 2 (April 2009 – March 2010). Summer = April to September, Winter = October to March.

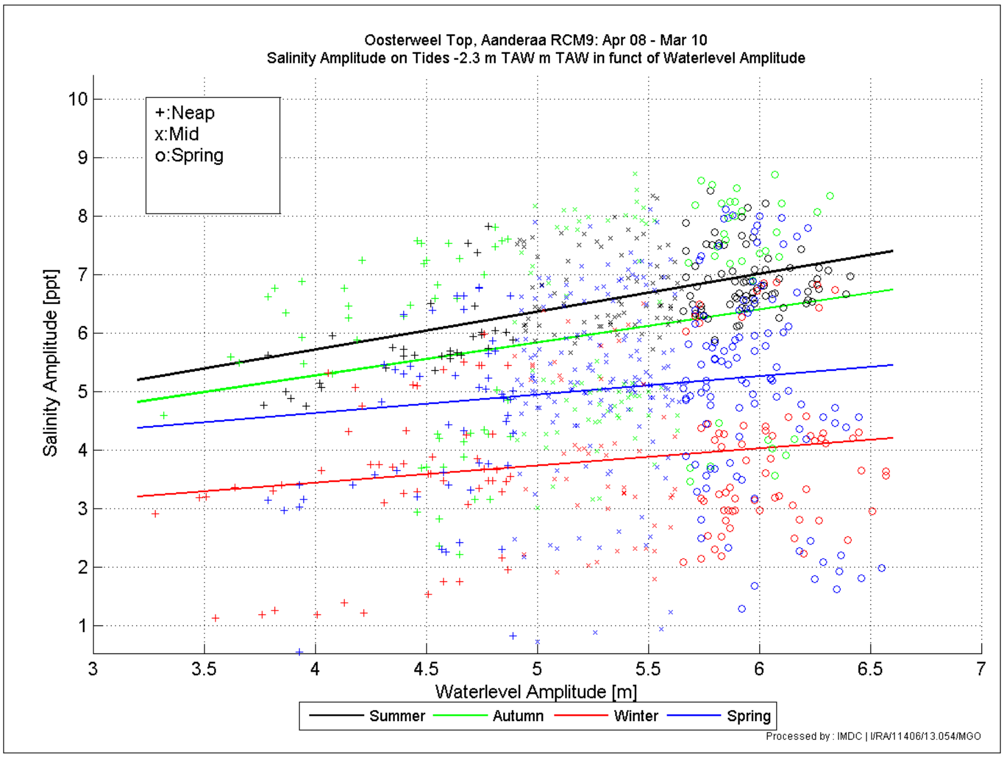
			Apr-Jun			Jul-Sep			Oct-Dec			Jan-Mar			Summer			Winter			Year 2			Total period		
			ΔS	σ	N	ΔS	σ	N	ΔS	σ	N	ΔS	σ	N	ΔS	σ	N	ΔS	σ	N	ΔS	σ	N	ΔS	σ	N
Buoy 84	-8.1 m TAW	Neap	2.6	0.4	26.0	2.7	0.3	38.0	3.3	0.3	22.0	3.0	0.3	22.0	2.7	0.3	64.0	3.0	0.4	62.0	2.9	0.4	108.0	2.8	0.5	277
		Avg	3.0	0.4	74.0	3.0	0.4	50.0	3.7	0.4	45.0	3.4	0.3	33.0	3.0	0.4	126.0	3.4	0.5	96.0	3.2	0.4	202.0	3.2	0.5	469
		Spring	3.5	0.3	59.0	3.5	0.4	61.0	3.9	0.4	27.0	3.8	0.3	8.0	3.5	0.4	120.0	3.7	0.5	57.0	3.6	0.4	155.0	3.6	0.5	389
		All	3.1	0.5	159.0	3.1	0.5	149.0	3.7	0.4	94.0	3.3	0.4	63.0	3.1	0.5	310.0	3.4	0.5	215.0	3.3	0.5	465.0	3.2	0.5	1135
	-5.6 m TAW	Neap	2.5	0.3	14.0	2.3	0.2	4.0	3.1	0.4	20.0	2.7	0.3	21.0	2.4	0.3	18.0	2.9	0.4	42.0	2.8	0.4	59.0	2.7	0.4	82.0
		Avg	2.7	0.3	17.0	2.8	0.3	2.0	3.4	0.3	43.0	3.0	0.3	31.0	2.7	0.3	19.0	3.2	0.3	74.0	3.1	0.4	93.0	3.1	0.4	190.0
		Spring	3.4	0.2	23.0	3.5	0.2	12.0	3.5	0.3	21.0	3.3	0.3	10.0	3.4	0.2	35.0	3.5	0.3	31.0	3.4	0.3	66.0	3.5	0.4	114.0
		All	2.9	0.5	54.0	3.1	0.5	18.0	3.3	0.3	84.0	3.0	0.4	62.0	3.0	0.5	72.0	3.2	0.4	147.0	3.1	0.4	218.0	3.2	0.5	386.0
Oosterweel	- 5.8 m TAW	Neap	5.2	1.2	25.0	6.7	0.5	24.0	-	-	1.0	-	-	1.0	6.0	1.2	49.0	7.0	0.1	2.0	6.0	1.2	49.0	5.0	1.7	196.0
		Avg	6.3	0.9	66.0	7.4	0.4	46.0	-	-	1.0	-	-	1.0	6.8	0.9	112.0	7.4	0.2	4.0	6.8	0.9	112.0	5.6	1.6	378.0
		Spring	6.3	1.1	46.0	8.0	0.4	37.0	-	-	1.0	-	-	1.0	7.0	1.2	83.0	-	-	1.0	7.0	1.2	83.0	5.8	1.9	287.0
		All	6.1	1.1	137.0	7.4	0.6	107.0	-	-	1.0	-	-	1.0	6.7	1.1	244.0	7.3	0.3	6.0	6.7	1.1	244.0	5.5	1.7	861.0
	- 2.3 m TAW	Neap	5.3	1.2	23.0	7.6	0.2	3.0	-	-	1.0	-	-	1.0	5.5	1.3	26.0	-	-	1.0	5.5	1.3	26.0	4.7	1.6	171.0
		Avg	6.3	0.9	67.0	7.5	0.2	17.0	-	-	1.0	-	-	1.0	6.6	1.0	84.0	-	-	1.0	6.6	1.0	84.0	5.4	1.6	352.0
		Spring	6.4	1.1	45.0	7.5	0.2	7.0	-	-	1.0	-	-	1.0	6.6	1.1	52.0	-	-	1.0	6.6	1.1	52.0	5.5	1.8	250.0
		All	6.2	1.1	135.0	7.5	0.2	27.0	-	-	1.0	-	-	1.0	6.4	1.1	162.0	-	-	1.0	6.4	1.1	162.0	5.3	1.7	773.0
Prosperpolder	- 1.5 m TAW	Neap	3.2	0.4	31.0	2.9	0.6	37.0	3.2	0.5	39.0	2.9	0.4	39.0	3.1	0.5	68.0	3.0	0.5	89.0	3.0	0.5	146.0	3.0	0.5	146.0
		Avg	3.7	0.4	70.0	3.6	0.5	47.0	3.6	0.5	78.0	3.6	0.5	44.0	3.6	0.4	119.0	3.6	0.5	131.0	3.6	0.5	239.0	3.6	0.5	239.0
		Spring	4.0	0.5	53.0	3.8	0.7	42.0	4.3	0.5	53.0	4.1	0.5	61.0	3.9	0.6	95.0	4.2	0.5	127.0	4.0	0.6	209.0	4.0	0.6	209.0
		All	3.7	0.5	154.0	3.4	0.7	126.0	3.7	0.7	170.0	3.6	0.7	144.0	3.6	0.6	282.0	3.6	0.7	347.0	3.6	0.6	594.0	3.6	0.6	594.0
Liefkenshoek		Neap	-	-	1.0	2.0	0.3	34.0	3.1	0.4	8.0	2.3	0.4	2.0	2.0	0.3	34.0	2.2	0.7	28.0	2.2	0.5	44.0	2.2	0.5	44.0
		Avg	-	-	1.0	2.2	0.3	26.0	3.3	0.6	25.0	-	-	1.0	2.2	0.3	28.0	2.9	0.7	39.0	2.7	0.7	51.0	2.7	0.7	51.0
		Spring	-	-	1.0	2.2	0.3	45.0	2.8	0.6	22.0	-	-	1.0	2.2	0.3	45.0	2.5	0.6	43.0	2.4	0.5	67.0	2.4	0.5	67.0
		All	-	-	1.0	2.1	0.3	105.0	3.0	0.6	55.0	2.3	0.4	2.0	2.1	0.3	107.0	2.5	0.7	110.0	2.4	0.6	162.0	2.4	0.6	162.0



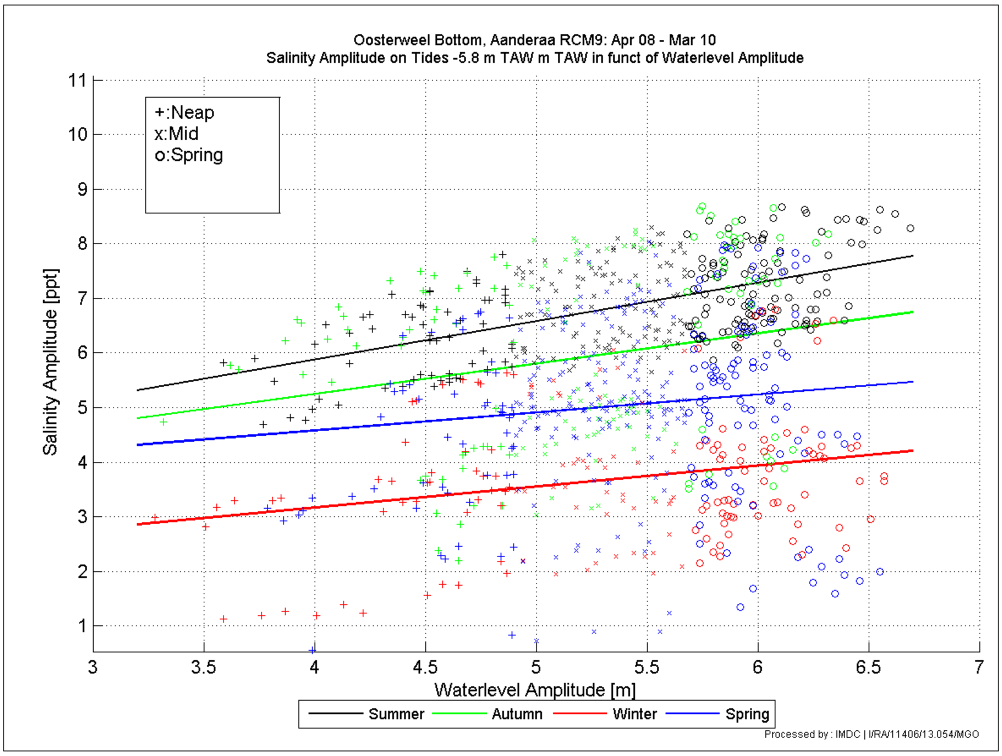
Annex-Figure D-11: Buoy 84 (-5.6 m TAW). Amplitude of the salinity vs. tidal amplitude (R = 0.51; sig = 0.00; n = 386). April 2008 – March 2010.



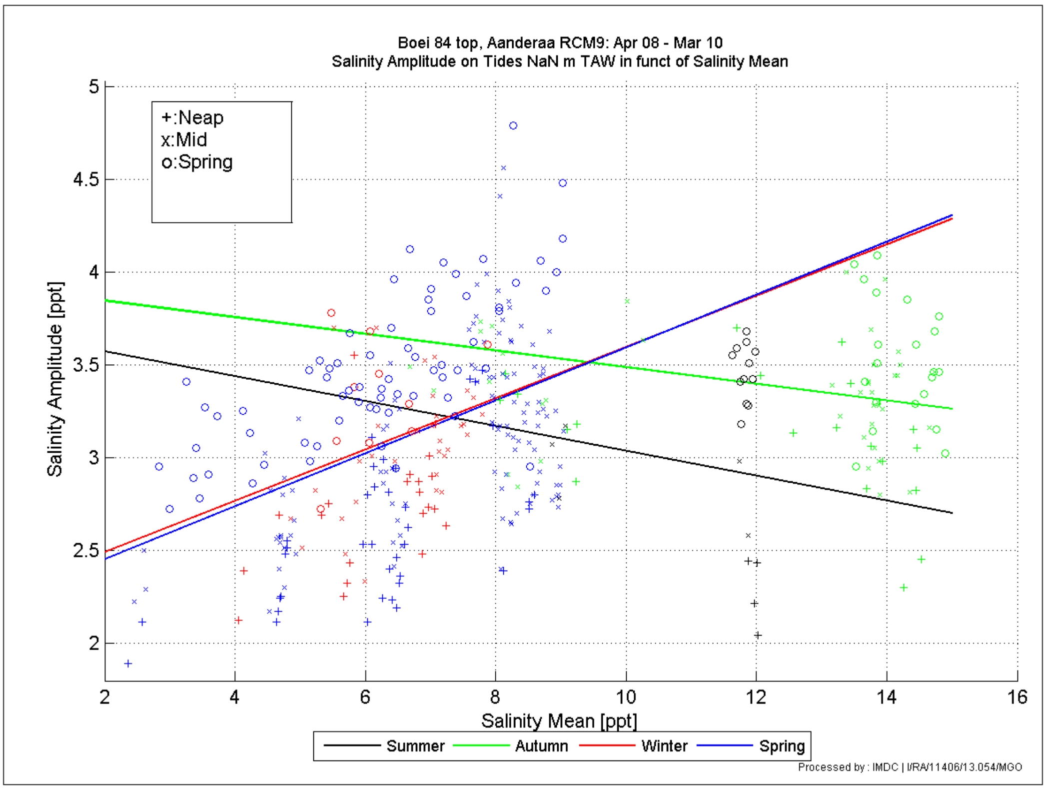
Annex-Figure D-12: Buoy 84 (-8.1 m TAW). Amplitude of the salinity vs. tidal amplitude (R = 0.54; sig = 0.00; n = 1137). April 2008 – March 2010.



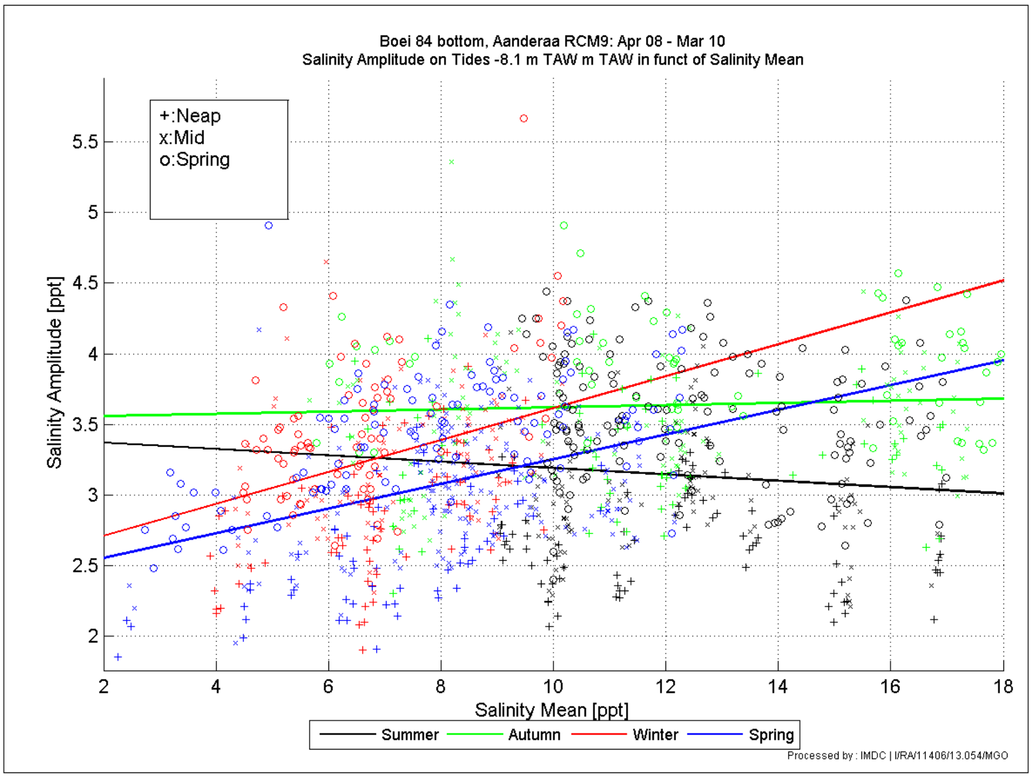
Annex-Figure D-13: Oosterweel (-2.3 m TAW). Amplitude of the salinity vs. tidal amplitude (R = 0.16; sig = 0.00; n = 819). April 2008 – March 2010.



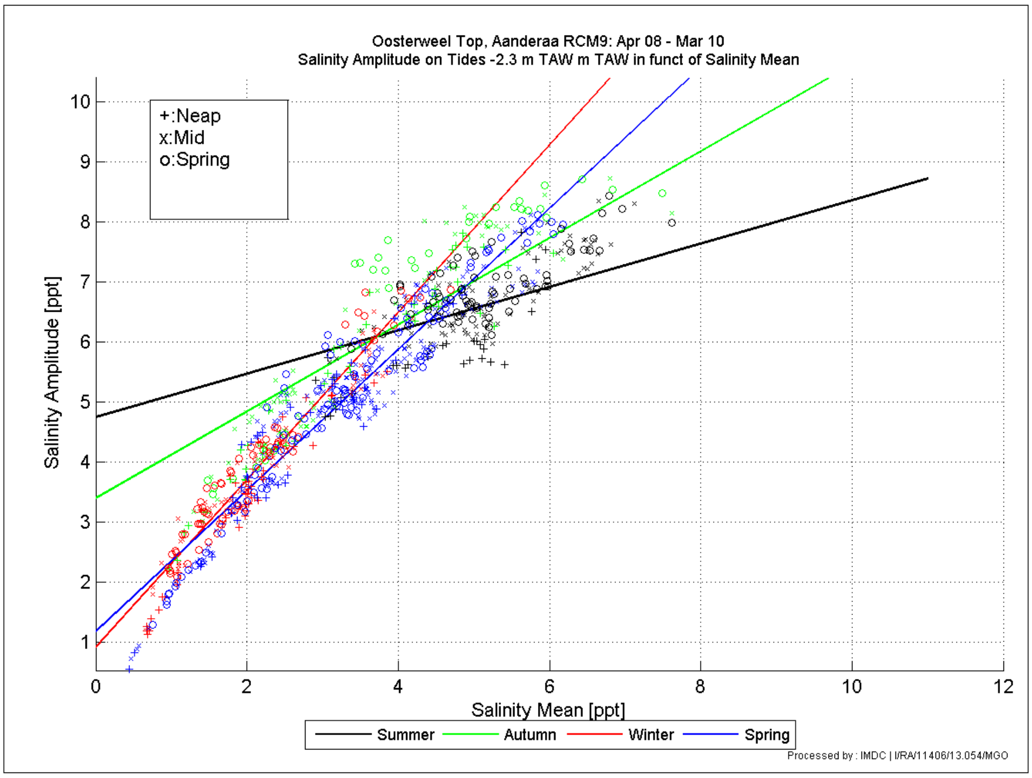
Annex-Figure D-14: Oosterweel (-5.8m TAW). Amplitude of the salinity vs. tidal amplitude R = 0.19; sig = 0.00; n = 902). April 2008 – March 2010.



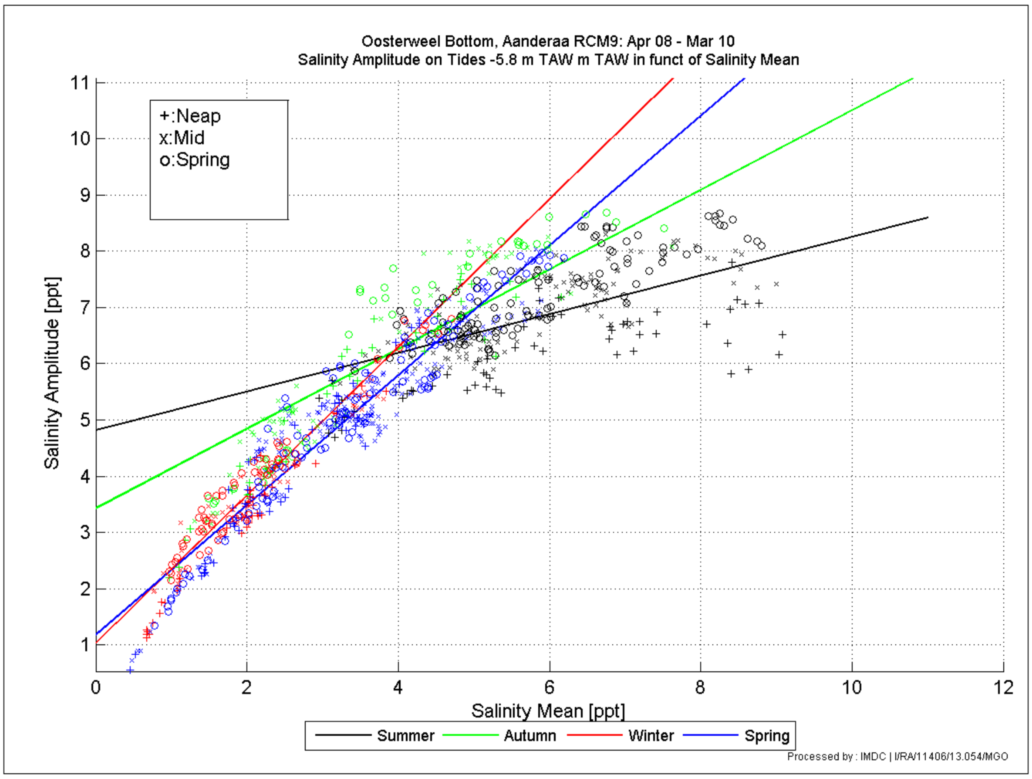
Annex-Figure D-15: Buoy 84 (-5.6 m TAW). Amplitude of the salinity vs. salinity mean (R = 0.24; sig = 0.00; n = 568). April 2008 – March 2010.



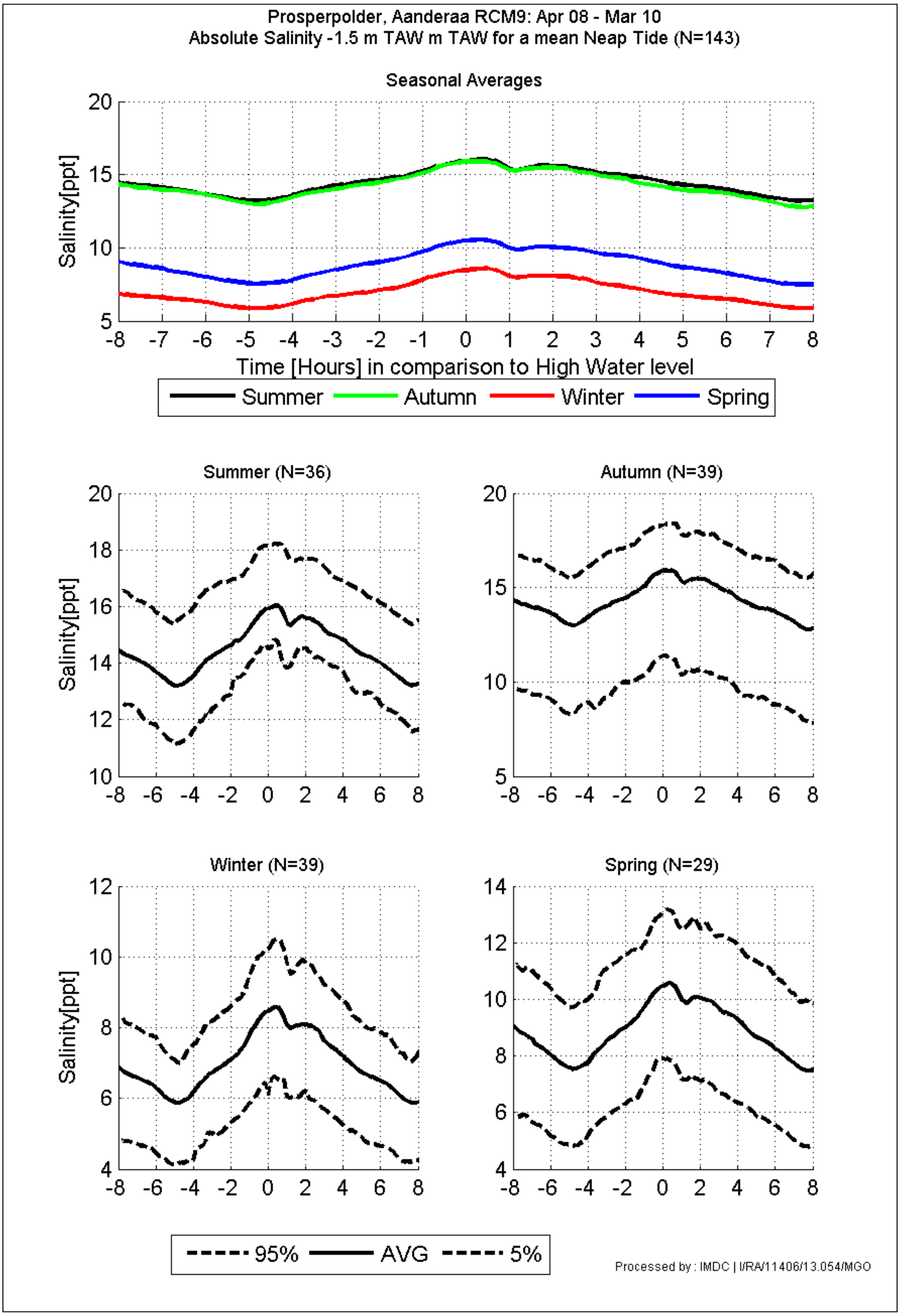
Annex-Figure D-16: Buoy 84 (-8.1 m TAW). Amplitude of the salinity vs. salinity mean (R = 0.18; sig = 0.00; n = 1321). April 2008 – March 2010.



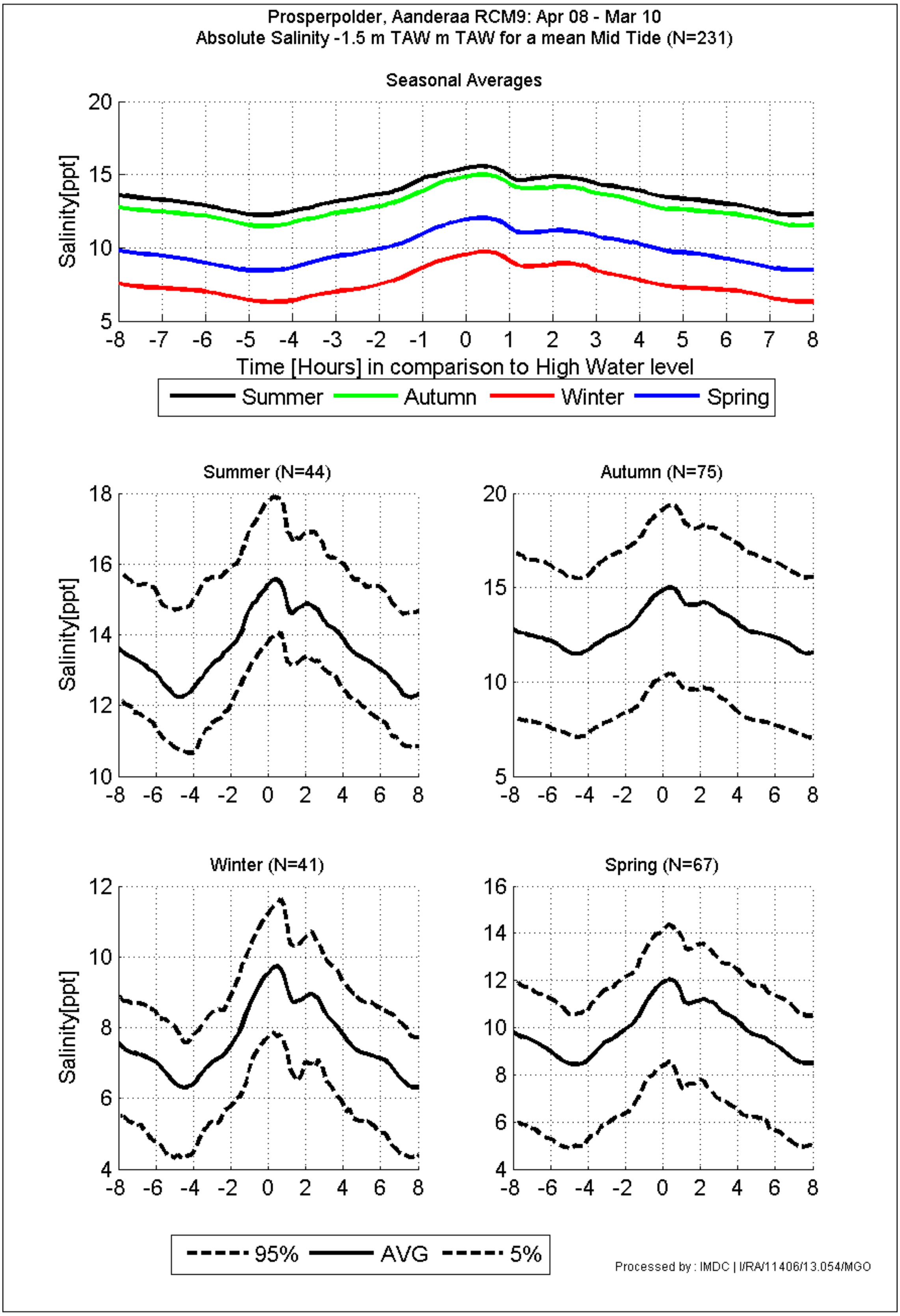
Annex-Figure D-17: Oosterweel (-2.3 m TAW). Amplitude of the salinity vs. salinity mean (R = 0.91; sig = 0.00; n = 1167). April 2008 – March 2010.



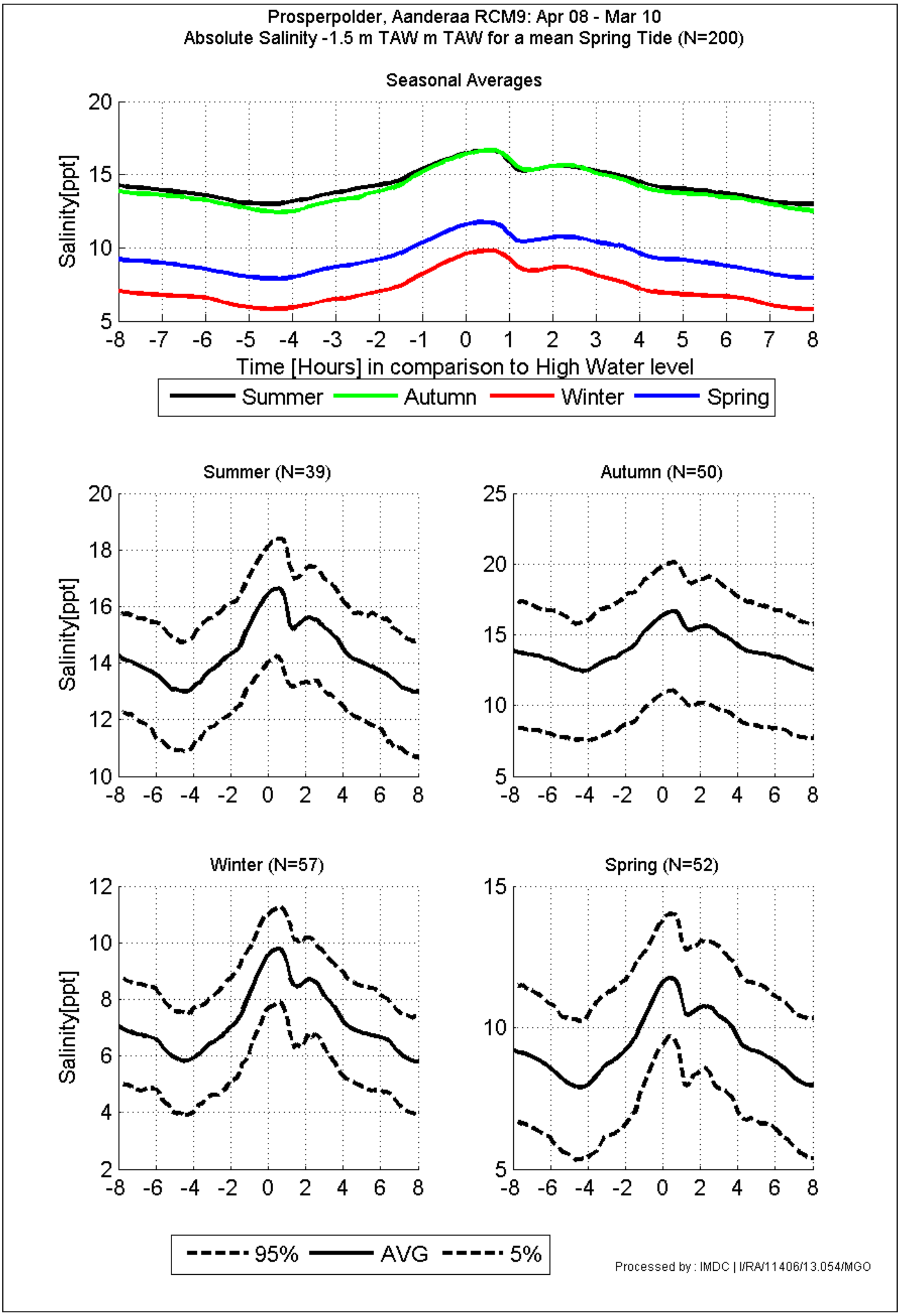
Annex-Figure D-18: Oosterweel (-5.8m TAW). Amplitude of the salinity vs. tidal amplitude (R = 0.89; sig = 0.00; n = 1281). April 2008 – March 2010.



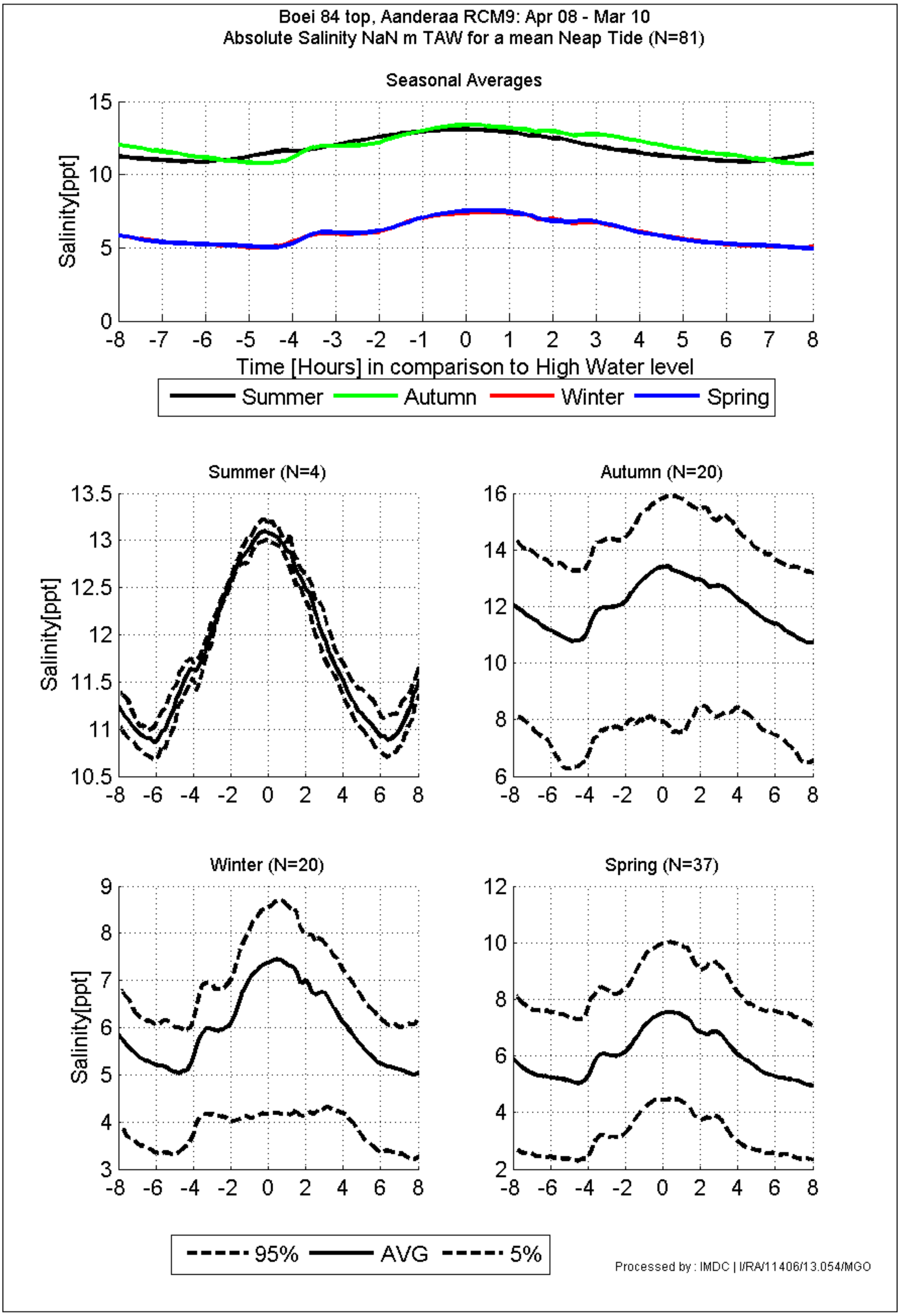
Annex-Figure D-19: Prosperpolder (-1.5m TAW), April 2008 – March 2010.
Average tidal curve of the salinity for an average neap tide.



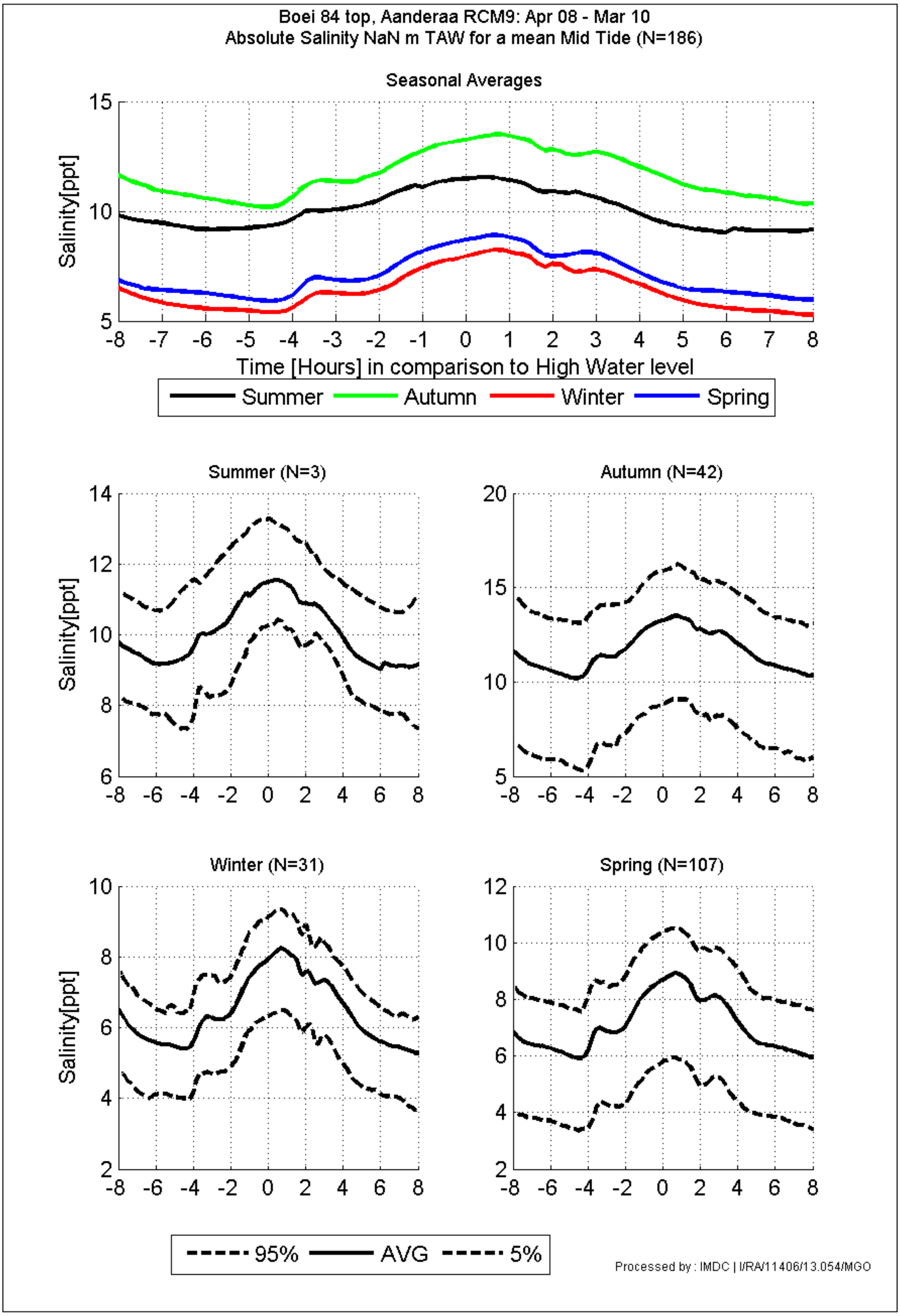
Annex-Figure D-20: Prosperpolder (-1.5m TAW), April 2008 – March 2010. Average tidal curve of the salinity for an average mean tide.



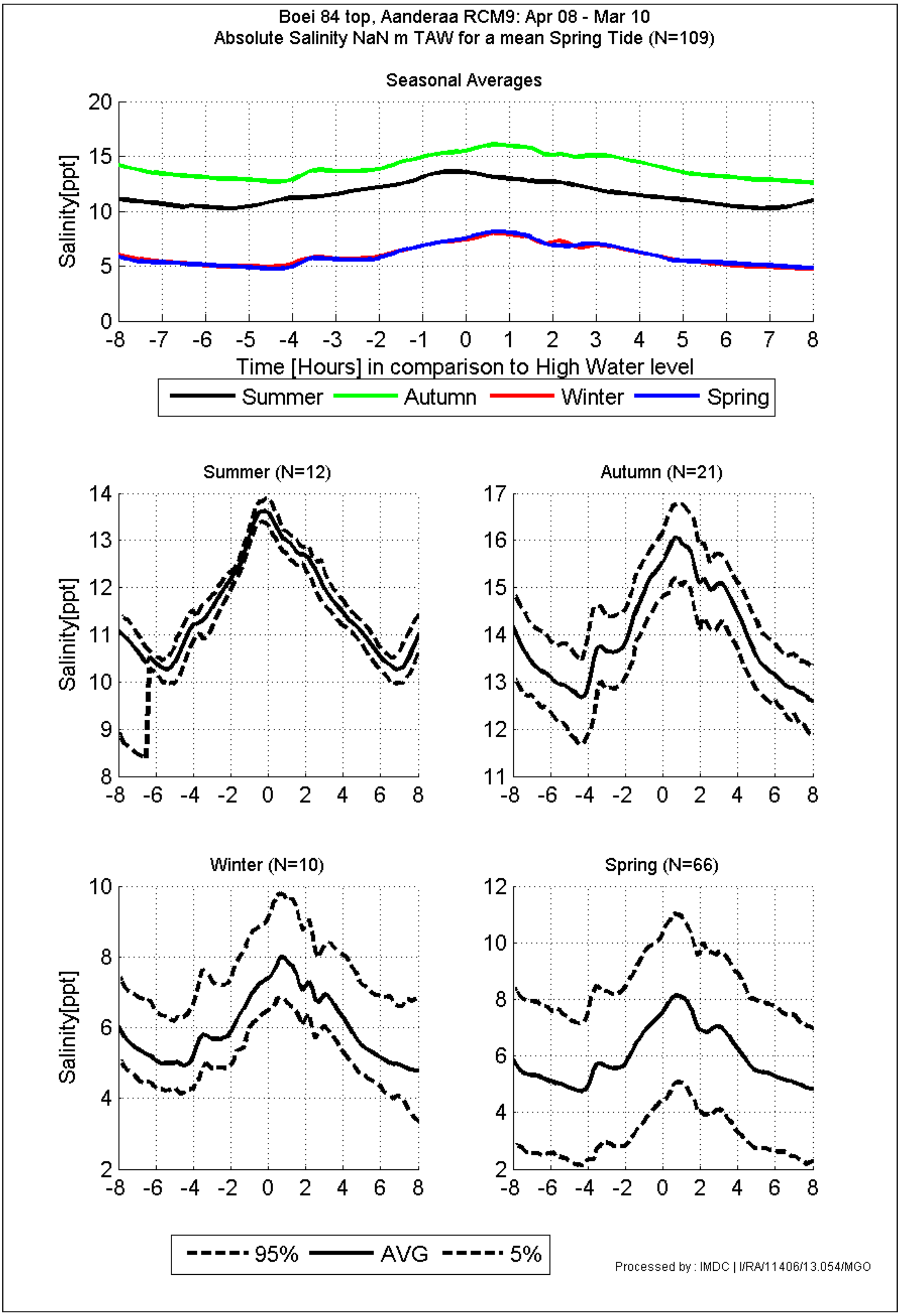
Annex-Figure D-21: Prosperpolder (-1.5m TAW), April 2008 – March 2010. Average tidal curve of the salinity for an average spring tide.



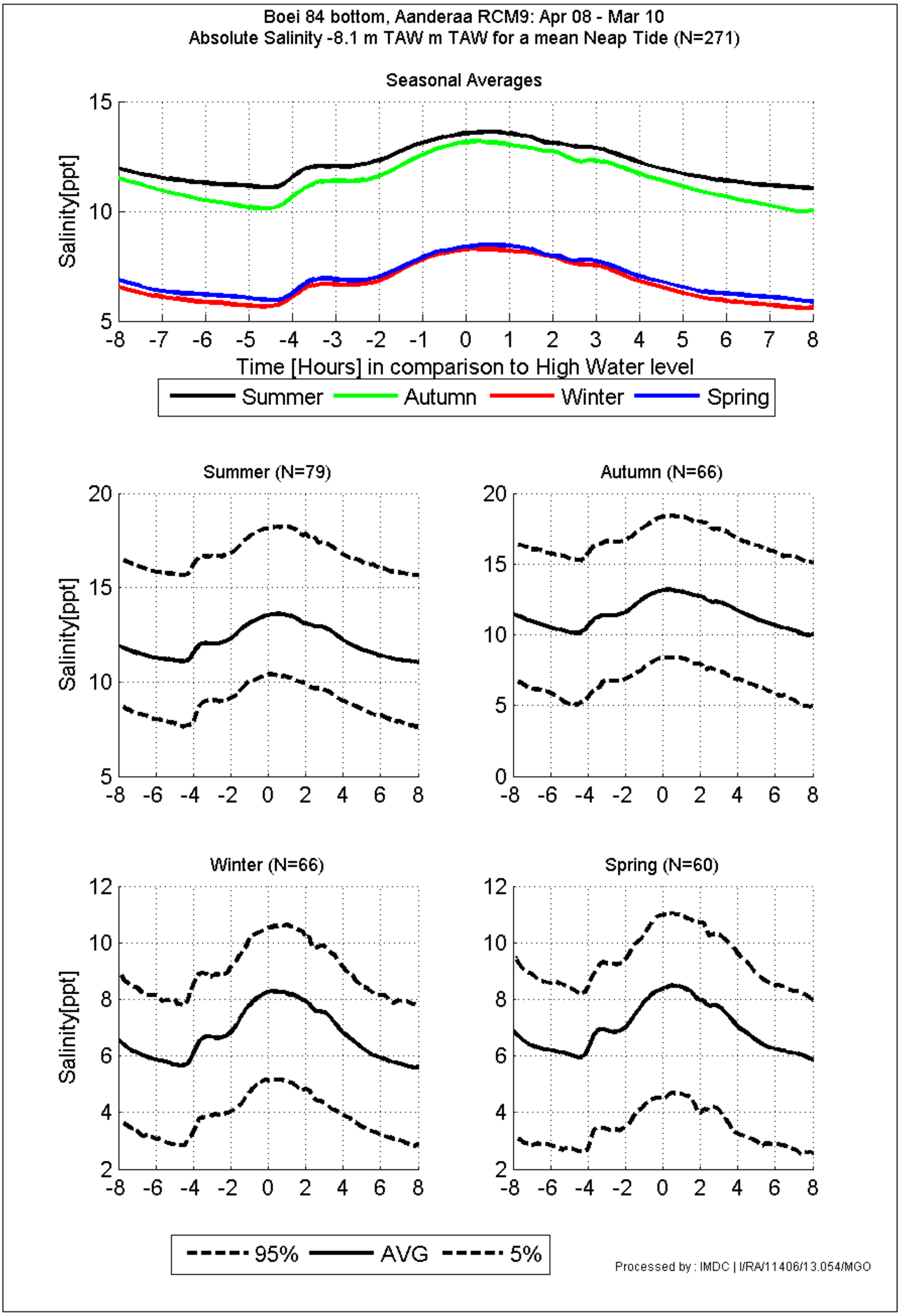
Annex-Figure D-22: Buoy 84 (-5.6m TAW), April 2008 – March 2010.
Average tidal curve of the salinity for an average neap tide.



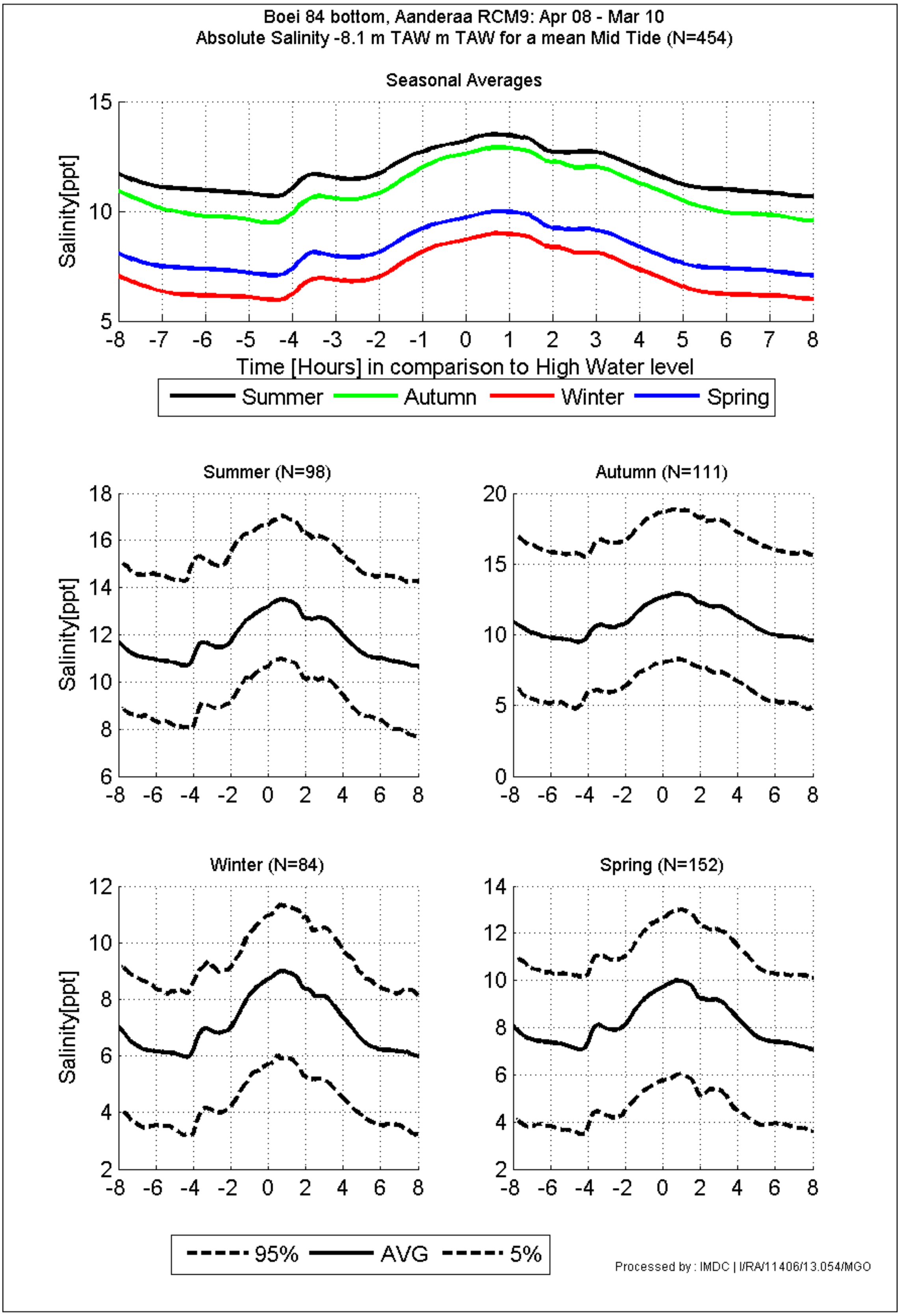
Annex-Figure D-23: Buoy 84 (-5.6m TAW), April 2008 – March 2010.
Average tidal curve of the salinity for an average mean tide.



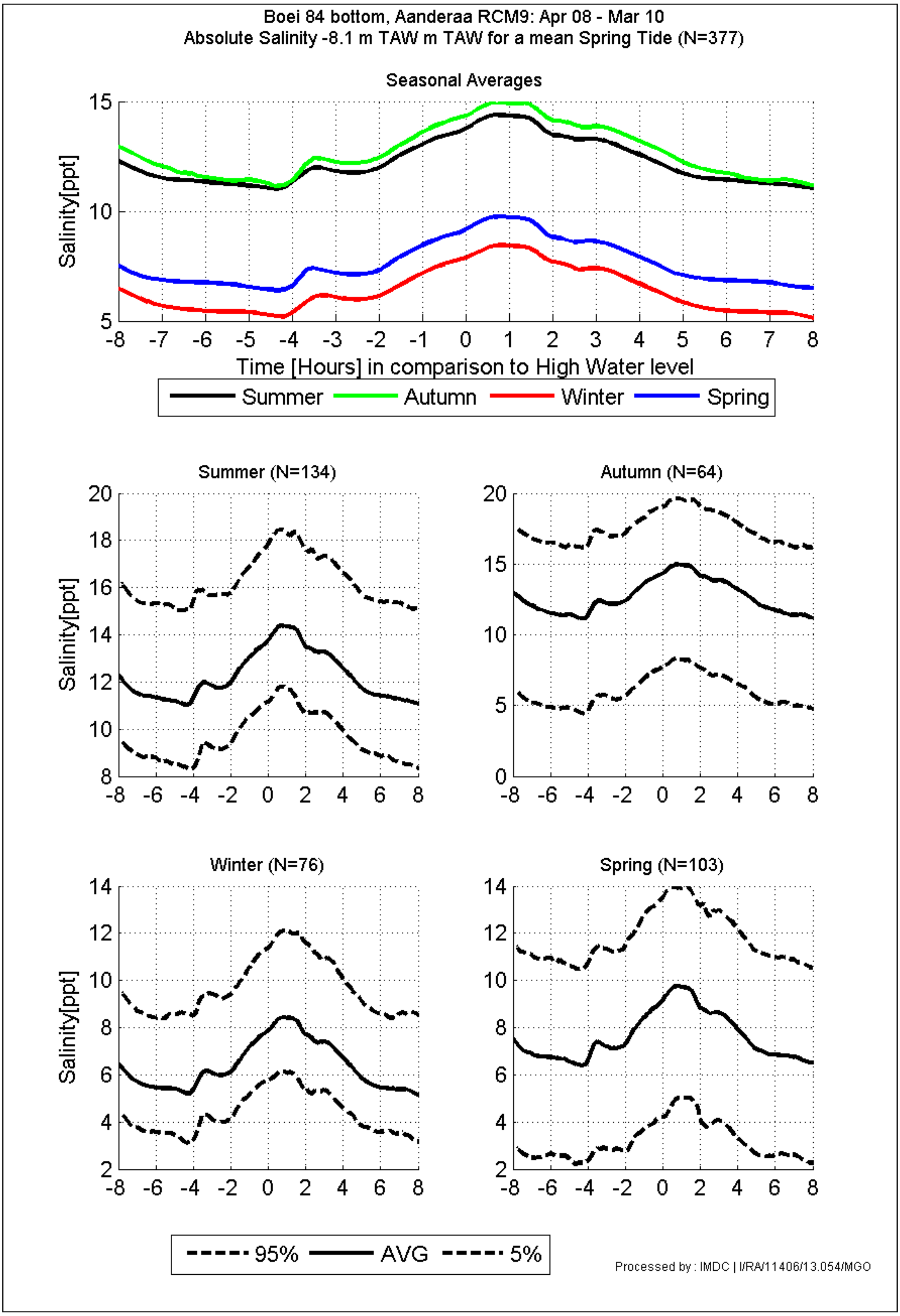
Annex-Figure D-24: Buoy 84 (-5.6m TAW), April 2008 – March 2010.
Average tidal curve of the salinity for an average spring tide.



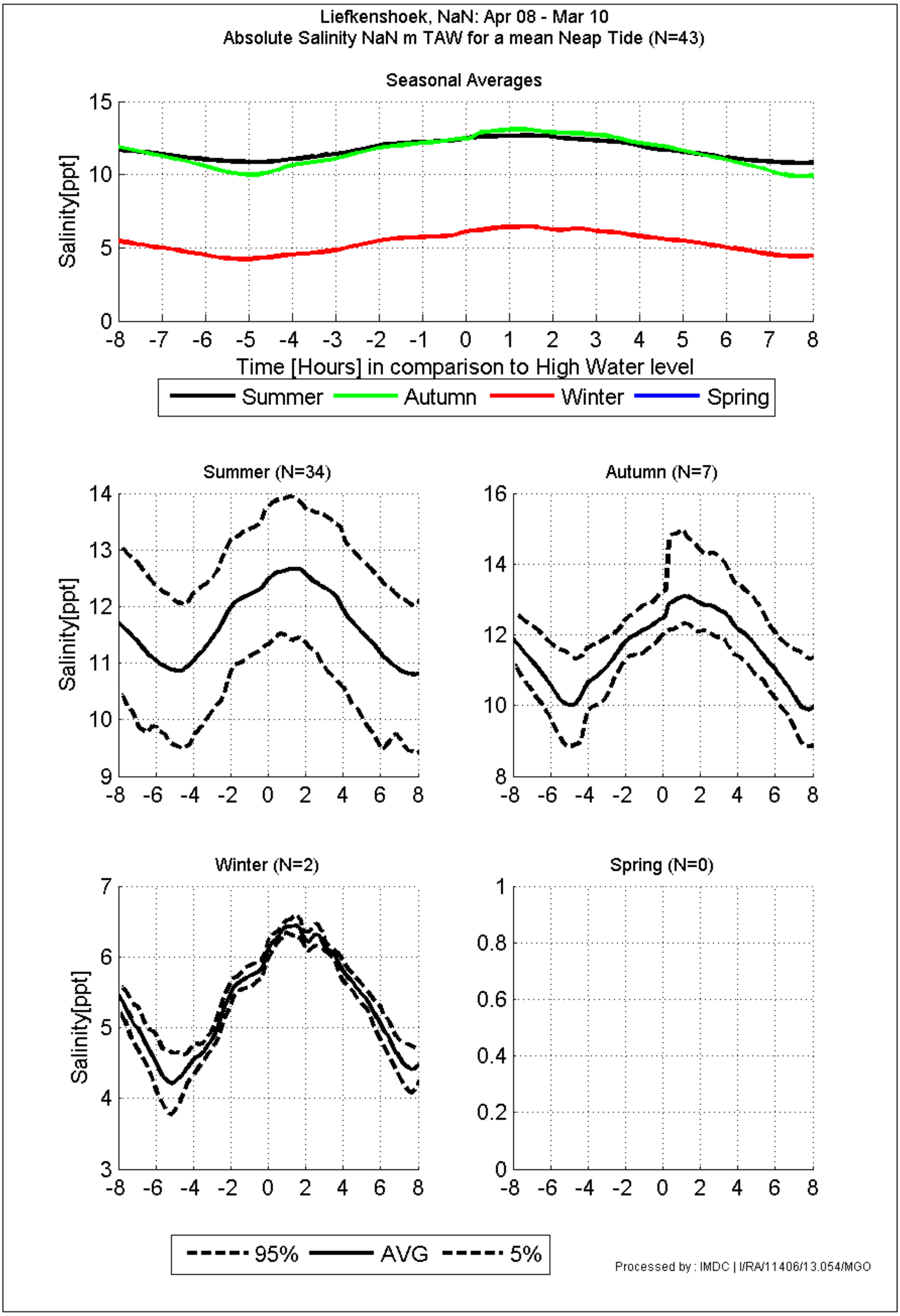
Annex-Figure D-25: Buoy 84 (-8.1m TAW), April 2008 – March 2010.
Average tidal curve of the salinity for an average neap tide.



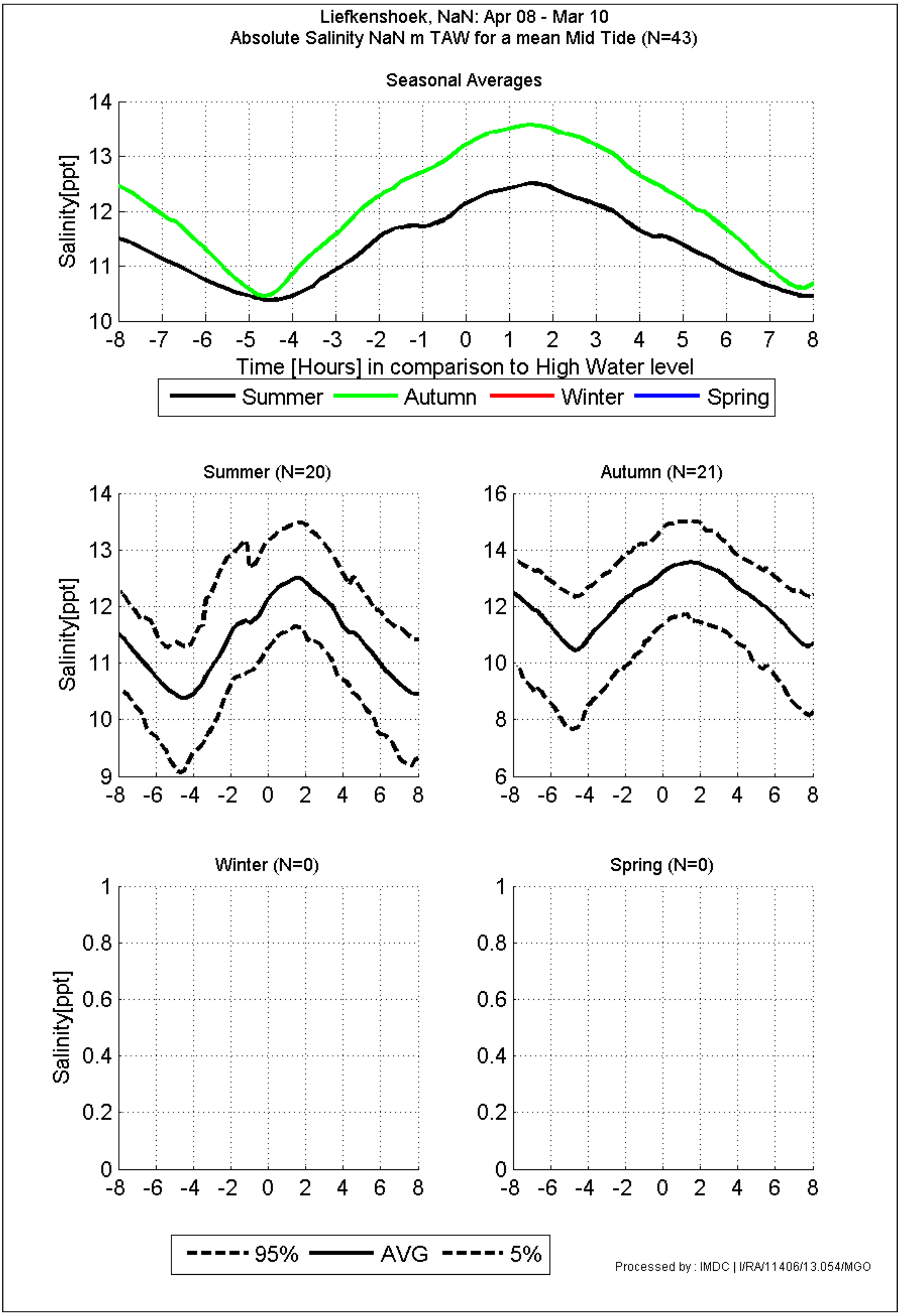
Annex-Figure D-26: Buoy 84 (-8.1m TAW), April 2008 – March 2010.
Average tidal curve of the salinity for an average mean tide.



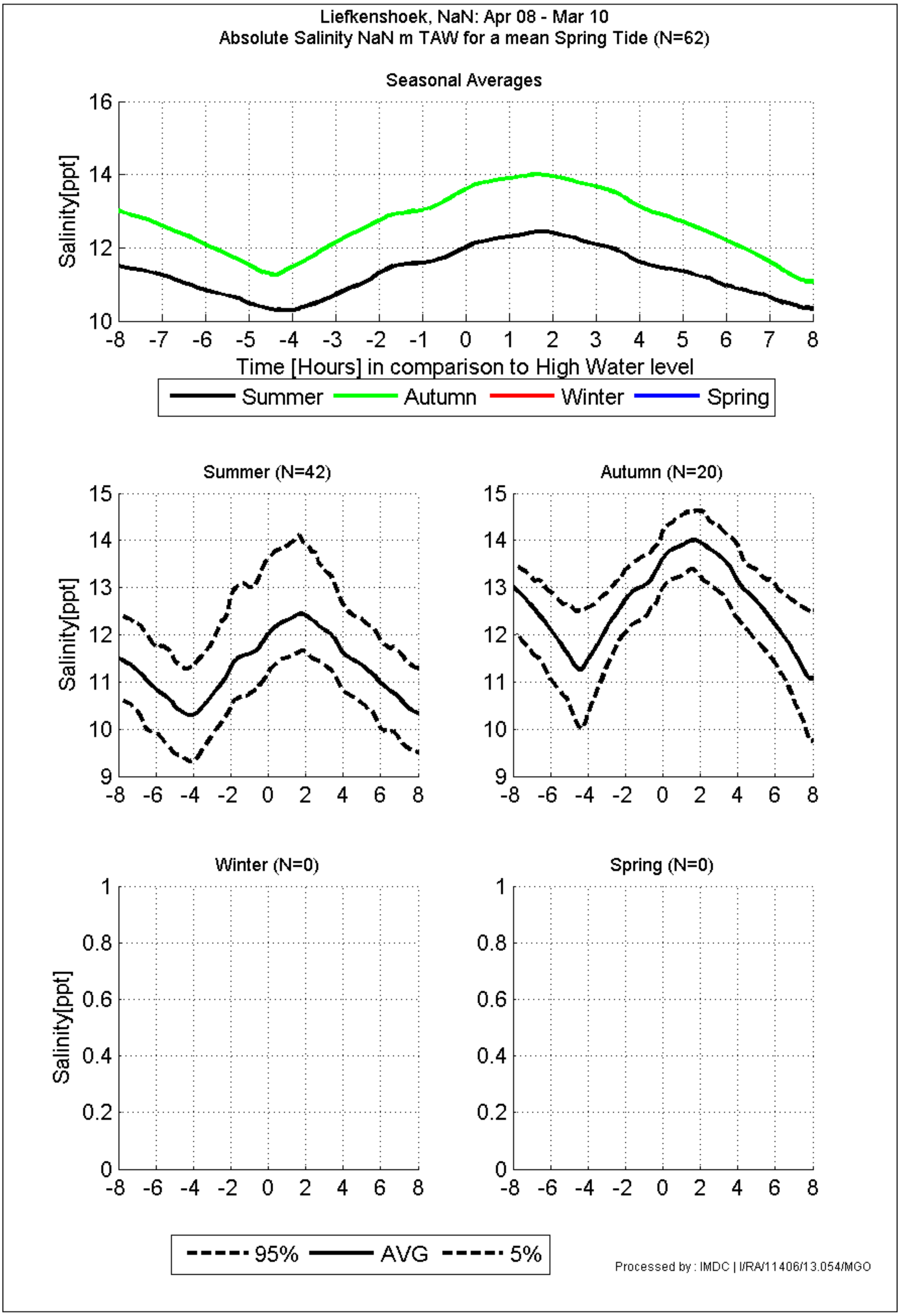
Annex-Figure D-27: Buoy 84 (-8.1m TAW), April 2008 – March 2010.
Average tidal curve of the salinity for an average spring tide.



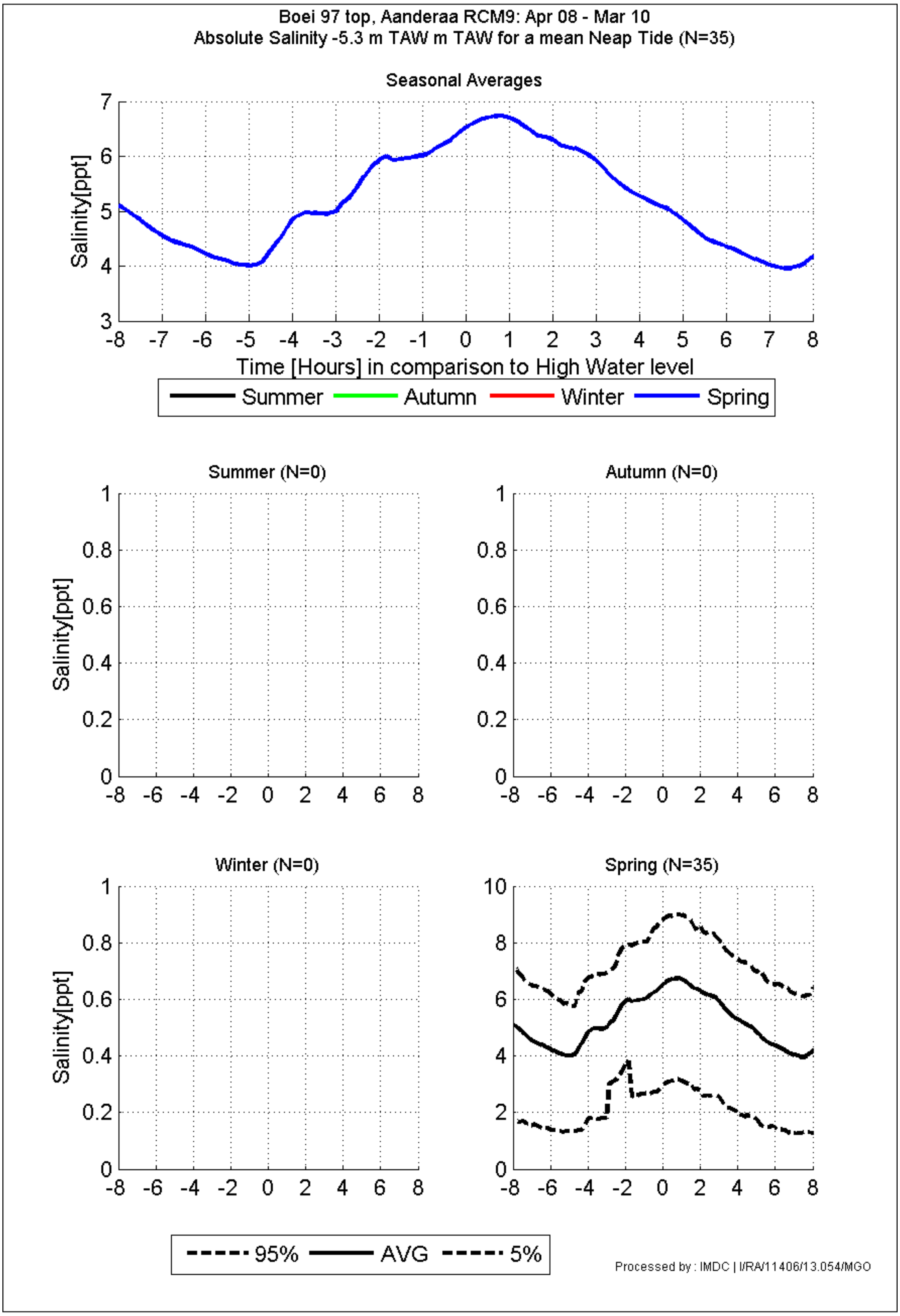
Annex-Figure D-28: Liefkenshoek, April 2008 – March 2010.
Average tidal curve of the salinity for an average neap tide.



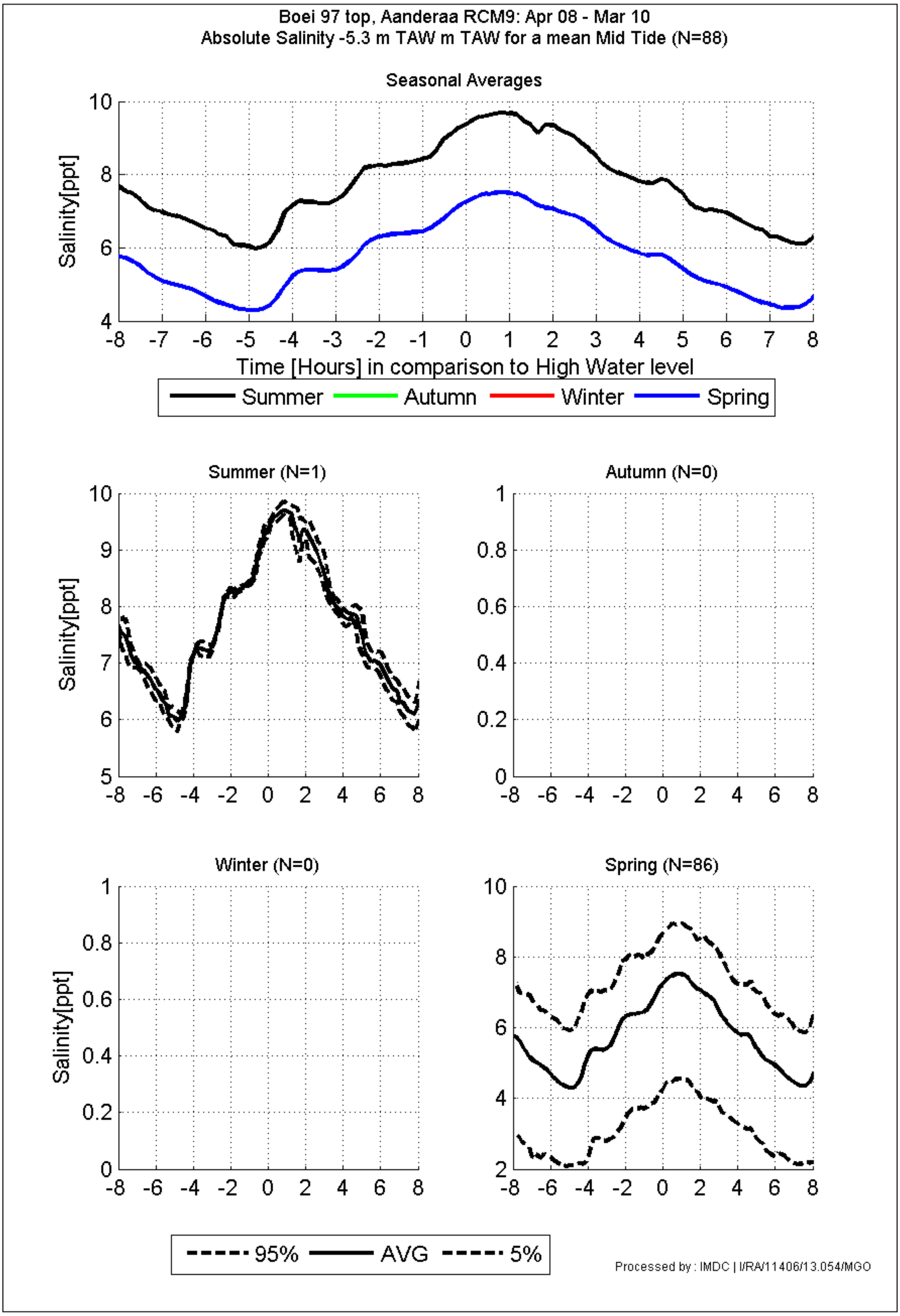
Annex-Figure D-29: Liefkenshoek, April 2008 – March 2010.
Average tidal curve of the salinity for an average mean tide.



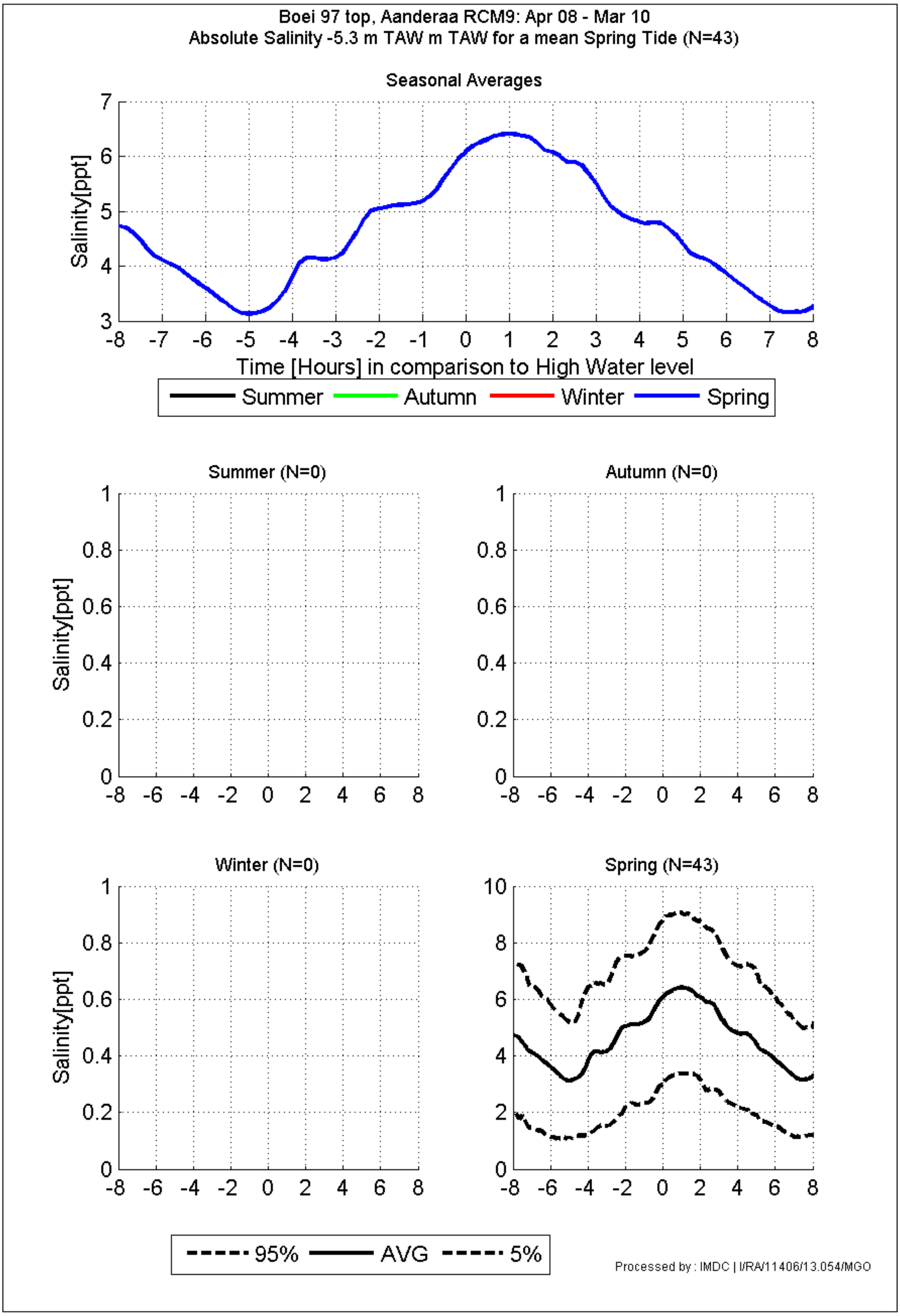
Annex-Figure D-30: Liefkenshoek, April 2008 – March 2010.
Average tidal curve of the salinity for an average spring tide.



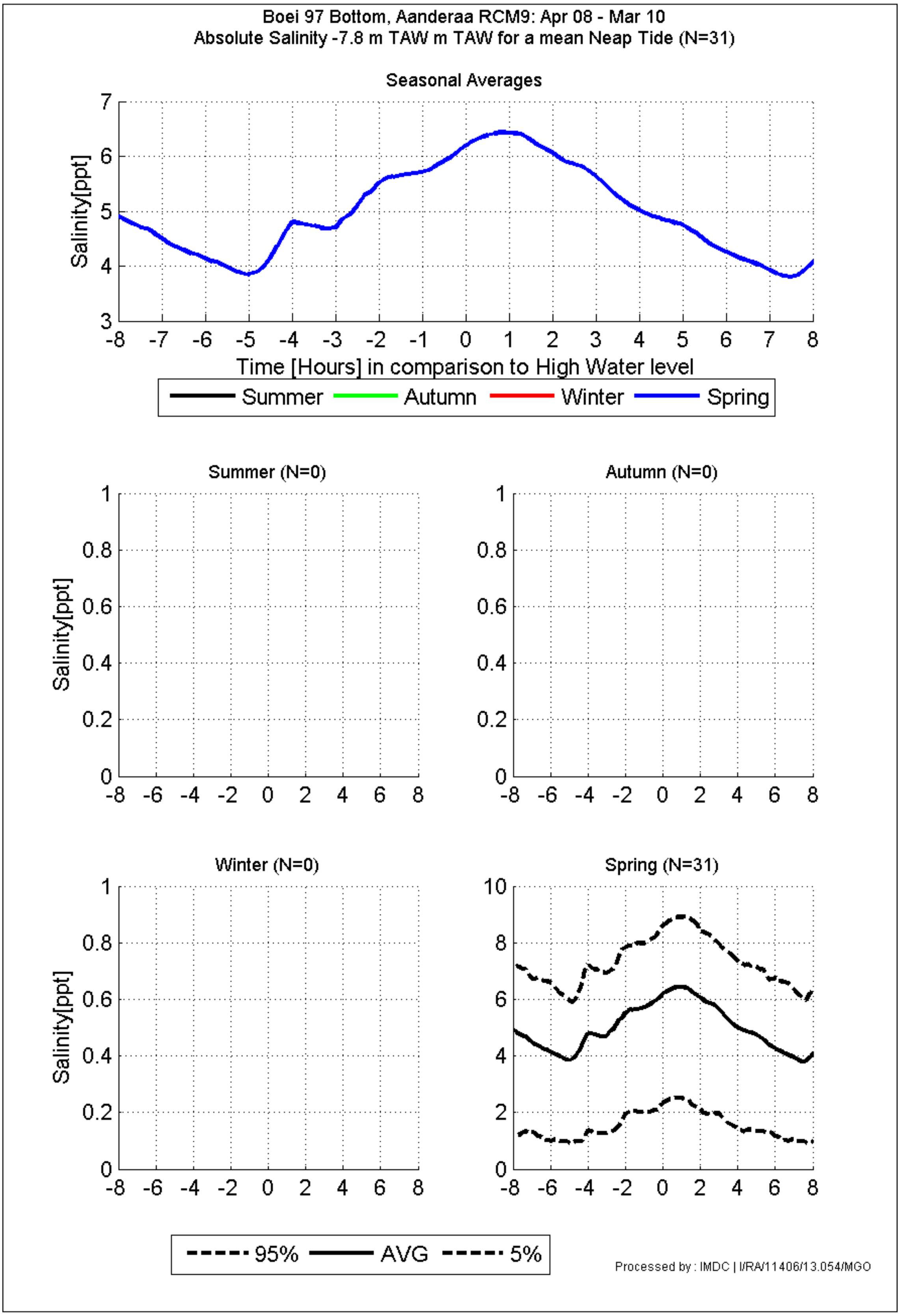
Annex-Figure D-31: Buoy 97 (-5.3m TAW), April 2008 – March 2010.
Average tidal curve of the salinity for an average neap tide.



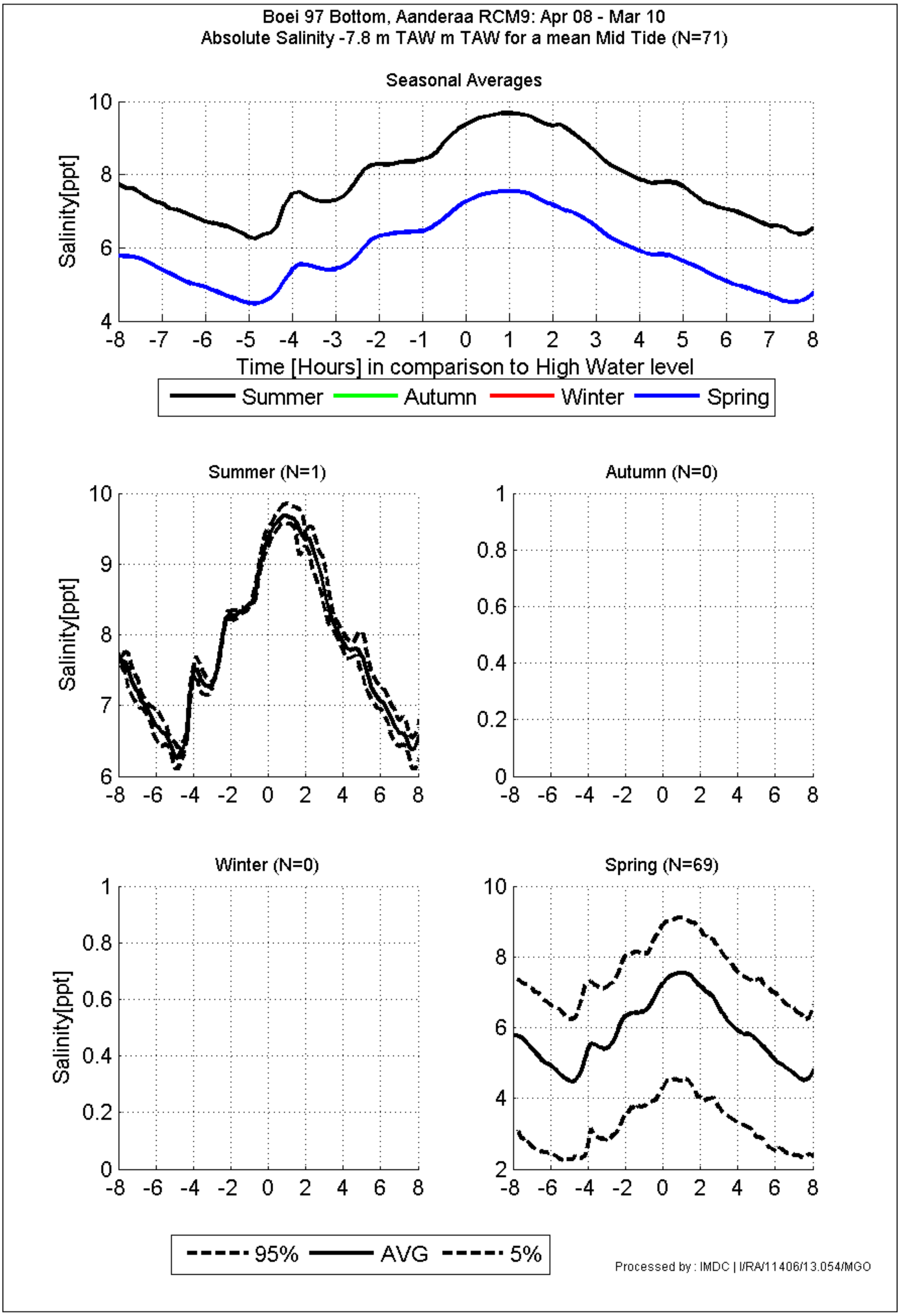
Annex-Figure D-32: Buoy 97 (-5.3m TAW), April 2008 – March 2010.
Average tidal curve of the salinity for an average mean tide.



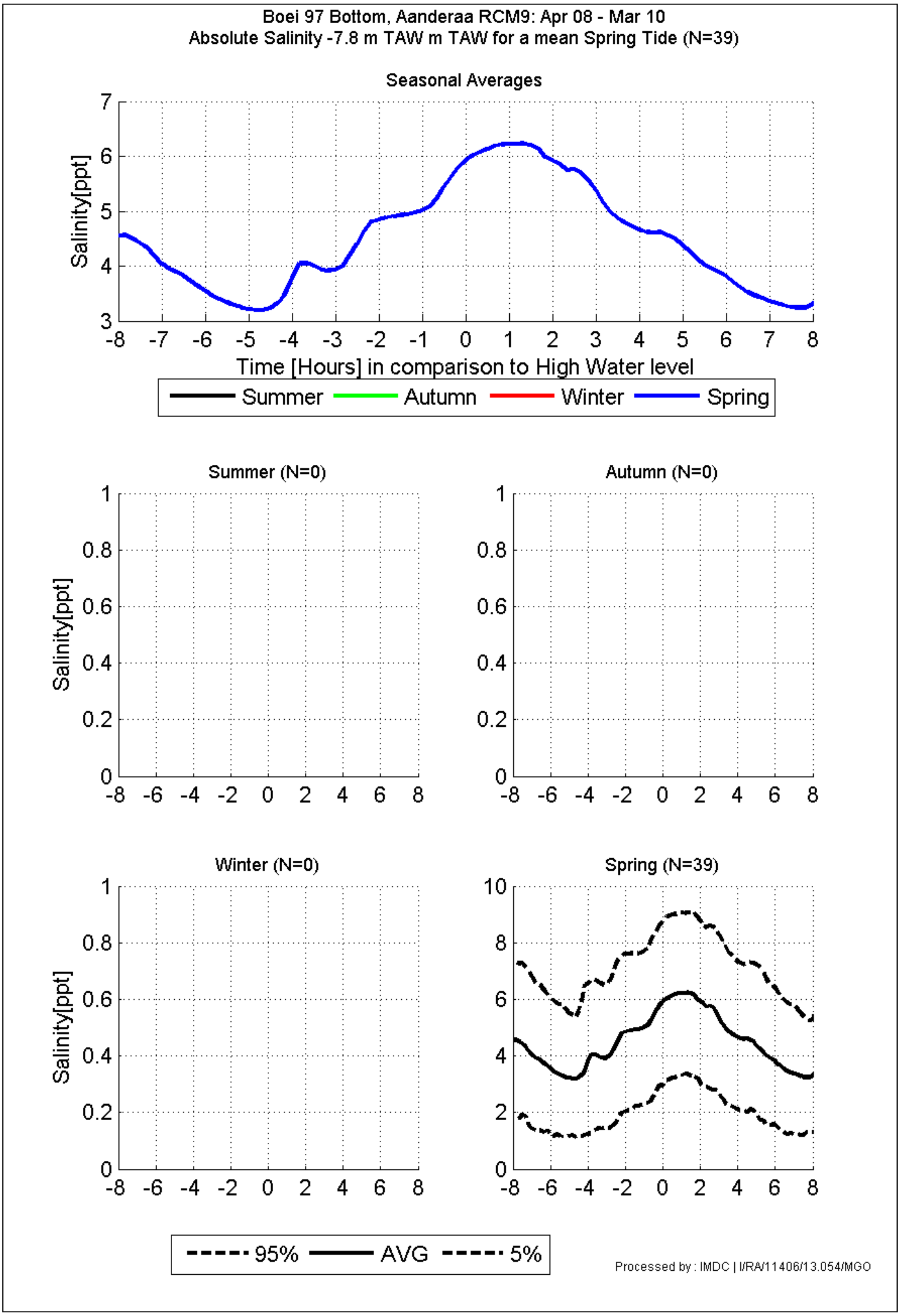
Annex-Figure D-33: Buoy 97 (-5.3m TAW), April 2008 – March 2010.
Average tidal curve of the salinity for an average spring tide.



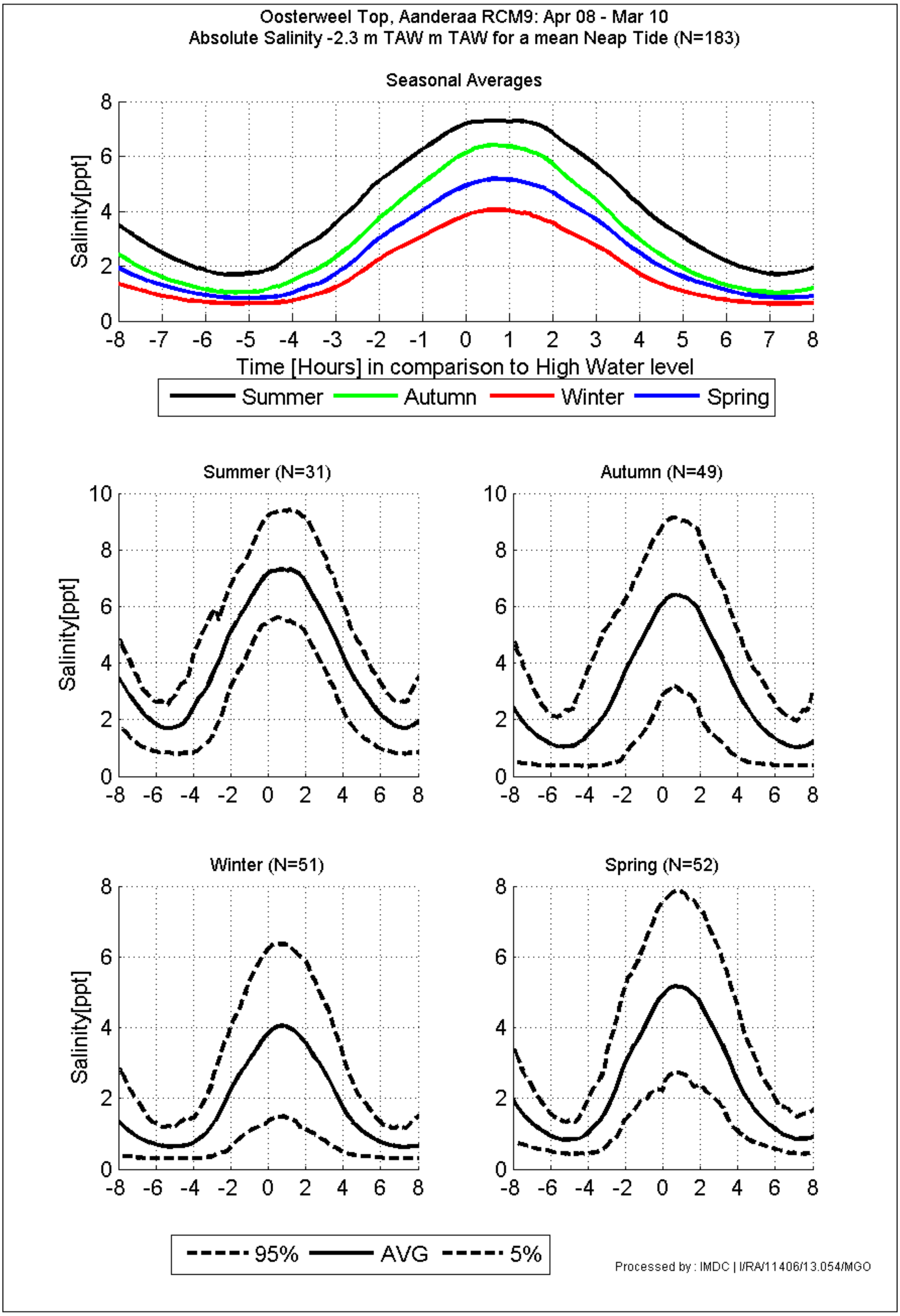
Annex-Figure D-34: Buoy 97 (-7.8m TAW), April 2008 – March 2010.
Average tidal curve of the salinity for an average neap tide.



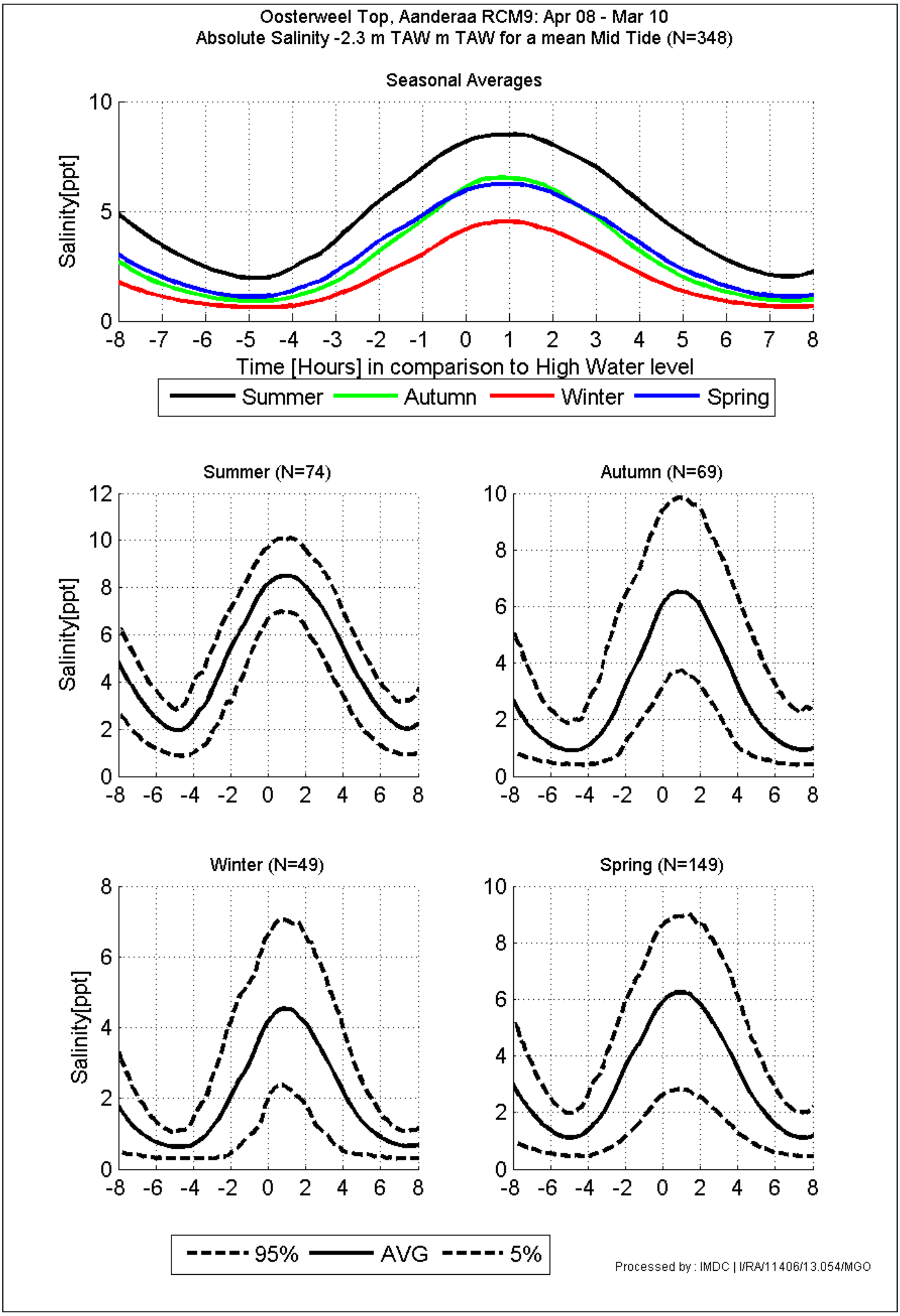
Annex-Figure D-35: Buoy 97 (-7.8m TAW), April 2008 – March 2010.
Average tidal curve of the salinity for an average mean tide.



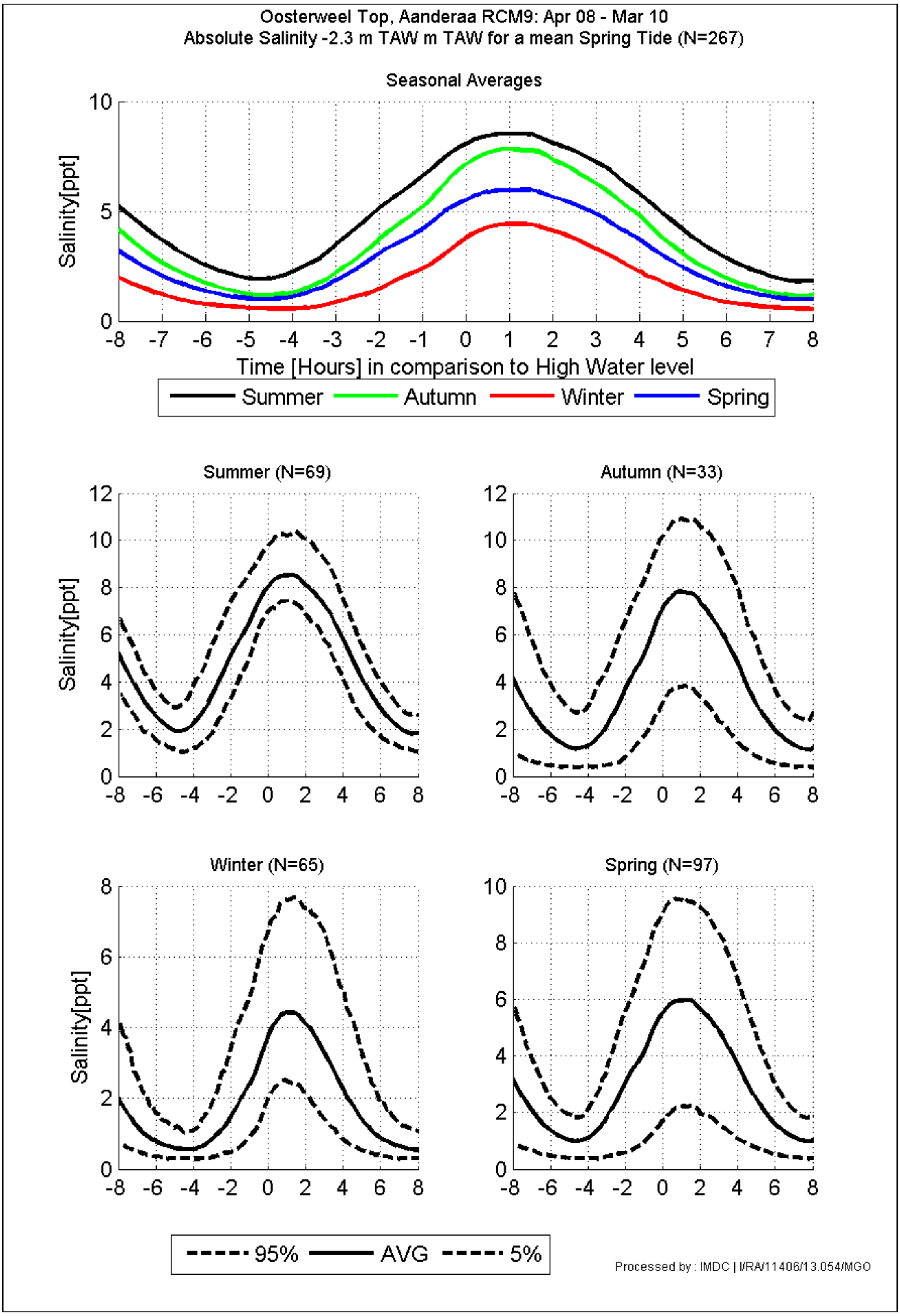
Annex-Figure D-36: Buoy 97 (-7.8m TAW), April 2008 – March 2010.
Average tidal curve of the salinity for an average spring tide.



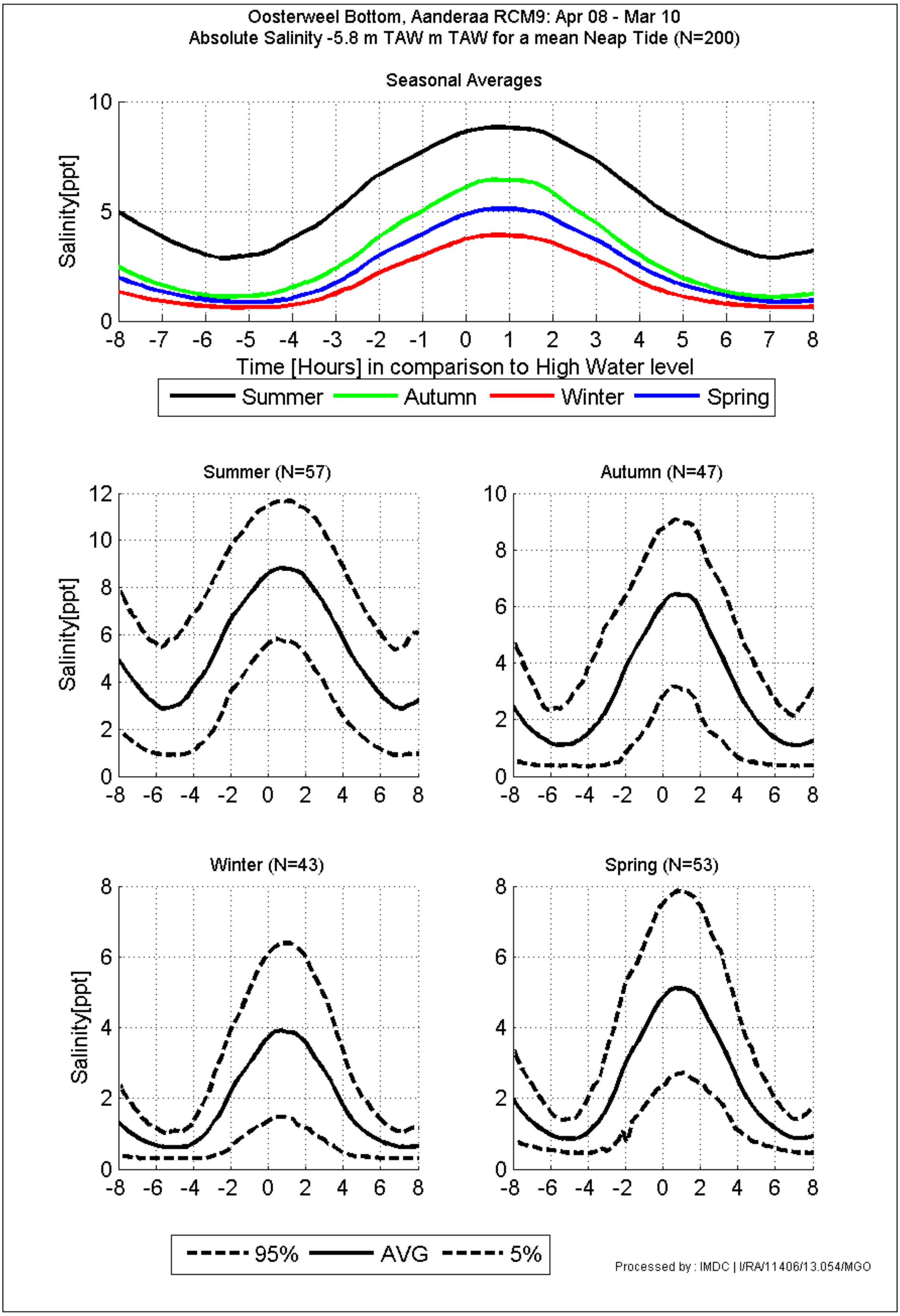
Annex-Figure D-37: Oosterweel Top (-2.3m TAW), April 2008 – March 2010. Average tidal curve of the salinity for an average neap tide.



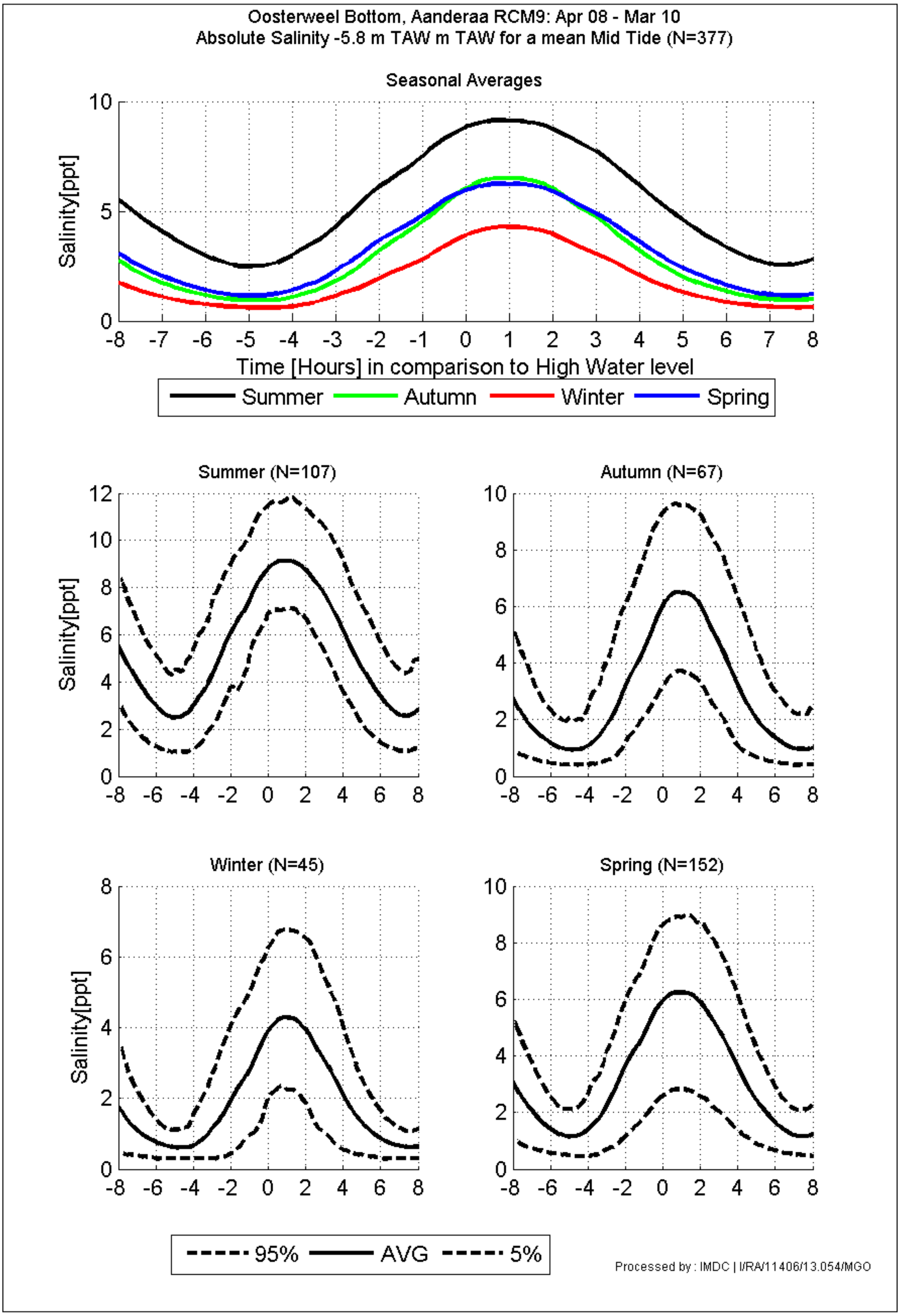
Annex-Figure D-38: Oosterweel Top (-2.3m TAW), April 2008 – March 2010. Average tidal curve of the salinity for an average mean tide.



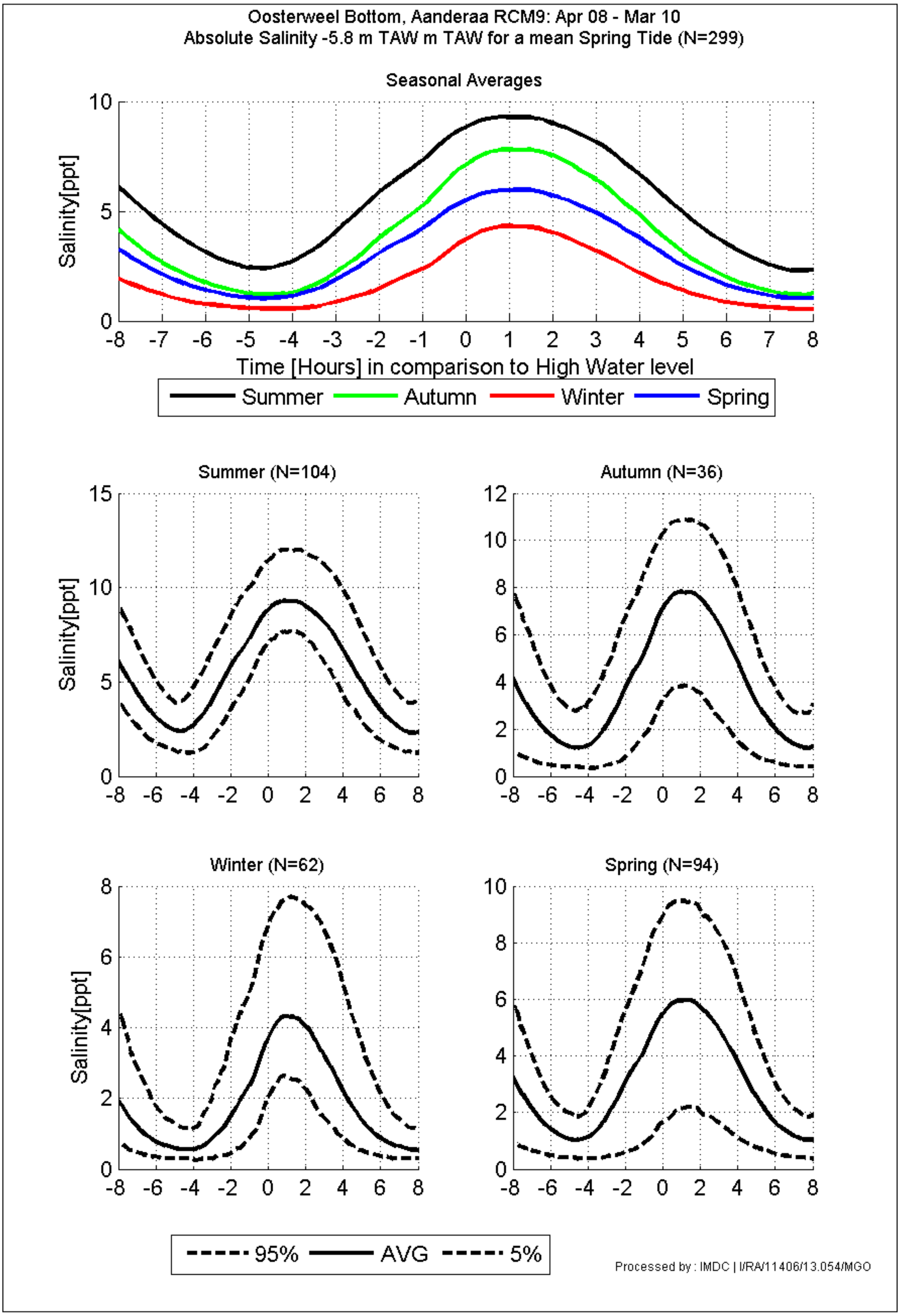
Annex-Figure D-39: Oosterweel Top (-2.3m TAW), April 2008 – March 2010. Average tidal curve of the salinity for an average spring tide.



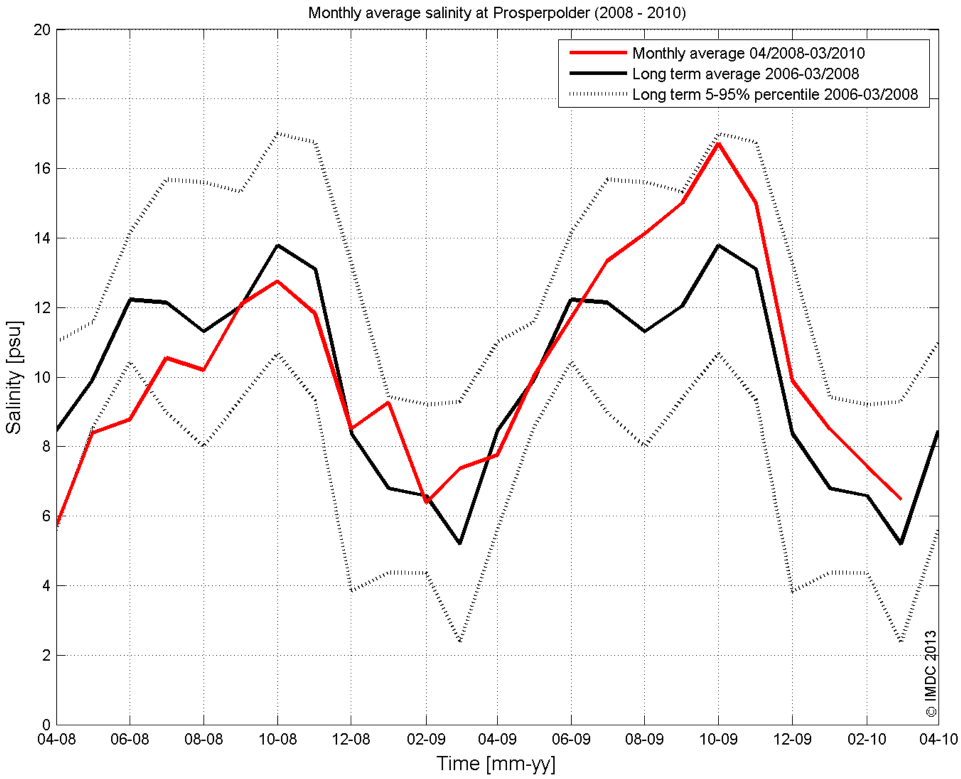
Annex-Figure D-40: Oosterweel bottom (-5.8m TAW), April 2008 – March 2010. Average tidal curve of the salinity for an average neap tide.



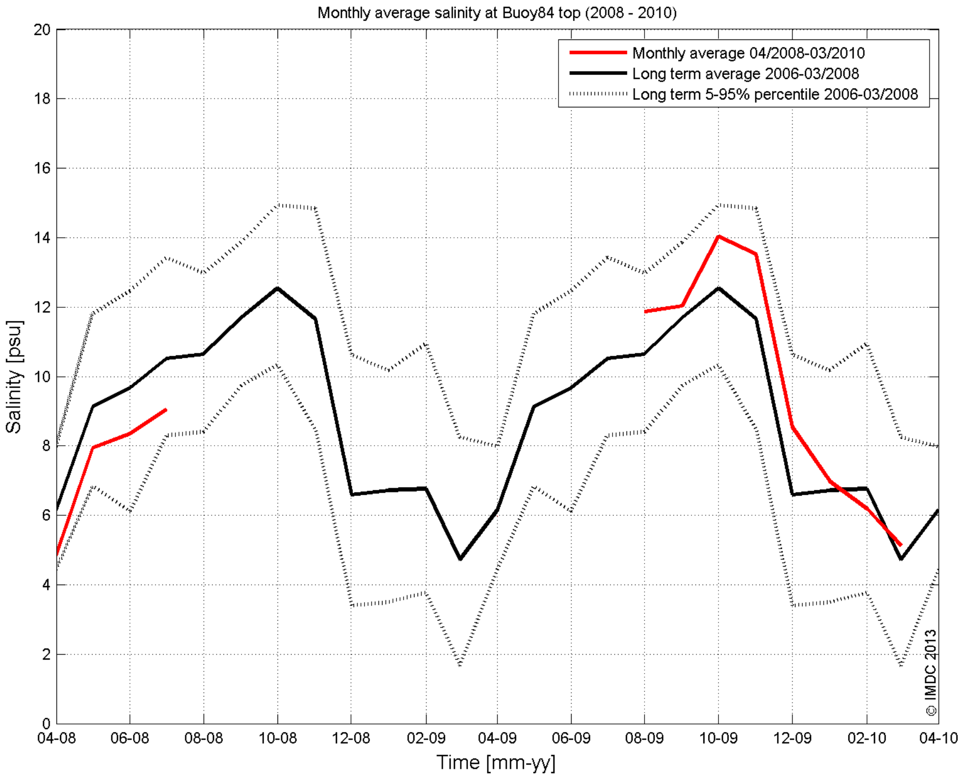
Annex-Figure D-41: Oosterweel bottom (-5.8m TAW), April 2008 – March 2010. Average tidal curve of the salinity for an average mean tide.

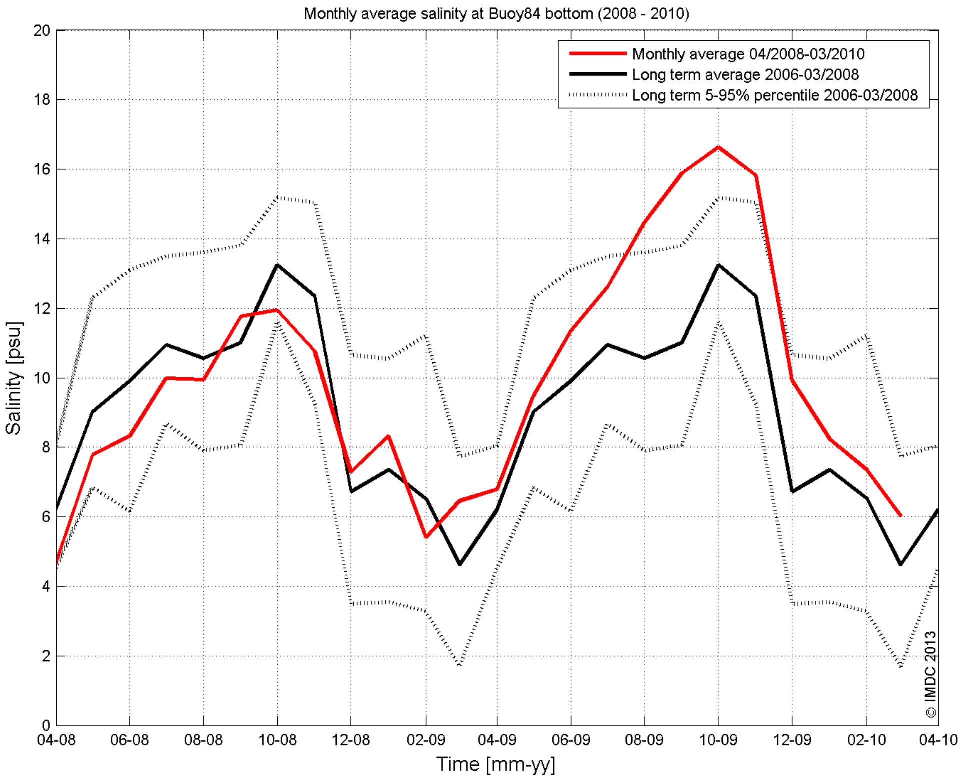


Annex-Figure D-42: Oosterweel bottom (-5.8m TAW), April 2008 – March 2010. Average tidal curve of the salinity for an average spring tide.

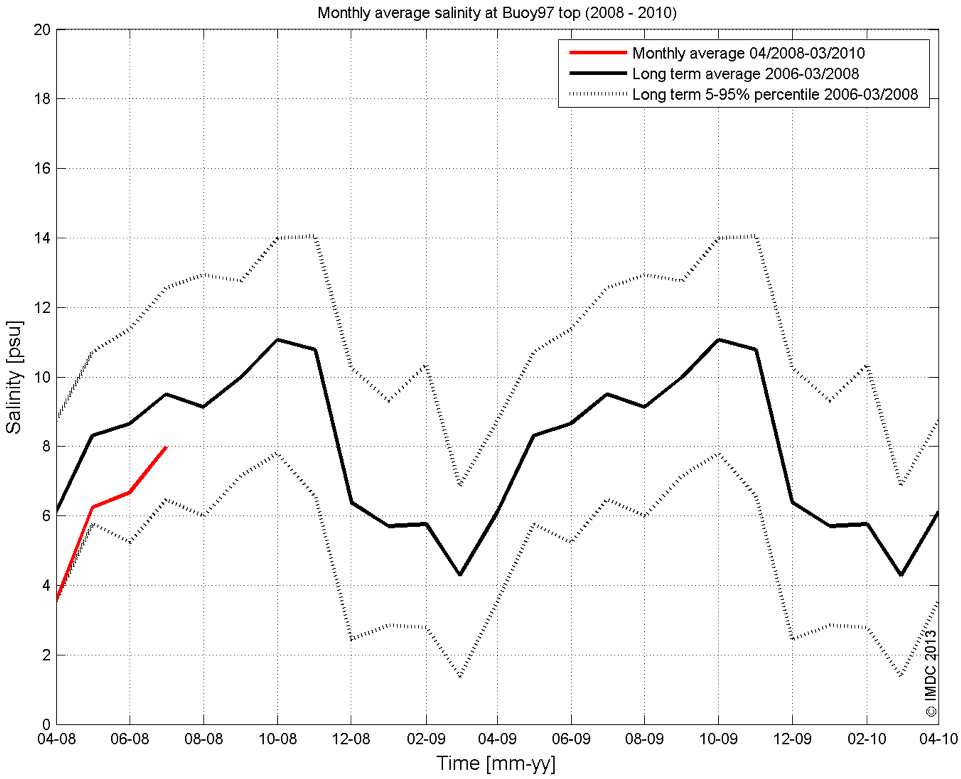


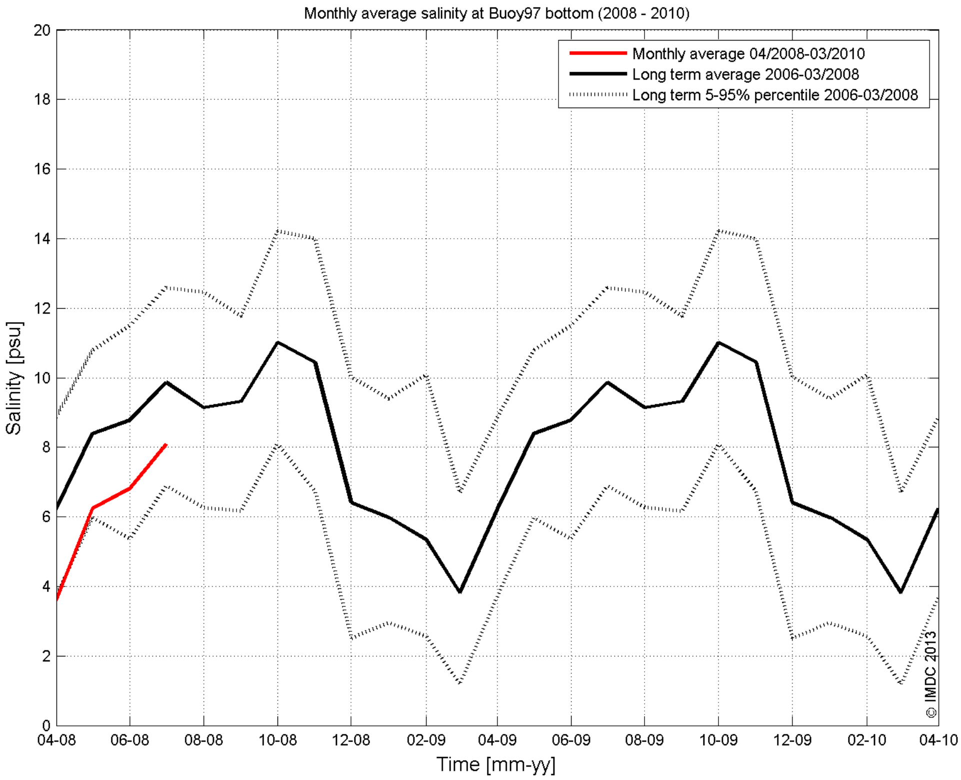
Annex-Figure D-43: The monthly average salinity curves of Prosperpolder between April 2008 – March 2010 and 2006 – March 2008 including the monthly 5/95% percentiles.



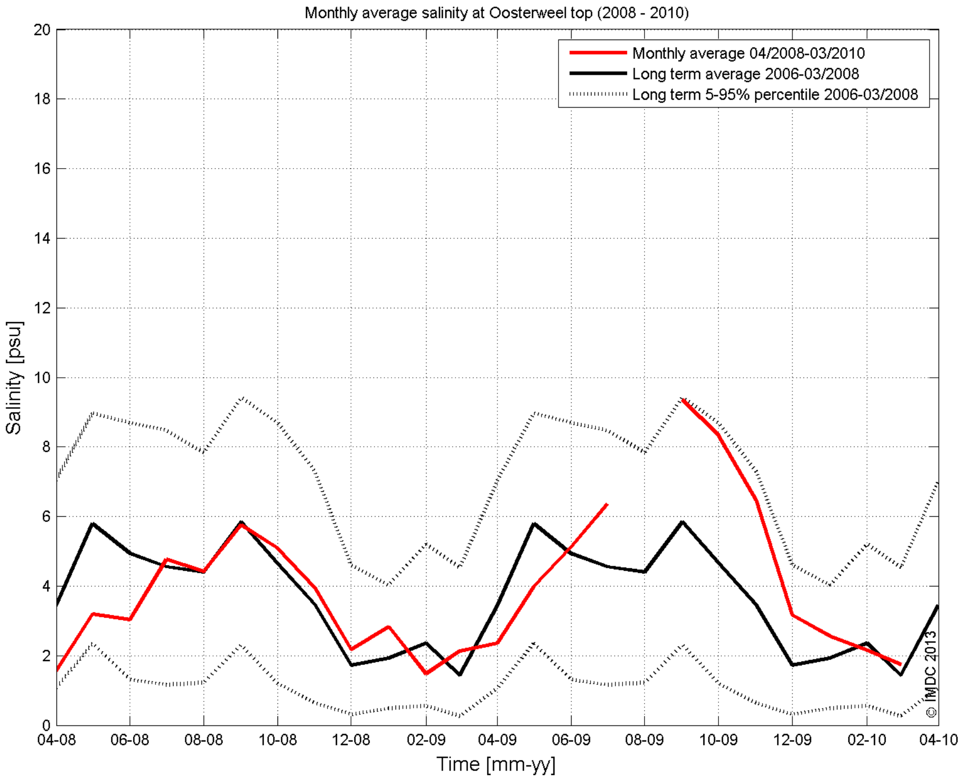


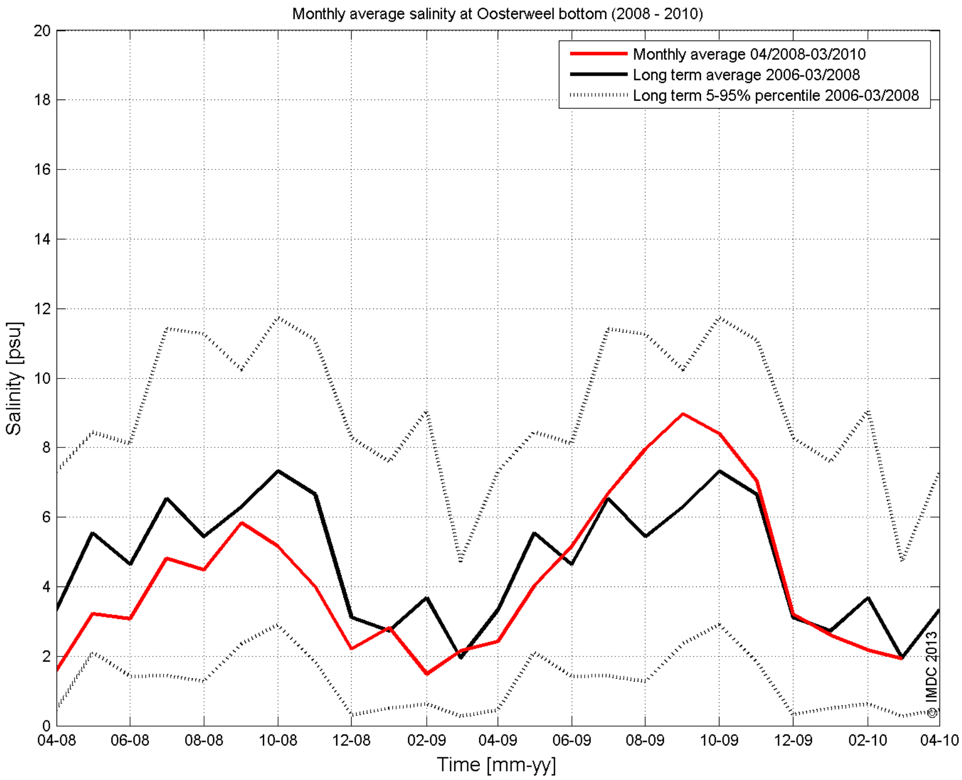
Annex-Figure D-44: The monthly average salinity curves of Buoy 97 top (a) and bottom (b) between April 2008 – March 2010 and 2006 – March 2008 including the monthly 5/95% percentiles.





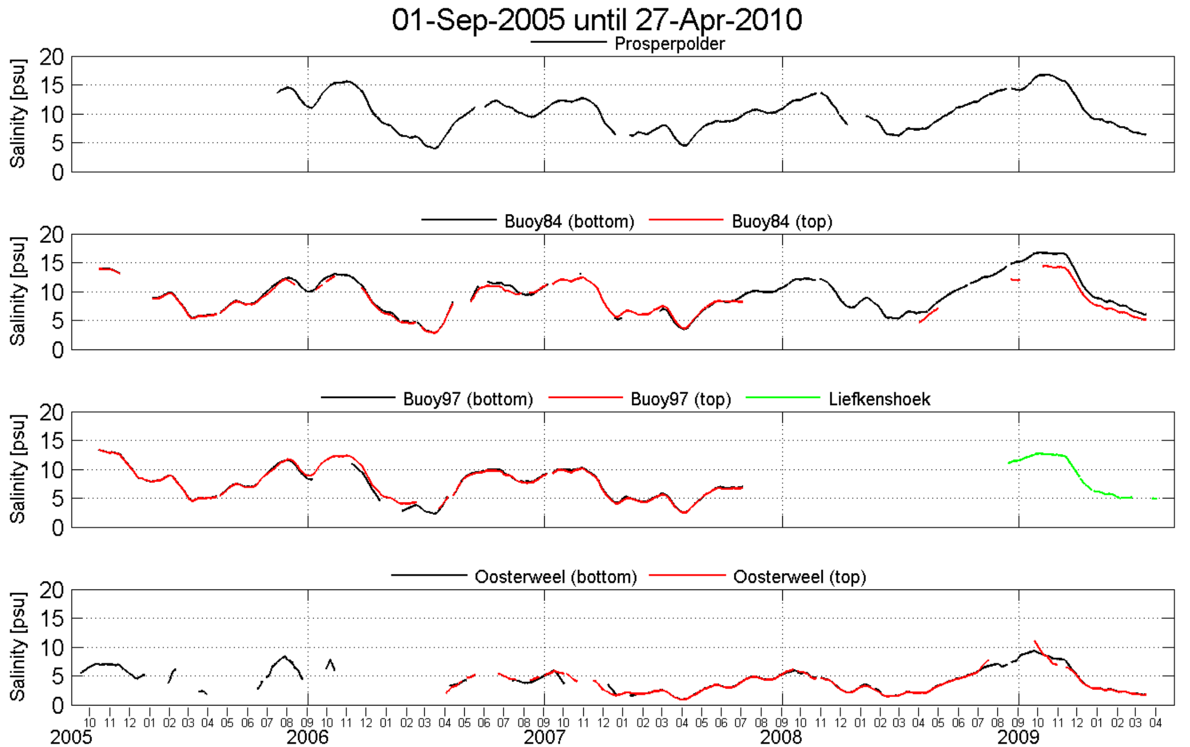
Annex-Figure D-45: The monthly average salinity curves of Buoy 97 top (a) and bottom (b) between April 2008 – March 2010 and 2006 – March 2008 including the monthly 5/95% percentiles.





Annex-Figure D-46: The monthly average salinity curves of Oosterweel top (a) and bottom (b) between April 2008 – March 2010 and 2006 – March 2008 including the monthly 5/95% percentiles.

11406 - External effects siltation Deurganckdok (2012-2014)



Timeseries of monthly moving average of salinity

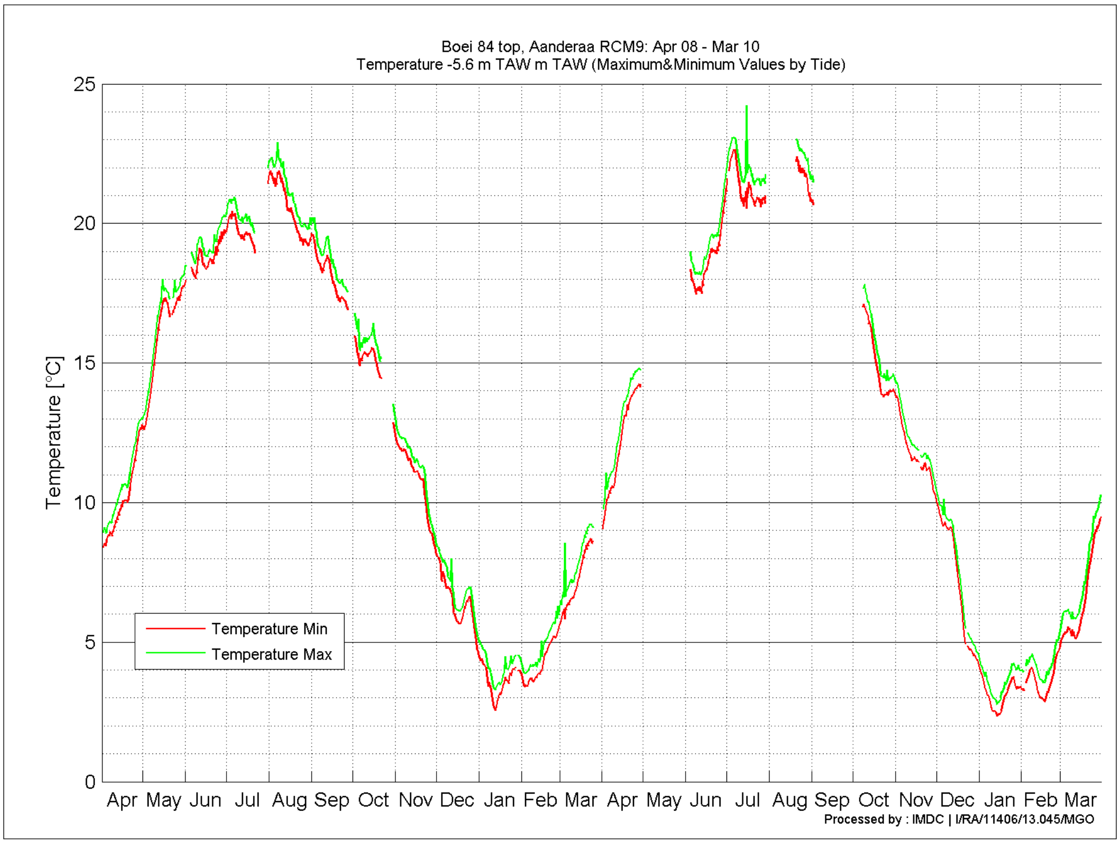
Processed by: IMDC

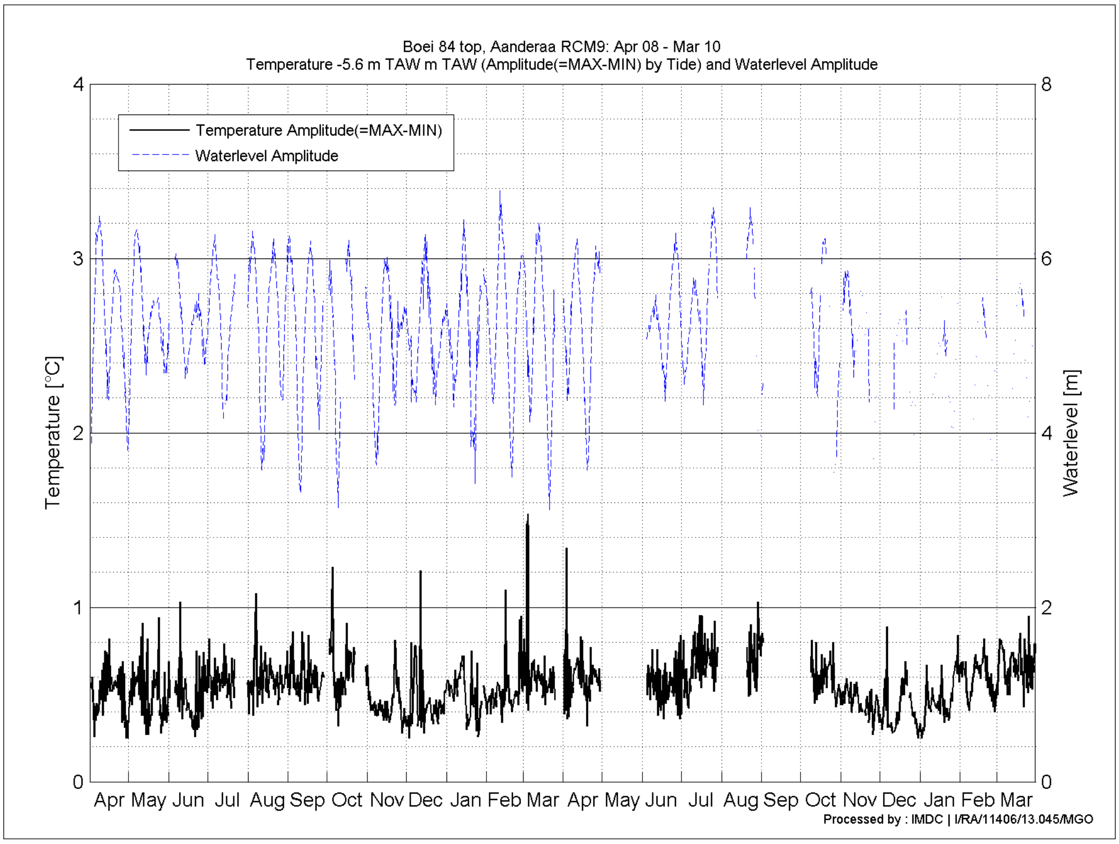
Location:
Sea Scheldt (Prosperpolder, Buoy84, Buoy97, Liefkenshoek and Oosterweel)

I/RA/11406/13.054/MGO

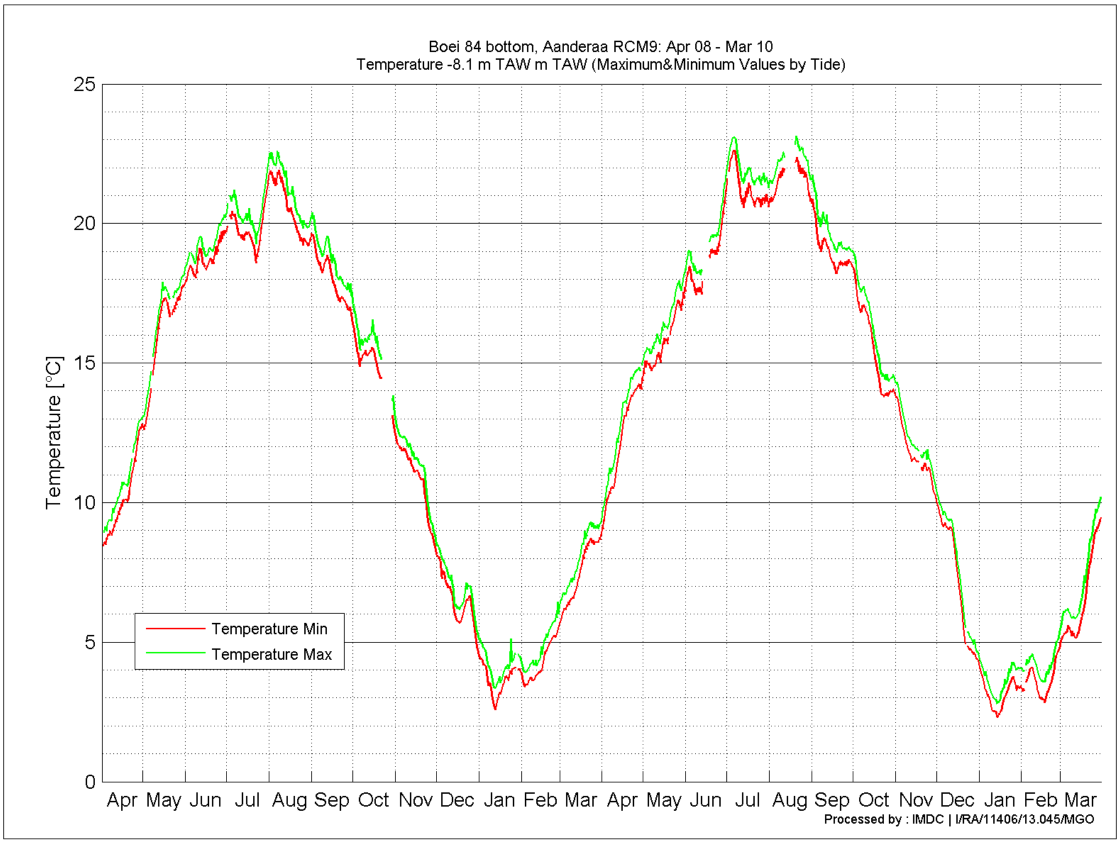
Annex-Figure D-47: Time series of monthly moving average of salinity measurement stations.

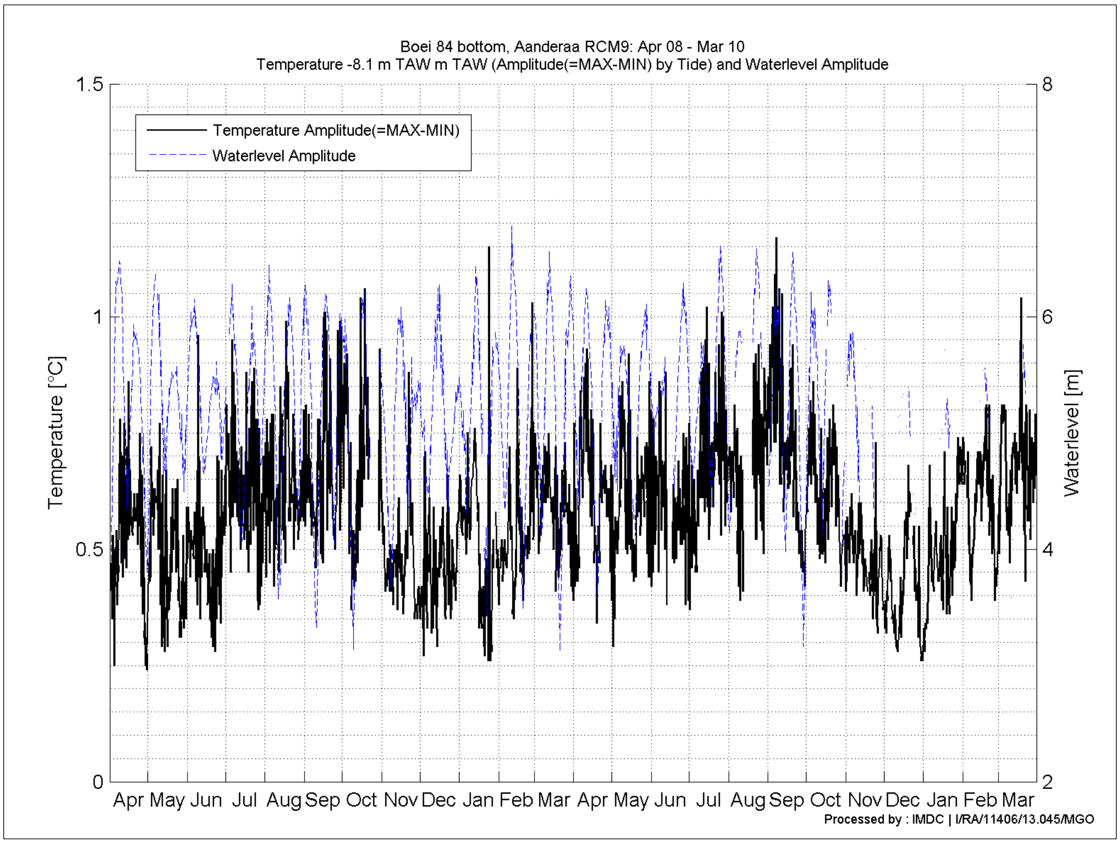
Annex E Figures Temperature



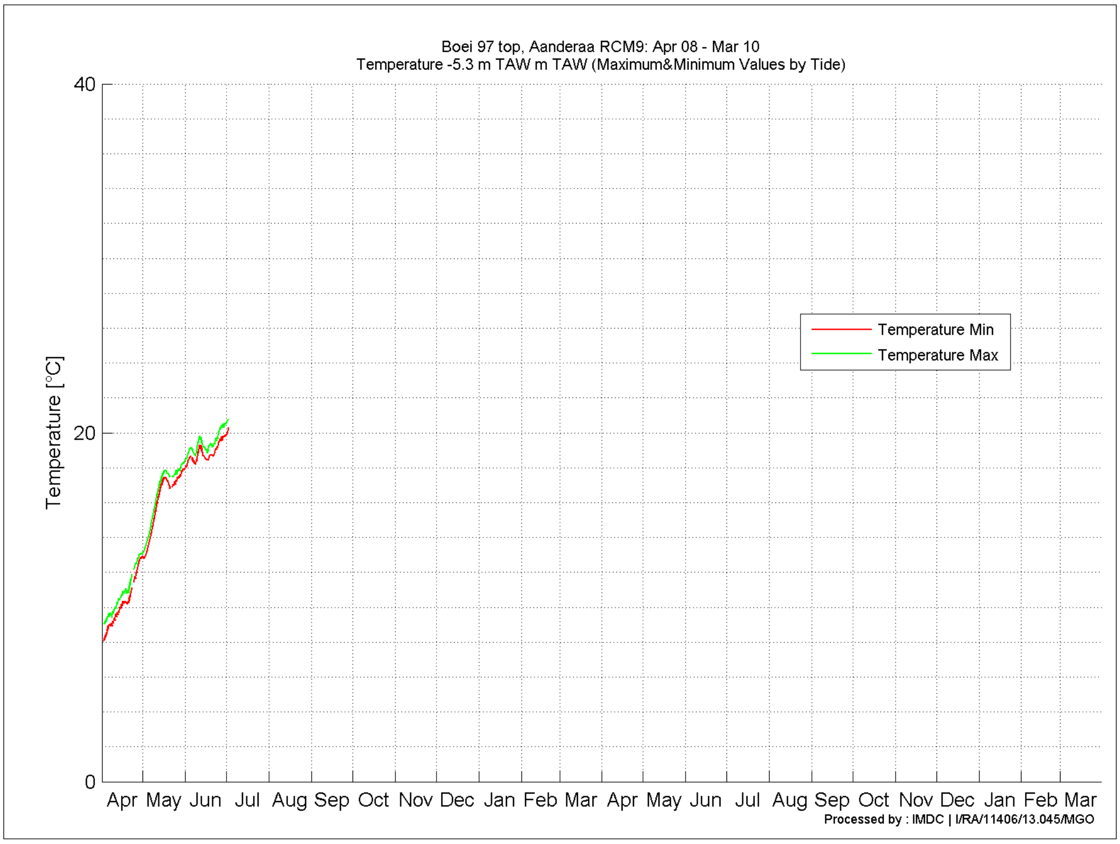


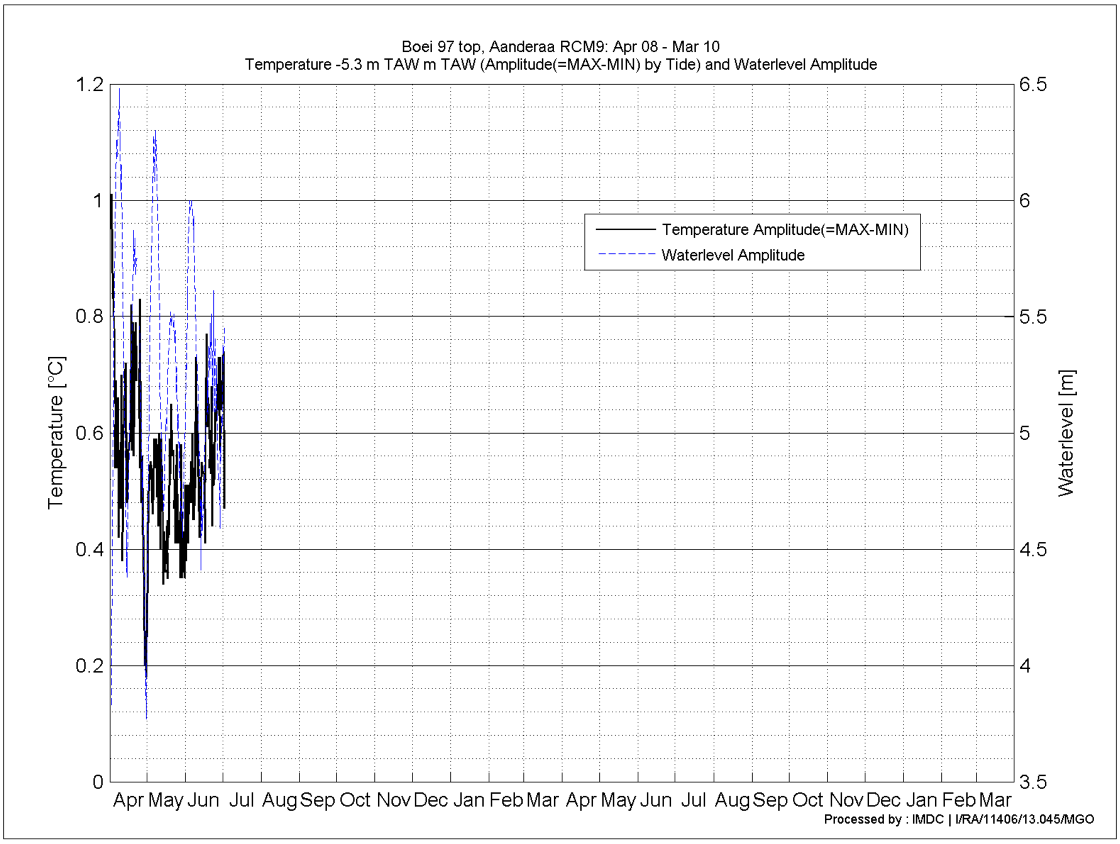
Annex-Figure E-1: Buoy 84 (-5.6m TAW), April 2008 – March 2010. (a) Tidal minimum & maximum temperature (b) Tidal temperature and water level amplitude.



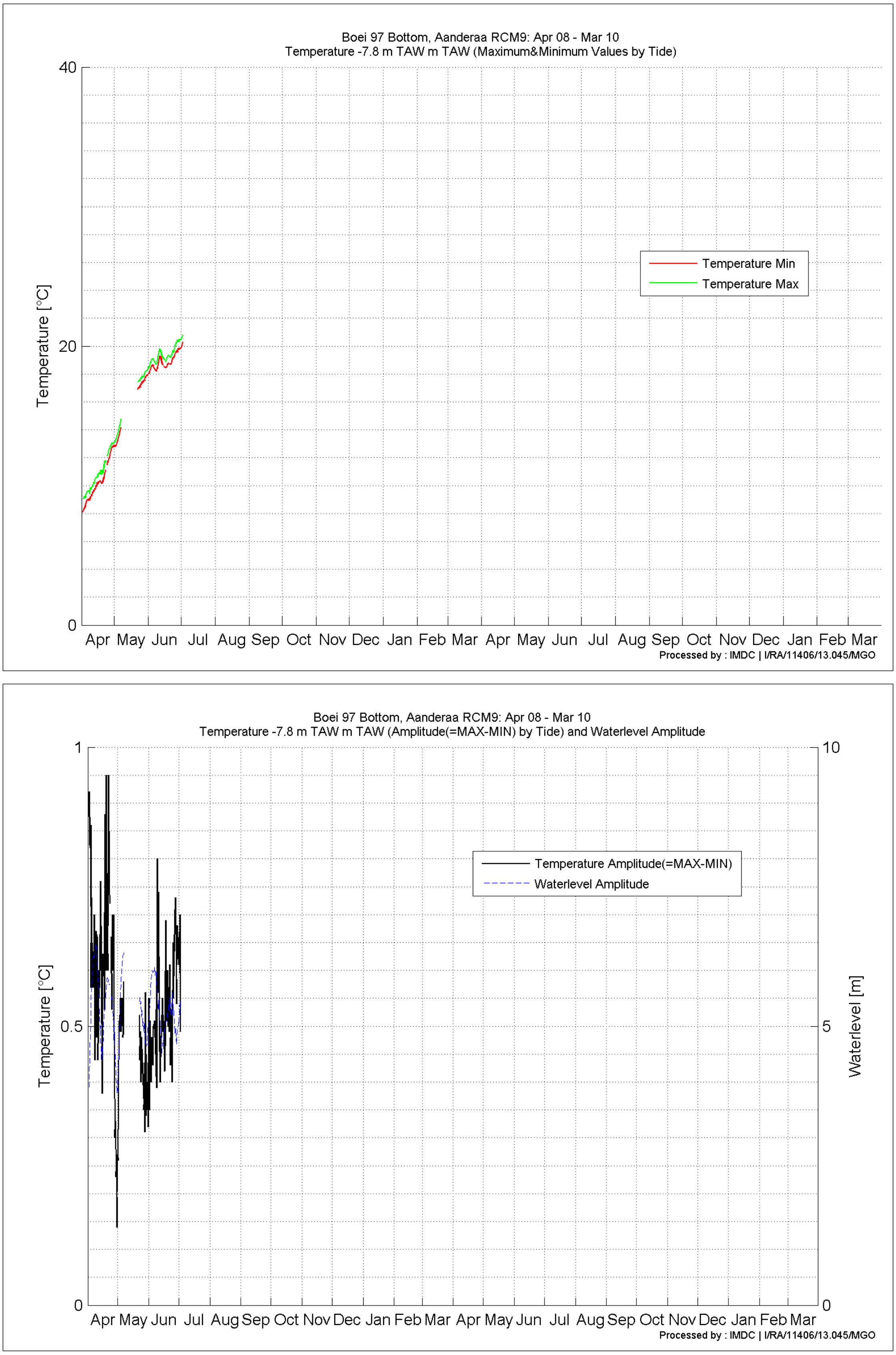


Annex-Figure E-2: Buoy 84 (-8.1m TAW), April 2008 – March 2010. (a) Tidal minimum & maximum temperature (b) Tidal temperature and water level amplitude.

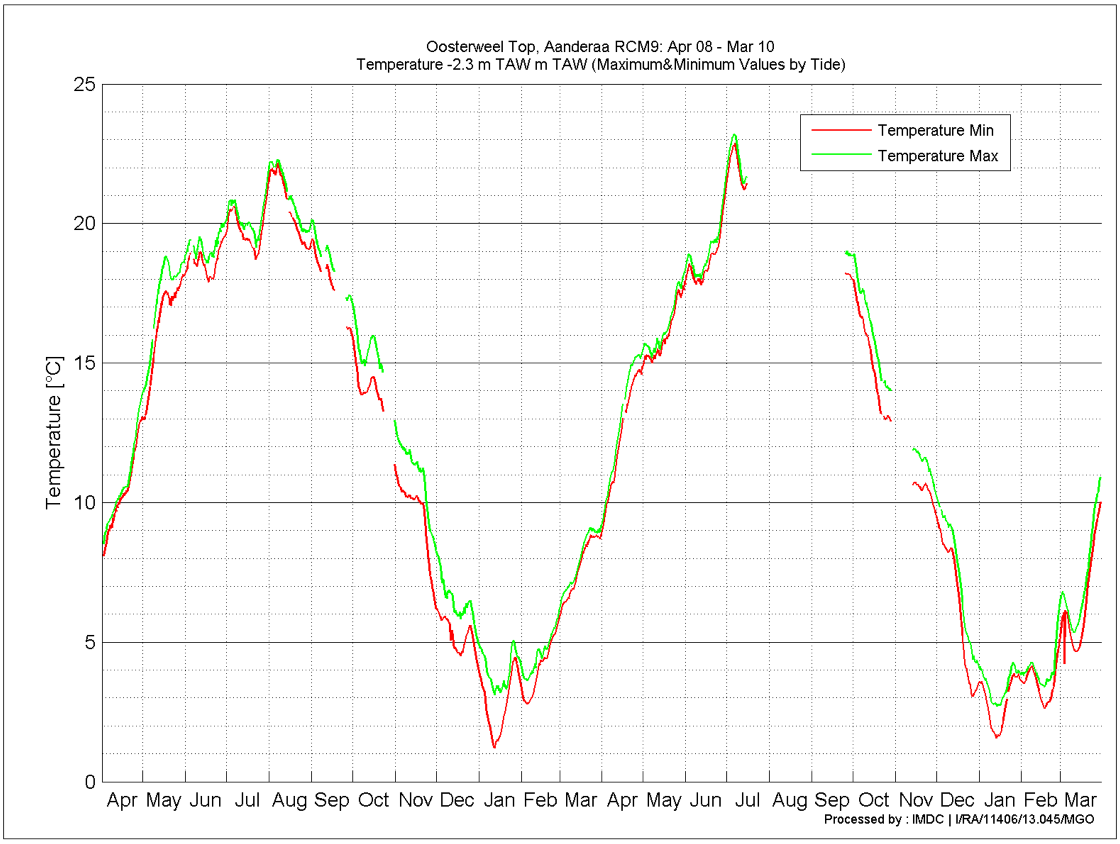


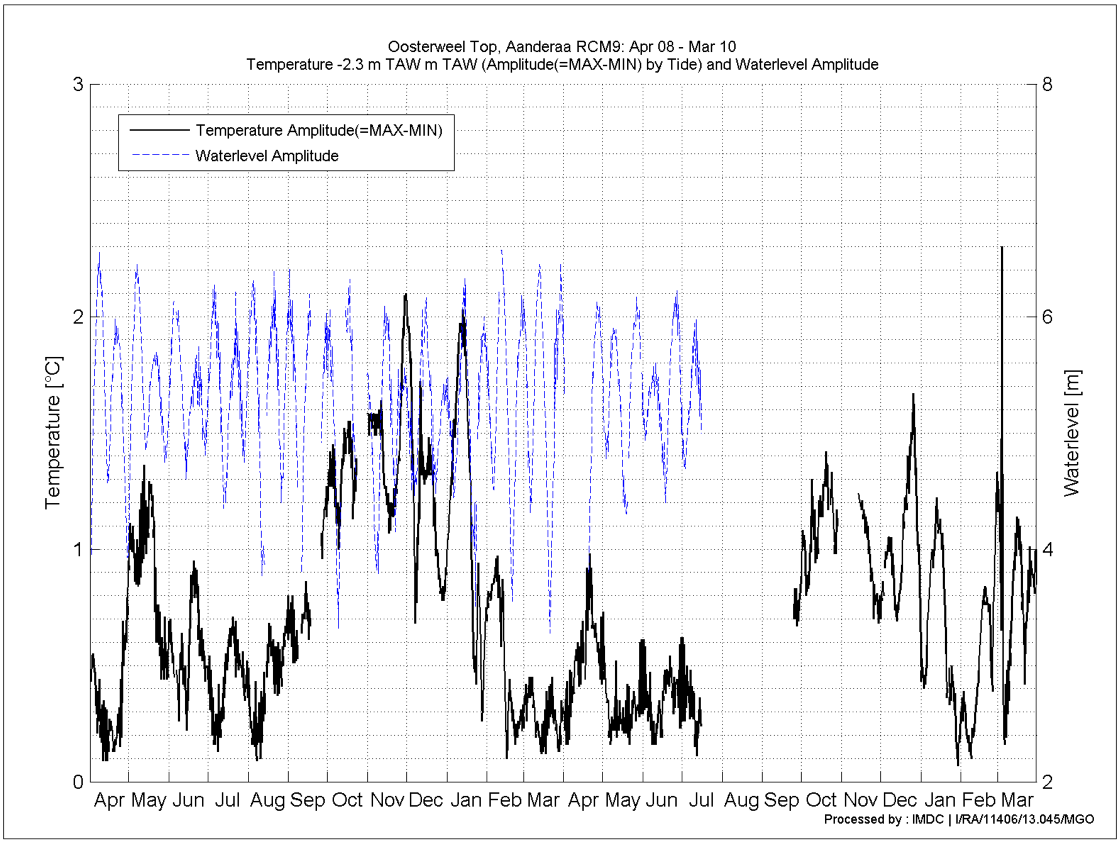


Annex-Figure E-3: Buoy 97 (-5.3m TAW), April 2008 – March 2010. (a) Tidal minimum & maximum temperature (b) Tidal temperature and water level amplitude.

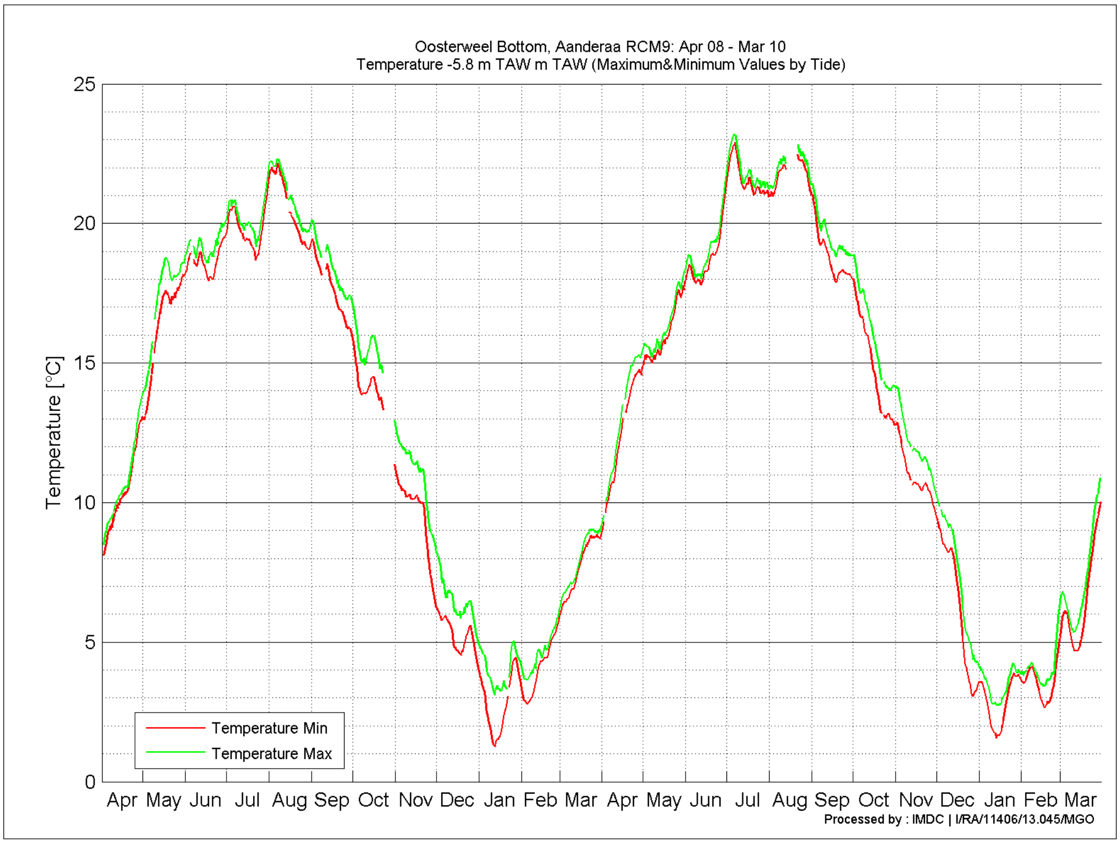


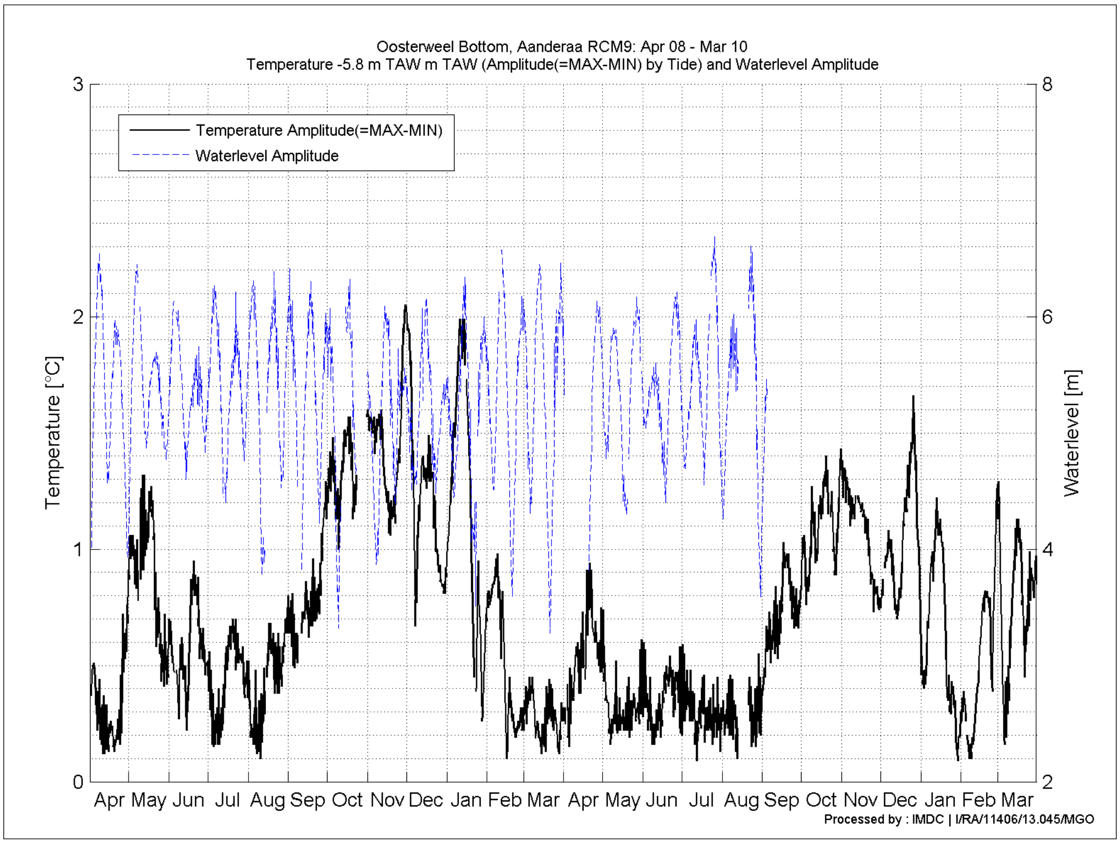
Annex-Figure E-41: Buoy 97 (-7.8m TAW), April 2008 – March 2010. (a) Tidal minimum & maximum temperature (b) Tidal temperature and water level amplitude.



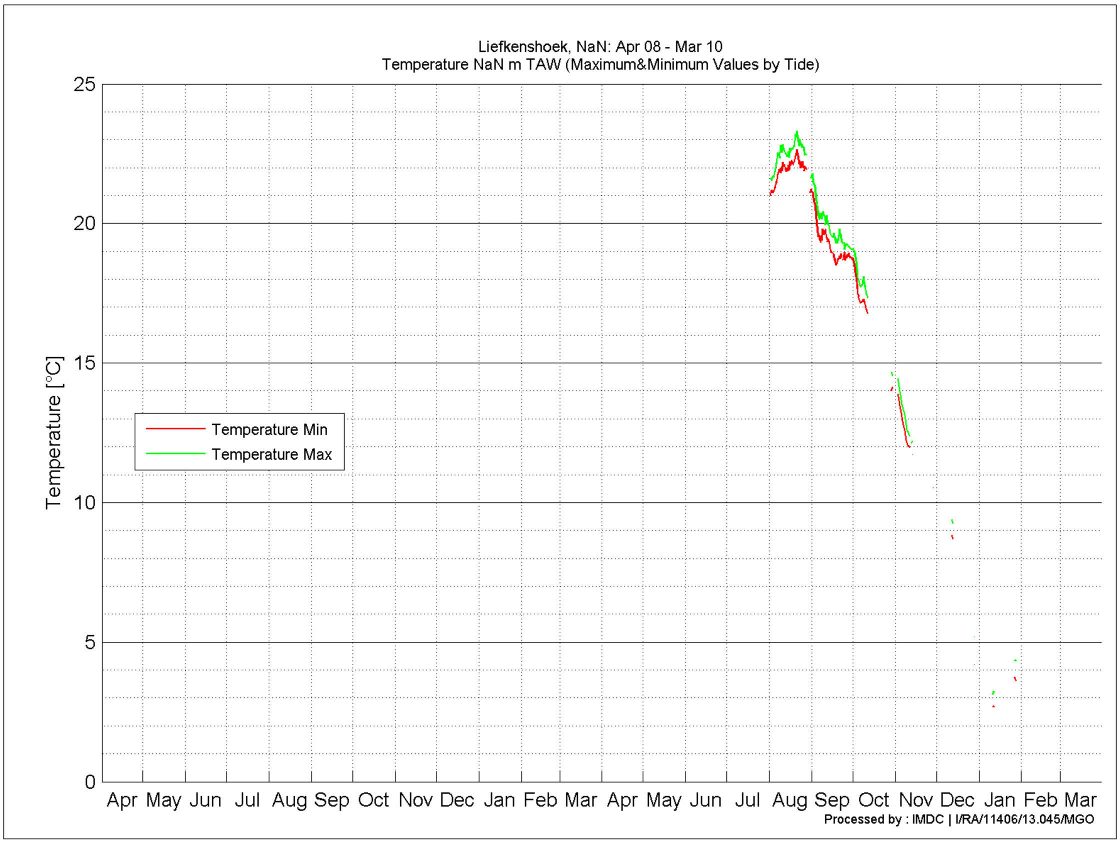


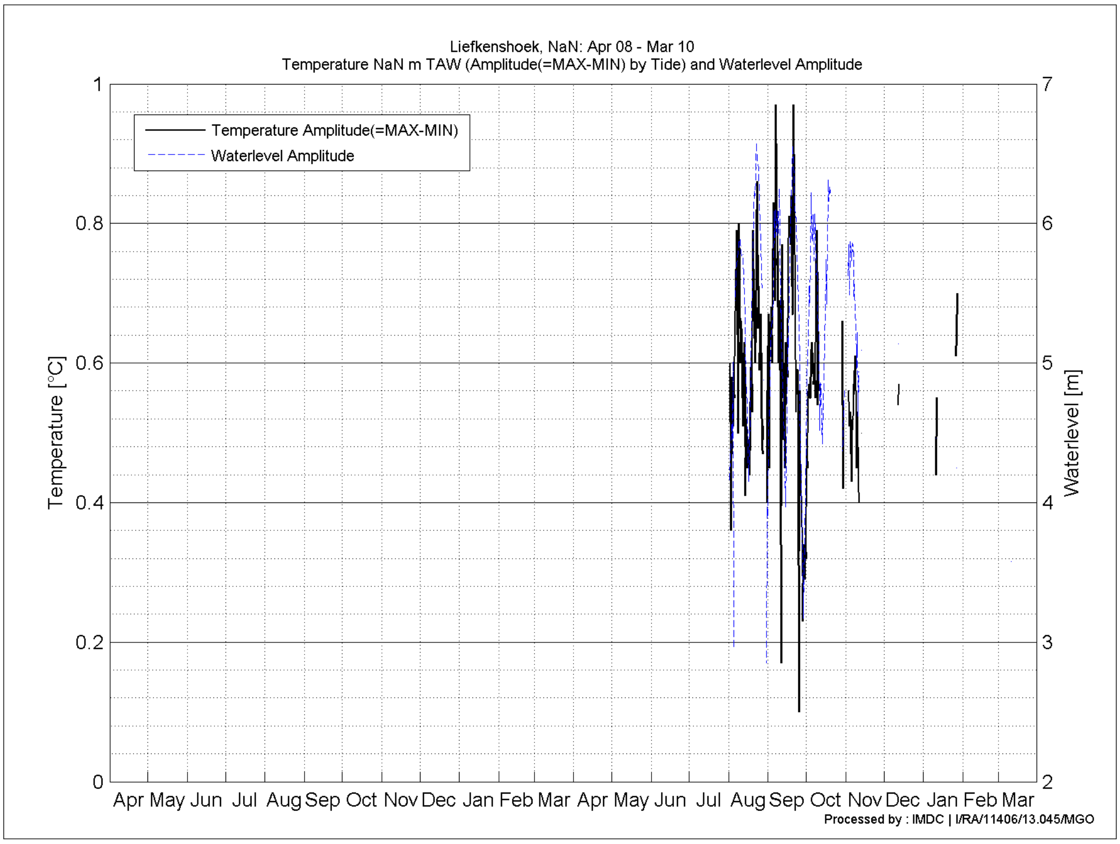
Annex-Figure E-5: Oosterweel Top (-2.3m TAW), April 2008 – March 2010. (a) Tidal minimum & maximum temperature (b) Tidal temperature and water level amplitude.



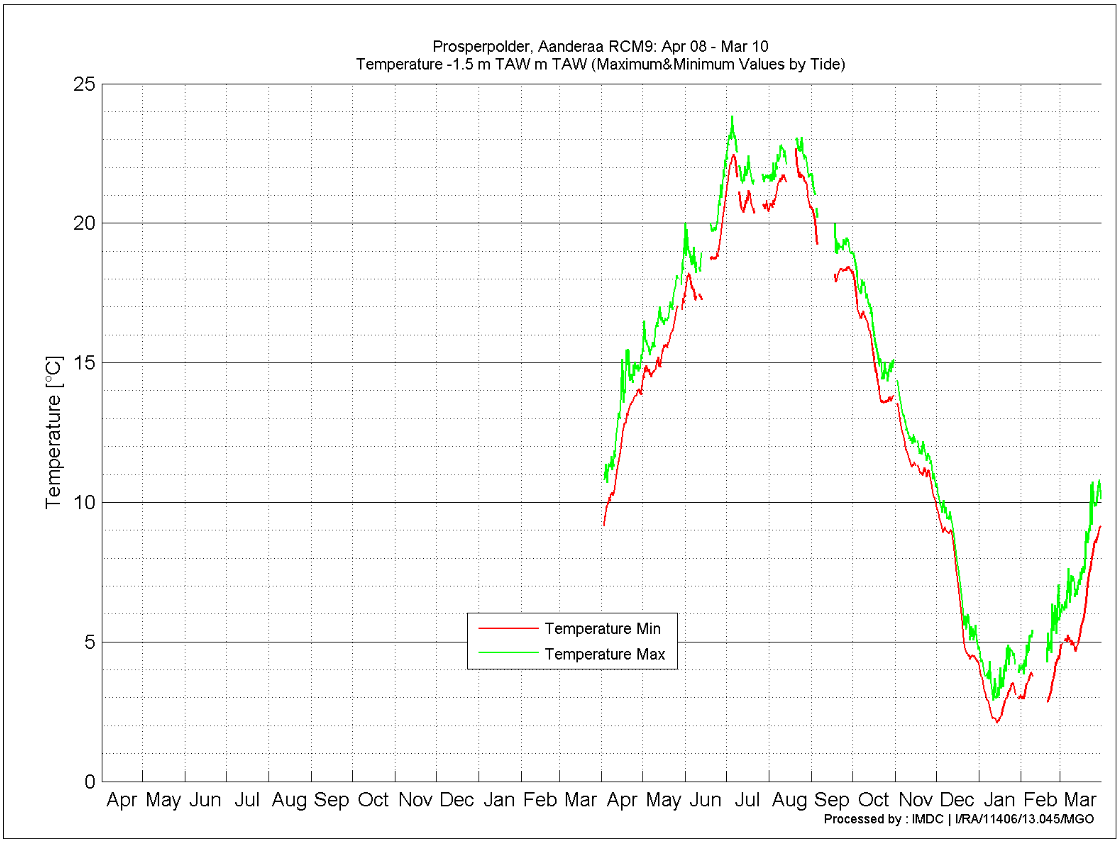


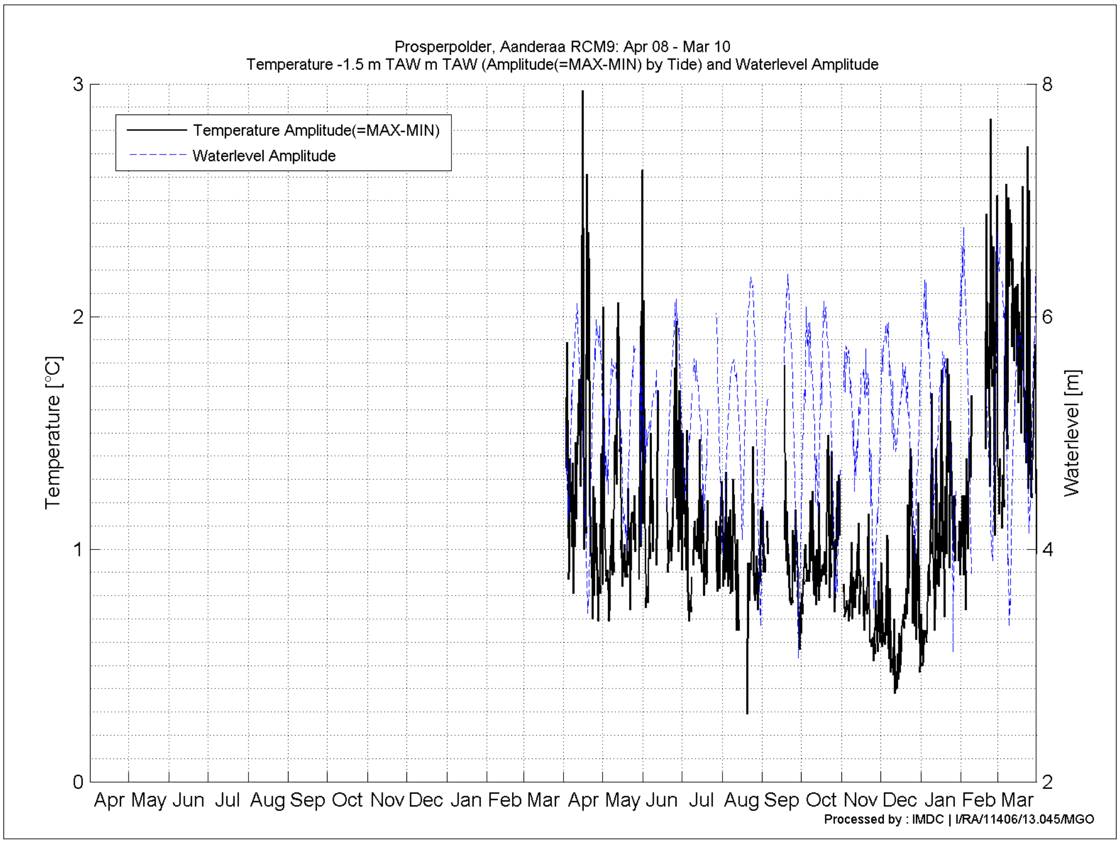
Annex-Figure E-6: Oosterweel Bottom (-5.8m TAW), April 2008 – March 2010. (a) Tidal minimum & maximum temperature (b) Tidal temperature and water level amplitude.



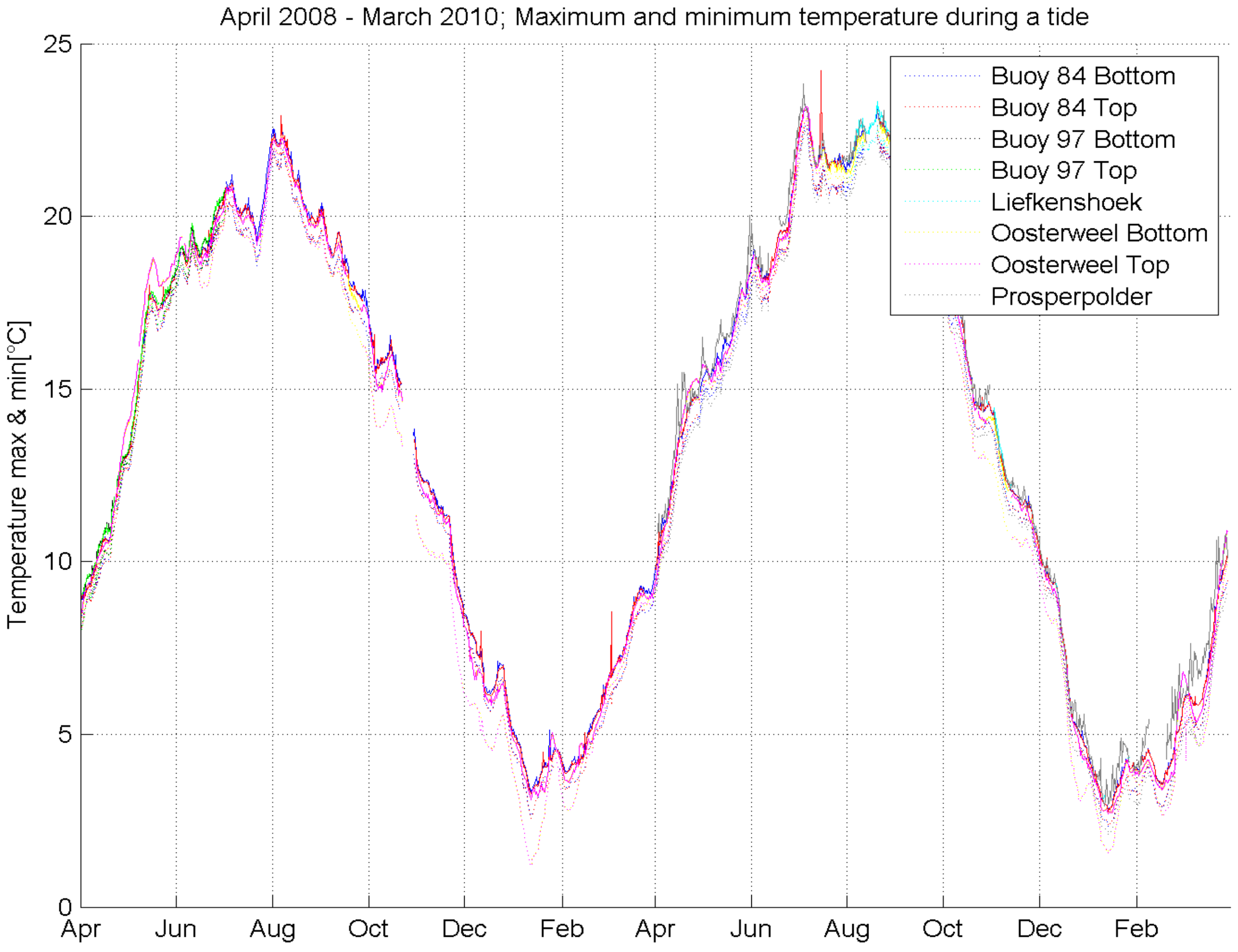


Annex-Figure E-7: Liefkenshoek, April 2008 – March 2010. (a) Tidal minimum & maximum temperature (b) Tidal temperature and water level amplitude.

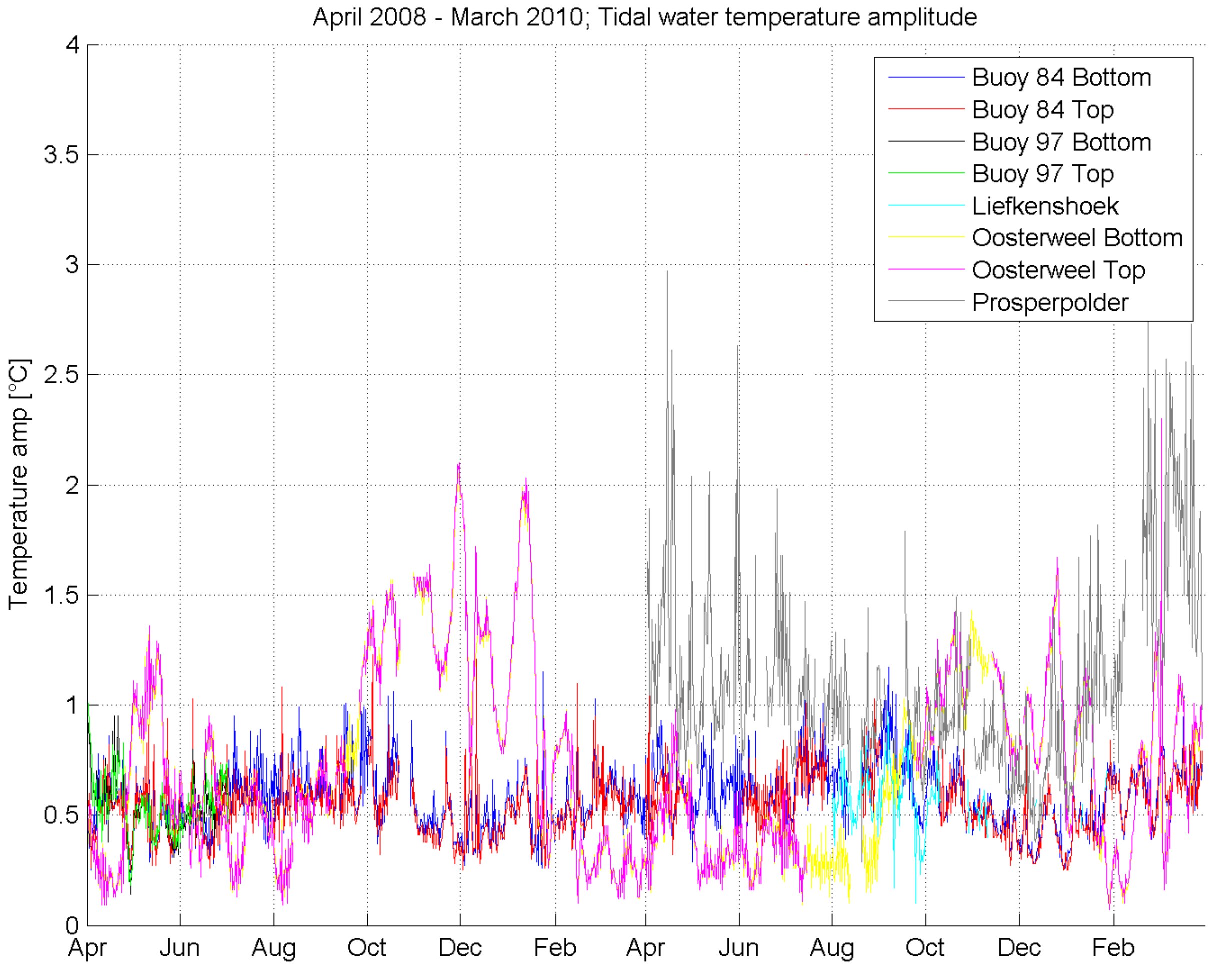




Annex-Figure E-8: Prosperpolder (-1.5m TAW), April 2008 – March 2010. (a) Tidal minimum & maximum temperature (b) tTdal temperature and water level amplitude.



Annex-Figure E-9: Maximal (-) and minimal (...) tidal temperature for all measurement stations.



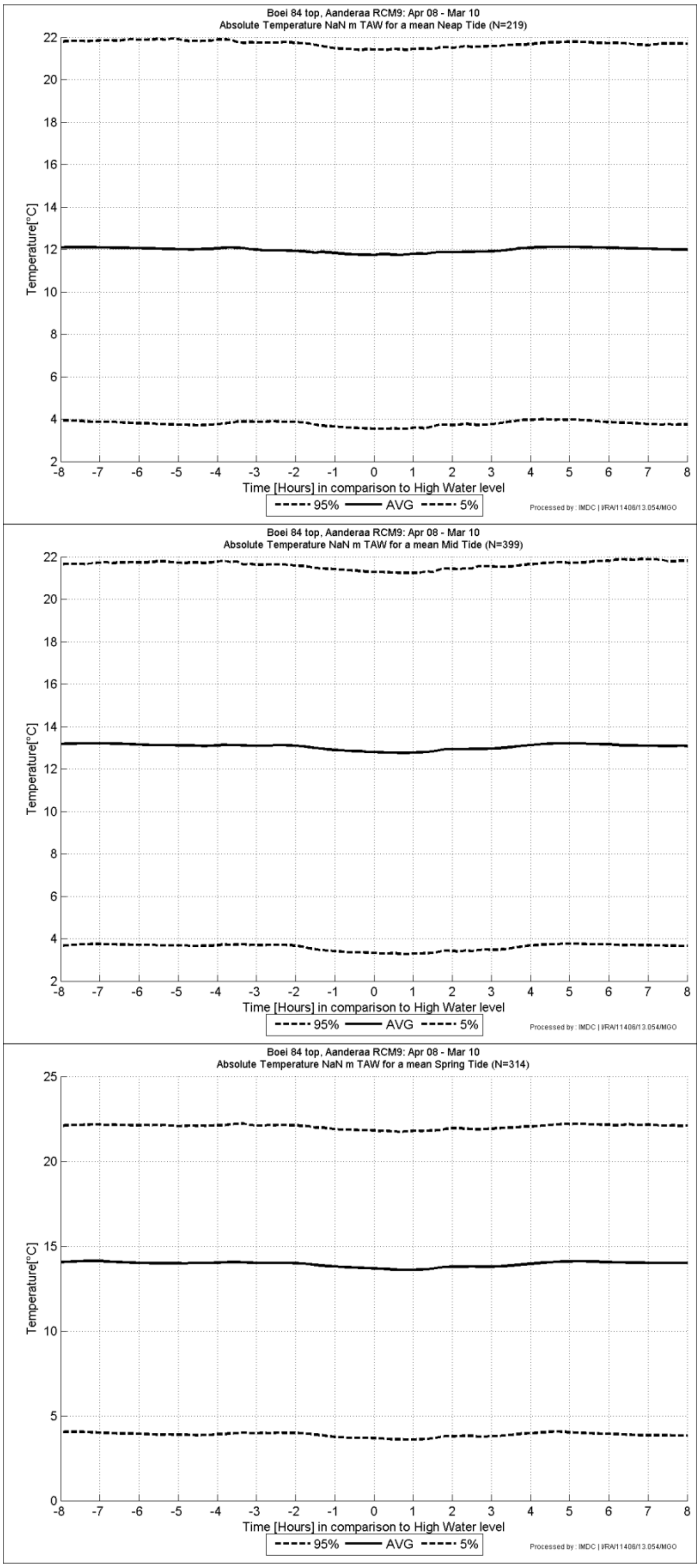
Annex-Figure E-10: Tidal temperature amplitude for all measurement stations.

Annex-Table E-1: Averaged tidal temperature amplitude [°C] (ΔT), standard deviation (σ), and amount of tide in the sample (N) for every measurement station during the period dealt with (Summer: Apr to Sep, Winter: Oct to Mar, Year 1: April 2008 – March 2009, Total period: April 2008 – March 2010).

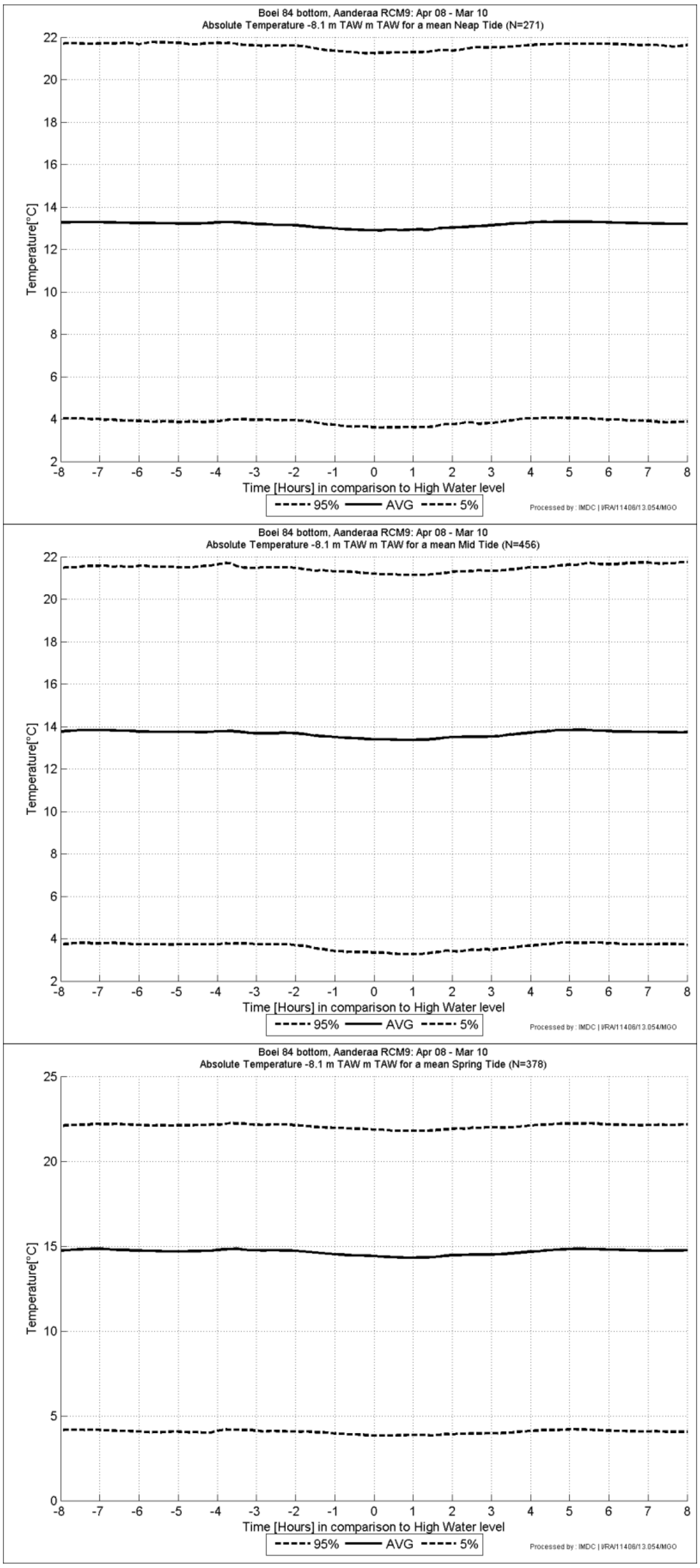
			Apr-Jun			Jul-Sep			Oct-Dec			Jan-Mar			Summer			Winter			Year 1			Total period		
			ΔT	σ	N	ΔT	σ	N	ΔT	σ	N	ΔT	σ	N	ΔT	σ	N	ΔT	σ	N	ΔT	σ	N	ΔT	σ	N
Buoy 84	-8.1 m TAW	Neap	0.44	0.14	34	0.59	0.10	44	0.50	0.13	44	0.52	0.13	48	0.53	0.14	78	0.51	0.13	92	0.52	0.13	170	0.53	0.12	279
		Avg	0.49	0.12	85	0.62	0.13	57	0.49	0.13	73	0.51	0.12	54	0.54	0.14	142	0.50	0.13	127	0.52	0.14	269	0.56	0.15	472
		Spring	0.56	0.11	50	0.71	0.14	74	0.60	0.20	40	0.58	0.12	69	0.65	0.15	126	0.59	0.15	109	0.62	0.15	233	0.65	0.15	388
		All	0.50	0.13	169	0.65	0.14	175	0.52	0.16	157	0.54	0.13	171	0.58	0.15	346	0.53	0.14	328	0.56	0.15	672	0.58	0.15	1139
	-5.6 m TAW	Neap	0.45	0.15	23	0.58	0.09	38	0.51	0.14	43	0.57	0.33	49	0.53	0.13	61	0.54	0.26	92	0.53	0.22	153	0.53	0.19	227
		Avg	0.51	0.16	95	0.57	0.08	46	0.46	0.16	71	0.49	0.11	49	0.53	0.14	141	0.47	0.14	120	0.50	0.14	261	0.53	0.22	408
		Spring	0.54	0.10	48	0.60	0.12	68	0.53	0.18	41	0.56	0.14	61	0.58	0.12	117	0.55	0.16	102	0.56	0.14	218	0.59	0.13	321
		All	0.51	0.14	166	0.59	0.10	152	0.49	0.16	155	0.54	0.21	159	0.55	0.13	319	0.52	0.19	314	0.53	0.16	632	0.55	0.19	956
Buoy 97	-7.8 m TAW	Neap	0.47	0.18	32	-	-	1	-	-	1	-	-	1	0.47	0.18	32	-	-	1	0.47	0.18	32	0.47	0.18	32
		Avg	0.55	0.12	71	0.59	0.15	2	-	-	1	-	-	1	0.55	0.12	73	-	-	1	0.55	0.12	73	0.55	0.12	73
		Spring	0.57	0.13	41	-	-	1	-	-	1	-	-	1	0.57	0.13	41	-	-	1	0.57	0.13	41	0.57	0.13	41
		All	0.54	0.14	144	0.59	0.15	2	-	-	1	-	-	1	0.54	0.14	146	-	-	1	0.54	0.14	146	0.54	0.14	146
	-5.3 m TAW	Neap	0.48	0.18	36	-	-	1	-	-	1	-	-	1	0.48	0.18	36	-	-	1	0.48	0.18	36	0.48	0.18	36
		Avg	0.56	0.12	88	0.61	0.19	2	-	-	1	-	-	1	0.56	0.12	90	-	-	1	0.56	0.12	90	0.56	0.12	90
		Spring	0.56	0.11	47	-	-	1	-	-	1	-	-	1	0.56	0.11	47	-	-	1	0.56	0.11	47	0.56	0.11	47
		All	0.54	0.13	171	0.61	0.19	2	-	-	1	-	-	1	0.54	0.13	173	-	-	1	0.54	0.13	173	0.54	0.13	173
Oosterweel	- 5.8 m TAW	Neap	0.51	0.25	28	0.50	0.21	35	1.26	0.24	49	0.64	0.47	52	0.51	0.23	63	0.94	0.49	101	0.77	0.46	164	0.68	0.44	215
		Avg	0.68	0.29	94	0.56	0.23	62	1.37	0.36	69	0.76	0.53	50	0.63	0.28	157	1.11	0.53	119	0.84	0.47	275	0.69	0.46	389
		Spring	0.50	0.32	49	0.57	0.28	72	1.35	0.11	38	0.58	0.57	67	0.55	0.30	122	0.86	0.59	105	0.69	0.48	226	0.60	0.44	310
		All	0.60	0.31	171	0.55	0.25	169	1.33	0.28	156	0.65	0.53	169	0.58	0.28	342	0.98	0.55	325	0.77	0.48	665	0.66	0.45	914
	- 2.3 m TAW	Neap	0.56	0.29	27	0.43	0.16	29	1.28	0.26	50	0.62	0.44	54	0.49	0.24	56	0.94	0.49	104	0.78	0.47	160	0.73	0.45	189
		Avg	0.67	0.31	91	0.54	0.24	58	1.38	0.36	71	0.78	0.53	51	0.62	0.29	150	1.12	0.53	122	0.84	0.49	271	0.73	0.48	356
		Spring	0.53	0.32	54	0.55	0.27	65	1.35	0.12	35	0.61	0.60	67	0.54	0.30	120	0.86	0.61	102	0.69	0.49	221	0.63	0.46	274
		All	0.61	0.32	172	0.52	0.24	152	1.34	0.29	156	0.66	0.53	172	0.57	0.29	326	0.98	0.55	328	0.78	0.49	652	0.69	0.47	819

Annex-Table E-2: Averaged tidal temperature amplitude [°C] (ΔT), standard deviation (σ), and amount of tide in the sample (N) for every measurement station during considered period (Summer: Apr to Sep, Winter: Oct to Mar, Year 2: April 2009 – March 2010, Total period: April 2008 – March 2010).

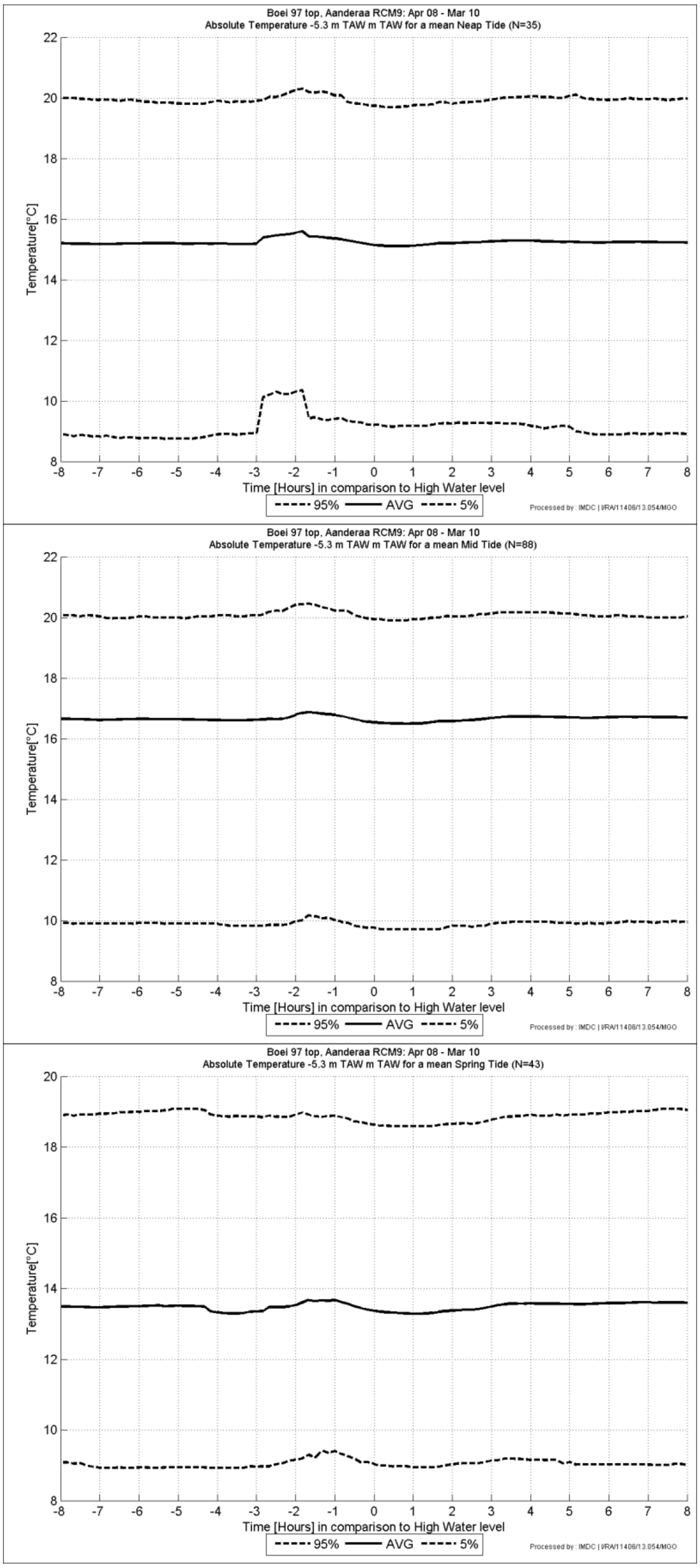
			Apr-Jun			Jul-Sep			Oct-Dec			Jan-Mar			Summer			Winter			Year 2			Total period		
			ΔT	σ	N	ΔT	σ	N	ΔT	σ	N	ΔT	σ	N	ΔT	σ	N	ΔT	σ	N	ΔT	σ	N	ΔT	σ	N
Buoy 84	-8.1 m TAW	Neap	0.48	0.09	26	0.61	0.11	38	0.49	0.08	23	0.54	0.09	22	0.56	0.12	64	0.51	0.09	45	0.54	0.11	109	0.53	0.12	279
		Avg	0.62	0.13	75	0.71	0.17	50	0.50	0.12	45	0.58	0.14	33	0.66	0.15	127	0.53	0.13	78	0.61	0.16	203	0.56	0.15	472
		Spring	0.67	0.11	58	0.73	0.17	62	0.64	0.11	27	0.71	0.08	8	0.70	0.15	120	0.66	0.10	35	0.69	0.14	155	0.65	0.15	388
		All	0.62	0.13	159	0.69	0.16	150	0.53	0.12	95	0.58	0.13	63	0.65	0.15	311	0.55	0.13	158	0.62	0.15	467	0.58	0.15	1139
	-5.6 m TAW	Neap	0.51	0.11	19	0.69	0.16	13	0.44	0.08	21	0.52	0.10	21	0.58	0.16	32	0.48	0.10	42	0.53	0.14	74	0.53	0.19	227
		Avg	0.58	0.17	49	0.77	0.64	24	0.48	0.12	43	0.55	0.13	31	0.64	0.40	73	0.51	0.13	74	0.58	0.30	147	0.53	0.22	408
		Spring	0.61	0.09	39	0.71	0.12	33	0.58	0.10	21	0.65	0.07	10	0.65	0.11	72	0.60	0.10	31	0.64	0.11	103	0.59	0.13	321
		All	0.58	0.17	107	0.72	0.38	70	0.50	0.12	85	0.56	0.12	62	0.64	0.27	177	0.52	0.12	147	0.58	0.23	324	0.55	0.19	956
Oosterweel	- 5.8 m TAW	Neap	0.46	0.23	25	0.32	0.12	26	-	-	1	-	-	1	0.39	0.19	51	-	-	1	0.39	0.19	51	0.68	0.44	215
		Avg	0.35	0.15	66	0.32	0.12	48	-	-	1	-	-	1	0.34	0.14	114	-	-	1	0.34	0.14	114	0.69	0.46	389
		Spring	0.40	0.14	48	0.30	0.09	36	-	-	1	-	-	1	0.36	0.13	84	-	-	1	0.36	0.13	84	0.60	0.44	310
		All	0.39	0.17	139	0.31	0.11	110	-	-	1	-	-	1	0.36	0.15	249	-	-	1	0.36	0.15	249	0.66	0.45	914
	- 2.3 m TAW	Neap	0.46	0.24	25	0.48	0.16	4	-	-	1	-	-	1	0.47	0.23	29	-	-	1	0.47	0.23	29	0.73	0.45	189
		Avg	0.35	0.16	67	0.32	0.10	18	-	-	1	-	-	1	0.35	0.15	85	-	-	1	0.35	0.15	85	0.73	0.48	356
		Spring	0.40	0.14	47	0.26	0.08	6	-	-	1	-	-	1	0.38	0.14	53	-	-	1	0.38	0.14	53	0.63	0.46	274
		All	0.39	0.17	139	0.33	0.12	28	-	-	1	-	-	1	0.38	0.17	167	-	-	1	0.38	0.17	167	0.69	0.47	819
Prosperpolder	- 1.5 m TAW	Neap	1.17	0.45	31	0.98	0.21	38	0.85	0.22	39	1.58	0.59	39	1.07	0.35	69	1.21	0.57	78	1.14	0.49	147	1.14	0.49	147
		Avg	1.23	0.44	70	0.97	0.18	48	0.79	0.23	78	1.49	0.43	44	1.12	0.38	120	1.04	0.46	122	1.08	0.43	240	1.08	0.43	240
		Spring	1.22	0.32	53	0.96	0.24	42	0.84	0.21	55	1.29	0.50	62	1.11	0.31	95	1.08	0.45	117	1.09	0.40	212	1.09	0.40	212
		All	1.21	0.40	154	0.97	0.21	128	0.82	0.23	172	1.43	0.52	145	1.10	0.35	284	1.10	0.49	317	1.10	0.43	599	1.10	0.43	599
Liefkenshoek		Neap	-	-	1	0.47	0.11	34	0.52	0.11	4	0.54	0.14	2	0.47	0.11	34	0.53	0.11	6	0.48	0.11	40	0.48	0.11	40
		Avg	-	-	1	0.57	0.16	31	0.56	0.09	21	-	-	1	0.57	0.15	33	0.56	0.09	21	0.57	0.13	52	0.57	0.13	52
		Spring	-	-	1	0.70	0.11	45	0.55	0.05	16	-	-	1	0.70	0.11	45	0.55	0.05	16	0.66	0.12	61	0.66	0.12	61
		All	-	-	1	0.59	0.16	110	0.55	0.08	41	0.54	0.14	2	0.59	0.16	112	0.55	0.08	43	0.58	0.14	153	0.58	0.14	153



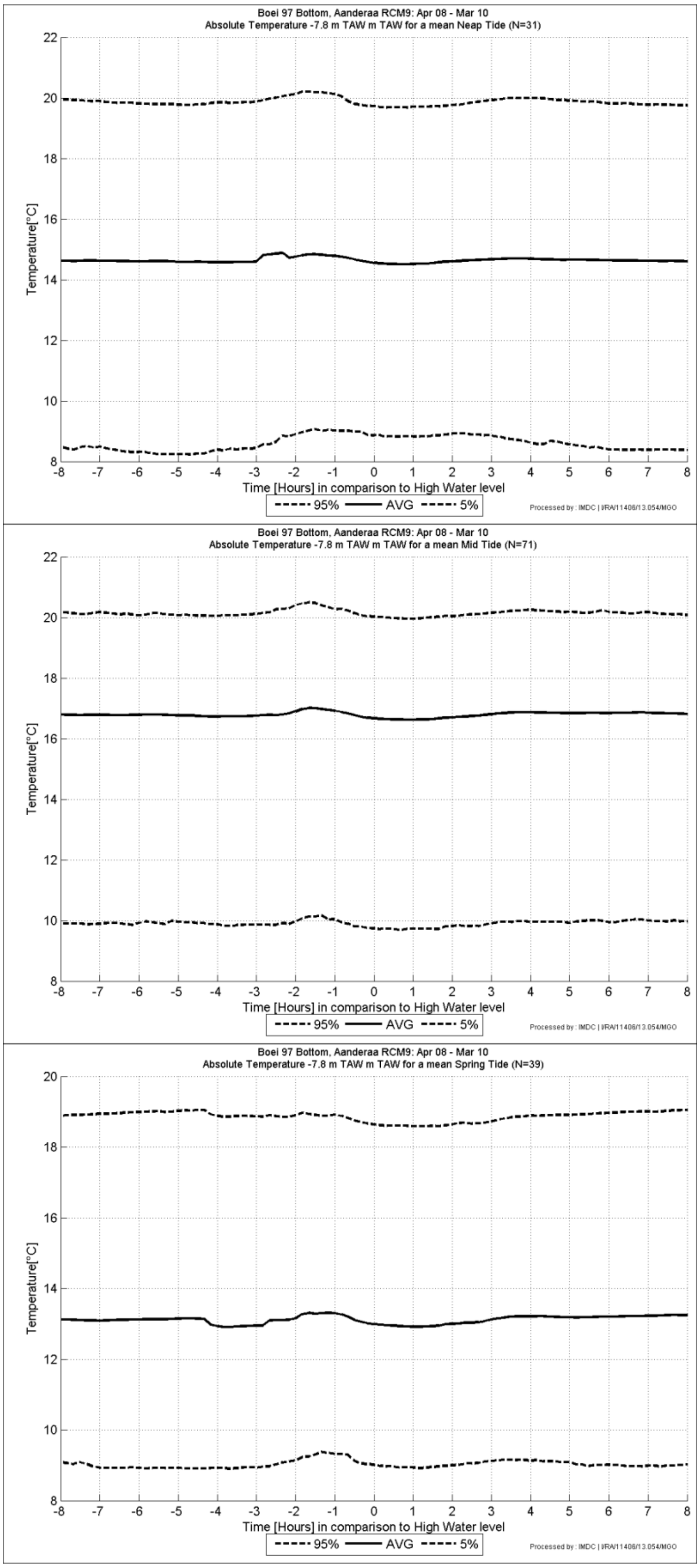
Annex-Figure E-11: Buoy 84 (-5.6m TAW), April 2008 – March 2010. Average tidal curve of the temperature for a (a) neap, (b) average, (c) spring tide.



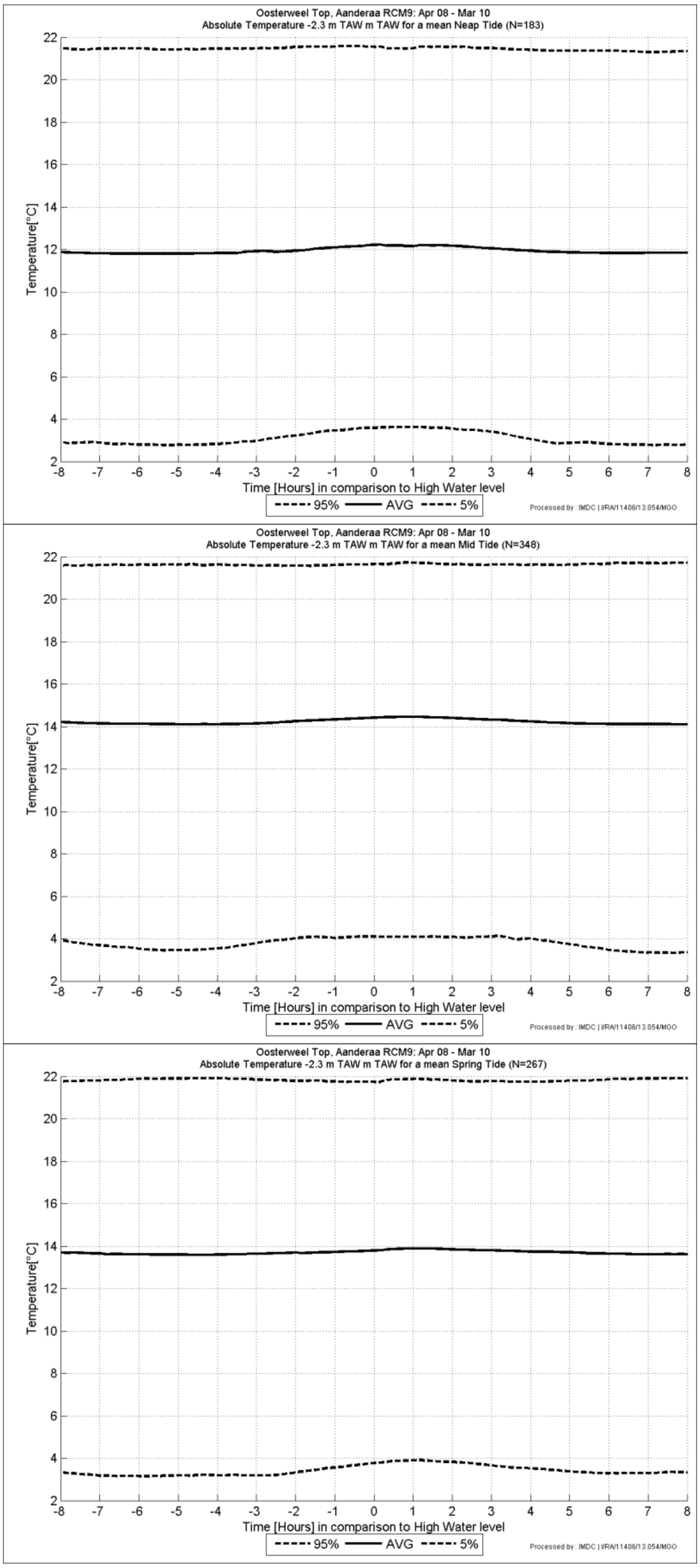
Annex-Figure E-12: Buoy 84 (-8.1m TW), April 2008 – March 2010. Average tidal curve of the temperature for a (a) neap, (b) average, (c) spring tide.



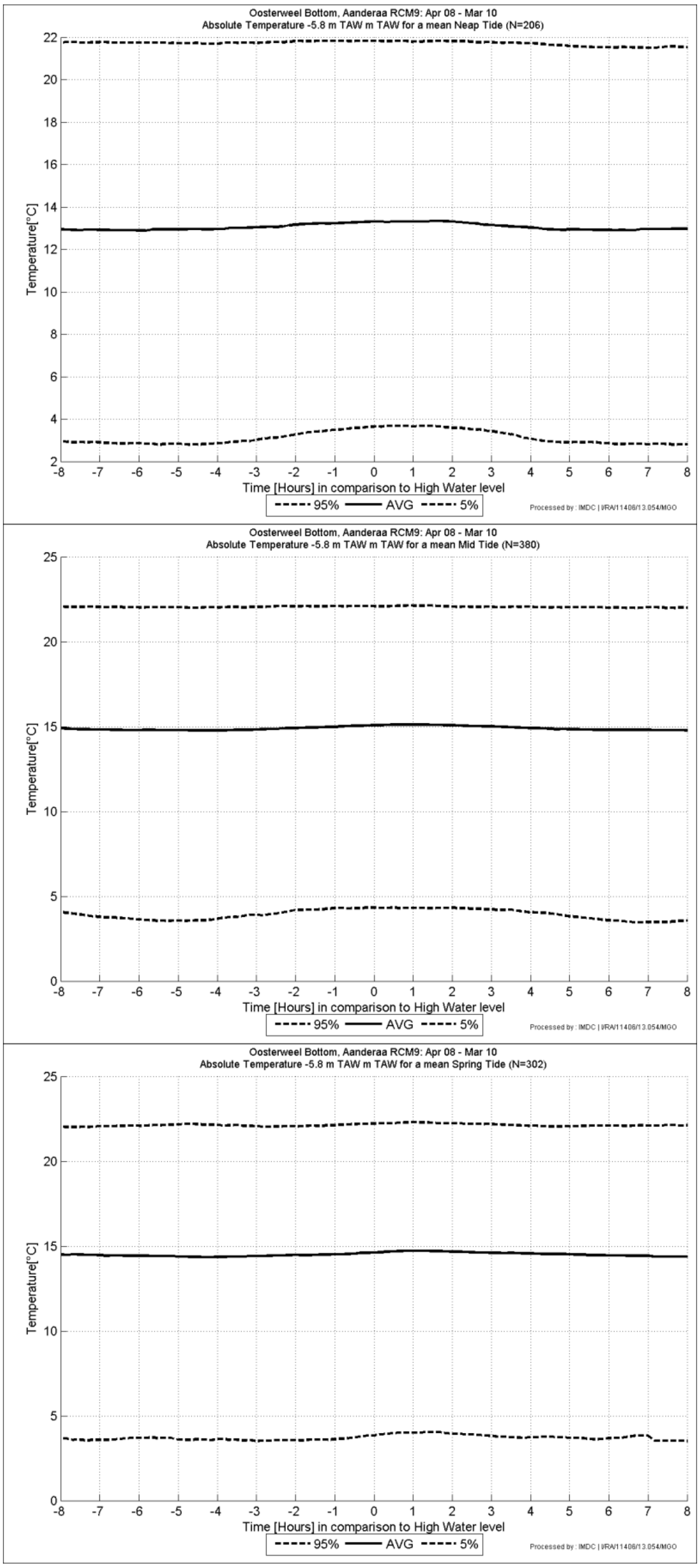
Annex-Figure E-13: Buoy 97 (-5.3m TAW), April 2008 – March 2010. Average tidal curve of the temperature for a (a) neap, (b) average, (c) spring tide.



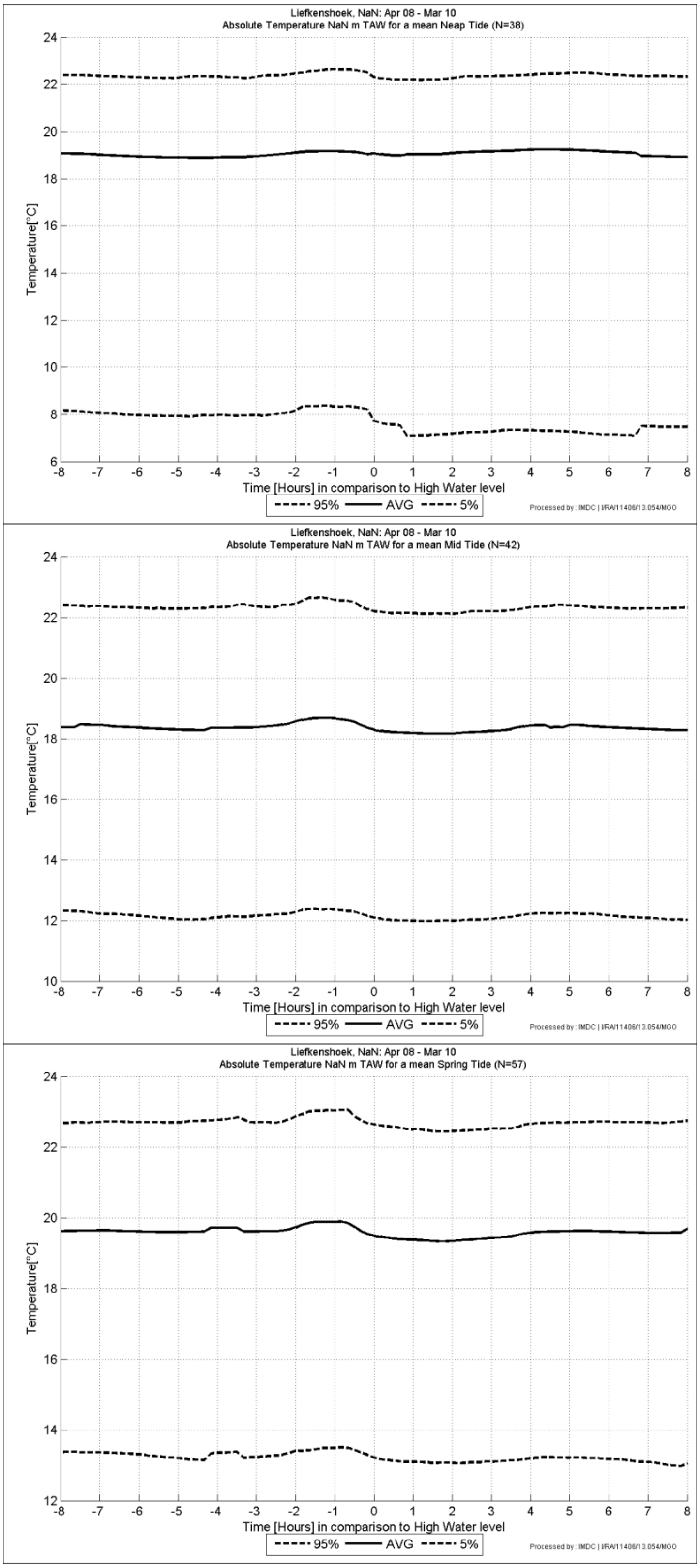
Annex-Figure E-14: Buoy 97 (-7.8m TAW), April 2008 – March 2010. Average tidal curve of the temperature for a (a) neap, (b) average, (c) spring tide.



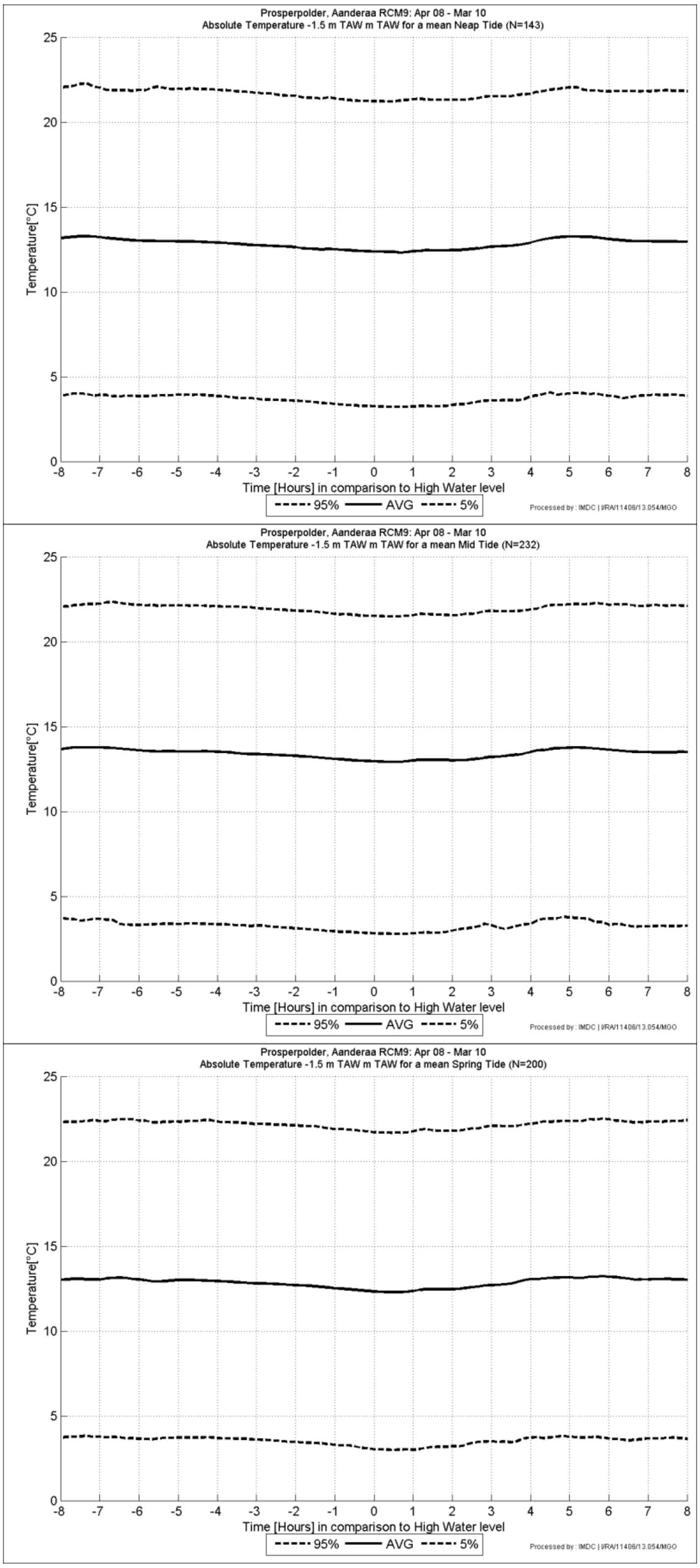
Annex-Figure E-15: Oosterweel Top (-2.3m TAW), April 2008 – March 2010. Average tidal curve of the temperature for a (a) neap, (b) average, (c) spring tide.



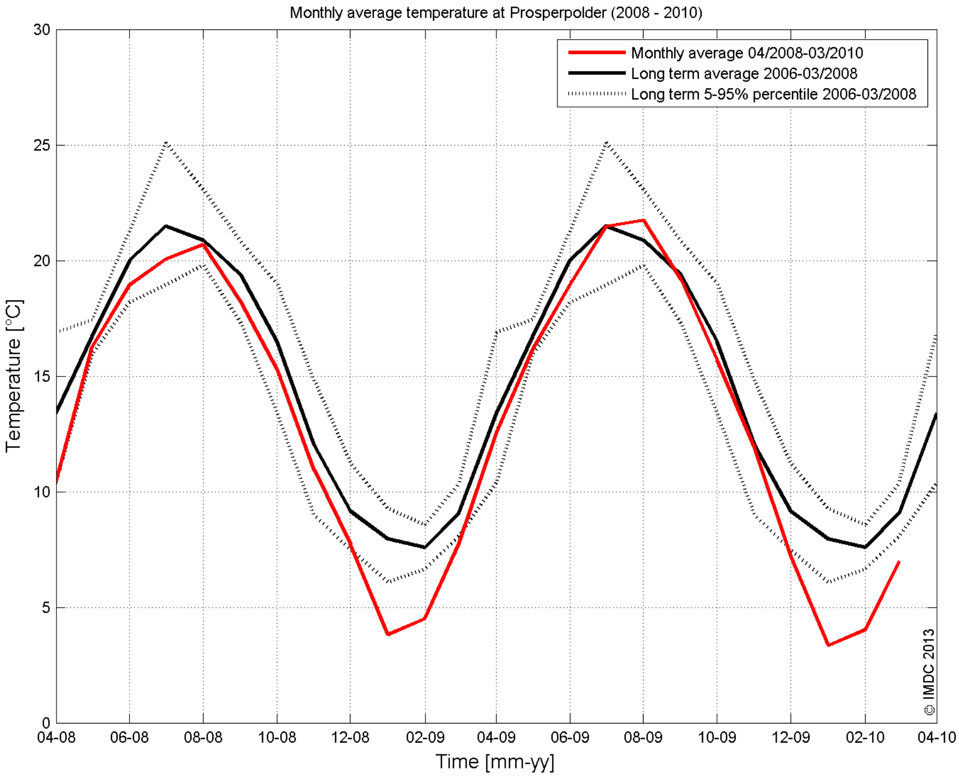
Annex-Figure E-16: Oosterweel Bottom (-5.8m TAW), April 2008 – March 2010. Average tidal curve of the temperature for a (a) neap, (b) average, (c) spring tide.



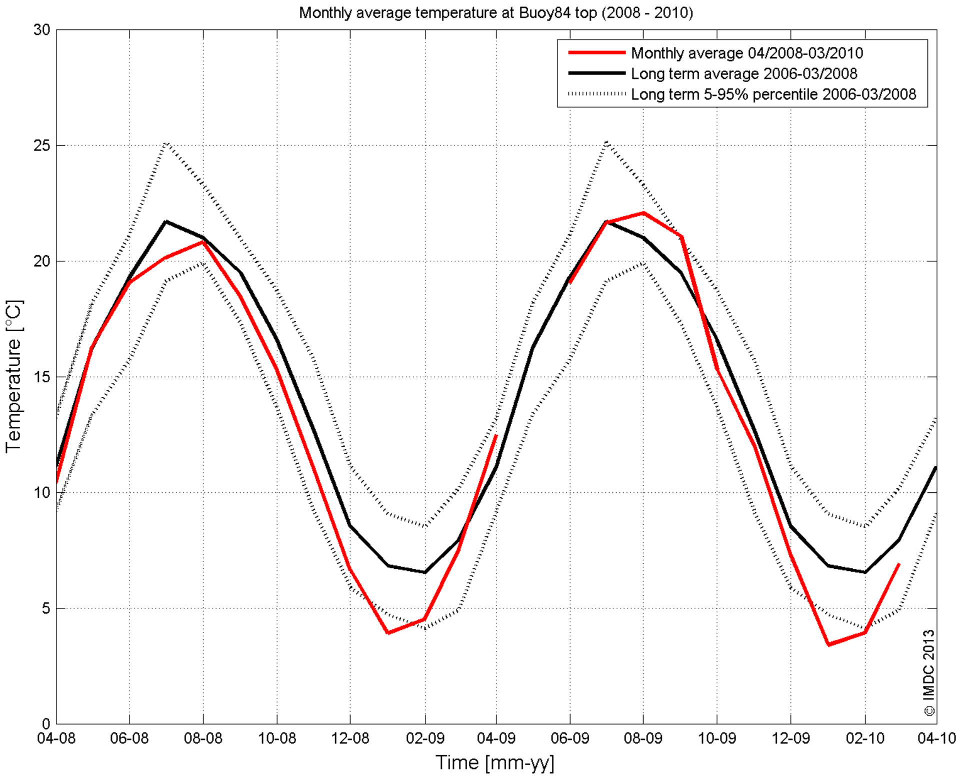
Annex-Figure E-17: Liefkenshoek, April 2008 – March 2010. Average tidal curve of the temperature for a (a) neap, (b) average, (c) spring tide.

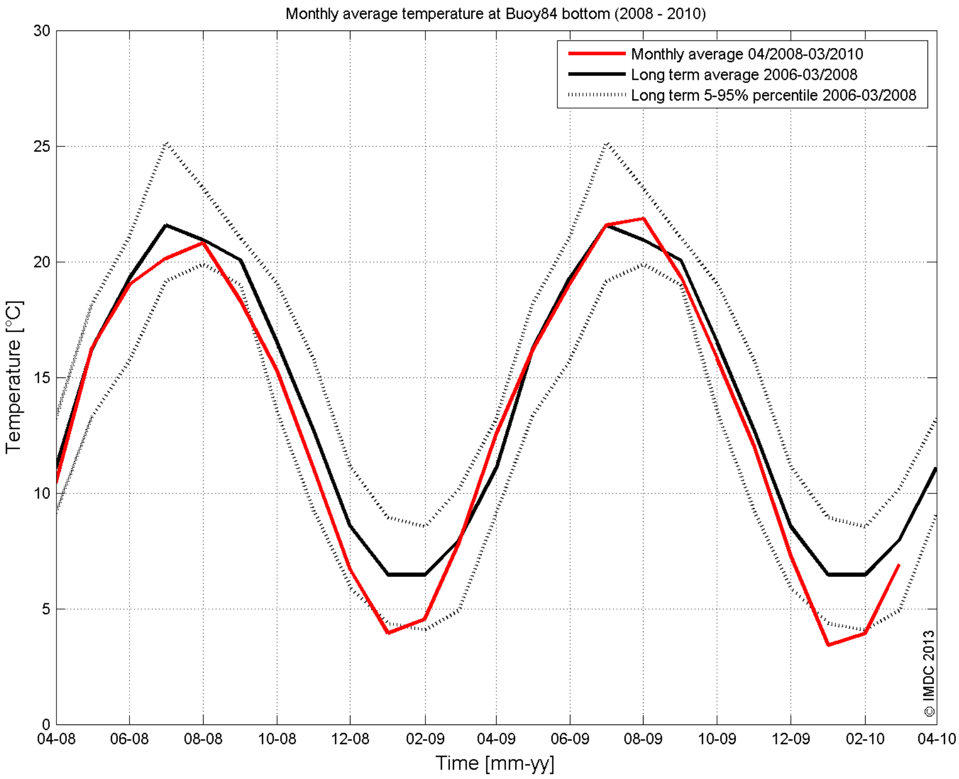


Annex-Figure E-18: Prosperpolder (-1.5 m TAW), April 2008 – March 2010. Average tidal curve of the temperature for a (a) neap, (b) average, (c) spring tide.

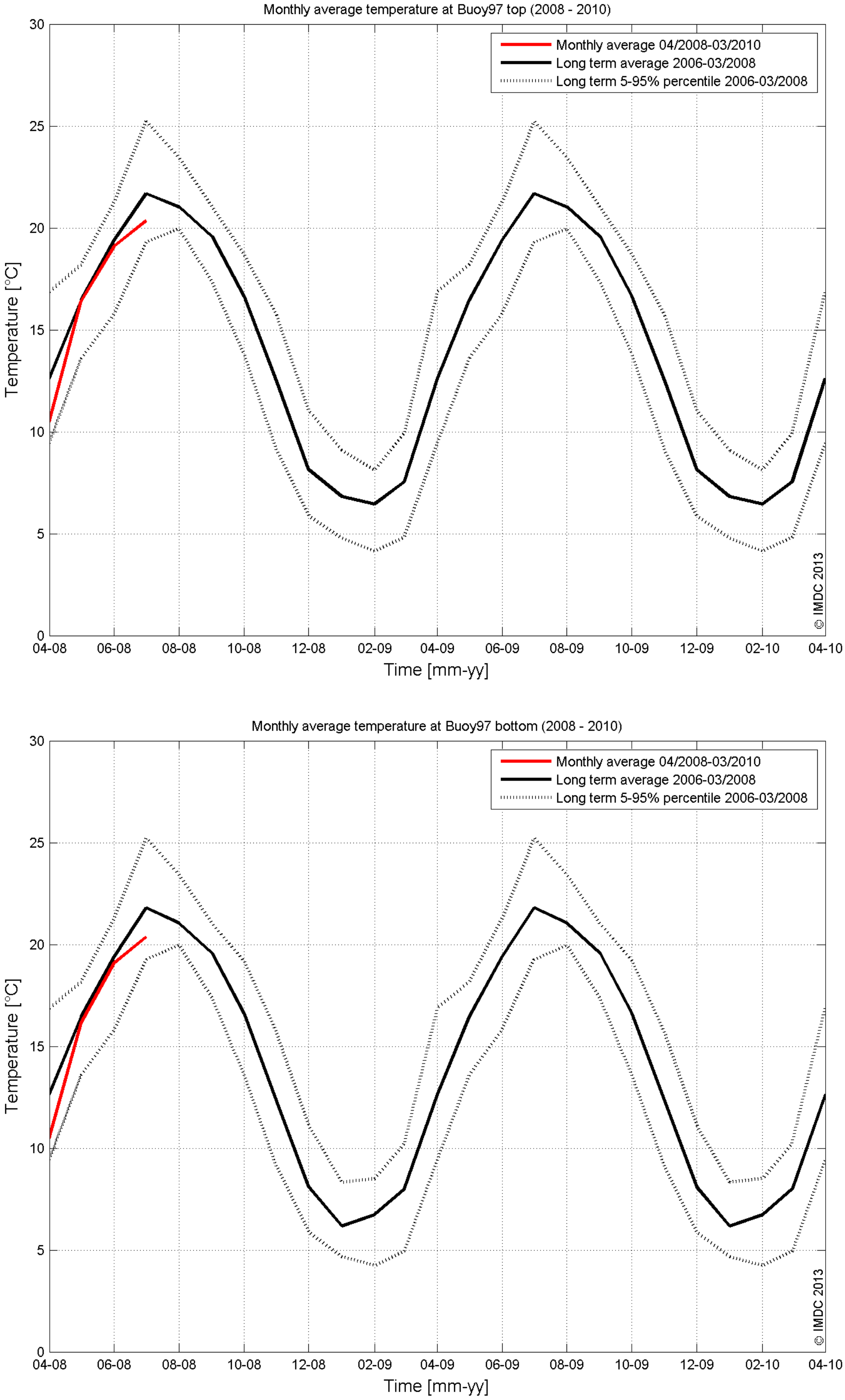


Annex-Figure E-19: The monthly average temperature curves of Prosperpolder between April 2008 – March 2010 and 2006 – March 2008 including the monthly 5/95% percentiles.

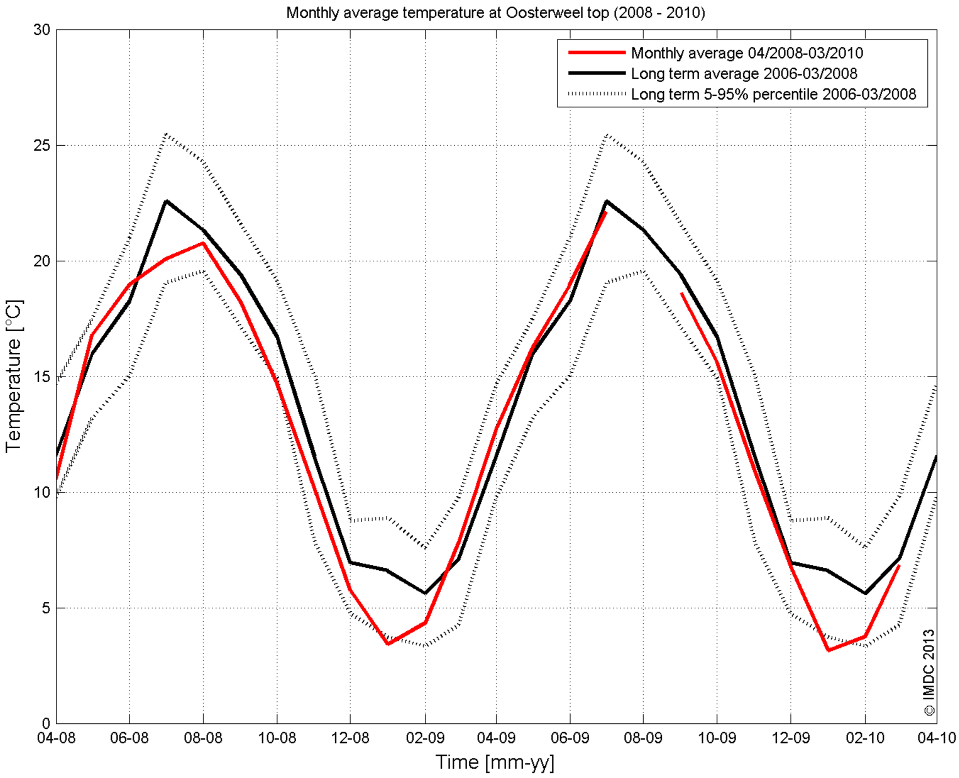


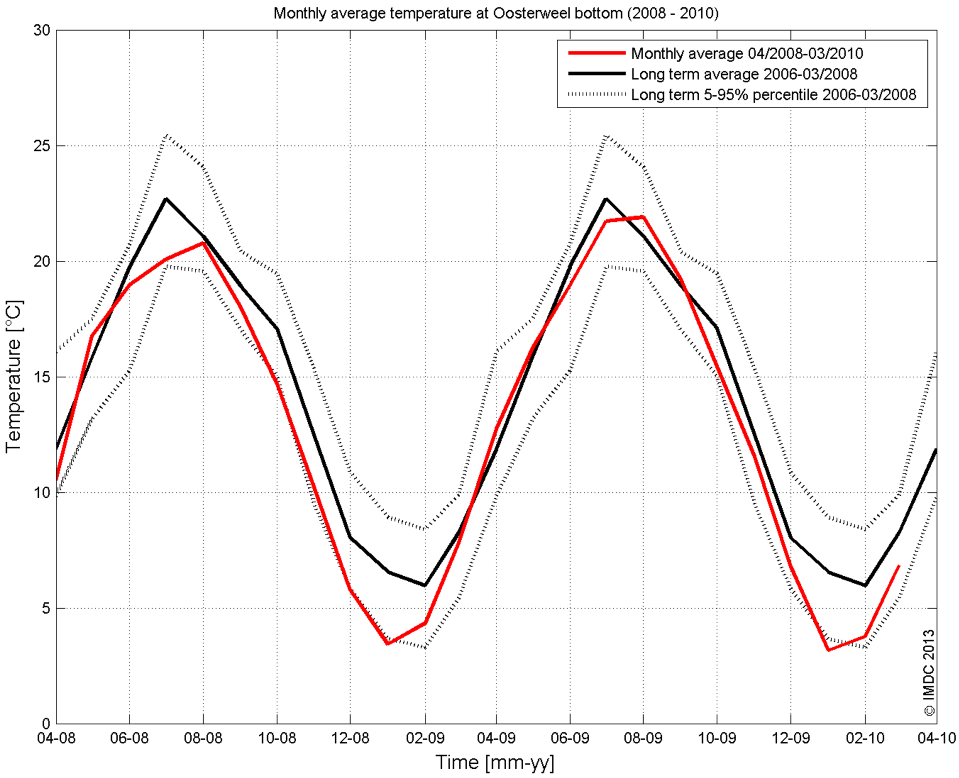


Annex-Figure E-20: The monthly average temperature curves of (a) Buoy84 top and (b) bottom between April 2008 – March 2010 and 2006 – March 2008 including the monthly 5/95% percentiles.



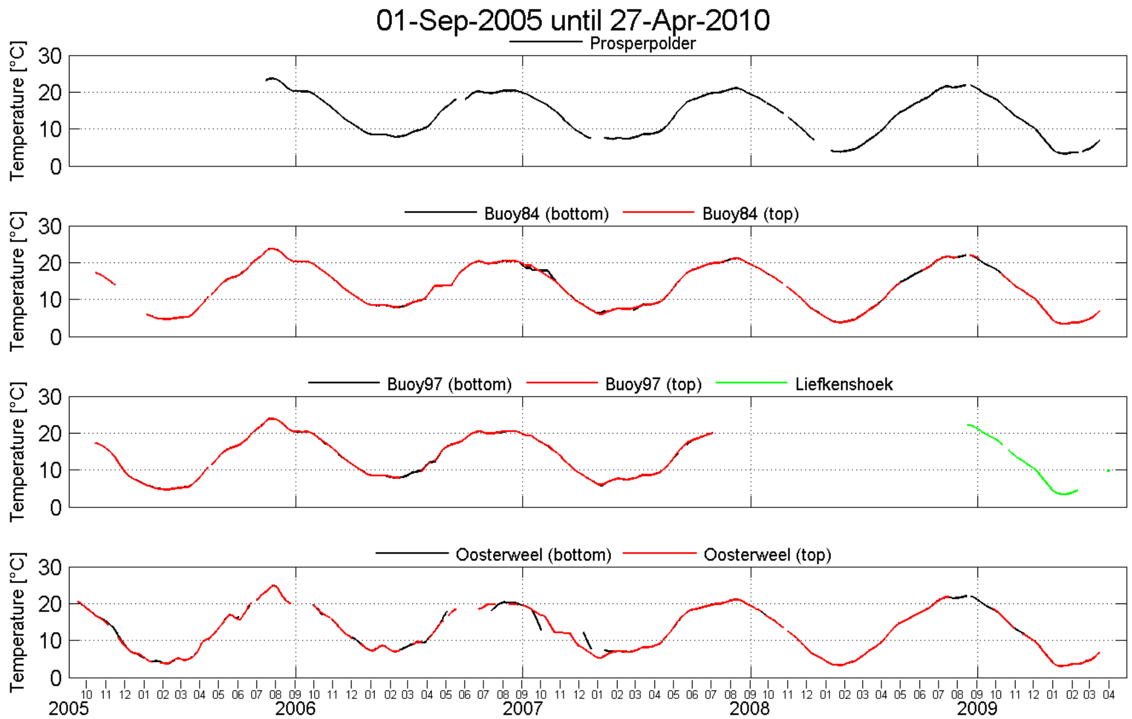
Annex-Figure E-21: The monthly average temperature curves of (a) Buoy97 top and (b) bottom between April 2008 – March 2010 and 2006 – March 2008 including the monthly 5/95% percetiles.





Annex-Figure E-22: The monthly average temperature curves of (a) Oosterweel top and (b) bottom between April 2008 – March 2010 and 2006 – March 2008 including the monthly 5/95% perctiles.

11406 - External effects siltation Deurganckdok (2012-2014)



Timeseries of monthly moving average of temperature

Processed by:

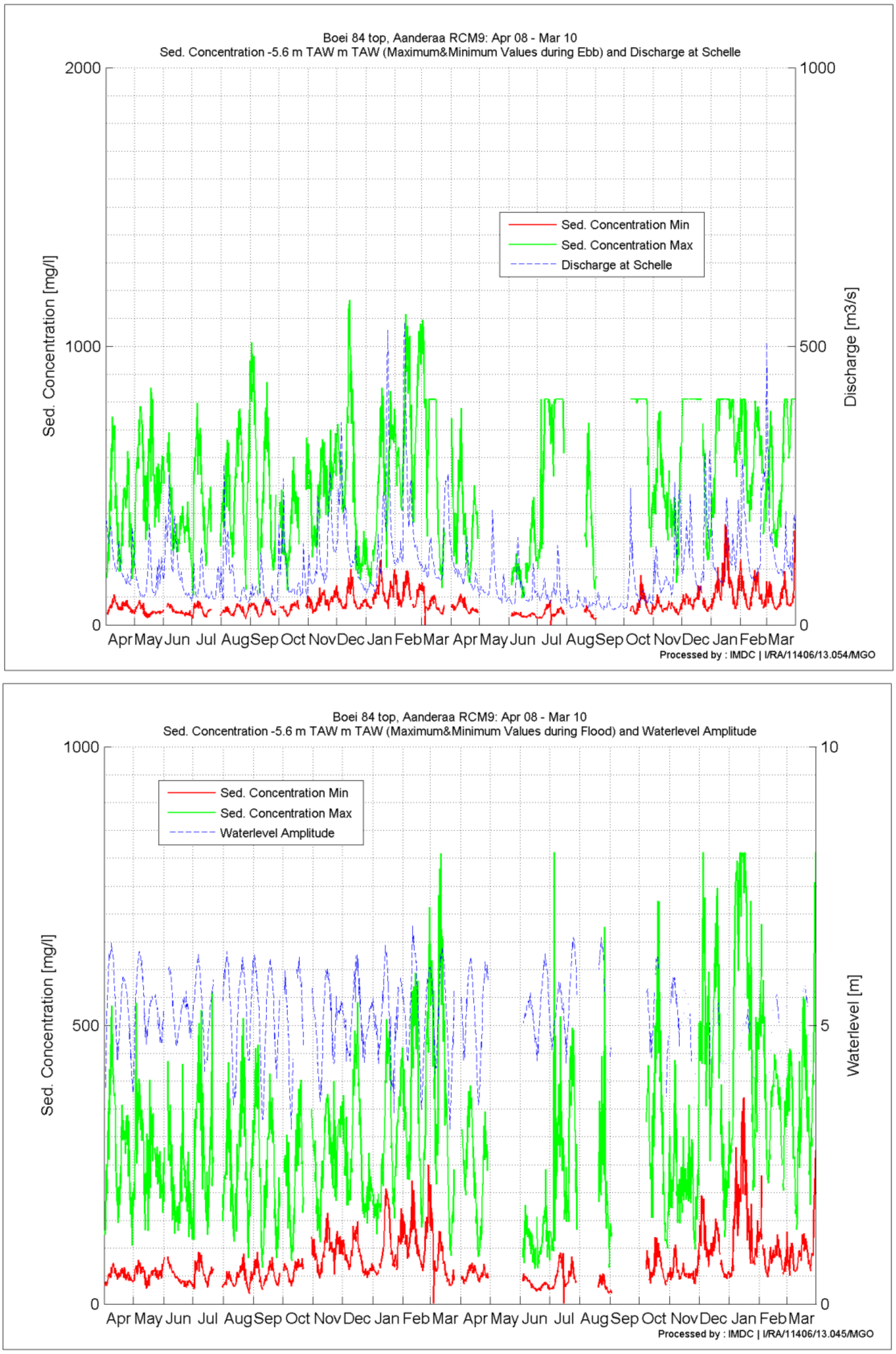
Location:

Lower Sea Scheldt

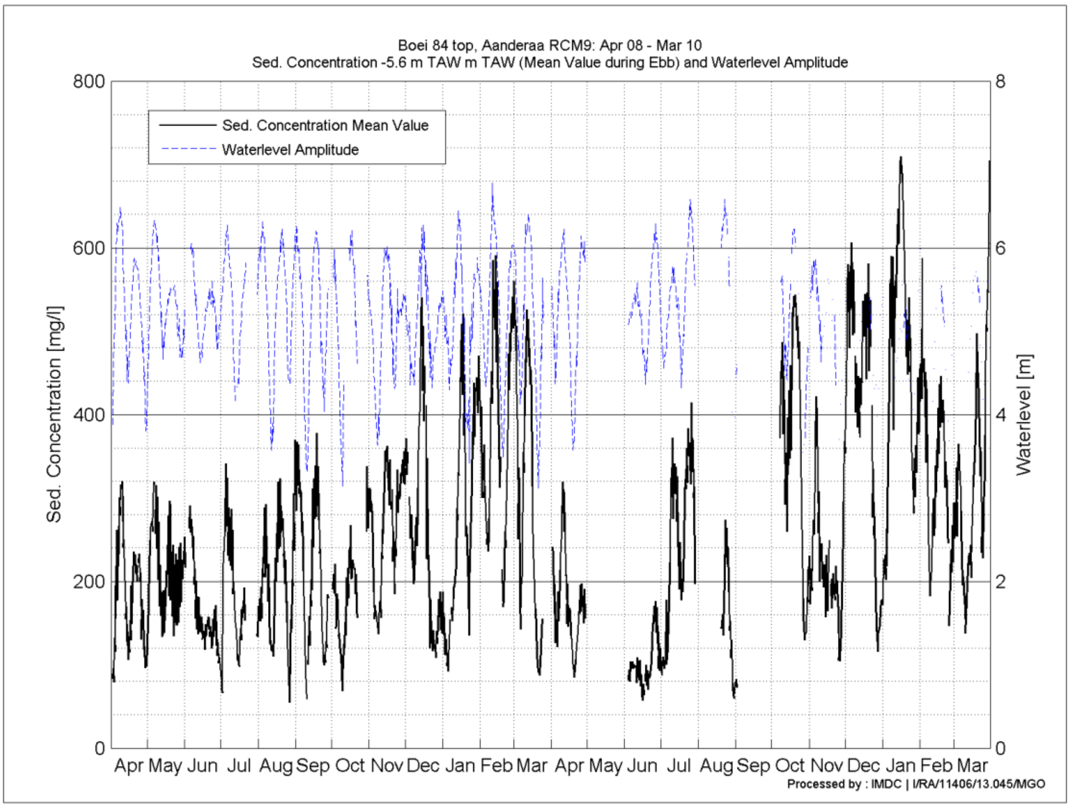
I/RA/11406/13.054/MGO

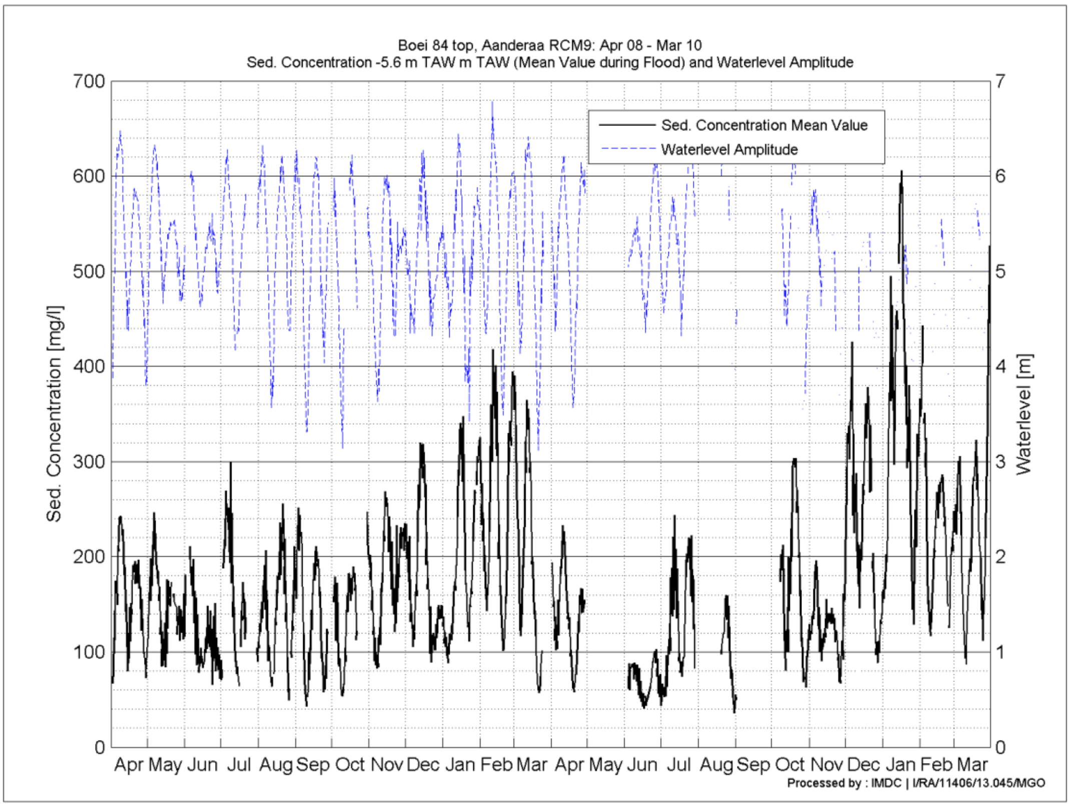
Annex-Figure E-23: Time series of monthly moving average of temperature at Prosperpolder, B84, Liefkenshoek, B97 and Oosterweel measurement stations.

Annex F Figures for suspended sediment concentration

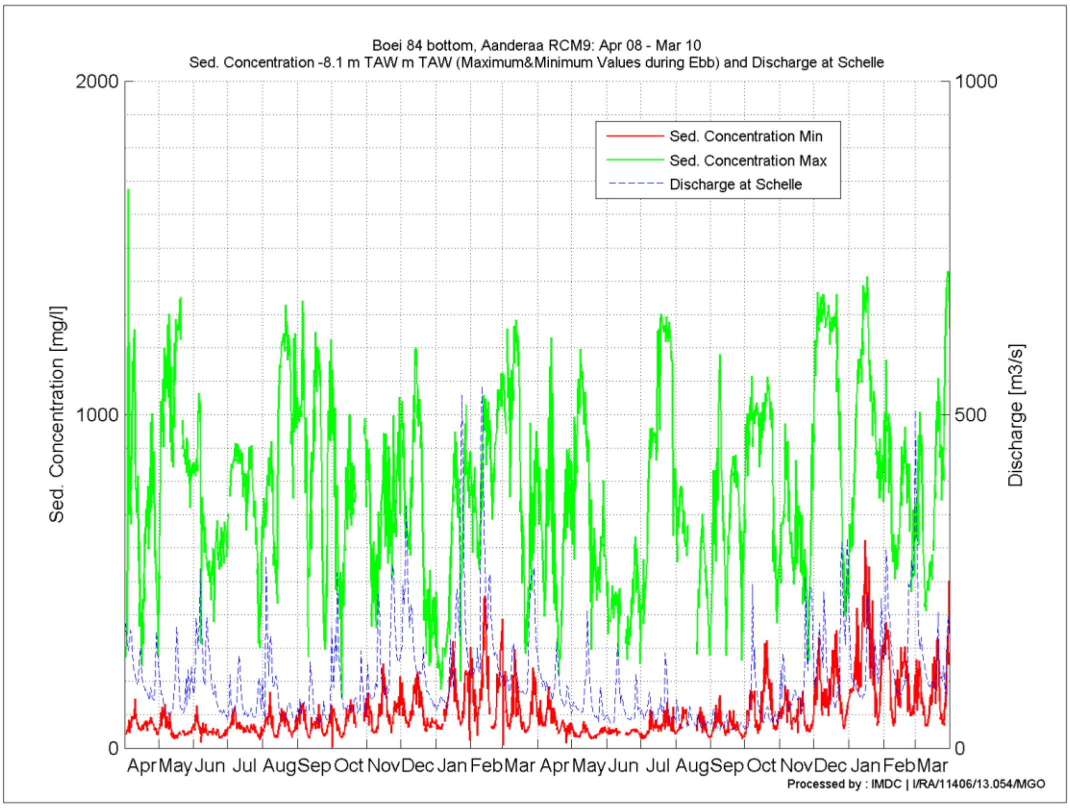


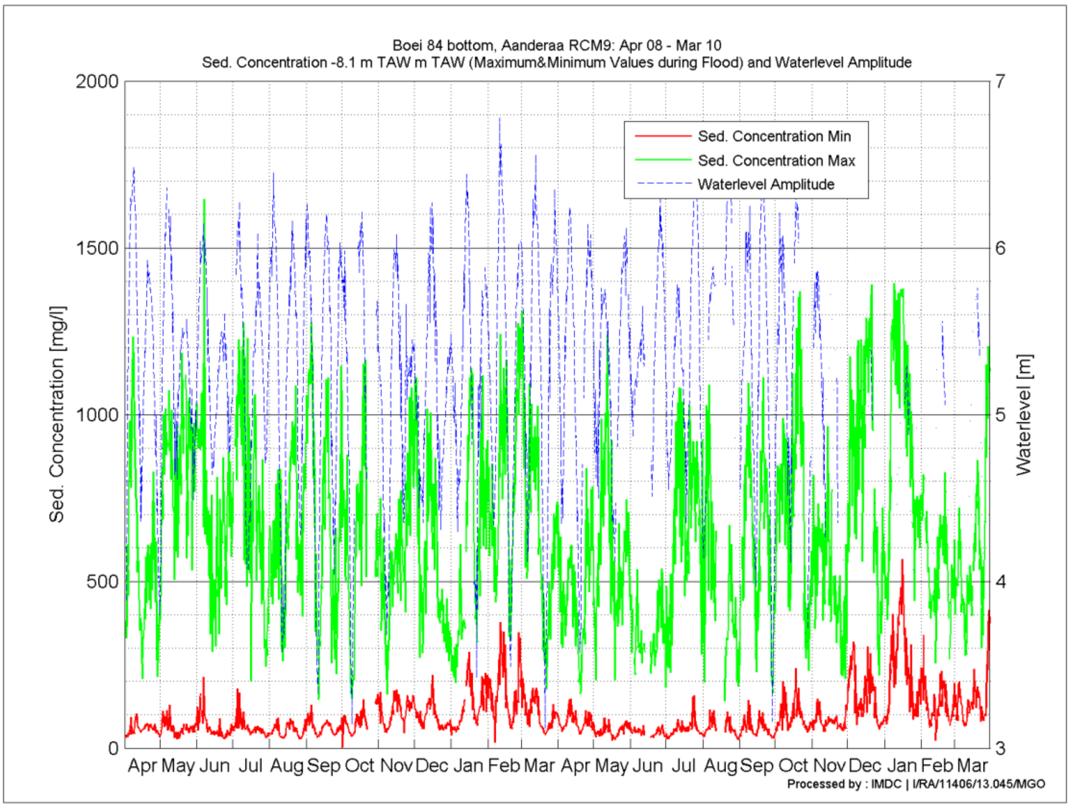
Annex-Figure F-1: Buoy 84 (-5.6m TAW), April 2008 – March 2010. Minimal and maximal (a) ebb phase (and Scheldt discharge) and (b) flood phase (and tidal amplitude) suspended sediment concentration.



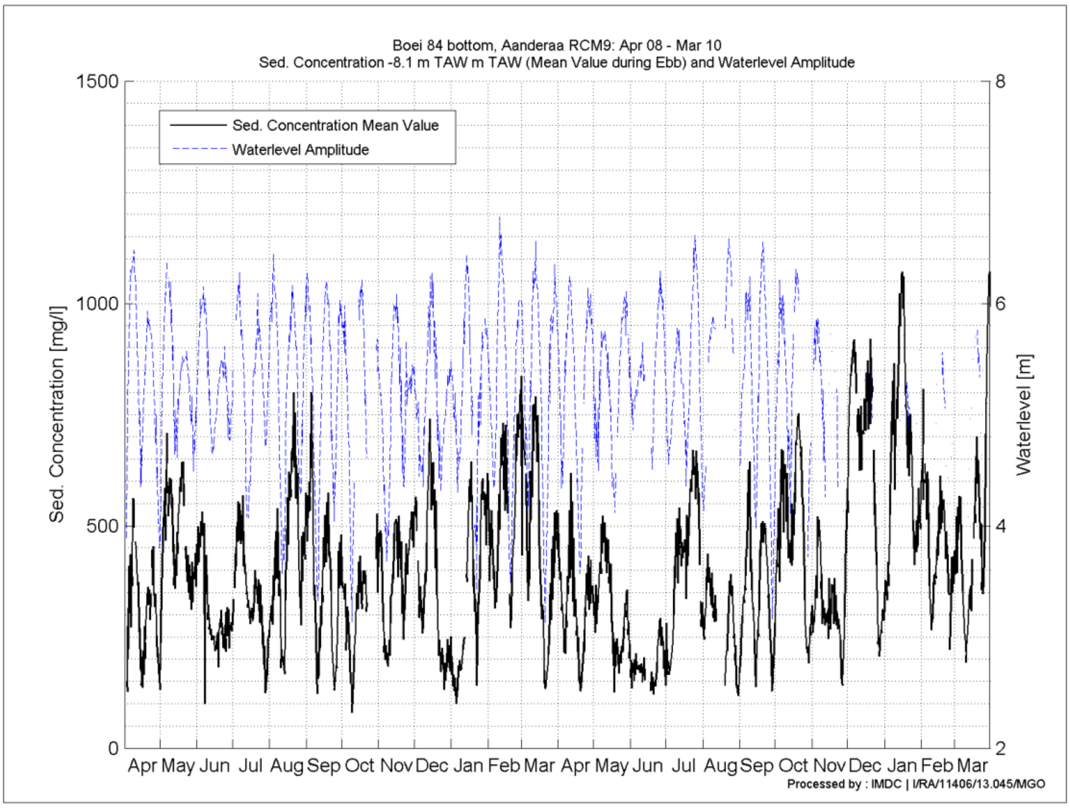


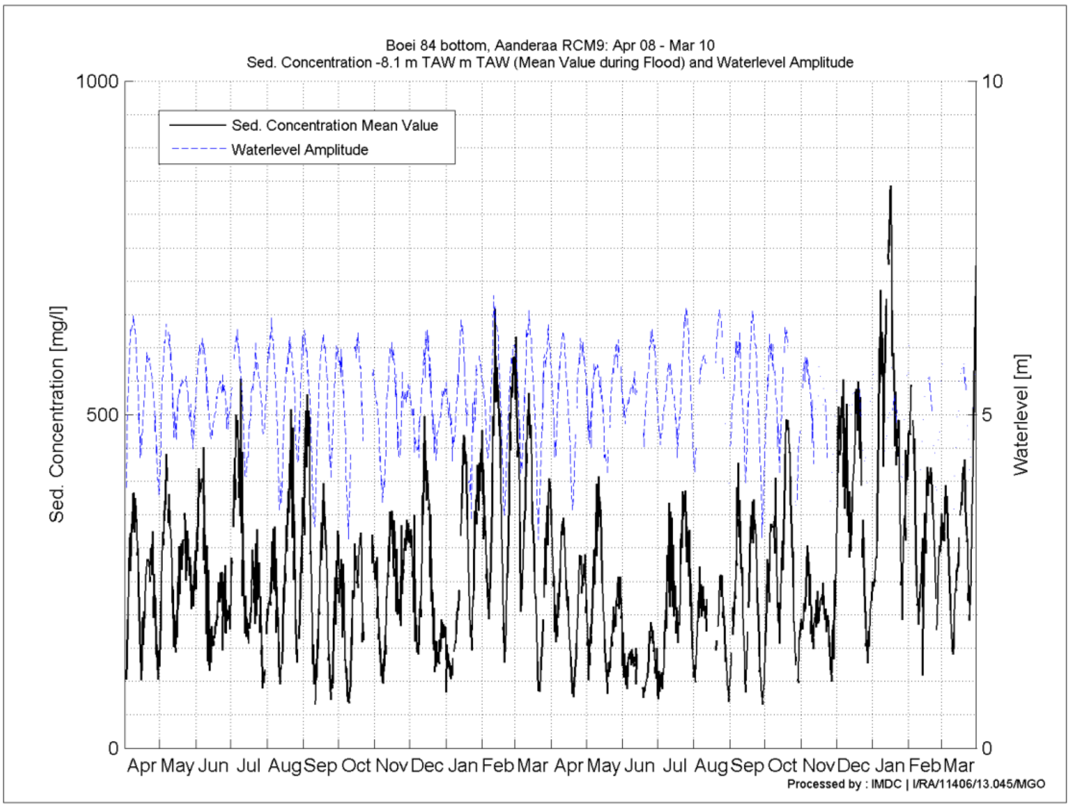
Annex-Figure F-2: Buoy 84 (-5.6m TAW), April 2008 – March 2010. Average (a) ebb phase and (b) flood phase suspended sediment concentration and tidal amplitude.



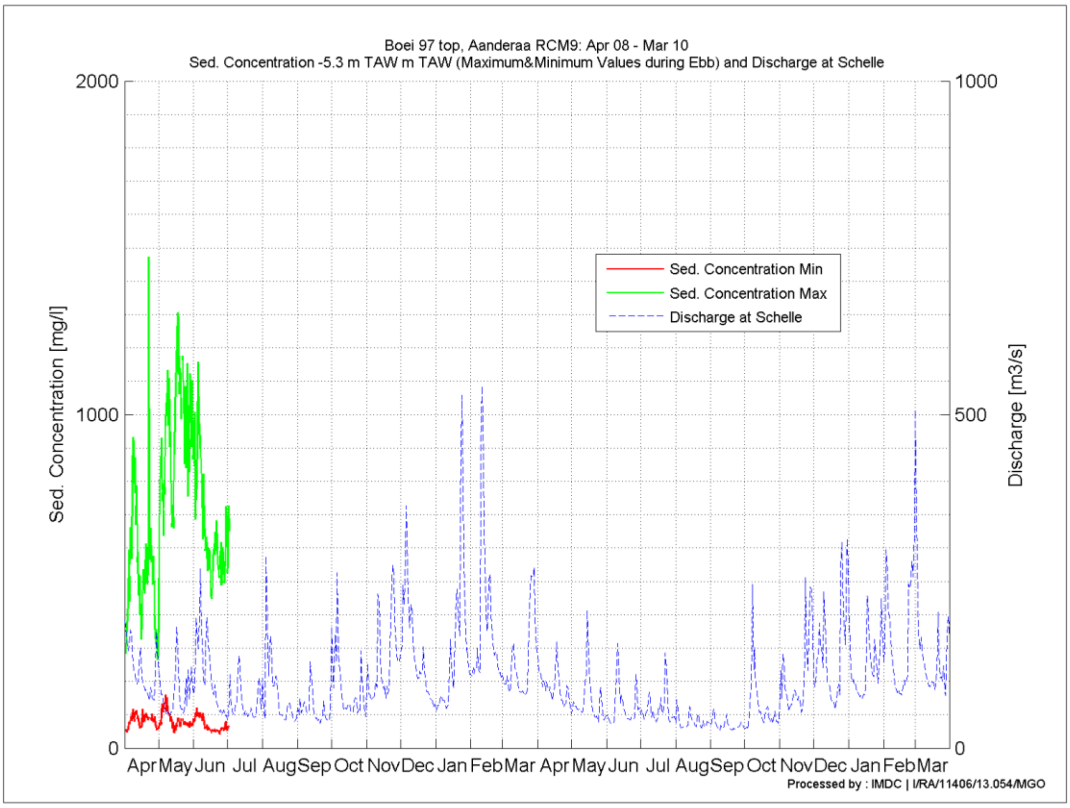


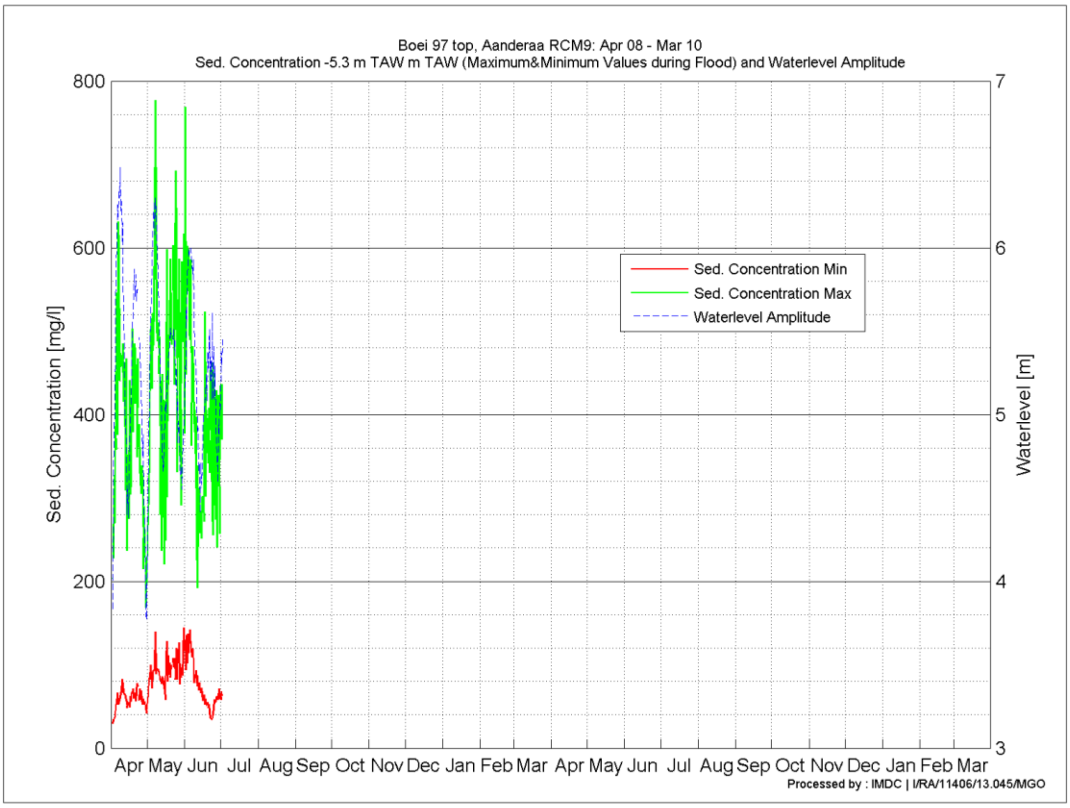
Annex-Figure F-3: Buoy 84 (-8.1m TAW), April 2008 – March 2010. Minimal and maximal (a) ebb phase (and Scheldt discharge) and (b) flood phase (and tidal amplitude) suspended sediment concentration.



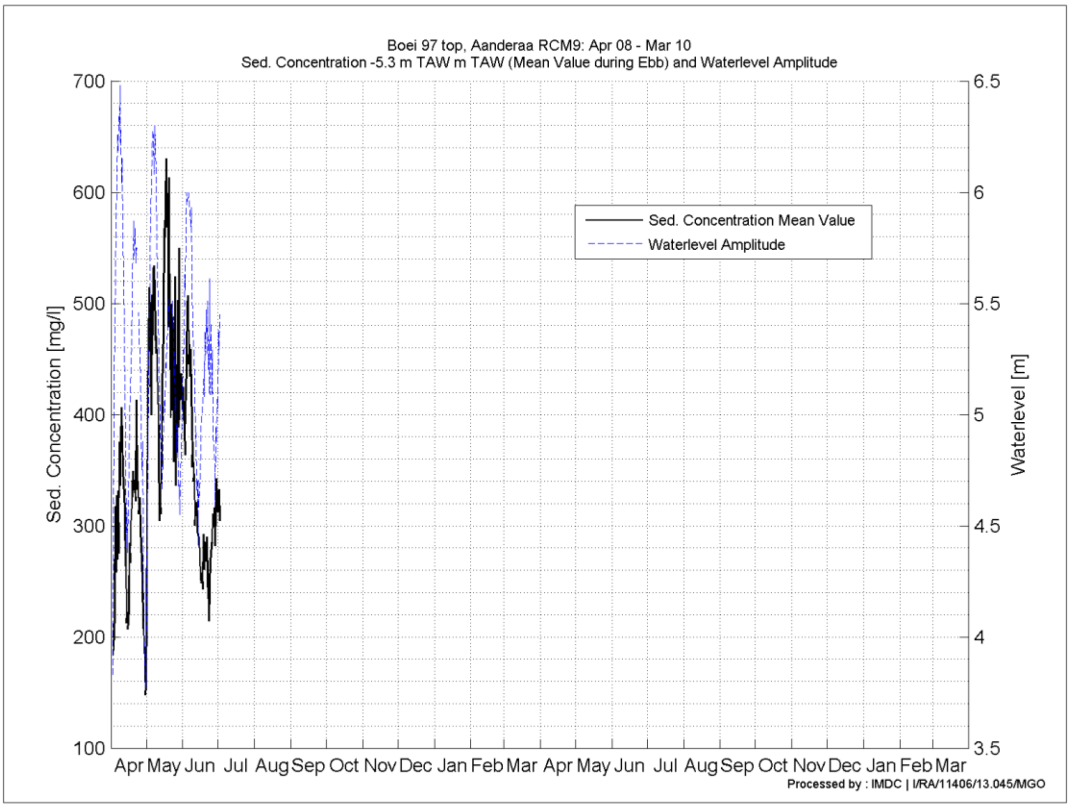


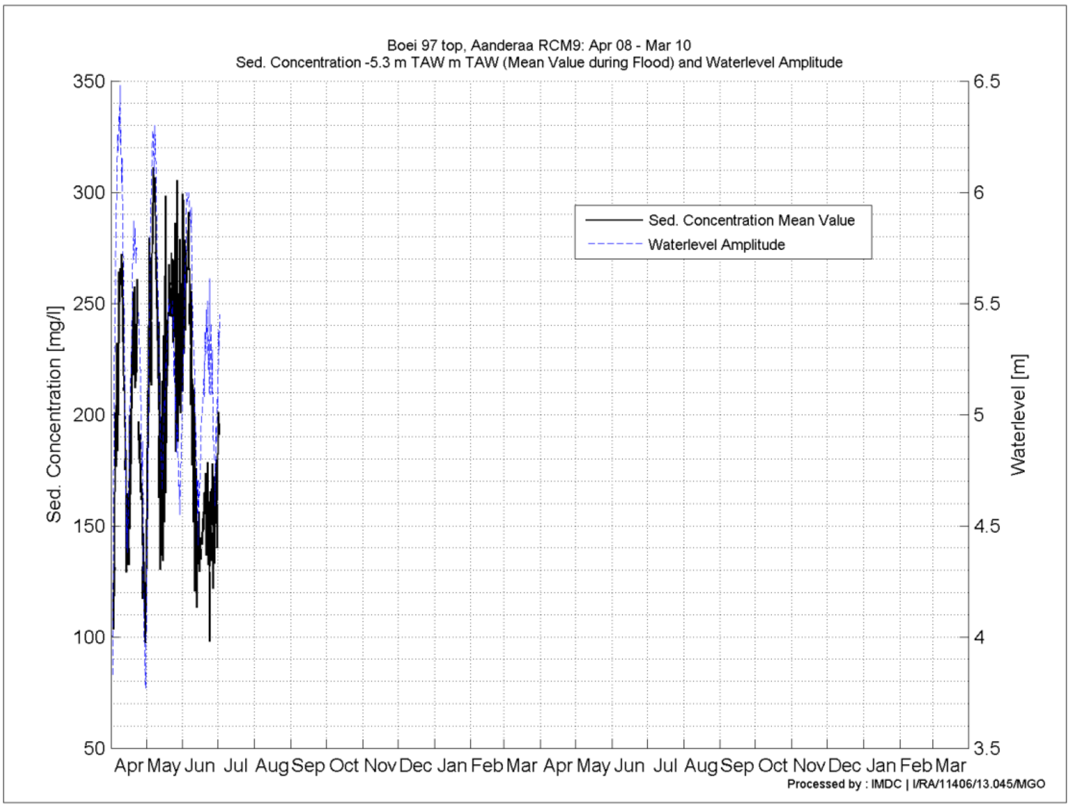
Annex-Figure F-4: Buoy 84 (-8.1m TAW), April 2008 – March 2010. Average (a) ebb phase and (b) flood phase suspended sediment concentration and tidal amplitude.



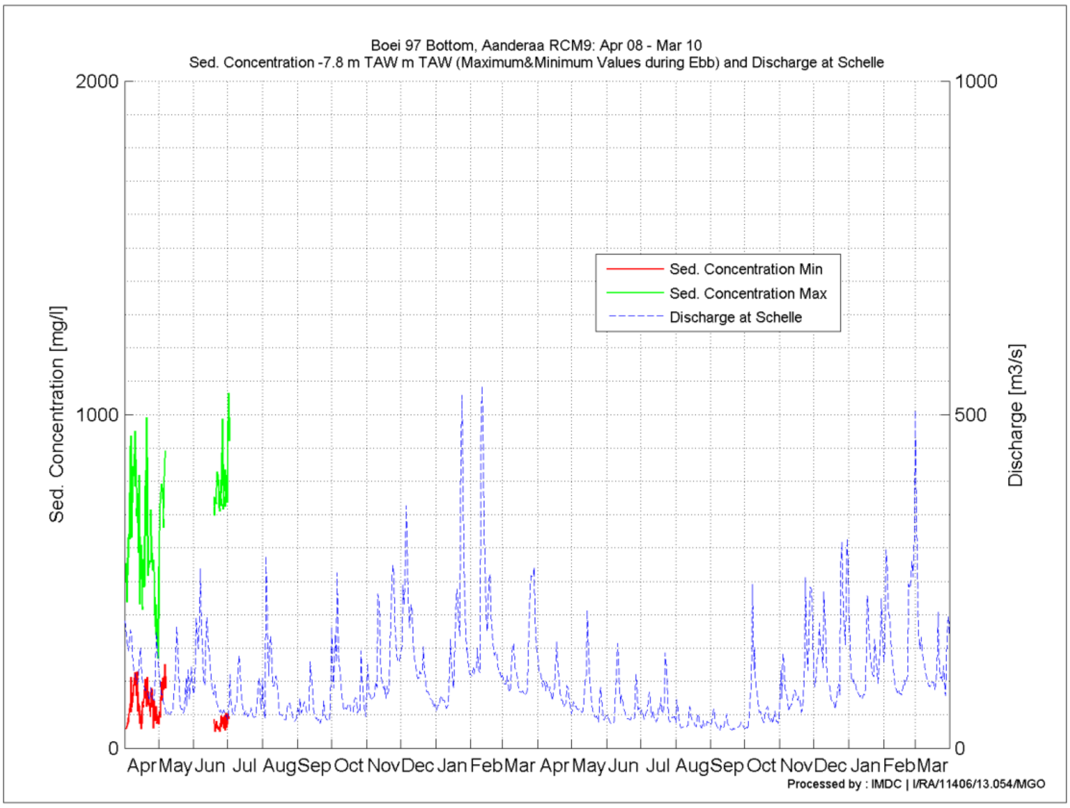


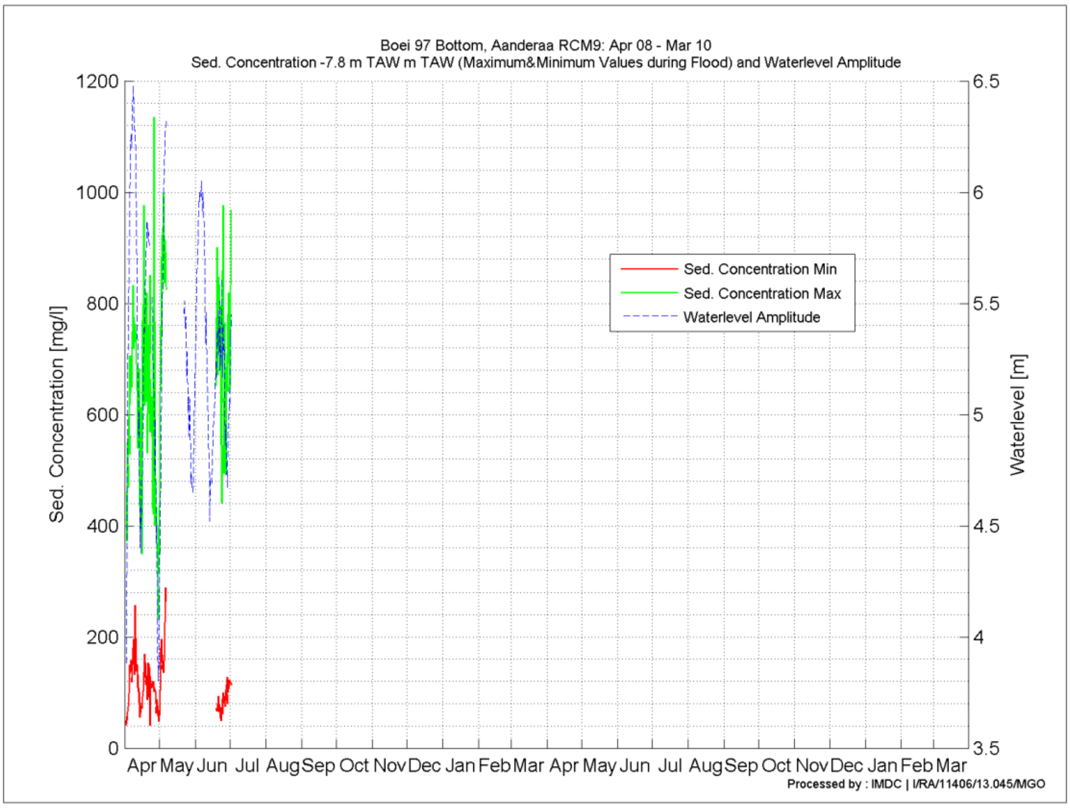
Annex-Figure F-5: Buoy 97 (-5.3m TAW), April 2008 – March 2010. Minimal and maximal (a) ebb phase (and Scheldt discharge) and (b) flood phase (and tidal amplitude) suspended sediment concentration.



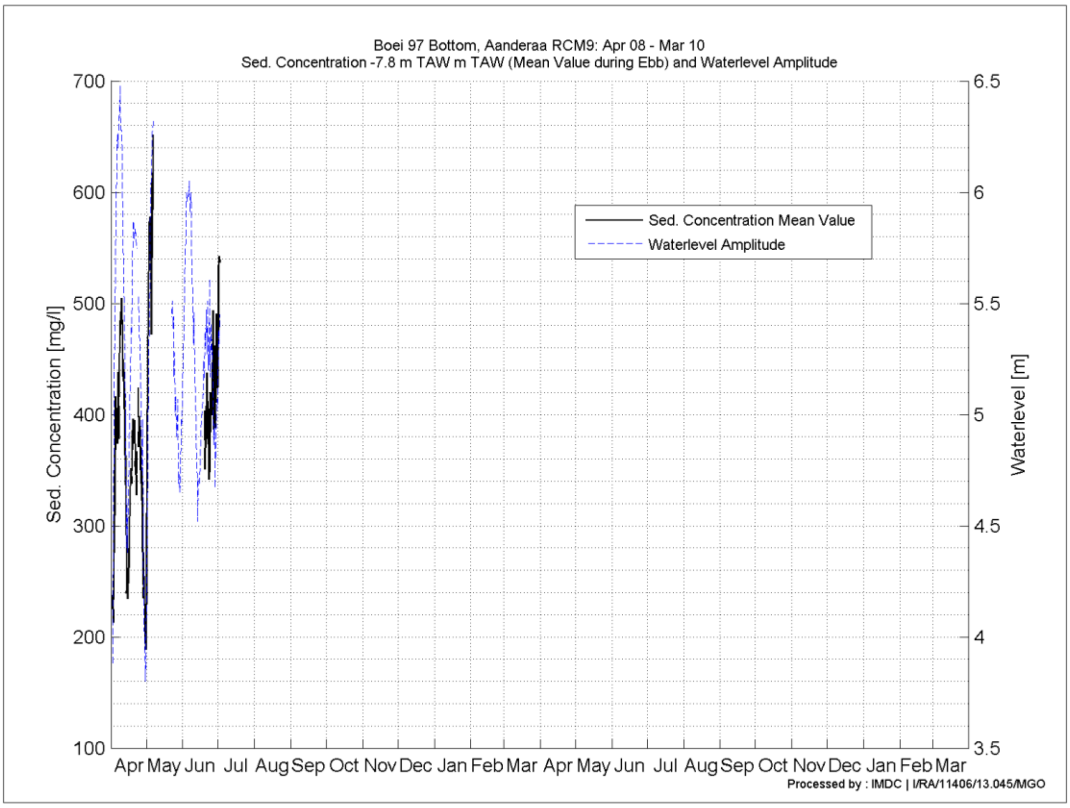


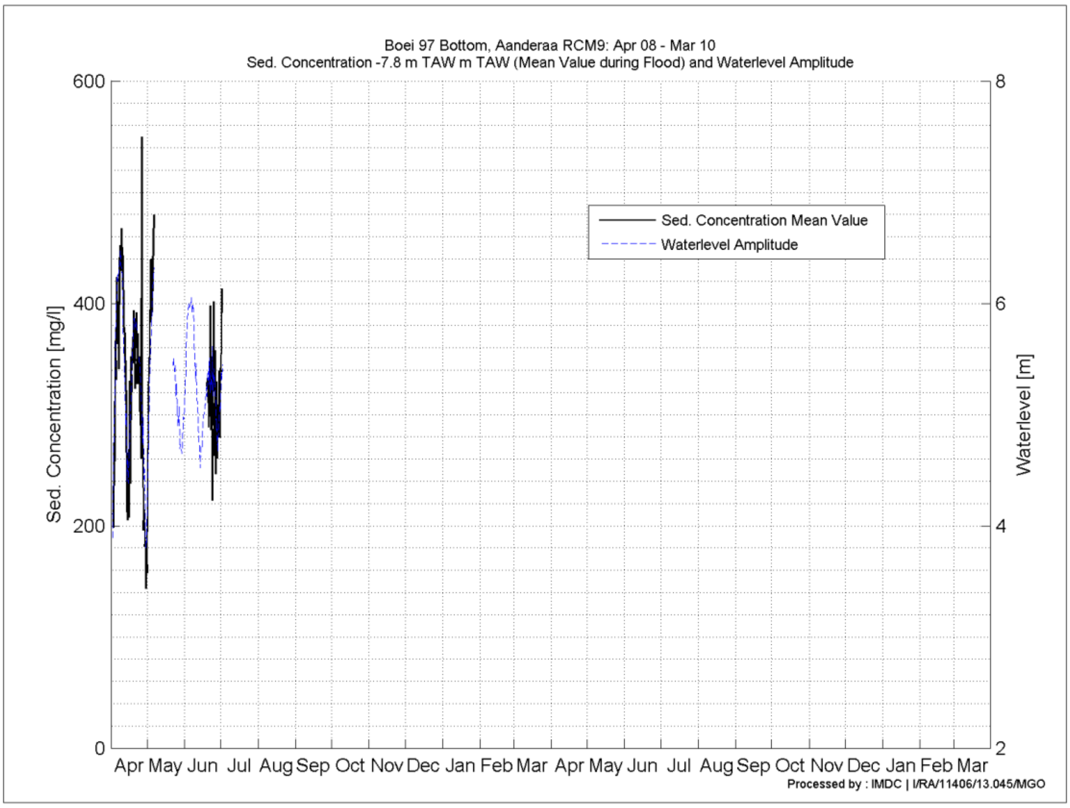
Annex-Figure F-6: Buoy 97 (-5.3m TAW), April 2008 – March 2010. Average (a) ebb phase and (b) flood phase suspended sediment concentration and tidal amplitude.



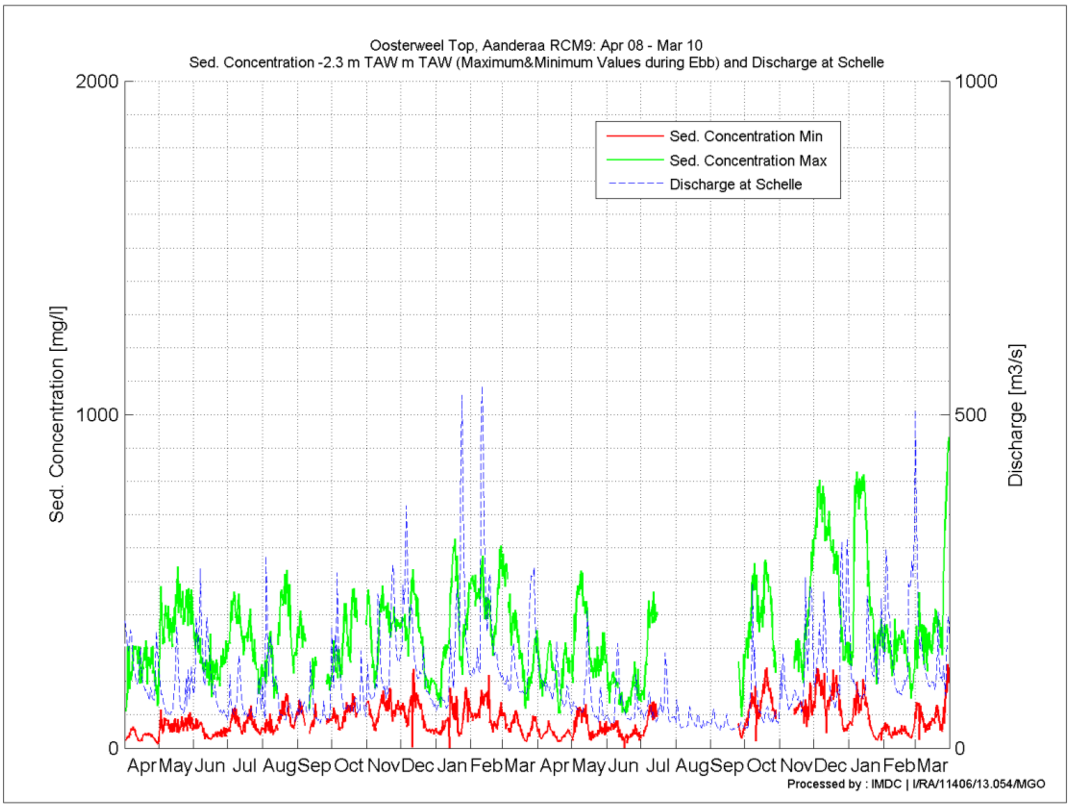


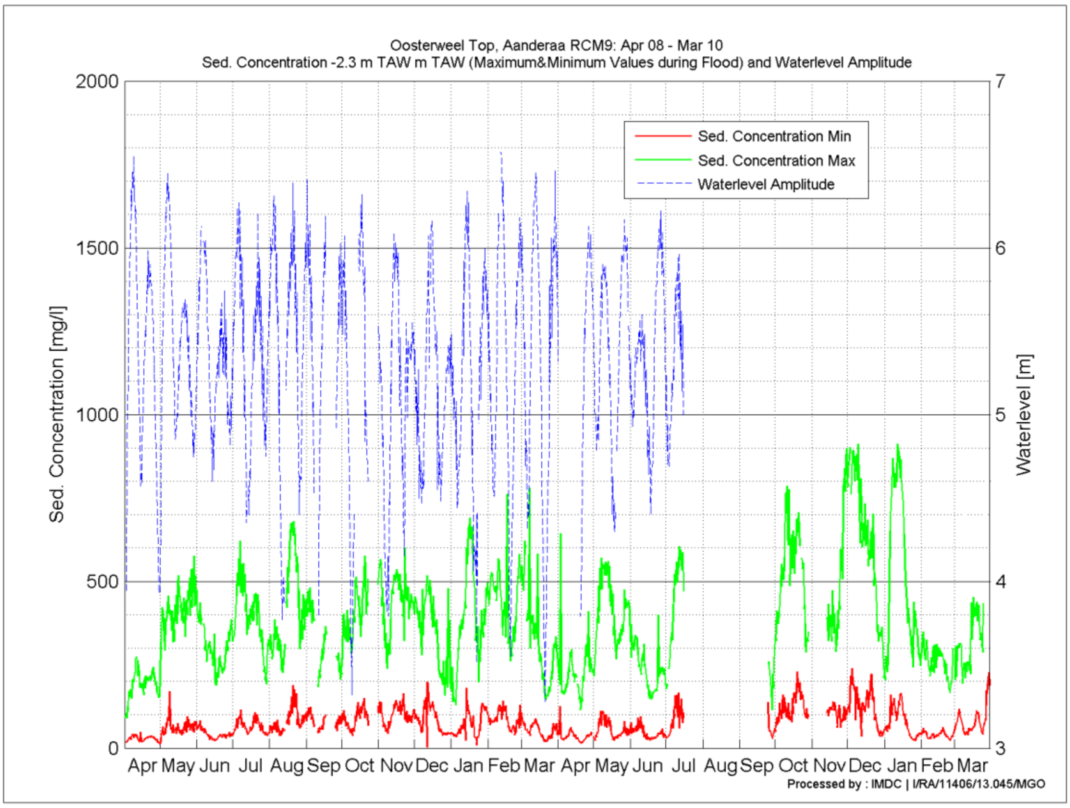
Annex-Figure F-7: Buoy 97 (-7.8m TAW), April 2008 – March 2010. Minimal and maximal (a) ebb phase (and Scheldt discharge) and (b) flood phase (and tidal amplitude) suspended sediment concentration.



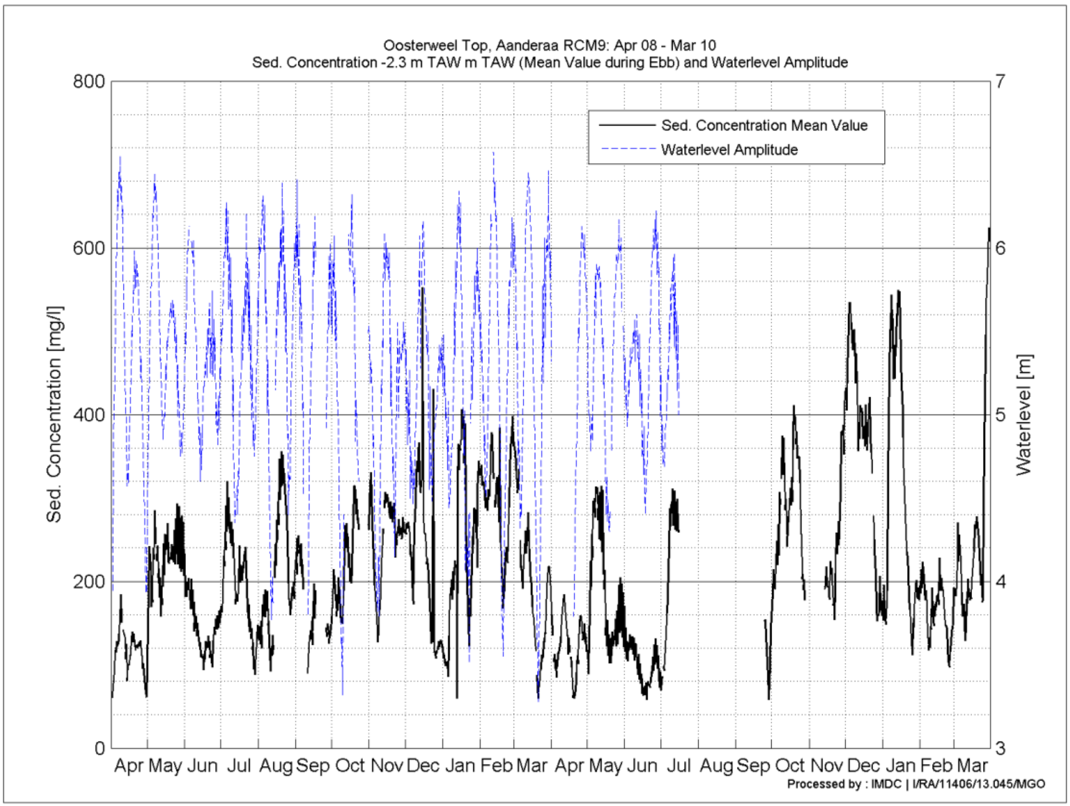


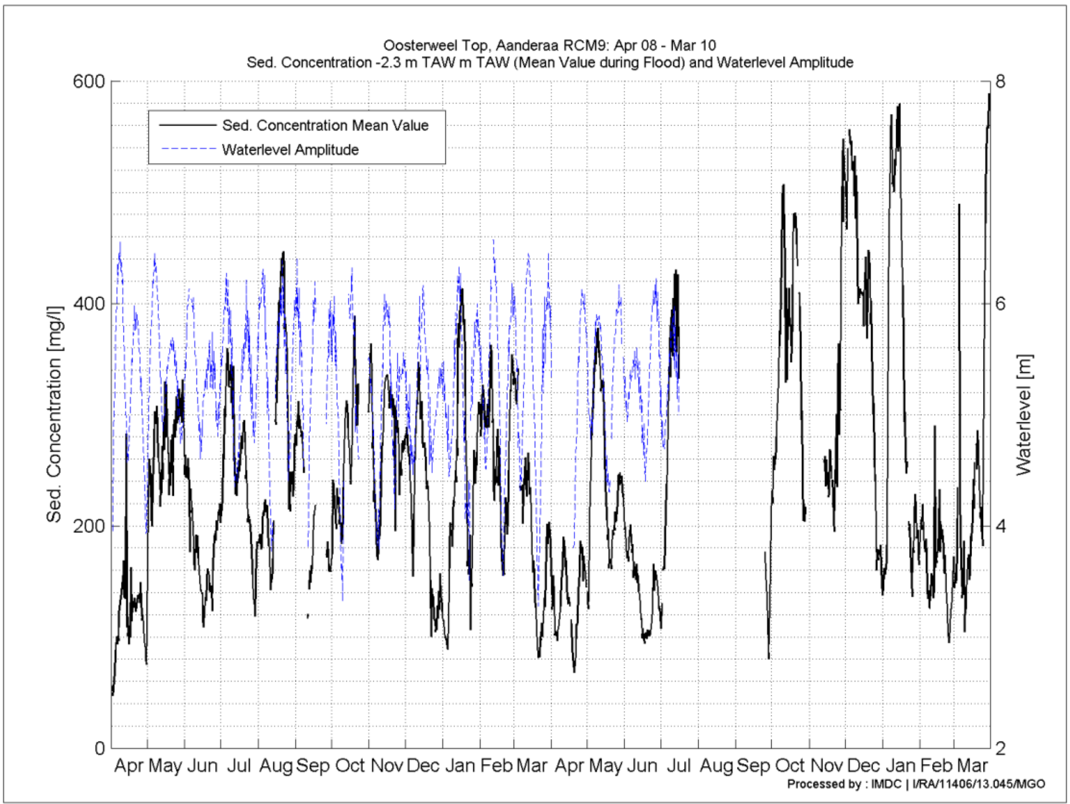
Annex-Figure F-8: Buoy 97 (-7.8m TAW), April 2008 – March 2010. Average (a) ebb phase and (b) flood phase suspended sediment concentration and tidal amplitude.



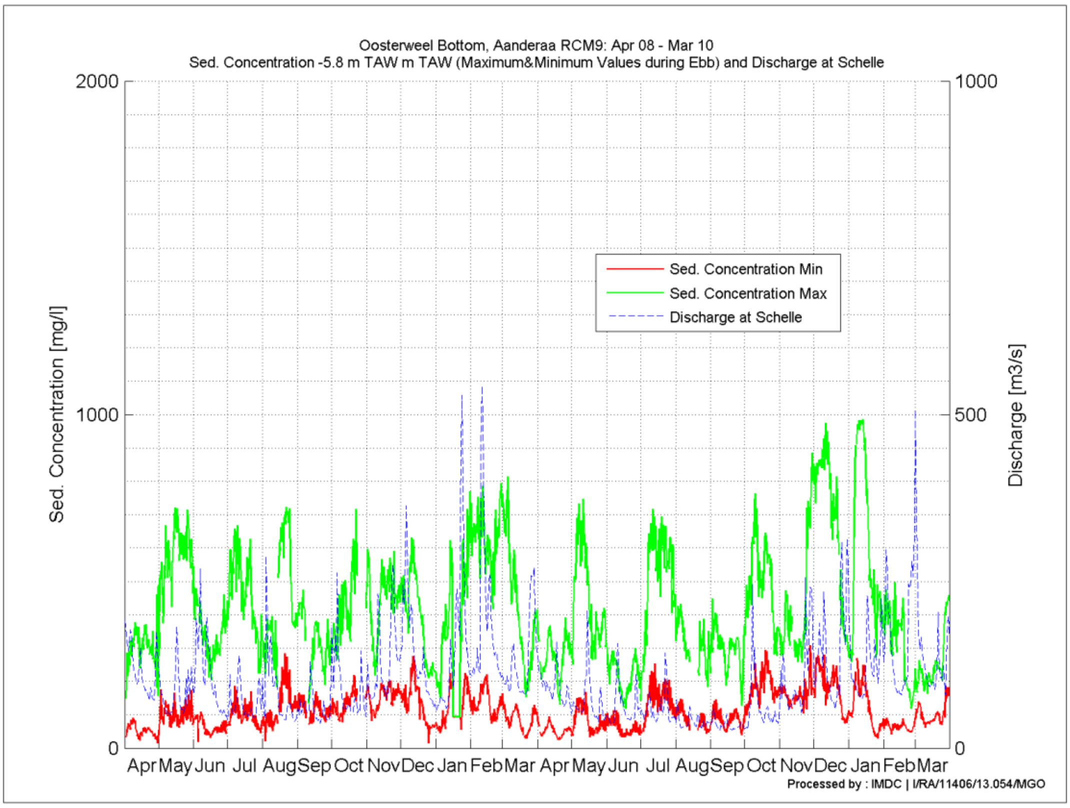


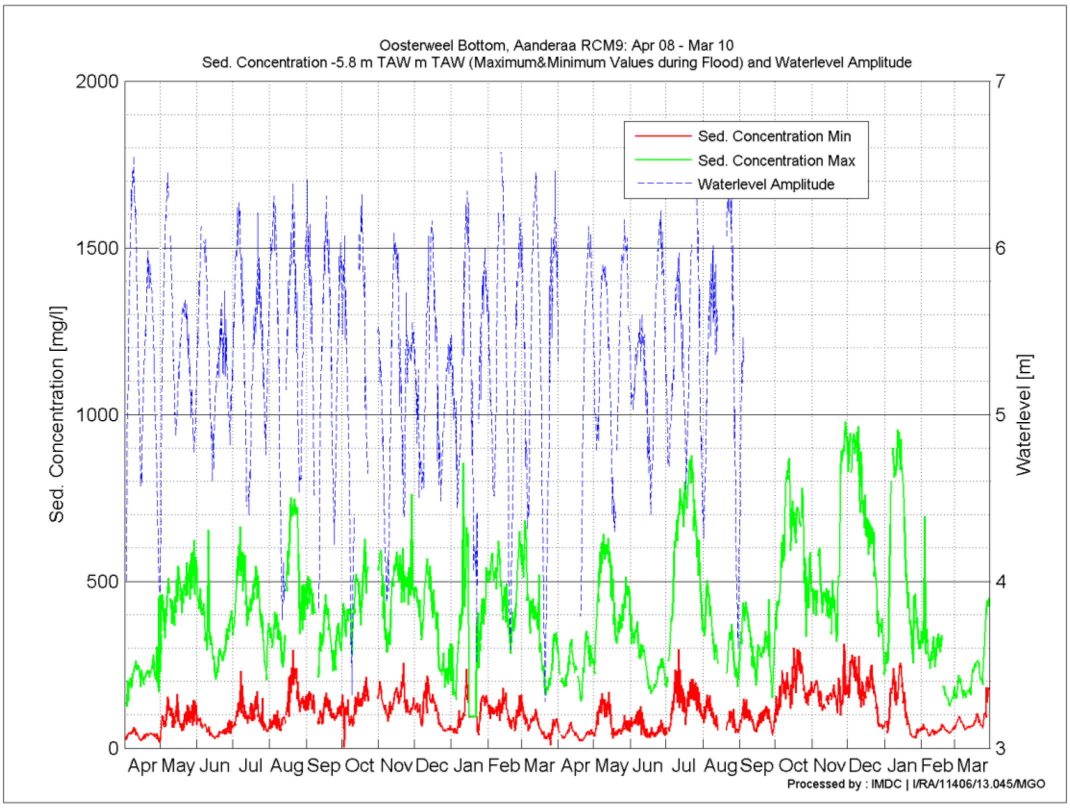
Annex-Figure F-9: Oosterweel Top (-2.3m TAW), April 2008 – March 2010. Minimal and maximal (a) ebb phase (and Scheldt discharge) and (b) flood phase (and tidal amplitude) suspended sediment concentration.



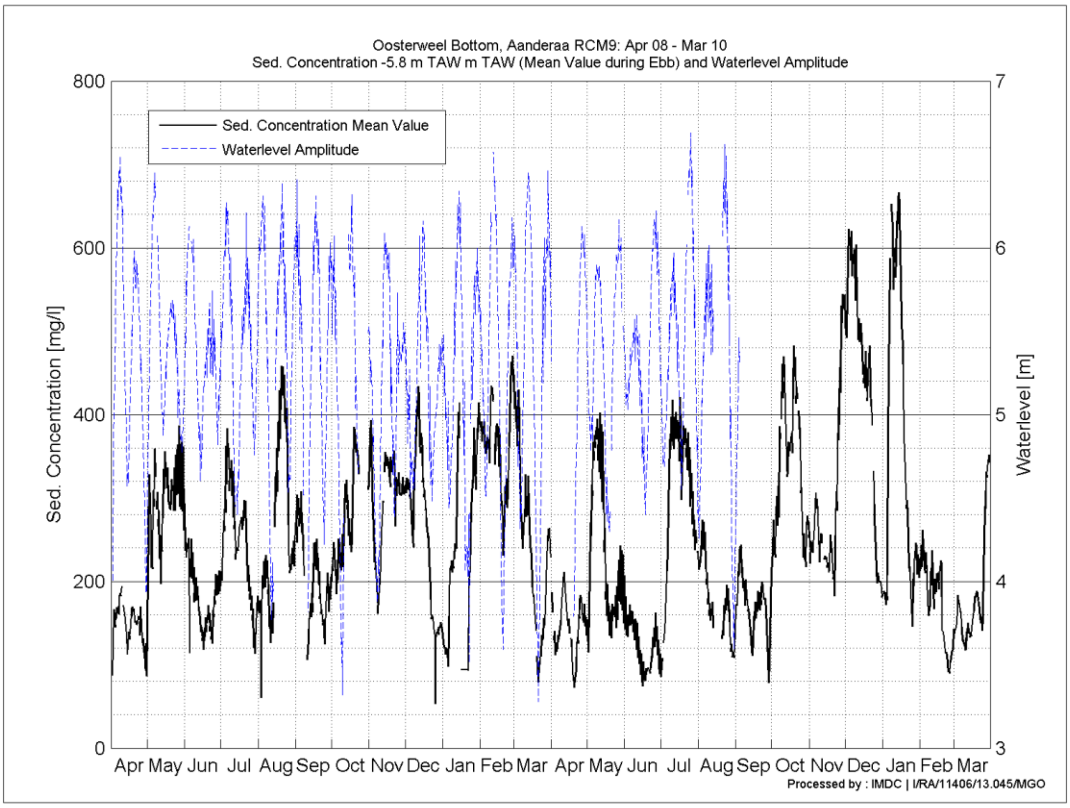


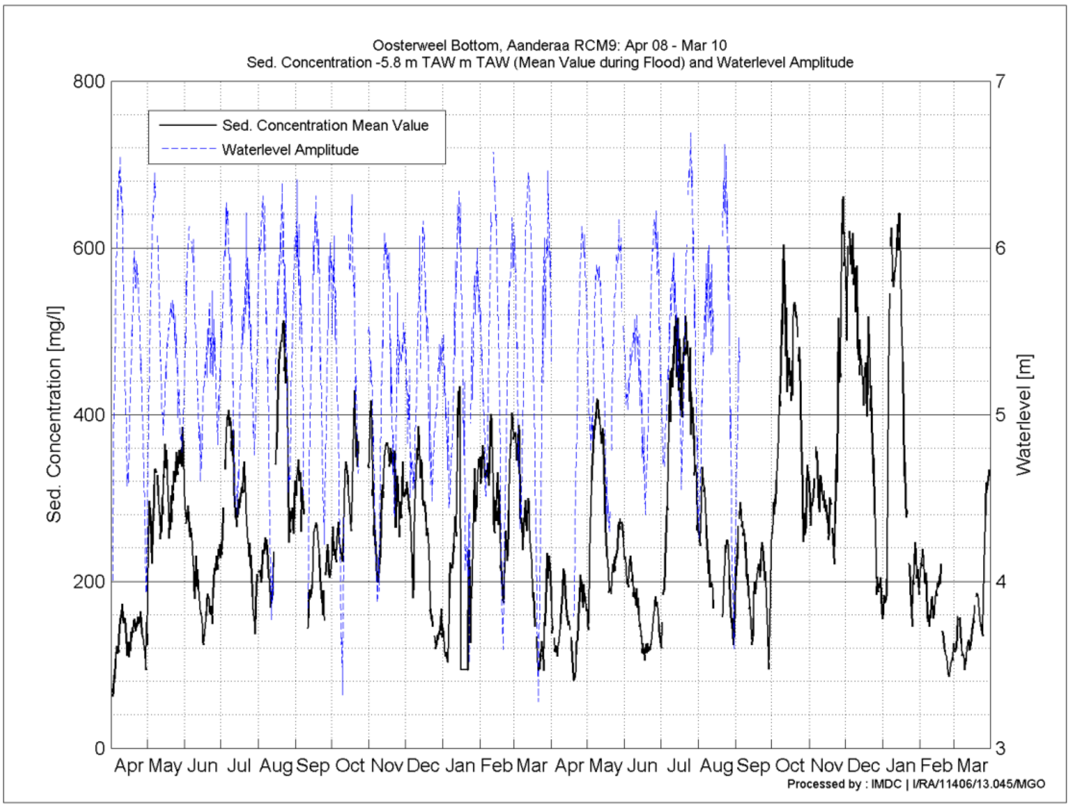
Annex-Figure F-10: Oosterweel Top (-2.3m TAW), April 2008 – March 2010. Average (a) ebb phase and (b) flood phase suspended sediment concentration and tidal amplitude.



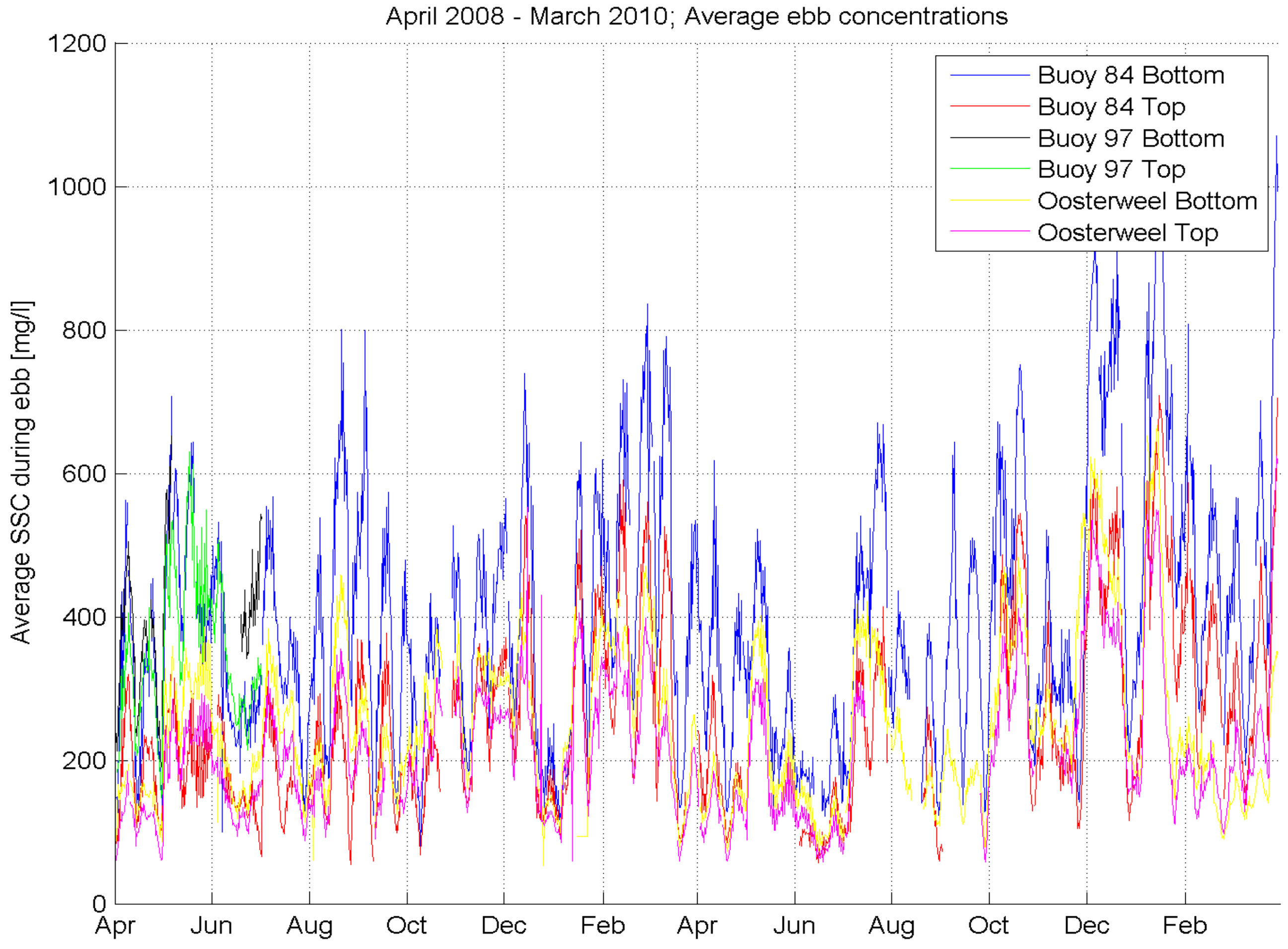


Annex-Figure F-11: Oosterweel Bottom (-5.8m TAW), April 2008 – March 2010. Minimal and maximal (a) ebb phase (and Scheldt discharge) and (b) flood phase (and tidal amplitude) suspended sediment concentration.

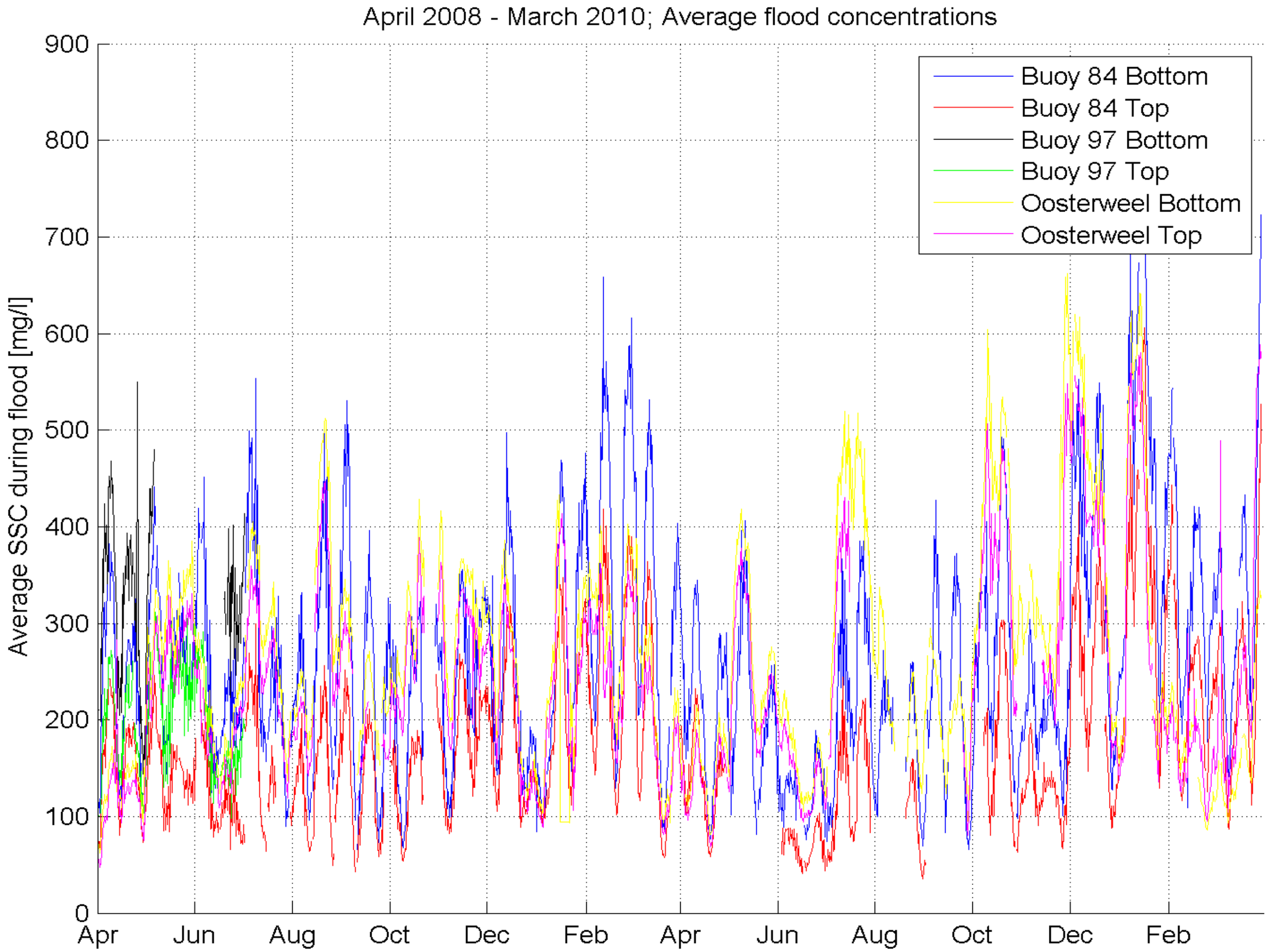




Annex-Figure F-12: Oosterweel Bottom (-5.8m TAW), April 2008 – March 2010. Average (a) ebb phase and (b) flood phase suspended sediment concentration and tidal amplitude.



Annex-Figure F-13: Tidally averaged sediment concentrations during Ebb at all measurement stations. April 2008 – March 2010.



Annex-Figure F-14: Tidally averaged sediment concentrations during flood at all measurement stations. April 2008 – March 2010.

Annex-Table F-1: Averaged ebb phase suspended sediment concentration, average value (C[mg/l]), standard deviation (σ) and amount of considered ebb phases (N) during period dealt with (Summer: Apr to Sep, Winter: Oct to Mar, Year 1: April 2008 – March 2009. Total period April 2008 – March 2010).

			Apr-Jun			Jul-Sep			Oct-Dec			Jan-Mar			Summer			Winter			Year 1			Total period		
			C	σ	N	C	σ	N	C	σ	N	C	σ	N	C	σ	N	C	σ	N	C	σ	N	C	σ	N
Buoy 84	-8.1 m TAW	Neap	256.69	99.11	34	254.88	92.65	43	233.98	67.04	44	300.62	113.78	45	255.68	94.92	77	267.68	98.95	89	262.11	97.00	166	278.14	120.17	276
		Avg	352.22	118.09	84	367.46	129.73	58	371.25	122.60	70	409.65	181.09	54	358.45	122.76	142	387.97	151.42	124	372.21	137.40	266	379.63	162.87	466
		Spring	444.77	115.27	49	478.50	118.82	73	461.40	105.94	41	572.26	151.41	67	463.28	117.87	124	530.18	145.80	108	495.58	135.53	230	469.95	148.53	383
		All	359.93	130.79	167	386.23	146.65	174	356.13	134.99	155	445.73	189.28	166	373.28	139.12	343	402.46	171.03	321	387.47	156.16	662	385.48	165.17	1125
	-5.6 m TAW	Neap	130.74	28.55	23	122.38	37.16	37	166.59	51.51	43	198.57	70.14	47	125.58	34.11	60	183.29	63.67	90	160.21	60.72	150	175.63	92.18	222
		Avg	170.63	45.47	94	180.77	57.88	47	251.26	81.41	68	281.96	113.57	48	174.01	49.97	141	263.96	96.76	116	214.61	87.08	257	231.27	118.30	402
		Spring	248.71	44.10	45	258.54	59.08	68	308.40	101.00	41	432.97	95.55	61	254.63	53.63	113	382.90	115.03	102	315.48	108.95	215	304.28	117.31	318
		All	186.66	59.25	162	201.35	77.66	152	242.72	96.10	152	315.88	137.22	156	193.77	69.06	314	279.78	124.06	308	236.36	108.93	622	242.81	122.45	942
Buoy 97	-7.8 m TAW	Neap	278.19	80.66	20	-	-	1	-	-	1	-	-	1	278.19	80.66	20	-	-	1	278.19	80.66	20	278.19	80.66	20
		Avg	386.41	57.55	40	535.32	8.31	3	-	-	1	-	-	1	396.80	67.47	43	-	-	1	396.80	67.47	43	396.80	67.47	43
		Spring	449.55	84.29	29	-	-	1	-	-	1	-	-	1	449.55	84.29	29	-	-	1	449.55	84.29	29	449.55	84.29	29
		All	382.67	95.36	89	535.32	8.31	3	-	-	1	-	-	1	387.64	97.67	92	-	-	1	387.64	97.67	92	387.64	97.67	92
	-5.3 m TAW	Neap	291.71	95.41	35	-	-	1	-	-	1	-	-	1	291.71	95.41	35	-	-	1	291.71	95.41	35	291.71	95.41	35
		Avg	357.70	107.36	87	319.91	14.26	3	-	-	1	-	-	1	356.44	105.78	90	-	-	1	356.44	105.78	90	356.44	105.78	90
		Spring	398.78	71.46	47	-	-	1	-	-	1	-	-	1	398.78	71.46	47	-	-	1	398.78	71.46	47	398.78	71.46	47
		All	355.46	102.54	169	319.91	14.26	3	-	-	1	-	-	1	354.84	101.76	172	-	-	1	354.84	101.76	172	354.84	101.76	172
Oosterweel	- 5.8 m TAW	Neap	170.62	82.01	28	189.80	54.43	35	245.35	63.16	49	221.97	105.10	53	181.27	68.16	63	233.20	87.86	102	213.37	84.56	165	202.17	85.37	214
		Avg	219.62	76.23	90	238.92	74.44	63	271.52	84.33	69	260.71	108.34	49	227.51	75.61	154	267.03	94.75	118	244.75	86.68	271	234.47	91.14	385
		Spring	209.67	60.56	48	263.17	85.81	72	308.59	58.88	37	316.37	97.40	66	241.53	80.54	121	313.58	85.34	103	274.94	90.20	223	261.59	94.67	307
		All	208.48	74.77	166	239.08	80.46	170	272.10	75.77	155	270.36	110.06	168	223.91	78.85	338	271.19	95.02	323	247.11	90.34	659	236.03	93.62	906
	- 2.3 m TAW	Neap	127.17	64.30	27	155.73	44.43	29	203.76	62.51	50	198.83	81.90	52	141.96	56.28	56	201.25	72.73	102	180.24	72.95	158	168.75	74.59	186
		Avg	167.56	57.04	88	191.24	57.53	59	228.40	66.87	71	234.64	94.61	51	177.00	58.03	148	231.01	79.34	122	201.53	73.57	269	191.30	76.34	351
		Spring	170.85	45.47	53	214.61	65.54	65	274.60	71.19	34	275.23	75.70	66	194.73	61.00	119	275.01	73.84	100	231.68	78.14	218	220.16	80.89	271
		All	162.11	56.74	168	194.44	62.44	153	230.59	70.89	155	239.47	89.09	169	177.46	61.41	323	235.22	80.90	324	206.50	77.47	645	195.79	79.81	808

Annex-Table F-2: Averaged ebb phase suspended sediment concentration, average value (C[mg/l]), standard deviation (σ) and amount of considered ebb phases (N) during period dealt with (Summer: Apr to Sep, Winter: Oct to Mar, Year 2: April 2009 – March 2010. Total period April 2008 – March 2010).

			Apr-Jun			Jul-Sep			Oct-Dec			Jan-Mar			Summer			Winter			Year 2			Total period		
			C	σ	N	C	σ	N	C	σ	N	C	σ	N	C	σ	N	C	σ	N	C	σ	N	C	σ	N
Buoy 84	-8.1 m TAW	Neap	238.93	80.55	27	246.28	92.99	38	320.21	116.01	23	458.20	189.95	22	243.22	87.45	65	387.67	169.75	45	302.32	145.65	110	278.14	120.17	276
		Avg	257.78	103.55	74	360.64	97.28	48	477.62	186.73	45	606.60	202.19	33	298.64	111.90	124	532.19	202.55	78	389.49	191.51	200	379.63	162.87	466
		Spring	335.38	106.87	57	441.80	129.94	61	542.81	135.40	27	660.46	247.01	8	390.39	130.30	118	569.70	170.57	35	431.41	159.02	153	469.95	148.53	383
		All	282.55	108.46	158	364.76	135.34	147	458.04	177.30	95	561.62	215.27	63	322.18	128.33	307	499.34	199.28	158	382.63	177.39	463	385.48	165.17	1125
	-5.6 m TAW	Neap	108.80	27.87	18	120.45	51.25	13	230.84	102.19	20	324.64	141.88	21	113.68	39.05	31	278.89	131.45	41	207.76	131.02	72	175.63	92.18	222
		Avg	115.30	44.38	47	207.20	72.64	24	335.36	123.62	42	416.81	134.18	32	146.37	70.32	71	370.58	133.71	74	260.79	155.30	145	231.27	118.30	402
		Spring	179.12	58.35	39	285.15	79.48	33	383.96	128.06	21	447.47	139.12	10	227.72	86.60	72	404.45	132.85	31	280.91	130.56	103	304.28	117.31	318
		All	138.11	57.35	104	227.84	95.07	70	322.47	131.00	83	390.95	143.72	63	174.21	86.66	174	352.02	140.34	146	255.33	144.55	320	242.81	122.45	942
Buoy 97	-7.8 m TAW	Neap	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	278.19	80.66	20
		Avg	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	396.80	67.47	43
		Spring	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	449.55	84.29	29
		All	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	387.64	97.67	92
	-5.3 m TAW	Neap	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	291.71	95.41	35
		Avg	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	356.44	105.78	90
		Spring	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	398.78	71.46	47
		All	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	354.84	101.76	172
Oosterweel	- 5.8 m TAW	Neap	134.65	61.01	25	195.50	81.96	24	-	-	1	-	-	1	164.45	77.62	49	-	-	1	164.45	77.62	49	202.17	85.37	214
		Avg	172.04	79.97	66	262.23	94.78	48	-	-	1	-	-	1	210.01	97.03	114	-	-	1	210.01	97.03	114	234.47	91.14	385
		Spring	198.29	93.19	48	263.33	91.95	36	-	-	1	-	-	1	226.17	97.63	84	-	-	1	226.17	97.63	84	261.59	94.67	307
		All	174.38	84.29	139	247.77	94.57	108	-	-	1	-	-	1	206.47	95.95	247	-	-	1	206.47	95.95	247	236.03	93.62	906
	- 2.3 m TAW	Neap	105.54	47.77	25	90.75	8.40	3	-	-	1	-	-	1	103.95	45.34	28	-	-	1	103.95	45.34	28	168.75	74.59	186
		Avg	140.03	66.62	64	220.82	75.73	18	-	-	1	-	-	1	157.77	76.08	82	-	-	1	157.77	76.08	82	191.30	76.34	351
		Spring	159.51	69.05	47	276.59	18.01	6	-	-	1	-	-	1	172.76	75.18	53	-	-	1	172.76	75.18	53	220.16	80.89	271
		All	140.42	66.73	136	218.76	80.52	27	-	-	1	-	-	1	153.40	74.87	163	-	-	1	153.40	74.87	163	195.79	79.81	808

Annex-Table F-3: Averaged flood phase suspended sediment concentration, average value (C[mg/l]), standard deviation (σ) and amount of considered ebb phases (N) during period dealt with (Summer: Apr to Sep, Winter: Oct to Mar, Year 1: April 2008 – March 2009. Total period April 2008 – March 2010).

			Apr-Jun			Jul-Sep			Oct-Dec			Jan-Mar			Summer			Winter			Year 1			Total period		
			C	σ	N	C	σ	N	C	σ	N	C	σ	N	C	σ	N	C	σ	N	C	σ	N	C	σ	N
Buoy 84	-8.1 m TAW	Neap	196	73	47	152	47	75	172	68	91	163	60	166	167	81	274	196	73	47	152	47	75	172	68	91
		Avg	292	119	54	240	77	139	265	95	127	252	87	266	252	108	466	292	119	54	240	77	139	265	95	127
		Spring	426	108	67	330	76	126	385	106	107	356	95	231	326	101	384	426	108	67	330	76	126	385	106	107
		All	318	141	168	254	97	340	278	125	325	266	112	663	256	116	1.124	318	141	168	254	97	340	278	125	325
	-5.6 m TAW	Neap	130	40	48	87	23	58	120	38	91	107	37	149	112	58	221	130	40	48	87	23	58	120	38	91
		Avg	193	68	48	129	38	139	182	55	119	154	53	258	158	77	404	193	68	48	129	38	139	182	55	119
		Spring	303	66	61	187	38	116	270	73	102	226	71	217	211	78	320	303	66	61	187	38	116	270	73	102
		All	216	95	157	143	51	313	193	83	312	168	73	624	165	82	945	216	95	157	143	51	313	193	83	312
Buoy 97	-7.8 m TAW	Neap	-	-	1	219	45	19	-	-	1	219	45	19	219	45	19	-	-	1	219	45	19	-	-	1
		Avg	-	-	1	327	57	42	-	-	1	327	57	42	327	57	42	-	-	1	327	57	42	-	-	1
		Spring	-	-	1	399	44	29	-	-	1	399	44	29	399	44	29	-	-	1	399	44	29	-	-	1
		All	-	-	1	327	82	90	-	-	1	327	82	90	327	82	90	-	-	1	327	82	90	-	-	1
	-5.3 m TAW	Neap	-	-	1	152	40	35	-	-	1	152	40	35	152	40	35	-	-	1	152	40	35	-	-	1
		Avg	-	-	1	195	50	89	-	-	1	195	50	89	195	50	89	-	-	1	195	50	89	-	-	1
		Spring	-	-	1	244	33	45	-	-	1	244	33	45	244	33	45	-	-	1	244	33	45	-	-	1
		All	-	-	1	199	54	169	-	-	1	199	54	169	199	54	169	-	-	1	199	54	169	-	-	1
Oosterweel	- 5.8 m TAW	Neap	201	90	52	206	84	62	224	81	99	217	83	161	214	86	211	201	90	52	206	84	62	224	81	99
		Avg	229	90	50	245	84	156	255	88	119	249	86	274	252	94	387	229	90	50	245	84	156	255	88	119
		Spring	284	84	68	267	96	120	296	75	106	281	88	225	281	97	308	284	84	68	267	96	120	296	75	106
		All	243	94	170	246	91	338	259	86	324	252	89	660	253	96	906	243	94	170	246	91	338	259	86	324
	- 2.3 m TAW	Neap	199	82	52	183	78	55	208	72	101	199	75	156	191	75	184	199	82	52	183	78	55	208	72	101
		Avg	221	91	51	215	75	149	234	81	122	224	78	270	221	82	354	221	91	51	215	75	149	234	81	122
		Spring	264	67	67	234	85	120	274	62	102	253	78	221	248	82	273	264	67	67	234	85	120	274	62	102
		All	231	84	170	217	81	324	239	77	325	228	80	647	223	83	811	231	84	170	217	81	324	239	77	325

Annex-Table F-4: Averaged flood phase suspended sediment concentration, average value (C[mg/l]), standard deviation (σ) and amount of considered ebb phases (N) during period dealt with (Summer: Apr to Sep, Winter: Oct to Mar, Year 2: April 2009 – March 2010. Total period April 2008 – March 2010).

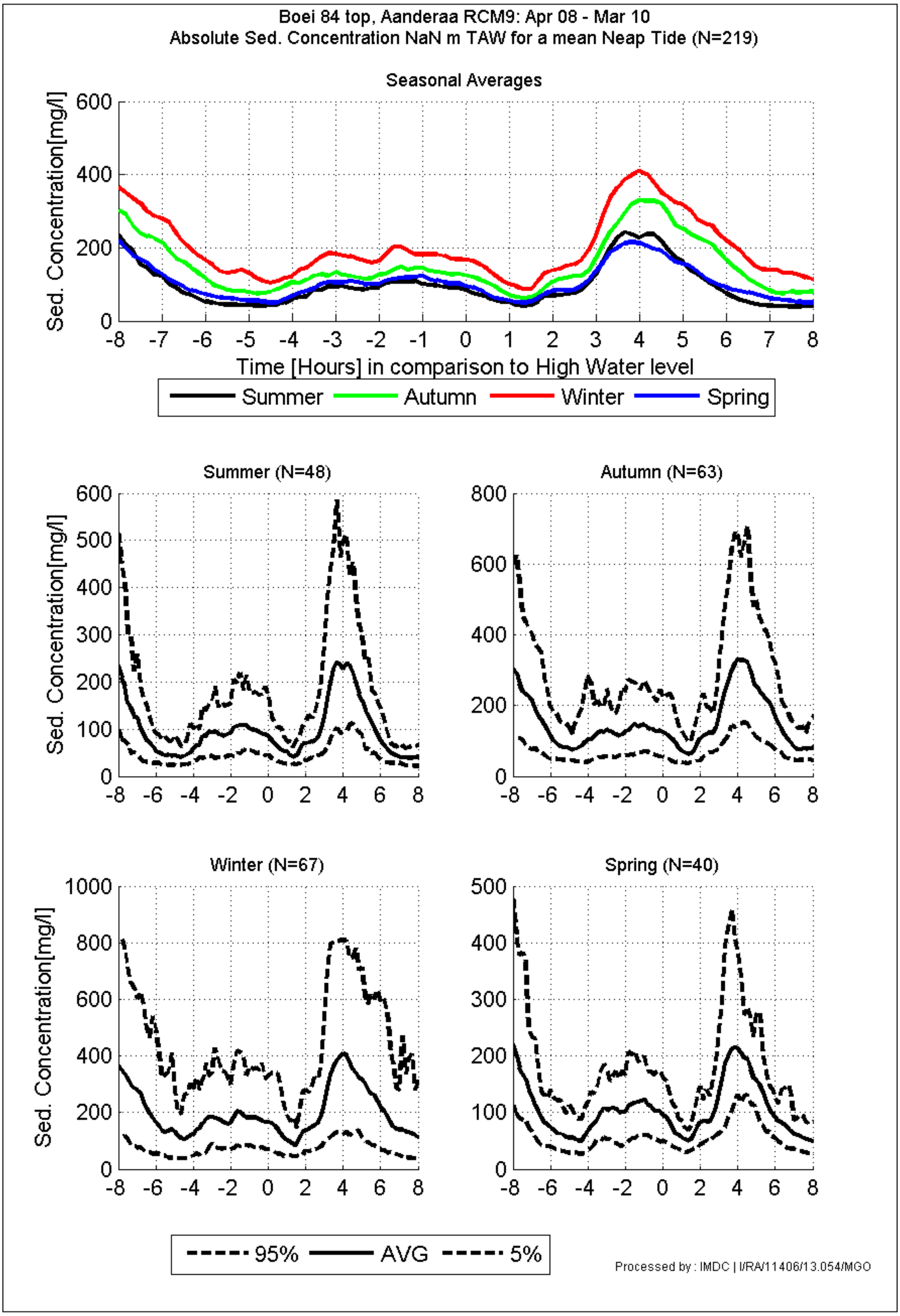
			Apr-Jun			Jul-Sep			Oct-Dec			Jan-Mar			Summer			Winter			Year 2			Total period		
			C	σ	N	C	σ	N	C	σ	N	C	σ	N	C	σ	N	C	σ	N	C	σ	N	C	σ	N
Buoy 84	-8.1 m TAW	Neap	132	45	26	119	37	38	175	56	22	314	145	22	124	41	64	245	129	44	173	106	108	167	81	274
		Avg	181	75	74	212	61	48	283	107	45	432	151	33	193	70	124	346	147	78	253	130	200	252	108	466
		Spring	236	69	59	279	66	60	320	88	26	473	135	8	258	71	119	356	119	34	279	93	153	326	101	384
		All	193	77	159	215	86	146	268	106	93	396	157	63	204	82	307	319	143	156	243	120	461	256	116	1.124
	-5.6 m TAW	Neap	77	26	18	63	15	13	110	38	20	212	109	21	71	23	31	162	96	41	123	87	72	112	58	221
		Avg	91	39	48	108	40	24	178	74	43	310	107	31	97	40	72	233	110	74	166	108	146	158	77	404
		Spring	135	51	39	163	39	33	199	64	21	342	98	10	148	48	72	245	101	31	177	81	103	211	78	320
		All	105	48	105	126	53	70	167	72	84	282	117	62	113	51	175	216	109	146	160	97	321	165	82	945
Buoy 97	-7.8 m TAW	Neap	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	219	45	19
		Avg	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	327	57	42
		Spring	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	399	44	29
		All	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	327	82	90
	-5.3 m TAW	Neap	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	152	40	35
		Avg	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	195	50	89
		Spring	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	244	33	45
		All	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	199	54	169
Oosterweel	- 5.8 m TAW	Neap	163	71	25	243	100	25	-	-	1	-	-	1	203	95	50	-	-	1	203	95	50	214	86	211
		Avg	210	77	66	327	116	47	-	-	1	-	-	1	259	111	113	-	-	1	259	111	113	252	94	387
		Spring	234	94	47	343	116	36	-	-	1	-	-	1	282	117	83	-	-	1	282	117	83	281	97	308
		All	210	85	138	313	118	108	-	-	1	-	-	1	255	113	246	-	-	1	255	113	246	253	96	906
	- 2.3 m TAW	Neap	143	64	25	144	31	3	-	-	1	-	-	1	143	61	28	-	-	1	143	61	28	191	75	184
		Avg	188	71	66	311	98	18	-	-	1	-	-	1	214	92	84	-	-	1	214	92	84	221	82	354
		Spring	207	82	46	375	27	6	-	-	1	-	-	1	226	95	52	-	-	1	226	95	52	248	82	273
		All	186	76	137	307	103	27	-	-	1	-	-	1	206	93	164	-	-	1	206	93	164	223	83	811

Annex-Table F-5: Averaged tide suspended sediment concentration, average value (C[mg/l]), standard deviation (σ) and amount of considered ebb phases (N) during considered period (Summer: Apr to Sep, Winter: Oct to Mar, Year 1: April 2008 – March 2009. Total period April 2008 – March 2010).

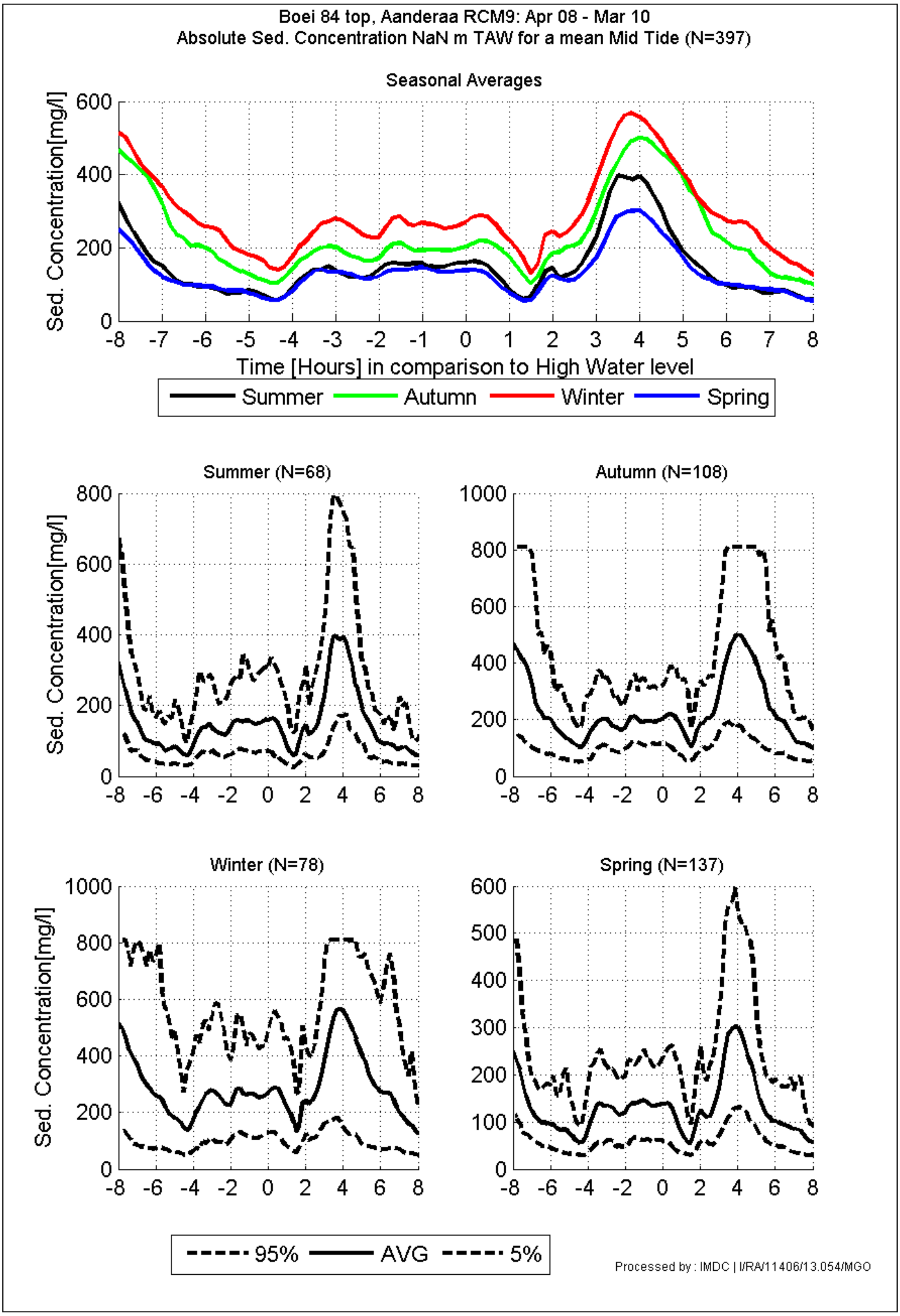
			Apr-Jun			Jul-Sep			Oct-Dec			Jan-Mar			Summer			Winter			Year 1			Total period		
			C	σ	N	C	σ	N	C	σ	N	C	σ	N	C	σ	N	C	σ	N	C	σ	N	C	σ	N
Buoy 84	-8.1 m TAW	Neap	205	63	34	195	65	41	188	55	44	240	84	45	200	64	75	214	75	89	208	70	164	218	95	272
		Avg	293	74	84	304	110	55	305	91	70	348	147	54	297	90	139	324	120	124	310	106	263	314	131	459
		Spring	385	74	47	403	95	74	389	79	40	501	124	66	394	88	123	459	122	106	425	109	227	397	119	378
		All	301	95	165	321	125	170	293	109	154	380	163	165	311	111	337	338	146	319	324	130	654	319	137	1.109
	-5.6 m TAW	Neap	113	22	23	101	30	35	138	40	43	163	53	47	106	27	58	151	49	90	133	47	148	143	73	220
		Avg	148	35	94	159	51	45	212	61	68	237	89	48	152	41	139	222	74	116	184	68	255	194	95	400
		Spring	219	36	45	222	46	67	264	76	41	368	79	61	221	42	113	326	93	102	271	88	214	257	95	317
		All	163	50	162	174	66	147	205	77	152	266	115	156	168	58	310	236	102	308	202	90	617	204	100	937
Buoy 97	-7.8 m TAW	Neap	250	61	19	-	-	1	-	-	1	-	-	1	250	61	19	-	-	1	250	61	19	250	61	19
		Avg	358	47	40	468	15	2	-	-	1	-	-	1	363	51	42	-	-	1	363	51	42	363	51	42
		Spring	425	61	29	-	-	1	-	-	1	-	-	1	425	61	29	-	-	1	425	61	29	425	61	29
		All	357	84	88	468	15	2	-	-	1	-	-	1	359	84	90	-	-	1	359	84	90	359	84	90
	-5.3 m TAW	Neap	225	64	34	-	-	1	-	-	1	-	-	1	225	64	34	-	-	1	225	64	34	225	64	34
		Avg	278	73	87	260	13	2	-	-	1	-	-	1	278	73	89	-	-	1	278	73	89	278	73	89
		Spring	320	48	45	-	-	1	-	-	1	-	-	1	320	48	45	-	-	1	320	48	45	320	48	45
		All	279	73	166	260	13	2	-	-	1	-	-	1	278	72	168	-	-	1	278	72	168	278	72	168
Oosterweel	- 5.8 m TAW	Neap	174	86	28	210	61	34	249	60	47	212	97	52	194	75	62	229	84	99	216	82	161	208	84	210
		Avg	223	77	91	257	78	61	272	82	69	246	98	49	236	79	153	262	90	118	247	85	270	244	91	383
		Spring	209	64	48	286	88	70	313	53	37	300	89	66	254	87	119	305	78	103	278	87	221	271	93	304
		All	211	77	167	259	84	165	275	73	153	257	101	167	235	84	334	265	89	320	250	88	652	245	93	897
	- 2.3 m TAW	Neap	141	73	27	183	53	28	211	56	49	200	81	51	162	66	55	205	70	100	190	71	155	180	73	183
		Avg	183	63	89	216	65	57	236	68	71	228	92	51	195	66	147	233	79	122	212	74	268	206	77	350
		Spring	180	55	53	242	73	64	284	54	34	270	69	66	214	72	118	275	64	100	242	75	217	234	78	269
		All	175	64	169	221	70	149	239	66	154	236	85	168	197	70	320	237	77	322	217	76	640	209	79	802

Annex-Table F-6: Averaged tide suspended sediment concentration, average value (C[mg/l]), standard deviation (σ) and amount of considered ebb phases (N) during period dealt with (Summer: Apr to Sep, Winter: Oct to Mar, Year 2: April 2009 – March 2010. Total period April 2008 – March 2010).

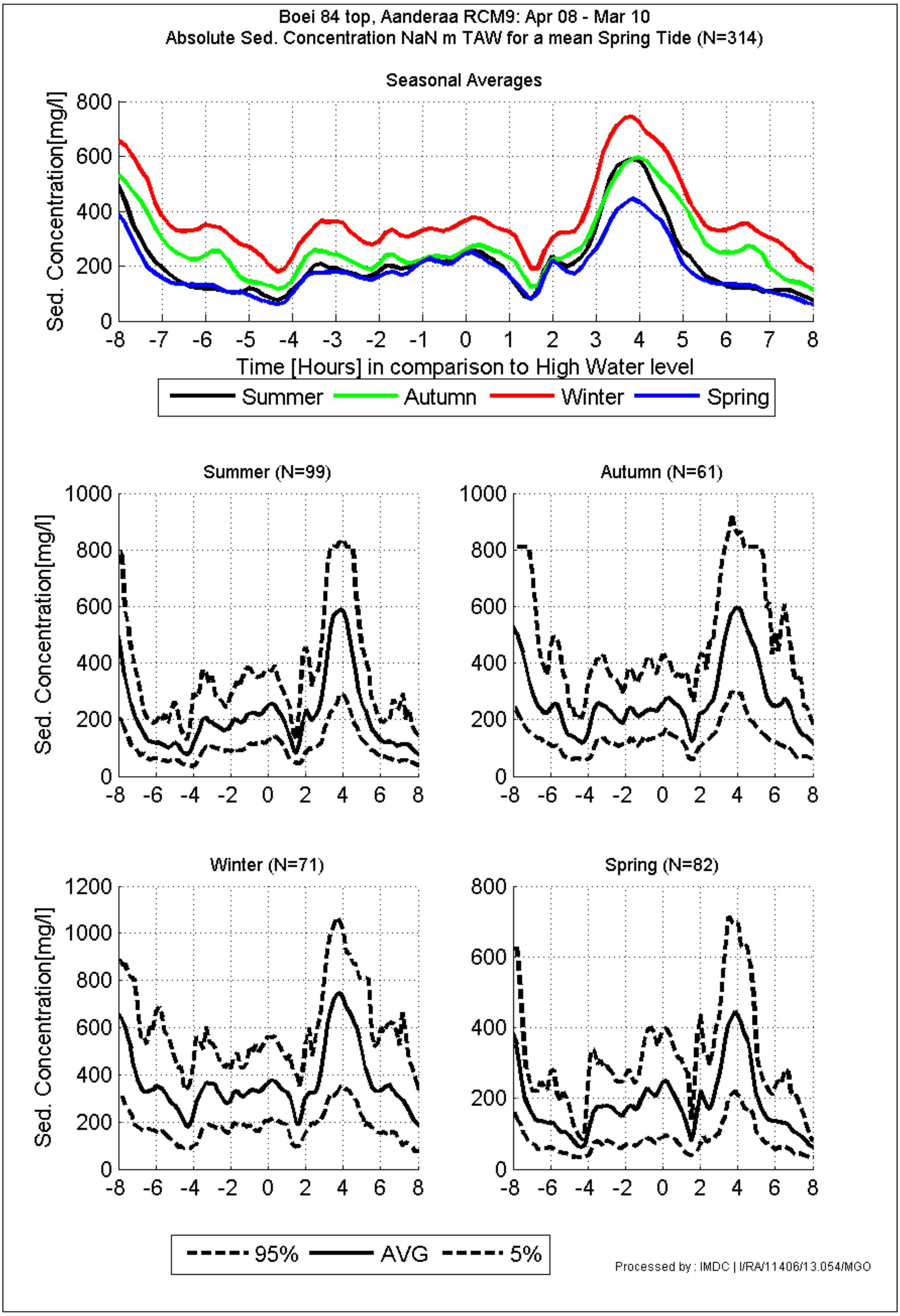
			Apr-Jun			Jul-Sep			Oct-Dec			Jan-Mar			Summer			Winter			Year 2			Total period		
			C	σ	N	C	σ	N	C	σ	N	C	σ	N	C	σ	N	C	σ	N	C	σ	N	C	σ	N
Buoy 84	-8.1 m TAW	Neap	182	57	26	176	59	38	243	79	22	383	166	22	178	58	64	313	147	44	233	123	108	218	95	272
		Avg	218	85	73	282	74	46	374	140	45	525	173	32	243	86	121	437	171	77	319	158	196	314	131	459
		Spring	286	84	57	360	91	60	428	110	26	568	191	8	324	95	117	461	143	34	355	122	151	397	119	378
		All	237	90	156	287	108	144	358	137	93	480	185	62	261	101	302	407	169	155	311	146	455	319	137	1.109
	-5.6 m TAW	Neap	93	26	18	91	31	13	168	65	20	267	124	21	92	28	31	219	110	41	164	106	72	143	73	220
		Avg	102	41	47	155	52	24	253	94	43	367	117	31	120	51	71	301	118	74	212	129	145	194	95	400
		Spring	157	53	39	223	57	33	290	94	21	395	116	10	187	64	72	324	111	31	229	102	103	257	95	317
		All	121	52	104	175	72	70	242	97	84	338	128	62	143	66	174	283	121	146	207	118	320	204	100	937
Buoy 97	-7.8 m TAW	Neap	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	250	61	19
		Avg	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	363	51	42
		Spring	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	425	61	29
		All	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	359	84	90
	-5.3 m TAW	Neap	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	225	64	34
		Avg	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	278	73	89
		Spring	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	320	48	45
		All	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	278	72	168
Oosterweel	- 5.8 m TAW	Neap	148	65	25	218	92	24	-	-	1	-	-	1	183	86	49	-	-	1	183	86	49	208	84	210
		Avg	191	78	66	295	105	47	-	-	1	-	-	1	234	104	113	-	-	1	234	104	113	244	91	383
		Spring	216	94	47	302	103	36	-	-	1	-	-	1	253	106	83	-	-	1	253	106	83	271	93	304
		All	192	84	138	280	106	107	-	-	1	-	-	1	230	104	245	-	-	1	230	104	245	245	93	897
	- 2.3 m TAW	Neap	123	54	25	116	19	3	-	-	1	-	-	1	123	51	28	-	-	1	123	51	28	180	73	183
		Avg	162	67	64	265	87	18	-	-	1	-	-	1	185	83	82	-	-	1	185	83	82	206	77	350
		Spring	182	75	46	323	19	6	-	-	1	-	-	1	198	84	52	-	-	1	198	84	52	234	78	269
		All	162	70	135	262	91	27	-	-	1	-	-	1	179	83	162	-	-	1	179	83	162	209	79	802



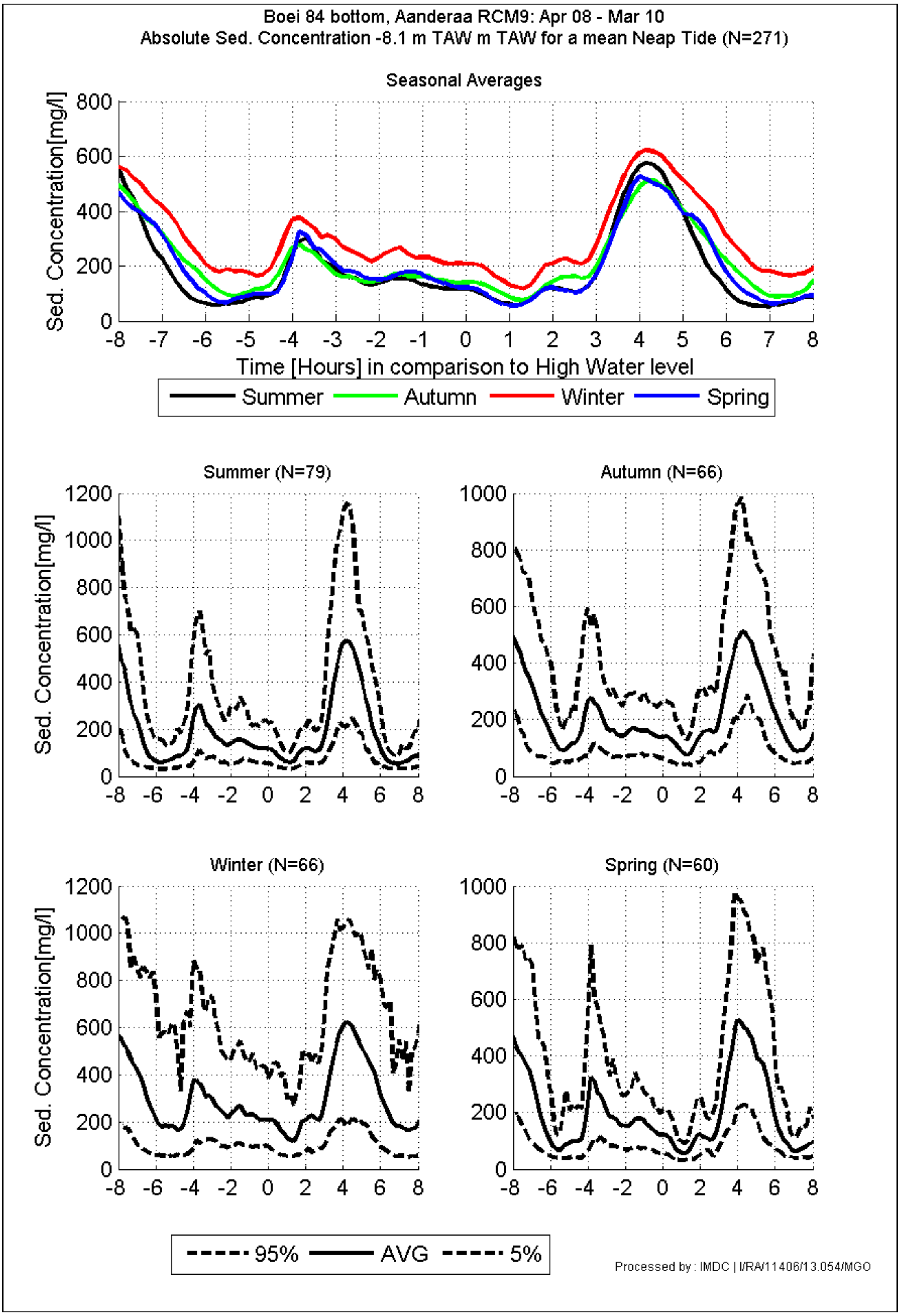
Annex-Figure F-15: Buoy 84 (-5.6m TAW), April 2008 – March 2010. Averaged tidal curve of the suspended sediment concentration for an averaged neap tide.



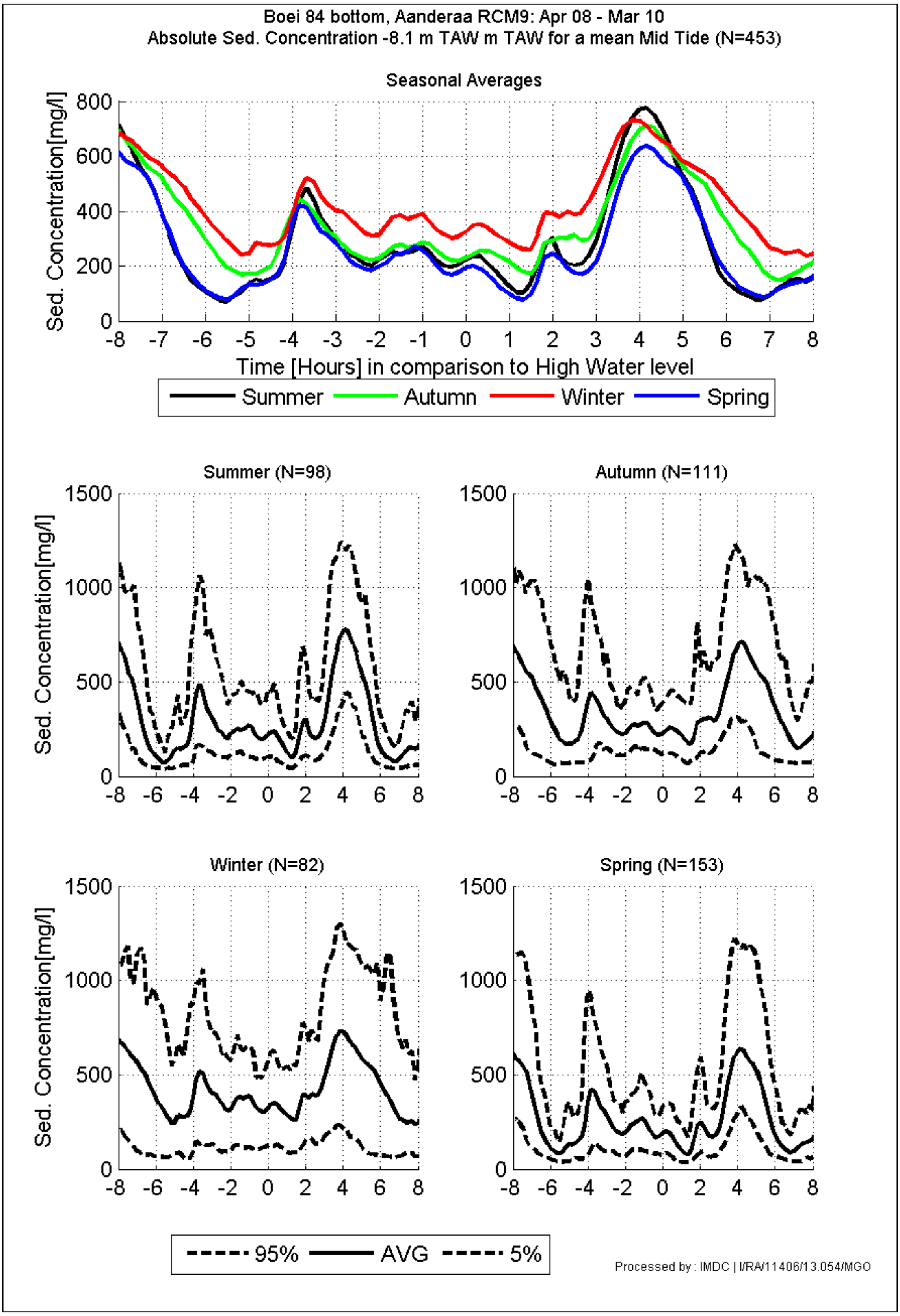
Annex-Figure F-16: Buoy 84 (-5.6m TAW), April 2008 – March 2010. Averaged tidal curve of the suspended sediment concentration for an averaged mean tide.



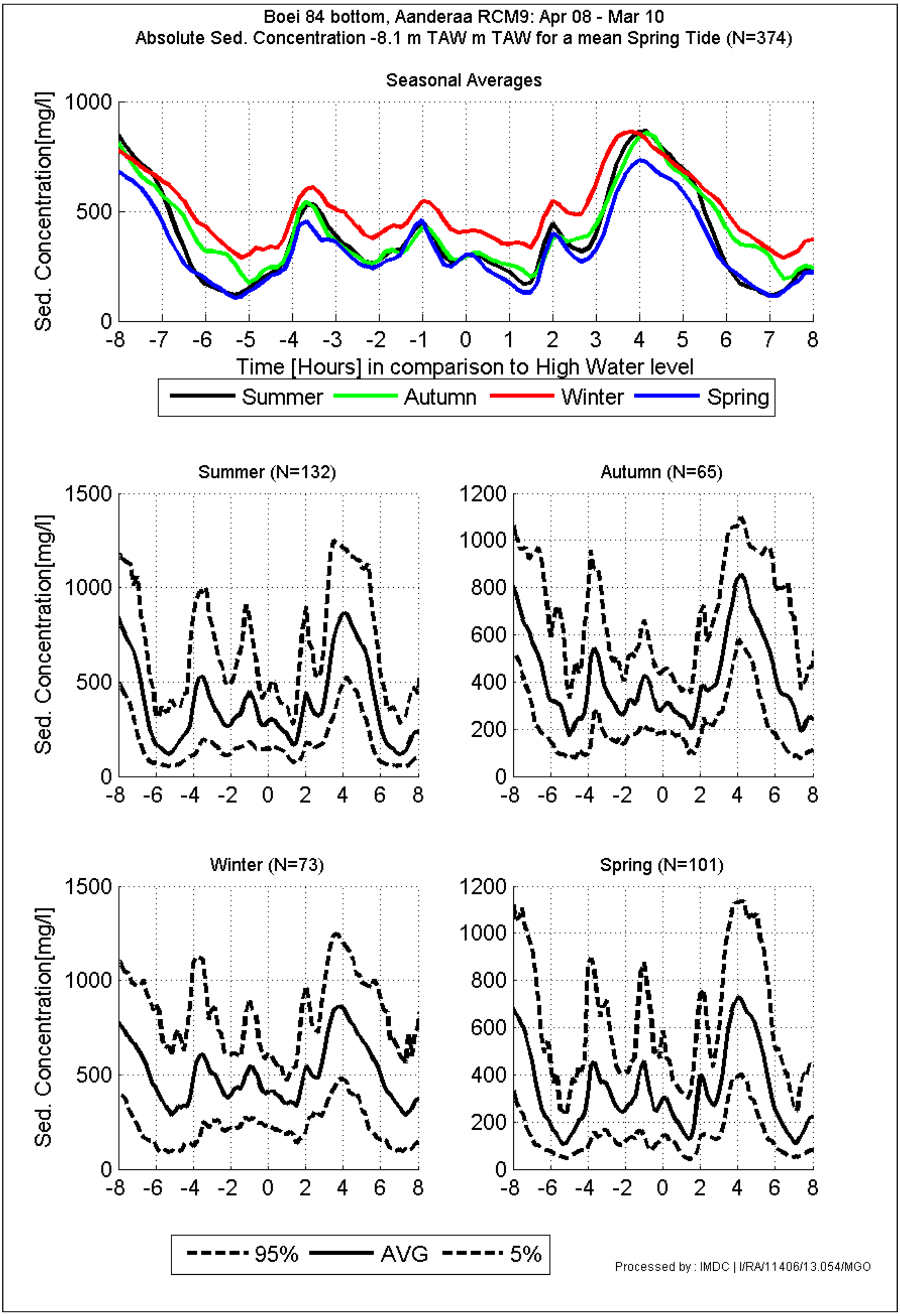
Annex-Figure F-17: Buoy 84 (-5.6m TAW), April 2008 – March 2010. Averaged tidal curve of the suspended sediment concentration for an averaged spring tide.



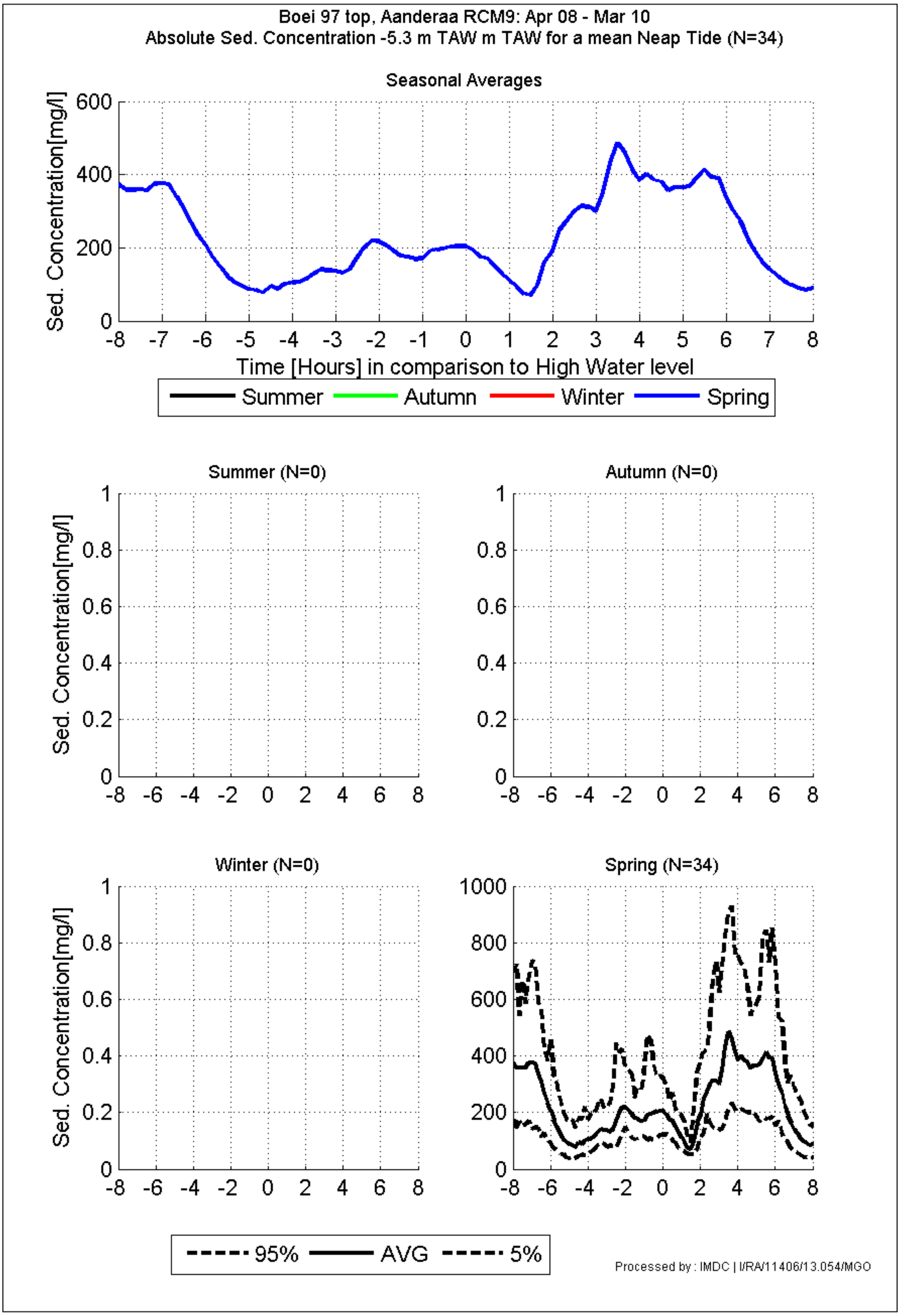
Annex-Figure F-18: Buoy 84 (-8.1m TAW), April 2008 – March 2010. Averaged tidal curve of the suspended sediment concentration for an averaged neap tide.



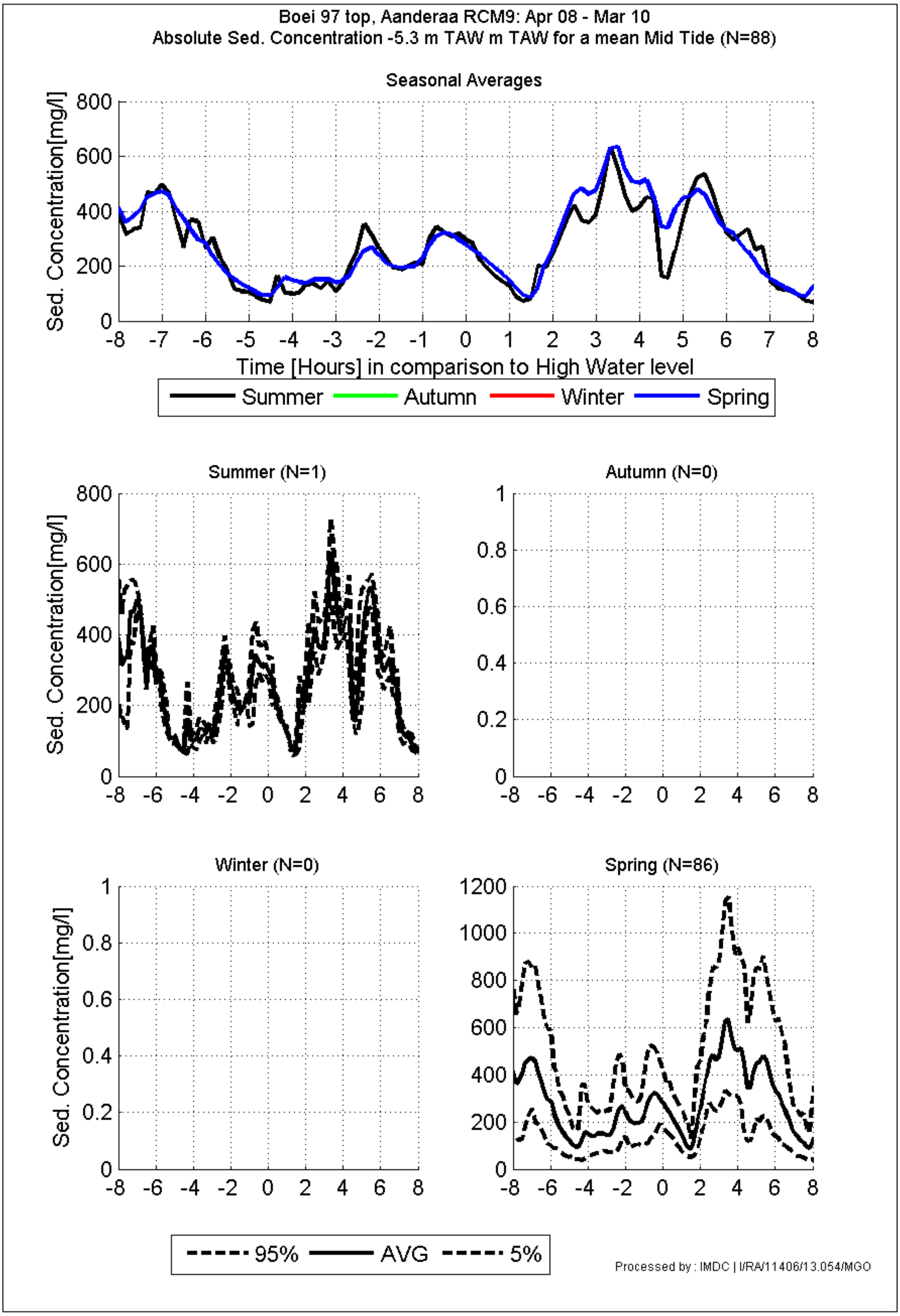
Annex-Figure F-19: Buoy 84 (-8.1m TAW), April 2008 – March 2010. Averaged tidal curve of the suspended sediment concentration for an averaged mean tide.



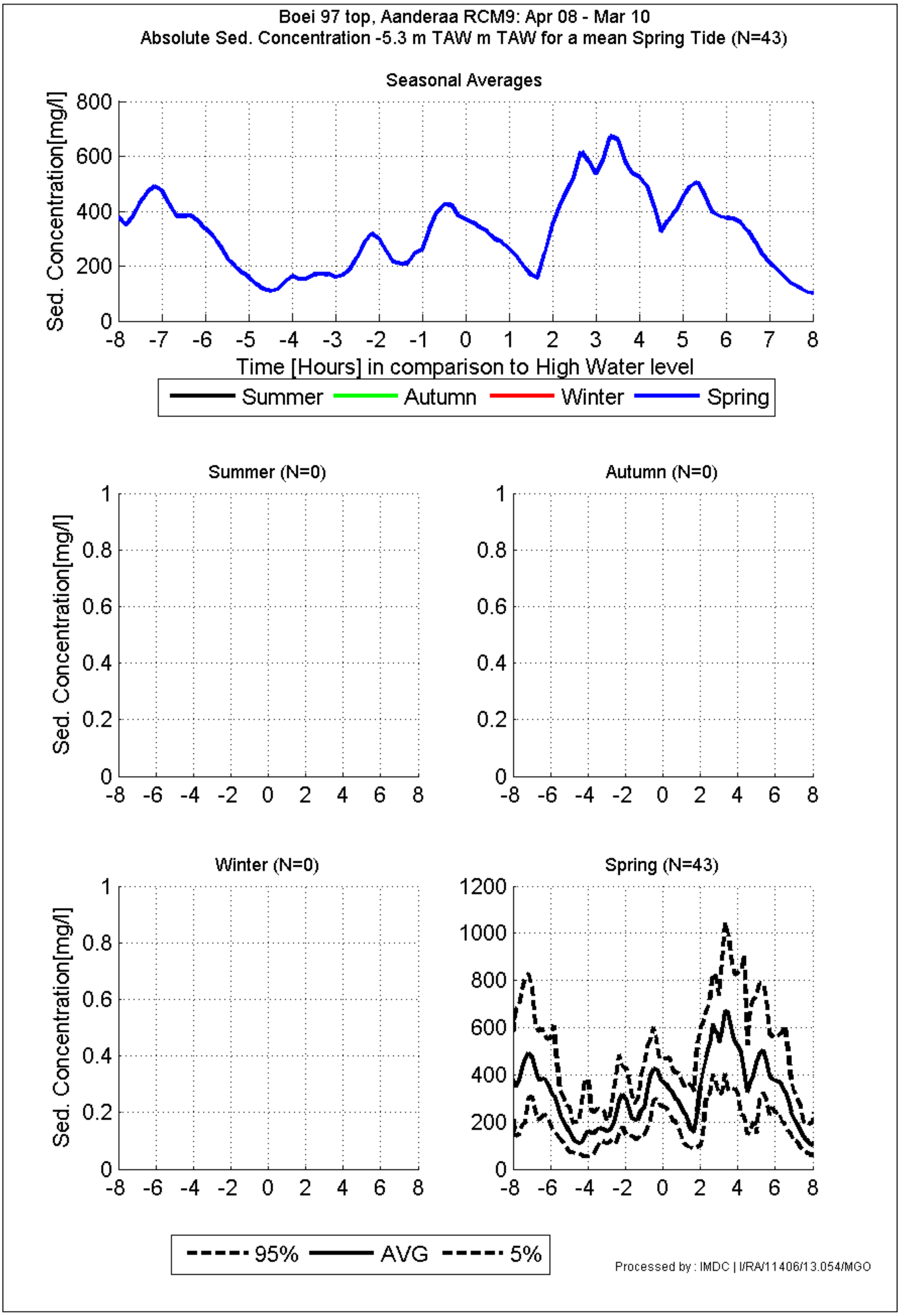
Annex-Figure F-20: Buoy 84 (-8.1m TAW), April 2008 – March 2010. Averaged tidal curve of the suspended sediment concentration for an averaged spring tide.



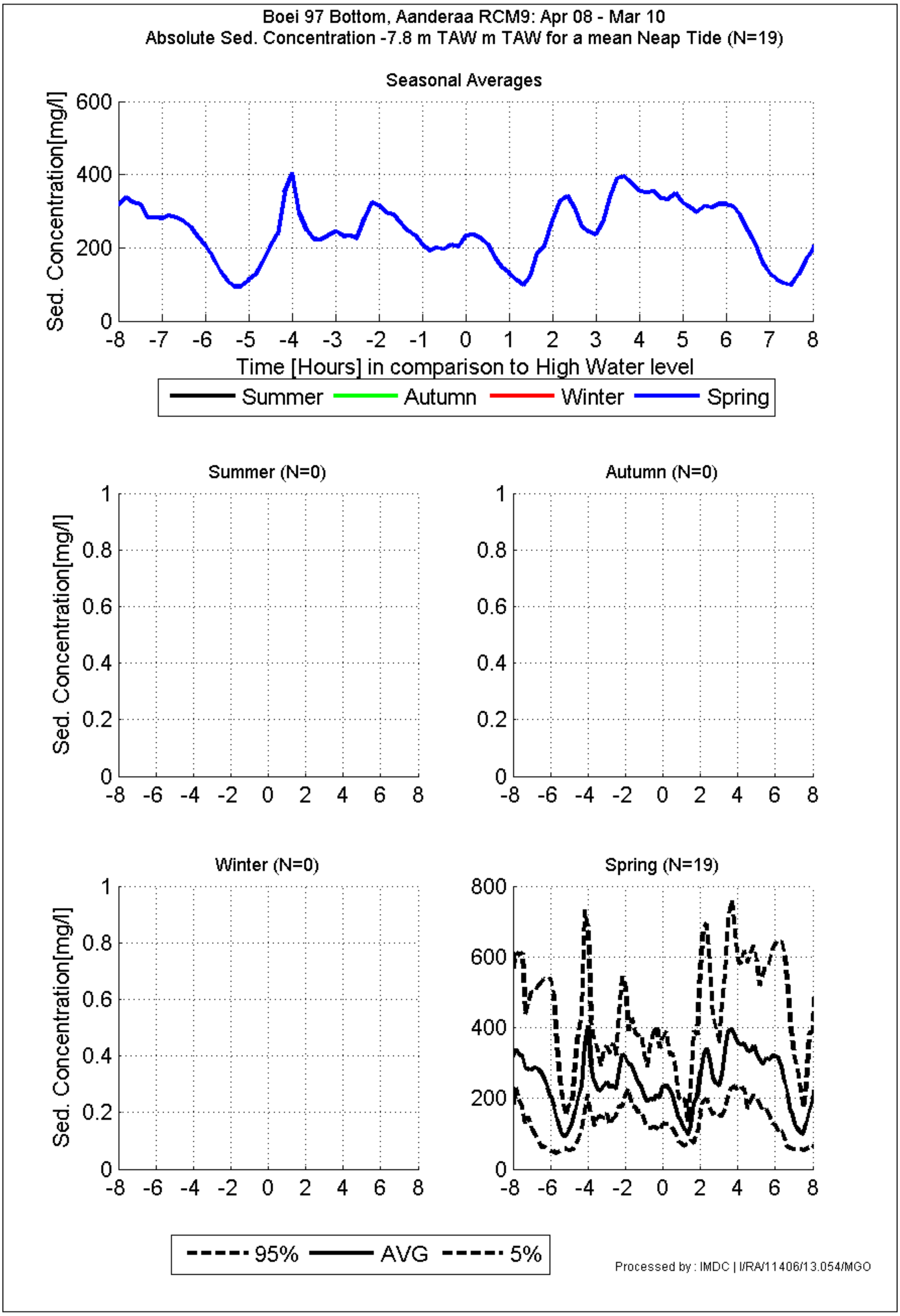
Annex-Figure F-21: Buoy 97 (-5.3m TAW), April 2008 – March 2010. Averaged tidal curve of the suspended sediment concentration for an averaged neap tide.



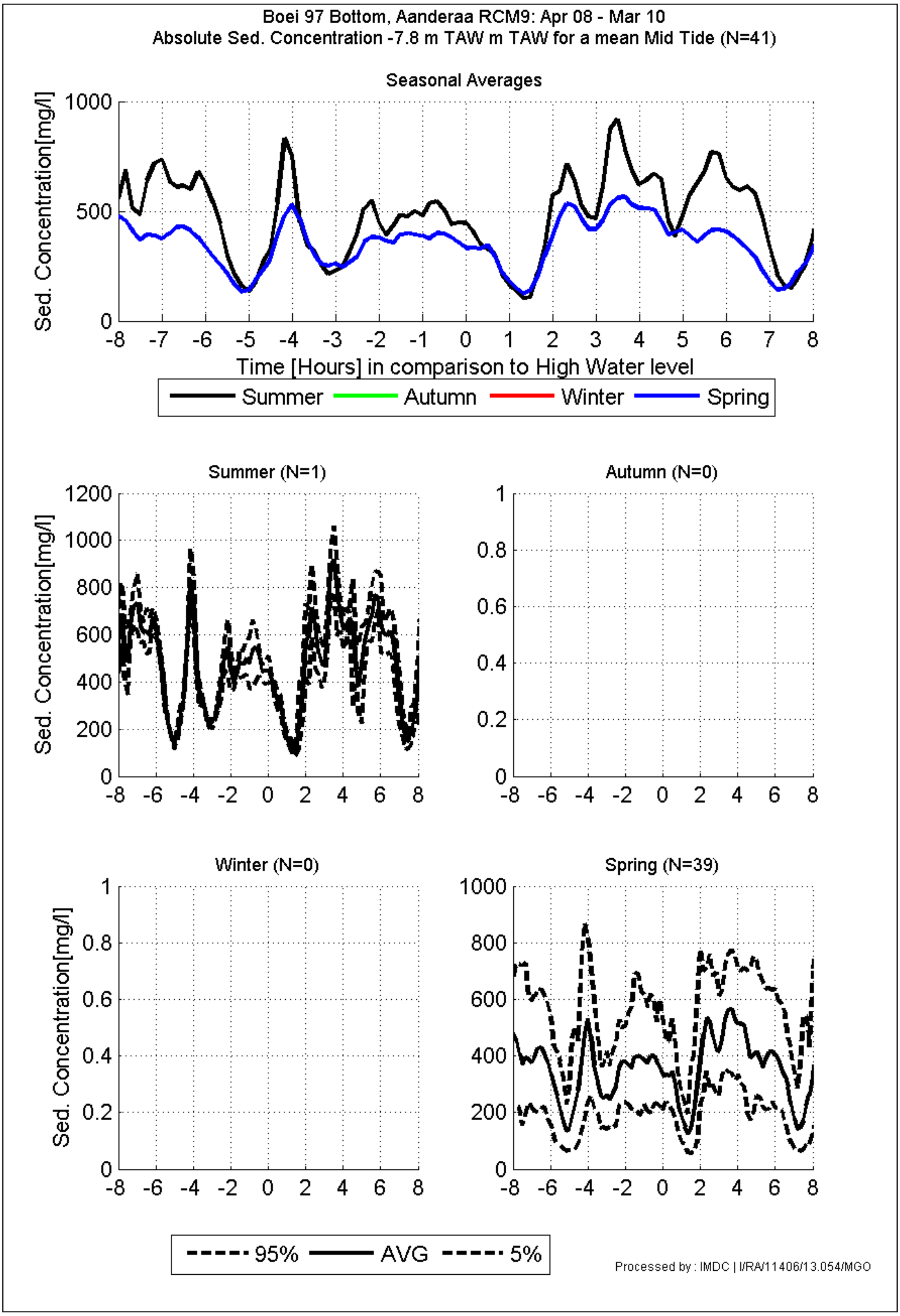
Annex-Figure F-22: Buoy 97 (-5.3m TAW), April 2008 – March 2010. Averaged tidal curve of the suspended sediment concentration for an averaged mean tide.



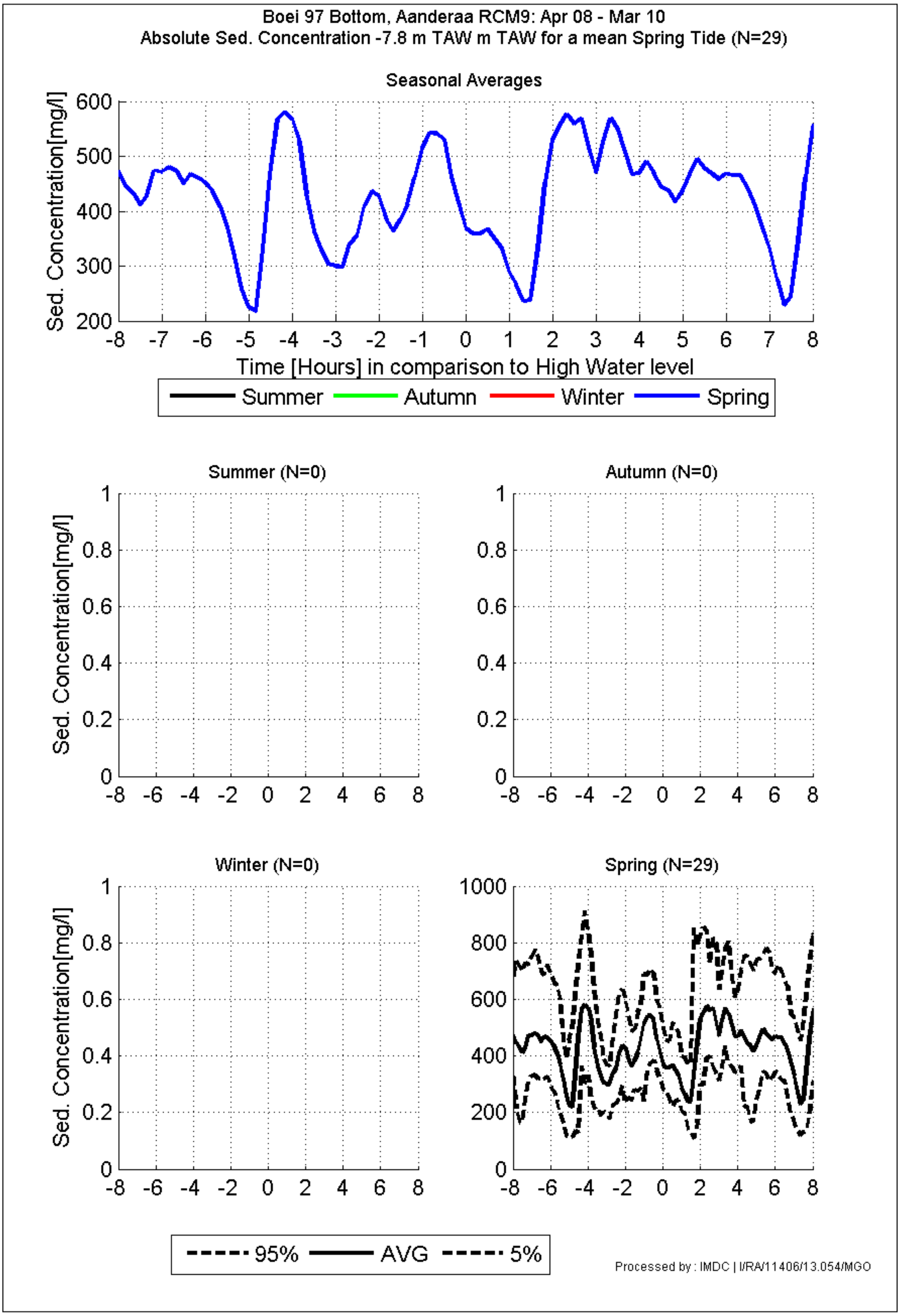
Annex-Figure F-23: Buoy 97 (-5.3m TAW), April 2008 – March 2010. Averaged tidal curve of the suspended sediment concentration for an averaged spring tide.



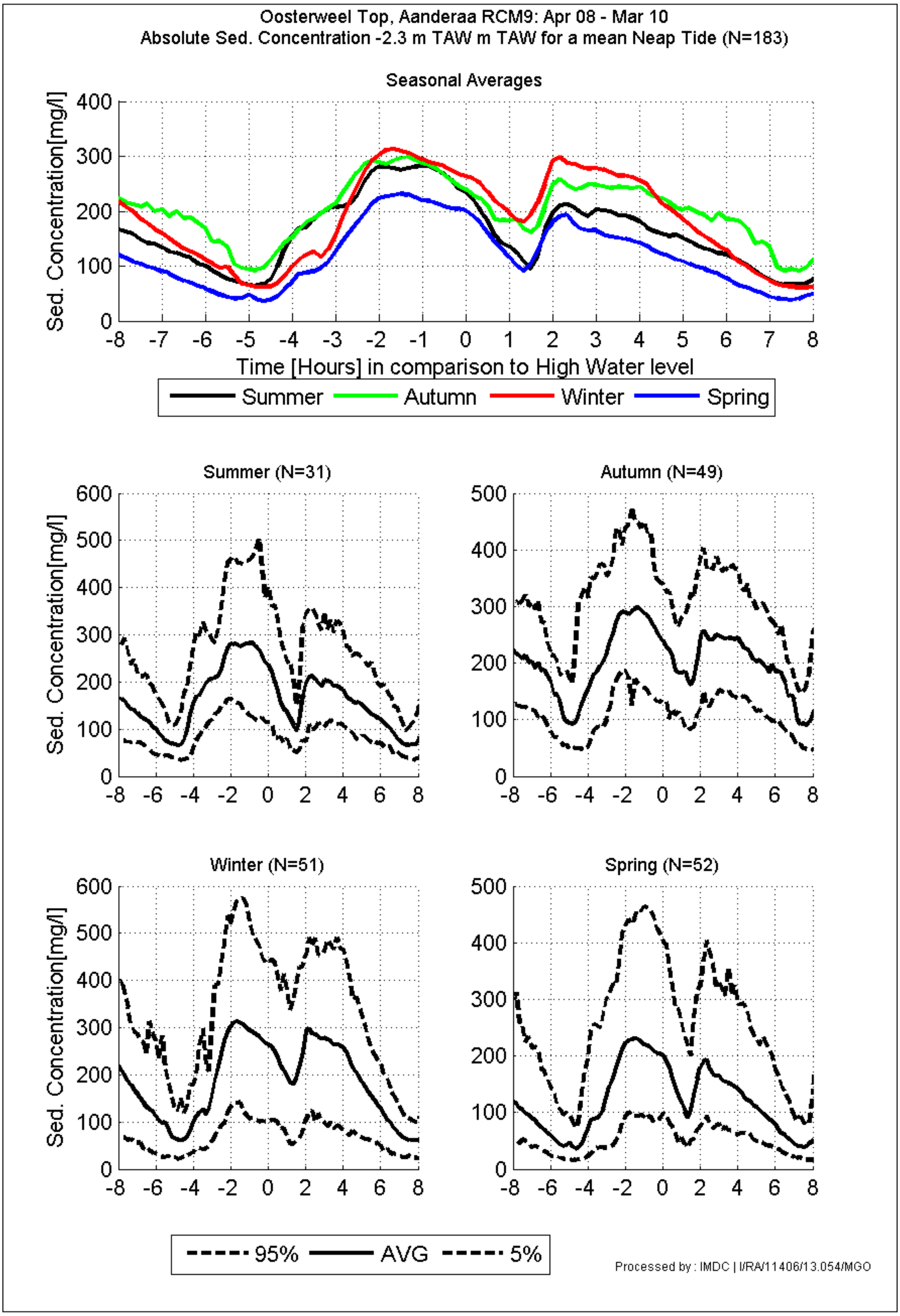
Annex-Figure F-24: Buoy 97 (-7.8m TAW), April 2008 – March 2010 .Averaged tidal curve of the suspended sediment concentration for an averaged neap tide.



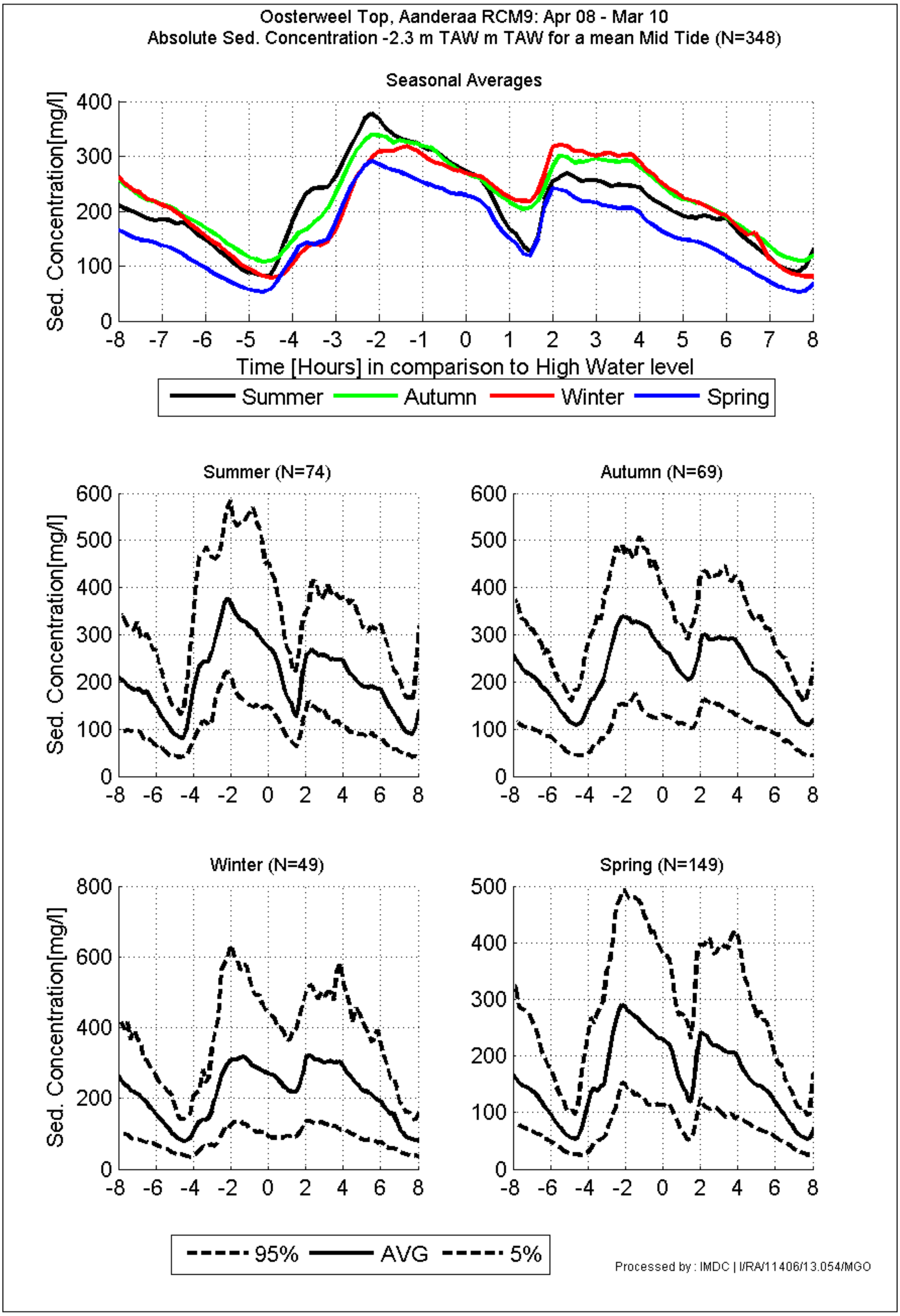
Annex-Figure F-25: Buoy 97 (-7.8m TAW), April 2008 – March 2010. Averaged tidal curve of the suspended sediment concentration for an averaged mean tide.



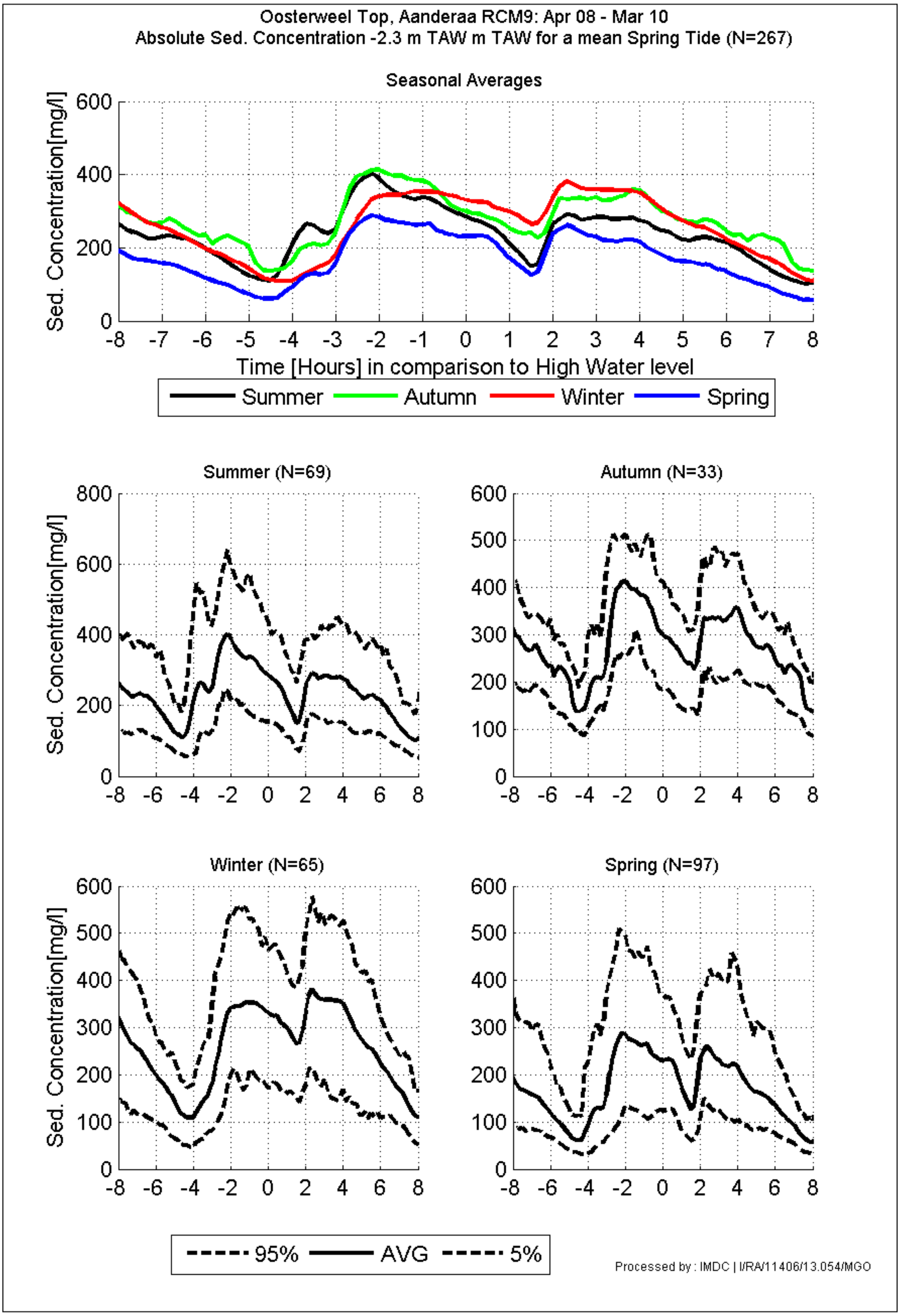
Annex-Figure F-26: Buoy 97 (-7.8m TAW), April 2008 – March 2010. Averaged tidal curve of the suspended sediment concentration for an averaged spring tide.



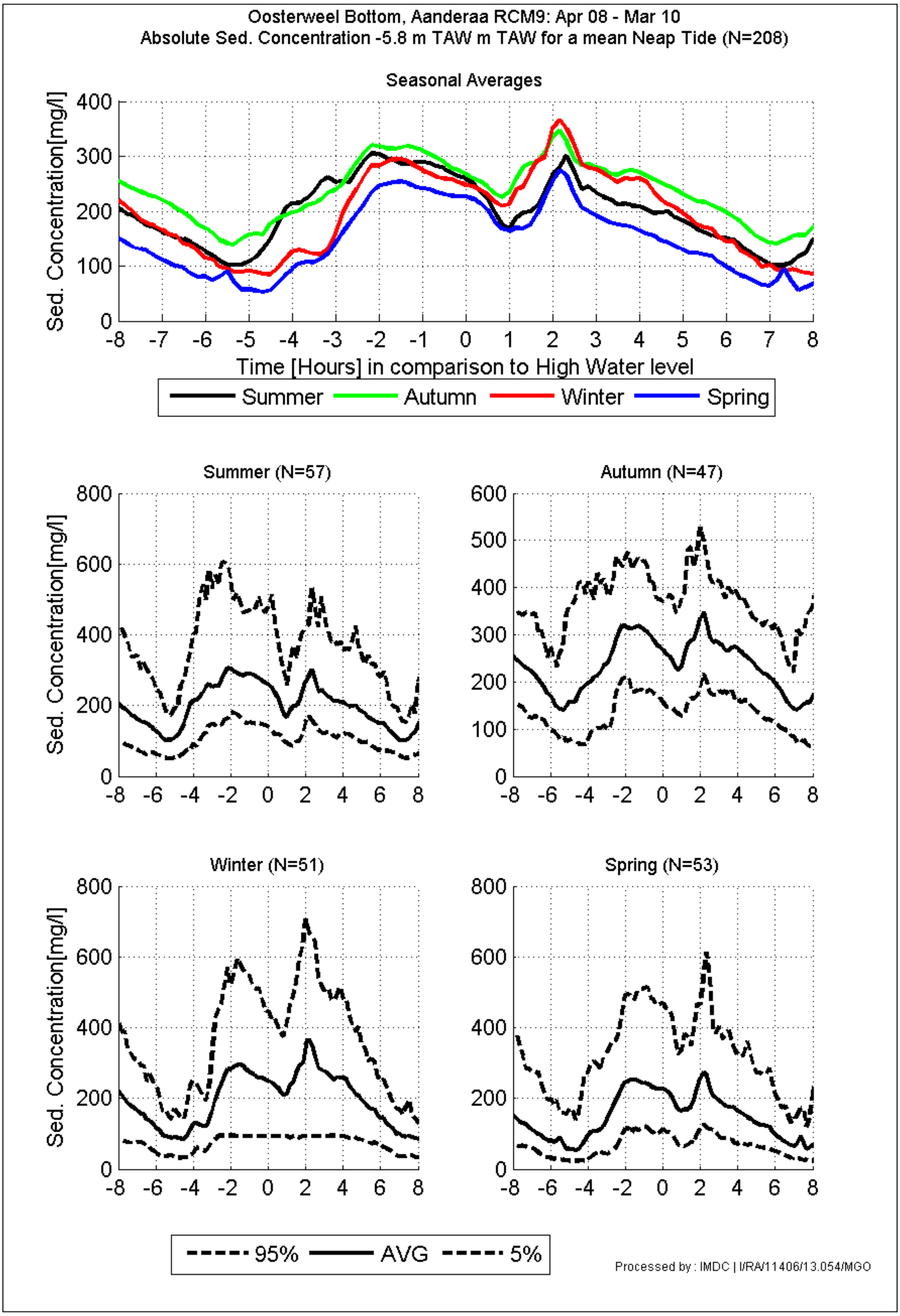
Annex-Figure F-27: Oosterweel Top (-2.3m TAW), April 2008 – March 2010. Averaged tidal curve of the suspended sediment concentration for an averaged neap tide.



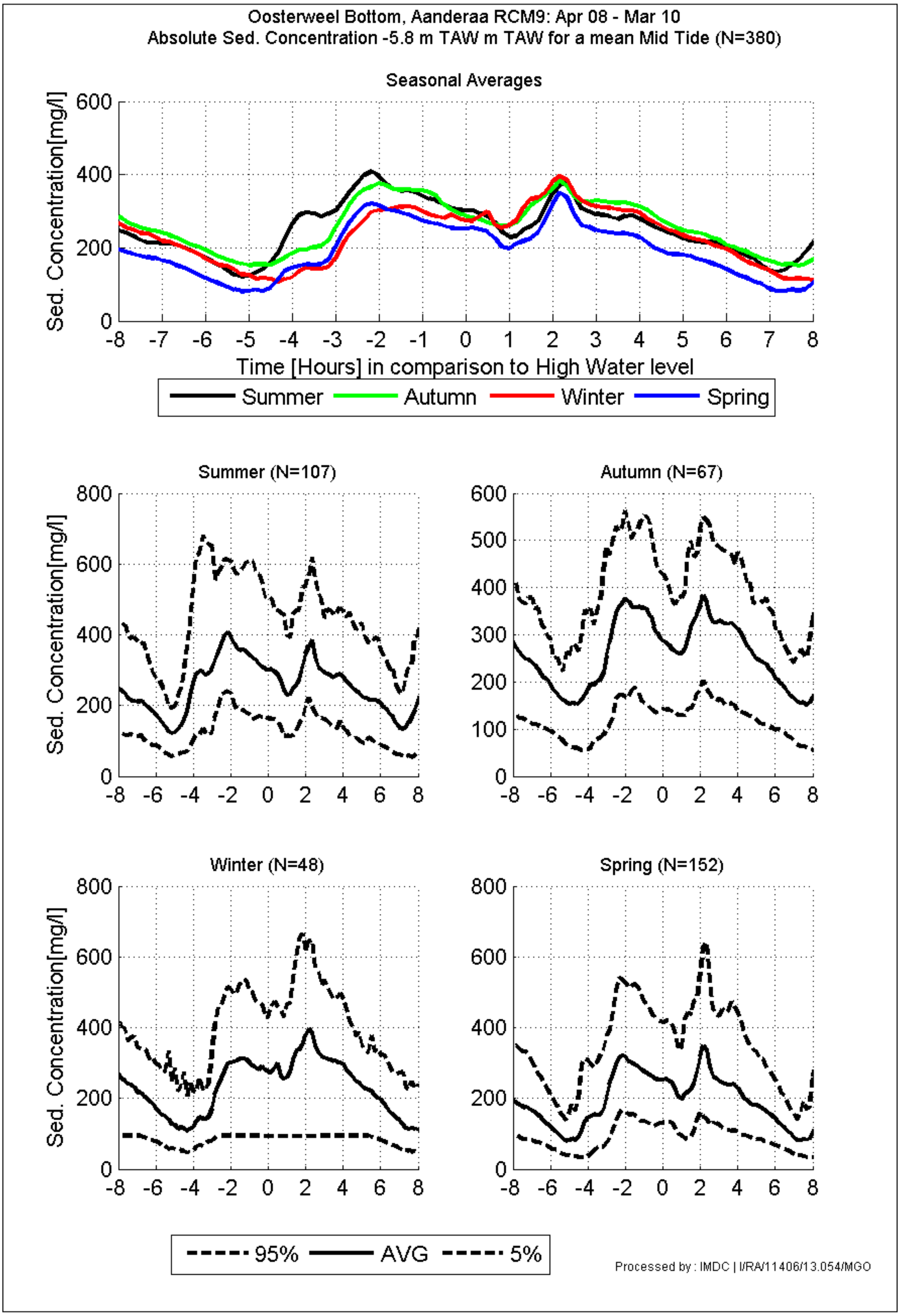
Annex-Figure F-28: Oosterweel Top (-2.3m TAW), April 2008 – March 2010. Averaged tidal curve of the suspended sediment concentration for an averaged mean tide.



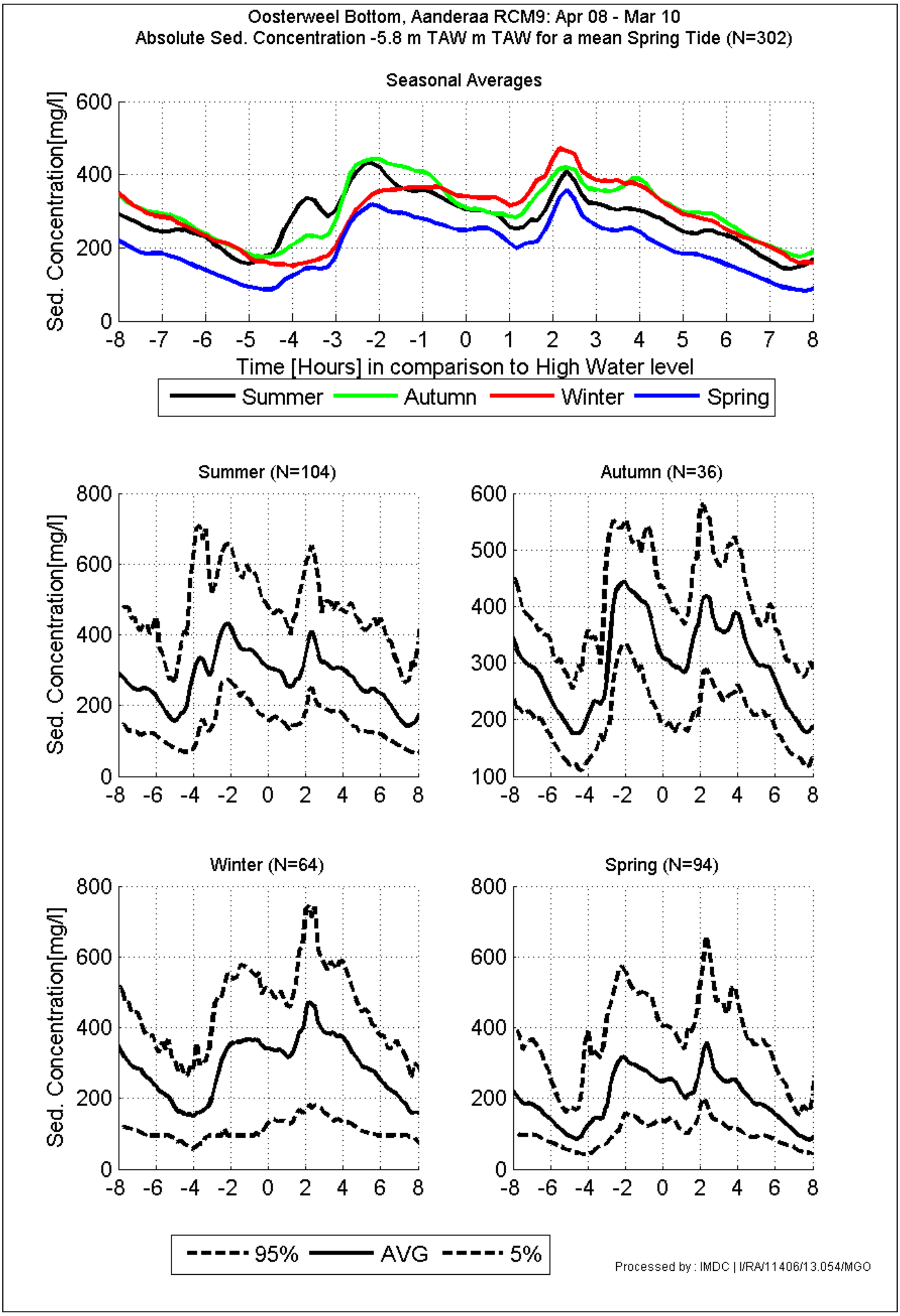
Annex-Figure F-29: Oosterweel Top (-2.3m TAW), April 2008 – March 2010. Averaged tidal curve of the suspended sediment concentration for an averaged spring tide.



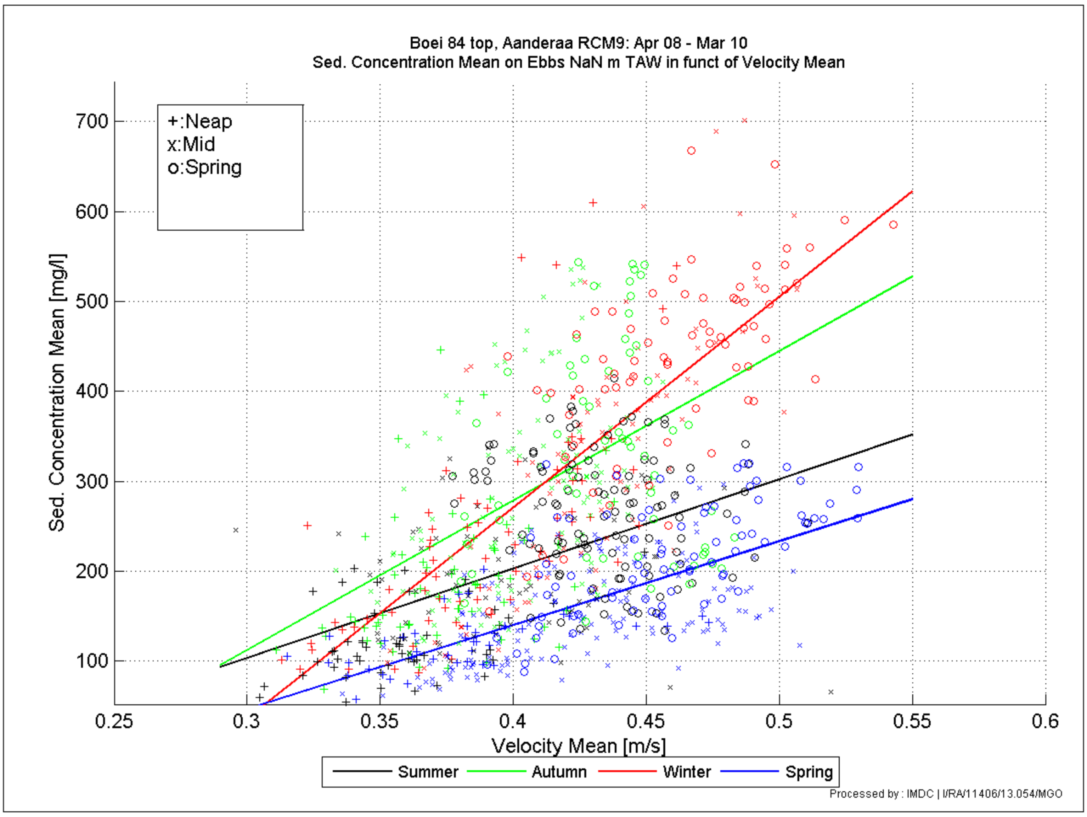
Annex-Figure F-30: Oosterweel Bottom (-5.8m TAW), April 2008 – March 2010. Averaged tidal curve of the suspended sediment concentration for an averaged neap tide.

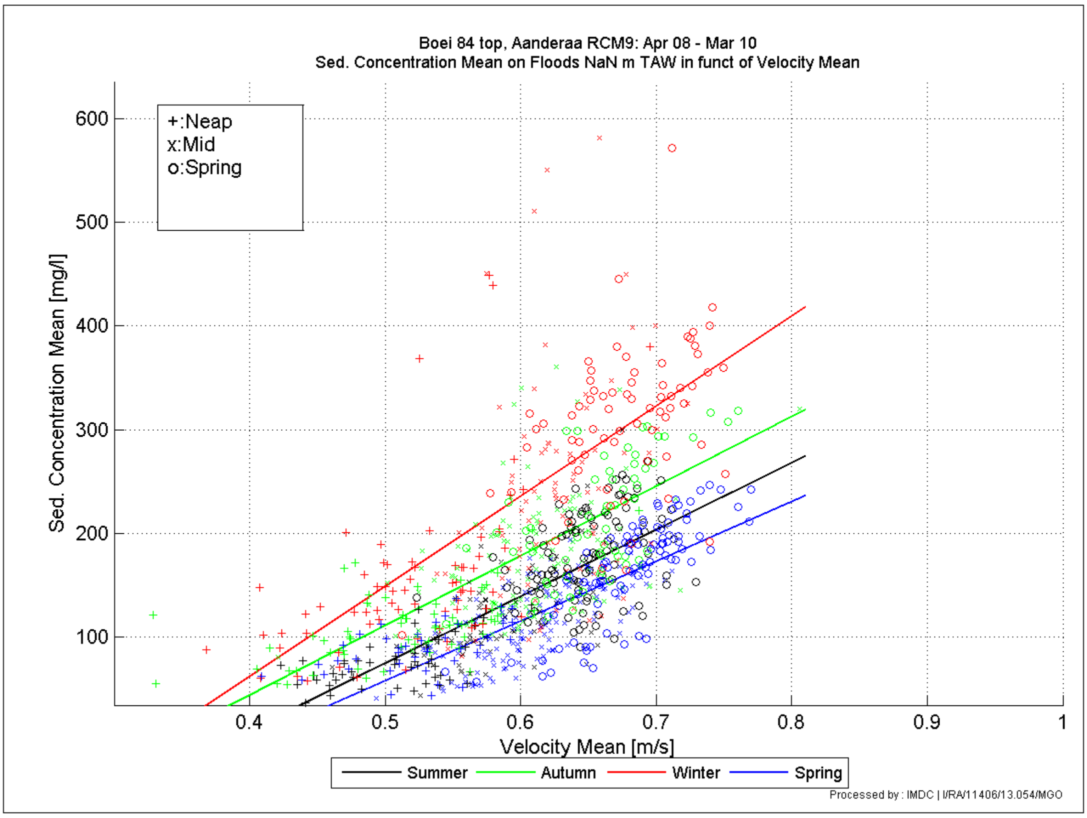


Annex-Figure F-31: Oosterweel Bottom (-5.8m TAW), April 2008 – March 2010. Averaged tidal curve of the suspended sediment concentration for an averaged mean tide.

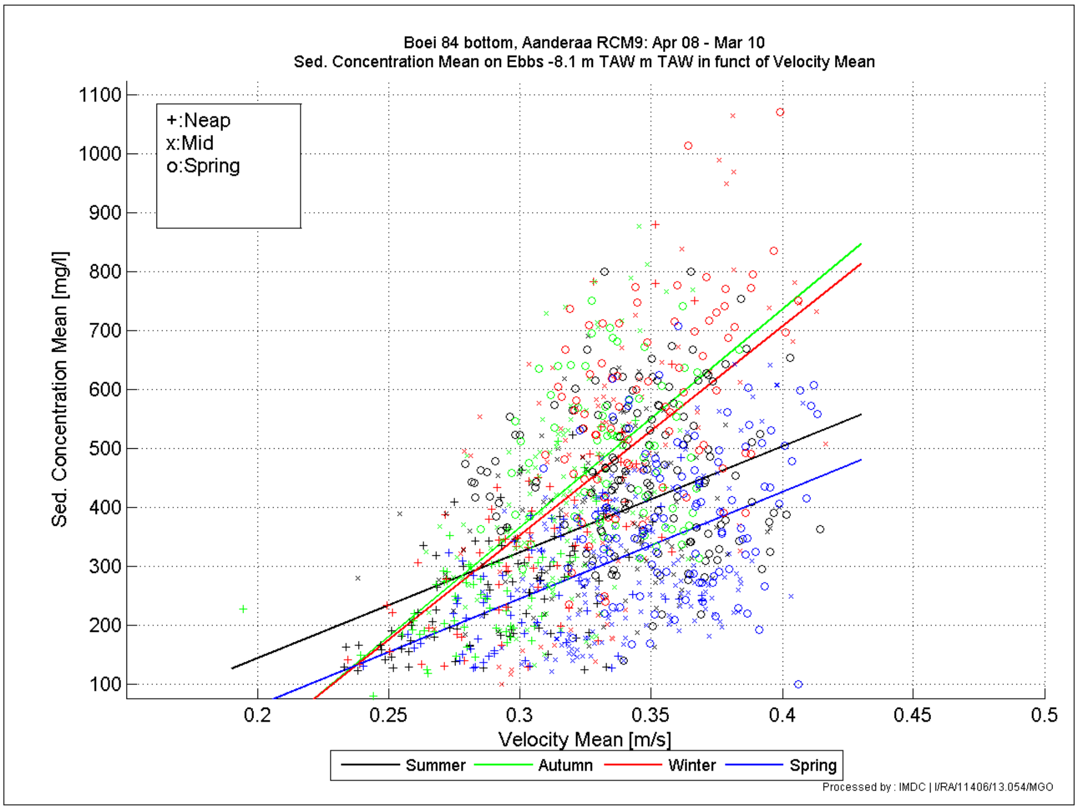


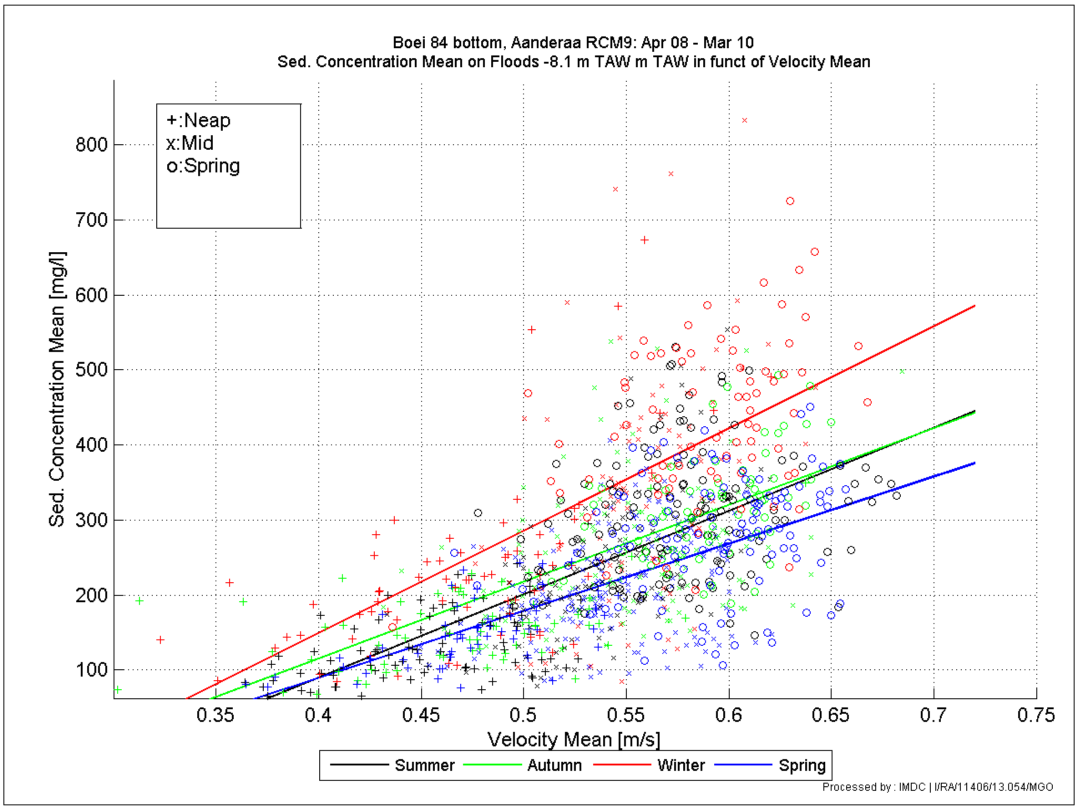
Annex-Figure F-32: Oosterweel Bottom (-5.8m TAW), April 2008 – March 2010. Averaged tidal curve of the suspended sediment concentration for an averaged spring tide.



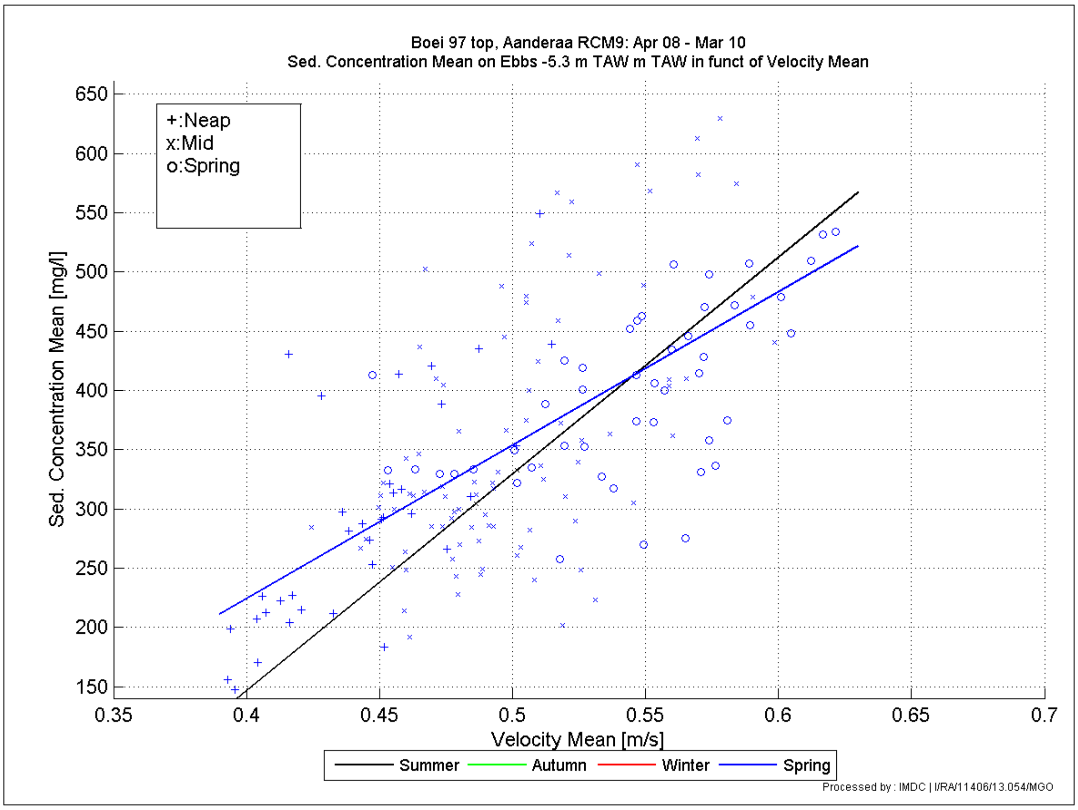


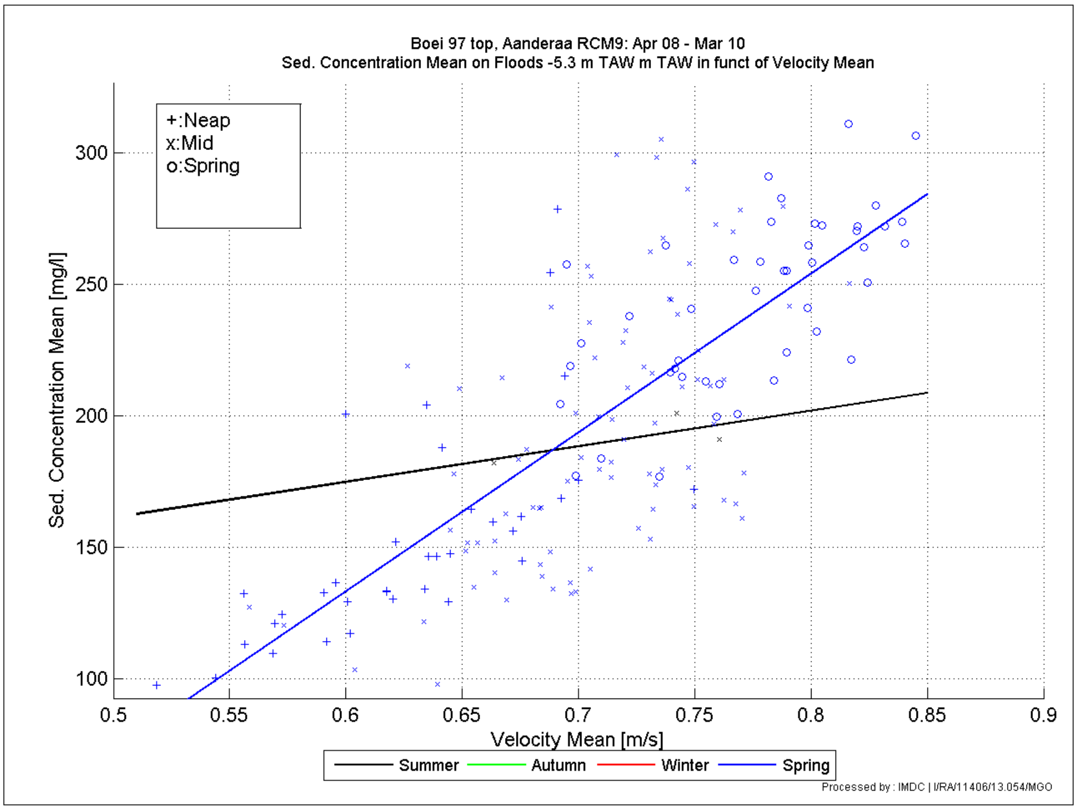
Annex-Figure F-33: Buoy 84 Top (-5.6m TAW). Ebb phase (R = 0.49; sig = 0.00; n = 1148) and flood phase (R = 0.56; sig = 0.00; n = 1148), average suspended sediment concentration vs. flow velocity.



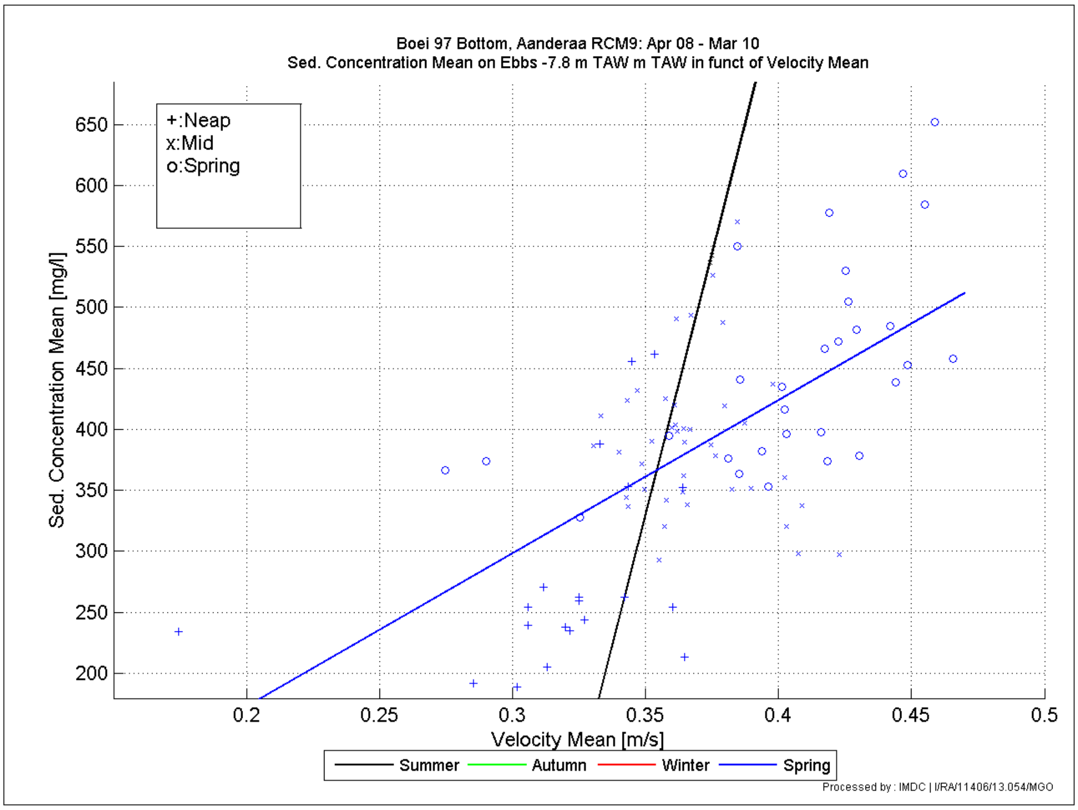


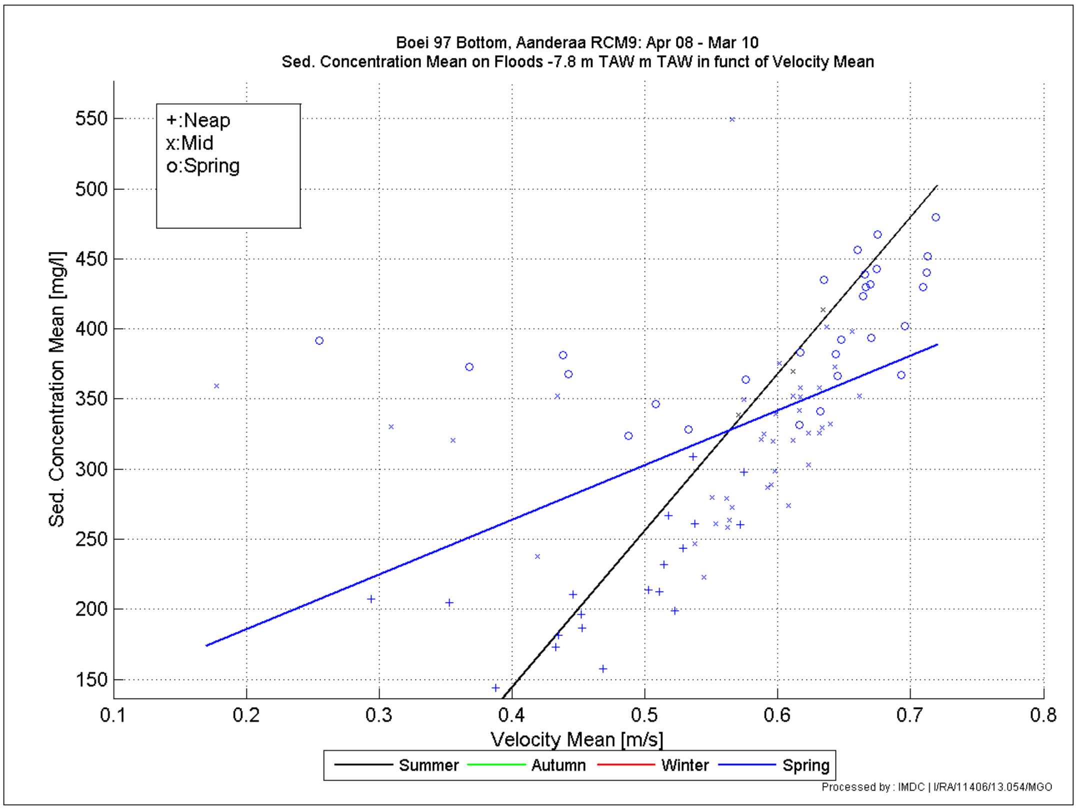
Annex-Figure F-34: Buoy 84 Bottom (-8.1m TAW). Ebb phase (R = 0.48; sig = 0.00; n = 1340) and flood phase (R = 0.58; sig = 0.00; n = 1342), average suspended sediment concentration vs. flow velocity.



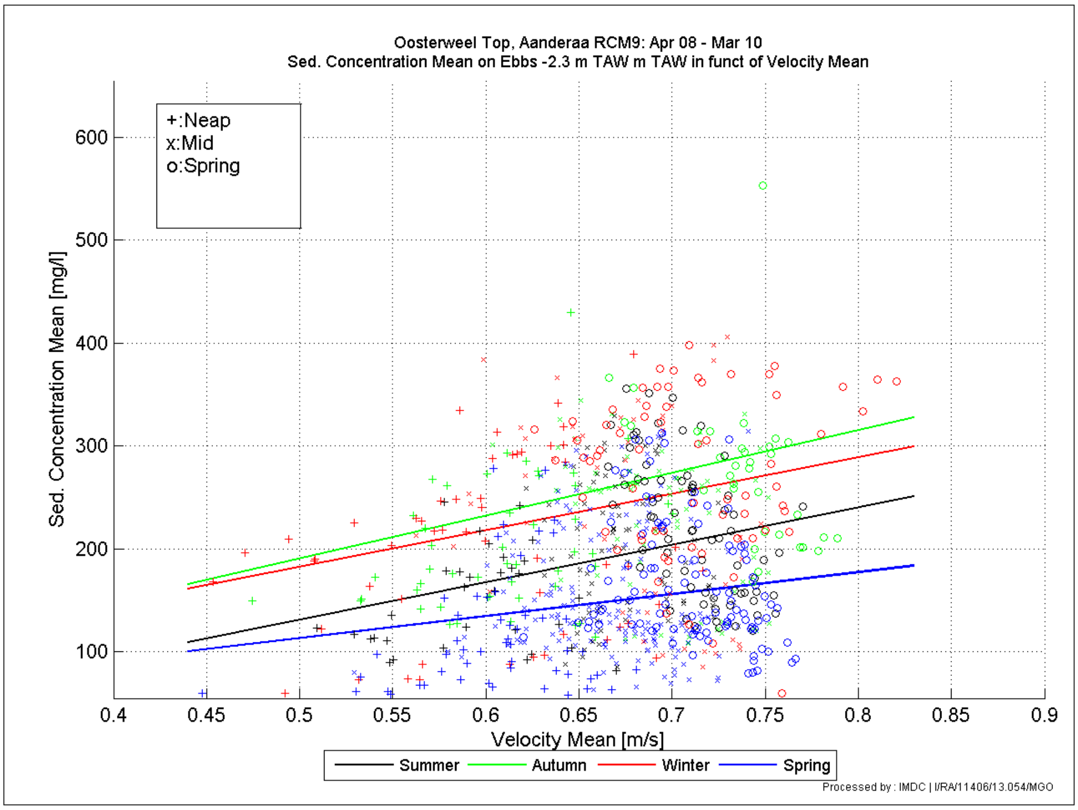


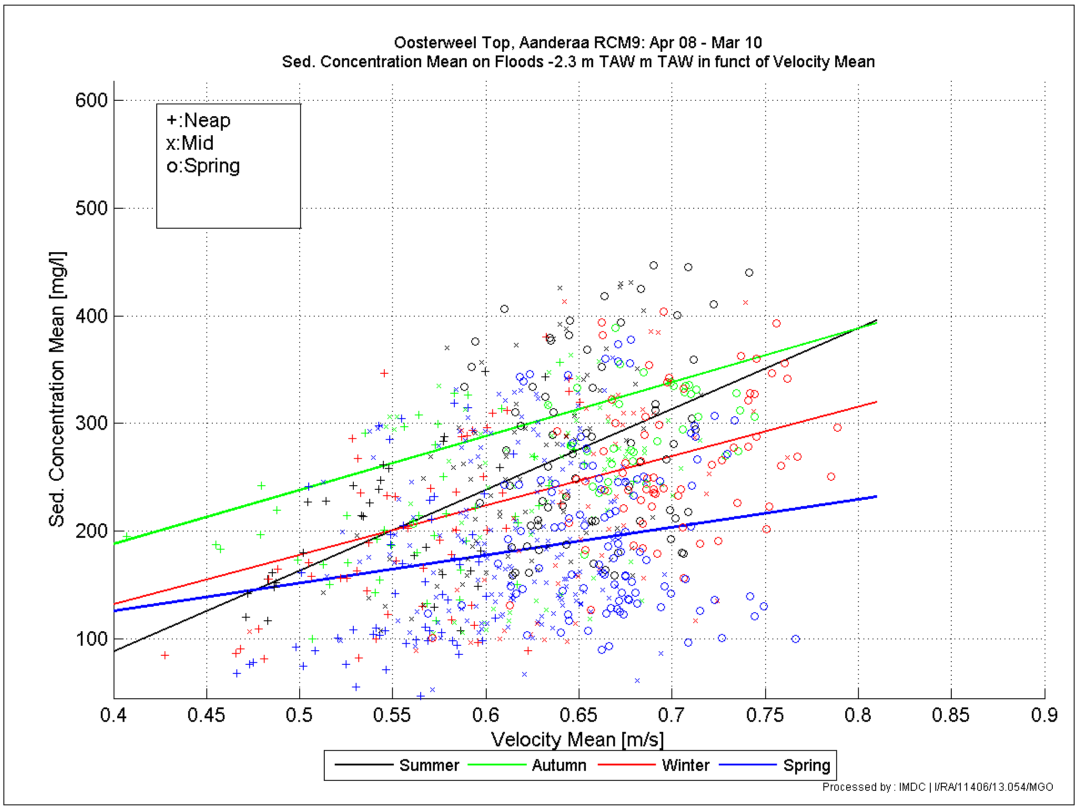
Annex-Figure F-35: Buoy 97 Top (-5.3m TAW). Ebb phase (R = 0.66; sig = 0.00; n = 174) and flood phase (R = 0.76; sig = 0.00; n = 171), average suspended sediment concentration vs. flow velocity.



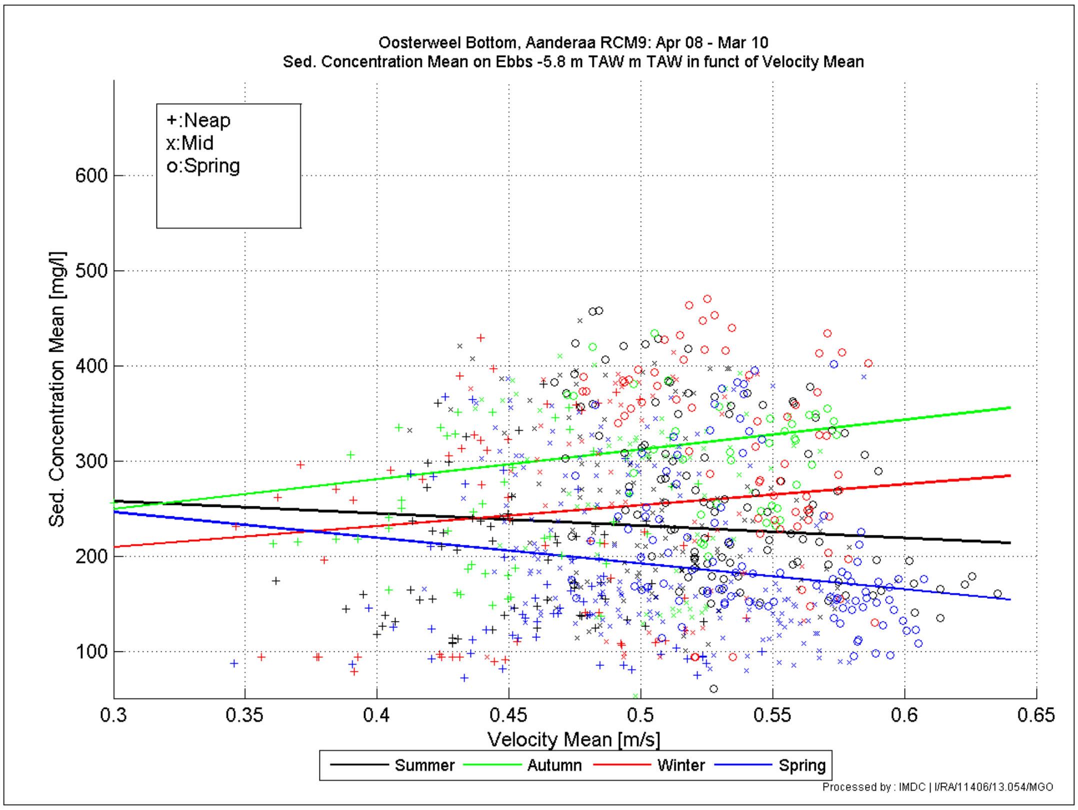


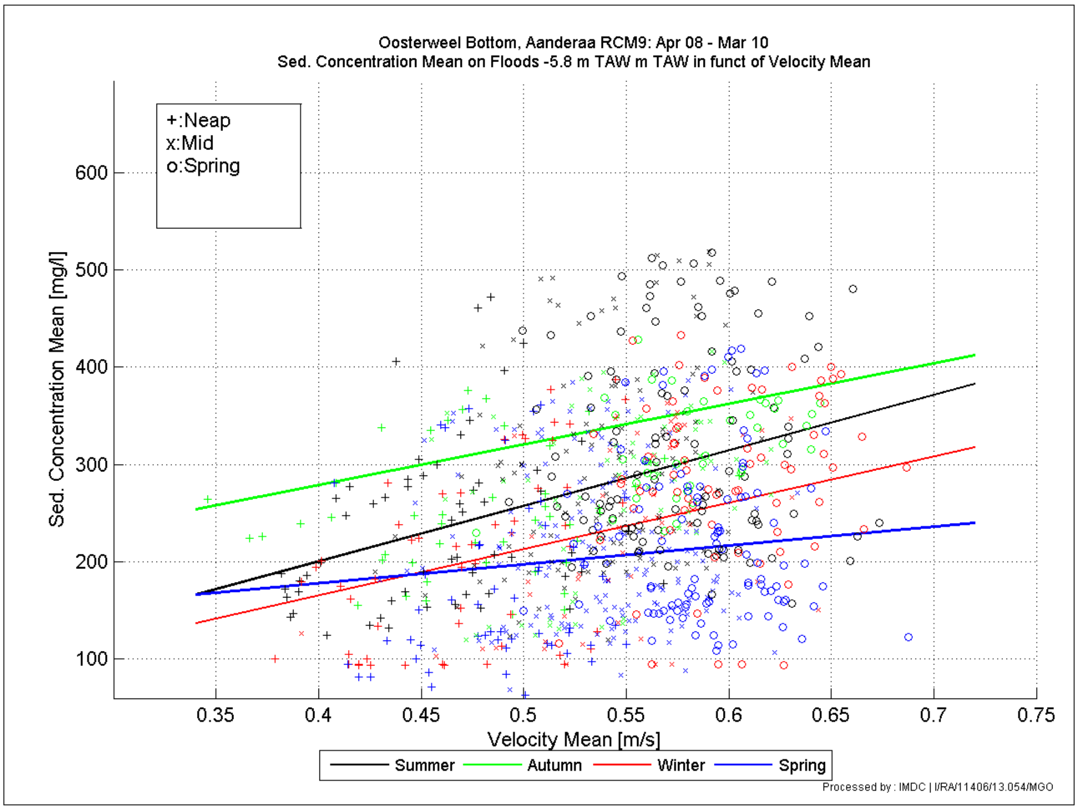
Annex-Figure F-36: Buoy 97 Bottom (-7.8m TAW). Ebb phase (R = 0.60; sig = 0.00; n = 93) and flood phase (R = 0.52; sig = 0.00; n = 91), average suspended sediment concentration vs. flow velocity.



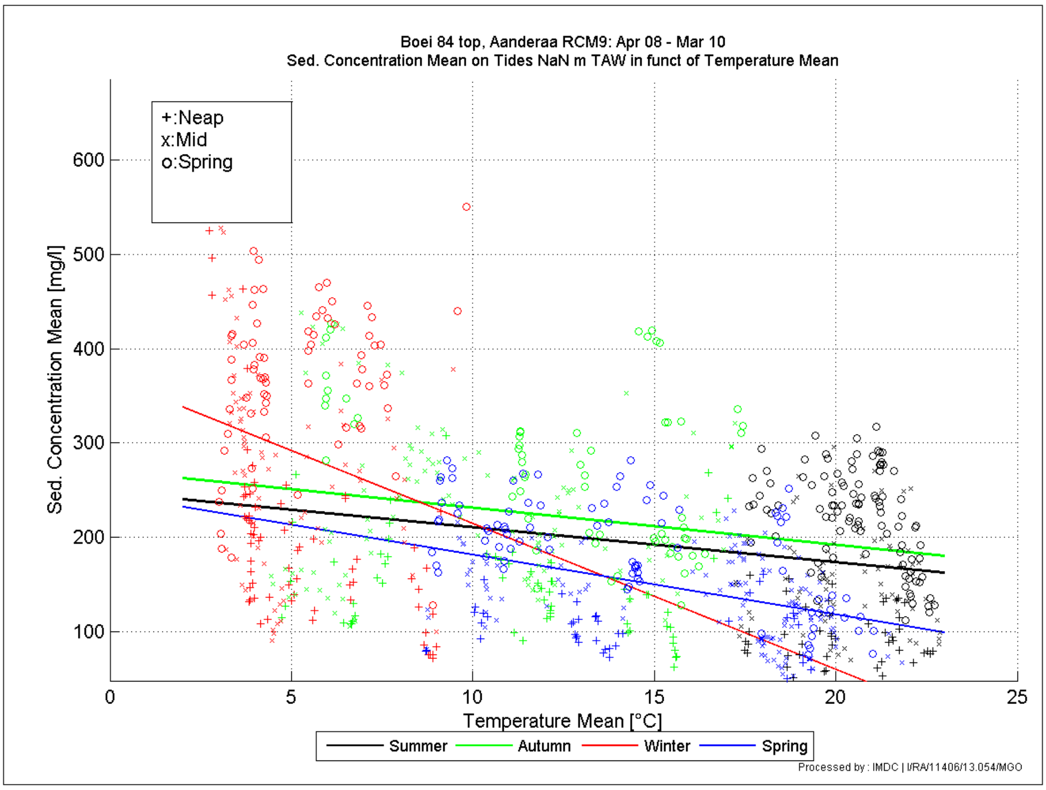


Annex-Figure F-37: Oosterweel Top (-2.3m TAW). Ebb phase (R = 0.23; sig = 0.00; n = 1185) and flood phase (R = 0.28; sig = 0.00; n = 1187), average suspended sediment concentration vs. flow velocity.

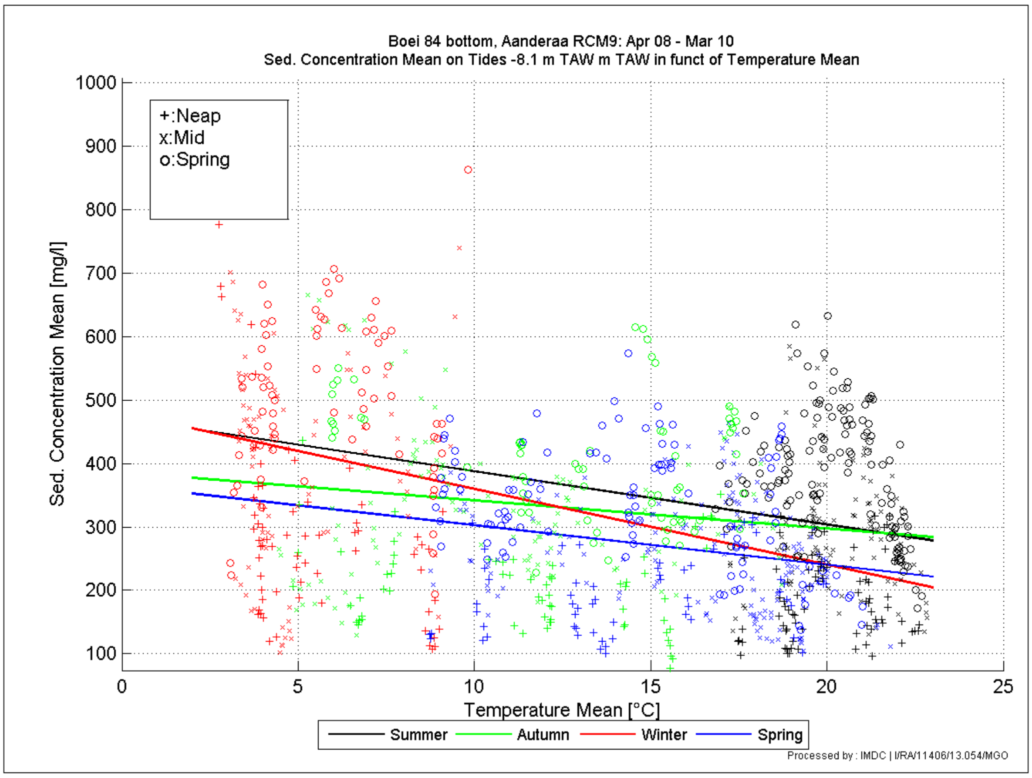




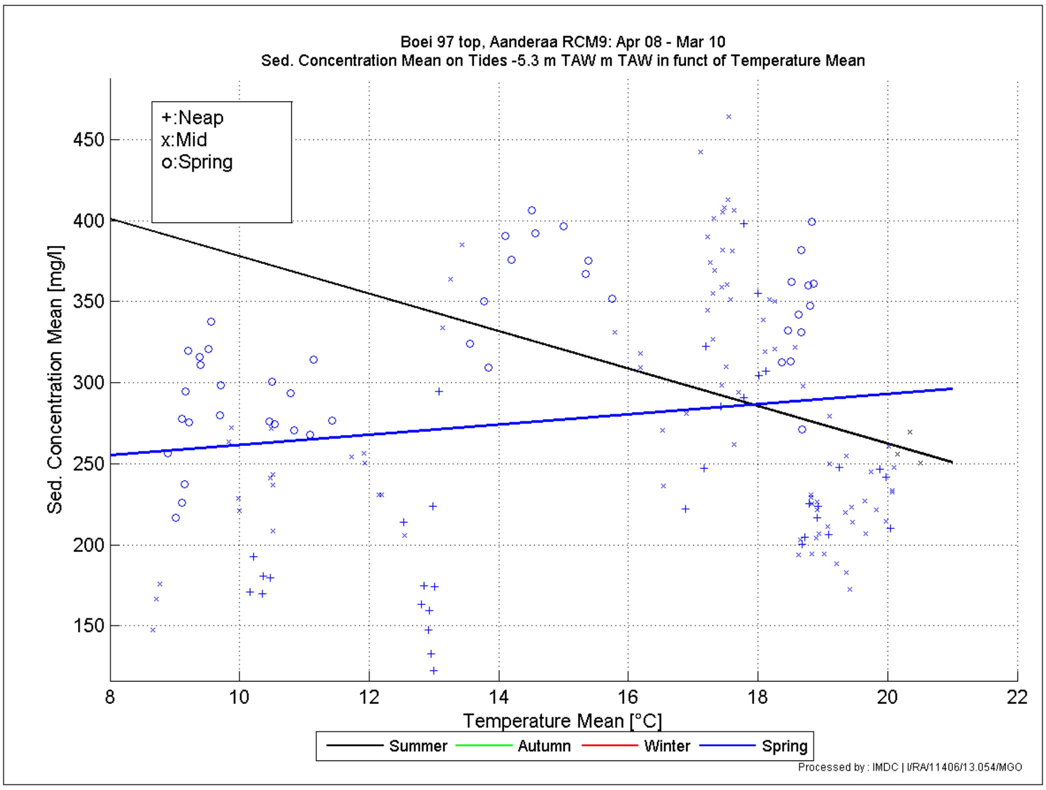
Annex-Figure F-38: Oosterweel Bottom (-5.8m TAW). Ebb phase (R=0.34; sig=0.03; n=1352) and flood phase (R=0.2; sig=0.00; n=1346), average suspended sediment concentration vs. flow velocity.



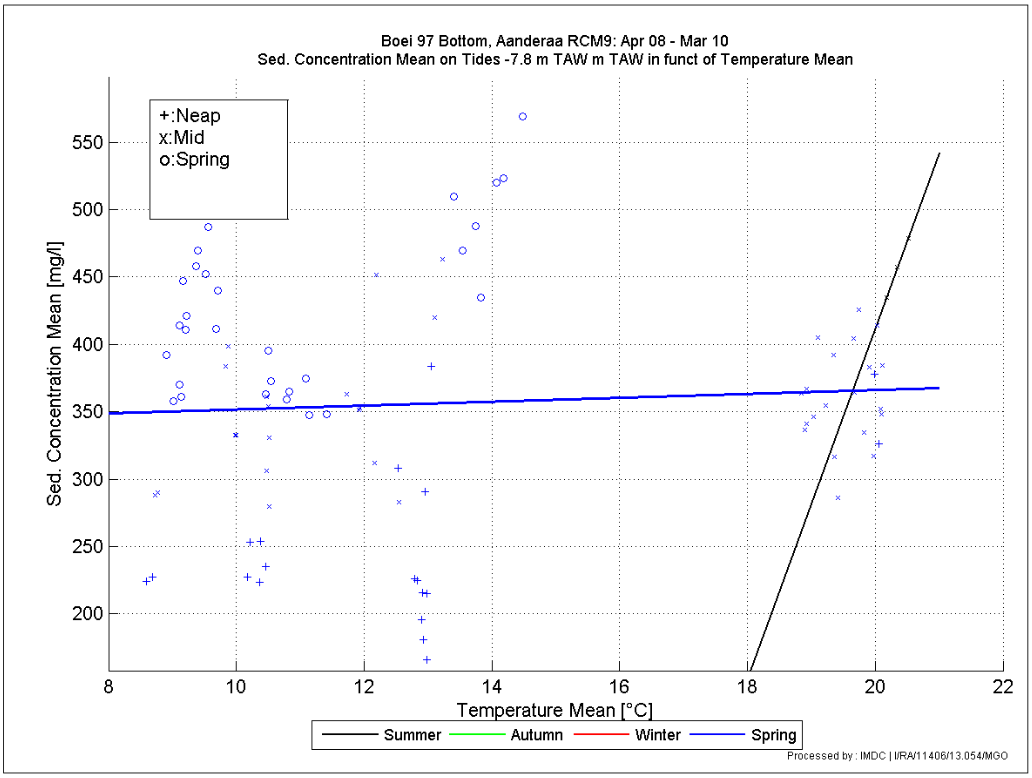
Annex-Figure F-39: Buoy 84 (-5.6m TAW). Tidal average sediment concentration vs. temperature (R=-0.49; sig=0.00; n=1132).



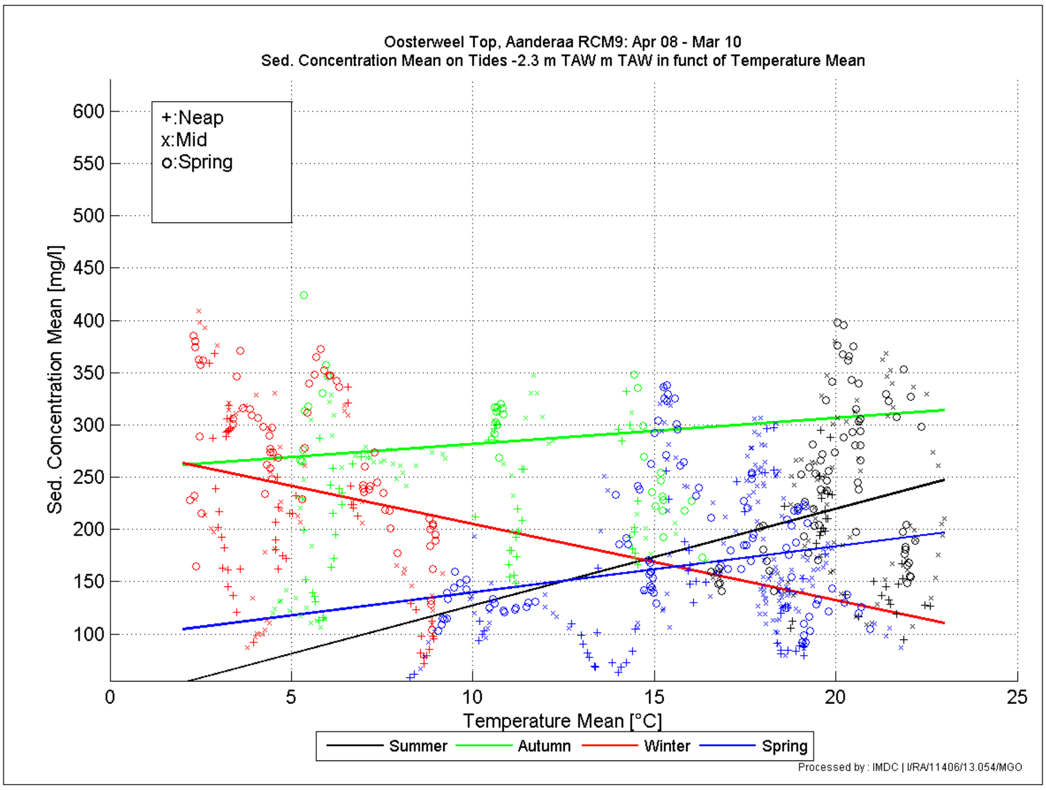
Annex-Figure F-40: Buoy 84 (-8.1m TAW). Tidal average sediment concentration vs. temperature (R=-0.34; sig=0.00; n=1313).



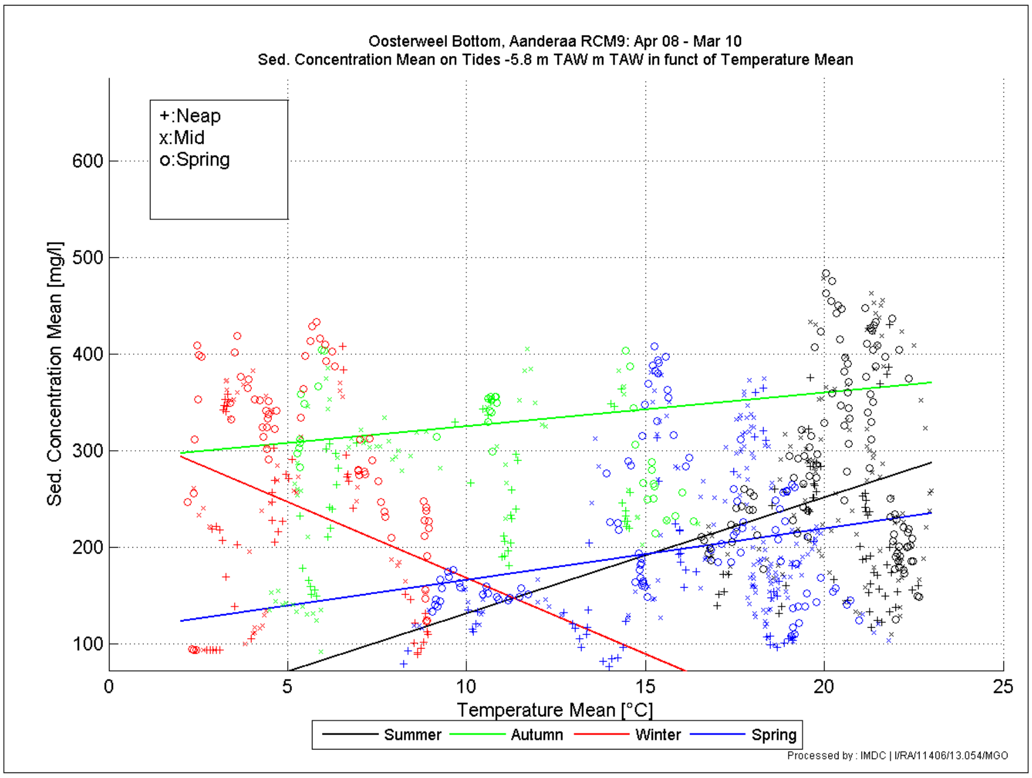
Annex-Figure F-41: Buoy 97 (-5.3m TAW). Tidal average sediment concentration vs. temperature (R=0.15; sig=0.05; n=168).



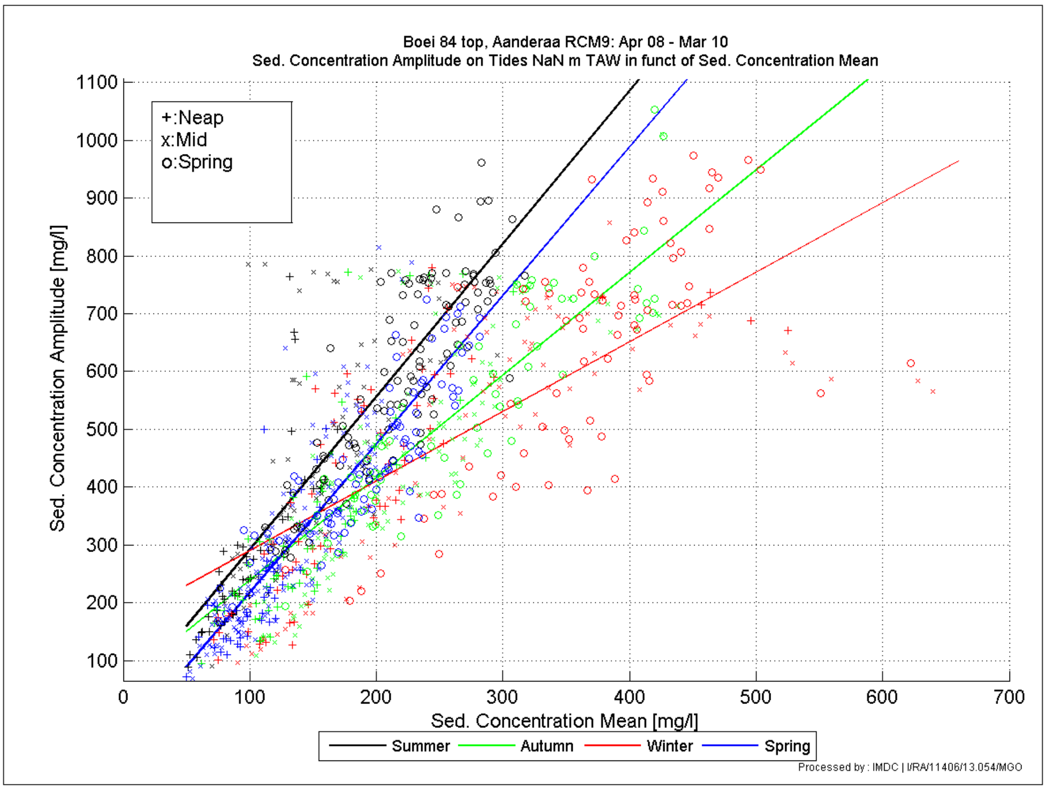
Annex-Figure F-42: Buoy 97 (-5.3m TAW). Tidal average sediment concentration vs. temperature (R=0.15; sig=0.05; n=168).



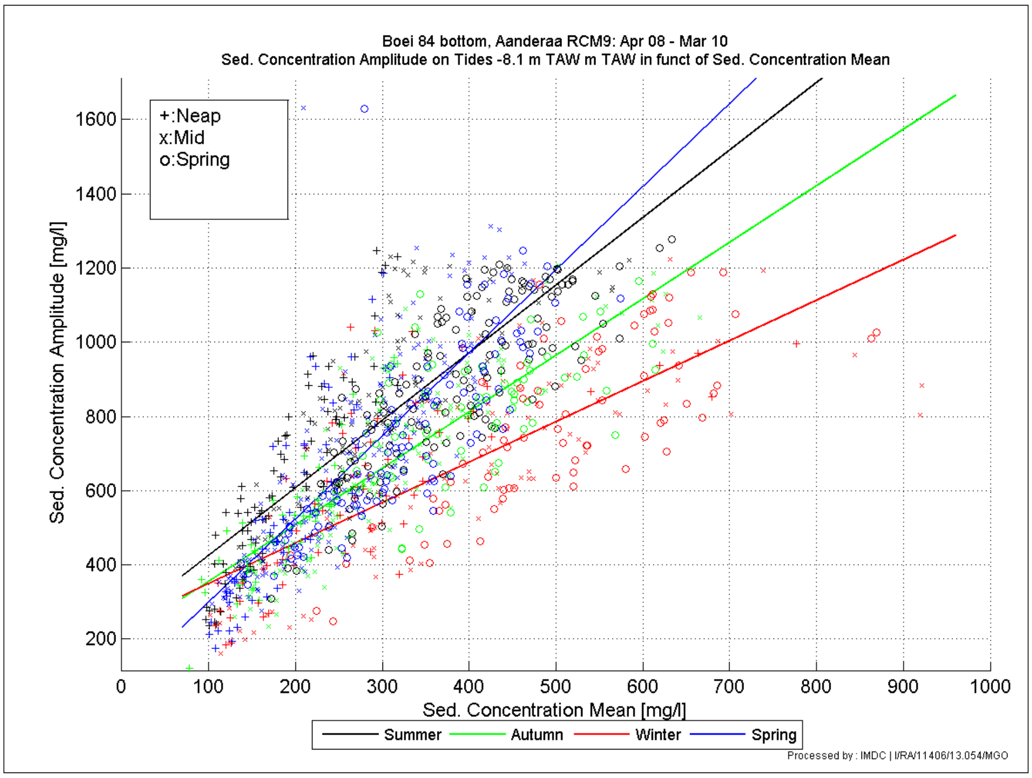
Annex-Figure F-43: Oosterweel Top (-2.3m TAW, Tidal average sediment concentration vs. temperature (R=-0.18; sig=0.00; n=1167).



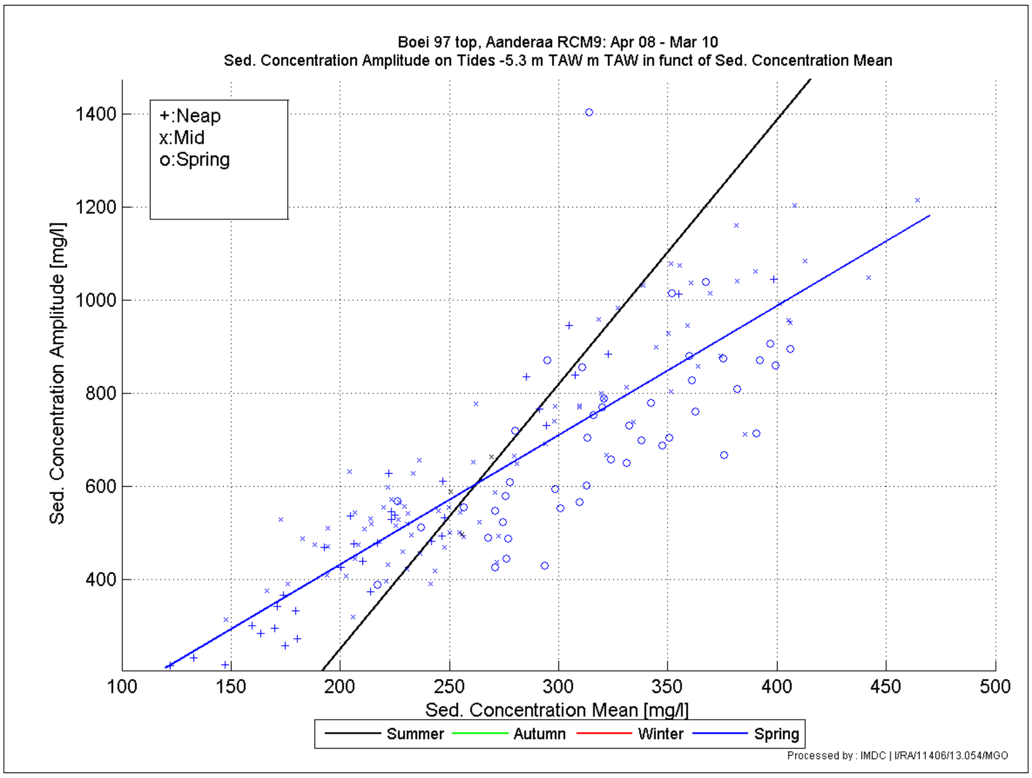
Annex-Figure F-44: Oosterweel Bottom (-5.8m TAW). Tidal average sediment concentration vs. temperature (R=-0.07; sig=0.01; n=1323).



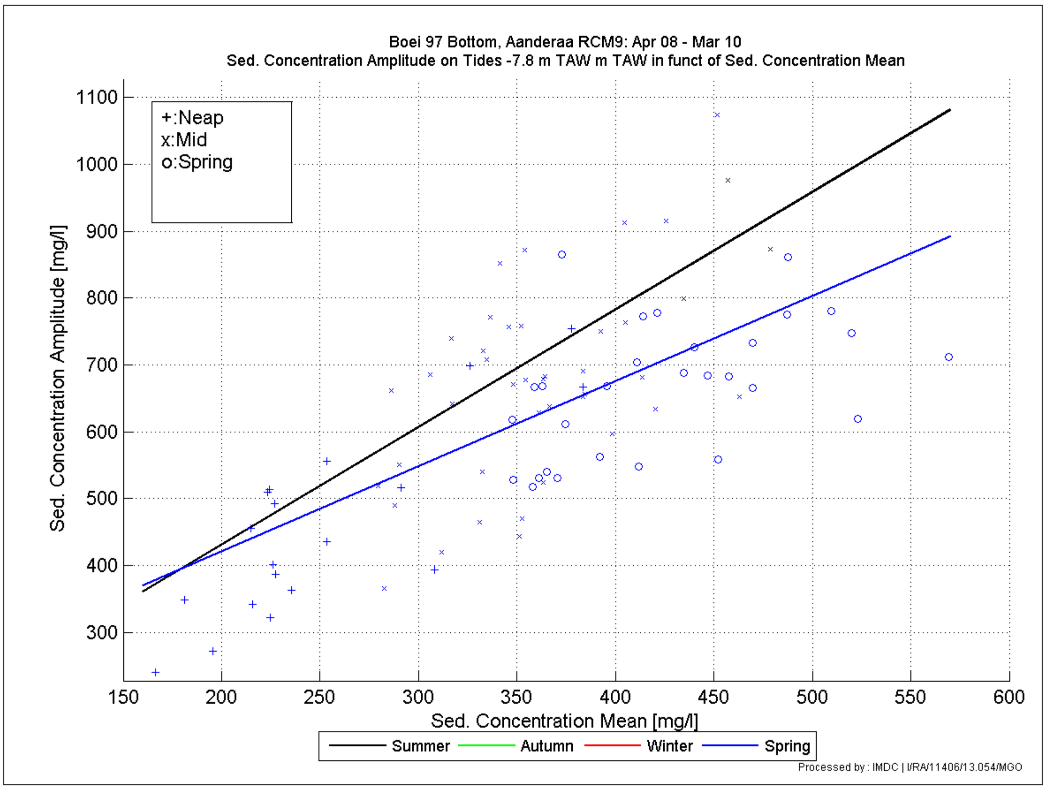
Annex-Figure F-45: Buoy 84 (-5.6m TAW). Sediment concentration amplitude vs. mean (R = 0.78; sig = 0.00; n = 1132).



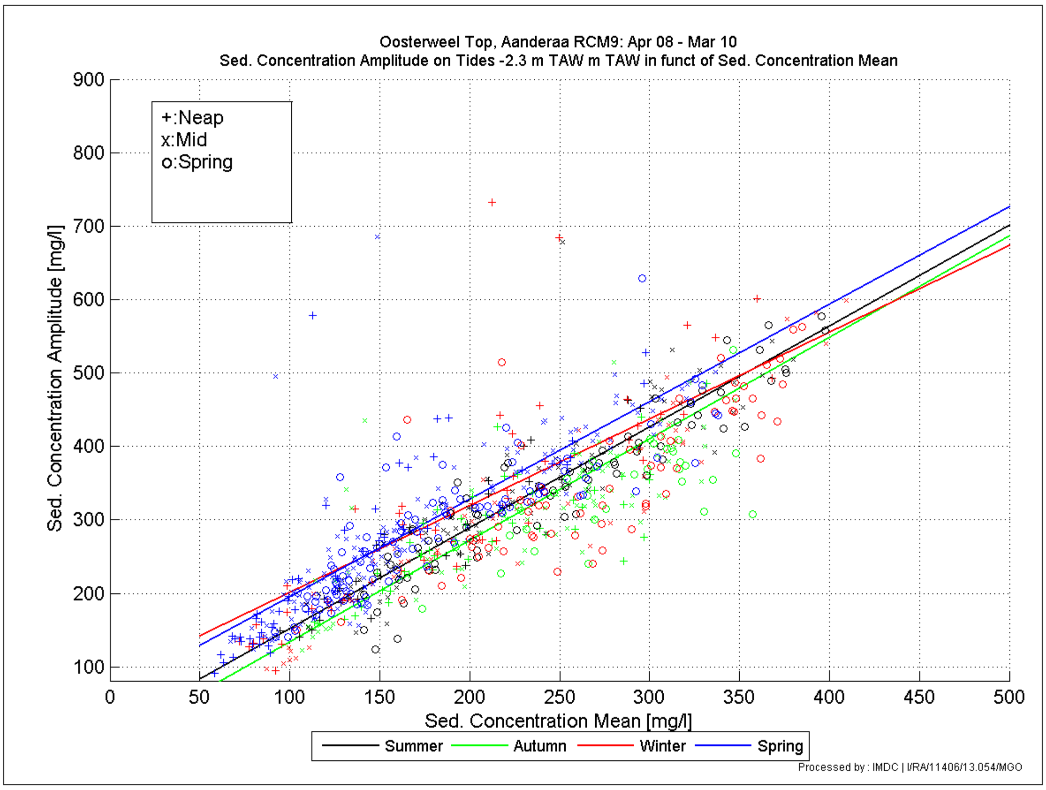
Annex-Figure F-46: Buoy 84 (-8.1m TAW). Sediment concentration amplitude vs. mean (R = 0.72; sig = 0.00; n = 1316).



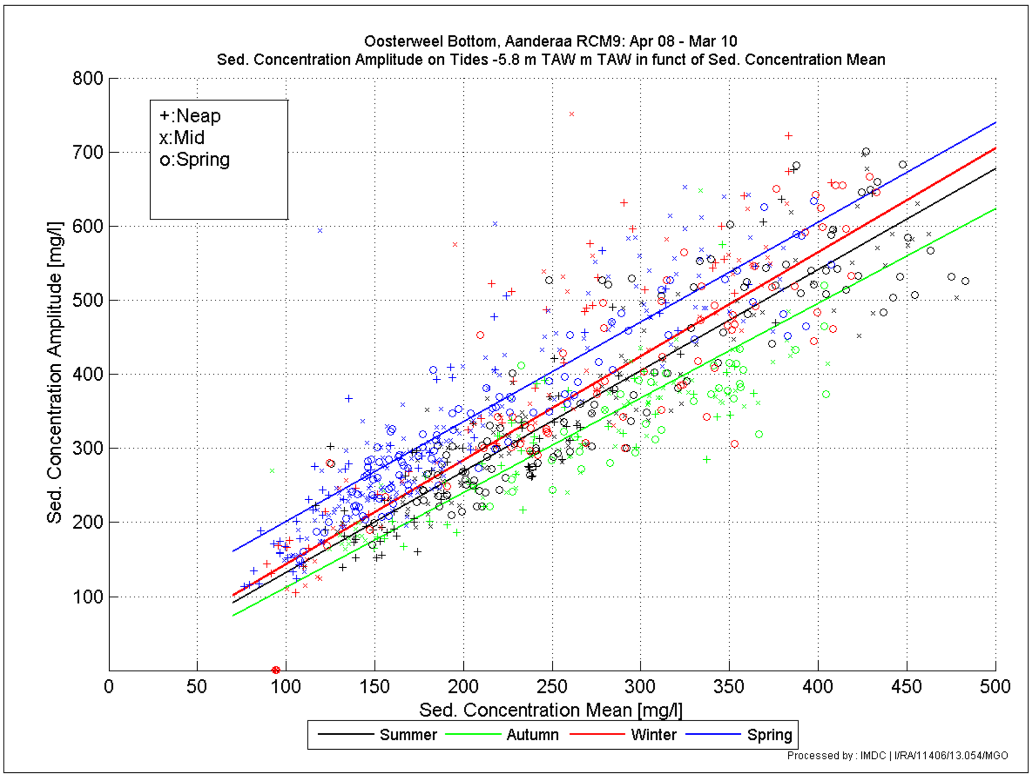
Annex-Figure F-47: Buoy 97 (-5.3m TAW). Sediment concentration amplitude vs. mean (R = 0.87; sig = 0.00; n = 168).



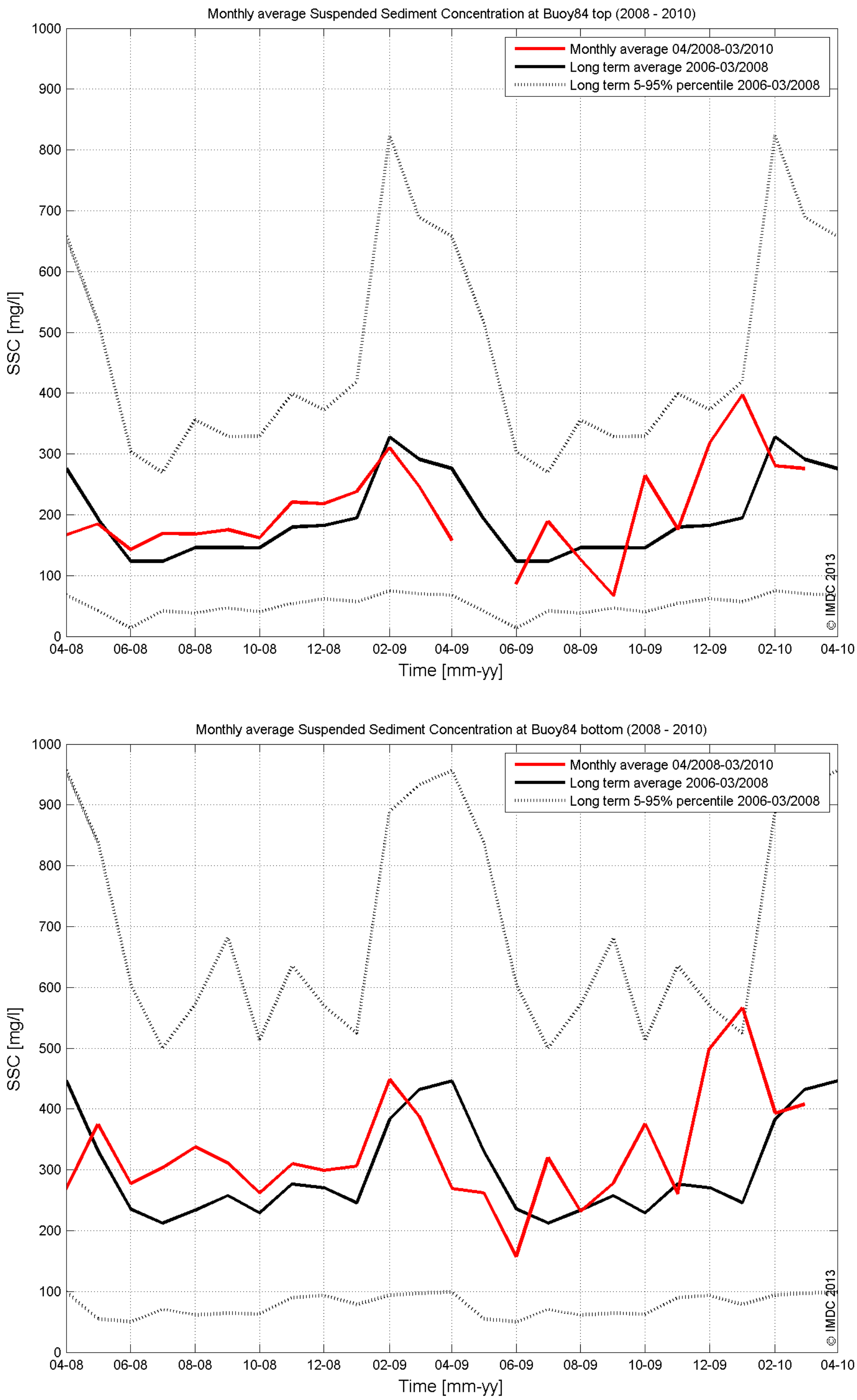
Annex-Figure F-48: Buoy 97 (-7.8m TAW). Sediment concentration amplitude vs. mean (R = 0.70; sig = 0.00; n = 90).



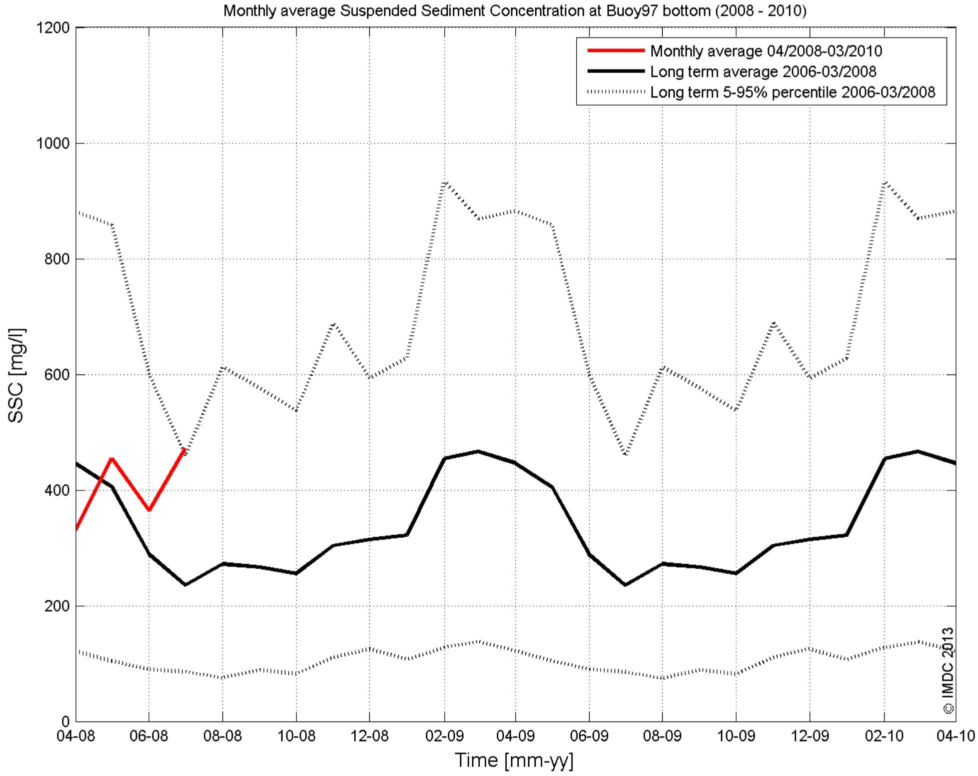
Annex-Figure F-49: Oosterweel Top (-2.3m TAW). Sediment concentration amplitude vs. mean (R = 0.72; sig = 0.00; n = 1167).

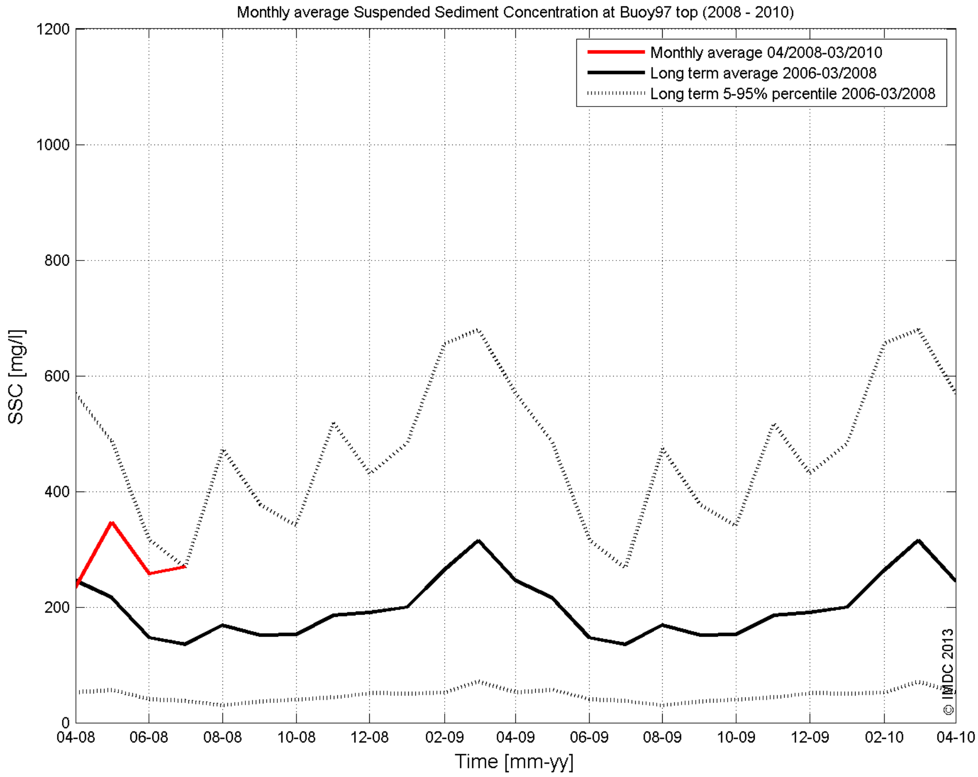


Annex-Figure F-50: Oosterweel Bottom (-5.8m TAW). Sediment concentration amplitude vs. mean (R = 0.81; sig = 0.00; n = 1326).

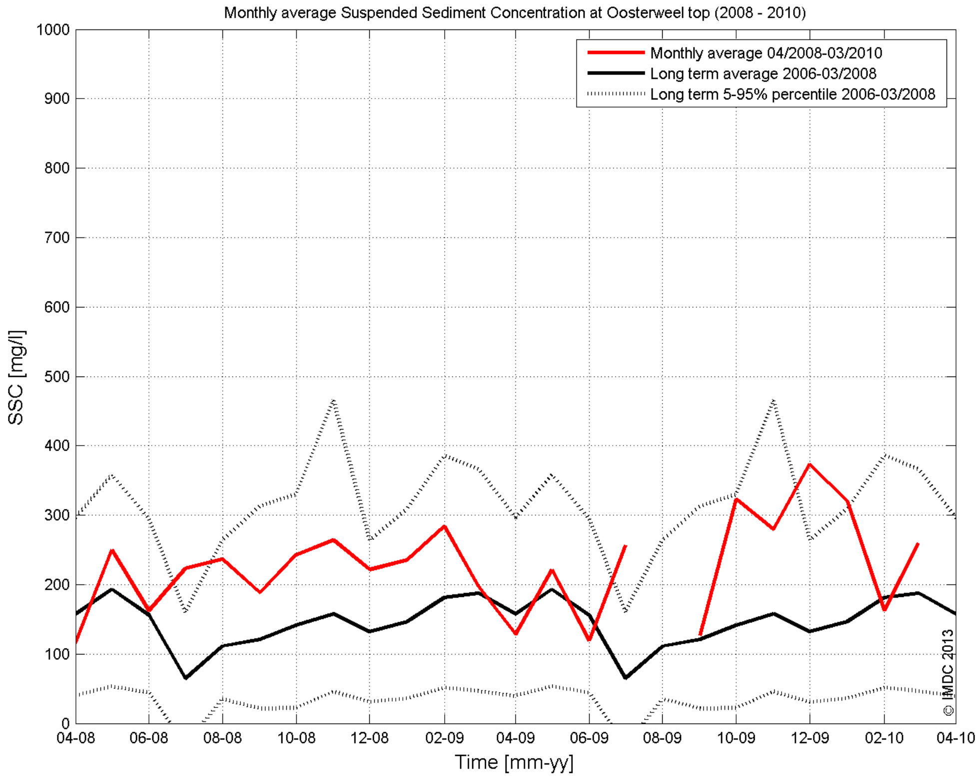


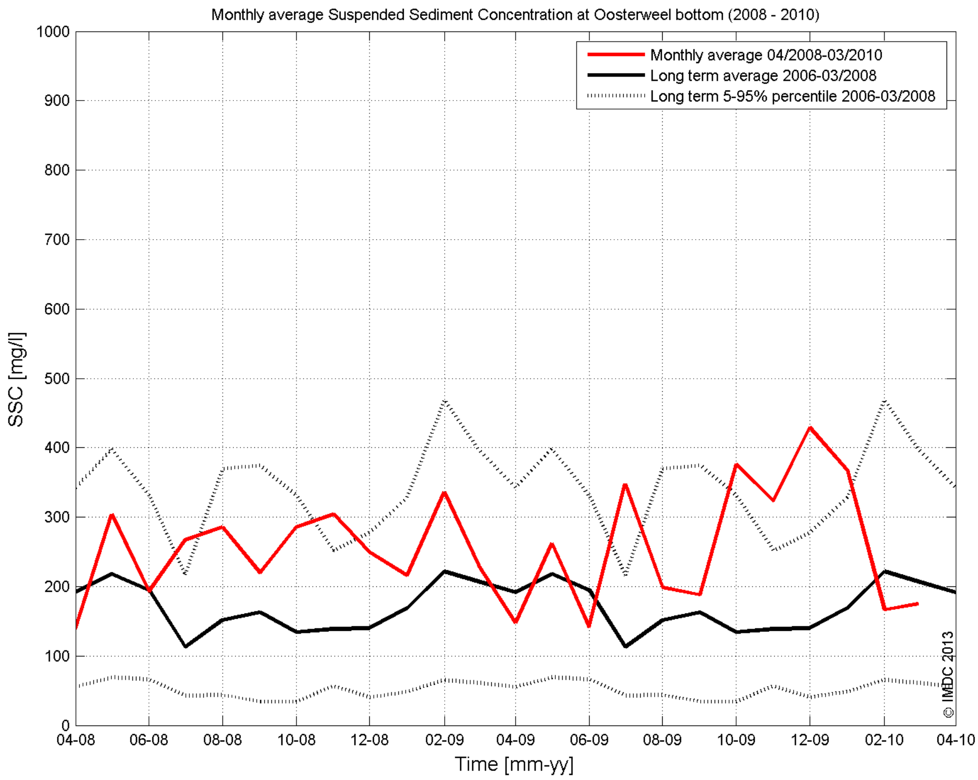
Annex-Figure F-51: The monthly average sediment concentration curves of (a) Buoy84 top and (b) bottom between April 2008 – March 2010 and 2006 – March 2008 including the monthly 5/95% percentiles .





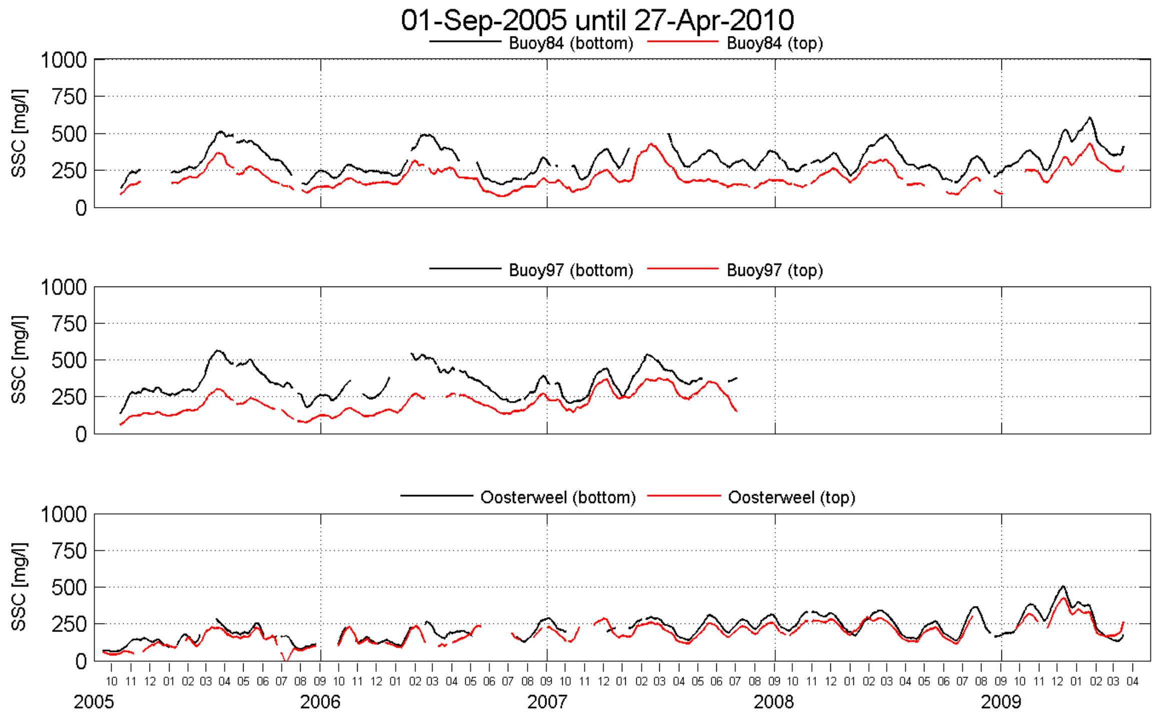
Annex-Figure F-52: The monthly average sediment concentration curves of (a) Buoy97 top and (b) bottom between April 2008 – March 2010 and 2006 – March 2008 including the monthly 5/95% percentiles.





Annex-Figure F-53: The monthly average sediment concentration curves of (a) Oosterweel top and (b) bottom between April 2008 – March 2010 and 2006 – March 2008 including the monthly 5/95% percentiles

11406 - External effects siltation Deurganckdok (2012-2014)



Timeseries of monthly moving average of
Suspended Sediment Concentration (SSC)

Location:
Lower Sea Scheldt (Buoy84, Buoy97 and Oosterweel)

Processed by:

I/RA/11406/13.054/MGO

Annex-Figure F-54: Time series of monthly moving average of Suspended Sediment Concentration at Oosterweel, B84 and B97 measurement stations.